This Handbook Is Identified As **ALD-3F2**

Allison

GM
GENERAL
MOTORS

HANDBOOK OF
Operation and Maintenance
for
Allison V-1710 "F" Type Engines

Third Edition

PUBLISHED APRIL 1, 1943
FOR INFORMATION ONLY

Compiled and Edited by the Allison Publications Department

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ALLISON DIVISION
GENERAL MOTORS CORPORATION
INDIANAPOLIS, INDIANA, U. S. A.

1st Edition Published February 5, 1942 as
Vol. I of Operation Maintenance and Overhaul Handbook
for V-1710-"F" Type Engines
G.M.P.S.—5000—2-5-42—U.S.A.
G.M.P.S.—1500—3-21-42—U.S.A.
G.M.P.S.—1000—5-15-42—U.S.A.

2nd Edition Published July 9, 1942 as
Vol. I of Operation Maintenance and Overhaul Handbook
for V-1710-"F" Type Engines
G.M.P.S.—5000—7-9-42—U.S.A.

3rd Edition Published April 1, 1943
G.M.P.S.—3000—4-1-43—U.S.A.

Litho, U.S.A.

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SECTION I
INTRODUCTION

This Handbook is issued for the information and guidance of personnel who are operating Model V-1710-F2R, F2L, F3R, F4R, F5R, F5L, F10R, F10L, F20R and F21R engines manufactured by the Allison Division of General Motors Corporation. All information necessary for the operating, routine servicing, and making minor adjustments is given in this Handbook.

These instructions are the result of our experience in the design, development, manufacture, and service operation of the Allison engine. Consequently, we urge that the suggestions outlined be followed closely.

For details of Engine Installation, refer to the Installation Handbook of the airplane manufacturer.

The following definitions shall apply to the nomenclature used throughout the text:

REAR.—The anti-propeller end is referred to as the "Rear" of the engine.

RIGHT AND LEFT.—The terms "Right" and "Left" are established when viewing the engine from the rear.

ROTATION.—The direction of rotation is established when viewing the engine from the rear. The directions of rotation of the accessory drives are established when facing the mounting pads.

CYLINDER DESIGNATIONS.—The cylinders are numbered from the rear of the engine toward the front. The rear cylinder of the right bank is designated as "1R", the next cylinder as "2R", etc., to "6R". The left bank cylinders are designated as "1L", "2L", etc. to "6L".

It should be observed that this system of cylinder numbering is the opposite to that used in British in-line engines. See Figure 1.

We desire close co-operation with the users of our engines, and ideas for the improvement of the engine, its equipment, and servicing are welcome and will be given our careful consideration. There may be problems arising in the operation or care of the engine, in which case our Service Department will be glad to co-operate in every way possible toward finding a solution.

Throughout this Handbook, all references pertain to all models covered in this Handbook unless specifically stated otherwise.

Necessary tools for accomplishing the work outlined herein will be found listed in Section X.

The following Commercial Handbooks contain related instructions and information and will be referred to when additional information is required:

ENGINE PUBLICATIONS—

*Allison Overhaul Manual for V-1710-"F" Type Engines.

*Commercial Overhaul and Service Parts Catalog for Allison V-1710-F3R Engines.

*Allison Commercial Parts Catalog for Models V-1710-F5R and F5L Engines.

*Allison Commercial Parts Catalog for Allison V-1710-F10R, F10L and F4R Engines.

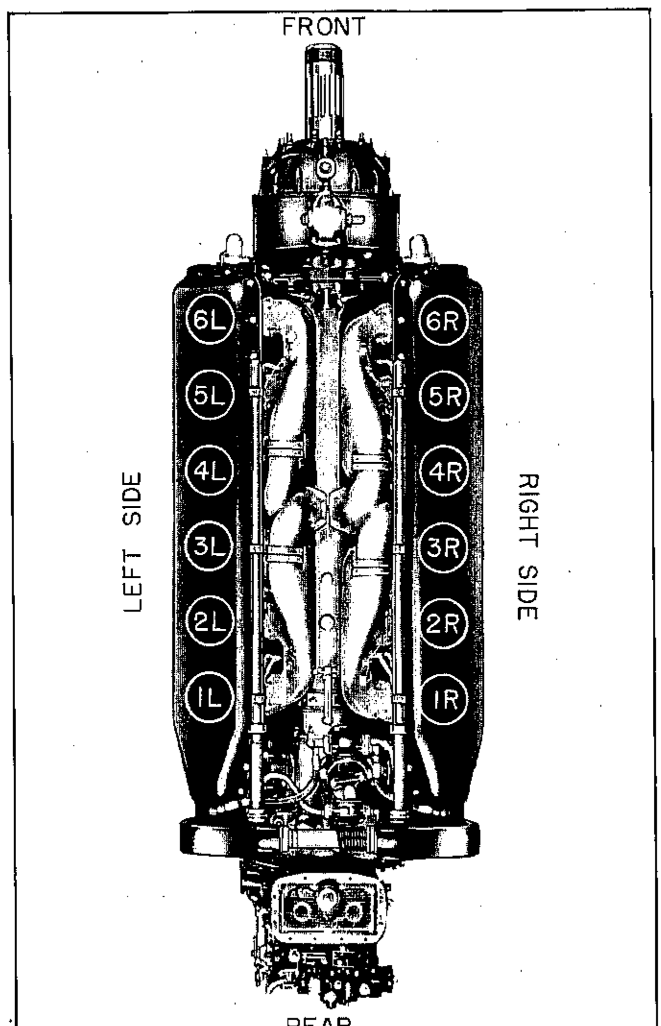


Figure 1—Cylinder Designation Chart.

Commercial Overhaul and Service Tool Catalog for Allison Engines.

Pilots Notes for Allison Engine Installations.

Operators Manual for Allison Engine Installations.

*NOTE: Similar handbooks are available on the V-1710-"C" and "E" type engines.

ACCESSORY PUBLICATIONS—

Service Manual and Parts Catalog for Cuno Aircraft Filters—Distributed by Cuno Engineering Corporation, Meriden, Conn.

Service Instructions — Parts List — D F Type Magneto — Distributed by Scintilla Magneto Division, Bendix Aviation Corp., Sidney, N. Y.

Service Manual — Stromberg Injection Carburetors for Aircraft—Distributed by Bendix Aviation Corporation, South Bend, Ind.

A C Aircraft Spark Plugs — Distributed by A C Spark Plug Division, Flint, Mich.

All correspondence with the company including requests for engine publications should be addressed to Allison Division, General Motors Corporation, Indianapolis, Indiana. Requests for accessories publications should be addressed to the accessory manufacturer.

ORDERING PARTS

Whenever possible, parts should be ordered from the Parts Catalog. Some parts are not furnished individually, but must be purchased as assemblies. This is due to the fact that such parts require special and extensive equipment for assembly, and cannot be fabricated except when a shop is especially equipped for this work. These special parts are appropriately indicated as such in the Parts Catalog. If an order is received for a detail part of an assembly coming under this classification, the assembly will be shipped.

Spare parts for such accessories as vacuum pumps, starters, generators, and fuel pumps are ordered as outlined in the airplane manufacturer's Handbook. Spare parts for such accessories as magnetos, spark plugs, etc., should be ordered from the accessory manufacturer. See Section IX.

When ordering engine spare parts or requesting service information, the serial number and model of the engine for which the request is made shall be furnished.

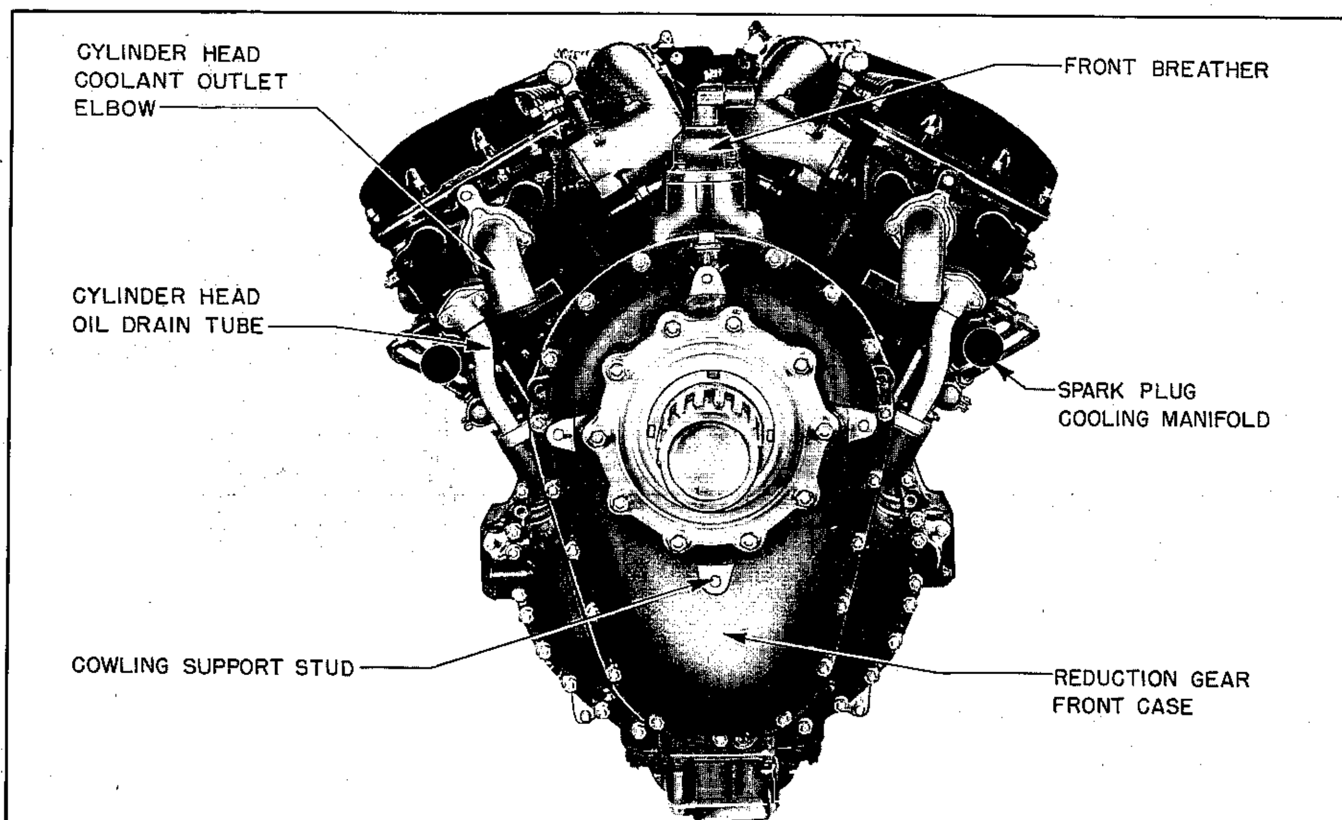


Figure 2—Front View of V-1710-F10R or F10L Model Engine.

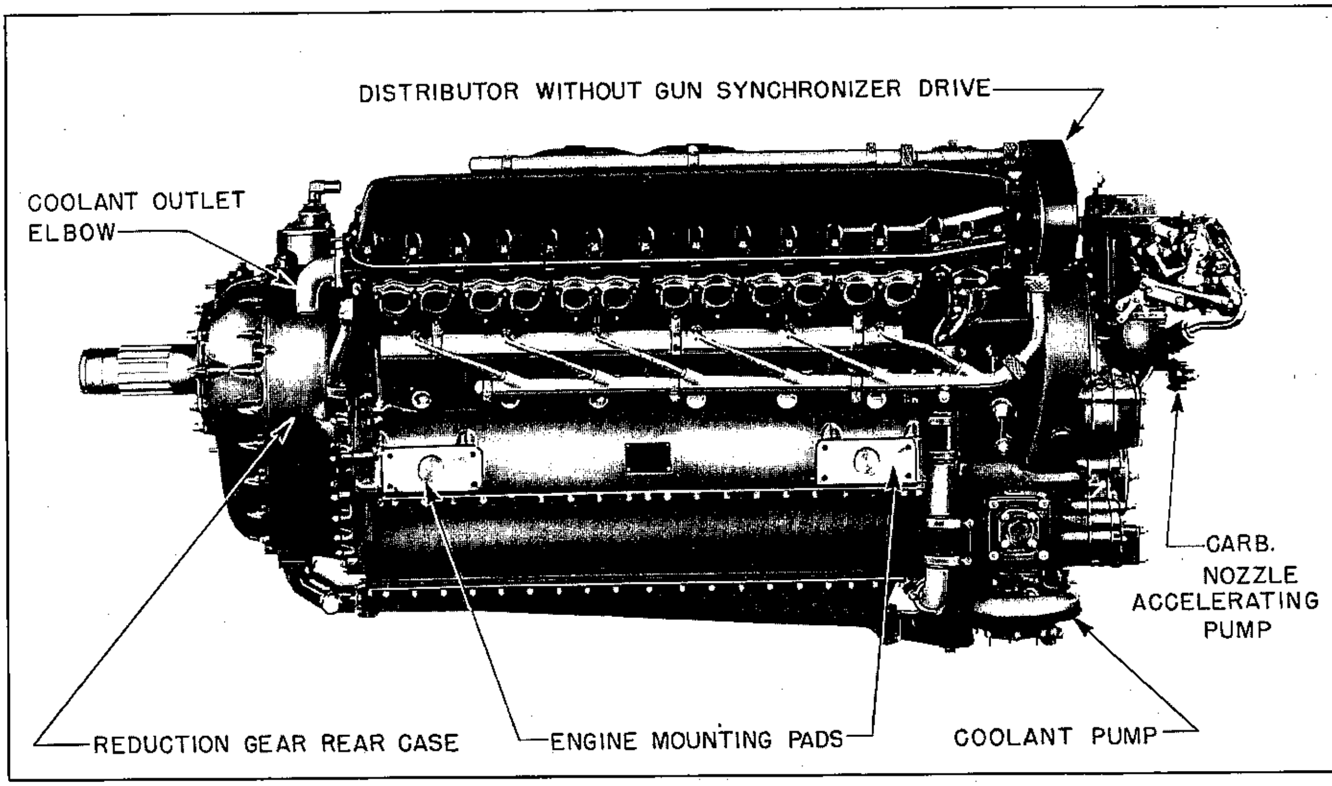


Figure 3—Left Side View of V-1710-F5R or F5L Model Engine.

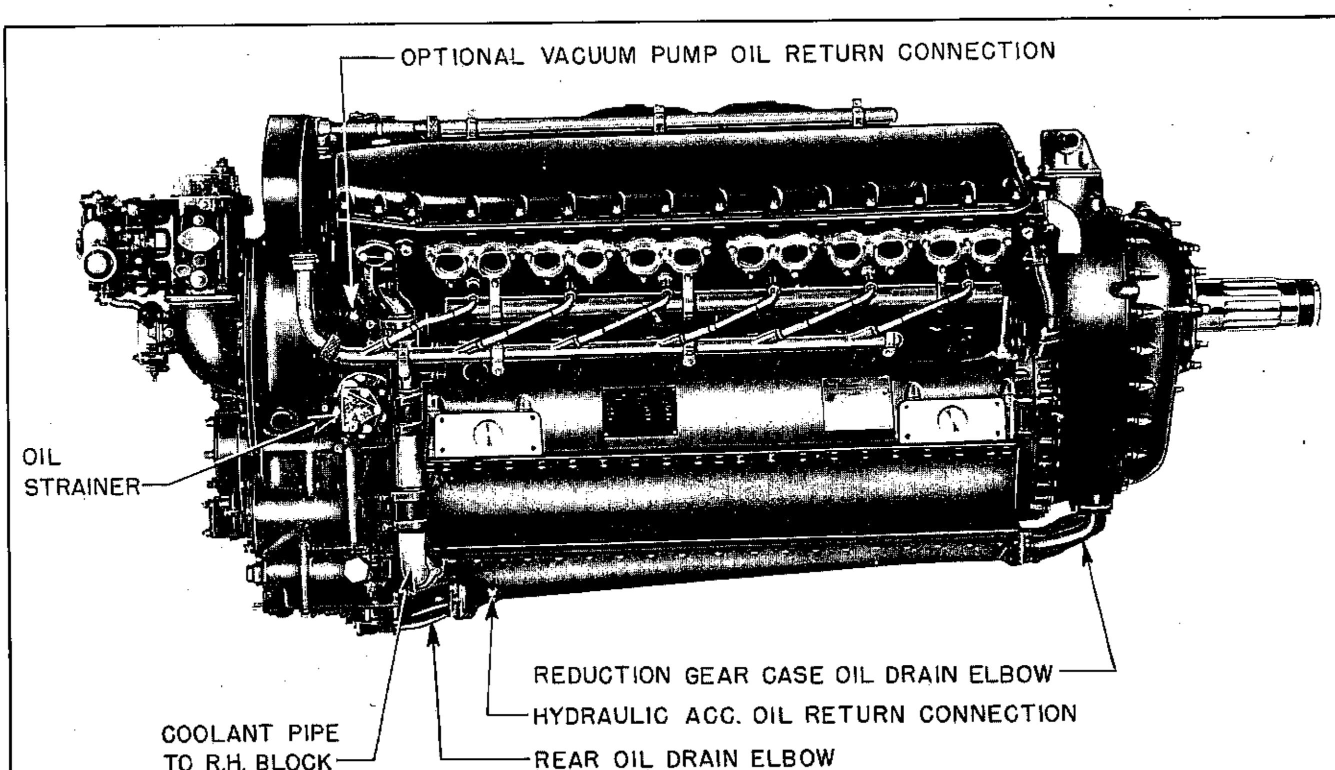


Figure 4—-Right Side View of V-1710-F10R or F10L Model Engine.

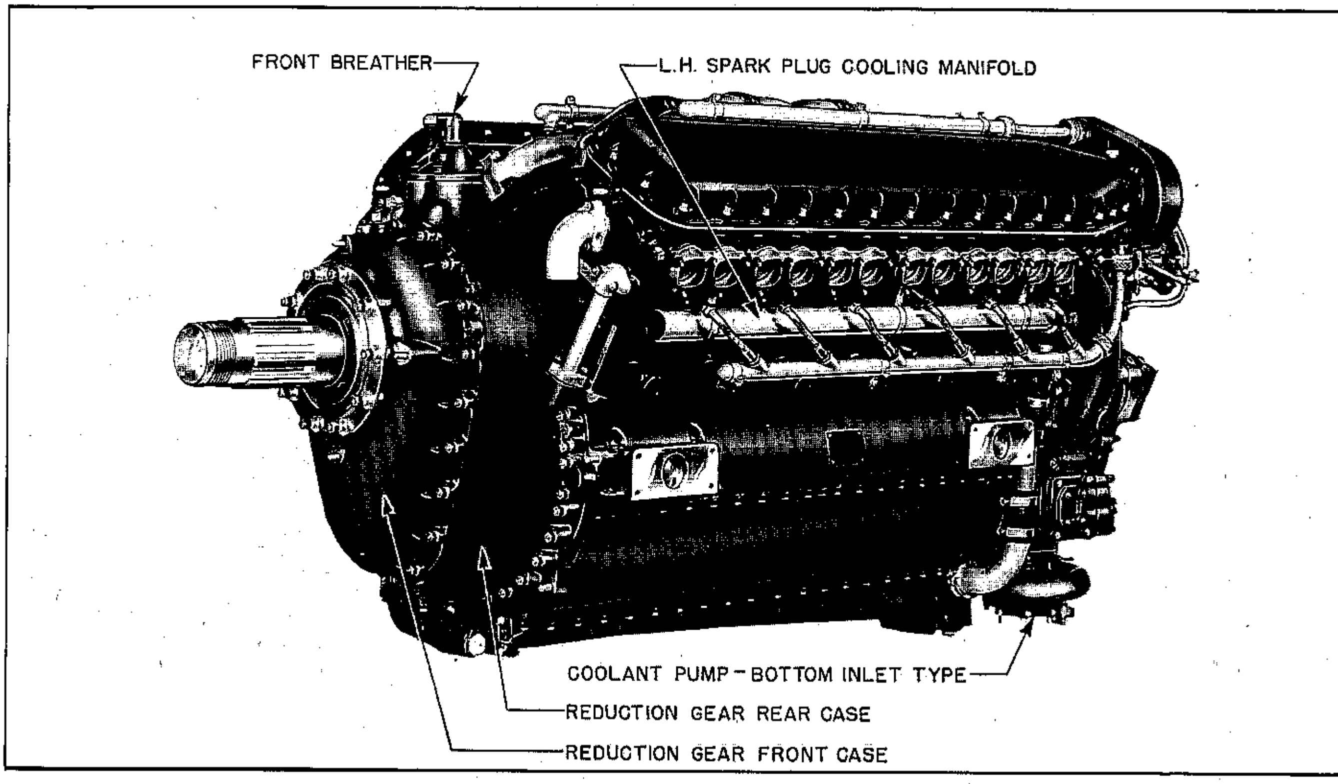


Figure 5—¾ Left Front View of V-1710-F2R, F2L, F5R or F5L Model Engine.

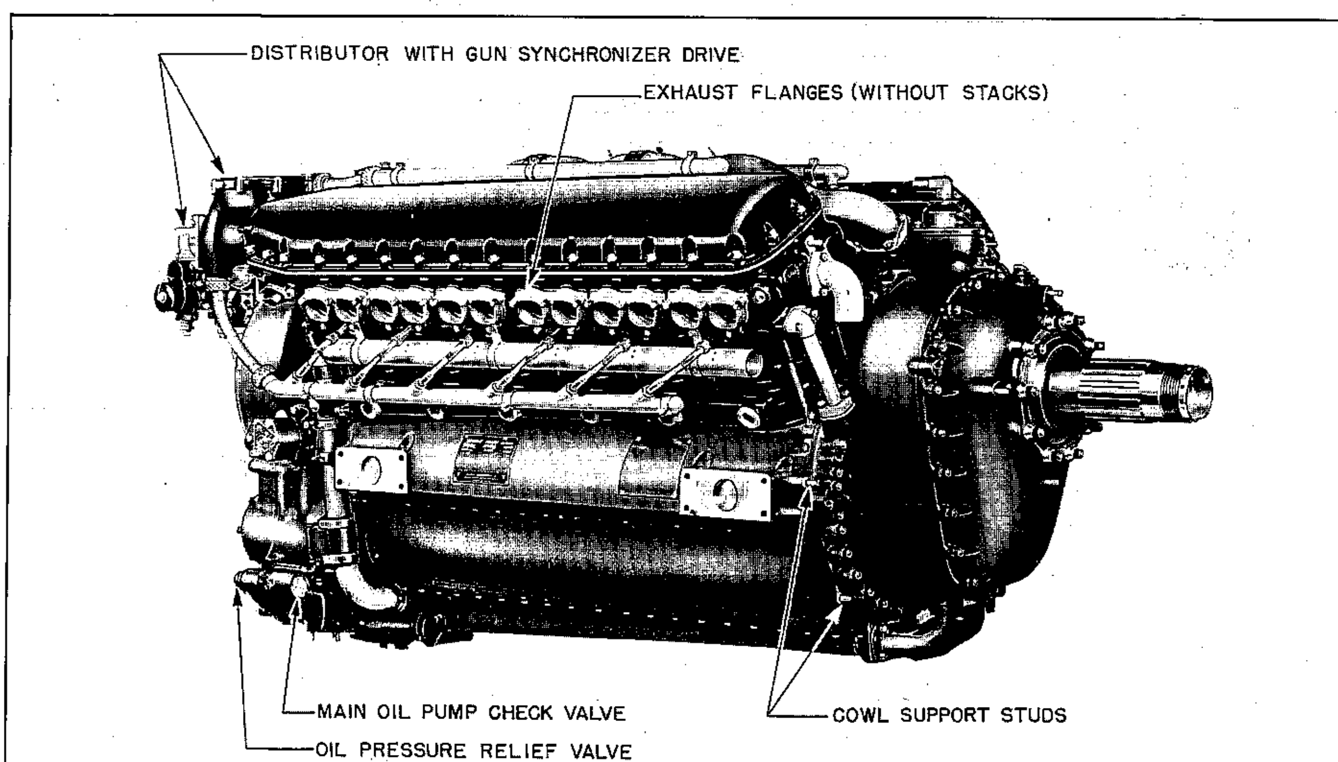


Figure 6—¾ Right Front View of V-1710-F3R Model Engine.

SECTION II

SPECIFICATIONS AND GENERAL DESCRIPTION

1. TABLE OF SPECIFICATIONS

GENERAL							
Model—V-1710	F2R and F2L	F3R	F5R and F5L	F10R and F10L	F4R	F20R	F21R
Type	Tractor	Tractor	Tractor	Tractor	Tractor	Tractor	Tractor
Number of Cylinders	12	12	12	12	12	12	12
Bore	5.50	5.50	5.50	5.50	5.50"	5.50"	5.50"
Stroke	6.00	6.00	6.00	6.00	6.00"	6.00"	6.00"
Piston Displacement in Cubic Inches	1710	1710	1710	1710	1710	1710	1710
Compression Ratio	6.65:1	6.65:1	6.65:1	6.65:1	6.65:1	6.65:1	6.65:1
Blower Gear Ratio	6.44:1	8.80:1	7.48:1	7.48:1	8.80:1	9.60:1	7.48:1
Impeller Diameter	9½	9½"	9½"	9½'	9½"	9½'	9½"
Rated Speed, R.P.M.:							
Normal	2600	2600	2600	2600	2600	2600	2600
Take-Off	3000	3000	3000	3000	3000	3000	3000
Military	3000	3000	3000	3000	3000	3000	3000
Rated B.H.P. at Sea Level:							
Normal at 2600 R.P.M.	1000	1000	1000	1100	1000	1000	1100
Take-Off at 3000 R.P.M.	1150	1150	1325	1325	1325	1200	1325
Rated B.H.P. at Rated Altitude:							
Normal at 2600 R.P.M.	1000	1000	1000	1100	1000	1000	1100
Military at 3000 R. P. M.	1150	1150	1325	1325	1150	1125	1325
Rated Altitude:							
Normal	Turbo to 25,000	10,800	Turbo to 25,000	Turbo to 25,000	10,800	14,000	2,500
Military	Turbo to 25,000	12,000	Turbo to 25,000	Turbo to 25,000	12,000	15,500	3,000
Propeller Rotation	R.H. (F2R) L.H. (F2L)	R.H.	R.H. (F5R) L.H. (F5L)	R.H. (F10R) L.H. (F10L)	R.H.	R.H.	R.H.
Crankshaft Rotation	L.H. (F2R) R.H. (F2L)	L.H.	L.H. (F5R) R.H. (F5L)	L.H. (F10R) R.H. (F10L)	L.H.	L.H.	L.H.
Propeller Reduction Gear Ratio	2.00:1	2.00:1	2.00:1	2.00:1	2.00:1	2.00:1	2.00:1
Propeller Shaft Spline	No. 50	No. 50	No. 50	No. 50	No. 50	No. 50	No. 50
Average Wt. of Engine (Complete)	1305	1335	1345	1345	1345	1352	1353
Position of Center of Gravity of Complete Engine:							
Distance from Front Face of Thrust Bearing Retainer Nut to Center of Gravity	34½"	34½"	34½"	34½"	34½"	34½"	34½"
Distance Center of Gravity is in Back of Centerline of Center Main Bearing	1¼"	1¼"	1¼"	1¼"	1¼"	1¼"	1¼"
Distance above Centerline of Crankshaft	7 1/16"	7 1/16"	7 1/16"	7 1/16"	7 1/16"	7 1/16"	7 1/16"
Overall Dimensions of Complete Engine:							
Length (Maximum)	85⅝"	85⅝"	85⅝"	85⅝"	85⅞"	85⅞"	85⅞"
Width (Maximum)	29 9/32"	29 9/32"	29 9/32"	29 9/32"	29 9/32"	29 9/32"	29 9/32"
Height	36 17/32"	36 17/32"	36 17/32"	36¾"	36¾"	36¾"	36 27/32"
Number of Mounting Bolts	8	8	8	8	8	8	8
Size of Mounting Bolt Holes	.4375"	.4375"	.4375"	.4375"	.4375"	.4375"	.4375"
Transverse Spacing of Mounting Bolts	18⅜"	18⅜"	18⅜"	18⅜"	18⅜"	18⅜"	18⅜"
IGNITION							
Magneto—Scintilla Double Fixed Timing—Type	DF	DF	DF	DF	DF	DF	DF
Direction of Rotation, Viewing Mounting Pad	R.H.	R.H.	R.H.	R.H.	R.H.	R.H.	R.H.
Magneto Speed, Times Crankshaft Speed	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Magneto Breaker Point Gap	.012"	.012"	.012"	.012"	.012"	.012"	.012"

SPECIFICATIONS AND GENERAL DESCRIPTION—Continued

Model—V-1710	F2R and F2L	F3R	F5R and F5L	F10R and F10L	F4R	F20R	F21R
Spark Plug Model	AC-LS85	AC-LS85	AC-LS85	AC-LS85	AC-LS85	AC-LS85	AC-LS85
Spark Plug Model (Alternate)	C34S	C34S	C34S	C34S	C34S	C34S	C34S
Spark Plug Model (Alternate)	C35S	C35S	C35S	C35S	C35S	C35S	C35S
Spark Plug Gap (Inches)	.011-.014	.011-.014	.011-.014	.011-.014	.011-.014	.011-.014	.011-.014
Spark Timing Advance (Degrees BTC):							
Intake Side	28°	28°	28°	28°	28°	28°	28°
Exhaust Side	34°	34°	34°	34°	34°	34°	34°
VALVE TIMING DATA							
Intake Opens, Degrees B.T.C.	48°	48°	48°	48°	48°	48°	48°
Intake Closes, Degrees A.B.C.	62°	62°	62°	62°	62°	62°	62°
Exhaust Opens, Degrees B.B.C.	76°	76°	76°	76°	76°	76°	76°
Exhaust Closes, Degrees A.T.C.	26°	26°	26°	26°	26°	26°	26°
Intake Remains Open, in Crankshaft Degrees	290°	290°	290°	290°	290°	290°	290°
Exhaust Remains Open, in Crankshaft Degrees	282°	282°	282°	282°	282°	282°	282°
Valve Lift—Inches	.533	.533	.533	.533	.533	.533	.533
Valve Rocker Clearances (cold), Measured at Valve Stem Tip for Timing and Running:							
Intake—Inches	.015	.015	.015	.015	.015	.015	.015
Exhaust—Inches	.020	.020	.020	.020	.020	.020	.020
Valve Spring Loads—Lbs.:							
Outer Spring—Valve Closed	33 to 37	33 to 37	33 to 37	43 to 47	43 to 47	43 to 47	43 to 47
Outer Spring—Valve Open	75 to 79	75 to 79	75 to 79	92 to 98	92 to 98	92 to 98	92 to 98
Inner Spring—Valve Closed	18 to 22	18 to 22	18 to 22	23 to 27	23 to 27	23 to 27	23 to 27
Inner Spring—Valve Open	47 to 51	47 to 51	47 to 51	58 to 62	58 to 62	58 to 62	58 to 62
FUEL SYSTEM							
Carburetor—Bendix-Stromberg, Model	PD-12G1	PD-12K2	PD-12G1	PD-12K3	PD-12K2	PD-12K6	PD-12K7
Fuel Required—Spec. No. AN-VV-F-781 (Amendment No. 5) Octane	100	100	100	100	100	100	100
Fuel Pressure—Lbs./Sq. In.	12-16	12-16	12-16	12-16	12-16	12-16	12-16
Fuel Pressure (Idling)—Lbs./Sq. In.	10	10	10	10	10	10	10
Fuel Inlet Connection (NPT Tap Size)	¾"	¾"	¾"	¾"	¾"	¾"	¾"
Induction System Drain (NPT Tap Size)	¼"	¼"	¼"	¼"	¼"	¼"	¼"
Mixture Temperature Connection (NF Thd. Tap)	⅝-18	⅝-18	⅝-18	⅝-18	⅝-18	⅝-18	⅝-18
Priming System Inlet Connect. (NPT Tap Size)	⅛"	⅛"	⅛"	⅛"	⅛"	⅛"	⅛"
LUBRICATION SYSTEM—ENGINE							
Maximum Allowable Oil Consumption, U. S. Quarts per Hour, Approx.:							
At Normal Rated Power at 2600 R.P.M.	13.3	13.3	13.3	14.6	13.3	13.3	14.6
British Equivalent—Imperial Pints	22.2	22.2	22.2	24.4	22.2	22.2	24.4
At Maximum Cruising Power at 2280 R.P.M.	10.0	10.0	10.0	11.0	10.0	10.0	11.0
British Equivalent—Imperial Pints	16.7	16.7	16.7	18.4	16.7	16.7	18.4
At Minimum Specific Fuel Flow	5-7	5-7	5-7	5-7	5-7	5-7	5-7
British Equivalent—Imperial Pints	8-12	8-12	8-12	8-12	8-12	8-12	8-12
Oil Required, Spec. AN-VV-O-446:							
Summer Grade	1120	1120	1120	1120	1120	1120	1120
Winter Grade	1100	1100	1100	1100	1100	1100	1100

SPECIFICATIONS AND GENERAL DESCRIPTION—Continued

Model—V-1710	F2R and F2L	F3R	F5R and F5L	F10R and F10L	F4R	F20R	F21R
Speed of Oil Pump, Times Crankshaft Speed	1.429	1.429	1.429	1.429	1.429	1.429	1.429
Minimum Safe Quantity of Oil in Engine System—U. S. Gallons	3	3	3	3	3	3	3
Add to this, quantity for oil cooling system and tank.							
British Equivalent—Imperial Gallons	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Oil Pump Drive Shaft, Direction of Rotation	L.H.	L.H.	L.H.	L.H.	L.H.	L.H.	L.H.
*Oil Inlet Connection—Flange Type (Open Dia.)	1½"	1½"	1½"	2"	2"	2"	2"
*Oil Outlet Connection—Flange Type (Open Dia.)	1½"	1½"	1½"	1½"	1½"	1½"	1½"
Oil Tank Vent Connection (No. and NPT Tap Size)	(2) ¾"	(2) ¾"	(2) ¾"	(2) ¾"	(2) ¾"	(2) ¾"	(2) ¾"
Pressure Oil Supply Hydro Instruments (N.P.T. Tap Size)	⅜"	⅜"	⅜"	⅜"	⅜"	⅜"	⅜"
Accessory Oil Return Connection (Number and N.P.T. Tap Size)	(3) ⅜"	(3) ⅜"	(3) ⅜"	(3) ⅜"	(3) ⅜"	(3) ⅜"	(3) ⅜"
Breather Connection (2 Hose Nipples)	1" O.D.	1" O.D.	1" O.D.	1" O.D.	1" O.D.	1" O.D.	1" O.D.

*Connecting Elbows not supplied with engine.

COOLING SYSTEM

Item	F2R and F2L	F3R	F5R and F5L	F10R and F10L	F4R	F20R	F21R
Coolant Required—Ethylene Glycol Conforming to A.C. Spec. No. AN-E-2, which superseded Spec. No. 14108							
Coolant Capacity, Engine Only:							
U.S. Gallons	6.7	6.7	6.7	6.7	6.7	6.7	6.7
British Equivalent—Imperial Gallons	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Coolant Outlet Temperatures: All Models—Desired (220°—240° F.) or (105°—115° C.)							
Max. Allowable (257°F.) or (125°C.)							
Min. for Take-Off Flight (185° F.) or (85° C.)							
Coolant Outlet Connections (2 Hose Nipples)	1¾"	1¾"	1¾"	1¾"	1¾"	1¾"	1¾"
Coolant Inlet Connections—Flange Type —(Open Dia.)	2½"	2½"	2½"	2½"	2½"	2½"	2½"
Cylinder Block Vent Connections (2 NPT Taps)	⅜"	⅜"	⅜"	⅜"	⅜"	⅜"	⅜"
Expansion Tank Connection at Pump Inlet (Number and N.P.T. Tap Size)	(1) ¾"	(2) ¾"	(1) ¾"	(1) ¾"	(2) ¾"	(2) ¾"	(2) ¾"
Speed of Coolant Pump, Times Crankshaft	1.234	1.234	1.234	1.234	1.234	1.234	1.234
Coolant Pump Rotation (Viewing Engine Drive)	R.H.	R.H.	R.H.	R.H.	R.H.	R.H.	R.H.

ACCESSORY DRIVES AND INSTRUMENT CONNECTIONS

Item	F2R and F2L	F3R	F5R and F5L	F10R and F10L	F4R	F20R	F21R
Oil Temperature Measurement Connection (Thd.)	⅝-18	⅝-18	⅝-18	⅝-18	⅝-18	⅝-18	⅝-18
Oil Pressure Connection (Pipe Tap)	⅛"	⅛"	⅛"	⅛"	⅛"	⅛"	⅛"
Fuel Pressure Connection (Pipe Tap)	⅛"	⅛"	⅛"	⅛"	⅛"	⅛"	⅛"
Fuel Nozzle Pressure Connection (Pipe Tap)	⅛"	⅛"	⅛"	⅛"	⅛"	⅛"	⅛"
Fuel Air Thermometer Conn. (Thd.)	⅝-18	⅝-18	⅝-18	⅝-18	⅝-18	⅝-18	⅝-18
Manifold Pressure Connection (Pipe Tap)	⅛"	⅛"	⅛"	⅛"	⅛"	⅛"	⅛"

SPECIFICATIONS AND GENERAL DESCRIPTION—Continued

Model—V-1710	F2R and F2L	F3R	F5R and F5L	F10R and F10L	F4R	F20R	F21R
Fuel Pump Drive—11 Tooth Spline (P.D.)	.458″	.458″	.458″	.458″	.458″	.458″	.458″
Speed, Times Crankshaft	.864	.864	.864	.864	.864	.864	.864
Rotation, Viewing Drive Shaft	L.H.	L.H.	L.H.	L.H.	L.H.	L.H.	L.H.
Starter Drive—Flange Diameter	6″	6″	6″	6″	6″	6″	6″
Starter Dog	3 Jaw	3 Jaw	3 Jaw	3 Jaw	3 Jaw	3 Jaw	3 Jaw
Speed, Times Crankshaft	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Rotation, Viewing Drive Shaft:							
V-1710-F2R, F3R, F4R, F5R, F10R, F20R and F21R	R.H.	R.H.	R.H.	R.H.	R.H.	R.H.	R.H.
V-1710-F2L, F5L and F10L	L.H.	L.H.	L.H.	L.H.	L.H.	L.H.	L.H.
Generator Drive—Flange Diameter	6″	6″	6″	6″	6″	6″	6″
Drive—16 Tooth Spline (P.D.)	.800″	.800″	.800″	.800″	.800″	.800″	.800″
Speed, Times Crankshaft	1.440	1.440	1.440	1.440	1.440	1.440	1.440
Rotation, Viewing Drive Shaft	R.H.	R.H.	R.H.	R.H.	R.H.	R.H.	R.H.
Accessory Gear Box Drive—Use	Gen. Dr.	Gen. Dr.	Gen. Dr.	Gen. Dr.	Gen. Dr.	Gen. Dr.	Gen. Dr.
Gun Synchronizer Impulse Generator Drives, for AN Type, Speed, Times Crankshaft	—	0.5	—	—	—	—	0.5
Rotation, Viewing Drive Shaft	—	L.H.	—	—	—	—	L.H.
Propeller Governor Drive—12 Tooth Spline (P.D.)	.600″	.600″	.600″	.600″	.600″	.600″	.600″
Speed, Times Crankshaft	.845	.845	.845	.845	.845	.845	.845
Rotation, Viewing Driveshaft	L.H. (F2R) R.H. (F2L)	L.H.	L.H. (F5R) R.H. (F5L)	L.H. (F10R) R.H. (F10L)	L.H.	L.H.	L.H.
Vacuum Pump Drives, AN Type, 12 Tooth Spline Drive (P.D.)	.600″	.600″	.600″	.600″	.600″	.600″	.600″
Rotation, Viewing Drive Shaft, Rear Pump	R.H.	R.H.	R.H.	R.H.	R.H.	R.H.	R.H.
Rotation, Viewing Drive Shaft, Side Pump	L.H.	L.H.	L.H.	L.H.	L.H.	L.H.	L.H.
Speed, Times Crankshaft	1.440	1.440	1.440	1.440	1.440	1.440	1.440
Tachometer Drive—Thread Type Mount (Thread Size)	⅞-18	⅞-18	⅞-18	⅞-18	⅞-18	⅞-18	⅞-18
Electric Tachometer Drive—Flange Type Mount (Square Hole Size)	.250″	.250″	.250″	.250″	.250″	.250″	.250″
Speed Times Crankshaft, Both Drives	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Rotation, Viewing Drive Shaft, Both Drives	R.H.	R.H.	R.H.	R.H.	R.H.	R.H.	R.H.
Provisions for Hydro-Controllable Feathering Propeller	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ACCESSORIES AND WEIGHT—LBS.							
Carburetor and Screen	35.1	36.0	36.0	36.0	36.0	33.0	33.0
Carburetor Air Duct and Cleaner	None	None	None	None	None	None	None
Domestic Engine Shipping Box	800	800	800	800	800	800	800
Export Engine Shipping Box	850	850	850	850	850	850	850
Exhaust Flanges, with Gaskets and Nuts	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Generator Drive (Weight Added)	None	None	None	None	None	None	None
Gun Synchronizer	None	None	None	None	None	None	None
Oil Strainer (Cuno)	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Magnetos	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Priming Connections and Lines	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Radio Shielding Complete	30.1	32.2	31.1	31.1	31.0	31.0	32.2
Tool Kit	4.9	5.1	5.1	5.1	5.1	5.1	5.1
Spark Plugs	7.0	7.0	7.0	7.0	7.0	7.0	7.0

2. DIFFERENCE BETWEEN MODELS.

a. GENERAL. — This Handbook pertains to the Allison V-1710-F2R Model engine and its associated Models, V-1710-F2L, F3R, F4R, F5R, F5L, F10R, F10L, F20R, and F21R. Basic similarity in design and appearance makes it convenient to include these models in a single Handbook. Identification of this basic engine type is readily determined by the characteristic short nose reduction gear housing with a high propeller thrust line. Service information required on other general types and models of Allison engines will be found in additional publications which are listed in Section I.

b. RELATION BETWEEN MODELS.—The engines covered in this Handbook are basically similar in appearance and design. The six Models, V-1710-F2R, F2L, F5R, F5L, F10R, and F10L are all sea level engines, and are always installed as pairs in dual installations, in which one of each pair is a right-hand propeller rotation engine, and the other, a left hand. These six models are constructed for adaptation of exhaust turbo supercharging to maintain full sea level ratings at altitude. These engines are always paired in one airplane twin engine installation as follows:

	R.H. Rotation Engine	*L.H. Rotation Engine*
First Installation	V-1710-F2R	V-1710-F2L
Second Installation ..	V-1710-F5R	V-1710-F5L
Third Installation ...	V-1710-F10R	V-1710-F10L

	Normal B.H.P.	*Take-Off B.H.P.*
First Installation	1000	1150
Second Installation	1000	1325
Third Installation	1100	1325

The V-1710-F3R, F4R and F20R Model engines are altitude rated engines with built in, single speed, single stage supercharger. Since the V1710-F20R is equipped with a 9.6:1 supercharger ratio, it has a higher normal and military altitude rating than the V-1710-F3R and F4R models, whose supercharger ratio is 8.8:1. The F21R model engine is a sea level rated engine with same supercharger ratio as the F10R and F10L models but is used in installations without additional supercharging of a turbo. This engine is capable of operating at full rated normal and rated military power at altitudes of 3000 and 2500 feet respectively.

c. BASIC DIFFERENCES.

(1) EXTERNAL APPEARANCE.—These models are basically similar in appearance, and positive identification of models should be made by consulting the engine name plate. However, the following tables may be used for partial identification.

(a) V-1710-F2R AND F2L ENGINES.

1. Distributor housing covers mounted in a vertical position.

2. No gun synchronizer drives provided.

3. Three-stud type oil pump inlet flange.

4. Small main oil pump.

5. Straight bottom type coolant pump inlet.

6. No connections provided for supercharging the distributors or magneto.

7. Open type magneto (not supercharged).

(b) V-1710-F5R AND F5L ENGINES.

1. Distributor housing covers mounted in a vertical position.

2. No gun synchronizer drives provided.

3. Three-stud type oil pump inlet flange.

4. Small main oil pump.

5. Straight bottom type coolant pump inlet.

6. Connections provided for supercharging the distributors and magneto.

7. Enclosed type magneto, for supercharging.

(c) V-1710-F10R AND F10L ENGINES.

1. Distributor housing covers mounted in a vertical position.

2. No gun synchronizer drives provided.

3. Four-stud type oil pump inlet flange.

4. Large main oil pump.

5. Straight bottom type coolant pump inlet.

6. Connections provided for supercharging the distributors and magneto.

7. Enclosed type magneto, for supercharging.

(d) V-1710-F3R ENGINE.

1. Distributor housing covers mounted in a horizontal position.

2. Gun synchronizer drives are provided.

3. Three-stud type oil inlet flange.

4. Small main oil pump.

5. Elbow type coolant pump inlet.

6. No connection provided for supercharging the distributor housings or magneto.

7. Open type magneto (not supercharged).

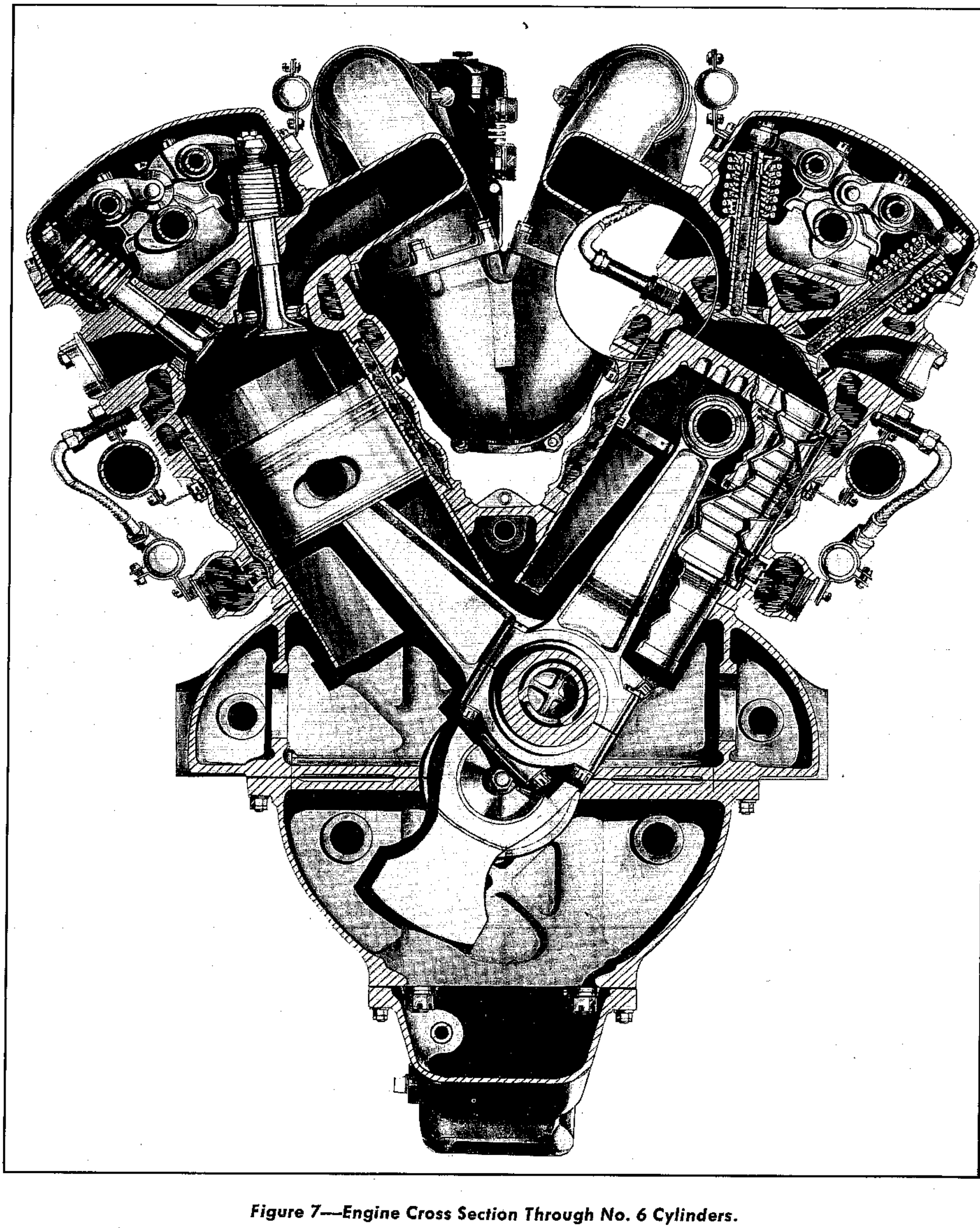


Figure 7—Engine Cross Section Through No. 6 Cylinders.

(*e*) V-1710-F4R ENGINE.

1. Distributor housing covers mounted in a vertical position.

2. No gun synchronizer drives provided.

3. Four-stud type oil inlet flange.

4. Large main oil pump.

5. Elbow type coolant pump inlet.

6. No connection provided for supercharging the distributor housings or magneto.

7. Open type magneto (not supercharged).

8. Equipped with automatic manifold pressure regulator.

(*f*) V-1710-F20R ENGINE.

1. Distributor housing covers mounted in a vertical position.

2. No gun synchronizer drives provided.

3. Four-stud type oil inlet flange.

4. Large main oil pump.

5. Elbow type coolant pump inlet.

6. No connections provided for supercharging the distributor housings or magneto.

7. Open type magneto (not supercharged).

8. Equipped with Automatic Manifold Pressure Regulator.

(*g*) V-1710-F21R ENGINE.

1. Distributor housing covers mounted in a horizontal position.

2. Gun synchronizer drives are provided.

3. Four-stud type oil inlet flange.

4. Large main oil pump.

5. Elbow type coolant pump inlet.

6. No connection provided for supercharging the distributor housings or magneto.

7. Open type magneto (not supercharged).

8. No flight tubes used.

(2) ACCESSORY DRIVES AND CONNECTIONS.—The accessory drives of all models have the same direction of shaft rotation, except for the propeller governor drive and the starter drive of the V-1710-F2L, F5L, and F10L engines. All instrument and vent connections are identical and similarly located except for the coolant pump inlet cover. The cover provides a straight bottom inlet on the V-1710-F2R, F2L, F5R, F5L, F10R and F10L models, while the cover of the F3R, F4R, F20R and F21R engines provide an elbow inlet from the rear of the engine.

(3) INTERNAL DIFFERENCES.

(*a*) REDUCTION GEAR ASSEMBLIES.—The detail parts of the reduction gear assemblies are similar on all models. The scavenger oil pump, located in the reduction gear housing, is so constructed that its porting can be shifted at assembly to accommodate either right or left hand rotation. The pump is assembled one way in the V-1710-F2R, F3R, F4R, F5R, F10R, F20R, and F21R models, but it is assembled with reverse porting for the V-1710-F2L, F5L, and F10L models. The reduction gear and pinion oiler nozzle is always located on the out of mesh side of the gears. The nozzle is assembled on the left of the reduction gears in the right hand engines, and on the right in the left hand engines.

(*b*) CRANKSHAFT AND CONNECTING ROD ASSEMBLIES.—The crankshaft and connecting rods are assembled identically on all models. The reduction gear coupling and dynamic balancer are installed at the front and rear respectively, on crankshaft, in the the case of right hand rotation engines. These two parts are interchanged and the whole crankshaft and rod assembly turned end for end when installed in the crankcases of a left hand engine.

(*c*) ACCESSORY DRIVE HOUSING ASSEMBLIES. — The gear arrangement of the various drives and the supercharger impeller provide the major differences in the complete accessory housing assemblies. The following list in conjunction with the gear train diagrams, Figures 24, 25 and 26 indicates these differences.

1. SUPERCHARGER IMPELLER.

a. Rotating guide vanes used on all models except F2R and F2L.

b. No rotating guide vanes used on V-1710-F2R and F2L.

2. SUPERCHARGER PINION AND DRIVE GEAR RATIOS.

Model	*Supercharger Ratio*
V-1710-F2R and F2L engines	6.44:1
V-1710-F5R and F5L engines	7.48:1
V-1710-F10R and F10L engines	7.48:1
V1710-F21R engine	7.48:1
V-1710-F3R engine	8.80:1
V-1710-F4R engine	8.80:1
V-1710-F20R engine	9.60:1

3. GENERAL DISCUSSION OF CONSTRUCTION AND PURPOSES.

a. CYLINDER BLOCK CONSTRUCTION.

(1) The engine has two cylinder blocks of six cylinders each. The cylinder block consists essentially of three parts: the head, the cylinder barrels and the coolant jacket. The head is a one piece aluminum alloy casting. Carburized, hardened cylinder barrels are shrunk into this head. A one piece cast aluminum alloy coolant jacket encloses the six cylinder barrels and is fastened to the head by a number of studs. The bottom of the coolant jacket is secured to each cylinder barrel by a nut threaded to the clinder barrel, thus completing the coolant seal for the head-cylinder-jacket unit.

(2) Each head-cylinder-jacket assembly is mounted on the upper half of the crankcase by fourteen stud bolts extending through the head. These studs clamp the cylinder barrels securely between the head and the crankcase and, in addition, transmit all of the power stroke forces directly to the crankcase. This construction relieves the head-barrel shrink-fit joint of all operating loads, and provides additional rigidity to the crankcase.

(3) The combustion chamber is of the roof-head type and provides the rigidity necessary to hold the shrink fit over the cylinder barrel. Each cylinder is equipped with two intake valves, two exhaust valves and two diametrically opposed spark plugs. Each pair of valves is set at $22\frac{1}{2}°$ with the cylinder axis permitting the use of a simple and compact valve actuating mechanism. The combustion chamber presents a relatively small area to the cylinder gases and the valve passages are adequate for high speed operation. Exhaust valve seats are forged alloy steel, faced with Stellite. Intake valve seats are alloy steel on late model engines and aluminum bronze on early models.

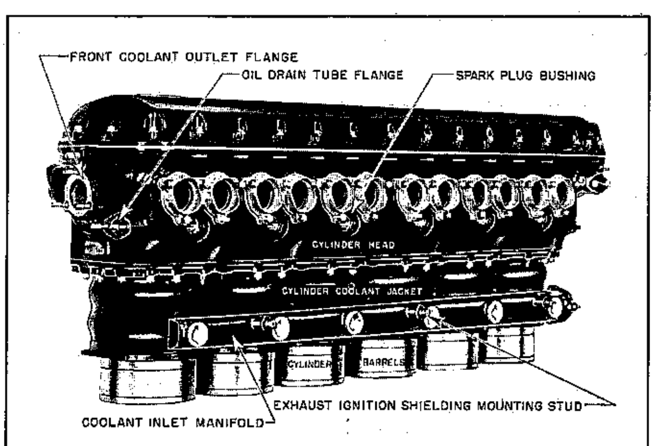


Figure 8—Left Hand Cylinder Bank.

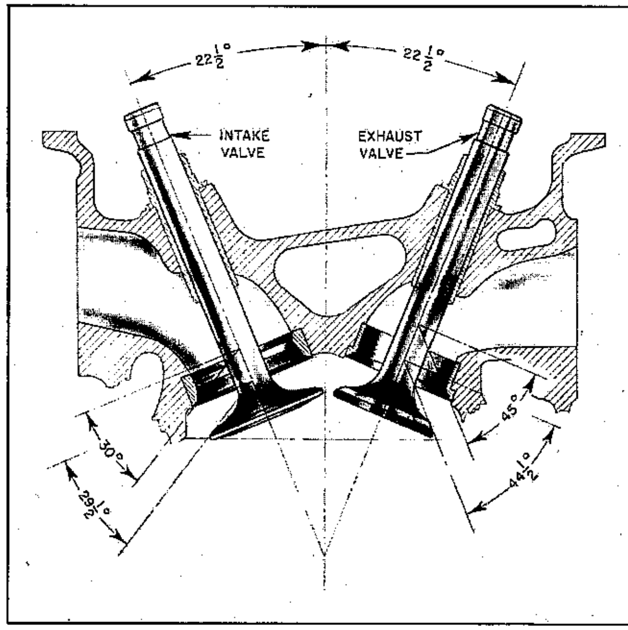


Figure 9—Angles of Valves and Valve Seats.

(4) The intake and exhaust valves are sodium cooled tungsten steel, faced with Stellite. The intake valve is faced to $29\frac{1}{2}°$ and the exhaust valve is faced to $44\frac{1}{2}°$.

b. VALVE OPERATING MECHANISM.

(1) The valve operating mechanism consists essentially of six rocker arm assemblies operated by a single camshaft on the top of each cylinder block. Each camshaft is driven through separate inclined shafts by bevel

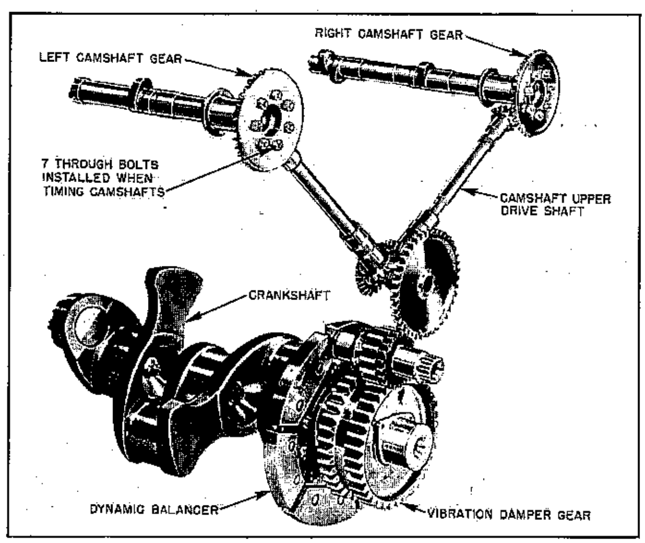


Figure 10—Camshaft Gear Train (Early Type).

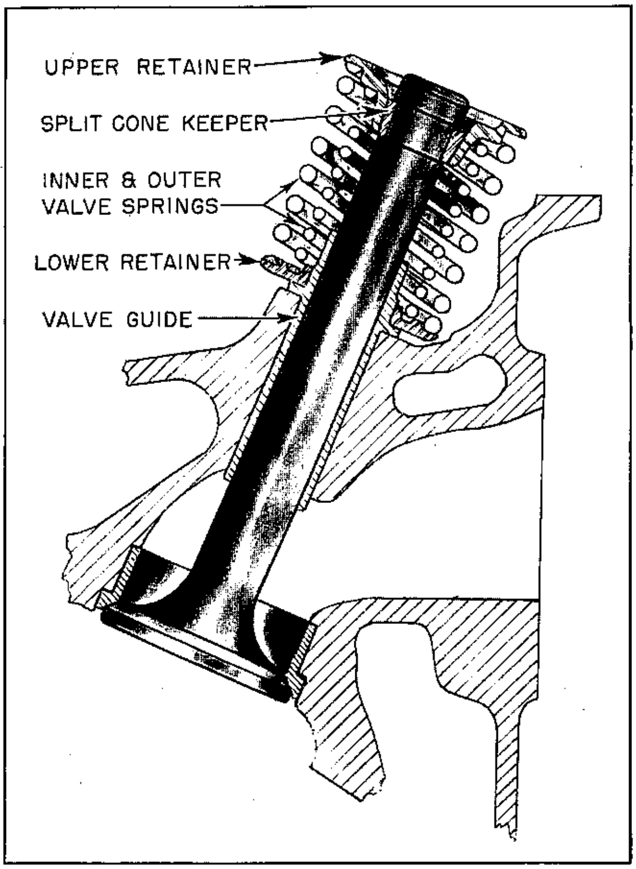


Figure 11—Valve Spring Arrangement.

gears from the accessory housing camshaft drive gear which in turn is driven through a spur gear-train from the crankshaft. Refer to Figure 10.

(2) The camshaft is mounted centrally over the cylinder head in eight plain bearings, one of which is a large flanged bearing located adjacent to the camshaft drive gear. This bearing provides axial location for the camshaft and takes the reaction from the drive gear.

(3) The camshaft gear is secured to the camshaft by means of seven bolts. This gear has 36 teeth which, in combination with the seven bolts, provides a minimum angular timing increment of 1.4° of camshaft rotation or 2.8° of crankshaft rotation.

(4) The valve actuating mechanism is lubricated by oil under pressure received through the camshaft locating bearing from the inclined shafts. The oil flows through the hollow camshaft to all the camshaft bearings. In addition, a small hole in the heel of each cam furnishes splash lubrication to the valve stem ends, the cam follower needle bearings, and the rocker arm bearings. The cylinder heads are provided with drains at both ends to return the oil to the crankcase sump.

c. CRANKSHAFT CONSTRUCTION.

(1) The crankshaft is a conventional six throw, seven bearing, counter-balanced type, machined all over. The counterweights are welded directly to the steel forging, providing a compact design. At each end of the shaft is a nine bolt flange, both flanges being identical.

(2) A pendulum type dynamic balancer is bolted to the flange at the accessory housing end of the crankshaft, to minimize the effect of two node crankshaft torsional vibration.

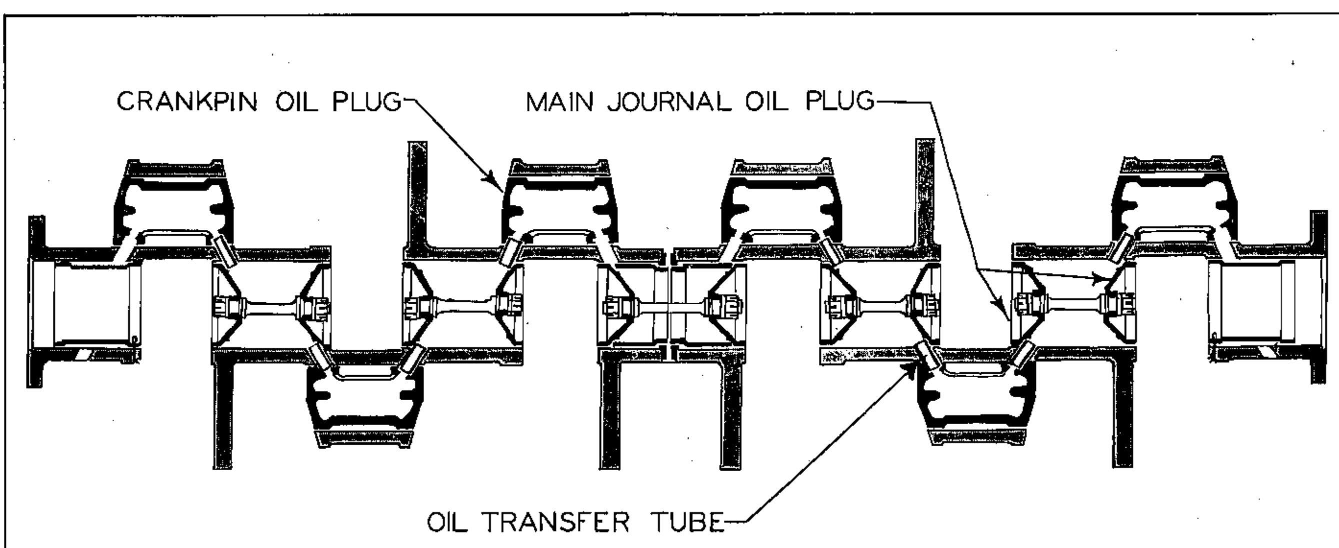


Figure 12—Crankshaft Oil Plug Arrangement.

(3) The driving mechanism for all accessories mounted on the rear of the engine is connected to the crankshaft through an internal spline in the dynamic balancer hub.

(4) An internally splined coupling is bolted to the flange at the propeller end of the crankshaft to provide a drive connection for the reduction gear assembly.

(5) All crankshaft journals are hollow and are fitted with removable aluminum alloy plugs. These provide a passage for lubricating oil and also permit the collection of foreign particles and possible oil sludge in the crankpin plugs.

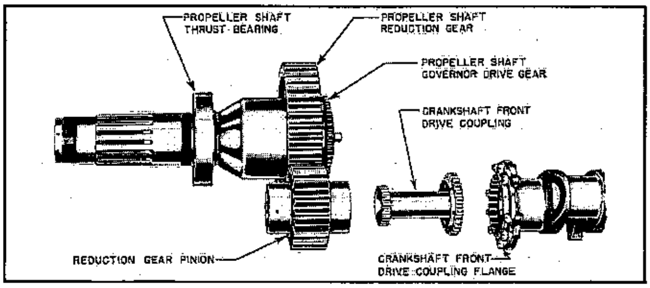


Figure 13—Reduction Gear and Coupling.

d. CRANKCASE AND OIL PAN CONSTRUCTION.

(1) The crankcase consists of two rigidly constructed aluminum alloy castings parted on the horizontal centerplane of the crankshaft, and a magnesium alloy oil pan. Fourteen long studs, set in each deck of the crankcase upper half, hold the cylinder blocks in place. Long studs are set in the parting face of the crankcase upper half and are located in the main bearing webs on both sides of each main bearing bore. These studs pass through the lower crankcase half and are used to clamp the two crankcase halves over the main bearing shells. Hollow dowels through which the main bearing studs pass locate the two halves with respect to each other. The cases are sealed completely around the outer parting flange by a series of closely spaced studs. Two engine mounting bosses are located on each side of the crankcase upper half.

(2) All seven main bearings are flanged steel shells, made in halves, and lined with a thin layer of bearing alloy. The bearings are located axially by the steel flanges and are prevented from rotating by a dowel in the lower crankcase at each bearing. The center main bearing is provided with bearing alloy faced flanges which bear on the center crankcheeks and provide axial location for the crankshaft.

(3) The magnesium alloy oil pan casting is bolted to the bottom of the crankcase lower half and provides breathing passages between the crankcase compartments. Oil is scavenged from both ends of the oil pan.

