Wright Aircraft Engines

Complete Instructions for their Installation,
Operation and Maintenance

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WRIGHT ENGINES FOR AIR SERVICE

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CONTENTS

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PREFACE

THIS book has been produced with the intention of providing the most complete possible instructions for operating and overhauling Wright aeronautical engines.

It is intended primarily for the use of those who have in their charge a number of such engines, but it covers the whole field. The airplane designer will find in it all the information he requires to enable him to provide the best installation. The pilot will find detailed instructions for handling the engine and a catalogue of the simple troubles. For hangar men there are hints for the daily care of those parts which should receive it.

Perhaps the greatest pains have been taken with that section devoted to the overhaul of the engine and its accessories. The methods described are all the result of the aggregate experience of men who have worked in field and base repair shops. They are methods adapted to the needs of such shops and frequently differ from factory methods, in that they call for a minimum of special tools and fixtures.

Particular emphasis is given to some instructions on points which may appear to the reader to be of small importance; however, great care has been taken not to stress anything unduly. Where small matters are made very prominent it is because field experience with thousands of engines has shown the necessity for special care.

The section of the book dealing with overhaul is written for the actual mechanic who does the work, as well as for his superintendent. It is assumed that he will be fully acquainted with the grade of workmanship necessary for aviation engine repair, for which reason there is no reference to elementary matters of craftsmanship.

For use when ordering spare parts the Wright Aeronautical Corporation publishes a parts list separate from this volume, which is an instruction book only.

For assistance, or for explanation of points found not to be fully covered in this book, application should be made to the company's Service Department.

WRIGHT AERONAUTICAL CORPORATION,
PATERSON, N. J., U. S. A.

MODEL E-2 WRIGHT ENGINE

AVERAGE PERFORMANCE AT SEA LEVEL

R. P. M.	H. P.	Lbs. Fuel Per H. P. Hour	Lbs. Fuel Per Hour	Lbs. Oil Per Hour
1600	176	.485	86.	3.6
1800	200	.48	96.	4.
2000	220	.487	107.	4.4

Recommended speed 1800-2000 R. P. M. Weight dry 480 lbs.
2.18 lbs. per Horse Power at 2000 R. P. M.

ALTITUDE PERFORMANCE MODEL E WRIGHT ENGINE AT 1800 R. P. M.

Altitude	Sea Level	5000′	10,000′	15,000′	20,000′	25,000′	30,000′
Horse Power	200	166	138	113	91	75	63

Altitude Performance Charts for Model E-2 have not been made, but the E-2 will give greater power than Model E given above.

MODEL H-3 WRIGHT ENGINE

AVERAGE PERFORMANCE AT SEA LEVEL

R. P. M.	H. P.	Lbs. Fuel Per H. P. Hour	Lbs. Fuel Per Hour	Lbs. Oil Per Hour
1800	325	.48	156.	6.5
2000	360	.5	178.	7.2

Recommended speed 1800-2000 R. P. M. Weight dry 617 lbs.
1.71 lbs. per horse power at 2000 R. P. M.

ALTITUDE PERFORMANCE MODEL H-3 WRIGHT ENGINE AT 1800 R. P. M.

Altitude	Sea Level	5000′	10,000′	15,000′	20,000′	25,000′	30,000′
Horse Power	325	272	224	184	148	120	102

"SUPER FIGHTER" WRIGHT ENGINE

MODEL H-2 OR H-3 USING 6½:1 COMPRESSION 50% GAS, 50% BENZOL

SEA LEVEL PERFORMANCE

R. P. M.	H. P.	Lbs. Fuel Per H. P. Hour
1800	360	.48
2000	390	.44

Recommended speed 1800-2000 R. P. M. Weight dry 617 lbs.
1.58 lbs. per Horse Power at 2000 R. P. M.

For guaranteed Horse Powers see Page 76.

SECTION I.

Description of Engines

WRIGHT AIRCRAFT ENGINES

General Description, Giving Particulars of and Reasons for the Main Features of Their Design

AT the present time—August, 1921—there are being produced, 2 different models of Wright engines. These are closely similar in design and differ mainly in size, being rated at 180 H. P. for Model E-2, which is the smaller, and at 300 H. P. for Model H-3.

