Cpl arnold

EO 10A-10AA-2

ROYAL CANADIAN AIR FORCE

DESCRIPTION AND MAINTENANCE INSTRUCTIONS

PRATT & WHITNEY R985, AN-5, -14B

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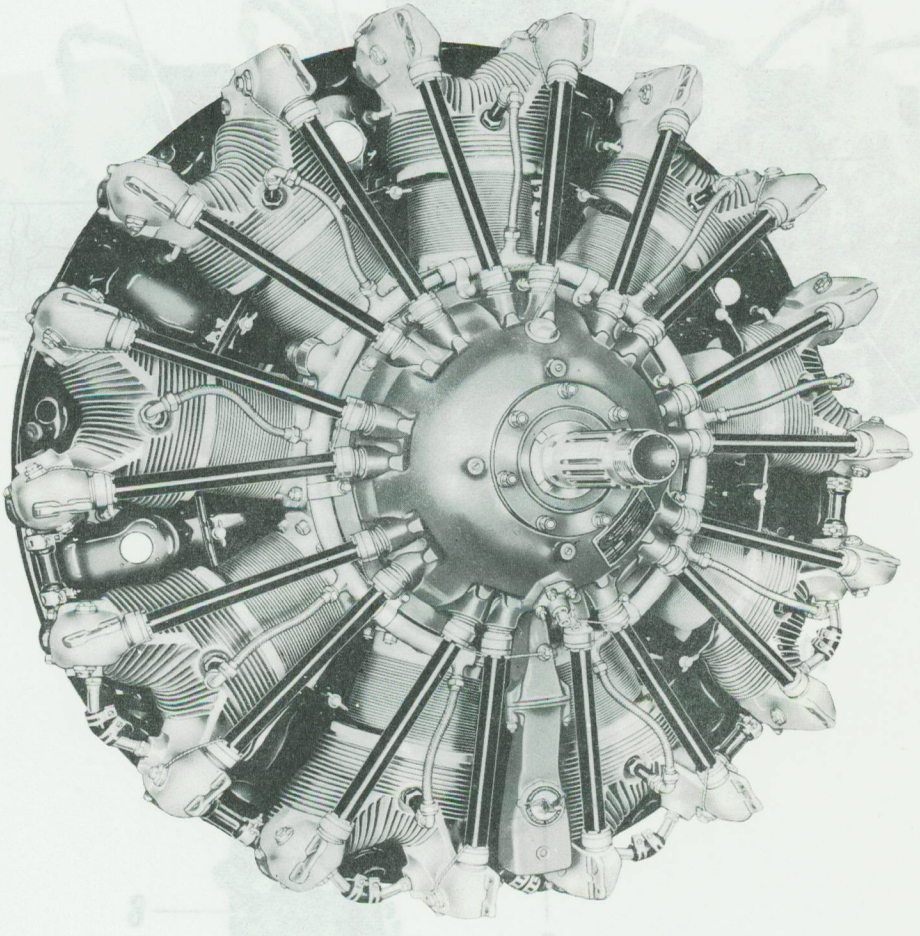
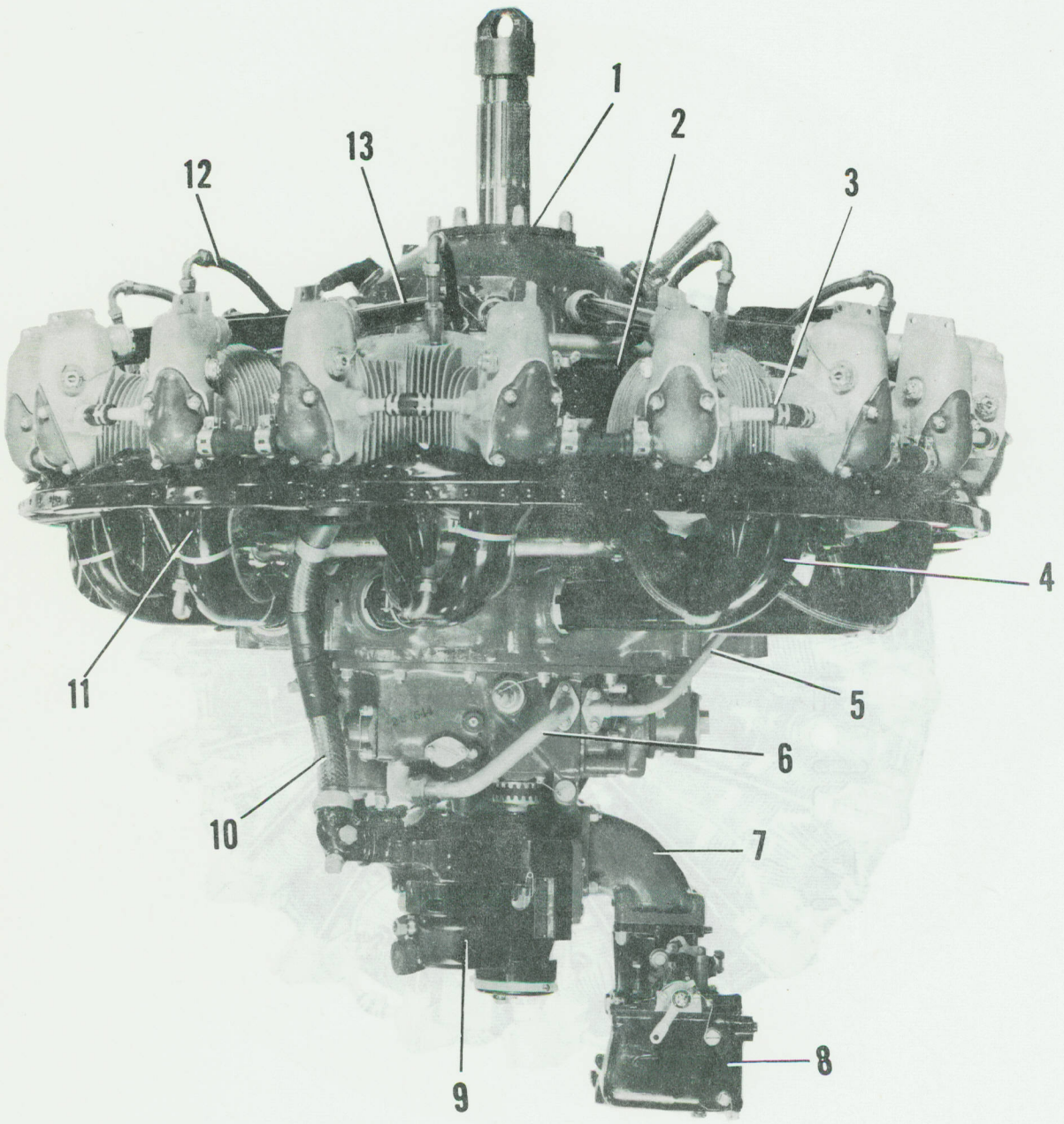
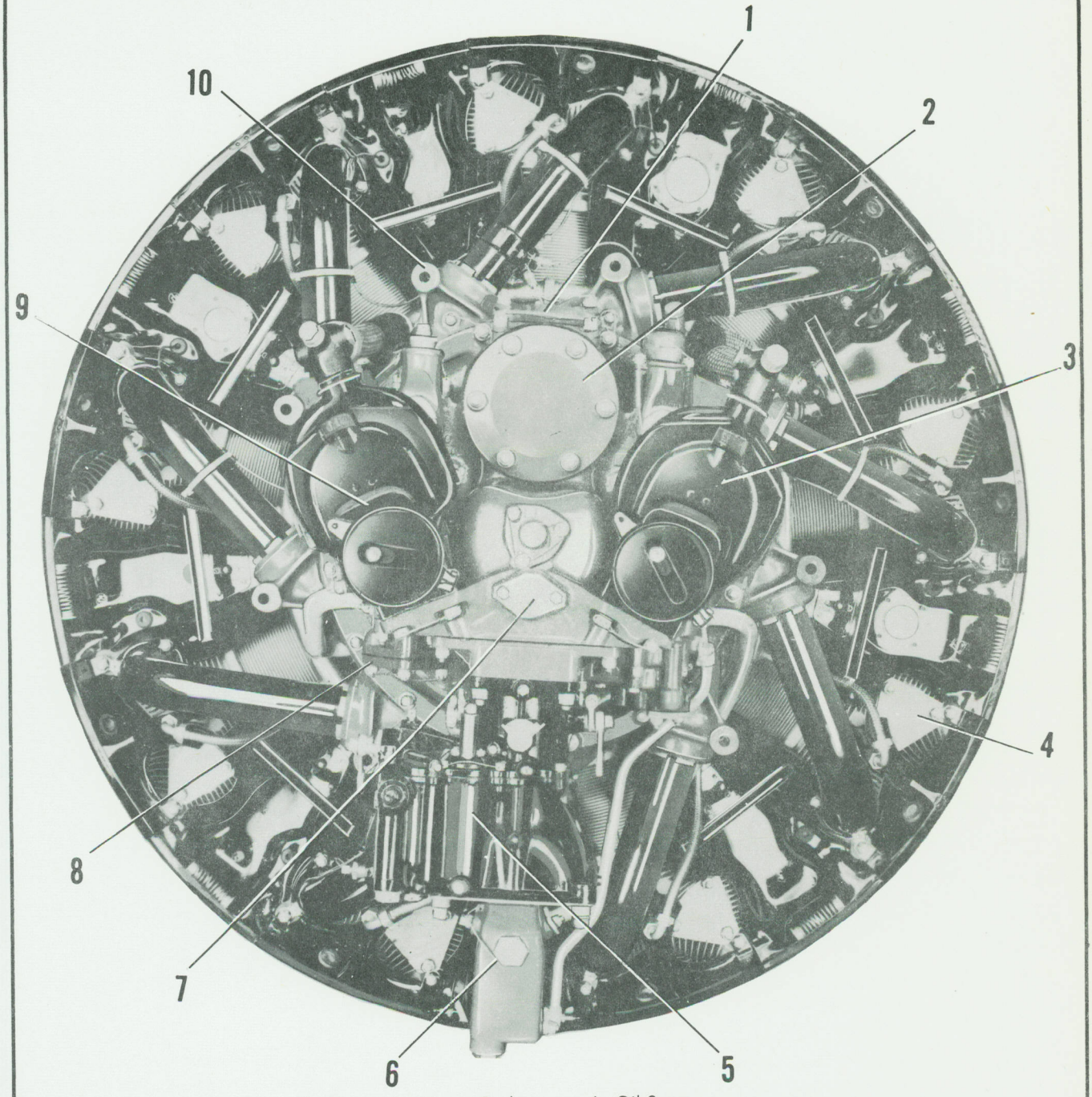


Front View



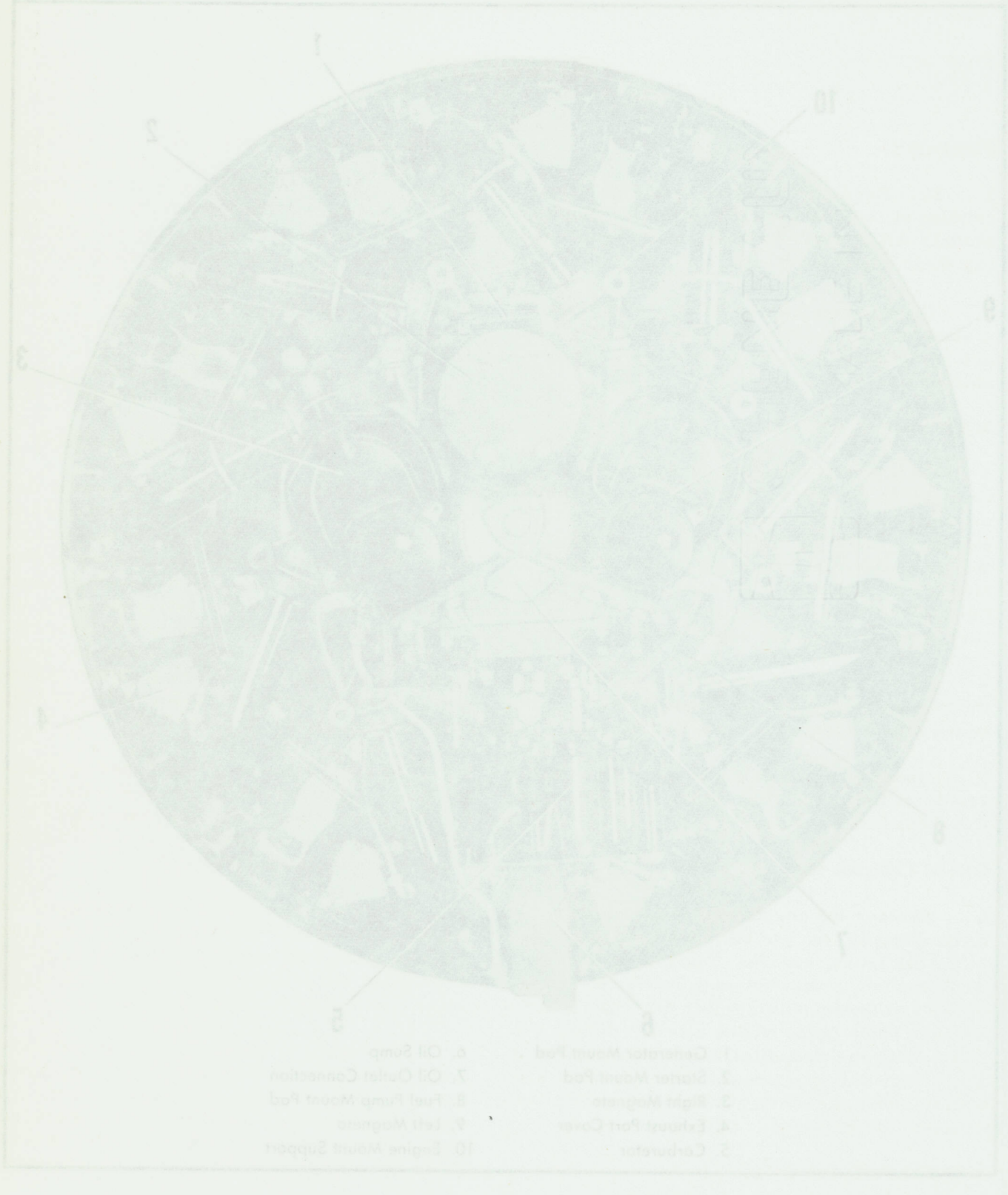
1. Thrust Bearing Cover
2. Inter-Cylinder Oil Drain Hose
3. Inter-Ear Oil Drain Hose
4. Intake Pipe
5. Front Section Oil Drain Tube
6. Rear Section Oil Drain Tube
7. Carburetor Adapter Elbow
8. Carburetor
9. Magneto
10. High Tension Lead
11. Primer Tube
12. Sparkplug Lead
13. Pushrod Cover

Side View



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

Rear View



PART 1

INTRODUCTION

PURPOSE

1 This Engineering Order contains a Description of the Pratt and Whitney R985 Engine, Models AN-5 and AN-14B, and Instructions for their maintenance.

2 The purpose of this Order is to provide maintenance personnel with the information and instruction necessary to ensure dependable engine operation.

METHOD OF USE

3 Throughout the Order, when reference is made to the R985 Engine, the description or instruction applies to both Models. For example: "The R985 Engine has nine cylinders". Where there is a difference between the two Models, the description or instruction will quote the Model number. For example: "The rear case of the AN-5 Model is used as an oil sump".

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

5 Procedures outside the scope of this Order are contained in EO 10A-10AA-3, Repair and Overhaul Instructions.

DIRECTIONAL REFERENCES

6 Whether the engine is installed vertically or horizontally, the propeller shaft is considered to be the front, and No. 1 cylinder the top. Right and left, clockwise and counter clockwise. upper and lower, and similar directional references apply to the engine as viewed from the rear, with the propeller shaft horizontal and No. 1 cylinder uppermost. The cylinders are numbered consecutively in the direction of crankshaft rotation. (Figure 1-1).

PRINCIPLE OF OPERATION

7 The engine operates on a four stroke cycle. Gasoline and air are mixed in the carburettor and passed through a compressor to the cylinders, where the mixture is ignited electrically. The resultant combustion forces a piston along each cylinder. A connecting rod attached to each piston converts the reciprocating motion of the piston to rotary motion of the crankshaft. The propeller is driven by the crankshaft through reduction gearing. The products of combustion are expelled from the cylinder by the piston on its next outward stroke and are exhausted to the atmosphere. (Figure 1-2).

A TYPICAL HELICOPTER INSTALLATION

8 A clutch housing, which carries the fan and the clutch driving member, is attached to the propeller shaft. Actuated by centrifugal force, the driving member engages the driven member, which rotates on ball bearings about the crankshaft. Through a universal joint, the clutch-driven member is connected to the vertical drive shaft, which in turn transmits power through a second universal joint to the reduction gear and free wheeling units from which the main rotor is driven. (Figure 1-3).

9 Tail rotor drive is accomplished by shafting from the tail rotor which joins the main rotor drive at a gear box. The take-off is before the free wheeling unit so that the tail rotor is operative during auto-rotation.

10 A separate lubrication system is provided for the gear boxes. The fan and clutch housing afford a sufficient amount of "flywheel effect" to protect the crankshaft and supercharger drive from undesirable vibrations.

11 The engine is mounted on a conventional-type tubular mount structure. Rubber bushings are used for vibration isolation. Number 1 cylinder is forward. Retention of the standard engine nomenclature results in the right side of the engine being on the left side of the aircraft.

12 As with other submerged engine instal-

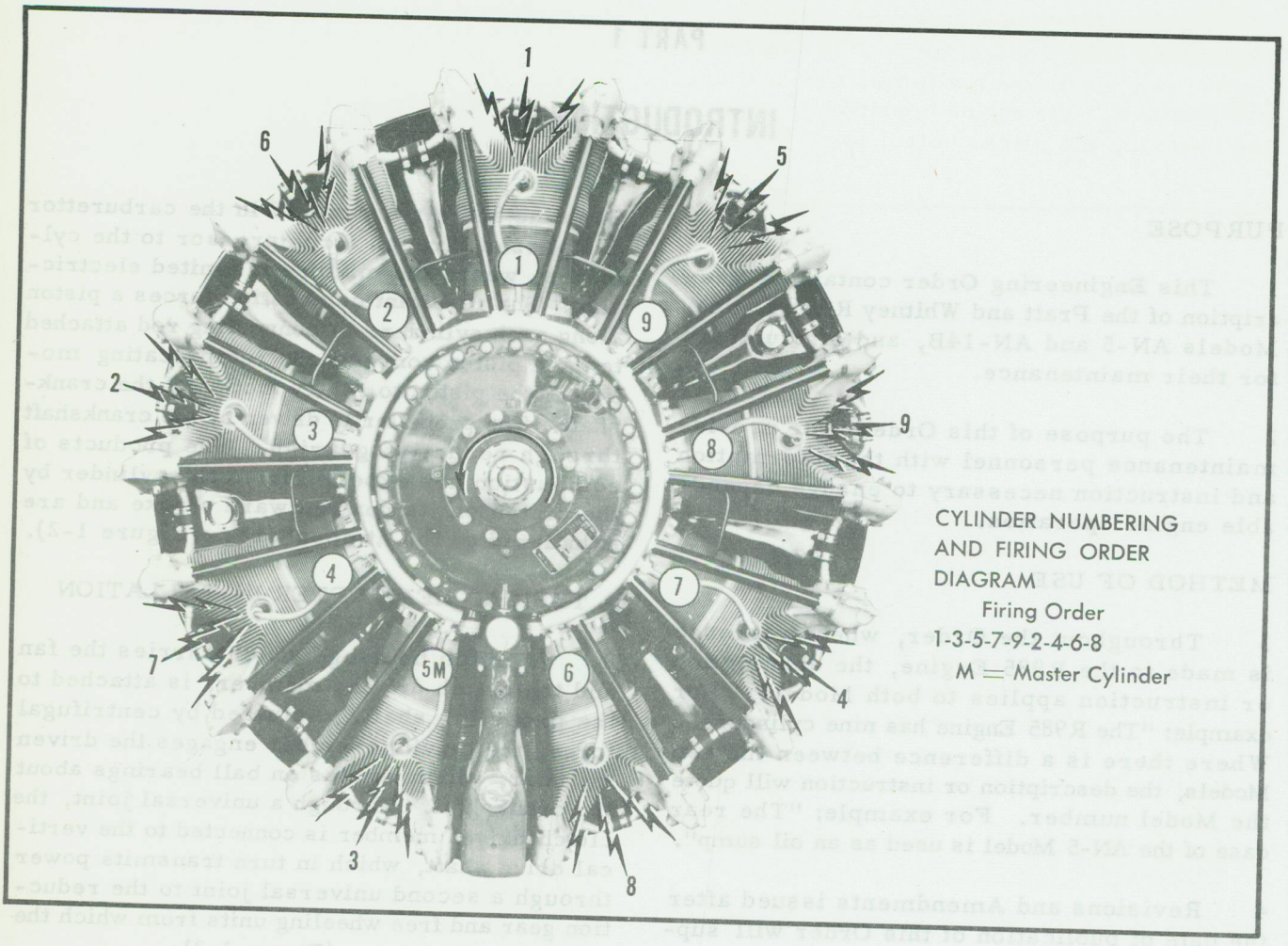


Figure 1-1 Cylinder Numbering

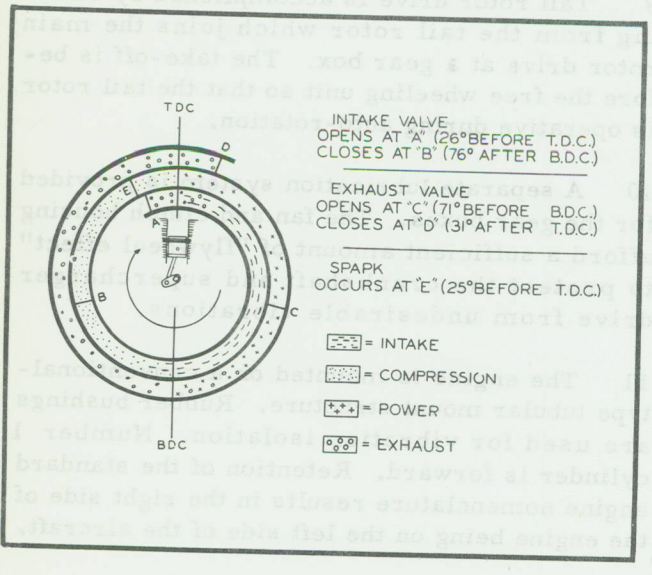


Figure 1-2 Four-Stroke Cycle

lations, auxiliary cooling is provided by a fan and suitable cowling. Cooling air is taken in through louvers at the forward side of the rotor pylon, and is exhausted at the sides of the aircraft. Recirculation of heated air back into the fan is prevented by means of a cloth diaphragm or seal near the cowl entrance which extends from the cowl to the sides of the engine compartment, thus isolating the cooling air exit from the fan entrance. A diaphragm or shroud separates the accessory compartment from the power section. Blast tubes for magneto cooling receive air from between the baffles.

13 The throttle and the pitch control are interconnected so that, as the pitch of the main rotor blade is increased the throttle is opened to provide more power. An override for throttle adjustment is incorporated in the rotatable hand

grip on the pitch control stick. The mixture control is conventional with full rich and full lean positions. The engine is primed by raising and lowering the pitch control lever with the mixture control in fully lean. The magneto switch, fuel selector valve, carburettor air control, starter switch and other controls are standard.

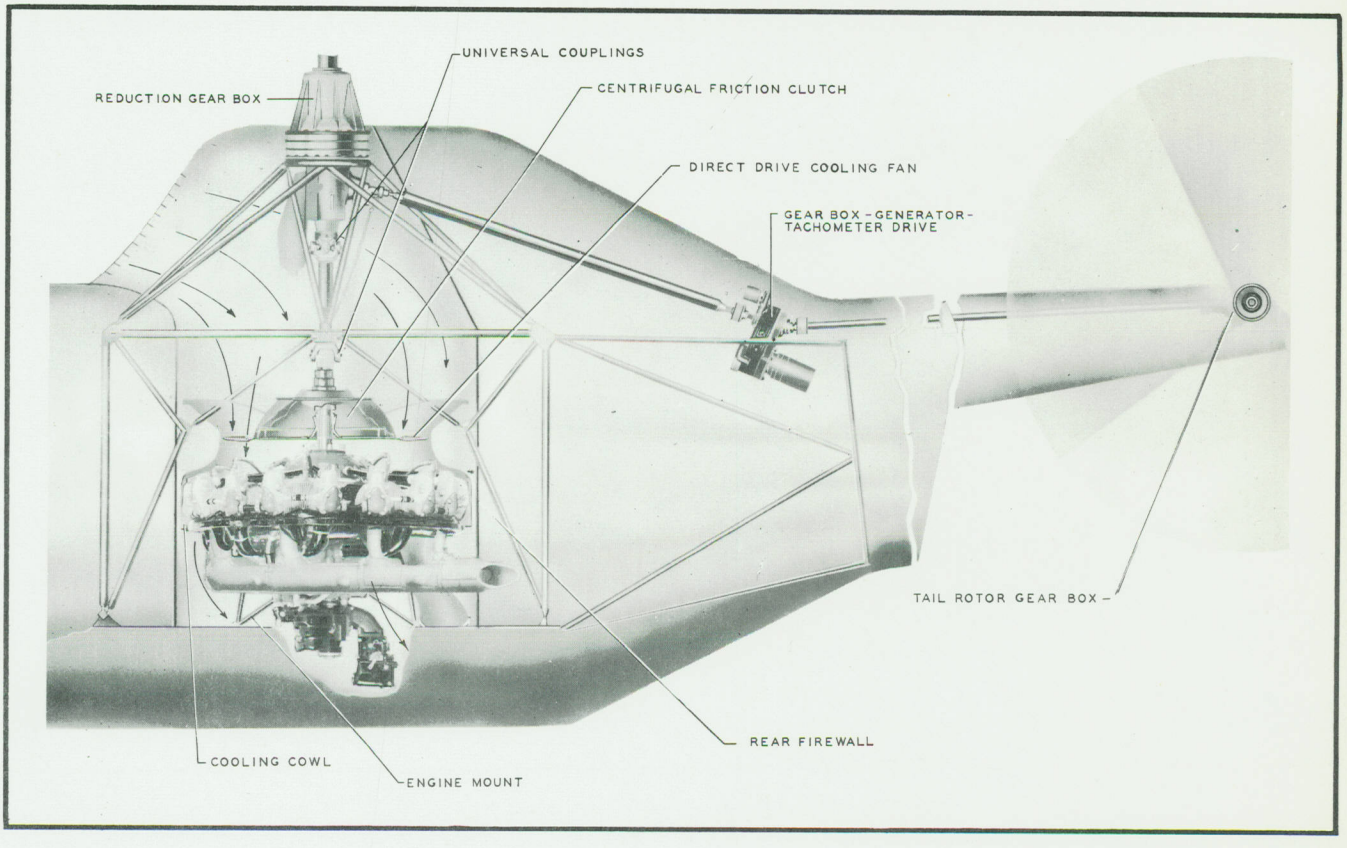


Figure 1-3 AN-5 Model in Helicopter

PART 2

LEADING PARTICULARS

SECTION 1

DETAILS

1	Models	AN-5, AN-14B
2	Type	9 Cylinder, Single row, Radial, Air cooled
3	Bore and Stroke	5.1875 inches
4	Total Piston Displacement	985 cubic inches
5	Compression Ratio	6:1
6	Impeller ratio	10:1
7	Crankshaft Rotation	Clockwise
8	Propeller Gear Ratio	Direct Drive
9	Propeller Shaft Spline Size	No. 30
10	Number of Mounting Brackets	9
11	Total Engine Dry Weight	
	AN-14B	682 pounds
	AN-5	684 pounds
12	Engine Overall Diameter	46.10 inches
13	Engine Overall Length	
	AN-14B	42.43 inches
	AN-5	47.69 inches

IGNITION SYSTEM

14	Magneto	Two Scintilla SB9RN-3 or -4
15	Conduit Type	PWA Shielded Ignition Cable Assembly
16	Sparkplug Types	706 SR, RC-26S, RB485S, SH-2K
17	Sparkplug Gap	Refer to EO 15-5F-2C

VALVE TIMING AND CLEARANCE

18	Inlet	
(a)	Opens Before Top Centre	26 degrees
(b)	Closes After Bottom Centre	76 degrees
19	Exhaust	
(a)	Opens Before Bottom Centre	71 degrees
(b)	Closes After Top Centre	31 degrees
20	Inlet Remains Open	282 degrees
21	Exhaust Remains Open	282 degrees
22	Valve Overlap	147 degrees
23	Valve Lift	
(a)	Inlet	.5625 in.
(b)	Exhaust	.4687 in.
24	Valve Rocker:	
(a)	Timing Clearance (Cold)	.060 in.
(b)	Adjusting Clearance (Cold)	.010 in.

FUEL SYSTEM

25	Carburettor Type	Stromberg NA-R9B

26 Fuel — Refer to EO 45 - 1 - 2

If 80/87 grade fuel is not available, 91/98 grade or better must be used.

LUBRICATION SYSTEM

27 Oil Grade S.U.S. at 210°F — 100

(For a list of the oils approved for use in Pratt & Whitney Aircraft engines see EO 45-1-2).

28 Oil Pump Ratio to Crankshaft Speed — .875:1

29 Oil Pump Drive Rotation — Counterclockwise

SECTION 2

OPERATING DATA

GENERAL

1 Operating limitations may vary with different aircraft installations. The applicable Engineering Order and Pilots Operating Instructions for the particular aircraft should be consulted before operating the engine.

2 Check oil pressure, oil temperature, fuel pressure and other items and manifold pressure equal to field barometric pressure, propeller in low pitch (HIGH RPM).

CYLINDER HEAD TEMPERATURE

3 Do not exceed 232°C (450°F) cylinder head temperature during ground operation.

OIL PRESSURE LIMITS

		psi
4	Minimum at 2300 rpm	70
	Maximum at 2300 rpm	90
	Minimum at 2000 rpm	60
	Desired at 2000 rpm	70
	Minimum at 1400 to 1800 rpm	50
	Minimum at Idle	10

OIL TEMPERATURE LIMITS

		°C	°F
5	Minimum for Ground Test	40	100
	Maximum for Ground Test	85	185
	Maximum for take-off and flight	40	100
	Maximum, level flight	85	185
	Maximum, climb	85	185

FUEL PRESSURE LIMITS

		psi
6	Maximum	6
	Desired	5
	Minimum	4
	Idling	2.25

SECTION 3

ACCESSORY DRIVES AND CONNECTIONS

ITEM	ACCESSORY DRIVE	TYPE OF DRIVE	PAD STUD CENTRES	RATIO TO CRANKSFT.	ROT-ATION
1	Starter	3 Tooth Jaw	5 inches dia.	1.00:1	CC
2	Vacuum Pump	12 Int. Inv. Splines	1-7/8 in. sq.	1.50:1	C
3	Fuel Pump	11 Int. Inv. Splines	2 in. sq.	1.00:1	CC

ITEM	ACCESSORY DRIVE	TYPE OF DRIVE	PAD STUD CENTRES	RATIO TO CRANKSHAFT	ROT-ATION
4	Tachometer (Right)	7/8 18NS-3 Coupling		.500:1	CC
5	Tachometer (Left)	7/8 18NS-3		.500:1	C
6	Auxiliary	16 Ext. Rect. Splines	1-7/8 in. sq.	1.00:1	CC

ITEM	CONNECTION	SIZE	TYPE
7	Fuel inlet	.375-18	NPT
8	Fuel pressure gauge	.125-27	NPT
9	Manifold pressure gauge	.125-27	NPT
10	Oil tank vent	.750-14	NPT
11	Oil pressure gauge	.125-27	NPT
12	Oil outlet thermo	.625-18	NF-3
13	Oil inlet thermo	.625-18	NF-3
14	Breather	.750	HOSE
15	Accessory oil return to engine left side of sump	.375-18	NPT
16	Magneto blast tube	.750-14	NPT

C - Clockwise
CC - Counterclockwise
in. - inches
Int. - Internal
Inv. - Involute
sq. - square
Ext. - External
Rect. - Rectangular

PART 3

DESCRIPTION

SECTION 1

GENERAL

TYPE

1 The Pratt & Whitney R985 Engine is a single row, nine cylinder, supercharged, radial, air-cooled engine.

DIFFERENCES BETWEEN MODELS

2 The AN-14B Model is designed for horizontal installation in a conventional type aircraft; the AN-5 Model is designed for vertical installation in a helicopter. To accommodate vertical installation, the AN-5 Model differs from the AN-14B Model in many ways, but the substitution of plain journal bearings at the impeller shaft in place of ball bearings, the use of the rear case as a collector of engine oil and the location of a breather in the engine nose section are the main differences.

3 For ease of description the engine is broken down into sections (Figure 3-1). The combination of cylinders and crankcase is sometimes referred to as the power section.

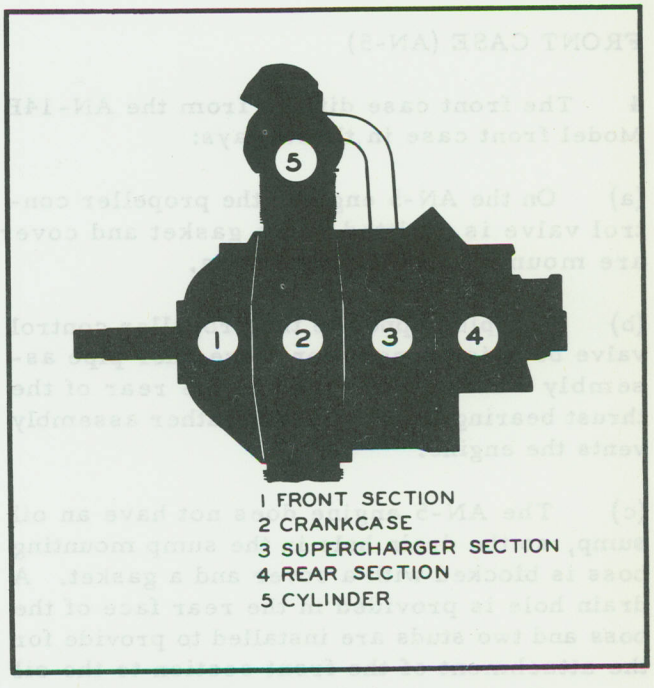


Figure 3-1 Engine Sections

SECTION 2

DETAIL

FRONT SECTION
(Item 1, Figure 3-1)

FRONT CASE (AN-14B)

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

2 Bosses in the front case provide support

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

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

FRONT CASE (AN-5)

4 The front case differs from the AN-14B Model front case in three ways:

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

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

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

CRANKCASE SECTION
(Item 2, Figure 3-1)

CRANKCASE

5 The crankcase section consists of the front and rear crankcases which are held together by nine crankcase bolts located between the cylinder mounting pads. 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 bushing is pinned in the forward face of the front crankcase to support the rear end of the cam reduction drive gear. The cam rotates on a sleeve supported on the crankshaft.

VALVE TIMING GEARS

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

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

CRANKSHAFT (Figure 3-3)

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

9 The front section of the crankshaft is splined to the rear section of the shaft and is held rigid by a through-bolt. The reciprocating and rotating parts of the crankshaft are counterbalanced by weights which are riveted to the cheeks of the crankshaft. Two flyweights in the rear counterweight insure vibrationless performance at all speeds.

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

MASTEROD AND LINKRODS (Figure 3-4)

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

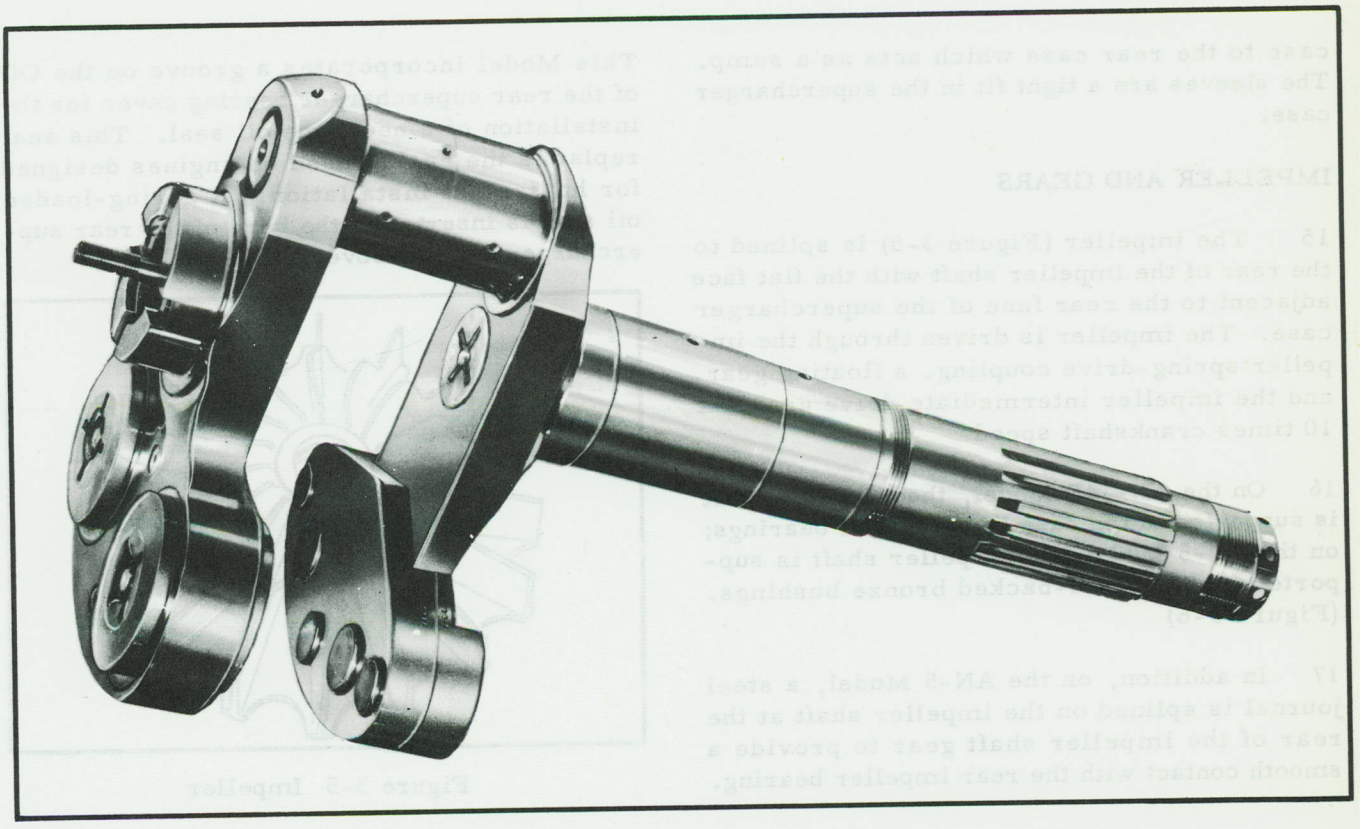


Figure 3-3 Crankshaft

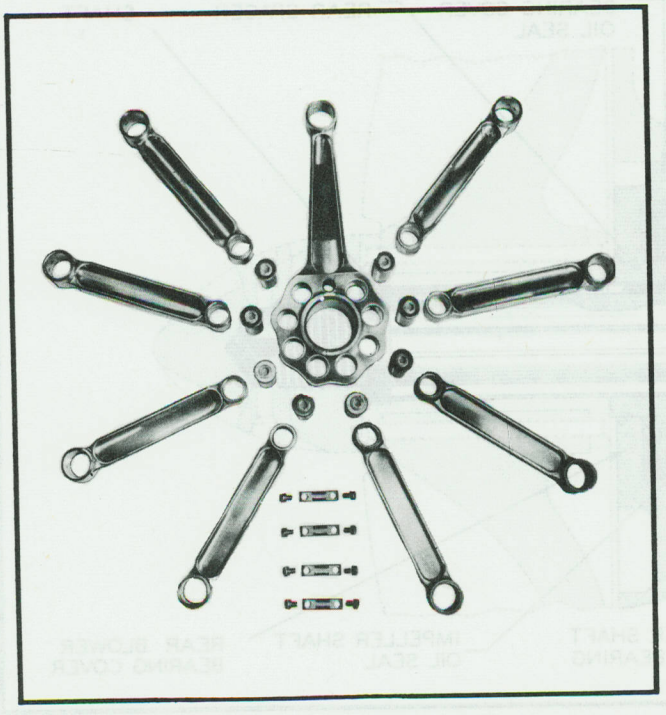


Figure 3-4 Master and Link Rods

SUPERCHARGER SECTION

(Item 3, Figure 3-1)

SUPERCHARGER CASE

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

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

14 On the AN-5 Model three duraluminum oil scavenge sleeves are provided in the supercharger case to carry oil from the supercharger

case to the rear case which acts as a sump. The sleeves are a tight fit in the supercharger case.

IMPELLER AND GEARS

15 The impeller (Figure 3-5) is splined to the rear of the impeller shaft with the flat face adjacent to the rear face of the supercharger case. The impeller is driven through the impeller spring-drive coupling, a floating gear, and the impeller intermediate drive gear, at 10 times crankshaft speed.

16 On the AN-14B Model, the impeller shaft is supported in the case by three ball bearings; on the AN-5 Model, the impeller shaft is supported by two steel-backed bronze bushings. (Figure 3-6)

17 In addition, on the AN-5 Model, a steel journal is splined on the impeller shaft at the rear of the impeller shaft gear to provide a smooth contact with the rear impeller bearing.

This Model incorporates a groove on the OD of the rear supercharger bearing cover for the installation of a neoprene oil seal. This seal replaces the gasket used on engines designed for horizontal installation. A spring-loaded oil seal is inserted in the bore of the rear supercharger bearing cover.

