MAINTENANCE MANUAL

Part No. 166498 March 1953

DOUBLE WASP (R-2800)
CB ENGINES

REVISED

DECEMBER 1955

PRATT & WHITNEY AIRCRAFT
DIVISION OF UNITED AIRCRAFT CORPORATION
EAST HARTFORD 8, CONNECTICUT

LIST OF REVISED PAGES

NOTE: A heavy black vertical line, in the margin of revised pages, indicates the extent of the revision. This line is not used if more than 50 per cent of the page is revised or if a picture is added or substituted. Insert latest revised pages. Destroy superseded pages.

PAGE NO.	LATEST REVISED DATE
5	August 1954
6	August 1954
7	August 1954
8	August 1954
28	August 1954
28A	August 1954
28B	August 1954
32A	August 1954
32B	August 1954
76	August 1954
81	August 1954
86	December 1955
87	December 1955
97	August 1954
98	August 1954
99	August 1954
100	August 1954
101	August 1954
102	August 1954
103	August 1954
104	August 1954
105	August 1954
106	August 1954
107	August 1954
108	August 1954
109	August 1954
110	August 1954
111	August 1954
112	August 1954
112A	August 1954
112B	August 1954
112C	August 1954
112D	August 1954
112E	August 1954
112F	August 1954
112G	August 1954
112H	August 1954
112J	August 1954
112K	August 1954
112L	August 1954
112M	August 1954
112N	August 1954
112P	August 1954
112Q	August 1954
112R	August 1954
112S	August 1954
112T	August 1954
112U	August 1954
112V	August 1954
112W	August 1954
112X	August 1954
112Y	August 1954
112Z	August 1954
112AA	August 1954
112AB	August 1954
112AC	August 1954
112AD	August 1954
112AE	August 1954
112AF	August 1954
112AG	August 1954
112AH	August 1954
112AJ	August 1954
112AK	August 1954
112AL	August 1954
112AM	August 1954
112AN	August 1954
112AP	August 1954
112AQ	August 1954
112AR	August 1954
112AS	August 1954
112AT	August 1954
112AU	August 1954

LIST OF REVISED PAGES (Continued)

PAGE NO.	LATEST REVISED DATE
112AV	August 1954
112AW	August 1954
112AX	August 1954
112AY	August 1954
112AZ	August 1954
112AAA	August 1954
112AAB	August 1954
112AAC	August 1954
112AAD	August 1954
133	August 1954
134	August 1954
137	August 1954
138	August 1954
138A	August 1954
138B	August 1954
149	August 1954
150	August 1954
157	December 1955
158	December 1955
159	December 1955
160	December 1955
161	December 1955
167	December 1955
168	December 1955
171	August 1954
172	August 1954
172A	August 1954
172B	August 1954
174	August 1954
175	August 1954
202	August 1954
203	August 1954
204	August 1954
209	August 1954
210	August 1954
212	December 1955
213	August 1954
217	August 1954

TABLE OF CONTENTS

INTRODUCTION

This publication is compiled and issued by the Service Department of Pratt & Whitney Aircraft, Division of United Aircraft Corporation, East Hartford, Connecticut. It includes approved and recommended engine maintenance and service procedures. The information and instructions contained herein are based upon actual experience acquired under varied and exacting conditions. The utmost in dependable engine performance will be gained by conforming to these instructions.

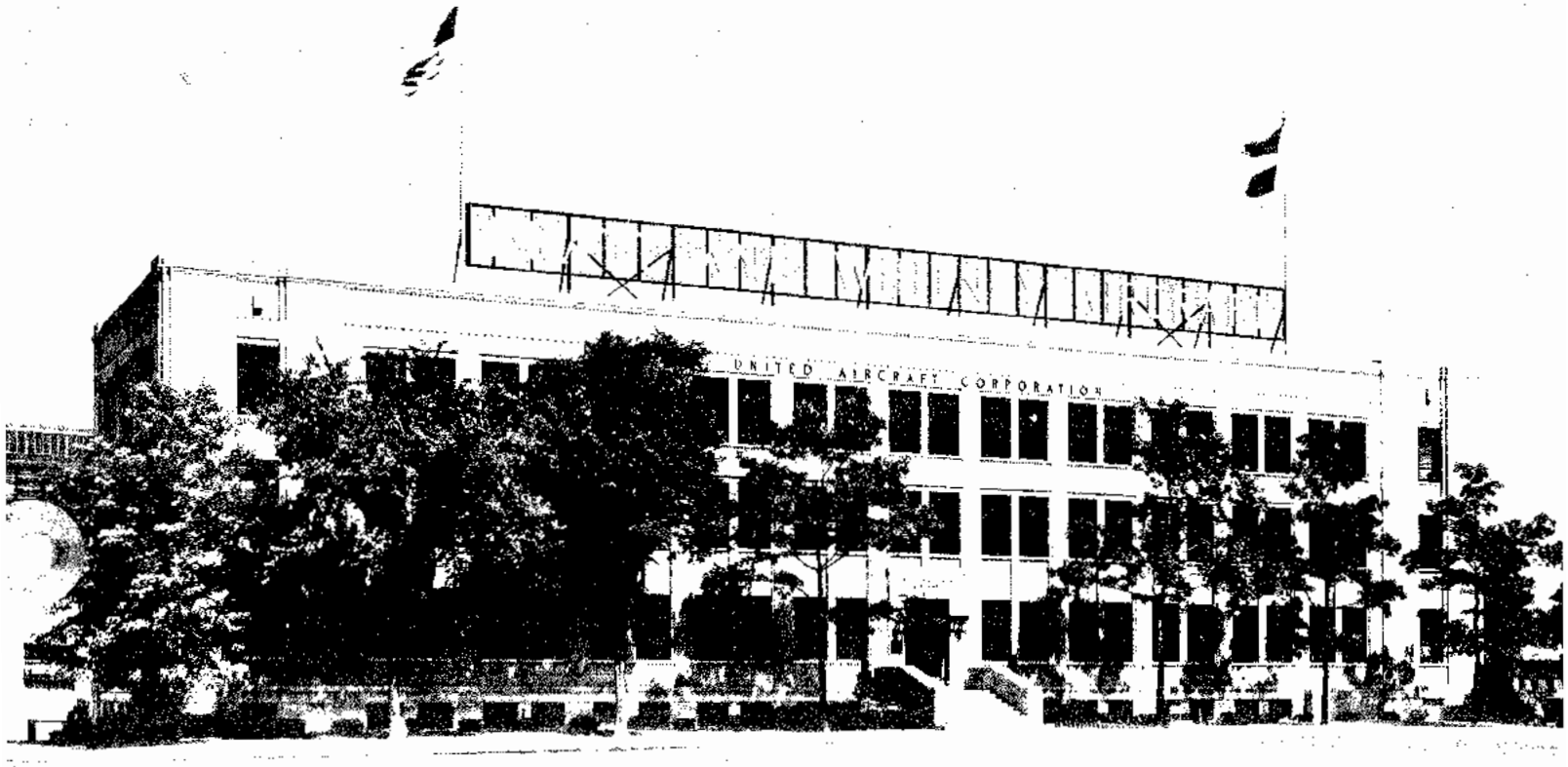
General information, in the form of conversion tables, weight tables, aircraft codes, engine power equations, and atmosphere tables, has been included as an Appendix.

Unusual problems concerning engine maintenance should be presented to the Service Department either through its field representatives or by direct contact. All possible assistance will be provided in the solution of these problems.

The Overhaul Manual, Part No. 166497 should be referred to for complete overhaul procedures. The Pratt & Whitney Aircraft Engine Parts Catalog, Part No. 119472 should be referred to when ordering engine parts.

When operators feel that the maintenance instructions contained in this publication are inadequate, suggestions for their amplification or modification will be gladly received and given thorough consideration by the Service Department.

At six month intervals this publication will be revised as necessary to incorporate latest maintenance data.



SERVICE PUBLICATIONS

It is recommended that personnel superintending engine maintenance be familiar with the following publications:

Service Bulletins — Service Bulletins are issued from time to time as additional information and improvements become available or when changes in certain maintenance or overhaul procedures are recommended. Service Bulletins serve the purpose of supplementing both Overhaul and Maintenance Manuals.

Engine Parts Catalog — The Parts Catalog, Part No. 119472 is published by the Spare Parts Department to assist the owners and operators, as well as maintenance and overhaul stations, in securing spare parts. The catalog lists all engine parts in convenient form for identification, and gives pertinent information concerning the ordering and shipment of these parts. Supplements are issued from time to time to keep the catalog up-to-date. The interchangeability of engine parts can be readily determined from this catalog.

Installation Information — The Installation Department publishes installation data to supplement the information presented on our engine installation drawings. Such data is issued as bulletins, information letters, and supplements to the Installation Handbook.

Overhaul Manual — The Overhaul Manual, Part No. 166497, contains the information required for the major overhaul of Double Wasp CB series engines. The object of the overhaul manual is to furnish overhaul and repair activities with the most up-to-date knowledge available on the maintenance of these engines. Any specific information not contained in this manual will be gladly furnished by the Pratt & Whitney Aircraft Service Department, to whom maintenance inquiries should be directed.

PARTS AND SERVICE

Service Department — Pratt & Whitney Aircraft maintains a Service Department to assist its customers in the operation and maintenance of Pratt & Whitney Aircraft engines. Service Department representatives maintain contact with operators and engine maintenance activities and are available for the investigation of any specific difficulty or problems. Any request for assistance should be addressed directly to the Service Department, Pratt & Whitney Aircraft, East Hartford, Connecticut.

Ordering Parts — Whenever possible, refer to the Pratt & Whitney Aircraft Engine Parts Catalog Part No. 119472 when ordering parts. These catalogs are furnished to operators and are available to other interested parties. In case a parts list is not available, give engine model, manufacturer's engine serial number and a full description of the part and where it is used. All spare parts ordered should be addressed directly to the Spare Parts Department, Pratt & Whitney Aircraft, East Hartford, Connecticut.

Because some parts require special or expensive equipment for assembling and cannot be fabricated except in a specially equipped shop, they are not furnished individually and must be purchased as assemblies. If an order is received for a unit of an assembly coming under this classification, the complete assembly will be shipped.

Spare parts for carburetors, magnetos, and special radio shielding, together with such accessories as propellers, hubs, vacuum pumps, starters, and generators, should be ordered directly from their respective manufacturers.

Returning Parts — Before returning parts for repair information, inspection, or credit, authority for their return should be obtained from the Service Department, Pratt & Whitney Aircraft, East Hartford, Connecticut. When requesting authority for the return of parts the following information should be given.

1. Reason for return.
2. Engine number.
3. Part number.
4. Type of engine from which parts are taken.
5. Number of hours of service of the part and of the engine.

If the parts are being returned directly to the factory, proper notification of shipment must be sent to the Service Department so that it will arrive at least one day in advance of the receipt of the parts.

When returning parts for repair only, it is unnecessary to obtain authority for return. All factory repair work is handled by the Airport Department, Rentschler Field, East Hartford, Connecticut. Only repair items should be sent to this address.

Time Between Overhauls — Where engines are consistently cruised at relatively low power, such as in operations involving long range aircraft, and where conservative cruising outputs can be consistently maintained, periods of 600 to 1000 hours between overhauls are feasible; but such extended periods between overhauls should be approached gradually, experience being the deciding factor. Extension of time between overhauls should be determined by experience with the engines of a particular model in the given type of operation, and their condition at overhaul. It is suggested that overhaul period increases be made in increments of 15 percent flight hours. Oil consumption is usually one of the best indications as to whether or not the engine requires overhaul, providing the engine is performing normally, and there is no indication of possible trouble or irregularities requiring more than normal line maintenance attention. A sudden increase of oil consumption, or a gradual increase of oil consumption to double that which has previously been average, is usually cause for overhaul.

SPECIFICATIONS

GENERAL

Model R-2800	CB3, CB4, CB16, CB17
Type	Twin Row, Radial, Air Cooled
Number of Cylinders	18
Bore	5.75 inches
Stroke	6.00 inches
Piston Displacement	2804 cubic inches
Compression Ratio	6.75:1
Impeller Gear Ratios:	
Low	7.29:1
High	8.5:1
Impeller Diameter	12.50 inches
Propeller Reduction Gear Ratio	.450:1
Propeller Shaft Spline Size	SAE No. 60A
Diameter of Mounting Bolt Circle	33.75 inches
Number of Mounting Bolts	6
Size of Mounting Bolts	½-20NF-3
Maximum Weight of Engine	2390 pounds
Maximum Diameter of Engine	52.80 inches
Maximum Length of Engine	81.40 inches

GENERAL (Cont'd)

Approximate Center of Gravity:
- Forward of Rear Face of Crankcase Rear Section ..... 11.6 inches
- Above Crankshaft Centerline ..... .20 inch

VALVES AND TIMING

Inlet Opens ..... 36° before top center

Inlet Closes ..... 60° after bottom center

Exhaust Opens ..... 70° before bottom center

Exhaust Closes ..... 26° after top center

Valves Remain Open ..... 276° of crankshaft rotation

Valve Timing Check Clearances:
- Front Inlet ..... .102 inch
- Front Exhaust ..... .127 inch
- Rear Inlet ..... .125 inch
- Rear Exhaust ..... .143 inch

Cold Valve Adjusting Clearance ..... .060 inch

IGNITION SYSTEM

Magneto Type:
- Low Tension System (Standard Equipment) DLN-10
- High Tension System (Optional Equipment) DF-18LN

Rotation of Magneto Drive ..... Clockwise

Magneto Drive Speed to Crankshaft 1.125:1

Sparkplug Type AC-181, AC-271, AC-171, R-115, R-103, R37S-1, RB27R

Sparkplug Gap ..... .011-.014 inch

Spark:
- Normal Advance ..... 20° before top center

LUBRICATION SYSTEM

Grade of Oil Required ..... 100 (S.U.S. at 210°F)

See the latest revision of Service Bulletin No. 1183 for a list of the oils approved for use in Pratt & Whitney Aircraft engines.

Oil Pump Drive Shaft Rotation ..... Clockwise

LUBRICATION SYSTEM (Cont'd)

Oil Pump Inlet Connection ..... 3 Studs, 5/16-24NF-3, Equally Spaced

Oil Pump Outlet Connection ..... 3 Studs, 5/16-24NF-3, Equally Spaced

Oil Tank Vent Connection ..... ¾-14 NPT

FUEL SYSTEM

Carburetor ..... Stromberg PR-58E5

Fuel Required in Flight:

CB3, CB16 ..... 100/130

CB4, CB17 ..... 108/135

See Water Injection Supplement for Recommended Water Injection Mixture.

Fuel Inlet Connection ..... ¾-14 NPT

Fuel Drain Coinnection ..... ⅜-18 NPT

Priming System Inlet Connections 5/16-32NF-3

ACCESSORY DRIVES

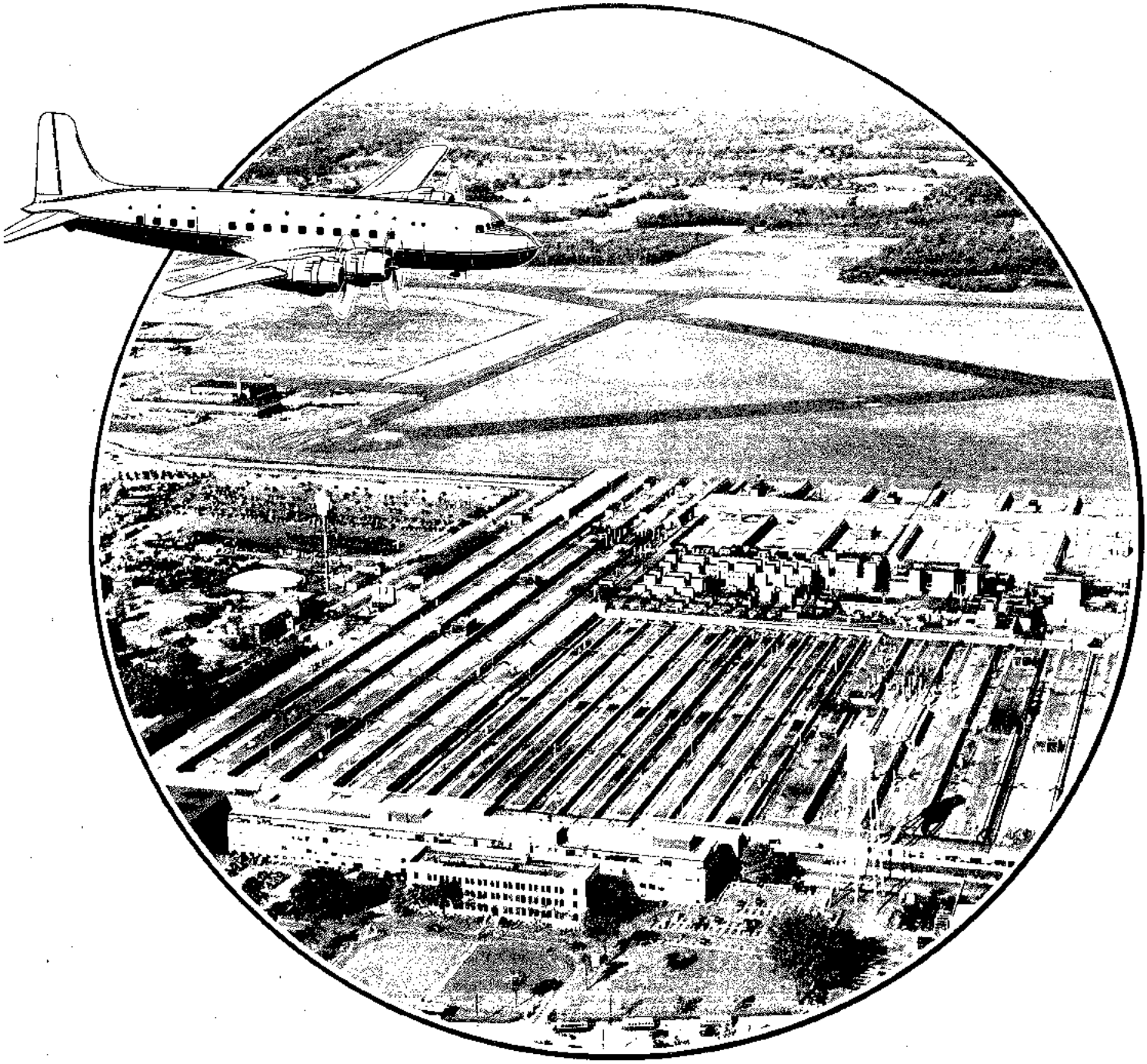
Accessory	Type of Drive	Pad Stud Centers	Speed Ratio to Crankshaft	Drive Rotation
Fuel Pump	11 Inv. Splines .4583 PD, 24/48 P	2 in. x 2 in., 4 Studs	864.1	Counterclockwise
Starter	12 Tooth Jaw	5.75 in. Dia. Bolt Circle, 6 Studs	1:1	Clockwise
Generator	16 Int. Inv. Splines	5 in. Dia. Bolt Circle, 6 Studs	3.033:1	Clockwise
Propeller Governor	12 Int. Inv. Splines	2-⅛ in. x 2-⅛ in., 4 Studs	.964:1	Counterclockwise
Tachometer	.250 Int.Sq.	1⅞ in. x 1⅞ in., 4 Studs	.500:1	Clockwise (L) Counterclockwise (R)
Vacuum or Hydraulic Pump	12 Inv. Splines .6 PD, 20/40 P	5 in. Dia. Sq. Pad, 4 Studs	1.400:1	Clockwise
Power Take-Off	24 Inv. Splines 1.2 PD, 20/30 P	5 in. Dia. Bolt Circle 6 Studs	1.400:1	Clockwise

ACCESSORY DRIVES (Cont'd)

Left Side Auxiliary	12 Inv. Splines .6 PD, 20/40 P	5 in. Dia. Sq. Pad, 4 Studs	1.400:1	Clockwise
Right Side Auxiliary	12 Inv. Splines .6 PD, 20/40 P	5 in. Dia. Sq. Pad, 4 Studs	1.400:1	Clockwise

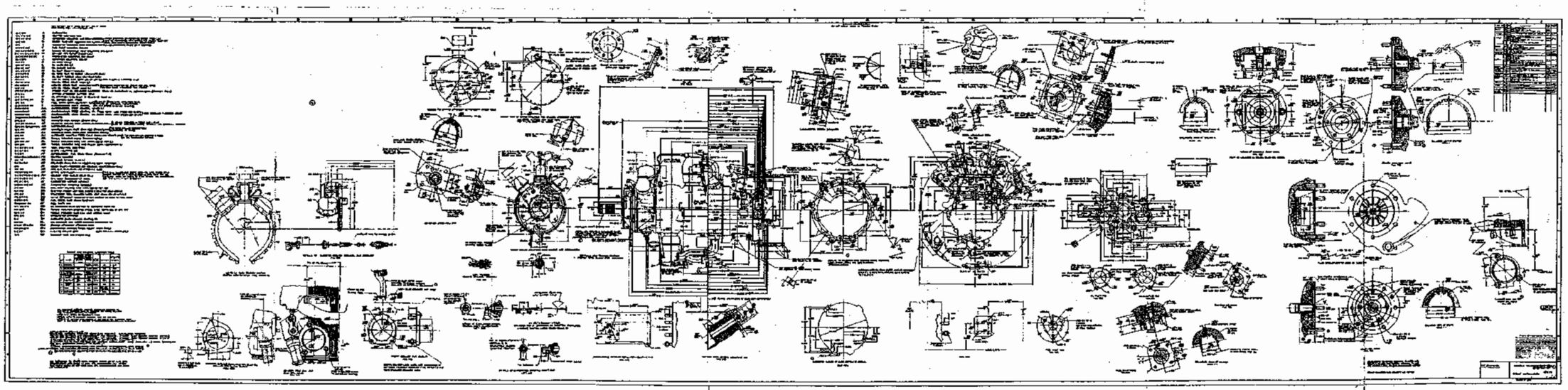
ACCESSORY AND INSTRUMENT CONNECTIONS

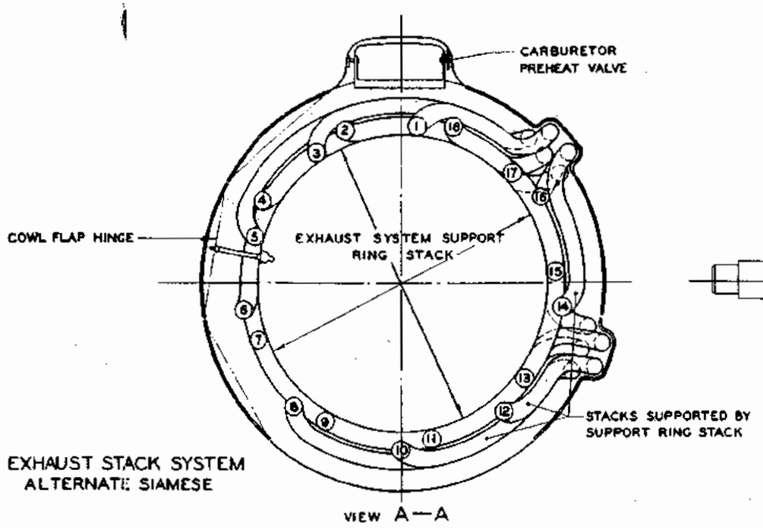
Oil-In Thermo Connection	5/8-18NF-3
Oil Pressure Gage Connection	1/4-18NPT
Vacuum Pump Oil Separator Discharger or Accessory Oil Return Connection	3/8-18NPT
Selector Valve High Ratio Clutch Oil Pressure Connection	1/8-27NPT
Selector Valve Low Ratio Clutch Oil Pressure Connection	1/4-18NPT
Magneto Ground Connection	11/16-24NEF-3
Manifold Pressure Gage Connection	1/8-27NPT
Torquemeter Gage Line Connection	1/8-27NPT
Torquemeter Gage Line Filler Connection	1/8-27NPT
Fuel Line Balance Line Connection	1/8-27NPT
Electric Primer Unit Connection	3/4-20NEF-3
Primer Line Connection	1/8-27NPT
Vapor Vent Return Line Connection	1/8-27NPT
Fuel Pressure Gage Connection	1/8-27NPT
Torquemeter Booster Oil Pressure Gage Connection	1/8-27NPT
Water Inlet Connection	3/8-18NPT
Water Inlet Vent Return to Water Tank	1/8-27NPT
Water Control Pressure Gage Connection	1/8-27NPT
Manifold Pressure Control Connection	1/8-27NPT



PREPARATION FOR SERVICE

INDEX

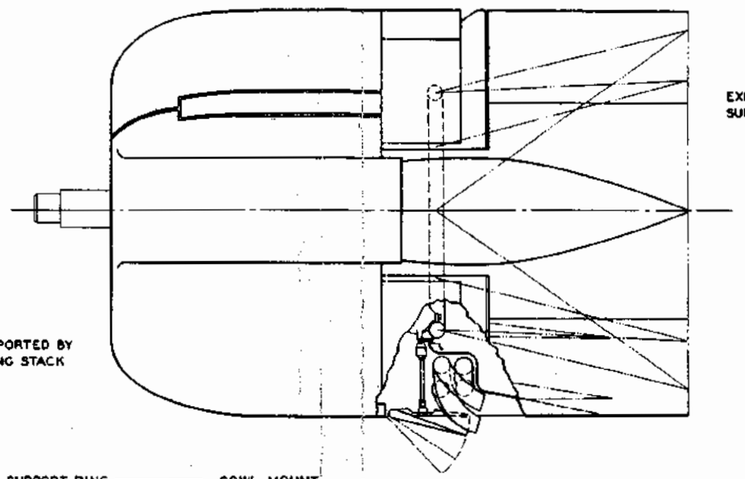


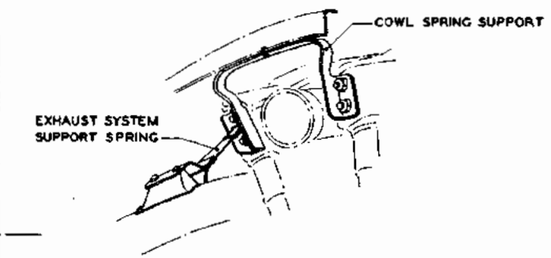


EXHAUST STACK SYSTEM
ALTERNATE SIAMESE

VIEW A—A

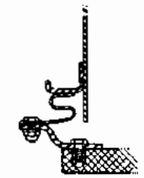
TOP VIEW



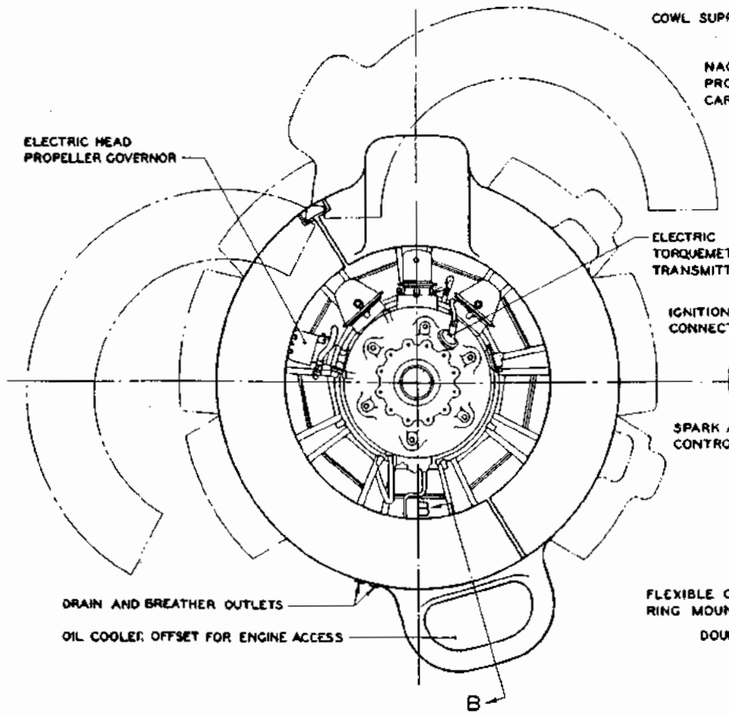


DETAIL OF COWL SUPPORT RING
STEEL INTER-EAR SPRING SUPPORT
AND EXHAUST SYSTEM SUPPORT SPRING

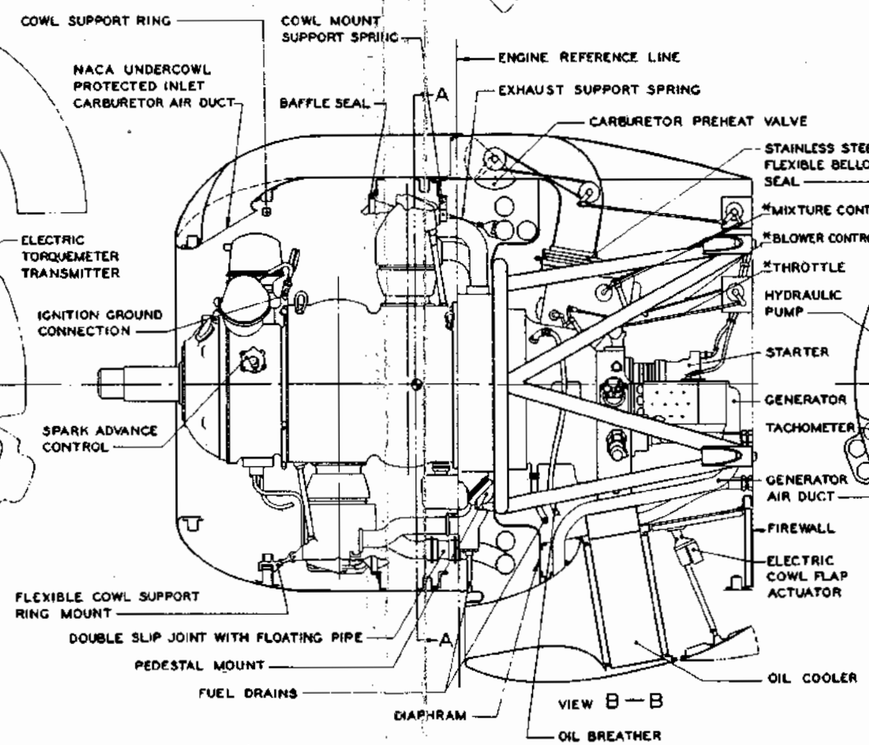
* NOTE:
CONTROL RODS POINTING TO ELASTIC CENTER ELIMINATE EFFECT OF ENGINE MOTION



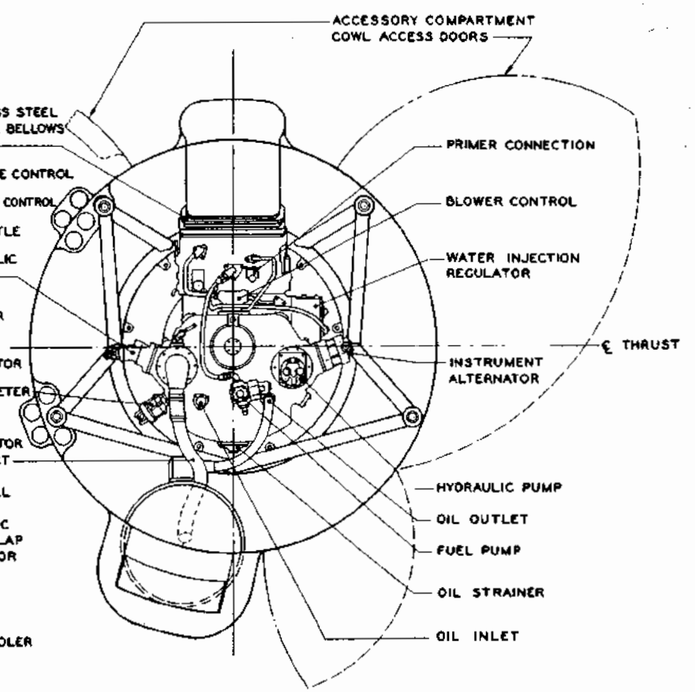
DETAIL OF CARBURETOR
STAINLESS STEEL
FLEXIBLE BELLOWS SEAL



FRONT VIEW



INBOARD PROFILE VIEW



REAR VIEW

SCALE $\frac{1}{20}$ SIZE (APPROX.)

Typical Installation

UNPACKING THE ENGINE

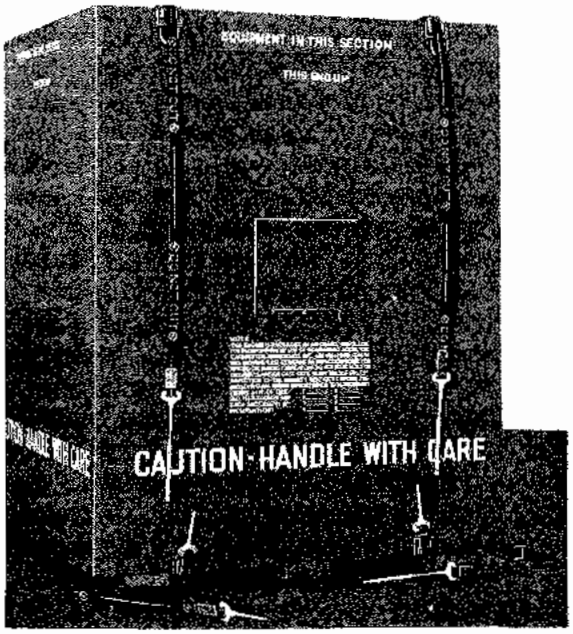
The engine packing case incorporates steel corner protectors which contain grooves for locating the vertical steel securing straps. Flush type rings in the corner protectors allow easy lashing, loading or unloading of the packing case. Four vertical straps and one horizontal strap provide security. For lifting or lowering the packing case, use a chain hoist with a minimum capacity of 2 tons. During the removal of the protective envelope from the engine, the room temperature should be above 68°F (20°C) as the envelope tends to stiffen at lower temperatures, thereby becoming vulnerable to rupture.

To unpack the engine, loosen the turnbuckles, remove the metal straps and attach a sling to the lifting rings on the cover. Raise the cover carefully so that the carburetor and other accessories fastened inside will not be damaged. Lift the four sides out of the base. Unfasten the tape and cut off the sealed portion of the envelope. Unscrew the protector cap and spanner nut; then remove the protective envelope and spacer from the propeller shaft.

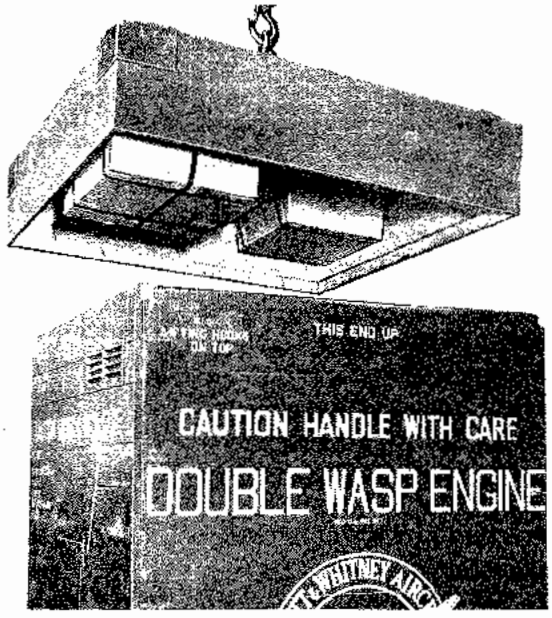
Unfasten the nuts holding the mounting plate to the support cone, screw PWA-2736 Lifting Eye on the propeller shaft, attach a hoist, and raise the engine carefully out of the cone. Unfasten the mounting plate, and remove it from the engine. Carefully roll down the protective envelope. Remove, clean, and store it for future use.

Remove the paper from around the power section, remove the humidity indicator, and the bags of dehydrating agent.

Cut the straps and remove the carburetor and accessory packing cartons from the packing case cover. After the engine has been removed from the packing case, do not turn the propeller shaft or remove the corrosion preventive mixture, dehydrating plugs, or any moisture resistant covers until just prior to depreservation.

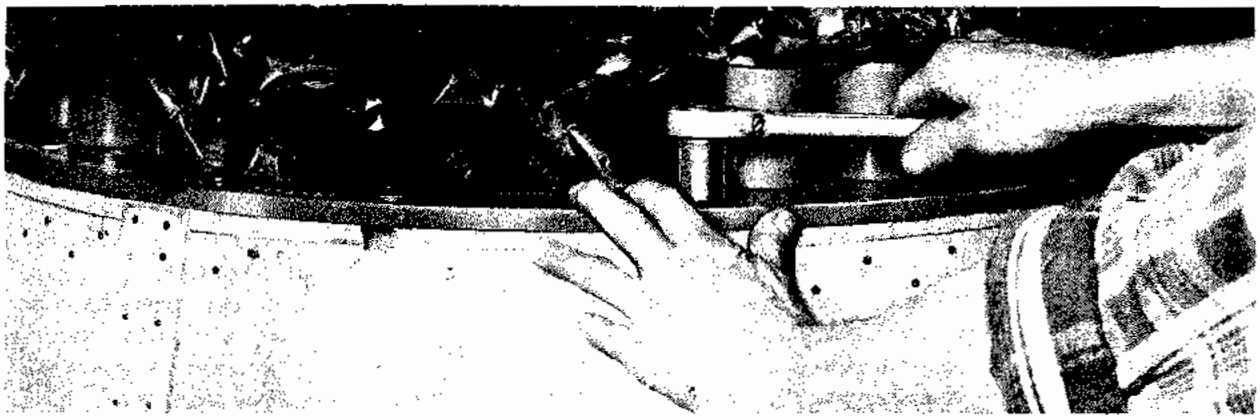


Turnbuckles Loosened



Raising Cover

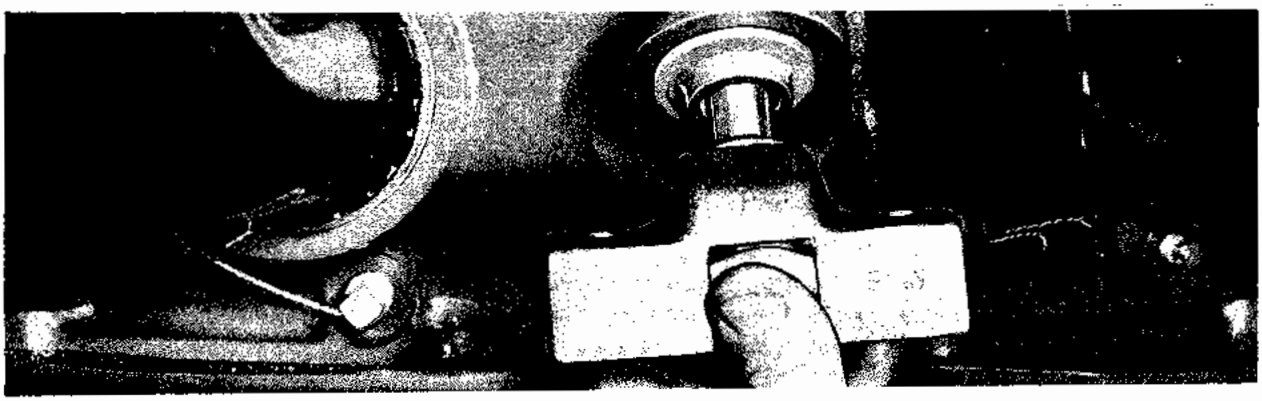
Cutting Seal



Unfastening Support Plate

Raising Engine From Cone

Removing Support Plate



Removing Shipping Bracket

ENGINE BUILD-UP

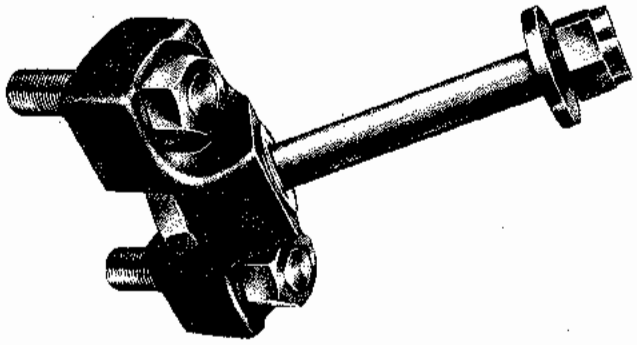
General — The instructions for engine build up treat only major components. In case any part of the following instructions are in conflict with or superseded by the airframe manufacturer's publications, the instructions contained in the latter are applicable. For additional details and specific requirements refer to the installation drawings for the particular aircraft involved, these drawings are provided by the aircraft manufacturer.

After unpacking and prior to operation, the moisture-proof coverings and dehydrator plugs must be removed and the engine completely drained of all corrosion preventive mixture.

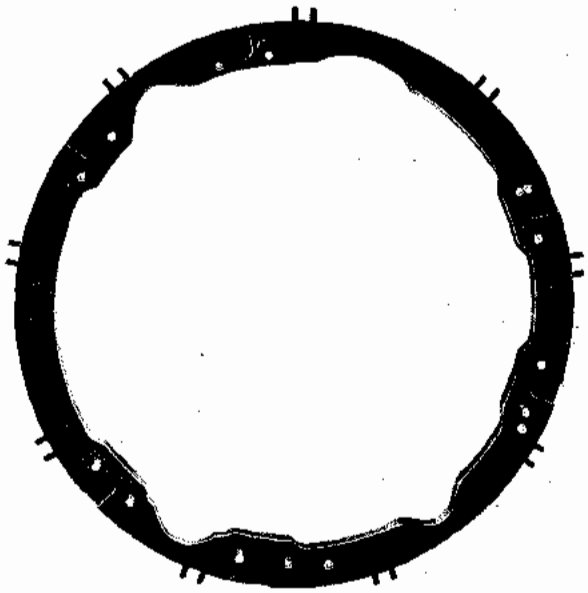
For torque recommendations refer to "Torque Recommendations" on page 207.

Installation of Engine in Engine Stand — Loosely fasten a Part No. TB-54529 Bracket to each bracket boss on the supercharger case, using nuts and washers. Attach PWA-2934 Sling or PWA-2736 Eye to the engine. Using a suitable hoist, carefully back or lower the engine into the Part No. TC-51260 Mounting Plate of TAM-1785 Engine Stand and secure the adapters to the mounting plate, using TAM-5810 Bolts. Tighten the nuts which secure the adapters to the supercharger case; then lock all nuts with cotterpins.

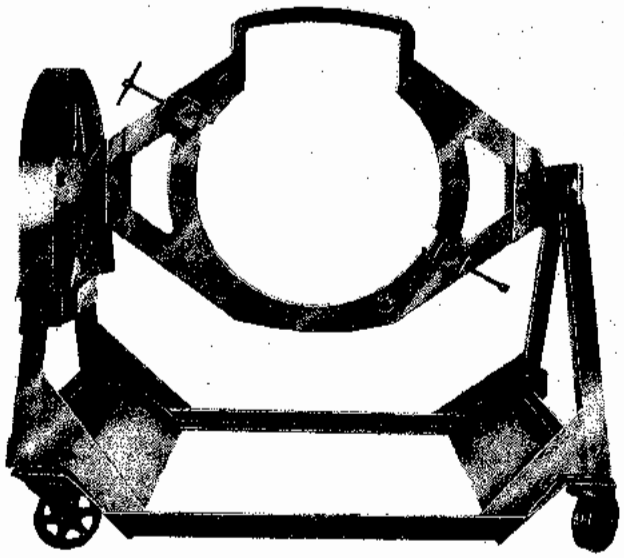
Depreservation —Remove the moisture-proof coverings, containers of dehydrating agent, and dehydrator plugs from the breathers and other engine openings. Do not remove the cover from the carburetor mounting pad until the carburetor is to be installed. Remove the drain plug from the sump and rockerbox drain oil manifold. Remove the sparkplug lead protectors from the dehydrator plugs; then remove the dehydrator plugs from the cylinders, governor pad, and from the rear case. Crank the bed of the engine stand until the engine



TB-54529 Bracket



TC-51260 Mounting Plate



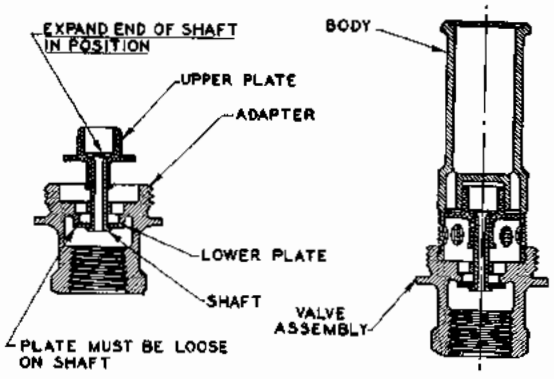
TAM-1785 Engine Stand

is in flight position. Allow the corrosion preventive mixture to drain. Using PWA-2741 Bar, rotate the propeller shaft in the normal direction of rotation to facilitate draining. Inspect the insides of the cylinders through the sparkplug holes, using a suitable inspection light. Make sure that excess oil or corrosion preventive mixture has not accumulated in them. If an appreciable amount is present, remove it with a hand pump.

Intake Pipe Drainage — Remove the lowermost intake pipe and inspect for excessive corrosion preventive mixture. Clean the pipe with unleaded gasoline or naphtha.

If excessive mixture is found, remove and examine the adjacent intake pipes on each side of the engine, continuing toward the top cylinders until no excess mixture is found.

When removing intake pipes, loosen the gland nut at the supercharger end first. When installing intake pipes, attach the supercharger end one thread, then attach and tighten the cylinder end before tightening the supercharger end. Use new seals that have been evenly coated with Dow Corning No. 4 Compound, when installing the intake pipe or pipes. Refer to page 141 for specific installation instructions.



Fuel Drain Valve Assembly

Prior to operation of the engine it must be determined that the lower cylinders and intake pipes are completely free of corrosion preventive mixture.

Oil Screens and Strainer — Wash the pressure oil strainer and scavenge oil screens thoroughly in unleaded gasoline. Install the screens and strainer. Install the drain plugs in the sump and rockerbox drain oil manifold and lockwire.

Fuel Drain Valve — Remove the automatic fuel drain valve from the intermediate rear case and flush with unleaded gasoline or naphtha. Check its operation, determining that the plate is not sticking and falls free of its seat when the upper valve assembly drops to its lowest position. The plate, insofar as damage to the engine through flooding with fuel is concerned, is the most important part of the assembly. Reinstall the fuel drain valve.

Fuel Drain Trap — Remove the shipping disc from the fuel drain trap as instructed on the warning tag which is attached to the housing nut. Remove and disassemble the trap using PWA-4591 Wrench. Clean the parts and the trap housing with unleaded gasoline or naphtha; then re-install.

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

Installing Engine in Engine Build-Up Stand — If desired, the engine may be installed in an engine build-up stand for build-up of a complete power unit as the particular installation may demand.

Exhaust Manifolds — Remove the exhaust port covers and install the exhaust manifolds.

For specific installations, refer to the applicable airplane Erection and Maintenance Manual.

Starter — Remove the shipping cover and gasket from the engine mounting pad.

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

Wipe the mounting pad and the starter mounting flange clean, and place a clean, dry gasket on the studs; then mount the starter and secure with washers and nuts.

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

Generator — Remove the cover plate and gasket from the engine mounting pad, wipe the mounting pad clean and reinstall the gasket on the pad.

Remove any paint, grease, and dirt from the generator flange to provide electrical bonding contact for the generator mounting nuts.

Coat the drive spline of the generator with a suitable spline lubricant.

Determine the best mounting position for alignment and attachment of the electrical leads. Place the generator on the mounting studs and secure with locknuts.

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

For additional details, refer to the installation drawings provided by the aircraft manufacturer.

Vacuum Pump — Remove the cover plate and the gasket from the engine pump pad, and wipe the pad clean. Check the oil holes in the pad to insure free oil passage.

Remove the shipping plugs from the two ports, and test the pump manually for freedom of operation.

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

Coat the drive spline of the pump with a suitable spline lubricant.

Place the mounting gasket that is supplied with the pump on the engine mounting pad studs making sure that the oil holes in the gasket line up with the oil holes in the engine mounting pad.

Carefully mate and engage the pump drive with the engine drive member then secure and lockwire.

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

Fuel Pump — Check the part and type numbers stamped on the pump against the specific requirements. Prepare the pump for installation by removing the shipping block from the flange, the dehydrator plug from the inlet port and the plain plug from the outlet port. Oil flushed pumps should be cleaned by flushing with clean unleaded gasoline or naphtha. Turn the drive shaft with the fingers to check freedom of pump operation.

Make certain the mounting surfaces of the pump and engine are clean. Place a new gasket on the studs and mount the pump. Secure with washers and nuts; then lockwire. Connect the proper fuel lines, using an ap-

proved antiseize thread compound, to the inlet and outlet ports. Remove the vent plug from the valve housing cover and install the balance line which vents this outlet with the carburetor top deck. Connect the drive shaft seal drain line to the drain hole.

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

Carburetor — If the carburetor has been prepared for storage, flush it with clear, unleaded gasoline or naphtha.

Fill the carburetor through the fuel inlet opening, remove the drain plugs from "C" and "D" Chambers and allow to drain. Repeat this procedure as many times as necessary to insure that the slushing oil is completely washed out.

If the carburetor has been in storage or is a new carburetor being installed for the first time, fill it with gasoline and allow to soak for at least 8 hours before flight. This insures flexibility of the fuel diaphragms and thus prevents flooding and incorrect metering. If it is impossible to soak the diaphragms for 8 hours, a minimum soaking period of 2 hours is permissible. In the latter case additional idling adjustment, as directed on page 131, will be necessary as the diaphragms become more flexible.

After depreservation, install the carburetor on the engine as described on page 169. To facilitate filling the carburetor for the first start after installation, remove the two ⅛ inch plugs from the top openings leading into "C" and "D" chambers of the carburetor. With the mixture control in normal, pump fuel at a pressure of 2 to 3 pounds per square inch until gasoline appears at these openings. When a booster pump is used, it should be operated intermittently. Replace and lockwire the plugs.

Installing Water Control Unit — Complete instructions on depreserving and installing the water control unit are incorporated in the supplement titled "Water Injection Operation and Service" which follows the Appendix.

Propeller Installation — Complete instructions for the installation of the propeller given in the Service Manual issued by the propeller manufacturer should be referred to before the propeller is installed.

Depreservation Valves, Sparkplugs, and Sparkplug Connectors

Install a PWA-5124 Depreservation Valve in the lower-most sparkplug hole of the following cylinders; 7-8-9-10-11 and 12. Refer to "Initial Ground Run", page 72 for engine operating instructions using depreservation valves. Sparkplugs are to be installed in the balance of the sparkplug holes.

> ***PWA-5124 Depreservation Valves are useful in removing fluid from the combustion chamber and intake pipe of the cylinder in which they are installed. The valve is a check valve so constructed to allow complete suction through the intake pipe on the intake stroke and to allow expulsion of any excess fluid within the combustion chamber on the compression stroke.***

Remove sparkplugs from their shipping container and place them in a rack for vapor degreasing.

Vapor degrease (tri-chloro-ethylene or equivalent) for 1 to 3 minutes (a longer period will do no harm). Vapor degreasing will serve

two functions (1) removes preservative and cleans the plugs, (2) drives off any accumulated moisture.

Remove plugs from degreaser and visually inspect. Observe condition of electrodes and inspect for mutilation of threads as shell and barrel end of plug.

Check the width of the electrode gap. Gaps should measure .011" to .014".

Bomb check the sparkplugs on a BG M519 tester (or equivalent) at 200 PSI. Observe spark to make certain that it occurs at the electrode and is steady. Plug should be rejected if there is failure to fire steadily at 200 PSI or if there is any indication of the plug firing below the electrodes.

Apply champion ✗ 119 anti-seize compound sparingly as a thin film on the first two shell threads.

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

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

Making certain that there is a serviceable copper gasket (only one) on the sparkplug, screw the plug into the cylinder with the fingers until the plug bottoms on the gasket. If the plug does not screw in easily, remove the plug and inspect the plug threads. Tighten the plug to the recommended torque, using PWA-3254 Wrench. On AC-181 sparkplugs, use only special AC AV1-1 Wrench to prevent damage to the plug barrel threads and the insulator. Avoid side loading or "cocking" the wrench.

Remove the plastic protector from the sparkplug lead connectors.

Wipe the hands dry; then using a clean, dry cloth, wipe the connector clean. If necessary moisten the cloth with cleaning naphtha or clean unleaded gasoline.

Visually inspect the connector insulator and spring. Do not touch with fingers. If desired, apply a light film of insulating compound to the connector by means of a clean cloth.

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

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

Run the sparkplug lead coupling nut down finger tight. Hold the lead in proper position and tighten the coupling nut 15 degrees more using PWA-1683 Wrench. Never use an open end wrench, since damage to the barrel insulator may result from side loading.

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

Installation of Engine — Raise the engine carefully by means of a suitable hoist and guide the engine and mount into position in the airplane. Bolt the engine mount to the airplane. Attach all fuel, oil, and control lines to their connections. For specific instructions, refer to the airplane manufacturer's handbook.

Preoiling Engine — Preoiling is required prior to the initial start of a new or newly overhauled engine to insure proper lubrication for all bearing surfaces and other moving parts.

To insure a clean flow of oil into the engine, install a 50 mesh screen in the preoiling system. Connect the preoiling pump to either of the oil pressure gage take-offs on the upper left or right sides of the rear case. Remove the main sump drain plug. Pump oil into the engine at 45 to 65 pounds per square inch pressure at a temperature of 140°F to 160°F (60°C to 71°C) until approximately one gallon of oil flows from the main sump drain plug hole. While the preoiling is in progress, turn the propeller shaft in the normal direction of rotation to prevent the accumulation of oil in the lower cylinders and to aid in the distribution of the oil to the bearings. At completion, install the drain plug and washer in the sump, and lockwire the plug in position.

Fuel And Oil Tank Servicing — Service the Aircraft fuel and oil tanks with the proper grade of fuel and oil as specified on page 4. After the oil tank has been serviced, turn the propeller over several times in order to prime the oil lines and the oil pump.

Prestarting Inspection — Before starting an engine for the first time after installation, the following procedure shall be observed: Check the magneto ground wires for proper connections. Determine that the terminal marked GRD on the ignition switch is connected to the airplane structure. Inspect all mounting bolts and nuts on both the engine and mount to determine that they are tight and properly locked. Inspect the propeller hub for tightness and proper locking. Inspect the pressure gauges, tachometer, thermometer and thermocouple for proper connection. Inspect all fuel, oil and primer lines and connections for working order and proper connections in accordance with the fuel and oil system diagram and the marking on the fuel drain valves. Inspect throttle mixture and clutch controls for proper connections and operate them to determine that they function smoothly over the entire operating range. Open fuel drain valves and operate auxiliary pump and check for fuel leaks. During this latter check, the mixture control shall be in idle cut-off position.

Initial Ground Run — If protector caps have not already been installed, cap or ground the leads to the depreservation valve cylinders with sparkplug terminal protectors before rotating the engine. Rotate the propeller by hand at least 6 revolutions. Start the engine in accordance with the starting instructions set forth on page 70 and operate the engine at 800 rpm to 1000 rpm for approximately 30 seconds. Replace the depreservation valves with sparkplugs and connect the leads. Refer to page 137 for sparkplug installation instructions.

Ground Run-In — Start the engine as directed on page 77.

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

After starting, run the engine slowly (600-800 rpm) for one minute and then at 1000 rpm in order to accomplish a gradual warm-up. After the engine has been warmed up and is functioning normally, run it approximately 1000 rpm for 1 hour. Then increase the speed to 1200 to 1400 rpm for 15 minutes.

During this run it may be necessary to adjust the carburetor idling mixture strength as directed on page 131.

It is recommended that all ground operation be conducted with the engine cowling installed since the overall engine cooling is dependent on the airflow across the engine with cowling installed. While it is possible to maintain cylinder head temperatures within limits at low powers without engine cowling, it is probable that cylinder barrel tempera-

tures will be exceeded due to the reduced airflow. If the barrel temperatures are exceeded the oil film may be destroyed with resultant ring and cylinder barrel damage.

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

After the preceding operation, stop the engine and inspect for leaks, loose nuts, and general condition.

Remove the pressure and scavenge oil strainer, inspect and clean.

Ground tests should be conducted in accordance with the instructions under "Ground Checks."

Take-off power and speed used for new and newly overhauled engines should be limited to the minimum practicable consistent with safety during the first ten hours of operation. Likewise, high power climbs, high BMEP lean mixture cruising (high manifold pressure) and overspeeding should be avoided during this period, except in cases of emergency. Higher than normal cylinder temperatures may be evident for the first several hours of operation until rings are properly seated, and particular care should be taken to insure that specified temperature and manifold pressure limits are not exceeded.

PRESTARTING INSTRUCTIONS

General — Before an engine is started the operator should consult the aircraft manufacturer's handbook for the applicable control position checks and specific ground operating procedures.

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

By means of tests it has been concluded that if a collection of liquid sufficient to cause hydraulic lock is trapped within the cylinder, the starter clutch will slip as the piston locks against this liquid on the compression stroke. In this event, the engine will stop abruptly without damage. It was further determined that after eight revolutions of the crankshaft, the collection of fuel in the intake pipes would be substantially reduced to a quantity which would render hydraulicking of the engine highly improbable.

It has further been determined that after a cold engine has been motored with the starter for a minimum of 12 to 15 crankshaft revolutions, an ample amount of lubrication to the reduction gear pinion bearings has been provided to avoid oil starvation damage, also if oil dilution has been used during the last shutdown, the above recommendation should be followed.

However, while motoring the engine through with the starter, the operator must be alert for any sign of the piston being forced against unusually high compression. This will be evidenced by a sudden slowing down when the starter is engaged. If this condition exists, any further attempt to rotate the crankshaft may result in damage to the engine.

If liquid lock is suspected, remove the front sparkplugs. Check for the presence of fuel or oil which could have caused the lock. If no liquid is found in any of the cylinders or exhaust pipes, leave the front sparkplugs out, and, with the ignition "OFF," crank the engine through, checking to see whether or not liquid is spewed from the sparkplug holes. If there is still no evidence of any condition which could cause hydraulic lock, install the sparkplugs and resume normal starting procedure. If liquid is found in any of the cylinders, remove these cylinders and inspect the linkrods for distortion. This may be checked by placing a straightedge along the sides of the linkrod in two planes, giving particular attention to the area in the vicinity of the linkpin hole. Any distortion of the linkrod, however slight, is cause for removal of the engine. If the linkrods are found to be free from damage, inspect the pistons, pistonpins, cylinders, and cylinder flange bolts thoroughly for evidence of injury. Bolt damage should be suspected if, when a cylinder is being removed, the flange nuts are found to be loose. If no abnormal condition is noted, the engine may be reassembled and considered satisfactory for further service.

Locating the cylinder containing liquid may be quickly and accurately done by performing the following check: Do not move the propeller from the point at which the lock was encountered. For DF-18LN magnetos, remove the breaker cover from either side of the magneto and locate No. 1 lobe on the cam. The No. 1 lobe is identified by a machined dot adjacent to the lobe on the edge of the cam. Starting with No. 1 lobe, count in the direction opposite that in which the cam rotates to, and including the lobe that the contact point follower is resting on. (The direction of the cam is indicated by an arrow on the cam). Apply this count to the firing order of the engine; for example, suppose the follower rests on the fifth lobe of the cam. The firing order of the Double Wasp is 1-12-5-16-9-2-13-6 etc. The lobe firing order is 1-2-3-4-5-6-7 etc. Therefore, cylinder No. 9, the fifth cylinder in the engine firing order, contains liquid.

Personnel — Personnel servicing the aircraft should be cautioned to stand clear when a start is anticipated.

Ignition Switch — The ignition switch must be in the "OFF" position at all times, except as the actual starting procedure may require.

Propeller Control — The propeller control for constant speed propellers will be found in the high rpm (low pitch) position from the previous shut-down. The control should be left in this position in order to reduce the load on the engine during starting and warm-up.

Carburetor Heat — Carburetor heat should be in the cold position (OFF).

Carburetor Air Filter — Carburetor air filter (where applicable) should be in the unfiltered (OFF) position to prevent damage to these installations in case of blockfires.

Cowl Flaps — It is essential that the cowl flaps be fully open during all ground operation.

Oil Cooler — The oil cooler shutters should be closed to assist in heating the oil during the warm-up period.

Mixture Control — The mixture control should be in idle cut-off position until such time as required by the following starting procedure.

Fuel Supply — The fuel supply valve should

not be opened until preparation for starting is made.

Throttle — Consistent starting is dependent to a great extent on the correct positioning of the throttle. With the pressure type carburetor such as used on the Double Wasp engine, the carburetor furnishes fuel entirely as the result of the position of the idle valve, which is directly linked to the throttle, during starting and idling. Air flow has no effect upon the quantity of fuel discharged. If the throttle is too far advanced, the fuel discharge will be too small for the amount of air flow that is being drawn into the cylinders resulting in backfiring and possible damage to the engine. A throttle opening such as recommended under "Starting Instructions" should provide the proper fuel-air ratio to obtain good starting under various conditions.

Priming — For the initial firing charge needed to start an engine, fuel must be supplied by the priming system. The priming system introduces atomized fuel into the air contained in the supercharger case. Under ideal priming conditions a fuel — air mixture of .125 is thus provided. As starter turns the engine through more air is introduced into the Induction System causing the mixture to be leaned out, but before the F/A ratio reaches the lower limit of combustion, a spark will ignite the mixture and a start is accomplished. The actual amount of priming desirable must be learned by experience, however, the operator may estimate the required amount by observing the following gages: Free Air Temperature (temperature of the air drawn into the engine during starting), Carburetor Air Temperature (temperature of the air in the duct), Oil Temperature (stiffness and temperature of the engine), Cylinder Head Temperature (the amount of heat available in the intake ports to vaporize the prime). Excessive priming will load the induction system of a cold engine with raw fuel, making the engine difficult to start. Excessive priming also has a tendency to wash the oil off the cylinder walls and may result in barrel scoring or piston seizure. Subject engines of current manufacture incorporate a carburetor mounted priming system which is of greater capacity than the preceding supercharger rim system. The amount of fuel which is discharged at recommended fuel pressures with the two systems is; Supercharger Prime.....90-100 lbs./hr. at 22 psi.....Carburetor Prime.....225-250 lbs./hr. at 22 psi. Since it is possible to have both type systems on multi-engined airplanes, underpriming of engines with the older type system or over-priming of the carburetor mounted prime equipped engines is a possibility. It therefore would be desirable to have all engines on one airplane equipped with the same type system or at least to have the flight crew aware of the type of system with which each engine is furnished so that proper priming can be accomplished. If the engine has been overprimed it is essential that fresh oil be sprayed on the cylinder walls, through the sparkplug holes, before starting. Care should be taken to insure complete circumferential coverage of the cylinder walls. Dry cylinders may be indicated by a squeaking heard while the engine is being pulled through by hand. Rusting of the piston rings and cylinder walls will occur if the engine is allowed to stand for a day or more after unsuccessful attempts to start. Underpriming usually results in weak firing which does not have sufficient energy to turn the engine over or else causes backfiring through the intake system with attendant hazards. In cold weather, fuel discharged from the fuel drain does not necessarily mean that the engine has been overprimed as only a small portion of the fuel will be vaporized by the priming system. When underpriming is suspected additional priming should be done cautiously.

Use of Oil Dilution System

Oil dilution is regulated by an electrically operated valve which admits fuel at a rate of 1½ to 2 quarts per minute, when desired, to the oil inlet line of the engine, usually at the drain cock, and thus reduces the viscosity of the oil in the engine and oil system. Because of substantial differences in the specific gravity and viscosity of gasoline as compared to aviation oil, there is very little tendency for them to mix when introduced into a common line or tank. However, if the two fluids, in any proportion, are forcibly brought together by some type of mechanical agitation, such as that provided by the oil pressure pump, a very permanent mixture is produced. Once the oil and gasoline are thoroughly mixed, diluted oil will not separate if allowed to stand. Oil dilution installations are usually accompanied by a hopper type oil tank which increases the effectiveness of the dilution by decreasing the amount of oil in circulation.

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

STARTING — A normal cold engine start should be made. Dilution of oil with fuel at the time of the previous stop will permit the starter to turn the engine at a high rate of speed, and no preheating of the oil will be necessary.

In extremely cold weather, adequate dilution will prevent oil cooler or oil line failures due to high pressure developed by the oil scavenge pumps when the engine is started. For conservative operation, however, it is desirable to heat the oil lines, the oil cooler, and accessories at the same time the engine cylinders are being heated.

WARM-UP — During the warm-up period, the gasoline will be gradually evaporated as the temperature of the oil, engine crankcase, and internal parts increases. With the high dilution and extremely cold weather, it will be necessary to perform the warm-up at a slightly higher rpm and for a longer period of time than are normally used.

If oil in the tank or lines is insufficiently diluted, flow to the engine pump will be restricted by the high viscosity of the cold oil. In such cases, it may be noted that oil pressure is unsteady or decreases with an increase in rpm. Oil dilution should be used during warm-up only if extreme temperature conditions do not permit warm-up in the normal manner. Over-dilution, however, can occur, so that oil pressure must be carefully watched for unusual fluctuation or drop-off during the remainder of warm-up, ground test, and the take-off.

If, for some reason, a flight of at least a half hour's duration is not made after warm-up, an appreciable quantity of gasoline will remain in the circulating oil or in the oil tank. This is especially true in extremely

cold weather. The dilution period should thus be shortened when the engine is shut down.

FLIGHT — The dilution valve should not be used in flight. A sudden loss or fluctuation of oil pressure or discharge of oil from the breather during flight can be caused by a leaking dilution valve. Momentarily turning the valve On and Off may assist in correcting the difficulty. Satisfactory operation will be restored after the gasoline has evaporated from the oil. The dilution valve mechanism should be checked after landing.

In extremely cold weather and when using long dilution periods before stopping the engine, the gasoline content of the circulating oil may become extremely high, particularly when the Note above under "Warm-Up" is not observed. Discharge from the breather may occur in this case. Consequently, in extremely cold weather, it is advisable to observe carefully the engine breather outlets during and after take-off. If a discharge from the breathers occurs, it can usually be stopped if the engine speed is reduced to 2000 rpm or lower.

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

STARTING INSTRUCTIONS

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

For proper engine starting sequence consult the airplane manufacturer's handbook. Check the following table for correct control positions before starting the engine:

Starting Control Position Check

Control	Position
Ignition	— Off
Mixture	— Idle Cut-off
Propeller	— High Rpm (Low pitch)
Supercharger (Two Speed Engines)	— Low Impeller Ratio
Carburetor Heat	— Cold (Off)
Filtered Air	— Unfiltered (Off)
Cowl Flaps	— Full Open
Oil Cooler Shutters	— Closed (or automatic)
Throttle	— 1/10 to ¼ open (to give 800-1000 rpm after engine starts).

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

2. Fuel supply — On.

3. Auxiliary fuel pump — On.

4. Motor engine over with the starter. If possible, watch propeller motion. At any sign of hesitation or stoppage, disengage the starter, turn off the auxiliary fuel pump and investigate. *Do not prime* until Step 6.

5. After the engine has turned freely fifteen blades for engines equipped with three-bladed propellers, or twenty blades for engines with four-bladed propellers, turn ignition on BOTH.

To avoid possible damage from hydraulic lock, a minimum of eight crankshaft rotations are required, however a minimum of 12-15 crankshaft revolutions are needed to pro-

vide lubrication to the reduction gear pinion bearings to avoid oil starvation damage. If oil dilution has been used during the last shutdown, the above recommendation should be followed. If oil dilution has been used, and the engine is started within two hours, crank the engine to eliminate hydraulic lock only. (Number of blades required = Number of crankshaft revolutions x number of propeller blades x propeller reduction gear ratio.)

6. Prime while cranking — Intermittently if engine is warm, continuously if cold.

7. After engine fires, slowly ease mixture control out of Idle Cut-Off to Automatic Rich using prime as required until engine is securely started.

8. After engine starts, adjust throttle to 600-800 rpm, watching for oil pressure rise.

If oil pressure does not register on gage immediately after engine starting, STOP engine and investigate. If a start is not effected within a reasonable time, an investigation should be made to ascertain the cause.

9. After oil pressure shows, readjust throttle to 1000 rpm.

WARM-UP

Warm-Up Control Position Check

Control	Position
Mixture	— Auto Rich
Propeller	— High Rpm
Supercharger (Two Speed Engines)	— Low Impeller Ratio
Carburetor Heat	— As needed
Filtered Air	— As needed
Cowl Flaps	— Full Open
Oil Cooler Shutters	— Closed (or automatic)
Throttle	— 1000 Rpm

With an extremely cold engine, the initial warm-up may have to begin at a lower speed if backfiring occurs at 1000 Rpm.

Ignition safety check (1000 Rpm) (May be performed during warm-up.)

a. Switch ignition from Both to Right and back to Both.

b. Switch ignition from Both to Left and back to Both.

c. Switch ignition to Off (momentarily) and back to Both.

A slight drop in rpm when operating on each separate magneto, and complete cutting out of engine at Off position indicates proper connection of ignition leads.

SPECIFIC GROUND CHECKS

The following ground checks must not be made until the oil-in temperature is at least 100°F (approximately 40°C). Make the checks with carburetor heat in the cold position, propeller control in High rpm unless otherwise specified.

Propeller Governor Check

Check propeller governor according to manufacturer's recommendations.

Personnel should be cautioned against using the propeller reverse feature (if applicable) for maneuvering aircraft on the ground and for backing aircraft into position at loading ramps. Such practice is very abusive to engines due to the inadequate cooling under such conditions. Serious damage to engines can occur whenever the reversing feature is used other than during the landing roll of an airplane. Under ground maneuvering condi-

tions the cooling aid flow around the engine is negligible resulting in almost instantaneous abusive temperatures of the cylinders, internal combustion chamber parts, ignition leads, as well as other engine conditions detrimental to satisfactory engine operation. ***Propeller reversing, therefore, should be limited to braking the forward speed of an airplane during the landing roll.***

Power Check

Open the throttle until the manifold pressure is equal to the field barometric pressure. (Indicated by the manifold pressure gage reading before starting the engine.)

The rpm obtained will be approximately 2200, depending on the low pitch setting of the propeller. When the rpm is once established for the installation, variation in altitude of various fields will not change the rpm that will result when opening the throttle to the manifold pressure equal to the field barometric pressure.

If the approximate check rpm cannot be secured when opening the throttle to the proper manifold pressure, either the engine is not delivering the proper power or the propeller is not set properly and an investigation should be made to determine the cause.

Impeller Ratio Selector Valve and Clutch Check

(At manifold pressure equal to field barometric pressure.)

(a) Shift from low impeller ratio to high impeller ratio.

Selector valve and clutch operation is indicated by a rise in manifold pressure (about 2 in. Hg) and a brief drop in oil pressure (maximum oil pressure drop should not exceed 8 psi).

When shifting from one impeller ratio to another, be sure to make the shift quickly, without dwelling between positions. This is to avoid dragging and slipping the clutches.

(b) Shift back to low impeller ratio as soon as satisfactory observation of the shift is made.

A drop in manifold pressure and a brief drop in oil pressure indicates that the clutches have shifted.

Should erratic changes in manifold pressure or other indications of improper clutch or selector valve operation appear, repeat cycle of shifting after first idling engine at 1000 rpm for two minutes to allow heat to dissipate.

Magneto Check

(At manifold presure equal to field barometric pressure.)

(a) Open throttle to required manifold pressure.

(b) Switch ignition from "Both" to "Right" and back to "Both".

(c) Switch ignition from "Both" to "Left" and back to "Both".

Normal drop-off in either "Right" or "Left" position is 50 to 75 rpm and should not exceed 100 rpm. Difference in drop between "Right" and "Left" should not exceed 40 rpm.

Instrument Readings

Check oil pressure, oil temperature, fuel pressure and other items using a manifold pressure which is equal to the field barometric pressure. (Indicated by the manifold pressure gage reading before starting the engine.)

Cylinder Head Temperature

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

To prevent heat damage to seals, gaskets, ignition components and similar items, 200°C or less is desirable for all ground operation.

Fuel Pressure Check

(At manifold pressure equal to field barometric pressure.)

Fuel pressure should be 22 ± 1 psi.

Oil Pressure Check

(Desired adjustment at manifold pressure equal to field barometric pressure.)

Oil pressure should be 85 — 90 psi at 140°F (60°C).

NORMAL OPERATING RANGE:

2000-2200 rpm	60-100 psi
1600 rpm	55- 90 psi
1400 rpm ... Minimum	50 psi
Idling Minimum	25 psi

Water Injection System Check

(a) Turn water injection switch "On".

(b) Advance throttle to obtain 44.0 In. Hg manifold pressure.

(c) Note water pressure.
Allowable range 22 — 25 psi.

(d) Note water flow indicator light (if installed).
Should indicate that control is flowing water into engine.

(e) Note torquemeter reading.

(f) Note fuel flow.

(g) Turn water injection switch "Off" without changing throttle position.

(h) Note water pressure.
Water pressure gage reading will be 0-15 psi depending on the installation.

(i) Note water flow indicator light (if installed). Should indicate that no water is flowing.

(j) Note torquemeter reading.
Should be less than (e).

(k) Note fuel flow.
Should be greater than (f).

(l) Retard throttle.