The general description of the motors and also the maintenance and overhaul instructions in the several sections of this volume, deal primarily with these two models. In the description which follows no dimensional data are given. This is all combined in a single table of specifications covering all the different models, which is printed on page 76.

Seven Models

Five other models have been built in America, first model A, then an improved type which was called model I, then model E, which is almost identical with model I except that it has higher compression and gives more power, model H, which was the first 300 H. P. Wright Engine, and H-2.

Large numbers of these engines are in use and in general respects they differ so little from the present production, models E-2 and H-3, that what applies to one applies to the whole seven models.

However, where differences exist these are dealt with fully in supplements which will be found at the end of this section of the book. Where instructions given do *not* apply to all seven engines this fact is noted and reference to the proper page and section is made.

Unique Features

There are two basic features peculiar to all Wright motors, the cylinder construction and the valve operation. The cylinders are separate steel sleeves flanged at the bottom for attachment to the crank-case and with flat steel heads in which the valve seatings are cut. These sleeves are threaded for almost their entire length and are screwed into an aluminum water jacket which carries the valves and the camshaft. The resulting effect of this construction is to provide an aluminum cylinder block completely lined with steel.

All stresses within the cylinder are transferred directly to the crankshaft and crankcase through the steel sleeves, the aluminum having only to carry the camshaft, and this means that the cylinder block is very strong, while being very light in weight. The cylinder block is enameled inside and out, protecting the aluminum from corrosion due to impurities in the cooling water or in the atmosphere.

The valve seats are cut in the steel heads of the cylinder sleeves and the valve stems project upwards through cast iron guides screwed into bosses in the aluminum. A flat tappet of mushroom form is attached directly to the upper end of each valve stem and the detail of the tappet adjustment is one of the most ingenious features of the motor. The valve stems are of large diameter and are hollow, being threaded internally; the tappet has a flat head with a notched edge and its underside is serrated, the top surface, on which the cam bears, being case-hardened. The stem of the tappet screws deeply into the hollow valve stem.

Easy Tappet Adjustment

Beneath each tappet there is a washer with fine serrations

DIFFERENCES BETWEEN VARIOUS MODELS

Models E-2 and H-3

Fully described pages 1 to 9. Description holds good generally for all models except as tabulated below and described fully pages 10 to 19.

Have heavy head sleeves, with increased cooling, minimizing valve trouble.

Model A

Connecting rod design peculiar to model A.

Piston design peculiar to model A.

Magneto drive peculiar to model A.

Propeller hub attachment peculiar to model A.

Valve guide design peculiar to model A.

Models E and I

These are identical except that model E has a longer piston giving higher compression than model I.

Magneto drive and mounting peculiar to models E, I and H.

Piston design peculiar to these two models.

Oiling system peculiar to these two models.

Model H

Larger than models E and I but generally similar except:

Oil pump design same as for H-2.

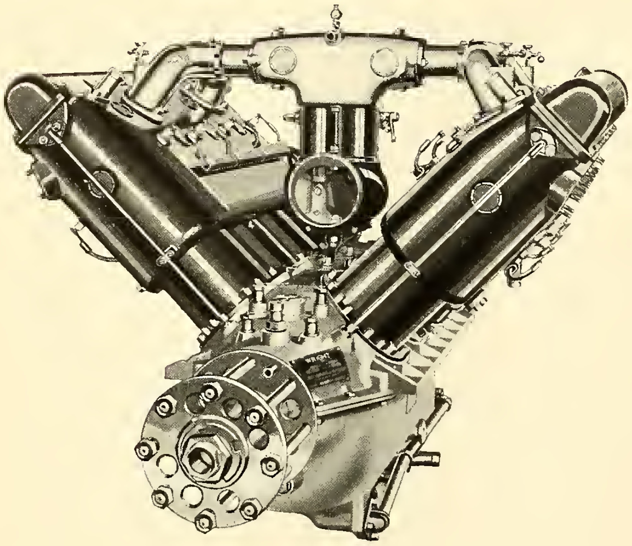
Piston same as for H-2.