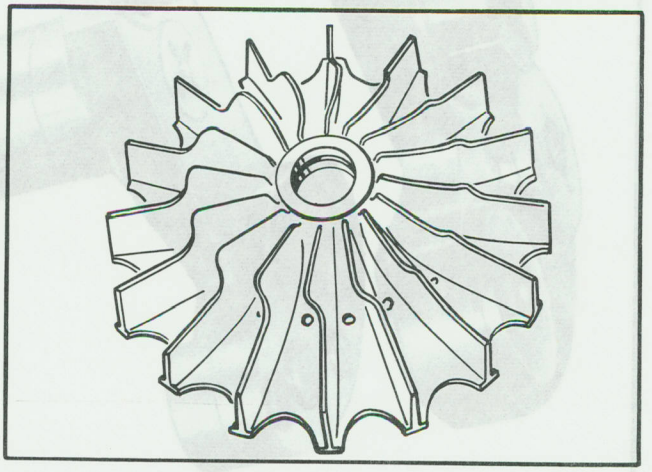


Figure 3-5 Impeller

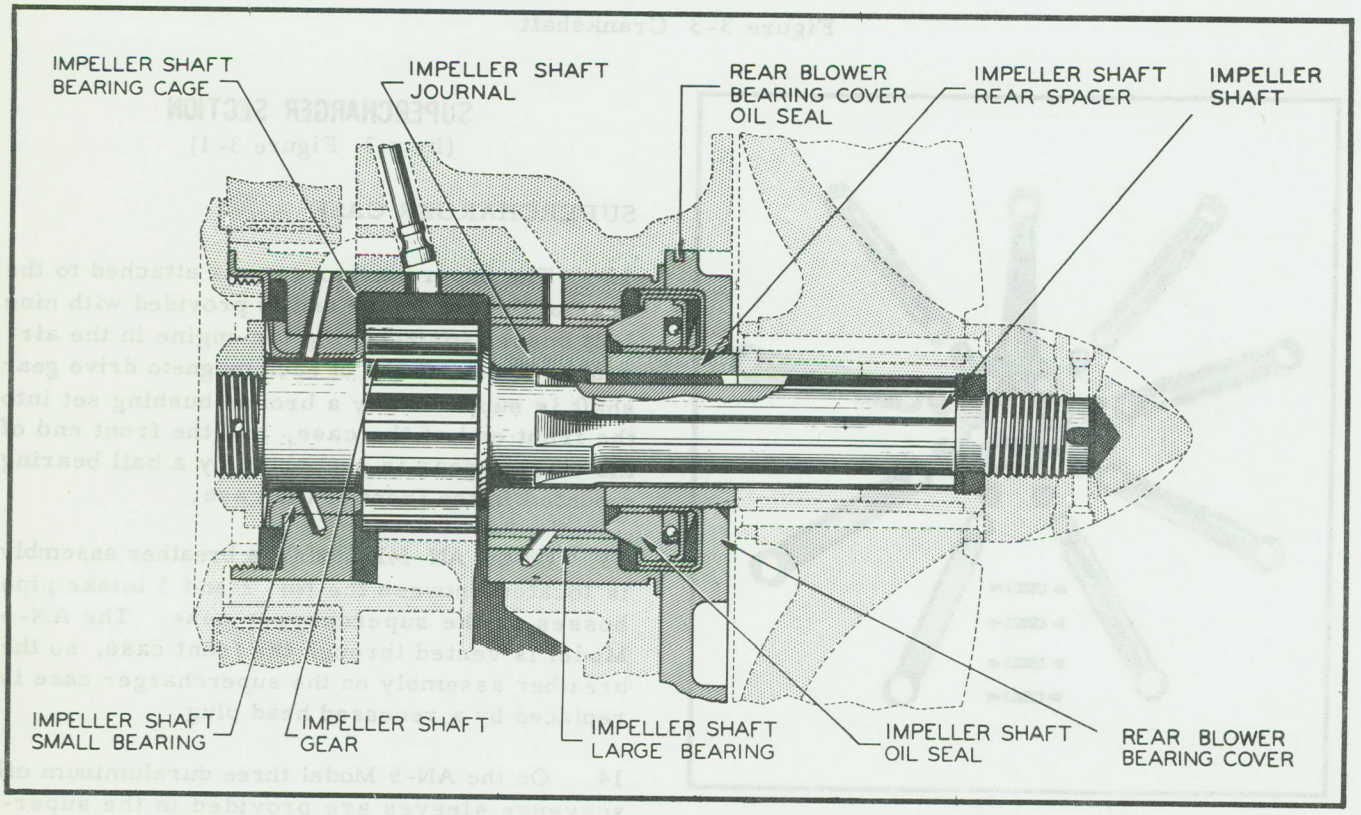


Figure 3-6 Cut-a-way of Supercharger Case at Impeller Shaft AN-5 Model

OIL SUMP

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

REAR SECTION

(Item 4, Figure 3-1)

REAR CASE

19 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 strainer and check valve, a three section oil pump and an oil pressure relief valve. Mounting pads are provided for the carburettor adapter, two magnetos, a fuel pump, starter, vacuum pump adapter, and tachometer. The AN-14B Model provides drives for a generator; the AN-5 Model does not. The generator may be driven by the helicopter's tail rotor shaft.

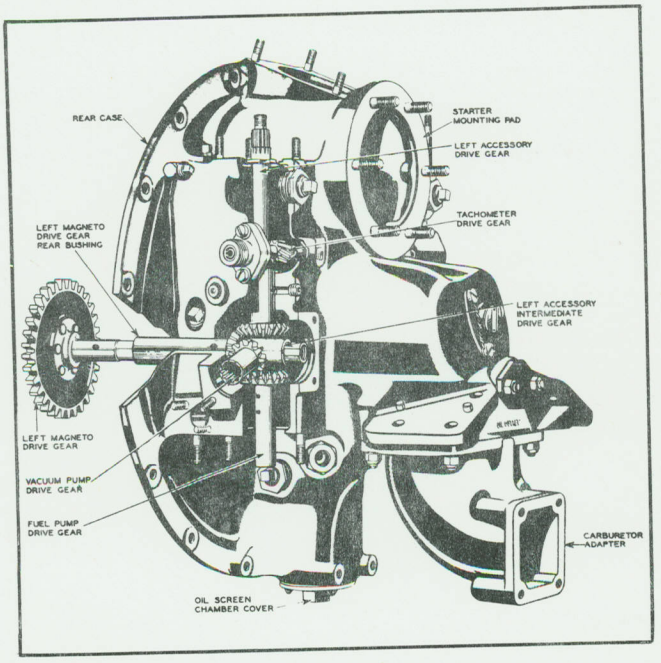


Figure 3-7 Rear Case Showing Accessory Drive

20 The accessories are driven by three shafts which extend entirely through the supercharger and rear sections (Figure 3-6). Each shaft carries a spur gear at its forward end which meshes with a gear coupled to the rear of the crankshaft. The upper shaft provides a drive for the starter and for the generator on the AN-14B Model. Each of the two lower shafts drives a magneto through an adjustable flexible coupling. Four vertical drives are provided for by a bevel gear keyed to each magneto drive shaft. Two vertical drive shafts for operating accessories and two tachometers are driven from the upper side of the bevel gears. The under sides of the bevel gears drive an oil pump on the right side and a fuel pump on the left. An additional drive for a vacuum pump is located at the lower left of the left magneto drive.

CYLINDERS

(Item 5, Figure 3-1)

CYLINDER HEADS AND BARRELS

21 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 cylinder 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.

VALVE MECHANISM

22 All valve operating parts are enclosed and are pressure lubricated. The rockers are housed in rockerboxes cast integrally with the cylinder

head and are supported on double row ball bearings. Eighteen tappets, located in the front case are actuated by the action of the rollers on the cam lobes and in turn actuate the rockers through tubular pushrods. The pushrods are protected by removable oil-tight covers. The valve clearance adjusting screw in the front end of each rocker has a screwball for self alignment with the valve stem. Rockerbox covers enclose the rockers in the rockerboxes.

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

PISTONS

24 The pistons are machined from aluminum alloy forgings and are of the flathead, 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. Pistons in cylinders five and six are undrilled in the bottom groove to prevent possible hydraulic lock. Steel piston-pins connect the pistons to the masterod and linkrods.

SECTION 3

SYSTEMS

OIL (See Figure, 3-8, 3-9, 3-10)

1 Oil is circulated through the engine by a three section gear pump (Figure 3-11) mounted in the lower right hand side of the rear case. Oil from the tank enters the oil inlet at the bottom of the pump and is directed to the pressure (lower) section of the pump from where it is forced to the oil screen chamber through a cored passage in the rear case. The oil passes through the screen assembly and the pressure of the oil opens the spring loaded check valve. When the engine is not operating, the check valve prevents oil from seeping into or out of the engine.

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

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

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

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

3 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.

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

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

6 In the AN-14B Model, oil from the cam oil feed bracket is piped to a two position valve in the nose section from whence it is introduced into the propeller shaft through an oil transfer for the operation of a hydro-controllable propeller. In the event that a constant speed governor is mounted on the rear section of the AN-14B

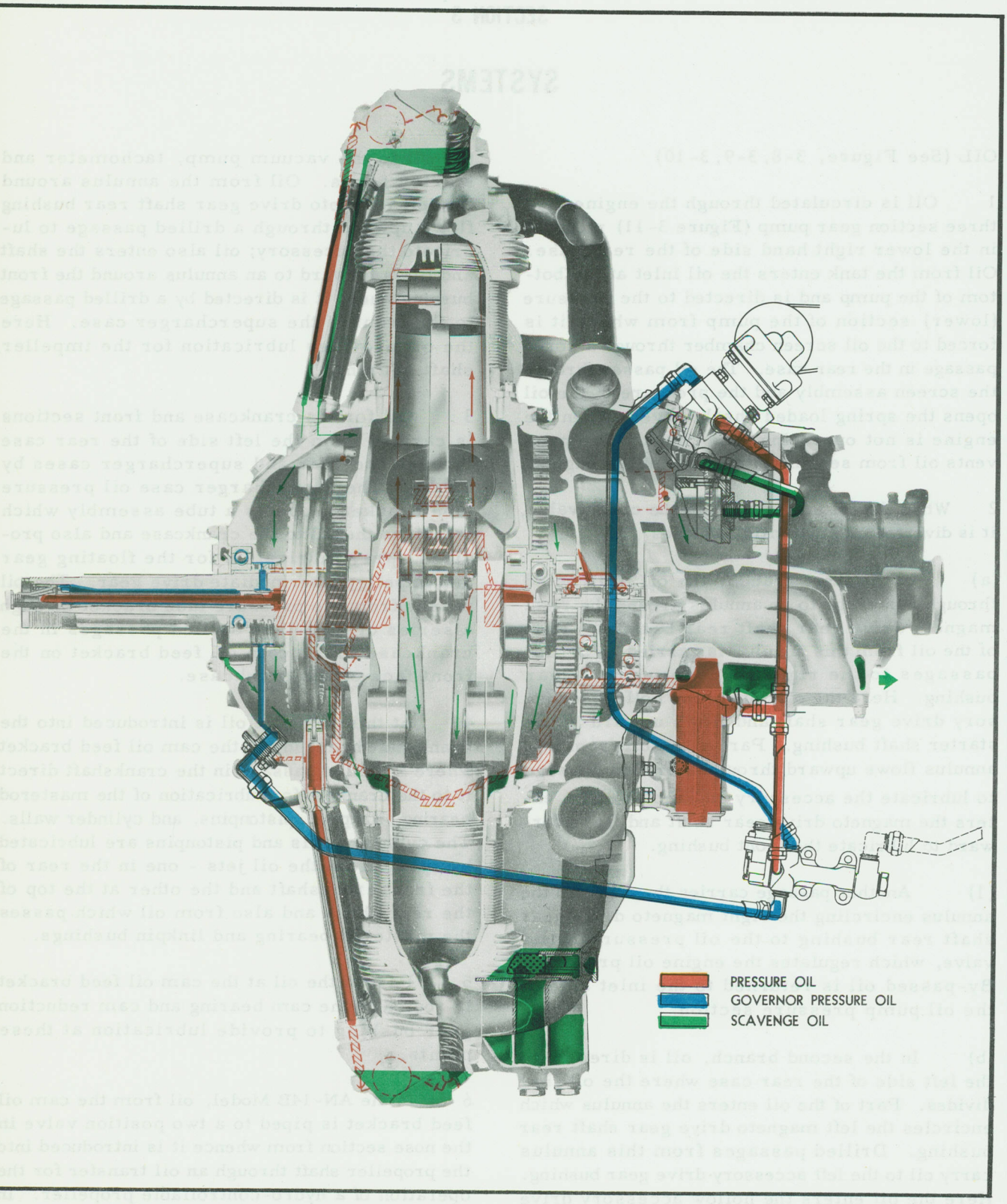


Figure 3-8 Oil Circulation in AN-14B Model

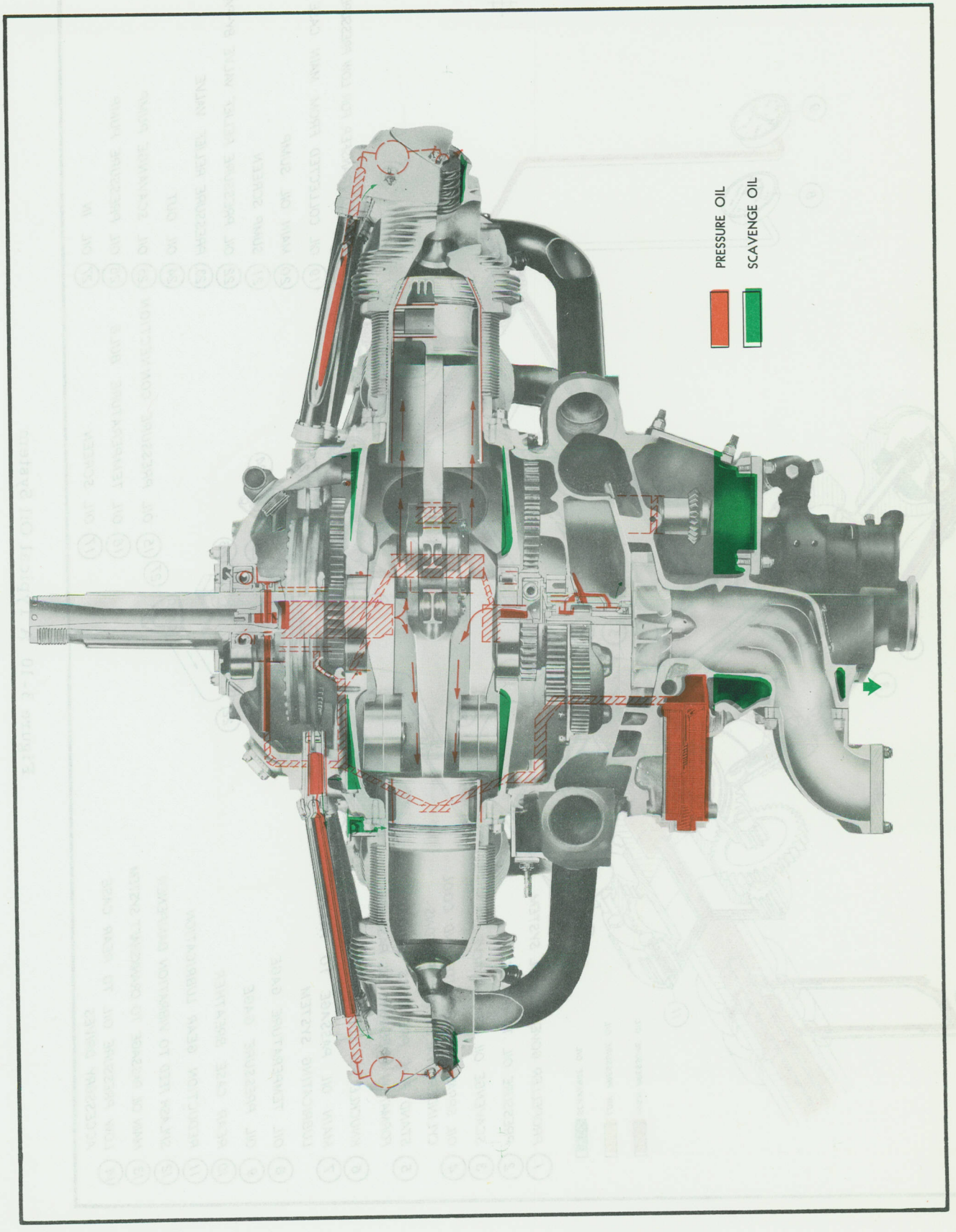


Figure 3-9 Oil Circulation in AN-5 Model

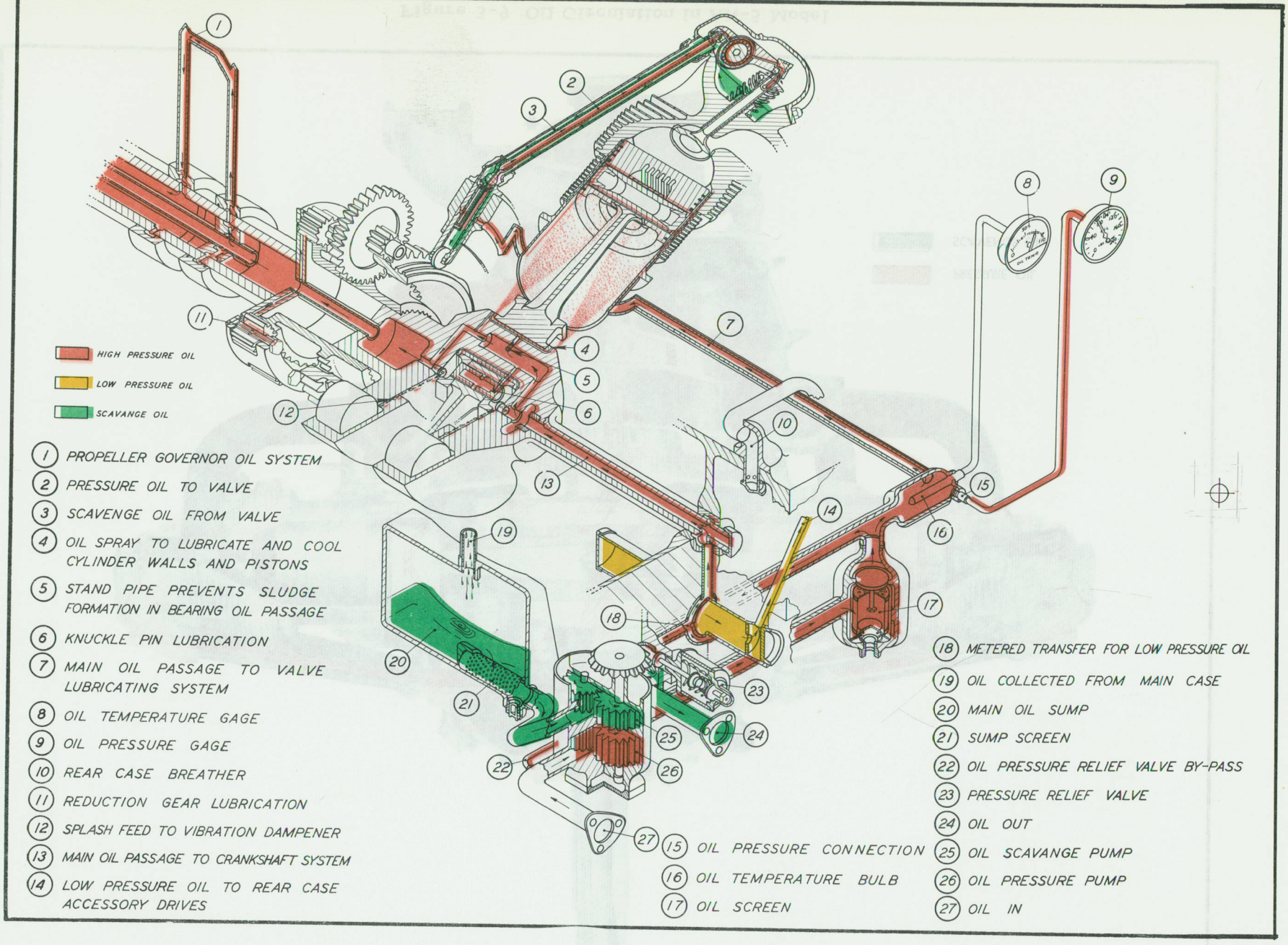


Figure 3-10 A Typical Oil System

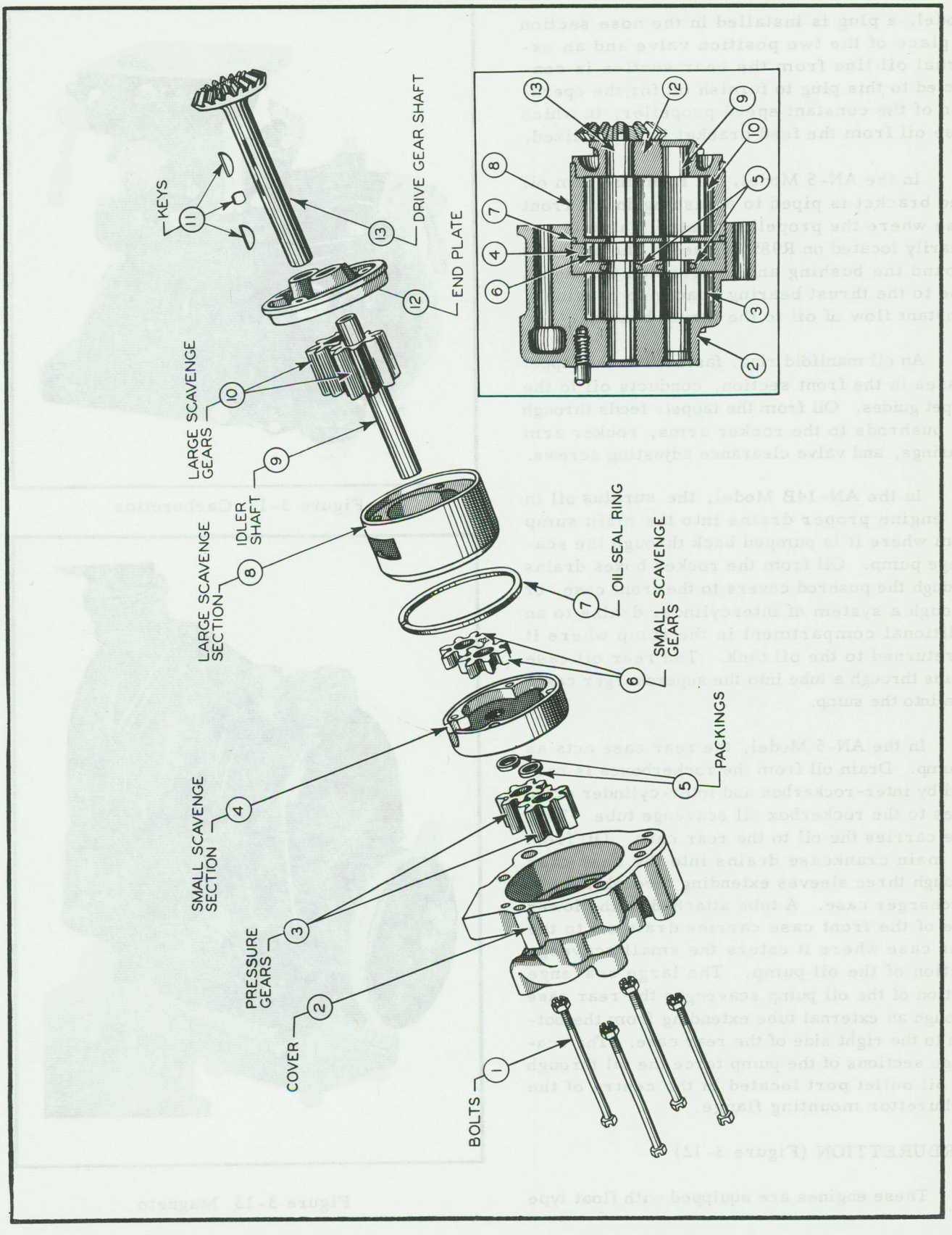


Figure 3-11 Exploded View of Oil Pump

Model, a plug is installed in the nose section in place of the two position valve and an external oil line from the rear section is connected to this plug to furnish oil for the operation of the constant speed propeller, in which case oil from the feed bracket is not utilized.

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

8 An oil manifold ring, fastened to the tappet bosses in the front section, conducts oil to the tappet guides. Oil from the tappets feeds through the pushrods to the rocker arms, rocker arm bearings, and valve clearance adjusting screws.

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

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

CARBURETTION (Figure 3-12)

11 These engines are equipped with float type

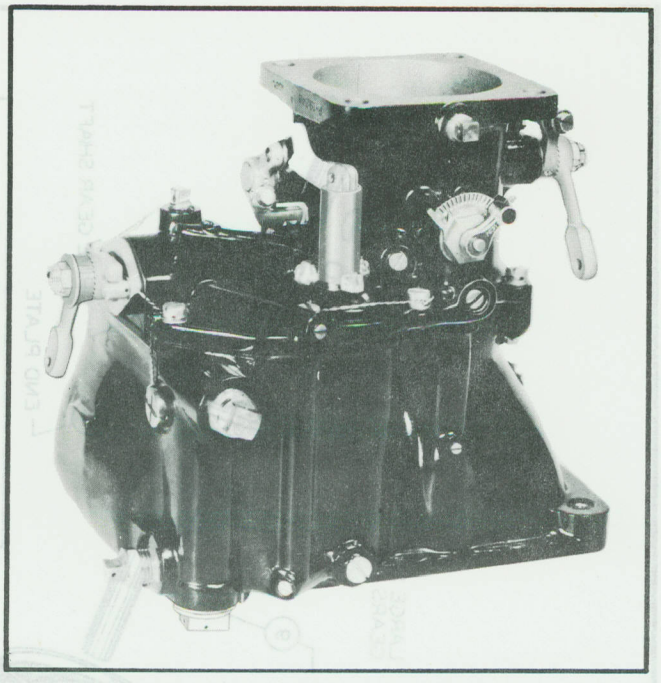


Figure 3-12 Carburettor

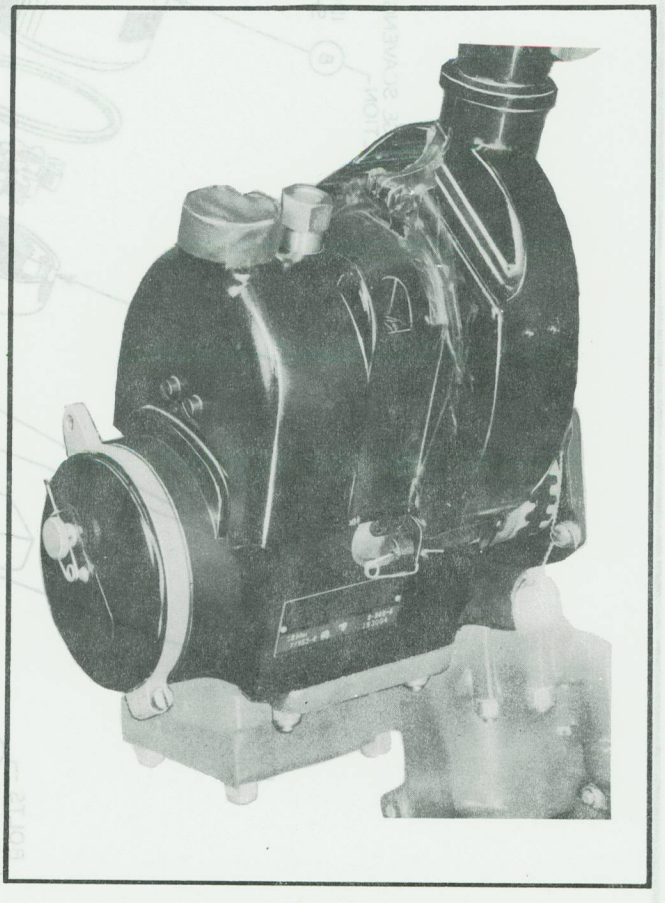


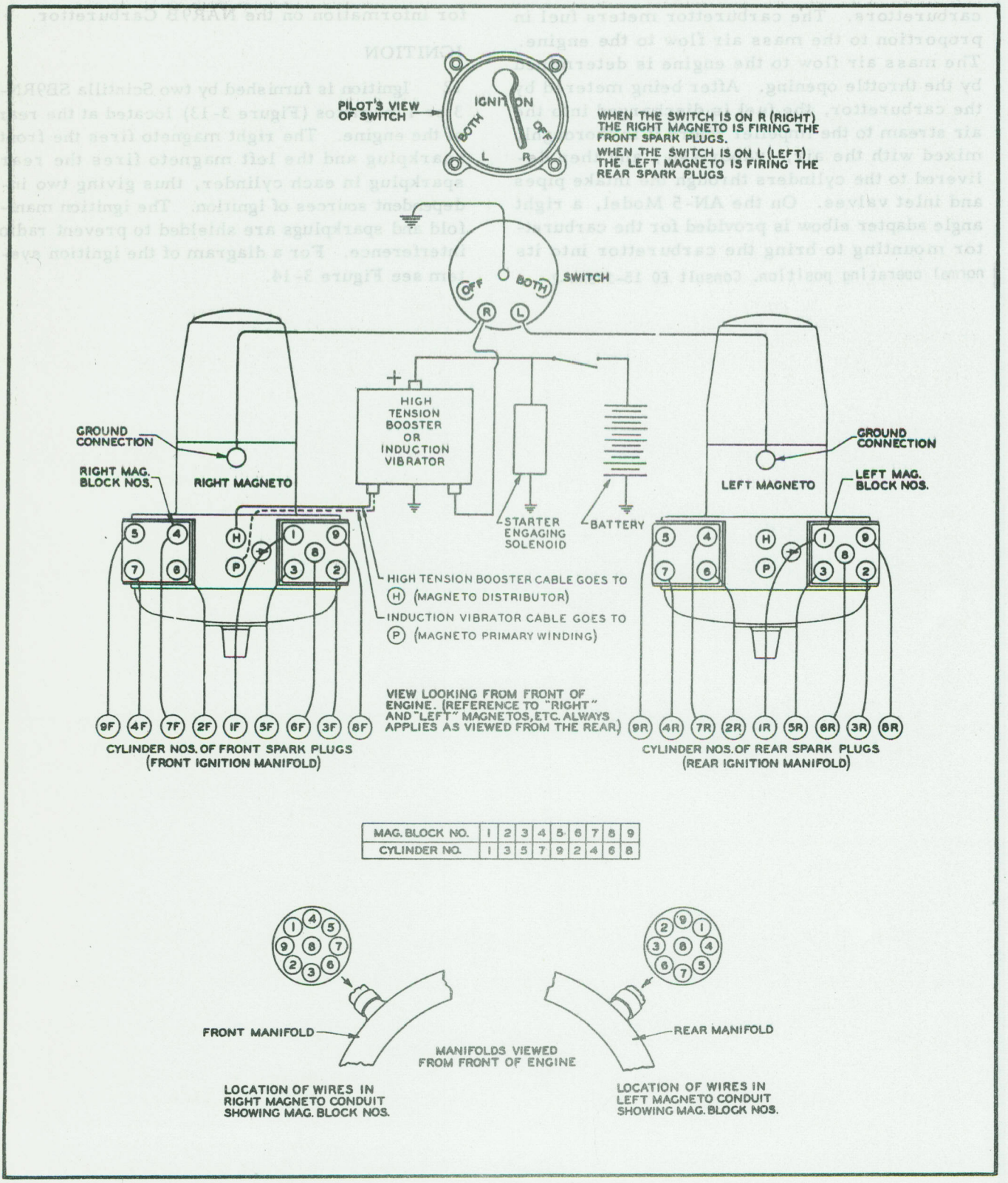
Figure 3-13 Magneto

carburettors. The carburettor meters fuel in proportion to the mass air flow to the engine. The mass air flow to the engine is determined by the throttle opening. After being metered by the carburettor, the fuel is discharged into the air stream to the impeller where it is thoroughly mixed with the air, vaporized, and then delivered to the cylinders through the intake pipes and inlet valves. On the AN-5 Model, a right angle adapter elbow is provided for the carburettor mounting to bring the carburettor into its normal operating position. Consult EO 15-10BAA-2 for information on the NAR9B Carburettor.

IGNITION

12 Ignition is furnished by two Scintilla SB9RN-3 or 4 magnetos (Figure 3-13) located at the rear of the engine. The right magneto fires the front sparkplug and the left magneto fires the rear sparkplug in each cylinder, thus giving two independent sources of ignition. The ignition manifold and sparkplugs are shielded to prevent radio interference. For a diagram of the ignition system see Figure 3-14.

EO 10A-10AA-2



MAG. BLOCK NO.	1	2	3	4	5	6	7	8	9
CYLINDER NO.	1	3	5	7	9	2	4	6	8

Figure 3-14 Ignition Wiring Diagram

PART 4

PREPARATION FOR SERVICE

SECTION 1

UNPACKING

For Instructions on Preservation, Inspection during storage, and Depreservation of R-985 Engines, refer to EO 10A-10AA-9.

SECTION 2

ENGINE BUILD-UP

GENERAL

1 The instructions for engine build-up treat only major components If any part of the following instructions is in conflict with, or superseded by, the particular aircraft Engineering Order, the instructions contained in the latter are applicable.

2 The vertical auxiliary accessory drive pads have drilled .188 in. diameter holes for pressure oil if the pads are of the low type. High pads have no provisions for pressure oil. An oil supply is available through the centre of the propeller shaft by removing a plug in the end of the shaft. The vacuum pump pad is provided with a .1405 in. drilled hole for pressure oil.

3 When a propeller governor is used on the R985 engine, oil under pressure should be piped from the main oil strainer chamber to the governor. The governor return oil should be drained to the rear section by an external pipe.

4 For lubrication requirements of various accessories, refer to the applicable accessory Engineering Order.

5 For torque recommendations refer to Part 7, Section 2.

6 After unpacking and prior to operation, the moisture-proof coverings and dehydrator plugs must be removed and the engine completely drained of all corrosion preventive mixture. Refer to EO 10A-10AA-9.

MIXTURE DRAINAGE

7 Remove the drain plugs from the oil sump.

NOTE

The oil sump on the AN-14B Model contains an upper and lower chamber. The upper chamber collects drain oil from the crankcase section. The lower chamber collects drain oil from the rockerbox drain system. The front plug drains the upper chamber, the rear plug drains the lower chamber.

Remove the starter pad shipping cover. Remove the oil inlet and outlet shipping cover. Remove the sparkplug leads from the dehydrator plugs; then remove the dehydrator plugs from the cylinders. Crank the bed of the engine stand until the crankshaft is in a vertical position (Figure 4-1). Allow the corrosion preventive mixture to drain. Turn the engine through by hand, using PWA-112 Turning Bar, at least six complete revolutions in the normal direction of rotation to facilitate draining. Using a small inspection light inspect the insides of the cylinders through the sparkplug holes to make sure that oil or mixture has not accumulated

in them. If an appreciable quantity is present, remove it with a hand pump.

8 To insure removal of the mixture from the intake pipes, process the engine as follows: Crank the bed of the engine stand until the crankshaft is in a horizontal position. Remove the two bottom-most intake pipes and drain all corrosion preventive mixture from them. If excess mixture is found in the intake pipes, remove and examine the adjacent intake pipes on each side of the engine, continuing toward the top cylinder until no excess mixture is found.

9 When removing intake pipes, remove the packing nut at the crankcase first and then the flange at the cylinder. Use new intake pipe seats that have been coated with a thin even coat of appropriate Dow Corning Compound at installation. Refer to paragraph 55, Section 3, Part 6, for complete intake pipe removal and installation instructions.

CAUTION

Prior to operation of the engine ensure that the lower cylinders and intake pipes are completely free of corrosion preventive mixture.

OIL STRAINER

10 Remove the oil strainer from the rear case (Figure 4-2). Allow any corrosion preventive mixture to drain through the oil strainer chamber. Clean the strainer thoroughly then reinstall it making certain that the cover gasket is in good condition.

WASHING THE ENGINE

11 If necessary, wash the exterior of the engine thoroughly with kerosene or cleaning solvent, being careful to keep the cleaning fluid away from the ignition cable assembly. Dry the engine with compressed air.

STARTER

12 Remove the shipping cover and gasket from the engine mounting pad. Check the jaw of a new starter with the engine meshing jaw for size, number and slant of teeth. If the sizes differ, the starter is the wrong model for the engine. Check the starter to make sure it rotates in the proper direction.

13 Wipe the mounting pad and the starter mounting flange clean, and place a clean, dry gasket on the studs; then mount the starter (Figure 4-3) and secure it with washers and nuts.

NOTE

Remove paint, dirt, grease, etc., under three nuts on the flange to ensure proper grounding.

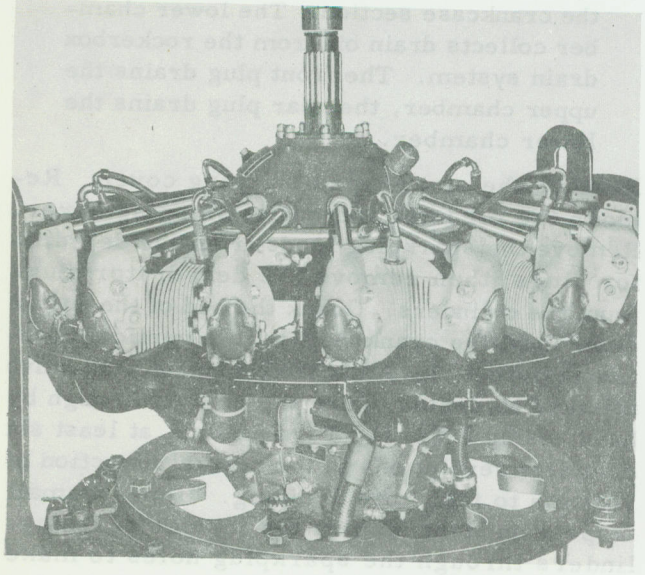


Figure 4-1 Engine In Stand

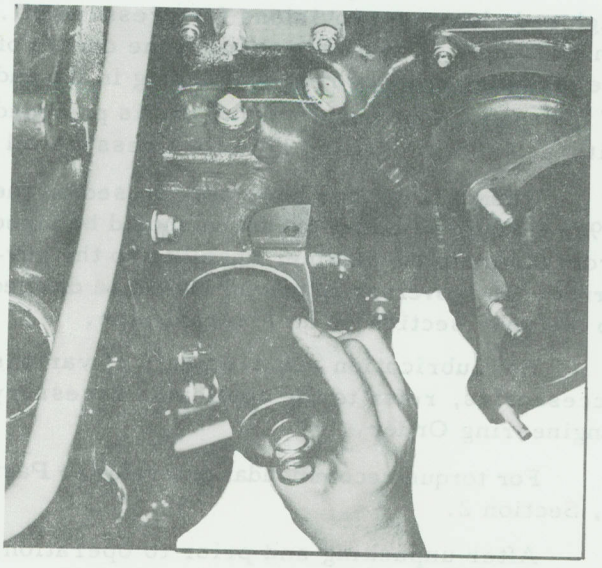


Figure 4-2 Remove Oil Strainer

ENGINE MOUNT (Figure 4-4)

14 Two types of engine mounting may be used. In one case, through-bolts are used to attach the mount lugs to the engine at the nine points of attachment on the ring. The second type of mounting uses vibration isolators. The vibration isolators are not engine parts and therefore are not covered in this Order.

15 Remove the engine from the engine stand by means of a suitable hoist and sling. For build-up, the engine may be supported by the hoist and sling or installed in a transportation stand if one is available. Align the mounting ring bolt holes with the mating holes in the mounting bosses (Figure 4-5). Install the bolts and nuts; then tighten (Figure 4-6) to the recommended torque. Refer to Section 2, Part 7.

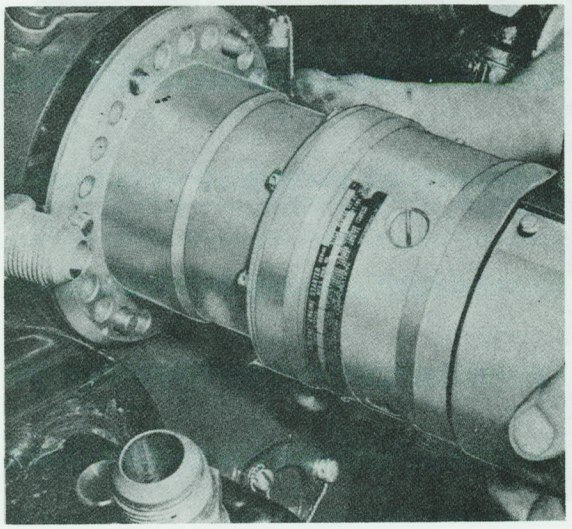


Figure 4-3 Mount Starter

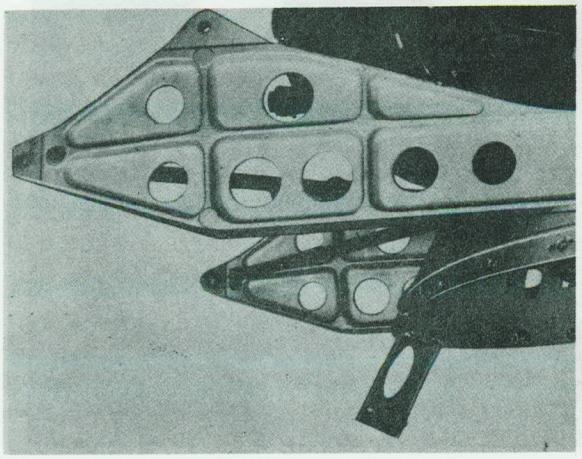


Figure 4-4 Engine Mount

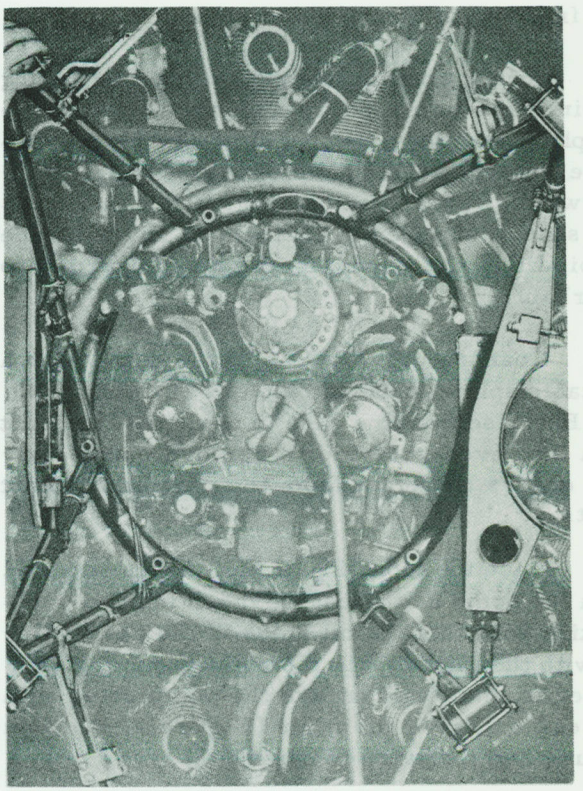


Figure 4-5 Align Bolt Holes

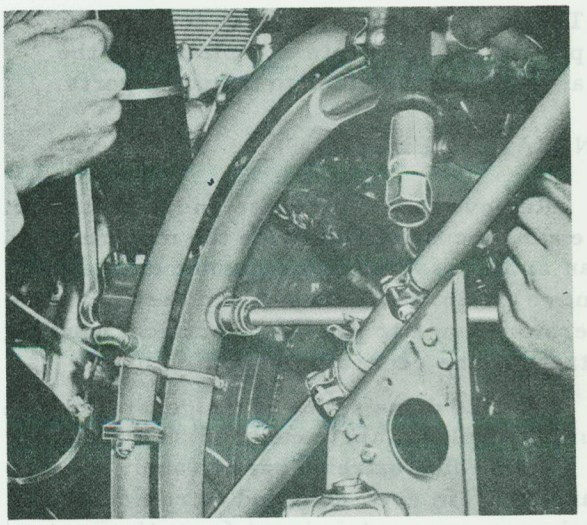


Figure 4-6 Tighten to Torque Value

VACUUM PUMP

16 Remove the cover plate and the gasket from the engine pump pad, and wipe the pad clean. Check the oil holes in the pad to ensure free oil passage. Remove the shipping plugs from the two ports, and test the pump manually for freedom of operation.

17 Pour a small quantity of engine lubricating oil into the pump ports and rotate the drive coupling assembly several times by hand to insure a good distribution of lubricating oil on the walls, vanes, and bearings. The pump rotor should turn freely. If there is any evidence of binding, the pump should be forwarded to overhaul.

