R-760 E2 14397
Eng. Spec # 243 ATC # 156

66

INSTRUCTION BOOK

WRIGHT WHIRLWIND
7 & 9
AIRCRAFT ENGINES

Series R-760E and R-975E

Installation, Operation, and Service Maintenance

Eleventh Edition
(PART No. 111429N11)

WRIGHT AERONAUTICAL CORPORATION
(A Division of Curtiss-Wright Corporation)
PATERSON, NEW JERSEY
NOVEMBER, 1942

PREFACE

THIS INSTRUCTION BOOK has been written for operators of Whirlwind Aircraft engines manufactured by the Wright Aeronautical Corporation, Division of Curtiss-Wright Corporation, Paterson, New Jersey, U.S.A.

Included in the instructions are a description of the engine parts; directions for preparing the engine for storage or service; general installation information; recommended operating procedures; a description of Wright engine performance curves; a list of the more elementary troubles, their causes and remedies; a periodic inspection chart, and complete overhaul instructions with Tables of Limits and Limits and Lubrication Charts. It is urgently recommended that these instructions be followed closely for all average conditions and that the Service Division of the Wright Aeronautical Corporation be consulted before any deviation from them is made.

For the benefit of its customers, the Wright Aeronautical Corporation issues separate publications which will be supplied to owners of Wright engines, at no charge, upon request to the factory. For non-owners, a price list of publications is available and will be supplied upon request. These publications are:

Service Bulletins — These are issued for those actively engaged in servicing Wright engines to supplement the instructions contained herein as additional information and improvements become available, or when changes in certain operating or servicing procedures are recommended.

Parts Catalog (Part No. 850343) — This catalog lists and describes the parts for the Whirlwind R-760E and R-975E engines. A separate Parts and Tools Price List is available and will be supplied upon request.

Tool Catalog (Part No. 851445) — This catalog lists and describes the tools for overhauling and reconditioning Wright Whirlwind R-760-E and R-975-E Aircraft engines. A separate Parts and Tools Price List is available and will be supplied upon request.

Limits and Lubrication Charts (20" by 30") — These charts, which are to be used in conjunction with current editions of the Tables of Limits, contain reference numbers indicating the location of fits and clearances. They also designate the engine lubrication system in colors. These charts are similar to the reduced size charts contained in this Instruction Book.

Cruising Power Calculators — These calculators furnish a quick means of computing the engine horsepower output for any normal combination of r.p.m. manifold pressure, and altitude.

The Wright Aeronautical Corporation welcomes suggestions for improving the engine, its equipment or its servicing, and invites constructive criticism of this Instruction Book. Such suggestions are greatly appreciated and will receive careful consideration. It is earnestly requested that all service problems be submitted to the Service Division.

TABLE OF CONTENTS

CHAPTER IV — Operation

CHAPTER V — Wright Engine Performance Curves

CHAPTER VI — Trouble Shooting

CHAPTER VII — Periodic Inspection

CHAPTER VIII — Dismantling, Cleaning, and Inspection

CHAPTER IX—Disassembly, Inspection, Repair, and Assembly

CHAPTER IX (Continued)

CHAPTER X — Final Assembly and Test

APPENDIX

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

RELEASED MATERIALS AND ACCESSORIES

THE WRIGHT AERONAUTICAL CORPORATION conducts a continual investigation of a large number of materials and accessories to determine which may be used with each model of Wright aircraft engines without impairing or adversely affecting the proper functioning or reliability of the engine. Certain materials and accessories thus investigated have been released by the Wright Aeronautical Corporation for use with each model of Wright aircraft engines. Such a release signifies that the specified material or accessory may be used with the specified engine model without thereby voiding the engine guarantee. The use of materials and accessories not released by the Wright Aeronautical Corporation constitutes a misuse of the engine and voids the guarantee.

The release of a material or accessory by the Wright Aeronautical Corporation is not a guarantee by the engine manufacturer of the durability or satisfactory operation of a material or accessory, inasmuch as they are usually guaranteed separately by their respective manufacturers.

Two classifications of released materials and accessories exist:

(1) Materials and accessories supplied but not manufactured by the Wright Aeronautical Corporation, such as carburetors, magnetos, oil strainers, ignition wire, and ignition wiring harnesses. Materials and accessories in this classification are released only when procured from the Wright Aeronautical Corporation or through its authorized agents. Replacement parts for released accessories in this classification must be procured from the accessory manufacturer or through the authorized agents of that manufacturer or from the Wright Aeronautical Corporation or through its authorized agents. Adequate service instructions for these accessories will be furnished by the accessory manufacturer upon request.

(2) Materials and accessories neither manufactured nor normally supplied by the Wright Aeronautical Corporation, such as fuels, lubricating oils, spark plugs, fuel pumps, starters, generators, alternators, vacuum pumps and hydraulic pumps. Spark plugs, although supplied by the engine manufacturer with new engines, are handled as an accommodation only. Whenever possible, spark plugs should be purchased directly from the spark plug manufacturer or through that manufacturer's authorized representative. Replacement parts for released accessories in this classification must be procured from the accessory manufacturer or through the authorized agents of that manufacturer.

All released materials and accessories in group (1) are listed in the parts catalogs, parts lists, or other publications of the Wright Aeronautical Corporation.

A wide selection of released materials and accessories in group (2) is available for each engine model and installation. A complete list of these items is not published by the Wright Aeronautical Corporation, because it would be practically impossible to keep such a large publication up to date with current releases. However, detailed information on these releases may be obtained upon request to the Service Division. When requesting such information, give the model designation and serial number of the engine involved. For the convenience of service stations and operators, bulletins will occasionally be issued listing certain released materials and accessories, such as engine lubricating oils and spark plugs.

Engine materials and accessories released by the Wright Aeronautical Corporation are recommended in the interest of safe flying, and to assist the operator in obtaining the maximum performance, reliability, and service life from his engine. It is therefore highly recommended that operators communicate with the Service Division whenever there is any doubt as to a release, or prior to any action concerning the installation of accessories on engines in new aircraft, the installation of accessories on modernized engines, the installation of additional accessories on an engine, or any changes which are to be made in the materials or accessories used with an engine.

Under no conditions should any structural engine part, such as an oil pump, bearing, valve, bushing, gasket, or piston ring, which has not been procured from the Wright Aeronautical Corporation or through its authorized agents be used on a Wright aircraft engine. The use of such a part is contrary to the interests of safe engine operation and voids the engine guarantee.

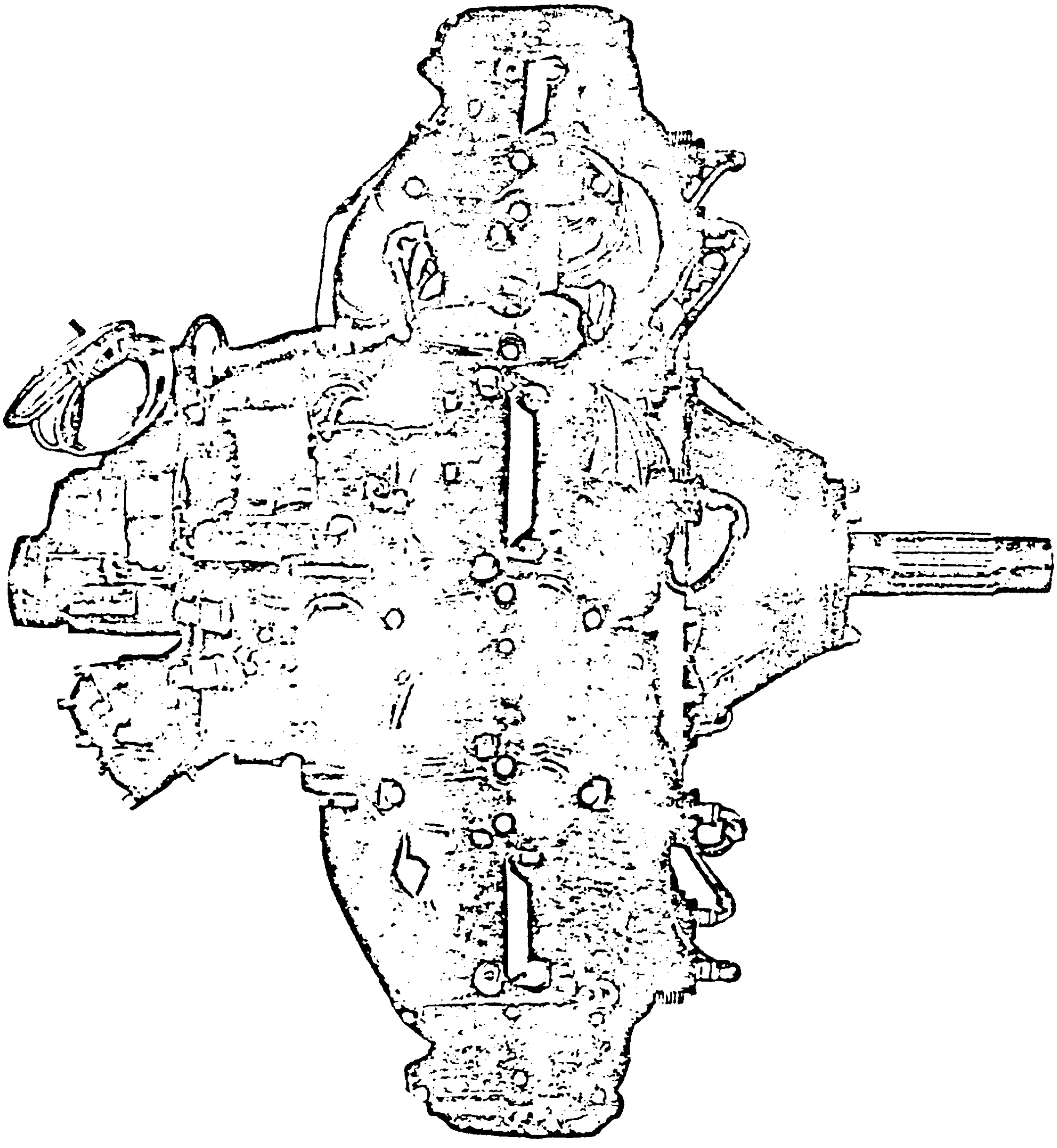


FIGURE A
Wright Whirlwind R-975E Aircraft Engine
(Right Side View)

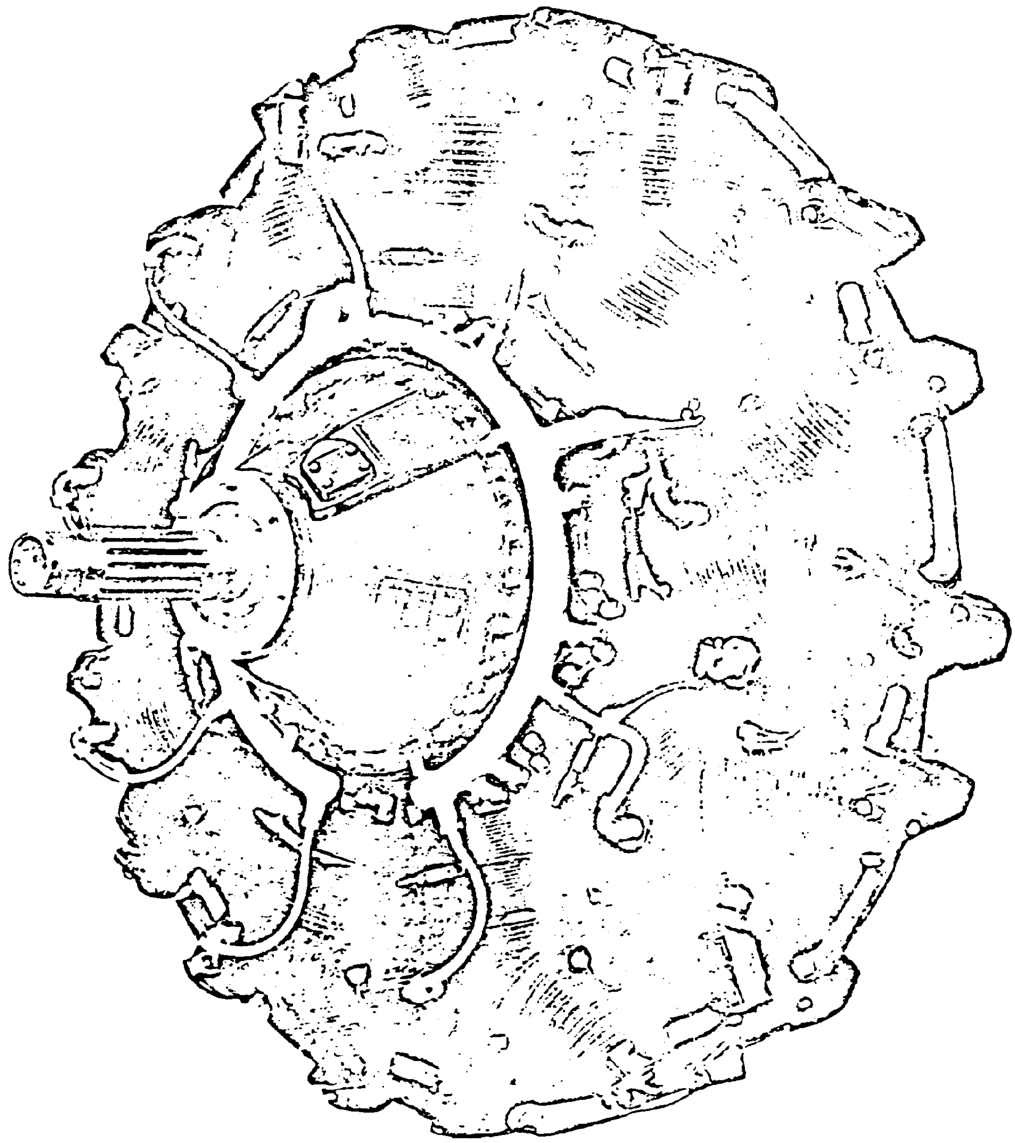


FIGURE B
Wright Whirlwind R-975E Aircraft Engine
(Three-Quarter Left Front View)

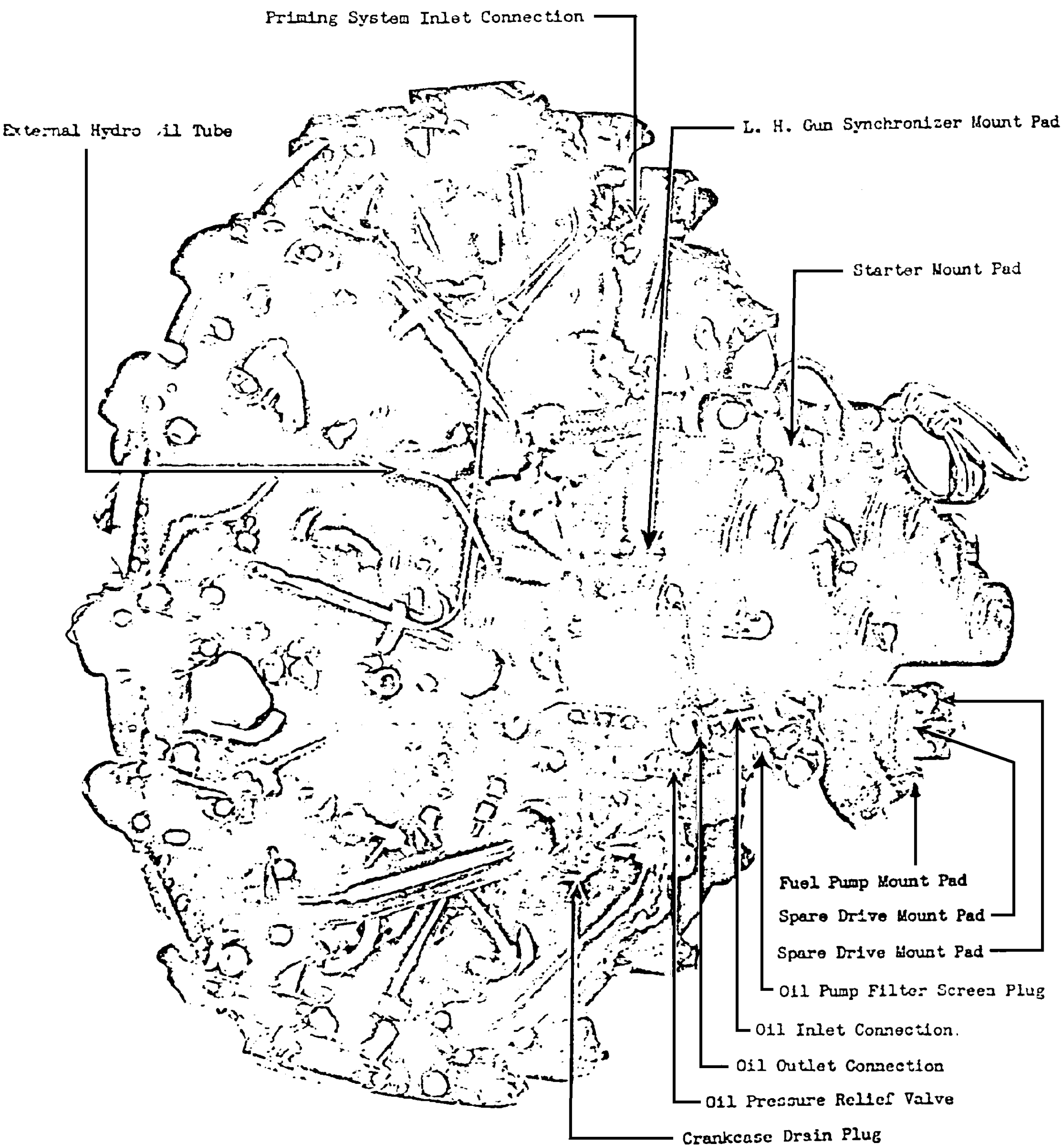


FIGURE C
Wright Whirlwind R-975E Aircraft Engine
(Three-Quarter Left Rear View)

(17)

ENGINE CHARACTERISTICS

NAME	Wright Whirlwind
SERIES	R-760E
MODELS	E-1, E-2, and ET
TYPE	Static Radial—Air Cooled
NUMBER OF CYLINDERS	7
BORE	5.00 In. (127.0 mm.)
STROKE	5.50 In. (139.7 mm.)
DISPLACEMENT	756 Cu. In. (12.39 Lit.)
RATED R.P.M. OF CRANKSHAFT	
Model ET	2000
Model E-1	2100
Model E-2 T.O: 320 HP 34"	2200 ← T.O. 2400, MAP 35" E-2 350 HP
RECOMMENDED CRUISING R.P.M. OF CRANKSHAFT	
Model ET	1800
Models E-1 and E-2	1900
MAXIMUM CRUISING R.P.M. OF CRANKSHAFT	
Model ET	1850
Models E-1 and E-2	2000
ROTATION OF PROPELLER SHAFT (Looking at Anti-Prop. End)	Clockwise
GRADE OF OIL REQUIRED	W.A.C. Spec. No. 5815
OIL CONSUMPTION (Approx. Max.—Service Figs. May be Lower)	
At Rated r.p.m.	
Model ET	0.6 Gal./Hr. (2.27 Lit./Hr.)
Models E-1 and E-2	1.0 Gal./Hr. (3.78 Lit./Hr.)
At Recommended Cruising r.p.m.	
Model ET	0.4 Gal./Hr. (1.52 Lit./Hr.)
Models E-1 and E-2	0.5 Gal./Hr. (1.90 Lit./Hr.)
OIL-IN TEMERATURE (Desired)	140° F. (60° C.)
OIL-IN TEMPERATURE (Max. Permissible)	190° F. (88° C.)
OIL PRESSURE	
Model ET	50-80 Lb./Sq. In. (3.51—5.62 Kg./Sq. Cm.)
Models E-1 and E-2	60-80 Lb./Sq. In. (4.21—5.62 Kg./Sq. Cm.)
HEAT TO OIL AT NORMAL POWER AND RATED R.P.M.	
Approximate Maximum	
Model ET	125 B.T.U./Min. (31.5 Kg. Cal./Min.)
Model E-1	130 B.T.U./Min. (32.8 Kg. Cal./Min.)
Model E-2	200 B.T.U./Min. (50.4 Kg. Cal./Min.)
OIL CIRCULATION AT RATED R.P.M. AND 140° F. (Approx. Max.)	
Model ET	9 Lb./Min. (4.1 Kg./Min.)
Models E-1 and E-2	10 Lb./Min. (4.5 Kg./Min.)

ENGINE CHARACTERISTICS (Continued)

EL CONSUMPTION

Curves which accompany the "Engine Specification" show minimum fuel consumption values obtainable under favorable conditions.

L REQUIRED

Models E-1 and ET (73 Octane Rating) .... W.A.C. Spec. No. 5809
Model E-2 (80 Octane Rating) .... W.A.C. Spec. No. 5804

EL SUPPLY PRESSURE .... 2.5—3.5 Lb. Sq. In. (.18—.25 Kg. Sq. Cm.)

NDER TEMPERATURES

Cylinder Head—Using Spark Plug Washer Type Couple
- Normal Maximum .... 450° F. (232° C.)
- Maximum Permissible for Short Periods .... 500° F. (260° C.)

Cylinder Barrel—Using Embedded Type Couple
- Maximum Permissible .... 325° F. (163° C.)

OPELLER SHAFT SPLINE SIZE

Models E-1, E-2 and ET .... S.A.E. No. 20
Models E-2 and ET .... S.A.E. No. 30

NGTH OF BARE ENGINE

Models E-1, E-2, and ET .... 42.44 In. (107.8 Cm.)

METER OF BARE ENGINE .... 45 In. (114.3 Cm.)

DRY WEIGHT OF BARE ENGINE INCLUDES THE FOLLOWING:

Scintilla Magnetos
Ignition Wiring and Spark Plugs
Radio Shielding—Model E-2 Engines
Stromberg NA-R7A Carburetor, Air Heater, and Cleaner
Propeller Hub Cones and Nut
Oil Filter
Fuel Pump Drive
Tachometer Drives
Generator Drive—Model E-2 Engines
Vacuum Pump Drive—Model E-2 Engines
Cylinder Barrel and Head Air Deflectors—Model E-1 and E-2 Engines
Provisions for use of:
- Hydraulic Controllable Propeller
- Impulse Generator Drives

TOTAL DRY WEIGHT
- Models E-1 and E-2 .... 570 Lb. ± 1% (258 Kg.)
- Model ET .... 540 Lb. ± 1% (245 Kg.)

WEIGHT OF EQUIPMENT NOT INCLUDED IN DRY WEIGHT OF BARE ENGINE

Nose Cowl .... 6.5 Lb. (2.95 Kg.)
Carburetor Air Duct and Screen .... 7.0 Lb. (3.18 Kg.)
Front Exhaust Collector Ring, Pipes, Flanges, and Elbows .... 22.5 Lb. (10.20 Kg.)
Rear Exhaust Flanges and Elbows .... 4.5 Lb. (2.04 Kg.)
Lifting Cable Assembly .... 3.25 Lb. (1.47 Kg.)
Tool Kit .... 18.0 Lb. (8.15 Kg.)
Instruction Book .... 1.0 Lb. (.45 Kg.)
Domestic Shipping Box (54" x 53" x 49" High—Approx.) .... 450 Lb. (204.00 Kg.)

APPROXIMATE TOTAL SHIPPING WEIGHT
- Models E-1 and E-2 .... 1080 Lb. (490 Kg.)
- Model ET .... 1050 Lb. (476 Kg.)

ENGINE CHARACTERISTICS (Continued)

NAME	Wright Whirlwind
SERIES	R-975E
MODELS	E-1 and E-3
TYPE	Static Radial—Air Cooled
NUMBER OF CYLINDERS	9
BORE	5.00 In. (127.0 mm.)
STROKE	5.50 In. (139.7 mm.)
DISPLACEMENT	973 Cu. In. (15.91 Lit.)
RATED R.P.M. OF CRANKSHAFT	
Model E-1	2100
Model E-3	2250
RECOMMENDED CRUISING R.P.M. OF CRANKSHAFT	
Models E-1 and E-3	1900
MAXIMUM CRUISING R.P.M. OF CRANKSHAFT	
Model E-1	1950
Model E-3	2000
ROTATION OF PROPELLER SHAFT (Looking at Anti-Prop. End)	Clockwise
GRADE OF OIL REQUIRED	W.A.C. Spec. No. 5815
OIL CONSUMPTION (Approx. Max.—Service Figs. May be Lower)	
At Rated r.p.m.	1.5 Gal./Hr. (5.68 Lit./Hr.)
At Recommended Cruising r.p.m.	0.75 Gal./Hr. (2.84 Lit./Hr.)
OIL-IN TEMPERATURE (Desired)	140° F. (60° C.)
OIL-IN TEMPERATURE (Max. Permissible)	190° F. (88° C.)
OIL PRESSURE	60-80 Lb./Sq. In. (4.22—5.62 Kg./Sq. Cm.)
HEAT TO OIL AT NORMAL POWER AND RATED R.P.M. (Approximate Maximum)	
Models E-1 and E-3	400 B.T.U./Min. (101 Kg. Cal./Min.)
OIL CIRCULATION AT RATED R.P.M. AND 140° F. (Approx. Max.)	
Model E-1	12 Lb./Min. (5.4 Kg./Min.)
Model E-3	14 Lb./Min. (6.35 Kg./Min.)

FUEL CONSUMPTION

Curves which accompany the "Engine Specification" show minimum fuel consumption values obtainable under favorable conditions.

FUEL REQUIRED	
Model E-1 (73 Octane Rating)	W.A.C. Spec. No. 5809
Model E-3 (80 Octane Rating)	W.A.C. Spec. No. 5804
FUEL SUPPLY PRESSURE	2.5—3.5 Lb./Sq. In. (.18—.25 Kg/Sq. Cm.)

ENGINE CHARACTERISTICS (Continued)

CYLINDER TEMPERATURES

Cylinder Head—Using Spark Plug Washer Type Couple

Normal Maximum	450° F. (232° C.)
Maximum Permissible for Short Periods	500° F. (260° C.)

Cylinder Barrel—Using Embedded Type Couple

Maximum Permissible	325° F. (163° C.)
PROPELLER SHAFT SPLINE SIZE	S.A.E. No. 30
LENGTH OF BARE ENGINE	41.2 In. (104.65 Cm.)
DIAMETER OF BARE ENGINE	45 In. (114.3 Cm.)

DRY WEIGHT OF BARE ENGINE INCLUDES THE FOLLOWING:

Scintilla Magnetos
Ignition Wiring and Spark Plugs
Stromberg NA-R9A Carburetor, Air Heater, and Cleaner
Oil Filter
Fuel Pump Drive
Tachometer Drives
Exhaust Elbows, Flanges, and Gaskets
Generator Drive—Model E-3 Engines
Vacuum Pump Drive—Model E-3 Engines
Cylinder Barrel and Head Air Deflectors—Models E-1 and E-3 Engines
Automatic Valve Gear Lubrication
All Cover Plates
Provisions for use of:
Hydraulic Controllable Propeller
Gun Synchronizer Impulse Generator Drives (two)

TOTAL DRY WEIGHT

Model E-1	660 Lb. ± 1% (299 Kg. ± 1%)
Model E-3	675 Lb. ± 1% (306 Kg. ± 1%)

WEIGHT OF EQUIPMENT NOT INCLUDED IN DRY WEIGHT OF BARE ENGINE

Nose Cowl	6.5 Lb. (2.95 Kg.)
Carburetor Air Duct and Screen	13.0 Lb. (5.90 Kg.)
Front Exhaust Collector Ring and Pipes	26.0 Lb. (11.79 Kg.)
Rear Exhaust Hot Spot and Piping	5.75 Lb. (2.61 Kg.)
Lifting Cable Assembly	3.25 Lb. (1.47 Kg.)
Tool Kit	18.0 Lb. (8.15 Kg.)
Instruction Book	1.0 Lb. (.45 Kg.)
Domestic Shipping Box (54" x 53" x 49" High—Approx.)	450 Lb. (204.00 Kg.)
APPROXIMATE TOTAL SHIPPING WEIGHT	1200 Lb. (545 Kg.)

GENERAL DESCRIPTION

THE Wright Whirlwind R-760E and R-975E aircraft engines are of the single row, static radial, air cooled type, operating on the conventional four stroke cycle. Series R-760E engines have seven cylinders and Series R-975E, nine cylinders.

CYLINDERS

Each cylinder is built up by screwing and shrinking a cast aluminum head onto a forged steel barrel, the threads of which have been treated with a sealing compound to prevent leakage. The rocker support boxes are cast integrally with the head. (Refer to figure 1.)

The head is finned for cooling, the fins being a part of the casting. The exhaust port faces to the side and the intake port to the rear of the cylinder. The side exhaust port permits the use of either a front or rear exhaust system. A bronze

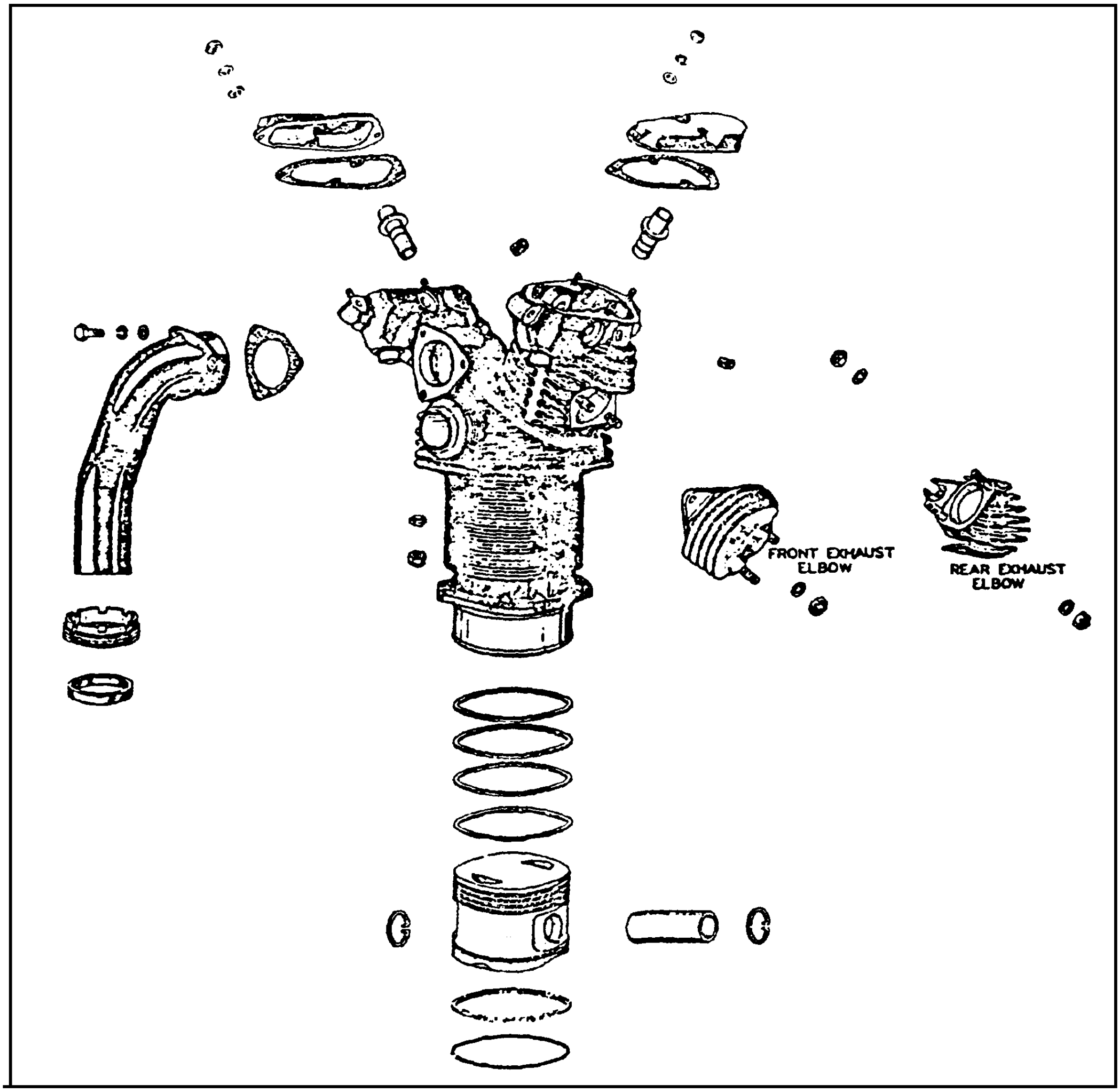


FIGURE 1—*Cylinder, Intake Pipe, and Piston*

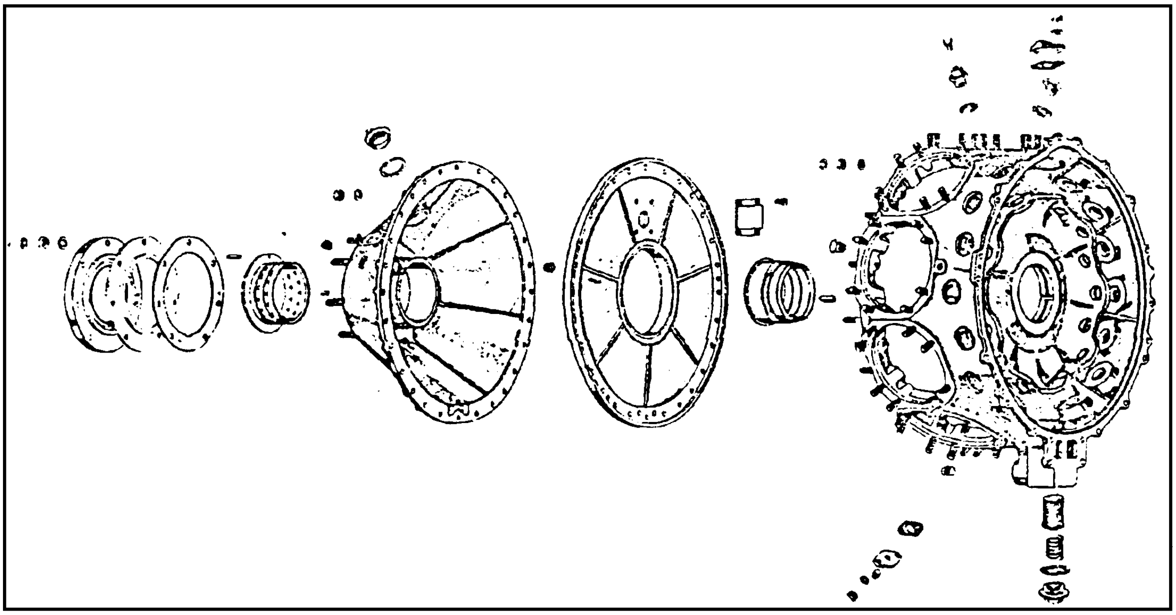


FIGURE 2—Crankcase Front Section (Without provision for mounting propeller governor), Main Bearing Support, and Main Section

intake pipe connection is shrunk and riveted into the intake port. The intake pipes are of steel tubing. They are fastened to the intake port connections of each cylinder by means of a flange and three cap screws. The inner end of each intake pipe fits into the tangential opening

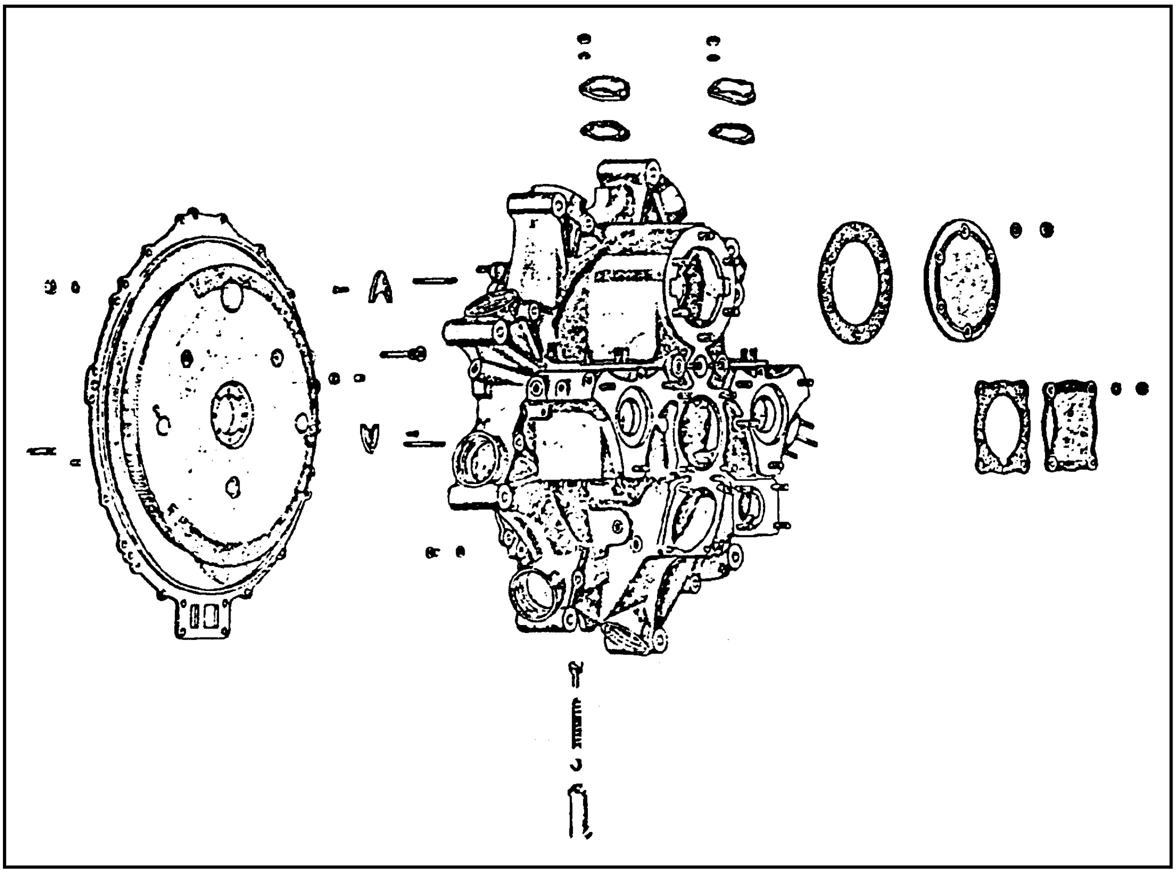


FIGURE 3—Crankcase Diffuser and Rear Sections

of the distribution chamber and is held snugly in place by means of a rubber seal and packing nut. The exhaust port has no inserted connection but is machined to receive an exhaust elbow and is provided with studs by which the elbow is fastened. The elbow is finned for cooling and is provided with studs by which the exhaust pipe is fastened. Bronze valve guides are shrunk into bosses within the valve ports. Valve seat inserts are shrunk into the inside of the head at an angle to the center line of the cylinder, permitting a hemispherical combustion chamber. The intake valve seat insert is made of bronze and the exhaust valve seat insert of steel. Openings are provided in both the front and rear of the cylinder head into which bronze spark plug inserts are screwed, shrunk, and pinned. These bronze inserts are fitted into finned caps which materially assist in the cooling of the region of the spark plug bosses. The intake and exhaust rocker boxes are provided with four studs for securing the rocker box covers. Bosses are cast at the front and rear of both rocker boxes for securing the engine cowling. Push rod housing connections are screwed into the rear end of the rocker box housings forming an oil tight seal.

The forged steel barrel is machined with a cylinder hold-down flange and closely spaced cooling fins. The barrel is heat-treated as an additional safeguard against scoring.

The cylinder is secured to the cylinder pad on the main section of the crankcase by means of eight studs, nuts, and palnuts.

CRANKCASE

The cranckcase is composed of five aluminum alloy castings, secured together through substantial flanges. The five sections are referred to as the front section, the front main bearing support, the main section, the diffuser section, and the rear section. (Refer to figures 2 and 3.)

The front section is a conical shaped casting which houses the thrust ball bearing and crankshaft oil seal adapter. In this section provision is made for mounting a propeller governor by means of a suitable adapter to obtain constant speed performance. The adapter is so constructed that either the governor drive assembly or the two-piston, hydro-controllable-pitch propeller operating valve may be used. (Refer to figures 4 and 5.) The front section incorporating only the hydro-control valve does not provide mounting for the adapter. A front cover, which acts as a retainer for the thrust bearing, is secured to the front section by studs.

The front main bearing support is a light metal diaphragm of which the principal function is to support the front main roller bearing.

The main section provides the cylinder pads

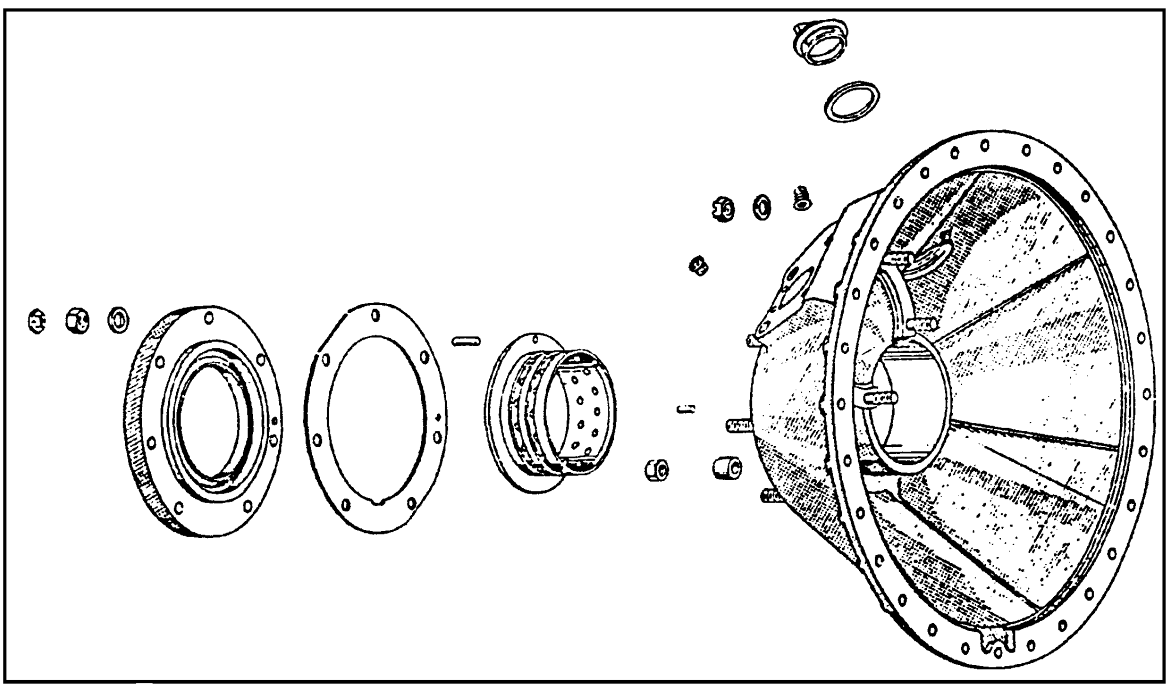


FIGURE 4—Crankcase Front Section (With provision for mounting propeller governor)

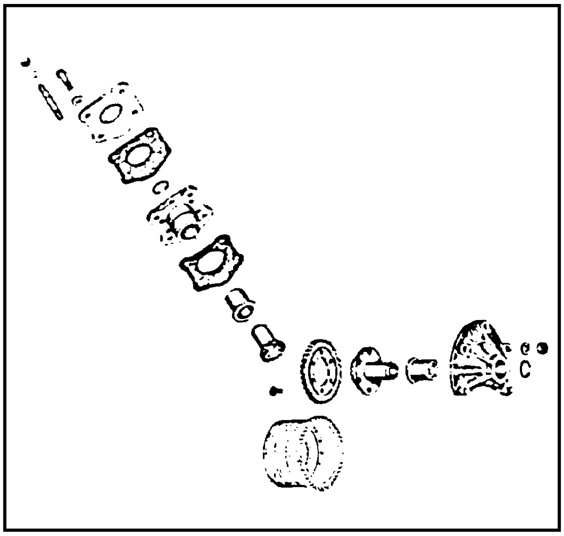


FIGURE 5—*Propeller Governor Drive*

and hold-down studs, supports the crankshaft rear main bearing, the cam follower or valve tappet guides, and houses the cam and the cam followers or tappets. Studs on the front parting flange of the section receive the flanges of the front main bearing support and front sections.

The diffuser section is a metal diaphragm, the rear side of which forms the front wall of the diffuser and distribution chamber. This section supports the supercharger impeller, and its drive, and in the R-975E series engines, two accessory drive idler gears. The R-760E series engines do not incorporate accessory drive idler gears. The R-760ET engines do not have an impeller or impeller drives. Three bushings in the diffuser section support the forward ends of the starter shaft and the two accessory drive shafts. These shafts extend through the diffuser chamber to the rear section. The three bushings in the diffuser section project out of the rear of the section to house the portions of the shafts which pass through the diffuser chamber.

The rear section supports the accessory drives and provides the mounting pads for the various accessories. The forward end of this section forms the rear wall of the diffuser and distribution chambers and provides the intake pipe connections which lead tangentially from the distribution chamber. The engine mounting bosses are located at the intake pipe connections. Series R-975E engines are provided with a double mounting bolt circle. In addition to the Whirlwind inner mounting circle, these engines have a mounting bolt circle which is of the same diameter as that of Wright Cyclone engines. The parting flange of the rear section is provided with studs to receive the main and diffuser sections.

CRANKSHAFT

The crankshaft is a two-piece, single-throw, counterbalanced assembly, machined from nickel-steel

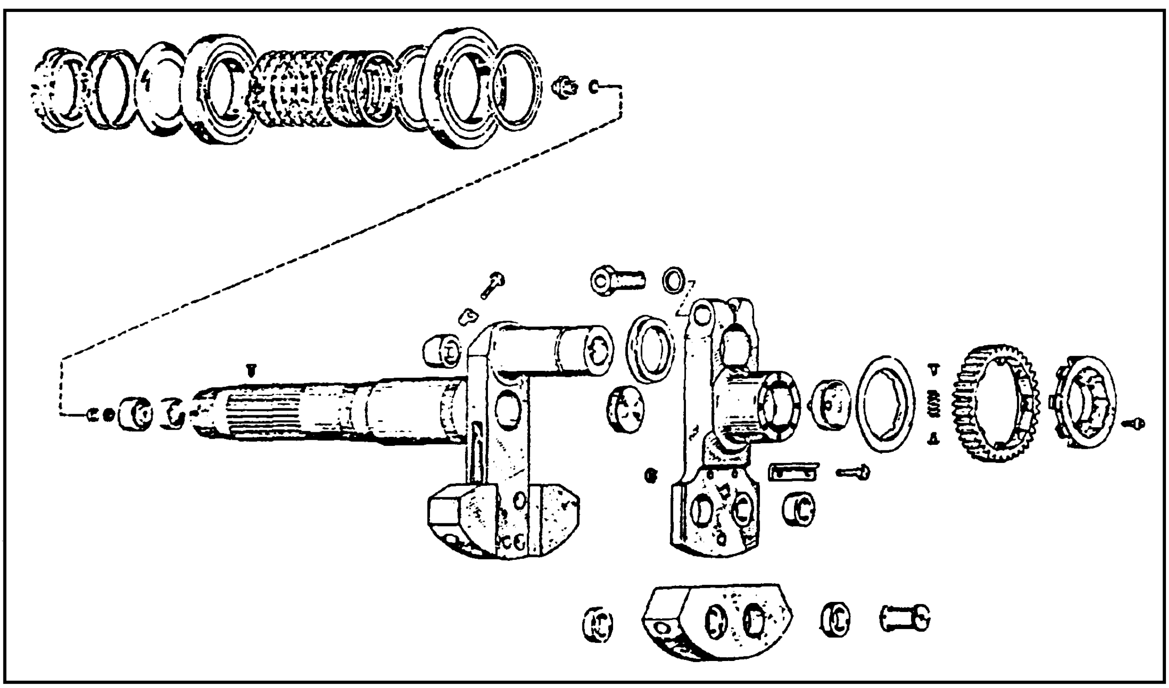


FIGURE 6—*Crankshaft and Associated Parts*

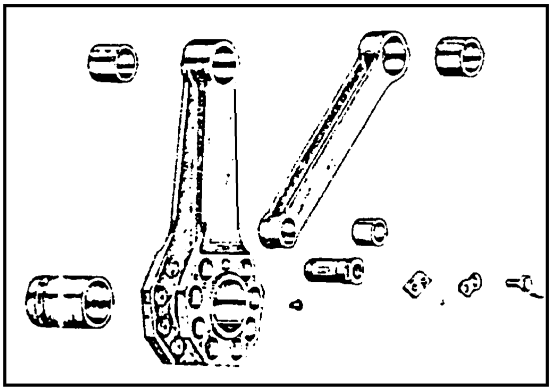


FIGURE 7—Master and Articulated Connecting Rods

forgings. The front section of the shaft consists of the shaft proper, the front crank cheek with its counterweight, and the crankpin. The rear section of the shaft consists of the rear crank cheek with its counterweight and the rear main bearing hub. (Refer to figure 6.)

The shaft proper and the crankpin are bored for lightness throughout their length except at the rear of the crankpin where a circular rib is provided to prevent distortion when the rear section of the shaft is clamped to the crankpin. The crankpin is provided with a straight groove to receive the clamping cap screw. The propeller end of the crankshaft is splined to receive the propeller hub and is threaded to receive the thrust bearing nut and the nut which holds the front roller bearing in place. A drilled disk is fitted inside of the forward part of the shaft to permit crankcase breathing. Steel tubes are installed in the bore of the shaft to transmit pressure oil to the hydro-controllable propeller pitch operating mechanism.

The rear crank cheek is bored at one end to receive the crankpin and is bored and tapped to receive the clamping cap screw. The crank cheek is slotted at the crankpin end in order to permit clamping action when the cap screw is tightened. A hardened steel washer under the head of the cap screw prevents scuffing the crank cheek during tightening of the cap screw. The crankshaft rear main bearing hub is hollow and is fitted with a screwed-in plug at the front end and a pressed-in plug at the rear. The rear crankshaft gear is bolted to the rear end of the rear main bearing journal.