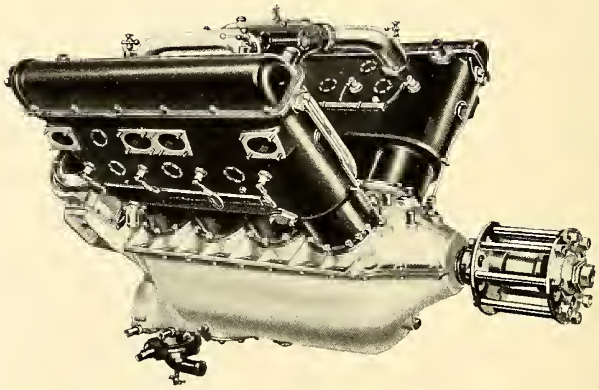
Magneto has hand advance control.

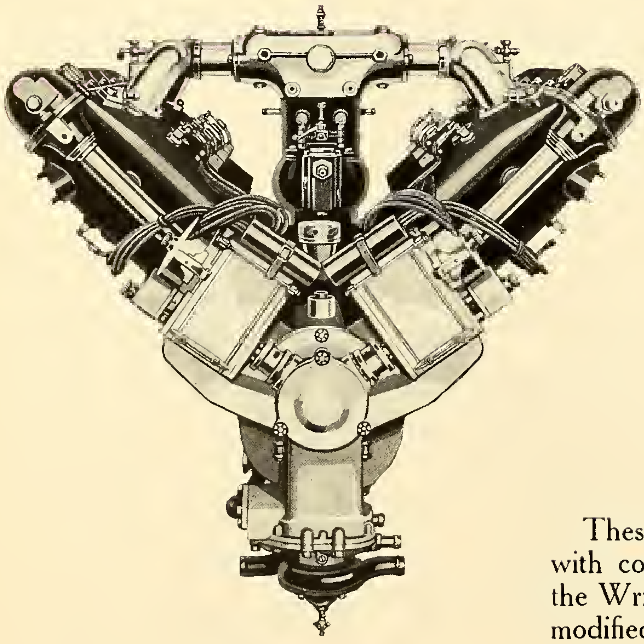
Model H-2

Does not have adjustable vertical shaft.

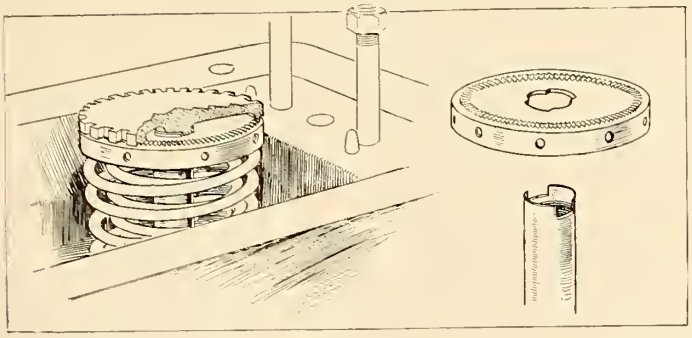
MODEL H-2 WRIGHT ENGINE







These views show the Model H-2 Wright Engine with complete standard equipment, as sent out from the Wright plant. H-3 identical externally except for modified water connections.



Explanatory diagram of valve tappet adjustment

which mesh with those on the underside of the tappet. The hole in the center of the washer is not circular but is made to fit slots cut on the top end of the valve stem, and around the periphery of this washer are a number of small holes. The valve springs [of which there are two for each valve, one inside the other] come immediately beneath the washer and hold it up against the tappet.

Now, owing to the washer fitting into the slots on the valve stem, it cannot turn on the valve and, if the washer is held, the tappet can be turned, the serrations between the two "clicking" over each other and yet having grip enough to lock the tappet securely, since they are subjected to the full pressure of the valve springs. A special wrench is used for this adjustment which can be performed with great ease and quickness.

The camshaft is mounted in three bronze bearings bolted to the top of the cylinder block, so that the cams act directly upon the tappets without any intermediate mechanism. Camshaft and valves are inclosed by an oiltight aluminum cover and operate in a perfectly lubricated condition.