18 Coat the drive spline of the pump with a suitable spline lubricant such as Plastilube No. 3. Exercise extreme care to apply the lubricant in a thin even coat and to remove completely any excess lubricant from the part or adjacent parts.

19 Place the mounting gasket that is supplied with the pump on the engine mounting pad studs making sure that the oil holes in the gasket line up with the oil holes in the engine mounting pad. Carefully mate and engage the pump drive with the engine drive member (Figure 4-7), then secure and lockwire (Figure 4-8).

NOTE

The pump may be rotated to the desired position to facilitate completion of the air tubing connections to the pump ports.

GENERATOR (Figure 4-9)

20 Remove the cover plate and gasket from the engine mounting pad; wipe the mounting pad clean and reassemble the gasket on the pad. Remove any paint, grease, and dirt from the generator flange to provide electrical bonding contact for the generator mounting nuts.

21 Coat the drive spline of the generator with a suitable spline lubricant such as Plastilube No. 3. Exercise extreme care to apply the lubricant in a thin even coat and to remove completely any excess lubricant from the part or adjacent parts.

22 Determine the best mounting position for alignment and attachment of the electrical leads. Place the generator on the mounting studs (Figure 4-10) and screw on the mounting stud nuts. Tighten the nuts securely (Figure 4-11).

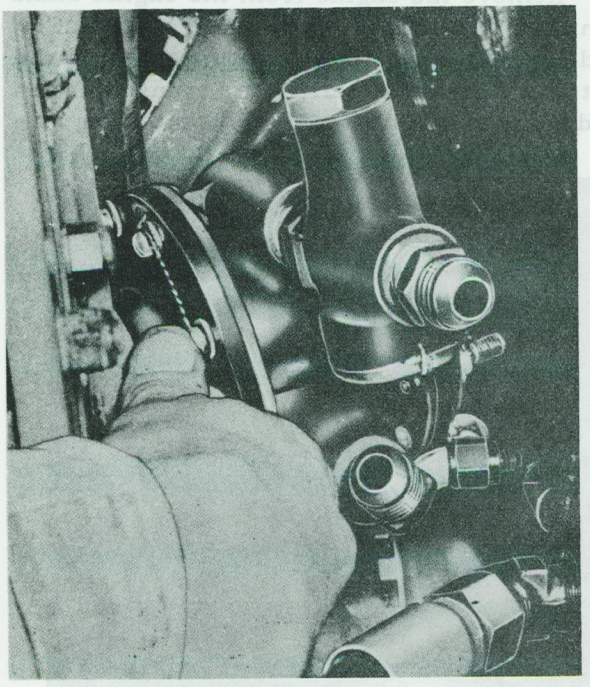


Figure 4-7 Engage Pump Drive

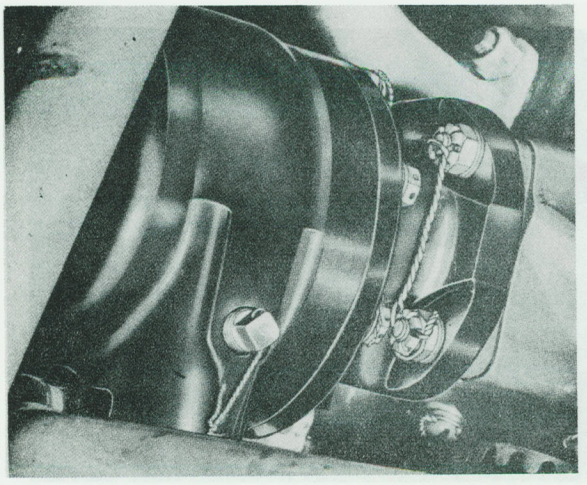


Figure 4-8 Secure on Wirelock

NOTE

Some engines will be found fitted with drilled studs. It is permissible to remove these studs and insert the undrilled type so that self-locking nuts may be used to secure the generator.

23 Loosen the screws holding the blast tube adapter, swing the adapter to the required angle.

EXHAUST STACKS

24 Place the exhaust stack and gasket on the mounting studs; then secure with nuts and palnuts (Figure 4-12).

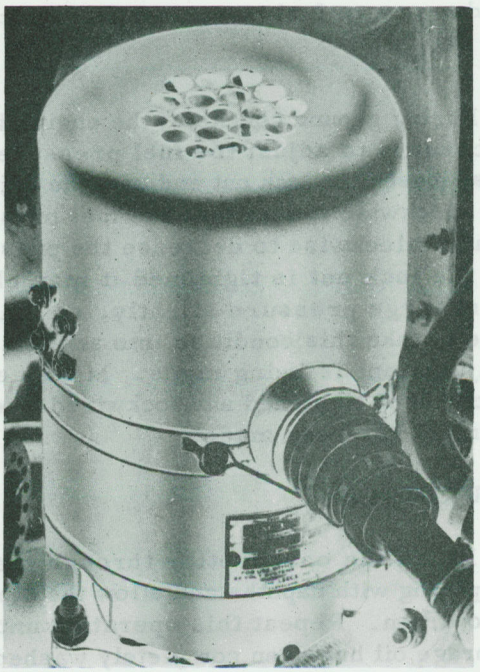


Figure 4-9 Generator

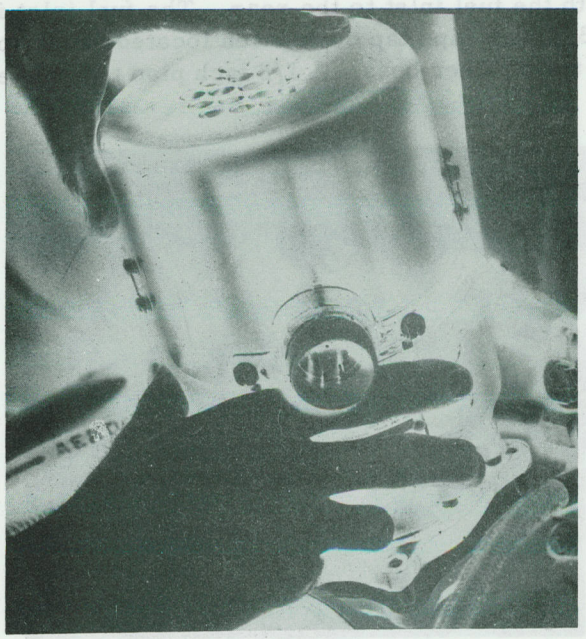


Figure 4-10 Generator and Studs

FUEL PUMP

25 Check the part and type numbers stamped on the pump against the specific requirements. Prepare the pump for installation by removing the shipping block from the flange, the Protek plug from the inlet port and the plain plug from the outlet port. Oil flushed pumps may be

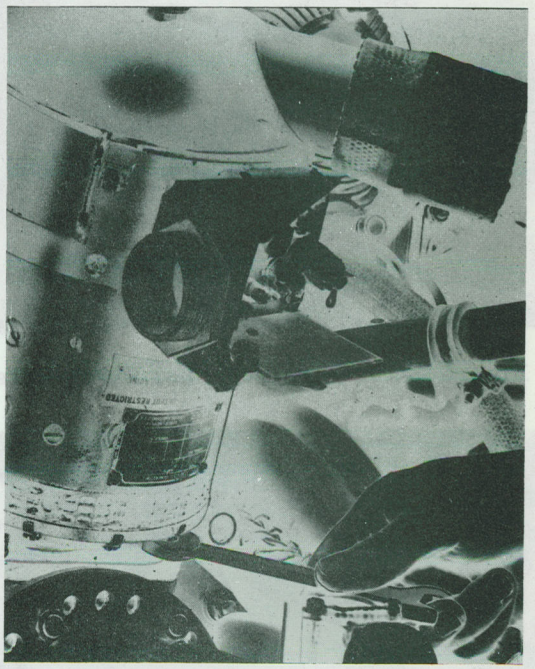


Figure 4-11 Tighten Nuts

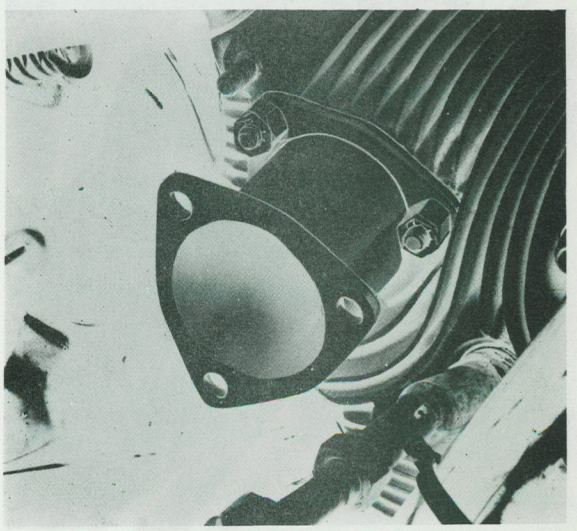


Figure 4-12 Secure Exhaust Stack

cleaned by flushing with naptha. Turn the driveshaft with the fingers to check freedom of pump operation.

26 Make certain the mounting surfaces of the pump and engine are clean. Place a new gasket on the studs and mount the pump. Secure with washers and nuts; then lockwire (Figure 4-13). Connect the proper fuel lines (Figure 4-14), using and approved antiseize thread compound

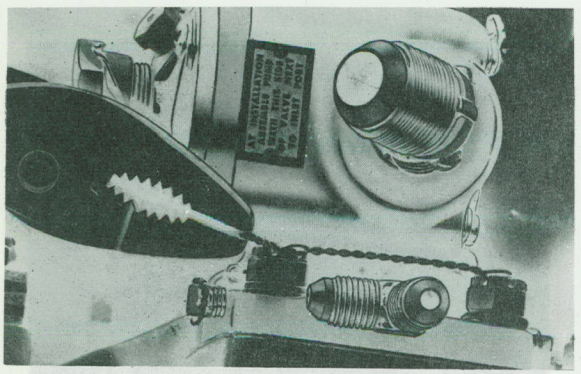


Figure 4-13 Wirelock Fuel Pump Nuts

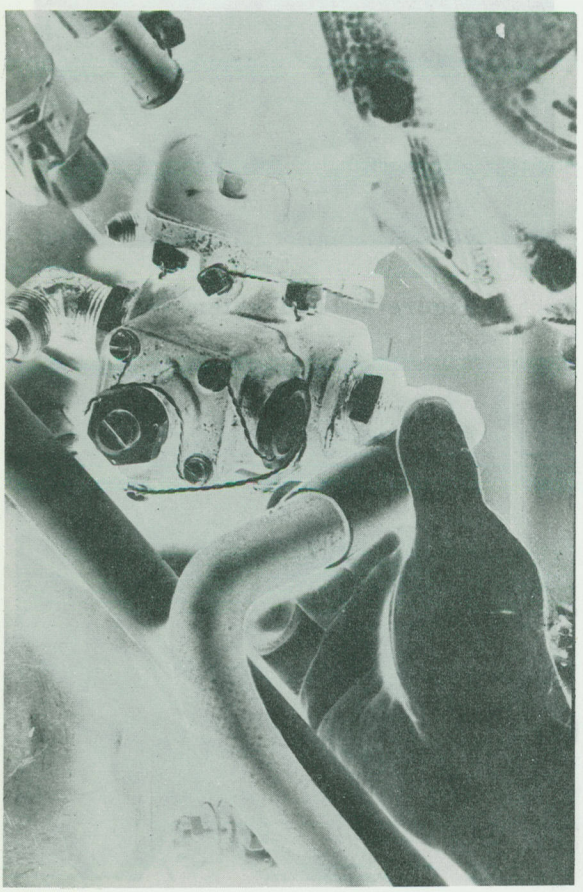


Figure 4-14 Connect Fuel Lines

to the inlet and outlet ports. Remove the vent plug from the valve housing cover and install the balance line which vents this outlet with the carburettor top deck. Connect the drive shaft seal drain line to the drain hole (Figure 4-15).

NOTE

Where engines are fitted with undrilled studs secure fuel pump with fibre locking nuts.

27 During ground checks of the engine it may be necessary to adjust the fuel pressure. To do this, loosen the lock nut and turn the adjusting screw clockwise to increase the fuel pressure, or counterclockwise to decrease the pressure. When the lock nut is tightened it may change the discharge pressure slightly, so it is advisable to take this condition into account when the adjustment is being made. Make certain the lock nut is tightened and lockwired after the adjustment has been made.

CARBURETTOR

28 Flush the carburettor through the fuel inlet opening with naphtha and allow the cleaning fluid to drain. Repeat this operation until all the storage oil has been completely washed out.

29 The NA-R9B carburettor is mounted on the engine with the float chamber at the side and with the fuel inlet to the rear. The fuel inlet is a 3/8 inch pipe tap connection located at the top of the strainer boss. A 1/8 inch pipe tap primer

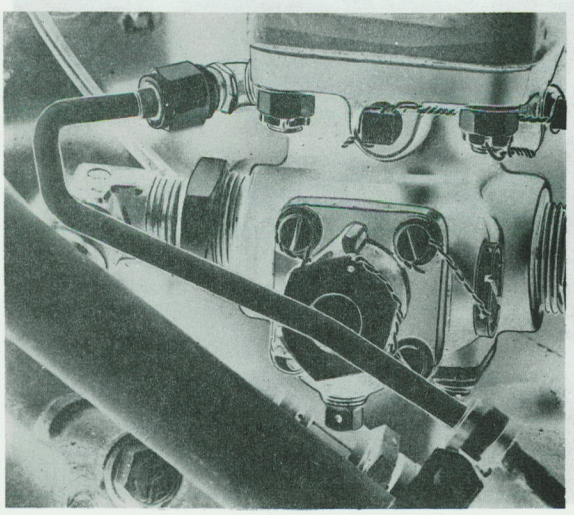


Figure 4-15 Connect Drain Lines

connection is located on top of the mixture control boss. The mixture control and throttle levers may be adjusted radially to any position. The 70 degree throttle lever travel, requires a control rod movement of 2-9/32 inches.

30 Detach the carburettor mounting pad cover from the engine. On the AN-14B Model install the carburettor adapter on the carburettor mounting pad, and tighten the six nuts (Figure 4-16). Install the carburettor and tighten the attaching nuts (Figure 4-17) and (Figure 4-18).

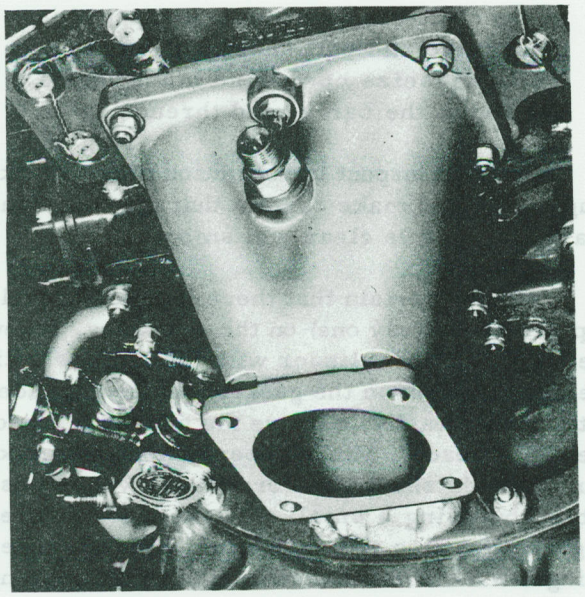


Figure 4-16 Carburettor Adapter

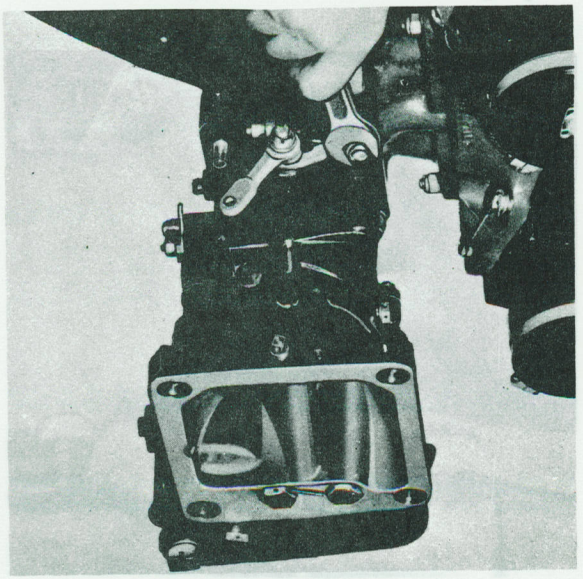


Figure 4-17 Install Carburettor

NOTE

Lead gaskets are to be fitted between the carburettor adapter and engines and between the carburettor adapter and carburettor. (For gasket part numbers and location see EO 05-45B-4).

AIRSCOOP ADAPTER

31 Install the carburettor air intake screen assembly using a gasket on either side of screen mounting flange. Place the airscoop adapter over the screen and secure with washers and screw (Figure 4-19); then lockwire (Figure 4-20).

MAGNETO VIBRATOR AND GROUND LEADS

32 Lightly coat the magneto ground spring connectors with appropriate Dow Corning Com-

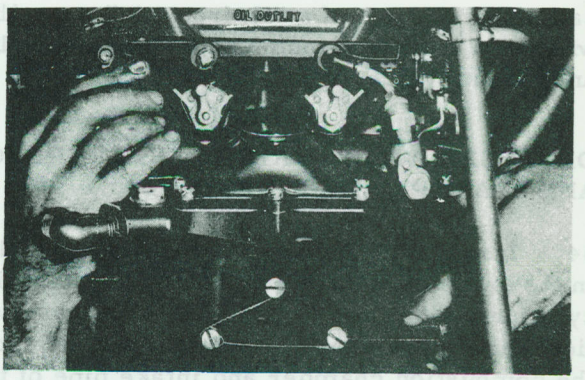


Figure 4-18 Secure Carburettor

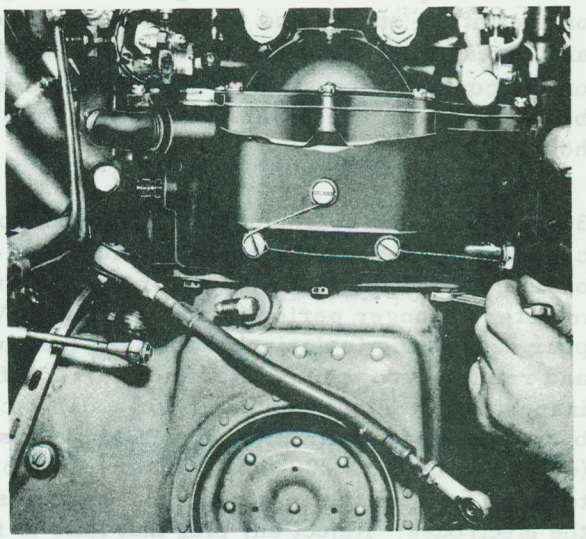


Figure 4-19 Air Scoop Adapter

pound if desired. Insert a connector into the ground terminal of each magneto. Screw the connector cap onto the ground terminal threads and secure with the clip.

PROPELLER GOVERNOR, AN-14B MODEL (Figures 4-21 and 4-22)

33 When a propeller governor is required, either the left or right vertical auxiliary drive may be used to mount a 35 degree angularly mounted constant speed control. Oil under pressure is piped from the main oil strainer chamber to the governor. Return oil from the governor is drained into the engine rear section through the oil tank vent connection. Propeller control oil is piped from the governor to the engine front case through an external tube. Installations calling for the use of a "Hydromatic" propeller will use a feathering pump and a transfer valve and cutout switch.

DEPRESERVATION VALVES, SPARKPLUGS AND SPARKPLUG CONNECTORS

34 Install a PWA-5124 Depreservation Valve in the lower-most sparkplug hole of the following cylinders; 4-5-6 and 7. PWA-5124 Depreservation Valves are useful in removing fluid from the combustion chamber and intake pipe of the cylinder in which they are installed (Figure 4-23). The valve is a check valve so constructed to allow complete suction through the intake pipe on the intake stroke and to allow expulsion of any excess fluid within the combustion chamber on the compression stroke. Sparkplugs are to be installed in the balance of the sparkplug holes.

35 Remove the sparkplugs from their shipping container. Vapour degrease (tri-chloroethylene or equivalent) the sparkplugs for one to three minutes (a longer period is not harmful). Vapour degreasing is desirable to clean the plugs and remove any accumulated moisture. After inspecting the electrode gap (.015-.018 inch), bomb check each sparkplug on a BGM 519 tester (or equivalent) at 200 psi. Observe the plug to make certain that a steady spark occurs at the electrodes. Reject any plug that fails to fire steadily at 200 psi or shows any indication of the plug firing below the electrodes.

36 Apply a light coating of anti-seize compound Spec 3GP-802, Ref 34A/58 sparingly as a thin film on the shell threads. A small brush should be used to apply the compound (Figure 4-24).

NOTE

Never allow anti-seize compound to get on the electrodes since this compound is conductive and will short out the plug. The anti-seize compound must not be applied to the barrel end threads.

37 Visually inspect the condition of the sparkplug insert and make certain that the top of the sparkplug hole is clean and smooth.

38 Making certain that there is a serviceable copper gasket (only one) on the sparkplug, screw the plug into the cylinder with the fingers until the plug bottoms on the gasket. If the plug does not screw in easily, remove the plug and inspect the plug threads. Minor imperfections of sparkplug threads should be corrected, where possible, by using a small three-cornered file. Tighten the plug to the recommended torque, using PWA-3168 Wrench. Avoid side loading or "Cocking" the wrench.

39 Remove the plastic protector from the sparkplug lead connectors. Wipe the hands dry;

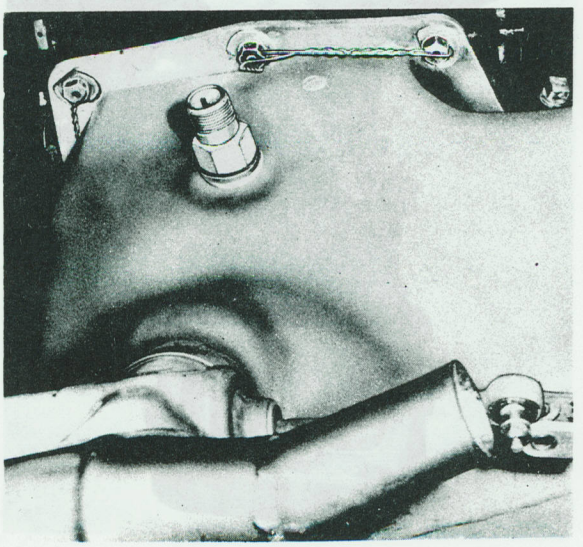


Figure 4-20 Wirelock Adapter

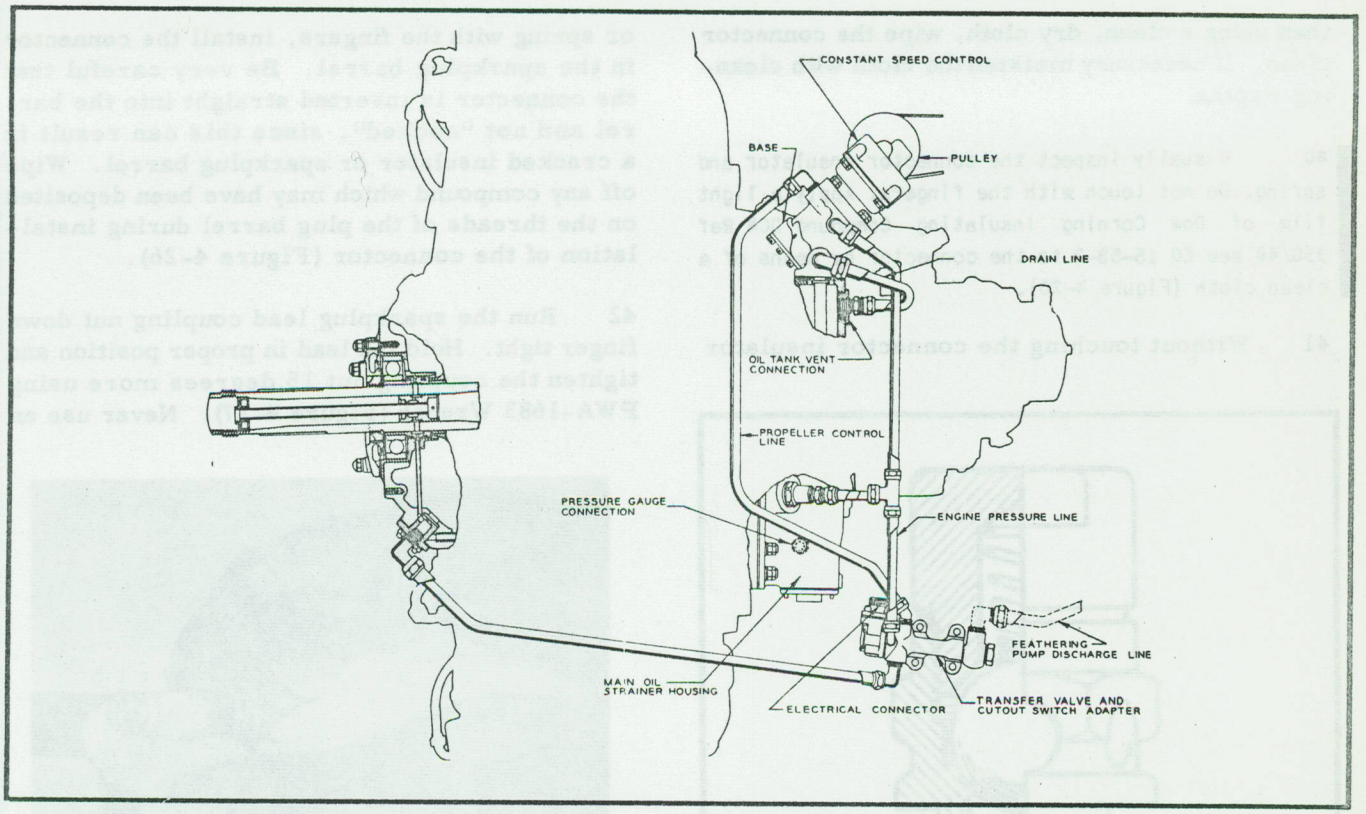


Figure 4-21 Diagram of Governor Installation for Hydromatic Propeller

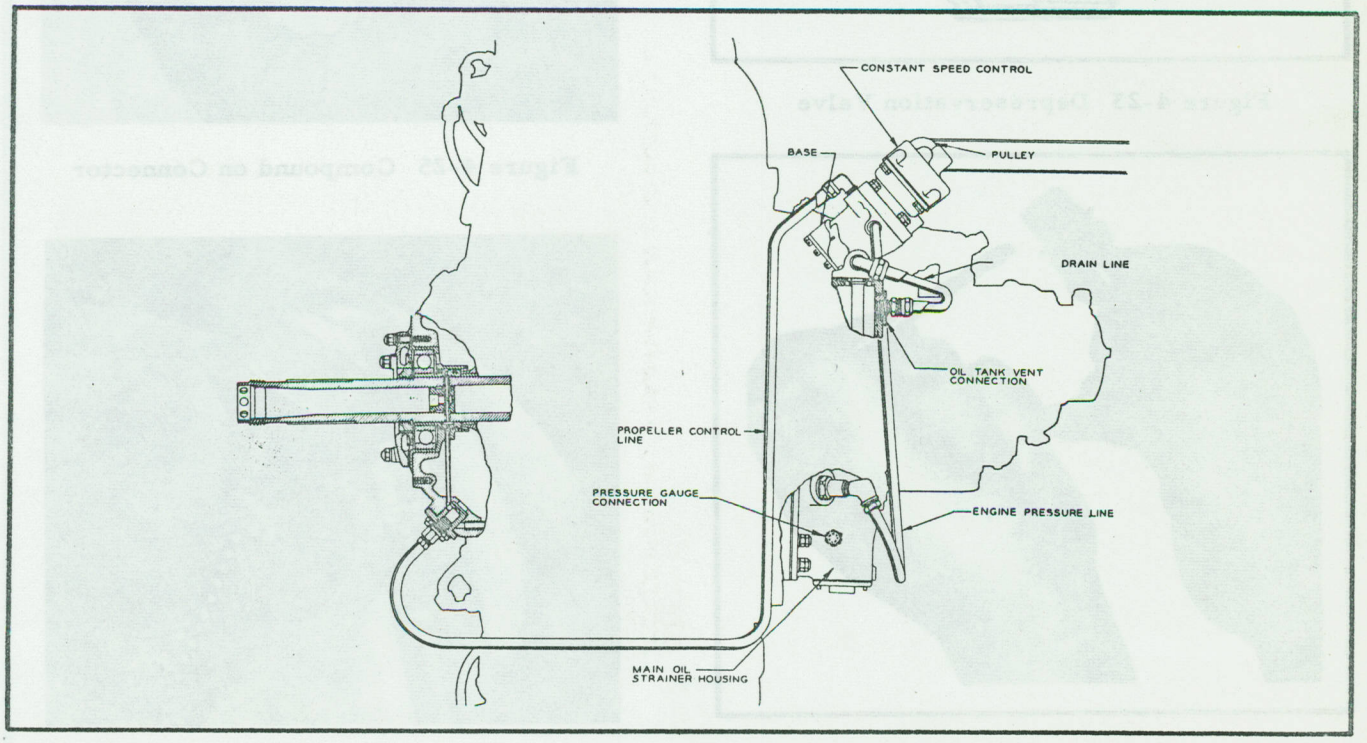


Figure 4-22 Diagram of Governor Installation for Constant Speed Propeller

then using a clean, dry cloth, wipe the connector clean. If necessary moisten the cloth with cleaning naptha.

40 Visually inspect the connector insulator and spring. Do not touch with the fingers. Apply a light film of Dow Corning Insulating Compound DC4 Ref 33G/49 see EO 15-5B-2 to the connector by means of a clean cloth (Figure 4-25).

41 Without touching the connector insulator or spring with the fingers, install the connector in the sparkplug barrel. Be very careful that the connector is inserted straight into the barrel and not "cocked", since this can result in a cracked insulator or sparkplug barrel. Wipe off any compound which may have been deposited on the threads of the plug barrel during installation of the connector (Figure 4-26).

42 Run the sparkplug lead coupling nut down finger tight. Hold the lead in proper position and tighten the coupling nut 15 degrees more using PWA-1683 Wrench (Figure 4-27). Never use an

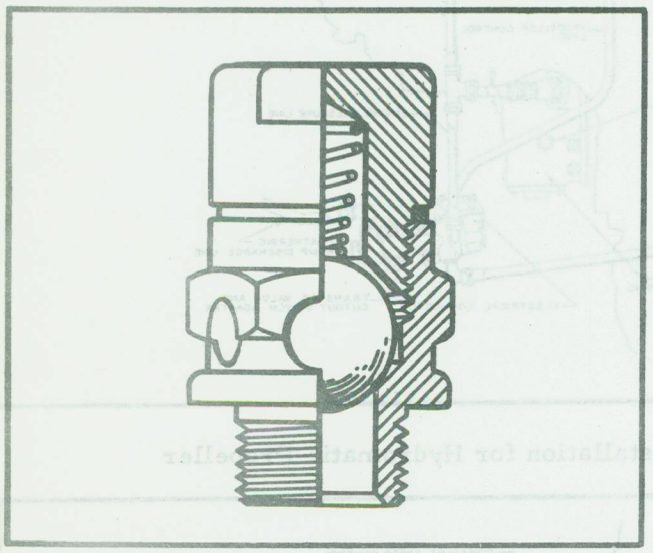


Figure 4-23 Depreservation Valve

Figure 4-24 Compound on Sparkplug

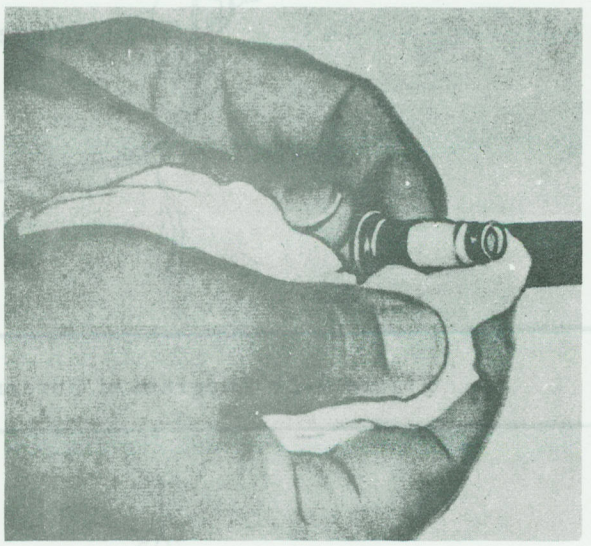


Figure 4-25 Compound on Connector

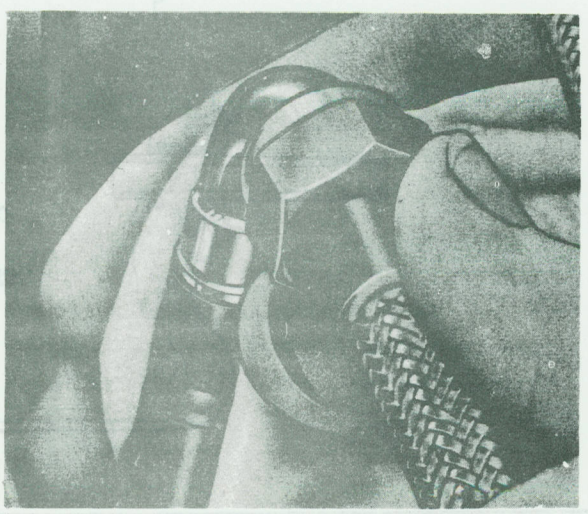


Figure 4-26 Remove Excess Compound

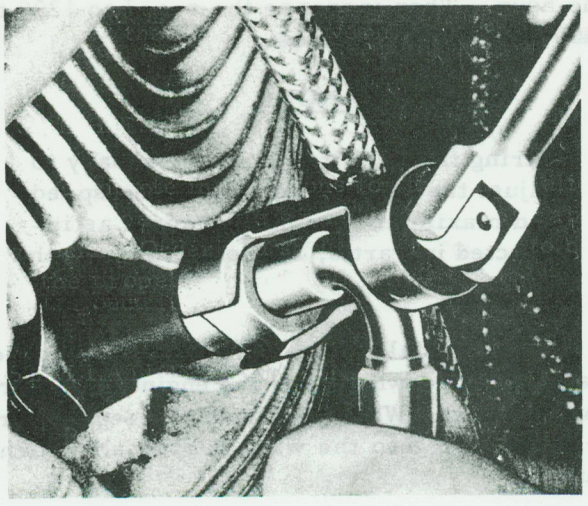


Figure 4-27 Secure Connector

open-end wrench, since damage to the barrel insulator may result from side loading.

43 Check the sparkplug leads to be sure that they do not interfere with the engine and are not twisted.

WARNING

The insulating compound contains minutely ground silica and mica which may act as irritants to the eyes and skin. When the compound is handled frequently, it is suggested that gloves be worn.

PROPELLER

44 Complete instructions for the installation of the propeller are given in the applicable Engineering Order and should be referred to before the propeller is installed.

INSTALLATION OF ENGINE

45 Raise the engine carefully by means of a chain hoist and guide the engine and mount into position in the aircraft Bolt the engine mount to the aircraft. Attach all fuel, oil, and control lines to their connections. For specific instructions, refer to the particular aircraft EO.

CAUTION

Prior to installing an engine on an aircraft, which had the previous engine removed because of internal failure, ascertain by sufficient disassembly of oil lines and oil cooler tubes, that the system is completely free of foreign material.

FUEL AND OIL TANK SERVICING

46 Service the aircraft fuel and oil tanks with the proper grade of fuel and oil as specified in EO 45-1-2. After the oil tank has been serviced, turn the propeller over several times in order to prime the oil lines and the oil pump.

NOTE

When gasoline has been stored in the aircraft's tanks for a period of time it may, by evaporation or contamination with fuel cell plasticizers, be altered in percentages of constituents and hence the tank should be drained and refilled.

PRE-STARTING INSPECTION

47 Before starting an engine for the first time after installation, the following procedure shall be observed:

(a) Check the magneto ground wires for proper connections. Determine that the terminal marked GRD on the ignition switch is connected to the aircraft structure.

(b) Inspect all mounting bolts and nuts on both the engine and mount to determine that they are tight and properly locked.

(c) Inspect the propeller hub for tightness and proper locking.

(d) Inspect the pressure gauges, tachometer, thermometer and thermocouple for proper connection.

(e) Inspect all fuel, oil and primer lines and connections for working order and proper connections in accordance with the fuel and oil system diagram and the marking on the fuel valves.

(f) Inspect throttle and mixture controls for proper connections and operate them to determine that they function smoothly over the entire operating range.

(g) Open fuel valves and operate auxiliary pump and check for fuel leaks. During this latter check, the mixture control must be in the IDLE CUT-OFF position.

INITIAL GROUND RUN

48 If protector caps have not already been installed, cap (or ground) the leads to the depreservation valve cylinders with sparkplug terminal protectors before rotating the engine. Rotate the propeller by hand at least six revolutions. Start the engine in accordance with the starting instructions and operate the engine at 800 rpm to 1000 rpm for approximately 30 seconds. Exchange the depreservation valves for sparkplugs and connect the leads.

INITIAL GROUND RUN-IN

49 Start the engine as directed.

WARNING

If the engine oil pressure does not begin to rise immediately after engine starting, stop the engine and determine the cause.

After starting, run the engine slowly (600-800 rpm) for one minute and then at 1000 rpm in order to accomplish a gradual warm-up. After the engine has been warmed up and is functioning normally, run it approximately 1000 rpm for one hour. Then increase the speed to 1200 to 1400 rpm for 15 minutes.

NOTE

During this run it may be necessary to adjust the carburettor for idling speed and maximum mixture strength as instructed in Part 6, Section 1, paragraph 15.

50 The initial run-in should preferably be made with no cowling over the engine accessory compartment. When practicable, keep the aircraft headed into the wind during all ground running.

51 After the preceding operation, stop the engine and inspect the entire installation. Remove the pressure and scavenge oil strainer; inspect and clean.

52 Ground tests should be conducted in accordance with the instructions in Sections 3, 4 and 5 of this Part.

53 Take-off power and speed used f[DELETED] and newly overhauled engines should [DELETED] to the minimum practicable co[DELETED] safety during the first ten ho[DELETED]on. Likewise, high power clim[DELETED]P lean mixture cruising (high [DELETED]ssure) and overspeeding should [DELETED]ring this period, except in ca[DELETED]ncy. Higher than normal cyli[DELETED]tures may be evident for the f[DELETED]hours of operation until ring[DELETED] seated, and particular care s[DELETED] to ensure that specified tem[DELETED] manifold pressure limits are not [DELETED].

SECTION 3

PRE-STARTING INSTRUCTIONS

GENERAL

1 Before an engine is started, the operator should consult the particular aircraft EO for the applicable control position checks and specific ground operating procedures.

HYDRAULICKING

2 During periods of idleness, residual oil from the power section will flow toward the lower cylinders, seep past the piston and piston-rings, then accumulate in the lower combustion chambers. Likewise, if the engine is overprimed, excess fuel will flow into the combustion chambers of the lower cylinders, through the inlet valves and intake pipes. With liquid in the combustion chamber, the original compression ratio will be raised causing extremely high pressures to be produced when the piston of a cylinder so affected is moved toward top centre of the compression stroke. These pressures may be great enough to damage the cylinder head, piston, or linkrod. In extreme instances the piston may actually "bottom" against the liquid. This condition is known as "hydraulicking" the engine.

3 Therefore, it is especially important to turn the propeller through four or five revolutions by use of the starter motor before starting an engine. While motoring the engine the operator must be alert for any sign of the piston being forced against unusually high compression. This will be evidenced by the engine kicking back or by the starter clutch slipping and preventing further turning of the engine.

4 If liquid lock is suspected, remove the lower sparkplugs. Check for the presence of fuel or oil which could have caused the lock. If no liquid is found in any of the cylinders or exhaust pipes, leave the front sparkplugs out, and, with the ignition OFF, crank the engine through, checking to see whether or not liquid is spewed from the sparkplug holes. If there is still no evidence of any condition which would cause hydraulic lock, install the sparkplugs and resume normal procedure.

5 If liquid is found in any of the cylinders, remove these cylinders and inspect the linkrods for distortion. This may be checked by placing a straight-edge along the sides of the linkrod in two planes, giving particular attention to the area in the vicinity of the linkpin hole. Any distortion of the linkrod, however slight, is cause for removal of the engine. If the linkrods are to be found free from damage, inspect the pistons, piston pins, cylinders, and cylinder hold down studs thoroughly for evidence of injury. Stud damage is to be suspected if, when a cylinder is being removed, and hold down nuts are found to be loose. If no abnormal condition is noted, the engine may be reassembled and considered satisfactory for further service.

NOTE

Locating the cylinder containing liquid may be desirable in certain instances. This may be quickly and accurately done by performing the following check: Do not move the propeller from the point at which the lock was encountered. Remove the breaker cover from one magneto and locate No. 1 lobe on the cam. (The No. 1 lobe is identified by a machined dot adjacent to the lobe on the edge of the cam). Starting with No. 1 lobe, count in the direction opposite that in which the cam rotates to and including the lobe that contact follower is resting. (The direction of the cam is indicated by an arrow on the cam). Apply this count to the firing order of the engine; for example, suppose the follower rests on the

fifth lobe of the cam. The firing order of a 9 cylinder is 1-3-5-7-9-2-4 etc. The lobe firing order is 1-2-3-4-5-6-7 etc. Therefore, cylinder No. 9, the fifth cylinder in the engine firing order, contains liquid.

PERSONNEL

6 b cipated.

IGNITION SWITCH

7 The switch must be in the "OF ition at all times, except for actual sta

PROPELLER CONTROL

8 The propeller control for ton Standard counterweight propeller be found in the LOW RPM (high pitch) pos om the previous shut-down. This is ect the blade operating cylinder from dr also to empty the oil within the cylinder otherwise might congeal in cold weather er the engine is running and obtaining oil ure, the propeller control should be shi HIGH RPM (low pitch). Start the engir the control in HIGH RPM if a hydromati eller is installed.

CARBURETTOR F

9 Carburett it should be in the cold position (OFF).

CARBURETT R FILTER

10 Carb air filter (where applicable) should be unfiltered (OFF) position to prevent d to these installations in case of backfire

COWL S

11 essential that the cowl flaps be fully ope g all ground operation.

CAUTION

out utilizing all cooling airflow mean

OIL COOLER

12 Close oil cooler shutters to assis at- ing the oil during the warm-up peri

MIXTURE CONTROL

13 The mixture control shoul the full lean or IDLE CUT-OFF position uch time as required by the following sta rocedure.

FUEL SUPPLY

14 The fuel supply valve not be opened until preparation for start made.

THROTTLE

15 Consistent starti ependent to a great extent on the correct ning of the throttle. With the float type c ctor such as used on the R985 engine, th rettor furnishes fuel to the engine only definite pressure differential exists b the idle discharge and the fuel in the fl mber. With too great a throttle openin differential becomes insufficient to pr e necessary flow for complete combust sulting, in all probability, in backfiring. ottle opening such as recommended in S 4, should provide the proper fuel-air rat btain good starting under various condi

PRIMIN

16 e initial firing charge needed to start gine, fuel must be supplied by the prim stem. The carburettor will not supply ithout airflow. The priming system int s atomized fuel into the air contained in , 2, 3, 8, and 9 cylinders. Under ideal g conditions a fuel-air mixture of .125 provided. As the starter turns the en- hrough, more air is introduced into the ed cylinders causing the mixture to be ed out, but before the F/A ratio reaches

17 The actual amount of priming desirable must be learned by experience, however, the operator may estimate the required amount by observing the following gauges

(a) Free Air Temperature (temperature of the air drawn into the engine during starting).