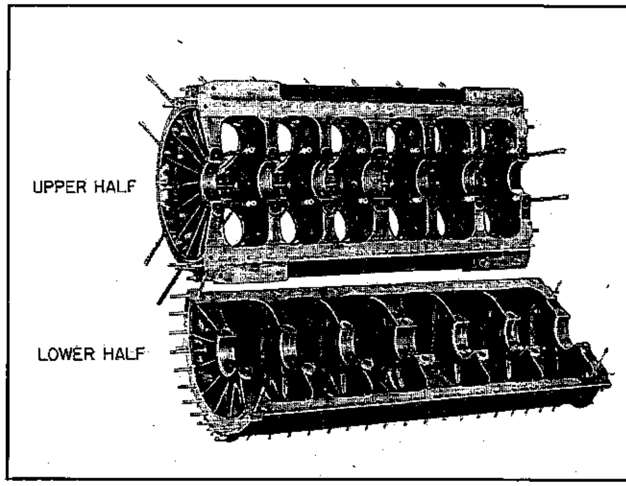


Figure 14—Crankcase Upper and Lower Halves.

e. CONNECTING ROD CONSTRUCTION.

(1) The connecting rods are of the forked and blade type, each forged to an "I" section column and machined all over. The bearing consists of two halves of a flanged steel shell lined with bearing alloy which bears on the crankpin journal and a bearing alloy overlay on the center portion of the outside diameter. The overlay acts as a journal for the blade rod. The bearing shells are clamped in the forked rod by two caps and four bolts. A short dowel in each forked rod cap prevents rotation of the bearing. The blade rod fits around the overlay and is held in place by a single cap and two bolts. A bronze piston pin bushing is pressed into the small end of each connecting rod.

(2) The connecting rod bearings are lubricated by oil under pressure from the crankshaft. The piston pins are splash lubricated.

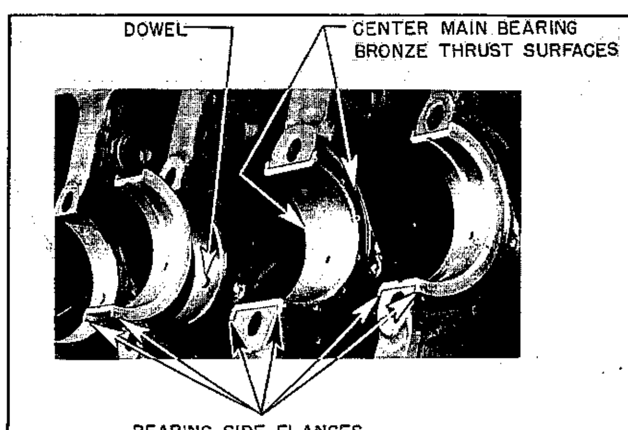


Figure 15—Main Bearing Lower Halves.

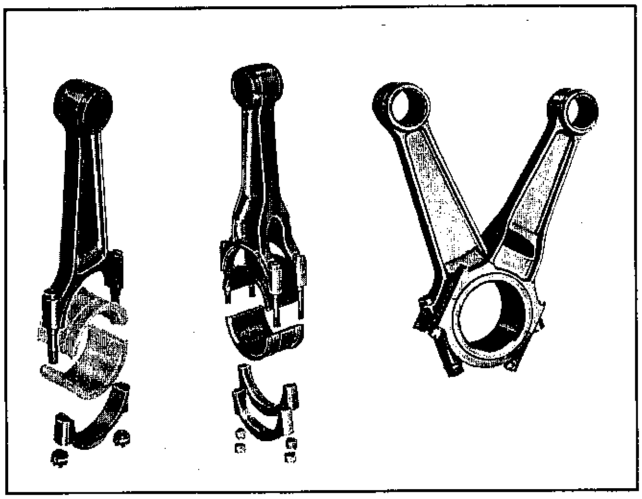


Figure 16—Connecting Rods—Blade, Forked, with Bearing.

f. PISTON AND PISTON PIN CONSTRUCTION.

(1) The pistons are machined from aluminum alloy forgings and the underside of the piston heads are grid ribbed to facilitate cooling. Each piston has three compression rings above the piston pin and two oil rings in a single groove below the piston pin. The piston pin floats in the piston and is retained by two snap rings, one at each end of the pin.

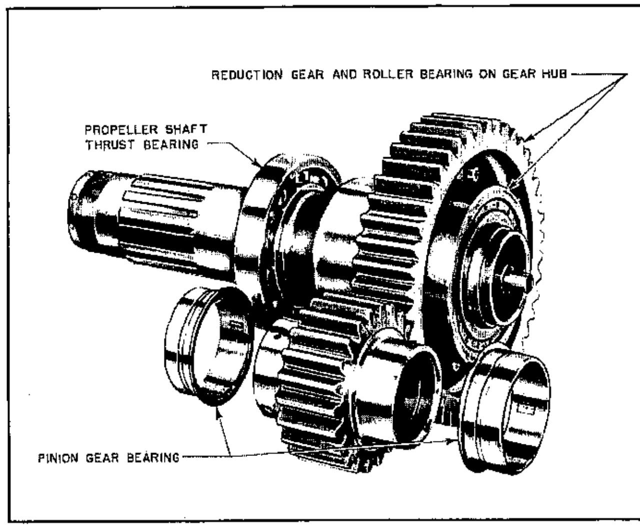


Figure 18—Reduction Gear and Bearings.

g. REDUCTION GEAR AND PROPELLER SHAFT.

(1) A two to one reduction between the crankshaft and the propeller shaft is provided by two external spur gears. Both the reduction gear and pinion as well as the propeller shaft are encased in a short nose section consisting of two aluminum alloy castings which are stud mounted to the front face of the crankcase.

(2) The reduction gear is bolted to a flange on the propeller shaft. The propeller shaft is supported at the front by a ball thrust bearing in the nose of the reduc-

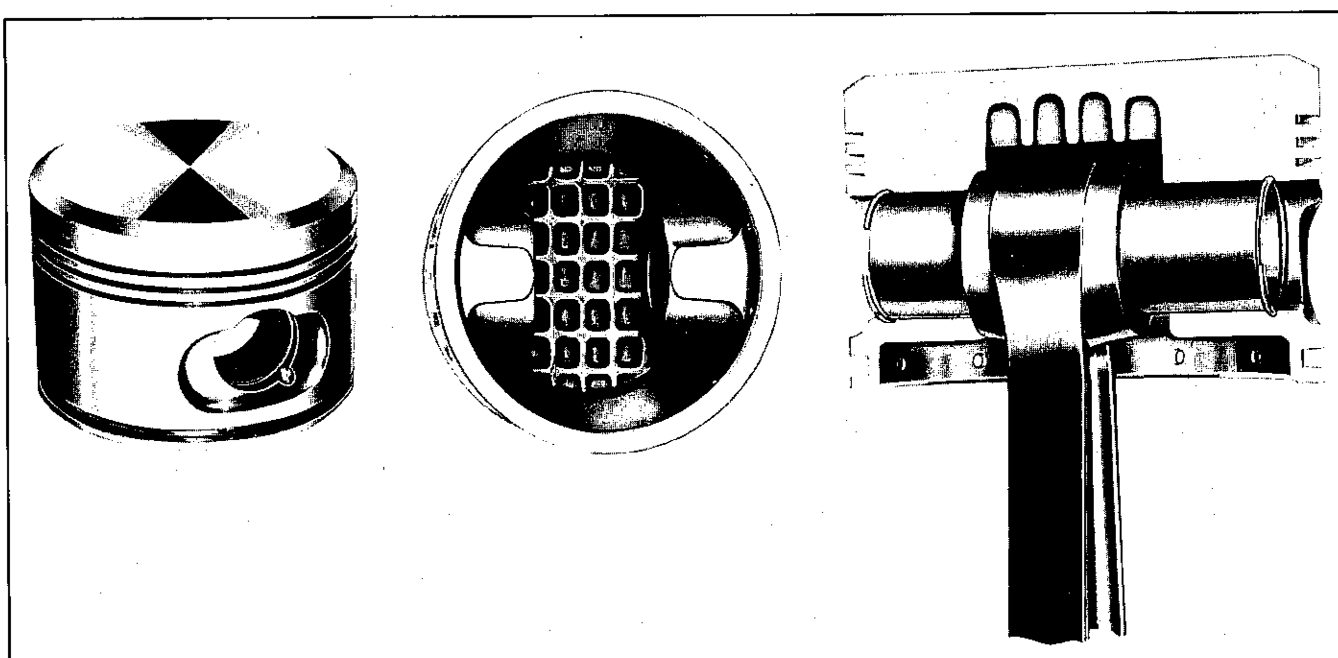


Figure 17—Piston—Side, Bottom and Sectional Views.

tion gear housing, and at the rear by a large roller bearing.

(3) The pinion gear is mounted between two plain bearings and is driven from the crankshaft through a flexible splined coupling. The propeller thrust line is located 8¼ inches above the centerline of the crankshaft.

(4) A front scavenge oil pump is located inside the reduction gear housing. A propeller governor drive is provided on the rear of the housing in the vee between the cylinder blocks. The housing is also provided with oil passages to supply both governor and engine oil pressure to the propeller shaft for hydromatic propeller operation. (Refer to Oil Pressure System Diagram, Figure 20.)

(5) The teeth of the reduction gears are lubricated by an oil nozzle supplying three jets of oil on the out of mesh side of the gears. For engines of right hand propeller rotation, the oil nozzle is located to the left of the point of mesh of the two gears. For engines of left hand rotation, the nozzle is placed to the right.

h. COOLING SYSTEM.

(1) A centrifugal coolant pump located on the bottom of the accessories housing supplies coolant to each cylinder block at two inlets, one located at the coolant jacket and the other at the rear of the cylinder head. The outlet scroll of the pump terminates in a tee with two flanged ends, and is connected by pipes to the dual inlets of each cylinder block. The coolant is admitted to the bottom of the cylinder block through an inlet manifold which is cast the full length of each jacket. These manifolds have an orifice at each cylinder barrel which meters the coolant flow. The inlet at the rear of the cylinder head provides a direct rapid flow over the combustion chambers. The Coolant System Diagram, Figure 19, illustrates the cooling principle used on these engines.

i. LUBRICATION SYSTEM.

(1) The moving parts throughout all engine models are supplied with oil from a pressure lubrication system. A diagrammatic sketch of the pressure system is

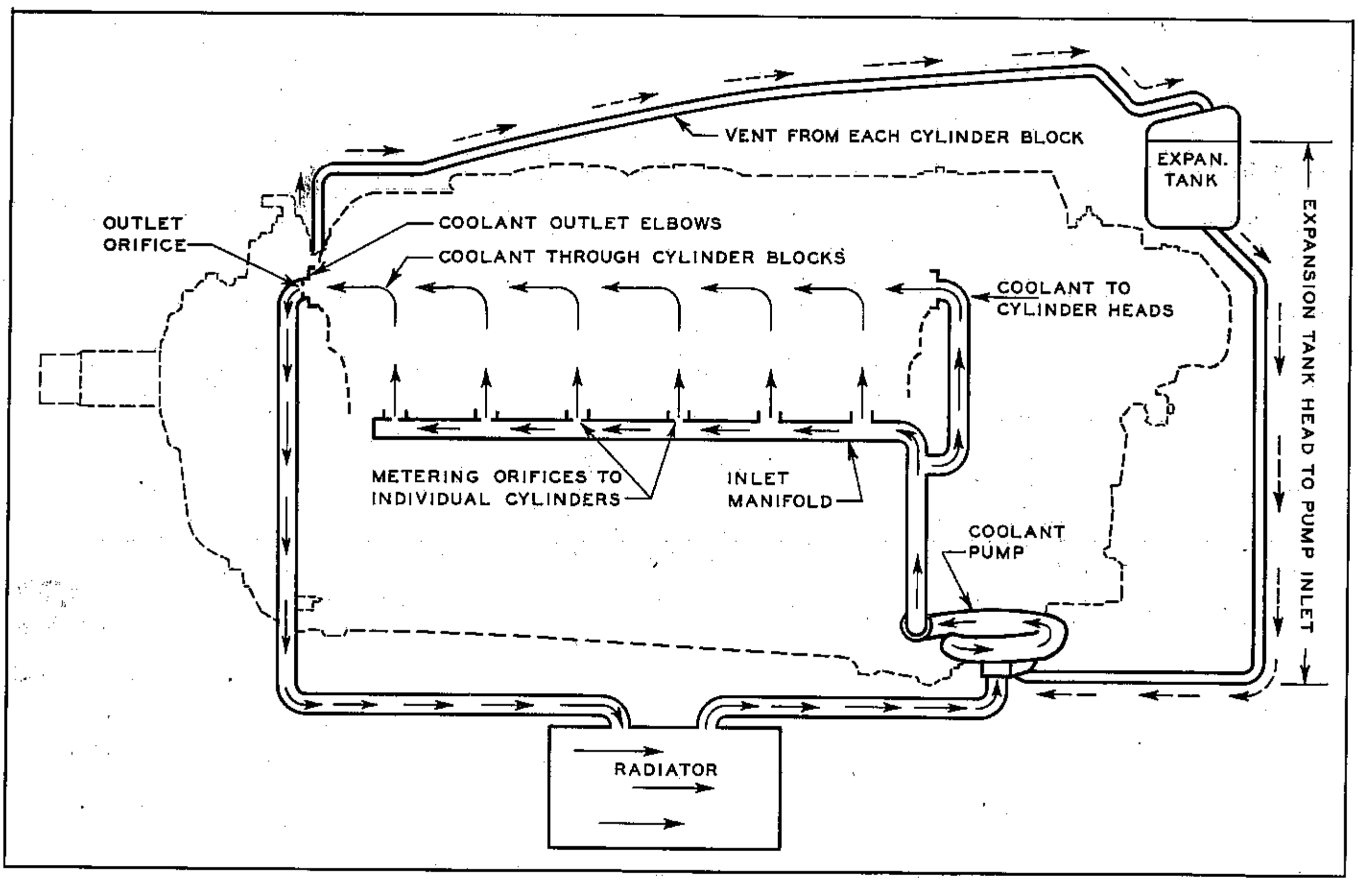


Figure 19—Typical Engine Cooling System.

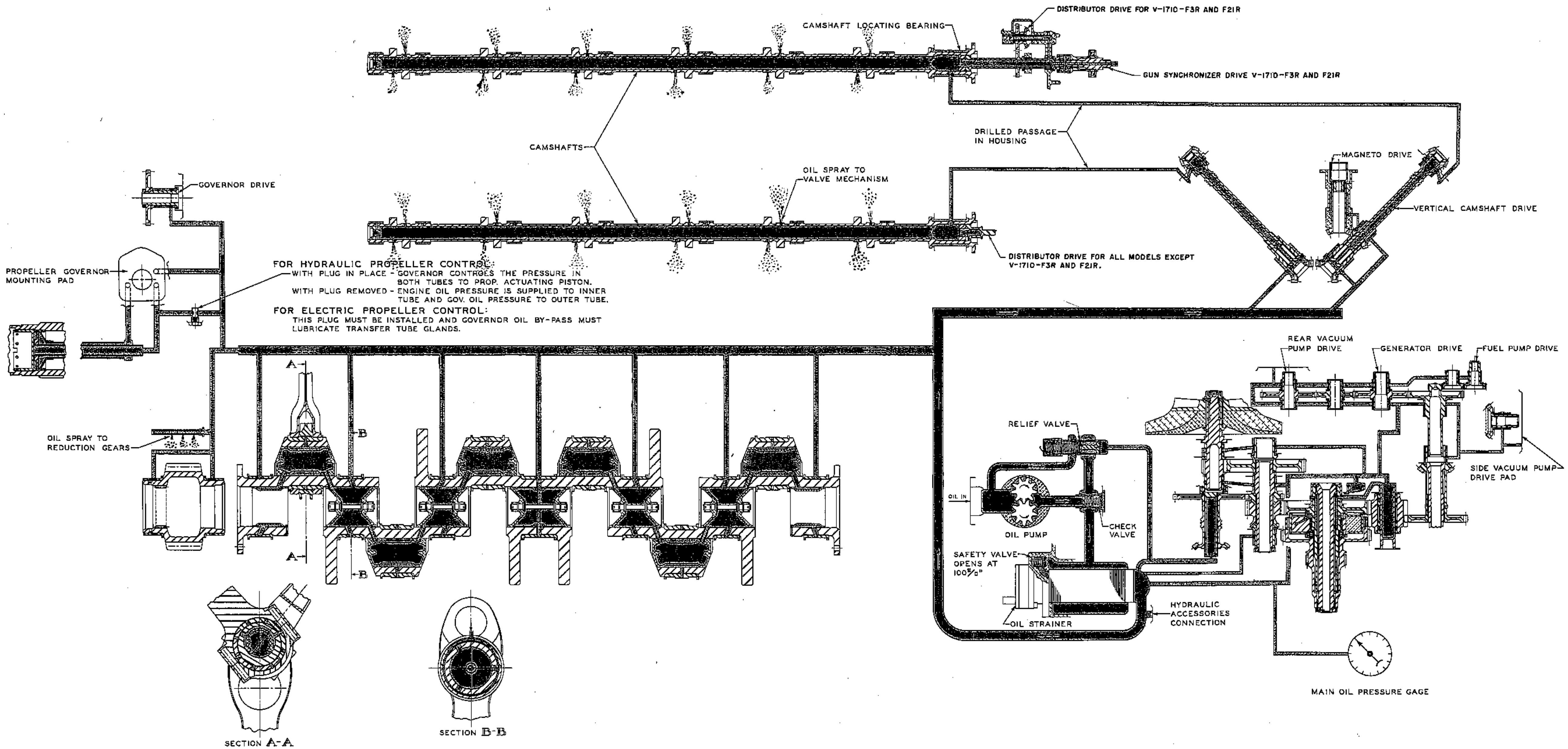


Figure 20—Oil Pressure System Diagram.

ALLISON "F" TYPE ENGINE LUBRICATION SYSTEM

V-1710-27, 29, 39, 49 & 53 ENGINES

E-4, V-1710-35 TYPE ENGINE APPLIES WITH EXCEPTION OF REDUCTION GEAR

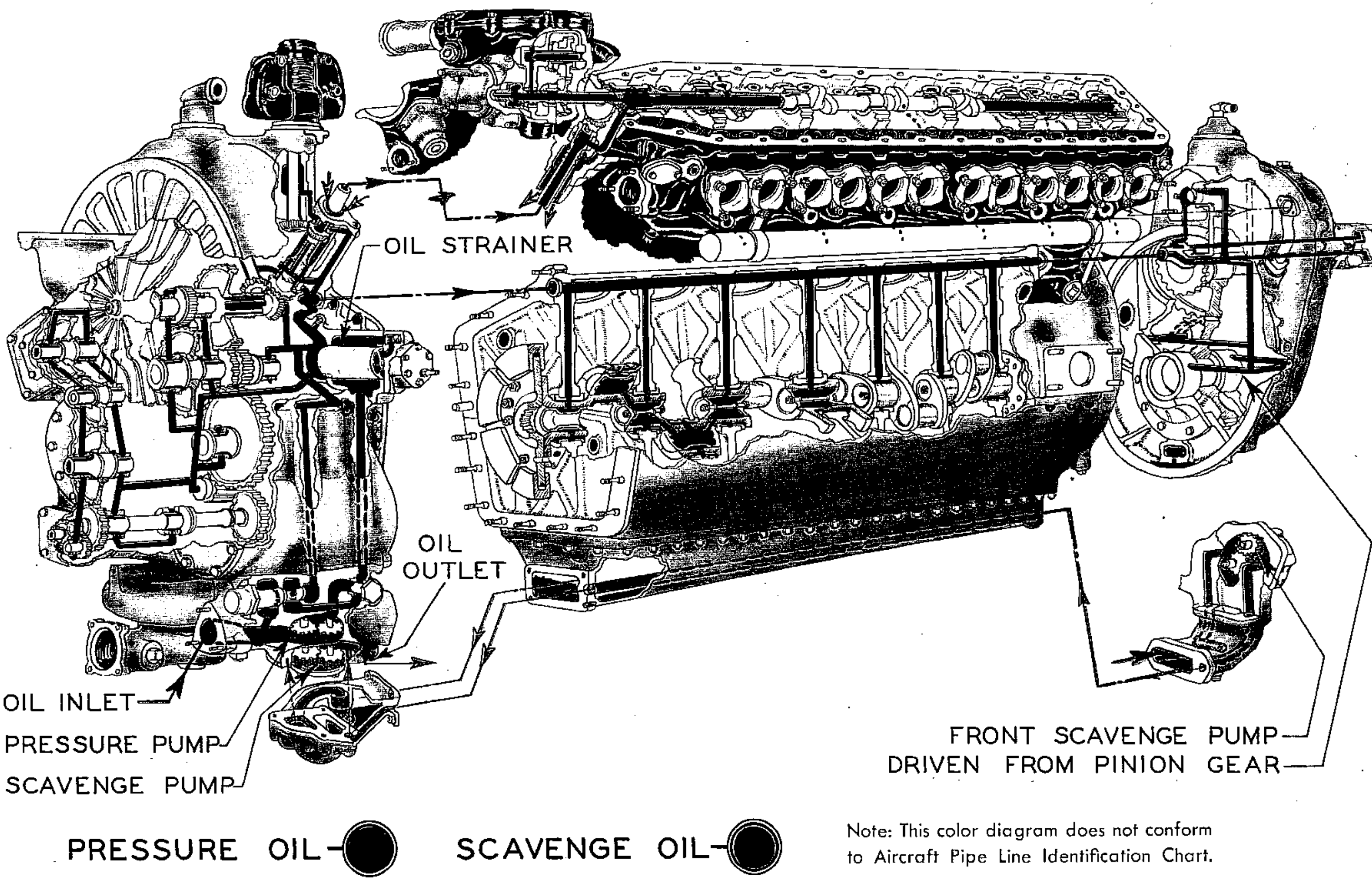


Figure 21—Cutaway "F" Type Engine Illustrating Main Principles of Lubrication

shown in Figure 20. Constant pressure is maintained by a single pressure pump in combination with a pressure sensitive relief valve. All oil to the engine passes through the Cuno disc type strainer which incorporates a safety by-pass valve. Provision for scavenging in both propeller up and propeller down positions is made by locating the main scavenge pump at the rear of the engine and an auxiliary scavenge pump in the reduction gear housing. The main scavenge pump and the pressure pump are arranged as a unit on the lower right hand side of the accessories housing. All pumps are of the conventional spur gear type.

(2) Oil, supplied to the pressure pump from an external tank, is delivered to the exterior of the Cuno oil strainer through a spring loaded check valve which prevents oil flow from the tank to the system when the engine is stopped. A pressure of only one pound per square inch from the oil pump side of the valve is necessary to provide check valve response in opening. Static oil pressure from the outlet of the Cuno strainer is maintained against the piston of the adjustable, spring opposed, balanced relief valve which by-passes excess oil directly from the outlet to the inlet of the pressure pump. This arrangement maintains a constant oil pressure in the engine with increased strainer restriction within the capacity of the oil pump. The relief valve is accessible for cleaning or pressure adjustment without removal of the oil pump.

(3) Oil is distributed from the strainer outlet to the moving parts of the engine. A large tube in the crankcase upper half connects with a drilled passage in each main bearing web, conveying oil to the main bearings. The main bearing and crankpin journals are fitted with aluminum alloy plugs and are all interconnected to carry oil to the connecting rod bearings from which it is thrown to lubricate the cylinder walls and the piston pins. A continuation of this tube provides oil for the plain bearings of the reduction gear pinion, the spray on the reduction gear, the propeller governor, and the governor drive bearings. From the governor pad, oil is carried to the propeller shaft to provide the operating pressures for hydromatic propeller installations.

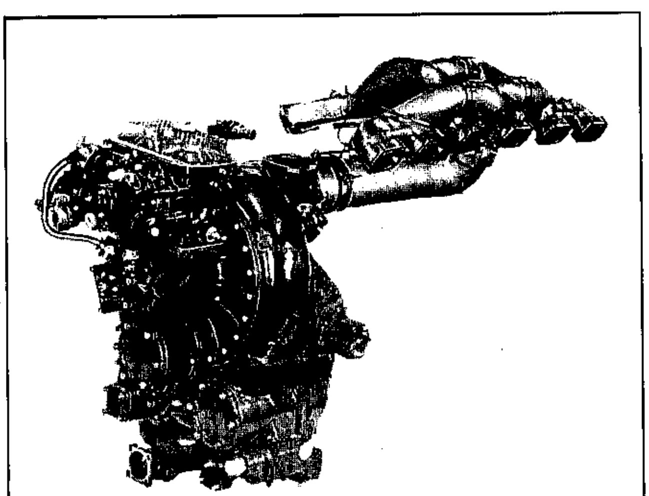


Figure 22—Induction System.

(4) A branch from the lead to the crankcase tube carries oil to the inclined shafts of the camshaft drive and to the magneto drive shaft bearing. Oil is carried through the inclined shafts to the camshaft locating bearing where it enters the hollow camshaft for lubrication of the camshaft bearings and the valve mechanism from a hole in each journal and in the heel of each cam.

(5) Three oil passages distribute oil from the Cuno strainer outlet to the supercharger and all accessory drives contained in the accessories housing.

(6) Oil drains through passages at both ends of the camshaft compartment to the crankcase. In level or propeller-end-up positions, all oil drains to the oil pan and is scavenged by the main scavenge pump from the accessories end of the oil pan. The second scavenge pump is located in the reduction gear housing and is driven by the oil plug of the reduction gear pinion. Its inlet is located low in the forward portion of the reduction gear housing so that oil will be scavenged in near vertical positions. The discharge from the forward scavenge pump is carried to the outlet of the main scavenge pump so there is but one oil outlet to the engine.

j. INDUCTION SYSTEM.

(1) A forced induction system is used to supply the fuel-air mixture to the cylinders. Carburetion of the fuel is obtained by use of a single Bendix-Stromberg two barrel injection carburetor. The carburetor consists of a throttle body, a regulator unit, and control unit mounted on the supercharger inlet cover. An external pipe carries the fuel from the control unit to the injection nozzle located to the rear of the supercharger elbow, where it is injected directly on the supercharger impeller. The location of the carburetor and nozzle adapter is shown in Figure 22.

(2) The supercharger is contained in the accessories housing. The impeller unit consists of two parts, one part having 15 radial blades with strengthening webs between each blade, and another part made up of 15 matched curved guide vanes. The parts maintain their matched relation through a common spline on the impeller shaft. The fuel-air mixture flows through a dif-

fuser passage having six curved vanes and then through a scroll to a single supercharger outlet in the vee of the cylinder blocks. A branched manifold system distributes the mixture to all 12 cylinders.

k. ACCESSORIES DRIVES.

(1) All accessories, with the exception of the propeller governor drive and the front oil pump, are mounted on the rear of the engine. A cast magnesium alloy accessories housing is stud mounted on the rear face of the crankcase and contains the supercharger and drives for the starter, oil pump, camshaft drive, fuel pump, generator, vacuum pump, two tachometers, magneto, and the coolant pump. Gear train diagrams are shown in Figures 24, 25 and 26.

(2) All accessories drives except the starter and oil pump are taken through a hydraulic vibration damper. The starter drive is taken off the rigid outer member of the damper, and is unaffected by damper operation. The oil pump is driven through bevel gears from the starter shaft. The outer member of the hydraulic damper is splined to the hub of the dynamic balancer, on the rear of the crankshaft. An inner member is connected to the outer rigid member by a flexible quill shaft, and reacts against the outer member through a hydraulic medium to minimize single node low frequency torsional vibration.

(3) One spur gear train from the flexible member of the vibration damper drives the accessory housing camshaft drive mechanism and the supercharger. In right hand rotation engines, this gear train is geared directly to the damper. In left hand rotation engines, an idler gear is used between the gear train and the damper. A second gear train is used to drive the generator, vacuum pump, the fuel pump, and the coolant pump. In right hand rotation engines, this gear train is driven through an idler gear from the damper, while in left hand rotation engines the train is driven directly from the damper.

l. IGNITION SYSTEM.

(1) Ignition is supplied by a dual high tension Scintilla magneto driven at 1½ times crankshaft speed. The voltage from the magneto is distributed to spark plugs through two separate engine driven high tension distributors. The magneto timing is fixed and fires the exhaust plugs 6° before the intake plugs. All high tension ignition cables are shielded to prevent radio interference.

(a) Two spark plugs are used for each cylinder. On all engines except the F21R, the exhaust plugs are cooled by a blast of cooling air conducted from the airplane slipstream through two aluminum alloy spark plug cooling manifolds. The exhaust plugs on the F21R are cooled by airplane cowling design.

(b) The distributor housings of the V-1710-F5R, F5L, F10R, and F10L engines are provided with connections for supercharging of the ignition at the distributor finger. The distributor housings of the other models covered have no connections for supercharging.

Fuel-Air Flow through Supercharger

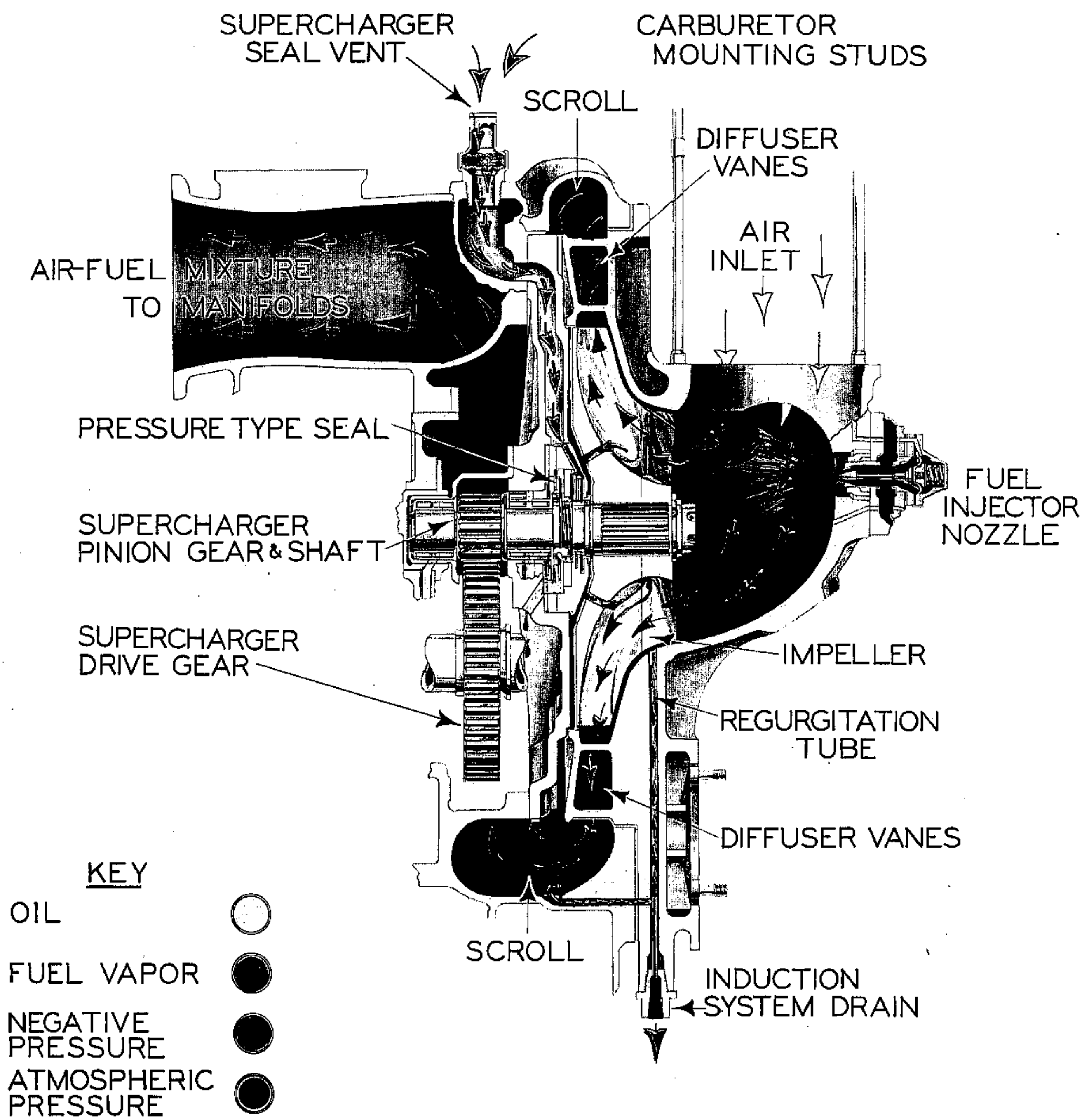
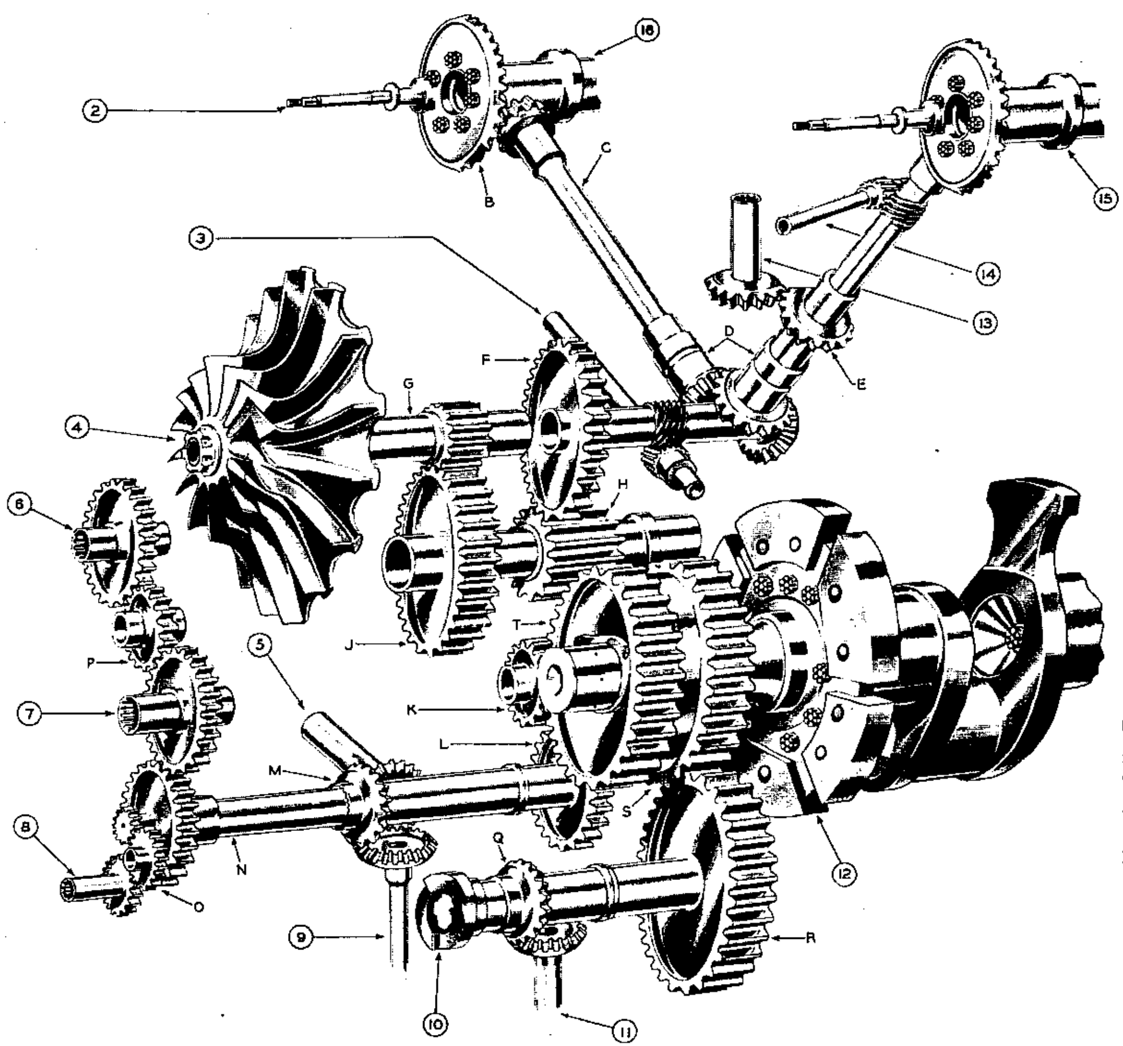


Figure 23—Fuel-Air Flow Through Supercharger



NUMERICAL KEY

2-DISTRIBUTOR DRIVE
3-ELECTRIC TACH. DRIVE
4-SUPERCHARGER IMPELLER
5-SIDE VACUUM PUMP DRIVE
6-REAR VACUUM PUMP DRIVE
7-GENERATOR DRIVE
8-FUEL PUMP DRIVE
9-COOLANT PUMP DRIVE
10-STARTER SHAFT JAW
11-OIL PUMP DRIVE
12-DYNAMIC BALANCER
13-MAGNETO DRIVE
14-MECHANICAL TACH. DRIVE
15-RIGHT CAMSHAFT
16-LEFT CAMSHAFT

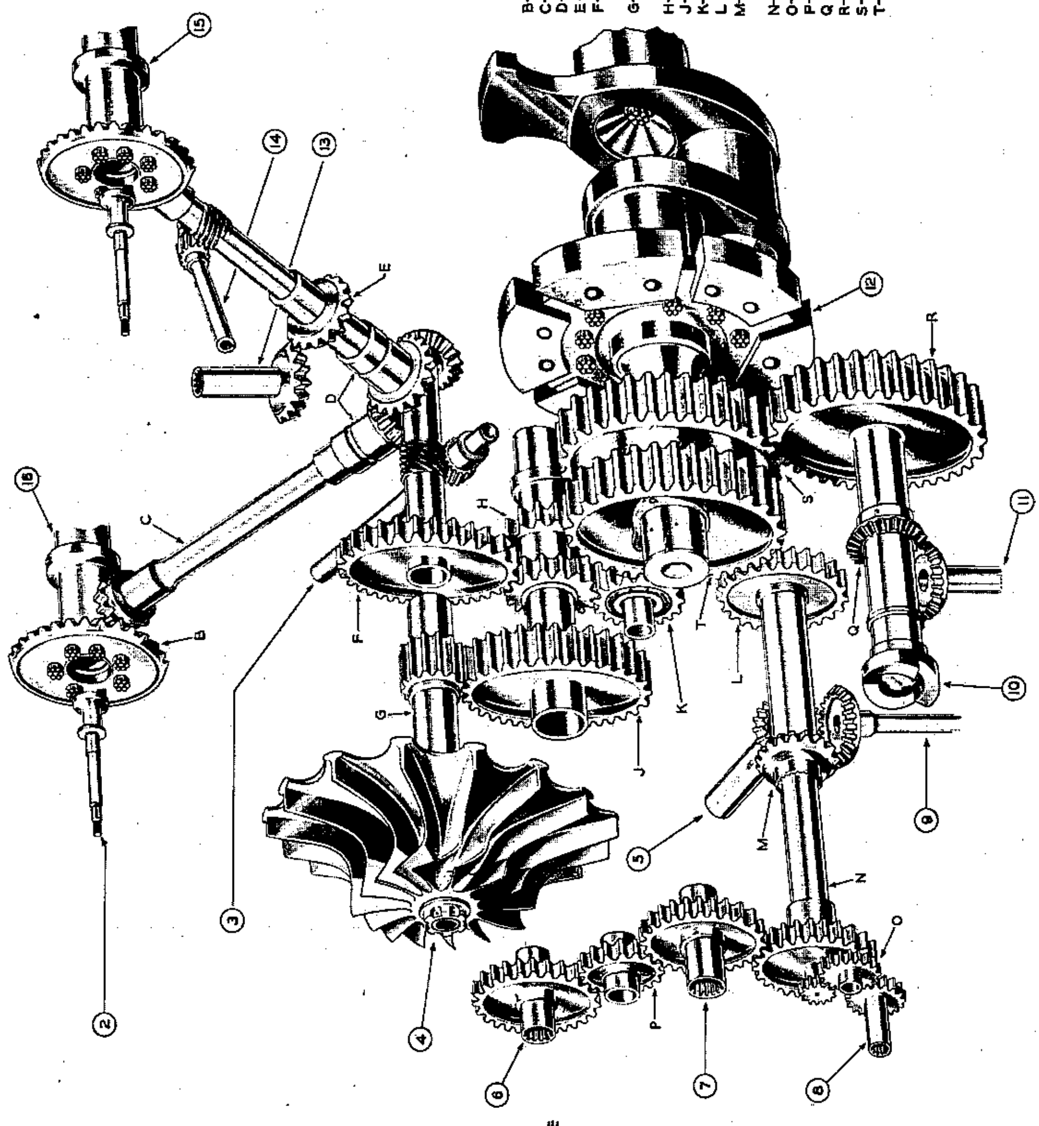
ALPHABETICAL KEY

B-CAMSHAFT GEAR
C-CAMSHAFT UPPER DRIVE SHAFT
D-CAMSHAFT LOWER DRIVE SHAFT
E-MAGNETO DRIVE SHAFT DRIVE GEAR
F-ACCESSORY HOUSING CAMSHAFT DRIVE GEAR
G-SUPERCHARGER IMPELLER PINION SHAFT
H-SUPERCHARGER DRIVE IDLER GEAR
J-SUPERCHARGER IMPELLER DRIVE GEAR
K-ACCESSORIES DRIVE IDLER GEAR
L GEN. & PUMP DRIVE SHAFT GEAR
M-GEN. & PUMP DRIVE SHAFT COOLANT PUMP DRIVE GEAR
N-GEN. & PUMP REAR DRIVE SHAFT
O-FUEL PUMP DRIVE IDLER GEAR
P-REAR VACUUM PUMP IDLER GEAR
Q STARTER SHAFT OIL PUMP DRIVE GEAR
R-STARTER SHAFT GEAR
S-HYDRAULIC DAMPER-OUTER SHAFT
T-HYDRAULIC DAMPER-INNER SHAFT

Figure 24—Gear Train Diagram for R.H. Prop. Rotation Engines without Gun Synchronizer Drives.

ALPHABETICAL KEY

B-CAMSHAFT GEAR
C-CAMSHAFT UPPER DRIVE SHAFT
D-CAMSHAFT LOWER DRIVE SHAFT
E-MAGNETO DRIVE SHAFT DRIVE GEAR
F-ACCESSORY HOUSING CAMSHAFT DRIVE GEAR
G-SUPERCHARGER IMPELLER PINION SHAFT
H-SUPERCHARGER DRIVE IDLER GEAR
J-SUPERCHARGER IMPELLER DRIVE GEAR
K-ACCESSORIES DRIVE IDLER GEAR
L GEN. & PUMP DRIVE SHAFT GEAR
M-GEN. & PUMP DRIVE SHAFT COOLANT PUMP DRIVE GEAR
N-GEN. & PUMP REAR DRIVE SHAFT
O-FUEL PUMP DRIVE IDLER GEAR
P-REAR VACUUM PUMP IDLER GEAR
Q STARTER SHAFT OIL PUMP DRIVE GEAR
R-STARTER SHAFT GEAR
S-HYDRAULIC DAMPER-OUTER SHAFT
T-HYDRAULIC DAMPER-INNER SHAFT



NUMERICAL KEY

2-DISTRIBUTOR DRIVE
3-ELECTRIC TACH. DRIVE
4-SUPERCHARGER IMPELLER
5-SIDE VACUUM PUMP DRIVE
6-REAR VACUUM PUMP DRIVE
7-GENERATOR DRIVE
8-FUEL PUMP DRIVE
9-COOLANT PUMP DRIVE
10-STARTER SHAFT JAW
11-OIL PUMP DRIVE
12-DYNAMIC BALANCER
13-MAGNETO DRIVE
14-MECHANICAL TACH. DRIVE
15-RIGHT CAMSHAFT
16-LEFT CAMSHAFT

Figure 25—Gear Train Diagram for L.H. Prop. Rotation Engines.

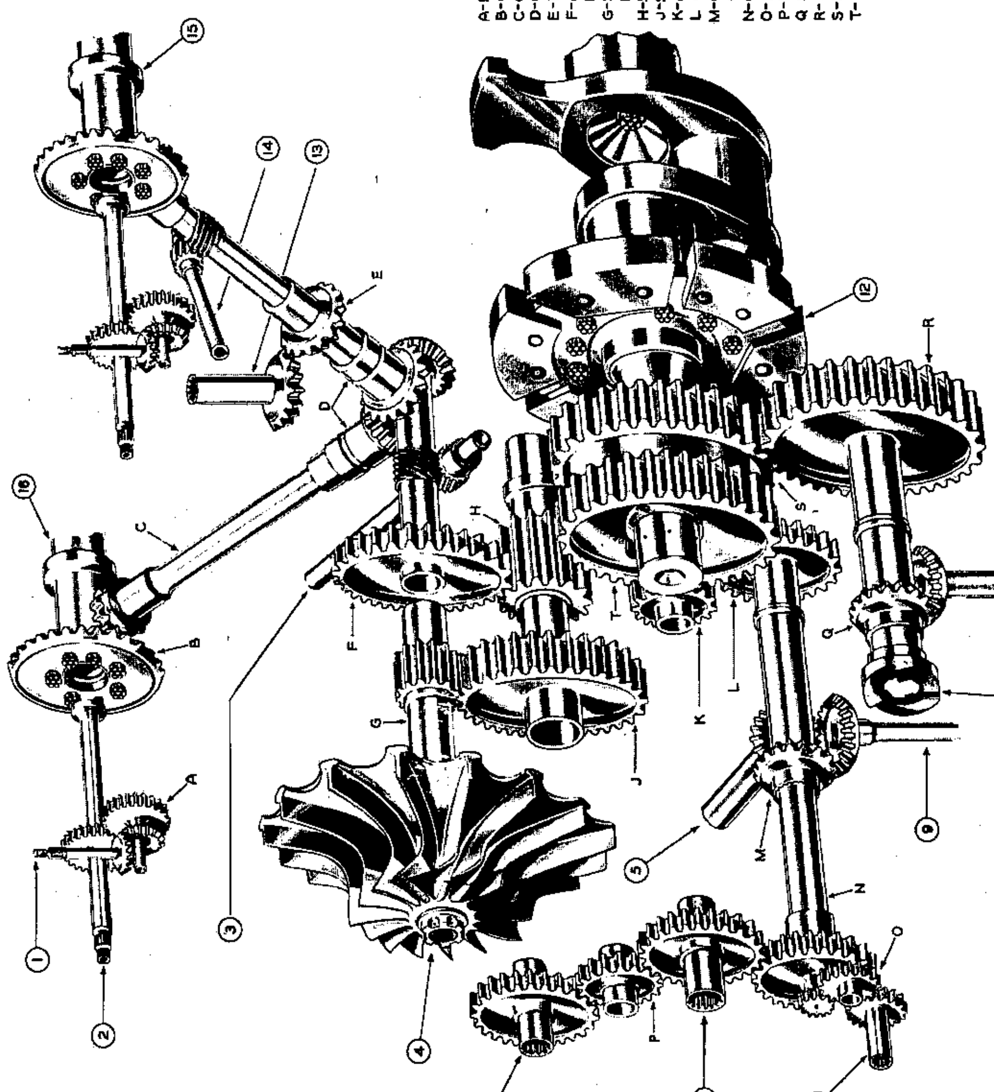


Figure 26—Gear Train Diagram for R.H. Prop. Rotation Engines with Gun Synchronizer Drives.

SECTION III

OPERATION AND FLIGHT INSTRUCTIONS

1. GENERAL.

The following information is of particular interest to the pilots and the personnel who must be familiar with the operations of these engines. It is important that these instructions be closely observed, regardless of any information furnished by sources other than the engine manufacturer. Any revisions to these instructions are applicable only when approved by the engine manufacturer. Failure to observe these instructions will void the contract warranty on these engines.

2. GENERAL OPERATING INSTRUCTIONS.

a. PROCEDURE PRELIMINARY TO STARTING.

(1) Before the engine is started the first time after installation or whenever the carburetor has been drained, observe the special procedure for cold weather starting outlined in paragraph *b.* (3) and (4) following.

(2) Make certain the ignition is "Off" and turn the engine slowly by hand four or five revolutions to insure that the combustion chambers are clear. If fuel or oil are present in the combustion chambers, it must be removed. Be sure the spark plugs are dry before replacing them.

CAUTION

Starting the engine with excessive oil or fuel in the cylinders may result in bent or broken rods.

(3) Set the oil cooler shutter to the "Closed" position.

(4) Set fuel valves in accordance with airplane instructions.

(5) Set the propeller to *manual* low pitch position.

(6) Set throttle at 1/10 open position corresponding to 1000 to 1200 R.P.M.

(7) Place intercooler shutters in "OPEN" position. (F2R and F2L Engines only.)

(8) Carburetor air heater should be in "Full-Off" or "Cold" position.

(9) Next set the mixture control in "Idle Cut-Off" and operate the wobble pump to obtain a fuel pressure of 4 lbs./sq. in. The desired normal operating fuel pressure is 12 - 16 lbs./sq. in. However, as fuel begins to discharge into engine at 4 lbs./sq. in. pressure, this pressure should not be exceeded when using wobble pump prior to turning over engine.

(10) Energize starter.

(11) On a cold engine, prime with 2 to 4 full strokes of the priming pump; on a warm engine, 1 to 2 full strokes are sufficient. The priming system is independent of the carburetor. Caution must be exercised not to overprime the engine in view of the extreme effectiveness of the priming system. No priming action nor fuel discharge is accomplished by pumping the engine throttle on a pressure type carburetor.

(12) Turn on ignition switch to "Both On" position.

b. STARTING.

(1) Engage starter and maintain fuel pressure of 4 lbs. by wobbling as propeller begins to turn. When engine starts firing, move mixture control to "Automatic Rich."

(2) Avoid excessive operation of the wobble pump to prevent flooding the supercharger inlet in case the engine does not start immediately. If the engine gives the impression of being loaded in starting, it can be cleared by moving mixture control to "Idle Cut-Off" position for brief intervals while the engine is turning over. In case of definite overloading, turn the engine over with the switch off, the mixture control in "Idle Cut-Off" and the throttle wide open.

(3) If, after a cold start, a heavy viscous oil is indicated by high or fluctuating oil pressure when the engine R.P.M. is increased for "warm up", the oil dilution valve control switch may be held "On" for 1 to 2 minutes to further dilute the oil and correct this condition. Over dilution of the oil will result in dangerously low oil pressure, and should be avoided if possible.

(4) If the engine should stop, return the mixture control immediately to "Idle Cut-Off" position to avoid flooding the engine with fuel, as the fuel pressure will build up to normal operating pressure of 16 lbs./sq. in. when engine starts firing.

(5) If engine is not overloaded, another start can be made using the same procedure. In case of overloading, the next start should be attempted without priming.

c. WARM UP AND GROUND TEST

(1) Warm up the engine prior to take off, until proper lubrication and engine operation are assured for flight. Do not exceed 1400 R.P.M. until the engine maintains not more than 75 pounds of oil pressure with-

out fluctuation, with an accompanying definite rise in oil temperature to at least 40°C (104°F). The oil gage reading may fluctuate during the start of the warm up, but this fluctuation should gradually lessen with increase of oil temperature until the gage reading remains nearly steady.

(2) The requirement of 75 pounds of oil gage pressure applies only when the oil dilution system is not in operation.

(3) When the above oil conditions become established and with mixture control still at "Automatic-Rich", set the propeller for "Take-Off". Increase the engine R.P.M. to check the operation of engine and instruments at the higher speeds. A speed of 2600 R.P.M. and a limit of 37.8 inches of manifold pressure should not be maintained for periods in excess of 20 to 30 seconds while on the ground.

(4) Under Extreme Icing Conditions, the carburetor air heater should be set for "Heat On" position during warm up. This will eliminate an ice formation developing in the carburetor, with a possible malfunctioning carburetor in the take-off.

NOTE

On engines equipped with intercooler shutters the shutters should be moved toward the "CLOSED" position if there is an indication of carburetor ice.

(5) After the engine is warm and functioning properly, make the single magneto ignition check with an engine speed at 2300 R.P.M. and not over 30 in. Hg. manifold pressure. On all engines with automatic manifold pressure regulators, the r.p.m. drop in speed should be read on the tachometer *immediately* after the switch to single magneto, before the automatic manifold pressure regulator has had time to compensate for the drop. The loss in speed should not exceed 100 R.P.M. when switching from double to single magneto. The ignition switch should be returned to the "Both On" position before switching to the other single magneto.

CAUTION

Single magneto checks should be made in as short a time as possible and should not exceed 15 seconds duration.

(6) After each engine warm-up period, two routine ground checks should be made on the automatic manifold pressure regulator.

(a) The first ground check consists of advancing the cockpit throttle control lever very gradually until the manifold pressure reaches 32" Hg. Note any unusual operating characteristics at various engine speeds up to the 32" Hg. manifold pressure. If the engine operates normally thru this cycle and then retards to idling speed, it is evident the regulator unit is operating.

(b) The second will be done as follows: Set the propeller in "AUTOMATIC" position for take-off R.P.M. Open the throttle control to obtain 2400 R.P.M., and note the manifold pressure with this fixed throttle and manifold pressure setting. Vary the engine speed from 2400 R.P.M. to 2000 R.P.M. by manually increasing the propeller pitch. The manifold pressure should remain constant within 1 inch Hg.

(7) MANIFOLD PRESSURE GAGE DRAIN.—When warming up the engine, the shut-off cock for the manifold pressure gage drain will be opened for a few seconds to clear the line of liquids and vapors. This will be done at idling speeds only.

(8) FUEL SUPPLY.—Functioning of the fuel system will be tested in accordance with airplane operating instructions.

d. TAKE-OFF.

(1) Set the propeller in *automatic position* for 3000 R.P.M. or slightly less. Set mixture control in "Automatic Rich". The detent stop position on cockpit throttle quadrant should not be exceeded during take-off except when War Emergency Powers are used as specified in the Specific Operating Instructions and in paragraph *e.* (6) below.

(2) Carburetor air heater should always be in the "Cold" position for "Take-Off".

(3) Do not start take-off with coolant temperature above 125°C (257°F).

(4) During take-off, Take-Off power for a maximum period of 5 minutes is permissible.

CAUTION

War Emergency Rating may be used only if automatic manifold pressure regulator is installed (Refer to Par. *e.* (5) following).

e. FLIGHT.

(1) The engine R.P.M., oil inlet temperature, oil pressure and coolant outlet temperature give the most satisfactory indication of the engine's performance. If any of these appear irregular, the engine should be throttled, and if the cause is not apparent, a landing should be made to investigate and remove the trouble.

(2) Consult the Specific Operating Instructions, in Section III for maximum and minimum oil temperature and for coolant temperature limitations.

NORTH AMERICAN P-51 INSTRUMENTS AND CONTROLS

1-OIL-COOLANT SHUTTER CONTROL
2-THROTTLE
3-MANUAL MIXTURE CONTROL
4-PROP. GOVERNOR CONTROL
5-RADIATOR SHUTTER POSITION IND.
6-CARBURETOR HEAT CONTROL
7-FUEL TANK SELECTOR
8-OIL TEMPERATURE GAGE
9-FUEL PRESSURE GAGE
10-OIL PRESSURE GAGE
11-COOLANT TEMP. GAGE
12-PROP. CONTROL SWITCH
13-PROP. CIRCUIT BREAKER
14-IGNITION SWITCH
15-PARKING BRAKE
16-OIL DILUTION SWITCH
17-STARTER SWITCH
18-AMMETER
19-PRIMER
20-MANIFOLD-PRESSURE GAGE
21-TACHOMETER
22-GENERATOR SWITCH

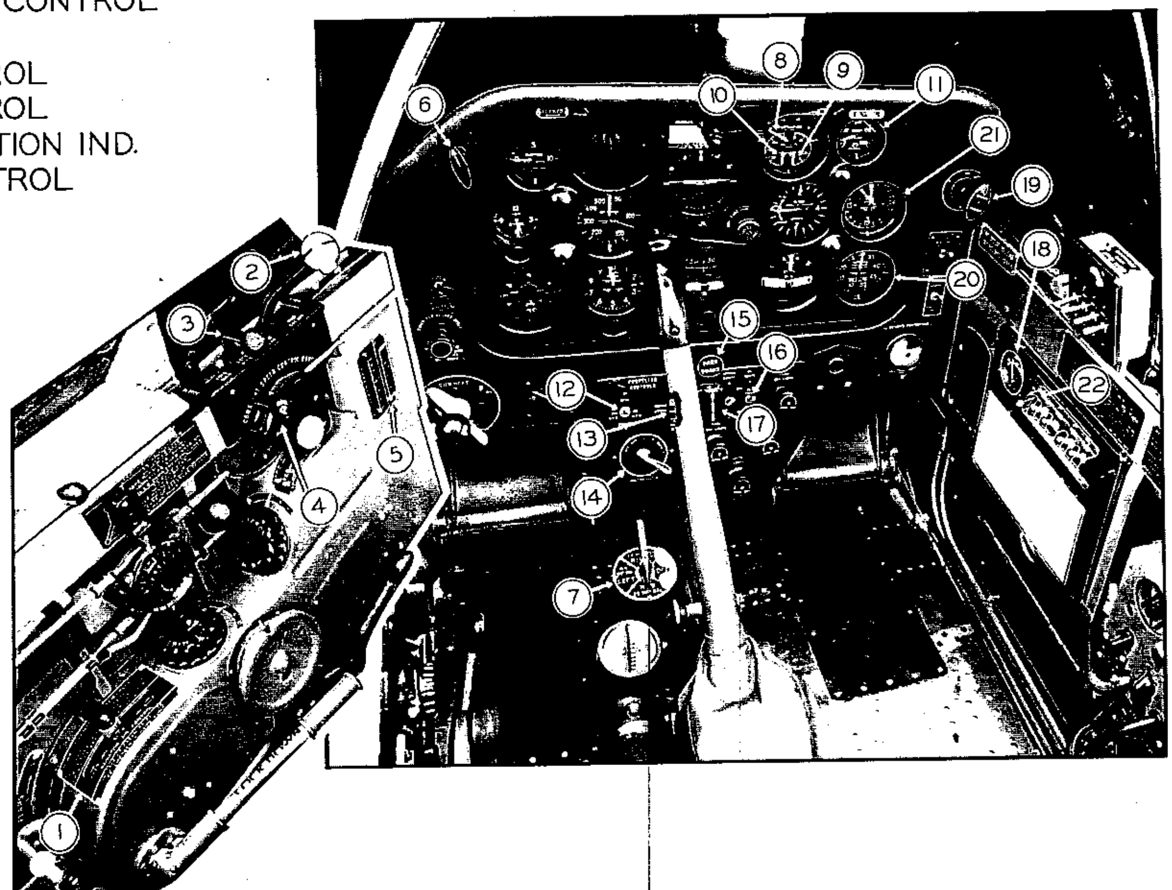


Figure 26A—Typical Instrument Panel and Controls in a P-51 Type Airplane

LOCKHEED P-38 E INSTRUMENT PANEL & CONTROLS

1-FUEL PRESSURE WARNING
2-RESERVE FUEL TANK GAGES
3-MAIN FUEL TANK GAGES
4-OIL SHUTTER POSITION INDICATOR
5-PROPELLER GOVERNOR CONTROLS
6-COOLANT SHUTTER CONTROLS
7-PROPELLER CIRCUIT BREAKERS
8-PROPELLER FEATHER SWITCHES
9-PROPELLER CONTROL SWITCHES
10-MANUAL MIXER CONTROL
11-THROTTLES
12-FUEL TANK SELECTOR
13-ENGINE PRIMER
14-PARKING BRAKE
15-GENERATOR SWITCH
16-OIL SHUTTER SWITCH
17-IGNITION SWITCHES
18-OIL DILUTION SWITCHES
19-STARTER SWITCHES
20-COOLANT TEMPERATURE WARNING
21-COOLANT TEMPERATURE GAGE
22-TACHOMETER
23-MANIFOLD PRESSURE GAGE
24-OIL PRESSURE GAGE
25-FUEL PRESSURE GAGE
26-OIL TEMPERATURE GAGE
27-CARBURETOR AIR TEMPERATURE GAGE
28-VOLTMETER
29-AMMETER

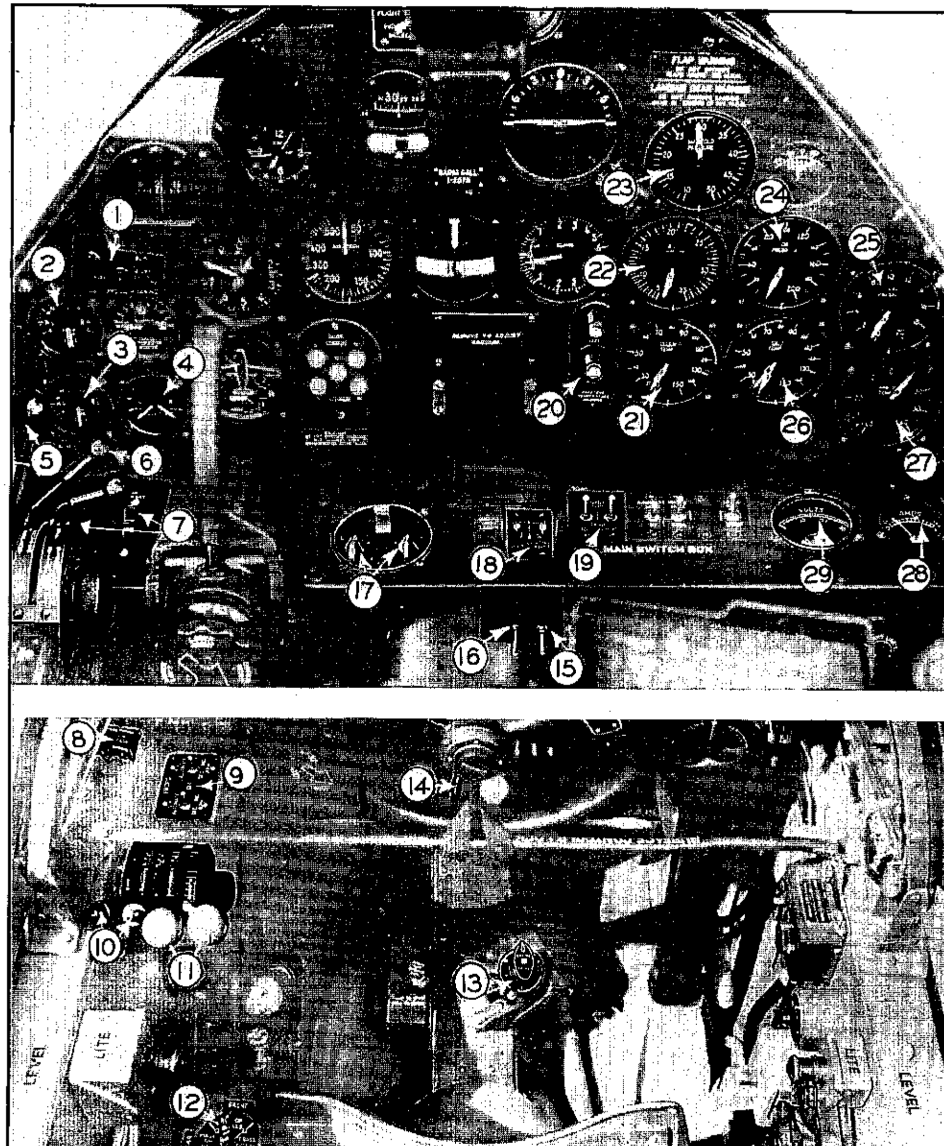


Figure 26B—Typical Instrument Panels and Controls in a P-38 Type Airplane

(3) If roughness is experienced at high altitude *when flying in "Auto-Rich" at or below maximum cruising manifold pressure and R.P.M.*, the mixture control may be set in "Auto Lean" as a means of correcting this condition.

(4) When cruising under icing conditions, it will be necessary to set the carburetor air heater in full "Heat On" position.

(5) When engine power is increased or decreased, the carburetor mixture control, propeller governor and throttle must be readjusted in the following order:

(a) INCREASING ENGINE POWER.

1. Adjust mixture control to obtain the fuel air ratio specified for the power desired.

2. Adjust propeller control to obtain the desired R.P.M.

3. Adjust throttle control to obtain the desired manifold pressure.

4. Readjust mixture control if necessary.

(b) DECREASING ENGINE POWER.

1. Adjust throttle control to obtain the desired manifold pressure.

2. Adjust the propeller control to obtain the desired R.P.M.

3. Readjust throttle if necessary.

4. Adjust the mixture control to obtain the desired fuel/air ratio.

(6) WAR EMERGENCY RATINGS. — War emergency ratings have been established in order to make available to the pilot in combat, a maximum manifold pressure which can be used for a period of five minutes under emergency conditions, within reasonable safety limits.

(a) These war emergency ratings are considerably in excess of the guaranteed ratings of these engines and the use of the war emergency ratings will appreciably decrease the service life of the engines and will necessitate special care in servicing. War emergency rating operation should, therefore, be held for use only where emergency conditions exist.

(b) War emergency ratings are not guaranteed power ratings but are maximum manifold pressure ratings, which may be used for emergency operation only when certain airplane and engine requirements have been met as outlined in the following paragraph:

(c) CONDITIONS UNDER WHICH WAR EMERGENCY RATINGS ARE PERMITTED.—War emergency ratings are to be used only when strict compliance to each of the following conditions is met:

1. In combat or precombat areas and then *only when emergency conditions exist.*

2. Only when 100 Octane fuel to Specification *No. AN-VV-F-781 amendment 5* is used.

3. The mixture control must be set in either "Auto-Rich" or "Full Rich" position.

4. The following spark plugs must be used: Champion Spark plugs C35S or C34S, or A.C. Spark plugs LS85.

5. Only when an automatic manifold pressure regulator is installed on the engine and the regulator setting modified as required for the particular engine model. Refer to Section IX paragraph 6 *d* (3)—Checking Regulator Setting for Required Maximum Emergency Manifold Pressure.

6. The engine throttle quadrant *must* be reworked for the incorporation of a *"break-through seal"* device.

a. A break-through of the seal mentioned above will call attention of the crew chief to the fact that the engine has been operated using war emergency ratings and he will make such special inspections and checks to insure that no damage to the engine has occurred.

b. Close coordination between the pilot, crew chief, and engineering officer will be required to keep an accurate record of the amount of time any engine has been operated at war emergency rating so that the engineering officer may determine when the engine should be pulled for tear-down inspection and reconditioning.