Camshaft Drive

At the end of each cylinder block there is a vertical shaft which drives the camshaft through bevel gearing. This is called "the *upper* vertical shaft" and has a disconnecting joint above the level of the crankcase so that it forms a unit with the cylinder assembly. Thus cylinders, valves, camshaft and camshaft-drive form a complete unit which is both light and compact.

Crankcase Construction

Owing to the nature of the cylinder assemblies the crankcase is comparatively simple. There are upper and lower halves split on the center line of the crankshaft, and the respective parts of the bearings are carried directly in the crankcase halves. The upper and lower crankcase halves are bolted together very strongly and, since each half takes its share in supporting the crankshaft, the case as a whole is very rigid and light in weight. Both halves are aluminum castings and the upper half has a projecting foot running the entire length of the case on each side forming the bedplate from which the engine is supported.

In the upper half, at the rear end, there are two short shafts in bronze carriers called the *lower* vertical shafts. Each of these shafts has a bevel gear at the lower inside end meshing with a bevel gear on the crankshaft. The upper ends of these two shafts project above the crankcase and are slotted to receive the tongues on the ends of the upper vertical shafts which are attached to the cylinder blocks as described. It is thus possible to remove and replace cylinders without disturbing any of the camshaft drive gearing.

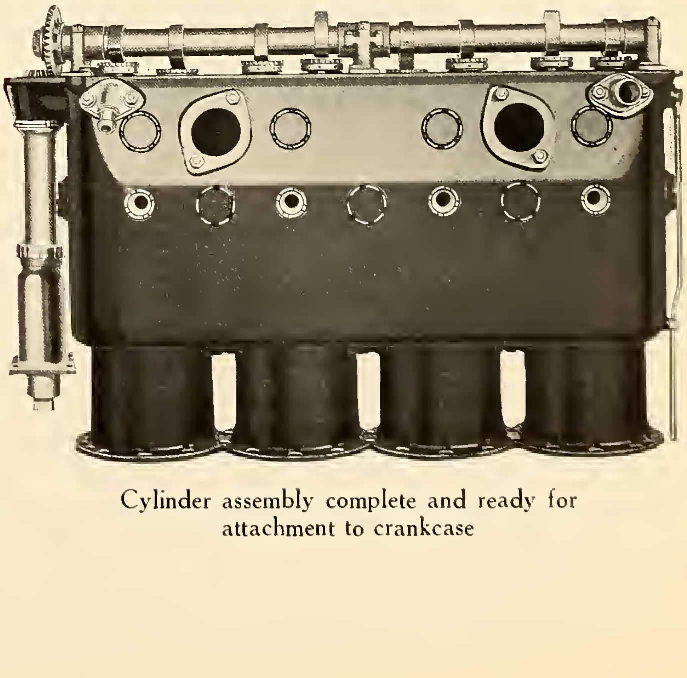
On five of the models of Wright engines timing the camshafts is a somewhat complicated operation and is dealt with fully on pages 66 to 70. In Model E-2 and H-3 it is rendered extremely simple by means of a serrated jaw coupling integral with each of the upper vertical shafts.

Timing Model E-2 and H-3

The upper bevel pinion which meshes with the camshaft gear sets in a bronze bearing pushed into the cylinder block casting. Through this bearing passes a short hollow shaft integral with the pinion. The lower end of this hollow shaft projects about three-quarters of an inch below the bearing and is splined. On these splines is forced a disk with fine radial serrations.

On the vertical driveshaft there is splined a corresponding disk and the shaft itself continues on upward, passing right through the hollow shaft of the bevel pinion and terminating in a thread on which there is a nut. By tightening this nut the driveshaft is lifted until the two serrated disks are locked together. In order to time the camshaft the nut is loosened and the shaft gently tapped downwards till the teeth on the disks come out of mesh. In this position the camshaft can be rotated freely and when set correctly it only remains to tighten the nut once more. (See cut page 67.)

A factor which increases the accuracy of this adjustment is that the vertical shaft runs at one and a fifth crankshaft speed, thereby giving a two and two-fifths to one reduction between vertical shaft and camshaft which means that for each degree of camshaft rotation there is a 2 deg.: 24 min. movement of the vertical shaft. This permits the serrations to be quite substantial and yet



Cylinder assembly complete and ready for attachment to crankcase allow a delicacy of adjustment within two degrees of accuracy.