(b) Carburettor Air Temperature (temperature of the air in the duct).

(c) Oil Temperature (stiffness and temperature of the engine).

(d) Cylinder Heat Temperature (the amount of heat available in the intake ports to vaporize the prime).

18 Excessive priming will load the cylinders of a cold engine with raw fuel, making the engine difficult to start. Excessive priming also has a tendency to wash the oil off the cylinder walls and may result in barrel scoring or piston seizure. If the engine has been overprimed it is essential that fresh oil be sprayed on the cylinder walls, through sparkplug holes, before starting. Care should be taken to ensure complete circumferential coverage of the cylinder walls of No. 1, 2, 3, 8 and 9 cylinders. Dry cylinders may be indicated by a squeaking heard while the engine is being pulled through by hand. Rusting of the piston rings and cylinder walls will occur if the engine is allowed to stand for a day or more after unsuccessful attempts to start.

19 Underpriming is usually indicated by backfiring of the engine through the intake system with attendant hazards. When underpriming is suspected, additional priming should be done cautiously.

USE OF OIL DILUTION SYSTEM

20 Oil dilution is regulated by an electrically operated valve which admits fuel at a rate predetermined to meet the requirements of the aircraft involved, when desired, to the oil inlet line of the engine, usually at the drain cock, thereby reducing the viscosity of the oil in the engine and oil system. Because of substantial differences in the specific gravity and viscosity of gasoline as compared to aviation oil, there is very little tendency for them to mix when introduced into a common line or tank. However, if the two fluids, in any proportion, are forcibly brought together by some type of mechanical agitation, such as that provided by the oil pressure pump, moving internal parts, and the oil scavenge pump, a very permanent mixture is produced. Once the oil and gasoline are thoroughly mixed, diluted oil will not separate if allowed to stand. Oil dilution installations are usually accompanied by a hopper type oil tank which increases the effectiveness of the dilution by decreasing the amount of oil in circulation.

(a) Stopping - When a cold weather start is anticipated, permit the engine to cool by idling until cylinder temperatures fall below 148°C (300°F) and oil temperatures below 50°C (120°F). If the oil tank needs filling, this should be done prior to starting dilution. With the engine running at approximately 800 to 1000 rpm, hold the oil dilution control in the ON position for a period varying between 1 and 8 minutes. The proper length of time is dependent upon the expected temperature and the grade and amount of oil in the system and will probably be different for each installation, because of different breather arrangements, oil line sizes and oil tank designs. Therefore, it will be necessary for the operator to consult the Engineering Order for the aircraft concerned. Only in very extreme weather, that is, where temperatures go below 0°F, will there be any necessity for diluting for more than 4 minutes. Under such extreme conditions, dilution of oil in hydromatic propellers is also necessary. This can be accomplished after 3 or 4 minute's dilution by increasing rpm to 1500 or 1600 rpm and moving the propeller control to the high pitch position at least three times. Stop the engine immediately at the end of the dilution period.

(b) Starting - A normal cold engine start should be made. Dilution of oil with fuel at the time of the previous stop will permit the starter to turn the engine at a high rate of speed, and no preheating of the oil will be necessary. In extremely cold weather adequate dilution will prevent oil cooler or oil line failures due to high pressure developed by the oil scavenge pump when the engine is started. However, for conservative operation, it is desirable to heat the oil lines, the oil cooler, and accessories at

the same time the engine cylinders are being heated.

(c) Warm-up - During the warm-up period, the gasoline will be gradually evaporated as the temperature of the oil, engine crankcases, and internal parts increases. With high dilution and extremely cold weather, it will be necessary to make the warm-up at a slightly higher rpm and for a longer period of time than are normally used. If oil in the tank or lines is insufficiently diluted, flow to the engine pump will be restricted by the high viscosity of the cold oil. In such cases, it may be noted that oil pressure is unsteady or decreases with an increase in rpm. The oil dilution process should be used during warm-up only if extreme temperature conditions do not permit warm-up in the normal manner. Over-dilution, however, can occur, so that oil pressure must be carefully watched for unusual fluctuation or drop-off during the remainder of warm-up, ground test, and the take-off.

CAUTION

If for some reason a flight of at least a half hour's duration is not made after warm-up some gasoline will remain in the circulating oil or in the oil tank. This is especially true in extremely cold weather. The dilution period should thus be shortened when the engine is shut down

(d) Flight - The dilution valve should not be used in flight. A sudden loss or fluctuation of oil pressure or discharge of oil from the breather during flight can be caused by a leaking dilution valve. Momentarily turning the valve on and off may assist in correcting the difficulty. Satisfactory operation will be restored after the gasoline has evaporated from the oil. The dilution valve mechanism should be checked after landing. In extremely cold weather and when using long dilution periods before stopping the engine, the gasoline content of the circulating oil may become extremely high, particularly when the caution under "Warm-up" is not observed. Discharge from the breather may occur in this case. Consequently, in extremely cold weather operation, it is advisable to observe carefully the engine breather outlets during and after take-off. If a discharge from the breather occurs, it can usually be stopped if engine speed is reduced to 2000 rpm or lower.

CAUTION

The introduction of gasoline into the oil system tends to loosen carbon and sludge deposits within the engine, so the pressure oil strainer should be removed for inspection and cleaning 1 to 2 hours after the dilution system is first used in the season. This inspection and cleaning must be repeated at short intervals until sludge and carbon no longer collect.

SECTION 4

STARTING INSTRUCTIONS

GENERAL

1 Ground operation of an engine should not be attempted until the aircraft has first been removed from the hangar. Preparing the engine for flight will include starting, warm-up, ground checks and, in the case of newly installed engines, complete inspection of the installation after the first run-up.

NOTE

For the AN-5 Model, various characteristics peculiar to helicopter installations may change some of the conditions of operation as contained in these instructions.

CONTROL POSITION CHECK

2 Check the position of the controls as follows:

(a) Ignition — OFF

(b) Mixture — FULL RICH or AUTOMATIC RICH

(c) Propeller counterweight
Type-LOW RPM (high pitch)
Other controllable types
HIGH RPM (low pitch)

(d) Carburettor — Cold (OFF)

(e) Filtered Air — Unfiltered (OFF)

(f) Cowl Flaps — Full OPEN

(g) Throttle Horizontal installations
1/10 to 1/4 Open - Set for 600 rpm

(h) Throttle Vertical Installations — CLOSED

(j) Oil Cooler Shutters — CLOSED

3 Note the manifold pressure gauge reading before starting the engine as a reference for the power and magneto checks.

4. Turn the propeller through 4 or 5 revolutions by use of the Starter. Refer to paras. 2, 3, 4 and 5, Section 3 of this Part.

5 Fuel SUPPLY - ON.

WARNING

Do not operate the throttle before the engine starts to fire. The fuel thus discharged from the accelerating pump may settle in the air intake, with the possibility of catching fire should the engine backfire as it starts.

6 Auxiliary fuel pump - build up fuel pressure, not to exceed 3 psi.

7 Energize starter (if inertia type).

8 Prime - Move mixture control to FULL LEAN or IDLE CUT-OFF. Then move throttle back and forth through its full travel, 0-2 strokes for a warm engine, 3-4 strokes for a cold engine. Return mixture control to FULL RICH or AUTOMATIC RICH. Raise fuel pressure to 3 psi momentarily.

9 Ignition - If using inertia starter, ignition on BOTH: if using direct cranking starter, ignition OFF, then switch to BOTH after one revolution of the crankshaft.

10 Engage starter (if manually controlled, close booster switch simultaneously).

11 After engine fires, adjust engine speed to 500-600 rpm watching for oil pressure rise.

WARNING

If oil pressure does not register on gauge almost immediately, STOP engine and investigate.

12 Move propeller control to HIGH RPM (low pitch) for 2-position and constant speed propellers (counterweight type).

13 Adjust the carburettor heat control to maintain 32°C, (90°F) carburettor air temperature.

14 Adjust throttle to 1000 rpm for horizontal installations or 200 to 300 rpm above the rotor engagement rpm (approximately 1500 rpm) for vertical installations.

15 If a start is not effected almost immediately, reprime and repeat starting procedure.

CAUTION

If the engine does not start after two or three attempts, an investigation should be made to ascertain the cause.

SECTION 5

WARM-UP

CONTROL POSITION CHECK

1 Check the position of the controls as follows:-

(a) Mixture.....FULL RICH

(b) Carburettor heat....To maintain 32°C (90°F) carburettor air temperature

(c) Filtered air.....As needed

(d) Cowl flaps.....Full OPEN

(e) Oil cooler shutters CLOSED.

(f) Propeller.....HIGH RPM (low pitch)

(g) Throttle (Horizontal installations)..... 1000 rpm

(h) Throttle (Vertical installations) 200 to 300 rpm above rotor engagement rpm. (approximately 1500 rpm.)

IGNITION SAFETY CHECK

2 Check ignition as follows during warm-up:

(a) R985 - AN5 - Switch ignition from BOTH to RIGHT and back to BOTH. Switch ignition from BOTH to LEFT and back to BOTH. A slight drop in rpm when operating on each separate magneto, and complete cutting out at OFF position indicates proper connection of the ignition leads so that higher powers may be safely imposed.

(b) R985 - AN14B - Switch OFF each magneto in turn. Switch OFF together momentarily. A slight drop in rpm when operating on each separate magneto, and complete cutting out when both magneto switches are in the OFF position indicates proper connection of the ignition leads so that higher powers may be safely imposed.

NOTE

The following tests must be made with a minimum oil-inlet temperature of at least 40°C (100°F) and with carburettor heat control in cold position.

PROPELLER GOVERNOR CHECK

3 Check propeller governor according to the applicable Engineering Order.

POWER CHECK (AN-14B)

4 Open the throttle until the manifold pressure is equal to the field barometric pressure (indicated by the manifold pressure gauge reading before the engine is started).

5 The rpm obtained should be approximately 2000 rpm, depending on the low pitch setting of the propeller. When the rpm is once established for the installation variation in altitude of various fields will not change the rpm that will result when opening the throttle to the manifold pressure equal to the field barometric pressure.

6 If the approximate check rpm can not be secured when opening the throttle to the proper manifold pressure, the engine is not delivering the correct power, and an investigation should be made to determine the cause of this improper engine functioning or proper pitch setting.

MAGNETO CHECKS (AN-14B Model)

7 Make magneto checks at manifold pressure equal to field barometric pressure. Switch right magneto OFF then ON. Switch left magneto OFF then ON.

8 Normal drop-off with either right or left magneto switched off is 50 to 75 rpm. Maximum drop-off with either right or left magneto switched off should not exceed 100 rpm.

Maximum difference in drop-off between right magneto and left magneto should not exceed 40 rpm.

NOTE

When the magnetos are checked at the power recommended above, the drop-off on the right magneto may be as high as 150 rpm. If this is the case, recheck the magnetos at 2200 rpm. At this higher power, if the drop-off on the right magneto, as well as on the left magneto, is less than 100 rpm and the difference in

drop between right and left is not more than 40 rpm, the check may be accepted as satisfactory. Advancing the spark (changing the magneto timing) to correct a high drop-off is definitely NOT recommended.

MAGNETO CHECK (AN-5 Model)

9 With rotor engaged, set the main-rotor pitch and throttle control to obtain approximately 2000 rpm and 20 in. manifold pressure.

10 Switch from operation on BOTH to LEFT and note drop in rpm. The normal drop-off is 75 to 100 rpm and should not exceed 120 rpm. Switch back to BOTH to clear the sparkplugs which have been inoperative; then operate on RIGHT. The difference between operation on L and R should not exceed 40 rpm. If the drop-off is in excess of these limits, the ignition system must be thoroughly checked and the cause for the excess drop-off determined.

INSTRUMENT READINGS

11 Check oil pressure, oil temperature, fuel pressure and other items at manifold pressure equal to field barometric pressure, propeller in low pitch (HIGH RPM).

CYLINDER HEAD TEMPERATURE

12 Do not exceed 232°C, (450°F) cylinder head temperature during ground operation

OIL PRESSURE ADJUSTMENT

13 Desired adjustment at manifold pressure equal to field barometric pressure and with 60°C (140°F) oil inlet temperature....75 to 85 psi.

FUEL PRESSURE ADJUSTMENT

14 Desired fuel pump adjustment at manifold pressure equal to field barometric pressure .....5 ± 1 psi.

OIL PRESSURE LIMITS

15 Oil pressure limits are as follows:

		Psi
(a)	Minimum at 2300 rpm	70
(b)	Maximum at 2300 rpm	90
(c)	Minimum at 2000 rpm	60
(d)	Desired at 2000 rpm	70
(e)	Minimum at 1400 to 1800 rpm	50
(f)	Minimum at Idle	10

OIL TEMPERATURE LIMITS

16 Oil temperature limits are as follows:

		°C	°F
(a)	Minimum for Ground Test	40	100
(b)	Maximum for Ground Test	85	185
(c)	Minimum for take-off and flight	40	100
(d)	Maximum, level flight	85	185
(e)	Maximum, climb	85	185

FUEL PRESSURE LIMITS

17 Fuel pressure limits are as follows:

		Psi
(a)	Maximum	6
(b)	Desired	5
(c)	Minimum	4
(d)	Idling	2

CARBURETTOR IDLING MIXTURE STRENGTH CHECK (450 to 500 rpm)

18 While observing the tachometer, slowly move the mixture control toward idle cut-off at full lean while noting rpm change. Return the mixture control to full rich before the engine dies. If a momentary rise of not more than 20

ADVANCE REVISION

Serial #1 dated 8 Mar 60
(Sheet 1 of 3)

The sheets of this Advance Revision are to be inserted in the EO as follows:-

Sheet 1 facing page 45
Sheet 2 facing page 74
Sheet 3 facing page 75

Part 4, Section 5, page 45, para. 18 (Note), line 3:-

Delete: 850 RPM

Insert the following:- 1000 RPM

ISSUED ON AUTHORITY OF THE CHIEF OF THE AIR STAFF

rpm is observed before normal drop-off, the mixture strength is correct. If a greater rise in rpm is noted, the mixture is too rich. If no rise in rpm is noted, the mixture is too lean.

NOTE

For the AN-5 Model, the throttle stop will be set to allow the engine to idle at approximately 850 rpm. At this rpm, a pickup of not more than 100 rpm when the mixture control is placed in full lean indicates the proper mixture strength.

19 This check should be made in relatively still air and with cylinder head temperatures at stabilized idling temperature. A strong wind or abnormal cylinder head temperatures affect the rpm change. Refer to Section 1, Part 6, for specific adjustment instructions.

ENGINE EQUIPMENT OR ACCESSORIES CHECK

20 Consult the applicable Engineering Orders for instructions.

STOPPING

21 If a cold weather start is anticipated, refer to paragraph 20, Section 3, for a general description on the use of oil dilution, and to the particular aircraft EO's for the specific dilution procedure to be used.

(a) Idle until cylinder head temperature is less than 205°C (400°F). Idle AN-5 engines 200 to 300 rpm above rotor engagement rpm.

(b) If Hamilton Standard counterweight propeller is used, shift propeller control to LOW RPM.

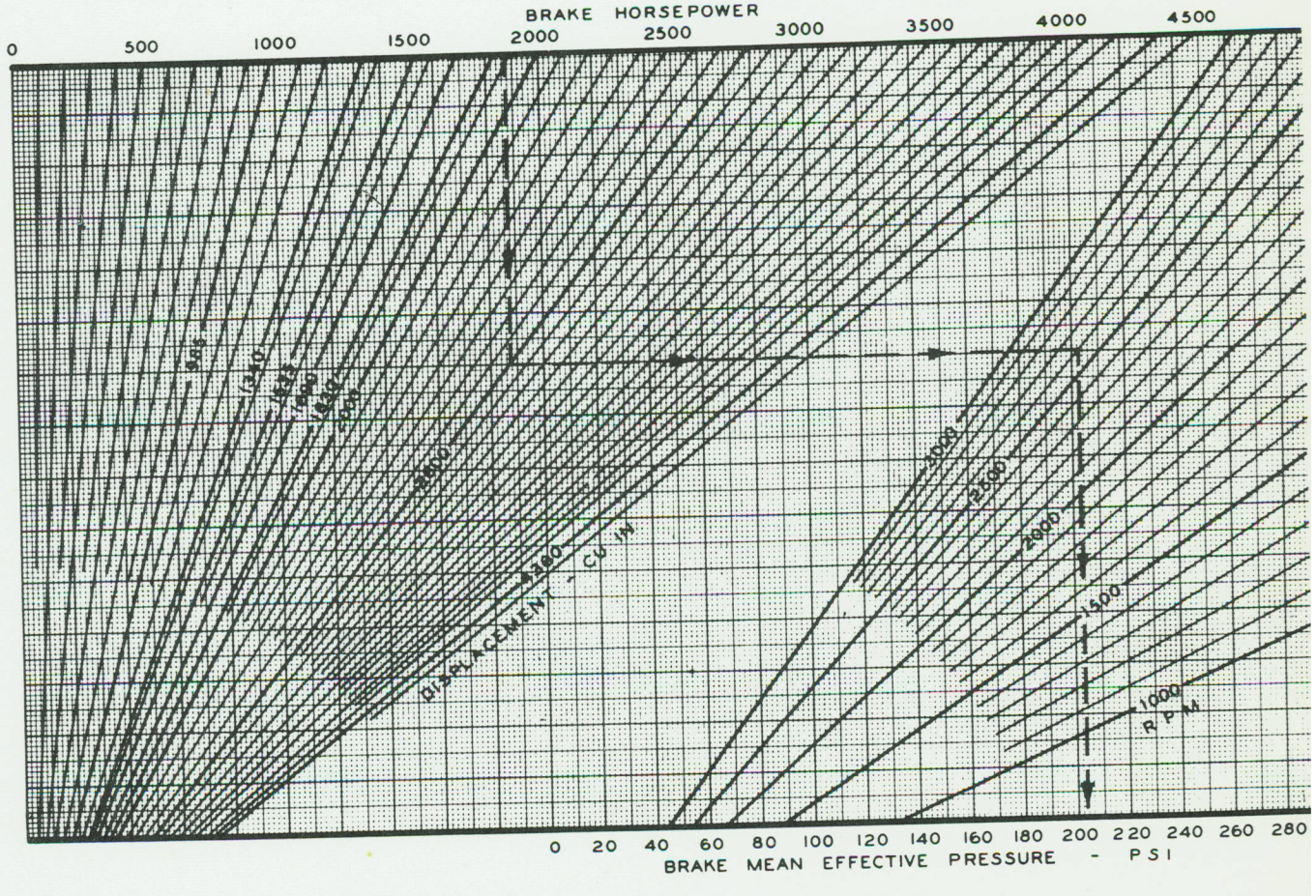


Figure 4-28 B.M.E.P. Chart for P.W.A. Engines of all Displacements

(c) Move mixture control to IDLE CUT-OFF or FULL LEAN.

(d) When engine stops, turn ignition OFF.

(e) Turn fuel selector OFF. After stopping, leave cowl flaps wide open for 15 minutes.

22 If idle cut-off or full-lean does not stop engine; close the throttle, turn OFF the ignition, then slowly open the throttle. After stop, leave cowl flaps wide open for at least 15 minutes.

23 In cold weather use normal engine shut-down procedures (except close throttle and leave closed before moving mixture control lever to IDLE CUT-OFF). The cowl flaps need not be fully open. This is to prevent rapid cooling of the engine which would result in condensation on sparkplugs with subsequent freezing. Also rapid cooling of the engine can cause valve warpage.

PART 5

TROUBLE SHOOTING

GENERAL

1 This part contains information on engine malfunctioning, its causes and rectification.

2 Experience will enable the operator to determine the mal-function. In this Part mal-functions of the engine having similar characteristics are grouped together. For example, vibration is treated under rough running, yet the experienced operator is able to distinguish between the two. Having recognized the true trouble he will not suspect causes associated only with the other.

3 The engine log book, pilots report and other sources of information must be consulted before starting work.

4 Engine trouble will be kept to a minimum if the maintenance instructions in this order are carefully obeyed. When trouble does occur, analyse the symptoms and then, starting with the most propable cause, eliminate the possible causes one by one until the trouble is discovered. Do not create more trouble by thoughtless and unnecessary investigation of the engine and accessories.

5 The most frequent troubles are:

(a) Failure to start

(b) Rough running

(c) Low power

(d) Improper idling

(e) Improper acceleration

(f) Involuntary stopping

(g) Low oil pressure

(h) Excessive oil consumption

(j) Oil foaming

(k) High oil temperature

(m) Complete loss of oil pressure

(n) High oil pressure

6 The cause of the trouble will occur in one of the following groups:

(a) Fuel and induction..... F

(b) Ignition I

(c) Lubrication L

(d) Mechanical ..... M

7 The following table lists the causes and remedies for each engine trouble. Helpful information and references are included where appropriate. The initial letter of the group in which the cause occurs is included in the margin of the table after the item number.

FAILURE TO START		
	CAUSE	REMEDY
1 F	Insufficient fuel pressure.	Change fuel shut-off valves not operating; check fuel quantity indicator and check fuel tanks with dipstick; change malfunctioning indicator; fill fuel tank to proper level; change leaking lines and tighten connections. Check adjustment screw on fuel pump; increase fuel pressure by turning adjustment screw. Check fuel strainer. Check fuel flow to entrance of pump. Check flow and rotation directions of newly installed pump.
2 F	Lack of fuel or wrong grade of fuel.	Check fuel gauge. Fill tank with recommended grade of fuel. Consult EO 45-1-2 Remove a sparkplug. If it is dry, little or no charge is entering cylinder.
3 F	Fuel leaks.	Check lines, connections, joints and clamps.
	It is normally possible to locate a fuel leak very precisely by visual inspection while the tanks are full. In rare instances, the exact source of the leak may be hidden or very difficult to find. In such cases only, use of an air pressure test is recommended. The pressure test requires emptying the tank and applying about three pounds per square inch of air pressure while soaping the external surfaces. It is necessary to conduct the air test soon after the tank has been drained and ventilated, because a tank that has been allowed to dry out thoroughly will show numerous "fizz" leaks at rivets. Brushing soap solution over these areas will show small rings of foam or slowly forming bubbles. This is a normal condition and such "fizz" leaks must be ignored. The air test is not intended to discover leaks, but merely to locate leaks precisely in event such leakage cannot be traced to exact point of origin when the tanks are full. During air test, therefore, the bubble fluid should be applied only to the area known to be leaking fuel. The leak may be large enough to blow away the bubble fluid without allowing bubbles to form. In this case, use a large soft bristle brush, dip it in the fluid, and draw it slowly across the affected area. The brush will restrict the air flow enough to allow bubbles to form as the tip of the brush passes over the leak. **WARNING** It should be remembered, following an air test, that the air under pressure in the tank is a potential explosion or fire hazard. MAKE CERTAIN THAT NO ELECTRICAL EQUIPMENT OR OTHER POSSIBLE SPARK SOURCE IS OPERATING IN THE AREA NEAR THE AIRCRAFT, OR ON THE AIRCRAFT, WHEN THE AIR UNDER PRESSURE IN THE FUEL TANK IS RELEASED.	
4 F	Overpriming (engine flooded).	With ignition OFF open throttle fully, and using starter intermittently turn engine over. Decrease priming time or strokes.

Table 5-1 Engine Trouble - Causes and Remedies

FAILURE TO START		
CAUSE		REMEDY
5 F	Primer inoperative.	Disconnect primer lines from distributor and operate primer to see if fuel flows from feed lines. Check primer lines.
	Proper use of the engine primer is a matter of judgment developed from experience; the amount of priming required will vary with operating conditions, engine temperature, and general condition of the engine. CAUTION Overpriming while cranking the engine allows fuel to exit from the exhaust system and drip to the engine shroud. After a short period of cranking with excessive prime, the engine fires and ignites the fuel which has collected on the shroud, causing an engine compartment fire. If fire breaks out as the engine starts or after the engine has started, close the throttle, turn off fuel and switches, and switch off ignition. If fire is of a serious nature, employ Cockpit fire extinguisher but not before engine has stopped. Employ portable CO_2 fire extinguishers normally used in starting Aircraft.	
6 F	Blistered or cracked manifold.	Change manifold.
7 F	Incorrect mixture control setting (mixture too lean).	Adjust throttle and mixture controls.
8 F	Carburettor loose or leaking at the mounting flange.	Rectify external leaks, if possible. If leaks are internal, change the carburettor. Refer to Section 3, Part 6.
9 F	Carburettor floods.	Place engine throttle lever in the idle position. If carburettor continues to flood while starting, change carburettor; check the fuel pump pressure before changing carburettor. Check float level.
10 F	Contaminated fuel (water in fuel or incorrect grade).	Drain and refill with correct grade of fuel. Refer to EO 45-1-2.
11 F	Clogged fuel lines.	Locate clogged lines, remove, clean, and reinstall.
12 F	Excessive booster pump operation.	Engine starting experience, especially in regions of extremely high ambient temperature, where short stop-overs do not allow engine to cool down adequately before restarted, has shown that more successful engine starts can be achieved if booster pump operation is limited to a very short period prior to cranking the engine. Limited booster pump operation will, under these circumstances, provide sufficient vapour mixture and minimize the possibility of overfueling the engine.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

FAILURE TO START		
CAUSE		REMEDY
13 F	Air leaks or restrictions in induction system.	Check security of ducts, carburettor and intake pipes; check main air scoop for restrictions; check air induction by-pass valve for operation. Tighten all loose connections. Check carburettor-air filters for foreign matter. Remove restrictions caused by foreign material. If necessary, change air induction by-pass valve. Check security of carburettor and intake pipe nuts.
14 F	Vapour in fuel system.	Operate booster pump, allowing vapour to vent from lines.
15 F	Incorrectly adjusted carburettor control linkage.	Adjust linkage so that movement of cockpit controls results in corresponding correct movement of throttle and mixture control levers on carburettor.
16 F	Internal carburettor trouble.	Change carburettor. Refer to Section 3, Part 6.
17 F	Defective accelerating pump.	Change carburettor. Refer to Section 3, Part 6.
18 M	Structural failure.	Turn the engine over by hand; any unusual noise, stiffness, or lack of compression may indicate major internal failure requiring overhaul.
19 I	Defective starter.	If the starter jaw does not advance into engagement, check for worn oil seal and binding action between screw shaft and spline nut. Check the power source for correct voltage. Change the control switch or relay if it is inoperative. Inspect wiring, internal and external, for possible grounded, shorted, or broken leads and for burned, cracked or unserviceable insulation. Internal wiring replacement will require overhauling of the starter. If the commutator is unserviceable or not concentric or the armature open, shorted, or grounded, change the starter.
20 I	Insufficient cranking speed.	Check batteries and starter. Connect booster battery. Change starter and/or batteries if necessary.
21 I	Moisture or oil in magneto and/or distributor.	Clean magneto and/or distributor rotor with Stoddard Solvent or equivalent, using clean cloth. Wipe clean with dry cloth. Check vent lines and screens for foreign matter.
22 I	Dirty, burned, or pitted breaker points.	Clean points with Stoddard Solvent or equivalent. Use clean, lint-free cloth. Change points badly burned or pitted.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

FAILURE TO START		
CAUSE		REMEDY
23 I	Ground manifold or lead from magneto ground connection to cockpit switch grounded.	Check wiring between ground connection and switch.
24 I	Magneto incorrectly timed to engine.	Check magneto timing. Refer to Section 1, Part 6.
25 I	Defective ignition switch.	Repair or exchange.
26 I	Carbon coating on spark-plug electrodes.	Clean plugs.
27 I	Closed sparkplug gap.	Change plugs. Refer to Section 3, Part 6.
28 I	Worn sparkplug bushings and gaskets.	Exchange for specified bushings and gaskets.
29 I	Wet sparkplug lead terminal sleeves.	Dry sleeves.
30 I	Corroded or damaged ignition cable caused by moisture.	Change cable.
31 I	Loose wiring terminals and elbows	Tighten connections.
32 I	Burned sparkplug shell electrodes.	Change Sparkplugs. Refer to Section 3, Part 6.
33 I	Damaged sparkplugs.	Change sparkplugs. Refer to Section 3, Part 6.
	Be sure that sparkplug inserts are clean, that the correct sparkplug gasket or thermocouple is installed and that the sparkplug can be turned all the way down by hand. Tighten to the correct value with a torque wrench.	
34 I	Defective sparkplug lead connectors.	Clean dirty connectors with a clean dry cloth. Change damaged connectors. If necessary, Stoddard Solvent or equivalent may be used for cleaning.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

FAILURE TO START		
	CAUSE	REMEDY
35 I	Burned sparkplug leads, defective ignition cable assembly, or moisture in the ignition manifold assembly.	Make continuity and high voltage test on manifold. Change cable assembly or leads if necessary. If continuity test shows leads to be unbroken, check conduit for moisture. If moisture is found, dry out conduit by loosening conduit coupling nuts and applying heat or air blast.
35 I	If a spark cannot be obtained at the sparkplugs, trace the current from the battery to the distributor. Check all terminals for security. If the ammeter shows a heavy discharge upon turning the switch, it is an indication of a wiring or ignition system short. If no flick of the ammeter is noticed when the engine is turned over it is an indication of an open circuit, bad coil or dirty coils.	
36 I	Defective booster.	Check wiring and connections. Change defective coil.
37 I	Defective wiring.	Examine wires for moisture, wear, breaks, and loose or incorrect connections. Repair or change wire or connections as necessary.
	ROUGH RUNNING	
38 F	Leaking connections.	Tighten or change connections.
39 F	Carburettor leaking.	Repair external leaks; change carburettor if leaking internally. Refer to Section 3, Part 6.
40 F	Vapour in fuel system.	Remove vent plug from carburettor, place mixture control in RICH, and operate booster pump until fuel spurts from vent; then reinstall vent plug.
	Vapour lock is the partial or complete interruption of fuel flow due to the presence of a mixture of water vapour and fuel vapour in the fuel feed system. The occurrence of vapour lock depends on the fuel characteristics, the pressure drop in the fuel feed system, the vapour handling capacity of the fuel system, and particularly the vapour pressure at the fuel temperature in the tank. Some causes of fuel boiling and vapour lock are: (a) Negative pressure in the fuel tank at low altitudes. (b) The vibration of piping forcing air out of solution. (c) Traps in the fuel system. (d) Heating of fuel by pump and engine. (e) Low fuel level in tank.	

Table 5-1 Engine Trouble - Causes and Remedies (continued)

ROUGH RUNNING		
CAUSE		REMEDY
41 F	Clogged lines or strainers.	Clean lines or strainers.
42 F	Improper grade or contaminated fuel.	Drain system and refill; clean strainers.
43 F	Air leaks in induction system (blown or leaking gaskets).	Change gaskets.
44 F	Defective pumps (insufficient fuel flow).	Change defective pumps.
45 F	Vibrating flexible fuel lines.	Tighten loose lines. Change if necessary.
46 F	Carburettor setting and intake scoop not matched.	Exchange for recommended parts.
47 F	Fluctuating fuel pressure.	Check fuel gauge to make sure tanks are full. Check operation of fuel and booster pumps. Repair or change pumps if necessary.
48 F	Internal carburettor trouble.	Change carburettor. Refer to Section 3, Part 6.
49 F	Accelerating pump faulty.	Change carburettor. Refer to Section 3, Part 6.
50 F	Mixture too rich.	Check for excessive fuel pressure and adjust pump if necessary. Change carburettor if it has internal trouble or if accelerating pump is faulty.
51 F	Mixture too lean.	Check for low fuel pressure; adjust pump if necessary; check for leaky or obstructed fuel lines or strainers, changing cracked lines, and removing obstructions. Check for air leaks in intake manifolds; make necessary repairs. Check for vapour in fuel system and repair any loose connections.
52 L	Sludge in the propeller dome.	If the condition is not corrected by moving propeller control from full INCREASE RPM to full DECREASE RPM several times, with engine running and oil hot, remove propeller dome and clean it out thoroughly

Table 5-1 Engine Trouble - Causes and Remedies (continued)

ROUGH RUNNING		
	CAUSE	REMEDY
53 M	Scarred or damaged blades.	Visually inspect blades for damage. Repair or change damaged parts.
54 M	Blades out of track or not all set at same angle.	Check blades for correct tracking. Check blade angle at correct station. Set blades at correct angle.
55 M	Loose propeller shaft nut.	Remove propeller and examine all parts for damage. Check engine thrust bearing nut for correct torque. Tighten shaft nut to proper torque. Refer to Section 2, Part 7.
56 M	Unbalanced propeller.	Change propeller.
57 ML	Faulty operation of propeller or governor.	Refer to applicable EO.
58 M	Loose or broken engine flexible mounting bracket.	Tighten loose flexible brackets to their proper torque. Consult Section 2, Part 7. Change broken brackets.
59 M	Loose exhaust collector ring.	Tighten loose nuts.
60 M	Improper valve clearance.	Adjust valves. Refer to Section 1, Part 3.
61 M	Loose intake manifold or defective gasket.	Intake manifolds should be checked periodically for looseness.
	A loose intake manifold or defective gasket will cause the cylinders to which the manifold is connected to operate unevenly at the lower engine speeds.	
62 M	Broken cam lobes	Return engine to overhaul.
63 M	Broken tappet roller.	Return engine to overhaul.
64 M	Stuck tappet.	Return engine to overhaul.
65 M	Broken tappet guide.	Return engine to overhaul.
66 M	Broken pushrod.	Change pushrod. Check valves and valve guides for sticking.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

ROUGH RUNNING		
CAUSE		REMEDY
67 M	Broken rocker arm.	Change rocker arm. Inspect valves and pushrods.
68 M	Worn rocker arm bearing.	Change bearing.
69 M	Bent valve stem.	Change valve and/or cylinder assembly. Refer to Section 3, Part 6.
70 M	Broken pistonpin.	Change cylinder assembly and/or engine. Refer to Section 3, Part 6.
71 M	Broken linkrod.	Return engine to overhaul.
72 M	Broken knucklepin.	Return engine to overhaul.
73 M	Exhaust port shipping plug not removed.	Remove plug and inspect.
74 M	Loose air ducts.	Check all air duct connections and supports; tighten where necessary.
75 M	Loose cowling supports or exhaust manifolds.	Check and tighten where necessary.
76 M	Loose or broken engine mounting brackets.	Change broken bracket assemblies.
77 M	Engine mounting flexible bracket assemblies loose or broken.	Check all core stem nuts and engine mount ring nuts to see that they are tightened to correct torque. Change any broken bracket assembly.
78 M	Loose exhaust collector ring.	Check the exhaust collector ring and tighten nuts if necessary.
	Ignition troubles commonly result from neglect in periodical inspection of breaker points, distributor brushes, distributor segments, sparkplugs, terminal connections and condition of batteries.	
79 I	Defective sparkplugs.	Determine what plugs are defective by magneto check. Remove the plugs and exchange them for new or reconditioned plugs. Refer to Section 3, Part 6.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

ROUGH RUNNING		
CAUSE		REMEDY
80 I	Defective sparkplug lead connectors.	Clean dirty connectors with a clean dry cloth. Change damaged connectors. Refer to Section 3, Part 6.
81 I	Internal trouble with the magnetos.	Change magneto. Refer to Section 3, Part 6.
82 I	Improper spark advance setting.	Check spark advance setting. Refer to Section 1, Part 6.
83 I	Moisture or oil in magneto and/or distributor.	Clean distributor rotors with Stoddart Solvent or equivalent using clean cloth. Wipe clean with dry cloth. Check vent lines and screen for foreign matter.
84 I	Defective ignition manifold.	Apply continuity check to ignition manifold using low voltage test light or buzzer circuit. Check continuity from the distributor block electrode to corresponding sparkplug lead. If the test indicates open circuit, locate break by examining connections or removing sparkplug lead. If necessary change ignition manifold.
	LOW POWER	
85 F	Insufficient fuel pressure.	To increase pressure, turn adjustment screw on fuel pump to right. See that fuel shutoff valves are operating; observe fuel quantity indicator and check fuel tanks with dipstick; check fuel lines for leaks.
86 F	Incorrectly adjusted carburettor control linkage.	Adjust linkage so that movement of cockpit control results in corresponding correct movement of throttle.
87 F	Air leaks or restrictions in induction system.	Check air scoop for foreign matter. Check security of carburettor and intake pipe nuts. Check for loose or disconnected primer lines. Check bypass valve for sticking; check ducts and connections; clean carburettor air filter.
88 F	Wrong grade of fuel.	Fill tank with recommended grade of fuel. Refer to EO 45-1-2.
89 F	Fluctuating fuel pressure.	Check fuel gauge to make sure tanks are full. Check operation of fuel and booster pumps. Repair or change pumps if necessary.
90 F	Throttle valve does not open fully.	Check rigging of throttle control.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

LOW POWER		
CAUSE		REMEDY
91 F	Carburettor air temperature too high.	Check rigging of carburettor preheat control.
92 F	Internal carburettor trouble.	Replace carburettor. Refer to Section 3, Part 6.
93 F	Restrictions in air intake system.	Check for clogged filter or incorrectly adjusted airscoop doors.
94 F	Dirt and grime on the venturi tubes.	Remove the air screen and clean the venturi surfaces. The characteristic of lean metering, due to dirt on the boost venturis, is especially present at high airflows such as those encountered during climb and takeoff operations. Such a condition may be evidenced by increased cylinder head temperatures.
95 F	Lack of fuel.	Check fuel gauge. Fill tank with recommended fuel. Refer to EO 45-1-2.
	Ignition troubles commonly result from neglect in periodical inspection of breaker points, distributor brushes, distributor segments, sparkplugs, terminal connections and condition of batteries.	
96 I	Improper spark advance setting.	Check spark advance setting. Refer to Section 1, Part 6.
97 I	Defective sparkplugs.	Determine whether front or rear plugs are defective by magneto check. Remove the plugs and exchange them for new or reconditioned plugs. Refer to Section 3, Part 6.
98 I	Magneto incorrectly timed to engine.	Check magneto timing. Refer to Section 1, Part 6.
99 I	Defective sparkplug lead connectors.	Clean dirty connectors with a clean dry cloth (Stoddard Solvent or equivalent may be used). Change damaged connectors.
100 I	Moisture or oil in distributor.	Clean distributor rotors with Stoddard Solvent or equivalent using clean cloth. Wipe clean with dry cloth. Check vent lines and screen for foreign matter.
101 I	Dirty, burned, or pitted breaker points.	Clean dirty points. Change badly burned or pitted points.
102 M	Improper valve clearance.	Adjust valve clearances. Refer to Section 1, Part 6.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

LOW POWER		
CAUSE		REMEDY
103 M	Sticking valves.	Lubricate sticking valves. Change cylinder if necessary. Refer to Section 3, Part 6.
104 M	Broken valve springs.	Install new springs. Refer to Section 3, Part 6.
105 M	Worn or sticking piston-rings, cracked pistons or cylinder heads.	Locate by compression check. Change piston and cylinder assembly as described in Section 3, Part 6.
106 M	Leaks or restrictions in exhaust system.	Check for leaking exhaust; check for foreign matter in exhaust system or cover plate left on exhaust port; adjust or change any part which causes leakage; remove foreign matter or cover plate.
107 L	Malfunctioning of governor.	Check mounting pad for damaged or wrong mounting pad gasket. If the transfer in the governor will not open, remove the valve and check for dirt. Check governor base plug for incorrect rotation. Inspect drive shaft for shearing. Change governor if necessary.
108 M	Governor high-rpm adjustment improperly set.	Check and correct as necessary.
109 M	Incorrect angle setting of blades.	Correct blade setting.
110 M	Governor low-rpm stop improperly adjusted.	Adjust and correct.
IMPROPER IDLING		
111 F	Incorrectly adjusted carburettor control linkage.	Adjust linkage so that movement of cockpit controls results in corresponding movement of throttle and mixture control levers.
112 F	Incorrect carburettor idle adjustment.	Adjust carburettor idle mixture. Refer to Section 1, Part 6.
113 F	Air leaks or restrictions in induction system.	Check security of ducts, carburettor, and intake pipes; check main air scoop for restrictions; check air induction by-pass valve for operation; change malfunctioning valve; tighten ducts and remove obstructions. Check for loose or disconnected primer lines.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

IMPROPER IDLING		
CAUSE		REMEDY
114 F	Excessive fuel pressure.	To decrease pressure, turn adjustment screw on fuel pump to left.
115 F	Internal carburettor trouble.	Change carburettor. Refer to Section 3, Part 6.
116 F	Clogged fuel lines.	Find clogged lines, remove, clean, and reinstall.
117 F	Accelerating pump faulty.	Change carburettor. Refer to Section 3, Part 6.
118 M	Improper valve clearances.	Adjust valve clearance. Refer to Section 1, Part 6.
119 M	Sticking valves.	Lubricate sticking valves. Change piston and cylinder assembly if necessary. Refer to Section 3, Part 6.
120 M	Broken valve springs.	Install new springs. Refer to Section 3, Part 6.
121 M	Worn or sticking piston rings, cracked pistons or cylinder heads.	Locate by compression check. Change piston and cylinder assembly as described in Section 3, Part 6.
122	Cold engine.	Allow engine to warm up before attempting to idle engine.
123 L	Sludge in the propeller dome.	If the condition is not corrected by moving propeller control from full INCREASE RPM to full DECREASE RPM several times, with engine running and oil hot, remove propeller dome and clean it out thoroughly.
124 M	Damaged propeller blades.	Visually inspect blades for damage. Repair or change damaged parts.
125 M	Propeller blades out of track or not all set at same angle.	Check blades for correct tracking. Check blade angle at correct station. Set blades at correct angle.
126 M	Loose propeller shaft nut.	Remove propeller and examine all parts for damage. Check engine thrust bearing nut for correct torque. Tighten shaft nut to proper torque.
	Ignition troubles commonly result from neglect in periodical inspection of breaker points, distributor brushes, distributor segments, sparkplugs, terminal connections and condition of batteries.	