Do not turn on the water injection system when the engine is not operating. All references to water refer to the recommended water injection mixtures.

Cylinder Head Temperature

Do not exceed 450°F (232°C) cylinder head temperature during ground operation. To prevent heat damage to seals, gaskets, ignition components and similiar items, 392°F (200°C) or less is desirable for all ground operation.

Oil Inlet Temperature

Minimum — 104°F (40°C)
Maximum — 212°F (100°C)

Carburetor Idling Mixture Strength Check (450-500 Rpm).

(a) While observing tachometer, slowly move the mixture control toward idle cut-off, manually adjusting to obtain best power mixture. Note any changes in rpm and/or manifold pressure.

(b) Return mixture control to automatic rich before engine dies.

If a momentary rise of not more than 20 rpm is observed before normal drop-off, mixture strength is correct. If greater rise in rpm is noted, the mixture is too rich. If no rise in rpm is noted the mixture is too lean.

This check should be made in relatively still air with cylinder head temperatures at stabilized idling temperature. A strong wind or abnormal cylinder temperatures affect the rpm change. If an adjustment is necessary, refer to page 131 for specific instructions.

Prolonged periods of idling may lead to the fouling of the sparkplugs. "Clearing Out" of the engine at 10 minute intervals is recommended. This should be done by running the engine up to field barometric pressure for one minute after each 10 minutes of idling. This recommendation is particularly pertinent during extended idling while awaiting runway clearance before take-off.

Engine Equipment or Accessories Check

Consult airplane manufacturer's instructions for other engine equipment or accessories checks.

Stopping

If a cold weather start is anticipated, refer to instructions on the "Use of Oil Dilution" page 76.

a. Idle until cylinder head temperature is less than 400°F (approximately 200°C).

b. Move mixture control to idle cut-off.

If idle cut-off does not stop engine, close throttle, turn ignition off, then slowly open throttle.

c. When engine stops, turn ignition off.

d. Turn fuel selector off.

e. After stop, leave cowl flaps *wide open* for at least 15 minutes.

Use of Torquemeter For Power Calculation

Calculation of the power as indicated by the torquemeter gage may be made as follows;

1. If a torque pressure gage is used:
   a. Observe torque pressure and rpm.
   b. BHP=RPM x K x Torque pressure (K=0.00632 for engine with 0.450:1 propeller reduction gear ratio)
2. If a bmep gage is used:
   a. Observe bmep and rpm.
   b. $BHP = \frac{RPM \times BMEP}{K}$

   (K = 283)

The torquemeter does not reflect the power absorbed by engine accessories, cabin superchargers, etc.

Cockpit Check of Fuel System

The following check of the fuel system should be made prior to the initial ground run and during the daily engine check. The check is made from the cockpit and is based on the principle of trapping fuel under pressure between the fuel selector valve and fuel feed valve nozzle. If the fuel gage is connected to indicate differential pressure between pump and metered fuel pressure, the line from the gauge to the metered fuel line should first be disconnected and capped.

With the ignition switch off and the carburetor mixture control in idle cut-off position, open the fuel selector valve and start the booster pump. (In some installations, booster pump operation is automatic with selector valve operation.)

When the fuel pressure gauge indicates that the fuel pressure is stabilized, move the mixture control to auto-rich position, then immediately turn the selector valve off and stop the booster pump.

If the fuel pressure now stabilizes slightly below nozzle opening pressure for two minutes, the fuel system between the selector valve and the fuel valve is tight. Return mixture control to idle cut-off.

If the pressure fails to stabilize at approximately nozzle closing pressure and drops rapidly to zero, then a second check must be made to localize the trouble.

With the ignition switch off and the carburetor mixture control in idle cut-off, open the

fuel selector valve and start the booster pump. When the fuel pressure gauge indicates that the pressure is stabilized, turn the selector valve off and stop the booster pump.

If the pressure stabilizes above fuel nozzle discharge pressure, then the system between the fuel selector valve and the carburetor vent valve is tight and a check for leakage should be made between the carburetor and the engine. If no leakage is found, the fuel feed valve should be removed, and tested as described on page 171.

If the pressure does not stabilize and falls rapidly to zero, then the system between the fuel selector valve and the carburetor vent valve is not tight and the usual checks should be made, starting with the vapor vent valve.

Repeat the first check to further insure that there is no leakage in the system. Return mixture control to idle cut-off.

Leakage at the fuel feed valve housing smaller seal will not affect fuel pressure in the foregoing tests. However, it may be recognized by rough engine operation or by excessively rich mixture in a group of cylinders in the low power range.

When this test is completed, make sure that all fuel is drained from the supercharger and the lower cylinders before attempting to start the engine.

PERIODIC INSPECTION

INDEX

Service inspection and associated maintenance include periodic inspection, cleaning, lubricating, adjusting, and all maintenance work associated with the routine inspection of the engine.

When an engine is new or has just been overhauled, it should be given a thorough check no later than 30 hours after it has been installed in the airplane. In the following periodic inspection schedule, it is suggested that "A" represent a 50 hour inspection period, "B" 100 hour, "C" 200 hour, and "D" the mid-point period between overhauls. Experience and the type and conditions of operation should establish an actual hourly inspection period breakdown similar to that given above, for each operator. Any periodic inspection should of course be performed each time the interval established for that inspection has elapsed.

PERIODIC INSPECTION SCHEDULE							
NATURE OF INSPECTION	**Preflight**	**Daily**	**A**	**B**	**C**	**D**	**REMARKS**
GENERAL							
Check operation of low and high ratio clutches (two speed engines).	✓						Refer to page 79.
Remove sufficient cowling to check engine section for leaks and failure.		✓					
Inspect engine ring cowling for security of attachment.		✓					Not excessively tight when engine is cold.
Inspect fire seal diaphragm for security of attachment.		✓					
Inspect propeller governor for oil leaks.		✓					

PERIODIC INSPECTION SCHEDULE							
NATURE OF INSPECTION	**Preflight**	**Daily**	**A**	**B**	**C**	**D**	**REMARKS**
Inspect engine section for oil throwing.		✓					
Inspect breather and magneto vent air intake screens and clean if necessary.		✓					
Inspect for loose nuts and broken lockwire.		✓					Frequently indicated by signs of oil or fuel leakage.
Inspect drain plugs and covers for proper lockwiring.			✓				
Check cowl flap operation and general condition.			✓				
Inspect deflectors for security and fin clearance.			✓				
Inspect cylinders for general condition.			✓				Refer to page 159.
Inspect cylinder bolts and flange nuts for tightness.			✓				If one or two cylinder flange nuts on any one pad are found to be loose to the extent that there is clearance between the nut and the flange and if this looseness is known to have existed during previous engine operation, replace the bolts engaged by, and on each side of, the loose nuts. If more than two nuts are loose, inspect, and if necessary, lap the

PERIODIC INSPECTION SCHEDULE							
NATURE OF INSPECTION	**Preflight**	**Daily**	**A**	**B**	**C**	**D**	**REMARKS**
							cylinder flange as directed on page 161 under "Cylinder Barrels", replace all of the flange bolts for that cylinder pad.
Remove rear section oil drain plug.			✓				Located on bottom of rear case to left of pressure oil strainer drain plug. Removal allows drainage of any acid and water that have settled out of the oil in low areas of rear case.
Inspect pushrod cover nuts for tightness and lockwiring.			✓				
Inspect thermocouple leads and connections for tightness.			✓				
Inspect exhaust piping for cracks and signs of burning.			✓				Slipjoints should be free, and all connections tight.
Examine all engine control linkages; remove excess play. Oil joints and bearings if necessary.			✓				
Inspect accessory pumps for security of mounting.			✓				
Inspect clamps, bonding, rods, and lines.				✓			
Inspect mounting brackets for condition and security.			✓				

PERIODIC INSPECTION SCHEDULE							
NATURE OF INSPECTION	**Preflight**	**Daily**	**A**	**B**	**C**	**D**	**REMARKS**
Inspect engine mount for cracks, tightness, and lockwiring.			✓				
Flush the clutches.				✓			Refer to page 130 for specific instructions.
Inspect fuel, oil and pressure gage lines for brittleness.							At engine change. Anneal copper or brass lines that are brittle.
IGNITION SYSTEM							
Remove sparkplugs and install new or reconditioned sparkplugs.				✓			Operating conditions may establish a longer period before removal.
Inspect ignition manifold for loose connections, damaged sparkplug leads, chafing, and security of mounting.		✓					
Inspect sparkplug lead ceramic connectors for presence of oil, dirt, cracks, and carbon tracking.					✓		Remove dirt and oil with a clean lint-free cloth. If necessary dampen with Varsol. If necessary replace ceramic connector.
Inspect the induction vibrator terminals and cables for security and broken insulation.			✓				

PERIODIC INSPECTION SCHEDULE							
NATURE OF INSPECTION	**Preflight**	**Daily**	**A**	**B**	**C**	**D**	**REMARKS**
Inspect magneto ground wires for security.			✓				
Remove ground wire from magneto, clean, inspect, and install.					✓		
Clean threads on high tension leads nuts, coupling bushings, and terminal blocks. Check breaker point timing to respective "E" gap position as well as proper spark advance angle, lubricate cam followers as required.				✓			Use a lint-free clean cloth dampened with Varsol. Wipe with a dry, clean cloth. Allow sufficient time for traces of cleaning solvent to evaporate before replacing.
Inspect sparkplug lead elbow nuts for tightness and security.			✓				Do not tighten excessively.
Inspect starter, generator, and magnetos for security of mounting and for condition.			✓				
Inspect all oil lines and connections for leaks, dents, cracks, chafing and security.				✓			
Inspect connections and clamps for general condition, location, and tightness.				✓			

PERIODIC INSPECTION SCHEDULE							
NATURE OF INSPECTION	**Preflight**	**Daily**	**A**	**B**	**C**	**D**	**REMARKS**
LUBRICATION SYSTEM							
Remove and clean pressure oil strainer.				✔			Examine strainer, screen, manifold, and sump plugs for metal particles.
	The introduction of gasoline into the engine oil system tends to loosen carbon and sludge deposits within the system. This carbon and sludge may collect in the engine pressure oil strainer in sufficient quantity to cause the strainer to collapse. Therefore, if gasoline is used to dilute the engine oil during cold weather operation, the engine oil strainer must be removed for inspection and cleaning within an hour or two after the dilution is first used in the season. This inspection and cleaning must be repeated at short intervals until the sludge and carbon no longer collect.						Examine strainer and sump plugs for metal particles or other foreign matter. If metal chips are found, they may be an indication of trouble within the engine and further investigation should be made to discover their source. In a new installation, the oil system has not always been entirely cleaned of metal particles and it is not necessarily cause for alarm when particles appear. If nothing wrong can be discovered after foreign matter has been found in the strainer or plugs, check these parts again after the engine has been given a ground test using new oil. If the quantity of metal chips found after a second ground test is sufficient to warrant removal of the engine, the oil tanks and lines should be cleaned and the oil cooler replaced before a new engine is installed.

PERIODIC INSPECTION SCHEDULE							
NATURE OF INSPECTION	**Preflight**	**Daily**	**A**	**B**	**C**	**D**	**REMARKS**
Remove sump plugs and examine cavity for metal particles.				✓			
Remove and clean scavenge oil strainer.				✓			
Inspect all oil lines and connections for leaks, dents, cracks, chafing, and security.				✓			
Remove rockerbox drain oil manifold plug and inspect plug cavity for metal particles.				✓			
Inspect oil for sludge and carbon.				✓			The presence of carbon and sludge indicates the need for an oil change.
Change oil.							The time between oil change should be determined by the type and conditions of operation to which the engine is subjected. When the oil tank has been refilled, turn the propeller several times in order to prime the oil lines and oil pump.
FUEL AND INDUCTION SYSTEM							
Check fuel strainers and tank drains. Inspect for water and foreign matter.		✓					

PERIODIC INSPECTION SCHEDULE							
NATURE OF INSPECTION	**Preflight**	**Daily**	**A**	**B**	**C**	**D**	**REMARKS**
Check operation of fuel drain valve.			✓				Using a piece of hose or the bare tube end itself, blow into the fuel drain line. If, after a few seconds of blowing, there is a sudden stoppage or restriction in the air passage, the fuel drain valve is operating. If the valve is stuck open, there will be no automatic closing of the valve, as indicated by the results of the above check. If the valve is stuck closed, pressure will be built up immediately in the drain line and prevent any further blowing in the line. If the drain valve is stuck in either position, it should be removed and cleaned. The fuel booster pump should not be used to check the operation of the valve.
Remove automatic mixture control unit.						✓	Check the unit for proper setting at midpoint between overhauls.
Check carburetor and fuel lines for leaks with pressure up.			✓				Fuel booster pump on.
Inspect fuel line supports and clamps for security, chafing, and looseness.			✓				

PERIODIC INSPECTION SCHEDULE							
NATURE OF INSPECTION	**Preflight**	**Daily**	**A**	**B**	**C**	**D**	**REMARKS**
Inspect all fuel lines and connections for bends, cracks, leaks, and signs of abrasion or interference with other parts.			✓				
Remove fuel drain trap.						✓	Remove and clean the float assembly. Inspect the float support stem for smoothness. Check the general condition of the float. If the float appears to be in good condition, and will float in gasoline, or kerosene, when assembled on the float support, it will be satisfactory for reuse.
Inspect all shut-off cocks for leakage in open and closed positions.			✓				
Inspect throttle and mixture controls for tightness and lockwiring.			✓				
Inspect carburetor air screen.			✓				Clean if necessary.
Inspect fuel strainers. Check carburetor float chamber for air lock.			✓				Clean the fuel strainers and install. Replace plugs, drain valves, and covers and lockwire them. Disconnect the vapor vent return line at the carburetor and pump gasoline to the carburetor with the booster pump.

PERIODIC INSPECTION SCHEDULE							
NATURE OF INSPECTION	**Preflight**	**Daily**	**A**	**B**	**C**	**D**	**REMARKS**
Clean all screens and strainers.			✓				
Remove and clean the fuel drain valve. Check for free movement of plate.			✓				Refer to page 68.
Inspect intake pipe nuts for tightness.			✓				Look for evidence of leakage at intake pipe nuts and unions. Excessive tightening of the nuts will tend to nick the pipes.
WATER INJECTION SYSTEM							
	Complete service instructions for the water injection system is incorporated as a supplement and follows the Appendix of this publication.						

TROUBLE SHOOTING

INDEX

This section outlines the most common symptoms of engine troubles, their possible causes, and remedies. It is intended to guide and expedite the work of the trouble shooter. Locating and correcting engine troubles should be accomplished by first studying the symptoms carefully and then checking each possible cause, beginning with the most probable, until the exact cause of the trouble is determined. Because some engine troubles are evident in only one range of engine speed, the engine's operation should be observed at low, medium and high speeds, whenever possible.

Before attempting to work on an engine which has been reported faulty in flight, consult the pilot's flight report and all other available sources for any pertinent information which might give a clue to the cause of the trouble.

Whenever irregular ground or flight operating characteristics are observed that can definitely be attributed to engine malfunctioning, or, whenever replacement of an engine part, requiring considerable labor is anticipated, it is advisable to remove the main oil strainer, drain the sump and inspect the oil for metal particles before attempting to locate the trouble or replace any parts. This procedure may eliminate subsequent and unnecessary labor and inspection.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES	REMEDIES
	Engine Starts But Fails to Run When Booster Switch is Released	
	IGNITION SYSTEM (Low-Tension System)	
Defective Magneto.		Inspect plug-in connector at magneto for looseness, magneto incorrectly timed to engine, wiring in magneto defective.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES Engine Fails to Start on Booster	REMEDIES
Defective Distributor.		Check for and correct the following: dirty or broken carbon brushes, foreign particles short-circuiting segments, dirty or glazed contact points, breaker out of adjustment, distributor incorrectly timed to engine, defective primary condenser or broken primary lead (manifold to distributor.)
Defective Manifold.		Inspect for broken or shorted primary wire, magneto-to-distributor, loose connection in the distributor block.
Defective Magneto.		Inspect plug-in connector for looseness at magneto, magneto coil wire for looseness, magneto coil for looseness, and for defective wiring in magneto.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES	REMEDIES
	Engine Seems Smooth on Either Side But Has Excessive Drop on One Side	
Defective Distributor.		Inspect for dirty or broken carbon brushes, dirty or glazed contact points, breaker out of adjustment, distributor incorrectly timed to engine, defective primary condenser, or broken primary lead (manifold to distributor).
Defective Manifold.		Inspect for broken or shorted primary wire (magneto to distributor), or loose connection in distributor block.
Defective Magneto.		Inspect plug-in connector at magneto for looseness, magneto coil wire loose, magneto coil loose, wiring in magneto defective, and for defective magneto coil.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES Engine Seems Rough on Either Side, Drop About Equal	REMEDIES
Defective Coil and High-Tension Leads.		Inspect for loose plug-in connector at coil, moisture or dirt in coil high-tension sock ets, high-tension lead insulation defective, or primary coil open circuited.
Defective Magneto.		Inspect for loose plug-in connector magneto, magneto incorrectly timed to engine, loose magneto coil wire, loose magneto coil, defective wiring in magneto, or defective magneto coil.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES	REMEDIES
	Excessive Drop And Roughness on One Side Only	
Defective Distributor.		Inspect for dirty or broken carbon brushes, foreign particles short-circuiting segments, dirty or glazed contact points, breaker out of adjustment, distributor incorrectly timed to engine, defective primary condenser, or broken primary lead (manifold-to-distributor).
Defective Manifold.		Inspect for broken or shorted primary wire (distributor-to-coil), broken or shorted primary wire (magneto-to-distributor), or loose connection in distributor block.
Defective Coils and High-Tension Leads.		Inspect plug-in connector at coil for looseness, moisture or dirt in coil high-tension sockets, high-tension lead installation defective, open circuited primary coil, defective secondary coil.
Defective Magneto.		Inspect magneto for loose plug-in connector, loose magneto coil wire, loose magneto coil, defective wiring in magneto, and for defective magneto coil.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES Engine Cuts Out on One Side	REMEDIES
Defective Distributor.		Inspect carbon brushes (dirty or broken), dirty or glazed contact points, breaker out of adjustment, distributor incorrectly timed to engine, defective primary condenser, and for broken primary lead (manifold-to-distributor).
Defective Manifold.		Inspect for broken or shorted primary wire (magneto-to-distributor), and for loose connection in distributor block.
Defective Magneto.		Inspect magneto for loose plug-in connector, loose magneto coil, and for defective wiring in magneto.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES	REMEDIES
	Engine is Rough at High Power	
Defective Distributor.		Inspect for dirty or broken carbon brushes, foreign particles short circuiting segments, dirty or glazed contact points, breaker out of adjustment.
Defective Manifold.		Inspect for loose connection in distributor block.
Defective Coils and High-Tension Leads.		Inspect for plug-in connector at coil, moisture or dirt in coil high-tension sockets, defective secondary coil.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES							REMEDIES
	Failure to Start	Rough Running	Low Power	Improper Idling	Improper Acceleration	Rich Mixture	Lean Mixture	
IGNITION SYSTEM (GENERAL)								
Internal trouble with magnetos.	✓	✓						Replace magneto.
Defective booster.	✓							
Improper spark advance setting.		✓	✓	✓	✓			Check spark advance setting. Refer to page 120.
Insufficient cranking speed.	✓							Check batteries and starter. Connect booster battery.
Defective sparkplugs.	✓	✓	✓	✓	✓			Determine whether front or rear plugs are defective by magneto check. Remove the plugs and replace them with new or reconditioned plugs.
Defective sparkplug lead connectors.	✓	✓	✓	✓	✓			Clean dirty connectors with a clean dry cloth. Replace damaged connectors. If necessary, Varsol may be used for cleaning.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES							REMEDIES
	Failure to Start	Rough Running	Low Power	Improper Idling	Improper Acceleration	Rich Mixture	Lean Mixture	
Moisture or oil in distributor.	✓	✓	✓	✓	✓			Clean distributor rotors with Varol, using clean cloth. Wipe clean with dry cloth. Check vent lines and screens for foreign matter.
Ground manifold or lead from magneto ground connection to cockpit switch grounded.	✓	✓		✓	✓			Check wiring between ground connection and switch.
Magneto incorrectly timed to engine.	✓	✓	✓	✓	✓			Check magneto timing. Refer to page 120.
Dirty, burned, or pitted breaker points.		✓	✓					Clean dirty points. Replace points badly burned or pitted.
Moisture or oil in magneto.	✓	✓		✓	✓			Wipe breaker compartment, distributor rotor, block, and bowl with a clean dry cloth.
FUEL AND INDUCTION SYSTEM								
Insufficient fuel pressure.	✓	✓	✓					To increase pressure, turn adjustment screw on fuel pump to right.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES							REMEDIES
	Failure to Start	Rough Running	Low Power	Improper Idling	Improper Acceleration	Rich Mixture	Lean Mixture	
Vapor in fuel system.	✓	✓						Remove vent plug from carburetor, and operate booster pump until fuel spurts from vent; then reinstall vent plug.
Incorrectly adjusted carburetor control linkage.		✓	✓	✓				Adjust linkage so that movement of cockpit controls results in corresponding correct movement of throttle and mixture control levers.
Incorrect carburetor idle adjustment.				✓				Adjust carburetor idle mixture. Refer to page 131.
Air leaks or restrictions.	✓	✓	✓	✓				Check air scoop for foreign matter. Check security of carburetor and intake pipe nuts. Check for loose or disconnected primer lines.
Fuel feed valve leaking or not operating properly.		✓		✓	✓			Remove fuel feed valve, disassemble, inspect and reinstall. Refer to page 171.
Clogged fuel lines.	✓	✓		✓	✓		✓	Locate clogged lines, remove, clean, and reinstall.
Accelerating pump faulty.		✓		✓	✓	✓	✓	Replace carburetor.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES							REMEDIES
	Failure to Start	Rough Running	Low Power	Improper Idling	Improper Acceleration	Rich Mixture	Lean Mixture	
Lack of fuel or wrong grade of fuel.	✓	✓	✓	✓	✓			Check fuel gage. Fill tank with recommended grade of fuel. Refer to page 6.
Fuel leaks.	✓	✓				✓	✓	Check lines, connections, joints and clamps.
Underpriming.	✓							Increase priming. Check fuel booster pump pressure. Check for clogged lines, leaks and operation of primer solenoid valve.
Overpriming.	✓							With ignition off, and carburetor mixture control in idle cut-off, open throttle fully and rotate propeller. Repeat starting procedure, maintaining priming to a minimum.
Defective priming solenoid valve.	✓	✓		✓		✓		If prime fuel is excessive, check priming solenoid valve for leakage and sticking. Replace solenoid valve if necessary.
Fluctuating fuel pressure.	✓	✓	✓					Check fuel gage to make sure tanks are full. Check operation of fuel and booster pumps. Repair or replace pumps if necessary.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES							REMEDIES
	Failure to Start	Rough Running	Low Power	Improper Idling	Improper Acceleration	Rich Mixture	Lean Mixture	
Excessive fuel pressure.		✓		✓		✓		To decrease pressure, turn adjustment screw on fuel pump to left.
Internal carburetor trouble.	✓	✓	✓	✓	✓	✓	✓	Replace carburetor.
Defective automatic mixture control unit.			✓		✓	✓	✓	Indicated by an engine which runs either too rich or too lean at altitude or at extreme ground temperatures. The unit should be checked for proper setting at midpoint between overhauls. Replace unit if necessary.
Dirt and grime on the venturi tubes.			✓				✓	Remove the air screen and clean the venturi surfaces. The characteristic of lean metering, due to dirt on the boost venturis, is especially present at high airflows such as those encountered during climb and take-off operations. Such a condition may be evidenced by increased cylinder head temperatures.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES							REMEDIES
	High Oil Pressure	Low Oil Pressure	Total Loss of Oil Pressure	High Oil Temperature	Low Oil Temperature	High Oil Consumption	Oil Foaming	
LUBRICATION SYSTEM								
Defective oil pressure gage.	✓	✓						Repair or replace gage.
Defective oil temperature gage.				✓	✓			Repair or replace gage.
Diluted, contaminated, or inadequate oil supply.		✓		✓		✓	✓	Drain engine and tank. Refill with oil of grade 100 (S.U.S. at 210°F).
Obstructions in main oil tank.		✓		✓				Drain oil and clean tank.
Obstructions or leaks in oil lines.		✓	✓	✓		✓		Check oil lines, remove obstructions, and repair leaks. Replace cooler if necessary.
Improper operation of oil cooler.				✓	✓			Check oil cooler shutter operation. Check for obstructions. Replace cooler or cooler control unit if necessary.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES							REMEDIES
	High Oil Pressure	Low Oil Pressure	Total Loss of Oil Pressure	High Oil Temperature	Low Oil Temperature	High Oil Consumption	Oil Foaming	
Clogged main oil strainer.		✓	✓	✓				Remove and clean strainer.
Excessive oil dilution.		✓		✓		✓	✓	Drain oil from engine and oil system. Check operation of oil dilution valve. Inspect valve seat for cleanliness. Replace valve if necessary. Refill tank with oil of grade 100 (S.U.S. at 210°F).
Improper operation of oil pressure relief valve.	✓	✓	✓					Remove any foreign material and check seating of valve. Check valve spring. Replace spring of insufficient or excessive pressure or length.
Leaking oil dilution valve.		✓				✓		Check oil dilution valve for leaks. Repair or replace valve if necessary.
Defective oil pump.	✓	✓						Clean pump and leaking seals. Replace pump if necessary.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES							REMEDIES
	Misfiring	Improper Acceleration	Improper Idling	Low Power	Vibration or Rough Running	Temperature Cylinder High	Loss of Compression	
PROPELLER								
Loose thrust nut.					✓			Remove propeller, inspect propeller shaft splines for cracking and galling. Tighten thrust nut, to the recommended torque, and replace propeller if shaft is acceptable.
Propeller not tracking evenly.			✓		✓			Replace propeller.
Propeller out of balance.			✓		✓			Replace propeller.
GENERAL								
Loose air ducts.				✓	✓			Check all air duct connections and supports. Tighten where necessary.
Loose cowling supports or loose exhaust manifolds.					✓			Check and tighten where necessary.

TROUBLE SHOOTING TABLE

CAUSES	TROUBLES							REMEDIES
	Misfiring	Improper Acceleration	Improper Idling	Low Power	Vibration or Rough Running	High Cylinder Temperature	Loss of Compression	
Loose or broken engine mounting brackets.					✓			Replace broken bracket assemblies. Refer to manufacturer's publications for required torque.
Faulty operation of propeller or governor.		✓	✓			✓		Refer to manufacturer's applicable publications.
Improper valve clearances.		✓	✓	✓	✓	✓		Adjust valve clearances. Refer to page 128.
Sticking valves.	✓	✓	✓	✓		✓		Lubricate sticking valves. Replace cylinder if necessary.
Broken valve springs.		✓	✓	✓	✓	✓	✓	Install new springs. Refer to page 157.
Worn or sticking piston-rings, cracked pistons or cylinder heads.			✓	✓		✓	✓	Locate by compression check. Replace piston and cylinder assembly as described on pages 154 through 169.
Excessive carbon deposits in cylinder head.						✓		Replace piston and cylinder assembly as described on pages 154 through 169.

LINE MAINTENANCE

INDEX

Pratt & Whitney engines give dependable and maximum performance provided they are properly serviced, periodically inspected, and overhauled at regular intervals. Between periods of overhaul, the replacement of valves, pistons, cylinders, or ignition system is not recommended except in case of emergency.

Should internal engine trouble be indicated at any time, remove the scavenge oil strainer and the pressure oil strainer, allowing the oil to drain through a clean cloth into a suitable receptacle. Inspect the cloth, plugs, and strainer for foreign material, such as metal chips. A careful examination of this material may offer a clue for the course of further investigation.

If, for some reason, it is necessary to adjust the valve clearances, retime and synchronize the magnetos, or to remove a cylinder prior to the time of engine overhaul, the following pages describe the correct procedure.

For torque recommendations refer to "TORQUE RECOMMENDATIONS" on page 207.

LOCKWIRING

GENERAL — Lockwiring is the most positive and satisfactory method of securing in place the various bolts, nuts, and studs which hold together the parts of an engine and which cannot otherwise be satisfactorily locked. Generally speaking, lockwiring is the tying together of two or more parts in such a manner that any tendency of any one part to loosen will automatically be encountered by the tightening of the wire. Cotterpins are usually associated with castle nuts; however, if the castle nut is used on a stud, a cotterpin would secure the nut to the stud, but would not prevent the stud from backing out of the housing. In a case such as this, the lockwire will act as a cotterpin and if the wire is then attached to an adjacent part, the stud also will be held securely in place.

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

A. LOCKWIRE MUST ALWAYS TEND TO TIGHTEN. The wire must be installed in such a way that it will always counteract any tendency of the part to loosen. In other words it must always tend to tighten and keep the part locked in place.

B. LOCKWIRE MUST NEVER BE OVERSTRESSED. Extreme care must be exercised when twisting the wires together to insure that wires are securely tightened but not stressed to the point where they will break under a slight load.

C. LOCKWIRE MUST BE TIGHT WHEN INSTALLED. That is most important to prevent vibration with resultant fatigue and failure, and also to prevent the wire from rubbing against some adjacent part, causing wear.

D. LOCKWIRE ENDS MUST ALWAYS BE BENT TOWARD THE ENGINE. This is primarily a safety percaution to guard against possible injury to the hands of the mechanics working on the engine. It is also imperative that the part or parts to be lockwired are torqued to specifications and the holes properly aligned before any attempt is made to proceed with the lockwiring.

HOLE ALIGNMENT — Check the units to be lockwired to make sure that they have been correctly torqued and that the wiring holes are properly positioned in relation to each other. When there are two units, the hole in the first unit should be between the three and the six o'clock positions and the hole in the second unit between the nine and twelve o'clock positions **[1]**.

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

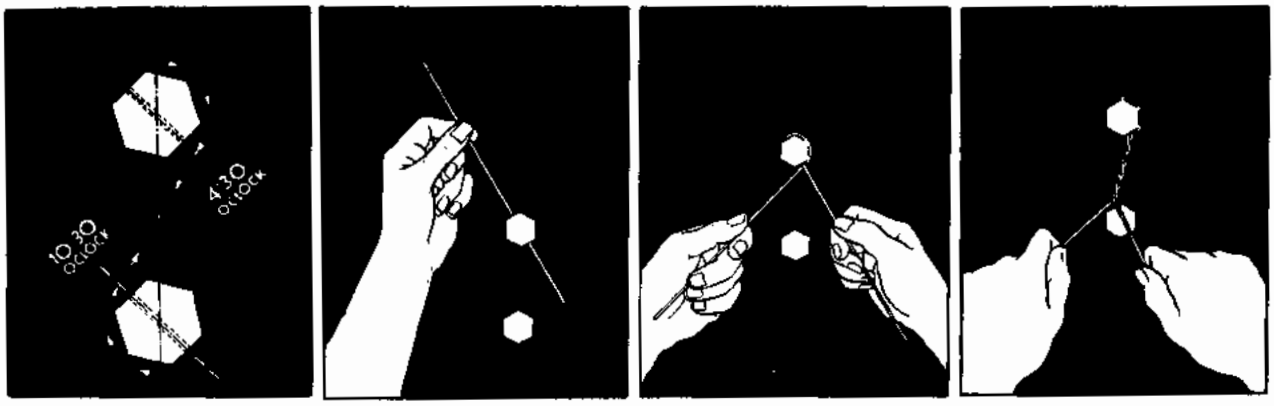
PROCEDURE — Bolts will be used for the purpose of describing the following general wiring procedure.

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

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

b. Grasp the left end of the wire with the fingers and bend it clockwise around the head of the bolt and under the other end of the wire **[3]**.

c. Pull the loop very tight all around the head of the bolt with the pliers. Grasp the wire only at the end in order not to mutilate any portion which is to be twisted. Holding the wire ends apart and keeping the loop tight around the head of the first bolt, twist the wires around each other in a clockwise direction to form the braid. Continue twisting



[1] *[2]* *[3]* *[4]*

the wires by hand toward the second bolt until the end of the braid is just short of the second bolt's hole which lies between the nine and the twelve o'clock positions **[4]**.

d. Make sure that the loop around the head of the first bolt is still tight and in place; then grasp the wires in the jaws of the pliers just beyond the end of the braid and, with the braid held taut, twist in a clockwise direction until the braid is stiff **[5]**.

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

e. After making sure that the braid is not so long that it cannot be pulled taut between the bolt, insert the end of the wire which is on top through the hole between the nine and the twelve o'clock positions on the second bolt head. Grasp the end of this wire with the pliers and pull braid taut **[6]**.

f. Bring the other end of the wire counterclockwise around the head of the second bolt and under the wire end which protrudes from the bolt hole **[7]**.

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

h. Grasping the ends of the wire beyond the twist with pliers and keeping the wires under tension, twist them tight in a counterclockwise direction. With the final twisting motion of the pliers, bend the twisted wire ends to the right around the head of the second bolt **[9]**.

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

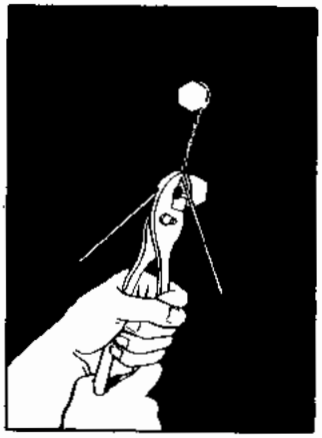
> ***Do not twist off the ends of the wires with pliers.***

BASIC TYPES OF WIRING

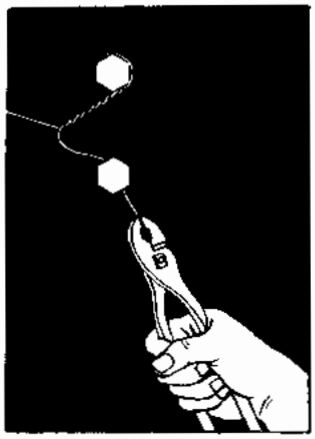
Many separate wiring operations are required, most of which are covered by the seven basic examples illustrated here **[11]**.

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

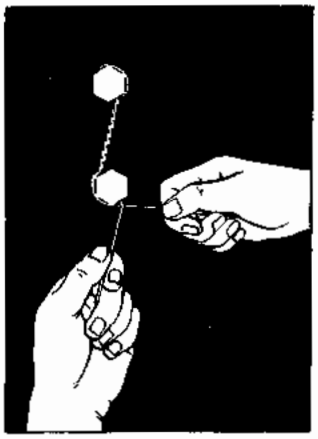
Example 2 illustrates the proper method of wiring a bolt or similar part to a castle or slotted nut.



[5]



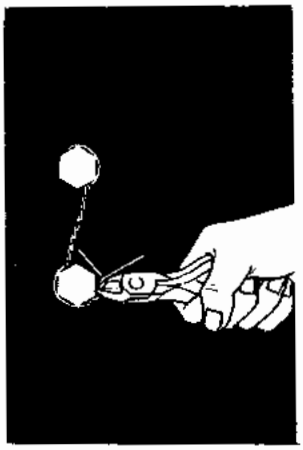
[6]



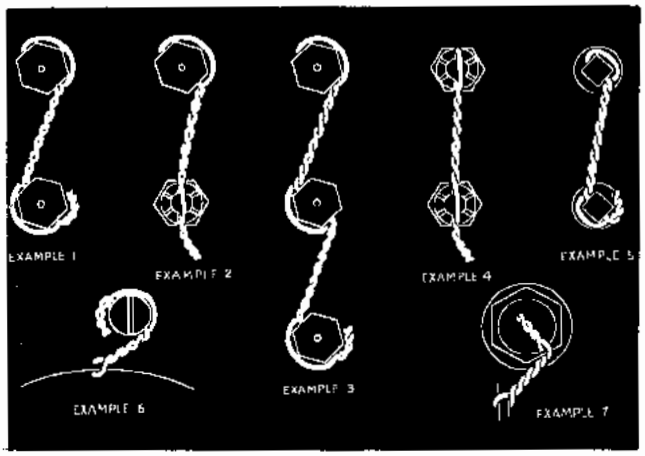
[7]

[8]

[9]



[10]



[11]

Example 3 shows how to wire three or more units together. Note that the braid between the second and third units should be twisted counterclockwise so that the wire from the hole in the second unit will be on top of the loop around the second unit to hold it down in place. The wire inserted in the lockwire hole in the third unit should be the lower wire of the braid and beyond the third unit this wire should be brought over the other wire to secure the loop in place around the head of the third unit.

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

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

CHECKS AND ADJUSTMENTS

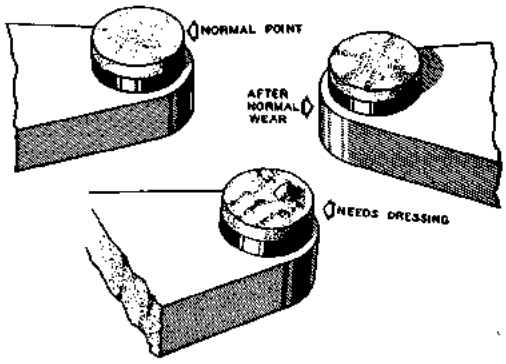
BREAKER POINTS

The breaker points seldom need attention between overhauls. Under normal conditions the wear or burning of the breaker points offsets the wear of the fiber cam follower, and the spark timing tends to remain approximately at its original setting. However, a faulty condenser or the presence of oil or grease on the breaker points may cause excessive burning of the points, or lack of lubrication may lead to excessive wear of the cam follower. If the wear at one of these locations exceeds the wear at the other, a change in spark timing results. If the points require attention beyond adjustment, replace the breaker assembly with a new or reconditioned unit.

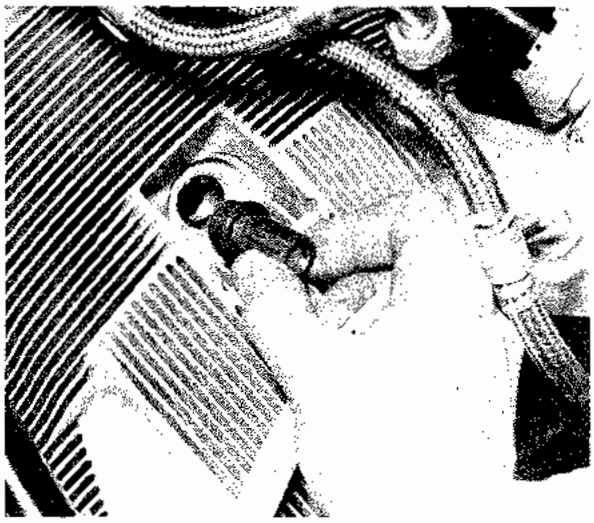
As a safety precaution, when making ignition checks, disconnect the primary leads from the collector plate of each distributor assembly (Low Tension System), or disconnect the magneto outlet conduit from the ignition manifold (High Tension System).

BREAKER POINT INSPECTION — If the breaker point surfaces are fouled with oil or dirt, or are burned **[12]** excessively, replacement of the complete breaker assembly is recommended. In an emergency, when no replacement parts are available, a fouled assembly can be made serviceable for temporary use by removing and washing the point surfaces carefully, using cleaning naphtha (Stoddard Solvent) as a cleaning agent. When this is done, the cleaning agent must be allowed to evaporate completely before placing the assembly back in service. After the assembly has thoroughly dried, check the cam follower felt for the proper amount of oil by squeezing the felt tightly between the thumb and forefinger. If the fingers are moistened with oil when this is done, the felt is adequately lubricated and NO more oil should be applied. If no oil is left on the fingers, the follower felt is too dry and should be oiled as follows: Apply one drop of S. A. E. No. 60 Aircraft engine oil to the bottom felt pad, and one drop to the upper felt pad. Allow at least 15 minutes for the felt to absorb the oil; then blot off any excess oil with a clean cloth. Reinstall the assembly and secure it with the locking screws. The breaker points must now be checked for proper adjustment (timing and synchronizing).

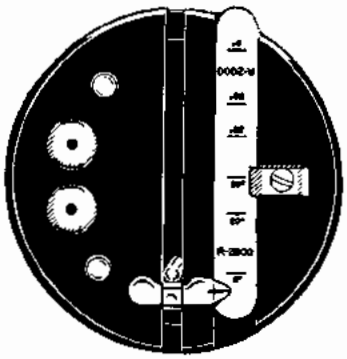
When inspecting the breaker points, do not raise the breaker main spring beyond a point giving 1/16 inch clearance between the points. Any further tension on the spring will weaken it and adversely affect the performance of the ignition system.



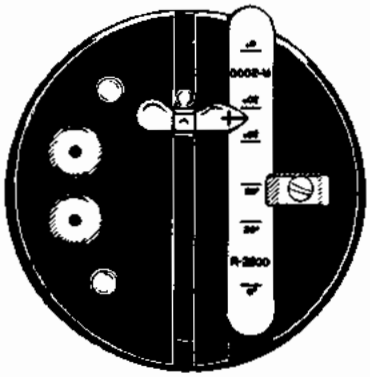
[12] Breaker Point Conditions



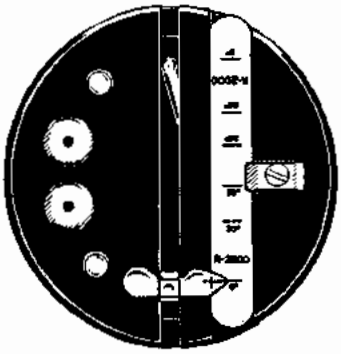
[13] Installing Vent Plug



[15] Slide at Farthest Point



[14] Slide Close to Pivot Arm

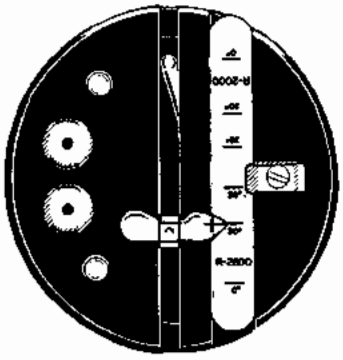


[16] 0° Aligned with Slide

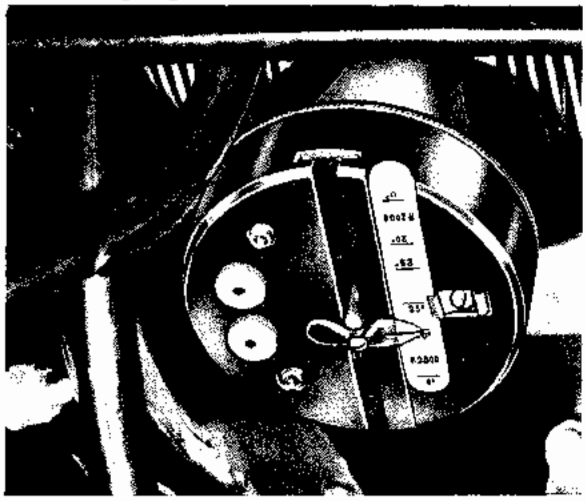
BREAKER POINT ADJUSTMENT AND MAGNETO TIMING CHECKS (HIGH TENSION SYSTEM)

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

Remove the front sparkplugs from all cylinders and install PWA-3252 Vent Plugs in the sparkplug holes **[13]** of all but the No. 1 cylinder. Locate the compression stroke of No. 1 cylinder by either of the following methods: [a] Hold finger over sparkplug hole and turn propeller in normal direction of rotation until compression stroke is noted; or [b] Remove the rockerbox covers from the No. 1 cylinder and turn the propeller shaft in the normal direction of rotation until the piston is at the top of its stroke as determined with the aid of the end of a pencil or a length of wood dowel. Move the propeller back and forward and note whether the valves of the cylinder are actuated. If the exhaust and intake valves of the cylinder are not actuated, the cylinder is on its compression stroke. If either or both valves are actuated, turn the propeller until the desired condition is obtained. Install Piston Firing Position Indicator (Time-Rite) in the No. 1 cylinder. (It may be necessary in some cases to loosen the sparkplug lead to permit installation of the indicator.) Align the cap of the indicator so that the pivot arm slide slot lines up with the vertical axis of the cylinder and the pivot arm is at the top of the slot. Push the slide up close to the pivot arm **[14]**.



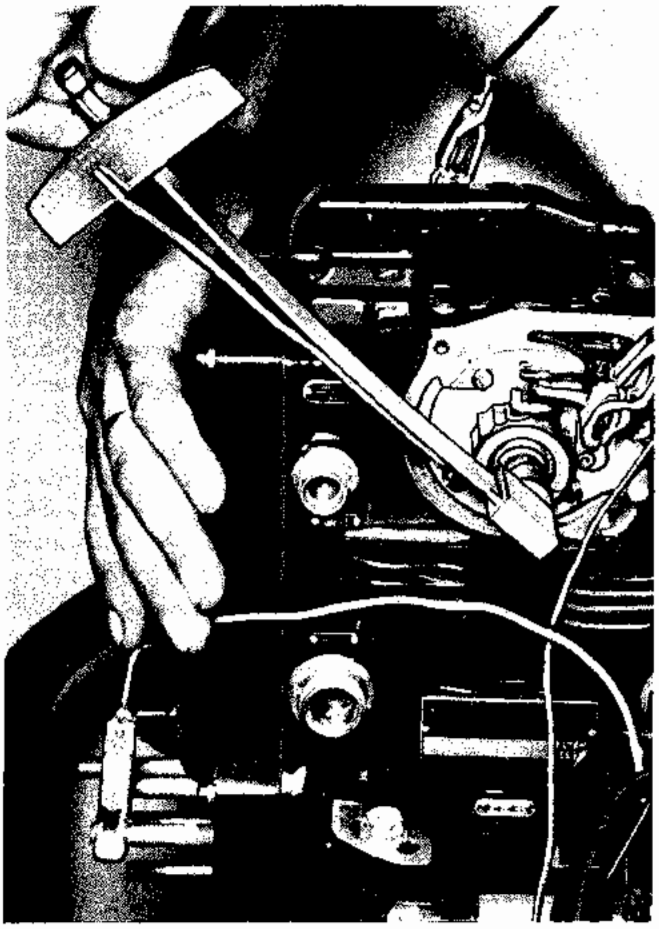
[17] Slide at 21° Mark



[18] Lower Light will Flash On

Turn the propeller in the normal direction of rotation until the pivot arm pushes the slide to its farthest point **[15]**. Turn the propeller opposite the normal direction of rotation to return the pivot arm to the top of the slot. Adjust the proper engine scale (the scale marked R-2800) so that the "O" degree mark on the scale aligns with the reference mark on the slide **[16]**. Move the slide up to align with the 21 degree mark on the scale **[17]**.

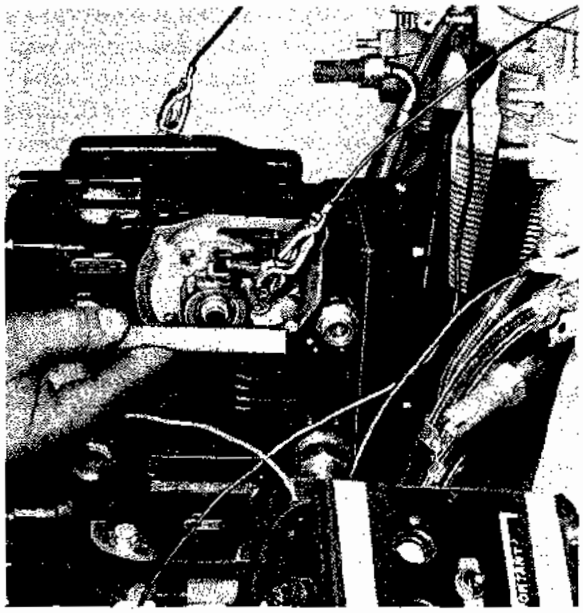
Although the spark advance timing is 20 ± 1°, it is desirable to set the breaker point timing at the most advanced position allowable (21°) as the timing tends to drift late due to cam follower and cam drive wear.



[19] Torquing Magneto Cam

Attach the red wires of PWA-2417 Timing Indicator to the breaker points of the magneto and ground the black wire to the engine. Turn the indicator switch on, and turn the ignition switch in the cockpit to the "Both" position.

Using a suitable torque wrench, maintain a torque of 40 inch-pounds, on the cam retaining screw, of the left hand breaker assembly, in the direction opposite that of cam rotation **[19]**. Turn the propeller in the normal direction of rotation until the pivot arm just contacts the slide, indicated by the lower light of the indicator (Time-Rite) flashing on **[18]**. The No. 1 piston is now at its 21 degree spark advance position and the breaker points should be just beginning to separate as shown by the lights of PWA-2417 Timing Indicator flashing on. In addition, a straight edge, placed along the magneto cam flats, should align with the



[20] Checking with Straightedge

magneto timing post marks **[20]**. If the timing indicator lights flash on, and the straight edge placed against the cam flats aligns with the magneto timing post marks when the pivot arm contacts the slide, the breaker points are in adjustment, and the magnetos are synchronized and properly timed to the engine.

> ***Do not use feeler strips to determine the point at which breaker points open as their use may cause an error of several degrees in magneto timing and may increase the possibility of fouling the points.***

In addition, if either of the following conditions exist, no adjustment of the breaker points or retiming of the magneto to the engine is necessary.

a. If the straight edge aligns with the timing post mark at the 21 degree spark advance position but the breaker points have not separated as shown by PWA-2417 Timing Indicator lights flashing on, rotate the propeller in the normal direction of rotation by jarring it until the indicator lights just flash on. At this point if the straight edge is within 1/32 of an inch of the mark on the timing post, no point adjustment or magneto-to-engine retiming is necessary.

b. If the breaker points separate, as shown by the PWA-2417 Timing Indicator lights, before the 21 degree spark advance position is reached and not over 1/32 of an inch separates the straight edge from the timing post mark, then no point adjustment or magneto to engine retiming is necessary providing the straight edge aligns at the 21 degree spark advance position.

If any of the following conditions exist, then either adjustment of the breaker points, or retiming of the magneto to the engine, or both are required.

a. If, at the 21 degree spark advance position, the straight edge aligns with the timing post marks but the breaker points do not separate as shown by PWA-2417 Timing Indicator and, after rotation of the propeller to a point where the indicator lights flash on, the straight edge is not within 1/32 of an inch of the timing post mark, then breaker point adjustment is necessary.

b. If the straight edge does not align with the timing post mark at the 21 degree spark advance position and over 1/32 of an inch exists between breaker point opening and straight edge alignment, then both point adjustment and retiming of the magneto to the engine are necessary. When both point adjustment and timing to the engine are necessary the breaker point adjustment must be performed first.

c. If the lights of PWA-2417 Timing Indicator flash on and the straight edge aligns within 1/32 of an inch of the timing post mark but the straight edge does not align at the 21 degree spark advance position, then only retiming of the magneto to the engine is necessary.

d. If the straight edge aligns with the timing post mark at the 21 degree spark advance position but over 1/32 of an inch is noted in the position of the straight edge at the timing post from the time one set of breaker points opens until the other set opens, then breaker point adjustment is required. This can occur, and is not to be included under (a), (b), or (c), if one set of breaker points opens before the 21 degree spark advance position is reached, and the other set afterwards.

If it is found that a straight edge aligns with the timing post mark on one set of points but not on the other, then the magneto must be removed and returned to Overhaul to correct the internal timing.

Breaker Point Adjustment (High Tension System) — With PWA-2417 Timing Indicator connected and Piston Firing Position Indicator (Time-Rite) installed, turn the propeller opposite the normal direction of rotation about 30 degrees, then in the normal direction until the straight edge aligns with the timing post mark on the magneto. Loosen the two contact bracket screws and turn the eccentric adjusting screw to a position where one indicator light just flashes on, indicating that the breaker points have started to separate. If both sets of breaker points are out of adjustment, loosen the two contact screws on the other set of points and repeat the adjusting operation. Tighten the contact bracket screws.

If necessary, reset the slide with the 21 degrees mark on the Piston Firing Position Indicator (Time-Rite) and check the setting of the points by turning the propeller opposite the normal direction of rotation about 30 degrees, then in the normal direction until the lights of PWA-2417 Timing Indicator just flash on. At this point the straight edge should align with the mark on the timing posts for proper breaker point adjustment.

If at this point the pivot arm on the Piston Firing Position Indicator (Time-Rite) has not contacted the slide or if it has pushed the slide past the 21 degree mark, then magneto to engine timing is necessary.

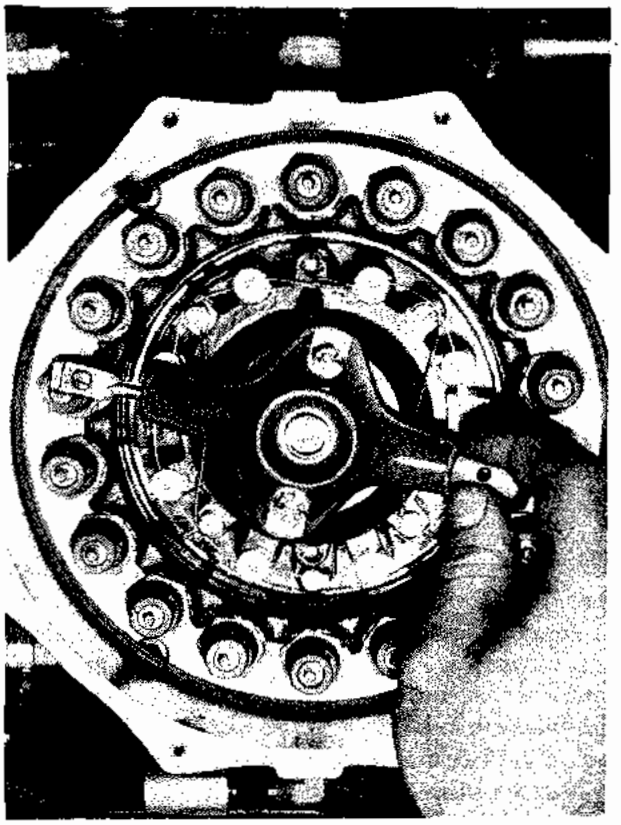
Magneto Timing (High Tension System) — If it has been determined that the magneto is not timed to the engine correctly, then proceed with the magneto timing by rotating the propeller opposite the normal direction of rotation about 30° and adjusting the slide of Piston Firing Position Indicator (Time-Rite) to the 21 degree spark advance position. Turn the propeller in the normal direction of travel until the pivot arm contacts the slide, indicated by the lower right of the indicator flashing on. Loosen the four nuts at the magneto flange and rotate the magneto as far as the slots will allow in the direction indicated by the arrow on the mounting flange. With PWA-2417 Timing Indicator turned on, rotate the magneto in the direction opposite to that indicated by the arrow on the mounting flange until the Timing Indicator lights just flash on.

Secure the nuts at the magneto flange, taking care that the magneto does not alter its position.

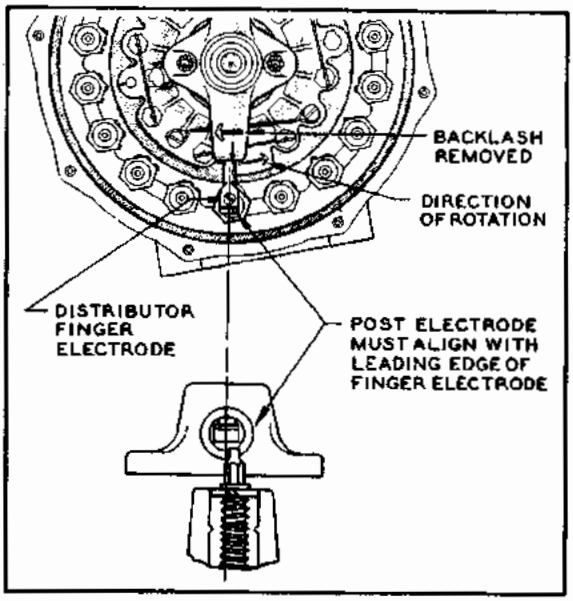
As a final check, turn the propeller shaft opposite the normal direction of rotation about 30 degrees; then rotate it in the normal direction until PWA-2417 Timing Indicator lights flash on. At that point the pivot arm should just contact the slide for correct magneto synchronization and timing.

Distributor Rotor Timing (High Tension System) — Position the No. 1 piston at its firing position, using Piston Firing Position Indicator (Time-Rite).

Remove the distributor housing cover and insulating bowl. Check the alignment of the distributor rotor electrode with the No. 1 distributor block electrode. The past electrode, with backlash removed **[21]**, must align with the leading edge of the rotor electrode **[22]**.

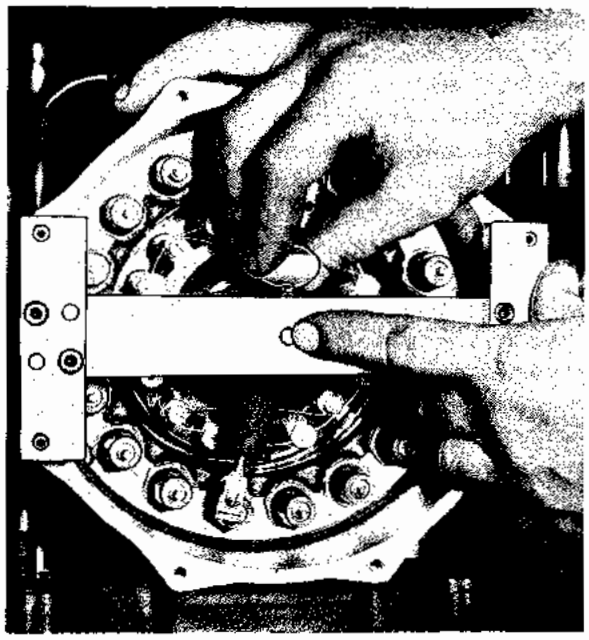


[21] Removing Rotor Backlash

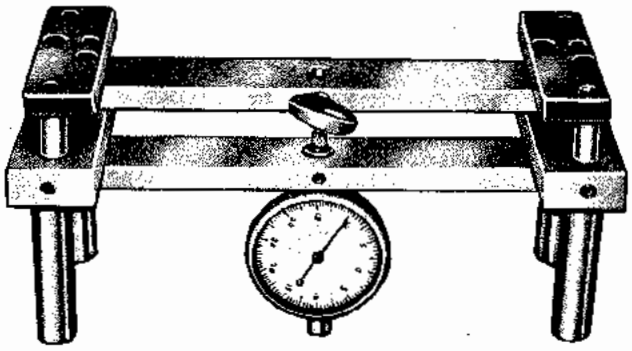


[22] Distributor Rotor Timing

Check the clearance between the rotor electrode and the black electrode. This clearance should be .029 ± .019 inch. If the clearance does not fall within these limits, remove or add brass shims underneath the distributor rotor plate which can be removed by taking off the distributor shaft nut. Whenever shims are removed or added under the distributor rotor plate the distributor cover high tension electrode jump gap must be checked as follows:



[23] Positioning Depth Gage



[24] Depth Gage on Indicator

Place PWA-4175 Depth Gage on the distributor housing and push the center contact of the gage in until it seats in the collector cup on the distributor rotor finger.

Tighten the thumb screw, holding the contact in place **[23]**, and then remove the gage.

Place PWA-4175 Depth Gage on top of PWA-4174 Indicator and observe the reading on the drive indicator **[24]** which is part of PWA-4174 Indicator.

Place the PWA-4174 Indicator on the distributor cover.

Install and tighten the 4 thumb screws which will hold the distributor cover firmly in place **[25]**.

Again observe the reading on the dial indicator.

Subtract the second indicator reading from the first; the result represents the jump gap clearance.

Clearance should be between .010 and .020 inch.

An alternate method for checking the distributor cover high tension electrode jump gap clearance is to place a small pellet of modeling clay or putty on the end of the electrode in the cover.

Thoroughly clean the cup on the rotor and apply a thin coating of oil to the inside of the cup. This is done to prevent adhesion of the plastic material to the electrode cup upon removal of the rotor for measuring.

Carefully place the distributor cover in position on the distributor bowl and press it down firmly against its sealing strip. Install and tighten at least four of the cover securing screws.

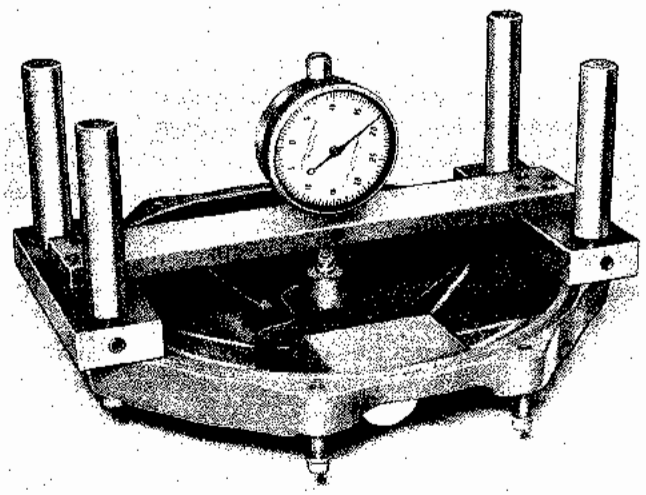
Remove the cover, and with a knife, cut away half of the modeling clay on the end of the electrode. Measure the thickness of the removing clay with a feeler gage.

The thickness of the clay or putty represents the clearance between the electrodes with no shims installed.

In order to obtain the .010 to .020 inch jump gap clearance, shims must be either added or removed as necessary under the screw type electrode.

If the distributor rotor is not in correct alignment, it may be corrected as follows:

Remove the two castle nuts which secure the distributor rotor to the plate and lift off the rotor.

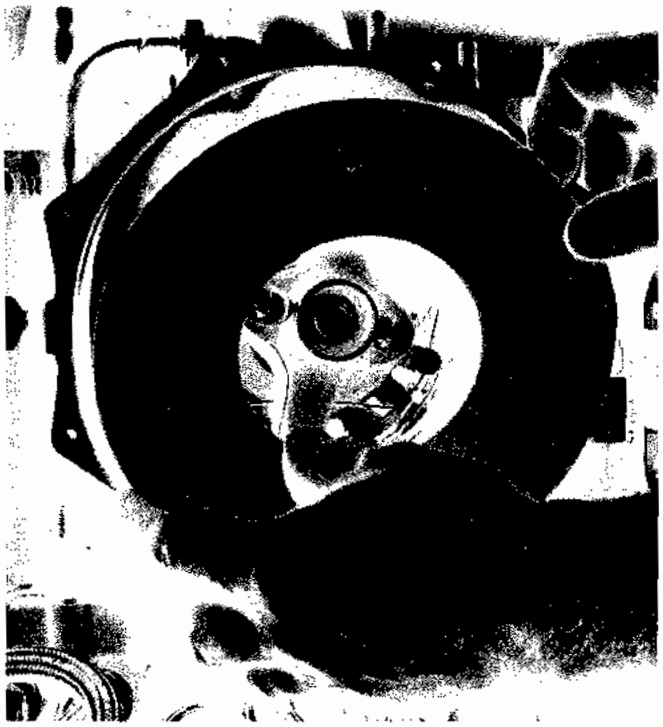


[25] Indicator Installed on Cover

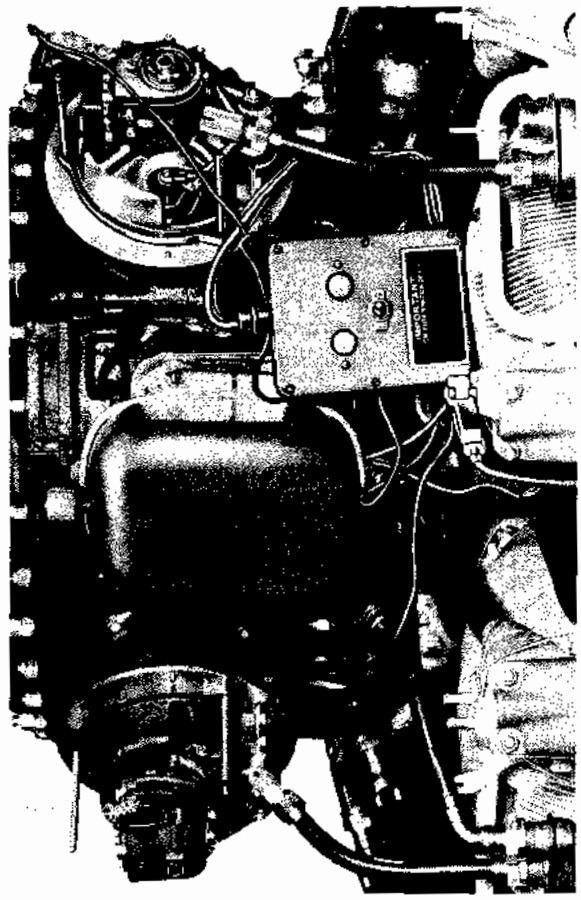
Loosen the castle nut on the top of the distributor drive shaft until the halves of the ratchet on the bottom of the shaft will disengage; then place the distributor rotor on the distributor rotor plate and turn the rotor in a clockwise direction until the post electrode aligns with the leading edge of the rotor ***[22]***.

Lift off the distributor rotor and remove the eight bolts which secure the ignition pressurizing pump. Remove the pump from the distributor block without changing the position of the distributor rotor plate. Check to see that the halves of the ratchet are perfectly mated; then turn down the drive shaft nut finger-tight and reinstall the pump. The splines on the driveshaft should mate with the internal splines on the distributor drive gear in such a way that when the distributor rotor is installed, the rotor electrode will be in the correct position in relation to the No. 1 electrode of the block. Secure the pump with the eight washers, lockwashers, and cap screws and lockwire the bolts.

Place the distributor rotor on its plate in order to check the alignment with No. 1 electrode of the block. When the alignment is correct, tighten the drive shaft nut and lock it in position with a cotterpin. Bend the tabs of the



[26] Installing Insulating Bowl



[27] Timing Light Connected

cotterpin in opposite directions around the outside of the nut; do not bend one of the tabs back over the top of the drive shaft.

Install the distributor rotor and secure it to the distributor rotor plate with the lockwasher and castle nut. Lock the distributor rotor nut in position with cotterpins. Inspect the insulating bowl for cracks. Inspect the large rubber spacer ring, which fits in the groove under the insulating bowl at the bottom of the distributor. If the spacer is deformed or deteriorated, replace it. Install the insulating bowl [**26**]; then install and secure the distributor cover.

Check the timing of the magneto after adjusting the timing of a distributor rotor.

Breaker Point Adjustment and Magneto Timing Checks (Low Tension Ignition System) — Attach PWA-2417 Timing Indicator to the No. 1 breaker points [**27**] of each distributor and locate the 21 degree spark advance position for the No. 1 piston as directed for the high tension ignition system on page 120.

When checking breaker point opening, it is recommended that the distributor shafts be held back in the direction opposite to normal rotation. This may be accomplished by holding back on the shaft nut with a 7/8" open end wrench.

At the 21 degree spark advance position the No. 1 breaker points should be just beginning to separate as indicated by the PWA-2417 Timing Indicator lights flashing on and by alignment of a straight edge with the No. 1 breaker timing marks when placed against each distributor shaft flat (timing step).

If the indicator lights flash on and alignment of the straight edge is obtained at the 21 degree spark advance position for No. 1 piston, then distributor-to-engine timing, and the No. 1 breaker points are correctly timed and adjusted.

Remove the locking clamp from the timing plunger, located at the magneto base, and press the plunger to ascertain whether the plunger pin engages a hole in the magneto shaft. If full engagement of the pin and the hole is obtained when the No. 1 piston is at its 21 degree spark advance position, the magneto-to-engine timing requires no adjustment.

Disconnect the PWA-2417 Timing Indicator from the No. 1 breaker points and connect it to the No. 2 points and rotate the propeller opposite the normal direction of rotation, then in the normal direction until a straightedge placed against the timing step of either distributor shaft aligns with the No. 2 breaker timing mark. At this point the No. 2 breaker points should be just separating as indicated by the lights of PWA-2417 Timing Indicator flashing on. If this condition exists, the No. 2 breaker points are in alignment and no further adjustment is necessary.

If any of the following conditions exist, adjustment of the breaker points, retiming of the distributors to the engine, or retiming of the magneto to the engine is necessary.

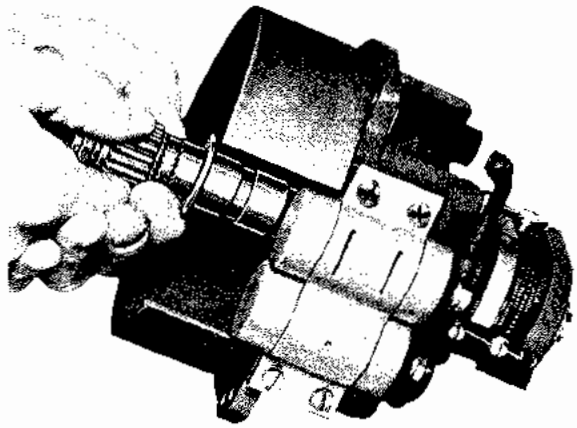
a. If, at the 21 degree spark advance position, the straightedge aligns with the timing marks for the No. 1 breaker points, and the breaker points do not begin to separate as indicated by the timing indicator lights flashing on, then No. 1 breaker points require adjustment.

b. If, at the 21 degree spark advance position, the straightedge aligns with the timing marks for the No. 1 breaker points, and the breaker points begin to separate, but upon rotating the propeller to the point where a straightedge placed against the timing step aligns with the No. 2 breaker point timing marks, the No. 2 points do not begin to separate, then No. 2 breaker point adjustment is required.

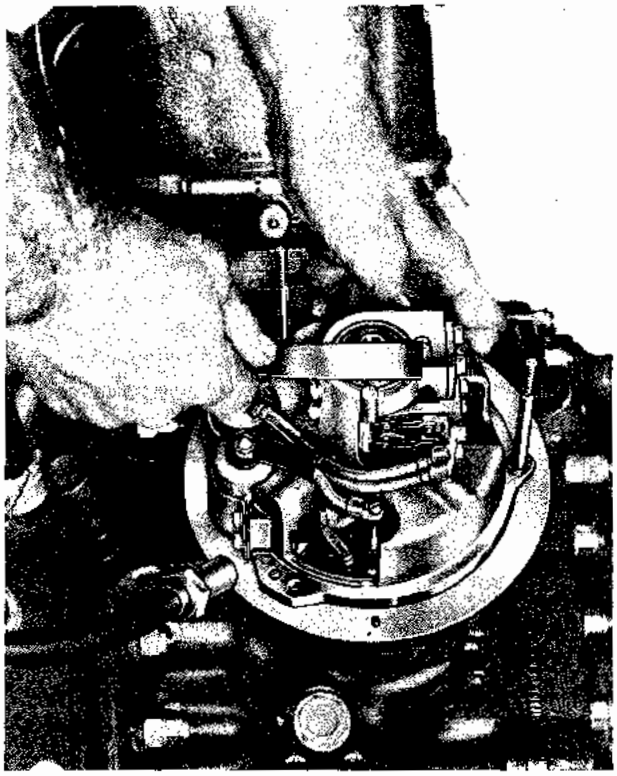
c. If, at the 21 degree spark advance position, alignment of the straightedge with No. 1 breaker point marks is not obtained, retiming of the distributor to the engine is necessary. By rotating the propeller to a point where alignment is obtained it can be determined whether breaker point adjustment is also required.

d. If, at the 21 degree spark advance position, full engagement of the magneto plunger pin with a hole in the shaft is not obtained, magneto-to-engine timing is in need of adjustment.

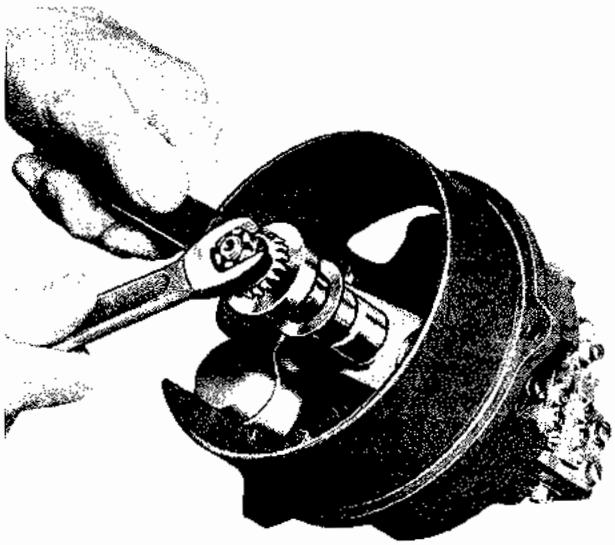
Breaker Point Adjustment (Low Tension System) — If at the 21 degree spark advance position for No. 1 piston, the No. 1 points are in need of adjustment, loosen the two screws which lock the breaker assembly to the breaker plate and, by means of the eccentric adjusting screw, shift the breaker until the points are just opening as indicated by the lights of PWA-2417 Timing Indicator flashing on. Tighten the locking screws and recheck breaker point opening. If the No. 2 breaker points require adjustment, rotate the propeller in the normal direction of rotation until the straightedge aligns with the No. 2 breaker timing marks and connect PWA-2417 Timing Indicator to the No. 2 points. Adjust the No. 2 breaker as directed in the previous



[28] Ratchet Halves Disengaged



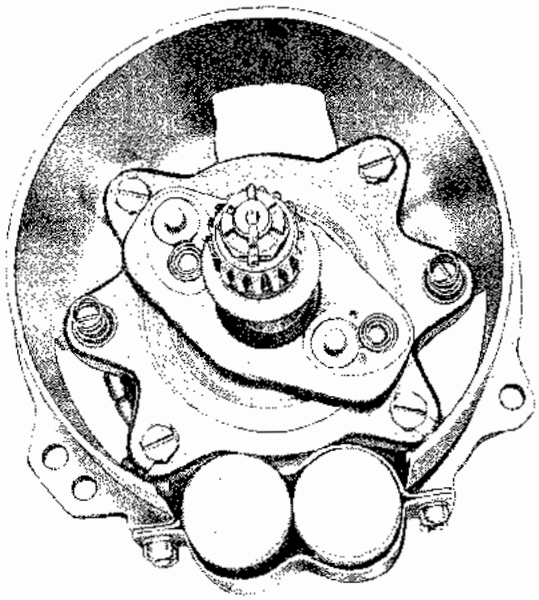
[29] Straightedge Aligned



[30] Tightening Shaft Nut

paragraph; then tighten the locking screws and recheck the setting.