The front and rear crank cheek pieces are rectangular in cross-section and the front crank cheek is provided with a slotted extension below the center line of the shaft proper to receive a bronze counterweight. The rear crank cheek is provided with a dynamic damper counterweight. An aligning hole is bored in each crank cheek and counterweight to receive the aligning bar when the two sections of the crankshaft are being assembled.

The dynamic damper counterweight consists of a steel counterweight, similar in shape to that of the conventional counterweight, hung on an extension of the rear crank cheek by two loose-fitting pins. The loose fit permits a limited travel of the weight with reference to the crank cheek extension. The ends of the pins are flanged so that they can be removed from the pin holes only when the holes of the weight are in line with those of the crank cheek extension. A steel stop is bolted to the rear side of the crank cheek extension, the purpose of which is to limit the travel of the weight when the propeller is turned by hand or rotating under power.

Model R-760E, R-760ET, and R-975E engines having S.A.E. No. 30 spline crankshafts are not equipped with dynamic damper counterweights. The rear crank cheeks of these engines are slotted and provided with bronze counterweights similar to those attached to the front crank cheeks. All other models of Whirlwind "E" series and the models listed above having S.A.E. No. 20 spline crankshafts are equipped with dynamic damper counterweights.

CONNECTING ROD ASSEMBLY

The connecting rod assembly consists of the master rod and articulated rods. The rods are all of H-section, forged from chrome-nickel steel, and finish machined throughout.

The master rod is of one-piece construction and operates in No. 1 cylinder. It has a steel-backed bearing at the crankshaft end and a bronze bushing at the piston pin end. A bronze thrust spacer which operates on the crankpin between the master rod and front crank cheek is used in conjunction with the master rod bearing. The widened flanges on the crankshaft end of the master rod are bored to receive the articulated rod knuckle pins. (Refer to figure 7.)

The articulated rods are connected to the master rod by knuckle pins. Pistons are attached to the connecting rods by piston pins. The knuckle pin and piston pin bushings of the articulated rods are bronze.

The knuckle pins are case-hardened nickel-steel,

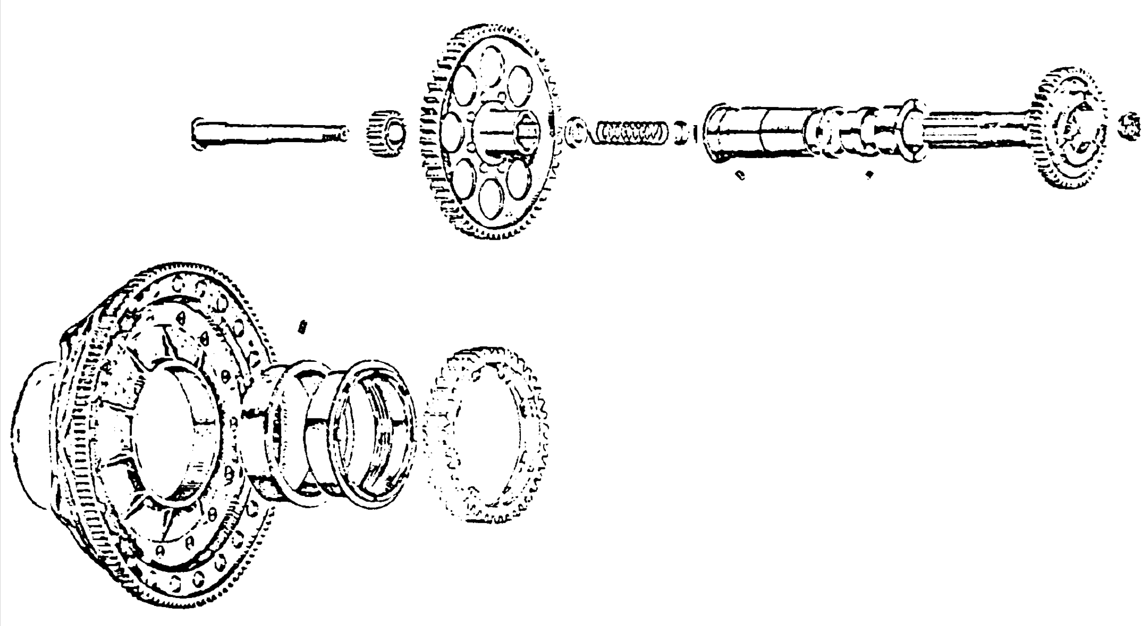


FIGURE 8—Cam and Starter Drive

ground to a high polish, and are hollow for lubrication. The front end has a flange which butts against the master rod in assembly. Each flange has flattened sides, used in conjunction with a flat locking plate to lock each pair of knuckle pins in place in the master rod. The locking plate is secured to the master rod by means of screws.

PISTONS

The pistons are full-trunk type, made from aluminum alloy forgings. The head of each piston is ribbed on the under side to increase the strength and improve the cooling. There are five piston ring grooves in each piston, four grooves above the piston pin and one below. The four top grooves bear a single compression ring each, while the lower groove bears a single inverted ring. (Refer to figure 1.)

The piston pins are machined from steel forgings, ground and lapped to a high finish. They are full floating, and are held in place in the pistons by split retainer rings of spring steel which fit into grooves in piston bosses at the ends of the piston pins. Some engines are equipped with piston pin plugs instead of spring retainers.

VALVE OPERATING MECHANISM

A circular cam, riding on a steel sleeve, screwed onto the crankshaft rear main bearing extension, actuates the intake and exhaust valves through valve tappets, push rods, and rockers. (Refer to figure 8.) The cam ring consists of a hardened steel ring with a double row of lobes and an external spur gear. The cam ring is bolted to an aluminum hub provided with a bronze-backed, babbitted bearing at the center. This bearing rides on the steel sleeve, known as the cam hub bearing support or the cam hub nut, which is screwed onto the crankshaft rear main bearing extension. The cam is driven through the following gear train: The crankshaft gear meshes with an intermediate gear on the starter shaft and imparts motion to that shaft; a pinion gear on the front end of the shaft meshes with the spur gear on the cam and so rotates the cam. The cam lobes acting on the valve tappets actuate the push rods and they in turn operate the rocker arms which open the valves.

The valve tappets, which ride over the lobes of the cam, and the tappet guides are arranged around the rear outside wall of the main section. The tappets are of hardened steel and are a close sliding fit in the guides. A steel cup, or socket, is located in the push rod end of the valve tappet. This socket is a close sliding fit in the tappet and is held against the push rod ball end by a coil spring in the tappet. (Refer to figure 9.) The tappet guides and tappets for the valve rockers located above the horizontal center line of the engine are drilled for metered pressure oil feed to the rocker arms on R-975E series engines. Only the guides of cylinders 1, 2, and 7 on R-760 series engines are pressure fed. It is necessary for

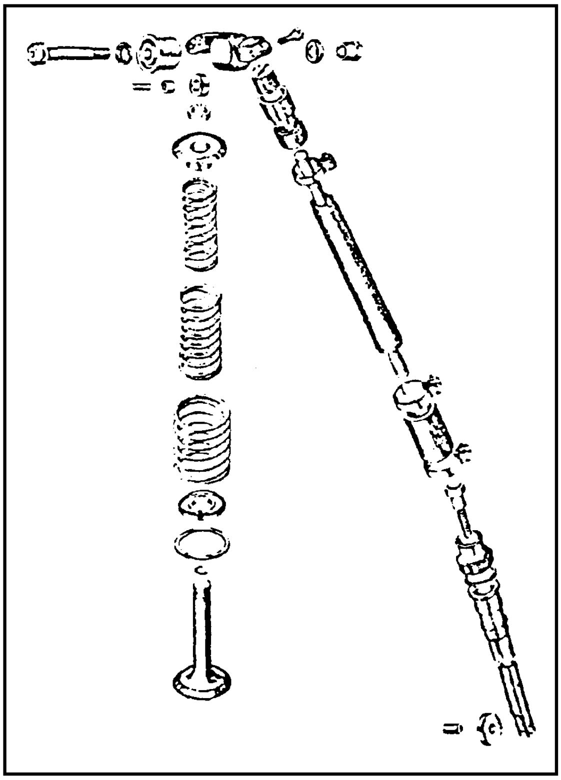


FIGURE 9—*Valve Operating Mechanism*

the tappet socket to be held against the push rod ball end in order to provide a closed passage through which the oil is metered to the rocker arm. Complete details concerning rocker arm lubrication are contained in the section of this Chapter entitled Lubrication System. The tappet guides for the rockers above the horizontal center line of the engines are not interchangeable with those below the center line. Since the upper guides differ from the lower guides only in the drilling, care must be taken in replacing guides to insure proper positioning. The roller end of the tappet is slotted to receive the tappet roller which rotates on a floating pin. The valve tappet can only be removed by first removing the pin and roller.

The push rods are of heat treated seamless steel tubing, with hardened steel ball ends pressed into each end. The push rod housings are of annealed seamless dural tubing. Each housing is connected to the valve tappet retaining nut at the main section and to a connection at the rocker box with an oil-tight hose connection of standard size.

The rocker arms are of I-Section machined from steel forgings. They are mounted on a double roller bearing, the inner races of which are clamped in the rocker box by a through bolt. The valve end of the rocker arm is forked to carry a roller operating on a hub and pin riveted in the arm. The push rod end of the rocker arm is provided with a tappet clearance adjusting screw and adjusting screw lock.

VALVE AND VALVE SPRINGS

Both intake and exhaust valves are machined from forgings of heat resisting steel. In some engines the exhaust valve

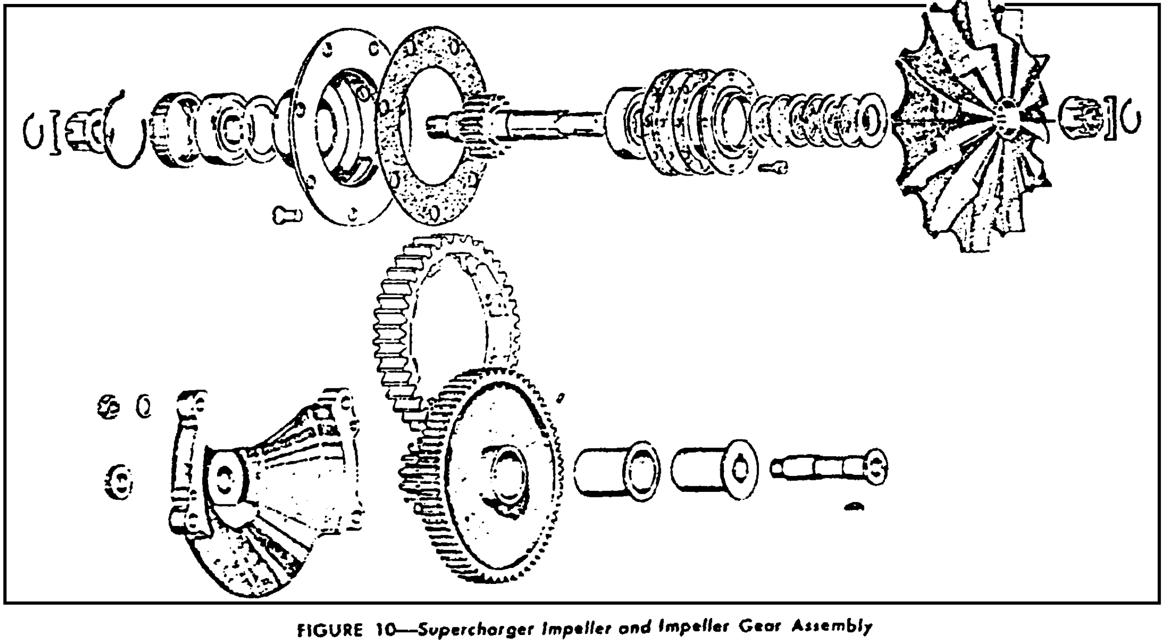


FIGURE 10—*Supercharger Impeller and Impeller Gear Assembly*

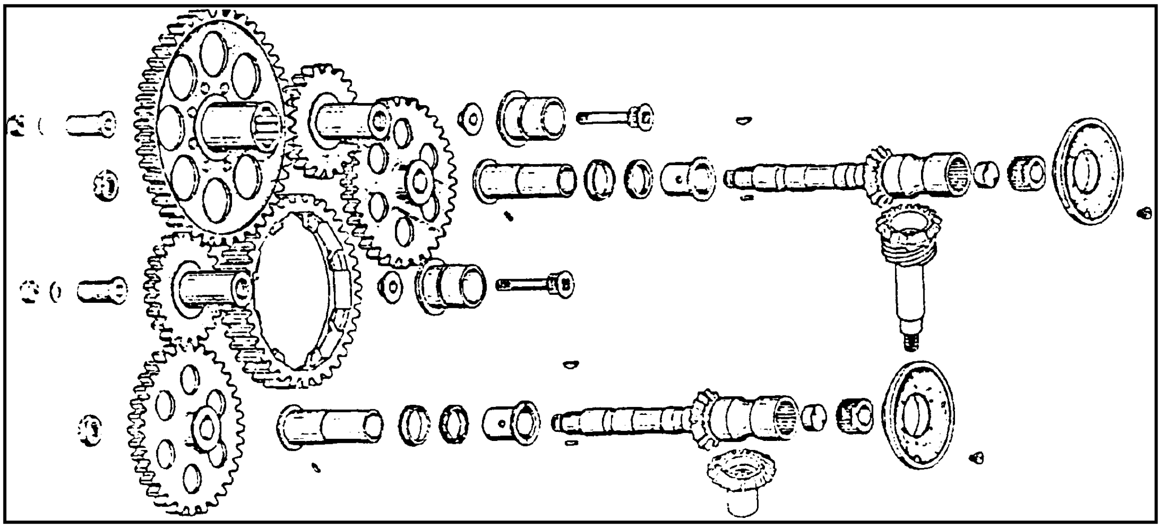


FIGURE 11—*Magneto, Oil Pump, and Tachometer Drives*

has a hollow stem which contains sodium as a cooling medium, and is mushroom shaped. The intake valve stem is smaller in cross section, is solid, and is tulip shaped.

Each valve is fitted with three concentric coil springs. The springs are seated at the base of the rocker box on washers and are retained by a shouldered washer which is held in position at the valve tip by a tapered split lock. (Refer to figure 9.)

SUPERCHARGER

The supercharger consists of the impeller, the impeller drive gear train, the diffuser chamber, and the distribution chamber.

The impeller is a centrifugal type, machined from a duralumin forging and carried on a splined shaft which rotates in two ball bearings supported by the diffuser section. The impeller shaft is equipped with a piston ring type oil seal to prevent oil from leaking by the shaft into the diffuser chamber.

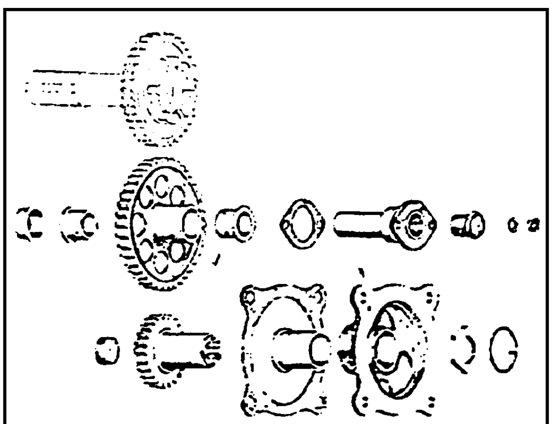


FIGURE 12—*Generator Drive (Spur Gear Type)*

The impeller is driven from the crankshaft gear. The crankshaft gear meshes with the smaller gear of a pair supported on a bronze bushing and steel hub by an intermediate shaft bracketted to the front wall of the diffuser section of the crankcase. The larger gear of the pair meshes with the impeller shaft gear to drive the impeller. (Refer to figure 10.)

The diffuser chamber is a narrow annular passage surrounding the impeller and formed by the space remaining between the crankcase rear section and the crankcase diffuser section. This space is kept constant by three spacers or fishplates of .200 inch (.508 cm.) thickness. The front wall of the diffuser chamber is formed by a machined disk on the rear wall of the diffuser section casting.

The distribution chamber is an annular passage beyond the outer circumference of the disk, also formed between the rear wall of the diffuser section and the front wall of the rear section.

All Whirlwinds except the R-760ET are super-

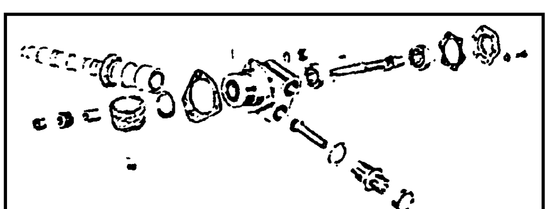


FIGURE 13—*Tachometer Drive*

charged. This engine is fundamentally the same as the other R-760 models, but the following changes have been made in the diffuser section: The impeller, impeller drive shaft, and other related parts have been removed. A flanged plug, used to support the rear end of the gear shaft in supercharged engines, is secured in the hole in the diffuser section. A cover and gasket screwed to the front side of the diffuser section encloses the circular oil passage located at the center of this section. A plate screwed to the rear side of the diffuser section over the large hole in the center of this section seals the diffuser chamber.

The impeller draws the intake mixture from the carburetor into the crankcase rear section and forces it through the diffuser chamber into the distribution chamber. Intake pipes, attached to the tangential leads from the distributor chamber, conduct the fuel mixture to the intake ports of the cylinders.

ACCESSORY DRIVE MECHANISM

The accessories are driven by the crankshaft gear which is attached by screws to the rear end of the crankshaft. In current engines a flexible spring drive type gear is used, which protects all accessories and the impeller from severe shock loads.

The crankshaft gear, impeller drive pinion, and the starter drive gear, all housed between the diffuser section and the annular web in the main section, mesh directly through spur gears. In Series R-760E engines the accessory drive shaft gears also mesh directly with the crankshaft gear. In Series R-975E engines the accessory drive shaft gears are driven through idler gears which mesh with the starter drive gear. The starter shaft and accessory drive shafts extend rearward through the diffuser chamber to the rear section. (Refer to figure 11.)

An oil seal is located at the forward side of the starter drive shaft rear bushing. This seal is held in position by an aluminum retainer which is forced against the cork seal by the starter shaft front bushing. A rubber oil seal ring is located between the front and rear bushings of both accessory drive shafts.

The starter drive gear is a splined fit on the starter shaft. The gear and shaft are clamped together by the starter shaft bolt which carries the cam drive pinion on its forward end and passes through the entire length of the shaft. A spur gear at the rear of the starter shaft meshes with the generator drive. (Refer to figure 12.)

The accessory drive shafts are of two-piece construction, consisting of a separate shaft and separate magneto coupling which is a spline fit on the shaft. A screw through the center of the coupling is used for retaining it on the shaft. The magnetos are driven directly from these shafts. The right hand accessory drive shaft drives the tachometer drive, fuel pump drive, and right gun synchronizer impulse generator drive. (Refer to figure 13.) The left hand accessory drive shaft drives the oil pump and the left hand impulse generator drive.

A three-way accessory drive adapter may be supplied with the engine. This adapter is attached to the studs on the rear section in place of the fuel pump and has mountings provided for the fuel pump, vacuum pump, and propeller governor drives. (Refer to figure 14.)

OIL PUMP

The oil pump is a gear type pump supported on the lower left hand side of the crankcase rear section. The pump is divided into two sections, consisting of a separate pressure pump and scavenge pump. The pump gears consist of two spur gears with large teeth for each section of the pump. Provision is made for driving a vacuum pump mounted on a pad at the rear of the oil pump. The vacuum pump drive is through a pair of beveled gears. The driving gear is splined to the oil pump drive shaft and the driven gear is supported in the body of the oil pump. The vacuum pump drive is standard equipment on Models R-760E-2 and R-975E-3 engines.

The oil pump incorporates a pressure relief valve, which is a spring loaded ball that rises when

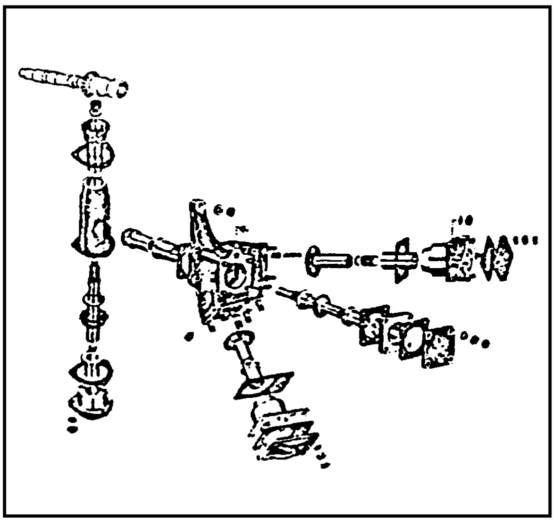


FIGURE 14—*Three-Way Accessory Drive*

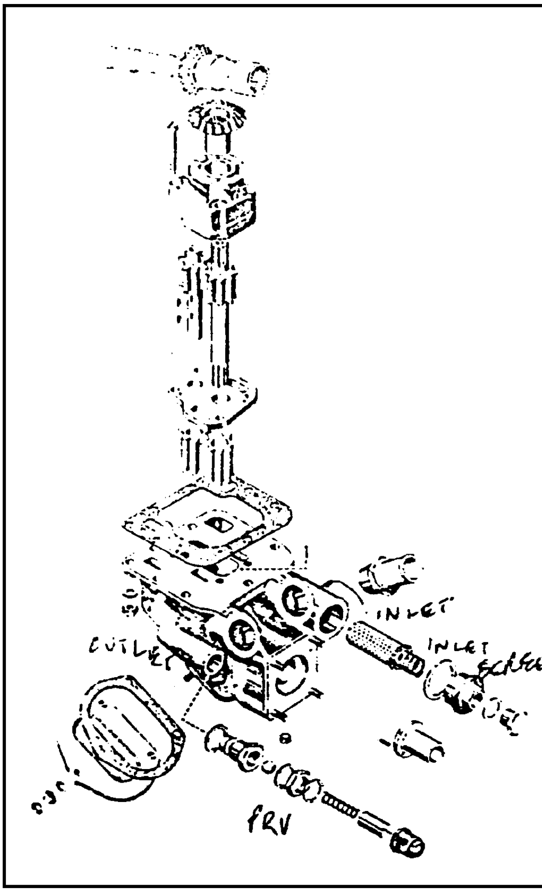


FIGURE 15—*Oil Pump*

the desired pressure is reached and allows the excess oil to be delivered to the inlet side of the pump. Pressure regulation is accomplished by turning the adjusting screw which raises or lowers the tension in the spring. Some engines include an oil check valve in the main oil passage. (Refer to figure 15.)

LUBRICATION SYSTEM

Since a large percentage of engine failures can be traced to lubrication difficulties, considerable space is devoted in this part of the manual to a discussion of the lubrication systems of these engines. The lubrication systems of the R-760E and R-975E series engines are identical with one exception: Series R-760E engines have no accessory idler gears or shafts and, consequently, the two lines necessary to feed oil to those parts in the R-975E series engines are eliminated.

All moving contact surfaces except ball and roller bearings and pistons are lubricated by pressure. The ball and roller bearings and pistons are lubricated by splash.

Oil is drawn from an external tank, through a finger strainer to the pump, and forced into a passage in the crankcase rear section casting. This passage in the rear section becomes the main supply for all pressure lines and is therefore termed the main pressure passage.

The first main oil pressure line is a drilled hole in the crankcase rear section casting, leading from the main pressure passage to indexing drilled holes in the parting flanges of the crankcase diffuser and main sections.

(Valve rocker lubrication is accomplished by pressure feed to the rocker arms which are located above the horizontal center line of the engine and by gravity to rocker arms below the horizontal center line. For this purpose, oil is led from the hole in the crankcase main section through passages in the valve guide bosses. Pressure feed is directed to the intake and exhaust valve tappets of cylinders No. 1, 2, and 9 and to the intake valve tappet of cylinder No. 3 or exhaust valve tappet of cylinder No. 8 in the case of the R-975E series engine. In the case of the R-760E series engine, both the intake and exhaust valve tappets of cylinders No. 1, 2, and 7 are pressure fed. These tappet guides and tappets are drilled to provide a metered feed of oil under pressure through drilled passages in the push rod ball ends upward through drilled passages in the rocker arm to the rocker arm bearing. Excess oil in the rocker boxes drains down between the push rod and housing and through passages in the crankcase rear section to the inside of the crankcase rear section.

Considering the R-975E series engines, the tappet guide bosses of cylinders No. 4, 5, 6, and 7 and the exhaust tappet guide boss of No. 3 cylinder and intake tappet guide boss of No. 8 cylinder are not drilled for pressure lubrication of the valve gear. Lubrication of these parts is accomplished by gravity feed. However, the No. 3 exhaust and No. 8 intake valve tappet guide bosses are provided with drain passages to increase the flow of oil to the rocker boxes. This is necessary because these rocker boxes are very nearly on the horizontal center line of the engine. In the case of the R-760E engines, the tappet guide bosses of cyinders No. 3, 4, 5, and 6 are not drilled for pressure lubrication. However, the No. 3 intake and No. 6 exhaust tappet guide bosses in this case, are near enough to the center line of the engine to warrant a drain passage for increased oil flow.

The second passage from the hole in the crankcase main section consists of a pressed-in tube feed pipe which conducts the oil to an annulus in the crankshaft rear main bearing support. This annulus becomes a source of supply for two different oil pressure feed lines, and in order to differentiate from other annular oil grooves, it is designated as annulus A.

The first pressure feed passage from annulus A consists of drilled holes in the crankshaft rear main bearing which conduct the oil to a narrow annulus on the inside of the bearing. Oil seeping from this narrow annulus lubricates the bearing. The oil passes from this same annulus through holes in the crankshaft rear main bearing hub and fills the hollow hub. A drilled hole in the hub, indexing with a similar drilled hole in the crankpin, conducts the oil into the hollow pin. The oil passes through an oil nozzle in the crankpin to oil the master rod bearing. Some of this oil forces out into the crankcase main section to assist in lubricating the cylinder walls, pistons, and piston pins by splash. The remainder of the oil running along the master rod bearing is caught in an annulus running around the inside diameter of the bearing, is led through holes to a similar annulus on the outside diameter of the bearing, and is then conducted through holes in the master rod to the knuckle pins. At each knuckle pin the oil passes into an annulus on the outside diameter of the pin, through two drilled holes to the inside of the pin, thence out two holes in the center of the pin to the knuckle pin bushing and oils that bushing. This oil forces out into the crankcase main section and helps to lubricate the cylinder walls, pistons, and piston pins by splash.

The second main oil pressure line from annulus A is an oil groove, perpendicular to the annulus, on the outside diameter of the crankshaft rear main bearing. This groove conducts the oil to an annulus on the inside diameter of the cam hub bearing support, where it passes through holes in the support to an annulus formed between the two sections of the cam hub bearing. After lubricating that bearing, the oil passes out into the rear portion of the crankcase main section to assist in oiling the tappets and tappet guides.

The second main oil pressure feed from the main pressure passage is a drilled hole which passes through the boss of the left accessory drive shaft. The oil then goes through a hole in the accessory shaft rear bushing into an annulus on the outside diameter of the shaft. It lubricates this bushing, passes through two holes to the interior of the shaft, and fills the shaft with pressure oil. The oil is then forced out of two similar holes in the forward part of the shaft where it fills an annulus on the outside diameter of the shaft, lubricates the front bushing of the shaft, and passes into a drilled hole in the diffuser section casting. This hole conducts the oil to a groove in the diffuser section which is concentric with the impeller shaft hole. This groove is sealed at assembly by the impeller shaft front main bearing support and supplies oil through radially drilled passages to the idler accessory drive gears, the impeller drive gear bushing, the starter shaft, and the right accessory drive shaft. The right hand accessory drive shaft is similar to the left hand accessory drive shaft. Oil flows through the right hand accessory drive shaft to the rear accessory drive shaft bushing. The starter drive gear hub is provided with a longitudinal groove which permits the oil to flow to an annular recess formed between the forward starter shaft bushing and the starter shaft. From this recess the oil passes to the rear starter shaft bushing, in which a longitudinal groove is provided at the top, lubricating the rear starter shaft bushing. Oil escaping from the bushing lubricates the gears by splash.

The third and last main pressure feed from the main pressure passage is a drilled hole in the rear section casting. This hole leads the oil to an annulus, which will be termed annulus B, formed on the outer diameter of the generator idler gear shaft, or on the outer diameter of the dummy, on engines not supplied with a generator drive.

From annulus B on engines supplied with a generator drive, a drilled hole in the generator idler gear shaft conducts the oil into the shaft. The oil is then forced out a drilled hole in the forward part of the shaft where it fills an annulus formed between the two sections of the shaft bearing, lubricates the bearing, and flows into the rear crankcase section.

From annulus B, a drilled hole in the rear section casting conducts the oil to an indexing hole in the generator drive gear support, or cover spacer on engines without generator drive. Two lines branch off at this point; one conducting oil through the generator drive gear support to the generator drive gear where the oil lubricates the gear and goes into the crankcase section; the other, leading oil through the generator support casting to an indexing drilled hole in the rear section casting. This hole conducts the oil to an annulus on the outside diameter of the tachometer and fuel pump drive adapter. From this annulus, one drilled hole conducts the oil through the rear section casting, through an indexing hole in the fuel pump adapter, to oil the fuel pump drive; a second drilled hole conducts oil to the tachometer and fuel pump drive shaft where it lubricates the shaft and flows into the rear crankcase section. In some engines a third drilled hole conducts oil through the rear section casting to the tachometer drive mounting pad.

The front main bearing and the thrust bearing receive a sufficient quantity of oil by splash.

Scavenge oil drains from the crankcase front section through indexing holes in the parting flanges of the crankcase front section, the front main bearing support, and the crankcase main section. The rear section drains through indexing slots in the rear, diffuser, and crankcase main section parting flanges. The main section drains into a scavenge sump cast in the rear of that section. Thus all scavenge oil of the engine finds its way into the sump. The oil scavenge pump sucks this oil from the sump; through a strainer; through a second set of slots in the parting flanges of the main, diffuser, and rear sections of the crankcase; and through a suction passage in the rear section. After passing through the scavenge pump, the scavenged oil is forced through the oil-out connection on the pump to the external oil tank.

A Cuno oil strainer is supplied which should be installed in the oil line which returns the oil from the engine to the tank. (Refer to figure 16.)

The transmitting of oil pressure from the crankpin to the propeller hub for hydro-controllable propeller pitch operating purposes is as follows: From the crankpin an oil passage through the rear steel tube in the shaft bore leads to a hole which is drilled in the wall of the shaft and which indexes with the rear inner annulus of the oil seal ring adapter. Through holes in the adapter the passage leads to the rear outer adapter annulus formed between the center and rear oil seal rings. From this annulus a passage drilled in the front section leads to the control valve. In a similar manner an oil passage is provided from the control valve to the front steel tube in the shaft. Through this tube the passage leads to the propeller hub.

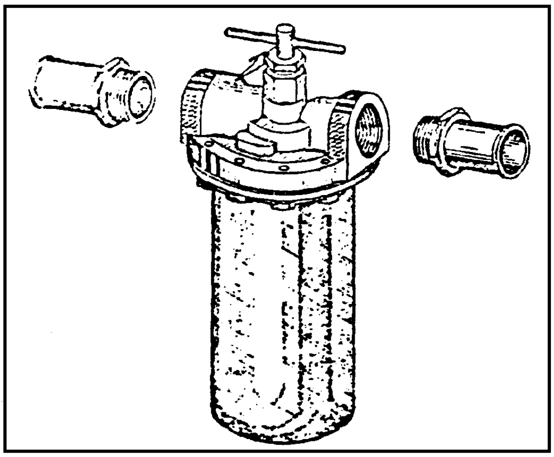


FIGURE 16—Cuno Oil Filter

Crankcase front sections which incorporate the propeller governor have oil passages drilled from the governor oil supply line to an annulus at the governor adapter bushing and from the adapter annulus to an indexing hole in the parting flange of the bracket. The bracket is drilled from the parting flange to an annulus around the governor intermediate drive shaft bushing. The oil runs from each annulus through holes in the bushings to pressure lubricate the bearing surfaces. In case a two position control valve adapter is used on the governor pad, the adapter is constructed with a pilot which seals the oil passages mentioned above.

Some engines incorporate a hydro oil pressure line to insure sufficient hydro oil pressure for changing propeller pitch. The tube runs from the tapped hole adjacent to No. 9 cylinder intake pipe boss on the crankcase rear section, through the inter-cylinder air deflector between cylinders No. 8 and 9, to the hydro oil pressure gage connection on the crankcase front section.

CRANKCASE BREATHING The "E" Series Whirlwind engines have an internal breathing system and neither the crankcase rear section nor the oil tank should be vented to the atmosphere. The oil tank, however, should be vented to the rear section. Two one-inch (25.4 mm.) holes are drilled through the rear wall of the crankcase main section on opposite sides near the bottom. The purpose of these passages is to provide breathing for the tappet portion of the crankcase main section and rear section to the main section. The internal venting is assisted by means of a hole drilled from the tappet portion of the crankcase main section into the sump passage which connects with the rear section oil drain. By this means, pressure in the rear section is equalized along the top of the rear section drain into the tappet portion of the main section without interfering with the scavenge pump intake to the sump. The rear section should therefore be closed up tight and the oil tank need not be vented to the atmosphere directly but should be vented to the rear section as indicated on the installation drawing. Breathing of the engine is accomplished either through a drilled disk located in the forward end of the crankshaft, through a screened breather plug located in the upper side of the crankcase front section, or through a breather directly behind cylinder No. I.

EXHAUST MANIFOLD

Most engines are equipped with rear exhaust manifolds and rear exhaust elbows. The front exhaust system is optional.

The front exhaust manifold of annular form with tangential connections to exhaust elbows is furnished with Series "E" Whirlwind engines. The connections from the exhaust elbows to the manifold slide into the pipes from the exhaust manifold, thus providing a free joint to permit free expansion and contraction of the parts.

The exhaust manifold for some of the current "E" series engines is of the segmental type. This manifold is mounted rigidly at the exhaust port flanges of the cylinders and free expansion, or contraction, of the parts is accomplished by means of sliding joints, between each pair of cylinders in the main body of the manifold. This type also relieves the nose cowl of any strain due to the support of the manifold.

COOLING SYSTEM

The nose cowl supplied with the engines consists of a forged aluminum plate fitted between the exhaust manifold and crankcase front section. It is rigidly supported with riveted plates at the fastening points. There is an opening at the lower part of the cowl to connect with the carburetor air duct.

A plate riveted to the top of the cowl provides an air scoop. From the scoop air is forced behind the exhaust manifold to the opening at the lower part of the cowl. A ring attached to the forward side of the manifold and cowl assembly prevents air entering the passage formed between the manifold and cowl through any opening other than the scoop. Rear exhaust engines do not incorporate a nose cowl.

Models R-760E-1, R-760E-2, R-975E-1, and R-975E-3 engines are supplied with cylinder air deflectors. (Refer to figure 17.) The air deflectors are the full pressure type and are formed so as to direct the cooling air well toward the rear of the cylinder head and barrel. The cylinder head deflectors are secured by cap screws to the cylinder heads, where the necessary attaching bosses are provided. All current "E" series engines are supplied with one piece, inter-cylinder baffles. On these baffles the leather at the top of the cylinder heads has been replaced with a lip running from one rocker box to the next. The cylinder barrel air deflectors are secured by cap screws and the cylinder air deflector clamps.

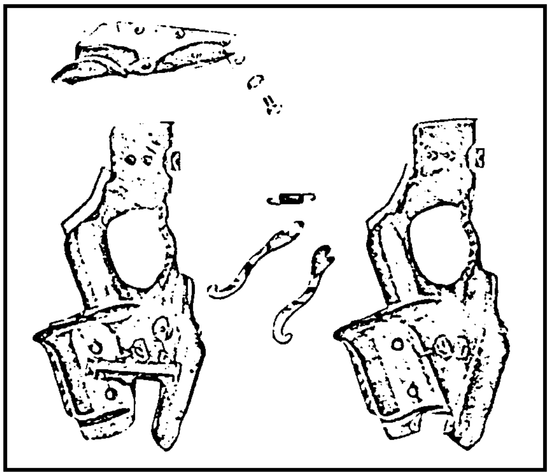


FIGURE 17—*Cylinder Air Deflectors*

IGNITION SYSTEM

Ignition is furnished by two Scintilla magnetos mounted on the rear section of the crankcase. The right hand magneto fires the front spark plugs and the left hand magneto fires the rear ones. The magnetos of the R-975E series are driven at 9/8 crankshaft speed and those of the R-760E series at 7/8 crankshaft speed.

All parts of the ignition wiring system of Models R-760E-2 and R-975E-3 engines are shielded against radio interferences. (Refer to figure 18.) Radio shielding is not included as standard equipment on other Whirlwind "E" models. The shielding is constructed so that any part, if damaged, may be readily replaced without discarding the entire shielding structure. Any defective ignition wire may be likewise replaced without disturbing other wires.

The wire is rubber insulated and covered with a protective coating to prevent wear and deterioration. A manifold running around the outside of the crankcase main section carries the wires to the base of each cylinder from which point they run up to the spark plugs. Suitable clips prevent the wires from coming in contact with the

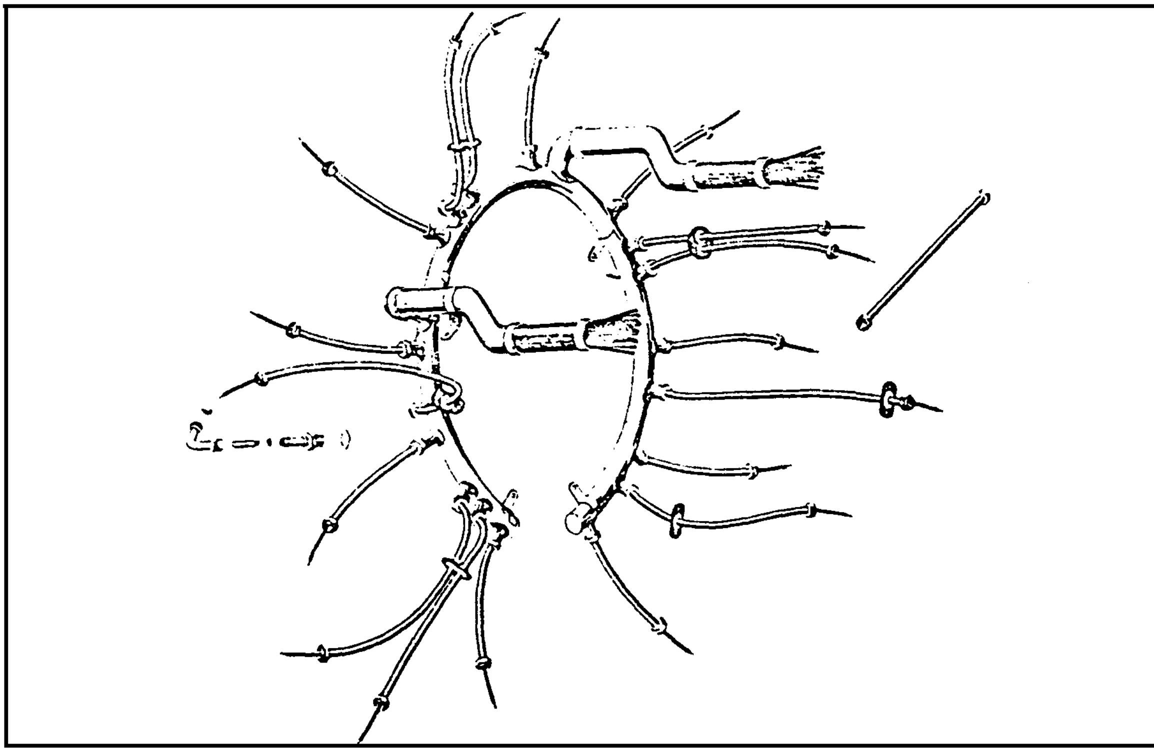


FIGURE 18—*Ignition Harness*

cylinder. Ignition wire terminal assemblies are provided at the front and rear of the cylinder forming a very compact and efficient connection at the spark plug.

FUEL SYSTEM

All Whirlwind engines are supplied with Stromberg carburetors. The carburetor and carburetor adapter are mounted on the rear of the crankcase rear section. These carburetors have a single venturi fed from a single float chamber and incorporate a needle valve type mixture control.

The fuel pump drive is located on the right hand side of the crankcase rear section. The mounting pad is of the standard type and is adaptable to any one of several fuel pumps.

ACCESSORIES

The engines will take any one of a number of starters complying with the standard starter mounting pad. The starter dog is located on the rear end of the starter shaft, which is geared to the crankshaft gear.

The rear section is provided with a standard flange type of generator mounting pad which permits the use of any of several types of generators. Models R-760E-2 and R-975E-3 incorporate, as standard equipment, a generator drive which rotates in the counter-clockwise direction.

A bevel gear on each magneto or accessory drive shaft furnishes the drive for two impulse generators. They rotate at crankshaft speed and in a counter-clockwise direction as viewed from the top.

A dual tachometer drive is located on the right side of the engine and just above the fuel pump. The drives rotate at ½ crankshaft speed, one in a clockwise and one in a counter-clockwise direction.

Provision is made for mounting a vacuum pump on the oil pump. The mounting pad is provided with the necessary oil passages to supply the vacuum pump with internal lubrication.

Provision is made for mounting an accessory drive housing on the crankcase rear section at the fuel pump location. The accessory drive housing has provisions for mounting a fuel pump, a vacuum pump, and a variable pitch propeller governor mechanism.

The crankshaft is splined to receive a metal propeller hub. The S.A.E. Spline Number of the crankshaft is given on the installation drawing for the engine involved.

PREPARATION FOR STORAGE OR SERVICE

ALL engines which are to be stored or to remain idle for periods exceeding 48 hours must be protected to prevent corrosion of metal parts. Protection is afforded by running the engine out on unleaded fuel, slushing the internal sections of the engine with a preservative compound, and, where possible, dehydrating the air in and around the engine by means of activated silica gel crystals and packing the engine in a Pliofilm engine envelope. The simplest procedure is obtained by performing the unleaded fuel run-out and slushing the internal sections of the engine simultaneously and can be followed where the engine is installed in an airplane or test stand. An alternative method is presented for cases where it is more convenient to slush the engine on a floor stand subsequent to run out on unleaded fuel.

Engines which cannot be turned over due to internal failure should be slushed in any practical manner to keep the salvageable engine parts in as good condition as possible. Engines which are to be disassembled and the parts washed and slushed within 48 hours need not be run out on unleaded fuel.

EQUIPMENT The following equipment is needed to prepare the engine properly for storage:

- Spray gun, Tool No. 84263 or Tool No. 83905
- Air driver, Tool No. 83903
- Rocker box covers, Part No. 83904-5 and -6
- Pliofilm engine envelope, Part No. 116602. Note: Pliofilm is sensitive to light and will deteriorate if exposed for any appreciable time.
- Pliofilm carburetor envelope, Part No. 116605
- Cylinder dehydrator plugs, Part No. 116538N1
- Spark Plug terminal protectors and cable attachment, 5/8 thread, Part No. 116539N1; $\frac{3}{4}$ thread, Part No. 116539N2
- Humidity indicator card, Part No. 116601
- Dehydrator agent Protek-Sorb (Silica Gel)—
  - 1/2 lb. package—Part No. 116600
  - 1/4 lb. package—Part No. 116618
- Heating iron for sealing Pliofilm bags, Part No. 802924
- Engine opening sealing envelope (Tachometer drive housing) Part No. 116625
- Carburetor mounting (Cover) washers, R-760, Part No. 116626
- Gasket and Protek-Sorb Assembly, R-760, Part No. 418105
- Gasket and Protek-Sorb Assembly, R-975, Part No. 418106
- Engine slushing compound, AMS Specification No. 3072
- Carburetor slushing compound, AMS Specification No. 3070
- Exhaust manifold opening envelope, Part No. 116628

Spray gun, Tool No. 84263, is recommended for use in overhaul shops where the volume of work is large. Equipment provided under this tool number includes the gun, pressure tank, pressure regulator, and all hoses and connections. Spray gun, Tool No. 83905, is recommended for use in overhaul shops where the volume of work is not particularly large. A small tank which contains the slushing compound is provided integrally with this spray gun.

An air driver, Tool No. 83903, which is installed on the engine starter pad and which is used to turn the engine crankshaft during some of the slushing operations, may be procured if desired. This driver is recommended for use in overhaul shops where the volume of work is large.

Rocker box covers, Part No. 83904-5 and -6, modified by cutting away the rear half, are used when slushing valve stems and valve guides.

The 1/4 and 1/2 lb. dehydrator bags contain activated silica gel crystals which absorb moisture. The degree of activity of the crystals may be determined only by referring to the relative humidity chart. The Protek-Sorb bags must be replaced with the freshly activated bags when the humidity chart indicates an unsafe humidity condition. The crystals in the bag are not color treated.

The cylinder dehydrator plugs which are used in the spark plug holes consist of transparent containers threaded at the end and filled with silica gel crystals. The crystals are cobalt blue when new and change in color, as they absorb moisture, from cobalt blue to light blue, to dark pink to light pink.

The humidity indicator chart is a 5 by 8 inch (12.7 by 20.3 cm.) card consisting of a color and relative humidity chart on each side of a transparent section filled with silica gel crystals. The crystals are cobalt blue when freshly activated and change in color as they absorb moisture. It is the purpose of this card to indicate the relative humidity in the engine envelope. As the crystals match with the color chart, the humidity within the engine envelope may be determined as safe or unsafe. When the crystals can be matched with the dark pink or light pink sections of the color chart, or when the humidity indicator shows a relative humidity greater than 20 per cent the dehydrating agents must be changed as described in these instructions.

SLUSHING PROCEDURE — ENGINE INSTALLED IN AIRPLANE OR TEST STAND

1. Change fuel to unleaded 65 octane fuel conforming to Wright Aeronautical Corporation Specification No. 5800.
2. At the time the fuel is changed, drain the oil from the engine and tank and fill with sufficient corrosion-preventive compound, AMS Specification No. 3072 for safe engine operation.
3. With the propeller set in low pitch, run the engine at 1000 r.p.m. for 15 minutes. Just prior to stopping, increase speed to 1200 r.p.m. for 30 seconds to scavenge oil from the sump.
4. Remove the spark plugs to permit escape of combustion vapors.
5. Remove the oil filter, carefully inspect for metal particles, wash in 50-50 gasoline-benzol mixture or equivalent, and slush in corrosion-preventive compound. Replace filter and lockwire securely.
6. To slush the fuel pump, attach a funnel to the fuel pump inlet by means of a rubber hose of approximately ¾" (19.05 mm.) I.D. Fill the funnel with a pint of compound and turn the crankshaft through several revolutions in the normal direction of rotation. Allow the compound to drain at the fuel pump outlet.
7. Spray the interior of all cylinders with the compound. Turn the crankshaft so that the position in the cylinder being sprayed is at the bottom of its stroke with the intake valve open. Spray for 10 to 15 seconds to insure that all parts of the cylinder interior and the interior of the intake port are coated. Repeat the operation with the piston down and the exhaust valve open. Care must be taken not to damage the threads in the spark plug insert when inserting and removing the nozzle of the spray gun. Install dehydrating "Protex" plugs in all spark plug holes. Attach the loose end of each ignition cable to a terminal protector and snap into place on the corresponding plug head.
8. Clean the spark plugs and adjust the gaps. Coat only the threads of plugs with the compound. Wrap in material conforming to Wright Aeronautical Corporation Specification No. 5530, and place in a special spark plug shipping box to be provided for the purpose. New plugs, when furnished, need not be given this treatment.
9. Remove the carburetor drain plugs and allow carburetor to drain completely. Insert brass nipples into the holes and by means of a rubber tube connection pour into the carburetor approximately one gallon of carburetor slushing compound, AMS Specification No. 3070, move the throttle and mixture control back and forth several times while filling carburetor. Remove the hoses and nipples and allow carburetor to drain thoroughly. Never apply air pressure to carburetor interior. Reinstall all plugs and lockwire securely.
10. Remove the screened plug from the sump. Wash thoroughly with 50-50 gasoline-benzol mixture or equivalent, and slush in AMS Specification No. 3072 compound. Reinstall screened plug.
11. Thoroughly cover, as well as possible, all openings into the engine and into the engine unit with moisture proof seals.

If the engine is to remain installed in airplane for storage: Coat the exposed surface of the propeller shaft and all other exposed bright metal parts with Wright Aeronautical Corporation Specification No. 5842C heated to 150-180° F. (66-82° C.).

If possible, the engine should be stored in a shipping box, since in this case the Pliofilm envelope may be used. Engines not protected with envelopes must be reslushed at least every six months. If stored near tidewater or in tropical climate, the procedure must be repeated at three-month intervals.

If engine is to be stored in a shipping box:

12. Remove engine from airplane or test stand and mount on revolving cradle type floor stand.

13. Remove carburetor, attach a 1/2 lb. bag of dehydrating agent (activated silica gel), and seal in a transparent Pliofilm moisture-resistant envelope.

14. Spray the induction chamber in the rear housing with corrosion-preventive compound. Seal the opening with the gasket and dehydrator bag assembly and a wood or metal plate cover.

15. Wash the engine exterior with a wash gasoline spray. Wrap magnetos to keep them dry while washing. Dry with an air blast.

16. Coat the exterior of the propeller shaft with the compound. Install a plug in the hydro oil connection, if any is provided.

17. Remove engine from stand with propeller shaft in vertical position. Draw envelope up and over the rear end of the engine, locating the colored gasket on the mounting boss below No. 1 cylinder. Fasten the envelope temporarily with spring clips to any protruding parts of the engine. It is advisable to reinforce the mounting bolt gaskets on the envelope with heavy cardboard or rubber. Lift the mounting plate into position under the engine. Align the mounting bosses, the envelope gaskets, and the holes in the mounting plate. Insert the mounting bolts and fasten in the usual manner. (Refer to figure 19.) Inspect the envelope for tears. Install in the shipping box. (Refer to figure 20.) Install a shipping cap on the propeller shaft.

