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Handbook

Overhaul Instructions

MODELS

R-985-AN-1, AN-3, AN-14B, -39, and -39A AIRCRAFT ENGINES

PUBLISHED UNDER AUTHORITY OF THE SECRETARY OF THE AIR FORCE AND THE CHIEF OF THE BUREAU OF NAVAL WEAPONS

15 July 1950
Revised 1 December 1962

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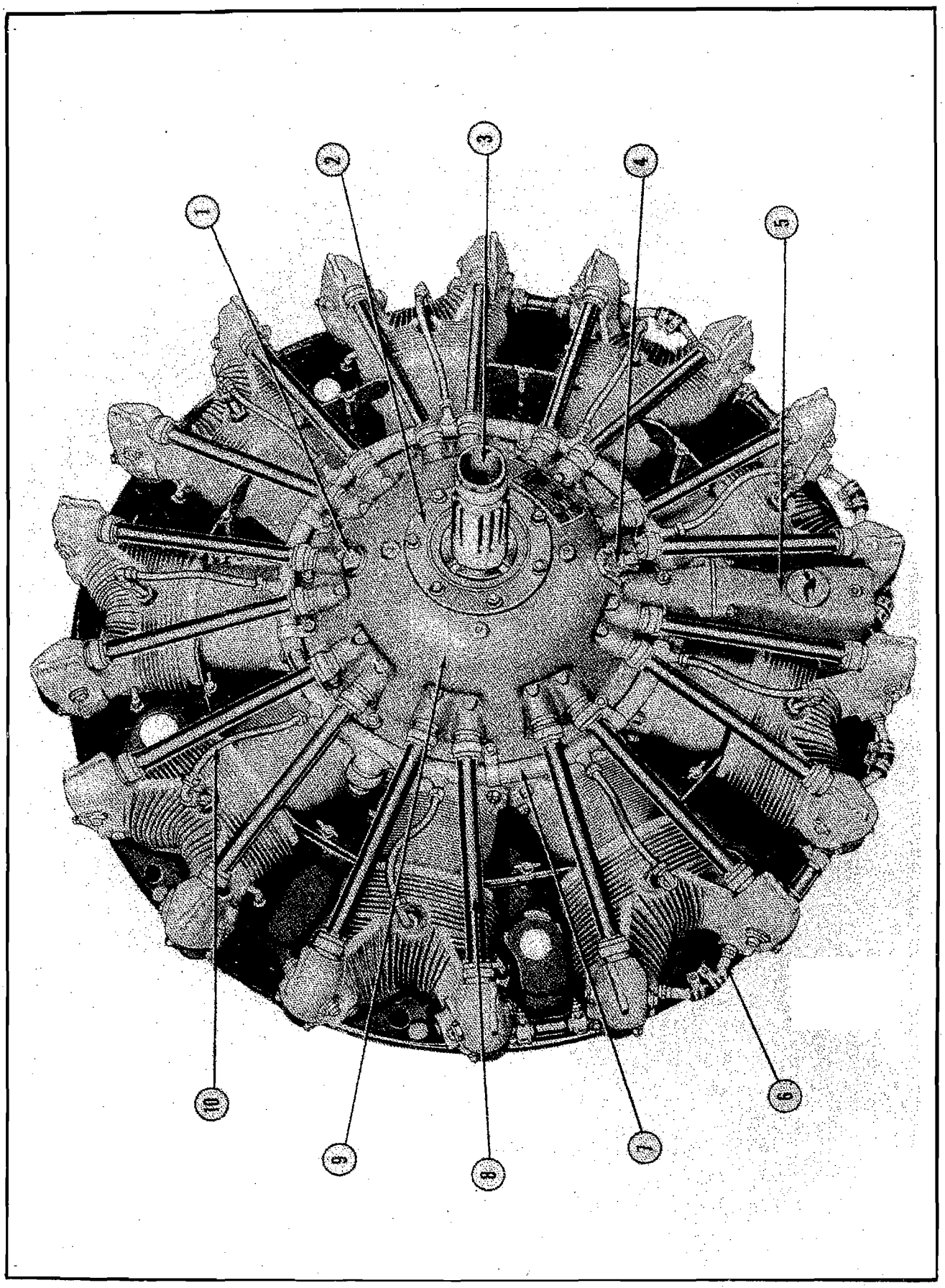

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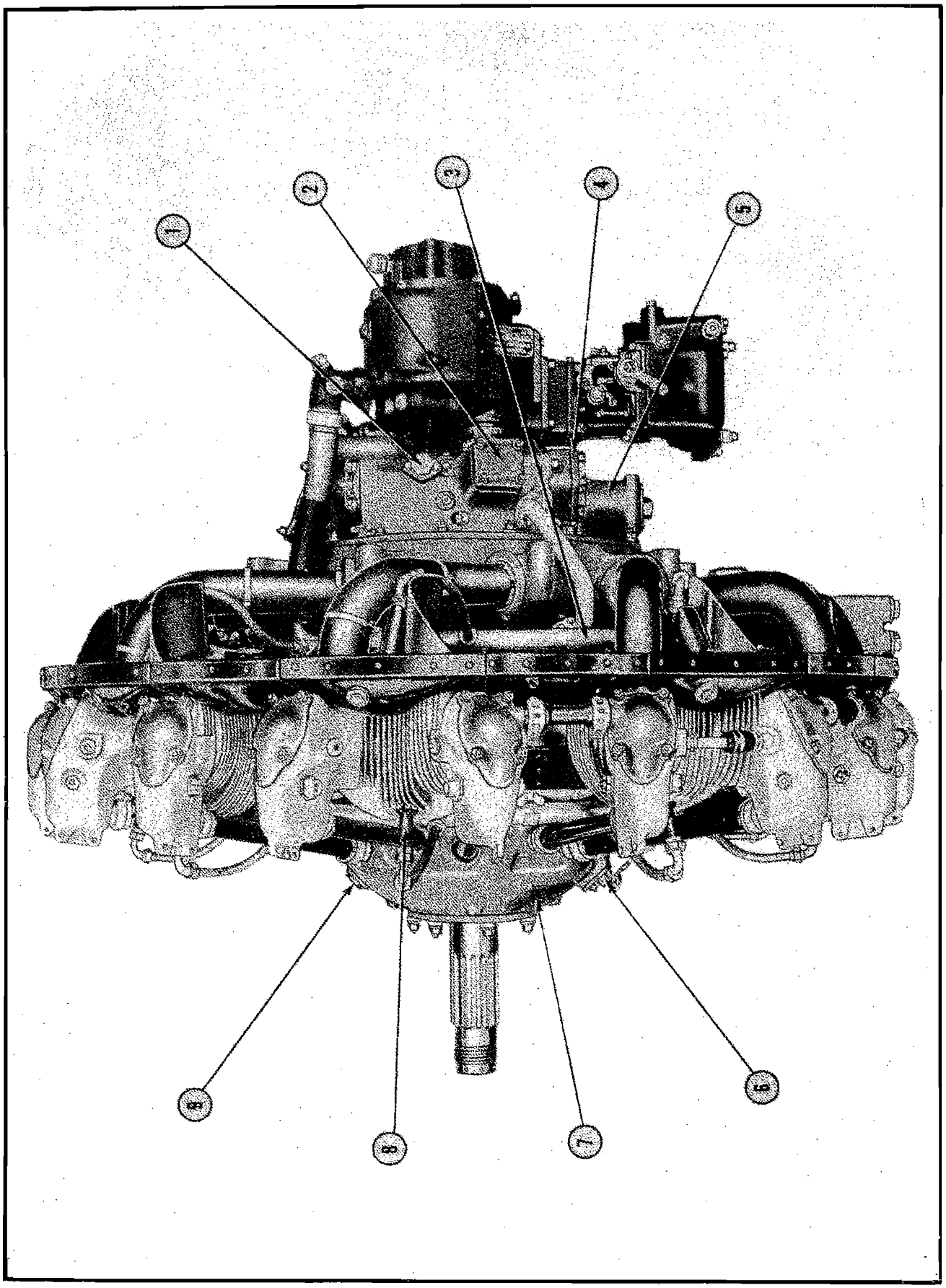

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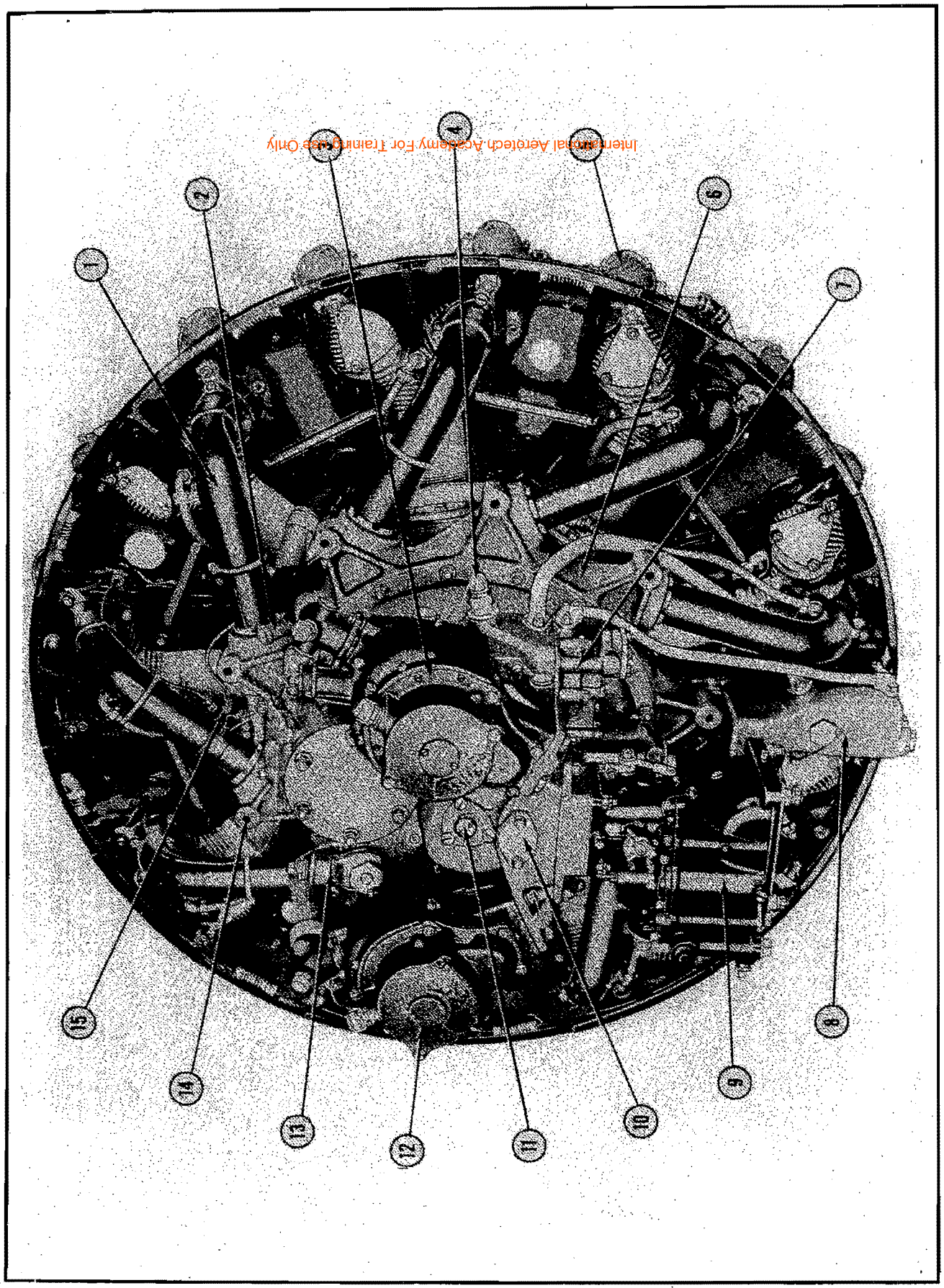

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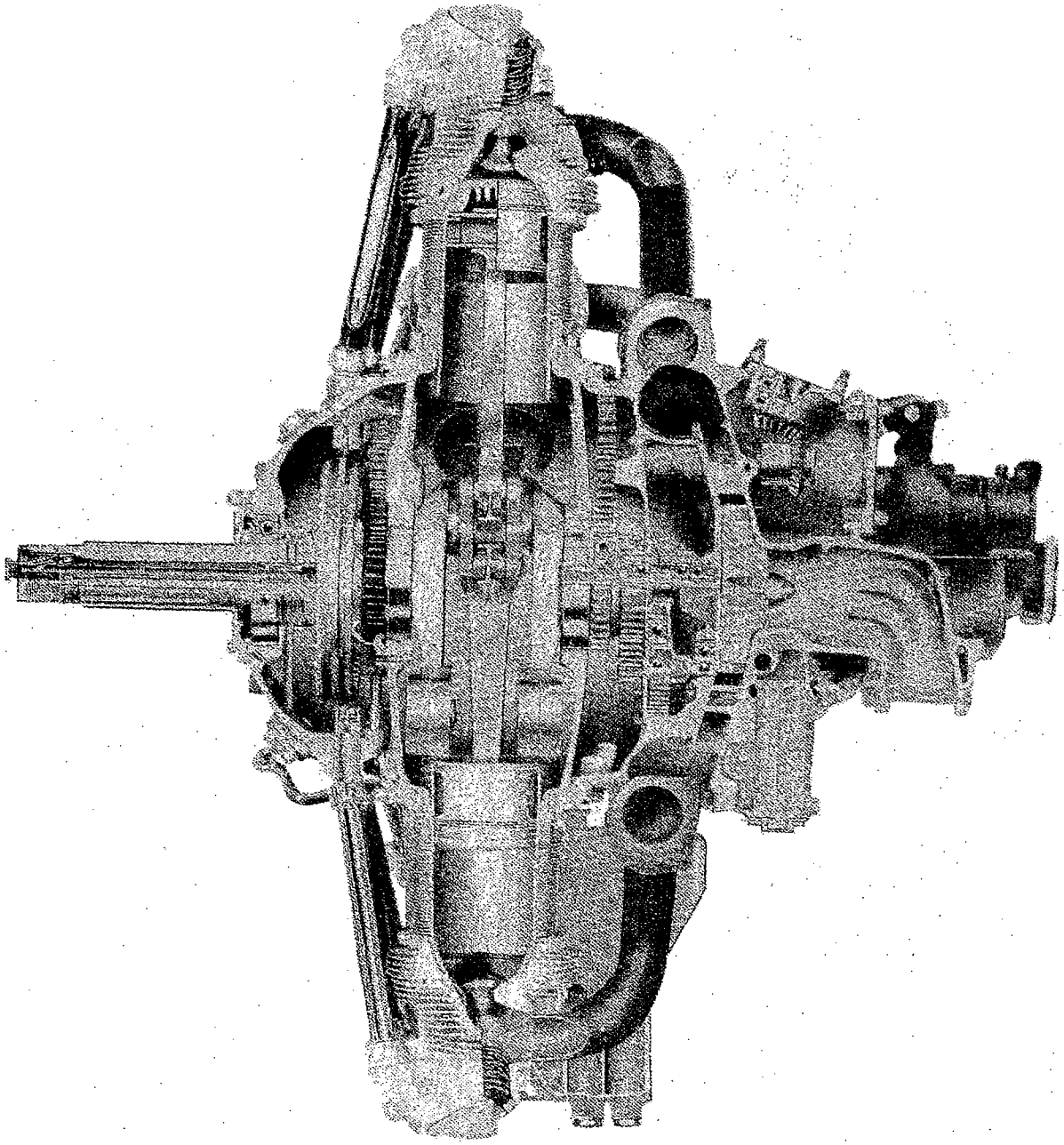

Figure 4. Cutaway View of Engine

SECTION I

INTRODUCTION

1–1. This publication comprises the overhaul instructions for the model R-985-AN-1 engines and associated models R-985-AN-3, -AN-6, -AN-12 and -AN-14B engines designed by Pratt & Whitney Aircraft, East Hartford 8, Connecticut.

1–2. Frequent reference is made to the Tables of Limits, section XII. These tables shall be regarded as the indispensable guide throughout the operations which involve measurement or the use of gages.

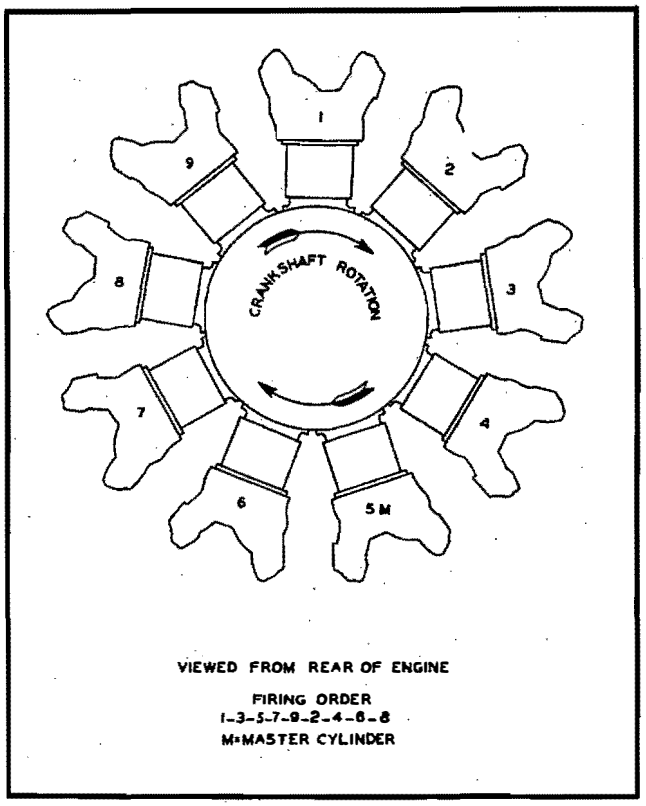

Figure 1–1

1–3. Right and left, clockwise and counterclockwise, upper and lower, and similar directional phrases apply to the engine as viewed from the rear with the crankshaft in the horizontal position and with No. 1 cylinder at the top of the engine. The normal direction of rotation of accessory drives is specified as it appears to an observer facing the accessory mounting pad.

1–4. The cylinders are numbered consecutively in the direction of crankshaft rotation beginning with the top cylinder. Cylinder numbering and firing order, as well as the position of the masterod, are illustrated (Figure 1–1).

1–5. Specification numbers as listed in this Handbook are basic numbers and will be interpreted to include all revisions and amendments thereto.

1–6. In cases in which portions of such AN and Nav-Aer Publications and Air Force Technical Orders are in conflict with, or are superseded by BuAer Bulletins, Changes, Technical Notes, Technical Orders, or other BuAer directives, instructions contained in the latter shall be applicable.

1–7. The text throughout this handbook refers frequently to the use of specialized tools. In each instance the tool number is listed in the text and also listed under Overhaul Tools in Section III. Subsequent revisions to this handbook which involve tool changes will be made in Section III only, with the procedural text referring to the old tools. Consequently, the tool numbers in the text and those in Section III may not necessarily agree. Therefore, each tool number appearing in the procedural text should be checked for the latest change against the tools listed in Section III.

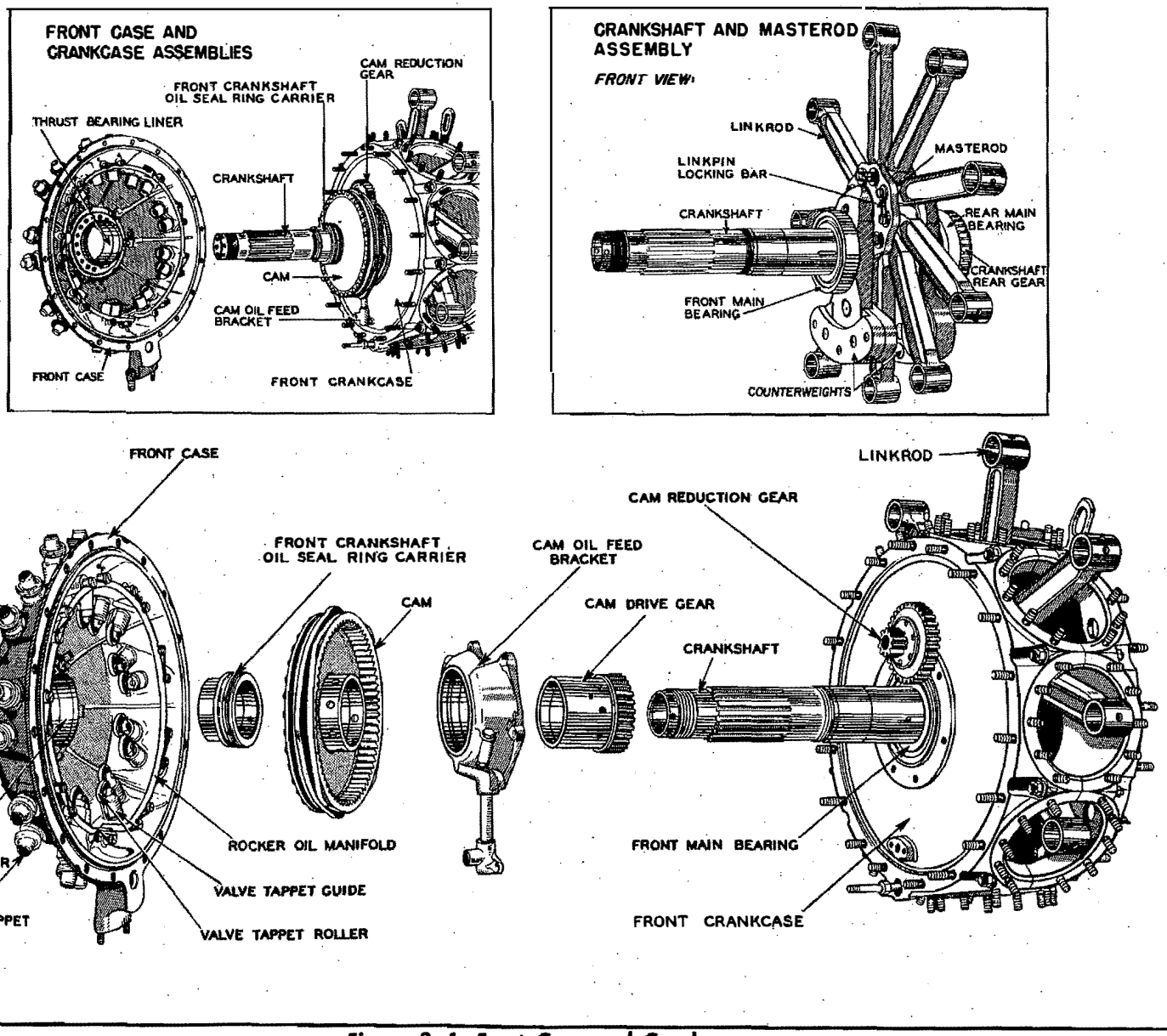

Figure 2–1. Front Case and Crankcase

SECTION II

GENERAL DESCRIPTION

2–1. GENERAL.

2–2. The model R-985-AN-1 engines and associated models are direct drive, nine cylinder, supercharged, single row, radial, air cooled engines. The engines are basically similar; however, the chart at the end of this section lists the minor differences between the models. The R-985-AN-1 engine is used as the basic model for descriptive purposes.

2–3. FRONT SECTION.

2–4. The front case supports in its bore a ball bearing which transmits part of the propeller thrust from the crankshaft to the engine mounting via the main crankcase (Figure 2–1).

2–5. Bosses in the front case provide support for the valve tappet guides which contain the valve tappets, rollers, and pins. A rocker oil manifold ring in the front case is part of the automatic rocker lubricating system.

2–6. This case also houses tubing for the 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 or hydromatic propeller).

2–7. CRANKCASE SECTION.

(Figures 2–1 and 2–2.)

2–8. CRANKCASE. The crankcase is comprised of the front and rear crankcases which are held together by the nine crankcase bolts. The crankcases are machined together and are not interchangeable. The front and rear main bearings, located in the front and rear crankcases, respectively, support the crankshaft assembly in the crankcase. A bronze bearing is pinned in the front crankcase to support the cam reduction gear. The cam oil feed bracket is secured to the front crankcase and provides for the transfer of pressure oil to the front section, the cam, and the crankshaft.

2–9. VALVE TIMING GEARS. The cam actuates the valves through two four-lobed tracks (Figure 2–1). It is rotated opposite to crankshaft direction at 1/8 crankshaft speed by means of the cam drive gear, the cam reduction gear, and internal teeth on the cam. The cam drive gear is keyed to the crankshaft.

2–10. CRANKSHAFT. The crankshaft is a single throw, two piece, split pin shaft, and is supported by the thrust bearing and the two main bearings which are contained in the liners located in the front case and the front and rear crankcases. The reciprocating and rotating parts connected to the crankpins are counterbalanced by weights riveted to the crankshaft cheeks. Two flyweights in the rear counterweight supress the torsional vibrations developed by power impulses. Attached to the rear of the crankshaft are the crankshaft rear gear and the impeller spring drive coupling which transmit the power for the drives in the supercharger and rear sections.

2–11. MASTEROD AND LINKRODS. The masterod is of one-piece construction, and incorporates a pressed-in, steel-backed, leaded silver bearing which is silver plated on the O.D. Eight I section linkrods, having bronze linkpin and pistonpin and bushings, are connected to the masterod by linkpins and to the pistons by pistonpins.

2–12. OIL SUMP. An oil sump containing two chambers is located between cylinders Nos. 5 and 6 and is fastened to the front and supercharger cases.

2–13. CYLINDERS.

2–14. CYLINDER HEADS AND BARRELS. 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 rockerboxes cast integrally. The head is screwed 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 sparkplugs, 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 rockerboxes and are connected by a rubber sleeve. Pressure type deflectors force a high velocity flow of cooling air between and over the cylinder fins.

2–15. VALVE MECHANISM. All valve operating parts are enclosed. The rockers are supported on double row ball bearings. A valve clearance adjusting screw and locknut are incorporated in each rocker. A steel insert in the adjusting screw is used as a contact between the adjusting screw and valve stem. The tappets actuate the rockers through tubular pushrods having hard-

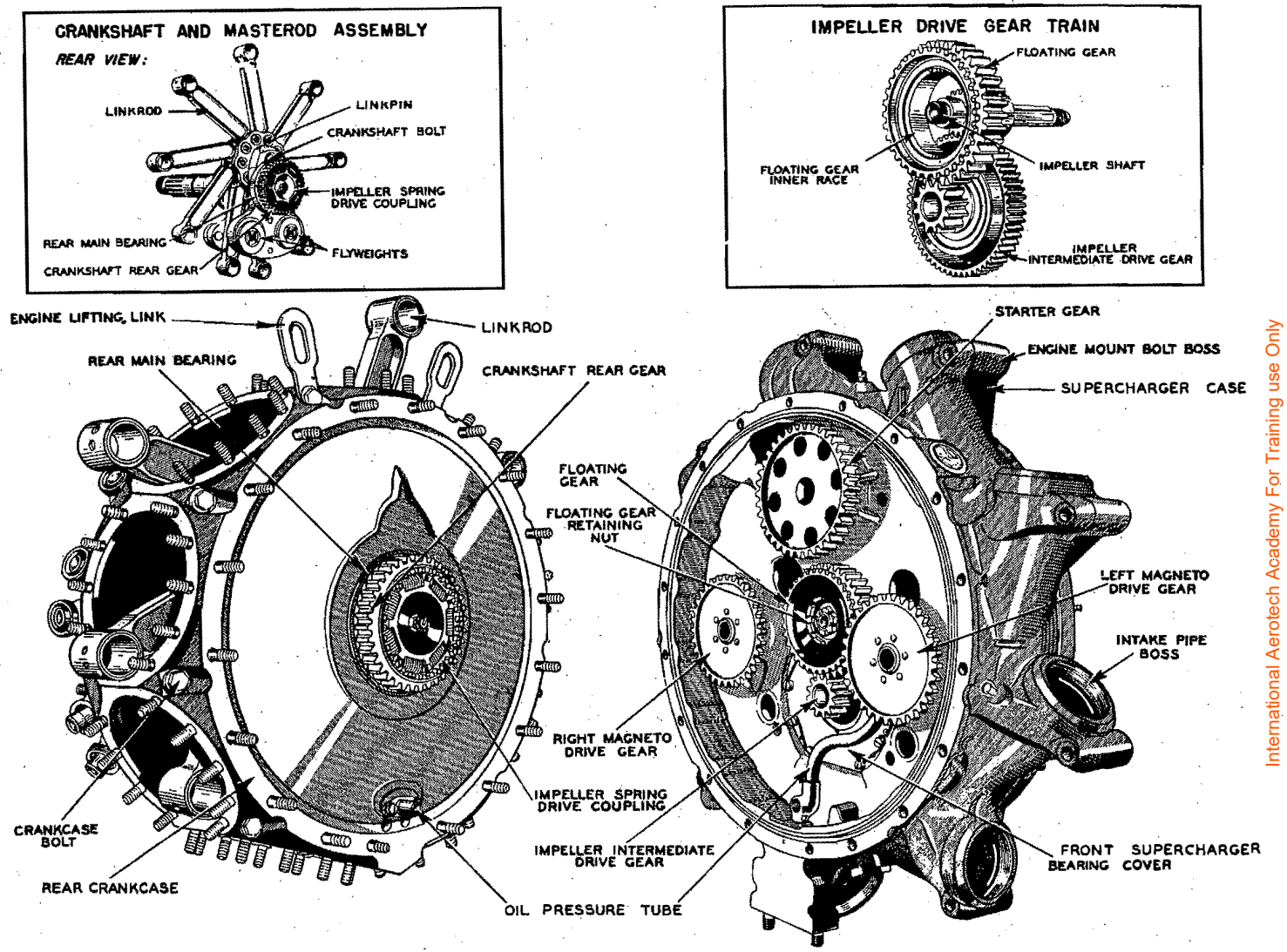

Figure 2–2. Crankcase and Supercharger Case

ened steel ballends which mate with hardened steel sockets in the tappets and the rockers. These rods are enclosed by removable covers which are held in place by a nut at each end. A cover is secured to each rockerbox.

2–16. Two concentric valve springs are secured to the valve stem by a washer and split cone. The inlet and exhaust valve springs are not interchangeable. Each inlet and exhaust valve has a safety circlet to prevent the valve from dropping into the cylinder. The exhaust valve is hollow and is sodium filled for cooling. A stellite face prolongs the life of the seating surface of the valve.

2–17. PISTONS. 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 pistonpins connect the pistons to the master and linkrods.

2–18. SUPERCHARGER SECTION.

2–19. SUPERCHARGER CASE. The supercharger case is attached to the rear of the crankcase and is provided with special bolt bosses for securing the engine in the aircraft (Figures 2–2 and 2–3). The front end of each magneto drive gear shaft is supported by a bronze bearing set into the front of this case, and the front end of the starter gear is supported by a ball bearing mounted in the front of the case. A breather tube assembly is located between the number 2 and 3 intake pipe bosses on the supercharger case.

2–20. IMPELLER AND GEARS. The impeller shaft is supported in the supercharger case by three ball bearings. The impeller is splined to the rear of the impeller shaft with its flat face next to the face of the 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. The impeller intermediate drive gear is supported in the case by two ball bearings and is secured in position by a special nut. The impeller delivers the fuel and air mixture to nine ports in the outside circumference of the supercharger case. Attached to each port is an intake pipe which carries the mixture to its respective cylinder.

2–21. REAR SECTION.

(Figures 2–3 and 2–4.)

2–22. REAR CASE. 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

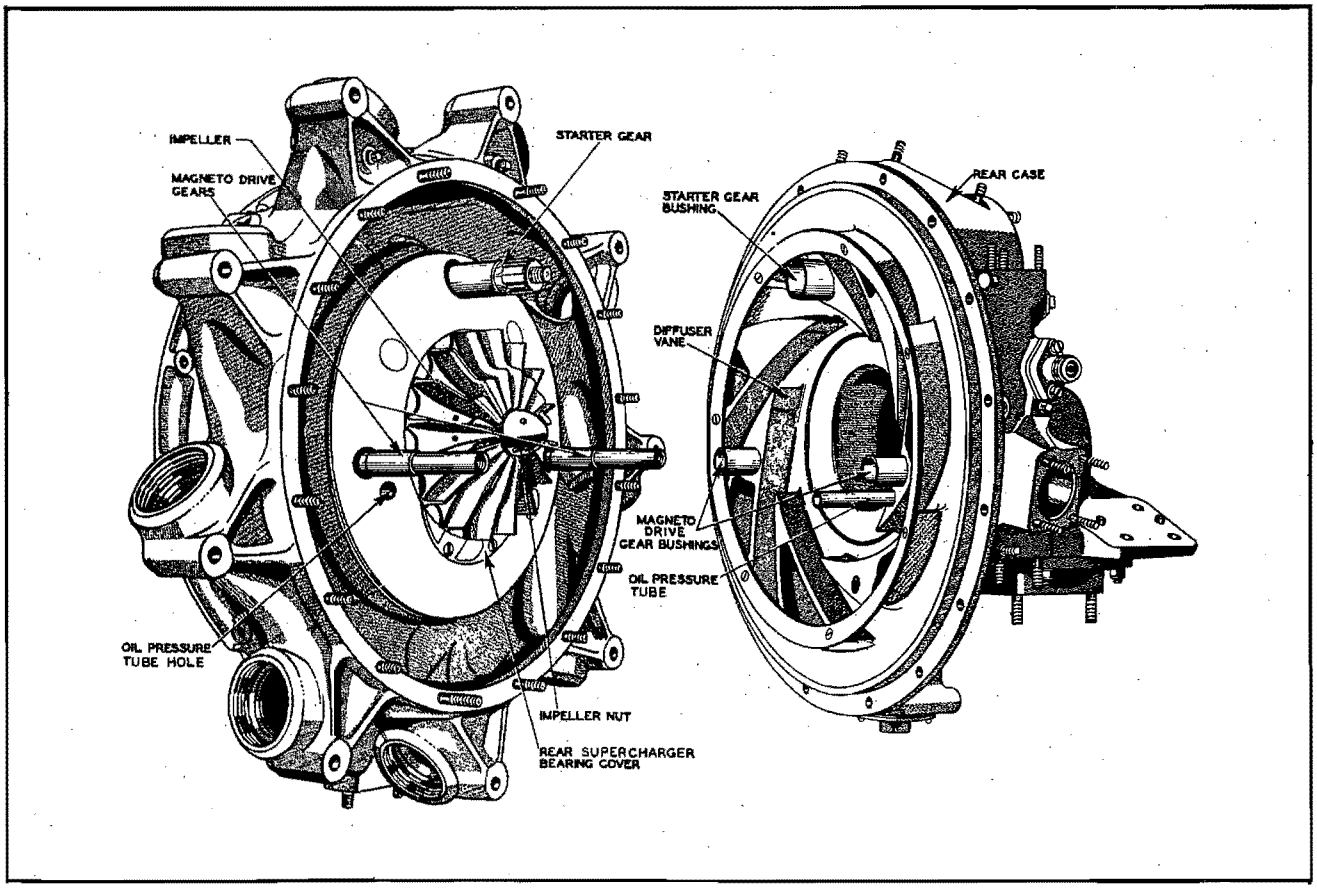

Figure 2–3. Supercharger Case and Rear Case

three section oil pump, and an oil pressure relief valve. Mounting pads are provided for the carburetor adapter, two magnetos, a fuel pump, starter, generator, vacuum pump adapter, and two tachometers. Three bronze bearings, extending from the rear into the supercharger case, support the rear ends of the two magneto drive gear shafts and the starter gear shaft.

2–23. STARTER GEAR. The starter gear is supported at its forward end by the ball bearing in the supercharger case and at the rear end by a bronze bearing in the rear case. The starter gear meshes with the crankshaft rear gear. A three tooth or a twelve tooth starter jaw is splined on the rear end of the starter gear shaft.

2–24. MAGNETO DRIVE GEARS. The two magneto drive gears are driven by the crankshaft rear gear. Each gear and its shaft is riveted into a semi-permanent assembly. An accessory intermediate drive gear is keyed to each magneto drive gear shaft. The magneto is driven by a rubber coupling which is driven by the magneto drive coupling. The magneto drive coupling is keyed to the rear end of the magneto drive gear shaft.

2–25. ACCESSORY DRIVE GEARS. An accessory drive gear is driven by each accessory intermediate drive gear. The accessory drive gears are supported at their inner ends by bronze bearings and at their outer ends by ball bearings.

2–26. FUEL PUMP DRIVE GEAR. The fuel pump drive gear is supported in a detachable adapter in the left side of the rear case. This gear is driven by the left accessory intermediate drive gear.

2–27. TACHOMETER DRIVE GEARS. The tachometer drive gears are located on the left and right sides of the rear case and are driven by the spiral gears which are integral with the accessory drive gear shafts.

2–28. VACUUM PUMP DRIVE GEAR. The vacuum pump drive gear is supported by a bronze bearing in the vacuum pump adapter and is driven by the fuel pump drive gear.

2–29. OIL PUMP GEARS. The oil pump is located in the right side of the rear case. The oil pump drive gear is driven by the right accessory intermediate drive gear. Three spur-type drive gears are secured to the drive gear shaft by keys and mesh with three spur-type idler gears.

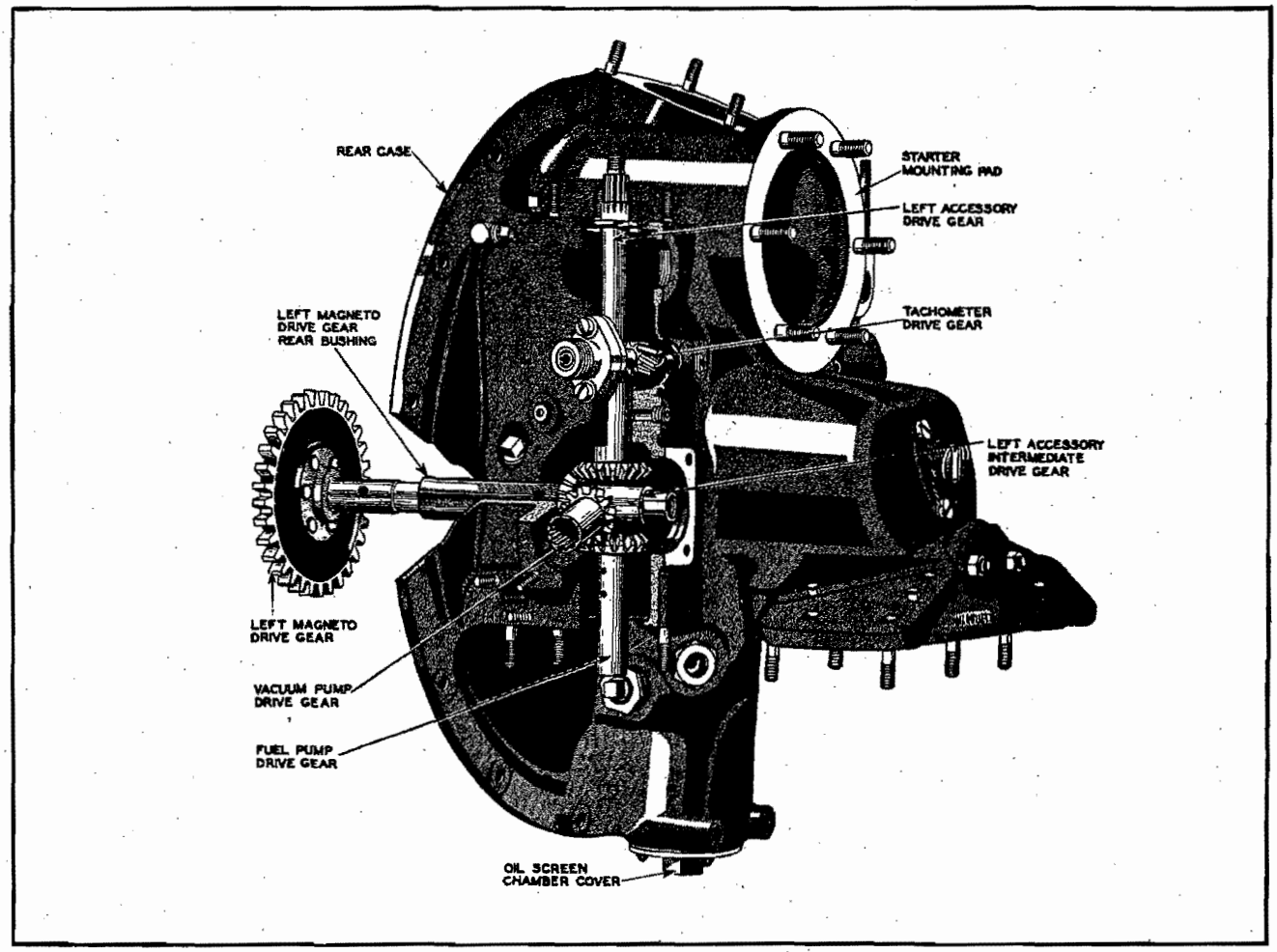

Figure 2–4. Rear Case

2–30. GENERATOR DRIVE GEAR. The generator drive gear is supported in the top center of the rear case by a ball bearing and is driven by the starter gear.

2–31. ENGINE LUBRICATION SECTION.
(Figures 12–1 and 12–2.)

2–32. GENERAL. Oil is circulated through the engine by the three section gear pump which consists of one pressure and two scavenge sections. The pump is located in the right side of the rear case.

2–33. Oil from the tank enters the oil pump through a port in the pump cover. The oil is then directed to the pressure stage of the pump and from there flows under pressure to the oil screen chamber, via a cored passage in the rear case. After entering the oil screen chamber, the oil passes through the screen assembly and then through the spring loaded check valve. When the engine is not running the check valve prevents oil from seeping into or out of the engine.

2–34. When the oil emerges from the check valve in the oil screen assembly, it is diverted into two main branches. The flow of oil through each branch is described separately under paragraphs 2–35 and 2–37.

2–35. FIRST BRANCH. The oil is directed through a passage to an annulus around the right magneto drive gear shaft rear bearing. Part of the oil from this annulus is carried by drilled passages to the right accessory drive gear bearing. Here the oil enters the hollow accessory drive gear shaft and flows upward to the starter shaft bearing. 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 bearing.

2–36. Another passage carries the oil from the annulus encircling the right magneto drive gear shaft rear bearing 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.

2–37. SECOND BRANCH. The oil in this branch 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 bearing. Drilled passages from this annulus carry oil to the left accessory drive gear bearing. Here the oil enters the hollow accessory drive gear shaft and flows upward to the starter shaft bearing. 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 bearing flows upward through a drilled passage to lubricate the accessory; oil also enters the shaft and flows forward to an annulus around the front bearing 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.

2–38. 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.

2–39. At the cam oil feed bracket the oil is directed into two channels. In the first channel the oil flows to the front case where it enters the rocker oil manifold. Hollow screws transfer the oil to the tappets. From there oil is forced through the pushrods to the rockers. In the second channel the oil is forced through the cam oil feed bracket into the crankshaft. Holes in the crankpin, the masterod bearing, and masterod provide passage for the oil to the linkpins and linkpin bushings. Additional holes in the crankshaft provide for the splash lubrication of the pistonpins, pistonpin bushings, and flyweights.

2–40. On models equipped for a hydro-controllable propeller, oil from the main oil transfer bracket is tubed to a two-position valve in the front section, from whence it is introduced into the propeller shaft through an oil transfer. In the event a constant speed governor is mounted on the rear section, a plug is installed in the front 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 this case, oil from the main transfer bracket is not utilized.

2–41. SCAVENGE OIL. 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 rockerboxes drains through the pushrod cover tubes to the front case, or through a system of inter-cylinder drains to an additional compartment in the sump from where it is returned to the oil tank. The rear case oil drains through a tube into the supercharger case, then into the sump.

2–42. CARBURETOR. These engines are equipped with float type carburetors. The carburetor 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 carburetor, the fuel is discharged into the air stream to the impeller where it is thoroughly mixed with the air, vaporized, and then delivered to the cylinders through the intake pipes and inlet valves.

2–43. IGNITION. Ignition is furnished either by two Bosch or two Scintilla 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 of the shielded type to prevent radio interference.

COMPARATIVE FEATURES OF ENGINE MODELS COVERED IN THIS HANDBOOK

ITEM	-AN-1	-AN-3	-AN-6	-AN-12
Starter Jaw	3 tooth	3 tooth	12 tooth	12 tooth
Carburetor	NA-R9B	NA-R9B	NA-R9C2	NA-R9C2
Setting	18	18	6	6
Magnetos	SB9RU-3	SB9RU-3	SB9RU-3	SB9RU-3
Propeller	Constant speed or two position	Constant speed or two position	Constant speed or two position	Constant speed or two position
Total Dry Weight of Engine	674.0 lb.	682.0 lb.	680.0 lb.	688.0 lb.
Crankcase	Aluminum	Aluminum	Aluminum	Aluminum

Models Having Magnesium Front, Supercharger and Rear Cases

R-985-AN-1
R-985-AN-6

Models Having Aluminum Front, and/or Supercharger, and/or Rear Cases

R-985-AN-3
R-985-AN-12

SECTION III

OVERHAUL TOOLS

3—1. GENERAL.

3—2. This section is a listing of tools necessary for the overhaul work described in this Handbook. In this list, the last word of each tool name is placed first and arranged in numerical order according to sections.

3—3. Revisions to this handbook which involve only tool changes will be made in this tool list only, with the procedural text referring to the superseded tool. The superseded tool will continue to be listed in the tool list but will be described as superseded. The new tool will also be listed in its proper order in the tool list.

3—4. DISASSEMBLY AND REASSEMBLY.

Fig. No.	Tool No.	Name	Application
	PWA-37	Sling	Engine lifting
4-45	PWA-51	Puller	Impeller
	PWA-55	Facer	Magneto drive shaft bushing
	PWA-62	Facer	Cam reduction gear bushing
	PWA-64	Drift	Supercharger shaft bearing cage assembly
4-10	PWA-67	Puller	Front case
	PWA-79	Sleeve	Crankshaft front main bearing
9-6	PWA-85	Pointer	Engine timing
	PWA-112	Bar	Crankshaft turning
	PWA-165	Puller	Floating gear inner race
	PWA-174	Wrench	Generator drive gear nut
	PWA-228	Wrench	Oil screen cover nut
	PWA-237	Wrench	Intake pipe nut
4-24	PWA-248	Holder	Cam reduction gear
	PWA-249	Clamp	Pistonring
8-32	PWA-268	Pusher	Crankshaft rear main bearing
8-24	PWA-296	Fixture	Linkpin assembly and disassembly
	PWA-338	Holder	Impeller intermediate drive gear
4-47	PWA-345	Wrench	Floating gear retaining nut
4-46	PWA-346	Puller	Intermediate gear bushing liner
4-26	PWA-448	Puller	Impeller spring drive gear fixed plate
	PWA-455	Depressor	Rocker
	PWA-459	Depressor	Valve spring
4-25	PWA-470	Puller	Crankshaft front main bearing
	PWA-520	Eye	Engine lifting
4-21	PWA-614	Drift and Base	Rocker ball bearing assembly and disassembly
	PWA-616	Adapter	Supercharger bearing cover locating
	PWA-620	Guide	Supercharger ball bearing cage assembly
	PWA-621	Puller	Magneto driven gear disassembly
	PWA-671	Wrench	Oil pressure relief valve body
	PWA-789	Wrench	Magneto drive shaft screw
8-24	PWA-992	Wedge	Masterod flange supporting
	PWA-1067	Puller	Crankshaft flyweight assembly
4-32	PWA-1068	Pusher	Crankshaft flyweight disassembly
	PWA-1093	Wrench	Thrust bearing nut
	PWA-1195	Wrench	Impeller spring drive coupling bolt
4-44	PWA-1269	Wrench	Impeller nut

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Fig. No.	Tool No.	Name	Application
	PWA-1285	Puller	Crankcase bolt
	PWA-1327	Puller	Oil pump
	PWA-1415	Drift	Vacuum pump oil seal assembly
	PWA-1443	Arbor	Vacuum pump drive gear backlash
	PWA-1462	Drift	Tachometer shaft oil seal assembly
	PWA-1558	Riveter	Impeller nut pin assembly
	PWA-1647	Wrench	Crankshaft rear plug
4-28	PWA-1742	Puller	Crankshaft rear bearing
	PWA-1787	Wrench	Oil sump drain plug
	PWA-1791	Pliers	Pistonring
	PWA-1836	Puller	Tachometer coupling oil seal
	PWA-1882	Pusher	Impeller assembly
	PWA-1886	Wrench	Ignition manifold
	PWA-1914	Wrench	Crankshaft bolt
	PWA-1919-2	Adapter	Crankshaft holding
	PWA-1998	Pusher	Vacuum pump housing disassembly
	PWA-2002	Arbor	Tachometer drive gear backlash
	PWA-2003	Arbor	Generator drive gear backlash
	PWA-2005	Stop	Vertical accessory drive shaft assembly
	PWA-2006	Wrench	Cylinder flange nut
	PWA-2044	Puller	Starter shaft bearing
8-17	PWA-2127	Arbor	Fuel pump drive gear backlash
4-8	PWA-2151-1	Drift	Pushrod ballend disassembly
	PWA-2239	Wrench	0-600 lb. in. torque
	PWA-2240	Adapter	Torque indicating wrench
	PWA-2274	Wrench	Oil plug
	PWA-2285	Drift	Fuel pump drive gear oil seal assembly
4-22	PWA-2289	Puller	Cam drive gear disassembly
4-7	PWA-2318	Wrench	Swivel fitting support
	PWA-2366	Wrench	Crankshaft oil plug
	PWA-2367	Drift	Pushrod packing gland assembly
	PWA-2373	Wrench	Breather plug
	PWA-2374	Puller	Fuel pump drive gear bracket
	PWA-2388	Hook	Engine lifting
	PWA-2397	Wrench	Cylinder flange nut
	PWA-2398	Wrench	Cylinder flange nut
8-40	PWA-2399	Wrench	Cylinder flange nut
	PWA-2411	Handle	Cylinder flange nut wrench
	PWA-2417	Indicator	Magneto synchronizer (battery type)
	PWA-2422-100	Pusher	Crankshaft assembly (Air Force personnel use PWA-2422-101)
	PWA-2423-100	Puller	Crankshaft disassembly (Air Force personnel use PWA-2423-101)
	PWA-2488	Holder	Master and linkrod
	PWA-2537	Indicator	Top center (battery type)
8-24	PWA-2557	Fixture	Linkpin assembly
	PWA-2569	Puller	Oil pump gear
8-24	PWA-2674	Drift	Linkpin assembly
	PWA-2712	Puller	Rear case disassembly
	PWA-2754	Wrench	Propeller oil control valve nut
	PWA-2792	Compressor	Impeller spring drive coupling spring
	PWA-2826	Holder	Masterod
	PWA-3012	Holder	Impeller shaft bushing facing
	PWA-3094	Guide	Vacuum pump oil seal
	PWA-3145	Puller	Intake pipe
	PWA-3164	Cutter	Impeller shaft small bushing facing
	PWA-3168	Wrench	Sparkplug

Fig. No.	Tool No.	Name	Application
	PWA-3215	Drift and Base	Cam reduction gear ring
	PWA-3252	Plug	Sparkplug bushing
	PWA-3360	Lock	Magneto shaft
	PWA-3482	Wrench	Breather body connection
4-29	PWA-3755	Pump	Hydraulic
	PWA-3762	Puller	Fuel pump drive gear oil seal (Navy personnel use R85-PAT-PM-1000)
	PWA-3762	Puller	Magneto drive coupling oil seal (Navy personnel use R85-PAT-PM-1000)
	PWA-3800	Protector	Intake port
	PWA-3926	Remover	Exhaust port cover
9-11	PWA-4142	Indicator	Time rite
	PWA-4152	Driver	Valve adjusting screw
	PWA-4153	Drift and Base	Magneto drive coupling oil seal
	PWA-4238	Puller	Crankshaft standpipe
	PWA-4251-10	Pusher	Pistonpin
	PWA-4478	Drift	Magneto drive lower packing spring assembly
4-34	PWA-4497-10	Drift	Linkpin
	PWA-4510-10	Pusher	Crankshaft rear oil tube support
	PWA-4512-10	Drift	Crankshaft front oil tube assembly and disassembly
	PWA-4531	Wrench	Pushrod tube gland nut (Superseded by PWA-5630)
	PWA-4635	Fixture	Generator drive shaftgear holding
	PWA-4636	Drift	Generator drive shaftgear inner bearing assembly
	PWA-4637	Drift	Generator drive shaftgear inner bearing assembly
	PWA-4638	Fixture	Generator drive shaftgear inner bearing assembly and disassembly
	PWA-4638	Fixture	Generator drive shaftgear outer bearing disassembly
	PWA-4639	Drift	Generator drive shaftgear outer bearing disassembly
	PWA-4640	Collar	Generator drive shaftgear inner bearing disassembly
	PWA-4675	Gage	Valve clearance
4-8	PWA-4877	Fixture	Pushrod ballend
	PWA-4885	Protector	Tappet guide threads
	PWA-5124	Valve	Depreservation
	PWA-5187-30	Wrench	Thrust bearing nut (hydraulic)
	PWA-5630	Wrench	Pushrod Tube Gland Nut (Torque)
4-24	TAM-255	Wrench	Cam reduction gear nut
4-32	TAM-1773	Wrench	Flyweight bolt
4-12	TAM-3146	Stand	Cylinder assembly

3—5. INSPECTION.

Fig. No.	Tool No.	Name	Application
	PWA-311	Gage	Inlet valve guide maximum wear
6-28	PWA-312-11	Indicator	Cylinder bore
6-29	PWA-737	Gage	Exhaust valve radius
	PWA-1451-13	Gage	Pistonpin bushing maximum wear
	PWA-1451-31	Gage	Magneto shaft bushing maximum wear
	PWA-1451-34	Gage	Rocker shaft large bushing maximum wear
	PWA-1451-41	Gage	Tachometer coupling bushing maximum wear
	PWA-1451-61	Gage	Cam reduction gear bushing maximum wear
	PWA-1451-61	Gage	Vertical accessory drive shaft bushing maximum wear
	PWA-1451-104	Gage	Vacuum pump drive gear bushing maximum wear
	PWA-1451-109	Gage	Valve tappet guide maximum wear
	PWA-1451-110	Gage	Rocker shaft small bushing maximum wear
	PWA-1451-111	Gage	Starter shaft bushing maximum wear
6-22	PWA-1781-61A	Fixture	Masterod aligning
	PWA-2630-20	Gage	Cylinder barrel flange
	PWA-4327	Gage	Exhaust valve guide maximum wear
6-28	3474-T-3	Gage	Cylinder bore

3–6. RECONDITIONING.

Fig. No.	Tool No.	Name	Application
7-44	PWA-6	Holder	Valve seat refacing arbor
7-53	PWA-10	Holder	Inlet valve lapping
7-53	PWA-11	Holder	Exhaust valve lapping
	PWA-55	Facer	Magneto drive bushing
	PWA-74	Riveter	Magneto drive cover
	PWA-94	Drift	Exhaust valve guide assembly
7-40	PWA-95	Drift	Inlet valve guide assembly
	PWA-220	Puller	Cam drive gear bushing
7-44	PWA-226-23	Facer	Inlet valve seat
7-38	PWA-301	Reamer	Inlet valve guide hole
	PWA-302	Reamer	Exhaust valve guide hole
	PWA-311	Gage	Inlet valve guide maximum wear
	PWA-318	Reamer	Supercharger bearing cover
	PWA-334	Tap	Sparkplug bushing
	PWA-346	Puller	Impeller intermediate drive gear bushing liner
	PWA-491	Driver	Pushrod tube packing gland
	PWA-538	Facer	Starter shaft bushing
	PWA-625-2	Adapter	Supercharger bearing cover reaming
	PWA-757	Drift	Rocker shaft small bushing assembly
	PWA-758	Drift	Rocker shaft large bushing assembly
	PWA-760	Puller	Oil pressure tube
	PWA-761	Drift	Oil pressure tube
	PWA-762	Drift	Starter shaft bushing
	PWA-815	Adapter	Starter shaft bushing reaming
	PWA-816	Adapter	Starter shaft bushing reaming
	PWA-817	Adapter	Starter shaft bushing reaming
	PWA-819	Adapter	Starter shaft bushing hole reaming
	PWA-820	Adapter	Magneto shaft bushing reaming
7-14	PWA-827	Gage	Valve tappet guide positioning
	PWA-828-3	Bar	Valve tappet guide aligning
7-64	PWA-849	Driver	Pushrod cover nut coupling
	PWA-860	Holder	Linkpin bushing facing
	PWA-861	Cutter	Linkpin bushing facing
	PWA-862-3	Bushing	Linkpin bushing facing
7-17	PWA-980	Holder	Crankpin lap
7-17	PWA-981-1	Lap	Crankpin
7-59	PWA-1352	Pusher	Rocker ball socket disassembly
	PWA-1369	Clamp	Valve tappet guide reaming
	PWA-1450	Gage	Valve tappet guide reaming
	PWA-1460	Drift	Vacuum pump bushing assembly
	PWA-1466	Drift	Rocker shaft large bushing assembly
	PWA-1493	Drift	Linkpin bushing assembly
	PWA-1526	Tap	Sparkplug bushing
	PWA-1572	Driver	Oil sump insert
	PWA-1641	Drift	Pistonpin bushing disassembly
	PWA-1648	Drift	Vacuum pump drive gear bushing assembly
7-57	PWA-1682	Reamer	Step rocker shaft bushing
	PWA-1746	Drift	Magneto drive shaft bushing assembly
	PWA-1747	Drift	Magneto drive shaft bushing disassembly
	PWA-1748	Drift	Magneto drive shaft bushing disassembly
	PWA-1749	Drift	Starter shaft bushing disassembly
	PWA-1776	Drift	Rocker shaft small bushing disassembly

Fig. No.	Tool No.	Name	Application
7-28	PWA-1777	Arbor	Pistonpin bushing expanding
	PWA-1799	Counterbore	Sparkplug bushing disassembly
	PWA-1800	Drift	Vertical accessory drive shaft bushing assembly and disassembly
7-30	PWA-1805-1	Gage	Pistonpin bushing reaming
	PWA-1805-3	Gage	Rocker shaft small bushing reaming
	PWA-1805-4	Gage	Rocker shaft large bushing reaming
	PWA-1805-6	Gage	Magneto drive shaft bushing reaming
	PWA-1805-9	Gage	Starter shaft bushing reaming
	PWA-1805-12	Gage	Vacuum pump drive gear bushing reaming
	PWA-1805-16	Gage	Tachometer coupling bushing reaming
	PWA-1805-36	Gage	Cam reduction gear bushing reaming
	PWA-1805-36	Gage	Vertical accessory drive shaft bushing drive
	PWA-1805-110	Gage	Linkpin bushing reaming
	PWA-1944	Drift	Impeller intermediate cage disassembly
	PWA-1969	Drift	Impeller intermediate cage assembly
7-10	PWA-1974	Holder	Valve tappet ball socket
	PWA-1981	Bar	Magneto drive gear shaft bushing alignment
	PWA-2284	Fixture	Vacuum pump drive gear bushing reaming
	PWA-2362	Drift	Valve tappet guide disassembly
7-63	PWA-2450	Fixture	Rocker ball socket assembly
	PWA-2466-35	Fixture	Cylinder holding
7-31	PWA-2551-4	Drift	Linkpin bushing assembly
7-33	PWA-2630-20	Plate	Surface
	PWA-2747	Driver	Thermocouple
	PWA-2766-8	Reamer	Exhaust valve guide
	PWA-2782-10	Drift	Exhaust valve seat
7-41	PWA-2869	Reamer	Inlet valve guide
	PWA-2881	Fixture	Tachometer coupling reaming
	PWA-2883	Jig	Tachometer coupling bushing drill
	PWA-2884	Drift	Tachometer coupling bushing assembly
7-33	PWA-2898	Lap	Cylinder barrel flange
	PWA-3064	Drill	Thermocouple hole
7-45	PWA-3149-24	Fixture	Exhaust valve guide facing
	PWA-3164	Cutter	Impeller shaft small bushing facing
7-70	PWA-3201-1	Gage	Pistonring gap
	PWA-3277-13	Scraper	Valve exhaust
	PWA-3372	Compressor	Hose clamp
	PWA-3633	Drift	Tachometer coupling bushing disassembly
	PWA-3931	Fixture	Pushrod cover ferrule staking
7-50	PWA-4000-30	Remover	Exhaust valve seat
7-37	PWA-4002-100	Puller	Intake valve guide disassembly
	PWA-4002-101	Puller	Exhaust valve guide disassembly
7-54	PWA-4005	Remover	Sparkplug bushing
7-48	PWA-4107-30	Remover	Intake valve seat
	PWA-4189-12	Gage	Exhaust valve guide reaming
7-42	PWA-4189-16	Gage	Inlet valve guide reaming
7-14	PWA-4234-30	Drift	Valve tappet guide assembly
7-69	PWA-4272-30	Fixture	Piston regrooving
	PWA-4548	Drift	Pistonpin bushing
7-49	PWA-4597-50	Holder	Inlet valve seat assembly
	PWA-4699-1	Reamer	Intake valve guide hole +3
	PWA-4699-2	Reamer	Intake valve guide hole +5

Fig. No.	Tool No.	Name	Application
	PWA-4699-3	Reamer	Intake valve guide hole +10
	PWA-4699-4	Reamer	Intake valve guide hole +15
	PWA-4699-5	Reamer	Intake valve guide hole +20
	PWA-4699-6	Reamer	Exhaust valve guide hole +3
	PWA-4699-7	Reamer	Exhaust valve guide hole +5
	PWA-4699-8	Reamer	Exhaust valve guide hole +10
	PWA-4699-9	Reamer	Exhaust valve guide hole +20
	PWA-4699-43	Reamer	Exhaust valve guide hole +30
	PWA-4700-505	Fixture	Valve guide reaming power
	PWA-4701-1	Reamer	Exhaust valve guide
	PWA-4701-6	Reamer	Intake valve guide
	PWA-4766	Remover	Stud
	PWA-4783	Cutter	Piston regrooving 8°
	PWA-5160-100	Puller	Valve tappet ball socket (Air Force personnel use PWA-5160-101)
7-6	PWA-5353-100	Remover	Masterod Bearing (Air Force personnel use PWA-5353-101)
	TAM-206	Fixture	Crankshaft holding
	TAM-315	Arbor	Masterod bearing assembly
	TAM-1113	Gage	Starter shaft bushing flush pin
	TAM-1161	Stand	Engine mounting
	TAM-3146	Stand	Cylinder assembly
	TAM-3574-7	Reamer	Vacuum pump drive gear bushing
	TAM-3574-51	Reamer	Tachometer coupling bushing
	TAM-3574-51	Reamer	Oil pressure tube hole
	TAM-3574-95	Reamer	Oil pressure tube hole +10
	TAM-3574-96	Reamer	Oil pressure tube hole +20
	TAM-3575-5	Reamer	Magneto shaft bushing
	TAM-3575-6	Reamer	Starter shaft bushing hole
	TAM-3575-7	Reamer	Magneto shaft bushing hole
	TAM-3575-8	Reamer	Starter shaft bushing
	TAM-3575-22	Reamer	Oil pressure tube hole +10
	TAM-3575-23	Reamer	Oil pressure tube hole +20
	TAM-3575-26	Reamer	Vertical accessory drive shaft bushing
	TAM-3575-29	Reamer	Starter shaft bushing hole +5
	TAM-3575-30	Reamer	Starter shaft bushing hole +10
	TAM-3575-31	Reamer	Starter shaft bushing hole +15
	TAM-3575-32	Reamer	Starter shaft bushing hole +20
	TAM-3575-33	Reamer	Starter shaft bushing hole +25
	TAM-3575-34	Reamer	Starter shaft bushing hole +30
	TAM-3575-35	Reamer	Magneto shaft bushing hole +5
	TAM-3575-36	Reamer	Magneto shaft bushing hole +10
	TAM-3575-37	Reamer	Magneto shaft bushing hole +15
	TAM-3575-38	Reamer	Magneto shaft bushing hole +20
	TAM-3575-39	Reamer	Magneto shaft bushing hole +25
	TAM-3575-40	Reamer	Magneto shaft bushing hole +30
	TAM-3575-45	Reamer	Cam drive gear rear bushing
	TAM-20932	Reamer	Valve tappet guide
7-15	TAM-20933	Reamer	Valve tappet guide
7-56	1068-T-3	Facer	Sparkplug bushing
7-56	1068-T-5	Facer	Sparkplug bushing
	1171-T-1	Fixture	Accessory drive shaft bushing reaming
	1320-T-120	Gage	Magneto drive shaft bushing clearance
	1621-T-17	Fixture	Cam drive gear rear bushing reaming
7-55	3510-T-16	Tap	Sparkplug hole
	TC-51259	Plate	Engine stand mounting

SECTION IV

DISMANTLING AND DISASSEMBLY

4—1. GENERAL.

4—2. DISPOSITION OF ENGINE PARTS. Each engine part, upon disassembly, should be placed on a parts rack or a suitable container to prevent possible damage. Ball and roller bearings should be wired together, as removed, to prevent scrambling, and should be forwarded to Bearing Maintenance Department for inspection and repair. No part should be cleaned until reference has been made to Section V.

4—3. LOCKWIRE, PALNUTS, COTTERPINS, AND GASKETS. The following instructions are written with the understanding that all lockwire, palnuts, cotterpins, lockwashers, and gaskets will be removed where necessary.

4—4. PRELIMINARY INSPECTION. During the disassembly procedure examine the parts carefully for signs of defects or other unsatisfactory conditions in the engine. Many valuable indications, which might not be apparent after the parts have been cleaned, may be observed at this time.

4—5. CRANKSHAFT ROLLER BEARINGS. Observe extreme care to prevent the interchanging of crankshaft roller bearing parts, whether they be new or used. Certain bearings of different makes have parts which are nearly alike dimensionally, and interchanged parts can be readily assembled, but improper internal clearance would result. The inner and outer races bear identifying marks as to the manufacturer, but the rollers are not so marked. Tag bearing parts to prevent the interchanging of parts in subsequent assembly.

4—6. POOLING OF PARTS.

4—7. If the volume of overhaul work is great enough it may be found advantageous to pool certain of the parts during the overhaul process. The following parts can be pooled and therefore need not be tagged to identify them with the engine from which they are removed: complete cylinder assemblies (exception: engines subject to sudden stoppage before one hundred (100) hours of total time or operating time since last overhaul are to have the cylinders, pistons and pistonpins kept together throughout overhaul and subjected to as little rework as possible), pistons and pistonpins, deflectors, pushrod covers and gland nuts, intake pipes, all ignition parts (assemblies only), all exterior nuts and bolts, priming systems, all exterior oil lines, all accessories (except oil pumps), exhaust pipes and clamps, and vent systems.

4—8. The foregoing does not prescribe the pooling of parts within subassemblies, such as carburetors, magnetos, distributor pressurizing pumps, etc. All parts of the engine not listed above should not only be kept with the engine but also should be so handled as to insure return to the original position in the engine.

4—9. PRELIMINARY OPERATIONS.

4—10. REMOVAL OF ENGINE FROM PACKING CASE. Refer to AN 02A-10AB-2.

4—11. INSTALLATION OF ENGINE IN ENGINE STAND. If the engine has just been removed from the airplane, remove the carburetor and gaskets. Remove all accessories except the magneto and ignition manifolds before the engine is mounted in the engine stand. Install PWA-520 Eye on the crankshaft, and using a chain hoist in conjunction with PWA-2388 Hook, carefully lower the engine into TAM-1161 Stand equipped with Part No. TC-51259 Mounting Plate. Secure the supercharger case to the mounting plate with four bolts, washers and nuts.

4—12. EXTERNAL CLEANING. Remove all traces of dirt and grease from the external surfaces of the engine by spraying with kerosene conforming to Federal Specification No. VV-K-211. The spraying should be done in a wash house which has positive ventilation to the outside and care should be taken to keep the cleaning fluid away from the ignition manifolds and magnetos.

4—13. DISMANTLING.

4—14. OIL DRAIN PLUGS AND OIL SCREENS.

4—15. Turn the engine to a horizontal position in the stand and provide screened receptacles under the engine to collect the drain oil. Unscrew the oil drain plug located next to the left accessory drive mounting pad. Use PWA-228 Wrench to unfasten the oil screen cover nut; then remove the cover, spring, oil screen and check valve assembly.

4—16. Use PWA-1887 Wrench to remove the drain plugs from the sump.

4—17. 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

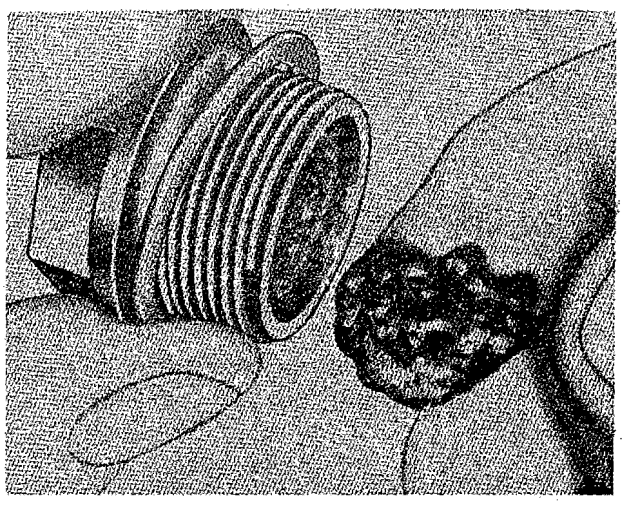

Figure 4—1

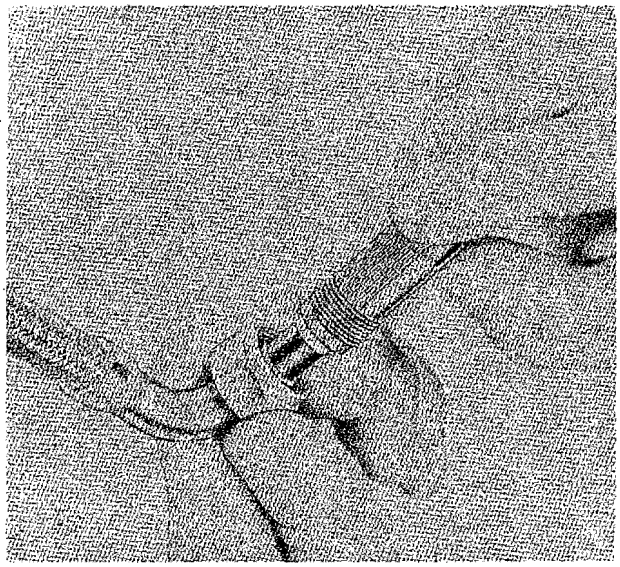

Figure 4—2

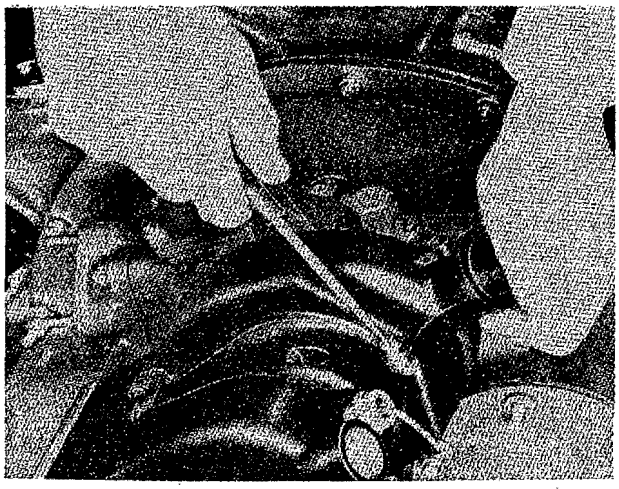

Figure 4—3

or some other unsatisfactory condition in the engine (Figure 4—1). After draining the engine, screw the plugs back into the sump so that they will not become lost.

4—18. IGNITION LEADS. Being careful not to bend or damage the elbows on the ignition cable, unfasten all ignition leads from the sparkplugs; then unfasten the ignition lead clips from the cylinders. Protect the lead connectors with suitable caps (Figure 4—2).

4—19. SPARKPLUGS. Remove the sparkplugs, using PWA-3168 Wrench; then install PWA-3252 Plugs in the sparkplug holes.

4—20. MAGNETOS.

4—21. 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.

4—22. If the engine is equipped with Bosch magnetos, remove the three screws which join the halves of each distributor block cover; then remove the four screws holding each cover to its coil cover and distributor block housing. Withdraw the cover halves from the distributor block. Remove the two distributor block fastening screws and lift out the distributor block. Wrap each distributor block in moisture proof paper to keep it clean and dry. Remove the three cap screws which secure each magneto in place and lift off each magneto and its rubber coupling. Reinstall the distributor block cover halves on the housing and secure them in place.

4—23. If the engine is equipped with Scintilla magnetos, remove the screw which joins the halves of each distributor block cover (Figure 4—3). Remove the two safety pins, disengage the two spring locks on each distributor block cover, and remove the cover halves. Lift out the distributor block (Figure 4—4) and wrap each distributor block in moisture proof paper to keep it clean and dry. Remove the three screws which secure each magneto in place and lift off each magneto and its rubber coupling (Figure 4—5). Insert a suitable dummy wooden block in place of each distributor block.

4—24. MAGNETO COUPLING GEAR SCREWS.—Loosen but do not remove the screws which fasten the magneto coupling gears to the rear ends of the magneto drive gear shafts.

4—25. STARTER JAW NUT. Loosen, but do not remove, the starter jaw nut.

4—26. PRIMER LINES AND PRIMER DISTRIBUTOR. Disconnect all primer lines at the primer distributor and at Nos. 1, 2, 3, 8, and 9 cylinders to which they are attached. Unfasten the clamps securing the lines the to intake pipes; then withdraw each primer line from the cylinder deflector through which it extends. Remove the primer distributor from No. 1 intake pipe.

4—27. PROPELLER SHAFT RUNOUT. (Navy personnel only.) Mount a dial indicator on a thrust bearing cover stud with the plunger resting on the propeller shaft

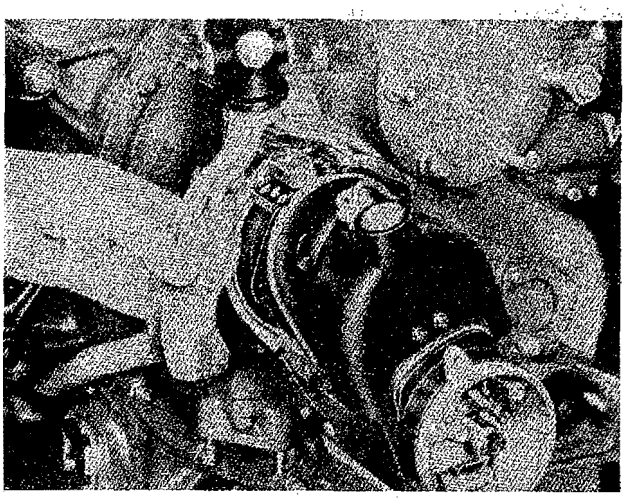

Figure 4—4

(Figure 4—6). The runout should not exceed .005 in. and .015 in. 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.

4—28. SWIVEL BREATHERS. Remove the nuts from the swivel breathers near the top of the right and left auxiliary drive shaft housings. Remove the swivels. Unscrew and remove the breather supports, using PWA-2318 Wrench.

