E-165
E-185
E-225

CONTINENTAL® AIRCRAFT ENGINE

OVERHAUL MANUAL

FAA APPROVED

Publication X30016

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Supersedure Notice

This manual revision replaces the front cover and list of effective pages for Publication Part No. X30016, dated October 1978. Previous editions are obsolete upon release of this manual.

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DEFINITIONS AND ABBREVIATIONS

A.B.C.	After Bottom Center
Approx.	Approximately
A.T.C.	After Top Center
Bar.	Barometric
B.B.C.	Before Bottom Center
B.H.P.	Braker Horsepower
B.T.C.	Before Top Center
C.G.	Center of Gravity
Dia.	Diameter
°	Degrees of Angle
°F.	Degrees of Fahrenheit
F.A.A.	Federal Aviation Administration
Fig.	Figure (illustration)
Front	Propeller End
Ft.	Foot or feet
H_2O	Water
Hg	Mercury
I.D.	Inside Diameter
in. (")	Inches
Hex.	Hexagon
Left	Side on which No's 2, 4 and 6 cylinders are located
lbs.	Pounds
Lockwire	Wire used to safety connections
Man.	Manifold or manometer
Max.	Maximum
Min.	Minimum or minute
30'	Thirty minutes of angle (60'=1°)
N.C.	National Coarse (thread)
N.P.T.	National Pipe Thread
N.F.	National Fine (thread)
O.D.	Outside Diameter
Press.	Pressure
p.s.i.	Pounds Per Square Inch
Rear	Accessory end of engine
Right Side	Side on which No's 1, 3 and 5 cylinders are located
R.P.M.	Revolutions per minute
Std.	Standard
T.D.C.	Top dead center
Temp.	Temperature
Torque	Force x lever arm (125 ft. lbs. = 125 lbs. force applied one foot from bolt center or 12.5 lbs. applied 10 ft. from center).

SECTION I

INTRODUCTION

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SECTION I. INTRODUCTION

1-1. This manual is published for the guidance of all facilities engaged in operation, maintenance and overhaul of E Series engines, as required by the Federal Aviation Administration.

1-2. Since the last general revision of the maintenance and overhaul manual for this series a number of significant changes in parts have been made. Because there is a high degree of interchangeability of parts between models in the series, the new parts do not seriously alter the applicability of instructions in the manual. This edition represents a revision of the third edition and the inclusion of data published in 1955 as a supplement to the second edition. Figures 3, 4, 9 and 10 illustrate wet sump and dry sump engines typical of all E Series models and show the present type ignition cable supports, Eclipse starter, new type of cylinder and the removable pushrod housings.

1-3. For applicability of all parts to the various models, refer to the latest revised Parts Catalog, Form X-30017.

1-4. In the following sections will be found a brief description of the engine construction and the differences between models of the series, a description of the operation of the various systems for starting, lubrication, cooling, induction, etc., a table of engine specifications covering dimensions and characteristics of the various models, a trouble shooting chart, instructions for packing, unpacking and preparation for storage, instructions for installation of the engines in aircraft and their removal, maintenance suggestions, overhaul instructions, instructions for testing after overhaul and a table of fits and limits, supported by charts which indicate the points at which fits are to be measured and which also provide a visual description of the internal lubrication system.

1-5. Important changes in part numbers, interchangeability of parts, urgent inspections, mandatory replacements and modernization information are among the subjects of limited interests and duration covered by factory service bulletins, which are distributed to all Approved Distributors of aircraft engines and parts and are available for study at their offices. Service bulletins of interest to aircraft owners, operators and maintenance personnel may be obtained by direct mail on an annual subscription basis. The charge for this service covers only postage and handling. Subscription order blanks may be obtained from Teledyne Continental Motors, P. O. Box 90, Mobile, Alabama 36601, Attention: Publications Department.

1-6. It is the policy of Teledyne Continental Motors to handle all reports of service difficulty and requests for information through Approved Distributors. You will find them more than willing to help solve your maintenance problems and well equipped with experience and facilities to perform any necessary maintenance work on Teledyne Continental Aircraft Engines. There is an Approved Distributor at every major airport.

SECTION II

TABLE OF SPECIFICATIONS

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TABLE I

GENERAL CHARACTERISTICS COMMON TO ALL MODELS

ENGINE TYPE	Horizontally Opposed, Air Cooled, Direct Drive
CYCLE OF OPERATION	Otto Cycle (4 strokes per cycle)
NUMBER OF CYLINDERS	6
CYLINDER BORE (in inches)	5
PISTON STROKE (in inches)	4
COMPRESSION RATIO	7:1
DISPLACEMENT (in cubic inches)	471
DIRECTION OF CRANKSHAFT ROTATION	Clockwise
TYPE OF VALVE MECHANISM	Overhead
OVERALL WIDTH OF ENGINE (in inches)	33-3/8
NUMBER OF MOUNTING BRACKETS	4

TABLE II

GENERAL CHARACTERISTICS PECULIAR TO VARIOUS MODELS

Feature	E-165-2	E-185-1	E-185-3	E-185-8	E-185-9	E-185-11	E-225-4	E-225-8
NORMAL RATED B.H.P.	165	185	185	185	185	185	225	225
RATED TAKE–OFF B.H.P.	165	185	205	185	205	205	225	225
NORMAL RATED R.P.M.	2050	2300	2300	2300	2300	2300	2650	2650
RATED TAKE–OFF R.P.M.	2050	2300	2600	2300	2600	2600	2650	2650
OVERALL LENGTH (inches)	43.75	47.65	47.65	48.95	48.40	48.95	48.95	48.95
OVERALL HEIGHT (inches)	28.31	24.95	28.31	21.65	25.00	21.65	25.00	21.65
PROPELLER SHAFT TYPE	Flange	Spline	Spline	Spline	Spline	Spline	Spline	Spline
SUMP TYPE	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
*WEIGHT OF ENGINE (lbs.)	325	318	326	325	326	325	330	322

Note: (*) Does not include accessories listed in Table III.

TABLE III

STANDARD ACCESSORIES

Accessory Name	No.	Manufacturer	Model	Weight (lbs.)
MAGNETOS	2	Scintilla	S6LN-21	11.6
CARBURETOR	1	Stromberg	PS-5C	6.0
CARBURETOR	1	Marvel-Stromberg	MA-4-5	5.13
PRIMING NOZZLE	1	Teledyne Continental	—	.1
FUEL PUMP	1	Romec	RD 7790	1.0
* SPARK PLUGS	12	Champion	C-27 & C-27S	1.92
* SPARK PLUGS	12	BG Corp.	706S & 706SR	2.52
* STARTER (E-165)	1	Delco-Remy	1109660	20.6
STARTER	1	Eclipse	397-13	18.8
GENERATOR	1	Delco-Remy	1101879	14.5
VOLTAGE REGULATOR	1	Delco-Remy	1118263	1.6
UNSHIELDED IGNITION CABLE ASSEMBLY	1	Teledyne Continental	—	3.75
SHIELDED IGNITION CABLE ASSEMBLY	1	Teledyne Continental	EQ5450	4.60
VIBRATION ISOLATORS	4	Lord	352043	1.75
RIGHT HAND ACCESSORY DRIVE	1	Teledyne Continental	EQ208	.40
LEFT HAND ACCESSORY DRIVE	1	Teledyne Continental	40722-A1	.20
ACCESSORY DRIVE COVERS	3	Teledyne Continental	—	.50

NOTE (*) Refer to Teledyne Continental spark plug application bulletin for a complete listing of spark plugs approved for use with these engines.

TABLE IV

GEAR DRIVE DATA

Name of Drive	Speed Ratio (Crankshaft: Drive)	Direction of Rotation
TACHOMETER DRIVE	1:0.5	Clockwise
MAGNETO DRIVES	1:1.5	Clockwise
OIL PRESSURE PUMP	1:0.5	Counterclockwise
OIL SCAVENGE PUMP	1:1.67	Counterclockwise
L. H. ACCESSORY DRIVE	1:1.67	Counterclockwise
R. H. ACCESSORY DRIVE	1:1.364	Clockwise
GENERATOR DRIVE	1:2.25	Counterclockwise
DELCO STARTER SHAFT	1:35.78	Clockwise
ECLIPSE STARTER JAW	1:1.15	Counterclockwise

TABLE V

IGNITION SYSTEM DETAILS

Feature	E-165	E-185	E-225
MAGNETOS (Scintilla)	S6LN-21	S6LN-21	S6LN-21
* SPARK PLUGS (Unshielded) Champion	C-27	C-27S	—
* SPARK PLUGS (Radio Shielded)	BG706S	BG706S	Champion C27S
SPARK PLUG THREAD SIZE	18 mm	18 mm	18 mm
SPARK PLUG TESTING PRESSURE	100 psi	100 psi	
RIGHT HAND MAGNETO FIRES UPPER PLUGS	26° BTC	26° BTC	26° BTC
LEFT HAND MAGNETO FIRES LOWER PLUGS	26° BTC	26° BTC	26° BTC
FIRING ORDER	1,6,3,2,5,4	1,6,3,2,5,4	1,6,3,2,5,4
MAGNETO SPREAD	50 RPM @ 2050 RPM	50 RPM @ 2045 RPM	50 RPM @ 1900 RPM

NOTE (*) Refer to Teledyne Continental spark plug application bulletin for a complete listing of spark plugs approved for use with these engines.

TABLE VI

VALVE TIMING

Valve Event	E-165	E-185	E-225
Intake Valve Opens B.T.C.	15°	15°	36°
Intake Valve Closes A.B.C.	60°	60°	72°
Exhaust Valve Opens B.B.C.	55°	55°	72°
Exhaust Valve Closes A.T.C.	15°	15°	36°

TABLE VII

VALVE MECHANISM DIMENSIONS

Feature	E-165	E-185	E-225
Intake Valve Lift (inches)	.482	.482	.506
Exhaust Valve Lift (inches)	.463	.463	.506
Valve-to-Rocker Clearance (Operating)	0	0	0
Valve-to-Rocker Clearance (lifters deflated)	.030-.110	.030-.110	.030-.110

TABLE VIII
FUEL SYSTEM DETAILS

Feature	E-165-2 E-185-2	E-185-1, -3, -8, -9, -11, E-225
Carburetor (Stromberg Pressure Type)	–	PS-5C
Carburetor (Marvel-Schebler)	MA-4-5	–
Minimum Fuel Octane Rating	80	80
Venturi Diameter (inches)	1.75	1.625
Fuel Pressure Range (p.s.i.)	1.5-9	9-15
Fuel Pump Supplied (Romec)	–	RD7790
Fuel Pump Delivery (Minimum at 2300 R.P.M.) (lbs./hr.)	–	166.5

TABLE IX
OIL FLOW AND CONSUMPTION LIMITS

Specification	Maximum Value
Oil Consumption at Rated Speed and Power	.018 lbs./B.H.P./Hr.
Oil Flow at Rated Speed and Power (E165)	34 lbs./minute
Oil Flow at Rated Speed and Power (E185)	40 lbs./minute
Oil Flow at Rated Speed and Power (E225)	50 lbs./minute

TABLE X
TEMPERATURE AND PRESSURE LIMITS

Indication	Minimum	Maximum
Oil Pressure at Cruising Speed (p.s.i.)	30	60
Oil Pressure at Idling Speed (p.s.i.)	10	–
Fuel Pressure at Carburetor (Stromberg PS-5C) (p.s.i.)	9	15
Fuel Pressure at Carburetor (Marvel-Schebler) (p.s.i.)	1.5	9
Oil Inlet Temperature at Take-Off (^{O} F.)	75	225
Oil Inlet Temperature in Flight (^{O} F.)	–	225
Cylinder Head Temperature on lower spark plug (^{O} F.)	–	525
Cylinder Base Temperature (E165, E185) (^{O} F.)	–	315
Cylinder Base Temperature (E225) (^{O} F.)	–	290
Crankcase Pressure (at 2300 R.P.M., Full Throttle)	–	1–1/2" H_2O

TABLE XI

OIL VISCOSITY GRADES

Outside Air Temperature	Below 40° F.	Above 40° F.
Required Oil Viscosity Grade	S.A.E. 30	S.A.E. 50

NOTE

Refer to current Teledyne Continental Fuel and Oil Recommendation Bulletin for detailed information on types and use of oil.

TABLE XII

INSTRUMENT AND LINE CONNECTIONS

Connection	Location	Size
Tachometer Drive	Accessory Case Rear Side	7/8-18 N.S.
Oil Outlet (Wet Sump)	Accessory Case Right Side	1/2 in. N.P.T.
Oil Outlet (Dry Sump)	Scavenge Pump Housing	3/4 in. N.P.T.
Oil Inlet (Wet Sump)	Crankcase Left or Right Side	1/2 in. N.P.T.
Oil Inlet (Dry Sump)	Accessory Case Left Side	5/8 I.D. Hose
Oil Pressure Gauge	Crankcase Left Side	1/8 in. N.P.T.
Oil Temperature Gauge	Oil Screen Cap (Dry Sump Only)	5/8-18 N.F.
Fuel Pressure Gauge	Carburetor Regulator Cover (PS-5C)	1/8 in. N.P.T.
Carburetor Fuel Inlet	Carburetor Regulator Cover (PS-5C)	1/4 in. N.P.T.
Fuel Pump Inlet	Fuel Pump Left Side	1/4 in. N.P.T.
Fuel Pump Outlet	Fuel Pump Right Side	1/4 in. N.P.T.
Manifold Pressure Gauge	Intake Manifold Upper Right Front	1/8 in. N.P.T.
Fuel Primer Nozzle	Intake Manifold, Cylinder Heads	1/8 in. N.P.T.
Breather Hose Elbow	Crankcase Upper Right Front	5/8 I.D. Hose
Accessory Case Vent	Accessory Case Upper Left (Dry)	1/4 in. N.P.T.
Vac. Pump Oil Sep. Drain	Accessory Case Right Side (Dry)	3/8 in. N.P.T.
Propeller Oil Drain	Accessory Case Left Side (Wet)	1/2 in. N.P.T.

SECTION III
GENERAL DESCRIPTION

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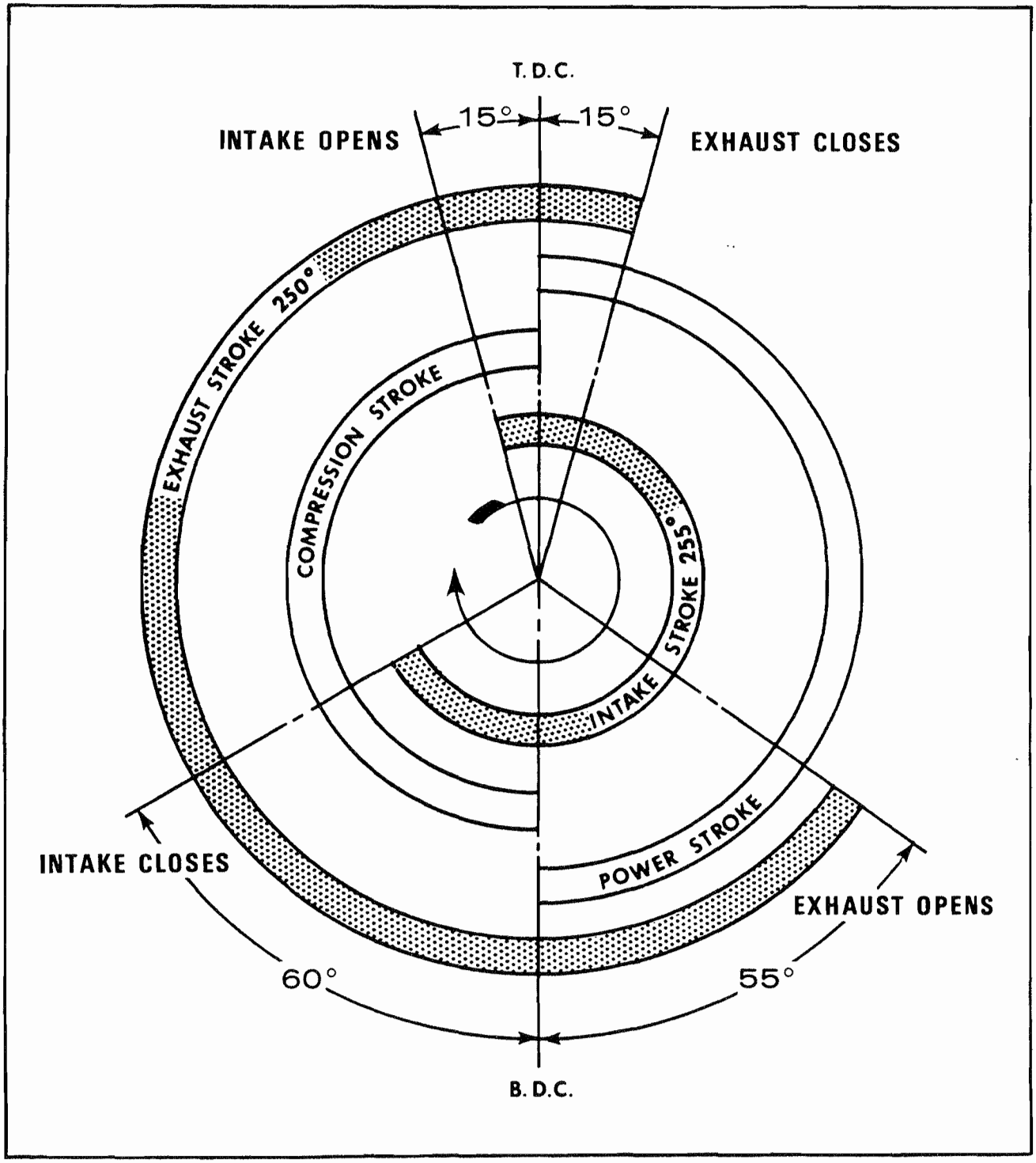


FIGURE 1. VALVE TIMING DIAGRAM—MODELS E165 AND E185.

3-1. FOREWORD.

The E Series Teledyne Continental Aircraft Engines includes all engines of model designations E-165, E-185 and E-225. Dash numbers following the basic model number indicate variations in equipment, as described generally in Table II, to adapt the engines to various types of aircraft. Most parts are interchangeable between models, however, there are important differences in types of crankshaft, oil sump, accessory case, and accessory equipment. The service parts catalog provides detailed information as to application of the parts which are not used in all models, and it should be consulted whenever it becomes necessary to order parts for a specific engine. The following description will provide a general idea of the construction of each model and detailed information on the operation of the various engine systems. A close observation of the illustrations will aid in following the descriptions.

3-2. CRANKCASE.

The crankcase is composed of two aluminum alloy castings, joined at the lengthwise vertical center plane of the engine by twenty one bolts through holes in external top and bottom flanges and by ten through bolts in holes drilled through bolts in holes drilled through lateral stiffening webs. Recently, the lower parting flanges of Model E-185 crankcases were made thicker for additional rigidity. This change made it necessary to use longer 5/16 inch attaching bolts, as indicated in the new Parts Catalog. The webs, cast integrally, have enlarged bosses which are line bored to provide seats for crankshaft main bearings and, below them, other bosses which are bored to act as camshaft bearings. The four main webs accommodate four bearings for each shaft. Lead coated, steel backed Tri-Metal precision inserts are installed in the four main bearing seats with the split matching the case parting surface. Each insert is retained by a tang which

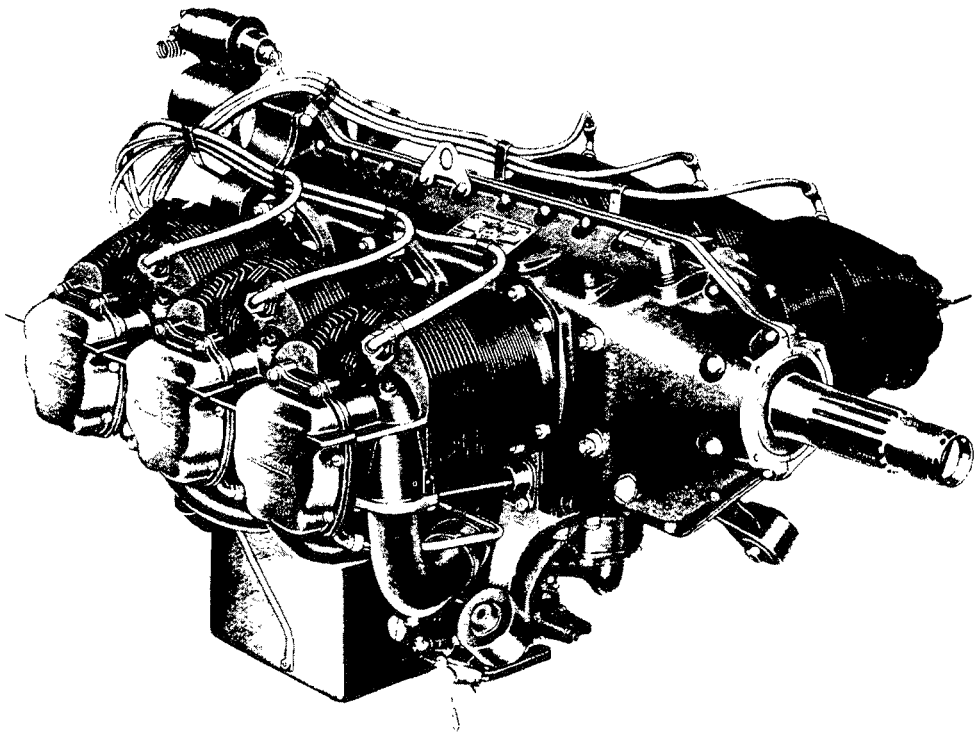


FIGURE 2. THREE–QUARTER RIGHT FRONT VIEW OF WET SUMP ENGINE.

engages a notch machined in the case seat. Each insert is drilled and relieved to conduct oil from a crankcase passage to the bearing surface. Similar inserts without oil holes installed in Model E-165-2 and some of Model E-185-1 in the crankshaft main-thrust bearing seat near the front of the case. When such inserts are installed, the propeller thrust is transferred to the case by split bronze thrust washers installed in the ends of the bearing boss. Current production engines of all models and all engines of Models E-185-1, E-185-9, E-185-11 and all E-225 Models are equipped with combination main-thrust bearings, in lieu of the bearing and washer combination just described. The main-thrust inserts are split, flanged, steel backed silver bearings with lead-indium alloy or lead-tin alloy. The flanged inserts can be installed in any crankcase regardless of original front bearing equipment.

3-3. On the left and right vertical surfaces of the crankcase are machined three mounting pads, each bored in the center to admit the skirt of a cylinder. Two of the long crankcase through bolts project from each cylinder mount pad and, with six studs driven into tapped holes spaced around the pad, serve to attach the cylinders. Models E-165 and the earliest production crankcases for the E-185 engines had six 7/16-14 X 3/8-24 studs set in each cylinder mounting pad. These were later changed to 7/16-14 X 7/16-24 studs, and the crankcase studding assembly part number changed to reflect the new composition. Pads for cylinders 1, 3 and 5 are located on the right side, while those for cylinders 2, 4 and 6 are on the left of the case. Thus, the right case half will be called the 1-3-5 side, and the left half casting the 2-4-6 side in this manual.

3-4. Below each cylinder, and horizontally opposite the camshaft, two hydraulic valve lifters are carried in guides bored through lateral case bosses. Over the outer, open end of each pair of lifter guides a cast aluminum push-rod housing flange is attached by three studs and nuts and is sealed to the case by a gasket.

3-5. The crankcases first released for this group of engines had a steel tube cast lengthwise in each crankcase half and were located between the cylinder openings and the valve lifter guides. These tubes served as the main oil galleries. Later the steel tubes were omitted from the crankcase castings, and the oil gallery holes cored in the castings, The oil gallery passages, both older and current type, are open at the rear and plugged at the front ends.

3-6. The front opening of the crankcase for the crankshaft is bored to receive the crankshaft oil seal. The crankcase rear surface has a surrounding flange which forms a

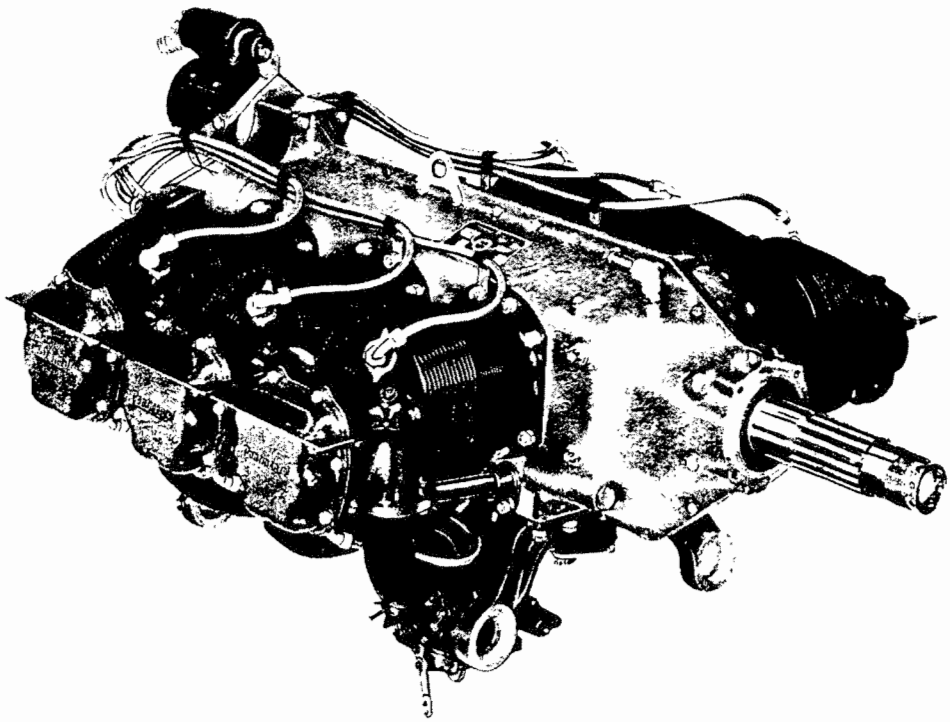


FIGURE 3. THREE–QUARTER RIGHT FRONT VIEW OF DRY SUMP ENGINE.

gasket surface for attachment and sealing of the accessory case. Lateral stiffeners at the rear provide studded mount pads for magneto drive gear supports and the starter pinion pivot.

3-7. Three large holes in the bottom of the crankcase allow oil drainage. The front and center openings register with passages of the intake and oil drain manifold, which is attached to the mount pad at each opening by two screws. The upper oil sump inlet tube fits into the left rear case drain opening. Six studs in the mount pad on the case bottom surface attach the sump. In dry sump models an oil drain housing is attached by two screws to the pad surrounding the rear case drain opening in place of the external sump.

3-8. The crankcase breather hose elbow is screwed into a tapped hole in the upper surface of the right case half ahead of No. 5 cylinder. The engine identification plate is attached by six drive screws to a pad to the rear of the breather hose elbow. A propeller oil drain connection is provided by a tapped hole through a boss near the breather elbow.

3-9. A pad is machined on the bottom surface of each case half for attachment of a front engine mount bracket. Four studs are driven into each pad. Rear engine mount brackets are attached to pads machined on left and right sides of the case by two studs and two long hex head through bolts. A third, and shorter, through bolt passes through the case between the two just described, but it does not pass through the brackets.

3-10. A lifting eye (B, Figure 6) is attached to the upper crankcase parting flange and provides a means of lifting the engine.

3-11. ACCESSORY CASE ASSEMBLY.

The magnesium accessory case assembly is attached to the crankcase rear flange by four special hex head screws installed through holes in the lower crankcase flange, two hex head screws through the accessory case internal front flange near the magneto gears, four hex head screws installed from the rear through accessory case holes above the magnetos, and by two hex head screws installed from the front through holes in upper projections of the crankcase rear flange. The latter two screws engage tapped holes in the Delco-Remy starter housing or are retained by nuts if the Eclipse starter drive is installed.

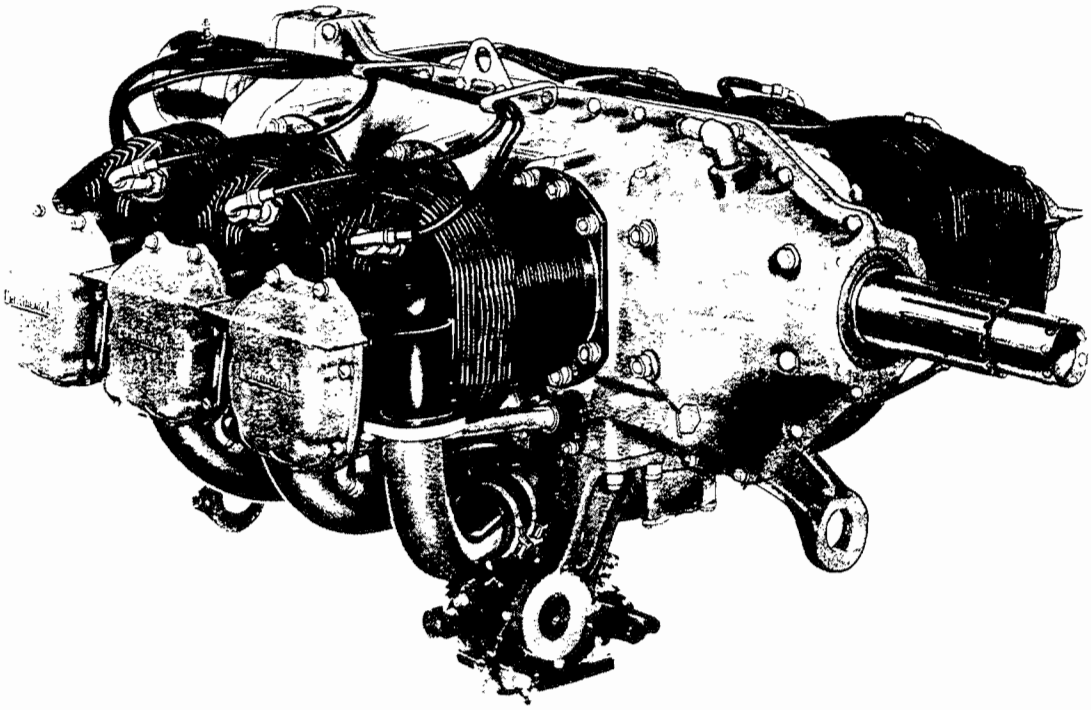


FIGURE 4. THREE–QUARTER RIGHT FRONT VIEW TYPICAL OF MODELS E185-8, E185-11 AND E225-8.

3-12. The accessory case conforms to the shape of the crankcase rear flange and is open at its front side within the height of the crankcase. The accessory case extends below the crankcase, forming a closed compartment which serves as the oil sump in dry sump models.

3-13. The rear surface of the accessory case is provided with raised, machined pads for mounting of the starter, generator, magnetos, left and right side accessory drive adapters, oil screen housing, tachometer drive housing, and accessory drive idler gear shaft. Tapped holes and studs provide attachments for adapters, housings and accessories. The upper center pad of E-185-8, -9, -11 and E-225-4, -8 accessory cases has five studs set into its machined face to accommodate the Eclipse starter and its adapter. The accessory cases of the earliest E Series engines had three studs set in this location on which the Delco-Remy starter was mounted.

3-14. The accessory case casting is provided with an external boss near the top of the left side. For use with wet sump engines, this boss is bored, and an oil filler neck is installed. For dry sump engines a hole is tapped through the boss for a vent connection to the oil tank.

3-15. The pressure oil screen assembly is screwed into a housing which is attached by five hex head screws to the rear surface of the accessory case below the right magneto. The open front end of the tubular screen assembly fits closely into a counterbore in cases of wet sump engines, while cases of dry sump models are equipped with a check valve assembly which fits in the same counterbore and receives a slightly different screen over its rear shoulder. The check valve offers no resistance to oil leaving the front end of the screen, but it prevents return flow during periods of idleness. The cavity surrounding the oil screen is connected by a passage to the pressure oil pump outlet port. The pressure oil screen exit cavity of cases for wet sump engines is drilled and tapped through from the right side of the case for an outlet oil line elbow fitting. No such outlet is machined in cases for dry sump engines. In these castings the screen exit is connected to the rear end of the crankcase right oil gallery.

3-16. The gear type pressure oil pump housing is attached to the front surface of the accessory case rear wall by five screws. One screw is installed from the rear and lies within the generator pilot counterbore of the case rear surface. Two of the pressure oil screen housing attaching screws pass through the case rear wall and into pump housing tapped holes. The other two points of pump housing attachment are the two tachometer drive housing attaching screws. The lower, or driving, impeller of the pres-

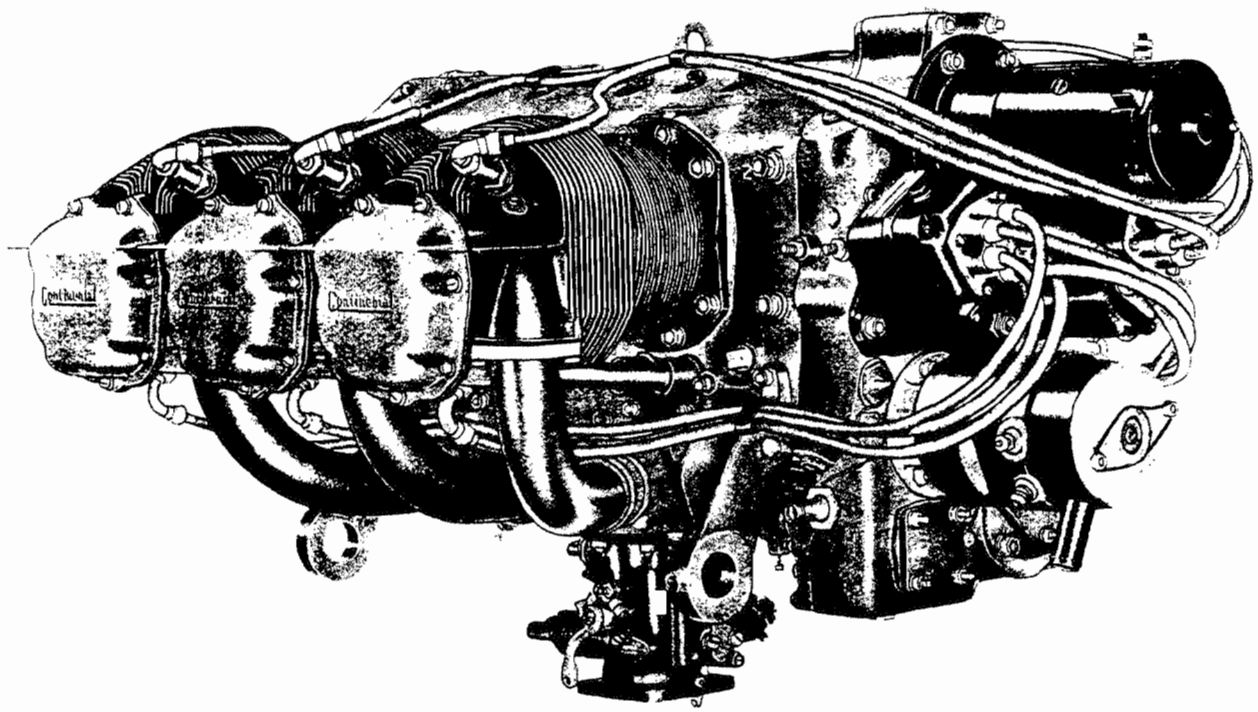
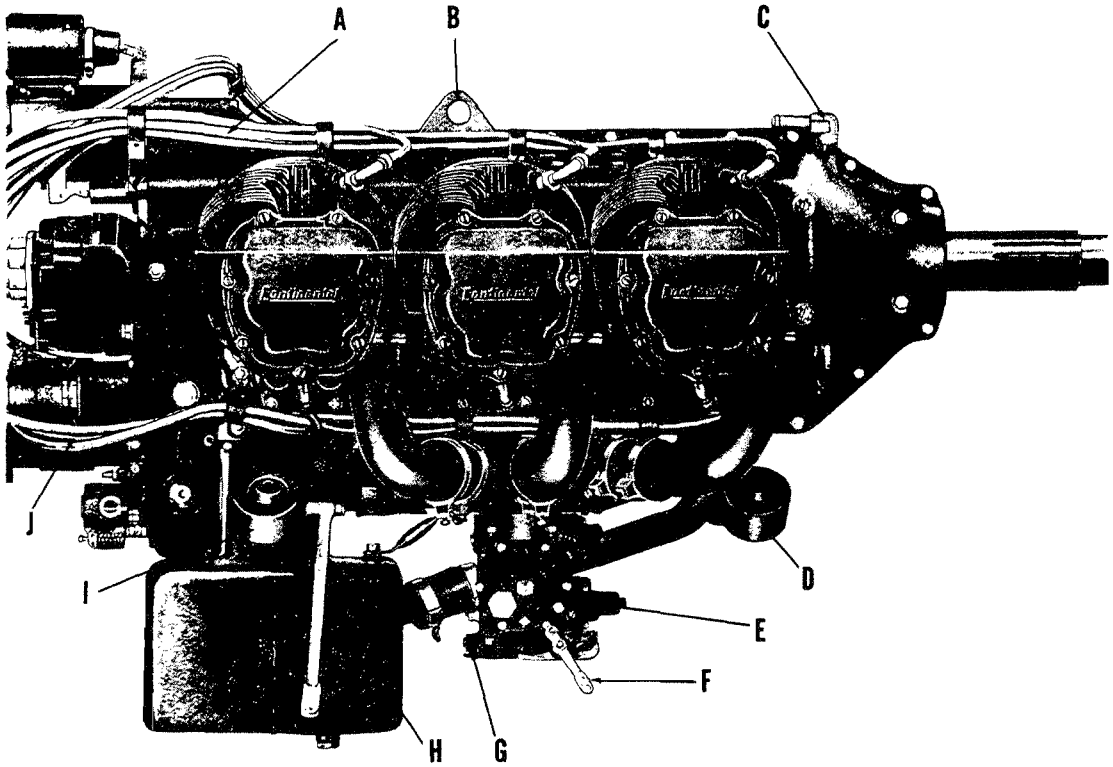


FIGURE 5. THREE–QUARTER LEFT REAR VIEW TYPICAL OF MODELS E185-8, E185-11 AND E225-8.

sure pump has a squared front shaft end which engages a squared hole in the center of the camshaft gear web. A rearward extension of the upper, or driven, pump impeller passes through the rear wall of the case and through a small cast housing provided with a shaft oil seal and threaded to receive the tachometer drive conduit nut. The tachometer drive cable end enters and is driven by a slotted hole in the impeller shaft.

3-17. Accessory cases for wet sump engines are equipped with an oil suction tube attached to the inlet port of the pressure oil pump and extending downward through a 1-1/4 inch hole in the bottom case surface. The oil sump by-pass tube is installed in the case hole, surrounding the suction tube, and is sealed to the case and to the oil sump inlet opening by two hydraulic "O" rings installed in grooves in the outer surface of the tube. The suction tube is attached to the left side wall of the accessory case by a clip, a speed nut and a round head screw. Accessory cases for dry sump engines do not have the large bottom hole for the by-pass tube, but they are tapped to receive a 5/8-18 drain plug. Instead of the suction tube, cases of dry sump engines are equipped with an oil inlet tube, connected to the pressure pump inlet port and extending through the left side of the case for connection of the oil inlet hose. A washer, a rubber seal ring and a nut prevent oil leakage around the inlet tube at the case surface.

3-18. The generator is mounted on a pad below the left magneto and is centered by a pilot which fits in a case counterbore. Three studs attach the assembly. Below the generator a pad is provided for mounting the left side accessory drive adapter. The adapter is bored lengthwise for a shaftgear bearing. The rear end of the left side accessory drive shaftgear is splined to receive and drive the accessory drive shaft. Current production engines have a fuel pump mounted on this drive. The left side accessory drive shaftgear installed in all dry sump models has a forward projection through the front wall of the case which



A. Upper Right Ignition Cable Assembly
B. Engine Lifting Eye
C. Breather Elbow
D. Right Front Engine Mount Bracket
E. Carburetor
F. Mixture Control Lever
G. Carburetor Fuel Inlet Connection
H. Oil Sump
I. Right Rear Engine Mount Bracket
J. Lower Right Ignition Cable Assembly

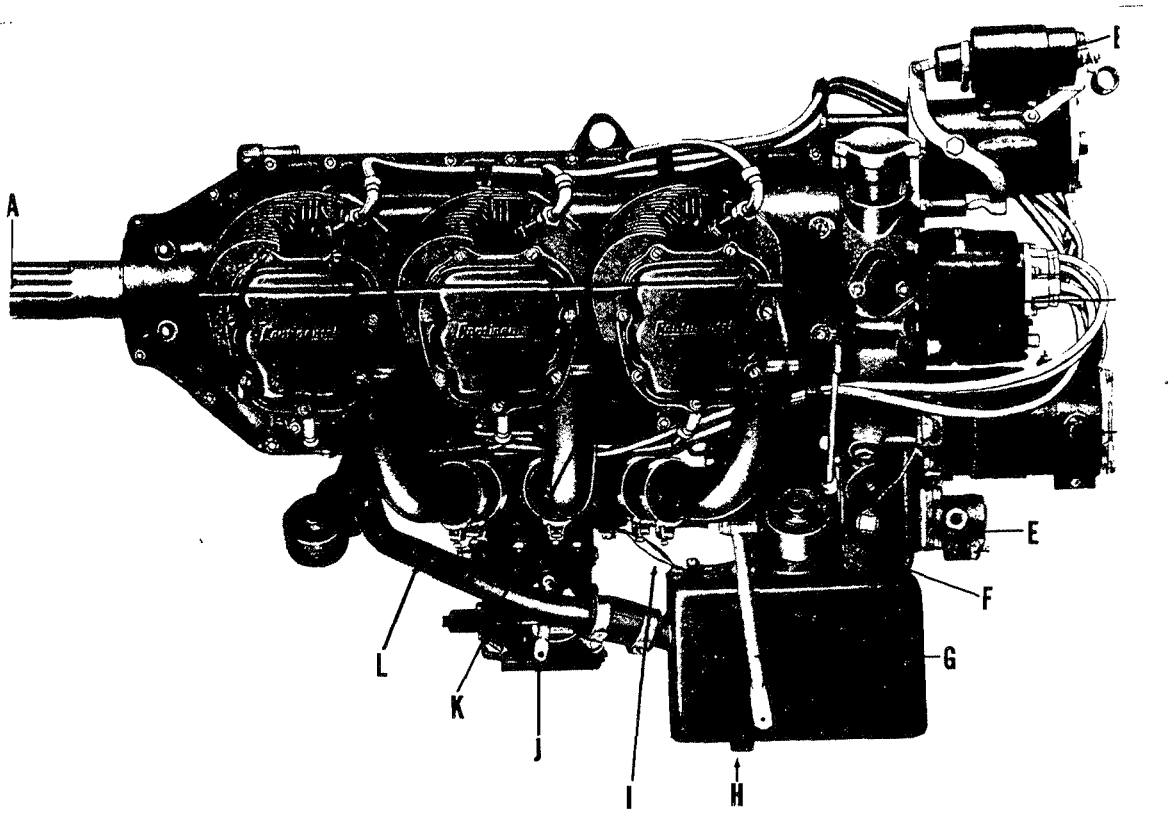
FIGURE 6. RIGHT SIDE VIEW OF WET SUMP ENGINE (E185-3).

drives a gear type oil scavenge pump. The scavenge pump is mounted on a pad machined on the front side of the case at the lower left corner. It is retained by six head screws. Early production cases had two dowels to center the scavenge pump housing. These are omitted in current production cases. The left side accessory drive shaftgear is driven by an idler gear which rotates on a shaft installed from the rear side of the case and retained by two screws. The right side accessory drive, consisting of a shaftgear and an adapter, is installed on a mount pad below the oil pressure screen housing.

3-19. Magnetos are mounted on pads at left and right sides of the accessory case rear surface and are attached by two studs and nuts each. Magneto drive gears are independently mounted on supports attached to the rear of the crankcase and are engaged to the magnetos through rubber padded couplings.