It may be remarked that while this adjustment is not employed on the older models of Wright motors it is capable of being applied thereto since all the parts interchange with those of the older designs.

Pump Drive

The lower half of the crankcase supports another shaft with a bevel pinion at its upper end, this pinion meshing with the same gear on the crankshaft which drives the upper vertical shafts. This shaft is also vertical and is mounted in a bronze carrier socketing into a hole in the aluminum of the case. The lower end of this shaft has a tongue through which the drive for the oil and water pumps is taken, in a manner to be described later. In order to minimize weight all the intermediate shafts run at a speed one-fifth greater than that of the crankshaft. The increase of speed also enables the size, and therefore the weight, of the oil and water pumps to be kept very low.

The crankshaft is hollow throughout, for lightness and for the passage of oil. It is supported on four babbitt faced bronze bearings and one ball bearing, the latter being at the rear end immediately in front of the bevel gear. The front end of the crankshaft has a taper on which the propeller hub is mounted and directly back of this is a ball thrust bearing housed in the crankcase.

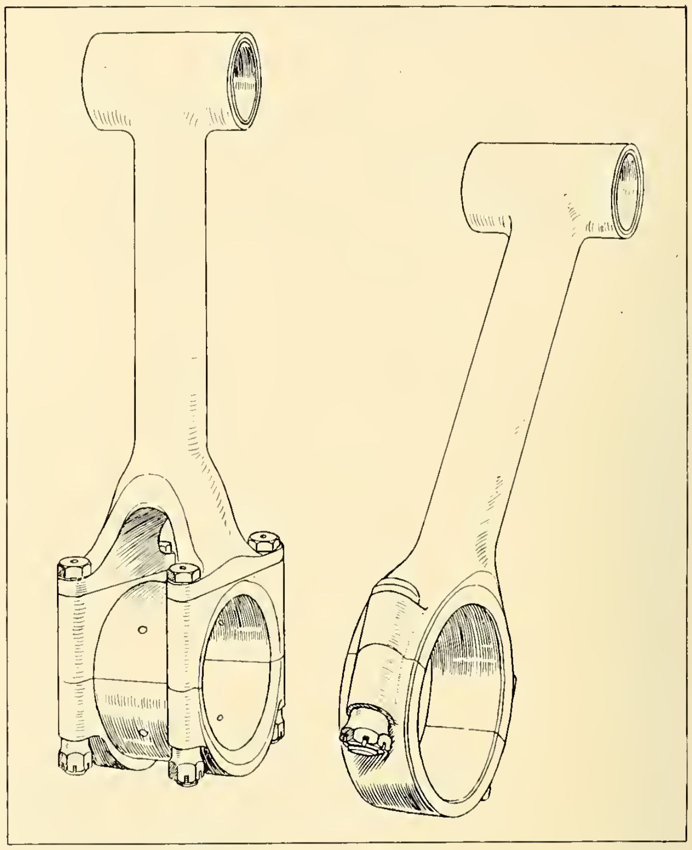
Magneto Drive Models E-2, H-2 and H-3

The rear end of the crankshaft is splined to receive the master bevel pinion which drives all the supplementary shafts. Immediately behind this short splined portion and across the extreme end of the shaft there is a deep slot, into which fits a corresponding tongue on the magneto drive shaft.

There are two magnetos, each eight-cylinder instruments. One is wired to all the spark plugs located on the outer sides of the cylinders, the other to all the plugs situated in the Vee, between the blocks. The magnetos are mounted crosswise with their distributor ends tilted upward and towards the outside of the engine, at an angle of 35 degrees to the horizontal, which in most installations makes the breaker boxes very accessible.

It should be observed that tilting the magnetos also has the advantage that it permits the engine bearers of the fuselage to be continued straight backward as far as the constructor of the airplane may desire; since no part of the motor interferes therewith.

Both magnetos, with their drive shaft and gears are made up in a unit and are demountable as such. The rear end of the crankcase has a circular, flanged opening provided with a ring of studs, and the aluminum magneto bracket attaches thereto. There are three magneto gears: central in the bracket is a short shaft with a tongue at the front end which fits into the slot in the end of the crankshaft and at the other end, housed in the bracket, is a ball bearing which supports the shaft. A bevel pinion on this shaft meshes with two others, one on each side, these being also mounted on ball bearings.