Table 5-1 Engine Trouble - Causes and Remedies (continued)

IMPROPER IDLING		
CAUSE		REMEDY
127 I	Defective sparkplugs.	Determine whether front or rear plugs are defective by magneto check. If necessary, remove the defective plugs and exchange them for new or reconditioned plugs. Refer to Section 3, Part 6.
128 I	Defective sparkplug lead connectors.	Clean dirty connectors with a clean dry cloth. If necessary, Stoddard Solvent or equivalent may be used for cleaning. Change damaged connectors.
129 I	Moisture or oil in magneto distributor.	Clean distributor rotors with Stoddard Solvent or equivalent using clean cloth. Wipe clean with dry cloth. Check vent lines and screen for foreign matter.
130 I	Grounded manifold or lead from magneto ground connection to cockpit switch grounded.	Check wiring between ground connection and switch.
131 I	Magneto incorrectly timed to engine.	Check magneto timing. Refer to Section 1, Part 6.
132 I	Moisture or oil in the magneto.	Wipe breaker compartment, distributor rotor, block, and bowl with a clean dry cloth.
133 I	Dirty, burned or pitted breaker points.	Clean dirty points. Change points badly pitted or burned. Check magneto condenser.
134 I	Dielectric failure.	Check distributor fingers, covers and bases for carbon tracks or burning. Change parts as required.
135 I	Defective ignition manifold; broken or shorted primary leads; loose connection in distributor block.	Check continuity, change defective lead or manifold assembly. Tighten connections.
IMPROPER ACCELERATION		
	For good acceleration it is necessary that the engine first be adjusted for Best Power Idle. See "Idling Adjustment", Section 1, Part 6.	
136 F	Incorrect idle adjustment.	Check and adjust idle mixture and idle speed. Refer to Section 1, Part 6.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

IMPROPER ACCELERATION		
CAUSE		REMEDY
137 F	Insufficient fuel pressure.	Check fuel pressure gauge to ensure that pressure drop is not caused by a temporary drop-off owing to increased demand for fuel. Check grade of fuel; fill tank with recommended grade of fuel if necessary. Refer to EO 45-1-2.
138 F	Malfunctioning fuel boost pump.	Change fuel boost pump.
139 F	Accelerating pump faulty.	Check for disconnected linkage to accelerating pump. If pump is internally defective, change carburettor. Refer to Section 3, Part 6.
140 F	Fluctuating fuel pressure.	Check fuel gauge to make sure tanks are full. Check operation of fuel and booster pumps. Repair or change pumps if necessary.
141 F	Internal carburettor trouble.	Change carburettor. Refer to Section 3, Part 6.
142 F	Air leaks or restrictions.	Check air scoop for foreign matter. Check security of carburettor and intake pipe nuts.
143 F	Mixture too lean in cruising range.	Engine will not accelerate properly to any given RPM if the mixture at that RPM is too lean for satisfactory operation. Check for low fuel pressure; adjust pump if necessary; check for leaky or obstructed fuel lines or strainers, changing cracked lines, and removing obstructions. Check for air leaks at intake manifolds; make necessary repairs. Check for vapour in fuel system and repair any loose connections.
144 F	Incorrectly adjusted carburettor control linkage.	Adjust linkage so that movement of cockpit controls results in corresponding movement of throttle and mixture control levers.
145 F	Ruptured balance diaphragm in fuel pump.	Change fuel pump.
	Ignition troubles commonly result from neglect in periodical inspection of breaker points, distributor brushes, distributor segments, sparkplugs, terminal connections and condition of batteries.	
146 I	Improper spark advance setting.	Check spark advance setting. Refer to Section 1, Part 6.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

IMPROPER ACCELERATION		
CAUSE		REMEDY
147 I	Defective sparkplugs.	Determine whether front or rear plugs are defective by magneto check. Remove the plugs and exchange them for new or reconditioned plugs. Refer to Section 3, Part 6.
148 I	Defective sparkplug lead connectors.	Clean dirty connectors with a clean dry cloth. Change damaged connectors. If necessary Stoddart Solvent or equivalent may be used for cleaning.
149 I	Moisture or oil in magneto distributor.	Clean distributor rotors with Stoddart Solvent, or equivalent using clean cloth. Wipe clean with dry cloth. Check vent lines and screen for foreign matter.
150 I	Ground manifold or lead from magneto ground connection to cockpit switch grounded.	Check wiring between ground connection and switch.
151 I	Magneto incorrectly timed to engine.	Check magneto timing. Refer to Section 1, Part 6.
152 I	Dirty, burned or pitted breaker points.	Clean dirty points. Change points badly pitted or burned. Check magneto condenser.
153 I	Dielectric failure.	Check distributor rotors, covers and bases for carbon tracks or burning. Change parts as required.
154 I	Defective ignition manifold; broken or shorted primary leads; loose connection in distributor block.	Check continuity, change defective lead or manifold assembly. Tighten connections.
155 L	Sludge in the propeller dome.	If the condition is not corrected by moving propeller control from full INCREASE RPM to full DECREASE RPM several times, with engine running and oil hot, remove propeller dome and clean it out thoroughly.
156 M	Improper valve clearances.	Adjust valve clearance. Refer to Section 1, Part 6.
157 M	Sticking valves.	Lubricate sticking valves. Change cylinder if necessary. Refer to Section 3, Part 6.
158 M	Broken valve springs.	Install new springs. Refer to Section 3, Part 6.
159 M	Worn or broken piston rings, cracked piston or cylinder head.	Locate by compression test. Change piston and cylinder assembly if necessary. Refer to Section 3, Part 6.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

INVOLUNTARY STOPPING		
	CAUSE	REMEDY
	WARNING If an engine cuts out or stops, the cause may be any of the troubles listed. If the engine can be started again and runs normally, every effort should be made before flight to ascertain the reason for the engine stopping. The trouble, may recur later, causing failure in the air.	
160 F	Out of fuel.	Determine fuel supply both by inspecting gauges and checking tanks. Check fuel cocks for ON position.
161 F	Fuel lines obstructed.	A piece of rag or other foreign matter may be floating in the fuel tank to act as a stopper every time it floats by and is sucked against the fuel-supply line. Disconnect gas line at the carburettor to see if gas flow is adequate. Any piping suspected of being even partially obstructed should be removed and blown out with compressed air
162 F	Vapour lock in fuel lines.	See that air vents in gasoline tanks are unobstructed. Fuel lines may be cleared by disconnecting the main supply line at the carburettor and pumping out some of the gasoline.
163 F	Carburettor jets restricted.	If possible, jets should be removed carefully and blown out with air pressure. If idling jets are partially restricted, engine will miss or cut out at low rpm. When the trouble is in the main jets, the engine will miss or fail to obtain rpm.
164 M	Structural failure.	Allow the engine to cool, then with ignition OFF turn the engine over by hand. Any unusual noise, stiffness, or lack of compression may indicate major internal failure requiring overhaul.
165 I	Short circuit.	Examine all ignition wiring especially switch wiring on instrument panel and magneto distributor high-tension wires. Look for moisture or corrosion. Check all wires for security even though they appear to be making good contacts.
	Oil pressure will change with varying engine speeds and oil temperature. Due allowance, therefore, should be made for pressure drop to be expected at increased temperatures. Engine should be immediately stopped if no pressure or sudden and unexplained drop in pressure is indicated on pressure gauge.	
166 L	Defective oil pressure gauge, transmitter or indicator.	Repair or change gauge, transmitter or indicator.
167 L	Diluted, contaminated, or inadequate oil supply.	Drain engine and tank. Refill oil tank with oil. Consult EO 45-1-2.
168 L	Obstruction in main oil tank.	Drain oil and clean tank.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

LOW OIL PRESSURE		
	CAUSE	REMEDY
169 L	Obstruction or leaks in oil lines.	Inspect oil lines, remove obstructions, and repair leaks. Change cooler if necessary.
170 L	Clogged main oil strainer.	Remove and clean strainer as directed in Section 1, Part 6.
171 L	Excessive oil dilution.	Drain oil from engine and oil system. Check operation of oil dilution valve. Inspect valve for cleanliness. Refill tank with oil. Consult EO 45-1-2.
	Oil dilution, and particularly over-dilution, loosens a great deal of anchored sludge and puts it into circulation, often to such an extent that oil screens become clogged and cause the oil screen by-pass valve to open, thus supplying the engine with unscreened dirty oil. Leaking oil dilution valves bring the same trouble and may also add spewing to the problems.	
172 L	Improper operation of oil pressure relief valve.	Remove any foreign material and check seating of valve. Check valve spring. Change spring of insufficient or excessive pressure or length.
173 M	Internal engine trouble.	Check main oil screen and main sump for metal particles.
174 L	Low outside temperature.	In very cold weather the oil may become congealed in the suction line from the oil tank, preventing the oil from reaching the pump in sufficient quantity. Check by lower rpm.
175 L	Foaming in oil supply tank.	Change the oil. Drain water from sumps.
	Foaming is a frequent cause of fluctuating oil pressure and loss of pressure. While the presence of air in the scavenge is normal, there should be little or no foam in the supply tank. The return line should be arranged to permit only a minimum of splashing in the tank and allow air which may be trapped to separate from the oil as readily as possible.	
176 L	Oil pressure pump not primed.	Disconnect the oil suction line and fill the pump with oil. Air may sometimes become trapped within the pump and relief valve mechanism. Removing and reinstalling the relief valve may eliminate the air lock.
177 L	High oil temperature.	With high temperature the viscosity is decreased, causing pressure to drop. Check operation of oil cooler.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

EXCESSIVE OIL CONSUMPTION		
CAUSE		REMEDY
178 M	Worn piston rings.	Return engine for overhaul.
179 M	Burned or scored pistons.	Return engine for overhaul.
180 M	Defective impeller shaft oil seal.	Return engine for overhaul.
181 M	Excessive wear to internal parts of the engine.	Return engine for overhaul.
182 L	Loose connections or broken lines.	Change broken lines and tighten connections.
183 L	Low grade oil.	Fill tank with correct grade of oil. Refer to EO 45-1-2.
OIL FOAMING		
184 L	Diluted, contaminated or inadequate oil supply.	Drain engine and tank, refill with oil. Consult EO 45-1-2.
185 L	Excessive oil dilution.	Drain oil from engine and oil system. Check operation of oil dilution valve. Inspect valve seat for cleanliness. Change valve is necessary. Refill tank with oil. Consult EO 45-1-2.
186 L	Vacuum pump oil-separator restrictor fitting missing.	Install restrictor fitting.
187 L	Engine nose scavenge pump failure.	Change pump.
188 L	Air leaks in external scavenge system.	Check pump seals and all oil lines.
189 L	Oil level too high.	Fill tank to correct level.
190 L	Obstruction in main oil tank.	Drain oil and clean tank. Refill tank with oil. Consult EO 45-1-2.
191 L	Obstruction or leaks in oil lines.	Check oil lines. Remove obstruction and repair leaks. Change cooler if necessary.
192 L	Improper operation of oil cooler.	Check oil cooler shutter operation. Check for obstructions. Change cooler or cooler control unit if necessary.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

HIGH OIL TEMPERATURE		
	CAUSE	REMEDY
193 L	Defective oil temperature gauge.	Repair or change gauge.
194 L	Inadequate oil supply.	Fill tank with oil. Refer to EO 45-1-2.
195 L	Diluted or contaminated oil.	Drain engine and tank. Refill with oil. Refer to EO 45-1-2.
196 L	Obstructions in main oil tank.	Drain oil and clean tank. Refill with oil. Consult EO 45-1-2.
197 L	Broken oil lines, loose connections, or leaks.	Change broken lines, tighten connections, repair leaks or install necessary parts.
198 L	Obstructions in oil cooling lines.	Remove obstructions. Change oil cooler if necessary.
199 L	Improper operation of oil cooler.	Check flap operation; check thermostat and/or flap actuator.
200 L	Clogged pressure oil strainer.	Remove, inspect, and clean oil strainer.
201	Leaking oil dilution valve.	Check oil dilution valve for leaks. Repair or change valve if necessary.
COMPLETE LOSS OF OIL PRESSURE		
202 L	Obstructions, breaks, or leaks in oil lines.	Check oil lines, remove obstructions, and repair leaks or breaks. Change cooler if necessary.
203 L	Improper operation of oil pressure relief valve.	Remove any foreign material and check seating of valve. Check valve spring. Change spring if necessary.
204 L	Defective oil pressure gauge, transmitter, or indicator.	Repair or change gauge, transmitter; or indicator.
205 L	Defective oil pump.	Clean pump and change leaking seals. Change pump if necessary.
206 L	Diluted, contaminated, or inadequate oil supply.	Drain engine and tank. Refill with recommended oil. Refer to EO 45-1-2.

Table 5-1 Engine Trouble - Causes and Remedies (continued)

COMPLETE LOSS OF OIL PRESSURE		
CAUSE		REMEDY
207 L	Excessive oil dilution.	Check dilution solenoid valve operation. Change oil in engine and in oil system. If oil dilution solenoid valve leaks, change.
208 L	Air lock in intake line.	Prime line - pre-oil engine.
209 L	Oil spewing or excessive breathing.	Scavenge pump trouble. Excessive blowby due to damaged piston or rings.
HIGH OIL PRESSURE		
210 L	Improper operation of oil pressure relief valve.	Remove any foreign material and check seating of valve. Check valve spring for tension. Change spring of insufficient or excessive pressure or improper length. Refer to Section 3, Part 6.
211 L	Cold oil.	Allow engine to warm up.
212 L	Defective oil pressure gauge.	Repair or change gauge.

SUMMARY

Engine malfunctioning can often be prevented by systematic inspection of the following items, which are known through experience to be causes of trouble.

IGNITION	FUEL & INDUCTION	LUBRICATION	MECHANICAL
Breaker points: -	Carburettor: -	Oil Strainer and Sump -	Valves -
Dirty Burned Pitted Oily	Vapour separator stuck Strainer clogged Leaky lines Incorrect idle adjustment Primer solenoid defective	Metal particles Clogged	Improper clearance Broken Springs Sticking

Table 5-2 Prevention of Engine Malfunctioning

IGNITION	FUEL & INDUCTION	LUBRICATION	MECHANICAL
Condenser - Shorted Open Burst	Accelerating pump - Defective	Oil Supply - Diluted Contaminated Inadequate	Piston Rings - Worn Sticking
Distributor Brushes and Segments - Worn Burned Dirty	Gauges - Defective	Oil pressure gauge - Defective	Piston - Cracked
Wiring - Loose Broken Shorted	Pumps - Defective	Lines and tank - Obstructions Leaks	Cylinder head - Cracked Excessive carbon deposit
Connectors - Loose		Oil Cooler - Leaks Clogged	Air ducts - Loose
Sparkplugs - Wet, Fouled Gap Setting Incorrect Insulation (cracked) Gaskets		Oil dilution valve- Stuck	Mounting brackets - Loose
Timing - Retarded Advanced Induction Vibrator - Defective			Cowling supports - Loose

Table 5-2 Prevention of Engine Malfunctioning (continued)

PART 6

TABLE OF CONTENTS

PART 6

LINE MAINTENANCE

SECTION 1

CHECKS AND ADJUSTMENTS

IGNITION SYSTEM

1 The magnetos seldom need attention between overhauls. Under normal conditions, the wear or burning of the breaker points offsets the wear of the cam follower. However, a faulty condenser or the presence of oil or grease on the points may cause excessive burning of the points. Lack of lubrication may lead to excessive wear of the cam follower. If the wear at one of these locations exceeds the wear at the other a change in spark timing will result. If ignition trouble occurs, examine the sparkplugs, leads, and connectors. If a magneto is found to be malfunctioning, change it for a new or reconditioned magneto.

BREAKER POINT INSPECTION

2 If the breaker point surfaces are fouled with oil or dirt, or are burned excessively (Figure 6-1), changing of the complete breaker assembly is recommended. In an emergency, when no exchange parts are available, a fouled assembly can be made serviceable for temporary use by removing it from the magneto and washing the point surfaces carefully using Stoddard Solvent or equivalent as a cleaning agent. When this is done, the cleaning agent must be allowed to evaporate completely before placing the assembly back in service. After the assembly has thoroughly dried, check the cam follower felt for the proper amount of oil by squeezing the felt tightly between the thumb and forefinger. If the fingers are moistened with oil when this is done, the felt is adequately lubricated and no more oil should be applied. If no oil is left on the fingers, the follower felt is too dry and should be oiled as follows:

(a) Apply one drop of S.A.E. No. 60 Aircraft engine oil to the bottom felt pad, and one drop to the upper felt pad.

(b) Allow at least 15 minutes for the felt to absorb the oil; then blot off any excess oil with a clean cloth.

(c) Reinstall the assembly in the magneto and secure it with the two locking screws. The breaker points must now be checked for proper adjustment (timing and synchronizing).

CAUTION

When inspecting the breaker points, do not raise the breaker main spring beyond a point giving 1/16 inch clearance between the points. Any further tension on the spring will weaken it and adversely affect the performance of the magneto.

BREAKER POINT ADJUSTMENT

3 Do not change the adjustment of the breaker points unless the following check indicates the necessity.

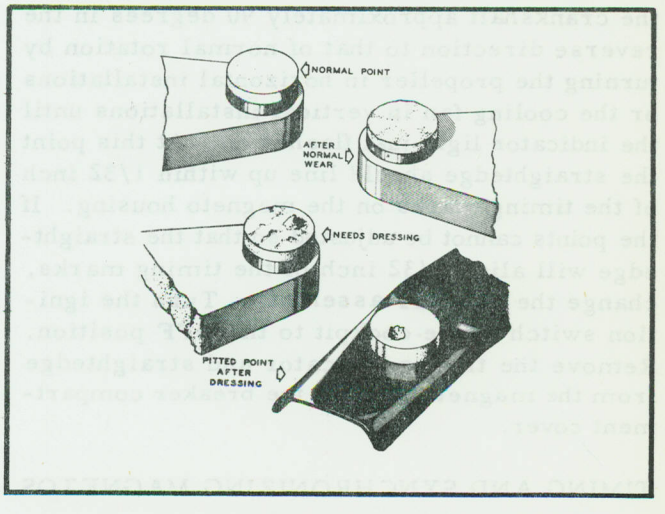


Figure 6-1 Conditions of Breaker Points

4 Remove one sparkplug from each cylinder and install PWA-3252 Vent Plugs in the sparkplug holes. Turn the crankshaft by means of the cooling fan or propeller until the piston of No. 1 cylinder is at the top centre of its compression stroke. Remove the breaker compartment covers of the magneto.

5 Attach the red wires of PWA-2417 Timing Indicator to the breaker points of the magneto and ground the black wire to the engine. Turn the ignition switch in the cockpit to the BOTH position.

6 Turn the propeller in horizontal installations or the cooling fan in vertical installations opposite the normal direction of rotation approximately 90 degrees; then turn it in the normal direction until the lights of the indicator just flash on. As the lights flash on, the cam of each magneto should be just beginning to open the breaker points, and a straightedge should align within 1/32 inch of the timing marks on the magneto housing. If the straightedge is not within the 1/32 inch alignment, adjust the breaker as follows:

7 With the magneto cam in its proper position to open the breaker points - that is, with the straightedge aligned with the timing mark on the magneto housing, loosen the contact bracket screws. Turn the eccentric adjusting screw until the indicator light just flashes on, indicating that the points are opening. Tighten the screws.

8 Check the setting of the points. Turn the crankshaft approximately 90 degrees in the reverse direction to that of normal rotation by turning the propeller in horizontal installations or the cooling fan in vertical installations until the indicator light just flashes on. At this point the straightedge should line up within 1/32 inch of the timing marks on the magneto housing. If the points cannot be adjusted so that the straightedge will align 1/32 inch of the timing marks, change the breaker assembly. Turn the ignition switch in the cockpit to the OFF position. Remove the timing indicator and straightedge from the magneto. Install the breaker compartment cover.

TIMING AND SYNCHRONIZING MAGNETOS

9 To determine whether the magnetos are properly timed to the engine and synchronized with each other, the following check should be made.

10 Remove one sparkplug from each cylinder and install PWA-3252 Vent Plugs. Rotate the crankshaft by means of the cooling fan or propeller until No. 1 piston is on the beginning of the compression stroke; then install PWA-4142 Indicator (Time-Rite) in the top or front sparkplug hole of No. 1 cylinder (Sketch A). Use pivot arm A with hook end up.

11 Attach the red wires of PWA-2417 Indicator to the breaker points of the magnetos and ground the black wire to the engine. Align the cap of PWA-4142 Indicator so the slide slot lines up with the vertical axis of the cylinder and the scale is at the right of the slot. Push the slide pointer up close to the pivot arm (Sketch B). Turn the crankshaft in the normal direction of rotation until the pivot arm pushes the slide pointer to its farthest point (Sketch C). Turn the crankshaft 90 degrees opposite rotation to return the pivot arm to the top of the slot. Adjust the proper engine scale (R-985) so that the zero degree mark on the scale aligns with the reference mark on the slide pointer (Sketch D). Move the slide pointer up to align with the 25 degree mark on the scale (Sketch E). Turn the crankshaft until the pivot arm just contacts the slide (Sketch F), at which time the lower light in PWA-4142 Indicator flashes on. The No. 1 piston is now 25 degrees before top centre.

NOTE

In timing engines that are not installed, the spark advance mark under the thrust bearing cover plate, rather than PWA-4112 Indicator, may be used. This requires removing the thrust bearing cover plate and the use of PWA-85 Timing Pointer with PWA-112 Turning Bar.

12 At this point the lights of PWA-2417 Indicator should flash on simultaneously, indicating that the points are just opening. Check the alignment of the timing marks with a straightedge (Figure 6-3). This will give the correct E gap. Permissible limits 1/32 inch on either side of the timing marks. An adjustment, described in the following paragraph, will be necessary if the

magnetos are not synchronized. When the piston is 25 degrees before top centre, the breaker points would break simultaneously if the straight-edge is in correct relationship to the timing marks. If the magnetos are found to be properly synchronized after the above check is made, restore the engine to its condition prior to this check.

13 If the timing of one or both magnetos to the engine is incorrect it will be necessary to remove the bolts which attach the incorrectly timed magneto to its mounting pad and move the magneto away sufficiently to turn the rubber drive coupling. Make sure the piston of No. 1 cylinder is 25 degrees before top centre. If it is desired to advance the timing, the rubber coupling should be turned one or two notches in a counterclockwise direction, the magnetos reinstalled in place, and the timing rechecked as described above. To regard the timing, the rubber coupling must be turned in a clockwise direction. Because the coupling has 19 notches on one side, and 20 notches on the other side a fine adjustment can be made by rotating it one notch. It is important that the two magnetos be synchronized to break simultaneously and with the straightedge or timing indicator in correct relationship to the marks on the breaker housing. Slide the magneto back into position and install the bolts. Recheck the magneto timing and synchronization. Lockwire the bolts. For a diagram of the Ignition System see Figure 6-4.

VALVE CLEARANCE ADJUSTMENT

14 Adjustment of valve clearances is usually not necessary during normal periods between

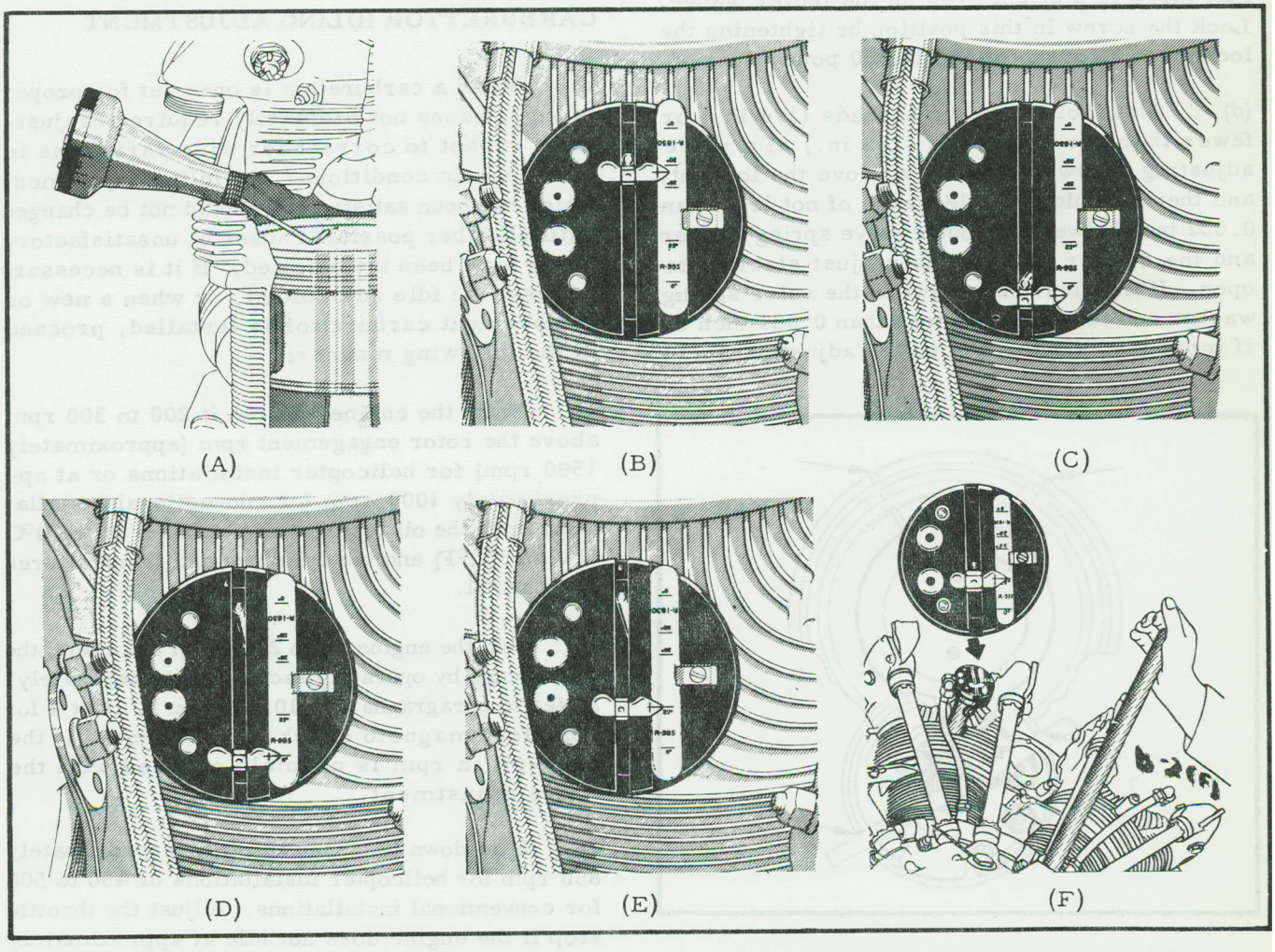


Figure 6-2 Positioning Piston when Timing Magneto to Engine

overhauls. If any adjustment should become necessary, however, perform the work when the engine is cool.

(a) Remove the rockerbox covers and one sparkplug from each cylinder.

(b) Adjust the valves in the order of cylinder firing (1-3-5-7-9-2-4-6-8). Turn the propeller in horizontal installations or the cooling fan in vertical installations in the normal direction of rotation until the desired piston is at top dead centre of its compression stroke.

(c) Insert the .010 inch feeler of PWA-4675 Gauge between the valve stem and the adjusting screw insert. In the event that adjustment is required, loosen the adjusting screw locknut. Using PWA-4152 Wrench set the adjusting screw so that there is a slight drag on the feeler gauge. Lock the screw in this position be tightening the locknut to a torque of 300 to 350 pound-inches.

(d) Not more than six threads (1/4 in.) or fewer than three threads (1/8 in.) of a valve adjusting screw should show above the locknut; and there should be a clearance of not less than 0.031 inch between the outer valve spring washer and the rocker with the valve just starting to open. If the clearance between the valve spring washer and the rocker is less than 0.031 inch or if more than six threads on the adjusting screw show above the locknut, the flat face of one or both of the pushrod ballend spacers may be ground, or the spacer can be changed for a thinner one or eliminated entirely to obtain the desired clearance. If fewer than one and one-half threads of the adjusting screw show above the locknut, a thicker spacer should be used at one or both ends of the pushrod.

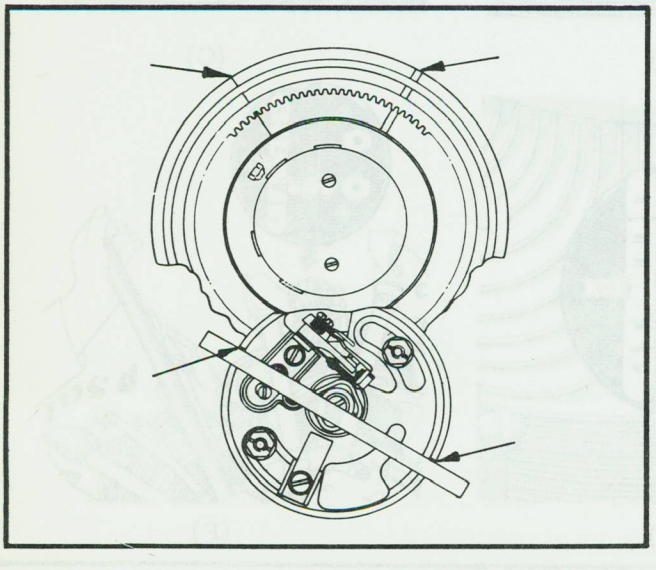


Figure 6-3 Aligning Timing Marks

(e) Make all other valve clearance adjustments in the same manner; then turn the propeller shaft in the normal direction of rotation two revolutions, and recheck the clearance of the valves which were adjusted.

(f) Install the rockerbox covers using new gaskets. Tighten the rockerbox cover nuts to a torque of 60 to 75 pound-inches.

CARBURETTOR IDLING ADJUSTMENT

15 When a carburettor is once set for proper idling, it does not ordinarily require readjustment except to correct for wide variations in atmospheric conditions. An idling adjustment which has been satisfactory should not be changed until all other possible causes of unsatisfactory idling have been investigated. If it is necessary to reset the idle adjustment, or when a new or replacement carburettor is installed, proceed in the following manner:

16 Start the engine and run it 200 to 300 rpm above the rotor engagement rpm (approximately 1500 rpm) for helicopter installations or at approximately 1000 rpm for conventional installations until the oil temperature reaches 60 to 70°C (140 to 158°F) and the cylinder head temperatures are normal.

17 Run the engine up to 2000 rpm and check the sparkplugs by operating each magneto separately. Refer to paragraphs 7 to 10, Section 5, Part 4 for complete magneto check instructions. If the drop-off in rpm is normal, proceed with the idling adjustment.

18 Slow down to closed throttle, approximately 850 rpm for helicopter installations or 450 to 500 for conventional installations. Adjust the throttle stop if the engine does not idle at approximately this rpm.

Part 6, Section 1, page 74, para. 18, line 2:-

Delete: 850 RPM

Insert the following: 1000 RPM

Part 6, Section 1, page 75, para. 19, line 7:-

Delete: 850 RPM

Insert the following: 1000 RPM

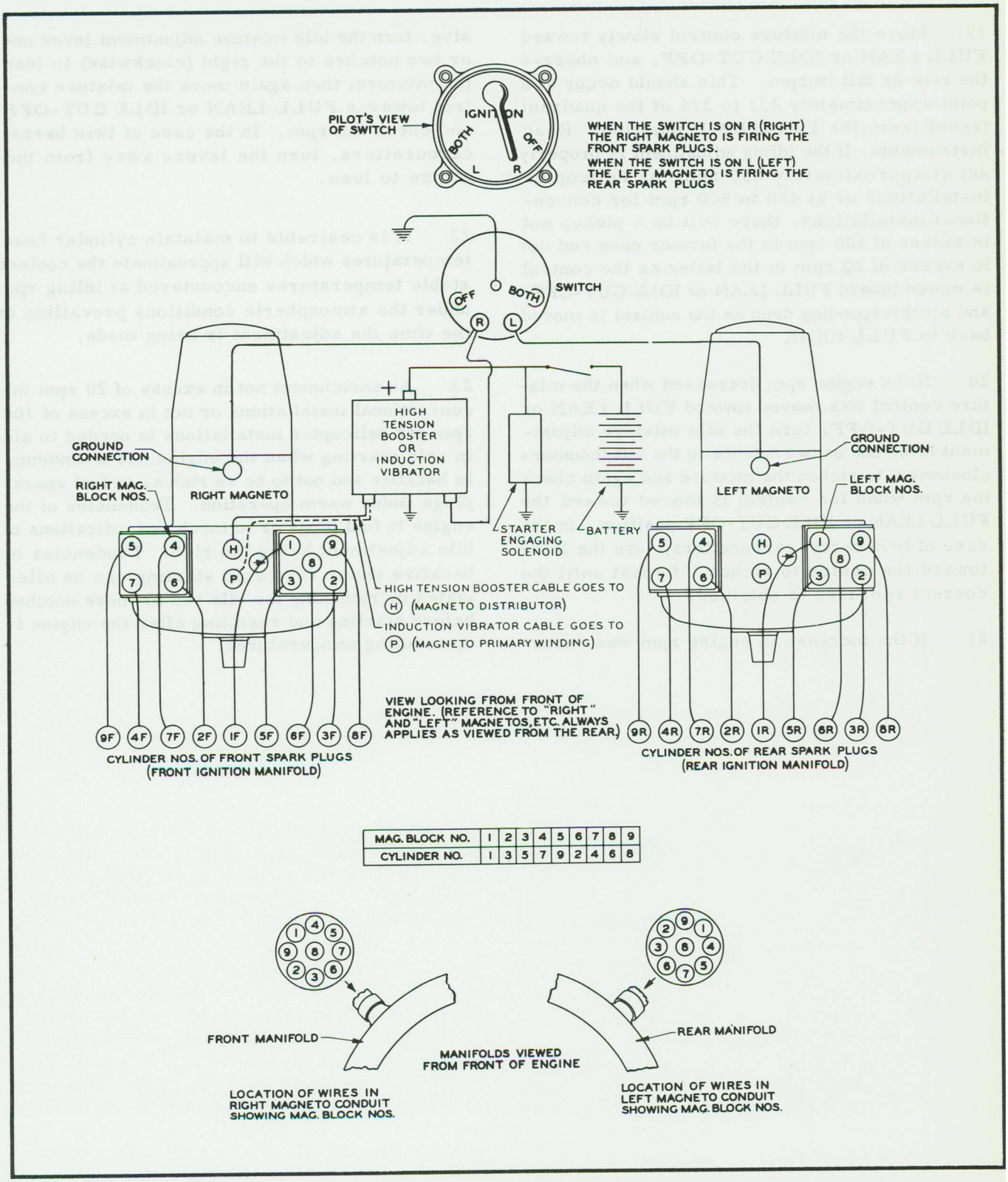


Figure 6-4 Ignition System

19 Move the mixture control slowly toward FULL LEAN or IDLE CUT-OFF, and observe the rise or fall in rpm. This should occur at a point approximately 2/3 to 3/4 of the quadrant travel from the FULL RICH position. Read instruments. If the idling adjustment is properly set at approximately 850 rpm for helicopter installations or at 450 to 500 rpm for conventional installations, there will be a pickup not in excess of 100 rpm in the former case and not in excess of 20 rpm in the latter as the control is moved toward FULL LEAN or IDLE CUT-OFF, and a corresponding drop as the control is moved back to FULL RICH.

20 If the engine rpm decreased when the mixture control was moved toward FULL LEAN or IDLE CUT-OFF, turn the idle mixture adjustment lever one or two notches to the left (counter-clockwise) to richen the mixture and again check the rpm when the control is moved toward the FULL LEAN or IDLE CUT-OFF position. In the case of twin barrel carburettors, turn the lever toward the centre to richen. Repeat until the correct rpm rise is obtained.

21 If the increase in engine rpm was excessive, turn the idle mixture adjustment lever one or two notches to the right (clockwise) to lean the mixture; then again move the mixture control towards FULL LEAN or IDLE CUT-OFF and check the rpm. In the case of twin barrel carburettors, turn the levers away from the centre to lean.

22 It is desirable to maintain cylinder head temperatures which will approximate the coolest stable temperatures encountered at idling rpm under the atmospheric conditions prevailing at the time the adjustment is being made.

23 An enrichment not in excess of 20 rpm for conventional installations or not in excess of 100 rpm for helicopter installations is needed to aid in cold starting when the engine has a tendency to backfire and not to be so rich as to foul spark-plugs under warm operation. Tendencies of the engine to foul plugs or to torch are indications of idle adjustment being too rich. Tendencies to backfire under very cold starting can be alleviated by richening the idle two or more notches before starting and resetting after the engine is up to idling temperatures.

SECTION 2

LOCKWIRING

GENERAL

1 Lockwiring is the most positive and satisfactory method of securing in place the various bolts, nuts, and studs which hold together the parts of an engine and which cannot otherwise be satisfactorily locked. Generally speaking, lockwiring is the tying together of two or more parts in such a manner than tendency of one part to loosen will automatically be countered by the tightening of the wire.

2 There are many combinations of lockwiring with certain basic rules common to all. These rules can be outlined as follows:

(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. In other words 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. That 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 ends 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 lockwired are torqued to specifications and the holes properly aligned before any attempt is made to proceed with the lockwiring.

3 Cotterpins are usually associated with castle nuts; however, if the castle nut is used on a stud, a cotterpin would secure the nut to the stud, but would not prevent the stud from backing out of the housing. In a case such as this, the lockwire will act as a cotterpin and if the wire is attached to an adjacent part, the stud also will be held securely in place.

HOLE ALIGNMENT

4 Check the units to be lockwired to make sure that they have been correctly torqued and that the wiring holes are properly positioned in relation to each other. When there are two units, the hole in the first unit should be between the three and the six o'clock positions and the hole in the second unit between the nine and twelve o'clock positions (Figure 6-5).

5 Positioning the holes in this manner insures that the wiring will have a positive locking effect on the two units, since the braid will always exert a tightening pull on both units. Never over torque or loosen units to obtain proper alignment of the holes. It should be possible to align the wiring holes when the units are torqued within the specified limits. However, if it is impossible to obtain a proper alignment of the holes without

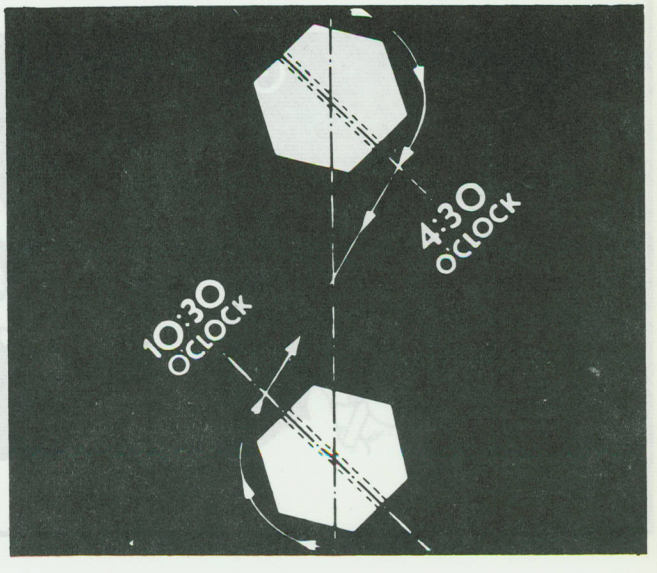


Figure 6-5 Position of Holes

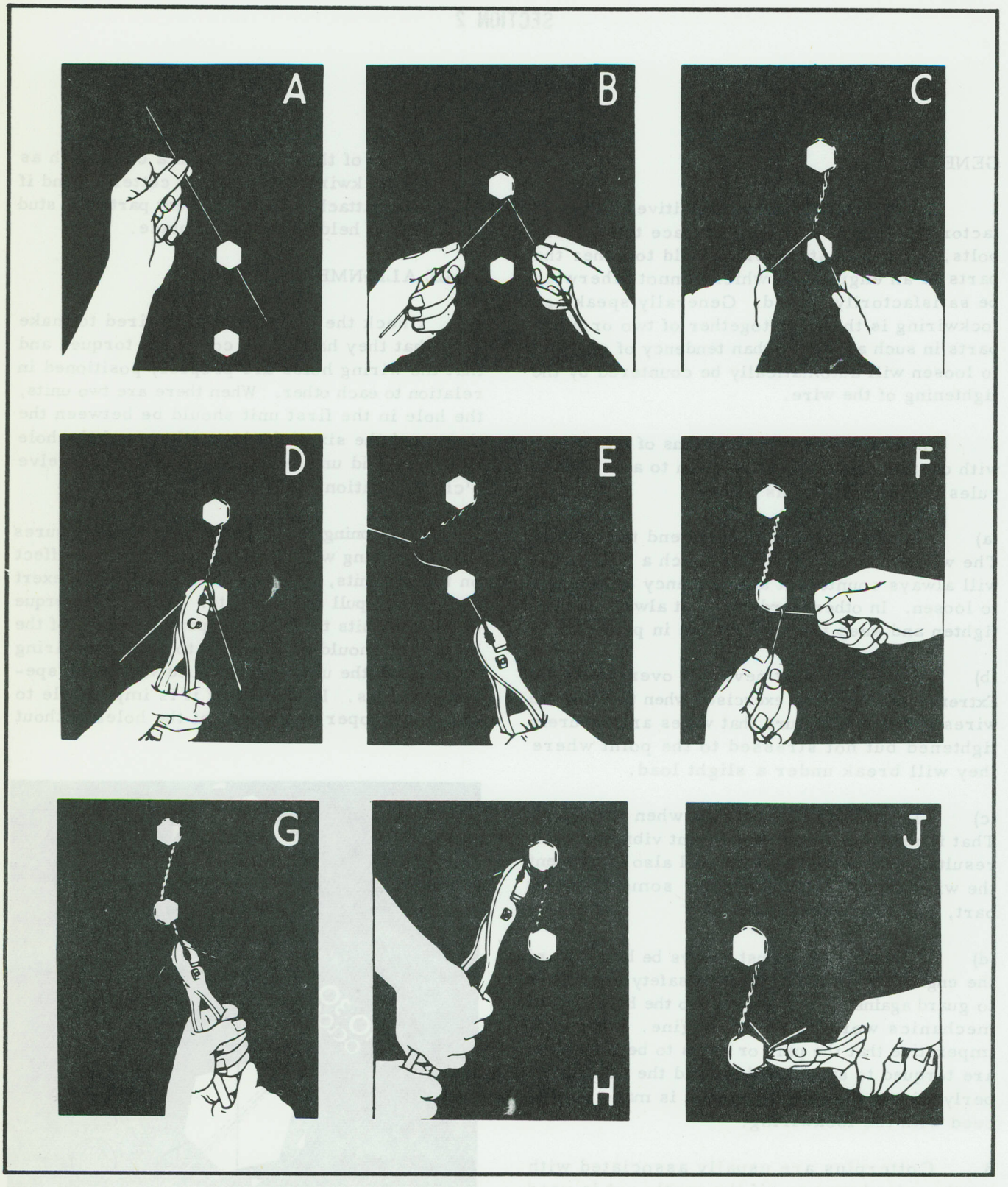


Figure 6-6 Steps in Wirelocking

either over or under torquing, another unit should be selected which will permit proper alignment within the specified torque limits.

PROCEDURE

6 Refer to Figure 6-6 for step-by-step illustrations of procedure.

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

NOTE

To determine the proper wire to be used in conjunction with a particular tightening operation, refer to EO 10A-10AA-4, in which 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 (Sketch B).

(c) Pull the loop very tight all around the head of the bolt with the pliers. Grasp the wire only at the end in order not to mutilate any portion which is to be twisted. Holding the wire ends apart and keeping the loop tight around the head of the first bolt, twist the wires around each other in a clockwise direction to form the braid. Continue twisting the wires by hand toward the second bolt until the end of braid is just short of the second bolt's hole which lies between the nine and the twelve o'clock position (Sketch C).

(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 (Sketch D).

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 vigration 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 braid taut (Sketch E).

(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 (Sketch F).

(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 (Sketch G).

(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 around the head of the second bolt (Sketch H).

(j) Cut off the excess wire at the ends with diagonal cutters, leaving at least three full twists, and avoiding sharp or projecting ends (Sketch J). Do not twist off the ends of the wires with pliers.