18. Secure the humidity indicator to the engine so that it may be readily observed through the inspection port in the shipping case cover.

19. Distribute bags of dehydrating agent evenly around the periphery and the fore-and-aft sections of the engine, and tie them in place. Use two 1/2 lb. bags per cylinder. (Refer to figure 21.)

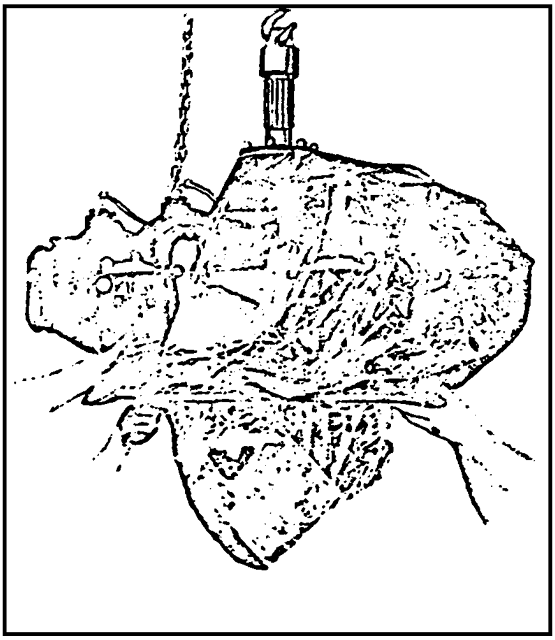


FIGURE 19—*Attaching Mounting Plate to Engine*

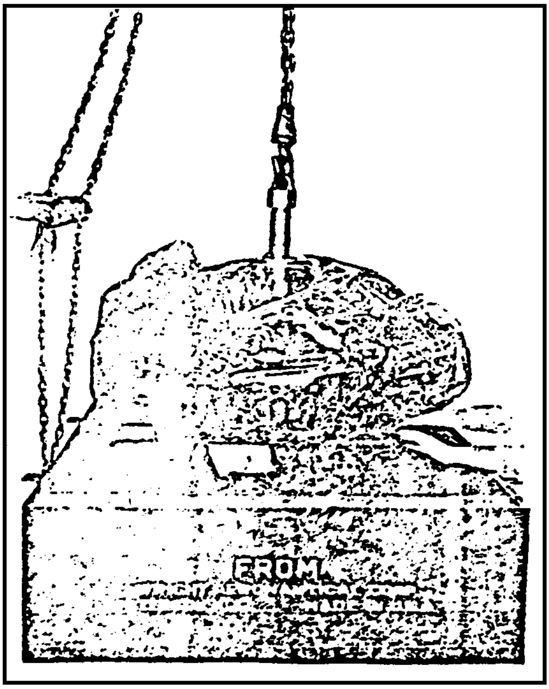


FIGURE 20—*Lowering Engine into Shipping Box*

FIGURE 21—*Location of Dehydrator Bags*

20. Immediately gather the edges of the engine envelope together and heat-seal to provide moisture-proof joints. Collapse the envelope as much as possible before sealing so as to enclose a minimum amount of air. Heat the sealing iron to 325-350° F. (163-170° C.) and seal a ½" (12.7 mm) wide strip about ¼" (6.2 mm.) from the edge of the material. Use a cardboard backed board to back up the Pliofilm when running the iron over it. A cloudy seam indicates insufficient heat or pressure. Repeat the operation to repair a cloudy or loose seam. Too much heat will damage Pliofilm. After sealing, fold the excess material around the engine and secure with adhesive tape so that there shall not be more than one thickness of material in front of the humidity indicator.

21. Lower the engine shipping box cover in such a manner as not to rupture the envelope. (Refer to figure 22.) The cover shall be provided with a hinged inspection port through which to observe the humidity indicator.

22. Inspect the humidity indicator at least once a month. If the reading is above 20%, new dehydrating agent must be provided. Remove the box cover, slit the Pliofilm envelope, and replace all dehydrator bags. Inspect all dehydrator plugs and replace those that have turned pink. Reseal the envelope.

23. Store engine indoors in a dry place and handle carefully at all times in order to insure that corrosion protection will remain effective.

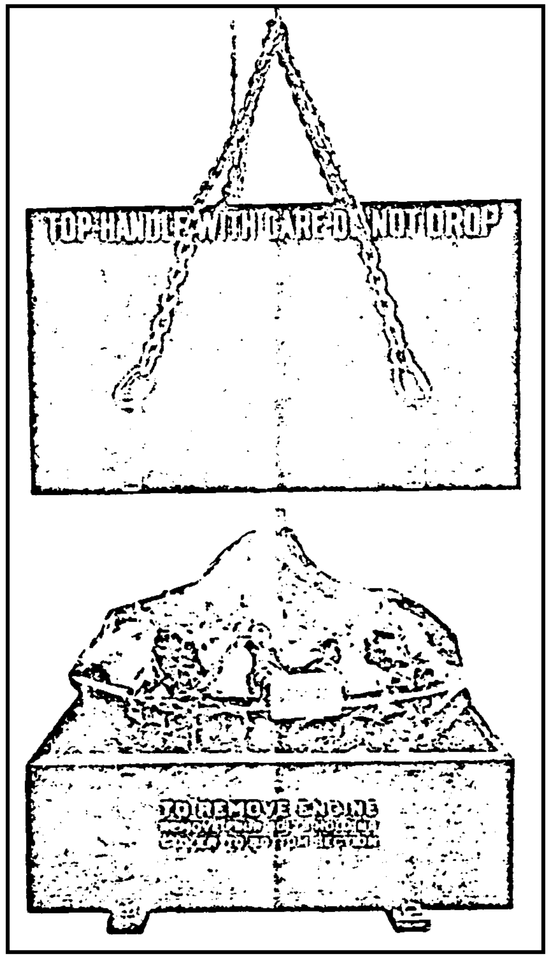


FIGURE 22—*Lowering Shipping Box Cover*

SLUSHING PROCEDURE — ENGINE MOUNTED ON FLOOR STAND

(Engine previously run out on unleaded fuel)

1. Follow instructions (5) and (6) above.

2. Remove the breather plug and slush the interior of the front section by spraying. Insert the nozzle of the spray gun into the open hole and spray for at least 30 seconds. Turn the crankshaft while spraying to insure that all parts are thoroughly coated. Re-install removed parts.

3. Wash all rocker box interiors, rocker arms, and valve spring assemblies with a wash gasoline spray. Dry with an air blast. Turn the engine front end down. Install modified covers on all rocker boxes and fill with slushing compound heated to 190° F. (82° C.). Turn the crankshaft at least 120 revolutions

to work the compound between the valve stems and guides. Remove the modified covers allowing the excess oil to drain. Spray all surfaces at the push rod end of the boxes and replace the standard covers.

4. Remove the oil tank vent tubes or plugs from the rear housing, located directly above the gun synchronizer mounting pads. Spray the compound through each opening for 5 to 10 seconds in order to coat thoroughly all internal parts. While spraying, turn the crankshaft slowly, using a turning hub or the air driver, to turn the accessory driving gears. Insert the nozzle of the spray gun into the oil filter hole and slush this cavity completely. Replace the filter and lockwire securely. Replace the oil tank vent tubes or plugs.

5. Remove the carburetor from the engine, wash all carbon and dirt from the exterior with naphtha. Remove the drain plugs at the bottom of the carburetor and drain completely. Hold the oil cup on the cam cover open, if any is provided. Plug the fuel inlet. Open the throttle control to wide-open position. Plug the hole in the solenoid, if a solenoid is provided. With the drain holes up fill the fuel passages through the drain holes with carburetor slushing compound, AMS Specification No. 3070. Allow the carburetor to stand for ten minutes, then turn it over and drain for ten minutes. Never apply air pressure to the interior of the carburetor. Replace and lockwire the plugs which were removed from the carburetor. Spray over external surface with the carburetor compound. Immediately after completion of the above slushing procedure, tie a ½ lb. bag of dehydrating agent to the carburetor and seal in a transparent moisture-resistant envelope.

6. Follow instructions (7), (8), (14), and (15) listed in the previous procedure.

7. If the engine is to be stored in a shipping box with a Pliofilm envelope, proceed as in items (17) to (23), inclusive, above.

PACKING SPARE PARTS

Spare parts to be packed for shipment or storage should first be slushed with a compound conforming to Wright Aeronautical Corporation Specification No. 5842C. Coat all surfaces, and allow to drain and dry for at least 10 minutes. Wrap with material conforming to Wright Aeronautical Corporation Specification No. 5530.

Store in a dry place. Protection will last indefinitely.

Parts to be shipped must be packed in suitable boxes with slings, blocks, or sufficient dunnage to prevent shifting. Specially constructed boxes are required for most large parts.

PREPARATION OF ENGINE FOR SERVICE

All engines which have been slushed for storage or shipment must be prepared for service. The slushing compound used is an adequate lubricant and need not be removed from all the lubricated sections of the engine.

1. Slit the Pliofilm envelope across the top seam.

2. Remove cylinder dehydrator plugs and, if possible, turn the engine front end up, to allow slushing compound to drain from the cylinders. Turn the crankshaft through 10 to 12 revolutions to assist in drainage. In each cylinder successively, close both valves and blow out remaining compound with an air blast applied through a spark plug hole.

3. Remove all other coverings and moisture-proof seals provided for dehydration.

4. Clean, inspect, and reinstall the oil filter.

5. Remove drain plugs from the carburetor and drain any slushing oil not removed when stored. Move the throttle and mixture controls back and forth several times to assist in drainage. Do not apply air pressure to the carburetor. Reinstall plugs and lockwire.

6. Remove the breaker point housing cover from each magneto. Using carbon tetrachloride, thoroughly clean all slushing compound from the breaker assembly and from the interior of the housing and cover. Do not use an inflammable compound.

7. Wash spark plugs in accordance with instructions furnished by the spark plug manufacturer. Install the spark plugs in the cylinders and attach the terminals.

INSTALLATION IN THE AIRPLANE

THIS chapter is devoted only to general instructions of interest to the operator and mechanic.

Installation drawings covering the Whirlwind engines may be obtained upon request to the Wright Aeronautical Corporation, Service Division. Detailed information may also be obtained upon request. These drawings consist of a basic drawing for the engine in question and supplementary drawings covering various individual requirements.

ENGINE HOISTING EQUIPMENT

Improper use of the engine hoisting equipment may result in serious damage to the engine.

The hoisting equipment supplied with the engine must not be used for the purpose of lifting an airplane or for lifting an engine which is attached to its mount. The equipment must not be attached to any part of the engine except where it was designed to be attached.

The hoist sling is attached by removing the rocker arm hub bolt nuts from the exhaust rocker arm bolt of No. 9 cylinder and the intake rocker arm bolt of No. 2 cylinder, and replacing these nuts with the attaching plates installed over the round portion of the nuts. (Refer to figures 23 and 24.)

FUEL AND OIL LINES

Only the best copper tubing or metal hose should be used in the construction of the fuel and oil lines.

All lines must be braced against vibration and

FIGURE 23—Hoisting Sling on Engine

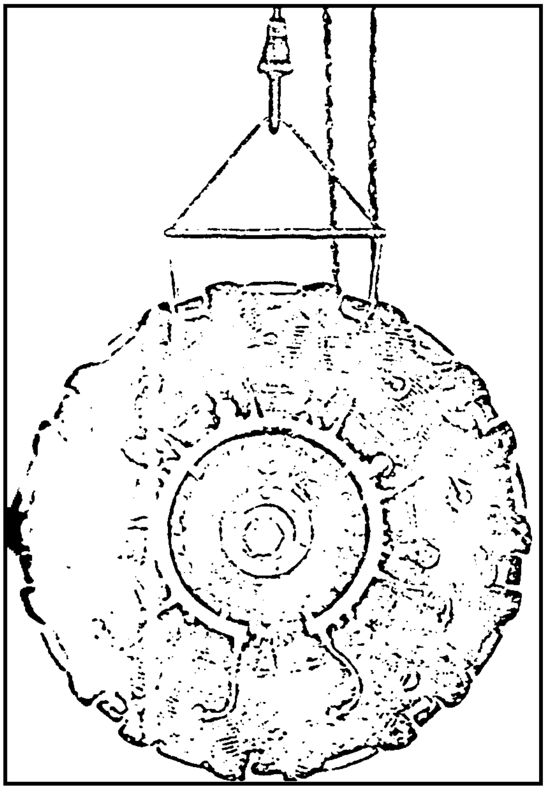


Figure 24—Hoisting Engine with Engine Sling

Line vibration can cause failure in an otherwise seemingly well-constructed line.

Protect the hose against chafing at all points. A slight amount of chafing can soon start a leak.

All lines, whether of copper tubing or metal hose should be as short and as straight as possible to avoid the formation of air locks. The fuel lines in particular must be free of vertical bends where air pockets or vapor locks might form.

Care should be exercised to see that all fuel lines are shielded as far as possible from all sources of heat since liability of vapor lock is greatly reduced by a reduction in fuel line temperatures.

For service in cold weather, the oil lines should be covered with some form of lagging. This enables the oil to maintain a higher temperature and a correspondingly higher rate of circulation.

LUBRICATION SYSTEM

The oil inlet and outlet connections will be found on the left side of the rear section, near the bottom. The connections are fitted with nipples of the proper size, and beaded for hose connections.

The external Cuno oil strainer furnished with the engines should be installed in the "Oil Out" line on the left side of the pump and at a point where it is readily accessible for removing and cleaning.

When installing the Cuno strainer make certain that the connections are made correctly, so that the oil will flow in the proper direction. If the connections are made so that the oil flows in the reverse direction, the strainer will not function properly and there is the additional possibility that the blades will be damaged. The oil-out line from the engine should be attached to the connection marked "IN" on the strainer, and the line from the strainer connection marked "OUT" should be led in the oil tank.

If the oil tank is so designed that the oil returning from the engine falls more than ten inches after entering the tank, considerable foam may result, eventually causing a decrease in oil pressure. This can be avoided by running the oil line entering the tank below the oil level so that the entering oil does not splash. In this system it is necessary to drill a small hole in the tank inlet pipe just after it enters the tank to act as a siphon breaker. Another method is to let the oil fall only a short distance into an inclined trough which permits it to run smoothly down into the oil supply.

The vent from the oil tank should be piped into the engine crankcase, entering the rear section through the tapped hole as indicated on the installation drawings. With the vent installed in this fashion, oil will not be spilled from the tank during aerobatics.

Oil-In temperature may be measured at the pump connection as shown on the installation drawing.

The oil pressure line should connect the pressure gage on the instrument board with the pressure outlet on the lift side of the crankcase rear section.

On some airplanes, particularly those with outboard installations, there is a possibility that the relatively long oil pressure gage lines connecting the lubricating system to the pressure gages in the cockpit may fill up with engine oil. Under extremely cold operating conditions, this oil may become so thick as to give slow and incorrect oil pressure readings. Under certain conditions this oil may congeal.

It is recommended that an S.A.E. 10-W oil of good quality, having a viscosity of approximately 40 at 210° F. (99° C.) be used in oil pressure gage lines for cold weather operation. After the oil pressure gage line is filled with this oil, all connections should be kept tight to prevent the oil from running out.

FUEL SYSTEM

The standard fuel pump mount and drive provided on Wright Whirlwind engines, makes it possible to install any one of a number of fuel pumps without alteration. The pump tang dimensions are according to S.A.E. standards. The pump discharge should be connected to the carburetor and the pressure relief line should be piped back to the fuel tank. If a pressure relief valve is not supplied with the type of pump used and the pump feeds directly to the carburetor, a relief valve must be furnished as a separate unit, located in the fuel line between the carburetor and the pump. If a sylphon type relief valve is used, it should be vented to the carburetor inlet air pressure. The fuel pump drain should be led outboard through a suitable tube.

As some pumps are of such design that inlet and outlet connections can be reversed for pump rotation, care should be exercised in mounting the fuel pump to see that the inlet and outlet connections are properly made.

The priming pump is furnished with a shut-off valve located near the primer plunger and provided with a right-angle handle which will extend across the plunger handle when in the off position, indicating in a clear and forceful manner whether or not the line is closed. This is a matter of utmost importance since leakage through the priming line is liable to flood the lower cylinders with raw gasoline and cause considerable damage.

NOTE: The Wright Aeronautical Corporation will not assume any responsibility for engines which are damaged due to the presence of a liquid or any other obstruction in a cylinder.

The primer fuel supply is drawn from the main fuel line through the reducing tee furnished with the engine and the primer discharge is connected to the diffuser chamber at the base of No. 1 cylinder intake pipe. All priming lines should be well protected against vibration and chafing.

The carburetor when correctly installed will have the throttle control lever on the right side and the altitude adjustment lever on the left when the engine is observed from the anti-propeller end. The locations and radii of action of the throttle and mixture controls are given in the installation drawings in the Appendix. Movement of one control must not affect the other control. See the installation drawing, also, for the location of the fuel pressure and carburetor mixture thermometer bulb connections.

In all engines where an air maze air cleaner is used in the air heater supplied as standard equipment, a drain pipe should be connected to the drain hole which is provided in the pan at the bottom of the air cleaner. The purpose of this drain is to prevent raw fuel from collecting at this point.

SUPERCHARGER PRESSURE GAGE LINE

The accumulation of small quantities of oil or water in the supercharger pressure gage line will result in incorrect supercharger pressure gage readings and may cause serious damage to the engine.

It is recommended that a valve be installed in the supercharger pressure gage line at a convenient location in the cockpit for the purpose of blowing out the line to remove any accumulation of oil or water. It is recommended that the valve be opened for a period of ten to fifteen seconds at regular intervals while the engine is idling to clear out the line.

MAGNETO WIRING

Connect the ground wires of the magnetos with the respective points R MAG and L MAG on the ignition switch. The point marked GRD on the switch should be connected to the engine crankcase. All the wiring should be held in clips at suitable points in order to prevent chafing and wear which might later develop into short circuits. This is vitally important since the safety of the individuals working around the engine or propeller as well as the proper functioning of the engine is dependent upon the ground and ignition wires being correctly connected and insulated.

The booster may be mounted in the cockpit with the high tension lead connected to the high tension wire on one of the magnetos. The ground wire from the booster may be grounded to the engine crankcase or to the switch ground. If it is desired to use a booster without installing it in plane, the high tension lead should be con-...ed temporarily to the high tension lead at ... of the magnetos and the body of the booster ...ded temporarily to the engine crankcase.

VACUUM PUMP

Provision is made for mounting a vacuum ... on either the oil pump or the three-way ...essory drive. When mounting the vacuum ... care should be exercised to see that lubri-... passages in the mounting flange are clear ... that the proper oil drainage lines are pro-...ded. If the vacuum pump is mounted on the oil ... the drainage line may be led from either ... connection in the vacuum pump just behind ... mounting flange or the connection just in ... of the accessory mounting pad on the oil ... If the vacuum pump is mounted on the ... -way accessory drive, the drainage line must ...ed from the connection in the vacuum pump. ... drain should be led outboard through a suit-... tube.

The vacuum pump exhaust should have the ...arge at the bottom. The discharge may be ... through an approved oil separator and re-...ed into the oil tank. If no oil separator is ... the discharge should be led either into the ... collector ring or outboard.

GOVERNOR DRIVE

Provision is made for mounting a variable ... propeller governor unit on the three-way accessory drive as well as on the crankcase front section of current engines. Complete details concerning the installation of the governor unit on the engine are given on supplementary installation drawings.

EXHAUST GAS ANALYZER

An exhaust gas analyzer or mixture indicator has been designed for use on Whirlwind engines. This indicator provides a means of controlling fuel consumption in flight. Complete instructions on the installation and operation of this indicator will be furnished upon request to the Service Division.

ACCESSORY DRIVES

The Wright Aeronautical Corporation will assume no responsibility for the failure of an engine directly traceable to the failure of an accessory.

The locations, types, and rotations of the various accessory drives are shown on the basic and supplementary installation drawings.

Information regarding approved accessories will be furnished upon request to the Service Division.

PROPELLERS

Complete information on the installation of propellers is given in the publications supplied by the propeller manufacturers.

CHAPTER IV

OPERATION

The instructions contained in this chapter are general operating instructions for the Wright Whirlwind engines. Complete airplane operating instructions for pilots use should be obtained from the airplane manufacturer. More specific engine operating instructions and engine specifications for the particular engine model concerned may be procured upon request to the Wright Aeronautical Corporation, Service Section.

PRE-OILING SCHEDULE

Improved performance and extended service life of engine parts, particularly master rod bearings, may be obtained by insuring that all pressure-fed parts of an engine receive sufficient quantities of oil immediately upon starting.

Pre-oiling is accomplished by filling the oil passages of the engine with oil under pressure before starting, so that lubrication of parts may be obtained as soon as the engine is started. To fill the oil passages of the engine, it is necessary to pump oil from an external source into the engine while the crankshaft is being rotated. A portable hand pump fitted to a suitable container, or, where pre-oiling is practiced on a large scale, a portable rig fitted with an electrically driven pump, a container, and a heating element may be used for forcing oil into the oil passages of the engine.

It is recommended that pre-oiling be used when starting a new engine in an airplane for the first time, when starting a newly overhauled engine on a test stand or in an airplane, or when first starting an engine which has been treated for storage.

To pre-oil the engine proceed as follows:

1. Fill the oil tank to its normal level.
2. Remove the oil inlet line connection at the oil pump and drain approximately one gallon of oil to insure that no air remains in the line.
3. Reinstall the oil inlet line to the oil pump.
4. Remove the oil pump relief valve.
5. With the ignition switch in the off position, and the carburetor mixture control in the idle cut-off position, turn the engine over by hand until sufficient oil is expelled through the relief valve opening to indicate that no air remains in the oil pump. Re-install the oil pump relief valve.

It is recommended that the engine be started as soon as possible after pre-oiling.

COLD WEATHER PRECAUTIONS

In extreme cold weather, it may be necessary to preheat the oil before starting. A great deal of time can be saved by draining the oil from the tank as soon as operations for the day are concluded and before the oil has cooled off. If left in the tank over night, the oil may become so viscous as to require considerable time to drain.

In cold weather it is also advisable to have some sort of lagging on the external oil lines to and from the tank. This will result in higher oil temperature at cruising speed and will decrease the danger of stoppage due to congealed oil. A layer of asbestos cord, shellacked, and then wrapped with friction tape provides a very good insulation. Lacking asbestos, several layers of ordinary packing cord can be used.

A large sized oil pressure gage line is essential in cold weather to obtain an immediate indication of any pressure variation in the engines. Refer to the chapter on Installation regarding the use of light oil in gage lines.

OIL DILUTION SYSTEM

The oil dilution system consists of a valve which, when open, admits raw gasoline to the oil inlet line of the engine, reducing the viscosity of the oil in the engine and oil system. In cold weather when a temperature less than 23° F. (-5° C.) is expected to prevail at the start, the oil dilution system should be employed to facilitate the starting procedure. If the engine heat is excessive while diluting the oil, the heat may evaporate the fuel out of the oil, leaving the viscosity of the oil in the engine unchanged. The engine should therefore be idled

…cooler shutters and cowl flaps in their …ing positions until the cylinder head …are below 150° F. (65° C.) and …temperature below 100° F. (38° C.). …rience indicate that this does not pro… …t cooling, the engine should be shut …short time and then restarted before …e oil dilution system.

…rate the oil dilution system, run the en… …a speed of approximately 1000 r.p.m., …oil dilution valve for a period varying …to four minutes as determined by ex… …and then stop the engine by moving …control to the cut-off position. The …of time is dependent on the antici… …ature at the start, the amount and …in the oil system, and the charac… …each installation. In all cases, leave …ion valve open until the engine stops, …the valve and turn off the standard …y valve. Turn the ignition switch to the …

…starting an engine whose oil system has …uted, a normal start and warm-up should … The oil when diluted will usually permit …to turn the engine at a fairly high rate …without the necessity of preheating the … the warm-up period, the fuel will …evaporate as the oil temperature rises. …starting, if a heavy viscous oil is indicated …pressure that is too high or by oil pressure …fluctuates or falls back when the engine …is increased, the dilution valve is some… …operated to correct this condition. This is …considered good practice, but in the event …emergency it may be resorted to, provid… …the oil dilution valve is operated intermit… …, and not continuously.

CARBURETOR … HEATER The formation of ice in the carburetor can be prevented or relieved by the …the carburetor air heater. Any roughness …eliminated or reduced by using the …

…important function of the air heater is to …formation of ice in the carburetor ven… …Vaporization of the fuel as it leaves the dis… …nozzle of the carburetor causes a tem… …drop at this point. This temperature …depends upon the volatility of the fuel, the …mixture ratio, and other factors.

…der certain conditions the drop in temperature causes the water vapor in the air flowing past the discharge nozzle to condense and freeze, and ice is deposited on the nozzle, and sometimes on the venturi or other parts of the induction passage beyond the nozzle. There have been cases of ice forming on the butterfly valve to such an extent that the throttle could not be moved.

This ice formation is dangerous for two reasons:

a. It chokes the air passage causing loss of power, and, under the worst conditions, may cause complete stoppage of the engine.

b. Small pieces of ice may break off and be carried into the supercharger impeller, thus damaging the blades of the impeller because of the high rotative speed of this unit. This may occur when the engine is apparently functioning in a normal manner so that extensive damage may be incurred without the operator knowing it, unless the proper precautions are taken in the use of the air heater.

Ice formation is most likely to occur during damp or rainy weather in the fall or spring when the atmospheric humidity is high and the ground air temperature is between 30° and 70° F. (-1° and 21° C.). Under these conditions the temperature at the carburetor discharge nozzle may be below the freezing temperature of water, and at the same time below the dew point of the air, i.e., the temperature at which the water vapor in the air, when cooled, will condense, forming drops of water or ice.

When flying in rain or clouds, the drops of water entering the carburetor may freeze in the induction passage if the slipstream air temperature is below 70° F. (21° C.), and if no heat is applied to the carburetor intake air.

With ground air temperatures below 20° F. (-6.7° C.) the danger from ice formation is lessened because the quantity of water vapor in the air at such times is very slight. The same is true at high altitudes at all seasons. In these two cases the function of the air heater is to improve the vaporization of the fuel and distribution to the cylinders. It will be found that in cold weather, or at high altitudes, that better economy can be obtained with the heater control in the hot position. Under these conditions heating of the carburetor air intake is particularly necessary for proper acceleration to prevent stalling when the engine is throttled back during a glide

In hot weather the control should be kept in cold position, which will permit the engine to develop the maximum power output without danger of overheating the cylinders.

Summarizing, the following rules should be followed:

1. See that the heater control operates through the total range. The control should be checked in the extreme hot and cold positions.
2. When operating in ice forming weather conditions, the temperature of the fuel air mixture, measured in the carburetor elbow, should be maintained between 35° F. and 40° F. (1.4° C. and 4.4° C.).
3. The temperature of the air entering the carburetor should not exceed 120° F. (48° C.).

When carburetor heat is applied, the mixture very definitely goes rich, and if prolonged running is to be done using carburetor heat, the mixture should be reset after applying the heat. Likewise, when heat is shut off, the mixture will definitely go lean until possible detonation is started. Therefore, in shutting off carburetor heat, always richen the mixture first.

PRE-FLIGHT INSPECTION

Before every flight, check:

1. The fuel and oil supply.
2. The fuel and oil lines for leakage.
3. All controls for proper movement.
4. For liquid lock. Pull the propeller through by hand for at least three complete revolutions. If it is difficult to turn the propeller, remove the spark plugs from the lower cylinders to determine whether any liquid has collected in the cylinders.

   WARNING: The presence of any quantities of liquid in the combustion chamber of an engine is likely to cause serious damage. It is, therefore, urgently recommended that all operators take steps to have engines pulled through three complete revolutions by hand before they are started. Wright Aeronautical Corporation will not assume any responsibility for engines which are damaged due to the presence of liquid or any other obstacle in the cylinders.
5. For any other abnormal conditions.

STARTING PROCEDURE

The following procedure should be followed in starting all Wright engines irrespective of the type of carburetor that is installed.

1. Head the airplane into the wind and turn the propeller by hand for at least three complete revolutions with the throttle wide open. If it requires abnormal effort to move the propeller, remove the spark plugs from the lower cylinders to determine whether liquid has collected in the cylinders.

   WARNING: The presence of any quantity of liquid in the combustion chamber of an engine is likely to cause serious damage. It is, therefore, urgently recommended that all operators take steps to have the propeller turned three complete revolutions before starting the engine. The Wright Aeronautical Corporation will not be responsible for damage to an engine caused by liquid or any other obstruction in a cylinder.
2. Place the controls as follows:
   a. Fuel Supply Cock.................................On
   b. Ignition Switch ....Off
   c. Throttle Control........Set for 1000 r.p.m.
   d. Mixture Control......................Idle Cut-off
   e. Propeller Governor Control
      Low pitch (high r.p.m.)
   f. Carburetor Air Preheat Control......Cold
   g. Oil Cooler Shutter Control............Closed
      (if manually operated)
   h. Cowl Flap Control............................Open
      (if manually operated)

   NOTE: Engines equipped with Stromberg float type carburetors may be started with the mixture control in full rich position. However, it is suggested that the idle cut-off position be used for starting in order that the procedures may be standardized to prevent mistakes when pilots change from one installation to another.
3. Obtain proper fuel priming pressure with hand or electric pump. The correct pressure for the Stromberg float type carburetor is 3-4 lb./sq. in. (.2109-.2812 kg./sq. cm.).
4. Engage starter.
5. After the propeller has turned two revolutions, switch ignition on.

In the event a ballistic or plain inertia type starter is used, operate primer as necessary and turn ignition switch on prior to engaging starter. Do not alter the procedure, however, when using a direct cranking inertia starter.

6. Operate booster ignition and primer simultaneously. Pump the hand primer approximately five strokes or engage a solenoid type of primer for several seconds. It is difficult to predict the exact number of strokes required to prime as it depends on the installation, temperature, and other such conditions. Therefore, the amount of priming may be varied as indicated by experience. If the engine is warm, priming may not be necessary.

7. As the engine starts to fire, move the mixture control to full rich.

8. Release booster ignition switch.

9. If the engine refuses to start after 10 to 20 revolutions, let starter cool and repeat the foregoing procedure.

10. Shut down if the oil pressure does not reach 40 lb. sq. in. (2.812 kg./sq. cm.) within 10 seconds after starting.

A priming charge can be obtained by pumping the throttle to the Stromberg float type carburetor because this carburetor has a linkage from the throttle to the accelerating pump.

Do not prime by pouring raw gasoline into the cylinders through exhaust ports or spark plug holes. Do not overprime. Overpriming may prevent any firing taking place or may result in only a few explosions, torching, and white fog from the exhaust stack. If the engine becomes overprimed, open the throttle and turn the engine over several revolutions until it has cleared out. Make certain that the ignition switch is off during this period. When cleared, return the throttle to the 1000 r.p.m. position.

The mixture control should always be left in the idle cut-off position when the engine is shut down.

A few instances have been encountered where the fuel has leaked through the primer pump and into the intake passages, thus filling the lower cylinders with raw fuel. It is absolutely necessary that the primer shut-off valve be closed except when the pump is being used. Check to make certain that this valve is working properly.

To insure against fires, overpriming, and flooding of the lower cylinders, an engine should not be started with the mixture control in the full rich position, nor be primed when the crankshaft is not being turned, except in the cases previously mentioned.

WARM-UP After the oil gage indicates pressure, shift the propeller to low pitch and run the engine at 600 to 800 r.p.m. until the pressure is normal for this speed. This will be a value of between 50 and 80 lb./sq. in. (3.516 and 5.625 kg./sq. cm.). This warm-up should be extended to at least five minutes after which the revolutions per minute can be increased to 1000. Should the oil pressure fall off at an increase in speed, the engine should be throttled back for further warm-up before speed is again increased. A thorough warming-up is recommended. A full rich mixture is advisable for all speeds above 1300 r.p.m. when running at sea level on the ground.

PERFORMANCE CHECK When the oil temperature is sufficient to indicate that the oil is circulating properly, open the throttle to obtain 1800 r.p.m. being sure that the mixture control is in the full rich position and that the propeller is in low pitch. Do not exceed 30 in. Hg manifold pressure. Check the oil pressure and the oil temperature and note the loss of r.p.m. when the ignition switch is turned to one magneto at a time. The speed should not drop more than 75 r.p.m. below the reading when operating on both magnetos. This check should be made in as short a time as practicable and should not extend over fifteen seconds.

If the oil pressure is not within the specified range, throttle the engine and adjust the oil pressure relief valve in the oil pump as described.

With the engine hot, adjust the idling control on the carburetor for smooth idling. Check for acceleration, being certain to have the mixture control at full rich. The accelercation should be smooth and rapid.

As the cooling of the cylinder heads and barrels is insufficient while on the ground, any prolonged running or at near maximum permissible throttle opening on the ground should be avoided.

The cylinder temperatures are a very good indication of trouble and will often reveal a trouble before it has gone far enough to cause serious damage. The following temperatures are afforded as a guide to the pilot:

CYLINDER HEAD

Using Spark Plug Washer Type Thermocouple (Maximum Permissible for Short Periods) ....500° F. (260° C.)

CYLINDER BARREL

Using Embedded Type Thermocouple (Maximum Permissible)........325° F. (163° C.)

TAKE-OFF PROCEDURE

1. It is not advisable to take-off with cylinder head temperatures below 250° F. (120° C.). The maximum cylinder head temperature immediately before take-off must be determined by experience to permit a normal take-off and climb without exceeding the maximum temperature limit.
2. Set the mixture control in the rich position.
3. Set the carburetor air preheat control in the full cold position unless atmospheric icing conditions are anticipated. If atmospheric icing conditions are anticipated, adjust the preheat control to provide enough carburetor air heat to clear out or preclude the formation of carburetor ice.
4. Open the throttle slowly to full throttle.

FLIGHT PROCEDURE

The mixture control, though primarily an altitude adjustment, may be used for the economy of fuel at cruising speeds but should be kept full rich during operation at maximum throttle position except when the altitude makes the mixture too rich for smooth operation. Extreme care should be exercised so as not to overheat the engine by too lean a mixture. Leaning the mixture in flight when operating at rated power is accompanied by a rise in cylinder temperatures. It is therefore necessary to exercise every precaution in the use of the mixture control. The use of a carburetor air heater definitely effects the mixture. Consult the paragraphs on air heater operation for information on this subject. The Wright Aeronautical Corporation recommends the procedure outlined in the following paragraphs.

When cruising 85% of rated speed or lower, it is possible to effect a considerable fuel economy by the intelligent use of the mixture control. If, for example, it is desired to cruise at approximately 1850 r.p.m. with best economy, with or without an exhaust gas analyzer and using a fixed pitch or two position propeller, adjust the throttle to the desired r.p.m. (1850) and move the mixture control toward the lean position. The r.p.m. will increase slightly and will then start to drop off. Observe the point of maximum r.p.m. and continue leaning the mixture until not more than 20 r.p.m. are lost. Do not change the throttle setting.

Another method of setting the mixture control is by leaning the mixture out until the r.p.m. falls slightly, then enrich the mixture to regain the original r.p.m. Do not change the throttle setting.

When using a Cambridge mixture indicator, or exhaust gas analyzer, the throttle should be set to give the desired manifold pressure and the mixture leaned out until the pointer on the mixture indicator indexes with the manifold pressure on the indicator dial which corresponds with the engine manifold pressure.

When using a constant speed propeller, the mixture should be set using an exhaust gas analyzer as described above. In cases of emergency, if it is known that the exhaust gas analyzer is not functioning properly, it is permissible to shift the constant speed propeller to high or low pitch and to set the mixture control subject to a 10 or 20 r.p.m. drop. This procedure is as follows: Adjust the throttle and propeller for the desired cruising power. Shift the propeller to the high pitch position and set the mixture control as instructed in the preceding paragraphs. Re-adjust the propeller pitch for the desired speed. Do not change the throttle setting during this procedure.

The use of the mixture control is considered proper at all cruising altitudes in level flight subject to a maximum cylinder head temperature restriction of 450° F. (233° C.) and subject to the requirement when using a fixed pitch or two position propeller that the engine r.p.m. shall not drop more than 10 to 20 r.p.m. at a constant throttle opening.

The mixture control should be used during a 70 to 75% power climb subject to the same restrictions as in the above paragraph. For take-off, initial climb, and other maneuvers below 4000 feet (1.22 Kilometers) altitude, the mixture control should be in the full rich position in order to prevent the possibility of misuse of the mixture control causing serious trouble.

The mixture control may be used in descent [illegible] to the restrictions in r.p.m. drop and cylinder temperature given above, but as the [illegible] gradually leans out during descent, it is [illegible] to operate on the rich side of the de[illegible] setting during this condition.

The r.p.m., the cylinder temperatures, the oil [illegible]atures, and the oil pressure give the most [illegible] indication of the engine's performance. [illegible] any one of these appears irregular, the [illegible] should be throttled, and if the cause is [illegible]parent, a landing should be made to in[illegible]te and remove the trouble. The oil inlet [illegible]ature should not exceed 190° F. (88° C.). [illegible] high temperature usually indicates trouble. [illegible] pressure varies with the engine speed, and [illegible] need cause no alarm by falling as low [illegible] (7 kg.) with the engine throttled. High pressure (above specified value) often accounts for high oil consumption and may be lowered by [illegible] out on the main pressure relief valve.

When coming in for a landing, the mixture control must always be set in the full rich position to insure best acceleration in case of need.

To avoid possible damage to engines resulting from operation at excessively lean mixtures, it is recommended that the precautions given below be observed by all operators.

Whenever the fuel supply to an engine is shifted from one fuel supply tank to another, the mixture control of the engine should be in the full rich position. The shifting of the fuel supply should be made as quickly as possible.

An engine fuel supply tank should not be permitted to run dry before the shift is made to an alternative fuel supply tank.

LANDING

When the throttle is closed to make a landing, the mixture control lever *must always be set back to the full rich* position. The propeller should be in low pitch position. This will insure ready acceleration if it becomes necessary to open the *throttle* again. Gunning the engine during long glides prevents too rapid cooling of the engine.

STOPPING PROCEDURE

To stop the engine by the use of the fuel shut-off, close the throttle until the engine is running at 700 to 800 r.p.m. Run the engine long enough at this speed to permit the cylinders to cool to 250° F. to 350° F. (120° C. to 175° C.). When the cylinder temperature is within this range, shift the propeller to high pitch. As soon as the r.p.m. begins to drop, move the mixture control to full lean. When the engine stops firing, move the ignition switch to the off position. For successful operation of the fuel shut-off, it is essential that the engine should not be *operated* at more than 1000 r.p.m., since above 1000 r.p.m. the economizer valve may be open and fuel will be admitted to the engine through the economizer *metering* jet. When stopping the engine, do not open the throttle, as this will force a charge of fuel into the engine. As precautions against accidental *starting, leave* the mixture control in the full lean position and the ignition switch in the off position.

FUEL SPECIFICATIONS

In the selection of fuel for aviation engines, the operator is faced with a problem which requires careful consideration. An inferior *fuel will cause serious damage to the* engine and a mediocre grade will cause continuous small troubles which are often obscure when an attempt is made to *trace them to their* source. The use of a high grade product, on the other hand, will be found to improve the reliability, power, and fuel economy of the engine and will, in the long run, decrease the cost of operation.

Gasoline specifications should be used in selecting fuel. The operator should have the assurance of the vendor that the fuel under consideration has an anti-knock value at least equivalent to that specified in the Engine Specification and stamped on the engine data plate.

***In an emergency, when an operator finds it* necessary to use other than recommended fuel, the mixture control should be left in the full rich position and the engine operated *at the lowest* output possible.** The Wright Aeronautical Corporation will not be responsible for damage to the engine when any but the specified grade of fuel is used. The use of fuel which does not meet the required specification constitutes misuse of the engine and voids the engine warranty.

The engine data plate is stamped with W.A.C. fuel specification for the engine. Fuel for use in Wright aviation engines must conform to the requirements for the specified grade.

OIL SPECIFICATIONS

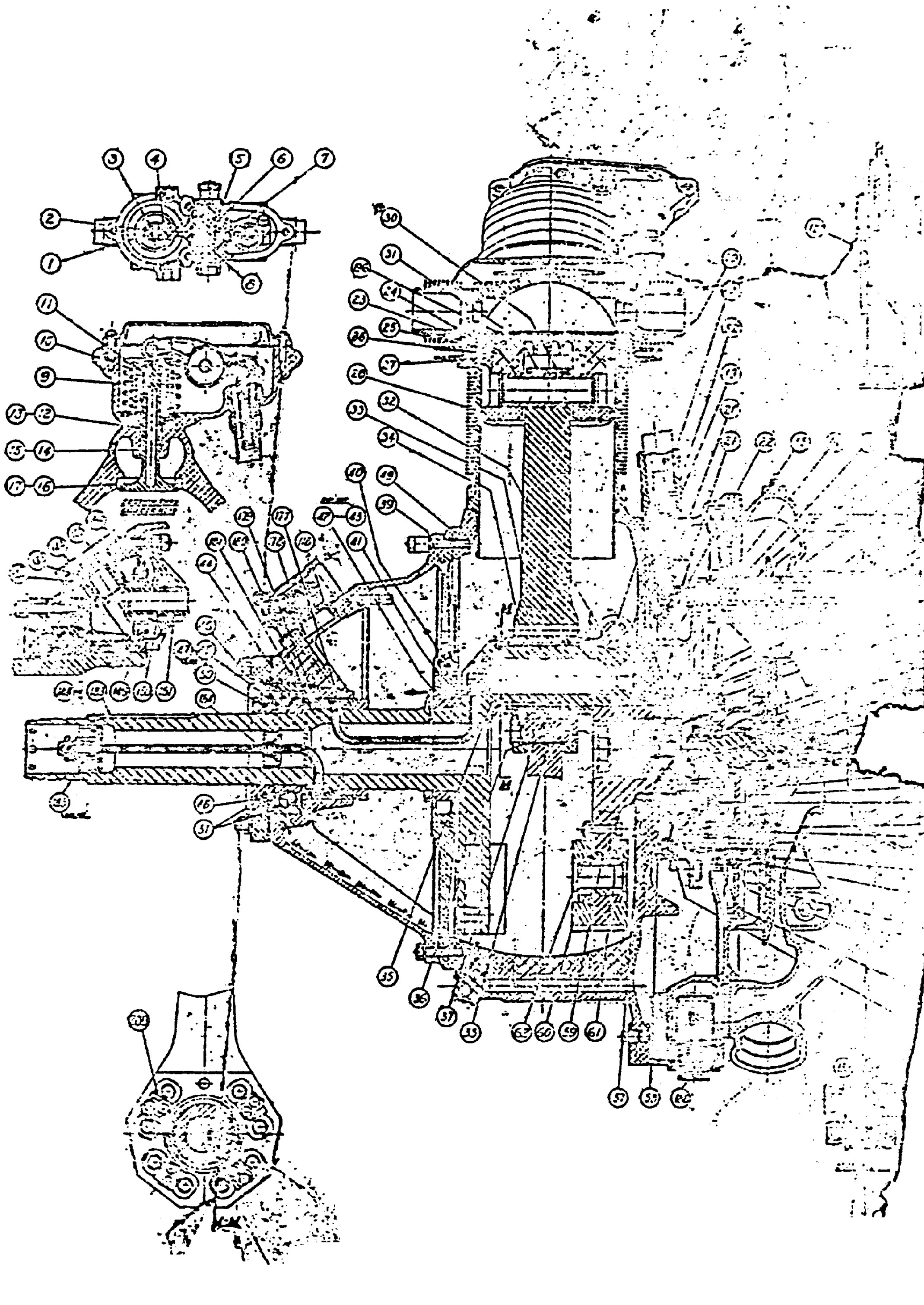
Due to the usual solvent action of one oil with the decomposition products of another, and other detrimental reactions which have been found to result from *mixing lubricating* oils

produced from different methods of refining, it is recommended that engine operators select and adhere exclusively to some one approved brand of engine oil.

If it is desired to change the brand of oil used, it is recommended that the change be made at the time of engine overhaul. This will permit the oil system and all engine parts to be cleaned thoroughly before installation of the new oil.

When lubricating parts during reassembly, or when lubricating rocker arms during periodic inspections, care should be taken to use only oil of the brand on which the engine is to operate.

In an emergency, if additional oil of the brand used in an engine cannot be obtained for replenishing the engine oil supply, the engine oil sump and the oil system in the airplane should be completely drained and the system refilled with an available supply of an approved brand of oil. However, the Wright Aeronautical Corporation will not be responsible for any damage which may be traced to the use of a mixture of different brands of oil in an engine.



CHAPTER V

WRIGHT ENGINE PERFORMANCE CURVES

DESCRIPTION

In Wright full throttle altitude performance curves, lines representing revolutions per minute (r.p.m.) and manifold pressure are plotted against horsepower on the vertical axis and against altitude in feet on the horizontal axis. The engine r.p.m. lines are plotted in increments of one hundred r.p.m. while the manifold pressure lines are in increments of one inch of mercury.

A line of horsepower vs. altitude at constant r.p.m. and manifold pressure is indicated on the curve. Only one such line is necessary and all other possible lines of horsepower vs. altitude at constant r.p.m. and manifold pressure are parallel to this one.

A standard temperature vs. altitude line is plotted at the bottom of most full throttle altitude performance curves.

The engine performance curves described above are designed for use with a specific engine model and cannot be used with any other model or with an engine which is not being operated in accordance with the engine specifications corresponding to the power curves. Performance curves are prepared for all commercial Whirlwind engines. Refer to the curve which is prepared specifically for a particular engine model to obtain performance figures for an engine of that model.

The powers as determined from the engine performance curves are subject to two and one-half per cent variation.

METHOD OF READING ENGINE PERFORMANCE CURVES

When reading performance curves, it must be borne in mind that they were made up using standard altitude temperatures and pressures, that they represent engine operation using fuel-air mixtures which give best power, and that they are based on air entering the carburetor under no ramming effect.

When using a full throttle altitude curve in flight to determine the horsepower developed by the engine, proceed as follows:

1. Locate the intersecting point of observed manifold pressure and engine r.p.m. on the curve.
2. Draw a line through this point parallel to the line of horsepower vs. altitude at constant r.p.m. and manifold pressure shown on the curve. Any point on this new line is at the observed manifold pressure and engine r.p.m.
3. Follow down along this line until the vertical line representing the altitude at which the airplane is being operated is reached.
4. From this point project a line horizontally to the left. Read the observed, or uncorrected, horsepower from the vertical horsepower scale at the left edge of the curve.
5. Correct the observed horsepower for variation in carburetor air temperature by adding or subtracting a horsepower correction equal to 1 per cent of the observed horsepower for each 10° F. (6° C.) variation in the observed carburetor air temperature from the standard altitude temperature. If the observed carburetor air temperature is less than the standard altitude temperature, add the horsepower correction to the observed horsepower. If the carburetor air temperature is more than the standard altitude temperature, subtract the horsepower correction from the observed horsepower.

EXAMPLE

(Refer to Chart)

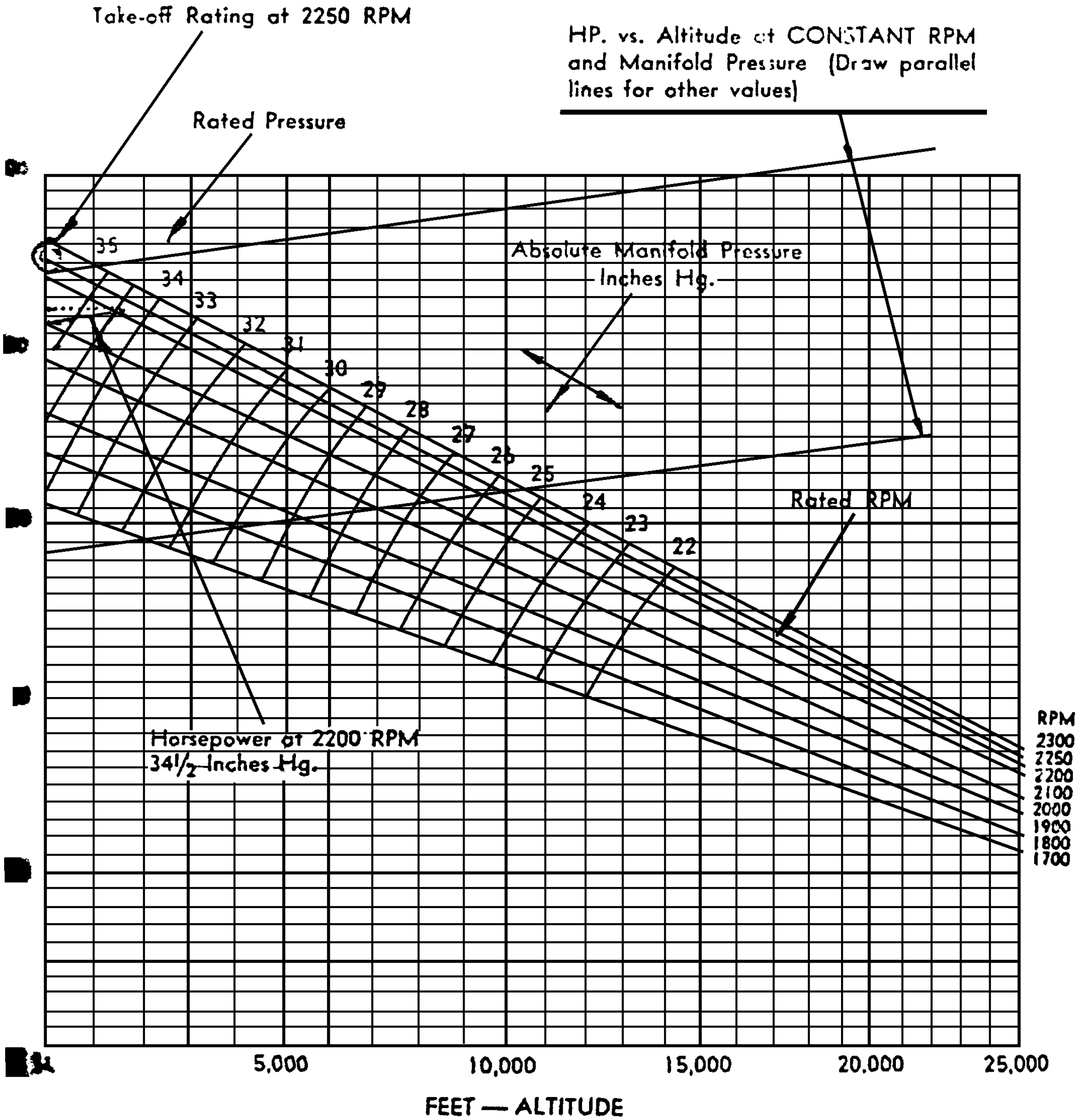
Flight Conditions:

Manifold Absolute Pressure ....28.3" Hg (71.9 cm. Hg)

Engine r.p.m. 2000

Altitude ....4000 Ft. (1220 m.)