3-20. The starter mount pad is at the upper rear of the accessory case. Delco-Remy starters have their own adapter plates and mount directly on the accessory case pad, while Models E-185-8, E-185-9, E-185-11 and all E-225 Models have a separate adapter for mounting Eclipse starters. The Delco-Remy starter has a hollow pinion and clutch shaft and gear assembly which is piloted on the starter pinion pivot of the crankcase and which is intermediate between the starter armature and the crankshaft gear. The Eclipse starter is self contained..

3-21. A vertical oil passage is drilled from the right side of the accessory case bottom surface to the outlet of the pressure oil screen. It is plugged at the case bottom surface. An intersecting diagonal passage is drilled from the right side of the case through a rib along the front case wall to outlets in the front bearings of the idler gear shaft and the left side accessory drive shaftgear. For use with



A. No. 20 Spline Crankshaft
B. Delco-Remy Starter
C. Left Magneto
D. Delco-Remy Generator
E. Romec Fuel Pump
F. Accessory Case
G. Oil Sump Side Support
H. Oil Sump Drain Plug
I. Oil Sump Front Support
J. Throttle Lever
K. Oil Pressure Gauge Connection
L. Front Oil Drain Tube

FIGURE 7. LEFT SIDE VIEW OF WET SUMP ENGINE (E185-3).

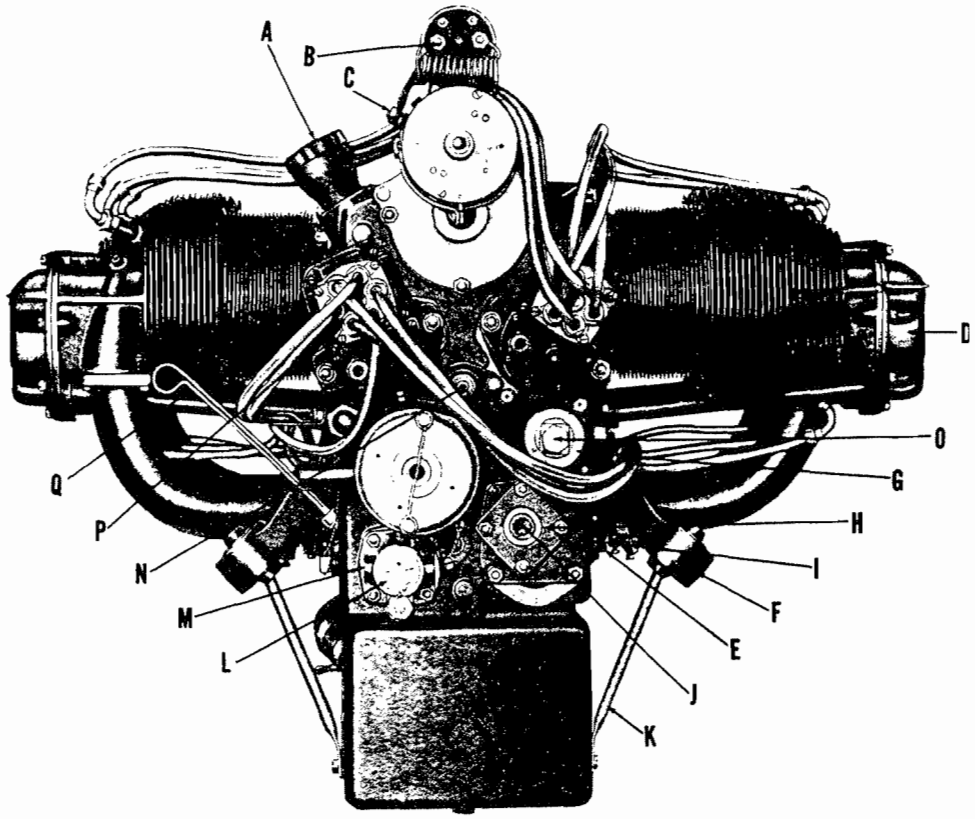
dry sump engines this passage is always plugged with a plain 1/8 inch pipe plug at the right side surface of the case. For wet sump engines in service which are not equipped with a left side accessory drive the diagonal passage must be closed with a special extension plug which fits closely in the drilled hole to prevent escape of oil through the open shaft bearings. A small hole drilled from the right side accessory drive mounting pad into the vertical oil passage registers with an oil hole in the drive adapter leading to the shaft-gear bearing.

3-22. The upper of two bronze acorn caps below the left magneto guides cover the oil pressure relief valve and spring. The relief valve seat registers with the rear end of the left oil gallery.

3-23. A connection for a vacuum pump oil separator drain line is provided by a 3/8 inch N.P.T. hole in the lower right side of the accessory case used with dry sump engines. A 1/2 inch N.P.T. hole in the lower left side of the accessory case used with wet sump models provides for connection of a propeller oil drain line. The bronze acorn cap below the oil pressure relief valve and the 1/2 inch socket pipe plug in the left side of the case have no present function other than to close the case openings.

3-24. OIL SUMP.

Wet sump engines are equipped with a sump composed of two pressed steel halves welded along a flanged vertical seam. Angle brackets welded to the top of the sump are



A. Oil Filler Neck and Cap
B. Solenoid Coil Terminals
C. Starter Power Terminal
D. Rocker Cover
E. Oil Outlet Connection
F. Rear Mount Bracket
G. Pressure Oil Screen
H. Right Side Accessory Drive
I. Right Side Accessory Mount Pad Cover
J. Accessory Drive Idler Gear Shaft
K. Oil Sump Side Support
L. Left Side Accessory Drive
M. Fuel Pump
N. Tachometer Drive
O. Oil Pressure Relief Valve Cap
P. Magneto Switch Wire Terminals
Q. Oil Gauge Rod

FIGURE 8. REAR VIEW OF WET SUMP ENGINE (MODEL E185-3).

attached to six crankcase studs by hex nuts. Inserts at lower left and right sides and one on the upper front horizontal surface of the cubical sump body are tapped for screws which attach the side and front support brackets. A drain tube welded to the top surface is grooved on the outside for a hydraulic "O" ring which seals it in the rear crankcase drain hole. The upper front oil inlet tube is connected by a hose to the intake and oil drain manifold rear outlet. The lower left oil inlet tube is connected by a hose to the front oil drain tube, the front end of which is attached by a flange to the front drain boss of the manifold. A sleeve welded inside the upper rear horizontal surface of the cubical body receives the oil sump by-pass tube. A smaller sleeve welded in the left side of the sump neck holds the oil gauge rod, which is graduated in increments of two quarts. A drain plug is screwed into a boss in the sump bottom surface.

3-25. FRONT OIL DRAIN TUBE.

This dog leg shaped tube has a flange at its forward end for attachment to the lower surface of the front drain boss of the intake and oil drain manifold. Its rear end is connected by a hose and two clamps to the left side inlet tube of the sump. The tube is not installed on dry sump models, and the lower surface of the manifold front boss is covered by a blank plate.

3-26. OIL DRAIN HOUSING.

This cast aluminum housing is installed on all dry sump models. It conducts oil from the rear outlet of the drain manifold to the sump space in the accessory case. An upper side inlet into the housing is flanged and attached by two screws to the flanged rear drain opening of the crankcase.

3-27. INTAKE AND OIL DRAIN MANIFOLD.

The magnesium manifold casting has two cored passages which are not connected. The induction passage opens at the lower side of the casting in the center of the carburetor mount pad. Four studs are driven into the pad to attach the carburetor. The induction passage occupies the center of the manifold, forming a chamber from which tubular outlets are connected by hoses to the six intake tubes. The oil drain passage surrounds the induction manifold chamber and extends forward to an opening centered in the manifold front mounting boss, where it registers with the crankcase front drain opening. To the rear of the induction chamber the rear manifold mount pad has a central opening registered with the center crankcase drain hole and opening into the rear portion of the oil drain passage. A tubular rear manifold extension provides an outlet from the oil drain manifold passage. The same type of manifold casting is used on both wet and dry sump engines, however, it should be noted that manifolds intended for mounting Marvel-Schebler carburetors have longer studs than those for Stromberg pressure carburetors. All manifolds of the current type have unequal lengths of outlet, so that a single length of intake tube is used to connect all cylinders. Early production manifolds had equal lengths of outlet and required three lengths of intake tube. Current manifolds have a pressure gauge connection tapped hole in the upper right front corner and a primer nozzle tapped hole just ahead of the carburetor pad.

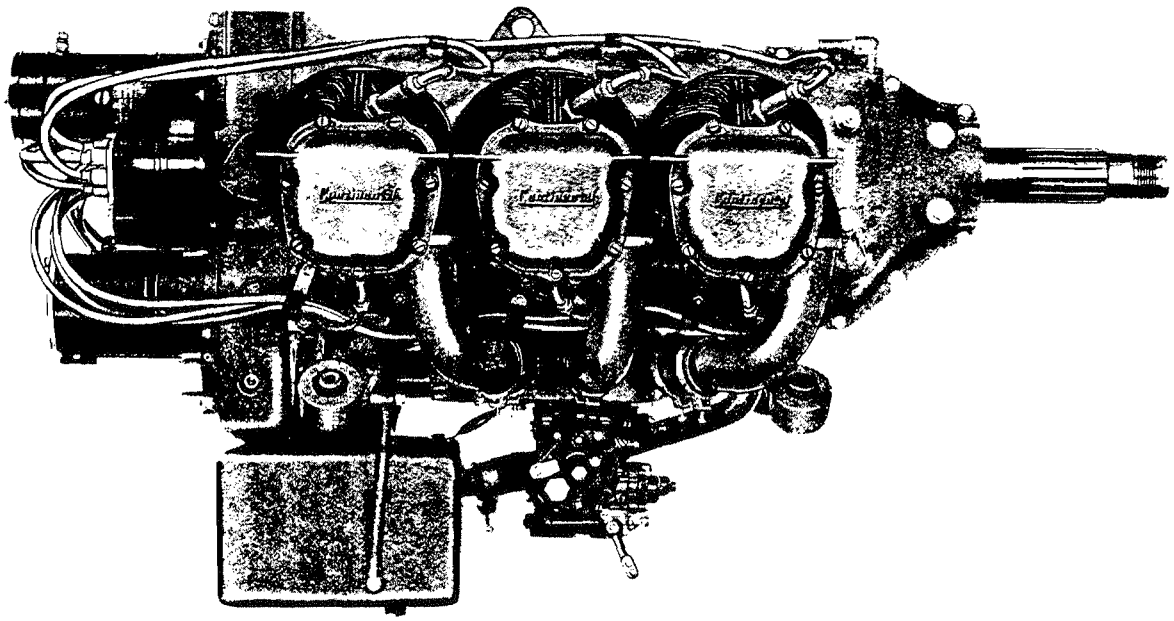


FIGURE 9. RIGHT SIDE VIEW TYPICAL OF MODELS E185-9 AND E225-4.

3-28. CRANKSHAFT ASSEMBLIES.

To meet the demand for crankshafts suitable for both fixed pitch and controllable propellers two types of front end propeller mounting are produced. One type has a No. 4 S.A.E. flange, intended primarily for a wood propeller hub, and equipped with eight pressed-in, internal thread bushings for propeller mounting bolts. Moisture impervious plates, retaining flanges, washers and bolts are available for this type of shaft. The other type of crankshaft has an S.A.E. No. 20 splined front end with a hub nut thread and nut locking pin holes.

3-29. Early production crankshafts were not equipped with counterweights. To reduce vibration when certain types of propellers are installed, crankshafts were then machined to accept two 6th order counterweights. Current crankshaft and counterweight assemblies are supplied with one 6th order and one 5th order damper counterweights to dampen these two overtones of the crankshaft fundamental frequency. The counterweights are straddle mounted on blade extensions of the crankcheek between Nos. 1 and 2 crankpins. They are retained by loose fitting pins of hardened steel working in steel bushings pressed in the counterweights and crankshaft extensions. The counterweight pins are retained endwise by thin steel plates, which are retained, in turn, by Truarc snap rings. The new type assemblies which include the 5th order counterweight are identified by a notch in the blade to clear a groove pin installed in the 5th order weight assembly.

3-30. All crankshafts are one piece, six throw, 60° type machined alloy steel forgings with four main journals and one double flanged main-thrust journal. They are heat treated for high strength and nitrided, except on the splines, or propeller mount flange, for maximum resistance to wear. Crankpins and main journals are ground to close limits of size and surface roughness. After grinding and nitriding crankshafts are balanced statically and dynamically. Final balance is checked after assembly of the counterweights and other parts. Since selection of counterweights is necessary to preserve the dynamic balance of the complete assembly they cannot be interchanged on the shaft or between crankshafts. For this reason neither counterweights nor bare crankshafts are supplied alone.

3-31. Crankshafts are line bored to reduce weight. The bore extends the full length of the shaft. Splined shafts have a threaded plug installed at the front end. A pressed-in Hubbard plug is installed in the front end of flange shafts. Crankpins are recessed at each end for lightness. Steel tubes permanently installed in holes drilled through

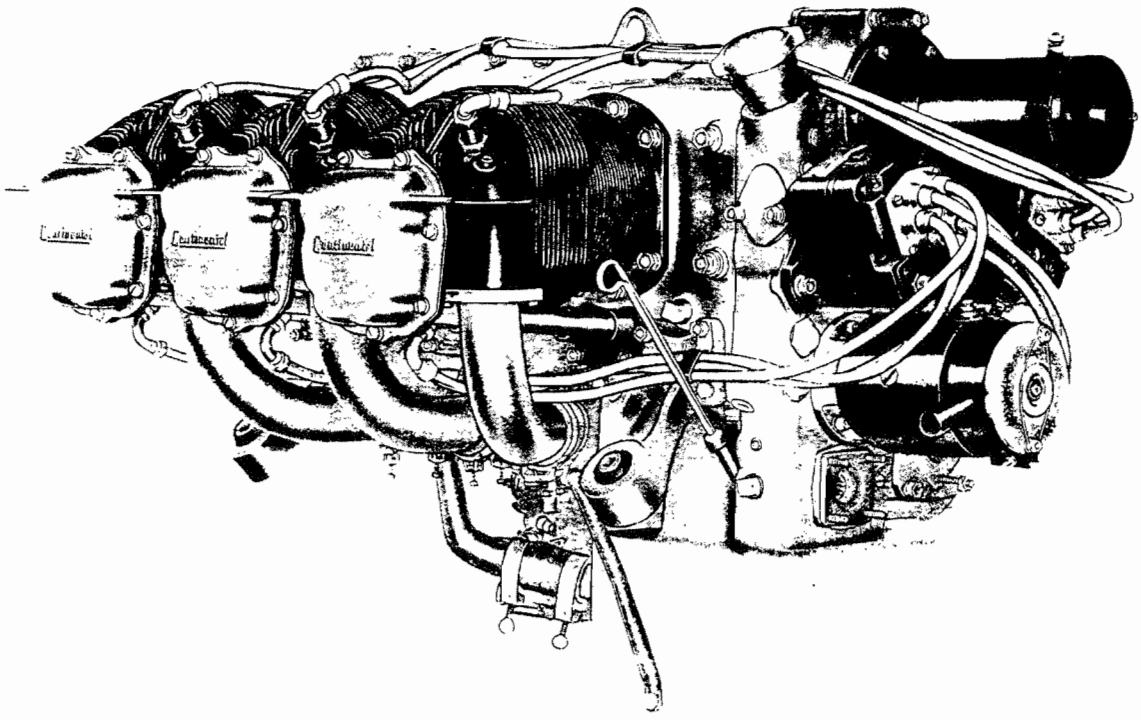


FIGURE 10. THREE–QUARTER LEFT REAR VIEW TYPICAL OF MODELS E185-9 AND E225-4.

the crankcheeks provide oil passages across the lightening holes to all crankpin surfaces from the journals. A U-shaped tube, permanently installed inside the front end of the shaft bore conducts oil from the second main journal to the front main-thrust journal.

3-32. At the rear end of the crankshaft six tapped holes receive the screws which attach the accessory drive gear. Originally these holes were tapped to accept 1/4-28 screws but current crankshafts require 5/16-24 screws. The original accessory drive gear was forged with an eccentric which was used to drive two diaphragm fuel pumps. Current production E-185-1 and E-185-3 gears are forged without this eccentric. This type of gear, as well as the single spur gear installed in Model E-185-8 and E-185-9 engines, is available for both 1/4 and 5/16 inch attaching screws. A change to the larger attaching screw size resulted in new part numbers to be assigned to both accessory drive gear and the crankshaft assembly. Refer to the Parts Catalog for the correct combination of crankshafts and gears for both sizes of screws.

3-33. An enlarged shoulder between the front crankshaft thrust flange and the splines of splined crankshafts is polished smooth for an oil seal race. The seal lip rides the shaft race, and the seal fits tightly in the front crankcase counterbore. The type of crankshaft oil seal installed depends on the type of crankshaft. With splined shafts a steel cased rubber and spring seal is used. Flange shafts require a split type of seal of soft material with a removable helical spring.

3-34. CONNECTING RODS.

Conventional automotive type, split big end rods are machined of steel forgings and sawed through the big end before machining of the crankpin bearing seat. The resulting bearing cap is attached to the rod by two hex head bolts and hex nuts. Rod and cap are numbered for position by stamping the bolt bosses on the upper side. After machining of the bearing seat, notches are cut in rod and cap to receive tangs of the production steel backed, Tri-Metal bronze inserts which have a lead plating for the actual crankpin bearing surface. From the big end the rod tapers, with an H beam section, to the piston pin boss, into which is pressed a split bronze bushing. The bushing split lies at an angle of 45° from the rod centerline and toward the big end. Bushings are bored in alignment with the big ends.

3-35. PISTON ASSEMBLIES.

The earlier and the current type pistons have solid skirts and are machined of aluminum castings with grooves for top and second compression rings and the third, slotted oil control ring all above the pin. The ring grooves in the new type piston are slightly greater in width, giving slightly greater side clearance and gaps than the old. The skirts of the new pistons have cylindrical relief cuts at the bottom to clear the crankshaft counterweights. Both compression rings of the current type piston assemblies are chrome faced, whereas only the top ring of the older piston assemblies was chromed faced. The top and second rings of both type piston assemblies have tapered faces to permit quicker seating. Four oil holes are drilled from the third ring groove to the interior of the piston to provide for drainage of oil scraped from the cylinder wall. Three types of piston pins have been used in this series engines. All pins are tubular steel, ground on the outside to accurate sizes and polish. The original pins had separate end plugs. These pins were replaced by pins which were made of the same tubular steel pin with a single aluminum plug pressed through and projected from both ends. The aluminum plug was then staked on each end. This pin was replaced by the current production pin assembly, which is similar to the second type, except that the aluminum plug is hot forged to a truncated conical shape beyond the ends of the steel tube. These changes in construction increase the pin weights; therefore, new and older type pins must not be mixed in any engine. The new pins may be installed in complete sets in an E-185 or E-225 engine as replacement parts providing the connecting rod bushings are machined to the dimensions specified in paragraph 10-20. The new and old type pistons must not be mixed in any engine. Refer to the Parts Catalog for the appropriate type pistons and rings to be installed with each type cylinder.

3-36. CAMSHAFT.

The original type of camshaft used in all E Series Models was a flame hardened cast iron part. Current production camshafts are machined steel forgings with hardened lobes and journals.

3-37. The camshaft has four journals. The rear journal has a flange at each end to restrict camshaft end movement by bearing against the ends of the crankcase rear bearing. The large flange at the rear end of the shaft has four tapped holes for gear retaining screws. Unequal spacing of the screw holes makes it impossible to install the camshaft gear in any but the correct relation to the cam lobes. In 1953 the tapped hole size and gear hole diameter were changed to accomodate 5/16 inch screws which resulted in new part numbers for these parts. Correct combinations of camshaft, gears and attaching screws for both sizes are indicated in the Parts Catalog. The camshaft has three groups of three cam lobes. In each group the center lobe actuates the hydraulic lifters of two opposite intake valves, while the outer lobes each actuate a single exhaust valve lifter. The front camshaft journal has a deep groove machined in the center of its length. This groove is aligned with holes drilled through

the crankcase front web from the front camshaft bearing to the oil gallery tube in each case half, thus providing a connecting passage from one gallery to the other.

3-38. CYLINDER ASSEMBLIES.

A number of significant construction changes have been made between the original cylinders and the current production assemblies. The bronze, 14 mm spark plug inserts installed in original type cylinders were replaced on superseding cylinders by the current 18 mm helical coil inserts. Studs, which were driven directly into tapped holes into exhaust port flanges are now driven into helical coil thread inserts installed in that location. This change permits renewal and correct tight fit of studs, should they require replacement.

3-39. Cylinder heads are partially machined aluminum alloy castings with rocker boxes molded in their outer ends. In 1950, the head casting was altered by increasing the dimensions of the rocker shaft support bosses to increase their strength. This changed the head casting part number and required a new rocker cover to clear the wider bosses. The intake and exhaust ports on all cylinders are directed downward and are flanged for attachment of the pipes. Intake pipes are attached by loose aluminum flanges which sit closely over a rubber seal ring in a groove of the pipe. The flange is attached to the cylinder head by two screws. Exhaust manifold tube flanges are attached to the two exhaust port flange studs by brass hex nuts. Each cylinder head is equipped with a steel intake valve seat and a steel exhaust valve seat. The seat inserts are installed when the head is at high temperature and are held tightly in place when the head shrinks as it cools. The cylinder barrel is also screwed and shrunk into the head. Bronze valve guides are pressed into cylinder head bosses which are bored for tight fit without shrinking. The plane of the valve seats is perpendicular to the cylinder axis and the axis of each valve guide is parallel to the cylinder axis. A 1/8 inch N.P.T. hole on the upper side of each cylinder head intake chamber is plugged by a socket head plug, which may be removed for installation of a primer nozzle. A 3/8-24 tapped hole in the lower side of the head permits installation of a plug type thermocouple.

3-40. The cylinder barrel is a steel forging, machined all over. Cooling fins are machined on the outside of the barrel. The base flange below the finned portion has eight reamed holes for crankcase studs and through bolts, to which the cylinder is attached by hex nuts. The original type cylinder base flange holes were reamed to accept 3/8 inch diameter holes. When the crankcase studs were changed to straight 7/16 inch diameter the cylinder barrel flange holes had to be enlarged to give the proper clearance for the new studs. This change plus the changes in the cylinder head resulted in a new cylinder assembly part number. The bore of original type cylinders is parallel in the lower portion from the open end to a point 2-3/8 inches above the base flange mounting surface. The bore of current type cylinders is parallel in the lower portion from the open end to a point 4-1/4 inches above the open end. Above this point the barrel of the original type cylinders is choked or tapered .008 to .010 inches. The barrel of current type cylinders is choked or tapered .010 to .012 inches. The choke or taper allows for expansion of the head end at operating temperatures. The cylinder assemblies with increased choke at the upper end are identified by the letter "N" stamped on the edge of the base flange. These cylinders were installed in wet sump engines beginning with serial number 6128-4-9 and in dry sump engines beginning with serial number 22198-4-11 surface roughness of the honed barrel bore is closely controlled to provide sufficient "scratch" area to hold oil during the break-in period without sacrificing adequate smooth bearing surface for piston rings.

3-41. After assembly of the barrel and head the base flange holes are machined in correct relation to the line of valve guides. The bore is also finished at this stage, and the valve guides are installed and broached to size. The finished guides pilot the valve seat cutters to assure correct seat alignment. This order must be taken into account in cylinder repair operations.

3-42. Rocker box covers are die cast aluminum alloy with seven holes in the surrounding flange for fillister head screws which attach each cover to the cylinder head.

3-43. VALVE MECHANISM.

Intake and exhaust valves are steel alloy forgings, machined all over. The exhaust valve has a face and a stem tip of extremely hard material welded on to resist heat. The exhaust valve stem is hard chrome plated to prevent scoring. Both types of valves have grooves near the outer end of the stems for spring retainer keys, and all valves are highly polished on the stem bearing surfaces and lapped to a fine finish on the stem tips.

3-44. Each valve is held on its seat by two co-axial springs would in opposite directions. A steel inner retainer protects the rocker box surface under the inner spring ends. The outer spring retainer has a conical center hole into which the tapered valve stem split key fits and is held by spring force.

3-45. Original valve springs required an aluminum spacer under the inner retainer for adequate spring force. Current production springs, identified by a blue paint stripe, do not require, and must not be installed with the spacers.

3-46. Valve rocker arms are steel forgings with bronze bushings pressed into the hub bores. Valve contact surfaces are hardened and ground. Spherical pushrod cups are drilled in the center to intersect holes leading to grooves around the hub bushings. Oil, fed to the groove around the bushing, enters the bearing surface through two holes through the bushing wall. The intake valve rockers have oil squirt passages drilled upward from the hub grooves and opening in a direction facing the exhaust valve stems.

3-47. The pair of rocker arms in each cylinder head is pivoted on a tubular steel shaft which passes through three cylinder head support bosses and fits closely within the rocker bushings. Each rocker rides the shaft between two support bosses and has only a small side clearance to maintain alignment with its valve stem.

3-48. Original type pushrods are composed of steel tubes and spherical ground, drilled ball ends. The ball ends are pressed into the tubes. The current type pushrod is composed of a steel tube and two ball ends which are spot welded in place. Each pushrod forms an oil passage from its hydraulic lifter cup to the rocker arm which it actuates.

3-49. Pushrods installed on the earlier engines are housed in steel tubes which are sealed in the downward extension of the rocker boxes and to flanges attached to the crankcase by rubber seal rings. Removable pushrod housings have been installed on cylinders, part number 532453 and higher. The heads of these cylinders are bored straight through for the pushrod housing seals, and a spring wire retainer bears against the under side of the cylinder head to hold the housing in place.

3-50. The hydraulic valve lifters consist of three principal parts, i.e., a body, a hydraulic unit, and a pushrod socket. The lifter body has a tubular shank, in which the hydraulic unit and socket are housed, and a large diameter follower end, integral with the shank, which contacts the cam lobe. The hydraulic unit rests against a shoulder in the lifter body, and the pushrod socket rests on the outer end of the unit plunger. The socket is retained by a wire snap ring in a groove near the outer end of the body bore. The socket base is grooved for oil passage to its center drilled hole into the cup. Oil reaches the socket groove from the space around the plunger, the space being fed by a hole through the lifter body wall. The hydraulic unit consists of a cylinder with an inlet tube at its inner end and a check valve to prevent flow of oil out of the tube. The plunger and spring are also parts of the unit. The plunger protrudes from the open end of the cylinder, and the spring is installed between the outer plunger head and the cylinder end, tending to push the plunger outward. An oil hole through the body wall supplies oil to the inner reservoir of the body under the unit cylinder. Outer and inner body oil holes are connected by a flat on the outer surface of the body shank, and a groove around the shank assures an oil path from the crankcase guide hole to the body flat as the lifter rotates. Rotation of valve lifters is achieved by a small taper on the toe of each cam lobe. The rotation is necessary to prevent excessive wear in a groove pattern on the follower face.

3-51. GEAR TRAIN.

Figure 11 is a schematic diagram of the gear train, as viewed from the rear of the engine. Speed ratios of all drives are listed in Table IV.

3-52. All gears are case-hardened spur gears. The accessory drive gear is a cluster gear, as installed in engines equipped with Delco-Remy starters, while the accessory drive gear for use with Eclipse starters is a single spur gear. The camshaft gear has both external and internal teeth. A punch mark on the rear side of the camshaft gear, in line with an external tooth, meshes between two punch marks on rear ends of accessory drive gear teeth to time the camshaft to the crankshaft. Magneto drive gears have bronze bushings which bear on steel supports. The left and right side accessory drive gears are shaftgears of forged steel with internally splined rear shaft ends to drive accessories. They bear in aluminum adapter bores. The accessory drive idler gear has a bored hub which bears on the bronze stationary shaft. The generator drive gear is mounted on the generator shaft, which it drives through a rubber bushing or, on latest type engines through two rubber bushings. The rubber bushings are retained in a pressed steel retainer and transmit the turning force of two gear lugs to the retainer, which, in turn, drives a hub keyed to the generator shaft. When an oil scavenge pump is installed, its driving impeller is keyed to the forward end of the left side accessory drive gear.

For starting, the Delco-Remy armature shaft pinion drives the larger wheel of the accessory drive cluster gear through an intermediate gear and pinion assembly which bears in the starter adapter and on a crankcase mounted pivot. The intermediate gear assembly incorporates a disengaging spring, and its pinion is driven through an over-riding clutch. With Eclipse starters the accessory drive gear is turned by a starter drive gear with three jaws, which, in turn, is engaged to the starter jaws. The starter drive gear bears on a crankcase mounted pivot.

3-53. LUBRICATION SYSTEM.

Figure 41 shows a typical external oil system for dry sump models. The supply line from the reservoir is connected to the engine oil inlet tube at the left side of the accessory case. Oil is supplied to the pressure pump inlet port through

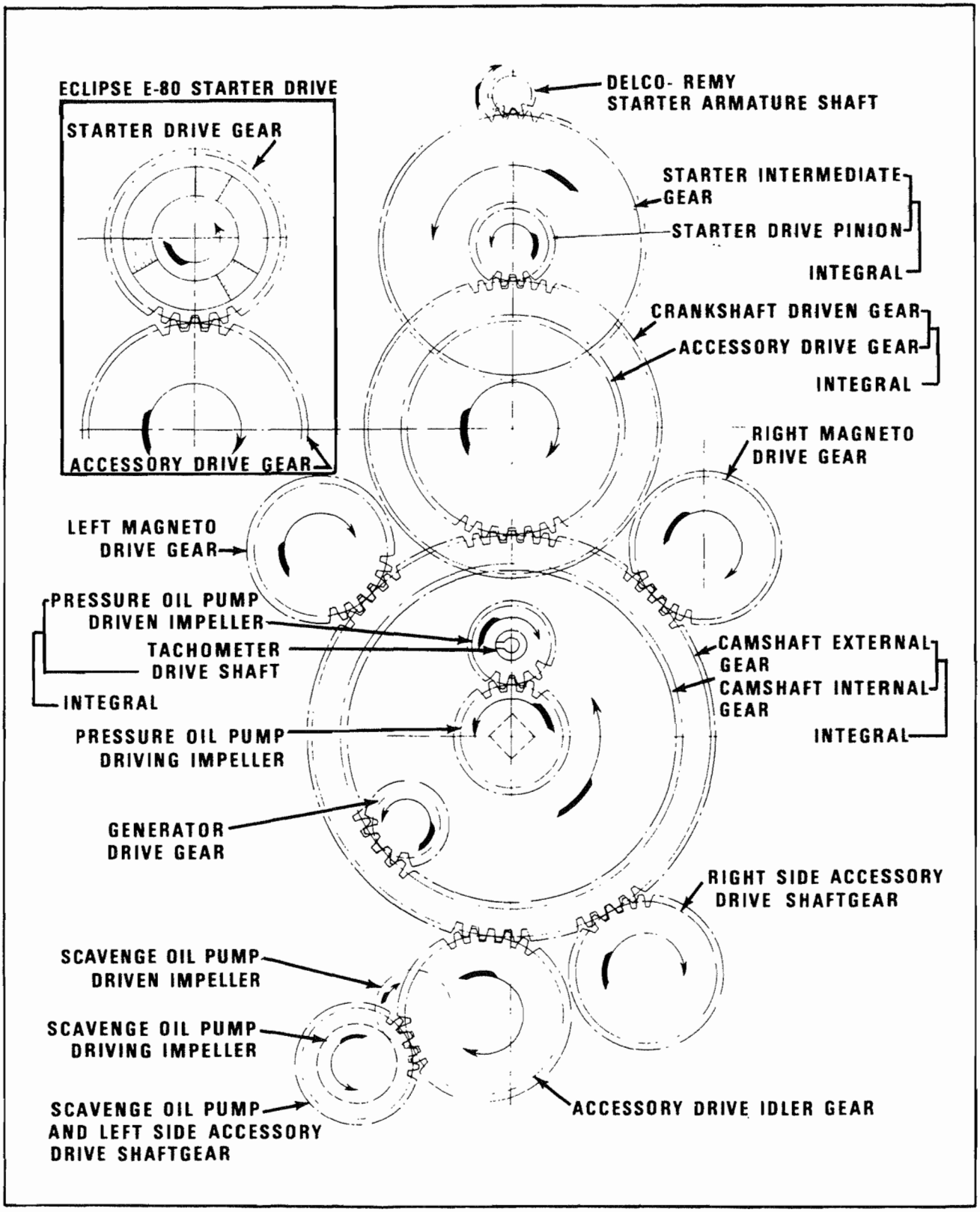
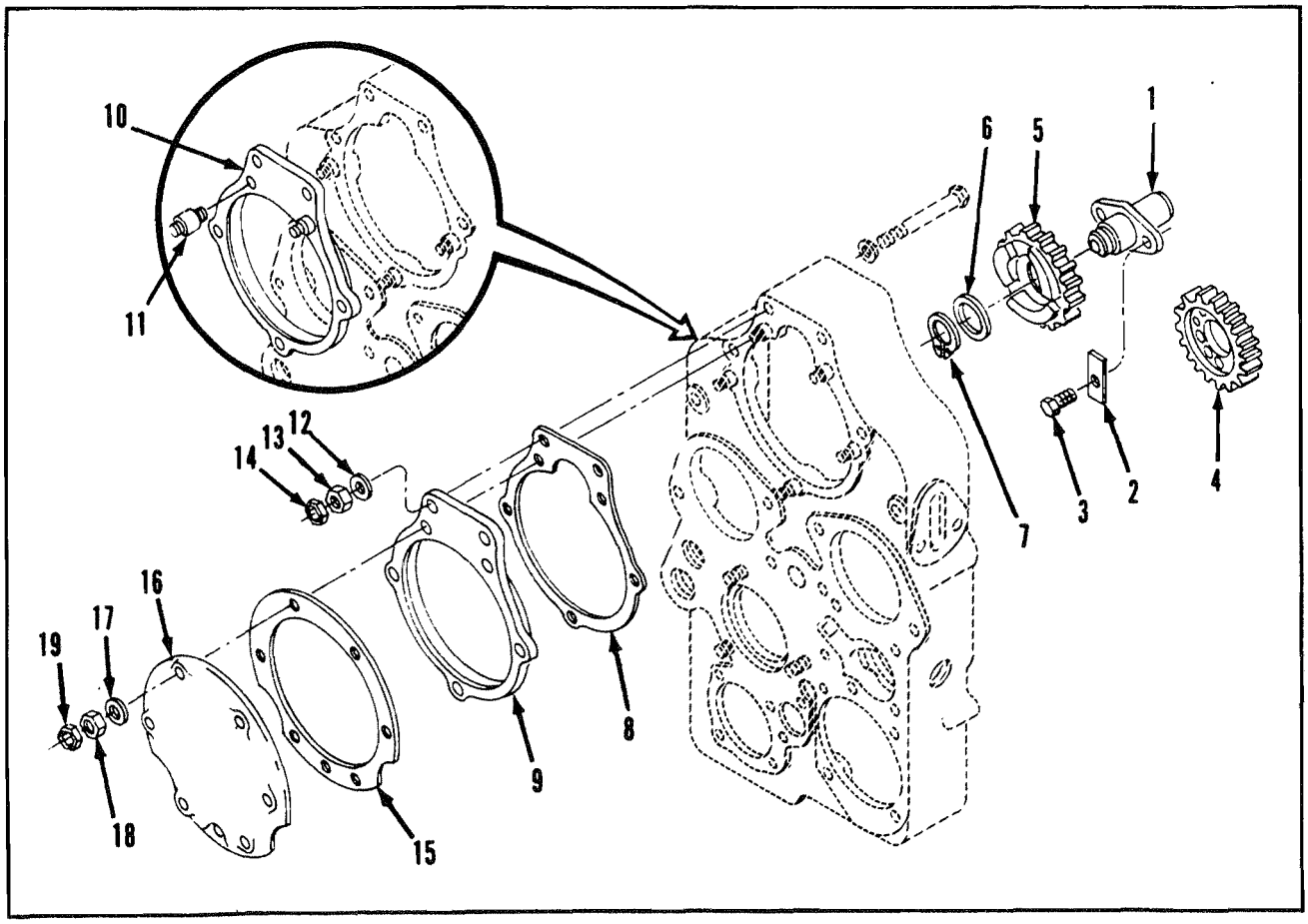


FIGURE 11. GEAR TRAIN DIAGRAM.

this tube. The pump delivers oil to the pressure oil screen housing and forces it through the double mesh screen, depositing foreign particles on the outside of the screen. After passing through the screen, the oil is led to the rear end of the right side main oil gallery tube in the crankcase. Oil flows forward through the gallery to the cross passage in the right case half, through this passage to the front camshaft bearing groove, through the groove into the cross hole drilled in the left case half and into the left side gallery. At the rear end of the side gallery the oil exerts a force on the oil pressure relief valve. If the delivery of the pressure pump builds up enough pressure to overcome the relief valve spring the valve plunger is forced from its seat, and oil flows through the seat and through a side outlet from the plunger guide into the open accessory case until the pressure falls below that required to open the valve.

3-54. Drilled passages in the left crankcase half conduct oil from the left gallery to all camshaft bearings and to all crankshaft main bearings, except the front main thrust bearing, which receives its supply through a "U" tube in the shaft from the second main bearing. Holes drilled from all valve lifter guides into the oil galleries provide oil for replenishment to the supply in the lifter reservoirs and for delivery through the lifter socket holes and hollow push-



1. Pivot, Starter Gear
2. No. 501868 Tab Washer
3. Screw, Starter Gear Pivot
4. Gear, Accessory Drive
5. Gear, Starter
6. Washer, Gear Retaining
7. Ring, Truarc Snap
8. Gasket, Adapter-to-Accessory Case
9. Adapter, Eclipse Starter (installed at factory)
10. Adapter, Eclipse Starter (field conversion)
11. Stud, Adapter-to-Starter
12. Washer, Plain, 5/16 Inch
13. Nut, Plain, Hex, 5/16 Inch
14. Palnut, 5/16 Inch
15. Gasket, Starter-to-Adapter
16. Cover, Starter Adapter (shipping)
17. Washer, Plain, 5/16 Inch
18. Nut, Plain, Hex, 5/16 Inch
19. Palnut, 5/16 Inch

FIGURE 12. ECLIPSE E–80 STARTER DRIVE EQUIPMENT.

rods to the valve rockers. Oil sprays from the inner ends of the valve lifter guides and from all crankshaft and camshaft bearings into the open interior of the crankcase.

3-55. Cylinder walls are lubricated by spray from the crankpins and the mist of oil in the crankcase. The piston rings scrape most of the oil from the walls, allowing only enough to escape into the cylinder head to prevent overheating of the ring contact surfaces. Piston pins also are lubricated by the spray in the cylinders.

3-56. The right magneto gear bushing is lubricated by oil which enters the center hole at the forward end of its support through a passage drilled from the right oil gallery. The left magneto gear bushing receives its oil through a passage drilled from the oil groove in the rear main bearing seat.

3-57. The right side accessory drive shaftgear and its guide in the adapter are lubricated by oil led through a hole drilled from the accessory case right side vertical passage rearward to the adapter mount pad and through a hole drilled through the adapter to the accessory mounting pad, with a cross hole drilled into the gear guide. The open hole at the accessory mounting pad provides lubrication for a vacuum pump which may be installed.

3-58. The vertical oil hole in the accessory case from the bottom surface to the oil screen exit cavity is plugged at its lower end. An intersecting diagonal hole drilled through a rib along the accessory case front lower wall leads oil to the idler gear shaft and left side accessory drive gear front bearings.

3-59. The generator drive is lubricated by spray in the accessory case, as are the other gear teeth.

3-60. The Delco-Remy starter pinion and clutch shaft has an Oilite bushing which bears on the starter pinion pivot of the engine and requires no lubrication. Another Oilite bushing is installed in the adapter plate for a clutch shaft rear bearing. An oil seal is pressed into the adapter ahead of the bushing.

3-61. The field modification parts for installation of the Eclipse starter drive include a pivot for the starter drive gear and jaw which is installed in the same location as the original pivot and is lubricated by drip feed through a cup formed in the attaching flange and an oil hole to the pivot center hole. This pivot must be replaced at the first overhaul with one designed for pressure feed from a hole which must be drilled into the rear main bearing seat. The pressure feed system is installed in Models E-185-8, E-185-9, E-185-11, E-225-4 and -8 at the factory.

3-62. In the dry sump lubrication system all oil which drains into the bottom of the crankcase is returned to the sump in the bottom of the accessory case through the oil drain passage of the intake and oil drain manifold and through the oil drain housing which is connected between the manifold rear outlet, the crankcase rear drain hole and the accessory case sump. From the sump oil is drawn into the oil scavenge pump through a coarse mesh screen. Oil draining from accessory drives falls into the sump and is scavenged in the same manner. A 3/4 inch N.P.T. hole into the scavenge pump housing on the exhaust side of the impellers is connected to the external system, as shown in Figure 41.

3-63. A typical oil system of wet sump engines is shown in Figure 42. The oil suction tube from the pump inlet port extends downward through the center of the by-pass tube installed in the opening in the bottom of the accessory case and dips into the oil sump supply. Rotation of the pump inlet side, and atmospheric pressure causes the sump oil to rise in the suction tube to fill the cavity, thus keeping the pump supplied. The pressure oil pump operates the same as in the dry sump system, delivering oil to the pressure oil screen and forcing it through the screen to the cavity ahead of the screen in the accessory case. In the wet sump accessory case an elbow is installed in a tapped hole in the right side of the case connected to the screen exit. Oil flows through this outlet to the hose connecting the elbow to the oil cooler inlet. The cooler usually has an integral by-pass and valve to permit cold oil to flow directly back to the engine. Whether the oil passes through the cooler or through its by-pass, it returns to the engine through either of two pipe tapped holes near the rear ends of the oil galleries in the crankcase. The internal pressure oil circulation in wet sump engines is the same as in dry sump models, as described in paragraphs 3-53 through 3-61, except that the flow through the galleries may be reversed, due to the inlet location.

3-64. Wet sump models are not equipped with oil scavenge pumps. Oil drains from the crankcase and accessory case through the manifold, front oil drain tube and by-pass tube to the attached sump to be recirculated.

3-65. INDUCTION SYSTEM.

Fuel is drawn into the vane type fuel pump from the supply line and is delivered through a hose to the carburetor inlet. The carburetor throat forms an air passage from the scoop to the manifold. Air passing through the carburetor throat is mixed with fuel sprayed into the stream from the main discharge nozzle, and the mixture is drawn into the manifold air chamber by the partial vacuum produced by piston intake strokes. From the manifold the fuel-air mixture is drawn into the cylinder intake ports through the curved intake tubes and hose connectors. Points of opening and

closing of intake valves in relation to crankshaft rotation for Models E-165 and E-185 are shown in Figure 1. Refer to Table VI for data relating to Model E-225. The absence of lash in the valve train assures uniform opening of intake valves and uniformity of the period during which they remain open.

3-66. Models E-185-2 and E-165-2 are equipped with Marvel-Schebler float type carburetors, when specified by the purchaser. These carburetors require no fuel pump when fuel is fed by gravity at a pressure, or "head", of at least 1.5 p.s.i. to the carburetor inlet. These models are equipped with wet sumps and require no oil scavenge pump or drive, so that the left side accessory drive may be omitted and its mount pad covered by a plate.

3-67. When the Stromberg Model PS-5C pressure type carburetor is installed on any model a fuel pump and drive must be installed also to provide the fuel inlet pressure required to operate the carburetor diaphragm metering system. Four Stromberg Parts List numbers assigned to Model PS-5C carburetors denote differences in discharge nozzles and throttle levers. Refer to the manufacturer's Service Bulletin No. 678 for information relative to modification to incorporate an adjustable enrichment valve opening screw for positive enrichment at full throttle. Refer to the manufacturer's handbook for a description of the operation of the Model PS-5C carburetor.

3-68. Both the Marvel-Schebler and Stromberg carburetors installed on E Series engines have a manual mixture control combined with an idle cut-off mechanism. The usual cockpit control positions are: forward for full rich, rearward to lean and full rear for idle cut-off. These carburetors, as installed on E Series engines, do not have automatic mixture controls.