BASIC TYPES OF LOCKWIRING

7 Many separate wiring operations are required, most of which are covered by the seven basic examples illustrated in Figure 6-7.

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

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

Example 3 shows how to wire three units together. Note that the braid between the second and third units should be twisted counterclockwise so that the wire from the hole in the second unit will be on top of the loop around the second unit to hold it down in place. The wire inserted in

the lockwire hole in the third unit should be the lower wire of the braid and beyond the third unit this wire should be brought over the other wire to secure the loop in place around the head of the third unit.

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

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

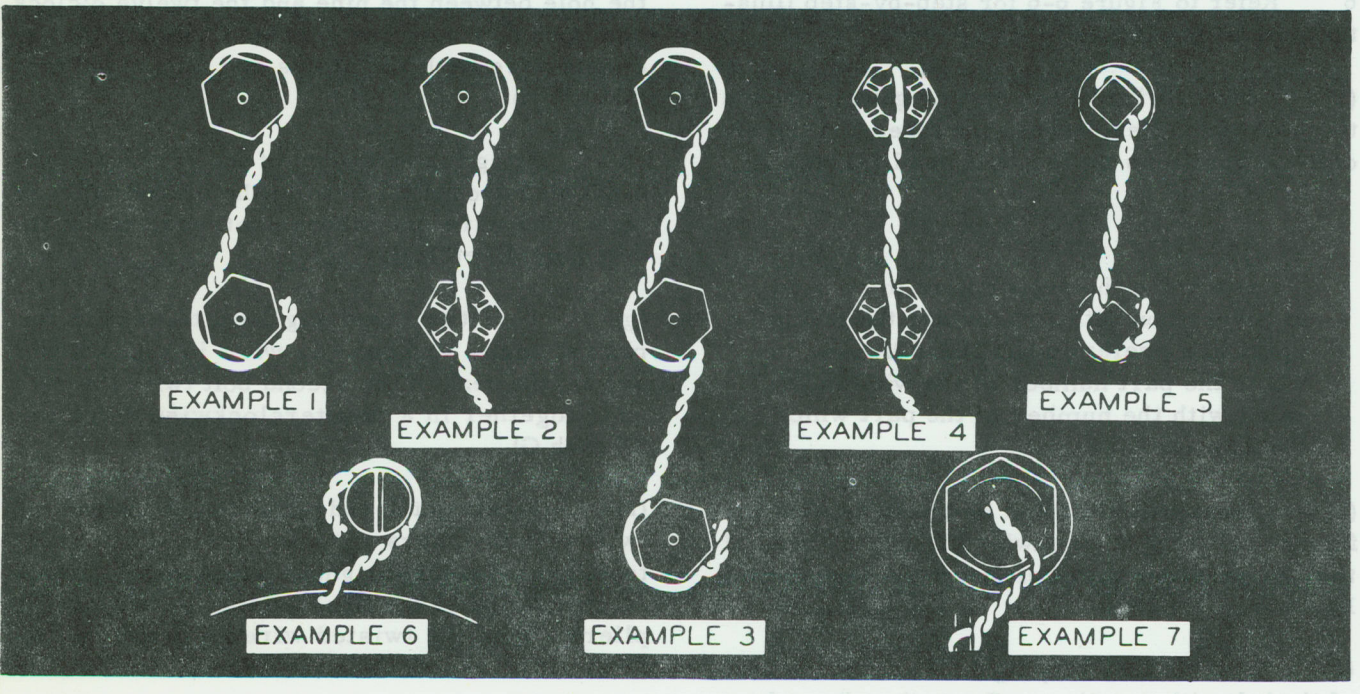


Figure 6-7 Examples of Wirelocking

SECTION 3

EXCHANGE OF PARTS

GENERAL

1 These instructions are written with the understanding that all lockwiring, cotter pins, cylinder flange locknuts, nuts, washers, bolts, and screws will be removed where necessary in disassembly procedures and that a new gaskets, rubber oil seal rings, packings, lockwire, and cotterpins will be used at assembly. Fibre insert nuts may be continued in service as long as they are free from mutilation and provide an effective lock.

2 Care should be taken to prevent dirt, dust, and other foreign matter from entering the engine during assembly and disassembly operations. Use suitable plugs and coverings over all openings in the engine.

3 When installing accessories that are secured by bolts, it is of the utmost importance that the insert holes in the accessory mounting pad be thoroughly cleaned. Bolts that are installed in recesses that are contaminated with oil, grease, preservative compounds, or other liquids can produce a hydraulic force which may cause the insert hole to be hydraulicked.

4 For torque recommendations refer to "Torque Recommendations" Section 2, Part 7.

5 When other engine parts interfere with the removal of a single part, the procedure for removing them can be found under their individual headings in the following text. For information about other interfering parts peculiar to the particular installation, the applicable Engineering Order should be consulted.

COWLING

REMOVAL

6 Remove sufficient cowling (Figure 6-8) to have easy accessibility during the removal of any parts.

INSTALLATION

7 Install the cowling sections that were removed.

EXHAUST PIPING

REMOVAL

8 Unfasten the nuts and bolts which fasten the exhaust piping to the engine (Figure 6-9). Loosen the exhaust manifold and lower it as far as possible so that the cylinders and related parts will be more accessible.

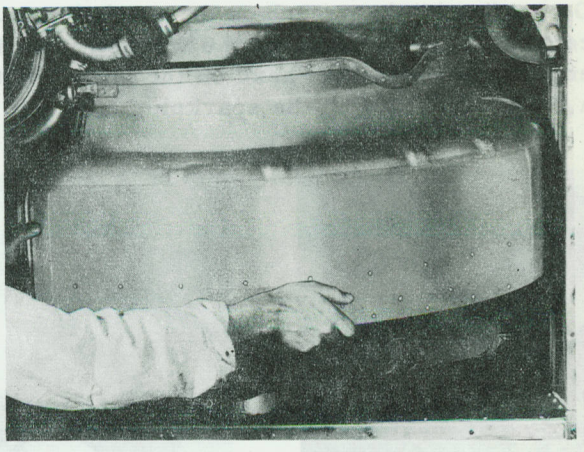


Figure 6-8 Cowling Removal

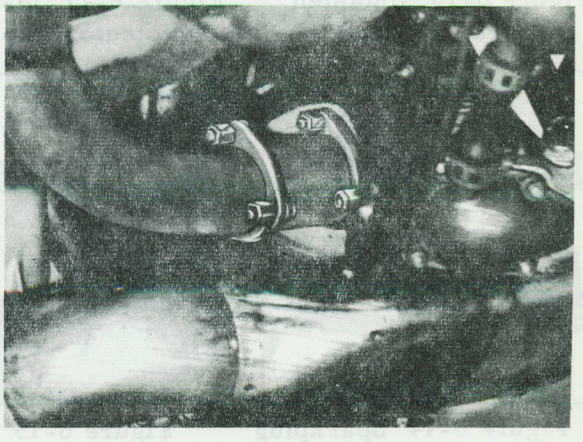


Figure 6-9 Exhaust Piping

INSTALLATION

9 Move the exhaust manifold upward and fasten the exhaust collector to the engine with nuts and bolts.

SPARKPLUG LEAD CONNECTORS AND SPARKPLUGS

REMOVAL

10 Unfasten the sparkplug lead from the sparkplug, using PWA-1683 Wrench (Figure 6-10). Be careful not to allow the elbow to turn or the wrench to slip; then unscrew the nut which secures the sparkplug elbow. Withdraw the ceramic connector from the sparkplug, pulling the lead straight out and in line with the centre line of the sparkplug barrel; then install a suitable protector cap over it (Figure 6-11). Remove the sparkplug using PWA-3168 Wrench (Figure 6-12). Do not "cock" the wrench on the sparkplug; make certain that the "hex" of the wrench is in full engagement with the "hex" on the plug. Install a PWA-3252 Plug in the sparkplug hole. If the plug is difficult to remove, removal may be facilitated in some cases by turning the plug first in a tightening direction and then in a loosening direction.

11 Inspect the firing end of the plug that was removed. If there are any signs of cracked or broken insulators, or bent or melted electrodes, it is recommended that an inspection of the cylinder be made for signs of operational damage to the piston and combustion chamber.

12 After cleaning (Figure 6-13), place removed plugs in a suitable rack or tray (Figure 6-14). If a plug has been dropped or damaged during removal, tag it for future reference. Install new ceramic connectors if necessary (Figure 6-15). After applying compound (Figure 6-16), wipe off excess with a clean cloth (Figure 6-17).

HANDLING

13 All other conditions being ideal, an engine will perform only as satisfactorily as the sparkplugs which are in it. The proper handling and

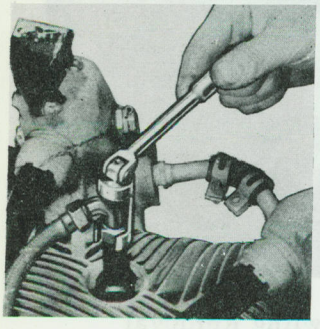


Figure 6-10 Unfasten Sparkplug Lead

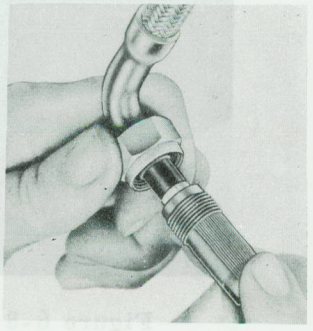


Figure 6-11 Install Protector Cap

Figure 6-12 Remove Sparkplug

Figure 6-13 Clean Sparkplug

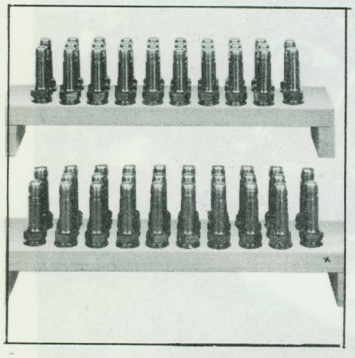


Figure 6-14 Sparkplug Rack

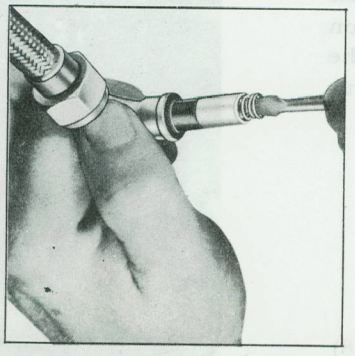


Figure 6-15 Insert Connector

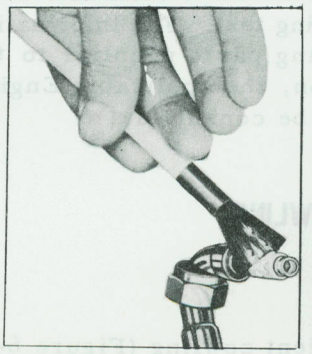


Figure 6-16 Apply Compound

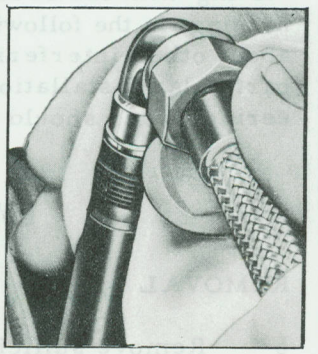


Figure 6-17 Wipe Clean

installation of sparkplugs is very important.

14 In the case of ceramic sparkplugs, shocks such as occur from dropping or striking them against hard objects, or from slipping of a sparkplug wrench can cause an invisible fracture of the ceramic insulation. Therefore, plugs which have been abused in any of the ways mentioned should be rejected. Such plugs might pass bomb and leakage tests only to fail after limited service in the engine.

15 Do not attempt to increase the cap of a ceramic plug by prying the electrodes apart. This will almost certainly result in damage to the plug.

16 Do not disassemble two-piece ceramic sparkplugs.

17 Do not use a metallic wire for the removal of particles of dirt or sand from these plugs. A piece of fibre, a clean straw from a broom, or a wooden toothpick may be used.

18 Do not leave the feeler gauge in the gap while the ground electrodes are being closed. If this is done, pressure thus transmitted to the central electrode will fracture the insulator.

19 Sandblasting time should be held to the absolute minimum, since excessive sandblasting will cause wear of electrodes and insulators. The colour of the ceramic after sandblasting is unimportant, provided the ceramic is clean and free from carbon, and provided the plug passes the bomb test.

20 Thoroughly clean all plugs before bomb testing, and set the gaps. During the bomb test, the plug should fire regularly for 15 seconds in an atmosphere of CO_2 to 200 lbs. pressure. The leakage from the bomb should not exceed 9 times the volume of the bomb in one minute. This is intended as a warning that any excess leakage would cause turbulence within the bomb, and that such turbulence would affect the voltage and cause inefficient operation of the bomb. Inasmuch as it is difficult to measure the volume of leakage, it is suggested that the following alternate check be made to ascertain the efficiency of the bomb: The pressure in the bomb should be brought to 200 lbs./sq. in. and the supply of CO_2 then cut off. The pressure should not drop more than 100 psi in one minute. The source of energy should be a magneto producing 950 to 1950 sparks per minute of alternating polarity. The leads from the magneto should be short (under three feet) and unshielded.

21 During the bomb test, it is immaterial to the performance of the plug if the spark "hunts" or if it fires at one point only. Do not attempt to make adjustments to correct such a condition.

22 Do not overtighten the elbow nut when installing the sparkplug leads, as this will damage the nut or fracture the ceramic sleeve.

23 Sparkplugs should be stored in a hot locker.

PREPARATION OF SPARKPLUGS FOR INSTALLATION

24 Remove sparkplugs from boxes and place in a rack for vapour degreasing.

25 Vapour degrease (trichlorethylene, or equivalent) for 1 to 3 minutes. (A longer period will do no harm.) Vapour degreasing removes preservative, cleans plugs, and removes any accumulated moisture.

26 Remove plugs from degreaser and inspect visually. Use a strong light to inspect the firing end of the insulator and barrel insulation for cracks, dirt, or lead compound accumulation. Observe the condition of the electrodes and inspect for mutilation of threads at the shell and barrel ends of the plug.

27 Check the gap clearance of each electrode with .015 inch "go" and .018 inch "no go" stainless steel piano wire. (Use Starrett pin vise as holder for wire and "roll" wire between the electrodes.) Do not attempt to push it through as an inaccurate gauge will result. The wire will easily "roll" through electrodes of some plugs; whereas the same wire cannot be pushed through. The desired gap is .016 inch; however, if a .015 inch gauge will pass through the electrodes but a .018 inch gauge will not, the gap clearance is satisfactory. Where a plug is found to be closed below the lower limits, no attempt should be made to disassemble the plug or to open the gaps to the specified clearances. Instead, return such plugs to the sparkplug overhaul shop.

28 Bomb check on a BG M519 Tester, or equivalent, at 200 psi. Observe the spark to make certain that it occurs at the electrode and is steady. The plug should be rejected if there is failure to fire steadily at 200 psi or if there is any indication of firing below the electrodes.

INSTALLATION

29 Visually inspect plugs prior to installation. Check the firing end of the ceramic insulator for cracks, dirt and gap setting. Observe the condition of electrodes and inspect for mutilation of threads at the shell and barrel ends of the plug. Never install a plug that has been dropped.

30 Apply anti-seize compound Spec 3GP-802, Ref 34A/58 sparinglyas a thin film on the shell threads, taking special care to coat the first several threads. Make sure that the compound is thoroughly mixed, because after settling, the finely powdered mica or graphite separates from the compound and collects in the bottom of the container. A small brush should be used to apply the compound. Do not apply with the fingers.

31 Visually inspect the condition of the sparkplug insert or bushing and make certain that the top of the sparkplug hole is clean and smooth. Wipe the threads with a clean dry cloth.

32 Making certain that there is a serviceable copper gasket (only one) on the sparkplug, screw the plug into the cylinder with the fingers until the plug bottoms on the gasket (Figure 6-18). If it does not screw in easily, remove and inspect the plug and bushing threads.

33 Minor imperfections of sparkplug threads should be corrected, where possible, by using a small three-cornered file. Avoid use of a die since the threads may be cut too deeply to permit a tight fit of the plug in the bushing. If a die must be used, it should be used by hand without a die holding handle. The die should be checked periodically to be certain it cuts a pitch diameter within the limits 0.6693 to 0.6683 inch.

34 Stainless steel sparkplug inserts or bushings may be cleaned with a stiff fibre or wire brush moistened with a cleaning solvent. The brush must be used so that no bristles will fall into the combustion chamber. The diameter of the brush and the technique used should be such as to preclude the removal of material from the cylinder head surrounding the insert. Special care should be taken on the sparkplug gasket seating surface, since removing material from this location could cause combustion leakage with subsequent damage to the cylinder head. Generally speaking, only a light application of a revolving brush will be required.

35 Bronze bushings may be cleaned by running a 18 by 1,5 millimeter tap through the bushing. Care should be exercised to steady the tap holding wrench to prevent the tap from wobbling, which would cause bell-mouthing of the bushing. The tap should be worked alternately in and out, a fraction of a turn at a time. Coating the flutes of the tap with grease will help prevent foreign matter or chips from entering the cylinder.

CAUTION

Do not use a tap if the cylinder is equipped with stainless steel sparkplug inserts or bushings.

36 Using PWA-3168 Wrench, tighten the spark plug to the recommended torque. Avoid side loading or "cocking" of the wrench.

37 Remove the plastic protector from the sparkplug lead connectors. Wipe hands dry, and wipe the connector clean with a clean cloth moistened in acetone, alcohol, or naptha.

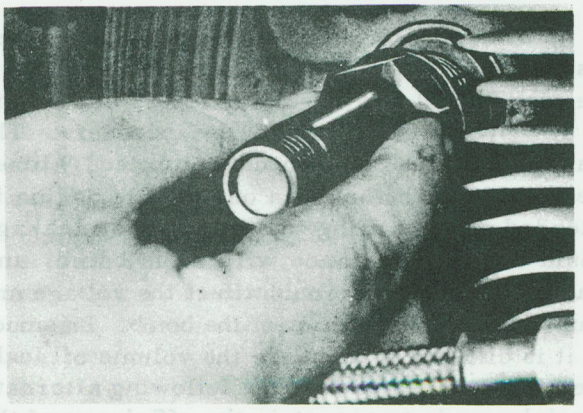


Figure 6-18 Sparkplug Installation

38 Visually inspect the connector and spring. Do not touch with fingers. If necessary, change the spring or insulator and wipe them clean. Apply a light film of Dow Corning Insulating Compound DC4 Ref 33G/49 see EO 15-5B-2 to the connector.

39 Without touching the connector or spring with the fingers, install the connector in the sparkplug barrel. Be very careful that the connector is inserted straight into the barrel and not "cocked", since this can result in a cracked insulator or sparkplug barrel.

40 Run the sparkplug lead coupling nut down finger tight. Hold the elbow or lead in proper position and tighten the elbow coupling nut 15 degrees more, using PWA-3315 Wrench. Never use an open end wrench, since damage to the barrel insulator may result from side loading.

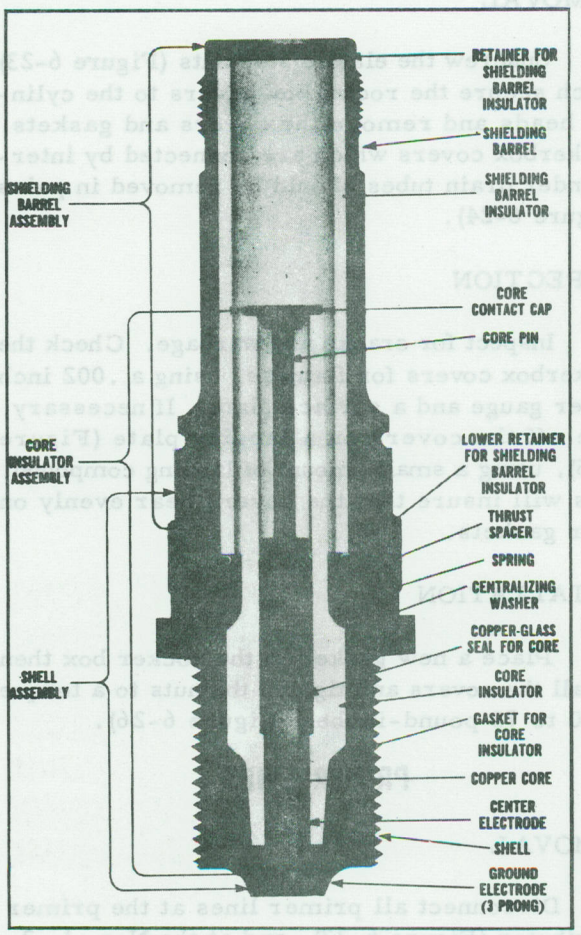


Figure 6-19 Cut-a-way View of Typical Sparkplug

41 Check that the sparkplug leads are not twisted. See Figure 6-19 for cutaway view of a typical sparkplug.

CYLINDER DEFLECTORS

REMOVAL

42 Remove the nuts that secure tha cylinder head deflectors to the cylinders. Release the spring loaded clamp (Figure 6-20) on the rear side of the inter-cylinder deflectors and remove the cylinder head deflectors. Remove the wing nuts (Figure 6-21) which secure the inter-cylinder deflectors to the retaining clamps; then remove the clamps and deflectors. The deflector between No. 7 and No. 8 cylinder cannot be removed until the clamp underneath the deflector has been loosened and the tee hose connection has been with-

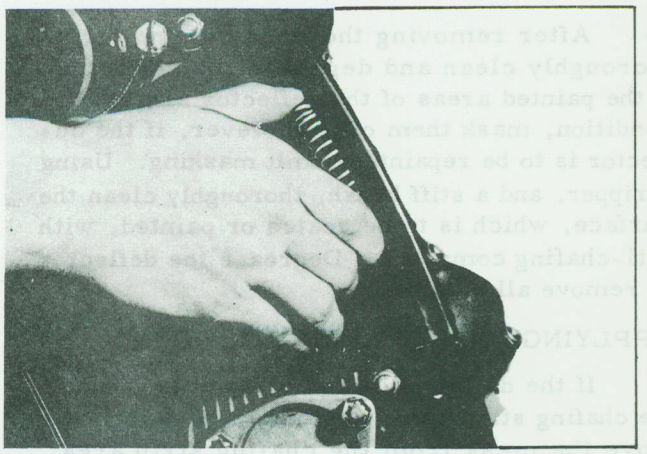


Figure 6-20 Spring Loaded Clamp

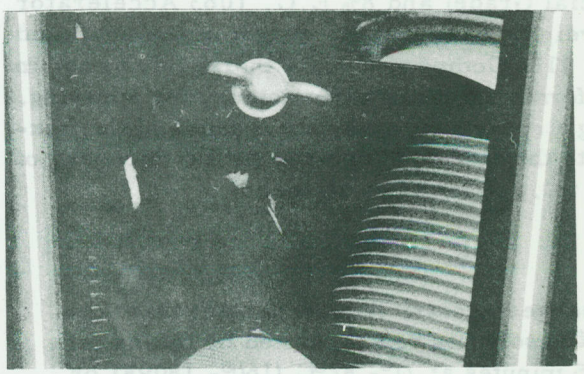


Figure 6-21 Wing Nut

drawn from the deflector. Tag each deflector as it is removed so that it will be reinstalled in its proper location.

INSPECTION

43 Examine the deflectors for dents, bonding, and the condition of the paint.

INSTALLATION

44 Install the head deflectors (Figure 6-22) and secure them with the necessary nuts. Assemble the inter-cylinder deflectors and secure them with the clamps and wing nuts.

CYLINDER DEFLECTOR CHAFING STRIP

REMOVAL OR WORN SHEET-TYPE CHAFING STRIPS

45 After removing the worn chafing strip, thoroughly clean and degrease the deflector. If the painted areas of the deflector are in good condition, mask them off. However, if the deflector is to be repainted, omit masking. Using stripper, and a stiff brush, thoroughly clean the surface, which is to be coated or painted, with anti-chafing compound. Degrease the deflector to remove all stains.

APPLYING ANTI-CHAFING COMPOUND

46 If the deflector is to be repainted, mask the chafing strip area, apply the new paint, remove the mask from the chafing strip area, and bake in accordance with the Overhaul Instructions. Dilute one part of E.C. 1186 Compound, with one to two parts Ethylene Dichloride (Commercial Grade) and 8% E.C. 1063 Accelerator (by weight, based on the weight of the undiluted E.C. 1186 Compound). Mix thoroughly to obtain a uniform mixture of a consistency for spraying. Using a spray gun, apply heavy coats of the mixture to the chafing strip area until a thickness of .018 to .028 inch is obtained.

NOTE

Between coats, it is important that volatile solvents be evaporated by baking for 15 minutes at 71°- 82°C (160°- 180°F) or by air-drying at room temperature for 30 minutes.

47 After the final coat has been applied, remove the mask from the painted areas and bake the deflector for 1 hour at 126°- 154°C (260°- 310°F).

STRIPPING ANTI-CHAFING COMPOUND

48 Thoroughly clean and degrease the deflector. If the painted areas are in good condition, mask them off. Immerse the area of the deflector from which the old chafing compound is to be stripped in a tank containing a 10% solution of nitric acid for 10 minutes. After rinsing the part twice thoroughly in air-agitated cold running water, dry the part and inspect. Apply anti-chafing compound as described above.

ROCKERBOX COVERS

REMOVAL

49 Unscrew the elastic stop nuts (Figure 6-23) which secure the rockerbox covers to the cylinder heads and remove the covers and gaskets. Rockerbox covers which are connected by inter-cylinder drain tubes should be removed in pairs (Figure 6-24).

INSPECTION

50 Inspect for cracks and warpage. Check the rockerbox covers for flatness, using a .002 inch feeler gauge and a surface plate. If necessary, face off the covers on a lapping plate (Figure 6-25), using a small amount of lapping compound. This will insure that the covers bear evenly on their gaskets.

INSTALLATION

51 Place a new gasket on the rocker box then install the covers and tighten the nuts to a torque of 60 to 75 pound-inches (Figure 6-26).

PRIMER LINES

REMOVAL

52 Disconnect all primer lines at the primer distributor (Figure 6-27), and at the Nos. 1, 2, 3, 8, and 9 cylinders to which they are attached (Figure 6-28). Unfasten the clamps holding them to the intake pipes (Figure 6-29), and withdraw

each line from the cylinder deflector through which it extends.

INSPECTION

53 Look for breaks, dents, pinched tubing, and broken unions. If necessary, exchange with new primer lines.

INSTALLATION

54 Connect all primer lines at the primer distributor and insert the lines through the deflectors. Attach them to the appropriate cylinders. Fasten the clamps holding them to the intake pipes and supercharger section.

INTAKE PIPES

(Figure 6-30)

REMOVAL

55 Remove the lockwire and loosen the nut at the supercharger section using PWA-237 Wrench (Figure 6-31). Remove the nuts and bolts at the cylinder end (Figure 6-32), then remove the pipe. Install PWA-3800 Protector in the intake port opening.

INSPECTION

56 Inspect for dents and cracks. Check condition of paint. Examine the nuts for thread and wrench slot condition. Change packing if it is not in good condition.

INSTALLATION

57 Install a flat rubber seal at the supercharger end of each intake pipe after first coating the seal with a thin even coat of insulating compound. Remove the supercharger case opening protector and place the pipe in position on the engine. Install the blower end of each pipe first and tighten the packing nut finger tight. Coat a copper gasket

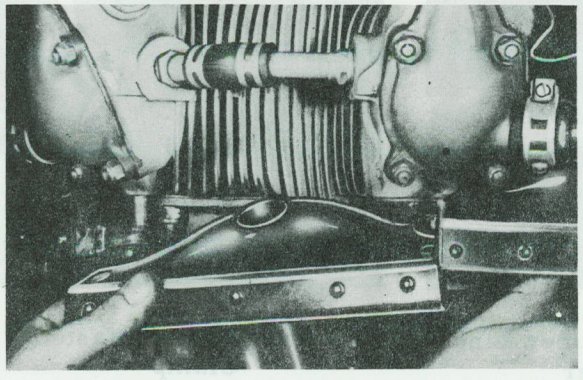


Figure 6-22 Deflector Installation

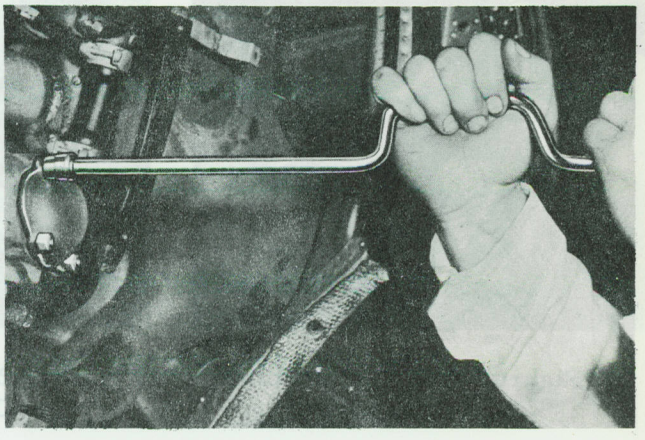


Figure 6-23 Stopnut Removal

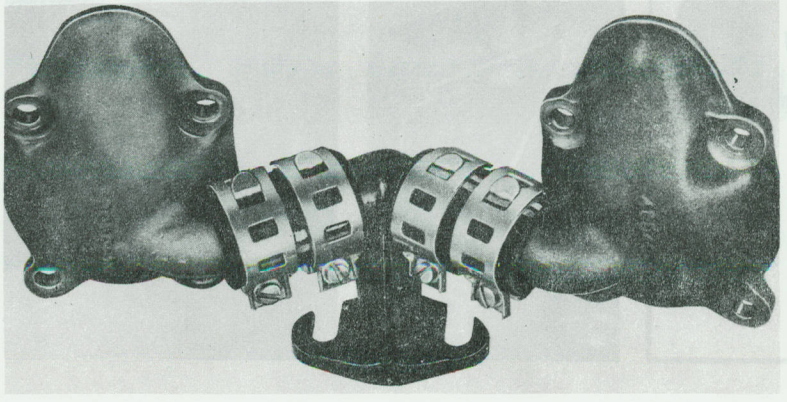


Figure 6-24 Rockerbox Covers

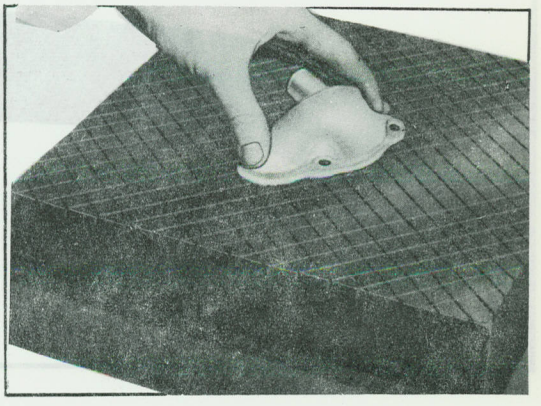


Figure 6-25 Lap Cover

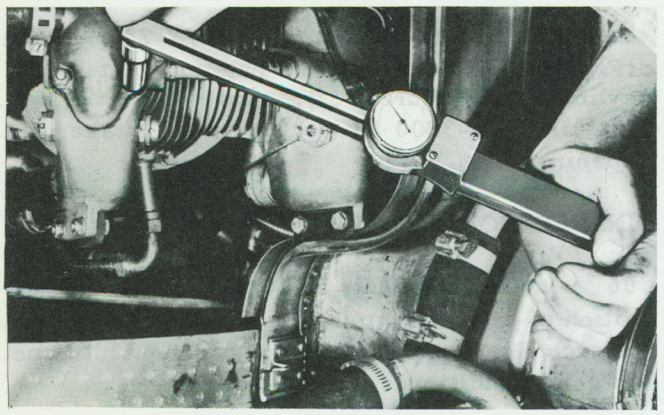


Figure 6-26 Torque Cover Nuts

with insulating compound; then install, split-side forward, at the cylinder intake port. Secure the pipe to the cylinder with the nut and bolts and lockwire (Figure 6-33). Tighten the packing nut, using PWA-237 Wrench.

NOTE

Dow Corning No. 4 Compound has remarkable properties as a non-hardening, non-softening preservative, lubricant and sealant at temperatures of -40° F to +500° F. As such, it tends to prevent the rapid oxidation and consequent hardening of intake pipe and

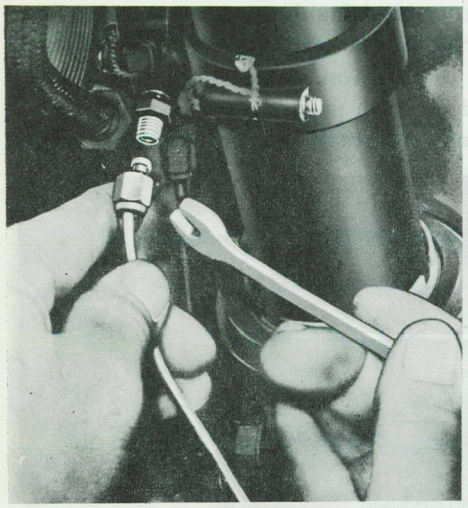


Figure 6-27 Primer Line at Distributor

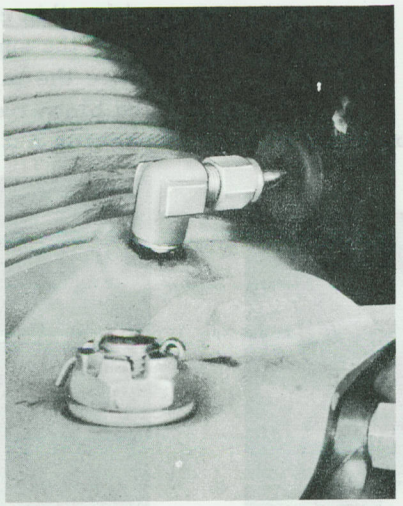


Figure 6-28 Primer Line at Cylinder

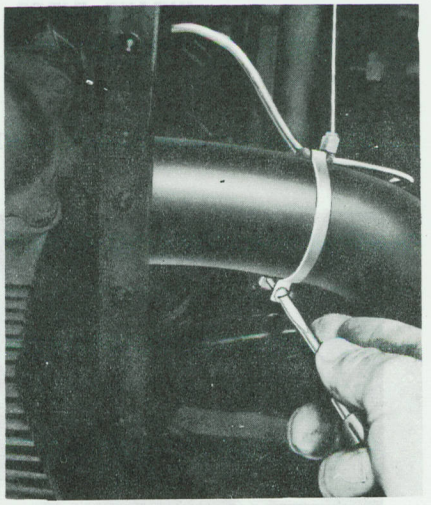


Figure 6-29 Unfasten Clamp

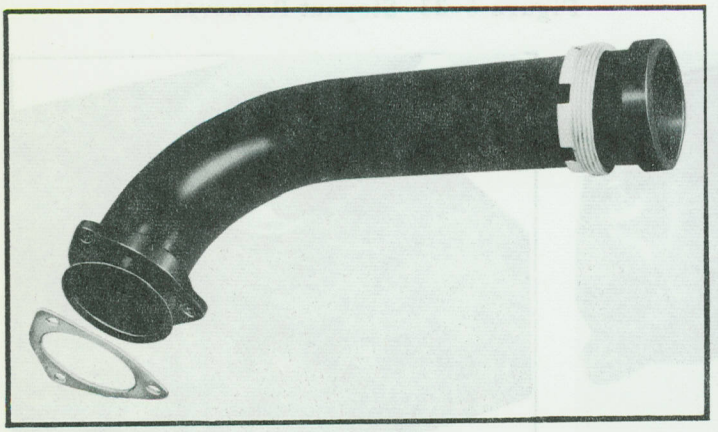


Figure 6-30 Intake Pipe

Figure 6-31 Remove Nut at Supercharger

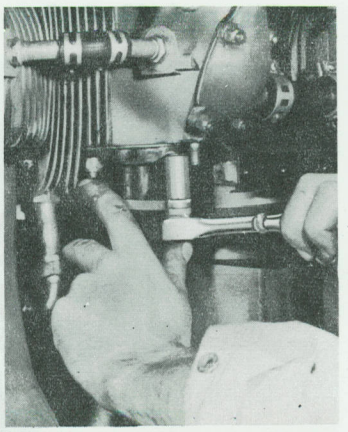


Figure 6-32 Remove Nuts at Cylinder

pushrod tube packings. It reduces friction to minimize the possibility of false torquing, acts as an excellent sealant, and prevents stickage at disassembly.

CAUTION

The compound contains minutely ground silica and mica which may act as irritants to the eyes and skin. When the compound is handled frequently, it is suggested that gloves be worn.

PUSHRODS AND COVERS

(Figure 6-34)

REMOVAL

58 Before removing the pushrods of a cylinder, make sure that the piston of the cylinder is near the top of its compression stroke. If the piston is not near the top of its compression stroke, turn the propeller until the piston is in the proper position (both valves closed). Loosen all pushrod cover nuts at the cylinder ends first; then at the crankcase ends using PWA-3639 Wrench. Depress the rockers with PWA-455 Depressor (Figure 6-36) and remove

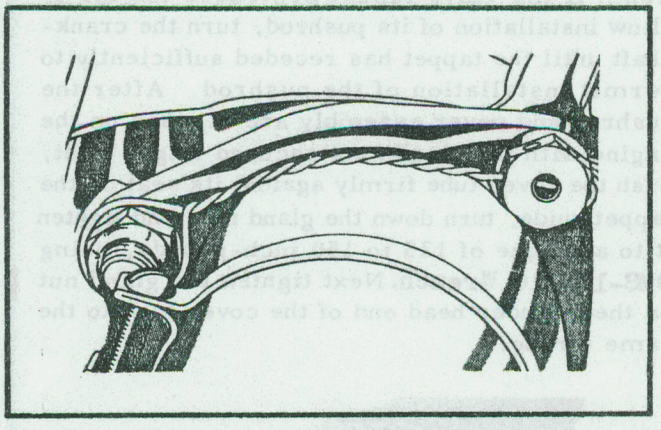


Figure 6-33 Secure Pipe to Cylinder

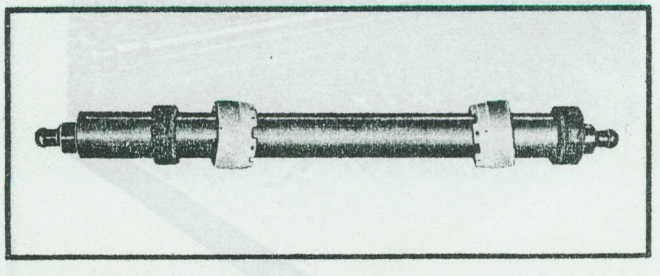


Figure 6-34 Pushrod and Cover

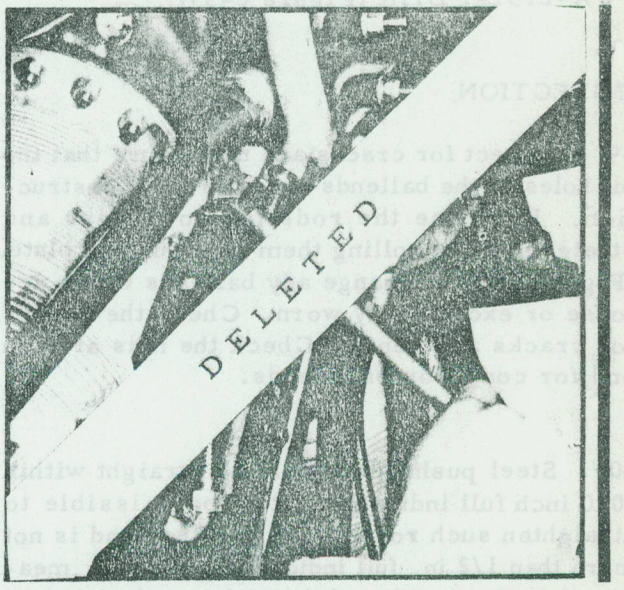


Figure 6-35 Loosen Pushrod Cover

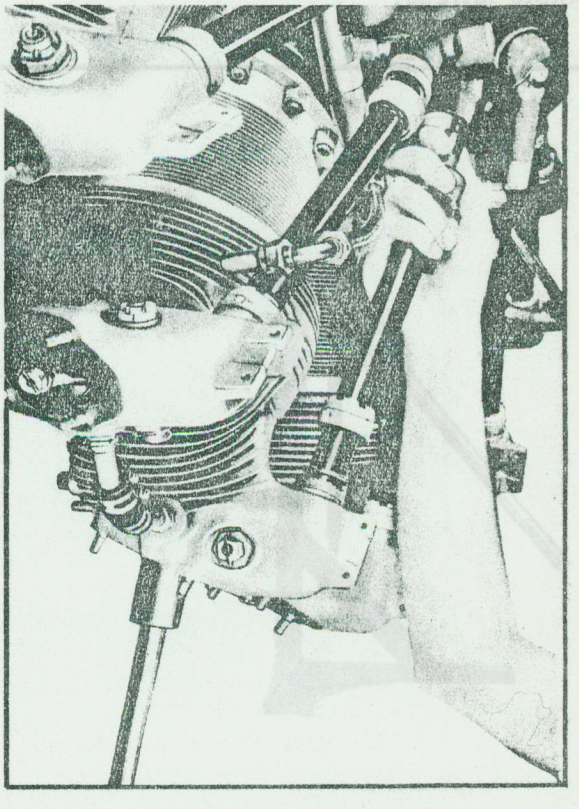


Figure 6-36 Depress Rocker

the pushrods and covers. If desired the ballends may be removed using PWA-4353 Fixture or PWA-2151-1 Drift (Figure 6-37).

INSPECTION

59 Inspect for cracks and make sure that the oil holes in the ballends are free from obstruction. Examine the rods for roundness and straightness by rolling them on a surface plate. (Figure 6-38). Change any ballends which are loose or excessively worn. Check the covers for cracks and dents. Check the nuts at each end for condition of threads.

60 Steel pushrods should be straight within .010 inch full indication. It is permissible to straighten such rods as long as the bend is not more than 1/2 in. full indication or 1/4 in. measured in the centre of the rod in relation to a straight reference. There should be no sharp corners or dents to act as stress raisers and promote fatigue.

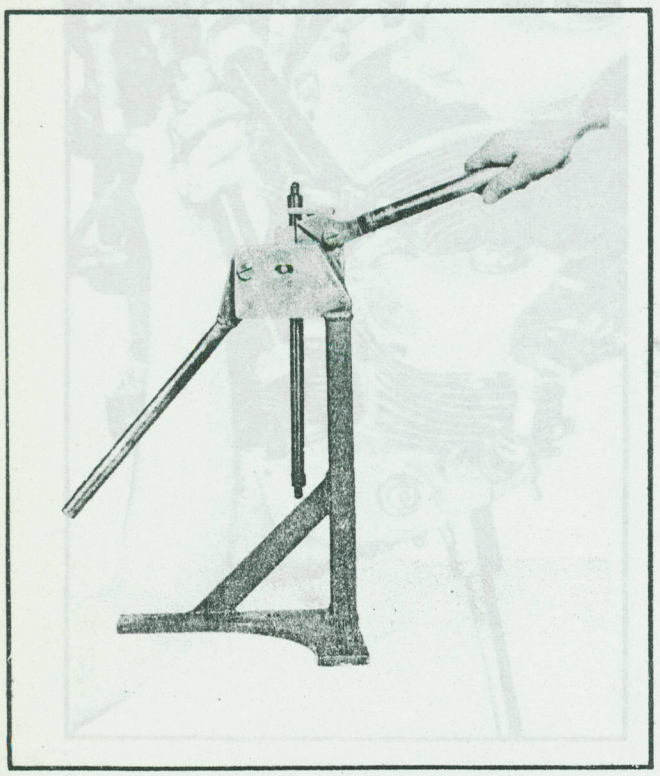


Figure 6-37 Ball-end Removal

INSTALLATION

61 The pushrod ballend that contacts the tappet bears the number of the cylinder into which it fits. The exhaust rods are marked "Ex" after the cylinder number and the intake rods are marked "In". Apply a thin even coat of Dow Corning No. 4 insulating compound to the oil seal packing rings, if a black seal is being used.