Carburetor Air Temperature ....26° F. (-4° C.)



Take-off Rating at 2250 RPM
Rated Pressure
HP. vs. Altitude at CONSTANT RPM and Manifold Pressure (Draw parallel lines for other values)
35
34
33
32
31
30
29
28
27
26
25
24
23
22
Absolute Manifold Pressure Inches Hg.
Rated RPM
Horsepower at 2200 RPM 34½ Inches Hg.
RPM
2300
2250
2200
2100
2000
1900
1800
1700
5,000
10,000
15,000
20,000
25,000
FEET — ALTITUDE

Locate the intersecting point of the observed manifold absolute pressure and engine r.p.m. on the section of the curve which is drawn for low supercharger ratio operation (Point A). Through this point draw a line of horsepower vs. altitude at constant r.p.m. and manifold pressure (Line AB). This line is to be drawn parallel to the line of horsepower vs. altitude at constant r.p.m. and manifold pressure which is shown on the curve. Project a line horizontally to the left from the intersection point (Point B) of the line just drawn and the 4000 ft. (1220 m.) altitude line. Read the uncorrected horsepower from the vertical horsepower scale as 310 (Point C).

Correct this observed horsepower for the difference between the actual carburetor air scoop temperature and the standard altitude temperature as follows:

Determine the standard altitude temperature from the standard temperature vs. altitude curve. The standard temperature at 4000 ft. (1220 m.) altitude is 46° F. (8° C.). This gives a temperature difference of 20° F. (12° C.) between the standard and the observed temperatures. Determine the horsepower correction as follows:

Horsepower correction
= 1% of 310 for each 10° F. (6° C.)
= .01 x 310 x 2 = 6.2 horsepower difference

Because the observed carburetor air temperature of 26° F. (-4° C.) is below the standard altitude temperature, add the horsepower correction to the observed horsepower.

Corrected horsepower = 310 + 6.2 = 316.2

It should be noted that the power curves are based on best power mixture strength. Therefore, if the engine is not being operated at best power mixture strength, the determined horsepower will not be entirely correct.

It should also be noted that if air enters the carburetor under a ramming pressure (as it does in some instances), the plane may operate at a specified manifold pressure and engine r.p.m. at altitudes slightly above the full throttle critical altitude of the engine as shown on the power curves. If this is the case, then the horsepower vs. altitude at constant r.p.m. and manifold pressure line must be extended to the right beyond the full throttle critical altitude point for the specified manifold pressure and r.p.m. The observed and corrected horsepowers may then be determined as described above.

CHAPTER VI

TROUBLE SHOOTING

DETERMINING the causes of engine troubles is at times rather involved due to the number of sources to which a given symptom may be attributed. The best method of "trouble-shooting" is to consider the possible causes and eliminate them one by one.

This chapter is devoted to a chart of the most common engine troubles and their probable causes. Its purpose is to minimize, in so far as possible, the time spent in ascertaining the source of a given trouble.

When reporting troubles, give the part name and number, the engine serial number, and the total time on the part and engine. The description of the failure with sufficient details should be included in the report.

TROUBLE	CAUSES	REMEDY
Failure of Engine to start	1. Lack of fuel	Repair any leaks in fuel system. Fill fuel tank. Clean dirty lines, strainers, or fuel cocks.
	2. Under-priming	Prime according to instructions in chapter on Operation.
	3. Over-priming	Rotate crankshaft through a few revolutions with throttle full open and ignition switch on.
	4. Incorrect throttle setting	Reset throttle opening according to the carburetor manufacturer's instructions.
	5. Defective booster	See that booster is grounded to the engine. Check booster electric output.
	6. Defective spark plug ignition	Clean and dry terminal. If sleeve is cracked, replace with a good sleeve.
	7. Defective ignition wire	Check wire with an electric tester.
	8. Dirty spark plugs	Clean plugs. Refer to manufacturer's instructions.
	9. Incorrect spark plug gap	Replace spark plugs with plugs set at proper gap. Use anti-seize compound during installation.
	10. Defective battery	Replace with charged battery.
	11. Magneto breaker points not working	Clean and adjust points. Test spark delivered by the magneto with an electric tester.
	12. Water in carburetor	Remove the plug to drain off fuel and water.
	13. Incorrect valve clearance	Refer to section titled Adjusting Valve Clearances.
	14. Incorrect valve timing	Refer to the section titled Valve Timing.
	15. Internal failure	Examine the oil sump strainer. Trapped particles indicate internal trouble, and complete overhaul may be required.

TROUBLE	CAUSES	REMEDY
Low Power and Uneven Running	1. Too rich a mixture indicated by black smoke from exhaust	Consult carburetor manufacturer's instructions.
	2. Too lean a mixture indicated by overheating, backfiring, low fuel pressure, or low fuel supply	Consult carburetor manufacturer's instructions. Raise fuel pressure at fuel pump. Replenish fuel supply.
	3. Leaks in induction system	Tighten all connections. Replace any leaking parts.
	4. Defective spark plugs	Clean plugs. Refer to manufacturer's instructions. Replace plugs if gap is incorrect. Use anti-seize compound during installation. Test for proper sparking with an electric tester.
	5. Poor fuel	Replace with recommended fuel
	6. Magneto breaker points not working properly	Clean and adjust points. Test spark delivered by magneto with an electric tester.
	7. Defective ignition wiring	Check wire with an electric tester.
	8. Engine overheating	Refer to items 2, 3, and 5.
	9. Carburetor leakage	Refer to carburetor manufacturer's instructions.
	10. Defective spark plug terminal insulators	Replace insulators with good ones.
	11. Incorrect valve clearance	Refer to section titled Adjusting Valve Clearances.
	12. Incorrect valve timing	Refer to section titled Valve Timing.
Low Oil Pressure	1. Lack of priming	Prime pump according to instructions.
	2. Leak in suction line	Replace any leaking parts.
	3. Dirty oil strainer	Remove and clean the strainer.
	4. Air lock or dirt in relief valve	Clean relief valve.
	5. Improper setting of relief valve	Adjust valve with engine running and oil at recommended temperature.
	6. High oil temperature	See High Oil Temperature in Trouble column.
	7. Oil foaming	Design of the oil tank may be faulty. This will necessitate replacing the tank.
Oil Accumulation in the Crankcase	1. Lack of priming in scavenge pump	Prime the scavenge pump.
	2. High oil temperature	See High Oil Temperature in Trouble column.
	3. High oil pressure	Readjust pressure relief valve.

TROUBLE	CAUSES	REMEDY
High Oil Temperature	1. Insufficient oil cooling 2. Insufficient oil supply 3. Low grade of oil 4. Scavenge pump not working properly 5. Bearing failing or failed 6. Clogged oil lines, strainers, or coolers 7. Improper venting of oil system	Check cooler for clogging. Replenish oil supply. Replace with oil of the proper specification. Prime the scavenge pump. Examine sump for metal particle. Clean lines, strainers, or coolers. Refer to Installation Drawing in the back of this book.
Excessive Oil Consumption	1. Low grade of oil 2. Scavenge pump not working properly 3. Bearing failing or failed 4. Worn piston rings 5. Piston rings incorrectly installed	Replace with oil of the proper specification Prime the scavenge pump. Examine sump for metal particles. Refer to section concerning bearings in Chapter 8. Refer to section concerning piston rings in Chapter 8. Refer to section concerning piston rings in Chapter 8.
Cold Weather Difficulties	1. Cold oil—if oil dilution is not used 2. Inaccurate pressure readings 3. Over-priming 4. Weak booster coil 5. Weak battery	Oil must be pre-heated to at least 125° F. (50° C.). Gage lines should be filled with S.A.E. 10-W oil. Follow instructions in chapter on Operation. An auxiliary hand booster may be necessary. A heavy duty battery should be used.

CHAPTER VII

PERIODIC INSPECTION

A RECOMMENDED procedure for inspecting the engine is included in this chapter. Section A is a chart designating the items which should be inspected or looked for at certain periods. Section B is a detailed explanation of items in Section A.

SECTION A

	Pre-flight	Starting	Daily	25 hour	100 hour	200 hour
1. Fuel supply	x		x			
2. Fuel leakage	x		x	x	x	x
3. Fuel connections	x		x	x	x	x
4. Fuel system strainer				x	x	x
5. Carburetor nuts					x	x
6. Carburetor controls				x	x	x
7. Carburetor fuel strainer				x	x	x
8. Carburetor air cleaners			x	x	x	x
9. Carburetor air screen					x	x
10. Fuel pressure		x				
11. Fuel tanks					x	x
12. Oil supply	x		x			
13. Oil change					x	x
14. Oil leakage	x		x	x	x	x
15. Oil connections			x	x	x	x
16. Cuno oil filter	x	x	x	x	x	x
17. *Oil sump strainer*					x	x
18. Oil cooler cores			x	x	x	x
19. Oil pressure		x				
20. Oil temperature		x				
21. Magneto operation		x				
22. Magneto lubricating felt					x	x
23. Spark plugs					x	x
24. Ignition terminals				x	x	x
25. Cylinder fins				x	x	x
26. Cylinder head temperature		x				

		Pre-flight	Starting	Daily	25 hour	100 hour	200 hour
27	Nuts and cap screws				x	x	x
28	Internal obstruction	x					
29	Crankcase breather screen					x	x
30	Engine exterior						x
31	Compression						x
32	Valve clearance						x
33	Intake pipes						x
34	Exhaust system						x
35	Push Rod Hoses						x
36	Miscellaneous						

SECTION B

1. Fuel supply—See that there is an adequate supply of fuel of the proper specification.

2. Fuel leakage—Inspect the engine carefully for fuel leakage. The location of a leak may not always be where the fuel is found. Repair or replace any parts which are causing the fuel to leak.

3. Fuel connections—See that all fuel connections are tight. Replace any parts that cannot be tightened properly.

4. Fuel system strainer—Remove and clean the strainer.

5. Carburetor nuts—See that the carburetor is securely fastened.

6. Carburetor controls—Check the carburetor controls for proper functioning and lubricate all the joints and bearings.

7. Carburetor fuel strainer—Remove and clean the carburetor fuel strainer.

8. Carburetor air cleaners—Service the carburetor air screen, particularly under dusty conditions, at least daily.

9. Carburetor air screen—Remove and clean the carburetor air screen.

10. Fuel pressure—Check the fuel pressure carefully to see that it is between 2.5 to 3.5 lb. per sq. in. (.18 to .25 kg./sq. cm.).

11. Fuel tanks—Drain and clean the fuel tanks.

12. Oil supply—See that oil tank has sufficient oil of the proper specification.

13. Oil change—Change the oil at 100 hours with oil of the proper specification.

14. Oil leakage—Check for oil leakage. If any leakage is indicated, locate the leak and repair. Leakage oil may not always be at the point of origin. Possible locations are: rocker box covers, push rod housing hoses, and any oil connections.

15. Oil connections—See that the oil connections are tight. Replace any part that cannot be tightened properly.

16. Cuno oil filter—Turn the handle of the filter at least one full turn. If the handle is difficult to turn, remove and clean the filter.

17. Oil sump strainer — Wash the oil sump strainer.

18. Oil cooler cores—Inspect the cores of the oil cooler to make sure they are not plugged or coated with dirt. The cores should be kept clean so that they will radiate the heat in an efficient manner.

19. Oil pressure—Watch the oil pressure when the engine first starts, and at frequent intervals during operation. Stop the engine if the oil pressure does not continue to rise to-

40 lb. per sq. in. (2.812 kg./sq. cm.) within 15 seconds after starting. Consult Engine Characteristics for the proper operating oil pressure.

20. Oil temperature—If the oil-in temperature is below 100° F. (38° C.), keep the engine running at idling speed at 600 r.p.m. until the engine oil is above 100° F. (38° C.). In extremely cold weather, engines having no oil dilution system should have the oil pre-heated to 125° F. (52° C.), before an attempt is made to start the engine. The oil-in temperature during operation should not exceed 190° F. (88° C.).

21. Magneto operation—Note the r.p.m. drop when switching from both magnetos to one magneto. This drop should not be greater than 75 r.p.m. with the proper octane fuel at 1800 r.p.m.

22. Magneto lubricating felt—If the felt is soft and shows oil on the surface when squeezed between the fingers, no additional lubricant is needed. If this felt is dry, however, apply a small amount of oil to the portion of the felt attached to the cam follower main spring. Use just enough oil to make the felt soft and so that oil can be brought to the surface by squeezing. Do not give it all it can hold. Lubricant of Viscosity S.A.E. 60 is suitable for average conditions. Whenever possible, choose a time for oiling when the engine and magneto are warm.

    Never permit oil to reach the breaker contacts as it would cause pitting, rapid wear, and interference with operation. Keep the rest of the breaker mechanism clean and dry. Wipe the interior of the breaker housing. Wash clean before replacing the cover, but do not permit lint or other foreign matter to lodge on the contacts.

    The ball bearings are packed in grease and need no additional lubricant between overhauls.

23. Spark plugs—Change all spark plugs with new plugs or plugs reset with the proper gap.

24. Ignition terminals — See that the ignition terminals are secure. The terminal nut should be snug. Care must be taken not to damage the nuts by overtightening.

25. Cylinder fins—Inspect the fins of the cylinders which are accessible to make sure they are not plugged or coated with dirt. Fins should be kept clean so that they will radiate the heat in an efficient manner.

26. Cylinder head temperature—See that the cylinder head temperatures do not exceed the operation temperatures as given in the engine characteristics in the Appendix of this book.

27. Nuts and cap screws—Inspect all accessible nuts and cap screws to insure that they are tight and properly locked.

28. Internal engine obstruction—Check for any obstruction in the lower cylinders. Rotate the engine crankshaft by energizing the flywheel, and tripping the starter dog. Continue this operation through three or more complete revolutions. If no obstacle is encountered during the first three revolutions, continue to turn the crankshaft through several more revolutions without stopping to insure complete freedom of rotation. If any obstruction is indicated, remove one spark plug from each of the lower cylinders to allow any fuel or oil to drain out. Rotate the engine several times.

29. Crankcase breather screen—Remove and clean the breather screen.

30. Engine exterior—Clean the exterior of the engine thoroughly before removing any parts or covers to prevent dirt from entering the engine.

31. Compression—Check compression of each cylinder, removing the rear spark plugs from all cylinders except the one being tested using a pressure gage.

32. Valve clearances—Remove the rocker box covers and check the valve rocker clearances. Reset any clearances which are not within the specifications. The engine should be cold when checking or setting these clearances.

33. Intake pipes—Check the intake pipe packing nuts and cap screws. Do not tighten the intake pipe packing nuts at this inspection to remedy leaks, since such tightening may result in breaking the adhesive seal of the rubber packing. When the packing ring has once broken loose from the intake pipe or intake pipe boss, it will not adhere again. Tightening packing nuts at this inspection to remedy leaks may therefore result in in-

increased leakage. Tightening packing nuts after no more than ten hours of operation on new rubber packing is permissible, because at this time the rubber packing is still soft and has not adhered to the nut. Leaking intake pipe packing is a fire hazard and a possible cause of improper mixture strength, and it is therefore recommended that the utmost caution be observed in following these recommendations.

34. *Exhaust system—Check the exhaust pipes,* exhaust manifold, and tail pipes for tightness and cracks. In order to reduce the possibility of difficulties arising from local overheating in the region of the exhaust port care should be taken to tighten equally all exhaust flange stud attaching nuts. Exhaust leakage *at this location caused by* flange distortion or insecure fastening may result in burning of the exhaust port.

WARNING: Care should be exercised to avoid pulling the exhaust flange attaching nuts too tightly and stripping the studs from the exhaust elbows. Use correct torque values as shown in Table of Limits, TL45.

35. Push rod hoses—Check the push rod hoses and surrounding area for any evidences of oil leakage.

MISCELLANEOUS

It is advisable to run the engine at part throttle for at least 1/4 to 1/2 hour every 48 hours in order to keep the interior parts slushed with oil. This will assist in preventing the vapor due to condensation in the crankcase from rusting steel parts.

The length of time between complete overhauls depends entirely upon the severity of the service to which the engine is subjected. Under normal conditions of operation and service, the engine should operate satisfactorily for 450 to 550 hours before a complete dismantling and overhaul is advisable. Where the service is severe and the conditions abnormal, more frequent overhauls may be required, and the same applies to inspection periods.

CHAPTER VIII

DISMANTLING, CLEANING, AND INSPECTION

WHEN the condition of the engine becomes such as to warrant a general overhaul, it should be removed from the airplane and sent to an overhaul depot. This depot should have a light, clean shop, equipped with a lathe, drill press, arbor press, buffing wheel, engine stand, and a complete set of overhaul tools.

The instructions in this chapter are presented in as great detail as space permits. In the event that any point seems obscure, it is suggested that reference be made to the sectional views in the Appendix and to the parts assembly views in the Parts Catalog as well as the figures dispersed throughout this text.

OVERHAUL STAND

The best overhaul stand is the type which permits rotating the engine to any desired angle, permitting the mechanics to do the work with the engine in the most advantageous position. It is assumed that this type of stand will be used. If, however, this type of stand is not available, the lower part of the shipping box can be used when it is desired to have the engine in the front-end-up position and a stand constructed from two 8 x 8 inch (20.32 x 20.32 cm.) beams can be used to hold the engine in the front-end-up position. This latter stand should be in the form of a cross with each beam about 4 feet (1.22 meters) in length, the intersection bored with a hole just large enough to receive the front end of the crankshaft. The stand can be mounted on casters for ease in moving.

INSPECTION BENCH

As the individual parts of the engine are removed, they should be placed on the inspection bench. This bench should be located near the dismantling work and where it will receive a good supply of light. A drop light will be required to inspect the cylinder bores and valve seats.

Small boxes, tins, or other receptacles should be provided in which nuts, washers, and other small parts can be placed as they are removed.

As each sub-assembly is removed from the engine, it should be inspected carefully before being cleaned and any unusual conditions such as sludge deposits or the collection of metallic particles should be noted. If sludge deposits or metallic particles are found, samples should be retained for analysis in case the condition of the engine warrants such a procedure. The general condition of each sub-assembly should be observed, particularly in regard to the free movement of all gears and bearing shafts.

TOOLS

A service tool kit is furnished with each engine sold by the Wright Aeronautical Corporation. (Refer to figure 25.) This kit contains all the tools necessary for general servicing of the engine and should be carried in the plane for use in emergencies. For completely dismantling and reconditioning the engine, a number of special tools are necessary. These are listed in a Tool Catalog published separately along with other tools not so necessary but of great convenience. A repair depot handling any large number of engines should be equipped with the entire set of tools.

CLEANING ENGINE PARTS

Upon completion of the dismantling operations all separate parts, sub-assemblies, and accessories, except the starter, generator, magnetos, and ignition wiring, should be washed with gasoline or other approved cleaning fluid before any further disassembly.

Experience has indicated that oil foaming and serious attendant difficulties may result from the use of water-mixed cleaning solutions, most of which contain either soap compounds or caustic soda. It has been found extremely difficult to remove all traces of these compounds from engine parts, and where compounds which contain soap are used, oil foaming may result immediately after starting the engine. In the case of alkaline cleaners, the alkaline compounds combine with the oil in the presence of acids which come from combustion gases and are normally present in the oil and form-soap which produces oil foaming. In this case foaming may occur

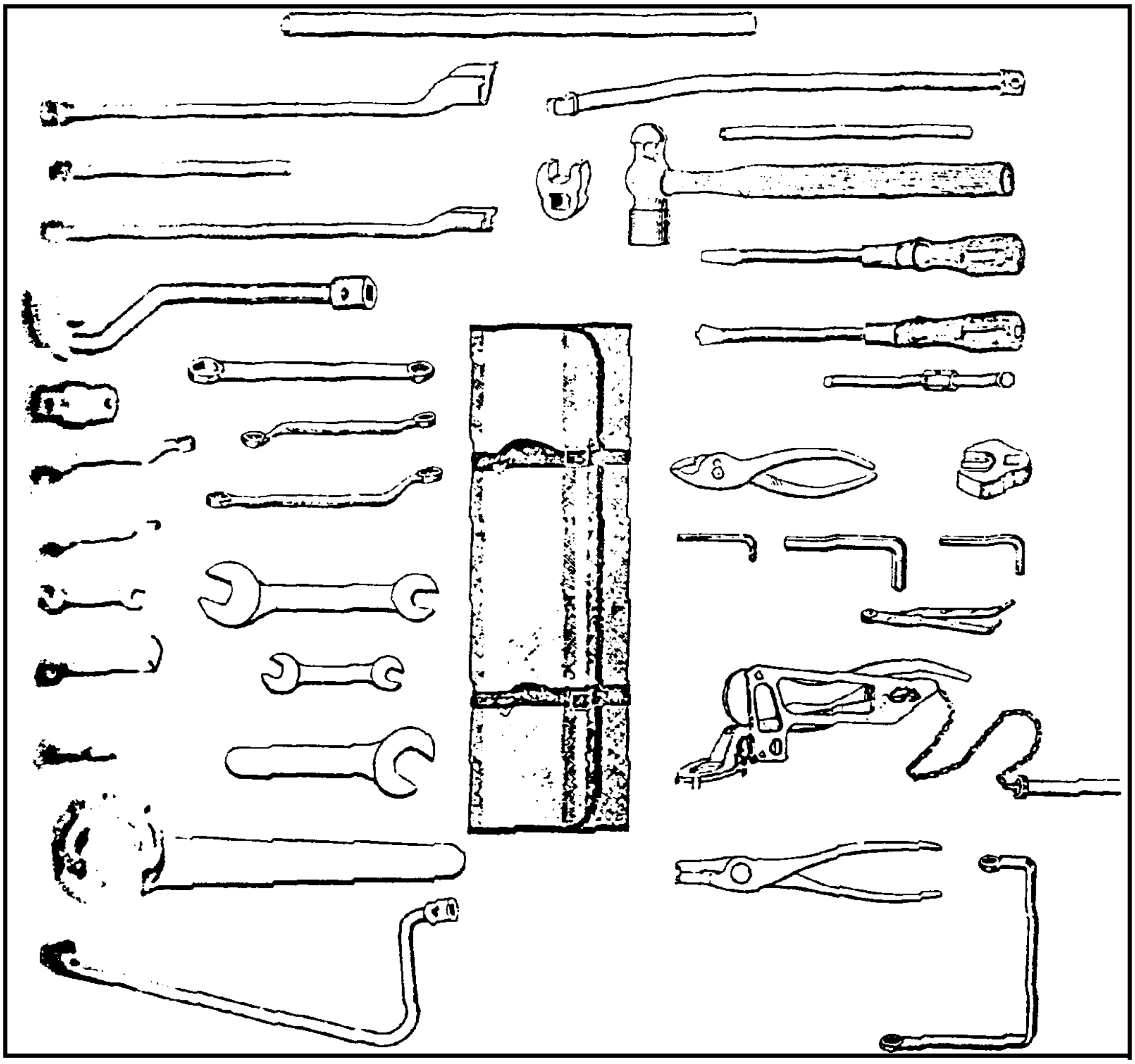


FIGURE 21—Service Tools

[illegible] or many hours after the engine is [illegible] in service.

[illegible] result of the above experience the [illegible] Aeronautical Corporation recommends [illegible] of gasoline, kerosene, or other hydro- [illegible] for cleaning purposes.

[illegible] mixed compounds containing any [illegible] or caustic soda are used for clean- [illegible] of the utmost importance that all parts [illegible] be thoroughly cleaned with clear [illegible] after using the compounds. It is [illegible] that all traces of the cleaning com- [illegible] removed before the parts are assem- [illegible] sh submerged, where these compounds [illegible] at the parts be scrubbed thoroughly [illegible] boiling water and then rinsed in a sepa- [illegible] of boiling water.

Engine parts may be cleaned with 50-50 carbon tetrachloride-benzol mixture or clear gasoline-benzol mixture. However, these mixtures introduce difficulties in handling and extreme care must be exercised to prevent injury to the operator.

As the washing of the various parts is completed, each part should be dried thoroughly with compressed air and placed on the rack. If the parts are to remain on the rack for any length of time, slush them to prevent rusting.

Do not wash the accessories with any liquid solvents or cleaners unless it is stated in the publications of the respective manufacturers that it is permissible to do so.

ABRASIVE CLEANING

Abrasive cleaning is recommended for removing hard carbon deposits from the interior portions of pistons and cylinder heads, also for removing paint and for cleaning exterior surfaces of engine parts prior to repainting. This type of cleaning removes hard carbon deposits and paint rapidly and easily from surfaces difficult to clean in any other manner. Caution must be exercised, however, to prevent damage to engine parts when performing this cleaning. The use of harmful abrasives, or the use of excessive air pressure, or failure to protect machined surfaces properly when cleaning, may result in damage to engine parts which might render those parts unsatisfactory for use.

Alundum No. 90 is the only material that is recommended for use in the abrasive cleaning of engine parts. Investigation has shown that other abrasives, such as crushed shot or grit, are unsuitable for this type of cleaning because of the tendency of particles of these materials to become imbedded in the metal parts being cleaned.

The use of excessive air pressure also increases the tendency of the abrasive to become imbedded in the metal parts being cleaned. Use only a pressure high enough to remove hard carbon deposits from parts being cleaned. The required pressure should be within the limits of 15 to 30 pounds per square inch (1.05 to 2.11 kg./sq. cm.), depending upon the degree of hardness and amount of carbon to be removed. Adjust the pressure first to 15 pounds per square inch (1.05 kg. sq. cm.). If this pressure will not remove carbon satisfactorily, increase the pressure in increments of 5 pounds per square inch (.35 kg./sq. cm.), checking the effectiveness of the blasting operation each time, until a pressure is reached which removes the carbon effectively.

When blasting, protect machined surfaces with suitable plugs, sleeves, or friction tape so that these surfaces will not be damaged.

MARKING ENGINE PARTS.

Investigation of some parts failures in the past has revealed that they have been caused directly by identification marking of the parts by the operator. The incorrect marking of parts or the marking of parts in certain areas may produce surface cracks which will progress, resulting in complete failure of the parts and serious damage to the engine. The Wright Aeronautical Corporation will not be responsible for any damage to an engine which may be traced to any marks placed on any steel parts of the engine by the operator either by stamping, punching, or electric etching.

The Wright Aeronautical Corporation marks major engine parts such as master rods, articulated rods, crankshafts, and propeller shafts for inspection acceptance and record purposes. These marks are placed on certain areas where experience indicates it will be safe to place them. During the manufacturing procedure, Wright Aeronautical Corporation employs a rubber stamp etching process for identification purposes. This does not, however, provide a permanent method of identification.

A rubber stamp etching fluid suitable for use on steel engine parts has been prepared and is recommended for shop practice for temporary identification of parts. This fluid may be procured under Part No. 87940. The above fluid, Part No. 87940, must not be used for etching steel parts to detect defects. The fluid may be used to saturate a stamping pad and ordinary rubber stamps may be used for the etching process. The method of stamping is the same as that used in ordinary ink stamping. Rubber stamps, which have a longer life when used with etching fluid, may be procured from Sheridan & Nichol, Inc., 64 Murray Street, New York City. After a part is etched, the surface should be oiled with engine oil to prevent corrosion.

HOISTING THE ENGINE

Attach a hoist eye to the crankshaft. Lift the engine onto the engine stand with a chain hoist of at least one ton capacity and fasten the engine securely through the mount holes with six bolts. If a rotating type stand is used, be sure that the bed plate is locked in position. Do not attempt to change the position of the engine without using a hoist. The engine should be located in the normal flight position before beginning the dismantling operations.

DISMANTLING PROCEDURE

In any dismantling which is going to require the removal of the thrust bearing nut, be sure to loosen the thrust bearing nut while the spark plugs are still in the engine.

Due to the sectional construction of the crankcase, it is possible to dismantle the Whirlwind engine in almost any desired position, permitting ready access to the various parts of the engine. However, two factors must be borne in mind.

[illegible] the crankshaft cannot be removed without removing the crankshaft gear bolted to the [illegible] end of the shaft and second, the diffuser [illegible] of the crankcase cannot be separated [illegible] the rear section without first removing the [illegible] the rear end of the starter shaft bolt and [illegible] on the three studs adjacent to the [illegible] and accessory drive shaft bosses.

[illegible] the following discussion of general dis[illegible], it is assumed that the exhaust mani[illegible] exhaust pipes, cowl, and air ducts have [illegible] removed before the engine is placed on [illegible] overhaul stand.

The procedure as outlined in the following text [illegible] for the dismantling of the engine into its [illegible] component parts or sub-assemblies.

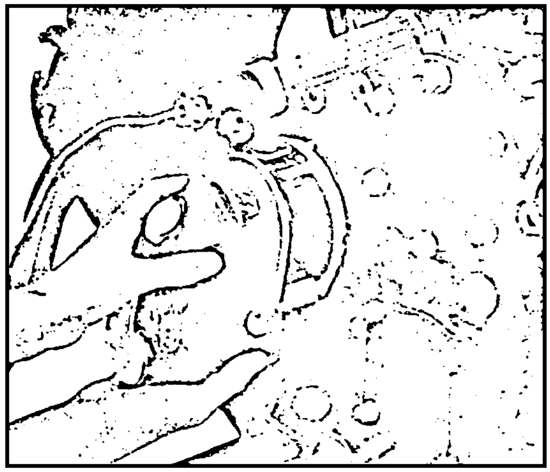


FIGURE 27—*Removing or Installing Magneto*

GENERATOR, STARTER, FUEL PUMP, VACUUM PUMP Should the starter, generator, fuel pump, or [illegible] pump be attached to the engine, re[illegible] them in the order given. (Refer to figure [illegible]) After removing an accessory which is [illegible] on the engine in conjunction with an [illegible], remove the adapter or take the neces[illegible] precautions to secure the various adapters [illegible] until the rear section is ready for dis[illegible]. If these accessories are not on the [illegible], but instead are substituted by cover [illegible], do not remove any but the starter cover [illegible] at this time. Remove the cotterpin from [illegible] on the rear end of the starter shaft bolt [illegible] the nut approximately one-half turn.

[illegible] *Three-Way Accessory Drive Housing*

CARBURETOR AIR HEATER, CARBURETOR, AND ELBOW Remove the carburetor air heater, carburetor, and carburetor elbow as a unit by removing the nuts which fasten the elbow to the rear section.

MAGNETOS Remove the magneto advance control rod and the distributor blocks from the magnetos. Do not detach the wires from the distributor blocks. Remove the nuts holding each magneto to the rear section and remove the magnetos. (Refer to figure 27.) Hold the magnetos firmly when removing the nuts as they are liable to fall if not supported.

THRUST BEARING NUT Loosen the thrust bearing nut using the special wrench. Loosening of the nut at this time while the spark

FIGURE 28—*Loosening Propeller Shaft Thrust Nut*

[illegible] are still in the cylinders is advisable as the [illegible] compression prevents the crankshaft [illegible] turning. Use a lead hammer to strike the [illegible] and loosen the nut until it can be turned [illegible] the fingers. (Refer to figure 28.) As soon as [illegible] operation has been completed, turn the [illegible] to the front-end-up position. Lock the [illegible]

AIR DEFLECTORS, INTAKE PIPES Remove the four nuts from the rocker box covers and remove [illegible] covers. Loosen the valve tappet clearance [illegible] screw lock screws and back out the [illegible] screws a few turns. Remove the nut [illegible] the end of each of the rocker arm bolts, [illegible] the bolts out, and remove the rocker arms. [illegible] the push rods. Unfasten the hose [illegible] on each of the push rod housings, slide [illegible] hoses toward the cylinder end of the [illegible] and remove the housings. Using the [illegible] designed for this purpose, loosen the [illegible] nuts at the crankcase end of the intake [illegible] (Refer to figure 29.) Back out the intake [illegible] flange cap screws and withdraw the intake [illegible] Remove the external hydro oil line, if used. [illegible] the air deflectors. In view of the slight [illegible] which may occur in the cylinder head [illegible] air deflectors, it is suggested that [illegible] be marked so that they may be replaced [illegible] the same cylinders from which they were [illegible]

CYLINDERS, PISTONS, [illegible] PISTON PINS Remove the spark plugs from each cylinder, [illegible] the special wrench and turn the crankshaft [illegible] No. 2 piston is at approximately the top [illegible] stroke. Remove the hold-down nuts from [illegible] cylinder. Remove the cylinder being careful

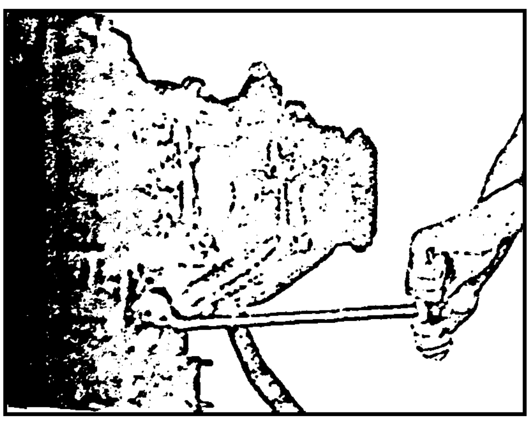


FIGURE 29—*Loosening Intake Pipe Packing Nut*

FIGURE 30—*Removing Cylinder*

that the piston does not strike an adjacent cylinder. (Refer to figure 30.) Remove the piston pin retainers, piston pin, and piston immediately after removing the cylinder. (Refer to figures 31 and 32.) Turn the crankshaft until No. 3 piston is at the top of its stroke and remove that cylinder and piston. Continue in this manner to remove all the cylinders and pistons with the exception of No. 1, which is not to be removed at this time. Install articulated rod protectors after removing the cylinders.

IGNITION WIRE MANIFOLD, RADIO SHIELDING Remove the nuts that secure the ignition wire manifold at the rear section parting flange and lift off the complete assembly.

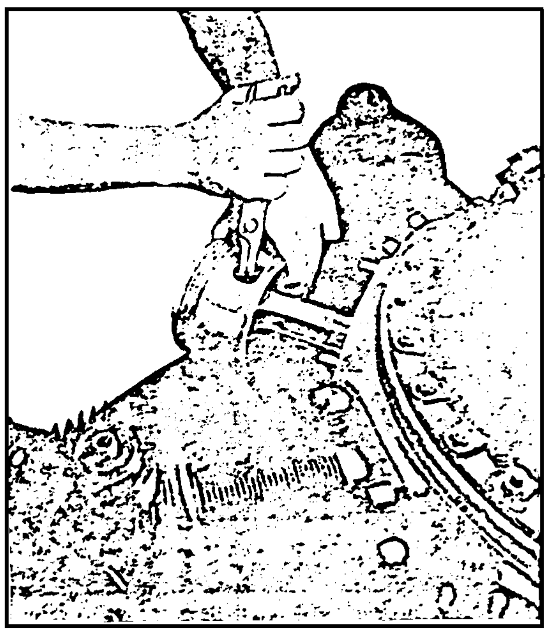


FIGURE 31—*Removing Piston Pin Retainer*

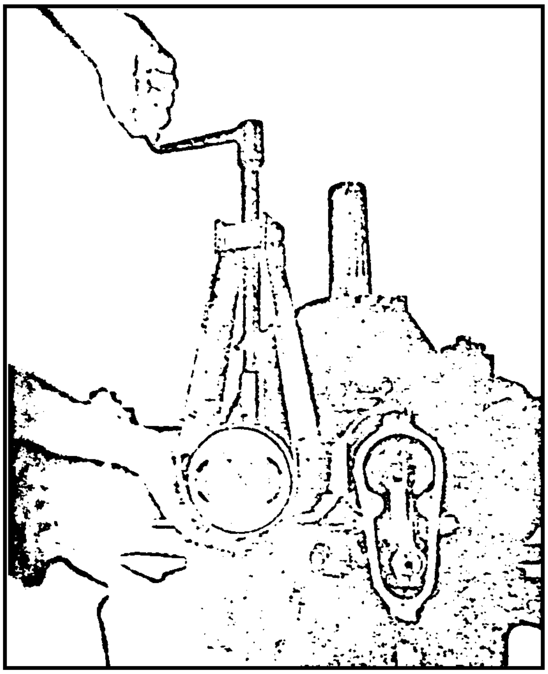


FIGURE 32—Removing Piston Pin

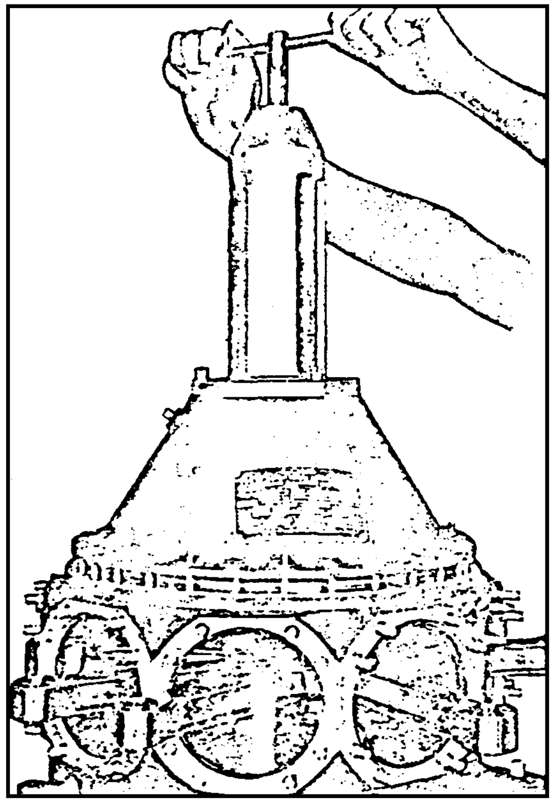


FIGURE 33—Removing Crankcase Front Section

CRANKCASE FRONT SECTION AND MAIN BEARING SUPPORT

Unscrew the thrust bearing nut and remove it from the crankshaft. Remove the nuts holding the crankcase [illegible] cover to the crankcase front section and [illegible] the cover. Remove the spacer, the lami[illegible] shim, and the oil slinger. Remove all the [illegible] and washers securing the front section to [illegible] crankcase main section and attach the spe[illegible] puller to the front cover studs. Turn down [illegible] handle of the puller until the front section [illegible], then lift it off. (Refer to figure 33.) When [illegible]ing the front section, be careful that the [illegible]shaft oil seal adapter does not fall, as this [illegible] will usually come off with the front section. [illegible] propeller governor gear is used, care must [illegible] taken that the crankshaft key does not fall [illegible]. Insert three pullers in the tapped holes in [illegible] mounting flange of the front main bearing [illegible]. Turn down evenly on these pullers until [illegible] support is free from the crankcase main sec[illegible]. (Refer to figure 34.) Lift it off the engine [illegible] careful not to allow the bearing sleeve to [illegible] against the crankshaft.

REAR SECTION AND DIFFUSER SECTION

Remove all the nuts and washers that secure the [illegible] and diffuser sections to the main section. [illegible] the position of the mounting bolt nuts securing the engine to the engine stand mounting plate to make certain that their position will not interfere with the separation of the rear and diffuser sections from the main section. At-

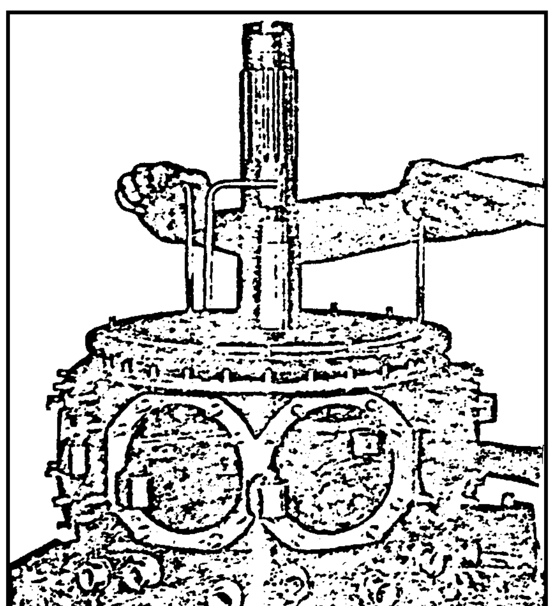


FIGURE 34—Removing Front Main Bearing Support

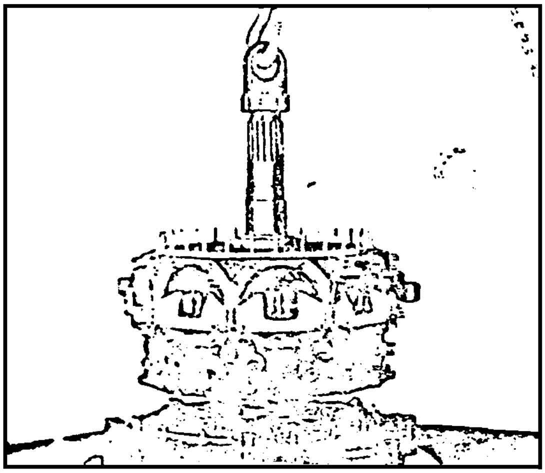


FIGURE 35—*Raising Crankshaft and Main Section from Rear Section*

tach the hoist eye to the crankshaft and, by means of the chain hoist or tackle, raise the crankshaft with the main section from the rear section. (Refer to figure 35.) As soon as a pull is exerted by the hoist, tap the rear section at the mounting lugs with a light mallet to assist in the separation of these two parts. Raise the main section until it is out of the way of the rear section and remove the rear section from the stand. Lower the main section onto the stand and fasten it securely. Remove the hoist eye from the crankshaft.

CRANKSHAFT, MASTER AND ARTICULATED RODS

Bend the lock away from the hex-flat of the knuckle pin lock-plate screws and remove the screws. Using a small brass drift and a light hammer tap out the knuckle pin locks from between the flats on the knuckle pin heads. Place the drift on the edge of the lock closest to the bearing and tap toward the outer edge of the master rod. The locks will slide out from between the knuckle pins. Do not attempt to force a screw driver or any similar tool between the lock and the face of the master rod. To remove the articulated rods, push out the knuckle pins with the knuckle pin inserting and removing tool, using the cup and drift provided for this purpose. (Refer to figure 36.) Remove the articulated rods from the master rod. Remove No. 1 cylinder, piston, and piston pin and install a protector on the cylinder pad to protect the master rod.

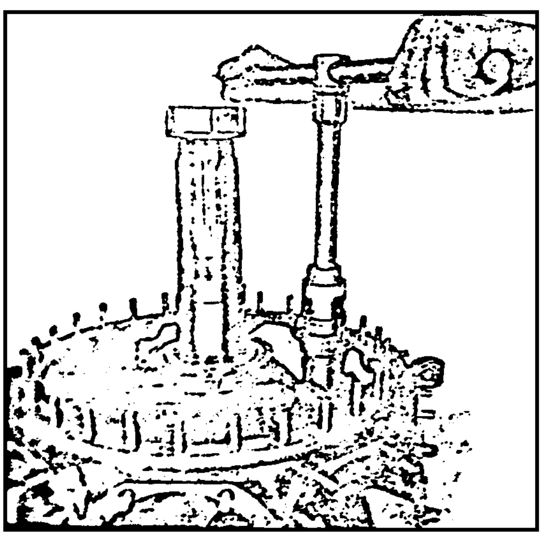


FIGURE 36—*Removing Knuckle Pin*

Place a small wooden block or wedge between the front counterweight and the crankcase to act as a support and also to prevent the shaft from turning when removing the crankshaft gear. Adjust the engine stand so that the crankshaft is in a horizontal position. Remove the safety wiring from the crankshaft gear screws and remove the screws and the gear. Remove the supporting block from under the front counterweight. Withdraw the crankshaft with the master rod. To do this turn the shaft until the counterweights are at the right side of the crankcase approximately 90 degrees from No. 1 cylinder location. (Refer to figure 37.) Be careful not to damage the rear main bearing when withdrawing the crankshaft.

CRANKCASE MAIN SECTION

Remove the crankcase main section from the engine stand.

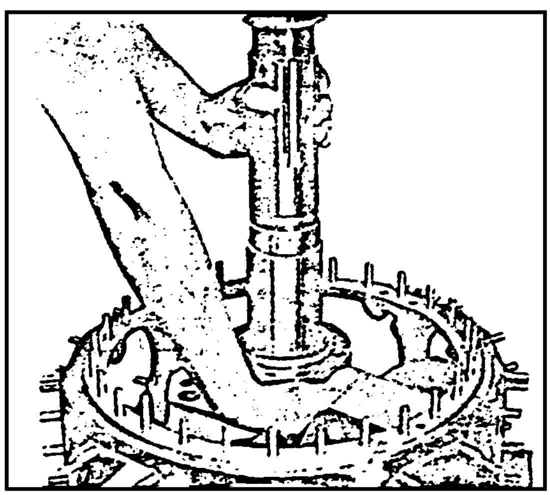


FIGURE 37—*Removing Crankshaft with Master Rod from Crankcase Main Section*

CHAPTER IX

DISASSEMBLY, INSPECTION, REPAIR, AND ASSEMBLY

THIS section is devoted to the treatment of sub-assemblies, and the instructions given herein insofar as is possible, deal with each assembly separately, completing the disassembly, inspection, repair, and assembly of each before proceeding to another assembly.

As each part is removed from the sub-assembly, it should be cleaned and dried. If the part is to stand for any length of time, it must be properly protected to prevent rusting.

ETCHING FLUID

It is possible to damage engine parts seriously by the use of certain etching fluids or by improper use of the recommended etching fluid. The Wright Aeronautical Corporation will not be responsible for any damage to an engine or part which may be traced to the use of an unapproved etching fluid or to the improper use of the approved etching fluid.

An etching fluid suitable for use on all steel engine parts except stainless steel has been prepared and is recommended by the Wright Aeronautical Corporation. This fluid may be procured in one-half ounce bottles under Part No. 87101.

Before applying the above etching fluid, the part should be washed in gasoline or benzol and dried thoroughly. The surface to be etched should then be washed with denatured alcohol before applying the fluid. The fluid should be applied uniformly over the surface, using a cotton swab. It should not be allowed to remain on the part for a period of more than thirty seconds after which it should be washed off immediately, using denatured alcohol. After inspecting the part, the slight discoloration caused by the etching fluid should be removed with crocus cloth and oil. In no case should this discoloration be left for a period exceeding five minutes.

MAGNETIC ANALYSIS INSPECTION

The examination of engine parts by magnetic type inspection is considered desirable by the Wright Aeronautical Corporation. This method of inspection of parts requires a competent and trained operator in order to obtain satisfactory results. Magnetic inspection requires not only an understanding of the equipment involved but a knowledge of the parts being inspected and the ability to determine the exact nature of an indicated defect. It is essential that the parts be thoroughly cleaned and polished before inspecting. Information concerning this equipment and recommended practices will be furnished upon request to the Wright Aeronautical Corporation, Service Division.

In order to prevent magnetic inspection solution from entering the engine, all parts must be thoroughly cleaned after the inspection. Oil passages should be blocked off with ordinary paraffin wax before magnetic inspection. This will prevent the solution from entering the oil passages and possible subsequent damage to the engine.

SERVICE FITS

The maximum and minimum clearances allowable in service before a part must be replaced are given in the Table of Limits. The maximum clearances should not be construed to mean that any part showing less wear is in satisfactory condition. The appearance of a part is frequently a much better indication than are the dimensions. The figures are merely guides where the fit is the sole consideration. When clearances are found in excess of those listed, an investigation should be made to determine the cause. This can very often be traced to the wear or failure of some other part.

REPLACEMENTS

While new parts will generally be found to be in satisfactory condition, it is advisable to inspect them carefully before installing them in the engine. This is especially true of steel parts which are to run in babbitt, bronze, or kelmet bearings. These parts must be checked for oil holes as sometimes oil holes must be drilled at the time of assembly. Burrs and sharp corners must be eliminated and this can ordinarily be accomplished with a sharp scraper or a fine stone.

STUDS Check all studs for tightness, condition of the threads, evidence of [illegible], and for being square with the surface. When checking for tightness, use a stud driver. Have the necessary replacements made with oversize parts. The size of the stud will depend on the condition of the female threads.

Remove a damaged stud with a stud remover and remove any erupted metal around the stud hole with a mill file. (Refer to figure 38.) Clean up the stud hole using the proper size tap.

The cylinder hold-down studs of current engines have ground threads. These studs may be identified by a drill mark at the nut end. When replacing a stud having ground threads, it is essential that the stud threads and the mating threads be thoroughly cleaned. When replacing a cylinder hold-down stud, or any stud having a through hole to the interior of the engine, use [illegible] Heldite on the threads. These compounds act as an oil sealing agent and lubricant [illegible]. Only a few drops of sealing compound are required and care should be taken to prevent the use of excessive quantities as the presence of this compound on parting surfaces or inside the engine is undesirable.

Drive the stud to the proper depth, using a stud driver. If it is a drilled stud, see that it is properly aligned.