NOTE

The amount of time an engine will stand up under the use of war emergency ratings will vary considerably, dependent upon the area in which the airplane is located; i.e., operation in areas having sandy runways will be less than from operation off concrete runways. Variations will also be noticeable between extremely cold, moderate, and hot climates. The engineering officer will have to take these factors into consideration in establishing the time when engines should be removed. Close correlation with the experience of engineering officers in other areas will be valuable.

c. Maintenance personnel must take particular care to maintain the engines in first class operating conditions at all times on airplanes that are certified for W.E.R. operation.

7. All operation for war emergency ratings *must* be with the propeller control set in automatic position to maintain 3000 r.p.m.

IMPORTANT

Never change propeller governor setting from the 3000 R.P.M. automatic position while using W.E.R. manifold pressures. Changing propeller pitch to any setting below 3000 R.P.M. will increase the B.M.E.P. of the engine in excess of established safe limits and may result in detonation with extremely damaging results to the engine.

8. During the use of war emergency ratings, the following oil inlet temperatures *must not* be exceeded:

Spec. No. AN-VV-O-446	Grade 1120	95°C (203°F)
Spec. No. AN-VV-O-446	Grade 1100	80°C (176°F)

CAUTION

If oil dilution has been used, it is desirable that the engine be given 10 to 15 minutes operation at from 80 percent normal to military power prior to the use of war emergency ratings.

9. During the use of war emergency ratings, the coolant system should be filled with ethylene glycol to AN-E-2 specification and the coolant outlet temperature should not be permitted to exceed *125°C (257°F).*

10. Operation at war emergency ratings must be limited to periods of not more than 5 minutes each.

WARNING

During operation at war emergency ratings the manifold pressure should be reduced immediately if there is any indication of engine malfunctioning such as detonation, rough engine, overheating, etc.

f. LANDING

(1) When the engine is throttled to make a landing, set the mixture control in "Automatic Rich" position and the propeller in "Automatic" control for 2800 R.P.M.

(2) Care should be exercised to prevent rapid cooling of the engine during long glides. If the coolant temperature falls below 85°C (185°F) in a glide, close cowl and coolant flaps.

(3) In the event it is found necessary to interrupt the glide and make another landing approach, the throttle will be opened first, and then the propeller controls placed in high R.P.M. (low pitch) position.

(4) After landing and during taxying, the propeller controls will be placed in the high R.P.M. (low pitch) position.

g. STOPPING

(1) Idle at 600 to 800 R.P.M. to cool. Accelerate to 1000 to 1200 R.P.M. and set the mixture control lever in "Idle Cut-Off" position. When the engine ceases firing, the ignition switch should be turned to the "Off" position. The mixture control lever should be left in "Idle Cut-Off" position to prevent accidental starting. Turn fuel selector valve to the "Off" position.

(2) Before stopping the engine when a cold weather start is anticipated, hold the oil dilution valve control "On" for approximately four minutes with engine running at 800-1000 R.P.M. and stop the engine by moving the mixture control to "Idle Cut-Off" position; turn ignition switch "Off", continue to hold the oil dilution valve control switch "On" until the engine stops. Turn the dilution switch and fuel tank selector valve "Off".

(3) If the engine heat is excessive when operating the oil dilution valve control, the heat may evaporate the fuel out of the oil, leaving the normal high viscosity oil in the engine. When this condition is encountered, the engine should be stopped and allowed to cool for fifteen minutes, then re-started and prepared for a cold weather start as outlined in above paragraph.

h. OPERATION OF CARBURETOR HEATER.

(1) The carburetor heat control should be in "Heat Off" or "Cold" position for all normal operation. If ice is present or forming, it should be used in full "Heat On" position.

NOTE

Do not operate engine with the carburetor heat control in any intermediate positions between "Full Off" and "Full On". Since the carburetor heat control door in carburetor air scoop disturbs the air flow at carburetor venturi and impact metering tubes when partially open, improper fuel metering will result.

(2) In the engines equipped with automatic manifold pressure regulators, icing of the carburetor or induction system *will not be apparent* by reduced manifold pressure gage reading or power loss. The regulator will automatically open the throttle and maintain the selected manifold pressure and power. Therefore, if there is any

suspicion that an icing condition exists, heat should be applied to the carburetor immediately.

(3) The use of carburetor heat at low power (50% or below) will result in roughness of the engine when operating in "Automatic-Rich". Engine can be smoothed out by "leaning-out" the carburetor mixture slightly, but should not be operated at "Automatic-Lean", as this mixture position is too "lean" when using carburetor heat.

(4) If a loss of power or critical altitude is encountered, check the carburetor heat valve door for air leakage, as the ramming pressure and carburetor air intake flow will be decreased due to the air flow through the heat valve door.

(5) F5R, F5L, F10R and F10L installations do not include intercooler shutters, or carburetor air heaters. When operating these installations under icing conditions, open throttle to obtain operation of the turbine supercharger until a carburetor air temperature of 15° to 40°C (59° to 104°F) is obtained.

i. MIXTURE CONTROL.

(1) These engines are equipped with pressure type carburetors incorporating a mixture control having four main control settings, namely: "Full-Rich," "Auto-Rich," "Auto-Lean," and "Idle Cut-Off" in the order mentioned.

(2) Above desired cruising manifold pressure and speed, set the mixture control lever at "Auto Rich".

(3) At or below desired cruising manifold pressure and speed, the mixture control may be set at "Auto Lean" if fuel economy is important.

CAUTION

When operating in "Auto Lean" mixture adjustment, change to "Auto Rich" immediately before a rapid change in altitude or a change in cruising conditions is made.

j. AUTOMATIC MANIFOLD PRESSURE REGULATOR.

(1) The F4R and F20R engines are equipped with an automatic manifold pressure regulator that automatically maintains, within desirable limits, a selected manifold pressure from sea level up to the critical altitude of the supercharger.

(2) Engines equipped with an automatic manifold pressure regulator are operated in accordance with the same procedure and within the same limits given in the Specific Operating Instructions in this section. The pilot simply opens the cockpit throttle lever until the specified manifold pressure is obtained. The regulator will then maintain the specified manifold pressure by automatically opening or closing the carburetor throttle as the altitude is increased or decreased, thus eliminating the necessity of the pilot's adjusting the throttle.

(3) The pilot can change the manifold pressure at any time by operating the throttle lever in the cockpit in the same manner as operating engines not equipped with the Manifold Pressure Regulator.

CAUTION

If ice forms in the intake system, it will tend to reduce the manifold pressure, and the automatic regulator will open the carburetor throttle valve wider to maintain the desired pressure. This operation will be so gradual that the pilot will have no warning of the icing condition until carburetor throttle reaches wide open position and the manifold pressure begins to drop. When atmospheric conditions likely to cause icing are encountered, heat must be supplied to the carburetor air in order to prevent ice from forming.

(4) The detent in the cockpit throttle quadrant is set at the location which permits the use of the required take-off manifold pressure listed in the Specific Operating Instructions. There will be sufficient throttle travel remaining beyond the throttle detent to permit the use of maximum emergency manifold pressures.

(5) If the automatic operation of the pressure regulator does not function properly, the pilot can continue to control the carburetor throttle through mechanical linkage with the cockpit throttle lever. Further there is more than ample power available with manual operation to maintain level flight. However, in an extreme condition, where the regulator malfunctioning is tending to hold the throttle open, there may not be sufficient mechanical control for the pilot to close the carburetor throttle to the idling position. In this case, it may be necessary to cut off the ignition when landing.

k. TURBO-SUPERCHARGER CONTROL. — (F2R, F2L, F5R, F5L, F10R and F10L Engines Only.)

(1) The exhaust turbine driven supercharger, used with these engines is controlled automatically by the throttle control lever through an automatic regulator, which opens and closes the turbine supercharger waste gate. The regulator is connected to the throttle lever by a linkage which makes the supercharger ineffectual from closed to approximately ⅔ full-open throttle position but takes effect for the last ⅓ of the throttle

lever motion when the engine throttle is nearest the full open position. When operating in this last 1/3 section of the quadrant, where the turbo-supercharger is effective, the turbine lags behind the adjustment of the throttle. Care must be exercised therefore to avoid overrunning the desired manifold pressure and r.p.m. This is particularly true when power is applied suddenly such as take-off or aerobatics.

(2) The operation of these engines is similar to normal internal supercharged engines since the turbine supercharger control and the throttle are operated by the same lever. The operation of the throttle is essentially the same as that for engines without a turbine supercharger except for the lag in turbo-supercharger boost mentioned in the first paragraph and for the fact that throttle movement is relatively small for a given change in power compared to conventional airplanes.

l. FUEL AND OIL.

(1) Fuel must conform to Spec. AN-VV-F-781 (Amendment No. 5) when operating at the take-off and military powers designated in this section (Specific Operating Instructions). If inferior quality fuel conforming to Amendment No. 4 fuel is used, the take-off and military power manifold pressures must be reduced 10%.

(2) The grade of oil to be used in these engines should conform to Spec. AN-VV-O-446, Grade 1120 for summer use and Grade 1100 for winter use.

(*a*) GRADES OF ENGINE OIL AND USE.

The following table lists the two grades of Lubrication oil, Grade 1120 and Grade 1100, with recommended operating temperature ranges to allow for selecting the most suitable grade of oil to be used under various conditions. The overlap of ground temperatures is intentional to avoid setting up a requirement for changing from one grade to another unnecessarily, particularly when frequent temperature changes occur locally.

GRADE OIL	*1120*	*1100*
*Air Temp. At Ground	****4° C (40° F) and above	−7° C to 27° C (20° F to 80° F)
**Safe Maximum "Oil In" Temp.	95° C (203° F)	85° C (185°F)
***Safe Minimum "Oil In" Temp.	20° C (68° F)	10° C (50° F)

* The low temperatures listed for each grade in this column are sufficiently high that even under severe conditions, starting or warming-up difficulties should not ordinarily result. Under ordinary conditions of airplane storage, etc., the two grades specified may be used without starting difficulties at lower temperatures than specified in the table.

** Temperatures in excess of those listed in this column should not be the cause of forced landings, unless they are also accompanied by oil pressures below the prescribed minimum.

*** The minimum "oil in" temperatures listed are conservative, but continued operation below the limits specified should be avoided. Oil thermometers at these temperatures are, as a rule, unreliable; and it should be remembered that a steady oil pressure reading within the limits prescribed for the particular engine installation is a much more reliable indication of proper lubrication at low temperatures than the oil temperature reading.

**** At temperatures above 38°C (100°F) Grade 1120 oil will, of course, be used, but at such high air temperatures it may be impossible to stay within the 95°C (203°F) maximum "oil in" temperatures under some flight conditions.

Grade 1120 oil will be used for block testing engines, except when low temperature conditions require the use of Grade 1100 oil to facilitate starting. Oil used for block testing will be drained and replaced with new oil at the completion of each approximate 20 hours of engine running time, or at the completion of the test if this period falls within the duration of the test run.

m. DETONATION.

(1) INDICATIONS OF DETONATION.—Engine roughness does not necessarily indicate that detonation is present but when unusual roughness is encountered it may be due to detonation.

(2) CAUSES AND PREVENTION.

(*a*) Use of fuel of too-low octane rating. See that proper grade of fuel is used.

(*b*) A too-low fuel/air ratio. Do not operate at mixtures that are too lean.

(*c*) Operating engine above permissible limitations. Observe Specific Operating Instructions in this section.

(3) STOPPING DETONATION IMMEDIATELY IF PRESENT.

(*a*) Reduce the manifold pressure.

(*b*) Enrich the mixture.

(*c*) Reduce the carburetor air preheating to the minimum temperature at which icing of the carburetor may be prevented.

TABLE I—SPECIFIC OPERATING DATA

For Allison V-1710-F2R, F2L, F5R, F5L, F10R and F10L (Engines equipped with Turbo-Superchargers)

STANDARD CONDITIONS

Carb. Inlet Temp............................15.6°C
Carb. Inlet Press............................30″ Hg.
Exh. Back Press............................30″ Hg.

Max. Diving Manifold Pressure.............40″ Hg.
Max. Diving Speed....................3120 R.P.M.
Fuel....................................100 Octane

OPERATING CONDITIONS

Condition	Fuel Pressure #/Sq. In.	Eng. Oil Pressure #/Sq. In.	Oil Temp. °C Summer Oil	Oil Temp. °C Winter Oil	Coolant Temp. °C.
Desired	12-16	60-65	70-85	60-70	121
Maximum	16	80	90	75	125
Minimum	12	55	40	35	85
Idling	10	15			

PERFORMANCE DATA

Power Settings	Eng. Model	Horse Power	R.P.M.	Man. Press. ″Hg.	Rated Alt. Feet	Mixture Control Position	Consumption: Fuel U. S. Gal./Hr.	Consumption: Fuel Imp. Gal./Hr.	Consumption: Oil U. S. Qt./Hr.	Consumption: Oil Imp. Pt./Hr.
Take-Off	F2R & F2L F5R & F5L F10R & F10L	*1150 *1325 *1325	3000 3000 3000	39.4 47.0 47.0	S.L. S.L. S.L.	Auto Rich Auto Rich Auto Rich	115 148 148	96 124 124		
Military	F2R & F2L	*1150	3000	39.4	Turbo to 25,000	Auto Rich	115	96		
Rated	F5R & F5L	**1325 or **1240	3000 2800	47.0 44.5	Turbo to 25,000	Auto Rich	148 136	124 113		
Power	F10R & F10L	**1325 or **1240	3000 2800	47.0 44.5	Turbo to 25,000	Auto Rich	148	124		
Normal	F2R & F2L	1000	2600	36.5	Turbo to 25,000	Auto Rich	90	75	13.3	22.2
Rated Power	F5R & F5L	1000	2600	37.8	Turbo to 25,000	Auto Rich	100	84	14.0	23.4
100%	F10R & F10L	1100	2600	41.0	Turbo to 25,000	Auto Rich	110	92	15.5	26.0
Maximum	F2R & F2L	750	2280	30.6	Turbo to 25,000	Auto Rich	59	49	10.5	17.6
Cruising	F5R & F5L	750	2280	31.1	Turbo to 25,000	Auto Rich	64	54	10.5	17.6
75%	F10R & F10L	825	2280	33.5	Turbo to 25,000	Auto Rich	70	58	11.6	19.2
Maximum	F2R & F2L	670	2280	28.5	Turbo to 25,000	Auto Rich Auto Lean	47 43	39 36	9.0 9.0	15.0 15.0
Cruising	F5R & F5L	670	2280	29.0	Turbo to 25,000	Auto Rich Auto Lean	53 49	44 41	9.5 9.5	15.8 15.8
67%	F10R & F10L	737	2280	30.5	Turbo to 25,000	Auto Rich Auto Lean	58 53	48 44	10.8 10.8	18.0 18.0
Desired	F2R & F2L	600	2190	27.4	Turbo to 25,000	Auto Rich Auto Lean	42 38	35 32	8.0 8.0	13.4 13.4
Cruising	F5R & F5L	600	2190	27.5	Turbo to 25,000	Auto Rich Auto Lean	50 45	42 38	8.5 8.5	14.2 14.2
60%	F10R & F10L	660	2190	29.0	Turbo to 25,000	Auto Rich Auto Lean	55 50	46 42	9.8 9.8	16.4 16.4

*For 5 minutes only.
* For 15 minutes only.

TABLE II—SPECIFIC OPERATING DATA

For Allison V-1710-F3R, F4R, F20R and F21R
(Engines not equipped with Turbo-Superchargers)

STANDARD CONDITIONS

Carb. Inlet Temp.............................15.6°C
Carb. Inlet Press.............................30" Hg.
Exh. Back Press.............................30" Hg.
Fuel...100 Octane

Max. Diving Manifold Press.
F3R and F4R.............................42" Hg.
F20R...44.5" Hg.
F21R...40" Hg.
Max. Diving Speed......................3120 R.P.M.

OPERATING CONDITIONS

Condition	Fuel Pressure #/Sq. In.	Eng. Oil Pressure #/Sq. In.		Oil Temp. °C.		Coolant Temp. °C.
		F3R & F21R	F4R & F20R	Summer Oil	Winter Oil	
Desired	12-16	60-65	60-70	70-85	60-70	121
Maximum	16	80	85	90	75	125
Minimum	12	55	55	40	35	85
Idling	10	15	15			

PERFORMANCE DATA

Power Settings	Eng. Model	Horse Power	R.P.M.	Man. Press. "Hg.	Rated Alt. Feet	Mixture Control Position	Consumption: Fuel U. S. Gal./Hr.	Fuel Imp. Gal./Hr.	Oil U. S. Qt./Hr.	Oil Imp. Pt./Hr.
Take-Off	F3R	*1150	3000	45.5	S.L.	Auto Rich	132	110		
	F4R	*1325	3000	51.0	S.L.	Auto Rich	142	118		
	F20R	*1200	3000	51.5	S.L.	Auto Rich	148	124		
	F21R	*1325	3000	47.0	S.L.	Auto Rich	148	124		
War Emergency Rating	F3R	*1470	3000	56.0	S.L.	Auto Rich	163	136		
	F4R	*1550	3000	60.0	S.L.	Auto Rich	174	145		
	F20R	*1360	3000	57.0	S.L.	Auto Rich	170	142		
	F21R	—	—	—	—	—	—	—		
Standard Emergency Rating	F3R	*1330	3000	52.0	S.L.	Auto Rich	149	124		
	F4R	*1450	3000	55.0	S.L.	Auto Rich	161	134		
	F20R	*1300	3000	55.0	S.L.	Auto Rich	163	136		
	F21R	—	—	—	—	—	—	—		
Military Rated Power	F3R	*1150	3000	42.0	12,000	Auto Rich	132	110		
	F4R	**1150	3000	42.0	12,000	Auto Rich	132	110		
	F20R	**1125	3000	44.5	15,500	Auto Rich	138	115		
	F21R	**1325	3000	47.0	2,500	Auto Rich	148	124		
Normal Rated Power 100%	F3R	1000	2600	37.2	10,800	Auto Rich	105	88	13.3	22.2
	F4R	1000	2600	37.2	10,800	Auto Rich	105	88	14.0	23.4
	F20R	1000	2600	39.2	14,000	Auto Rich	109	91	14.0	23.4
	F21R	1100	2600	41.0	3,000	Auto Rich	110	92	15.5	26.0
Maximum Cruising 75%	F3R	750	2280	30.3	10,800	Auto Rich	67	56	10.5	17.6
	F4R	750	2280	30.3	10,800	Auto Rich	67	56	10.5	17.6
	F20R	750	2280	31.7	14,000	Auto Rich	74	62	10.5	17.6
	F21R	825	2280	33.5	S.L.	Auto Rich	70	58	11.6	19.4
Maximum Cruising 67%	F3R	670	2280	28.2	10,800	Auto Rich	56	47	9.0	15.0
						Auto Lean	50	42	9.0	15.0
	F4R	670	2280	28.2	10,800	Auto Rich	56	47	9.5	15.8
						Auto Lean	50	42	9.5	15.8
	F20R	670	2280	29.3	14,000	Auto Rich	59	49	9.5	15.8
						Auto Lean	54	45	9.5	15.8
	F21R	737	2280	30.5	S.L.	Auto Rich	58	48	10.4	17.4
						Auto Lean	53	44	10.4	17.4
Desired Cruising 60%	F3R	600	2190	26.0	10,800	Auto Rich	50	42	8.0	13.4
						Auto Lean	45	38	8.0	13.4
	F4R	600	2190	26.0	10,800	Auto Rich	50	42	8.5	14.0
						Auto Lean	45	38	8.5	14.0
	F20R	600	2190	27.5	14,000	Auto Rich	52	43	8.5	14.0
						Auto Lean	48	40	8.5	14.0
	F21R	660	2190	29.0	S.L.	Auto Rich	55	46	9.7	16.2
						Auto Lean	50	42	9.7	16.2

*For 5 minutes only. **For 15 minutes only.

SECTION IV

PACKING, UNPACKING AND PREPARATION FOR STORAGE

1. GENERAL.

Due to the inter-relation of procedures involved in packing, unpacking, preparation of engines for storage, and preparation of engines for service, these items are covered in this section in the following order:

Preparation for Storage

Packing

Unpacking

Preparation for Service

2. PREPARATION FOR STORAGE.

Preparation for storage describes all the steps necessary to seal an engine against moisture, whose harmful corrosive action would damage an engine in a short time. It includes the treatment necessary for various types of storage and for various periods of time.

a. TYPES OF STORAGE.

(1) STORAGE WITH ENGINE INSTALLED IN AIRPLANE.

(a) EXTENDED STORAGE.—Idle period of one month or over.

(b) TEMPORARY STORAGE.—Idle period of one week to one month.

(c) SHORT STORAGE.—Idle period of less than one week.

(2) STORAGE WITH ENGINE NOT INSTALLED IN AIRPLANE.

b. REQUIRED MATERIALS AND EQUIPMENT.—Considerable use is made in the preparation for storage of a corrosion-preventive mixture. This is made up of a mixture of one part by volume of corrosion-preventive compound, conforming to AN Spec. AN-VV-C-576, and three parts of lubricating oil in conformance with AN Spec. No. AN-VV-O-446, Grade 1120. This compound and lubricating oil mixture will be designated throughout this section as C.L.O. mix (compound and lubricating oil mixture). This C.L.O. mix sprays readily above 15°C (60°F) but may require heating for application at lower temperatures. Materials and equipment required to accomplish complete preparation for storage are as follows:

Nomenclature	*AN Specification No.*
C.L.O. mix consisting of:	
Corrosion-preventive compound (1 part)	AN-VV-C-576
Lubricating Oil (3 parts)	AN-VV-O-446, Grade 1120
Silica Gel-Dehydrating Agent	AN-O-S-366
Plastic Film-Moisture Impervious	AN-O-P-406
Crankcase Dehydrator Plug	Allison No. 42288
Cylinder Dehydrator Plug	AN-4062
Cap-Propeller Shaft Thread	AN-5012
Protector-Propeller Shaft Spline	Allison No. 40104
Tape-Adhesive Moisture Proof	AAF Spec. No. 16121
Spray Gun-Oil	AC Spec. No. 50127

c. STORAGE PROCEDURE WITH ENGINE INSTALLED IN AIRPLANE.

(1) EXTENDED STORAGE (one month or over)

(a) The oil in the engine oil system should be drained into clean containers for later use. The engine oil tank should then be refilled with at least 6 gallons of C.L.O. mix. Loosen the oil pump inlet connection and bleed air from line. The oil coolers should be bypassed sufficiently to produce the maximum permissible oil temperature. Engine should then be run with clear fuel at or below 1400 R.P.M. for at least fifteen minutes using C.L.O. mix as the lubricant. In all cases the following itemization lists the step by step procedures which should be completed within 12 hours after conclusion of above *clear* fuel run.

1. Drain engine oil system. *(Note a.)*
2. Drain coolant system. *(Note a.)*
3. Blow out coolant system. *(Note a.)*
4. Remove:
   - Cuno oil strainer
   - Exhaust manifolds (if practicable)
   - Cylinder head covers
   - Mixture thermometer connection or plug
   - Spark plugs
5. Replace all drain plugs and safety.

6. Immerse Cuno oil strainer in C.L.O. mix, then reinstall.

7. Clean and spray valve mechanism. *(Note b.)*

8. Spray the exhaust valves. (Thru ports or spark plug holes.) *(Note c.)*

9. Spray combustion chamber and intake valves. *(Note d.)*

10. Spray supercharger impeller and shaft. *(Note e.)*

11. Clean exterior of engine.

12. Install front and rear breather outlet covers or close tubes. *(Note h.)*

13. Replace cylinder head covers, mixture thermometer connection or plug.

14. Install supercharger scroll drain cover or close drain tubes. *(Note h.)* Seal supercharger vent screen.

15. Install 1/4" hose nipple covers on each distributor drive drain.

16. Prepare carburetor. *(Note f.)*

17. Install 24 cylinder dehydrator plugs. (Plugs to be inspected weekly.) *(Note d.)*

18. Attach spark plug lead connections.

19. Install crankcase dehydrator plug. *(Note g.)*

20. Install exhaust port covers, then manifolds, or cover manifold outlets.

21. Disconnect magneto leads. Cover ends of magneto leads.

22. Reduction gear.

a. Spray outside and inside of propeller shaft.

b. Install propeller shaft spline protector, if propeller is removed.

c. Install propeller-shaft thread protector, if propeller is removed.

23. Check to see that all engine openings have been sealed. *(Note h.)*

NOTES:

The following notes provide detailed information regarding the above itemized storage procedure.

(Note a.) Before the engine has cooled down from the clear gas run, drain the oil and coolant from the engine and airplane systems. Blow out engine coolant passages and airplane coolant system with dry compressed air.

(Note b.) Cylinder head covers shall be removed and the interior of the cover, the camshaft and valve mechanism thoroughly cleaned. The camshaft and valve mechanism shall then be sprayed with the C.L.O. mix, turning the crankshaft over during the spraying operation so that the entire surface of cams and protruding ends of valve stems are coated. After spraying these parts, replace the covers.

(Note c.) Each exhaust port should be sprayed with a sufficient quantity of C.L.O. mix to thoroughly coat the exhaust valves. The exhaust ports or stacks should then be sealed with oil and moisture resistant covers.

(Note d.) Spray each cylinder combustion chamber thoroughly thru the spark plug holes with C.L.O. mix with the piston at the lower end of the stroke. Make certain that all surfaces of cylinder walls are adequately covered. Install and tightly seat cylinder dehydrator plugs AN-4062 in all spark plug openings. Do not remove seal from each dehydrator plug until immediately before installation. All cylinder bore and crankcase dehydrator plugs must be inspected weekly, and, if at any time a relative humidity above 20 per cent is indicated, they must be replaced.

(Note e.) Remove mixture thermometer connection plug (1 in Figure 28) in supercharger inlet cover. Insert spray gun in that opening

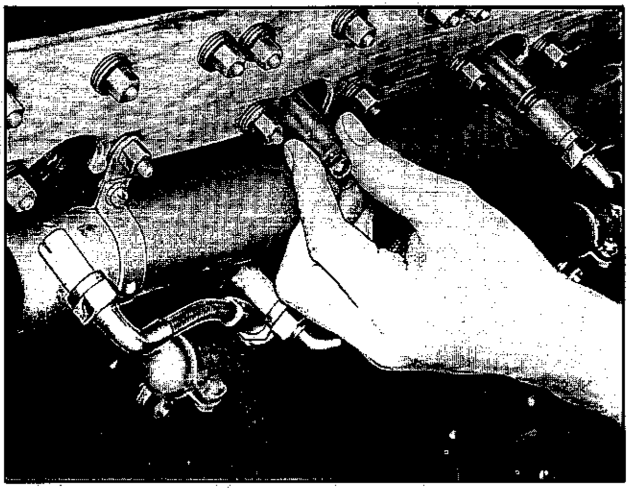


Figure 27—Installing Cylinder Dehydrator Plugs.

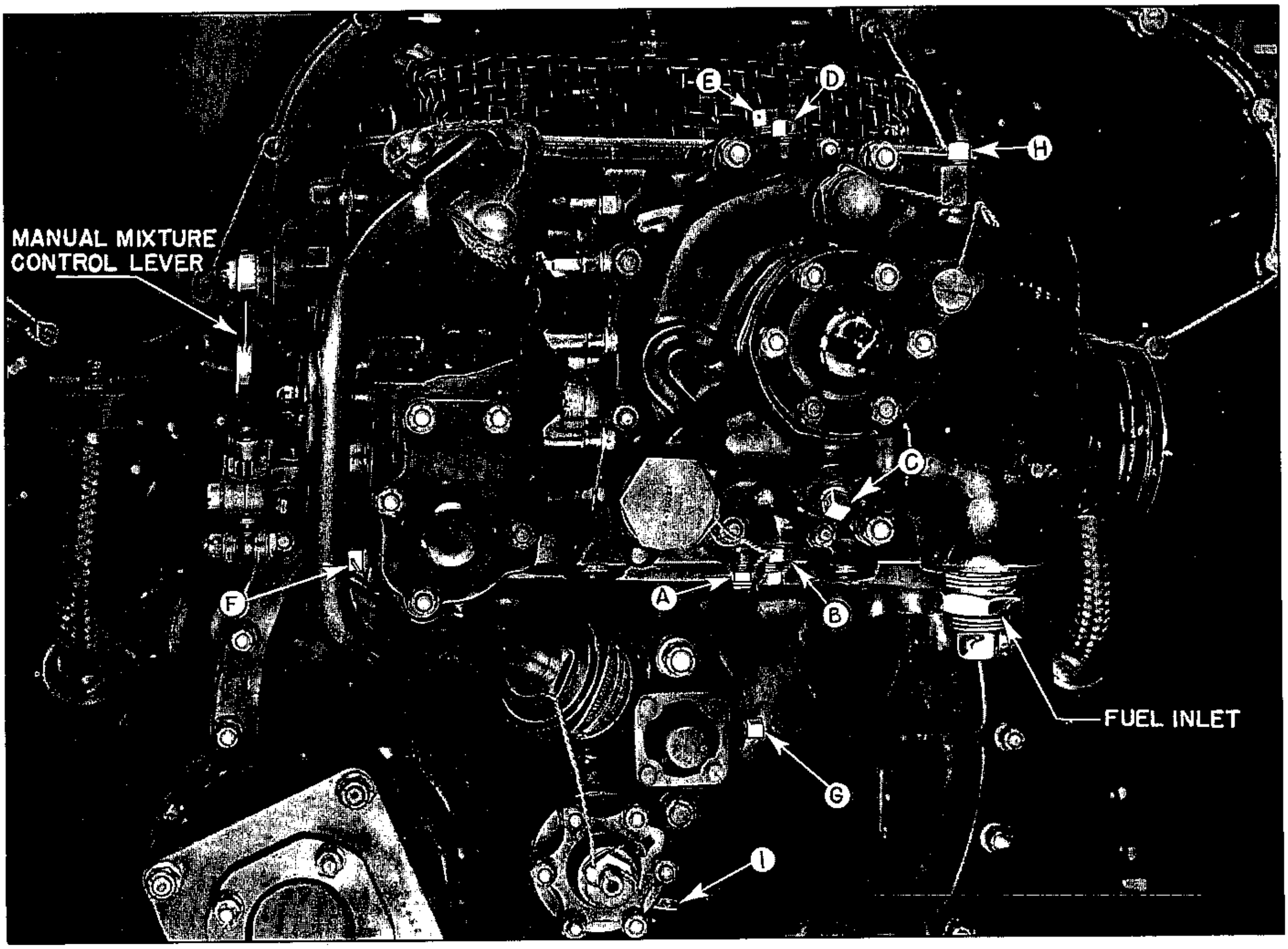


Figure 28—Guide to Plugs and Fittings for Preparing Carburetor for Storage.

and spray impeller and shaft thoroughly with C.L.O. mix. Replace plug.

(Note f.) Preparation of the carburetor.

1. Place the manual mixture control lever in Full Rich or Automatic Rich and the throttle in open position.

2. Remove the carburetor fuel strainer, inspect, clean if necessary, and reinstall.

3. Remove the three fuel drain plugs A, B, and F, and the fuel inlet plug *(Figure 28).* Allow all gasoline to drain. Replace drain plugs and the fuel inlet plug temporarily.

4. Remove pipe plugs D, E, G, and H *(Figure 28)* and install in place of plug E a No. 4 Weatherhead fitting. Then thru this fitting, inject oil conforming to Grade 1065 A, Spec. No. AN-VV-O-446. The pressure applied to the fuel chamber or passages should not exceed 8 lbs./sq. in. and should be obtained by the use of a pressure type hand pump. Pump oil until oil flows from the opening at D. The oil line must be equipped with filters to exclude all foreign matter, since oil does not pass thru the fuel strainer. The regulator air chambers, air passages and automatic mixture control must *not be flushed with oil* but *must be kept dry at all times.* Exercise care so as not to damage moving parts, such as needle valve or floats.

5. Replace plug D and remove brass plug I from supercharger inlet elbow. Maintain pressure on oil flushing line until oil flows from the discharge nozzle opening G. Replace plug G and maintain oil pressure until oil flows through the discharge nozzle. This may be determined by the appearance of oil at opening I.

6. Remove oil pressure line; fitting at location E; plugs A, B, F, and G; and fuel inlet plug; allowing all excess oil to drain.

7. Replace and wire all metal plugs on the carburetor and nozzle and replace fuel inlet plug.

8. Wire throttle in wide open position and the manual mixture control lever in idle cut off position.

9. Install 1 pound bag of silica gel, AN Spec. No. AN-O-S-366, in the carburetor air intake scoop. Seal end of scoop with a double thickness of moisture-impervious plastic material, Spec. AN-O-P-406, and anchor securely to the scoop with special tape, AAF Spec. No. 16121.

(Note g.) Remove the ¾" pipe plug from the reduction gear front case and attach it to engine in the region of the plug opening. Then install Allison crankcase dehydrator plug No. 42288 in that opening.

(Note h.) Since the quantity of dehydrating agent used in this procedure is only capable of absorbing the amount of moisture that may be enclosed in the engine itself, it is important that no engine openings have been left uncovered. In most cases when the engine is in the airplane the overboard drains, including the gang drain, can be satisfactorily sealed by wrapping the ends with moisture impervious plastic film. If the engine is out of the airplane all openings must be sealed with suitable plugs or covers.

(2) TEMPORARY STORAGE (ONE WEEK TO ONE MONTH).

(a) The treatment of engines for temporary storage will be accomplished as in the case of Extended Storage. See Paragraph 2 *c,* (1), except that:

1. Clear fuel run using C.L.O. mix will not be made.

2. Coolant system will not be drained.

3. Carburetor will not be drained or flushed; however, a 1 lb. bag of silica gel will be placed in the carburetor air intake scoop and the scoop sealed with double thickness of moisture proof material.

(3) SHORT STORAGE (TWO DAYS TO ONE WEEK).

(a) On alternate days the propeller shaft should be rotated at least four complete revolutions by hand.

(b) On intervening alternate days, the engine should be given a ground run-up in accordance with standard starting and warm-up procedure. Run engine until the "Oil in" temperature reaches normal operating temperature. Excessive ground operation other than stated above should be avoided.

d. STORAGE PROCEDURE FOR ENGINES NOT TO BE STORED IN AIRPLANE.

(1) GENERAL.—This type of storage will be performed when engines are being removed from airplane for shipment to overhaul bases or for periods of idleness in excess of 48 hours when engine is not in airplane.

(2) PROCEDURE.

(a) Follow procedure outlined in Extended Storage making the clear fuel run when practicable. In every case when possible the engine should have the clear gas run portions of the preparation for storage made before the engine is removed from the airplane. In these cases all engines will be prepared for storage following the complete procedure outlined in Extended Storage, paragraph 2 *c,* (1).

NOTE

In cases of inoperative engines, the clear gas run using the C.L.O. mix in the oil system will be omitted.

(b) In addition to the Extended Storage Procedure the following steps are necessary in the preparation for storage of engines removed from airplane.

1. When accessories have been removed, spray a small quantity of C.L.O. mix inside the engine drives and install the various accessory drive covers with gaskets. These include starter, generator, fuel pump, two vacuum pumps, and propeller governor drive covers.

2. There are additional openings, not requiring attention in the Extended Storage procedure, which must be sealed, using standard Allison shipping parts and standard pipe plugs. Refer to the appropriate Parts Catalog for detail part numbers. These additional openings are as follows:

Coolant Outlet Elbows (2)
Coolant Inlet Flange
1/4" Coolant Pump Drain Nipple
Oil Pump Inlet Flange
Oil Pump Outlet Flange
Carburetor Screen (metal carburetor cover will be used to seal top of carburetor in place of intake scoop).
All distributor housing vents or air inlet openings must be covered or plugged.

All standard connections: When other airplane fittings and connections have been removed these engine openings will be closed using appropriate size standard pipe plugs.

3. Wipe engine dry.

4. Touch up the crankcase split line and painted surfaces where necessary with touch-up lacquer.

5. Pack engine in the shipping box as described in this section, Paragraph 3, Packing.

3. PACKING.

All engines must be prepared for storage in accordance with Paragraph 2. *c.*, prior to packing for shipment or storage.

a. PACKING FOR SHIPMENT OR STORAGE (OTHER THAN AIR TRANSPORT SHIPMENT).

(1) Check the engine mounting surface of the stand for roughness and smooth if necessary. Then place the four shipping box bearing strips over each anchor bolt hole. Insert anchor bolts and place pliofilm engine shipping bag on stand, with four slots in bag over anchor bolts and with the bag spread out to make way for the lowering of the engine on the stand.

(2) Place engine on stand, bolt completely and safety.

(3) Attach spark plugs and other loose parts securely in shipping box with webbing.

(4) Install a humidity indicator chart, conforming to drawing No. AN-7511-1, on the carburetor cover so that it can be observed through the shipping case inspection port.

(5) Hang twelve 1-pound bags of silica gel around engine, spacing them evenly so as to include the front and rear sections of the engine. Do not remove bags from their moisture-resistant containers until immediately before attachment to the engine. The silica gel should conform to AN Spec. AN-O-S-336, type V.

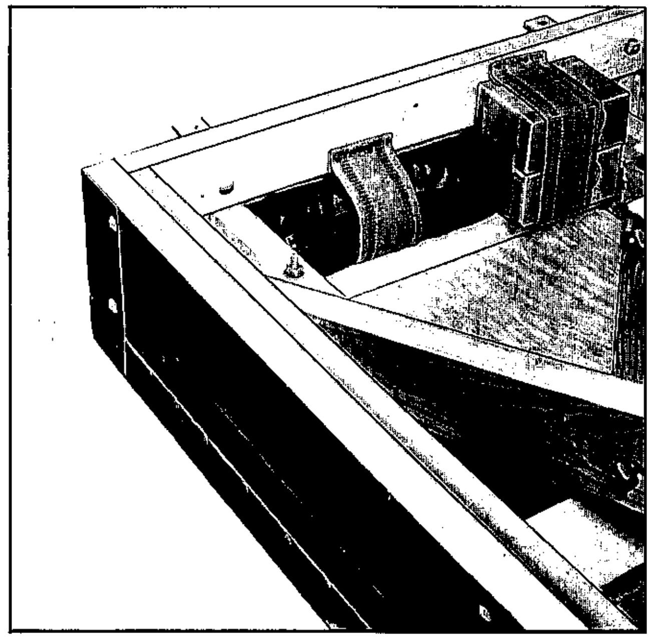


Figure 29—Location of Spark Plugs and Tool Kit in Shipping Box.

(6) Cover the top of the engine with a canvas cover, of suitable width so that the engine envelope will not be punctured by any projecting surfaces.

(7) As soon as possible, but not longer than 15 minutes after securing silica gel bags, close and seal the pliofilm bag by joining its two ends and heat-seal with plastic film sealing iron AAF Spec. No. 40399, brought to a temperature of 163°C to 177°C (325°F to 350°F), to provide a moisture proof joint. Care should be taken that pliofilm material is not discolored or burned. Heat-seal bag in such a manner as to allow resealing of the bag for subsequent re-use.

(8) Fold excess material of engine envelope around the engine so that there shall be no more than

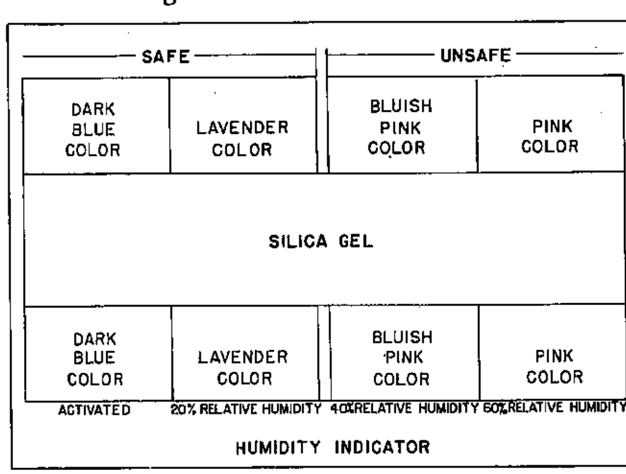


Figure 30—Indicator Card Chart Showing Interpretation of Chemical Color.

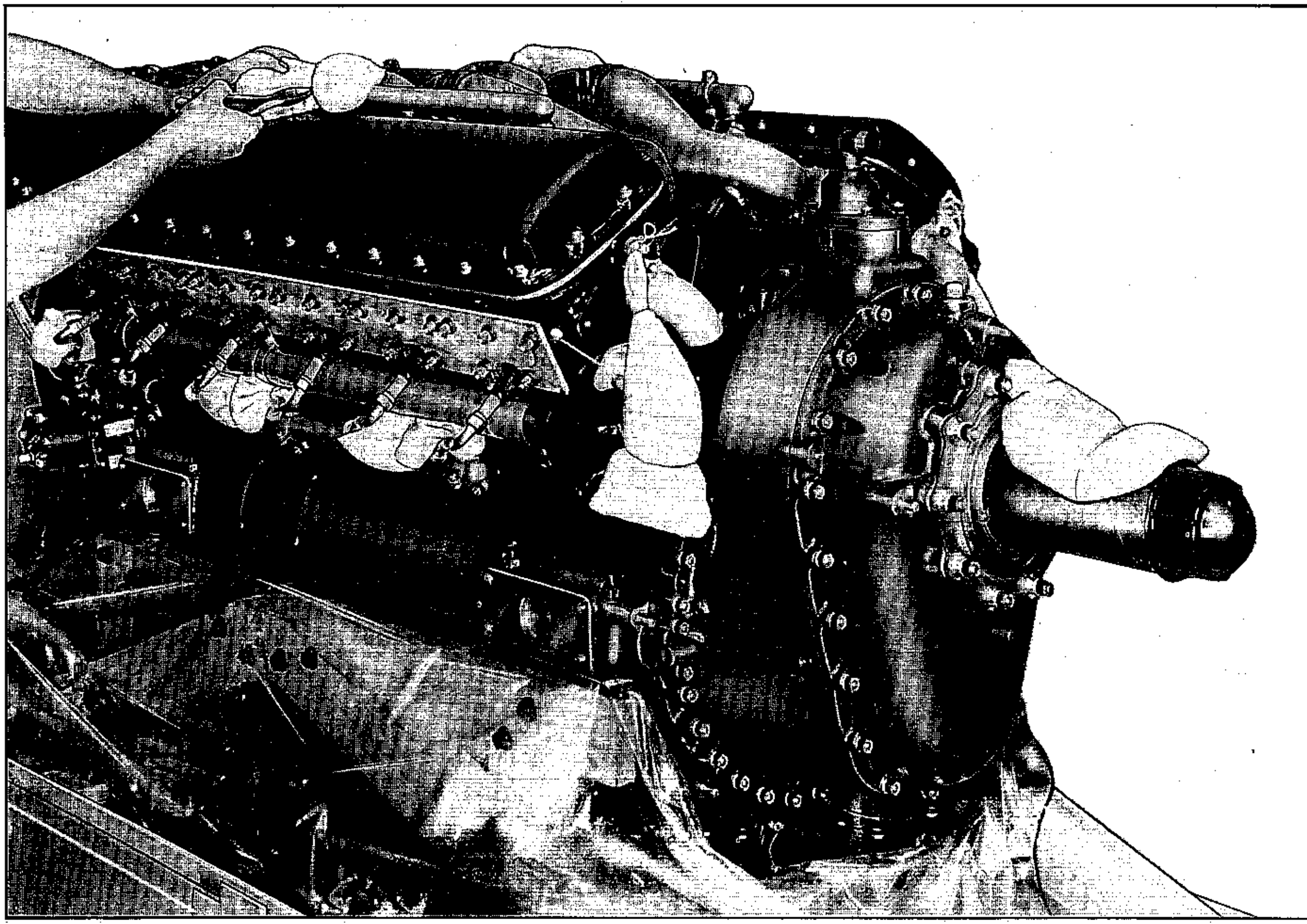


Figure 31—Attaching Silica Gel Bags to Engine Immediately Before Sealing.

one thickness of the bag between the indicator card and the inspection port. Secure with tape if necessary.

(9) Lower the shipping box cover over the engine in such a manner as not to rupture the envelope. See Figure 32. Secure cover with four bolts.

NOTE

The above procedure should be followed for the preservation of either new or overhauled engines, except, when it is *definitely* known that the engine will be placed in service within 30 days, the engine envelope and silica gel bags need not be used. In all cases the engine cylinder and crankcase dehydrator plugs should be inspected bi-weekly and changed as soon as their color indicates that they are no longer functioning. However, under an extremely damp storage condition where engine deterioration could occur in less than the expected storage period, the complete procedure should be followed. Replacement of the dehydrator plugs should not be made on highly humid or rainy days.

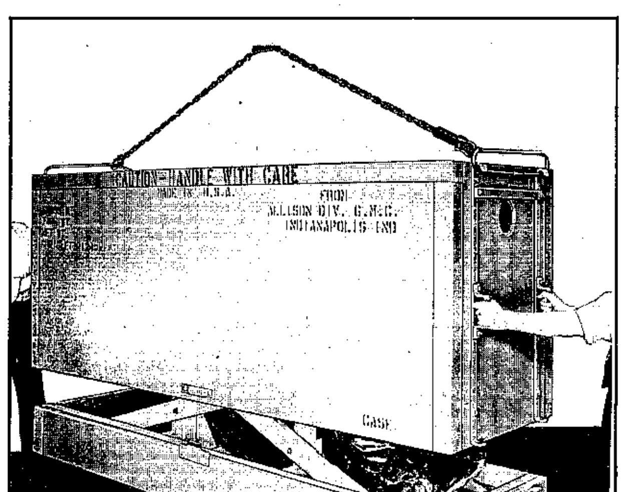


Figure 32—Lowering Shipping Box Cover over Engine.

b. PACKING FOR SHIPMENT BY AIR TRANSPORT.

(1) Packing for shipment by air transport requires the use of a special air transport cradle, which prevents the use of the engine envelope and the silica gel bags. Upon arrival at destination, if engine is not going to be placed in service within seven days after arrival, it should be immediately hung with silica gel bags and enclosed in the engine envelope as described in Paragraph 3 *a.* If engine is going into service within a few days and if it is to be left uncovered, all dehydrator plugs should be inspected daily and replaced whenever a relative humidity above 20 per cent is indicated.

4. UNPACKING.

a. The upper part of the engine shipping box is merely a cover and is held to the lower part by four ½" bolts. The cover may be lifted off after removing these bolts. Care must be taken to lift the cover straight up so that it will not damage any part of the engine.

b. Before removing engine from mounting rails, the engine envelope must be carefully opened at or near the original seal in order to preserve the envelope in satisfactory condition for subsequent re-use. Since the engine envelope has been designed for re-use at least six times, every care should be given it to assure maximum service life. Remove the twelve silica gel bags from around the engine. Remove shipping cover and silica gel bags from carburetor.

c. To remove the engine from the shipping box, remove the $\frac{7}{16}$" hold down nuts and attach the hoisting sling (No. 2229) as shown in Figure 33. Two of the hooks will be connected to the No. 1 right and left intake studs, and the other two hooks are connected to the No. 6 right and left intake studs. The junction ring of the hoisting sling is secured to the pick-up hook of the hoist.

d. Special precaution should be taken to insure that the engine be hoisted vertically and not allowed to swing to avoid possible damage while transferring the engine from the shipping box to the engine mount.

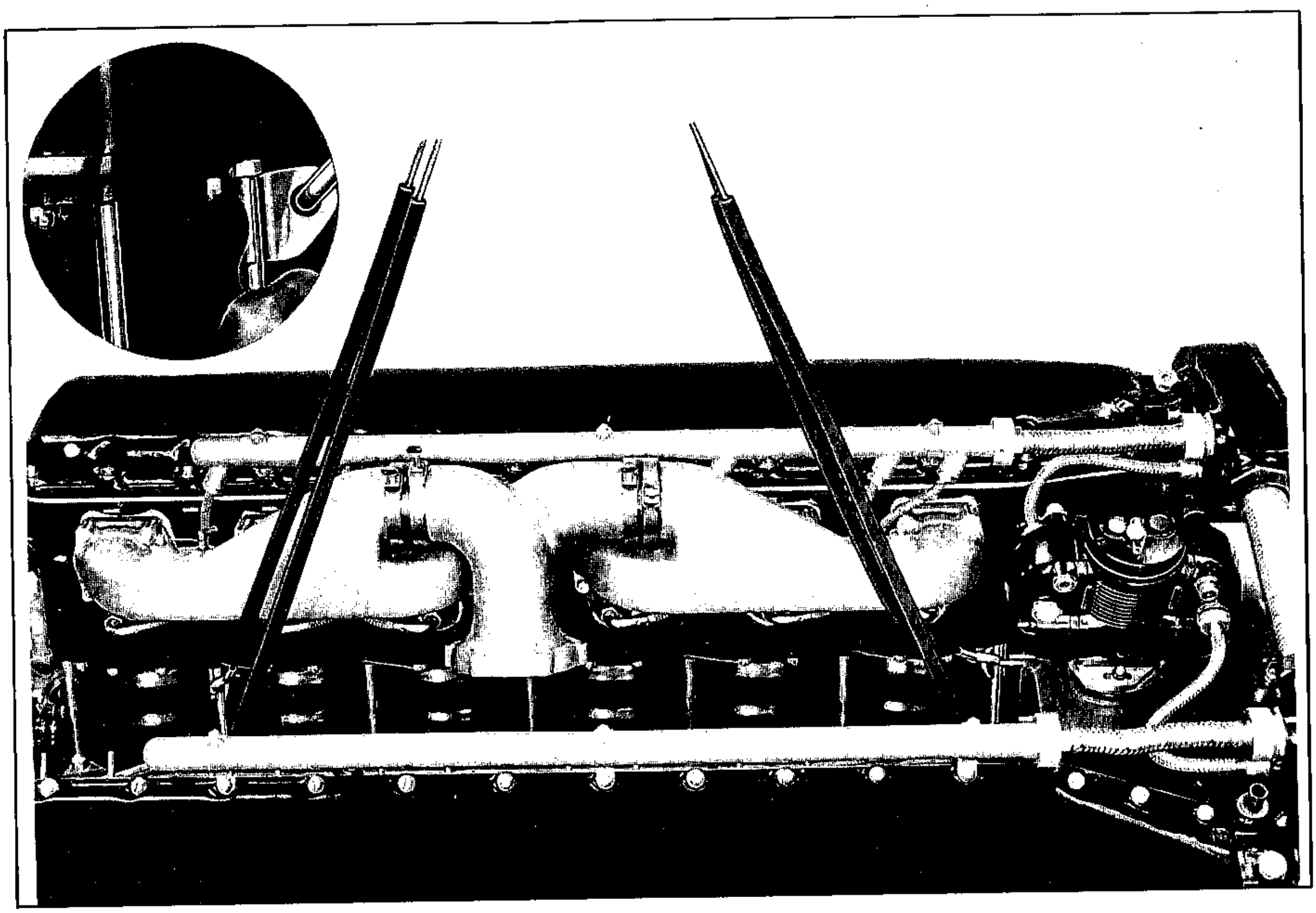


Figure 33—Attaching Engine Lift Sling.

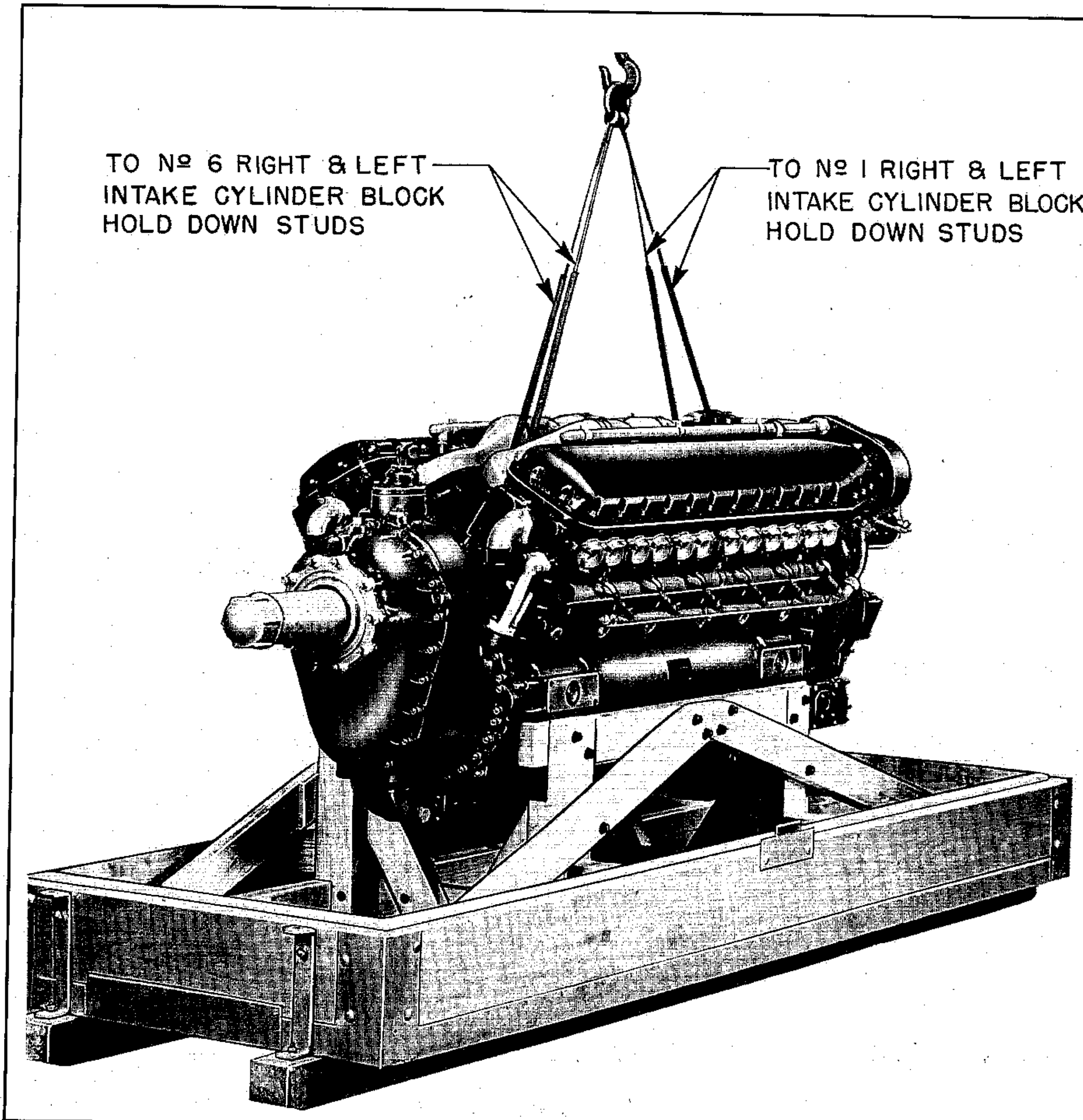


Figure 34—Removing Engine From Stand.

5. PREPARATION FOR SERVICE.

a. Engines which have been prepared for short storage need no preparation for service.

b. Engines which have been treated for temporary or extended storage will be prepared for service as follows:

NOTE

Engines which are to be unpacked, installed in airplane and placed in service will be prepared for service in accordance with this paragraph. For convenience paragraphs (1) through (6) below will be accomplished before the engine is installed in the airplane.

(1) Remove cylinder bore dehydrator plugs from the spark plug holes. Before installing the spark plugs, slowly rotate the crankshaft three or four revolutions and observe for proper operation of the valve mechanism. Any valves that are found to be sticking shall have the stems generously lubricated with a mixture of gasoline and lubricating oil. Continue to turn the engine over by hand until all evidence of sticking valves has been eliminated. Make certain too that no excess C.L.O. mix is present in the cylinders.

CAUTION

Exercise care in the removal of dehydrating plugs. If any are broken and the silica gel therefrom falls into engine, the affected section of the engine must be disassembled and thoroughly cleaned.

(2) Remove the Allison crankcase dehydrator plug No. 42288 from the reduction gear front case and replace with standard 3/4" pipe plug or vent connection.

(3) Remove all other plugs, covers, silica gel bags, etc., which have been used to seal the various engine openings.

(4) Wipe off the breaker mechanism of the magneto thoroughly, then lubricate the magneto and breaker mechanism with light engine oil.

(5) Remove the Cuno oil strainer, immerse in gasoline, wash without rotating the strainer, and then blow out with compressed air. Repeat this until the strainer is thoroughly clean. *(See Figure 35.)* Following this cleaning procedure, the discs of the strainer should be lubricated by immersing in clean engine oil and blowing with compressed air. Re-immerse the cartridge in engine oil. Clean the Cuno compartment of the engine and then install the strainer, using new strainer gasket.

CAUTION

The Cuno strainer should not be rotated when removed from the engine, as damage may result from possible twisting of the strainer cartridge. The cartridge may be rotated several revolutions after installation by means of the turning shaft nut.

(6) OIL SCREENS.

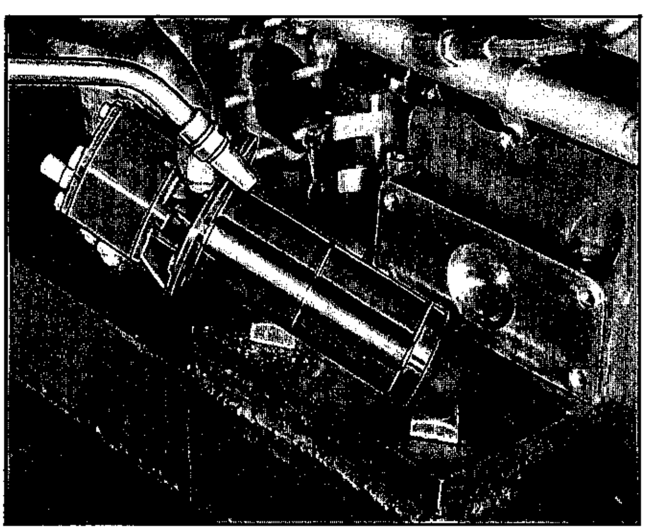
(a) On early model engines, there is a removable oil screen in the reduction gear case oil drain elbow. This should be removed, cleaned in gasoline, dried, re-oiled and then reinstalled.

(b) On late model engines, the entire elbow assembly must be removed in order to clean the screens. If accessible for removal, this should be done in accordance with Section VIII, Paragraph 8.

(c) The rear oil drain elbow should be removed, if accessible, and its screen cleaned in accordance with Section VIII, Paragraph 8.

(d) In cases where new engines are being installed in an airplane that will be placed in service, both elbows must be removed and cleaned. Due to better accessibility, the elbows and screens will be cleaned before engine is placed in the airplane.

(7) After all controls and fittings are connected on carburetor, it will be filled with fuel and vented in



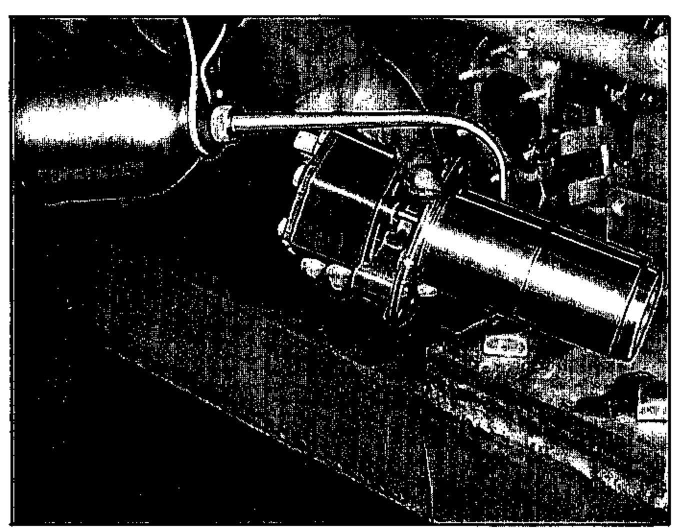


Figure 35—Cuno Oil Strainer—Preparation for Service.

the following manner:

(a) Open fuel tank valve.

(b) Set mixture control at "Automatic-Rich" and the throttle valve at half open.

(c) Operate wobble pump slowly to raise fuel pressure to 4 lbs. sq. in. Then continue to operate wobble pump until fuel appears at supercharger drain.

(d) Next remove any included air by removing the 1/8 inch pipe plug located on top of the regulator body and nearest the throttle body. Work wobble pump until fuel stands level with plug opening then replace plug.

(e) Allow carburetor to set from eight to ten hours to allow diaphragms to become flexible.

(8) The following pre-oiling procedure must be performed on all engines being placed in service to insure proper bearing lubrication at initial start.

(a) Fill oil tank to proper level.

(b) Open air vent drain cock on oil inlet adapter if airplane is so equipped; otherwise, disconnect oil inlet line connection at the oil pump, bleed air, and establish solid oil flow to that point.

(c) Re-install or tighten the oil inlet line to oil pump.

(d) Remove drain plug from bottom of rear oil drain elbow.

(e) Remove all exhaust (outside) spark plugs from the engine if previously installed.

(f) Place mixture control in "Idle Cut-Off" position.

(g) Place fuel valve in "OFF" position.

(h) Make sure that the ignition switch is "OFF."

(i) Make "dummy" starts of engine using a portable energizer or external battery source, until approximately 1 gallon of oil drains from the drain plug opening.

(j) Replace and safety drain plug.

(9) Install spark plugs, using only solid copper gaskets. Lubricate all plugs with Spark Plug Lubricant, Air Corps Specification No. 3578.

(10) Refill the oil tank and the coolant expansion tank with sufficient oil and coolant to operate the engine safely during warm-up. In general one-half of the oil tank capacity will be sufficient for this purpose.

(11) After the engine has been properly *pre-oiled* the engine will be started, warmed-up and ground tested in accordance with procedure in Section V, Paragraph 2 *k*. Upon completion of ground tests and while engine is still warm the lubricating oil will be drained from the engine and airplane oil system. This oil drainage is made to clean the engine of excessive quantity of C.L.O. mix and sludge that may have accumulated during the period of storage. The oil drained out after the ground test is not suitable for further use, because the C.L.O. mix in the oil would cause rapid sludging during subsequent engine operation.

(12) Refill oil system and flight test airplane in accordance with Section V, Paragraph 2 *l*. After flight test, the airplane is ready to release for service.

6. DIMENSIONS AND WEIGHTS.

The following table gives the size and weight of the engine shipping boxes:

FOR DOMESTIC SHIPMENT

Model	*Outside Dimension Inches*	*Weight of Shipping Box Lbs.*	*Weight of Engine and Box Packed Lbs.*
V-1710-F2R	36½ x 55$\frac{5}{16}$ x 112	800	2105
V-1710-F2L	36½ x 55$\frac{5}{16}$ x 112	800	2105
V-1710-F3R	36½ x 55$\frac{5}{16}$ x 112	800	2110
V-1710-F5R	36½ x 55$\frac{5}{16}$ x 112	800	2145
V-1710-F10R	36½ x 55$\frac{5}{16}$ x 112	800	2145
V-1710-F5L	36½ x 55$\frac{5}{16}$ x 112	800	2145
V-1710-F10L	36½ x 55$\frac{5}{16}$ x 112	800	2145
V-1710-F4R	36½ x 55$\frac{5}{16}$ x 112	800	2145
V-1710F20R	36½ x 55$\frac{5}{16}$ x 112	800	2150
V-1710-F21R	36½ x 55$\frac{5}{16}$ x 112	800	2150

FOR OVERSEAS SHIPMENT

Model	*Outside Dimension Inches*	*Weight of Shipping Box Lbs.*	*Weight of Engine and Box Packed Lbs.*
V-1710-F2R	36½ x 55$\frac{5}{16}$ x 112	850	2155
V-1710-F2L	36½ x 55$\frac{5}{16}$ x 112	850	2155
V-1710-F3R	36½ x 55$\frac{5}{16}$ x 112	850	2160
V-1710-F5R	36½ x 55$\frac{5}{16}$ x 112	850	2195
V-1710-F10R	36½ x 55$\frac{5}{16}$ x 112	850	2195
V-1710-F5L	36½ x 55$\frac{5}{16}$ x 112	850	2195
V-1710-F10L	36½ x 55$\frac{5}{16}$ x 112	850	2195
V-1710-F4R	36½ x 55$\frac{5}{16}$ x 112	850	2195
V-1710-F20R	36½ x 55$\frac{5}{16}$ x 112	850	2200
V-1710-F21R	36½ x 55$\frac{5}{16}$ x 112	850	2200

SECTION V

INSTALLATION IN AIRPLANE AND REMOVAL THEREFROM

1. GENERAL.

a. Since each airplane presents individual engine installation problems the following paragraphs will, of necessity, be little more than generalized recommendations. For complete instructions on installations, refer to Handbook of Instructions for the particular airplane in which the engine is installed.

b. For additional information pertaining to installation refer to Allison Installation Drawings:

V-1710-F2R	No. 36970
V-1710-F2L	No. 37300
V-1710-F3R	No. 37550
V-1710-F5R	No. 37310
V-1710-F5L	No. 41450
V-1710-F10L	No. 41000
V-1710-F10R	No. 41580
V-1710-F4R	No. 42135
V-1710-F20R	No. 43320
V-1710-F21R	No. 43205

2. INSTALLATION OF ENGINE IN AIRPLANE.

a. In the case of new or overhauled engines they will be unpacked in accordance with Section IV, Paragraph 4 and the first steps for preparation for service will be performed in accordance with Section IV, Paragraph 5.

b. Install the exhaust stacks in place in accordance with the instructions of the airplane manufacturer's handbook. All models covered in this handbook, except the F21R, have spark plug cooling manifolds. On these models it is necessary to first remove the spark plug cooling manifolds before the exhaust stacks can be installed. Remount the right and left exhaust spark plug cooling manifolds on the engine by securing to the three right and three left hand bracket assemblies, respectively. These brackets are secured to the lower flange studs of Nos. 2, 6 and 11 exhaust ports by the brass exhaust flange nuts and to the three long studs in the coolant jacket upper flange by plain and palnuts.

c. To install engine in airplane, attach Engine Lifting Sling No. 2229 to the engine and raise into position. Take care that no part of the accessory section is damaged. The starter and generator may be installed before mounting the engine in the ship, if installation clearances are limited.

d. Brake lining strips (four pieces about 8″x1¼″x ¼″) should be placed between the crankcase and the engine mounting bearers, if rubber mounts are not used. The strips should be punched to provide clearances at raised rivet heads on bearers. Fasten engine to mounting bearers with eight $\frac{7}{16}$″ bolts. The engine must rest evenly on the bearers before mounting bolts are tightened. In case of some types of rubber mounts, it may be necessary to install the mounts on the engine mounting flanges before lowering the engine into the airplane. Provision should be made for a smooth supporting surface for the bottom face of the flange to rest on.

e. All airplane accessories such as starter, generator, fuel pump, vacuum pump, propeller governor, etc., will be mounted on the engine using the engine gaskets on the mounting flanges. Additional composition gaskets are not required when sheet aluminum gaskets are furnished.

f. On F4R and F20R Models attach the airplane cockpit throttle linkage to the automatic manifold pressure regulator main lever, and check linkage in accordance with Section IX, Paragraph 6. *e*, Ground Check of Regulator.

g. Make all necessary connections. Refer to Section II, Table of Specifications, and Figure 37 for Size and location of connections. Due to variations in detail of airplane to engine connections, only typical engine installations can be shown. The following diagram will illustrate typical systems:

Figures 38, 39 and 40 illustrate typical engine installations.