Distributor Rotor Timing (Low Tension System) — If it has been determined that distributor rotor timing needs readjustment, (this can occur only if the distributor was installed incorrectly), remove the securing screws and

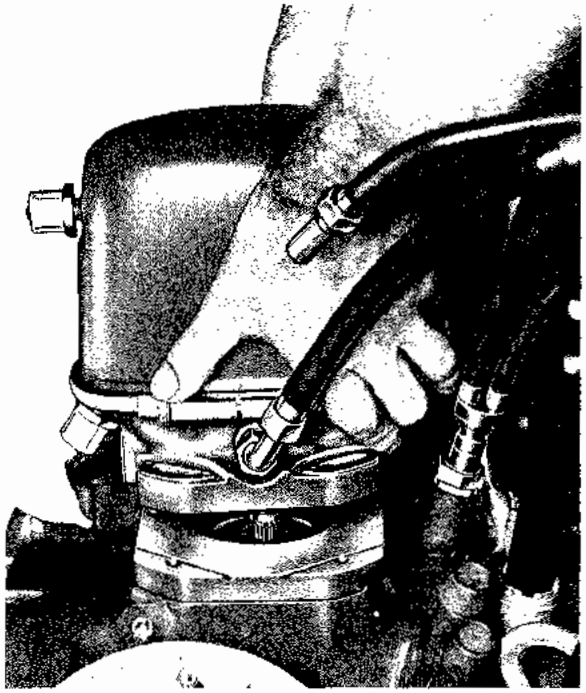


[31] Drive Shaft Nut Locked

the distributor from the distributor base; then loosen the distributor shaft nut only enough to disengage the ratchet halves **[28]**. With the No. 1 piston at its 21 degree spark advance position, install the distributor in position on the engine. Using an open end wrench on the large distributor shaft nut, ratchet the shaft to the position where, with the rachet fully engaged, the straightedge, held against the shaft timing step, will align with the No. 1 breaker timing mark **[29]**. Be sure the ratchet is fully engaged at the instant of timing mark alignment to prevent shifting when the drive shaft nut is tightened.

> ***Turning the rotor one notch to the right changes the position of the rotor 15.65 degrees, and turning it back one notch changes it 15 degrees leaving a resultant change of .65 degrees.***

Remove the distributor; then tighten **[30]** and cotterpin the drive shaft nut **[31]**, making certain that the ratchet teeth are fully meshed. Reinstall the distributor so that the straightedge aligns with its timing mark when the No. 1 piston is at its 21 degree spark advance posi-

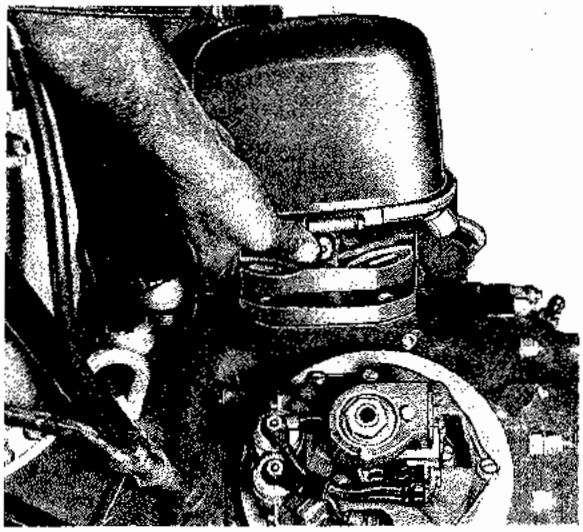


[32] Removing Magneto

[33] Engaging Timing Plunger

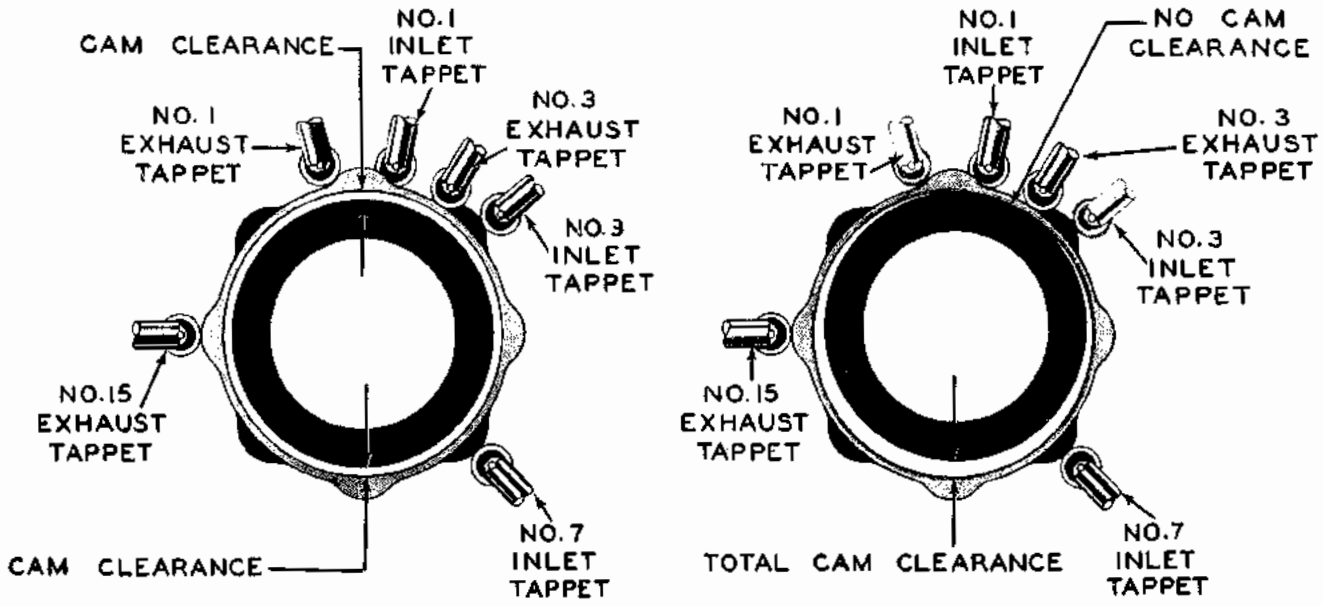
tion. Install and tighten the three distributor securing screws, noting if any misalignment of the straightedge with the timing mark occurs. If both distributors require retiming, repeat the operation for the other distributor.

As a final check, attach PWA-2417 Timing Indicator to the No. 1 points and rotate the propeller opposite the normal direction of rotation approximately 30 degrees, then in the normal direction until the No. 1 piston is at its 21 degree spark advance position at which time the straightedge should align with the timing mark and the indicator lights should just flash on.



[34] Installing Magneto

Magneto Timing (Low Tension System) — If it has been determined that magneto-to-engine retiming is necessary, (this can occur only if the magneto was initially installed wrong), loosen the four securing bolts and shift the magneto, while pressing the timing plunger until full engagement of the plunger pin with a notch in the shaft is attained. If full engagement is not attained, remove the four securing bolts and the magneto **[32]**. Rotate the magneto shaft while pressing the timing plunger until full engagement is made **[33]**. With the plunger pin and notch fully engaged, install the magneto on the engine **[34]**, engaging the drive spline with the mating engine part in such a relation that the magneto securing bolts will be approximately centered in the magneto flange elongated slots. If the magneto cannot be installed in this manner, remove the magneto and turn the shaft either way 90 degrees until the timing pin engages the next notch in the shaft. Reinstall



BEFORE DEPRESSING ROCKERS AFTER DEPRESSING ROCKERS

[35] Cam Position

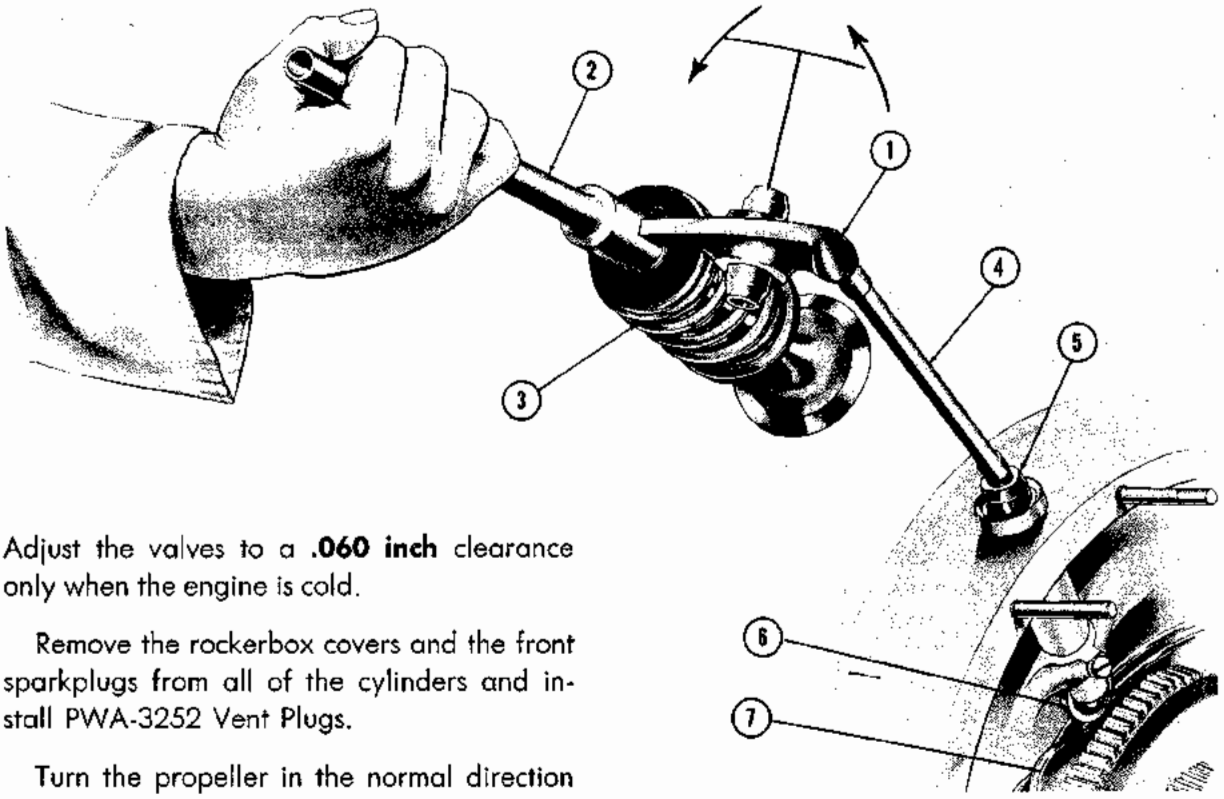
SET PISTON AT TOP CENTER OF ITS EXHAUST STROKE	DEPRESS ROCKERS		ADJUST VALVE CLEARANCES	
	INLET	EXHAUST	INLET	EXHAUST
11	7	15	1	3
4	18	8	12	14
15	11	1	5	7
8	4	12	18	18
1	15	5	9	11
12	8	16	2	4
5	1	9	13	15
16	12	2	6	8
9	5	13	17	1
2	16	6	10	12
13	9	17	3	5
6	2	10	14	16
17	13	3	7	9
10	6	14	18	2
3	17	7	11	13
14	10	18	4	6
7	3	11	15	17
18	14	4	8	10

[36] Valve Adjusting Chart

the magneto on the engine with the securing bolts approximately centralized in the elongated slots. Secure the magneto in position and recheck the adjustment.

> ***There are four notches on the magneto shaft, 90 degrees apart. Any one of these notches may be used for pin engagement when installing the magneto, providing the securing bolts are approximately centralized in the elongated slots.***

Valve Clearance Adjustment — Proper valve clearance adjustment is obtained by the use of a positive method which eliminates cam float **[35]**. The elimination of cam float is necessary to prevent valve clearances of wide variation on an engine. In order that all of the valves will have uniform clearances, the inlet and exhaust valves of each cylinder must be adjusted while the cam rests as nearly as possible against the cam bearing at that cylinder. To move the cam into such a position and to adjust the clearance of each valve, it will be necessary to use the following method **[36]**:



[37] Depressing Rocker

Adjust the valves to a **.060 inch** clearance only when the engine is cold.

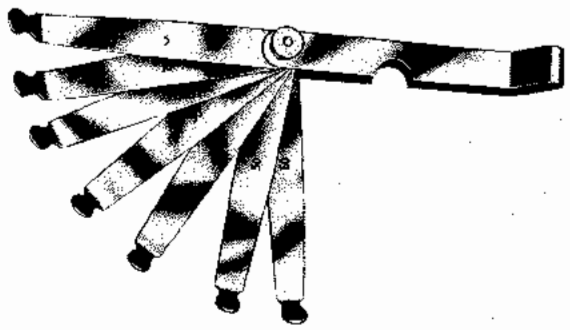
Remove the rockerbox covers and the front sparkplugs from all of the cylinders and install PWA-3252 Vent Plugs.

Turn the propeller in the normal direction of rotation until the required piston (see above chart) is at top center of its exhaust stroke. Back off the valve adjusting screws to insure sufficient clearance.

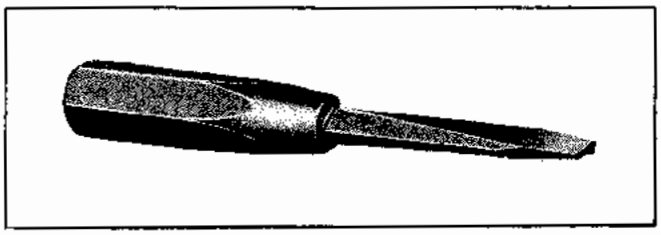
Follow the valve adjusting chart [36] with extreme care to see that the proper valves are depressed. The valves listed will be open, due to normal cam action, and may be fully depressed without the pushrod ball ends' falling free of their sockets. A pushrod ball end may fall out of its socket if a closed valve is fully depressed.

[37] Depress No. 15 exhaust and No. 7 inlet rockers [1] simultaneously with PWA-1392 Rocker Depressors [2]. This action relieves the valve spring [3] pressures at the pushrods [4], the valve tappets [5], the valve tappet rollers [6], and at the cam [7]. The valve spring pressure on No. 1 exhaust and No. 3 inlet valve tappets pushes the cam toward the cam bearing in the direction of the depressed valve springs.

Slowly release the No. 15 exhaust and No. 7 inlet rockers simultaneously. Insert the .060 inch feeler of PWA-672 Gage **[38]** between



[38] PWA-672 Gage



[39] PWA-4152 Wrench

the adjusting screw insert and No. 1 inlet valve stem and turn down the adjusting screw, using PWA-4152 Wrench **[39]** until there is a slight drag on the feeler. Tighten the locknut to the recommended torque. Adjust the No. 3 exhaust valve to the same clearance and tighten its locknut to the same torque.

Not more than six threads (¼ in.) or fewer than three threads (⅛ in.) of a valve adjusting screw should show above the locknut; and there should be a clearance of not less than .031 inch between the outer valve spring washer and the rocker with the valve closed. If the clearance between the valve spring washer and the rocker is less than .031 inch or if more than six threads on the adjusting screw show above the locknut, the flat face of one or both of the pushrod ball end spacers may be ground (minimum .055), or the spacer can be replaced with a thinner one, or eliminated entirely to obtain the desired clearance. If fewer than one and one-half threads of the adjusting screw show above the locknut, a thicker spacer should be used at one or both ends of the pushrod. Make all other valve clearance adjustments in the same manner; then turn the propeller shaft in the normal direction of rotation two revolutions, and recheck the clearance of the valves which are adjusted.

Changing pushrod length to obtain correct adjustment should be done only when it is assured that no other discrepancies exist in the valve gear train.

When this procedure is repeated for all the valves in order of the listing in the chart ***[36]***, the valve clearances have been properly adjusted.

Before the rockerbox covers are reinstalled, examine the gaskets and replace any of them that are not in good condition. If any covers have become distorted, reface them on a lapping plate. Tighten the rockerbox cover nuts to the recommended torque.

Remove the vent plugs from the cylinders and reinstall the sparkplugs to the recommended torque.

Clutch Flushing — For efficient clutch operation, it is important that the clutches be flushed according to the following procedure. Varsol is the most satisfactory flushing agent, but kerosene or unleaded gasoline may be used.

The following equipment is necessary for the power pump or wobble pump method of flushing.

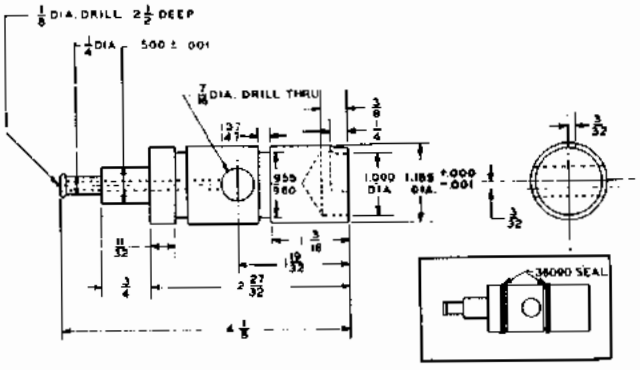
1. Twenty gallon tank of Varsol or other flushing agent.

2. Shut-off valve on bottom of Varsol tank.

3. Portable power pump or wobble pump with mounting base.

4. Strainer between pump and small hose leading to dummy valve adapter.

5. Dummy valve adapter **[40]**.



[40] Dummy Valve Adapter

6. Pressure hose supply line from pump.

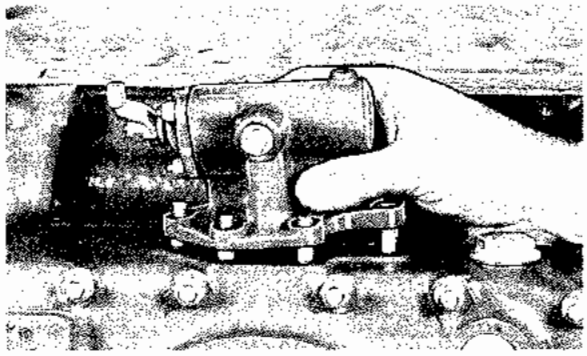
7. One inch hose nipple connection to fit into rear section drain plug holes and 1 inch return hose from nipple to tank.

Remove the clutch selector valve **[41]** and insert the dummy valve adapter. Attach the pressure hose to the dummy intake, being sure there is a strainer between the tank outlet and the dummy valve. Fit the 1 inch nipple in the rear drain plug hole and connect one end of the 1 inch hose to the nipple and the other end to drain into the top of the tank. Using PWA-1787 Wrench, ***remove the main oil sump drain plug*** **[42]**. Provide a suitable receptacle for collecting drain oil.

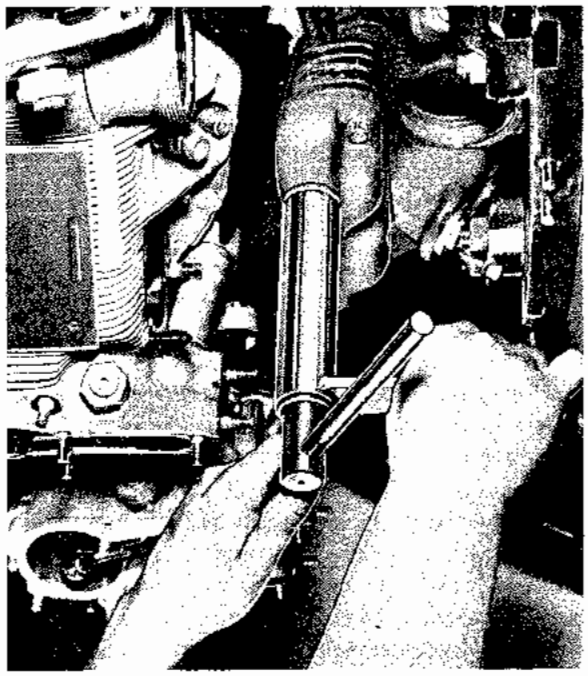
Start the pump and allow the Varsol to be pumped at 200 pounds per square inch for 45 minutes while in the low clutch position. Move the lever on the dummy valve to the high position and flush for 15 minutes.

> ***A pulsating action of the flushing agent in the clutches is advantageous over a steady flow at constant pressure. It is recommended that pulsating action be used whenever it can be obtained with the pumping equipment available. To assure a good oil flow, when flushing clutches of the creeper desludger type, rotate the clutches by turning the propeller slowly during the flushing operation. Remove one sparkplug from each cylinder when turning the propeller.***

Shut down the pump; disconnect the hose from the dummy valve and the hose from the oil drain plug hole. Install the selector valve and rear section oil drain plug. Install the main oil sump drain plug. Run the engine at 800 rpm until the minimum allowable cylinder head temperature is attained; then increase to 1800 rpm while the oil is still relatively cool. Shift to the high position without hesitation, at which point oil pressure should momentarily drop and manifold pressure increase. After one or two more shifts at this speed return the selector valve lever to low position and reduce rpm to 1000 to allow the clutches to cool.

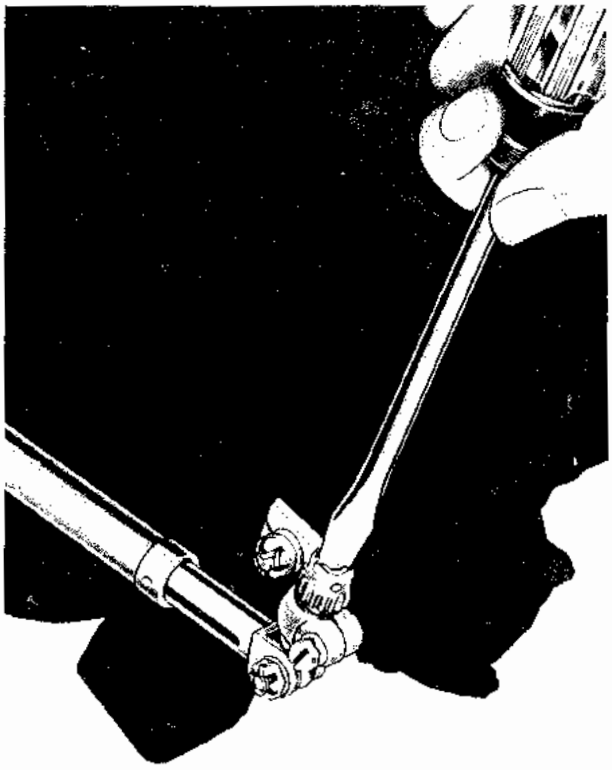


[41] Removing Selector Valve



[42] Removing Sump Drain Plug

Carburetor Idling Adjustment — When a carburetor is once set for proper idling, it does not ordinarily require readjustment except to correct for wide variations in atmospheric conditions. An idling adjustment which has been satisfactory should not be changed until all other possible causes of unsatisfactory idling have been investigated. If it is necessary



[43] Adjusting Idle Mixture

to reset the idle adjustment, or when a new or replacement carburetor is installed, proceed in the following manner:

Start the engine and run it at approximately 1000 rpm until the oil temperature reaches 140°F to 158°F and the cylinder head temperatures are normal.

Run the engine up to 2000 rpm and check the sparkplugs by operating each magneto separately. Refer to page 72 for specific magneto check instructions. If the drop-off in rpm is normal, proceed with the idling adjustment.

Slow down to closed throttle, approximately 450 to 500 rpm. Adjust the throttle stop if the engine does not idle at approximately this rpm.

Move the mixture control *slowly toward Idle Cut-Off*, manually adjusting to obtain best power mixture. Observe the rise or fall in rpm and/or manifold pressure. This should occur at a point approximately ⅔ to ¾ of the quadrant travel from the Auto Rich position. Read instruments. If the idling rpm adjustment is properly set to the recommended rpm, there will be a pickup not in excess of 20 rpm as the control is moved toward Idle Cut-Off, and a corresponding drop as the control is moved back to Auto Rich.

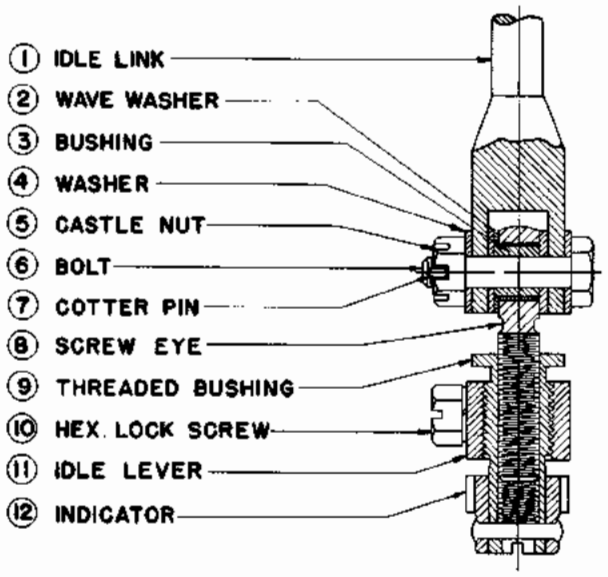
If the increase in engine rpm was excessive when mixture control was moved toward Idle Cut-Off, turn the idle mixture adjustment lever **[43]** one or two notches to the *right* (clockwise) to richen the mixture and again check the rpm when the control is moved toward the Idle Cut-Off position. Repeat until the correct rpm rise is obtained.

If the increase in engine rpm was excessive, turn the idle mixture adjustment lever one or two notches to the *left* (counterclockwise) to lean the mixture; then again move the mixture control slowly towards Idle Cut-Off (manually adjusting to obtain best power mixture) and check the rpm.

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

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

In case there is insufficient travel of the idle mixture adjustment **[44]** to obtain the correct idle mixture, disconnect the idle link (1), from screw eye (8) by removing the link bolt (6). Then screw the screw eye *into* the threaded bushing (9) if leaner mixtures are required, or



[44] Idle Adjusting Mechanism

out of the bushing if richer mixtures are desired. One revolution of the screw eye is equivalent to approximately 13 notches of the mixture adjustment indicator (12). Reconnect the idle link (1) with extreme care to be certain that the various parts are in their correct positions. The four plain washers (4) should be in the positions shown. The spring wave washer (2) must be carefully placed so that it fits over the outside diameter of the bushing (3) and so it is next to the screw eye (8). The castle nut (5) must be tightened enough to allow the yoke of the idle link (1) and plain washers (4) to clamp the bushing (3) tightly in place so it cannot move on the bolt (6). If the castle nut (5) is not tightened sufficiently, the clearance between the inside diameter of the bushing (3) over the outside diameter of the bolt (6) will allow enough play in the linkage to cause inconsistent engine idling.

When the idling has been properly adjusted, tighten and lock the idle mixture adjustment lockscrew.

Prolonged periods of idling may lead to the fouling of the sparkplugs. "Clearing Out" of the engine at 10 minute intervals is recommended. This should be done by running the engine up to field barometric pressure for one minute after each 10 minutes of idling. This recommendation is particularly pertinent during extended idling while awaiting runaway clearance before take-off.

Fuel Pressure Adjustment — The fuel pressure gage is the only instrument connected directly to the carburetor. It is connected between the poppet valve and the fuel strainer chamber and the pressure registered on the gage is the differential pressure between that of the fuel and that of the atmosphere. (Generally, at the carburetor entrance).

The pressure of the fuel at the entrance of the carburetor has an important effect on the fuel-air ratio. If it does not fall within the specified limits, the carburetor will not meter fuel correctly in response to airflow. The operator has no control of the fuel pressure produced by the engine-driven fuel pump while in flight. Consequently, he should check to see that it registers correctly during the ground tests and have all necessary adjustments made prior to take-off.

If it is necessary to adjust the fuel pressure, loosen the locknut of the fuel pump pressure relief valve and turn the adjusting crew *clockwise to increase* the fuel pressure, or *counterclockwise to decrease* the pressure. When the locknut is tightened it may change the discharge pressure slightly, hence it is advisable to take this condition into account when the adjustment is being made. Make certain the locknut is tightened and lockwired after the adjustment has been made.

FUEL PRESSURE CHECK

(At manifold pressure equal to field barometric pressure.)

Fuel pressure should be 22 ± 1 psi.

Idling—14 psi Minimum.

Oil Pressure Adjustment — Remove the adjusting screw acorn cap on the oil pressure relief valve, using PWA-978 Wrench. Loosen the locknut and turn the adjusting screw *clockwise to increase* the oil pressure, or *counterclockwise to decrease* the pressure.

Adjust to give an oil pressure of from 85 psi to 90 psi at an oil temperature of 140°F (60°C), and an engine speed that results from operating at a manifold pressure equal to field barometric pressure. It may be necessary to make several tries before the desired pressure is obtained.

Tighten the adjusting screw locknut; then, using a new gasket, install, tighten, and lockwire the acorn cap.

OIL PRESSURE CHECK

(At manifold pressure equal to field barometric pressure.)

Desired for adjustment 85-90 psi at 140°F (60°C).

SAFE OPERATING RANGE

2000-2200 rpm	60-100 psi
1600 rpm	55- 90 psi
1400 rpm	Minimum 50 psi
Idling	Minimum 25 psi

REPLACEMENT OF PARTS

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

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

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

For torque recommendations refer to "Torque Recommendations" on page 207.

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

Cowling

REMOVAL — Remove sufficient cowling sections to have easy accessibility during the removal of any parts.

INSTALLATION — Install the cowling sections that were removed.

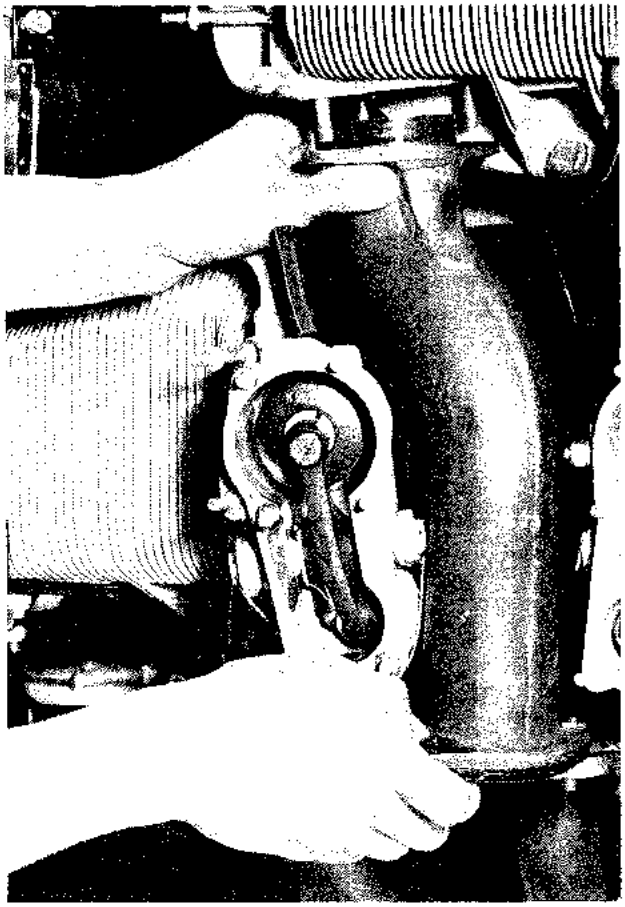
Exhaust Piping

REMOVAL — Unfasten the nuts and bolts which fasten the exhaust piping to the engine. Loosen the exhaust manifold and move it to the rear as far as possible so that the cylinders and related parts will be more accessible. The front exhaust extension may be removed, if necessary **[45]**.

INSTALLATION — Move the exhaust manifold forward and fasten the exhaust pipes to the engine with nuts and bolts.

Sparkplug Lead Connectors and Sparkplugs

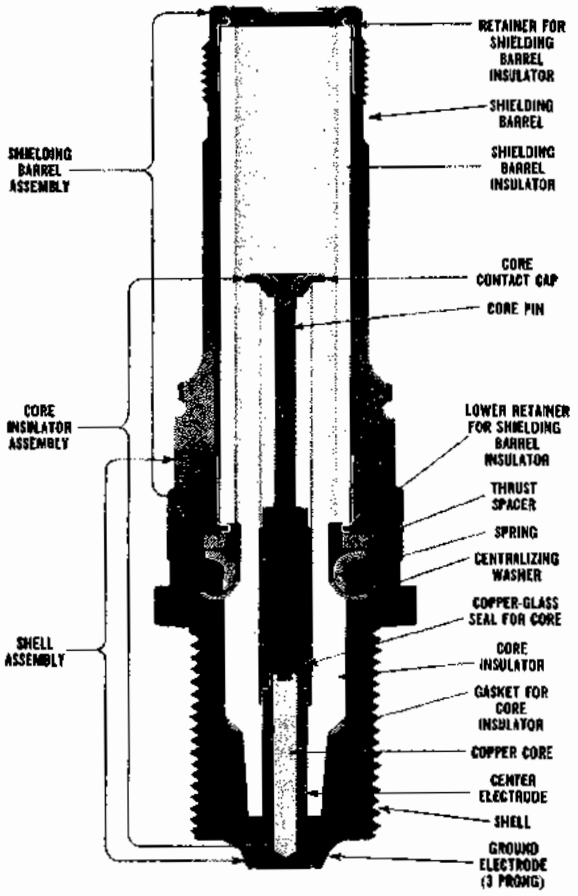
REMOVAL — Unfasten the sparkplug lead from the sparkplug, using PWA-1683 Wrench. Be careful not to allow the elbow to turn or the wrench to slip; then unscrew the nut which secures the sparkplug elbow. Withdraw the ceramic connector from the sparkplug, pulling the lead straight out and in line with the center line of the sparkplug barrel; then install a suitable protector cap over it. Remove the sparkplug, using PWA-3168 Wrench. On AC-181 sparkplugs, use only a special AC AV1-1 Wrench to prevent damage to the plug barrel threads and the insulator. Do not "cock" the wrench on the sparkplug; make certain that the "hex" of the wrench is in full engagement with the "hex" on the plug. Install a PWA-3252 Plug in the sparkplug hole. If the plug is difficult to remove, removal may be facilitated in some cases by turning the plug first in a tightening direction and then in a loosening direction.



[45] Removing Exhaust Extension

GENERAL — A sparkplug **[46]** is fundamentally only an insulator. Its function is to sufficiently insulate the current, generated by the magneto, to assure delivery of enough electric energy to overcome the resistance at the sparkplug gap. All other conditions being ideal, an engine will perform only as satisfactory as do the sparkplugs which are in it. The proper handling and installation of sparkplugs has proven to be one of the most important factors contributing to the elimination of engine backfiring both on the ground and in flight.

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



[46] Typical Sparkplug

The cylinder inspection should be made by (1) removal of the cylinder, (2) inspection of the piston through the sparkplug hole, and inspection of the valves by means of a compression check.

Clean the sparkplug lead terminal sleeve with Stoddard Solvent. Inspect the sleeve to see that it is not cracked, perforated, burned, or has carbon tracks, all of which cause flashover. Replace the sleeve, if necessary.

Place removed plugs in a suitable rack **[47]** or tray. If a plug has been dropped or damaged during removal, tag it for future reference.

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

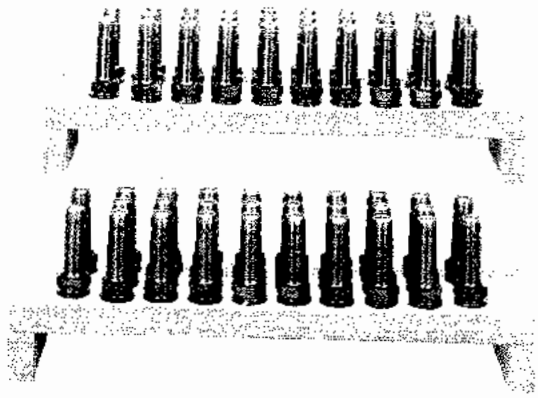
Do not attempt to increase the gap of a sparkplug by prying the electrodes apart. This will almost certainly result in damage to the plug.

Do not disassemble two-piece ceramic sparkplugs.

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

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

Sandblasting time should be held to the absolute minimum, since excessive sandblasting will cause wear of electrodes and insulators. The color of the ceramic after sand-



[47] Sparkplugs in Rack

blasting is unimportant provided the ceramic is clean and free from carbon, and provided the plug passes the bomb test.

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

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

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

Sparkplugs should be stored in a hot locker at a temperature of approximately 170°F, to keep them dry until ready for installation.

PREPARATION OF SPARKPLUGS FOR INSTALLATION — Remove sparkplugs from boxes and place in a rack for vapor degreasing.

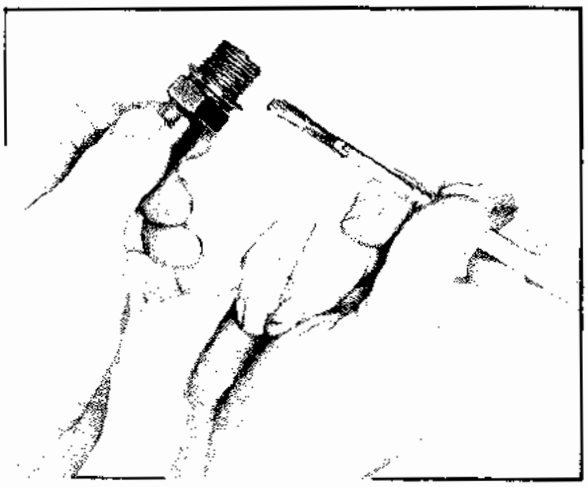
Vapor degrease (trichlorethylene, or equivalent) for 1 to 3 minutes — a longer period will do no harm. Vapor degreasing serves two functions: (1) removes preservative and cleans plugs, (2) removes any accumulated moisture.

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

Check the gap clearance of each electrode with .011 inch "go" and .014 inch "no go" stainless steel piano wire. (Use Starrett pin vise as holder for wire and "roll" wire between the electrodes.) Do not attempt to push it through as an inaccurate gauge will result. The wire will easily "roll" through electrodes of some plugs, whereas the same wire cannot be pushed through. The desired gap is .012 inch; however, if .011 inch gauge will pass through the electrodes but .014 inch gauge will not, the gap clearance is satisfactory. Where a plug is found to be closed below the lower limits, no attempt should be made to disassemble the plug or to open the gaps to the specified clearances. Instead, return such plugs to the sparkplug overhaul shop.

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

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



[48] Applying Compound

Apply Champion No. 119 anti-seize compound sparingly as a thin film on the shell threads, taking special care to coat the first several threads only. Make sure that the compound is thoroughly mixed, because after settling, the finely powdered mica or graphite separates from the compound and collects in the bottom of the container. A small brush should be used to apply the compound **[48]**. Do not apply with fingers.

> ***Never allow anti-seize compound to get on the electrodes since this compound is conductive and will short out the sparkplug. Do not apply anti-seize compound to the barrel end threads.***

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

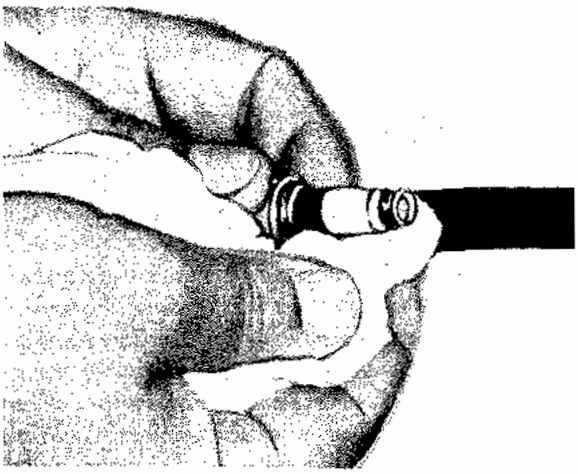
Making certain that there is a serviceable copper gasket (only one) on the sparkplug, screw the plug into the cylinder with the fingers until the plug bottoms on the gasket. If the plug does not screw in easily, remove the plug and inspect the plug and insert threads.

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

Stainless steel sparkplug inserts may be cleaned with a stiff fiber or wire brush moistened with a cleaning solvent. The brush used must be of a type which does not disintegrate with use, so that no bristles will fall into the combustion chamber. The diameter of the brush and the technique used should be such as to preclude the removal of material from the cylinder head surrounding the insert. Special care should be taken on the sparkplug gasket seating surface, since removing material from this location could cause combustion leakage with subsequent damage to the cylinder head. Generally speaking, only a light application of a revolving brush will be required.

Using PWA-3168 Wrench, tighten the sparkplug to the recommended torque. On AC-181 plugs, use only a special AC AV1-1 Wrench to prevent damage to the plug barrel threads and the insulator. Avoid side loading or "cocking" of the wrench.

Remove the plastic protector from the sparkplug lead connectors.



[49] Applying Compound to Connector

Wipe hands dry, using a clean, dry cloth; wipe the connector clean with a clean cloth moistened in Stoddard Solvent.

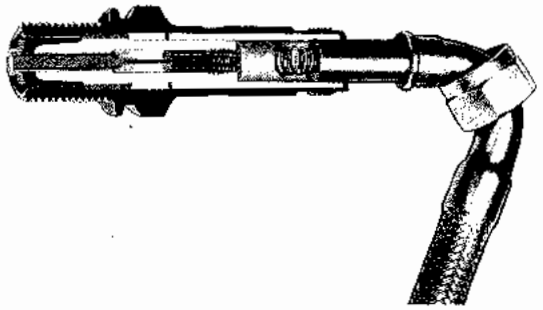
Visually inspect the connector and spring. Do not touch with fingers. If necessary, replace the spring and/or insulator and wipe them clean.

If desired, apply a light film of Dow Corning No. 4 insulating compound to the connector by means of a clean cloth [**49**].

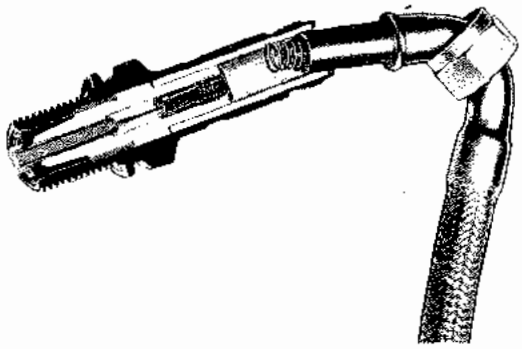
Without touching the connector or spring with the fingers, install the connector in the sparkplug barrel. Be very careful that the connector is inserted straight [**50**] into the barrel and not "cocked" [**51**], since this can result in a cracked insulator or sparkplug barrel.

Run the sparkplug lead coupling nut down finger tight. Hold the lead in proper position and tighten the coupling nut 15 degrees more, using PWA-1683 Wrench [**52**]. Never use an open end wrench, since damage to the barrel insulator may result from side loading.

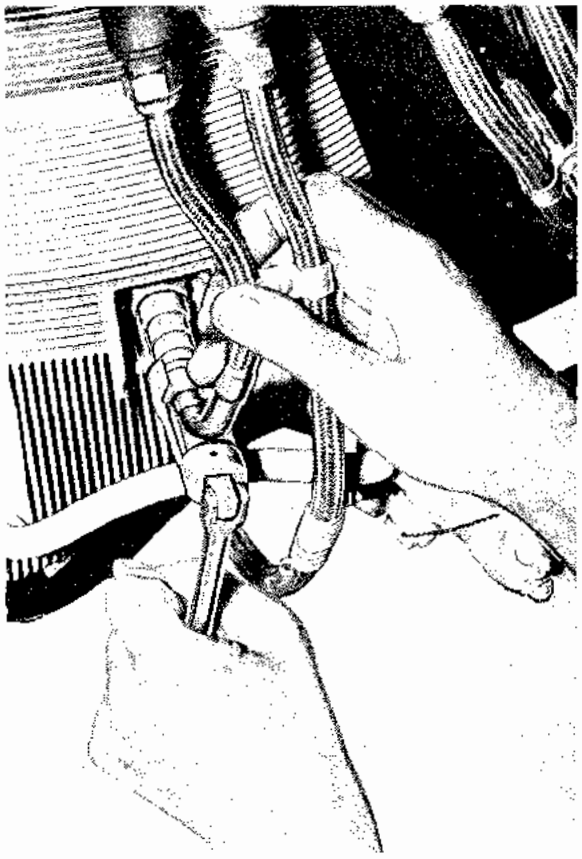
Check the sparkplug leads to make sure that they do not interfere with the engine and are not twisted.



[50] Proper Installation of Connector



[51] Improper Installation of Connector



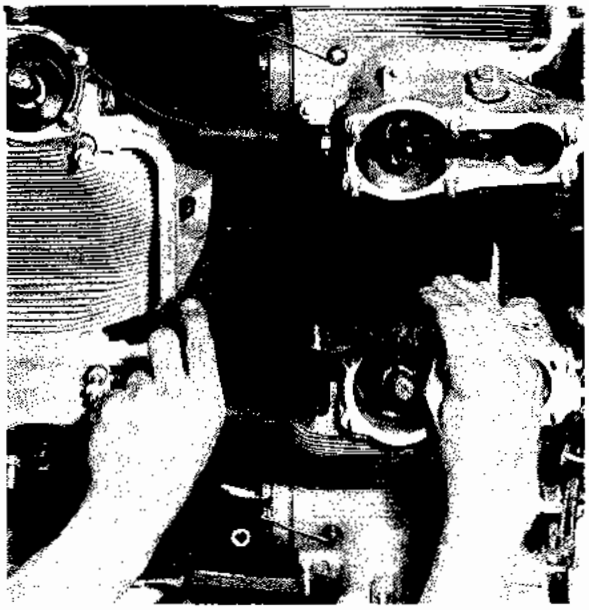
[52] Tightening Lead Nut

Inter-Ear Deflectors

REMOVAL — To remove a deflector through which a sparkplug lead passes, disconnect the lead at the sparkplug and remove the nuts which secure the deflector to the cylinder; then lift the grommet lock and remove the grommet from the deflector, and the deflector from the sparkplug lead. Remove the propeller controls before attempting to remove a deflector through which these controls pass.

INSPECTION — Check for cracks and dents and inspect the condition of the paint.

INSTALLATION — If the cylinder head fin support has been removed, reinstall it on the cylinder head so that the deflector tabs will



[53] Removing Deflector

seat in the support slots; then install the deflector. Pass the sparkplug lead through the deflector hole; then install the grommet on the lead and position the grommet in the deflector hole. Secure the grommet at this location with the provided grommet lock.

Intercylinder Deflectors

REMOVAL — Remove the clamp which secures the intercylinder deflectors to the base of the cylinder. Unfasten and remove the deflector from its cylinder **[53]**. Leave the cylinder head fin support in position on the cylinder.

INSPECTION — Check for cracks and dents and inspect the condition of the paint.

INSTALLATION — Place the intercylinder deflectors on the studs provided for them on each side of the cylinder. Fasten the metal clamp ring loosely around the deflectors at the base of the cylinder. Secure the deflectors to the cylinder with nuts and washers; then make sure the clamp ring is against the crankcase and tighten it in position.

The tightening screw and nut on the intercylinder deflector clamp should be toward the front on the front row cylinders and toward the rear on the rear row cylinders.

Magneto (High Tension System)

REMOVAL — Disconnect the high tension leads, the ground leads, and the pressurizing lines at the magneto. If rigid high tension leads are installed, remove the distributor covers to free the leads. Remove the lockwiring from the four flange bolts and remove the bolts. Lift off the magneto.

INSPECTION — Examine the high tension electrode bushings for carbon tracks and cracks. To insure an electrical bond, clean any dirt or paint from the mounting surface.

INSTALLATION — Place the rubber seal ring on the mounting flange shoulder. Time the magneto to the engine as directed on Page 120, then secure it in place and recheck the timing.

Coat the end of each right tension lead with Dow Corning No. 4 compound; then insert each lead in its magneto outlet and secure it with the nut.

Fasten each pressurizing line to its connection on the side of the magneto, and connect the ground leads.

Ignition Manifold and Cable Assembly (High Tension System)

REMOVAL — Unfasten the propeller governor controls and all controls and tubing which interfere with the removal of the assembly. Remove the propeller, the propeller governor, and the magneto. Detach the leads from the sparkplugs. Disconnect the pressurizing lines at the front of the distributor housings; then unfasten and remove the distributor air intake

covers and the intake air filters. Remove the distributor housing covers and the high tension leads; then lift out the distributor insulating covers. Unfasten and remove the distributor rotors from their respective plates; then unfasten and remove the air pumps from the distributor housings. Remove the bolts and spacers which secure the manifold assembly to the crankcase front section; then lift off the assembly.

By disconnecting the sparkplug leads at the manifold, the assembly can be removed without disconnecting the leads from the sparkplugs.

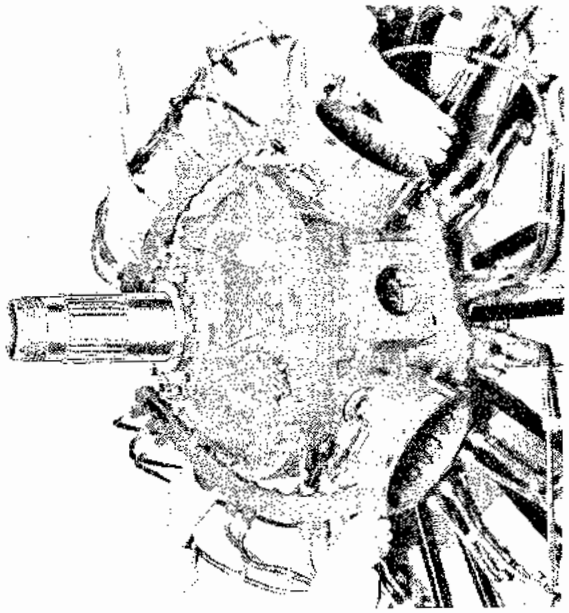
INSPECTION — Inspect the manifold casting for cracks. Make sure all screws are tight and the manifold ring cover is secured to the manifold at all points. Make certain there are no visible cracks between the manifold and its cover. If a crack exists with the screws tight, seal it with shellac. Inspect the insulating sleeves in the outlet sockets of the manifold. A crack in any sleeve is cause for rejection of the manifold assembly.

Using a suitable tester, check for continuity from each distributor block electrode to the end of its corresponding sparkplug lead. If an open circuit is found, replace the sparkplug lead and repeat the test through the replaced lead. If an open circuit still exists, replace the entire assembly.

INSTALLATION — If not already in firing position, rotate the propeller until the No. 1 piston is at its correct spark advance position.

The accuracy of the ignition timing is dependent, to a great extent, on accurately establishing the firing position of No. 1 piston. Personnel must exercise the greatest care in performing this operation.

Coat both sides of the gaskets with Formagasket No. 6; then place one in position on each distributor housing mounting pad. Place the ignition manifold and cable assembly on the engine **[54]**, aligning the distributor housings with their respective pads. Install the pressurizing pumps and time the distributor rotors as directed on page 123.



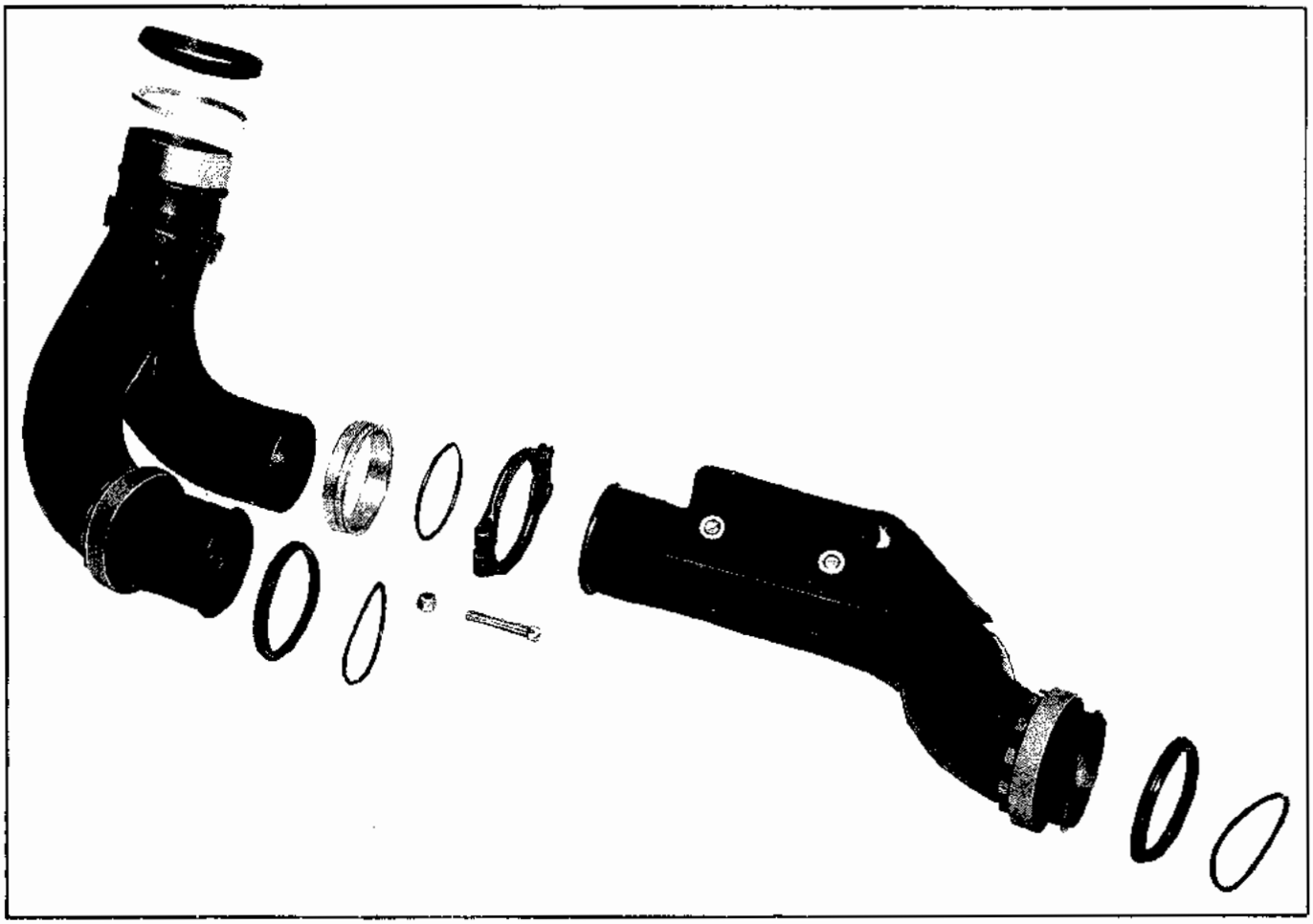
[54] Installing Manifold

Place the spacers between the manifold assembly and the crankcase front section; then secure the assembly in position with the bolts. Lockwire the bolts.

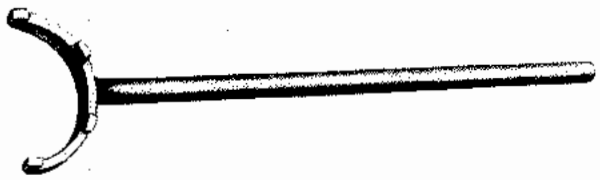
Intake Pipes [55]

REMOVAL — Remove the lockwire and loosen the nut at the supercharger end with PWA-5074 Wrench; then, using PWA-5073 Wrench **[56]**, loosen the nuts at the cylinder end and remove the pipe. If necessary, use PWA-3145 Puller **[57]** to remove the pipe **[58]**. To remove the intake pipe on some installations it may be necessary to remove part of the exhaust system and loosen the intake pipe clamp.

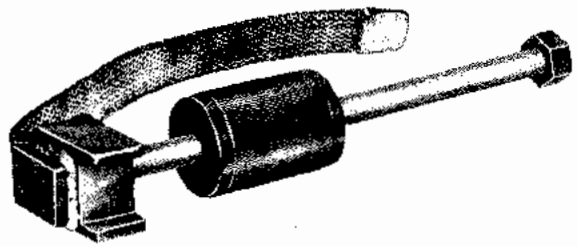
INSPECTION — Check for dents and cracks and inspect the condition of the paint. Examine the nuts for thread and wrench slot condition. Examine the condition of the intake



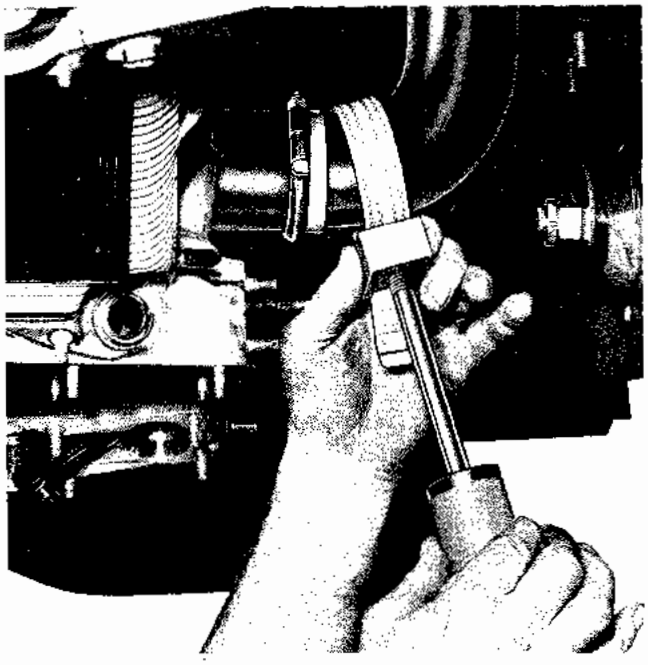
[55] Intake Pipe and Related Parts



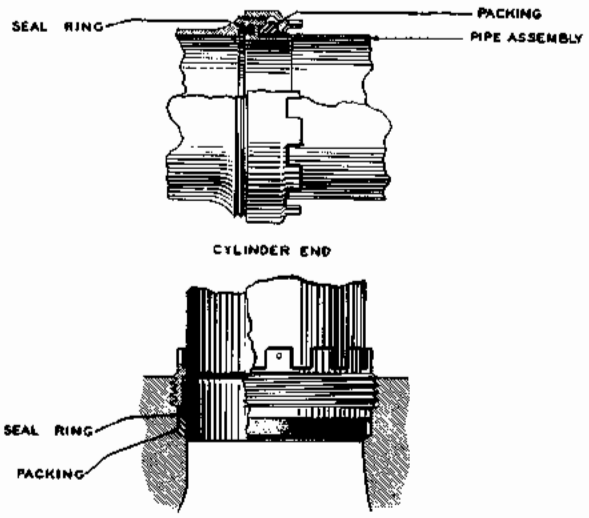
[56] PWA-5073 Wrench



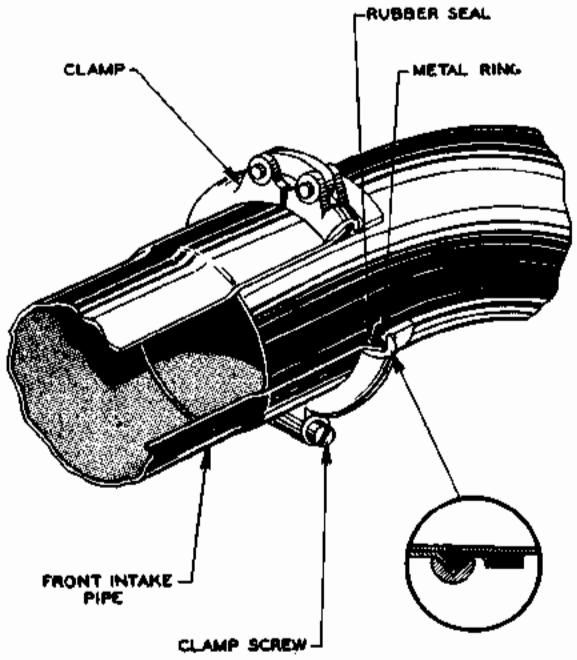
[57] PWA-3145 Puller



[58] Removing Intake Pipe



[59] Intake Pipe Packing



[60] Front Extension Seals

pipe clamp and the silver plated ring. Check the tightness and general condition of the exhaust stack shields.

INSTALLATION — Slip the cadmium plated ring over the front intake pipe rear section so that the flange is away from the supercharger end; then install the rubber seal ring **[59]**. Slide the intake pipe front section over the rear section so that it overlaps for approximately one inch. Slide both rings against the flared end of the front section; then install the clamp over the end of the pipe so that the clamp groove fits over the flared end of the pipe and over the ring flange **[60]**. Draw the clamp tight with the screw and self-locking nut.

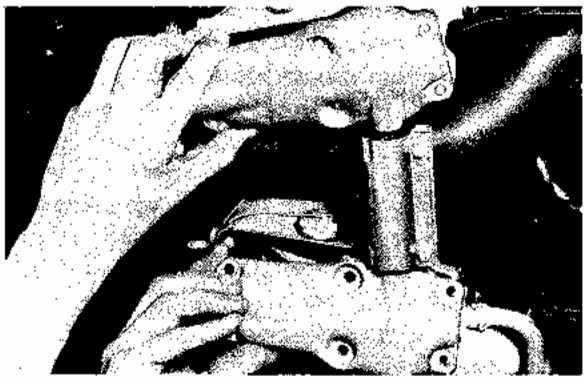
At this location use clamps etched "intake" on the screw boss.

Install new intake pipe packings and new seal rings at the cylinder ends. First install the packing; then install the seal ring on the cylinder end so that the ring is against the flared end. At the case end install the steel gland ring first, then a new packing so that the ring is against the bead near the end of the pipe.

Place the assembly in position and catch the nut at the supercharger case end one turn; then attach the pipe at the cylinder ends and tighten with PWA-5073 Wrench. Using PWA-5074 Wrench, tighten the nuts at the supercharger ends. Lockwire the nut at the supercharger end to the provided lugs on the supercharger case. Lockwire the nuts at the cylinder ends to the pipelug above the intake port.

Rockerbox Covers

REMOVAL — Unscrew the elastic stop nuts which secure the rockerbox cover. Remove the



[61] Removing Rockerbox Covers

[62] Inspecting Rockerbox Covers

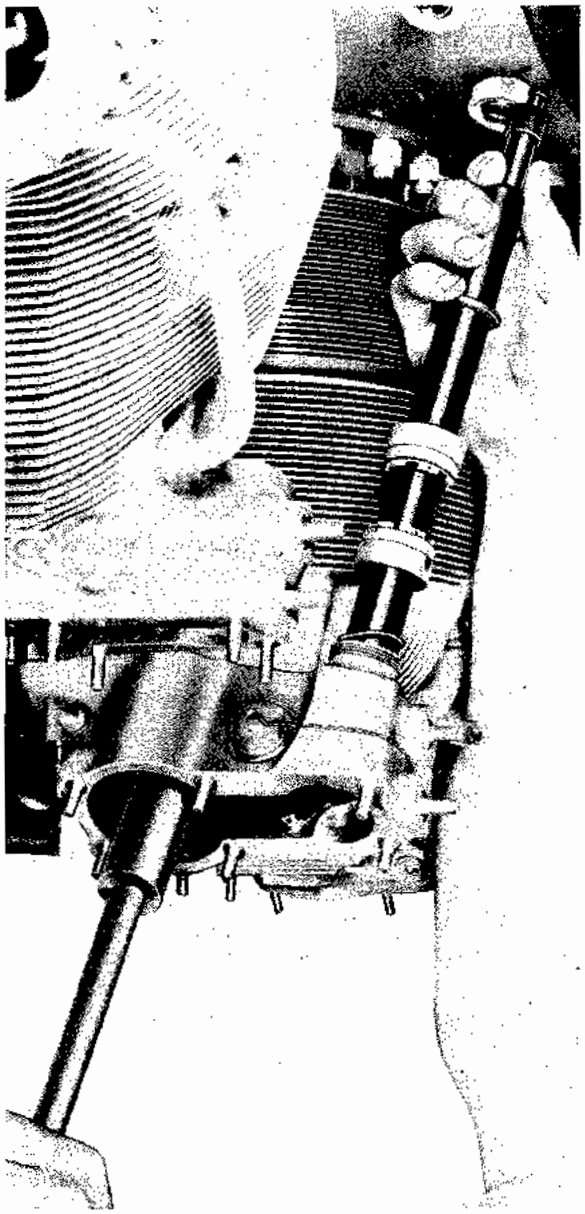
cover and gasket, removing in pairs the covers connected by rubber hose **[61]**. The rockerbox covers of No. 10 cylinder, the exhaust cover of No. 11 cylinder, and intake cover of No. 9 cylinder should be removed with the rockerbox drain oil manifold.

INSPECTION — Inspect for cracks and examine the condition of the parting surface. Check for flatness, using a .002 inch feeler gage and a surface plate **[62]**. Face off, if necessary, on a lapping plate.

INSTALLATION — Make certain that the rockerbox cover gaskets are serviceable. With the gaskets in place, install the covers and tighten the nuts to the recommended torque.

Pushrods and Covers [63]

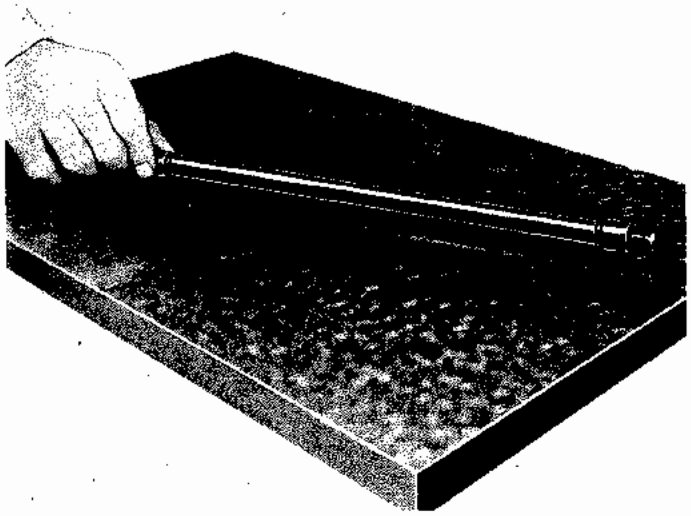
REMOVAL — Before removing the pushrods of a cylinder, make sure the piston of the cylinder is near the top of its compression stroke. If the piston is not near the top of its compression stroke, turn the propeller until the piston is in the proper position. Unscrew the pushrod cover nuts at the cylinder and at the crankcase ends, using PWA-3639 Wrench.



[64] Removing Pushrod

With PWA-455 Depressor depress the rocker until the pushrod is free of its socket in the tappet. Remove the pushrod cover from the cylinder together with its pushrod **[64]**.

[63] Pushrod and Related Parts



[65] Inspecting Pushrod

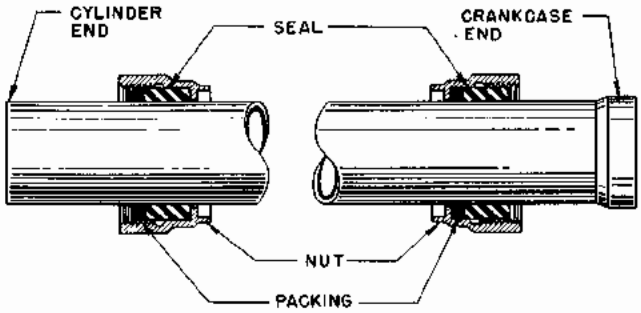
As for the rear exhaust pushrods, remove the exhaust rockerbox cover and the rocker and rocker shaft as directed on page 156; then withdraw the pushrod from its cover through the rockerbox. Remove the pushrod cover as directed in the previous paragraph.

INSPECTION — Check for cracks and see that the oil holes in the ballends are free from obstruction. Check for straightness by rolling on a plane surface **[65]**. Replace ballends which are loose or excessively worn, using PWA-4877 Puller.

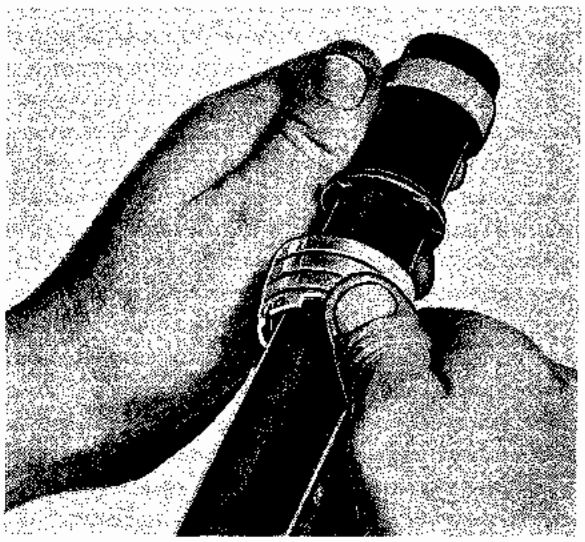
Steel pushrods should be straight within .010" full indication. It is permissible to straighten such rods as long as the bend is not more than ½" full indication or ¼" measured in the center of the rod in relation to a straight reference. There should be no sharp corners or dents to act as stress raisers and promote fatigue.

Inspect the cover for cracks and dents. Check the condition of the paint. Examine the nuts for thread and wrench slot conditions.

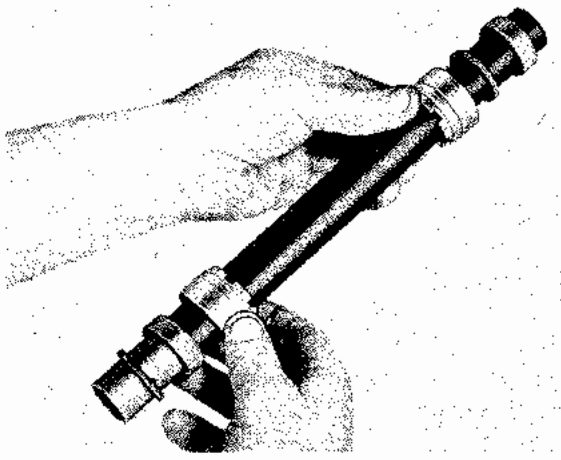
INSTALLATION — Install the seals, packings **[66]**, and gland nuts on the pushrod covers. The fiber (black) packing should be adjacent to the nut on the flared crankcase end **[67]**



[66] Pushrod Seals and Packing

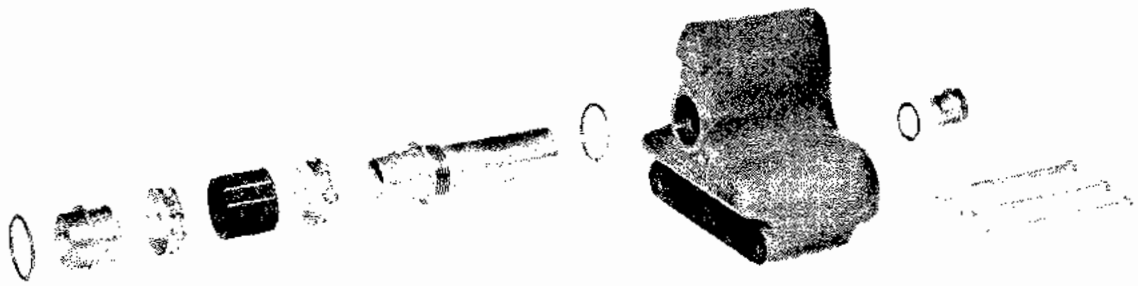


[67] Installing Seals (Crankcase End)



[68] Proper Location of Seals

and the silicon (red) seal adjacent to the nut on the cylinder end **[68]**. Assemble the pushrod and cover assembly with the marked end



[69] Oil Sump and Related Parts

of the pushrod and the flared end of the cover tube at the crankcase. Depress each rocker with PWA-455 Depressor and fit the corresponding pushrod and cover into position. If the valve tappet protrudes too far to allow installation of its pushrod, turn the propeller until the tappet has receded sufficiently. After the pushrod and cover assembly are in place on the engine with the gland nuts secured finger tight, push the cover tube firmly against its seat on the tappet guide, turn down the gland nut, and tighten it to the recommended torque, using PWA-3639 Wrench. Next tighten the gland nut on the cylinder head end of the cover tube to the same torque and lockwire both nuts.

Install the rear exhaust pushrod cover and insert the pushrod into position through the rockerbox and pushrod cover.

Check the valve stem-rocker clearance as directed on page 128, referring to the "Valve Clearance Chart" for the particular cylinder(s) involved.