ASSEMBLY PRECAUTIONS The successful operation of the engine is entirely dependent upon the attention given to every detail in the inspection and assembly. It should be borne in mind by the inspector and mechanic that the slightest neglect on their part may result in the failure of the engine.

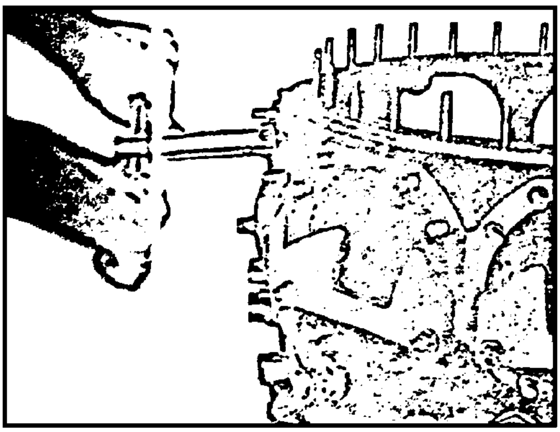


FIGURE 38.—*Removing Cylinder Hold-Down Stud*

WARNING: Cotterpins, piston pin retainers, palnuts, and safety wire should never be used a second time. Other safety features which have been bent or worn should be replaced with new parts.

Gaskets and oil seal rings should be replaced with new parts at overhaul.

Great care should be taken to prevent dirt, dust, cotterpins, nuts, washers, and other small particles from falling into the engine during the assembly. Such foreign material can work into the gears, the supercharger, or the oil lines and cause considerable damage.

Before assembly, all parts should be carefully cleaned. The careful use of compressed air for this purpose is strongly recommended since rags or waste leave lint and other bits which may clog oil lines and strainers.

Completely finish each step in the process of assembly as the work progresses. Do not leave a bolt loose or a nut uncottered with the idea of coming back to it later.

In places where there is a possibility of oil seeping out from between machined surfaces, as between the crankcase section parting flanges, the surfaces should be coated with a gasket compound before assembly. Use new rubber oil seal rings under the cylinder hold-down flanges and new seals at the ends of the push rod housings.

Remember that the oil pump will not begin to furnish the regular supply of oil until the engine has turned over several revolutions. For this reason it is necessary to coat all surfaces, normally lubricated by the oil circulated by the pump, with a good supply of engine oil as the parts are assembled. All parts which are a drive or push fit should likewise be coated with oil to facilitate their assembly in the engine. In order to avoid chafing or scoring of crankshafts and propeller shafts when ball or roller bearings are pressed in place, it is recommended that micro-graphite be used between the inner race of the bearing and the shaft. The shaft should be wiped clean with a dry cloth and a small quantity of micro-graphite applied to the surface of the shaft and the shoulder against which the inner race rests before pressing on the bearing. After the bearing is in place, the excess powder should be removed. As a further precaution to prevent chafing, the inner race should be rotated to a new position at each overhaul. In the assembly procedure following, it will be assumed that the above recommendations and precautions have been applied.

PALNUTS The proper installation of palnuts is as follows: Tighten the nut to be locked to the desired tension. Spin the palnut on the stud or screw until it touches the nut, and then lock the palnut with a wrench by tightening 1/4 to 1/3 of a turn.

CRANKCASE FRONT SECTION ASSEMBLY

DISASSEMBLY

Tap the thrust ball bearing out of the front section with a fibre drift. Remove the two nuts and flat washers from the hydro-control valve cover attaching studs and lift out the valve with the cover attached. Remove the cap screw which clamps the hydro-control valve lever to the valve stem, disengage the lever, and withdraw the stem from the valve. Back the packing nut out of the cover. The packing should be discarded and replaced with new packing at overhaul. Remove the four bolts that hold the control valve adapter and withdraw the adapter. In case the engine incorporates a propeller governor, remove the four nuts and flat washers from the attaching studs and remove the governor assembly. Lift out the governor drive shaft adapter. Inside of the front section, remove the nuts and flat washers that hold down the intermediate bevel gear governor drive shaft bracket and remove the bracket gear assembly. Remove the circlets from the shafts in the adapter and bracket and withdraw the shafts. If necessary for magnetic inspection, the spur gear may be removed from the intermediate governor drive shaft by removing the six bolts on the front face of the gear.

INSPECTION

FRONT SECTION Inspect the front section for cracks, using a magnifying glass or microscope. Replace a section that is cracked.

Inspect all finished surfaces for nicks and burrs.

Check the fit of the thrust bearing in its recess against the limits of the Table of Limits.

Inspect the oil passages for clearness.

Check the steel oil seal sleeves in both the front section and front section cover for tightness, for cracks, and for galling and wear caused by the oil seal rings. A loose or cracked sleeve must be replaced.

Inspect the front cover for cracks, nicks, and burrs. If the cover is cracked, it must be replaced.

Check the front cover spacer and shim for bends or breaks. Otherwise they should be fit for further use.

Check the data and name plate rivets for tightness. Replace any loose rivets.

Inspect the oil slinger for roughness and burrs.

HYDRO-CONTROL VALVE Check the hydro-control valve for fit in the front section and for nicks, burrs, or cracks. Inspect the control lever for cracks and wear of the linkage hole. Examine the cover for cracks and conditions of the finished surfaces. Determine whether the packing nut threads are in a satisfactory condition. Inspect the control valve adapter for cracks and the condition of finished surfaces and for clearness of oil passages. Check the hydro-control valve attaching studs for tightness and for the condition of the threads.

PROPELLER GOVERNOR DRIVE ASSEMBLY Check the intermediate bevel gear governor drive bracket for cracks, condition of finished surfaces, and clearness of the oil passage. Inspect the bracket bushing for scores and check the fit with the intermediate bevel gear drive shaft. Inspect the intermediate bevel gear drive shaft for nicks or burrs, worn or pitted teeth, and cracks. Check the spur gear bolt safety wire but do not separate the gear from the flange unless the parts are to be magnetically inspected. Check the bevel gear drive shaft for nicks or burrs, and the teeth for wear or pitting. Inspect the bevel gear drive shaft adapter for the condition of finished surfaces and the bushing. Check the bevel gear shaft for fit in the adapter.

THRUST BALL BEARING Clean the bearing thoroughly with gasoline and then remove all traces of gasoline with an air hose. Do not spin the bearing while drying it as this is likely to damage the balls or races when all traces of lubricant have been removed. After drying the bearing, lubricate the balls and races with a few drops of engine oil. Check for roughness or uneveness by spinning the outer race and noting the feel of the bearing. Flat spots, cracks, or a pitted condition of the balls or races will warrant replacement of the bearing. If necessary, check for the presence of any one of these conditions with a magnifying glass.

Check the ball retainers for cracks, particularly at the location of the rivets.

Check the fit of the bearing on the crankshaft.

After the inspection is completed, lubricate the bearing with a good supply of engine oil to prevent corrosion.

REPAIR

Make whatever stud replacements are required.

Remove any nicks or burrs from the finished surfaces with a fine stone and polish with crocus cloth.

Smooth any slight irregularities of the steel oil seal sleeves with a fine stone and polish with crocus cloth.

Polish the inner and outer edges of the shim and spacer with fine emery cloth.

If the thrust bearing is satisfactory for further use, polish the inner and outer diameter with crocus cloth.

Remove any roughness or burrs from the oil slinger with a fine stone and polish.

Remove nicks and burrs from the hydro-control valve cylinder and polish with crocus cloth.

Clean all parts thoroughly, paying particular attention to the hydro-control oil passages.

If a propeller governor drive is used, replace worn or damaged bushings in the adapter and bracket by pressing the old bushings out and new bushings in with an arbor press. Bore and ream the adapter bushing to run true with the outside diameter of the pilot and face the shouldered end of the bushing to size, holding the face true with the inside diameter of the bushing. Bore and ream the bracket bushing, holding it true to the flange seat, and face the shouldered end of the bushing to size holding it true to the inside diameter of the bushing. Check the backlash of the mating gears.

ASSEMBLY

Lubricate the thrust bearing thoroughly with engine oil and insert it in its recess with the numbered side out. Tap it into place with a fiber hammer or drift. The outer race should be bottomed in the recess. Place the oil slinger on the bearing with the outer edge of the slinger away from the bearing and place the shim in its position. Place the cover and spacer over the studs. Using washers, nuts, and palnuts, secure the cover in place.

Check the clearance between the spacer and thrust bearing by inserting a feeler gage. If the clearance is not great enough, a thicker shim should be used. If the clearance is too great, remove some of the laminations on the shim until the proper clearance is obtained.

HYDRO-CONTROL VALVE

Lubricate the hydro-control valve with engine oil and insert the valve in its recess in the crankcase front section or in the adapter. Place a new gasket over the valve cover hold-down studs and assemble the cover in position, securing it with flat washers, nuts, and cotterpins. Slide a new packing gland on the valve stem. Assemble the packing nut, and tighten just enough to obtain a drag when the valve is turned. Assemble the lever on the valve stem. If the engine is equipped with a hydro-controllable pitch propeller, the slot on the valve stem should be facing in such a direction that the lever can be attached with the lug on its lower side located between the flight and take-off stops which are integral parts of the valve cover casting, and with the scribed lines on the upper side of the lever and the face of the valve stem indexing. If the engine is not equipped with a hydro-controllable pitch propeller, the slot on the valve stem should be facing in such a direction that the lug can be located in the recess which is provided on the cover for locking the valve in a stationary position. Assemble the clamping cap screw in the slotted end of the lever, screw on the nut, tighten, and secure with a cotterpin. Assemble a new gasket on the adapter and attach the adapter to the mounting pad with four bolts.

PROPELLER GOVERNOR DRIVE

Slip the intermediate bevel gear drive shaft into the bracket bushing and place a new circlet on the end of the shaft. Repeat the above procedure for the bevel gear drive shaft and adapter. Attach the intermediate bevel gear bracket assembly on the studs in the front section using flat washers and nuts. Do not install the governor drive shaft adapter assembly on the mounting pad studs until the final reassembly of the crankcase front section, crankcase main bearing support, and the crankcase main and rear sections is completed.

FRONT MAIN BEARING SUPPORT

DISASSEMBLY

The disassembly of the front main bearing support is unnecessary unless it is found, during inspection, that one or more of the parts is damaged beyond repair.

INSPECTION

Inspect the support for cracks. If this part is cracked, it should be replaced.

Check the fit of the front main bearing support pilots with the crankcase front and main sections by placing one section on top of the other. See the Table of Limits.

Check the front main bearing sleeve for burrs and for tightness in the section. If the ring is loose in the support, it should be replaced. Insert the front main bearing and check the clearance. See the Table of Limits.

Check the clamping surfaces for nicks, burrs, and roughness.

Examine the oil deflector for cracks around the flange and the condition of the lock wire on the four retaining screws. If the wire is broken, remove it and check the tightness of the screws. Replace the lock wire.

REPAIR

Remove all burrs and signs of wear from the front main bearing ring and polish with crocus cloth.

Remove any nicks, burrs, or roughness from the clamping surfaces with a fine stone and polish with crocus cloth.

Replace the oil deflector if it is damaged. Place the oil deflector so that the opening faces the right side of the support when viewed from the rear of the engine.

If the fit of the front main bearing support on the crankcase front and main sections is not within the limits specified by the Table of Limits, it is permissible to roll the flanges to obtain the desired fit. It is important that this fit be correct to prevent the front main bearing loads being carried by the studs at the parting flange of the crankcase main section.

CRANKCASE MAIN SECTION AND CAM ASSEMBLIES

DISASSEMBLY

Remove the cotterpins from the cam hub bearing support and unscrew the support, using the wrench designed for this purpose. (Refer to figure 39.) Remove the cam and the cam hub bearing spacer.

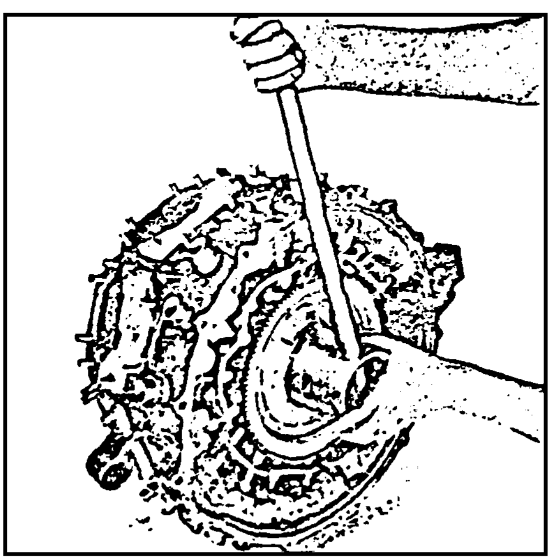


FIGURE 39—Loosening or Tightening Cam Hub Bearing Support

Back out the valve tappet retaining nuts and remove the sockets and springs. (Refer to figure 40.) Push the tappets toward the center of the section and remove the valve tappet roller pins and rollers. Withdraw the tappets.

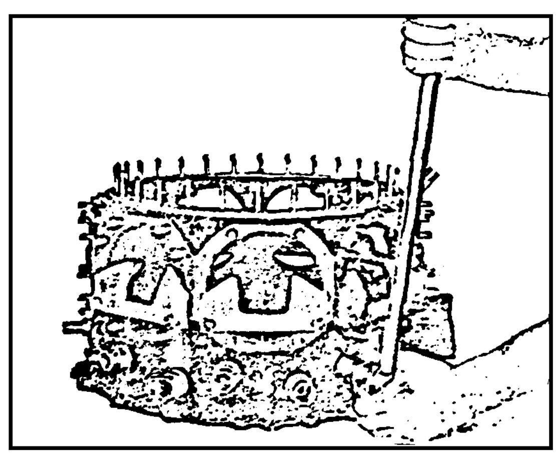


FIGURE 40—Removing Valve Tappet Retaining Nut

The tappet guides and rear main bearing are shrunk into the main section and should be left in place unless it is found at inspection that their removal is necessary.

Remove the oil strainer cover, gasket, spring, and finger screen.

Remove the nuts and flat washers from the studs which retain the oil drain cover. Remove the cover and gasket.

Remove the nuts and washers which secure the breather to the crankcase and remove the breather.

INSPECTION

MAIN SECTION Inspect the main section for cracks, paying particular attention to the inter-cylinder webs, the cylinder pads, the valve tappet guide web, the rear main bearing support, and the parting flanges.

Check all studs for tightness with a stud driver and for condition of the threads.

Check all threaded holes for condition of the threads.

Inspect all finished surfaces for nicks, burrs, and roughness.

Check the pressed-in tube that forms the oil passage from the rear parting flange to the rear main bearing support for tightness.

Inspect the oil passages for clearness. This may be done by applying compressed air at the hole in the left hand side of the rear parting flange and noting how the air escapes at the rear main bearing and at the adjacent valve tappet guides. If necessary, stop all passages except the one being tested by placing the fingers over the outlets.

If the enamel is chipped or discolored, the section should be re-enameled.

Check the oil drain cover for condition of the finished surfaces, cracks, nicks, and burrs.

Check the oil strainer for condition of the cover, spring and screen.

Clean the crankcase vent thoroughly.

REAR MAIN BEARING Check the fit of the rear main bearing with the crankshaft journal. Check the bearing for tightness in the crankcase. If the bearing is loose, it should be replaced. Check the surface for scores and the condition of the cam hub bearing support threads.

VALVE TAPPET GUIDES Check the valve tappet guides for cracks, alignment, and tightness in the section. If a guide is loose or cracked, it should be replaced. Check the inner surfaces for scores.

VALVE TAPPETS Check the fit of the valve tappets in their respective guides. If any fit is not within the specified limits, the tappet should be replaced. Examine the tappets for cracks, particularly at the roller pin support holes. A cracked tappet must be replaced. Examine the socket for fit in the tappet and for cracks where the push rod ball end seats. Inspect the condition of the springs in the tappets. If it is badly burred, the tappet must be replaced. Inspect the surface for scores. Examine the pins for abnormal conditions. Check the fit of the pins in the rollers and in the support holes in the valve tappet. Inspect the rollers for cracks, flat spots on the outside diameter, and for chipped edges. Replace any rollers that are cracked. Examine the valve tappet packing for general condition. Torn or crushed packing should be replaced.

CAM Inspect the cam hub and ring assembly for cracks. Check the bolts for tightness. Loose bolts may necessitate replacing the hub, depending on the extent of time that they have been loose, but the whole assembly should be replaced or sent back to the factory for replacing the hub. Never separate the hub and ring. Inspect the lobes for a worn or pounded condition. Examine the external gear teeth for scores. Check the bearing for tightness in the hub and for the condition of the inner surface. Make sure that the bearing retaining pins are secure in the cam hub. Check the radial fit of the bearing on the cam hub bearing support. Examine the support for burrs and for the condition of the threads. Check the outer surface of the support for roughness. Check the cam hub bearing spacer for burrs, roughness, and uniform thickness.

REPAIR

MAIN SECTION Remove any nicks, burrs, or roughness from finished surfaces with a fine stone and polish.

Make whatever stud replacements are necessary. When replacing studs with ground threads, use only engine oil as a thread lubricant and be sure that both stud threads and mating threads are clean. Cylinder hold-down studs having ground threads may be identified by a drill mark at the nut end.

Smooth any scores found in the inner surface of the rear main bearing with a burnishing tool. If the bearing is not marred or scored, do not touch the surface.

Do not use emery cloth to polish the inner diameter of the valve tappet guides as the fit of the tappet in the guide is within very close limits.

VALVE TAPPET GUIDE REPLACEMENT

If it is necessary to replace a valve tappet guide, heat the crankcase in an oven to approximately 200° F. (95° C.) and remove the guide. Allow the case to cool and ream the guide holes in the crankcase for the proper fit on the new oversize guide. See the Table of Limits. Place the new guide in a bath of dry ice and reheat the case to 175° F. (80° C.). Insert the new guide and align the slots at the inner end with the tool provided for this purpose. Be sure that the flange of the guide is bottomed in its recess. Care must be taken that the correct replacement guide is used depending upon whether its position is above or below the horizontal centerline of the engine.

REAR MAIN BEARING REPLACEMENT

If it is necessary to replace the rear main bearing, heat the crankcase in an oven to 200° F. (95° C.) and remove the bearing with the puller designed for this purpose. Allow the case to cool. Clean and polish the bore in the crankcase and check the fit of the new bearing in the crankcase. Place the crankcase in the oven and reheat to 200° F. (95° C.). Install the key in its slot in the bearing shell with the radiused corners out. The key should be a light drive fit in its slot. Remove the crankcase from the oven and assemble the bearing in place, exercising care to see that the flange is shouldered on the front face and to prevent damaging the threads on the outer diameter of the shell.

Plug the oil holes in the bearing with paraffin. Assemble the bearing boring fixture, the crankcase front section, the main bearing support on the crankcase main section, and bore the bearing to size. Break all sharp edges.

Disassemble the crankcase sections and the boring fixture. Clean the paraffin from the oil holes and blow out the oil passages with air.

VALVE TAPPETS

If the tappets are scored, the scores should be removed with a fine stone. Polish with crocus cloth. Use only crocus cloth to polish the push rod socket end. Smooth any slight irregularities found on the tappet rollers and pins with a fine stone and polish with crocus cloth.

CAM

Remove any roughness or burrs from the cam hub bearing spacer with a fine stone and polish with crocus cloth.

Remove any roughness from the bearing surface of the cam hub bearing support with a fine stone and polish with crocus cloth.

If a bearing clearance is within the specified limits given in the Table of Limits, smooth any irregularities found on the bearing surface with a burnishing tool. Do not touch the bearing unless the surface is scored. Remove any roughness or burrs on the external gear teeth with a fine stone and polish with crocus cloth.

If the cam hub or ring requires replacement, it will be necessary to return the cam to the factory.

CAM HUB BEARING REPLACEMENT

If the cam hub bearing has to be replaced, mount the cam on a suitable lathe face plate with the gear side out. Bore out the bearing until the remaining shell is approximately .015 inch (.381mm.) thick. Remove the cam from the lathe and break out the shell. Drive the pins from the holes, ream the peened material from the holes, and smooth up the inside diameter of the hub.

To install the new bearing, submerge the cam and hub assembly in boiling water and allow it to remain until the hub has expanded sufficiently to permit the two halves of the bearing to be pressed into place. Care should be exercised to see that the two halves of the bearing are properly seated in the hub. Use an arbor press for this operation.

Drill and ream the bearing pin holes. Install the pins and peen over the metal to secure them.

Center the cam on a lathe face plate with the gear side out and bore the bearing to size. The bearing bore must be concentric with the pitch diameter of the gear. Face both ends and break all sharp edges, cutting a $\frac{1}{16}$ inch (1.5875 mm.) radius at the extremities of the bearing bore. When facing the cam hub bearing ends, care should be exercised to see that the faces are held within limits to obtain the correct end clearance of the cam and to center properly the cam lobes under the rollers.

ASSEMBLY

Install a new gasket over the oil drain cover hold-down studs, place the cover in position, install the flash washers, and assemble the nuts on the studs. Tighten the nuts and secure each with a cotterpin.

Insert the finger screen of the oil strainer in its recess and place the spring in position. Install a new gasket on the oil strainer cover and insert the cover in position. Tighten the cover and secure it with lock wire.

Lubricate the valve tappets with engine oil. Insert the tappets in their respective guides and slide them toward the center of the main section until the tappet roller pin support holes are exposed. Place the rollers and pins in position and slide the tappets outward until the pins are housed within the guides. Insert oil seals in the recesses provided. Lubricate the springs and socket ends and place them in their respective tappets. Apply white lead to the tappet retaining nuts, assemble the nuts in position, and tighten.

Install the cam hub bearing spacer over the rear main bearing extension. Lubricate the cam hub bearing with engine oil and place the cam in position. Lubricate the threads in the cam hub bearing support, insert the support, and tighten it with the wrench designed for this purpose. Check the side clearance of the cam hub bearing on the support. Check the alignment of the cam periphery with the tappet rollers. If the rollers extend over the rear edge of the cam periphery, the spacer must be replaced. It may be necessary to grind the new spacer to the desired thickness. If it is necessary to grind the spacer, it is essential that the surfaces be kept square with the inside diameter and parallel within .002 inch (.0508 mm.). When the final assembly of the cam has been completed, cotter the cam hub bearing support to the rear main bearing extension with two cotterpins, exercising care to see that these pins fit snugly in their holes.

If the cotterpins do not fit snugly in their holes, remove the cam hub support and cam and drill two holes in the support with a 5/64 inch (1.9843 mm.) drill, locating the new holes approximately 90° from the original holes and 180° away from each other. The new holes should be centered in the wrench lugs on the support 7/64 inch (2.7781 mm.) from the rear face of the lugs. Ream the new holes to .089 inch (2.2606 mm.) diameter. A special reamer may be procured for this purpose. Assemble the cam hub bearing support and spacer on the rear main bearing extension and tighten the support.

Drill two holes in the rear main bearing extension directly inside the holes in the support. To perform this operation, use an electric hand drill and a No. 44 drill .086 inch (2.1844 mm.) diameter attached to an extension which is long enough to allow the electric drill to be operated beyond the outer diameter of the crankcase main section. Pass the drill through the holes already drilled in the support and at as small an angle as possible. Neither of the new holes in the bearing extension must be drilled nearer than ⅝ inch (15.875 mm.) to the original hole. This distance is measured between the centers of the holes along the outer diameter of the bearing. Ream the holes in both parts with the special reamer. Back off the cam hub bearing support and break all sharp edges in both the bearing extension and support 1/64 inch (.3968 mm.). Reassemble the cam hub spacer, cam, and cam hub support on the rear main bearing extension. Tighten the support and secure it with two cotterpins.

CYLINDERS

DISASSEMBLY

Remove the lock wire, nuts, and flat washers from the exhaust elbow hold-down studs and remove the exhaust elbows. Place a cylinder on the valve assembling block and put the valve spring compressor in place on one of the rocker boxes, pinning the compressor in position through the rocker bolt holes. Hold the lever down firmly against the valve spring washer and strike the lever directly over the valve with a rawhide mallet. This will loosen the washer from the locks. Compress the springs and remove the locks. (Refer to figure 41.) Remove the compressor and lift off the washer. Withdraw the three springs and the two lower washers. Remove the other valve springs and washers in a similar manner. Holding the valves so that they cannot slide through the guides, lift the assembling block. Lay the cylinder on its side and withdraw the valves, tagging each valve with the number of the cylinders from which it was removed. Repeat this procedure on the remaining cylinders.

Remove the rubber oil seal rings located on the lower side of the mounting flanges.

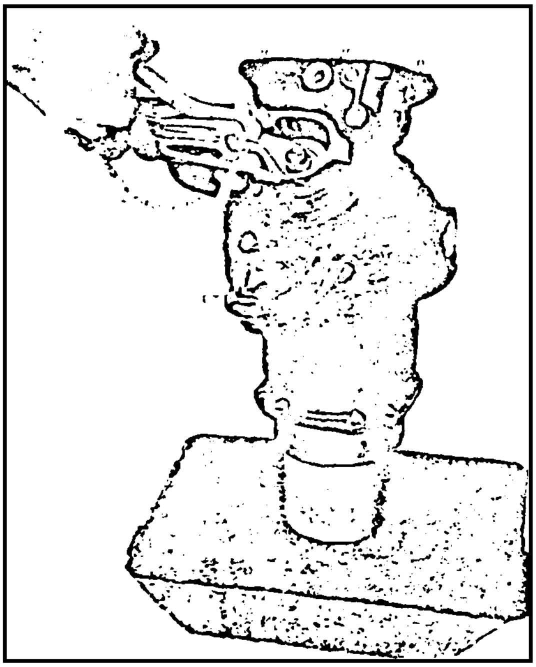


FIGURE 41—Compressing Valve Springs

INSPECTION

Check the rocker boxes, cylinder head, and barrel for cracks, noting the condition of the fins and the enamel. Examine the cowl support lugs. If the enamel is chipped, the cylinder should be re-enamelled.

Examine all external finished surfaces for nicks, burrs, and roughness.

Check the exhaust elbow studs for tightness. Check the studs for condition of the threads.

Check the spark plug inserts for tightness and condition of the threads, noting whether the pins are properly secured. Examine the spark plug coolers for cracks.

Inspect the mounting flange for cracks, warpage, roughness, burrs, and condition of the hold-down stud holes.

Examine the rocker box cover studs for tightness and for the condition of the threads and check the condition of the threads in the cylinder head baffle mounting bosses.

Examine the intake and exhaust port surfaces for cracks. Check the intake port bushing for roughness, burrs, tightness, and condition of the tapped holes. Check the exhaust port seat for nicks and burrs and erosion from excessive heat.

Check the condition of the rocker bolt holes.

TESTING CYLINDER FOR LEAKS

Check the cylinder for leaks. To do this, insert the dummy spark plugs and the dummy intake valves. Insert a plug in the exhaust valve guide and attach a cover plate to the exhaust port studs. Place the cylinder on the air test fixture. Make sure that the flange gasket is in place and secure the cylinder with clamps. Using a small paint brush coat the cylinder with 50-50 mixture of engine oil and gasoline at the head barrel joint, at the spark plug inserts, and around the exhaust port. Apply at least ninety pounds air pressure and check for leaks as evidenced by the bubbling of oil. Be sure to release the pressure in the cylinder before removing the clamps.

VALVE GUIDES

Check the valve guides with a flat plug gage to determine the maximum wear. Inspect the guides for loosening in the head, cracks, and condition of the bores.

VALVE SEATS

Inspect the valve seats for pounding and a pitted or burned condition. Pounding will be denoted by a ridge on the outer face of the seat caused by the outer diameter of the valve head.

CYLINDER BORE

Examine the cylinder sleeve for dents. Check the bore for ring wear, corrosion, scores, nicks, out-of-round, taper, and the minimum and maximum diameters.

Ring wear is denoted by a ridge near the top and bottom of the sleeve, and corrosion by pits or rust.

The minimum and maximum diameters of the bore can be determined with a micrometer or other suitable dial indicator. Set the gage for 5.000 inches (12.7 cm.) and insert it in the cylinder bore. Check the diameters between the thrust and anti-thrust surfaces at a number of different depths. Watching the hand of the indicator as the micrometer is moved to different

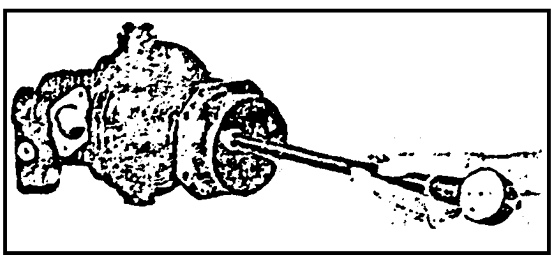


FIGURE 42—Checking Cylinder Bore Dimensions

positions in the cylinder will show the diameters at the various positions. (Refer to figure 42.) Taper is determined by the maximum difference between the head end and crank end diameters of the cylinder bore. Out-of-round is the maximum difference found between diameters at any one depth.

EXHAUST ELBOWS

Examine the exhaust elbows for cracks, erosion, and warpage of the clamping surfaces.

Check the condition of the enamel and fins. Inspect the clamping surfaces for nicks and burrs. Check the studs for tightness and condition of the threads.

AIR DEFLECTORS

Inspect the air deflectors for mutilation and bends, and for condition of the retaining holes, the leather cowl pads on 975E-1 engines, and the tightness of the rivets. Examine the threads and spring of the air deflector clamp for abnormal conditions.

INTAKE PIPES

Examine the intake pipes for dents, cracks, or any condition which might produce air leaks.

Check the flanges for cracks, warpage, and condition of the finished surfaces. Examine the condition of the cap screw threads.

VALVES AND VALVE SPRINGS

Inspect the valves for pitting, for warpage of the head, and for size of the stem. Check the tips, locks, and locking grooves for wear. Check the exhaust valves for stretch, limit of the valve tip regrind, and limit of the valve face regrind with the exhaust valve limit gage.

Operators are cautioned that, at any time when exhaust valves are discarded, any of these valves which may be sodium filled offer the possibility of a fire or of causing personal injuries due to the inflammability of sodium in the presence of water.

Inspect the valve springs for cracks, breakage, and loss of tension. See Table of Limits.

Inspect the valve spring washers for cracks and excessive wear.

REPAIR

Remove any nicks, burrs, or roughness from finished surfaces with a fine stone and polish. Remove the carbon from the walls of the combustion chamber and valve ports.

Small cracks or broken edges near the surface of cooling fins may be removed with a fine file. Sharp corners should be rounded off. Any other cracks necessitate the replacement of the damaged part.

Make whatever stud or dowel replacements are necessary.

If the cylinder mounting flange is cracked, the cylinder barrel must be replaced. Slight warpage may be corrected and small nicks may be smoothed with a fine stone.

A leaky joint between the cylinder head and barrel necessitates replacement of the barrel. The cylinder assembly should be returned to the factory if it is necessary to replace the barrel.

Hard carbon and tetra-ethyl lead deposits or other foreign material may readily accumulate in the joint between the cylinder head and the top of the cylinder sleeve. Because it is difficult to clean this joint due to its location, special tools have been designed to facilitate cleaning this area. It is recommended that cylinder assemblies be cleaned with these tools as described below.

A special cleaning gun is available which is designed for use with all Whirlwind cylinder head and sleeve assemblies. A good grade of ordinary motor gasoline to which no detonation inhibitor or coloring matter has been added should be used when cleaning cylinders with this gun. The gun should be inserted through the flange end of the cylinder sleeve and rotated several times through 360° with the nozzle directed into the joint at the top of the sleeve. The nozzle end should not be used for scraping material from this joint.

To remove material which has become firmly lodged in this joint, a special scraper designed for this purpose should be used. The scraper should be held between the thumb and forefinger and drawn around the circumference of the joint, held approximately at right angles to the surface being scraped. Care should be exercised to avoid removing metal or scratching the sleeve when using these scrapers.

VALVE SEATS

Before replacing a valve seat, it should be remembered that carbon particles are frequently mistaken for pits. Therefore, it is advisable to make a thorough inspection of the valve seat before any rework operations are performed. Variation in the color of the valve seats is an indication of the degree of valve tightness, but does not show which is at fault, the valve or the valve seat. If it is necessary to reface a valve seat due to irregularity or eccentricity of the surface, this should be done carefully to remove the least amount of metal possible.

The trueness of a bronze seat can be checked by inserting the 45° valve seat cutter in place and turning it through a complete revolution. The pressure on the cutter should be just enough to polish the seat without removing a perceptible amount of bronze. Check the concentricity of a steel exhaust valve seat with the blue gage designed for this purpose. If the valve seat is in excess of .0075 inch (.1905 mm.) out of line with the valve guide, it is advisable to replace the valve guide with a new oversize part rather than to regrind the seat. See the instructions entitled Valve Guides.

If a bronze valve seat is pitted or burned to such an extent that lapping in the valve will not bring it to a satisfactory condition, it will be necessary to recut the seat.

If the condition of a steel valve seat is such that it warrants being refaced, it will be necessary to regrind the seat.

Before grinding a steel seat, the stone must be dressed to the required angle. Set up the blue gage between centers in a lathe. Using an indicator in the tool post, adjust the compound rest to the same angle as the blue gage. Remove the indicator and the blue gage. Set up the stone and pilot designed for this purpose in the lathe centers and, using a diamond dresser, dress the stone to the required angle. It is most important when inserting the stone dresser in the tool post, that it be set exactly the same height at which the indicator was set when it was used to adjust the compound rest. Otherwise the same angle will not be obtained.

To grind the valve seat, insert the pilot sleeve in the valve guide from the rocker box side. Insert the wheel and lock the pilot to the drive of a flexible shaft machine. The drive of the flexible shaft machine should be adjusted to give a wheel speed of approximately 4200 r.p.m. Use machine oil to lubricate the stone and pilot and lift the stone from the seat frequently. Grind until a perfect seat is obtained, as indicated by the blue gage. If difficulty is encountered in getting the proper impression on the blue gage, it may be necessary to reset the diamond dresser and redress the stone. Stones should be redressed after each twenty minutes of grinding. Approximately one hour is required to accomplish the initial grinding operation on each seat, depending upon its concentricity with the guide.

A valve seat should never be wider than the valve face. If this condition occurs, the width of a bronze seat can be reduced by using a 20° cutter and removing that portion of the valve seat which extends beyond the outer edge of the valve. The width of a steel seat can be reduced with a stone dressed to 20°. The width of the seat should be approximately 1/32 inch (.7937 mm.) less than the width of the valve face. Use a 70° cutter, for bronze seats, or a stone dressed to 70° for steel seats, to clean up the inside diameter of the valve seat, if necessary.

After refacing a valve seat, the valves should be lapped in, using Clover Leaf compound, Grade "A", or its equivalent. The lapped surface of a steel valve seat should not exceed $\frac{1}{16}$ inch (1.5875 mm.). This applies to only newly faced valves and newly ground seats. Do not allow the lapping compound to get on the valve stem. Remove all traces of the compound when the lapping operation is completed.

If it is necessary to replace the valve guide, do not reface the valve seat until after the new guide has been installed and reamed.

A number of special tools are required to replace valve seats. If a complete set of these tools is not available, it is recommended that the cylinder be returned to the factory for valve seat replacement.

To remove a bronze valve seat, mount the cylinder in the drill press fixture, using the correct size adapted and attaching it with the hold-down nuts. Adjust the position of the cylinder by means of the cradle locknuts, the adapter clamps, and the indexing pins so that the valve seat boring tool, when inserted in the valve guide, is in a vertical position. Adjust the valve seat cutter so that it will remove all but a thin shell on the outer diameter of the seat. Bore out the seat and break out the remaining shell. Care should be exercised to prevent damaging the valve seat recess when boring out the seat.

To remove a steel valve seat, it will be necessary to cut a recess in the cylinder head just above the valve seat. It is necessary to cut this recess only at the time of the first valve seat replacement. Use the cutter and cutter setting gage designed for this purpose. Heat the cylinder to 300° F. (150° C.) for one hour and drive out the seat, using special tools.

Check the diameter of the recess in the cylinder head and the outer diameter of the valve seat for the required shrink fit. The cylinder should be cold when this check is made. Recesses should be bored out to accommodate the oversize valve seat insert, using the counterbore cutter with the standard valve seat cutter handle sleeve and spindle. This counterbore is also used for increasing the depth of the recess. Care must be taken to obtain a smooth surface at the bottom of the recess and the correct depth dimension.

Place the new valve seat either intake or exhaust, on the inserting tool adapter, and chill both the seat and adapter in a bath of dry ice and alcohol. Heat the cylinder in an oven to 600° F. (315° C.). Insert the seat and pull it into place with the inserting tool. Allow the cylinder to cool in the air before removing the inserting tool.

Check the concentricity of steel exhaust valve seats with the valve guide. It is essential that the concentricity be held within close limits due to the difficulty experienced in grinding steel seats.

Reface the valve seats by either cutting or grinding as instructed in the previous paragraphs.

VALVE GUIDES

If a valve guide is loose in the cylinder or if the valve fit in the guide is not within the limits specified in the Table of Limits, the guide should be replaced. If the guide is to be removed, mount the cylinder in the cylinder holding fixture and bore out the guide using the counterbore cutter and pilot. This counterbore leaves a thin shell of the guide remaining in the cylinder head which must be broken out.

Check the size of the valve guide hole in the cylinder against the outer diameter of the valve guide for the proper shrink fit. See the Table of Limits. Using the pilot bushing located in the valve seat, ream the guide hole in the cylinder to the correct size.

Heat the cylinder in an oven to 350°—400° F. (175°-200° C.). If an oven is not available, heat the cylinder with a blow torch, but play the flame well over the cylinder head to prevent setting up local stresses. Place the guide to be installed on the mandrel designed for this purpose and submerge it in a solution of dry ice and alcohol. Remove the cylinder from the oven and insert the guide. Hold the guide in position with a hammer handle until the cylinder has cooled down enough to grip it lightly and strike the end of the mandrel sharply with a fiber drift and hammer to set the guide firmly in place.

Ream the valve stem hole in the guide to obtain the proper fit on the valve stem. If the cylinder is equipped with a steel exhaust valve seat, it will be necessary to use a pilot bushing located in the valve seat while reaming the exhaust valve guide.

After replacing a valve guide, reface the valve seats by cutting or grinding, as required. See the previous instructions on refacing valve seats.

It is recommended that an inspection of all valve seat inserts be made after a valve guide installation or whenever the head has been heated.

For checking, a .001 inch (.025 mm.) feeler should be tried between the cylinder recess and the insert. If the feeler does not enter at any point, it is an indication that the insert is bottomed correctly. However, if the feeler does enter at any point, it is an indication that the insert is not bottomed correctly. In this case, remove the insert and replace with an oversize insert.

SPARK PLUG INSERTS

Damaged spark plug inserts should be replaced. To replace a spark plug insert two special counterbores are necessary. Counterbore the metal cooler with the larger of the two counterbores to a sufficient depth to permit the removal of the pin portion of the insert. With the other counterbore, cut away the threaded portion of the insert until only a thin shell remains. Break out this shell and remove the loose locking pins. Clean up the threads in the cylinder head by tapping out the holes with the proper oversize tap. Clean up the face of the tapped hole location with a spot facer.

Apply Heldite sealing paste in the threads of the new oversize insert and screw it into position. Drill the two locking pin holes midway between the original holes, using the jig provided for this purpose. Install the new pins, tap out the hole in the new insert, and spotface the face of the insert. Drill the hole for the thermocouple wires with the tools designed for this purpose.

TESTING CYLINDER

The cylinder should be tested again for leaks in the manner described under Inspection if new valve seats, valve guides, or spark plug inserts have been installed. If new spark plug inserts were installed, test the cylinder for leaks before pinning the inserts in place.

CYLINDER BORE Small dents on the flange and fins or on the cylinder skirt may be corrected. Dents in the main bore, however, will require replacement of the barrel.

Ring wear at the top and bottom of the ring travel in the sleeve may be smoothed out with a fine round stone if not too deep.

Slight scores or rough areas may be touched up with a fine round stone. When the dimensions and finish of the cylinder barrel are satisfactory, the barrel should not require honing. When hand polishing is not sufficient, honing will be necessary.

Set the cylinder up in the cylinder holding fixture and locate the fixture directly under the spindle of a honing machine. Adjust the spindle for a speed of approximately 65 r.p.m. for rough honing and 35 r.p.m. for finishing with 26 to 28 up and down strokes per minute. Install the special hone and driver and adjust the stones by means of the calibrated knurled nuts so that they just touch the cylinder wall. Extra stones for this hone may be procured from the Wright Aeronautical Corporation.

INTAKE PIPES Intake pipes that are severely dented should be straightened. Back up the part to be straightened with a metal rod of the proper size and shape. Be careful when hammering out dents that the wall thickness is not reduced or cracked. Repaint the pipes, if necessary.

Slight burrs and nicks may be removed from the intake pipe flanges with a fine stone. The finished surface should then be lapped on a lapping plate. Replace any flanges that are cracked.

Remove the burrs from the cap screw heads and clean up the threads.

AIR DEFLECTORS Cylinder air deflectors which are bent or dented should be straightened and, if slightly cracked, it is permissible to weld. Repaint, if necessary, when the repairs are completed.

VALVES AND VALVE SPRINGS If a valve face is pitted or warped, reface it in a standard valve grinding machine. Do not remove more metal than is absolutely necessary to true up the face. All valves should be refaced to 44° to 44°15'. Valve tips are of uniform hardness so that it is permissible to remove signs of wear on the upper ends with a stone, or with a grinder.

The stems should not be stoned unless it is considered absolutely necessary. The stem acquires a hard glazed surface after a few hours of running, and, under normal conditions, will keep this glaze indefinitely. All burrs in the lock end of the valve stems caused by the locks should be carefully removed with a fine stone.

Lap the valves in the cylinders after they have been reconditioned. See the instructions given in the paragraphs under valve seat replacement.

Valve springs exhibit a tendency to break off at the ends for an inch (2 cm.) or so where the wire has been ground thin. Such a condition, however, does not impair their efficiency in operation. Smooth off the broken ends with a stone to prevent wear on the retaining washers. Inspect the springs for cracks by magnetic inspection when the equipment is available. Inspect the retaining washers for wear and cracks. Check the valve springs for tension. See the Table of Limits. Any deviation above or below the limits allowed is sufficient cause to warrant replacement.

Clean all parts thoroughly, using the greatest care to remove all traces of grinding and lapping compounds.

ASSEMBLY

Lubricate the valve stems with engine oil. Insert the valves in their guides in a cylinder and place the cylinder on the assembling block. Insert the lower valve spring washers and assemble the three valve springs and upper valve spring washer in position. Pin the valve spring compressor in place through the rocker hub bolt support holes. Compress the springs and slip the split locks in place.

Install the exhaust elbows in position on the studs at the exhaust port flanges. Assemble the washers and nuts on the studs. Tighten the studs and secure them with lock wire.

VALVE OPERATING MECHANISM

DISASSEMBLY

Remove the hose connections and hose clamps from the push rod housings. Remove the rocker arm clamp screws and the adjusting screws from the rocker arms.

INSPECTION

ROCKER ARMS Examine the rocker arms for cracks and condition of the adjusting screw threads. Check the adjusting screw for cracks and for the condition of the threads, the slots, and the push rod ball end seat. Check the oil passages for clearness. Check the rollers for cracks, flat spots, and fit on the pins. See the Table of Limits. The clearance of the roller on the pin can be determined with a dial indicator. Check the pin for tightness in the rocker arms. Examine the lower side of the rocker arms for evidence of interference with the upper valve spring washer.

ROCKER ARM BEARINGS Check the rocker hub bearing for tightness. If the bearing is loose enough to be pushed out by hand, the rocker arm must be replaced. To inspect the roller bearing, it is absolutely necessary that every trace of grease be removed, as dried grease tends to make the bearing stick. Dry the bearing and lubricate with oil. Check the end play of the bearing. See the Table of Limits. Flat spots or roughness on either the races or rollers can be detected by exerting opposite thrust on the inner and outer races first in one direction and then in the other, while rotating the inner race and holding the outer race fixed.

Since the rollers and races are assembled with selective fits, it is recommended that the rollers and outer races of each side of the bearing be placed in separate cloth bags or other suitable containers at disassembly. These selective fits require that extreme care be taken to reassemble the sets of rollers with the same races from which they were removed.

ROCKER HUB BOLTS Inspect the rocker hub bolts for scores and cracks. Examine the condition of the threads. Check the fit of the bolt in the support holes in the rocker box and in the hub bearing.

PUSH RODS Check the push rod ball ends for excessive wear, looseness, and the formation of projections on the extremeties. Check the rods for bends by rolling on a flat plate.

PUSH ROD HOUSINGS Examine the push rod housings for dents, cracks, and condition of the enamel. Check the condition of the hose connections, and hose clamps. If the hoses show signs of deterioration, they must be replaced. Damaged hose clamps must be replaced.

ROCKER BOX COVERS Inspect rocker box covers for cracks and for the condition of the finished surfaces.

REPAIR

ROCKER ARMS To remove a rocker arm roller, file or grind one end of the pin flush with the fork. Do not injure the fork surface. Hold the arm on a piece of stock which has a hole in it just large enough to allow the pin to enter when it is driven out of the arm. Hold the arm in the proper position so that the pin is directly over the hole and drive the pin out.

To install a new roller, hold the roller and hub in place in the arm and drive in a new pin until the ends extend an equal amount on both sides of the arm. Rivet both ends slightly with a light hammer, then spin the ends in a drill press. The fork in the arm will not be closed up by riveting as the roller hub is slightly wider than the roller.

If replacement of the bearing is necessary, the old bearing should be pressed out on an arbor press. The bearing should be placed in dry ice and alcohol, and the rocker arm in oil at 250° F. (120° C.) and allowed to remain thus until the bearing can be pressed into the rocker arm with very slight pressure. Usually fifteen minutes in each is sufficient. When starting the new bearing, make sure that it enters in the chamfered end of the hub.

The adjusting screws should have all burrs or nicks removed from the screw driver slot and the threads dressed if necessary. Polish the cup with crocus cloth. If the oil passages are not clear, they should be cleaned with a wire.

If the clamp screws are not to be renewed, the heads should be stoned to remove any burrs. Renew the lock washers if tapered locks are not used.

ROCKER ARM HUB BOLTS, PUSH ROD HOUSINGS Check for cracks and stone any nicks or burrs on the hub bolt.

The push rod housings should have all dents removed by tapping them out when the housing is placed on a mandrel. Finish all straightening with fine emery cloth and repaint.

PUSH RODS Push rods which are slightly bent and are to be straightened should be rolled on a flat plate to determine the high spot and tapped back to proper shape with a light mallet. Continue this operation on each rod until it is straight so far as can be determined by visual inspection. The ball ends should be polished with crocus cloth. Clean the oil holes in the ball ends.

Do not attempt to renew push rod ball ends, as it is impractical to fit a new end tightly in an old rod.

ASSEMBLY

Run the adjusting screws in the rocker arms a few turns. Place the lock washers on the clamp screws and assemble on the arm.

Slip the hose connections over the push rod housings and locate within a half inch of the bead which is directly on the end of the housing. Do not put the clamps on the hose connections at this time.

If the valve seats have been replaced, assemble the rocker arms in the cylinder and check for interference between the rocker arm and upper valve spring washer. If interference exists, the upper washer may be replaced with a washer that has an undersize bore which has been designed to remedy this condition.

PISTON AND PISTON RINGS

DISASSEMBLY

Remove the piston rings from the piston with the piston ring spreader and scrape the carbon from the tops of the pistons only. An aluminum scraper should be used and care taken to see that the surface is not scratched. Wash the piston with an approved cleaner.

Remove the piston pin retainers and order replacements. Piston pin retainers should not be used more than once and should be scrapped whenever they are removed to prevent any possibility of further use. Piston pin plugs may be reused if the plugs are in good condition. Replace all piston rings.

INSPECTION

PISTONS Examine the pistons for scores, cracks, and erosion. Inspect the ring lands for cracks by applying light side pressure. Check the width of the ring grooves with a standard piston ring and feeler gage. (Refer to figure 43). Examine the piston ring bearings for scores and wear. Check the dimensions of the pistons against the cylinder bores and compare with the Table of Limits.

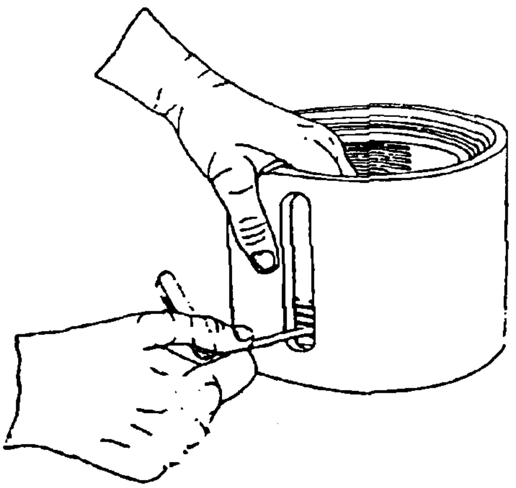


FIGURE 43—Measuring Side Clearance of Wedge Type Piston Rings

PISTON PINS Check the piston pins by magnetic inspection for cracks, scoring, flat spots, straightness, and for fit in their respective pistons. See the Table of Limits.

REPAIR

If cracks or severe erosion are found, the piston should be replaced. Light scores and rough spots can be smoothed over with a fine stone and kerosene. Unless the piston bearing surfaces are badly scratched or scored, the normal polish or glaze resulting from service should be left untouched.

Clean the carbon from the ring grooves. However, there is a small radius between the bottom of the ring groove and ring land, and care should be exercised to see that this radius is not scratched when removing the carbon. Remove the carbon from the inside of the piston and clean out the oil holes. Clean the piston pin holes with crocus cloth. Do not buff pistons. If the ring lands are worn to the extent that truing up is necessary, it is permissible to remachine the grooves for oversize width piston rings. Consult the Parts Catalog and the Table of Limits.

A cracked or bent piston pin must be replaced. Slight scoring or wear may be corrected with a fine stone.

the master rod and check the diameter against the size of the new bearing to be installed. See the Table of Limits for the correct shrinkage. The importance of this fit cannot be overemphasized. The most accurate results in checking the sizes of these two parts are obtained when the room temperature is between 60° and 70° F. (15° and 20° C.).