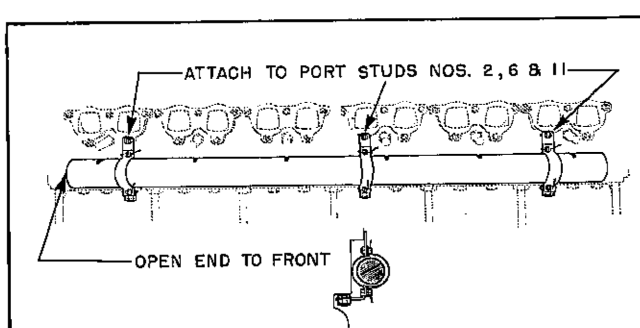


Figure 36—Installation of Cooling Manifold Brackets.

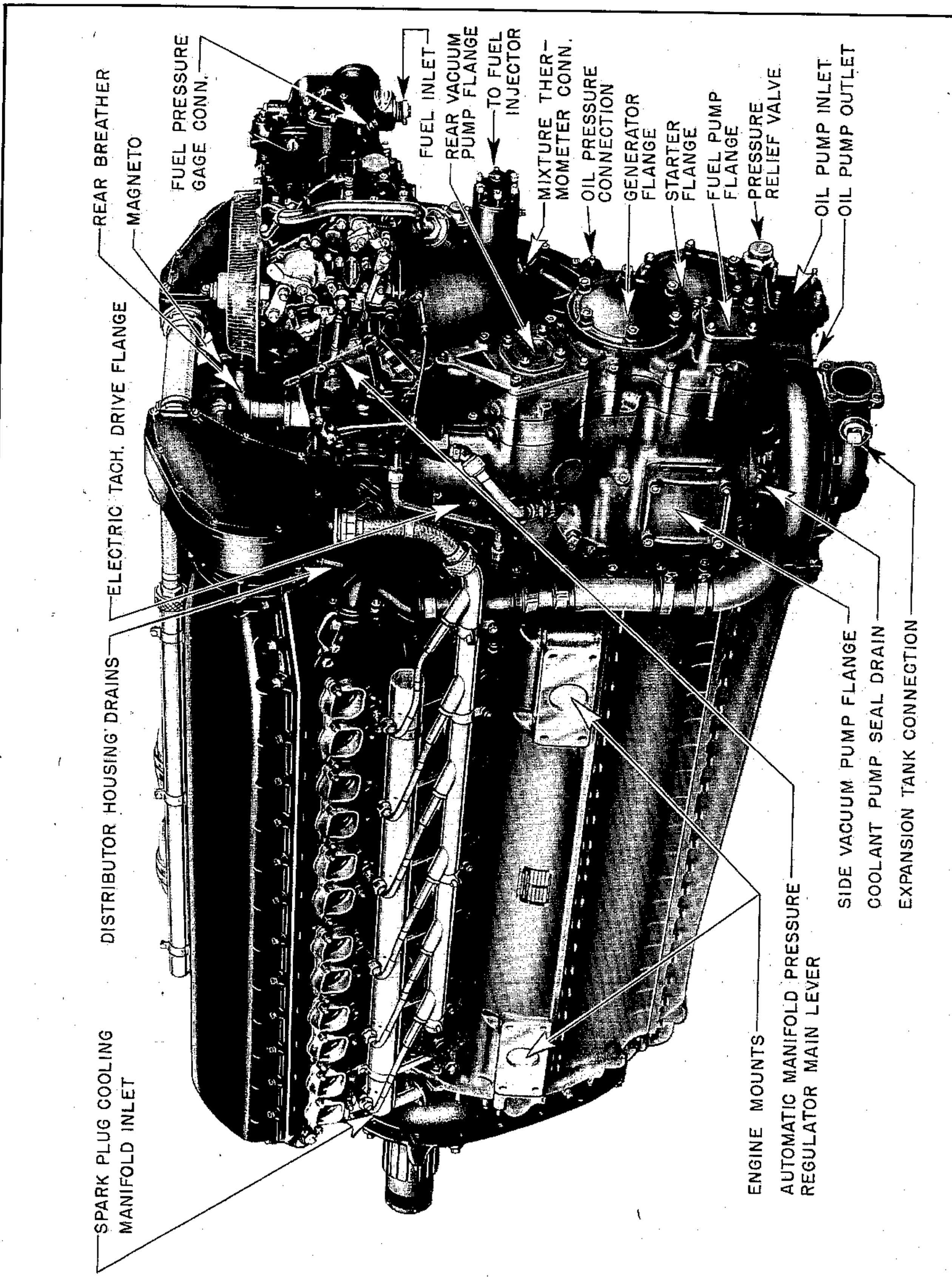


Figure 37—Location of Accessories and Connections on Engine.

ALLISON F-2R & L V-1710-27 & 29 INSTALLATION IN LOCKHEED P-38

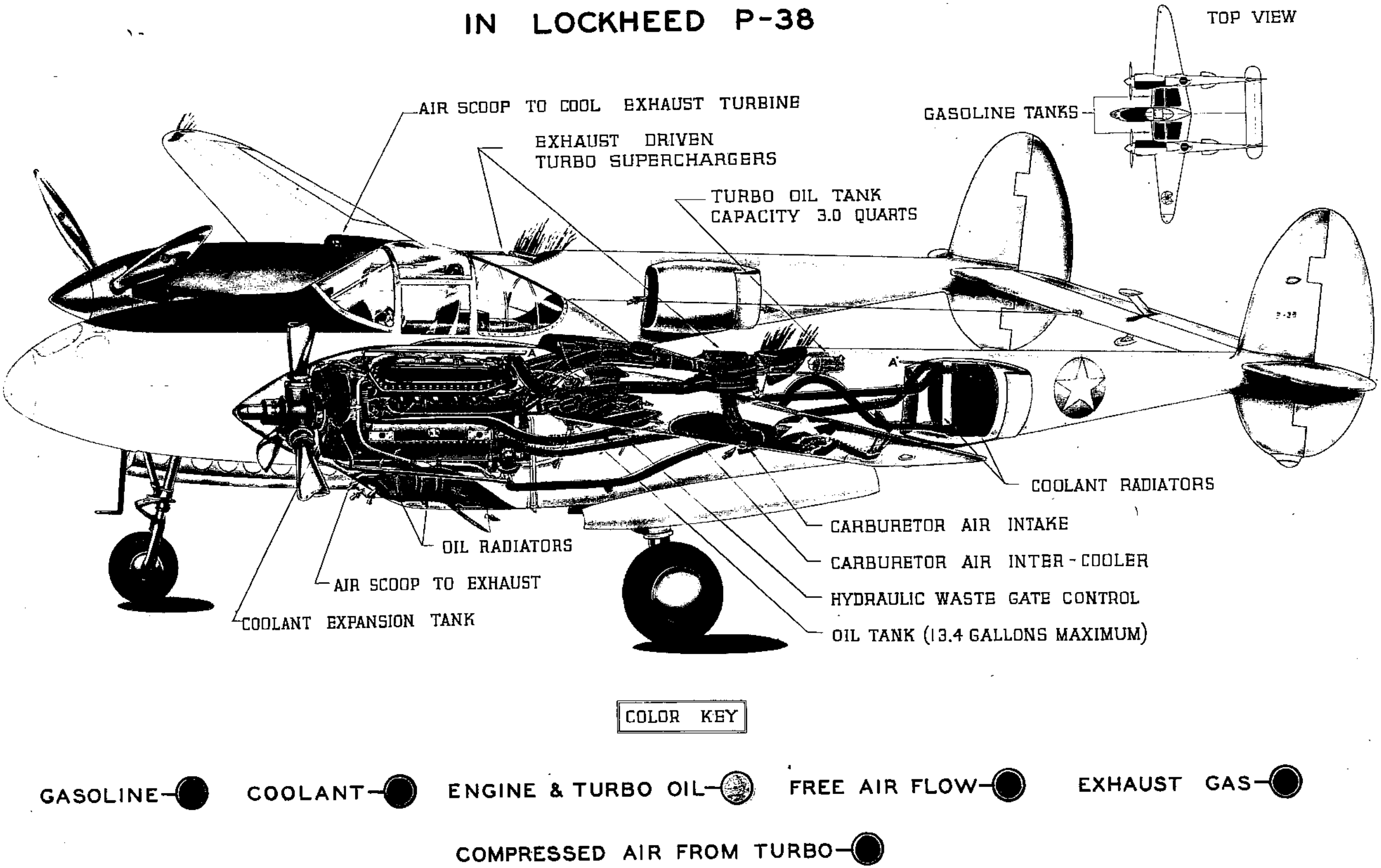


Figure 38—Typical Installation of V-1710 Engine in P-38 Type Airplane

ALLISON F-3R V-1710-39 INSTALLATION IN CURTISS P-40-D

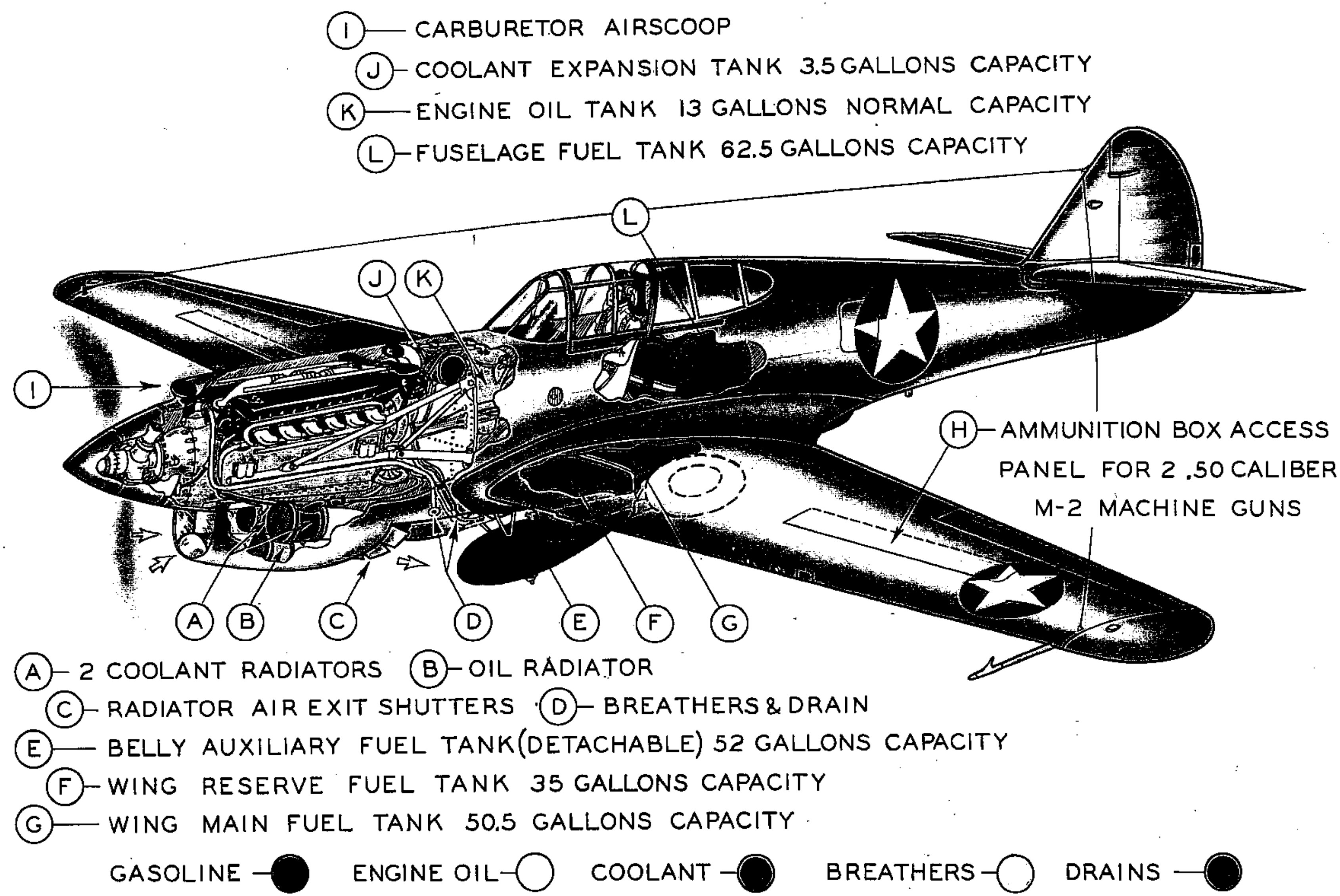


Figure 39—Typical Installation of V-1710 Engine in P-40 Type Airplane

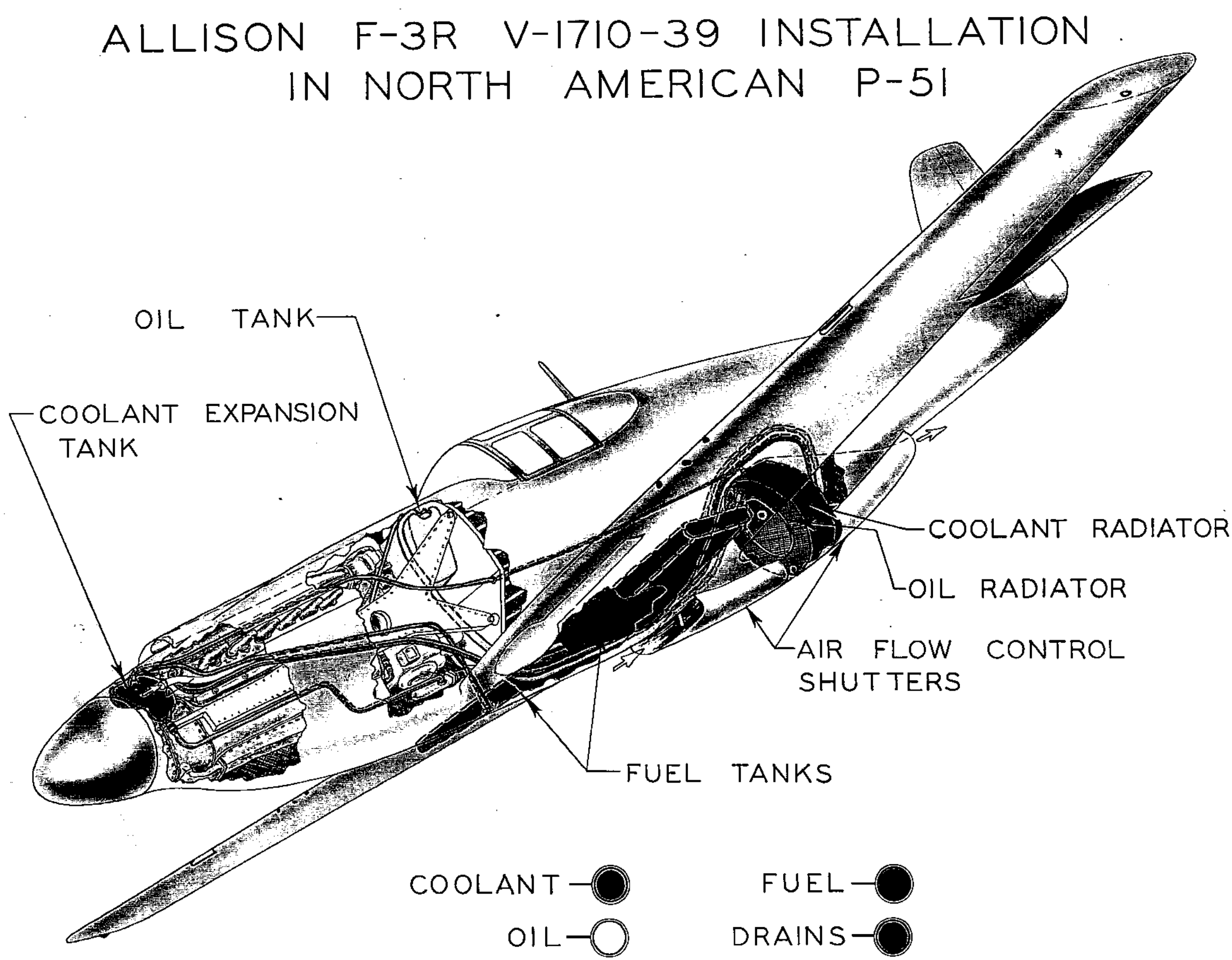


Figure 40—Typical Installation of V-1710 Engine in P-51 Type Airplane

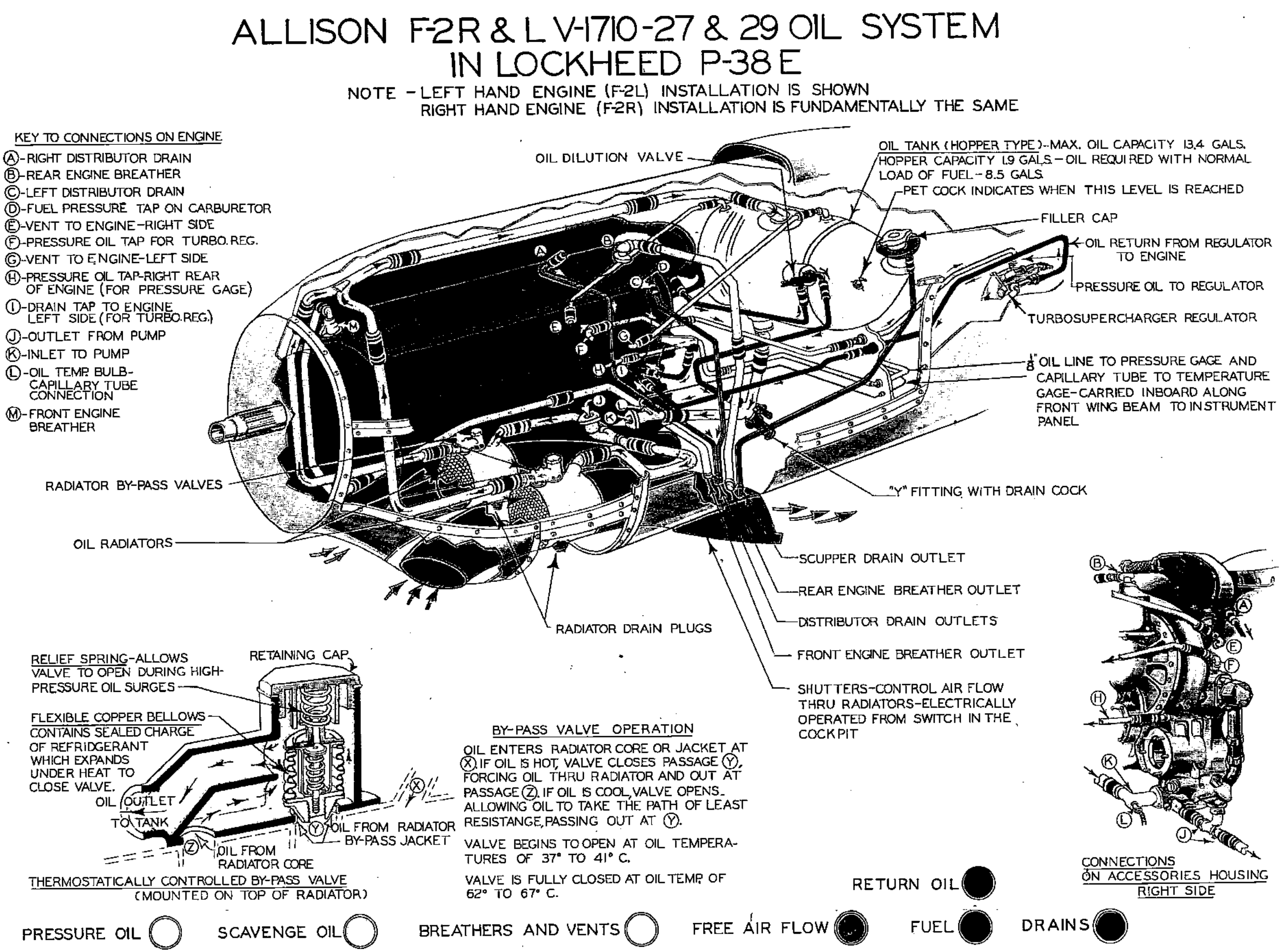


Figure 41—Typical Oil System in P-38 Type Airplane

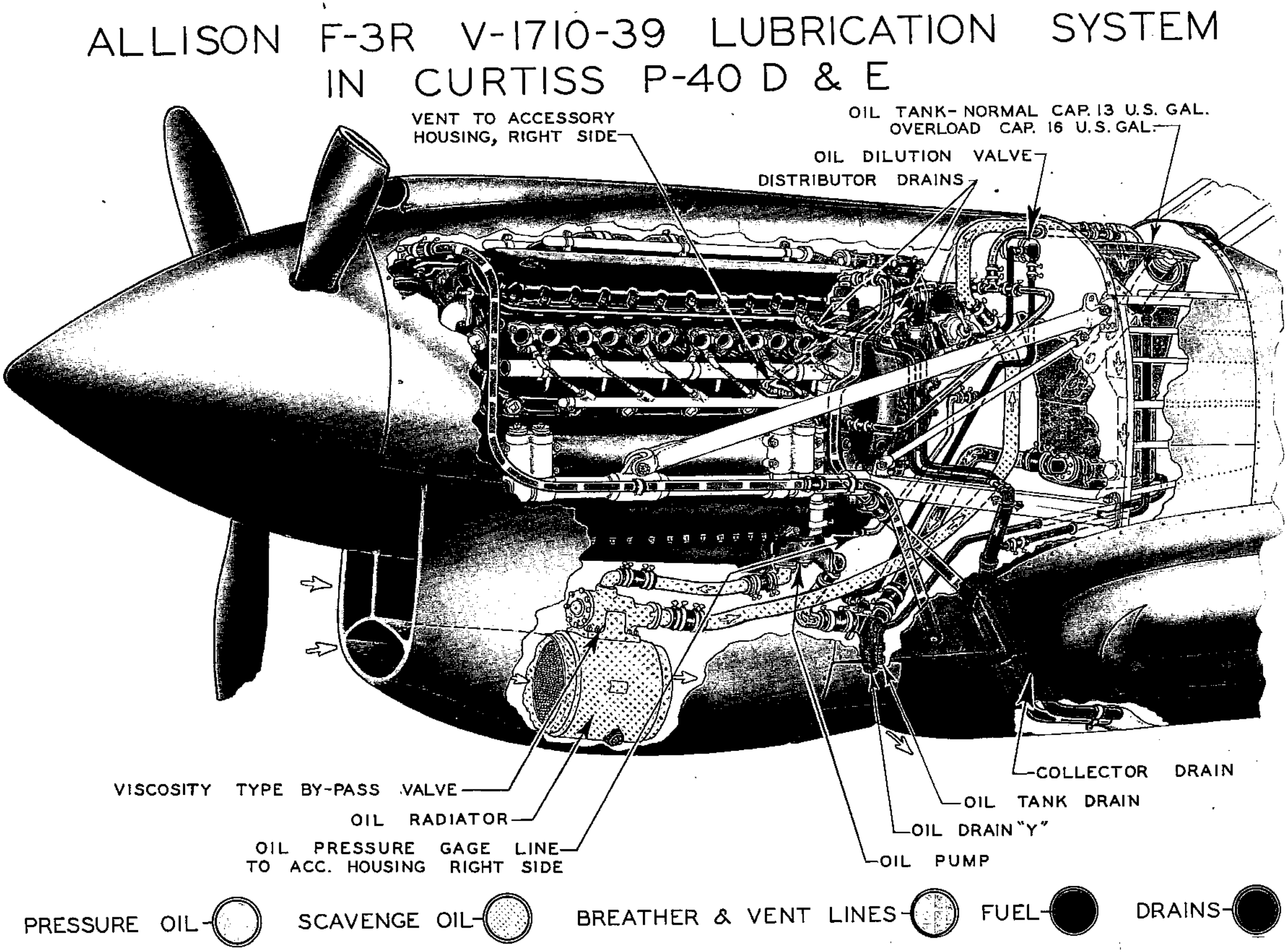


Figure 42—Typical Oil System in P-40 Type Airplane

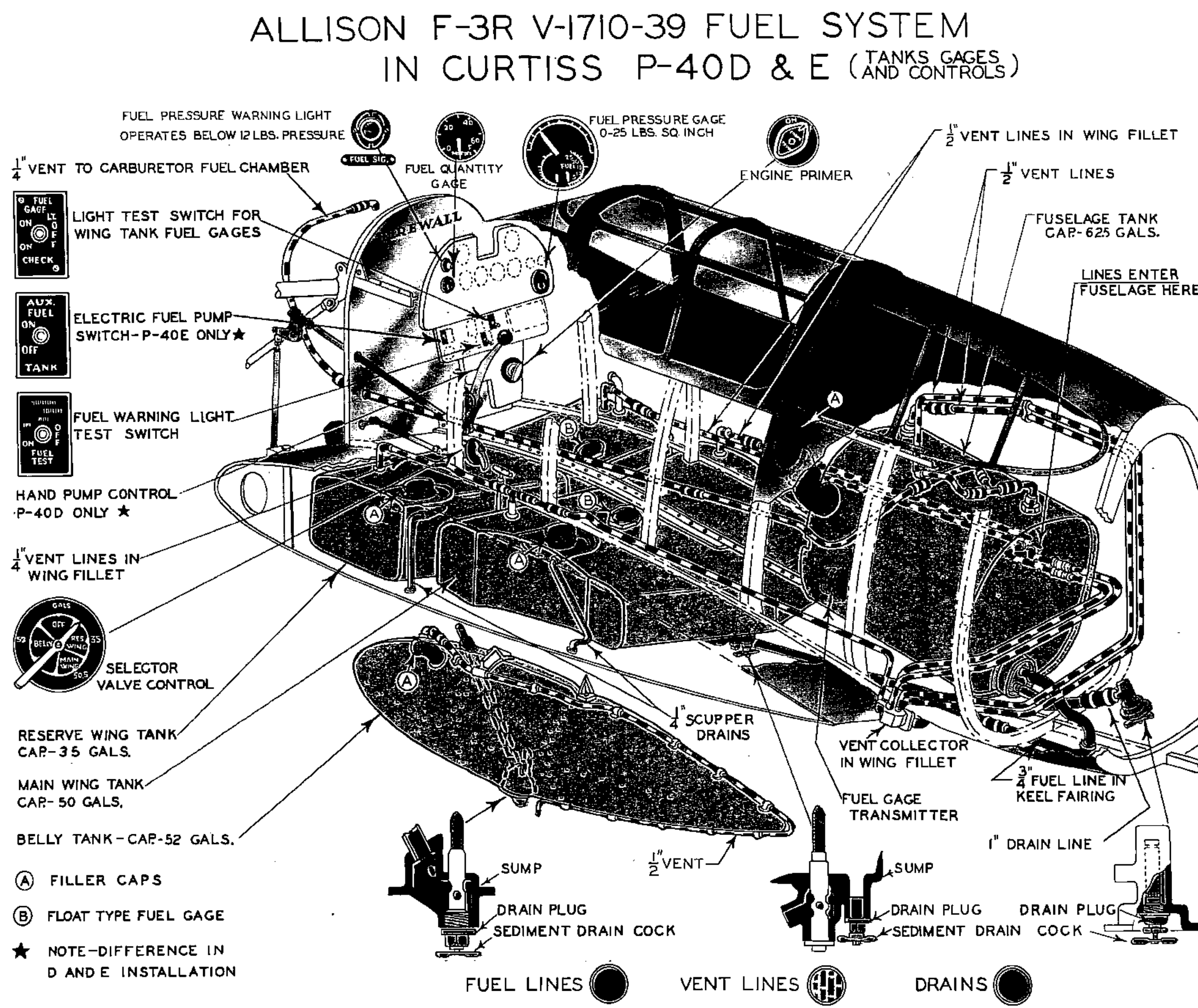


Figure 43—Typical Fuel System in P-40 Type Airplane

ALLISON F-3R V-1710-39 INSTALLATION IN CURTISS P-40D & E (ENGINE COMPARTMENT)

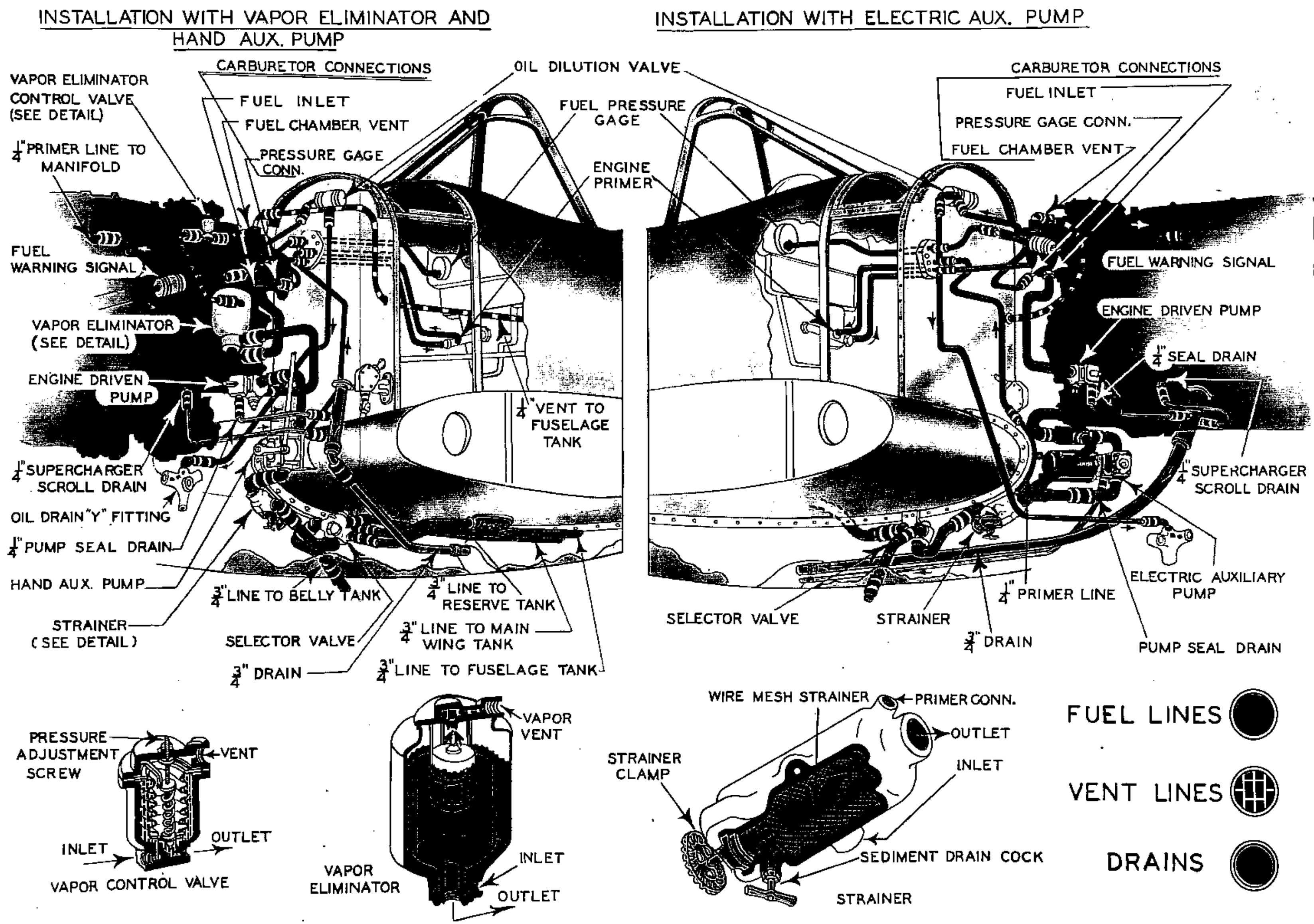


Figure 44—Typical Fuel System in P-40 Type Airplane (Engine Compartment)

ALLISON F3R V1710-39 OIL SYSTEM IN NORTH AMERICAN P-51

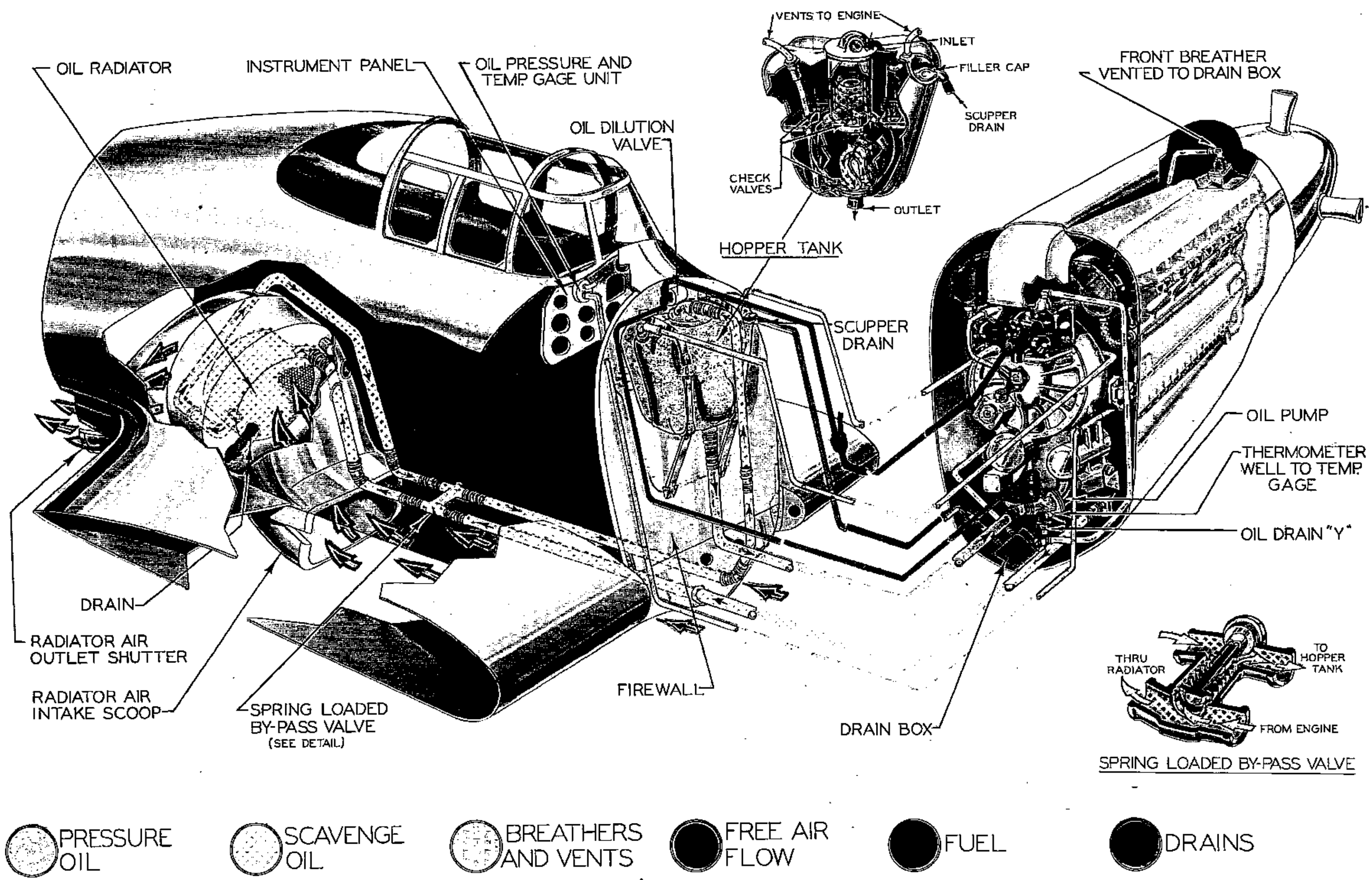


Figure 44A—Typical Fuel System in P-51 Type Airplane

Figures 41 and 42 illustrate typical lubrication system installations.

Figures 43, 44 and 44A illustrate typical fuel system installations.

h. Install propeller hub and tighten. For complete instructions as to the proper procedure, refer to the manufacturer's handbook covering the particular type propeller used.

i. All engines covered in this handbook are equipped with a propeller governor oil bypass plug, for bypassing the oil away from the propeller governor. Only when a hydraulic propeller is to be installed, is *this plug to be removed.*

(1) Remove the ½"-20 Hex. head brass plug from the rear face of the reduction gear rear case, located just below the right side of the propeller governor mounting pad. The oil bypass plug is located in the hole back of the ½"-20 brass plug.

(2) The plug is extracted by screwing an inertia type puller with a ¼"-28 threaded end into the tapped hole in the governor oil bypass plug.

(3) After the bypass plug is removed, replace the ½"-20 Hex. head brass plug. Safety this plug with lockwire to the adjacent square head brass plug.

j. The remainder of the preparation for service, as stipulated in Section IV, Paragraph 5, will be completed at this time. This includes filling carburetor, pre-oiling of engine, and installing spark plugs.

k. INSTALLATION GROUND TESTS.

(1) WARM-UP AND OPERATION.

(a) Whenever a new or overhauled engine is installed in an airplane, the installation will be warmed-up and ground tested by running the engine for approximately 30 minutes during which time the operation of the engine, its instruments and related accessories will be thoroughly checked for proper functioning. The warm-up operation should be made below 1400 R.P.M. and the ground test operation at or below 2280 R.P.M. and Cruising Manifold Pressure. This speed and manifold pressure is sufficient to give an indication of proper functioning of instruments and accessories, except for checking the Take-Off setting of the automatic manifold pressure regulator. Continued operation at manifold pressures approaching rated power must not be longer than 30 seconds duration.

(2) SINGLE MAGNETO CHECK. — A single magneto check will be made between 2200 and 2300 R.P.M. with propeller control and carburetor mixture control set as follows:

Electric Propellers — Set propeller in normal control with fixed pitch which provides 2300 R.P.M. at or near 28" Hg.

Hydraulic Propellers — Set propeller control at Take-Off (full low pitch position)

Mixture Control—Set at "Automatic-Rich"

The loss in speed in running on either single magneto should not exceed 100 R.P.M. when the engine is warm and functioning properly.

CAUTION

On engines equipped with automatic manifold pressure regulator observe the tachometer reading immediately after switching to single magneto operation before the regulator has had time to compensate for the R.P.M. drop.

WARNING

Do not make single magneto checks over 2300 R.P.M. and 30" Hg. manifold pressure. The checking of the ignition switch for proper "ground" when in "OFF" position should be accomplished at "idling" speeds only.

(3) AUTOMATIC MANIFOLD PRESSURE REGULATOR CHECK.—A ground check should be given the automatic manifold pressure regulator to determine whether the regulator unit has been properly installed and is operating. See Section IX, Paragraph 6 *e.*

l. INSTALLATION FLIGHT TEST.—Upon completion of installation ground tests specified above, airplanes in which new or overhauled engines have been installed, will be flight tested in the vicinity of the airdrome before being released for service use.

(1) The flight test shall consist of a flight of one hour's minimum duration, the first 50 minutes of which will be at reduced power, and the last 10 minutes at normal rated power, followed by a careful inspection for evidence of any visible defects, malfunctioning parts, etc. If no malfunctioning or defects are noted, fly an additional one-half hour at cruising power prior to release of the airplane.

3. REMOVING ENGINE FROM AIRPLANE.

a. Before an engine is removed from an airplane the initial steps of preparation for storage as outlined in Section IV, Paragraph 2 *d,* must be performed.

b. Remove propeller.

c. Remove cowling that is necessary to permit the disconnection of the controls, other connections and removal of the various accessories.

d. Remove the eight 3/8″ bolts holding the engine to the mount, or in the case of rubber mounts, detach the mounting brackets from the rails if necessary.

CAUTION

The spark plug cooling manifold assemblies are a part of the engine and will be kept with the engine when it is removed from the airplane.

e. After the bolts have been removed, guide the engine carefully from the mount, lower it and fasten in the box or engine overhaul stand securing it with four 3/8″ bolts.

f. Prepare the engine for storage as outlined in Section IV, Paragraph 2 *d.*

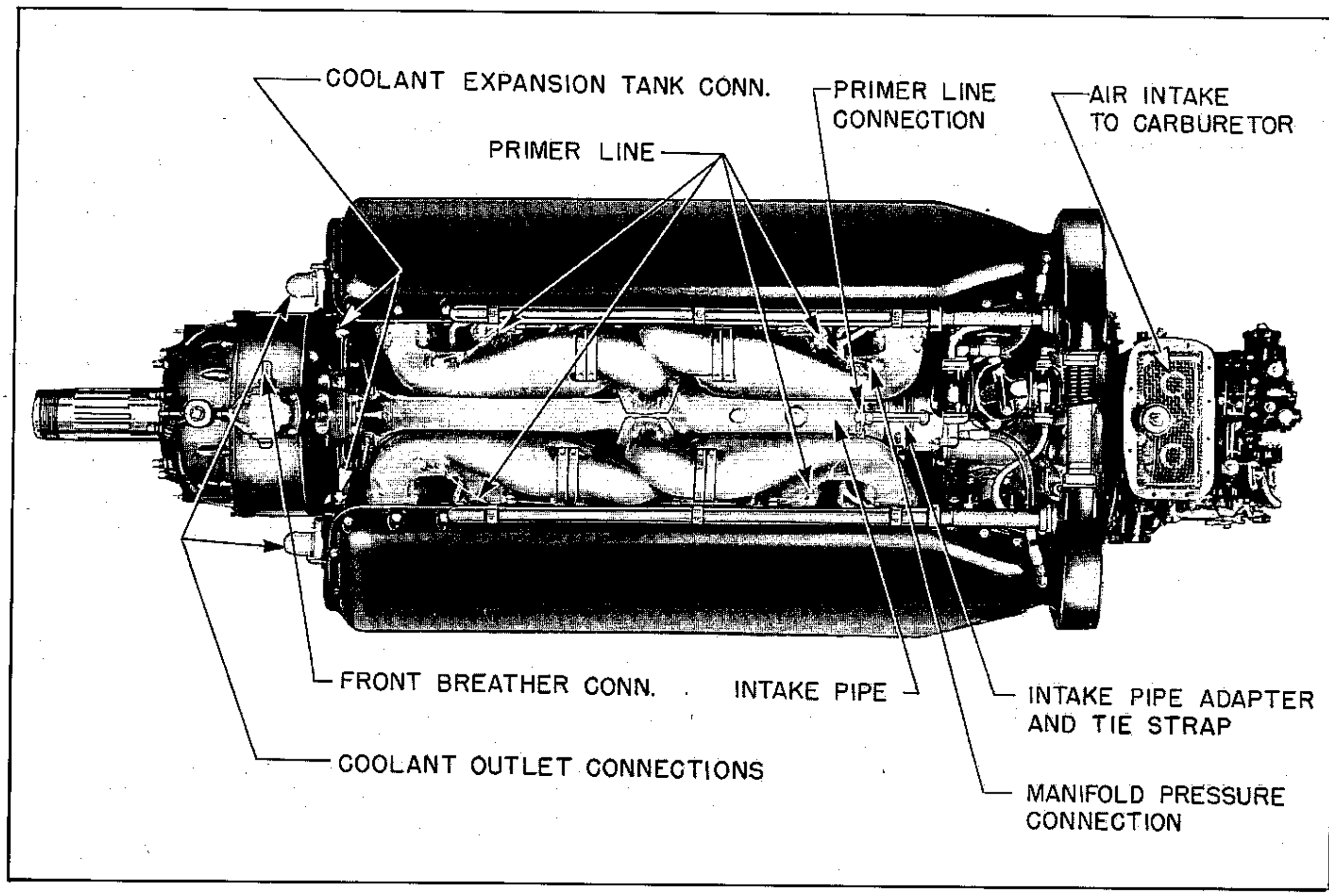


Figure 45—Intake Manifold System with Primer Lines.

SECTION VI

ENGINE TROUBLES AND SERVICE REPAIRS

1. ENGINE FAILS TO START.

If engine fails to start, it may be due to one or more of the following conditions:

a. LACK OF FUEL AT CARBURETOR, OR INSUFFICIENT FLOW.

(1) Check fuel in tank and see that the correct tank valve setting is being used. This is indicated by flow of fuel at wobble pump.

(2) Check carburetor strainer or airplane gasoline strainer. (Priming fuel does not pass through carburetor.)

(3) The carburetor vent connection should be removed and the engine rotated. The issuance of a spout of fuel from the vent would constitute a check on the fuel pump and fuel lines.

b. STARTING PROCEDURE.

Incorrect starting procedure is frequently the cause of the engine's failing to start. The correct starting procedure is as follows:

(1) First set the propeller to *manual* low pitch position.

(2) Carburetor air heater should be in "Full-Off" or "Cold" position.

(3) Set throttle at 1/10 open position corresponding to 1000 to 1200 R.P.M.

(4) Next set the mixture control in "Idle Cut-Off" and operate the wobble pump to obtain a fuel pressure of 4 lbs./sq. in. The desired normal operating fuel pressure is 12-16 lbs./sq. in. However, as fuel begins to discharge into engine at 4 lbs./sq. in. pressure, this pressure should not be exceeded when using wobble pump prior to turning over engine.

(5) Energize starter.

(6) On a cold engine, prime with 2 to 4 full strokes of the priming pump; on a warm engine, 1 to 2 full strokes are sufficient. The priming system is independent of the carburetor. Caution must be exercised not to over-prime the engine in view of the extreme effectiveness of the priming system. No priming action nor fuel discharge is accomplished by pumping the engine throttle on a pressure type carburetor.

(7) Turn on ignition switch to "Both On" position, engage starter, maintain fuel pressure of 4 lbs. by wobbling as propeller begins to turn. When engine starts firing, move mixture control to "Automatic Rich."

(8) Avoid excessive operation of the wobble pump to prevent flooding the supercharger inlet in case the engine does not start immediately. If the engine gives the impression of being loaded in starting, it can be cleared by moving mixture control to "Idle Cut-Off" position for brief intervals while the engine is turning over. In case of definite overloading, turn the engine over with the switch off, the mixture control in "Idle Cut-Off" and the throttle wide open.

(9) If, after a cold start, a heavy viscous oil is indicated by high or fluctuating oil pressure when the engine R.P.M. is increased for "warm-up," the oil dilution valve control switch may be held "ON" for 1 to 2 minutes to further dilute the oil and correct this condition. Overdilution of the oil will result in dangerously low oil pressure, and should be avoided if possible.

(10) If the engine should stop, return the mixture control immediately to "Idle Cut-Off" position to avoid flooding the engine with fuel, as the fuel pressure will build up to normal operating pressure of 16 lbs./sq. in. when engine starts firing.

(11) If engine is not overloaded, another start can be made using the same procedure. In case of overloading, the next start should be attempted without priming.

c. UNDERPRIMING OR OVERPRIMING.

(1) UNDERPRIMING is sometimes caused by leaking primer line connections or priming pump packing. Also check the fuel supply to the primer and wobble pump.

(2) OVERPRIMING is first indicated by a very weak combustion followed by black smoke from the exhausts. Excessive overpriming is evidenced by wet plugs and by gasoline appearing at the exhaust stacks. This condition constitutes a dangerous fire hazard, as well as a detriment to the oil film on the cylinder walls.

(a) To relieve overloading, crank the engine several revolutions with the switch off, throttle wide open, and the mixture control lever in "Idle Cut-Off."

d. CARBURETOR MANUAL SETTING INCORRECT.

(1) Set pressure type carburetor on "Automatic-Rich" after engine begins to fire from priming charge.

(2) Set throttle at the position corresponding to 1000 to 1200 R.P.M.

e. DEFECTIVE IGNITION.

NOTE

Before checking ignition, remove any excess fuel in the induction system as indicated in Paragraph 1. *c.* (2), *(a)* above.

(1) Remove spark plug terminal and see if current is reaching spark plug.

(2) Next check magneto by removing one magneto terminal and inserting screwdriver into socket so as to touch contact post. Turn engine over with starter to see if spark appears between screwdriver and socket wall.

(3) If spark appears at magneto, then check ignition wiring, ground connection and switch for broken wires and insulation. Also check for short circuits and incorrect connections. Refer to Section VIII for replacement of defective cable.

(4) Determine if magneto terminal is making good contact inside magneto. When terminal is placed in socket, the contact post inside the magneto should deflect enough to spring terminal back at least 1/8". If pressure on terminal is weak, then reach inside the magneto with a bent point scriber and bend contact post toward terminal socket.

(5) If spark fails to appear at magneto, remove magneto cover and check points for opening, pitted condition, dirt, or corrosion.

(6) Check distributor rotors and heads for loose contacts, short circuits, cracks, dirty surfaces and wrong connections. Refer to Wiring Diagrams, Figures 75, 76 and 77.

(a) When cleaning distributors, ignition cables, and other ignition parts, special care must be used in the choice of a solvent. Do not use carbon tetrachloride as it leaves a deposit which may cause shorting.

(b) Avoid use of excessive quantities of solvent, since most types attack the lacquer coating and rubber insulation of the ignition cables. Do not slosh the inside of the distributor head as the solvent may run down into the ignition shielding or become pocketed in recesses and damage the insulation and lacquer coating of the ignition cables.

(c) Dampen, but do not saturate, a cloth with a suitable solvent and wipe the distributor or other ignition parts to be cleaned. Clean one part at a time and wipe it dry with a clean cloth immediately afterward. Allow the cleaned part to dry thoroughly by normal evaporation before reassembling it.

CAUTION

To avoid danger of fire or explosion, be sure all solvent fumes have been removed from the ignition parts before reassembling them into the shielding or housings.

(d) Acetone is recommended as the solvent in cleaning the distributor finger and head. Clear gasoline or mineral spirits is recommended on all other parts.

(7) Check magneto timing, making sure that the magneto is not displaced by 180°.

(a) If magneto is out of time, it is probable that the valve mechanism is out of time also.

f. VALVE TIMING.

(1) Remove cylinder head covers (loosen intake ignition tube connector nuts and brackets), and check valve timing.

(a) Check valves for freedom of action.

(b) Check for damaged valve springs, retainers, keepers, etc.

(c) Check tappet clearance. (Section VIII, Paragraph 5.)

(d) Inspect for broken tappets.

g. INSUFFICIENT CRANKING SPEED.

(1) Defective starter or battery.

(2) Cold oil. (Not applicable if oil dilution system is used.)

(a) With ignition switch off and throttle wide open, turn propeller over by hand. During extremely cold weather, if engine is too stiff to be turned by hand, it will be necessary to heat the oil and ethylene glycol before starting the engine.

h. AIR LEAKS.

(1) Check intake manifolds, hose connections and clamps for security.

(2) Check intake manifolds for holes, cracks or blistering.

(3) Check carburetor gaskets for tightness.

(4) Check tightness of plugs and connections in intake manifolds.

(5) Check intake manifold nuts and gaskets for tightness.

TYPICAL FUEL SYSTEM COMPONENTS

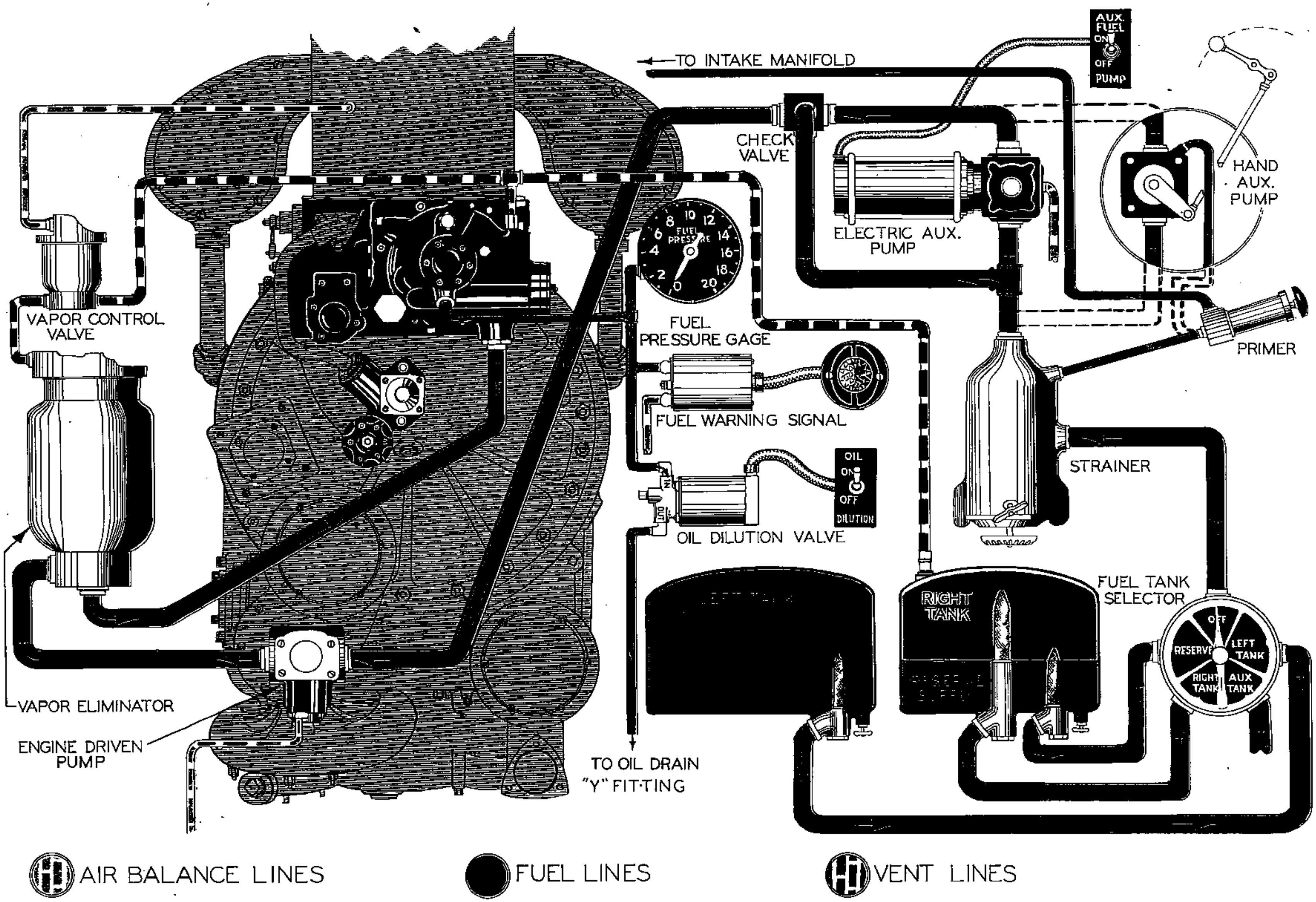


Figure 46—Typical Fuel System Components

EXHAUST FLAMES *And Their* CHARACTERISTICS

OVER LOADED (GENERAL)

NOTICED ONLY WHEN STARTING. THICK, BLACK, BILLOWY SMOKE, OFTEN FOLLOWED BY FIRE FROM STACKS, THIS TYPE IS CAUSED BY OVER PRIMING, CONSTITUTES A DANGEROUS FIRE HAZARD, AND IS DETRIMENTAL TO THE ENGINE.

RICH MIXTURE (GENERAL)

ENGINE SPEED-2500 R.P.M. SHORT, RED FLAME AT STACK, FOLLOWED BY AN AREA OF NO NOTICEABLE FLAME, THEN AN AREA BLUISH IN COLOR. IF VERY RICH, A BLACK, SOOTY SMOKE WILL BE NOTICED. AS MIXTURE IS CORRECTED, THE BLUISH FLAME WILL MOVE INWARD.

LEAN MIXTURE (GENERAL)

ENGINE SPEED - 2000 R.P.M.

LEAN MIXTURE IS INDICATED BY A BLUISH, WHITE FLAME DIRECT FROM STACKS. ENGINE TENDS TO BACK FIRE AT HIGHER SPEEDS. AVERAGE LENGTH OF FLAMES, 6 TO 8 INCHES.

OIL FLAME (GENERAL OR LOCAL)

ENGINE SPEED-2500 R.P.M. A SHORT, SNAPPY, DULL RED FLAME. AVERAGE LENGTH, 4 TO 7 INCHES. USUALLY ACCOMPANIED BY WHITISH, BILLOWY SMOKE. THIS FLAME MAY BE NOTICED IN ONE SET OF STACKS AND BE ENTIRELY LACKING IN ANOTHER.

LEAN MIXTURE & BURNING OIL

REDDISH FLAME WITH BLUISH TIP. ONE OF THE MOST COMMON FLAMES, ENCOUNTERED. OFTEN CONFUSED WITH OIL FLAME. TO CHECK, MOVE MIXTURE CONTROL TO FULL RICH POSITION. IF FLAME LESSENS, MIXTURE IS LEAN & BURNING OIL. AVERAGE LENGTH 6 TO 8 IN.

DEFECTIVE SPARK PLUGS

INDICATES DETONATION. ENGINE SPEED-2500 R.P.M. VERY LONG WHITISH, ORANGE FLAME APPEARING INTERMITTENTLY. INCLINED TO BE SPASMODIC OR EXPLOSIVE IN APPEARANCE USUALLY APPEARS FROM ONE OR MORE STACKS.

INCOMPLETE COMBUSTION (GEN)

BLUISH, WHITE FLAME DANCES OUT FROM STACK. USUALLY NOTICED WHEN TAKING A MAG. CHECK. CAUSED BY INCOMPLETE BURNING OF FUEL/AIR MIXTURE IN COMBUSTION CHAMBER. A DROP IN R.P.M. MAY ALSO BE NOTICED.

CORRECT MIXTURE (USUALLY GEN.)

ENGINE SPEED - 2600 R.P.M.

A SHORT, SNAPPY, BLUISH PURPLE FLAME. AT TIMES DEPENDING ON LIGHTING CONDITIONS, THIS FLAME MAY BE VERY HARD TO DISTINGUISH.

Figure 47—Exhaust Flames Chart

2. LOW OIL PRESSURE.

(Less than 55 lbs./sq. in.)

a. LOW OIL PRESSURE DURING GENERAL OPERATION.

(1) The main oil pressure is maintained between 60 and 70 lbs./sq. in. by the pressure relief valve over an engine speed range from 1950 to 3000 R.P.M. with an oil temperature of 60°C to 80°C, (140°F-176°F). If oil pressure drops below 55 lbs./sq. in. when the engine is operating under these conditions, an investigation for the trouble should be made. Failure of oil gage to show required pressure may be due to one of the following causes:

(a) Clogged or dirty oil pressure relief valve.

(b) Incorrect oil pressure relief valve adjustment.

1. Visual inspection of the relief valve adjusting screw will determine if the adjustment setting is approximately correct (flush to one turn inside body). If adjusted more than four turns inside body, either the spring is defective and should be replaced, or the adjustment is wrong.

(c) Insufficient oil in supply tank.

(d) Clogged Cuno oil strainer.

(e) Restriction or obstruction in supply tank or sump.

(f) Restriction or leakage in oil pressure gage line.

(g) Broken or defective oil pressure gage. Check gage for correct reading.

(h) A loose or broken oil line connection on the inlet side of the oil pump.

(i) Oil inlet temperature exceeding 95°C (203°F).

(j) Leaking oil dilution valve causing overdilution of oil.

(k) Damaged oil line or crankshaft oil plug in engine.

(l) Excessive bearing clearance.

b. LOW OIL PRESSURE AT START.

(1) Use of oil unsuited to engine requirements. Refer to Section II, Table of Specifications, of this handbook.

(2) Clogged or defective oil pump check valve.

(3) Cold oil in the pressure gage line will make the gage slow to respond, and register pressure below that existing in the engine. Make certain engine is sufficiently warmed up to eliminate this condition.

(4) Defective pressure gage.

3. LOW POWER.

a. Check propeller for correct design or setting.

b. Be sure the correct grade of fuel is being used. On engines of high output this extremely important. Refer to Table of Specifications, Section II of this handbook.

c. Check magnetos at 2200 R.P.M. with switch to determine drop in R.P.M. on each magneto individually. A drop of more than 100 R.P.M. generally indicates faulty ignition in one or more of the following sources:

(1) Poor spark plugs.

(2) Broken or damaged ignition wires.

(3) Defective magneto or connections.

(4) Faulty distributor rotors.

(5) Dirty or broken distributor heads.

(6) Magneto breaker points pitted or set improperly.

d. Check fuel supply to carburetor for proper pressures which are as follows:

Condition	*Fuel Pressure Lbs./Sq. In.*
Desired	12-16
Maximum	16
Minimum	12
Idling	10

e. On engines *not* equipped with automatic manifold pressure regulator check throttle throw to determine whether carburetor throttle valve is capable of being opened to the full throttle position.

NOTE

Do not open the throttle to the fully open position with the engine operating.

f. On engines equipped with automatic manifold pressure regulators, inspect linkage and regulator. See Section IX, Paragraph 6.

g. Check fuel lines and strainers for restriction to flow.

h. Check magneto and valve mechanism for operation and timing.

i. Check carburetor air intake system for restriction or induction of exhaust gases.

j. Check for air leaks in intake manifolds and gaskets, carburetor mounting flange and gaskets, and carburetor body gasket.

k. Incorrect fuel-air ratio. Check mixture control lever.

l. Leaking intake or exhaust valves. With ignition switch off, rotate propeller shaft to check compression.

(1) Check compression. Remove a spark plug from each cylinder, either intake or exhaust, whichever is the most accessible. Install the second plug in each cylinder individually and turn the engine over by hand to determine if any noticeable difference in compression exists.

m. Check coolant temperature.

n. On engines equipped with Turbo-supercharger, check operation of Turbo waste gate.

4. ROUGH RUNNING.

a. Check propeller balance and track.

b. Check propeller hub nut for tightness.

c. Check propeller shaft thrust bearing nut for tightness. Use wrench No. 2115. Check propeller hub near cone for galling.

d. Check spark plugs and terminals. See that only solid copper gaskets are used, and are properly seated.

e. Check removable sleeves in the exhaust detachable leads.

f. Check magneto timing and operation, including condition of magneto breaker points. Check ignition harness for broken wires, poor connection and damaged insulations.

g. Check engine mount bolts for tightness.

h. Check engine mount for cracked or broken members.

i. Check mixture control lever setting and operation for proper functioning.

j. Check engine operation with carburetor heat control "Full On" to determine if poor distribution or ice formation in carburetor is causing roughness.

k. Check distributor finger drive shaft bearings.

l. Check valve mechanism operation and timing.

m. Make sure there is no water in the fuel, and that the proper grade of fuel is being used. Refer to Section II, Table of Specifications, of this handbook for proper grade of fuel.

n. Check coolant temperature. Coolant temperatures below 85°C (185°F) may cause poor distribution and rough running.

o. Examine distributor rotors and heads for failures or signs of arcing or cracks.

5. HIGH OIL INLET TEMPERATURE.

(Over 95°C) (203°F)

a. Check amount and grade of oil in tank.

b. Check oil cooling system, particularly installations which have oil coolers with bypass valves. Check for restriction in air ducts to oil coolers.

c. Check Cuno strainer for foreign particles.

d. Check magneto timing.

e. Check carburetor for lean mixture.

f. Check valve timing and adjustment.

g. Check for high oil flow due to damaged crankshaft oil plug, broken main oil line, defective bearings, etc.

6. HIGH OIL PRESSURE.

(Over 85 lbs. per sq. in.)

a. Cold oil. See that the oil is diluted or warmed up sufficiently before operating the engine over 1400 R.P.M.

b. Improper setting of oil pressure relief valve. (A quarter turn of the adjusting screw will change the pressure approximately 1½ lbs.)

c. Oil pressure relief valve not functioning properly.

d. Cuno strainer clogged with foreign particles.

e. Restriction in oil passages or main oil line.

7. BACKFIRING.

a. Violent backfiring of the engine, if allowed to occur repeatedly, will cause serious damage. Consequently the cause of the trouble should be located quickly and corrected. The following items are conducive to backfiring:

(1) Cold engine. The coolant temperature should be above 85°C (185°F) before engine is operated above 1800 R.P.M. The oil temperature should be between 60°C to 80°C (140°F to 176°F).

(2) Lean mixture setting.

(3) Foreign substance under intake seat preventing the valve from closing. Set ignition switch on "Off" and check valves for leaks by slowly rotating the propeller shaft.

(4) Insufficient valve tappet clearance.