Not more than six threads (¼ in.) or fewer than three threads (⅛ in.) of a valve adjusting screw should show above the locknut; and there should be a clearance of not less than .031 inch between the outer valve spring washer and the rocker, with the valve closed. If the clearance between the valve spring washer and the rocker is less than .031 inch, or if more than six threads on the adjusting screw show above the locknut, the flat face of one or both of the pushrod ballend spacers may be ground, or the spacer can be replaced with a thinner one or eliminated entirely to obtain the desired clearance. If fewer than one and one-half threads of the adjusting screw show above the locknut, a thicker spacer should be used at one or both ends of the pushrod.

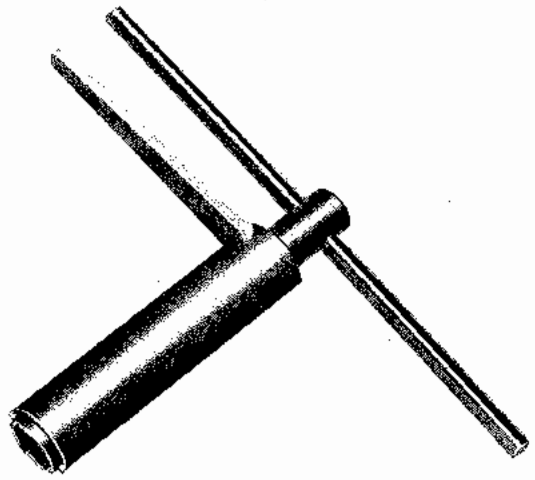
Make all other necessary valve clearance adjustments in the same manner; then turn the propeller in the normal direction of rotation two revolutions, and recheck the clearance of the valves which were adjusted.

Changing pushrod length to obtain correct adjustment should be made only when it is assured that no other discrepancies exist in the valve gear train.

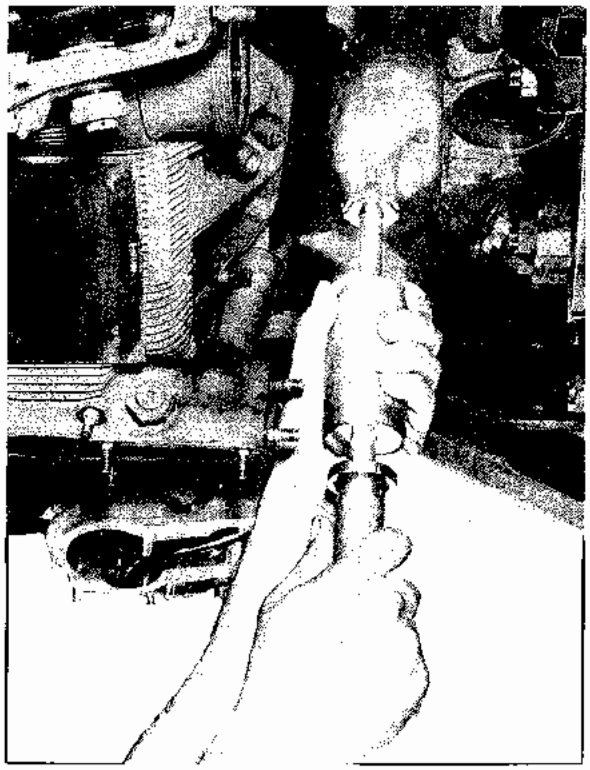
Sump [69]

REMOVAL — Provide a suitable receptacle for collecting the drain oil. Remove the sump drain plug, using PWA-1787 Wrench **[70]**. Remove the bolts which secure the main sump to the supercharger section. Unfasten the inner clamp of the hose connection located between the sump and the crankcase rear section and pull out the sump, using PWA-1686 Puller **[71]**.

INSPECTION — Check condition of the paint. The mounting surface must be clean and free from mutilation. Inspect the sump for cracks.

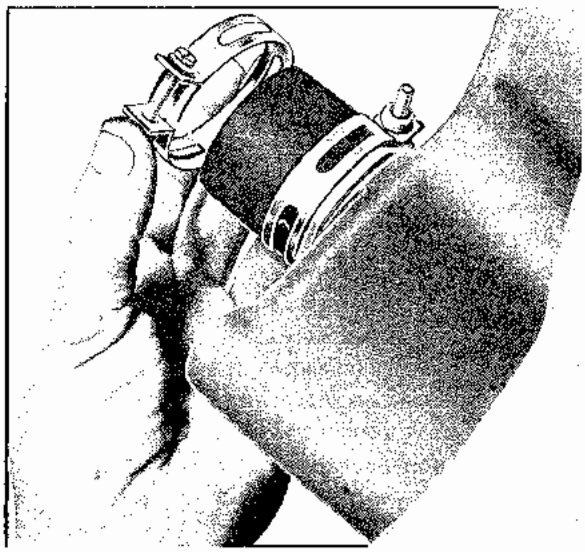


[70] PWA-1787 Wrench



[71] Removing Sump

Before installing the sump on the engine slip the sump hose over the return oil connection and secure it with the lower clamp. The bolt side of the clamp should be on the crankcase mating face side of the sump. With



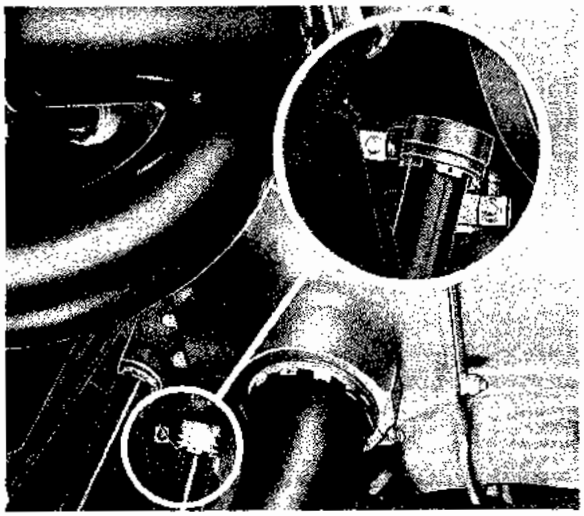
[72] Installing Upper Clamp

the bolt head of the upper clamp on the right hand side, place the clamp on the hose [**72**] in position to secure the main crankcase return oil connection. Holding the sump in the installation position, turn the clamp so that the bolt head is in the five o'clock position and tighten it sufficiently to prevent excessive slippage when securing the main crankcase return oil connection.

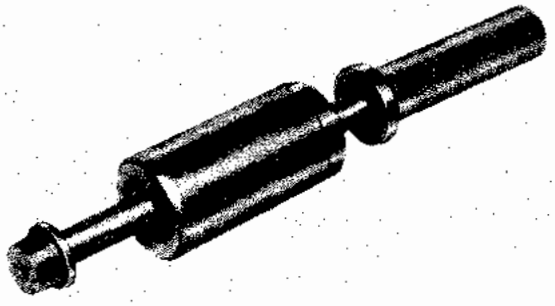
> ***Due to the interference of the pushrod covers and intake pipes, the crankcase return oil connection clamp must be in this position [73] or it will be impossible to tighten the clamp after the sump is installed on the engine. Excessive clamp slippage will necessitate sump removal and repositioning of the clamp.***

INSTALLATION — Make sure that all of the old gasket material has been removed from the mounting surface of the sump and crankcase rear section.

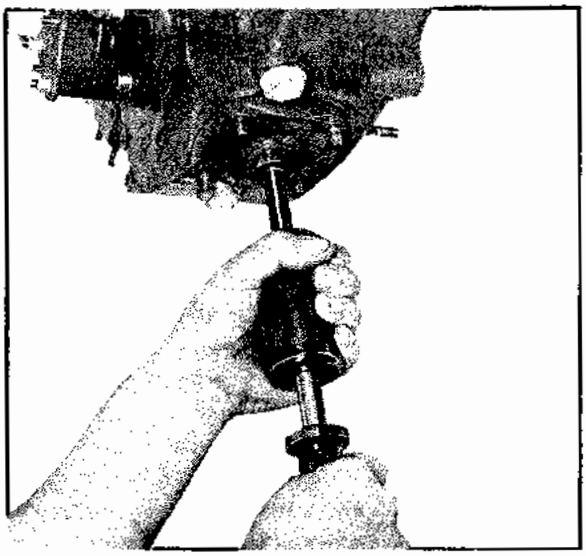
Place a new gasket on the parting surface of the sump; then carefully slide the sump into position on the engine. Make sure that the sump drain tube slips all the way into the drain tube connection on the crankcase and that the



[73] Clamp Location

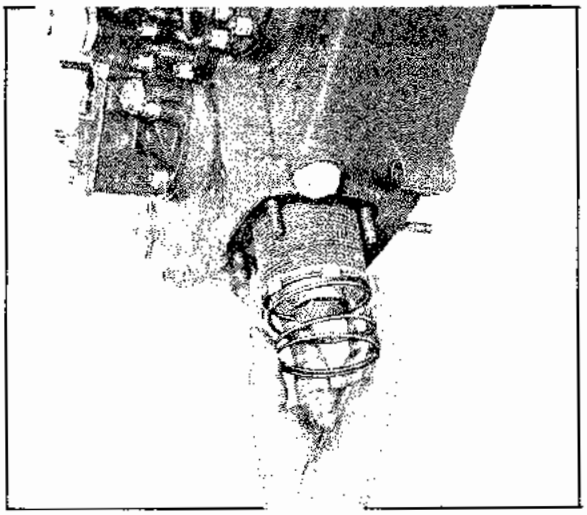


[74] PWA-1687 Puller



[75] Removing Cover

hose connection is on the outside of the drain tube connection. Secure the sump with the two bolts. Tighten the upper clamp on the hose connection; then lockwire the clamps and the sump bolts.



[76] Removing Strainer

Oil Strainer Assembly

REMOVAL — Provide a suitable receptacle for collecting the drain oil. Using PWA-1687 Puller **[74]**, remove the oil strainer chamber cover **[75]**. Withdraw the strainer assembly **[76]**. Special attention should be given to insure that the strainer is not dropped or otherwise mishandled.

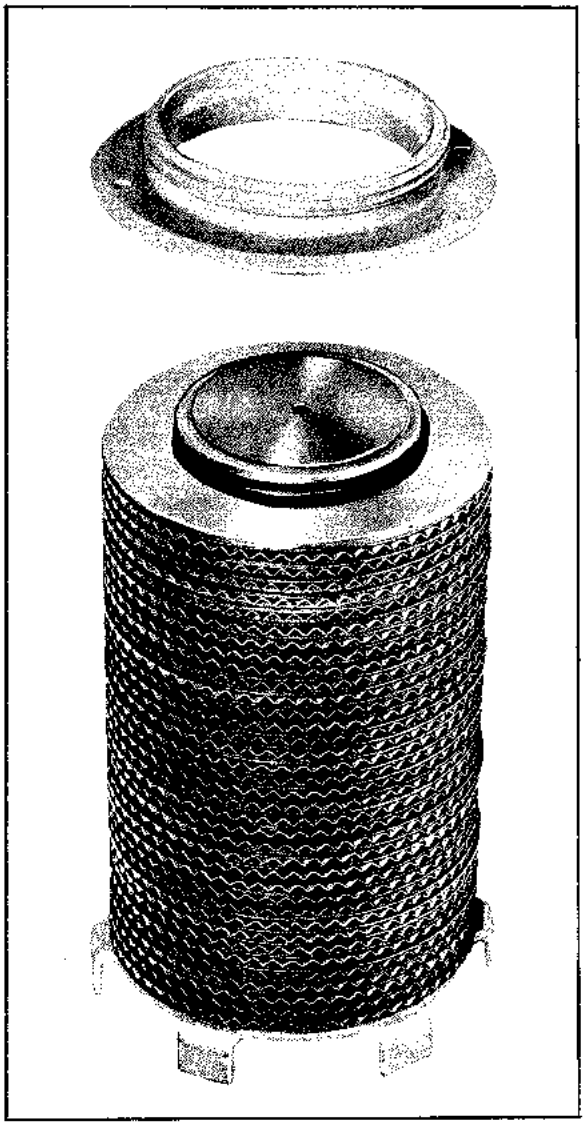
Examine the strainer assembly and cover plug for the presence of metal chips or foreign matter which would indicate a failure or some other unsatisfactory condition in the engine.

There are three types of disc type main oil strainers which have been furnished with subject engines:

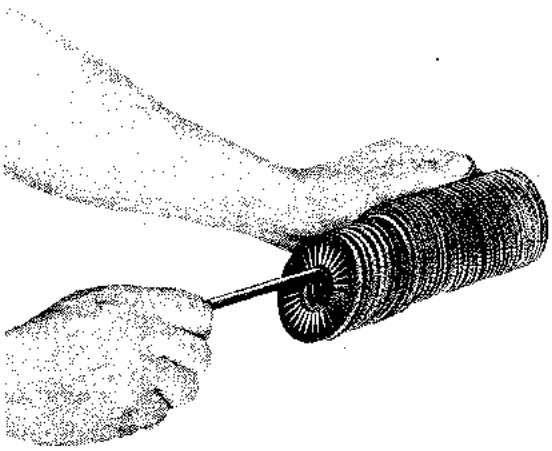
Type I incorporates a body assembly which includes the oil return check valve and perforated central tubular baffle. This strainer will be installed in the engine with a gasket unless it has a modified body having an annulus around the pilot diameter to permit the use of a rubber seal.

Type II strainer assembly **[77]** is used with an adapter which screws into the rear case. A rubber seal ring is installed in a groove in the pilot diameter of the strainer body assembly.

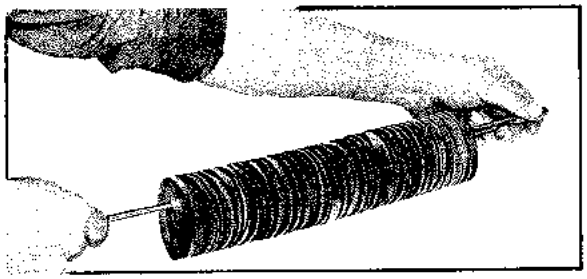
Type III consists of a separate valve and seat assembly which is screwed into the case with a gasket between the flange of the seat and the case and a strainer assembly.



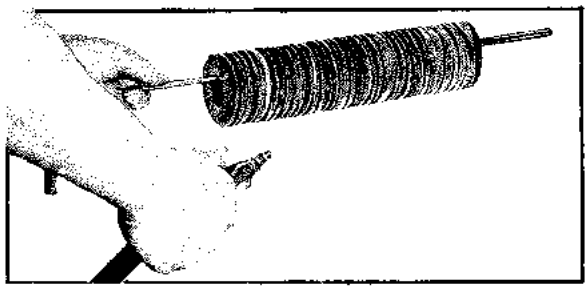
[77] Type II Strainer



[78] Sliding Parts on Rod



[79] Screens and Spacers Separated



[80] Drying with Air Jet

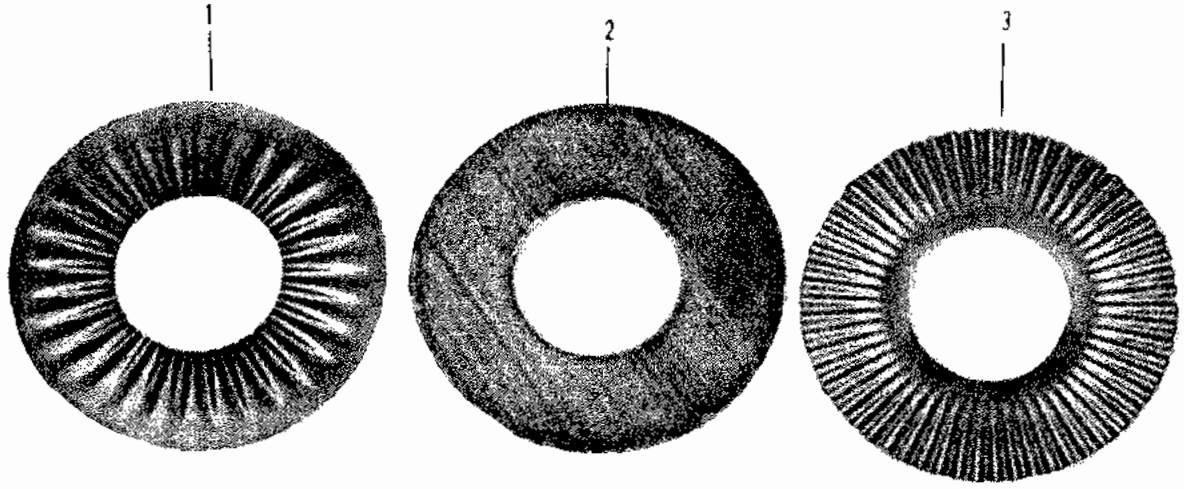
The cleaning and assembling instructions described in the following paragraphs deal with a type II strainer assembly. Procedure for all three types is quite similar except that the assembled length of type III strainer assembly is 4.235 to 4.365 inches.

CLEANING — Remove the lockwire and the plug. Slide the support, the screens, and the spacers onto a ¾ inch diameter rod **[78]** which is approximately 18 inches long and which is provided with means of preventing the parts from sliding off the rod during the cleaning operation.

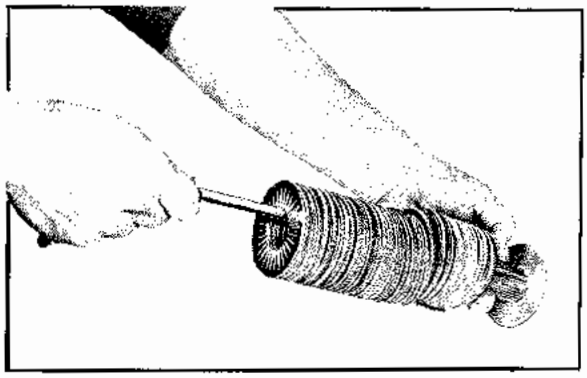
Loosen the screens from the spacers by sliding the parts along the rod **[79]**; then immerse in an approved carbon remover at room temperature for a few minutes. Rinse in degreaser fluid or carbon tetrachloride and blow dry with an air jet **[80]**.

Examine the screens for cleanliness and repeat the cleaning operation, if necessary.

ASSEMBLY AFTER CLEANING — Check the parts on the cleaning rod to make sure that the parts are properly arranged in the following order: Outlet spacer, screen, inlet spacer **[81]**, screen, and so on in the same order and ending with an outlet spacer and the support assembly.



[81] 1. Inlet Spacer 2. Screen 3. Outlet Spacer



[82] Sliding Parts on Body

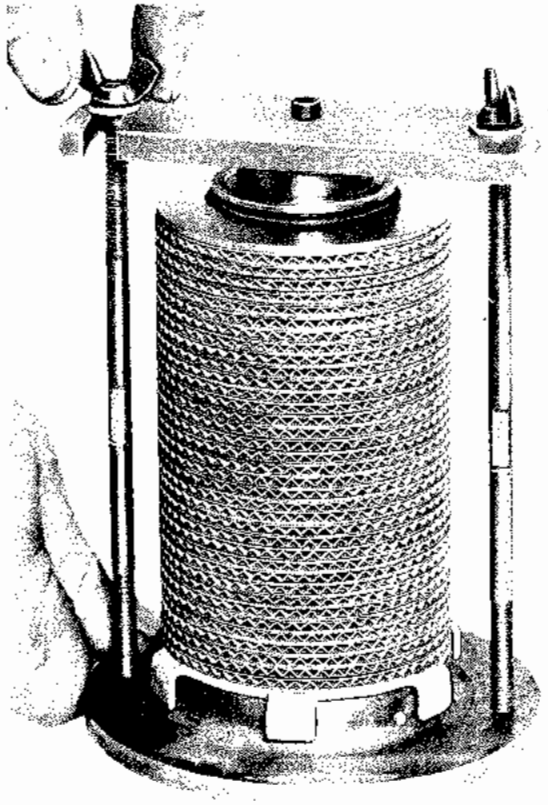
Slide the spacers, screens, and support assembly from the cleaning rod onto the body assembly [**82**] and place the assembly in PWA-5313 Assembly Fixture so that the pilot diameter of the support protrudes through the adapter.

> ***PWA-5313 Assembly Fixture is equipped with two Detail 5 Rods for use with the Double Wasp oil strainer. Prior to use, install these rods in the adapter and lock them with two jam nuts.***

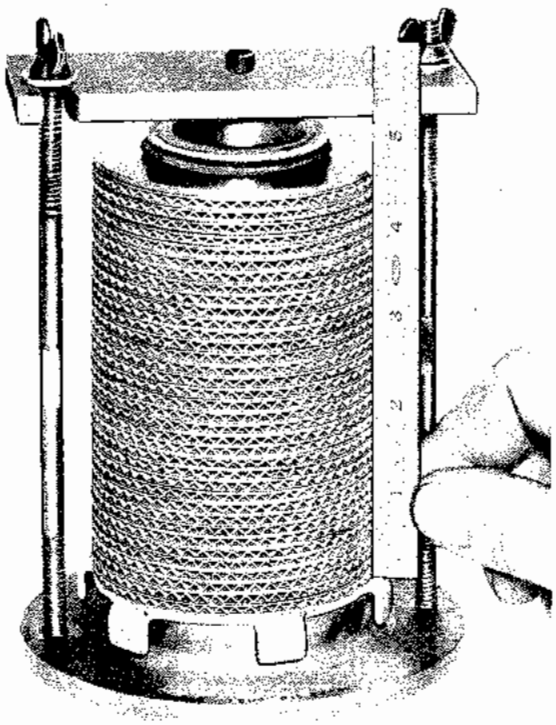
Make sure that the pin in the support assembly is entered in the slot in the body assembly and install the Detail 1 plate assembly on the fixture so that the boss is entered in the valve recess in the body. Tighten the two wing nuts [**83**] on the rods until the spacers and screens cannot be turned by hand and measure the assembled length between the body and the support [**84**]. This should measure 4.610 inches to 4.480 inches for the type II strainer [**85**] assembly and 4.365 inches to 4.235 inches for the type III strainer assembly [**86**]. If necessary, adjust the assembled length by adding or removing spacers and screens in sets consisting of one inlet spacer, one outlet spacer and two screens.

> ***One set measures approximately .120 inch when compressed.***

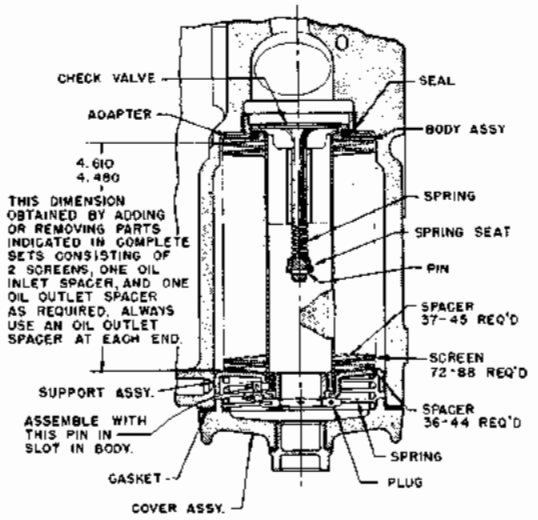
Install the plug in the body assembly [**87**] and tighten it finger tight. Loosen the wing nuts and remove the strainer assembly from the fixture. Place the assembly in a soft-jawed vise and tighten the plug to the recommended torque [**88**]. A plug which is not properly torqued results in a loose stacked assembly which is susceptible to rapid wear of the screens and spacers. Lockwire the plug to the pin in the support assembly.



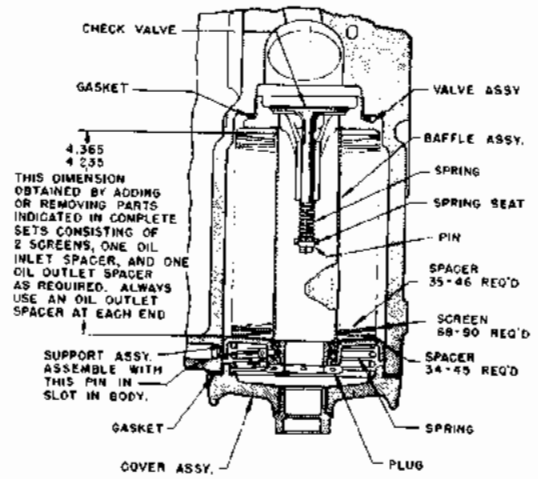
[83] Installing Strainer in Fixture



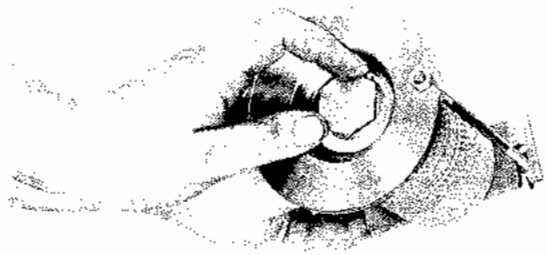
[84] Measuring Strainer



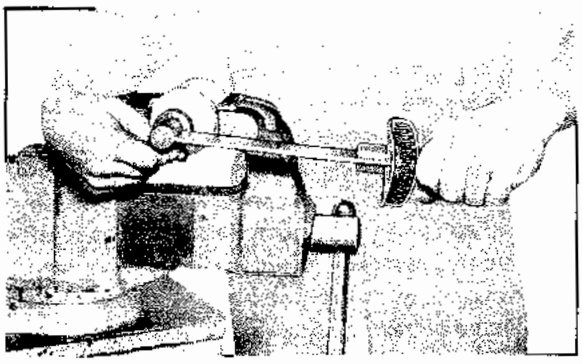
[85] Type II Strainer



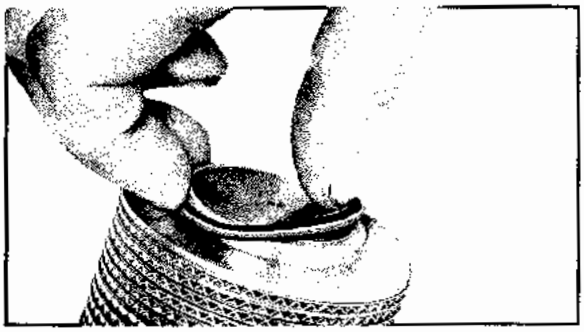
[86] Type III Strainer



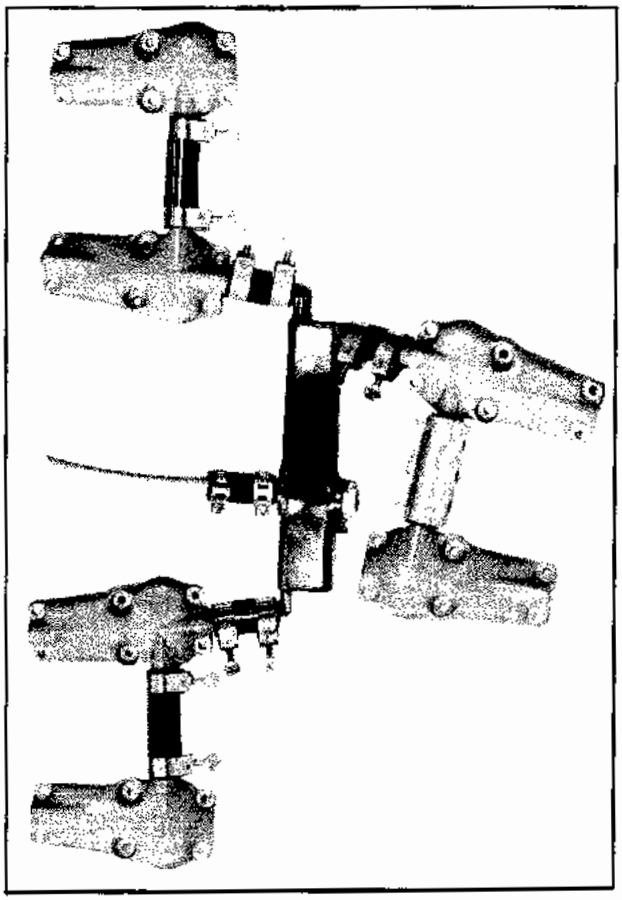
[87] Installing Plug



[88] Torquing Plug



[89] Installing Seal



[90] Drain Oil Manifold

INSTALLATION — Always use a new pilot (top) gasket **[89]** when installing the oil strainer assembly in the engine and be sure the old gasket is removed. In no case should more than one gasket be used. Make sure that all of the old gasket material has been removed from the gasket seating surface of the strainer chamber cover and from the rear case. Center a new oil strainer chamber cover gasket on the cover, using a small amount of grease on both sides of the gasket.

Install the strainer assembly, making sure the pilot of the oil strainer body assembly is properly located in the recess provided in the engine. If the pilot of the strainer body assembly is off to one side, and an attempt to install the strainer chamber cover is made, the perforated tube of the body assembly may be bent.

Special attention should be given to insure that the strainer assembly is not dropped or otherwise mishandled.

Install the strainer chamber cover. Secure with the four fiber insert nuts. After the nuts have been tightened, the studs should either project slightly beyond the fiber insert in the nut or be flush with it. If the studs are found to have insufficient projection, which may be due to the thickness of the cover gasket, back the studs out three or four threads and then drive them to the desired projection. If the driving torque for redriving a stud is below recommended limits, replace the stud with the appropriate oversize.

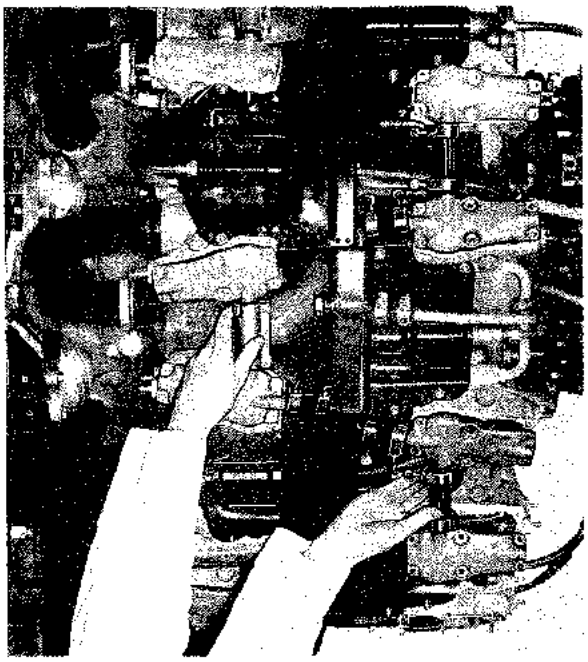
Rockerbox Drain Oil Manifold [90]

REMOVAL — Unfasten the rockerbox drain suction tube from the front oil scavenge and booster pump, and remove the tube clip from No. 10 cylinder **[91]**. Loosen the clamps which fasten the rubber hose connection between the rockerbox drain oil manifold and the suction tube. Lift off the tube **[92]**. Remove the nuts from both rockerbox covers of No. 10 cyl-

[91] Removing Suction Tube Clip

[92] Removing Suction Tube

inder, the exhaust rockerbox cover of No. 11 cylinder, and intake rockerbox cover of No. 9 cylinder. Remove the manifold together with the four rockerbox covers from the engine **[93]**.

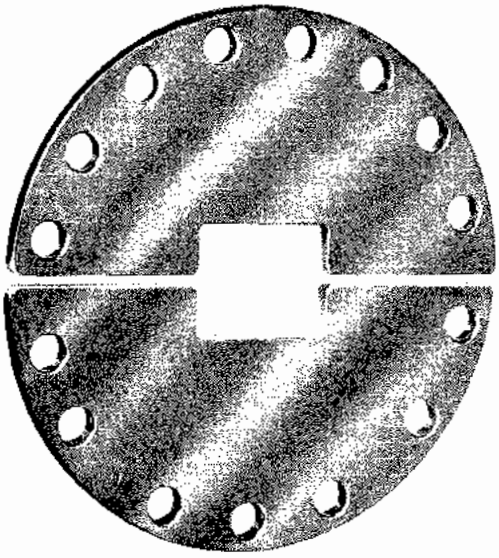


[93] Removing Drain Oil Manifold

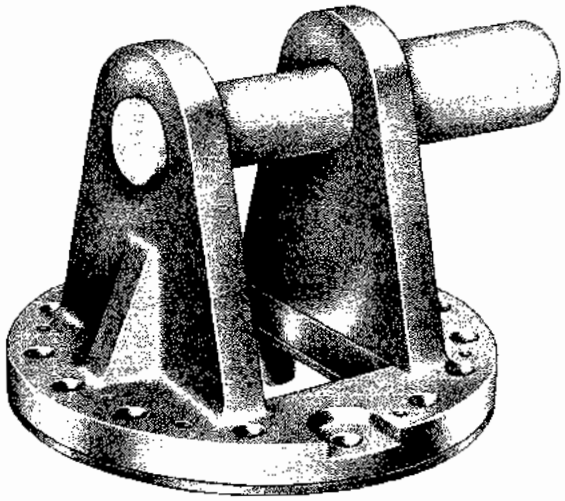
INSPECTION — Check for cracks and condition of paint. Inspect the threads in the manifold proper and the threads on the drainplug. Hose nipples must be clean and smooth.

INSTALLATION — If the manifold has been disconnected from the rockerbox covers, place the rockerbox drain oil manifold hose connection on the exhaust rockerbox cover of No. 11 cylinder, and on both rockerbox covers of No. 10 cylinder; then, holding the manifold in position, slide the hose connections over the arms of the manifold. Tighten the clamps on all the hose connections of the rockerbox drain oil manifold assembly. If a clamp does not have a reasonable amount of take-up left after tightening, replace the hose connection. Install four new rockerbox cover gaskets in position on the cylinders. Install the drain oil manifold together with the four rockerbox covers. Secure the covers with the nuts and tighten them to the recommended torque. Secure the rocker drain oil suction tube to its boss on the front scavenge and booster pump cover together with a new gasket; then secure the tube clip to No. 10 cylinder inter-ear drain tube. Slide the hose connection to the manifold into position and tighten the two clamps.

[94] Scavenge Oil Tube



[95] PWA-2069 Support



[96] PWA-2414 Holder

Scavenge Oil Tube [94]

REMOVAL — Loosen the clamps on the hose connections which secure the front and rear

[97] PWA-4985 Guide

sections of the tube; then unfasten and remove the front section of the tube together with the hose connection. Remove the necessary deflectors, exhaust stack, and intake pipe from the No. 8 cylinder; then unfasten the rear section of the scavenge tube from the supercharger case and withdraw it through the cut-out in the intercylinder deflectors.

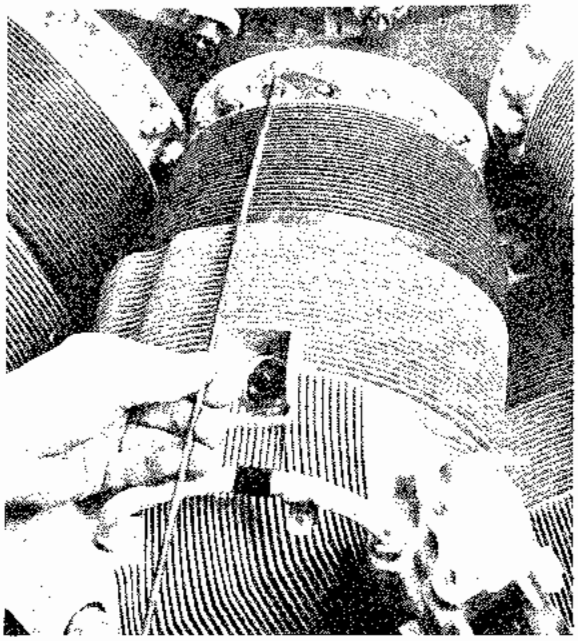
INSPECTION — Check for cracks, dents, and condition of brazed ends. Seating and hose connection surfaces must be clean and smooth.

INSTALLATION — Insert the rear section of the tube through the cut-out in the intercylinder deflector between the Nos. 8 and 9 cylinders. Place the rubber oil seal on the end of the rear section of the tube and secure the tube to its mounting pad on the supercharger case. Install the steel liner between the rear and front sections of the scavenge oil tube and couple these sections together with the hose connection. Place the rubber oil seal under the flange at the front of the tube front section and secure the tube to its mounting pad on the front accessory section.

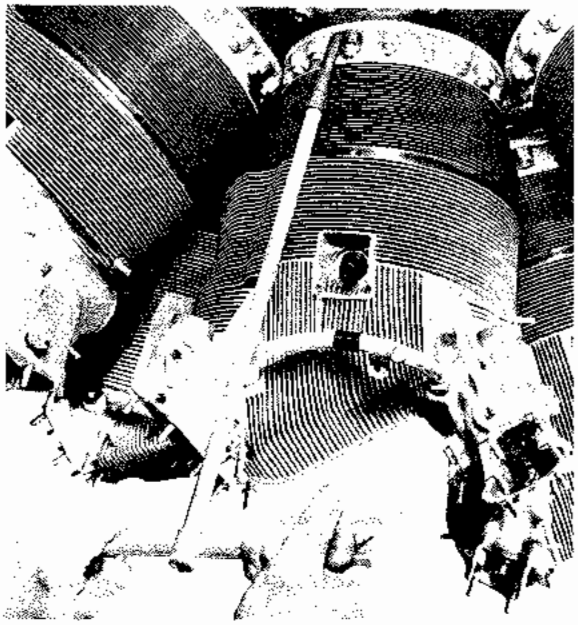
Cylinders

PRELIMINARY INSTRUCTIONS — Observe the following instructions before removing cylinders:

Remove the masterod cylinders (Nos. 8 and 9) last, when their removal with one or more front or rear cylinders becomes necessary. Upon removal of a masterod cylinder, the pistonpin end of the masterod should be centered in the crankcase opening by PWA-2069



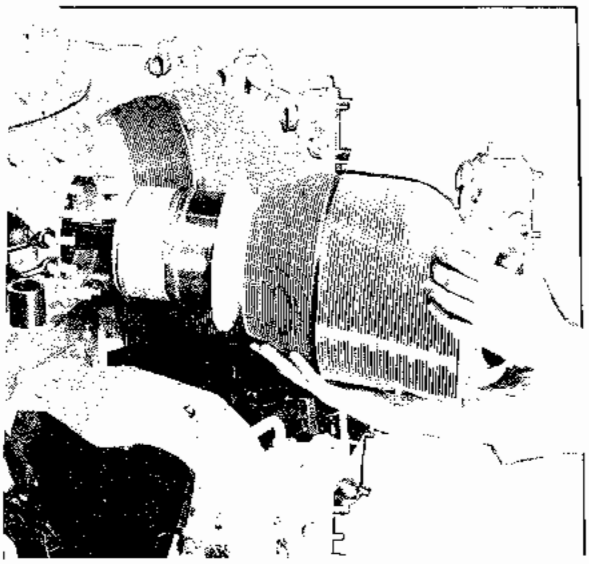
[98] Removing Locknut



[99] Removing Flange Nut

Support **[95]**, PWA-2414 Holder **[96]**, or PWA-4985 Guide **[97]**. The guide allows rotation of the propeller without risk of damage to the cylinders and the crankcase section, should rotation of the propeller, after removal of the masterod cylinder, become necessary.

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



[100] Removing Cylinder

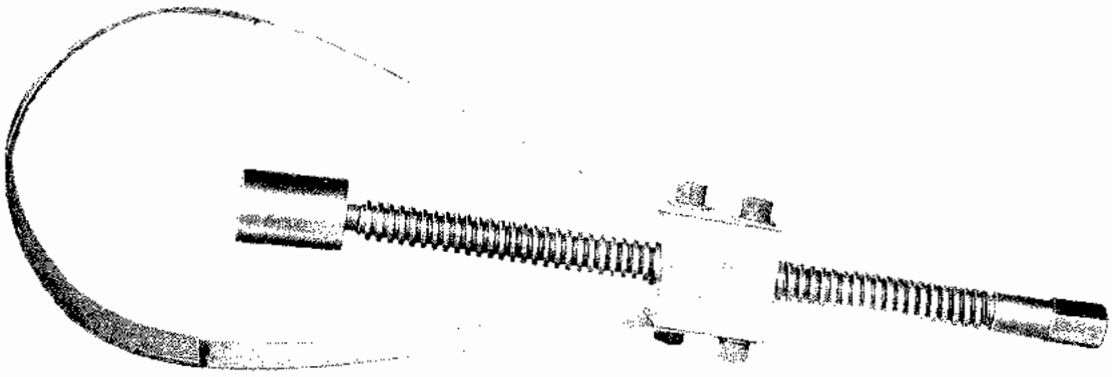
Remove sections of the distributor air intake tubes, oil scavenge tube, or any tubes and controls which interfere with cylinder removal. Disconnect the pushrod covers and remove the interfering intake pipes and exhaust stack extensions.

REMOVAL — Turn the propeller shaft until the piston in the cylinder to be removed is at the top of its stroke (compression stroke preferred). Remove the locknuts **[98]** and cylinder flange nuts **[99]** with PWA-3923 and PWA-5061 Wrench, respectively.

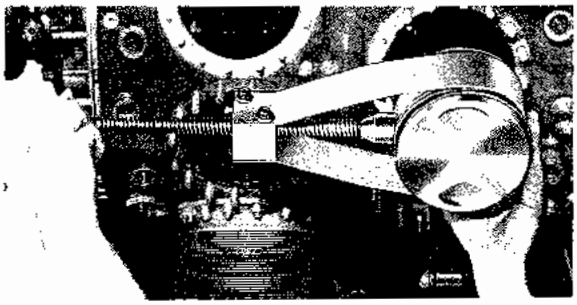
If a nut is found to be loose or there has been failure of a stud, replace that stud and the two adjacent studs in accordance with the paragraph entitled ***Flange Nuts and Bolts*** *in this chapter.*

If only two adjacent studs have failed or two adjacent nuts have been found loose, the cylinder may be reused provided the nuts adjacent to the failed studs or adjacent to the loose nuts are found to be at least to the minimum torque (under ***CYLINDER FLANGE NUTS*** *in* ***SPECIFIC TORQUE RECOMMENDATIONS****), and the cylinder barrel passes the flange flatness check (****CYLINDER BARRELS*** *this chapter).*

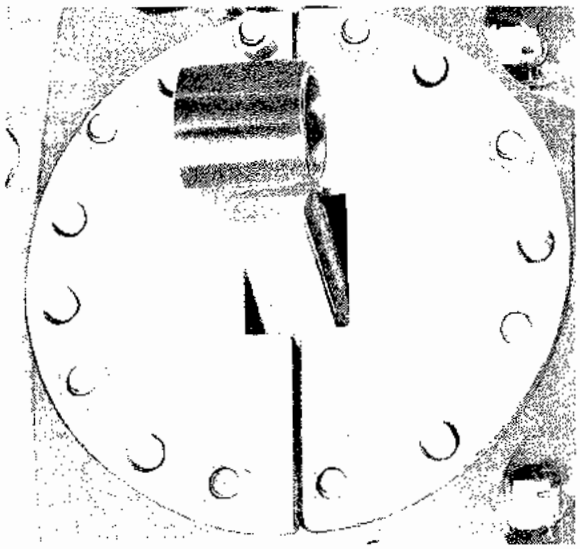
If more than two adjacent studs have failed or if more than two adjacent



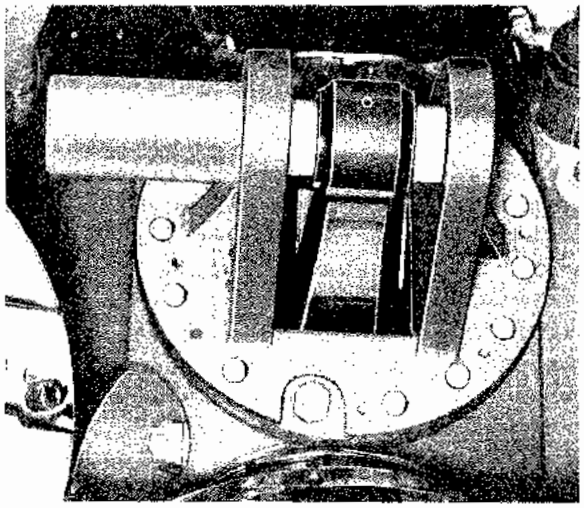
[101] PWA-4911 Pusher



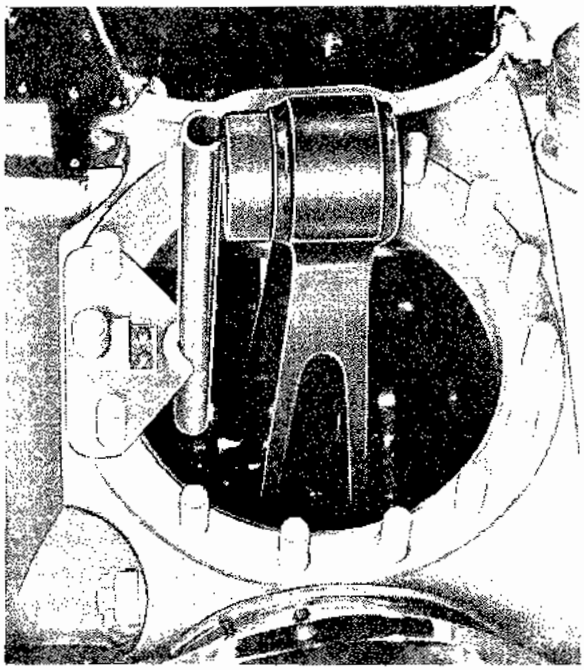
[102] Removing Pistonpin



[103] Masterod Supported



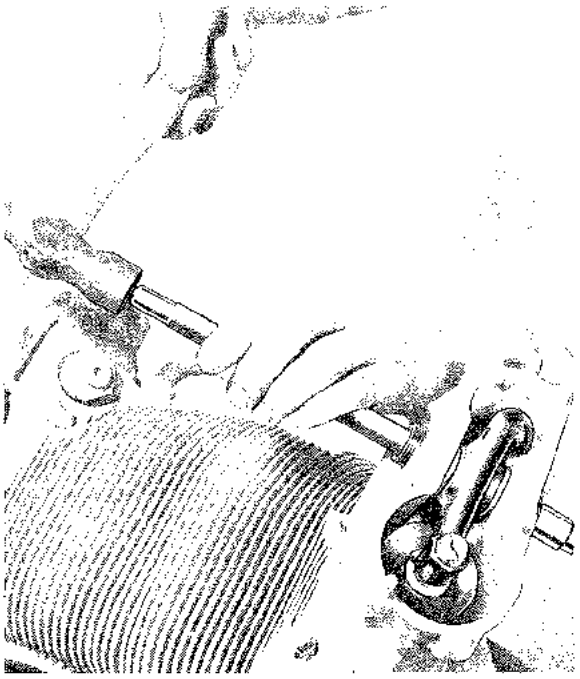
[104] Masterod Supported



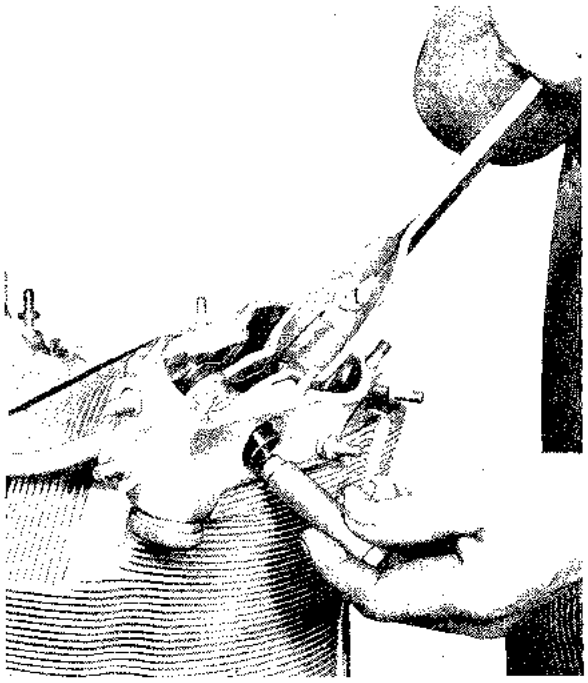
[105] Masterod Supported

nuts are known to have been loose during engine operation, the cylinder should be returned to overhaul and all the studs on the cylinder mounting pad replaced.

Withdraw the cylinder **[100]**. After removal, place the cylinder in an appropriate carrier so that the fins and barrel skirt will not



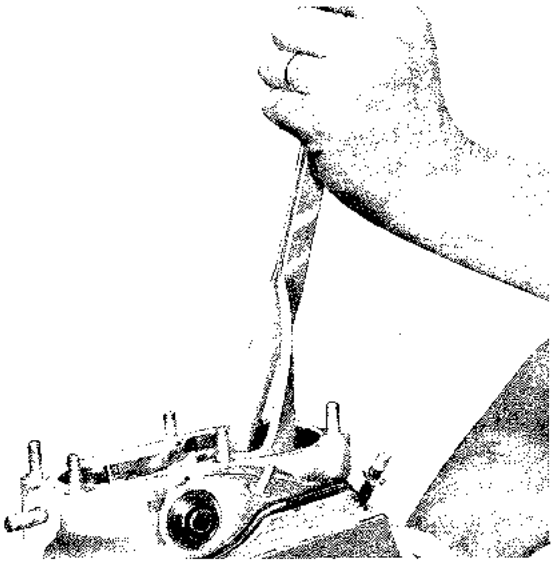
[106] Removing Rocker Shaft



[108] Installing Compressor

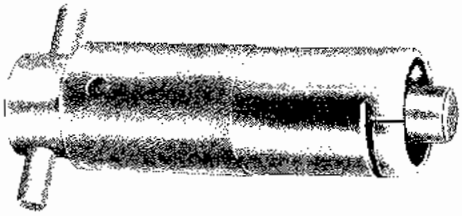
be damaged. Using PWA-4911 Pusher **[101]**, push out the pistonpin **[102]**, and remove the piston. Secure the rod with a suitable holder as soon as the cylinder is removed **[103]**, **[104]**, **[105]**. Cover all openings in the crankcase and supercharger case to prevent the entrance of foreign matter.

DISASSEMBLY — If the valve springs and rockers are to be removed from a cylinder on the engine, the propeller should be rotated until the piston of the cylinder from which the springs and rockers are to be removed is at top center position on the compression stroke. This will prevent the valves from falling out of their guides into the cylinder when the split

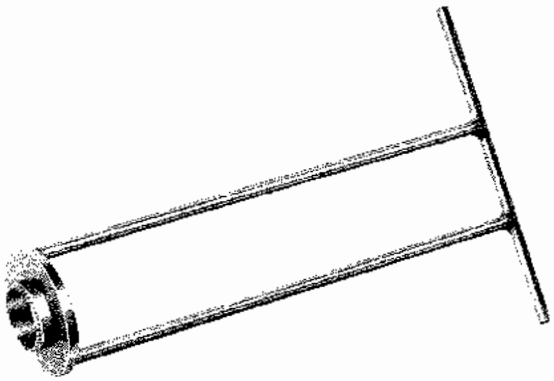


[109] Compressing Spring

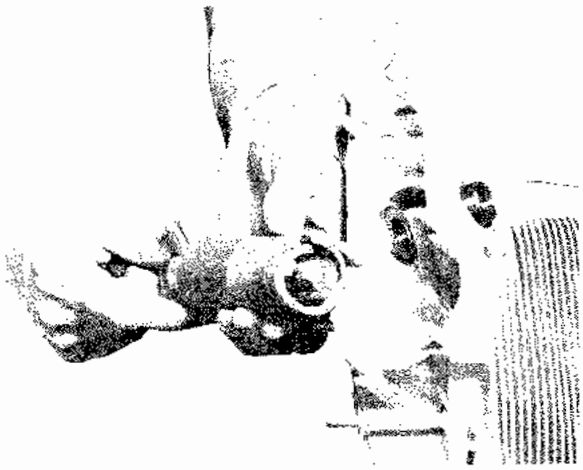
[107] PWA-4310 Compressor



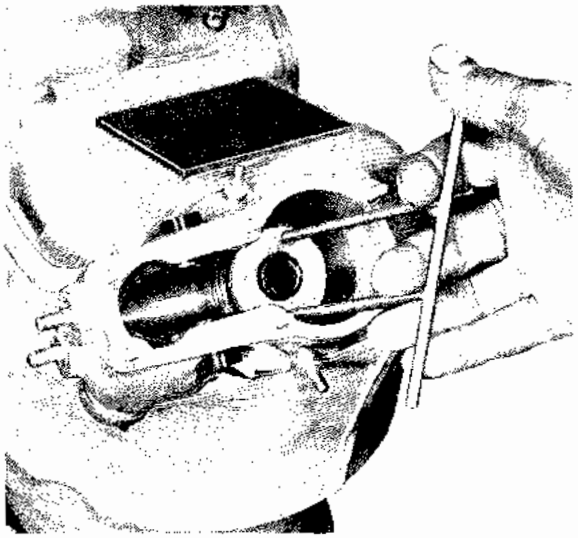
[110] PWA-4333 Remover



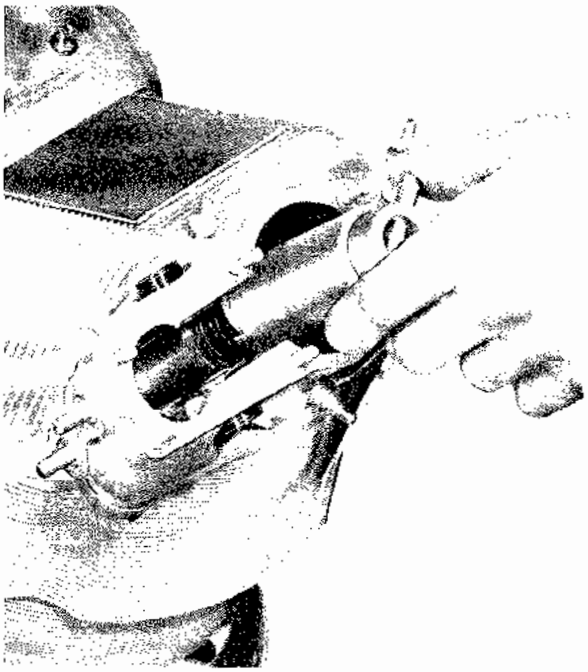
[113] PWA-3277-12 Scraper



[111] Installing Remover



[114] Cleaning Exhaust Valve Guide



[112] Removing Snapring

locks, washers, and valve springs are being removed, in addition to facilitating removal.

Rockers — Remove the rocker shaft caps and their gaskets. While holding the rocker, drive the rocker shaft out of its bushings with PWA-3899 drift **[106]**; then remove the rocker and spacer from the rockerbox.

Springs — Place the cylinder over a wooden mounting block shaped to fit the dome of the cylinder head. Install PWA-4310 Compressor **[107]** and **[108]**; then compress the valve springs **[109]** and remove the split locks. Withdraw the valve spring upper washers, valve springs, and inlet valve spring lower washer. Remove the circlet from the outer end of the exhaust valve guide, using PWA-4333 Remover **[110]**, **[111]**, and **[112]**. Use PWA-

3277-12 Scraper **[113]** and **[114]** to clean up the outside of the valve guide if necessary, to facilitate removal of the exhaust valve spring lower washer. Remove the exhaust valve spring lower washer.

Valves — Place a rubber band over the valve stems and block. Slide the valves out of their guides, being careful not to allow them to strike the cylinder wall.

INSPECTION OF CYLINDER AND RELATED PARTS

If facilities are inadequate for the repair or replacement of defective parts, replace the cylinder with a complete new assembly, including a new piston and rings assembly, the rings of which have been lapped. Refer to the Overhaul Manual for lapping instructions.

Flange Nuts and Bolts — All cylinder flange studs or bolts and flange nuts should be examined for cracks, damaged threads, and other visible defects. Clean the threads of the studs or bolts and nuts thoroughly, using a hand wire brush if necessary. Remove any roughness or burrs on the nuts, bolts, or cylinder flange.

Observe replacement recommendations in the paragraph entitled REMOVAL under cylinders in this chapter.

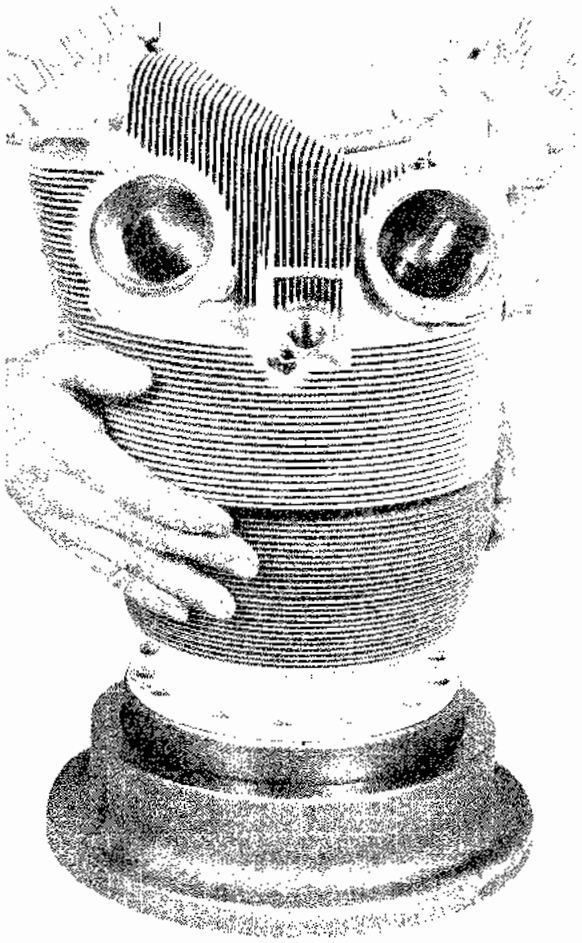
Cylinder Heads — Examine the head fins for cracks and breaks, paying particular attention to the exhaust port section. Small cracks on the head fins are not cause for rejection. If more than 12 inches of any one fin is completely broken off or if the total area of fin breakage on any one cylinder head exceeds 71 square inches, replace the cylinder. Where adjacent fins are broken, the total permissible length of breakage is 6 inches on two adjacent fins and 4 inches on three or more adjacent fins. The length limits given are measured at the base of the fin. "Fin area" is defined merely as the total area exposed (both sides of fins) to cooling air. Any roughness or sharp corners should be carefully blended into the adjacent surface to eliminate a possible source of new cracks. A cracked fin should be reworked in a manner that will prevent further extension of the crack.

Use spherical tungsten carbide rotary files of various diameters from 3/16 inch to ⅝ inch in an air drill. Finish blend the reoperated areas with a Metalite, or equivalent, No. 50 Grit cloth pencil ⅝ inch OD, 5/16 ID, and 2¾ inches long.

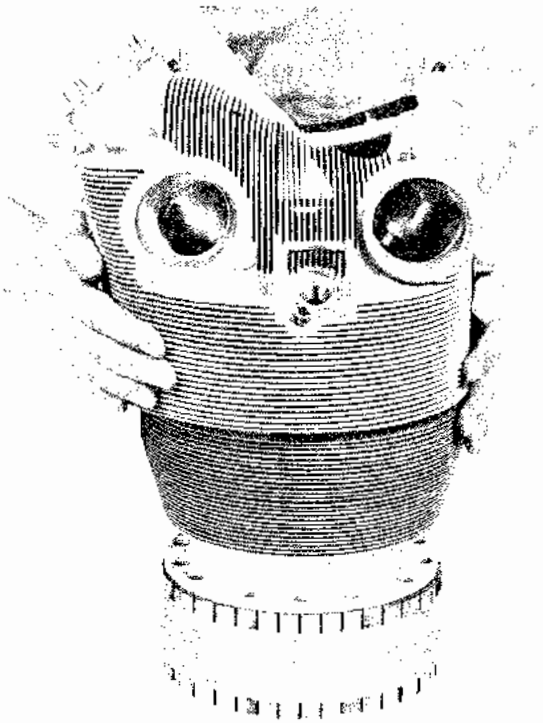
Following reoperation, carefully etch the area from which the crack was removed. If no further indications are found, thoroughly remove any remaining etching or neutralizing solution by flushing with water, using particular care to see that none remains on any portion of the cylinder.

Examine the condition of the sparkplug inserts and check the cylinder head for cracks especially adjacent to the sparkplug holes. Inspect the inside surface of the cylinder head and the areas adjacent to the inlet and exhaust ports for cracks. Inspect the heavy flange at the base of the head for cracks. Examine the inside of the rockerbox walls for indications of valve spring chafing and for cracks. Check the condition of the pushrod cover nut unions.

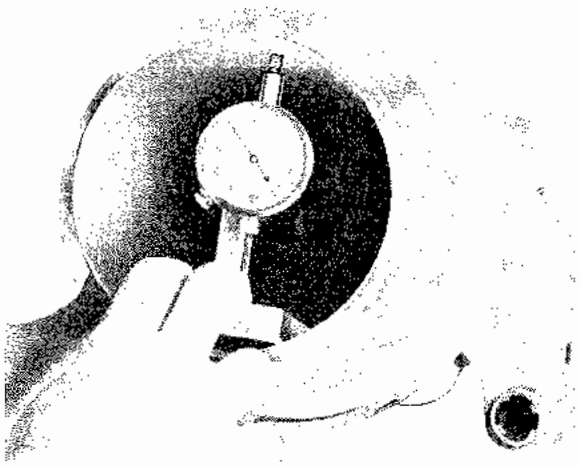
Cylinder Barrels — Examine the condition of the fins on the cylinder barrel muff and check the muff for tightness. If one complete muff fin or an amount equal to one complete fin is broken, the cylinder should be replaced. To preclude hot spots, avoid continued operation of cylinders on which muff fin breakage, although within limits, is concentrated in one localized area. Using pencil carbon paper, check the cylinder hold down flange for trueness on PWA-2630-23 Plate **[115]**. If the flange is uneven or distorted and providing the distortion does not exceed .003 inch, lap the flange, using PWA-2199 Lap **[116]**. If the flange is uneven or distorted in excess of .003 inch, replace the cylinder. The greatest wear in a cylinder barrel usually occurs at the rear, slightly toward the thrust side, where the upper piston ring reaches the top of its travel. This wear extends only a short way down the bar-



[115] Checking Cylinder Flange



[116] Lapping Cylinder Flange



[117] Checking Cylinder Barrel

rel, and the main part of the barrel choke is not appreciably affected unless the condition is very extreme. As wear increases at the top of the barrel, a step is formed. If this step exceeds .006 inch at any part of the circumference, replace the cylinder and piston and rings assembly. Check the bore of the barrel for out of roundness **[117]**. The barrel should not be out of round more than .006 inch. It is permissible to let the diameter at the location of the ring step reach .006 inch over the diameter of a standard bore, as measured at the bottom of the barrel, providing the out of roundness is not excessive. If either the out of roundness or the diameter at the ring step is found to be excessive before 2000 hours of service, and if the head is still in good condition, the cylinder may be returned to stock and held for return to the manufacturer for rebarreling. Examine the bore of the barrel for irregularities, cracks, and scoring. If a cylinder barrel is scored or has other irregularities which cannot be cleaned up by hand, replace the complete cylinder assembly.

Failed Cylinder Assemblies — Experience has proven that an engine which has suffered a valve or cylinder head failure may be successfully returned to service if the cylinder assembly is replaced. In order to understand the

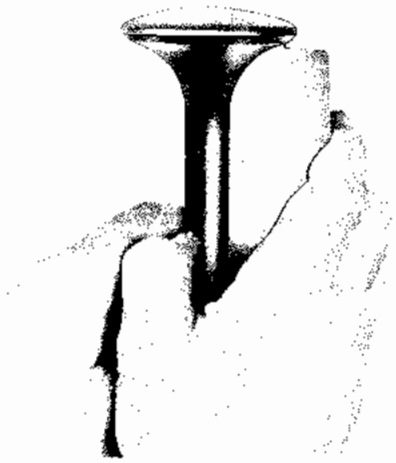
success of this practice, it is necessary to re-
check of the engine, paying particular atten-
view the circumstances which cause cylinder head and valve failures.

Cylinder heads usually fail when the tensile strength of their material has been lowered by the excess heat and when the pressure inside the cylinder is extremely high. These two factors can cause rupture of the head. The same conditions may exist in other cylinders which do not fail and they regain their tensile strength when they have cooled. Because of this regeneration, it is clear that the cylinders are not permanently weakened by the excessive temperatures and pressures to which they are subjected.

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

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

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

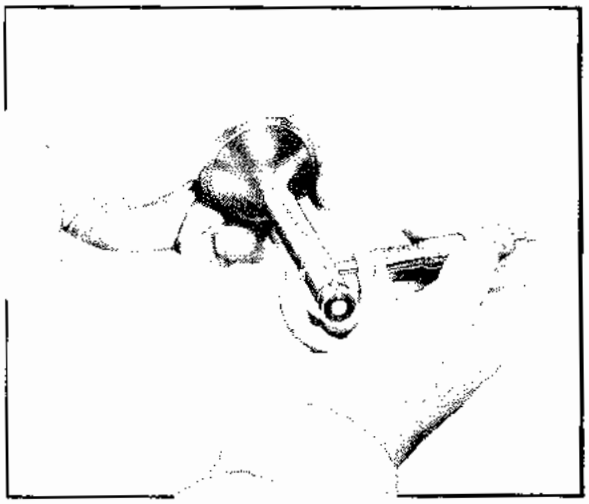


[118] Checking Valve for Stretch

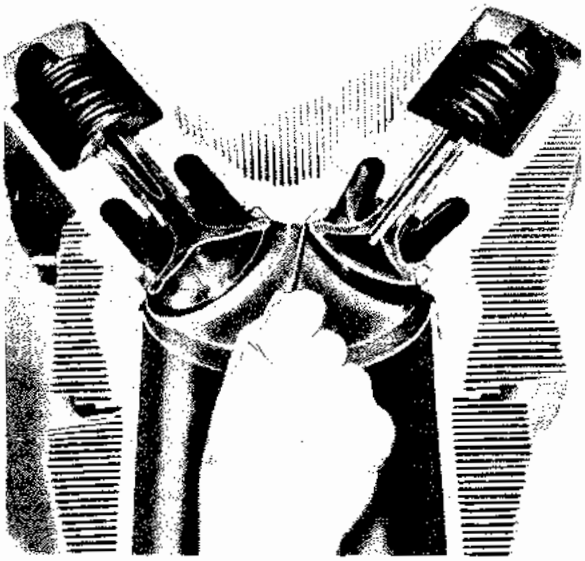
[119] Valve Stretch Checking Point

After the installation of new cylinder assembly, a complete compression check should be made. Regardless of the number of cylinders being replaced, the engine is to be run-in for ½ hour at 1000 RPM, ½ hour at 1400 RPM, and ½ hour in short spurts to 2000 RPM. During this run-in the cylinder head temperature should not exceed 205°C (400°F). The engine should then be given a complete ground check, a second compression check should be made. In addition, make a thorough visual check of the engine, paying particular attention to the condition of the cylinder flange studs, cylinder heads, and combustion chambers.

Inlet and Exhaust Valves — Inspect the stems for stretch, pitting, taper, and out of roundness. If a valve stem is worn, tapered, or out of round .006 inch or more, the valve should be replaced. Check the valve lock grooves for galling, scoring, and burrs. Check the fit of each valve in its respective guide. Inspect the valve heads for excessive wear and pitting. Using PWA-3004 Gage **[118]** and **[119]**, check the exhaust valve for stretch. Using PWA-5364 Gage, check the inlet valve for stretch. Hold the valve at eye level with the



[120] Checking Valve Stem



[121] Checking Valve Seat

edge of the gage against the valve stem and the curved portion of the gage against the radius of the valve head, so that any passage of light between the valve and the gage may readily be seen. A clearance of 1/32 inch or more between the gage and the valve is cause for replacement of the valve. The illustration indicates the point at which the valves should be checked for stretch. Inspect the necked down area (where the head joins the stem) of exhaust valves for erosion pits, creases, signs of swelling, or drawing, or any abnormal surface condition. The removal of material caused by the use of a wire brush or emery cloth to clean up such irregularities should be held to the minimum necessary to produce surface required. Using a ball point micrometer, check reworked valves for size. The minimum rework limit of the diameter for the Part Number 50724 is .665 and the Part Number 168735 TPM valve is .655 and for the Part Number158175 TAA valve is .665. In conjunction with these limits, any exhaust valve which is not completely void of any evidence of corrosion pits or surface irregularities should be replaced. Examine the tip of the exhaust valve stem for cupping and wear.

If the tip of the valve is cupped in excess of .025 inch, replace the valve; otherwise, stone it flat. Remove a minimum amount of material necessary to regain the original flatness. Check the distance from the tip of the valve stem to the near side of the valve lock groove. This measurement should not be less than .190 inch. Check the valve stem for taper and out-of-roundness **[120]**. If a valve stem is tapered or out-of-round .006 inch or more, replace the valve.

Check the exhaust valve for erosion, starting at the edge of the valve head and extending down under the coating on the seating surface.

The judgment and experience of a qualified inspection must be the deciding factor as to whether or not an exhaust valve is acceptable for further service. Too much emphasis cannot be placed on the importance of careful inspection of the exhaust valves and the decisions involved. If doubt exists as to the serviceability of a particular valve, it is recommended that the valve be replaced.

Check the inlet valve for erosion.

Exhaust Valve Seats — Inspect the seat for signs of warping, pitting, burning, and looseness. Using a .001 inch feeler gage, check for clearance between the cylinder head and the O.D. of the valve seat **[121]**. If the feeler gage can be inserted to a depth of .025 inch or more, for 180° or more on the circumference, replace the cylinder. If the feeler gage can be

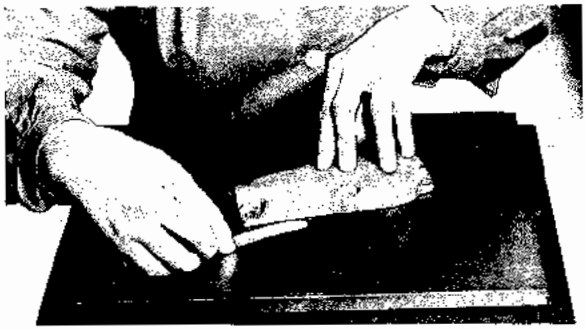
inserted less than .025 inch for 360°, the seat is acceptable for further service if it has otherwise passed inspection. If it should be realized that these limits are at best only guides and that in the final analysis the judgment of a qualified inspector must be the deciding factor. Tag defective cylinder(s) and send to Overhaul for repair.

Valve Lapping — Place a small amount of Clover 2A lapping compound, or its equivalent, on the seating surface of the valve and lap it to the refaced valve seat with which it will be used in the cylinder. Insert the stem of the valve in its guide after removing any lapping compound from the valve stem. Using PWA-2269 Holder, lap the valve with an oscillating motion, lifting the valve every few turns to a new location until the "feel" indicates that the lapping is complete. Remove the valve and thoroughly clean the valve and valve seat to remove all the lapping compound. A properly lapped valve will have a dull satin finish covering the seating surface. Valve lapping facilitates inspection of the contact pattern as well as insures a satisfactory surface condition.

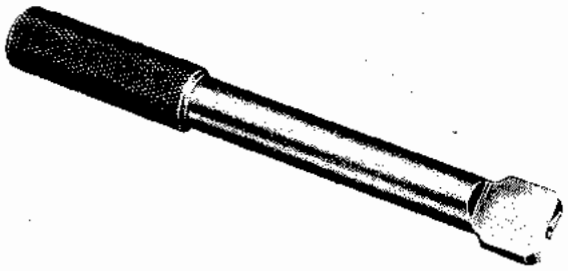
After lapping, check the valve for proper seating by lightly rubbing the valve seating face with pencil carbon paper; then install the valve in the guide and valve seat. In order to avoid smearing and resultant false indications, do not wipe an excessive amount of carbon on the seating face of the valve. Press the valve into position; then remove the valve and examine the valve seat surface. A properly seated valve will show approximately 100% contact with the seat as indicated by the picked-up carbon on the valve seat.

It is no longer considered necessary to check the valve seat by filling the cylinder with gasoline and watching for leaks.

TO AVOID POSSIBLE INJURY TO PERSONNEL, DOMESTIC OPERATORS SHOULD SHIP UNSERVICEABLE SODIUM-FILLED EXHAUST VALVES COLLECT TO THOMPSON PRODUCTS, INC., CLEVELAND 17, OHIO. FOREIGN OPERATORS SHOULD DUMP THESE VALVES IN DEEP WATER WHERE THEY CANNOT BE RECOVERED.



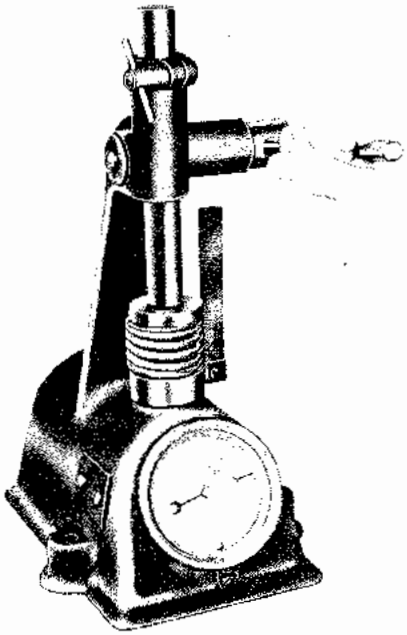
[122] Inspecting Cover



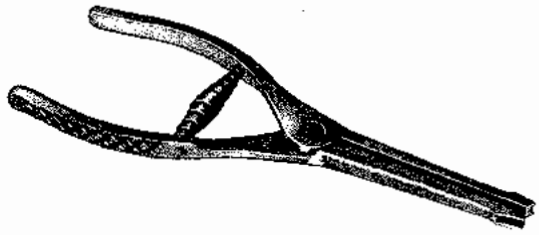
[123] PWA-4315 Gage

Rockerbox Covers — Inspect for cracks and examine the condition of the parting surface. Check for flatness, using a .002 inch feeler gage and a surface plate **[122]**. Face off, if necessary, on a lapping plate.