4—29. ACCESSORY DRIVE GEAR NUTS. Loosen, but do not remove, the accessory drive gear nuts.

4—30. THRUST BEARING NUT. To facilitate later removal, loosen the thrust bearing nut one turn, using PWA-1093 Wrench and PWA-2318 Turning Bar (Figure 4—7).

4—31. CYLINDER DEFLECTORS. Remove the nuts which secure the cylinder head deflectors to the cylinders. Release the spring loaded clamp on the rear side of the inter-cylinder deflectors, and remove the cylinder head deflectors. Remove the wing nuts which secure the inter-cylinder deflectors to the retaining clamps and remove the clamps and deflectors. Each deflector should be tagged according to its location.

4—32. ROCKERBOX COVERS. Remove the nuts which secure the covers to the rockerboxes; then remove the covers. Loosen the rocker adjusting screw nuts, but do not remove them at this time.

4—33. PUSHRODS AND COVERS.

4—34. Install PWA-112 Bar on the crankshaft. Unscrew the pushrod cover packing nuts at the cylinder end first, then unscrew the nuts at the crankcase end, using PWA-3639 Wrench.

4—35. Turn the crankshaft until the valve actuated by the pushrod to be removed is closed; then depress each rocker with PWA-455 Depressor and remove the corresponding pushrod and cover.

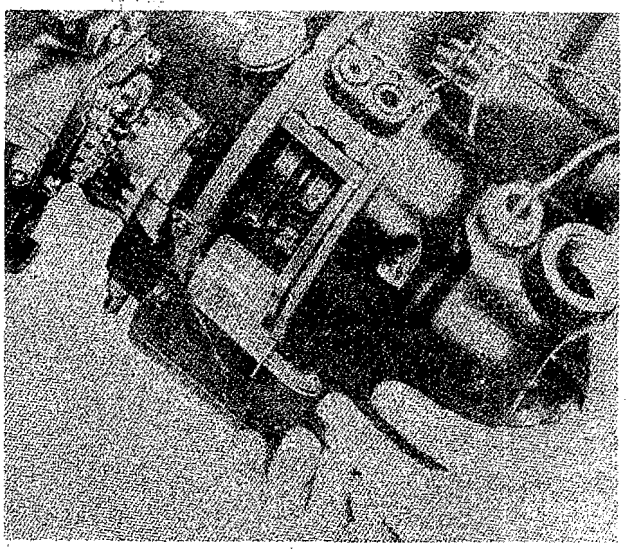

Figure 4—5

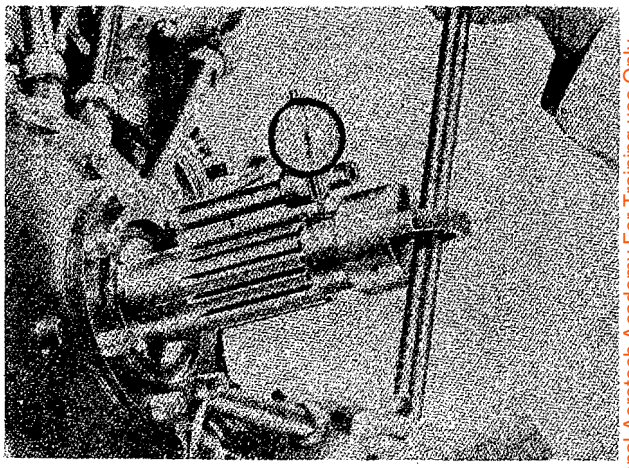

Figure 4—6

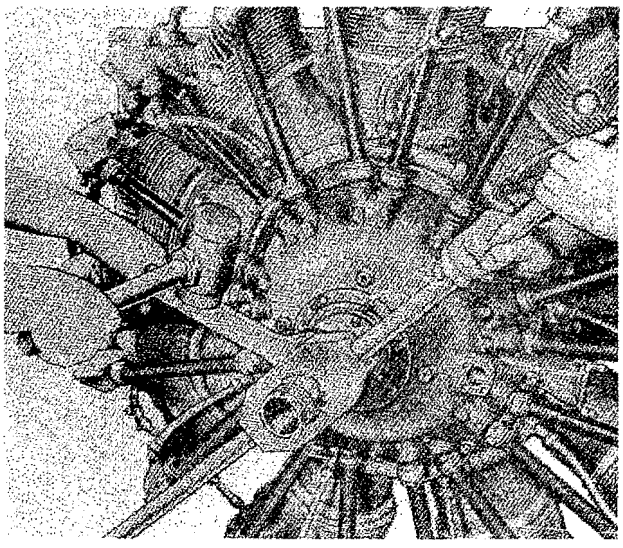

Figure 4—7

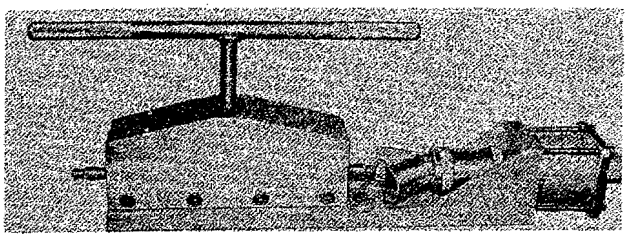

Figure 4–8

Figure 4–9

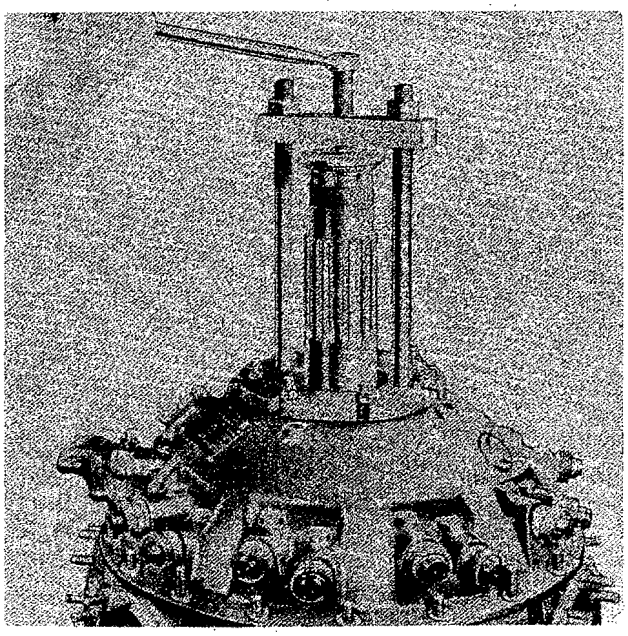

Figure 4–10

4–36. Withdraw the pushrods from the covers and drift the ballends from the pushrods, using PWA-2152-1 Drift or PWA-4877 Puller (Figure 4–8). Tie each ballend and spacer to the corresponding pushrod for correct location at assembly.

4–37. Remove the packing nuts from the pushrod covers and remove the packing from the nuts.

4–38. OIL SCAVENGE TUBES. Unfasten the nuts which secure the main oil sump to the oil pump and rocker oil sump to the oil pump scavenge tubes and remove these tubes.

4–39. OIL SUMP. Remove the nuts which fasten the sump to the front and supercharger cases, and pull the sump straight out to remove it (Figure 4–9).

4–40. IGNITION MANIFOLD. Remove the nuts which secure the ignition manifold to the front and supercharger cases, uncouple the union on the rear manifold using PWA-1886 Wrench, and withdraw the manifolds from the engine.

4–41. FRONT SECTION.

4–42. FRONT CASE.

4–43. If necessary, use PWA-1093 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.

4–44. Mount PWA-67 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 certain that 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 4–10).

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 crankcase front section.

4–45. TAPPET ROLLERS AND PINS. Withdraw the valve tappet assemblies from the guides and remove the pins and rollers from the tappets. Install PWA-4885 Protectors over the threads of each tappet guide.

4–46. ROCKER OIL MANIFOLD. 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.

4–47. BREATHER PLUG. Remove the plug from the breather assembly aperture.

4–48. THRUST BEARING AND RING CARRIER. Use a fiber drift and mallet to drive the bearing and crankshaft front oil seal ring carrier from the front case.

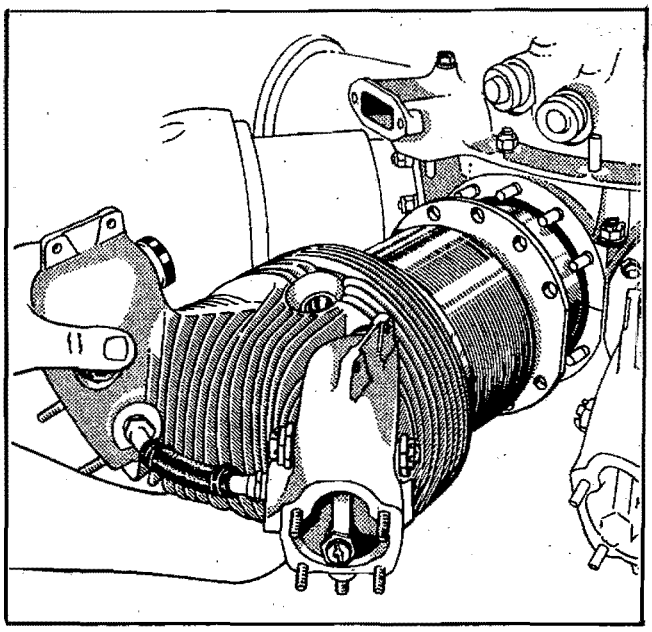

Figure 4—11

Remove the rings from the ring carrier, with PWA-1791 Pliers. Press the ring carrier from the bearing.

4—49. GOVERNOR ENGINE VALVE PLUG. Remove the pressure type governor engine valve cover and plug and the oil feed tube leading from the control valve boss to the thrust bearing liner.

4—50. CRANKSHAFT PLUG. Cut off the flared end of the standpipe securing the plug in the shaft and drift out the standpipe. Use PWA-2366 Wrench to remove the threaded plug and withdraw the inner plug with PWA-3060 Drift.

4—51. INTAKE PIPES. Using PWA-237 Wrench, loosen the packing nuts at the supercharger case. Remove the screws and nuts at the cylinder ends of the pipes; then remove the pipes. If a pipe sticks in place, use PWA-3145 Puller to remove it. Install PWA-3800 Protectors in the intake pipe ports in the supercharger case.

4—52. CYLINDERS AND PISTONS.

4—53. Install PWA-112 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 with PWA-2397, PWA-2006 or PWA-2399 Wrench in conjunction with PWA-2398 or PWA-2411 Handle.

4—54. Do not remove the top flange nut until just prior to the cylinder removal.

CAUTION

If one or two cylinder flange nuts on any one pad are found to be loose to the extent that there is a clearance between the nut and the flange and if this looseness is known to have existed during previous engine operation, replace the studs engaged by, and on each side of the loose nuts. If more than two nuts are loose, check the cylinder flange for flatness and lapping, if necessary, as described in paragraph 6—108.

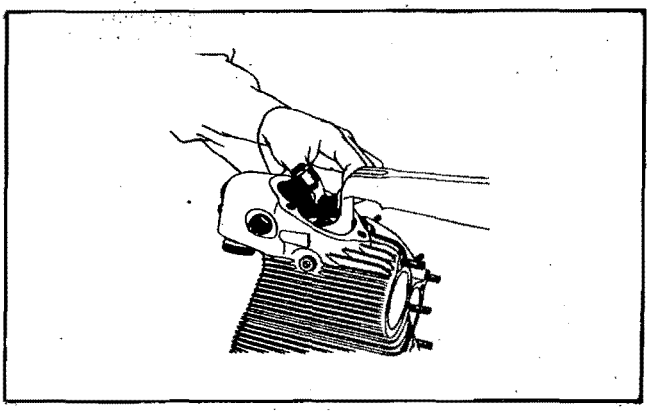

Figure 4—12

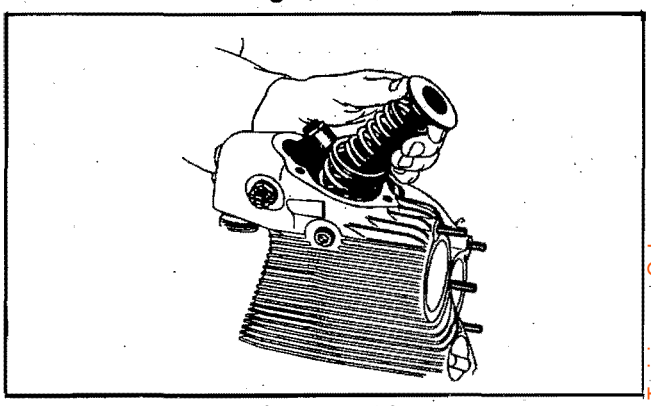

Figure 4—13

4—55. 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.

4—56. Support the cylinder with both hands while the top flange nut is being removed; then withdraw the cylinder straight out from the engine (Figure 4—11). Place each cylinder in an appropriate carrier to prevent damage to the cooling fins and barrel.

4—57. Directly after removal of a cylinder, push the pistonpin from the piston, using PWA-4251-10 Pusher if necessary. Lift the piston from the linkrod and remove the rings from the piston with PWA-1791 Pliers. Tag the rings to indicate the piston from which they were removed. Record any stuck, broken or sluggish rings on the Inspection Report.

4—58. Remove the plugs from the pistonpins. 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.

4—59. INLET AND EXHAUST VALVES. Mount and secure the cylinder on TAM-3146 Stand. Compress the valve springs with the swivel arm of the stand and take out the split locks (Figure 4—12). Withdraw the upper washer and the inner and outer valve springs from each rockerbox (Figure 4—13). Remove the safety circlets

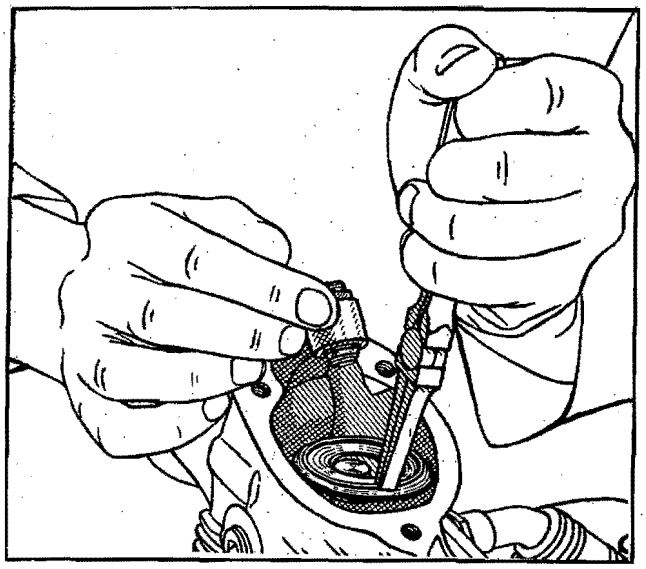

Figure 4–14

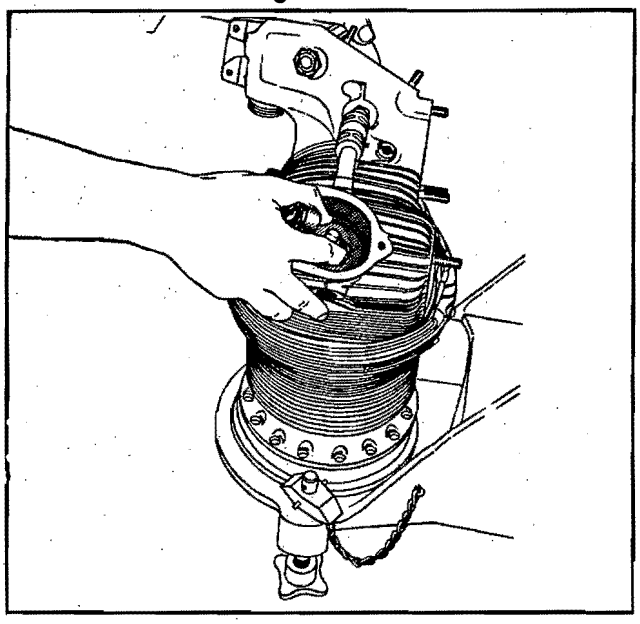

Figure 4–15

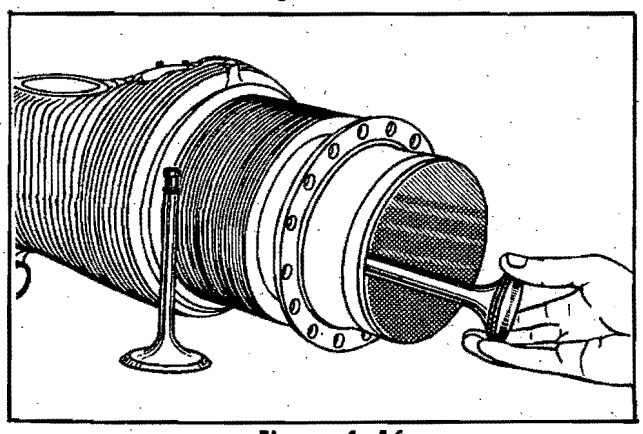

Figure 4–16

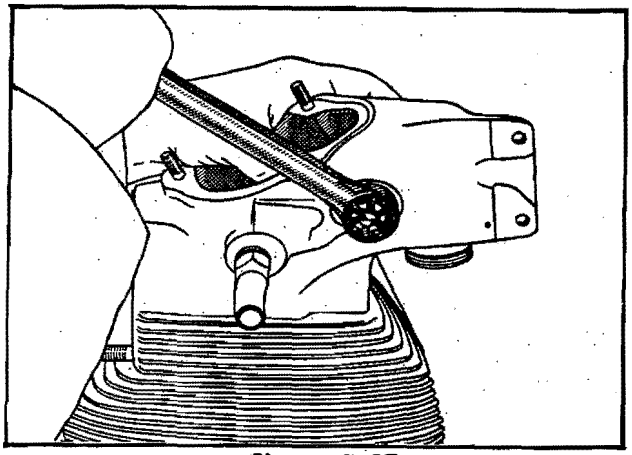

Figure 4–17

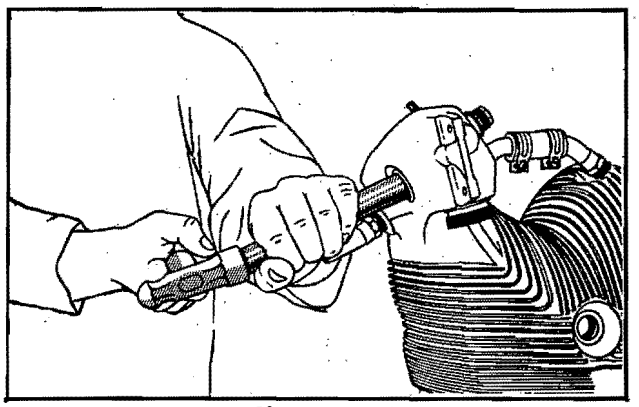

Figure 4–18

from the valve stems, then lift out the valve springs lower washer with long nosed pliers (Figure 4–14). Remove the cylinder from the stand, holding the valve stems with the fingers (Figure 4–15) 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 4–16) and place them in a rack provided with numbered positions.

4–60. ROCKER SHAFTS. Unfasten and remove the inner and outer rocker shaft nuts (Figure 4–17). Drift out the shaft by driving on the smaller end of the shaft with a fiber drift (Figure 4–18). Lift out the rocker (Figure 4–19). Unscrew the valve adjusting screw and locknut from the rocker (Figure 4–20).

4–61. ROCKER SHAFT BEARINGS. Use PWA-614 Drift and Base in conjunction with an arbor press to remove the bearing from the rocker (Figure 4–21).

4–62. CRANKCASE SECTION.

4–63. CAM. Lift off the cam.

4–64. CAM OIL FEED BRACKET. 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

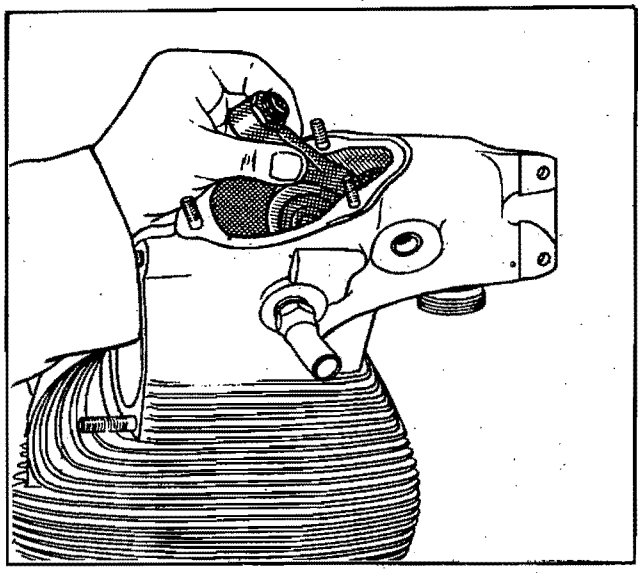

Figure 4–19

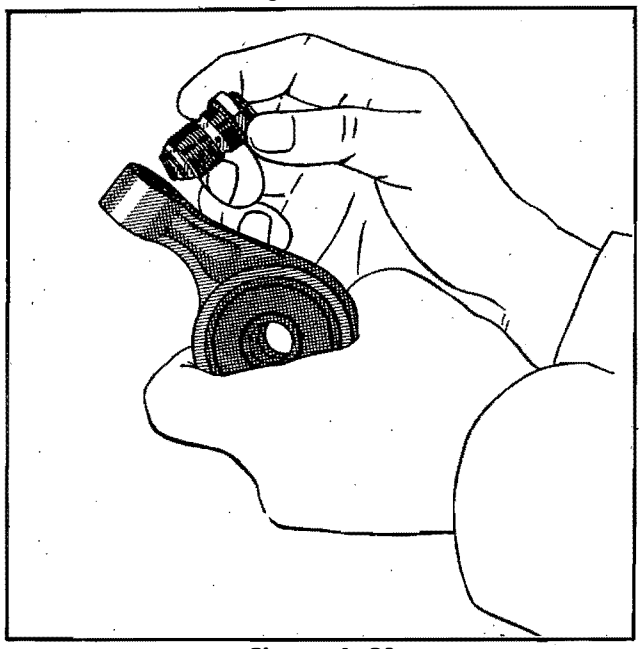

Figure 4–20

engine as a unit. Remove the floating rings from the inner side of the bracket.

4–65. CAM DRIVE GEAR. 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 PWA-2289 Puller (Figure 4–22). Use PWA-3215 Drift and Base in conjunction with an arbor press to separate the gear and the ring. Remove the key from the crankshaft.

4–66. CRANKCASE FRONT SECTION.

4–67. 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 crank-

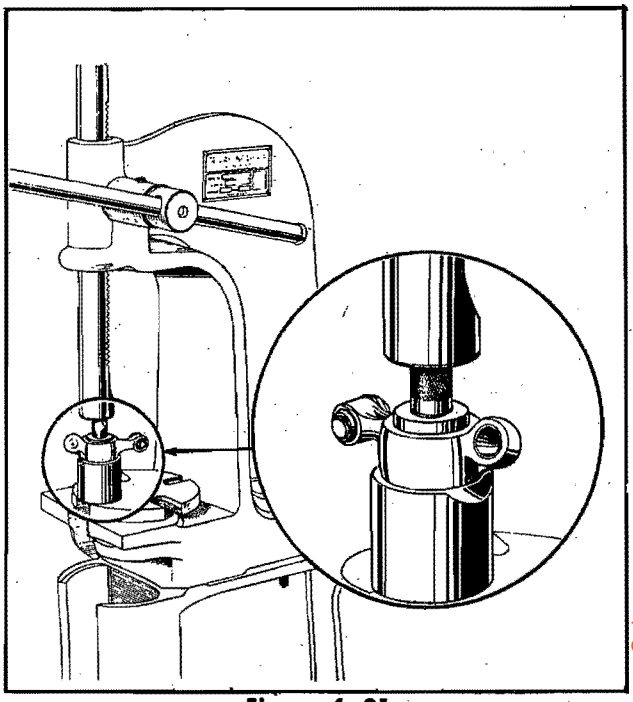

Figure 4–21

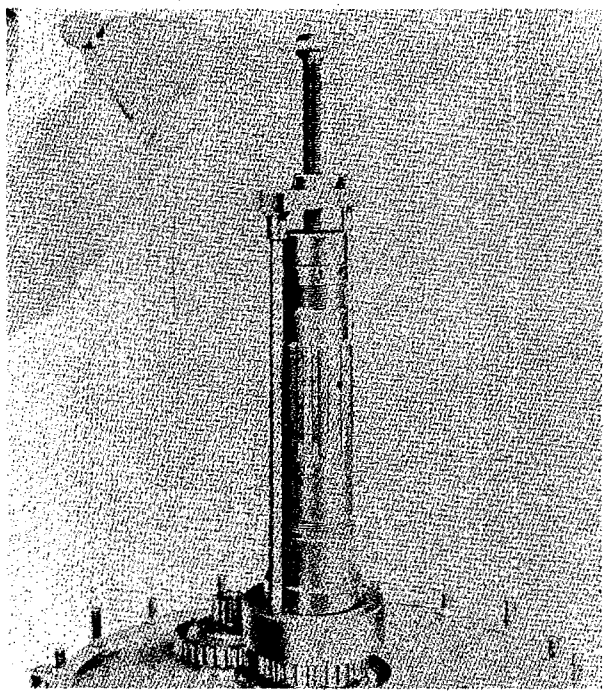

Figure 4–22

case bolts and drift the bolts downward until they bottom on the supercharger case.

4–68. Remove the washers from the bolt bosses on the crankcase front section.

4–69. Remove the crankcase front section from the rest of the engine by lifting evenly on both sides of the crank-

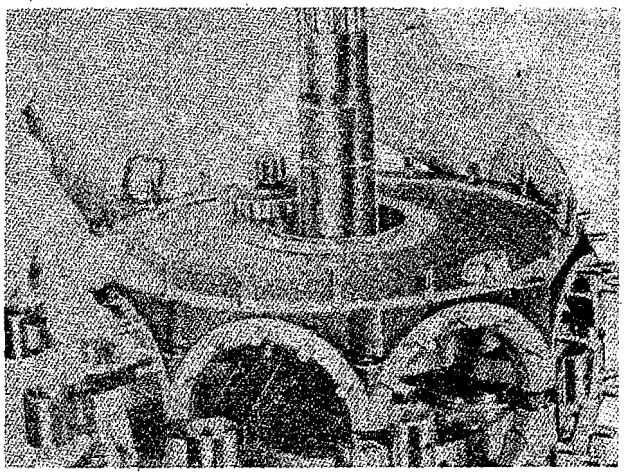

Figure 4—23

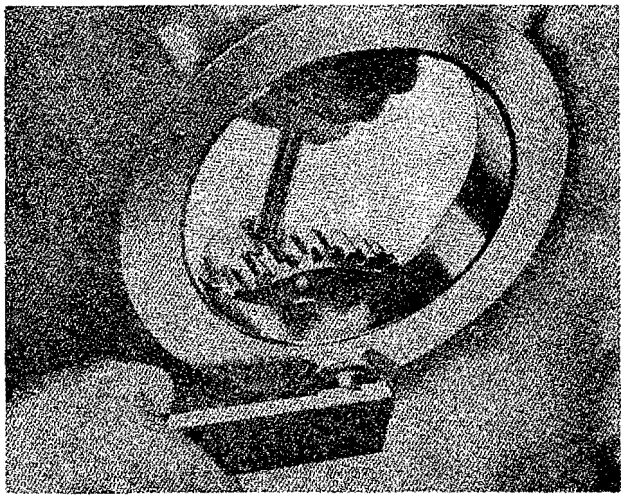

Figure 4—24

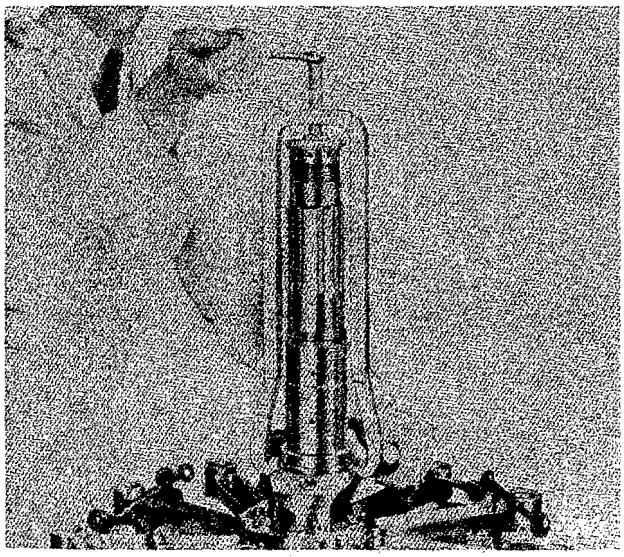

Figure 4—25

case to prevent cramping the front main bearing (Figure 4—23). Remove the front main bearing outer race and the front section of the inner race from the crankshaft.

4—70. CAM REDUCTION DRIVE GEAR. Place the crankcase front section on a bench. Unfasten the cam reduction drive gear retaining nut, using TAM-255 Wrench in conjunction with PWA-248 Holder (Figure 4—24). Withdraw the gear from the crankcase.

4—71. CRANKSHAFT AND MASTEROD ASSEMBLY.

4—72. FRONT MAIN BEARING INNER RACE. Use PWA-470 Puller to remove the front main bearing inner race from the crankshaft (Figure 4—25).

4—73. CRANKSHAFT. Attach PWA-520 Eye on the crankshaft and in conjunction with PWA-2388 Hook and a chain hoist, lift the crankshaft assembly from the crankcase rear section.

4—74. IMPELLER SPRING DRIVE COUPLING.

4—75. Mount the splined end of the crankshaft in TAM-206 Fixture equipped with PWA-1919-2 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 link-rod assembly in position, thus preventing damage to any part of the assembly.

4—76. Remove the cotterpin, nut and washer which attach the fixed spider of the spring coupling assembly to the crankshaft rear gear. Use PWA-448 Puller to pull the spring drive coupling from the crankshaft rear gear (Figure 4—26). Disassemble the fixed spider, floating spider, floating spider friction band, springs and buttons (Figure 4—27).

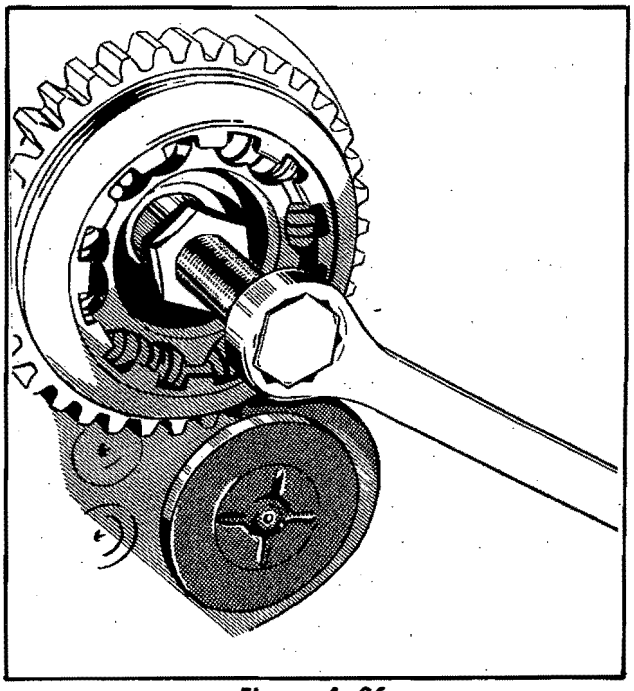

Figure 4—26

4–77. CRANKSHAFT REAR GEAR. Unfasten the four retaining screws attaching the crankshaft rear gear to the rear of the crankshaft. Remove the gear.

4–78. IMPELLER SPRING DRIVE BOLT. Use PWA-1195 Wrench to remove the impeller spring drive bolt from the crankshaft rear section.

4–79. REAR MAIN BEARING. Remove the outer race, rollers and rear section of the inner race of the rear main bearing. Use PWA-1742 Puller to pull the remainder of the inner race from the crankshaft (Figure 4–28).

4–80. CRANKSHAFT FRONT AND REAR SECTIONS.

4–81. Remove the cotterpin located near the head of the crankshaft bolt. Use PWA-1914 Wrench to unscrew the crankshaft bolt. Coat the threads of PWA-2423 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 using PWA-3755 Pump (Figure 4–29).

CAUTION

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

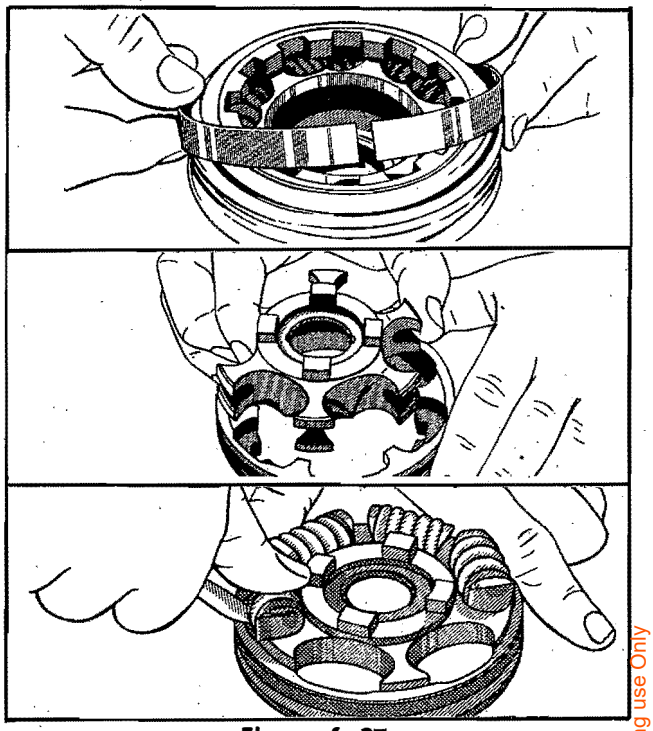

Figure 4–27

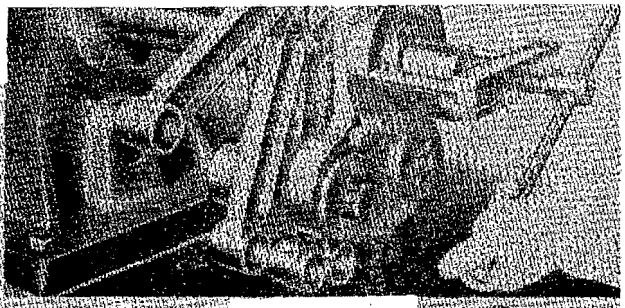

Figure 4–28

Figure 4–29

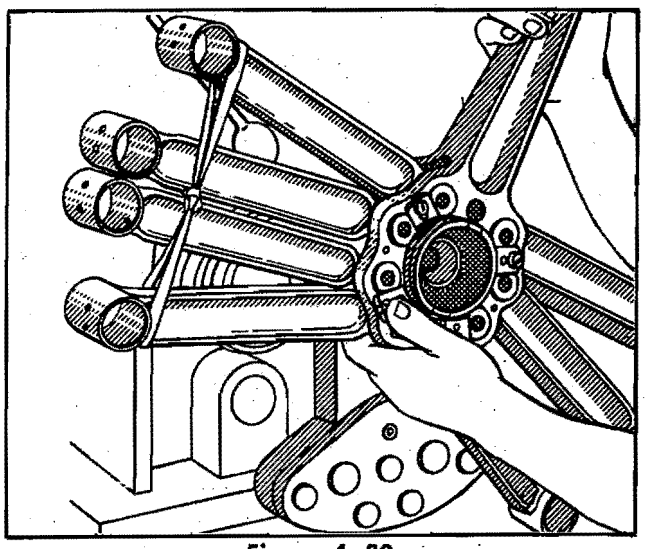

Figure 4—30

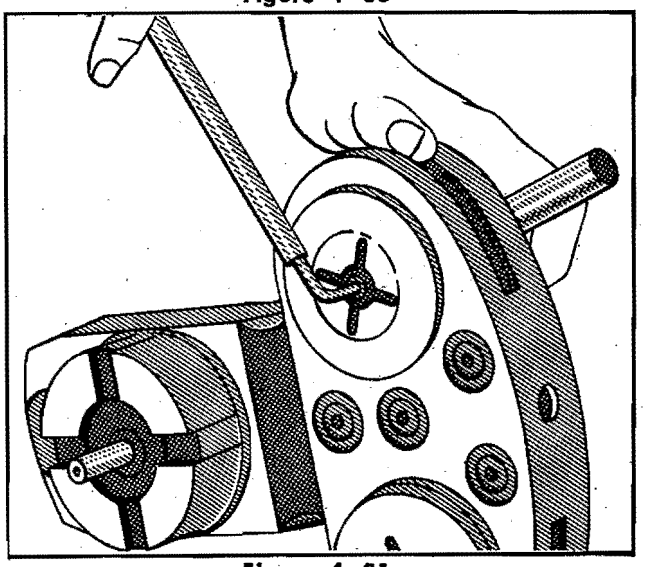

Figure 4—31

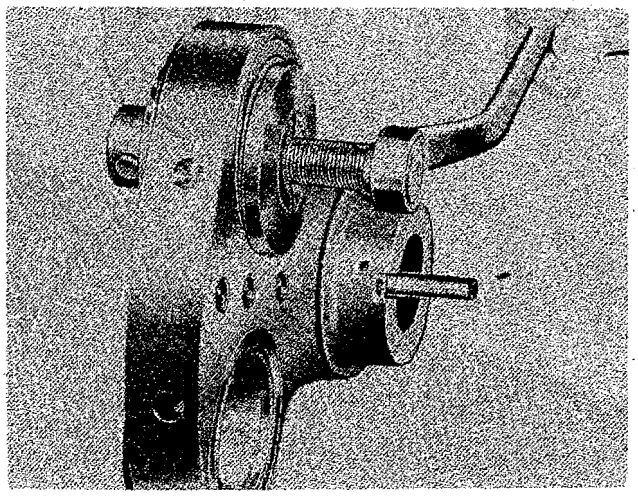

Figure 4—32

4—82. 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 4—30); then remove the crankshaft front section from the fixture.

4—83. FLYWEIGHTS. Use a long handle allen wrench to loosen the allen plug in the flyweight bolts (Figure 4—31); then unscrew the flyweight bolt, using TAM-1773 Wrench. Jack the flyweight sections apart, using PWA-1068 Pusher (Figures 4—32 and 4—33).

4—84. OIL PLUGS. Remove the crankshaft rear plug from the crankshaft, using PWA-1647 Wrench. Remove the crankshaft front oil plug, using PWA-2366 Wrench.

4—85. LINKPINS.

4—86. Remove the two screws which hold the locking bar at the front end of each pair of linkpins; then drift off the locking bars.

4—87. Rest the masterod assembly on top of PWA-296 Fixture with the forward side of the masterod facing upward and with the pilot of the fixture fitted through the masterod bearing. Insert PWA-992 Wedge between the masterod flanges to prevent their distortion when pressure is applied to the linkpin.

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.

4—88. Turn the masterod so that the linkpin to be removed is located directly over one of the slots in the base of the fixture. Locate the L head plunger over the linkpin; then place PWA-4497-10 Drift between the plunger and the linkpin and press the linkpin out by bringing the plunger down (Figure 4—34). If necessary, tap the plunger with a copper hammer until the linkpin starts to move.

CAUTION

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

4—89. CRANKCASE REAR SECTION. 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 fiber drift to release it from the supercharger case. Use PWA-1285 Puller to remove the crankcase bolts from the crankcase rear section.

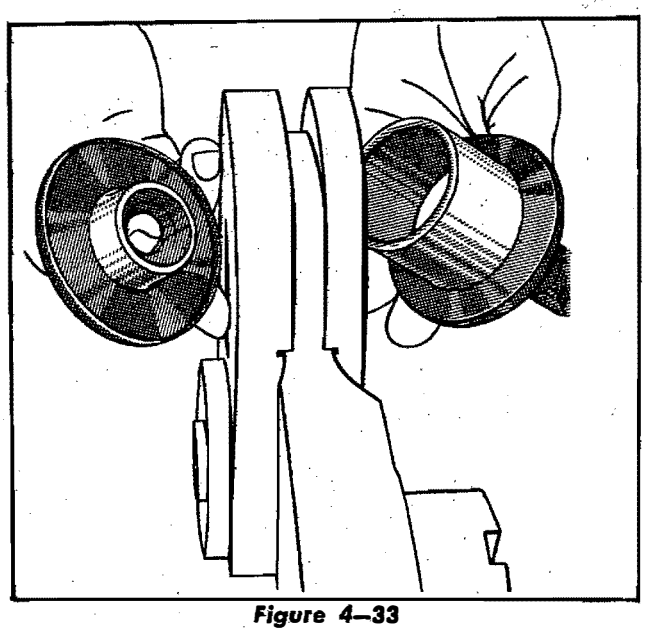

Figure 4—33

4—94. Use PWA-2044 Puller to remove the bearing from the gear shaft. Remove the spacer from the gear shaft.

4—95. CARBURETOR ADAPTER. Remove the nuts attaching the carburetor adapter to the rear case and lift off the adapter.

4—96. TACHOMETER DRIVES. Unscrew the cap on each tachometer drive shaft. Use a 1 inch box wrench. Remove the screw 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 with PWA-1836 Puller.

4—97. FUEL PUMP DRIVE GEAR.

4—98. Remove the nuts attaching the fuel pump drive gear adapter to the rear case; then withdraw the adapter and gear from the case. Use PWA-2374 Puller to facilitate removal of the adapter and gear.

4—99. Pull the fuel pump drive gear from its adapter. Remove the fuel pump drive gear oil seal, using PWA-3762 Puller.

4—90. REAR SECTION.

4—91. STARTER JAW AND GEAR.

4—92. Crank the bed of the engine stand until the supercharger and rear sections are in a horizontal position.

4—93. Remove the starter jaw nut and starter jaw. Drift the starter gear forward in the supercharger case, using a fiber drift and hammer; then lift the gear free of the case (Figure 4—35).

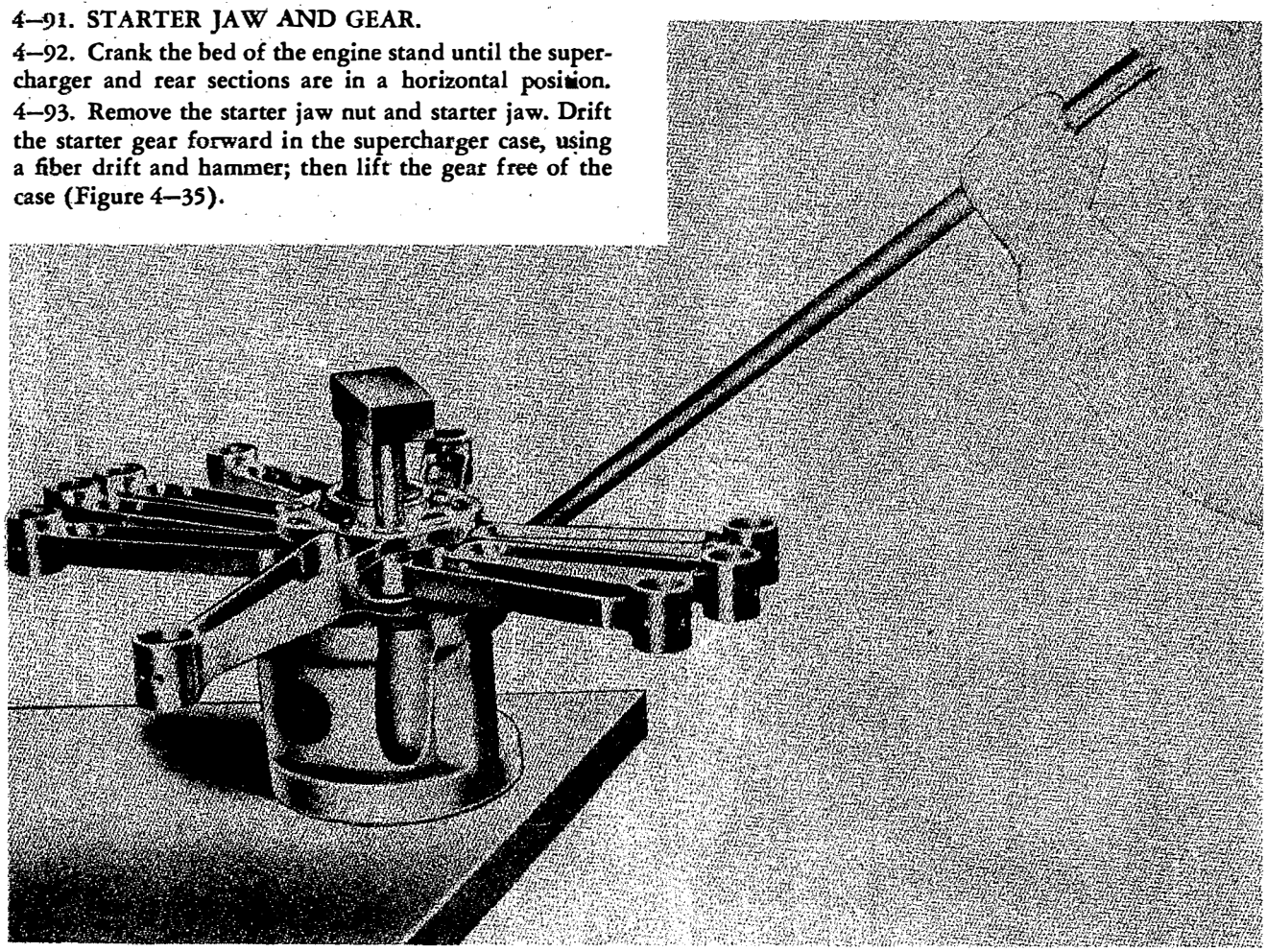

Figure 4—34

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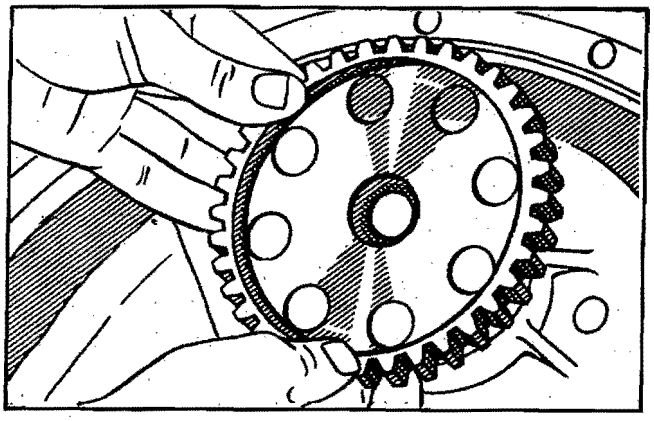
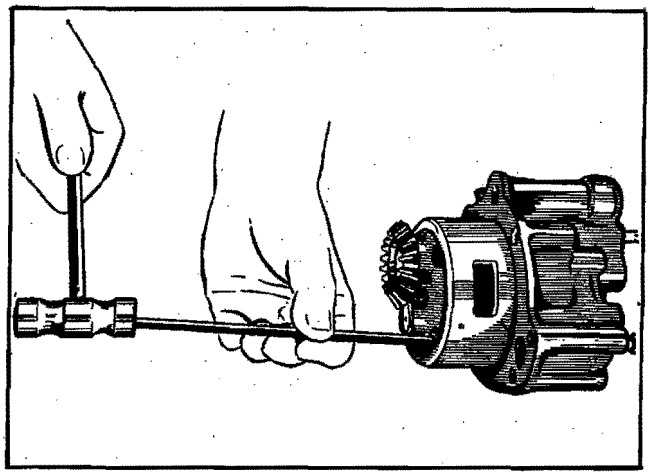


Figure 4—35



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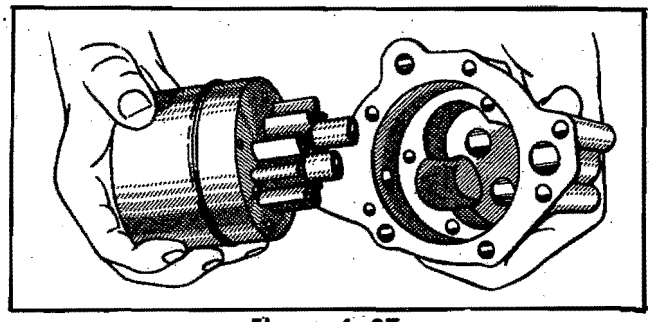

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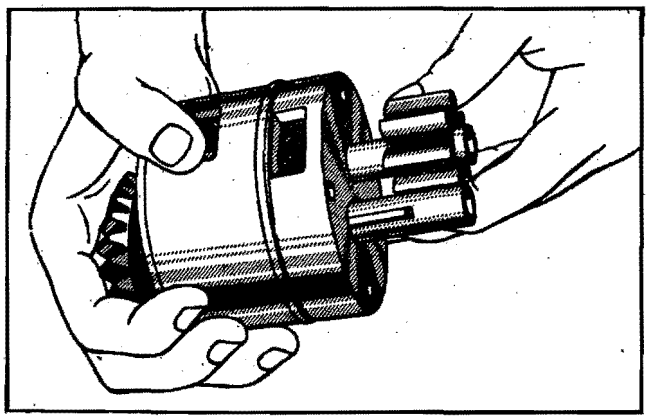


Figure 4—38

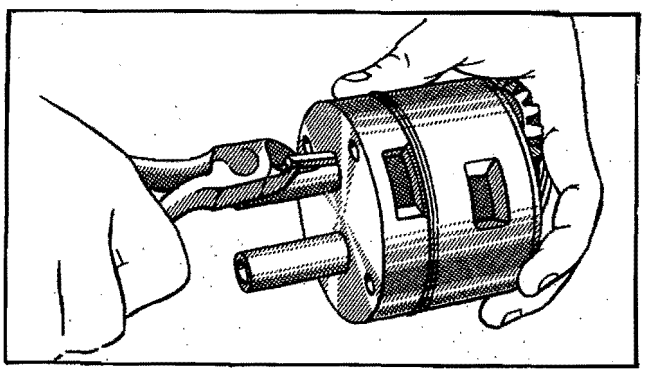


Figure 4—39

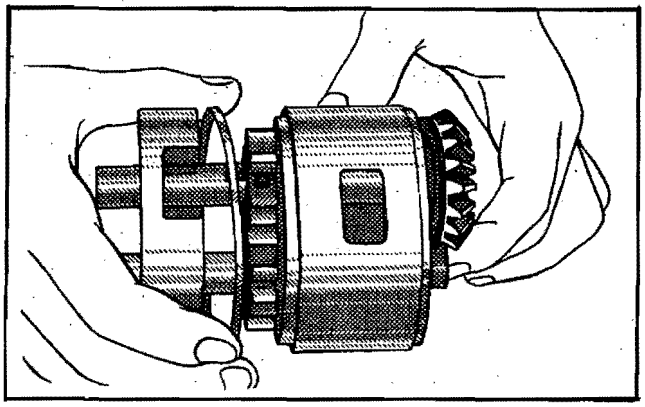


Figure 4—40

4—100. OIL PUMP.

4—101. Remove the nuts attaching the oil pump to the rear case. Attach PWA-1327 Puller to the oil inlet port studs and pull the pump from the rear case.

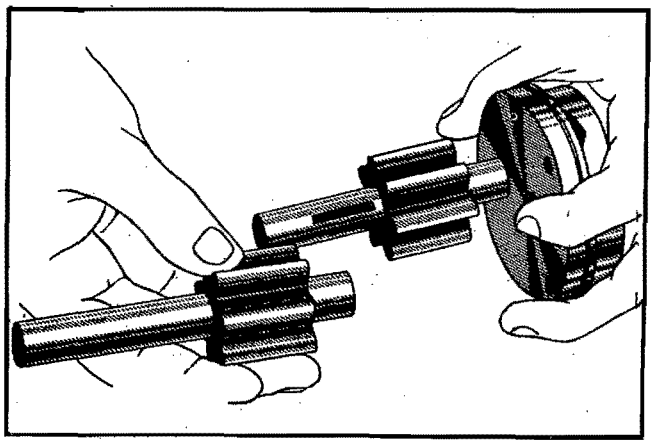
4—102. Loosen and remove the four nuts on the four through bolts which hold the pump together. Two of these bolts can be pulled out with the fingers but the other two must be drifted out (Figure 4—36). Lift off the cover, or pressure section (Figure 4—37), and the gears (Figure 4—38); then remove the key from the drive shaft (Figure 4—39). Lift off the first scavenge section and oil seal ring (Figure 4—40). Remove the gears; then, remove the key from the drive shaft. Remove the oil seals from the shaft holes in this section. Lift off the second scavenge section and remove the idler shaft and gear (Figure 4—41). Remove the drive gear and key and withdraw the drive shaft from the pump end plate (Figure 4—42). If difficulty is experienced in removing the gears, they may be removed with PWA-2569-100 or PWA-2569-101 Puller.

4—103. INTAKE DUCT VIEW PORT. Remove the intake duct view port plug and cover.

4—104. PLUGS. Remove the connection constant speed control plug, the oil thermometer connection plug, and all allen plugs from the rear case.

4—105. MAGNETO DRIVE GEARS.

4—106. Remove the magneto coupling screws. Pull the coupling gear from each magneto drive gear shaft with PWA-621 Puller. Unfasten the bolts attaching the seal



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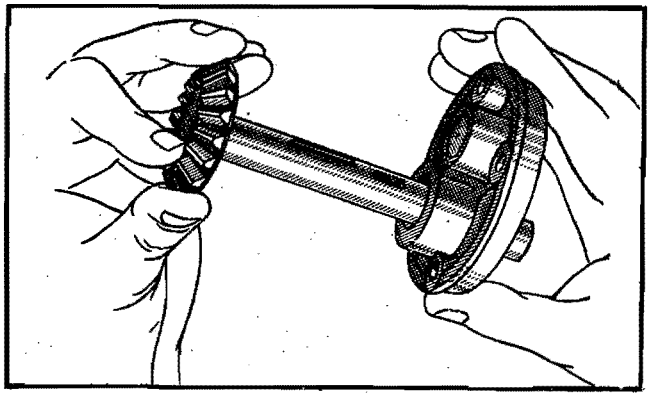


Figure 4—42

housing to the rear case and pull out the oil seal, using PWA-3762 Puller.

4—107. Pull the magneto drive gears forward (Figure 4—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.

4—108. VACUUM PUMP DRIVE GEAR.

4—109. Attach the adapter of PWA-1998 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.

4—110. Use a fiber drift to drive the vacuum pump drive gear from the adapter. Remove the spacer from the shaft. Use PWA-3762 Puller to remove the oil seal.

4—111. GENERATOR DRIVE GEAR ASSEMBLY.

4—112. Unfasten the four nuts that hold the generator drive assembly to the top of the rear section and remove the assembly.

4—113. On the single bearing drive assembly, 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, with PWA-174 Wrench. Withdraw the gear from housing and drift the bearing from the gear.

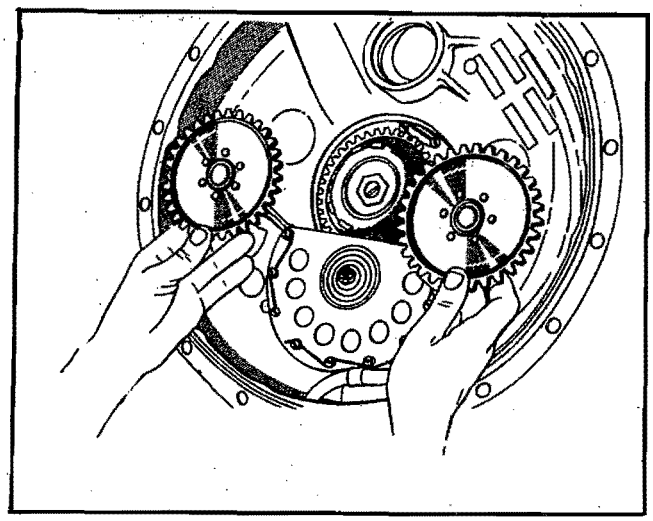


Figure 4—43

4—114. On the double bearing drive assembly, remove the screws from the retainer plate and drift the cork from the generator drive gear shaft bore.

4—115. Install the drive gear in PWA-4635 Fixture and remove the spanner nut with PWA-174 Wrench. Lift out the washer. Install the assembly in PWA-4638 Fixture and drift the gear and inner bearing from the housing, using PWA-4639 Drift. Remove the spacer from the gear shaft. Install the drive gear in PWA-4638 Fixture and use PWA-4639 Drift and PWA-4640 Collar to remove the inner bearing from the gear shaft. Use PWA-4636 Drift and PWA-4638 Fixture to remove the outer bearing from the housing.

4—116. GUN SYNCHRONIZER (AN-6 Engines only). Unscrew the cam follower cap and lock plunger or plug from the gun synchronizer cover, using suitable wrenches. Remove the four screws which fasten the gun synchronizer cover; then remove the cover and shim. Withdraw the cam follower, cam and gear shafts, and bearings and bearing retainer as a unit from the housing. Remove the cotterpin, nut, and bolt from the cam and gear shaft by tapping on the end of the shaft with a dural drift and hammer; then remove the cam follower. After both of these parts have been removed from the shaft, push the bearing out of the retainer with the fingers; then remove the lower bearing.

4—117. VERTICAL ACCESSORY DRIVE GEARS.

4—118. Remove the nut, washer, and spacer or gear from each vertical accessory drive gear shaft. Using a fiber drift and hammer, tap the drive gears downward, being careful not to let them fall. Remove the drive gear adapters from the rear case.

4—119. Remove the drive gear ball bearings, using a fiber 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.

4—120. OIL PRESSURE RELIEF VALVE. Remove the acorn shaped cap from the oil pressure relief valve. Re-

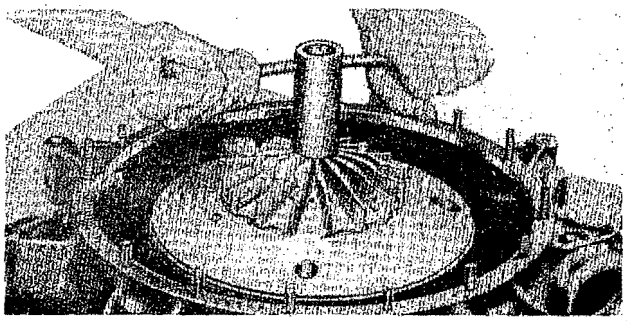


Figure 4—44

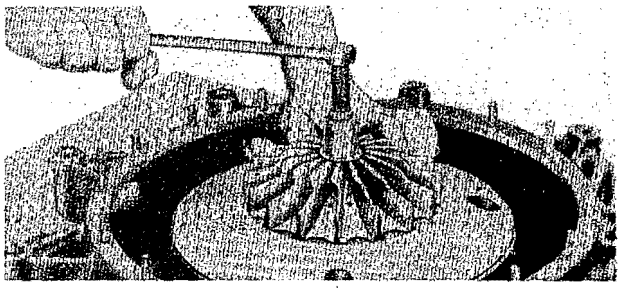


Figure 4—45

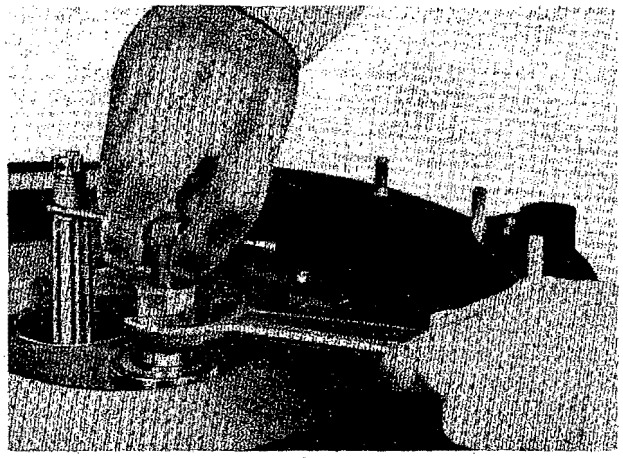


Figure 4—46

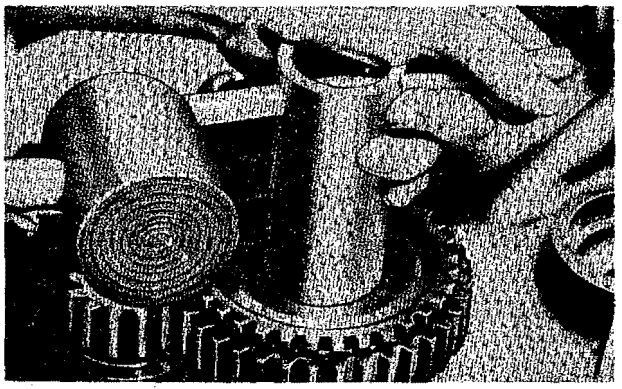


Figure 4—47

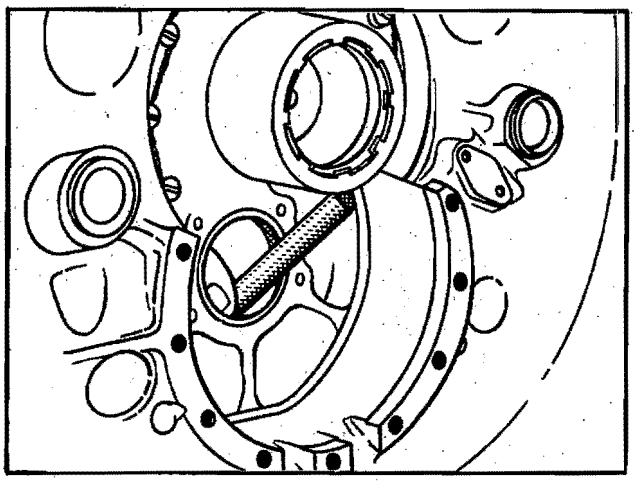


Figure 4—48

move the oil pressure relief valve body; then withdraw the spring and plunger. Use PWA-671 Wrench to remove the valve seat from the rear case.

4—121. REAR CASE. Unfasten and remove the nuts attaching the rear case to the supercharger section. Pull the rear case free with PWA-2712 Puller and lift off the case.

CAUTION

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

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.

4—122. SUPERCHARGER SECTION.

4—123. BREATHER ASSEMBLY. Remove the screws from the breather exhaust connection; then lift off the washer, exhaust connection, and gasket. Use PWA-3482 Wrench to disassemble the breather connection body. Use PWA-2373 Wrench to remove the left breather hole plug.

4—124. REMOVAL OF IMPELLER. Lock the floating gear and the impeller intermediate drive gear with PWA-338 Holder. Insert a small steel drift in the flared end of the impeller nut locking pin and drive out the pin. Use PWA-1269 Wrench to remove the impeller nut which has a LEFT HAND thread (Figure 4—44). 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 PWA-51 Puller to pull the impeller from the shaft (Figure 4—45).

4—125. REAR SUPERCHARGER BEARING COVER. 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, oil slinger, baffle, and spacer. With the gears still locked, remove the impeller intermediate drive gear rear bearing and inner liner, using PWA-346 Puller (Figure 4—46). Press the liner from the bearing using an arbor press and a drift.

4—126. FLOATING GEAR. Bend down the tablock and unscrew the floating gear retaining nut, which has a LEFT HAND thread, using PWA-345 Wrench (Figure 4—47). Remove the front 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.

4—127. IMPELLER SHAFT. Make sure the nut and the locking pin are removed from the front end of the impeller shaft. Use a fibre drift to tap the impeller shaft from the rear to the front and withdraw the shaft from the supercharger case. Tap the two front ball bearings from the shaft. Withdraw the impeller shaft rear ball bearing from its liner in the case.

4—128. IMPELLER INTERMEDIATE DRIVE GEAR. Unscrew the front supercharger cover retaining screws and jack the cover from the supercharger case by inserting four 1/4 inch-28 screws in the holes provided. Be careful not to tilt the cover and cramp the impeller intermediate drive gear front bearing. Remove the gear; then tap the bearing from the gear shaft by inserting a 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 (Figure 4—48).

4—129. SUPERCHARGER SECTION PLATES. Remove the lockwire and screws from the two supercharger section plates and remove the plates.

4—130. REMOVAL OF SUPERCHARGER CASE. Crank the bed of 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.

SECTION V

CLEANING

5—1. GENERAL.

5—2. AIR FORCE AND NAVY INSTRUCTIONS. Air Force and Navy personnel should refer to the latest applicable technical publications for cleaning instructions.

5—3. PRELIMINARY INSTRUCTIONS. Following disassembly, all engine parts should be thoroughly cleaned. It is very important that all parts for which specific cleaning instructions are given in paragraphs 5—12 through 5—28 be cleaned in accordance with those instructions. All other parts should be cleaned in accordance with the instructions in paragraphs 5—4 through 5—11. After steel parts have been cleaned, they should be covered with a thin coat of light oil to protect them against rusting and corrosion.

5—4. DEGREASING. Oil, sludge, grease, and soft carbon deposits may be removed from engine parts by one of the following methods.

5—5. SPRAY METHOD. Spray the parts in a cleaning booth which has positive ventilation to the outside. The cleaning fluid should be kerosene conforming to Specification No. VV-K-211 or a cleaning solvent conforming to Specification P-S-661.

5—6. BATH METHOD. Immerse the parts in a cleaning agent such as kerosene or a cleaning solvent conforming to Specification P-S-661. A soft brush may be used to facilitate removal of soft carbon deposits. Blow off any excess cleaning agent with compressed air.

5—7. VAPOR CONDENSATE METHOD. Place the parts in a steam heated tank which contains the cleaning fluid vapor. The vapor will condense on the parts and thoroughly degrease them. Parts cleaned by this method will be absolutely dry and free from oil and grease when they are removed from the tank and, therefore, should be sprayed with a light oil immediately after removal from the tank to protect them against rusting and corrosion. The cleaning fluid should be stabilized trichlorethylene conforming to Specification MIL-T-7003.

Note

If any aluminum alloy tubing or other aluminum alloy components are cleaned by this method, these parts should immediately be submerged in a hot bath of five percent chromic acid solution at 140°F for 20 minutes, then rinsed in 180°F water or anodized to prevent possible corrosion.

5—8. DECARBONIZING.

5—9. CARBON SOLVENTS. Hard carbon deposits which cannot be removed by degreasing may be removed by a carbon solvent.

5—10. Some carbon solvents will attack aluminum and magnesium parts if the parts are allowed to stand too long in the solution. Whenever a carbon solvent is used, the instructions of the manufacturer of the solvent should be carefully observed. Immerse the parts to be decarbonized in a solvent conforming to AAF Specification No. 20025. (Navy personnel should use carbon removal compound, Specification C-86C. An alkaline carbon solvent is not specified as it will remove preservative varnish from steel parts.) After removing the parts from the solvent, wash them thoroughly in hot water to remove all the cleaning agent. If any of the cleaning agent is allowed to remain on the parts it may combine with the moisture in the engine lubricating oil and, when the engine is next run, may cause violent foaming of the oil with resultant discharge of oil from the breather tubes.

5—11. Blasting should not be used for cleaning except as directed in paragraphs 5—12 through 5—28. Any part to be blasted should first be thoroughly degreased, and all threaded areas, bearing surfaces, and highly polished machined surfaces of the part should be fully protected with suitable plugs, rubber sleeves, or masking tape. Blasting should be done uniformly, and the nozzle should not be allowed to dwell in one place.

Note

Cellulose acetate pellets, clover seed, or cracked wheat may be used for removing hard carbon deposits. Sandblasting may be used on exhaust valves.

CAUTION

Make sure that all blast material as well as loose carbon is completely removed from grooves, recesses or oil passages. The use of a mirror will permit a more thorough examination of such obscure locations.

5—12. SPECIFIC CLEANING INSTRUCTIONS.

5—13. PARTS WITH LEADED BEARING SURFACES. The masterod bearing has a leaded bearing surface and requires special care to prevent damage to this surface. It should be cleaned only by flowing kerosene conforming to Federal Specification No. VV-K-211, or a cleaning solvent conforming to Federal Specification P-S-661, over the bearing surfaces and wiping the bearing surfaces with a soft, smooth cloth.

5—14. BALL BEARINGS.

5—15. Ball bearings are at all times susceptible to magnetism 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 removable during the soaking and washing operations. To prevent the possibility of foreign particles remaining, completely demagnetize each ball bearing before cleaning.

5—16. Demagnetize non-demountable ball 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.

5—17. After the 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.

5—18. 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 to 88°C (170°F to 190°F). If equipment for heating the oil is not available, soak the bearings in a cold solvent conforming to Federal Specification No. P-S-661.

5—19. Bearings having hard carbon deposits should be decarbonized according to instructions given in paragraph 5—8.

5—20. 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 solvent conforming to Federal Specification No. P-S-661. 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.

5—21. 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.

5—22. If the bearing is not to be used immediately, it should be well oiled, wrapped in greaseproof wrapping paper conforming to Specification No. JAN-B-121, and placed in a box or covered container.

5—23. CYLINDERS. Clean the cylinders in accordance with instructions in paragraphs 5—5 and 5—6.

5—24. PISTONS.

5—25. Clean the pistons according to the instructions in paragraphs 5—5 and 5—8 through 5—11. Using a soft metal or wood scraper, scrape any remaining carbon from the ring grooves. Be careful not to remove any metal from the small radii between the lands and the bottoms of the ring grooves and be careful not to damage the lands.

5—26. Carbon lodged in oil holes may be removed by reaming out the holes with an undersize drill. If necessary, the piston may be polished with crocus cloth and kerosene; however, if this is done, the piston should again be cleaned as directed in paragraph 5—5.

5—27. VALVES. Clean the valves according to the instructions in paragraph 5—5. Any carbon remaining on the heads of the valves may be removed with a fine wire brush. Exhaust valves may be sandblasted as directed in paragraph 5—11, provided grade 120 round sand, propelled by air pressure not exceeding 30 pounds per square inch is used, and provided the valve stem is protected from the sandblasting. Use a cloth wheel free of any abrasive compound to clean valve stems, as scratches will invite cracks and subsequent failure of the valve. Do not remove the glaze and discoloration on the valve stem.

5—28. INTERNAL OIL PASSAGES. The internal passages of all parts should be cleaned thoroughly and blown out with compressed air. Remove the oil passage plugs where necessary. Particular attention should be paid to the supercharger intake insert assembly. Hold the assembly on a wash stand so that the fuel inlet passage is at the bottom. Direct a strong spray of cleaning fluid through the fuel holes around the front of the liner.

SECTION VI

INSPECTION

6—1. GENERAL.

6—2. AIR FORCE AND NAVY INSTRUCTIONS. Air Force and Navy personnel should refer to the latest applicable technical publications for inspection instructions.

6—3. PRELIMINARY INSTRUCTIONS.

6—4. Thorough and intelligent inspection of all engine parts is the controlling factor in efficient and dependable overhaul, and too much emphasis cannot be placed on the importance of careful inspection and the decisions it involves. In most cases, the main purpose of the instructions contained in this Section is to supplement the judgment and experience that a qualified inspector has gained after years of this work. However, less experienced personnel should carefully follow the instructions in this Section.

6—5. All parts of the engine should be arranged on one inspection table so that the inspector can judge the condition of the engine as a whole and can readily make reference to other engine parts which may have been affected by a worn part. In this way, it will often be possible for the inspector to determine at once the cause of any abnormal wear.

6—6. When inspecting the surface condition of parts, it should be noted that some surfaces are given a metallic or chemical treatment to eliminate chafing at steel-to-steel contact locations. In some cases, these surfaces have been mistaken for used or unfinished parts and instructions have been given to polish them. The following two methods are used to eliminate chafing.

a. Plating the part with either silver, copper, tin, chromium or lead. This treatment results in a surface discoloration that resembles the color of the metal used in the plating.

b. Treating the surface of the part with chemicals. This treatment results in the surface having a dull black satin-like appearance. No attempt should be made to polish surfaces having these treatments unless such polishing is required at points necessary to assure a good contact for passing electrical current during the magnetic inspection.

6—7. Use care in checking the condition of splines and threaded areas. See that oil jets are unobstructed and make sure that oil passages have been thoroughly cleaned.

6—8. FITS, CLEARANCES, AND SPRING PRESSURES. When the inspection procedure involves the measurement of fits, clearances, or spring pressures, refer to the tables in Section XII for the proper limits. Details regarding the use of these tables are given in paragraphs 12—1 through 12—7 of Section XII.

6—9. PHYSICAL, MAGNETIC, AND FLUORESCENT PENETRANT INSPECTION.

6—10. All engine parts should be subjected to physical inspection. General physical inspection instructions covering groups of similar parts are given in paragraph 6—1 through 6—55, and specific physical inspection instructions covering parts which require special procedure and parts which cannot be readily grouped are given in paragraphs 6—56 through 6—169.

6—11. Most steel parts should be subjected to magnetic inspection in accordance with the instructions in paragraph 6—170, and non-ferrous parts should be subjected to fluorescent penetrant inspection in accordance with the instructions in paragraph 6—192.

6—12. After inspection, whenever it is deemed that sufficient time will elapse before re-assembly to allow damage to parts from corrosion, observe the following procedure. Cover all unprotected surfaces of magnesium and steel parts or any other parts with which corrosion difficulties are experienced, with a light coat of one part of aircraft engine corrosion preventive compound, Specification No. AN-VV-C-576, to three (3) parts of aircraft engine lubricating oil, grade 1065.

6—13. If the volume of overhaul work is great enough, it may be found advantageous to pool certain of the parts during the overhaul process. The following parts can be pooled and therefore need not be tagged to identify them with the engine from which they are removed: complete cylinder assemblies (exception: engines subject to sudden stoppage before one hundred (100) hours of total time or operating time since last overhaul are to have the cylinders, pistons and pistonpins kept together throughout overhaul and subjected to as little rework as possible), pistons and pistonpins, deflectors, pushrods, pushrod covers and gland nuts, intake pipes, all ignition parts (assemblies only), all exterior nuts and bolts, priming systems, all exterior oil lines, all accessories, (except oil pumps) exhaust pipes and clamps, and vent systems. The foregoing does not prescribe the pooling of parts within subassemblies, such as carburetors, magnetos, etc. All parts of the engine not listed above should not only be kept with the engine but also should be so handled as to insure return to the original position in the engine.

6—14. INSPECTION RECORDS.

6—15. During inspection, keep a record of the condition of all parts and a record of all fits, clearances, and spring pressures. Refer to Section XII for proper limits. At-

tach a tag, indicating that replacement is necessary, to any part which is found to be unfit for further service. Attach a tag describing the necessary reconditioning to any part which requires repair (Figure 6—1). If the reconditioning will affect a fit or clearance, the tag should remain attached to the part until final assembly to serve as a warning to check the fit or clearance.