TURBO-SUPERCHARGER AND REGULATOR

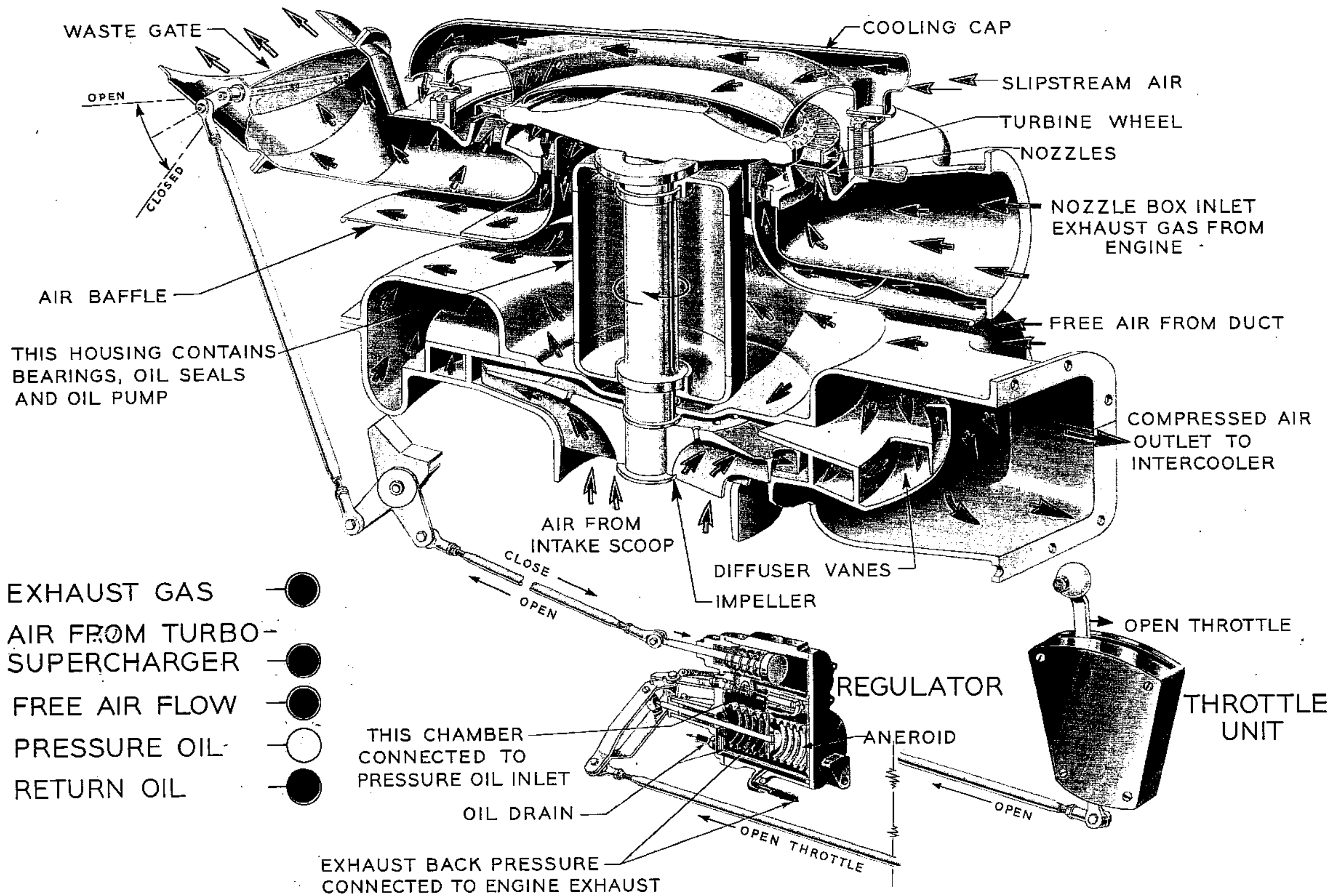


Figure 47A—Typical Turbo Supercharger and Regulator

(5) Valve mechanism failure. Remove cylinder head covers for examination.

(6) Incorrect valve or ignition timing.

(7) Moisture or dirt on distributor rotors. Make sure the vent screens are not clogged.

(8) Loose ground connection on ignition cable shielding at the mounting brackets on the cable tubes.

(9) Excessive carburetor air temperature.

(10) Low carburetor fuel pressure. The fuel pressure at the metering unit should not be less than 12 lbs./sq. in.

(11) Leaks at the intake manifold gaskets, when manifold pressure is below atmospheric pressure.

(12) Loose spark plugs or damaged spark plug gaskets.

b. Immediately after the correction of any prolonged ignition difficulties or misfiring of the engine, inspect each intake valve for burning on the valve face. This will be accomplished by removing the intake manifolds and turning the crankshaft until the individual valve to be inspected is approximately one half open. Visual inspection of the intake valve seat face will be made through the intake valve port while casting a light on the seat of the valve. Each intake valve will be rotated a full 360° by turning the upper valve spring washer during the inspection in order that the entire periphery of the seat can be observed.

8. COOLANT OR OIL LEAKS.

a. Damaged gaskets or parting surfaces.

b. Incorrect gasket material or coating.

c. Cracked casting.

d. Loose cylinder hold down stud nuts. Tighten nuts through an angle of 90°. For correct procedure, refer to Section VII, Par. 2. *i.*

e. Damaged cylinder hold down stud nut seals.

f. Worn coolant pump shaft or damaged coolant seals.

g. Poor hose connections, clamps, etc.

9. HIGH COOLANT TEMPERATURE.

(Over 125°C) (258°F)

a. Insufficient quantity of coolant in expansion tank.

b. Insufficient coolant flow. Check coolant pipes for restrictions, leaks (especially on the inlet side), and examine coolant pump for failures.

c. Check coolant for water content.

d. Restriction in air ducts to radiators.

e. Shutters left in closed position.

f. Expansion tank line to pump inlet inadequate to care for flow of vent lines, causing low pressure at pump inlet. Check for desired pressure, 0-1 lbs. at pump inlet.

g. Coolant leaks between the inlet and outlet headers in the radiator. Also check for jammed pressure control valve on the coolant expansion tank.

h. Coolant vent lines too small or not located properly, resulting in air traps in the system.

i. Insufficient idling speed for continuous ground idling.

j. Incorrect ignition or valve timing.

10. PROPELLER SHAFT MISALIGNMENT.

a. When an airplane noses over, taxis into an obstruction or crashes, causing the propeller to stop abruptly (one or two turns) from any power driven speed, severe internal damage may result.

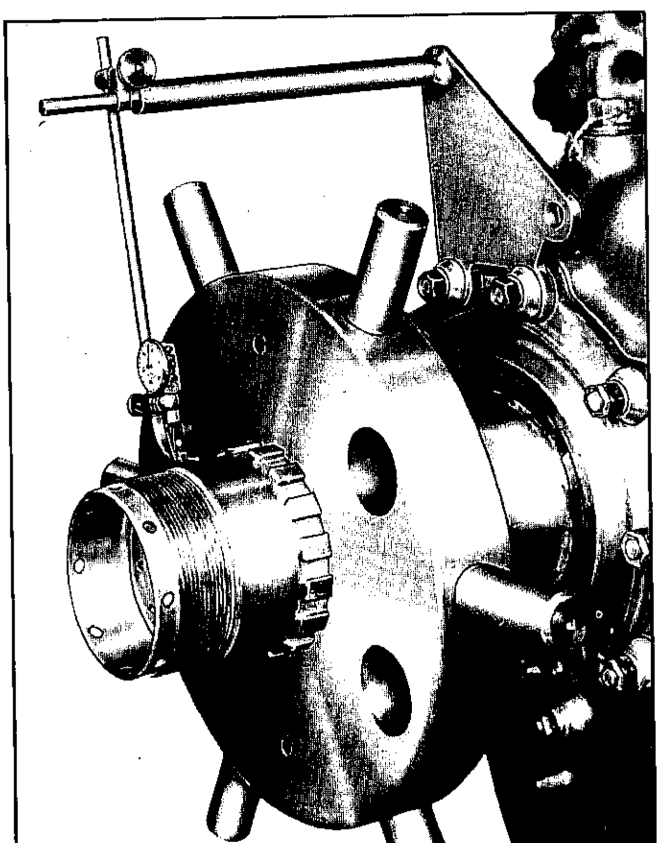


Figure 48—Checking Propeller Shaft Alignment.

(1) Whenever an accident as described above occurs to any of the engines covered in this handbook, the engine should be removed as soon as possible and forwarded to the control depot for disassembly and inspection.

(2) In the case of a propeller striking some object, which momentarily reduces the speed but does not completely stop the engine, inspection should be made of the engine to determine whether or not it may be continued in service. The inspection should include a misalignment check of the propeller shaft with a dial indicator and Allison Tool No. 2447. The propeller shaft runout when measured in this manner should not exceed .005″ at the front cone seat location. See Figure 48.

11. CARBURETOR MALFUNCTIONING.

a. Refer to section IX, Paragraph 2 *e*, Trouble Shooting, for corrective measures, when, under specific conditions of flight, the following carburetor malfunctioning is indicated.

(1) Engine runs too rich or too lean at Cruising Power.

(2) Engine runs too lean at Take-Off or Rated Power but satisfactorily at Cruising Power.

(3) Engine runs too lean or too rich at altitude in Automatic position, but satisfactorily at sea level.

(4) Engine does not accelerate properly but runs satisfactorily with slow throttle movements.

(5) Engine does not shut off in Idle Cut-Off position.

SECTION VII

SERVICE, INSPECTION AND MAINTENANCE

1. GENERAL.

a. The work outlined in this section is a normal function of the operating organizations at Air Corps stations. It consists of the periodic inspection, cleaning, servicing, lubricating, adjusting and such maintenance work as the organization facilities permit. For preflight inspection, refer to the Handbook for the airplane in which the engine is installed.

b. The necessary tools for this work may be found listed in Section X—Service Tools.

2. INSPECTION AND MAINTENANCE.

a. DAILY—POWER PLANT.

(1) Inspect high tension ignition leads for evidence of burning due to leaks in exhaust system.

(2) Inspect for evidence of engine throwing oil.

(3) Inspect for proper safetying of all drain plugs, covers, etc.

(4) If the Cuno Strainer becomes clogged, it should be removed and cleaned in some solvent until it turns freely.

b. IGNITION AND ELECTRICAL.

(1) Inspect and maintain spark plugs in accordance with Section IX, Paragraph 4 and magnetos in accordance with Section IX, Paragraph 3.

(2) 25 HOURS.—Inspect the three threaded connectors in each distributor drive housing for looseness. The three connectors are the two distributor head housing to ignition cable tube connectors and one ignition cable cross tube connector. If there is any looseness, remove the loose connector from the housing and install a new connector in the manner described in Section VIII, Paragraph 11.

CAUTION

It is important that the above inspection be carried out periodically because, once the connector has started to work loose at its threaded fitting in the distributor housing, continued engine operation may damage the housing beyond repair. A new connector should be installed at the slightest indication of looseness.

(3) 50 HOURS.

(a) Inspect ignition shielding for proper anchorage and security of union nuts.

NOTE

Whenever it is necessary to resolder any part of the ignition manifold assembly, the following will apply:

Only solder, Specification 57-99-1 (lead and silver rod, 1/8 inch diameter) should be used due to its resistance to higher temperatures. This solder should be applied with a soldering iron, properly heated; however, extreme care should be exercised to prevent burning any adjacent ignition cable insulation. Whenever possible, the ignition cable should be withdrawn from the parts that are to be soldered.

c. FUEL SYSTEM.

(1) Inspect and maintain carburetor in accordance with Section IX, Paragraph 2.

d. OIL SYSTEM.

(1) SPECIAL PERIODS.

(a) Inspection and servicing of Cuno oil strainers require special 10 and 25 hour attention. Refer to Section IX, Paragraph 5 for details.

(2) 25 HOURS.

(a) The complete engine and airplane oil system should be drained at every 25 hour inspection and refilled with the grade of oil specified in Table of Specifications. The draining operation should be accomplished immediately upon completion of flight while the oil is hot. At the same time the oil is drained, the magnetic plug will be removed from the rear oil drain elbow of the engine and inspected for accumulation of metal particles or sediment.

NOTE

After filling oil tank at oil change, the oil pump inlet line must be bled of all included air. Disconnect the oil inlet line connection at the oil pump to bleed air and establish solid oil flow.

(b) Remove and clean Cuno oil strainer and the strainer compartment on the engine. On all models equipped with automatic Cuno strainers, even distribution of dirt on disc surface indicates that the automatic Cuno has not been turning during engine operation. Observe cleaning procedure in Section IX, Paragraph 5.

CAUTION

Do not attempt to remove Cuno by taking out the 3 Hex. head cap screws located in the head, since the removal of these will only separate the head from the cleaning element. Cuno is secured to accessory housing by the 6 self-locking nuts located on flange in rear of the Cuno head. When replacing the Cuno strainer be sure that the mounting face is wiped dry of oil and that a new gasket is installed each time the Cuno is removed.

(c) Inspect all oil lines for: leaks, particularly at connections; security of anchorage; wear due to chafing or vibration; and dents or cracks.

(d) Check supercharger oil seal vent (non-removable screen type) by removing vent assembly and blowing through with mouth. In case of clogging, wash thoroughly and recheck. In case washing does not clean screen the new type assembly (having removable screen) should be installed.

(3) 50-HOUR.—During each second 25-hour oil change remove and clean the engine oil screens located in the front and rear oil drain elbows. Removal and reinstallation of the drain elbows must be accomplished in accordance with the special procedure given in Section VIII, Paragraph 8, *c*.

(4) AT ENGINE CHANGE.—Clean removable oil screens and the Cuno strainer on newly installed engines by removing and washing in gasoline. See instructions Section V, Paragraph 2—Installation of Engine in Airplane. When cleaning Cuno oil strainers, the compartment in which the filter is installed will also be cleaned.

e. COOLING SYSTEM.

(1) 25-HOUR.

(a) Inspect lines for evidence of leaks, particularly at connections; security of elbow anchorage; wear due to chafing or vibration; condition of hose connections; and tightness and location of clamps at rubber connections.

NOTE

In replacing hose connections, refer to Section VIII, Paragraph 15.

(b) Inspect coolant pump for evidence of leaks. The coolant pump has a spring loaded type packing which will not require manual tightening. If leakage is excessive do not attempt to replace packing or any part of the pump. Replace the entire pump as a unit.

(2) 100-HOUR.

(a) Drain and flush the coolant system. Drain the coolant while hot from the lowest point in the coolant system. The filler cap should be removed to speed drainage and *the airplane kept in its normal ground attitude.* Coolant should be drained off into clean stoppered containers for salvage. Be sure to drain out all water and coolant in each draining operation.

(b) With the drain open and with a hose in coolant expansion tank filler, run water through system until water drains out clear.

(c) Close drain and fill system with water.

(d) Drain water from the cooling system by removing plug.

(e) Refill in accordance with Paragraph *(c)*.

(f) Run engine until coolant temperature reaches 90°C.

(g) Drain water from the cooling system by removing plug. If draining water is still dirty, repeat *(e)*, *(f)*, and *(g)*.

(h) Fill engine with flushing Ethylene Glycol, conforming to Specification AN-E-2.

(i) Run engine until coolant temperature reaches 100°C.

(j) Drain flushing Ethylene Glycol by removing plug described above.

NOTE

The flushing Ethylene Glycol is used to remove the water left in the cooling system from the water flush. It can be re-used in cleaning other cooling systems until the water content of the flushing glycol is approximately 20% or until the coolant is contaminated. The boiling point of 80% Ethylene Glycol — 20% Water — is about 257°F. or 125°C. If coolant reclamation equipment is available at the overhaul depot, the Ethylene Glycol can be reclaimed for coolant use by this equipment. If

RELATIONSHIP OF OIL PUMP, OIL STRAINER AND PRESSURE RELIEF VALVE

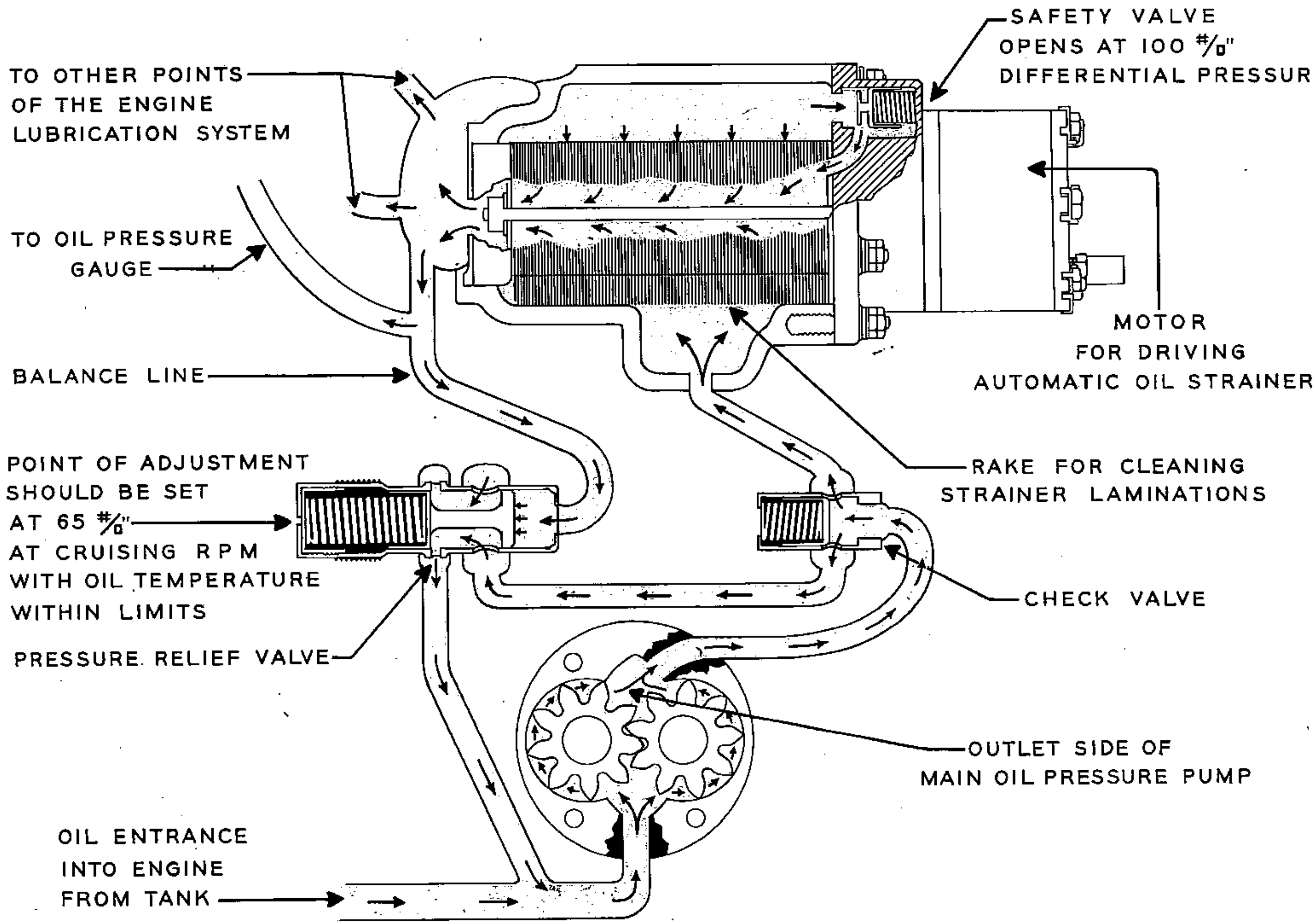


Figure 49—Relationship of Oil Strainer to Pressure Relief Valve and Main Oil Pump

ALLISON F-5R&L V-1710-49&53 COOLANT SYSTEM IN LOCKHEED P-38F

LEFT ENGINE INSTALLATION SHOWN—RIGHT ENGINE INSTALLATION FUNDAMENTALLY THE SAME

(A)-AUTOSYN CONTROLLED TEMPERATURE GAUGE
(B)-COOLANT TEMPERATURE WARNING SIGNALS (LIGHTS)
(C)-EXPANSION TANK FILLER CAP & ACCESS DOOR
(D)-VENT VALVE TO OUTSIDE SHIP (SEE DETAIL)
(E)-VENTS FROM CYLINDER HEADS TO EXPANSION TANK
(F)-VENT LINE FROM RADIATORS TO EXPANSION TANK
(G)-THERMOMETER WELL FOR TEMPERATURE WARNING SIGNAL. CONNECTED TO ELECTRICAL JUNCTION BOX
(H)-THERMOMETER WELL FOR TEMPERATURE GAUGE CONNECTED TO AUTOSYN JUNCTION BOX
(I)-AIRBLEED COCK
(J)-AIRSCOOP FOR RADIATORS
(K)-2 RADIATORS (CARTRIDGE CORE TYPE) ATTACHED TO BOOM STRUCTURE BY 4 (EACH) LORD BUSHINGS
(L)-RADIATOR AIR EXIT SHUTTERS HYDRAULICALLY OPERATED FROM CONTROL HANDLE IN COCKPIT
(M)-DRAIN COCKS
(N)-AUTOSYN INSTRUMENT JUNCTION BOX
(O)-COOLANT PUMP SEAL DRAIN
(P)-LOCATION OF THERMOMETER WELL FOR TEMPERATURE GAUGE ON RIGHT ENGINE INSTALLATION ONLY
(Q)-COOLANT EXPANSION LINE

CAPACITIES

COOLANT CAPACITY ENTIRE SYSTEM. APPROX. 25 GALS.
COOLANT CAPACITY OF TANK 1.8 GALS.
EXPANSION SPACE - 2 GALS.

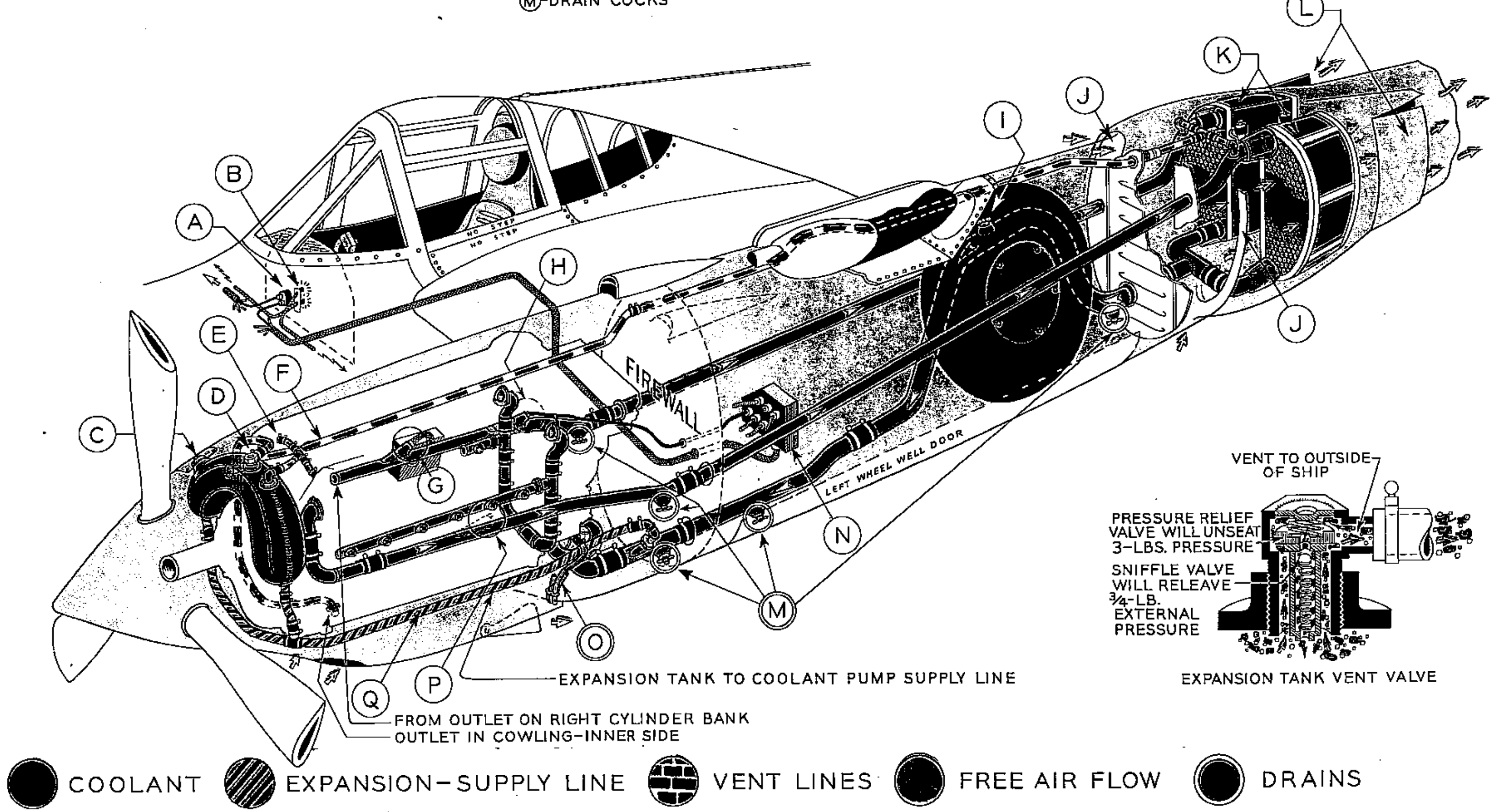


Figure 50—Typical Coolant System V-1710 Engine in P-38 Type Airplane

ALLISON F-3R V-1710-39 COOLANT SYSTEM IN CURTISS P-40D & E

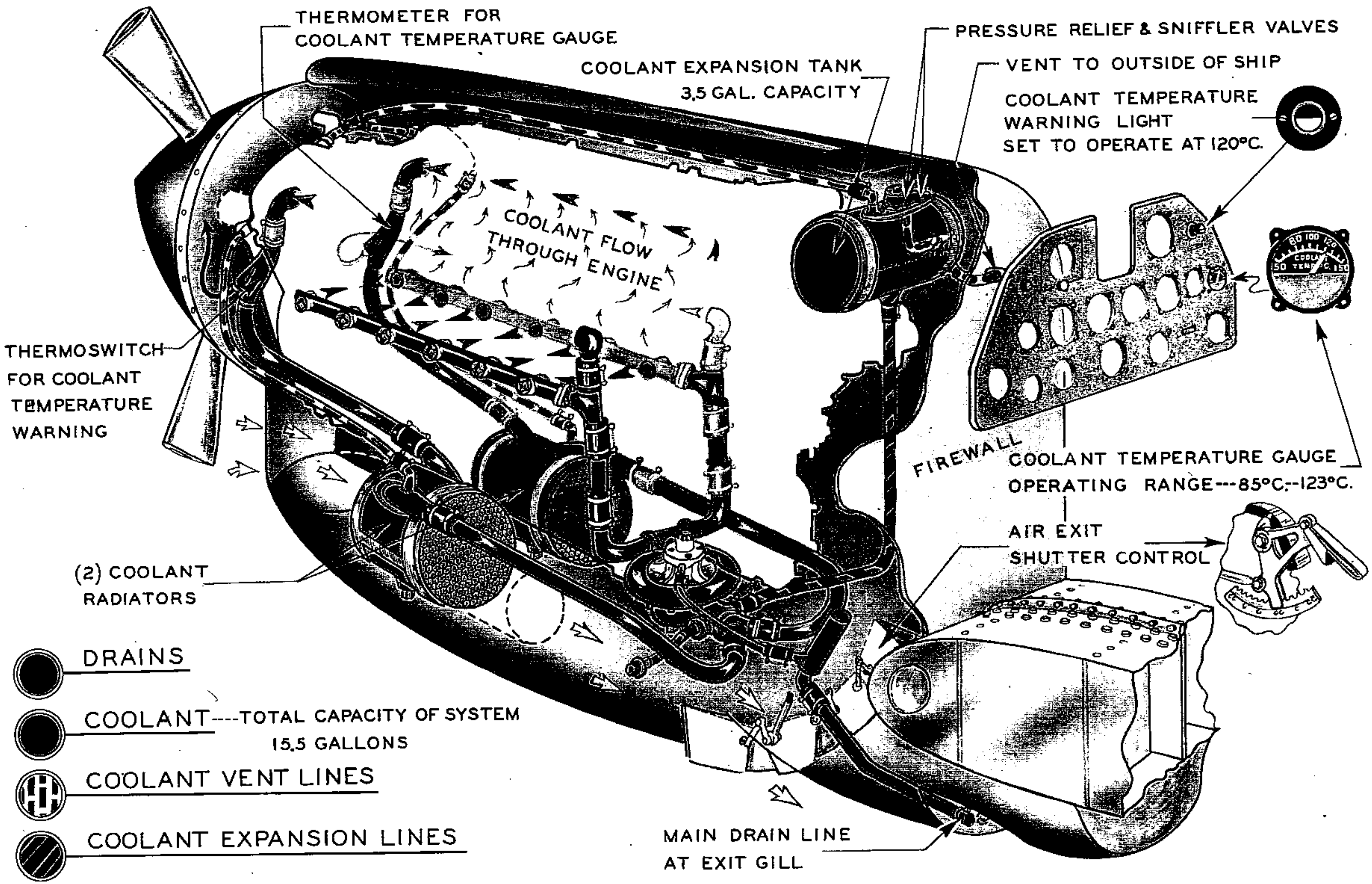


Figure 51—Typical Coolant System V-1710 Engine in P-40 Type Airplane

ALLISON F-3R V-1710-39 COOLANT SYSTEM IN NORTH AMERICAN P-51

TOTAL COOLANT CAPACITY-20.4 GALLONS

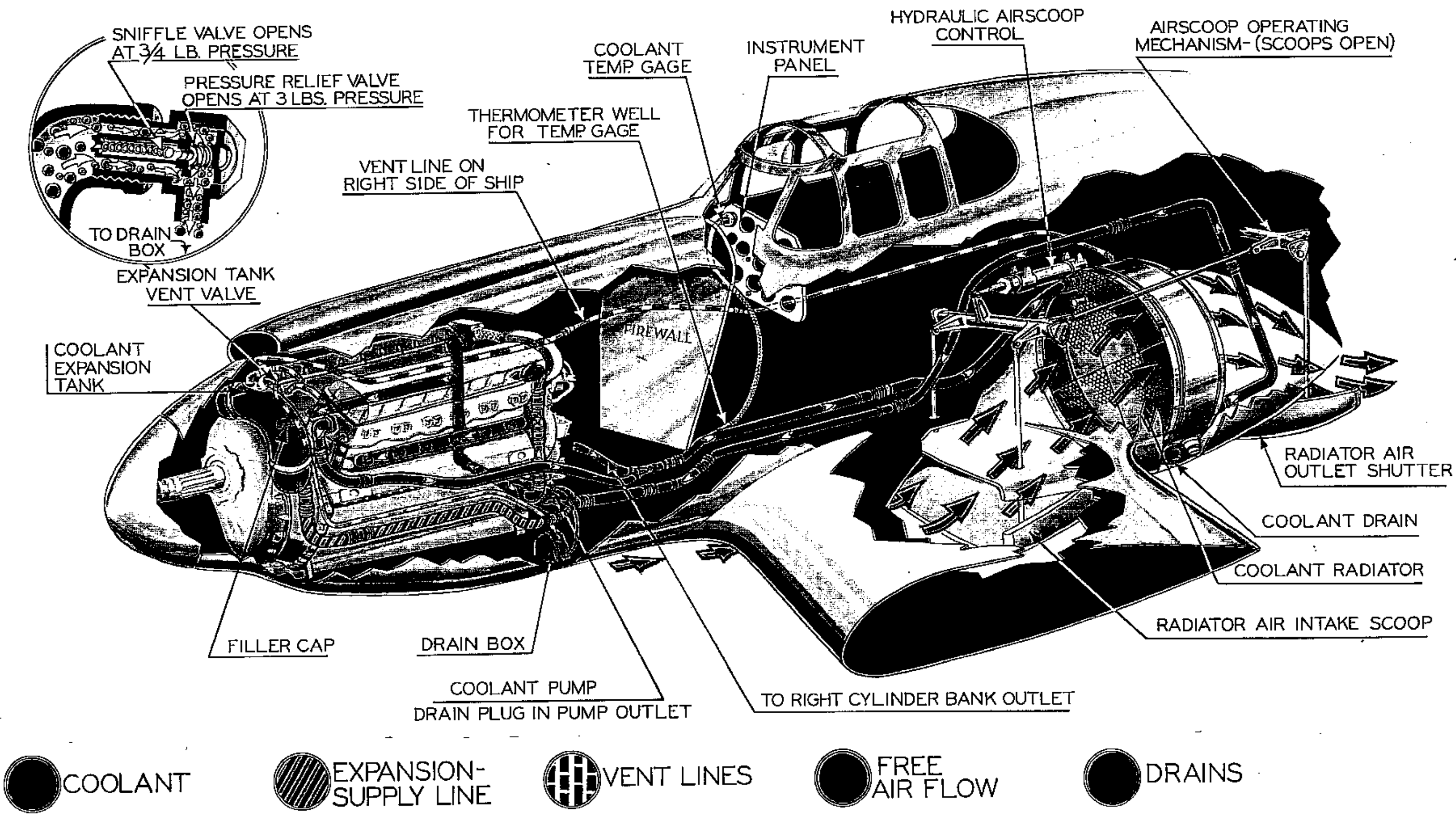


Figure 52—Typical Coolant System V-1710 Engine in P-51 Type Airplane

it is not available, the Ethylene Glycol can, in an emergency, be boiled to remove sufficient water to permit its re-use for flushing operations. Contaminating solids should be strained from the coolant or allowed to settle before re-use in flushing operations.

(k) Reinstall drain plug, then tighten and secure with safety wire. Extreme care should be exercised to insure that drain plug is properly installed.

CAUTION

It is important that the above draining instructions be carried out completely to avoid any possibility of an excessive amount of water remaining in cooling system. The latter would cause boiling of coolant at standard operating temperatures, with possible damage to engine and airplane.

(l) Refill coolant system with coolant conforming to table of specifications, making certain that the airplane is kept in its normal ground attitude during this operation. Reinstall filler cap.

f. VALVES.

(1) At each 50-hour period the following inspection of the valve mechanism will be performed.

(a) Check condition of cylinder head cover gasket.

(b) Check for damaged valve springs, retainers, keepers, etc.

(c) Check valve clearances. (Section VIII, Paragraph 5.)

g. MANIFOLDS AND SUPERCHARGER.

(1) 25-Hour-Automatic Manifold Pressure Regulator.

(a) Inspect oil supply line, oil drain line, and air line, for leaks, security of anchorage, wear, dents or cracks, condition and location of clamps at rubber connections.

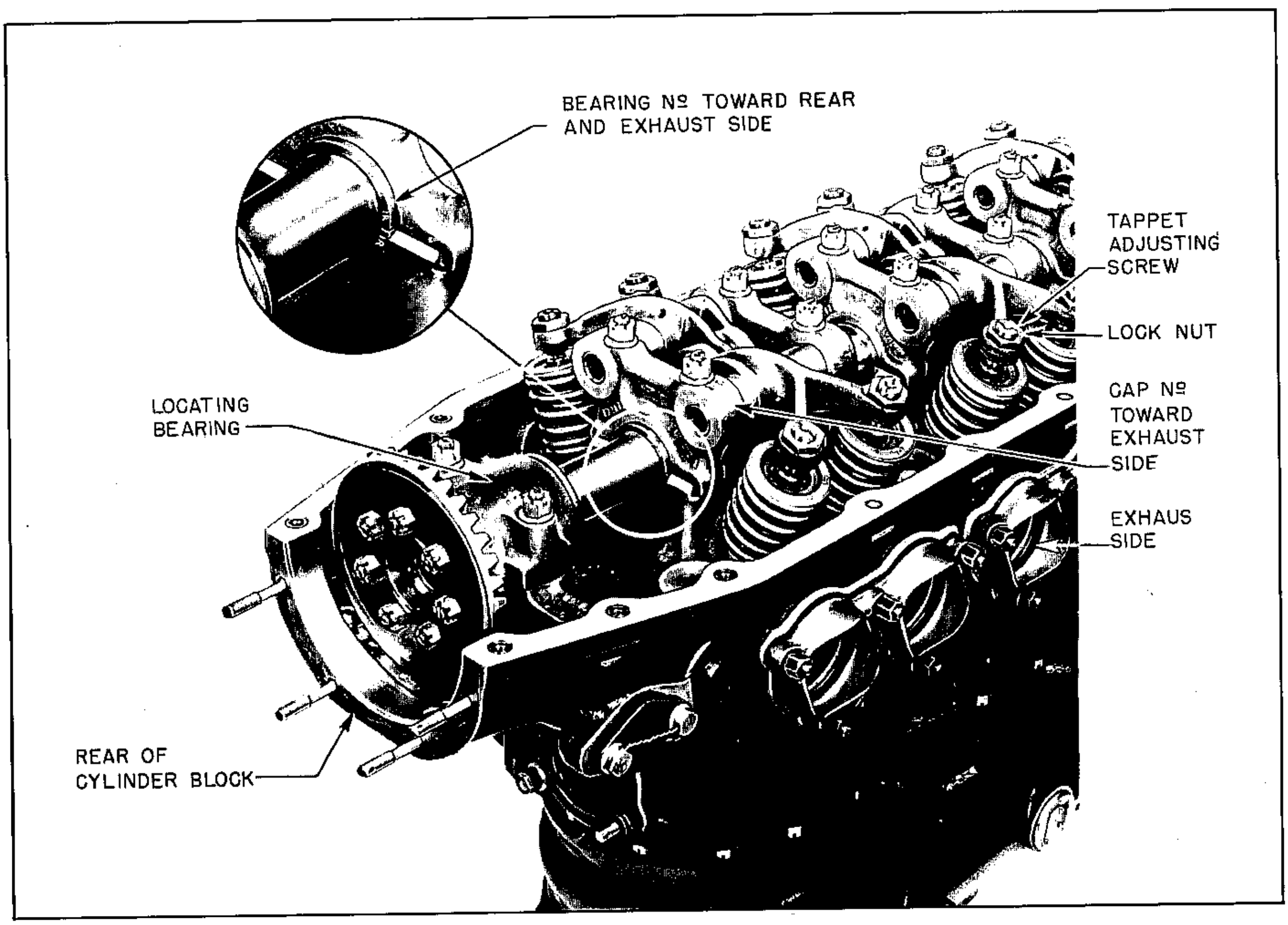


Figure 53—Valve Operating Mechanism.

(*b*) Oil all linkages with light lubricating oil.

(*c*) Inspect all safety wiring.

(2) 50-HOUR.

(*a*) Inspect intake system for broken studs and security of attachment of pipes. Intake pipes should be inspected carefully for any leaks or damage.

(*b*) Check exhaust manifolds and studs for looseness. Examine gaskets for evidence of leakage.

(*c*) Check supercharger inlet cover to carburetor flange and gasket for security.

(*d*) Ascertain that carburetor heater and air scoop is securely fastened at carburetor flange.

(3) 100-HOUR.—Repeat ground test in Section IX, Paragraph 6., *e*, to determine if automatic manifold pressure regulator is functioning properly.

h. PROPELLERS AND ACCESSORIES.—Inspect thrust bearing nut and tighten, if necessary, at the first 50-hour inspection and at every third 50-hour inspection thereafter.

i. POWER PLANT—GENERAL.

(1) CYLINDER HOLD-DOWN NUTS.—At the end of the first five hours flying time of a new or newly overhauled engine, the cylinder hold-down nuts should be inspected for tightness. No further checking of these nuts will be necessary until the next overhaul. In general the nuts will usually be somewhat loose because of settling of the cylinder blocks and compression of gasket paste on the cylinder barrel bearing plates. The nuts are tightened as follows: Turn the nut so that it just makes contact with the boss, but does not load the stud. Then tighten it by turning through an angle of 90° to 110°. Cotter each nut after final tightening. In doing this, *only one nut* on a block should be tightened at a time to avoid possibility of breaking the crankcase cylinder block seal. The tightening sequence indicated in Fig. 54 should be followed.

NOTE

It should be held in mind when tightening the cylinder head stud nuts by angular displacement that the washer must be pulled down sufficiently to compress the shoulder of the rubber packing sleeve and permit the washer to make contact with the cylinder head boss before the 90° and 110° tightening angle is made. Washers with 1/64 chamfer on bottom I. D. must be used.

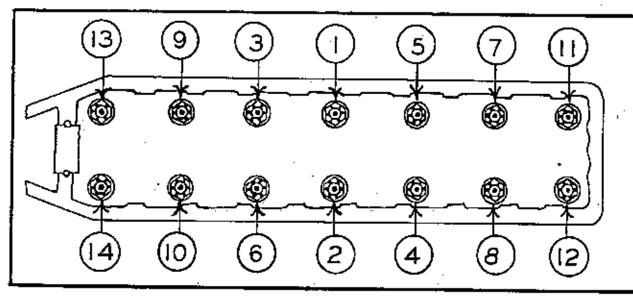


Figure 54—Cylinder Head Stud Tightening Sequence.

CAUTION

Engine *must be cold* when hold-down nuts are tightened.

(2) DAILY.—On engines equipped for W.E.R. the break-through seal on the cockpit throttle lever will be inspected daily. A break-through of the seal indicates that the engine has been operated using W.E.R. and such inspections and checks as are necessary must be made to insure that no damage to the engine has occurred due to the high manifold pressures which have been used.

(3) AT ENGINE CHANGE.

(*a*) When an engine is changed, accomplish all special inspections and maintenance work prescribed in this section that are applicable to engine change as well as special technical instructions that are to be done at engine change.

CAUTION

In the event of an engine change due to an internal failure of the engine, such as main bearing failure, the entire airplane oil system, including oil tanks and piping, must be thoroughly cleaned by flushing with clean kerosene or with steam. After cleaning the oil system, the oil temperature regulators must be replaced.

(*b*) Newly installed engines shall be ground tested in accordance with Section V, Paragraph 2., *k*. Newly installed engines will also receive a flight test in accordance with Section V, Paragraph 2., *l*. upon completion of the installation ground tests specified above.

SECTION VIII

ADJUSTMENT, REPLACEMENT AND MINOR REPAIR

1. GENERAL.

a. The work outlined in this section can be performed with the facilities usually available at service fields.

2. REPLACEMENT OF EXHAUST MANIFOLD GASKETS.

a. Remove the necessary cowling to permit access to the exhaust manifolds. (Refer to the Service Handbook for the particular airplane.)

b. The exhaust manifold gaskets of early engines of some of these models were of the copper asbestos type, while the later engines use a graphite painted sheet steel type. All replacements will be made with the steel gasket. The exhaust flange at each cylinder is secured by five 1/4-28 brass nuts. Remove these nuts from the flanges that secure one complete bank of manifolds to the cylinder block. Next, remove the three bottom fillister head screws from spark plug cooling manifold brackets in order to free the brackets from the exhaust flange studs. Then lift off the exhaust manifolds.

c. Remove *all* old gaskets and discard. Carefully clean the faces of the exhaust flanges and the mounting face of each exhaust port thoroughly. Examine all studs for looseness. Check the exhaust manifold flanges on a surface plate to determine if warping is responsible for the blown gasket. Reface if necessary.

d. In replacing the steel type gaskets on these engines, paint both sides of gasket with a mixture of electric furnace graphite and mineral oil mixed to a consistency suitable for application with a brush. Install the new gaskets with the bead toward the steel flange of the manifold, and replace exhaust manifolds and spark plug cooling manifolds. Tighten the nuts of the exhaust flange evenly to avoid distorting gaskets. Safety the bracket screws of the spark plug cooling manifolds.

NOTE

On V-1710-F2R, F2L, F5R, F5L, F10R and F10L model engines, two gaskets should be installed with the beads toward each other and the shroud sheet of the gas collector between them. See Fig. 55. In this case, pal nut should be installed to safety the standard brass exhaust flange stud nuts.

3. REPLACEMENT OF INTAKE MANIFOLD GASKETS.

a. Intake manifold gaskets can be removed without disturbing the rubber manifold connections or removing any section of the manifold proper. Using Service Wrench No. 2140-29, remove cap screws in top of manifold bottom flange just enough to free gasket. The gasket is made with slotted lower holes to allow removal from the studs. Install new gaskets and tighten evenly so as not to damage manifold flange.

(1) It should be determined when loosening the cap screws and nuts if improper tightening was responsible for the gasket leak. If not, check for evidence of distortion. In case of distortion, the hose connection clamps at the tee should be loosened and the manifold removed from the engine. Check mounting face of the manifold on a surface plate for evidence of distortion. Lap if necessary.

4. REPLACEMENT OF VALVE SPRINGS AND TIGHTENING ROCKER ARM BRACKETS.

CAUTION

The valve stems of these engines are *not* equipped with a stop ring to avoid valve dropping into cylinder when the springs are removed.

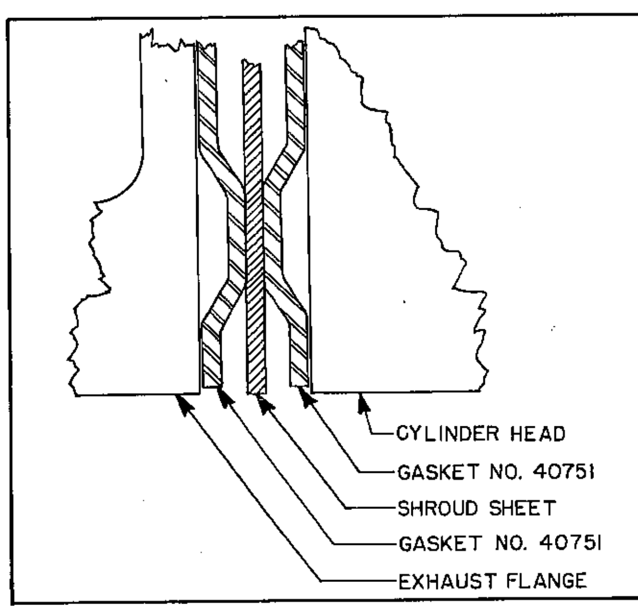


Figure 55—Installation of Manifold Gaskets on Engines Equipped with Turbo Supercharger

a. Replacement of a valve spring should be attempted on a service engine only when authorized by Field Supervision.

CAUTION

Two types of valve springs are used on these engines. The late type spring, identified by a painted yellow stripe on the spring, must be used on V-1710-F10R, F10L, F4R, F20R, and F21R model engines. All other engines may use either the late or early type spring providing all of the springs (inner and outer) are of the same type on all four valves of any particular cylinder.

b. Remove the exhaust spark plug from the particular cylinder in which the valve spring is to be replaced. Turn engine over until the rocker arm rollers rest on the cam heels (valves closed). Insert Valve Holding Tool No. 2294 in spark plug bushing. This tool shank is marked with two etched rings to indicate position of finger for depth. The mark nearest the finger shows location in depth to support either exhaust valve, while the other mark is for the intake valves. The straight arm, on the end of the tool shaft, indicates the position of the supporting finger. Turn the tool until the straight arm points in the direction of the proper valve and tighten the knurled clamping bushing to hold tool in this position. Refer to Figure No. 56.

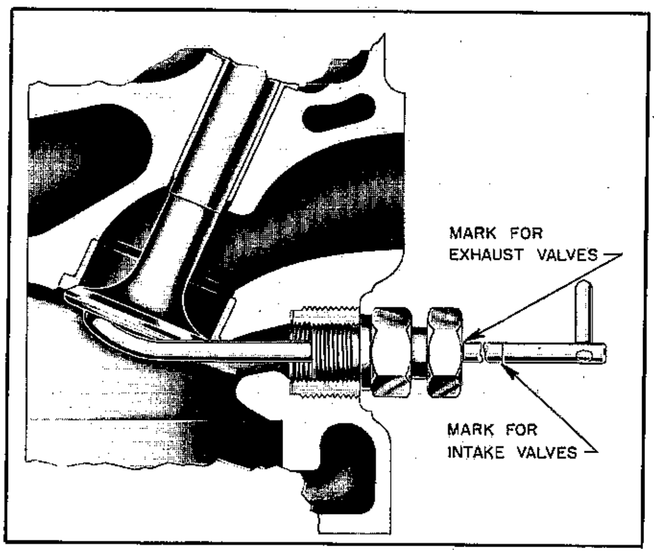


Figure 56—Valve Holding Tool.

c. Remove the four nuts from the rocker arm brackets and lift off the rocker arm assembly. Using Overhaul Tool No. 2315, compress the springs of the supported valve, and remove keepers and springs. Replace valve springs, and be sure the keepers are properly seated. The spring height is next gaged, using Gage No. 2443. See Fig. 57. In case the spring height exceeds the range given on the Gage, an undersize retainer must be substituted to provide the proper spring height. Replace rocker arm bracket assembly. The rocker arm bracket stud nuts should not be tightened too tightly, or high temperature strains will result. Neither should the stud nuts be left too loose, or battering of the brackets will result.

(1) Tighten all nuts down firmly, so as to seat the bracket and cap on the cylinder head bosses, with cam lobes in proper position.

(2) Loosen one nut, then turn it down to a finger tight position or pull it down lightly with a wrench, whichever is necessary for the nut to make contact with the rocker arm bracket and for the lower face of the bracket to make contact wtih the mounting boss; from this position, tighten to the following angularity and cotter.

(a) Nos. 1, 3, 5, 7, 9, 11, and 12 brackets (with bearings) tighten 65°-85°.

(b) Nos. 2, 4, 6, 8, and 10 brackets (without bearings) tighten 55°-70°.

(3) Loosen and tighten the other nuts on the bracket in the same manner.

d. This procedure insures proper camshaft bearing clearance. Be sure to reset both intake and exhaust valves to their proper clearance. (See Section II, Table of Specifications.) Remove the valve holding tool and re-install the spark plug.

5. SETTING VALVE TAPPET CLEARANCES.

a. When adjusting valves, make sure that the engine is thoroughly cool, 10°C to 50°C (50°F to 122°F). In order to check the valve clearances, first remove the cylinder head covers and rotate the propeller shaft so that the cam roller is on the base circle or heel of the cam for the particular valve being checked. Then use feeler gage between the valve stem tip and the valve adjusting screw ball end. The proper valve clearance when cold is .015" for the intake valves and .020" for the exhaust valves. If adjustment is necessary, loosen the lock nut and back off or turn down the valve adjusting screw. When re-tightening the lock nut, be careful not to turn the adjusting screw.

CAUTION

Adjusting screw lock nuts must be drawn tight. *Tighten by hand, but do not strike wrench with any object.*

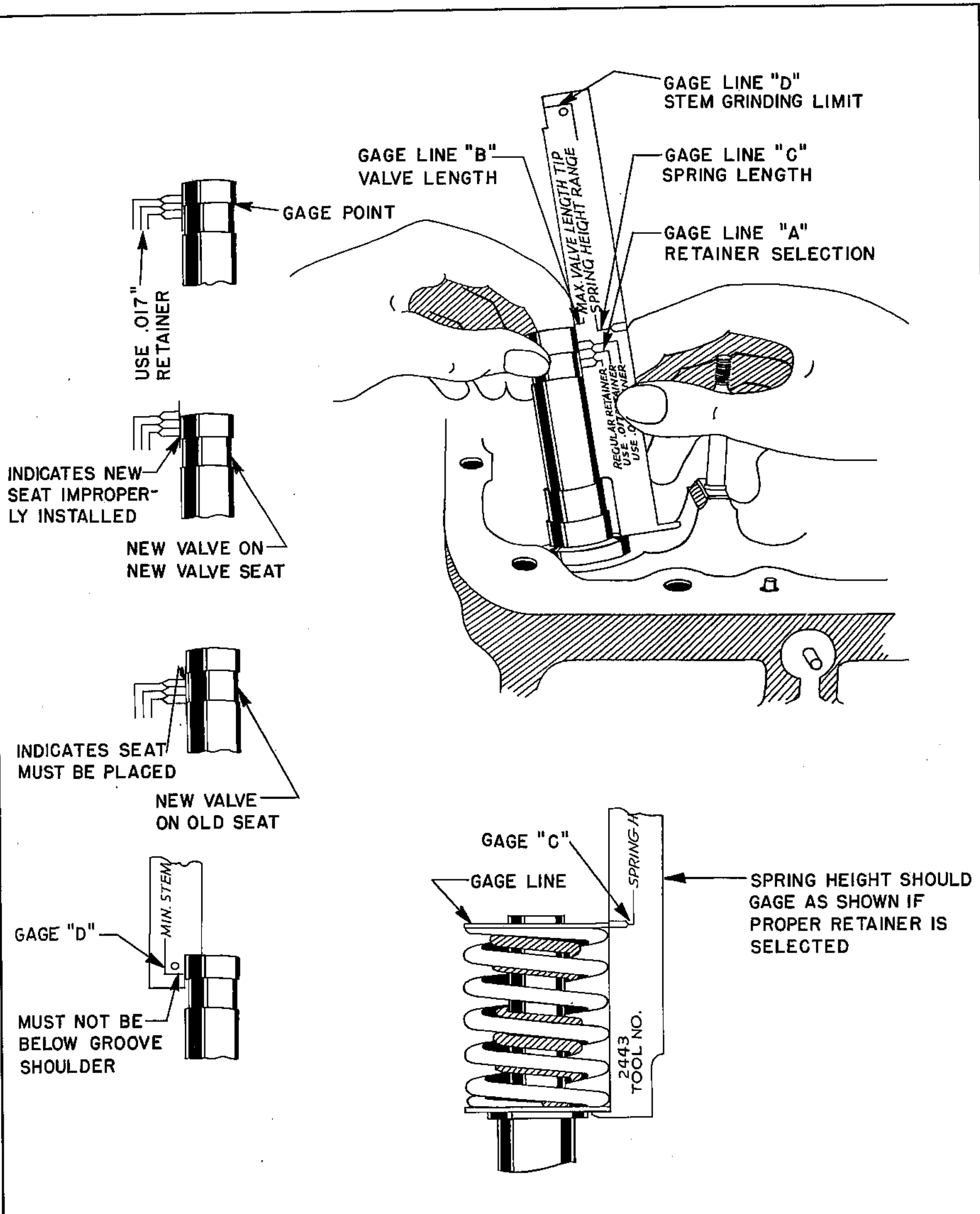


Figure 57—Checking Valve and Spring Height Using Gage No. 2443.

b. After tightening the lock nut, the clearance should again be checked. All clearances which are found to be below the proper amount (.015″ for intake valves; .020″ for exhaust valves) *should be reset to proper clearances. Reset any* intake valve if clearance exceeds .017″, and reset any exhaust valve if clearance exceeds .022″.

c. When checking valve clearances, if any are found to have opened to .025″ or more for the exhaust and .020″ for the intake, it is well to remove the adjusting screws and examine the ball ends for abnormal wear or breaks. Otherwise the adjusting screws need not be removed between overhauls.

6. REPLACEMENT OF VALVE TAPPETS.

a. Locate the rocker arm rollers on the cam heels. Loosen the four nuts, holding rocker arm brackets, sufficiently to allow removal of the tappet through the rocker arm from the bottom. Remove the lock nut and screw tappet from the arm. Replace new tappet and lock nut. Tighten the four bracket nuts as in Paragraph 4, above, and set clearance as outlined in Paragraph 5, above.

7. REPLACEMENT OF OIL PRESSURE RELIEF VALVE SPRING.

a. Remove the 1½″ hex. cap from the pressure relief valve body, using Service Wrench No. 2244. Refer to Figure 58. Remove the locking spring holding the oil pressure relief valve adjusting screw. The adjusting screw is next removed with the small end of Wrench No. 2244. The spring can then be removed.

b. After inserting new spring, screw in adjusting screw until it is flush with the valve body. It is necessary then to readjust the oil pressure. It is important that the engine oil be maintained at operating temperature, approximately 80°C (176°F), and the engine operated at cruising speed of approximately 2200 R.P.M. Set relief valve adjusting screw to get steady oil pressure gage reading between 60 and 70 lbs./sq. in. Replace lock. If necessary to move the relief valve adjusting screw to do this, be sure not to lower oil pressure. Put washer in place and replace aluminum cap on outside of pump body, and safety.

8. CLEANING OF OIL SCREENS.

a. GENERAL.—There are two oil screens in these models, one located in the front drain elbow and the other in the rear drain elbow.

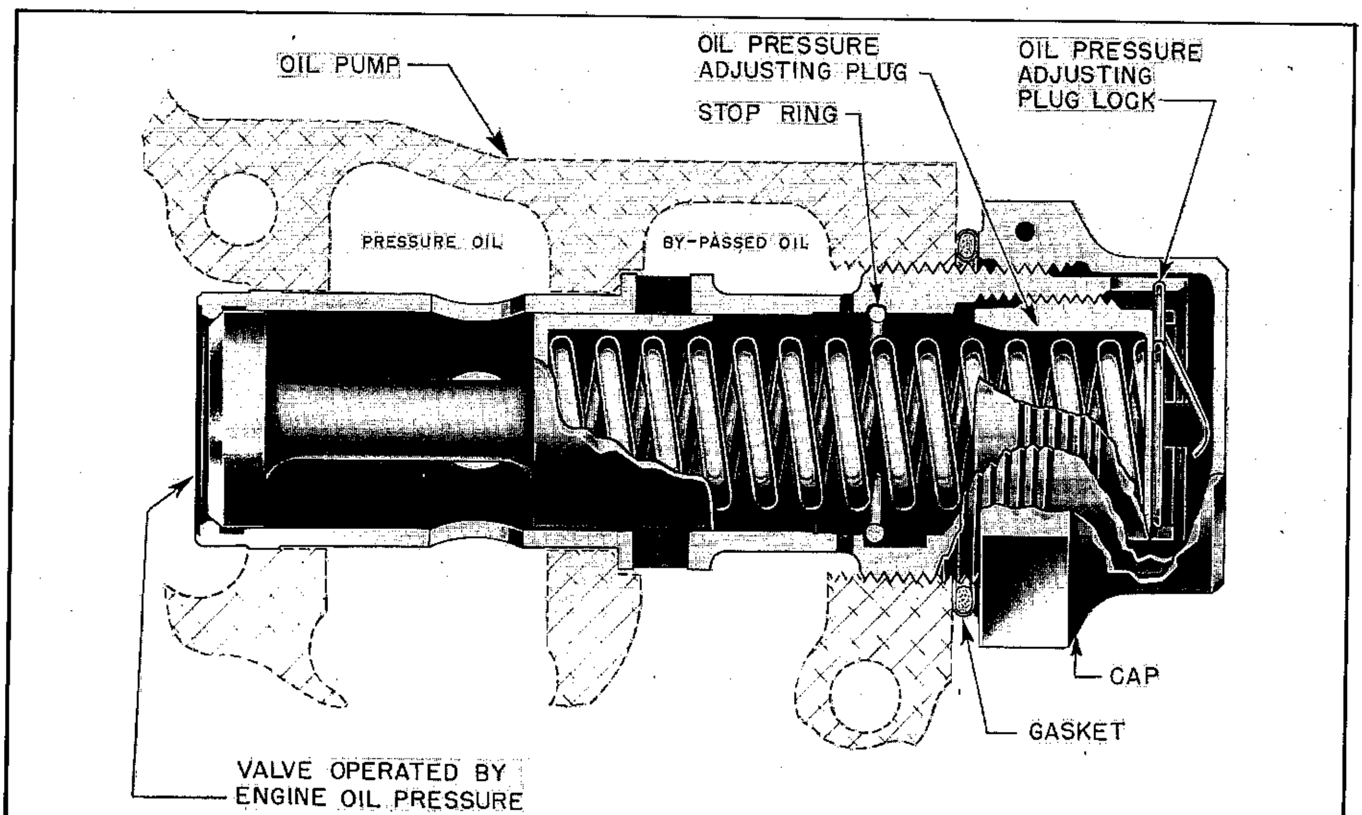


Figure 58—Sectional View of Oil Pressure Relief Valve.

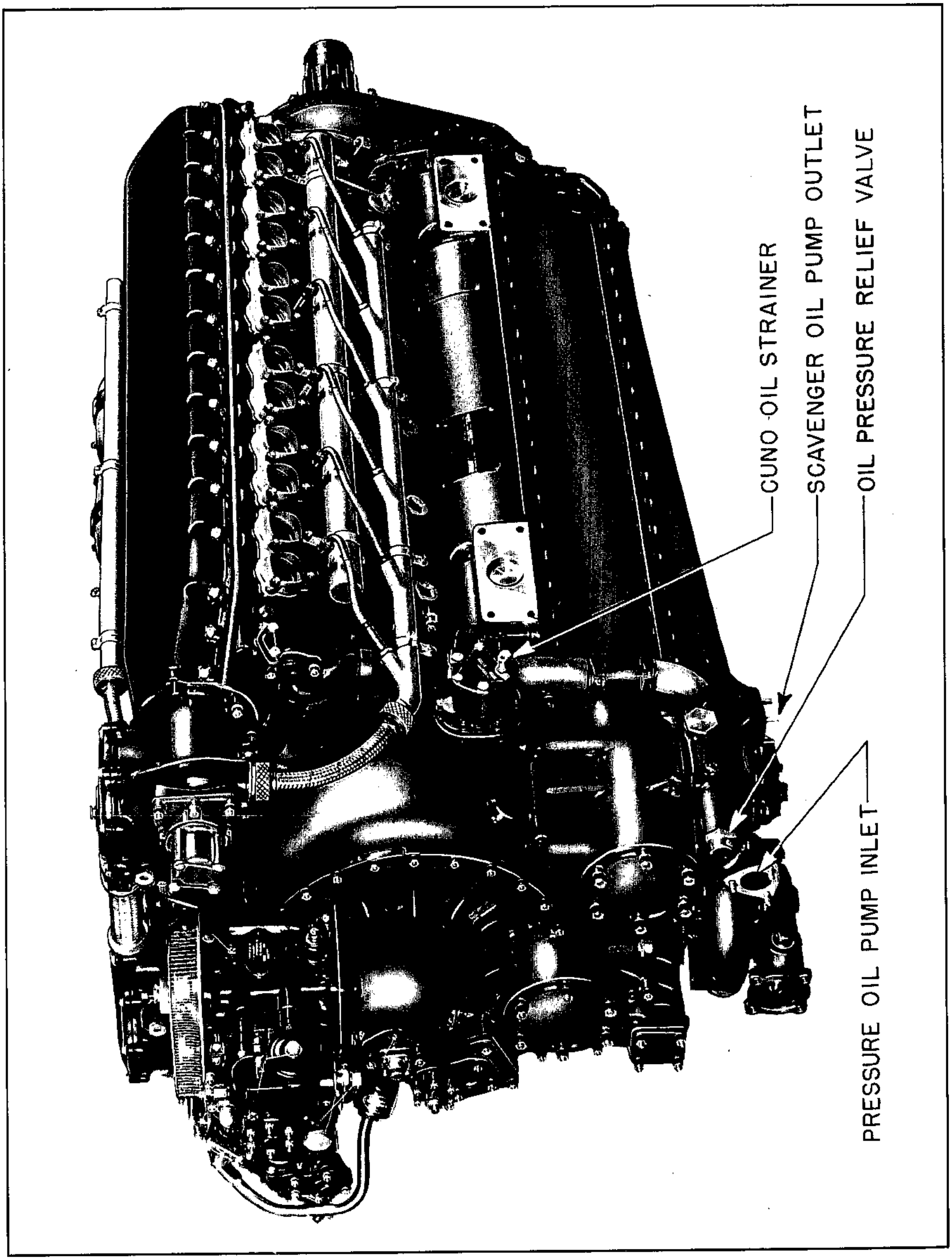


Figure 59—¾ Right Rear View—V-1710-F3R Model Engine.

b. ENGINE OIL SCREENS.—The engine oil screens located in the front and rear oil drain elbows on late model engines, require removal of the elbows to clean. Early model engines have a removable oil screen in the front oil drain elbow which does not require removal of elbow. When accessibility of the engine in the airplane permits, the elbows will be removed at the time indicated in periodic inspection and the screens cleaned as follows:

(1) REAR OIL DRAIN ELBOW SCREEN REMOVAL.

(a) Remove drain plug from rear drain elbow and drain oil.

(b) Remove the 4 cap screws that secure the rear drain elbow to the oil pan.

(c) Remove the 4 plain nuts and pal nuts that secure the elbow to the oil pump adapter.

(d) Remove the elbow.

(e) The 1/4" castellated nut is removed through the drain plug opening using a socket wrench. The through bolt and screen are then taken out.

(f) Clean elbow and screen by washing thoroughly in gasoline.

(g) Replace screen, install through bolt, washer and castellated nut, tighten and safety nut with cotter pin.

(h) Before re-installing elbow, the rear flange of the oil pan and oil pump adapter should have the old gaskets removed and thoroughly cleaned. Do not scrape mounting faces to clean.

(i) Install new gaskets and locate drain elbow into position. The four cap screws and the four plain nuts should be installed finger tight.

IMPORTANT

It is important that the following tightening procedure be followed closely to prevent the elbow from being misaligned with resulting possible oil leakage.

(j) First tighten the four cap screws into the oil pan to approximate final tension.

(k) Next permanently tighten the four plain nuts onto the oil pump adapter studs to 70-80 in. lbs.

(l) After the stud nuts are tightened, *release* tension on all 4 cap screws in pan and *re-tighten* to 90-100 in. lbs. Safety the cap screws with lock wire and install pal nuts over the plain nuts.

(2) REDUCTION GEAR CASE OIL DRAIN ELBOW SCREEN REMOVAL.

(a) On early model engines, there is a removable oil screen in the reduction gear case drain elbow. This should be removed, cleaned in gasoline, dried, re-oiled and then re-installed.

(b) On late model engines, the entire elbow assembly must be removed in order to clean the screens. This should be done in the following manner:

1. Remove the 4 cap screws that secure the front drain elbow to the oil pan.

2. Remove the 4 plain nuts and pal nuts that secure the elbow to the reduction gear assembly.

3. Remove the elbow and gaskets and clean the mounting flanges.

4. Unsafety and remove the two fillister head screws and take off the oil screen.

5. Clean elbow and screen by washing thoroughly in gasoline.

6. Re-install screen and safety the two fillister head screws with lock wire. The lock wire is threaded through both screws and runs across the face of the screen.

7. Install new gaskets and locate drain elbow into position. The 4 cap screws and 4 plain nuts should be installed finger tight.

IMPORTANT

It is important that the following tightening procedure be followed closely to prevent the elbow from being misaligned with resulting possible oil leakage.

8. First tighten the 4 cap screws into the oil pan to approximate final tension.

9. Next permanently tighten the 4 plain nuts onto the reduction gear assembly studs to 90-100 in. lbs.

10. After the stud nuts are tightened, *release* tension on all 4 cap screws in pan and *retighten* to 90-100 in. lbs. Safety the cap screws with lock wire and install pal nuts over plain nuts.

9. REMOVAL AND REPLACEMENT OF IGNITION SHIELDING ASSEMBLY AND TIMING DISTRIBUTORS.

a. GENERAL.—The ignition shielding assembly consists of: two intake ignition cable tubes with flexible extensions; two exhaust ignition cable tubes with flexible

extensions; a flexible cross tube; and
neto cables. The entire assembly is jo
distributor housing assemblies. Tl
mounted on the engine by several l
are made of aluminum. Metallic l
shield the wires from the cable tube
terminals. Figs. 60 and 61 show th
shielding and distributor drive asse

b. REMOVAL OF SHIELDING
ENGINE.