3-69. Two types of manifold priming nozzle, differing only in the type of primer line fitting for which they are designed, are available. The manifold primer nozzle is installed in a tapped hole in the lower side of the intake manifold ahead of the carburetor. The nozzle extends into the central manifold chamber. For extreme cold weather starting AN4022-1 primer jet nipples may be installed in 1/8 inch N.P.T. holes in the upper surfaces of cylinder head intake valve chambers. It is recommended that the four rear cylinders, at least, be so equipped and connected to a primer distributor (Part No. 532767) fed by the hand primer pump. The aircraft manufacturer should be consulted for recommendations on installation of cylinder head priming equipment and the availability of a parts kit designed for the specific type of aircraft.

3-70. IGNITION SYSTEM.

Two Scintilla Model S6LN-21 magnetos are driven by the engine gears through rubber bushed couplings, or "drive discs", of bonded rubber and steel. Gear lugs drive the bushings or discs, which, in turn, drive the magneto impulse couplings. Impulse couplings operate only while the engine is cranked and act as rigid drives at all engine running speeds. They serve to retard the sparks and to spin the magneto rotors through the firing point to facilitate starting. Magnetos are radio shielded and accomodate either shielded or unshielded spark plug cables and switch wires. The magneto switch wire terminal bears against a spring inside the magneto terminal bushing. The spring is connected to the insulated breaker point and contacts the magneto housing whenever the switch wire is removed, thus grounding the primary circuit to prevent build up of secondary current and possible spark discharge in any cylinder in the event that the crankshaft should be turned. Magneto high-tension outlet plates have six tapped spigots into which are screwed the coupling nuts of radio shielded spark plug cables. Unshielded cables are not retained by coupling nuts. A large rubber grommet ahead of the high tension plate has six hollow bosses which fit into conical holes in the front side of the plate and receive the spark plug cables. The cables are attached to the grommet by washers and cable piercing screws. The screws provide contact with the magneto distributor rotor. The high tension outlet plate is attached to the magneto by four screws. The cable and plate assembly may be removed from the magneto and from the engine as a unit.

3-71. Radio shielded ignition cable and plate assemblies for Scintilla magnetos consist of flexible cables held together by brackets which attach the assemblies to crankcase studs. Each cable assembly has six cables divided into groups of three. The six cable of the right magneto assembly lead to the three upper right and three upper left spark plugs while those of the left magneto assembly lead to the lower right and lower left plugs. Left and right groups of upper and lower cable assemblies for Eisemann mangetos are not joined, since the magneto terminals are individual. Corresponding groups of cables for Scintilla magnetos are joined by the outlet plates, as described in paragraph 3-70.

3-72. All radio shielded ignition cables are equipped with standard spark plug elbows and contact sleeves. The magneto terminal ends have ferrules swaged on a short distance from the wire ends, and coupling nuts hold the ferrules to the magneto outlets to prevent pulling loose and to provide continuity of the shielding. The cable construction consists of the usual type of high tension wire and insulation, surrounded by a braided sheather of copper strands and covered by a plastic protective coating. The conductor is seven strand copper wire.

3-73. Unshielded ignition cables are standard seven strand copper wire with high tension insulation. Safety terminals for unshielded spark plugs are attached. Scintilla magnetos require no magneto and terminals on unshielded cables.

3-74. In addition to types of shielded and unshielded spark plugs listed in Tables III and V, a number of BG and other plugs are approved by the F.A.A. for use with E Series engines. Refer to the F.A.A. Type Specification or to Teledyne Continental Service Bulletins on this subject for the complete list.

3-75. COOLING SYSTEM.

Engine cylinders are cooled by air flow between fins machined on heads and barrels. The air flow is directed through the fins by cylinder baffles and other cowling parts furnished by the aircraft manufacturer to suit each type of aircraft installation.

3-76. EXHAUST SYSTEM.

Exhaust gasses are carried from the cylinder ports through manifolds supplied by the aircraft manufacturer.

SECTION IV
PACKING, UNPACKING AND PREPARATION FOR STORAGE

INTENTIONALLY

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4-1. FACTORY PRESERVATION.

During the last few minutes of the factory run-in and test, each engine is sprayed through the carburetor air intake with a mixture of engine lubricating oil and corrosion-preventive compound until an oil fog comes from the short exhaust stacks. The engine is stopped while still taking in the corrosion-preventive mixture. After exterior cleaning the engine is mounted on the shipping crate base to be "dressed up" by installation of fittings, plugs and protective covers. The spark plugs are removed, and the corrosion preventive mixture is sprayed into each spark plug hole. The crankshaft is not turned after this operation. Dehydrator plugs are installed in the upper spark plug holes to absorb any water vapor remaining in the air in cylinders. Plain shipping plugs are installed in the lower spark plug holes. Ignition cable contacts are attached to the dehydrator plugs with protective caps. A moisture proof shroud is placed over the finished assembly to protect the engine from dripping water.

4-2. SHIPPING CRATE.

The domestic shipping crate is composed of a heavy base, to which the assembly of top and side panels is attached by eight bolts which are screwed into plate nuts fastened to members around the sides and ends of the base. Lengthwise bolsters and lateral struts on the upper side of the base form a rigid box, to which the engine supports are bolted. Engine mount brackets are fastened to the steel supports by machine bolts for shipment. Skids of 2" X 4" wood on the bottom side of the base allow cables, chains or lift truck forks to pass under the base for lifting the crate.

CAUTION

Do not lift the engine shipping crate with grab hooks or by attachment of any lifting device to the side or top of the crate.

The export shipping crate is similar to the domestic shipping crate, but the sides and top are of double thickness wood with water proof paper between the laminations.

4-3. UNPACKING THE ENGINE.

To remove the crate top and side panel assembly, loosen and unscrew the eight square head bolts around the bottom of the sides and ends. Lift the assembly straight upward until it clears the engine. Attach a hoist hook to the engine lifting eye. The eye is triangular plate attached by the fourth and fifth bolts from the rear of the crankcase upper flange. If the hoist hook will not enter the eye a loop of aircraft cable or an adapter hook may be made for the purpose. Take up the engine weight on the hoist. Remove the bolts which attach the four engine mounting brackets to the crate, and hoist the engine. It will be advisable to mount the engine on an assembly stand for installation of aircraft fittings. Be sure that all shipping plugs are completely removed and fittings installed immediately thereafter to prevent entrance of foreign matter. Adjust the generator brush cover so that the ventilator tube points in the proper direction to connect with the aircraft tube and scoop.

4-4. PREPARATION FOR SERVICE.

Remove the dehydrator plugs and plain plugs from all spark plug holes in cylinder heads, and rotate the crankshaft several revolutions to allow drainage of any excess of corrosion-preventive oil mixture from the cylinder combustion chambers. While turning the crankshaft, listen for sticking valves. Do not confuse the snap action of magneto impulse couplings with valve action. If any valve sticks in its guide remove the rocker cover, and apply a mixture of engine oil and gasoline to the stem. Continue crankshaft movement until all valves work freely. Remove the oil drain plug, and allow the oil mixture to drain from the sump. Replace and safety the plug, using a serviceable gasket. Use a new gasket under any rocker cover which was removed, and make sure that the plain and lock washers are reinstalled under all screw heads.

4-5. Install all spark plugs, after coating their 18 mm threads with a film of engine oil. Tighten spark plugs to the torque specified in Section XV. Install cable contact sleeves in shielded plugs carefully, and tighten the elbow union nuts only enough to hold firm.

4-6. If slotted nuts are removed from crankcase through bolts to permit installation of cylinder baffle brackets, it is imperative that the brackets provide smooth nut seats and that the nuts be tightened to specified torque when they are reinstalled.

4-7. If the oil pressure gauge line fitting is an elbow it is particularly advisable that it be installed before the engine is mounted in the aircraft, due to its inaccessible location.

4-8. PERIODIC WARM—UP.

When not in regular flight operation, the engine should be started and warmed up at least once each week. In damp climates the frequency of warm-up should be increased to prevent corrosion of parts from which oil has drained while standing. Also, the running assists in preventing accumulation of moisture in fuel lines. Fuel tanks should be kept full to prevent excessive condensation of atmospheric moisture.

4-9. PREPARATION FOR STORAGE.

If an engine is to be stored longer than a week, and if periodic running is not desirable it will be necessary to preserve the engine for long term storage in the following manner:

a. Drain the oil sump and the external supply tank, if installed.

b. Fill the supply tank with a suitable mixture of engine lubricating oil and corrosion-preventive compound. The compound should be a type which can be used for operation of the engine and which will mix with oil to provide a good lubricant and leave no wax or other deposits.

c. Start and warm up the engine until oil temperature is normal.

d. Stop the engine, and remove the air filter. Arrange a container of clean preservative oil mixture and a suitable pump and hose equipped with a nozzle which may be placed at the air scoop mouth.

e. Start the engine, and spray the preservative mixture into the air intake until a fog appears at the exhaust outlet. Stop the engine while the spray is still in operation.

f. Remove the spark plugs. Rotate the propeller, and spray the mixture into all cylinders. Spray each cylinder after stopping the propeller, and do not turn the propeller thereafter.

g. Replace spark plugs with dehydrator plugs in all cylinders, and protect cable terminals.

NOTE

Recommendations for preservation of Stromberg carburetors are contained in the manufacturer's handbook.

SECTION V
INSTALLATION IN AIRCRAFT AND REMOVAL

INTENTIONALLY

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5-1. INSTALLATION.

5-2. HOISTING.

The engine assumes a horizontal position when hoisted by the engine lifting eye. No other attachment is needed and none should be used.

5-3. ENGINE MOUNT BRACKETS.

The type of mount brackets installed on any one engine is governed by the customer's specifications. One type of bracket is fitted with a one-piece, tube form rubber isolator bushing. This type of bracket is designed to be installed in aircraft whose engine mounting pads are in an oblique position. The second type requires two conical rubber isolator assemblies and are designed to be installed in aircraft whose engine mounting pads are in a horizontal position. The conical isolator assemblies are not supplied with the engine, but must be obtained and fitted, together with the proper washers and bolts. Earlier brackets for the E-185-1, -3, -8 and -9 were drilled for a 5/16 inch through bolt at the rear bottom of the crankcase. Current brackets now have a 13/32 inch hole in this location for the 3/8 inch through bolt now being installed in the rear hole. The E-185-11 and E-225-8 engine mount brackets are similar to the E-185-1 brackets except the holes for isolator bushings are bored straight through and require a different shape mount bushing. This type of bushing has not been supplied by the engine manufacturer. Refer to the Parts Catalog for the correct type of mounting brackets to be installed on each engine.

5-4. PUMP AND ACCESSORIES.

Install any pumps or accessories required before mounting the engine in the aircraft.

5-5. PRECAUTIONS WHEN MOUNTING ENGINE.

The exact maneuvers necessary to place the engine in position on the aircraft engine mount will depend entirely on the aircraft design. A mobile hoist or mono-rail hoist is recommended. Proper tightening torque for mounting bolts will depend on the bolt design and material. Make sure that all isolator bushings contact the engine mount uniformly and that their bolt holes are aligned with those of the mount.

NOTE

Do not remove moisture-proof covering of crankshaft, breather nipple, or other connectors until necessary for installation of other parts.

5-6. PREPARING ENGINE FOR OPERATION.

If an engine equipped with a Stromberg pressure carburetor is to be operated within eight hours after installation, connect the carburetor fuel inlet to fuel pump and the fuel supply line to the pump immediately after bolting the engine to its mount. Also connect carburetor controls, wobble pump line, fuel pressure gauge line, carburetor air pressure gauge (if installed) and carburetor to fuel tank vent line. Carry out the flushing, filling and venting instructions given in the carburetor manufacturer's handbook.

5-7. CONNECTIONS.

Connect the following lines and controls to the engine:

a. Oil supply and return lines (See Figures 14, 41 and 42).

b. Oil temperature gauge capillary (See Figures 41 and 42).

c. Oil pressure gauge line (See Figures 7, 41 and 42).

d. Tachometer drive cable (See Figure 8).

e. Primer lines to pump and to engine.

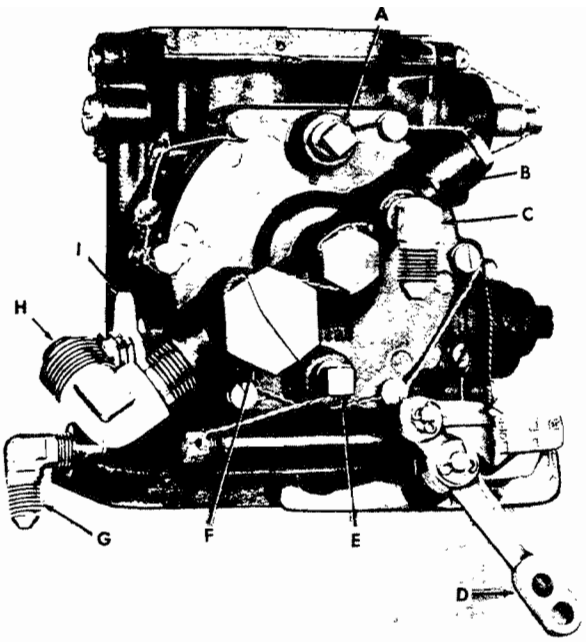
f. Ignition switch wires (See Figures 8 and 33).

g. Starter solenoid and power cables (See Figures 8).

h. Generator cables.

i. Carburetor heat control.

j. Thermocouple.



A. Vent Connection
B. Remove Plug to Vent and Fill Carburetor
C. Fuel Pressure Gauge Connection
D. Manual Mixture Control
E. Remove Plug to Vent and Fill Carburetor
F. Fuel Strainer
G. Carburetor Air Pressure Connection (if used)
H. Carburetor Fuel Inlet
I. Mounting Pad for Automatic Mixture Control

FIGURE 13. CARBURETOR CONNECTIONS (STROMBERG PS–5C).

A. Oil Supply Line Connection
B. Oil Return Line Connection

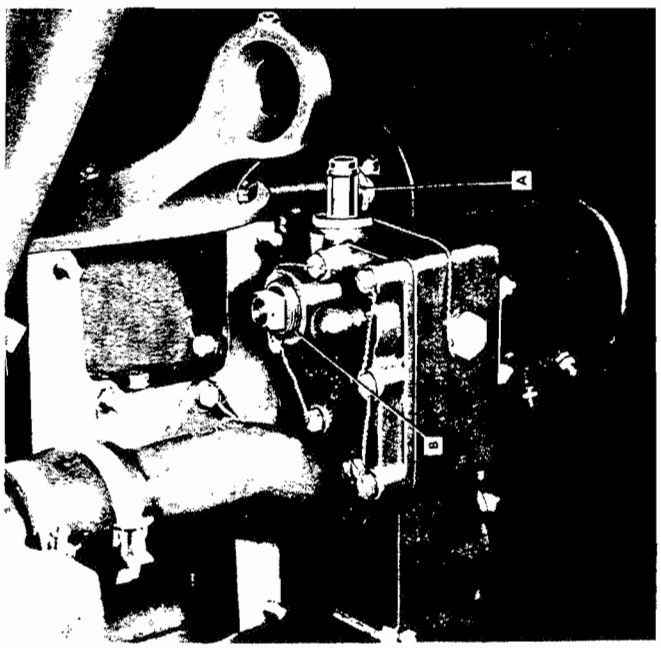


FIGURE 14. DRY SUMP ENGINE OIL HOSE CONNECTIONS.

k. Crankcase breather hose (See Figures 6, 41 and 42).

l. Propeller control.

5-8. INSPECTION.

Check the operation of all controls for freedom and full travel. Check entire installation for safety of connections, tightness of hose clamps, fuel leakage, proper support of all electrical wires and cables, and clearance of all hoses and tubes from structure.

5-9. MOUNTING THE PROPELLER.

The procedure for mounting the propeller will depend on the type of propeller to be installed and the type of crankshaft end. Later production engines have four tapped holes in the crankcase front surface for attaching variable pitch propeller control units. Refer to the Table of Torques (Section XV) for correct tightening torque.

5-10. OIL SUPPLY.

When the installation is complete, fill the oil sump or external supply tank with aircraft engine oil of the grade specified in Table II for the prevailing temperatures. Use one quart less than the normal quantity to allow for pre-oiling.

5-11. PRE—OILING.

In order to assure lubrication of all bearings when the engine is first started, it is recommended that one quart of warm engine oil (100°F.) be injected into the main oil galleries while the crankshaft is rotated by hand or by starter. This may be accomplished most easily as follows:

a. Connect the pre-oiling pump delivery hose on the engine oil inlet fitting. (Refer to Figures 41 and 42.)

b. Operate the pre-oiling pump and rotate the crankshaft until one quart of oil has been fed into the engine.

CAUTION

If the crankshaft is rotated by the starter, be sure that the magneto switch wires are connected, that the switch is in the "off" position, the throttle full open, and the mixture control in "Idle Cut-Off" position.

c. Disconnect the pre-oiling pump and reconnect the oil inlet hose to dry sump engines.

5-12. REMOVING ENGINE FROM AIRCRAFT.

5-13. Remove or disconnect the following items in the most convenient manner.

a. Disconnect propeller control.

b. Remove the propeller and wrap the exposed crankshaft end.

c. Disconnect all electrical wires and cables.

d. Disconnect carburetor controls.

e. Drain the oil sump (or external tank and accessory case).

f. Disconnect fuel supply line and primer line(s).

g. Remove thermocouple and wires.

h. Disconnect tachometer drive cable.

i. Disconnect all gauge lines.

j. Disconnect carburetor heat control and air box, if removed with engine, or detach scoop from carburetor.

k. Disconnect crankcase breather hose.

l. Disconnect oil supply and return hoses.

5-14. REMOVE ENGINE.

Attach a hoist to the engine lifting eye and take up the engine weight on the hoist. Loosen and remove the engine mounting bolt nuts, washers and bolts. Hoist the engine as required, being careful not to strike the aircraft structure. Remove the engine or roll the aircraft away, and mount the engine on an assembly stand or shipping crate base.

CAUTION

Do not lay the engine on bench or floor. Cover all openings with plugs or moisture-proof material unless overhaul is to be started immediately.

CAUTION

On retractable landing gear aircraft which have made gear up landings do not use the lifting eye on the top of the engine to raise airplane.

SECTION VI
MAINTENANCE INSTRUCTIONS

INTENTIONALLY

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6-1. DAILY INSPECTION.

Before the first flight of the day, an inspection of the engine installation should be made for the purpose of detecting dangerous conditions. The points mentioned here are confined to equipment supplied by Teledyne Continental Motors.

a. Inspect fuel and oil connections and lines for evidence of looseness, chafing and leakage.

b. Inspect starter cable and magneto switch wires for proper connection to engine, chafing and proper support.

c. Inspect spark plug wire terminals and wires (or conduits) for tightness of connection and damage.

d. Inspect oil level gauge for quantity and cleanliness of oil and inspect oil filler cap for condition of retainers.

e. Inspect carburetor for proper attachment of control rods, safety of all plugs and nuts, full travel and free operation of manual mixture control and throttle.

f. Daily cleaning and inspection of the carburetor strainer and fuel filter may be necessary under certain conditions.

g. Inspect mounting bolts for safety of attachment. Look for any missing palnuts, broken lockwires or missing cotter pins. See that oil drain plug and main oil gallery front plugs are tight and lockwire properly installed.

h. Inspect all gauge lines for attachment, support and condition.

i. After starting, check operation as indicated by engine instruments.

6-2. 100—HOUR INSPECTION.

This inspection must be performed by a certificated aircraft engine mechanic and the results must be reported on the Periodic Aircraft Inspection Report Form. The following points should be given particular attention:

a. Cowling should be removed to permit access to entire engine.

b. Check tightness and security of propeller shaft nut, or hub bolts. (See Table of Torques, Section XV.)

c. Inspect all fuel and oil lines, connectors, and supports for security of attachment and condition. Pay particular attention to condition of rubber hoses and connectors. Check tightness of hose clamps and tube fittings. Observe any evidence of leakage at fittings, chafing of hoses or tubes at supports, and possibility of tubes or hoses rubbing against electrical wiring or structure. Check condition of tube grommets or unions at firewall. Metal tubes are most susceptible to cracking near supports and end fittings.

d. Inspect all joints, connectors, clamps, bolts, screws, nuts and tubes of the induction system. If it is found necessary to remove any intake pipe, handle it with extreme care to avoid deformation. When it is reinstalled, two new hydraulic "O" rings must be used at the flange. Leakage of oil at the flanges attaching the intake and oil drain manifold to the crankcase often may be corrected by tightening the attaching bolts to specified torque.

e. Inspect carburetor air intake for dirt or other restrictions. Inspect carburetor air heater for security and operation of valve.

f. Inspect all safety wires, seals, plugs, nuts, nipples and screws on the exterior of the carburetor. Remove the fuel strainer (Refer to Figure 13), and clean the screen in an approved solvent. Excessive gum or dirt indicates the need of more frequent inspection of the strainer and should be brought to the operator's attention. Check for wear of throttle and mixture control lever pins and full control travel. Drain carburetor. Refill, flush and vent Stromberg pressure carburetors in accordance with manufacturer's instructions.

g. Remove, clean, inspect visually and test all spark plugs. Spark plug gaps should be reset between .018" and .022" before testing. Consult Service Bulletin on Spark Plug Applications for recommended gaps for specified plugs. Coat the 18 mm threads with clean engine oil. Reinstall spark plugs, using serviceable gaskets. Tighten all plugs to

specified torque. Inspect spark plug cable terminals and replace any damaged shiedled terminal elbows or contact sleeves. Inspect all spark plug cables for condition of insulation, proper attachment and condition of manifold brackets, and tightness of magneto terminal plate nuts. Pay particular attention to points at which wires pass through or touch cylinder baffles.

h. Inspect magneto breaker assemblies for condition of points. Remove any excess oil in housings. Inspect all wire terminals. No breaker point gap is specified. If it is thought necessary to check breaker point opening position, refer to Table V, Timing Instructions in Section VII, and to the Magneto Manufacturer's Service Instruction for specifications and procedure.

i. Remove the pressure oil screen from its housing and clean it in an approved solvent. Observe any metallic particles of considerable size on the screen or in the housing. Use a new copper-asbestos gasket when the screen is reinstalled. Excessive dirt or moisture on the screen indicates the need of more frequent cleaning and should be brought to the operator's attention.

j. Remove rocker covers and inspect condition of valve springs, retainers, keys and rocker arms. If all parts within the box are liberally coated with oil, a dangerous stoppage of the feed passage is indicated. If such a stoppage should exist in a push rod, the latter may be removed for cleaning, however, if no stoppage is found in the push rod, it will be necessary to remove the cylinder and the valve lifter hydraulic units or to disassemble the engine to locate it. Replace rocker covers, using new cover gaskets and new lockwashers under the screw heads.

k. Inspect cylinder fins and baffles for condition and evidence of chafing.

l. Check adjustment of Delco-Remy starter shift levers. (Refer to paragraphs 12-31, Section XII.)

m. Test engine mount bolts for proper tightness. Refer to aircraft specifications for torque limits. Reinstall cotter pins (if used).

n. It is not necessary to check valve timing, since it is fixed, or valve lash, since it is zero.

6-3. CARBURETOR MAINTENANCE.

Refer to the carburetor manufacturer's service instructions for permissible adjustment. If defective operation is traced to the carburetor, it will be necessary to remove the carburetor for overhaul or adjustment. No such overhaul should be attempted unless proper tools and flow bench are available.

6-4. MAGNETO MAINTENANCE.

If it becomes necessary to dress magneto points, the magneto may be removed from the engine. The coil and condenser should be tested and the magneto should undergo an operation test before it is reinstalled. Instructions for installing and timing magnetos to the engine will be found in Section XII. For repair and testing data, refer to the magneto manufacturer's handbook.

6-5. IGNITION REPLACEMENTS.

Defective spark plug wire terminals and elbows may be replaced without disturbing the cable attachment to the engine. Defective cables will require replacement of the particular assembly of which they are part. Such replacement may be made without considerable disassembly. The assemblies are supplied ready for installation and complete with all parts. Connect replacement cables to the magnetos according to instruction in Section XII.

6-6. DELCO–REMY STARTER REPLACEMENT AND ADJUSTMENT.

The starter adapter is attached to the accessory case by three studs, nuts and palnuts, and by two bolts which pass through the accessory case from the front. Removing these bolts and nuts will allow the starter to be pulled to the rear and free of the engine. Notice that the starter pinion is supported by a close-fitting pivot attached to the rear of the crankcase. The pinion shaft slides over the pivot and must be moved straight to the rear until it is clear. The same precaution applies in installing a new or rebuilt starter. After installing a starter, it is necessary to check the adjustment of the shift lever. See "Starter Installation", Section XII.

6-7. GENERATOR REPLACEMENT.

The generator, drive gear and rubber-cushioned coupling may be removed as a unit by removing three self-locking nuts and washers attaching it to the accessory case studs. Standard practice applies to generator repairs. When a new or rebuilt generator is to be installed, a new type gear and two-piece bushing should be assembled in the coupling. A new generator to accessory case gasket must be used. Refer to Table of Torques, Section XV, for correct tightening torque to be applied to the shaft nut.

6-8. TOP OVERHAUL.

Top overhaul may be performed by removing the cylinders according to instructions contained in Section VII. Valve and valve seat refacing may be accomplished by the use of standard equipment. Push rods and rocker arms should be

reinstalled in their original locations, as should pistons, piston pins, plugs and rocker shafts. New cylinder base packing rings, intake pipe seals, push rod housing seals and rocker cover gaskets must be used. Tighten cylinder base nuts to specified torque. Use new lockwashers under rocker cover screw heads. The cylinder bores are tapered and cannot be resurfaced successfully, except at the factory.

6-9. TROUBLES AND CORRECTIONS.

6-10. ENGINE WILL NOT START.

a. Check fuel supply.

b. Check position of all fuel line valves.

c. Check fuel pump screens for dirt and moisture.

d. Disconnect fuel supply line at carburetor and observe whether fuel flows when the starter is operated.

e. Follow instructions in the carburetor manufacturer's handbook to fill, flush and vent a new, rebuilt, or previously drained Stromberg pressure carburetor.

f. Remove and inspect carburetor fuel strainer.

g. Check for stuck idle cut-off plunger in carburetors of Stromberg pressure type.

h. Insufficient priming may be due to restrictions in primer lines or nozzles, worn priming pump, or leakage.

i. Correct over-priming by turning the crankshaft through several revolutions with manual mixture control in Idle Cut-Off position, throttle wide-open, and ignition switch off. In very cold weather spark plugs which are fouled by excessive priming may have to be dried.

j. Check for bare and grounded magneto switch wires.

k. Check magneto breaker points for oil, moisture, operation and point condition.

WARNING

The Scintilla magnetos currently being supplied are no longer equipped with an automatic grounding spring (i.e., the magneto is in a "SWITCH–ON" condition when switch lead wires are disconnected). Exercise the usual precautions when servicing the ignitions system.

l. Check spark plug electrodes for proper gap and for fouling by moisture, oil or carbon.

m. While turning the crankshaft, observe any excessive friction, knocks or looseness. Do not confuse the noise of dynamic dampers with damaged bearings or other knocks.

n. Check for serious air leaks in the induction system and for air intake restrictions.

o. During check m. above, notice whether compression is built up in cylinders. Valves may be sticking open or may be held open by congealed oil in hydraulic lifters. Exhaust valves may be burned or warped.

p. If the engine fails to fire at all, the trouble will usually lie in the ignition system.

q. If the engine fires intermittently or even a few times, the trouble will usually be traceable to the fuel system or the induction system, though insufficient cranking speed due to low battery charge or congealed oil in extremely cold weather will make starting difficult, if not impossible.

r. During cold weather when aircraft are stored in unheated hangars, it is advisable to drain the entire oil system soon after the last flight of the day. Oil should be warmed to 100°F. or more before refilling the oil system. The propeller should be turned a number of times by hand to circulate preheated oil before cold starting attempts are made.

6-11. ENGINE WILL NOT IDLE.

a. Check idle speed and mixture adjustments. Refer to the carburetor manufacturer's Service Instructions for procedure.

b. Check propeller pitch adjustment.

c. Check for induction system leaks, particularly at carburetor mounting flange.

d. Check operation and position of manual mixture control.

e. Observe decrease in fuel pressure with decrease in R.P.M. to point of cutting out. Fuel pressure must remain within limits specified in Table X.

f. If trouble, other than idling adjustments, is traced to the carburetor, it will require overhaul as described in the carburetor manufacturer's handbook.

6-12. ENGINE RUNS IRREGULARLY AT IDLING SPEED.

a. Check mixture control position at carburetor. The engine should be idled only at Full Rich setting.

b. Check for leakage through the priming system into the engine. If suction applied to the priming nozzle(s) produces a flow of fuel, the priming pump will require repair or replacement.

c. Check idle mixture adjustment. Refer to the carburetor manufacturer's service instructions.

d. Check for air leaks in the induction system.

e. Check fuel pressure.

f. Check spark plugs for fouling. Worn intake valve guides will permit oil to be drawn into cylinder heads at low R.P.M. (and high manifold vacuum), thereby fouling the plugs.

g. Check spark plug gaps for proper setting.

h. Check compression of all cylinders. See Step o, paragraph 6-10.

6-13. ENGINE WILL NOT ACCELERATE PROPERLY.

a. Check engine temperature gauges. Acceleration will be sluggish until the engine is warmed up.

b. Check position of mixture control at carburetor. Linkage may be loose or improperly adjusted.

c. Check for mixture enrichment due to leakage through priming pump.

d. If the trouble is traced to the carburetor, refer to carburetor manufacturer's instructions for checking procedure.

e. Check throttle linkage throughout for full travel.

6-14. ENGINE RUNS ROUGH AT HIGH SPEED.

a. Check engine mounting bolts, brackets and isolator bushings.

b. Propeller may be out of balance or out of track.

c. Propeller blade pitch may not be correct.

d. Check spark plugs for tight installation, gasket condition, proper gap and fouling. Test spark plugs under pressure for insulation breakdown.

e. Check all spark plug cables for continuity and check insulation with a high tension tester.

f. Check magneto breaker point condition.

g. Check operation on each magneto alone. R.P.M. should not drop more than the value specified in paragraph 6-15, step "c" when either magneto is switched off, and firing should be equally uniform with either or both magnetos operating.

h. Observe exhaust for signs of rich or lean mixture. See carburetor manufacturer's Service Instructions for checking procedure and causes of trouble.

i. Inspect rocker boxes for broken valve springs. If only one spring on any valve is broken, the valve will close at low speeds but not at high speed.

j. Remove and blow out carburetor vapor vent line.

k. If exhaust valves are not seating, top overhaul is necessary.

l. Check valve lift for possible wear on cam lobes.

6-15. SLUGGISH OPERATION AND LOW POWER.

a. If instrument indications are normal, check for full throttle opening and looseness in linkage, look for restrictions in carburetor air intake and check closing of carburetor air heater valve.

b. If indicated maximum R.P.M. is low:

1. Check accuracy of tachometer.

2. Are propeller pitch and diameter as specified?

c. If R.P.M. spread of the magnetos is in excess of 50 R.P.M. for each model at the following speeds:

2050 R.P.M. for E-165 Models,
2045 R.P.M. for E-185 Models,
1900 R.P.M. for E-225 Models,

perform the following checks:

1. Inspect upper or lower spark plugs for gap. Test under pressure.

2. Inspect upper or lower spark plug wires and terminals.

3. Inspect magneto breaker points and timing.

4. Remove and overhaul defective magneto.

d. If lean or rich mixture is indicated, refer to carburetor manufacturer's Service Instructions for checking procedure. Lean mixture is accompanied by high cylinder head temperature. Observe fuel pressure. It must be between 9 and 15 p.s.i. if a Stromberg pressure carburetor is installed. If the mixture is too lean, application of carburetor air heat decreases the roughness which may accompany it. The trouble must be corrected, usually by overhaul of the carburetor.

e. If cylinder compression is low, need of a top overhaul is indicated. Low compression may be due to either worn piston rings, loose spark plugs or warped valves.

f. If valve lift is sub-normal check for worn cam lobes and malfunction of valve lifter hydraulic units.

6-16. HIGH CYLINDER HEAD TEMPERATURE, DETONATION.

a. Is the fuel 80 octane or higher?

b. Is tachometer accurate? Is engine speed within limits?

c. Are all cooling air passages clear?

d. Is the engine overloaded by high propeller pitch? Is the aircraft being "mushed" with high load and low air speed?

e. See carburetor manufacturer's Service Instructions for lean mixture checks and causes.

f. Check compression for evidence of exhaust valve warpage.

6-17. HIGH OIL TEMPERATURE.

a. Measure oil supply.

b. Is oil of correct viscosity? (Refer to Table XI.)

c. Has oil become thin by crankcase dilution?

d. Check oil screen for sludge. Some oils form deposits when they are mixed. Deposits in oil passages and on screen reduce oil flow and increase temperature.

e. Is cylinder head temperature within limits? High cylinder temperature, like high bearing temperature, adds heat to oil.

f. Check oil cooler shutter for full opening.

g. Check oil cooler for internal restrictions and restricted air passage. Check thermo by-pass valve for proper operation.

h. Do not prolong high speed operation on the ground. Cylinder heads and oil cooler depend on forward motion for air flow to cool them.

6-18. LOW OIL PRESSURE.

a. Check oil supply and viscosity.

b. Remove and clean pressure oil screen.

c. Remove and clean oil pressure relief valve and cap.

d. Test oil pressure relief valve spring.

e. Observe condition of relief valve face and seat.

f. Test oil pressure gauge and clean line.

g. If relief valve is functioning properly and a master gauge shows low pressure with warm oil and clear screen, oil lines and cooler, then one of the following causes is present:

1. The oil supply line leaks air.

2. The inlet tube to pump gasket leaks.

3. The pressure oil pump is defective.

4. There is an internal oil leak in the engine.

5. Bearing clearances are excessive.

6-19. HIGH INDICATED OIL PRESSURE.

a. Do not alter the oil pressure relief valve to decrease pressure unless a flow check proves that the flow from the return line (or outlet line) is excessive. See Section II for specifications.

b. Do not increase R.P.M. beyond 1500 if indicated pressure is excessive and oil is cold. Cold oil will not pass through bearing clearances or oil screen at the normal rate for high speed operation.

6-20. LOW INDICATED OIL TEMPERATURE.

a. Check oil cooler thermo by-pass valve.

b. Check oil temperature gauge and capillary.

c. In cold weather install the proper oil cooler shutter to maintain specified temperature.

SECTION VII
DISASSEMBLY

INTENTIONALLY

LEFT

BLANK

7-1. FOREWORD.

Procedures described in this section will be limited to parts supplied by Teledyne Continental Motors. For instructions on overhaul of standard accessories, refer to the respective accessory maintenance instructions issued by accessory manufacturer.

7-2. DISCARDED PARTS.

Discard all palnuts, lockwashers, cotter pins, lockwires, oil seals, hydraulic "O" rings, cylinder base packing rings, hoses, gaskets and the synthetic rubber generator coupling disc, or bushing, in such a way that they will not be used again.

7-3. WORK STAND.

The engine should be mounted on a suitable assembly stand. Be sure that the four mounting brackets contact the stand adapters uniformly before installing attaching bolts.

7-4. AIRCRAFT PARTS.

If the cylinder baffles, carburetor air heater, hydraulic and/or vacuum pump, priming tube (or manifold), and propeller control valve were not previously removed, they should be disconnected and removed at this point.

7-5. PRELIMINARY CLEANING.

Brush and spray all exterior surfaces with an approved grease solvent to remove all grit and oil. Be especially careful to remove foreign matter from exposed stud threads, palnuts and nuts, cotter pins and nut castles and lockwire holes. Drain any oil remaining in the oil sump.

7-6. PARTS STORAGE.

As parts are removed, they should be stored on a suitable parts rack having marked containers for all parts of which two or more are used, excepting magnetos. It is of particular importance that rocker arms, push rods and hydraulic valve lifters be reassembled in exactly their original positions, therefore they should be so marked and stored that their identities are preserved. Notice that push rod ball ends may not wear uniformly and should, therefore, be marked so that their crankcase ends are unmistakable. Piston pins and plugs should remain in their proper pistons during storage. All steel parts should remain covered with oil to prevent corrosion.

7-7. MARKING PARTS.

No part will need to be marked by the electric needle, and since this process is dangerous to highly stressed material, its use is not recommended. Some steel parts are marked at the factory by etching ink imprinted by rubber stamp. This process is safe if used on unfinished surfaces and if the etching action is neutralized before it becomes excessive. Aluminum and magnesium parts are stamped with factory numbers and inspectors' stamps on non-critical surfaces. It should not be necessary to stamp any aluminum or magnesium part, other than pistons, for the sake of identification after it leaves the factory. Paint should not be used for marking interior surfaces or parts. If crayon or chalk marks are used for any purpose on interior parts, all traces must be removed before reassembly.

Notice that each piston is stamped with its cylinder number on the rim of the head near the forward edge. Numbers are stamped on cylinder base flange edges. Each connecting rod has its cylinder number stamped on the rod and cap top bolt bosses. These numbers determine relative positions of rod and cap upon reassembly. Timing marks are stamped on the Accessory Drive Gear and on the Camshaft Gear. Of these markings, only those on replacement pistons need be duplicated outside the factory. Ordinarily the attachment of marked tags will be sufficient and safe means of identifying parts.

7-8. DISASSEMBLY.

7-9. DELCO–REMY STARTER.

If the engine is equipped with this type starter, remove the two through bolts at the extreme top of the crankcase rear flange. These bolts pass through the accessory case and thread into the starter adapter. Remove the three palnuts, nuts and washers which attach the large circular plate of the starter adapter to the accessory case studs. Withdraw the starter and adapter assembly straight to the rear, carrying the drive pinion with it. Notice that the driven pinion shaft fits over a pivot attached to the crankcase. When the pinion clears the pivot the starter will be free.

7-10. ECLIPSE STARTER AND ADAPTER.

Loosen the five hex nuts which attach the starter to the lower three accessory case studs and to the upper two adapter studs. Remove the lower three nuts, and support the starter while the upper two are removed. The starter will be free when clear of the studs. Loosen and remove the hex nuts from the two bolts which pass from the front side of the upper extension of the crankcase rear flange through the accessory case and adapter plate. Remove the bolts and the plate.

7-11. FUEL PUMP.

Remove the four palnuts, nuts and washers, which attach the fuel pump to the accessory case studs. Withdraw the pump from its drive adapter. The plastic spacer located between the pump and the adapter may be removed also. The accessory drive should not be disturbed. In dry sump models the shaftgear cannot be removed before the scavenge pump.

7-12. MAGNETOS AND IGNITION CABLES.

Remove all spark plug cable terminals from the spark plugs. Remove the palnuts, nuts and washers which attach ignition cable brackets to the crankcase studs. Always remove a palnut before loosening the plain nut under it to avoid backing out the stud. Remove the two palnuts, nuts and washers which attach the right magneto to the accessory case studs. Remove the right magneto and the upper ignition cable assembly. Notice whether the magneto drive coupling disc remains with the magneto; if not, remove it from the drive gear. Remove the left magneto and lower ignition cables similarly. Remove the two magneto drive gears from their supports inside the accessory case.

7-13. GENERATOR.

Remove the three self-locking nuts and washers which attach the generator to the accessory case studs. Withdraw the generator and drive gear assembly.

7-14. PRELIMINARY WORK ON CYLINDERS.

Remove cotter pins from upper crankcase through bolts, and remove palnuts from upper cylinder to crankcase studs. Remove upper cylinder base nuts. Remove all spark plugs.

7-15. OIL SUMP (Wet Sump Engine).

Remove the oil gauge rod from the oil sump. Invert the engine. Remove the screws which attach the sump side and front supports to the sump. Remove the two palnuts, nuts and washers which attach the side supports to the rear engine mounting bracket studs. Remove the side supports. Loosen and remove the bolt which attaches the front support to the intake manifold, and remove the support. Loosen the front oil drain tube to sump hose clamps and slide the hose onto the sump inlet tube until it clears the joint. Similarly loosen and slide the manifold to sump drain hose to the rear. Remove the six palnuts, nuts and washers which attach the sump mounting brackets to crankcase studs. Lift the sump straight up, being careful not to damage the oil suction tube projecting from the accessory case or to drop the oil sump by-pass tube which seals the sump to accessory case opening.

7-16. OIL DRAIN HOUSING (Dry Sump Engines).

After removing the generator, invert the engine and loosen the intake and oil drain manifold to oil drain housing hose clamps. Slide the hose rearward on the housing until it clears the joint. Remove the lockwires and four screws which attach the oil drain housing flanges to the crankcase and to the accessory case. Remove the housing.

7-17. CARBURETOR.

Remove the four palnuts, nuts and washers which attach the carburetor to the manifold studs. Remove the carburetor and drain the fuel remaining in it.

7-18. INDUCTION SYSTEM.

Loosen the intake and oil drain manifold to intake tube hose clamps. Slide the hoses onto the intake tubes until they clear the manifold. Remove the two screws which attach each intake tube flange to the cylinder head flange. Remove the tubes, being very careful not to deform them. Remove the lockwire and two screws which attach the intake and oil drain manifold front flange to the crankcase, and remove the front oil drain tube or cover plate, as the case may be. Remove the two rear manifold to crankcase screws, and lift the manifold from the crankcase.

> *NOTE*
>
> *The manifold and intake tubes may be removed in a cluster and disassembled on the bench, if desired.*

7-19. ACCESSORY CASE.

Remove the three long screws and one short screw which attach the accessory case to the lower rear flange of the crankcase. Slightly loosen the four hex head screws which pass through the accessory case from the rear and thread into the crankcase rear flange. These screws are installed in

holes above the magneto mounting pads, two on each side of the case. Bend down the tabs of the two washers which secure the hex head screws adjacent to the magneto drive gear supports. Remove the two screws which attach the accessory case at these points. Remove the four long screws from the accessory case. The case is now held only by gasket compound in the joint between it and the crankcase. Tap the case carefully, if necessary, to break this joint.

> *CAUTION*
>
> *Do not use a pry bar to break the joint.*

Tilt the top of the accessory case to the rear until the pressure oil pump drive square clears the camshaft gear. Lift the case until it clears the camshaft gear. The case is now free. All accessory drive gears installed will remain in place, and the case assembly may be stored on the parts rack until the drives and pumps are disassembled late.

7-20. CYLINDERS.

Before removing cylinders, protectors similar to those illustrated in Figure 15 should be made of 1/4 inch plywood so that they may be installed immediately.