6—16. When making out inspection records or reports, use only descriptive words which accurately qualify existing conditions. In order to eliminate confusion and to maintain consistent terminology, various physical conditions which might be encountered are defined in the following table:

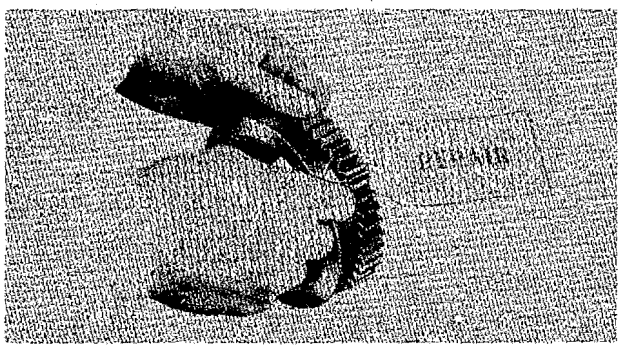
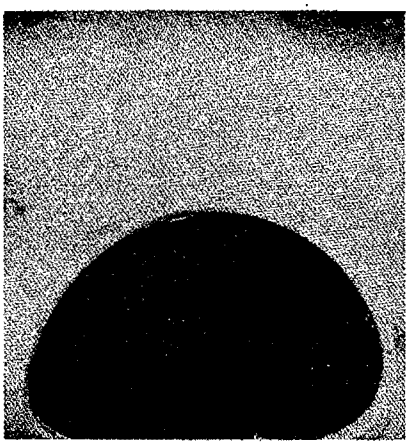
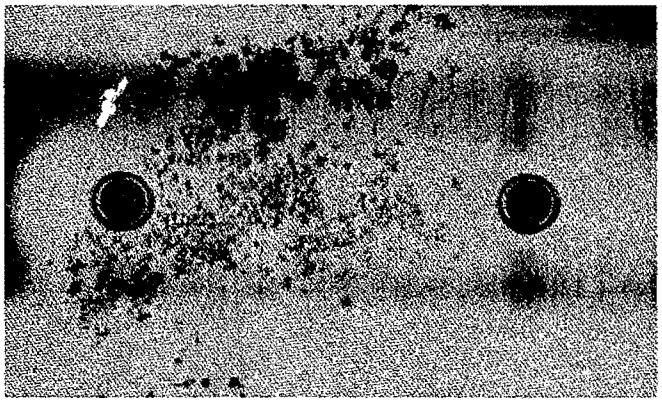
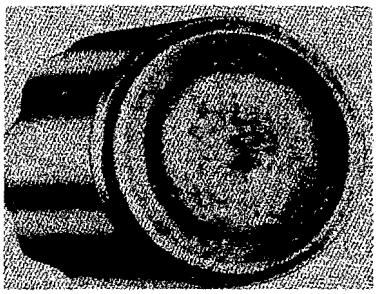
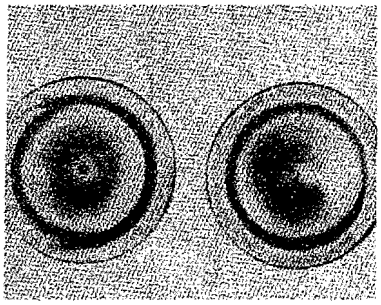
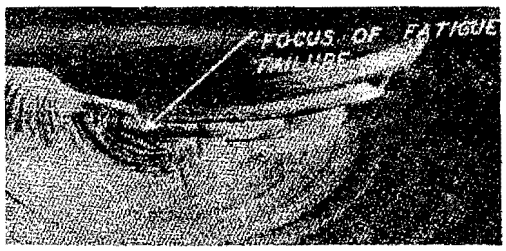


Figure 6—1

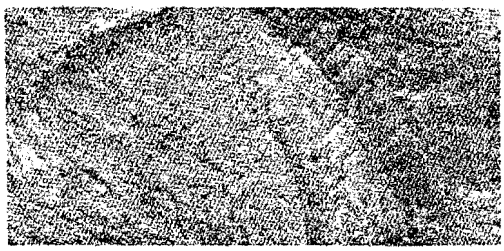
PHYSICAL CONDITIONS		
Term	**Discussion**	**Usual Causes**
Abrasion	A roughened area. Varying degrees of abrasion can be described as light or heavy, depending upon the extent of reconditioning which will be neccesary to restore the surface.	Presence of fine foreign material between moving surfaces.
Blistering	Raised areas indicating separation of the surface from the base. Usually found on plated or painted surfaces. Associated with **flaking** and **peeling.**	Imperfect bond with the base, usually aggravated by the presence of moisture, gas, heat, or pressure.
Blow-by	The passage of combustion products, under pressure, past pistonrings, valves, etc. Severe cases indicated by characteristic discoloration and frequently by **erosion** or **guttering.** **Note** 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 through 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 indications of such a condition.	Improper seating of pistonrings or valves.
Break	Complete separation by force into two or more pieces.	Fatigue; shock; overload.
Brinelling	Indentations sometimes found on the surfaces of ball or roller bearing parts. **Note** Bearings which do not have full, constant rotation and are subjected to shock loading, have brinelling tendencies. Crankshaft thrust bearings have been known to become brinelled when the engine was partially supported at the crankshaft during transit in a railroad car or truck.	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	Injury to the surfaces by excessive heat. Evidenced by characteristic discoloration or, in severe cases, by loss or flow of material.	Excessive heat due to lack of lubrication, improper clearance, blow-by, detonation, etc.

PHYSICAL CONDITIONS		
Term	**Discussion**	**Usual Causes**
Burnishing	Mechanical smoothing of a metal surface by rubbing, not accompanied by removal of material but sometimes by discoloration 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.	Normal operation of parts.
Burr	A sharp projection or rough edge.	Machining operations; excessive wear; peening.
Chafing	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 (Figure 6—2) 	Breaking out of small pieces of metal. Not to be confused with **flaking.**	Concentration of stress due to shock, nicks, scratches, inclusions, peening, etc.; careless handling of parts, etc.
Corrosion (Figure 6—3) 	Breakdown of the surface by chemical action.	Presence of corrosive agents.
Crack	A partial fracture.	Excessive stress due to shock, overloading, or faulty processing; extension of a nick or scratch; defective material.

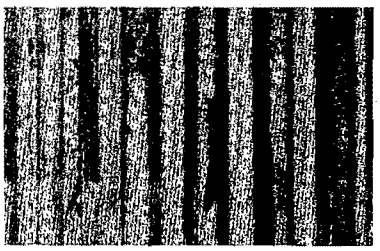
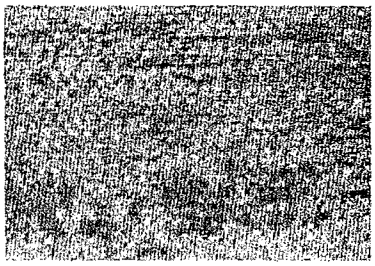
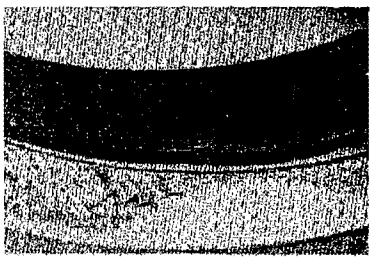
PHYSICAL CONDITIONS		
Term	**Discussion**	**Usual Causes**
Cupping (Figure 6—4) 	Hollowed out areas resulting from repeated contact of two operating parts.	Improper hardness; excessive sliding motion; impact.
Dent	Small, smoothly rounded hollow in the surface.	Concentrated overload resulting from peening or the pressure of chips between loaded surfaces; striking of part with dull object through careless handling.
Electrolytic Action	Breakdown of the surface by electrical action between parts composed of dissimilar metals.	Galvanic action between dissimilar metals.
Erosion (Figure 6—5) 	Carrying away of material by the flow of hot gases, grit or chemicals. (See also **guttering**).	Blow-by; flow of corroding liquids, hot gas, or grit laden oil.
Fatigue Failure (Figures 6—6 and 6—7)	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, as many mechanics believe.	Tool marks; sharp corners; nicks; cracks; inclusions; galling; corrosion; insufficient tightening of studs or bolts to obtain proper stretch.

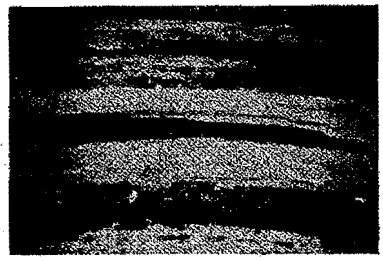
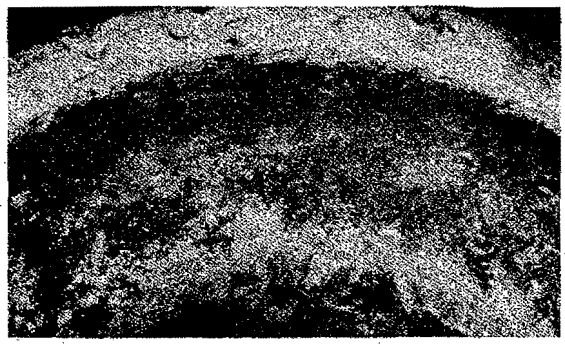


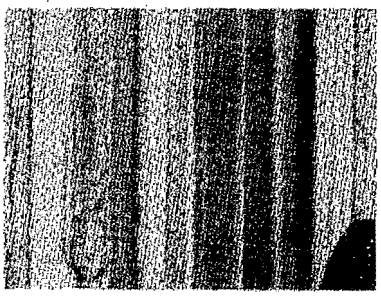
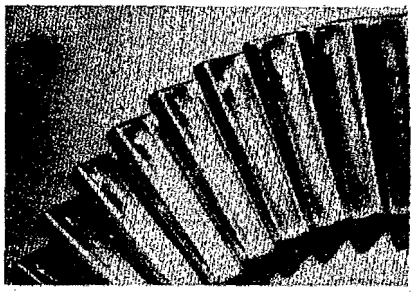
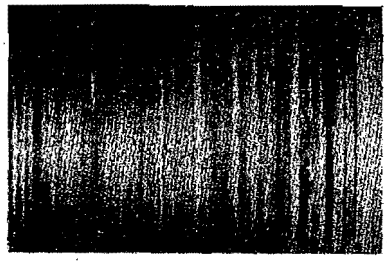
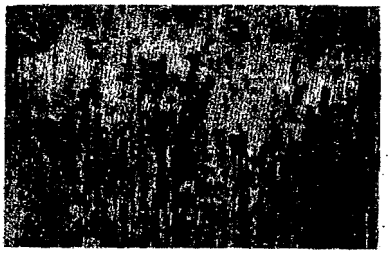
Aluminum

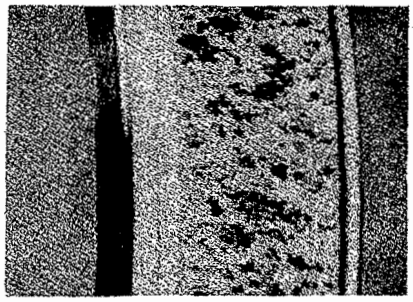


Steel

PHYSICAL CONDITIONS		
Term	**Discussion**	**Usual Causes**
Fatigue Failure (continued)	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 center, or "focus," of which discloses the original point or line of the failure.	
Feathering	A rough, featherlike edge, sometimes found on pistonrings or oil seals.	Excess pressure resulting from insufficient end gap, insufficient lubrication, or excessive temperature; failure to remove all abrasive after lapping.
Flaking (Figure 6—8)	 Breaking away of pieces of a plated or painted surface.	Incomplete bond; excessive load; blistering.
Fracture	See **Break.**	
Fretting	See **Chafing.**	
Fretting Corrosion (Figure 6—9)	Discoloration. May occur on surfaces which are pressed or bolted together under high pressure. On steel parts the color is reddish brown and is sometimes called "cocoa" or "blood." On aluminum or magnesium, the oxide is black. 	Rubbing off of fine particles of metal by slight movement between parts and oxidizing of these particles.
Galling (Figure 6—10)	 A transfer of metal from one surface to another. **Note** Do not confuse with **pick-up, scoring, gouging,** or **scuffing.**	Severe chafing or fretting action caused during engine operation by a slight relative movement of two surfaces under high contact pressure.
Glazing	Development of a hard, glossy surface on plain bearing surfaces or pistons. An often beneficial condition.	Combination of pressure, oil, and heat.
Gouging	Displacement of material from a surface; a cutting, tearing, or displacement effect.	Presence of a comparatively large foreign body between moving parts.

PHYSICAL CONDITIONS		
Term	**Discussion**	**Usual Causes**
Grooving	Smooth rounded furrows, such as score marks whose sharp edges have been polished off.	Concentrated wear as by an oil seal ring; abnormal relative motion of parts; parts out of alignment.
Guttering	Deep, concentrated erosion.	Enlargement of a crack or defect by burning of an exhaust flame, as on a valve head or seat.
Inclusion	Foreign material enclosed in the metal. Surface inclusions are indicated by dark spots or lines. **Note** 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.	Lack of proper control in preparation of metal.
Lead Sweating (Figure 6—11)	Patches of lead on the surface of a bearing or bushing, the alloy of which contains a relatively high percentage of free lead. 	Heat or pressure producing separation of free lead.
Nick	A sharp indention caused by striking of part against another metal object.	Carelessness in handling of parts or tools prior to, or during, assembly; sand or fine foreign particles in engine during operation.
Peening (Figure 6—12)	Deformation of the surface. 	Impact of foreign object, such as occurs in repeated blows of a hammer on part.

PHYSICAL CONDITIONS		
Term	**Discussion**	**Usual Causes**
Pick-up (Figure 6—13) 	Rolling up of metal, or transfer of metal from one surface to another.	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	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 (Figure 6—14) 	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.	Corrosive pitting—breakdown of the surface by oxidation or some other chemical or electrolytic action. Mechanical pitting—chipping of loaded surfaces because of overloading, improper clearances, or the presence of foreign particles.
Scoring (Figure 6—15) 	Deep scratches made during engine operation by sharp edges or foreign particles; elongated gouges.	Presence of chips between loaded surfaces having relative motion.
Scratches	Narrow, shallow marks caused by the movement of a sharp object or particle across a surface.	Carelessness in handling of parts or tools prior to, or during, assembly; sand or fine foreign particles in engine during operation.
Scuffing (Figure 6—16) 	Surface injury resulting from the incipient seizure of reciprocating parts. Evidenced by **pick-up** and **pile-up**.	Insufficient clearance or lubrication.

PHYSICAL CONDITIONS		
Term	**Discussion**	**Usual Causes**
Spalling (Figure 6–17)	 Sharply roughened area characteristic of the progressive chipping or peeling of surface material. Not to be confused with **flaking.**	Surface crack, inclusion, or similar surface injury causing a progressive breaking away of the surface under load.
Stresses	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: **Compression**—action of two directly opposed forces which tend to squeeze a part together. **Tension**—action of two directly opposed forces which tend to pull apart. **Shear**—action between two opposed parallel forces. **Torsion**—action of two opposed forces around a common axis. **Shock**—instantaneous application of stress.	

6–17. GAGES. 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 connections tightened securely.

6–18. When taking a measurement with a feeler gage, the final size of the feeler must be a reasonably snug fit. Both the plug type and the flat type gages 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 gage enters, the part is worn beyond the allowable limit. Because certain parts do not always wear evenly, the flat type gage must be tried at several different diameters. If the gage enters at any point, the part is worn beyond the allowable limit.

6–19. PRESERVATIVE VARNISH.

6–20. 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 used, need not be replaced at overhaul.

6–21. Parts which require magnetic inspection should be stripped of this coating 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.

6–22. To strip an engine part of resin coating, refer to paragraphs 7–33 through 7–36.

6–23. PHOSPHATE COMPOUND COATING. Other steel parts 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 color and somewhat granular in texture.

6–24. 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 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.

6–25. SHOT PEENING. Various steel and aluminum parts are shot-peened to put their surfaces under compression to make them more resistant 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 surfaces are not serious. If an area on a shot-peened surface is smoothed or 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 matte rather than a polished surface. Where only certain portions of a part are

shot-peened (as in the case of crankshafts), nicks, and scratches on the portions which are not shot-peened may be cleaned up in the ordinary way.

6–26. ALUMINUM AND MAGNESIUM PARTS. Inspect 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 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 in paragraphs 7–23 through 7–27.

6–27. BALL AND ROLLER BEARING VISUAL INSPECTION.

6–28. Make certain that the parts of one bearing are not mixed with those of another. Visually inspect each bearing or component part and reject for the following causes:

6–29. BALLS AND ROLLERS.

1. Pits.
   a. Larger than .006 inch diameter.
   b. Cluster or chain.
2. Dents, nicks, or indentations.
   a. .010 long and .002 wide maximum for diameters ½ inch or less.
   b. .012 long and .002 wide maximum for diameters ½ inch or more.
3. 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.
4. Scuffs.
   a. Any that can be felt with a .020 inch radius scriber.
5. Discoloration.
   a. Discoloration due to heat.

6–30. RACES.

1. Pits.
   a. Larger than .010 inch diameter and readily felt with a .020 inch radius scriber.
   b. Cluster or chain.
2. Dents, nicks, and indentations.
   a. More than .010 inch across and readily felt with a .020 inch radius scriber.
3. 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.
4. Cracks.
   a. Any cracked race unacceptable.
5. Discoloration.
   a. Discoloration due to heat.

6–31. ASSEMBLIES.

1. Damaged or excessively loose retainers.
2. Stains that are not readily removed with light polishing.
3. Spalled load carrying surfaces.
4. Loose or missing rivets.
5. Badly dented or otherwise damaged race shields.
6. Excessive corrosion or rust in raceways or in rolling elements.

Note

Clean minor pitting or corrosion from the raceways by dry buffing, using Sea Compound No. 305A or No. 5 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.

6–32. GENERAL.

6–33. 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 condition established above.

6–34. Quite frequently a bearing will show evidence of wear on the bore, outside circumference, 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 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.

6–34A. BALL BEARING FEEL TEST.

6–34B. 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.

6–34C. 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

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load. Any rough-running bearings should be thoroughly cleaned and flushed as described in the Cleaning Chapter. If, after the recleaning, the bearing continues to run rough, reject the bearing.

6–35. BOLTS. Inspect for cracks, especially under the bolt head and at the base of the threads. Check the condition of the threads.

6–36. BUSHINGS AND PLAIN JOURNAL BEARINGS. Examine for cracks, scoring, looseness, and indications of overheating and lead sweating. Check for concentricity and excessive wear, using the proper Maximum Wear Gage. (See paragraph 3–5.)

6–37. COUPLINGS. Examine for burrs and check the fit with mating parts. Inspect splined areas for pitting, pick-up, galling, and roughness.

6–38. DOWELS. Inspect for chipped edges and looseness. Check projection length.

6–39. GEARS. 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.

6–40. LEADED BEARINGS.

6–41. 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 bearings 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.

6–42. The lead coating is attacked occasionally by acid in the lubricating oil. The attack may be indicated by pits, areas of corrosion, or lead washing. Small isolated pits or small areas of incipient corrosion are not considered detrimental. In most cases it will be safe to continue the bearing in service if no part of the lead coating has disappeared to the extent that the silver or bronze underneath can come in contact with the mating surface. Usually, a polished lead surface and an exposed and polished silver surface are readily distinguishable; however, if there is any doubt run a fingernail lightly over the surface. A lead surface will scratch readily, but a silver surface will be hard and glossy. Do not scratch the surface of a bearing unnecessarily. Serious pitting, corrosion, or lead washing necessitates replacement of the bearing.

6–43. Hen tracking, which is a form of incipient corrosion, is a closely knit group of interconnected furrows. Where this condition is found and is confined to small well defined areas, the bearing may be continued in service. Where the hen tracking is extensive or shows signs of spreading all over the surface, the bearing should be replaced.

6–44. Foreign matter accumulating in the oil system may result in particles becoming embedded in the lead surface of a bearing. Where a few isolated particles have become embedded in the lead surface and the lead has formed a protective coating over and around the particles in such a manner that they cannot damage the mating surface, the bearing may be continued in service. If there is any doubt as to the serviceability of a leaded bearing, it should be replaced or returned to stock and held for return to the manufacturer for reprocessing.

6–45. LINERS. Examine for pitting and galling. If the liner accommodates a bearing, check the fit of the bearing in the liner. If the liner accommodates oil seal rings, check the liner for excessive grooving. If the I.D. of the liner has been worn .003 inch or if a groove of .0015 inch or more has been worn at any one point, the liner should be replaced or reground to accommodate oversize rings.

6–46. NUTS. 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.

6–47. OIL SEAL RINGS. Replace all bronze oil seal rings with 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 or liners for wear, roughness, and indications of overheating.

6–48. OIL SEAL RING CARRIERS. Check the condition of the ring grooves, and examine splined areas for galling and burrs. Check the fit of each carrier with its mating parts.

6–49. RIVETS. Check for secure anchorage.

6–50. SCREW BUSHINGS. Check for looseness. Inspect the threads for nicks, cracks, and burrs.

6–51. SHAFTS. Check shafts for straightness by rolling them on a plane surface, or by rotating them on V-Blocks or lathe centers and checking the runout with a dial indicator. 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. Make sure any oil passage is clean.

6–52. SPACERS. Inspect for nicks and cracks. Check mating surfaces for smoothness. Examine any splines for galling and burrs.

6–53. SPRINGS. Inspect for pitting, cracks, and burrs. Check the spring pressure (Figure 6–18).

6–54. STUDS. Check for looseness, cocking, possible fracture at the base of the threads, and projection length. Inspect the threads for nicks, cracks, and burrs.

6–55. TUBES. 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 oil pressure.

6–56. FRONT SECTION.

6–57. OIL SLINGER. Inspect for galling and distortion.

6–58. THRUST BEARING NUT. Inspect the front and rear faces for galling. Examine the wrench slots for cracks, burrs, and other damage. Check the condition of the threads.

6–59. VALVE TAPPETS. 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. Replace the socket if an area more than 1/32 inch wide has been worn on the surface of the socket or if the surface is rough or uneven.

6–60. VALVE TAPPET GUIDES. Examine for cracks, especially at the slotted ends. Inspect for scoring. Check the tightness of each guide in the front case by tapping the end of the guide with a leather mallet. Check for excessive wear with PWA-1451-109 Gage. Check the alignment of each guide.

6–61. VALVE TAPPET ROLLERS. Check the fit between the rollers and pins. The rollers 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 necessitate replacement. Inspect the roller pins for scoring, pitting, cracks and signs of overheating.

6–62. GOVERNOR ENGINE VALVE FLANGE. Check the condition of the pressure type governor engine valve flange and plug.

6–63. THRUST BEARING OIL FEED TUBES. Check the condition and the fits of the oil feed tubes. Replace a tube if it is mutilated, cracked, or is a loose fit.

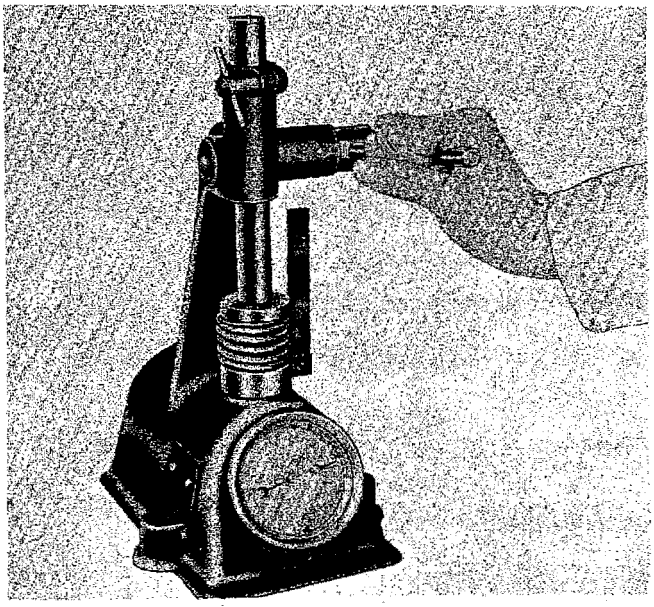

Figure 6–18

6–64. CRANKCASE SECTION.

6–65. CAM. Inspect the gear teeth for wear, pitting and signs of improper contact. Examine the I.D. for smoothness. Inspect the cam lobes for pitting and uneven wear.

6–66. CAM OIL FEED BRACKET. Check the fit of the bracket on the cam hub. Examine the steel bushings for smoothness.

6–67. CYLINDER FLANGE STUDS. If one or two cylinder flange studs on any one pad have failed, replace the failed studs and replace the studs on each side of the failures. If more than two studs have failed, or are found to be loose, replace the cylinder and all of the flange studs for that cylinder.

6–68. ENGINE LIFTING LINKS. Inspect for cracks and general condition.

6–69. CRANKSHAFT ASSEMBLY.

6–70. CRANKSHAFT.

6–71. To check the crankshaft for runout, assemble the shaft, except for the flyweights, as described in Section VIII. 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 center line of the crankshaft will be parallel to the plane table. This is accomplished by placing shim stock under the front block.

6–72. Check the runout at the front and rear cone seats, using a dial indicator (Figure 6–19). A maximum runout of .008 inch at the front cone seat and of .004 inch at the rear cone seat is permissible.

6–73. While the crankshaft is still 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 6–20). 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 masterod 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 crankshaft to stock and hold for return to the manufacturer for repair. Slight scoring or roughness may be cleaned up with crocus cloth and oil.

6–74. 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 is .2532 inch. It is permissible to use the shaft if three or less splines, which are not adjacent, are below the minimum measurement, but if four or more splines are below the minimum measure-

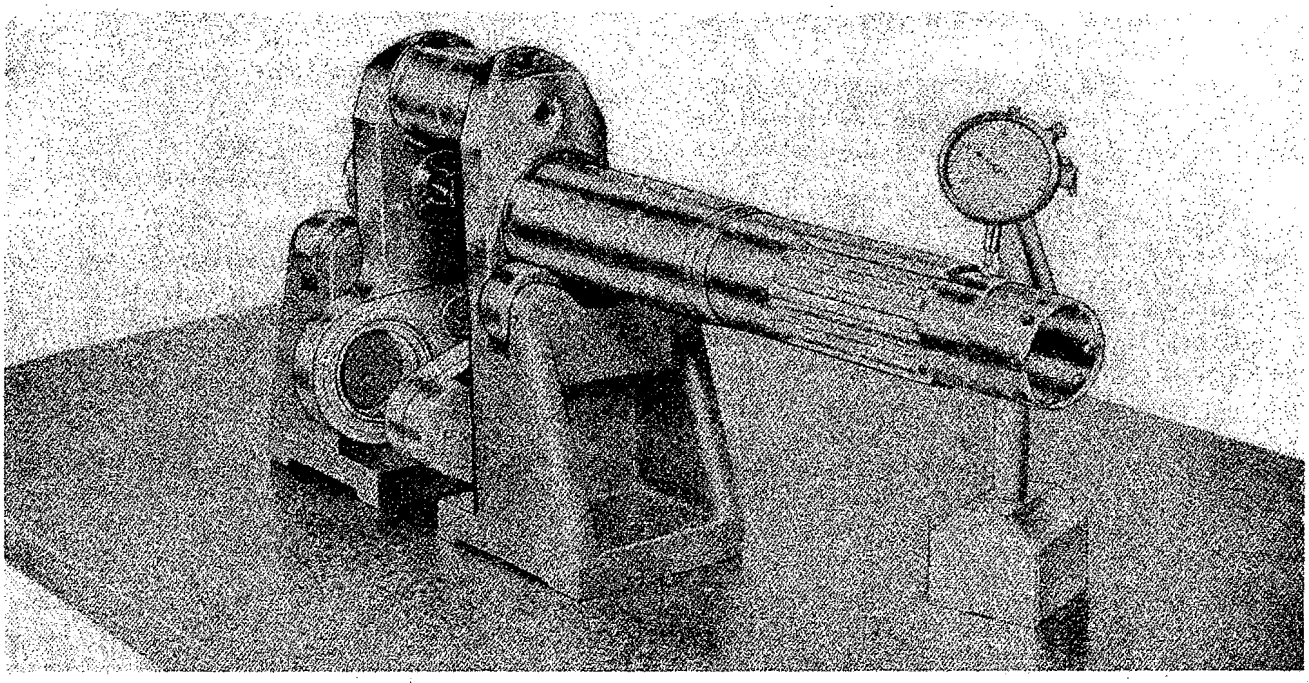

Figure 6–19

ment, return the shaft to stock 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 6–21).

6–75. Disassemble the crankshaft as described in Section IV.

6–76. Check the conditions of all threaded areas. Threaded portion for propeller thrust bearing nut will be inspected to insure that threads are smooth, also that no cracks or corrosion are present. See that the oil jets are unobstructed, and make sure that all oil passages have been thoroughly cleaned. Inspect the flyweight liners for scoring, pitting, and galling. Refer to paragraph 7–82 for instructions on cleaning up galled liners.

6–77. Check the front and rear main bearing journals for galling and wear. If either journal is excessively galled or worn, return the shaft to stock and hold for return to the manufacturer for repair. Slight scoring or roughness may be cleaned up with crocus cloth and oil.

6–78. Clean and polish any galled surface before the crankshaft is magnetically inspected.

6–79. CRANKSHAFT BOLT. Inspect the tin plating on the crankshaft bolt.

6–80. FLYWEIGHTS. 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.

6–81. FRONT AND REAR MAIN BEARINGS. 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. View-

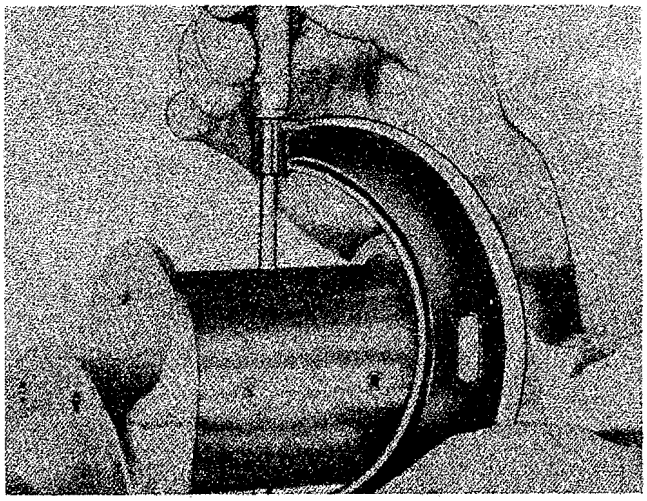

Figure 6–20

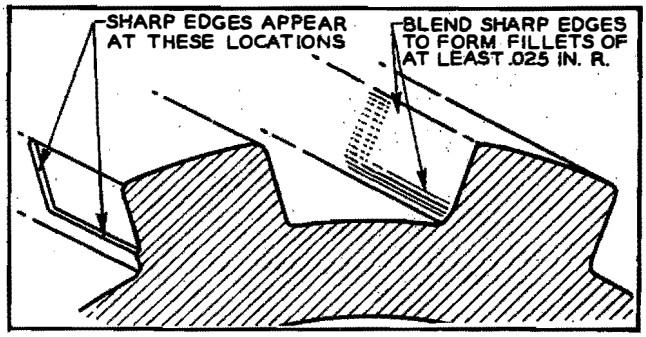

Figure 6–21

ing the shaft from the rear with the crankpin uppermost, this section is located at about the "five o'clock" position. At reassembly, turn the bearing inner race about 120 degrees from the original position on the shaft, which will allow another turning at the succeeding overhaul.

6–82. 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, replace 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.

6–83. Use the following table when ordering replacement inner races. The manufacturer of the bearing can be determined from his mark on the bearing.

Part No.	Part	Mfg. Mark
71139	Bearing	SKF or MRC
12117	Inner Race	SKF
47481	Inner Race	MRC
32835	Bearing	SKF, MRC or Bower
37019	Inner Race	MRC
45058	Inner Race	SKF
106521	Inner Race	Bower

6–84. IMPELLER SPRING DRIVE COUPLING. 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. Replace a spring if it is worn more than 1/32 inch on the ends. Inspect the buttons for galling on the ends and stone smooth any galled areas.

6–85. MASTEROD ASSEMBLY.

6–86. LINKPINS.

6–87. Clean up any galled areas, using crocus cloth and oil; then inspect the linkpins for cracks. Check the condition of the plating on all silver plated linkpins. If the silver plating is worn to the extent that the surface underneath is exposed at any point, return the linkpin to stock for return to the manufacturer for replating. When linkpins are returned, specify the letter size to which they are to be ground. Air Force Personnel can accomplish this work at the Depot after referring to T.O. No. 02A-10-36. Renew at every overhaul the copper flash plating on non-intersected linkpins, first stripping any old copper flash plating from the linkpins. (Refer to paragraph 7–38.) The new plating should be .0001 inch thick.

6–88. Polish the linkpin holes in the masterod with a fine stone or fine abrasive such as crocus cloth, or equivalent, 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 gage. 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.

6–89. Linkpins are available in the following sizes, the pin diameters increasing in increments of approximately .0003 inch.

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

6–90. Masterod linkpin holes are classified in the same way.

6–91. Be sure that each linkpin is marked with the proper positioning number so that it will be mated with the proper holes at assembly.

6–92. 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. Replace a linkpin if it is more than .0015 inch out of round.

6–93. 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 bushing in the linkrod.

6–94. LINKROD.

6–95. 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 paragraph 7–96. Check the fit of each pistonpin bushing with the corresponding pistonpin.

6–96. Check the alignment of the linkrods with the bushing in place, using PWA-1781-61A Fixture. Secure the arbor, detail 33 of the fixture, in the bracket of the fixture so that it is approximately five inches above the

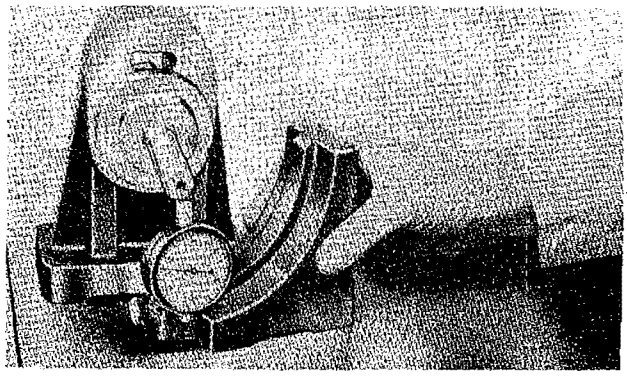

Figure 6–22

surface plate. Indicate the arbor to make sure that it is parallel with the surface plate (Figure 6–22). Insert the expanding sleeve, detail 17, in the pistonpin bushing and expand it with the tapered sleeve, detail 34. Place the

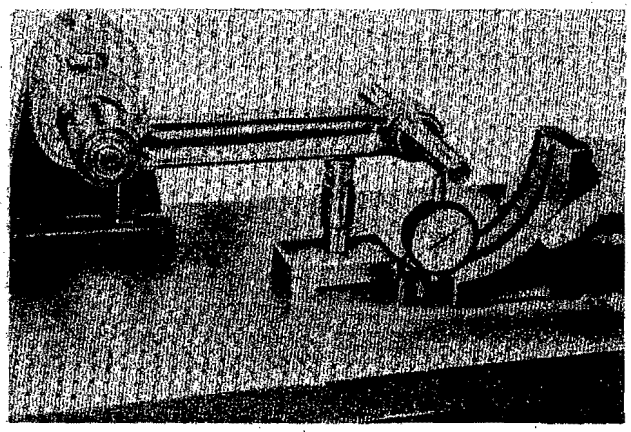

Figure 6–23

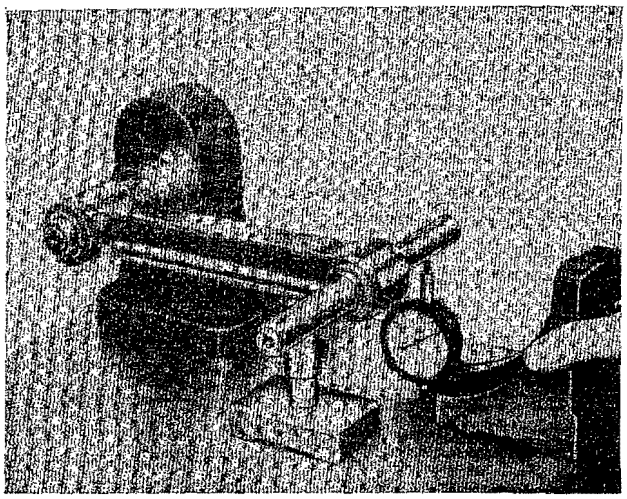

Figure 6–24

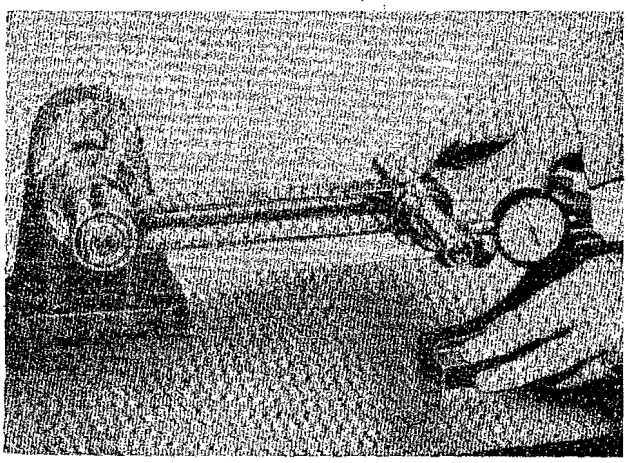

Figure 6–25

expanding sleeve, detail 17, in the pistonpin 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 center of the linkpin bushing. (Figure 6–23). 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 center of the bushing (Figure 6–24). 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 center 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.

6–97. 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 6–25). 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 center of the linkpin bushing. The maximum allowable misalignment of the bushings, as well as the maximum allowable bend in the rod is .010 inch a total distance of six inches (three inches on each side) from the center of the linkpin bushing.

6–98. 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 paragraphs 7–99 and 7–104, and check the alignment of the rod without the bushings in place. The procedure is the same as when 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, replace 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 paragraphs 7–99 and 7–104.

6–99. 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 6–26). Any noticeable buckling or distortion is cause for rejection of the rod.

6–100. MASTEROD.

6–101. Inspect the masterod for nicks, cracks and burrs. Check the masterod for rust pitting. If rust pitting is present, the rods may be reconditioned as described in paragraph 7–96.

6–102. Check the alignment of the masterod with the pistonpin bushing in place, using PWA-1781-61A Fixture. Secure the masterod arbor, detail 45 of the fixture, in the bracket of the fixture; then indicate the bearing surface of the fixture; then indicate the bearing surfaces of the arbor to make sure that they are parallel with the surface plate. Insert the expanding sleeve, detail 17, in the pistonpin bushing and expand it with the tapered arbor, detail 41. 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. Using the block and indicator, indicate the underside of the tapered arbor, detail 41, at a distance of three inches from the center of the pistonpin bushing (Figure 6–27). Note the maximum indicator reading; then indicate the underside of the opposite end of the arbor at a distance of three inches from the center 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 center of the pistonpin 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 (see insert, figure 6–27). 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. 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 center of the pistonpin bushing. 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 center of the pistonpin bushing.

6–103. 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 paragraph 7–99, 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 tapered arbor, detail 41. If the misalignment or bend is still excessive, replace 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 in the rod and bore to size according to the instructions in paragraph 7–99.

6–104. 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.

6–105. MASTEROD BEARING. Refer to paragraph 7–20.

6–106. CYLINDERS.

6–107. CYLINDER BARRELS.

6–108. Using PWA-2630-20 Gage and pencil carbon paper, check the cylinder hold down flange for flatness and squareness. If the flange is uneven or distorted and providing the distortion does not exceed .005 inch, lap the flange as described in paragraph 7–107, under Cylinder Flange Repair. If the distortion exceeds .005 inch, replace the cylinder. 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 paragraph 7–107 under Cylinder Flange Repair for instructions on re-spotfacing these areas.

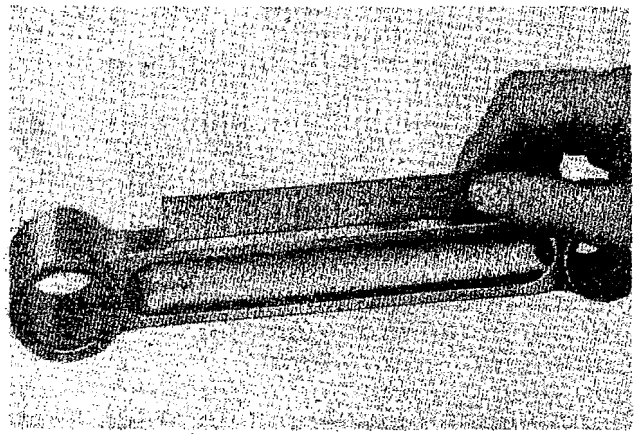

Figure 6–26

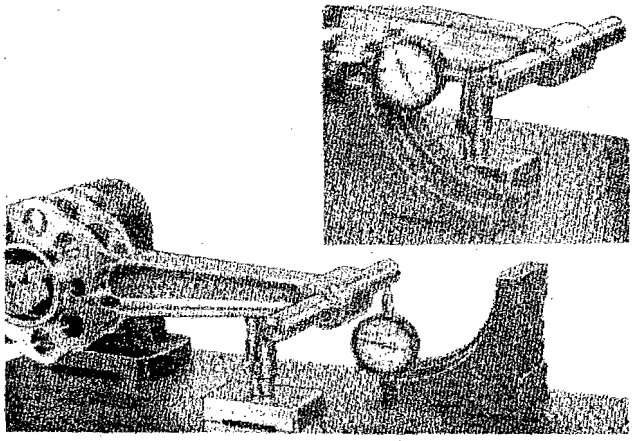

Figure 6–27

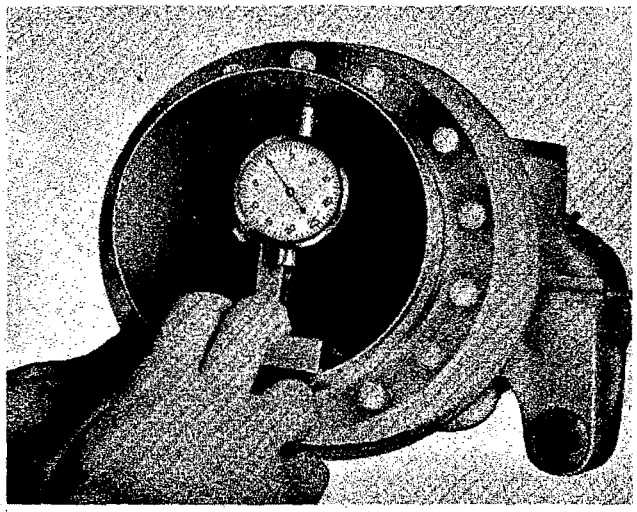

Figure 6–28

6–109. If a cylinder barrel flange has been subjected to flexing due to a failure of more than two of its hold down studs or looseness of more than two hold down studs, subject the cylinder flange to a flatness check and lap the flange, if necessary. It is also recommended that on cylinder pads where more than two studs have failed or were loose during engine operation, that all studs on that pad be replaced.

6–110. 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, remove it as described in paragraph 7–109.

6–111. 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, as measured at the bottom of the barrel, 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 before 3000 hours of service, and providing the cylinder head is still in good condition, return the cylinder to the manufacturer for rebarreling.

6–112. Use 3472-T-3 Gage and PWA-312-11 Indicator to measure the wear and out-of-roundness of the barrel (Figure 6–28). Set the needle of the indicator at the zero mark in the Gage, which represents the basic diameter of the cylinder barrel. The presence or extent 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 (pre-ground) 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.

6–113. 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 paragraph 7–161.

6–114. CYLINDER HEADS.

6–115. 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 is completely broken off or if the total area of fin breakage on one head exceeds 20 square inches, replace the cylinder. 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. Carefully blend any roughness or sharp corners into the adjacent surface to eliminate a possible source of new cracks.

6–116. Examine the areas adjacent to the sparkplug bushings for cracks. Inspect the outside surfaces of the cylinder heads. If a cylinder is to be resurfaced, refer to paragraph 7–161.

6–117. 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 housing for cracks, and 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.

6–118. DEFLECTORS. Inspect for cracks and dents. Check the condition of the paint. See that the blast tubes are tight.

6–119. EXHAUST VALVES.

6–120. Inspect for burning and pitting. Check the valve-lock grooves for galling, scoring and burrs. Use PWA-737 Gage to check each exhaust valve for stretch (Figure 6–29). A clearance of 1/32 inch or more between the gage and the radius of the valve head is cause for replacement of the valve.

6–121. If an exhaust valve is creased or shows signs of swelling or drawing where the head joins the stem, replace the valve regardless of what the radius gage 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 6–30). Replace a valve if the stem is tapered or out-of-round .006 inch or more.

6–122. 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

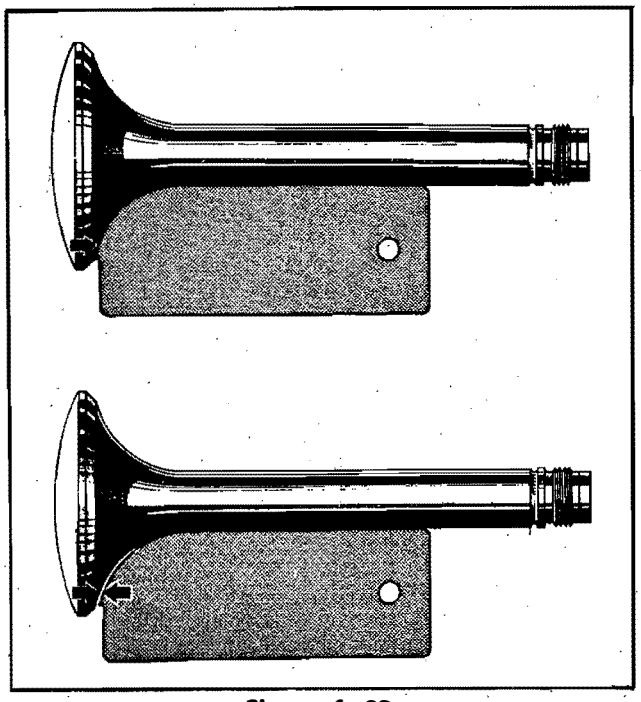

Figure 6—29

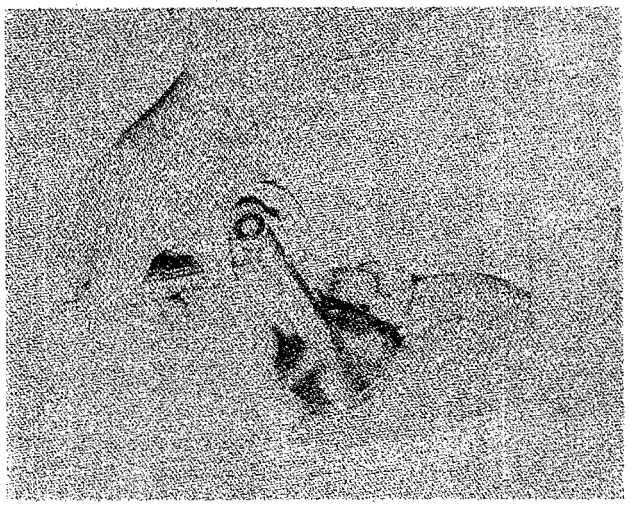

Figure 6—30

seating surface. This reoperation is discussed in paragraph 7—142.

6—123. INLET VALVES. 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.

6—124. INTAKE PIPES. Inspect for dents and cracks. If a pipe is questionable, subject it to a pressure test. Check the condition of the paint.

6—125. INTAKE PIPE COUPLINGS. Inspect for cracks, and check the condition of the threads and anodized surfaces.

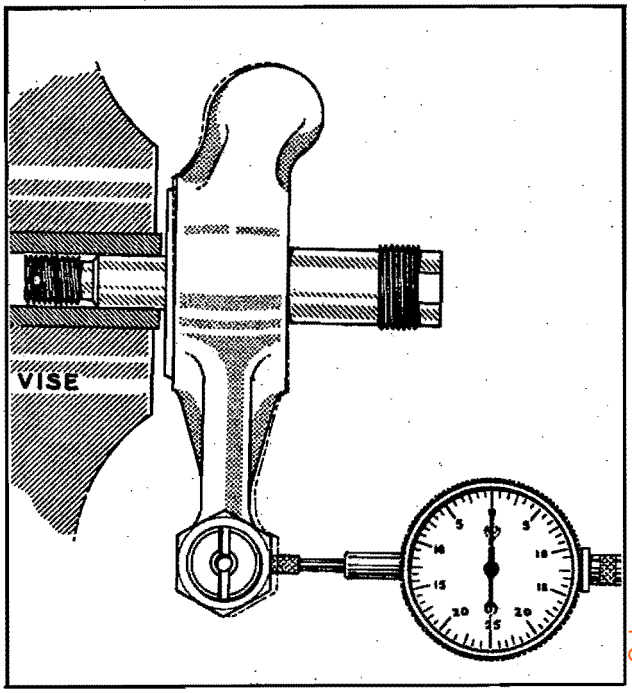

Figure 6—31

6—126. PRIMER LINES AND PRIMER DISTRIBUTOR. Inspect for dents, cracks, obstructions and breaks. Check the condition of the threads on the elbows, unions, and couplings.

6—127. PUSHRODS. Inspect for cracks. Check the rods for straightness by rolling them on a plane surface. Check the fit of the ballends on the rod. Replace ballends which are loose or worn.

6—128. PUSHROD COVERS. Inspect for cracks or dents. Check the condition of the paint.

6—129. PUSHROD COVER NUTS. Inspect for cracks and check the condition of the threads.

6—130. ROCKERS, BEARINGS AND ADJUSTING SCREWS.

6—131. 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 impair its fit in the rocker, a replacement is necessary.

6—132. To check the side play of the rocker, assemble the shaft, bearing, and rocker and secure one end of the shaft in a vise between lead plates or wooden blocks (Figure 6—31). Indicating where shown in the illustration, measure the play of the arm on the shaft (see dotted lines). The side play of rockers having Timken roller bearings should be .025 inch, while the side play of rockers having ball bearings should be .015 inch. Replace the bearing if the limit is exceeded.

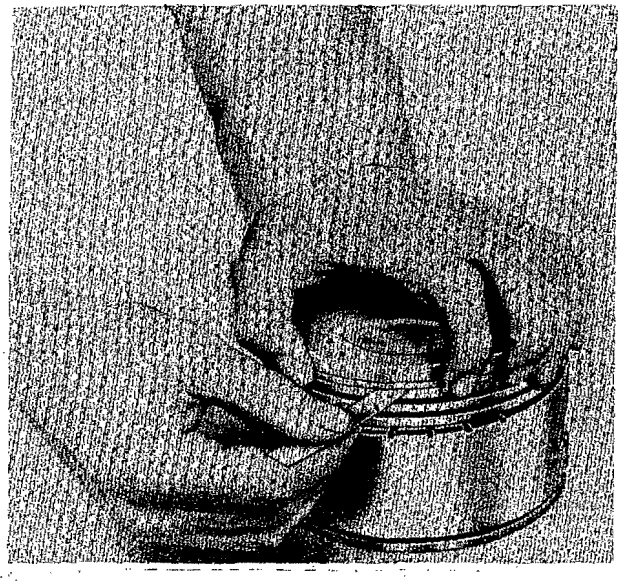

Figure 6—32

6—133. 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 or 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.

6—134. 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 practical for prolonging its life. When installing part of a set of new bearings, always assemble the new ones in the exhaust rocker.

6—135. Examine the ball socket in each rocker for looseness and wear. Replace 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. Replace any damaged locknuts.

6—136. ROCKERBOX COVERS. Inspect for cracks and check the condition of the paint. Check the condition of the parting surface.

6—137. SPARKPLUG BUSHINGS. Inspect for burning and check the condition of the threads.

6—138. VALVE GUIDES. Check for excessive wear, using PWA-311 Gage for the inlet valve guides and PWA-4327 Gage for the exhaust valve guides. Since valve guides wear unevenly and become out of round, check them for excessive wear at both ends. If the gage enters either end of the guide more than 1/2 inch, replace the guide.

6—139. VALVELOCKS. 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.

6—140. VALVE SEATS. Examine for signs of warping, pitting, burning and looseness. Replace 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. Replace 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.

6—141. VALVE SPRING WASHERS. Inspect for cracks, pitting and galling.

6—142. PISTONS, PISTONPINS AND PISTONRINGS.

6—143. PISTONS.

6—144. 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.

6—145. 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 6—32). If the side clearance is excessive, it will be necessary to use oversize pistonrings.

6—146. 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 center of the piston and note the readings. A depression of .006 inch or more within 3/8 inch of the O.D. is cause for rejection of the piston.

6—147. PISTONPINS. Inspect for scoring, cracks and rust pitting. Polish the I.D. of each pin and carefully inspect for cracks. Check the fit of each pin in its bushing in the corresponding linkrod and in its bosses in the corresponding piston.

6—148. PISTONPIN PLUGS. Check for damage and fit in the pistonpins.

6—149. PISTONRINGS.

6—150. Replace 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.

6—151. 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.

6—152. To determine whether the plating is still present on the O.D. 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, ½ per cent sulphuric acid, and 97½ 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.

6—153. SUPERCHARGER SECTION.

6—154. FLOATING GEAR BEARING AND INNER RACE. Examine the floating gear inner race for roughness or pitting. Check the needles for pit marks or excessive wear, particularly at their extremities.

6—155. FRONT SUPERCHARGER BEARING COVER. Check the front supercharger cover for condition of the bearing race bores and for tightness in the case.

6—156. IMPELLER AND IMPELLER SHAFT. 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.

6—157. Use local etching to assist in detecting defects. Apply an etching solution consisting of 1 ounce of commercial technical grade caustic soda in ½ 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.

6—158. Remove all traces of the caustic solution, using a solution of 1 part of concentrated technical grade nitric acid to 5 parts of water; then thoroughly wash the impeller in clean water. Dry the impeller; then dip it in kerosene conforming to Federal Specification No. VV-K-211.

CAUTION

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.

6—159. 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.

6—160. 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.

6—161. REAR SECTION.

6—162. FUEL PUMP DRIVE ADAPTER. 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.

6—163. GUN SYNCHRONIZER. (AN-6 Engines only.) Examine the cam follower, cam, and gear teeth for evidence of wear. Check the ball bearing retainer for a free fit in the housing and the dowel pin for proper depth. Inspect the lock plunger and be sure it is of such a width that it will fit in the notch of the cam follower to the desired clearance. This plunger must not be rounded at the end. Be sure that the cam follower slides freely in its respective holes in the housing.

6—164. OIL PRESSURE RELIEF VALVE. 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.

6—165. OIL PUMP. 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. Replace the packing in the center section of the pump body.

6—166. OIL SCREEN AND CHECK VALVE ASSEMBLY. 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.

6—167. OIL SUMP. Check the sump for chafing. If it is chafed more than 1/16 in., the sump should be rejected. If it is chafed less than 1/16 in., blend the chafed areas and treat with zinc chromate primer and paint.

6—168. REAR CASE. Inspect the vanes in the intake duct for nicks and cracks, with particular attention to the welded joints. Inspect the carburetor mounting pad for smoothness. Check the tightness of magneto locating dowels.

6—169. STARTER JAW. Check for cracks and burrs, and inspect the splines for galling and pickup.

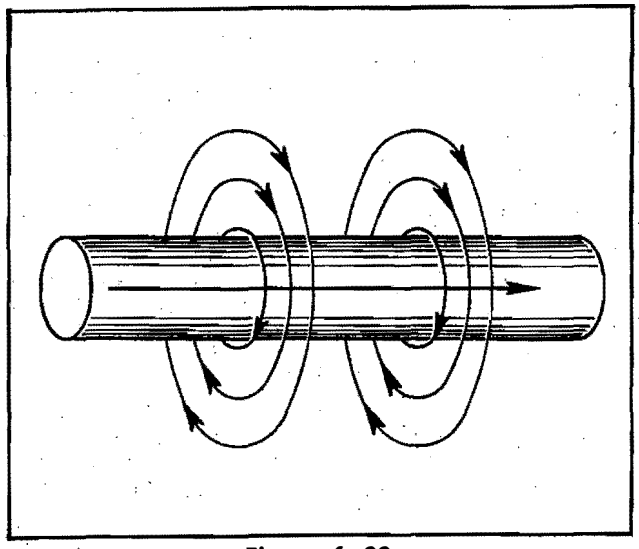

Figure 6–33

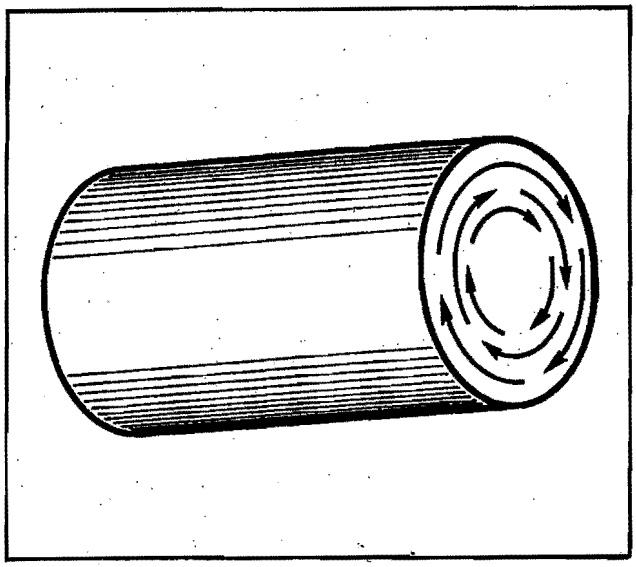

Figure 6–34

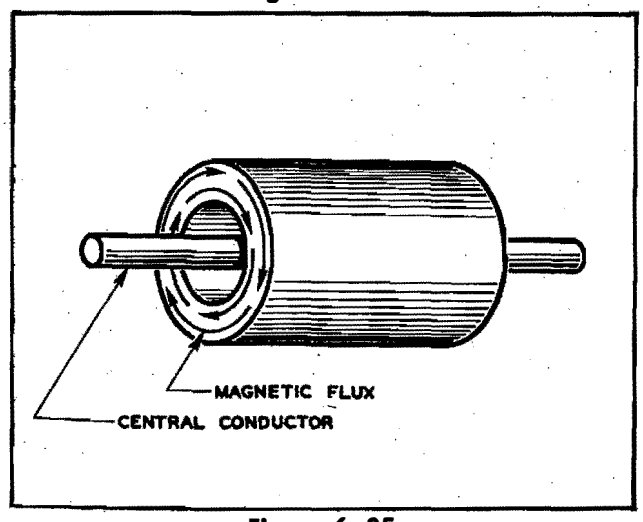

Figure 6–35

6–170. MAGNETIC PARTICLE INSPECTION.

6–171. DESCRIPTION.

6–172. 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.

6–173. 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 extent of the discontinuities indicated and the final decision as to the suitability of the parts for further service, as indicated above. Inspectors in this field, 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.

6–174. 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 or type of discontinuity to be found. 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 6–33). 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, although direct current has been generally accepted as a standard in the aircraft industry. These are, further, two classes of magnetic particle inspection methods; the residual and the continuous method. The residual method makes use of the mag-

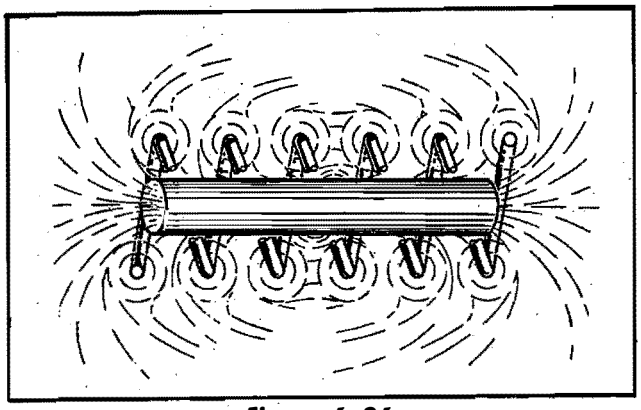

Figure 6—36

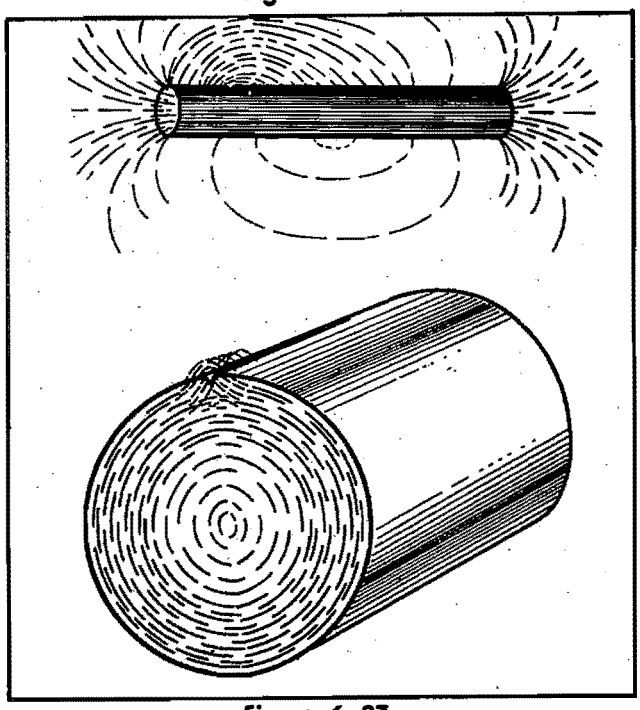

Figure 6—37

netism 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.

6—175. 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 6—34).

6—176. 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 6—35).

6—177. 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 centerline of the solenoid (Figure 6—36).

6—178. 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.

6—179. 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 6—37). 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 gradually decrease in strength as the angle approaches zero.

6—180. 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 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.

6—181. PROCEDURE.

6—182. The parts to be inspected by the magnetic method are listed in the table in paragraph 6—191. 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. **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 fiber or wooden plugs.

6—183. The horizontal Direct Current type of magnetic machine equipped with 4 inch and 8 inch solenoids and

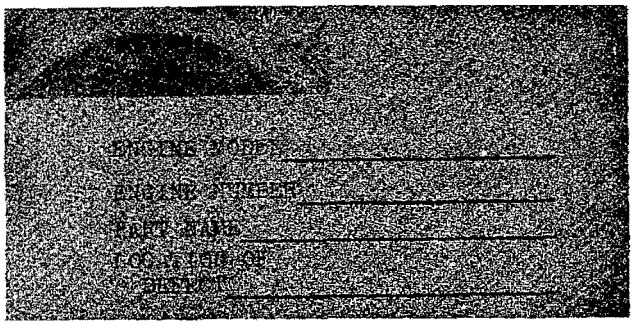

Figure 6–38

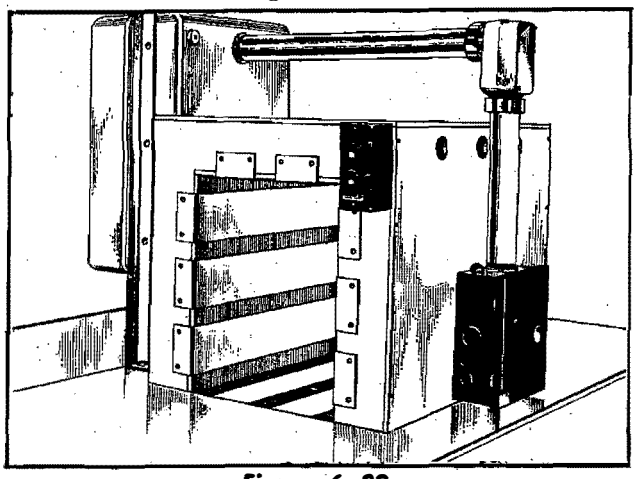

Figure 6–39

the wet residual method of testing are recommended for overhaul bases. Magnetize the parts in accordance with the instructions in the table in paragraph 6–191.

6–184. 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.

CAUTION

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 process. Indications on varnished parts are not so strong as those on bare steel and are easily distorted or removed if not handled carefully.

6–185. 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.

6–186. 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."

6–187. Remove the parts from the testing bath and subject each one to a thorough visual inspection. (For fluorescent penetrant inspection use the light described in paragraph 6–197.) 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 area 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 also listed.

6–188. 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 some 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. This may be done by applying a piece of transparent scotch tape to the indication; then applying it to a card, with applicable data. The pattern is thus transferred from the specimen to the card (Figure 6–38).

6–189. After final 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 6–39). The part should be removed from the demagnetization 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.

6–190. Unplug all previously plugged oil passages and thoroughly wash and oil each part.

6–191. TABLE OF MAGNETIC INSPECTION DATA. This table should be used in conjunction with the instructions in paragraph 6–170 through 6–190. 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 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 method 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, 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	Magnetic circularly, rotating eccentrically on a copper rod							
C	Magnetize longitudinally in a solenoid							
D	Magnetize circularly, contacting on ends Magnetize circularly, contacting on O.D.							
E	Magnetize circularly, contacting on ends Magnetize longitudinally in a solenoid							
F	Magnetize circularly, rotating eccentrically on a copper rod Magnetize circularly, contacting on O.D.							
G	Magnetize circularly, rotating eccentrically 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

Nomenclature	Method	Item for Special Attention
Ballend — Pushrod	A-2	
Bolt — Crankcase	E-4	
Bolt — Crankshaft	E-4-2	
Bolt — Impeller Spring Drive	A-4	
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 6—40).
Cage — Impeller Intermediate Drive Gear Shaft Ball Bearing	B-5	
Cage — Impeller Shaft Bearing	F-5-4	
Cage — Reduction Drive Gear Pinion	F-7-6	
Carrier — Crankshaft Oil Seal Ring	B-5	
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	

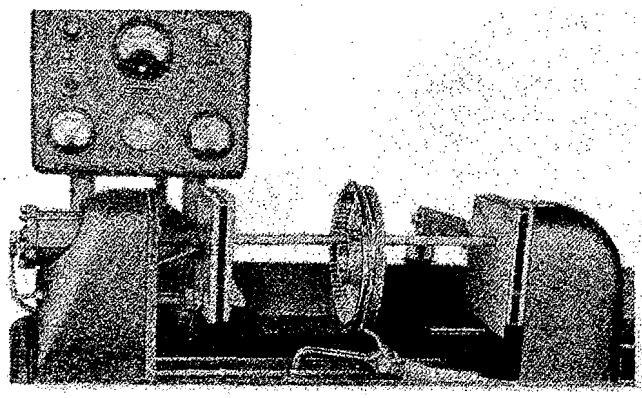

Figure 6—40

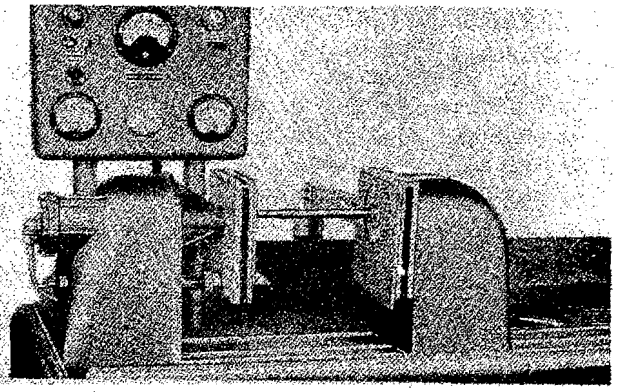

Figure 6—41

Nomenclature	Method	Item for Special Attention
Gear — Vertical Accessory Drive Gear	B-4	
Gear — Oil Pump Drive	E-5-3	Be careful not to burn sharp edges of teeth
Gear — Magneto Drive	F-7-6	(Figure 6—41)
Gear — Starter Drive	D-5-4	
Gear — Tachometer Drive	A-4	
Gear — Vacuum Pump Drive	F-4-3	
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 I.D. is cause for rejection.
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 — Valve Rocker	A-3	
Socket — Pushrod Ball	A-2	
Screw — Flyweight	A-4	

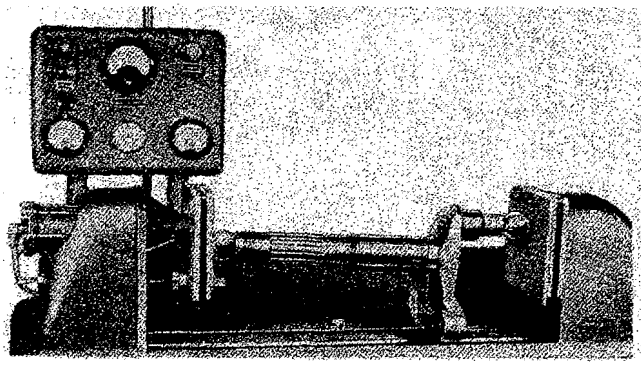

Figure 6—42

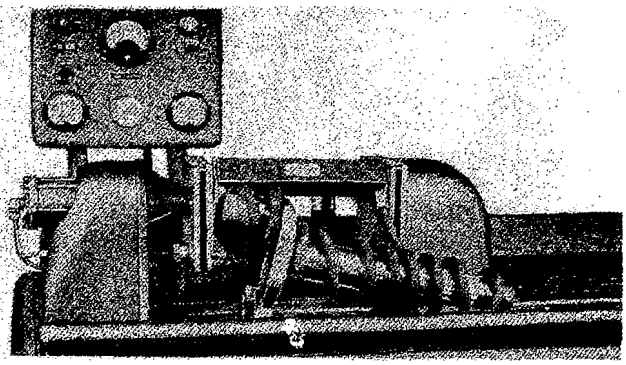

Figure 6—43

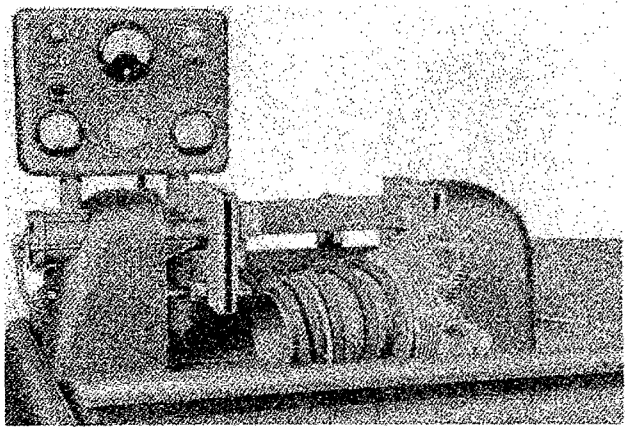

Figure 6—44

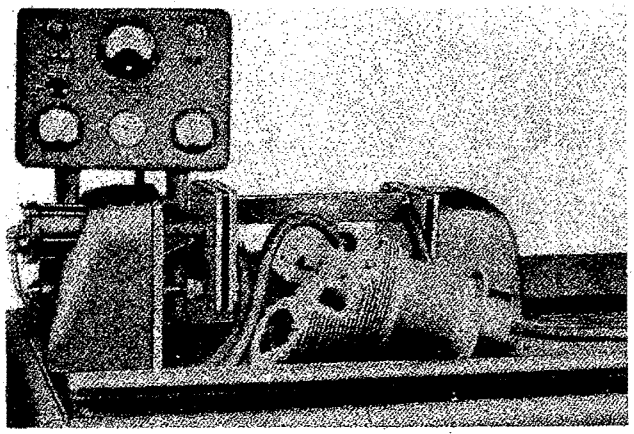

Figure 6—45

Nomenclature	Method	Specific Procedure
Spacer — Crankshaft Thrust Bearing	B-5	
Spider — Driving Spring Drive Supercharger	F-6-5	
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 Hold-down	A-2	
Tappet — Valve	A-3	
Washer — Upper Valve Spring	B-4	

Nomenclature	Specific Procedure
Crankshaft, Front	3000 amps., circularly, using bronze balls to make contact (Figure 6—42). Examine splines, crankpin shoulder, and fillets carefully for defects. 3000 amps., circularly, between plates, contacting crankpin cheek and counterweight radius. 500 amps., longitudinally, by wrapping two turns of No. 0000 insulated copper cable around the crankpin and eight turns around the crankshaft (Figure 6—43).
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.

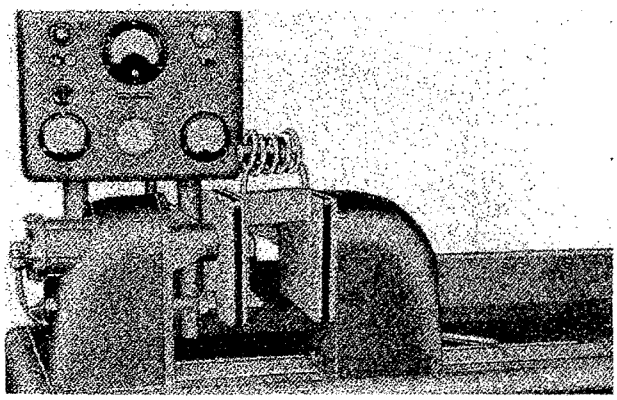

Figure 6—46

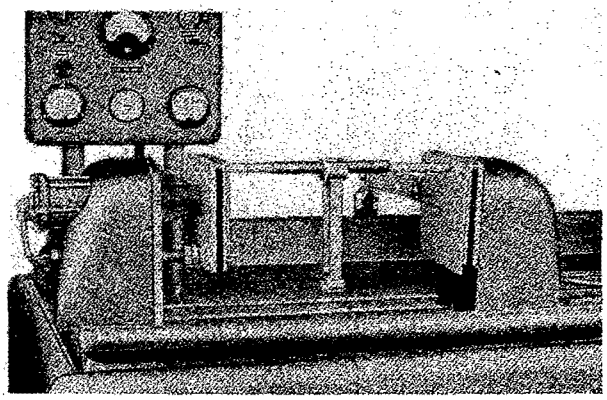

Figure 6—47

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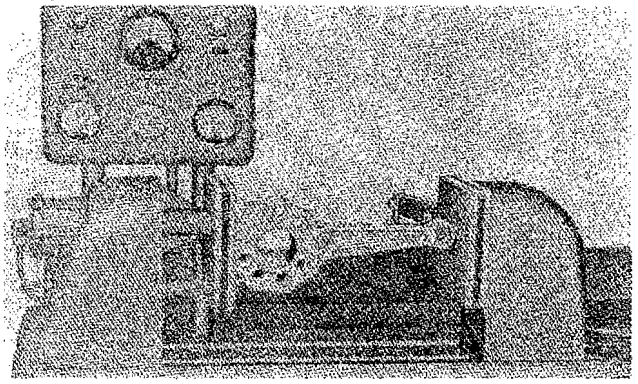


Figure 6—48

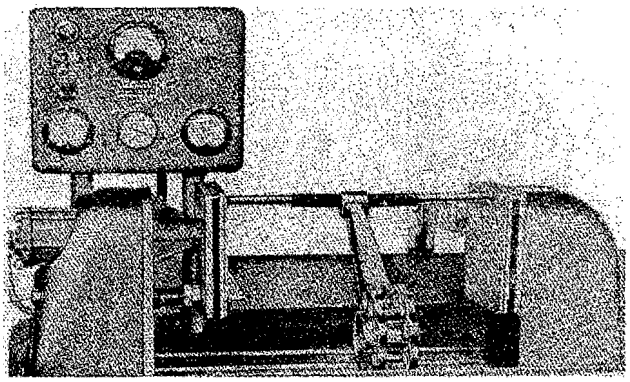


Figure 6—49

Nomenclature	Specific Procedure
Cylinder	1000 amps., longitudinally, by wrapping five turns of No. 0000 insulated cable around barrel (Figure 6—44). 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 6—45). Examine bore of cylinder for lengthwise defects. Examine cylinder hold-down flanges particularly around stud holes. **Note** This check is not necessary, unless it is known that the cylinder was involved in an accident of any kind.
Linkpin	1500 amps., circularly, by contacting on ends. 1000 amps., longitudinally in 4 in. solenoid (Figure 6—46).
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 6—47). Check for crosswise defects in "I" section. 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 6—48). Check for cracks in or around linkpin holes. 3000 amps., circularly, on a copper rod through pistonpin hole (Figure 6—49). Check for defects in "I" section. 3000 amps., circularly, by contacting on the faces of the hub (Figure 6—50). 1500 amps., longitudinally by placing "I" section in 8 in. solenoid (Figure 6—51).