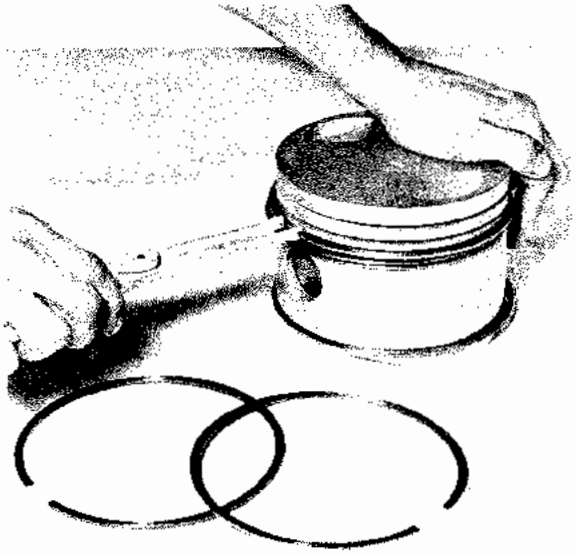
Valve Guides — Clean the guides with a soft bristle rotary brush. The use of naphtha and Bon-Ami has proven most satisfactory as a cleaning solvent. Inspect for excessive wear, using PWA-804 Gage for inlet valves and PWA-4315 Gage **[123]** for exhaust valves. Since valve guides wear unevenly and become out of round, they should be checked for excessive wear at both ends. If the gage enters



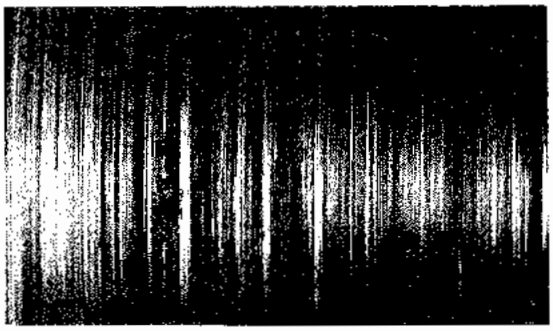
[124] Testing Spring Tension



[125] PWA-1791 Pliers



[126] Removing Pistonrings



[127] Scoring

either end of the guide more than ½ inch, the guide should be replaced.

Valve Seats — Examine for signs of warping, pitting, and looseness.

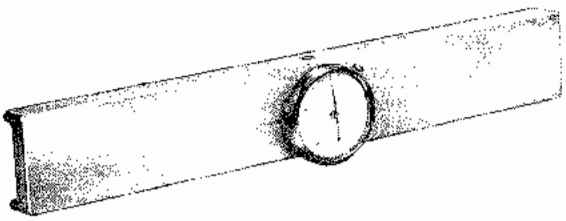
Valve Spring Washers — Check for scoring, galling, pitting, cracks, and excessive wear.

Valve Springs — Inspect for cracks, broken ends, inadequate spring pressure **[124]**, rust, and improper length.

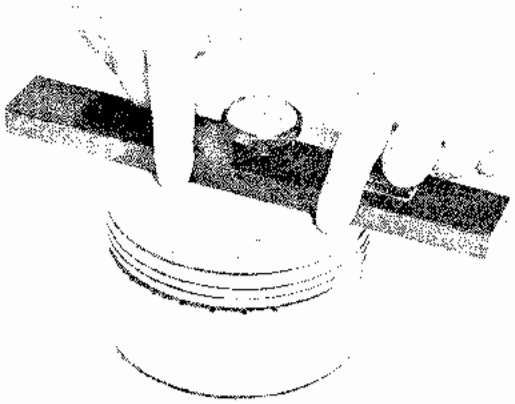
Valve Locks — Check for burrs and galling. Check the fit of each pair of locks with its valve. A properly fitted lock will have no perceptible movement when in place on the valve, and the radii of the valves and locks should coincide.

Rocker and Rocker Spacers — Inspect the rockers for cracks and galling. See that the oil passages are free from obstruction. Examine each rocker ball socket for looseness and wear. Check the spacers for galling and scoring. Replace any ball socket which is uneven or excessively worn, galled, or scored.

Valve Adjusting Screws and Locknuts — Inspect the nuts for burrs and nicks. Check the condition of the threads. Inspect the valve adjusting screw inserts for wear, looseness in their sockets, nicks, and pitting. See that the oil passages are not obstructed and check the condition of the adjusting screw threads.

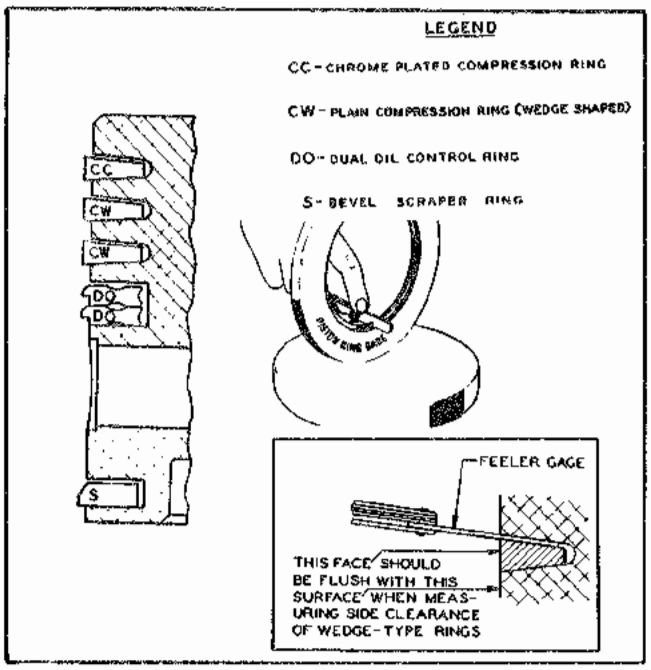


[128] PWA-3140 Gage

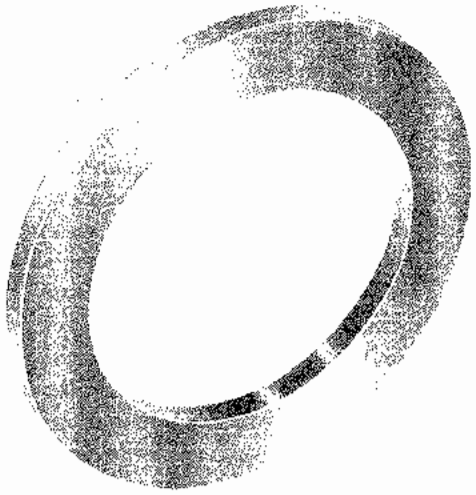


[129] Inspecting Piston For Dishing

Pistons—Remove the pistonrings, using PWA-1791 Pliers **[125]** and **[126]**. After soaking the piston in a suitable carbon remover, use a soft metal or wood scraper to remove carbon from the ring grooves, being careful not to damage any of the ring lands or to remove any metal from the small radii between the ring lands and the bottom of the ring grooves. Inspect the skirts and ring lands for cracks, and examine pistonpin holes for scoring **[127]**. Examine the top for nicks, paying particular attention to the circumference edge. Due to the danger of fire burning down the side of the piston, any nicks in this area, however slight, are cause for rejection. Inspect the inside surfaces for cracks, paying particular attention to the under side of the head, the fins, and the pistonpin bosses. If the piston is heated slightly, residual oil will seep from any cracks. Using PWA-3140 Gage **[128]**, inspect piston for dishing **[129]**. If piston head is dished in excess of .008 inch, replace the



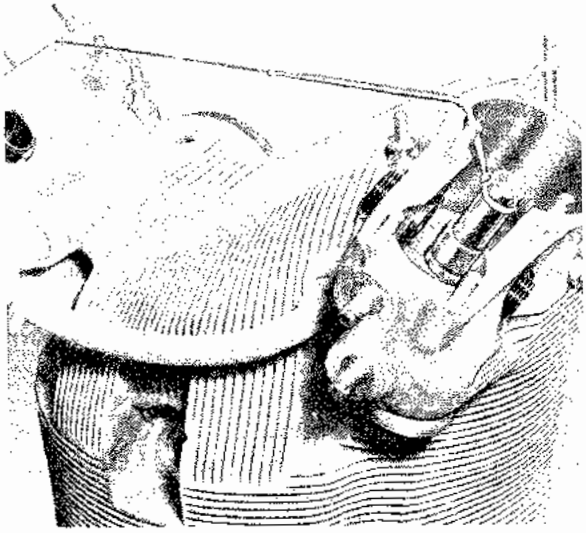
[130] Pistonring Inspection



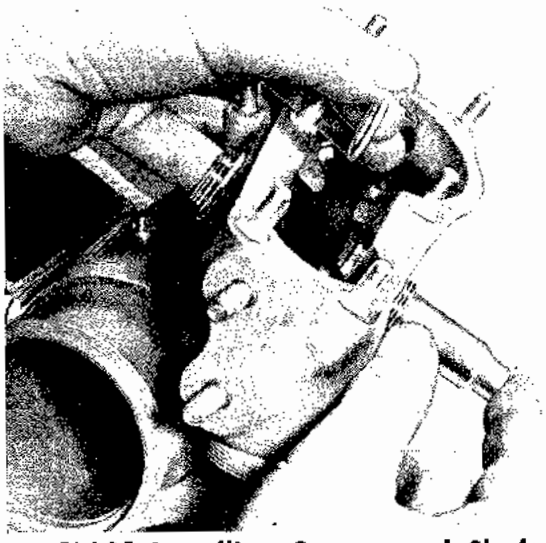
[131] PWA-3201 Gage

piston. Make sure that all carbon has been removed from the ring grooves; then check the width of the grooves by measuring the side clearance of standard size rings **[130]**. Check the pistonring end clearances, using PWA-3201 Gage **[131]**. (Refer to the limits on page 200.)

Pistonpins — Inspect for scoring, cracks, and rust pitting. Check the fit of each pistonpin in its linkrod bushing and in its piston. Check the fit of the plugs in each pistonpin.



[132] Rubber Band Over Stems

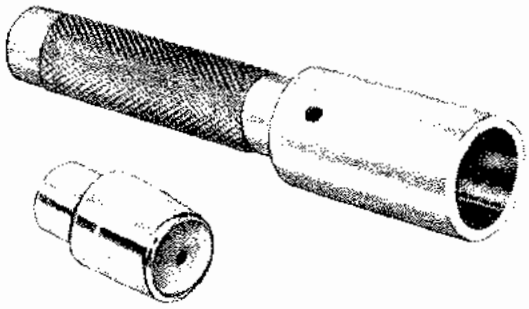


[133] Installing Spacer and Shaft

ASSEMBLY

Valves — Clean and oil the valve guides and stems. Insert the valve stems in their guides. Install a rubber band over the stems **[132]** and place the cylinder over a domed wooden block to prevent the valves from falling into the barrel.

Rockers — Place the rocker and the rocker spacer in position in the rockerbox **[133]** with the spacer on the inner side of the rocker.



[134] PWA-4334 Drift

Install the rocker shaft. Place a gasket on each rocker shaft bushing, install the rocker shaft caps, and tighten the caps to the recommended torque. Lockwire the caps.

Installation of the spacer next to the outer bushing will cause damage to the valve mechanism.

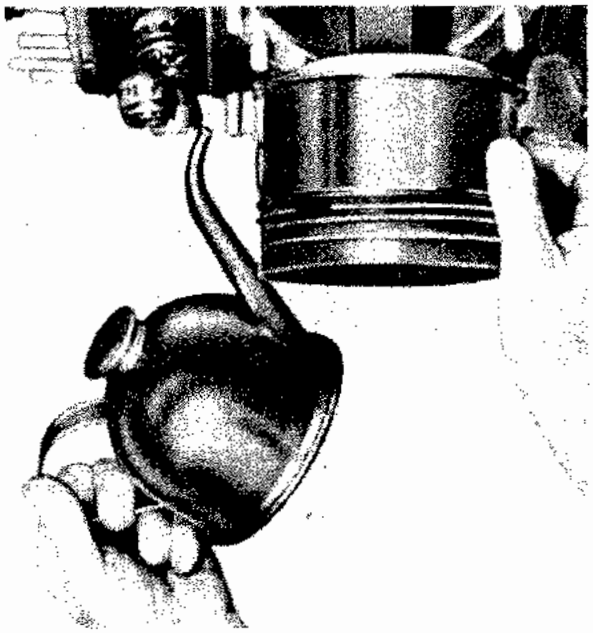
Install the rocker in position and insert the shafts through the bushings. Screw on the rocker shaft caps on both the inside and outside bushings of each rocker and tighten them to the recommended torque. Lockwire the caps.

Springs — Insert the exhaust valve spring lower washer, and install the circlet on the outer end of the exhaust valve guide, using PWA-4334 Drift **[134]**. Install the inlet valve spring lower washer and the inlet and exhaust valve springs in the rocker housing and place the upper valve spring washers in position; then compress the valve springs with PWA-4310 Compressor and install the split locks.

INSTALLATION

The masterod cylinders (Nos. 8 and 9) should be the first to be installed in each row, if they are to be installed with one or more front or rear cylinders. Do not allow the masterod to move to either side when the cylinder is being installed.

Observe replacement recommendations in the paragraph entitled REMOVAL under **Cylinders** in this chapter.



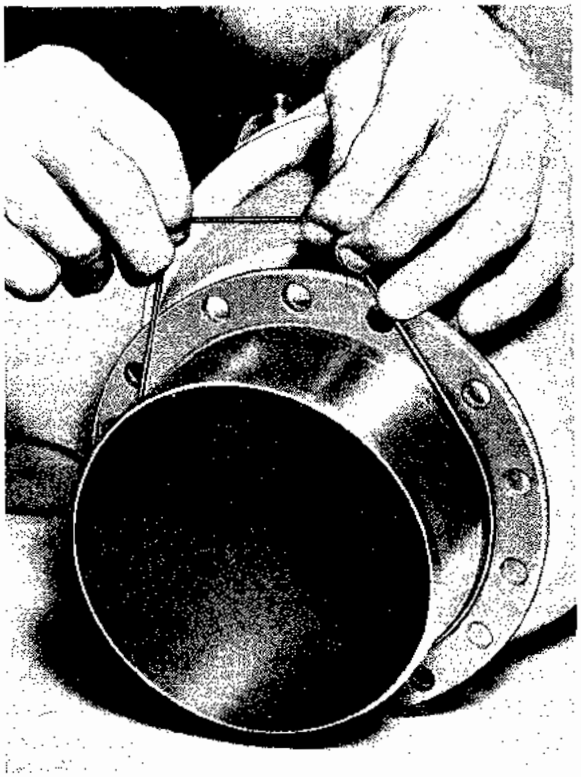
[135] Applying Oil to Piston

[136] Staggered Pistonring Gaps

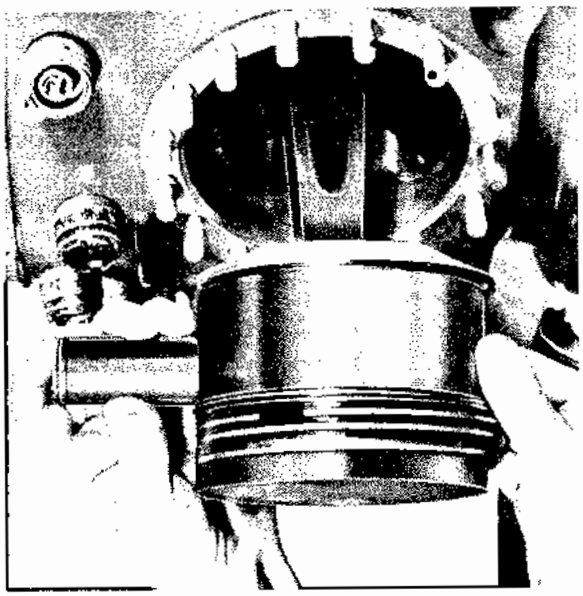
Coat the cylinder walls, pistonpins, pistons, and pistonrings with a generous amount of oil **[135]**. Stagger the ring gaps **[136]** around the circumference of the pistons. Fit a new rubber seal ring under the cylinder flange **[137]**.

Rotate the propeller until the linkrod or masterod of the cylinder to be installed is at the full outward position.

Hold the piston in position over the end of

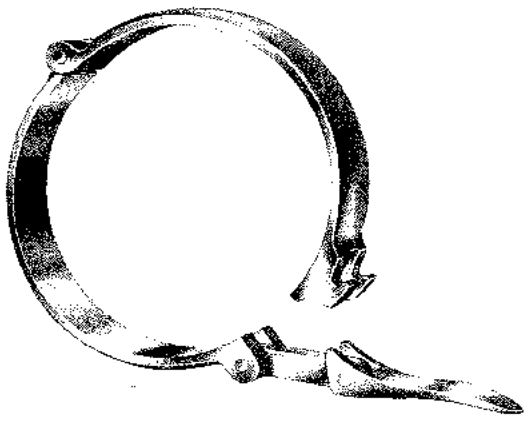


[137] Installing Seal Ring



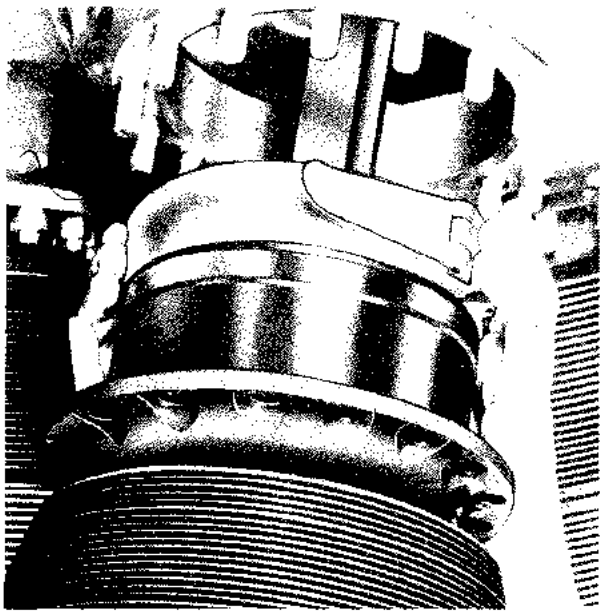
[138] Installing Pistonpin

the rod and slide the pistonpin into position in the pistonpin bushing **[138]**. Each piston, pistonpin, and cylinder is marked with a number denoting the proper installation position on the engine. Install the piston and pin with their numbered sides toward the front of the engine.

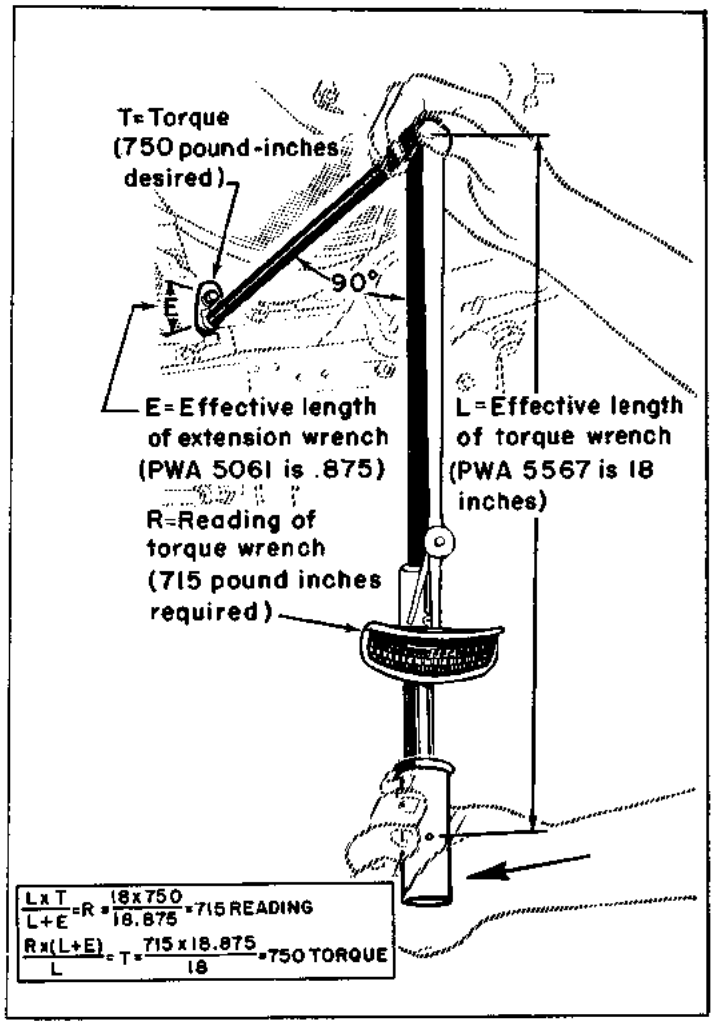


[139] PWA-13 Clamp

[140] Installing Clamp

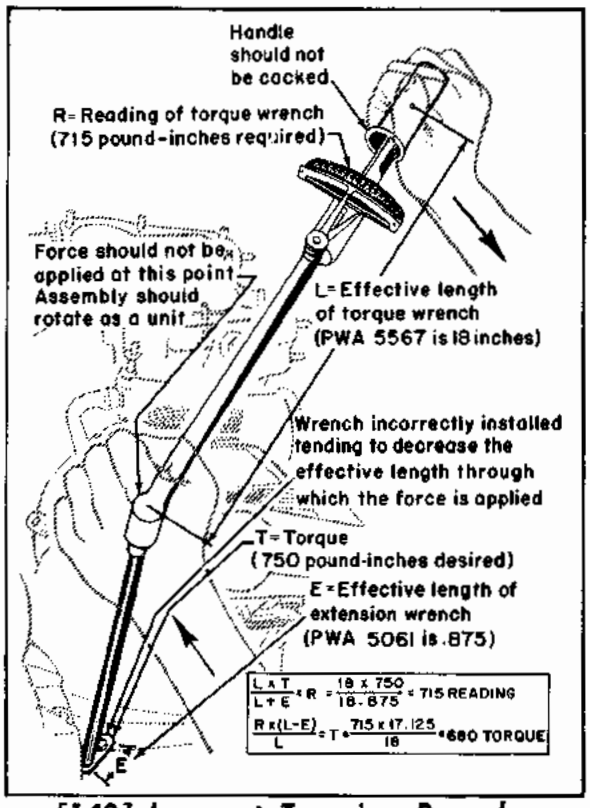


[141] Installing Cylinder



[142] Correct Torquing Procedure

Using PWA-13 Clamp **[139]**, compress the outer pistonrings **[140]**; then slide the cylinder over the outer rings. Compress the scraper ring with the clamp; slide the cylinder over the ring **[141]**, remove the clamp, and slide the cylinder into place against its mounting pad. Secure the cylinder with three nuts equally spaced before proceeding with the installation of the next cylinder. When all the cylinders have been installed, secure each cylinder with the remaining cylinder flange nuts and tighten the nuts to the recommended torque, using PWA-5061 Wrench, PWA-3109 Extension, and PWA-5567 Torque Wrench **[142]** and **[143]**. Lock the nuts in position with cylinder flange locknuts, using PWA-3923 Wrench. Any cylinder flange locknut which becomes loose or is



[143] Incorrect Torquing Procedure

backed off for any reason after wrench pressure is applied must be removed and discarded.

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

Regardless of the number of cylinders being replaced, the engine is to be run-in ½ hour at 1000 RPM, ½ hour at 1400 RPM, and ½ hour in short spurts to 2000 RPM. During this run-in the cylinder head temperature should not exceed 205°C (400°F).

Carburetor

REMOVAL — Disconnect all controls and tubing from the carburetor. Disconnect the fuel transfer tube at both ends. Unfasten and remove the carburetor air duct and screen from the mounting flange on the carburetor. Disconnect all lines. Remove the 10 bolts which secure the carburetor to the engine and lift off the carburetor.

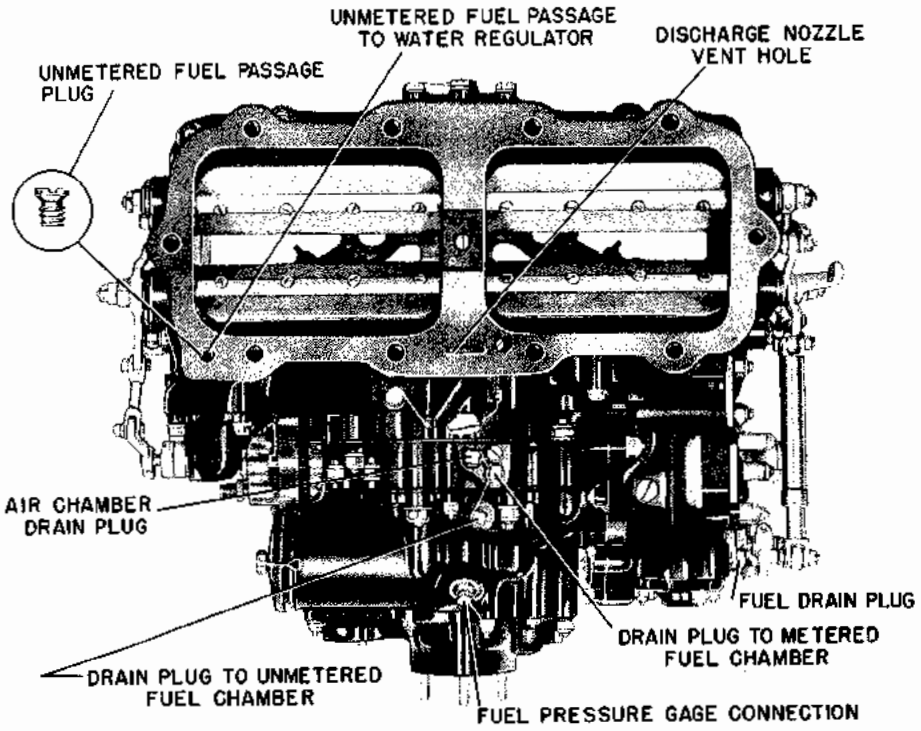
Immediately place a cover on the carburetor mounting flange of the engine.

INSTALLATION — Place the carburetor mounting pad gasket in its correct position on the mounting pad, making certain that the bleed holes in the gasket line up with the holes in the pad. Make sure the unmetered fuel transfer passage plug **[144]**, located on the carburetor mounting face, is removed. If the carburetor is removed for flow bench test, insert the plug. This plug serves the dual purpose of sealing the passage during shipment of the carburetor and preventing the flow of unmetered fuel to the water regulator pad in the engines not equipped with water injection. If the plug has not been removed, the water regulator will not function properly. Should difficulty be experienced with water regulator operation when a carburetor has been newly installed, make the following check to determine whether the taper seat plug has been removed from the unmetered fuel passage of the carburetor:

a. Cut the lockwire and remove the right hand lower plug from the base of the carburetor.

b. Remove the external unmetered fuel plug from the top of the water regulator **[145]**.

c. Place one end of a small flexible hose over the lower plug hole and blow into the other end. If fuel or air comes out of the



[144] Bottom View of Carburetor

external unmetered fuel opening at the water regulator, the taper seat plug is not in the passage. If fuel does not come out of the unmetered fuel opening, the taper seat plug is in the unmetered fuel passage. To remove the plug it will then be necessary to remove the carburetor from the engine.

An alternate method of checking for the plug is to remove the external unmetered fuel plug from the top of the water regulator and then turn on the fuel booster pump. If a stream of fuel does not come out of the opening, the plug is in the passage and must be removed.

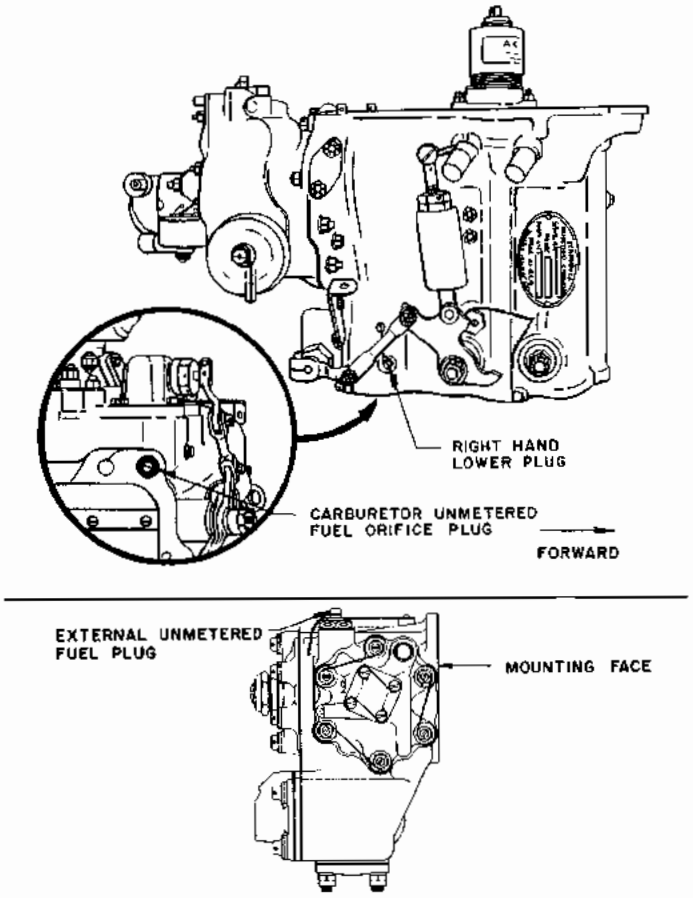
In the event that the water injection system is removed from an engine, it is recommended that the taper seat plug be reinstalled in the carburetor unmetered fuel passage.

Use no sealing compound on the gasket. Install the carburetor on the mounting pad [**146**]; secure it with the 10 bolts. Torque the bolts to the recommended torque and lockwire.

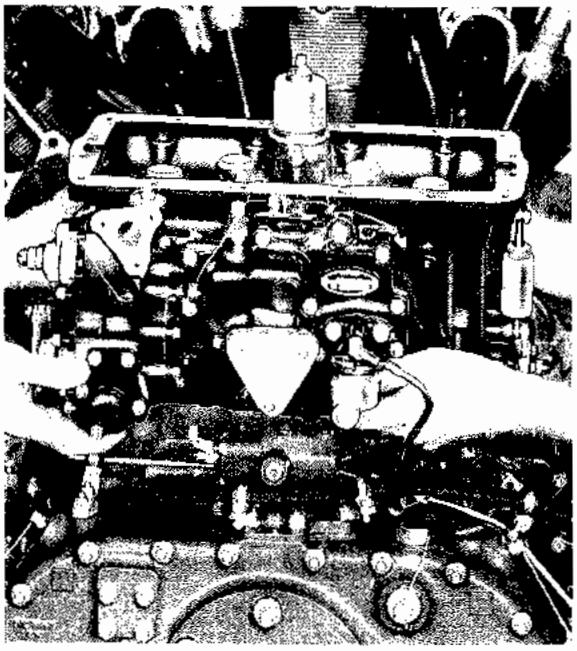
In order to preclude the possibility of distorting the carburetor by improper torquing of the bolts, install the bolts all the way around and snug them down. Then start in the center of the carburetor and torque the bolts out to each side.

Install and secure the fuel transfer tube, placing a gasket at the carburetor mounting flange and a copper asbestos gasket on each side of the connection at the fuel transfer bolt. Fasten each end of the transfer tube loosely with the fuel transfer bolt and the fillister head screws and washers, respectively; then alternately tighten each end so that correct seating is assured. On those installations equipped for water injection, the fuel transfer tube and the water transfer tube should be installed simultaneously.

The derichment valve covers of current PR58E5 carburetors have two tapped outlets. Formerly, one of these was used to



[145] Plug Locations



[146] Installing Carburetor

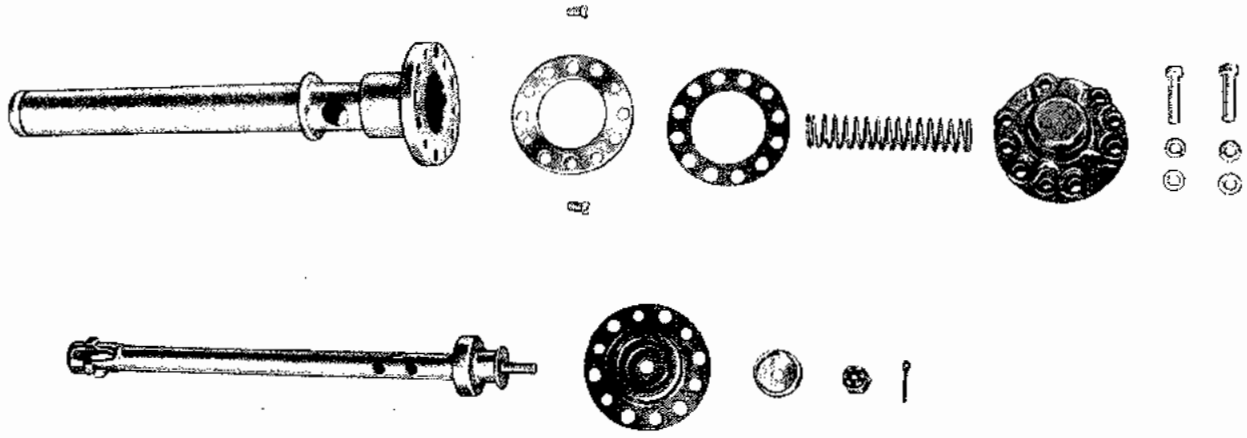
attach the derichment line and the other was used to attach the water regulator flow indicating light. Since the latter indicating light is not attached at this location in current water injection systems, one of these tapped outlets will normally remain plugged off when the installation is completed. Since the carburetors are shipped with one solid plug and one vented plug installed in the aforementioned tapped outlet, it is important that the vented plug be removed when installing the derichment line.

Place the carburetor air screen lower gasket, the air screen, and the upper gasket in position on the top of the carburetor; then mount the air duct on the carburetor. Connect the fuel pump balance line, the electric primer connection, the line to the primer distributor, the vapor vent line, the fuel pressure gage connection, and the fuel inlet line.

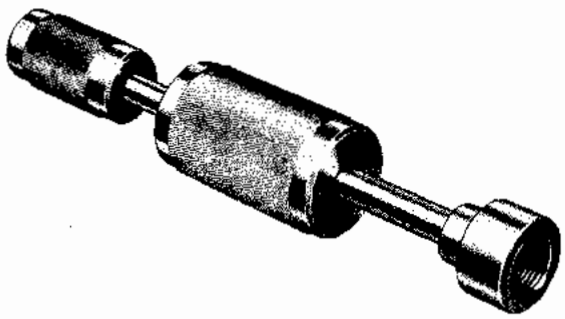
Field Maintenance of Fuel Feed Valve [147]

REMOVAL — Remove the carburetor and the adapter and install a plywood carburetor flange cover on the engine to prevent small parts and other foreign matter from entering the air intake passage.

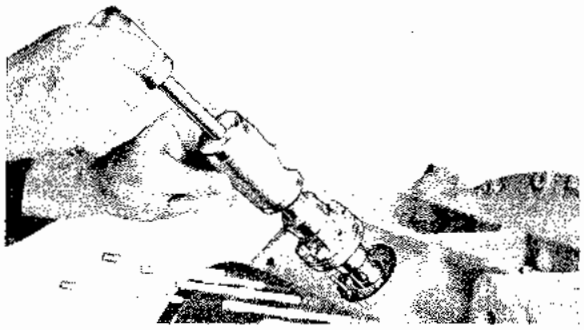
Remove the six long screws which secure the valve assembly to the supercharger collector case, but do not loosen the two shorter screws which secure the cover to the valve housing. Using PWA-3501 Puller **[148]**, pull the fuel feed valve assembly from the case **[149]**; then remove the two cover screws. Lift off the valve housing cover and spring; then unfasten and remove the diaphragm retaining ring from the valve housing. Withdraw the valve and diaphragm assembly from the valve housing; then remove the guide nut and the guide washer and lift off the diaphragm. Remove the two rubber seal rings from the outside of the valve housing.



[147] Fuel Feed Valve Assembly



[148] PWA-3501 Puller

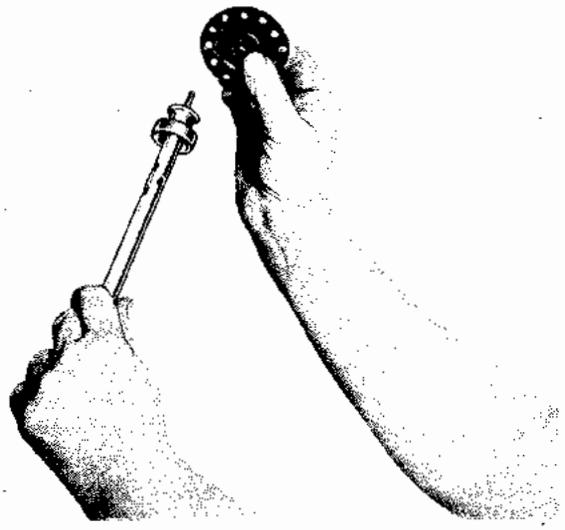


[149] Removing Valve Assembly

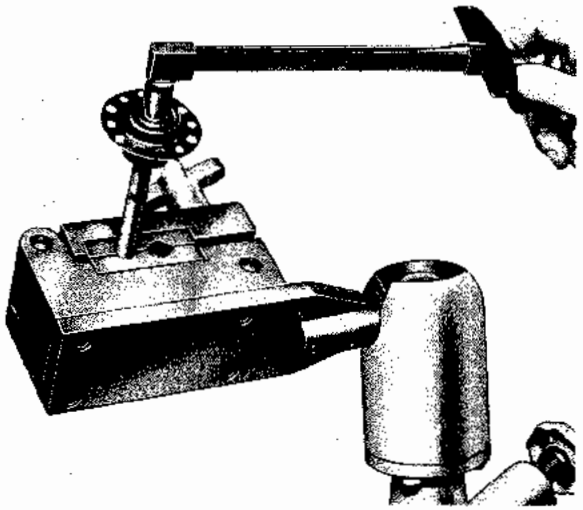
INSPECTION — Inspect the spring for damage or corrosion. Examine the diaphragm for indications of deterioration. Check the seating of the valve in the housing.

RECONDITIONING — Remove minor injuries or corrosion from the assembly. Polish seating surfaces with crocus cloth. If the housing has been dented or the valve seat damaged, replace the unit. The valve and valve seat should be lapped with lapping compound until each has an even, soft gray surface. After cleaning, apply polishing rouge to these surfaces. Insert the valve in the housing and polish them together. After polishing, again thoroughly clean the parts. Hold the valve and the housing firmly together and rest the valve stem on the bench. Test for proper seating by filling the recess in the nozzle with kerosene or white furnace oil. Introduce a jet of compressed air into the housing through a fuel entrance hole while the other fuel entrance holes are covered by the fingers. If the oil remains undisturbed when the housing is rotated on the valve to several positions, the seating is satisfactory. If inspection disclosed the least indication of deterioration or injury to the diaphragm, it should be replaced. Check the valve spring for proper tension. Polish the flange and all mating surfaces with crocus cloth to eliminate any roughness which might cause damage to the diaphragm during operation. Make sure that the vent hole is clear.

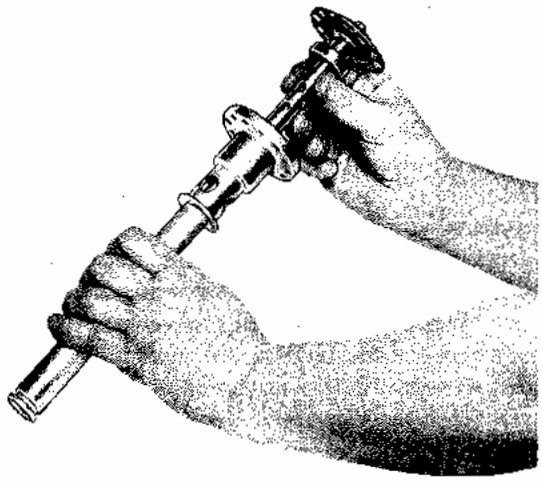
ASSEMBLY — Install the diaphragm **[150]**, the guide nut washer, and the guide nut, using a guard to protect the diaphragm while the nut is being tightened and lockwired. A guide may readily be prepared by cutting a 7/16 inch diameter hole in an exhaust port cover. Make sure the diaphragm is not pinched or distorted



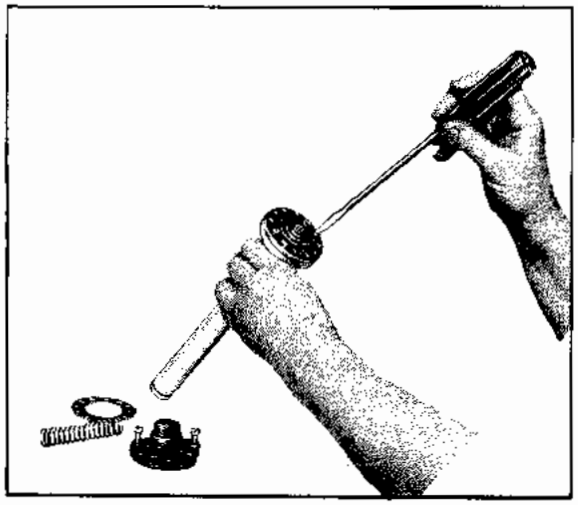
[150] Installing Diaphragm



[151] Torquing Guide Nut



[152] Installing Valve in Housing

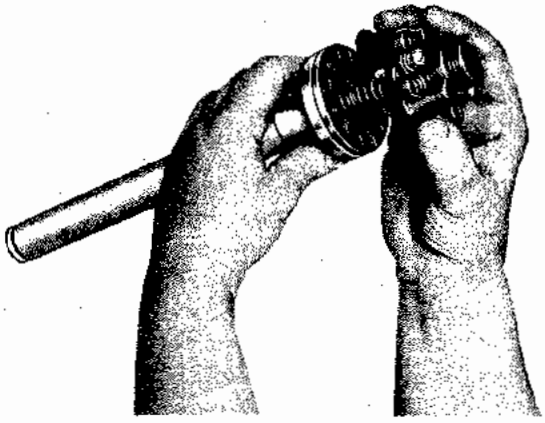


[153] Securing Retaining Ring

when the nut is tightened. Tighten the guide nut to the recommended torque **[151]**; then turn to the next castellation, if necessary.

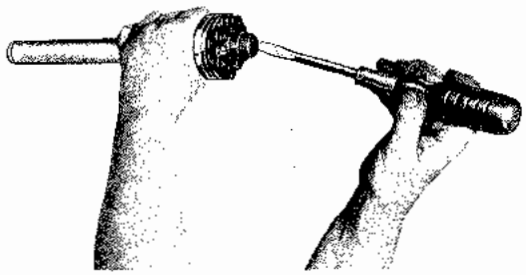
> ***Do not turn the nut beyond the next castellation after the recommended torque has been reached.***

Install the cotterpin in such a way as to avoid interference when the spring is compressed. Place the valve assembly in the valve housing **[152]**. With the holes in the diaphragm and retaining ring lined up with the holes in the valve housing, secure the retaining



[154] Installing Cover

ring with its two screws **[153]**. Line the holes in the housing cover with the holes in the valve



[155] Tightening Cover Screws

housing flange **[154]** and secure the cover with its two screws **[155]**.

INSTALLATION — Install a new housing gasket. Install a new seal on the valve housing below the flange and a new seal in the groove near the nozzle. Dip the lower seal in engine oil, insert the housing in the case and press it in place by hand. Owing to the difficulty of holding moulded rubber parts to a close tolerance, it may be necessary to try several different seals to be sure that the one used is neither too tight nor too loose. The seal should be large enough so that resistance is felt as the seal is compressed in the passage during approximately the last ½ inch of travel. If the resistance is too great to permit full seating of the housing by hand, do not use force as this will damage the seal. Selection of the seal may be made, if necessary, by measuring the section diameter of several seals of the correct part number. When the flange seal reaches its seat, the housing should protrude approximately 3/32 inch above the mounting pad to assure correct compression of the seal when the six attaching screws have been installed and tightened.

TESTING — Test the feed valve by introducing kerosene or white furnace oil at 18 to 22 lb./sq. in. pressure into the fuel passage in the case. The valve should open at from 7 to 10 lb./sq. in. Close the supply valve. If there is no leakage, the pressure should remain constant for approximately 2 minutes at 3 lb./sq. in.

Leakage at the gaskets may readily be detected and usually may be corrected by retightening the screws. Leakage through the diaphragm is indicated by leakage from the vent hole in the carburetor mounting pad. If leakage is indicated, remove and disassemble the valve assembly and examine the seal seating surface for injury or for the presence of foreign material. When the parts have been reassembled in the case, the pressure test should be repeated. If no leakage is indicated, lockwire the valve housing attaching screws and install the carburetor on the engine.

Drain the lower cylinders as soon as this test has been completed.

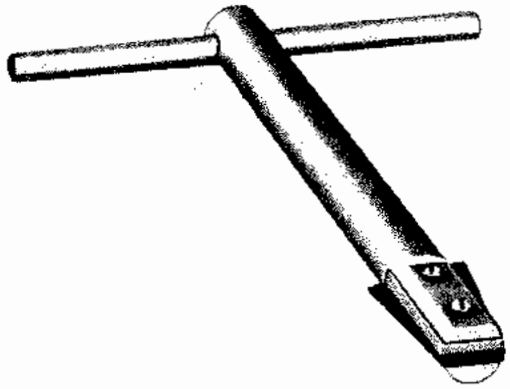
Water Regulator Unit

Service instructions for the water injection equipment are incorporated as a supplement which follows the Appendix of this publication.

Stud, Screw Bushing, and Sparkplug Bushing Replacement

REMOVAL — Loose or broken studs normally can be replaced without damage to the threads in the hole. Select the proper oversize stud. Broken studs can generally be removed by using the hole in the flange of the mating part as a guide for a drill which is used to spot a center in the broken stud after which a smaller drill is used to drill out the central portion of the stud. Drive some type of steel extractor, such as an Easy-Out or a home made extractor, into the drilled center and turn out the broken stud with a wrench on the extractor. If a small amount of damage is noted in the threads of the hole where the stud was removed, clean the threads with an oversize tap.

When installing an oversize stud in a stud hole which goes completely through a part, make



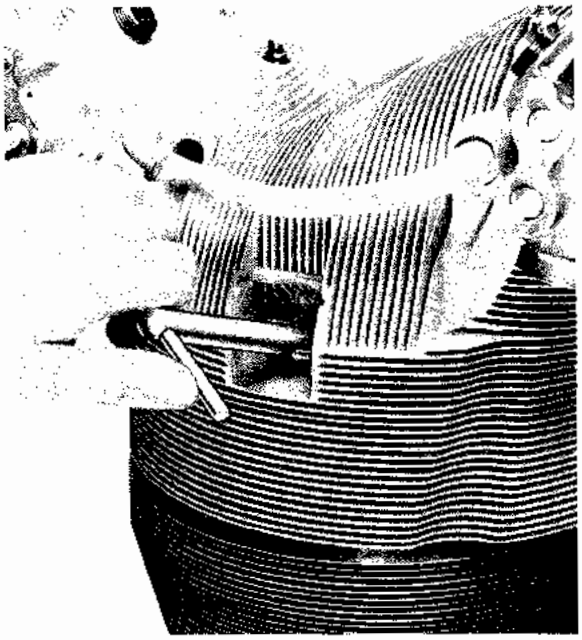
[156] PWA-4102 Extractor

sure that the anchor end of the stud does not project beyond the hole sufficiently to cause interference with other parts. If necessary, file off the anchor end enough to insure against such interference; then reidentify the stud with the proper oversize mark.

If one or two cylinder flange studs or bolts on any one pad have failed, replace the failed studs or bolts on each side of the failures. If more than two studs or bolts have failed inspect and, if necessary, lap the cylinder flange as directed on page 159 under "Cylinder Barrels". Replace all of the flange studs or bolts for that cylinder.

Screw Bushings

If a screw bushing requires replacement, drill out any lockpins; then remove the bushing, using the proper Insert Driver listed in the illustration index covering each specific engine section pages 180 through 192. Install the new bushing with the driver; then, if necessary, drill new lockpin holes and install new lockpins.



[157] Removing Insert

Sparkplug Inserts

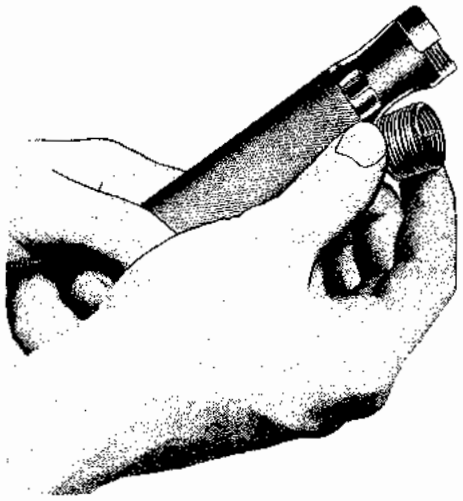
REMOVAL OF SPARKPLUG INSERT — Lift the staked portion of the insert from the cylinder head by means of a sharp tool used as a lever. Insert PWA-4102 Extractor **[156]** in the sparkplug hole and apply a light below to the end of it to embed the knife edges in the insert. Turn the extractor in a counterclockwise direction to back the insert out of the head **[157]**.

INSTALLATION OF SPARKPLUG INSERT (CYLINDER ON ENGINE)

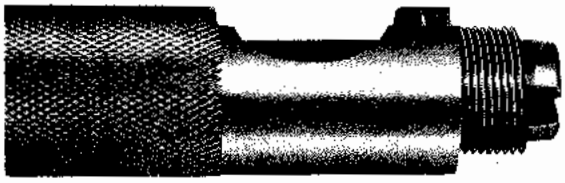
Before installing a new sparkplug insert make certain that the face of the sparkplug hole is free from burrs; that the threads of the sparkplug hole are completely clean and dry; and that the new insert is perfectly clean and dry. Inserts are available in +.003, +.005, and +.010 oversizes.

Use no oil on the insert or the tapped threads when installing the insert.

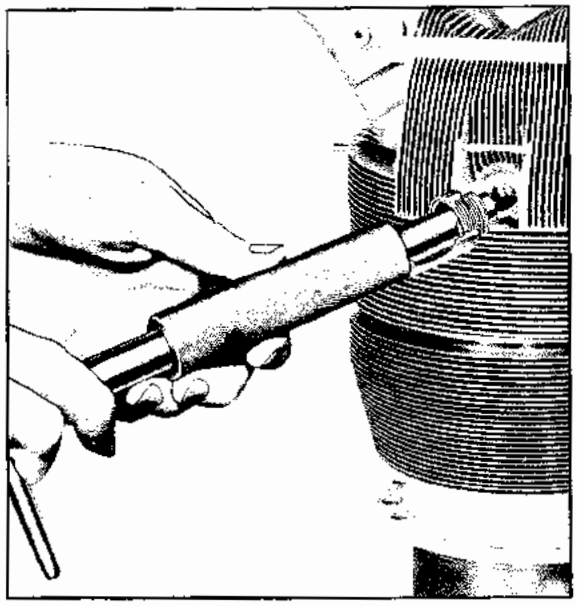
To clean up the sparkplug hole counterbore, screw the pilot of PWA-4647 Counter-



[158] Insert and Driver



[159] Coil Wound Tightly



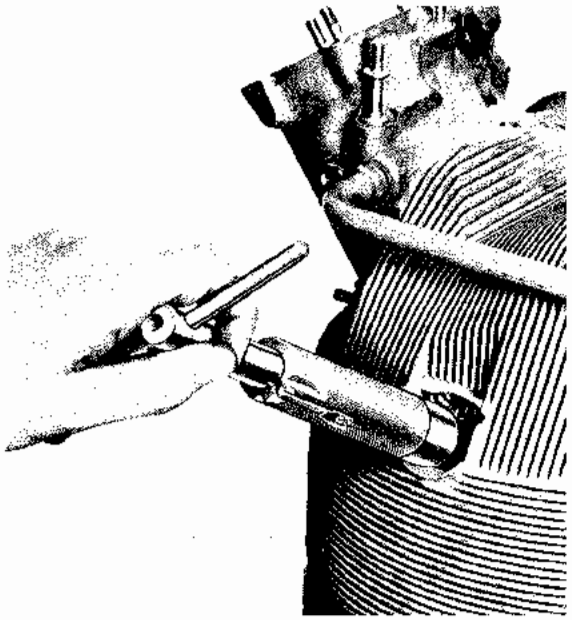
[160] Starting Insert in Hole

sink into the sparkplug insert hole. Install the cutter, the sleeve, and the handle over the pilot in that order. Remove only enough material to clean up the counterbore. To prevent damaging the insert hole threads remove all chips with an air hose before withdrawing the pilot of the tool from the sparkplug insert hole.

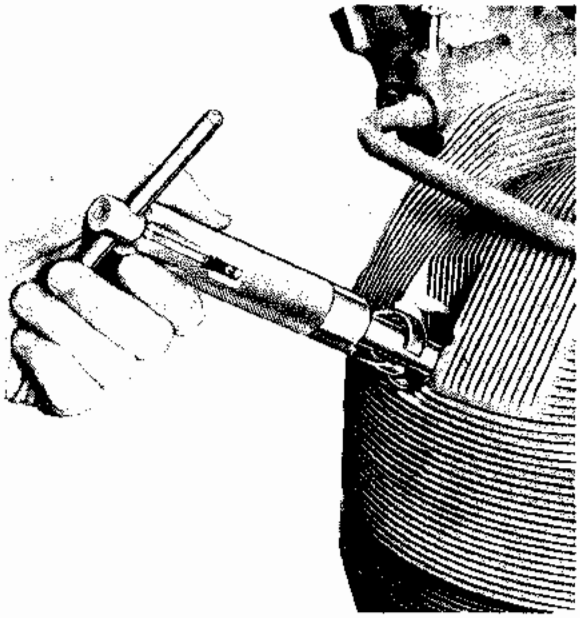
Using PWA-4921 Driver, withdraw the mandrel beyond the recessed section of the sleeve; then slip the insert into the recess, tang forward **[158]**, and advance the mandrel until the slot engages the tang of the coil. Press forward slightly on the handle of the mandrel and turn it clockwise to engage the insert in the threaded end of the sleeve. While holding the sleeve, continue turning the handle of the mandrel until the serrated portion of the insert disappears into the first thread of the sleeve. The insert should be wound tightly around the mandrel, with each coil touching the adjacent one **[159]**. Start the insert into the sparkplug hole **[160]** by turning the entire inserting tool over the hole **[161]** until the first coil picks up the first thread. Turn the insert into the hole until the face of the sleeve is approximately 1/16 of an inch from the face of the hole **[162]**. Then; holding the sleeve stationary, continue turning the insert with the mandrel until the insert is free of the threaded portion of the sleeve. Continue turning the insert in a clockwise direction until the serrated end of the insert has entered from ½ to 1 turn into the top thread of the hole **[163]**.

Remove the inserting tool and check the depth of the insert, using PWA-4691. Insert depth gage. If the gage indicates that the insert has not been driven to the correct depth, the tool can be reinserted and the insert driven further.

Do not put excessive pressure on the inserting tool during the inserting operation, as this may prematurely break off the tang

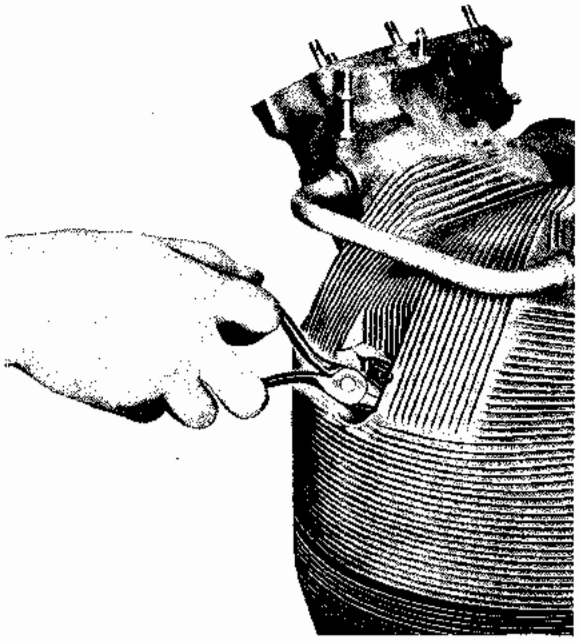


[161] Turning Insert with Driver



[163] Entered ½ to 1 Turn

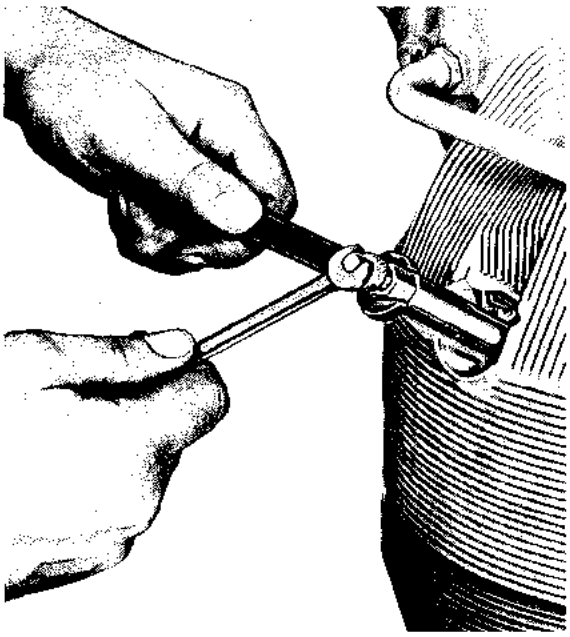
[162] Insert Entering Hole



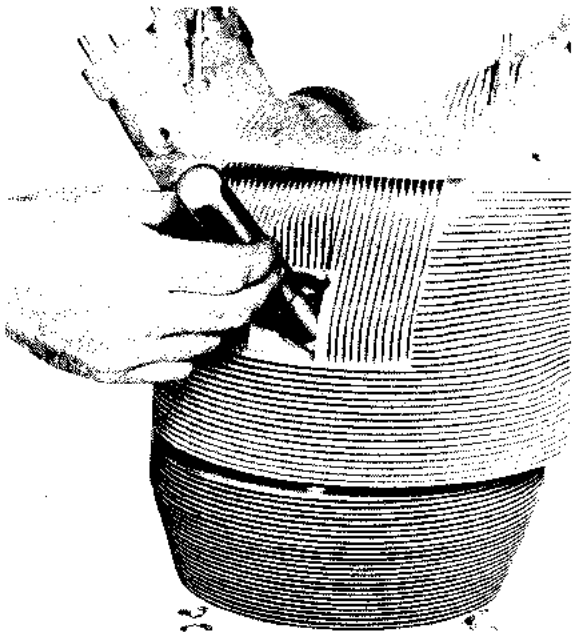
[164] Breaking Tang

of insert. In reinserting the tool to drive the insert in farther, be careful when engaging the tang in the slot of the tool to avoid pushing the bottom coil of the insert out of its thread. Do not try to back an insert out by using the inserting tool; this will probably break off the tang.

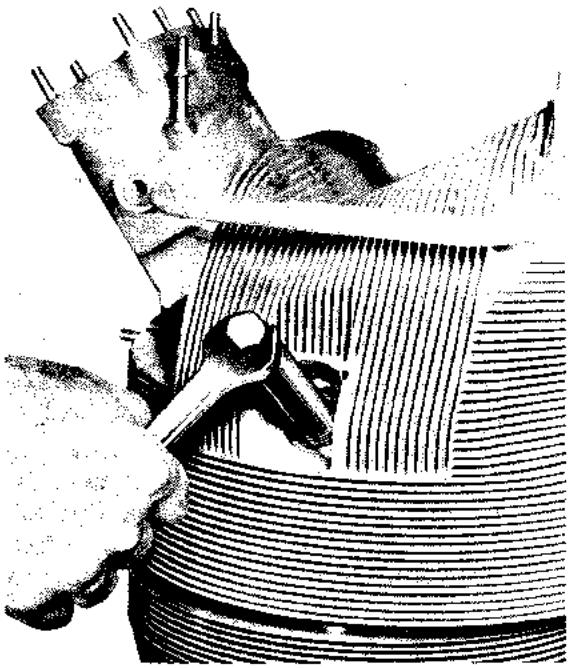
Slip a noose of string over the tang and draw the noose taut. Using a pair of long-nose pliers, grasp the tang near the notch and break off the tang [**164**], being careful not to lift the coil from the thread.



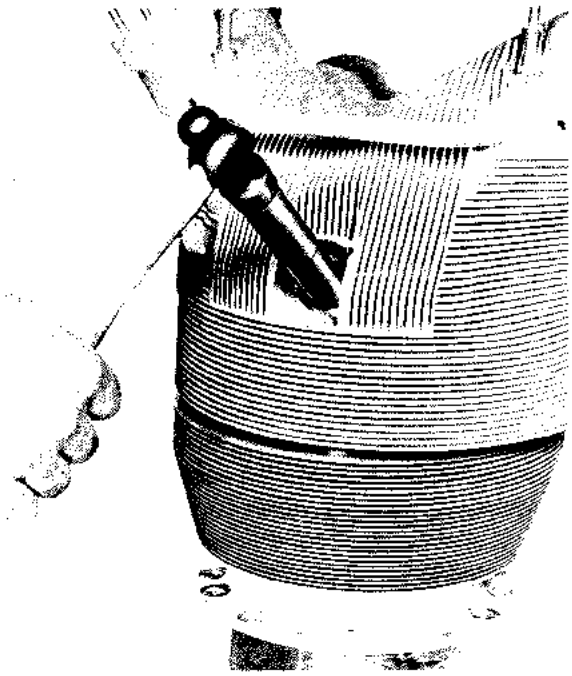
[165] Using Primary Expander



[167] Turning Expanding Tool



[166] Installing Sleeve



[168] Tapping Sleeve

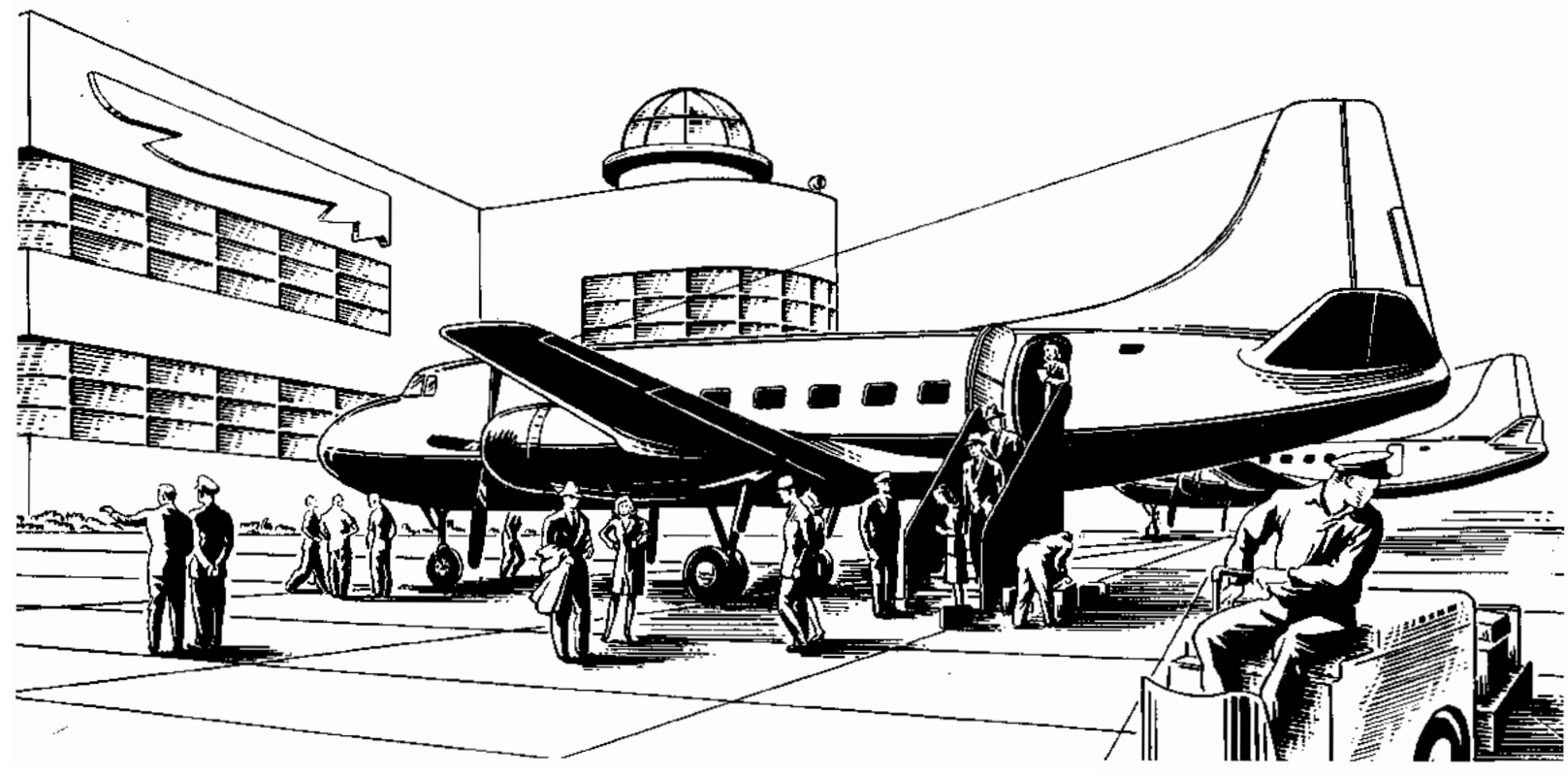
Screw PWA-3367 Primary Expander into the insert as far as it will go. Set the adjustable nut **[165]** and tap the head of the plunger until the insert coil is firmly seated in the tapped threads of the sparkplug hole. Draw out the plunger by turning down the adjustable nut; then back out the expanding tool. Insert PWA-3944 Gage into the insert for a check of the inside diameter. If the inside diameter is too small, use PWA-3367 Primary Expander again. If necessary, the expander may be reset for additional expansion by moving the position of the fixed nut slightly towards the head of the plunger. If the inside diameter is too large (this is less likely to occur), the insert must be removed and a new insert installed.

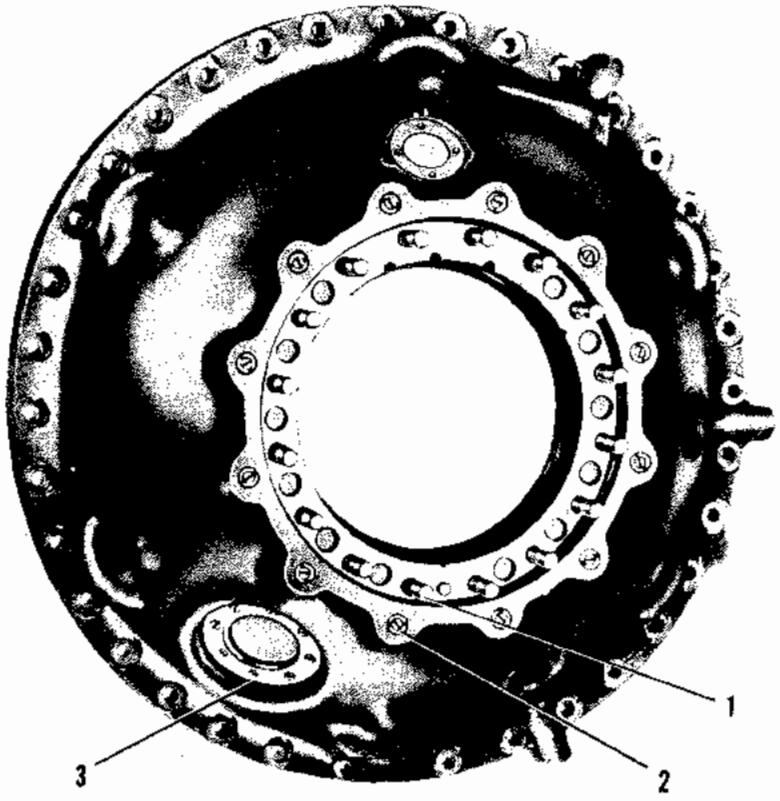
Using PWA-4568 Offset Expanding Tool, stake the insert as follows: Screw the tool all the way into the insert until the uppermost thread of the tool (the run-out threads) has started to engage a wrench, continue to turn the tool in until the scribed index line on the shank has turned past the end of the insert approximately ¼ inch in a clockwise direction **[166]**. Simultaneously, a rapid increase in the turning torque required will be evident. This will insure that the end of the top coil is sufficiently offset.

When installing the insert directly in aluminum heads, slightly peen the inner portion of the chamfer after the offsetting to insure a smooth surface. To do this, slip PWA-4568-2 Sleeve over PWA-4568-1 as a pilot before the latter is unscrewed from the insert **[167]**. Tap the end of the sleeve lightly with a hammer **[168]**, rotating it between taps.

Insert PWA-3944 Gage into the insert for a check of the inside diameter. Again examine the face of the hole for roughness and/or high spots. Remove any irregularities with PWA-3641 Facer.

Cleaning Sparkplug Inserts — A wire brush may be used in conjunction with a power tool to facilitate the cleaning of the sparkplug inserts. However, the following precautions should be taken: The cleaning brush should be of a type which does not disintegrate with use, so that no bristles will fall into the combustion chambers. The diameter of the brush and the technique applied in the cleaning operation should preclude the removal of material from the coil proper or from the cylinder head surrounding the insert. Extreme care should be taken to prevent damaging of the sparkplug gasket seating surface, since removing material from this location could cause combustion leakage with subsequent damage to the cylinder head. Ordinarily only a light application of a revolving brush will be required to clean an insert completely.



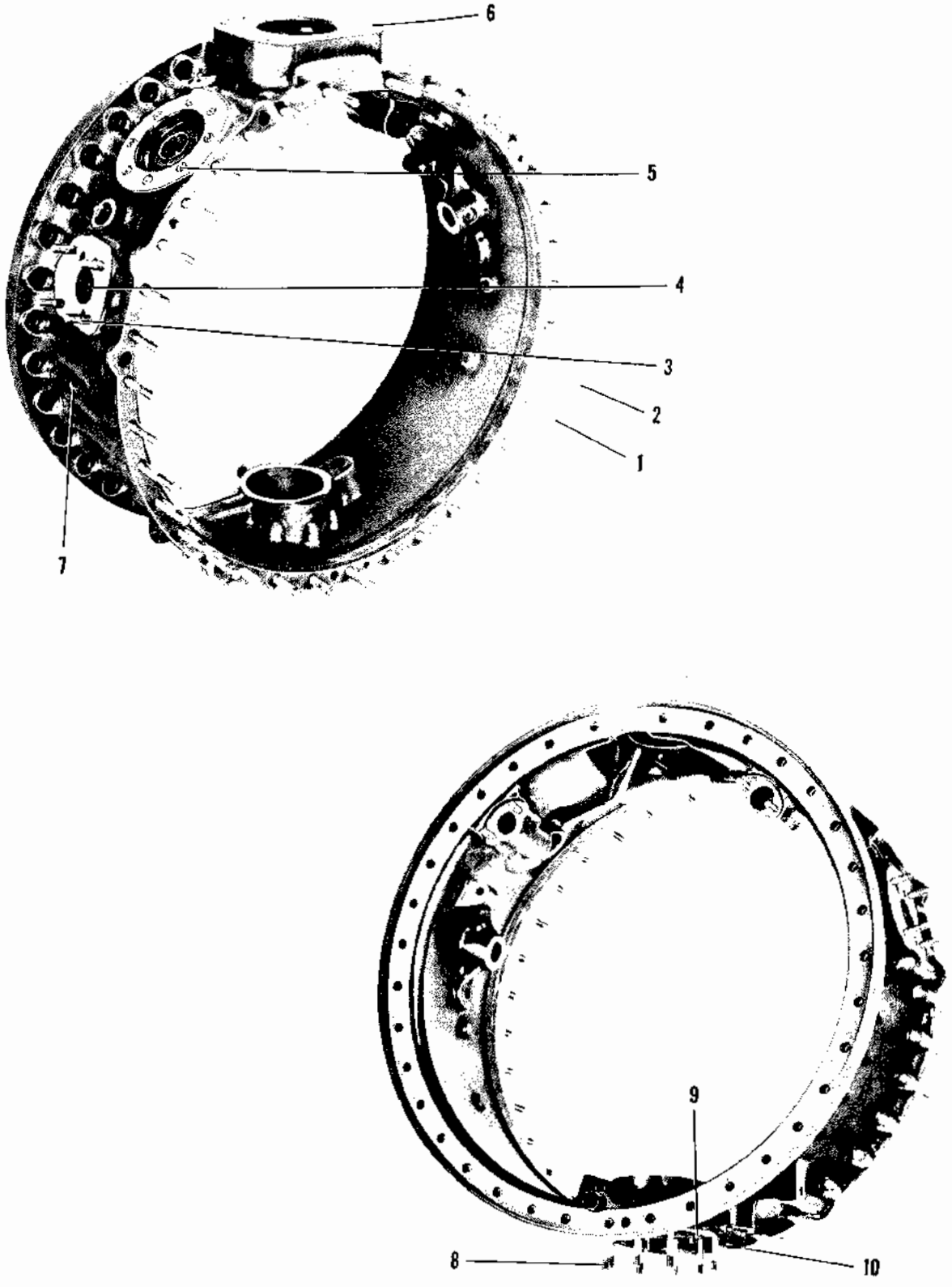


Index No.	Part Name	Part No.	Units Per Ass'y	Projection Length	Tools Required	Notes and References
1	Thrust Bearing Cover Studs	76123	16	1.640 1.650	7/16-20 Driver	Drive bushing flush to .010 inch below surface.
2	Front Case Screw Bushings Pins	95003 28151	16 18		PWA-1655 Driver No. 51 (.066-.068) Drill	Drill pin hole to depth of .180-.200 inch at an angle of 30° to 45° to face of bushing.
3	Torquemeter Oil Pressure Transfer Cover Screw Bushings Pins	34119 28151	8 8		PWA-1654 Driver No. 51 (.066-.068) Drill	Drive bushing flush to .010 inch below surface. Drill pin hole to depth of .180-.200 inch at an angle of 30° to 45° to face of bushing.