NOTE

Do not apply Dow Corning No. 4 when red seals are used. Red seals are used during the manufacture of new engines and are incorporated in the spare pushrod cover assemblies.

62 Install the packing rings in place in each gland nut. Coat the ballends of each rod with oil. Assemble the pushrod and cover assembly with the marked end of the pushrod and the flared end of the cover tube toward the crankcase. Depress each rocker with PWA-455 Depressor and fit the corresponding pushrod and cover into position. If the valve tappet protrudes too far to allow installation of its pushrod, turn the crankshaft until the tappet has receded sufficiently to permit installation of the pushrod. After the pushrod and cover assembly are in place on the engine with the gland nuts secured finger tight, push the cover tube firmly against its seat on the tappet guide, turn down the gland nut, and tighten it to a torque of 125 to 150 inch-pounds, using DMS-196010 Wrench. Next tighten the gland nut on the cylinder head end of the cover tube to the same torque.

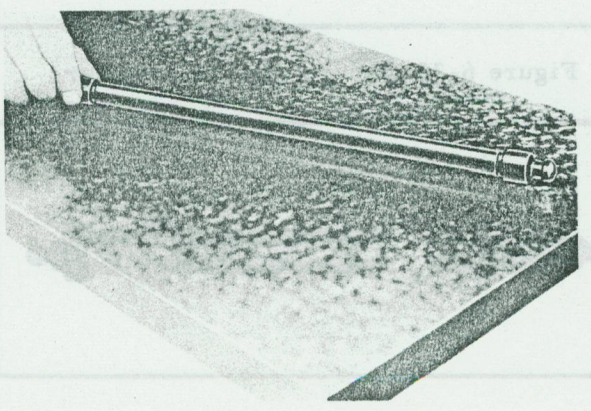


Figure 6-38 Straightness Check

ROYAL CANADIAN AIR FORCE

EO 10A-10AA-2
19 Nov 57

ADVANCE REVISION

Serial #3 dated 26 Jul 60
(Sheet 1 of 2)

The sheets of this Advance Revision are to be inserted in the EO as follows:-

Sheet 1 facing page 91
Sheet 2 facing page 92

Part 5, Section 3, Page 91, para. 54, line 11-

Delete - "Observe the following instructions before removing cylinders:"

Insert the following:

Observe the following instructions before removing cylinders and ensure that EO 10A-10AA-2C is conformed with prior to re-installation:-

ISSUED ON AUTHORITY OF THE CHIEF OF THE AIR STAFF

ADVANCE REVISION

Serial #3 dated 26 Jul 60
(Sheet 1 of 2)

The sheets of this Advance Revision are to be inserted in the EO as follows:-

Sheet 1 facing page 91
Sheet 2 facing page 92

Part 6, Section 3, Page 91, para. 64, line 1:-

Delete - "Observe the following instructions before removing cylinders:"

Insert the following:

Observe the following instructions before removing cylinders and ensure that EO 10A-10AA-2C is conformed with prior to re-installation:-

CAUTION

Never reverse the above sequence of operation as it might cause the packing on the tappet guide end to be pushed into the tappet compartment. Eventual mutilation of the packing during engine operation would result.

63 If the pushrod cover was not removed from the crankcase, install the marked end of the pushrod toward the crankcase and guide the pushrod into the rocker socket while the cylinder is being installed on its pad. Check the valve stem-rocker clearance. Adjust if necessary as directed in Section 1.

NOTE

Not more than six threads (1/4 in.) or fewer than three threads (1/8 in.) of a valve adjusting screw should show above the locknut; and there should be a clearance of not less than .031 inch between the outer valve spring washer and the rocker with the valve closed. If the clearance between the valve spring washer and the rocker is less than .031 inch or if more than six threads on the adjusting screw show above locknut, the flat face of one or both of the pushrod ball end spacers may be ground, or the spacer can be changed for a thinner one or eliminated entirely, at one or both ends of the pushrod, to obtain the desired clearance. If fewer than one and one-half threads of adjusting screw show above the locknut, a thicker spacer should be used at one or both ends of the pushrod.

DISASSEMBLY OF CYLINDER

PRELIMINARY INSTRUCTIONS

64 Observe the following instructions before removing cylinders:

65 Remove the masterod cylinder (No. 5) last when its removal with one or more cylinders becomes necessary. If all cylinders are to be removed the following sequence should be observed: No. 6, No. 7, No. 8, No. 9, No. 1, No. 2, No. 3, No. 4, and No. 5.

66 Remove sections of the distributor air intake tubes, oil scavenge tube, or any tubes and controls which interfere with cylinder removal. Disconnect the pushrod covers and remove the interfering intake pipes and exhaust stack extensions.

REMOVAL

67 Turn the propeller shaft until the piston in the cylinder to be removed is at the top of its stroke (compression stroke for preference.) Remove the palnuts and remove the cylinder hold down nuts with PWA-2397, PWA-2006 or PWA-2399 Wrench in conjunction with PWA-2398, PWA-2240 or PWA-2411 Handle. Do not remove the top hold-down nut until just prior to the cylinder removal (Figure 6-39). Support the cylinder with both hands while the top hold-down nut is being removed; then withdraw the cylinder straight out from the engine (Figure 6-40).

CAUTION

Do not allow the masterod to move sideways at any time, as damage to the piston rings and cylinder may result.

68 After removal of the cylinder, push the pistonpin from the piston, using PWA-4251-10 Pusher. Lift the piston from the linkrod and remove the rings from the piston with PWA-1791 Pliers. Place the cylinder in an appropriate carrier to prevent damage to the pins and the bottom edge of the barrel.

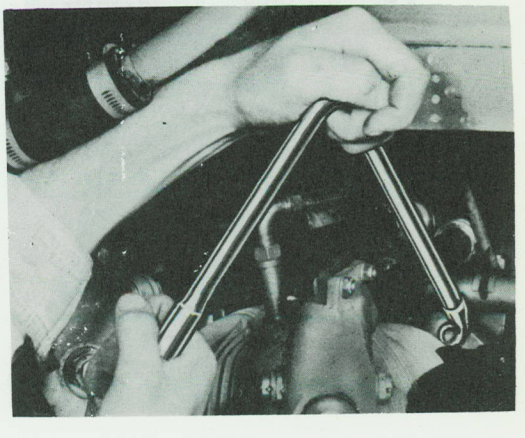


Figure 6-39 Top Hold-Down Nut Removal

NOTE

If a nut is found to be loose or there has been failure of a stud, change that stud and the two adjacent studs in accordance with paragraph 127. If only two adjacnet studs have failed or two adjacent nuts have been found loose, the cylinder may be reused provided the nuts adjacent to the failed studs or to the loose nuts are found to be at least to the minimum torque. If more than two adjacent studs have failed or if more than two adjacent nuts are known to have been loose during engine operation, the cylinder should be returned to overhaul, and all the studs on the cylinder mounting pad renewed.

INSPECTION OF CYLINDER PARTS

NOTE

If facilities are inadequate for the repair or exchange of defective parts, change the cylinder for a complete new assembly, including new piston and rings which have been run in or lapped.

CYLINDER BARRELS

69 Using PWA-2630-20 Gauge, and pencil carbon paper, check the cylinder hold-down flange for flatness and squareness. If the flange is uneven or distorted and the distortion does not exceed .003 inch, lap the flange, using PWA-2898 Lap (Figure 6-41). If the distortion exceeds .003 inch, change the cylinder assembly. If a cylinder has never been subjected to stud failure, the flange may be lapped flat to the minimum dimensions shown (Figure 6-42). If a cylinder has been subjected to stud failure and the flange warpage has not exceeded .003 inch, the flange may be lapped flat to a maximum of .003 inch, but in no case below the minimum dimensions shown (Figure 6-42). If, however, a cylinder which has been subjected to stud failure and which has once been lapped, is again subjected to stud failure, it must be scrapped or rebarreled.

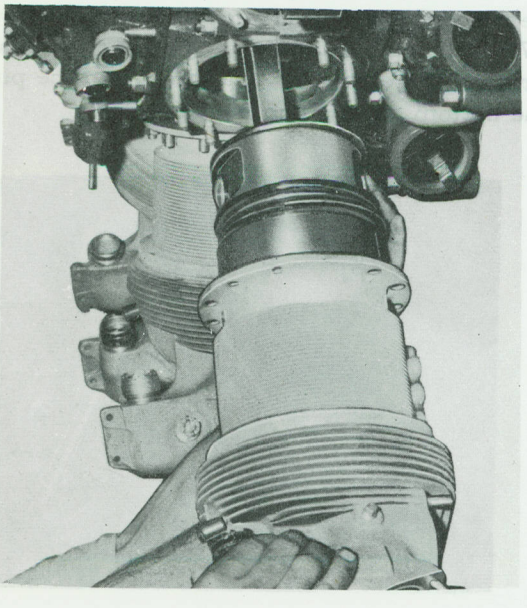


Figure 6-40 Cylinder Removal

CYLINDER FIN BREAKAGE

70 If more than 8 inches in length of any one fin is completely broken off or if the total fin breakage on any one cylinder head exceeds 20 square inches, the cylinder must be changed. Where adjacent fins are broken in the same area, the total permissible length of breakage is 6

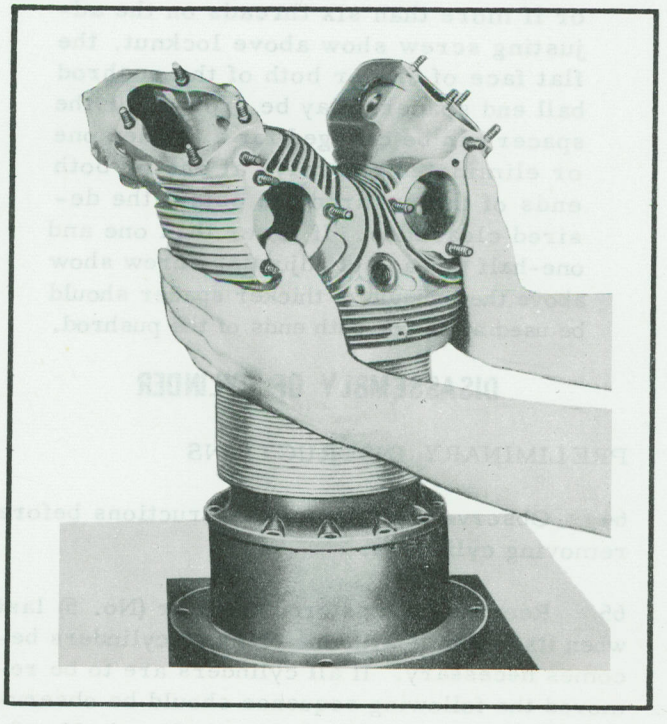


Figure 6-41 Lap Flange

Part 6, Section 3, page 92, para. 68 (Note), line 4

Delete para. 127.

Insert para. 107.

inches on any two adjacent fins and 4 inches on any three or more adjacent fins.

NOTE

The length limits given are measured at the base of the fin. "Fin area" is the total area exposed (both sides of fins) to cooling air.

CYLINDER HOLD-DOWN NUTS AND STUDS

71 All cylinder studs and hold-down nuts should be examined for cracks, damaged threads and other visible defects. Clean the threads of the studs and nuts thoroughly, using a hand wire brush if necessary. Remove any roughness or burrs on the nuts, studs, or cylinder flanges. See NOTE in paragraph 68.

PISTONS

72 Inspect the pistons for cracked heads and skirts, broken or distorted ring lands, scored or worn pistonpin holes, excessive carbon deposits, broken rings, or rings seized in their grooves. Rings may be removed with pliers (Figure 6-43). Clean the ring lands (Figure 6-44). Inspect the piston head for dishing, using PWA-3140 Gauge. Change the piston and rings together with the cylinder if necessary.

PISTONPINS

73 Inspect the pistonpin for scoring, cracks, excessive wear, rust pitting, and out-of-roundness. Check the fit of each pistonpin in its bushing in the corresponding linkrod and in its bosses in the corresponding piston.

NOTE

If during a cylinder change, it is found that the engine incorporates heavy duty pistonpins Part 354954, the pistonpin in the affected cylinder, if serviceable, should not be replaced by the lighter pistonpin Part 234221, supplied in the cylinder kit. If the heavy duty pistonpin, in the affected location is found to be unserviceable, pistonpin Part 234221 may be installed. However, due to the weight difference between the heavy duty pistonpins Part 354954 and the superseded parts, not more than two of the lighter pistonpins Part 234221 are to be installed in an engine incorporating the heavier pins.

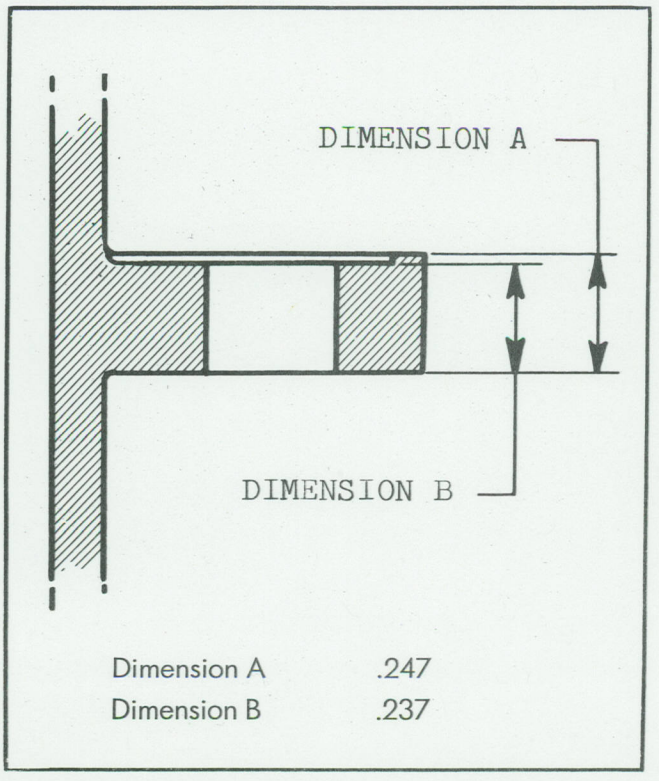


Figure 6-42 Flange Minimum Dimensions

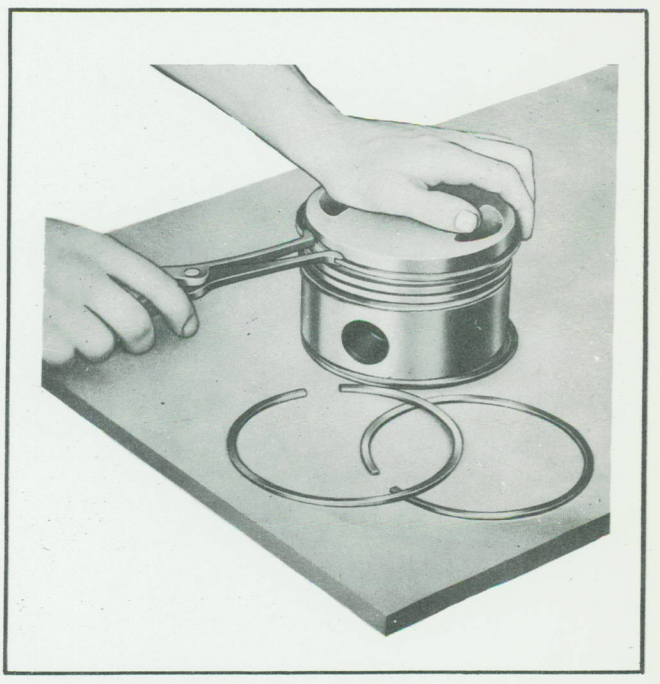


Figure 6-43 Remove Rings

FAILED CYLINDERS

74 Experience has proved that an engine which has suffered a valve or cylinder head failure may be successfully returned to service if the cylinder assembly is changed. In order to understand the success of this practice, it is necessary to review the circumstances which cause cylinder head and valve failures.

75 Cylinder heads usually fail when the tensile strength of their material has been lowered by excess heat and when the pressure inside the cylinder is extremely high. These

two factors can cause rupture of the head. The same conditions may exist in other cylinders which do not fail, and they regain their tensile strength when they have cooled. Because of this regeneration, it is clear that the cylinders are not permanently weakened by the excessive temperatures and pressures to which they are subjected.

76 Exhaust valve failures can usually be traced to an adverse condition in the particular cylinder in which they fail. For instance, there may have been insufficient valve clearance, valve sticking, high cylinder head temperature, or other factors which tend to weaken the valve.

77 Although experience has proved that engines with valve or cylinder head failures may be successfully returned to service, it is not recommended that all engines subjected to these failures be kept in service. Before changing the cylinder be certain that no metal particles have entered the engine. Examine the linkrod to ascertain whether or not it has been bent or damaged Make visual check of all combustion chambers to determine whether or not they have been damaged in any way. Examine the pushrods for damage also.

78 After the installation of a new cylinder assembly, a complete compression check should be made. The engine should then be given a complete ground check. After this ground check, a second compression check should be made. In addition, make a thorough visual check of the engine, paying particular attention to the condition of the cylinder hold down studs, cylinder heads, and combustion chambers.

79 After the exchange of a cylinder assembly, operate the engine in accordance with a recommended run-in schedule.

INSTALLATION OF CYLINDER AND PISTON

NOTE

Before reusing any cylinders refer to paragraphs 64 to 79.

80 If the masterod cylinder (No. 5) has been removed, it must be installed first. Coat the cylinder walls, pistonpin, piston, and piston-rings with oil. Install a new rubber oil seal ring under the hold down flange of the cylinder. Rotate the crankshaft until the masterod or linkrod of the cylinder is at the full outward position. Each piston, pistonpin, and cylinder has a number denoting its proper position. Install the piston and pin with their numbered sides toward the front of the engine (Figure 6-45).

Figure 6-44 Clean Ring Lands

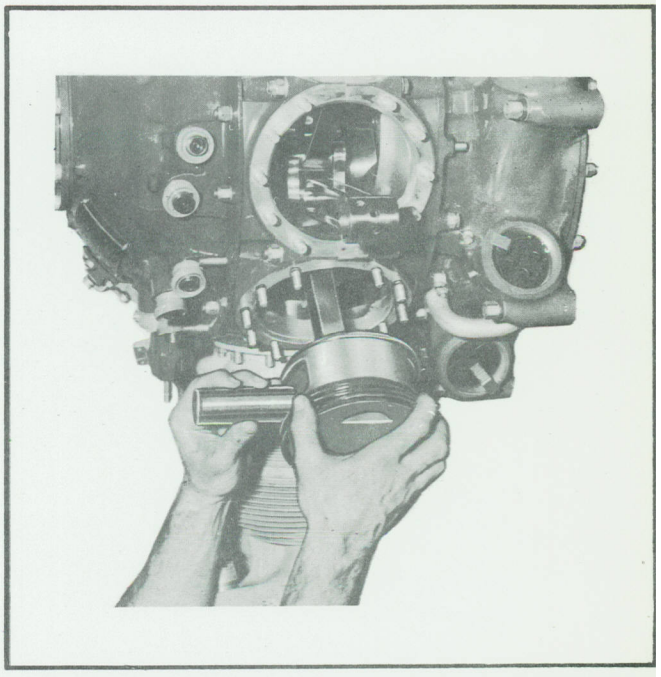


Figure 6-45 Piston Installation

81 Stagger the ring gaps (Figure 6-46) and apply a generous coating of oil to the rings; then compress the outer rings, using PWA-249 Clamp, and slide the cylinder over the rings (Figure 6-47). Compress the scraper ring with the clamp; then slide the cylinder over the ring and into place against the mounting pad. Centre the cylinder with two locating nuts and install washers and nuts on the other studs. Tighten the hold-down nuts to a torque of 300 to 350 pound-inches (Figure 6-48), using PWA-2006, PWA-2397, or PWA-2399 Wrench, and PWA-2398 or PWA-2411 Handle. Install palnuts over the hold-down nuts, running them down finger tight. Tighten the palnuts 1/4 turn with PWA-1608 Wrench.

82 Install the pushrods and covers as directed in paragraphs 63 and 64, then check the valve stem to rocker clearance as directed in Section 1 paragraph 14.

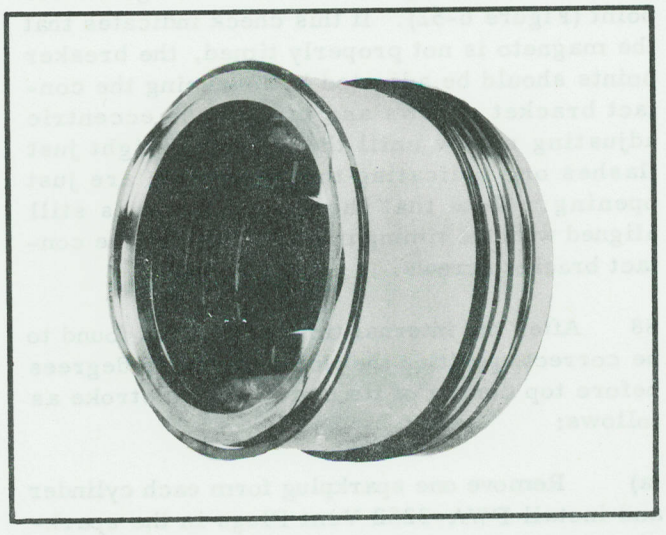


Figure 6-46 Ring Gaps

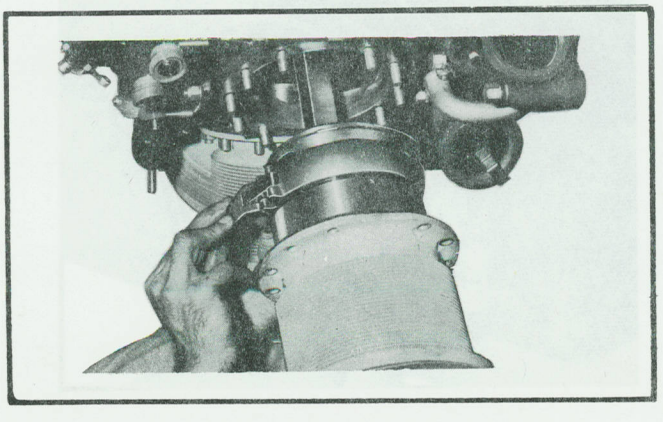


Figure 6-47 Cylinder Installation

83 Regardless of the number of cylinders being exchanged, the engine is to be run-in for 1/2 hour at 1000 rpm, 1/2 hour at 1400 rpm, and 1/2 hour in short spurts to 2000 rpm. During this run-in the cylinder head temperature should not exceed 205°C (400°F).

CAUTION

Because of the special design of cylinder hold-down nut wrenches, care should be exercised in tightening hold-down nuts. See that the cylinder hold-down nut wrench, the extension, and the torque indicating handle are so assembled that the handle is directly opposite the box end of the wrench, and apply torque by rotating the assembly as a unit. Do not let the shaft of the wrench twist to one side.

MAGNETOS

(Figure 6-49)

REMOVAL

84 Loosen the knurled coupling which secures the flexible conduit of its distributor block cover

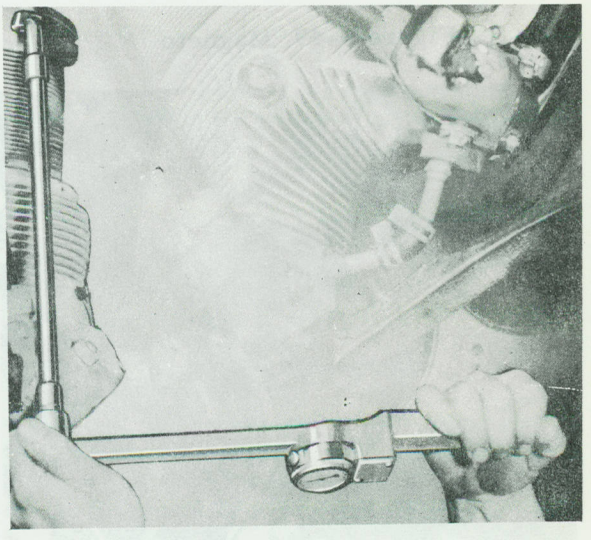


Figure 6-48 Torque Hold-Down Nuts

elbow using PWA-1886 Wrench. Remove the screws which secure the elbow to the distributor block cover.

85 Remove the screw which secures the distributor block halves of the magneto. Remove the safety pin, disengage the two spring locks on the distributor block cover; then remove the cover halves (Figure 6-50). Lift out the distributor blocks and wrap each block in oiled paper.

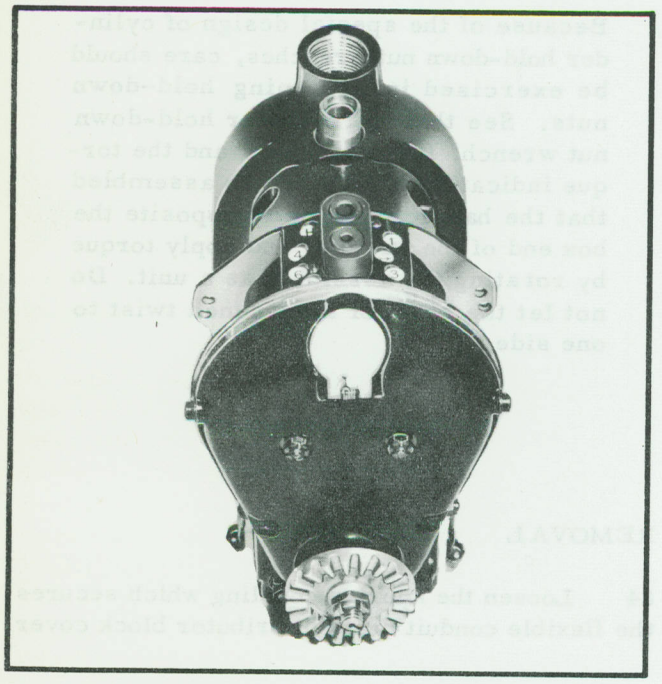


Figure 6-49 Magneto

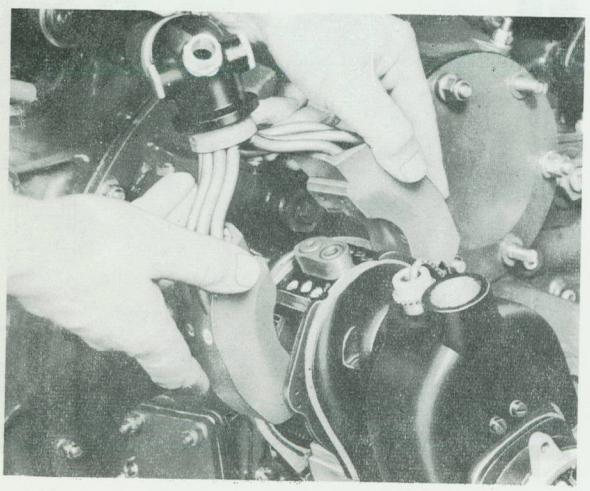


Figure 6-50 Remove Distributor Cover

86 Remove the three bolts which secure the magneto to its mounting pad and lift off the magneto and rubber coupling.

INSTALLATION

87 Before installing a magneto on the engine, the internal timing of the magneto to should be checked (Figure 6-51). To do this, remove the breaker compartment cover. Attach the red wire of PWA-2417 Indicator to the breaker points and ground the black wire to the magneto housing. Place a straightedge against the step on the breaker cam and turn the magneto drive shaft in the normal direction of rotation. The light of the indicator should flash on just as the straightedge comes into alignment with the timing marks on the magneto housing. The timing marks shown through the timing window should align at this point (Figure 6-52). If this check indicates that the magneto is not properly timed, the breaker points should be adjusted by loosening the contact bracket screws and turning the eccentric adjusting screw until the indicator light just flashes on, indicating that the points are just opening. Note that the straightedge is still aligned with the timing marks. Tighten the contact bracket screws.

88 After the internal timing has been found to be correct, position the No. 1 Piston 25 degrees before top centre of its compression stroke as follows:

(a) Remove one sparkplug form each cylinder and install PWA-3252 Vent Plugs in the sparkplug holes.

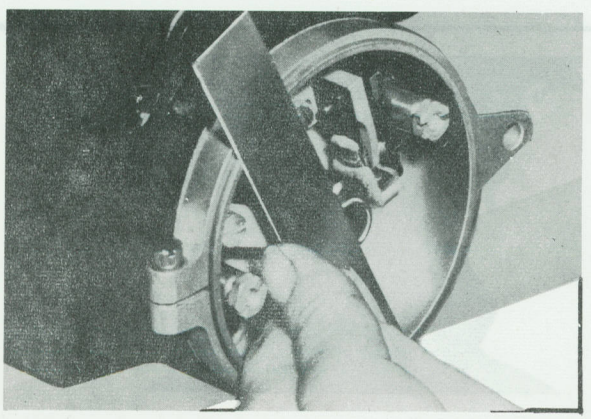


Figure 6-51 Internal Timing

(b) Turn the engine crankshaft by means of the cooling fan or the propeller until the piston of No. 1 cylinder is at the beginning of the compression stroke.

(c) Install the PWA-4142 Indicator in the top of front sparkplug hole of No. 1 cylinder (Figure 6-2A). Use pivot arm A with hook end UP.

(d) 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 6-2B).

(e) Turn the propeller shaft in the direction of rotation until the pivot arm pushes the slide pointer to its farthest point (Figure 6-2C). Turn the propeller shaft about 90 degrees in the opposite direction. This will return the pivot arm to the top of the slot. 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 6-2D).

(f) Move the slide pointer up to align with the 25 degree mark on the scale (Figure 6-2E).

(g) Turn the propeller shaft in the normal direction of rotation until the pivot arm just contacts the slide (Figure 6-2F). At this point the lower light on the indicator should flash on. The No. 1 piston is now positioned 25 degrees before top centre.

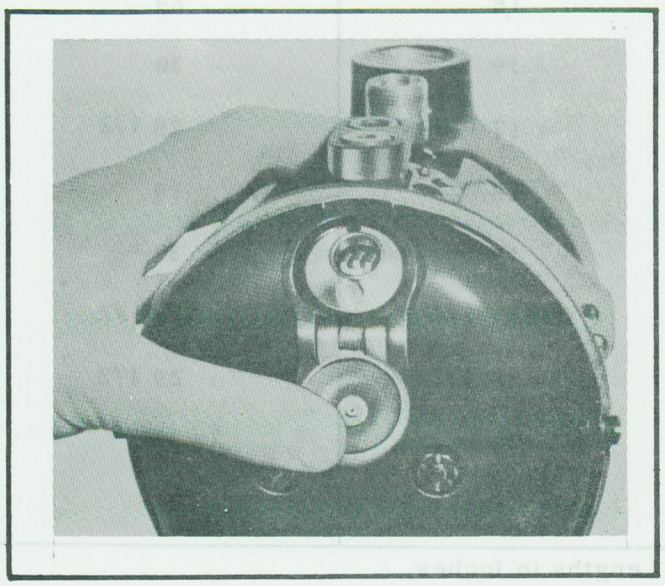


Figure 6-52 Timing Window

89 Mount the left or right magneto on the engine without installing the rubber coupling. Measure the distance between the magneto drive shaft and the magneto shaft couplings, making sure that the two shafts are at their maximum distance apart. Rubber couplings are provided 1/32 inch oversize, indentified by "B + 1/32 inch" moulded on the face. The rubber coupling used should be .020 inch to .030 inch less in thickness than the distance between the two metal couplings. Remove the magneto from the engine.

90 With a locally manufactured locking tool (Consult E015-5ADB-2) in lieu of a straightedge in exact alignment (Figure 6-3) and with the rubber coupling in place (Figure 6-53), rest the magneto on the magneto mounting pad (Figure 6-54). Hold the magneto in place and rotate the rubber coupling between the two metal couplings until the rubber coupling can be engaged with the metal couplings without causing the magneto shaft to turn. Fit the magneto over the two dowel pins on the mounting pad (Figure 6-55). Secure the magneto with the three bolts. Install the distributor block halves; (Figure 6-56), the distributor cover (Figure 6-57) and tighten the knurled coupling. Check to see that the magnetos are properly synchronized as directed in Section 1, paragraph 9. After this check has been completed, lockwire the three magneto retaining bolts (Figure 6-58).

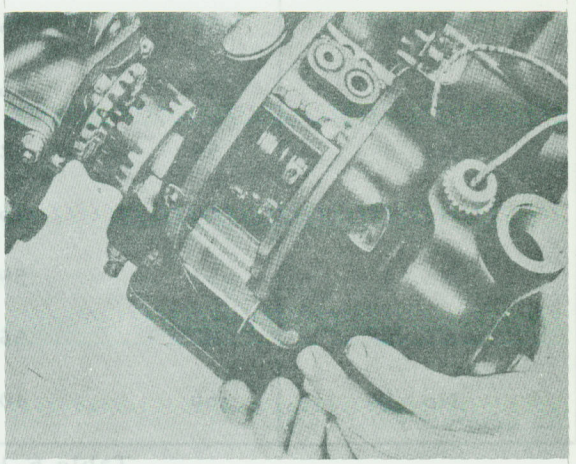


Figure 6-53 Rubber Coupling

CHANGING IGNITION CONDUIT LEAD

91 If a continuity or high voltage test indicates a defective lead, change the lead as follows:

(a) Remove the connector at the sparkplug end of the lead, and the sparkplug lead conduit from the ignition cable assembly. Loosen the coupling nut on the conduit and slide the conduit towards the rear. Remove the lead from the distributor block. Determine in which direction the lead will pull the easiest; then splice and solder the new lead into the opposite end of the old lead. Dust the lead with Talc Ref 33C/11 see EO 15-5B-2 to prevent friction. Push the new lead through as the old lead is slightly pulled out. When the new lead is through far enough, cut if off to the proper length.

(b) Remove 1/2 inch of insulation from the distributor block end of the lead, being careful not to cut any of the lead strands. Separate the strands and bend them back along the insulation. Mark a new copper ferrule with the proper number, using a metal stamp; then install the ferrule and secure it with a crimping tool. Place the lead in its proper hole in the distributor block and secure it with the piercing screw. Push the wire through the sparkplug lead conduit; then secure the conduit to the manifold.

(c) Remove 1/8 inch of insulation from the lead, being careful not to cut any of the lead strands. The insulation must bear firmly against the brass disc inside the sparkplug connector. Treat the ends of the insulation with an insulating lacquer. After the lacquer has dried, slide the connector into position on the wire. Bend the strands back over the lead opening in a radial pattern. Do not solder the lead.

OIL PRESSURE RELIEF VALVE

REMOVAL

92 Remove the acorn shaped cap from the oil pressure relief valve. Remove the oil pressure relief valve body, then withdraw the spring and plunger. Use PWA-671 Wrench (Figure 6-59) to remove the valve seat from the rear case (Figure 6-60).

INSPECTION

93 Check the tension of the relief valve spring.

No. of Distributor Block	Total Length		Wire Length from Rear Conduit to Left Magneto	Wire Length From Front Conduit to Right Magneto
	Front Conduit	Rear Conduit		
No. 1	53	37	18	29
No. 2	47	55	19	30
No. 3	58	66	17 1/2	28 1/2
No. 4	71	46	18	29
No. 5	58	32	19	30
No. 6	46	46	17 1/2	28 1/2
No. 7	53	59	18 1/2	29 1/2
No. 8	82	55	29	31
No. 9	66	40	19	30

Table 6-1 Lead Lengths in Inches.
(R985 Engines Equipped with SB9RN Magnetos)

Note the condition of the valve in the valve seat. Lap these parts 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.

INSTALLATION

94 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 valve

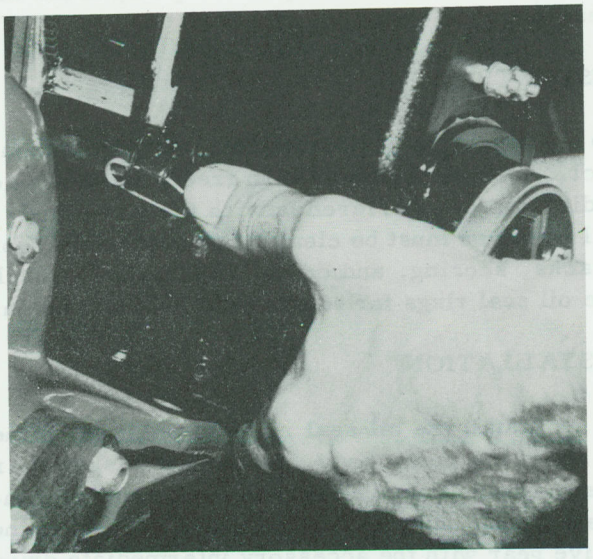


Figure 6-54 Magneto Pad

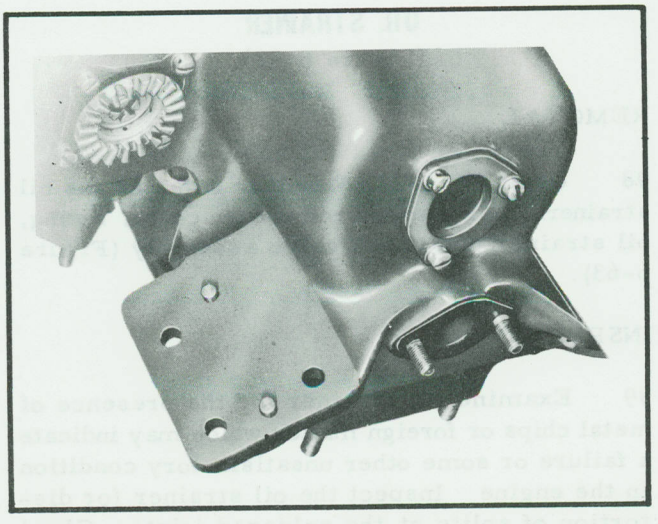


Figure 6-55 Pad Dowel Pins

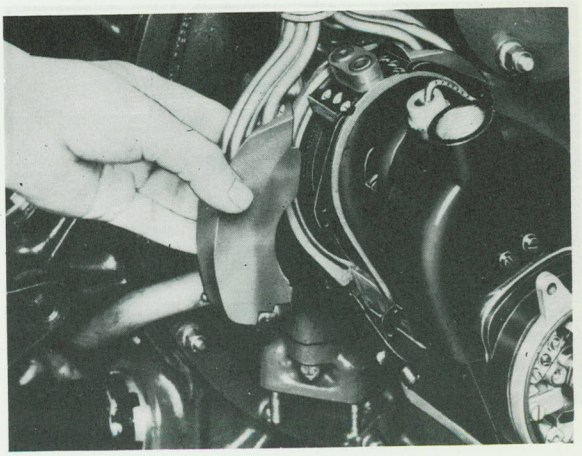


Figure 6-56 Distributor Block

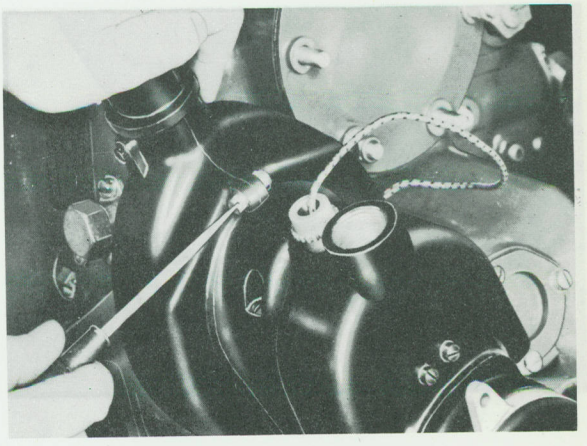


Figure 6-57 Install Distributor Cover

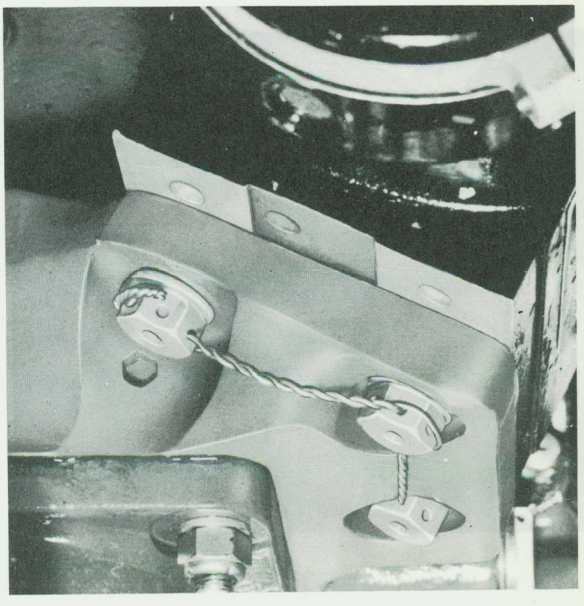


Figure 6-58 Retaining Bolts Wirelocked

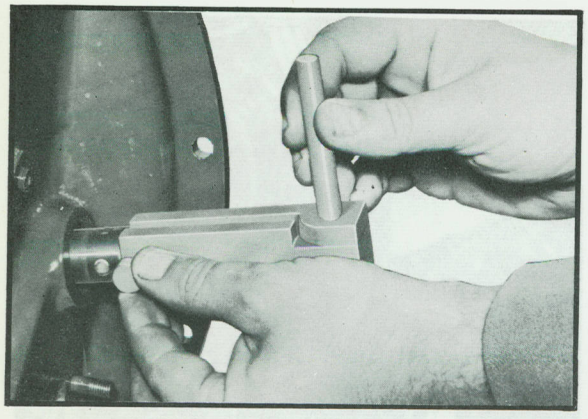


Figure 6-59 PWA-671 Wrench

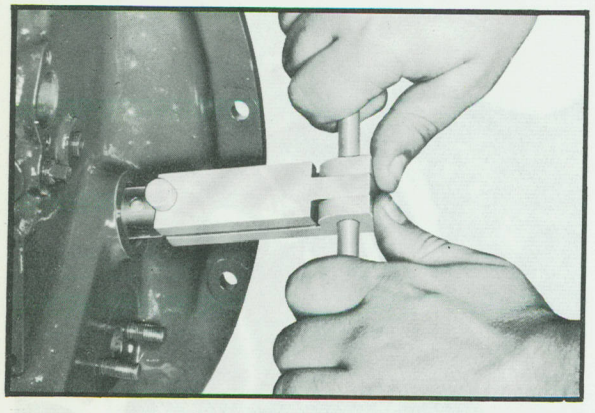


Figure 6-60 Remove Valve Seat

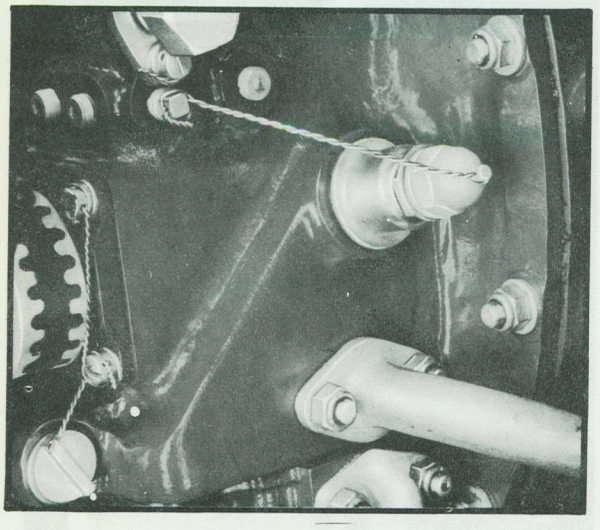


Figure 6-61 Wirelock Cap

body into the rear case. Adjust the engine oil pressure. (See Part 2 for oil pressure limits). Install a gasket and screw the acorn shaped cap on the outer end of the valve body. Lockwire the cap to the adjacent squarehead plug (Figure 6-61).