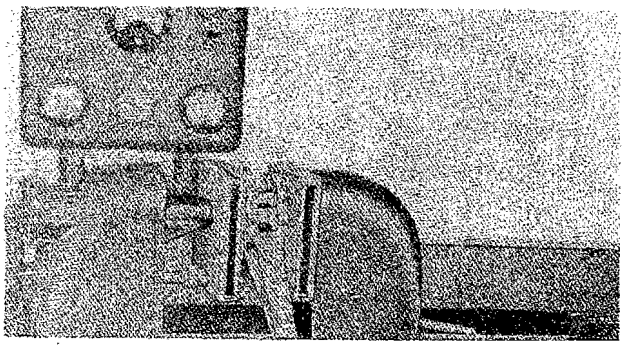


Figure 6—50

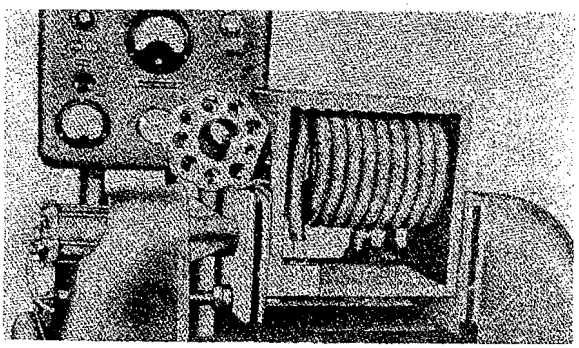


Figure 6—51

Nomenclature	Specific Procedure
Rocker, Inlet and Exhaust Valve	1700 amps., circularly, by contacting on ends. 1500 amps., circularly, by magnetizing 15 to 18 at a time on a 19/64 in. copper rod (Figure 6–52).
Rollers, Tappet	Check faces and bores. 1000 amps., longitudinally, by placing in solenoid (Figure 6–53).

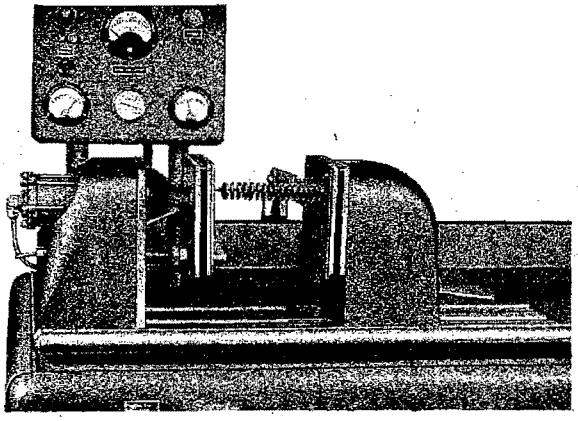


Figure 6–52

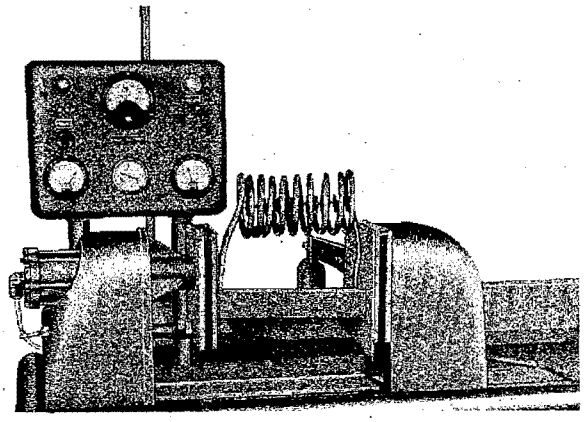


Figure 6–53

6–192. FLUORESCENT PENETRANT METHOD OF INSPECTION.

6–193. DESCRIPTION.

6–194. The fluorescent penetrant method of inspection is a non-destructive means of testing non-magnetic parts for cracks and other discontinuities which have an opening to the surface. It should be used to supplement the regular inspection procedures described in this section. This inspection should include the testing of the parts, the tabulation of the nature and extent of the discontinuities found, and the final decision as to the suitability of the parts for further service. Inspectors in this field should be specialists who have been thoroughly trained to evaluate correctly the various indications which may be encountered.

6–195. The process consists of thoroughly cleaning, then immersing the part to be inspected in an oil penetrant that will fluoresce when exposed to black light (ultra-violet) rays (Figure 6–54). After immersion, the part is drained; then it is washed with warm water to remove the penetrant from the surface. When a part is dried and time allowed for development of fluorescent penetrant indications at room temperature, a dry developer (ZP-2) should be used to verify questionable indications. As an alternate means of developing fluorescent indications, a part may be dipped into a collodal suspension of wet developer (ZP-3) and dried with recirculating hot air. The development interval is followed by a visual inspection for fluorescent indications under the black light. When the wet developer is used acceptable parts must be thoroughly washed again after visual inspection.

6–196. EQUIPMENT.

6–197. The recommended black light (ultra-violet) units are a Westinghouse or General Electric mercury projector lamp No. CH-4 (spot) or EH-4 (flood), using a Corning 5CVX.RDL filter or its equivalent. The lamp cannot be operated directly from 110 volt lighting current. A suitable reactor-transformer must be used between the lamp and the 110 volt current source.

6–198. A recommended oil penetrant is ZL-1, and recommended blotting agents are dry developing powder ZP-2 or wet developing powder ZP-3. The penetrant is compounded to operate best and maintain its properties correctly when used at room temperature.

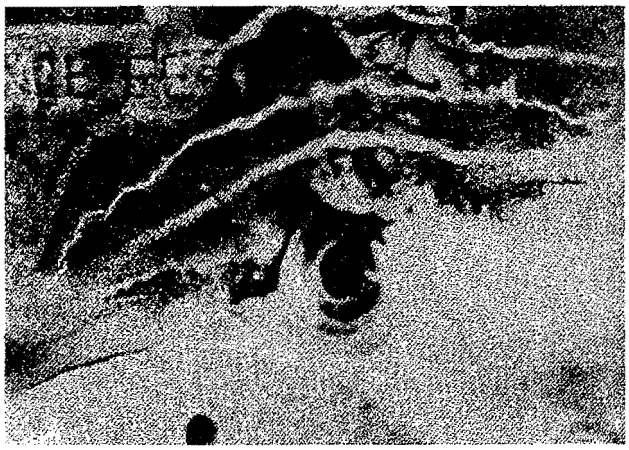


Figure 6–54

6—199. When a recirculating hot air dryer is used it should have a thermostatic control to keep the air in the dryer at a constant temperature of 116°C (240°F).

6—200. SURFACE PREPARATION.

6—201. Thoroughly clean each part to be inspected. Surfaces should be free of foreign material, which might prevent adequate penetration of discontinuities or might hold penetrant and cause nonrelevant indications. Paint removal by volatile paint removers is not recommended, as paint remover and dissolved paint may enter discontinuities, thus preventing adequate penetration of fluorescent penetrant.

6—202. Heavy oils should be removed by degreasing; inert dirt and scale by cleaning or sandblasting. Any blasting used for cleaning must be of the type that would not smear over and close up surface openings of discontinuities. Shot blasting and polishing operations cause poor fluorescent indications. Sand or grit blasting on unfinished surfaces is satisfactory if nozzle pressure does not exceed 75 psi.

6—203. Discontinuities must be free of strong caustic and acid materials. Parts must be dry before applying penetrant. Pre-heating immediately before immersion in the penetrant increases sensitivity and may be readily accomplished by a hot vapor degreasing.

6—204. PENETRATION. Immerse the parts in the tank containing the fluorescent penetrant and allow penetration for the amount of time shown in the table below. Penetrant is drawn into the discontinuity by capillary action. The part may be put on a drain rack to permit the excess penetrant to drain back into the tank, and the time on the drain rack may be included in the penetration time. If the part is on the drain rack for more than 20 minutes, redip it in penetrant just prior to washing.

CAUTION

As the oil penetrant is a skin irritant, the operator should wear neoprene gloves.

6—205. WASHING.

6—206. The surface film of penetrant must be cleaned from the part after the penetration time has elapsed. Wash the parts with a spray of warm water (90°F). Use of the spray nozzle is essential since the penetrant is readily emulsified by the physical action of the water droplets. Washing may be carried out under black light to assure complete cleaning of surfaces.

6—207. Steel components should be wiped thoroughly dry of water and coated with a corrosion preventive immediately after immersion in wet developer or immediately after washing if dry developer is to be used.

6—208. DEVELOPING.

6—209. Discontinuities will be shown by the fluorescence of the penetrant where it has developed out of the flaws. Development may be hastened by either of two methods.

6—210. ZP-2 Dry Developer is a powder preparation, which may be dusted or brushed over the entire part or only on suspected areas to fix the indications or verify questionable fluorescence.

6—211. ZP-3 Wet Developer is a powder preparation, which must be mixed with warm water to make a colloidal suspension. Parts are dipped into this suspension immediately after washing. In order to maintain the proper consistency it is necessary to replace water lost by evaporation. To check the consistency, pour a streak of well mixed bath down a glossy black surface. Compare this with a standard sample obtained at the time the original bath was prepared and kept in a corked bottle. Stir the developer lightly before each use. ZP-3 developer is corrosive and steel components must be protected as noted in the paragraph on "Washing."

6—212. After washing the parts, allow a suitable time interval for drying and for development of fluorescent indications at room temperature.

6—213. Rapid drying is necessary when parts are dipped into wet developer. Drying time in a recirculating hot air dryer at a temperature of 116°C (240°F) varies from 5 to 10 minutes depending on size and shape of the part. Remove the parts from the dryer as soon as they are dried and allow them to cool to handling temperature before inspection.

6—214. INSPECTION. Parts are inspected with black light in a darkened area or booth. Small parts may be held under a fixed light. Use a portable hand light over the surface of large parts. Discontinuities will be shown by the fluorescence of the pentrant where it has developed out of the flaw.

6—215. TABLE OF FLUORESCENT PENETRANT DATA.

Part	Immersion	Drain	Development
Cylinder (Cast Type) Heads	10 min.	5 min.	10 min.
Magnesium or Aluminum Castings	10 min.	10 min.	15 min.
*Crankcase Section, and similar Forged Aluminum Parts	45 min.	15 min.	30 min.

*Heat in degreaser before immersion in penetrant.

SECTION VII

REPAIR AND REPLACEMENT

7—1. GENERAL.

7—2. Air Force and Navy personnel should refer to the latest applicable technical publications for repair instructions.

7—3. The instructions in this Section have been written with the understanding that all parts requiring repair or replacement have been thoroughly inspected and have been tagged to indicate what repairs or replacements are necessary. Subject reworked parts to a second magnetic inspection as described in paragraph 6—170.

7—4. 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 in the same location as the part it replaces. Any new part should be tagged, so that any involved fits or clearances will be checked at assembly.

7—5. The tables in Section XII should be used as a guide in all repair and replacement operations involving fits, clearances, backlashes, spring pressures, and torques.

7—6. Repair and replacement instructions covering groups of similar parts and covering general repair procedures are given in paragraphs 7—7 through 7—48. Repair instructions covering parts which require special procedures and parts which cannot be readily grouped are given in paragraphs 7—49 through 7—223.

7—7. GENERAL REPAIR AND REPLACEMENT INSTRUCTIONS.

7—8. ALUMINUM AND MAGNESIUM PARTS.

7—9. Smooth over or remove burrs or scratches which do not impair the serviceability of a part. If the paint on a part is excessively flaked, chipped, or scratched, the part should be completely repainted (see paragraph 7—29). Clean up galling, scratches, burrs, or unevenness of mating or parting surfaces, using crocus cloth and oil. Remove corrosion from magnesium parts as described in paragraph 7—23.

7—10. Whenever magnesium parts are reworked, care must be taken to remove dust, filings, turnings, and shavings as they are formed. Magnesium, when in these forms, burns very rapidly and under certain conditions when mixed with air becomes explosive.

7—11. Finely divided scrap magnesium, when mixed with water or water soluble cutting oils, also presents a very serious fire hazard. When ignited, such mixtures burn with extreme violence and, if confined in a deep melting pot or drum will develop enough pressure to spray the burning material over a large area.

7—12. To prevent these dangers, use a liquid coolant of a straight neutral oil type with a high enough flash point so that its ignition does not become a problem. Mineral seal oil or kerosene are satisfactory coolants. Unsatisfactory types are water soluble oils, acid oils or oils that become rancid on exposure to air. Magnesium, when once ignited, burns much more rapidly in the presence of water than in the presence of air or a straight or a neutral oil. As a further safeguard, accomplish magnesium finishing or rework operations away from the vicinity of sparks, open flames and other possible means of ignition.

7—13. Magnesium, unlike aluminium which is harmless, is approximately 2/3 as heavy as aluminum. Magnesium castings also may be identified by dark brown to black surface color produced by the chemical finishing treatment. However, this characteristic must not be considered alone for identification purposes inasmuch as other methods of treatment may be used which impart an entirely different appearance to the surface. Magnesium castings may be identified by the material specification number with which they are usually marked. P & W specification numbers are 221-A, 199, 859. AMS specification numbers are 4420-B, 4422-A, 4424-B, 4434-A, and 4490-A.

7—14. BUSHINGS AND PLAIN JOURNAL BEARINGS REPLACEMENT.

7—15. 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.

CAUTION

Never touch a leaded bearing with an abrasive of any kind.

7—16. When replacing a bushing, use the tools which are listed in the picture index covering each specific bushing or bearing (Figure 7—1 through 7—7). If the bushing is pinned in place, remove the lockpins before attempting to pull or drift out the bushing. When a bushing is pinned in such a way that it is necessary to drill out the lockpin, a drill jig, which should be used as a guide in drilling out the pin, is included in the list of tools given in the picture index or paragraph covering the specific bushing. If a drill jig is not included, the lockpin should be driven out with a suitable punch. When driving out a pin, be careful not to damage the bushing boss

adjacent to the pin. If damage is likely to occur, mark the center of the pin with a prick punch and drill out the pin with a drill being careful not to drill through the bushing boss. After the lockpin has been removed, pull or drift out the bushing, using the proper puller or drift. Before installing a new bushing, check the condition of the bushing hole and, if necessary, clean up the hole, using crocus cloth and oil.

7—17. When installing a new bushing, make sure that oil holes or grooves in the bushing are lined up properly with oil holes or grooves in the corresponding boss. If the bushing has a flange, check the flange with a .001 inch feeler gage to make sure it is properly seated. If a drill jig was used in drilling out the lockpin, 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, or break through the wall of the bushing boss. If the old lockpin was driven out with a punch, transfer-drill the new pin hole, using the existing pin hole in the boss as a guide. Install all new lockpins with a punch.

7—18. Ream new bushings to size, polish them with crocus cloth and oil, and check them for size with the proper reaming gages. *Thoroughly clean bushings and oil passages after reaming operations.*

7—19. Figure 7—1 illustrates the application of the various tools used in bushing replacement.

7—20. LEAD-INDIUM PLATED BEARING SURFACES. New or reprocessed lead-indium plated bearings which have been in storage may acquire an oxide film or stained appearance which is sometimes in the form of hard and black spotted areas on the bearing surfaces. 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-indium plated surfaces in accordance with the following procedure:

7—21. Remove the oil, grease, or corrosion preventive from the bearing by degreasing or by some other appropriate method. Clean the bearing electrolytically by immersing it in an alkaline cleaner heated to 82°C to 93°C (180°F to 200°F) with the bearing as the cathode, and a line voltage of approximately 6 volts supplying the current. Alkaline cleaners recommended are Pennsalt K7, Anodex, or any similar electrolytic cleaner at 9 to 14 ounces per gallon of water. Approximately 4 to 6 seconds is required for the cleaning, except where the bearings have been in long time storage, in which case cleaning time should not exceed 10 seconds.

7—22. Rinse the bearing first in cold water and then in hot water. Wipe the bearing dry with a clean soft cloth or a cotton swab; then oil it immediately with a corrosion preventive conforming to Federal Specification AN-C-52.

Note

Avoid contacting the bearing surface with the hands between the wiping and oiling procedure.

7—23. CHROMIC ACID TREATMENT.

7—24. Treat magnesium parts on which there are signs of corrosion or on which the original chrome pickling is no longer effective as described in the following paragraphs to protect them against corrosion.

7—25. Thoroughly clean the part to be treated as described in paragraph 5—10; then remove any paint as described in paragraph 7—29. Where close tolerances are not required, remove the corrosion with a wire brush or abrasive paper. Where close tolerances are required, swab or brush the surface with a hot 82°C to 93°C (180°F-200°F) chromic acid solution containing 1½ pounds of chromix oxide (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 solution. After treating, rinse the part thoroughly first in cold, then in hot 82°C (180°F Min.) water. Drain the part and dry it with compressed air.

7—26. Spot treat areas cleaned of corrosion or the original chrome pickling by swabbing or brushing the area with a chrome pickling solution containing 1½ pounds of sodium dichromate ($Na_2Cr_2O7—2H_2O$) and 1½ pints of nitric acid (HNO_3—Sp. Gr. 1.42), with enough water to make one gallon of solution. Using an acid resistant container, pour in 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.

Note

The operator should wear rubber gloves during this operation.

7—27. Maintain the chrome pickling solution at a temperature of 12°C to 29°C (55°F—85°F), but do not apply it for more than 15 seconds. Immediately following the application of the solution, rinse the part in cold and then in hot 82°C (180°F Min.) water and dry the part with compressed air. If the part was painted before treatment, apply new primer and paint as described in paragraph 7—29.

7—28. EXPANSION OF PARTS BY HEAT. With a tight fitting part that requires replacement, it may be necessary to apply heat to the metal surrounding the part in order to facilitate removal of the old part and installation of the new part. The method of heating which is least likely to cause warping is to place the part in an oven and gradually bring the entire part up to the required temperature. However, it is usually more convenient to heat a part with a torch, and this method is satisfactory, provided sufficient care is exercised in its

use. When applying heat with a torch, use a soft flame gas torch and play the flame over the entire area surrounding the part to be removed. Do not hold the flame too long in one spot. Never heat a magnesium part with a torch. Immersing magnesium parts in actively boiling water will expand them sufficiently for the removal of liners without the attendant fire hazard or danger of warping occasioned by the use of a torch. Except where otherwise specified, keep magnesium parts below 120°C (248°F) and aluminum parts below 150°C (302°F).

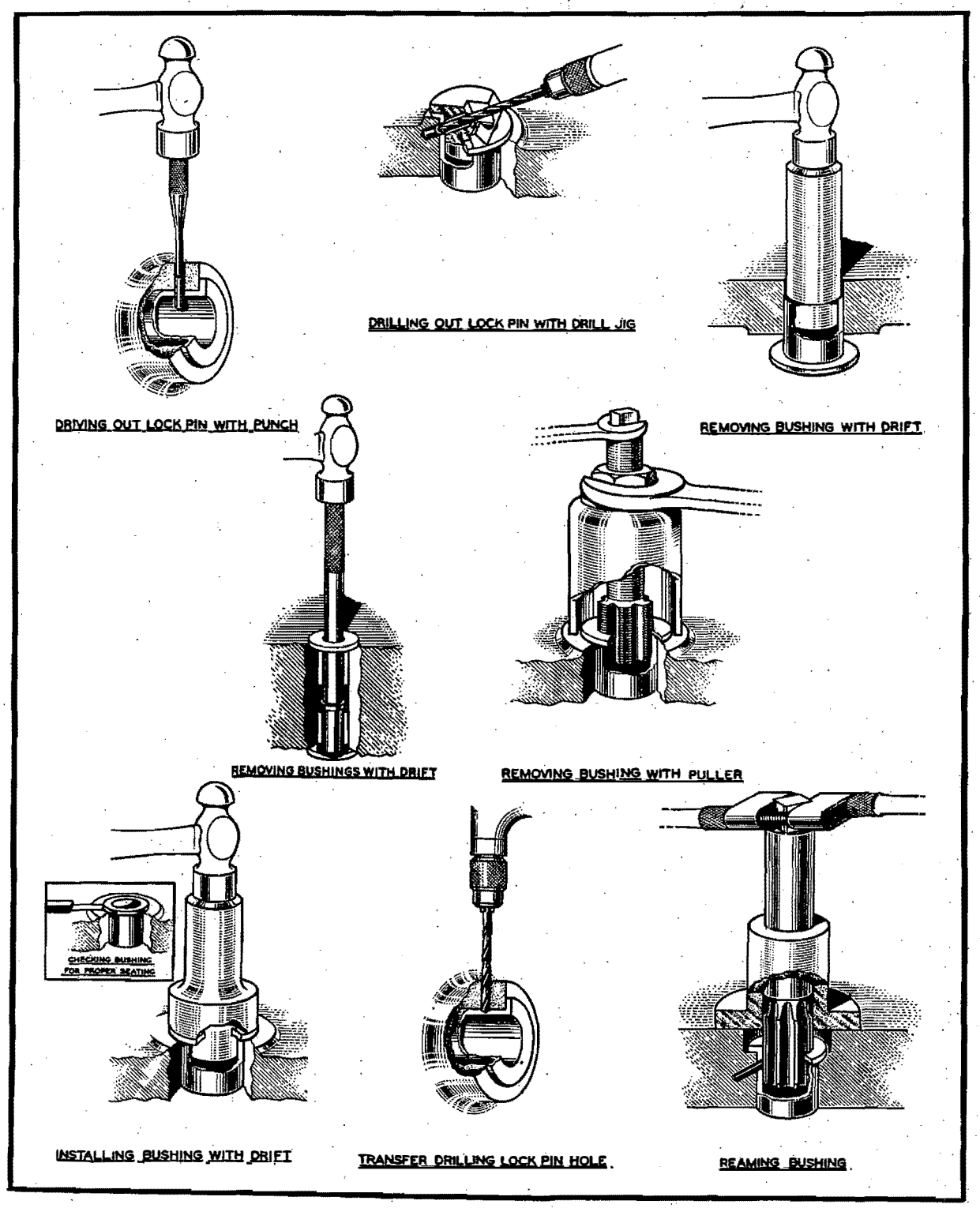


Figure 7—1. Replacing a Bushing

7—29. PAINTING.

7—30. Before parts are repainted at overhaul, their surfaces must be properly prepared to receive the paint. 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 parts in a heated stripping solution. The Gerlach No. 70 Stripper is satisfactory for use in this method. A second method is to brush a heavy coat of paint remover conforming to Federal Specification No. TT-R-251 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 a magnesium part with a wire brush, treat the part to prevent corrosion as described in paragraph 7—23.

7—31. If the old paint is not to be removed, smooth the surface with emery or crocus cloth before the part is repainted. Thoroughly clean 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 conforming to Specification No. AN-TT-P-656; then bake the part for ½ hour at 120°C (248°F). Next apply two coats of grey enamel conforming to Specification No. AN-E-3 or black enamel conforming to Specification No. AN-TT-E-501, baking each coat for 1¾ hours 135°C (275°F). Paints may be applied with a spray gun or 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 of primer or paint is completely dry before applying the next coat.

7—32. Magnesium alloy mating surfaces which contact flat gaskets are to be given a chromic acid treatment as described in paragraph 7—23; then apply one coat each of permanent resin coating, conforming to Specification No. AN-C-148 and enamel, conforming to Specification No. AN-E-3 or Specification No. AN-TT-E-501. Magnesium alloy mating surfaces which do not contact flat gaskets are to be given a chromic acid treatment plus one coat of permanent resin coating, conforming to Specification No. AN-C-148. Do not treat or paint the magneto mounting pad surfaces. If facilities are not available for applying the permanent resin coating, two coats of zinc chromate primer, conforming to Specification No. AN-TT-P-656, may be substituted.

7—33. PRESERVATIVE VARNISH STRIPPING.

7—34. To strip an engine part of resin coating, prepare a solution in a clean steel tank in the following proportions. Mix 4 to 6 ounces of Metex No. 5 to a gallon of tap water. If Metex No. 5 is not available, an alternate cleaning solution, or its equivalent in performance may be prepared for commercial grades of materials. Dissolve 8 ounces of the following mixture per gallon of tap water.

Material	*Parts by Weight*
Sodium Resinate	1
Sodium Metasilicate	3
Trisodium Phosphate	1
Sodium Carbonate	2
Sodium Hydroxide	4

Note

It is believed that this type of resin coating can have no contaminating effects whatsoever on costly cleaning solutions used in mechanized cleaning systems, however, it would be well to check vendors of cleaning solutions for any possible deleterious effects as noted herein.

7—35. Mask off any lead or silver surfaces with rubber stoppers. Heat the solution to 200°F to a boiling point and immerse the engine part until the old varnish or resin has been removed. Removal may be facilitated by scrubbing with a fiber brush.

CAUTION

As the stripping solution is a strong alkali, avoid spilling or spattering it. The hands and clothing of personnel should be protected with rubber gloves and an apron.

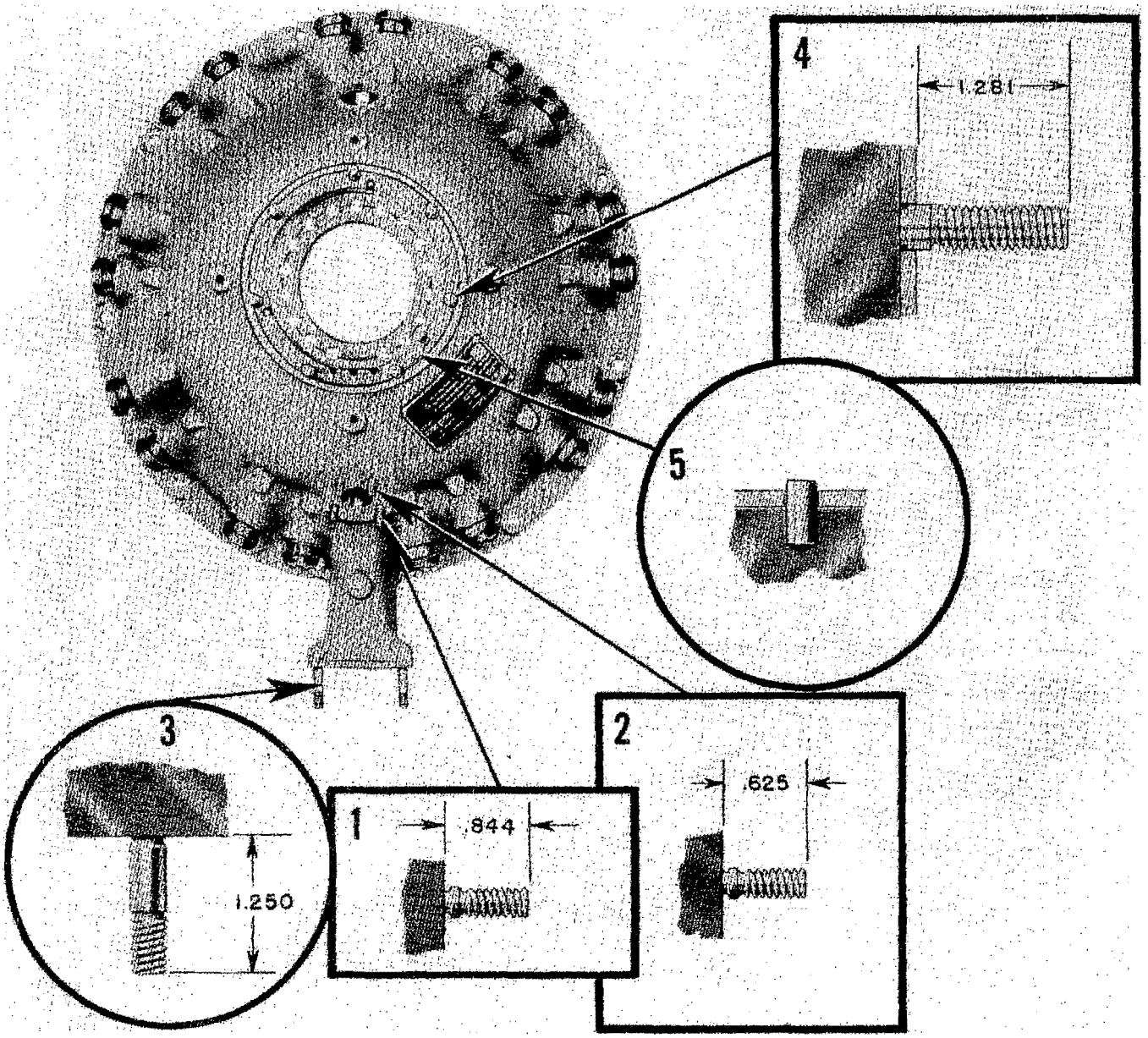
7—36. Rinse the parts thoroughly in a tank of cold, air agitated water to remove all traces of alkali. Then rinse thoroughly in clean water heated to 180°-200°F. Dry the parts with an air hose then cover the parts with a light preservative oil to protect the surfaces.

7—37. PERMANENT RESIN COATING APPLICATION. If desired, apply permanent resin coating conforming to Specification AN-C-158, to the masterod, linkrods, the crankshaft, springs, the cam, and cam tracks, gears (including gear teeth), and all other surfaces of internal steel parts which have not been previously coated. Do not coat plain bearing surfaces in general, tight fitting spline surfaces, bearing contact surfaces of ball and roller bearings, cylinder barrels, pistonrings and pushrod balls and sockets. The coating, which is intended primarily for steel parts, may also be applied to non-ferrous parts. No attempt need be made to mask off non-ferrous inserts unless they are bearing surfaces.

7—38. PLATING.

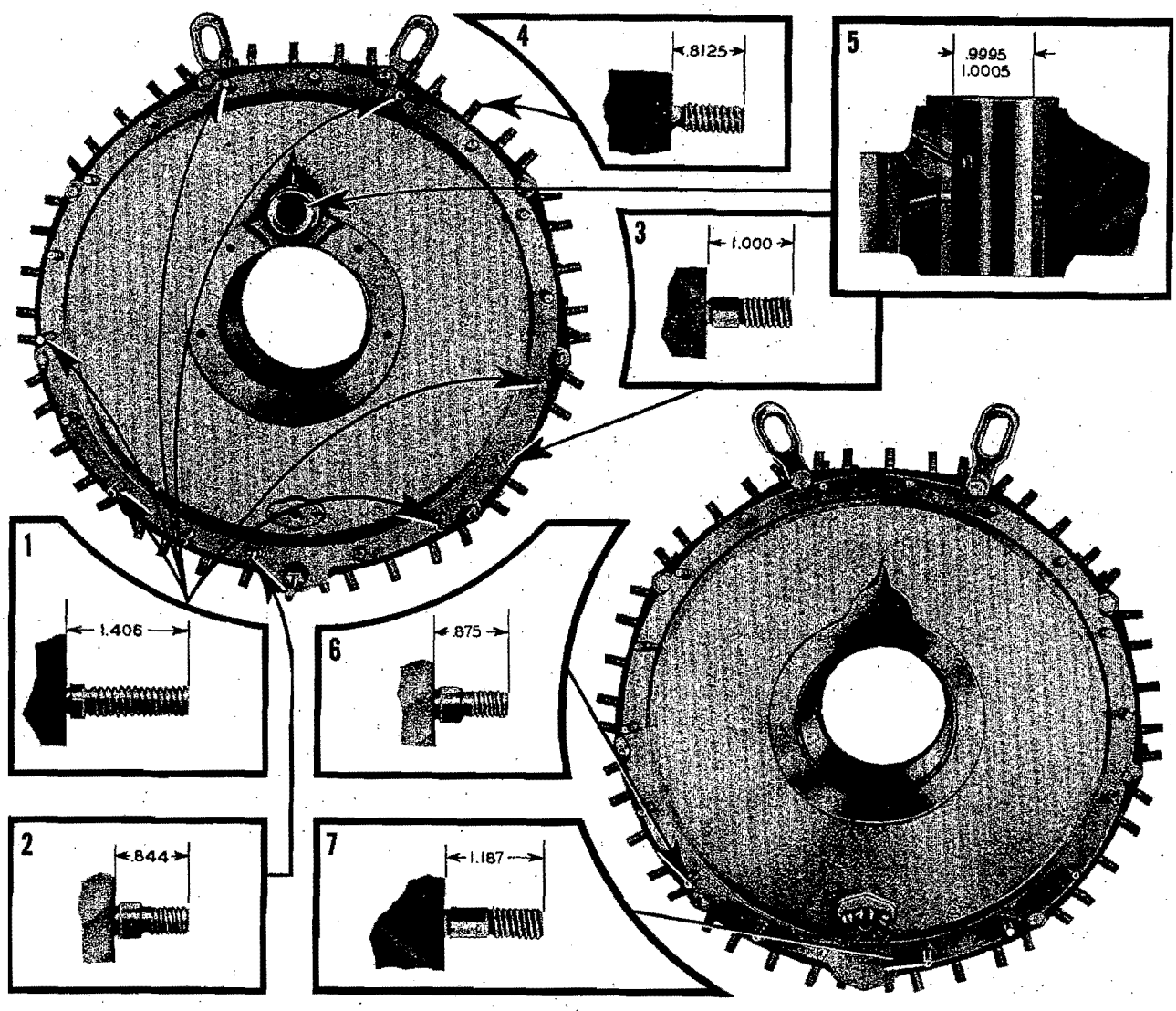
7—39. Plating of engine parts should be done only by personnel experienced in this work. Certain engine parts require plating at overhaul to prevent galling, corrosion, or pick-up. It is extremely important that the plating be well bonded, and that each engine part be treated as an individual problem in plating.

7—40. It is very important that any engine parts which are replated at overhaul be heat treated. Stresses are set up in the metal during the plating operation which, if not relieved, are apt to cause embrittlement which may result in cracks and subsequent failure of the plated part.



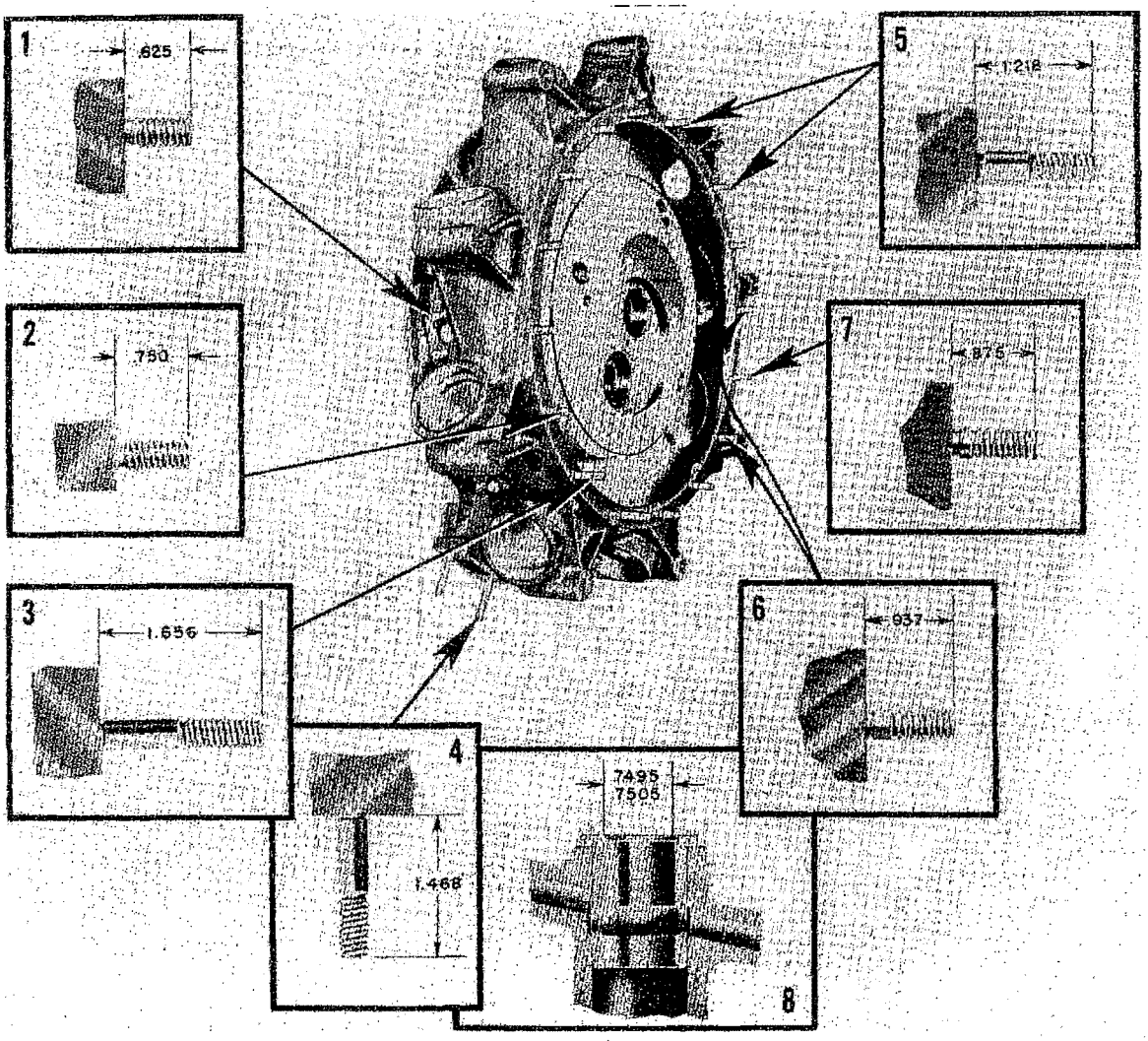
Index No.	Part Name	Part No.	Units Per Ass'y	Tools Required	Notes and References
1	Regulator Valve Stud	12088	4	¼-28 Stud Driver	See "Studs," paragraph 7—46.
2	Regulator Valve Stud	12089	2	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
3	Oil Sump Fastening Stud	12055	2	⅜-24 Stud Driver	See "Studs," paragraph 7—46.
4	Thrust Cover Stud	42419	7	⅜-24 Stud Driver	See "Studs," paragraph 7—46.
5	Thrust Cover Dowel	62	1		Drive in until dowel bottoms.

Figure 7—2. Front Case Stud Replacement



Index No.	Part Name	Part No.	Units Per Ass'y	Tools Required	Notes and References
1	Crankcase Front Section Fastening Stud	38300	6	3/8-24 Stud Driver	See "Studs," paragraph 7—46.
2	Front Case Fastening Stud	42422	1	3/8-24 Stud Driver	See "Studs," paragraph 7—46.
3	Crankcase Front Section Fastening Stud	54610	11	3/8-24 Stud Driver	See "Studs," paragraph 7—46.
4	Cylinder Flange Stud	12081	90	3/8-24 Stud Driver	See "Studs," paragraphs 7—46 and 6—109.
5	Cam Drive Gear Rear Bushing Bushing Pin	5670 15	1 1	PWA-220 Puller and Pusher TAM-3575-45 Reamer 1621-T-17 Reaming Fixture PWA-1805-6 Reaming Gage	Drill .125 inch for pin.
6	Oil Sump Fastening Stud	12085	1	3/8-24 Stud Driver	See "Studs," paragraph 7—46.
7	Supercharger Case Fastening Stud	12057	17	3/8-24 Stud Driver	See "Studs," paragraph 7—46.

Figure 7—3. Crankcase Bushing and Stud Replacement



Index No.	Part Name	Part No.	Units Per Ass'y	Tools Required	Notes and References
1	Oil Drain Tube Stud	12054	2	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
2	Supercharger to Rear Case Stud	9085	1	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
3	Supercharger to Rear Case Stud	9385	1	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
4	Cover Attaching Stud	9252	2	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
5	Supercharger to Rear Case Stud	7959	3	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
6	Supercharger to Rear Case Stud	11345	2	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
7	Supercharger to Rear Case Stud	625	9	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
8	Magneto Drive Shaft Short Bushing	1172	2	PWA-1748 Disassembly Drift TAM-3575-7 Hole Reamer PWA-1746 Assembly Drift PWA-1981 Aligning Bar TAM-3575-5 Reamer PWA-1805-6 Gage 1320-T-120 Clearance Gage	

Figure 7—4. Supercharger Case Bushing and Stud Replacement

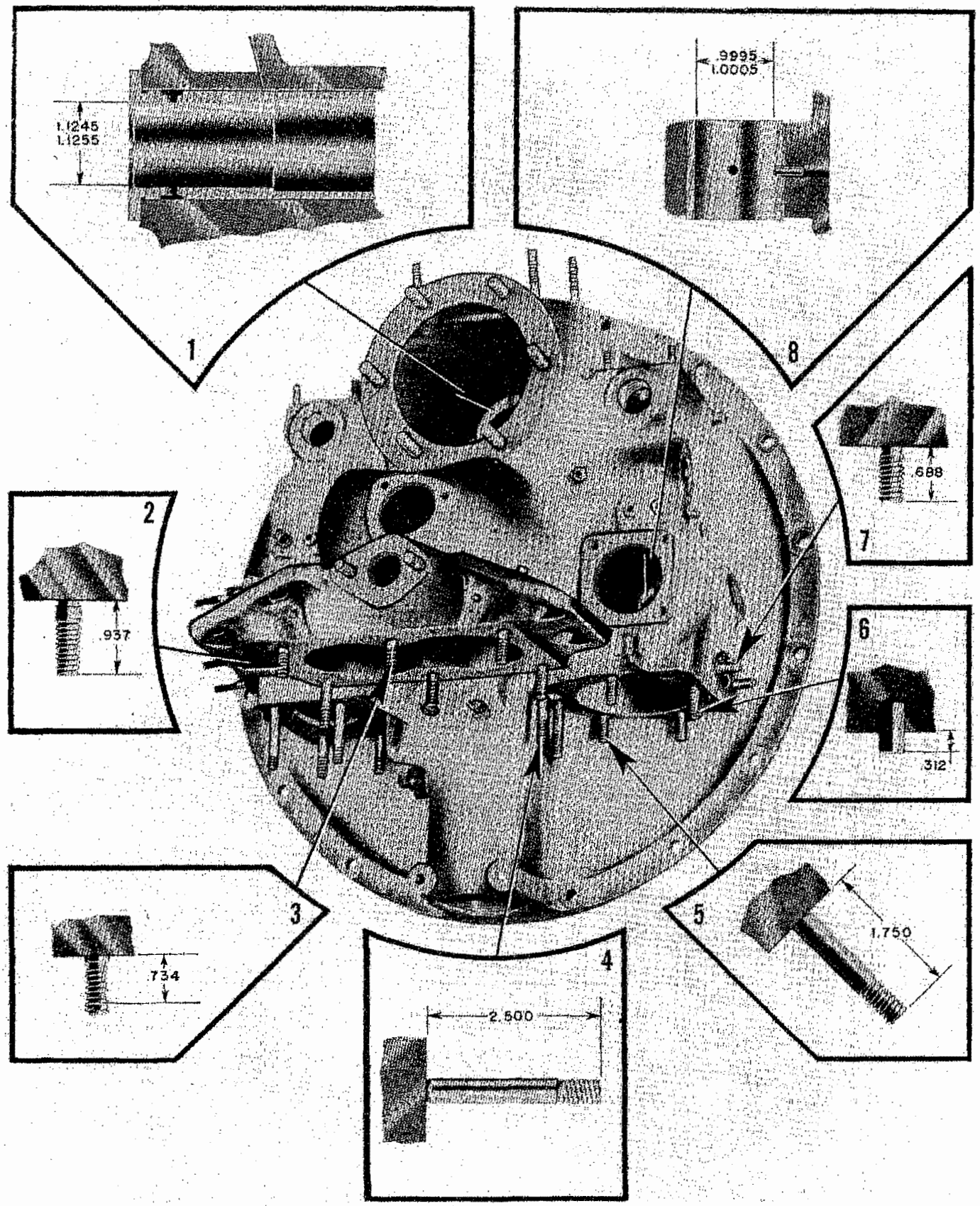


Figure 7—5. Rear Case Bushing, Stud and Dowel Replacement (Sheet 1 of 4 Sheets)

Index No.	Part Name	Part No.	Units Per Ass'y	Tools Required	Notes and References
1	Starter Shaft Bushing	1191	1	PWA-1749 Disassembly Drift PWA-762 Assembly Drift PWA-819 Hole Reaming Adapter TAM-3575-6 Hole Reamer TAM-3575-8 Reamer PWA-815 Reaming Adapter PWA-816 Reaming Adapter PWA-817 Reaming Adapter PWA-1805-9 Gage TAM-113 Flush Pin Gage PWA-538 Facer	Temporarily assemble supercharger and rear cases and line ream bushing hole if an oversize bushing is installed. Cuts on bushing flange should be on vertical. Slot from oil hole on bushing stem should be on right as viewed from rear.
2	Carburetor Adapter Stud	11345	3	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
2A	Carburetor Adapter Stud	18S9186	1	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
3	Carburetor Adapter Stud	626	2	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
4	Oil Pump Stud	23299	2	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
5	Oil Pump Stud	19868	4	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
6	Oil Pump Locating Dowel	62	1		Drive in until dowel bottoms.
7	Oil Scavenge Tube Stud	12317	2	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
8	Accessory Drive Shaft Bushing	1171	2	PWA-1800 Assembly and Disassembly Drift TAM-3575-26 Reamer	Drill No. 20 (.161 inch) for pin.
	Bushing Pin	25	2	1171-T-1 Reaming Fixture PWA-1805-36 Gage	Drill No. 20 (.161 inch) after assembly through both sides of bushing for oil passages.
9	Vertical Accessory Drive Stud (Right Hand)	5206	4	1/4-28 Stud Driver	See "Studs," paragraph 7—46.

Figure 7—5. Rear Case Bushing, Stud and Dowel Replacement (Sheet 2 of 4 Sheets)

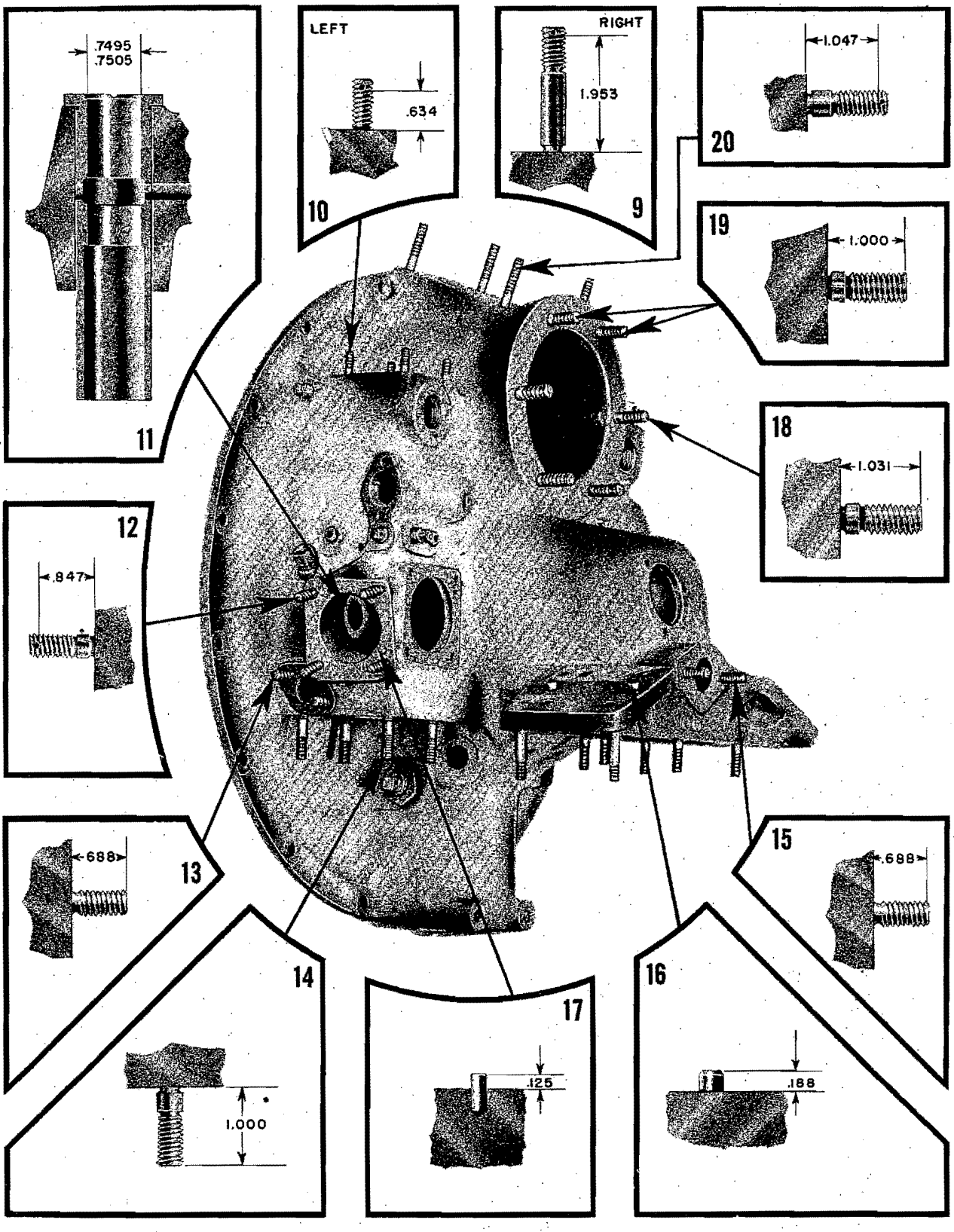
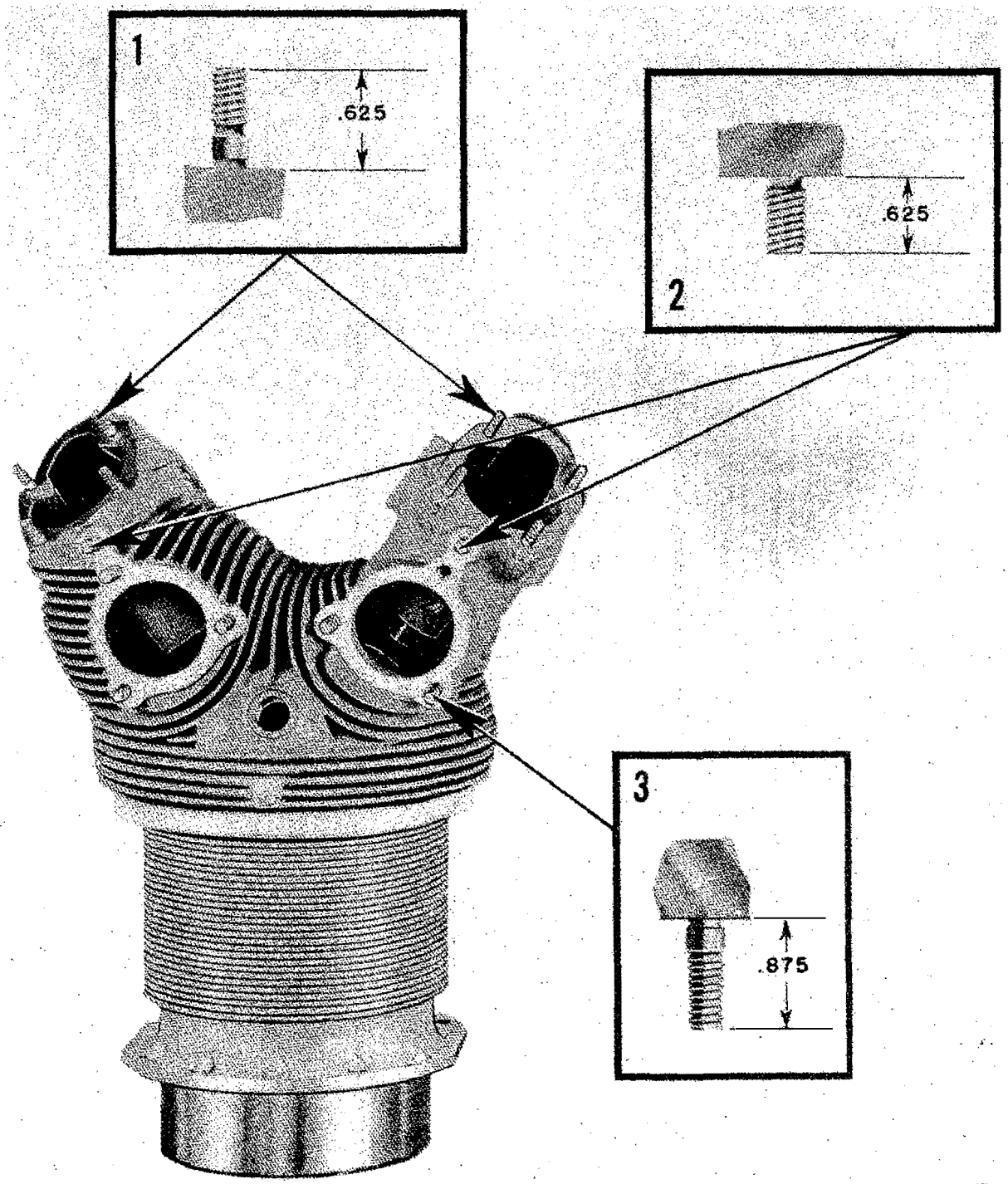


Figure 7—6. Rear Case Bushing, Stud and Dowel Replacement (Sheet 3 of 4 Sheets)

Index No.	Part Name	Part No.	Units Per Ass'y	Tools Required	Notes and References
10	Vertical Accessory Drive Stud (Left Hand)	43613	4	1/4-28 Stud Driver	See "Studs," paragraph 7—46.
11	Magneto Drive Shaft Long Bushing	1174	2	PWA-1747 Disassembly Drift TAM-3575-7 Hole Reamer PWA-1746 Assembly Drift PWA-1981 Aligning Bar TAM-3575-5 Reamer PWA-1805-6 Gage 1320-T-120 Clearance Gage PWA-820 Adapter	
12	Vacuum Pump Pad Stud	35142	4	1/4-28 Stud Driver	See "Studs," paragraph 7—46.
13	Oil Scavenge Tube Stud	12317	2	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
14	Fuel Pump Pad Stud	656	4	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
15	Oil Scavenge Tube Stud	12317	2	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
16	Magneto Locating Dowel	11051	4		Drive in until dowel bottoms.
17	Vacuum Pump Adapter Locating Dowel	28834	1		Drive in until dowel bottoms.
18	Starter Pad Stud	12091	4	3/8-24 Stud Driver	See "Studs," paragraph 7—46.
19	Starter Pad Stud	12082	2	3/8-24 Stud Driver	See "Studs," paragraph 7—46.
20	Generator Pad Stud	26264	4	5/16-24 Stud Driver	See "Studs," paragraph 7—46.

Figure 7—6. Rear Case Bushing, Stud and Dowel Replacement (Sheet 4 of 4 Sheets)



Index No.	Part Name	Part No.	Units Per Ass'y	Tools Required	Notes and References
1	Rocker Cover Stud	15072	8	¼-28 Stud Driver	See "Studs," paragraph 7—46.
2	Deflector Fastening Stud	12054	2	5/16-24 Stud Driver	See "Studs," paragraph 7—46.
3	Intake and Exhaust Flange Stud	625	5	5/16-24 Stud Driver	See "Studs," paragraph 7—46.

Figure 7—7. Cylinder Stud Replacement

To relieve these stresses, bake all plated parts for three hours at a temperature of 135°C to 150°C (275°F to 302°F) immediately after they have been plated. If facilities for baking are not available, place the parts in actively boiling water for approximately 4 hours. If parts are sent to a commercial plating concern, these precautions should be emphasized in the instructions which accompany the parts.

7—41. Parts which have been chromium plated may require other plating during normal overhaul and since the electrolytic cleaning or stripping process preceding any plating operation would be injurious to the chromium plated surface, it is important that areas which have been chromium plated be masked off before the parts are placed in an electrolytic bath. If the presence of chromium plating is questionable as on a polished journal surface, thoroughly clean and dry the area in question; then with a cloth of sponge, apply a solution composed by weight of 2 percent copper sulphate crystals, ½ percent sulphuric acid, and 97½ percent water.

Note

The sulphuric acid is not essential to the test, but it will speed up the reaction time.

7—42. When the solution is applied, any area, which has not been plated will take on a copper brown tint, while the color of an area protected by chromium plating will remain unchanged. This test and the resultant copper tint on the unplated surface of the part will in no way affect the subsequent use of the part. However, if the part is not to be placed in the stripping bath immediately, dip it in oil to renew the protective oil film.

7—43. RIVETS. Tighten any loose rivet if possible; otherwise replace it.

7—44. RUBBER PARTS AND PACKINGS. Replace all rubber parts and packings at every overhaul.

7—45. STEEL PARTS. Clean up and blend in any burrs and minor galling, pitting, or scratches with crocus cloth and oil or with a fine stone. Be sure that all bearing journals are smooth. It is usually advisable to use a fine flat stone when cleaning up gear teeth.

7—46. STUDS.

7—47. Replace any studs which are stretched, loose, or have damaged threads by oversize studs. Refer to the picture index, (Figures 7—2 through 7—7). Whenever a stud which is already oversize requires replacement, replace it with 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 retap the hole for a special stepped stud. Navy personnel refer to General Engine Bulletin No. 55 for further details concerning the replacement of studs. The table which follows illustrates the various methods of marking oversize studs for identification. The identifying mark or dye is on the anchor end of the stud, the conical projection or green dye for .004 inch oversize studs, the conical recess or red dye for .008 inch oversize studs, and the

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			

drilled hole or purple dye for .012 inch oversize studs are the Pratt & Whitney standard identifying marks. The other marking methods are illustrated because they are used by various vendors and may be encountered in the field. When installing an oversize stud in a stud hole, make sure the anchor end of the stud does not project beyond the hole sufficiently to cause interference with other parts. If necessary, file off the anchor end enough to insure against such interference; reidentify the stud with the proper oversize mark. When installing a stud which incorporates a cotterpin or a lockwire hole, the projection length should be measured from the bottom of the hole.

7—48. SCREW BUSHINGS. If a screw bushing requires replacement, drill out any lockpins; then remove the bushing, using the proper driver. Install the new bushing with the driver; then, if necessary, drill new lockpin holes and install new lockpins. Refer to the picture index (Figures 7—2 through 7—7).

7—49. THRUST BEARING LINER REPLACEMENT.

7—50. See "Expansion of Parts by Heat," paragraph 7—28. Heat the portion of the case adjacent to the liner to a temperature of 93°C to 121°C (200°F 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.

7—51. Chill the new liner with dry ice; reheat the case to the same temperature as above and insert the liner in the case. Make 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 gage.

7—52. 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 7—8).

7—53. Using a portable grinder mounted on the tool rest, grind the bore of the liner to size. 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.

7—54. CAM REPAIR.

7—55. 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

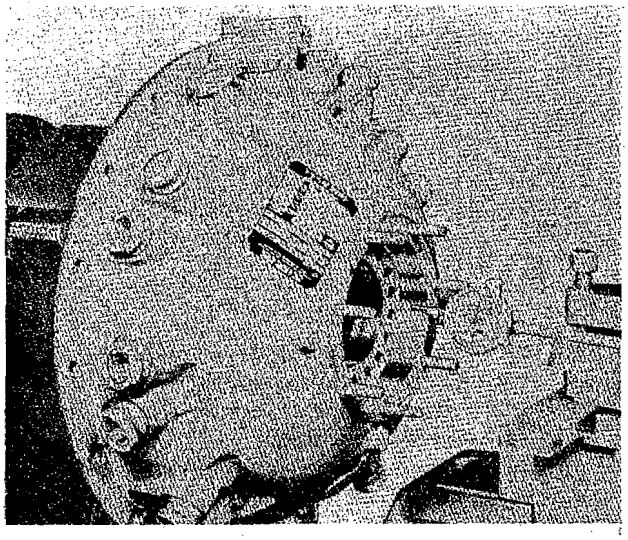


Figure 7–8

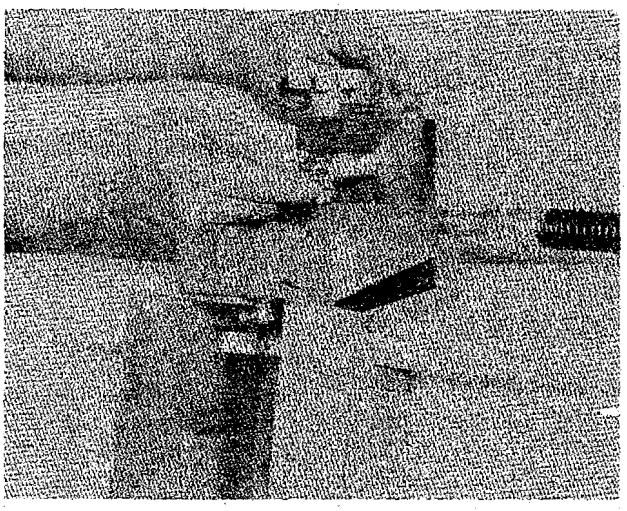


Figure 7–9

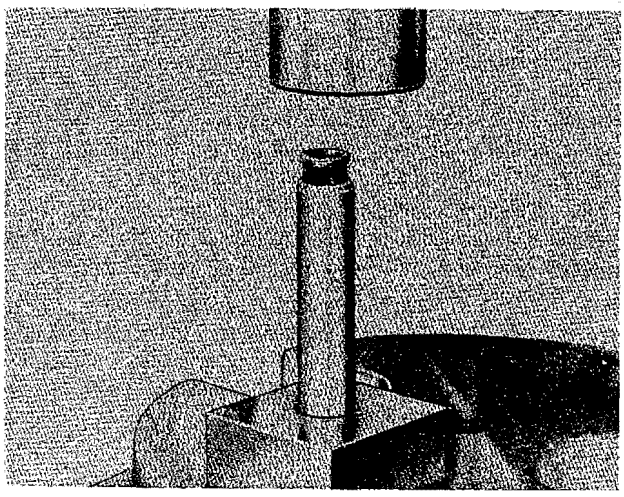


Figure 7–10

.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 .015 inch of material from the entire cam track, return the cam to the manufacturer for regrinding.

7–56. To replace the cam hub, 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.

7–57. 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.

7–58. CAM OIL FEED TUBE AND BRACKET. If the oil feed tube is loose in the bracket, tighten it by coating the end of the tube with solder.

7–59. VALVE TAPPET BALL SOCKET REPLACEMENT.

7–60. Place the tappet between the clamp and holder of PWA-5160 Pusher (Figure 7–9) so that the oil hole can be engaged by the cone pointed set screw; then secure the clamp with the handknobs, and plug the oil hole in the socket with a steel pin.

7–61. Close the cover; then, using PWA-3755 Pump, connected to the coupler, hydraulically eject the socket from the tappet.

7–62. Install a new socket in the tappet, using an arbor press and PWA-1974 Holder (Figure 7–10). Check the tappet diameter for distortion. If necessary, lap the tappet down to its original diameter (Figure 7–11).

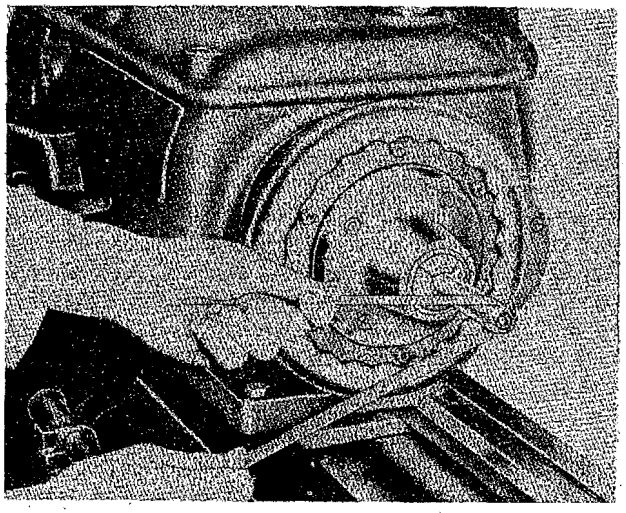


Figure 7–11

7–63. VALVE TAPPET GUIDE REPLACEMENT.

7–64. Refer to "Expansion of Parts by Heat," paragraph 7–28, and heat the case adjacent to the guide to 120°C (248°F); then remove the old guide, using PWA-2362 Drift. Clean up the guide hole with crocus cloth and oil.

7–65. If a standard size guide will not give the desired fit, .010 inch oversize guides are available. When an oversize guide is to be installed, ream the hole only enough to insure roundness (Figure 7–12); then turn down the outside diameter of the oversize guide to give the desired fit (Figure 7–13). See reference 25, Section XII. Prior to installation, coat the guide and the case hole with a suitable lubricant. Heat the case again to 120°C (248°F), chill the guide if necessary and install it in the case.

7–66. To insure the proper positioning of the guides, the following table gives the part number and type of guide to be installed in each position.

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

7–67. If two adjacent valve tappet guides are to be installed, insert PWA-828-3 Aligning Plug in one guide hole; then place PWA-827 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 PWA-4234-30 Drift (Figure 7–14). If only one guide is to be installed, place PWA-827 Aligning Bar in the slotted end of the installed guide and drive the new guide into position, using PWA-4234-30 Drift.

7–68. After all the guides have been installed and before the case has cooled, drive each guide solidly into position, using PWA-4234-30 Drift and a mallet; then check the alignment of all guides, using PWA-827 Aligning Bar. If the aligning bar does not slide freely in the guide slots, the guides are not parallel and must be repositioned.

7–69. Tap the screw holes in each newly installed guide with a 5/16-24 NF-3 tap.

7–70. Install PWA-1369 Clamp on the slotted end of the guide to prevent expansion; then finish ream the guide, using TAM-20933 Spiral Reamer (Figure 7–15). See reference 26, Section XII.

7–71. FRONT BREATHER PLUG. Replace the front breather plug if any defects were found at inspection.

7–72. PROPELLER OIL FEED TUBES. Clean up any minor defects on the tubes. If serious defects exist, replace the tubes.

7–73. THRUST BEARING COVER. Stone out any minor defects and replace any loose rivets.

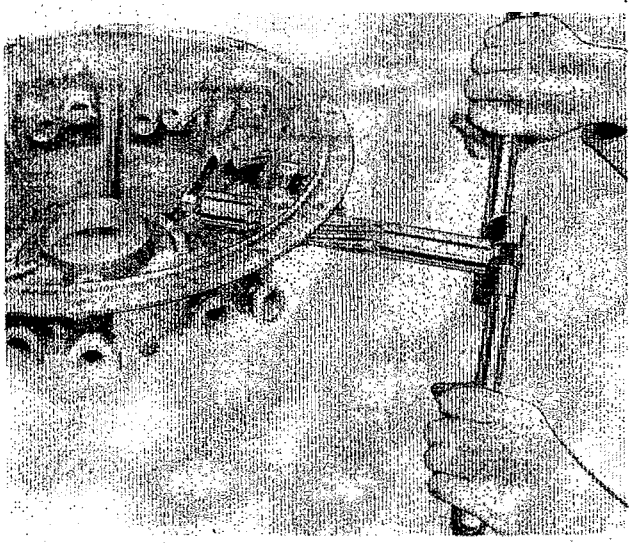


Figure 7–12

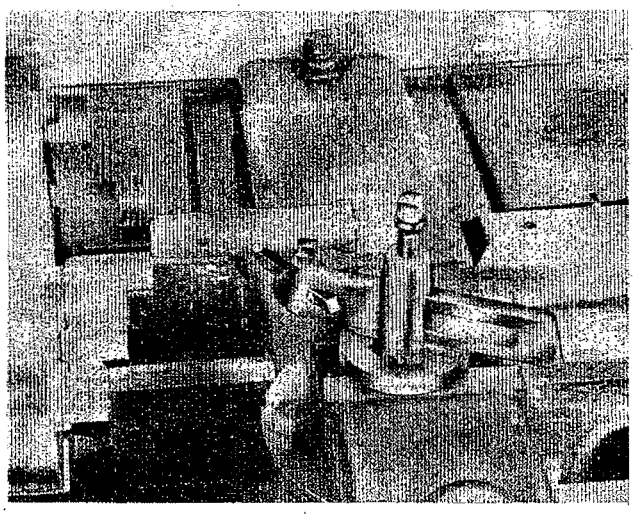


Figure 7–13

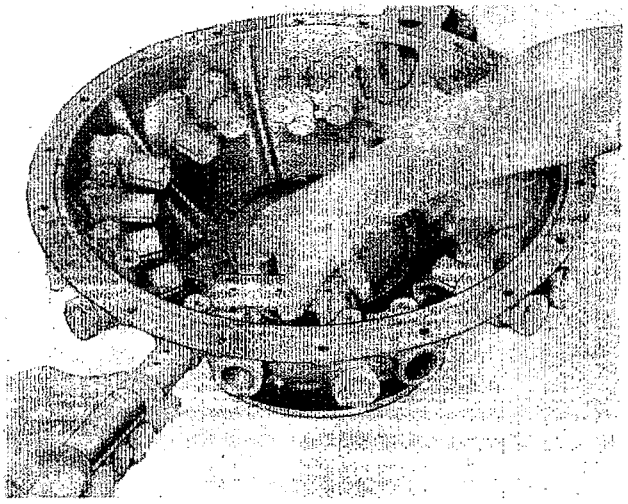


Figure 7–14

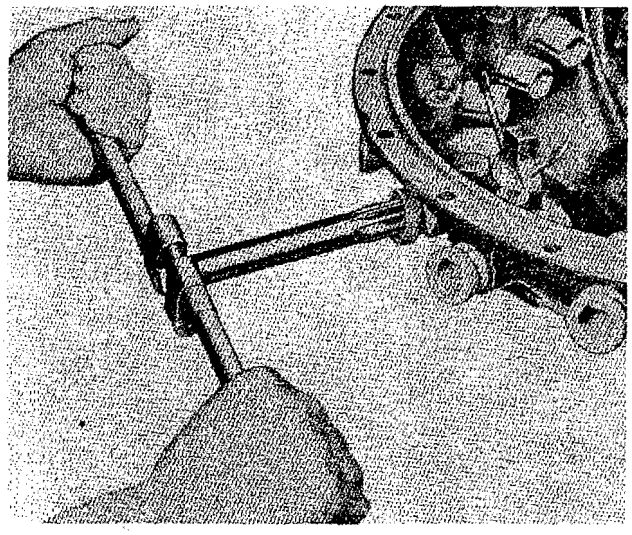


Figure 7–15

7–74. THRUST BEARING OIL SLINGER. Minor mutilations may be stoned with a smooth stone.

7–75. FRONT CRANKSHAFT OIL SEAL RING CARRIER. Replace all front crankshaft oil seal rings at every overhaul.

7–76. CRANKSHAFT FRONT AND REAR BEARING LINERS.

7–77. If either of these liners requires replacement, mount the crankcase front or rear 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 ⅛ 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 "Expansion of Parts by Heat," heat the crankcase to 120°C to 150°C (248°F to 302°F); then drive out the liner. Clean up the bore of the case.

7–78. Reheat the crankcase to 120°C to 150°C (248°F to 302°F), and chill the new liner; then drift the liner into position, placing the lockpin 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.

7–79. Bolt the crankcase front and rear 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 O.D. of the crankcase front section. Grind the liners to the prescribed diameter (Figure 7–16).

7–80. The following grinding procedure and equipment is satisfactory for grinding crankcase liners:

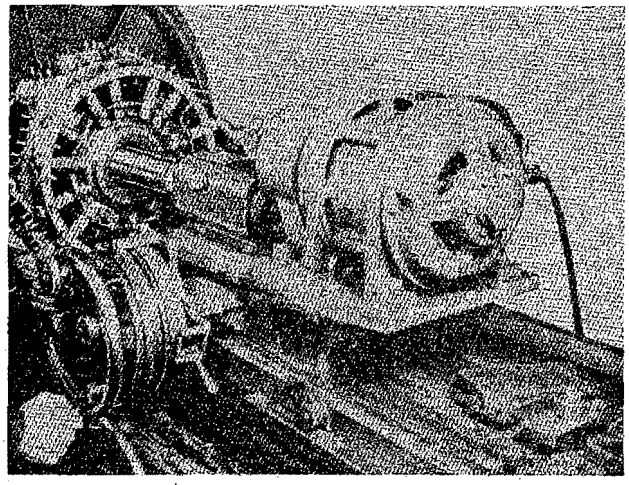


Figure 7–16

Method	Wet Grinding
Surface Speed	5859 ft./min.
Wheel Speed	5500 rpm.
Work Speed	100 rpm.
Type of Wheel	3880 18BE

7–81. MAIN ROLLER BEARINGS. All components of the main roller bearings may be tin flashed if desired, to prevent corrosion and to restore small pits and irregularities on the bearing races. The tin flash must be kept to a maximum thickness of .0001 inch.

7–82. OUTER FLYWEIGHTS AND LINERS.

7–83. If the outside diameter of an outer flyweight is galled, grind down the galled surface. Remove only enough material to clean up the galling.

7–84. After grinding, the outside diameter of the outer flyweight must not be less than the dimensions shown in the following table. The ground surfaces must be treated with Parco-Lubricate.

Outer Flyweight Part No.	Minimum Dimension
34462	1.814 inches
34463	2.163 inches

7–85. If the inside diameter of a 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 the dimensions shown in the following table.

Flyweight Liner Part No.	Maximum Dimension
34461	2.310 inches

7–86. CRANKPIN LAPPING. Plug the holes in the crankpin with heavy grease or soft wax; then lap the

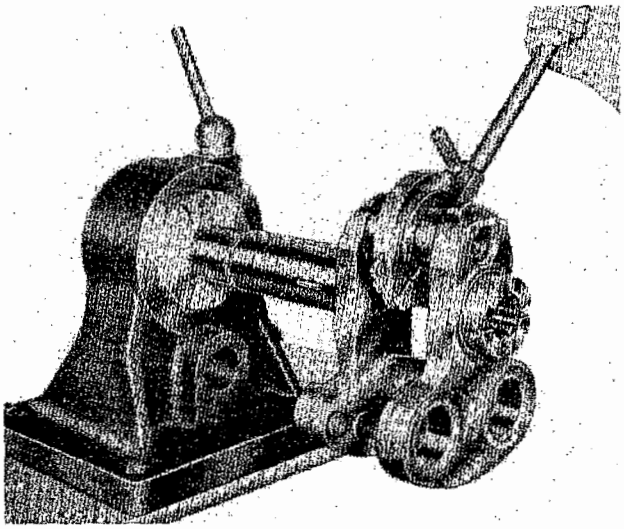


Figure 7–17

crankpin with PWA-981-1 Lap, and PWA-980 Lap Holder (Figure 7–17). 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.

7–87. MASTEROD BEARING REPLACEMENT.

7–88. 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.

7–89. When ordering bearings, standard sizes will be supplied unless otherwise specified. When standard size bearings no longer give the desired fit a .002 inch undersize bearing is available. In exceptional cases, when the crankpin has been ground to a size where the .002 inch undersize bearings give excessive crankpin clearances, special undersize bearings are available. In ordering the special undersize bearings, specify the diameter of the crankpin rather than the size of the bearing.

7–90. To remove the masterod bearing, heat the masterod in an oil bath to 218°C to 232°C (425°F to 450°F). Place the masterod, bearing flange side down, on a wooden block incorporating a hole large enough to receive the bearing.