Remove the seven fillister head screws which attach No. 1 cylinder rocker cover. Tap the cover with a plastic hammer to break the joint, and remove it. Rotate the crankshaft until No. 1 piston is at top dead center with both valves closed. Remove the cotter pin from the slotted nut on the crankshaft through bolt at the rear side of the cylinder base flange. Remove three palnuts from cylinder to crankcase studs. Remove four cylinder base nuts. Withdraw the cylinder, pushrods and pushrod housing assembly. Make sure that the pushrods are removed with the assembly. Catch the piston and connecting rod as the cylinder skirt comes away so that the rod will not strike the crankcase cylinder hole chamfer. Store the cylinder on the parts rack, after removing pushrods and housings. Pushrods slide out freely, and housings are retained only by the friction of the oil seal rings. Remove the retainers from current style

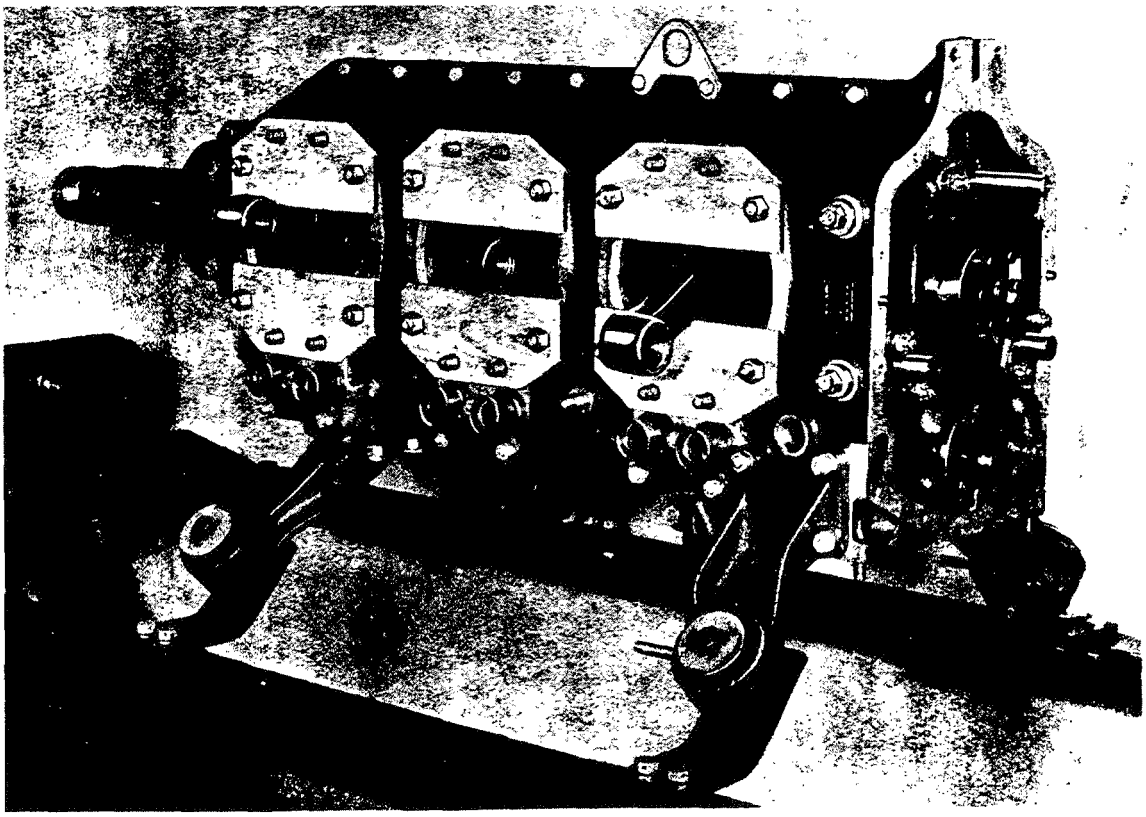


FIGURE 15. CRANKCASE WITH CYLINDER PAD PROTECTORS ATTACHED.

housings. Remove and discard oil seal rings. Install two crankcase protectors on No. 1 cylinder pad to guide the connecting rod. Push the piston pin endwise until the piston can be removed. Push the pin and plug assembly back into the piston and store the piston and pin assembly. In the same manner, remove cylinders numbers 6, 3, 2, 5 and 4, in that order. Before removing any cylinder turn the crankshaft to place its piston at T.D.C. with both valves closed. Take care to prevent damage to machined surfaces of the crankcase.

7-21. CAMSHAFT GEAR AND ACCESSORY DRIVE GEAR.

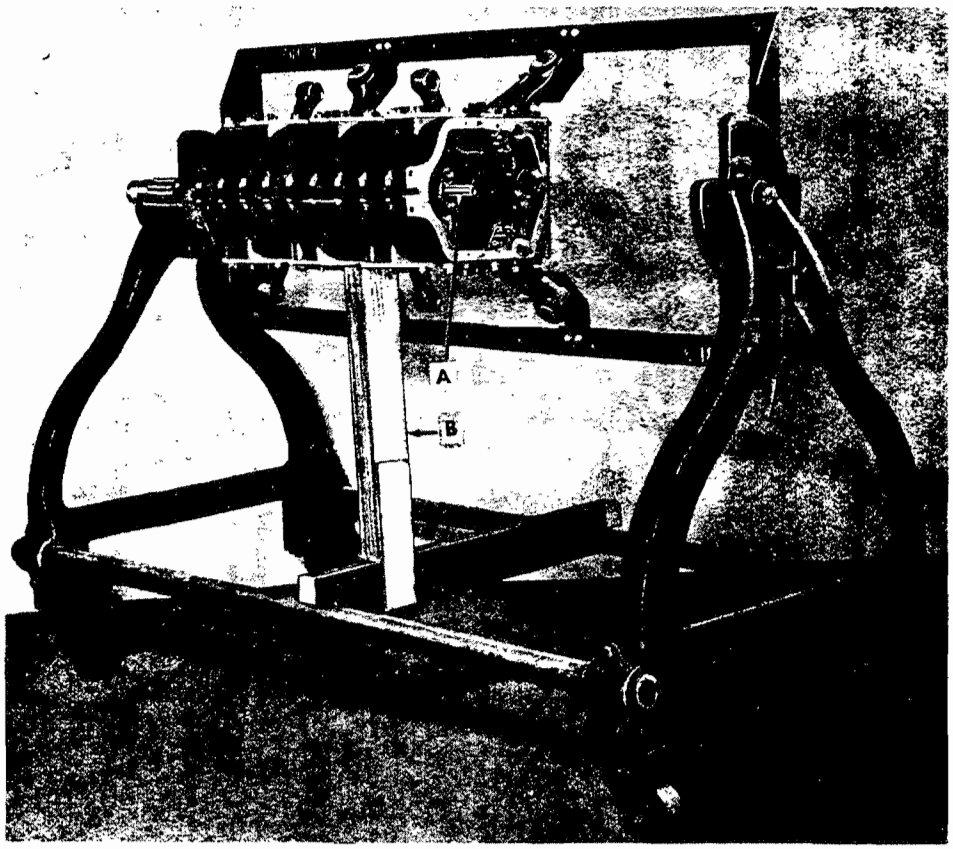
Remove the lockwire and four screws which attach the camshaft gear. The gear will slide off the shaft easily. Remove the lockwire from the socket head or hex head screws which attach the accessory drive gear to the crankshaft. Loosen the screws. Early production gears were retained only by these six screws, four or more of which were shoulder screws. Later production engines have six plain screws and a dowel installed in the crankshaft, which engages a hole in the gear. If necessary, install two 1/4-28" or 5/16-24 bolts, whichever is applicable, in the tapped puller holes of the gear and tighten them to push the gear away from the shaft.

7-22. ECLIPSE STARTER DRIVE GEAR.

Remove the snap ring from the groove at the rear end of the pivot by spreading with a pair of Truarc snap ring pliers of proper size and type. Slide the gear and retaining washer off the rear end of the pivot.

7-23. CRANKCASE.

Remove the two cotter pins from the castle nuts which attach the Delco-Remy starter pinion pivot to the crankcase studs. (See Figure 16.) Remove the castle nuts and withdraw the pivot.



A. Starter Pinion Pivot
B. Support

FIGURE 16. CRANKCASE SUPPORTED FOR SEPARATION.

If the engine is equipped with an Eclipse starter the starter gear pivot is retained by two hex head screws. To remove the pivot, bend down the two tab washers from the screw heads and remove the screws. If the pivot is tight in its pilot hole it may be tapped out with a drift inserted from the inside of the crankcase.

Remove the two palnuts, nuts and washers from the two front 3/8" diameter crankcase through bolts, and withdraw the bolts and washers. Remove the palnuts, nuts and washers from the two long 5/16" diameter or one 5/16 and one 3/8" diameter bolts through the rear mount brackets and crankcase, and remove the palnut, nut and washer from the shorter 5/16" diameter through bolt between the long ones. Withdraw the long bolts. The short through bolt cannot be removed, however, it will not interfere with crankcase disassembly.

7-24. Rotate the engine bed to place the 1, 3, 5 side of the crankcase up, as shown in Figure 16. Place under the crankcase a support similar to that shown in Figure 16. Remove the two bolts which attach the 1, 3, 5 side mount brackets to the stand adapters.

7-25. Slip one used cylinder base packing ring over each pair of valve lifter followers, of cylinder Nos. 1, 3, and 5. and let it bear on the lifter bearing surfaces. Push the lifters away from the camshaft as far as they will go. Pull the packing ring tight and place it in a loop over the push-rod housing adapter. The packing rings will hold the lifters and prevent them from falling when the 1, 3, 5 side is lifted off.

7-26. Tap the eight long 7/16" diameter crankcase dowel bolts through the crankcase and withdraw them. Remove the twenty-one palnuts, nuts, washers and screws from holes in the crankcase top and bottom flanges.

7-27. Lift the 1, 3, 5 side enough to place a one-inch thick block between the parting surfaces at top and bottom flanges, as shown in Figure 17, and place pads made of rags in positions to cushion the fall of Nos. 1, 3, and 5 connec-

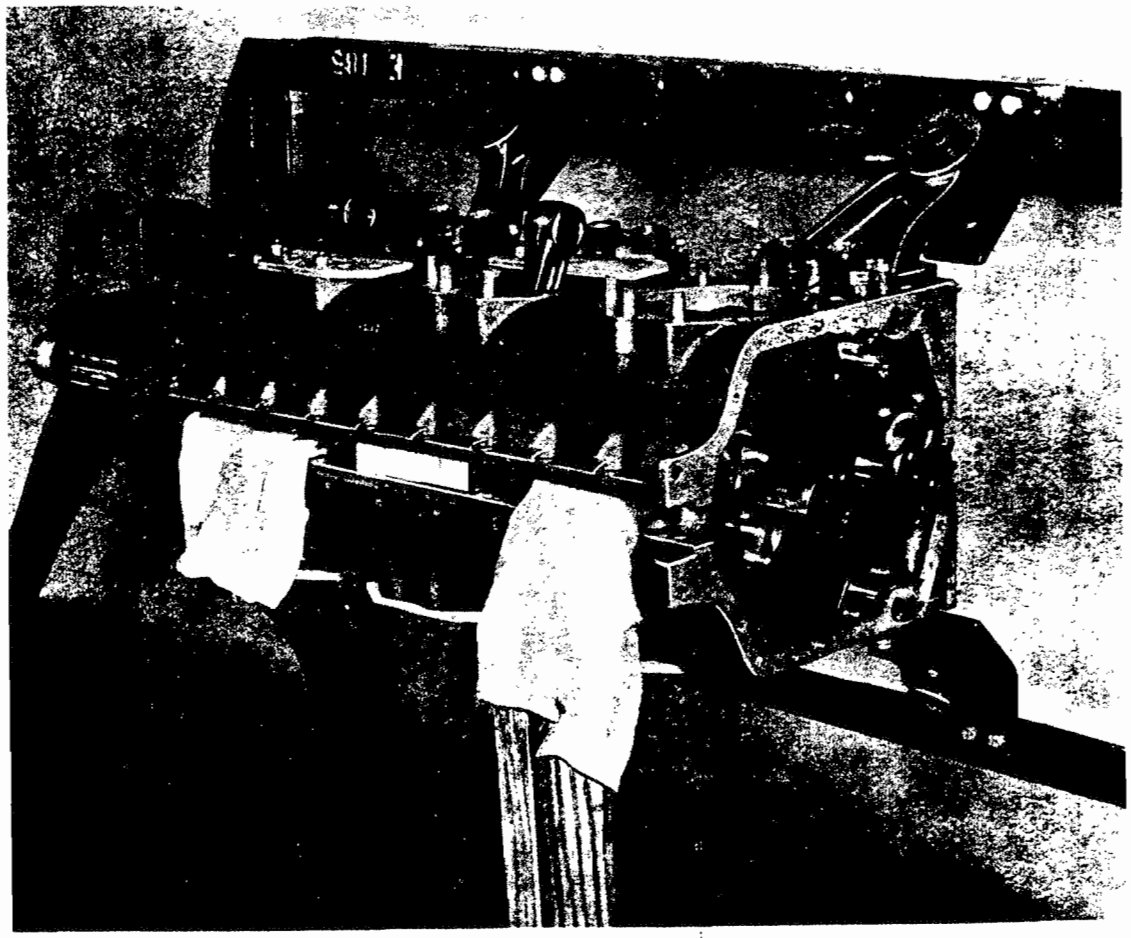


FIGURE 17. CRANKCASE SEPARATED (CLOTH PADS IN PLACE).

ting rods. Lift the 1, 3, 5 side away, as shown in Figure 18, and store it on the parts rack, being careful not to damage the parting surfaces.

7-28. Tap the crankshaft oil seal out of its seat at the front end of the crankcase and discard it. Lift the camshaft from the 2, 4, 6 case half and store it on a suitable support on the parts rack. Lift the hydraulic valve lifters from their guides and store them in marked containers. Lift the crankshaft and connecting rod assembly from the 2, 4, 6 case half and store it on the parts rack. If thrust washers are installed do not allow them to fall when the crankshaft is lifted. Remove the 2, 4, 6 crankcase side from the stand, and store it on the parts rack.

7-29. Remove the crankcase breather elbow and other tube fittings. Remove the three palnuts, nuts and washers which attach each pushrod housing flange to the crankcase studs. Remove the flanges and gaskets. If either magneto gear support is excessively worn remove the cotter pins and castle nuts which attach the support to the crankcase studs. Withdraw the support carefully and squarely. The engine mount brackets need not be removed from the crankcase halves unless they are damaged or require replacement of pressed-in rubber isolator bushings. Remove all main bearing and thrust bearing inserts.

7-30. ACCESSORY CASE.

Remove the four palnuts, nuts and washers which attach the right side accessory drive adapter to the crankcase studs. Withdraw the adapter and shaftgear together.

7-31. If the engine is a dry sump type, remove the screws which attach the scavenge oil pump to the case,

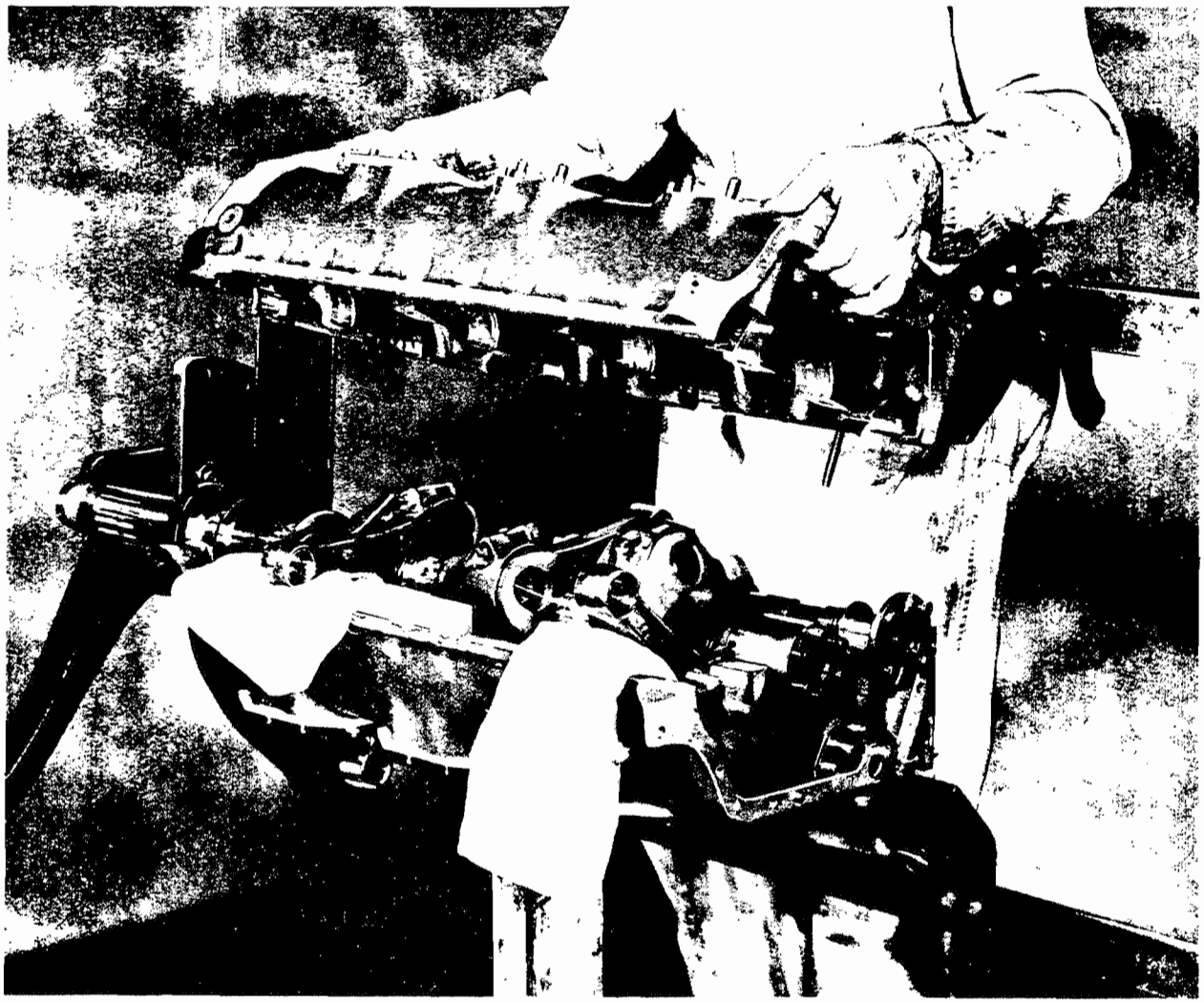


FIGURE 18. REMOVING CRANKCASE 1, 3, 5 SIDE.

and withdraw the pump housing and impellers. Remove the Woodruff key from the scavenge pump and accessory drive gear shaft. Remove the left side accessory drive shaftgear and adapter by tapping the forward end of the shaft.

7-32. Remove the lockwire and two fillister head screws which attach the idler gear shaft flange to the accessory case, and withdraw the shaft. Remove the idler gear through the right side accessory drive adapter opening.

7-33. Loosen and remove the pressure oil screen from its housing. Remove the lockwire and five screws which attach the oil screen housing to the case and remove the housing. If the engine is a dry sump type, remove the oil check valve assembly from the case counterbore under the screen housing pad.

7-34. Remove the lockwire and two hex head screws which attach the oil suction tube (or oil inlet tube) flange to the pressure oil pump housing. If the engine is a wet sump type, remove the slotted head screw and copper gasket which secure the suction oil tube to accessory case clip to the left side of the case. The suction oil tube may now be withdrawn through the front case opening. If the engine is a dry sump type, remove the oil pump inlet tube nut, packing, washer and hydraulic "O" ring at the left side of the case. The inlet tube may be removed now.

7-35. Remove the lockwire and two hex head screws which attach the tachometer drive housing to the case. Remove the housing.

7-36. The only remaining screw which attaches the pressure oil pump to the case is located in a counterbore in the generator mounting pad. Remove this screw and withdraw the oil pump and impellers. Notice that the tachometer drive shaft is part of the oil pump driven impeller and should be removed with the pump. If it should be necessary to tap the pump housing to break the joint, be very careful not to cock it, since the tachometer drive shaft will not permit the pump driven impeller to be cocked and may damage the impeller chamber.

7-37. Unscrew the oil cooler by-pass valve cap (no valve is installed), which is the lower of two acorn head bronze caps below the left magneto mounting pad. Loosen the upper acorn head cap, which is the oil pressure relief valve cap (See Figure 8). Hold against spring pressure as it comes free of the case thread. Remove the relief valve spring and plunger.

7-38. Remove the oil passage plugs at the bottom and both side of the case. If the engine is a wet sump type, remove the oil cooler outlet elbow from the right side of the case.

7-39. CYLINDER.

Place the cylinder on a suitable support which will prevent the valves dropping when they are released. Slide out the rocker shaft, and remove both rockers. Compress either valve spring with a suitable type of valve spring compressor bearing on the valve spring outer retainer. Remove the keys from the valve stem and release the spring. Remove both springs and the inner and outer spring retainers. Similarly remove the valve keys, retainers and springs from the other valve. Lift the cylinder by the two valve stems. Lay it on its side and remove the two valves after a careful inspection to determine that there are no nicks at the stem lock grooves which would scratch the guides. Leave the rocker shaft in place. By the same process, remove the valves, springs, retainers and keys from the remaining cylinders.

7-40. CRANKSHAFT AND CONNECTING RODS.

Place the assembly on suitable wood supports. Remove the cotter pins from all connecting rod bolts. Remove the slotted nuts, and tap the bolt ends to free the rod caps. Remove the bearing inserts and discard them. Notice that the cylinder numbers on rods and caps are stamped on their upper sides. Reassemble rods and caps in correct pairs, or tie the parts together. If the crankshaft has a splined propeller end, unscrew and remove the slotted front end plug. Do not remove the small screw installed between two adjacent splines, unless it has been damaged. With Truarc No. 1 or 21 pliers, compress and remove the internal retaining rings; then remove the retaining plates and pins from the counterweights, and take counterweights from crankshaft.

8-1. MATERIALS AND PROCESSES.

No attempt will be made to list the numerous types of equipment or the trade marked materials which are marketed for industrial cleaning purposes. The equipment, processes and materials already in use in aircraft engine overhaul shops will be suitable in most cases for cleaning E Series engine parts, however, it is considered necessary to insert here certain precautions and advice regarding types of material and processes which have been found satisfactory and those which are known to be harmful to certain metals.

8-2. The accessory case, original type rocker covers and the intake and oil drain manifold are magnesium castings. This metal is not affected by alkaline cleaning solutions, however, any alkali such as caustic soda or any soapy deposits must be completely removed. Alkaline compounds remaining in the pores of the metal and in crevasses will combine with acids normally present in the oil to form soap. The emulsion thus formed in the oil will foam. If petroleum base solvents are used in cleaning magnesium parts, only those which have a high flash point should be selected, since magnesium ignites at a relatively low temperature and produces intense heat with a tendency to scatter in the presence of water. Kerosene and certain other petroleum derivatives are satisfactory as regards the fire hazard. A non-combustible grease solvent is the safest cleaning material for magnesium parts.

8-3. Aluminum castings and parts machined or formed of wrought aluminum must not be cleaned with any strong alkaline preparation, since it would attack the metal. Carbon tetrachloride, cleaners' naptha and many other solvents are entirely suitable for this purpose. No film or deposit should be left when solvent is evaporated. An inhibited, mild alkaline cleaner solution may be employed for cleaning aluminum parts, provided that the immersion time is not unnecessarily prolonged, and, further, provided that all alkaline deposit is removed by a stream jet or by spraying with a solvent liquid. Any trace of alkali remaining in pockets or on surfaces of parts after such cleaning will result in violent oil foaming. Mild alkaline cleaners of the inhibited type are usually employed as a bath and are kept in a tank with provision for maintaining the temperature at approximately 200°F.

> *NOTE*
>
> *Do not clean the oilite bushings in a Delco-Remy starter adapter and pinion with any petroleum solvent.*

8-4. Steam cleaning processes are not recommended for any parts of this engine. Some of these processes employ soaps and strong alkaline materials. Mild, inhibited alkaline compounds, such as Oakite No. 61 are permissible.

8-5. Trichloroethylene condensation plants provide excellent degreasing action for steel, aluminum and bronze parts. Their disadvantages lie in the toxic quality of the vapors, removal of enamel from painted parts and the drying and hardening effect on carbon deposits.

8-6. No polishing compound or abrasive paste or powder should be needed or employed for cleaning engine parts.

8-7. The use of wire brushes and wheels is not recommended for cleaning or removal of carbon deposits. The danger of costly damage outweighs the possible saving of time by this method. Carbon deposits may be removed by scraping provided care is taken to avoid scratching or denting aluminum surfaces. The most satisfactory method of removing soft carbon is by blasting at the minimum effective pressure with plastic pellets or by vapor blasting. Hard carbon may be safely removed by softening in a carbon solvent by the open tank or the pressure tank methods, followed by blasting. Open carbon solvent tanks usually work at moderately high temperatures and require agitation by compressed air. Exhaust fans for removal of the toxic vapors are also required with some solvents.

8-8. Bottle brushes and bristle rifle cleaning brushes of various diameters are useful for loosening deposits in oil passages and small diameter holes. Bristle brushes of this type may be obtained in various lengths and of diameters as small as 1/4 inch.

SECTION VIII
CLEANING PARTS

INTENTIONALLY

LEFT

BLANK

8-9. ACCESSORY CASE.

Dissolve and remove all deposits of gasket paste, sludge and oil from all surfaces, threads and oil passages of the case. Make sure that oil holes are clear.

8-10. INTAKE AND OIL DRAIN MANIFOLD.

Remove all foreign matter from machined surfaces and stud threads. Since the oil drain passage cannot be brushed, the casting should be soaked in the solvent, to loosen any sludge deposits, and sprayed through the hole in the front mounting flange.

8-11. OIL SUMP.

Remove the oil drain plug and flush the sump to remove all sludge deposits. If a considerable amount of dirt is evident it will be advisable to pour about two gallons of solvent into the top inlet tube before removing the drain plug and allow it to stand in the sump for a few hours. After such soaking, flush the sump interior to remove loosened material.

8-12. CYLINDERS.

If a carbon solvent solution is employed, the cylinders should be placed in it in the inverted position so that no air is trapped in the combustion chambers. If the fluid depth in the tank is greater than the cylinder length, the cylinders may be turned to any position after being completely filled. Where agitation is employed, due consideration must be given to cylinder position to permit circulation.

NOTE

If a blasting process is used, all machined surfaces must be covered by tight fitting protectors. Blasting should be followed by airblast cleaning and finally by spraying with cleaning solvent to remove all traces of blast grain. Use vapor blast grit No. 50 for best results.

Particular care should be given to removal of carbon around valve seat inserts, valve guides and spark plug inserts.

8-13. VALVES.

Carbon may be removed by immersion in carbon solvent, by blasting, or by scraping. If a polishing head is available, the valves may be polished with crocus cloth while turning at high speed. A lathe equipped with draw-in collets will serve as a polishing head if high speeds are possible. Care must be exercised to avoid damage to the stems. Coat the valves with preservative oil after cleaning.

8-14. VALVE SPRINGS, RETAINERS, ROCKER ARMS, PUSHRODS, HOUSINGS.

These parts will usually require only removal of oil and sludge. Pushrods should be soaked to remove deposits and inspected after drying for clear passages. Rocker arm oil passages should be inspected during cleaning for possible restrictions. If possible, the solvent should be fed under pressure into the bearings and should emerge from pushrod cups and spray holes.

8-15. PISTONS.

The same methods of carbon removal used on cylinders will be suitable for pistons. If carbon must be scraped from piston heads and ring grooves, use extreme caution to avoid scratching. Always use a soft aluminum scraper. Automotive type ring groove cleaners are not recommended, because they may cut into the metal at the sides, bottom and fillets of the groove. Do not attempt to polish the piston skirts. After cleaning piston pins, coat them with engine oil and replace them in their respective pistons with end plugs in place.

NOTE

If piston heads are vapor blasted to remove carbon deposits, use vapor blast grit No. 80. Do not vapor blast skirts or ring grooves unless a much finer grit is available.

8-16. CAMSHAFT AND ALL GEARS.

These parts will require only degreasing. They should be coated with clean preservative oil and wrapped in greaseproof paper, pending inspection.

8-17. CRANKSHAFT.

The exterior surfaces and journals should be cleaned with the usual solvent. In addition, the oil tubes should be flushed and brushed. Remove all sludge from the rear recess and clean all tapped holes in the rear surface. Clean out the front end bores of splined shafts, being careful not to damage the U-shaped oil tube.

8-18. CONNECTING RODS.

Clean steel parts in grease solvent, paying due attention to bolt and nut threads and bolt holes.

8-19. SILVER MAIN–THRUST BEARING INSERTS.

These inserts may be cleaned in a grease solvent. They should not be subjected to extreme heat, though temperatures of up to 200°F. are safe. Be extremely careful not to tumble the inserts or to allow any hard object to touch the bearing surfaces, which are soft lead-indium alloy or lead-tin alloy.

8-20. INTAKE TUBES, OIL DRAIN TUBE, BOLTS, NUTS, SCREWS AND WASHERS.

Discard all lockwashers, palnuts and gaskets. Clean the parts in grease solvent. Keep the intake tubes separate to prevent damage. Bolts, nuts, screws and washers should be soaked, followed by brushing or spraying.

8-21. HYDRAULIC VALVE LIFTERS.

Clean these parts only as directed in Section XIII.

8-22. CARBURETOR AND MAGNETOS.

Refer to the accessory manufacturer's manual for instructions.

SECTION IX
INSPECTION

INTENTIONALLY

LEFT

BLANK

9-1. FOREWORD.

When all engine parts have been cleaned and dried, place them on a clean bench where circulation of air and dust are at a minimum. Parts should be covered and steel parts coated with preservative oil when not actually being inspected. The visual and dimensional inspections outlined below and indicated by the Table of Limits furnish a basis for determining the need for replacements due to wear or damage, however, these inspections reveal only surface conditions.

Highly stressed steel parts should be inspected by either the Magnaflux process or the fluorescent particle penetrant method. Necessary information for Magnaflux inspection and a list of parts which require such inspection at each overhaul are given in Table XIII.

9-2. CRANKCASE.

Inspect all machined surfaces for nicks and scratches. Check tightness, squareness, and thread condition of all studs. Any stud which appears longer than others of the same group has partially backed out and must be replaced with the next oversize. Inspect all tapped holes for damaged threads. Look for cracks, especially around bolt holes, bearing bosses and flanges. Inspect oil passages for restrictions. If any nicks appear on machined surfaces, tag the casting for repair by stoning.

9-3. If cracks are suspected, but not clearly confirmed by visual inspection the area should be stripped of enamel, if necessary, and the surface etched. Avoid scratching the surface to prevent false indications. Paint the suspected area with a solution made of 2 pounds of caustic soda dissolved in 1 gallon of water at room temperature. Expose the surface to the action of the solution no longer than one minute. Immediately rinse the casting in running water. Neutralize the alkali with a solution of 1 part nitric acid in 3 parts water, heated to 100°F. Allow the acid to remain in contact with the surface long enough to dissolve the black deposit. Rinse the casting in running water, and dry with compressed air. The etching process will leave a black deposit in any crack, while the surrounding surface will be clean. Fine cracks may be detected with the aid of a magnifying glass.

9-4. Clamp the crankcase halves together with all through and flange bolts, and measure the diameter of each camshaft bearing. Measure diameters of all valve lifter guides. Record these dimensions for comparison with camshaft journal diameters and lifter shank diameters, respectively.

> *NOTE*
>
> *It will not be necessary to measure main or main-thrust bearing inserts or to install them in the crankcase during this dimensional inspection. All lead plated Tri-Metal bronze inserts should be replaced with new parts at each overhaul. If lead-indium plated silver main-thrust bearing inserts are used, their surface condition, as regards presence of the gray plating and absence of imbedded metal particles, will determine their serviceability.*

Disassemble the crankcase halves, and tag to indicate any necessary repairs.

> *NOTE*
>
> *If the camshaft bearings are excessively worn, the crankcase may be line bored for 0.020 inch oversize camshaft.*

9-5. ENGINE MOUNT BRACKETS.

Inspect mount brackets for cracks. If brackets for oblique mount bolts are installed, inspect the pressed-in Lord bushings for condition. If the rubber bushings must be replaced, it will be necessary to remove the brackets from the crankcase for the purpose of pressing out the old bushings and installing new parts.

9-6. THRUST WASHERS.

The plain inserts and thrust washers installed in early production engines are no longer available. For replacement of similar unserviceable parts, install flanged inserts shown in the Parts Catalog. The flanged inserts may be installed

TABLE XIII

MAGNETIC INSPECTION DATA

Part	Method of Magnetization	Amperes	Method of Inspection	Critical Areas	Possible Defects
Crankshaft	Circular	2500	Wet Continuous	Journals, Fillets, Oil Holes, Crankpins, Thrust Flanges	Fatigue Cracks Heat Cracks
Connecting Rod	Circular	1800	Wet Continuous	All Areas	Fatigue Cracks Forging Laps
Camshaft (forged)	Circular	1500	Wet Continuous	All Areas	Fatigue Cracks Forging Laps, Grinding Cracks
Piston Pin	Circular	1500	Wet Continuous	Shear Planes, Ends	Fatigue Cracks Stringers
Rocker Arms	Circular	1800	Wet Continuous	Valve Contact Face, Socket	Fatigue Cracks
Camshaft Gear	Circular	1800	Wet Continuous	Teeth, Square Hole	Fatigue Cracks
Accessory Drive Gear	Circular	1800	Wet Continuous	Teeth Eccentric Screw Holes	Fatigue Cracks Heat Cracks
Magneto Drive Gear	Circular	1800	Wet Continuous	Teeth, Drive Lugs	Fatigue Cracks
Oil Pump Gear	Circular	1800	Wet Continuous	Teeth, Shaft, Drive	Fatigue Cracks
Scavenge Pump Gear	Circular	1800	Wet Continuous	Teeth, Shaft, Keyway	Fatigue Cracks
Gears – All Shaftgears	Circular	1800	Wet Continuous	Teeth, Shaft, Splines	Fatigue Cracks

NOTE: If the crankshaft is suspected of any defect it should be demagnetized and magnetized longitudinally for further inspection.

in any crankcase regardless of original bearing equipment. The latter should be replaced with new parts at each overhaul.

9-7. ACCESSORY CASE.

Inspect the casting visually for nicks on machined surfaces, thread condition and tightness of all studs, clear oil passages, condition of tapped holes and cracks. Inspect the oil filler neck and cap of wet sump cases for secure fit and deformation. Inspect the oil pressure relief valve seat for true surface. If out-of-roundness is suspected, the valve assembly should be installed and a leak test should be made by pouring gasoline into the recess ahead of the valve seat with the case laid front side up.

9-8. Measure the accessory case front bearing bore for the oil scavenge and accessory drive shaftgear, if the case is for a dry sump engine, and record the bore for comparison with the diameter of the shaftgear front end. Measure the bore (or bushing bore) for the tachometer drive end of the oil pressure pump driven impeller and the bore for the driving impeller shaft. Record these diameters for comparison with the impeller shafts.

9-9. Inspect the pressure oil pump housing and the scavenge oil pump housing, if installed, for scoring in the shaft bores and gear chambers. Inspect for nicks on parting surfaces. Measure the housing shaft bores for comparison with impeller shaft diameters. (Refer to the Table of Limits, Section XV, for allowable clearances.) Inspect all oil pump impeller teeth for nicks, scoring, feathering and excessive wear. Inspect the driving square of the pressure pump driving impeller for wear on the corners. Inspect the flange sealing surface of the oil inlet or oil suction tube for warpage. If the flange is not perfectly flat, mark the part for lapping. Inspect for deformation of the tube.

9-10. Inspect the pressure oil screen for distortion, foreign matter in the mesh, secure attachment of all parts, condition of cap threads and distortion of the cap wrench square.

9-11. Inspect the oil screen housing for cracks, nicks on machined surfaces, warp of the parting surface and thread condition. If the parting surface is not flat, it must be lapped.

9-12. Inspect the accessory drive adapters and the idler gearshaft, if installed, for nicks, cracks, clear oil holes, stud condition and stripped threads, as applicable. Measure bearing surface diameters and compare with the corresponding gearshaft and hub bore diameters, as applicable, to determine clearances. End clearances may be checked by installation of the complete drives. Inspect all gear teeth for wear, chipping, burning, cracks and roughness.

9-13. MAGNETO DRIVE GEARS.

Inspect the gear teeth for condition, and compare the bushing diameters with the corresponding gear support diameters. Bushings which are worn to excessive diameter cannot be replaced, and the gear assembly must be discarded.

NOTE

It is recommended that the old type gears for use with the magneto coupling discs be replaced with the current type gears and couplings. The new type gears and couplings can be installed in place of the old type parts in any E Series engine.

9-14. ACCESSORY DRIVE AND CAMSHAFT GEARS.

Inspect gear teeth for chipping, cracks, excessive profile wear, burning and scoring. Mount the camshaft gear on a square arbor through the oil pump drive hole and check for wobble with a dial indicator. The pilot counterbore must run true within .004 inch.

9-15. GENERATOR DRIVE.

Inspect the gear teeth, shaft bore and drive lugs. Inspect the hub for cracks, scoring in the retainer slot, shaft bore and key slot condition, and fit on the generator shaft. Inspect the bushing retainer for deformation. Inspect the generator shaft nut for condition of the rear face of its flange and deformation of the hex.

NOTE

It is recommended that old type gears for single piece rubber drive discs be replaced with gears designed with longer lugs for the current type split rubber bushings.

9-16. CRANKSHAFT.

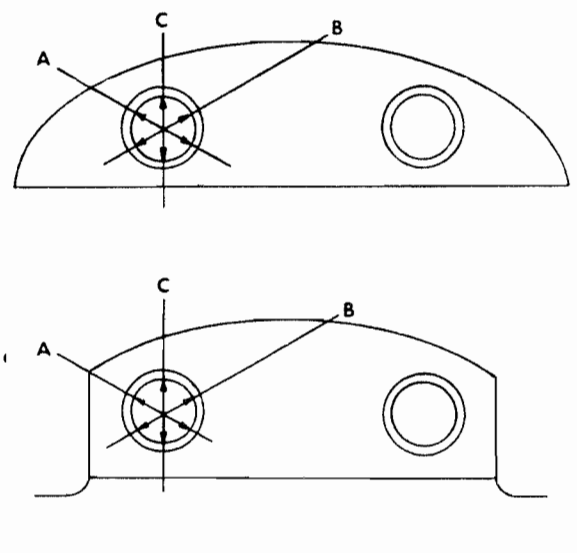
Inspect the crankshaft main journals and crankpins for scoring and compare measured diameters with values stated in the Table of Limits. Inspect the screw hole threads in

the rear end. Inspect the front plug thread of splined shafts. Inspect the propeller bolt bushing threads of flange shafts, and mark the shaft for replacement of any bushings with stripped threads. Inspect oil tubes for cleanliness. Check tightness of installation of the "U" tube in the front end bore of splined shafts. Inspect the propeller nut thread of splined shafts, and mark for stoning of any nicks. Inspect threads and cone seat of splined shaft front oil plugs. Inspect dynamic damper counterweight and crankshaft pin bushings for wear and tight fit. Mark the shaft and counterweights for replacement of any defective pin bushings. Inspect counterweight pins for wear and scoring. Inspect counterweight slots for pin retainer plates for diametrical wear.

9-17. CRANKSHAFT AND COUNTERWEIGHT BUSHINGS.

a. Excessive localized brinelling of the crankshaft dampener pin bushings can affect propeller blade tip stresses. It is, therefore, recommended that at each major overhaul the pin bushings be inspected and replaced as required. This applies to both the dampener bushings and the crankshaft blade bushings.

b. Inspect in the following manner: Measure the inside diameter of bushing across points A, B and C. Take the average of A and B and deduct this from C. If the difference exceeds 0.001 inch, the bushing should be replaced.



1. The C measurement should be the point of maximum diameter, which is generally a point perpendicular to the lengthwise centerline of the crankshaft.

2. Measurements A and B should be taken at points approximately 60° either side of Point C.

3. After removing the bushings from the dampeners or the crankshaft blades, measure the inside diameter of the holes. Select a replacement bushing which will give an interference fit of 0.001 to 0.002 inch into each of the crankshaft blade holes. Only the crankshaft bushing may be replaced with oversize bushings.

c. Replacement bushings are available in standard 0.0015, 0.003 and 0.005 oversize on the outside diameter.

d. A special tool for removing and replacing these bushings has been developed by Borrough's Tool and Equipment Corporation, 2429 North Burdick Street, Kalamazoo, Michigan (See Section III). It is recommended that this tool only be used for these operations. Removing and replacing bushings with makeshift tools and methods can result in irreparable damage to the crankshaft and/or dampeners.

e. This tool, Borrough's Part No. 4965, should be ordered directly from Borrough's Tool and Equipment Company.

9-18. Place the crankshaft on matched Vee blocks on a surface plate, so that it is supported at the centers of thrust and rear main journals. (Refer to Figure 19.) Attach a dial indicator to a surface gauge or suitable support, and adjust the indicator needle position on the center main journal to clear the oil hole. Set the dial to zero in the lowest needle position, and measure the deflection as the crankshaft is turned through a complete revolution. Compare the measured run-out with the value stated in the Table of Limits. Similarly, measure the front end run-out between thread and splines of splined shafts. Front end run-out of flange crankshafts should be measured on the hub ahead of the propeller flange, however, the value will be much less than the maximum allowed for splined shafts, unless the crankshaft has been bent.

9-19. CAMSHAFT.

Inspect visually for excessively worn or pitted holes and for scored journals. Measure journal diameters, and compare with bearing bores. (Refer to the Table of Limits.) Inspect tapped holes in the rear flange for thread condition. Mount the shaft on Vee blocks placed on a surface plate, supporting the front and rear journals, and measure the run-out, or total dial indicator deflection, at the center journals. Compare the measured value with that stated in the Table of Limits.

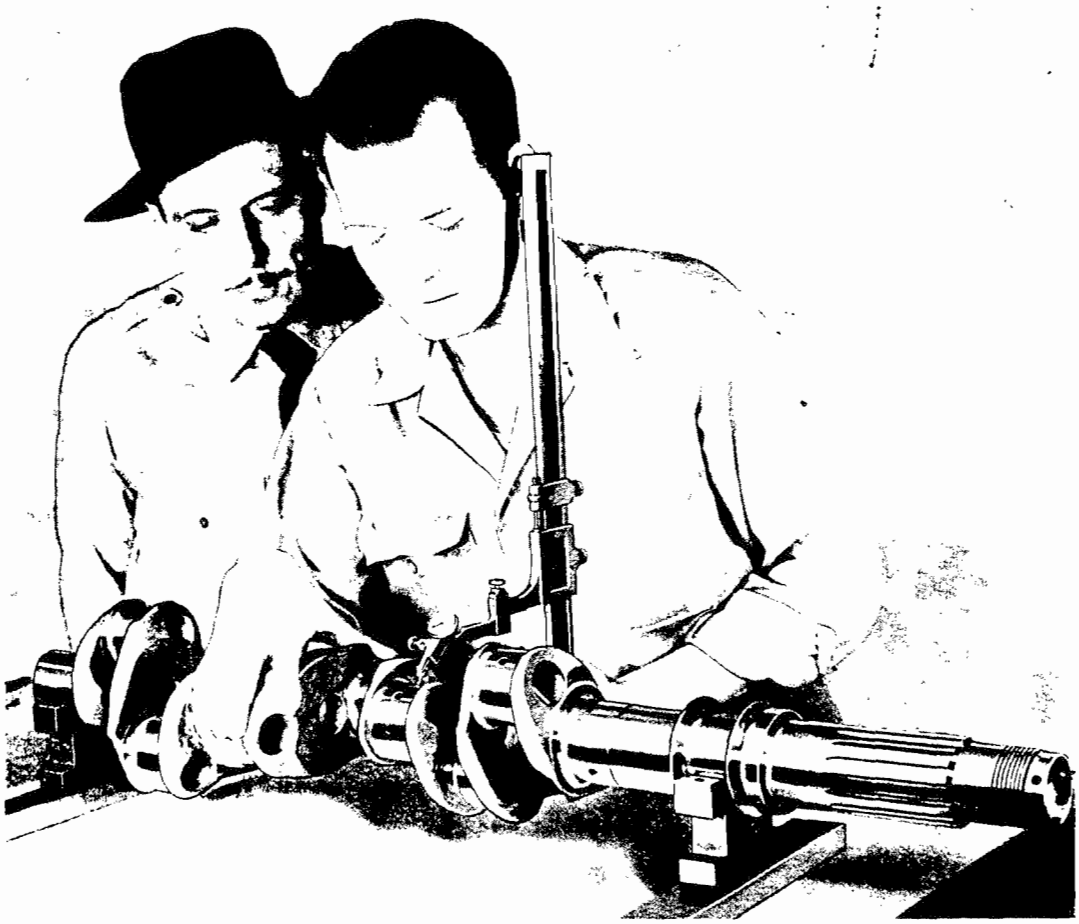


FIGURE 19. INSPECTING CRANKSHAFT ALIGNMENT.

9-20. CONNECTING RODS.