(1) Disconnect spark plug ter

(2) Remove the nuts and pal n
ignition tube brackets to the engin
clamping screws of the brackets. E
tube is secured to the engine by three
screws. Each exhaust ignition tube
engine by four nuts on studs located
manifold bosses. The exhaust brack
are attached by screws instead of s

(3) Disconnect the magneto shi
magneto.

(4) On each cylinder head, lo
cylinder head cover screws nearest th
ing. This operation releases the distri
packing ring which is clamped in
distributor housing diameter by the
moving the 4 pal nuts and plain nu
of each distributor housing, the igni
distributor housings are free to be
engine as a unit.

NOTE

On the V-1710-F5R, F5L, F1
model engines, it will be necess
nect the air blast tubes from the
on the distributor housings bef
the complete shielding assembly
gine.

c. REPLACEMENT OF SHIELD
ON ENGINE.—With the cylinder
screws loosened as directed above in
ing assembly, a complete replacement
assembly can be installed as a unit

(1) Remove the distributor hous
three mounting screws from the fl
tributor head. This much disassem
that the heads may be lifted off their
to permit turning the distributor fi
the driving lug with the camshaft
as the assembly is mounted.

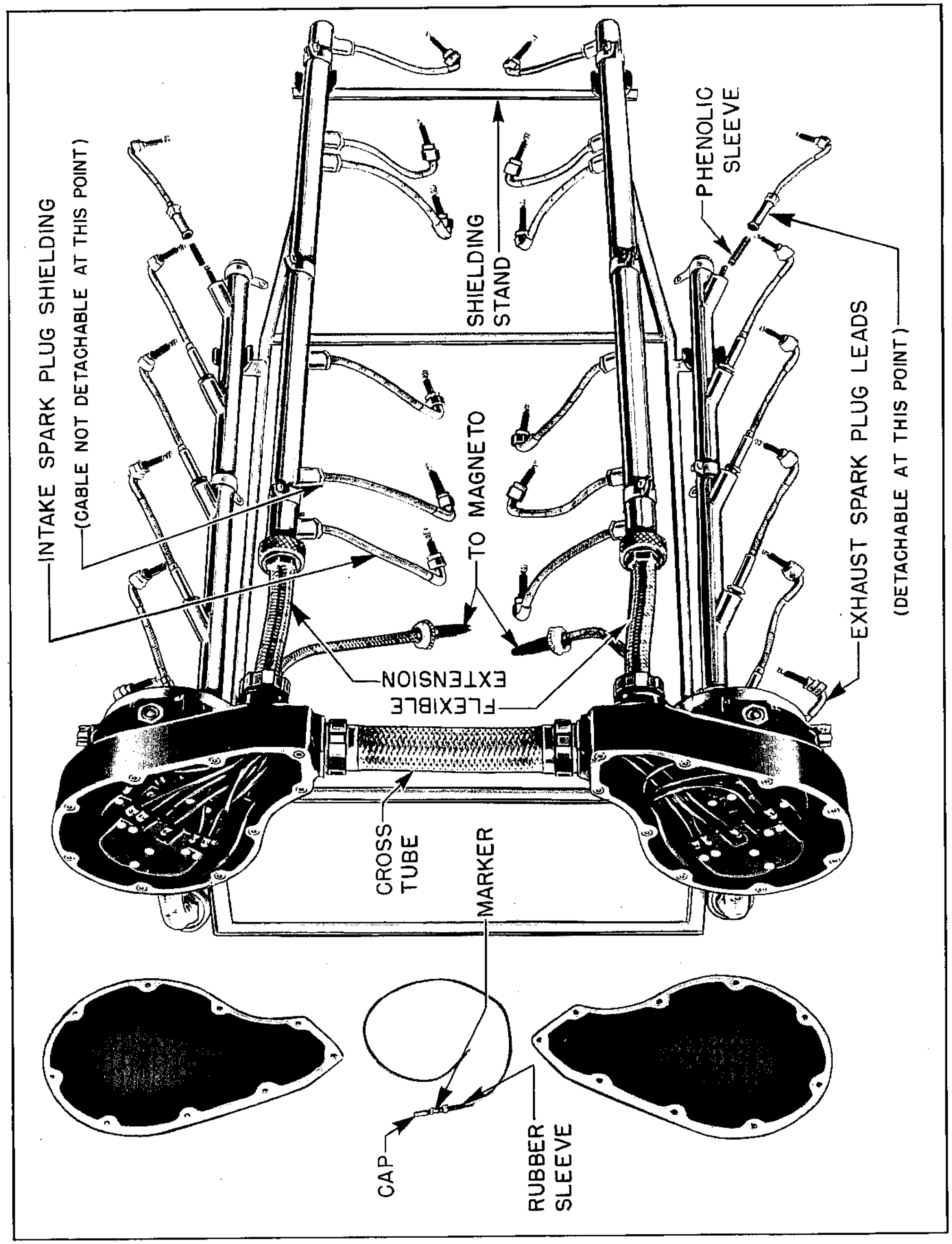
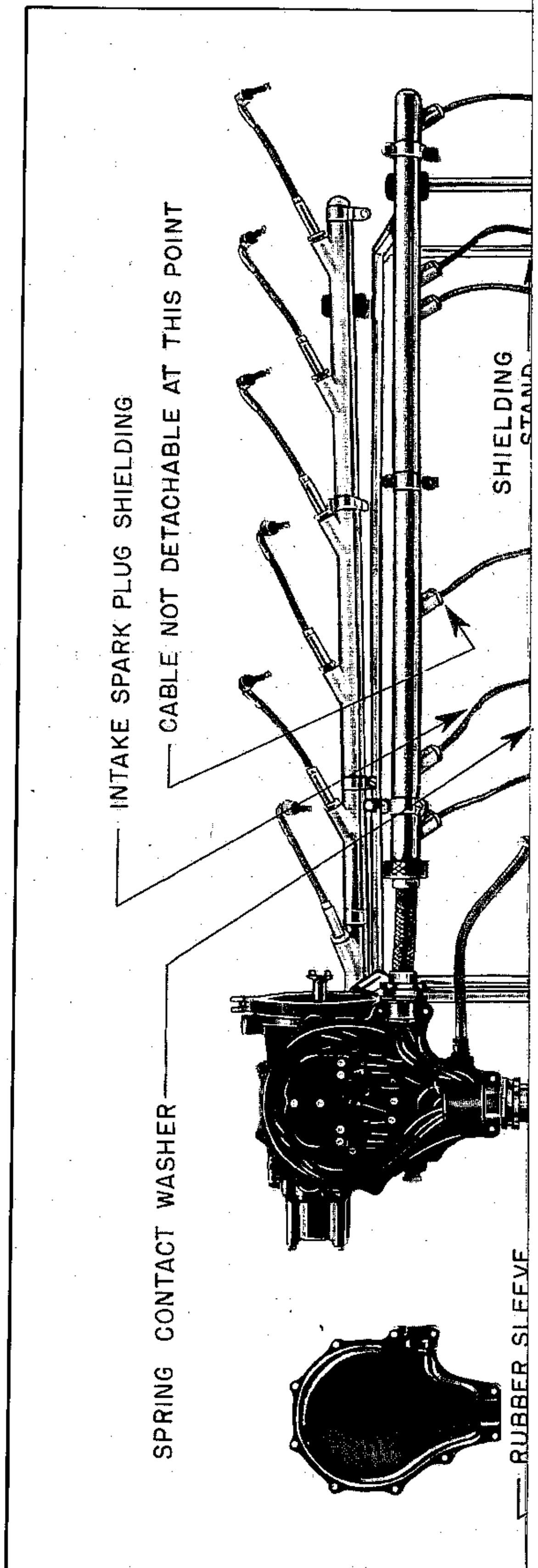
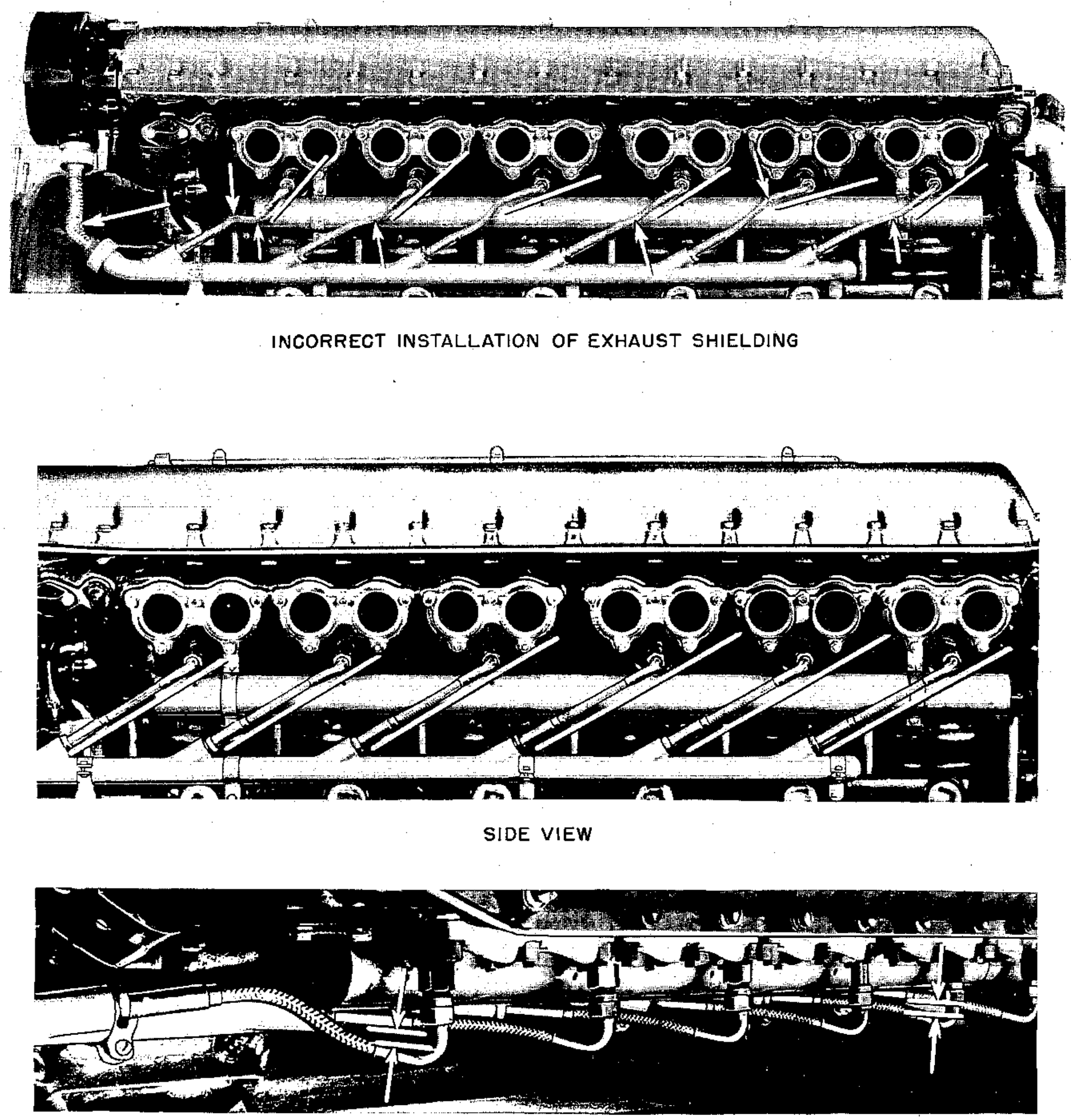


Figure 60—Distributor Drives and Ignition Shielding Assembled Unit. (Type without gun synchronizer drives.)





INCORRECT INSTALLATION OF EXHAUST SHIELDING

SIDE VIEW

TOP VIEW
CORRECT INSTALLATION OF EXHAUST SHIELDING

Figure 63—Aligning Exhaust Spark Plug Cable Shielding Leads.

manifolds, and to relieve the exhaust spark plug leads and extension tube flexible shielding from kinking, as these strained conditions would eventually result in tube breakage.

(a) Apply a light coat of either soapstone or mica dust to the wire lead connectors. This will reduce sticking of connectors inside the spark plugs after they are subjected to heat from normal operation of the engine.

(b) Loosen clamping screws of all brackets on exhaust tubes. The knurled nuts that join the flexible extension tubes are next loosened only one turn.

(c) Loosen all ¾" hexagon connector nuts one turn at the base of the detachable spark plug leads, then draw up all spark plug elbow nuts *finger tight.*

(d) Rotate and slide the tube back and forth until the flexible exhaust spark plug cable shielding assumes a series of straight lines or smooth curves. Be sure that no flexible tubing is pulled so tight that it loses its flexibility. This may be checked by testing the tension of each lead with the fingers. At this point it may be necessary to rotate the ignition cable tube slightly to secure the correct tension and provide the proper alignment of the exhaust spark plug detachable leads.

(e) When all the exhaust spark plug detachable leads are in proper position, tighten all ignition cable tube bracket clamping screws. Tighten the screws of the center clamps first, then tighten the screws of the end clamps.

(f) Tighten the ¾" hexagon nuts that secure the exhaust spark plug terminals and be careful to prevent the ignition cable from shifting its clamped position. Be sure that these leads do not turn while the nut is being tightened. Such turning would cause serious kinking.

(g) Next, tighten the exhaust spark plug cable shielding elbow nuts. Prevent the elbows from shifting position while tightening the nuts, as the elbows must line up with the exhaust spark plug cable shielding flexible tubes, and the tubes must not be kinked.

WARNING

When connecting elbow terminals to spark plugs do not tighten the elbow nut excessively as both the elbow terminal and spark plug may be damaged. It may also be found, when unscrewing tightly installed elbow nuts from spark plugs, that the barrel will tend to loosen and unscrew from the shell. If spark plug barrel is turned as above, the plug should not be used until the gap has been rechecked.

(h) Figure 63 illustrates the type of installation to be desired and the type of installation to be avoided.

(i) The intake spark plug cable shieldings cannot be connected to form a series of straight lines, but must be connected to form a series of smooth curves which are free from kinking or twisting. Be sure the cable shielding of one intake spark plug does not rub against the cable shielding of another spark plug or against the intake manifolding.

(j) When adjusting the intake spark plug leads, the bracket clamp screws and the connecting nut at the base of the leads will be loosened, then the spark plug nut drawn up finger tight. The knurled nut at intake tube extension tube will also be loosened. Rotate the tube slightly if necessary and adjust spark plug leads as in paragraph *(i)* above. After adjustments, tighten

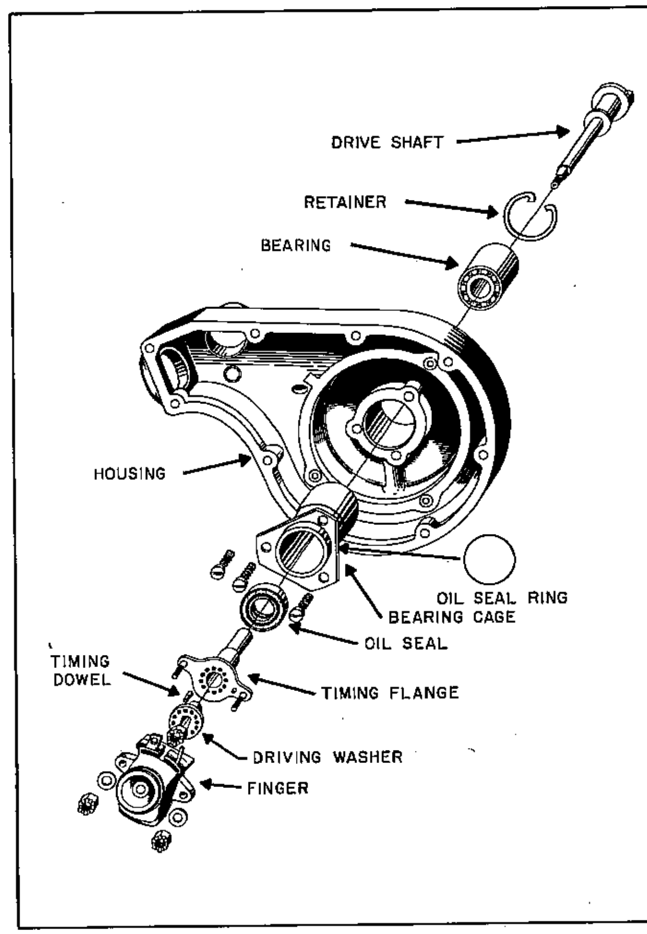


Figure 64—Exploded View of Distributor Showing Relation of Timing Dowel and Washer (Type without gun synchronizer drives).

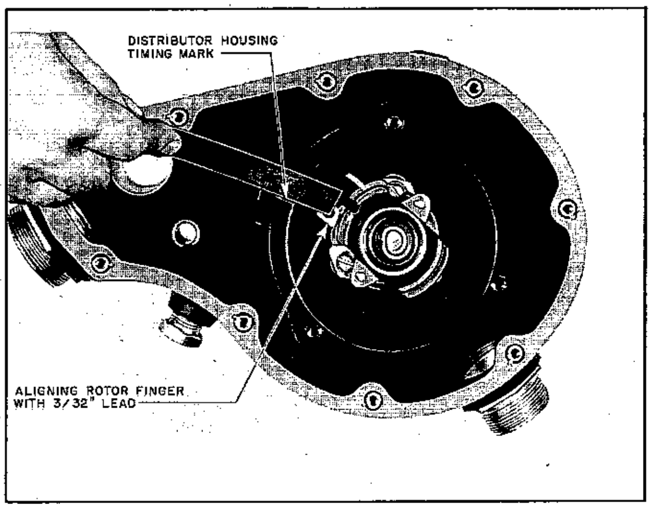


Figure 67—Aligning Distributor Finger with Timing Mark.

e. INSTALL NEW CONNECTOR IN HOUSING.

(1) If a distributor head housing to ignition tube connector is being replaced, the new connector should measure 1¾" across the flats of the hex head instead of 1⅝" as on the old connector.

(2) If a distributor head housing to cross tube connector is being replaced, the new connector should measure 2⅛" across the flats of the hex head instead of 2" as on the old connector.

(3) Screw the new connector into the distributor drive housing until the hexagon is drawn up tight against the face of the boss.

f. Using the hole in the threaded portion of the connector as a drill guide, drill with a ⅛" diameter drill to a depth of $\frac{9}{32}$".

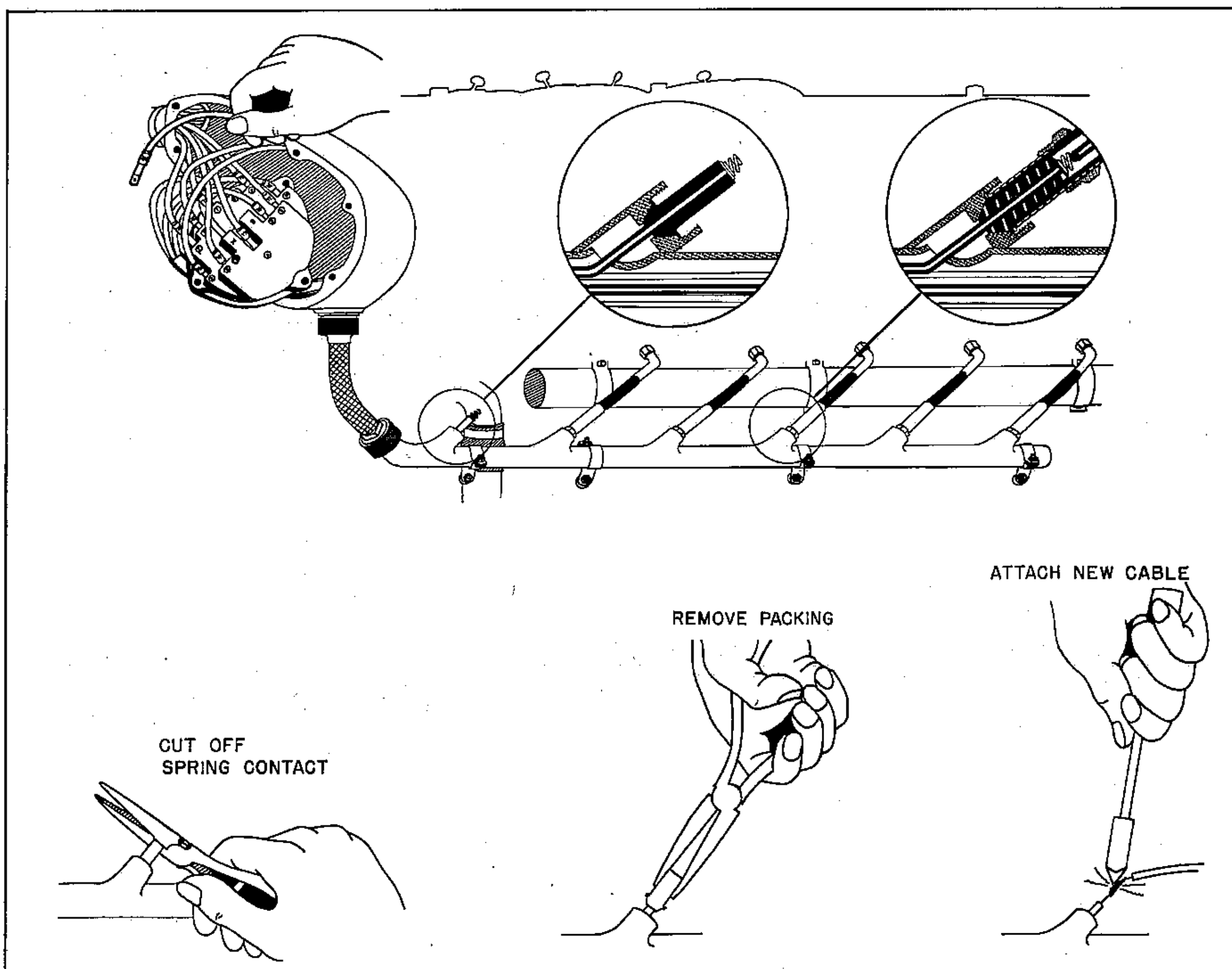


Figure 68—Removing Defective Exhaust Ignition Tube Cable.

g. In the hole drilled above, install a stainless steel lock pin and stake the metal over the pin. Make certain to use the 1/8" stainless steel lock pin instead of the 3/32" brass lock pin formerly used.

h. Thread the ignition cables through the connector and connect them in their proper positions.

i. Connect and tighten the ignition cable shielding connector nut on the connector and lock the nut to one of the drilled holes in the hexagon of the connector with lock wire.

12. REPLACING DEFECTIVE IGNITION CABLE.

a. DETERMINING DEFECTIVE CABLE.

(1) With the distributor housing covers removed, the distributor heads dismounted and spark plug nut detached; determine which cable is defective by the recognized electrical test. If a defective cable is discovered between the spark plugs and the distributor on the exhaust side of the ignition system, remove the detachable spark plug lead of the defective cable to determine if this lead is the source of the trouble. Replace the detachable lead with a new part if this test proves it defective. Refer to Paragraph 10.

(2) In case the detachable lead is found not to be at fault, the next step is to replace the defective cable between the point where the lead connects to the tube and the distributor head. The replacing of a defective cable, other than the detachable exhaust leads, is accomplished as set forth in the following paragraphs. Due to difficulty of working in the confined engine compartment, it is recommended that the ignition shielding assembly, with distributor housings, be removed from the engine as a unit in order to replace any defective

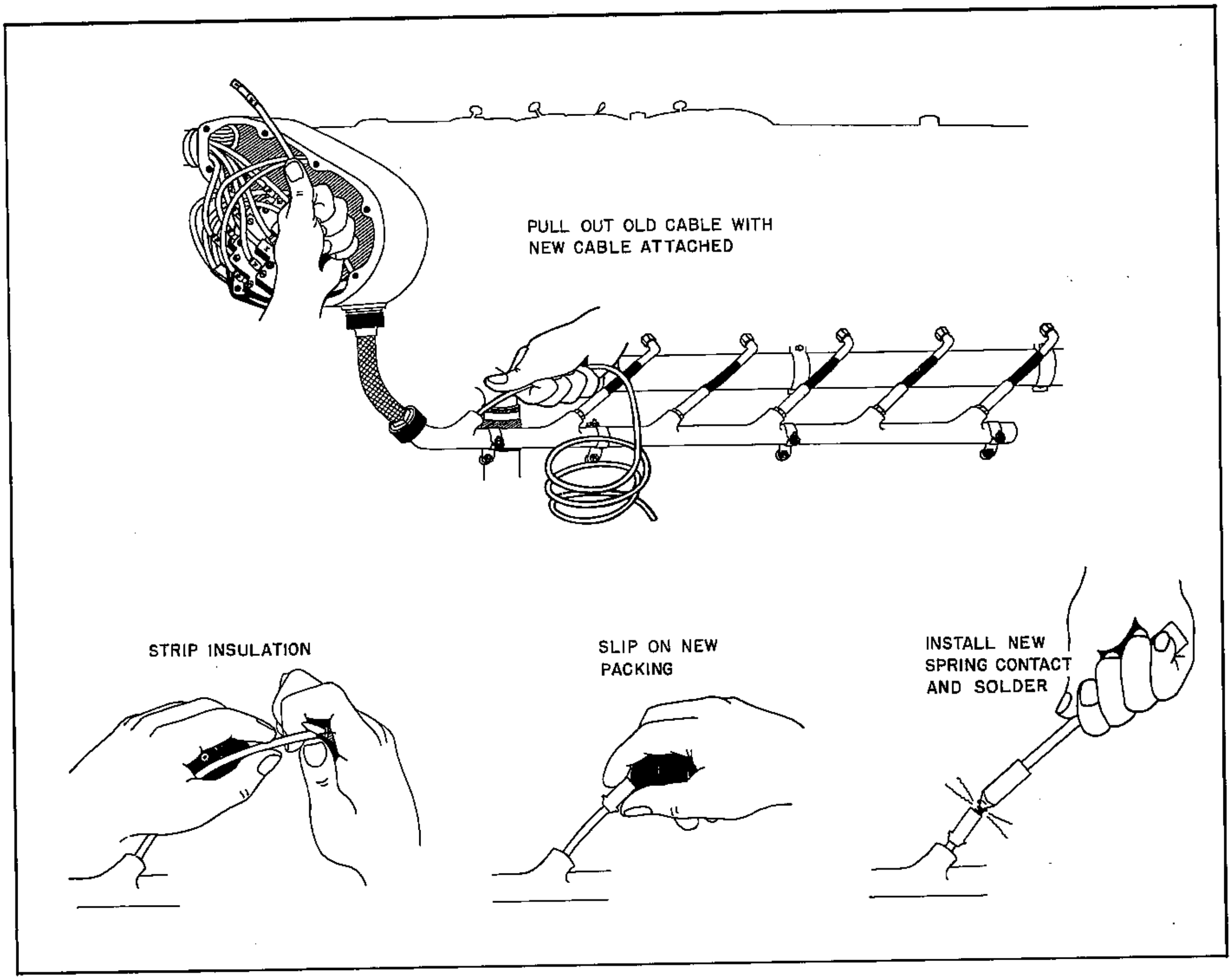


Figure 69—Installing Replacement Exhaust Ignition Tube Cable.

cables other than the exhaust detachable leads. See Paragraph 9 above for details on removing the ignition shielding assembly from the engine.

b. REPLACING EXHAUST TUBE CABLE.

(1) To replace a defective cable in the exhaust ignition tubes, first remove the spring contact washer from the cable by cutting the cable immediately behind the washer. (See Figure 68.) Slip the branch tube packing off the cable. Refer to the "Table of Cable Lengths" shown in the following paragraph *c.* and cut new cable length for the replacement. Solder the new cable to the old at this end, and dust with talc or soapstone to prevent seizing or friction. Pull the old cable out, at the same time feeding the new cable in carefully so as not to injure its protective coating. Leave approximately four inches extending from the exhaust branch tube and slip a new rubber packing sleeve over this end. Next install the spring contact washer by cutting the cable insulation squarely, leaving approximately 1/8" of the seven wire strands protruding. Insert the wires into the center hole of the washer, then spread the wire ends, press firmly against the contact washer, and apply solder. (See Figure 69.) Use a solder composed of 90% lead and 10% tin. Pull the cable into place and push the packing sleeve snug against its seat in the connector. (See Figure 71.) Do not attempt to pull the packing sleeve into the connector by the cable alone as the soldered contact may be broken.

(2) The original cable length was only approximate. Consequently, the cable should next be threaded into the distributor housing and measured exactly to its proper contact in the distributor block and cut off. The replaced cable should be threaded into the housing and to its proper contact, in the same manner as the old cable. Refer to Figure 70. Slip the 7mm. rubber bushing and the appropriate marker over the distributor end of the cable. The copper cap is then installed. Remove 1/2" of insulation, slip the 7mm. bushing up

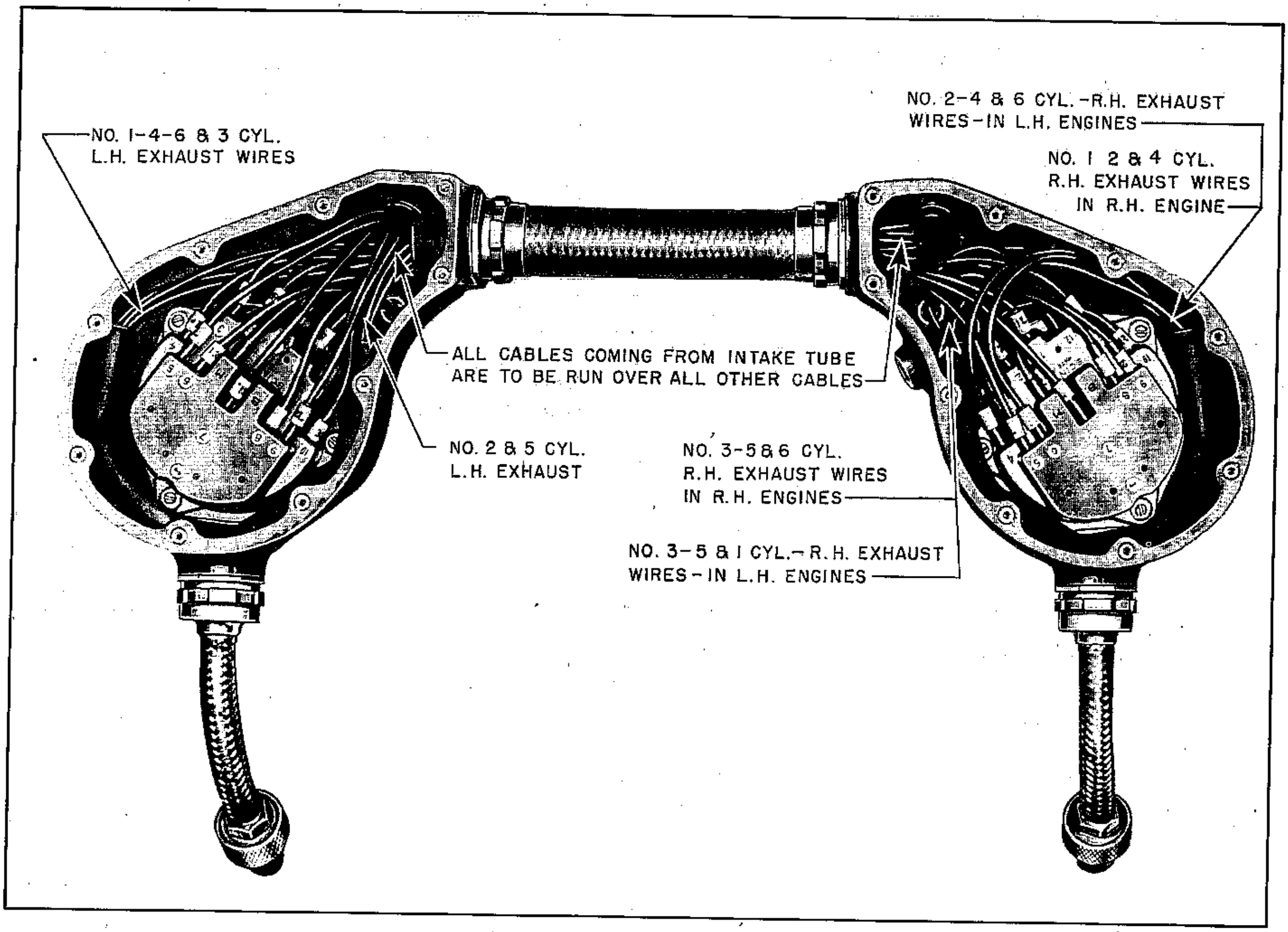


Figure 70—Method of Threading Ignition Cables to Distributor Head Connections.

flush with the end of the insulation, untwist the wires. Fold wires back over the bushing, and slip the copper cap over the end. Crimp the cap on the bushing, using Crimping Tool No. 251283. Remove the contact screw from the distributor head, insert cable end and reinstall screw, puncturing the copper cap with screw.

c. REPLACING INTAKE TUBE CABLE.

(1) A defective cable in an intake ignition tube is replaced in essentially the same manner as an exhaust ignition tube cable. However, one difference in the method of replacement of the two cables is that the intake ignition cables are run continuously from the distributor head to the spark plug contact spring, instead of terminating at the ignition tube branch tube.

(2) It is important that the mechanic becomes acquainted with the differences between the intake spark plug shielding assemblies used on early engines and those used on late engines since each requires a distinct method of wiring. Figure 72 illustrates these differences. Note that the elbows marked "A" and "B" have a square flange which use a square shouldered packing. The elbow marked "C" is supplied with an internal chamfer and can only be used with the late type packing which is beveled to fit. It will also be noted that elbows marked "B" use a packing similar to "A" except that it is moulded with a smaller diameter end for installation of the new ceramic contact.

NOTE

Service Packing No. S-43524 must be used in lieu of packing No. 37465 when rewiring spark plug shieldings having the flat type flange illustrated in "A" and "B" of Figure 72.

(3) A defective cable in an intake ignition tube is replaced by first cutting off the spark plug contact at the spark plug shielding elbow. The remainder of the

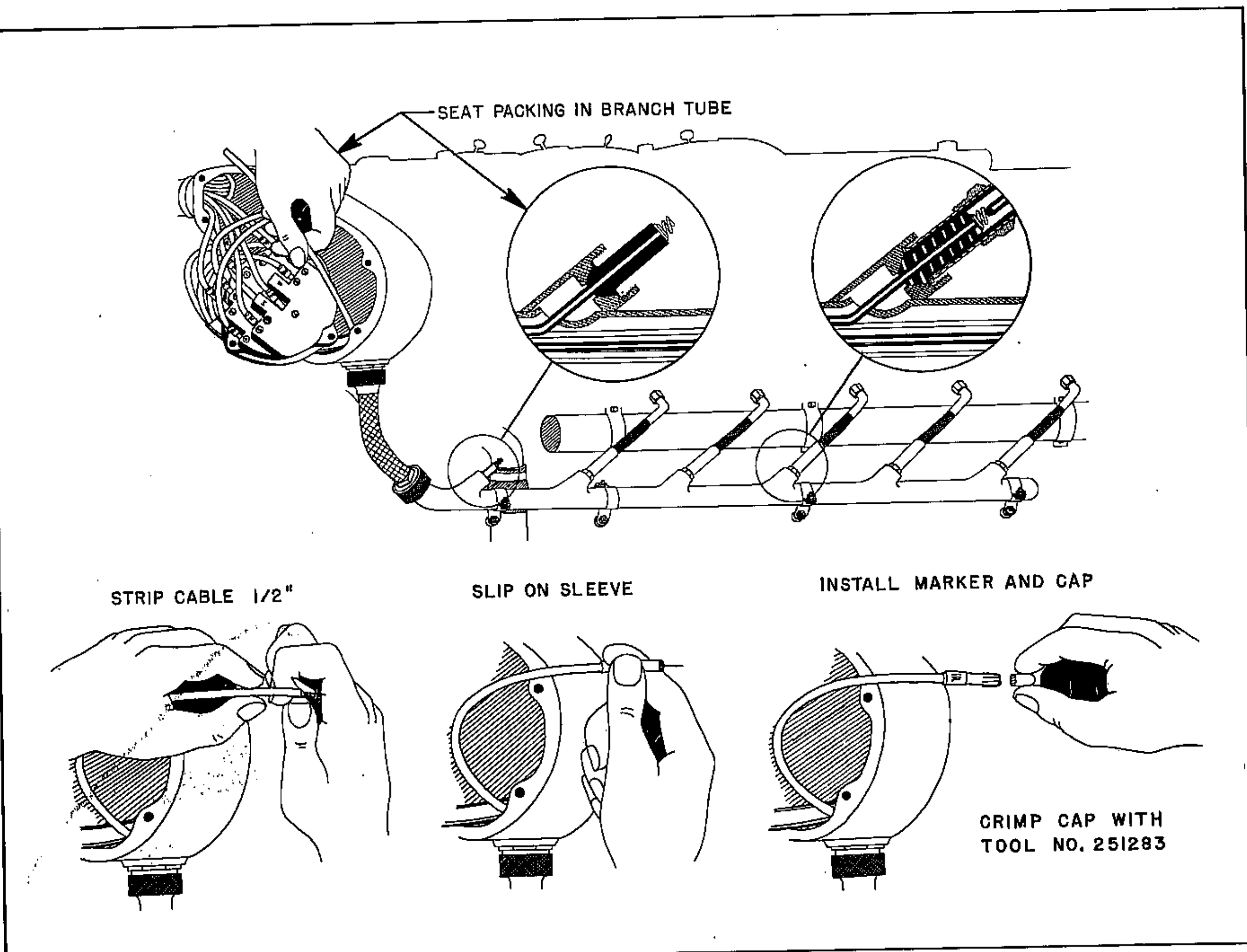


Figure 71—Capping Distributor End of Ignition Cable.

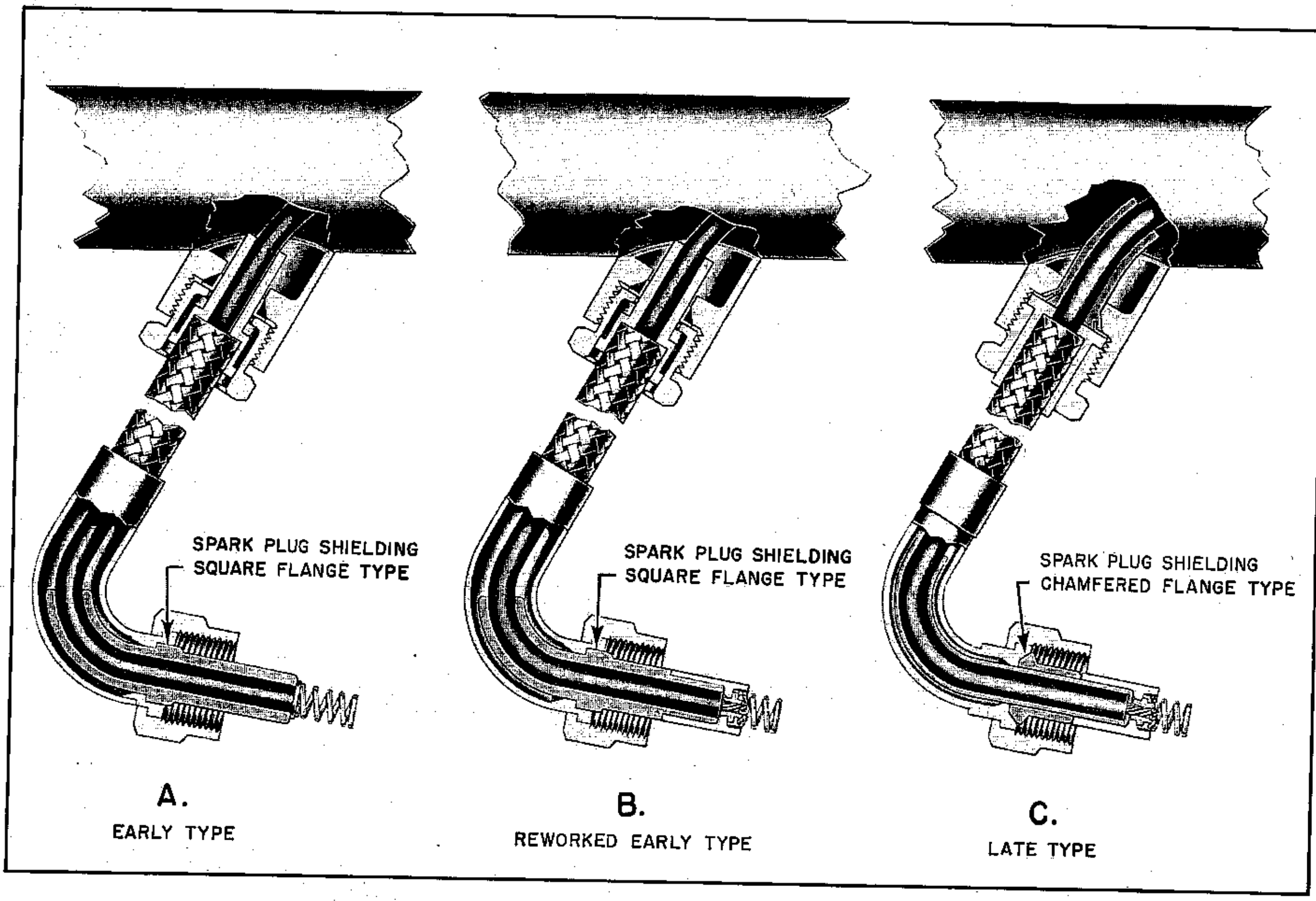


Figure 72—Intake Spark Plug Shielding Types and Methods of Wiring.

packing is then removed from inside the elbow. Disconnect the spark plug shielding nut located at the branch tube and slip the lead off the cable. See Figure 73. Remove the packing from the branch tube. Refer to Table of Cable Lengths, cut new cable to appropriate length, solder to old cable at branch tube end, pull into place as described under the exhaust cable installation Paragraph *b.* (2) above. Leave approximately 12″ of the new cable extending from the branch tube opening. The intake side spark plug shielding leads are packed at the ignition tube branch tube opening by two methods. Refer to Figure 72 and note that the early type shielding lead extends through the branch tube while the late type terminates in a flange and the connecting nut is non-removable. The early type shielding will have the branch tube nut No. 36496, copper ferrule No. 18073 and packing No. 18071 placed on the end of the shielding. On late shielding slip a new branch tube packing over the cable with beveled side down so that the extended end protrudes into the intake tube. Next thread the spark plug shielding lead over the end of the cable leaving approximately 4″ or 5″ of cable extending beyond the end of the elbow. The proper elbow packing is then selected as explained in Paragraph (2) above and installed as follows:

(a) REPACKING EARLY TYPE SPARK PLUG SHIELDING ELBOWS.—Examine the end of the elbow flange to determine if it has a square face as shown in "A" and "B" of Figure 72. Cut the cable insulation squarely 11/32″ from the end and strip off. Install the packing part No. S-43524 on the cable after dusting with soapstone or talc. Thread the spark plug contact assembly over the end of the wire and onto the small diameter end of the elbow packing. The strands of the wire will protrude into the inside diameter of the spark plug contact spring. Separate the strands of the wire and bend them radially and firmly over the base of the contact spring. Do not solder. The packing is then slipped carefully into the elbow until the shoulder is seated. The extra cable length is then taken up and the shielding assembly attached at the branch tube. (See Figure 74.)

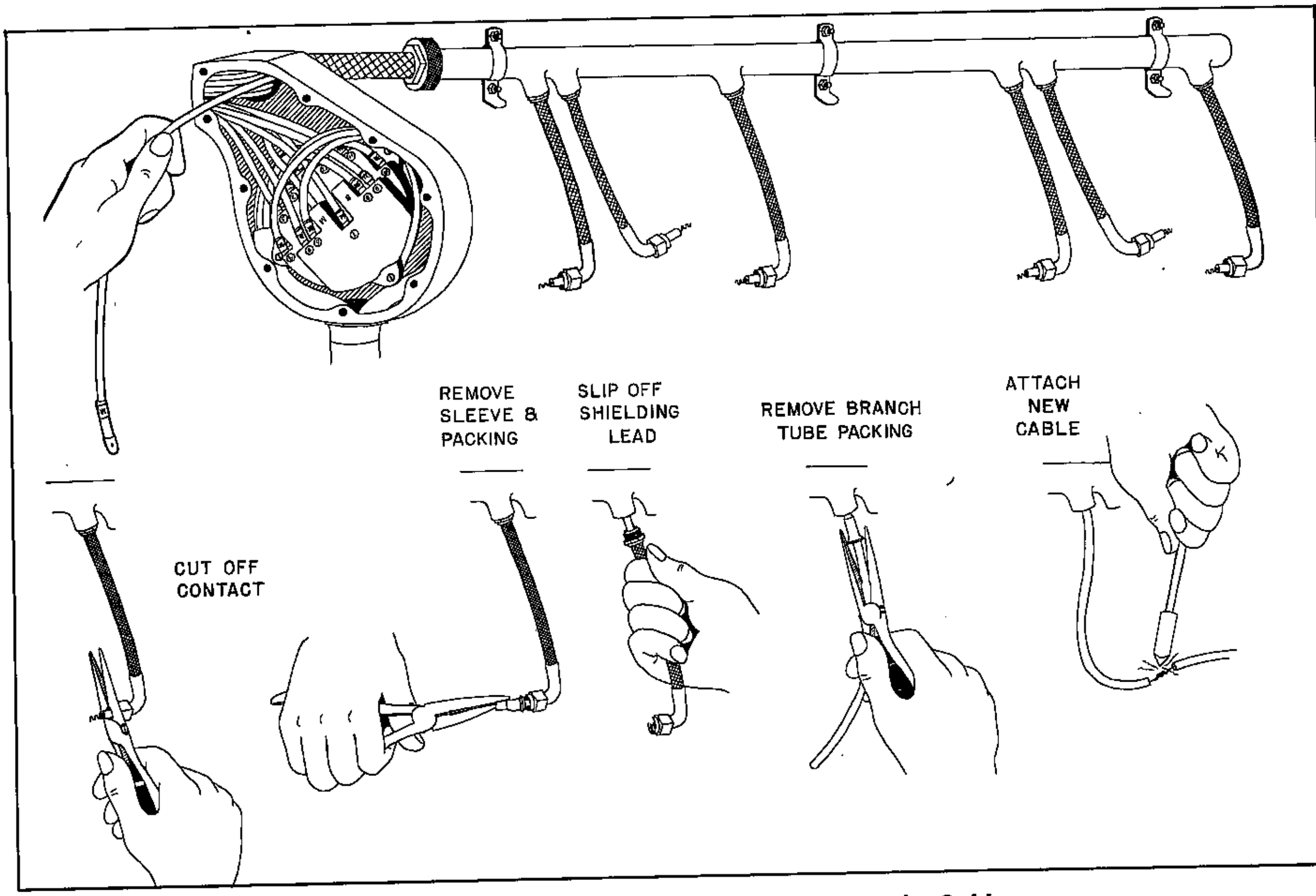


Figure 73—Removing Defective Intake Ignition Tube Cable.

(*b*) REPACKING LATE TYPE SPARK PLUG SHIELDING ELBOWS. — Examine the end of the elbow flange to determine if it has a chamfered face as shown in "C" of Figure 72. Cut the cable insulation squarely 11/32" from end and strip off. The small diameter sleeve approximately 3½" long is dusted with talc or soapstone and slipped over the end of the cable. Next slip the beveled flange packing over the sleeve. Thread the spark plug contact assembly over the end of the wire and onto the cable end. The strands of the wire will protrude into the inside diameter of the spark plug contact spring. Separate the strands of the wire and bend them radially and firmly over the base of the contact spring. Do not solder. The chamfered packing should then be slipped back until it butts firmly against the end of the contact spring assembly. The assembled end is then slipped carefully into the elbow until the shoulder is seated. The extra cable length is then taken up and the shielding assembly attached at the branch tube. (See Figure 74.)

(4) The cable is then measured to its appropriate contact point in the distributor head, cut off, and rubber sleeve, marker and cap installed as in the case of the exhaust cables covered in Paragraph 12, *b.* (2)

TABLE OF CABLE LENGTHS

V-1710-F2R, F5R, F10R, F4R and F20R

Cylinder No.	*Exhaust R.H.*	*Exhaust L.H.*	*Intake R.H.*	*Intake L.H.*
1	31"	44¼"	43"	27"
2	34"	47½"	44¼"	32½"
3	39½"	58"	51¼"	38¼"
4	50"	65¼"	64¼"	49½"
5	52½"	65¾"	65"	50¾"
6	57¼"	78¾"	68¾"	58½"

V-1710-F2L, F5L and F10L

Cylinder No.	*Exhaust R.H.*	*Exhaust L.H.*	*Intake R.H.*	*Intake L.H.*
1	26½"	44¼"	43"	27"
2	37"	47½"	46½"	32½"
3	37½"	58"	50"	38¼"
4	49¾"	65¼"	64½"	49½"
5	52"	65¾"	65"	50¾"
6	60¾"	78¾"	70"	58½"

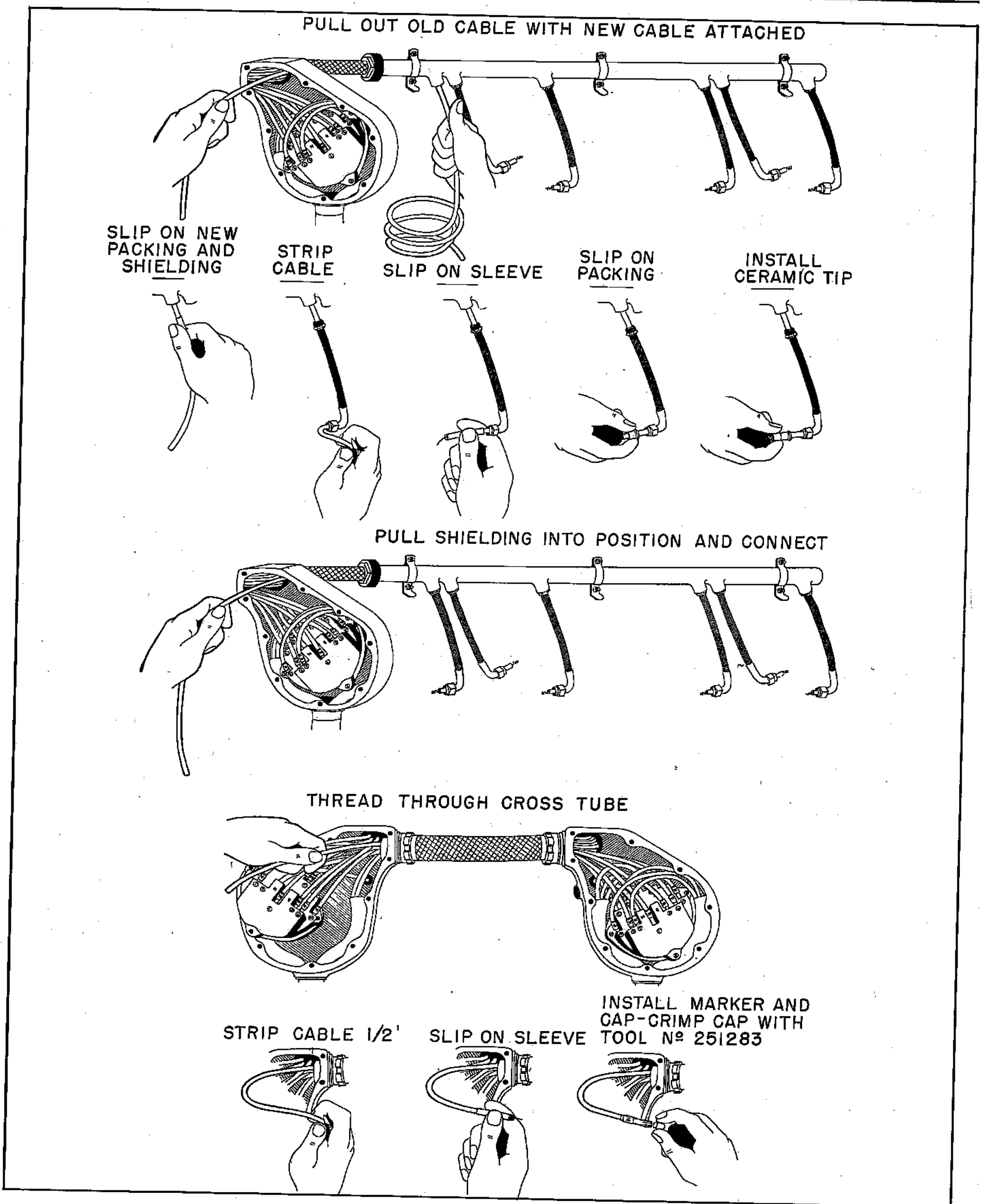


Figure 74—Installing Replacement Intake Ignition Tube Cable.

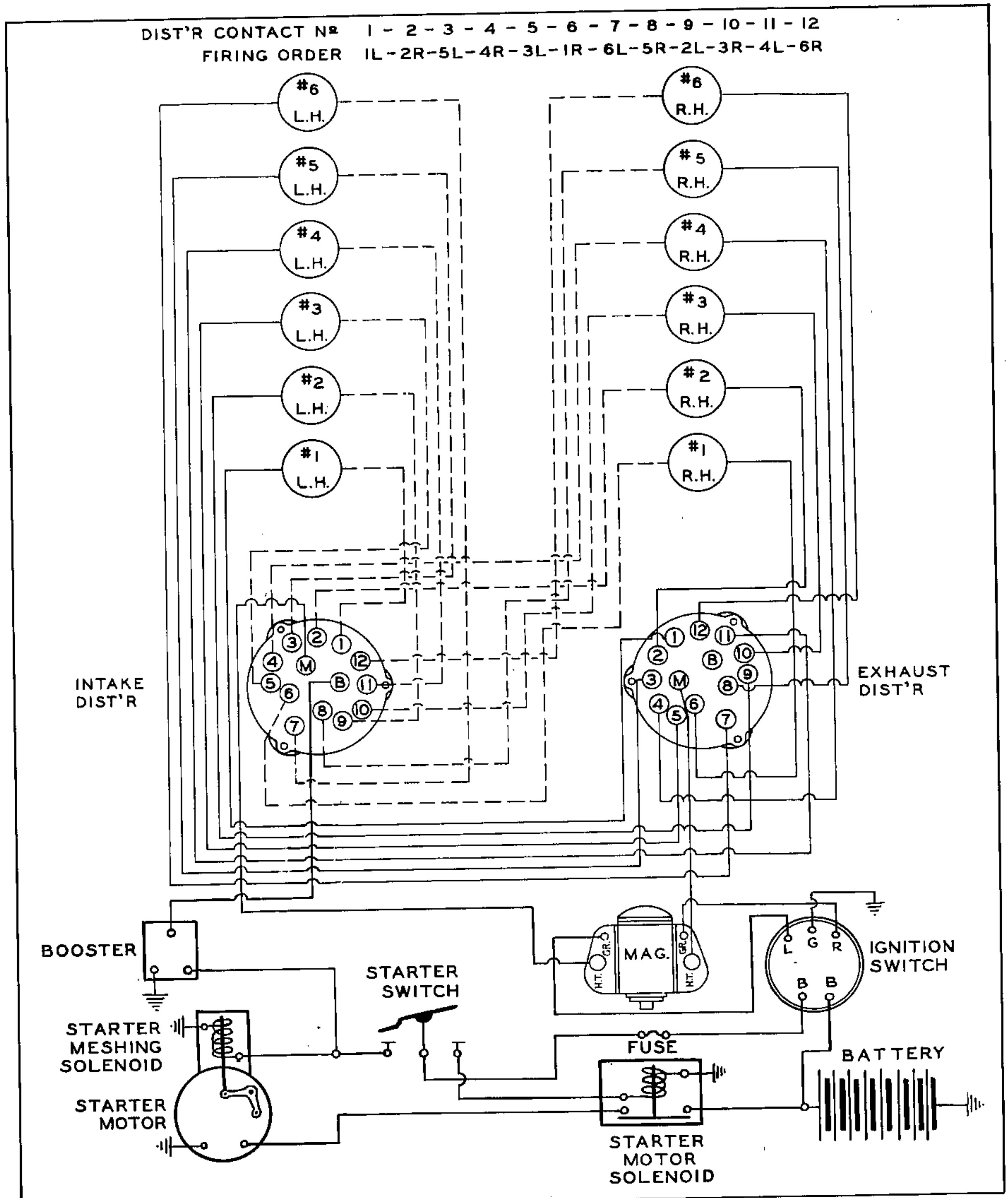


Figure 75—Wiring Diagram for R.H. Prop. Rotation Engines—Not Using Gun Synchronizer Type Distributor Housing.

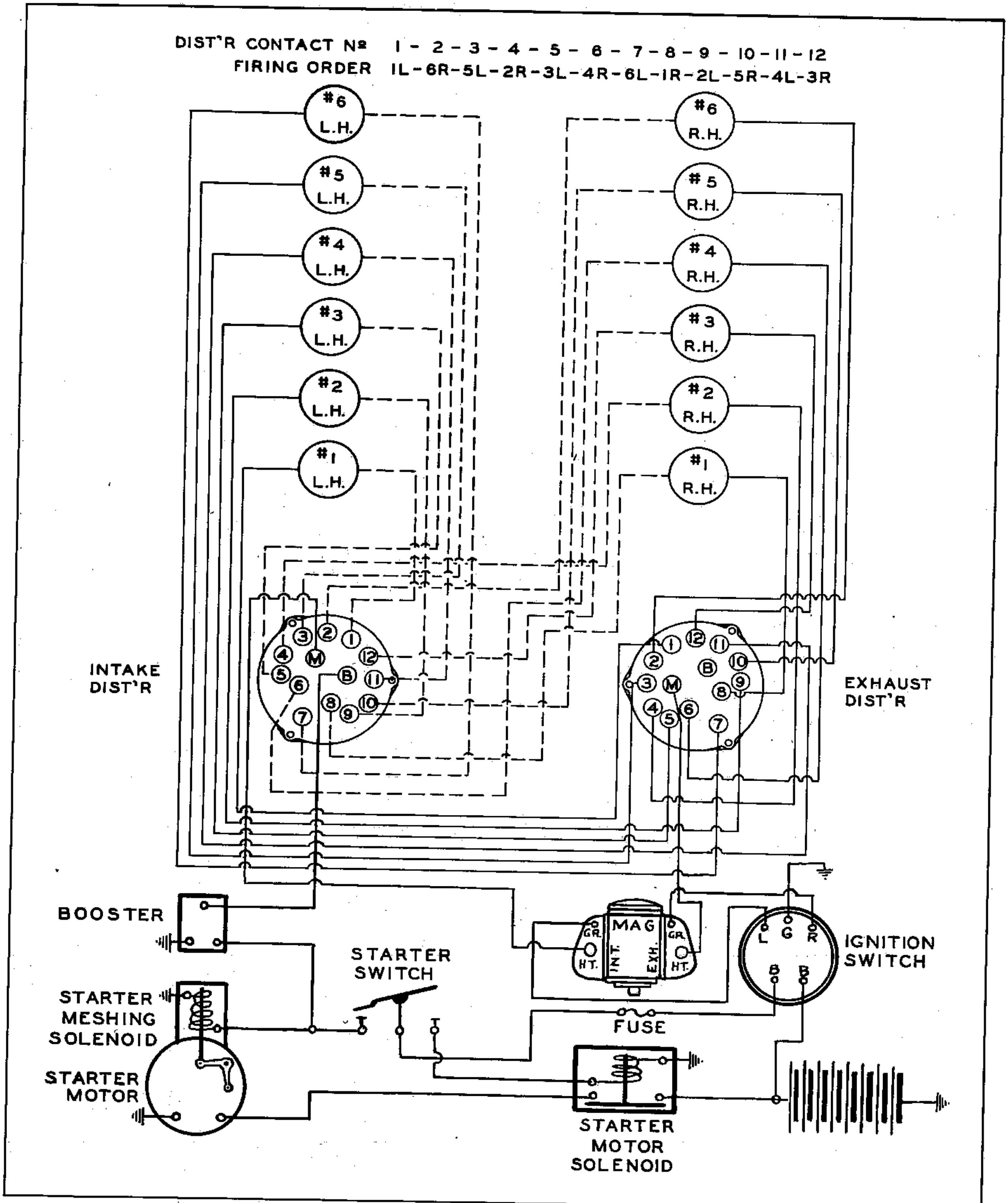


Figure 76—Wiring Diagram for L.H. Prop. Rotation Engines.

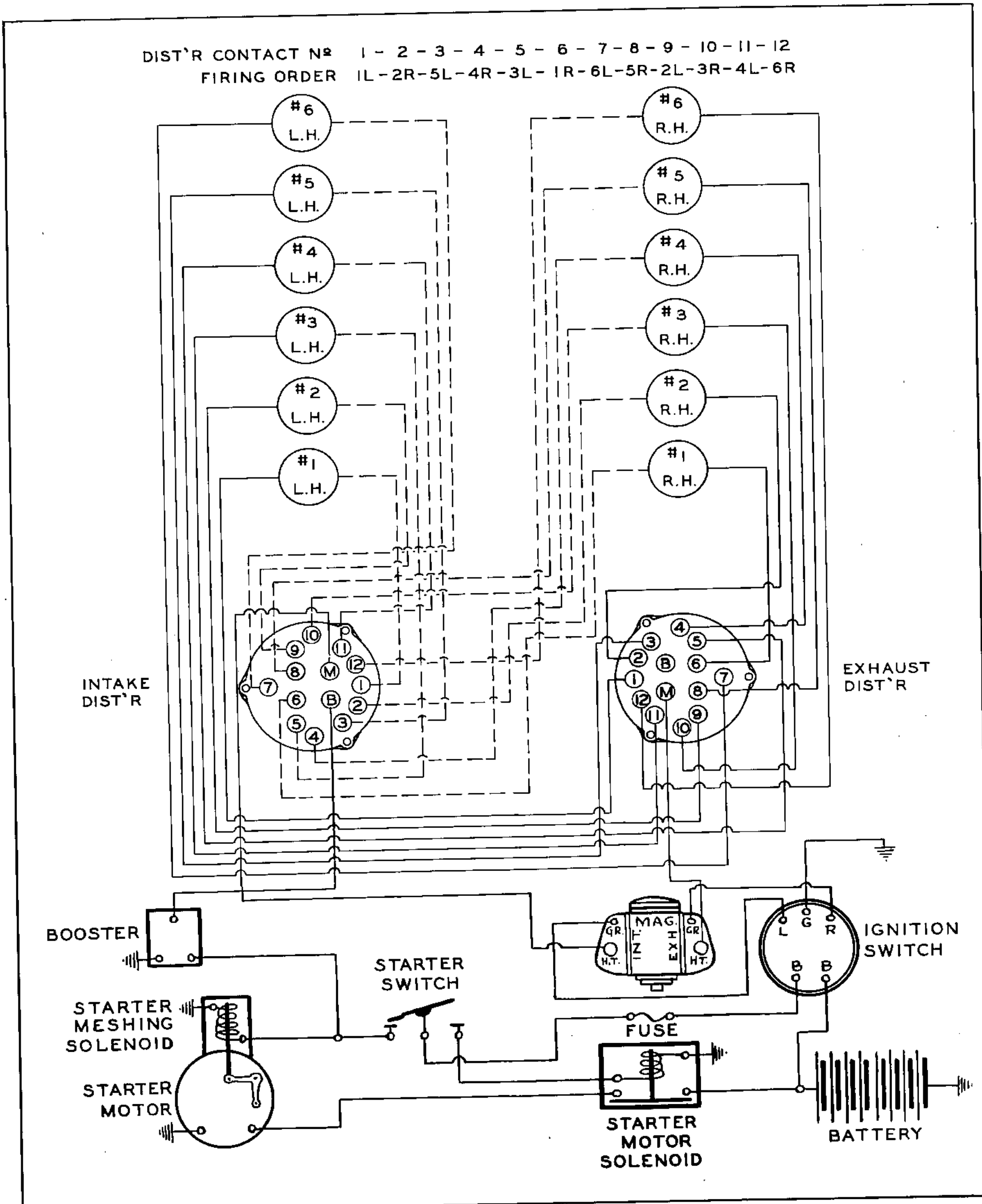


Figure 77—Wiring Diagram for R.H. Prop. Rotation Engines—Using Gun Synchronizer Type Distributor Housing.

V-1710-F3R AND F21R

Cylinder No.	*Exhaust R.H.*	*Exhaust L.H.*	*Intake R.H.*	*Intake L.H.*
1	33½"	39½"	40½"	30"
2	37½"	48½"	38½"	45"
3	48½"	54½"	46½"	38"
4	52½"	60½"	58½"	61"
5	62½"	66½"	59½"	50"
6	66½"	74"	63½"	58"

13. REPLACEMENT OF DISTRIBUTOR HEADS AND FINGERS.

a. DISTRIBUTOR HEADS. — The two distributor heads which are located in the distributor drive housings at the rear of the engine are accessible for replacement by removing the distributor housing covers. With the covers removed from the distributor housings, take out the three screws of the distributor head flange and lift the head from its mount. Twist the head sufficiently to remove the piercing screws and slip all cables from their openings. The cables are next attached to the new head by re-inserting the cable ends and installing the piercing screws. The number discs located on top of the distributor heads indicate the firing order of the magneto, and not the firing order of the cylinders. The terminal on the distributor head marked No. 1 will be connected to the cable end of No. 1L cylinder, and the terminal marked No. 2 will be connected to the cable end of the second cylinder to fire, etc., through the firing order as follows:

DISTRIBUTOR WIRING SEQUENCE

(Right Hand Engines)

Contact No.	1	2	3	4	5	6	7	8	9	10	11	12
Cable No.	1L	2R	5L	4R	3L	1R	6L	5R	2L	3R	4L	6R

(Left Hand Engines)

Contact No.	1	2	3	4	5	6	7	8	9	10	11	12
Cable No.	1L	6R	5L	2R	3L	4R	6L	1R	2L	5R	4L	3R

Replace head, secure the three screws and safety with lockwire.