7–91. Install PWA-5353 Drift in the bearing, apply water, and drift out the bearing with a heavy hammer.

7–92. 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.

7–93. Magnetically inspect the bore of the masterod whenever a bearing is removed. It is recommended that the bearing be removed and the rod bore magnafluxed at about 2500 hours whether or not the bearing requires replacement. See "Magnetic Inspection," paragraph 6–170.

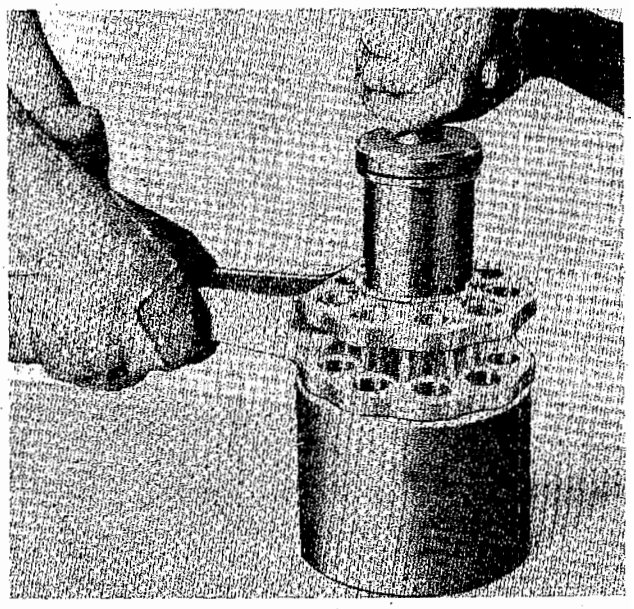


Figure 7–18

7–94. To install a bearing, heat the masterod in an oil bath to 218°C to 232°C (425°F to 450°F.) Place the bearing in position on TAM-315 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 the bearing and arbor with dry ice.

7–95. 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 7–18). 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 TAM-315 Arbor, press the flange of the bearing against the face of the rod.

7–96. REMOVAL OF RUST PITTING ON MASTER AND LINKRODS. In order to salvage rust pitted master and linkrods, the rods must first be cleaned in an alkali bath; then polished and buffed. Check the polished rods for weight, dimensions, and amount of pitting. The minimum acceptable weight of the masterod (including pistonpin bushing and standard size masterod bearing) after polishing and buffing, is 9.045 pounds, and the minimum acceptable weight of a linkrod (and bushings)

is 1.675 pounds. Minimum acceptable weights for masterods may be reduced .005 pound for each linkpin hole which is .005 inch oversize or .010 pound for each linkpin hole which is .010 inch oversize. For undersize masterod bearings, add .004 pound for each .001 inch undersize.

7–97. Do not deviate from the blueprint tolerances listed, when polishing master and linkrods.

7–98. The location and extent of the pitting which still remains on sample reworked rods is illustrated in (Figures 7–19 through 7–24). Four of the illustrations, (figures 7–19 through 7–22), show the maximum acceptable pitting on the rods and two illustrations, (figure 7–23 and figure 7–24), show unacceptable pitting. A rust pitted condition is least acceptable in that area of the rod where the channel section merges into the pistonpin or linkpin strap. The acceptance or rejection of the reworked rods must necessarily depend to a certain extent on the inspector's judgement and discretion so far as rust pitting is concerned; however, no reworked rod should be accepted on which pitting exceeds that shown in the last two illustrations; (figures 7–23 and 7–24).

7–99. PISTONPIN BUSHING REPLACEMENT.

7–100. Press out the old bushing, either solid or split

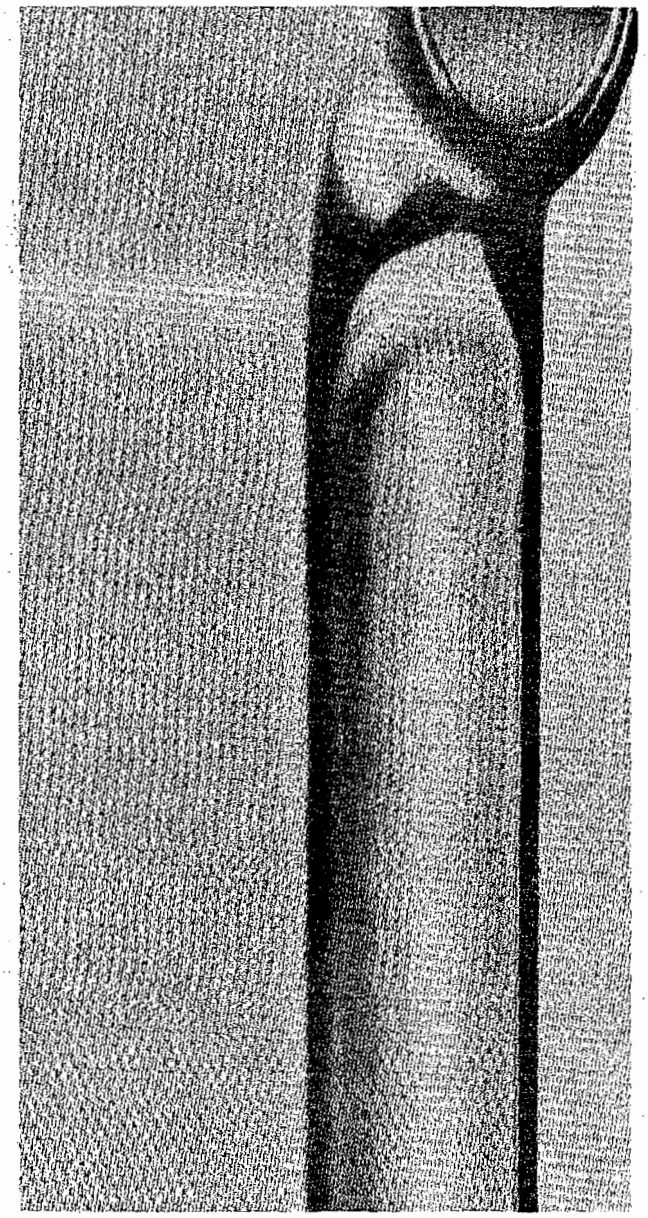


Figure 7–19. Maximum Acceptable Rust Pitting in Channel Section of Linkrod

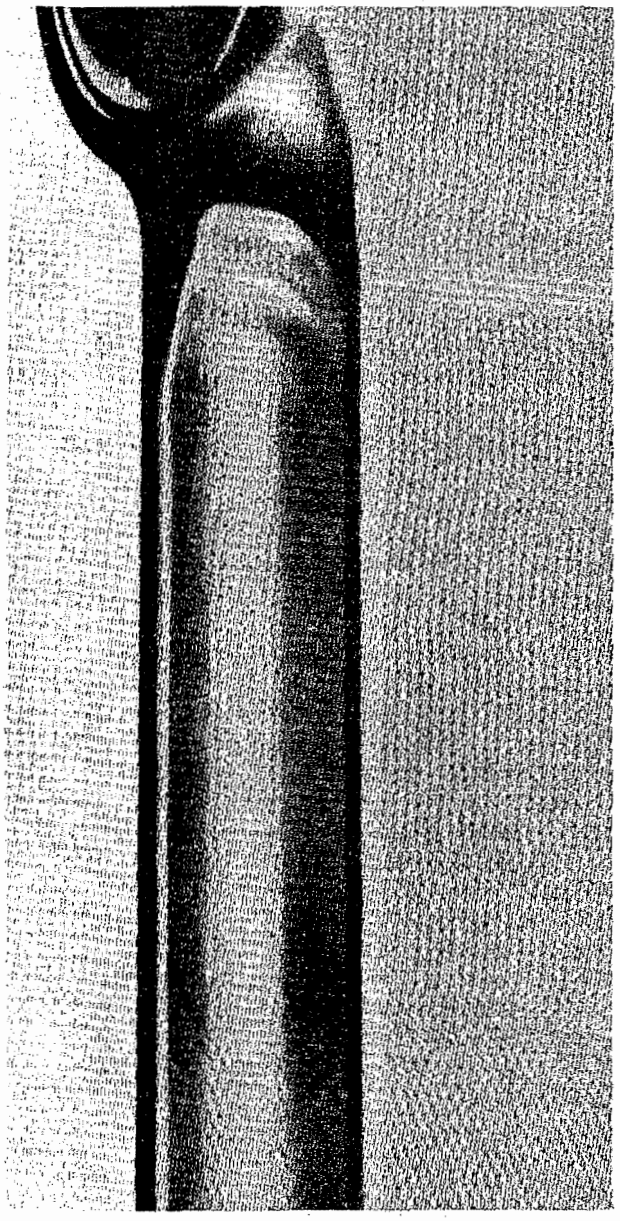


Figure 7–20. Maximum Acceptable Rust Pitting in Channel of Linkrod

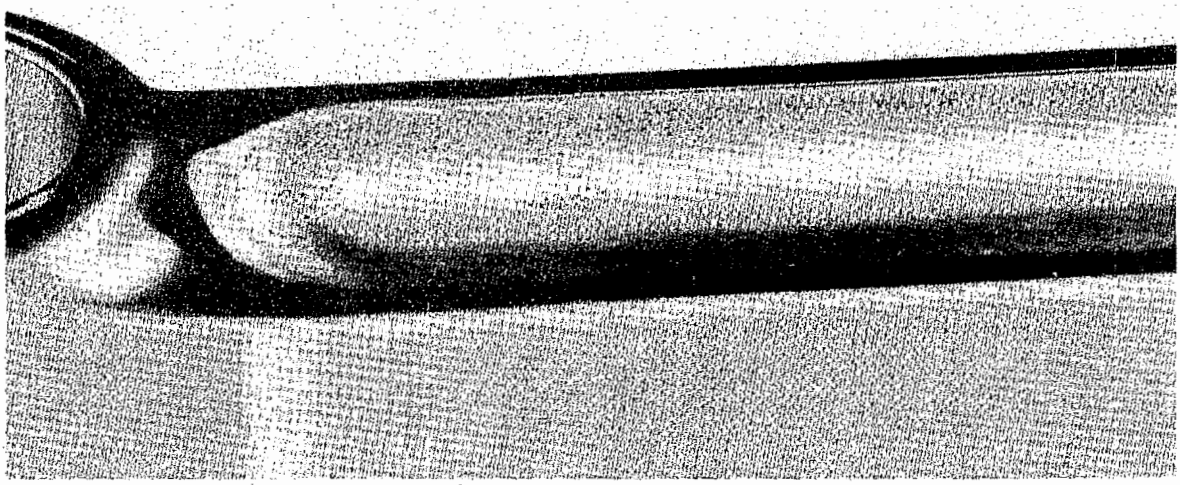


Figure 7—21. Maximum Acceptable Rust Pitting in Channel Section of Linkrod

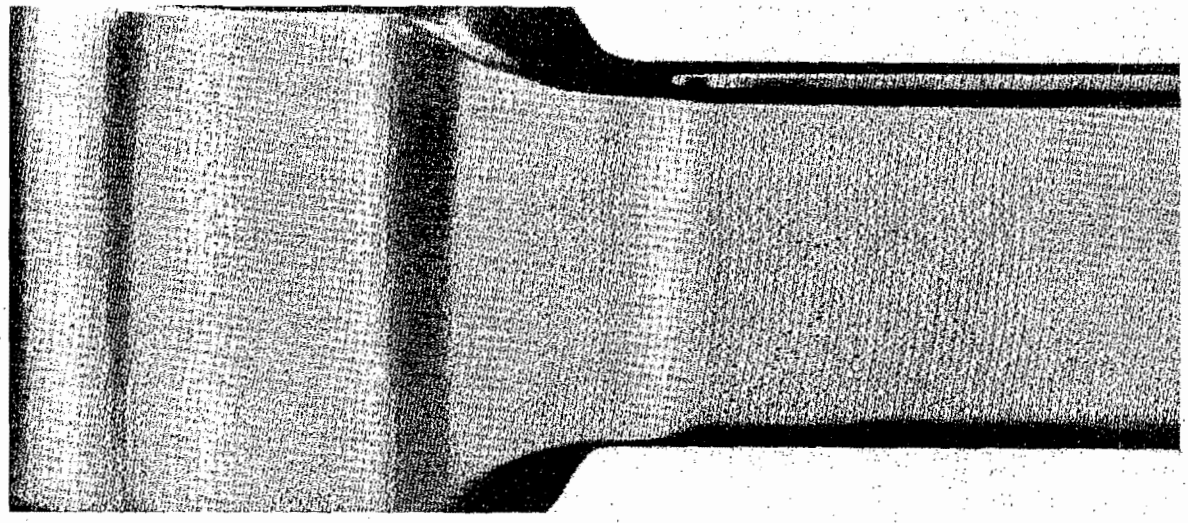


Figure 7—22. Maximum Acceptable Rust Pitting in Channel Section of Linkrod

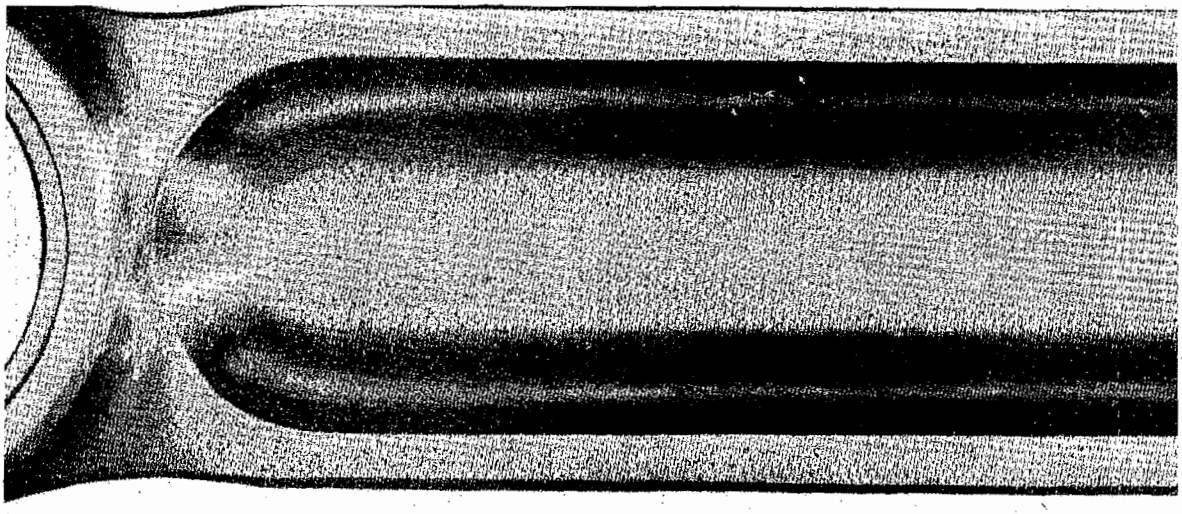


Figure 7—23. Unacceptable Rust Pitting in Channel Section of Linkrod

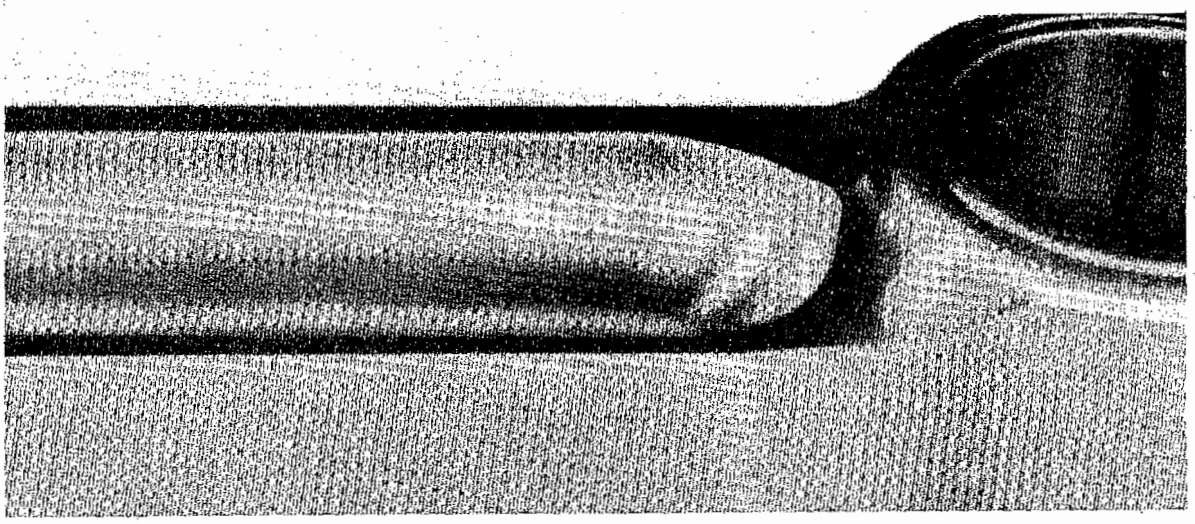


Figure 7–24. Unacceptable Rust Pitting in Channel Section of Linkrod

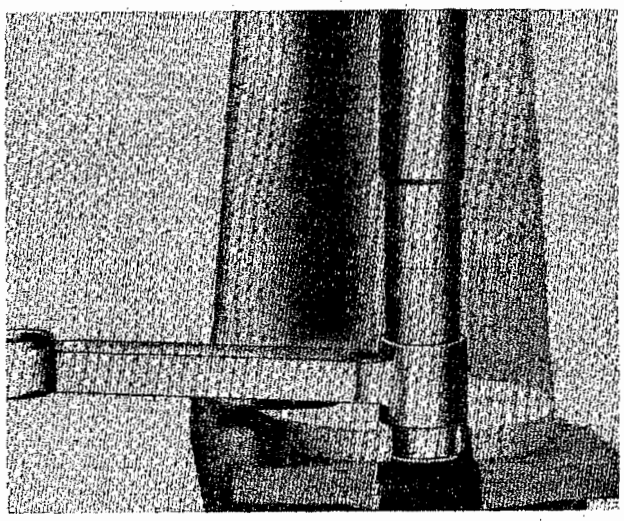


Figure 7–25

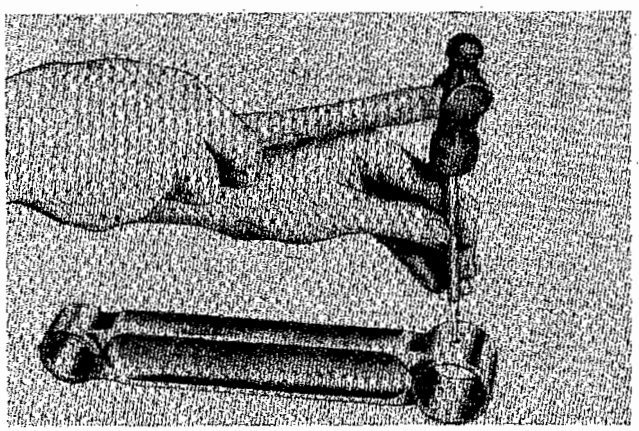


Figure 7–26

type, using PWA-1641 Drift and an arbor press (Figure 7–25). Drift the sheared lockpin out of the rod (Figure 7–26).

7–101. Press a new bushing into the rod, using PWA-4548 Drift. See reference 307, Section XII. 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 centerline of the rod. Transfer drill the lockpin hole half way through the wall of the bushing, using a No. 19 (.166 inch) drill with the end ground flat (Figure 7–27). Drive in the new lockpin, using PWA-1777 Arbor (Figure 7–28), and smooth the outer end of the pin to conform to the contour of the bushing boss.

7–102. Bore the bushing to size, using a Fulmer Aircraft Rod Borer, or equivalent, (Figure 7–29). Align the rod against the plates of the fixture, stoning the edges of the rod lightly, if necessary.

7–103. Check the size of the bore of the bushing with PWA-1805-1 Gage (Figure 7–30). See reference 306,

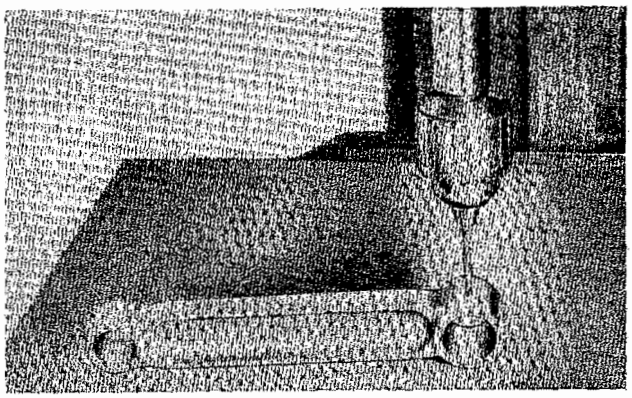


Figure 7–27

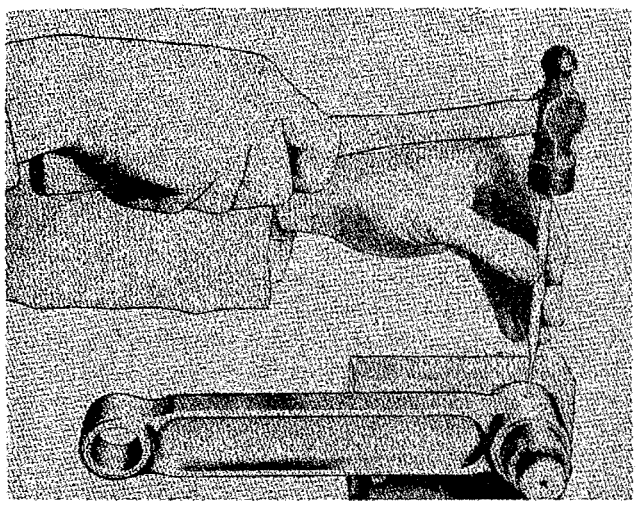


Figure 7–28

Section XII. Recheck the rod alignment as directed in paragraphs 6–96 to 6–102.

7–104. LINKPIN BUSHING REPLACEMENT.

7–105. Press out the old bushing, using PWA-1493 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 PWA-2551-4 Drift and an arbor press (Figure 7–31). See reference 320, Section XII.

7–106. Bore the bushing, using a Fulmer Aircraft Rod Borer, or equivalent, (Figure 7–29). Lead flash plate the inside diameter of the bushing; then check the size of the bore of the bushing with PWA-1805-110 Gage. Check the fit of the corresponding linkpin in the new bushing (Figure 7–32). See reference 321, Section XII. Recheck the alignment of the rod as directed in paragraph 6–96.

7–107. CYLINDER FLANGE REPAIR. If necessary, lap the cylinder barrel parting surface, using PWA-2898 Lap. Check the flange for flatness using PWA-2630-20 Surface Plate, and pencil carbon (Figure 7–33).

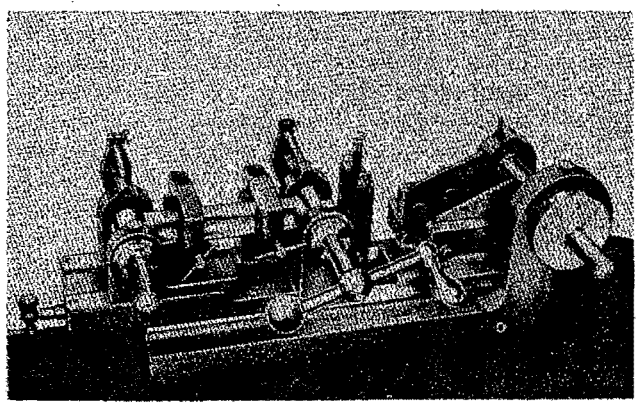


Figure 7–29

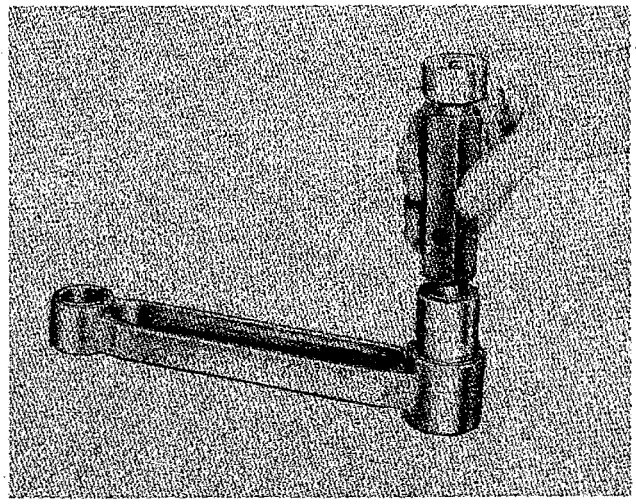


Figure 7–30

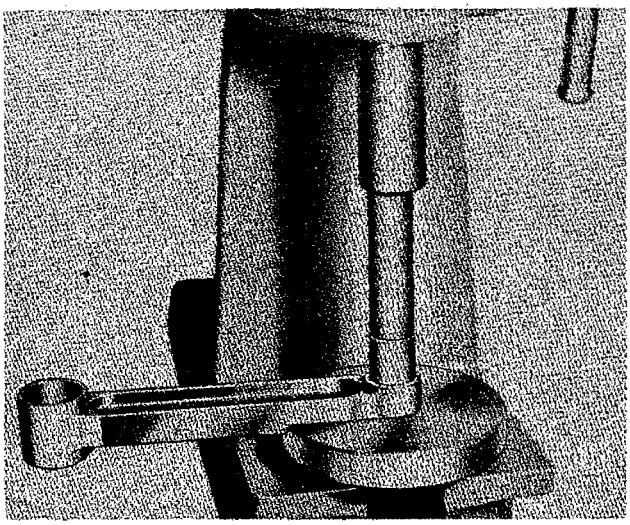


Figure 7–31

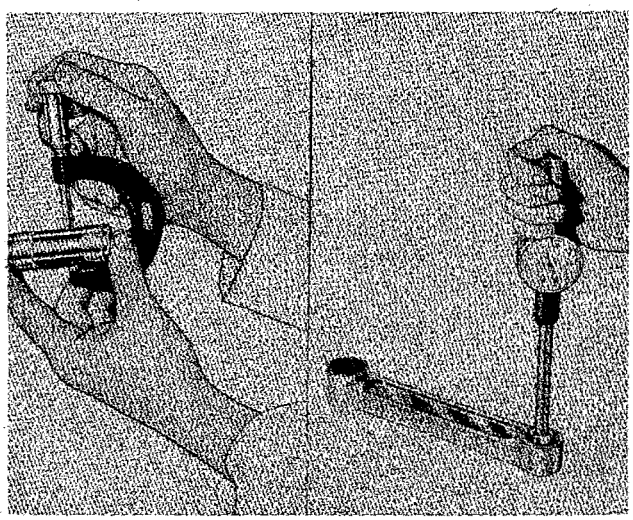


Figure 7–32

7—108. 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.

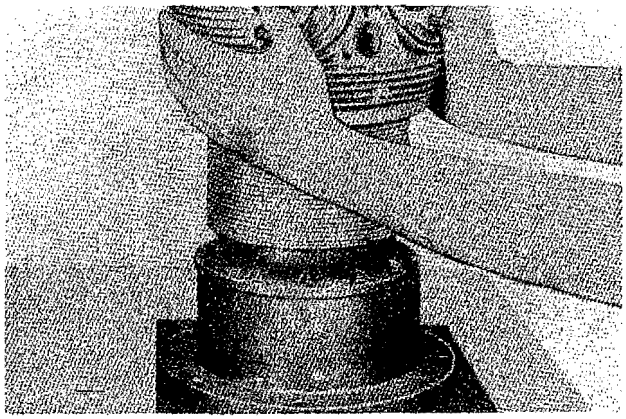


Figure 7—33

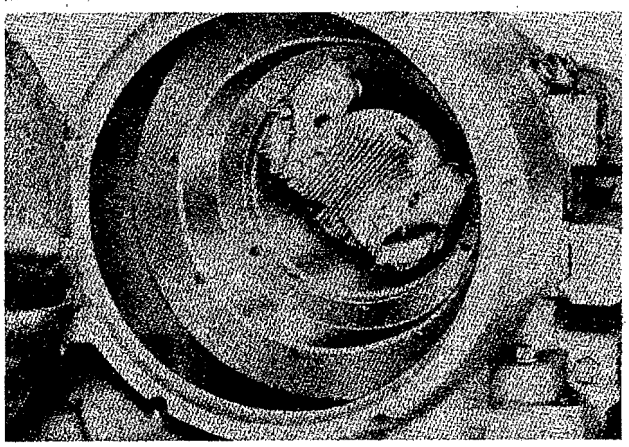


Figure 7—34

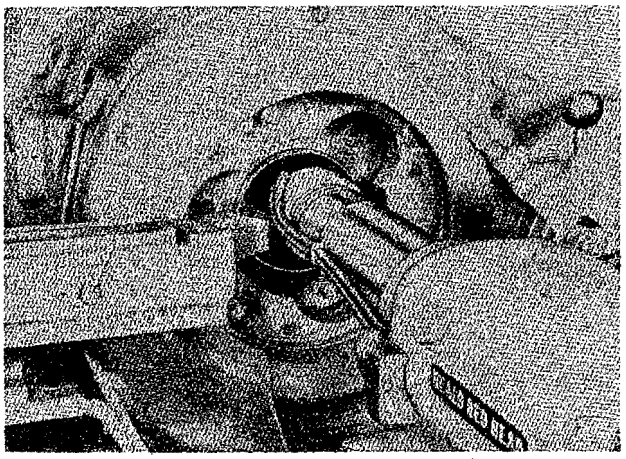


Figure 7—35

7—109. CYLINDER BARREL REPAIR.

7—110. When a step of .006 inch or more has been worn at the upper extremity of the top pistonring travel and the barrel is within the limits in other respects, remove the step by one of the following methods.

7—111. Use a small portable grinder equipped with a small grinding wheel, and grind only the part of the cylinder wall about the top ring travel. Blend the reground surface into the adjacent part of the cylinder barrel.

7—112. Mount the cylinder enough off center in a grinding machine such as the Heald No. 73 or Heald No. 50 to permit the stepped portion to be ground without the removal of much material from the rest of the top of the barrel bore (Figure 7—34). Use a standard grinding wheel which has been undercut for a part of its width and whose remaining standard diameter is approximately equal in width to the part of the cylinder barrel above the step. Use a Norton 3860-18BE grinding wheel, a wheel-speed of 4600 to 5200 rpm, and a grinding fluid such as International Chemical Compound No. 141 (Figure 7—35). If the cylinder is mounted in a Heald No. 50 Grinder, the arm of the grinder should turn at approximately 75 rpm, if the cylinder is mounted in a Heald No. 73 Grinder, the chuck speed should be 280 to 360 rpm. Blend the reground surface into the adjacent part of the cylinder barrel.

7—113. Use a tapered grinding wheel which conforms to the angle of barrel choke and remove the same amount of material all around the top of the barrel bore (Figure 7—36). Blend the reground surface into the adjacent part of the cylinder barrel.

7—114. When scoring or other irregularities make it necessary to hone or grind a cylinder barrel and it is desired to recondition rather than to rebarrel the cylinder, it is important that the normal choke contour of the barrel be retained. The curve (Figure 7—36) shows the desired contour for the cylinder wall, and every effort should be made to hold as closely as possible to this contour.

7—115. Where honing is to be used for reconditioning, special equipment, such as that furnished by the Micromatic Hone Corporation, Detroit, Michigan, is required. Operators should be specially trained for this work since closely controlled manipulation of the hone is very important in retaining the desired cylinder wall contour. Cylinder wall finish is dependent on the grade of stone as well as the technique of the operator. A surface finish of 15 to 20 micro-inches root mean square is desirable.

7—116. For details regarding the grinding or honing of cylinder barrels Air Force personnel should refer to T.O. No. 02-1-16 and Navy personnel should refer to General Engine Bulletin No. 24.

7—117. Profile grinding through the use of a cam type grinder is preferable to honing since, with profile grinding, greater consistency and accuracy are generally possible.

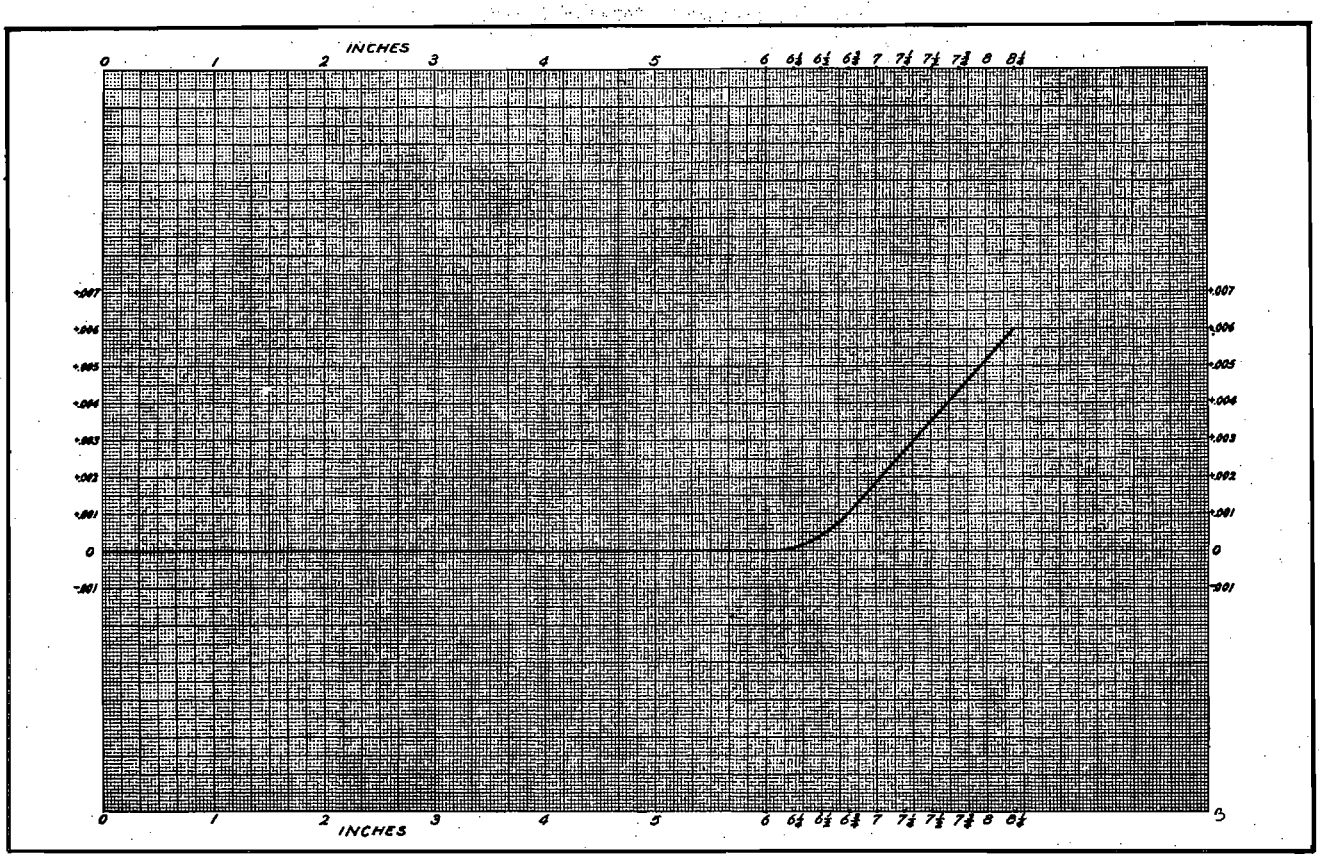


Figure 7–36

7–118. As the heat resulting from grinding or honing causes expansion of the cylinder barrel, any measurement of the bore should be taken after the barrel has cooled to room temperature.

7–119. Arrange and fit the rings as described in paragraph 7–176; then lap the rings as described in paragraph 7–179.

7–120. INLET VALVE GUIDE REPLACEMENT.

7–121. Heat the cylinder head to 95°C (203°F) as directed in "Expansion of Parts by Heat," paragraph 7–28. Install PWA-4002-100 Puller, apply water, and remove the old guide (Figure 7–37).

Note

If an inlet valve seat is to be replaced, do not remove the corresponding valve guide until after the seat has been removed.

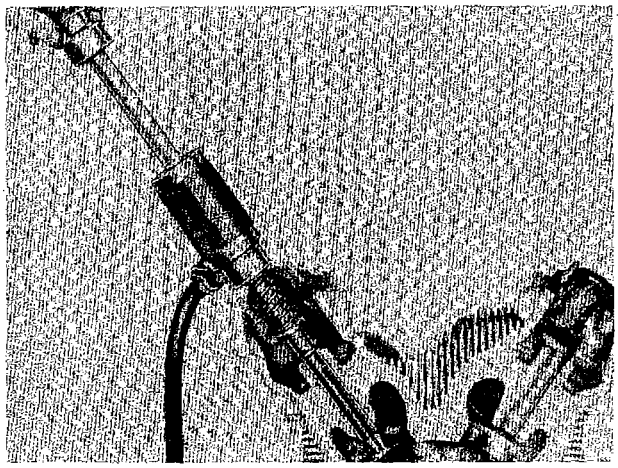


Figure 7–37

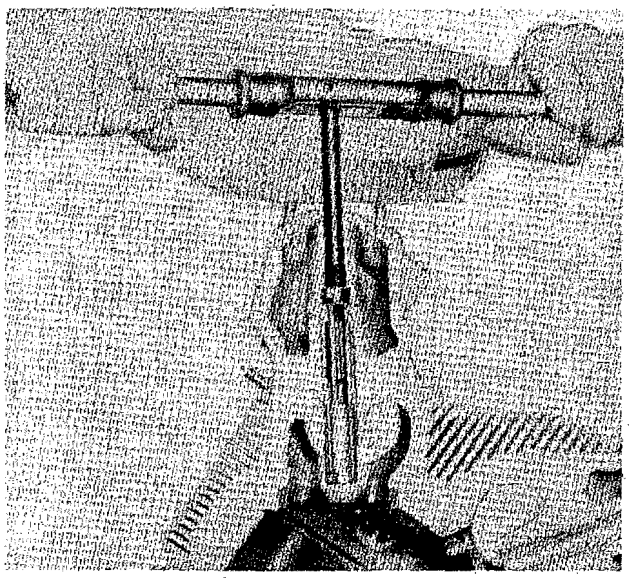


Figure 7–38

7–122. Check the guide hole in the cylinder head for damage and out-of-roundness, particularly at the bottom. If necessary, ream the hole oversize only enough to make it round, using PWA-301 Reamer (Figure 7–38). Turn down the next oversize guide to give the desired fit (Figure 7–39). See reference 40, Section XII. Inlet guides are available in .003 inch, .005 inch, and .010 inch oversize.

7–123. Heat the cylinder to about 95°C (203°F) as directed in "Expansion of Parts by Heat," paragraph 7–28, smear the new guide with a mixture of oil and graphite grease, conforming to Specification No. AN-G-6, and install the new guide, using PWA-95 Drift (Figure 7–40). See reference 40, Section XII.

7–124. Ream the new guide, using PWA-2869 Reamer (Figure 7–41) and check the guide for size with PWA-4189-16 Gage (Figure 7–42). See reference 39, Section XII.

7–125. OPTIONAL METHOD OF REAMING VALVE GUIDE HOLES AND VALVE GUIDES. Refer to Figure 7–43 and to Overhaul Tools in Section III for a list of fixtures and reamers required to powder

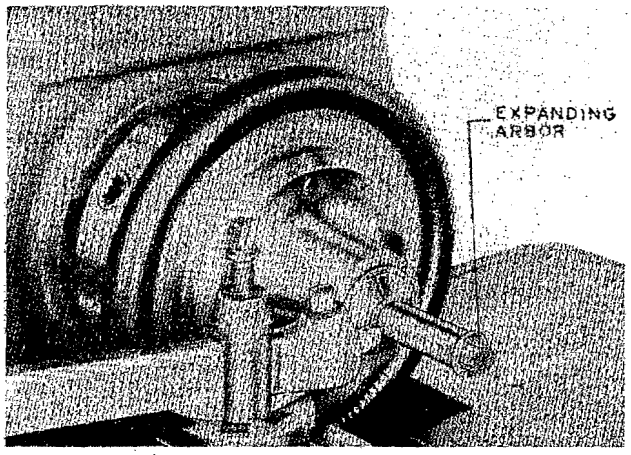


Figure 7–39

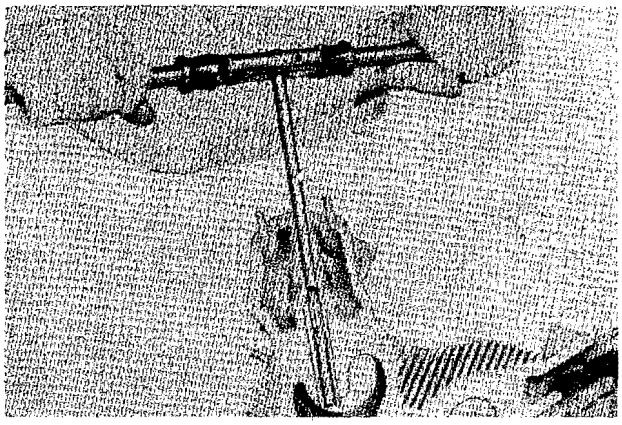


Figure 7–41

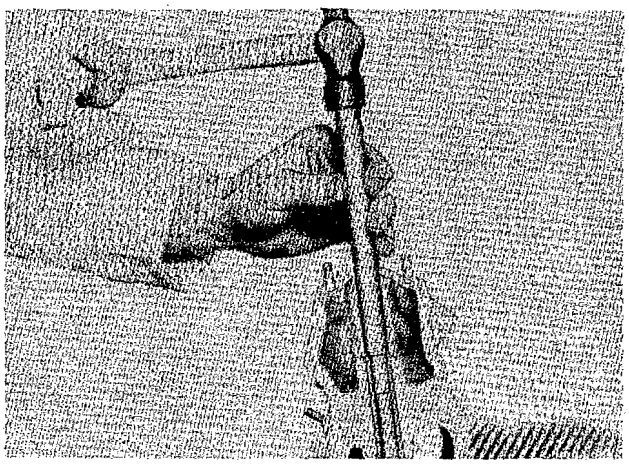


Figure 7–40

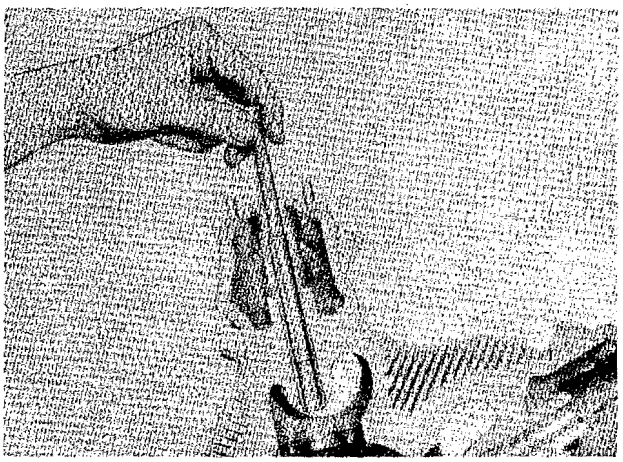


Figure 7–42

ream the cylinder inlet and exhaust valve guide holes and valve guides.

7—126. INLET VALVE SEAT FACING.

7—127. Face off the seating surface of all inlet valve seats at every overhaul, removing only enough material to obtain a smooth seating surface of the proper width. Replace valve guides requiring replacement, as directed in paragraph 7—120 before facing off the corresponding valve seat. To face the valve seat, take a light cut, using PWA-6 Holder and PWA-226-23 Facer (Figure 7—44).

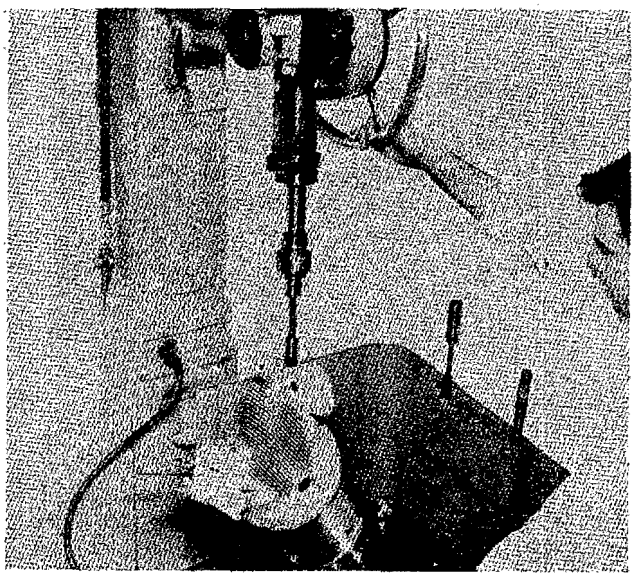


Figure 7—43

CAUTION

Remove only enough material to clean up the seating surface of the valve seat; otherwise the life of the seat will be seriously affected.

7—128. If further cutting of the seat would damage the cylinder head, replace the seat as described in paragraph 7—137.

7—129. EXHAUST VALVE GUIDE REPLACEMENT. Clean up the end of the exhaust valve guide, using PWA-3277-13 Scraper. Follow the procedure outlined for the removal of the inlet valve guide, paragraph 7—120, using the below-listed tools and referring to references 46 and 47, Section XII. Ream the new exhaust valve guides to .5590 ± .0005 diameter after being installed in the cylinder.

PWA-4002-101	Puller
PWA-4699-6	Hole Reamer +.003
PWA-4699-7	Hole Reamer +.005
PWA-4699-8	Hole Reamer +.010
PWA-4699-9	Hole Reamer +.020
PWA-4699-43	Hole Reamer +.030
PWA-4700-505	Reaming Fixture (Power)
PWA-94	Assy. Drift
PWA-4701-1	Guide Reamer
PWA-4327	Max. Wear Gage (guide)
PWA-41989-12	Reaming Gage (guide)

Note

If an exhaust valve seat is to be removed, do not remove the valve guide until after the removal of the seat.

7—130. EXHAUST VALVE GUIDES AND BOSSES.

7—131. Face off all exhaust valve guides and bosses only enough to bring the lower end of each guide flush with the lower end of its boss and to remove any burned portions. Use PWA-3149-24 Fixture.

7—132. Place the base of the fixture on the table of a drill press on which the head has been inverted; insert the spindle through the base and engage it with the chuck of the drill press (Figure 7—45). Invert the cylinder and place it on the base with the spindle inserted through the valve guide. Attach the cutter to the projecting end of the spindle with its bayonet lock (Figure 7—46). Face off the guide and boss, being careful not to exceed the minimum length of 2.312 inches.

7—133. EXHAUST VALVE SEAT FACING.

7—134. Face off the seating surface of all exhaust valve seats at every overhaul, removing only enough material to obtain a smooth seating surface of the proper width.

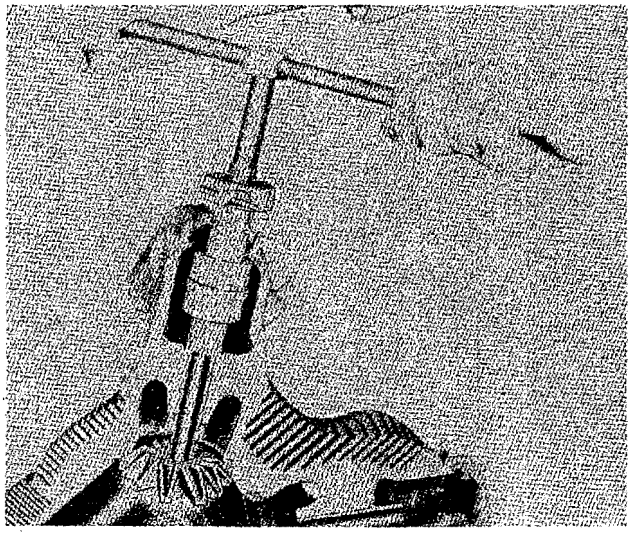


Figure 7—44

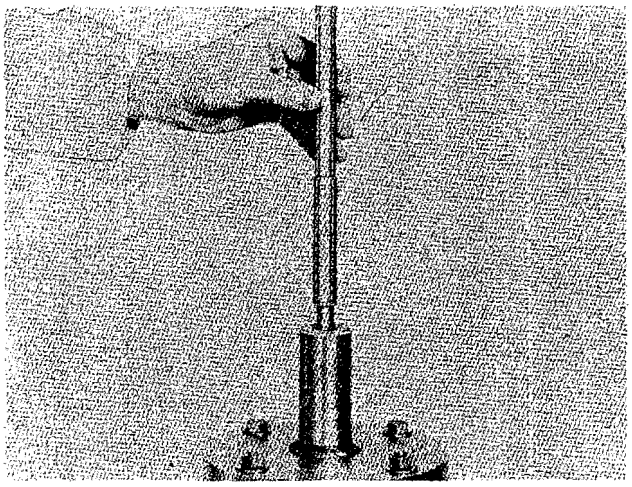


Figure 7—45

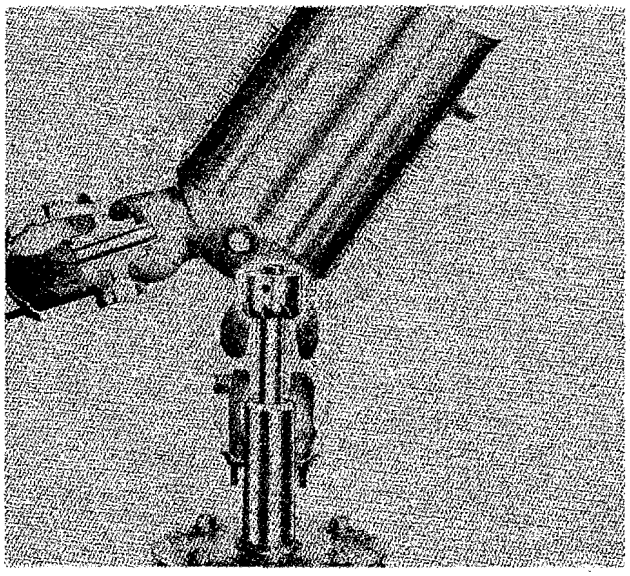


Figure 7—46

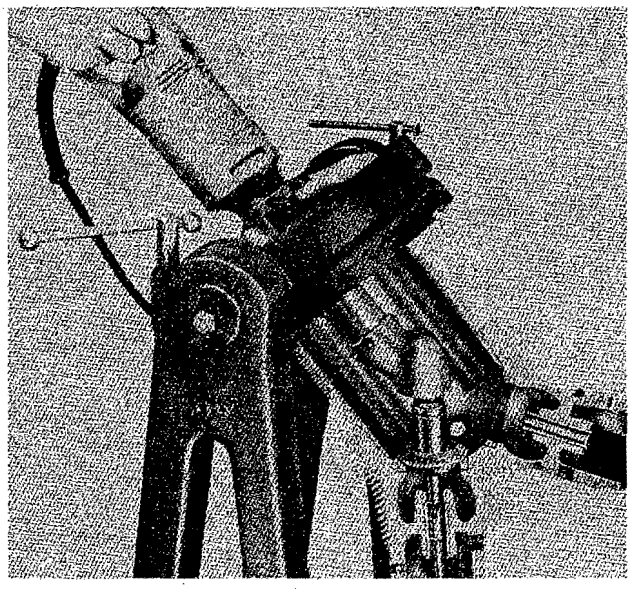


Figure 7—47

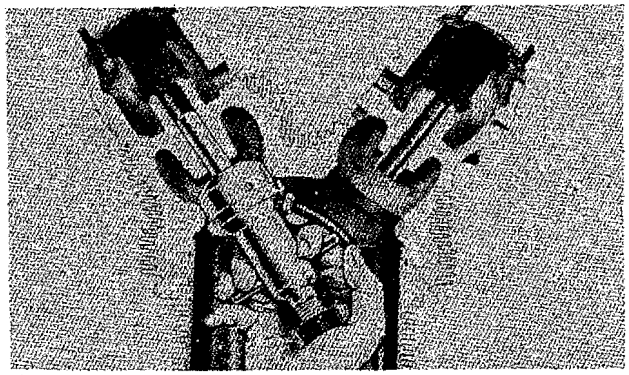


Figure 7—48

It is not necessary to remove small isolated dark spots entirely, particularly if they are not at the edge of the valve seating surface. To insure proper relationship between the seating surface of an exhaust valve seat and the axis of the corresponding valve guide, replace any exhaust valve guide which requires replacement before facing off the corresponding valve seat. See "Exhaust Valve Guide Replacement," paragraph 7—129.

7—135. Face off the valve seats, using a grinding wheel which has been dressed to exactly 45 degrees (Figure 7—47).

CAUTION

Remove only enough material to clean up the seating surface of the valve seat; otherwise the life of the seat will be seriously affected.

7—136. When the wall thickness at the lower extremity of an exhaust valve seat has been reduced to a point where further grinding would damage the cylinder head, replace the seat as described in "Exhaust Valve Seat Replacement," paragraph 7—140.

7—137. INLET VALVE SEAT REPLACEMENT.

7—138. Heat the cylinder head to 205°C (401°F) as directed in "Expansion of Parts by Heat," paragraph 7—28; then install PWA-4107-30 Remover in the valve seat (Figure 7—48). Apply water and withdraw tool and valve seat. Clean up the bore in the cylinder head, using a scraping tool.

CAUTION

Do not attempt to remove an inlet valve seat by driving or pulling, as aluminum tends to adhere to bronze and the cylinder head might be damaged.

7—139. Again heat the cylinder to 205°C (401°F); then install a new seat in the cylinder head, using PWA-4597-50 Holder (Figure 7—49). See reference 41, Section XII. Be careful not to turn the head on the barrel.

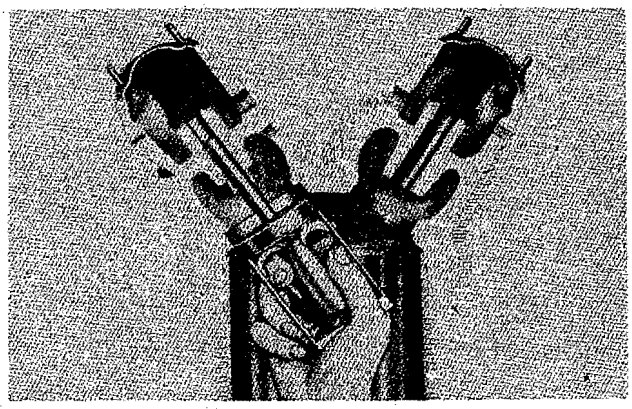


Figure 7—49

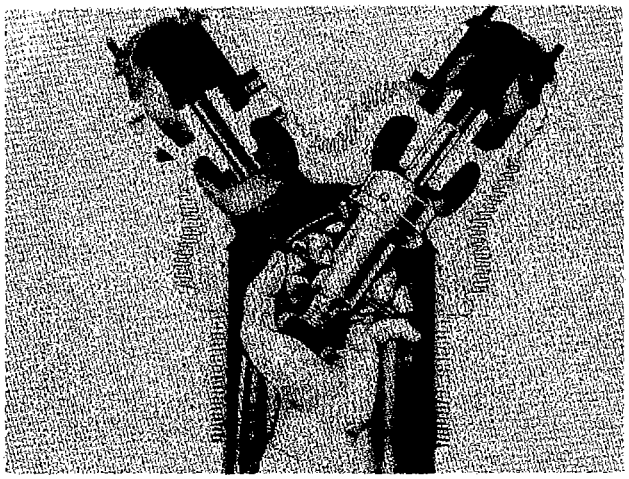


Figure 7—50

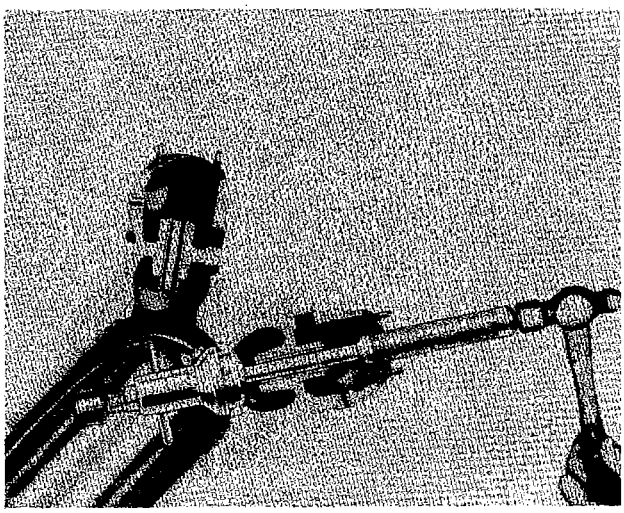


Figure 7—51

7—140. EXHAUST VALVE SEAT REPLACEMENT. To replace a valve seat heat the cylinder in an oven to 232°C to 260°C (450°F to 500°F), depress the plunger of PWA-4000-30 Remover and install the tool in the valve seat (Figure 7—50). Insert the drift (a detail of PWA-4000-30 Remover) through the valve guide, apply water, and drift out the valve seat (Figure 7—51). Clean up the valve seat bore in the cylinder head with crocus cloth and oil. Again heat the cylinder to 232°C to 260°C (450°F to 500°F) and install a new seat, using PWA-2782-10 Drift. While the cylinder is still hot, install and ream a new guide as described in "Exhaust Valve Guide Replacement," paragraph 7—129. Face off the seat as described in "Exhaust Valve Seat Facing," paragraph 7—133.

7—141. INLET VALVE REPAIR. Dress the seating surface of the inlet valves at each overhaul. Set the facing machine for an angle cut of exactly 45 degrees. Remove only enough material to clean up the surface. Replace an inlet valve when further facing will cause a sharp edge to be formed at the outer rim of the head.

7—142. EXHAUST VALVE REPAIR. To remove erosion from an exhaust valve, mount the valve in a Brown and Sharp No. 2 grinder, or equivalent, using a standard collet in the headstock to hold the valve. Grind the eroded portion at the edge of the valve head where it extends down into the stellite seat (Figure 7—52). Do not remove any more material than is necessary to remove the erosion, and make certain that the removal of material does not cause the valve head diameter to decrease to less than the minimum O.D. (Figure 7—52). With the valve still turning in the grinder, blend the ground edge of the valve into the rounded portion of the head; then buff the blended surface to a smooth finish. Reface the seating surface on the valve according to the instructions in paragraph 7—141 and acid etch the O.D. of the valve head lightly to make certain that the valve seating surface is entirely protected by stellite.

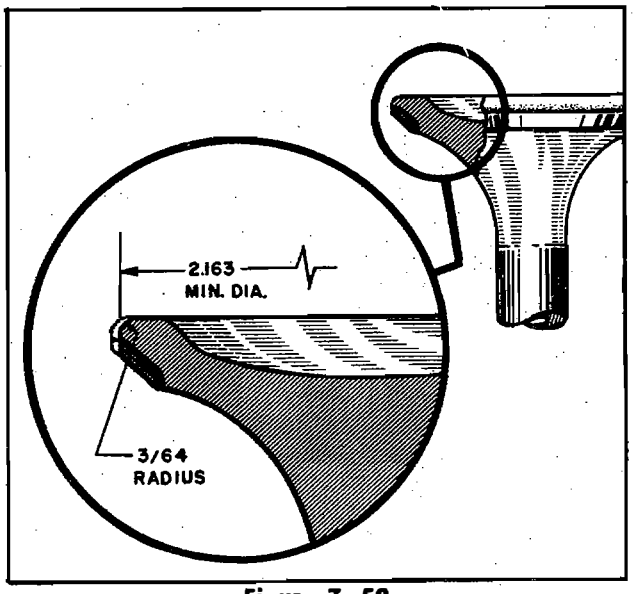


Figure 7—52

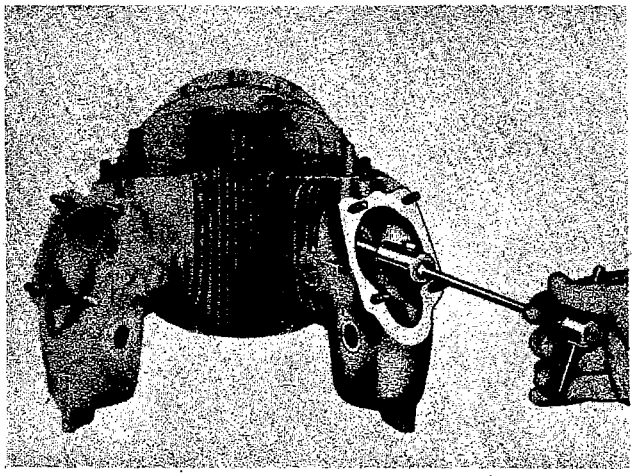


Figure 7—53

7—143. VALVE LAPPING. Place a little Clover 2A

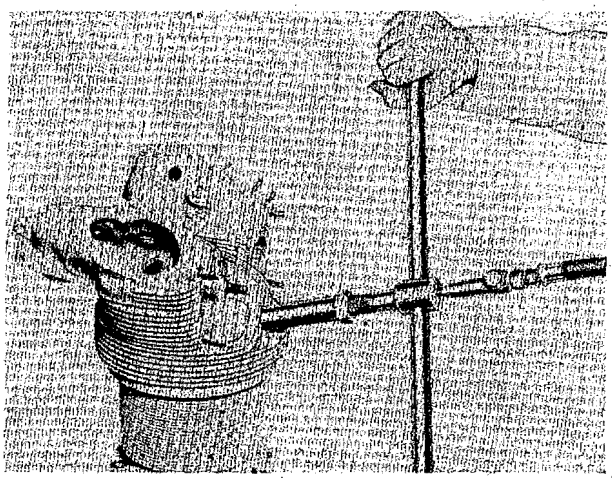


Figure 7–54

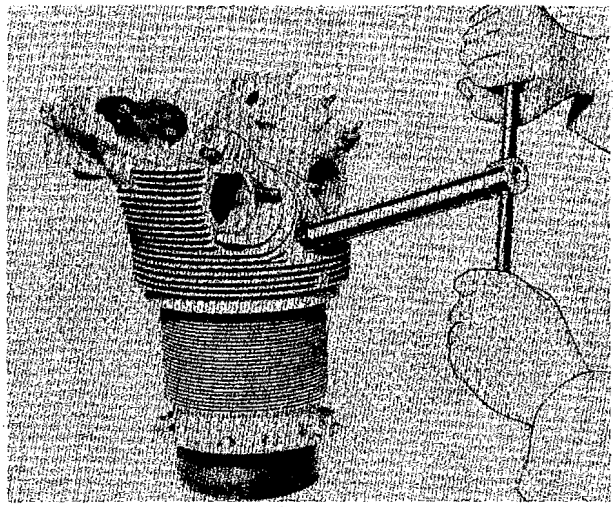


Figure 7–55

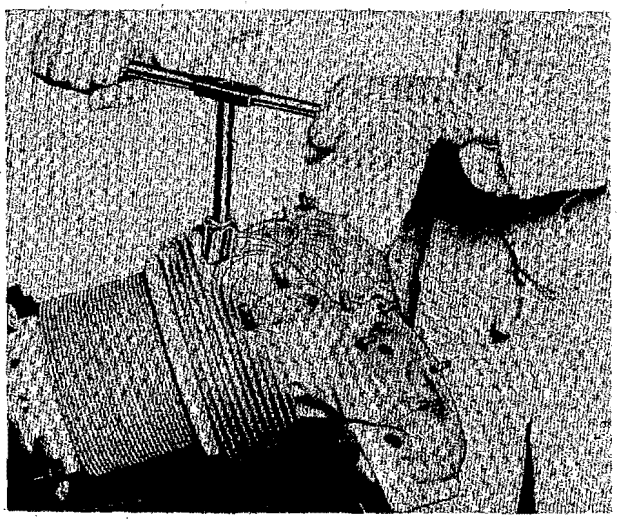


Figure 7–56

lapping compound or its equivalent on the seating surface of the valve, and insert the stem of the valve in its guide. Keep the compound away from the valve stem. Lap the valve with an oscillating motion, using PWA-10 Holder for inlet valves or PWA-11 Holder for exhaust valves (Figure 7–53). Clean the valve and valve seat. Check the valves for proper seating by partially filling the cylinder with fuel and checking for leaks.

7–144. SPARKPLUG BUSHING REPLACEMENT.

7–145. Heat the cylinder head to 250°C (401°F) as directed in "Expansion of Parts by Heat," paragraph 7–28. Install PWA-4005 Remover in the bushing, apply water, and unscrew the bushing by turning it in a clockwise direction (Figure 7–54). If necessary, the threads in the cylinder head should be cleaned up with PWA-334 Hole Tap and cutting oil. Insert the tap only enough to clean up the threads.

7–146. Again heat the cylinder head to 205°C (401°F), as directed in "Expansion of Parts by Heat," paragraph 7–28. Cover the threads with a suitable lubricant and install the bushing, which has a LEFT HAND thread on the O.D. using 3510-T-16 Driver (Figure 7–55).

CAUTION

While the cylinder head is hot, take care that it does not turn on the barrel.

7–147. If the engine is equipped with bronze bushings, PWA-1799 Counterbore may be used to bore the bushing to a thin shell which may be easily collapsed and removed.

7–148. If a bronze bushing is not flush with the recess in the cylinder head, face it off with 1068-T-5 Facer for the front bushing and 1068-T-3 Facer for the rear bushing (Figure 7–56). After the cylinder has cooled to room temperature, clean up the threads in the bushing with PWA-1526 Tap.

7–149. ROCKER SHAFT BUSHING REPLACEMENT. If it is necessary to replace one of the bushings for a rocker shaft, both bushings must be replaced. After referring to "Expansion of Parts by Heat," paragraph 7–28, heat the section of the cylinder adjacent to the bushings to 120°C (248°F). Remove the old bushings using PWA-1776 Puller for the small bushing and PWA-1466 Drift for the large bushing. 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 PWA-757 Drift for the small bushing and PWA-758 Drift for the large bushing. Do not install the large bushing until the small bushing has been installed in the thicker wall section of the rockerbox. Line ream the bushings, using PWA-1682 Reamer (Figure 7–57), then check the bushings for size, using PWA-1805-4 Gage. See references 52 and 54, Section XII.

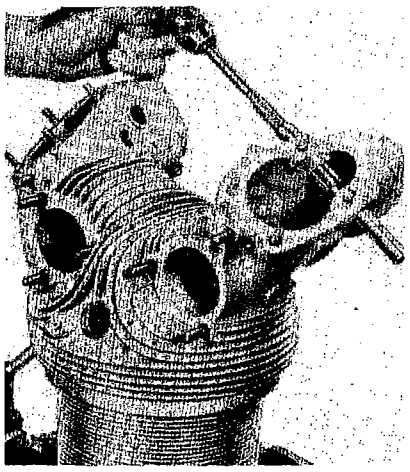


Figure 7—57

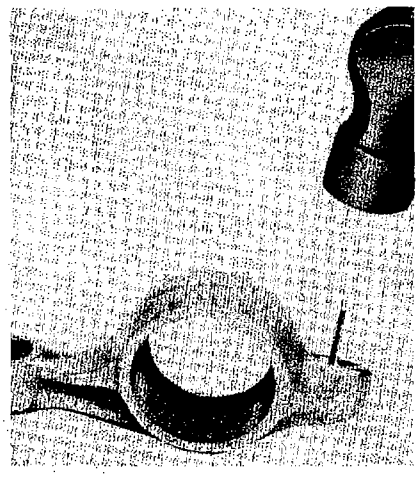


Figure 7—58

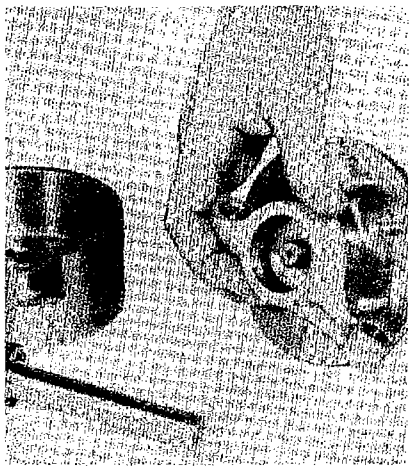


Figure 7—59

7—150. ROCKER BALL SOCKET REPLACEMENT.

7—151. Insert a tapered pin in the oil hole in the ball socket (Figure 7—58). With the rocker bearing removed, place the rocker on the pilot of PWA-1352 Fixture (Figure 7—59). Fill the plunger guide about half full of heavy oil and insert the plunger (Figure 7—60). Using a hammer or an arbor press, drive or press the plunger so as to drive the socket from the rocker (Figures 7—61 and 7—62).

7—152. Install a new socket, using PWA-2450 Fixture and an arbor press (Figure 7—63). See reference 35, Section XII.

7—153. COWL MOUNTING LUG REPAIR.

7—154. 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.

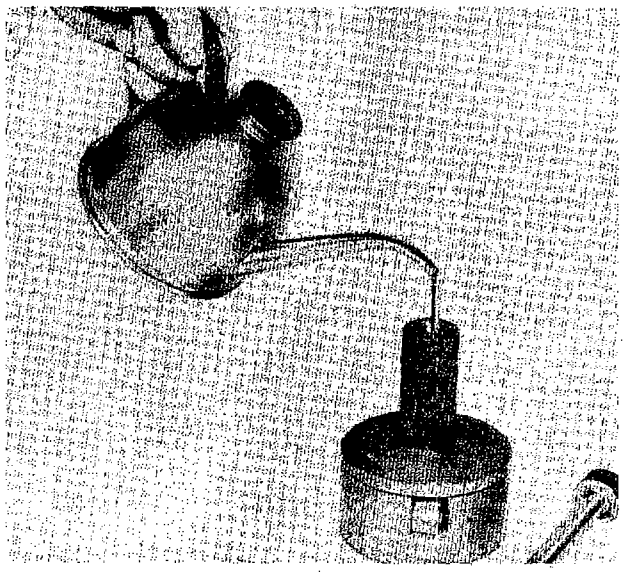


Figure 7—60

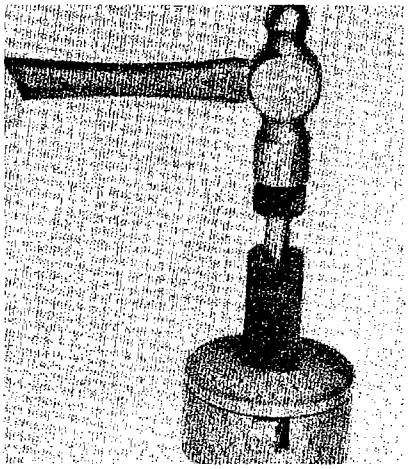


Figure 7—61

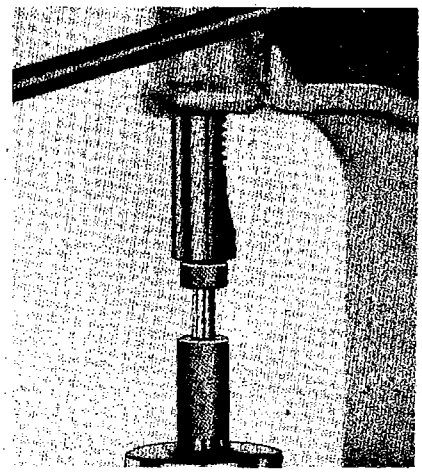


Figure 7—62

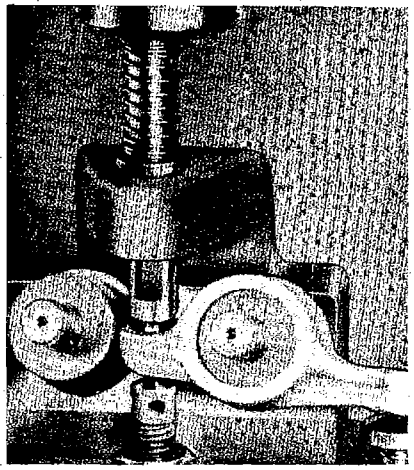


Figure 7—63

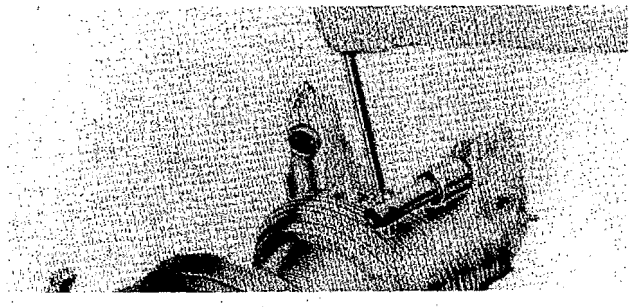


Figure 7–64

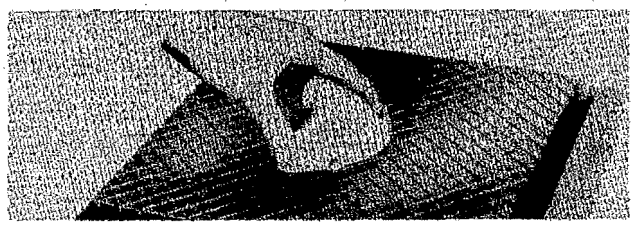


Figure 7–65

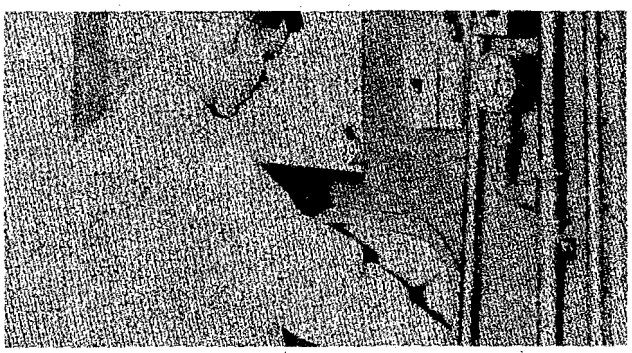


Figure 7–66

7–155. 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.

7–156. PUSHROD COVER NUT COUPLING REPLACEMENT. To replace a pushrod cover nut coupling, first remove the old coupling, using PWA-849 Driver (Figure 7–64). If a standard size replacement coupling will not give a sufficiently tight fit to prevent oil leakage, use a .004 inch oversize coupling. Install the new coupling, using PWA-491 Driver.

7–157. ROCKERBOX COVERS AND INTER-CYLINDER DRAIN TUBES. Remove the rubber hoses which join the rockerbox covers. These hoses must be replaced at every overhaul. Face off the rockerbox covers on a lapping plate, using a small amount of lapping compound (Figure 7–65). Wash the covers thoroughly to remove all of the lapping compound. Install new hoses

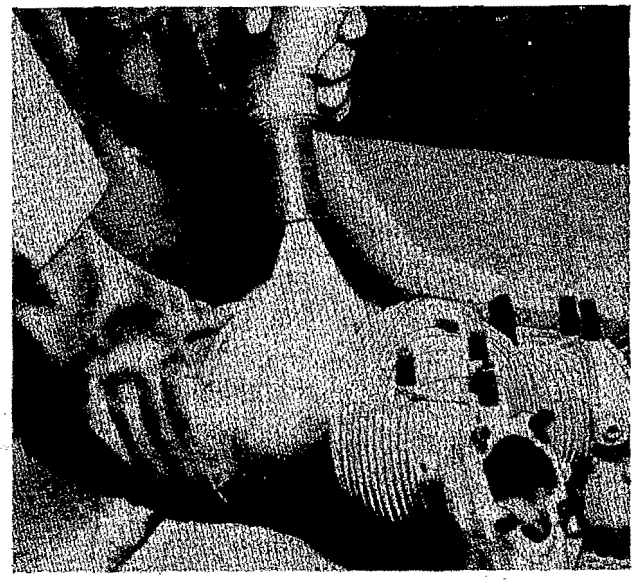


Figure 7–67

on the rockerbox cover inter-cylinder tube connections; then tighten the hose clamps.