Inner and outer connecting rods

The magnetos themselves are attached to the bracket by cap screws and a very simple and effective form of coupling is used. On the end of the armature shaft is a small spur gear with 23 teeth and on the bevel pinion shaft is a similar gear but with 24 teeth. To connect the armature and pinion shafts there is a sleeve furnished at both ends with an internal gear which just fits the little spur gears. When this sleeve is located symmetrically both the internally toothed portions mesh with the spur gears and so give a solid drive connection which has ample freedom to allow for such small inaccuracies of alignment as may exist. A spring is used to maintain the sleeve in its driving position, but by removing a cotter pin the sleeve is freed, can be slid back out of mesh, and the magneto can then be timed with great accuracy; since by moving *forward* one of the 23 teeth and simultaneously moving *backward* one of the 24 teeth the effect is obtained of an advance of seven-tenths of one degree.

A magneto can, of course, be removed without affecting the coupling, since the gear simply slides out when the cap screws holding the magneto to the bracket are removed. If a hand starting crank is used, it is attached directly to the back of the magneto bracket, the shaft being prolonged and the end of the bracket flanged for this purpose. In cases where a gasoline pump is employed, this also is attached to the bottom of the magneto bracket, taking its drive from a short vertical shaft and another bevel gear meshing with the main magneto driving gear. It should be noted that the magnetos are absolutely identical since, owing to the bevel gear drive, they both rotate in the same direction.

Pistons of Models E-2, H-2 and H-3

The pistons are of aluminum alloy and are of quite simple design. There is no ribbing beneath the heads of E-2, H-2 and H-3 as the section of the head is heavy enough both for strength and, what is more important, to carry away the heat from the center of the head rapidly.

Each piston carries four compression rings and one scraper ring near the bottom of the skirt. Here occurs one of the small differences between the E-2 and the H-3 engines, the H-3 having four ring grooves, one for each ring, and the E-2 having the rings in pairs in two grooves of double width. Wrist pin bearing surface is about equally divided between the small end of the connecting rod and the bosses of the piston, the pin being free to turn in either. On model H-2, to prevent endwise movement of the pin, there is an aluminum cap at each end, the cap itself being held against turning by tongues which fit in slots cut in the piston.

In the case of model E-2 and H-3 a bronze button is forced into either end of the wrist pin which leaves the pin perfectly free to float or turn as it likes while the presence of the bronze removes any possibility of scratching the wall of the cylinder.

Connecting Rods

There are, of course, two connecting rods operating on each crankpin and these are of different form. They are known as outer and inner rods respectively. The inner rod has a hollow, tubular shank which is split toward the lower end and opens out into two flat feet which attach to a bronze "box" by four bolts. These same four bolts hold together the two halves of the bronze box, which is split in two halves and babbitt lined, so forming a conventional lower connecting rod end of the marine type.

The outside of the bronze, in the space between the two feet of the forked rod, is turned and forms the bearing for the outer connecting rod lower end, this being split in the normal way and held together by two bolts. This design allows for the fitting of a new set of bearings with ordinary tools and methods; also the bronze being a very good conductor helps to dissipate the heat produced by the friction. Model A has rods of an entirely different design described on page 11.