CAUTION

Extreme care must be taken when securing the distributor head to the distributor drive housing. Before tightening the three securing screws, insure that the head rests squarely and is fully seated on the distributor drive housing mounting flange. The three screws should not be tightened too securely. If the distributor head has been washed in gasoline, insure that it is thoroughly dry before reinstalling, to avoid any possible explosion of gasoline vapors.

b. DISTRIBUTOR FINGERS.—The distributor fingers are covered by the distributor heads and are accessible when the heads and covers are removed. The distributor finger incorporates an integral high tension segment and a booster electrode which trails the high tension segment. All fingers should be of the late type which use a conical spring contact located in the top recess of the finger.

NOTE

Conical spring type fingers must always be used with distributor heads having a fixed carbon brush main electrode.

Distributor fingers can be replaced without affecting or disturbing engine timing. Remove the old finger which is secured to the distributor drive flange by two slotted engine nuts. The new finger is then placed over the drive flange studs, being sure to index the finger in accord with the locating dowel. Install two No. 10 plain washers, slotted engine nuts, and cotter. Replace heads and covers in accordance with Paragraph *a.* above.

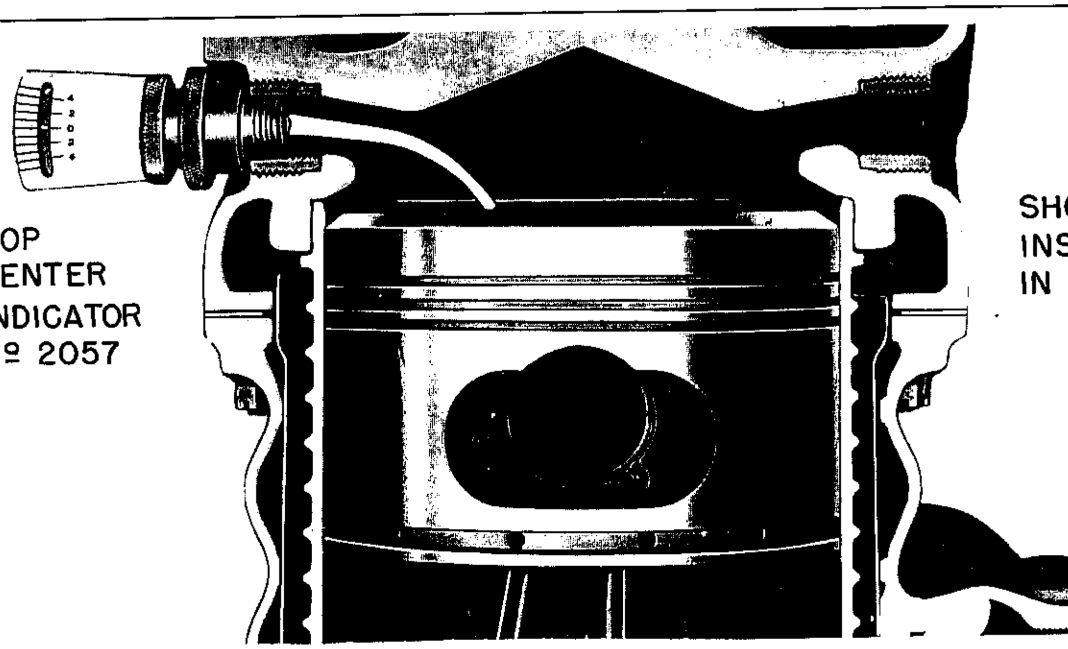
c. SERVICE PARTS REFERENCE.—For information on serviceable details of distributor heads and fingers refer to Service Instructions—Parts List—DF Type Magneto, Scintilla Magneto Division, Bendix Aviation Corporation.

14. CHECKING VALVE, MAGNETO AND DISTRIBUTOR TIMING ON ENGINE INSTALLED IN AIRPLANE.

a. TOOLS REQUIRED.—Due to lack of accessibility to the starter pad of engines when they are installed in airplanes, a Magneto Type Timing Disc No. 2380 should be used to check engine timing instead of the starter pad type which is used at overhaul.

(1) The following two Special Tools are required:
Disc—Magneto Type Timing No. 2380
Indicator—Top Center No. 2057

(a) The degrees calibrated on the Magneto Type Timing Disc indicate degrees of crankshaft travel. It will be noted that the disc is calibrated to 120° each



THE FIGURES 4-2-0-2-4 ON INDICATOR ARE REFERENCE MARKS ONLY. THE "O" MARK THEREFORE DOES NOT INDICATE TOP CENTER.

1. – WHEN CHECKING TIMING WITH CAMSHAFT BEVEL GEAR INSTALLED ; FIRST ROTATE ENGINE FORWARD (IN NORMAL DIRECTION OF ROTATION) UNTIL INTAKE VALVES OF NO. 6 L. CYL. ARE JUST BEGINNING TO OPEN.
2. – SLIP ADAPTER OFF TOP CENTER INDICATOR AND SCREW ADAPTER INTO NO. 6 L. INTAKE SPARK PLUG HOLE.
3. – PRESS INDICATOR INTO ADAPTER ------ BENT ARM DOWN.
4. – ROTATE ENGINE FORWARD UNTIL INDICATOR POINTER SHOWS PISTON IS COMING UP. (POINTER MOVING DOWN) STOP AT ANY PRE-SELECTED POINT ------ SAY "O".
5. – WITH TOP CENTER INDICATOR IN THIS POSITION , NEXT SET TIMING DISC AND POINTER TO ZERO. ON MAGNETO TYPE TIMING DISC ROTATE DISC UNTIL ZERO ON INNER DIAL IS UNDER CROSS HAIR OF POINTER AND CLAMP DISC IN PLACE. ON STARTER TYPE TIMING DISC LOOSEN POINTER KNURLED NUT AND LOCATE POINTER AT ZERO T. D. C. AND SECURE.
6. – WATCH TOP CENTER INDICATOR AND ROTATE ENGINE FORWARD UNTIL THE POINTER MOVES FROM THE PRE-SELECTED POINT "O" DOWN AND BACK UP TO THE SAME POINT.
7. – READ THE DEGREES OF CRANKSHAFT TRAVEL ON TIMING DISC. WITHOUT TURNING ENGINE RESET TIMING DISC OR POINTER TO ONE-HALF THIS READING. (EXAMPLE -- READING IS 36° A.T.C., RESET TIMING DISC OR POINTER TO 18° A.T.C. THIS IS THE ACTUAL POSITION OF PISTION IN NO. 6 L. CYL.)
8. – TO CHECK -- REVERSE ENGINE BEYOND THE FIRST STARTING POINT THEN TURN FORWARD AGAIN - UNTIL - THE INDICATOR POINTER MOVES DOWN AND STOPS AT ZERO OR THE PRE-SELECTED MARK.
9. – THE TIMING DISC READING SHOULD NOW READ SAME AS LAST SETTING - I.E. - EXAMPLE - THIS READING WOULD BE 18° A.T.C. THE ENGINE WILL BE AT TOP CENTER WHEN THE POINTER ON THE TIMING DISC IS AT "O" T.D.C.

Figure 78—Locating Top Center Piston Position.

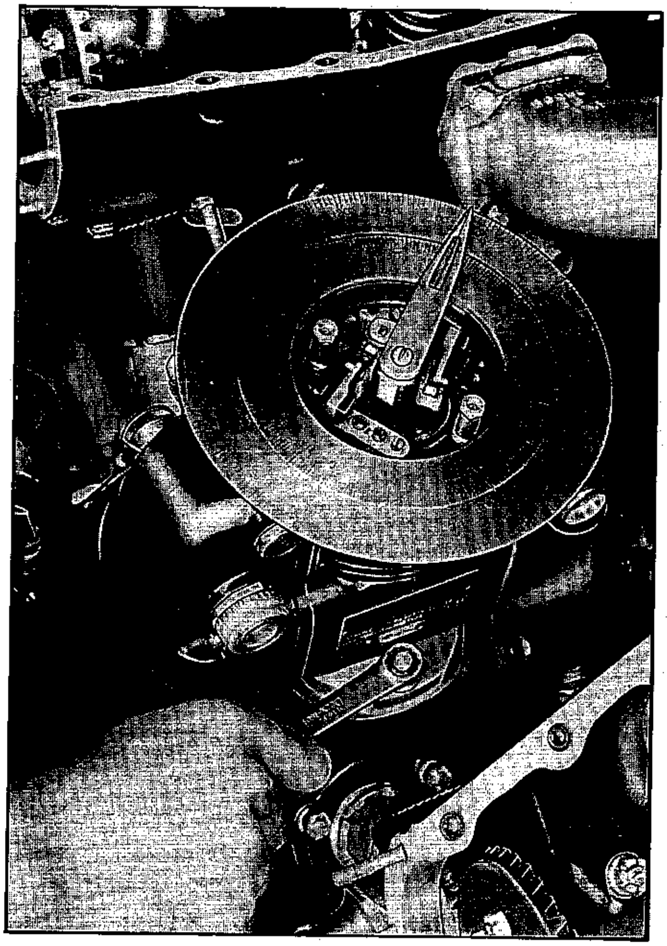


Figure 79—Magneto Type Timing Disc Installed.

way from T.D.C. This is due to the fact that the magneto turns 1.5 times crankshaft speed; consequently 120° movement of the crankshaft causes the pointer on the timing disc to turn one-half of a complete revolution. This means that the disc will indicate crankshaft rotation from 120° before T.D.C. to 120° after T.D.C. without resetting the disc. Considerable less than this movement is required to completely check engine timing. It will also be noted that there are two scales of degrees on the disc. The inner scale is used for "left bank" timing, and the outer scale for "right bank" timing. The pointer will always turn clockwise when the propeller is rotated in its normal direction of rotation, whether on a right hand or left hand rotation engine.

b. PROCEDURE.

(1) Remove valve covers and set tappet clearances as per Paragraph 5 of this section.

(2) Install Top Center Indicator in No. 6L intake spark plug bushing.

(3) Remove magneto cover and cam screw. Slip Timing Disc on magneto housing, install pointer, indexing its step with the step on the magneto cam, and secure with the special screw.

(4) Locate the No. 6L piston in top dead center position, using both the Top Center Indicator and the Timing Disc, for accuracy. Figure 78 gives the step by step procedure for locating top center.

NOTE

The No. 6L piston must be located at T.D.C. on the intake stroke (intake valves beginning to open). No. 1L piston will then be at T.D.C. but on firing stroke (all valves closed).

(5) Remove the distributor housing covers and lift each distributor head from its pilot. Each head is secured by three flange screws.

(6) With magneto type timing disc pointer reading "O" T.D.C. on inner scale, proceed to check timing of valves, magneto and distributors in the following order.

(a) TIMING CHECK—*Exhaust Valve Closing —Left Bank.*—Turn propeller in normal direction of rotation until the exhaust valves of No. 6L cylinder are closed. (Pressure off rocker arm roller.) Check reading on inner scale of Timing Disc No. 2380. The reading should be 26° ± 2° A.T.C.

(b) TIMING CHECK — *Exhaust Magneto Breaker.*—Back up engine until Timing Disc Pointer indicates approximately 50° B.T.C. on inner scale. Insert a piece of shim stock or metal feeler blade (not over .0015" thick) between the exhaust breaker points. Turn propeller in normal direction of rotation until the points start to open, as indicated by slipping of feeler gage.

Check reading on inner scale of Timing Disc. The reading should be 34° + 1° — 0° B.T.C. Check R.H. distributor next with engine located at this position.

(c) TIMING CHECK—*R.H. Distributor.*—With engine set at 34° B.T.C. check location of R.H. distributor finger. Leading edge of finger should be $\frac{3}{32}'' \pm \frac{1}{32}''$ past distributor housing flange mark.

(d) TIMING CHECK—*Intake Magneto Breaker.* —First insert feeler blade (not over .0015" thick) between the intake breaker points. Next tap propeller carefully in normal direction of rotation until points start to open, as indicated by slipping of feeler gage.

NOTE

Engine was set at 34° B.T.C. during preceding check. Only slight movement of propeller is necessary to open intake breaker which fires 6° later.

Check reading on inner scale of Timing Disc. The reading should be 28° + 1° — 0° B.T.C. Check L.H. distributor next with engine located in this position.

(e) TIMING CHECK—*L.H. Distributor.*—With engine set at 28° B.T.C. check location of L.H. distributor finger. Leading edge of finger should be $\frac{3}{32}'' \pm \frac{1}{32}''$ past distributor housing flange mark.

(f) TIMING CHECK—RIGHT HAND PROPELLER ROTATION ENGINE.—*Exhaust Valve Closing—Right Bank.*—In Paragraph *(a)* above, the No. 6L exhaust valve closing was checked. The next valve to operate in the Right Bank is No. 5R. (See firing order in Paragraph 13 of this Section.) The exhaust valve closing of No. 5R is checked on the *outer scale* of the Timing Disc. Turn propeller in normal direction of rotation until the exhaust valves of No. 5R are closed. (Pressure off rocker arm roller.) Check reading on *outer scale* of Timing Disc. The reading should be 26° ± 2° A.T.C.

(g) TIMING CHECK—LEFT HAND PROPELLER ROTATION ENGINE.—*Exhaust Valve Closing—Right Bank.*—In Paragraph *(a)* above, the exhaust valve closing of No. 6L was checked. The next valve to operate in the right bank is No. 1R. (See firing order in Paragraph 13 of this section.) The exhaust valve closing of No. 1R is checked on the *outer scale* of the Timing Disc. Turn propeller in normal direction of rotation until the exhaust valves of No. 1R are closed. (Pressure off rocker arm roller.) Check reading on *outer scale* of Timing Disc. The reading should be 26° ± 2° A.T.C.

(7) When timing check is completed, remove timing disc from magneto and replace cover. Replace all covers and spark plugs.

IMPORTANT

Replace magneto cam screw that was removed to install Timing Disc Pointer. This is not same screw used to secure pointer. Use magneto screw.

c. MAGNETO CHECKS LATE.

(1) When, by the above check, it is found that the engine is firing slightly late, the common practice of rotating the magneto on its base will cause the points to break for correct engine timing. However, worn contact breaker cam followers, or some other fault in the magneto breaker mechanism, may cause the breaking to be out of phase with the maximum flux of the magneto. With such a condition, a weakened spark would be produced and only a part of the potential efficiency of the magneto would be utilized. Therefore, the magneto breaker timing should be checked, whenever an engine is found to be *firing late.*

(a) Turn the engine until No. 1L cylinder is in firing position (34° B.T.C.) for the exhaust side. Insert a piece of shim stock or metal "feeler" blade (not over .0015" thick) between the exhaust breaker points and carefully turn the engine or rotate the magneto on its base, until the points start to open, as indicated by the slipping of the shim.

(b) Place a steel scale or other straight edge against the shoulder of the step, cut on the end of the breaker cam. If the straight edge aligns with the timing marks on the rim of the breaker cup, it will indicate that the points are breaking in phase with the maximum flux of the magneto. The magneto is correct for operation.

(c) If the straight edge *does not align* with the timing marks, within $\frac{1}{32}''$, when the exhaust breaker points are beginning to open for firing No. 1L cylinder, it will indicate that the magneto timing is out of phase with the maximum flux.

(d) If the "Exh." breaker points are opening too late, adjust by loosening breaker clamp screw and turning eccentric screw.

(e) The intake magneto breaker timing will also be checked in the case of late firing. This check is made exactly the same as the above procedure on the exhaust breaker except that the engine is located at 28° B.T.C. instead of 34° B.T.C.

d. GAGING MAGNETO BREAKING POINT.

(1) The use of shim stock or a metal "feeler" blade, .0015" thick, has been recommended for inserting between the magneto breaker points in the timing test. These have replaced cellophane paper in this operation because cellophane, a non-conductor of electricity, would not make an electrical contact if any particles were left between the breaker points.

(2) An electric timing light, connected to the arms of the two breaker points, is preferable, if available, to any of the materials in above paragraph.

(3) If circumstances make the use of cellophane paper imperative, be sure that *no cellophane,* even minute particles, *remains between the breaker points.*

15. REPLACEMENT OF COOLANT HOSE.

a. It is important that hose suitable for use with ethylene glycol be installed, i.e., hose conforming to Specification AN-22-H-456.

(1) If hose does not slip on the pipe readily, lubricate with ethylene glycol. Be careful not to cut the hose with the pipe.

(2) Slip the hose up to the etched mark on the coolant pipes. This will give the proper gap between the ends of the pipes.

(3) Place the hose clamps 1/2" to 5/8" from the end of the hose. These clamps can be safely tightened to 8 to 10 ft. lbs.

(4) The location of the thumb screws of the clamps will differ on various airplane installations. An arrangement at installation must be established after determining where close clearances exist with engine mounts and accessories.

16. INSPECTION OF COOLANT METERING ORIFICE ARRANGEMENT.

a. In case there is evidence of localized overheating in the cylinder blocks, an inspection of the arrangement of the metering orifices in the coolant jacket inlet manifold should be made by removing the core hole plugs in the manifold with Wrench No. 2316 (Overhaul Tool) and the metering orifice plug with Wrench No. 2149 (Overhaul Tool). The coolant metering orifice plug arrangement should agree with the following table. Lubricate the threads of the core hole plugs with a mixture of white lead and engine oil, and install new copper gasket before replacing plugs in the manifold.

METERING PLUG ARRANGEMENT

Cylinder No.	*Double Coolant Inlet Orifice Size*	*Single Coolant Inlet Orifice Size*
1	None Used	None Used
2	None Used	None Used
3	3/8"	27/32"
4	3/8"	25/32"
5	3/8"	11/16"
6	5/16"	5/16"

NOTE

Coolant is admitted to the cylinder blocks of V-1710-C15 models by a single inlet located at the coolant jacket inlet manifold, while on the cylinder blocks of models covered in this handbook coolant is admitted at double inlets. The cylinder blocks, installed on engines using double or single coolant inlets, are interchangeable, provided the metering orifices are altered to conform to the above table. The possibility of V-1710-C15 cylinder blocks being installed on models covered in this handbook without the metering orifices being changed may require that the above inspection be made in case of localized overheating.

17. TIGHTENING GAS INTAKE PIPE SEALING CLAMP.

a. The clamp should be inspected for roundness before assembly and any irregularities or sharp bends corrected by reshaping on an arbor.

b. Tighten the screw with one hand using a medium length screwdriver.

c. From this position tighten the screw 1 1/2 to 2 full turns, using a wrench.

SECTION IX
ACCESSORIES

1. GENERAL ACCESSORY INFORMATION.

a. The engine accessories covered in this section, while furnished with the engine, are manufactured by other than the engine manufacturer. For the above reason, this engine handbook will give maintenance personnel only sufficient information to maintain and service the accessory on the engine as well as instructions for its installation and removal. Complete service parts information and service and overhaul instructions on each accessory are furnished by specific Technical Orders as tabulated below. In other words, if maintenance personnel requires the part number of a detail part on a specific accessory, the parts catalog of that accessory must be referred to. The parts catalog of the particular engine model concerned lists only each complete accessory by its Allison part number with a cross reference to the accessory manufacturer's assembly part number. With this assembly part number, refer to the accessory parts catalog, and the part number of any accessory detail will be listed thereunder.

Accessory	*Handbook*
Carburetor	Service Manual—Stromberg Injection Carburetors for Aircraft—Bendix Products Division of Bendix Aviation.
Magneto	Commercial Handbook — Scintilla Magnetos and Distributors.
Distributors	Commercial Handbook — Scintilla Magnetos and Distributors.
Spark Plugs	Commercial Handbook of Spark Plug Manufacturer.
Oil Strainer	Service Manual and Parts Catalog for Cuno Aircraft Filters.
Manifold Pressure Regulator	Allison Automatic Manifold Pressure Regulator Handbook.

2. CARBURETOR.

a. GENERAL.

(1) The Bendix-Stromberg Injection Carburetors used on the engine models covered in this handbook are the PD-12G1, PD-12K2, PD-12K3, PD-12K6 and PD-12K7 models. The injection type carburetor differs from previous types of carburetors in that it has a closed fuel system from fuel pump to discharge nozzle instead of a vented float chamber. Injection carburetors used in these engines differ from other injection carburetor installations in that the accelerating pump and the spray nozzle adapter assembly is fastened directly to the outside of the supercharger inlet cover and the fuel is supplied to the adapter by an external tube from the carburetor. Located on the lower rear portion of the spray nozzle adapter assembly is a cylindrical body which houses the diaphragm type of accelerating pump.

NOTE

There are two types of accelerating pumps used on the engine models covered in this handbook. One type is the double diaphragm accelerating pump type (approximately 4″ over-all length) and is required on the V-1710-F21R and all altitude rated engines covered in this handbook, which are equipped with the new constant velocity gas intake pipe and tees. It is also required on all engines which have been approved for operation under W.E.R. conditions. The other type is the single diaphragm accelerating pump type (approximately 1½″ over-all length) and is satisfactory for use on the balance of the models covered in this handbook.

b. INSTALLING CARBURETOR.

(1) This carburetor is mounted directly to the top of the supercharger inlet cover with seven long studs. The flanges and gasket should be wiped clean and dry, and carburetor assembled on the cover without any sealing compound or gasket paste. After the seven carburetor mounting stud nuts are secured and safetied with cotter pins, the carburetor air screen is installed. The screen is mounted to the carburetor upper flange with two composition gaskets, one placed under the screen flange and the second on top of the screen flange and secured to the carburetor by four No. 8 screws. Fasten automatic manifold pressure regulator brace to carburetor, if regulator is already in place.

(2) Before the spray nozzle and adapter are mounted to the supercharger inlet cover, the packing

nut for the adapter fuel inlet will be removed and placed over the end of the fuel inlet tube. The packing gland should then be carefully removed from the adapter inlet opening and also slipped onto the fuel inlet tube. Insert tube and packing into the adapter fuel inlet and start the packing nut into its threads. The flanges and the gasket should be wiped clean and dry and the gasket placed on the mounting pad of the inlet cover matching the slot and vent holes of the gasket with the slot and vent holes of the inlet cover mounting pad. Do not use gasket compound. The nozzle adapter with inlet pipe in place is then located on the two studs of the supercharger inlet cover and secured with two $\frac{5}{16}$ plain washers, plain nuts and pal nuts. The fuel inlet tube is attached to the triangular mounting boss at the top of the carburetor, using a composition gasket, secured with three screws and safetied with lockwire. After the tightening and safetying of the three fillister head screws on the large fuel tube, the packing nut is then tightened into the adapter and safetied with lockwire.

(3) The air scoop should be connected to the carburetor upper flange with sufficient security to prevent possible air leakage.

(4) Connect the cockpit throttle and mixture control rods to carburetor on engines not using automatic manifold pressure regulator. On installations using regulators, the carburetor throttle lever is connected by a short adjustable rod to the regulator throttle lever. Refer to Paragraph 6. *c.* this section for adjustment of the carburetor throttle rod length.

NOTE

Carburetors which are being installed on engines using Automatic Manifold Pressure Regulators require a different carburetor throttle lever and mixture control lever than the levers used on carburetors installed without regulators.

(5) Connect fuel supply line, fuel pressure gage line, carburetor vent line, carburetor inlet pressure gage line, etc., in accordance with the appropriate Airplane Service Instructions Technical Order.

(6) After all controls and fittings are connected on carburetor, it will be filled with fuel and vented in accordance with instructions in Section IV, Paragraph 5. *b.*, (8).

c. REMOVAL OF CARBURETOR.

(1) Disconnect fuel supply to carburetor at fuel inlet connection, located at the rear of the carburetor.

(2) Disconnect throttle and mixture control rods to carburetor.

(3) Remove the air scoop and screen.

(4) If manifold pressure regulator is used disconnect the automatic manifold pressure regulator brace from carburetor nut.

(5) Disconnect all carburetor gage lines, vent lines, etc.

(6) Remove the fuel nozzle adapter assembly and fuel inlet tube which are mounted to the engine supercharger inlet cover by two studs and secured to the carburetor by the inlet tube upper flange screws.

(7) Remove the nuts from the seven long studs on which the carburetor is mounted and lift off the carburetor.

d. PERIODIC INSPECTION AND MAINTENANCE.

(1) PRE-FLIGHT.

(a) Before starting engine, check free operation of throttle and mixture control rods.

(b) Check wobble pump and engine fuel pump.

(c) Check fuel pressure gage.

(2) DAILY.

(a) Inspect carburetor and fuel line connections for fuel leakage, paying particular attention to drain plugs, passage plugs, and parting surfaces between regulator castings.

(b) Inspect throttle and mixture control rods and levers for tightness and safetying.

(c) Inspect the safety wiring of all nuts, bolts and studs fastening carburetor to engine.

(3) 25-HOUR.

(a) Check carburetor air scoop flange nuts for tightness.

(b) Remove and clean the fuel strainer.

NOTE

Fuel supply line does not have to be disconnected in order to clean strainer.

(c) After the above operations have been completed, and while the carburetor strainer is filled with air, disconnect the flexible hose in the vent line at the carburetor. Then apply fuel pressure of 14 lbs. per square inch with the wobble pump and observe the action of the vapor eliminator. There should be a

INJECTION CARBURETOR
WITH FUEL HEAD ENRICHMENT VALVE

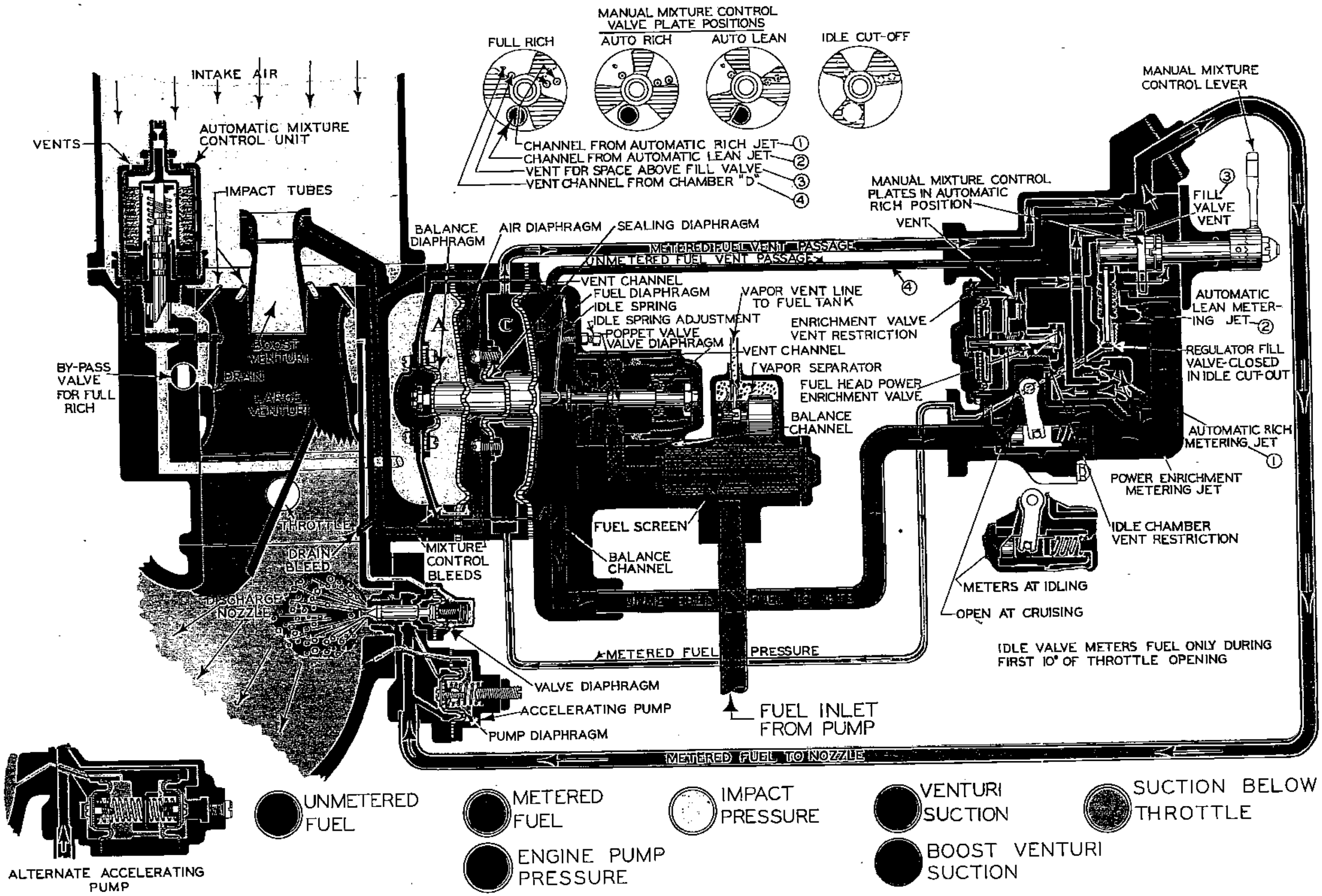


Figure 80—Diagrammatic Sketch of Injection Type Carburetor

noticeable rush of air being expelled, which stops when the fuel level raises the float and shuts off the vent passage. There should be only a seepage of a few drops of fuel from the vent line.

(4) 50-HOUR.

(a) Grease mechanism of mixture control latch, using grease, Specification VV-G-681-Medium.

(b) Drain regulator unit, air chamber and fuel chambers, and the fuel control unit through plugs in bottom.

(c) Lubricate throttle shaft bushings using machine gun oil, Specification 2-27.

e. TROUBLE SHOOTING.

(1) GENERAL.—See that the specifications and setting of the carburetor are correct for that particular installation. Make no carburetor adjustments until unsatisfactory engine operation has been definitely attributed to carburetion.

(2) ENGINE WILL NOT START OR CONTINUE TO RUN AFTER STARTING.

(a) Improper starting procedure. Refer to Starting Instructions—Section VI, Paragraph 1. *b.*

(b) Insufficient fuel pressure. Fuel pressure gage reading should conform to required pressures given in Table of Specifications—Section II.

(c) Idle adjustment too rich or too lean. Readjust idle needle.

(d) Air in regulator unit. Remove vent plug at top of unmetered fuel chamber of regulator unit. Pump fuel until it stands level with plug opening. Air in regulator unit may be due to long periods of idleness or failure to vent carburetor following installation. See Preparation for Service—Section IV, Paragraph 5.

(e) Check position of manual mixture control to see that it is not in "Idle Cut-Off" position.

(f) Main discharge nozzle sticking open. Nozzles should hold 3 lbs. pressure before opening and discharging fuel. Otherwise fuel will boil under high vacuum giving erratic metering. Raise fuel pressure to 3 lbs. with wobble pump and check for appearance of fuel at supercharger scroll drain.

(3) ENGINE RUNS TOO RICH OR TOO LEAN AT CRUISING POWER.

(a) Fuel pressure low. Check fuel pump and fuel pressure gage and clean strainer.

(b) Foreign material in cruise jet.

(c) Economizer needle leaking or stuck open. Remove bushing above needle to check needle for free motion, or remove fuel control unit cover body to check needle and seat.

(d) If carburetor is running rich or lean in automatic position at altitude, check automatic mixture control unit setting and bellows.

(4) ENGINE RUNS TOO LEAN AT TAKE-OFF OR RATED POWER, BUT SATISFACTORILY AT CRUISING POWER.

(a) Economizer valve binding. Remove fuel control unit cover body and check mechanism for freedom of movement.

(b) Insufficient fuel pressure.

(5) ENGINE RUNS TOO LEAN OR TOO RICH AT ALTITUDE IN AUTOMATIC POSITION, BUT SATISFACTORILY AT SEA LEVEL.

(a) Vapor separator float needle stuck in the closed position. Remove strainer and inspect float for free movement.

(b) Automatic mixture control unit incorrectly set, or malfunctioning. Remove this unit and check travel and set per instructions.

(c) The manual mixture control valve set in wrong position. Check linkage to manual mixture control lever.

(d) Emergency full rich valve plates open or leaking. Remove valve cover on throttle body and see that slots in plates are open only in emergency full rich position, and that plates do not leak.

(6) ENGINE DOES NOT ACCELERATE PROPERLY, BUT RUNS SATISFACTORILY WITH SLOW THROTTLE MOVEMENTS.

(a) Accelerating pump not adjusted to give required travel. Readjust.

(b) Fuel inlet to acceleration pump, clogged at the intake restriction, can be examined by removing pump cover and diaphragms.

(c) Discharge nozzle leaking.

(d) Fuel leak into air chamber in regulator unit. Remove air chamber drain plug.

(e) Suction hole to air side of accelerating pump diaphragm closed. Check to see that holes line up correctly.

(7) ENGINE DOES NOT SHUT OFF IN IDLE CUT-OFF POSITION.

(*a*) Idle cut-off valve washer on mixture control needle not seating properly. Remove plug on side of fuel control unit adjacent to cruise jet to see if washer seats in idle cut-off position. Check control rods for full travel. Check for burr on metering jet.

(*b*) Economizer needle not seating properly. Remove fuel control unit cover body and check mechanism for freedom of movement.

(*c*) Check regulator unit for proper operation.

f. REFERENCE.—If in performing any of the above maintenance or inspection procedures, further information on service tools, part number of service parts, or additional details regarding procedures is required, refer to the following Technical Orders covering Bendix Injection Type Carburetors.

Service Manual—Stromberg Injection Carburetors for Aircraft—Bendix Products Division of Bendix Aviation Corporation.

3. MAGNETO AND DISTRIBUTOR ASSEMBLIES.

a. GENERAL.

(1) Ignition is furnished by one double Scintilla DF Magneto mounted directly in front of the carburetor at the top of the accessory housing. Only the V-1710-F5R, F5L, F10R and F10L models have supercharged magnetos. The magneto terminals are marked to designate the coils firing the exhaust and intake set of spark plugs. The high tension terminal for the intake side spark plugs is marked "H. T. INT." and the one for the exhaust side is marked "H. T. EXH." The ground terminal for the intake side is marked "GR. INT."; and the one for the exhaust side is marked "GR. EXH.". These last two terminals should be connected to their respective switches.

(2) The magneto is mounted on the engine by a two-bolt flange, having two elongated slots for the holding studs. This permits turning the magneto through an angle of 20° to obtain correct timing of the engine.

b. INSTALLATION.

(1) Before installing a replacement magneto on an engine it is necessary to locate the engine crankshaft in the magneto timing position, 34° B.T.C. on No. 1L cylinder for the exhaust ignition circuit. Extra steps in the timing procedure are eliminated if the engine is positioned before the old magneto is removed. Mount the magneto type Timing Disc No. 2380 on the old magneto and locate the engine on 34° B.T.C. for No. 1L cylinder. Refer to Timing Procedure, Section VIII, Paragraph 14.

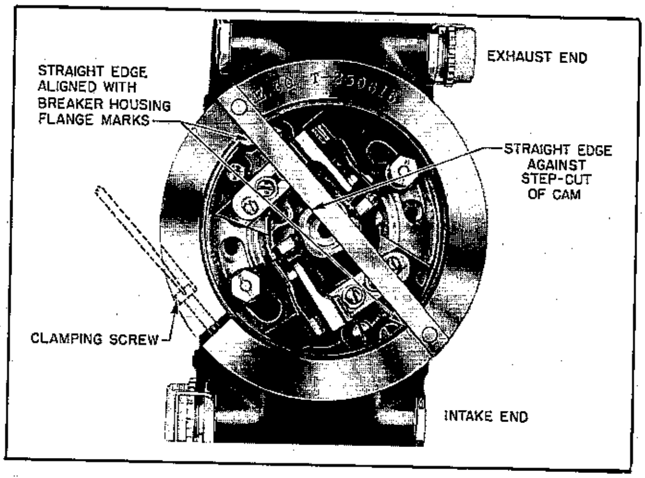


Figure 81—Magneto Timing Clamp Tool in Place on Magneto.

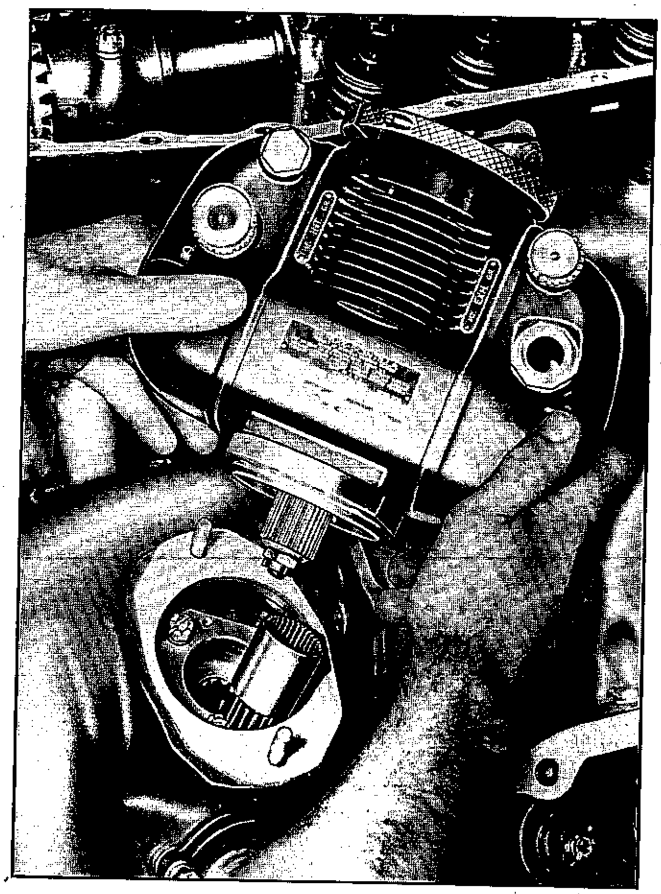


Figure 82—Installing Magneto Showing Magneto Drive Shaft Coupling and Clamping Tool.

ALLISON V-1710 ELECTRICAL SYSTEM DIAGRAM

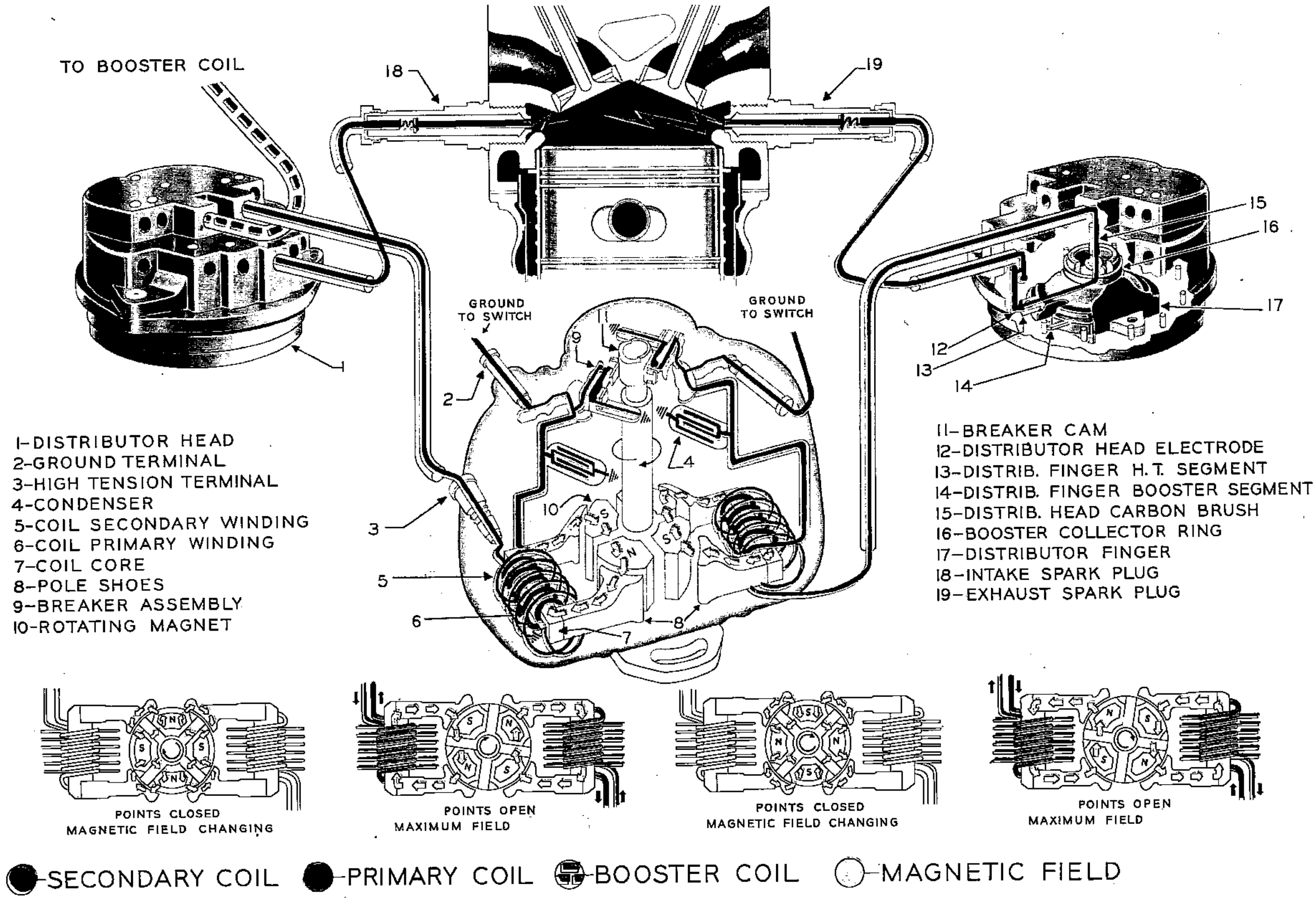


Figure 83—V-1710 Engine High Tension Electrical System Diagram

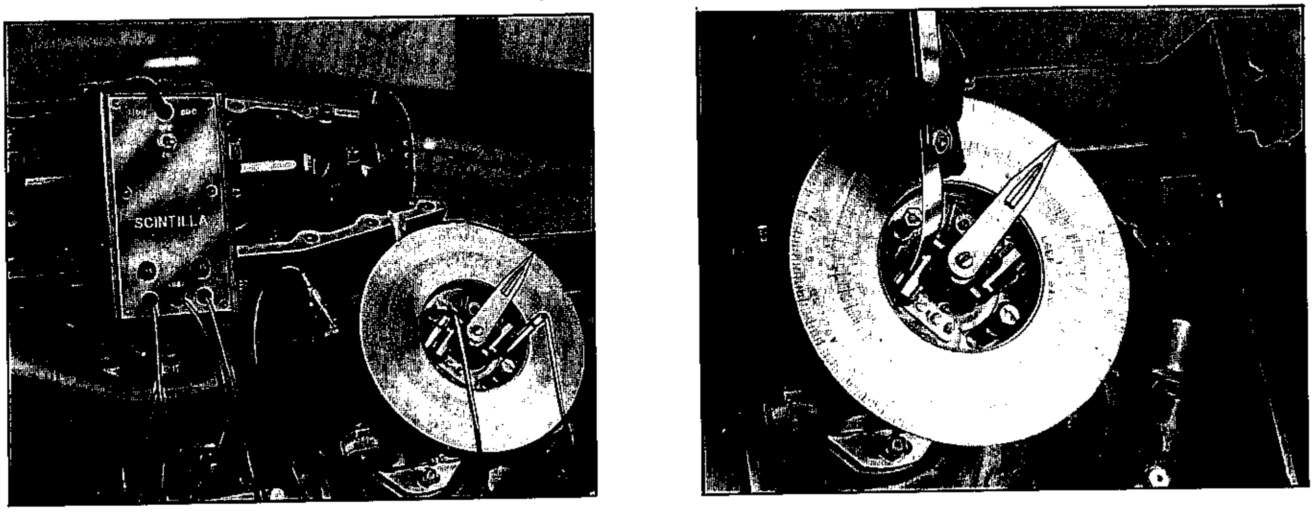


Figure 84—Two Methods of Checking Exhaust Breaker Point Opening.

CAUTION

Particular care should be taken to avoid the engine timing being disturbed until the new magneto is located in place on the engine and secured.

(2) Before the magneto is placed on engine remove the magneto breaker cover. Install Timing Clamp Tool No. 250616 (Overhaul Tool) firmly on top of the breaker cup, locating the straight edge of the tool against the shoulder of the step cut on the upper end of the cam, then align the straight edge with the two diametrically located marks on the breaker cup diameter. (See Figure 81.) Make certain that face of magneto mounting flange and mounting pad surface on engine are clean and smooth. With the engines located in the above timing position set the magneto on the engine with the magneto gasket in place and the end marked "Exh." toward the front. If the magneto does not drop into the coupling spline and locate within 5° of the engine center line, remove the magneto. The magneto drive shaft coupling is then removed from inside the magneto drive shaft and relocated until the magneto locates within 5° of the engine centerline. With the magneto located in this position on the mounting flange *remove the clamping tool.* The magneto will then be engaged with the drive coupling member so that it is possible to open the contact points when the magneto is turned thru the angle provided by the curved slots in the flange. When viewing the magneto from the top, twist the magneto clockwise approximately 10° off engine centerline and insert a piece of shim stock or metal feeler blade (not over .0015" thick) between the exhaust breaker points. Next twist the magneto back in the opposite direction toward the engine centerline until the points start to open, as in-

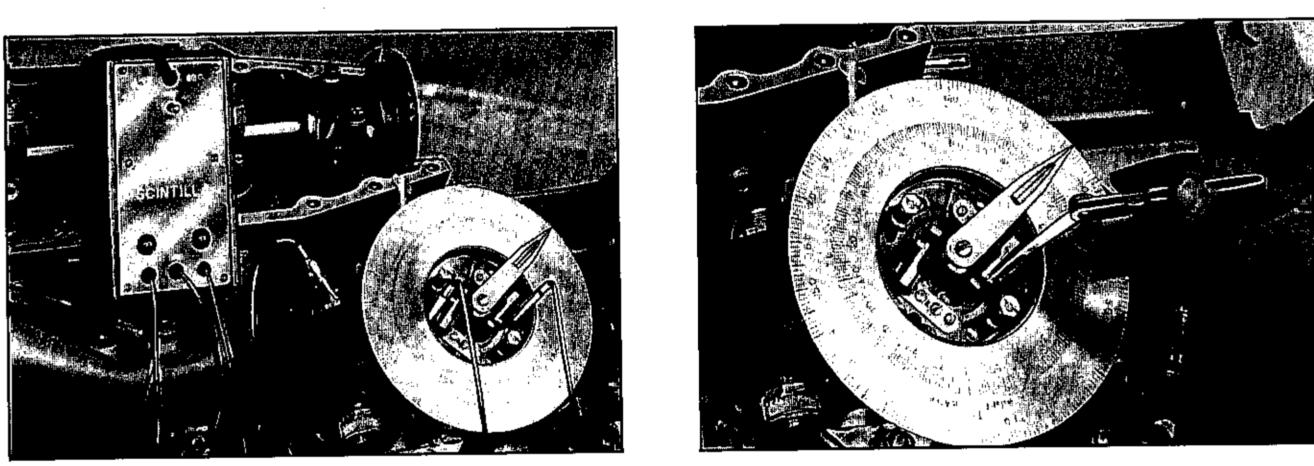


Figure 85—Two Methods of Checking Intake Breaker Point Opening.

dicated by the slipping of the shim or feeler blade. The magneto is then fastened securely in position. The timing between the exhaust and intake firing position is fixed by the magneto design at 6° of crankshaft rotation, however, it is necessary to check both the exhaust and intake side of the magneto to be certain that the relation of the exhaust and intake breaker is correct.

(3) Replace the Magneto Type Timing Disc No. 2380 on the magneto and recheck both exhaust and intake side timing in accordance with Paragraph 14 of Section VIII. In case this check shows that the magneto timing is slightly early or late, say 2 or 3 degrees, the magneto mounting nuts can be loosened and the magneto tapped slightly in a clockwise direction to give a later timing if the points are breaking early or counterclockwise if they are breaking late.

(4) Retighten magneto flange nuts.

(5) Remove Timing Disc and Top Center Indicator.

IMPORTANT

Reinstall magneto cam screw that was removed to install timing pointer. This is not same screw used to secure pointer. Use magneto screw.

(6) Replace magneto housing cover.

(7) Connect high tension cable leads to magneto terminals and spring safety clip over nuts.

(8) On installations requiring supercharging of the magneto the air tube will be connected as specified in the appropriate airplane service handbook.

c. REMOVAL.

(1) If a magneto is to be removed for a replacement the engine should be first placed in the magneto firing position for No. 1L cylinder of the exhaust ignition circuit. See Paragraph *b.* (1) above and Section VIII, Paragraph 14.

(2) After engine is in timed position, remove the Timing Disc from magneto.

IMPORTANT

Replace magneto cam screw that was removed to install Timing Disc Pointer. This is *not* the same screw used to secure pointer. Use magneto screw.

(3) Replace magneto cover.

(4) On installations using supercharged magnetos, disconnect the air tube at the magneto.

(5) Remove the magneto flange mounting nuts and lift magneto off engine.

(6) The high tension ignition openings and the air tube opening of the magneto will be covered after the magneto is removed.

d. PERIODIC INSPECTION AND MAINTENANCE.—These magnetos require very little attention in service beyond proper lubrication of the contact breaker felts and inspection of the contact breaker.

(1) 25 HOURS.—Remove breaker cover and inspect cam and breaker cap for excessive amount of lubricant. If any excess, remove breaker assembly and clean with gasoline, allowing to dry thoroughly, then apply three or four drops of oil, lubricating, aircraft engine, grade 1100, Specification AN-VV-O-446. After application of oil, the felt should be soft and contain just enough lubricant so that oil can be brought to the surface when felt is squeezed. Do not give it all it can hold and do not permit oil to drip from the felt lubricators nor to touch the breaker contacts. No additional lubrication of the breaker should be required between engine overhaul periods unless subsequent cleaning is necessary.

(2) Under no circumstances will any other type of grease or lubricant other than that specified be applied to breaker mechanism.

e. DISTRIBUTOR HEADS AND FINGERS.—For general information on replacement of distributor heads and fingers refer to Section VIII, Paragraph 13. For timing of distributor fingers refer to Section VIII, Paragraph 9. *d.*

f. REFERENCE.—If in performing any of the above maintenance or inspection procedures, further information on service tools, parts numbers of service parts, or additional details regarding procedures is required, refer to Commercial Handbook covering Scintilla Magnetos and Distributors.

4. SPARK PLUGS.

a. GENERAL.—Spark plugs specified for use on all models covered in this text are the Champion plugs C34S or C35S and AC plug LS85, shielded type long reach ceramic spark plugs.

b. INSTALLATION.

(1) All spark plugs, including new plugs, should be checked for proper spark gap, prior to installation in engine. The correct gap is .012", + .002", — .001".

(a) In measuring gap, use hard steel wires of suitable diameter, inserted parallel to center electrode. *Do not use* flat-feeler, half round, crow bar or wedge type gap gages.

(b) For gap setting, use AC tool No. 1558087 with the correct size bushing. Adjust the gap carefully and precisely. *Do not attempt to use any other method.*

CAUTION

Never regap with wire gage in gap because the pressure resulting on the center electrode will crack or break the insulator. For the same reason, do not use the center electrode as a pry to increase the clearance between shell and center electrodes.

(c) If the gap has been closed below the low limit during regapping, the plugs can still be used if the gap clearance is not less than .008". If less than .008" the plugs must not be used, but must be returned to the control depot for their handling. *Do not try to widen the gap.*

(2) The shell threads of the plugs should then be lightly lubricated with a small amount of spark plug thread lubricant Spec. 3578, with the lubricant thoroughly stirred prior to use. Make certain to remove any lubricant from the firing end of the plug, which may have been accidentally deposited there.

(3) Install the spark plug with a good spark plug copper gasket on the plug, making certain that there is *no old gasket* sticking to the cylinder head. The new gasket should be free of deep ridges or nicks and should not be excessively flared out nor flattened to insure leakproof compression.

(4) Start the plug into spark plug hole by hand, making certain that it turns freely before using the wrench. Then, with a torque wrench having not more than a 10 inch leverage, tighten plugs with a maximum of 480 inch pounds. Pressures greater than this should be avoided since cracked or distorted shells are apt to result.

CAUTION

Do not install or tighten spark plugs in a hot engine, as thread seizure with subsequent damage to the spark plug shell and cylinder bushing may result.

(5) When connecting elbow terminals to plugs do not tighten the terminal and shielding nut excessively but *only sufficiently for a snug fit,* as the elbow terminal and plug may be damaged. It may also be found, when unscrewing tightly installed elbow nuts from spark plugs, that the barrel will tend to loosen and unscrew from the shell. If the barrel is turned at any time as above, the plug should not be used until gap is checked.

(6) All plugs should be inspected at the time of installation for evidence of damage to the threads or terminal. Those which are damaged either on the threads or the entrance to the terminal well will be replaced.

c. REMOVAL.—Remove the ignition cables by first loosening all the elbow terminal nuts with the proper wrench, then pulling the cable connectors straight out. Loosen all the plugs with a socket wrench, remove and place in a spark plug tray.

d. PERIODIC INSPECTION AND MAINTENANCE.

(1) 25 HOURS.—Spark plugs should be removed and the gap clearance reset to .012", +.002", —.001". Reinstall plugs with gaskets (new, where necessary), then check the elbow terminal and shielding nuts for security. In the latter operation, the barrel must not be loosened or rotated with respect to the shell, since this will change the gap setting.

(2) 100 HOURS.—All spark plugs will be removed at 100-hour intervals and replaced with new or reconditioned plugs of the approved types. In an emergency, wherein new spark plugs are not available, regapping of the old ones usually is sufficient as a temporary measure.

(3) Whenever a spark plug is removed from the engine, the spark plug ports in the cylinder heads should be inspected for foreign particles. The high operating temperature, in the cylinder combustion chambers, sometimes causes the residue from the fuel and oil to fuse together, forming residual deposits around the ports. These may eventually bridge the spark plug electrodes, causing the spark plug to become short circuited.

(a) If a deposit is found, it should be carefully removed. Care must be used to avoid damaging the spark plug insert or other engine parts. A sharp wooden stick is sufficient to remove such deposits.

e. REFERENCE.—For further information on spark plugs, see spark plug commercial handbook.

5. CUNO OIL STRAINER.

a. GENERAL.—The Cuno Oil strainers used on all Allison engine models covered in this text are of the automatic turning type. By means of a combing action between steel discs and the cleaner blades in the strainer, undesirable solids are removed from the engine oil and are deposited in the engine compartment which houses the strainer. The solids are removed from the engine compartment by cleaning at intervals stated in a subsequent paragraph.

b. INSTALLATION.—The Cuno oil strainer is installed on the right side of the accessory housing and bolted to the latter by means of six stud nuts, with a new gasket placed between the accessory housing and the Cuno mounting flange. The six mounting flange nuts must be 1/4-28 self locking type. Do not use plain and pal nuts.

c. REMOVAL.

(1) The Cuno strainer can be removed only at the six stud nuts which bolt the Cuno mounting flange to the accessory housing. Do not attempt to remove the Cuno strainer by loosening any of the six cap screws, which assemble the hydraulic motor body to the strainer assembly. These six screws are locked with tang washers, which may be unlocked and the cap screws tightened if an oil leak is indicated between the hydraulic motor body and the strainer body.

(2) The gasket between the hydraulic motor drive and the mounting flange which is installed and supplied by the accessory manufacturer should not be confused with the Allison supplied gasket between the Cuno mounting flange and the accessory housing.

d. PERIODIC INSPECTION.

(1) 10 HOURS.

(a) The operation of the automatic turning mechanism should be checked at least once every ten hours of engine operation. This is done by removing the cover nut from over the manual turning shaft and installing on to that shaft as directed on the name plate. Mark one face of the manual nut and note position of this face. Run the engine at idling speed for approximately five minutes then note the position of the mark on this nut. If turning mechanism is operating, nut should have turned from original position. If nut has apparently not moved, start engine again and run at idling speed for about two minutes to recheck, since nut may have returned to starting position during first check. If nut has not turned, replace strainer with clean unit the operation of which is known to be satisfactory, and mark defective unit for overhaul.

(2) 25 HOURS.

Remove strainer cartridge from engine or housing. Clean and inspect as follows:

(a) Cartridge Rotation.—All cartridges will be rotated through 360 degrees and torque variations should not exceed 50%. Hard spots or points of catching are cause for rejection.

(b) Cleaner Blades.—All cleaner blades must be straight and flat and must not show an angular displacement in the plane of the discs greater than 8° from the mid-position when the cartridge is rotated. Bent or torn blades, unless such bending is limited to the extreme edge of the blade most remote from the discs, is cause for rejection. In an emergency a torn or badly bent blade may be carefully removed, making sure that all parts are recovered, and that no other parts are damaged. The strainer should be used only until a replacement is available, provided no other cause for rejection exists.

(c) Discs.—All discs must be flat, evenly spaced and free from burrs or nicks.

e. MAINTENANCE.

(1) GENERAL.

(a) Be very careful when removing or reassembling cartridge from the housing and at all times when the discs and cleaner blades are exposed. These parts are very easily bent or thrown out of alignment.

(2) CLEANING.

(a) Every time that a Cuno strainer is removed from an engine, the strainer should be cleaned by immersion in kerosene, gasoline, a 50% mixture of carbon tetrachloride and benzol, or a similar noncorrosive solvent. While in the solvent, the cartridge should be rotated.

CAUTION

The Cuno strainer should not be rotated when removed from the engine, unless the element is supported in a housing for which it is designed or in a suitable fixture which will support the outer end and hold it in correct alignment, necessary to prevent binding of the strainer discs. The cartridge may be rotated several revolutions after installation by means of the turning shaft nut.

Be sure that all foreign matter adhering to the strainer is removed. If the strainer is to be reinstalled on engine after washing, it should be oiled with engine oil. If it is to be shipped or stored, coat with Rust Preventive Compound, Spec. 3568 or C.L.O. mix. See Section IV, Paragraph 2. *b.*

(3) SERVICING.

(a) If cartridge cannot be rotated the full 360°, and surface inspection reveals no mechanical defects;

1. Loosen packing gland if used.

2. Repeat cleaning procedure described in 3. *e.* (2) and rotate gently but firmly, permitting solvent to work in and free up any parts stuck with sludge. If this fails to free cartridge, the unit should be sent in for overhaul.

CAUTION

Never use a wrench or other tool in an endeavor to turn a strainer which has become plugged.

(b) If hydraulic motor fails to operate, send strainer in for overhaul. *The hydraulic motor should not be opened up at stations other than overhaul depots.*

f. REFERENCE.—If in performing any of the above maintenance or inspection procedures, further information on service tools, part number of service parts, or additional details regarding procedures is required, refer to Cuno commercial handbook.

6. AUTOMATIC MANIFOLD PRESSURE REGULATOR.

a. GENERAL.—All V-1710-F4R and F20R engines are equipped with Automatic Manifold Pressure Regulators. Some V-1710-F3R engines are equipped with service-installed or overhaul depot-installed regulators. (None of the V1710-F2R, F2L, F5R, F5L, F10R, F10L, and F21R model engines will have regulators.) The Automatic Manifold Pressure Regulator maintains, within desirable limits, a selected manifold pressure from sea level up to the critical altitude of the supercharger. The manifold pressure selected at sea level is carried up to altitude without further throttle adjustment but with a drop of 1½" Hg. at engine critical altitude. This droop is incorporated in the regulator design to prevent the horsepower increasing excessively which is the natural tendency when the manifold pressure is held constant in a climb.

(1) Different Types of Automatic Manifold Pressure Regulator Installations.—The Automatic Manifold Pressure Regulator Units are the same on all models covered in this handbook. However there are three different methods of installing the regulator which are dictated by the degree of engine changes which have been incorporated between early and late model engines. Due to this variation in the method of mounting the regulator, on early or late engines, we have classified these different installations as Type I, Type II, and Type III which have the following detailed differences.

(2) Type I Installation: In the Type I installation the regulator is mounted to the flange of the supercharger inlet cover by using spacer washers and shims to clear the spot faces of the inlet cover flange. (See Figure 91.) The supercharger pressure is conducted to the regulator from the top of the center gas intake pipe by a long air line tube assembly. Engine oil pressure is conducted to regulator from a nipple located in the top of the Cuno oil strainer chamber on the right side of the accessories drive housing by a long oil pressure tube assembly which passes over the top of the accessories drive housing. (See Figure 92.) To summarize, the Type I regulator installation includes the following three special features:

(a) Spacer washers, No. 42686 and leveling shims, No. 42687 for use under the mounting flange.

(b) Long air line tube to center gas intake pipe.

(c) Long oil pressure tube to right side of engine.

(3) Type II Installation: In the Type II installation the regulator is mounted on a mounting pad machined on the upper left side of the rear face of the supercharger inlet cover. (See Figure 93.) It will have the same long oil pressure tube assembly as described for Type I. Engines equipped with this machined mounting pad contain a drilled passage leading from the supercharger scroll to the face of this mounting pad. This supercharger inlet cover air hole then matches up with an angular air hole in the regulator mounting flange, with the supercharger pressure conducted directly into the pressure bellows of the regulator unit. To summarize, the Type II regulator installation includes the following three special features:

(a) Machined supercharger inlet cover requires no spacers or shims to mount regulator.

(b) Mounting boss drilled for air pressure—no air line required.

(c) Long oil pressure tube to right side of engine required.

(4) Type III Installation: In the Type III installation, the regulator is mounted on the machined mount-

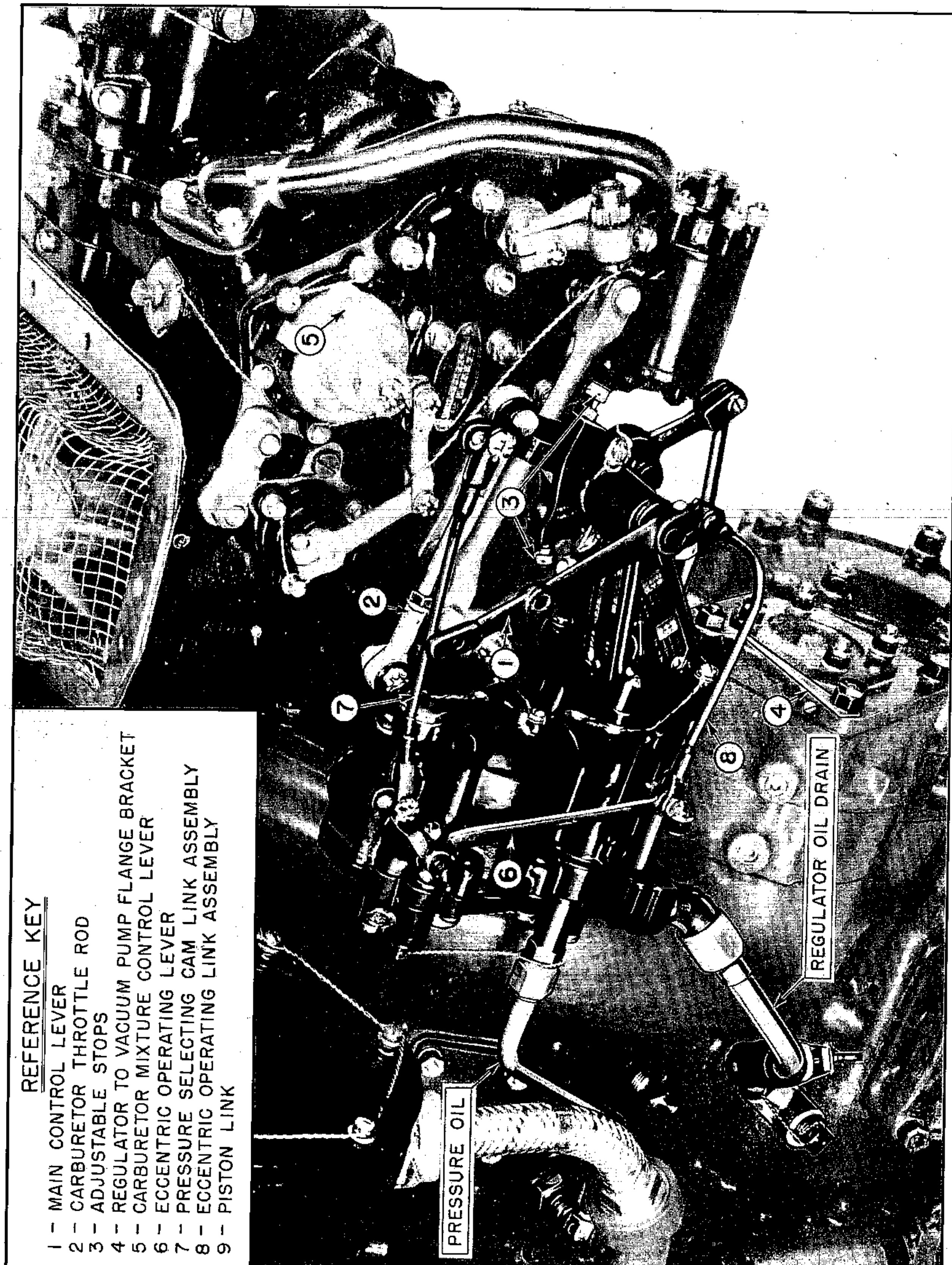


Figure 86—Automatic Manifold Pressure Regulator Installed.