7–158. INTER-EAR DRAIN TUBES.

7–159. All inter-ear drain tube hose connections must be replaced 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.

7–160. If an inter-ear drain tube requires replacement, remove the rubber hose connection; then back out the damaged tube. Coat the new tube threads with a thread lubricant; then install the tube. Metallize the new tube as described in "Cylinder Metallizing," paragraph 7–161; then install a new rubber hose connection and secure it with clamps.

7–161. CYLINDER METALLIZING.

7–162. Thoroughly clean and sandblast all surfaces to be metallized (Figures 7–66 and 7–67). 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.

7–163. Protect all areas not to be metallized with suitable masks. Mask the entire cylinder head except for the inter-ear drain tube. Mask the spot faced areas on the cylinder flange. Support the cylinder in a 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 and a turntable. The operator should wear an asbestos mitten, a respirator, and goggles.

7–164. Hold the spray gun approximately six inches from the cylinder barrel and at an angle of from 15 to 20 degrees to the fin surfaces in both directions, so that

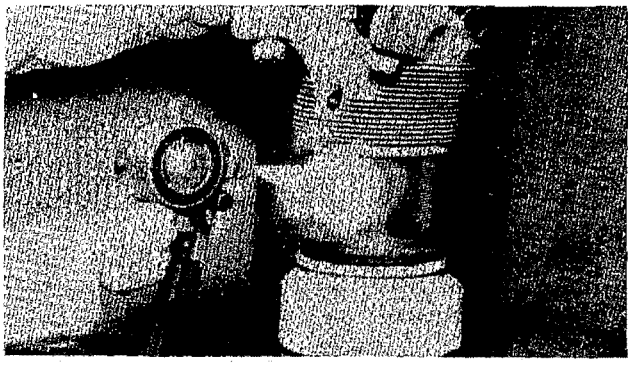


Figure 7—68

both sides of the fins will be effectively coated. Apply a final coat, holding the gun at right angles to the surface to insure a good coating on the edges of the fins (Figure 7—68). The desired thickness of the finish is .003 inch and should nowhere exceed .005 inch. Excessively thick coating will have a rough finish and a tendency to flake off.

7—165. When cylinders are to be stored after metallizing, completely coat them with corrosion preventive conforming to Specification No. AN-VV-C-576.

7—166. REPAIRING INTAKE PIPES, PUSHROD COVERS, AND DEFLECTORS.

7—167. Smooth out any dents. Repair cracks in deflectors by welding. Repaint scratched, chipped or flaked parts as directed in "Painting," paragraph 7—29.

7—168. PRIMER LINE SPAGHETTI REPAIR. 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.

7—169. PISTON COMPRESSION RING GROOVE REWORKING.

7—170. 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 replaced.

Note

Do not confuse warpage with wear. If a groove is worn evenly, reoperation may not be required. When necessary, the grooves may be cleaned up by the procedure described below.

7—171. Mount the piston to be reworked on PWA-4272-30 Fixture (Figure 7—69), which has been bolted to the face plate of a lathe. Mount the Detail 19 Adapter on the fixture, place the Detail 4 Plug in the pistonpin hole in the piston and through the hole in the Detail 2 Shaft. Tighten the Detail 9 Wedge Screw and secure the pistonpin securely in place by tightening the Detail 3 Ring. Check the piston for runout within .001 inch FIR at both ends.

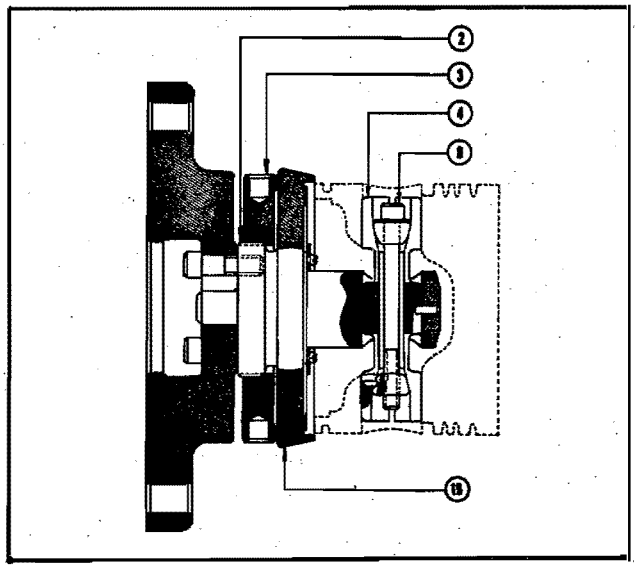


Figure 7—69

7—172. Place PWA-4783 Cutter in a tool holder at right angles to the piston, at zero rake, and on the horizontal centerline 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 centerline. Fabricate a special holder which will support the shank of the cutter for at least three inches and within one inch of the cutting point.

7—173. Align the cutter with the pistonring groove. With a spindle speed of approximately 375 RPM, and with a coolant of seventy-five percent kerosene and twenty-five percent lard oil flowing on the cutter, feed the cutter slowly by hand until it reaches the bottom of the groove. Feed the cutter against one side of the groove until the groove is cleaned up, then move the cutter to the other side of the groove and clean up that side.

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.

7—174. Cut an equal amount from each side of the ring groove until the groove will accommodate the nearest oversize ring with the proper side clearance. Refer to AN 02A-10AB-4 Parts Catalog and reference 302, Section XII.

7—175. PISTON DUAL OIL CONTROL RING GROOVE REWORKING. To oversize dual oil control ring grooves, mount the piston on PWA-4272-30 Fixture as directed in the preceding paragraph. Inasmuch as these grooves are not wedge shape, any cutter of suitable width, sharpness, and strength may be used to rework

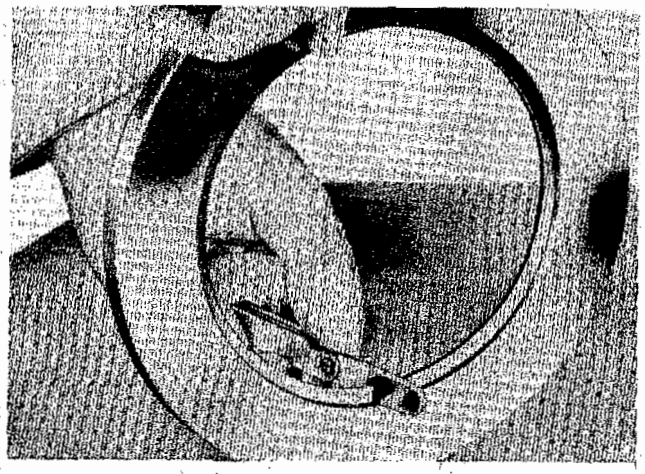


Figure 7–70

the grooves. Using the same spindle speed and coolant as directed for compression ring groove until it will accommodate the next oversize ring with proper side clearance. Refer to AN 02A-10AB-4 Parts Catalog and reference 302, Section XII.

7–176. PISTONRING FITTING.

7–177. Check the end clearance or gap of the rings. Insert the pistonring in PWA-3201-1 Gage. Measure the gap with a feeler gage (Figure 7–70). See reference 301, Section XII. Increase the gap, if necessary, with a fine file. Oversize rings should have the same gaps as standard rings.

7–178. Install the pistonring assemblies in accordance with the arrangement shown (Figure 7–71). Check the

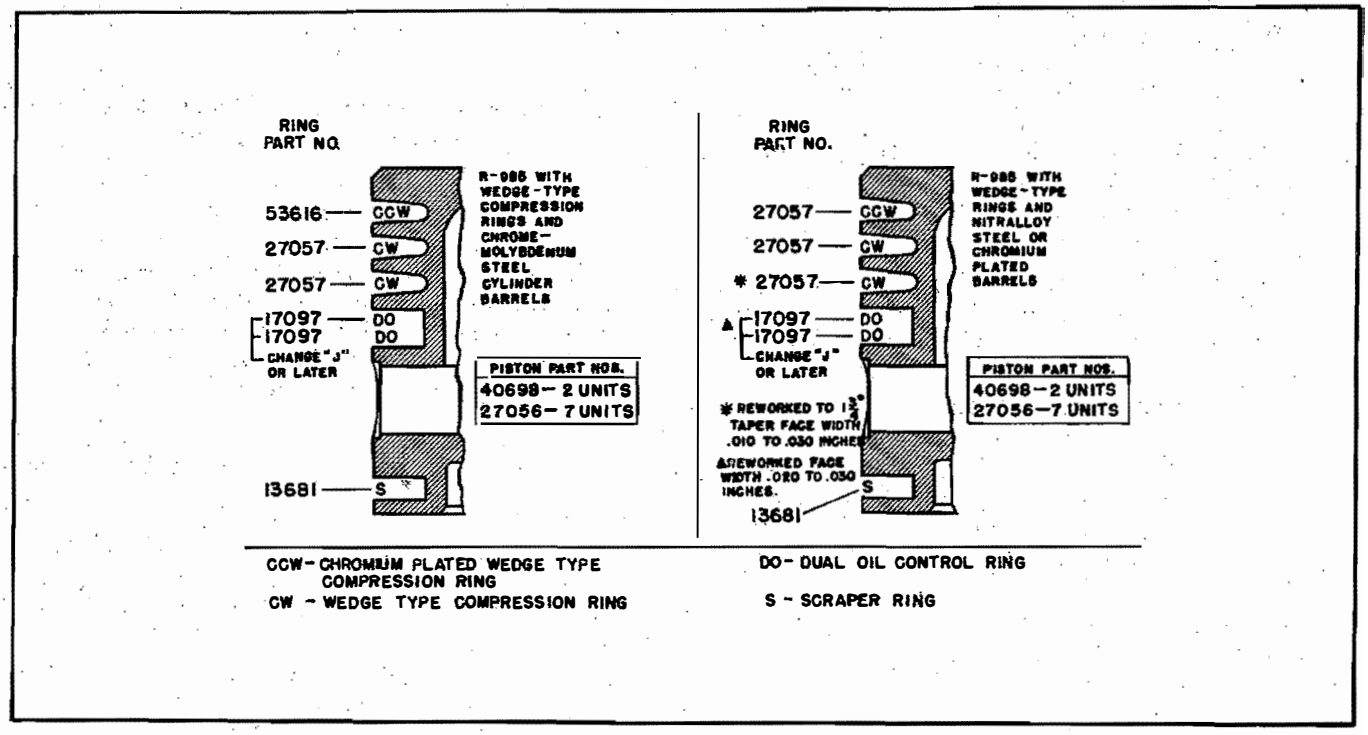


Figure 7–71

side clearance of each ring with a feeler gage. See reference 302, Section XII. Nitralloy, chromium plated and chrome-molybdenum cylinder barrels and pistons are involved. The recommended arrangement for particular combination of piston and cylinder barrel will be used. Where two different pistons are shown for 9 cylinder engines, the two units are for cylinders Nos. 5 and 6 and the seven units are for the other cylinders. Nitrolay 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. All cylinders with chrome plated barrels may be identified by an international orange band, covering the attaching flange and extending up to the lower fin. In addition, the words "Chrome Plated" are etched on the skirts of chromium plated cylinders.

Paragraphs 7—179 through 7—186 DELETED.

Figures 7—72, 7—73, 7—74 DELETED.

7—187. IMPELLER SHAFT BEARING CAGE REPLACEMENT. Bend back the lugs of the retaining screw and remove the screw, using PWA-4008 Screw

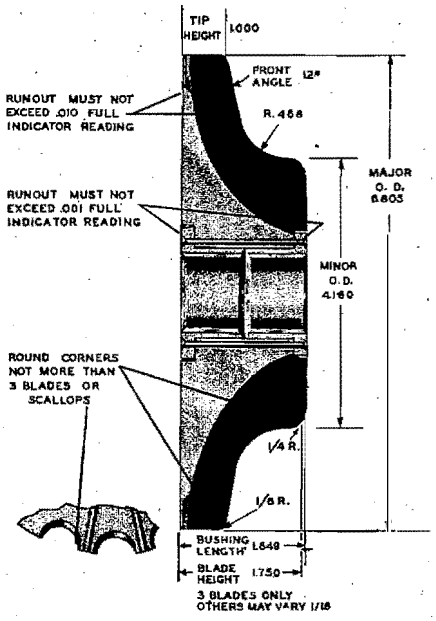


Figure 7—75

Driver. After referring to "Expansion of Parts by Heat," paragraph 7—28, 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 the new cage, using PWA-64 Drift and PWA-620 Guide. Transfer drill a new hole in the cage and tap it with a ¼-28 N. S. tap. Install a new retaining screw and bend back the lugs to lock it in place.

7—188. IMPELLER AND SHAFT.

7—189. The impeller and shaft are originally installed in the engine as a matched and balanced set. It is desirable, although not imperative, that these parts be retained as a matched assembly once they have been used together.

7—190. 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 7—75).

7—191. Nicks, scratches, cracks, or damaged corners should be carefully blended so as to round any sharp corners or high spots. Blending must be kept within the limits shown (figure 7—75), 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 several injuries are grouped in such a way as to impair the strength of the remaining material, replace the impeller.

Note

To assist in determining the extent of the defects while blending, use an etching solution as described in paragraph 6—157.

7—192. 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 7—75). If material is machined from the leading edges, restore the contour of the blades to approximately the original form.

7—193. Impeller bushing faces which have become galled may be cleaned up by grinding within the limits shown (Figure 7—75). The bushing faces must be kept square with the axis of the impeller within .001 inch full indicator reading.

7—194. 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.

7—195. IMPELLER INTERMEDIATE DRIVE GEAR REAR BEARING OUTER LINER REPLACEMENT. Drift the liner from the supercharger case, using PWA-1944 Drift. Clean up the bore of the hole then line up the notch in the edge of the new liner with the staking

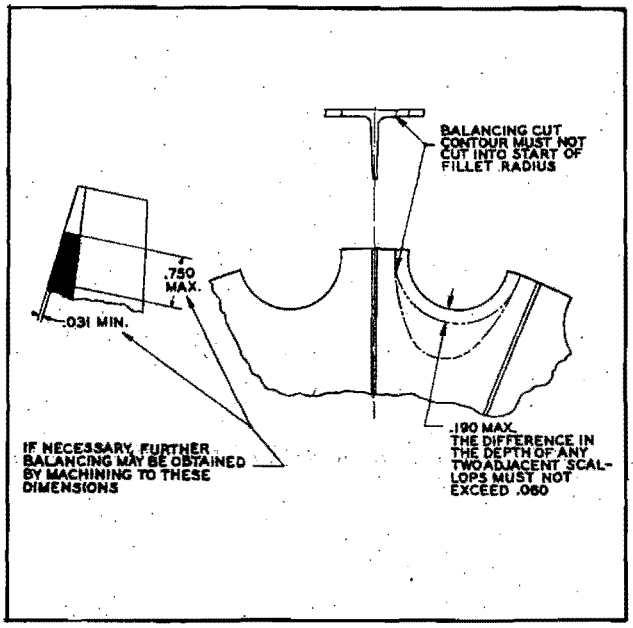


Figure 7—76

pin in the case. Drift in the liner, using PWA-1969 Drift.

7—196. BALANCING IMPELLER AND SHAFT ASSEMBLY.

7—197. The original balance of an impeller and shaft assembly may be affected by replacement, 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.

7—198. 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.

7—199. Install the impeller and shaft assembly in the balancing machine, using cradle detail 81058-T-1 and 1⅛ 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 ball 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.

7—200. Set the impeller in motion and observe any static unbalance. If unbalance exceeds .020 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 .020 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.

7—201. 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 7—76).

CAUTION

Take care not to remove more material than is necessary when grinding or filing the impeller.

7—202. 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 the balance is restored or until it is evident that the impeller cannot be repaired.

7—203. OIL SUMP. If the sump is chafed where it comes in contact with the baffle, blend the chafed areas and treat them with zinc chromate primer. Paint the blended areas as described in paragraph 7—29.

7—204. OIL PRESSURE TUBE. Remove the oil pressure tube, if necessary, using PWA-760 Puller. Using PWA-761 Drift, install the new tube. If an oversize tube is required, temporarily assemble the supercharger and rear cases; then using the proper oversize of TAM-3574-51 Reamer, line ream the cases. Do not enter the reamer beyond a depth of $4\frac{7}{16}$ inches.

7—205. INSTALLATION OF A NEW SUPERCHARGER CASE ON AN OLD REAR CASE.

7—206. Refer to Figures 7—5 and 7—6 and remove the magneto drive shaft bushings, starter shaft bushing, and oil pressure tube from the rear case. If any of these bushings or the oil pressure tube were previously installed oversize, the corresponding holes in the supercharger case must be line reamed with the rear case to accommodate the oversize.

7—207. To accomplish the reaming operations, install an oiled gasket on the supercharger case parting surface and assemble the supercharger and rear cases loosely. Install PWA-1981 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 TAM-3575-7 Reamer and PWA-820 Adapter. Line ream the oil pressure tube hole, using TAM-3574-51 Reamer and line ream the starter shaft hole from the rear face of the rear case, using TAM-3575-6 Reamer and PWA-815, and PWA-819 Adapters.

7—208. Disassemble the cases, remove all oil passage plugs from the rear case and wash both cases thoroughly. Do not reinstall the plugs at this time.

7—209. Refer to "Bushing and Bearing Replacement" in paragraph 7—14. Line up the oil holes in the starter shaft bushing with the oil holes in the rear case and install the bushing, using PWA-762 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 PWA-1746 Drift.

7—210. 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 PWA-1746 Drift. Line ream the magneto drive gear shaft bushings from the front face of the supercharger case, using TAM-3575-5 Reamer and PWA-820 Adapter and check the installation with PWA-1805-6 Gage. Line ream the starter shaft bushing from the rear face of the rear case, using TAM-3575-8 Reamer, PWA-815, PWA-816, and PWA-817 Adapters and check the bushing with PWA-1805-9 Gage.

7—211. Face off the starter shaft bushings using PWA-538 Facer and PWA-817 Adapter. Check the height of the bushing with TAM-1113 Flush Pin Gage. Face off the magneto drive gear shaft bushings, using PWA-55 Facer and check with 1320-T-120 Gage.

7—212. Break all sharp edges of bushings which have been faced.

7—213. Disassemble the cases and wash both cases thoroughly to remove all chips.

7—214. INSTALLATION OF A NEW REAR CASE ON AN OLD SUPERCHARGER CASE.

7—215. Bushings and the pressure oil tube are not installed in the new rear case as received from the factory. In order to insure 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. Refer to paragraph 7—14, "Bushing and Bearing Replacement," and to Index No. 8, Figure 7—4, for instructions on the removal of these bushings.

7—216. Install an oiled gasket on the supercharger case rear parting surface and assemble the supercharger and rear cases loosely. Install PWA-1981 aligning bars in the magneto drive gear shaft bushing holes and tighten the nuts attaching the cases together. Remove the aligning bars.

7—217. Refer to "Installation of a New Supercharger Case on an Old Rear Case" in paragraph 7—205 for instructions on line reaming bushing holes, installing bushings, and line reaming the bushings in the supercharger and rear cases.

7—218. OIL PUMP.

7—219. If, on inspection, any one of the oil pump housing sections is rejected, replace the entire housing assembly. Small scratches and burrs in any section of the hous-

ing, 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.

7–220. To replace 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.

7–221. TACHOMETER DRIVE INNER COUPLING BUSHING. If it is necessary to replace 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 PWA-3633 Drift and an arbor press. Install a new bushing, using PWA-2884 Drift and an arbor press. Drill the lockpin hole 90 degrees from any existing hole, using PWA-2883 Drill Jig, and install the lockpin. Transfer drill the oil holes in the bushing, using a No.42 (0.935 inch) drill. Using PWA-2881 Fixture and TAM-3574 Reamer, ream the bushing. Check the bushing for size, using PWA-1805-16 Gage.

7–222. VACUUM PUMP DRIVE GEAR BUSHING REPLACEMENT. Drift the bushing from the housing, using PWA-1460 Drift. Install a new bushing, using PWA-1648 Drift, then ream the bushing, using TAM-3574-7 Reamer, PWA-2284 Fixture, and PWA 1805-12 Gage. See "Bushings and Plain Journal Bearings," paragraph 7–14.

7–223. GUN SYNCHRONIZER. (AN-6 Engines only.) If the lock plunger is damaged, replace it with a new plunger. Make no attempt to file smooth a plunger, as filing may reduce the plunger diameter so it will be a loose fit in the notch. A loose fit will seriously affect the clearance between the cam and the roller on the cam follower.

SECTION VIII

ASSEMBLY OF SUBASSEMBLIES

8—1. GENERAL.

8—2. To avoid unnecessary repetition in the detailed assembly instructions, certain general assembly methods and procedures are described in the paragraphs which follow. These items play an important part in efficient engine overhaul, and the ultimate life and performance of the engine can be seriously affected, if they are slighted through carelessness or neglect.

8—3. Care should be taken to prevent dirt, dust, cotterpins, lockwire, 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 and coverings to fit all openings.

8—4. If any parts were coated with corrosion preventive compound in accordance with paragraph 6—12, all traces of this compound and accumulated foreign matter must be removed. While assembling with engine or subassemblies, heavily coat these parts with a mixture of one part Specification No. AN-VV-C-576 compound to three (3) parts aircraft engine lubricating oil, grade 1120. Use this mixture during assembly on all internal parts on which corrosion may occur, which includes all bearing surfaces, cylinder bores, and pistonrings.

8—5. A. F. personnel will use high compression and temperature resisting grease conforming to Specification No. AN-G-5, Stock No. 7500-326250 for all fiber-asbestos gaskets subject to high compression and temperature.

8—6. When splines of any kind are to be mated they should be properly lubricated. Norm Paste No. 30, or its equivalent, is recommended for tight press fit splines, and a lubricant conforming to Specification No. AN-G-5 or its equivalent, is recommended for loose fit splines such as those on accessory drives. In blind spline cavities not lubricated by internal oiling from the engine, pack the cavity with lubricant to insure continuous lubrication and prevent moisture pockets. After splined parts have been assembled, wipe off any surplus lubricant.

8—7. A thin even coat of sealing compound conforming to Specification No. AAF-2-86-A or No. AN-G-14 should be applied to tube plugs and threaded fittings, such as primer fittings and oil and vent tube fittings, and to metal-to-metal or gasketed mating surfaces. Do not use sealing compounds on carburetor or carburetor mounting surfaces, on splined areas, on parts which have shrink or pinch fits, on metallic seal rings or oil seal ring grooves, on crankcase mating surfaces, or on any parts which have relative motion to each other during engine operation. In no case should a heavy application of a sealing compound or heavier compounds be used.

8—8. Replace all gaskets, packings, rubber parts, and bronze oil seal rings having gaps, at every overhaul.

8—8A. When a copper-asbestos gasket is to be installed on an engine, install the gasket with the crimped or asbestos-exposed side toward the engine. This procedure keeps the gasket from turning and wearing a pattern into its sealing part while the plug is being tightened.

8—9. The tables in Section XII should be used as a guide in all assembly operations involving fits, clearances, backlashes, spring pressures, and torques. The assembly of tight fitting parts may be facilitated by heating the outer part in an oil bath. 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 area before attempting a torque operation intended to secure the retention of the heated or cooled part, either directly or indirectly.

8—10. When a nut is to be lockwired or cotterpinned, it should first be brought to its low torque limit; then the next castellation of the nut should be lined up with the hole in the stud or bolt. If this cannot be done without exceeding the high torque limit, a new nut which will line up properly should be selected. Never reinstall used lockwire, tablocks, cotterpins, or palnuts. Lockwire and cotterpins should fit snugly in their holes. Install a cotterpin so that the head fits into the castellation of the nut and, unless otherwise specified, bend one end of the pin back over the stud or bolt and the other end down flat against the nut. Only lockwire and cotterpins made of corrosion resisting steel should be used. Zinc coated or brass wire and cotterpins may be used externally in the event corrosion resisting steel wire and cotterpins are not immediately available. No substitute is permissible for the corrosion resisting wire and cotterpins used internally.

8—11. LOCKWIRING. (Figure 8—1.)

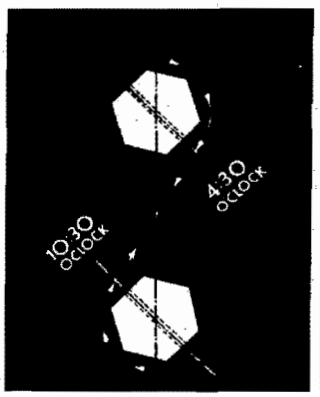
8—12. BASIC RULES.

a. Lockwire Must Always Tend To Tighten. The wire must be installed in such a way that it will always counteract any tendency of the part to loosen. It must always tend to tighten and keep the part locked in place.

b. Lockwire Must Never Be Overstressed. Extreme care must be exercised when twisting the wires together to insure that wires are securely tightened but not stressed to the point where they will break under a slight load.

c. Lockwire Must Be Tight When Installed. This is most important to prevent vibration with resultant fatigue and failure, and also to prevent the wire from rubbing against some adjacent part, causing wear.

d. Lockwire End Must Always Be Bent Toward The Engine. This is primarily a safety precaution to guard against possible injury to the hands of the mechanics working on the engine. It is also imperative that the part or parts to be lockwires are torqued to specifications and



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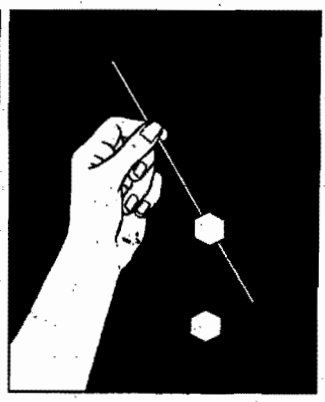

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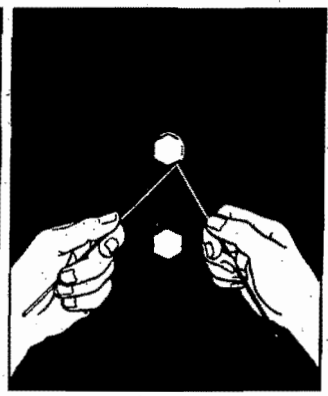

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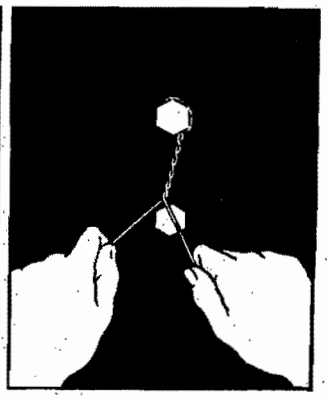

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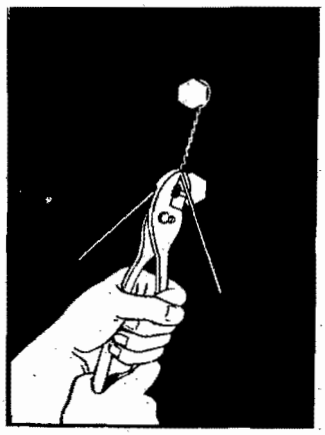

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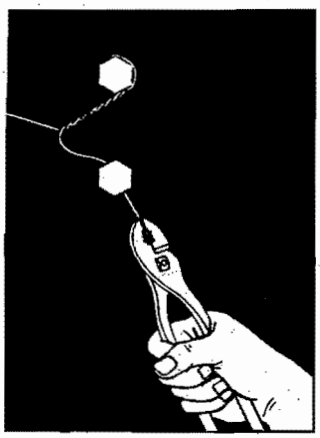

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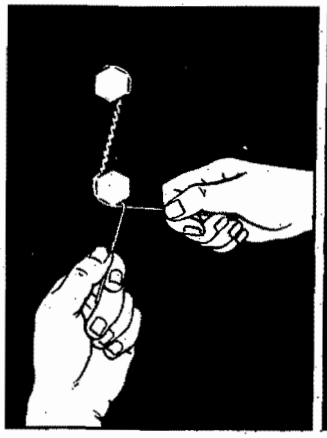
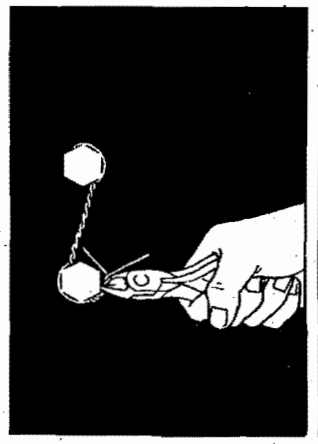


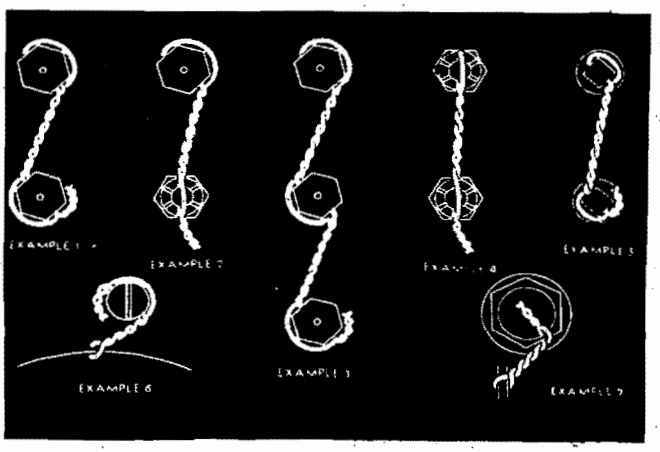
STEP 7

STEP 8

STEP 9



STEP 10



EXAMPLES

Figure 8—1

the holes properly aligned before any attempt is made to proceed with the lockwiring.

8–13. HOLE ALIGNMENT. Check the units to be locked 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 positions (Step 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 overtorque 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 undertorquing, another unit should be selected which will permit proper alignment within the specified torque limits.

8–14. PROCEDURE. Hex head bolts will be used for the purpose of describing the following general wiring procedure:

a. Insert wire of the proper gage through the hole which lies between the three and the six o'clock positions on the bolt head (Step 2).

Note

To determine the proper wire to be used in conjunction with a particular tightening operation, refer to the Engine Parts Catalog. The part number of the wire is located with the number of the part which it locks.

b. 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 (Step 3).

c. Pull the loop very tight 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 which lies between the nine and the twelve o'clock positions (Step 4).

d. 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 (Step 5).

Note

Twisting the braid in a clockwise direction has the effect of securing the loop down around the head of the first bolt. The rigidity of the stiff braid reduces vibration and resultant wear. Do not overstress the wires by attempting to twist the braid too tightly.

e. 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 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 (Step 6.)

f. 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 (Step 7).

g. Pull the resulting loop tight with the pliers; then, to keep the wire in place down around the head of the second bolt, twist the wire ends together in a counterclockwise direction (Step 8).

h. Grasping the ends of the wire beyond the twist 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 counterclockwise around the head of the second bolt (Step 9).

i. Cut off the excess wire at the ends with diagonal cutters, leaving at least three full twists and avoiding sharp or projecting ends (Step 10).

CAUTION

Do not twist off the ends of the wires with pliers.

8–15. BASIC EXAMPLES. Many separate wiring operations are required, most of which are covered by the seven basic examples illustrated:

a. Examples 1 and 5 illustrate the proper method of wiring bolts, screws, square head plugs, and similar parts which are wired in pairs.

b. Example 2 illustrates the proper method of wiring a bolt or similar part to a castle or slotted nut.

c. Example 3 shows how to wire three or more units together.

d. Example 4 illustrates the proper method of wiring studs and castle nuts together.

e. Examples 6 and 7 illustrate the proper method of wiring a screw, bolt, or plug to a fixed point, such as a lug.

8–16. SUPERCHARGER SECTION.

8–17. SUPERCHARGER CASE. Crank the bed of TAM-1161 Engine Stand to a horizontal position and place the supercharger case, front face up, on Part No. TC-51259 Mounting Plate. Attach the case to the mounting plate with four bolts, washers, and nuts.

8–18. IMPELLER INTERMEDIATE DRIVE GEAR. Install the large ball bearing on the intermediate drive gear, thrust side facing outward. 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.

8–19. FLOATING GEAR.

8–20. Install the floating gear inner race on the supercharger front bearing cover, making sure the dowel on

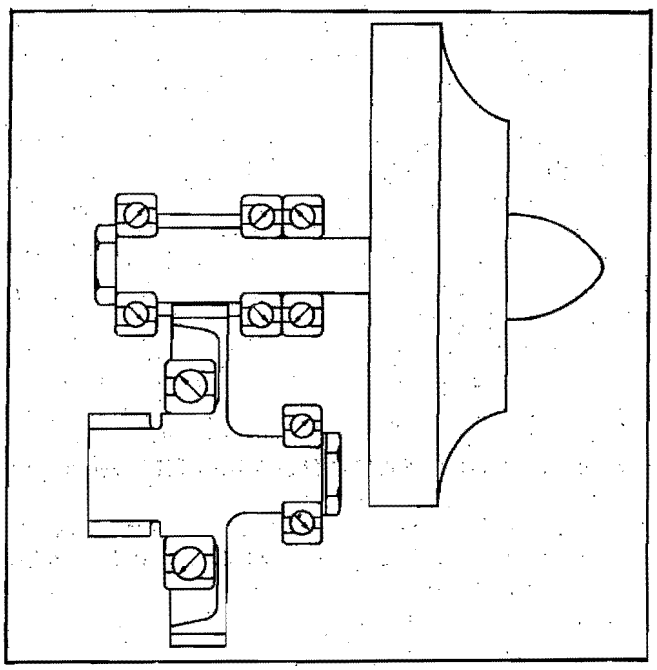


Figure 8–2

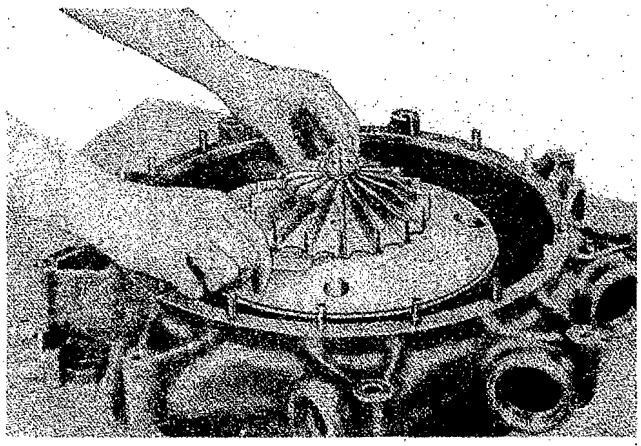


Figure 8–3

the cover engages the notch in the inner race. Install and attach the cover in the supercharger case. Insert the needles in position in the floating gear, using 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.

8–21. Place the rear thrust cover, 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 tablock, and the floating gear retaining nut which has a LEFT HAND thread. Lock the impeller intermediate drive and floating gears with PWA-338 Holder. Tighten the floating gear retaining nut, using PWA-345 Wrench.

8–22. Check the end clearance between the floating gear and the rear thrust spacer. See reference 619, Section XII. If the clearance is excessive, 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.

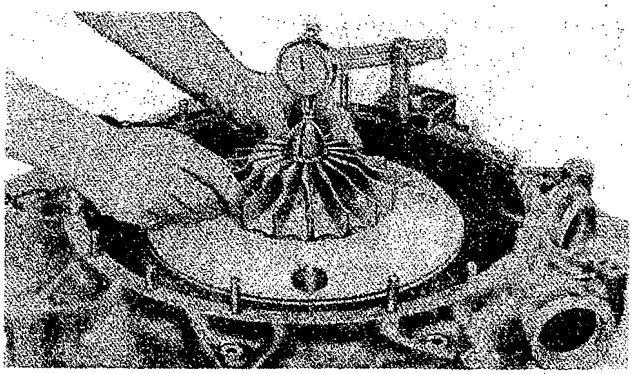


Figure 8–4

8–23. Turn the supercharger case over and tap the intermediate drive gear rear bearing with a fiber drift to insure that it is seating properly; then tighten the intermediate drive gear nut, and lock it with a cotterpin.

8–24. IMPELLER SHAFT.

8–25. Install the front bearing on the impeller shaft with the thrust side in position (Figure 8–2). Install the nut, 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 (Figure 8–2).

Note

Navy Personnel should replace the three impeller shaft bearings at every overhaul, using new bearings. Inspect all bearings removed, and if satisfactory, hold in stock for use in the impeller intermediate drive gear location.

8–26. 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.

8–27. 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 PWA-1882 Pusher to install the impeller on the shaft. Install and tighten the impeller locknut which has a LEFT HAND thread, using PWA-338 Holder and PWA-1269 Wrench.

8–28. Measure the clearance between the front face of the impeller and the rear face of the supercharger case (Figure 8–3). See reference 640, Section XII. 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 FIR. Try the spacer at various positions on the shaft until this condition is obtained.

8–29. Check the end clearance of the impeller shaft and bearing assembly (Figure 8–4). An end play of .010 inch with new bearings is permissible; if the play exceeds this limit, select different bearings.

8–30. Remove the impeller locknut and pull the impeller from the shaft with PWA-51 Puller.

8–31. Tighten the screws in the supercharger bearing cover. Use a feeler gage to check the clearance between the supercharger bearing cover and the impeller shaft spacer. Lockwire the supercharger bearing cover screws (Figure 8–5).

8–32. Install the impeller, using PWA-1882 Pusher. Install the locknut and tighten it with PWA-1269 Wrench and lock it with a lockpin, using PWA-1558 Riveter.

8–33. SUPERCHARGER SECTION PLATES. Attach the supercharger section plates to the supercharger case. Lockwire the screws in the plates.

8–34. OIL PRESSURE TUBE. Insert one end of the tube in its aperture in the supercharger case. Attach the bracket on the end of the tube to the case with two screws. Lockwire the screws (Figure 8–6).

8–35. BREATHER. Place a rubber seal under the breather body in the supercharger case. Tighten the body in the case with PWA-3482 Wrench. Place a gasket on the breather body and install the breather tube. Secure the breather tube with a screw and lockwire the screw.

8–36. Coat the left breather plug with thread compound conforming to Specification No. 3590-A. Place a rubber seal on the plug. Install and tighten the plug, using PWA 2373 Wrench.

8–37. INTAKE PORT PROTECTORS. Install PWA-3800 Protectors in the intake pipe ports in the supercharger case.

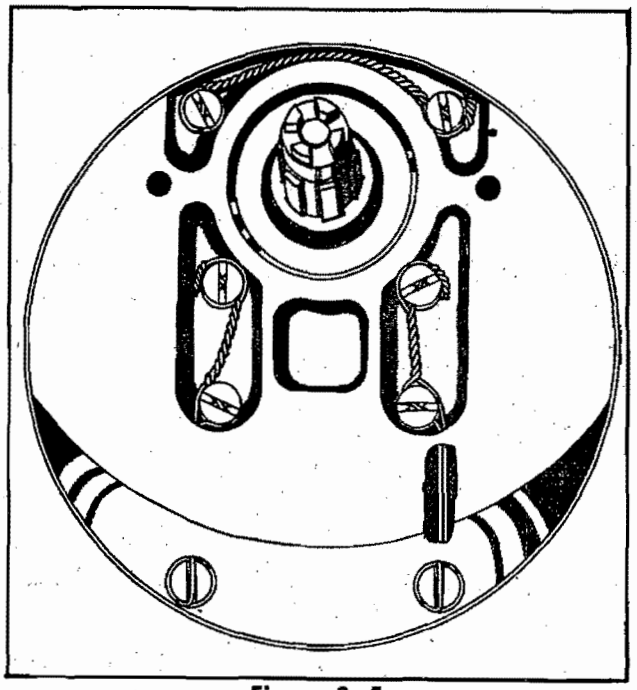


Figure 8–5

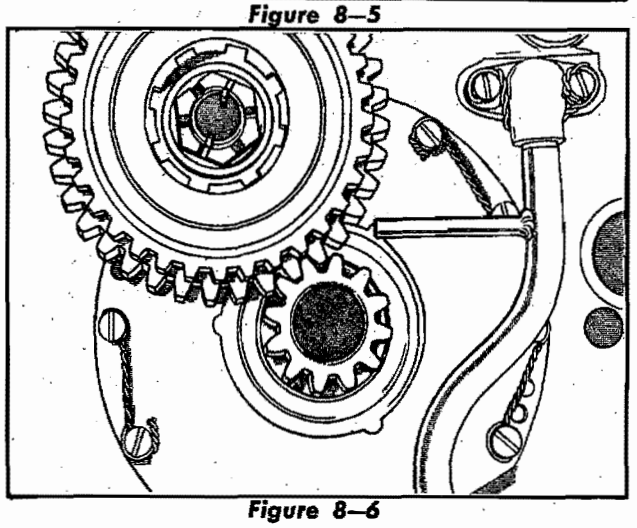


Figure 8–6

8–38. REAR SECTION.

8–39. ASSEMBLY OF REAR CASE TO SUPERCHARGER CASE.

8–40. Apply a thin coating of Fairpreen Neoprene Cement No. 5128 to the O.D. of the starter and magneto drive bushings. Apply this coating from the base of the bushing to approximately 1/2 inch from the end.

8–41. 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 and the drive shaft bushings. It may be necessary to tap the rear case with a fiber drift at the magneto and starter shaft bushings. Secure the cases with washers and nuts. Tighten the nuts to the required torque.

8–42. PLUGS.

8–43. Install the connection constant speed control plug and gasket. Install the allen plugs in the rear case, using a 1/8 inch allen wrench and tighten with an allen socket and ratchet.

8–44. Install the small squarehead oil plugs, using a 1/8 inch box wrench. Install a wooden cover over the carburetor 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.

8–45. STARTER SHAFT AND GEAR.

8–46. Assemble the starter shaft spacer, bevel side against the radius on the shaft. Press the bearing into position on the shaft.

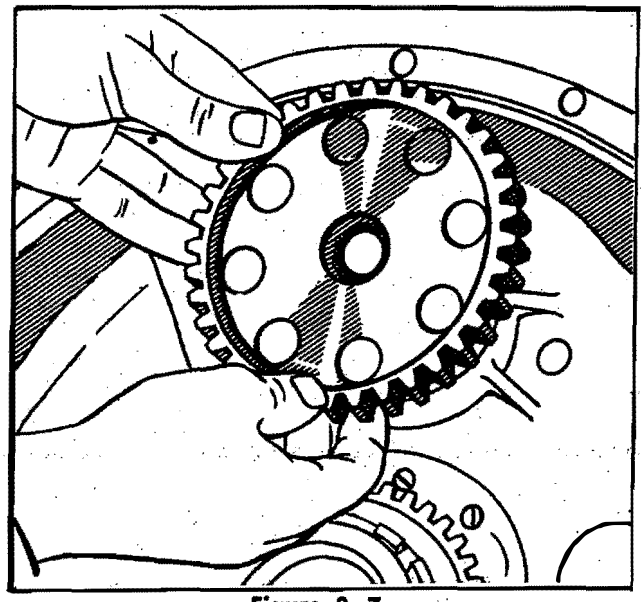


Figure 8–7

8–47. Insert the starter gear through its bushings from the forward face of the supercharger case (Figure 8–7). If necessary, tap the gear with a fiber 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.

8–48. Use a feeler gage to check the clearance between the starter jaw and the face of the starter gear bushing. See reference 611, Section XII. 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 minimum clearance is found with the original parts installed, check to see that the bushing is properly seated in the rear case.

8–49. If the desired clearance is not obtained, install a thicker starter gear spacer or grind the original spacer.

8–50. GENERATOR DRIVE GEAR ASSEMBLY.

8–51. Use a depth micrometer to measure the 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.

8–52. 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 PWA-174 Wrench. Cotterpin the nut.

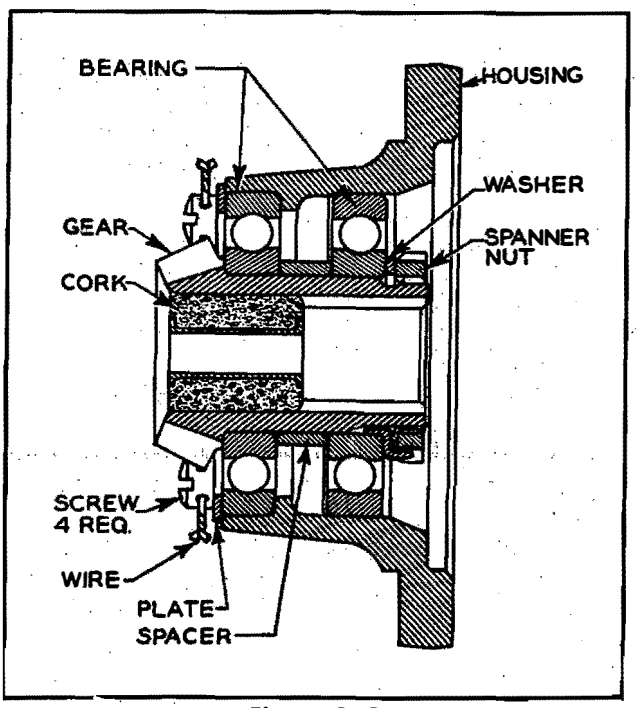


Figure 8–8

8–53. On double bearing assemblies (Figure 8–8), hold the drive gear with PWA-4635 Fixture and drift the inner bearing in the shaft, using PWA-4636 Drift. Install the spacer on the gear shaft and install the gear and inner bearing in the housing, using PWA-4637 Drift. With the assembly held with PWA-4635 Fixture, install the outer bearing in the housing, using PWA-4636 Drift. Install the washer and spanner nut, which has a LEFT HAND thread, using PWA-174 Wrench. Cotterpin the nut. Shellac a new Part No. 50681 cork and install it in the gear shaft, using an arbor press and a drift. Install the cork from the anti-spline end of the shaft 1.750 to 2.250 inch from the rear face of the cork to the end of the spline.

8–54. 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 screws. Lockwire the screws.

8–55. 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.

8–56. Check the backlash between the generator drive gear and the starter jaw gear using a dial indicator and PWA-2003 Arbor. See reference 605, Section XII. First check the backlash with the starter jaw pushed as far forward as possible and again with the starter jaw contacting the flange of the starter shaft rear case bushing. 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.

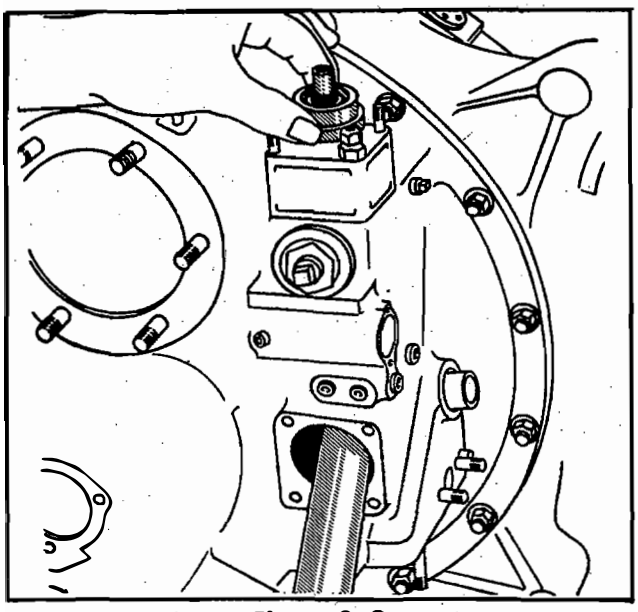


Figure 8—9

8—57. Tighten the four nuts on the generator drive cover and lockwire the nuts.

8—58. Install the starter drive cover and gasket and secure it in place with six 3/8 inch self-locking nuts.

8—59. VERTICAL ACCESSORY DRIVE GEARS.

8—60. 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.

8—61. 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 PWA-2005 Stop through the magneto drive shaft housing. Press the cover liner and bearing over the end of the shaft (Figure 8—9). 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.

8—62. 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.

8—63. If an accessory is to be installed, substitute a gear for the spacer on the upper end of the shaft.

8—64. TACHOMETER DRIVES.

8—65. Install new oil seals in the outer couplings of the left and right tachometer drive gears, using PWA-1462 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.

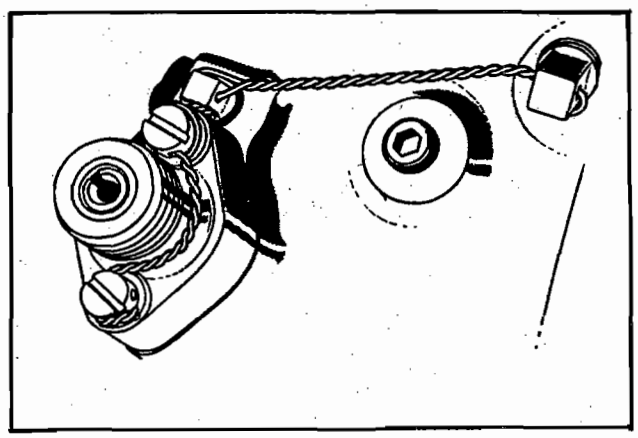


Figure 8—10

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.

8—66. Use a dial indicator to check the end clearance of each tachometer drive gear. See reference 659, Section XII. If the end clearance is insufficient, lap the inner face of the inner coupling. If the end clearance is excessive, replace the inner coupling.

8—67. Lockwire the tachometer drive assembly retaining screws (Figure 8—10). Install a gasket in each outer coupling cap and screw the caps onto the couplings.

8—68. MAGNETO DRIVE GEARS AND SHAFTS AND ACCESSORY INTERMEDIATE DRIVE GEARS.

8—69. Hold 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 accessory 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.

8—70. 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 XII. If the clearance is insufficient, face off the flange of the magneto drive gear shaft front bushing, using PWA-55 Facer. If the end clearance is excessive, replace the magneto drive gear shaft bushing according to the instructions in Figure 7—4.

8—71. 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

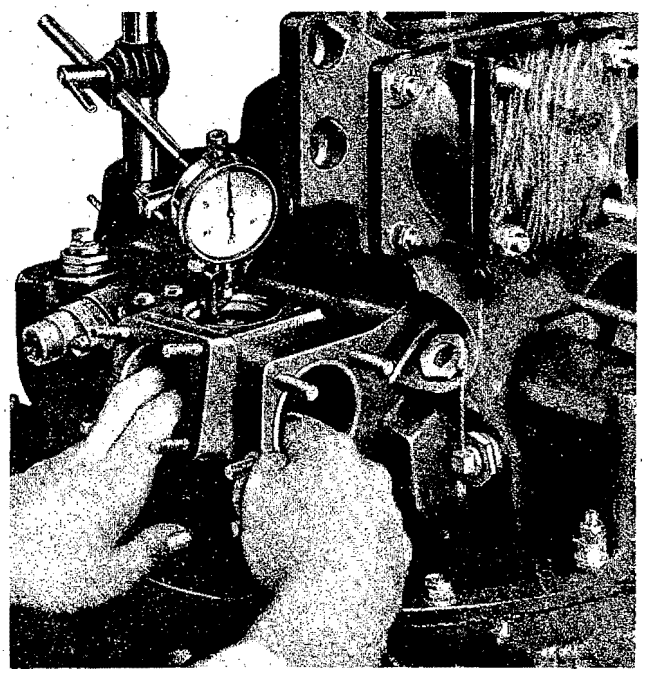


Figure 8–11

vertical accessory drive gear (Figure 8–11). See reference 672, Section XII. If the backlash is insufficient, face off the flange of the magneto drive gear shaft front bushing, using PWA-55 Facer. If the backlash is excessive, replace the magneto drive gear shaft bushing according to the instructions in Figure 7–6.

8–72. 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.

8–73. GUN SYNCHRONIZER (AN-6 Engines Only).

8–74. Press the lower ball bearing on the cam and gear shaft; then fit the upper ball bearing in the bearing retainer and insert the cam follower in the hole of the retainer. Press the upper ball bearing onto the cam and gear shaft. Secure the ball bearings and retainer on the shaft; then install the cam follower, cam and gear shaft, and bearings and bearing retainer in the housing as a unit.

8–75. Place laminated shims over the gun synchronizer cover mounting flange and housing and fasten the cover in position with four screws. Screw the lock plunger in the cover, insuring that it seats properly in the notch of the cam follower.

8–76. Coat the gun synchronizer mounting pad with shellac; then fasten the gun synchronizer to its mounting pad with washers and nuts. Lockwire the nuts.

8–77. Make certain that the bevel gear in the synchronizer is properly meshed with the gun control gear. Check the backlash with the gun control gear. See reference 729, Section XII.

8–78. OIL PUMP. *(Figure 8–12).*

8–79. Insert the drive gear shaft through the end plate of the oil pump (Figure 8–13). 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.

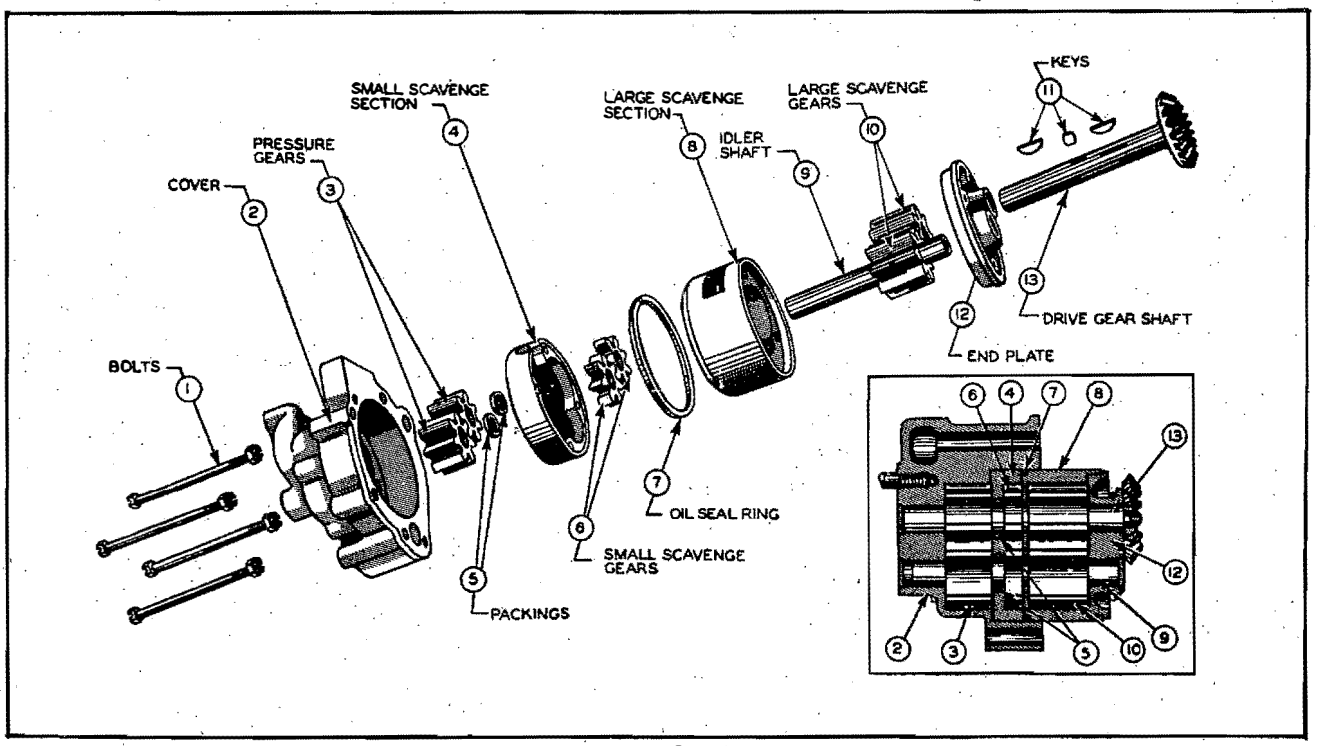


Figure 8–12

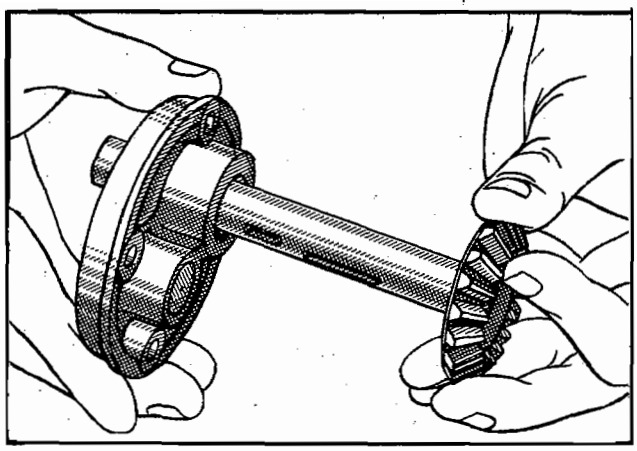


Figure 8—13

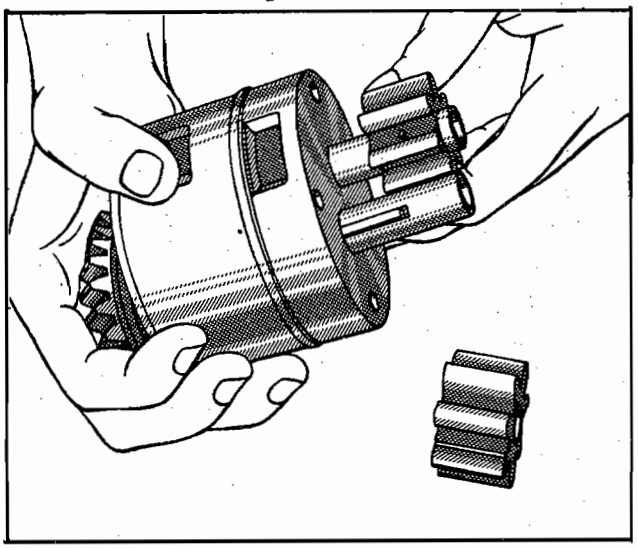


Figure 8—14

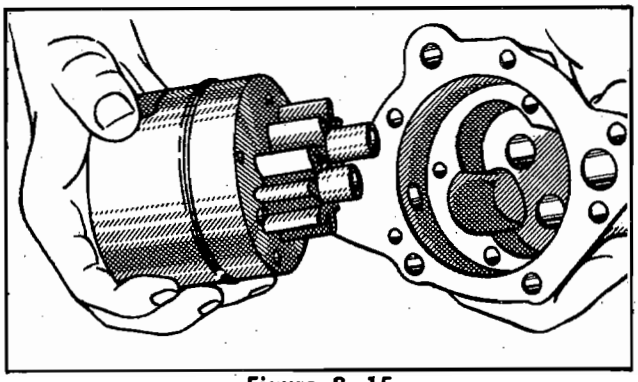


Figure 8—15

8—80. Insert new leather packings in the shaft holes of the small scavenge section, and install the section over the shaft, 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 8—14). Install the cover or pressure section of the pump over the drive and idler shafts and fit it to the scavenge section (Figure 8—15).

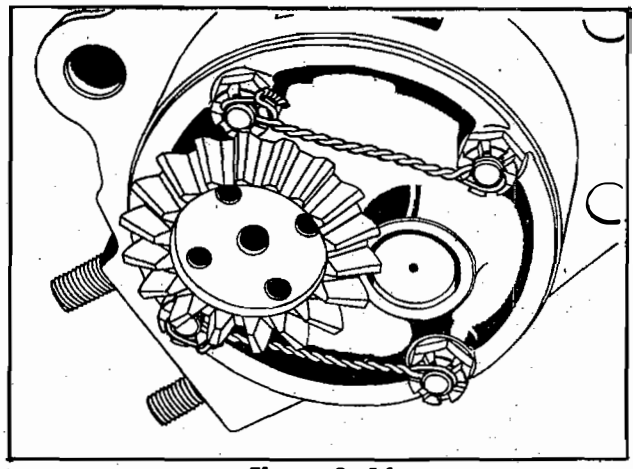


Figure 8—16

8—81. Insert the two loose fitting bolts and install and tighten the nuts finger tight. Insert the two tight fitting bolts; then tighten all four nuts securely. Lockwire the nuts (Figure 8—16).

8—82. 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.

8—83. Install the oil seal rings in position on the O.D. of the pump body and check the side clearance of the rings. See reference 750, Section XII. If the side clearance is insufficient, grind the rings on a surface grinder.

8—84. 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.

8—85. Use a dial indicator to check the backlash between the oil pump drive gear and the accessory intermediate drive gear. See reference 697, Section XII. Adjustment of the backlash may 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 front bushing, using PWA-55 Facer or by replacing the same bushing according to the instructions in figure 7—6.

8—86. The backlash of the accessory drive gear will be affected by a change in the magneto drive gear shaft bushing; therefore, recheck the accessory drive gear backlash.

8—87. FUEL PUMP DRIVE.

8—88. Install a new oil seal in the fuel pump drive adapter, using PWA-2285 Drift. Install the fuel pump drive gear in the adapter.

8—89. 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.

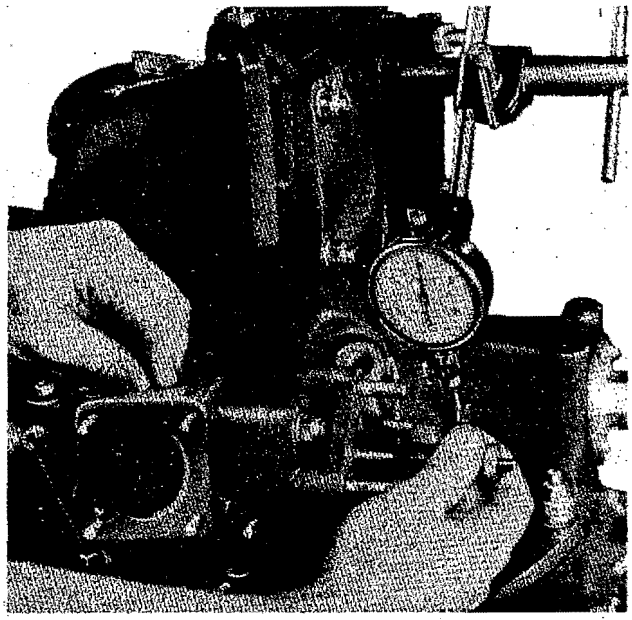


Figure 8–17

8–90. Use a dial indicator and PWA-2127 Arbor to check the backlash between the fuel pump drive gear and the left accessory intermediate drive gear (Figure 8–17). See reference 674, Section XII. 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 8–18).

8–91. VACUUM PUMP DRIVE GEAR.

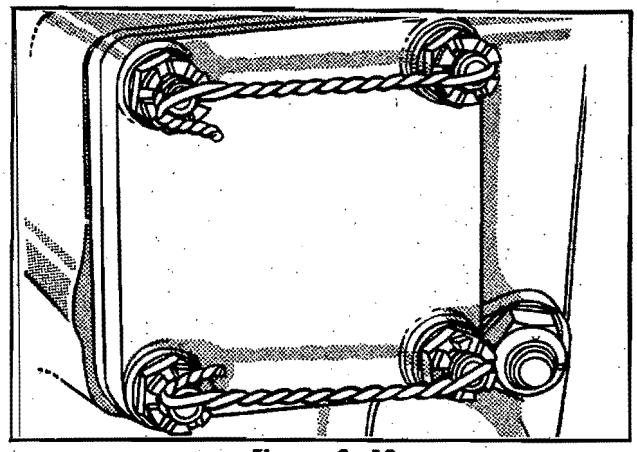


Figure 8–18

8–92. Install a new oil seal in the vacuum pump drive housing, using PWA-1415 Drift. Place the spacer on the drive gear shaft and, using PWA-3094 Guide, install the gear in the housing. Place the proper gasket (Figure 8–19) over the mounting flange of the vacuum pump drive adapter, and install the housing in the rear case. Use a dial indicator and PWA-1443 Arbor to check the backlash between the vacuum pump drive gear and the fuel pump drive gear. See reference 741, Section XII.

8–93. 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 ground or a thicker spacer may be installed. Install the proper gasket and the vacuum pump or cover and secure it with washers and nuts. Lockwire the nuts in pairs.

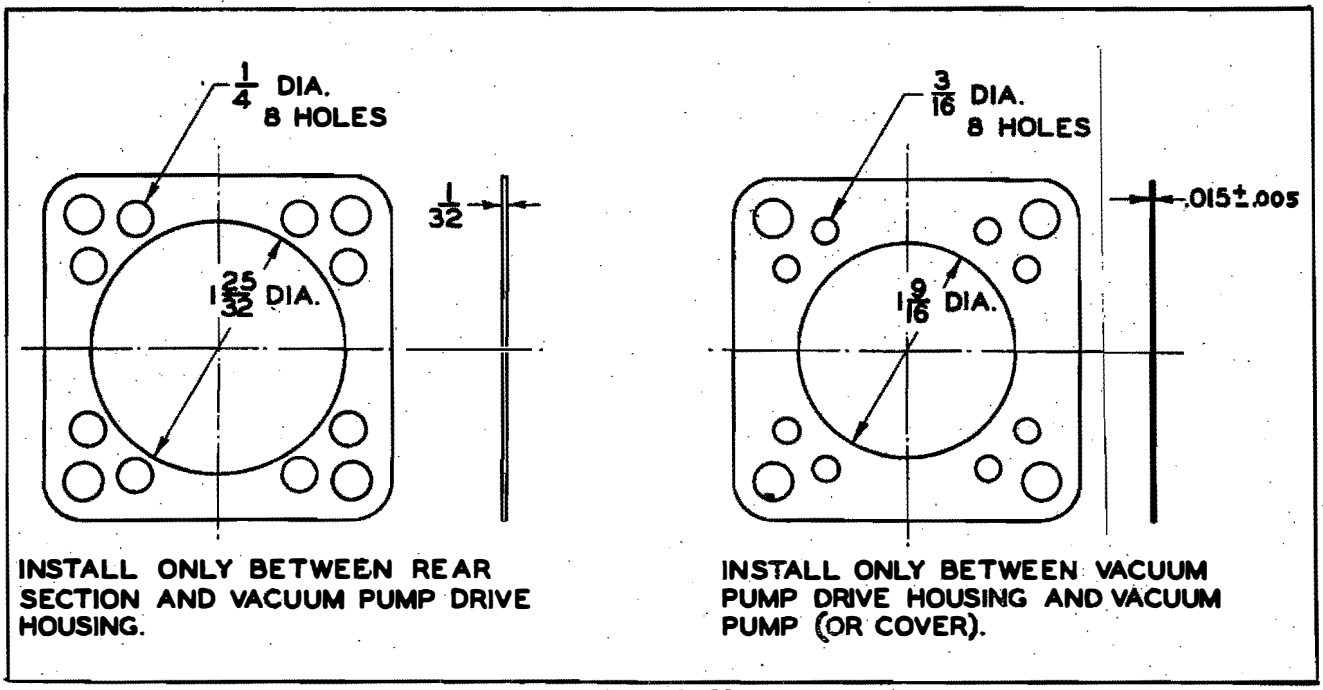


Figure 8–19

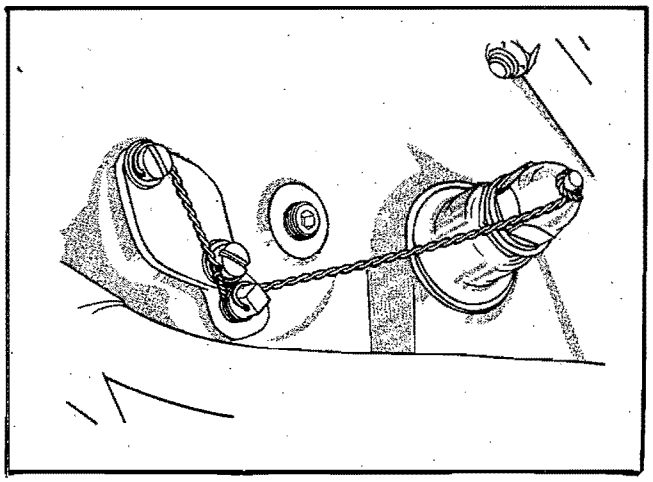


Figure 8—20

8—94. MAGNETO COUPLING DRIVE GEARS.

8—95. Assemble a new seal in the seal housing using PWA-4153 Drift and Base. Install the seal housing in the magneto drive location in the rear case and secure with 3 bolts and washers, leaving out the fourth bolt.

8—96. Install the magneto drive coupling and secure with a coupling screw using PWA-789 Wrench.

8—97. Insert a cotterpin through the flange and the coupling screw. Install the fourth washer and bolt. Lockwire the bolts.

8—98. OIL PRESSURE RELIEF VALVE. Install the valve seat in the rear case, using PWA-671 Wrench. Insert the plunger and spring into the oil pressure relief valve body. Fit a new gasket under the flange on the oil pressure relief valve body 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 8—20). Do not disturb the setting of the adjustment screw.

8—99. CARBURETOR ADAPTER. Attach the carburetor adapter to the rear case with washers, nuts and lockwire.

8—100. BREATHER. Install the swivel breather supports on the rear case. Tighten the supports with PWA-2318 Wrench. Push the swivels onto the supports with the bulge surface out. Install the gaskets and nuts. Tighten and lockwire the nuts (Figure 8—21).

8—101. INTAKE DUCT VIEW PORT. Install the intake duct view port plug and cover in position in the rear case. Lockwire the plug.

8—102. OIL SCREEN AND CHECK VALVE. 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 PWA-228 Wrench. Lockwire the cover (Figure 8—22).

8—103. OIL OUTLET TEMPERATURE BULB CONNECTION. Install the connection and gasket on the lower right side of the rear case. Lockwire the connection (Figure 8—23).

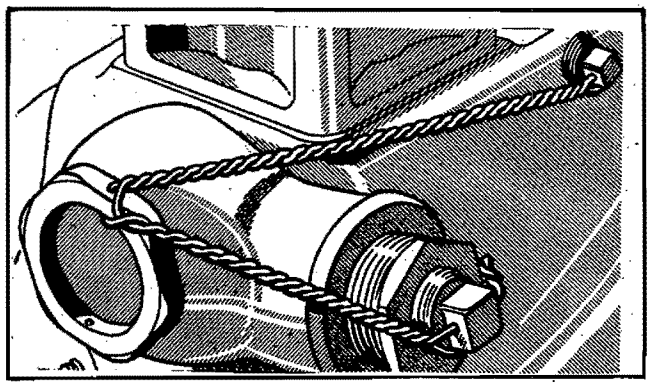


Figure 8—21

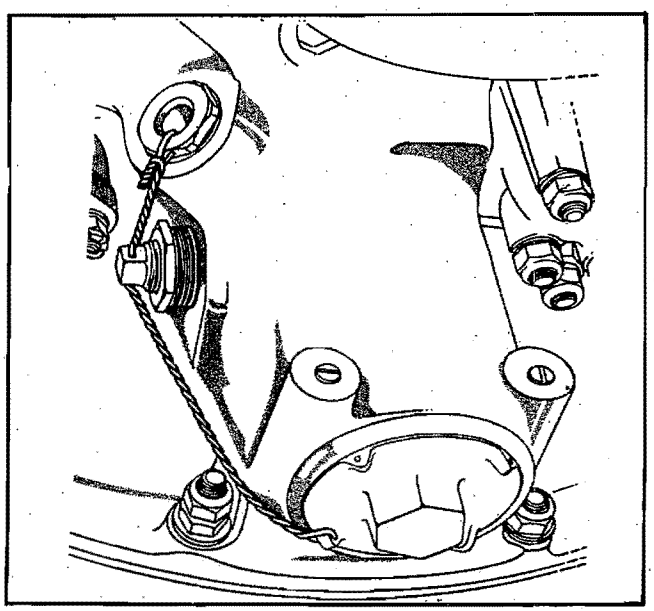


Figure 8—22

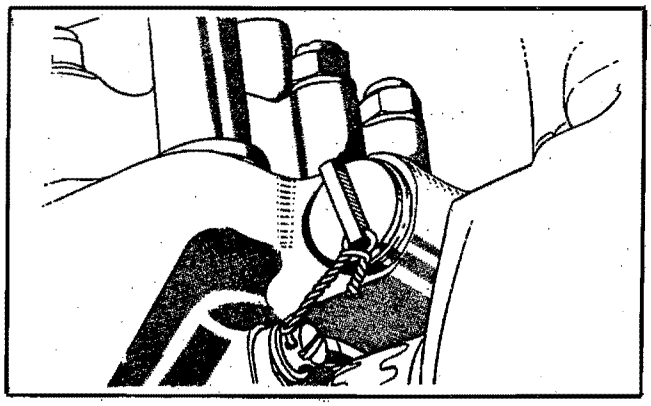


Figure 8—23

8—104. CRANKSHAFT AND MASTEROD ASSEMBLIES.

8—105. MASTEROD AND LINKRODS.

8—106. 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

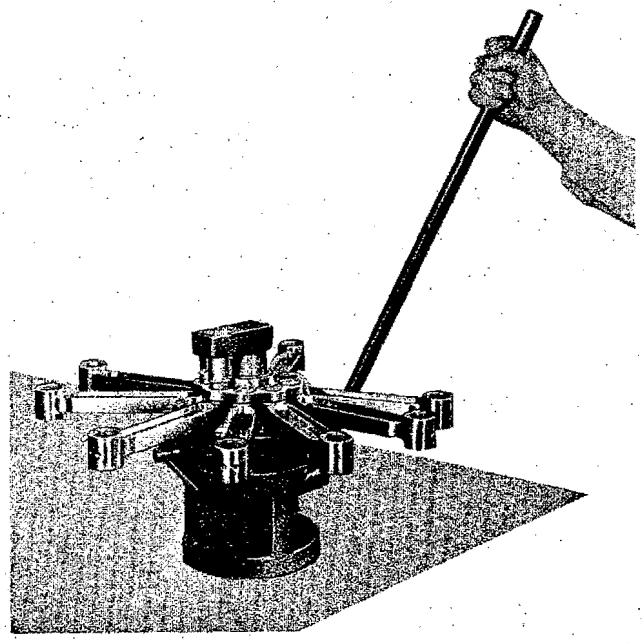


Figure 8—24

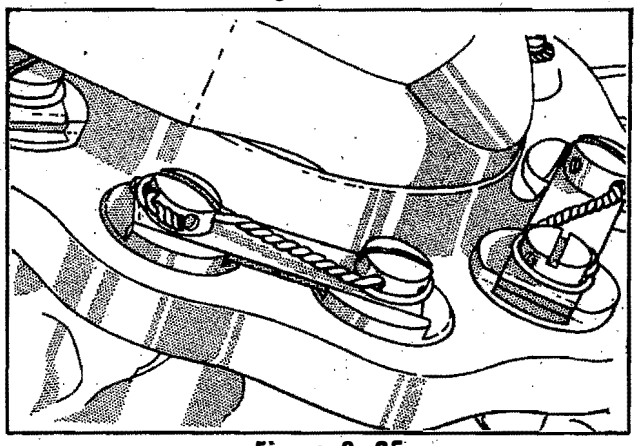


Figure 8—25

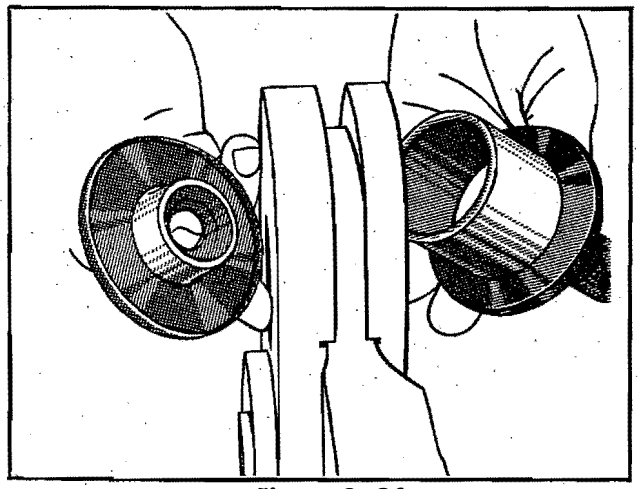


Figure 8—26

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.