Inspect visually for nicks on critical surfaces, bolt thread condition, stretched bolts and deformed nuts. Measure the piston pin bushings, and compare diameters with piston pin diameters. Mark any rod which will require replacement of the bushing. Test for twist and convergence of the crankpin bearing seat bore in the big end and the piston pin bushing. To make this check, an arbor must be fitted to the big end bore and another to the bushing. Support the big end arbor in Vee blocks on a surface plate, and place two accurately ground parallel blocks of uniform thickness under the piston pin bushing arbor, with the rod in a horizontal position. With the small arbor touching one of the parallel blocks, measure the twist as the feeler gauge clearance between the other block and the arbor. Divide the distance in inches between points of contact by the clearance to obtain the twist per inch. Ascertain that the big end arbor is parallel to the surface plate. Swing the rod to the upright position and adjust a dial indicator and support to read "O" at the high point of one end of the upper arbor. Read the indicator at the high point of the other end of the upper arbor. The difference in indicator deflection is the total convergence. Divide this figure by the distance in inches between measured points to obtain the convergence per inch. Compare the measured values with those specified in the Table of Limits.

9-21. PISTON ASSEMBLIES.

Inspect the following features:

a. Inspect pistons visually for cracks, nicks, scoring and cleanliness.

b. Inspect piston pins for scoring and other visible defects.

c. Measure diameters of pistons below the third ring grooves and at the bottom of their skirts in a direction at right angles to the pin bore. Compare with bore dimensions of the corresponding cylinders.

d. If piston pins are not a push fit in piston bores compare diameters of pin and piston bore. (Refer to the Table of Limits.)

e. If loose fitting type piston pin end plugs are used check for snug fit in pins. If apparently loose, measure plug shank diameter and compare with pin bore.

> *NOTE*
>
> *If piston pin end plugs are of the pressed-in type no attempt should be made to remove them. These assemblies are not repairable. Loose fitting plugs in original type pins may be replaced.*

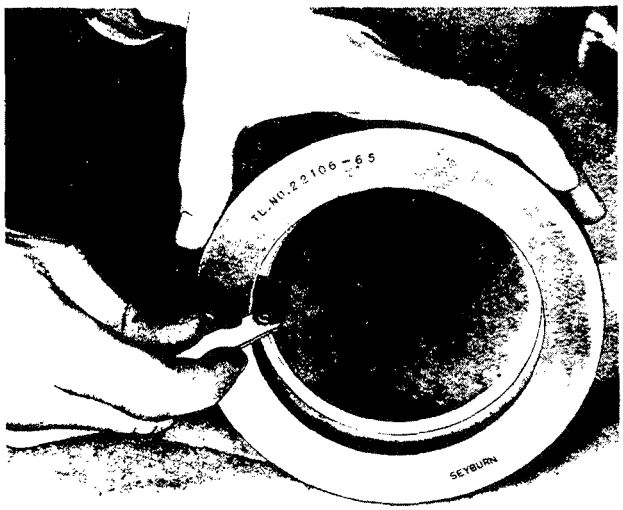


FIGURE 20. INSPECTING PISTON RING GAP.

f. Measure over-all lengths of piston pin and plug assemblies, and compare with lower end bore diameters of corresponding cylinders. (Refer to the Table of Limits for clearance.)

g. If piston pin bores are excessively worn they may be marked for reaming to fit oversize pins, and the original pins may be used with other pistons.

9-22. Select a new set of piston rings for the standard or oversize pistons and cylinders, as required. If cylinder bores are .005 inch oversize or slightly more than original, standard size pistons may be fitted with .005 inch oversize rings. If cylinder wear is greater, or if the cylinder must be reground for any reason, .015 inch oversize rings must be installed and cylinders ground to this oversize. Inspect new rings and their fit as follows:

FIGURE 21. INSTALLING THIRD PISTON RING.

a. Place each ring, in turn, either in a standard 5.000 inch gauge ring (or oversize, as required) or place each ring squarely in the lower end of the cylinder. Check the ring gap with a thickness gauge, as shown in Figure 20. This is to assure use of correct standard or oversize rings. Identification marks on rings should correspond to gauge diameters, if correctly marked, and gaps should be within limits specified in Section XV.

b. Install oil control rings in the third piston grooves. (See Figure 21.) Do not allow ring ends to dig into piston lands. Spread the rings to avoid such damage. Similarly, install second and top compression rings, in that order. The marked sides of all rings are placed toward the piston head. With a thickness gauge, measure the side clearance of all rings. (See Figure 22.) Compare the measured values with side clearances specified in Section XV.

9-23. CYLINDER ASSEMBLIES.

Examine interior combustion chamber face of cylinder head No. 532452 for heat checks which occur in extended or raised areas of the combustion chamber face, and lead toward a relief section. If examination of combustion chamber face reveals heat checks between the exhaust valve counterbore and the top or bottom spark plug inserts, the cylinder heads are NOT considered serviceable and should be replaced. Heat checks are usually present between the intake and exhaust valve counterbores and between the intake valve counterbore and either top or bottom spark plug insert. If either of these conditions exist in any cylinder head, the cylinder may be considered acceptable and continued in service. Inspect for dirt between cylinder head and barrel fins. Look for cracks in head fins, and notice any bent barrel fins. A few small sections of cylinder head fins may be cut out to remove cracks and stop their pro-

FIGURE 22. INSPECTING PISTON RING SIDE CLEARANCE.

gress. Cylinders requiring fin repair should be marked and set aside. If a crack in a head fin extends toward the base and cannot be removed by cutting out it may eventually penetrate the head, hence the cylinder assembly must be discarded. Cylinders should be re-examined after fin repairs have been made. Also inspect the following features:

a. Inspect finished surfaces for nicks, cracks and distortion.

b. Inspect thread condition of all tapped holes, helical coils and studs.

c. Inspect rocker shaft support bosses for possible cracks, and compare support bore diameters with shaft diameters if any looseness is evident.

> *NOTE*
>
> *Worn rocker shaft support bosses in the earliest cylinders for E-185-1 and E-185-3 engines may be returned to a serviceable condition by reaming to fit oversize shafts. They may be reamed and fitted with bushings for standard rocker shafts, provided that at least 1/8 inch radial thickness of metal remains at the thinnest point after reaming. Repair worn holes by installing bushings in all cylinders for models E-185-8, -9 and -11, all E-225 models and all E-185-1 and -3 engines with the wider support bosses.*

d. Inspect valve guide bores for scoring and measure diameters. Compare bore sizes with valve stem diameters.

e. Inspect cylinder bores for scoring, pitting, surface finish and burning. Measure cylinder bore diameters and chokes. (Refer to Section XV for out of roundness and minimum choke values.)

f. Tag all cylinders to indicate necessary repairs.

9-24. VALVES.

Exhaust valves in "E" Series engines should be replaced 100% with valve part specified in latest parts catalog at major overhaul, and at subsequent normal major overhauls can be replaced as required. Use only exhaust valves in these engines. Inspect all valves for nicks, scores, warp, stretch, excessive pitting of faces, cracks, checks and wear on stem tips and sides of lock grooves. Serviceable valves will usually require regrinding of their faces. If the tips are grooved, they must be ground flat, however, they must be re-inspected for minimum length after grinding. Exhaust valves must be inspected after grinding to determine that the faces have not been ground beyond the depth of Stellite which is originally .031 inch thick. All valve faces must be inspected after grinding to assure that the head thickness at the outer edge of the face is adequate. No sharp edge must remain, and the face must not cut into the rounded edge.

9-25. VALVE SPRINGS, KEYS, RETAINERS.

Inspect these parts for cracks, scoring, chatter marks, wear, broken edges and corrosion. Keys must fit valve stem grooves snugly. Test valve springs on a spring test machine. (Refer to the Table of Spring Tensions in Section XV.)

9-26. ROCKER ARMS.

Inspect visually for cracks, chipped edges, wear on the actuating surfaces and pushrod cups, and clear oil holes. The pushrod cups are designed to wear slightly until they seat perfectly on the pushrod ball ends, however, this wear must be uniform. Measure the diameters of rocker arm bearings and compare with corresponding rocker shaft diameters. Measure rocker arm side clearances. If these clearances exceed the values specified in the Table of Limits, the rocker arms must be segregated for discard after F.A.A. inspection. If oversize rocker shafts are to be installed because of wear in the cylinder head boss bores, the rocker arm bearings must be fitted, by reaming if necessary, to the oversize shafts.

9-27. PUSHRODS AND HOUSINGS.

Inspect pushrod ball ends for cracks and galling. Inspect for restrictions of oil passages. Roll the rods on a smooth, flat surface to detect bending. Inspect housings for dents, bending, cracks and out of roundness at the ends. Segregate any parts which must be replaced.

SECTION X
REPAIR AND REPLACEMENT

10-1. CASTINGS.

Smooth small nicks with a hard Arkansas stone of suitable shape. If parting surfaces are warped they should be lapped flat. A lpa plate of true surface must be used for satisfactory results, and fine grade lapping compound should be used to produce the fine finish required. Dress nicks in machined surfaces with a hard Arkansas stone, being careful not to alter the surface. Use kerosene on the stone to preloading with metal.

10-2. STUD REPLACEMENT.

Remove damaged whole studs with a standard pattern stud remover or a small pipe wrench, turning slowly to avoid heating the casting. Remove broken studs which cannot be gripped by drilling on center to correct diameter for unscrewing them with a splined stud extractor. (Splined extractors and drills are usually sold in sets.) Examine the coarse thread end of the damaged stud before discarding it to determine its size. Standard studs have no markings. For oversize identification refer to Figure 23. Clean the casting's tapped hole with solvent and blow dry with compressed air; then examine the thread. If it is not torn, install the next larger oversize stud. If the old stud was of the maximum oversize, or if the thread is damaged, the hole may be tapped and a helical coil thread insert installed for a standard size stud. Coat the new stud coarse threads with a film of Alcoa thread lube if the hole is blind, or with National Oil Seal compound if the hole goes through to a cavity subject to oil spray. It is advisable to drive the new stud with a "T" handle stud driver as shown in

TYPICAL PART NO.	OVERSIZE ON PITCH DIA OF COARSE THREAD (inches)	OPTIONAL IDENTIFICATION MARKS ON COARSE THREAD END		IDENTIFICATION COLOR CODE
		STAMPED	MACHINED	
XXXXXX	STANDARD	NONE		NONE
XXXXXXP003	.003			RED
XXXXXXP006	.006			BLUE
XXXXXXP009	.009			GREEN
XXXXXXP007	.007			BLUE
XXXXXXP012	.012			GREEN

FIGURE 23. STUD IDENTIFICATION CHART.

Figure 24. Turn it slowly, and compare with the estimated torque values listed in Section XV. Drive the stud in until it projects a distance equal to the appropriate "Setting Height" listed in Table XIV.

10-3. HELICAL COIL THREAD INSERT INSTALLATION.

Helical coil inserts are installed in the exhaust port flange stud holes of current production cylinders. Stainless steel helical coil inserts of special design are installed in all spark plug holes. Any of these inserts may be replaced if damaged.

10-4. To remove a damaged helical coil insert, use the proper size of extracting tool for the nominal thread size. Tap it into the insert so taht the sharp edge gets a good "bite", then turn the tool to the left and back out the helical coil until it is free. To install a new insert in properly tapped hole (after blowing out all liquid and chips), slide it over the slotted end of the driving mandrel of proper size installing tool, and engage the driving tang (bent end) of the helical coil in the mandrel slot; then wind the insert slowly into the tapped hole. The outer end of the insert should lie just within the first full thread of the hole. Break off the driving tang of a notched helical coil by bending back and forth across hole with long-nose pliers or with a special tang break-off tool.

10-5. WELDING.

Do not attempt to weld any casting. The danger of subsequent failure of a welded part outweighs any consideration of economy of either time or cost in repair work.

10-6. CYLINDERS.

10-7. FIN REPAIRS.

File the edges of small broken sections of aluminum head fins. If it is necessary to cut out a portion of an aluminum fin to stop a crack use a clothespin type drill bushing to guide the drill, which should be of a diameter slightly larger than the fin thickness. Round the edges of the Vee cut with a file. This repair should not be attempted if the crack has progressed to a point near the head surface. Only 10% of the fin area may be removed in this manner without impairing cooling efficiency. Straighten bent steel barrel fins carefully with duckbill pliers. If fin damage is extensive, the cylinder should be discarded.

10-8. SPARK PLUG HOLE HELICAL COIL INSERTS.

Before attempting to back out a damaged insert, use a sharp pointed tool to pry the teeth at the outer end away from the cylinder head metal. Tap a helical coil extractor tool into the insert until it has a good "bite". Place a new helical coil in the cut out side of the installing tool sleeve with the driving tang toward the threaded end. Engage the tang with the slotted end of the driving mandrel and wind the insert into the sleeve thread thus compressing it. Hold the sleeve so that the helical coil can be seen through the slot in the threaded end, and turn the mandrel crank until the insert starts into the cylinder head hole. If the sleeve is then not in contact with the head surface, grip sleeve and mandrel and turn until the sleeve touches lightly. Wind the helical coil into the cylinder head until its toothed end lies just within the first full thread. The teeth should be in position to enter the depressions made by the original insert. If it is driven too far, the insert will emerge in the combustion chamber and will have to be wound through. When the helical coil is in correct position, use long nose pliers to bend the driving tang back and forth across the hole until it breaks off at the notch. Coat a helical coil expanding tool threaded end with Alcoa thread lube or a mixture of white lead and oil, and screw it into the new insert until its final thread forces the teeth firmly into the cylinder head metal.

10-9. ROCKER SHAFT BOSSES.

If the rocker shaft bores are worn beyond the maximum allowable clearance of the shaft they may be reamed and oversize shafts installed. If an oversize shaft has already been installed and wear has increased clearance beyond allowable limits, the bosses may be bored or reamed and bushings installed if adequate thickness of the metal remains after reaming or boring. If cylinder has large bosses, install bushing in all instances.

CAUTION

After rocker shaft bosses have been reamed for repair bushings the radial thickness of the boss metal around the hole must be at least 0.14 inch to provide sufficient strength.

After installation of repair bushings in rocker shaft bosses, ream or bore the bushings to the correct fit with the shaft, as specified for new parts.

NOTE

The center line of the rocker shaft must be maintained at the distance from the mounting face of the cylinder base flange as shown in Figure 25.

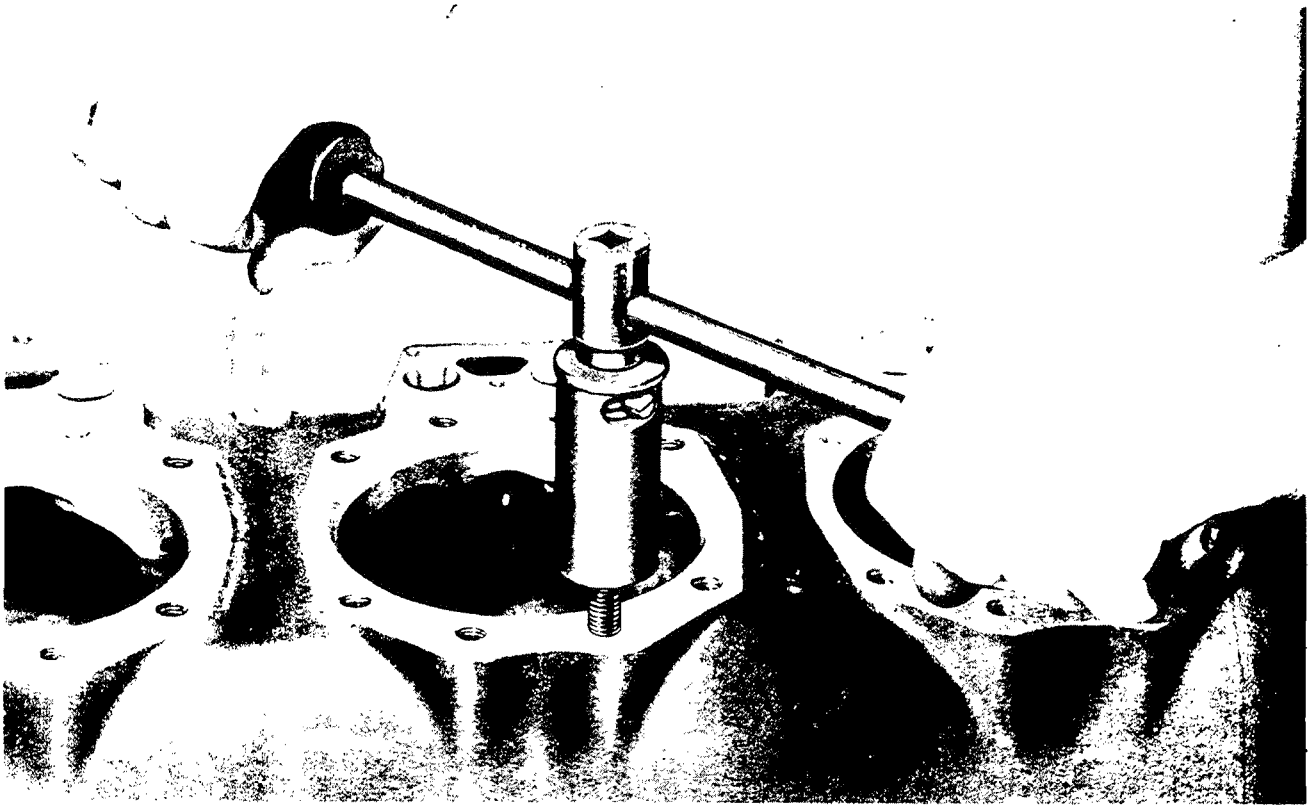


FIGURE 24. DRIVING CYLINDER BASE STUD.

10-10. VALVE GUIDE REPLACEMENT.

Remove excessively worn valve guides after cleaning all carbon from their inner ends. The cylinder must be held in the inverted position in a suitable fixture and the guide driven out with a drift which is piloted in the guide bore. The drift must not touch the cylinder head bore. If the guide cannot be driven out easily, heat the cylinder to 575°F. in an oven to expand the head. If no aluminum is removed when the guide is driven out, the replacement may be made with a standard size part. If the cylinder head bore was scored or galled, or if the specified tight fit of the new standard guide cannot be maintained an oversize part must be used. The cylinder head bore must be reamed or rebored to the specified tight fit with the new oversize guide.

NOTE

A broach for enlarging the cylinder head bore may be purchased from Borrough's Tool Company. Similar broaches may be obtained for finishing the stem bores of the replacement guides.

Use the smallest oversize guide for which the head bore can be cleaned up. Make all measurements of guide and head hole diameters at room temperature. Drive the replacement guide with a driver which will fit closely outside the outer end of the guide and will bear on its flange. Do not use a plain drift or use the end of the guide for driving. It is advisable to press the guide in with an arbor press, as illustrated in Figure 26. Immediately before driving the new guide, dip its entering end in a light grade of engine oil. The cylinder should be supported in the upright position in a suitable fixture which will support the base flange. Place the guide and driver in position, and bring the ram down on the driver. Check alignment of the guide by eye, and see that it remains square with the hole as the press is operated to force it into the cylinder head.

Replacement valve guides must be reamed or broached, as shown in Figure 27. to obtain the required hole diameter. Stem holes of intake guides are slightly smaller than those of exhaust guides.

10-11. VALVE SEAT REPLACEMENT.

Remove any cracked, pitted, burned or excessively reground valve seats with a magnetic or other suitable puller. The

TABLE XIV

STUD SETTING HEIGHTS

Location of Stud	Thread Sizes	Total Number	Setting Height (inches)
CRANKCASE			
Cylinder Pads (6)	7/16-14 X 3/8-24	36	.87
Cylinder Pads (6)	7/16-14 X 7/16-20	36	.87
Front Mount Bracket Pads (2)	3/8-16 X 3/8-24	8	1.00
Pushrod Housing Flanges (6)	1/4-20 X 1/4-28	18	.69
Oil Sump Pad	5/16-18 X 5/16-24	6	.56
Rear Mount Bracket Pads (2)	5/16-18 X 5/16-24	4	.91
Magneto Drive Gear Support (2)	5/16-18 X 5/16-24	4	.50
Starter Pinion Pivot (Delco)	5/16-18 X 5/16-24	2	.53
REAR MOUNT BRACKETS			
Oil Sump Side Supports (2)	5/16-18 X 5/16-24	2	1.50
ACCESSORY CASE			
Generator Pad	5/16-18 X 5/16-24	3	.81
Starter Pad (Delco-Remy)	5/16-18 X 5/16-24	3	.81
Fuel Pump and Left Side Accessory Drive Pad	1/4-20 X 1/4-28	4	1.12
Left Side Accessory Drive Pad Cover	1/4-20 X 1/4-28	4	.62
Side Fuel Pump Pad Covers (2)	5/16-18 X 5/16-24	4	.84
Magneto Pads (2)	5/16-18 X 5/16-24	4	1.00
Right Side Accessory Drive	5/16-18 X 5/16-24	4	.72
Starter Pad (Eclipse)	5/16-18 X 5/16-24	5	Shoulder
Starter Adapter (Eclipse)	5/16-18 X 5/16-24	2	Shoulder
Oil Cooler Bracket	5/16-18 X 5/16-24	4	1.22
RIGHT SIDE ACCESSORY DRIVE ADAPTER			
Accessory Mount Pad	1/4-20 X 1/4-28	4	.87
CYLINDER ASSEMBLY			
Exhaust Pipe Flange (6)	5/16-18 X 5/16-24	12	.78
INTAKE AND OIL DRAIN MANIFOLD			
Carburetor Mount Pad:			
Stromberg PS-5C	5/16-18 X 5/16-24	4	.87
Marvel-Schebler MA-4-5	5/16-18 X 5/16-24	4	1.12

cylinder must be heated in an oven to a temperature of 575°F. for an hour, not longer, to expand the head. The position of the cylinder during the removal operation will depend on the type of puller employed. Magnetic pullers work best when the cylinder is upright. The puller must have a provision for feeding cold water to the inside of the insert to shrink it without cooling the head by overflow. They employ a rubber syringe to feed water into the insert through the puller pilot, which is inserted through the valve guide and is center drilled for a water passage. Alnico VI magnets are built into these tools. Two pullers are required to fit the two diameters of valve seat insert.

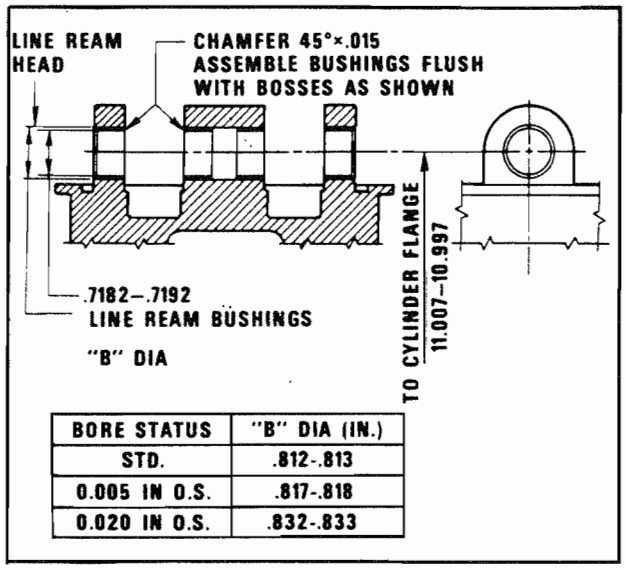
TABLE XV

ROCKER SHAFT SUPPORT BOSS REPAIR DIMENSIONS

Repair Sequence	Diameter "B" (inches)
For First Time Repair	.812–.813
For Second Time Repair	.817–.818
For Third Time Repair	.832–.833

10-12. After removal of a valve seat insert, inspect the cylinder head counterbore for condition. Clean the recess, and compare its diameter with that of the replacement standard size part. If the counterbore is smooth and undamaged, and if the specified tight fit can be obtained, the standard size replacement insert may be installed; however, scored counterbores must be bored to clean up, and oversize inserts must be installed with the specified fit.

10-13. Heat the prepared cylinder in an oven for an hour at a temperature of 575°F. to expand the cylinder head. Remove the assembly, and place it, in the inverted position, on a suitable holding fixture. Place the new valve seat insert on a suitable installing tool, which must have a device to retain the insert and a pilot to fit into the valve guide to assure perfect alignment of the insert. Insert the tool pilot in the guide, and set the insert in place. Tap it with the installing tool to assure full seating, and hold until the head has shrunk to a tight fit.



BORE STATUS	"B" DIA (IN.)
STD.	.812-.813
0.005 IN O.S.	.817-.818
0.020 IN O.S.	.832-.833

FIGURE 25. DIMENSIONS OF ROCKER SHAFT SUPPORT BUSHINGS.

10-14. VALVE SEAT REFACING.

It will be necessary to face new inserts, and it will usually be necessary to reface worn valve seats at this overhaul. Refacing may be done with any style of machine of either fixed or portable type.

Soft stones must be used on both intake and exhaust valve seats, which are Chrome Molybdenum alloy steel. The angle between the valve seat and the valve guide axis must be between 44° 30' and 45°. Thus, the angle of the cutting stone must be carefully maintained. The finished seats should be checked with a 45° bluing gauge for angle, concentricity with the guides, squareness with the guides, smooth surface, and seat width. If seats are ground over width, they should be narrowed by chamfering the outside edge with a 22° stone. The valves should overhang the seats at least 1/64" as indicated by the bluing gauge. Refaced valves should be lightly lapped to the finished seats. After thorough cleaning, the valves should be installed for a leak test. This may be done by inverting the cylinder and pouring in gasoline. Serious leakage will be evident at the intake and exhaust ports. A closer check involves application of 5 to 10 lbs./sq. inch air pressure at the ports and observing any bubbles through the gasoline in the combustion chamber.

10-15. UNSERVICEABLE CYLINDERS.

If a cylinder head is loose or appears to have turned, or if the cylinder bore must be ground to an oversize it is recommended that the defective cylinder be exchanged,

through an authorized dealer, for a reconditioned assembly. For assistance in selecting available cylinder assemblies, pistons and rings for the various models of the E Series, refer to Table XVI.

NOTE

Engines equipped with stepped cylinder attaching studs may be converted to accommodate the current type removable pushrod housings by installing a set of either 533096A1 or 539344A1 service assemblies (with valve mechanism parts from original engine). These service assemblies do not include the pushrod housing seals, which are supplied in the complete gasket set for these engines.

10-16. VALVES.

Measure the warp (run-out) of valve faces by dial indicator before regrinding. If it exceeds the value specified in the Table of Limits, the valve must be discarded.

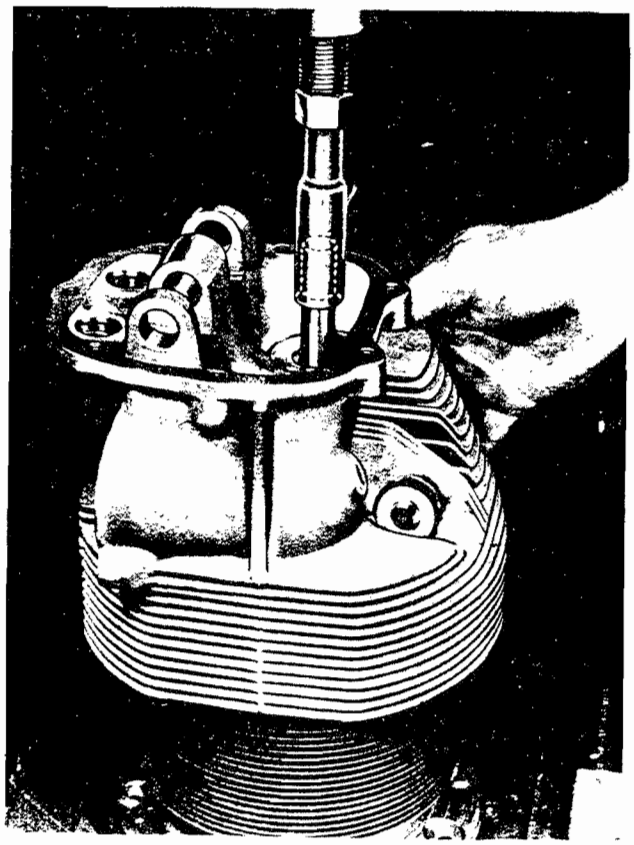


FIGURE 26. INSTALLING VALVE GUIDE.

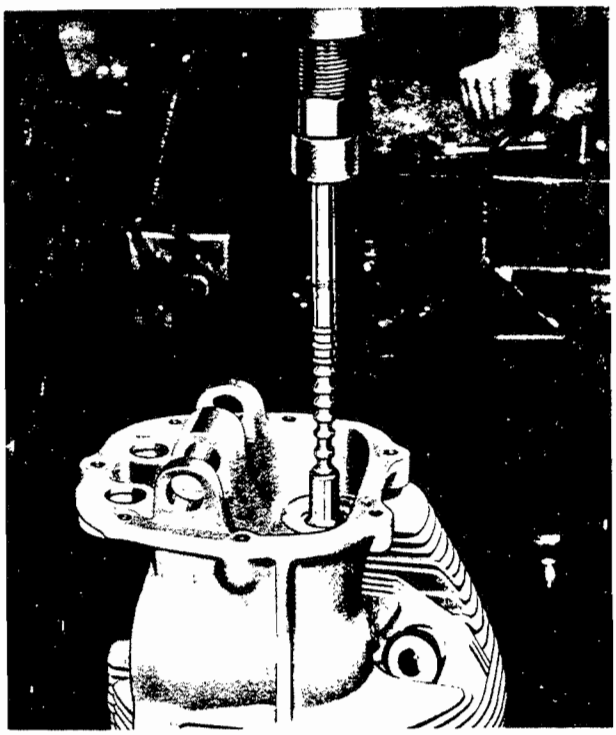


FIGURE 27. BROACHING VALVE GUIDE.

The valve refacing machine should have an accurate check so that the run-out of the finished face will be less than .001" when the valve is chucked in any radial position other than that used for grinding.

Use a hard Arkansas stone or fine India stone to break the sharp outer edge of the finished face.

If the cut must be carried deep enough to exceed the depth of Stellite, which is originally .031" thick, on an exhaust valve face, the valve must be discarded.

If the cut must be carried deep enough that the outer edge of the face has entered the rounded edge of the head so as to leave a knife edge and reduce the head diameter, however little, the valve must be discarded.

Use the stem grinding attachment to resurface the end of any valve stem which is cupped or grooved. The finished surface must be smooth, flat and square with the stem. Do not grind beyond the specified limit. Break the sharp edge with a fine hand stone.

Dress small nicks with a hard Arkansas stone except on the stem bearing surface. If this surface is scored or nicked, discard the valve.

10-17. CONNECTING RODS.

> *CAUTION*
>
> *Replacement rods must weigh within 1/2 ounce in opposite bays.*

10-18. PISTON PIN BUSHING REPLACEMENT.

Press out any unserviceable connecting rod piston pin bushing on an arbor press, using a pressing tool which fits the bushing bore closely and which has a flat shoulder, the O.D. of which is 1.230"-1.232". The rod should be supported on a steel ring whose surface is flat and smooth and which has a hole of 1.245"-1.250" diameter, through which the bushing can pass freely. Do not heat the connecting rod for removal or installation of the bushing.

Inspect the connecting rod bushing bore. If any bushing material adheres to the bore it must be removed carefully with a fine round hand stone without enlarging the bore. Polish the bore with crocus cloth. Do not use a hone or any tool or material which will remove metal rapidly for this purpose. Measure the rod bore diameter. It must be 1.234"-1.235" in order to produce the proper tight fit with a new, standard O.D. bushing.

Place the connecting rod on a flat plate in the arbor press. Dip the new bushing in light engine oil and insert the pressing tool. Place the tool and bushing on the rod end, as shown in Figure 28, with the bushing split forming an angle of 45° with the crankpin end of the rod center line and on the side opposite the cylinder numbers stamped on the rod and the bearing cap. Press the bushing squarely into the rod until it is flush with the rod surface.

10-19. PISTON PIN BUSHING BORING.

Set up the rod and cap assembly in a connecting rod bushing boring machine or on a suitable fixture in a lathe,

TABLE XVI

RELATIONSHIP OF CYLINDERS, PISTONS AND RINGS

Cylinder Part Number	Cylinder Flange Stud Hole Size	Engine Model Application	Use Piston Part Number	Use Ring Set Part Number
*520113	3/8"	E165, E185	50399	536938A2
*532453	7/16"	E165, E185	50399	536938A2
*533096A1	3/8"	E165, E185	50399	536938A2
*535291	7/16"	E165, E185, E225	50399, 534895 534895	536938A2 536938A2
538348 (Green Paint) †625051	7/16"	E165, E185 E225	50399, 534895 534895	536938A2 536938A2
538610 (Black Paint)	7/16"	E165, E185, E225	50399, 534895 534895	536938A2 536938A2
539344A1	3/8"	E165, E185	50399, 534895	536938A2

** No longer in production, but may still be available in Distributor's stocks.*

† No. 625142 Rocker Shaft and Retaining Screw and Washers go into effect with this cylinder.

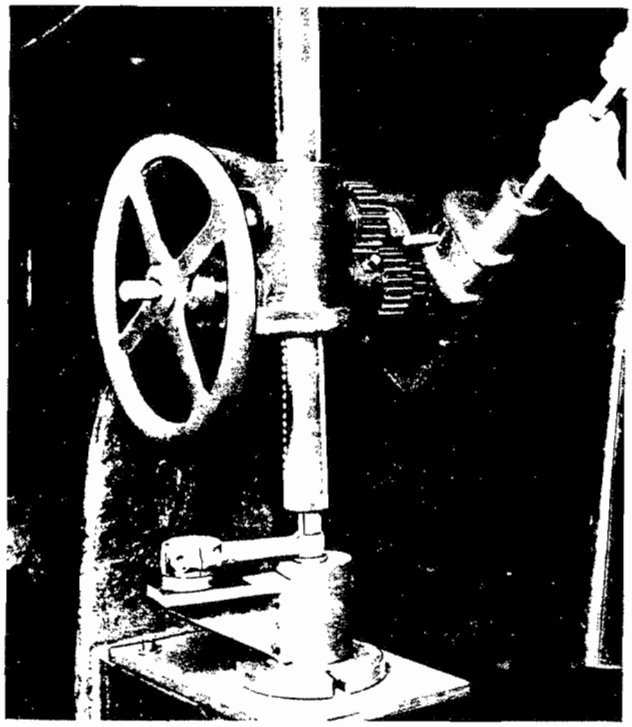


FIGURE 28. INSTALLING CONNECTING ROD BUSHING.

milling machine or universal boring machine. Accurate spacing and alignment of the big end bore and piston pin bushing bore must be achieved by whatever set-up is employed. For this reason the only satisfactory method of locating is by an arbor installed in the big end (with inserts removed).

10-20. The big end bore is 2.3755" to 2.3760". It is finished at the factory while the cap bolts are tightened to 400-420 in. lbs. torque. With the rod installed on a suitable arbor and supported and clamped securely, the boring spindle should be indicated parallel with the arbor in all planes and the center to center distance of bearings must be established at 6.623"-6.627" and held. If original type pins with separate end plugs or pins with a single aluminum plug staked at both ends are to be installed, bore the new piston pin bushing to a diameter of 1.1257"-1.1261", for standard size piston pins. If piston pins are the current production type, bore the new piston pin bushing to a diameter of 1.1263"-1.1265", for standard piston pins. In either case, boring must produce the lowest possible surface roughness. Break sharp edges at ends of bushing bore.

10-21. Place the repaired connecting rod on the alignment checking fixture and test for twist and convergence of the bores.

10-22. PISTONS, PINS AND PLUGS.

10-23. OVERSIZE PISTON PINS.

If .005" oversize piston pins must be fitted, ream the piston bores in line, using a reamer which will produce a hole diameter of 1.1300"-1.1305" in the 50399 piston, and a hole of 1.1296"-1.1300" in the 534895 piston, unless the bores of the piston are to the respective diameter without reaming.

Measure the refinished piston bores and compare with the O.D. of the oversize pin to be installed. The connecting rod piston pin bushings must also be bored to fit the new oversize pins. The pistons and rods should be kept in their original relations, notwithstanding the piston pin change. Since wear will usually be fairly uniform in the engine, it is recommended that all pistons be fitted with oversize pins at the same overhaul. This work should be performed before the new piston rings are installed, as described under "Inspection of Parts". Thoroughly clean pistons after reaming to remove all cuttings.

NOTE

Pistons are balanced in sets by weight at the factory. If a piston is replaced, the new part must weigh within 1/2 ounce in opposite bays.

10-24. FINISHED SURFACES.

Piston skirts may be smoothed with a hard Arkansas stone if light scratches appear. Only the projecting edges should be dressed down, and no attempt should be made to eliminate the depressions, since to do so would reduce the diameter of the piston and render it worthless. If deep or continuous scratches remain, the piston must be discarded. It is not necessary or desirable to polish seasoned piston surfaces. Discoloration will do no harm.

10-25. PISTON PIN PLUGS.

Piston pin plugs of the original, loose fitting type may be replaced with new parts if excessively worn on the bearing diameter or ends. Pins which have the single plug swaged on both ends and the current production pins must be replaced if the plug is excessively worn or loose.

10-26. CRANKSHAFT.

Lightly scored crankpins and journals may be smoothed with a flat hard Arkansas stone. Do not use a coarser

abrasive. Polish the surfaces with a long strip of crocus cloth. Do not attempt to remove deep or continuous scoring or bluing, because these defects render the shaft unserviceable.

10-27. Crankshafts which have not been overheated or bent, may be reground to 0.010 undersize. Reground crankshafts must be re-nitrided.

10-28. Nicks in crankshaft propeller nut threads may be dressed down carefully with a triangular hard Arkansas stone. If the section of the shaft which lies under the bronze propeller cone is fretted, it should be polished with a long strip of crocus cloth. Polish the oil seal race with crocus cloth.

10-29. The six screw holes in the end of the rear main journal of the original type crankshaft may be cleaned out with a 1/4-28 N.F. tap if screws do not enter freely. Use a 5/16-24 N.F. tap to clean out the six holes in the end of rear main journal of current production crankshafts.

10-30. If counterweight bushings or crankcheek bushings are worn irregularly, galled, or loose, they may be replaced. It may be necessary to chill the old bushings in order to drive them out.

10-31. Measure the hole diameter and compare it with the new bushing O.D. at room temperature. Chill the new bushing and drive it in squarely. Crankshafts and counterweights need not be heated for this work.

10-32. GEARS.

Do not attempt to dress scored or deformed gear teeth. Any indentation or deformation at gear tooth faces is cause for rejection of the gear. Small nicks may be dressed down and the gear shafts may be polished with crocus cloth.

10-33. The only gears which are bushed are the magneto drive gears. Due to the extreme difficulty of boring replacement bushings concentric with the pitch circles of these gears, and in view of the low cost of new gear and bushing assemblies, it has been decided that magneto drive gear bushings will not be supplied as service parts.

10-34. PUSHRODS AND HOUSINGS.

Straighten slightly bent pushrod tubes by tapping with a non-marring hammer. If ball ends are badly chattered, scored, worn or loose, discard the pushrod.

Remove dents from housings by tapping with a non-marring hammer while the housing is supported on a mandrel. Remove enamel and inspect for cracks after straightening.

10-35. INTAKE TUBES.

These tubes are made of 3S aluminum and are quite soft. Dents and out of roundness should be corrected by tapping with a light weight, non-marring hammer only enough to remove the irregularity, while the tube is supported on a curved mandrel. Do not hammer the metal to a thinner wall. Inspection for cracks should be made by local etching after repair. The enamel must be removed for this purpose. Repaint repaired tubes with a good quality, heat resistant engine enamel.

10-36. WET OIL SUMP.

Small dents in the oil sump need not be removed. Large dents are cause for rejection. Slightly bent mounting brackets may be straightened. If it is necessary, in order to repair mounting brackets or lockwire clips, or in order to stop leaks, acetylene welding or electric arc welding may be employed, provided it is approved in advance by the F.A.A. inspector for the district. Oil sumps must be thoroughly cleaned inside and outside by steam to remove all traces of combustible substances before welding is attempted.

10-37. FRONT OIL DRAIN TUBE.

If the bolt flange is not perfectly flat, it should be lapped on a lap plate using a fine lapping compound. Straighten any dents by tapping while the tube is supported on a mandrel. Remove enamel after straightening, and inspect for cracks.

10-38. ACCESSORY DRIVE ADAPTERS AND TACHOMETER DRIVE HOUSING.

Refer to the paragrpahs on repair of castings for general information. All gear shaft oil seals must be removed with suitable pullers, and new seals must be installed. Install all oil seals so that the lip of the rubber sealing member points in the direction from which oil will strike the seal. When shafts are inserted in the adapters, be sure that the rubber lip is not pushed ahead of the shaft and reversed. The same precautions apply to installation of the generator shaft oil seal and assembly of the coupling.

10-39. PROTECTIVE COATINGS.

10-40. Engine parts currently manufactured from aluminum alloy are protected from corrosion by treating them with "Alodine 1200". "Alodine" treated parts are easily distinguished by their gold color. In order to maintain a uniform appearance, the manufacturer is painting certain steel and magnesium parts with gold color enamel.

10-41. Ferrous parts when painted with gold enamel will be baked with infrared equipment, for 15 minutes at 275°-285° following application of each coat. Magnesium parts will be pickled and primed; then baked with infrared equipment, for 15 minutes at the same temperature as ferrous parts following application of each coat of enamel.

NOTE

If a part which was originally "Alodized" is to be refinished with enamel, it will not be necessary to apply zinc chromate primer except to the surface areas completely stripped of "Alodine".

CAUTION

Before application of primer and enamel to a part, carefully mask all connection joints and mating surfaces. No primer or enamel permissible on interior surfaces of fuel pump drive, oil pump housing, oil sump, crankcase or any other parts contacted by engine lubricating oil after assembly.

10-42. "ALODIZING" AND REPAIR OF ALODIZED SURFACES.

Aluminum alloy castings, sheet metal and tubing are now protected from corrosion by treating all surfaces of the parts with "Alodine 1200" (Amchem Products, Inc., Ambler, Pa.) "Alodine" unlike enamel or primer, will not flake or peel off to contaminate engine lubricating oil; therefore, corrosion protection can be afforded to all interior aluminum surfaces and parts. If an enamel coating is required for a part previously treated with "Alodine", application of a primer is not necessary. "Alodizing" will be performed after all machining and/or repair operations have been completed. The surface color of an "Alodized" part may vary from light gold to dark brown. When a part is treated with "Alodine 1200" the thickness of the film, or buildup on the mating or bearing surface is so fine that the effect on dimensional tolerances is negligible.

10-43. APPLICATION OF "ALODINE 1200".

In the event the original finish of an aluminum part has deteriorated or been removed, the part may be "Alodized" as described in "Alodine" manufacturer's Technical Service Data Sheet No. AL-1200-D. Wrought or die cast (smooth surface) parts, such as valve rocker covers and intake tubes, should be tumbled or sand blasted to roughen before treatment.

10-44. REPAIR OF "ALODIZED" SURFACES.

If "Alodized" parts have been remachined, rubbed with abrasives or scratched in handling so as to expose areas of bare aluminum, the surface may be repaired by local application of "Alodine" solution as described in the following steps:

a. Clean the part's bare area thoroughly with carbon tetrachloride. Do not use an oil base solvent such as Federal Specification P-S-661, TT-291 or alkaline cleaner under any circumstances.

b. Mix a small quantity of hot water (180°F) with 1-1/2 to 2 ounces of "Alodine 1200" powder to form a paste; then gradually add hot water until a gallon of solution is attained. Adjust the solution to a Ph value of 1.6 (1.5 to 1.7) by adding nitric acid.

c. Application shall be made, with a rubber set brush, so that the solution flows over the area.

d. Allow the solution to remain on the part from one to five minutes or until color of the new film is approximately the same as the original.

e. Flush the part with clear water and dry with air. Do not blast or rub with a cloth to dry new film area. If the color is too light, repeat steps "c" and "d" until the desired color is obtained.