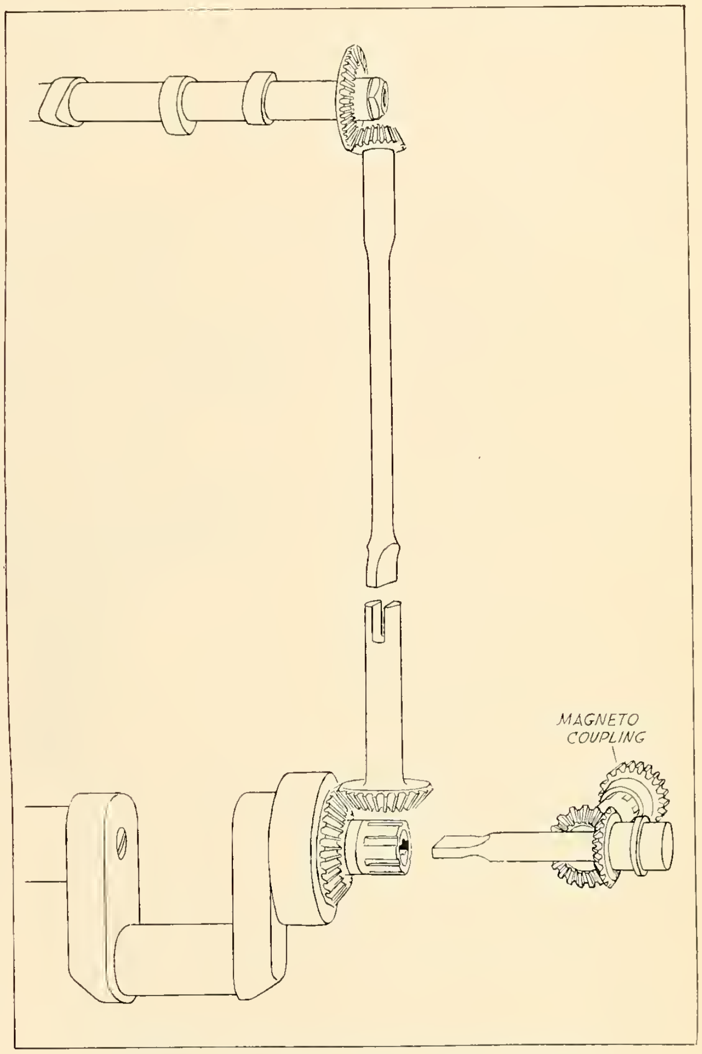
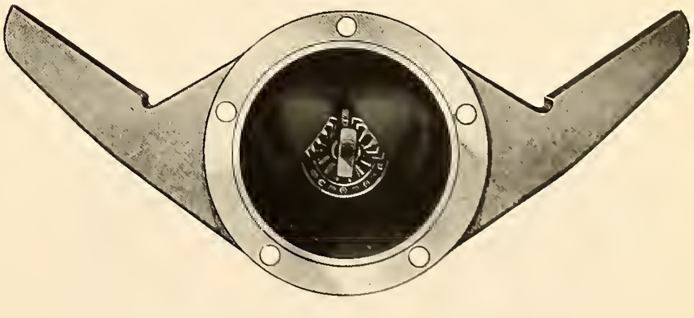


Diagram of gear train for one cylinder block

Lubrication System Models E-2 and H-3

There is one main oil channel, this being a steel tube cast in the lower half of the crankcase, in which the oil pump is located as already described. From this main channel oil passes to the four main bearings of the crankshaft. Each of the main bearing bushings is completely encircled by a groove cut in the aluminum which is thus kept full of oil. Passing through holes in the