8—107. Place the masterod, front face down in PWA-296 Fixture equipped with PWA-2557 Fixture. Place the linkrods in position in the masterod. Install PWA-992 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. Align the slot in the linkpin with the projecting tongue of PWA-2557 Fixture. Place the "L" head plunger of PWA-296 Fixture through the center guide holes of both fixtures and, in conjunction with PWA-2674 Drift, bring the plunger down to press in the linkpin (Figure 8—24). Rotate the plunger to the next linkpin, and change the position of PWA-992 Wedge until all the pins are assembled.

8—108. LINKPIN LOCKING BARS.

8—109. 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 8—25).

8—110. If the locking bar does not fit properly, replace it with 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 insure 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.

8—111. CRANKSHAFT PLUG. Install the plug in the crankshaft, using PWA-3061 Drift. Install the standpipe in the crankshaft and through the plug, then flare over the end of the standpipe. Install the threaded plug and gasket, using PWA-2366 Wrench to tighten the plug.

8—112. CRANKSHAFT FRONT SECTION.

8—113. Mount the splined end of the crankshaft front section in TAM-206 Fixture equipped with PWA-1919-2 Adapter.

8—114. Screw the crankshaft front plug in place on the rear face of the crankshaft front throw. Use PWA-1647 Wrench to tighten the plug. 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.

8—115. Leave the crankshaft front section in the fixture until the crankshaft rear section has been assembled.

8—116. SUPERCHARGER SPRING DRIVE BOLT. Install the supercharger spring drive bolt from the front side of the crankshaft rear section. Use PWA-1195 Wrench to tighten the bolt in the crankshaft.

8—117. FLYWEIGHTS.

8—118. 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.

8—119. Turn the counterweight on its edge and press the inner halves of the flyweights on by hand (Figure 8—26). If the flyweight does 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 PWA-1067 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.

8—120. 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 flyweight bolts in snugly by hand (Figure 8—27). Install TAM-1773 Wrench over one flyweight. Use a 1/2 inch bar to turn the wrench and screw the flyweight bolt all the way in. Repeat the procedure to install the second flyweight.

8—121. Tighten the expander plugs in the flyweight bolts with a 1/4 inch allen plug wrench while holding the head of the flyweight bolt with a 1-1/4 inch hex wrench. The expander plug is sufficiently tight when it is even with the flyweight (Figure 8—28).

8—122. Measure and record the length of the flyweight bolt, using an outside micrometer. Use TAM-1773 Wrench with PWA-2238 Torque Wrench to torque the flyweight bolt to approximately 1300 inch pounds. Measure the flyweight bolt stretch. The recommended flyweight bolt stretch is .001 to .0015 inch.

8—123. Torque the expander plugs to 220 to 225 inch pounds, using an allen wrench with a long handle and PWA-2239 Wrench. The expander plug should in no case project more than 1-1/2 threads.

8—124. Check the end clearance of the assembled flyweights with a feeler gage. See reference 333, Section XII.

8—125. ASSEMBLY OF CRANKSHAFT REAR SECTION TO FRONT SECTION.

8—126. 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 on the crankpin with the linkpin locking bars facing the operator.

8—127. Screw the rod of PWA-2422 Pusher in the crankshaft bolt hole in the crankshaft front section.

8—128. 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.

8—129. Thread the crankshaft rear section over the pusher bar (Figure 8—29) and engage the ends of the

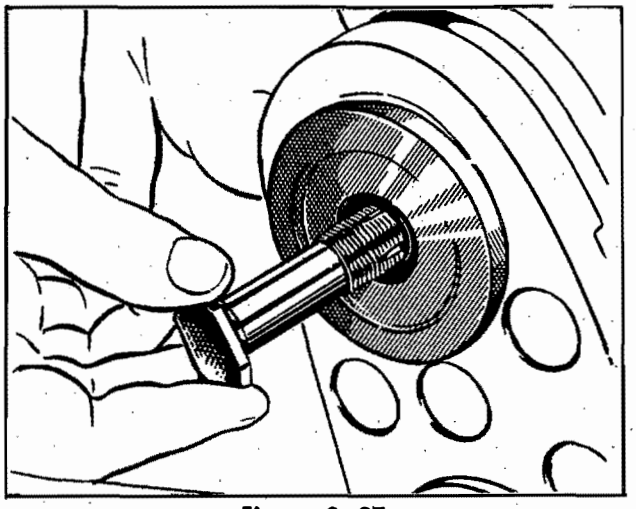


Figure 8—27

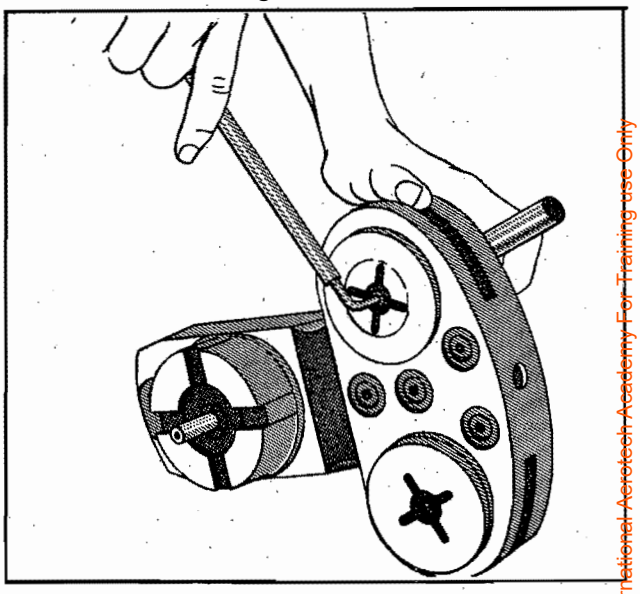


Figure 8—28

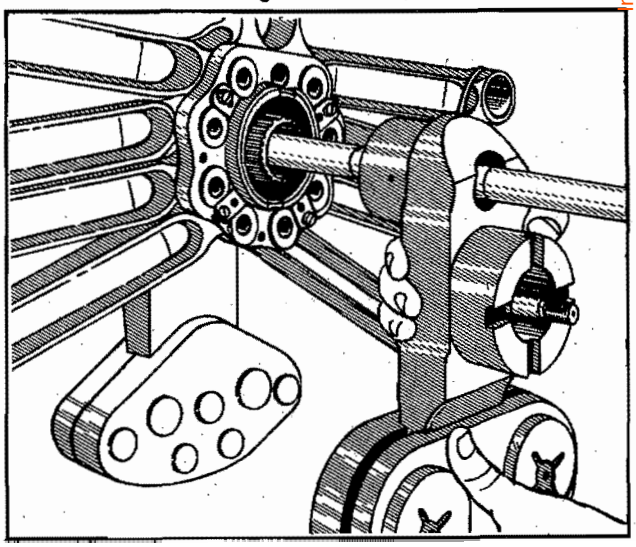


Figure 8—29

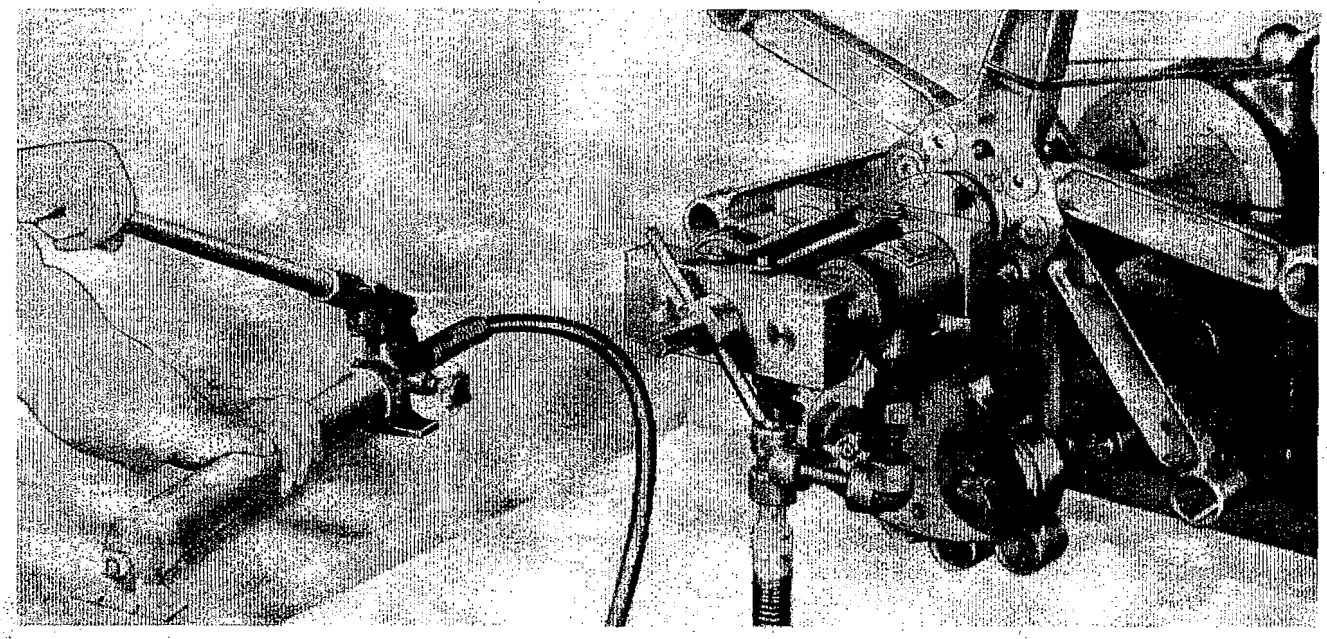


Figure 8—30

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.

8—130. Push the ram unit up 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 PWA-3755 Pump and force the two sections of the crankshaft together (Figure 8—30). Remove the pusher from the crankshaft.

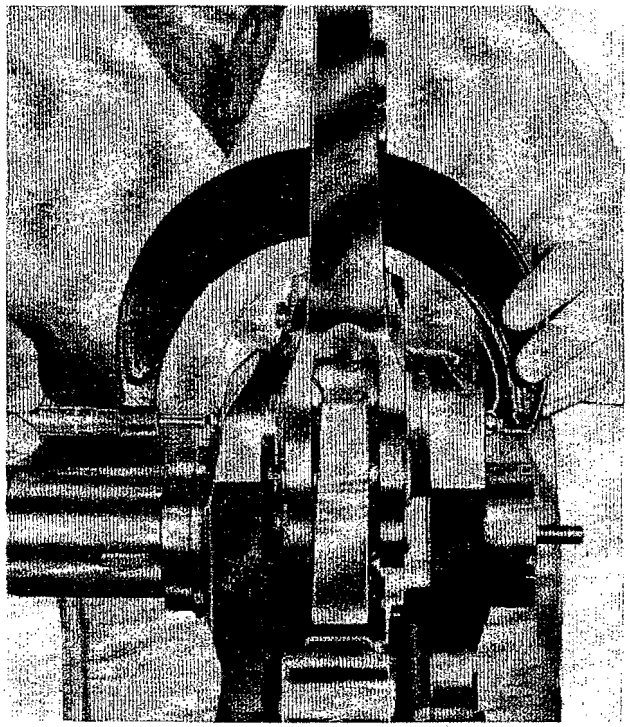


Figure 8—31

8—131. 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 8—31). Alternately tighten and gage the bolt, using the micrometer, ball ends, and PWA-1914 Wrench until 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 the crankshaft rear cheek and anchor the cotterpin in place.

8—132. In the event 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.

8—133. Use a feeler gage to check the end clearance of the masterod bearing. See reference 314, Section XII. If the clearance is insufficient, disassemble and grind the flanged end of the bearing. If the clearance is excessive, replace the bearing.

8—134. REAR MAIN BEARING.

8—135. Apply oil to the inside surface of the rear main bearing inner race and to the seating surface on the crankshaft.

8—136. Install the front half of the rear main bearing inner race, using PWA-268 Pusher (Figure 8—32); then install the rear section of the inner race. Install the rollers and the bearing outer race.

8—137. In the event the inner race pusher is not available, heat the inner race in an oil bath to 175° to 204°C (347° to 400°F) for 3 minutes. Allow the race to drain

and install it on the crankshaft, using lint-free asbestos gloves.

8–138. CRANKSHAFT REAR GEAR.

8–139. 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.

8–140. 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 fiber drift in order to install it. Recheck the clearance between the gear and the crankshaft, using a feeler gage. If the clearance is insufficient, grind the lugs on the gear. Secure the gear to the crankshaft with four screws.

8–141. IMPELLER SPRING DRIVE COUPLING. Place the buttons and springs in place in the fixed spider of the impeller spring drive coupling, using PWA-2792 Compressor. Install the friction band on the floating spider and insert the floating 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.

8–142. FRONT MAIN BEARING.

8–143. 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.

8–144. Install the rear section of the front main bearing inner race on the crankshaft, using PWA-79 Sleeve; then install the front section of the inner race. Install the rollers and the outer race.

8–145. In the event 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.

8–146. CRANKCASE SECTION.

8–147. CRANKCASE REAR SECTION.

8–148. 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.

8–149. 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.

8–150. 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

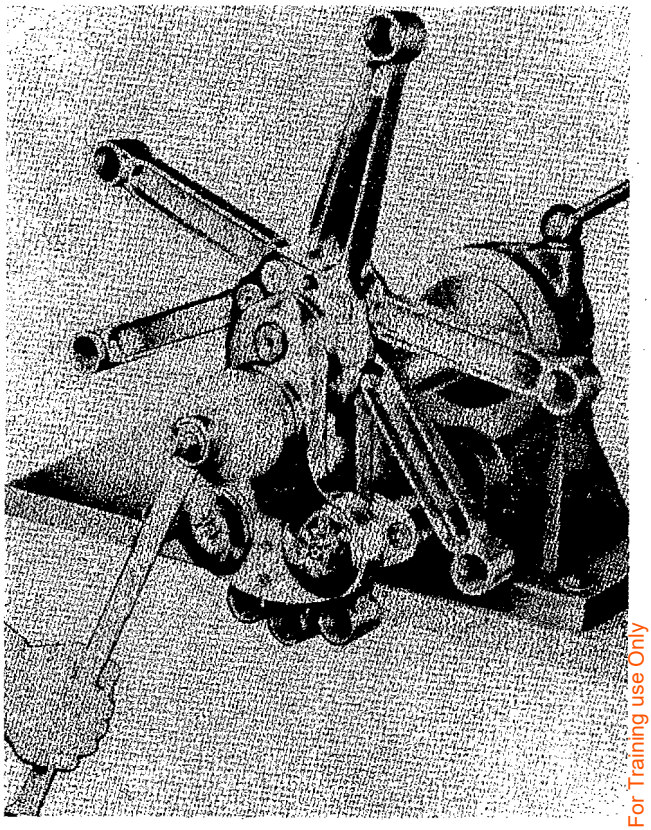


Figure 8–32

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.

8–151. 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 No. 1 and 5 clockwise and 4 and 7 counterclockwise from the sump mounting pad. The ignition manifold will be attached to these studs during final assembly before the nuts are installed. Install palnuts on the crankcase rear section studs.

8–152. ASSEMBLY OF CRANKSHAFT AND MASTEROD ASSEMBLY TO ENGINE. Oil the impeller spring drive coupling and the crankshaft rear gear. Attach PWA-520 Eye to the front end of the crankshaft, and in conjunction with PWA-2388 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 PWA-2488 Supports over the masterod and each linkrod. Pull the No. 1 linkrod to its full outward position.

8–153. CRANKCASE FRONT SECTION.

8–154. 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. Reinstall the nut on the gear and tighten it with TAM-255 Wrench in conjunction with PWA-248 Holder (Figure 8–33). Check the clearance between the nut and the bushing. See reference 310, Section XII. If the clearance is insufficient, face off the bushing with PWA-62 Facer. When the clearance is satisfactory, tighten and cotterpin the nut in the gear.

8–155. 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.

8–156. It may be necessary to tap the crankcase front section downward with a fiber drift.

8–157. 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; then cotterpin the nuts.

8–158. CAM DRIVE GEAR.

8–159. Check the fit of the cam drive gear key in the keyway in the crankshaft. See reference 3, Section XII. If the clearance is insufficient, grind down the key in a surface grinder, or select a new key.

8–160. Insert the key in the keyway, using a brass drift and a hammer.

8–161. Install the cam drive gear ring on the cam drive gear, using an arbor press and PWA-3215 Drift and Base. Place the cam drive gear over the crankshaft, aligning the key and keyway. Mesb 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.

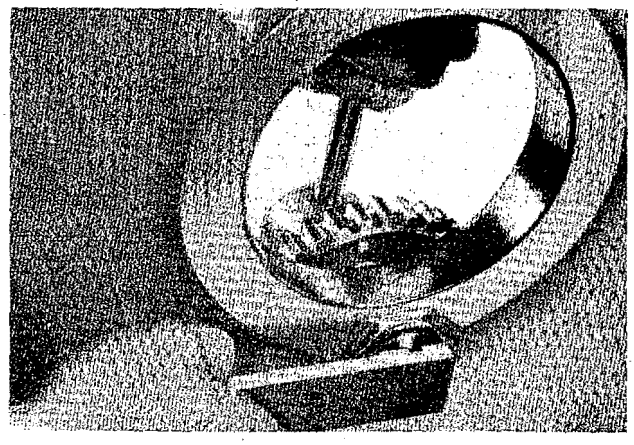


Figure 8–33

CAUTION

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

8–162. CAM OIL FEED BRACKET. Center the floating rings in the cam oil feed bracket. 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 8–34).

8–163. CAM AND CRANKSHAFT FRONT OIL SEAL RING CARRIER.

8–164. Make sure that the floating rings in the cam oil feed bracket are properly centered. 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.

8–165. 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 center position (Figure 8–35).

8–166. Install the two oil seal rings on the front oil seal ring carrier. Use a feeler gage to check the side clearance and gap clearance of each ring. See references 13 and 14, Section XII. Adjust the clearances to conform to the specified limits.

8–167. 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 sleeve. Temporarily install the oil slinger and the thrust bearing nut on the crankshaft. Check the clearance between the bottom of the oil seal ring carrier and the top of the cam drum, using a feeler gage (Figure 8–36). See reference 9, Section XII. 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.

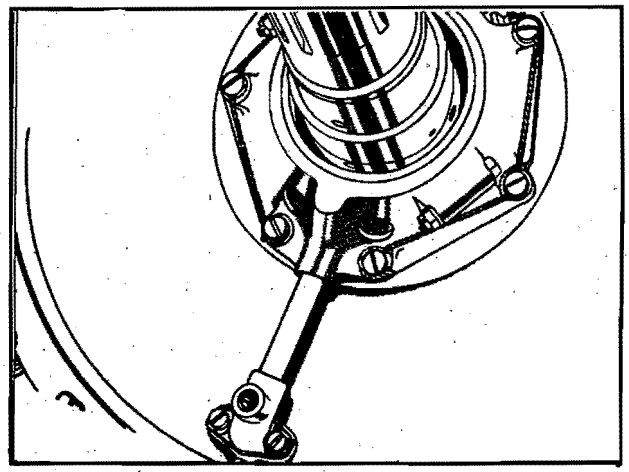


Figure 8–34

8—168. FRONT SECTION.

8—169. FRONT BREATHER PLUG. Install the plug in the breather aperture in the front case.

8—170. ROCKER OIL MANIFOLD. Insert the ends of the manifold in the front case. Attach the manifold to the case with screws. Lockwire the screws (Figure 8—37).

8—171. THRUST BEARING COVER PINCH FIT.

8—172. Install the thrust bearing cover on the front case and secure it with nuts. Use a feeler gage 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.

8—173. 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.

8—174. The pinch fit is the difference between the average distance and the average thickness measured. See reference 7, Section XII. If the pinch fit is not within the specified limits, adjust it by grinding or replacing the thrust bearing cover spacer ring.

8—175. TAPPETS, ROLLERS, AND PINS.

8—176. Coat the tappets, rollers and pins with oil and install the tappets in their guides.

8—177. 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.

8—178. ASSEMBLY OF FRONT CASE TO ENGINE.

8—179. PROPELLER OIL FEED TUBE AND PLUG. Install the oil feed tube leading from the control valve boss to the thrust bearing liner, and the pressure type governor engine valve cover, gasket and plug.

8—180. 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.

8—181. 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 driving alternately on opposite sides of the case, using a fibre drift and a hammer.

8—182. 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.

8—183. THRUST BEARING.

8—184. Place the crankshaft adjusting spacer in posi-

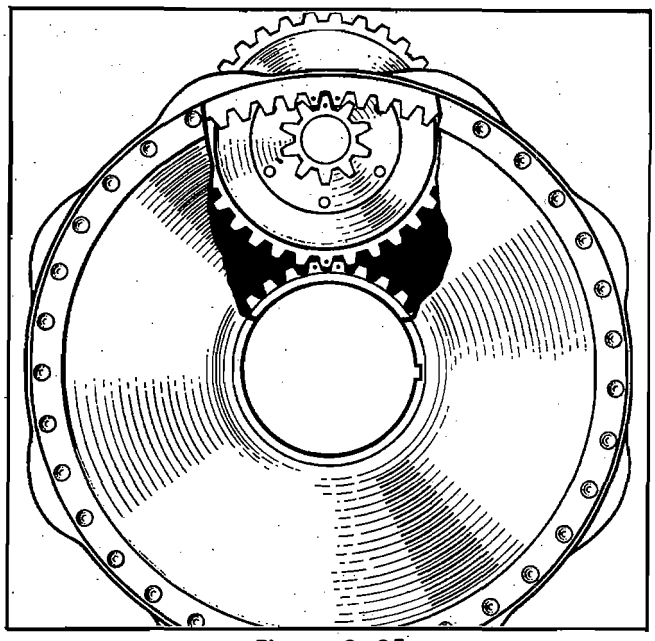


Figure 8—35

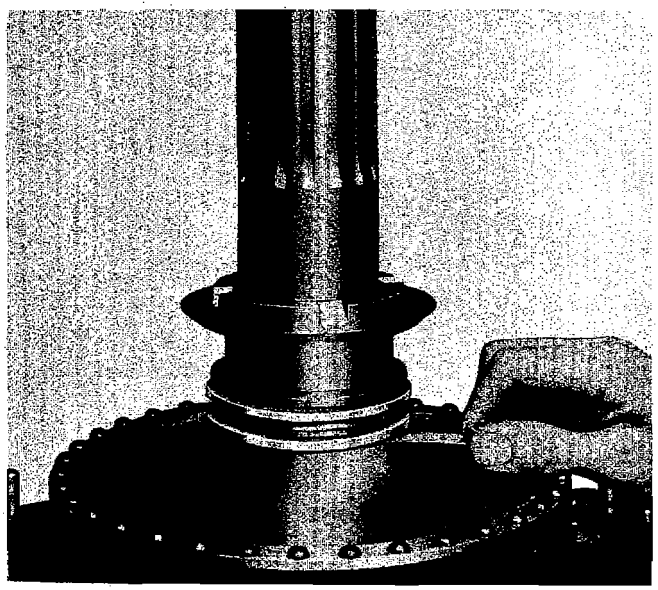


Figure 8—36

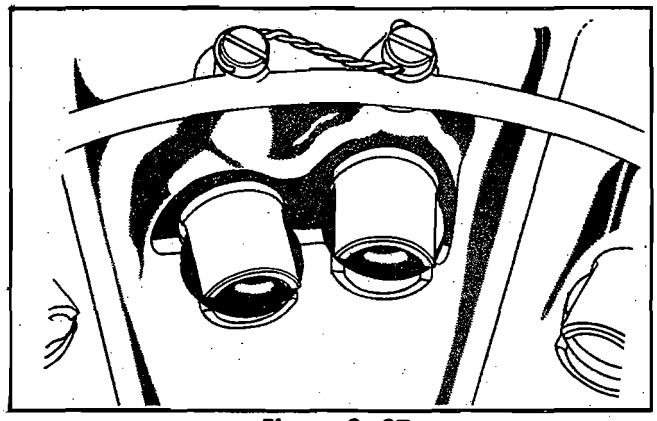


Figure 8—37

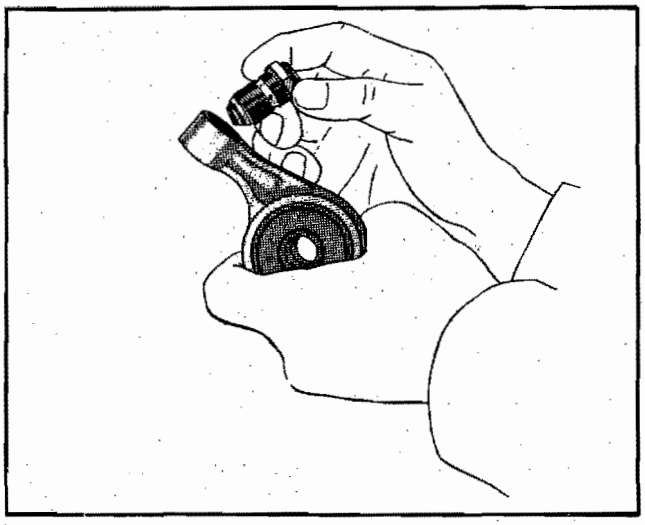


Figure 8—38

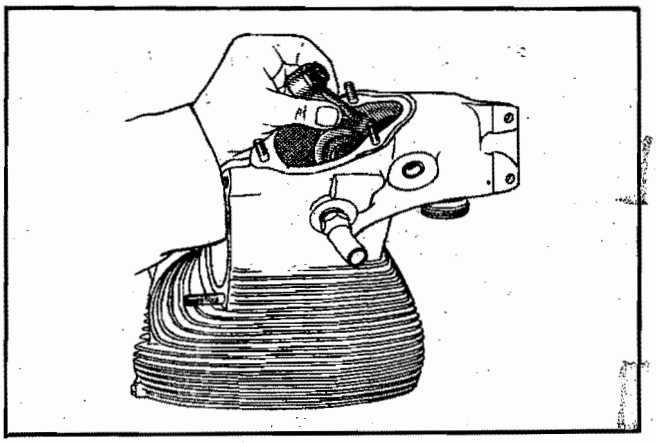


Figure 8—39

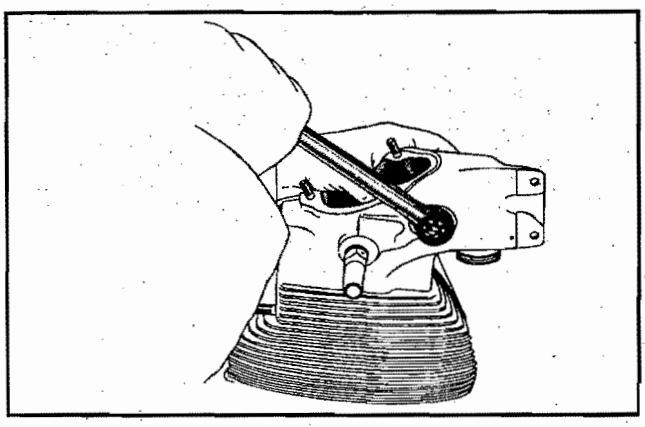


Figure 8—40

tion on the crankshaft front oil seal ring carrier. Install the thrust bearing in its liner in the front case.

8—185. Screw PWA-520 Eye on the front end of the crankshaft and in conjunction with PWA-2388 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.

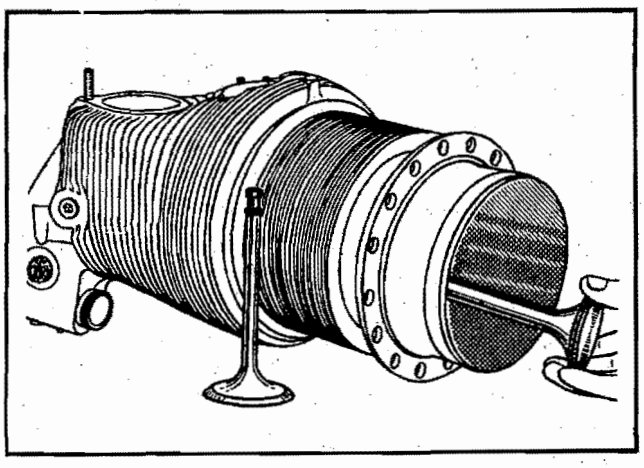


Figure 8—41

8—186. Remove the eye and chain hoist; then drive the thrust bearing into its liner, using PWA-79 Sleeve. Install the oil slinger, making sure it is centered over the shoulder on the crankshaft.

8—187. THRUST BEARING NUT. Screw the thrust bearing nut on the crankshaft and torque to 250 ft.-lbs.; then tighten an additional 25° to 30°. PWA-1093 Wrench and PWA-112 Bar will be used to keep crankshaft from turning.

CAUTION

Remove the fiber that was inserted under the crankshaft rear counterweight.

8—188. CYLINDERS AND PISTONS.

8—189. Deleted.

8—190. ROCKER, ROCKER BEARINGS, AND ADJUSTING SCREWS.

8—191. Screw the valve adjusting screw into the rocker (Figure 8—38) and install the locknut on the adjusting screw.

8—192. Press the rocker bearing into the rocker, using an arbor press and PWA-614 Drift and Base.

8—193. Place the rocker in position in the rockerbox on the cylinder (Figure 8—39) and install the shafts, small end first, through the bushings 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, using PWA-2399 Wrench.

8—194. Install the rubber oil seal, copper covered gasket with the smooth side adjacent to the nut, and the nut. Tighten the nut to the recommended torque, using PWA-2399 Wrench (Figure 8—40).

8—195. Insert a cotterpin through each nut and bend the upper end of the cotterpin back through the hollow shaft.

8—196. VALVES AND VALVE SPRINGS.

8—197. Prior to assembling the valves in the cylinders,

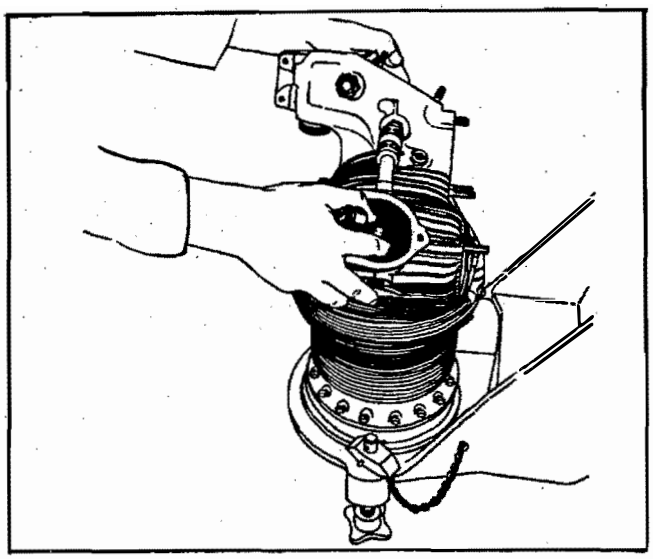


Figure 8—42

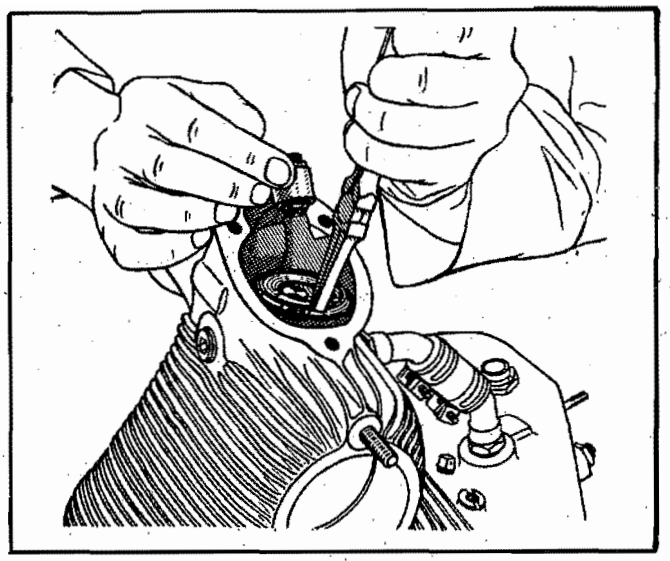


Figure 8—43

clean and oil the valve stems and valve guides.

8—198. Set the cylinder on its side on a clean bench. Install the inlet and exhaust valves in their respective guides (Figure 8—41). Hold the valves in place with the forefingers while setting the cylinder on TAM-3146 Stand (Figure 8—42).

8—199. Install a safety circlet on each valve stem. Using a pair of long-nose pliers, install the valve spring lower washers in position (Figure 8—43). Install the valve outer springs and the inner springs (Figure 8—44). Place the valve spring upper washers in position.

8—200. 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

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 8—45).

8—201. 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.

8—202. Install a PWA-3252 Plug in each sparkplug hole.

8—203. PISTONS AND PISTONRINGS. Refer to figure 7—71 and, using PWA-1791 Pliers, install each set of piston rings in their proper groove on the piston (Figure 8—46). Expand the piston rings just enough to clear the piston O.D.—no more. Check the side clearance of each ring with a feeler gage. When measuring the side clearance of a wedge-shaped ring, hold the outer face of the ring flush with the piston.

8—204. PISTONPINS AND PLUGS. If the plugs which were removed at disassembly are undamaged, they may be reinstalled in the pistonpin. If new plugs are to

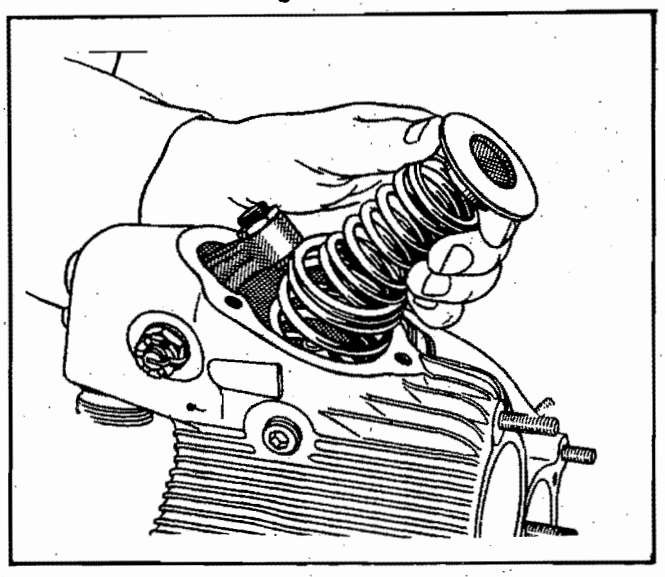


Figure 8—44

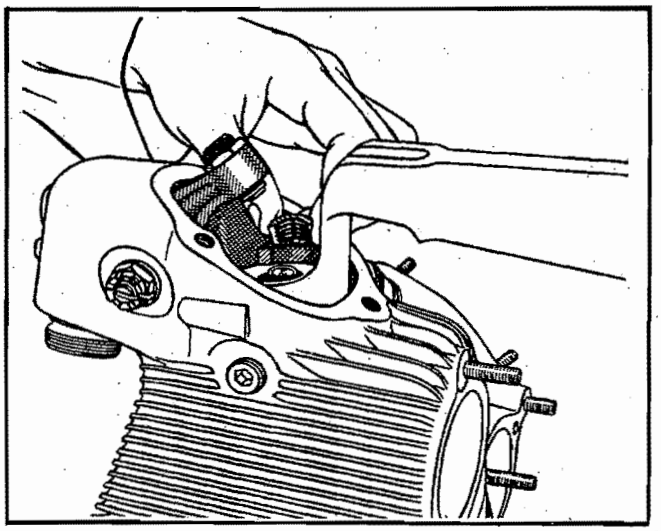


Figure 8—45

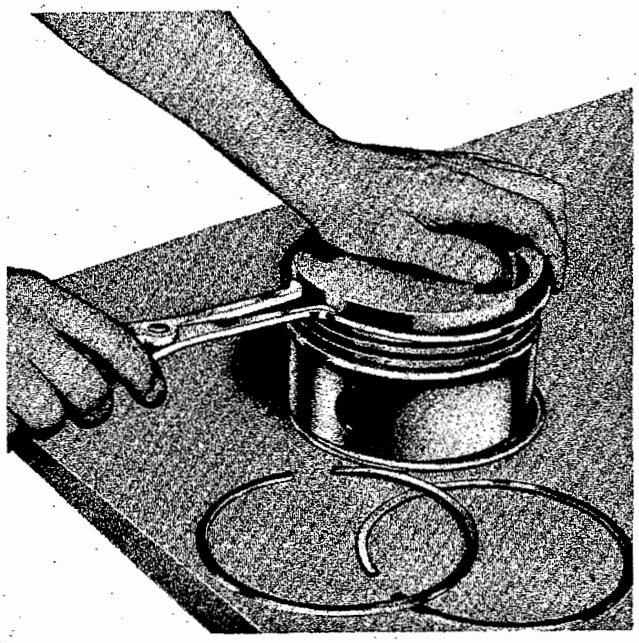


Figure 8–46

be installed, turn down the plug to the desired fit. Install the plugs in the pistonpin, using an arbor press and a drift shaped to fit the contour of the plug dome. Stamp the cylinder number next to the O.D. of the dome of one of the plugs in each pin.

8–205. ASSEMBLY OF PISTONS AND CYLINDERS TO THE ENGINE.

8–206. Install PWA-112 Bar on the crankshaft and turn the crankshaft until the masterod, No. 5, is at the top dead center position. Remove the rubber rod protector.

8–207. 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 pistonrings and apply a generous coating of oil to the rings.

8–208. Lock PWA-249 Clamp over the pistonrings. 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 8–47).

8–209. Center the cylinder with two locating nuts and install washers and nuts on the other studs. Tighten the nuts uniformly with PWA-2397, PWA-2006, or PWA-2399 Wrench in conjunction with PWA-2398 OR PWA-2411 Handle. Torque the nuts to the recommended torque, using PWA-2399 Wrench. Install palnuts over the hold down nuts, running them down finger tight. Tighten the palnuts 1/4 turn with PWA-1608 Wrench.

8–210. INTERCYLINDER OIL TUBE HOSE. Install new rubber hoses on the intercylinder drain tubes of cylinder numbers 3, 4, and 5 and 6, 7, and 8. Secure each hose with two clamps. Tighten the clamp bolts.

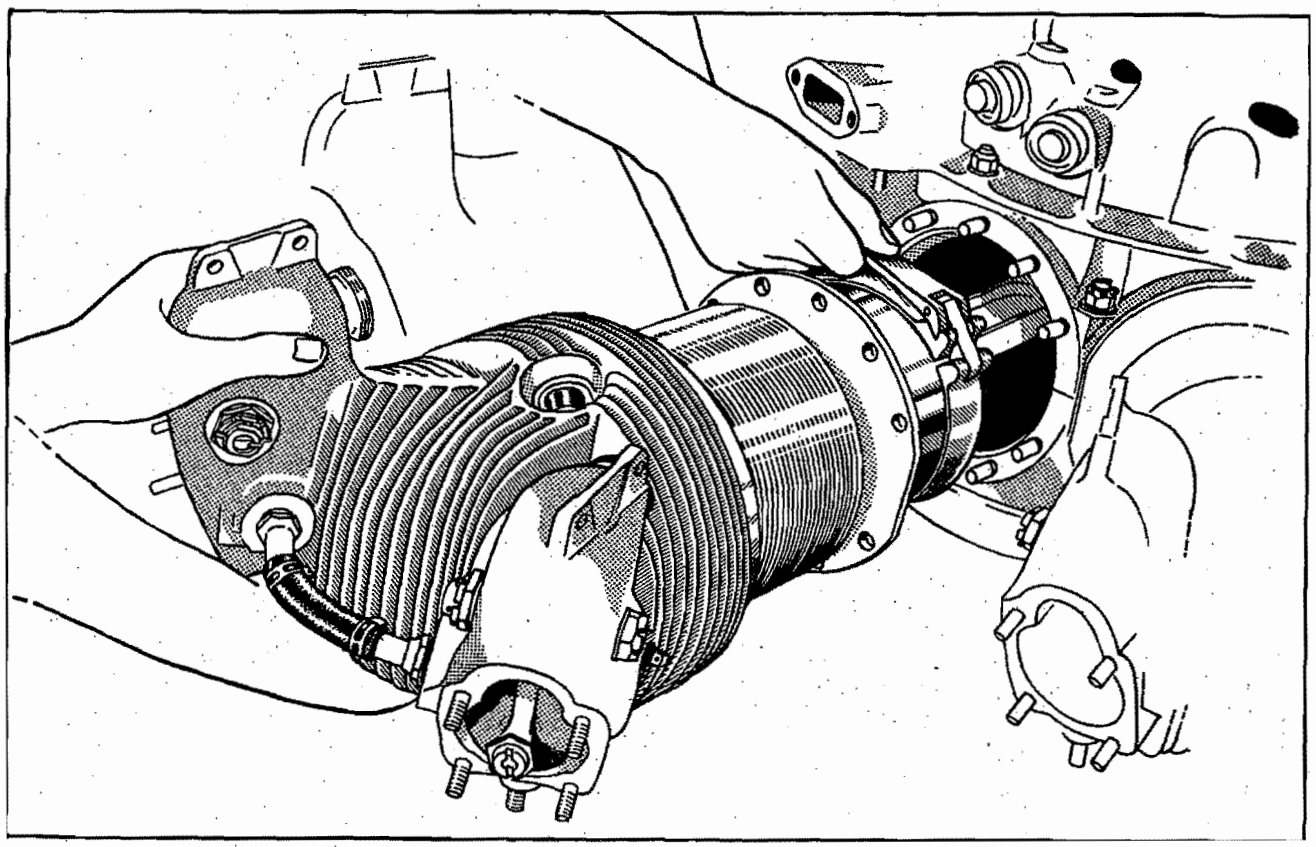


Figure 8–47

SECTION IX

9–1. GENERAL.

9–2. The directions in paragraphs 8–1 through 8–15 are to be followed wherever applicable in performing the final operations described by paragraphs 9–3 through 9–58.

9–3. FINAL OPERATIONS.

9–4. IGNITION MANIFOLDS.

9–5. Mount the front ignition manifold over the crankshaft and front case. Attach the manifold to the crankcase front section with five screws. Lockwire the screws.

9–6. Uncouple the union on the rear ignition manifold and install the manifold on the supercharger section. Tighten the union on the manifold with PWA-1886 Wrench. Fasten the manifold to the supercharger section with five screws. Lockwire the screws. Install the washers and nuts on the supercharger case studs supporting the ignition manifold.

9–7. OIL SUMP.

9–8. Place the intercylinder sump deflector on the sump while the sump is still on the bench.

9–9. Check the clearance between the sump and the deflector. If necessary, bend the deflector to provide approximately a 3/16 inch clearance between the sump and the deflector.

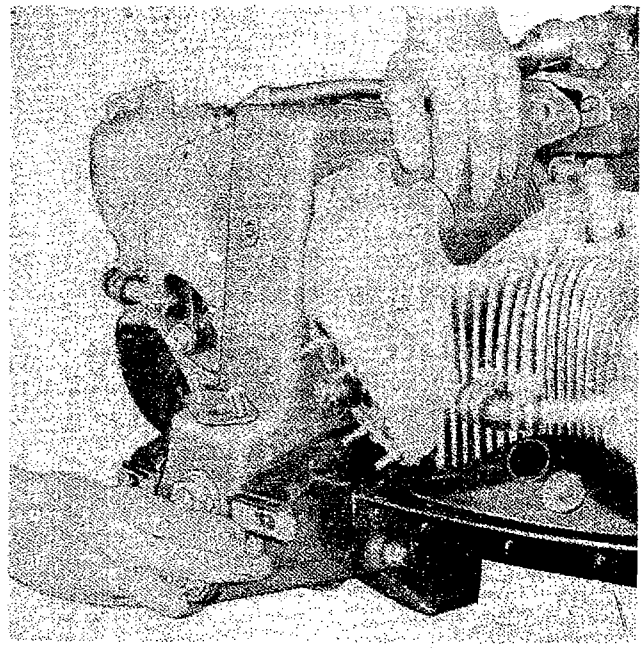


Figure 9–1

9–10. Install the strainer and retainer in the sump, using PWA-1572 Driver to make sure they are in as far as possible.

9–11. Screw the oil drain plugs into the sump.

9–12. Place a gasket on each sump mounting flange. Install the sump on its mounting pads (Figure 9–1). Install a fibre insert nut on each stud and tighten the nuts.

9–13. OIL SCAVENGE TUBES. Insert gaskets under the connecting brackets and install the main oil sump to the oil pump and rocker oil sump to oil sump scavenge tubes on the engine.

9–14. CYLINDER DEFLECTORS. Unless a shroud is used for cooling purposes during the post-overhaul running 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.

9–15. PRIMER DISTRIBUTOR. Clamp the primer distributor to the No. 1 intake pipe. Lockwire the clamp screws.

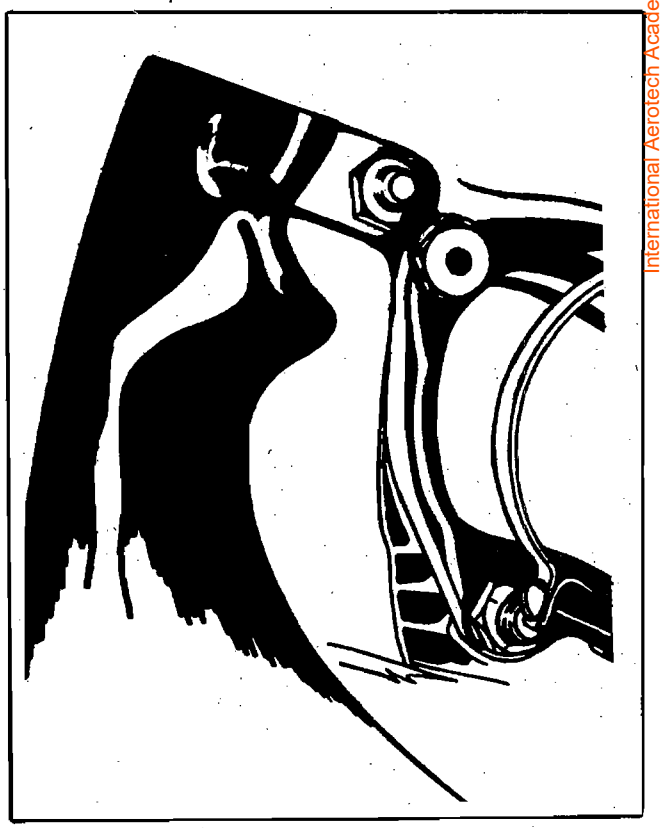


Figure 9–2

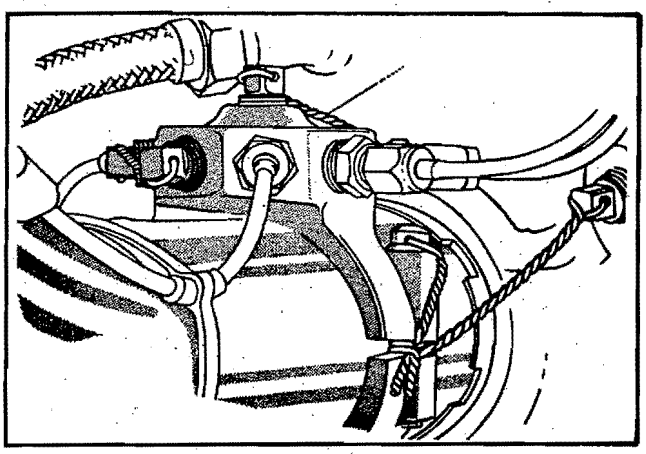


Figure 9–3

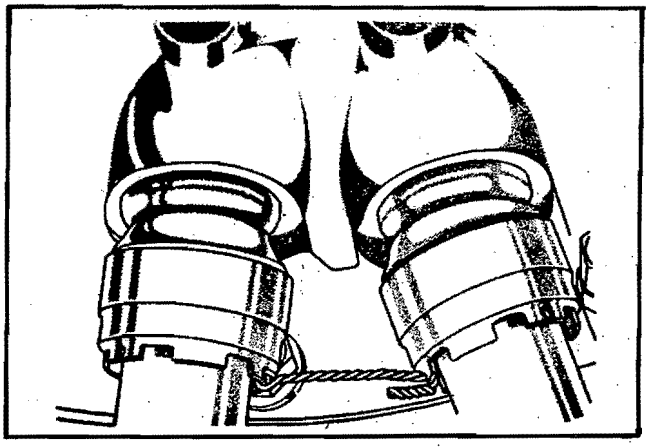


Figure 9–4

9–16. INTAKE PIPES. Remove the port protectors from the supercharger case. Install the flange gland nut and rubber packing on each intake pipe, after first coating the rubber packing with insulating compound, specification AN-C-128, and place the pipe in position. Screw the gland nut finger tight in the supercharger case. Coat a copper gasket with insulating compound, specification AN-C-128; then install it split side forward at the cylinder intake port. Secure the pipe flange to the cylinder with two self-locking nuts and one cap screw. Safety wire the cap screw to the deflector assembly inter-ear bracket with a figure eight tie (Figure 9–2). Tighten the packing nut, using PWA-237 Wrench. Use care in tightening the nuts to avoid damaging the pipes.

9–17. PRIMER TUBES. 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 9–3).

9–18. VALVE TIMING CHECK.

9–19. Refer to paragraph 9–24 and install the inlet and exhaust valve pushrods for the No. 1 cylinder.

9–20. Mount PWA-85 Pointer over the crankshaft. Install PWA-112 Bar on the crankshaft and turn the crankshaft counterclockwise until the piston of No. 1 cylinder is at the top dead center position of the compression stroke; both valves should be closed.

9–21. 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 gage 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 gage. At this point the inlet valve is just opening and the timing pointer should align approximately with the I.O. mark.

9–22. 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 gage 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 gage begins to release. The exhaust valve is now just closing and the pointer should align approximately with the E.C. mark.

9–23. If the pointer aligns properly (the important 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 in 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.

9–24. PUSHRODS.

9–25. One of the ballends 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."

9–26. Coat the ballends of each pushrod with oil and insert the rod into its cover.

9–27. Depress the rocker, using PWA-455 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.

9–28. VALVE CLEARANCE ADJUSTMENT. 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.

9–29. 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 center) of the compression stroke. Insert a .010 inch leaf of PWA-4675 Gage 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 lock-

nut to a torque of 300 to 350 inch pounds.

9–30. 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.

9–31. Adjust the clearances of the valves in the remaining cylinders, always turning the piston to exact T.D.C. before making the adjustment.

9–32. 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.

9–33. ADJUST LENGTH OF PUSHRODS.

9–34. If more than six threads of the valve adjusting screw can be seen above the locknut, the pushrod is too long. If the adjusting screw shows fewer than three threads, the pushrod is too short. In either case adjust the pushrod to the proper length. This adjustment is accomplished by removing the pushrod ballend and washer and replacing the washer with a thicker or thinner washer to establish the proper length.

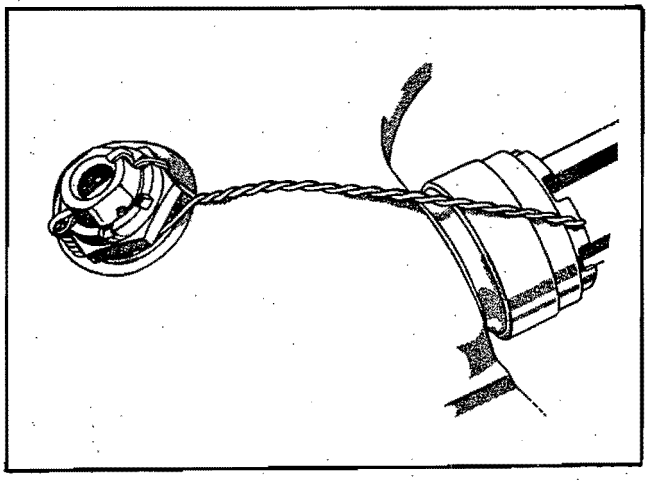


Figure 9–5

9–35. Tighten the pushrod cover gland nuts at the crankcase end first; then tighten the gland nut at the cylinder end, using PWA-4531 Wrench for both nuts. Tighten the nuts to the recommended torque and lockwire the nuts (Figures 9–4 and 9–5).

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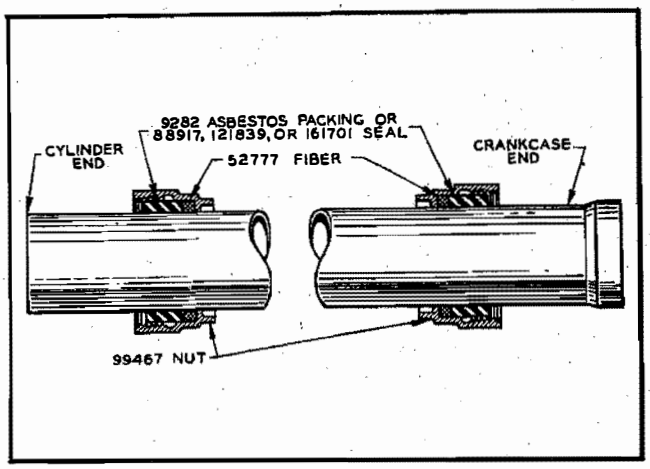

Figure 9–5A

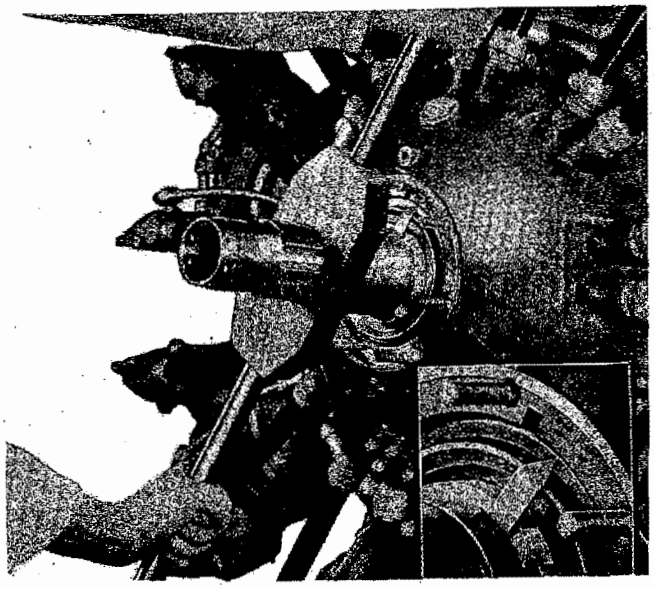

Figure 9–6

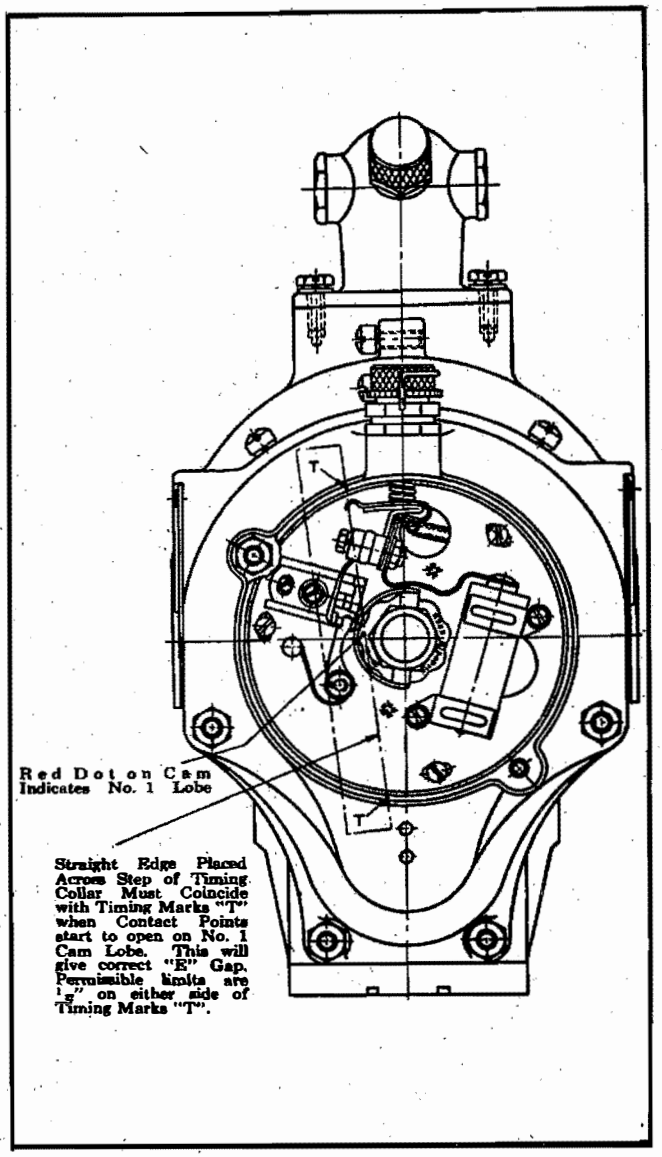

Figure 9–7

9–35A. On engines incorporating pushrod cover assemblies having shallow nuts, the packing or seal is confined between the fiber washer and the tappet guide at the crankcase end and between the fiber washer and connector at the cylinder end (Figure 9–5A).

9–36. ROCKERBOX COVERS. Place a new gasket on each rockerbox. Place the covers on the rockerboxes and install the fiber nuts or screws. Tighten the nuts or screws to the recommended torque.

9–37. INSTALLATION AND TIMING OF MAGNETOS.

9–38. Crank the bed of the stand until the engine assumes a horizontal position. Turn the crankshaft until No. 1 piston is on the compression stroke and the Timing Pointer aligns with the spark advance mark on the front case (Figure 9–6).

9–39. If Bosch magnetos are to be installed, rotate the magneto shaft until the step in the cam shield is in a position so that a straightedge placed across the step will coincide with a line between the marks on the breaker housing (Figure 9–7).

9–40. If Scintilla magnetos are to be installed, 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 straightedge placed across the marks on the breaker housing (Figure 9–8). If the internal timing of the magneto is correct, a white dot will be visible through the hole under the cap in the top of the breaker housing.

9–41. Mount the magneto on the engine without installing the magneto rubber coupling. Measure the distance between the magneto drive shaft and the magneto shaft couplings, making certain that the two shafts are at their maximum distance apart. Magneto rubber couplings are provided 1/32 in. oversize, identified by "B+1/32" molded on the face. The rubber coupling used should be

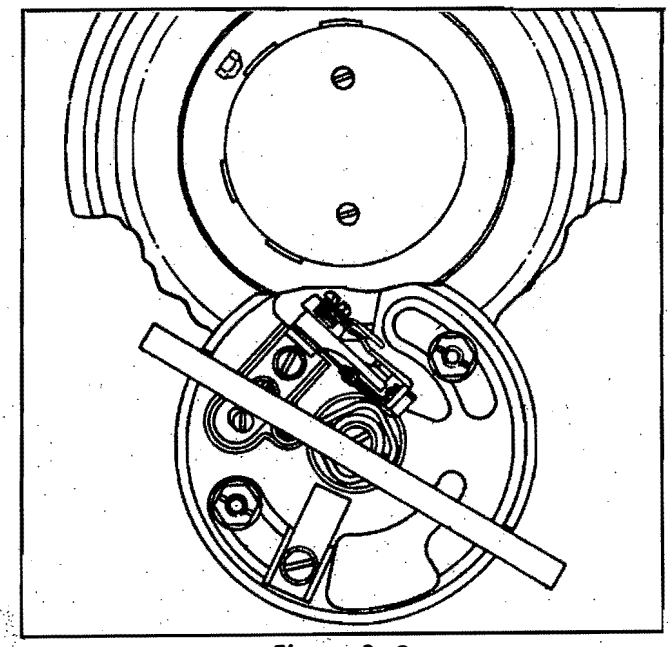

Figure 9–8

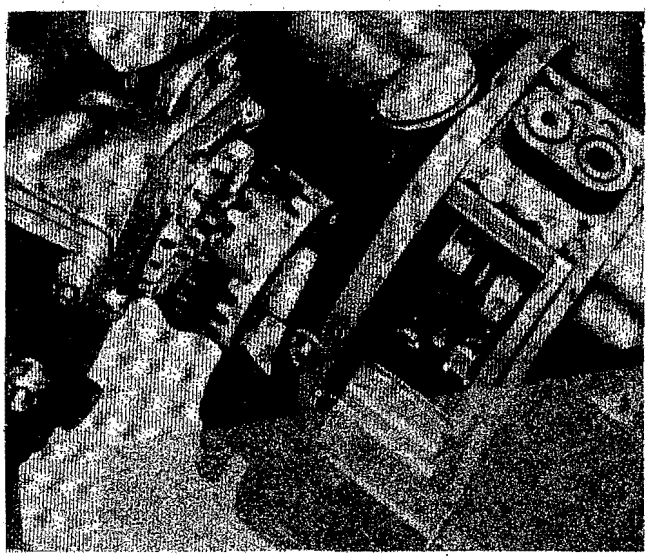

Figure 9–9

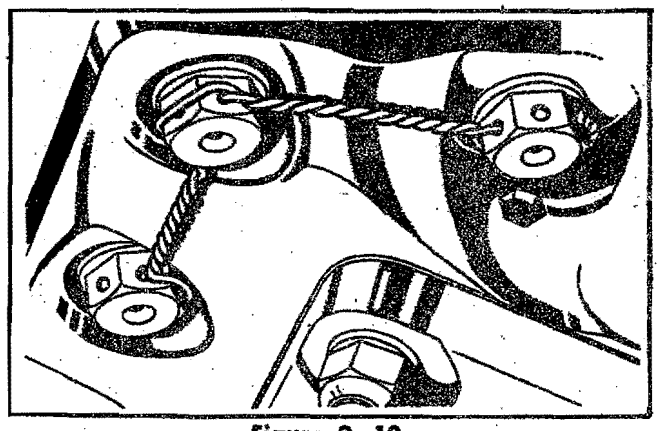

Figure 9–10

.020 in. to .030 in. less in thickness than the distance between the two metal couplings. Remove the magneto from the engine.

9–42. Turn the magneto drive rubber coupling until it can be engaged with its mating flanges without causing the magneto shaft to turn (Figure 9–9). Engage the rubber coupling and fit the magneto over the dowel pins in the mounting pad (Figure 9–10). Secure the magneto to the mounting pad with screws.

9–43. When both magnetos have been installed, attach PWA-2417 Timing Indicator to the ground lead of each magneto, and attach the ground lead of the indicator to the engine. Turn the crankshaft 90 degrees in a clockwise direction; then reverse the rotation and slowly bring the timing pointer to the spark advance mark. The indicator lights should light simultaneously when the pointer aligns with the spark advance mark.

9–44. If the indicator light shows that the contact points are breaking before the pointer aligns with the spark advance mark, remove the magneto and rubber coupling, and turn the rubber coupling clockwise one or two notches on the magneto coupling. Reinstall the magneto and coupling and recheck the magneto. If the contact points are breaking after the pointer aligns with the spark advance mark, the correct procedure is the same except that the rubber coupling is turned counterclockwise one or two notches. Remove the Timing Indicator, Crankshaft Turning Bar, and Timing Pointer.

9–45. If Bosch magnetos have been mounted on the engine, install the distributor blocks in their correct positions and secure with screws. Install the cover halves on the magnetos and secure with screws; then fasten the cover halves together with the necessary screws.

9–46. If Scintilla magnetos have been mounted on the engine, install the distributor blocks in their correct positions. Install the distributor block cover halves, and engage the two spring locks on each cover. Install the lockpins in the locks.

9–47. As an alternate method for positioning the No. 1 piston 25 degrees before top center, turn the crankshaft in the normal direction of rotation to bring the No. 1 piston at the beginning of the compression stroke, then install PWA-4142 Indicator (Time-Rite) in the front sparkplug hole of No. 1 cylinder (Figure 9–11). 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 (Figure 9–12). Turn the crankshaft in the direction of rotation until the pivot arm pushes the slide pointer to its furthest point (Figure 9–13). Turn the crankshaft about 90 degrees in the opposite direction. This will return the pivot arm to the top of the slot.

9–48. Adjust the proper engine scale(the scale marked R–985) so that the zero degree mark on the scale aligns with the reference mark on the slide pointer (Figure 9–14). Move the slide pointer up to align with the 25 degree mark on the scale (Figure 9–15). Turn the crankshaft in the normal direction of rotation until the pivot

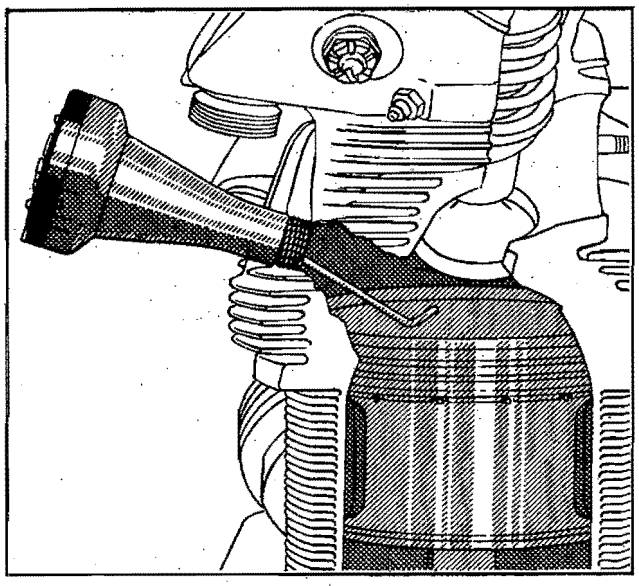

Figure 9—11

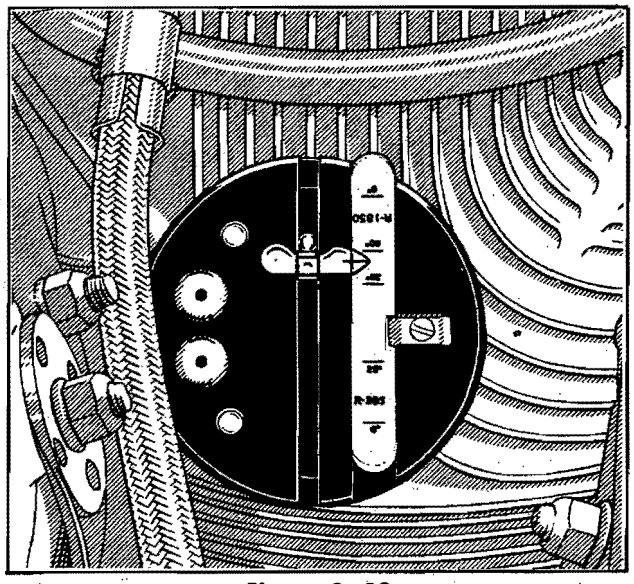

Figure 9—12

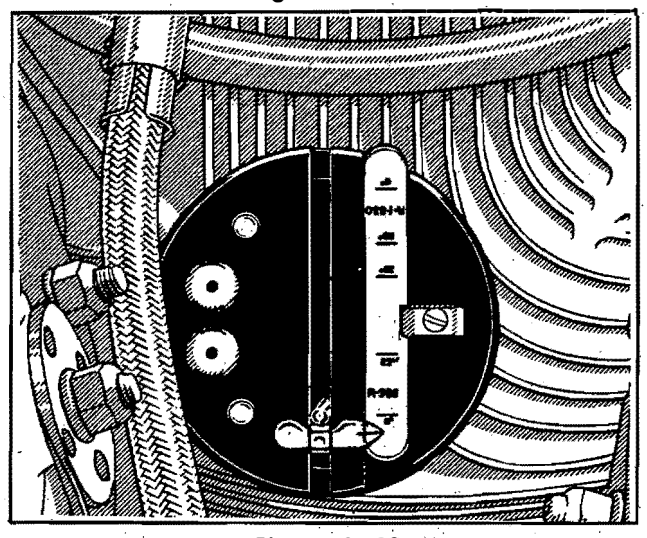

Figure 9—13

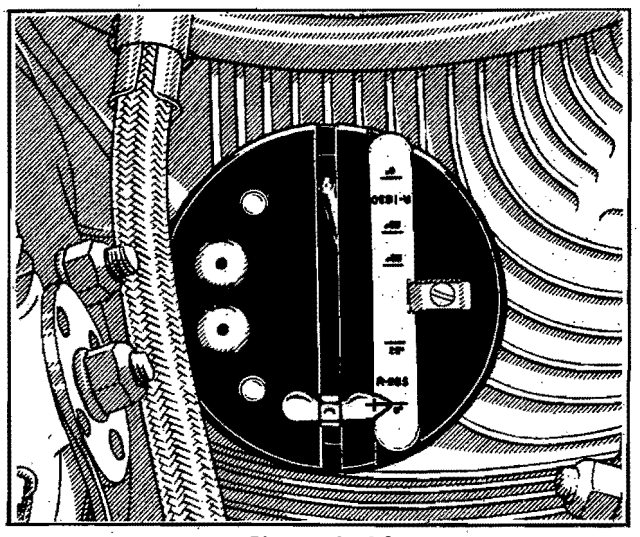

Figure 9—14

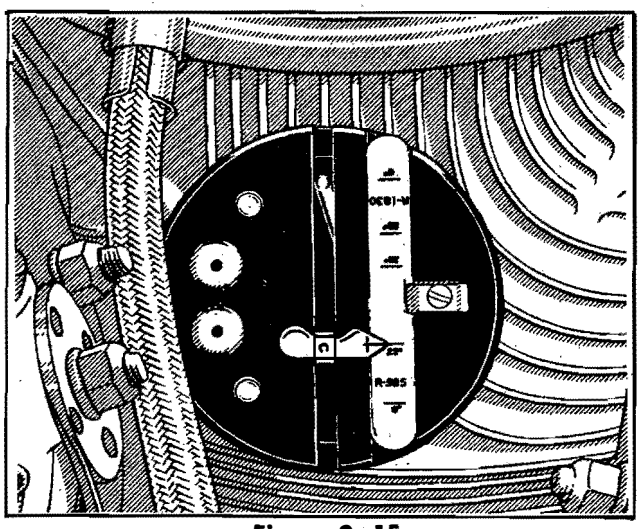

Figure 9—15

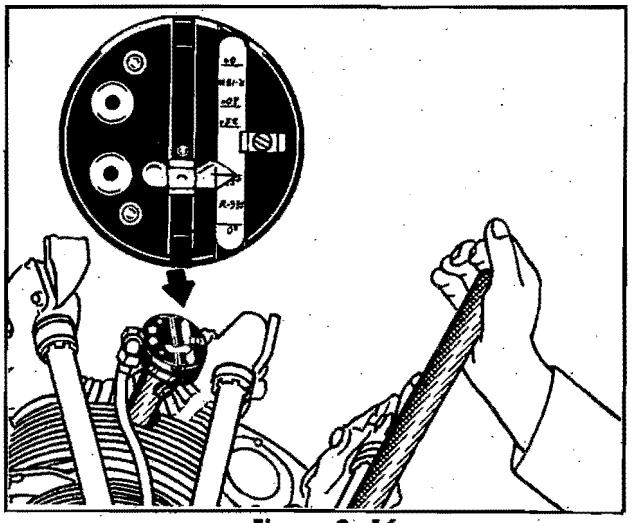

Figure 9—16

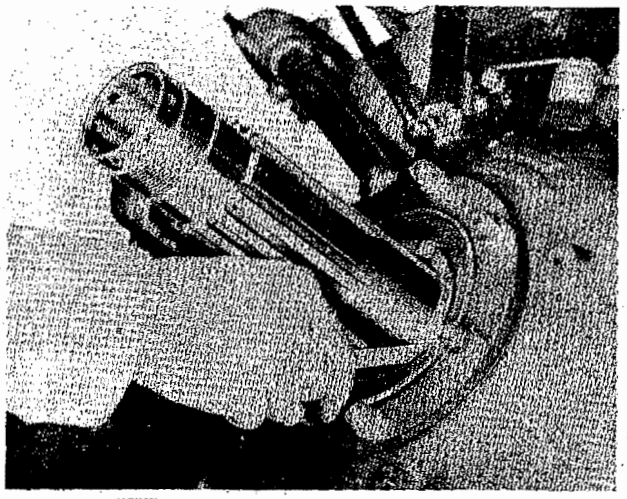

Figure 9—17

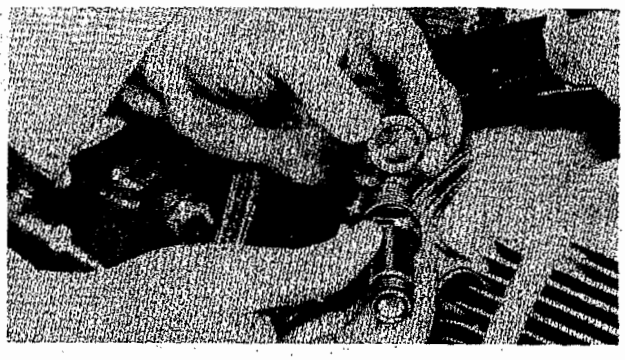

Figure 9—18

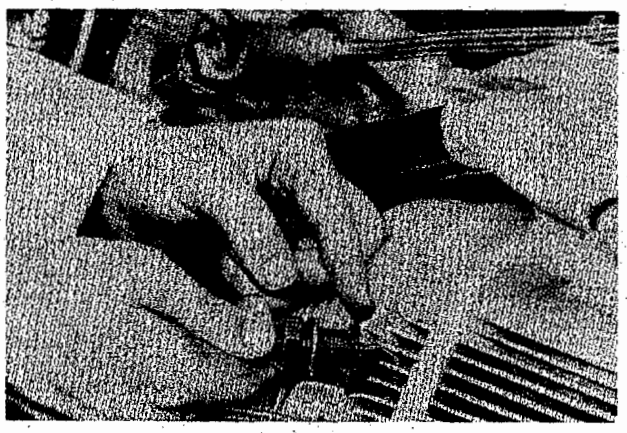

Figure 9—19

arm just contacts the slide (Figure 9—16). At this point the lower light on the indicator should flash on. The No. 1 piston is now positioned 25 degrees before top center.

9—49. THRUST BEARING COVER. 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 gage will pass between the thrust nut and the cover at all points (Figure 9—17).

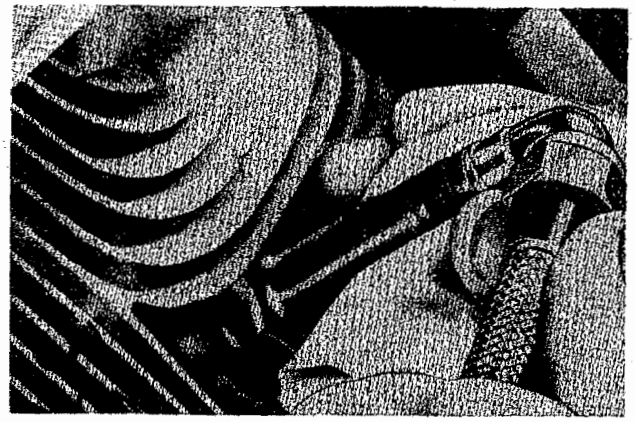

Figure 9—20

9—50. SPARKPLUGS.