NOTE

If "Alodine" does not adhere to metal, a more severe cleaning method must be used. A solution of 12 to 16 ounces of Oakite No. 61 per gallon of water is preferred. Apply and remove the solution with caution because an alkaline cleaner of this type will remove any "Alodine" film previously applied. Remove cleaning solution thoroughly with plenty of hot water and vigorous brushing.

SECTION XI
ASSEMBLY OF SUBASSEMBLIES

INTENTIONALLY

LEFT

BLANK

11-1. FOREWORD.

Following approval of all repair work and replacement parts, assemble the parts according to the following instructions. Some variations of the order in which parts are assembled and installed are permissible, however, it should be ascertained that such deviations from the given order as may be desired will not interfere with later operations.

11-2. GENERAL PROCEDURE.

Use only parts which have passed inspection and new replacement parts. Inspect these visually immediately before they are installed for identity, completeness, cleanliness and any damage due to handling. Replacement parts are shipped in carefully designed packings which protect them from damage and atmospheric conditions only until the wrappings are removed. For this reason it is best not to unwrap new parts until ready to install them.

11-3. PREPARATION.

Obtain a complete set of new gaskets, self-locking nuts, hydraulic "O" rings, lockwashers, tab washers and cotter pins. Also obtain an adequate supply of the proper lockwire. It is suggested that all such small parts, including serviceable used nuts and washers, and enough replacements for the complete assembly, be placed in marked boxes or bags where they can be found and identified easily.

11-4. LOCKWIRES.

The proper method of installing lockwires to secure plugs and screw and bolt heads is illustrated in Figure 29. Notice that the lockwire in each illustration passes through a hole in the threaded part, that the end looped around passes under the end emerging from the hole and that the direction of twist in the pair from that point tends to hold the loop inward. Since only right hand threads are employed, lead the twisted wire in the direction illustrated in all instances to hold the plug, screw or bolt against loosening. Twist lockwire while exerting moderate tension, but do not stress enough to cause failure. Bend down ends to prevent snagging clothing.

11-5. TIGHTENING TORQUES.

If the slots of any castle nut do not align with the cotter pin hole of the stud or bolt when it is tightened to minimum specified torque, continue tightening until either alignment is achieved or specified maximum torque is reached, whichever occurs first. If alignment is not obtainable within torque limits, either or both of two remedies may be applied. First, the nut may be replaced by a serviceable used or new nut of the same part number. Second, the washer may be exchanged for a new washer of the same part number having a slightly greater thickness. If a castle nut runs in so far that the cotter pin hole of the bolt or stud lies beyond or at the end of the nut, then either (a) the bolt or stud is stretched, (b) the stud has backed out partially, (c) the washer(s) is (are) worn and must be replaced, (d) the wrong nut was used, or (e) the thickness of the part or parts through which the bolt or stud passes has been reduced excessively. Whatever the reason, the situation must be corrected by whatever replacements are indicated.

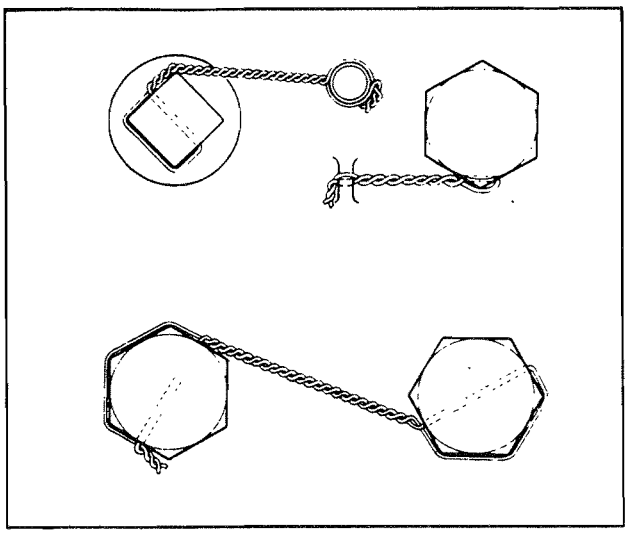


FIGURE 29. INSTALLATION OF LOCKWIRES.

11-6. FINAL CLEANING.

If original engine parts have not been wrapped, wash them with an approved grease solvent; dry them thoroughly, and coat them with clean engine oil immediately before installation.

11-7. CRANKSHAFT AND CONNECTING RODS.

With the crankshaft supported on suitable blocks or, preferably, on an assembly fixture designed for the purpose, install the front plug. Screw plugs of splined shafts should be tightened by two or three solid blows of a lead or copper mallet on the wrench tee bar. Tap the press-in plug into the hub hole of any flanged shaft with a tube which fits the hole loosely. Seat and expand the plug with one blow of a hammer on a 3/4 inch diameter punch. Do not strike so hard as to dent the plug. Install retaining plates and Truarc rings in the pin holes on one side of each counterweight. Attach the counterweights to the crankshaft blade with two pins each; then install the retaining plate and Truarc rings on the other side. The groove pin in the 5th order counterweight assures installation only on the proper blade of the correct type of crankshaft, though it does not assure against incorrect installation of a 6th order counterweight. This error must be avoided.

11-8. Install new crankpin bearing inserts in the connecting rods and bearing caps. Make sure that the inserts are fully seated. Their ends should protrude very slightly and equally. Coat them with clean engine oil. Insert the connecting rod bearing cap bolts in the caps, and install the rods and caps on their original crankpins with the rod and cap members matched and registered and all numbers on the same side so that they will all be up when the rod and shaft assembly is installed in the crankcase. Install and tighten the cap bolt nuts to specified torque. Check each connecting rod for free turning. Install cotter pins in all cap bolts.

11-9. CRANKCASE SUBASSEMBLY.

Place a new copper-asbestos gasket on plugs, and screw them into the tapped holes at the front ends of the crankcase main oil galleries. Tighten the plugs. If mount brackets were removed re-install them on the case halves.

> *NOTE*
>
> *If a rear mount is replaced, install new part with thru bolt hole to match size of 5/16 or 3/8 inch thru bolt. Use thru bolt to fit hole in crankcase.*

11-10. Install all new pushrod housing flange gaskets on the crankcase halves.

11-11. Install the 2, 4, 6 side on the assembly stand, supporting it as in the final stages of disassembly.

11-12. If a flanged crankshaft is installed, place a new split crankshaft oil seal on the shaft, behind the propeller flange and install the spring in the seal. Coat seal lip with Gredage No. 44 grease. Spread a film of TiteSeal in the case recesses.

11-13. Coat the hydraulic valve lifters of cylinder Nos. 2, 4 and 6 with clean engine oil and insert them in their original positions.

11-14. Install new Tri-Metal inserts in intermediate and rear main bearing seats. If Tri-Metal inserts are used in the front main-thrust bearing, these must be new parts also. If silver main-thrust bearing inserts are employed, used parts may be installed, provided that they are in good condition. The ends of each insert should project slightly and equally above the case parting surfaces. If any insert stands high remove it, ascertain the reason, and correct the interference.

11-15. Install the crankshaft and connecting rod assembly in the 2, 4, 6 side bearings, and place cloth pads between Nos. 1, 3, and 5 connecting rods and the parting surface.

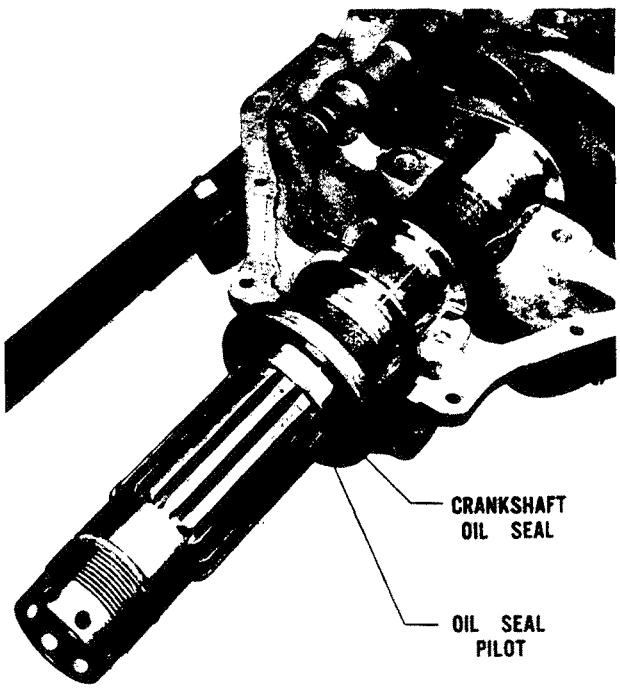


FIGURE 30. INSTALLING CRANKSHAFT OIL SEAL.

Install crankcase protectors on Nos. 2, 4 and 6 cylinder mount pads.

NOTE

After installing a flanged crankshaft, turn the oil seal until its split is about 5/8 inch below the crankcase parting flange surface. Push the seal all the way back into its recess in the case. Make sure the ends are together and flush.

11-16. If bronze thrust washers, retained by crankcase dowels are employed, they must be installed in the case before the crankshaft is laid in position. If thrust washers with short dowels are employed, slide the plain halves into the recesses after the crankshaft is in position. Then place the dowel half washers in position, and rotate the complete washers till the dowels lie in the case notches. Measure crankshaft end clearances with a thickness gauge.

11-17. Thoroughly clean and dry the camshaft, and coat it with clean engine oil. Install it in the 2, 4, 6 side bearings.

11-18. If a splined crankshaft is installed, place a tapered sleeve on the splined end to guide the oil seal onto the shaft race. The pilot sleeve should be smooth and should match the race diameter at its rear end. Coat the seal race and the seal lip with LubriPlate, or a similar lubricant, and spread a thin film of lightweight TiteSeal, or similar gasket paste, on the crankcase counterbore surfaces into which the seal will fit. Slide the oil seal over the shaft end and pilot sleeve and onto the race, raising the shaft to admit the seal to the case recess. Lower the shaft, and see that the seal is fully seated in its case counterbore with its lip to the rear. Remove the pilot sleeve.

11-19. Coat the hydraulic valve lifters for cylinders Nos. 1, 3 and 5 with clean engine oil and install them in their original positions in the 1, 3, 5 side. Attach the packing rings to hold these lifters in positions, as was done in disassembly.

11-20. Prop up Nos. 1, 3 and 5 connecting rods to clear the 2, 4, 6 side parting flange surface. With a small bristle brush, apply a thin, uniform film of non-hardening gasket paste to the parting surface. Be very careful not to use excessive paste or to spread it thick enough that it will be squeezed out into the crankcase. If this material reaches and covers the pressure oil screen, engine failure will follow. When the paste has dried to a tacky consistency, lay lengths of No. 50 silk thread along top and bottom flanges over sealer. The thread must lie inside bolt or stud holes. The thread is led off at the front just under edges of the crankshaft oil seal. Allow ends to overhang openings. Clip off excess after completion of crankcase assembly.

11-21. Ascertain that all thrust and main bearing inserts and valve lifters are in position. Then, with the help of a second man, lower the 1, 3, 5 side on the 2, 4, 6 side, guiding the Nos. 1, 3 and 5 connecting rods into their cylinder pad holes. Install crankcase protectors on the 1, 3, 5 side cylinder pads.

11-22. Insert the eight through bolts in the crankcase holes. Install spacers and castle nuts on the upper ends of the two front bolts and on the lower ends of the two rear bolts. Install the two 3/8" X 4-15/16" front through bolts with washers under the heads. Install washers and nuts at the lower ends but do not tighten them yet. Install the two longest 5/16" through bolts and install washers and nuts on all three bolts. Run the nuts down but do not tighten them yet. Insert the two longer 1/4" flange bolts for the lifting eye in upper flange holes. Install the remaining nineteen flange bolts with washers under the heads. Install nuts and washers on all flange bolts but do not tighten them yet.

11-23. If silver main thrust bearing inserts are installed, pull the crankshaft forward fully to align the thrust surfaces before tightening crankcase bolts. This is particularly important in early production crankcases.

11-24. Install the starter pinion pivot or starter gear pivot in its pilot bore in the rear crankcase web. Do not install nuts or screws to retain the pivot until the crankcase through bolts and flange bolts have been tightened.

11-25. Tighten all flange bolt nuts. Tighten the nuts of the three 5/16" and two 3/8" through bolts to specified torques.

11-26. Insert the mounting bolts in the right front and right rear mount bracket bushings to attach the 1, 3, 5 side to the stand. Use wood plugs or other conical spacers with brackets for horizontal mount bolts if the loose rubber bushings are not available or suitable. Check the security of the four points of attachment to the stand. Then turn the engine bed to place the crankcase in the upright position. Remove the packing rings used to retain the 1, 3, 5 side valve lifters.

11-27. Tap the starter pinion pivot or starter gear pivot to seat it firmly. If the pivot is for a Delco-Remy starter pinion, install two slotted nuts on the crankcase studs. Tighten them to specified torque, and install cotter pins. If the pivot is for an Eclipse type starter gear align the

pivot flange holes with crankcase holes, and install two hex head screws and tab washers. Tighten the screws, and bend the washer tabs up beside the screw heads and down beside the pivot flange.

11-28. If removed, install the two magneto drive gear supports in their original positions at the rear of the crankcase. Tap them home, and run slotted nuts on the studs. Tighten nuts to specified torque, and install cotter pins.

11-29. ACCESSORY CASE.

Thoroughly clean and dry all parts of the subassembly. As each steel part is installed, coat it liberally with clean engine lubricating oil.

11-30. PLUGS.

Install the two plain 1/8 inch pipe plugs in the ends of the oil passages at the bottom and at the right side of the case if the assembly is for a dry sump engine or for a wet sump model equipped with a left side accessory drive. If the case assembly is for a wet sump engine which still employs diaphragm fuel pumps and has no left side accessory drive, install the special extension plug (Part No. 25055) in the end of the oblique passage at the right side of the case. This plug has an extension end which closes the oil passage to the open front bearings for the idler and left side accessory drive gears. Install the socket head 1/2 inch pipe plug in the oblique tapped hole in the left side case projection. In assemblies for wet sump engines install a square head 1/2 inch pipe plug or propeller oil drain line elbow in the tapped hole in the left case wall, and install the oil outlet hose connector elbow in the oil screen exit hole in the right wall of the casting. In assemblies for dry sump engines, install the accessory case vent fitting in the 1/4 inch N.P.T. hole in the round boss at the upper left corner of the casting, and install the oil drain plug, with a new copper-asbestos gasket, in the tapped hole in the case bottom surface.

11-31. OIL PRESSURE RELIEF VALVE.

Install the relief valve plunger on its seat in the case. Insert the spring. Place a new copper-asbestos gasket on the relief valve cap, and screw the cap into the case thread. Tighten the cap enough to prevent oil leakage.

NOTE

Install a new No. 530838 relief valve spring with first three coils color coded black. This spring is required to provide 60 psi maximum oil pressure.

11-32. BY–PASS VALVE CAP.

Since no valve is installed, it will be necessary only to install the bronze cap in the tapped hole below the relief valve, with a new gasket under its head. Tighten the cap. Install lockwire through the hex corner hole. Twist it, and pass the twisted wire around to the corresponding hole in the relief valve cap in such a direction that it will tend to tighten both caps.

11-33. PRESSURE OIL PUMP.

Insert the driving and driven impellers in the pressure oil pump housing and install the housing in the case. It is essential that the pump housing and accessory case parting surfaces fit perfectly. Gasket paste must not be used in this joint. Install the special 1/4"-20 X 5/8" hex head screw with an external tooth lockwasher against its head and a plain washer against the case surface. This screw is located in a small counterbore in the generator mounting pad. Do not tighten it yet.

11-34. TACHOMETER DRIVE HOUSING.

Install the tachometer drive housing and oil seal assembly, using a new gasket. Be sure that the oil seal rubber ring passes over the tachometer drive shaft and does not double back. Insert the two 1/4"-20 X 1-3/8" drilled hex head screws and flat washers through the flange holes. Tighten them very little.

11-35. PRESSURE OIL SCREEN HOUSING AND OIL CHECK VALVE.

If the accessory case is for a dry sump engine, install the oil check valve, the new No. 537145 spring, retainer and self-locking nut in the valve seat. Install a new hydraulic "O" ring in the groove of the seat, and slip the assembly in place in the counterbore inside the accessory case screen chamber. Install the pressure oil screen housing with a new gasket. A thin film of non-hardening gasket paste may be used at this joint, but not enough to squeeze out into the housing. Insert the two 1/4"-20 X 1-5/8" drilled hex head bolts and flat washers through the housing flange holes nearest the center of the case. These bolts thread into the oil pump housing. Tighten them lightly. Install and tighten the three 1/4"-20 X 1" drilled hex head bolts and flat washers in the remaining screen housing flange holes.

NOTE

Install new No. 537145 check valve springs with yellow color code.

11-36. OIL PUMP (FINISH AND CHECK).

Tighten to specified torque the five screen housing bolts, the two tachometer drive housing screws and the special oil pump to case screw. Tighten these bolts and screws evenly in stages, meanwhile testing for free rotation of the pump impellers. If the pump impellers bind, the pump must be removed and the cause determined. When this phase of the assembly is satisfactorily completed, install lockwire in the tachometer drive housing screws and the oil screen housing bolt heads.

11-37. PRESSURE OIL SCREEN.

Place a new copper-asbestos gasket on the oil screen and screw the assembly into the screen housing. Place a new copper-asbestos gasket on the oil screen plug and screw the plug into the screen nut. Do this, whether a capillary is to be installed, later or not. If a capillary is not to be used, secure the plug with a lockwire.

11-38. OIL SUCTION TUBE AND OIL COOLER BY—PASS TUBE.

NOTE

A wet sump engine case should have a thin film of non-hardening gasket paste spread on each side of the oil suction tube flange gasket before being placed in position on the pump housing.

Insert the oil pump suction tube through the open side of the case so that its lower end projects through the large hole in the bottom of the case. Set the tube flange on the pump gasket, and install the two 1/4"-20 X 9/16" drilled hex head screws. Tighten the screws and secure them with lockwire. Locate the tube clip at the screw hole in the left side of the case. Place the speed nut over the screw holes of the clip with the arch away from the clip. Place a new copper-asbestos gasket on the No. 10-20 X 1-1/4" round head sheet metal screw, and install it through the case hole. Tighten the screw. Check the centering of the oil suction tube in the large hole in the case bottom surface. Install two new hydraulic "O" rings on the oil sump by-pass tube and slip it over the lower end of the suction tube and into the case hole. The centrally located flange of the by-pass tube must seat against the accessory case surface all around.

11-39. OIL PUMP INLET TUBE.

If the case is for a dry sump engine, install the oil pump inlet tube on the pump with the beaded, tubular end projecting through the large tapped hole in the left side of the case. Insert the hydraulic "O" ring in the tapped hole surrounding the tube. Insert the bronze packing washer (23854). Screw the special nut (24857) into the hole. Tighten it only enough to expand the "O" ring and to form an oil seal, then secure it with lockwire.

11-40. SCAVENGE OIL PUMP DRIVE.

Coat the scavenge oil pump drive shaftgear generously with engine oil, if the case is for a dry sump engine not equipped with a hydraulic pump drive. Insert the gear in its adapter. Install a new gasket (AN4045-1) on the lower left accessory pad. Install the assembly in the case, guiding the gear shaft through the front bearing. Install the four washers and nuts on the attaching studs.

11-41. SCAVENGE AND FUEL PUMP DRIVE.

If the case is to be installed on a dry sump engine, inspect splined end of scavenge oil pump and fuel pump drive shaftgear for installation of socket head pipe plug, if the shaftgear is the old type. Make sure that the plug is tight if it is present in shaftgear. See that the new oil seal is properly installed in the adapter, and push the gear shaft through it carefully to avoid reversing the rubber seal ring. Install the drive in the lower left drive opening, using a new gasket. Install the pump gasket (AN4045-1) and a temporary cover. Install the four washers and nuts.

11-42. ACCESSORY DRIVE IDLER GEAR OR COVER.

If the accessory case is for a dry sump engine, or any wet sump engine equipped with a left side accessory drive, install the idler gear and shaft as follows: (1) Coat gear with clean engine oil and insert through vacuum pump drive opening under idler shaft hole. Insert idler shaft with new gasket under flange. Install and tighten two 1/4"-20 X 5/8" fillister head screws in shaft flange holes. Secure screws with lockwire.

NOTE

If case is for wet sump engine not equipped with a left side drive, install gasket (520004), cover (25007) and two screws in place of idler shaft and gear. Secure screws with lockwire.

11-42. RIGHT SIDE ACCESSORY.

If a right side drive is to be installed, inspect installation of new adapter oil seal. Inspect press in plug in gear shaft for tight fit. Install a new gasket on mounting pad. Coat

shaftgear with clean oil and insert into adapter, taking care to push shaft through oil seal ring without reversing it. Install drive assembly on mounting pad, and install the four washers and nuts on attaching studs. Install a new gasket on pump mounting pad, of the adapter, then install cover and four washers and nuts temporarily on attaching studs. Inspect installation and tightness of 1/16" socket head pipe plug in right side of adapter.

11-44. SCAVENGE OIL PUMP.

Install scavenge oil pump in accessory cases for dry sump engines as follows: Install Woodruff key (AN280H304) in key slot of forward projecting shaft of scavenge oil pump drive gear at lower front side of accessory case. Install scavenge oil pump driving impeller on gear shaft. Coat both driving and driven impellers with clean oil. Insert driven impeller in scavenge oil pump housing. Install scavenge oil pump screen in hole provided in accessory case, making sure that it is seated. Install housing and driven impeller, meshing impellers as it moves inward. Tap housing onto dowels until is is seated. Install and tighten 1/4"-20 X 1-3/8" drilled hex head bolts with AN960-416L washers. Rotate idler gear and notice any binding in pump or drive gear train. If binding occurs, pump must be removed and the cause corrected. When this phase of the assembly has been completed satisfactorily, install a 3/4" pipe elbow of desired type in scavenge pump housing tapped outlet hole.

11-45. If a left side accessory drive is to be installed on a wet sump engine, follow procedure for installing the scavenge and fuel pump drive. In this case the gear shaft will not protrude through the front of the accessory case, since no scavenge pump is used. If no left side drive is used on a wet sump engine, install gasket (AN4045-1) and cover plate on lower left accessory drive pad.

11-46. CYLINDER ASSEMBLIES.

Following repair work and preparation for the leak test described in paragraph 10-14, clean all component parts, and dry them. Lay the cylinder on its side. Coat each valve stem with a film of Gredag No. 44 grease (Gredag, Inc., Streeter Bldg., Niagra Falls, New York), and insert each valve through the cylinder and into its guide. Seat the valves and check for the correct positions. Lift the cylinder by valve stems, and place it on a fixture which will hold the valve heads on their seats and will hold down the base flange.

11-47. Place the two inner retainers over the valve guides and seat them in the bottom of the rocker box. Place one inner and one outer valve spring over each stem. Place an outer spring retainer on each pair of springs. With a lever type spring compressor, pivoted on the rocker shaft, compress either set of valve springs. Insert two keys in the valve stem groove, small ends inward and release springs. Make sure that the keys seat perfectly in the spring retainer and stem groove. Similarly, install the keys on the other stem.

CAUTION

Do not allow outer valve spring retainers to be cocked so as to touch and score valve stems.

NOTE

If old type valve springs are reinstalled (without blue stripe color code) it will be necessary to install aluminum spacers under the inner spring retainers. Do not use spacers under new type springs.

11-48. Install all rocker arms and shafts in their original locations after checking valve seating. If rocker shafts and center support bosses are drilled for shaft anchoring screws, install these parts at this time. Install new rubber seal rings on all pushrod housings and insert housings in rocker box recesses. If the pushrod housings are the removable type, snap a spring release into the space between beads of each housing, install new rubber seal rings and push seals into cylinder head holes until retainers touch. Place appropriate type pushrod housing flange over ends of both housings, making sure it is fully seated over exposed ends of the housings. Lay pushrods in a pan of oil with one end elevated. This should be done in advance of assembly. When pushrods are filled with oil, insert them in their respective housings, making sure they are seated in the valve rocker sockets. Place a new cylinder base packing ring on each cylinder skirt against base flange without twist. Coat the cylinder bore with No Scuff Oil (Cities Service Oil Co., Detroit, Michigan).

11-49. Lubricate all piston pins with castor oil. Install them in their respective pistons, leaving the connecting rod opening clear. (Pins should protrude from the left sides of pistons so that they may be pushed in with the left hand at installation.) Place the pistons with their respective cylinders, standing upright on the bench. Spread the oil control rings, and install them in the third grooves. Install the second groove compression rings, then the top rings so that the numbered sides of all rings are upward. Place the gaps of the top rings at the top sides of pistons (operating positions) and the oil control ring gaps approximately in line.

Place the second groove ring gaps opposite the first and third. Ring gaps should lie on a line at right angles to the pin.

CAUTION

Three types of piston pin assemblies have been produced for use in the E Series engines, each heavier than the one it superseded; therefore, new and old type pin assemblies must not be mixed in any engine.

11-50. Compress the rings of any piston, and insert the piston assembly in its cylinder until the protruding pin almost touches the skirt. Install all remaining pistons in the same manner. The pins should project to the left with cylinders in operating position. Cylinders may be placed upside down with upper head fins and rocker box flange on the bench until installed on the engine.

SECTION XII
FINAL ASSEMBLY

12-1. TIMING GEARS.

Turn the crankshaft to place No. 1 crankpin at T.D.C. Make sure that the accessory drive gear is clean, observing particularly the recess which pilots the gear on the crankshaft. Coat the gear liberally with clean engine oil. Place it on the rear end of the crankshaft with the timing marks at the bottom. The crankshaft dowel will align with the dowel hole in the gear web. The screw holes will also be aligned. Push the gear on the dowel until it is seated; then install and tighten the 1/4 or 5/16 inch screws, whichever is applicable. Lockwire the screws in pairs as shown in Figure 29.

12-2. Without turning the crankshaft, turn the camshaft until No. 1 intake lobe (center of rear group) is in position to open its valve and No. 1 exhaust lobe (rear one of rear group) is ending its lift. Clean and lubricate the camshaft gear. See that the rear camshaft flange is clean and dry. Place the gear on the shaft with its marked tooth meshed between the two marked teeth of the accessory drive gear. (Refer to Figure 31.) Install and tighten the four 1/4 or 5/16 inch hex head retaining screws. Install lockwire. (Refer to Figure 29.)

CAUTION

The accessory drive and camshaft retaining screws were changed from 1/4"-28 to 5/16"-24 to increase strength of attachment. This change made it necessary to enlarge gear attaching hole diameter and crankshaft and camshaft rear journal tapped holes. These changes resulted in new part numbers for the parts involved. It is possible to install gears designed for 5/16 inch attaching screws on crankshafts and camshafts which require 1/4 inch retaining screws. This mismatch must be avoided by installing and/or ordering correct replacement gears. Consult the Parts Catalog for the correct match of crankshaft, camshaft, gears and attaching screws.

12-3. ECLIPSE STARTER GEAR.

Place the gear and bushing assembly on the pivot, with the bushing flange forward. Place the retaining washer on the end of the pivot. Spread the Truarc snap ring with the proper Truarc pliers only enough to allow it to pass over the end of the pivot. Release the snap ring in its groove.

12-4. CYLINDERS.

The order of cylinder installation is not fixed, however, it is advisable to start with No. 3 and progress in the firing order of 2, 5, 4, 1, 6 to prevent unbalance and to minimize turning of the crankshaft. Before installing any cylinder, remove the crankcase pad protector, and turn the crankshaft to place the crankpin for that cylinder at T.D.C. Check the valve lifters to ascertain that they are at their innermost positions, corresponding to the end of the compression stroke.

12-5. Turn the engine bed to place the crankcase in the inverted position. Cradle the cylinder and piston subassembly in the right arm, keeping the pushrods, housings and flanges on top. With the left hand, lift the connecting rod to a horizontal position and move the cylinder subassembly inward until the rod bushing is aligned with the piston pin; then push the pin through the bushing and piston until end plugs are both flush with piston skirt. Push the cylinder inward over piston and pin until attaching studs have passed through the cylinder base flange and pushrod housing flange holes. Install four nuts on studs and through bolt above the cylinder barrel. Install remaining four nuts finger tight only. Install remaining cylinders in the same manner. After all cylinders have been installed, turn engine bed to place crankcase upright; then tighten all cylinder attaching nuts to specified torque. Install cotter pins in the drilled through bolt holes and nut locks on the remaining attaching nuts.

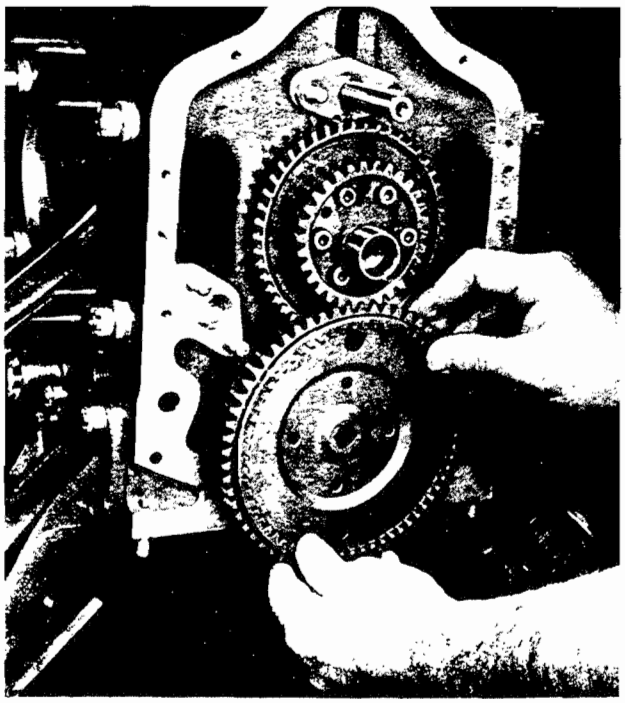


FIGURE 31. INSTALLING CAMSHAFT GEAR.

NOTE

When tightening through bolt slotted nuts, it will be necessary to adjust their position so that both cotter pin holes lie within the nut slots.

12-6. ACCESSORY CASE INSTALLATION.

a. Spread a very thin, uniform coat of non-hardening gasket paste on the rear flange parting surface of the crankcase. Remove any excess which might be squeezed inside the case or into the main oil galleries. Place a new gasket on the crankcase surface and see that all holes are registered. Spread a very thin film of paste on the parting surface of the accessory case, and make sure that no excess will be squeezed into the screen chamber outlet, relief valve inlet, or the interior of the case.

b. Bring the accessory case to the rear of the crankcase and tilt the top to the rear. Lift it so that the camshaft gear enters the case opening, keeping the lower side of the accessory case flange just in front of the camshaft gear. Watch the gasket to make sure that it is not disturbed as the accessory case is lifted into position. Insert the four 1/4"-20 X 3-1/4" hex head screws with lockwashers and plain washers into the four holes above the magneto mounting pads. If the engine is to be equipped with an Eclipse starter, omit the two top screws until the Eclipse starter adapter has been installed. Screws installed thus far should be tightened finger tight only. Invert the engine, and install the three No. 352107 hex head shoulder screws (1/4"-20 X 1-11/16") and the hex head screw (1/4"-20 X 15/16") with lockwashers and plain washers in the four holes in the crankcase lower rear flange. Tighten these four screws, observing alignment of the gasket. Place tab washers on the two 1/4"-20 X 15/16" hex head screws and insert the screws in the accessory case lug holes adjacent to the magneto drive gear supports. The single bent tab of each washer must point forward along the side of the case lug and be as far in the counterclockwise direction as permitted by the lug. Tighten these screws to specified torque and bend the two small tabs up beside each screw head. If required, install the Eclipse starter adapter over a new gasket and install the two upper bolts and five sets of washers, nuts and palnuts. Tighten the four screws which were installed first.

If it is a wet sump engine, install the oil filler cap.

12-7. OIL SUMP (WET SUMP ENGINES).

Install a new AN123879 hydraulic "O" ring in the groove of the oil drain tube at the top of the sump. Install a new copper-asbestos gasket on the drain plug and screw it into the drain hole. Tighten the plug, and install lockwire.

Invert the sump, and lower it onto the engine, making sure that the hydraulic "O" rings on the top drain tube and on the by-pass sleeve enter their respective holes without leaving the grooves. Install the six washers, nuts and palnuts on the bracket attaching studs. Install the two sump side supports and the washers and nuts which attach them to the engine rear mount bracket studs. Install the two side supports to sump screws, and secure them with lockwire. Install the sump front support and the screw which attaches it to the sump. Do not tighten the screw yet.

Slide a rubber boss hose connector and two clamps on the upper sump inlet tube and the smaller hose connector, and two clamps on the lower left sump inlet tube. Push the hoses back as far as they will go.

12-8. OIL DRAIN HOUSING.

On any dry sump engine, install the oil drain housing with new flange gaskets at the housing to crankcase flange and the housing to accessory case flange. A thin film of non-hardening gasket paste may be spread carefully on each case and housing flange to assure sealing at the gaskets. Insert the four 1/4"-20 X 3/4" drilled hex head bolts in the housing flange bolt holes, with lock and plain washers under the heads. Tighten the four bolts in stages to assure contact of the housing at both flange joints. Slide the hose connector and two clamps on the front end of the housing, and push the hose back as far as it will go.

12-9. INDUCTION SYSTEM.

12-10. INTAKE AND OIL DRAIN MANIFOLD (WET SUMP ENGINES).

If a manifold pressure gauge or vacuum instrument connection is desired, install a 1/8" pipe and flared tube elbow in the 1/8" N.P.T. hole in the top surface of the intake and oil drain manifold. If no manifold pressure gauge or vacuum line is to be used with the engine, plug the hole. If manifold priming is to be used with the engine, install the priming nozzle in the lower diagonal tapped hole of the manifold. The priming nozzle hole was not provided in the No. 352082 and No. 6731 manifolds installed on early production engines. In these manifolds install the priming nozzle in the right or left upper 1/8" N.P.T. hole, as required.

12-11. Spread a very thin film of non-hardening gasket paste on each surface of a new gasket, and center it on the crankcase front drain hole flange. Similarly install a new gasket on the crankcase center drain hole flange. Place the intake and oil drain manifold on the crankcase flange gasket with bolt holes aligned. Swing the front end of the oil sump front support to center the bolt hole over the left rear manifold bolt hole. Insert the two 5/16"-18 X 3-5/8" drilled hex head bolts and plain washers in the rear bolt holes of the manifold and tighten them with fingers only. Install a new gasket on the outer front bolt flange of the

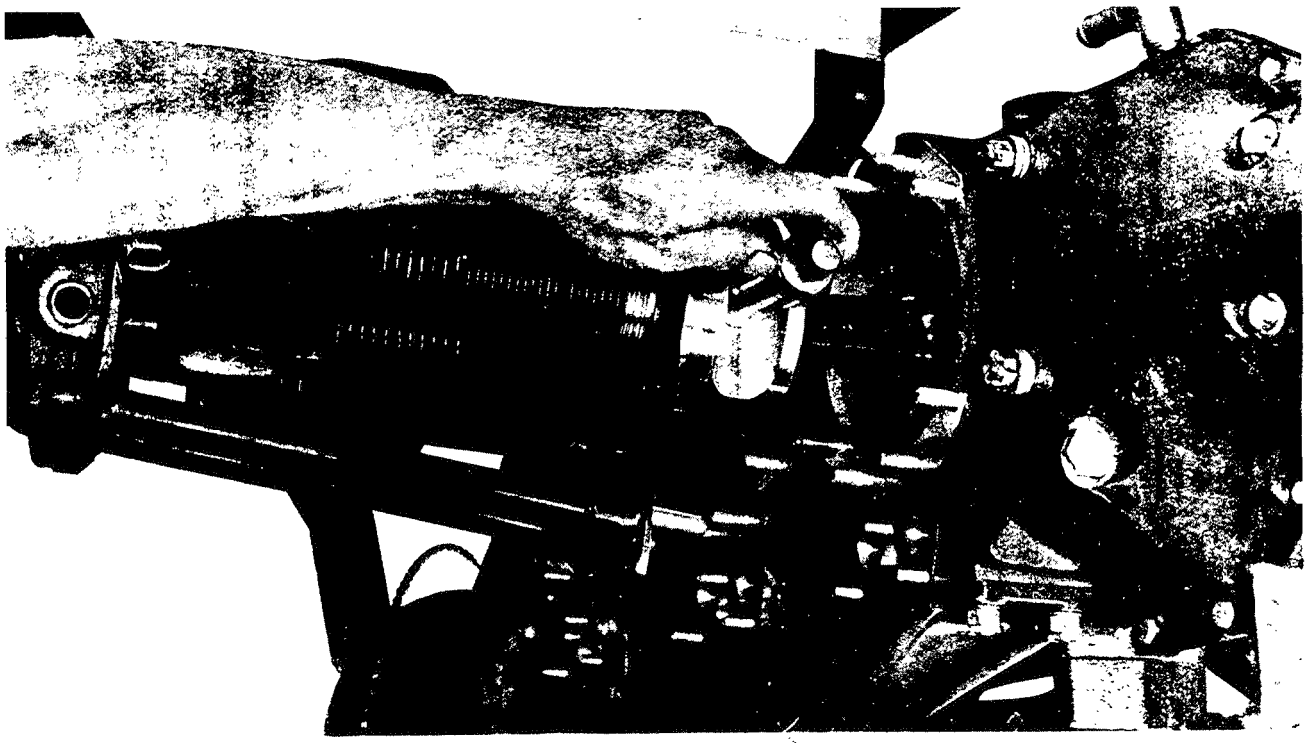


FIGURE 32. INSTALLING CYLINDER.

manifold. Insert the two 5/16"-18 X 2-1/8" drilled hex head bolts and washers in the flange holes of the front oil drain tube, and install the tube on the front manifold flange gasket, tighten the four bolts evenly and to specified torque, and secure them in pairs with lockwire. Slide the upper oil drain hose forward onto the rear end of the manifold until it covers an equal length of tube at each end. Similarly locate the hose connector on the rear end of the front oil drain tube and the lower sump inlet tube end. Tighten the hose clamps.

12-12. INTAKE AND OIL DRAIN MANIFOLD (DRY SUMP ENGINES).

Follow the instructions of the preceding paragraph with the following exceptions. Since no front oil drain tube is needed, install the cover plate No. 352091 on the outer front manifold flange if manifold has a through hole at this location. The oil sump front support will be omitted, since no sump is installed.

12-13. INTAKE TUBES.

Place a rubber hose connector and two clamps on the straight end of each intake tube. Place the aluminum flange over the grooved tube end with its counterbore facing the end of the tube. Install a new No. 536740 seal in the groove of each tube. Place each tube in position between the manifold and the cylinder head. Slide the rubber hose connector over the manifold extension. Place a new lockwasher and a plain washer on each of the twelve hex head bolts. Insert two bolts in the bolt holes of each intake tube flange and run them into the tapped holes of the cylinder intake port flanges. Tighten the bolts uniformly. Place each hose connector so that it covers equal lengths of the manifold extension and the intake tube. Tighten the hose clamps.

12-14. CARBURETOR.

Place a new gasket on the carburetor mounting pad of the intake and oil drain manifold. Install the Stromberg carburetor so that the throttle lever is on the 2, 4, 6 side. Install four washers and nuts on the carburetor attaching studs. Install all nipples or elbows for attachment of fuel lines, vent line and instrument lines to the carburetor.

12-15. FUEL PUMP.

Turn the engine bed to place the engine in the upright position. Check the fuel pump for installation and tightness of the outlet elbow. Place a new gasket on the pump mounting pad. Install the pump and its plastic spacer on the accessory drive. Tighten the retaining nuts.

12-16. GENERATOR.

Install a new oil seal in the generator adapter counterbore with the open end of the rubber seal ring outward. Insert the Woodruff key in the key slot of the shaft. Slide the coupling over the shaft and key, being careful not to push the oil seal rubber ahead of it. Insert two bushings in the retainer, and install the assembly in the slot of the coupling. Place the drive gear on the shaft end with its lugs between bushings. Install the special shaft nut, and secure it with a cotter pin.

Place a new No. 352066 gasket on the generator mounting pad and slide the generator over the three attaching studs, meshing the drive gear with the internal camshaft gear. Install and tighten three washers and self-locking nuts.

12-17. IGNITION SYSTEM.

12-18. METHOD.

The ignition cables may be installed either before or after the magneto is installed and timed. Assuming that shielded cables are to be installed on each magneto before it is installed on the engine, the procedure is as described below.

12-19. MAGNETO (Scintilla Model S6LN-21).

The spark plug wires terminate in a rubber grommet, which fits tightly inside the magneto housing. The disc has six cone shaped bosses on each side. The rear cone bosses fit tightly in the six hollow bosses of the metal cable outlet plate and have large holes to accommodate the insulated wires. The front bosses of the rubber disc also have holes large enough for the insulated wires to a plane near their forward ends where a flange in each boss covers the end of the wire insulation, allowing the bare wire to pass through a small central hole. A brass washer is installed over the bare wire end and is seated in the end of the rubber boss. The wire is attached to the washer, which is in contact with the proper distributor block contact in the installed position. The entire assembly of spark plug cables, rubber grommet and cable outlet plate is held together by a nut on each shielded spark plug cable threaded into the hollow outlet plate bosses and against the cable ferrule flange.

12-20. To install shielded upper ignition cables on the right magneto, preceed as follows: Seat the rubber terminal grommet in the cable outlet plate. Remove the insulation from a 3/8" length at the magneto end of each spark plug wire. Hold the outlet plate so that the two most widely spaced screw holes are at the top. Check this position with screw holes in the magneto housing. Locate at the 11 o'clock position the outlet plate cable boss which is marked "No. 1" inside the rear hole. Insert in this boss

No. 1 upper spark plug wire, pushing it in until the bare end protrudes through the small hole in the rubber disc front boss. Place one of the six notched brass washers over the wire end and seat it in the boss. Divide the wire strands into two groups. Bend each group of strands outward, through the washer notches, and under the washer. Install No. 6 upper spark plug wire in the next plate boss in the counterclockwise direction, No. 3 next, No. 2 in the next, No. 5 in the next, and No. 4 in the last. As each wire is installed, screw its cable nut into the outlet plate boss to retain it. To install the cable, and terminal plate assembly on the magneto, it is only necessary to push it into the rear magneto case opening so that the front bosses of the rubber grommet enter the proper distributor block sockets and to install and tighten the four attaching screws and lockwashers. The cable and plate assembly should not be installed until the magneto has been installed and timed to the engine, because the wire ends may be pulled out of the terminal washers if the plate and cables are removed after being installed in the magneto housing. To overcome this possible trouble, a drop of molten solder may be placed on the end of each wire terminal if a small soldering iron is available and if care is taken to protect the rubber grommet bosses from burning.

12-21. The lower spark plug cables are installed in the left magneto in the same manner and same positions.

12-22. MAGNETO INSTALLATION AND TIMING (SCINTILLA MODEL S6LN-21).

Turn the crankshaft until No. 1 piston is on the compression stroke. This position may be determined by installing No. 1 lower plug temporarily and turning the crankshaft backward (counterclockwise), with the thumb plugging No. 1 upper plug hole, until air rushes in as the thumb is removed.

12-23. Install the Time Rite instrument in No. 1 upper spark plug hole as shown in the instructions accompanying the instrument. The tee slot in which the slide moves must be aligned with the nearest rocker cover screw, and the scale must be above the slide. Be sure to check the position of the pivot arm in the instrument before the Time Rite is installed. With the face of the Time Rite as described above, the protruding bent end of the pivot arm must point away from the piston.

12-24. Place the Time Rite slide against the pivot arm, and turn the crankshaft slowly clockwise until No. 1 piston has passed T.D.C. The slide pointer will remain at the highest point of its travel, indicating T.D.C. Move the scale to place zero under the pointer index mark. The other figures now show crankshaft angles in degrees B.T.C. when the pivot arm pushes the slide pointer-index over them. Also, if the pointer is placed over any degree mark, the upper lamp will light when the pivot arm is moved by No. 1 piston to contact the slide, thus indicating that No. 1 crankpin has reached the pre-selected position. Now turn the crankshaft counterclockwise, reversing the compression stroke. Place the slide pointer index at the correct angle for firing upper spark plugs (See Section I). Turn the crankshaft clockwise. Tap the turnhandle gently as the pivot arm approaches the slide and stop at the instant the lamp is first lighted.