Front Case Stud Replacement

Index No.	Part Name	Part No.	Units Per Ass'y	Projection Length	Tools Required	Notes and References
1	Front Case Studs	50336	27	1.930 1.950	3/8-24 Driver	
2	Front Case Studs	80433	8	2.414 2.434	3/8-24 Driver	
3	Governor Pad Studs	106587	4	.990 1.010	5/16-24 Driver	
4	Governor Drive Gear Bushing Pin	 48690 4229	 1 1		.125 inch Drill PWA-1669 Disassembly Drift PWA-3591 Assembly Drift PWA-1039 Reaming Adapter TAM-3574-59 Reamer PWA-1805-12 Reaming Gage	Transfer drill the pin hole; install and stake the pin.
5	Distributor Pad Screw Bushings Pins	35446 28151	16 16		PWA-1653 Driver No. 51 (.066-.068) Drill	Drive bushing flush to .031 inch below surface. Drill pin hole to depth of .178 to .198 inch at an angle of 30° to 45° to face of bushing. Install and stake pin.
6	Magneto Pad Screw Bushings Pins	95003 28151	4 4		PWA-1655 Driver No. 51 (.066-.068) Drill	Drive bushing flush to .031 inch below the surface.
7	Cowl Mount Screw Bushings	95003 28151	6 6			Drill pin hole at an angle of 30° to 45° from the face of the bushing to a depth of .178 to .198 inch.
8	Scavenge Oil Pump Pad Studs	 38138	 8	1.615 1.635	5/16-24 Driver	
9	Scavenge Oil Pump Pad Dowel	39899	1	.240 .260		
10	Scavenge Oil Tube Studs	29981	2	.678 .698	5/16-24 Driver	

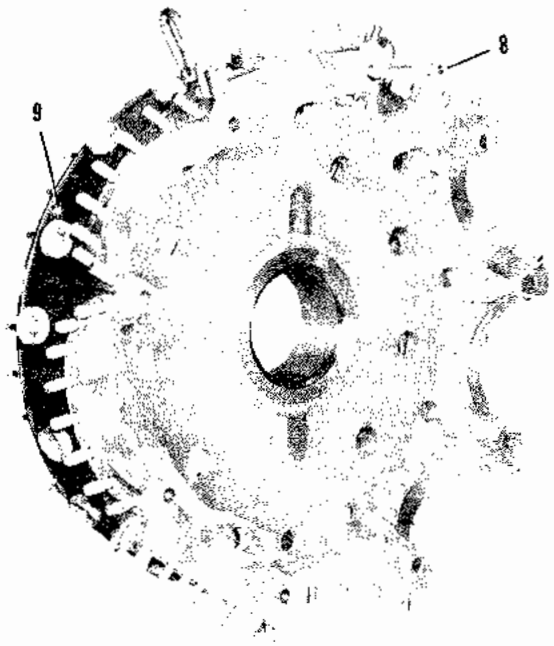
Front Accessory Case Bushing and Stud Replacement

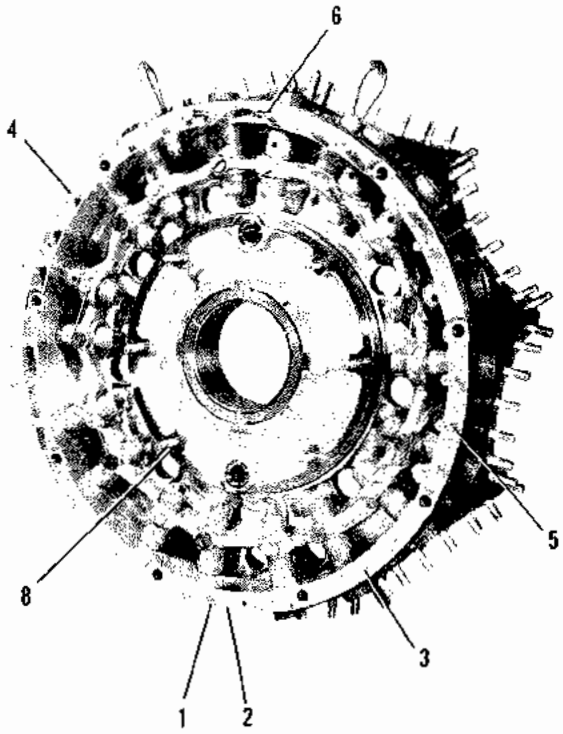


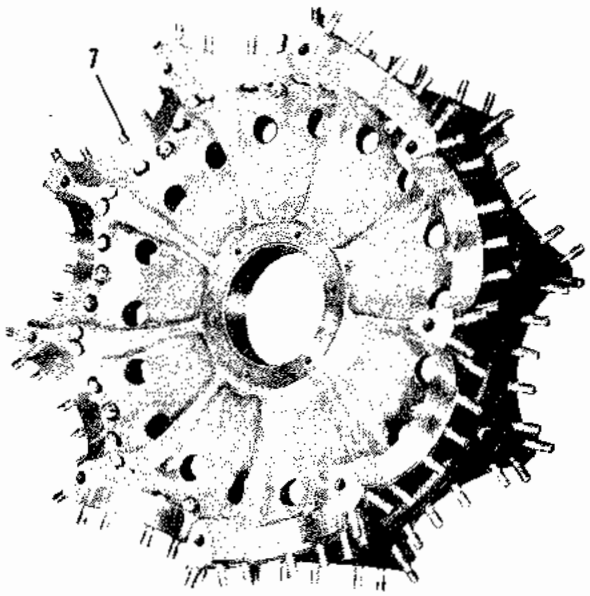
Front Accessory Case Bushing and Stud Replacement

Index No.	Part Name	Part No.	Units Per Ass'y	Projection Length	Tools Required	Notes and References
1	Crankcase to Front Accessory Case Dowels			.286		
	Bottom	20781	1	.306		
	Top	20781	1	.224-.244		
2	Crankcase to Front Accessory Case Studs	16032	1	1.302 1.322	3/8-24 Driver	
3	Crankcase to Front Accessory Case Studs	94476	4	1.990 2.010	3/8-24 Driver	
4	Crankcase to Front Accessory Case Studs	80432	8	1.912 1.932	3/8-24 Driver	
5	Crankcase to Front Accessory Case Studs	87741	12	1.490 1.510	3/8-24 Driver	
6	Crankcase to Front Accessory Case Studs	56985	2	1.193 1.213	3/8-24 Driver	
7	Cylinder Flange Bolts and Studs					
8	Crankcase Front Section to Center Section Stud	37850	1	3.256 3.276	1/2-20 Driver	
9	Ignition Manifold Mount Screw Bushing	48023	4		PWA-1655 Driver No. 50 (.069-.071) Drill	Drive bushings flush or slightly below surface.
	Pin	28151	4			Drill pin hole to depth of .180-.200 inch at an angle of 30° to 45° to face of bushing.

Crankcase Section Bolt and Stud Replacement



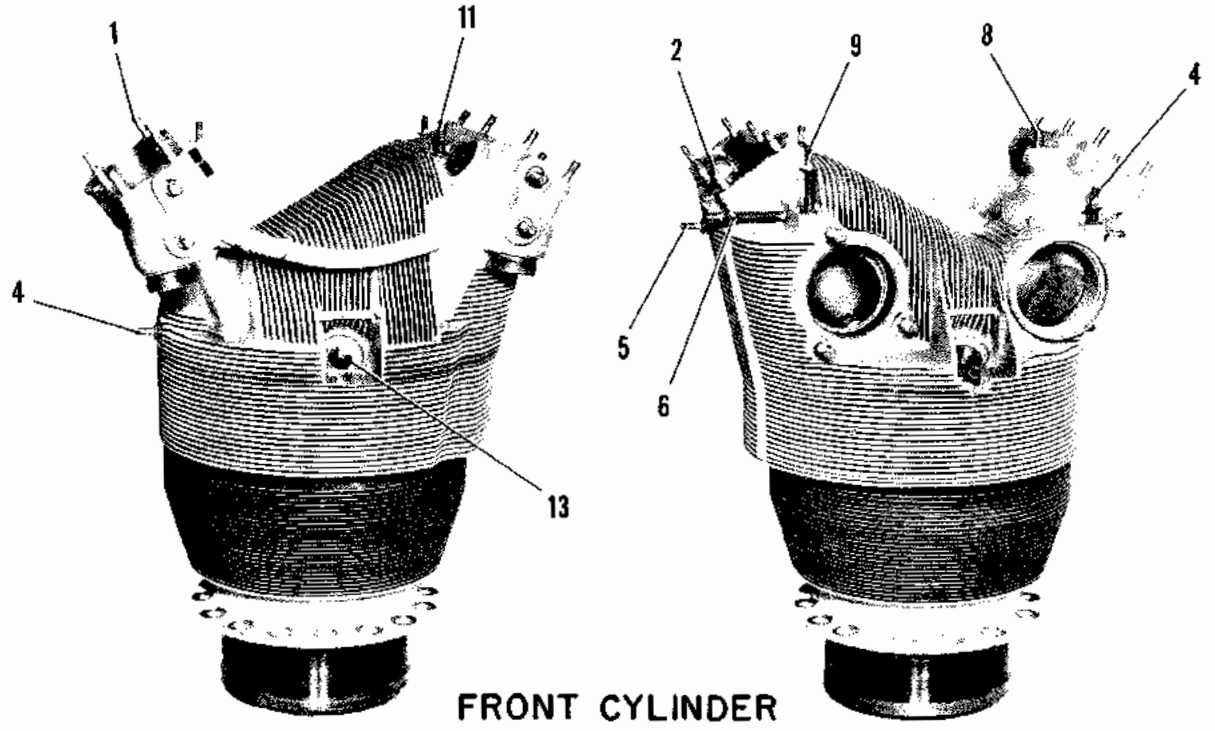




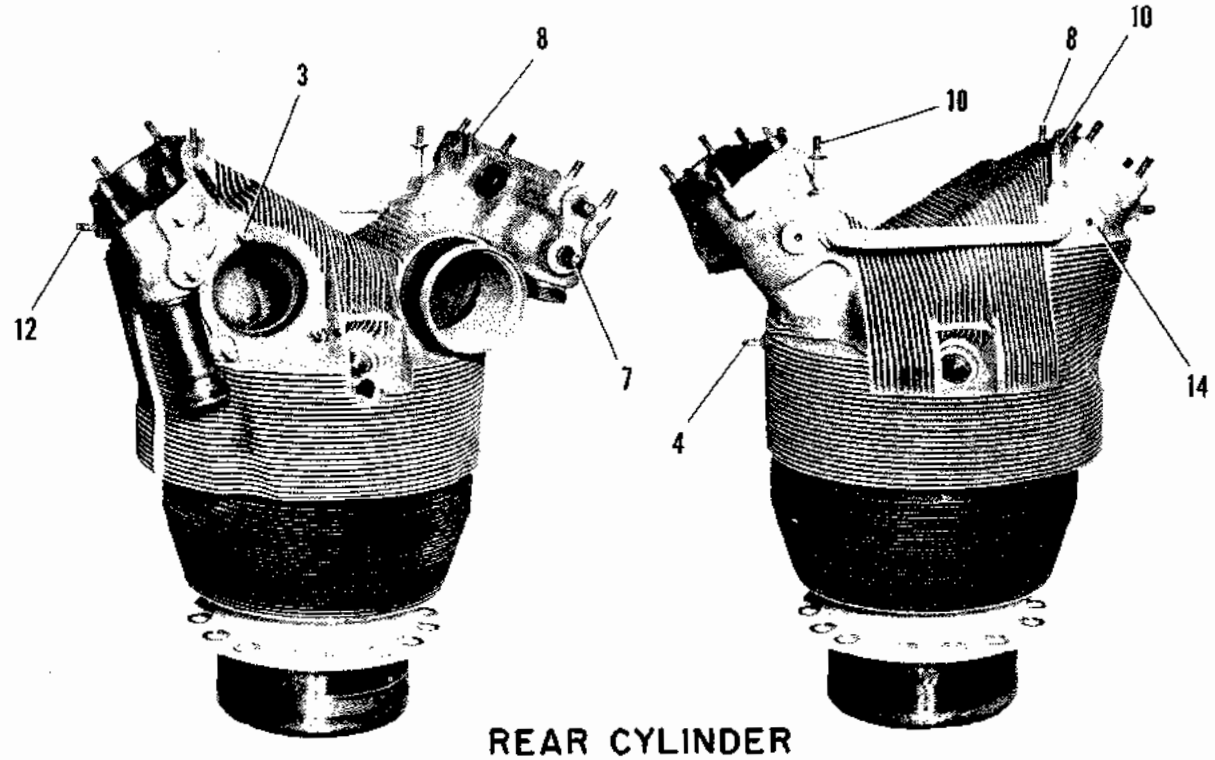
Crankcase Section Bolt and Stud Replacement

Index No.	Part Name	Part No.	Units Per Ass'y	Projection Length	Tools Required	Notes and References
1	Rockerbox Cover Studs	87581	11		1/4-28 Driver	Drive stud until shoulder bottoms.
2	Rockerbox Cover Studs	89751	1		1/4-28 Driver	
3	Exhaust Port Studs					
	(Front)	125669	3		3/8-24 Driver	
	(Rear)	127654	3			
4	Deflector Studs					
	(Front)	76866	2		1/4-28 Driver	
	(Rear)	76866	1			
5	Deflector Studs					
	(Front)	81609	2		1/4-28 Driver	
6	Deflector Studs					
	(Front)	76863	1		1/4-28 Driver	
7	Deflector Studs					
	(Front)	87584	4		5/16-24 Driver	
	(Rear)	128466	4			
8	Deflector Stud					
	(Front)	87582	1		1/4-28 Driver	
	(Rear)	87582	2			
9	Deflector Stud					
	(Front)	88179	1		1/4-28 Driver	
10	Deflector Stud					
	(Rear)	88180	2			
11	Deflector Stud					
	(Front)	88178	1		1/4-28 Driver	
12	Deflector Stud					
	(Rear)	87586	1		1/4-28 Driver	
13	Deflector Stud					
	(Front)	88885	1		1/4-28 Driver	
14	Sparkplug Insert	119589	2			
15	Deflector Screw Bushing (Rear)	12669	2		PWA-3916 Driver	

Cylinder Stud Replacement

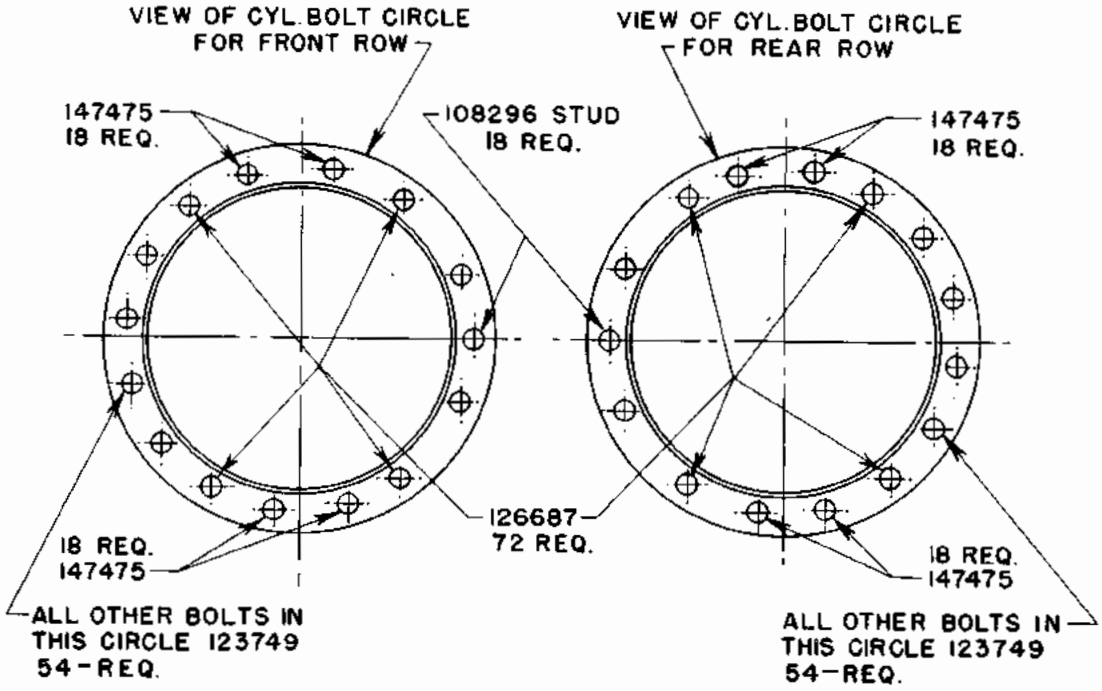


FRONT CYLINDER



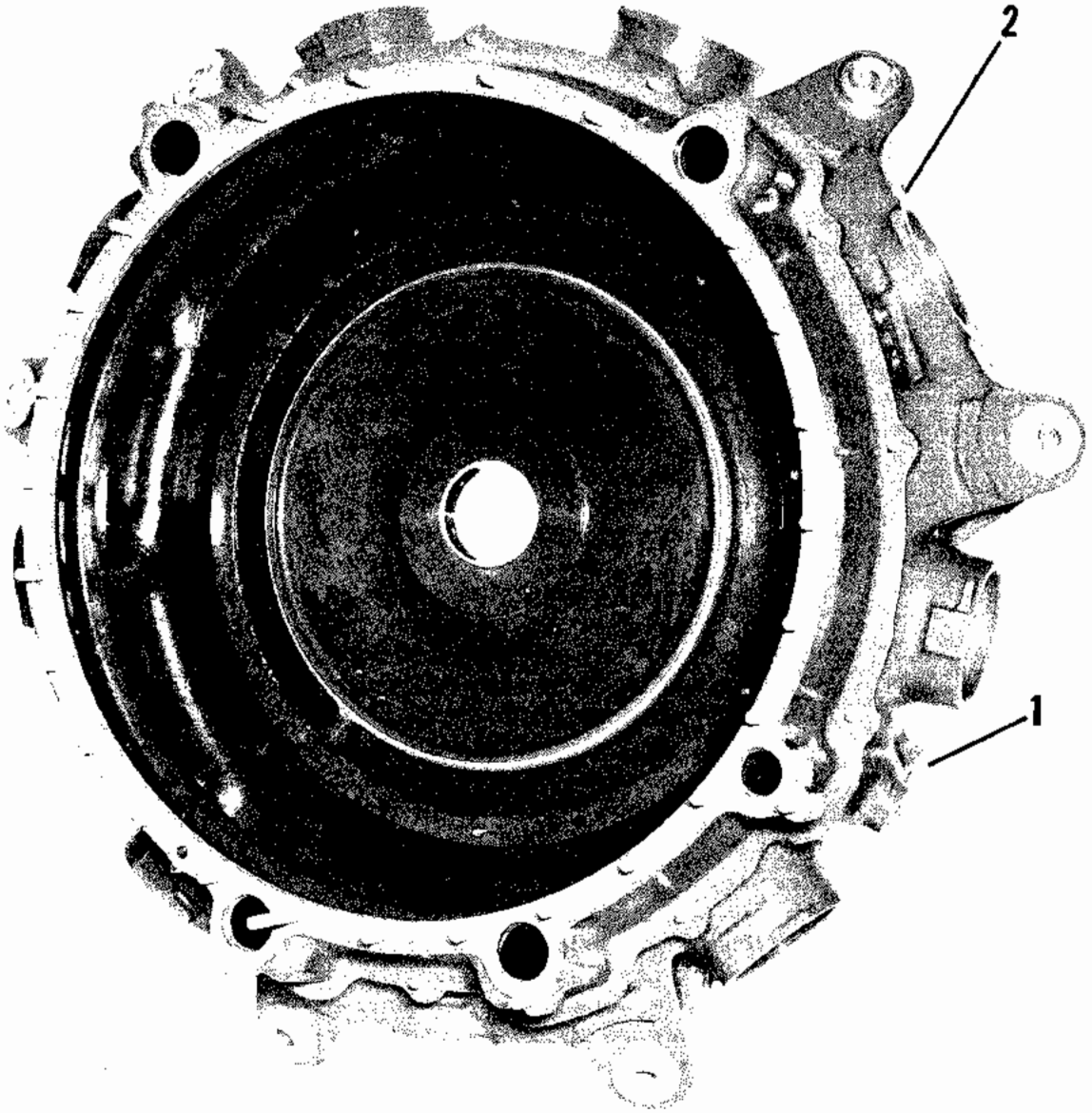
REAR CYLINDER

Cylinder Stud Replacement



Index No.	Part Name	Part No.	Units Per Ass'y	Projection Length	Tools Required	Notes and References
1	Cylinder Flange Bolts and Studs					Refer to drawing.

Cylinder Stud Replacement

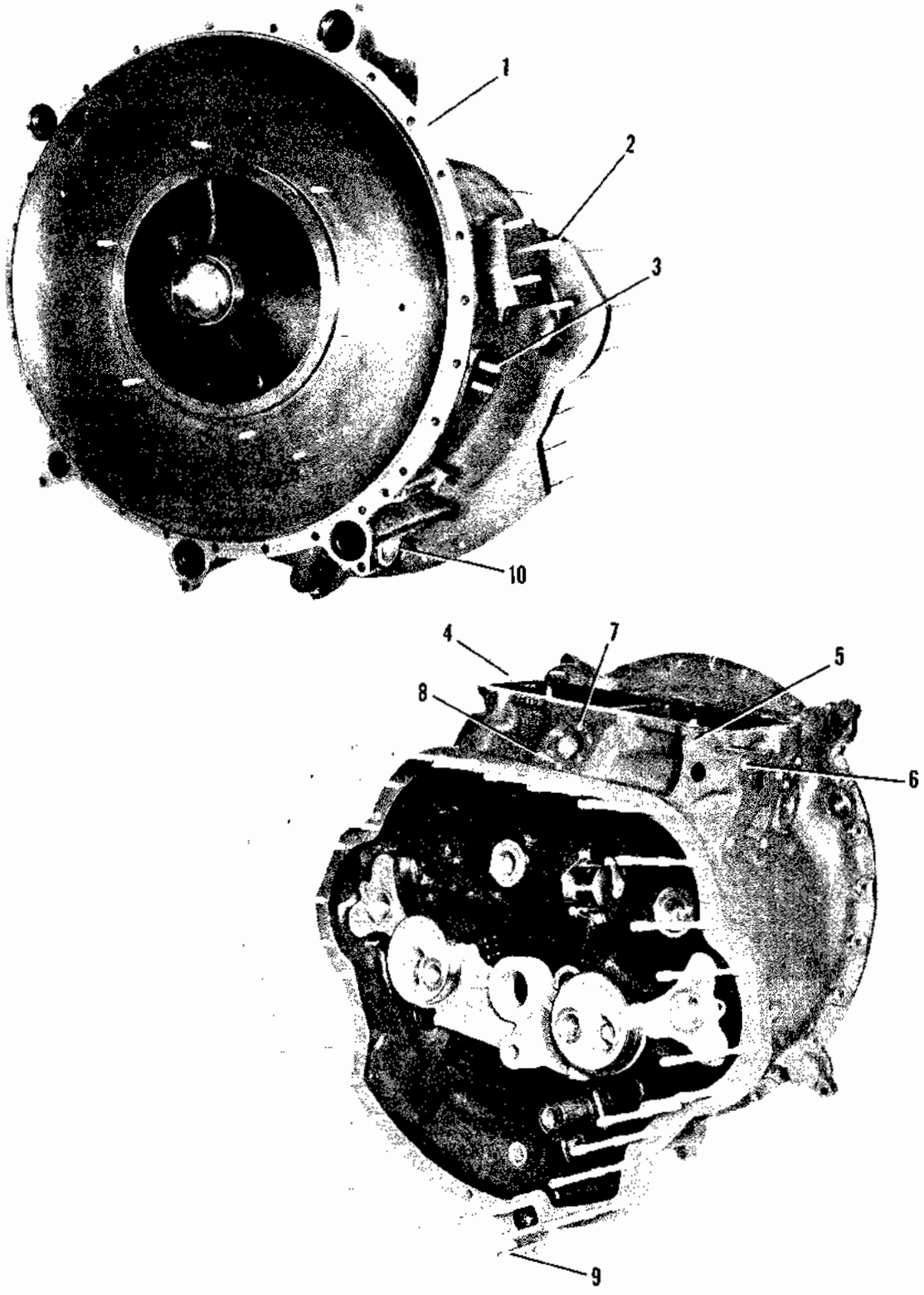


Index No.	Part Name	Part No.	Units Per Ass'y	Projection Length	Tools Required	Notes and References
1	Scavenge Oil Tube Studs	29981	2	.690	5/16-24 Driver	
2	Oil Sump Mount Inserts	83355	3		PWA-2261-3 Disassembly Driver PWA-3349-3 Assembly Driver PWA-3347-3 Thread Gage PWA-3345-5 Rough Tap PWA-3345-6 Finish Tap	Insert must be flush or slightly below surface. Break off tang.

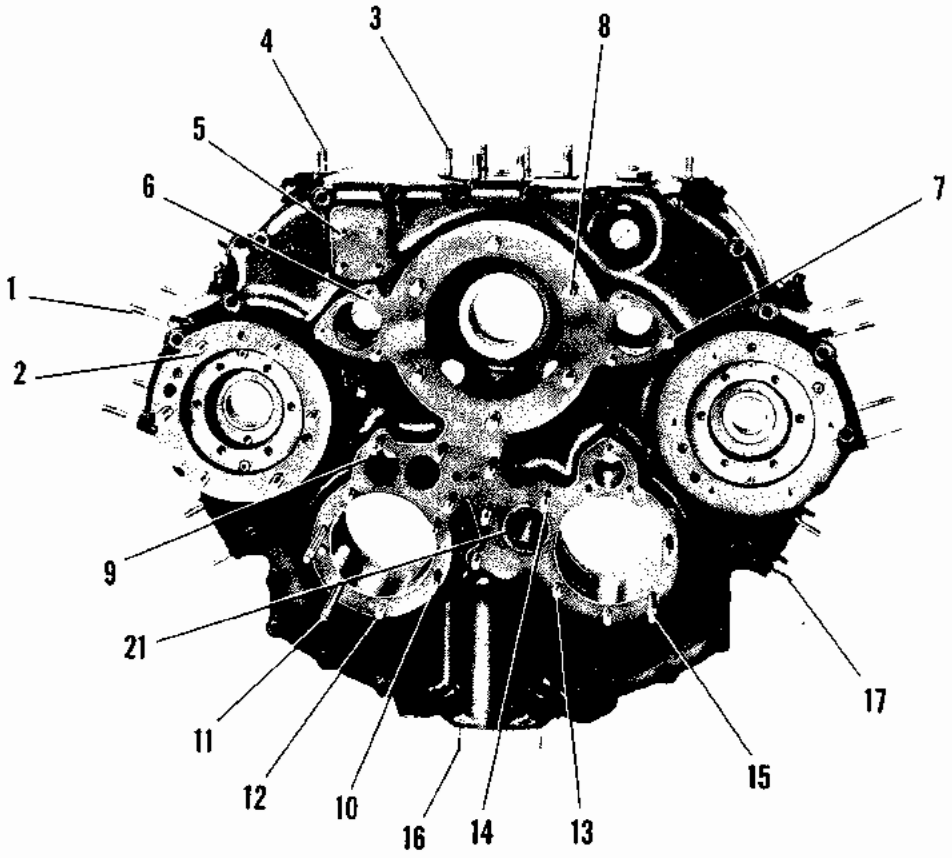
Supercharger Case Stud Replacement

Index No.	Part Name	Part No.	Units Per Ass'y	Projection Length	Tools Required	Notes and References
1	Fuel Transfer Tube Studs	97281	3	.310 .330	1/4-28 Driver	
2	Manifold Regulator Pad Studs	37840	4	.870 .890	5/16-24 Driver	
3	Intermediate Rear Studs	77902	2	1.190 1.210	1/4-28 Driver	
4	Carburetor Mount Pad Screw Bushings Pins	30643 28151	10 10		PWA-1564 Driver No. 51 (.066-.068) Drill	Drive bushing flush to .031 inch below surface. Drill pin hole in insert slot to depth of .180-.210 inch at an angle of 30° to 45° to face of insert.
5	Fuel Transfer Tube Mount Pad Inserts Pins	97424 28151	3 3		PWA-4537 Driver No. 51 (.066-.068) Drill	Drive bushing flush to .031 inch below pad. Drill pin hole in insert slot to depth of .180-.210 inch at an angle of 30° to 45° to face of pad.
6	Water Control Mount Inserts Pins	48023 28151	4 4		PWA-1655 Driver No. 51 (.066-.068) Drill	Drive bushing flush to .031 inch below pad. Drill pin hole in insert slot to depth of .180-.210 inch at an angle of 30° to 45° to face of pad.
7	Fuel Feed Valve Cover Screw Bushings Pins	34119 28151	6 6		PWA-1564 Driver No. 51 (.066-.068) Drill	Drive bushing flush to .031 inch below pad. Drill pin hole in insert slot to depth of .180-.210 inch at an angle of 30° to 45° to face of pad.
8	Fuel Feed Valve Pad Dowel	94305	1	.850 .870		
9	Intermediate Rear Stud	38771	1	2.120 2.140	5/16-24 Driver	
10	Oil Strainer Bushing Pins	56154 56007	1 3			

Intermediate Rear Case Stud Replacement



Intermediate Rear Case Stud Replacement



Index No.	Part Name	Part No.	Units Per Ass'y	Projection Length	Tools Required
1	Side Auxiliary Drive Pad Studs	77912	8	1.458	5/16-24 Driver
2	Generator or Vacuum Drive Pad Studs	43858	12	1.010	3/8-24 Driver
3	Selector Valve Mount Pad Studs	625	7	.891	5/16-24 Driver
4	Accessory Mounting Studs	79095	2	.765	5/16-24 Driver
5	Accessory Mounting Studs	43056	4	.840	5/16-24 Driver
6	Clutch Shaft Cover Studs	12317	5	.688	5/16-24 Driver
7	Clutch Shaft Cover Stud	625	1	.891	5/16-24 Driver
8	Starter Pad Studs	77901	6	1.125	7/16-20 Driver
9	Pressure Oil Pump Mount Stud	17938	1	1.688	5/16-24 Driver
10	Pressure Oil Pump Mount Studs	12101	5	1.562	5/16-24 Driver
11	Pressure Oil Pump Mount Studs	38829	2	2.938	5/16-24 Driver
12	Pressure Oil Pump Mount Stud	19604	2	.843	5/16-24 Driver
13	Scavenge Oil Pump Mount Studs	19604	6	.843	5/16-24 Driver
14	Scavenge Oil Pump Mount Studs	77915	2	1.574	5/16-24 Driver
15	Scavenge Oil Pump Mount Studs	14782	2	2.125	5/16-24 Driver
16	Oil Strainer Cover Mount Studs	77655	4	1.000	5/16-24 Driver
17	Tachometer Pad Studs	77914	8	.843	1/4-28 Driver 5/16-24 Driver

Rear Case Stud Replacement

TOOLS

SERVICE TOOLS

Tool No.	Tool Name	Description or Use
PWA-29	Screwdriver	9½ in. long
PWA-30	Screwdriver	4 in. long
PWA-31	Pliers	8 in. combination adjustable pipe
PWA-36	Container	Tool
PWA-43	Pliers	Thin nose
PWA-211	Bag	Tool kit
PWA-1055	Wrench	Adjustable — tabulated
PWA-1056	Wrench	8 in. adjustable
PWA-1057	Pliers	5⅞ in. diagonal cutting
PWA-1058	Screwdriver	Offset
PWA-1059	Mirror	2½ wide x 4 in. long (for checking magnetos)
PWA-1102	Wrench	⅛ in. pipe plug — Allen
PWA-1113	Wrench	Open end (to fit ½ to 9/16 in. nuts)
PWA-1114	Wrench	Open end (to fit ¾ and ⅝ in. nuts)
PWA-1239	Wrench	Box — double end
PWA-1265	Wrench	0.1 flange connection
PWA-1270	Socket wrench	½ in. double hexagon (⅞ in. long)
PWA-1392	Depressor	Rocker
PWA-1394	Handle	⅜ in. ratchet
PWA-1395	Drift	Fibre
PWA-1396	Extension	16 in. handle — ⅜ in. square drive
PWA-1397	Handle	⅜ in. square hinge
PWA-1400	Bar	Wrench handle cross

SERVICE TOOLS (Con't)

Tool No.	Tool Name	Description or Use
PWA-1401	Wrench	Open end (⅜ and 7/16 in.)
PWA-1402	Socket wrench	Sump plug — 1 in. hexagon
PWA-1404	Socket wrench	7/16 in. hexagon (⅞ in. long)
PWA-1405	Joint	⅜ in. drive — universal
PWA-1407	Hammer	Ball peen (½ lb.)
PWA-1424	Wrench	Pushrod cover nut
PWA-1437	Wrench	Relief valve box
PWA-1471	Wrench	Starter and generator nuts
PWA-1585	Wrench	Relief valve — open end
PWA-1606	Extension	Ratchet
PWA-1609	Wrench	7/16 in. palnut
PWA-1610	Socket wrench	⅝ in. mounting brackets
PWA-1683	Wrench	Sparkplug elbow
PWA-1786	Wrench	Intake pipe nut
PWA-1858	Wrench	⅝ in. hexagon — starter stud nut
PWA-1948	Socket wrench	9/16 in. hexagon
PWA-1950	Wrench	11/16 in. crowfoot
PWA-2410	Wrench	1⅛ in. crowfoot
PWA-2682	Wrench	⅜ x 7/16 in. box end
PWA-2806	Wrench	Cylinder nut (semi long)
PWA-2810	Wrench	¾ in. sparkplug elbow
PWA-2812	Wrench	Pushrod cover nut
PWA-2835	Wrench	Valve tappet adjusting
PWA-2960	Wrench	Cylinder nut
PWA-3121	Wrench	Intake pipe nut
PWA-3130	Compressor	Valve spring
PWA-3254	Wrench	⅞ in. hexagon — sparkplug
PWA-4245	Service tool kit	
PWA-4715	Depressor	Valve spring

MAINTENANCE TOOLS

Baffle screw

wrench	PWA-2788

Breather

body driver — rear	PWA-2716
tube nut wrench	PWA-1424

Carburetor

auto mixture control wrench	PWA-3264

Cylinder

flange lap	PWA-2199
palnut spinner	PWA-5003
palnut wrench	PWA-3923
barrel flange checking plate	PWA-2630—23
flange nut wrench	PWA-5061

Engine

lifting sling	PWA-2934
mounting bolt nut wrench	PWA-3340
mounting bolt	TAM-5810
mounting bracket	TB-54529
mounting plate	TC-51260
stand	TAM-1785
timing pointer	PWA-2761
timing indicator	PWA-2417
timing segment	PWA-3113
depreservation valve	PWA-5124

Exhaust pipe

wrench (front nut)	PWA-4182

Exhaust port cover

remover	PWA-3926

Fuel feed valve

housing puller	PWA-3501

Fuel feed valve mount pad screw bushing

driver	PWA-4537

MAINTENANCE TOOLS (Con't)

Hose clamp

compressor	PWA-3372

Intake pipe

coupling nut wrench (supercharger end)	PWA-5074
coupling nut wrench (cylinder end)	PWA-5073
puller	PWA-3145

Intake pipe coupling

protector	PWA-4132—2

Intake port

protector	PWA-4999

Linkrod

support holder	PWA-2488

Low tension ignition coil

nut wrench	PWA-4650

Masterod

holder	PWA-2069
guide	PWA-2414
support	PWA-4985

Oil return check valve

wrench	PWA-3626

Oil temperature bulb boss plug

wrench	PWA-2274

Oil return connection (crankcase)

wrench	PWA-3162

Oil strainer

assembly fixture	PWA-5313

Piston

indicator (top center)	PWA-2537
dish gage	PWA-3140
ring expanding pliers	PWA-1791
indicator (firing position)	Time Rite

Pistonpin

pusher	PWA-4911

MAINTENANCE TOOLS (Con't)

Pistonring

clamp	PWA-13	
end clearance gage	PWA-3201—3	
expanding pliers	PWA-1791	

Indicator

magneto synchronizing	PWA-2417	***Heli-Coil Corporation Tool Numbers***
spark advance timing	Time Rite	
top center	PWA-2537	

Inserts (helical)

1/4-20NC-3 assembly driver	PWA-3349—2	B-528-4N
1/4-20NC-3 disassembly driver	PWA-2261—1	1227-6-TS
1/4-20NC-3 finish tap	PWA-3345—4	A-187-4
1/4-20NC-3 gage	PWA-3347—2	A-188-4
1/4-20NC-3 rough tap	PWA-3345—3	A-186-4
10-24 assembly driver	PWA-3349—1	B-528-3N
5/16-18NC-3 assembly driver	PWA-3349—3	B-528-5N
5/16-18NC-3 disassembly driver	PWA-2261—3	1227-16-TS
5/16-18NC-3 finish tap	PWA-3345—6	A-187-5
5/16-18NC-3 gage	PWA-3347—3	A-188-5
5/16-18NC-3 rough tap	PWA-3345—5	A-186-5

Inserts (sparkplug)

finishing tap	PWA-3942	A-427
finishing tap	PWA-3942+3	A-2-55
finishing tap	PWA-3942+5	A-2-56
finishing tap	PWA-3942+10	A-2-57
go-no go gage	PWA-3943	B-420
go-no go gage	PWA-3943+3	A-2-58
go-no go gage	PWA-3943+5	A-2-59
go-no go gage	PWA-3943+10	A-2-60
inserting tool	PWA-4921	B-889
expanding tool	PWA-3367	B-422
offset expanding and staking tool	PWA-4568	A-808
18 MM go-no go gage	PWA-3944	B-424
facer	PWA-3641	
extractor	PWA-4102	B-426
countersink	PWA-4647	

Pressure oil pump

puller	PWA-2151—11

MAINTENANCE TOOLS (Con't)

Pressure Oil Strainer

assembly fixture	PWA-2151-11

Pressure oil relief valve

cap wrench	PWA-978
housing wrench	PWA-977
lap holder	PWA-4586—12
seat wrench	PWA-3418

Propeller shaft

lifting eye	PWA-2736
turning bar	PWA-2741

Pushrod

ballend assembly holder	PWA-2223
ballend disassembly fixture	PWA-4877
ballend assembly and disassembly puller	PWA-4877
cover nut wrench	PWA-3639
cover nut wrench (heavy duty)	PWA-2370

Rocker

ball socket assembly fixture	PWA-2450
ball socket disassembly pusher	PWA-2506
depressor	PWA-455

Rocker shaft

assembly and disassembly drift	PWA-3899
bushing gage	PWA-4329—10

Screw bushings

cylinder head deflector driver	PWA-3916
distributor pad driver	PWA-1653
crankcase front section driver	PWA-1655
low pressure relief valve driver	PWA-1653
spark advance adapter drill jig	PWA-3898
spark advance adapter driver	PWA-1653
sump bushing driver	PWA-1572
scavenge oil strainer bushing driver	PWA-2305
thrust bearing cover driver	PWA-3276
1/4-28 driver	PWA-1653
5/16-24 driver	PWA-1563
5/16-24-I.D. driver	PWA-1655
10-32 driver	PWA-1654
3/8-24 driver	PWA-1564
3/4-16 driver	PWA-3091

MAINTENANCE TOOLS (Con't)

Selector valve

lever puller	PWA-2749
oil seal assembly drift	PWA-1462
oil seal guide	PWA-3748
shaft puller	PWA-2536

Sparkplug

hole protector plug	PWA-3252
wrench	PWA-3168
wrench	AC AV1-1

Starter jaw

puller	PWA-1586

Sump

drain tube connection wrench	PWA-3162
opening protector	PWA-5027
plug wrench	PWA-1787
puller	PWA-1686
tube connection wrench	PWA-4063

Thermocouple

fitting wrench	PWA-5006
adapter cap wrench	PWA-4634

Thrust bearing

cover puller	PWA-3275-100
nut wrench	PWA-2745

Torquemeter

cover puller	PWA-2939

Torque wrench

0 to 600 pounds-inch	PWA-2239
0 to 1200 pounds-inch	PWA-5567
0 to 2400 pounds-inch	PWA-2238
adapter	PWA-2240
handle — use with PWA-2240	PWA-3109

Valve

adjusting screw driver	PWA-4152
maximum wear gage (inlet valve guide)	PWA-804
clearance gage (stem-rocker)	PWA-4675
maximum wear gage (exhaust valve guide)	PWA-4315
radius gage — exhaust	PWA-3004
radius gage — inlet	PWA-5364
spring depressor	PWA-4310
exhaust valve circlet remover	PWA-4333
exhaust valve circlet drift	PWA-4334
holder (for lapping valves)	PWA-2269

LIMITS

These tables should be used in conjunction with the Limits and Lubrication Charts, pages 203, through 206. The letters "L" and "T" are used to represent loose and tight fits, respectively. The symbol "*" indicates that worn parts should be replaced if any looseness is found. The expression "Fit To" indicates that a fitting operation may be necessary at assembly to obtain the required fit. The expression "By Selection" indicates that it may be necessary to select other parts or relationships of parts to obtain the required fit. Unless otherwise specified, all fits between circular parts are diametrical; spline fits are calculated from chordal dimensions. Reference numbers not listed in the following tables but appearing in the Limits and Lubrication Charts are required only in overhaul procedures, and are covered in the Overhaul Manual, Part No. 115635.

LIMITS FOR PAGE 203

Ref. No.	Description	Min.	Max.	Replacement
3	Thrust Bearing Nut Oil Seal Rings Gap	.020	.030	
4	Thrust Bearing Nut Oil Seal Rings Side Clearance	.001	.005	.007
6	Thrust Bearing Cover — Front Case	.001	.005	

LIMITS FOR PAGE 204

Ref. No.	Description	Min.	Max.	Replacement
356	Magneto Adapter Smaller Diameter — Front Accessory Housing	.001	.005	
357	Magneto Drive Gear Snapring Side Clearance	.000	.006	
358	Magneto Drive Gear Bushing — Gear	.002	.004	.006
359	Magneto Drive Gear Bushing — Adapter	.001T	.003T	*
361	Magneto Adapter Larger Diameter — Front Accessory Housing	.0005	.0045	
362	Magneto Drive Coupling Splines — Drive Gear Splines	.002	.006	.010
363	Magneto Drive Coupling Splines — Pinion Splines	.0026	.0056	
420	Pistonpin Bushing — Pin	.0017	.0033	.005
421	Pistonpin Bushing — Master and Linkrods	.0045T	.006T	*
422	Piston — Cylinder Barrel	.026	.030	
423	Pistonpin Plug — Pin	.0015T	.0035T	.001
	(Service Fit)	.000	.0015T	.001

LIMITS FOR PAGE 204 (Con't)

Ref. No.	Description		Min.	Max.	Replacement
424	Pistonrings Side Clearance	Top Groove	.004	.006	
		2nd Groove	.005	.007	
		3rd Groove	.003	.005	
		4th Groove	.004	.0075	
		5th Groove	.003	.0055	
425	Pistonrings End Clearance (Before Lapping or Engine Operation)	Top Groove	.095	.107	
		2nd Groove	.095	.107	
		3rd Groove	.095	.107	
		4th Groove	.095	.107	
		5th Groove	.095	.107	
435	Exhaust Valve Guide — Cylinder Head		.001T	.003T	*
437	Exhaust Valve Guide — Valve		.003	.0055	
439	Rocker Ball Socket — Rocker		.000	.0025T	*
441	Intake Valve Guide — Valve		.002	.0045	
442	Intake Valve Guide — Cylinder Head		.0005T	.003T	*
443	Rocker Shaft Bushing — Cylinder Head		.001T	.003T	*
444	Rocker Shaft Bushing — Shaft		.0023	.0035	.005
445	Rocker Shaft — Rocker		.0001	.0007	.002
446	Valve Rocker Side Clearance		.004	.014	.022
508	Rocker Shaft Inner and Outer Nuts		275	325	
511	Valve Adjusting Screw Locknut		300	350	

LIMITS FOR PAGES 205 AND 206

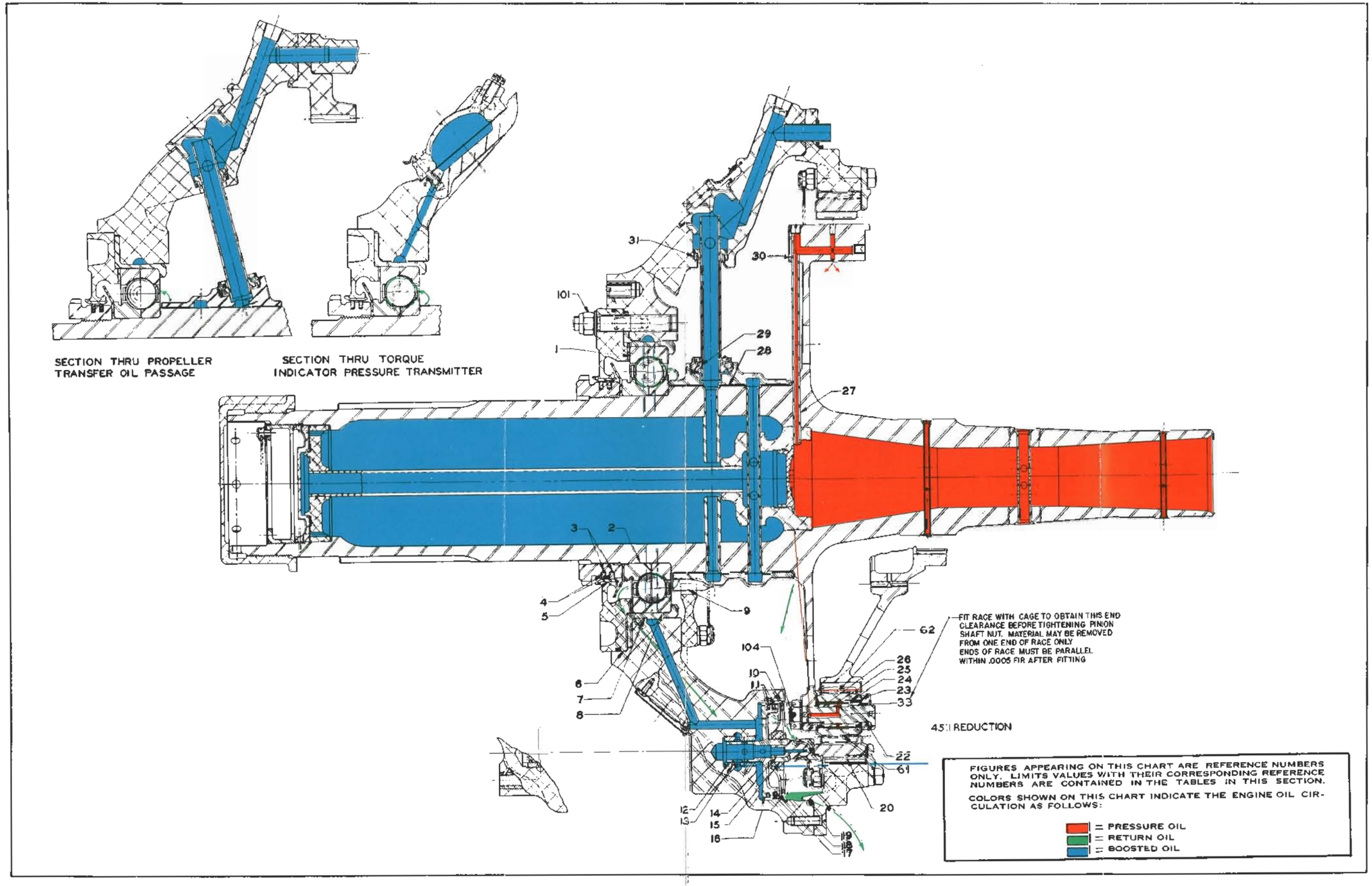
Ref. No.	Description	Min.	Max.	Replacement
627	Fuel Drain Valve Upper Housing — Valve	.004	.012	
629	Fuel Drain Valve Lower Housing — Valve Stem	.004	.012	
680	Pressure Oil Screen Check Valve — Valve Seat	.0005	.0015	
672	Fuel Pump Drive Gear Oil Seal — Oil Scavenge Pump Rear Cover	.001T	.007T	*
695	Compensating Relief Valve Seat — Valve	.002	.006	
696	Compensating Relief Valve Piston — Housing (Small End)	.0012	.0028	
697	Compensating Relief Valve Housing — Oil Pressure Pump Rear Cover	.013	.017	
698	Compensating Relief Valve Piston — Housing (Lage End)	.0015	.0035	

LIMITS FOR PAGES 205 AND 206 (Con't)

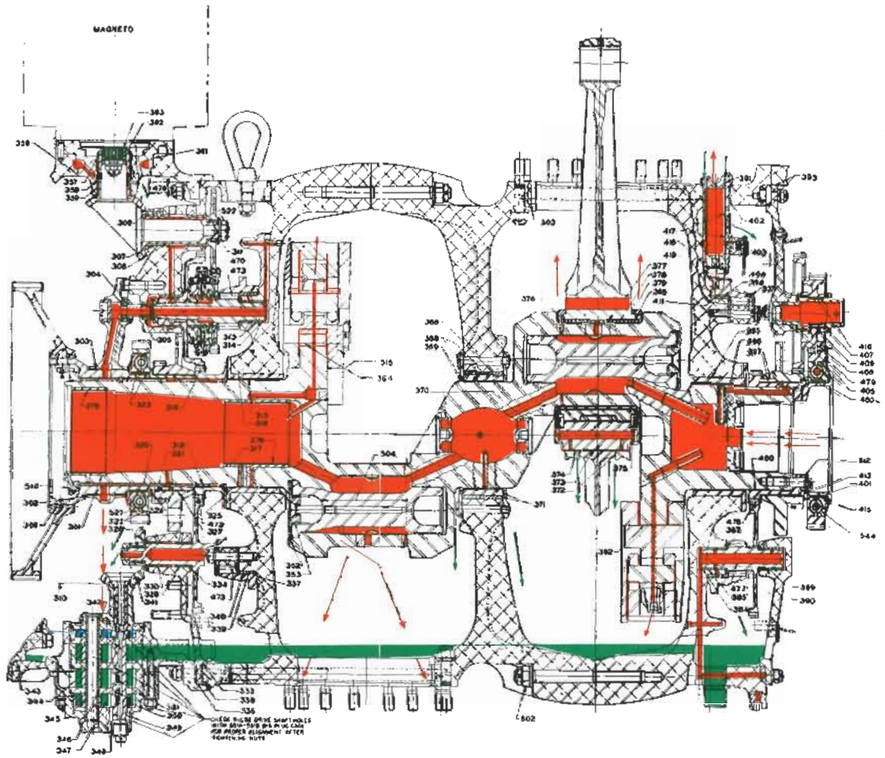
Ref. No.	Description	Min.	Max.	Replacement
698	Relief Valve Spring at 1-3/32 in.	34	37	30
700	Strainer By-Pass Valve Housing — Piston	.002	.006	
700	Strainer By-Pass Valve at 1⅜ in.	4	5	3
701	Strainer By-Pass Valve Housing — Oil Pressure Pump Rear Cover	.000	.0035	
718	Low Pressure Oil Relief Valve Housing — Valve	.002	.006	
743	Side Auxiliary Drive Adapter — Oil Seal	.0015T	.0065T	*
747	Hig Speed Generator Drive Shaft Oil Seal Liner — Oil Seal	.001T	.007T	*
769	Tachometer Drive Gear Oil Seal Liner — Rear Case	.000	.002	
770	Tachometer Drive Gear Oil Seal Liner — Oil Seal	.000	.006T	
835	Clutch Selector Valve Shaft End Clearance	.001	.005	
836	Clutch Selector Valve Shaft Support — Shaft	.002	.014	
837	Clutch Selector Valve Shaft Oil Seal — Shaft Support	.0005T	.0055T	*
838	Clutch Selector Valve Shaft Support — Housing	.0005T	.0025	
839	Clutch Selector Valve Shaft Housing — Shaft	.001	.003	
845	Vacuum Drive Gear Oil Seal Liner — Seal	.001T	.007T	*
934	Rear Section Scavenge Oil Strainer and Plug	300	400	
957	Low Pressure Oil Relief Valve Spring at 1⅜ in.	4	5	3

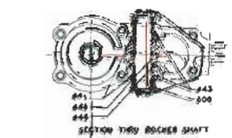
SPRING PRESSURES

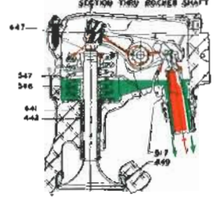
Ref. No.	Description	Min.	Max.	Replacement
542	Booster Pump Relief Valve Spring at 1.375 in.	10.6	11.8	9.5
543	Front Counterbalance Spring Drive Spring at .930 in.	112	122	105
544	Rear Counterbalance Spring Drive Spring at .930 in.	112	122	105
545	Exhaust Valve Outer Spring at 1.450 in.	123	131	117
546	Exhaust Valve Inner Spring at 1.450 in.	101	109	95
547	Intake Valve Outer Spring at 1.450 in.	126	134	120
548	Intake Valve Inner Spring at 1.450 in.	105	113	99
698	Pressure Oil Relief Valve Spring at 1-3/32 in.	34	37	30
700	Strainer By-Pass Valve Spring at 1⅜ in.	4	5	3
951	Fuel Feed Valve Spring at 1.140 in.	5.77	6.13	5.62
954	Oil Return Check Valve at 13/16 in.	3.31	3.94	2.75
957	Low Pressure Oil Relief Valve Spring at 1⅜ in.	4	5	3

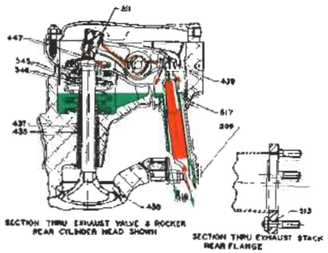


Limits and Lubrication Chart for Front Section

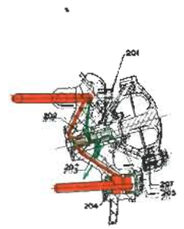


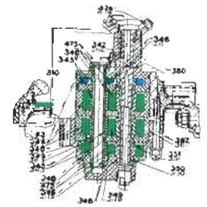

SECTION THRU ROCKER SHAFT

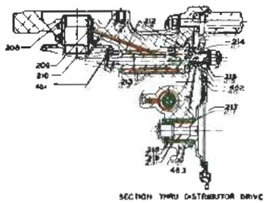

SECTION THRU INLET VALVE & ROCKER REAR CYLINDER HEAD SHOWN

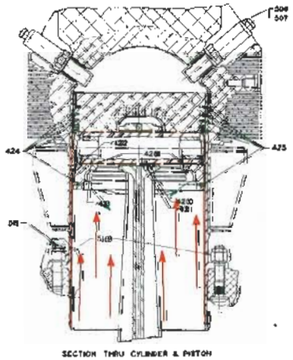

SECTION THRU EXHAUST VALVE & ROCKER REAR CYLINDER HEAD SHOWN

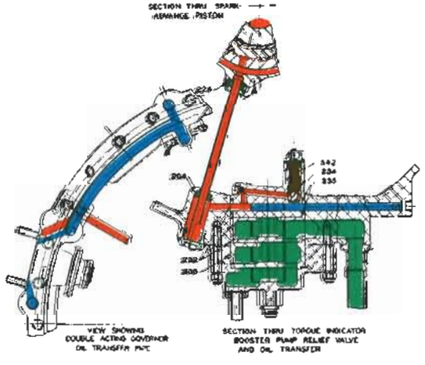
SECTION THRU EXHAUST STACK REAR FLANGE


SECTION THRU SPARK ADVANCE VALVE AND COVER

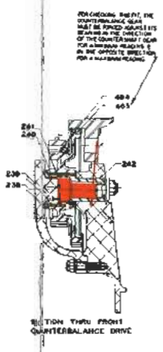

SECTION THRU FRONT OIL PUMP (NEW DESIGN)

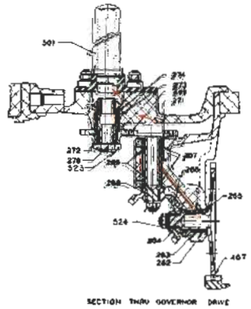

SECTION THRU DISTRIBUTOR DRIVE

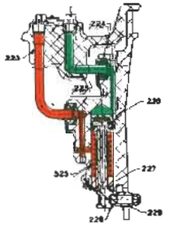

SECTION THRU CYLINDER & PISTON

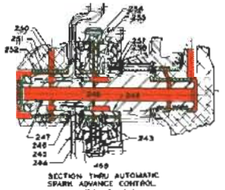

VIEW SHOWING DOUBLE ACTING GOVERNOR OIL TRANSFER PIPE

SECTION THRU TORQUE INDICATOR BOOSTER PUMP RELIEF VALVE AND OIL TRANSFER


SECTION THRU FRONT QUARTERBALANCE DRIVE


SECTION THRU GOVERNOR DRIVE



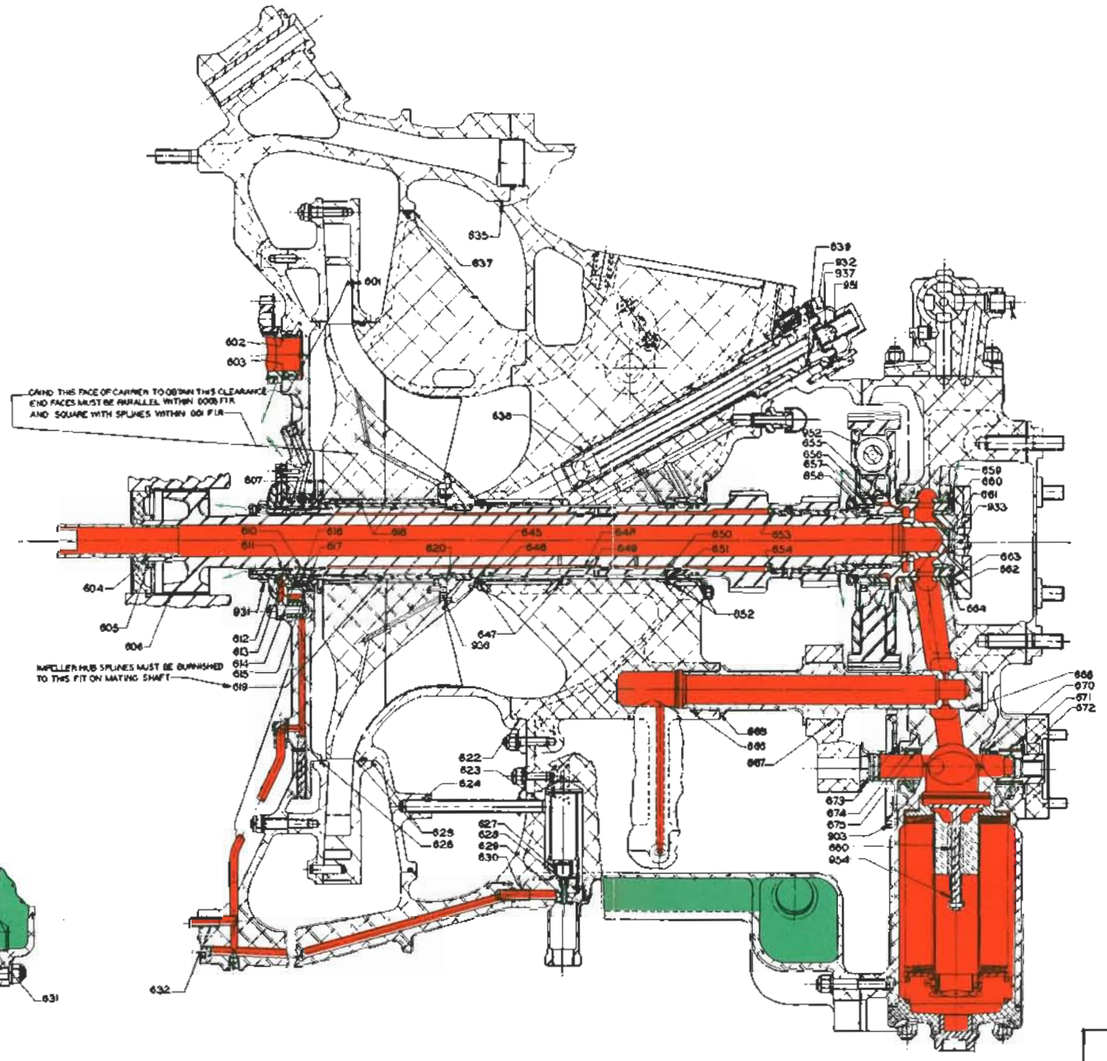

SECTION THRU AUTOMATIC SPARK ADVANCE CONTROL (SCALE 1.5:1)

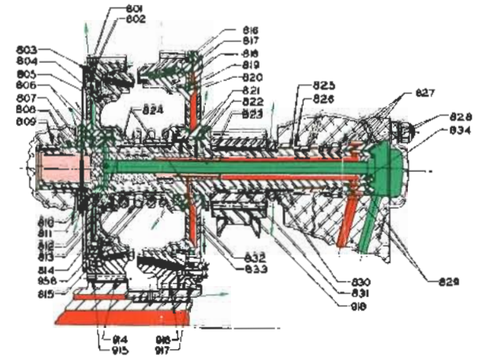
FIGURES APPEARING ON THIS CHART ARE REFERENCE NUMBERS ONLY. LIMITS VALUES WITH THEIR CORRESPONDING REFERENCE NUMBERS ARE CONTAINED IN THE TABLES IN THIS SECTION.

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

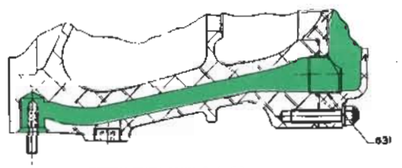
= PRESSURE OIL
= RETURN OIL
= BOOSTED OIL

Limits and Lubrication Chart for Power Section





SECTION THRU IMPELLER DRIVE CLUTCHES



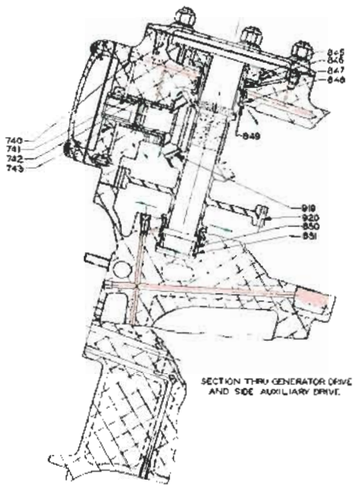
SECTION THRU MAIN BLOWER SCAVENGE OIL PASSAGE

FIGURES APPEARING ON THIS CHART ARE REFERENCE NUMBERS ONLY. LIMITS VALUES WITH THEIR CORRESPONDING REFERENCE NUMBERS ARE CONTAINED IN THE TABLES IN THIS SECTION.

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

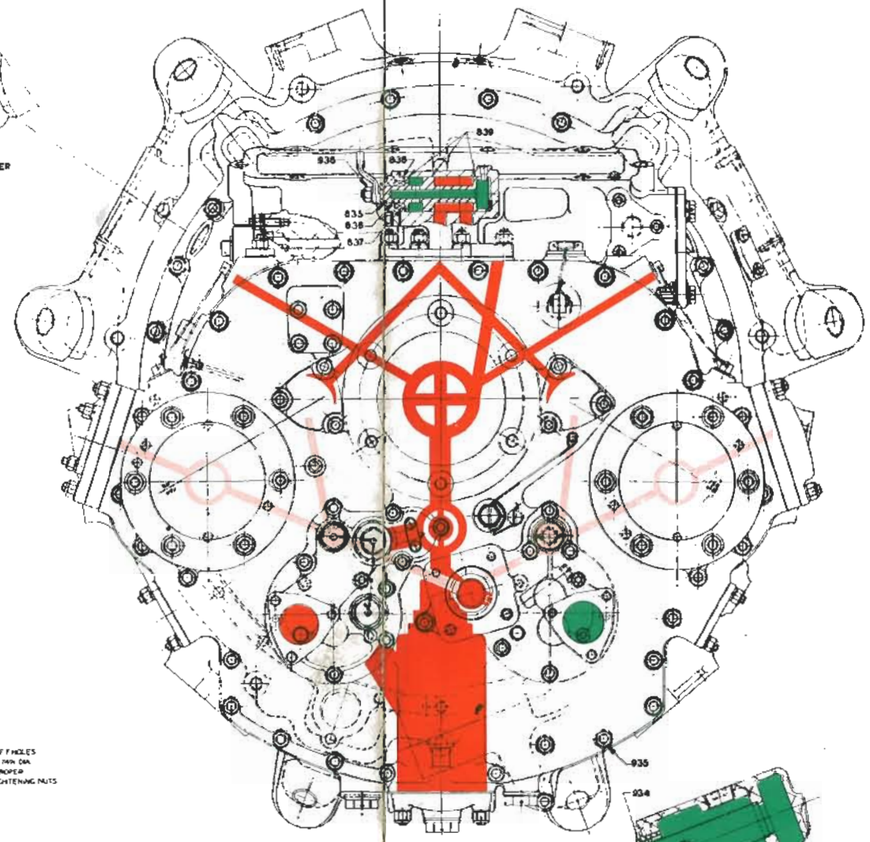
= PRESSURE OIL
= LOW PRESSURE OIL
= RETURN OIL

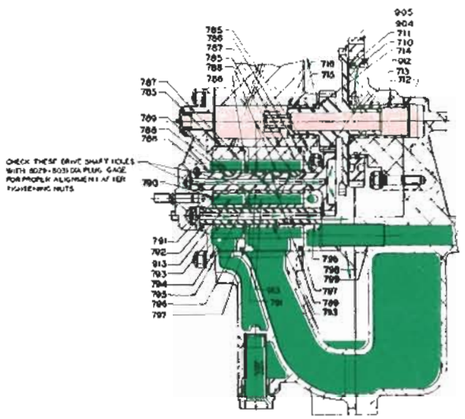
Limits and Lubrication Chart for Accessory Section



SECTION THRU GENERATOR DRIVE AND SIDE AUXILIARY DRIVE.

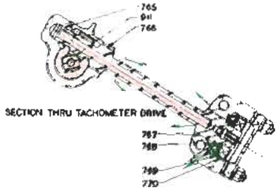
SECTION THRU REAR BREATHER



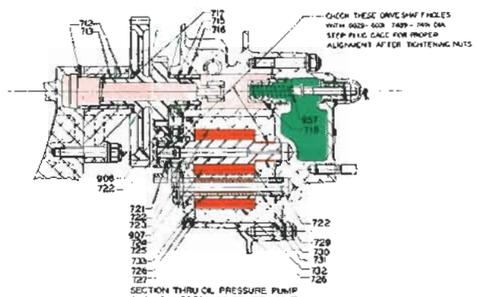


SECTION THRU SCAVENGE OIL PUMP AND REAR CRANKCASE OIL STRAINER

OIL PRESSURE RELIEF VALVE & BY-PASS VALVE



SECTION THRU TACHOMETER DRIVE



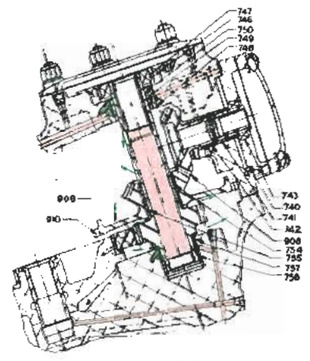
SECTION THRU OIL PRESSURE PUMP AND LOW PRESSURE RELIEF VALVE

SECTION THRU INTERMEDIATE REAR CASE OIL STRAINER

FIGURES APPEARING ON THIS CHART ARE REFERENCE NUMBERS ONLY. LIMITS VALUES WITH THEIR CORRESPONDING REFERENCE NUMBERS ARE CONTAINED IN THE TABLES IN THIS SECTION.

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

= PRESSURE OIL
= LOW PRESSURE OIL
= RETURN OIL



SECTION THRU HIGH SPEED GENERATOR DRIVE AND SIDE AUXILIARY DRIVE

Limits and Lubrication Chart for Rear Section

TORQUE RECOMMENDATIONS

GENERAL

The following torque values in pound-inches are recommended for use during maintenance of the Double Wasp CB Series Engines. These values are based on the use of parts which have no oil or special lubricant applied, except where maintenance instructions or these instructions specifically recommend a special lubricant or surface coat.

Torque indicating devices should be checked daily and calibrated by means of weights and a measured lever arm to insure accuracy. Checking one torque wrench against another is not sufficient. Some wrenches are quite sensitive as to the way they are supported during a tightening operation and instructions furnished by their respective manufacturers should be followed. Tightening should be done slowly and evenly for consistency and accuracy.

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

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

Because of the necessarily unconventional design of cylinder flange nut wrenches, particular care should be exercised in tightening cylinder flange nuts. The specified torque limits apply only when Pratt & Whitney Aircraft wrenches, or wrenches of identical design, are used. See that the cylinder flange nut wrench, the extension, and the torque indicating handle are so assembled that the handle is directly opposite the box end of the wrench, and apply torque by rotating the assembly as a unit. Do not let the shaft of the wrench twist to one side.

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

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

(2) Loosing of the core insulator and loss of pressure seal.

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

(4) Breakage upon removal.

(5) Stretched core threads.

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

USE OF TORQUE WRENCHES WITH EXTENSIONS OR ADAPTERS.

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

T = Desired torque on the part.

E = Effective length of special extension or adapter.

L = Effective length of torque wrench.

R = Reading on scale or dial of torque wrench.

A = Distance through which force is applied to part.

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

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

$$\text{Then: } R = \frac{LT}{L+E} = \frac{15 \times 1440}{15+3} = 120$$

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

GENERAL RECOMMENDATIONS

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

NUTS, BOLTS, AND SCREWS

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

STEEL PIPE PLUGS IN ALUMINUM AND MAGNESIUM CASES

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

PLAIN NECKED

STANDARD STUDS

Thread Size	Torque Limits		
	Minimum	Maximum	
	Plain and Necked	Plain	Necked
8-32-36	10	30	30
10-24-32	15	45	40
12-24-28	20	75	65
1/4-20-28	40	105	95
5/16-18-24	85	230	210
3/8-16-24	160	425	375
7/16-14-20	200	675	600
1/2-13-20	250	1050	950
9/16-12-18	425	1500	1400
5/8-11-18	625	2100	1900
3/4-10-16	1100	3800	3500

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

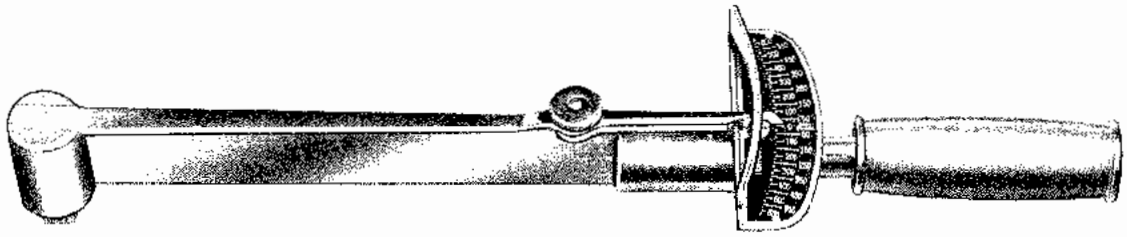
If the torque required to drive a stud to the correct projection length should not come up to the minimum or should exceed the maximum, another stud should be selected.