9—51. Remove the breather plug from each sparkplug hole just prior to installing the sparkplug.

9—52. Examine the sparkplugs to be certain they are of the approved type.

9—53. Install a serviceable solid copper gasket (Figure 9—18). Lightly lubricate the first two threads of the sparkplug with Champion No. 119 graphite anti-seize compound or a 50-50 graphite and petrolatum compound (Figure 9—19).

9—54. 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.

9—55. Using PWA-2254 Wrench, tighten the sparkplug to a torque of 300 to 360 inch-pounds.

9—56. 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 with a clean cloth, to the connector. Do not place any compound in the sparkplug barrel.

CAUTION

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

9—57. Remove any compound from the threads of the sparkplug to insure an electrical bond between the sparkplug and its lead and to prevent radio interference from this source. Install the sparkplug lead (Figure 9—20). Tighten the lead nut finger tight and then a half turn using PWA-1683 Wrench.

9—58. INSPECTION OF ASSEMBLED ENGINE. 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 X

TEST AFTER OVERHAUL

10—1. GENERAL.

10—2. AIR FORCE AND NAVY ENGINES. Before testing an engine after overhaul, Air Force personnel should refer to A.T.O. Nos. 02-1-4 and 02-1-4a and Navy personnel should refer to NavAer 02-1-508, section 2, Engine Test Manual for Aircraft Engines.

10—3. PURPOSE OF TEST AFTER OVERHAUL. Run-in of an engine after overhaul is essential as a means of seating the pistonrings, burnishing certain other new engine parts which may have been installed, and generally checking the performance of the engine.

10—4. HORSEPOWER CHECK. 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 Handbook, it should develop essentially the same horsepower as when new, provided the carburetor and magneto have also been overhauled and tested correctly. A check on manifold pressure and rpm, using a calibrated test propeller and correcting for carburetor air inlet temperature, will provide a sufficiently close check on horsepower for most purposes.

10—5. INSTALLATION OF ENGINE IN TEST STAND. With the engine in a horizontal position, suspend PWA-37 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 TAM-1161 Engine Stand of the weight of the engine, then unfasten TC-51259 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.

10—6. INSTALLATION OF STARTER AND FUEL PUMP. Put a new gasket on the starter pad; then mount the starter in position and secure it with the nuts. Mount the fuel pump on the fuel pump mount pad, using a new gasket, and install the fittings needed for connecting the fuel lines.

10—7. INSTALLATION OF CARBURETOR. After the carburetor has been overhauled and tested, install the carburetor on the engine and secure the screws. Lockwire the screws in position.

CAUTION

Before installing the carburetor, check for, and remove any dirt, shellac, or other foreign material on the flange of the carburetor. Use no grease or sealing compounds between the engine carburetor mounting pad, the carburetor adapter, and the carburetor. Grease or sealing compound so used might stop some of the passages within the carburetor.

10—8. Service instructions for the carburetors used on the engines described in this Handbook are identified in paragraph 11—30.

10—9. PRE-OILING OF ENGINES. 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 electrically driven oil pump to the pressure oil gage 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 gage for indicating the oil pressure 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 until the oil starts to run out of the sump drain.

10—10. INSTRUMENT AND CONTROL CONNECTION.

10—11. Connect the lines, controls, and leads in the following list. The numbers in parentheses in the following list also appear in Figure 10—1 to identify the location of the various connections on the engine and carburetor. Hose connections at the end of the list which have no numbers do not appear in the illustrations.

(1) Supercharger rim manifold pressure manometer line.

(2) Thermocouple lines on at least four cylinders. Refer to paragraph 10—34.

(3) Breather Line at the breather outlet on the rear case.

(4) Throttle control.

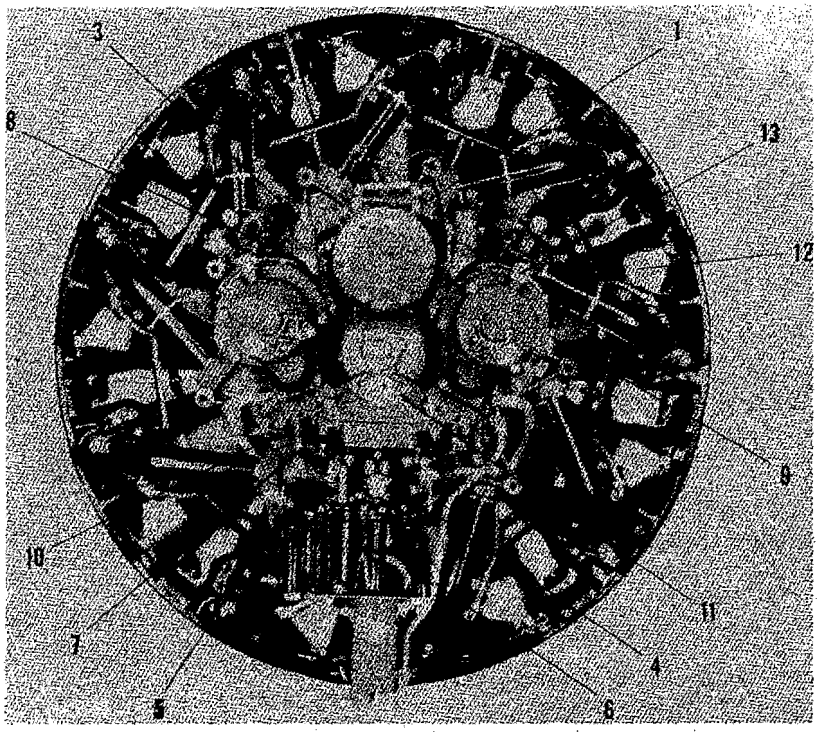

Figure 10–1

(5) Mixture control.

(6) Fuel pressure gage line to the carburetor.

(7) Fuel lines to the fuel pump and carburetor; and a fuel pressure relief valve if the fuel pump does not incorporate one.

(8) Main oil pressure gage line to the pressure oil gage take-off on the left rear face of the rear case.

(9) Tachometer.

(10) Fuel pump drain line.

(11) Oil inlet and oil outlet lines.

(12) Install the exhaust stacks.

(13) Magneto ground wires.

10–12. Install the carburetor air intake duct to the air scoop on the carburetor.

10–13. Air intake thermometer line in the air intake duct.

10–14. Starter control; and any other connections which the particular type of starter used may require.

10–15. TEST PROPELLERS.

10–16. GENERAL.

10–17. 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. 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 in paragraph 10–24 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 vary ± 59 from the normal rated rpm.

10–18. 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

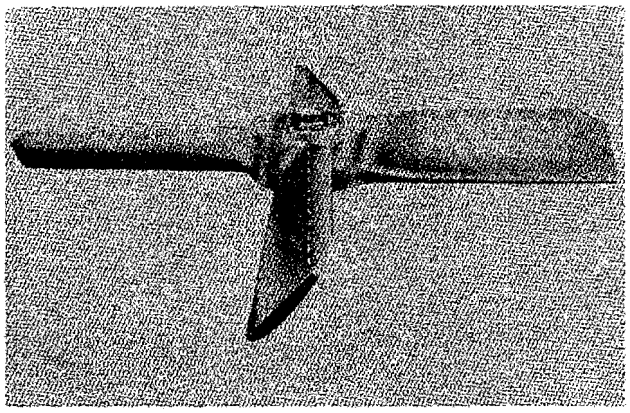

Figure 10–2

remove nicked and splintered stock, it can often be recalibrated for use with less powerful engines.

10–19. When wooden propellers are not in use they should be protected from the weather.

10–20. CALIBRATION.

10–21. 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 not 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.

10–22. 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 10–2). 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 10–3). At the point marked, scribe a line across the width of the blade. Because of the angle of the blade, a gage 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 10–4). Saw off the tip of the blade along the cross line and smooth all sharp edges with a rasp or draw knife (Figure 10–5).

10–23. After the diameter of the propeller has 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, draw a line to a point on the trailing edge 4 inches from the end of the blade and

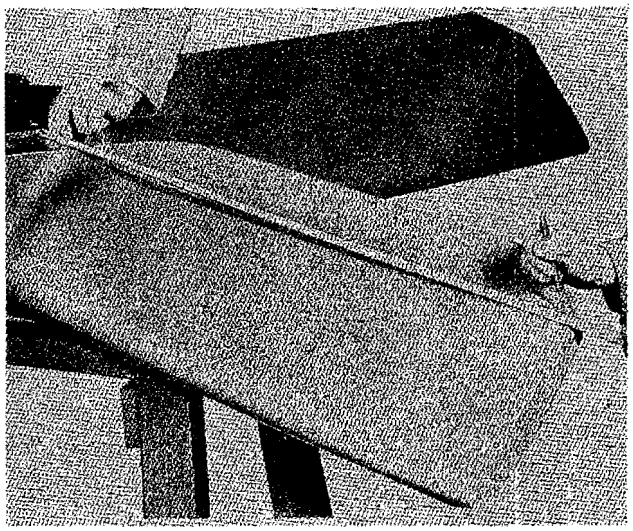

Figure 10–3

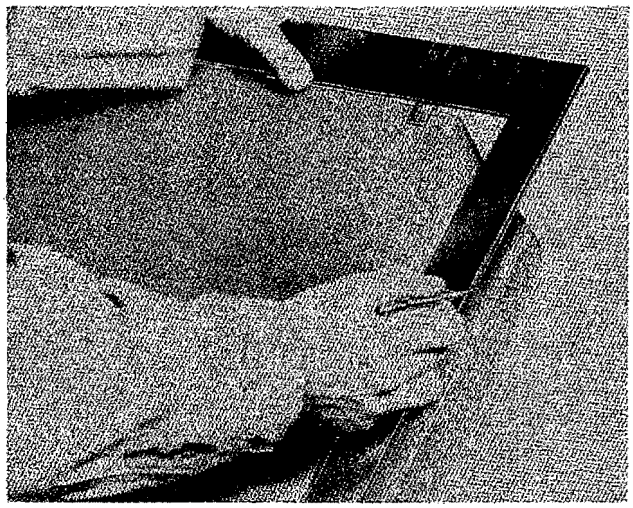

Figure 10–4

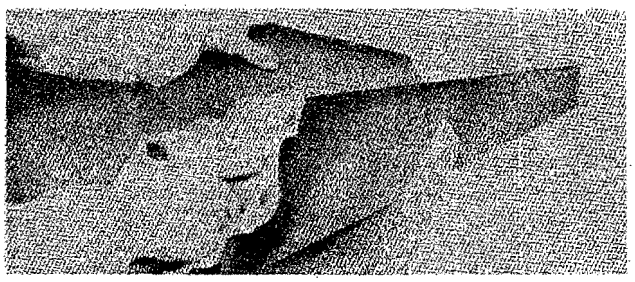

Figure 10–5

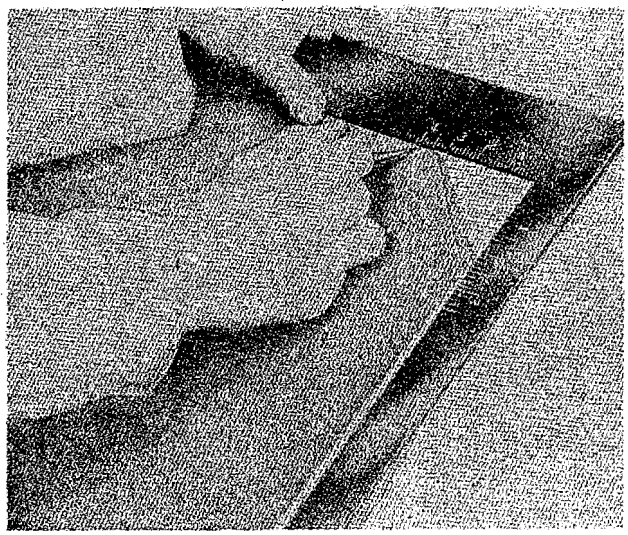

Figure 10–6

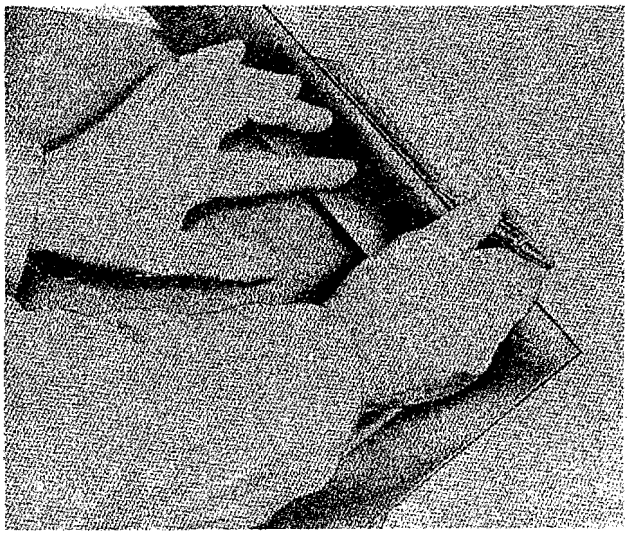

Figure 10–8

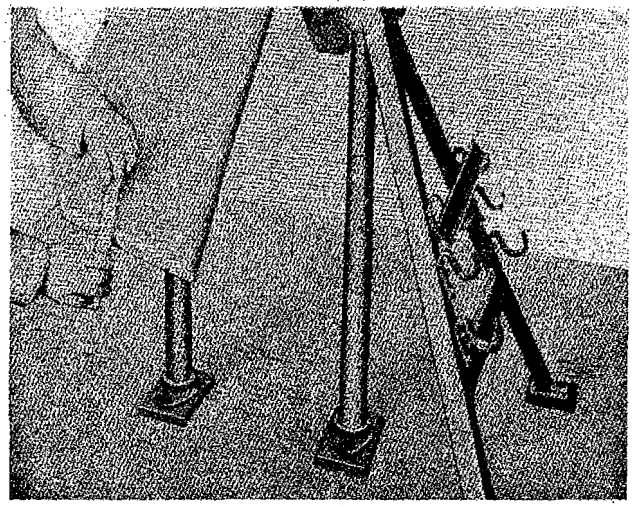

Figure 10–7

saw off the corner along this line (Figure 10–6). Smooth all sharp edges with a rasp or draw knife.

10–24. REBALANCING.

10–25. 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.

10–26. Set the propeller so that the two blades are horizontal. If one blade drops, bevel the end of that blade on the curved side with a rasp or draw knife (Figure 10–7). 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.

10–27. 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 3½ 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 ½ 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 10–8). 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.

10–28. INSTALLATION OF TEST PROPELLER. 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 2½ 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.

10—29. TEST PROCEDURE.

10—30. GENERAL.

10—31. 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 gage 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 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 color of the flames. Misfiring sparkplugs, mixtures that are too lean or too rich, and other discrepancies can often be diagnosed from flame color.

10—32. AIR TEMPERATURE. It is desirable to maintain the carburetor air inlet temperature between 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 32°F to 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. Refer to paragraph 10—46.

10—33. FUEL GRADE. Grade 91/96 fuel must be used throughout the test run.

10—34. CYLINDER TEMPERATURES.

10—35. 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 thermocouple embedded in the fillet of the hold-down flange at the rear of the barrel.

10—36. Unless cylinder barrel thermocouples have already been installed in the cylinders, holes must be drilled for them. Using PWA-3064 Drill, drill two holes at an angle of 45 degrees to the center 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 ⅛ inch deep and ¼ inch apart. Drive in the rivet type thermocouples, using PWA-2747 Drift, upsetting them to secure them in place.

10—37. 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 500°F.

10—38. STARTING THE ENGINE.

10—39. Remove the front sparkplugs 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 no oil has collected inside the cylinders from which the sparkplugs were removed; then reinstall the sparkplugs and attach the sparkplug leads, renewing the Dow Corning No. 4 compound on the connectors if necessary. Refer to paragraph 9—56.

10—40. Operate the wobble pumps in the oil system until the engine pump is supplied with oil. In extremely cold weather the oil feed line should be disconnected at the engine oil pump so that the cold oil may be forced out of the line with the wobble pump just before the engine is started.

10—41. Start the engine.

10—42. OIL PRESSURES AND TEMPERATURES. If the oil pressure, after starting, does not register on the gage almost immediately, the engine should be stopped and an investigation made of the cause. The oil pressures and temperatures are as follows:

OIL PRESSURE LIMITS	
Range	70-90 lbs.
Desired	85 lbs.
Fluctuation	5 lbs.
Idle (minimum)	15 lbs.

OIL TEMPERATURES	
Inlet	
Range	140-170°F
Desired	165°F
Oil Temperature Rise (Maximum at rated speed)	40°F

10—43. FUEL PRESSURE. If the fuel pressure is not within the desired range of 3-6 pounds per square inch at 1000 rpm and above, adjust the fuel pressure relief valve.

10—44. ENGINE RUN-IN SCHEDULE. The following is the recommended schedule for the run-in of engines after overhaul.

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, 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.

i. Run the engine for one minute at take-off manifold pressure and speed.

Note

At the discretion of the overhaul activity, the engine may be operated at take-off power for as long as five minutes (no longer) provided that the test facilities are such that the engine can be operated at take-off power without exceeding cylinder head temperature limits.

j. 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.

k. Shut down the engine.

10—45. SPECIFIC REQUIREMENTS.

1. Take fuel consumption readings in increments of 100 rpm beginning at 1400 rpm. (See paragraph 10—46.)

2. When fuel is to be weighed, take the measurement at a period of not less than sixty seconds.

3. Take fuel readings at not more than fifteen minute intervals.

4. The idling and accelerating characteristics of the engine should be checked when practicable.

5. When taking oil consumption measurement add no oil to the tank and do not permit the oil inlet temperature to vary more than 3°C (5°F) from that specified.

*6. Use actual horsepower to calculate specific oil and fuel consumptions.

7. Fuel and oil pressures, fuel consumption, oil temperatures, cylinder temperatures, and manifold pressure should be recorded at all speeds.

8. The barometer reading, corrected for brass scale, should be used to figure absolute manifold pressure.

*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 carburetor air temperature existing at time of test.

10—46. CHECKING FUEL CONSUMPTION.

10—47. After the engine has been run-in, check the gross fuel consumption in pounds or gallons per hour. The metering characteristics of the carburetor should be determined on a flow bench after the carburetor has been overhauled. However, it is advisable to make an additional check on the gross fuel consumption when the carburetor 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.

10—48. During fuel consumption checks it is desirable to maintain the carburetor air inlet temperature between 70°F and 90°F (21°C—32°C), using preheat if necessary.

10—49. If the test stand is equipped with a fuel flow meter in the fuel line to the engine, gross fuel consumption in pounds per hour can be read directly on the meter. The flow meter should be accurately calibrated for the specific gravity of the fuel used within ± 1 percent and the calibration of the meter should be checked every two months. If a flow meter is not available, it will be necessary to determine the time it takes for the engine to consume a given weight of fuel from a weight tank mounted on a scale or, if no weight tank is available, of a given volume of fuel from a volume fuel flow tank. A volume fuel flow tank should be accurately calibrated for the specific gravity of the fuel. When fuel consumption is being determined by the weight or volume method, the check should continue for at least 60 seconds. A longer time will give more accurate results and is therefore preferable. Gross fuel consumption is computed in pounds per hour by means of the formula: Flow = Pounds x 3600/Seconds. Thus if it takes 74.5 seconds to consume 9 pounds of fuel, the fuel flow = 9 x 3600/74.5 =435 pounds per hour.

10—50. CHECKING OIL CONSUMPTION. The gross oil consumption should be determined at a definite speed 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 weight tank scales at the end of the period, from the weight indicated at the beginning of the period.

10—51. During the run-in determine the 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 or less and decreasing, the condition of the newly fitted pistonrings should be considered satisfactory. If the oil consumption is more than .015 pounds of oil per horsepower hour, the run-in should be continued to further seat the pistonrings, 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 60 pounds per minute at normal rated speed.

10—52. FINAL ENGINE CHECK. Since the test propeller does not have the same fly-wheel effect as a rotor, it is impractical to make a final idle adjustment of the carburetor 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.

10—53. ENGINE SHUT-DOWN. If the engine is to be placed in storage after the test has been completed, shut down the engine as directed in AN 02A-10AB-2, Handbook of Service Instructions.

10—54. VALVE CLEARANCE CHECK. After the test run, remove the engine from the test stand and install it in TAM-1161 Engine Stand. When the engine is thoroughly cool, remove the rockerbox covers; then check the valve clearances as described in paragraph 9—28. Make sure that all valve adjusting screw locknuts are tight. Reinstall the rockerbox covers, using new gaskets.

10—55. SERVICE INSTRUCTIONS. Directions for preparing the engine for installation in an airplane or for completing the preparation of the engine for storage will be found in AN 02A-10AB-2, Handbook of Service Instructions.

SECTION XI

ACCESSORIES

11—1. IGNITION MANIFOLDS.

11—2. GENERAL. The ignition manifolds consist of a front and rear manifold to which are attached the braided conduits for the distributor blocks and sparkplug leads. The single piece front manifold is fastened to the front case. The rear manifold, which is attached to the supercharger case, is made in two sections, and joined by a union so that it may be separated to facilitate assembly and disassembly operations. The ignition wire assembly and radio shielding should be completely disassembled at each overhaul and the ignition wires, sparkplug connectors, and all sealing gaskets replaced.

11—3. DISASSEMBLY. Remove the connector sleeves, unscrew the union nuts at the elbows, and remove the elbows from the ends of the sparkplug leads. Unscrew the union nuts at the manifolds and remove the braided sparkplug leads. Remove the grommets from inside the union nuts. Loosen the screws which fasten the cables to the distributor blocks, and remove the cables. Remove the magneto elbow assembly from the braided conduit and the braided conduit from the manifold by unscrewing the union nuts. Remove the ignition wires from the manifolds.

11—4. CLEANING.

11—5. Wash all metal parts thoroughly. It is recommended that the distributor blocks be cleaned at overhaul in the following manner to remove possible moisture or acid accumulations:

11—6. All dielectric parts should be cleaned entirely free of oil, grease, and acid deposits. Any varnish, lacquer, or other coating should be removed. Minute carbon tracks should be removed by scraping with a knife prior to solvent treatment. Dielectric parts, with the exception of magneto coils and condensers, should be immersed in acetone, Specification No. O-A-51A, and scrubbed with a stiff bristle brush. Place all parts in an oven at 65.6°C to 71.1°C (150°F to 160°F) for approximately 2 hours until all moisture is evaporated.

11—7. INSPECTION.

11—8. DISTRIBUTOR BLOCKS. Examine the distributor blocks to see that they are free from cracks. Check the carbon brushes for excessive wear or chipping. The brushes should work freely in their sockets without binding or sticking when pushed in by hand. Any defective parts should be replaced.

11—9. MANIFOLDS. Examine the manifold ring for cracks, especially around the outlets and at each supporting bracket connection. Inspect the ring for dents, and the threaded connections for damaged threads. Examine the wire shieldings for abrasions. Any worn conduits or shieldings should be replaced. Inspect the condition of the clips that fasten the manifold ring to the engine.

11—10. REPAIR. Repair any cracks in the manifold ring by brazing or soldering. Remove any dents from the manifold ring. Clean up any damaged threads on the connections. Replace any damaged conduits, shielding, or clips.

11—11. WAX TREATING.

11—12. All repaired and replaced parts should be cleaned as described in paragraph 11—4 before wax treating. Place all parts in an oven at 65.6°C to 71.1°C (150°F to 160°F) for approximately 2 hours until all moisture is evaporated. A warm wax solution should be used for treating parts immediately following their removal from the oven. Mix a solution of one part by volume of wax (Air Force Stock No. 7300-983750, Navy Stock No. R52-C-3107-100), to two parts of carbon tetrachloride (Air Force Specification No. AN-4-503-110B, Navy Specification No. L-14a), and heat it to 54.4°C to 60°C (130°F to 140°F). The solution should be maintained at this temperature throughout the process of mixing and application. Since carbon tetrachloride evaporates very quickly when exposed, the mixture may become thick when treating a large number of parts. It will then be necessary to add more carbon tetrachloride to retain the desired consistency.

11–13. Dielectric parts should be brushed with or dipped in the wax solution. Surplus wax should be poured out of holes and recesses after dipping or brushing. Place wax coated parts in an oven at 65.6°C to 71.1°C (150°F to 160°F) for approximately 2 hours to remove solvent from the wax and to impregnate the wax into the dielectric material. After removal from the oven, excess wax on parts should be removed with a clean dry cloth. Do not attempt to rub the wax dry.

11–14. Remove all paint and protective coating from all the mating surfaces of the distributor assembly and magneto mounting pad. A light film of Dow Corning No. 4 compound should be applied as soon as they are cleaned, as corrosion is likely to set in immediately.

11–15. ASSEMBLY.

11–16. Cut the ignition wires to the lengths specified in the above Table of Wire Lengths.

11–17. Install a copper ferrule on one end of each wire; then stamp the numbered position of the distributor block in which it is to be installed on the ferrule in three places so that the fastening screw of the block will not obliterate all identifications. Install the ferrules, using PWA-1937-20 Ferrule Crimper.

11–18. Install the wires in the manifold in the positions shown in the wiring diagram (Figure 11–1). Pull each wire through its respective sparkplug hole with a small wire hook. An application of soapstone or talc to the wires will assist in slipping the wires through the manifold. Insert a grommet in each sparkplug lead union nut; then install the braided sparkplug leads and secure

TABLE OF WIRE LENGTHS

Engines Equipped With SB9R(U) – 3 Magnetos

No. of Distributor Block	Total Length Front Manifold	Total Length Rear Manifold	Wire Length from Rear Manifold to Left Magneto	Wire Length from Front Manifold to Right Magneto
No. 1	55″	37″	20½″	33″
No. 2	48¾″	53¾″	20½″	33″
No. 3	63¼″	68¼″	19″	31½″
No. 4	74⅔″	45⅔″	18½″	31″
No. 5	61½″	29½″	17½″	30″
No. 6	47¼″	45¼″	18″	30½″
No. 7	55⅞″	59⅞″	17½″	30″
No. 8	82⅔″	54⅔″	18½″	31″
No. 9	69″	39″	19″	31½″

Engines Equipped With SB9R(N) – 4 Magnetos

No. of Distributor Block	Total Length Front Manifold	Total Length Rear Manifold	Wire Length from Rear Manifold to Left Magneto	Wire Length from Front Manifold to Right Magneto
No. 1	57″	39″	18″	29″
No. 2	60″	55″	19″	30″
No. 3	62″	67″	17½″	28½″
No. 4	74″	45″	18″	29″
No. 5	61″	29″	19″	30″
No. 6	47″	45″	17½″	28½″
No. 7	54″	58″	18½″	29½″
No. 8	81″	53″	20″	31″
No. 9	69″	39″	19″	30″

DIMENSIONS OF FLEXIBLE CONDUITS

	Length	Inside Dimension	Outside Dimension
Magneto to Rear Manifold	10⅛″ ± 1/16″	1 5/32″ ± 1/16″	1.335″ – 1.345″
Magneto to Front Manifold	21½″ ± 1/16″	1 5/32″ ± 1/16″	1.335″ – 1.345″

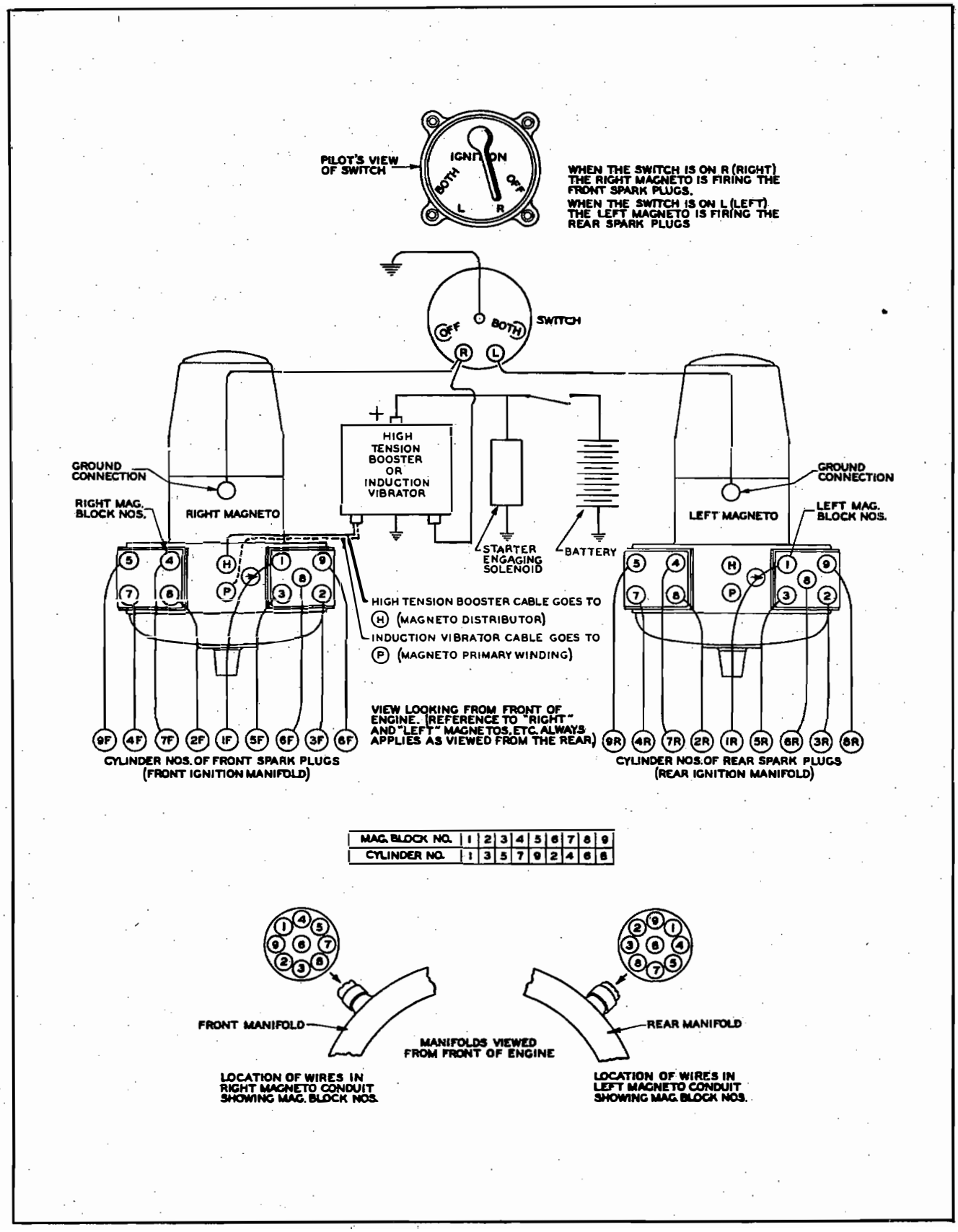

Figure 11—1

them with the union nuts. Install the sparkplug lead elbows and secure them in place.

11–19. Particular care should be taken when installing the sparkplug connectors on the sparkplug leads. Cut sufficient insulation from the wire to permit the central wire core to extend through the wire outlet approximately 1/8 inch. Do not cut the wire core when removing the insulation. Treat the ends of the wire insulation (cotton braiding) with an insulating lacquer and allow the lacquer to dry. This will prevent the cotton from acting as a wick, thus preventing moisture from finding its way into the insulation of the wire. After the lacquer is dry, slide the connectors in position on the ignition wires, taking care not to twist or bend the wire during this procedure. Bend the wire of the central core back over the wire opening in a radial pattern. Do not solder the wire in position.

11–20. After the connectors have been installed, they should be wiped clean. Following this, they should not be touched with the hands or allowed to become dirty. Install a protector on each connector. Any dirt, grease, acid, or scratches on this surface greatly increase the possibility of flashover and is very apt to result in damage to the connectors and subsequent faulty operation.

11–21. Install the magneto elbow assembly on the ignition wires. Insert each ignition wire in its proper location in the distributor block, as indicated by the numbers stamped on the ferrules.

11–22. ELECTRICAL TEST OF HARNESS.

11–23. GENERAL. After rewiring, the ignition harness should be given a continuity test and a high voltage test. Air Force personnel should use a low voltage test light or buzzer circuit, and a Delco Model 7244420 ignition tester (stock No. 7800-728800). Navy personnel should use a BG tester in accordance with G.E.B. No. 47 or TAKK Model 41 high tension direct current tester.

11–24. CONTINUITY TEST.

11–25. Continuity from each distributor electrode to the corresponding sparkplug lead should be checked. If the test indicates an open circuit, the break should be located by examining the connections or by removal of the individual wire.

11–26. The following table shows the connections between the distributor block electrodes (D.B.E.) and the sparkplug (S.P.) ends of the leads.

Right Distributor Block									
D.B.E.	1	2	3	4	5	6	7	8	9
S.P.	1F	3F	5F	7F	9F	2F	4F	6F	8F

Left Distributor Block									
D.B.E.	1	2	3	4	5	6	7	8	9
S.P.	1R	3R	5R	7R	9R	2R	4R	6R	8R

Note

While making tests, insure that there is good contact at the connector sleeve.

11–27. HIGH VOLTAGE TEST. After all the circuits are determined to be continuous, the manifold assembly should be subjected to a high voltage test to determine electrical leakage. This test should be accomplished with a direct current tester imposing no more than 10,000 volts DC on the manifold assembly. The electrical resistivity between leads and from any lead to ground should be not less than 100 megohms and no electrical breakdown should be indicated. Set the ignition tester at 10,000 volts and on high resistance the microammeter should indicate no more than 50 microamperes leakage and the breakdown indicator should not flash. If there is any internal leakage in the tester, it should be eliminated by cleaning the insulating surfaces or by other means prior to conducting this test. If excessive leakage is still indicated after cleaning the distributor block surface and the sparkplug terminals, replace the wiring.

11–28. REPLACEMENT OF A DAMAGED IGNITION WIRE. If, by an electrical test, a wire in a manifold should prove to be defective, it may be replaced with a new wire without disturbing the other wires in the manifold. Remove the spargplug connector, elbow, grommet, and conduit. Remove the wire from the distributor block. Find out in which direction the wire will pull the easier and splice and solder a new wire to the opposite end of the wire. Dust the new wire with soapstone or talc and pull out the old wire, at the same time carefully feeding the new wire into the manifold. After the wire is in place, reinstall the sparkplug conduit, grommet, elbow, and connector. In making emergency repairs, no soldering should be attempted on the manifold as heat is apt to damage the insulation on the wires and cause failure.

SECTION XII

TABLE OF LIMITS

12—1. GENERAL.

12—2. TABLES. The tables which follow are to be used in conjunction with figures 12-1 and 12-2.

12—3. REFERENCE NUMBERS. Reference numbers on the figures indicate the location of fits, clearances, and parts for which torques and spring pressures are specified. A description of, and limits for these fits, clearances, backlashes, torques and spring pressures are located in the tables by corresponding reference numbers.

12—4. LIMITS. The Minimum and Maximum columns contain the desired fits and clearances between new parts. The figures in the Replace column indicate the allowable limit to which parts may wear before replacement is necessary at overhaul.

12—5. TERMS AND SYMBOLS. The symbol "T" in the Minimum and Maximum columns indicates a tight fit. An asterisk (*) in the Replace column indicates that the parts should be replaced if any looseness is found. The term "By Selection" indicates that the parts must be matched by choosing units that will provide the correct fit. The term "Fit To" means that a grinding, filing, or other fitting operation may be necessary to obtain the desired fit at assembly. Unless otherwise specified, all fits are diametrical, except spline fits which are calculated from chordal dimensions.

12—6. UNITS. The figures in the Minimum, Maximum, and Replace columns should be interpreted as follows: torque in inch-pounds, spring pressures in pounds, and all other limits in inches.

12—7. TORQUE APPLICATION. Unless otherwise specified in Sections VII, VIII, and IX, thread lubricants should not be applied to parts which are to be torqued. After a castle nut or screw has been tightened to the proper torque, it should not be loosened to permit the insertion of lockwire or a cotterpin. If the slots in a nut or the lockwire holes in a screw are not properly aligned at the minimum torque limit, the nut or screw should be further tightened to the next aligning position, but the maximum torque limit must not be exceeded. If this alignment cannot be accomplished without exceeding the maximum torque limit, remove the nut or screw and try another one.

12—8. FRONT, POWER, AND ACCESSORY SECTIONS.

Ref. No.	Chart No.	Description	Min.	Max.	Replace If Over
1	1	Hydromatic Control Valve Body — Front Case (Fit To)	.0005		.0015
2	1	Front Case Oil Feed Tube — Front Case	.001T	.0025T	*
3	1	Key — Crankshaft, Front (Fit To)	.000	.0015T	*
3	1	Key — Cam Drive Gear	.0015	.0045	.006
4	1	Thrust Bearing Liner — Front Case	.002T	.006T	*
5	1	Thrust Bearing — Bearing Liner	.0002	.002	.004
7	1	Thrust Bearing Cover Spacer Ring Pinch — Thrust Bearing Cover (Fit To)	.004T	.008T	*
8	1	Propeller Control Oil Feed Tube — Thrust Bearing Liner	.000	.0015	.003
9	1	Cam Drum End Clearance (Fit To)	.008	.010	.015
11	1	Crankshaft Oil Seal Ring Carrier — Crankshaft	.0005	.0025	.004
12	1	Thrust Bearing — Crankshaft Oil Seal Ring Carrier	.0002T	.0014T	.0005
13	1	Oil Seal Ring Carrier Ring Side Clearance — Carrier	.0005T	.0025T	*
13	1	Oil Seal Ring Carrier — Side Clearance	.003	.008	.015
14	1	Oil Seal Ring Carrier Gap (Mitre Cut)	.010	.018	.030
14	1	Oil Seal Ring Carrier Gap (Double Ring — Butt Type)	.005	.015	.020
15	1	Cam Drive Gear — Crankshaft	.0005	.0025	.004
16	1	Cam Drive Gear — Cam Drum	.003	.0045	.006
17	1	Cam Oil Feed Bracket Ring — Cam Drum	.004	.008	.010
19	1	Cam Drive Gear Backlash — Cam Reduction Gear	.004	.012	.020

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Ref. No.	Chart No.	Description	Min.	Max.	Replace
20	1	Cam Reduction Pinion Backlash — Cam Rim	.009	.019	.030
21	1	Cam Reduction Pinion — Cam Reduction Gear	.0005T	.0015	.003
22	1	Valve Tappet Roller Side Clearance — Tappet	.008	.020	.025
22	1	Valve Tappet Roller Side Clearance — Guide	.008	.010	.018
23	1	Valve Tapper Roller Pin — Tappet (By Selection)	.0005	.002	.003
24	1	Valve Tappet Roller Pin — Roller	.001	.0025	.004
25	1	Valve Tappet Guide — Front Case	.0015	.004T	*
26	1	Valve Tappet — Guide (By Selection)	.0005	.0015	.003
28	1	Pushrod Ball Socket — Valve Tappet	.0005T	.0025T	*
29	1	Pushrod Ballend — Socket	(See section IX, paragraph 9—33)		
30	1	Cam Drum — Cam Rim	.0025T	.0005	.0015
31	1	Cam Oil Feed Bracket Oil Feed Tube — Feed Bracket	.0005T	.0035T	*
32	1	Cam Oil Feed Bracket Tube — Tube Bracket	.0015T	.0045T	*
33	1	Hydromatic Control Valve Oil Feed Tube — Tube Bracket	.000	.0015	.003
34	1	Front Case — Crankcase, Front Section	.000	.004	
35	1	Pushrod Ball Socket — Valve Rocker	.000	.0025T	*
36	1	Pushrod Ballend — Pushrod	.0015T	.0035T	*
39	1	Inlet Valve Guide — Valve	.0015	.004	.010
40	1	Inlet Valve Guide — Cylinder Head	.0005T	.003T	*
41	1	Inlet Valve Seat — Cylinder Head (Shrink)	.0065T	.010T	*
43	1	Cold Valve Clearance (Inlet and Exhaust)	.010	.010	
46	1	Exhaust Valve Guide — Valve	.004	.0065	
46	1	Exhaust Valve Guide Valve (Navy Personnel)	.004	.0065	
47	1	Exhaust Valve Guide — Cylinder Head	.0005T	.003T	*
48	1	Exhaust Valve Seat — Cylinder Head (Shrink)	.0065T	.010T	*
49	1	Rocker Bearing — Valve Rocker	.0005T	.0015T	*
50	1	Rocker Bearing — Rocker Shaft	.000	.0008	.0015
51	1	Rocker Shaft Small Bushing — Shaft	.000	.001	.002
52	1	Rocker Shaft Small Bushing — Cylinder Head	.001T	.004T	*
53	1	Rocker Shaft Large Bushing — Shaft	.000	.001	.002
54	1	Rocker Shaft Large Bushing — Cylinder Head	.001T	.004T	*
55	1	Rocker Oil Manifold — Crankcase Front Section	.000	.002	.004
301	1	Pistonrings — End Clearance			
		Four Groove Piston, Straight Bore — Top Groove	.0225	.0295	
		Four Groove Piston, Straight Bore — 2nd Groove	.0175	.0245	
		Four Groove Piston, Straight Bore — 3rd Groove	.0175	.0245	
		Four Groove Piston, Straight Bore — 4th Groove	.0115	.0185	
		Five Groove Piston, Straight Bore — Top Groove	.0225	.0295	
		Five Groove Piston, Straight Bore — 2nd Groove	.0225	.0295	
		Five Groove Piston, Straight Bore — 3rd Groove	.0225	.0295	
		Five Groove Piston, Straight Bore — 4th Groove	.0225	.0295	
		Five Groove Piston, Straight Bore — 5th Groove	.0115	.0185	
		Five Groove Piston, Tapered Bore — (Rectangular and Wedge Type Rings)			
		Five Groove Piston, Tapered Bore — Top Groove	.052	.062	
		Five Groove Piston, Tapered Bore — 2nd Groove	.0515	.0585	
		Five Groove Piston, Tapered Bore — 3rd Groove	.0515	.0585	
		Five Groove Piston, Tapered Bore — 4th Groove	.0515	.0585	
		Five Groove Piston, Tapered Bore — 5th Groove	.0115	.0185	
		Five Groove Piston, Tapered Bore — (With Chrome-Moly Barrels Using Compression Ring in Place of Scraper Ring)			
		Five Groove Piston, Tapered Bore — 5th Groove	.0515	.0585	

Ref. No.	Chart No.	Description	Min.	Max.	Replace If Over
302	1	Pistonring Side Clearance			
		Four Groove Piston — Top Groove	.007	.009	
		Four Groove Piston — 2nd Groove	.0055	.0075	
		Four Groove Piston — 3rd Groove	.0025	.0045	
		Four Groove Piston — 4th Groove	.001	.003	
		Five Groove Piston (Straight Type Rings) — Top Groove	.007	.009	
		Five Groove Piston (Straight Type Rings) — 2nd Groove	.0055	.0075	
		Five Groove Piston (Straight Type Rings) — 3rd Groove	.003	.005	
		Five Groove Piston (Straight Type Rings) — 4th Groove	.0035	.007	
		Five Groove Piston (Straight Type Rings) — 5th Groove (Wedge Type-Top Three Rings)	.001	.0035	
		Five Groove Piston — Top Groove	.002	.004	
		Five Groove Piston — 2nd Groove	.002	.004	
		Five Groove Piston — 3rd Groove	.0035	.007	
		Five Groove Piston — 4th Groove	.002	.004	
		Five Groove Piston — 5th Groove (Wedge Type Ring Clearance is Measured with Outer Face of Ring Flush with Piston)	.001	.0035	
303	1	Pistonpin — Piston (Light Hand Push Fit When Parts Are Oiled and at Room Temperature)			.003
304	1	Pistonpin Plug — Pin	.0015T	.0035T	.001
304	1	Pistonpin Plug — (Service Fit)	.000	.0015T	.001
305	1	Piston — Cylinder Barrel	.018	.022	.028
306	1	Pistonpin Bushing — Pin	.0017	.0033	.005
307	1	Pistonpin Bushing — Master and Linkrod	.0045T	.006T	*
308	1	Cam Reduction Gear Bushing — Gear	.001	.003	.005
309	1	Cam Reduction Gear Bushing — Crankcase, Front Section	.001T	.003T	*
310	1	Cam Reduction Gear End Clearance (Fit To)	.006	.012	.016
311	1	Front Main Bearing Liner — Crankcase Front Section	.008T	.012T	*
312	1	Front Main Bearing — Front Main Bearing Liner	.0002	.0017	.004
313	1	Front Main Bearing — Crankshaft	.001T	.0003	.001
314	1	Masterod Bearing End Clearance — Crankshaft (Fit To)	.009	.015	.024
314	1	Masterod Bearing End Clearance — Crankshaft (Bronze Bearing) (Fit To)	.010	.014	.024
315	1	Masterod Bearing Pinch — Masterod	.001T	.002T	*
315	1	Masterod Bearing Pinch — Masterod (Bronze Bearing)	.0008T	.0022T	*
316	1	Masterod Bearing Diametrical Clearance — Crankshaft (Prefitted Bearing)	.003	.007	.0095
316	1	Masterod Bearing Diametrical Clearance — Crankshaft (Bronze Bearing)	.004	.0045	.0065
317	1	Crankshaft Front Splines — Crankshaft Rear Splines	.001T	.002T	*
318	1	Linkrod Side Clearance	.008	.014	.018
319	1	Linkpin Plug — Pin	.0005T	.003T	*
320	1	Linkrod Bushing — Rod	.0015T	.0025T	*
321	1	Linkrod Bushing — Linkpin	.0013	.0033	.004
322	1	Linkpin — Masterod	.0004T	.001T	*
323	1	Oil Transfer Ferrule — Crankcase Rear Section	.000	.003T	*
324	1	Oil Transfer Ferrule — Crankcase Front Section	.000	.003	
325	1	Rear Main Bearing Liner — Crankcase Rear Section	.008T	.012T	*
326	1	Rear Main Bearing — Rear Main Bearing Liner	.0002	.0017	.004
327	1	Rear Main Bearing Pinch — Crankshaft Rear Gear (Fit To)	.002T	.004T	*
328	1	Rear Main Bearing — Crankshaft	.0012T	.0001	.001

Ref. No.	Chart No.	Description	Min.	Max.	Replace If Over
329	1	Impeller Spring Drive Fixed Spider Splines — Crankshaft Splines	.0005T	.0005	
330	1	Oil Pressure Tube — Crankcase Rear Section	.000	.002	
331	1	Flyweight Liner — Crankshaft	.001T	.003T	*
332	1	Inner Flyweight — Outer Flyweight	.000	.001T	.001
333	1	Flyweight End Clearance	.008	.012	.018
601	1	Starter Shaft Ball Bearing — Supercharger Case	.0004T	.0014	.004
602	1	Starter Shaft Spacer — Shaft	.000	.004	.006
603	1	Starter Shaft Ball Bearing — Shaft	.000	.001T	.001
604	1	Generator Drive Pinion Splines — Generator (On Width)	.001	.006	.030
605	1	Starter Jaw Gear Backlash — Generator Drive Gear	.002	.030	.035
606	1	Generator Drive Shaft Bearing — Shaft	.0006T	.0002	.001
607	1	Generator Drive Housing — Rear Case	.000	.004	.006
608	1	Generator Drive Shaft Bearing — Housing	.0004T	.0011	.004
609	1	Generator Drive Shaft Bearing Pinch—Retainer (Fit To)	.000	.0077T	*
610	1	Rear Case — Supercharger Case	.000	.006	
611	1	Starter Jaw End Clearance	.012	.015	.020
612	1	Starter Jaw Splines — Starter Drive Shaft	.001	.005	.007
613	1	Starter Shaft Bushing — Rear Case	.0005T	.0025T	*
614	1	Starter Shaft Bushing — Shaft (Fit To)	.0025	.003	.004
615	1	Starter Shaft Bushing — Supercharger Case (By Selection)	.000	.001	.0015
616	1	Starter Gear Backlash — Crankshaft Rear Gear	.004	.012	.020
618	1	Impeller Spring Drive Coupling Floating Spider — Floating Gear	.011	.019	
619	1	Floating Gear End Clearance (Fit To)	.006	.008	.012
620	1	Needle Bearings End Clearance	.0085	.0225	
621	1	Floating Gear — Needle Bearings	.0016	.0032	.005
622	1	Floating Gear Inner Race — Front Supercharger Bearing Cover	.000	.002	.005
623	1	Front Supercharger Bearing Cover — Impeller Shaft Bearing Cage	.0005	.0035	
624	1	Impeller Shaft Front Bearing — Impeller Shaft Bearing Cage	.0002T	.0011	.003
625	1	Impeller Shaft Front Bearing — Shaft	.0002T	.0005	.001
626	1	Impeller Shaft Oil Jet — Supercharger Case	.000	.004T	*
627	1	Impeller Shaft Bearing Cage — Supercharger Case	.000	.002T	*
628	1	Impeller Intermediate Drive Gear Backlash — Floating Gear	.003	.015	.020
629	1	Impeller Intermediate Drive Gear Backlash — Impeller Shaft Gear	.004	.013	.020
630	1	Impeller Intermediate Drive Gear Front Bearing — Front Supercharger Bearing Cover	.0005T	.0009	.002
631	1	Impeller Intermediate Drive Gear Front Bearing — Shaft	.0004T	.0012T	.0005
632	1	Impeller Intermediate Drive Gear End Clearance	.011		
633	1	Supercharge Case Oil Pressure Tube — Tube Bracket	.0005	.0025T	.001
634	1	Oil Pressure Tube — Tube Bracket	.000	.002	.004
635	1	Supercharger Case Oil Pressure Tube Bracket — Supercharger Case	.0005T	.0015	
636	1	Impeller Shaft Rear Front Bearing — Impeller Shaft Bearing Cage	.008	.014	
637	1	Impeller Shaft Rear Bearings — Shaft	.0004T	.0003	.001
638	1	Impeller Shaft Rear Gear Bearing — Impeller Shaft Bearing Cage	.0002T	.0011	.003
639	1	Clamp — Impeller Shaft Bearing (Fit To)	.002T	.004T	*
640	1	Impeller Flat Clearance (Fit To)	.025	.035	.045
641	1	Impeller Throat Clearance (Fit To)	.025	.035	
642	1	Impeller Spacer — Impeller Shaft Bearing Cover (Fit Per Side)	.0012	.0023	.003
643	1	Impeller Shaft Spacer — Impeller Shaft	.0002T	.0013	.004
644	1	Impeller Splines — Impeller Shaft	.000	.0005T	.001
645	1	Impeller Intermediate Drive Gear Rear Bearing Inner Liner — Gear	.0005T	.001	.002
646	1	Impeller Intermediate Drive Gear Rear Bearing — Inner Liner	.0005T	.0003	.001
648	1	Impeller Intermediate Drive Gear Rear Bearing — Outer Liner	.0008	.0021	.003
649	1	Impeller Intermediate Drive Gear Rear Bearing Outer Liner — Supercharger Case	.000	.002T	*
650	1	Rear Supercharger Bearing Cover — Supercharger Case	.007	.015	.022
652	1	Oil Return Check Valve — Valve Guide	.0005	.0035	

12–9. REAR SECTION.

Ref. No.	Chart No.	Description	Min.	Max.	Replace If Over
656	2	Tachometer Drive Gear Oil Tube – Rear Case	.001T	.003T	*
657	2	Tachometer Drive Gear – Rear Case	.001	.003	.005
658	2	Tachometer Drive Gear Backlash – Accessory Drive Gear	.008	.016	.020
659	2	Tachometer Drive Gear End Clearance (Fit To)	.008	.016	.030
660	2	Tachometer Drive Gear Inner Coupling – Rear Case	.000	.004	.006
661	2	Tachometer Drive Gear Inner Coupling Bushing – Gear	.001	.003	.005
662	2	Tachometer Drive Shaft Insert – Shaft	.0008T	.0023T	*
347	2	Magneto Drive Oil Seal Housing–Rear Crankcase	.000	.012	
348	2	Magneto Drive Oil Seal Housing – Oil Seal	.001	.007T	*
663	2	Magneto Drive Gear Backlash – Crankshaft Rear Gear	.004	.012	.020
664	2	Magneto Drive Gear Shaft End Clearance (Fit To)	.012	.045	.060
665	2	Magneto Drive Gear Shaft Front Bushing – Supercharger Case	.0005T	.0025T	*
665	2	Magneto Drive Gear Shaft Rear Bushing – Rear Case	.0005T	.0025T	*
666	2	Magneto Drive Gear Shaft Bushings – Gear Shaft	.001	.003	.0045
667	2	Magneto Drive Gear Shaft Rear Bushing – Supercharger Case	.000	.001	.0015
668	2	Key – Magneto Drive Gear Shaft	.001T	.002	.004
668	2	Key – Accessory Intermediate Drive Gear	.0005	.0035	.005
669	2	Accessory Drive Gear Oil Metering Plug – Gear	.000	.004T	*
670	2	Accessory Drive Shaft Bushing – Shaft	.001	.003	.005
671	2	Accessory Drive Shaft Bushing – Rear Case	.001T	.003T	*
672	2	Accessory Drive Gear Backlash – Accessory Inter. Dr. Gear (Fit To)	.004	.012	.020
673	2	Accessory Intermediate Drive Gear – Magneto Drive Gear Shaft	.000	.002	.004
674	2	Accessory Inter. Drive Gear Backlash – Fuel Pump Drive Gear	.004	.012	.020
675	2	Fuel Pump Drive Shaft – Pump Bracket	.002	.004	.0045
676	2	Fuel Pump Drive Gear Adapter – Rear Case	.000	.004	
679	2	Vertical Accessory Drive Shaft Bearing – Shaft	.0005T	.0003	.001
680	2	Vertical Accessory Drive Shaft Bearing – Accessory Drive Cover	.0006	.002	.004
683	2	Vacuum Pump Drive Oil Seal Housing – Rear Case	.000	.004	.007
684	2	Vacuum Pump Drive Oil Seal Housing – Oil Seal	.0015T	.0045T	*
685	2	Vacuum Pump Drive Bearings – End Clearance	.002		
686	2	Vacuum Pump Drive Liner – Rear Case	.000	.002T	*
687	2	Vacuum Pump Drive Liner – Bearings	.0003	.0018	.003
688	2	Vacuum Pump Drive Gear Bearings – Gear	.005T	.0003	.0015
689	2	Vacuum Pump Drive Gear Backlash	.004	.012	.020
690	2	Oil Pump Idler Shaft – Gears	.000	.0015	.003
691	2	Oil Pump Idler Shaft – Bodies	.001	.003	.005
692	2	Oil Pump Gears Backlash	.003	.013	.020
693	2	Keys – Oil Pump Drive Shaft	.0015T	.0015	.0025
693	2	Keys – Oil Pump Gear	.000	.002	.003
694	2	Oil Pump Drive Shaft – Bodies	.001	.003	.005
695	2	Oil Pump Drive Shaft – Gears	.000	.0015	.003
696	2	Oil Pump Gears End Clearance	.003	.0055	.0085
697	2	Oil Pump Drive Gear Backlash – Accessory Intermediate Drive Gear	.004	.012	.020
698	2	Oil Pump Body End Plate – Body	.000	.004	
699	2	Oil Pump Gears – Oil Pump Bodies	.003	.007	.010
700	2	Oil Pump Body – Rear Case	.001	.003	.005
701	2	Oil Pump Cover – Body	.0015	.0045	.006
702	2	Oil Pressure Relief Valve Piston – Seat	.002	.006	.010
704	2	Supercharger Case Oil Pressure Tube – Tube Bracket	.0005T	.0025	*
705	2	Rear Case to Supercharger Oil Pressure Tube – Supercharger Case	.000	.002	.003
706	2	Rear Case to Supercharger Oil Pressure Tube – Rear Case	.0005T	.0025T	*
707	2	Rear Case Oil Pressure Tube – Rear Case	.001T	.003T	*

Ref. No.	Chart No.	Description	Min.	Max.	Replace If Over
708	2	Rubber Coupling End Clearance (By Selection)	.020	.030	
716	2	Bearing Retainer Dowel – Gun Synchronizer Housing	.0025	.0045	.006
717	2	Gun Synchronizer Roller – Cam (Shim or Adjustable Type)	.002	.005	
718	2	Gun Control Cam Shaft Bearing – Shaft	.0005T	.0003	.001
719	2	Gun Control Cam Shaft Bearing – Housing	.0005	.002	.003
720	2	Gun Synchronizer Roller – Follower	.0005	.002	.003
721	2	Gun Synchronizer Follower – Housing	.001	.0025	.004
722	2	Gun Synchronizer Bearing Bushing – Housing	.0005T	.0025	
723	2	Gun Synchronizer Follower – Cover	.001	.0025	.004
724	2	Gun Synchronizer Housing – Dowel	.0005T	.0025T	*
725	2	Gun Synchronizer Cover – Dowel	.000	.002	
726	2	Gun Synchronizer Drive Gear – Auxiliary Drive Shaft Splines	.0005	.0035	
727	2	Gun Synchronizer Drive Shaft Bearing Liner – Rear Case	.000	.002	.005
727	2	Accessory Drive Gear Bearing Liner – Rear Case	.000	.002	.005
729	2	Gun Control Cam Shaft Gear – Gun Synchronizer Drive Gear	.004	.010	.014
730	2	Gun Synchronizer Drive Shaft Bearing Liner – Housing	.000	.002	.003
731	2	Accessory Drive Gear Bearing Liner – Bearing	.000	.0015T	.0015
732	2	Accessory Drive Gear Bearing – Gear	.0005T	.0003	.001
733	2	Bearing Retainer Dowel – Gun Synchronizer Bearing Bushing	.001T	.003T	*
734	2	Impeller Intermediate Drive Gear Shaft Splines – Gear	.001T	.003T	*
735	2	Impeller Intermediate Drive Gear Shaft – Bushing	.0005T	.001	.002
736	2	Impeller Intermediate Drive Gear Shaft Bushing – Bearing	.000	.0007	.0015
737	2	Vacuum Pump Drive Gear Oil Seal – Pump Adapter	.0015T	.0065T	*
738	2	Vacuum Pump Drive Adapter – Rear Case	.000	.003	
739	2	Vacuum Pump Drive Gear Bushing – Gear	.0015	.0035	.005
740	2	Vacuum Pump Drive Gear Bushing – Pump Adapter	.001T	.003T	*
741	2	Vacuum Pump Drive Gear Backlash – Fuel Pump Drive Gear (Fit To)	.004	.012	.020
742	2	Tachometer Drive Gear Coupling Oil Seal – Coupling	.0015T	.0065T	*
743	2	Fuel Pump Drive Gear Oil Seal – Pump Adapter	.0015T	.0065T	*
749	2	Oil Screen By-Pass Valve Plug – Rear Case	.000	.0025	
750	2	Oil Pump Body Oil Seal Ring Side Clearance (Fit To)	.0005	.0025	
751	2	Tachometer Drive Inner Coupling Bushing – Coupling	.0005T	.0025T	*

12–10. SPRING PRESSURE.

Ref. No.	Chart No.	Description	Min.	Replace If Under
27	1	Valve Tappet Spring Dia. Wide .051 at 1 5/8"	4#	2#
37	1	Inlet Valve Spring (Inside) Dia. Wire .154 at 1 1/2"	53#	48#
38	1	Inlet Valve Spring (Outside) Dia. Wire .183 at 1 1/2"	68.5#	64#
44	1	Exhaust Valve Spring (Inside) Dia. Wire .162 at 1 1/2"	62 1/4#	58#
45	1	Exhaust Valve Spring (Outside) Dia. Wire .192 at 1 1/2"	79 1/2#	75#
617	1	Impeller Spring Drive Spring Rectangular Wire at 7/8"	95#	50#
653	2	Oil Return Check Valve Spring Dia. Wire .038 at 13/16"	2 1/4#	1 3/4#
654	2	Oil Screen Retaining Spring Dia. Wire .069 at 1-3/32"	9#	5#
703	2	Oil Pressure Relief Valve Spring Dia. Wire .0625 at 1-7/16"	19#	9 1/2#

12–11. TORQUE LIMITS.

12–12. GENERAL.

PLAIN NECKED

PLAIN NECKED

STANDARD STUDS

Thread Size	Torque Limits		
	Minimum	Maximum	
	Plain and Necked	Plain	Necked
8-32-36	10	30	30
10-24-32	15	45	40
12-24-28	20	75	65
1/4-20-28	40	105	95
5/16-18-24	85	230	210
3/8-16-24	160	425	375
7/16-14-20	200	675	600
1/2-13-20	250	1050	950
9/16-12-18	425	1500	1400
5/8-11-18	625	2100	1900
3/4-10-16	1100	3800	3500

STEPPED STUDS*

Thread Size (Nut End)	Torque Limits		
	Minimum	Maximum	
	Plain and Necked	Plain	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

STEEL PIPE PLUGS IN ALUMINUM AND MAGNESIUM CASES†

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

NUTS, BOLTS, AND SCREWS

Thread Size	Limits		Thread Size	Limits	
	Min.	Max.		Min.	Max.
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

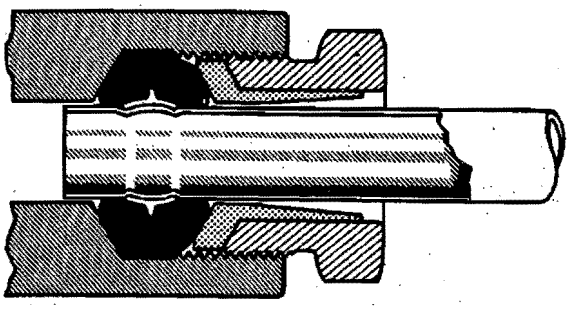
*If the torque required to drive a stud to the correct projection length should not come up to the minimum or should exceed the maximum given above, another stud should be selected.

The above general recommendations should be followed with the exceptions included in paragraph 12–13.

†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 (AN-C-53-3) applied to the threads. The plug should be reinstalled and retightened to the desired limits.

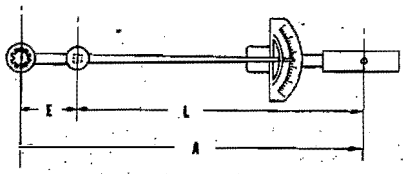
When plugs are tightened in a hot engine, the torque recommended above should be reduced about 20%, owing to the different expansion characteristics of steel plugs and the aluminum or magnesium cases.

Unless otherwise specified, the torque on a nut that is shallower than standard should be reduced in proportion to the reduction in depth of the nut from standard. A standard nut has a depth equal to the diameter of the bolt. Castellations are additional.



Tube Size	* *Alternate Method*	*Min.*	*Max.*
1/8	90	25	30
3/16	90	25	30
1/4	90	25	30
5/16	90	30	35
3/8	90	30	35
1/2	180	55	60
5/8	180	65	70
3/4	180	70	80
7/8	180	75	85
1 in.	180	80	90
1-1/8	180	100	110
1-1/4	180	100	110
1-1/2	180	100	110

*Approximate angle of turn beyond finger tight.



TORQUE WRENCHES AND ADAPTERS

On occasion, it is necessary to use a special extension or adapter wrench together with a standard torque wrench. 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
L = Effective length of torque wrench
R = Reading on scale or dial of torque wrench
A = Distance thru which force is applied to part

$$R = \frac{LT}{A} = \frac{LT}{L+E}$$

Example: A torque of 1440 pounds-inches is desired on a part, using a special extension, having a length of 3 inches from center to center of its holes, and a torque wrench, measuring 15 inches from center of handle or handle swivel pin to center of its square adapter.

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 pounds-inches torque will provide the desired torque of 1440 pounds-inches on the part.

12–13. SPECIFIC

Nomenclature	Recommended Torque
Crankcase Thru Bolt Nuts (7/16 in. Hollow Type Bolt)	350 to 400 in. lbs.
Crankshaft Bolt	.009 to .011 in. stretch
Crankshaft Thru Bolt Expanders	200 to 225 in. lbs.
Cylinder Flange Nuts	300 to 350 in. lbs.
Propeller Shaft Thrust Bearing Nut	Tighten to 250 pounds-feet; then turn to tighten thru an angle of 25° to 30°.
Propeller Shaft Thrust Bearing Cover Nuts	100 to 150 in. lbs.
Pushrod Cover Connectors	Select to obtain 300 lb.-inch minimum driving torque.
Pushrod Cover Nuts	125 to 150 in. lbs.
Rocker Shaft Caps and Nuts (Aluminum)	65 to 100 in. lbs.
Rocker Shaft Nuts (Steel)	200 to 250 in. lbs.
Sparkplugs	300 to 360 in. lbs.
Starter and Starter Cover Nuts (Two Top Nuts Only)	175 to 200 in. lbs.
Supercharger Intermediate Gear Shaft Nut	600 to 675 in. lbs.
Valve Adjusting Screw Locknuts	300 to 350 in. lbs.

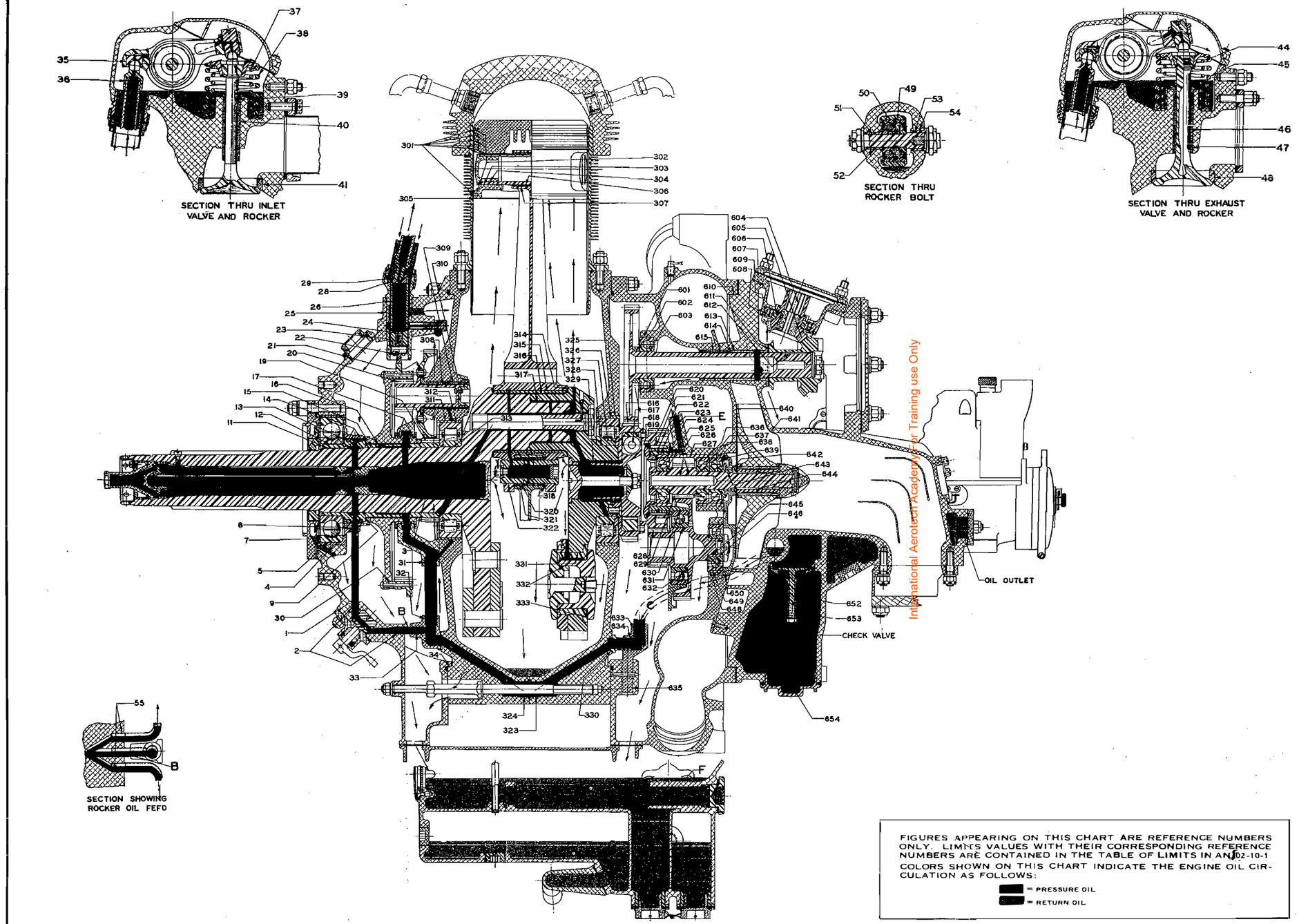


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Figure 12–1. Clearance and Lubrication Chart — Front, Power and Accessory Sections

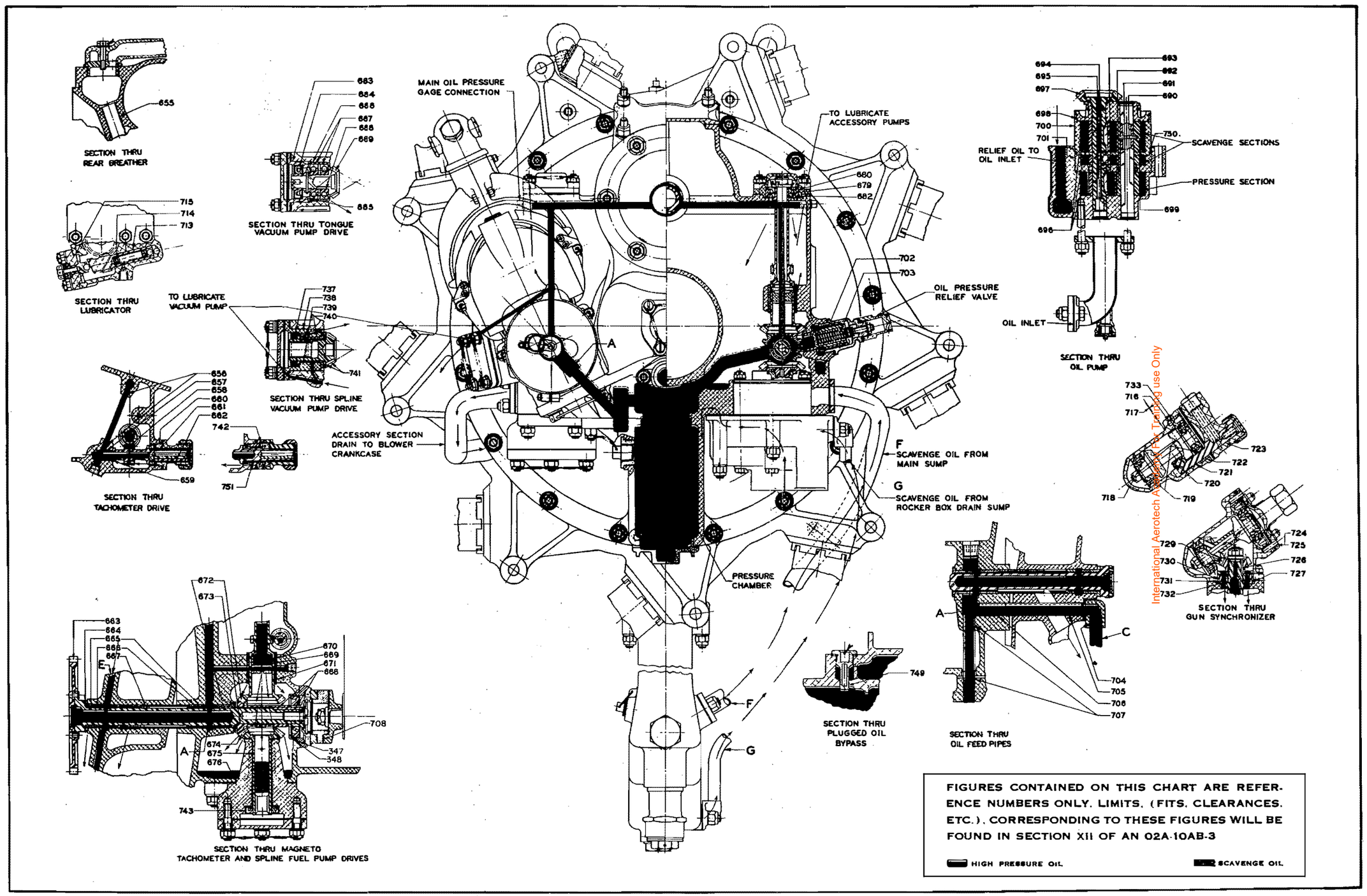

Figure 12–2. Clearance and Lubrication Chart – Rear Section

APPENDIX I

GOVERNMENT SPECIFICATIONS

A—1. GENERAL.

A—2. This appendix is included for the purpose of listing the specifications of various materials. The table will be used in servicing engines and in obtaining suitable substitutes.

A—3. The specifications listed are those which are considered to be acceptable for use by the U.S. Air Force and U.S. Navy.

A—4. TABLE OF GOVERNMENT SPECIFICATIONS.

SPECIFICATION NO.	TITLE	APPLICATION (PRIMARY)
MIL-F-5572	Aircraft Fuel — Grade 100/130 Aircraft Fuel — Grade 91 Aircraft Fuel — Grade 87 Aircraft Fuel — Grade 73	
MIL-O-6082	Oil — Lubricating Grade 1120 Grade 1100 Grade 1080 Grade 1065	
AN-G-3	Grease — Low Temperature Lubricating	Control Bearings General Low Temperature
AN-G-4	Grease — Aluminum Soap Grade AA Grade B	Propellers, Rockers
AN-G-5	Grease — High Temperature Water-resistant	Magneto, Generator (Engine Compt.)
AN-G-6	Grease — Lubricating Graphite	Engine Starter
AN-G-14	Grease — Gasoline and Oil Resistant	Fuel System Gasket Paste
FED. SS-G-659	Graphite	Lubrication
AN-O-3 Grade Medium	Oil — Low Temperature Lubricating Gear	Reduction Gears
AN-O-4	Oil — Gyro Instrument Lubricating	Instruments
AN-O-6	Oil — General Purpose, Low Temperature Lubricating	General Purpose "Squirt Can Lubricants"

SPECIFICATION NO.	TITLE	APPLICATION (PRIMARY)
AN-VV-O-366	Oil — Hydraulic, Petroleum Base	Hydraulic Systems, (Synthetic Rubber Seals) and Other Low Temperature Uses
AN-F-13	Eluid — Anti-icing (Isopropyl Alcohol)	
VV-K-211	Kerosene	Cleaning, etc.
AN-C-52	Compound — Exterior — Surface Corrosion Preventive	External Preservative
AN-VV-C-576	Compound — Corrosion-Preventive Aircraft Engines	Preservation of Engine Interior for Storage or Shipment
AN-VV-C-566	Compound — Antiseize, Mica-base (For Threaded Fittings)	Sparkplugs, Head Bolts, Exhaust Systems
JAN-A-669	Compound — Antiseize White Lead Base	Threaded Fittings
AN-C-86	Compound — Antiseize and Sealing for Oxygen Systems	Oxygen Systems (High and Low Pressure)

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