OIL PUMP

(Figure 3-11)

REMOVAL

95 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.

INSPECTION

96 Inspect the teeth for pitting and uneven contact. The gears should turn freely and show no indication of interference with the pump body. Oil passages must be clean. Inspect the body for cracks, scoring, and condition of paint. Check the oil seal rings for scoring and loss of tension.

INSTALLATION

97 Install the oil seal rings in position on the O.D. of the pump body. 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.

OIL STRAINER

(Figure 6-62)

REMOVAL

98 Using PWA-228 Wrench, unfasten the oil strainer cover nut;then remove the cover, spring, oil strainer and check valve assembly (Figure 6-63).

INSPECTION

99 Examine the strainer for the presence of metal chips or foreign matter which may indicate a failure or some other unsatisfactory condition in the engine Inspect the oil strainer for distortion of splits at the soldered joints. Check the fit of the strainer in its chamber in the rear

case. Inspect 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.

INSTALLATION

100 Insert the check valve assembly, oil seal and oil strainer into the chamber in the rear case. Install the gasket and cover. Tighten the cover with PWA-228 Wrench. Lockwire the cover.

OIL SUMP

(Figure 6-64)

REMOVAL

101 Unscrew the elastic stop nuts which secure the rocker box covers of cylinders No. 5 and No. 6 which are next to the sump. Disconnect the hose connecting them to the sump and remove the covers and hose. Remove the suction tubes from the rear of the sump. Remove the nuts which fasten the upper ends of the tubes to the right hand side of the rear section. Unfasten the clamps and remove the tubes. Unscrew the four nuts securing the oil sump to the engine, using a 1/2 inch universal socket and ratchet. Pull the sump from the engine (Figure 6-65) taking care not to damage the oil pressure tubes which fit into the sump.

INSPECTION

102 Inspect the sump for cracks and condition of the paint. Seating surfaces must be clean and smooth. Check scavenge strainer for distortion and condition of soldered joints. Make sure that the strainer is thoroughly cleaned before it is reinstalled.

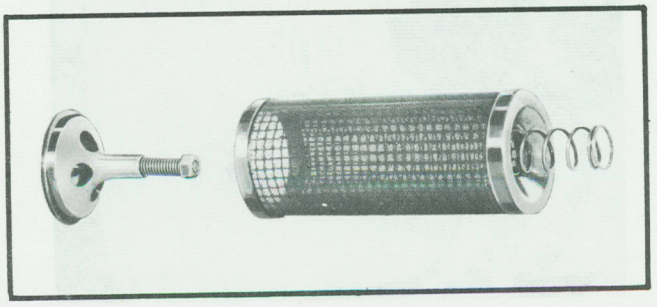


Figure 6-62 Oil Strainer

INSTALLATION

103 Place the inter-cylinder sump deflector on the sump while the latter is still on the bench and secure it. Use a 3/8 inch box wrench and a screw driver. Screw the oil drain plugs into the bottom of the sump and tighten them with a 2 inch box wrench. Place a new gasket on each mounting

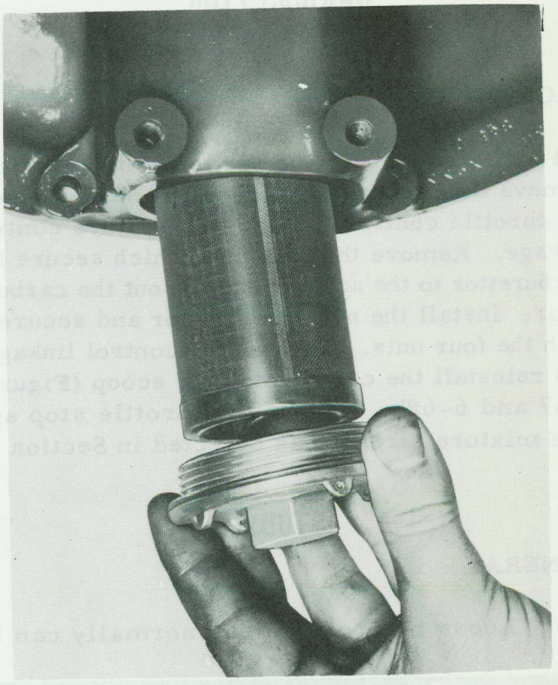


Figure 6-63 Strainer Removal

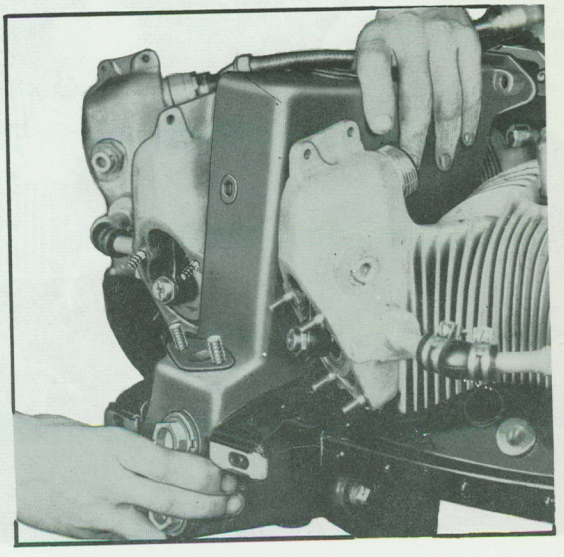


Figure 6-64 Oil Sump

flange of the sump. Place the sump on its mounting pads. Screw the fibre nuts on the studs using a 1/2 inch universal socket and speed handle. Secure the two oil suction tubes to the sump and rear case, tightening the nuts with a 1/2 inch socket and speed handle, and install the tube clamps. Reinstall rocker box covers and hose connections.

CARBURETTOR

(Figure 6-66)

PROCEDURE

104 Depending upon the particular installation, remove the carburettor air scoop and disconnect the throttle control linkage and mixture control linkage. Remove the four nuts which secure the carburettor to the adapter and lift out the carburettor. Install the new carburettor and secure it with the four nuts. Connect the control linkages and reinstall the carburettor air scoop (Figures 6-67 and 6-68). Adjust the throttle stop and idle mixture strength as directed in Section 1.

STUDS

GENERAL

105 Loose or broken studs normally can be changed without damage to the threads in the hole. Select the proper oversize stud. Broken studs can generally be removed by using the hole in the flange of the mating part as a guide for a drill which is used to spot a centre in the broken stud after which a smaller drill is used to drill out the central portion of the stud. Drive some type of steel extractor, such as an Easy-Out or a home made extractor, into the drilled centre and turn out the broken stud with a wrench on the extractor. To facilitate stud removal,

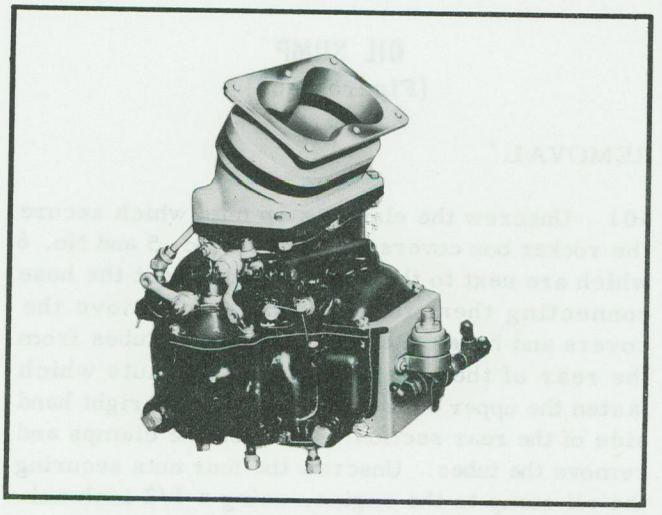


Figure 6-66 Carburettor and Adapter

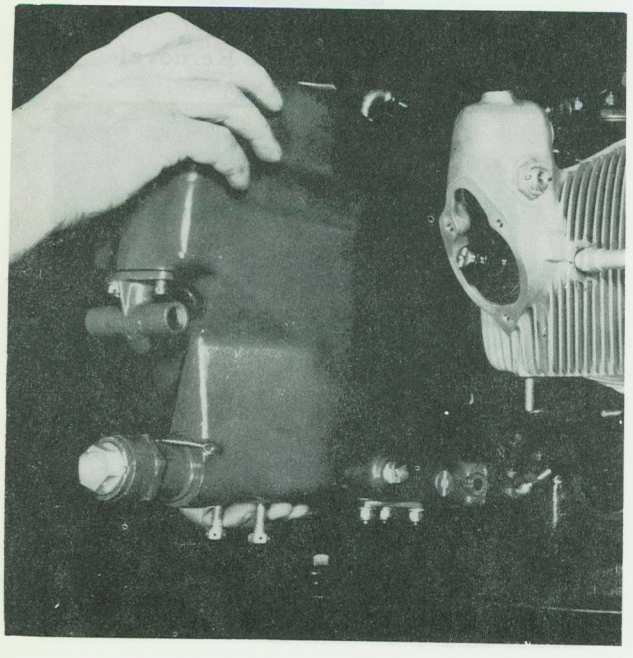


Figure 6-65 Sump Removal

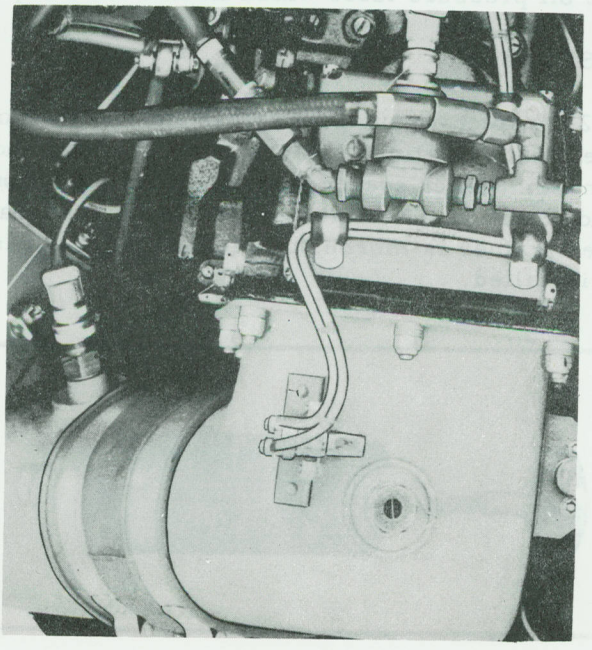


Figure 6-67 Airscoop

head may be applied to the particular locality. If a small amount of damage is noted in the threads of the hole where the stud was removed, clean the threads with an oversize tap.

106 Figure 6-69 illustrates the various methods of marking oversize studs for identification. The identifying mark is on the anchor end of the stud. The conical projection or green dye for .004 inch oversize studs, the conical cup or red dye for .008 inch oversize studs, and the drilled hole or purple dye for .012 inch oversize studs are the Pratt & Whitney Aircraft standard identifying marks. The other marking methods are illustrated because they are used by various vendors and may be encountered in the field.

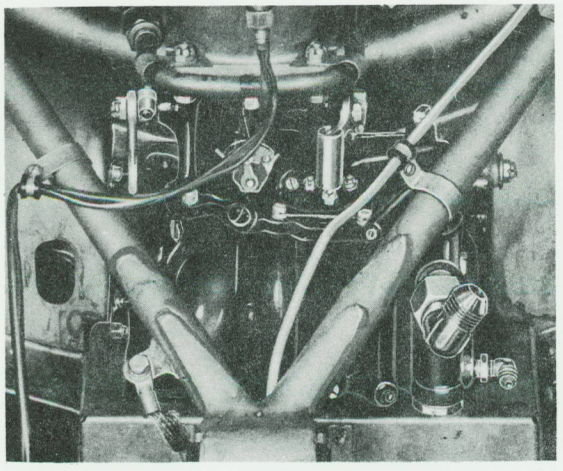


Figure 6-68 Carburettor Installation

CAUTION

When installing an oversize stud in a stud hole which goes completely through a part, make sure that the anchor end of the stud does not project beyond the hole sufficiently to cause interference with other parts. If necessary, file off the anchor end enough to insure against such interference; then reidentify the stud with the proper oversize mark.

107 If one or two cylinder flange studs on any one cylinder pad have failed, change the failed studs and change the studs on each side of the failures. If more than two studs have failed inspect and, if necessary, lap the cylinder flange as directed in paragraph 69. Change all of the flange studs for the cylinder pad.

THREADED INSERTS

108 If a threaded insert is to be changed, drill out any lock pins; then remove the insert, using the proper tools. Install new inserts with the proper driver; drill new lock pin holes if necessary and install new lockpins. Refer to the EO 10A-10AA-3 for detailed insturctions.

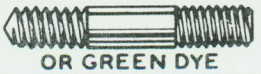
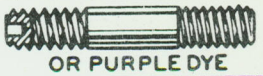
OVERSIZE	+.004 in.	+.008 in.	+.012 in.
P. & W. A. STANDARD	 OR GREEN DYE	 OR RED DYE	 OR PURPLE DYE
STAMPED NO. WITH PREFIX +			
STAMPED NO. WITHOUT PREFIX			
STAMPED OR SCRIBED LINE			
STAMPED OR SCRIBED LINE			

Figure 6-69 Oversize Stud Markings

ADVANCE REVISION

Serial #4 dated 18 Jan 61
(Sheet 1 of 1)

The sheet of this Advance Revision is to be inserted in the EO as follows:-

Sheet 1 facing page 104

Part 6, Section 3, page 104, para. 109.

CRANKCASE THROUGH BOLT WASHERS

INSPECTION

109 Inspect the crankcase through bolt washers Part 186 for cracks. Any washers found cracked are to be entered in the L14-1A and inspected each primary inspection to ensure that no part of the washer has fallen out. When it is found that part of the washer has fallen out unit is to request MRP or fly in repair as per EO 00-50-1, this request is to include information on which way the crankcase through bolts are installed i.e., whether head of the bolt is to the front or rear of the engine.

PART 7

LIMITS AND TORQUE RECOMMENDATIONS

SECTION 1

LIMITS

GENERAL

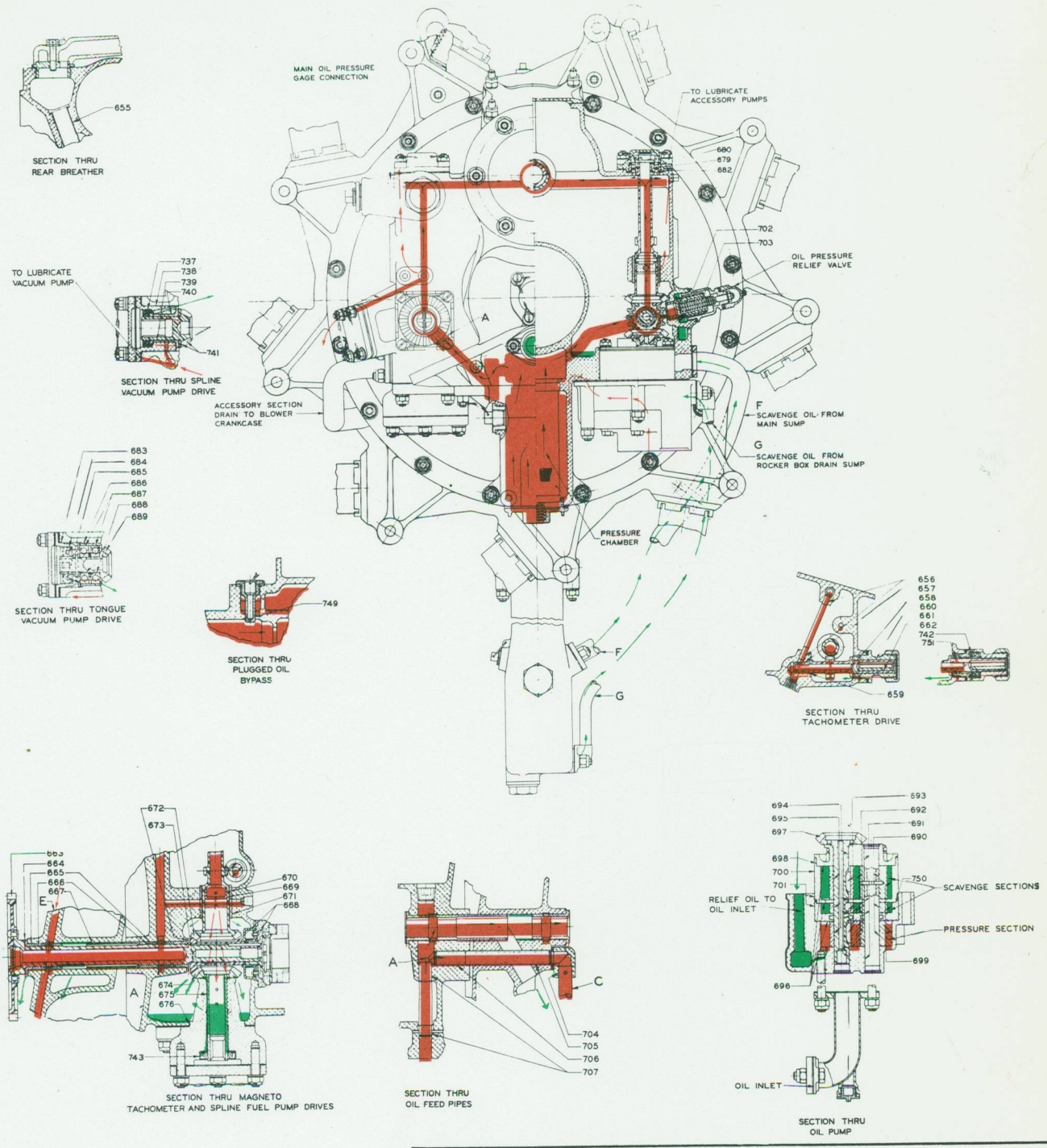
1 These tables should be used in conjunction with the Limits and Lubrication Charts, (Figures 7-1, 7-2, 7-3 and 7-4). The letters "L" and "T" are used to represent loose and tight fits, respectively. The symbol "*" indicates that worn parts should be changed if any looseness is found. The symbol "<" in the Exchange column indicates that, contrary to the column heading, the spring should be changed when its rate is less than the limit. The expression "Fit To" indicates that a fitting operation may be necessary at assembly to obtain the required fit. The expression "By Selection" indicates that it may be necessary to select other parts or relationships of parts to obtain the required fit. Unless otherwise specified, fits are diametrical. Reference numbers not listed in the following table but appearing in the Limits and Lubrication Charts are required only in overhaul procedures, and are covered in EO 10A-10AA-3 Repair and Overhaul Instructions.

REFERENCE NUMBER	NAME OR DESCRIPTION	MINIMUM	MAXIMUM	EXCHANGE
7	Propeller Shaft Thrust Bearing Spacer Pinch - Thrust Bearing Cover (Fit To)	.004T	.008T	*
28	Pushrod Ball Socket - Valve Tappet	.0005T	.0025T	*
29	Pushrod Ballend - Socket (Refer to EO 10A-10CA-3)			
35	Pushrod Ball Socket - Valve Rocker	.0005T	.0025T	*
36	Pushrod Ballend - Pushrod	.0015T	.0035T	*
37	Inside Inlet Valve Spring Pressure (Dia. of Wire .154) at 1-1/2 in.	53 lb.	56 lb.	< 48 lb.
38	Outside Inlet Valve Spring Pressure (Dia. of Wire .183) at 1-1/2 in.	68.5 lb.	72.5 lb.	< 64 lb.
39	Inlet Valve Guide - Valve	.0015	.004	.010
42	Valve Adjusting Screw Ball Socket (Fit To)	.0005	.007	.020
43	Cold Valve Clearance (Inlet and Exhaust)	.010	.010	
44	Spring (Inside) Exhaust Valve (Dia. of Wire .162) at 1-1/2 in.	62.25 lb.	65.25 lb.	< 58 lb.
45	Spring (Outside) Exhaust Valve (Dia. of Wire .192 at 1-1/2 in.	79.5 lb.	83.5 lb.	< 75 lb.
46	Exhaust Valve Guide - Valve	.003	.0055	.010

Table 7-1 Table of Limits

REFERENCE NUMBER	NAME OR DESCRIPTION	MINIMUM	MAXIMUM	EXCHANGE
49	Rocker Bearing - Valve Rocker	.0005T	.0015T	*
50	Rocker Bearing - Rocker Shaft	.000	.0008	.0015
301	Pistonring - End Clearance			
	Five Groove Piston, Tapered Bore (Rectangular and Wedge Type Rings)			
	Top Groove	.052	.062	
	2nd Groove	.0515	.0585	
	3rd Groove	.0515	.0585	
	4th Groove	.0515	.0585	
	5th Groove	.0115	.0185	
	(With Chrome-Moly Barrels Using Compression Ring in Place of Scraper Ring)			
	5th Groove	.0515	.0585	
302	Pistonring Side Clearance			
	Five Groove Piston (Wedge Type-Top Three Rings)			
	Top Groove	.002	.006	
	2nd Groove	.002	.006	
	3rd Groove	.002	.006	
	4th Groove	.0035	.007	
	5th Groove	.001	.0035	
	(Wedge Type Ring Clearance is Measured with Outer Face of Ring Flush with Piston)			
303	Pistonpin - Piston (Light Hand Push Fit When Parts are Oiled and at Room Temperature)			.003
304	Plug, Piston Pin - Pin (Service Fit)	.0015	.0002T	
305	Cylinder Barrel - Piston	.018	.022	.028
306	Pistonpin Bushing - Pin	.017	.0033	.005
347	Magneto Drive Oil Seal Housing - Rear Crankcase	.000	.012	
348	Magneto Drive Oil Seal Housing - Oil Seal	.001T	.007T	*
652	Oil Return Check Valve - Valve Guide	.0005	.0035	
653	Oil Return Check Valve Spring Pressure at 13/16 in.	2.25 lb.	2.75 lb.	< 1.75 lb.
654	Oil Strainer Retaining Spring Pressure at 1-3/32 in.	9 lb.	13 lb.	< 5 lb.
703	Oil Pressure Relief Valve Spring Pressure at 1-7/16 in.	19 lb.	21 lb.	< 15 lb.
737	Vacuum Pump Drive Shaft Oil Seal - Pump Adapter	.0015T	.0065T	*
743	Fuel Pump Drive Shaft Oil Seal - Pump Bracket	.0015T	.0065T	*

Table 7-1 Table of Limits (continued)



FIGURES CONTAINED ON THIS CHART ARE REFERENCE NUMBERS ONLY. CLEARANCE VALUES WITH THEIR CORRESPONDING REFERENCE NUMBERS ARE CONTAINED IN THE TABLE OF CLEARANCES FOR THE SUBJECT ENGINE MODELS.

COLORS SHOWN ON THIS CHART INDICATE THE ENGINE OIL CIRCULATION AS FOLLOWS:

= PRESSURE OIL
= RETURN OIL

Figure 7-2 Limit Chart for Rear Section AN-14B Model

SECTION 2
TORQUE VALUES

INTRODUCTION

1 The following torque values, in pound-inches unless otherwise specified, are recommended for the Pratt & Whitney Aircraft R985 Engine. The torque values for all nuts, bolts and screws, are based on the use of a thread lubricant, such as engine oil or equivalent, except where otherwise specified or where the applicable overhaul instructions recommend a special lubricant or surface coating. Torque values for interference fit applications such as studs, pushrod cover cylinder connectors and pipe plugs may be obtained with or without lubrication, unless otherwise specified.

2 Torque indicating devices should be checked daily and calibrated by means of weights and a measured lever arm to make sure that inaccuracies have not crept in. Checking one torque wrench against another is not sufficient. Some wrenches are quite sensitive to the way they are supported during a tightening operation, and every effort should be made to adhere to the instructions furnished by the respective manufacturers. Tightening should be done slowly and evenly for consistency and the best possible accuracy.

3 There may be certain instances other than those included under "Specific Recommendations", where it is obvious that the torque recommended for tightening a nut on a bolt or stud of given size should not be used, due to the kind of material or the design of the engine part involved. Common sense and good judgement must be exercised in such cases.

4 After a castle nut, screw, or bolt has been tightened to the proper torque, it should not be loosened to permit the insertion of lockwire or a cotterpin. If the slots in a nut or the lockwire holes in a bolt or screw are not properly aligned at the minimum torque limit, the nut, screw, or bolt should be further tightened to the next aligning position, but the maximum torque limit, if any, must not be exceeded. If this alignment cannot be accomplished without exceeding the maximum torque limit, back off the nut, screw, or bolt half a turn, then retighten. Occasionally, it may be necessary to select a new part.

5 Because of the unconventional design of cylinder flange nut wrenches, particular care should be exercised in tightening cylinder flange nuts. Whenever special extensions and adapter wrenches are used to tighten cylinder hold down nuts, the torque specified in this bulletin is at the nut.

6 The importance of using a torque wrench when tightening a sparkplug cannot be too highly emphasized. Some serious troubles resulting from subjecting the plug to excessive installation torques are:

(a) Stretching the shell threads away from the shell flange which is seated on the cylinder gasket and bushing.

(b) Loosening of the core insulator and loss of pressure seal.

(c) Compression of the gasket to a point where the unthreaded portion of the shell fouls against the sparkplug bushing threads.

(d) Breakage upon removal.

(e) Stretched core threads.

CAUTION

Except in an emergency, never install a sparkplug in a hot engine as this may result in thread seizure with subsequent damage to the sparkplug bushing and the plug shell when removal is attempted.

7 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 applied to the threads. The plug should then be reinstalled and retightened to the desired limits.

8 If the torque required to drive a stud to the correct projection length should not come up to the minimum or should exceed the maximum given above, another stud should be selected. Consult the following tables to determine the torque to be applied to a particular fastener.

GENERAL RECOMMENDATIONS

NUTS, BOLTS, AND SCREWS

9 A standard nut has a height approximately equal to the diameter of the bolt. Unless otherwise specified, for thin nuts, where the height of the nut is approximately half the size of the bolt diameter, reduce the listed torque values fifty percent. Castellations are additional and do not affect torque.

STEEL PIPE PLUGS IN ALUMINUM AND MAGNESIUM CASES

10 If a pipe plug is found to leak after it has been tightened to these limits, it should not be tightened further, but should be removed, and more sealing compound (JAN-A-669) applied to the threads. The plug should then be reinstalled and retightened to the desired limits.

11 When plugs are tightened in a hot engine, the torques recommended should be reduced about 20%, owing to the different expansion characteristics of the steel plugs and the aluminum or magnesium cases.

Thread Size	Limits	
	Minimum	Maximum
8-32	15	20
8-36	15	20
10-24	20	30
10-32	20	30
12-24	35	45
12-28	35	45
1/4-20	50	70
1/4-28	65	85
5/16-18	110	150
5/16-24	125	170
3/8-16	200	270
3/8-24	225	300
7/16-14	325	430
7/16-20	360	480
1/2-13	500	650
1/2-20	560	750
9/16-18	700	950
9/16-18	800	1050
5/8-11	1000	1300
5/8-18	1150	1500
3/4-10	1700	2300
3/4-16	2000	2600

Table 7-2 Nuts, Bolts, and Screws

Thread Size	Torque Limits	
	Minimum	Maximum
1/16 in. A.N.P.T.	30	40
1/8 in. A.N.P.T.	30	40
1/4 in. A.N.P.T.	70	85
5/16 in. A.N.P.T.	70	85
3/8 in. A.N.P.T.	95	110
1/2 in. A.N.P.T.	140	160
3/4 in. A.N.P.T.	210	230

Table 7-3 Steel Pipe Plugs in Aluminum and Magnesium Cases

HEX HEAD STRAIGHT THREADED FLANGED PARTS

12 Tighten a hex head straight threaded plug or connector until the under side of the head or flange makes contact with its mating face and then tighten to a maximum of 50 pound-inches additional torque, unless otherwise specified.

STEPPED STUDS

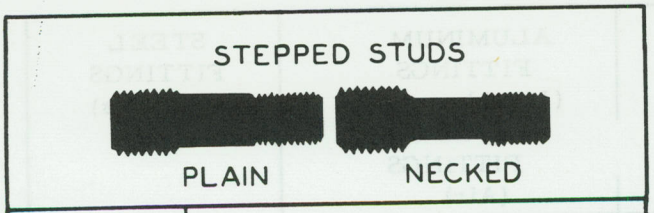
13 If the torque required to drive a stud to the correct projection length should not come up to the minimum or should exceed the maximum recommended, select another stud.

STANDARD STUDS

14 If the torque required to drive a stud to the correct projection length should not come up to the minimum or should exceed the maximum recommended, select another stud.

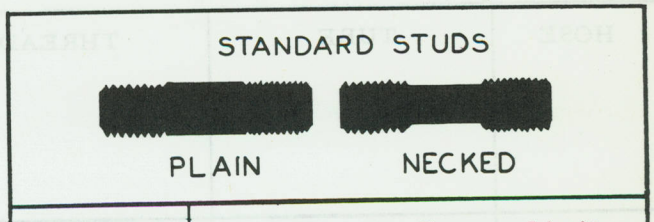
FLEXIBLE TUBE CONNECTIONS

15 The seals must be wet with engine oil immediately prior to installing and tightening.



Thread Size (Nut End)	Driving Torque Limits		
	Minimum Plain and Necked	Maximum	
		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

Table 7-4 Stepped Studs



Thread Size	Driving Torque Limits		
	Minimum Plain and Necked	Maximum	
		Plain	Necked
8-32	10	30	30
10-24	15	45	40
12-24	20	70	65
1/4-20	40	105	95
5/16-18	85	230	210
3/8-16	160	425	375
7/16-14	200	675	600
1/2-13	250	1050	950
9/16-12	425	1500	1400
5/8-11	625	2100	1900
3/4-10	1100	3800	3500

Table 7-5 Standard Studs

Make certain that the tube is properly aligned and that the seal has bottomed before applying the listed torque.

HOSE, TUBE AND THREADED CONNECTORS

16 All locknuts on connectors, elbows and fittings shall be tightened to 1/2 the values given under General Recommendations for Nuts, Bolts and Screws. The torque value for the nut on all hose fittings and tubes (not covered under Flexible Tube Connections) shall be in accordance with the following table. No attempt should be made to correct any leakage of the joint by overtightening. The fitting should be disassembled and checked for nicks, burrs, dirt, etc. If necessary use new parts.

17 If either of the mating sealing surfaces are aluminum, the required torque limits for aluminum fittings apply.

Tube Size	Single Wall Tubes	Double Wall Tubes
	Limits	Limits
1/8 in.	25 to 30	
3/16 in.	25 to 30	
1/4 in.	25 to 30	
5/16 in.	30 to 35	
3/8 in.	30 to 35	
1/2 in.	90 to 100	
5/8 in.	90 to 100	
3/4 in.	90 to 100	
7/8 in.	90 to 100	
1 in.	90 to 100	245 to 285
1-1/8 in.	100 to 110	245 to 255
1-1/4 in.	100 to 110	245 to 255
1-1/2 in.	100 to 110	245 to 255

Table 7-6 Flexible Tube Connections

HOSE	TUBE	THREAD	ALUMINUM FITTINGS (Liquid or Air) STEEL FITTINGS (Air)	STEEL FITTINGS (Liquids)
Size	O. D.	Size	Limits	Limits
3	3/16 in.	3/8-24	30 to 50	70 to 800
4	1/4 in.	7/16-20	40 to 65	90 to 100
5	5/16 in.	1/2-20	60 to 80	135 to 150
6	3/8 in.	9/16-18	75 to 125	270 to 300
8	1/2 in.	3/4-16	150 to 250	450 to 500
10	5/8 in.	7/8-14	200 to 350	650 to 700
12	3/4 in.	1-1/16-12	500 to 700	900 to 1000
16	1 in.	1-5/16-12	600 to 900	2200 to 2400
18	1-1/8 in.	1-1/2-12	600 to 900	2200 to 2400
20	1-1/4 in.	1-5/8-12	600 to 900	2200 to 2400
24	1-1/2 in.	1-7/8-12	600 to 900	2200 to 2400

Table 7-7 Hose, Tube, and Threaded Connectors

INSTALLATION OF CRUSH TYPE ASBESTOS FILLED GASKETS

18 Install all crush type gaskets except the self-centering type, with the unbroken surface against the flange of the plug or part being tightened against the seal. Turn mating part until sealing surfaces are in contact and tighten to the angle of turn shown below for the appropriate thread pitch.

Thread Pitch On Part to be Tightened	Angle of Turn in Degrees	
	Aluminum Asbestos	Copper Asbestos
8 Threads per Inch	135	67
10 "	125	67
12 "	180	90
14 "	180	90
16 "	270	135
18 "	270	135
20 "	270	135
24 "	360	180
28 "	360	180

Table 7-8 Crush Values for Asbestos Filled Gaskets

HOSE CLAMPS

19 Tighten thumb-screw type hose clamps to 10 pound-inches minimum to 20 pound-inches maximum. Retighten after a period of 1 hour or immediately following the next operation of the engine to 10 pound-inches minimum to 20 pound-inches maximum.

USE OF TORQUE WRENCHES WITH EXTENSIONS OR ADAPTERS

20 On occasion it is necessary to use a special extension or adapter wrench together with a standard torque wrench (Figure 7-7). In order to arrive at the resultant required torque limits, the following formula should be used:

T = Desired torque on the part.
E = Effective length of special extension or adapter. (See Figure 5-68)

L = Effective length of torque wrench (See Figure 7-5)

R = Reading on scale or dial of torque wrench.

A = Distance through which force is applied to part.

ADVANCE REVISION

Serial #2 dated 18 Mar 60
(Sheet 1 of 1)

The sheet of this Advance Revision is to be inserted in the EO as follows:-

Sheet 1 facing page 119

Part 7, Section 2, page 119, para. 22(c)

Delete present para. 22(c). Insert new para. 22(c) as follows:-

Propeller shaft thrust bearing nut.

Tighten to 250 foot-pound; then turn to tighten through an angle of 25 to 30 degrees.

ISSUED ON AUTHORITY OF THE CHIEF OF THE AIR STAFF

$$R = \frac{LT}{A} = \frac{LT}{L+E}$$

Example: A torque of 1440 pound-inches is desired on a part using a special extension having a length of 3 inches from centre to centre of its holes, and a torque wrench measuring 15 inches from centre of handle or handle swivel pin to centre of its square adapter.

$$\text{Then: } R = \frac{LT}{L+E} = \frac{15 \times 1440}{15 + 3} = 1200$$

With the axis of the extension or adapter and the torque wrench in a straight line, tightening to a wrench reading of 1200 pound-inches torque will provide the desired torque of 1440 pound-inches on the part.

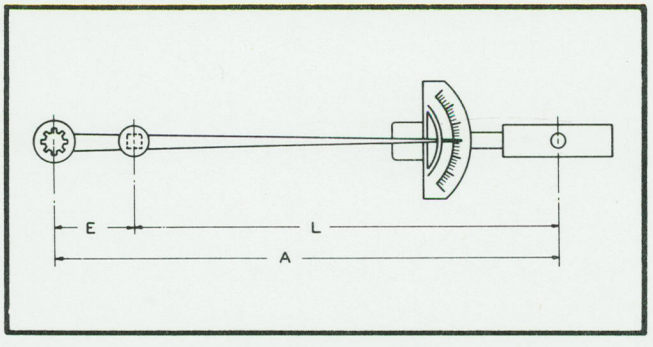


Figure 7-5 Extension of Torque Wrench

SPECIFIC RECOMMENDATIONS

21 The following values are exceptions to those contained in paragraphs 9 through 20.

22. FRONT SECTION

(a) Dehydrator Plugs - 3/4 and 1 in. dia. thread	35 to 45
(b) Propellor Shaft thrust bearing cover nuts	100 to 150
(c) Propellor Shaft thrust bearing cover nuts	Tighten to 250 pound-feet; then turn to tighten through an angle of 15 to 20 degrees

23. POWER SECTION

(a) Crankcase Through - bolt 7/16 in. Hollow Type Bolt	350 to 400
(b) Crankshaft Bolt	.009 to .011 in. stretch
(c) Crankshaft Flyweight Through Bolts Expander (Through Bolt)	.001 to .0015 in. stretch 200 to 225
(d) Cylinder Flange Nuts	300 to 350
(e) Dehydrator Plugs	
(1) Cylinder	20 to 25
(2) 3/4 and 1 in. dia thread	35 to 45
(f) Rockerbox Cover Nuts	60 to 75
(g) Rockershaft Caps and Nuts (Aluminum)	65 to 100
(h) Rockershaft Nuts	200 to 250
(j) Sparkplugs	300 to 360
(k) Sparkplug Lead Coupling	
(1) 5/8-24 Thread	100 to 120
(2) 3/4-20 Thread	140 to 160
(m) Valve Adjusting Screw Lock Nuts	300 to 350

24. SUPERCHARGER AND ACCESSORY SECTION

(a) Supercharger Intermediate Gear Shaft Nut	600 to 675
(b) Starter and Starter Cover Nuts (Two top nuts only)	175 to 200
(c) Dehydrator plugs 3/4 in. and 1 in. dia. thread	35 to 45

PART 8

SPECIAL TOOLS

TOOL NUMBER	TOOL NAME	CODE R-985	CODE R-1830
DMS-196010	Wrench - Pushrod cover nut	x	x
PWA-17	Eye - Crankshaft lifting (or PWA-520)	x	
PWA-144	Wrench - Nut coupling		x
PWA-249	Clamp - Ring compressing	x	
PWA-455	Depressor - Rocker arm (or PWA-1392)	x	x
PWA-459	Depressor - Valve spring	x	x
PWA-459-1	Depressor - Valve spring		x
PWA-489	Clamp assembly - Piston ring		x
PWA-491	Wrench - Packing gland	x	x
PWA-527	Wrench - Intake jacking nut		x
PWA-671	Wrench - Oil pressure relief valve body	x	
PWA-672	Gauge - Valve clearance (or PWA-4675)	x	x
PWA-917	Sling - Lifting	x	x
PWA-996	Strip - Alignment	x	x
PWA-1059	Mirror - Magneto checking	x	x
PWA-1075	Wrench - Valve adjusting (or PWA-2835)	x	x
PWA-1093	Wrench - Propeller shaft thrust bearing 10#30	x	
PWA-1295	Wrench - Oil flange connection	x	x
PWA-1327	Puller - Oil pump	x	x
PWA-1333	Eye - Prop shaft lifting		x
PWA-1390	Puller - starter jaw		x
PWA-1393	Wrench - Cylinder hold down nut (or TAM-5534)	x	
PWA-1402	Socket - 1 in. hexagon sump pump wrench	x	x
PWA-1409	Pipe - Sump drain		x
PWA-1415	Drift - 874 Dia. pilot 1-23/32 shoulder	x	x
	DELETED		
PWA-1468	Wrench - Sparkplug 5/8 in.	x	x
PWA-1471	Wrench - Starter & generator nut	x	x
PWA-1500	Wrench - Intake pipe nut	x	
PWA-1502	Wrench - Rocker shaft	x	
PWA-1541	Wrench - Oil pressure release valve		x
PWA-1606	Handle - Extension ratchet		x
PWA-1608	Wrench - 3/8 in. palnut	x	x
PWA-1633	Wrench - Cylinder nut offset L.H.		x
PWA-1634	Wrench - Cylinder nut offset R.H.		x
PWA-1640-10	Driver - 28 studs 1/4 in.	x	x
PWA-1640-11	Driver - 24 studs 5/16 in.	x	x
PWA-1640-12	Driver - 24 studs 3/8 in.	x	x
PWA-1640-13	Driver - 20 studs 7/16 in.	x	x
PWA-1640-14	Driver - 20 studs 1/2 in.	x	
PWA-1640-21	Driver - 18 studs 9/16 in.		x
PWA-1655	Driver - 24 screw bushing 5/16 in.		x
PWA-3254	Wrench _ Sparkplug 7/8 in.	x	x
PWA-1686	Puller - Main oil sump		x
PWA-1787	Wrench - Oil sump drain plug	x	x
PWA-1791	Pliers - Piston ring	x	x

TOOL NUMBER	TOOL NAME	CODE R-985	CODE R-1830
PWA-1886	Wrench - Adjustable strap	x	x
PWA-1937-20	Crimper - Ignition cable	x	x
PWA-1954	Puller - Magneto drive pinion		x
PWA-2003	Arbor - Generator drive gear backlash	x	
PWA-2006	Wrench - Cylinder hold down 9/16 in. (or PWA-2397)	x	x
PWA-2043	Pliers - Piston ring		x
PWA-2210	Wrench - Oil Sump support stud		x
PWA-2279	Arbor - Blower intermediate drive pinion		x
PWA-2285	Drift - Fuel pump drive oil seal	x	
PWA-2302	Pusher - Pistonpin (or PWA-4911 or PWA-4205-10)	x	
PWA-2398	Handle - Wrench	x	x
PWA-2399	Wrench - Cylinder hold down nut	x	x
PWA-2411	Handle - Cylinder holdown nut wrench	x	x
PWA-2414	Holder - Masterod	x	
PWA-2486	Holder - Masterod		x
PWA-2488	Holder - Articulating rod	x	x
PWA-2713	Wrench- Crankshaft front plug nut	x	
PWA-2826	Holder - Masterod	x	
PWA-2834	Holder - Masterod		x
PWA-3094	Guide - Angular drive gear side oil seal		x
PWA-3145	Puller - Intake pipe	x	x
PWA-3197	Locator - Cylinder nut		x
PWA-3198	Guide		x
PWA-3418	Wrench - Oil release valve seat		x
PWA-3762	Puller - Oil seal complete	x	x
PWA-3916	Driver - Cylinder head deflector insert screw		x
PWA-4093	Bar - Crankshaft turning (or PWA-112)	x	
PWA-4102	Bar - Crankshaft turning (or PWA-197)		x
PWA-5002	Wrench - Spinner starting palnut		x
PWA-5124	Valve - Depreservation	x	x
PWA-5313	Screen - Oil disc type		x
PWA-35/00070	Kit - Timerite position indicator (EO 10A-1-2AG)	x	x
PWA-35/10135	Motorstat - complete with case (EO 10A-1-2AH)	x	x
PWA-35/10177	Magnetic inspector - S435 (EO 10A-1-2-A)	x	x