The general recommendations should be followed with the exceptions included in the following list:

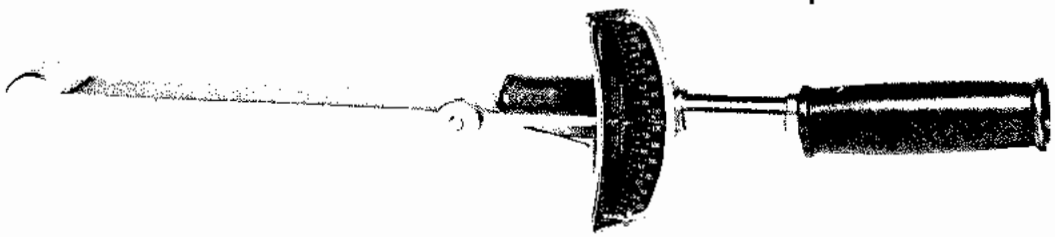
PLAIN NECKED

STEPPED STUDS

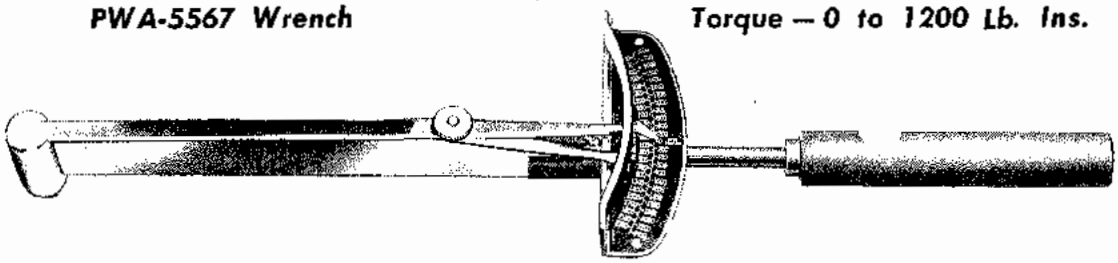
Thread Size (Nut End)	Torque Limits		
	Minimum	Maximum	
	Plain and Necked	Plain	Necked
8-36	10	30	30
10-32	15	50	45
12-28	20	75	65
1/4-28	40	125	115
5/16-24	85	260	240
3/8-24	160	500	450
7/16-20	200	800	700
1/2-20	250	1300	1150
9/16-18	425	1800	1600
5/8-18	625	2600	2400
3/4-16	1100	4600	4200



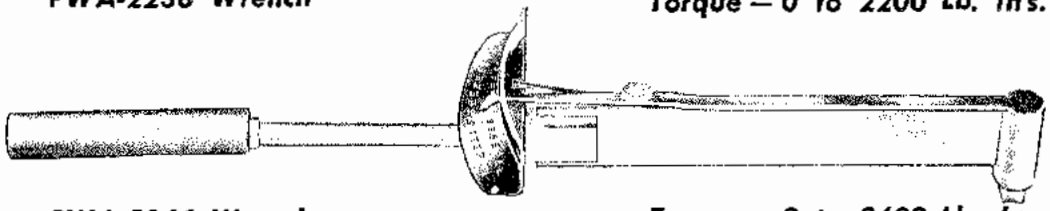
PWA-2239 Wrench ***Torque — 0 to 600 Lb. Ins.***



PWA-5567 Wrench ***Torque — 0 to 1200 Lb. Ins.***



PWA-2238 Wrench ***Torque — 0 to 2200 Lb. Ins.***



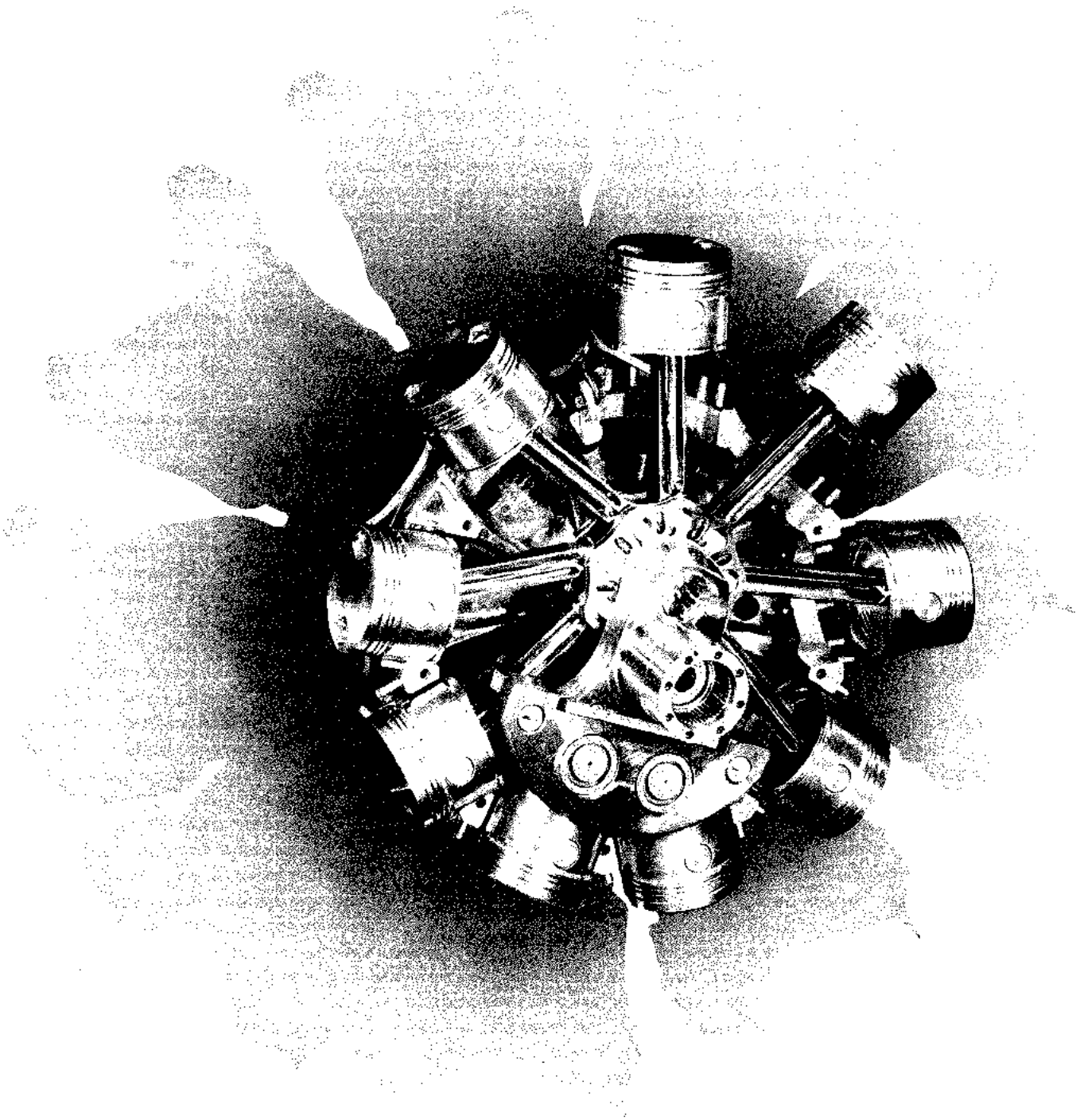
PWA-5266 Wrench ***Torque — 0 to 3600 Lb. Ins.***

SPECIFIC RECOMMENDATIONS

Engine Parts	Torque Limits
CARBURETOR ATTACHING BOLTS	200 to 225
CLUTCH SELECTOR VALVE SHAFT NUT	70 Max.
CYLINDER FLANGE NUTS	Using standard engine oil (Grade 1100) as a lubricant, tighten the complete set of nuts to 575 pound-inches. One at a time, loosen each nut to zero pound-inches and retighten to 575 pound-inches. The angle of turn required to tighten the nut from 50 pound-inches to 575 pound-inches must not exceed 90 degrees on either tightening. ***To provide a surface which will ensure uniform load distribution under the cylinder flange nuts, it is important that the spot faced area around the stud holes in the cylinder flanges be smooth and free from metal spray or other foreign material.***
DEHYDRATOR PLUGS ¾ inch and 1 inch diameter thread sparkplug	 35 to 45 20 to 25
EXHAUST PIPE REAR FLANGE STUD	100
EXHAUST PIPE VEE CLAMP BOLT NUTS	35 to 50
EXHAUST PORT STUDS (7/16-14 THREAD)	200 Min.
FUEL FEED VALVE DIAPHRAGM AND COVER RETAINING SCREWS	Tighten to 24-26 pound-inches minimum and allow to set for 10 minutes; then retighten to 24-26 pound-inches.
FUEL FEED VALVE DIAPHRAGM RETAINING NUT	Tighten to 10-15 pound-inches and allow to set for 10 minutes; then retighten to 10-15 pound-inches.

SPECIFIC RECOMMENDATIONS (Con't)

INTAKE PIPE VEE CLAMP BOLT NUTS	25 to 35
OIL PRESSURE RELIEF VALVE SEAT	250 to 300
PROPELLER SHAFT THRUST BEARING COVER NUTS	200 to 250
PROPELLER SHAFT THRUST NUT	Tighten to 250 pound/feet; then turn thru an angle of 8° to 11°.
PUSHROD COVER CONNECTOR (IN CYLINDER)	Select to obtain 300 min. driving torque.
PUSHROD COVER NUTS	125 to 150
REDUCTION GEAR SPANNER NUT	Tighten to 250 pound-feet. Then turn nut an additional 35 to 40 degrees.
REAR CASE ATTACHING NUTS Long Studs	Tighten nuts to approx. 50 pounds-inches. Then finish tightening by turning each nut an additional 180 to 240 degrees.
Short Studs	The short stud in the intermediate rear case at the bottom of the oil scavenge passage and the short stud in the bottom of the rear case in front of the pressure oil strainer should be tightened to 150 to 175 pounds-inches.
REAR SECTION SCAVENGE OIL STRAINER AND PLUG ASSEMBLY	300 to 400
ROCKER SHAFT NUTS	200 to 250
ROCKERBOX COVER NUTS	60 to 75
SPARKPLUGS	300 to 360
SPARKPLUG LEAD NUTS	Fingertight; then tighten an additional 15°.
STARTER JAW NUT	325 to 375
VALVE ADJUSTING SCREW LOCKNUTS	300 to 350



PRATT & WHITNEY AIRCRAFT

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DEPENDABLE ENGINES

PRESERVING THE ENGINE

INDEX

PRESERVING THE ENGINE

The corrosion preventive mixture referred to in the following instructions is composed of three parts engine lubrication oil and one part Rust Ban 606, or equivalent. Heating the corrosion preventive mixture to a temperature of 220°F to 250°F (104°C to 121°C) is desirable to eliminate moisture from the mixture and to facilitate application.

Proper engine preservation is of the utmost importance. The loss of flying hours due to corrosion will be eliminated, if idle engines are properly preserved.

ENGINE INACTIVE FROM ONE TO SEVEN DAYS

When it is definitely known that the airplane will be idle for more than one day, but not more than seven days, the engine should be operated every second day at 1000 rpm for 15 minutes or until the oil temperature reaches 65°C (149°F).

ENGINES INACTIVE OVER SEVEN DAYS

PARTS	PROCEDURE	INSTALLED 7 to 30 days	INSTALLED 30 days or more	Not installed in aircraft
Engine Cleaning	Before washing the engine look for oil leaks which may indicate loose connections, packing, or nuts. Wash the engine externally with kerosene or cleaning solvent removing all oil, grease, and dirt.			✓
Preliminary Preservation	**METHOD REQUIRING AUXILIARY TANK** Drain the oil from the engine, the oil cooler, and from the oil tank. Reinstall the oil drain plugs, and fill the oil tank with enough corrosion preventive mixture to insure lubrication during the preservative run.		✓	✓

PARTS	PROCEDURE	INSTALLED 7 to 30 days	INSTALLED 30 days or more	Not installed in aircraft
Preliminary Preservation (Con't.)	Blank off or by-pass the oil cooler so as to produce an outlet oil temperature of 203°F to 215°F (95°C to 102°C). Run the engine, using the service fuel specified for the engine, for at least 15 minutes at idling speeds, using the corrosion preventive mixture as a lubricant. At the end of the run, open the throttle sufficiently to insure operation of the scavenge pump and rotation of the propeller shaft through four cycles of operation for each cylinder after the mixture control is moved to Idle Cut-Off. At this speed, inject atomized engine corrosion preventive compound, maintained at 200°F to 250°F (93°C to 121°C), into the induction system at a rate of approximately 30 gallons per hour. Use an appropriate opening such as a mixture thermometer opening or the carburetor. If injection is made through the carburetor, care must be exercised to prevent clogging of the impact tubes. If the engine stops, injection must be stopped immediately. Continue injection until the engine smokes from all of the cylinder exhausts. Some engines must be tested with the exhaust system installed. Determine on an engine with an exhaust header removed at what time smoking at the cylinder exhaust occurs after injection has begun; then use the period so established to govern the duration of injection for such engines. Stop the engine. If the mixture cannot be introduced through the induction system, spray the cylinder bores within 2 hours after shut-down. See "Cylinder Treatment" on page 222. **METHOD NOT REQUIRING AUXILIARY TANK** The following method affords the use of the same preservative compound contained in the engine oil system during the preservation run and thus eliminates the need of a supplementary tank, and heating system, for preserving the induction system. This procedure is satisfactory provided the temperature loss in the approximately 20 feet of line is not so great as to result in the injected compound being below 203°F (95°C). For am-			

PARTS	PROCEDURE	INSTALLED 7 to 30 days	INSTALLED 30 days or more	Not installed in aircraft
Preliminary Preservation (Con't.)	bient temperatures below 45°F, this fact must be established by test. Quantity of compound injected is preferably controlled by injecting measured quantities of the material. If equipment is not at hand for injecting measured quantities of compound, the time required to inject the preferred quantity can be determined by spraying into a graduated container and the time so determined can be used for control purposes. Drain the oil from the engine and from the oil tank. Reinstall the oil drain plugs and fill the oil tank with enough corrosion preventive mixture to insure adequate lubrication during the preservation run plus the quantity needed to preserve the induction system. Prepare the engine for preservation of the induction system as follows: Join together two separate lengths of number 6 hydraulic hose by means of a suitable two-way valve. Remove the oil strainer cover drain plug and install a suitable adapter in the drain plug hole. Install a 45° elbow (.125-27 NPT) in an appropriate opening in the supercharger case (such as the alternate manifold pressure gage connection). If desired, the control valve may be located in the cockpit and be manipulated by the operator or his assistant. Make sure that the control valve is in the closed position. Block off or by-pass the oil cooler to produce a minimum oil inlet temperature of 203°F (95°C) during the preservation run. Start the engine and then continue to run (on normal service fuel) at idling speed for at least 15 minutes, using the corrosion preventive mixture as a lubricant. At the end of the run, open the throttle to attain a speed of 1600 rpm or to the rpm required to insure propeller rotation of approximately 30 revolutions after the mixture control is moved to idle cut-off. With the throttle advanced as described, and with the oil temperature at no less than 95°C (203°F), open the control valve to allow the engine preservation mixture to be intro-			

PARTS	PROCEDURE	INSTALLED 7 to 30 days	INSTALLED 30 days or more	Not installed in aircraft
Preliminary Preservation (Con't.)	duced into the induction system. Caution should be exercised when operating the control valve to prevent hydraulicking. (If desired, injection may be made through carburetor if care is exercised to avoid clogging the impact tubes.) When the exhaust stacks are smoking profusely, move the mixture control to idle cut-off position to stop the engine. After the engine has stopped, close the control valve within 5 seconds. For engine types which must be tested with exhaust system installed, the period of injection shall be established by trials on an engine with an exhaust header removed to determine at what time smoking at the cylinder exhaust occurs after injection has begun. The time period so established shall then govern the duration of injection for such engines. ***The following operations must be completed not later than four hours after the preservation run. If it is impossible to accomplish this work within the four hour period, spray the cylinders, seal the exhaust ports or stacks, and close the sparkplug openings temporarily with dehydrator plugs. If time does not permit these minimum requirements, the entire preservation run and compound injection should be repeated prior to removal of the engine from the airplane. Engine should not be allowed to remain in this category for longer than three days.***			
Mixture Drainage	Remove the propeller; then remove the engine from the airplane. Install the engine in a suitable engine build-up stand or PWA-1785 Engine Stand. While the mixture is still warm, allow the corrosion preventive mixture to drain from the engine. Remove the pressure and scavenge oil strainer. Clean the strainers, using a suitable cleaning solvent and blow dry with an air jet. Immerse the strainers in corrosion preventive mixture and allow to drain.		✓	✓

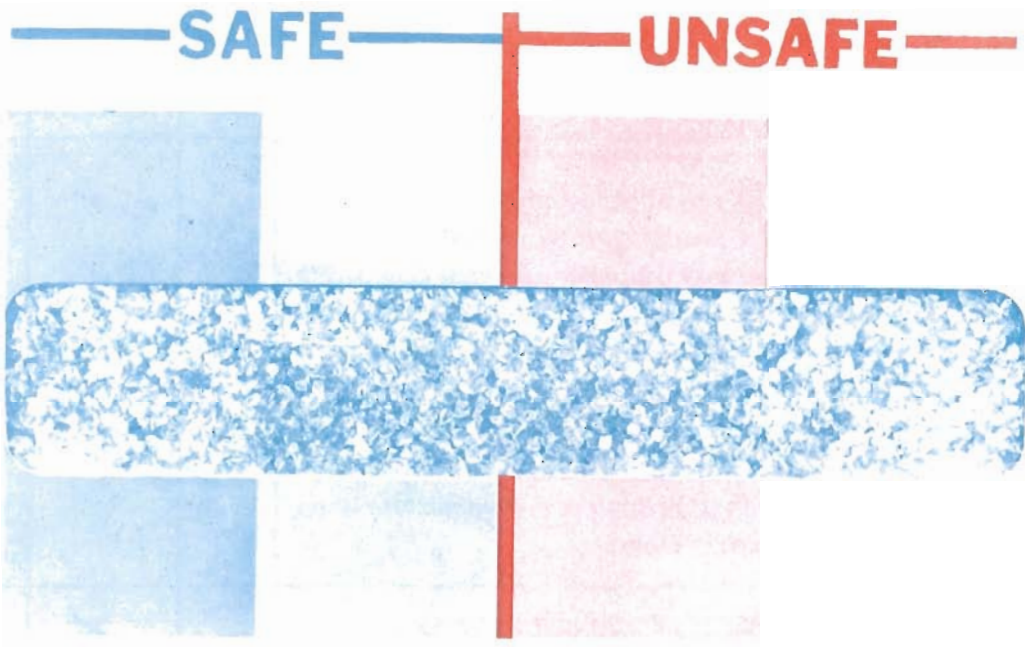
PARTS	PROCEDURE	INSTALLED 7 to 30 days	INSTALLED 30 days or more	Not installed in aircraft
	After the engine has drained, reinstall the strainers and all drain plugs. During the draining operation or as soon as practicable, remove the accessories and other equipment that is to be shipped or stored with the engine.			
Exhaust Valves	Thoroughly spray each exhaust valve with corrosion preventive mixture through the sparkplug holes or the exhaust ports. Be sure each exhaust valve is fully open when it is being sprayed. Use only dry air to operate the spray gun. Rotate the propeller shaft at least four revolutions in the normal direction of rotation to work the mixture into the exhaust valve guides. Install exhaust port covers.	✓	✓	✓
Rockerboxes	It will not be necessary to remove the rockerbox covers and spray the rockers if the engine was preserved at specified oil temperatures. Engines preserved under low temperature or if the alternate method of treating cylinder bores is used, must have the rockerbox covers removed and the rockers, valve springs, washers, and valves sprayed with corrosion preventive mixture.	✓	✓	✓
Sparkplugs	Disconnect the sparkplug leads and remove sparkplugs. Install protector caps on the sparkplug lead connectors. Clean the sparkplugs in Stoddard Solvent and dry them with compressed air. Coat the sparkplug threads with a light oil or suitable rust inhibitor and store them in a dry place. Install protector caps on both ends of the plugs if special cylindrical protective cartons are not available. Place the plugs in a suitable container to be shipped with the engine.	✓	✓	✓
Sparkplug Leads	Wipe each sparkplug lead terminal sleeve clean and dry with Stoddard Solvent or equivalent and dry with a clean, lint-free cloth. Insert a small amount of insulating compound, Dow Corning No. 4, in the terminal lead protector and carefully	✓	✓	✓

PARTS	PROCEDURE	INSTALLED 7 to 30 days	INSTALLED 30 days or more	Not installed in aircraft
	assemble the protector on the terminal sleeve. Wipe off excess compound and snap the protector onto the nipple provided on the end of the dehydrator plug. ***Use only Stoddard Solvent or equivalent. Never use chlorinated solvents, alcohol, or acetone.***			
Dehydrator Plugs	Install dehydrator plugs in the sparkplug holes of all cylinders and tighten them to the recommended torque. Do not remove the moisture seals from the plugs until ready to install. Install a dehydrator plug in the front case.	✔	✔	✔
Thrust Bearing	Remove any parts of the installation that prevent access to the thrust bearing cover. Take out the ⅛ inch plug in the recess at the top of the cover. Insert the nozzle of the spray gun in the hole where the plug was removed and spray enough corrosive preventive mixture to cover the thrust bearing thoroughly. Reinstall the plug.		✔	✔
Cylinder Treatment	With the piston at the bottom of its intake stroke, spray hot, 210°F to 220°F (99°C to 104°C), corrosion preventive mixture into the front sparkplug hole of each cylinder and in the same sequence as the firing order. This spray should be deposited on the inlet valves and the cylinder walls. Rotate the propeller shaft at least six revolutions to insure pistonring coverage for each cylinder. Respray each cylinder without turning the propeller shaft to cover the cylinder walls. **Do Not Turn the Propeller Shaft After This Spraying of the Cylinders.** If the shaft is turned the spraying procedure must be repeated. ***Do not apply excessive amounts of material. All that is necessary is a uniform thin coating on all surfaces. Excessive amounts of material do not contribute to the preservation;***	✔	✔	✔

PARTS	PROCEDURE	INSTALLED 7 to 30 days	INSTALLED 30 days or more	Not installed in aircraft
	they cause difficulty at the time of depreservation and increase the chances of hydraulic lock.			
	It is of the utmost importance that personnel entrusted with the cylinder spray operation be properly trained in the techniques required. It is recommended that the operator practice on dummy cylinders until the desired even coat can be applied. The type of spray pattern formed can be observed by spraying into a suitable receptacle. The recommended procedure to be used by the operator is as follows:			
	a. Place the preservation mixture in the reservoir, heat to the correct operating temperature, and mix thoroughly. Premixing and preheating the compound prior to placing it in the reservoir will be a timesaver.			
	b. Close the vessel and connect the gun and all lines.			
	c. Discharge the gun into a clean container until a fine uniform spray is produced at the nozzle. The mixture discharged during this operation should be retained for the final operation.			
	d. Insert the discharge tube of the gun into the cylinder and determine the position of the piston. Use the free hand to mark the distance the gun will travel into the cylinder to come to a point just short of the piston. Withdraw the gun tube until the nozzle is at the sparkplug opening.			
	e. Start spraying. As soon as the trigger is pressed move the gun so that the nozzle will travel slowly from the sparkplug opening to the piston, but without touching the piston head, then back to the sparkplug opening where the trigger should be released immediately.			
	f. Proceed at once to spray each of the remaining cylinders in the same manner. If the spray gun will be idle more than one minute, re-			

PARTS	PROCEDURE	INSTALLED 7 to 30 days	INSTALLED 30 days or more	Not installed in aircraft
	peat step (c) to insure that a slug of cold preservation compound is not ejected and to insure that a fine even spray is obtained.			
Carburetor Opening in the Intermediate Rear Case	When the carburetor is removed from the engine, secure two ½ pound bags of dehydrating agent to the inside of the carburetor mounting flange cover. Secure the cover to the flange, using acid-free waxed paper as a gasket between the cover and the flange. Seal the parting line of the cover and flange with tape.	✓	✓	✓
Fuel Feed Valve and Diaphragm	Remove the fuel feed valve cover and spring. Withdraw the fuel feed valve assembly from the engine and immerse it in slushing oil. Drain the excess oil and reinstall the assembly in the engine; then replace the spring, cover, bolts, and washers. Lockwire the bolts. Where it is not feasible to remove the valve assembly from the engine, flow the slushing oil into the valve via the fuel inlet in sufficient quantity to fill completely the valve passages, using not more than 3½ psi. When the passages are full, remove the fuel line from the fuel inlet. Using a suitable hand pump to which a length of rubber hose is attached, remove excess oil from the valve assembly. Seal the fuel inlet with a suitable plug and secure.			✓
Propeller Shaft	Clean the exposed surfaces of the propeller shaft with dry cleaning solvent, Stoddard Solvent or equivalent; then follow with an application of finger print neutralizer, and dry. Coat the surfaces with soft film corrosion preventive compound. After the compound has set, protect the surfaces by wrapping with a suitable acid-free waxed paper and secure with tape. Install a propeller thread protector. If the hoisting eye is installed, which will be needed to replace the engine in the shipping container, installation of the shipping cap should be delayed until after the engine is secured to the base of the packing box.			✓

PARTS	PROCEDURE	INSTALLED 7 to 30 days	INSTALLED 30 days or more	Not installed in aircraft
Accessories	All accessories not attached to the engine should be treated for proper storage preparation. Slush the fuel pump and propeller governor pump with the specified slushing oil. Drain the excess oil and wrap these accessories in acid-free waxed paper before placing them in a shipping carton.		✓	✓
Accessory Drives	Remove all accessory drive cover plates. Cover the drive ends with corrosion preventive mixture; then reinstall the cover plates.			✓
Openings	Seal all breathers, oil inlet and outlet connections, or any other openings not otherwise covered by plates or covers with moisture-resisting sealing tape. Place dehydrating agent in the exhaust tail pipe.		✓	✓
External Inspection	Inspect the engine carefully, checking all nuts and bolts for tightness. Inspect for loose or broken safety wire, missing plugs, or damaged parts. Make certain that the intake pipes are tight at both ends.		✓	✓
Warning Tag	Place a warning tag on the propeller or the propeller shaft and a similar tag in the airplane cockpit, stating that the propeller or the propeller shaft must not be turned until all dehydrating materials have been removed from the engine.	✓	✓	✓
Inspection	All dehydrator plugs must be inspected every 7 days and the color of the dehydrating agent compared with that on the humidity indicator. Any plugs, indicating a relative humidity of more than 20 percent are unsafe and should be replaced. When it becomes necessary to replace a dehydrator plug, the dehydrating agent in the exhaust tail pipe and in the carburetor air scoop should also be replaced. If frequent replacement of a particular plug becomes necessary, the section of the engine in which that plug is located should be checked for inadequate sealing.	✓	✓	✓



Humidity Indicator

Preserving Carburetor Installed on Engine

Disconnect the carburetor fuel transfer tube from the carburetor and the fuel supply line from its mounting pad. Install a suitable nipple in the carburetor fuel inlet connection. Taking care to keep the slushing oil away from the automatic mixture control and the air chambers of the carburetor, completely fill the carburetor through the fuel inlet with slushing oil. Remove the drain plugs from the bottom of the carburetor and allow the slushing oil to drain. Actuate the throttle and mixture control several times while flushing the carburetor, reinstall the connections and plugs, but leave the fuel transfer tube disconnected. Seal all of the openings in the carburetor and the ends of the fuel lines with suitable plugs.

Preserving Carburetor Not Installed on Engine

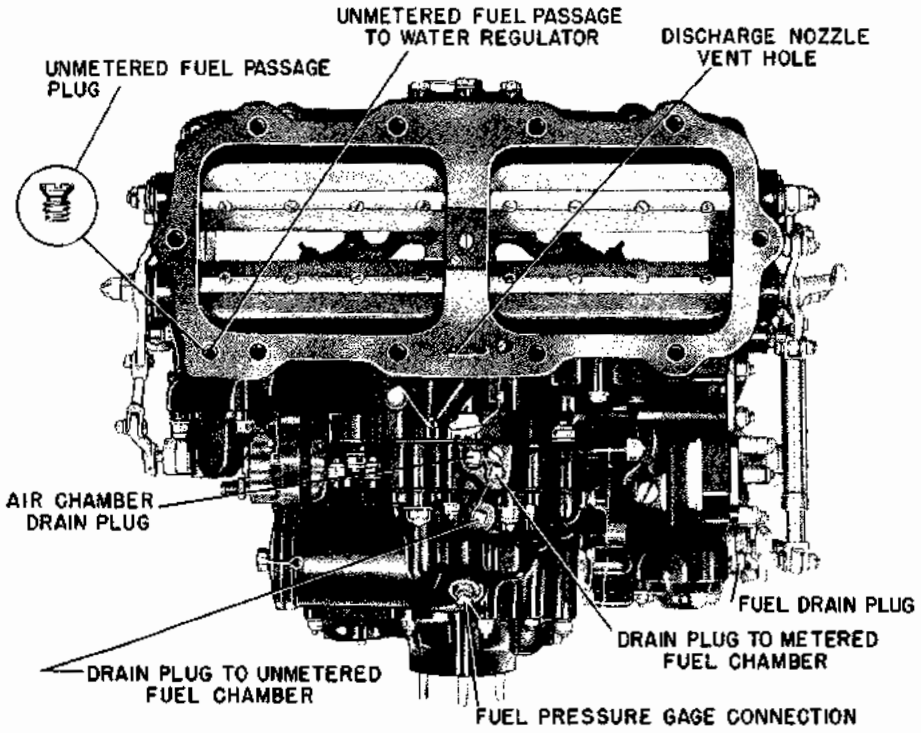
When an injection carburetor is to be out of service for a period exceeding 10 days, prepare it for storage in accordance with one of the methods outlined in the following instructions. Use only unleaded gasoline or naphtha for cleaning.

REGULAR METHOD—Remove the drain plugs from the metered and unmetered fuel chambers. Remove the fuel drain plug from the lower left side of the carburetor adjacent to the knurled idle mixture adjusting nut. The fuel will drain from the carburetor when these plugs are removed. Unscrew the air chamber drain plug and allow any moisture to drain out, replacing this plug immediately so that no slushing oil will get into the air chambers.

When the carburetor has drained thoroughly, replace the three plugs. Remove, inspect, and reinstall the fuel strainer. If there is a plug installed in the vapor vent outlet, remove it at this time.

Place the manual mixture control lever in the auto rich position and the throttle valves in the wide open position.

Connect the oil supply line to the carburetor fuel inlet and inject slushing oil at 10 to



Carburetor Drain Plugs

15 pounds per square inch pressure until oil flows from the fuel outlet. Do not permit the overflow oil to run into the main or boost venturis and the impact tubes, or on the automatic mixture control unit, because the presence of oil on these parts will cause a collection of dust and grime which will tend to alter the contour of the main and boost venturis, clog the impact tubes, and cause a variation in the calibration of the automatic mixture control unit.

Remove the fuel drain plug and the plugs to the metered and unmetered fuel chambers and drain the excess oil.

> ***Slushing oil used in carburetor preservation is continually picking up gasoline. Although the oil can be reused, it should be discarded when the gasoline content reaches 2 percent by volume.***

Replace and lockwire all plugs. Plug the fuel inlet. If the fuel transfer tube from the fuel control unit to the fuel feed valve is not to be left on the carburetor, plug the outlet provided for this tube. Plug the vapor vent line connection and all other openings in the carburetor. Lubricate all joints in the control linkages with slushing oil; then lockwire the throttle valve in the closed position.

If the carburetor is to be shipped over salt water or stored near salt water, spray the exterior surfaces with slushing oil, making sure no oil comes in contact with the main or boost venturis, the impact tubes, or the automatic mixture control unit. Set the carburetor aside and allow the excess oil to drain.

AIR PRESSURE METHOD OF CARBURETOR PRESERVATION — The oil slushing operations may be expedited by applying a definitely controlled air pressure to the air chamber in the regulator front body. This air pressure will open the poppet valve and allow oil to flow freely into the carburetor. This operation should be performed with extreme caution according to the following instructions:

Flush and drain the carburetor as previously described in the regular method; then remove the "A" chamber plug in the top of the regulator front body and install a fitting, having a 5/16-24 thread, a taper seat, and a No. 40 (.098 inch) drilled hole.

Attach an air pressure line to the fitting, with a pressure regulator and a pressure gage incorporated in the air line. Regulate the air pressure so that it will not exceed 20 pounds per square inch.

It is extremely important that the air pressure applied to the regular air chamber does not exceed 20 pounds per square inch. Any increase in this pressure could cause damage to the large air diaphragm or reverse the small balance diaphragm, both of which are in this chamber of the regulator.

When the oil line and the air line are connected to the carburetor, turn on the oil pressure; then turn on the air pressure. Let the oil flow into the carburetor until it comes out the fuel inlet in the fuel control unit. Turn off the air pressure first; then turn off the oil pressure.

Replace and lockwire all plugs. Plug the fuel inlet. If the fuel transfer tube from the fuel control unit to the fuel feed valve is not to be left on the carburetor, plug the outlet provided for this tube. Plug the vapor vent line connection and all other openings in the carburetor. Lubricate all joints in the control linkages with the slushing oil; then lockwire the throttle valves in the closed position.

If the carburetor is to be shipped over salt water or stored near salt water, spray the exterior surfaces with slushing oil, again making sure that no oil comes in contact with the main or boost venturi surfaces, the impact tubes, or the automatic mixture control unit. Set the carburetor aside and allow the excess oil to drain.

Water Control Unit

Complete instructions in preserving the water control unit are incorporated in the Appendix of this publication entitled "Water Injection Operation and Service."

Preservation of Engines Removed from Service Because of Mechanical Difficulty

Engines which are inoperative because of mechanical difficulty should be preserved as directed in the preceding chart under "Engines Not Installed." However, to prevent further engine damage in cases of suspected or determined engine failure, "Preliminary Preservation" should be accomplished without engine run-up as follows:

With the engine in flight position, drain the oil from the engine. Connect a line from a preoiling pump or some other pressure source to the oil pressure gage connection. Pump corrosion preventive mixture into the engine at 45 to 65 pounds per square inch pressure until clean fluid flows from the oil sump drain plug hole. Remove one cylinder and spray the cylinder barrel and all the internal parts of the power section with the corrosion preventive mixture. Spray the cylinder that was removed and reinstall it. Carefully inspect all exterior surfaces of the engine, and seal all openings with plugs or moisture resistant sealing tape.

Preservation of Engines Subjected to Salt Water Immersion

Engines which have been removed from salt water should be cleaned with steam or fresh hot water as soon as possible after recovery. Disassemble the engine at least as far as removal of all the cylinders. Clean and

preserve the crankshaft, crankcase and cam reduction gearing through the cylinder pad holes. Clean miscellaneous parts, sub-assemblies, and accessories with steam or hot water. If an oven is available, bake parts at approximately 200°F until thoroughly dry. After parts are dry, coat them with grease or corrosion preventive mixture. Reassemble the engine, utilizing any part which will assist in sealing the engine as completely as possible. Wrap the remaining parts and accessories in acid-free waxed paper and pack in an appropriate box.

Procedure for Determination of Severity of Corrosion

The following procedure may be followed to determine whether a reciprocating engine is corroded and, if so, to what degree:

Inspect the condition of the exterior of the engine, paying particular attention to the propeller shaft. For other than the propeller shaft external corrosion should not be classified as serious unless it was occurring in a highly stressed area and, in the opinion of the inspector, there is indication of incipient failure of studs, bolts, fastenings, or of perforation of major parts. External corrosion of cylinder fins or sections thereof. Corrosion of such parts would be classified moderate if it could be removed without overhaul or minor repair, or without replacement of a cylinder. All other corrosion would be considered slight. On propeller shafts there is no such thing as slight corrosion. The corrosion is moderate if it is a light surface rust which can be removed by rubbing with crocus cloth without leaving pits in the lands, fillets, or sides of the individual splines. Corrosion of the propeller shaft is considered serious if there is a concentration of pits immediately in front of the thrust nut or if there are pits in the lands, fillets, and sides of the individual splines.

Inspect the cylinders through the sparkplug holes for continuity of coating. If the coating is continuous, it may normally be assumed that the cylinder is free of corrosion. If, however, there is reason to suspect the engine regardless of the continuity of coating because of incomplete history or because of the general condition of the exterior of the engine, then a minimum of one cylinder from each row should be removed and the internal condition of the cylinder and of the power section of the engine observed.

Inspect the internal surfaces of the cylinder for evidence of corrosion. If corrosion is found to be present, rotate the engine by hand in such a manner that each piston moves through its full stroke at least six times and reinspect the cylinders. If any evidence of corrosion remains, the corrosion is at least moderate and the engine shall be handled accordingly. If all corrosion is removed by this process, the corrosion can be considered as slight. If surface rust is removed and scattered pits remain, the corrosion can be considered as moderate. If the surface corrosion cannot be removed by this process or if relatively deep pitting remains and is concentrated in an area of approximately one square inch or in a band equal to or greater in length than one and one half inches, the corrosion is to be considered as serious and the engine should be sent to overhaul.

If the pits are such as not to be readily classifiable by inspection through the sparkplug opening, remove at least one cylinder from each row. Remove all corrosion preventive compound from the internal surfaces of the cylinder by wiping and washing with dry cleaning solvent, Stoddard Solvent or equivalent, and briskly rub rusty surfaces with crocus cloth. Inspect the pits for depth and concentration and classify the engine in accordance with the criteria given above.

While the cylinder is removed, inspect the steel parts in the power section for the presence of corrosion. If corrosion is found, briskly rub with crocus cloth. If all evidence of

corrosion is removed, the corrosion is then slight. If pits are left on the rods, the corrosion is moderate or serious depending upon the standards for acceptence or rejection of rods at overhaul.

Inspection of Engine in Storage

The humidity indicator is a color chart with dehydrating agent which is viewed through a window in the center of the indicator. The color chart shows the safe and unsafe color ranges of the dehydrating agent. This agent is a deep blue when dry, ranging to a lighter blue and into a pink as it becomes moist. When the relative humidity exceeds 20 percent, the dehydrating agent assumes an unsafe color as shown on the color chart. If the humidity indicator registers unsafe, represerve the engine.

Represerving the Engine

At inspection, when the color of the crystals of the dehydrating agent contained in the humidity indicator indicates a humidity greater than 20 percent, use the following procedure to represerve the engine:

Unfasten the five turnbuckles, remove the metal straps, and attach a sling to the lifting ring on the cover. Raise the cover carefully so that the carburetor and other accessories fastened inside will not be damaged. Lift the four sides out of the base.

Cut off the engine envelope seal and carefully roll the envelope down to the top of the support cone.

Remove all of the bags of dehydrating agent and all dehydrator plugs, indicating an unsafe color and any bags of dehydrating agent in the induction system or the exhaust manifolds of the cylinders affected. Remove the humidity indicator.

Cylinders on which dehydrator plugs indicate a greater humidity than 20 percent should be inspected through the sparkplug holes. If a band of corrosion is observed at the top of the cylinder barrel, remove one cylinder and inspect for further corrosion. Remove the rust and respray. If significant corrosion is present other than in a band at the top of the cylinder, or if there is corrosion in the power section, turn in the engine for overhaul.

Attach fresh bags of dehydrating agent to the cylinders and install new dehydrator plugs in the open sparkplug holes. Secure new bags of dehydrating agent in the induction system and exhaust manifold in place of those removed.

If the crepe paper around the cylinders was removed, replace it after attaching a new humidity indicator in place on No. 1 cylinder.

Roll up the envelope, clean the open edges, and seal them with a heat-sealing iron along the top. Gather the envelope and fasten it around the propeller shaft.

PACKING THE ENGINE

INDEX

After the engine has been prepared for storage or shipment, it should be packed in the packing case. The use of the protective envelope eliminates the need for covering the outside metal parts with a protective coating of grease or other anti-corrosive compounds. At low temperatures, the protective envelopes tend to become stiff, thereby becoming more vulnerable to rupture and presenting difficulties in handling. This condition can be overcome if the envelopes are handled in a room where the temperature is maintained at 20°C (68°F) or higher. Use two pounds of dehydrating agent for each cylinder.

With the engine in a vertical position in the engine stand, install PWA-2736 Lifting Eye on the propeller shaft and insert the hook of a chain hoist (minimum capacity 2 tons) in the eye. Remove the nuts, washers, and bolts which hold the engine in the stand. Lift the engine from the stand.

Remove the engine mounting brackets and install the shipping brackets. A strip of tape may be placed around the fireseal diaphragm to prevent injury of hands on its sharp edge.

Lift the pliofilm envelope up over the bottom of the engine, and fit the holes on the envelope over the studs in the shipping brackets. Gather the envelope in at the bottom with a strip of tape.

Install the shipping ring with its spacers and bolts and tighten the bolts.

Place the support cone on the packing case base, lining up the holes in the cone with the studs in the base; then secure the support cone to the base with the washers and nuts. Carefully lower the engine on to the support cone, lining up the holes in the shipping ring with the studs in the cone. Fasten the shipping ring to the cone with nuts and washers.

Cover with tape any protruding nuts, studs, or lockwire which might damage the protective envelope.

Fasten two 1 pound bags of dehydrating agent to each cylinder. Attach the humidity indicator to No. 10 cylinder, wrap crepe paper around the power section, and make a cut-out for the humidity indicator. Also place a crepe paper cover over the propeller shaft and make sure it covers everything up to the power section. Coat the propeller shaft with soft, film corrosion preventive compound and wrap the splines on the propeller shaft with paper. Carefully bring the protective envelope up around the engine. Install the spacer, place the envelope reinforced opening over the propeller shaft, and screw the spanner nut tight against the envelope. Install the protector cap, and seal the protective envelope, first withdrawing as much air as possible without shrinking the envelope tight against the engine. Fasten the excess envelope material around the propeller shaft.

A vacuum cleaner with a suitable attachment provides an excellent method of with drawing air from the envelope. The sealing iron should be heated to a temperature of 329°F to 348°F (165°C to 175°C). During the sealing process, the edges being sealed should be backed with a board to which has been fastened a piece of blotting paper, soft cardboard, or a similar yielding material; hard backing would permit a hot iron to burn

through the envelope. A good seal is transparent. If the seal does not appear to be good, run the iron over it until the seal is transparent.

Packing Carburetor — Pack the carburetor in its original carton with the moisture-resistant protective envelope . Attach the carburetor warning tag, advising that it has been completely slushed with preserving oil. Attach a 1 pound bag of dehydrating agent to the carburetor. Expel as much trapped air as possible before sealing the envelope. With the sealing iron, seal the edges of the envelope carefully and close the flaps of the carton. Secure the carburetor packing carton to the engine packing case cover with steel straps.

If a carton is not available, remove the wooden support plate from the packing case cover and attach the carburetor to the plate; then bolt the plate to the cover.

Packing Miscellaneous Parts — All accessories such as sparkplugs, tubes, carburetor screens, and miscellaneous small parts which are detached from the engine for shipment, should be packed in a single container with a protective envelope lining. Include a half-pound bag of dehydrating agent in the envelope. Expel as much air as possible from the envelope and then fold the edges and seal tightly with the sealing iron. Close the cover of the carton and fasten the carton securely to the packing case cover with steel straps. If desired, the carton may be shipped separately from the engine packing case.

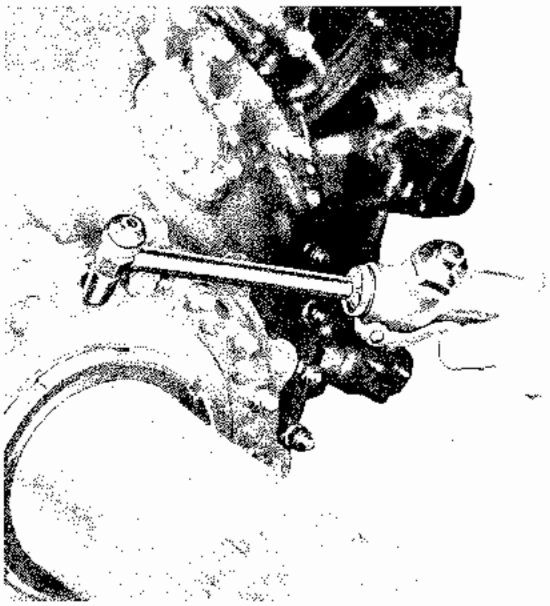
Tubes which are too long to be packed in the accessory carton should be thoroughly coated with corrosion preventive mixture, wrapped in waxed paper and held inside the packing case cover, there attached with cotton strips.

Securing the Packing Case for Shipment — Install the four side panels of the engine packing case in the base, taking care to see that the panel with the inspection slot is located so that the humidity indicator on the number 10 cylinder is visible through the inspection port. Lower the packing case cover into position on the case so that the carburetor shipping carton will not interfere with the magneto. The cover fits snugly, and it may be necessary to use a rubber mallet to force it in place. Make certain the cover is firmly seated.

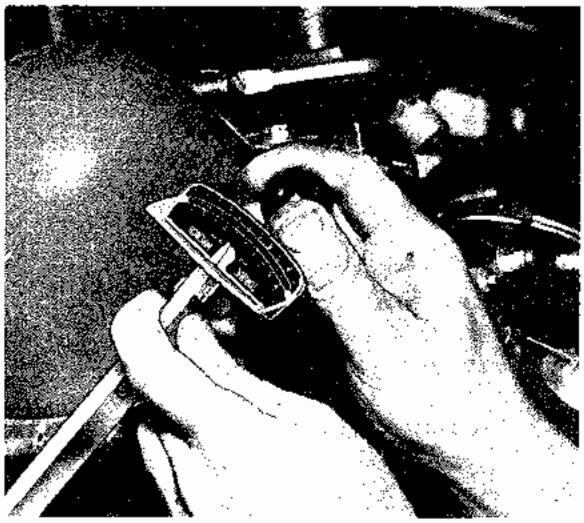
Secure four metal straps with turnbuckles around the case vertically so that each fits in the corner protector grooves. Install another strap around the case horizontally. Wire the cover of the humidity indicator inspection slot securely.

Weight and Dimensions — The overall dimensions of the packing case are: 58 by 58 by 88-7/16 inches. The approximate weight of the packing case with the engine is 3347 pounds.

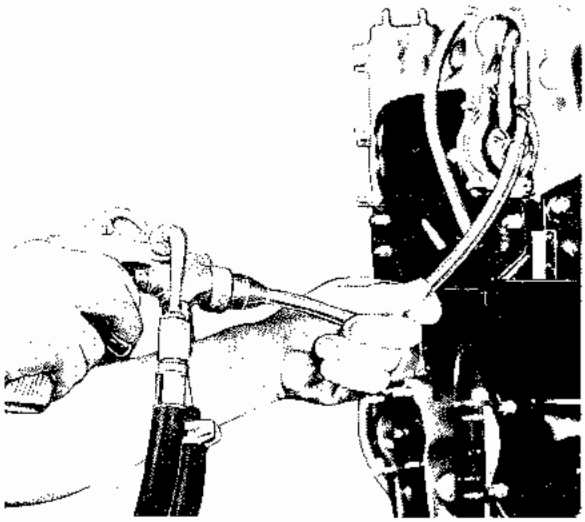
Removing Dehydrator Plug Cap [1]



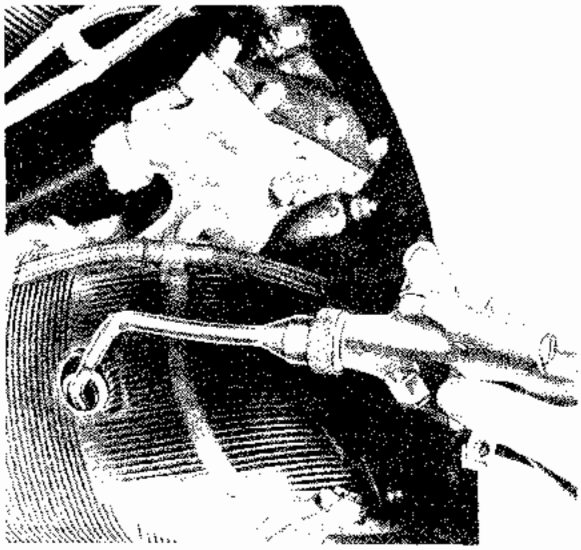
Spraying Thrust Bearing [4]



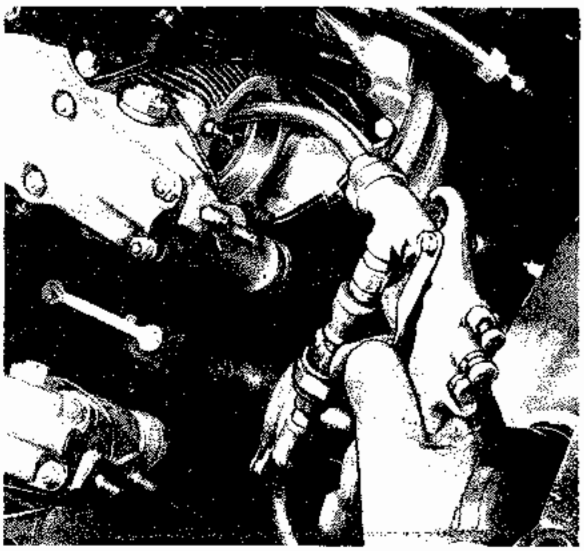
Torquing Dehydrator Plug [2]



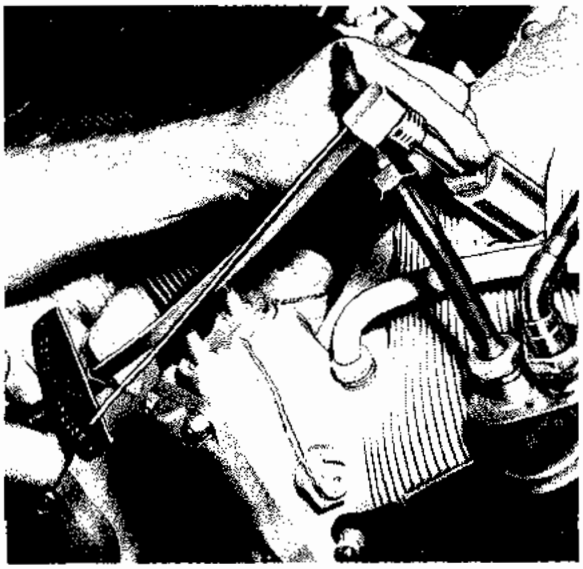
Spraying Rockerbox [5]



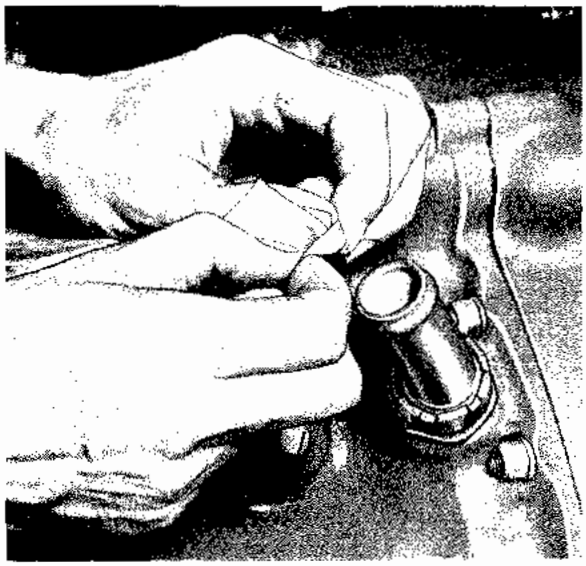
Spraying Cylinder [3]



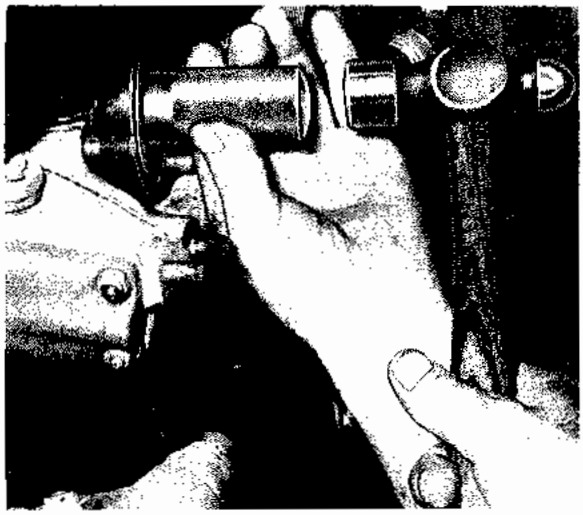
Spraying Exhaust Port [6]



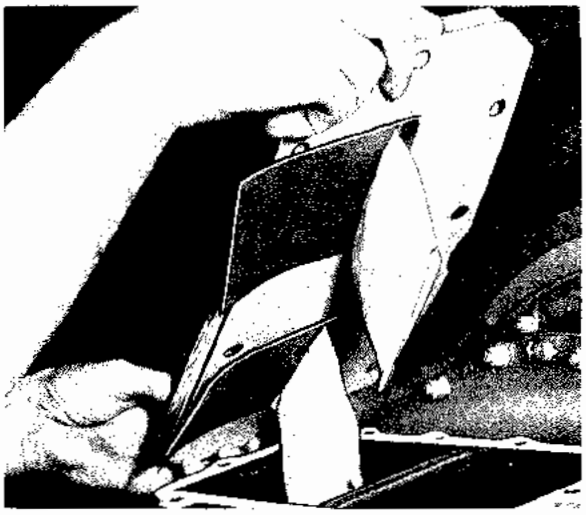
Torquing Dehydrator Plug [7]



Installing Breather Cover [10]

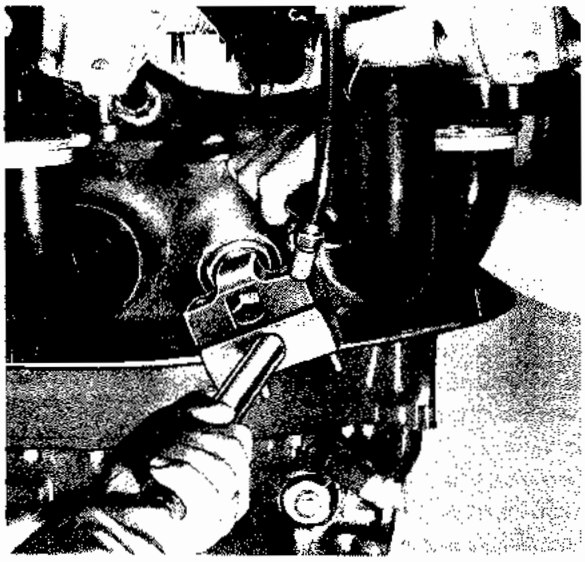


Installing Exhaust Port Cover [8]

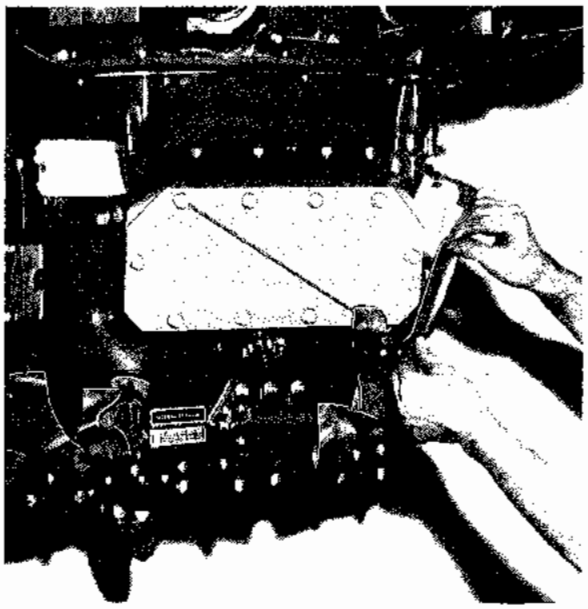


Installing Dehydrating Agent [11]

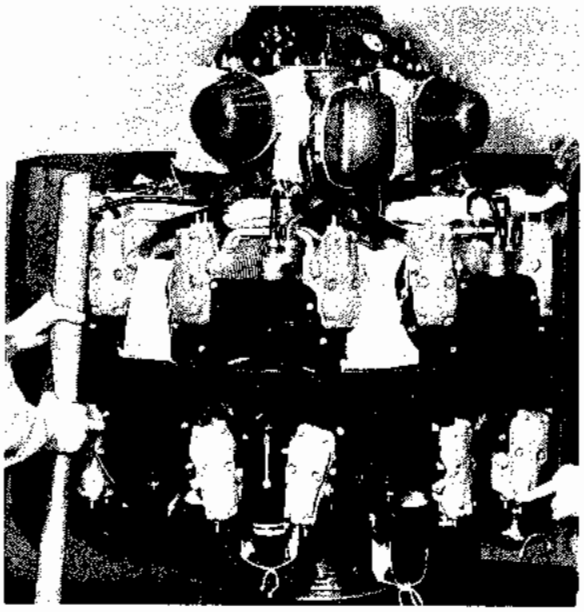
Installing Lead Protector Cap [9]



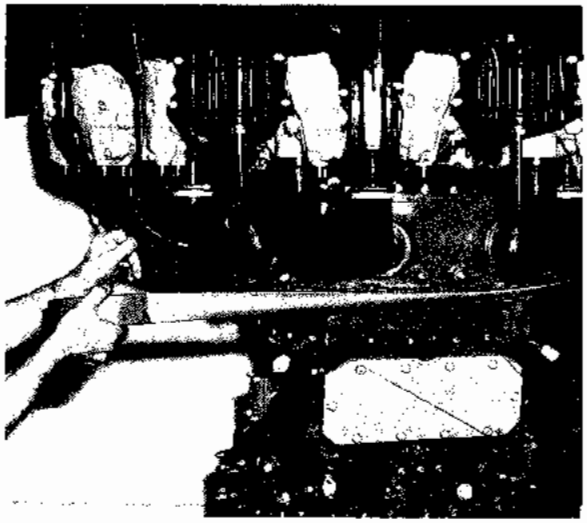
Removing Engine Stand Bracket [12]



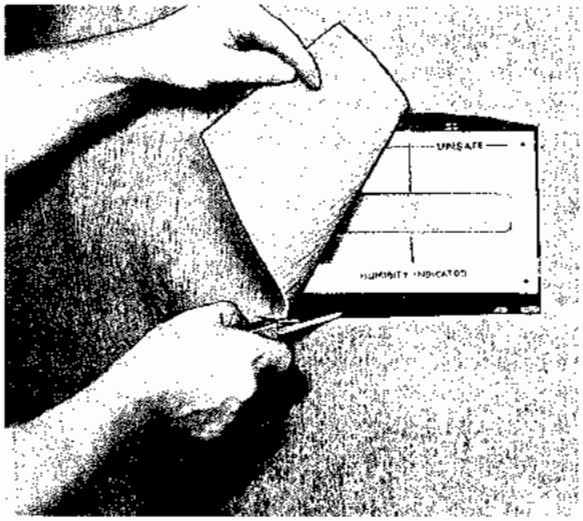
Covering Protruding Objects with Tape [13]



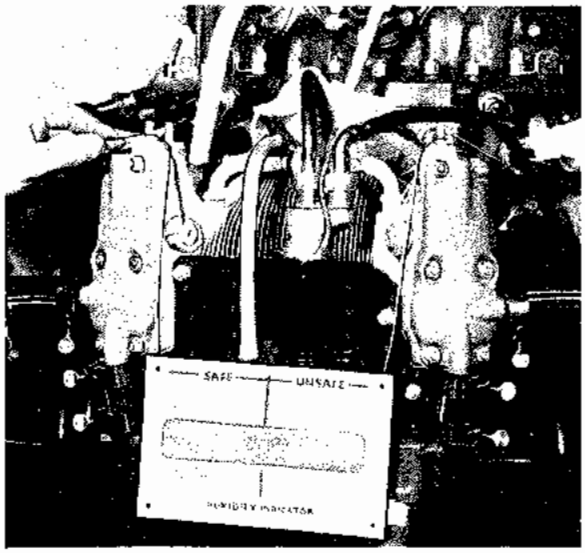
Attaching Creap Paper [16]



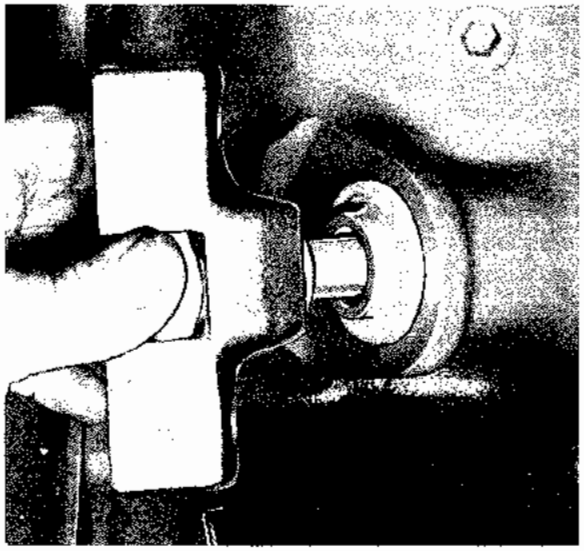
Applying Tape to Diaphragm [14]



Indicator Cut-out [17]



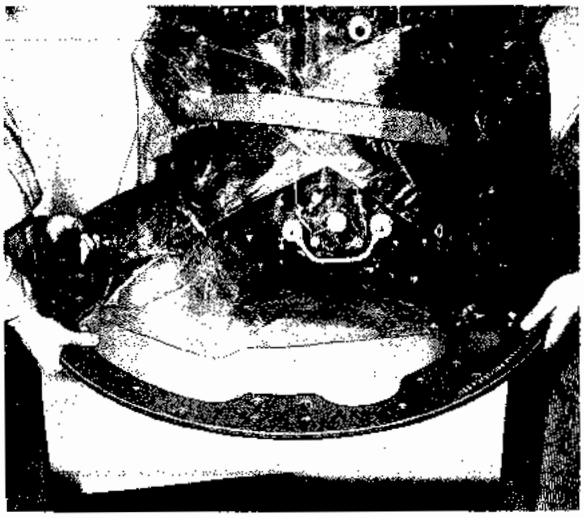
Installing Humidity Indicator [15]



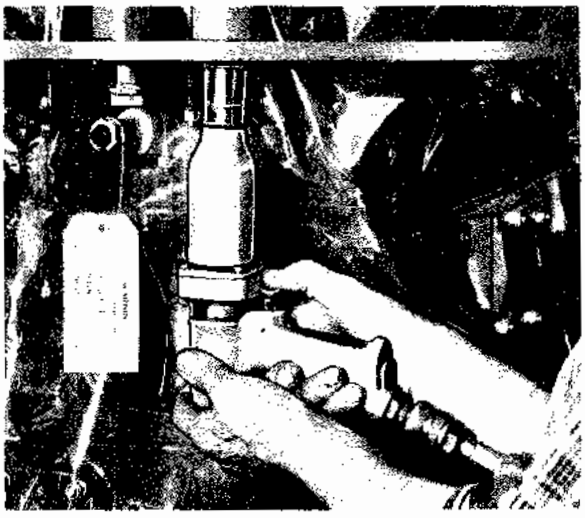
Installing Shipping Bracket [18]

Installing Protective Envelope [19]

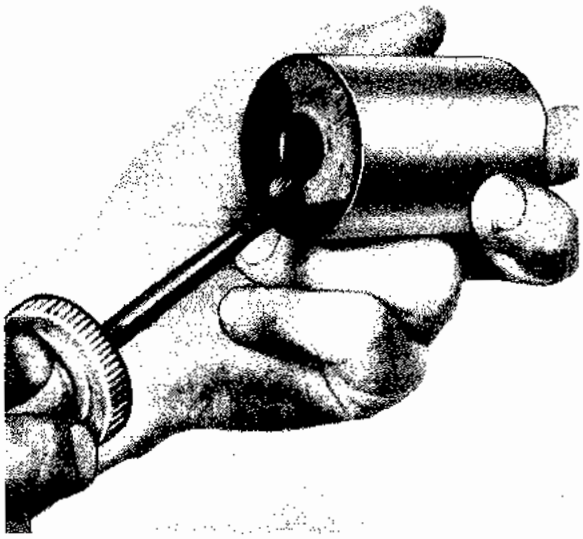
Installing Spacer [22]



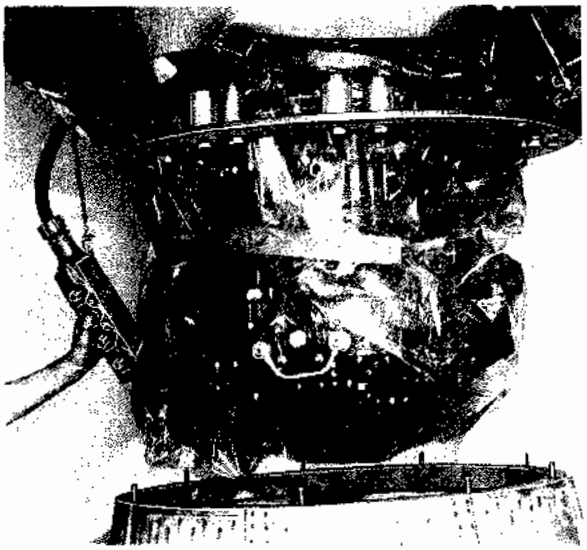
Installing Shipping Ring [20]



Tightening Shipping Ring [23]



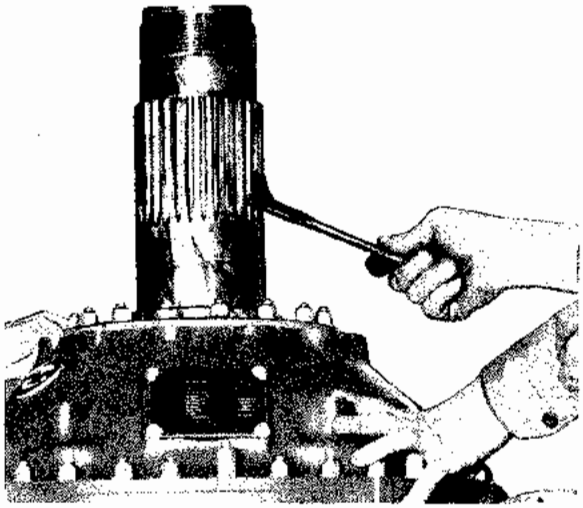
Applying Sealing Compound [21]



Lowering Engine into Cone [24]

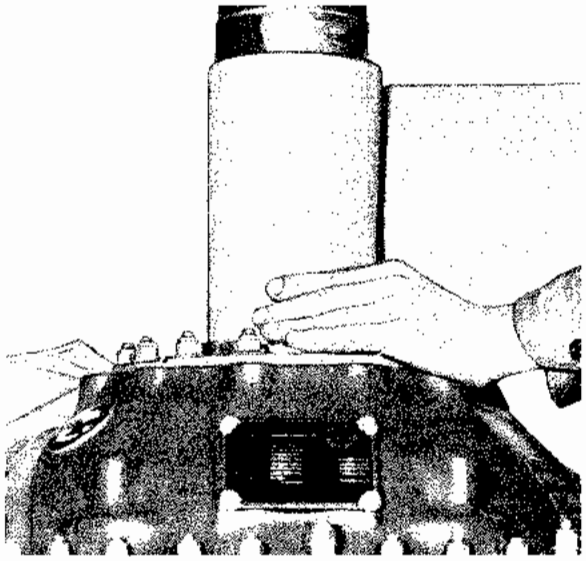
Securing Mounting Plate [25]

Installing Spacer [28]

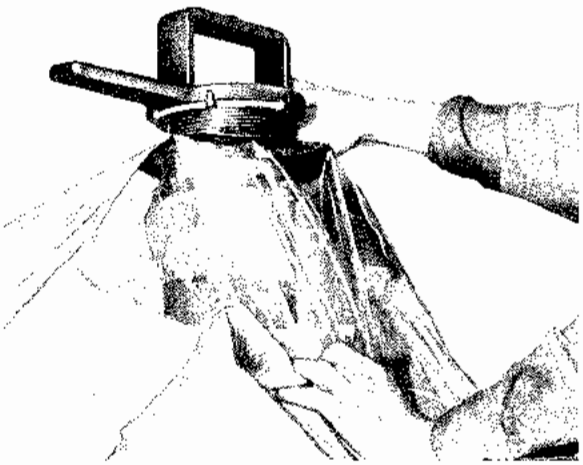


Coating Propeller Shaft [26]

Placing Envelope over Shaft [29]

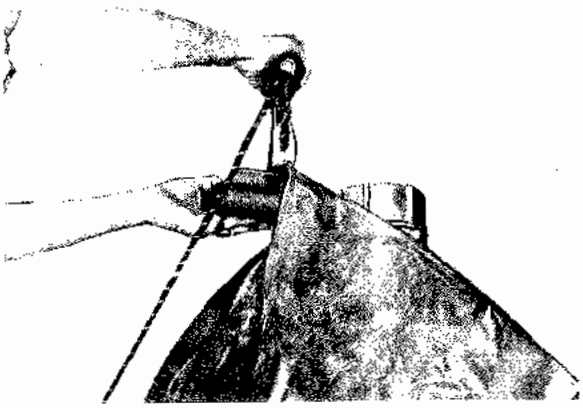


Covering Propeller Shaft [27]

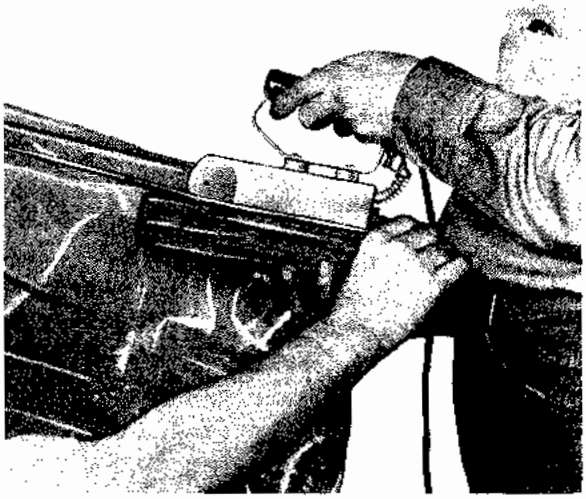


Installing Spanner Nut [30]

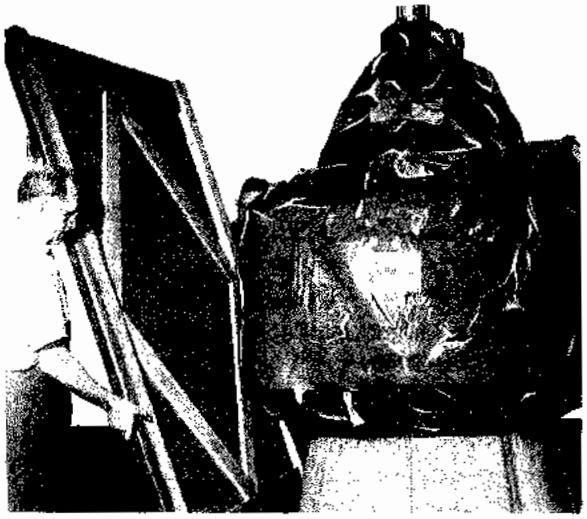
Installing Thread Protector [31]



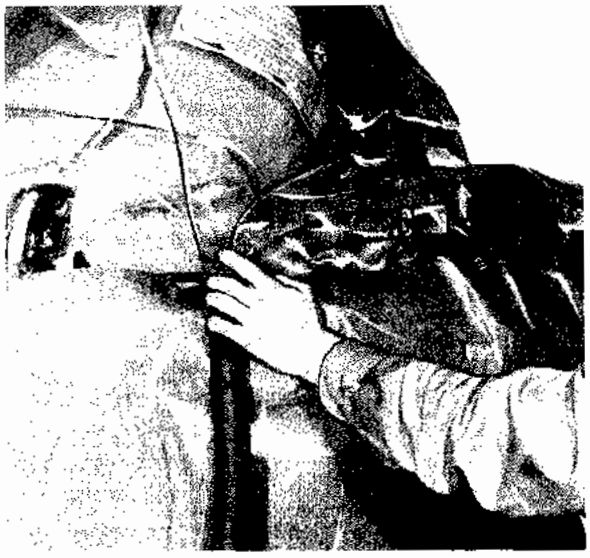
Final Sealing [34]



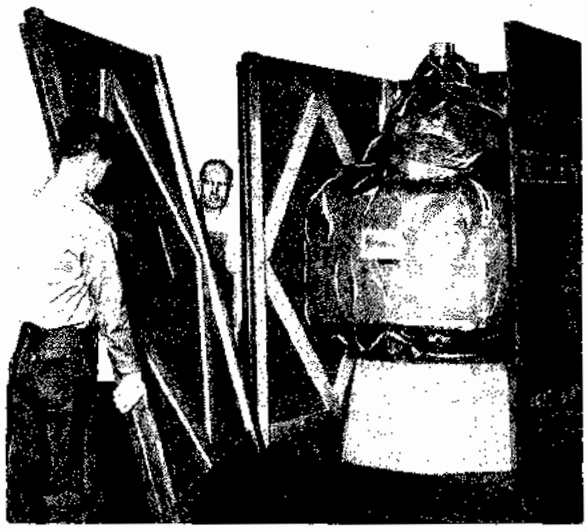
Sealing First Part of Envelope [32]



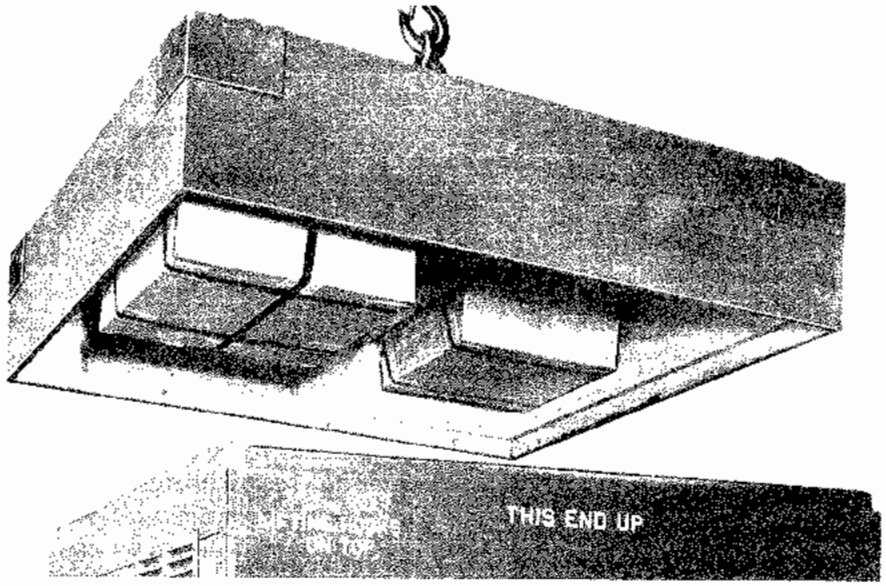
Installing Panel [35]



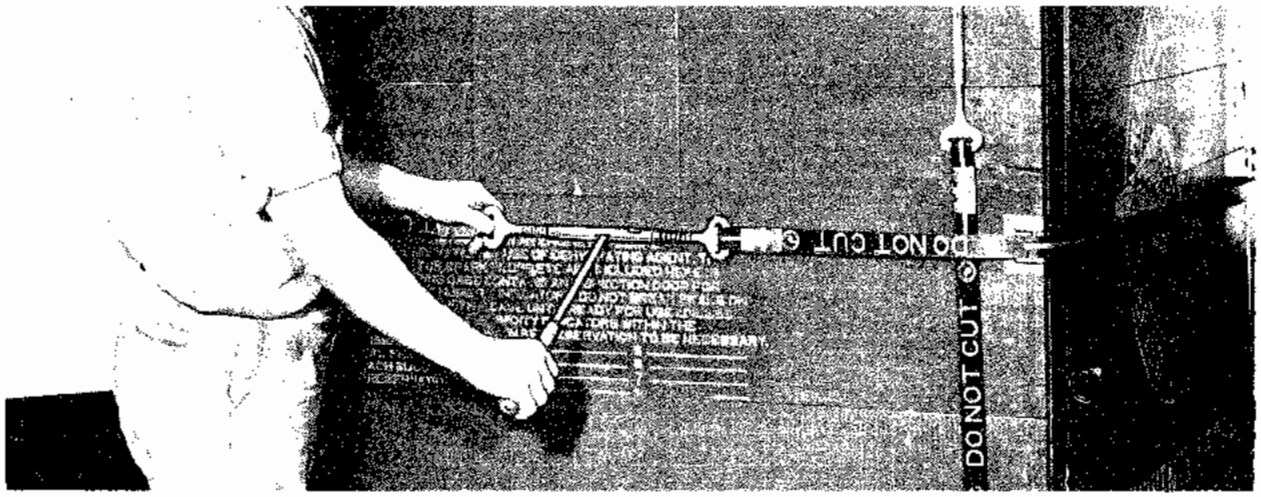
Withdrawing Air [33]



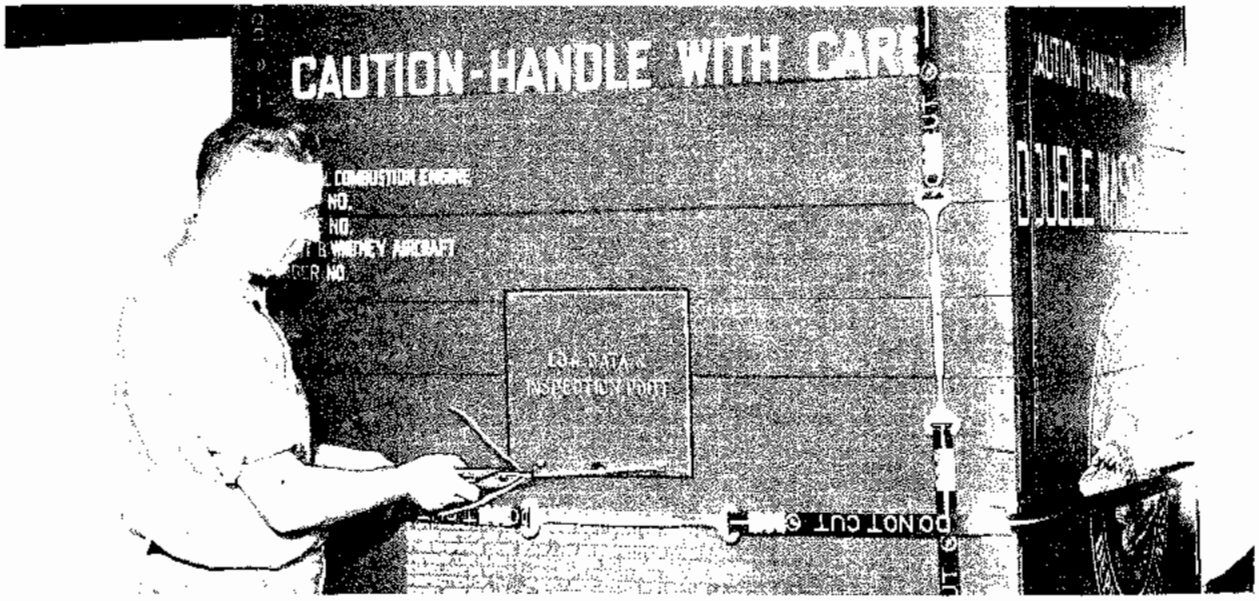
Installing Final Panel [36]



Lowering Packing Case Cover [37]



Securing Metal Strap with Turnbuckle [38]



Lockwiring Inspection Window [39]

MAINTENANCE INSTRUCTIONS

FOR

CHANDLER-EVANS

WATER INJECTION REGULATORS

SUPPLEMENT

TO

DOUBLE WASP

(R-2800)

MAINTENANCE MANUAL

Part No. 166498

Published by

Service Department

PRATT & WHITNEY AIRCRAFT

Division of United Aircraft Corporation

EAST HARTFORD, CONNECTICUT

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PRINTED IN UNITED STATES OF AMERICA

INTRODUCTION

This publication comprises the Service, Maintenance, Operation and Installation Instructions for the Water Injection Regulators listed in the table. These regulators are manufactured by the Chandler-Evans Division of Niles Bement Pond Co., West Hartford, Connecticut, and furnished by Pratt & Whitney Aircraft, Division of United Aircraft Corporation East Hartford, Connecticut.