Heat the rod in an oil bath at a temperature of 450° F. (235° C.) for at least one hour. The oil used in the bath must have a flash point considerably above this temperature. Remove the rod from the bath and insert the new bearing, using the fixture and arbor press plug designed for this purpose. When this operation is performed, particular attention should be paid to the alignment of the oil holes in the bearing with those in the master rod. Allow the rod to cool in air.

Drill the locking pin hole in the bearing shell and ream out the counterbore in the rod. Place the rod on a suitable mandrel and tap the locking pin in place. Peen over the metal to secure the pin.

Preparatory to boring the bearing, assemble the knuckle pins in the rods, except where fixture locating bars are used, to counteract any distorting effect of the bearing hole that the pressure exerted by the knuckle pins might cause. Seal the oil holes with beeswax to prevent any metal entering the oil passages. Place the rod in the holding fixture and bore the bearing the correct fit on the crankpin, using the tools designed for this purpose. See the Table of Limits. Remove the rod from the fixture and break all sharp edges. Clean the rod thoroughly. Withdraw the knuckle pins and remove the beeswax from the oil holes. Clean the knuckle pins.

In the event the bearing has been turning in the rod, thereby enlarging the inside diameter of the rod, it will be impossible to obtain the proper fit by using a standard size bearing. To obviate the necessity of discarding the master rods which have become worn in this manner, a master rod bearing which is oversize on the outside diameter has been made available. Inasmuch as the rod must be reground to permit the installation of the oversize bearing, it will be necessary to send the rod to the factory for bearing replacement.

REPLACING KNUCKLE AND PISTON PIN BUSHINGS

To remove the knuckle pin bushing, insert the small end of a plug, or arbor, into the knuckle pin bushing. Place the base on an arbor press table and insert the collar in the base. Support the rod over the collar. Press out the old bushing. Remove the plug and the rod. Clean the rod bore and remove all burrs.

To install the new knuckle pin bushing, place the bushing on the small end of the plug, and screw the cap on the plug. Place the knuckle pin end of the rod over the collar and insert the large end of the plug through the bore so that it extends into the collar. Locate the split in the bushing so that it is 45° from the tip of the rod as measured from the center line of the rod and away from the side bearing the rod number. Using an arbor press, press down on the cap on top of the plug until the press-in plug bottoms against the collar. Remove the plug and collar.

After a new knuckle pin bushing has been installed, it should be broached to provide a satisfactory surface contact between the bushing and the bushing bore in the rod. This is accomplished by pressing a proper size burnishing broach through the bushing by means of an arbor or hydraulic press using from 300 to 400 lb. per sq. in. (21-28 kg. sq. cm.) pressure. Thus the bushing is expanded and the possibility of its turning in the rod is eliminated. Next the bushing is spot-faced so that the ends of the bushing will extend between .060 to .090 inch (1.524 to 2.286 mm.) beyond the end of the rod bore.

Burring or cutting a radius removes the sharp edge on the outside circumference of the end of the bushing. The bushing is next diamond bored for the correct size. Check the diameter of the knuckle pin at the knuckle pin bushing location. Refer to Table of Limits for special clearance. The burring procedure is repeated to effect a smooth edge on the inside circumference of the end of the knuckle pin bushing.

The replacement of piston pin bushings is accomplished in the manner just described. To protect the protruding ends of the piston pin bushings counterbore the ends of the bushings after boring, with a tool designed for this purpose. The master rod piston pin bushing, however, is spun-in instead of spot-faced.

KNUCKLE PINS

Remove any scratches or scores from the knuckle pins by stoning and polish them with crocus cloth. Clean out the oil passages.

ASSEMBLY

Place the front section of the crankshaft in a holding fixture and again check the crankpin for nicks or burrs. Replace the master rod bearing

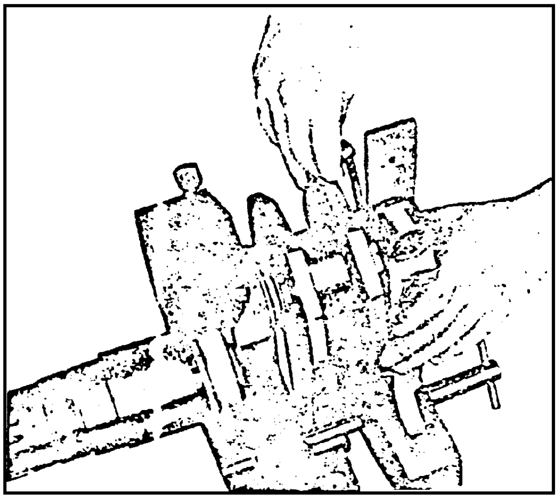


FIGURE 55—Checking Master Rod End Clearance

spacer by heating it in oil to approximately 300° F. (150° C.) and slipping it in place on the crankpin making sure the chamfered side is against the crankpin fillet. Coat the crankpin with engine oil. Install the master rod on the crankpin with the knuckle pin locking screw holes towards the front. Insert a wedge in the slot of the crankshaft rear section and slide this section on the crankpin until the master rod bearing has its proper end clearance. (Refer to figure 55.) Remove the wedge and line up the two halves of the crankshaft by inserting the crankshaft aligning bar through the holes in the counterweights. Coat the threads of the crankshaft rear section cap screw with a mixture of white lead and lubricating oil and install the cap screw and the cap screw washer, which is placed with the chamfered side against the head of the cap screw. Remove the aligning bar and run the cap screw in. Before tightening, however, check the length of the cap screw by placing a 5/8 inch (15.875 mm.) diameter steel ball in the chamber at either end and measuring over these balls with a micrometer. Then tighten the cap screw, using the wrench provided for this purpose and a pipe extension, until the length of the screw has been increased by the specified amount of stretch. Refer to the Table of Limits. The stretch is determined by the difference in the length of the cap screw before and after tightening. The alignment of the two crankshaft sections should be checked with the aligning bar at various intervals during the process of tightening the cap screw and upon completion of the tightening. Do not leave the bar through both counterweights while the cap screw is being tightened since any movement of the rear section will cause the bar to bend. If the two sections are in line, secure the cap screw with a cotterpin. Insert the cotterpin from the inside.

In the event that the original cotterpin holes are not in line, it will be necessary to drill a new hole in the cap screw. The new hole must be removed from all other adjacent holes by at least 1/4 inch (6.35 mm.) the distance being measured between the edges of the holes along the root of the threads. If the amount of stretch specified by the Table of Limits makes this impossible, it is permissible to reduce the thickness of the cap screw washer as much as .010 inch (.254 mm.) by grinding from one side or both sides of the washer. Care must be taken in grinding as it is essential that all points of the washer bear evenly on the cap screw head. After grinding break all sharp edges 1/64 inch (.40 mm.) and check for interference on the fillet under the cap screw head.

Remove the crankshaft and master rod assembly from the holding fixture and place the assembly on the adjustable rollers. Check the alignment of the crankshaft with a dial indicator as previously instructed in the paragraph on Crankshaft Alignment in this chapter.

This completes the crankshaft assembly as the articulated rods are not installed until the engine is ready for final assembly.

CRANKCASE DIFFUSER AND REAR SECTIONS

DISASSEMBLY

Place the diffuser and rear section assembly on a rear section assembly stand with the forward end facing down. Back off the starter shaft bolt nut. Remove the starter shaft and gear. Then turn the assembly over in the stand so that the diffuser section is on top.

Hold the gears of the accessory drive gear train stationary by inserting a small piece of fibre between the teeth and remove the cotterpins and nuts from the accessory drive gear shaft. (Refer to figure 56.) Lift off the accessory driven gears and remove the accessory driven gear keys.

Remove the cotterpins and nuts from the diffuser section to rear section studs. Separate the two crankcase sections with the three pullers designed for this purpose exercising care to screw down evenly on the pullers while the operation is being performed. (Refer to figure 57.)

ASSEMBLY

PISTON RINGS

Before installing the piston rings they should be checked for proper gap and side clearance.

To check the piston rings for gap, set a piston in the cylinder in which the piston is to be installed with the bottom end about 1/2 inch (1.3 cm.) from the end of the barrel. (Refer to figure 44.) Then set the ring to be checked inside the barrel and up against the piston. Such a position insures its being square with the cylinder bore. With a set of feeler gages, check the clearances between the ends. If this clearance exceeds the amount specified by the Table of Limits, replace the ring. The piston ring side clearance should be checked with the rings in position in the piston. The clearances are given in the Table of Limits.

The compression rings are marked with the word "Top" stamped on the ring denoting their position in the piston. The proper position of the ring is with the ring tapering in at the top thereby allowing the bottom of the ring to bear against the cylinder wall. This taper permits the piston ring to seat itself or "wear in" quickly and consequently decreases the time required for running in an engine after piston ring replacement.

Extreme care should be taken when installing new compression rings to make certain the ring is in its proper position with the word "Top" nearest the top of the piston. The taper should be checked with a square to prove that the rings have been properly stamped.

If the compression rings are removed and replacement is not made, the word "Top" may be found worn off the ring. By careful examination of the ring it will be possible to determine the bottom edge due to the difference in wear at that point. The sharper edge of the ring will have worn off and will be shiny as compared with the top edge.

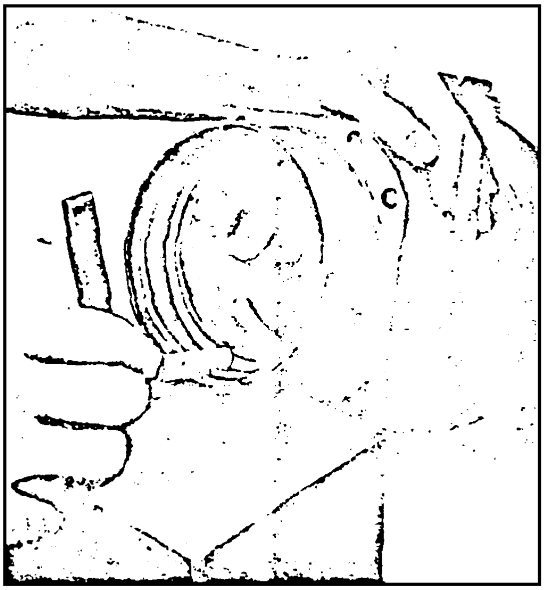


FIGURE 44—Checking Piston Ring Gap

The proper position of the oil scraper rings, which are installed in the lower grooves, is with the ring tapering in at the top allowing the bottom of the ring to bear against the cylinder wall. However, in Uniflow pistons, the ring in the groove below the piston pin is inverted. In this case, the word "Top" faces the bottom of the piston.

Install the rear piston pin retainer. The part number, compression ratio, and cylinder number are stamped on the forward side of the piston.

CRANKSHAFT

DISASSEMBLY

Place the crankshaft in a holding fixture and remove the cotterpin from the rear section cap screw. Using a box wrench with a pipe extension, remove the cap screw. Insert a wedge in the slot in the rear crankshaft and remove the rear section from the crankpin. (Refer to figure 45.) Inspect the rear end of the crankpin for nicks or burrs. Smooth any slight irregularity that might be found and then slide the master rod off. Removal of the master rod bearing spacer is accomplished by pouring hot oil (approximately 300° F. (150° C.) over the spacer and then removing by hand with a cloth over the spacer as protection for the hands. Remove the crankshaft

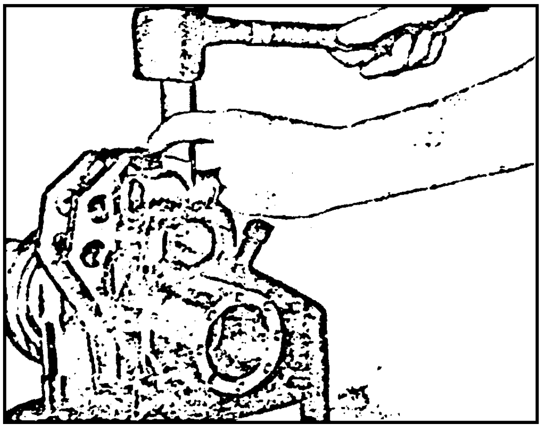


FIGURE 45—Spreading Rear Crankcheek

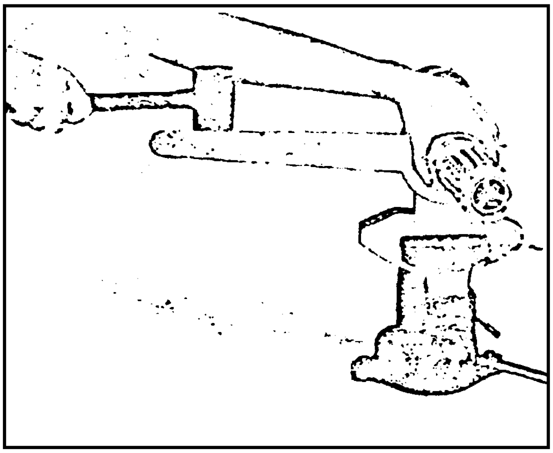


FIGURE 46—Removing Front Main Bearing Lock Nut

front section from the holding fixture and clamp the crank cheek, with the shaft pointing in a vertical direction, in the jaws of a vice padded with copper or some other soft material. Remove the cotterpin from the front main bearing lock nut and unscrew the lock nut with the wrench designed for this purpose, using every precaution to prevent marring the shaft. (Refer to figure 46.) Remove the nut and wrench and lift off the roller retainer plate and the rollers. Remove the inner race with a puller. Bend the edge of the crankpin bore plug retaining screw lock plate away from the plug retaining cap screw and remove the cap screw and lock plate. Withdraw the crankpin bore plug with the puller designed for this purpose.

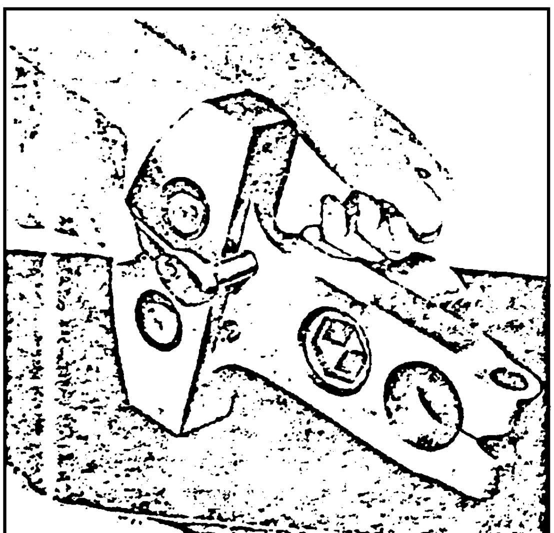


FIGURE 47—Removing Bolt from Counterweight Stop

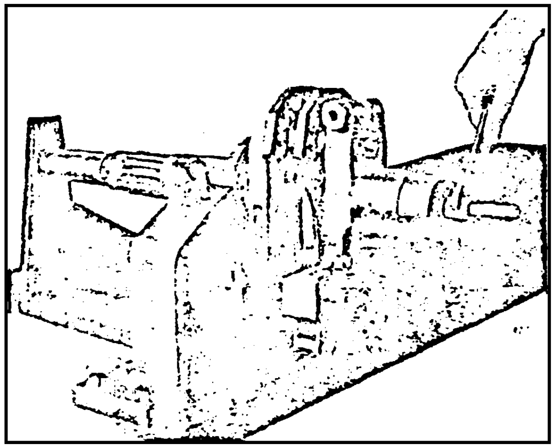


FIGURE 48—Removing Rear Main Bearing Journal Plug

Remove the cotterpins from the crankshaft rear section dynamic damper stop bolt nuts. (Refer to figure 47.) Unscrew the nuts and remove the bolts and stop. Align the holes of the dynamic damper with those of the crank cheek extension and withdraw the pins. Slide the damper weight from the crank cheek. Remove the rear plug from the crankshaft rear main bearing journal bore with the puller designed for this purpose. (Refer to figure 48.)

Remove the spring retainer from the crankshaft gear assembly and pry out each spring with its two pins. Turn the hub within the gear until the lugs of the gear are no longer engaged by the slots in the hub and separate the hub and gear.

INSPECTION

CRANKSHAFT FRONT SECTION

Inspect the crankshaft front section carefully for cracks. Inspect the crankpin fillet with a magnifying glass. Examine the propeller hub splines closely.

Inspect the condition of the propeller hub cone journals, and the propeller hub retaining nut clevis pin holes. Check the splines for nicks and wear.

Inspect the front main and thrust bearing locations for galling and check the fit of the bearings on the crankshaft. See the Table of Limits.

Examine the condition of all threaded areas.

Note the condition of the front crankcheek and extension and check the counter weight for tightness of the rivets. Examine the condition of the threads of the tapped hole which receives the crankpin bore plug retaining cap screw.

Check the hydro control oil tubes for clearness, tightness, and cracks. Note the position of the supporting plugs and see that the crankshaft breather screen is clean.

Inspect the crankpin bore for sludge deposits. Check the oil nozzle for tightness and clearance.

Examine the propeller hub retaining nut for burrs, cracks, and condition of the threads.

Inspect the thrust bearing nut for burrs, cracks, and for condition of the threads and oil seal ring grooves.

Examine the oil seal ring adapter for cracks, condition of the ring grooves, clearness of the oil holes, and fit on the shaft.

Inspect the front main bearing lock nut for burrs, cracks, and condition of the threads. Check the spacer and under the spacer for roughness and burrs. Carefully inspect the front main bearing rollers and races with a magnifying glass for flat spots, cracks, or a pitted condition of the surfaces. The presence of any of these conditions will warrant replacement.

Examine the master rod thrust bearing spacer for roughness and cracks.

Check the crankpin bore plug for burrs, condition of the puller threads, and fit in the crankpin bore.

See that all oil passages are free from any obstruction.

It is recommended that the thrust nut and hydro-control oil seal rings be replaced at overhaul. Check the new oil seal rings for proper gap. See the Table of Limits.

CRANKSHAFT REAR SECTION

Check the crankshaft rear section for nicks, burrs, and cracks.

Examine the threads in the cap screw hole for evidence of pulling and check the inner clamping surface for burrs.

Check the rear main bearing journal for roughness, clearness of the oil passages, and the condition of the crankshaft gear retaining screw hole threads. Measure the diameter at various points of the journal with a pair of micrometers, recording the maximum and minimum diameters measured to determine the out-of-round. If the out-of-round will prevent obtaining the fits allowed by the Table of Limits, remove the high points with a fine stone. Polish with crocus cloth. It is essential that this operation be performed before the alignment of the shaft is checked.

Check the dynamic damper pin bushings for tightness in the crank cheek, cracks, scores, wear, and out-of-round.

Examine the dynamic damper stop for nicks, burrs, and cracks. Check the stop retaining bolts and nuts for burrs and condition of the threads.

Inspect the dynamic damper weight for burrs and roughness. Check the pin bushings for tightness in the weight, cracks, scores, and out-of-round. Examine the pins for cracks, roughness, wear, condition of the flanges, and out-of-round.

Check magnetically the cap screw for burrs and cracks. Examine the cap screw threads for evidence of pulling. Check the cap screw washer for burrs, cracks, and proper seating at the cap screw head.

Check the size of the crankpin bore against the O.D. of the clamping surface on the crankpin. See the Table of Limits.

CRANKSHAFT GEAR

Check the crankshaft gear for cracks. Examine the teeth for scores and wear. Examine the lugs for nicks and burrs.

Examine the hub for cracks, nicks, and burrs. Check the condition of the crankshaft gear hub screw holes and the alignment of the screws and screw holes.

Examine the spring retainer for burrs.

Check the springs for cracks and the pins for wear and burrs. Replace any springs which are cracked or broken and any pins which are excessively worn. Check the spring and pin assemblies for a snug fit in their positions.

Check the crankshaft gear hub screws for condition of the threads and heads.

CRANKSHAFT ALIGNMENT

Place the crankshaft front section in a holding fixture. Insert the wedge in the slot of the rear section of the shaft and slide this section over the crankpin and against the shoulder. Line up the two halves of the shaft by inserting the crankshaft aligning bar through the holes. Remove the wedge and install the cap screw and washer. Do not tighten. Measure the length of the cap screw with the stretch measuring tool and a pair of micrometers. Remove the aligning bar and tighten the cap screw. Check the alignment at various intervals during the tightening of the cap screw. No

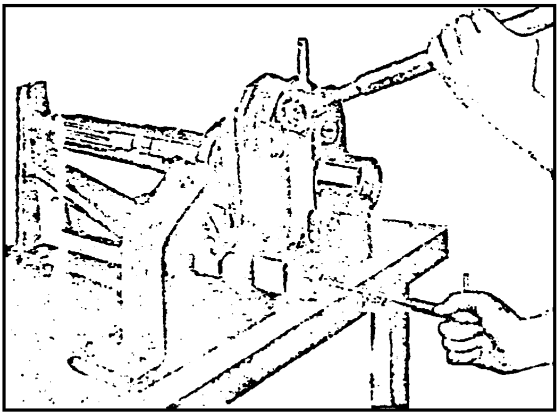


FIGURE 49—*Tightening Rear Crankcheek Cap Screw*

tightening or loosening of the cap screw should be done while the aligning bar is through both counterweights, as any movement of the rear section of the shaft will cause the bar to bend. Tighten the cap screw until its length has been stretched the amount specified by the Table of Limits. (Refer to *figures* 49 *and* 50.)

The alignment of the shaft should be checked with a dial indicator while rotating the shaft on adjustable alignment rollers.

Place the shaft on the adjustable rollers; one set of rollers located at the rear bearing journal and the other at the front main bearing location. The shaft and bench must be *level*. Locate the dial indicator so that it will register against the thrust bearing location and revolve the shaft. (Refer to figure 51.) Note the amount of run-out at this point and also at the point between the threads and the splines at the front end of the

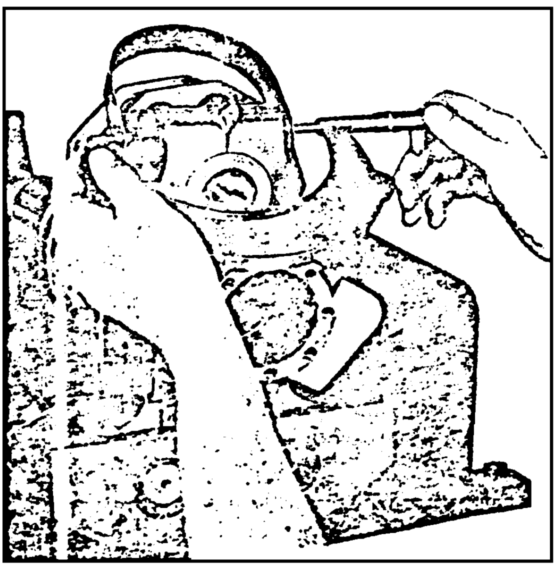


FIGURE 50—*Measuring Crankcheek Cap Screw Stretch*

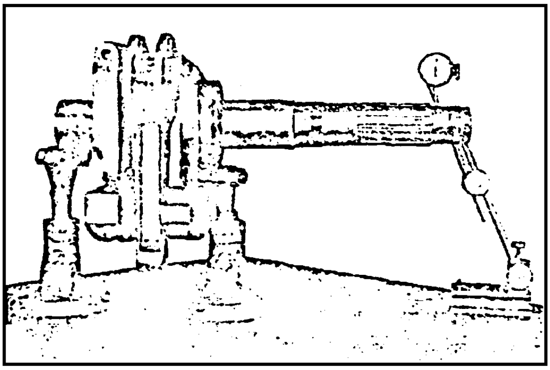


FIGURE 51—*Checking Crankshaft Alignment*

shaft. Any run-out greater than that specified by the *Table of Limits will necessitate replacement* of the shaft. Do not attempt to straighten a bent shaft.

Measure the crankpin diameter with a micrometer. Measurements should be taken at several different points on the crankpin and the largest and smallest diameters recorded. Crankpins of which the out-of-round prevents obtaining the fits specified by the Table of Limits must be stoned back to shape.

It is essential that the dimensions of the crankpin be checked at this time due to any distorting effect that the clamping action of the crankshaft rear section might have.

REPAIR

CRANKSHAFT FRONT SECTION Crankshafts which are more than .0015 to .002 inch (.0381 to .0508 mm.) out-of-round at the crankpin should be either honed or returned to the factory to be reworked. If the amount of wear does not exceed this limit, it is permissible to stone the crankpin back in shape. It is advisable to have the rear section of the shaft clamped to the crankpin while stoning as the stoning can best be done while the shaft is on the alignment rollers. This greatly assists in the handling of the shaft.

Check the crankpin with a micrometer to determine the location of the high spots that will require stoning. Extreme care must be taken when stoning to keep the crankpin even across its entire width. A rocking movement of the stone will avoid the possibility of causing flat spots. Frequent wetting of the stone in gasoline insures a better finish and prolongs the life of the stone. Upon completion of the stoning, polish the journal with crocus cloth and gasoline. Separate the two halves of the shaft in the manner previously described.

Remove any nicks, burrs, or scores from the master rod bearing spacer with crocus cloth and gasoline.

Remove any burrs or roughness from the propeller hub splines with a fine stone and polish with crocus cloth. Clean up all threads with a fine stone.

Unscrew the plug at the center of the breather support plug in the front of the crankshaft and remove the packing gland and the packing, using every precaution to prevent damaging the oil tube. Examine the condition of the packing gland. Check the condition of the threads of both the crankshaft breather plug and the crankshaft to hydro-controllable propeller oil tube outlet plug. Check crankshaft spline screw for tightness.

If the breather screen is damaged, the crankshaft breather plug will have to be replaced. In performing this operation, the greatest care should be exercised to prevent damaging the oil tube. Back out the crankshaft spline screw and withdraw the crankshaft breather plug with the tool designed for this purpose. Inspect the bore of the shaft with a light for traces of foreign material. Align the crankshaft spline screw holes in the new crankshaft breather plug with the hole in the wall of the crankshaft and insert the crankshaft breather plug. Make certain that the hydro-controllable propeller oil tube passes through the hole in the center of the breather plug and tap the breather plug into position with a hollow brass rod. Check the alignment of the crankshaft spline screw holes. Insert the screw and tighten.

Install a new oil packing around the hydro-control oil tube at the crankshaft breather plug. Insert the packing gland. Assemble the crankshaft to hydro-controllable propeller oil tube outlet plug in position, tighten and lockwire it to the crankshaft breather plug.

Remove any nicks or burrs from the outer surfaces of the shaft, crank cheek, and counterweight with a fine stone and polish with crocus cloth.

Smooth up the thrust ball bearing nut and oil slinger with a fine stone.

Remove any nicks or burrs from the oil seal ring adapter with a fine stone and polish with crocus cloth.

Smooth up the front main bearing lock nut and spacer with a fine stone. Polish the inner and outer races of the bearing with crocus cloth.

CRANKSHAFT REAR SECTION

Remove nicks or burrs from the crankshaft rear section with a fine stone and polish with crocus cloth.

Clean up the cap screw threads and remove any nicks or burrs from the cap screw and cap screw washer.

Remove nicks or burrs from the dynamic counterweight and stop with a fine stone and polish with crocus cloth. Remove any scores from the pins and pin bushings with a fine stone and polish with crocus cloth.

If it is necessary to replace the dynamic damper pin bushings, press them out with an arbor press. An arbor press plug and press table may be procured for performing this operation. When removing the bushings from the counterweight, a support must be used in the slot of the counterweight.

Chill the new bushings in a bath of dry ice and press them into place, using the press plug and locating fixture designed for this purpose. See the Table of Limits for the proper press fit of the bushings.

Remove slight scores or signs of wear from the crankshaft gear with a fine stone and polish with crocus cloth. Smooth up any nicks or burrs found on the lugs.

Remove any burrs and smooth any slight roughness found on the hub with a fine stone and polish with crocus cloth.

Remove any slight roughness or burrs from the spring retainer with a fine stone.

ASSEMBLY

Coat the crankpin bore plug with a mixture of engine oil and white lead and insert the plug in its recess. Tap the plug into position and secure it with the retaining cap screw and a new lock plate. Bend one prong of the lock plate over the edge of the crank cheek and the other up against a hex flat of the retaining cap screw.

Clamp the crank cheek of the crankshaft front section with the shaft in a vertical position in the jaws of a vice that have been padded with copper or some other soft material. Coat the front main bearing and the bearing spacer with engine oil. Place the spacer on the shaft with the chamfered side against the crank cheek and place the bearing on the shaft with the roller retainer toward the front if a roller bearing, or with the numbered side toward the front, if a ball bearing. If the inner race of the front main

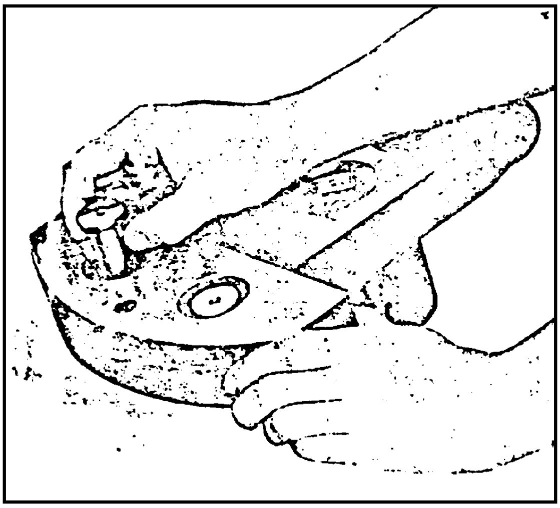


FIGURE 52—*Installing Dynamic Damper Counterweight Pin*

roller bearing is a tight fit on the shaft, it may be necessary to heat the inner race in engine oil at 180-200° F. (80-90° C.) before assembling it on the shaft. Coat the front main bearing lock nut threads with a mixture of engine oil and white lead. Assemble the lock nut in position and tighten with the tool provided for this purpose, taking every precaution to prevent marring the shaft. Align the cotterpin holes of the lock nut and crankshaft and install a new cotterpin from the outside.

To assemble the crankshaft rear section, slide the crank cheek extension through the slot in the dynamic counterweight, align the pin holes of the weight with those of the crank cheek extension, and insert the pins. (Refer to figure 52.) Attach the stop plate with two bolts, the bolt heads being placed against the stop. Secure the bolts with slotted nuts and cotter the nuts.

Coat the rear bearing journal bore plug with a mixture of white lead and engine oil and insert it in the journal bore. Tap the plug into position with a fiber drift. This plug is retained by the crankshaft gear.

This completes the assembly operation, as the two halves of the crankshaft are not to be assembled until the master rod is ready to be installed.

CRANKSHAFT GEAR

Insert the crankshaft gear hub in the gear and turn it so that the gear lugs are between the slots in the hub. Insert the pins in the end of each spring, and push the spring and pin assemblies into position. Place the retainer in position on the gear assembly, aligning the cutouts with the screw holes in the hub.

MASTER ROD, ARTICULATED RODS, AND KNUCKLE PINS

INSPECTION

It is unnecessary to check the alignment of a rod unless the engine from which it has been taken has been severely damaged or subjected to some misuse, such as starting with liquid in the cylinders. Any slight misalignment which might exist is automatically overcome by the installation and boring of new bushings. If the misalignment is excessive, it will be detected when the rod is placed in the boring fixture. A maximum of .015 in. (.381 mm.) misalignment is allowable. (Refer to figure 53.)

A satisfactory check to detect bending in a plane at right angles to the bushing bores is to place a straight edge of the shank of the rod. Allowance must be made for any slight irregularities as these surfaces are hand finished. If the straight edge is applied to opposite sides of the shank, it is easy to distinguish between a normal irregularity and a shank which is actually bent. A maximum of .015 in. (.381 mm.) twist is allowable. (Refer to figure 54.)

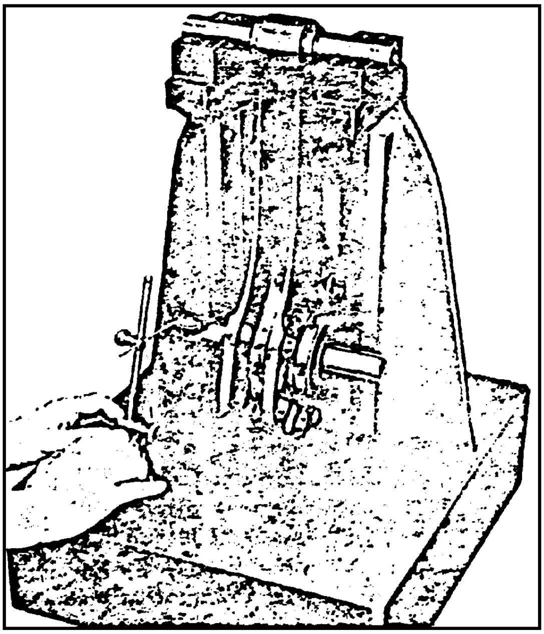


FIGURE 53—*Checking Master Rod Alignment*

the master rod and check the diameter against the size of the new bearing to be installed. See the Table of Limits for the correct shrinkage. The importance of this fit cannot be overemphasized. The most accurate results in checking the sizes of these two parts are obtained when the room temperature is between 60° and 70° F. (15° and 20° C.).

Heat the rod in an oil bath at a temperature of 450° F. (235° C.) for at least one hour. The oil used in the bath must have a flash point considerably above this temperature. Remove the rod from the bath and insert the new bearing, using the fixture and arbor press plug designed for this purpose. When this operation is performed, particular attention should be paid to the alignment of the oil holes in the bearing with those in the master rod. Allow the rod to cool in air.

Drill the locking pin hole in the bearing shell and ream out the counterbore in the rod. Place the rod on a suitable mandrel and tap the locking pin in place. Peen over the metal to secure the pin.

Preparatory to boring the bearing, assemble the knuckle pins in the rods, except where fixture locating bars are used, to counteract any distorting effect of the bearing hole that the pressure exerted by the knuckle pins might cause. Seal the oil holes with beeswax to prevent any metal entering the oil passages. Place the rod in the holding fixture and bore the bearing the correct fit on the crankpin, using the tools designed for this purpose. See the Table of Limits. Remove the rod from the fixture and break all sharp edges. Clean the rod thoroughly. Withdraw the knuckle pins and remove the beeswax from the oil holes. Clean the knuckle pins.

In the event the bearing has been turning in the rod, thereby enlarging the inside diameter of the rod, it will be impossible to obtain the proper fit by using a standard size bearing. To obviate the necessity of discarding the master rods which have become worn in this manner, a master rod bearing which is oversize on the outside diameter has been made available. Inasmuch as the rod must be reground to permit the installation of the oversize bearing, it will be necessary to send the rod to the factory for bearing replacement.

REPLACING KNUCKLE AND PISTON PIN BUSHINGS

To remove the knuckle pin bushing, insert the small end of a plug, or arbor, into the knuckle pin bushing. Place the base on an arbor press table and insert the collar in the base. Support the rod over the collar. Press out the old bushing. Remove the plug and the rod. Clean the rod bore and remove all burrs.

To install the new knuckle pin bushing, place the bushing on the small end of the plug, and screw the cap on the plug. Place the knuckle pin end of the rod over the collar and insert the large end of the plug through the bore so that it extends into the collar. Locate the split in the bushing so that it is 45° from the tip of the rod as measured from the center line of the rod and away from the side bearing the rod number. Using an arbor press, press down on the cap on top of the plug until the press-in plug bottoms against the collar. Remove the plug and collar.

After a new knuckle pin bushing has been installed, it should be broached to provide a satisfactory surface contact between the bushing and the bushing bore in the rod. This is accomplished by pressing a proper size burnishing broach through the bushing by means of an arbor or hydraulic press using from 300 to 400 lb. per sq. in. (21-28 kg. sq. cm.) pressure. Thus the bushing is expanded and the possibility of its turning in the rod is eliminated. Next the bushing is spot-faced so that the ends of the bushing will extend between .060 to .090 inch (1.524 to 2.286 mm.) beyond the end of the rod bore.

Burring or cutting a radius removes the sharp edge on the outside circumference of the end of the bushing. The bushing is next diamond bored for the correct size. Check the diameter of the knuckle pin at the knuckle pin bushing location. Refer to Table of Limits for special clearance. The burring procedure is repeated to effect a smooth edge on the inside circumference of the end of the knuckle pin bushing.

The replacement of piston pin bushings is accomplished in the manner just described. To protect the protruding ends of the piston pin bushings counterbore the ends of the bushings after boring, with a tool designed for this purpose. The master rod piston pin bushing, however, is spun-in instead of spot-faced.

KNUCKLE PINS

Remove any scratches or scores from the knuckle pins by stoning and polish them with crocus cloth. Clean out the oil passages.

ASSEMBLY

Place the front section of the crankshaft in a holding fixture and again check the crankpin for nicks or burrs. Replace the master rod bearing

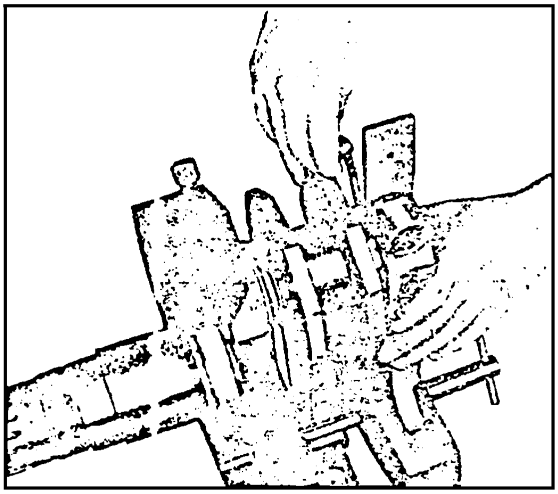


FIGURE 55—*Checking Master Rod End Clearance*

spacer by heating it in oil to approximately 300° F. (150° C.) and slipping it in place on the crankpin making sure the chamfered side is against the crankpin fillet. Coat the crankpin with engine oil. Install the master rod on the crankpin with the knuckle pin locking screw holes towards the front. Insert a wedge in the slot of the crankshaft rear section and slide this section on the crankpin until the master rod bearing has its proper end clearance. (Refer to figure 55.) Remove the wedge and line up the two halves of the crankshaft by inserting the crankshaft aligning bar through the holes in the counterweights. Coat the threads of the crankshaft rear section cap screw with a mixture of white lead and lubricating oil and install the cap screw and the cap screw washer, which is placed with the chamfered side against the head of the cap screw. Remove the aligning bar and run the cap screw in. Before tightening, however, check the length of the cap screw by placing a 5/8 inch (15.875 mm.) diameter steel ball in the chamber at either end and measuring over these balls with a micrometer. Then tighten the cap screw, using the wrench provided for this purpose and a pipe extension, until the length of the screw has been increased by the specified amount of stretch. Refer to the Table of Limits. The stretch is determined by the difference in the length of the cap screw before and after tightening. The alignment of the two crankshaft sections should be checked with the aligning bar at various intervals during the process of tightening the cap screw and upon completion of the tightening. Do not leave the bar through both counterweights while the cap screw is being tightened since any movement of the rear section will cause the bar to bend. If the two sections are in line, secure the cap screw with a cotterpin. Insert the cotterpin from the inside.

In the event that the original cotterpin holes are not in line, it will be necessary to drill a new hole in the cap screw. The new hole must be removed from all other adjacent holes by at least 1/4 inch (6.35 mm.) the distance being measured between the edges of the holes along the root of the threads. If the amount of stretch specified by the Table of Limits makes this impossible, it is permissible to reduce the thickness of the cap screw washer as much as .010 inch (.254 mm.) by grinding from one side or both sides of the washer. Care must be taken in grinding as it is essential that all points of the washer bear evenly on the cap screw head. After grinding break all sharp edges 1/64 inch (.40 mm.) and check for interference on the fillet under the cap screw head.

Remove the crankshaft and master rod assembly from the holding fixture and place the assembly on the adjustable rollers. Check the alignment of the crankshaft with a dial indicator as previously instructed in the paragraph on Crankshaft Alignment in this chapter.

This completes the crankshaft assembly as the articulated rods are not installed until the engine is ready for final assembly.

CRANKCASE DIFFUSER AND REAR SECTIONS

DISASSEMBLY

Place the diffuser and rear section assembly on a rear section assembly stand with the forward end facing down. Back off the starter shaft bolt nut. Remove the starter shaft and gear. Then turn the assembly over in the stand so that the diffuser section is on top.

Hold the gears of the accessory drive gear train stationary by inserting a small piece of fibre between the teeth and remove the cotterpins and nuts from the accessory drive gear shaft. (Refer to figure 56.) Lift off the accessory driven gears and remove the accessory driven gear keys.

Remove the cotterpins and nuts from the diffuser section to rear section studs. Separate the two crankcase sections with the three pullers designed for this purpose exercising care to screw down evenly on the pullers while the operation is being performed. (Refer to figure 57.)

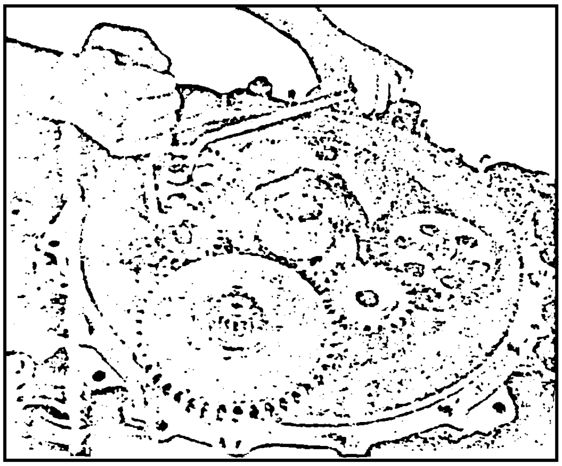


FIGURE 56—Removing Nut from Accessory Drive Shaft

REAR SECTION

Place the rear section on the bench with the forward end facing downward. Remove all locking devices, nuts, and flat washers from the accessory drive attaching studs. Withdraw the parts in the following order: The fuel pump adapter or the three-way accessory drive, the tachometer drive, the tachometer and fuel pump drive adapter, the oil pump, the generator drive idler gear shaft, the generator drive shaft, and the generator drive gear. (Refer to figure 58.)

Remove the accessory drive shafts and oil seals. (Refer to figure 59.)

Drive out the starter shaft oil seal retainer and oil seal from the rear of the crankcase rear section with a fibre drift.

Do not remove the fish plate spacer at the

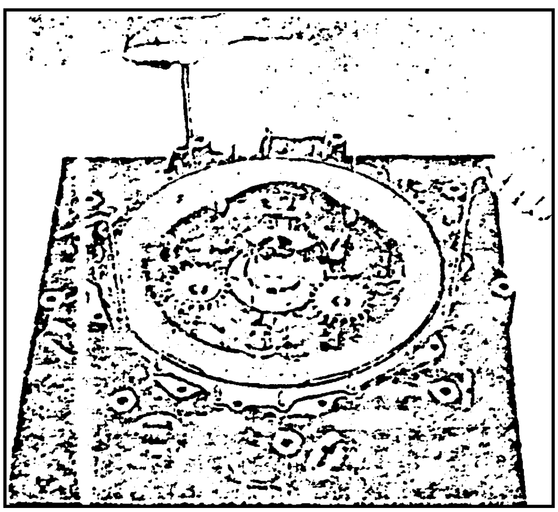


FIGURE 57—Removing Diffuser Section from Rear Section

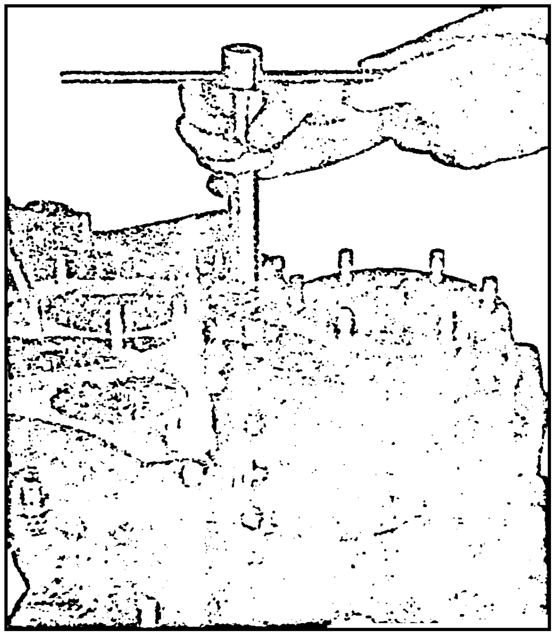


FIGURE 58—Removing Generator Idler Gear Shaft

starter shaft hole unless it is cracked or appears to be otherwise damaged.

Back out the intake pipe packing nuts and withdraw the packing.

DIFFUSER SECTION

Place the diffuser section on a rear section assembly stand with the impeller on the lower side. Remove the cotterpins, nuts, and flat washers from the impeller drive gear shaft support attaching studs. Remove the cotterpin and nut from the forward end of the impeller drive gear shaft. Lift off the support. Turn the impeller so that the flange on the rear end of the impeller drive gear shaft will clear the exit angles of the

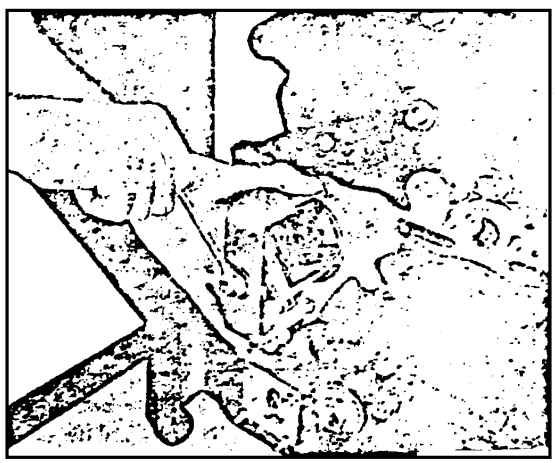


FIGURE 59—Removing Magneto Oil Seal

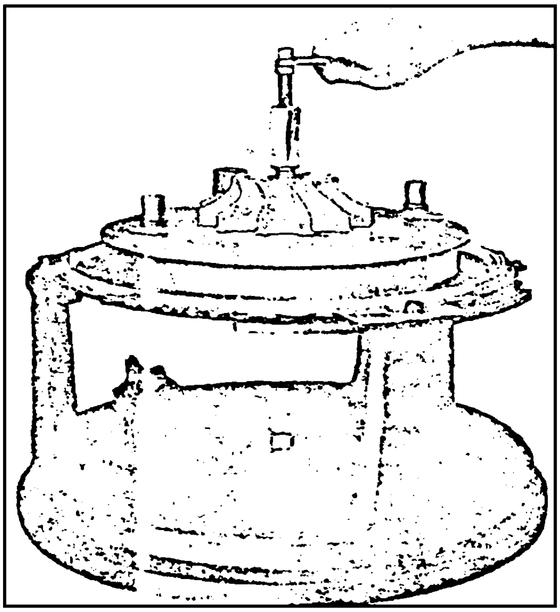


FIGURE 60—Removing Impeller Rear Nut

impeller and with a fibre drift tap the impeller drive gear shaft out toward the rear of the section. Withdraw the impeller drive gear assembly.

Remove the cotterpins, nuts, flat washers, and spacers from the idler accessory drive gear retainers. Lift out the gears and the "L" shaped washers.

Turn the diffuser section over so that the impeller is on the upper side of the section. Remove the impeller rear nut lock ring and lock. Holding the impeller shaft stationary with the impeller shaft gear locking tool unscrew the impeller rear nut. (Refer to figure 60.) Install the impeller puller and remove the impeller.

Remove the impeller front nut lock ring and lock. Hold the impeller shaft stationary with the impeller shaft locking tool and remove the front impeller nut.

Remove the screws holding the impeller shaft ball bearing cage to the rear wall of the diffuser section. The impeller shaft may be tapped to the rear with a fibre drift, carrying before it the rear bearing, the rear bearing cage, and oil seal rings.

Engines having a 9.17:1 or 10.15:1 impeller ratio incorporate an oil slinger on the shoulder of the impeller shaft between the rear ball bearing and the impeller shaft drive gear, with the thicker shoulder of the slinger adjacent to the gear. If the slinger is used, it will be necessary to remove this part at this time.

The front ball bearing may be removed by taking out the retaining nut lock ring, unscrewing the nut, and tapping the bearing out of its support. Note the shim between the bearing and the support. The support may be removed by removing the screws holding it to the front wall of the diffuser section. However, it is strongly recommended that this support be left in place as it provides an oil seal for the annulus holding pressure oil for the lubrication of the accessory shafts.

Do not remove the fish plate spacers at the accessory drive shaft bushings unless they are cracked or appear to be otherwise damaged. Slide the rubber oil seals off the accessory drive shaft bushings.

INSPECTION

REAR SECTION Examine the crankcase rear section for cracks, paying particular attention to the stud locations at the mounting flange and the accessory mounting pads, the engine mounting bosses, and the accessory drive mechanism internal supports.

Inspect the condition of the enamel. If it is chipped, the section should be re-enamelled.

Check the studs and dowels for tightness and the studs for condition of the threads.

Examine all finished surfaces for nicks, burrs, and roughness and inspect the oil passages for clearness. Check all oil seal plugs for tightness in the section.

Check the engine mounting bosses for wear and the tangential intake leads for condition of the threads.

Inspect the starter and accessory drive shaft bushings for scores and tightness in the section.

Examine the fish plate spacer for nicks and burrs.

Examine the starter shaft oil seal retainer for nicks and burrs. Replace the Duprene oil seal.

Examine all covers for roughness of the finished surfaces, cracks, and condition of the enamel. Replace all gaskets.

Examine the oil check valve in the oil passage line at the oil pump pad. If the valve appears to be in good working condition, nothing should be done to it. If it is pulled out, remove and check the plug, spring, and ball.

DIFFUSER SECTION

Inspect the diffuser section for cracks.

Examine the clamping surfaces for nicks and burrs.

Examine the diffuser chamber surface for roughness.

Check the studs for tightness with a stud driver.

Examine the oil passages for clearness and check all oil plugs for tightness.