12-25. Place the right hand magneto drive gear on its support in the accessory case. Install the drive coupling on the right hand magneto impulse lugs. Bring the magneto (with upper ignition wires, if installed) to the rear of the engine. Place a new gasket on the right magneto mounting pad. Turn impulse coupling backward, so latches will not engage, until timing pointer inside inspection hole is aligned with marked distributor gear tooth. The magneto is now in position to fire No. 1 upper spark plug. Notice that one impulse flyweight has just passed under the stud. This flyweight must remain under the stud while the magneto is installed and timed, otherwise it will be stopped as it strikes the stud and will delay the opening of the breaker points until it is forced under the stud.

12-26. Notice the positions of the magneto drive gear lugs and the drive coupling front slot. If they are not aligned when the magneto is in mounting position, slip the gear out, and turn it to align with the coupling slot, and reengage it with the camshaft gear. Mount the magneto, keeping the rotor arm centered in the window as the coupling is engaged. Install washers and nuts on the attaching studs, and tighten with fingers only.

12-27. Install a switch wire and insulated terminal in the switch wire terminal bushing of the magneto case. Plug one of the long Time Rite leads into the lower jack on the face of the instrument, and connect its other end clip to the bared end of the switch wire. The lower lamp should be lighted. If it is not, the trouble must be found and corrected. Hold the camshaft gear in the clockwise direction to take up backlash. Rotate the magneto slightly clockwise and notice the brightness of the lower Time Rite lamp. Tap the magneto counterclockwise until the lamp dims. The lamp will not be extinguished during this operation unless the primary coil lead is disconnected at the top of the condenser, and that requires removal of the distributor housing. When the lamp is dimmed, the breaker points have just opened, and the magneto is in position to fire No. 1 spark plug. Tighten the attaching nuts. Now back up the crankshaft about six or eight degrees. This will not move the impulse flyweight from under the stud. Place the slide pointer index at the correct firing angle and tap the crankshaft forward (clockwise) until the upper lamp is lighted. At the same instant, the lower lamp will

dim if the timing is correct. In that same manner, install and time the left magneto. Be sure to use the firing angle for lower spark plugs. Remove Time Rite studs. Install the magneto distributor block covers.

12-28. Before installing the magneto, remove the 11/16" hex head aluminum plug from the top of the housing. Beneath the plug hole will be seen a stationary white index line. Rotate the drive coupling backward until the chamfered tooth of the distributor gear is aligned with the white mark. This is the No. 1 firing position and the breaker points are just open. Install the magneto with these marks aligned and with the crankshaft in the correct firing position.

12-29. SPARK PLUGS AND IGNITION CABLES.

Install all spark plugs with serviceable gaskets after spreading a film of clean engine oil on the 18 mm threads. Tighten all spark plugs to the specified torque. If the upper cable support brackets are the original type, they should be replaced with the current type, which are attached to the crankcase upper parting flange by one of the flange attaching bolt and nut groups. If a new harness has been procured as a spare part the new brackets will be riveted in their proper positions. When replacing the old type support brackets with the new ones, rivet them in the locations shown in Figures 3 and 4. Install spark plug elbows carefully to prevent damage to the contact sleeves. Tighten elbow union nuts only enough to prevent elbows from turning.

12-30. DELCO–REMY STARTER. INSTALLATION.

Install a new oil seal in the starter pinion sleeve bearing counterbore. Early production starters were not equipped with this seal. Place a new No. 352179 gasket on the starter mounting pad, and place the starter in position. Install the washers and nuts on the three attaching studs. Insert the two 5/16"-18 X 3-9/16" drilled hex head bolts and AN960-516L washers in the top holes of the crankcase rear flange. Push the bolts through the accessory case and screw them into the starter adapter. Tighten the bolts to specified torque and install lockwire. Tighten the three starter adapter attaching stud nuts.

12-31. STARTER ADJUSTMENT.

Delco-Remy solenoid operated starters should be inspected and adjusted in the following manner:

a. Turn the crankshaft until the clutch travel is minimum. The starter gear and pinion are now abutted. Make sure that there is some clearance between the pinion and gear.

b. Turn the crankshaft until the pinion jumps into mesh with the gear when the shift lever is held toward the solenoid.

c. Pull the upper end of the shift lever rearward as far as possible. Attempt to push the clutch shaft further into the accessory case.

d. If the clutch could not be moved inward in step c, remove the toggle link pin from the upper end of the shift lever, and turn the link to the left to lengthen the plunger rod.

e. Reassemble the toggle link, and repeat steps b and c.

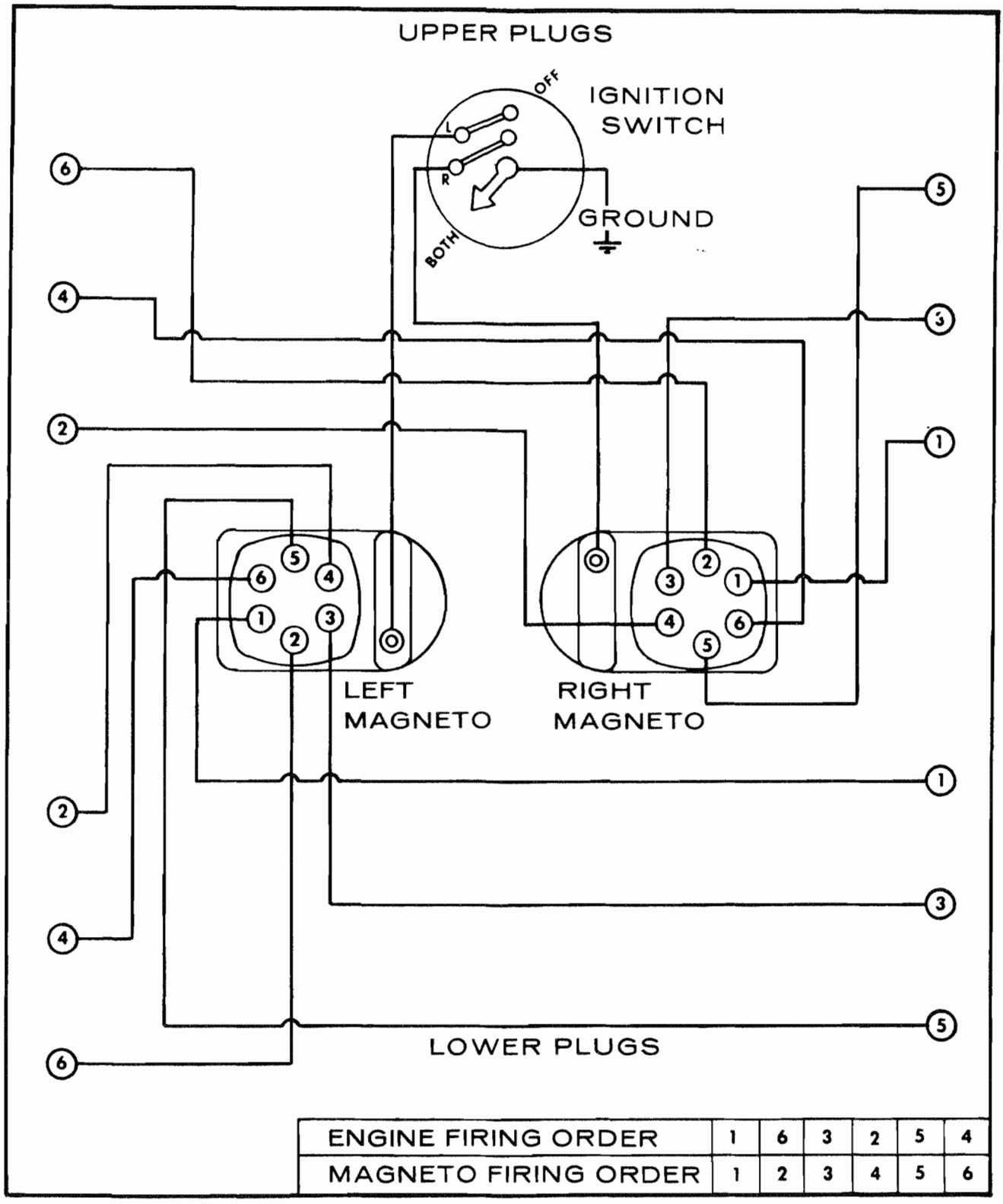
f. Make the final adjustment such that slight movement is obtainable at the clutch shaft when the pinion is meshed and the shift lever pulled full rearward at the solenoid end. The adjustment must not allow more than 9/16" clutch travel nor less than 1/2" travel.

12-32. INSPECTION AND COMPLETION OF ASSEMBLY.

Install the oil gauge rod in the oil sump of a wet sump engine. Inspect all visible joints, safety wires, nipples, elbows, plugs and covers for completeness of the assembly, correct and safe attachments, tightness, seating and serviceable condition. Cover all openings with moisture proof tape.

> *NOTE*
>
> *When lockwiring oil gallery plugs, loop wire around cylinder hold down nut.*

Install whatever optional accessories are required by the aircraft, unless the engine is to be tested on a propeller test stand or dynamometer. In the latter case, the installation of a vacuum pump or hydraulic pump before the engine test will be advisable only if appropriate plumbing is installed on the test stand. If any accessory is not installed during the engine test its drive should be covered by the proper gasket and cover plate. Inspect these drives after the test to ascertain that the accessory drive oil seals are not leaking.



ENGINE FIRING ORDER	1	6	3	2	5	4
MAGNETO FIRING ORDER	1	2	3	4	5	6

FIGURE 33. IGNITION SYSTEM DIAGRAM.

SECTION XIII
MAINTENANCE OF HYDRAULIC VALVE LIFTERS

INTENTIONALLY

LEFT

BLANK

13-1. HOW THE HYDRAULIC VALVE LIFTER WORKS.

The hydraulic valve lifter consists of three basic parts:

a. The Lifter Body.

b. The Hydraulic Unit, which is inserted into the body.

c. The Pushrod Socket.

NOTE

Refer to Figures 34 and 35 for complete nomenclature of parts and system.

The hydraulic unit in turn consists of a plunger that operates in a cylinder. A light spring holds the plunger in its outermost position, against the push rod, leaving a small

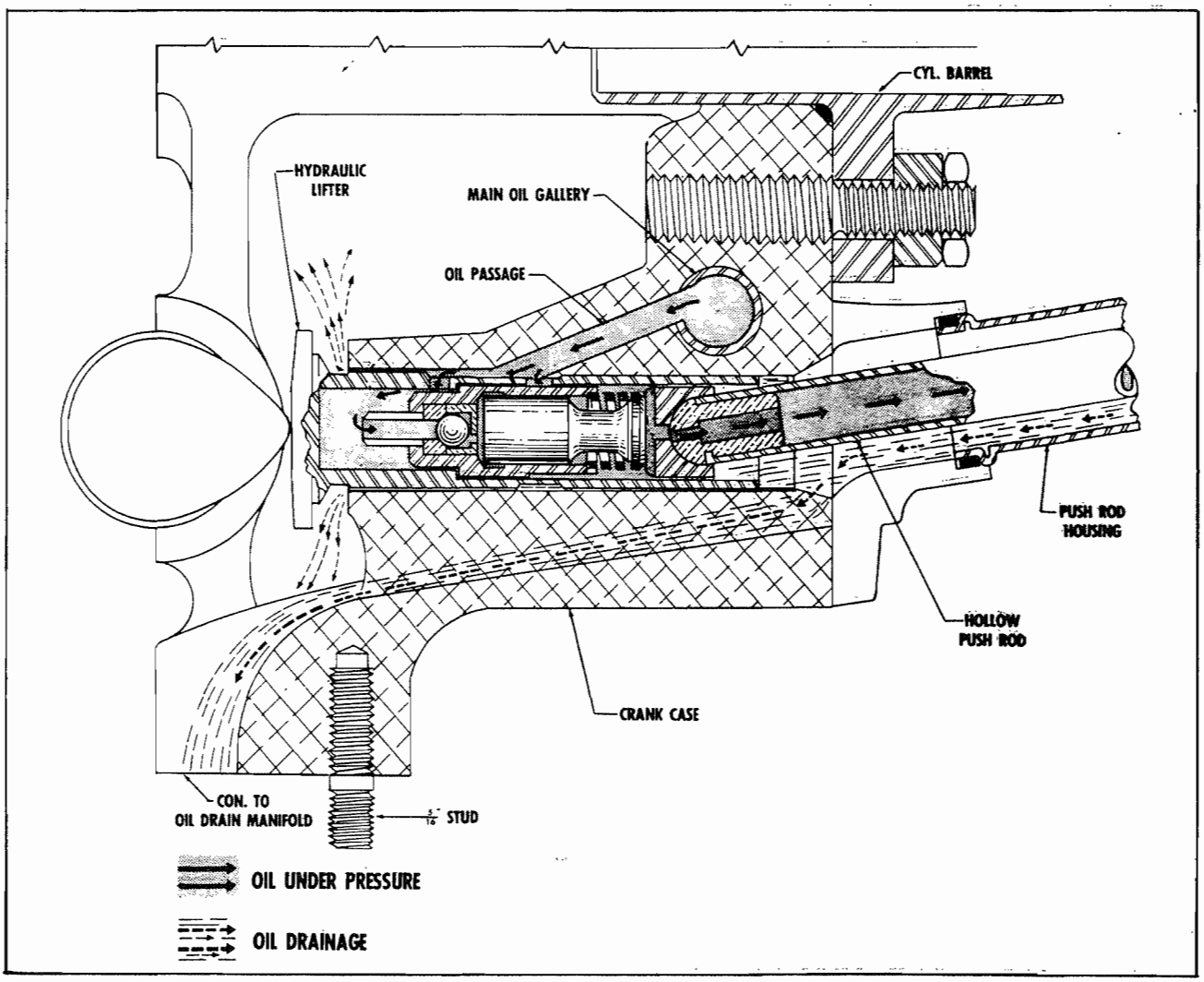


FIGURE 34. CROSS SECTION THROUGH HYDRAULIC VALVE LIFTER.

chamber in the bottom of the cylinder, below the plunger. This chamber is kept filled with oil by pressure from the engine's lubricating system. The oil enters the chamber through inlets in the body and in the base of the cylinder. A ball check-valve, located at the cylinder inlet, controls the flow of oil. When the ball check-valve is closed, the oil in the chamber, being non-compressible, completes a lifting mechanism that operates against the push rod as positive as through the whole lifter were a single piece of solid steel.

13-2. HOW LIFTER COMPENSATES FOR EXPANSION & CONTRACTION IN VALVE TRAIN.

As the valve train expands and contracts with changes in engine temperature, the lifter adjusts its own length to compensate for the changes. Accurately determined clearance is provided between the plunger and the cylinder wall, which permits the escape (or leakdown, as it is commonly called) of a small amount of oil from the chamber. The amount of leak-down may vary with lifter and engine design. This leakage automatically compensates for any expansion in the valve train, allowing positive valve seating.

On the other hand, when the valve train contracts, the plunger spring holds the plunger outward. This relieves pressure on the oil in the chamber, and on the ball check-valve. The ball moves from its seat and permits the intake of oil from the engine's lubricating system. Thus the lifter corrects its length each time the valve closes, to maintain zero clearance. You can see, then, that at all times the hydraulic lifter acts as a solid mechanism, yet automatically adjusts its length as conditions in the valve train change.

13-3. WHY VALVE LIFTERS NEED SERVICING.

Like any other device with moving parts, hydraulic valve lifters will require occasional attention. In time, the parts of the lifter may show signs of wear, and inspection may reveal the necessity for the replacement of parts. The operation of the lifters may also be affected by external conditions. The lifter depends for its operation upon a supply of clean oil from the lubricating system. Therefore, the lifters will not operate properly if the oil is excessively dirty, if the oil level is too low or if the oil pressure is too low.

The following conditions of the lifter itself may cause inefficient operation:

a. Too rapid leak-down.

b. Ball seat worn out-of-round.

c. Fouled or damaged ball-check valve.

d. Deformed or weak spring.

e. Lifter face scored, pitted, spalled or excessively worn.

f. Plugged oil passages.

13-4. VALVE LIFTER SERVICING PROCEDURE.

13-5. CLEANLINESS.

The most important factor in the servicing of the valve lifters is cleanliness. There are two kinds of cleanliness: First, your own methods of working should be orderly. The working area should be cleared of all material and tools that will not be required in the servicing job. The working surface should be thoroughly cleaned to be free from dirt, oil, metallic particles or other foreign matter. Second, the lifter parts should be thoroughly cleaned, not only at that point in the servicing operation that is set aside for it, but any other time when the presence of dirt is detected.

Following is the step-by-step servicing procedure:

a. Remove lifters from the engine.

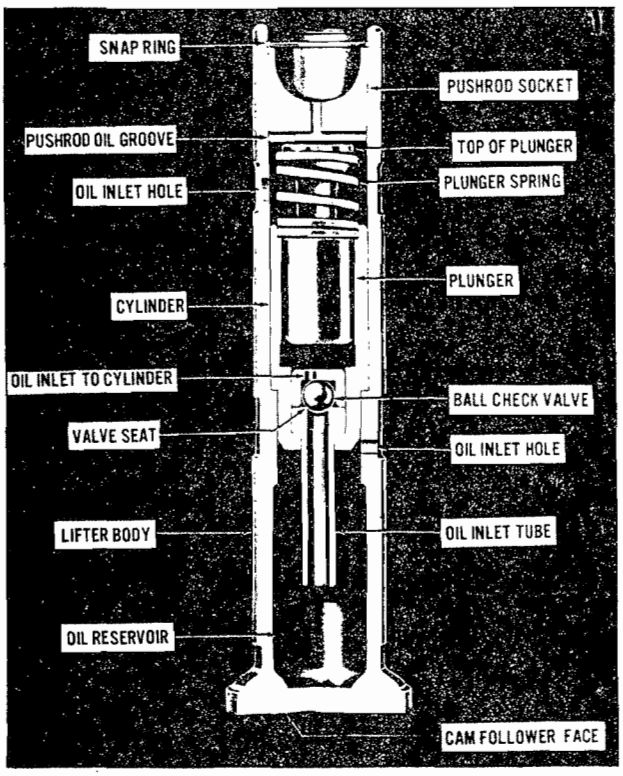


FIGURE 35. NOMENCLATURE OF HYDRAULIC VALVE LIFTER.

b. Disassemble the lifter.

c. Clean all parts.

d. Inspect, test and reassemble.

e. Reinstall lifters in the engine.

f. Check and adjust the pre-starting clearance. In the following paragraphs you will see, in detail, how to perform each of these six steps.

13-6. IMPORTANT ITEMS OF SERVICING EQUIPMENT.

Make sure that you are equipped with the proper tool and materials. There are only a few items but each has a definite use. If it is available at the time you need it, your job will be much easier.

a. Cleaning Solvent.

b. Pan.

c. Clean Cloths.

d. Two racks.

e. A pair of pliers, with the jaws taped to avoid metal-to-metal contact with the surfaces of the plunger.

f. Wooden sticks about the size of matches, to be used for unseating the ball check valve.

g. Feeler Gauges.

One rack should be provided with compartments to hold the complete lifters as they are removed from the engine. The compartments should be numbered by cylinders, so that each lifter can be returned to the cylinder from which it was removed.

The second rack should be provided with holes. The separate parts of the hydraulic unit will be placed in these holes so that no interchange between plungers and cylinders will take place. It is important that the parts of one unit do not get mixed up with the parts of another unit.

13-7. HOW VALVE LIFTER IS POSITIONED IN ENGINE.

The lifter in this engine is located between the cam and the pushrod and fits into an aluminum alloy guide in the crankcase. A removable socket is inserted in the lifter body and sets on the plunger. The pushrod, which is hollow in its entire length, engages this socket when assembled. The socket is drilled and slotted in such a manner that an oil passage is provided to carry oil under pressure through the hollow pushrod to the rocker arm bearings. An additional oil inlet is provided in the lifter body to permit passage of oil, to oil holes in the socket. A snap ring retains the socket and hydraulic unit in the body.

13-8. REMOVING VALVE LIFTER FROM ENGINE.

If erratic performance has been traced to the valve lifters, the entire valve lifter may be removed and inspected after the crankcase halves have been separated. If the engine is not to be disassembled, the hydraulic unit may be removed as follows:

a. Remove the rocker box cover.

b. Place the crankpin for that cylinder at T.D.C. Check that both valves are fully closed.

c. If rocker shaft is equipped with an anchor screw and washers, remove these parts; then using an aluminum drift push out rocker shaft.

> *NOTE*
>
> *Do not use finger to push rocker shaft out. This may cause injury due to expansion of hydraulic valve lifter.*

d. Remove the rocker arms from the cylinder head.

FIGURE 36. RELEASING HYDRAULIC UNIT CHECK VALVE.

e. Remove pushrods from their housings. If current type housings are installed, remove spring clip retainers from the housing head and pull housings and seals out through rocker box holes.

f. If the cylinders are the older type, remove cylinder base attaching parts and pull cylinder and pushrod housings from crankcase.

g. Remove the snap ring from the lifter body.

h. Insert the forefinger into the lifter guide and press it against the concave surface of the removable socket. The socket will usually stick to the finger firmly enough to be pulled out of the lifter body. If not, it can be removed by inserting a small hooked wire in the oil hole drilled in the socket.

> *CAUTION*
>
> *Extreme care should be exercised to avoid scratching the socket.*

i. Remove the hydraulic unit from the lifter body. This can be done by bending a hook in the end of a short piece of wire, hooking the plunger spring, and drawing the hydraulic unit from the lifter body. It may happen, in rare cases, that the plunger will come out alone, leaving the cylinder in the body. If so, it may be necessary to turn the engine over by hand, until oil pressure forces the cylinder far enough out of the lifter body to be grasped by the fingers. All lifter parts should be placed in a rack so that they will remain in their original relationship all through the servicing operations. Cleaning and inspection should be done at the bench.

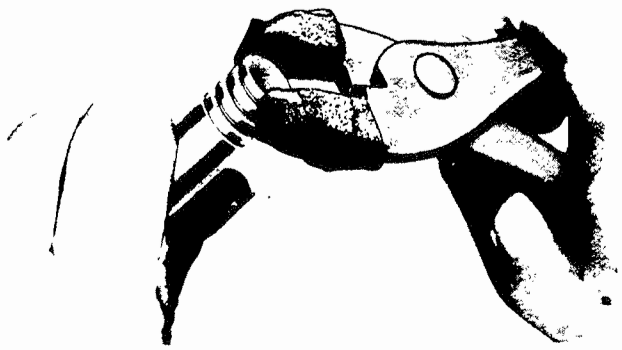


FIGURE 37. REMOVING PLUNGER FROM HYDRAULIC UNIT WITH PLIERS.

13-8. PREPARATION FOR DISASSEMBLY.

13-9. If the entire lifter was removed from the engine, remove the snap ring, socket insert, and the hydraulic unit from the body. Give the parts a thorough cleaning in solvent. Place the socket and lifter body in their place in the rack, and proceed with the disassembly of the hydraulic unit. If the lifter body has not been removed from the engine, clean the socket insert and the hydraulic unit, place the socket in its place in the rack and proceed with the disassembly of the hydraulic unit.

13-10. DISASSEMBLING THE HYDRAULIC UNIT.

The plunger is locked to the cylinder by the plunger spring which fits into a counterbore in the cylinder. To remove the plunger from the cylinder, first disengage the spring. This is done by simply twisting the plunger and spring in the direction that would "wind up" the spring. Pull outward at the same time, and the plunger should then come out easily.

> *NOTE*
>
> *Sometimes it may be found that the plunger cannot be removed easily from the cylinder. If you encounter this condition, it will be caused by one of two things:*

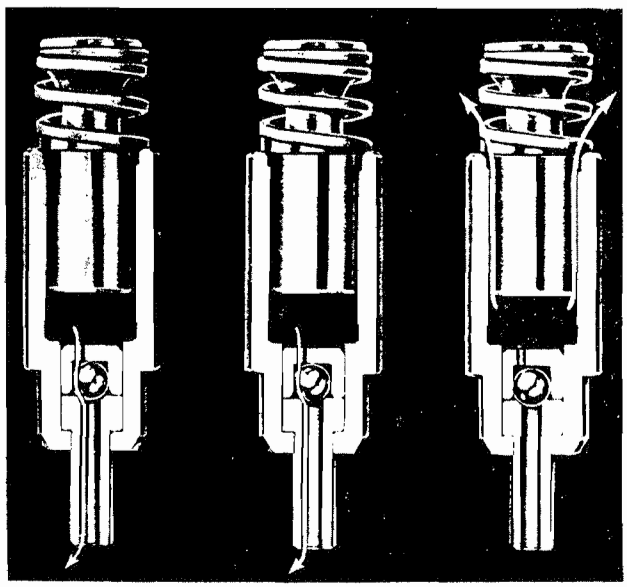


FIGURE 38. DEFECTS OF HYDRAULIC UNIT CHECK VALVE.

a. In very rare cases, the plunger will be struck in the cylinder—always in the "down" position. If the plunger seems stuck, do not discard the unit, because:

b. In most cases, the condition is due to a deposit of carbon which has formed at the shoulder of the cylinder, above the plunger. If the oil chamber is still filled with oil, sealed in by the ball check-valve, the plunger will be held rigidly against the carbon ring and with the oil trapped under the plunger will give the impression that it is "stuck". To determine whether or not the plunger is stuck, insert a wooden stick into the tube at the bottom of the cylinder, as shown in Figure 36. This will unseat the ball check valve, and allow the oil to drain out.

You should now be able to press the plunger down, which indicates that the plunger is not stuck, but is held in the cylinder by the carbon deposit. If the plunger cannot be removed because of the carbon deposit, soak the unit in solvent and use taped pliers, if necessary. A combination twisting and pulling motion will separate the plunger from the cylinder. See Figure 37.

> *NOTE*
>
> *The plunger and the cylinder are selectively fitted at the factory, and the plunger from one cylinder cannot be used in other cylinders.*

In servicing a lifter, if you find it necessary to discard a faulty plunger, its mating cylinder must also be discarded, regardless of its condition. Use the rack described in paragraph 13-6 to keep the parts of each unit together.

13-11. CLEANING VALVE LIFTER PARTS.

With the lifter parts separated, next give them a thorough cleaning. Even though they received a preliminary cleaning when first removed, they should now be cleaned separately, so that no possible trace of foreign matter remains. Immerse the parts in clean, approved solvent and wash thoroughly. This procedure should remove all traces of dirt.

13-12. INSPECTION, TESTING & REASSEMBLY.

13-13. CHECKING THE LEAK–DOWN RATE.

By leak-down rate is meant the rate at which oil escapes between the cylinder and plunger of the hydraulic unit. This rate is accurately determined at the factory. However, the clearance may increase due to wear, and therefore, should be checked. There are fixtures available for checking the leak-down rate. If these are used, the instructions which accompany them should be followed exactly. However, you can check the unit without equipment to determine whether or not it will operate properly. To do this, proceed as follows: Make sure there is no lubricating oil on the cylinder wall or plunger. It is best to check immediately after washing in solvent. With the cylinder held upright in one hand, start the plunger into the cylinder with the other. Depress the plunger with the finger and release quickly. Remember that the plunger is now operating against air instead of oil. This air is sealed in by the ball check-valve, and by the close fit of the plunger to the cylinder. It should yield slightly to the pressure of the finger on the plunger, but the plunger should kick back upon release of the finger. If there is no kick back, the unit may or may not be defective. It is due to one of three conditions:

a. Air is escaping past the check-valve because of dirt which prevents the ball from seating properly. (See left hand view, Figure 38.)

b. Air is escaping past the check-valve because of damage to the ball seat. (See center view, Figure 38.)

c. Air is escaping because the clearance between the plunger and cylinder wall is too great, indicating excessive leak-down rate. (See right hand view, Figure 38.) First, determine whether the condition is due to a leaking check-valve. To do this, place a finger over the tube at the bottom of the cylinder, as shown in Figure 39. Now, depress the plunger again and release quickly. If it kicks back properly, the fault lies with the check-valve. In this case, rewash the unit to eliminate the possibility that dirt might be fouling the check-valve. Now, repeat the test without holding the finger over the tube. If the plunger still does not kick back, then the check-valve is damaged and the entire unit (cylinder and plunger) should be discarded.

> *NOTE*
>
> *In the above testing procedure it is important that the plunger be released IMMEDIATELY after depressing. If the plunger is held down too long, the air trapped under the plunger will leak out, and the test would not mean anything.*

13-14. INSPECTING THE HYDRAULIC UNIT.

In addition to improper leak-down rate, or damaged check-valve, there may be other conditions which would make it necessary to discard a part. Therefore, additional inspection is necessary.

a. Examine the removable socket. Make sure that it is thoroughly clean and that the oil passage is not plugged.

b. Inspect the plunger and cylinder for any unusual worn places, cracks and so on. Discard both parts of the unit if any damage is found.

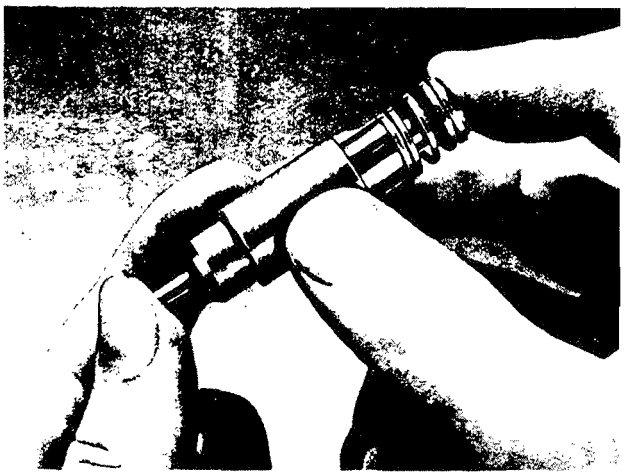


FIGURE 39. TESTING ACTION OF CHECK VALVE.

13-15. INSPECTION OF TAPPET BODIES.

If the lifter body is being serviced, examine the lifter face. This is the surface which, during operation, makes contact that would require the discarding of the lifter. The tappet will not operate properly unless the face of the lifter is free of defects. Clean the face of the lifter with solvent and wipe dry with a clean cloth.

A lifter face is scored when small, scratch-like lines are formed on the surface. They are usually found near the outer edge of the face and appear to radiate from the center. (See A, Figure 40.) Other scoring marks may be present and extend to the center. If the lifter face is in this condition, the body must be discarded and replaced by one in good condition. The wear that takes place on a lifter face that does not rotate will show up as a path that has been formed by the wiping action of the cam. (See B, Figure 40.) In addition to the path that extends all the way across the face, there will usually be extra wear at the center. If the wear is excessive, it will be noticeable to the touch if a finger-nail is rubbed across the lifter face. If this condition is present the lifter body must be discarded. If the worn path is visible but not noticeable to the touch, it should still be discarded unless by so doing a badly needed engine would be kept out of service. Pitting or spalling, is illustrated in C, Figure 40.

13-16. ASSEMBLING THE HYDRAULIC UNIT.

a. Insert the plunger in the cylinder. Both parts must be free of lubricating oil if the unit is to be re-installed in the engine immediately. If the unit is not to be reinstalled immediately, the parts should be given a light film of oil to prevent rusting.

b. Push down on the plunger so that the spring can be engaged with the counterbore of the cylinder. This is done by twisting the spring and plunger in the direction that "winds up" the spring.

c. Insert the hydraulic unit in the lifter body.

d. Insert the removable socket.

e. Install the snap ring in the groove at the open end of the body.

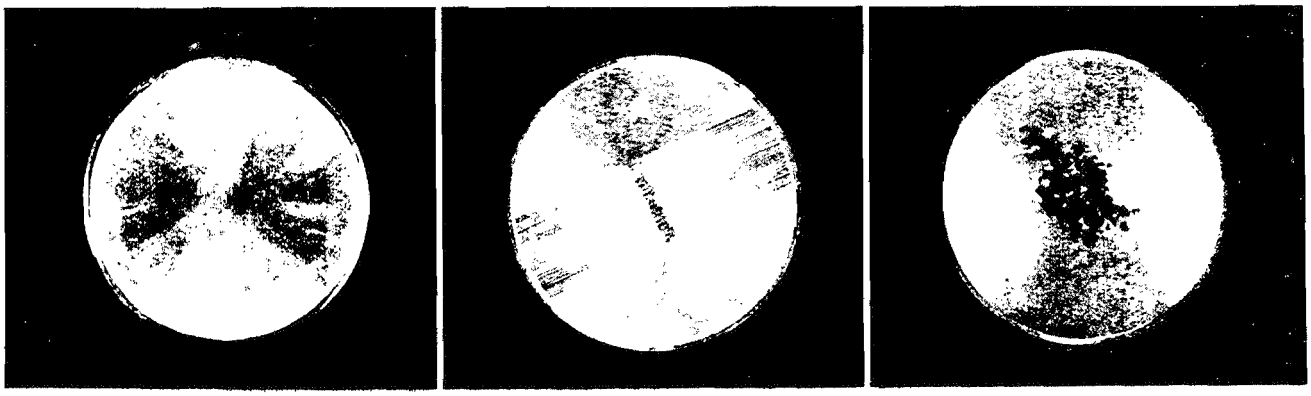


FIGURE 40. DEFECTS OF LIFTER FACE.

13-17. REINSTALLING VALVE LIFTER IN ENGINE.

Install the valve lifters in the same engine valve lifter guides from which they were removed.

> *NOTE*
>
> *If the lifters have not been removed from the engine, take the rack, with the hydraulic units and sockets arranged in it, to the engine.*

Insert the units carefully in their proper lifter bodies, and then insert the removable sockets. Install the snap rings in the grooves of the bodies.

Rotate the crankshaft until the cams are at "valve closed" position.

If the cylinder is equipped with the new type removable pushrod housings, install a new seal ring on the two push-rod housings and spread a drop of oil around the periphery of each seal. Insert the single headed end of each housing through rocker box holes. Seat both housings in the flange of the crankcase. Hold each housing inward while retainer is tapped between the two beads just behind the rocker box.

If the engine is the older type, which required removal of the cylinder and pushrod housings as a unit, install these parts.

Replace the pushrods in the pushrod housings. Make sure that they engage the sockets in the lifters. Otherwise, the rocker arms cannot be installed. Replace the rocker arms and shaft. If rocker shaft is drilled for anchoring screw and washers, install these parts at this time.

Install and tighten the cylinder base nuts, and install cotter pins.

Install the rocker cover with new serrated lockwashers and plain washers under the seven screwheads.

13-18. CHECKING PRE–STARTING CLEARANCE.

13-19. CLEARANCE IS NOT FOR HEAT EXPANSION.

The clearance that is to be provided in the valve train is not for the purpose of allowing for heat expansion. The hydraulic unit takes care of that. The clearance described here is necessary because the hydraulic unit has been re-installed minus the oil column. This leaves a clearance in the unit that will be taken up automatically by the oil when the engine is started.

13-20. WHERE CLEARANCE IS MEASURED.

In this engine, the clearance is measured between the rocker arm and the valve stem. The valve train will function properly if, with the cam in the "valve closed" position, the clearance ranges from .030" to .110". If the clearance does not come between these limits, remove the pushrod and insert a longer or shorter pushrod as required to correct the clearance. Inserting a longer rod will cause a decrease in the clearance. There are times when you will be required to check the clearance even though the lifters have not been removed from the engine; for example, after the installation of new valves, push rods, or rocker arms. In this case, the lifter must be cleared of oil before the clearance measurement can be taken. Turn the engine to the "valve open" position. The valve spring pressure acting against the plunger will force the oil from the unit. Check the distance from the valve spring outer retainer to the bottom of the rocker box immediately after the valve is fully opened. As the valve spring pressure forces oil from the hydraulic unit the distance will increase. Wait until it ceases to increase. The valve setting tool can now be used to keep pressure on the hydraulic unit, while the engine is turned to the "valve closed" position. This maintains clearance between the rocker arm shoe and the valve stem, and clearance can now be checked with the feelers.

SECTION XIV
ENGINE TEST

INTENTIONALLY

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NOTE

The airframe can be considered a suitable test stand for running in overhauled engines, contingent on use of a test propeller and equipped with a suitable shroud or scoop to gather and direct cooling air over the cylinders. Engine must be equipped with cylinder head temperature pickups on all cylinders and other instrumentation as required.

For most accurate testing, however, it is recommended that the engine be run-in on a rigid test stand within a cellular enclosure of sufficient size to prevent recirculation of air.

14-1. TEST EQUIPMENT.

14-2. TEST CLUB.

Unless a dynamometer is used to apply controlled loads to the crankshaft, it will be necessary to install a wood test club such as those supplied by the Hartzell Propeller Company of Piqua, Ohio. Test clubs are customarily supplied in standard diameters, so that the blade length must be reduced by the "cut and try" method until the club will absorb the B.H.P. at the R.P.M. specified in Table XVII for the model on test when used in the cell, stand and engine combination for which it was calibrated.

14-3. WEIGHING AND MEASURING EQUIPMENT.

The following equipment is recommended for such a testing installation, however, it should be considered the minimum. The use of additional gauges and superior weighing and measuring equipment is desirable.

a. An accurate clock for timing test run.

b. An oil cooler with a thermo by-pass valve.

c. Accurate scale for weighing oil supply (100 lbs. capacity).

d. Ten (10) gallon oil supply tank (with air separator).

e. Oil strainer (40 lbs. per minute capacity).

f. Oil supply and return hoses, connections and valves.

g. Fuel supply tank (50 gallons minimum capacity).

h. Fuel supply line, connectors and shut-off valve.

i. Fuel vent line (from carburetor to supply tank).

k. Remote instruments and control panel (preferably enclosed) incorporating the following:

(1) Fuel flowmeter (in supply line) or scale of 300 lbs. capacity.

(2) Tachometer and drive cable.

(3) Oil pressure gauge and line to engine.

(4) Scavenge oil pressure gauge with line and connection to scavenge oil line.

(5) Fuel pressure gauge and line to carburetor.

(6) Water manometer (for crankcase pressure).

(7) * Oil inlet temperature gauge and capillary.

(8) * Oil outlet temperature gauge and capillary.

(9) Cylinder head temperature gauge and thermocouple.

(10) Throttle control and linkage with fine adjustment.

(11) Mixture control and linkage (with position indicator).

(12) Starter engaging pull control (solenoid switch is required with some engines).

(13) Magneto Switch with wiring to Magnetos.

(14) Priming pump and line to engine nozzle.

NOTE

Gauges marked thus (*) may be replaced by a poentiometer with a selector switch and thermocouple for the various points of temperature measurement.

14-4. LUBRICATION SYSTEMS.

The lubricating oil systems installed on test stands should be adaptable to either wet sump or dry sump engine requirements. See Figures 41 and 42 for information on required lines, cooler and points of connection. See Table XII for engine fitting sizes. The inside diameters of external lines, fittings and valves must be at least equal to the I.D. of engine oil inlet and outlet fittings. Oil coolers of adequate area and capacity must be provided. Such radiators should incorporate thermo by-pass valves unless a manually operated by-pass is preferred. Means of heating the oil supply in cold weather should be provided.

14-5. FUEL SYSTEMS.

The fuel systems installed on test stands should provide gravity feed of fuel to the engine pumps. Fuel lines, fittings and valves must have inside diameters at least equal to the I.D. of the fuel pump inlet fitting supplied with the aircraft. If a fuel flow meter is not installed in the fuel supply line, the fuel tank should be supported on a reliable scale so that fuel consumption can be measured. Connect Stromberg carburetor vent line back to the fuel tank.

14-6. BREATHERS.

Crankcase breathers must be provided on test stands for all E Series engines. In addition a vent pipe should be available for connecting the accessory cases of dry sump engines to the oil tank air space as shown in Figure 41. Breather hoses and vent pipes must have inside diameters at least as large as the I.D.'s of engine fittings to which they are attached. They must be adequately supported, yet flexibly connected on the stand.

14-7. PROTECTION OF LINES.

All gauge lines, fuel lines, oil hoses and breathers should be covered at the engine ends when not attached for testing in order to exclude all foreign matter. Protection of fitting threads at tube ends is as important as sealing the tubes.

14-8. GAUGES.

Inaccurate gauges are worthless for testing purposes, since performance records must reflect actual, rather than comparative values. For this reason, permanent test stand instruments should be inspected and tested regularly. Instruments should be of highest quality manufactured in order that their performance under all atmospheric conditions will be uniform and unlikely to err seriously between inspections.

14-9. ENGINE TEST AFTER OVERHAUL.

a. After a partial or complete disassembly and repair of an engine in which no major part (cylinder, piston, bushing, gears, etc.) was replaced Model E-165, E-185 and E-225 engines will be tested in accordance with Table XVIII.

b. Extend the second period of the test schedule if necessary to raise the oil temperature to the desired minimum in Table XVII.

c. Take instrument readings at the beginning, in the middle and at the end of the full throttle period. Take one reading during each of the other periods as soon as conditions have stabilized.

NOTE

If oil consumption exceeds the specified value for the model engine tested, replenish oil supply to original quantity and weight. Pour oil into sump or external tank and repeat oil consumption run. Upon the second completion of oil consumption run, again weigh and determine oil consumption. The oil consumption of dry sump engines utilizing an external system as shown in Figure 41 may be determined by subtracting the weight of oil, as indicated on the weight tank scale at the end of the final period, from the weight recorded at the beginning of the period. If consumption is still in excess of the specified value, return engine to overhaul.

TABLE XVII

OPERATING TEST LIMITS

Feature	Value		
	E-165	E-185	E-225
Full Throttle Speed (RPM)	2050-2100	2300-2350	2650-2700
Fuel Consumption (at full throttle)	86-93 lbs./hr. @ 2050	95-103 lbs./hr. @ 2300	121-131 lbs./hr. @ 2650
Oil Viscosity	S.A.E. 50	S.A.E. 50	S.A.E. 50
Grade	1100	1100	1100
Fuel Rating (Octane)	80/87	80/87	80/87
Idling Speed (RPM)	575-625	575-625	575-625
Manifold Vacuum (at full throttle)	0.8-1.3 in. Hg	0.8-1.3 in. Hg	1.3-1.8 in. Hg
Magneto Spread (at full throttle) (RPM)	50 @ 2050	50 @ 2045	50 @ 1900
* Crankcase Pressure (Maximum)	1.5 in. H_2O	1.5 in. H_2O	1.5 in. H_2O
Oil Temperature (Desired)	150-200°F.	150-200°F.	150-200°F.
Oil Temperature (Maximum)	225°F.	225°F.	225°F.
Oil Pressure (at full throttle)	30-60 psi	30-60 psi	30-60 psi
Oil Pressure (at idle speed)	10 psi	10 psi	10 psi
Cylinder Head Temperature (Maximum) (at lower spark plug)	525°F.	525°F.	525°F.

* *A sudden increase in crankcase pressure, during which the liquid in the manometer fluctuates rapidly is not desirous and usually is an indication of rings beginning to stick. However, before removing cylinders, investigate the breather and the manometer to be sure such lines are not restricted in any way.*

d. Make one check on performance of each magneto alone at the RPM specified in Table XVII. Clear plugs by operating with both magnetos on for a few seconds between checks.

NOTE

The maximum cylinder head temperature and maximum allowable oil temperature must not be exceeded at any time during the test.

14-10. PRESERVATION.

If the engine is not to be installed in an aircraft and placed into service immediately, the last 15 minutes of operation should be used to circulate a corrosion-preventive oil mixture (suitable for flight operation). This will be an additional run period, since the engine must be stopped to change oil. During this same period unleaded gasoline should be supplied to the carburetor.

TABLE XVIII

TEST SCHEDULE

Final Test Run After Partial or Complete Teardown Minor or Major Parts Replacement.