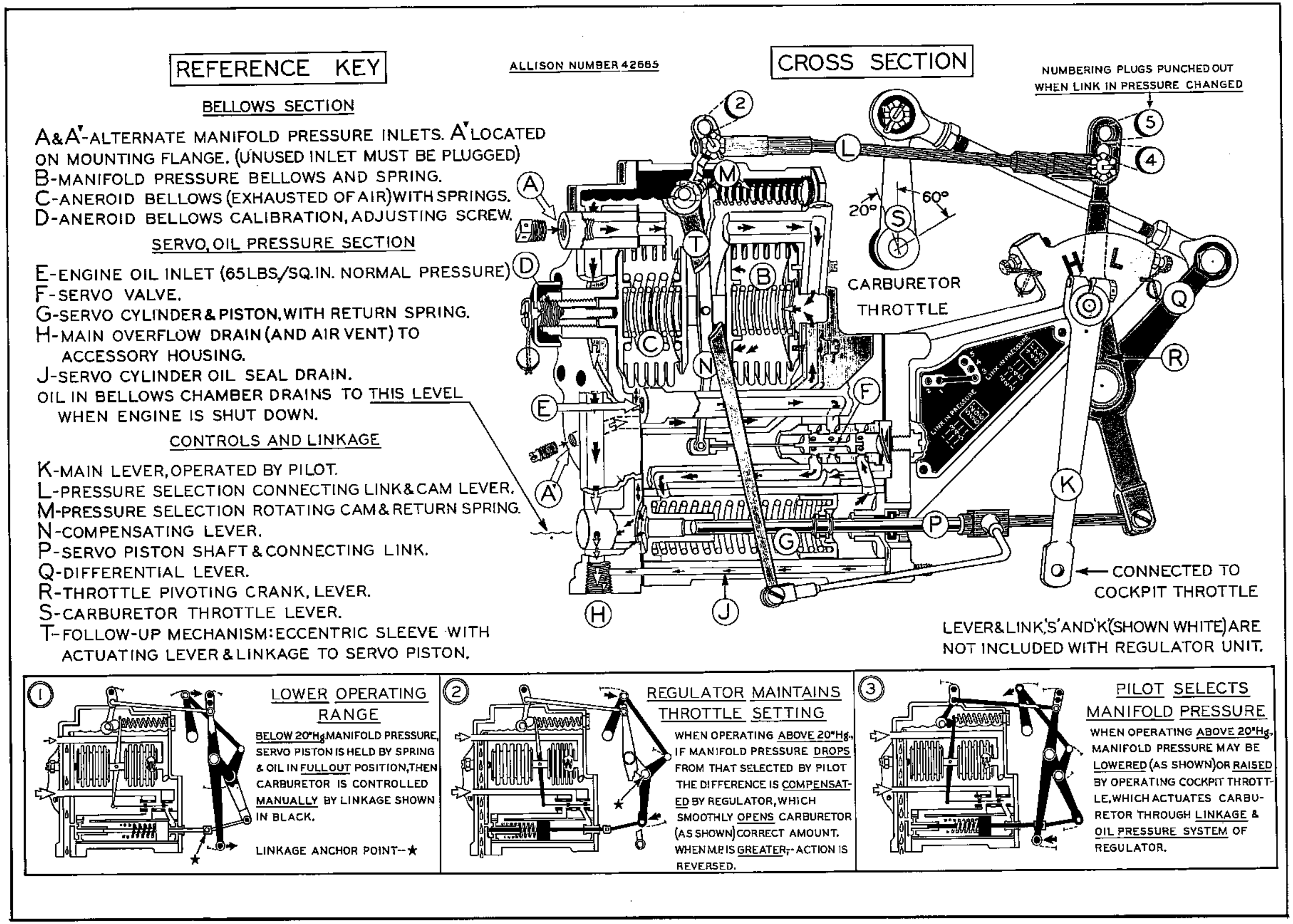


Figure 87—Diagrammatic Sketch of Automatic Manifold Pressure Regulator.

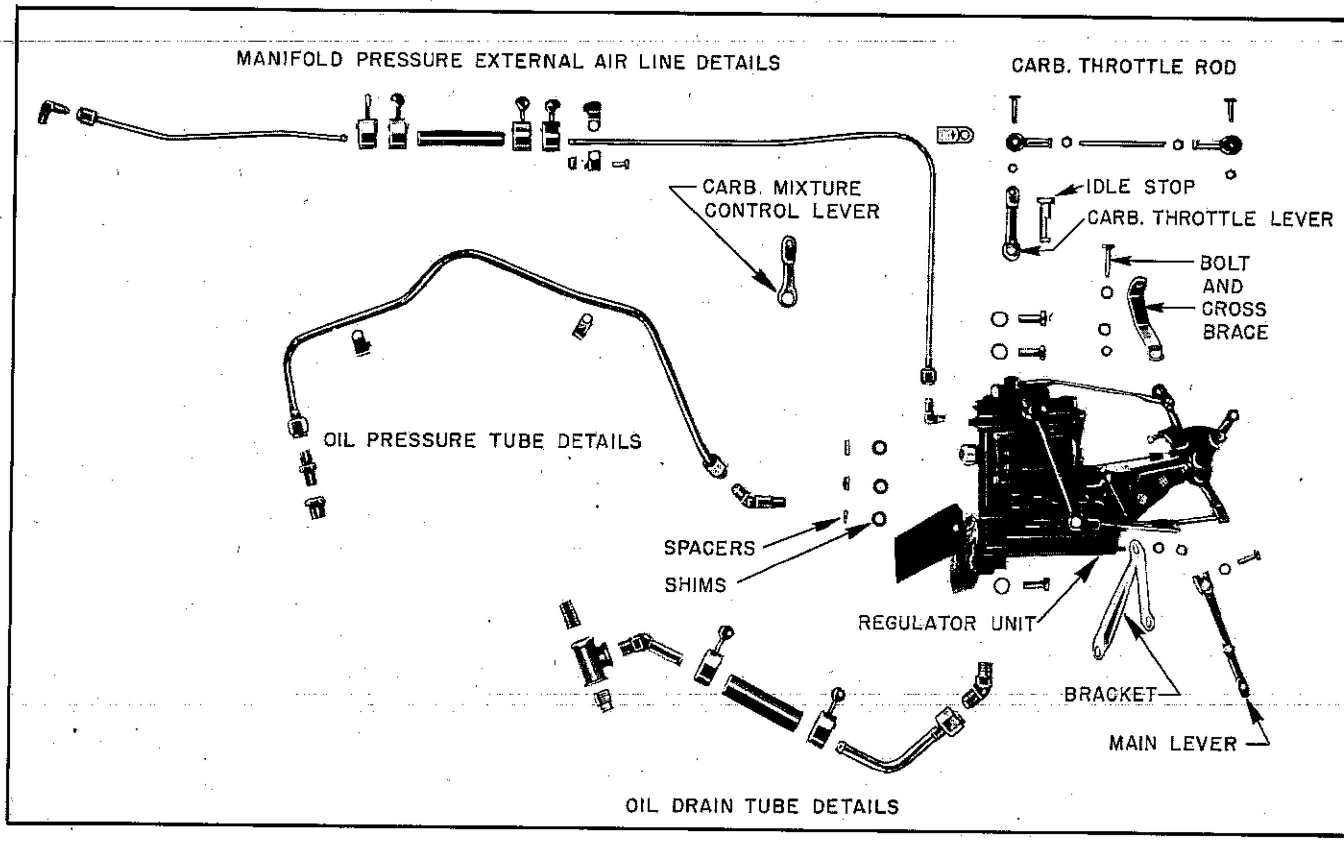


Figure 88—Automatic Manifold Pressure Regulator Showing Type I Installation Detail Parts.

ing pad as in the Type II method of installation, but will have a short oil pressure tube assembly connected to a boss on the left side of the accessories drive housing. This boss is located just below the front corner of the electric tachometer drive mounting pad. The Type III method of installation is the production installation used by the engine manufacturer on all V-1710-F4R and F20R engines. To summarize, the Type III regulator installation includes the following three special features:

(*a*) Machined supercharger inlet cover requires no spacers or shims to mount regulator.

(*b*) Mounting boss drilled for air pressure—no air line required.

(*c*) Short oil pressure tube to left side of engine required.

b. REMOVAL FROM ENGINE.

(1) It is important that all connecting fittings, tube assemblies and linkages be left with the engine whenever regulator is removed. These specific details are mentioned in the following procedure for removal.

(2) All regulator installations require a connection for manifold pressure air, a connection for engine oil pressure and a connection for oil drainage. As stated above in the case of Type I installations, these connections are made by three external lines. In the cases of Type II and Type III installations no external line is used to supply the manifold pressure air, since supercharger scroll pressure is supplied through the mounting pad.

(*a*) Disconnect the oil drain tube union nut from the elbow located at the extreme lower point at the front of the regulator body. The 45° elbow is then unscrewed from the body and attached to the oil drain tube to avoid its being misplaced. Install a 3/8" N.P.T. plug in the oil drain opening of the regulator body.

(*b*) Disconnect the oil pressure tube union nut from the pipe fitting located on the left side of the regulator body at the front immediately below the aneroid chamber. Remove the fitting from the regulator and attach to the oil pressure tube to avoid being misplaced. Plug the opening in the regulator with 1/4" N.P.T. plug.

NOTE

On Type I & II installations remove the cover screw in case of interference with the 45° elbow fitting. After fitting is removed replace screw and lockwire.

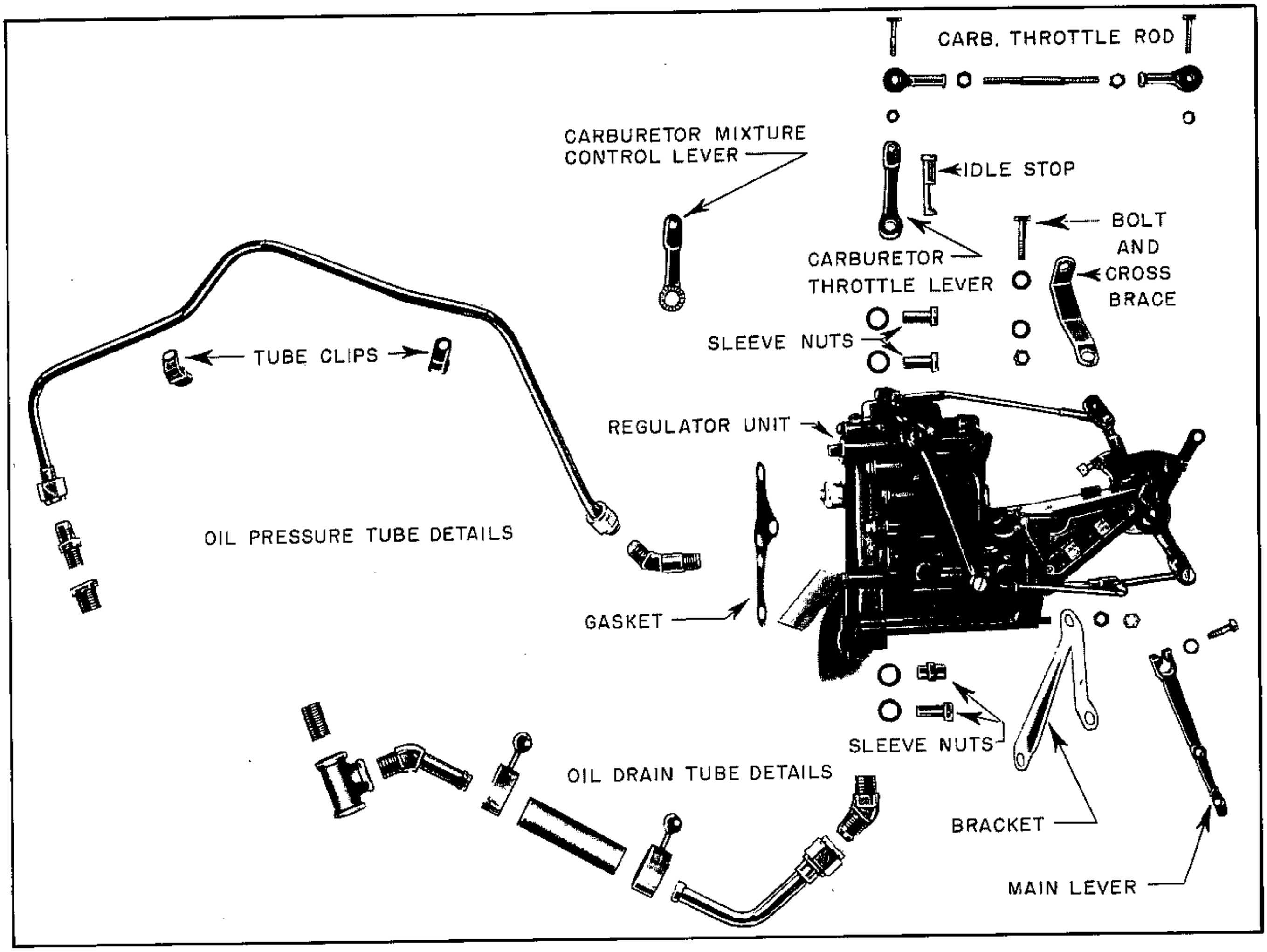


Figure 89—Automatic Manifold Pressure Regulator Showing Type II Installation Detail Parts.

(c) On the Type I installations only, it will be necessary to disconnect the manifold pressure external air line. Disconnect the air tube union nut from the 90° "L" pipe fitting located at the uppermost boss on the front of the regulator. Remove the 90° elbow from the regulator and attach it to the manifold pressure air line to avoid its being misplaced. Plug the opening in the regulator with a 1/8" N.P.T. plug.

(d) The regulator main lever is next disconnected. Remove the clamp bolt from the large end of the main lever and tap it from serrated shaft. Replace the bolt and lock washer and leave the lever attached to the airplane connecting linkage.

(e) The carburetor throttle rod will be disconnected at the regulator lever end. Remove the cotter pin and $\frac{3}{16}$ shear castle nut from the rear end of the carburetor throttle rod and differential lever. Tap out the special bolt and leave the carburetor throttle rod attached to the carburetor lever.

(f) Remove the bracket from the stud located at the lower rear of the regulator and from the two studs of the vacuum pump flange pad.

(g) Remove the cross brace which runs between the regulator and the carburetor. This brace is secured to the regulator support bracket by a 1/4-28 bolt, washer and elastic stop nut and to a carburetor stud.

(h) The regulator is now ready to be removed from the supercharger inlet cover. The regulator is secured to the studs of the supercharger inlet cover by three sleeve nuts. On late model engines there is an additional sleeve nut which attaches to a stud that has been added to the supercharger inlet cover. Remove the lockwire and sleeve nuts using a $\frac{3}{16}$" Allen wrench. Lift off the regulator.

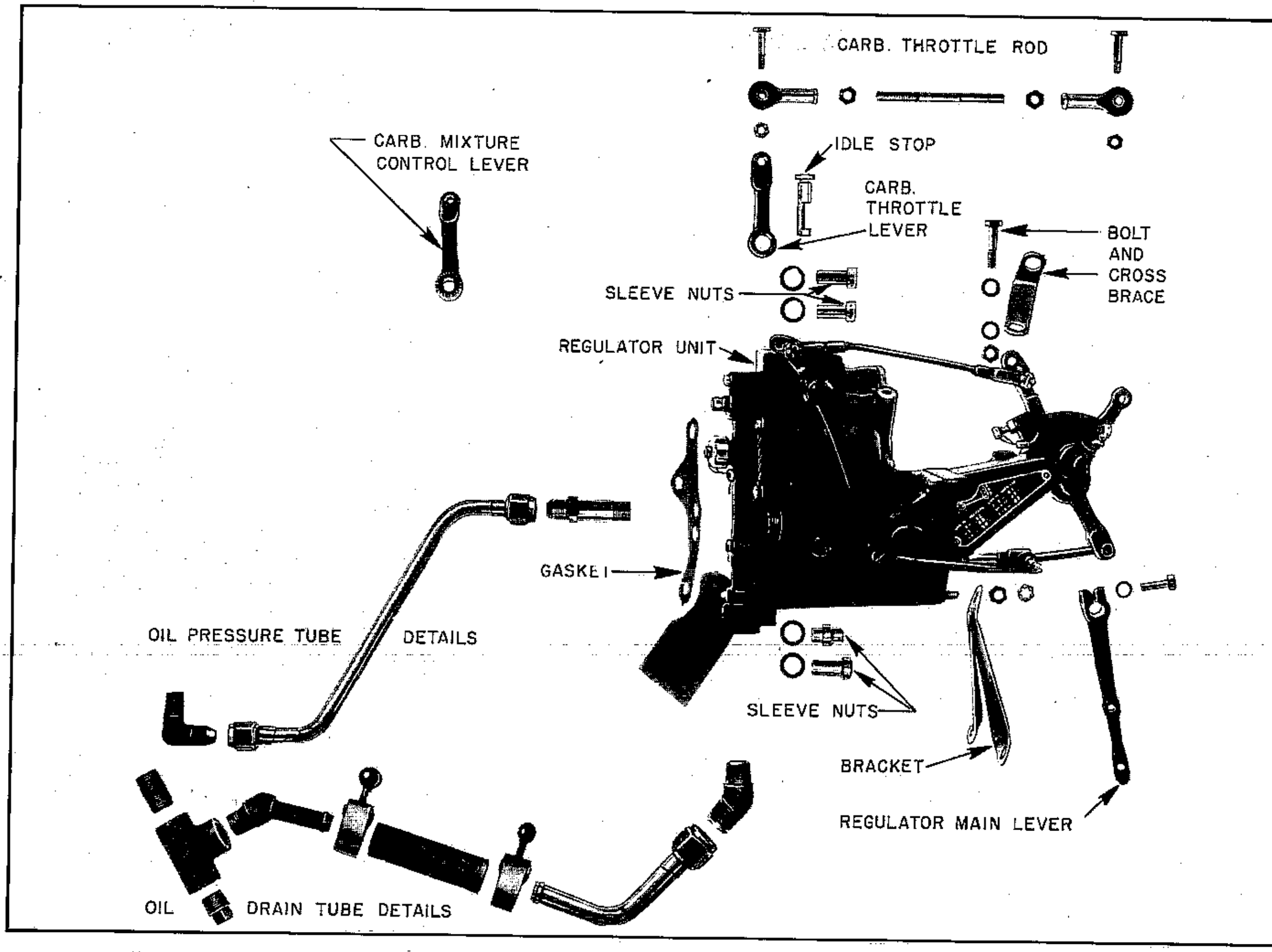


Figure 90—Automatic Manifold Pressure Regulator Showing Type III Installation Detail Parts.

NOTE

On the Type I installations which do not have a machined mounting pad, spacer washers and shims must be removed from the studs after the regulator has been taken off.

(i) After removing the regulator from the engine in the case of Type II or Type III installations, the manifold pressure air line hole located in the face of the regulator mounting pad must be plugged. This plug is a special 1/4-28 screw with a $\frac{3}{16}$" diameter slotted head. This screw should be installed with the red "caution" tag attached.

WARNING

All connecting tubes and linkages have purposely been left attached to the engine and airplane. These specific items will not, in any case, be returned with the regulator unit since they are needed for installation of the replacement regulator unit. This precaution is necessary since different attaching parts are required when making either Type I, Type II or Type III installation.

(j) If regulator is being removed from malfunctioning, make a careful diagnosis of the probable cause so that a comprehensive report can be made to cover the faulty regulator. After removal of regulator, attach a tag to the regulator indicating either the probable defect or the necessity for flushing. State also the number of hours the regulator was in operation.

(k) Box and pack the regulator so that damage will not occur during handling and shipment. All regulators, removed in the field, should be shipped to the Control Depot in accordance with existing regulations for accessories.

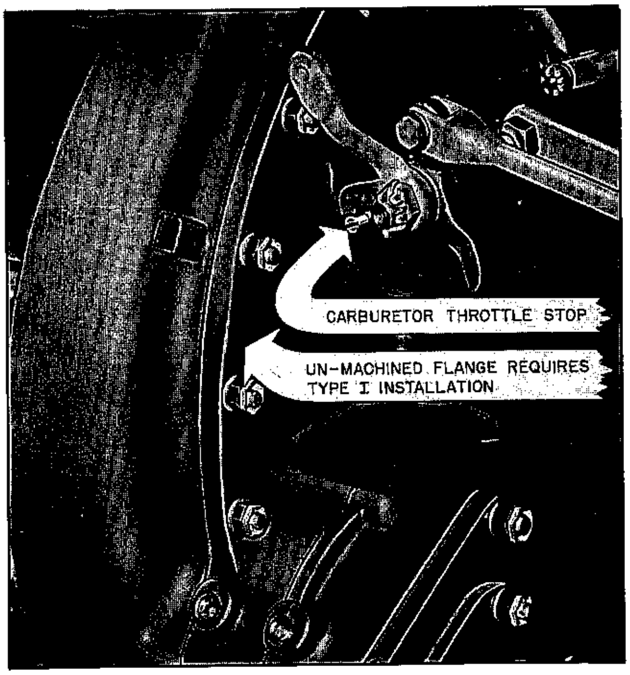


Figure 91—Supercharger Inlet Cover Flange which requires Type I Installation of Regulator.

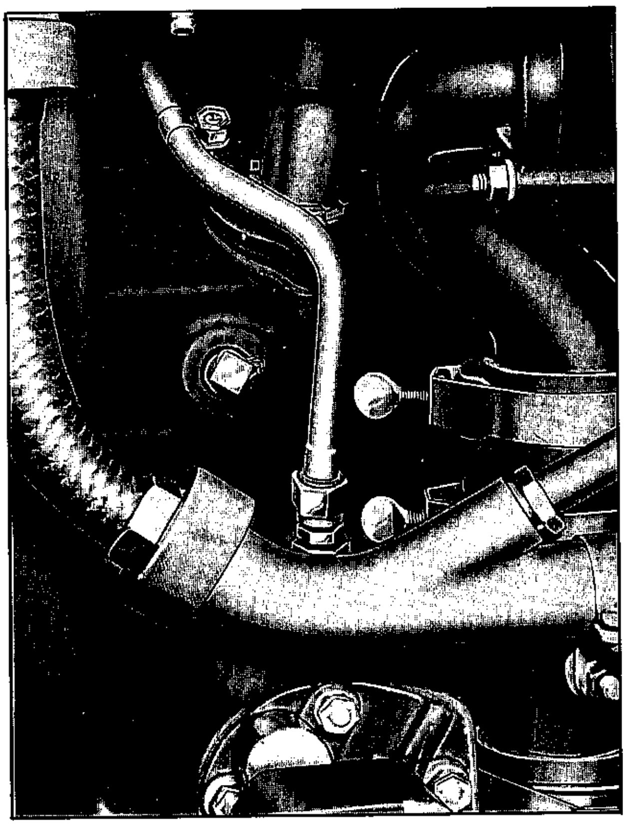


Figure 92—Source of Engine Oil Pressure Supply for Type I and Type II Installations on Right Side of Engine.

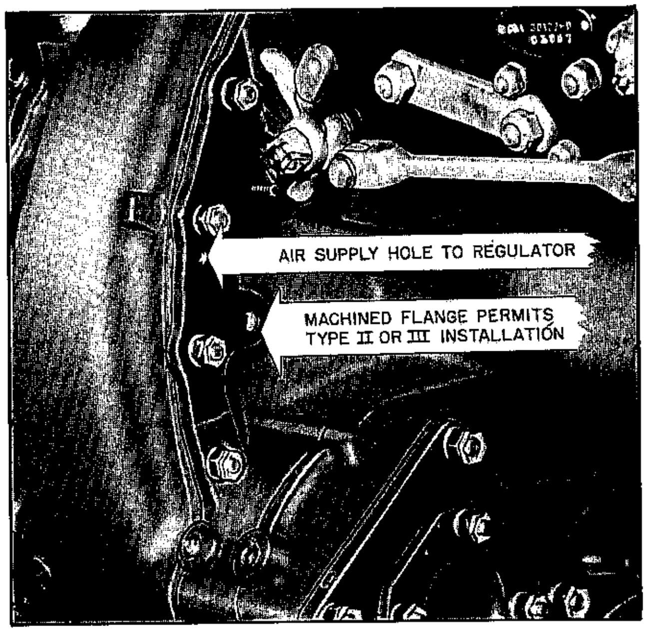


Figure 93—Supercharger Inlet Cover Flange which requires Type II or Type III Installation of Regulator.

c. INSTALLATION ON ENGINE.

(1) When installing a replacement regulator unit the connecting tubing and carburetor linkage should be in place on the engine as directed in the removal procedure given in Section IX Paragraph 6 *b.*

NOTE

For installation of a regulator on an engine not previously equipped with a regulator, refer to Allison Automatic Manifold Pressure Regulator Handbook.

(2) Type I installation is mounted to the supercharger inlet cover by a different method than that required for a Type II or Type III installation.

(a) Since the Type I installation is mounted on a supercharger inlet cover that does not have a machined pad, it is necessary to use spacer washers and leveling shims between the regulator mounting face and the engine. Place the spacer washers over the thru mounting studs with the small diameter of the washer against the supercharger cover. Use a straight edge and see if these washers are flush and form a level mounting surface. (See Figure 94.) If not, then level using the .002" thick special shims. See Paragraph *a.* (2) *(a)* for part numbers. Remove the red "caution tag" which is wired to the slot headed plug located in the angular air inlet hole in the mounting face of the regulator. Screw this plug in sufficiently tight to seal this air inlet passage.

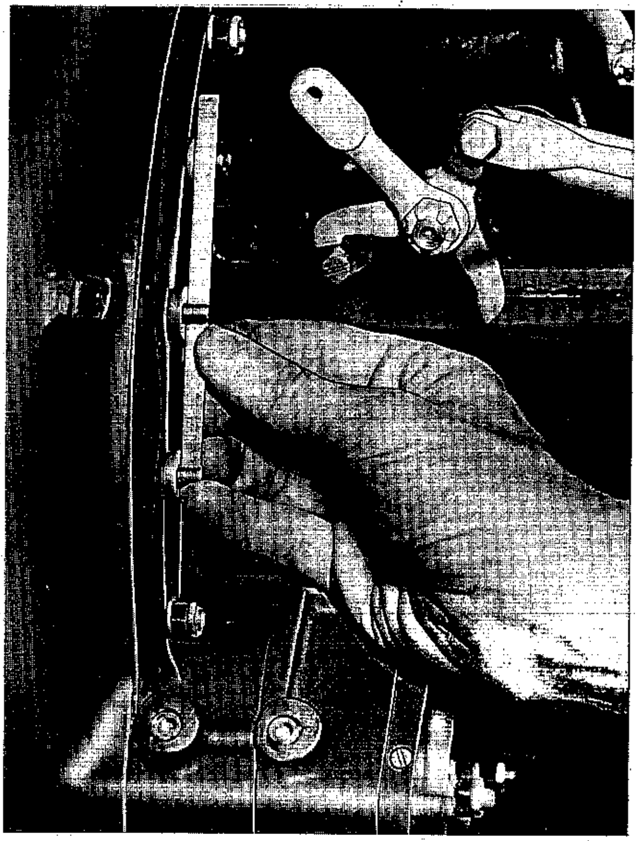


Figure 94—Checking Level of Spacer Washers on Type I Installation.

CAUTION

This plug must be in place in all Type I installations. Place the regulator in position on the leveled spacers and secure with the three long sleeve nuts. Tighten these nuts with a $\frac{3}{16}$" Allen wrench and safety with lockwire.

(b) In Type II or III installations, before mounting the regulator to the machined mounting pad of the supercharger inlet cover the red "caution" tagged screw plug will be removed from the mounting face of the regulator. Clean both mounting surfaces of all dirt or foreign matter which might prevent forming an air tight joint. Remove the No. 10 hex. head screw and washer from the supercharger inlet cover mounting pad air hole if it has been installed.

WARNING

After removing No. 10 screw, check this air opening to be sure there is no obstruction. Insert a length of lockwire into the opening and make certain the hole is open to the inside of the supercharger scroll. In case a late type supercharger inlet cover is replaced on an early type accessories housing, this hole will be blocked at the scroll, since no matching hole is in the accessory housing. If the lockwire check indicates this is the case, the external air line must be installed as in Type I installation.

Locate the mounting gasket over the attaching studs and place regulator in position. Secure to the mounting studs with three long sleeve nuts and an additional short sleeve nut, which is used on late engine installations equipped with the fourth stud. These sleeve nuts are tightened with a $\frac{3}{16}$" Allen wrench. Safety with lockwire.

(3) Install the triangular shaped bracket securing it to rear stud of the regulator and to the vacuum pump flange two upper studs. (See Figure 95.) Use 1/4-28 plain nuts and pal nuts without washers on all three studs. *This bracket must fit freely and align without strain.*

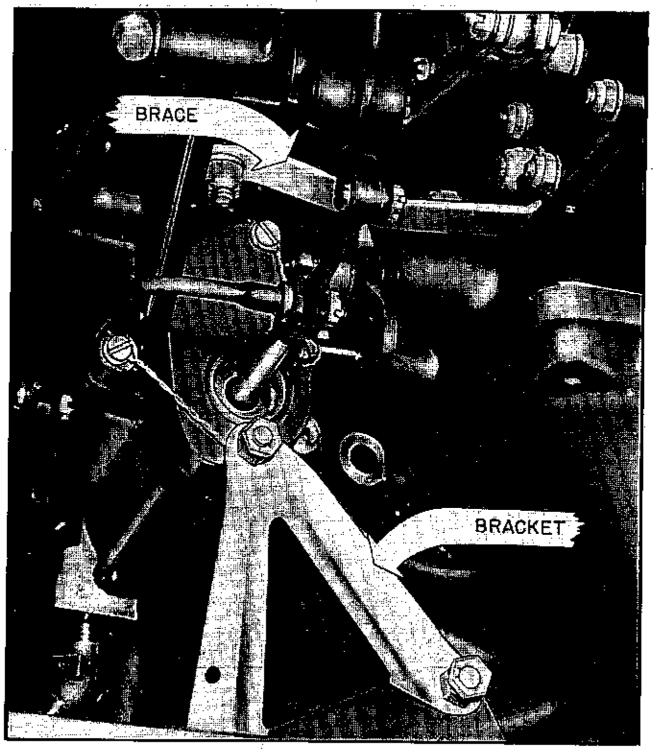


Figure 95—Location of Regulator to Carburetor Brace and Regulator to Vacuum Flange Bracket.

(4) Remove the rear nut and washer from the carburetor regulator to throttle body support bracket and install the 90° angle end of the regulator to carburetor brace on this stud. (See Figure 95.) Secure with a self-locking nut but do not install the washer, as the brace will take place of the washer. The hole, in the other end of the horizontal support bracket should now align with the vertical hole in the lever support bracket on the rear of the regulator unit. These holes must align, so that the bolt can be inserted *without binding*. If these holes do not align, loosen the carburetor mounting stud nuts and re-locate the carburetor on the mounting studs so that these bolt holes do align. Install 1/4"-28 x 1" long bolt using two washers and secure with self-locking nut.

(5) The carburetor throttle rod, which was left attached to the carburetor throttle lever during removal of the regulator, will be connected to the differential lever of the regulator. Place the throttle rod on the right side of the differential lever and install the 3/16" special bolt from the lever side. The 3/16" shear castle nut should then be installed finger tight. The length of the throttle rod is next checked and adjusted to the proper length. The length of the rod is correct when there is a gap, or cushion clearance of .005" to .015" between the rear adjustable stop and the throttle pivoting crank lever while the throttle lever of the carburetor is in the fully closed position against the idle stop. (See Figure 98.) Do not disturb the adjustable idle stop setting. Set this gap with a feeler gage by lengthening or shortening the carburetor throttle rod assembly. After the rod is adjusted, tighten the rod-end jam nuts and the shear castle nut on the bolt, and cotter.

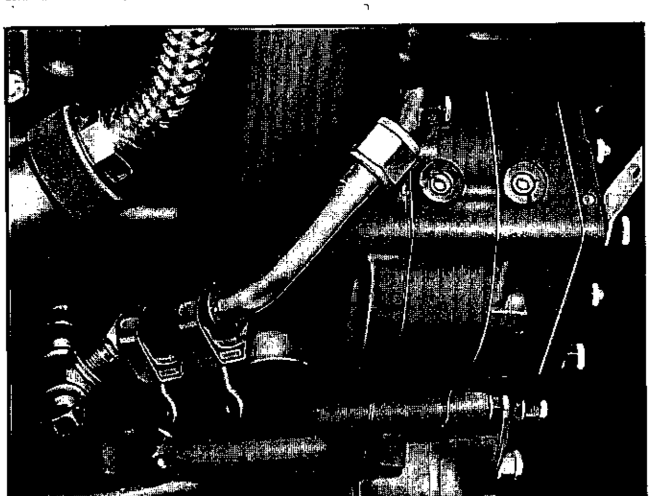


Figure 96—Regulator Oil Drain Tube Installed—All Types.

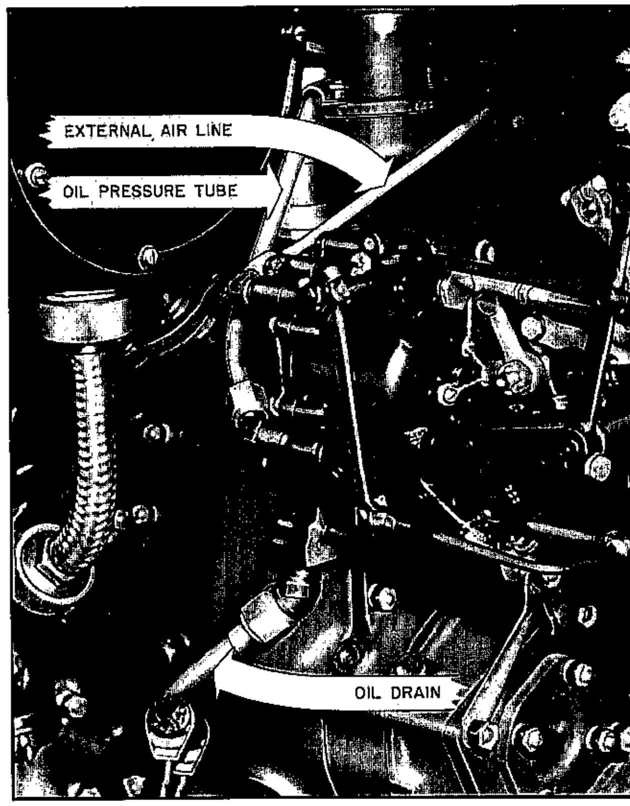


Figure 97—Type I Installation of Regulator Completed.

CAUTION

The throttle pivoting crank lever front and rear adjustable stops, on the rear of the manifold pressure regulator, are set with a gage and locked into the correct position. THESE ADJUSTABLE STOPS MUST NOT BE CHANGED FROM THEIR ORIGINAL SETTING, EXCEPT WHEN DEFINITE INCREMENTS OF ADJUSTMENT ARE AUTHORIZED. All adjustment at installation must be done by lengthening or shortening the carburetor throttle rod.

(6) Remove the 3/8" N.P.T. plug in the oil drain hole located in the bottom of the regulator unit at the front. The 45° elbow which was removed from the drain hole of the replaced regulator is then installed with the elbow pointing forward and about 45° out from a fore and aft centerline. Use standard pipe thread compound on elbow threads when installing. Attach the oil drain tube union nut to the 3/4-16 thread end of the elbow and tighten. Check the security of the oil drain tube hose clamps and re-tighten if necessary. (See Fig. 96.)

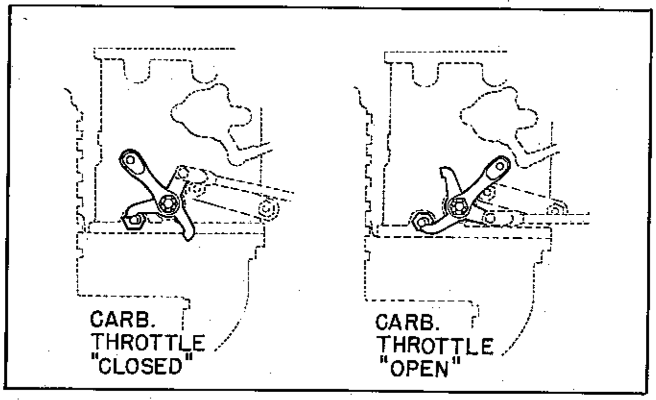


Figure 98 — Positions of Carburetor Throttle Lever with Throttle Closed and Open.

(7) The oil pressure tube is next connected. Remove the pipe plug from the 1/4" N.P.T. tapped hole located on the left side of the regulator unit directly below the aneroid bellows chamber. The oil pressure tube connection is then made to this hole using the appropriate fitting as indicated below.

(a) Type I and Type II installations use a 1/4" N.P.T. by 9/16-18, 45° elbow installed with the tube connection pointed toward the oil pressure tube which was left in position when the replaced regulator was removed. Attach the oil pressure tube union nut to the elbow and tighten. Check the security of the tube at the two tube clips.

NOTE

On Type I and II installations, remove the cover screw in case of interference. After fitting is installed, replace screw and lock-wire.

(b) The Type III installation uses the short oil pressure tube which connects to the left side of the engine. The oil inlet tube is connected to the regulator by a straight 1/4" N.P.T. by 9/16-18 thread fitting instead of an elbow fitting as in the case of Type I and Type II installations. Install the fitting and attach the oil pressure tube union nut.

(8) The manifold pressure air inlet located at the top front of the regulator body is connected to an external air line in the case of Type I installations only.

(a) Remove the 1/8" N.P.T. square shank plug from the air inlet boss of the regulator and install a 1/8" N.P.T. by 7/16-20 thread 90° elbow with the tube connection pointing towards the right side of the engine. Connect the union nut of the air inlet tube which was left in position on the engine when the replaced regulator was removed. Recheck the security of the hose clamps of the manifold air inlet line as well as the security of the tube clips.

(9) The regulator main lever is next mounted on the serrated shaft which is located on the left side at the rear of the regulator lever support bracket. (See Fig. 97.) The main lever clamping bolt must be removed before the lever can be installed on the serrated shaft. Since the regulator main lever was left attached to the airplane throttle linkage when the replaced regulator was removed, the approximate main lever angular position on the serrated shaft can be determined by the following procedure.

(a) Place the cockpit throttle lever 1/4" to 1/8" from the fully closed position.

(b) Push the differential lever of the regulator to the front until the carburetor throttle is in the fully closed position and pressing against the closed throttle stop of the carburetor. (See Figure 98.)

(c) The airplane throttle link rod to which the regulator main lever was left attached during removal, is next held in its approximate normal position. Then the main lever is slipped into position on the serrated shaft.

(d) Before the main lever clamping bolt is installed, the complete linkage from the cockpit throttle through the regulator to the carburetor throttle must be checked to determine if the airplane link rod is set at the proper length to give full emergency throttle position. This is done by moving the cockpit throttle to its open position past the quadrant detent until the throttle pivoting crank lever of the regulator comes in contact with the front stop screw. If the airplane throttle linkage is of the correct length the cockpit quadrant throttle lever will be slightly short (1/8" to 1/4") of reaching the full quadrant travel when the throttle pivoting crank lever of the regulator comes in contact with its front stop screw. Install the main lever clamping screw with lock washer and tighten. The regulator is next checked to determine if it is properly adjusted to provide the required maximum manifold pressure.

d. CHECKING REGULATOR SETTING FOR REQUIRED MAXIMUM EMERGENCY MANIFOLD PRESSURE.

(1) MEANING OF THE REGULATOR MAXIMUM PRESSURE PLATE.

(a) On the left side of the regulator lever support bracket there is a triangular shaped red plate. This

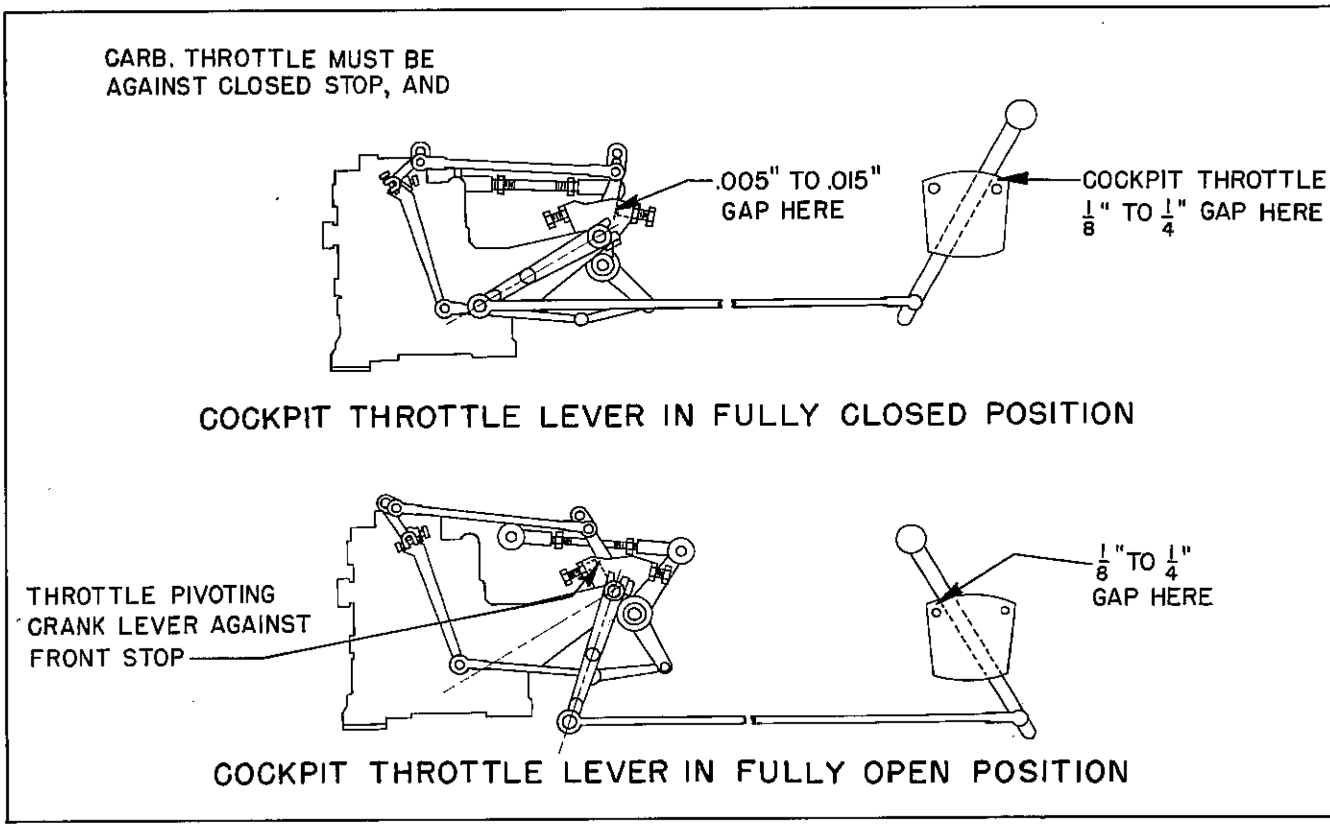


Figure 99—Schematic Sketch of Cockpit Throttle and Regulator Stop Clearances.

plate lists the six possible link rod arrangements and is stamped to show the maximum emergency manifold pressure to which each of these combinations will regulate the engine. The manufacturer calibrates all regulators to provide these standard maximum values which are stamped on the plate. The front adjustable stop screw is installed, locked and sealed with a lead seal at the factory in order to maintain the regulator at the calibrated setting.

(*b*) It will be noted as indicated on the red plate, that when the link rod is located in the 1-3 position, the maximum manifold pressure that the regulator will permit the engine to pull is 52″ Hg. If the link rod is shifted from 1-3 position to 1-4 position, the maximum available pressure will be changed to 59″ Hg., which is an increase of 7″ Hg. In case an intermediate manifold pressure is required, it will be necessary to turn the front adjustable stop screw in or out *a definite number of degrees to obtain* these intermediate pressures. Turning the front adjustable stop screw *counterclockwise* (out) approximately 120°, increases the maximum pressure 1″ Hg., and turning the screw *clockwise* (in) approximately 120° decreases the maximum pressure 1″ Hg.

CAUTION

To use the front adjustable stop screw for obtaining any intermediate maximum manifold pressure setting, the manifold pressure should be limited to an increase of 1″ Hg. over the value stamped on the red plate for a particular link rod position. However, the screw may be adjusted to decrease the pressure as much as 6″ Hg. from the figure stamped on the name plate. Therefore, by shifting the link rod and changing the adjustable stop screw a definite amount, any manifold pressure value between those listed on the red plate may be obtained.

IMPORTANT

Whenever regulator has been adjusted to any intermediate setting, the new setting must be *painted* in *yellow figures* on the red plate. These figures provide a warning that the adjustable stop screw has been changed a definite number of degrees and indicates the maximum emergency manifold pressure to which the regulator will limit the engine.

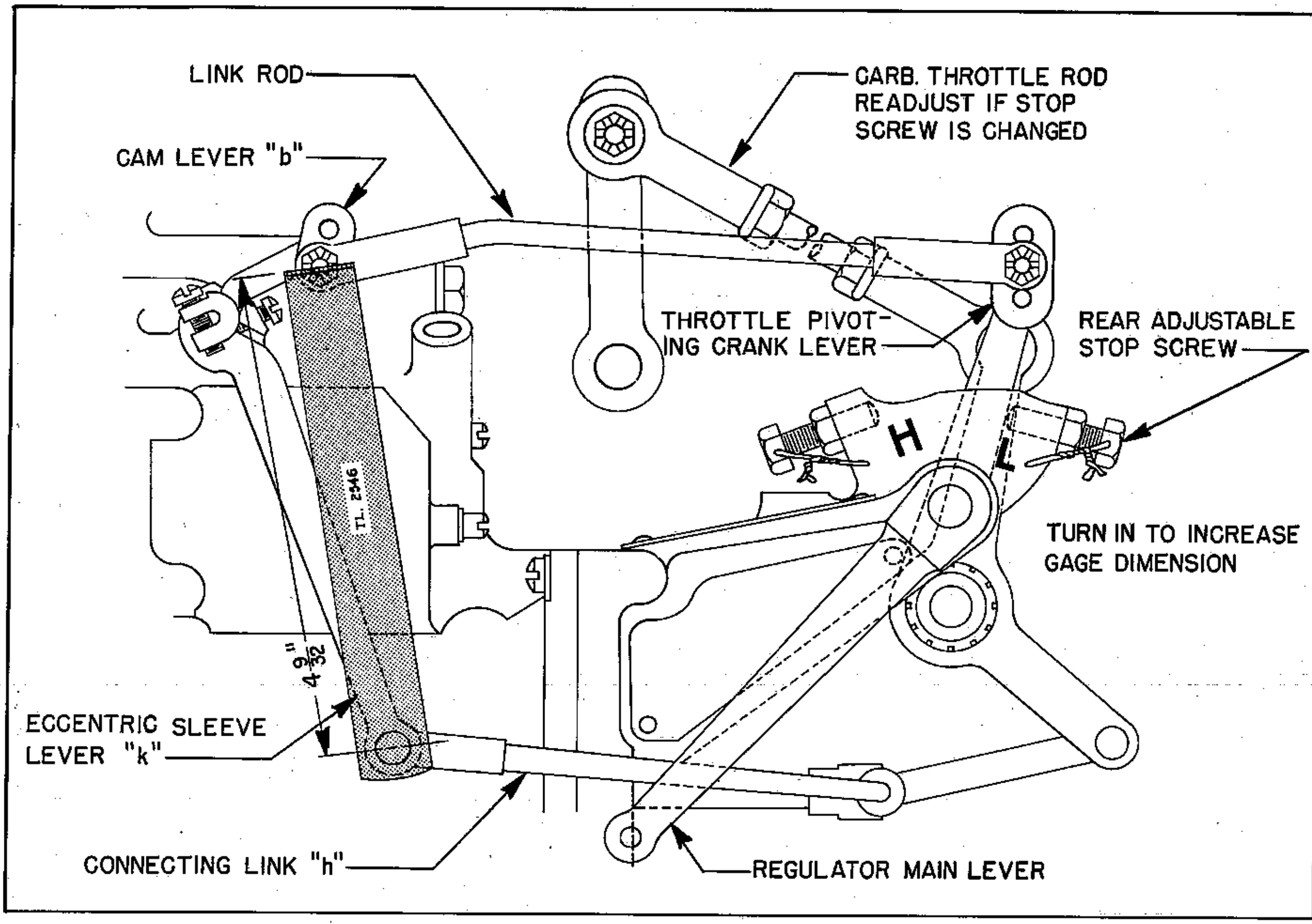


Figure 100—Checking Regulator Cam Lever Minimum Position.

(2) REQUIRED MAXIMUM EMERGENCY MANIFOLD PRESSURES.—The maximum allowable emergency manifold pressure is different for the various models covered in this handbook and depends on whether or not war emergency powers are being used on the particular airplane. After installation all regulators will be checked to see if the maximum emergency manifold pressure indicated on the red plate conforms to the required value for the particular model and condition of operation as indicated in the following table:

TABLE I

Engine Model	Max. Manifold Pressure for W.E.R. Operation	Max. Manifold Pressure for Standard Emergency Operation
V-1710-F3R	56" Hg.	52" Hg.
V-1710-F4R	60" Hg.	55" Hg.
V-1710-F20R	57" Hg.	55" Hg.

In case the figure painted on the red plate of the regulator lever support bracket, or in case the stamped value, does not conform to the specified manifold pressure above, the regulator will be readjusted to the proper manifold pressure.

(3) ADJUSTING REGULATOR TO PROVIDE THE REQUIRED MAXIMUM EMERGENCY MANIFOLD PRESSURE.

(*a*) Table II gives the necessary adjustments that must be made on the regulator to change its maximum setting from any possible setting to any required setting. (See Table I.) The adjustment includes changing the front adjustable stop screw a definite number of degrees and shifting the link rod combination if the table indicates this is necessary.

TABLE II

TABLE OF ADJUSTMENTS FOR CHANGING REGULATOR MAXIMUM MANIFOLD PRESSURE SETTING

Item	Changing Setting From	Changing Setting To	Linkage Hook-Up Before Changing	Linkage Hook-Up Change to	Turn Front Adjustable Stop Screw Degrees	FLATS
1	52″	55″	1-3	1-4	Clockwise (in) 480°	8
2	52″	56″	1-3	1-4	Clockwise (in) 360°	6
3	52″	57″	1-3	1-4	Clockwise (in) 240°	4
4	52″	60″	1-3	1-4	Counterclockwise (out) 120°	2
5	55″	52″	1-4	1-3	Counterclockwise (out) 480°	8
6	55″	56″	1-4	1-4	Counterclockwise (out) 120°	2
7	55″	57″	1-4	1-4	Counterclockwise (out) 240°	4
8	55″	60″	1-4	1-4	Counterclockwise (out) 600°	10
9	56″	52″	1-4	1-3	Counterclockwise (out) 360°	6
10	56″	55″	1-4	1-4	Clockwise (in) 120°	2
11	56″	57″	1-4	1-4	Counterclockwise (out) 120°	2
12	56″	60″	1-4	1-4	Counterclockwise (out) 480°	8
13	57″	52″	1-4	1-3	Counterclockwise (out) 240°	4
14	57″	55″	1-4	1-4	Clockwise (in) 240°	4
15	57″	56″	1-4	1-4	Clockwise (in) 120°	2
16	57″	60″	1-4	1-4	Counterclockwise (out) 360°	6
17	60″	52″	1-4	1-3	Clockwise (in) 120°	2
18	60″	55″	1-4	1-4	Clockwise (in) 600°	10
19	60″	56″	1-4	1-4	Clockwise (in) 480°	8
20	60″	57″	1-4	1-4	Clockwise (in) 360°	6

(*b*) It will be noted that the adjustable stop screw is always turned in steps of 60° or 120°. This is done since each flat on the head of the hex head stop screw represents 60° and provides an easy method of observing the number of degrees the screw is turned.

(*c*) To indicate the use of Tables I and II the following example is given of a regulator installation which requires an adjustment.

Adjustment Example:

1. A replacement regulator is installed on a V1710-F3R engine.

2. This engine is to be operated at standard maximum emergency manifold pressure (not to be operated at War Emergency Rating).

3. Refer to Table 1 to determine the *required* emergency manifold pressure that must be set on the regulator. This Table shows that the V-1710-F3R engine requires 52″ Hg. as listed in the column marked "Maximum Manifold Pressure for Standard Emergency Operation."

4. Since the regulator just installed is marked with a yellow figure "55" on the red plate, it will be necessary to readjust the maximum setting to the required value of 52″ Hg.

5. Refer to Table II. Note that item 5 of this Table indicates the regulator adjustment that is necessary to change the setting from 55″ to 52″ Hg.

6. Item 5 of the Table indicates that the linkage is shifted from 1-4 position to 1-3 position.

7. Shift the linkage. The stop screw is then backed out (turned counterclockwise) 480° which is equivalent to 8 flats of the adjustment screw.

8. Tighten jam nut on screw without disturbing the screw setting.

9. Remove the yellow figure No. 55 from the face of the red plate.

NOTE

Do not mark the figure "52" in yellow on the red plate since "52" is already stamped on the plate for the standard setting with the linkage in the 1-3 position.

e. GROUND AND FLIGHT CHECK OF AUTOMATIC MANIFOLD PRESSURE REGULATOR AFTER INSTALLATION.

(1) Ground Check (engine *not* running).

(a) Check the carburetor mixture control linkage to see that all four mixture control positions are obtainable in accordance with the markings on the cockpit engine control quadrant.

(b) Pull back the cockpit throttle lever as far as it will go to the fully closed position.

1. When the hand pressure on the lever is released there should be a gap of 1/8″ to 1/4″ between the cockpit throttle and the stop at the "closed" end of the throttle quadrant. Adjust the cockpit to regulator linkage if this gap is not obtained. This is done by changing link rod lengths.

2. With cockpit throttle lever in the correct position recheck regulator and carburetor stops. That is, the regulator throttle pivoting crank lever should have a gap of .005″ to .015″ with its rear stop as originally set during installation, and the carburetor throttle lever should be in contact with the idle stop. This recheck is made to insure that no error was made during original installation adjustment of the carburetor throttle rod covered in paragraph 6. *c.* (5).

(c) Next, push the cockpit throttle lever forward, as far as it will go to the full "open" position.

1. When the hand pressure is released from the lever, there should be a gap of 1/8″ to 1/4″ between the cockpit throttle lever and the stop at the "open" end of the throttle quadrant. (See Figure 99.)

2. At the regulator unit, check to see that the throttle pivoting crank lever is against its front adjustable stop. If it is not, adjust the linkage between the regulator unit and the cockpit throttle lever. If this linkage is adjusted be sure to re-check the closed throttle gap, as outlined in Paragraph *(b)* above.

(d) To insure that the replacement regulator linkage has not been sprung or damaged in storage or shipment, which could result in the throttle control mechanism locking in the fully closed position, the following check should be made. This check is made by measuring the distance between the points shown in Figure 100.

1. After all linkage has been checked and adjusted as stipulated in Paragraphs *(b)* and *(c)* above, place the cockpit throttle lever in the fully closed position.

2. Use Manifold Pressure Regulator Cam Lever Minimum Position Gage, No. 2546, and gage the minimum position of the cam lever. Place the hole in the lower end of gage over the fillister head of the bolt, which attaches the sleeve lever "k" to the connecting link "h". Place the upper end of the gage against the pressure selecting cam lever "b". (See Figure 100.)

NOTE

If gage No. 2546 is not available, this distance can be measured with a scale as shown in Figure 100.

3. If the centerline of the link connecting hole No. 1 in the cam lever "b" is in line with or above the upper edge of the gage, the minimum position of the linkage is satisfactory. If the centerline of the link is below the upper edge of the gage, loosen the locknut on the rear adjustable stop screw, then turn the latter clockwise (without breaking the seal) until the centerline of hole No. 1 is on a line with the upper edge of the gage. (See Figure 100.) Since one half to three quarters of a turn should be sufficient this adjustment can be made without breaking the seal. It will be necessary to readjust the length of the carburetor throttle rod if the setting of the adjustable stop screw is changed.

4. If the minimum position is set correctly as indicated above, opening and closing the cockpit throttle several times should show no indication of locking.

(2) Ground Check (engine running).

(a) After all the above checks have been completed and carried out explicitly as per above paragraph (1), the regulator unit is ready for an operation check with the engine running.

(b) Tie the airplane to the ground and start the engine in accordance with standard starting procedure specified in Section VI, Paragraph 1. *b.* and warm up engine following the instructions in Section V, Paragraph 2. *k.* (1).

(c) After the engine is warmed up to normal operating temperatures, check the engine for idling and adjust the carburetor idle stop in accordance with the requirements of the appropriate airplane Service Handbook, if necessary.

(d) Following the idle adjustment check, the first functional check of the regulator installation is made to determine that no manifold pressure air leaks exist either in the air connections or in the regulator itself. This ground check consists of advancing the cockpit throttle control lever very gradually until the manifold pressure reaches 32" Hg. Note any unusual operating characteristics as the engine speed increases to the R.P.M. which gives 32" Hg. manifold pressure. If the engine operates normally through this cycle and then retards to idling speed, it is evident the regulator unit is operating and no air leaks exist.

(e) The next operation is to locate the *detent position* on the cockpit throttle quadrant for Take-Off manifold pressure. With the airplane tied down, open the throttle gradually until Take-Off manifold pressure is obtained. Then set the detent on the cockpit throttle lever quadrant so that it will stop the lever at the Take-Off position. Refer to the appropriate engine "Handbook of Operating Instructions" to determine the correct Take-Off manifold pressure. After locating the detent in Take-Off position, tighten the detent securely.

WARNING

Do not operate the engine at Take-Off manifold pressure longer than a few seconds when airplane is on the ground.

(3) Flight Check.

(a) Following satisfactory completion of the above ground checks, the regulator installation will next be checked with the airplane in flight. This check is made to determine if the regulator linkage is correct for pulling the stipulated maximum emergency manifold pressure. This is the manifold pressure which is available to the pilot for emergency operation when the cockpit throttle lever is pushed through and beyond the detent stop.

(b) Although the ground check, with the engine running, permits the checking of the regulator linkage for satisfactory operation at Take-Off manifold pressure, the airplane must be in flight when the engine is operated for checking the high emergency powers.

WARNING

Do not check the maximum emergency manifold pressure setting with the engine operating on the ground. Ground operation will not provide sufficient cooling at these emergency powers to protect the engine from possible damage.

(c) The airplane will be warmed up and taken off in accordance with procedure of the appropriate "Pilots Handbook of Flight Operating Instructions". The airplane will then be climbed at military speed and manifold pressure to approximately 5000 feet. The speed and manifold pressure will be selected at the start of the climb and then the climb made without disturbing the setting of the cockpit throttle lever. Observe the manifold pressure during climb. The manifold pressure gage should not fluctuate more than ±1" Hg. from the selected setting. This check indicates that the regulator installation is satisfactory and that the regulator is automatically controlling the throttle to compensate for altitude change.

(d) The maximum emergency check will next be made with the airplane in level flight and in accordance with the following procedure.

1. Set propeller governor control in automatic position to maintain 3000 R.P.M.

2. Set mixture control in Automatic Rich or Full Rich.

3. Open the cockpit throttle past the quadrant detent stop to the full open position. Observe the maximum manifold pressure registered on the gage and record. This check should not require full throttle operation for more than 15 to 30 seconds to get a maximum stabilized manifold pressure reading.

(e) The maximum reading obtained during the flight check will be checked with the value appearing on the red plate of the regulator lever support bracket. This value should check within plus 0", minus 2" Hg. In other words if the regulator is marked "56" the check should show that the regulator has limited the engine to a maximum manifold pressure somewhere between 54" and 56" Hg.

CAUTION

The maximum setting of the regulator is for engines operating with streamline manifolds. In case the check is being made on an engine using Tee backfire screens, the resistance to air flow through the backfire screens will reduce the maximum pressure available an additional 2" Hg. In other words a regulator set to provide 54" to 56" Hg. for an engine with streamline manifolds will only allow a maximum manifold pressure of 52" to 54" for an engine operating with Tee backfire screens and no adjustment is necessary.

(*f*) The regulator maximum emergency manifold pressure setting is correct and no adjustment is necessary provided the flight check manifold pressure falls within the limits indicated on the following table:

If Regulator is Marked for Max. Press. of:	Engines with Streamlined Manif. Flight Check Should Show:	Engines with Tee Backfire Screens Flight Check Should Show:
"52"	50 to 52″ Hg.	48 to 50″ Hg.
"55"	53 to 55″ Hg.	51 to 53″ Hg.
"56"	54 to 56″ Hg.	52 to 57″ Hg.
"57"	55 to 57″ Hg.	53 to 55″ Hg.
"60"	58 to 60″ Hg.	56 to 58″ Hg.

(*g*) If the flight check shows that the maximum manifold pressure does not fall within the limits given in the above table, adjust stop screw to bring manifold pressure within the above limits. The adjustable stop screw is turned 120° in (clockwise) to reduce the manifold pressure 1″ Hg., and is turned 120° out (counter-clockwise) to increase the manifold pressure 1″ Hg.

(2) Installing Cockpit Throttle Detent Breakthrough Seal.

(*a*) On engines which are to be operated under W.E.R. conditions, a cockpit quadrant detent breakthrough seal will be installed.

f. PERIODIC INSPECTION AND MAINTENANCE.—For periodic inspection and maintenance on the automatic manifold pressure regulator, refer to Section VII, Column 27.

g. TROUBLE SHOOTING. — Regulator malfunctions will be indicated by the following abnormal engine operations.

(1) Manual throttle adjustments necessary to maintain constant manifold pressure while ascending or descending indicates that the regulator is not getting engine oil pressure.

(2) Increasing manifold pressure with plane in level flight indicates a slight crack in the aneroid bellows.

(3) A sudden increase in manifold pressure in an amount equalling atmospheric pressure indicates ruptured aneroid bellows.

(4) Erratic engine operation, with the manifold pressure at times rising above the pressure selected and at other times falling below, could be caused by metallic chips or other foreign particles circulating in the engine oil system and lodging in one of the orifices of the servo valve.

(5) The manifold pressure increasing while climbing and decreasing while descending can be brought about by two regulator conditions.

(*a*) Leaky air pressure passage.

(*b*) Manifold pressure bellows crack.

(6) The throttle suddenly opening to full open from a setting of manifold pressure above atmospheric pressure indicates either a disconnected or plugged air pressure passage or a manifold pressure bellows rupture.

h. REPLACEMENT OF REGULATOR.—A regulator should be replaced when any of the above or other unsatisfactory operations are encountered.

(1) When a regulator is to be replaced on account of malfunctioning, make certain, before removing the regulator assembly, that the trouble does *not* lie in faulty or improperly installed attaching parts. Check to see that all attaching parts are properly connected and that all joints are tight. *This rechecking is important,* since it may avoid the replacement of a regulator unit when the trouble is in some attaching part.

(2) When there has been serious contamination of the engine oil system, due to bearing failures, breakage of engine parts, or the presence of metallic chips or other foreign matter, the regulator must always be removed and returned to the Depot for their inspection and flushing.

CAUTION

Before installing a replacement regulator unit after removal of one for flushing, be sure to drain the oil from the engine and clean all engine and airplane oil passages and lines thoroughly.

(3) Refer to Paragraph 6, *b.*, this Section for procedure on removal of regulator.

SECTION X

SERVICE TOOLS

NUMERICAL LIST

TOOL NO.	NOMENCLATURE	APPLICATION
2057	Indicator	T. D. C.
2072	Wrench	3⅞" Crankshaft Pinion and Starter Gear Nut
2115	Wrench	Propeller Shaft Thrust Bearing
2140-29	Wrench	"L" Head Manifold (with bar)
2149	Wrench	1⅛" Cylinder Jacket Coolant Metering Plug
2166	Wrench	Camshaft Drive Housing Packing Nut
2228	Wrench	11/16" Spark Plug Cable Shielding Elbow
2229	Sling	Engine Lift
2241	Wrench	⅞"-12 Point Spark Plug Socket
2243	Wrench	Oil Pressure Relief Valve Body
2244	Wrench	Oil Pressure Relief Valve
2246	Wrench	Strap for Ignition Tube Connector Nuts
2247	Gage	10 Blade Thickness
2294	Tool	Valve Holding
2312	Wrench	Camshaft Turning
2315	Compressor	Valve Spring
2316	Wrench	Core Hole Plug
2380	Disc	Magneto Type Timing
2425	Wrench	1¼"-3" Adjustable Spanner
2443	Gage	Valve and Spring Height
2447	Bracket	Propeller Shaft Run Out Indicator
2454	Wrench	¾" Spark Plug Cable Shielding Elbow
2546	Gage	Manifold Pressure Regulator Cam Lever Minimum Position
250616	Tool	Timing Clamp
251283	Tool	Ignition Wire Cap Crimping
34A4632	Universal Joint Assembly	Spark Plug Wrench (Allison Tool No. 2255)
34A4651	Bar	Spark Plug Wrench ⅜" Dia. (Allison Tool No. 2254)
34B4630	Ratchet Handle Assembly	½" Square Drive (Allison Tool No. 2251)
34B4645-1	Extension	Spark Plug Wrench (5⅝" long) (Allison Tool 2252)
34B4645-2	Extension	Spark Plug Wrench (3¼" long) (Allison Tool 2253)

NOTE

This list is taken from the Service Tool Catalog which shall be referred to for additional information, illustrations, et cetera.

APPENDIX

U.S.A.-BRITISH GLOSSARY OF NOMENCLATURE

AMERICAN	BRITISH
GENERAL	
Anti-friction bearings	Ball and roller bearings
Blade connecting rod (used on multi-bank in-line engines)	Plain connecting rod
Block test	Bench test under engine's own power, usually after overhaul
Cap screw	Setscrew or screw
Capsule stack or pack	Aneroid
Clevis	Fork joint or knuckle joint end
Cotter pin	Split pin
Crock (used in heat-treatment)	Earthenware jar
Fillister head screw	Cheese head screw
Filter (air)	Air cleaner
Flat head screw	Countersunk head screw
Gall	Fret or score
Gasoline (Gas)	Petrol (preferable to use "Fuel")
Green run	Running in
Ground (electrical)	Earth
Kerosene	Paraffin
Lock ring	Circlip
Lock washer	Spring washer
Manifold pressure (usually measured in inches Hg. absolute)	Boost (usually measured in lb. per sq. in. gage, i.e. above atmospheric pressure)
Manifold pressure regulator	Boost control unit
Oil pan (use on in-line engines)	Sump
Palnut	Locknut (type of)
Paraffin	Paraffin wax
Pilot (a guide fitting in a recess for location purposes)	Spigot
Piston pin	Gudgeon pin
Propeller	Airscrew (now obsolete. Use "Propeller")
Round head screw	Cup head screw
Screen (oil)	Filter
Setscrew	Grub screw
Slushing compound	Corrosion inhibitor
Spanner nut	Ring nut
Split cone or wedge (on valve)	Collet
Stack	Exhaust pipe
Sylphon	Sylphon (i.e. aneroid containing an inert gas)
Strainer (oil)	Filter
Tag	Label
Test club	Test fan
Tachometer	Engine speed indicator
Vise	Vice
#	lb. or No.

TOOLS

AMERICAN	BRITISH
Box-end wrench	Ring spanner
Closed spanner-wrench with internal lugs or surface lugs	Ring spanner
Socket wrench	Box spanner
Spanner	C—Spanner
Spanner-wrench	Ring spanner

NOTE

The nomenclature of tools is somewhat vague in the case of both the American and the British terms, but generally speaking, the word "wrench" is used in one country to describe what is known as a "spanner" in the other country, and vice versa.

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