Check the two fish plate spacers for cracks, nicks, and burrs.

Replace all oil seals at assembly.

Inspect the bushings for scores and tightness in the section.

BUSHINGS

See that the three fish plate spacers are in position and assemble the crankcase diffuser and rear sections. To perform this operation, place the diffuser section in position over the studs at the parting flange of the rear section and tap the two sections together with a fiber drift, exercising care to see that the diffuser section is tapped down evenly. Assemble the three flat washers and nuts on the rear section to diffuser section studs and tighten the nuts.

Assemble the "L" shaped washers, the idler accessory drive gears, spacers, flat washers, and nuts in their respective places on the diffuser section. Tighten the nuts and check the end clearance of the gears.

Assemble the starter drive gear and starter shaft in place in the bushing in crankcase sections and check the side clearance. Screw on the starter shaft nut and tighten enough to hold these two parts firmly together. Check the end clearance of the starter shaft assembly.

Insert the accessory drive shafts in position in their bushings and check the side clearances. Assemble the accessory driven gears and nuts on the forward end of the shafts. Tighten the nuts and check the end clearance of the shafts.

Check the backlash of all gears on the front side of the diffuser section. Turn the crankcase assembly over and check the backlash between the two beveled gears on the accessory drive shafts with the various accessory drives. Refer to the Table of Limits.

Disassemble the gear assemblies and the two crankcase sections.

IDLER ACCESSORY DRIVE GEAR

Examine the spacers and the "L" shaped washers for cracks, burrs, and evidence of wear.

Check the idler accessory drive gears for worn or scored teeth, cracks, galling, and for the proper fit of the gears in their bushings. See also the paragraph under the heading of Bushings.

IMPELLER AND IMPELLER SHAFT

Due to the high speeds at which the impeller operates, it must be in perfect condition. Examine it carefully for cracks, nicks, and for tightness of the splines. Check the splines for cracks, nicks, and fit on the impeller shaft. A cracked impeller must be replaced.

Examine the impeller shaft carefully for cracks. Inspect the teeth for scores and wear. Check the condition of the threads. Examine the ball bearing locations for galling of the shaft.

The impeller shaft ball bearings should be replaced at overhaul. Check the fit of the new bearings on the impeller shaft and in the bearing support and cage.

Examine the impeller ball bearing support and cage for cracks and nicks. Check the bore in the cage for galling and wear caused by the oil seal rings. Check the bore in the support and cage for galling caused by the impeller shaft ball bearings.

Examine the ring guides and spacer of the impeller oil seal for nicks, burrs, cracks, and wear. Replace the oil seal rings and check the new rings for gap and side clearance. Refer to the Table of Limits.

Check the impeller nuts and the front bearing retainer nut for condition of the threads. Replace the impeller nut locks and lock rings at assembly.

Examine the shim. If the shim is not bent or otherwise damaged, it should be fit for further use. Check the solid steel shim for cracks, wear, and uniform thickness.

REPAIR

REAR SECTION

Make whatever stud replacements are necessary.

Remove nicks, burrs, and roughness from the finished surfaces with a fine stone and polish with crocus cloth.

If the oil check valve has been disassembled, remove nicks and burrs from the body, and inspect the condition of the spring and the ball, and replace if required. Reassemble and press into the rear section at the oil pump pad.

Smooth the accessory drive and starter shaft bushings with crocus cloth.

If the starter shaft bushing is worn or loose in the section, bore out the bushing until the remaining shell is approximately .015 inch (.38 mm.) thick and pry out the remaining shell. Clean the hole. Check the size of the new bushing for proper fit in the crankcase and press it in place, bottoming the flange against the boss. Drill a new locking pin hole in the crankcase section, piloting the drill through the hole in the bushing, and install the locking pin.

If an accessory drive shaft bushing is worn or loose, tap the bushing out and clean the hole. It is not necessary to remove the pin. Check the size of the new bushing for proper fit in the crankcase and insert it in place. Align the slot in the flange of the bushing with the pin in the boss and press in the bushing, bottoming the flange against the boss.

Assemble the rear and diffuser sections together and line ream a new bushing with the tools provided for this purpose. Check the fit of the new bushing on its receptive shaft and check the end clearance. Check the backlash of the beveled gear on the accessory drive shaft and spot-face the rear face of the bushing if necessary. Disassemble the rear and diffuser sections, break all sharp edges, and clean all parts thoroughly.

DIFFUSER SECTION

Remove any nicks or burrs from the finished surfaces with a fine stone and polish with crocus cloth.

Replace any loose dowels or studs or studs with damaged threads. Lubricate the studs with engine oil and white lead before driving.

If the bushings are scored, smooth them with crocus cloth or replace them.

In the event that it is necessary to replace an idler accessory drive gear bushing, unscrew the gear retainer with the wrench designed for this purpose. Bore out the bushing until the remaining shell is approximately .015 inch (.38 mm.) thick, and break out the shell exercising care to prevent damaging the idler accessory drive gear retainer threads. Clean the hole and check the inside diameter of the hole against the outside diameter of the new bushing. Refer to the Table of Limits. Align the oil holes in the bushing with those in the diffuser section and press the bushing into position. Ream the bushing, using the tools designed for this purpose and exercising care to prevent striking the bottom of the hole. Refer to the Table of Limits. Break all sharp edges. Apply gasket compound to the heads of the gear retainers and replace the retainers.

If an accessory drive or starter shaft bushing is loose or worn, bore out the bushing until the remaining shell is approximately .015 inch (.38 mm.) thick and pry out the remaining shell. Tap out the locking pin and clean the bore in the crankcase. Check the size of the new bushing for proper fit in the crankcase and press it into place, bottoming the flange against the boss. Drill a locking pin hole in the bushing, piloting the drill through the pin hole in the crankcase. Install the locking pin.

Whenever the accessory drive shaft bushings in the diffuser section are replaced, the oil holes should be drilled completely through the bushings in line with the oil passages before the bushings are reamed. This should be done with a drill bushing tool which is screwed into the oil pressure passage plug hole. When this is accomplished, every precaution should be observed to insure the installation of a new lead plug and the screw before the engine is reassembled.

Spare diffuser sections are supplied with lead plugs and headless screws, which are used in the diffuser section oil passages at the accessory drive shaft locations. These parts are not installed before shipment, but are supplied in a bag included in the diffuser section shipping box, in order that the oil passages may be burred and cleaned out after the bushings have been reamed. Extreme care should be exercised here also to insure that these parts are installed following the reaming and cleaning operations required in the assembly of the diffuser section.

Install the diffuser chamber oil seals and spacers in place and assemble the rear and diffuser sections together. Line ream a new bushing. Assemble the respective shaft and gear assembly in the bushing. Check the fit of the shaft in the bushing and check the end clearance. Spot-face the bushing if necessary. Disassemble the rear and diffuser sections. Break all sharp edges and clean all parts thoroughly.

IMPELLER DRIVE GEAR ASSEMBLY

Remove slight burrs or scores from the gear teeth by stoning. Remove any slight nicks or burrs from steel surfaces with a fine stone and polish with crocus cloth. Smooth the hub bushing with crocus cloth or replace it.

If it is necessary to replace the bushing, drill out the bushing lock pin. Support the assembly on a suitable piece of tubing with the gear up and press the old bushing out with an arbor press.

Check the sizes of the gear bore and the outside diameter of the new bushing for the correct fit. Press the new bushing in place with an arbor press. Drill the locking pin hole in the bushing and install the pin. The face of the bushing must be ground parallel with the opposite face of the gear, and the bushing bore must be concentric with the pitch diameter of the gear.

IDLER ACCESSORY DRIVE GEARS

Remove any slight gear teeth or hub scores from the with a fine stone and polish with crocus cloth. Polish the spacer with crocus cloth and smooth the "L" shaped washers with a fine stone and polish with crocus cloth.

IMPELLER AND IMPELLER SHAFT

Remove any slight nicks from the impeller with a fine stone; but should there be any cracks or bent blades, replace the impeller. When stoning nicks from the blades, extreme care must be exercised not to remove too much metal as the impeller might be thrown out of balance, and due to the high speeds at which the impeller rotates, it is of the utmost importance that it is perfectly balanced. Clean the splines. If the splines are loose in the impeller, it is necessary to return this part to the factory for repair.

Remove slight scores or burrs from the impeller shaft journals, splines, or gear teeth with a fine stone and polish with crocus cloth. Clean the threads.

Remove slight nicks or burrs from the impeller ball bearing cage and support with a fine stone and polish with crocus cloth, paying particular attention to the bore in the cage on which the oil seal rings bear.

Smooth the spacer and the ring guides of the impeller oil seal with a fine stone and polish them with crocus cloth. Replace a cracked spacer or ring guide or a ring guide that does not provide sufficient clearance for the oil seal rings.

ASSEMBLY

DIFFUSER SECTION

If it was necessary to remove the fish plate spacers, assemble the oil seal retainers on the accessory drive bushing extensions with the flanged end up. Slide on new rubber oil seals. Place the two fish plate spacers in position, insert the screws, tighten, and stake in the metal to secure the screws.

Assemble the rear impeller shaft ball bearing on the impeller shaft marked "gear side" against the wear. If used, install the oil slinger before installing the rear ball bearing. Place a shim with a gasket on each side under the rear ball bearing cage and place the cage in position. Insert the screws, tighten, and secure with lock wire.

Place the shim in the recess in the front ball bearing support and tap the front ball bearing in place with the gear side against the impeller shaft gear. Assemble the front ball bearing retainer nut and impeller front nut and tighten both. Use the impeller shaft locking tool while tightening the impeller nut.

Install the impeller shaft oil seal rings, guides, and spacer over the impeller shaft within the bore of the rear ball bearing cage. Apply a mixture of white lead and engine oil to the impeller and impeller shaft spline and tap the impeller on the shaft. The impeller must be a tight fit on the shaft. Screw the impeller rear nut on the shaft and tighten, holding the shaft stationary with the impeller shaft locking tool. (Refer to figure 61.)

Check the clearance between the impeller and the diffuser section by inserting feelers of the

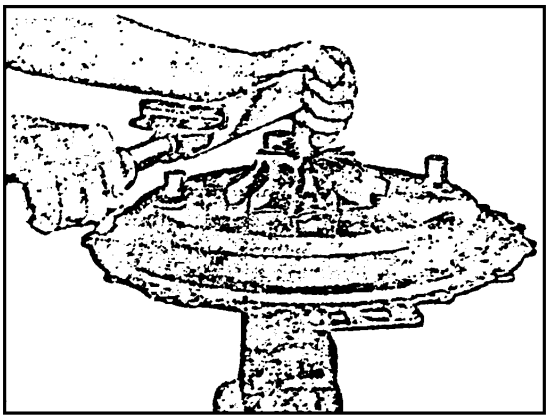


FIGURE 61—Tightening Impeller Rear Nut

same thickness directly opposite each other under both sides of the impeller. Refer to the Table of Limits. If the clearance is not within the specified limits, remove the rear impeller nut, the impeller, the front impeller nut, the front ball bearing retainer nut, and the rear ball bearing cage, and change the shim thickness the desired amount. If the clearance is in excess of the specified limit, install a new shim of increased thickness. The solid steel shims are supplied in ten different thicknesses, varying from .015 to .060 inch (.381 to 4.064 mm.). Only one shim is required per assembly.

Provided the clearance is correct, align the ball bearing retainer and the front and rear impeller nut locking slots. Lock the bearing retainer nut with the wire lock ring and the impeller nuts with the locks and lock rings.

Insert the impeller drive gear hub in the gear bushing from the anti-pinion gear end. Place the gear and hub assembly in position, aligning the key slot in the drive gear hub with the key slot in the diffuser section. Tap the key in the slot in the impeller drive gear shaft and apply a light coating of gasket compound to the flange of the shaft head. Insert the shaft in position from the near side of the diffuser section. Place the shaft support in position and screw on the shaft nut. Assemble the four flat washers and nuts on the drive gear shaft support attaching studs, and secure the nuts with cotterpins. Tighten the drive gear shaft nut and lock it with a cotterpin.

Insert the following parts into position in the order named:

The "L" shaped idler accessory drive gear washers with the flat sides against the diffuser section, the idler accessory drive gears and the bronze spacers with the flanges toward the rear. Assemble the two flat washers and nuts. Tighten the nuts and secure them with cotterpins.

REAR SECTION Install a new Duprene oil seal in the starter shaft bushing. Tap the oil seal retainer with oil seal in position from the front side of the rear section.

Insert the rubber intake pipe packing rings in the intake leads, and screw in the packing nuts, but do not tighten them.

DIFFUSER AND REAR SECTIONS Apply a light coating of gasket compound to the parting flanges of the diffuser section and place this section over the studs provided at the rear section parting flange and tap the diffuser section down into position. Assemble the flat washers and nuts on the rear section to diffuser section studs. Tighten the nuts and secure them with a cotterpin. Check the clearance between the rear face of the impeller and the wall of the diffuser chamber by inserting the special feeler gage through the intake openings.

Insert the diffuser section oil seal in position at the flange.

ACCESSORY GEAR TRAIN, ACCESSORY DRIVES, AND OIL PUMP

DISASSEMBLY

ACCESSORY GEAR TRAIN Compress the starter shaft bolt spring by applying pressure on the pin retainer and push out the pin. Remove the pin retainer, spring, spacer, and bolt. from the hub of the starter shaft gear. Press the starter shaft bolt from the cam pinion with an arbor press, using a suitable piece of tubing to support the pinion.

Remove the cotterpins from the rear end of the accessory drive shafts, back out the magneto coupling screws, and remove the couplings from the shafts.

Remove the cotterpin, nut, and washer from the end of the tachometer and fuel pump drive shaft and separate the gear and shaft from the adapter.

ACCESSORY DRIVES Remove the ring from the rear end of the fuel pump drive gear hub and separate the gear from the adapter.

Remove the cotterpin and nut from the end of the generator drive gear and separate the gear from the support.

Back the two tachometer drive shaft bushings out of the tachometer drive housing. Withdraw the tachometer drive shafts. Back out the tachometer housing cover attaching screws. Remove the cover, the tachometer drive shaft, and the two ball bearings.

If the engine incorporates the three-way accessory drive, lift the vacuum pump drive shaft gear from the fuel pump and vacuum pump drive housing. Remove the palnuts, nuts, and flat washers and covers from the fuel pump and vacuum pump drives. Withdraw the two adapters and drive shafts.

OIL PUMP Lift off the oil pump beveled gear. Remove the lock wire from the oil pump body screws, and back out the screws. Remove the pressure section of the oil pump body and disassemble the remaining parts. The scavenge pump drive gear is keyed on the oil pump drive shaft.

If the pump is provided with spare drive gears, remove the palnuts, nuts, and washers from the covers. Lift off the covers and remove the two beveled gears.

Remove the strainer.

INSPECTION

Examine all parts for cracks and check all gear teeth for scores and wear. Check the fit of the bearing journals in their respective bushings. Check all bushings for tightness and condition of the bearing surface.

Inspect all threads for evidence of pulling and crossing.

Check all splines for nicks, cracks, and fit.

Inspect all finished surfaces for roughness.

See that the oil passages are clear.

Check the condition of the serrated surfaces of the cam pinion and the starter drive gear. The cam drive gear and the starter gear must be kept together as an assembly. Each part is marked with the same serial number. Check the rivets in the starter drive gear for tightness. Check the starter dog for cracks; inspect the splines for pitting, chipping, burring, and wear; and inspect the jaws for burred and broken edges and for scoring and galling.

Check the fit of the cam pinion on the starter shaft bolt.

Check the plug in the forward end of the generator drive gear for tightness.

See that the plug in the fuel pump gear is tight.

Check the balls and races of the tachometer drive shaft ball bearings for cracks or a pitted or worn condition. Assemble the tachometer drive shafts, bushings, and gaskets in the tachometer drive housing and check the end clearance of the shafts. Disassemble the parts.

Check the clearance between the oil pump gears and body diameters. Check the end clearance of the scavenge gears.

Assemble the idler and drive shafts, the pressure and scavenge sections of the oil pump body, and the spacer together. Insert the oil pump body screws and tighten them. Check the end clearance of the gears in the pressure section of the pump with a dial indicator. Refer to the Table of Limits. Disassemble the pump.

Check the condition of the oil pump pressure relief valve seat and examine the ball for pitted or worn surfaces. If the ball is pitted or worn, it must be replaced. Examine the strainer for cleanliness and check the condition of the spring for cracks and for proper tension. Refer to the Table of Limits.

REPAIR

Remove scores from gear teeth with a fine stone and polish with crocus cloth. Remove scores or galling from bearing journals with a fine stone and polish with crocus cloth. Clean all threads. Clean all splines with a fine stone.

Smooth any slight irregularities found on the finished surfaces of the adapters and covers with crocus cloth. Replace a loose or damaged bushing.

The vacuum pump drive bushing in the oil pump, the bushing in the fuel pump adapter, the vacuum pump drive bushing, and the fuel pump drive bushing in the three-way accessory drive are Oilite bushings. If it is necessary to replace or rework an Oilite bushing, do not use a reamer or an abrasive. Use the special burnishing broaches provided for this purpose to obtain the proper size.

Soak the fuel pump drive gear in white gasoline long enough to saturate the felt wick contained in the hub of the gear. Insert a drill rod through the tang drive hole in the gear hub and squeeze the wick dry. Remove the rod and soak the gear for 5 hours in oil, W.A.C. Specification No. 5816, at 150 F. (65° C.).

Replace the leather washer of the accessory drive shaft oil seal and then soak the seals in Neatsfoot oil until the leather is saturated. After soaking the seals, it is necessary that they be compressed in order to install them in the crankcase. This can be done with an ordinary hose clamp of suitable size. Leave the seals in the clamp a sufficient length of time for the seal to take on a permanent set.

Do not use a stone on the clamping surfaces of the oil pump body sections. If it is necessary, lap the surfaces on a lapping plate.

If necessary, rework the oil pressure relief valve seat with the tools designed for this purpose.

ASSEMBLY

ACCESSORY GEAR TRAIN

Apply white lead to the head of the starter shaft bolt and insert the bolt through the cam pinion gear. Align the flats of the head with the slot in the gear. Support the gear on a suitable tube and press the bolt into position on an arbor press. Assemble the starter drive gear on the starter shaft bolt. Check the fit of the serrations. Place the spacer, spring, and pin retainer in position on the bolt. Compress the spring and insert the pin.

Lubricate the splined end of the accessory drive shafts with engine oil and assemble the magneto couplings and screws in position on the ends of the shafts. Tighten the screws and align the cotterpin holes. Install the cotterpins.

Insert the tachometer and fuel pump drive shaft in its adapter. Assemble the beveled gear and key at the lower end of the shaft. Install the flat washer and nut on the end of the shaft, tighten the nut, and secure it with a cotterpin.

ACCESSORY DRIVES

Assemble the fuel pump drive gear in the fuel pump adapter and install a new wire circlet in the groove on the rear end of the gear hub.

Assemble the generator drive gear in the support. Install the nut on the rear end of the gear hub, tighten the nut, and align the wire lock ring holes in the nut and gear hub. Install the lock ring. It is permissible to grind the forward face of the nut to align the lock holes in the nut with the hole in the gear hub.

See that the ball bearing, spacer, tachometer drive gear, nut, and cotterpin are properly installed on the driving end of the tachometer drive shaft. Assemble the drive shaft in the tachometer drive housing. Assemble the tachometer drive shafts, bushings, and gaskets in the tachometer drive housing. The shaft with the etched ellipse on the shoulder is the upper shaft. Tighten the bushings and make sure that the drive shafts have the proper end clearance. Pack the housing with vaseline and install the other drive shaft ball bearing. Place the housing cover and gasket in position. Insert the cover attaching screws, tighten the screws, and secure with lock wire.

If the engine incorporates the three-way accessory drive, assemble the parts in position in the following order: the vacuum pump drive shaft gear; the vacuum pump drive shaft, with collar in position against the flange; the vacuum pump drive shaft adapter with gasket; the fuel pump drive and adapter assembly with gasket; the governor drive and adapter with gasket; and the adapter covers with gaskets, flat washers, and nuts. Tighten the nuts and secure with palnuts.

OIL PUMP

Insert the drive and driven shafts in position in the pressure section of the oil pump body. Apply a thin coating of shellac or gasket compound to the clamping surfaces of the spacer and assemble the spacer in position on the pressure section of the body. Assemble the scavenge gears on the shafts, exercising care to see that the scavenge drive gear is properly keyed to the oil pump drive shaft. Place the spare drive beveled gears in position in the scavenge section of the pump body and assemble the scavenge and pressure section and the pressure section of the pump together. Insert the oil pump body screws. Tighten and secure with lock wire. Place the covers and gaskets in position on the scavenge section and secure them with washers, nuts, and palnuts.

Insert the finger strainer and spring in posi-

FIGURE 62—*Installing Generator Drive Idler Gear Assembly*

tion. Install a gasket on the strainer cover and screw the cover into the pump body.

Install the oil pressure relief valve body in the oil pump. Insert the ball and spring in position and screw in the adjusting screw. Assemble the lock nut and cap. The valve should be adjusted for the correct pressure when the engine is tested. Place the oil pump beveled gear in position.

GENERAL Coat the accessory drive shafts and gears with engine oil and insert the shafts in position. Assemble the accessory drive gears on the front ends of the shafts, exercising care to see that the gears are properly keyed. Install the nuts and secure them with cotterpins.

Lubricate the starter drive gear and starter shaft with engine oil and place these parts in position. Assemble the nut on the end of the starter shaft bolt but do not tighten it.

The various accessory drives and the oil pump are installed in the following order: the tachometer and fuel pump drive shaft assembly; the tachometer drive assembly; the fuel pump drive assembly; the generator drive gear and shaft; the generator drive idler gear assembly; and the oil pump. (Refer to figure 62.) Use the proper gaskets when installing these parts. Care should be exercised to see that the gears mesh correctly and that the parts have the proper fit. Cotter or lockwire all nuts.

Place the accessory drive shaft oil seals in position.

IGNITION WIRE MANIFOLD AND RADIO SHIELDING

DISASSEMBLY

At the time of each engine overhaul, the ignition wire assembly or the radio shielding assembly should be disassembled and the ignition cable discarded.

Disassembly of a standard ignition wire manifold calls merely for removal of the ignition wire.

If the assembly is of the radio shielded type, the manifold ring, magneto and spark plug conduits, and the magneto covers should be separated from each other by unscrewing the knurled nuts. The disassembly can best be accomplished by first removing the distributor blocks and the terminal assemblies, from the spark plug conduits, then the conduits from the manifold ring. The wires can then be pulled from the manifold. The conical rubber gaskets found on the wires should be discarded.

Prior to inspection wash all the parts of the assembly thoroughly.

INSPECTION

Examine the manifold ring for cracks particularly at the outlets and at the bracket locations. Note if the ring is dented and inspect the threads on each outlet.

Examine the brackets carefully for cracks.

Inspect carefully the large flexible conduits between the manifold ring and the magnetos for evidence of abrasion or broken braid. Any injured parts will require replacement.

Check all the clips used to secure the conduits to the engine to ascertain whether or not they are fit for further use.

The terminals should be inspected for cracks, and the condition of the springs should be noted.

REPAIR

Hammer out all dents from the manifold ring. Cracks should be repaired by silver soldering or brazing. Clean any burred threads on the outlets.

Flexible conduits which are damaged should be replaced. Likewise replace any clips, terminals, or springs that are injured.

ASSEMBLY

A copper ferrule is wedged over the end of the ignition cable which is inserted in the magneto block. The cable strands are folded back under the ferrule to insure good contact and each ferrule is stamped with its distributor block number.

Rewire the manifold ring, installing the wires in the proper numerical order. (Refer to figure 63.)

Extreme care must be taken to avoid abrasion or other damage to ignition cables while wiring the manifold ring. A weak spot in the lacquer protective coating allows the rubber to be attacked resulting in ultimate failure.

Install the flexible conduits over each spark

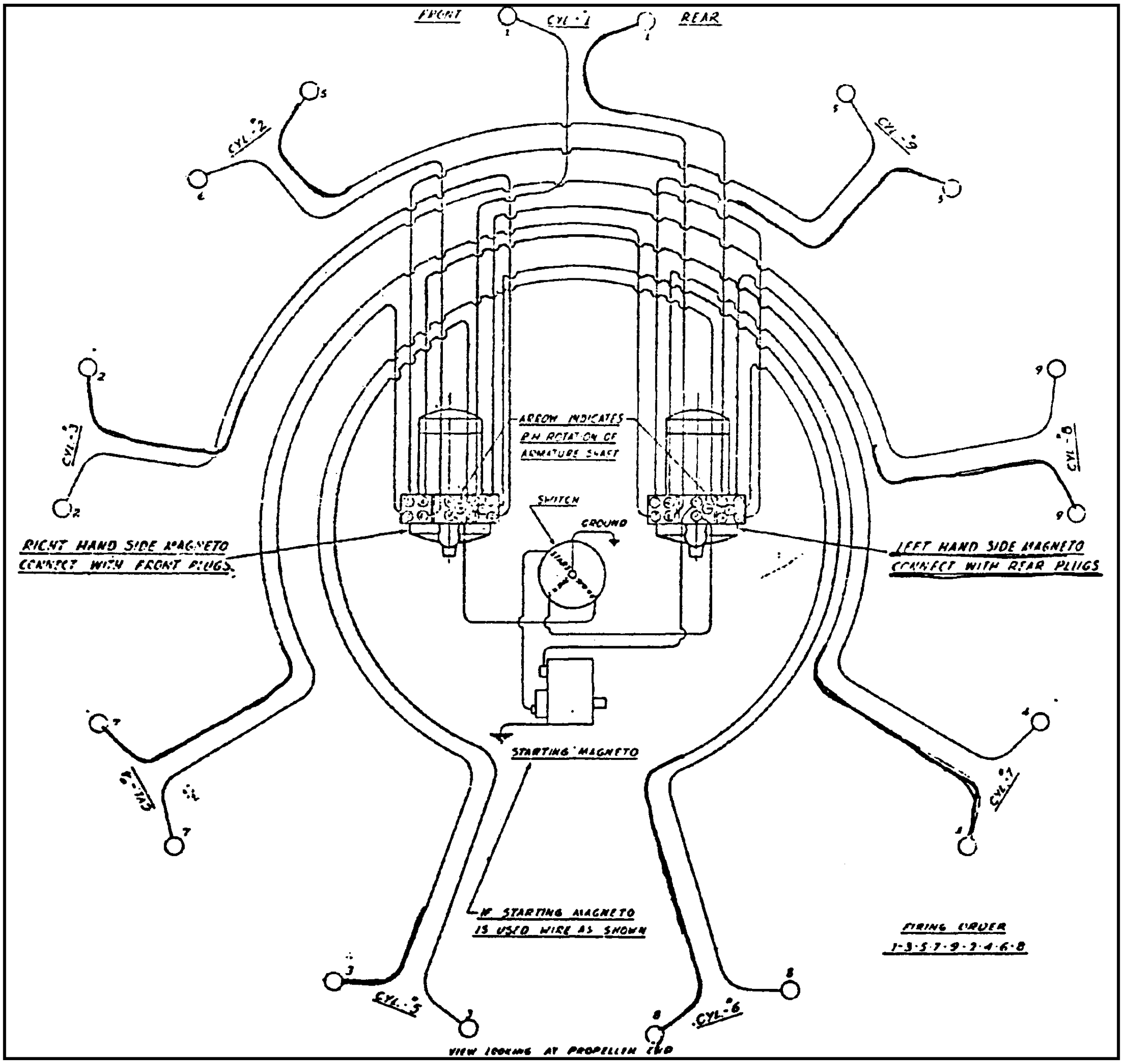


FIGURE 63—Ignition Wiring Diagram

plug cable and attach the terminals and springs. New conical rubber gaskets should be installed on the cables at the terminal connection. Should the extending ends of the cables appear to be unnecessarily long, feed them back into the manifold ring as much as possible so that the extra length will be available for future repairs.

Attach the magneto distributor blocks and test all ignition wires with a buzzer.

If it is necessary to replace one ignition wire, strip the insulation from the magneto end of the ignition cable to be replaced so that approximately one inch of the wire is bared. Bare the same length of wire at one end of the new cable to be installed. Be careful not to cut any wire strands when removing the insulation. Attach the new cable to the cable requiring replacement by tying a tight square knot in the two wires. Cover the knot with a smooth ball of solder of a diameter smaller than the outside of the cable. Observe these instructions in order to prevent damage to other cables when the new cable is pulled into the manifold assembly.

Draw the new cable into the manifold assembly by pulling on the spark plug end of the old cable. This may be more easily accomplished if two men work together, one pulling slowly on the old cable and the other feeding the new cable into the main conduit at the magneto end. Use as little force as possible in pulling the cable, since excessive tension greatly decreases the insulating properties of the rubber. Coat the new cable lightly with talc or powdered mica; no other anti-friction agent should be used for this purpose.

When the new cable has been drawn through the manifold assembly far enough to permit re-assembly of the wiring harness, cut the old cable from the new, and cut the new cable to the correct length. Re-install the shielded spark plug conduit, replacing the used rubber washer with a new washer. Re-install the spark plug terminal elbow and a new rubber washer. Attach a new spark plug terminal contact sleeve to the spark plug end of the new ignition wire.

SEALING COMPOUND It is recommended that a sealing compound (Scintilla Sealing Compound No. 47—W.A.C. 115973N1) be used to fill the air space around the cable in the spark plug elbows, spark plug terminal wells, and magneto terminal wells. The compound is a non-hardening, semi-solid compound and is tested to insure its consistency and insulating qualities.

The following instructions cover specific applications:

SPARK PLUG WELLS Hold the terminal securing nut back and apply a thin coat of the compound on the outside surface of the insulating sleeve. Also fill the contact spring secured to the insulating sleeve with the compound. Push the insulating sleeve into the spark plug well until the ridge at the end of the elbow rests in position on top of the spark plug barrel. Since the compound is an insulator, remove any excess which may be forced out at the top of the spark plug barrel with a clean lintless cloth.

Insure that the excess compound is wiped off clean to prevent its being forced into the threaded portions of the terminal nut and spark plug or past the shoulder on the elbow thus insuring that the required metallic bond is not broken. After the excess compound is wiped off, tighten the terminal nut.

SPARK PLUG ELBOWS Spark plug elbows may be filled by use of an alemite type pressure gun with a suitable adapter to fit the terminal nut.

Remove the spark plug terminal sleeve from the ignition cable. Insert the end of the ignition cable into the adapter of the pressure gun and screw the spark plug terminal nut down tight on the adapter. Inject the sealing compound into the spark plug elbow by means of the pressure gun.

NOTE: Care must be taken to prevent the compound from forcing the ignition cable back into the spark plug elbow. After filling the spark plug elbow, remove the pressure gun and wipe any excess compound from the ignition cable with a clean lintless cloth. Install the spark plug terminal sleeve in the usual manner.

MAGNETO BLOCK TERMINAL WELLS Apply a thin coating of compound on the outside surface of each ignition cable for a distance equivalent to the depths of the respective terminal wells in the distributor block. Push the ignition cables into the proper terminal well and secure with piercing screws in the usual manner. Remove any excess compound with a clean lintless cloth.

NOTE: Since the compound has an adhesive quality, care must be taken that the coated surfaces are kept clean of foreign particles and dirt before installing the terminals.

EXHAUST MANIFOLD AND COWL SUPPORT

Inspect the air heater ring for breaks and dents.

Inspect the exhaust pipes and flanges for cracks and nicks. Examine the condition of the finished surfaces.

Inspect the exhaust manifold for cracks.

Examine the cowl support for cracks, paying particular attention to the supporting plates and the stud supports. Check all nuts and rivets for tightness. Check the studs for tightness and for condition of the threads.

Replace the air heater pipe clamp if it is damaged.

Make whatever stud or rivet replacements are necessary. Cracked parts should either be replaced or welded.

ACCESSORIES

Information concerning the disassembly, inspection, repair, and assembly of the carburetor, magnetos, and spark plugs may be obtained from the Wright Aeronautical Corporation, Service Division or the respective manufacturers.

CHAPTER X

FINAL ASSEMBLY AND TEST

CRANKCASE MAIN SECTION AND CRANKSHAFT

Place the crankcase main section on a bench with the forward end up.

Lubricate the rear main bearing hub on the assembled crankshaft and the rear main bearing in the crankcase main section. Lower the crankshaft assembly into the crankcase, inclining the shaft at such an angle that the master rod can be thrust through No. 1 cylinder opening without the shaft striking the crankcase at any point. The counterweights are kept approximately 90° to the master rod during this operation. Straighten the crankshaft assembly and lower it into the rear main bearing.

ARTICULATED RODS

Clean the articulated rods and knuckle pins and lubricate the pins and their holes in the master rod before assembling the connecting rod group. The knuckle pins and master rod are so designed that the pins are a press fit in the flanges of the master rod.

The knuckle pins, articulated rods, lock plates, and master rod flange all bear numbers which must index in assembly. This is of the utmost importance since it insures the alignment of oil holes and the satisfactory fitting of the parts. The knuckle pin lock plates must be a tight fit between the pins.

Select two articulated rods which employ the same lock plate, hold them in place, and insert the two knuckle pins. Assemble the lock plate and the guides on the master rod, exercising care to see that the guides are bottomed in the lock plate screw holes. Align the slots of the pins with the with the ends of the lock plates. Place the ram in position on the knuckle pins and press the pins in with the inserting and removing tool. Remove the tool and lock plate guides and assemble the lock plate screws and screw locks in position. Tighten the screws and bend the edges of the screw locks over the hex flats of the lock plate screws. Install the remaining articulated rods.

If it is necessary to install a new lock plate, this part will have to be fitted as all new lock plates are made slightly oversize. The lock plate must be a tight fit between the knuckle pins.

FRONT MAIN BEARING SUPPORT

Place gasket compound on the parting flange of the intermediate section and slip the section into position over the front end of the crankshaft, being careful not to injure the surfaces and noting that the oil holes in the parting flange index with similar holes in the parting flange of the main section of the crankcase.

FRONT SECTION

See that the seven crankshaft adapter oil seal rings are properly installed on the adapter and lubricate the adapter and ring assembly thoroughly with engine oil. Insert the adapter with rings in the front section from the rear with the flanged end of the adapter toward the front. If the engine is not equipped with the hydro-controllable propeller operating mechanism, place the thrust bearing spacer on the crankshaft.

Apply a thin coating of gasket compound to the parting flanges of the front section and install the front section in position, exercising care to prevent damaging the shaft splines or threads. Assemble the washers and nuts on the main section to front section studs, except the studs which receive the cowl support. Tighten the nuts and secure them with lock wire.

If the engine is equipped with a propeller governor assembly, the following procedure is recommended to assemble the front section on the crankshaft. Two teeth, which are directly above the keyway on the crankshaft propeller governor gear, should be marked with red paint, or its equivalent, in such a manner that the marks can be seen through the breather plug hole when the oil seal and gear assembly are placed in the front section. The key is placed in the groove on the crankshaft. The nose section can then be worked onto the crankshaft taking care to see that the red marks on the crankshaft propeller governor gear line up with the key. The governor bevel gear drive shaft adapter can then be mounted on the governor pad.

Lubricate the threads in the thrust nut and on the shaft with a mixture of white lead and engine oil and install the thrust nut on the shaft, using the front cover crankshaft oil seal ring inserting clamp to prevent damaging the thrust nut oil seal rings.

CRANKSHAFT GEAR

Install the crankshaft gear on the rear end of the crankshaft with screws provided for this purpose. Secure the screws with lock wire.

CRANKCASE REAR SECTION

Fasten the crankcase rear and diffuser section securely through the mount holes to the assembly stand with six bolts with the forward side of the diffuser section facing up.

Apply a thin coating of gasket compound to the rear parting flange of the main section and assemble the main section to the combined diffuser and rear sections. Assemble the washers and nuts on all rear to main section studs with the exception of the studs which receive the ignition wire manifold clips. Tighten the nuts and secure them with lock wire.

RADIO SHIELDING

Install the ignition wire manifold radio shielding, placing the manifold clips over the front section to main section studs. Assemble the washers and nuts on these studs. Tighten the nuts and secure them with lock wire.

THRUST NUT

Insert fiber drift through the piston pin bushing of the master rod and tighten the thrust nut with the wrench designed for this purpose and a lead hammer. Refer to figure 64.) Care must be taken that the parts have been installed properly and that the thrust nut is bottoming correctly.

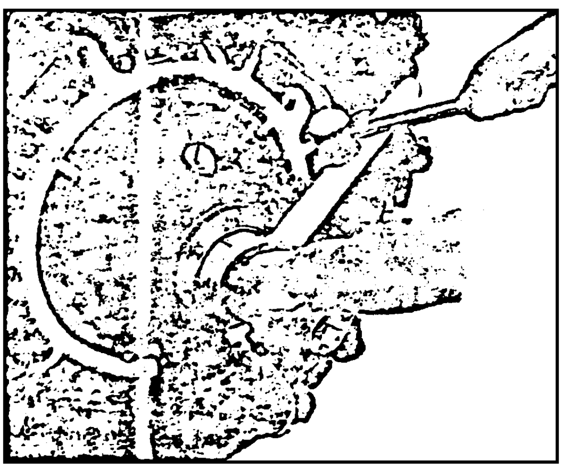


FIGURE 64—*Tightening Propeller Shaft Thrust Nut*

CYLINDERS

Starting with No. 1 cylinder, the master rod cylinder, assemble the piston and piston pin in place, lubricating the piston pin before its insertion. Make sure that the piston pin retainers are in place and that the side of the piston bearing the stamped number is towards the front of the engine. USE NEW PISTON PIN RETAINERS.

Apply a coating of lubricating oil to the pistons and rings. Avoid excessive use of the oil as drainage into the combustion chamber may cause fouling of the spark plugs. Coat the cylinder bore with oil, place the rubber oil seal ring over the barrel and down against the cylinder mounting flange, and place the piston at approximately top center. Using a clamp to compress the piston rings, slip the cylinder over the piston and hold-down studs. (Refer to figure 65.) Install the ignition wire clip in place and assemble the hold-down stud nuts on the studs. Tighten the hold-down nuts and screw on the palnuts.

As soon as No. 1 cylinder is installed, proceed with the installation of the remaining pistons and cylinders.

INTAKE PIPES, AIR DEFLECTORS, AND HYDRO OIL LINE

Slip the intake pipes into the packing nuts and assemble the air deflectors on the cylinders. Secure the baffles and the intake pipe flanges. Do not neglect to insert the gaskets under the intake pipe flanges. Tighten the intake pipe packing nuts with the wrench provided for this purpose, exercising care to prevent injury to the pipes while performing this operation; it is possible to swedge the pipes by excessive tightening of the packing nuts. Install the hydro oil line if one is used.

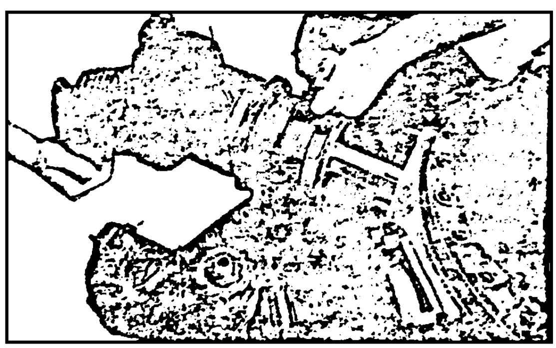


FIGURE 65—*Installing Cylinder*

VALVE OPERATING MECHANISM

Install the push rod housing hose connections and clamps at each end of the push rod housings. Only one clamp is used at the rocker box end. This end of the housing may be identified by its smaller diameter while at the crankcase end there is beading directly on the end of the housing. Be sure the tappet springs and sockets are in place. Install the housings on the engine and slide the hose connections into position at each end. The housing should be held against the connection at the rocker box end while the clamps are being tightened.

Insert the push rods and assemble the rocker arms and rocker hub bolts in the rocker boxes. Insert the bolts from the cylinder side of the boxes. Assemble the washers and hub bolt nuts. Tighten the nuts. If these nuts are not tightened securely, the inner races of the bearings will turn, resulting in wear of the rocker boxes. If tightening the nut causes the bearing to bind, it is an indication that the bearing is defective or not clean.

VALVE TIMING

Slip the timing disc over the front end of the crankshaft and attach the pointer. Insert the top dead center indicator in No. 1 cylinder front spark plug hole and check the accuracy of the pointer setting. To do this, turn the crankshaft in the normal direction of rotation until the pointer on the top dead center indicator registers zero. Note the reading on the timing disc pointer. Continue to turn the crankshaft in the same direction until the pointer on the top dead center indicator has gone past and returned to the zero mark. Again note the reading on the timing disc. Turn the crankshaft backward about one-quarter of a revolution; then turn it forward until the timing disc pointer indicates a point on the timing disc exactly midway between the two readings previously obtained.

Adjust the pointer to indicate exactly zero degrees on the timing disc. Screw in No. 9 cylinder intake valve clearance adjusting screw until the thread is flush with the rocker arm.

Rotate the crankshaft in the direction of rotation until No. 9 cylinder intake valve begins to open. Tap the push rod end of the rocker arm of No. 1 cylinder with a piece of fibre or a mallet. Set the clearance of both valves of No. 1 cylinder at .070 inch (1.778 mm.).

Clasp the rocker roller of No. 1 intake valve with fingers and turn the crankshaft in the normal direction of rotation. As soon as the rocker roller binds, loosen the lock nut on the rear end of the starter shaft bolt. Insert a screw driver in the slot provided on the end of this bolt and push the bolt forward to disengage the timing serrations on the front end of the bolt. (Refer to figure 66.)

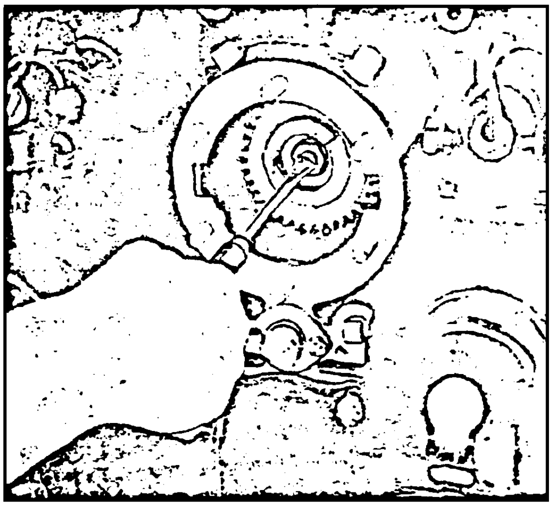


FIGURE 66—Disengaging Timing Serrations

Turn the crankshaft until the timing disc registers 10° before top center.

Permit the starter shaft bolt to slip back into position, re-engaging the timing serrations. Tighten the nut on the rear end of the bolt. Back it off one-half turn and attempt to rotate the bolt to make sure that the serrations are in mesh. Tighten the nut and secure it with a cotter-pin, exercising care to prevent dropping the pin in the rear section. Rotate the crankshaft again in the direction of normal rotation and note the point at which the cam opens No. 1 intake valve and the point at which No. 1 exhaust valve closes. Allowable variations are: intake valve opens 8° to 12° before top center; exhaust valve closes 28° to 32° after top center.

VALVE CLEARANCE

As soon as the engine is timed correctly, turn the crankshaft until the valves of No. 1 cylinder indicate that the piston of No. 1 cylinder is at top center at the beginning of the suction stroke. At this point both valves will be open. Turn the crankshaft through one complete revolution, insert a .010 inch (.254 mm.) clearance shim under the rocker arm roller and tighten the valve clearance adjusting screw until the shim is a snug fit between the roller and the valve stem. (Refer to figure 67.)

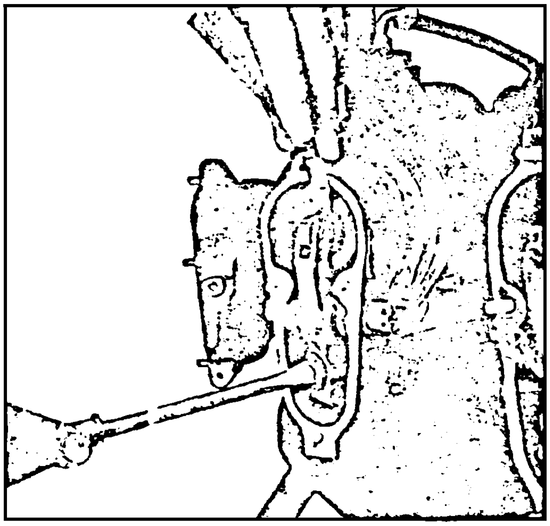


FIGURE 67—*Adjusting Valve Clearance Adjusting Screw*

Having adjusted the clearance of both valves of No. 1 cylinder to .010 inch (.254 mm.) proceed to adjust the clearance of the remaining valves, taking the cylinders in order of their firing and repeating the operations explained for No. 1 cylinder.

As a means of insuring that the valve clearance adjusting screws will not work loose in operation, it is recommended that their tightness be tested each time they are readjusted. This check should be made after the clamp screws have been tightened. Use a screw driver on each adjusting screw to make certain that they will not move. Replace any that move with parts selected to give the proper fit. The desired fit is one which will require moderate exertion on a screw driver to move the adjusting screw before the clamp screw is tightened. Take care to insure that the holes in the adjusting screw do not line up with the split in the rocker arm.

At the time the clamp screws are tightened, make certain that the lock washers which are used under them are not cracked or broken.

Install gaskets and rocker box covers on all cylinders except No. 1.

MAGNETOS, ADJUSTMENT OF PIVOTLESS TYPE BREAKERS

Magnetos equipped with the pivotless type breaker must not under any conditions be altered to obtain the .012 inch (.304 mm.) gap which is required with the lever type breaker. Any such change is almost certain to throw the magneto badly out of time with resultant danger of loss of power and fire hazard in starting.

Before installing the magneto, check the adjustment of the breaker contacts as directed in the following paragraphs:

Before a breaker is adjusted in service, it should be wiped out with a clean cloth moistened in gasoline. When doing this, do not permit gasoline to come in contact with the cam follower or the follower felt. Gasoline on these would remove the glaze from the follower and thin the oil in the felt. To check the contact breaker adjustment, turn the magneto drive shaft until the timing mark provided on the distributor cylinder lines up with the corresponding mark on the magneto front end plate. The distributor rotor is now in position to distribute a spark to the distributor block electrode of cylinder No. 1.

Place a straight edge, preferably a steel scale, against the face of the step cut in the cam. Turn the magneto drive shaft slightly until this straight edge coincides with the lines cut in the rim of the breaker housing. In this position the breaker contacts should be just opening.

Pivotless breakers must be adjusted so that the contacts open at the proper position of the cam; they are not adjusted for any fixed clearance between the contacts as is the case with lever type contact breakers.

If inspection shows that the position of opening of the contacts requires adjustment, loosen the two screws which fasten the breaker support to the breaker housing. Hold the cam in position to open the contacts as indicated by the straight edge and adjust by means of the eccentric in the breaker housing until the contacts are just opening. Secure them in this relation by tightening the screws.

The position of opening can be most conveniently checked by placing a piece of thin cellophane tissue of the thickness used for cigar or cigarette wrappings between the contacts and pulling against it lightly. When the tissue slips, the contacts are opening. Be sure, however, no trace of such material is allowed to remain between the contacts. The position of opening can also be checked with a lamp and battery, in which case a piece of thin insulating material must be placed between the primary contact brush of the coil and the back of the breaker housing to prevent battery current from flowing through the coil.

When checking the adjustment of magneto pivotless type breakers with cellophane, if the

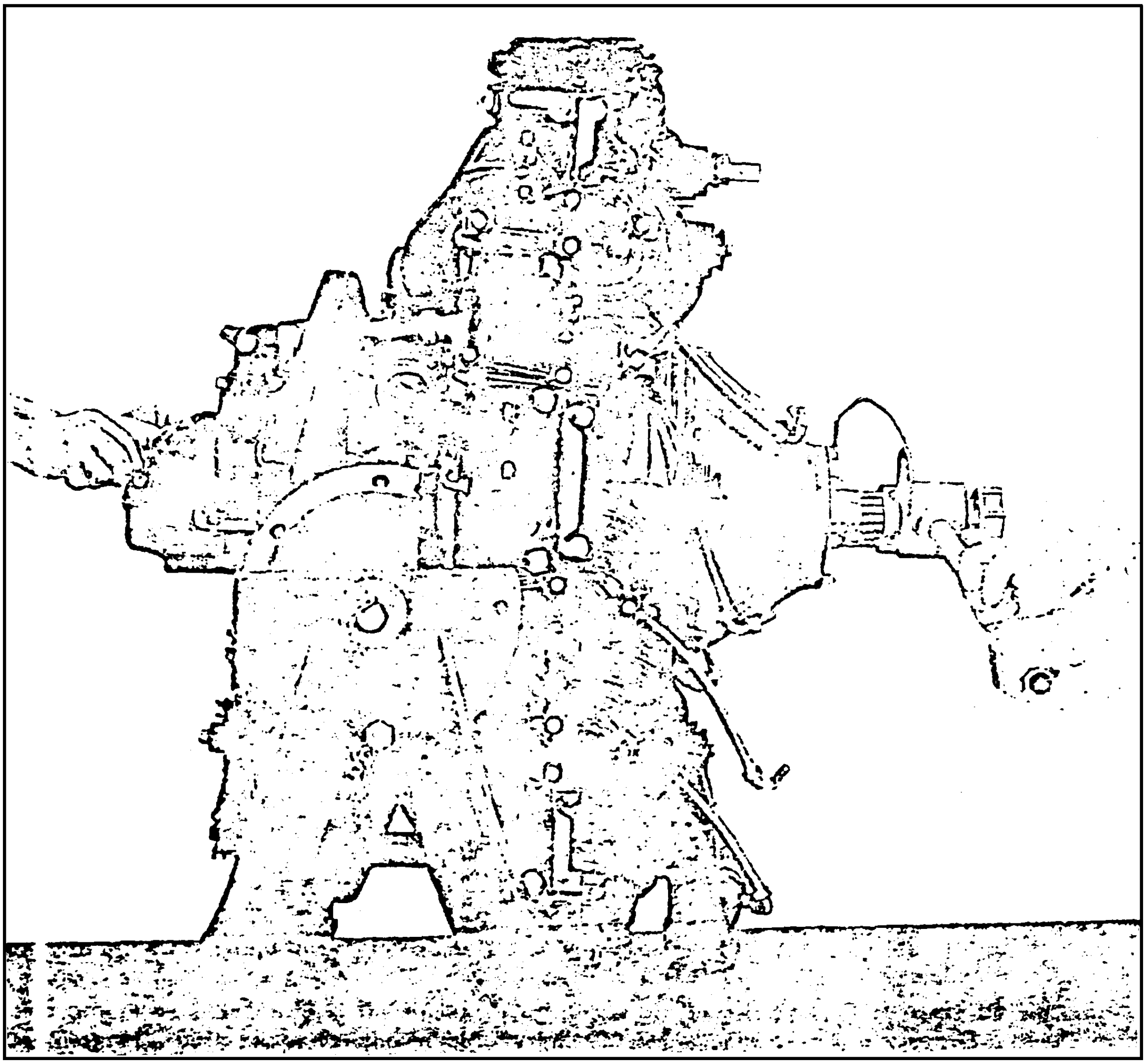


FIGURE 68—Timing Magnetos to the Engine

breaker spring itself is lifted to insert cellophane or paper between the points, a permanent set may result from excessive bending. The correct procedure in adjusting the points is to lift the cam follower, causing the points to open. Do not lift the spring. Inasmuch as the movement of the cam follower is limited to a safe amount by its construction, the breaker spring cannot be damaged by this procedure. If a breaker spring is suspected of having low tension, it can be checked by using a common spring balance reading in ounces (grams) up to at least two pounds (.90718 Kg.). The correct value for the tension of this spring is 20 to 32 ounces (566.95 to 907.18 g.) at the instant the points break. Measure the tension of the spring by using the spring balance at the point normally in contact with the fibre cam follower.