Period	Time (minutes) E-165, E-185, E-225	RPM E-165	RPM E-185	RPM E-225
1	15	Warm Up 900-1700	Warm Up 900-2000	Warm Up 900-2300
2	10	1800	2100	2400
3	5	600 ± 25 Idle Cooling Period	600 ± 25 Idle Cooling Period	600 ± 25 Idle Cooling Period
		Stop engine, drain oil, weigh oil in for oil consumption determination.		
		START OIL CONSUMPTION DETERMINATION		
1	5	Warm Up to 1700	Warm Up to 2000	Warm Up to 2300
2	10	1800	2100	2400
3	10	1950	2200	2500
4	10	2050-2100 F.T.	2300-2350 F.T.	2650-2700 F.T.
		2050 Check Magnetos	2045 Check Magnetos	1900 Check Magnetos
5	5	600 ± 25 Idle Cooling Period	600 ± 25 Idle Cooling Period	600 ± 25 Idle Cooling Period

Magneto drop to be taken after completion of oil consumption run. Engine must be throttled to specified RPM and temperature allowed to settle out before taking magneto spread.

Stop engine, drain oil, weigh and record engine oil consumption.

Oil consumption at rate of 1.0 lbs./ 1/2 hr. maximum acceptable for E185.

Oil consumption 1.50 lbs./ 1/2 hr. maximum acceptable for E225.

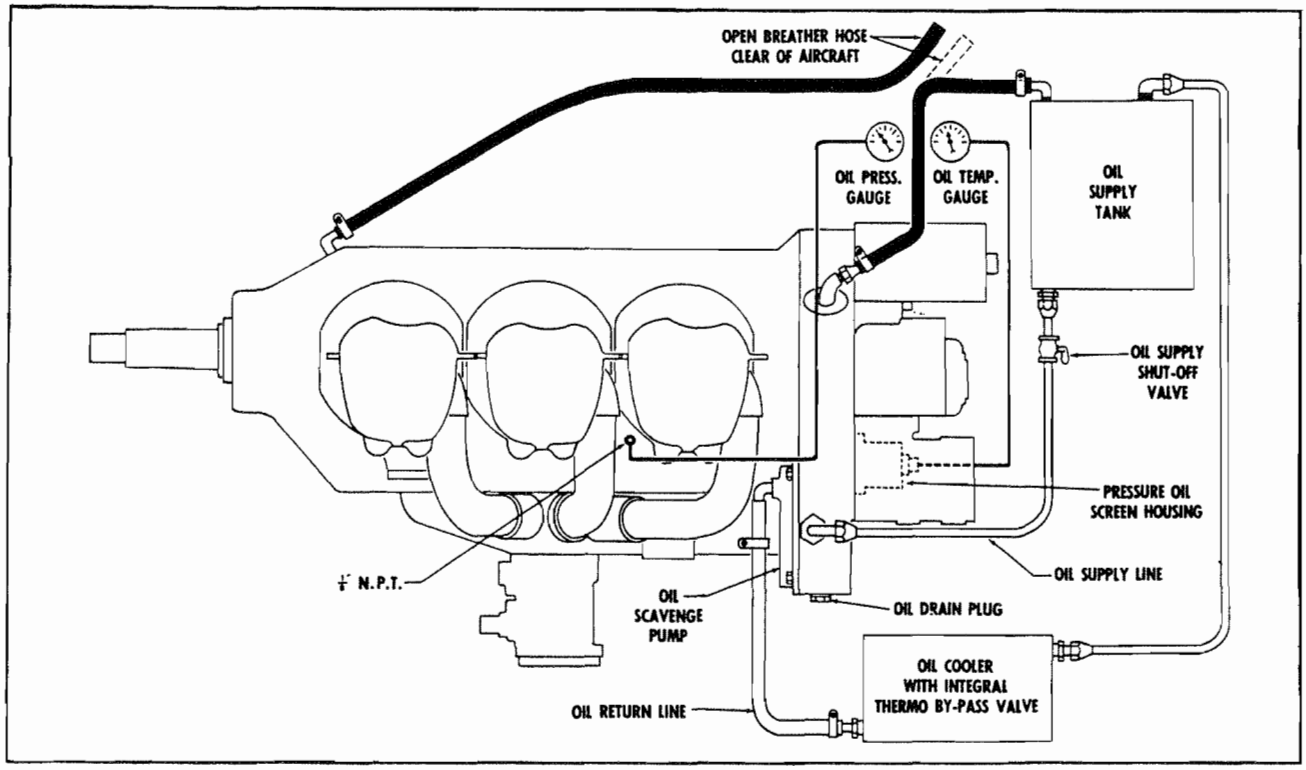

FIGURE 41. EXTERNAL OIL SYSTEM OF DRY SUMP ENGINE.

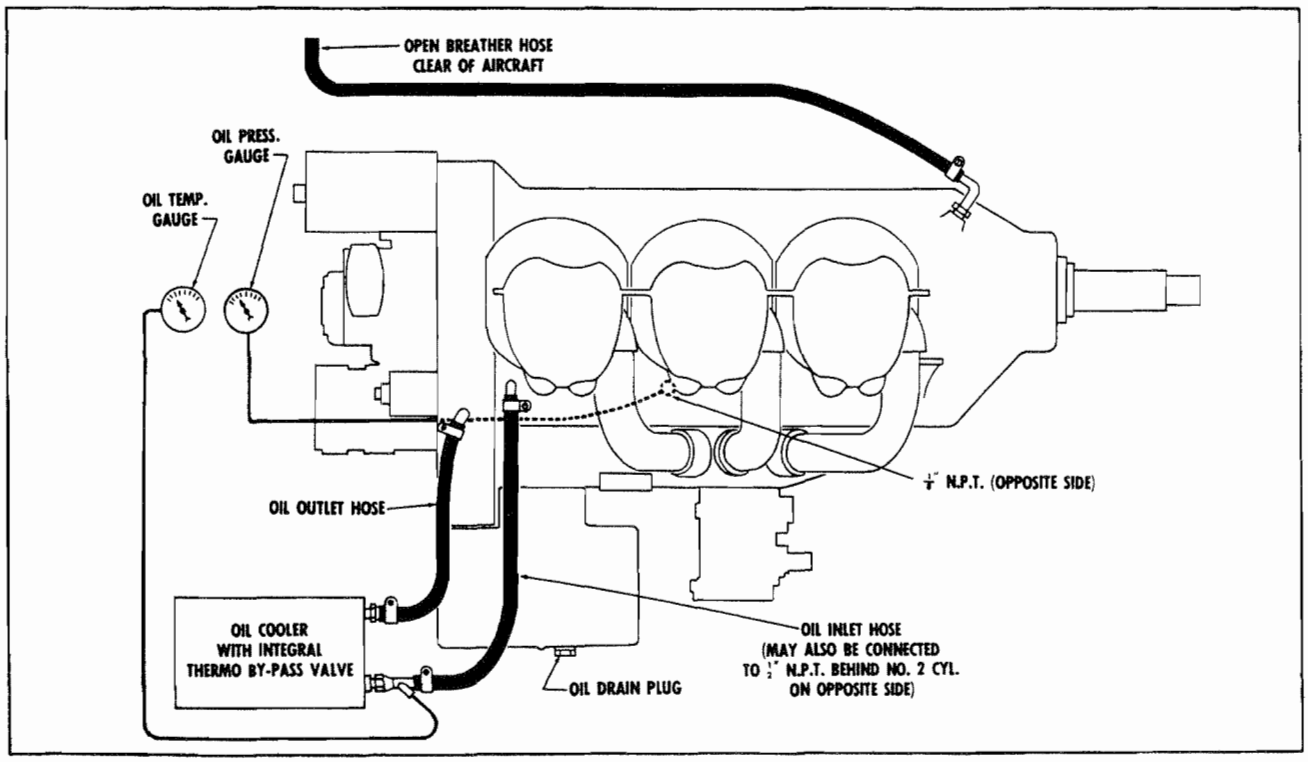

FIGURE 42. EXTERNAL OIL SYSTEM OF WET SUMP ENGINE.

SECTION XV
TABLE OF LIMITS

INTENTIONALLY

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Chart No.	Ref. No.	Description	Service Limit	New Parts Min.	New Parts Max.
		CYLINDERS AND CYLINDER HEADS			
		Cylinder Assemblies No. 535291, 538348, 538610			
1	1	Cylinder Bore (Lower 4.25" of barrel) . . . . . Diameter:	5.006	5.001	5.003
1	2	Cylinder Bore (Top of barrel) . . . . . Diameter:	5.000	4.989	4.993
1	3	Cylinder Bore Choke (From 3.25" above flange to top) . . . . . Taper:	.0035	.010	.012
1	4	Cylinder Bore . . . . . Out-of-Round:	.003	.000	.002
1	5	Cylinder Bore (Reground) (.015) . . . . . Allowable Oversize:	5.021	5.016	5.018
1	6	Intake Valve Seat Insert in Cylinder Head . . . . . Diameter:		.009 T	.012 T
1	7	Exhaust Valve Seat Insert in Cylinder Head . . . . . Diameter:		.007 T	.010 T
1	8	Intake Valve Guide in Cylinder Head . . . . . Diameter:		.001 T	.0025T
1	9	Exhaust Valve Guide in Cylinder Head . . . . . Diameter:		.001 T	.0025T
1	10	Intake Valve Seat . . . . . Width:		.107	.156
1	11	Exhaust Valve Seat . . . . . Width:		.120	.171
1	12	Valve Seat (To Valve Guide Axis) . . . . . Angle:		44° 30'	45°
1	13	Rocker Shaft in Cylinder Head Bosses . . . . . Diameter:	.003 L	.000	.0015L
		ROCKER ARM AND SHAFTS			
1	14	Rocker Shaft in Rocker Arm Bearing . . . . . Diameter:	.006 L	.001 L	.0025L
1	15	Rocker Arm Bearing in Rocker Arm . . . . . Diameter:		.0015T	.0035T
1	16	Rocker Arm . . . . . Side Clearance:	.015	.004	.011
		VALVES			
1	17	Intake Valve in Guide . . . . . Diameter:	.005 L	.0012L	.0032L
1	18	Exhaust Valve in Guide . . . . . Diameter:	.006 L	.002 L	.0035L
1	19	Intake Valve Face (To Stem Axis) . . . . . Angle:		45°	45° 30'
1	20	Exhaust Valve Face (To Stem Axis) . . . . . Angle:		45°	45° 30'
1	21	Intake Valve (Maximum Tip Regrind .015) . . . . . Length:	4.789	4.804	4.824
1	22	Exhaust Valve (Maximum Tip Regrind .015) . . . . . Length:	4.791	4.806	4.826
1	23	Intake and Exhaust Valve Warp . . . . . Full Indicator Reading:	.004	.000	.002
		PISTONS, RINGS AND PINS			
		Piston Assembly No. 50399			
1	24	Piston (Bottom of Skirt) in Cylinder . . . . . Diameter:	.014 L	.007 L	.010 L
1	25	Piston (Below Third Ring Groove) in Cylinder . . . . . Diameter:	.024 L	.017 L	.021 L
1	26	Top Piston Ring in Groove . . . . . Side Clearance:	.009	.005	.007
1	27	Second Piston Ring in Groove . . . . . Side Clearance:	.0075	.0035	.0055
1	28	Third Piston Ring in Groove . . . . . Side Clearance:	.0065	.0025	.0045
		Piston Assembly No. 534895 Piston			
1	24	Piston (Bottom of Skirt) in Cylinder . . . . . Diameter:	.014 L	.008 L	.011 L
1	25	Piston (Below Third Ring Groove) in Cylinder . . . . . Diameter:	.024 L	.018 L	.021 L
1	26	Top Piston Ring in Groove . . . . . Side Clearance:	.0105L	.0065L	.0085L
1	27	Second Piston Ring in Groove . . . . . Side Clearance:	.009 L	.005 L	.007 L
1	28	Third Piston Ring in Groove . . . . . Side Clearance:	.0075L	.0035L	.0055L

Chart No.	Ref. No.	Description	Service Limit	New Parts Min.	New Parts Max.
1	29	Piston Ring (Ring in Cylinder Barrel) Comp. Ring . . . . . Gap:	.065	.038	.054
		Piston Ring (Ring in Cylinder Barrel) Oil Ring . . . . . Gap:	.060	.033	.049
1	30	Top Piston Ring (Standard Gap) . . . . . Tension*:	9.75 lbs.	10.75 lbs.	14.75 lbs.
1	31	Second Piston Ring (Standard Gap) . . . . . Tension*:	9.75 lbs.	10.75 lbs.	14.75 lbs.
1	32	Third Piston Ring (Standard Gap) . . . . . Tension*:	8 lbs.	9 lbs.	14 lbs.
1	33	Piston Pin (539467) . . . . . Diameter:		1.1243	1.1245
1	34	Piston Pin in Piston (50399) . . . . . Diameter:	.0018L	.0005L	.0012L
1	34	Piston Pin in Piston (534895) . . . . . Diameter:	.0013L	.0001L	.0007L
1	35	Piston Pin in Cylinder . . . . . End Clearance:	.090	.031	.048
1	36	Piston Pin in Connecting Rod Bushing . . . . . Diameter:	.004 L	.0018L	.0022L
1	37	Piston Pin Bushing in Connecting Rod . . . . . Diameter:		.0025T	.005 T
1	38	Connecting Rod Bearing on Crankpin (Tri-Metal Brg.) . . . . Diameter:	.006 L	.0009L	.0034L
1	39	Connecting Rod on Crankpin . . . . . End Clearance:	.016	.006	.010
1	40	Connecting Bearing and Bushing — . . . . . Twist or Convergence per inch of Length:	.001	.000	.0005
1	41	Bolt in Connecting Rod . . . . . Diameter:		.000	.0018L
		CRANKSHAFT			
4	42	Crankshaft in Thrust Bearing (Silver) . . . . . Diameter:	.0055L	.0009L	.0041L
4	43	Crankshaft in Main Bearings (Tri-Metal) . . . . . Diameter:	.005 L	.0005T	.0025L
4	44	Crankshaft in Thrust Bearing (No. 40644 Silver) . . . . End Clearance:	.018	.006	.008
4	45	Crankpins . . . . . Out-of-Round:	.0015**	.000	.0005
4	46	Main Journals . . . . . Out-of-Round:	.0015**	.000	.0005
4	47	Crankshaft Main and Thrust Journals . . . . . Diameter:	2.372 **	2.3740	2.3750
4	48	Crankpins . . . . . Diameter:	2.247 **	2.2490	2.2500
4	49	Crankshaft — Runout at Center Main Journals (Shaft Supported at Thrust and Rear Journals) . . Full Indicator Reading:	.015	.000	.015
4	50	Crankshaft Runout Between Splines and Front Thread (Shaft supported at Thrust and Rear Journals) . . . . . Full Indicator Reading:	.007		
4	51	Crankshaft Runout Between Splines and Front Thread in Assembled . . . . . Full Indicator Reading:	.006		
4	52	Damper Pin Bushing, in Crankcheek Extension . . . . . Diameter:		.0015T	.003 T
4	53	Damper Pin Bushing in Counterweight . . . . . Diameter:		.0015T	.003 T
4	54	Damper Pin in Counterweight . . . . . End Clearance:	.040	.001	.025
4	55	Crankcheek in Counterweight . . . . . Side Clearance:	.017	.006	.012
4	56	Crankshaft Gear on Crankshaft . . . . . Diameter:		.000	.002 L
		CRANKCASE ASSOCIATED PARTS			
4	57	Crankshaft Oil Seal in Crankcase . . . . . Diameter:		.002 T	.008 T
4	58	Through Bolt (10-11/16") in Crankcase . . . . . Diameter:		.0007T	.0011L
1	59	Hydraulic Valve Lifter in Crankcase . . . . . Diameter:	.0035L	.0005L	.002 L
4	60	Starter Pinion Pivot in Crankcase . . . . . Diameter:		.0015T	.0005L
2	61	Magneto Drive Gear Support in Crankcase . . . . . Diameter:		.0005T	.0025T

* *Measure piston ring tension on diameter perpendicular to gap when ring is compressed to specified value.*

** *If crankshafts are worn beyond these limits they may be repaired by grinding journals to .010 inch under new shaft limits and renitriding journals.*

NOTE: Refer to Section 9-17, Page 48 for allowable wear at damper pin bushings.

Chart No.	Ref. No.	Description	Service Limit	New Parts Min.	New Parts Max.
		CAMSHAFT			
4	62	Camshaft Journals in Crankcase Bearings . . . . . Diameter:	.005 L	.001 L	.003 L
4	63	Camshaft in Crankcase . . . . . End Clearance:	.014	.005	.009
4	64	Camshaft – Runout at Center Journals (Shaft Supported at End Journals) . . . . . Full Indicator Reading:	.003 ***	.000	.003
4	65	Camshaft Gear on Camshaft Flange . . . . . Diameter:		.0005T	.0015L
		OIL PRESSURE RELIEF VALVE ASSEMBLY			
2	66	Oil Pressure Relief Valve Plunger in Cap . . . . . Diameter:	.009 L	.003 L	.006 L
		OIL PRESSURE PUMP			
4	67	Oil Pressure Pump Impeller in Housing . . . . . Diameter:	.007 L	.003 L	.005 L
4	68	Oil Pressure Pump Impeller in Housing . . . . . End Clearance:	.007	.002	.005
4	69	Oil Pressure Pump Impeller Shafts in Housing . . . . . Diameter:	.004 L	.001 L	.0025L
4	70	Oil Pressure Pump Impeller Shafts in Accy. Case . . . . . Diameter:	.004 L	.001 L	.0025L
4	71	Oil Pressure Pump Drive Shaft in Camshaft Gear (Across Flats) . . . . . Side Clearance:	.017	.0055	.0135
		LEFT SIDE ACCESSORY DRIVE			
2	72	Fuel Pump Drive & Scavenge Pump Drive in Adapter Gear (531240) Adapter (530443) . . . . . Diameter:	.005 L	.0015L	.003 L
2	73	Fuel Pump Drive & Scavenge Pump Drive in Accessory Case . . . . . End Clearance:	.050	.007	.031
2	74	Left Side Accessory Drive Oil Seal in Adapter . . . . . Diameter:		.001 T	.007 T
2	75	Left Side Accessory Drive Gear Adapter Pilot in Accessory Case (Fuel Pump Adapter 530443) . . . . . Diameter:		.0002L	.0017L
		ACCESSORY DRIVE IDLER			
2	76	Accessory Drive Idler Gear on Shaft . . . . . Diameter:	.0045L	.0015L	.003 L
2	77	Accessory Drive Idler Gear . . . . . End Clearance:	.050	.007	.034
2	78	Idler Shaft in Accessory Case (Rear) . . . . . Diameter:		.0002L	.0017L
2	79	Idler Shaft in Accessory Case (Front) . . . . . Diameter:	.003 L	.0005L	.002 L
		RIGHT SIDE ACCESSORY DRIVE			
2	80	Right Side Accessory Drive Shaftgear in Adapter-Vacuum Pump . . . . . Diameter:	.005 L	.001 L	.003 L
2	81	Right Side Accessory Drive Shaftgear (Vacuum Pump Drive) . . . . . End Clearance:	.070	.018	.056
2	82	Right Side Accessory Drive Adapter Pilot in Accessory Case (Vacuum Pump Adapter) . . . . . Diameter:		.0005L	.0025L
2	83	Right Side Accessory Drive Oil Seal in Adapter . . . . . Diameter:		.001 T	.007 T
		TACHOMETER DRIVE ASSEMBLY			
4	84	Seal in Tachometer Drive Housing . . . . . Diameter:		.001 T	.007 T

*** *Straightening of the camshaft is permissible if runout does not exceed .005 inch.*

Chart No.	Ref. No.	Description	Service Limit	New Parts Min.	New Parts Max.
		GENERATOR			
4	85	Generator Adapter Pilot in Accessory Case . . . . . Diameter:		.001 L	.005 L
4	86	Oil Seal in Generator Adapter . . . . . Diameter:		.002 T	.008 T
4	87	Generator Drive Gear on Shaft . . . . . Diameter:		.001 L	.003 L
4	88	Generator Coupling Hub on Generator Shaft . . . . . Diameter:		.0005T	.0005L
		Generator Drive Gear Lugs in Retainer and Bushing Generator Drive (Note Rubber Bushings Replace Bushings When Worn) . . . . . Side Clearance:		.043 T	.039 L
		Retainer Generator Dr. Coupling Between Lugs on Hub Generator Coupling . . . . . Side Clearance:	.025 L	.005 T	.015 L
		STARTER			
4	89	Starter Adapter Pilot in Accessory Case . . . . . Diameter:		.002 L	.006 L
		MAGNETO			
2	90	Magneto Drive Gear Bushing on Support . . . . . Diameter:	.005 L	.0015L	.0035L
2	91	Magneto Drive Gear Bushing in Gear . . . . . Diameter:		.001 T	.003 T
2	92	Magneto Drive Coupling Retainer Between Gear Lugs Magneto Drive . . . . . Side Clearance:	.040 L	.002 T	.028 L
2	93 †	Magneto Drive Coupling on Magneto Drive Lugs . . . Side Clearance:		.052 T	.010 L
2	94	Magneto Pilot in Accessory Case . . . . . Diameter:		.001 L	.005 L
		Magneto Drive . . . . . End Clearance:		.001 T	.129 L
		GEAR BACKLASH			
2	95	Camshaft Gear and Accessory Drive Gear . . . . . Backlash:	.014	.006	.010
2	96	Camshaft Gear and Magneto Drive Gear . . . . . Backlash:	.018	.010	.014
2	97	Camshaft Gear (Internal) and Generator Drive Gear . . . . . Backlash:	.019	.010	.014
2	98	Camshaft Gear and Accessory Drive Idler Gear. . . . . Backlash:	.015	.007	.011
2	99	Camshaft Gear and Right Side Accessory Drive Gear. . . . . Backlash:	.015	.007	.011
2	100	Accessory Drive Idler And Left Side Accessory (Scavenge) Pump Drive Gear . . . . . Backlash:	.016	.008	.012
2	101	Oil Pressure Pump Impellers . . . . . Backlash:	.017	.009	.013
		SPRING TEST DATA			
2	102	Oil Pressure Relief Valve Spring No. 530838 . . . . . Load: (Compressed to 2.3" Length)	6.5 lbs.	7.0 lbs.	8.0 lbs.
1	103	Inner Valve Spring Number 520106 . . . . . Load: (Compressed to 1.329" Length)	73 lbs.	78 lbs.	88 lbs.
1	103	Inner Valve Spring Number 520106 . . . . . Load: (Compressed to 1.809" Length)	37 lbs.	43 lbs.	49 lbs.
1	104	Outer Valve Spring Number 520105 . . . . . Load: (Compressed to 1.360" Length)	100 lbs.	107 lbs.	120 lbs.
1	104	Outer Valve Spring Number 520105 . . . . . Load: (Compressed to 1.840" Length)	62 lbs.	65 lbs.	71 lbs.
2	105	Oil Pressure Check Valve Spring Number 25134. . . . . Load: (Compressed to .75" Length)	0.50 lbs.	0.58 lbs.	0.72 lbs.

† *Replace Rubber Bushings When Worn.*

Chart No.	Ref. No.	Description	Service Limit	New Parts Min.	New Parts Max.
		OIL CHECK VALVE ASSEMBLY			
3	106	Oil Check Valve Seat in Accessory Case . . . . . Diameter:		.002 L	.017 L
3	107	Oil Check Valve Stem in Seat . . . . . Diameter:	.0045L	.001 L	.0035L
		OIL SCAVENGE PUMP			
3	108	Oil Scavenge Pump Impeller in Housing . . . . . Diameter:	.006 L	.002 L	.004 L
3	109	Oil Scavenge Pump Impeller in Housing . . . . . End Clearance:	.008 L	.003 L	.006 L
3	110	Oil Scavenge Pump Driven Impeller Shaft in Housing . . . . Diameter:	.0035L	.001 L	.0025L
3	111	Oil Scavenge Pump Drive Gear Shaft in Accessory Case . . . Diameter:	.0035L	.001 L	.0025L
3	112	Oil Scavenge Pump Driving Impeller on Drive Gear Shaft 352016-531240 . . . . . Diameter:	.0025L	.000	.0015L
3	113	Oil Scavenge Pump Gear Shaft in Adapter 352016 & 40657 . . . . . Diameter:	.005 L	.0015L	.003 L
3	114	Oil Scavenge Pump Drive Gear . . . . . End Clearance:	.050	.007	.031
3	115	Oil Scavenge Pump Drive Gear Adapter Pilot in Accessory Case 40657 . . . . . Diameter:		.0002L	.0017L
		STARTER			
3	116	Starter Gear Bushing in Gear (530338 Gear) . . . . . Diameter:		.001 T	.003 T
3	117	Starter Gear Bushing on Starter Pivot . . . . . Diameter:	.005 L	.001 L	.003 L
3	118	Starter Gear on Starter Pivot . . . . . End Clearance:	.070	.012	.055
3	118	Starter Gear on Starter Pivot (352006 & 35976) . . . . . Diameter:	.005 L	.001 L	.003 L
		GEAR BACKLASH			
3	119	Oil Scavenge Pump Impellers . . . . . Backlash:	.012	.004	.008
3	120	Starter Gear (E80 Starter) and Crankshaft Gear . . . . . Backlash:	.015	.007	.011

NOTE: Parts 352016 and 40657 are used when Fuel Pump is not required.

TABLE OF TIGHTENING TORQUES

Chart No.	Ref. No.	Part Name	Thread Size	No.	Tightening Torque
1	T1	Nut – Crankcase-to-Front Mounting Bracket Stud	3/8-24	8	275-325 in. lbs.
4	T2	Nut – Crankcase Through Bolt	5/16-24	3	180-220 in. lbs.
2	T3	Nut – Starter Pinion Pivot and Magneto Gear Support Stud	5/16-24	6	180-220 in. lbs.
4	T4	Nut – Crankcase Front (5" long) Through Bolt	3/8-24	2	370-390 in. lbs.
4	T5	Nut – Crankcase (10-11/16" long) Dowel Bolt & Cyl. Stud	7/16-20	16	490-510 in. lbs.
1	T6	Nut – Crankcase-to-Cylinder Stud	3/8-24	36	410-430 in. lbs.
1	T7	Nut – Connecting Rod Bolt	3/8-24	12	400-475 in. lbs.
4	T8	Screw (Socket Head) (25167) Gear-to-Crankshaft	1/4-28	6	140-160 in. lbs.
4	T8	Screw (Hex Head 534904) Gear-to-Crankshaft	1/4-28	6	170-175 in. lbs.
4	T8	Screw – Gear-to-Crankshaft	5/16-24	6	240-260 in. lbs.
4	T9	Cap Screw (Hex Head) Gear-to-Camshaft	1/4-28	4	140-160 in. lbs.
4	T9	Screw – Gear-to-Camshaft	5/16-24	4	240-260 in. lbs.
1	T10	Spark Plug	18 mm	12	300-360 in. lbs.
		Propeller Nut Number 20 Splined Shaft	2-1/16-12	1	400-410 ft. lbs.
		Generator Retaining Nut	5/16-24	1	175-200 in. lbs.
		Generator Retaining Nut (Nut 531231 & Washer 401507)	3/8-24		175-195 in. lbs.

TABLE XIX

GENERAL USE - TIGHTENING TORQUES

Size	Bolts, Nuts and Screws		Driving Studs	
	In. Lbs.	Ft. Lbs.	In. Lbs.	Ft. Lbs.
8-32	22.0-30.0	1.8-2.5		
10-32	36.0-50.0	3.0-4.2		
1/4-20	75.0-85.0	6.3-7.1	50.0-70.0	4.2-5.8
1/4-28	90.0-110	7.5-9.2		
5/16-18	155-175	13.0-14.6	100-150	8.3-12.5
5/61-24	180-220	15.0-18.3		
3/8-16	220-260	18.3-21.7	200-275	16.6-22.9
3/8-24	275-325	22.9-27.1		
7/16-14			300-425	25.0-35.4
7/16-20	400-450	33.3-37.5		
1/2-20	550-600	45.8-50.0		

NOTE

Torque loads are listed for use with oil on threads, except for studs. Stud driving torques apply when the threads are coated with Alcoa thread lube if hole is blind, or with National Oil Seal compound if hole is through to a cavity subject to oil.

If cotter pin holes must be aligned, set torque wrench at low limit and tighten nut to first hole beyond this torque. However, on connecting rod nuts the torque limits must be maintained. Replace nut and repeat as required. In no case shall connecting rod nuts be torqued below low limit or over high limit.

TABLE XX

PIPE PLUGS

Size	In. Lbs.	Ft. Lbs
1/8-27	60-80	5.0-6.7
1/4-18	130-150	10.9-12.5
3/8-18	185-215	15.4-18.0
1/2-14	255-285	21.2-23.8
3/4-14	310-350	25.8-29.2

NOTE

Torque values for pipe plugs are for use with "Never Seeze" (Snap-On Tool Corporation) on threads.

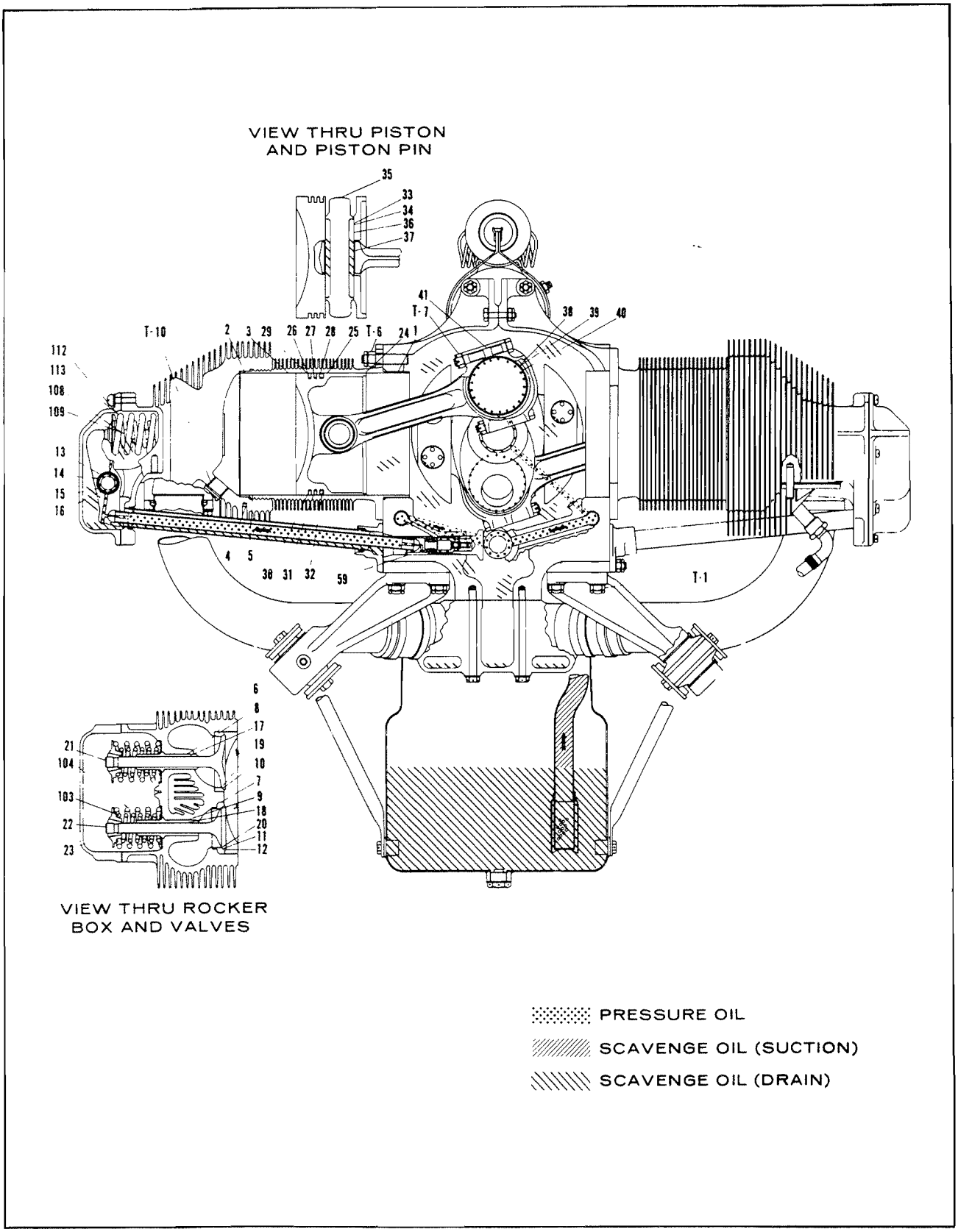

FIGURE 43. LIMITS AND LUBRICATION CHART NO. 1.

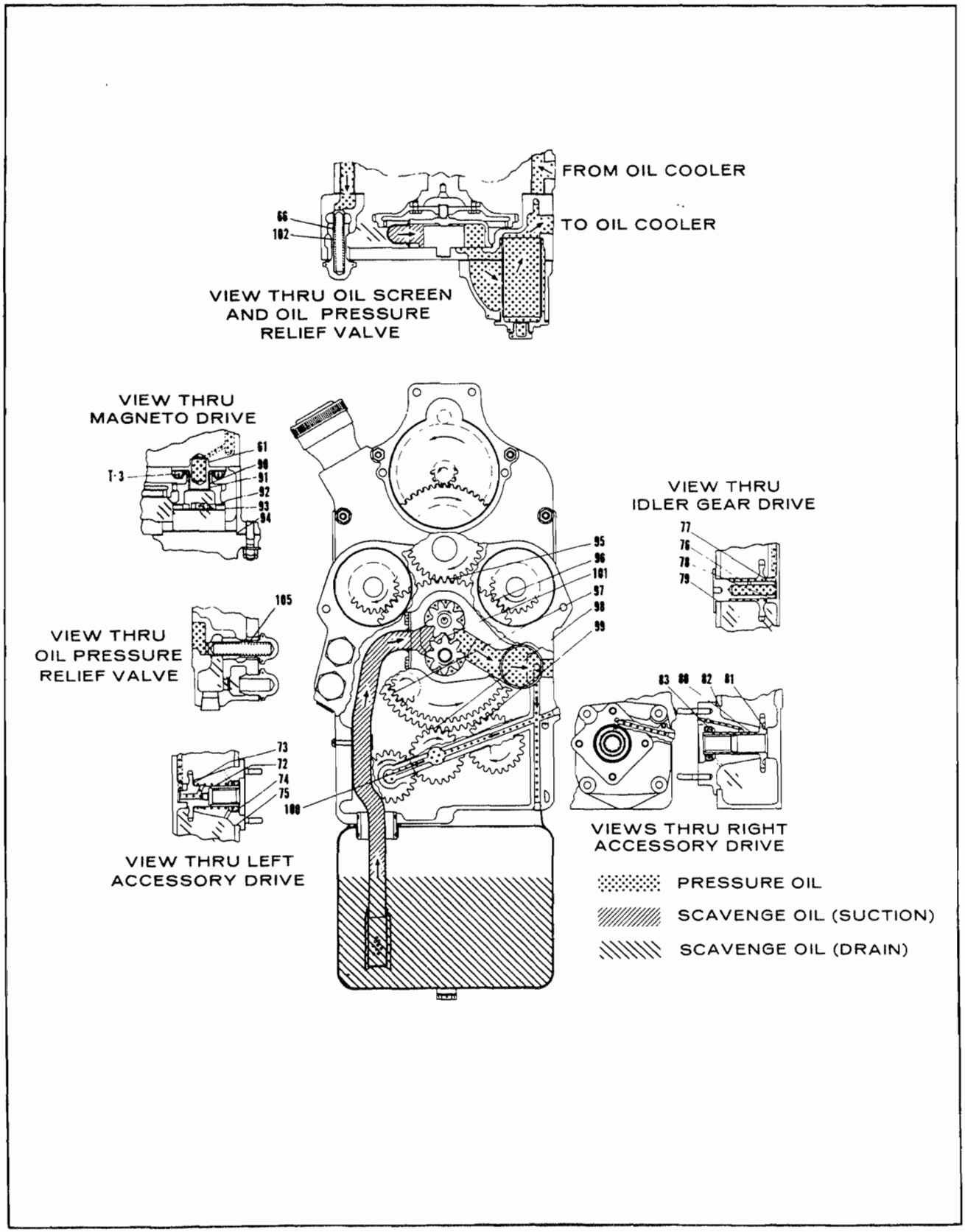

FIGURE 44. LIMITS AND LUBRICATION CHART NO. 2.

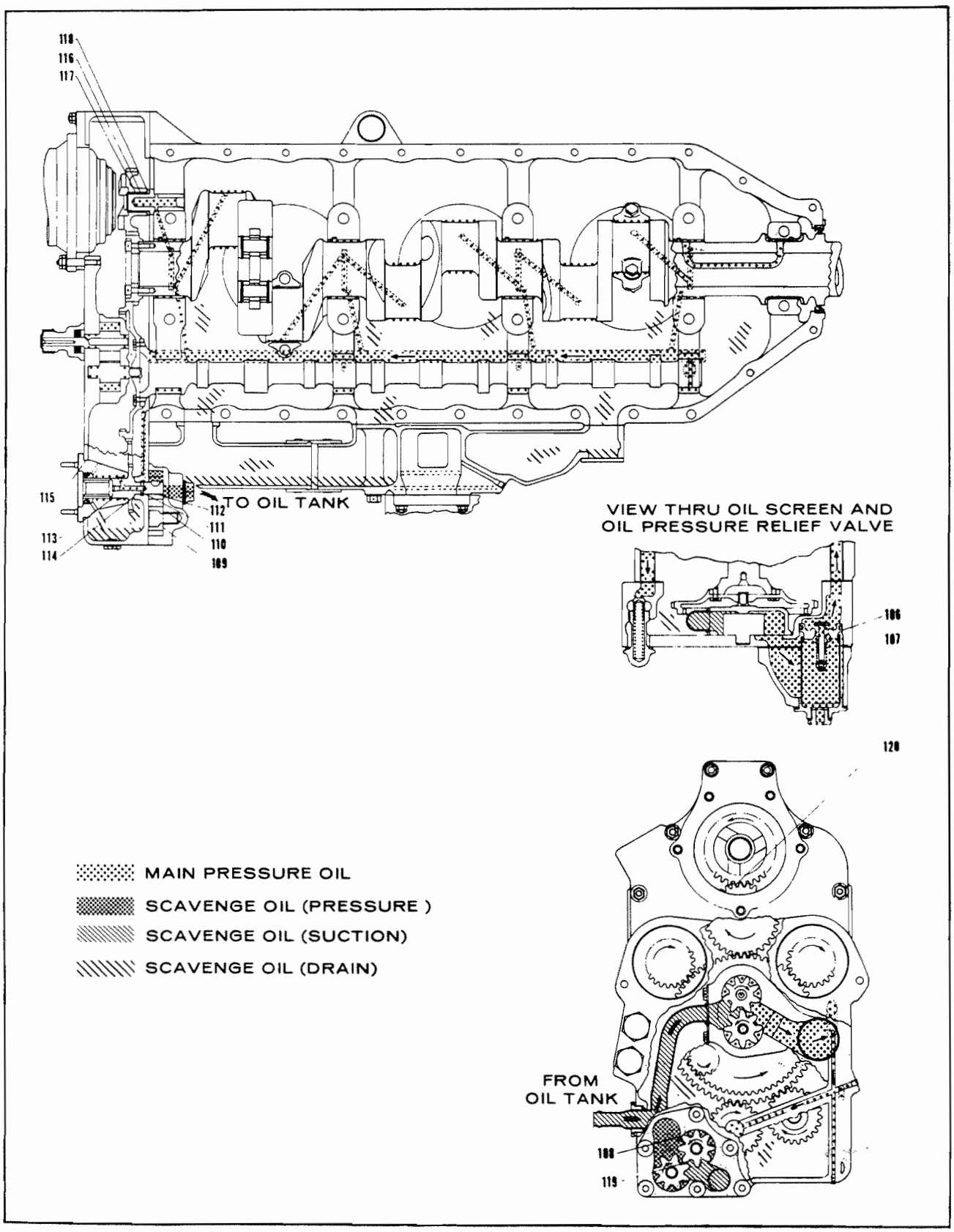

FIGURE 45. LIMITS AND LUBRICATION CHART NO. 3.

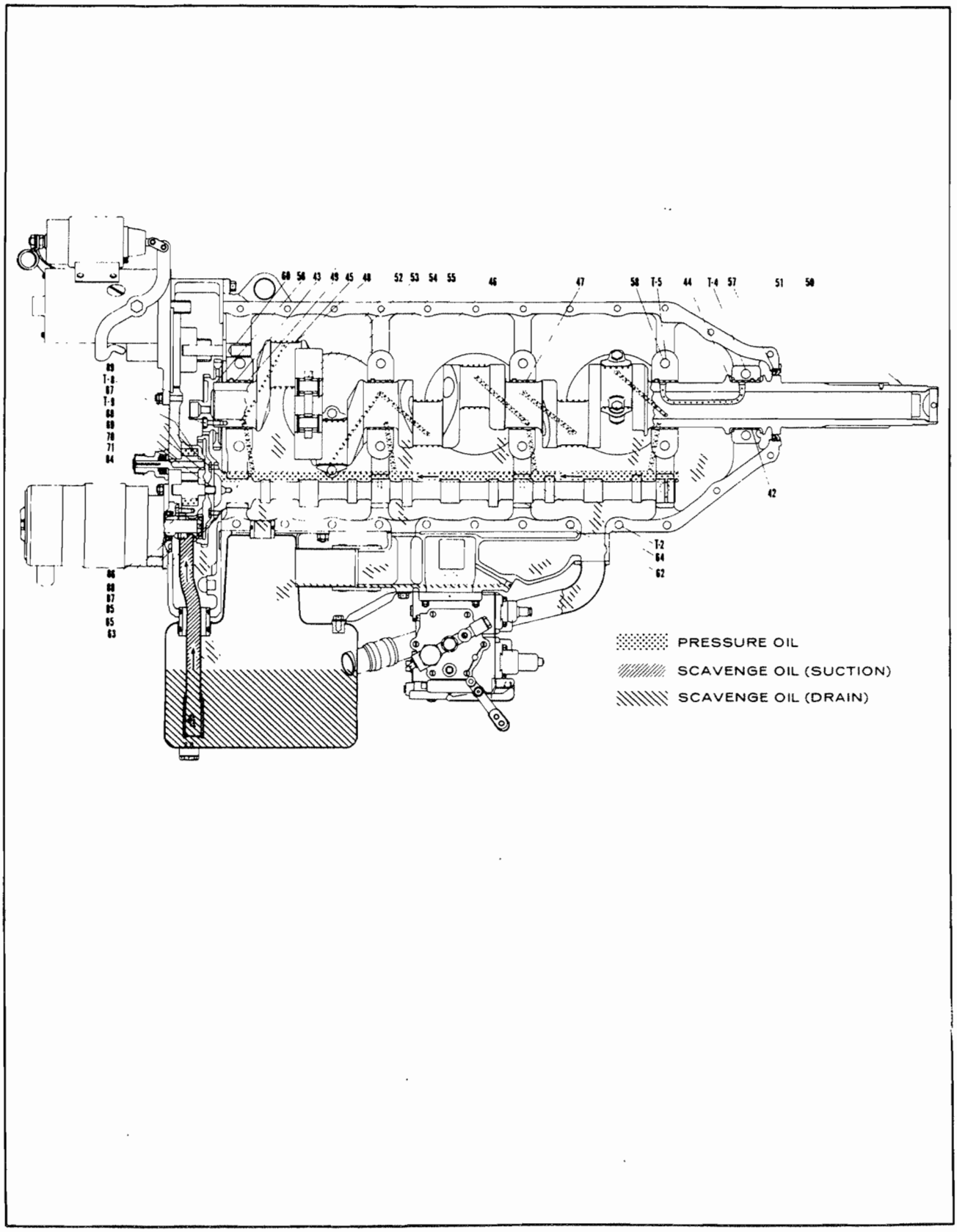

FIGURE 46. LIMITS AND LUBRICATION CHART NO. 4.

INTENTIONALLY

LEFT

BLANK

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