WATER INJECTION REGULATOR IDENTIFICATION TABLE

Type	*Part Number*		*Engine Models*
	Pratt & Whitney	*Chandler-Evans*	*R-2800 R-4360*
Variable Flow	190255	14148	CA3 CA5 CA15 CA17 CA18 CA19 CB3 CB4 CB16 CB17
Constant Flow	169952		CB2 B6

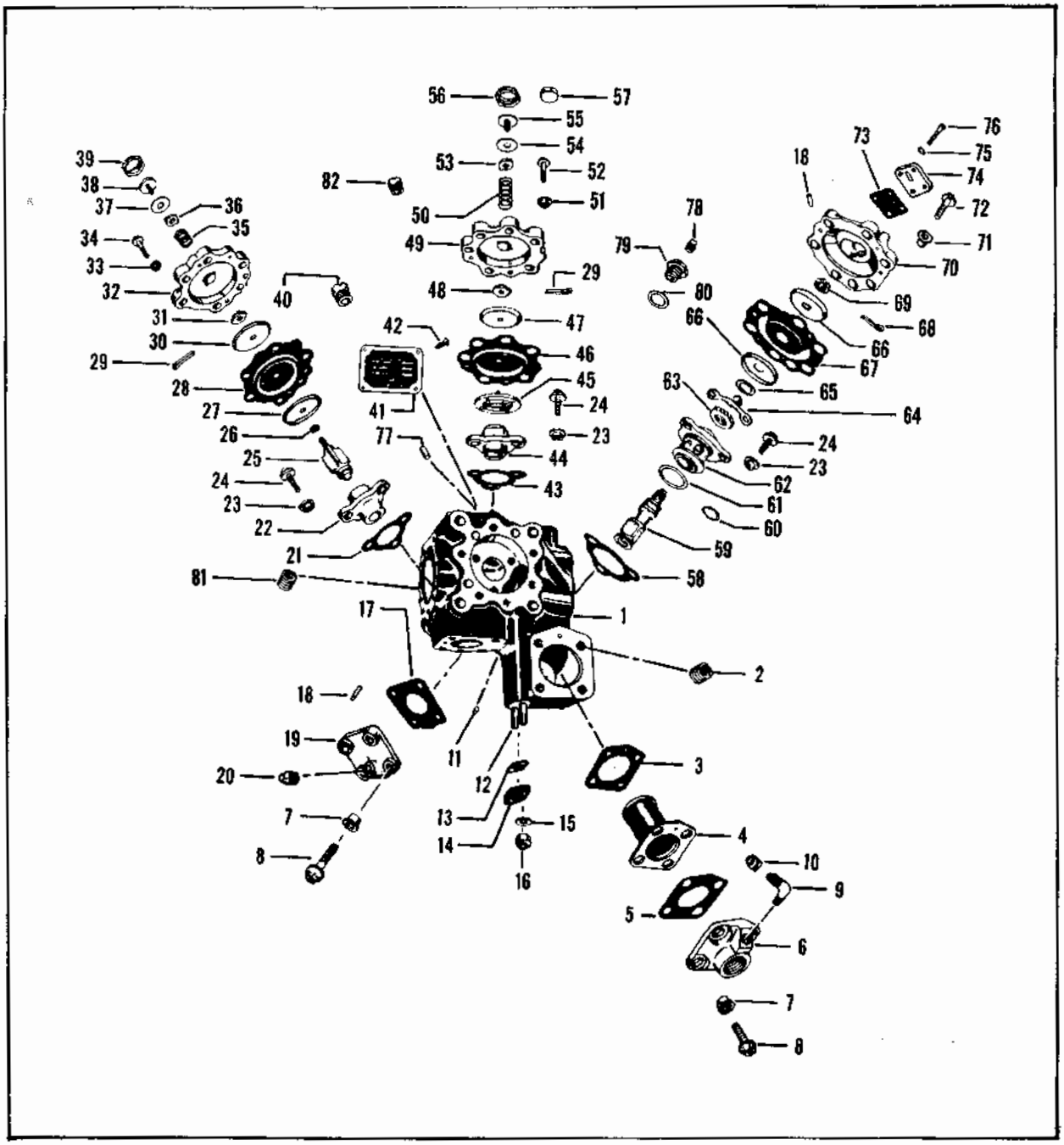
For complete overhaul instructions see the water injection regulator supplement in the Overhaul Manuals listed in the following table.

Manual Part No.	*Engine Models*
115635	R-2800-CA
166497	R-2800-CB
201529	R-4360-CB2 -B6

DESCRIPTION

Purpose

The function of the regulator is to meter the water entering the fuel system in such manner that the flow of water will be directly proportional to the mass air flow. The water replaces the fuel normally used to cool the combustion charge below the detonation point when operating in the extreme power range, thus effecting fuel economy while at the same time permitting a safe increase in power output for a period of time limited by the amount of water available. Figures **[1]** and **[2]** illustrate the general construction of the variable flow and constant flow regulators respectively.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Key to Figure [1]

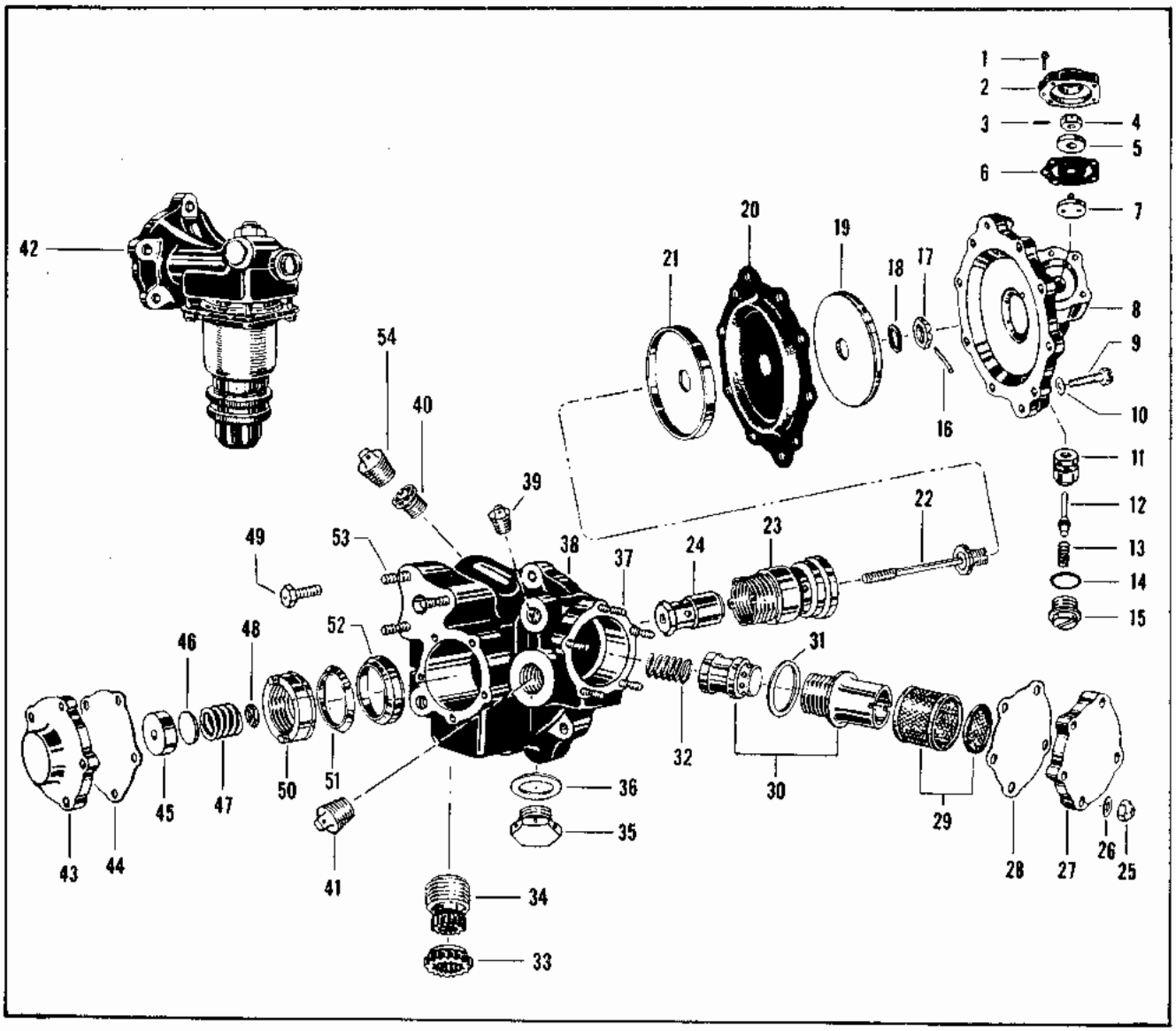
1. Water Regulator Housing
2. Housing Insert
3. Water Inlet Screen Gasket
4. Water Inlet Screen
5. Water Inlet Screen Cover Gasket
6. Water Inlet Screen Cover
7. Cover Bushing
8. Cover Retaining Screw
9. Derichment Tube Fitting
10. Cap
11. Plug
12. Stud
13. Drain Cover Gasket
14. Drain Cover
15. Washer
16. Retaining Nut
17. Reset Valve Mounting Pad Cover Gasket
18. Plug
19. Reset Valve Mounting Pad Cover
20. Pipe Plug
21. Enrichment Valve Seat Gasket
22. Enrichment Valve Seat
23. Seat Bushing
24. Seat Retaining Screw
25. Enrichment Valve
26. Diaphragm Seal
27. Diaphragm Inner Support
28. Enrichment Valve Diaphragm
29. Cotterpin
30. Diaphragm Outer Support
31. Diaphragm Retaining Nut
32. Enrichment Valve Diaphragm Cover
33. Cover Bushing
34. Cover Retaining Nut
35. Enrichment Valve Spring
36. Adjusting Screw Spring Follower
37. Adjusting Screw Gasket
38. Check Valve Adjusting Screw
39. Adjusting Screw Locknut
40. Enrichment Jet
41. Control Data Plate
42. Control Data Plate Drive Screw
43. Check Valve Seat Gasket
44. Check Valve Seat
45. Check Valve
46. Check Valve Diaphragm
47. Diaphragm Outer Support
48. Diaphragm Retaining Nut
49. Check Valve Diaphragm Cover
50. Check Valve Spring
51. Cover Bushing
52. Diaphragm Cover Screw
53. Adjusting Screw Spring Follower
54. Adjusting Screw Gasket
55. Check Valve Adjusting Screw
56. Check Valve Adjusting Screw Locknut
57. Adjustment Seal
58. Valve Seat Gasket
59. Main Metering Valve
60. Valve Retaining Lockring
61. Valve Seat Seal
62. Main Metering Valve Seat
63. Pressure Regulating Valve Nut
64. Retaining Plate
65. Diaphragm Seal
66. Diaphragm Support
67. Main Metering Valve Diaphragm
68. Cotterpin
69. Main Metering Valve Retaining Nut
70. Main Metering Valve Diaphragm Cover
71. Diaphragm Cover Bushing
72. Diaphragm Cover Screw
73. Solenoid Mounting Pad Gasket
74. Solenoid Mounting Pad Cover
75. Solenoid Pad Cover Washer
76. Solenoid Pad Cover Retaining Screw
77. Plug
78. Pipe Plug
79. Unmetered Fuel Connection Bushing
80. Gasket
81. Insert
82. Main Metering Jet

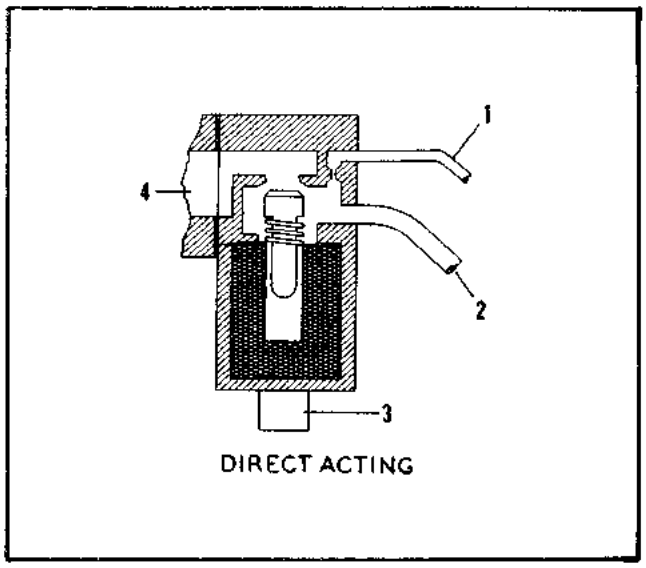
Component Parts

The water regulators, which are listed in the table, consist primarily of the following main components:

1. Water Inlet Screen
2. Main Metering Valve
3. Check Valve
4. Enrichment Valve (Variable Only)
5. Main Metering Jet
6. Enrichment Jet (Variable Only)
7. Solenoid Valve (Constant Only)

The solenoid operated water inlet control is the direct acting type for the constant flow units [**3**].





[3]

Key to Figure [3]

1. Vapor Vent Line
2. Water Feed Line
3. Electrical Connection
4. To Check Valve Chamber

Key to Figure [2]

1. Unmetered Fuel Valve Diaphragm Cover Screw
2. Unmetered Fuel Valve Diaphragm Cover
3. Cotterpin
4. Diaphragm Retaining Nut
5. Diaphragm Outer Support
6. Unmetered Fuel Valve Diaphragm
7. Unmetered Fuel Feed Valve Diaphragm Plate
8. Main Metering Valve Diaphragm Cover
9. Main Metering Valve Diaphragm Cover Screw
10. Washer
11. Unmetered Fuel Feed Valve
12. Unmetered Fuel Valve
13. Spring
14. Gasket
15. Retaining Plug
16. Cotterpin
17. Main Metering Valve Diaphragm Retaining Nut
18. Diaphragm Seal
19. Diaphragm Outer Support
20. Main Metering Valve Diaphragm
21. Diaphragm Inner Support
22. Main Metering Valve Stem
23. Valve Seat
24. Main Metering Valve
25. Solenoid Valve Pad Cover Retaining Nut
26. Washer
27. Solenoid Mounting Pad Cover
28. Gasket
29. Water Inlet Screen
30. Check Valve and Seat
31. Gasket
32. Spring
33. Lockring—Serrated Screw Bushing
34. Serrated Screw Bushing
35. Check Valve Chamber Drain Plug
36. Gasket
37. Solenoid Valve Mounting Stud
38. Control Housing
39. Vent Plug
40. Main Metering Jet
41. Check Valve Chamber Plug
42. Solenoid Valve Assembly
43. Main Metering Valve Cover
44. Gasket
45. Spring Guide
46. Spring Spacers
47. Valve Spring
48. Valve Adjusting Locknut
49. Valve Cover Retaining Screw
50. Valve Seat Retainer
51. Valve Seat Packing Washer
52. Valve Seat Packing
53. Water Transfer Tube Adapter Stud
54. Main Metering Jet Cover Plug

Operation

The variable flow regulator provides an enriched water flow for the higher power requirements and a leaner mixture for the lower limits of the extreme power range. An added feature of this regulator is that below a set power requirement the water flow is automatically cut off.

The operation of the constant flow regulator is satisfactory and provides for a constant water air ratio at all power conditions. It follows that this type of regulator must be set to provide for safe operation at the highest power requirements, thus allowing an excess flow of water at the lower power settings resulting in unnecessary water consumption.

Water Injection Mixture

The optimum mixture for high power operation is a 50-50 mixture by volume of methyl alcohol and water. As a substitute, for localities where large quantities of ethyl alcohol and only small quantities of methyl alcohol are available, a mixture of 25% methyl, 25% ethyl and 50% water by volume may be used. The operating characteristics of this mixture compare favorably with those of the 50-50 methyl alcohol-water mixture. Also, the use of this mixture helps to conserve the supply of methyl alcohol.

Of particular interest to many operators is an alcohol-water mixture in a ratio of 60% alcohol to 40% water. Laboratory tests on the relative corrosive properties of the various mixtures have shown the 60-40 blend to be definitely less corrosive than blends of 70-30, 50-50, 40-60 or 30-70 alcohol-water ratio.

The engine power rating, availability of alcohol and freezing are the principal factors which will influence the final decision in regard to the water-alcohol mixture which will be used in commercial water injection installations.

The recommendations of Pratt and Whitney Aircraft covering the components and mixtures for anti-detonant injection systems of its design are given in the following paragraphs:

MIXTURES

Mixture Type	*Composition Parts by Volume Before Mixing*		*Specific Gravity at 15.4C*	*Initial Freezing Point Deg. Fahr. Max.*
1	Methyl Alcohol	48—52	0.9255—0.9340	—45
	Water	48—52		
2	Methyl Alcohol	24—26	0.9255—0.9380	—32
	Ethyl Alcohol	24—26		
3	Water	48—52		
	Methyl Alcohol	58—62	0.9050—0.9150	—65
	Water	38—42		

Physical Properties

1. Methyl Alcohol —
   Shall conform to the latest issue of AMS 3004.

2. Ethyl Alcohol —
   Shall conform to the latest issue of AMS 3002.

3. Water —
   May be treated by a softening or a demineralization process, or distilled if necessary, to ensure conformance:

Total Solids, ppm	175 max.
ph	6.0—8.0
Chlorides, ppm	15 max.
Sulfates, ppm	10 max.

Preparation — Alcohol-water mixtures shall be prepared by thoroughly mixing the required components. They shall be filtered through a medium with pores having no dimension greater than 10 microns (0.01 mm), unless each component is filtered, before mixing, through such a medium.

It is important to note that these products are deadly poison if taken internally. There is no antidote and they cannot be rendered non-poisonous. Repeated inhalations have the same effect as internal consumption. They should not be used or left uncovered in closed unventilated spaces. These products are also highly flammable and the same general precautionary measures used in handling high octane fuel should be observed.

Additional approval has been extended to specific British Ministry of Supply Specifications as follows:

Methyl Alcohol	—Specification No. 506-1933 dated Oct. 1933
Denatured Methanol	—Specification No. D-Eng. R.D. 2481 dated Jan. 8, 1946
Methanol Water	—Specification No. D-Eng. R.D. 2470 dated Jan. 8, 1946

The British Methanol Water Specification requires that inhibited distilled water be used and is prepared by mixing 40 parts of distilled water with 1 part of a specific anti-corrosion oil, Stores Reference 34A/193, and adding to 60 parts of methanol. This sequence is required to prevent separation. The addition of a soluble oil to an anti-detonant mixture will have an adverse effect on the detonation rating, but in this case may be compensated by an increase in the methanol-water ratio to 60-40. Therefore, pending further study, no mixture other than those indicated will be considered as approved.

INSTALLATION

The instructions set forth in this section are intended as a guide to facilitate the installation of the water injection regulators. All of the various types of mounting brackets, tubing clips, adapters, etc. are not completely discussed, but the functional connections of the two types of regulators are adequately covered.

Depreserving Water Regulator Unit

Some engines are currently shipped with the preserved water regulator installed on its mounting pad. It is absolutely necessary that the regulator be removed from the engine and flushed with clean, unleaded gasoline to remove all of the slushing oil. Water regulators which have been prepared for storage and stocked, or packed separately, should also be depreserved prior to installation. In every case, depreservation of the regulator should be accomplished in accordance with instructions in the following paragraphs.

Variable Flow

a. Break the lockwire and remove the four bolts which secure the regulator to its pad on the left side of the supercharger inlet case; then remove the regulator from the engine.

b. If the unit has been packed separately or received from stock, remove the shipping cover and gasket.

c. Remove all pipe plugs.

d. Drain out all oil, turning the regulator to various positions and shaking it to clear all recesses and passages.

e. Immerse the regulator in clean gasoline and roll it around to cause all of the chambers to vent and fill with gasoline.

f. When the regulator is full, slush the gasoline around and then drain it off.

g. Repeat the above procedure until all preservation oil has been washed out.

h. Using a small amount of anti-seize compound (white lead base) on the threads, reinstall all plugs except those normally removed when the regulator is installed on the engine.

> ***If any slushing oil remains in the chambers of the regulator, a sticky emulsion of water and oil will be formed which may cause extreme malfunctioning.***

Constant Flow

a. Disconnect the fuel transfer tube adapter and remove the water transfer tube clip and the four bolts which attach the regulator to its mounting bracket on the accessory case.

b. Remove the water regulator, water transfer tube and fuel transfer tube adapter as a unit, then remove the water transfer tube from the regulator.

c. Remove the shipping cover and gasket (if regulator has been shipped separately) from the water transfer tube pad on the regulator.

d. Install a gasoline-tight cap over the electrical connection on the solenoid valve and then remove all pipe plugs except the ⅜ inch jet cover plug.

e. Drain and clean the regulator as outlined in steps d through h of the preceding paragraph.

Variable Flow Regulator Installation

See figure **[4]**

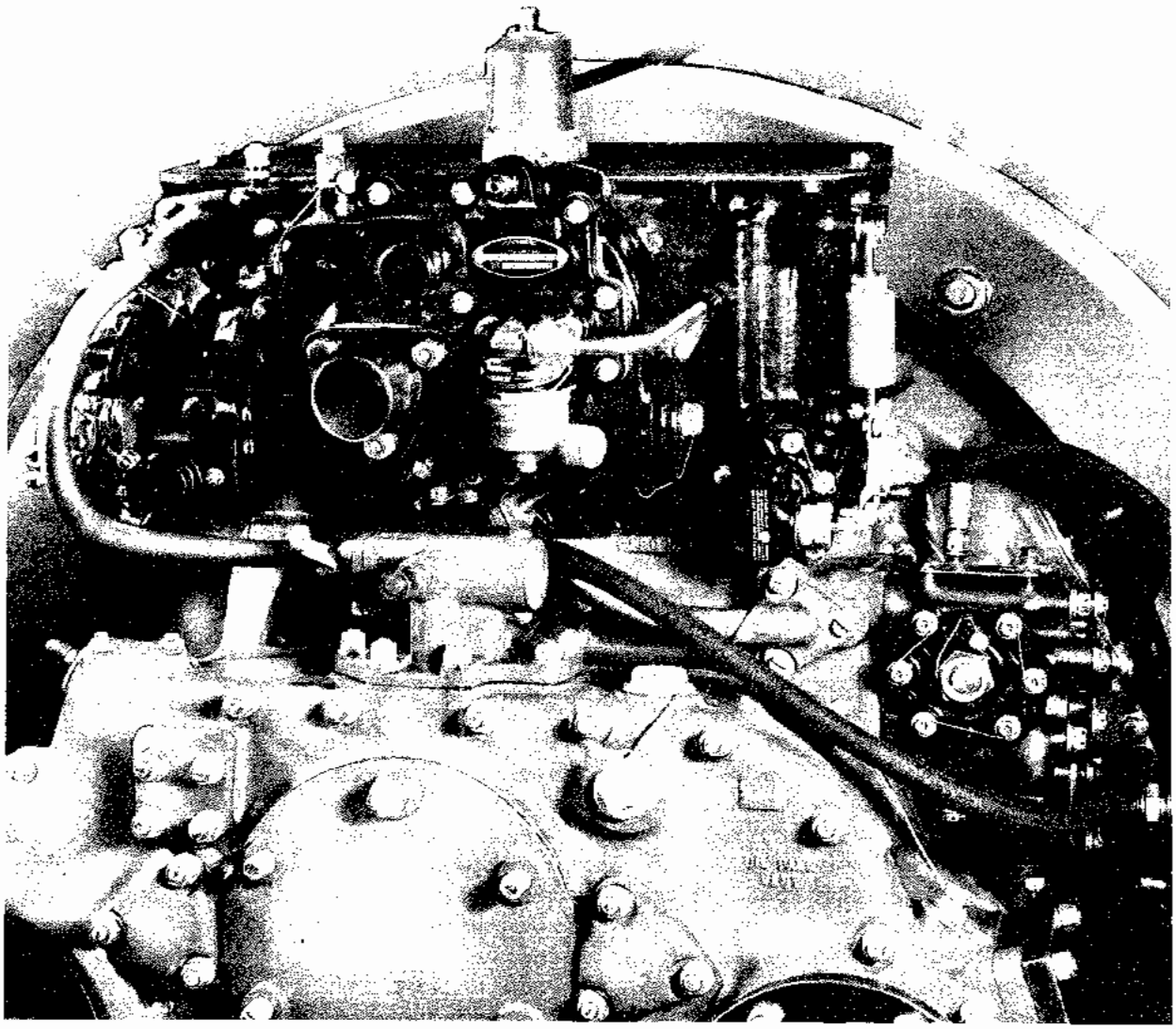
a. Make certain that the gasket is in good condition; then mount the water regulator unit on the auxiliary supercharger case and secure it in place.

b. Install a tee fitting in place of the plug in the water inlet screen cover section of the water regulator unit, and install a fitting in place of the plug in the lower section of the derichment valve cover on the carburetor.

c. Connect the tube which carries water pressure from the water regulator unit to the derichment valve diaphragm chamber.

d. Attach the tube supporting clips to the rim at the rear of the auxiliary supercharger case.

e. Install a water pressure gage on the tee fitting described in step b; then install the vapor vent return line to the water tank and the regulator inlet supply line.



[4]

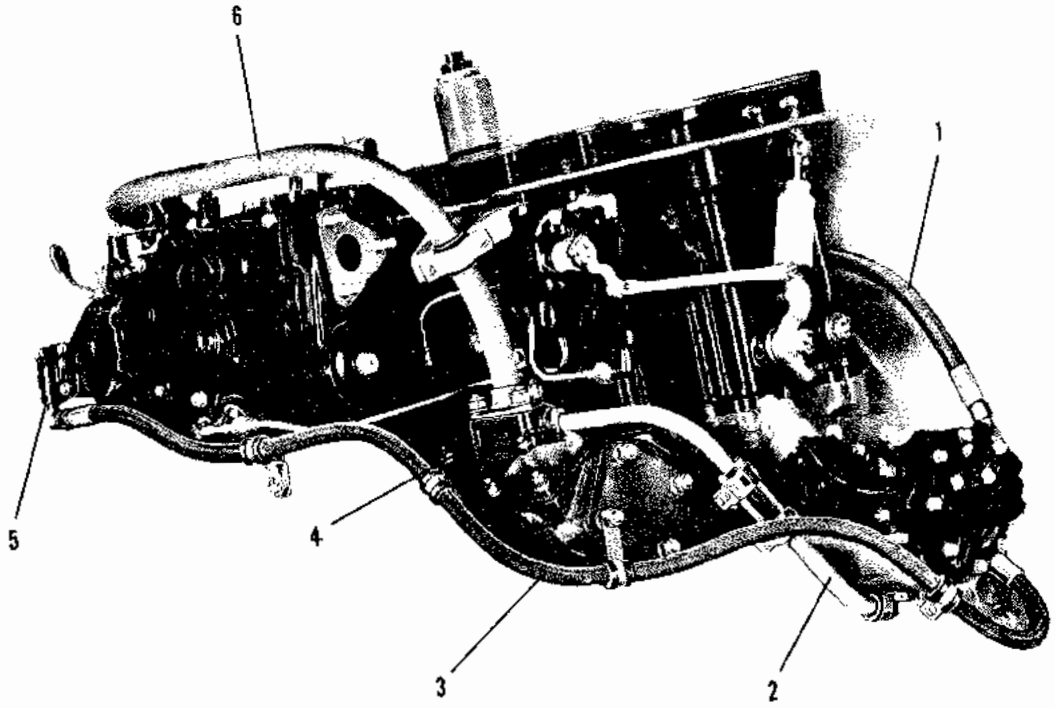
Constant Flow Regulator Installation

See figure **[5]**

a. Place a gasket on the water transfer pad of the water regulator; then install and secure the water transfer tube on the water regulator.

b. Secure the water unit to the mounting bracket on the case with washers and bolts. Lockwire the bolts. Position the water transfer tube in the water transfer tube adapter and secure the tube at the adapter. Tighten the tube connector and position the ferrule. Install the fuel pressure tube fitting in place of the plug in the top of the unmetered fuel chamber on the carburetor **[6]** and install an elbow in place of the ⅛ inch plug in the upper right side of the water regulator unit **[7]**. Connect the tube which carries unmetered fuel from the carburetor to the unmetered fuel chamber in the water regulator unit, and secure it with clips and brackets.

c. Install an elbow in place of the ⅛ inch plugs in the name plate side of the water regulator unit [7] and install an elbow in place of the ⅛ inch plug in the lower section of the carburetor derichment valve cover [6]; then connect the tube which carries water pressure from the water regulator unit to the derichment valve diaphragm chamber, and secure it with clips and brackets.

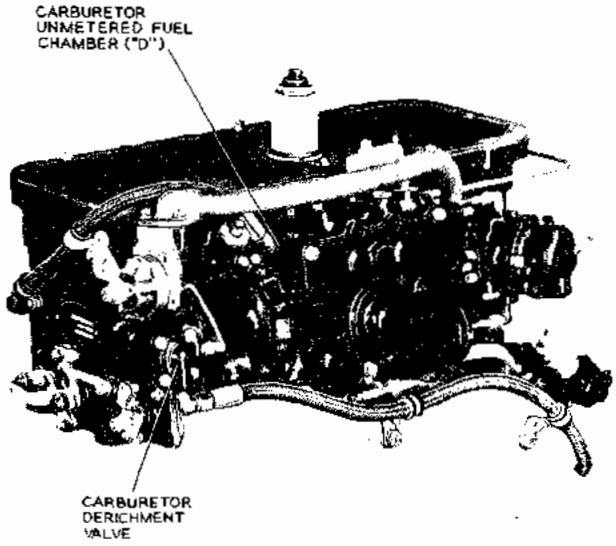


[5]

Key to Figure [5]

1. Unmetered Fuel Pressure Line
2. Water Transfer Tube
3. Derichment Valve Pressure Line
4. Fuel Transfer Tube Adapter
5. Derichment Valve Cover
6. Fuel Transfer Tube

d. If the engine is equipped with a power control unit, install an elbow in place of the remaining ⅛ inch plug on the name plate side of the water regulator, and install an elbow in the boss marked "Water" on the top of the power control. Connect the two fittings with the appropriate tube and secure it with clips and brackets.



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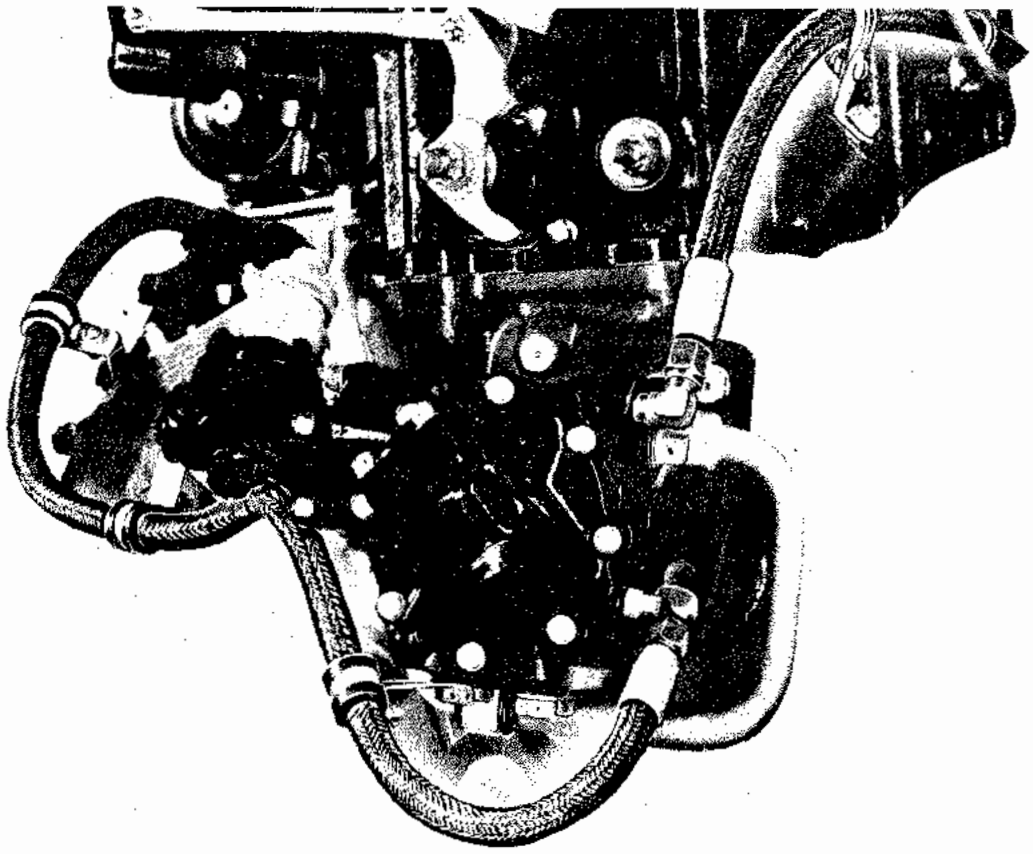


[7]

OPERATION

Variable Flow Regulator — Figure **[8]** illustrates the operating principle of the regulator. Unmetered fuel pressure from the carburetor builds up a pressure on the diaphragm of the metering pressure control valve [4] and holds this valve open. When the water injection switch is closed, water pressure is built up in the valve chamber, counteracts the pressure on the diaphragm, and closes the valve. As the unmetered fuel pressure increases in response to greater engine power requirements, the water pressure against the diaphragm is unbalanced and the valve opens. However, water does not enter the engine until sufficient metering force is developed to permit water pressure to build up and open the check valve [2]. At a predetermined power the check valve begins to open giving a rapid increase in water-air ratio as the power is increased. The water pressure built up in the inlet check valve chamber is also transmitted to the carburetor derichment valve diaphragm. This valve closes and reduces fuel flow through the carburetor to a predetermined setting for best power mixture ratio. Further increase of pressure differential with increased airflow causes the enrichment valve [9] to start opening. When the enrichment valve is completely open in response to power demands, the water-ratio levels off at a constant value determined by the enrichment jet. This enriching action, or increase in water-air ratio, corresponds to the action of the enrichment valve and jet in the pressure type carburetor.

Constant Flow Regulator — Figure [9] illustrates the operating principle of the regulator. Water entering the regulator through the solenoid valve opens the spring loaded check valve (2), but cannot pass through the metering pressure control valve (4) until pressure is built up in chamber "A." This pressure opens the unmetered fuel valve (8) admitting unmetered fuel to chamber "B" which opens the metering pressure control valve (4) through the action of the large diaphragm. Water then begins to flow to the engine through the regulator at a rate proportional to the unmetered fuel pressure which, in turn, is proportional to the mass airflow. The metering jet (5) controls the quantity of water injected into the engine. During the time that pressure is being built up in chamber "A," pressure is also being built up to actuate the derichment valve on the carburetor through an external line connected to the regulator. This action reduces fuel flow to best power mixture setting for water injection operation.

Operating Instructions

The operation of the water injection system involves the use of a system of switches, the number and type of which will depend on the installation. Basically it is required that a switch be closed to energize the regulator solenoid and start the system pump.

> ***It is recommended that a pressure switch, actuated by engine rear oil pressure, be used to prevent the operation of the water injection system unless the engine is running.***

All references to "water" refer to water injection mixtures recommended in DESCRIPTION of this publication.

Ground Check (Variable Flow Regulator)

The following ground check instructions are given with the assumption that the water injection regulator switch will be manually operated. For more detailed instructions see the airplane manufacturer's instruction manual.

a. Start and warm the engine in the usual manner.

b. Turn the water injection switch on while the engine is still in the lower power range to clear the lines of air.

> ***No appreciable amount of water enters the engine until the power demands are increased.***

c. Note water pressure and adjust the pump pressure relief valve, if necessary, to obtain a pressure reading three to five pounds above fuel pressure.

d. Increase engine power to a point between normal rated and take-off power; then check to see that the flow indicating light has come on and that the water pressure closely approximates fuel pressure.

e. Check the engine performance at this r.p.m. and manifold pressure by comparing torquemeter readings and fuel flow against operation at the same point without water injection.

f. Make the final water pressure check during flight as it is undesirable to draw full engine power with the airplane at rest.

g. Turn the water injection switch off. The water pressure gage should indicate approximately zero pressure reading, and the flow indicating light should go out.

h. Check fuel flow and torquemeter reading. The fuel flow should be greater and the torquemeter reading should be less than that indicated in step e.

i Close the throttle at the completion of the ground check.

Ground Check (Constant Flow Regulator)

The operation of the constant flow regula-

tor is essentially the same as that of the variable unit with the exceptions noted below:

a. Start and warm the engine in the normal manner.

b. Advance the throttle to obtain 2200 engine r.p.m.

c. Turn on the water injection regulator switch.

Do not turn on the water injection regulator switch unless the engine is running, as water entering the engine may cause hydraulicking.

d. Note the water pressure. Proper action of the pump and solenoid will be indicated by a water pressure reading at the regulator up to five pounds per square inch higher than the desired pressure for flight. The exact ground check value must be determined by a test at take-off power.

e. Adjust the water pump relief valve, if necessary, to give the desired water pressure (closely approximating fuel pressure) for flight at take-off power.

f. Determine the ground check water pressure (slightly higher than fuel pressure) without disturbing the adjustment obtained in step e in order to establish pressure limits for subsequent ground checks at powers less than normal rated.

g. Turn off the water injection regulator switch and check to see that the water pressure reading returns to its original indication of fuel nozzle pressure.

h. Throttle the engine at the completion of the ground check.

OPERATION AT TAKE-OFF

Variable Flow Regulator

a. Turn on the water injection regulator switch any time prior to take-off.

b. Check the water flow indicating light at take-off.

Do not exceed dry take-off power if the flow indicating light is not on.

c. Shut off the water injection switch when take-off power is reduced.

Constant Flow Control

a. With the throttle set for 2200 engine r.p.m., turn on the water injection control switch for a few seconds to clear the lines of air. Check the water pressure reading and be sure it indicates a pressure slightly above fuel pressure.

b. At take-off power the water pressure should drop to approximately fuel pressure showing that water is flowing to the engine.

If the water pressure does not drop, indicating that water is flowing to the engine, do not exceed dry take-off power.

c. Shut off the water injection switch when take-off power is reduced.

Operation During Flight

Water injection may be used during flight as required if engine power is advanced to a point above normal rated power.

When the water supply is exhausted the pump may maintain pressure for a sufficient length of time to keep the carburetor deriched although there is no water flow to the engine. Continued operation under these conditions may cause engine oveheating and detonation with resultant serious engine damage. It is also possible that the injection of air through the fuel feed valve will disrupt the carburetor metering to such an extent that backfiring and loss of power will result.

To prevent the operating conditions described in the preceding paragraph it is recommended that the water regulator be shut off before the entire supply of water becomes exhausted.

SERVICE INSPECTION AND MAINTENANCE

Service Tools Required

No special service tools are required, and it shall be understood that all operations outlined in the following paragraphs will be performed in accordance with standard procedures except as otherwise noted.

Service Inspection

The conditions under which the regulator has been operating determine, to a great extent, the time interval between periodic inspections. These inspections should be performed at intervals which are accepted as standard for the type of activity in which the operating organization is engaged.

All periodic inspections shall incorporate the preflight and daily checks. The following schedule may be used as a guide in making necessary inspections:

INSPECTION SCHEDULE

Preflight and Daily Checks

1. Examine wiring to electrical connections on the system pump.

2. Check each unit of the system to make sure that it is securely fastened and lockwired.

3. Fill the tank with water and check all external water lines for leaks, chafing and security.

25 Hour Inspection

1. Check the water tank, tank supports and the strainer in accordance with the airplane maintenance instructions.

2. Test water pressure to the regulator as follows:

a. Remove the supply line at the regulator and attach this line to a pressure gage.

b. When the pump is operated, pressure shown on the gage should be slightly higher than that recommended for flight performance.

c. If the pump fails to deliver the desired pressure, adjust the pump by-pass valve.

d. If the adjustment mentioned in step c fails to give adequate pressure, replace the pump.

> ***Whenever a pump is known to have been operated after the water supply has been exhaused, the water pressure to the regulator should be tested as outlined in steps a through d.***

3. Remove and clean the regulator unit strainer.

4. Check the operation of the solenoid unit by closing the regulator switch. A person standing near the solenoid unit can hear or feel the unit if it is operating correctly.

5. Examine the wiring from the regulator switch to solenoid unit and the pump for breaks in the insulation or faulty fastening.

MAINTENANCE

Torque Recommendations

The following are the recommended torque values for the nuts, bolts, and screws on the various water injection controls listed below:

a. Constant Flow Controls.

10-32 elastic stop nuts	35—45
10-24 screws except as noted by*	35—40
*10-24 screws for 101840 unmetered fuel valve cover on the non-hesitating water controls	25—30
*10-24 screws for main diaphragm cover	40—50
101834 or 79314 poppet valve adjustment locknut	25—30
79304 main diaphragm locknut	35—45 not to exceed 45 to align cotterpin

b. Variable Flow Controls.

10-24 internal hex head screws	40—45
¼-20 internal hex head screws	55—60
¼-20 hex head bolts	55—60
¼-28 elastic stop nut	70—85

Where the nuts, bolts, or screws are clamping diaphragms or soft gaskets, the units must be initially torqued to the values given and then rechecked, and if necessary, retorqued after 20 minutes to the recommended values. This will permit adequate time for the diaphragms or gaskets to take a final set so that, after retorquing, the nuts will not loosen at a later date.

Preserving Variable Flow Regulators

a. Drain the water from the system; then remove the water regulator unit from the engine. The regulator may be shipped separately to overhaul or may be reinstalled on the engine for shipment to overhaul. In either event prepare the water regulator for storage as follows, [**10** and **11**].

b. If the regulator is to be shipped separately, install a shipping cover and gasket on the water regulator mounting pad.

c. Remove the drain cover and gasket from the bottom of the water regulator.

d. Remove all the pipe plugs from the water regulator except the ½ pipe plug in the water inlet.

e. Rotate the regulator in various positions allowing the water to drain out.

f. Attach a special adapter which will allow oil to be forced into the three holes located on the drain pad. Do not apply oil pressure at this time.

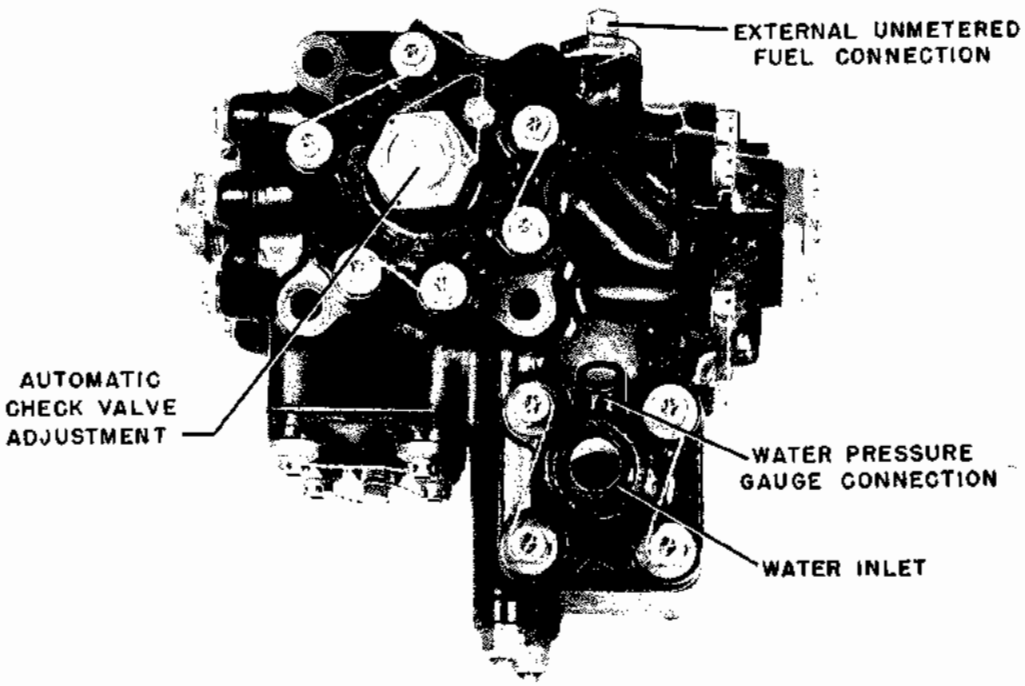
g. In the following steps hold the regulator in a vertical position.

h. Apply 4 to 5 pounds per square inch oil pressure to the supercharger throat passage. Remove the hose and allow oil pressure to be reduced in the passage. Repeat until air-bubble-free oil drains back out.

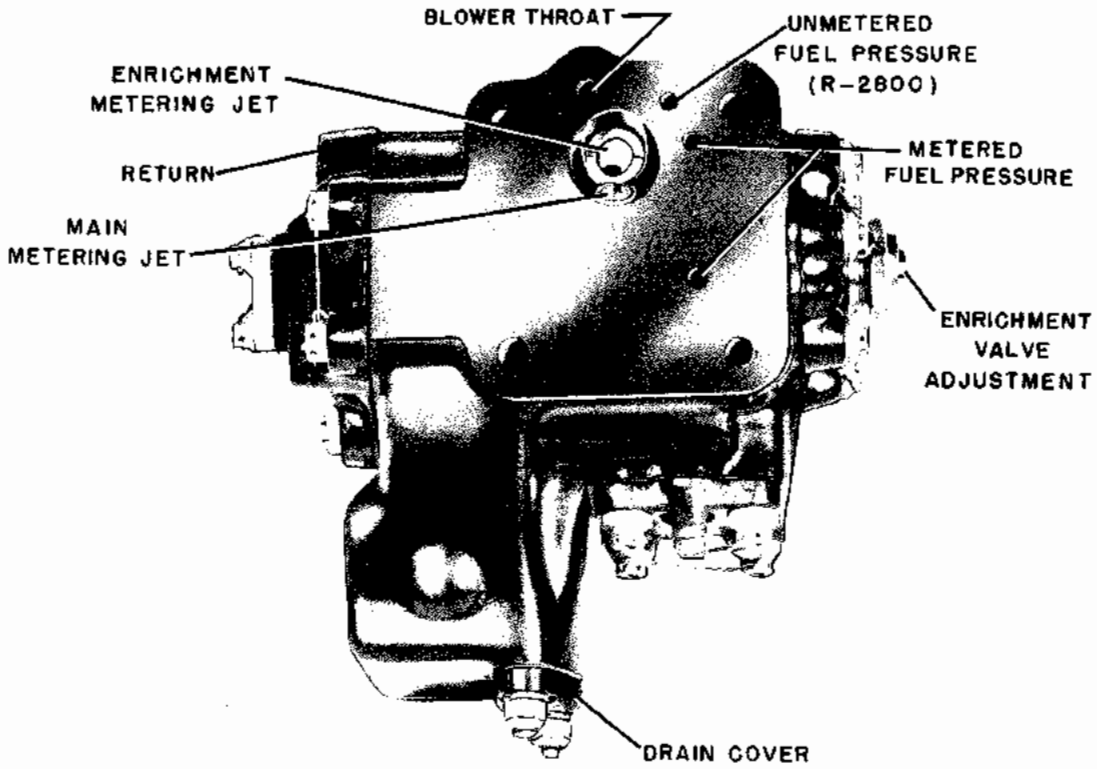
i. Apply 4 to 5 pounds per square inch oil pressure to the unmetered fuel passage until oil flows out of the ⅛ inch external unmetered fuel pipe tap. Plug this external hole with a ⅛ inch pipe plug.

j. Hold a finger over the lower metered fuel hole to prevent oil from draining out during the next step.

k. Attach an oil line to the special adapter noted in step f and apply 4 to 5 pounds per square inch oil pressure. When air-bubble-free oil flows out of the tapped holes, plug them


EXTERNAL UNMETERED FUEL CONNECTION
AUTOMATIC CHECK VALVE ADJUSTMENT
WATER PRESSURE GAUGE CONNECTION
WATER INLET

[10]


BLOWER THROAT
UNMETERED FUEL PRESSURE (R-2800)
ENRICHMENT METERING JET
RETURN
METERED FUEL PRESSURE
MAIN METERING JET
ENRICHMENT VALVE ADJUSTMENT
DRAIN COVER

[11]

with pipe plugs in the order named: water inlet pressure and vapor vent return. Continue applying pressure until air-bubble-free oil flows out of the jet hole on the mounting face of the regulator.

l. Place the regulator with the mounting face up; then remove the oil line and special adapter and install the gasket and drain cover.

m. Pour oil into the jets and install the mounting flange shipping cover if the unit is to be shipped separately, or reinstall the unit on the engine if the engine is to be shipped to overhaul.

n. Lockwire all pipe plugs.

o. Tag the control to indicate it has been oiled.

Preserving Constant Flow Regulators

a. Drain the water from the system and remove the water regulator unit from the accessory section of the engine. The regulator may be shipped separately to overhaul or may be installed on the engine for shipment to overhaul. In either event prepare the water regulator for storage as follows:

b. Remove all the plugs from the water regulator unit, except the ⅜ inch jet cover plug, and the two water pressure take-off plugs beneath the jet cover **[12]**. Remove the ⅜ inch pipe plug from the water inlet opening in the solenoid valve, and the ⅛ inch pipe plug from the solenoid vent line opening [12]. Remove the cover on the triangular water transfer tube pad. Shake all the water out of the outlets.

> ***In the following steps, the corrosion preventive mixture is to be left in the regulator; therefore, the appropriate plugs and covers must be replaced to prevent the mixture from running out as the regulator is turned.***

c. Connect an oil line to the water inlet opening of the solenoid valve, and pump in oil at 7 to 9 pounds per square inch pressure until it flows out of the vent line opening. Disconnect the oil line, and plug both openings.

d. Attach the oil line to a T line incorporating a No. 50 restrication. Connect one end of the T to the ⅜ inch pipe thread water screen chamber opening on the right side of the regulator unit and connect the other end to the ⅛ inch pipe thread unmetered fuel chamber opening on the upper front face of the regulator [12]. Apply oil at 7 to 9 pounds per square inch pressure until oil, free of air bubbles, flows out of the two ⅛ inch tapped openings. Work the metering valve back and forth lightly to flex the diaphragm, allowing the oil to flow into the unmetered fuel chamber. Plug both openings.

e. Place the regulator in an inverted position and apply oil at 7 to 9 pounds per square inch pressure for two minutes. While still applying oil pressure, right the regulator unit and loosen the four screws which secure the unmetered fuel valve chamber cover two turns each. When oil, free of air bubbles, flows out at the parting surface, tighten the screws securing the cover. Continue pumping oil and when it flows out of the water outlet opening in the triangular water transfer tube mounting pad on the left side of the regulator, place thumb over the opening in order to build up pressure within the control. Release and apply pressure with the thumb several times until oil, free of air bubbles, flows out of the opening.

f. Remove the oil feed line and place a gasket and a plywood cover on the water outlet pad. Install all the pipe plugs, using a small amount of anti-seize compound (white lead base) on the plug threads. Lockwire the plugs and screws. Attach a caution tag stating that the control unit has been preserved with oil. Roll the regulator around to insure coverage of all surfaces.

g. If oil feed equipment is unavailable, place the water regulator so that the three-stud water outlet pad is face up and fill the control

by pouring oil into the water outlet, the ⅛ inch opening beside the metering valve cover, and the ⅜ inch check valve chamber opening [12]. When the regulator unit is full, replace all plugs and the metering valve cover and roll the control around to cover all the internal parts with oil. Finally, mark the unit with a caution tag stating that the regulator unit has been preserved with oil.

Preserving Water Supply System

a. Disconnect the water supply line tube at the pump discharge port; then attach a hose to the port. Plug the end of the hose, and close the drain valve; then fill the tank and pump with slushing oil Grade 1065. With the hose overboard and unplugged, and the drain valve open, operate the water pump to insure complete coverage of the interior of the pump with oil.

b. Close the drain valve, plug the pump discharge port with a suitable cap, and seal the overboard vent line at the outer end with suitable plugs or moisture resistant tape. Install the water tank cap, and plug all lines disconnected from the regulator unit which have not been removed from the engine.

c. Attach a warning tag to the ignition switch stating that it is unsafe to start the engine until the water injection equipment has been reinstalled or entirely removed.

Depreserving — Regulators should be depreserved in accordance with instructions in INSTALLATION of this publication.

Cleaning Variable Flow Regulator Strainer

a. Remove the regulator supply line and the water pressure gage line.

b. Break the lockwire and remove the four internal hex head screws securing the control inlet cover.

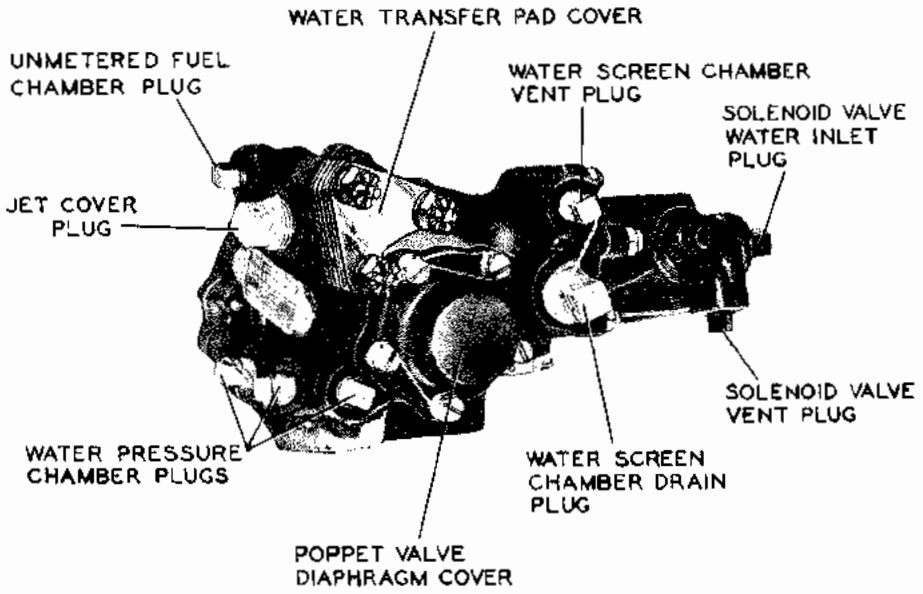
c. Remove the cover, strainer assembly, and gaskets.

d. Clean the strainer thoroughly with compressed air.

e. Replace the gaskets under and over the strainer flange with new ones; then reassemble the strainer and cover assembly and secure it with the four screws.

f. Lockwire the screws in pairs.

g. Connect and secure the regulator supply and pressure gage lines.



[12]

Cleaning Constant Flow Regulator Strainers

a. Remove the regulator supply line, the vapor vent line, and the electrical connection to the solenoid unit.

b. Remove the five locknuts and remove the solenoid valve assembly.

c. Lift out the regulator inlet strainer and clean it thoroughly with compressed air.

d. Replace the strainer and solenoid valve assembly with a new gasket and secure all lines and connections removed.

Solenoid Unit Check

If the solenoid unit of the regulator inlet valve (constant flow regulators) or the vapor vent valve (variable flow regulators) is suspected of faulty operation the unit may be checked as follows:

a. Connect an ammeter in series with the electromagnet circuit; then close the electric circuit. If the ammeter fails to register, the coil is open and must be replaced.

b. Test the coil with an ohmmeter. The coil resistance at room temperature should be between 36 and 40 ohms. If the resistance is not within these limits, the coil should be replaced.

Constant Flow Regulator Solenoid Unit Replacement.

a. Remove the electrical connection to the coil unit.

b. Break the lockwire and remove the four fillister head screws securing the solenoid unit to the inlet valve assembly.

c. Install the new unit and secure it with the screws, washers, and lockwire.

d. Secure the control wire connector plug in position on the new unit.

Lubrication

No lubrication is required for the water injection regulator covered by this publication.

Service Troubles and Remedies

The following Trouble Shooting Chart is provided as a guide to the nature of, cause, and suggested remedy for some of the more common water injection system operational irregularities.

For inspection and repair instructions referred to in the Trouble Shooting Chart, but not covered by this publication, see the water injection regulator OVERHAUL INSTRUCTIONS.

TROUBLE SHOOTING CHART — VARIABLE FLOW REGULATORS

Trouble	Probable Cause	Correction
High water injection pressure under no flow condition.	Pressure regulator or pump relief valve out of adjustment.	Low pressure setting.
Flow indicating light does not come on, comes on late, or flickers.	1. Flow indicating light switch is set too high.	1. Check flow indicating light switch for proper operation. The pressure at which the flow indicating light comes on and goes off should be checked in accordance with the airplane manufacturer's instructions. The minimum pressure to close the light switch recommended by Pratt and Whitney is 17 pounds per square inch.
	2. Water injection pressure is low.	2. Increase pressure.
	3. Unmetered fuel pressure plug in bottom of carburetor was not removed when carburetor was installed.	3. A check for the plug is to remove the external unmetered fuel plug from the top of the water regulator and then turn on the fuel booster pump. If a stream of fuel does not come out of the opening, the plug is in the passage and must be removed.
	4. Defective flow indicating light switch.	4. Replace switch assembly.
	5. Defective wiring in flow indicating light circuit.	5. Check circuit and correct as required.
	6. Flow indicating light bulb burned out.	6. Replace bulb.
	7. Improper flow indicating light bulb contact.	7. Check bulb and installation. Replace bulb and/or socket if necessary.

TROUBLE SHOOTING CHART — VARIABLE FLOW REGULATORS

Trouble	Probable Cause	Correction
	8. Water inlet line valves stuck in closed position.	8. Disconnect line at regulator and replace valve if no water flow with water injection switch on.
	9. Carburetor metering head low.	9. Replace carburetor if leanness substantiated by other data.
	10. Carburetor air temperature excessively high.	10. Make certain carburetor heat control is in full cold position.
Flow indicating light comes on early.	1. Improper setting of flow indicating light switch.	1. Check operation of derichment pressure light switch.
	2. Vapor vent shut off valve stuck closed.	2. Repair or replace valve.
	3. Leaking solenoid or check valve.	3. Replace valves.
Engine roughness with water switch on (low power).	1. Water regulator pressure regulating valve diaphragm failed or leaking.	1. Replace water injection control.
	2. Plug left in carburetor unmetered fuel passage.	2. A check for the plug is to remove the external unmetered fuel plug from the top of the water control and then turn on the fuel booster pump. If a stream of fuel does not come out of the opening, the plug is in the passage and must be removed.
Momentary loss of power when water turned on at low engine power.	1. Partial restriction of unmetered fuel passage.	1. Remove restriction.
	2. Vapor vent shut-off valve stuck closed.	2. Repair or replace vapor vent valve.

TROUBLE SHOOTING CHART — VARIABLE FLOW REGULATORS

Trouble	Probable Cause	Correction
Continual water flow out of supercharger drain (carburetor in idle cut-off) when water injection switch turned on.	1. Water injection regulator vent valve stuck closed.	1. Disconnect vapor vent line down stream of valve and replace if no flow observed.
(a) Fuel boost pump off.	2. Unsatisfactory sealing of drain pad cover on regulator.	2. Replace blank gasket (and cover if distorted).
	3. Pressure regulating valve not seating properly.	3. Replace water injection regulator if water flows out of derichment line connection.
(b) Fuel boost pump operating.	1. Bent or leaking fill valve.	1. Replace carburetor.
	2. Poppet valve diaphragm failure.	2. Replace carburetor.
Liquid flow into water tank.	Vapor vent line valve leaking and	Disconnect vent line at tank end and build up nozzle pressure. Repair or replace valve if flow observed.
(a) Through vent line.	a. Main metering valve diaphragm leaking, or	a. Replace water injection regulator.
	b. Check valve leaking, or	b. Replace water injection regulator.
	c. Check valve diaphragm leaking.	c. Replace water injection regulator.
(b) Through water inlet line.	Water inlet valve leaking and	Disconnect line at water regulator and turn on water pump. Repair or replace valves if leakage observed.
	a. Main metering valve diaphragm leaking, or	a. Replace water injection regulator.
	b. Check valve leaking, or	b. Replace water injection regulator.
	c. Check valve diaphragm leaking.	c. Replace water injection regulator.

TROUBLE SHOOTING CHART — VARIABLE FLOW REGULATORS

Trouble	Probable Cause	Correction
Flow indicating light stays on at low power.	1. Water injection pressure too high.	1. Reduce pressure.
	2. Vapor vent shut-off valve stuck closed.	2. Repair or replace valve.
Low water injection pressure under no flow condition.	1. Low voltage at water injection pump.	1. Check voltage at pump. Normal voltage drop at pump with pump running is approximately 1 volt.
	2. Dirty water injection pump strainer.	2. Remove, clean and reinstall strainer.
	3. System strainer dirty.	3. Remove, clean and reinstall system strainer.
	4. Pressure regulator out of adjustment.	4. Increase pressure setting of pressure regulator.
	5. Water injection pump defective.	5. Replace water injection pump.
	6. Defective pressure transmitter and/or pressure indicator.	6. Check pump pressure with a direct reading gauge and replace defective unit.
No pressure indication when water injection switch is turned on.	1. Inverter switch off.	1. Turn inverter switch on.
	2. Defective wiring in water injection pump circuit.	2. Check circuit.
	3. Defective wiring in water injection pressure indicator system.	3. Check circuit.
	4. Defective water injection pressure transmitter and/or indicator.	4. Check water injection pump pressure with a direct reading gauge. If this does not compare with indication of airplane's gauge, replace either the indicator or the transmitter as required.

TROUBLE SHOOTING CHART – VARIABLE FLOW REGULATORS

Trouble	Probable Cause	Correction
	5. Defective water injection pump assembly.	5. Replace water injection pump assembly.
	6. Stuck water feed line valves.	6. Replace valve.
Backfiring and loss of power.	1. Water supply exhausted, pump supplying air to control system.	1. Fill tank with water.
	2. Automatic pump shut-off inoperative.	2. Check wiring and adjustment of shut-off.
	*3. Derichment valve stuck open or partially open (carburetor).	3. Remove derichment valve cover and check movement of valve. Repair or replace as necessary.

*Sticking of the derichment valve in the full open position permitting underiched fuel flow and water flow will cause a maximum power loss of approximately 5 per cent due to the high liquid/air ratio.

TROUBLE SHOOTING CHART – CONSTANT FLOW REGULATORS

Trouble	Probable Cause	Correction
Low fluid pressure in the operating range of the water injection system.	1. Low voltage at pump.	1. Check voltage at pump. Normal voltage drop at pump with pump running is approximately 1 volt.
	2. Dirty pump strainer.	2. Remove, clean, and reinstall strainer.
	3. Inverter switch off.	3. Turn inverter on.
	4. Pressure regulator out of adjustment.	4. Increase pressure setting of pressure regulator.
	5. Pump defective.	5. Replace pump.
	6. Defective wiring in pump circuit.	6. Check circuit and repair as required.
	7. Defective wiring in water injection pressure indicator system.	7. Check circuit and repair as required.

TROUBLE SHOOTING CHART – CONSTANT FLOW REGULATORS

Trouble	Probable Cause	Correction
	8. Defective water injection pressure transmitter and/or indicator.	8. Check water injection pump pressure with a direct reading gage. If this does not compare with indication of airplane's gage, replace either the indicator or the transmitter as is required.
	9. Defective manifold pressure valve or wiring.	9. Check by turning on manual by-pass switch. Repair or replace as required.
	10. No fluid in water tank.	10. Fill tank.
	11. Improperly operating float switch.	11. Repair float switch or replace tank.
Low water flow in the operating range of the water injection system.	1. Unmetered fuel pressure passage from carburetor to control plugged.	1. If no unmetered fuel flow to water injection regulator, check for shipping plug in carburetor base flange or obstruction in drilled passage.
	2. Unmetered fuel valve not opening.	2. Replace water injection regulator.
Backfiring and /or loss of power with water injection system on.	1. Water supply exhausted and/or pump supplying air to system.	1. Fill with water injection fluid.
	*2. Derichment valve stuck open or partially open (carburetor).	2. Remove derichment valve cover and check movement of valve. Repair or replace as required.
**Excessive liquid flow from the supercharger drain when the engine is inoperative, the water injection switch turned on, the mixture control in idle cutoff and fuel boost pump off.	1. Pressure regulating valve not seating properly.	1. Replace water injection regulator.
	2. Excessive clearance between pressure regulating valve and guide.	2. Replace water injection regulator.
	3. Ruptured unmetered fuel valve diaphragm.	3. Replace water injection regulator.

TROUBLE SHOOTING CHART — CONSTANT FLOW REGULATORS

Trouble	Probable Cause	Correction
**Excessive liquid flow from the supercharger drain when the engine is inoperative, the water injection switch turned on, the mixture control in idle cut-off and the fuel boost pump operating.	1. Bent or leaking fill valve. 2. Poppet valve diaphragm failure.	1. Replace carburetor. 2. Replace carburetor.
Backfiring or lean operation at lower power with water off.	Metered fuel returning to water tank.	Repair or replace water regulator check valve and water inlet shut-off valve.
Engine roughness or loss of power when water injection regulator is operating.	1. Punctured derichment valve diaphragm. 2. Punctured diaphragm in water injection regulator. 3. Water injection regulator poppet valve not seating or sticking open. 4. Excessive water flow due to incorrect water injection regulator setting.	1. Replace diaphragm. 2. Replace water injection regulator. 3. Replace water injection regulator. 4. Replace water injection regulator.
Liquid flow to water injection regulator with water injection switch off.	Leaking water injection regulator valve line solenoid and firewall shut-off valve.	Repair or replace both units.
Lower than nozzle pressure registering on gage with water injection switch off.	1. Defective gage or wiring. 2. Improper venting of discharge nozzle or water pressure gage.	1. Repair or replace. 2. Check for restrictions in either vent line and for venting to same reference pressures.

*Note — Sticking of the derichment valve in the full open position permitting underiched fuel flow and water flow will cause a maximum power loss of approximately 5% due to high liquid/air ratio.

**Normal flow approximately 50 pounds per hour.

TROUBLE SHOOTING CHART — CONSTANT FLOW REGULATORS

Trouble	Probable Cause	Correction
	3. Fuel feed valve sticking open, leaking, or spring broken.	3. Repair or replace fuel feed valve assembly.
Higher than nozzle pressure registering on gage with water injection switch off.	1. Ruptured derichment valve diaphragm. 2. Fuel feed valve diaphragm vent plugged. 3. Sticking fuel feed valve.	1. Replace diaphragm. 2. Repair or replace fuel feed valve assembly or carburetor. 3. Replace fuel feed valve assembly.
Water inlet pressure registering with pump on and water inlet switch off.	Leaking water inlet valves.	Repair or replace valves.
Take-off fuel flow does not decrease when water injection operating pressure is obtained.	1. Derichment line clogged. 2. Derichment valve stuck open.	1. Clean or replace line. 2. Repair or replace derichment valve.

Water Injection Regulators

INDEX