Owing to the wear of the cam follower, it may be found necessary to adjust the eccentric to its maximum position in order to permit the cam follower to lift the main spring and movable contact points at the instant the straight edge coincides with the timing marks. If this relation can be obtained, the cam follower is satisfactory for further service. However, during major overhaul, if, after having adjusted the eccentric to its maximum position, it is found that, the straight edge slightly passes the timing mark (as the drive shaft is turned in direction of the rotation of the magneto) before the contact points begin to open, install a new cam follower. During periodical inspections made between major overhaul periods an allowance of 1/8 inch (3.175 mm.) between the timing mark on the rim of the breaker cup and straight edge is permissible.

MAGNETO TIMING

Turn the crankshaft in the direction of normal rotation until the timing disc indicates 25° before top center on the compression stroke of No. 1 cylinder piston. (Refer to figure 68.) When the piston is in this position, both valves are closed. Apply a heavy grade of vaseline to the spline of the magneto coupling gear and drive, and place the right magneto into position on the rear section of the crankcase, noting that the marks on the magneto distributor gear index with the marks on the front cover. If a magneto pilot spacer is used, make sure that this part is in place.

Place a thin sheet of cellophane between the breaker points of the magneto and move the magneto by tapping it lightly near the base until the paper can be slipped from between the points of the breaker. Remember that the hold-down nuts on the flange of the magneto must be loose enough to permit this movement of the magneto by light taps. As soon as the paper can be slipped from between the breaker points, tighten the hold-down nuts of the magneto so that the magneto is rigid. If the slots in the magneto flange hit the studs before the proper timing is obtained, remove the magneto and mesh the next tooth in the coupling.

Replace the paper between the breaker points and rotate the crankshaft again, noting the point at which the breaker points part and release the paper. If this is within 1° of 25° before top center, no further adjustment need be applied.

The same procedure is followed in the timing of the left magneto. Both magnetos should be synchronized.

Install the rocker box covers on No. 1 cylinder.

SPARK PLUGS

Assemble the spark plugs and washers in the cylinders. Use a solid copper spark plug gasket, the thickness of which is between the limits of .068 periods and allowance of 1/8 inch (3.175 mm. be-cylinder head thermocouple under the rear spark plug of No. 1 cylinder. Tighten the plugs with the special wrench designed for this purpose.

GENERAL

Check the ignition wires for correct location with a buzzer. Connect the wires to the spark plugs and magnetos, and see that the wires are properly braced to prevent abrasion.

Place the gaskets on the exhaust elbows and install the exhaust flanges with stacks. Secure the flanges with washers, nuts, and cotterpins.

Fasten the cowl support on the main to front section studs with the air scoop at the top.

Assemble the exhaust manifold and heater rings on the cowl support.

Place the gasket over the carburetor elbow attaching studs and install the elbow, carburetor, and heater assembly as a unit. Assemble the washers and nuts on the studs. Tighten the nuts and secure them with lock wire.

Install the air heater pipe in position and secure the pipe to the air heater with the clamp provided for this purpose.

TEST PROPELLERS

Whirlwind engines that are to be tested should be fitted with a four-blade test propeller or a modified flight propeller. Due to the difficulty which is normally experienced in obtaining the proper flow of cooling air over the cylinder barrels while running an engine fitted with a modified flight propeller on a test stand, it is desirable to use the conventional type four-blade test propeller. If a test propeller is not available and it is necessary to use a modified flight propeller, care should be exercised to see that the specified cylinder and oil temperatures given in the Table of Engine Characteristics are not exceeded during the test.

To modify a flight propeller for test purposes, the blade tips should be cut-off, the pitch increased, and the propeller balanced.

There are two factors which must be taken into consideration: first, the pitch setting should be such that the engine will turn its rated revolutions per minute without exceeding the maximum permissible manifold pressure; and second, the propeller blades must be short enough to allow an increase in pitch sufficient to provide the proper cooling while at the same time their length must be great enough to give the necessary flywheel effect when determining the idling characteristics of the engine.

Additional information on the subject of test propellers may be obtained from the Wright Aeronautical Corporation, Service Division.

DURATION OF TESTS

The run-in time which should be given an overhauled engine depends largely upon the number and the nature of the parts replaced. The following tables may be varied according to the judgment of the operator but it is recommended that in all cases the total time given for the various runs be considered as the minimum.

Before starting an engine the first time after overhaul, the engine oil should be heated to 140° F. (60° C.).

OVERHAUL WITHOUT REPLACEMENT OF PARTS

Start run at 45% rated speed. Run for ten minutes.
Increase to 58% rated speed. Run for ten minutes.
Increase to 67% rated speed. Run for ten minutes.
Increase to 74% rated speed. Run for ten minutes.
Increase to 79% rated speed. Run for ten minutes.
Increase to 85% rated speed. Run for ten minutes.
Increase to 90% rated speed. Run for ten minutes.
Increase to 95% rated speed. Run for twenty minutes.
Increase to rated speed. Run for thirty minutes.

CHECK the idling characteristics, operation on either magneto at a M.A.P. of less than 30" Hg., and acceleration when throttle is opened both slowly and rapidly.

OVERHAUL WITHOUT REPLACEMENT OF CYLINDERS OR PISTONS

Start run at 45% rated speed. Run for ten minutes.
Increase to 58% rated speed. Run for ten minutes.
Increase to 67% rated speed. Run for ten minutes.
Increase to 74% rated speed. Run for ten minutes.
Increase to 79% rated speed. Run for ten minutes.
Increase to 84% rated speed. Run for ten minutes.
Increase to 88% rated speed. Run for thirty minutes.
Increase to 91% rated speed. Run for thirty minutes.
Increase to 95% rated speed. Run for thirty minutes.
Increase to rated speed. Run for thirty-five minutes.

CHECK the idling characteristics, operation on either magneto at a M.A.P. of less than 30" Hg., and acceleration when throttle is opened both slowly and rapidly.

OVERHAUL WITH REPLACEMENT OF MAJOR PARTS

1000 RPM Start run at 45% rated speed. Run for ~~fifteen~~ minutes.
Increase to 60% rated speed. Run for fifteen minutes. 1300
1475 Increase to 67% rated speed. Run for twenty minutes.
Increase to 75% rated speed. Run for twenty minutes. 1650
1750 Increase to 80% rated speed. Run for twenty minutes.
Increase to 85% rated speed. Run for thirty minutes. 1850
1950 Increase to 88% rated speed. Run for thirty minutes.
Increase to 90% rated speed. Run for sixty minutes. 1975
2100 Increase to 95% rated speed. Run for sixty minutes.
Increase to rated speed. Run for thirty minutes. 2200

CHECK the idling characteristics, operation on either magneto at a M.A.P. of less than 30" Hg., and acceleration when throttle is opened both slowly and rapidly.

WRIGHT WHIRLWIND 7 AND 9

TABLE OF LIMITS TL—45 —— TIGHTENING TORQUE VALUES

ALL MODELS

All changes in the Table of Limits are issued as Service Bulletins by the Service Division, Wright Aeronautical Corporation

Standard Studs, Bolts, Screws, and Capscrews

NAME	Size of Thread Nut End	Min. Dia. of Thread Root or Neck (Inches)	Min. Rockwell Hardness	Torque Values: Driving Stud, Minimum, In. Lb.	Driving Stud, Minimum, Cm. Kg.	Driving Stud, Maximum, In. Lb.	Driving Stud, Maximum, Cm. Kg.	Tightening Nut, Screw, or Capscrew, Minimum, In. Lb.	Tightening Nut, Screw, or Capscrew, Minimum, Cm. Kg.	Tightening Nut, Screw, or Capscrew, Maximum, In. Lb.	Tightening Nut, Screw, or Capscrew, Maximum, Cm. Kg.
Button Head Screw	10-32	.1467	B-50	—	—	—	—	20	23,1	25	28.8
Button Head Screw	12-24	.1585	B-50	—	—	—	—	25	28,8	30	34,6
Studs, Bolts, Screws and Capscrews	10-32	.1467	C-19	—	—	—	—	35	40,4	40	46,1
Studs, Bolts, Screws and Capscrews	12-24	.1585	C-19	—	—	—	—	45	51,9	50	57,6
Studs, Bolts, Screws and Capscrews	1/4-28	.180	C-26	50	57,6	70	80,7	80	92,3	85	98,0
Studs, Bolts, Screws and Capscrews	5/16-24	.229	C-26	100	115,2	150	173,0	160	184,5	175	202,0
Studs, Bolts, Screws and Capscrews	3/8-24	.285	C-26	200	231,0	275	317,0	225	259,5	250	288,0
Studs, Bolts, Screws and Capscrews	7/16-20	.331	C-26	300	346,0	425	490,0	350	404,0	375	432,0
Studs, Bolts, Screws and Capscrews	1/2-20	.387	C-26	500	576,0	700	807,0	550	635,0	600	692,0
Studs, Bolts, Screws and Capscrews	9/16-18	.436	C-26	750	865,0	975	1123,0	825	950,0	875	1003,0
Studs, Bolts, Screws and Capscrews	5/8-18	.493	C-26	1100	1269,0	1400	1614,0	1125	1297,0	1200	1383,0

Standard Practices for Special Applications

NAME	Size of Thread Nut End	Min. Dia. of Thread Root or Neck (Inches)	Min. Rockwell Hardness	Driving Stud, Minimum, In. Lb.	Driving Stud, Minimum, Cm. Kg.	Driving Stud, Maximum, In. Lb.	Driving Stud, Maximum, Cm. Kg.	Tightening, Minimum, In. Lb.	Tightening, Minimum, Cm. Kg.	Tightening, Maximum, In. Lb.	Tightening, Maximum, Cm. Kg.
Cylinder Hold-Down Stud	3/8-24	.313	C-32	325	375,0	450	519,0	29.2 350	404,0	31.2 375	432,0
Cylinder Hold-Down Capscrew	7/16-20	.330	C-26	—	—	—	—	375	432,0	400	461,0
Cylinder Hold-Down Stud	7/16-20	.331	C-32	400	461,0	550	635,0	425	490,0	450	519,0
Rocker Hub Bolt	7/16-20	.371	C-32	—	—	—	—	250	288,0	325	375,0
Rocker Hub Bolt	15/32-20	.400	C-19	—	—	—	—	250	288,0	325	375,0
Rocker Hub Bolt	9/16-18	.488	C-26	—	—	—	—	300	346,0	375	432,0
Spark Plug	18 mm.	—	—	—	—	—	—	450	519,0	500	575,0

95

TL-79 WRIGHT AERONAUTICAL CORPORATION

TABLE OF SERVICE LIMITS TL-79
WRIGHT WHIRLWIND 7 AND 9 ENGINES

Refer to Drawing Number 415842

All changes in the Table of Limits are issued as Service Bulletins by the Service Division, Wright Aeronautical Corporation

Item No.	Chart No.	ITEM NAME		Minimum (in.)	Maximum (in.)	Minimum (mm.)	Maximum (mm.)
1	1	Rocker Roller Hub and Pin	Dia.	.001T	.002L	0,025T	0,051L
2	1	Rocker Roller Hub and Roller	Dia.	.0015L	.020L	0,038L	0,508L
*3	1	Rocker Roller Hub and Rocker Arm	Side Clearance	Rivet	Tight	Rivet	Tight
4	1	Rocker Roller and Rocker Arm	Side Clearance	.0095L	.050L	0,241L	1,270L
5	1	Rocker Box and Rocker Bearing (Before Clamping)	Side Clearance	.004L	.020L	0,102L	0,508L
6	1	Rocker Bearing Bore and Rocker Bolt	Dia.	.000	.004L	0,000	0,102L
7	1	Rocker Bearing Outside Diameter and Rocker Arm	Dia.	.0007T	.002L	0,018T	0,051L
8	1	Rocker Bolt and Cylinder Head	Dia.	.0005L	.005L	0,013L	0,127L
9	1	Outer Valve Spring—Wire Dia. .175" (4,445 mm.) Tension at 1.38" (35,052 mm.) Height		49.32	lb.	22,35	kg.
10	1	Intermediate Valve Spring—Wire Dia. .135" (3,429 mm.) Tension at 1.38" (35,052 mm.) Height		30.07	lb.	13,63	kg.
11	1	Inner Valve Spring—Wire Dia. .112" (2,845 mm.) Tension at 1.34" (34,036 mm.) Height		20.91	lb.	9,50	kg.
#12	1	Valve Guide and Valve Intake (Large Dia. Valve Stem)	Center Dia. End Dia.	.0025L .0025L	.006L .008L	0,064L 0,064L	0,152L 0,203L
#12A	1	Valve Guide and Valve Intake (Small Dia. Valve Stem)	Center Dia. End Dia.	.0025L .0025L	.008L .010L	0,064L 0,064L	0,203L 0,254L
#13	1	Valve Guide and Valve Exhaust (Large Dia. Valve Stem)	Center Dia. End Dia.	.005L .005L	.010L .013L	0,127L 0,127L	0,254L 0,330L
#13A	1	Valve Guide and Valve Exhaust (Small Dia. Valve Stem)	Center Dia. End Dia.	.005L .005L	.012L .015L	0,127L 0,127L	0,305L 0,381L
14	1	Valve Guide and Cylinder Head—Intake (Shrink Fit)	Dia.	.0008T	.0023T	0,020T	0,058T

* # Refer to correspondingly numbered notes on page 108.

WRIGHT AERONAUTICAL CORPORATION TL-79

Item No.	Chart No.	ITEM NAME	Minimum (in.)	Maximum (in.)	Minimum (mm.)	Maximum (mm.)
15	1	Valve Guide and Cylinder Head—Exhaust (Shrink Fit) Dia.	.002T	.0035T	0,051T	0,089T
16	1	Valve Seat and Cylinder Head—Exhaust (Shrink Fit) Dia.	.011T	.015T	0,279T	0,381T
17	1	Valve Seat and Cylinder Head—Intake (Shrink Fit) Dia.	.011T	.015T	0,279T	0,381T
*18	1	Cam Hub Bearing Spacer				
19	1	Valve Tappet Ball Socket Spring Wire Diameter .051" (1,295 mm.) Tension at 2.18" (55,372 mm.)	7.74	lb.	3,55	kg.
20	1	Valve Tappet Guide and Valve Tappet (Select Tappet to Obtain This Fit) Dia.	.0003L	.0018L	0,006L	0,046L
21	1	Valve Tappet Guide and Crankcase Dia.	.001T	.003T	0,025T	0,076T
22	1	Valve Tappet Roller and Roller Pin Dia.	.003L	.007L	0,076L	0,178L
23	1	Piston and Piston Pin Dia.	.0005T	.003L	0,013T	0,076L
24	1	Piston Groove #1 (Top) and Ring Side Clearance	.0075L	.010L	0,191L	0,254L
#24A	1	Piston Groove #1 (Top) and Ring (Wedge) Side Clearance	.002L	.006L	0,051L	0,152L
25	1	Piston Groove #2 and Ring Side Clearance	.006L	.0085L	0,152L	0,216L
#25A	1	Piston Groove #2 and Ring (Wedge) Side Clearance	.002L	.006L	0,051L	0,152L
26	1	Piston Groove #3 and Ring Side Clearance	.0045L	.007L	0,114L	0,178L
27	1	Piston Groove #4 and Ring (Scraper Ring) Side Clearance	.0045L	.007L	0,114L	0,178L
#27A	1	Piston Groove #4 and Ring (Uniflow Piston) Side Clearance	.009L	.012L	0,229L	0,305L
27a	1	Piston Groove #4 and Ring (Oil Control Ring) Side Clearance	.0045L	.0075L	0,114L	0,191L
28	1	Piston Groove #5 and Ring Side Clearance	.0045L	.007L	0,114L	0,178L
#29	1	Piston and Cylinder—Center of Skirt Dia.	.023L	.035L	0,584L	0,889L
30	1	Piston Pin Bushing and Master and Articulated Rods (Split Bush.) Dia.	.0045T	.0065T	0,114T	0,165T
#30A	1	Piston Pin Bushing and Master and Articulated Rods (Solid Bush.) Dia.	.001T	.005T	0,025T	0,127T

* # Refer to correspondingly numbered notes on page 108.

TL-79	WRIGHT AERONAUTICAL CORPORATION					
Item No.	Chart No.	ITEM NAME	Minimum (in.)	Maximum (in.)	Minimum (mm.)	Maximum (mm.)
31	1	Piston Pin and Bushing Dia.	.0015L	.005L	0,038L	0,127L
32	1	Master Rod End Clearance on Crankpin	.013L	.050L	0,330L	1,270L
33	1	Crankpin Bearing and Master Rod (Shrink Fit) Dia.	.001T	.003T	0,025T	0,076T
34	1	Crankpin Bearing and Crankpin (Select at Assembly) Dia.	.0025L	.006L	0,064L	0,152L
*34a	1	Crankpin Bearing and Crankpin (Select at Assembly) Dia.	.003L	.0065L	0,076L	0,165L
*34b	1	Crankpin Bearing and Crankpin (Select at Assembly) Dia.	.0035L	.006L	0,089L	0,152L
35	1	Knuckle Pin and Master Rod. Dia.	.000	.0015T	0,000	0,038T
36	1	Knuckle Pin Bushing and Master Rod Side Clearance	.006L	.030L	0,152L	0,762L
37	1	Knuckle Pin Bushing and Articulated Rod (Split Bush.) Dia.	.0045T	.0065T	0,114T	0,165T
*37A	1	Knuckle Pin Bushing and Articulated Rod (Solid Bush.) Dia.	.001T	.005T	0,025T	0,127T
38	1	Knuckle Pin Bushing and Knuckle Pin Dia.	.0015L	.005L	0,038L	0,127L
39	1	Main Bearing Support and Crankcase Front Section Dia.	.003T	.005L	0,076T	0,127L
40	1	Main Front Bearing Support and Bearing Ring Dia.	.003T	.006T	0,076T	0,152T
41	1	Main Front Bearing and Bearing Ring Dia.	.0002T	.006L	0,005T	0,152L
42	1	Main Front Bearing and Crankshaft Dia.	.0002T	.0013T	0,005T	0,033T
43	1	Allowable Run Out of Crankshaft at Center Brg. When Supported at Thrust and Rear Main Bearing	.004 Max. Full Indicator Reading		0,102 Max. Full Indicator Reading	
44	1	Thrust Brg. and Frt. Section Dia.	.0002L	.004L	0,005L	0,102L
45	1	Thrust Bearing and Crankshaft Dia.	.0002T	.0009L	0,005T	0,023L
46	1	Thrust Bearing and Front Cover Clamp Shim	.005T	.007T	0,127T	0,178T
47	1	Allowable Run-Out of Crankshaft at Thrust Bearing Journal When Supported at Front and Rear Bearings	.004 Max. Full Indicator Reading		0,102 Max. Full Indicator Reading	

* = Refer to correspondingly numbered notes on page 103.

53 AK2 NUMBER ON PROP SHAFT

WRIGHT AERONAUTICAL CORPORATION TL-79						
Item No.	Chart No.	ITEM NAME	Minimum (in.)	Maximum (in.)	Minimum (mm.)	Maximum (mm.)
48	1	Crankcase Front Cover and Crankcase Front Cover Sleeve Dia.	.003T	.006T	0,076T	0,152T
49	1	Main Bearing Support and Crankcase Main Section Dia.	.002T	.006L	0,051T	0,152L
50	1	Propeller Shaft Thrust Bearing Nut and Oil Seal Ring Side Clearance	.002L	.028L	0,051L	0,711L
*51	1	Thrust Bearing Play .		.020		0,508
52	1	Crankshaft Front and Crankshaft Rear (Before Tightening Screw) Dia.	.001T	.005L	0,025T	0,127L
53	1	Crankshaft Rear End Plug and Crankshaft Dia.	.000	.002T	0,000	0,051T
54	1	Crankshaft Rear Gear Hub and Crankshaft Gear Dia.	.001L	.005L	0,025L	0,127L
55	1	Crankshaft Rear Gear Hub and Crankshaft Gear Side Clearance	.001L	.008L	0,025L	0,203L
56	1	Crankshaft Rear Spring—Wire Dia. .125" (3,175 mm.) Tension at .713" Height (18,110 mm.)	181	lbs.	82,2	kg.
57	1	Crankshaft Rear Bearing and Rear Crankshaft Dia.	.002L	.0045L	0,051L	0,114L
58	1	Crankshaft Rear Bearing and Crankcase Main Section (Shrink Fit) Dia.	.002T	.004T	0,051T	0,102T
59	1	Rear Crankshaft and Counterweight Pin Bushing Dia.	.001T	.0025T	0,025T	0,064T
60	1	Rear Crankshaft and Counterweight Side Clearance	.006L	.015L	0,152L	0,381L
61	1	Rear Counterweight and Stop	.041L	.060L	1,041L	1,524L
62	1	Rear Counterweight and Bushing Dia.	.0015T	.003T	0,038T	0,076T
63	1	Starter Drive Gear Bushing and Diff. Section Dia.	.001T	.003T	0,025T	0,076T
64	1	Starter Drive Gear and Bushing Dia.	.001L	.008L	0,025L	0,203L
65	1	Starter Shaft Bushing and Shaft Dia.	.001L	.008L	0,025L	0,203L
66	1	Starter Shaft Bushing and Rear Section Dia.	.001T	.003T	0,025T	0,076T
67	1	Starter Shaft End Clearance	.013L	.050L	0,330L	1,270L
68	1	Starter Drive and Crankshaft Gear Backlash	.008	.025	0,203	0,635

* = Refer to correspondingly numbered notes on page 108.

TL-79	WRIGHT AERONAUTICAL CORPORATION					
Item No.	Chart No.	ITEM NAME	Minimum (in.)	Maximum (in.)	Minimum (mm.)	Maximum (mm.)
69	2	Oil Check Valve Spring—Wire Dia. .036" (0,914 mm.) Tension at 1.44" (36,576 mm.) Height	1.575	lb.	0,715	kg.
70	2	Oil Suction Strainer Spring—Wire Dia. .063" (1,600 mm.) Tension at 3⅛" (79,502 mm.) Height	6	lb.	2,72	kg.
71	2	Vacuum Pump Drive Shaft and Vacuum Pump Drive Gear Backlash	.004	.025	0,102	0,635
72	2	Oil Pump Idler Shaft and Oil Pressure Pump Body. Dia.	.001L	.0025L	0,025L	0,064L
73	2	Oil Pump Idler Shaft and Pump Spacer Dia.	.002L	.0035L	0,051L	0,089L
74	2	Reverse Type Generator Idler Pinion and Bracket Dia.	.001L	.008L	0,025L	0,203L
75	2	Reverse Type Generator Idler Gear and Pinion Backlash	.004	.050	0,102	1,270
76	2	Oil Pressure Relief Valve Body and Oil Pump Body Dia.	.000	.005L	0,000	0,127L
77	2	Oil Check Valve Body and Crankcase Rear Section Dia.	.001T	.001L	0,025T	0,025L
78	2	Oil Pressure Relief Valve Spring Wire Dia. .048" (1,2192 mm.) Tension at 1¼" (31,750 mm.) Height	4.95	lb.	2,245	kg.
79	2	Oil Pump Drive Shaft and Oil Pump Idler Shaft Backlash	.004	.025	0,102	0,635
80 #1	2	Oil Pressure Pump Body and Oil Pump Idler Shaft End Clearance	.002L	.005L	0,051L	0,127L
81	2	Oil Pump Body and Oil Pump Idler Shaft Dia.	.001L	.0025L	0,025L	0,064L
#82	2	Oil Pump Body and Pump Gear Side Clearance	.005L	.009L	0,127L	0,229L
#83	2	Oil Pressure Pump Body and Oil Pump Idler Shaft Side Clearance	.004L	.010L	0,102L	0,254L
#84	2	Oil Pump Body and Oil Pump Idler Gear Side Clearance	.004L	.010L	0,102L	0,254L
85	2	Oil Pump Body and Oil Pump Drive Shaft Dia.	.001L	.0025L	0,025L	0,064L
86	2	Oil Pump Body and Vacuum Pump Drive Shaft Bushing Dia.	.001T	.003T	0,025T	0,076T
87	2	Oil Pump Idler Gear and Body End Clearance	.002L	.005L	0,051L	0,127L

* # Refer to correspondingly numbered notes on page 108.

/101

WRIGHT AERONAUTICAL CORPORATION TL-73

Item No.	Chart No.	ITEM NAME		Minimum (in.)	Maximum (in.)	Minimum (mm.)	Maximum (mm.)
88	2	Oil Pump Drive Shaft and Oil Pressure Pump Body	Dia.	.001L	.0025L	0,025L	0,064L
89	2	Oil Pump Drive Gear and Oil Pressure Pump Body	Dia.	.001L	.008L	0,025L	0,203L
90	2	Oil Pump Drive Shaft and Oil Pump Gear Spacer	Dia.	.002L	.0035L	0,051L	0,089L
‡91	2	Oil Pump Drive Shaft Gear and Oil Pressure Pump Body	Side Clearance	.004L	.010L	0,102L	0,254L
92	2	Oil Pump Gear and Oil Pump Idler Gear (Total Permissible Backlash in Finished Pump)	Backlash		.025		0,635
93	2	Oil Pump Body Bushing and Vacuum Pump Driveshaft	Dia.	.001L	.008L	0,025L	0,203L
‡94*	1	Impeller Shaft Rear Ball Bearing	Side Clearance	.005L	.0665L	0,127L	1,689L
95	1	Impeller Shaft Ball Bearing and Impeller Shaft	Dia.	.0001L		0,003L	
96	1	Impeller Shaft Bearing Support and Bearing	Dia.	.0005L	.0013L	0,013L	0,033L
97	1	Impeller Shaft Rear Bearing and Cage	Dia.	.0005L	.0013L	0,013L	0,033L
98	1	Impeller Oil Seal Ring	Side Clearance	.006L	.011L	0,152L	0,279L
99	1	Impeller Oil Seal Ring	Gap	.003	.010	0,076	0,254
100	1	Impeller and Shaft (Impeller Must Be Tight Fit on Splines)					
101	1	Impeller Shaft Nut Lock and Nut	Side Clearance	.003L	.006L	0,076L	0,152L
102	1	Impeller Shaft Nut Lock and Nut	End Clearance	.000	.004L	0,000	0,102L
103	1	Impeller and Supercharger Housing (Front)	Side Clearance	.022L	.027L	0,559L	0,686L
104	1	Impeller and Supercharger Housing (Rear)	Side Clearance	.018L	.072L	0,457L	1,829L
105	1	Impeller Drive Gear Bearing and Support		Clamp	Tight	Clamp	Tight
106	1	Impeller Drive Gear Pinion and Bearing	Side Clearance	.008L	25L	0,203L	0,635L
107	1	Supercharger Intermediate Gear and Bushing	Dia.		.003T	0,025T	0,076T

* ‡ Refer to correspondingly numbered notes on page 108.

TL-79 WRIGHT AERONAUTICAL CORPORATION

Item No.	Chart No.	ITEM NAME	Minimum (in.)	Maximum (in.)	Minimum (mm.)	Maximum (mm.)
108	1	Impeller Drive Gear Hub Bearing and Impeller Drive Gear Bushing Dia.	.003L	.006L	0,076L	0,152L
109	1	Impeller Shaft Gear and Drive Gear Backlash	.002	.010	0,051	0,254
110	1	Impeller Drive Pinion and Crankshaft Gear Backlash	.010	.025	0,254	0,635
111	1	Cam Drive Pinion Spring—Wire Dia. .062" (1,575 mm.) Tension at 1⅜" (35,052 mm.) Height	8	lbs.	3,63	kg.
112	1	Cam, Cam Hub and Attaching Screw Dia.	.000	.002T	0,000	0,051T
113	1	Cam Hub and Cam Bearing Dia.	.0015T	.0045T	0,038T	0,114T
114	1	Cam Hub Support and Cam Bearing Dia.	.003L	.008L	0,076L	0,203L
115	1	Cam Hub Side Clearance	.007L	.025L	0,178L	0,635L
116	1	Cam and Cam Drive Pinion Backlash	.006	.025	0,152	0,635
117	2	Accessory Driveshaft and Bushing Dia.	.001L	.008L	0,025L	0,203L
118	1	Hydro Control Valve Adapter and Crankcase Dia.	.002L	.006L	0,051L	0,152L
119	2	Accessory Drive Idler and Starter and Accessory Drive Gears Backlash	.004	.025	0,102	0,635
120	1	Accessory Drive Idler Gear Side Clearance	.011L	.050L	0,279L	1,270L
121	1	Accessory Drive Idler Gear Bushing and Diffuser Section Dia.	.001T	.003T	0,025T	0,076T
122	1	Accessory Drive Idler Gear and Bushing Dia.	.001L	.008L	0,025L	0,203L
123	2	Accessory Drive Shaft Bushing and Crankcase Rear Section Dia.	.000	.002L	0,000	0,051L
124	2	Accessory Drive Shaft and Rear Bushing Dia.	.001L	.008L	0,025L	0,203L
125	2	Accessory Drive Shaft Rear Bushing and Crankcase Rear Section Dia.	.001T	.003T	0,025T	0,076T
126	2	Accessory Drive Shaft and Bushings Side Clearance	.012L	.050L	0,305L	0,270L
127	2	Accessory Drive Shaft—Bevel Gear and Tachometer and Fuel Pump Drive Shaft Backlash	.004	.025	0,102	0,635
128	2	Tachometer Drive Gear and Sleeve and Tachometer Shaft Bushing Dia.	.001L	.008L	0,025L	0,203L
129	2	Tachometer and Fuel Pump Drive Shaft and Fuel Pump Drive Gear Dia.	.000	.002L	0,000	0,051L

* = Refer to correspondingly numbered notes on page 108.

WRIGHT AERONAUTICAL CORPORATION							TL-79
Item No.	Chart No.	ITEM NAME		Minimum (in.)	Maximum (in.)	Minimum (mm.)	Maximum (mm.)
130	2	Tachometer and Fuel Pump Drive Shaft and Tachometer and Fuel Pump Drive Shaft Adapter	Dia.	.001L	.008L	0,025L	0,203L
131	2	Tachometer and Fuel Pump Drive Shaft and Tachometer and Fuel Pump Drive Shaft Adapter	Side Clearance	.006L	.020L	0,152L	0,508L
*132	2	Tachometer Driving Gear and Drive Shaft Gear	Backlash	.004	.025	0,102	0,635
133	2	Tachometer Driving Gear and Sleeve	Dia.	.0035T	.0015L	0,089T	0,038L
134	2	Tachometer Drive Gear and Housing	Side Clearance	.003L	.050L	0,076L	1,270L
135	2	Rear Crankcase and Tachometer and Fuel Pump Drive Shaft Adapter	Large Dia.	.001L	.005L	0,025L	0,127L
136	2	Fuel Pump Adapter Bushing and Fuel Pump Gear	Dia.	.001L	.005L	0,025L	0,127L
137	2	Rear Crankcase and Tachometer and Fuel Pump Drive Shaft Adapter	Small Dia.	.000	.002L	0,000	0,051L
138	2	Crankcase Rear Section and Packing Retainer Ring	Dia.	.001T	.004T	0,025T	0,102T
139	2	Fuel Pump Drive Gear and Tachometer and Fuel Pump Drive Shaft	Backlash	.004	.025	0,102	0,635
140	2	Fuel Pump Adapter and Bushing	Dia.	.001T	.003T	0,025T	0,076T
141	2	Drive Shaft Bushing and Diffuser Section	Dia.	.001T	.003T	0,025T	0,076T
142	1	Governor Drive Adapter and Crankcase	Dia.	.000	.004L	0,000	0,102L
143	1	Governor Drive Bevel Gear Bushing and Adapter	Dia.	.0015T	.0035T	0,038T	0,089T
144	1	Governor Drive Bevel Gear and Bushing	Dia.	.001L	.005L	0,025L	0,127L
145	1	Governor Drive Intermediate Bevel Gear and Governor Drive Bevel Gear	Backlash	.004	.025	0,102	0,635
146	2	Reverse Type Generator Gear and Support	Dia.	.006L	.010L	0,152L	0,254L
147	2	Reverse Type Generator Gear and Bracket	Dia.	.002L	.008L	0,051L	0,203L
148	1	Crankshaft (Front) Gear Oil Seal Ring	Gap	.008	.013	0,203	0,330
149	1	Crankshaft (Front) Gear and Governor Drive Intermediate Spur Gear	Backlash	.004	.025	0,102	0,635

* = Refer to correspondingly numbered notes on page 108.

TL-79	WRIGHT AERONAUTICAL CORPORATION					
Item No.	Chart No.	ITEM NAME	Minimum (in.)	Maximum (in.)	Minimum (mm.)	Maximum (mm.)
150	1	Governor Drive Intermediate Bevel Gear and Bushing Dia.	.001L	.005L	0,025L	0,127L
151	1	Governor Drive Intermediate Bevel Gear Bushing and Bracket Dia.	.0015T	.0035T	0,038T	0,089T
152	2	Tachometer Driving and Drive Shaft Gear Backlash	.004	.025	0,102	0,635
153	2	Tachometer Drive Shaft and Bushing Dia.	.0025L	.008L	0,064L	0,203L
154	2	Tachometer Housing and Bushing Dia.	.0005T	.0025T	0,013T	0,064T
155	2	Tachometer Drive Shaft Side Clearance	.008L	.040L	0,203L	1,016L
156	2	Tachometer Drive Shaft and Bushing Dia.	.001L	.008L	0,025L	0,203L
157	2	Tachometer Drive Shaft Cover and Bushing Dia.	.0035T	.0055T	0,089T	0,140T
158	2	Tachometer Drive Packing Gland Spring—Wire Dia. .095" (2,413 mm.) Tension at 19/32" (15,113 mm.) Height	16	lb.	7,27	kg.
159	2	Tachometer Drive Shaft and Gland Dia.	.009L	.020L	0,229L	0,508L
160	2	Generator Idler Gear and Starter Gear Backlash	.004	.020	0,102	0,508
161	2	Generator Idler Gear Bushings and Shaft Dia.	.001L	.008L	0,025L	0,203L
162	2	Generator Idler Gear and Bushings Dia.	.0005T	.0035T	0,013T	0,089T
163	2	Generator Idler Gear Side Clearance	.003L	.050L	0,076L	1,270L
164	2	Generator Drive Gear Support and Bushing Dia.	.0015T	.0035T	0,038T	0,089T
165	2	Generator Drive Gear and Generator Drive Support Bushing Dia.	.0025L	.008L	0,064L	0,203L
166	2	Generator Drive Gear and Generator Drive Support Side Clearance	.006L	.020L	0,152L	0,508L
167	2	Tachometer Drive Shaft and Housing Dia.	.006L	.016L	0,152L	0,406L
168	2	Tachometer Drive Shaft Side Clearance	.005L	.035L	0,127L	0,889L
169	2	Tachometer Shaft Spiral Gear Backlash	.004	.025	0,102	0,635
170	2	Tachometer Drive Sleeve and Bushing Dia.	.0005T	.0025T	0,013T	0,064T
171	2	Tachometer Drive Shaft and Bushing Dia.	.001L	.0065L	0,025L	0,165L
172	2	Generator Drive Gear Support and Rear Crankcase Dia.	.001T	.003L	0,025T	0,076L

* ‡ Refer to correspondingly numbered notes on page 108.

WRIGHT AERONAUTICAL CORPORATION TL-79

Item No.	Chart No.	ITEM NAME	Minimum (in.)	Maximum (in.)	Minimum (mm.)	Maximum (mm.)
173	2	Generator Idler Gear Shaft Bushing and Rear Crankcase Dia.	.001T	.003T	0,025T	0,076T
174	2	Generator Idler Gear Shaft and Rear Crankcase Dia.	.000	.003L	0,000	0,076L
175	2	Generator Idler Gear Shaft and Bushing Dia.	.000	.003L	0,000	0,076L
176	2	Generator Idler Gear and Starter Shaft Gear and Generator Gear Backlash	.004	.025	0,102	0,635
#177	1	Crankshaft Constant Speed Governor Drive Gear and Oil Seal Ring Side Clearance	.001L	.006L	0,025L	0,152L
178	1	Hydro Control Prop. Operating Valve and Hydro Control Valve Adapter Dia.	.0005L	.0037L	0,013L	0,094L
179	1	Crankcase Sleeve and Crankcase Front Section Dia.	.001T	.0035T	0,025T	0,089T
180	1	Crankshaft Constant Speed Governor Drive Gear and Crankcase Front Section Sleeve Dia.	.017L	.034L	0,432L	0,864L
#181	1	Crankshaft Constant Speed Governor Drive Gear and Crankshaft Dia.	.0005L	.003L	0,013L	0,076L
182	2	Generator Idler Gear and Bushing Dia.	.0005T	.0035T	0,013T	0,089T
183	1	Spline Side Clearance—(Movement of Prop. Hub on Crankshaft Measured at 15" (381,0 mm.) Radius From Center of Crankshaft)		.040		1,016
184	1	Propeller Thrust Bearing Nut Oil Seal Ring Gap	.000	.002	0,000	0,051
185	1	Allowable Run-Out of Crankshaft Between Threads and Splines at Forward End When Supported at Front and Rear Main Bearings	.012 Max. Full Indicator Reading		0,305 Max. Full Indicator Reading	
186	1	Oil Sump Strainer Spring—Wire Dia. .094" (2,388 mm.) Tension at 1" (25,400 mm.) Height	1.45	lb.	0,659	kg.
187	2	Gear and Accessory Drive Shaft Spline	.001L	.008L	0,025L	0,203L
188	2	Gear and Accessory Drive Shaft Dia.	.001L	.005L	0,025L	0,127L
189	2	Gear and Tachometer and Fuel Pump Drive Adapter Dia.	.0015L	.008L	0,038L	0,203L
190	2	Gear and Accessory Drive Shaft Adapter and Bushing Dia.	.0005L	.008L	0,013L	0,203L

\# = Refer to correspondingly numbered notes on page 108.

TL-79	WRIGHT AERONAUTICAL CORPORATION					
Item No.	Chart No.	ITEM NAME	Minimum (in.)	Maximum (in.)	Minimum (mm.)	Maximum (mm.)
191	2	Tachometer and Fuel Pump Drive Cover and Bushing Dia.	.0005L	.0025L	0,013L	0,064L
192	2	Accessory Drive Shaft and Vacuum Drive Bevel Gear Backlash	.004	.025	0,102	0,635
193	2	Gear and Vacuum Pump Drive Shaft Spline	.001L	.012L	0,025L	0,305L
194	2	Vacuum Pump Drive Shaft and Fuel Pump Drive Gear Backlash	.004	.025	0,102	0,635
195	2	Fuel Pump Adapter and Bushing Dia.	.0025T	.0045T	0,064T	0,114T
‡196	1	Piston Rings Gap	.032		0,813	
197	2	Fuel Pump Drive Gear and Bushing Dia.	.002L	.006L	0,051L	0,152L
198	2	Vacuum Pump Adapter and Bushing Dia.	.0035T	.0055T	0,089T	0,140T
199	2	Vacuum Pump Drive Shaft and Bushing Dia.	.001L	.005L	0,025L	0,127L
200	2	Gear and Vacuum Pump Drive Shaft Dia.	.001L	.006L	0,025L	0,152L
201	2	Accessory Drive Housing and Bushing Dia.	.0015T	.0035T	0,038T	0,089T
202	2	Vacuum Pump Drive Shaft Gear and Bushing Dia.	.001L	.008L	0,025L	0,203L
203	2	Vacuum Pump Drive Shaft Side Clearance	.008L	.040L	0,203L	1,016L
204	2	Governor Drive Gear and Vacuum Pump Drive Shaft Backlash	.004	.025	0,102	0,635
205	2	Governor Drive Gear and Bushing Dia.	.002L	.008L	0,051L	0,203L
206	2	Governor Adapter and Bushing Dia.	.0015T	.0035T	0,038T	0,089T
*207	1	Crankcheek Cap Screw Stretch	.004	.005	0,102	1,127
208	1	Select Knuckle Pin Locks to Obtain a Light Tapping Fit When Assembled Between Knuckle Pins				
209	1	Thrust Bearing and Crankcase Front Cover Spacer Side Clearance	.001L	.004L	0,025L	0,102L
210	..	Cylinder Barrel Bore Taper		.010		0,254
211	..	Cylinder Barrel Bore Out of Round		.005		0,127
212	..	Crankshaft Adapter Oil Seal Ring Side Clearance	.001L	.015L	0,025L	0,381L
213	..	Crankshaft Adapter Oil Seal Ring Gap	.008	.013	0,203	0,330

* ‡ Refer to correspondingly numbered notes on page 108.

WRIGHT AERONAUTICAL CORPORATION TL-79						
Item No.	Chart No.	ITEM NAME	Minimum (in.)	Maximum (in.)	Minimum (mm.)	Maximum (mm.)
214	..	Hydro Control Prop. Operating Valve and Crankcase Front Section Dia.	.0005L	.004L	0,013L	0,106L
215	..	Valve Tappet Guide and Valve Tappet (External Lubrication) Dia.	.0002L	.003L	0,005L	0,076L
216	..	Impeller Drive Gear Pinion and Bushing Dia.	.001T	.003T	0,025T	0,076T
217	..	Impeller Drive Pinion Bearing Ring and Pinion Dia.	.0025T	.0045T	0,064T	0,114T
218	..	Impeller Drive Pinion and Clutch Band and Dog-Slot Side Clearance	.000	.020L	0,000	0,508L
219	..	Impeller Drive Ring Gear and Clutch Assembly Total Clearance	.000	.020L	0,000	0,508L
220	..	Starter Drive-Gear Bushing and Rear Section Dia.	.000	.002L	0,000	0,508L
221	..	Governor Drive Bracket and Crankcase Dia.	.000	.004L	0,000	0,102L
222	..	Starter Shaft (With Riveted Starter Drive Gear) End Clearance	.009L	.050L	0,229L	1,270L
223	..	Crankshaft Adapter and Oil Seal Ring Side Clearance	.0085L	.030L	0,216L	0,762L
224	..	Crankshaft Adapter and Crankcase Front Section Sleeve Dia.	.033L	.050L	0,838L	1,270L
225	..	Crankshaft Adapter and Crankshaft Dia.	.0025L	.005L	0,064L	0,127L
226	..	Crankshaft Adapter Oil Seal Ring Gap	.000	.015	0,000	0,381
227	..	Prop. Thrust Bearing Nut and Front Cover Sleeve Dia.	.0215L	.0485L	0,546L	1,232L
228	..	Tachometer Drive Shaft and Gland Dia.	.010L	.020L	0,254L	0,508L
229	..	Tachometer Drive Shaft and Housing Dia.	.006L	.016L	0,152L	0,406L
500	2	Intake Pipe Flange to Cylinder Head Attaching Bolt Tightening Torque	125 in. lb.	150 in. lb.	144 cm. kg.	173 cm. kg.
501	..	Valve Clearance Adjusting Screw Lockscrew (With Tapered Head) Tightening Torque	135 in. lb.	150 in. lb.	156 cm. kg.	173 cm. kg.

* = Refer to correspondingly numbered notes on page 108.

NOTES

#	Item revised September, 1942.
3	Select to obtain .000"—.001"T (0,000mm — 0,025T mm.) before riveting.
18	Select spacer to align cam with valve tappet rollers.
24A, 25A, 27A	Side clearance for wedge rings obtained when rings are held in contact with a straight edge which in turn is held in contact with lands #1, #2, and #3.
34a	For R-760E series engines only.
51	Between inner and outer races measured on an axis parallel to crankshaft.
94	Do not use to set impeller shaft.
207	Use .625" (15,875mm.) diameter ball at head end when measuring.

APPROVED ACCESSORIES

The following accessories are approved by the Wright Aeronautical Corporation for use with Wright Whirlwind-engines:

STARTERS

Eclipse Hand And Electric Inertia, Series 6, Model 2048C
Eclipse Hand Inertia, Series 6, Model 2209C
Eclipse Hand Inertia, Series 6, Model 2046C
Eclipse Hand Inertia, Side Cranking, Series 16, Model 2526
Eclipse Hand Inertia, Cockpit Cranking, Series 16, Model 2111A
Eclipse Direct Electric With Hand Crank, Type E-160, Model 2612B
Eclipse Direct Electric Without Hand Crank, Type F-141, Model 2394
Eclipse Hand Turning, Type 3-HB8, Model 2364

GENERATORS

Eclipse Type G-2, Model 2560G, 15 Volts, 15 Amperes
Eclipse Type D-2, Model 2368-D, 15 Volts, 25 Amperes
Eclipse Type E-3, Model 2512-A, 15 Volts, 50 Amperes

FUEL PUMPS

Evans No. 9030, By-pass and Relief Valve Not Incorporated
Evans No. 9023-E7, With By-pass And Relief Valve
Pesco Type F-4, With Relief Valve, By-pass Not Incorporated
Romec Type F-4RB, With By-pass And Relief Valve
Romec Type F-4, By-pass And Relief Valve Not Incorporated
WAC Type C-3 Modified, With By-pass And Relief Valve
WAC Type C-5 Unmodified, By-pass and Relief Valve Not Incorporated

FUEL PRESSURE RELIEF VALVES

Aero. Supply Company Type C-2 By-pass and Relief Valve
Air Corporation Type B-1 Relief Valve.
Romec Type E-3 By-pass and Relief Valve

PRIMING PUMPS

Dole Type PR-3
Lunkenheimer Type D-1299-A
Parker Type 4050

CARBURETOR AIR CLEANER

Air-Maze Company, 5⅞ Dia. x 6⅛ Long, Used With Banjo Type Air Heater

THERMOMETERS

Weston Type V10, Model 602, For Carburetor Fuel Air Mixture

VACUUM PUMPS

Eclipse Model 2932-D-1A, Anti-clockwise Rotation
Eclipse Type B-1, Model M-3170-2, Anti-clockwise Rotation
Eclipse Type B-2, Model M-3166, Anti-clockwise Rotation
Pesco Model B-1, No. 190, Rotation In Either Direction
Romec Type B2A (R-D2112), Rotation In Either Direction
Eclipse Vacuum Pump Relief Valve, For Use With Eclipse Vacuum Pump
Pesco Vacuum Pump Relief Valve For Use With Pesco Vacuum Pump
Romec Vacuum Pump Relief Valve For Use With Romec Vacuum Pump

OIL FILTER

Cuno No. 1522 Filter, 3¼ Long, For Use In External Oil System

OIL COOLERS

G And O No. B-2495, 604 Tubes With By-pass Relief Valve
Harrison C-2297, 604 Tubes With By-pass Relief Valve
United Aircraft Products No. U-2060, 4 Ins. With By-pass Relief Valve
United Aircraft Products No. U-2053, 5 Ins. With By-pass Relief Valve

IGNITION SWITCHES

Scintilla Type A-1A-4, Single Engine, Radio Shielded
Scintilla Type A-2A-4, Two Engines, Radio Shielded
Scintilla Type A-3A-4, Three Engines, Radio Shielded
Scintilla Type A-1A, Single Engine, Radio Shielded
Scintilla Type A-2A, Two Engines, Radio Shielded
Scintilla Type A-3A, Three Engines, Radio Shielded

THERMOCOUPLES

Spark Plug Washer Type Couple, Iron-Constantan
Lewis Or Weston Iron-Constantan Thermocouple Leads May Be Procured In Lengths From 10 to 50 Ft. In Increments of 5 Ft.

THERMOCOUPLE INSTRUMENTS

Lewis, Calibrated In Degrees Fahrenheit, Used With Iron-Constantan
Lewis, Calibrated In Degrees Centigrade, Used With Iron-Constantan
Weston, Calibrated In Degrees Fahrenheit, Used With Iron-Constantan
Weston, Calibrated In Degrees Centigrade, Used With Iron-Constantan

THERMOCOUPLE SWITCHES

Lewis 18 Point, Used With Iron-Constantan
Lewis 2 Point, Used With Iron-Constantan
Lewis 2 Point, Used With Iron-Constantan, Small Type
Lewis 3 Point, Used With Iron-Constantan
Lewis 4 Point, Used With Iron-Constantan
Weston 2 Point, Used With Iron-Constantan