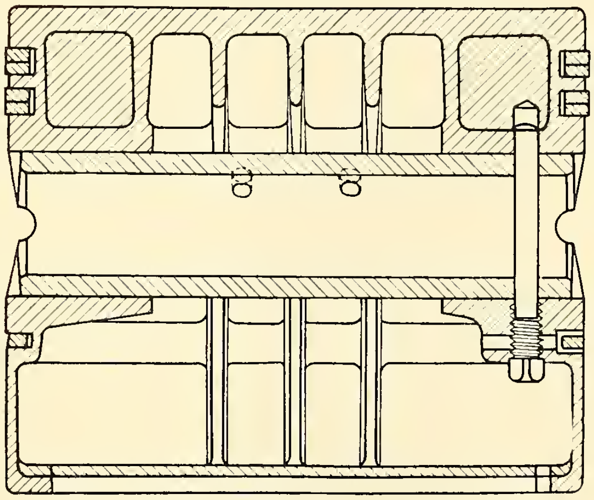


Rear view of inclined magneto bracket

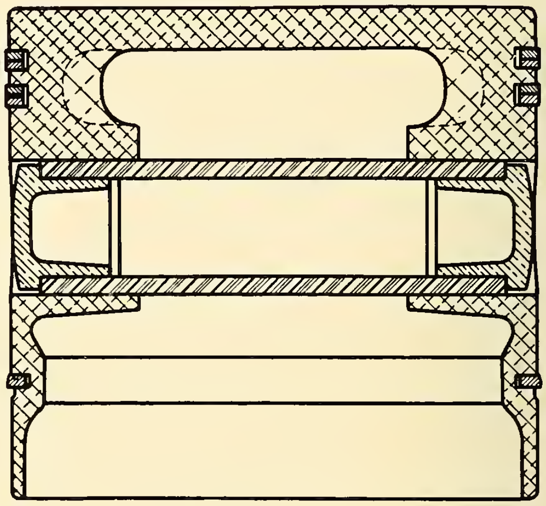
E-2—Inclined bracket has boss on bottom for attaching Wright geared fuel pump. A hand starter or Bijur starter can be attached in addition to fuel pump.

H-2 and H-3—Inclined bracket has pad for attaching Sylphon fuel pump at back. There is no provision in this bracket for attaching Wright geared fuel pump or starters.

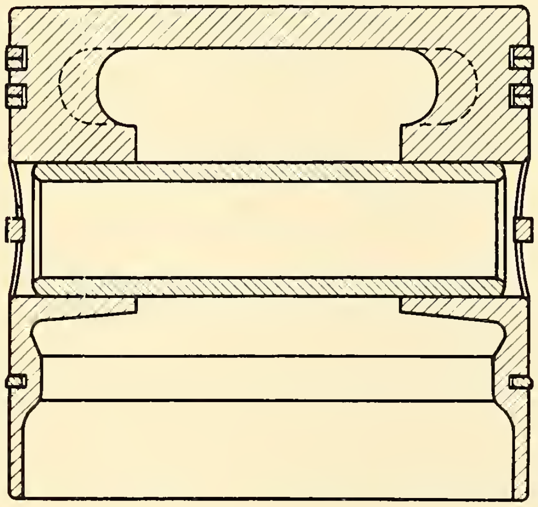
DIFFERENT TYPES OF PISTONS USED IN VARIOUS MODELS



Original Model A design



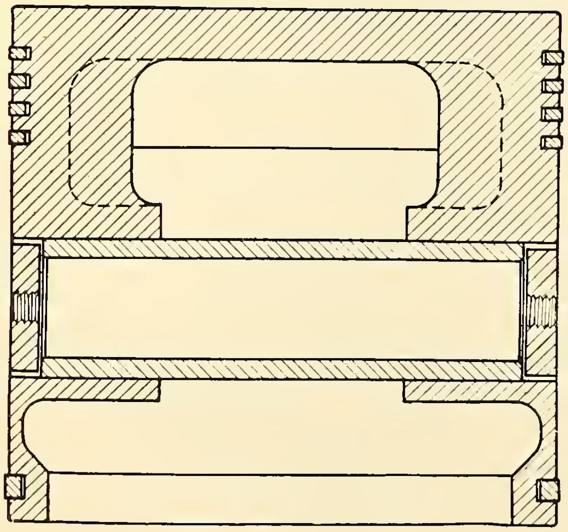
E-2 Piston



Type of ring grooves on A, I, E, E-2

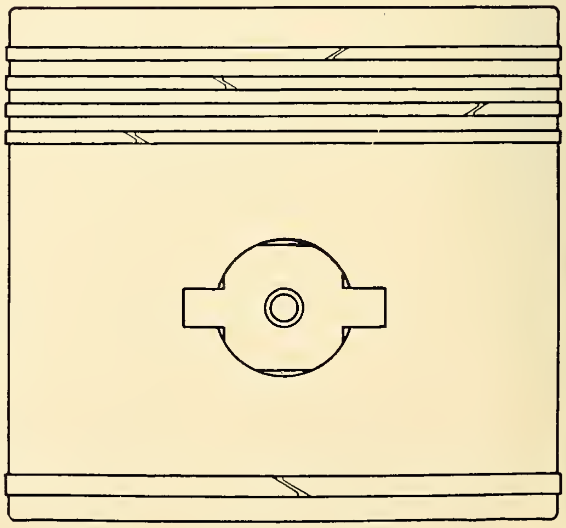
Piston pin retainer ring on early E and I

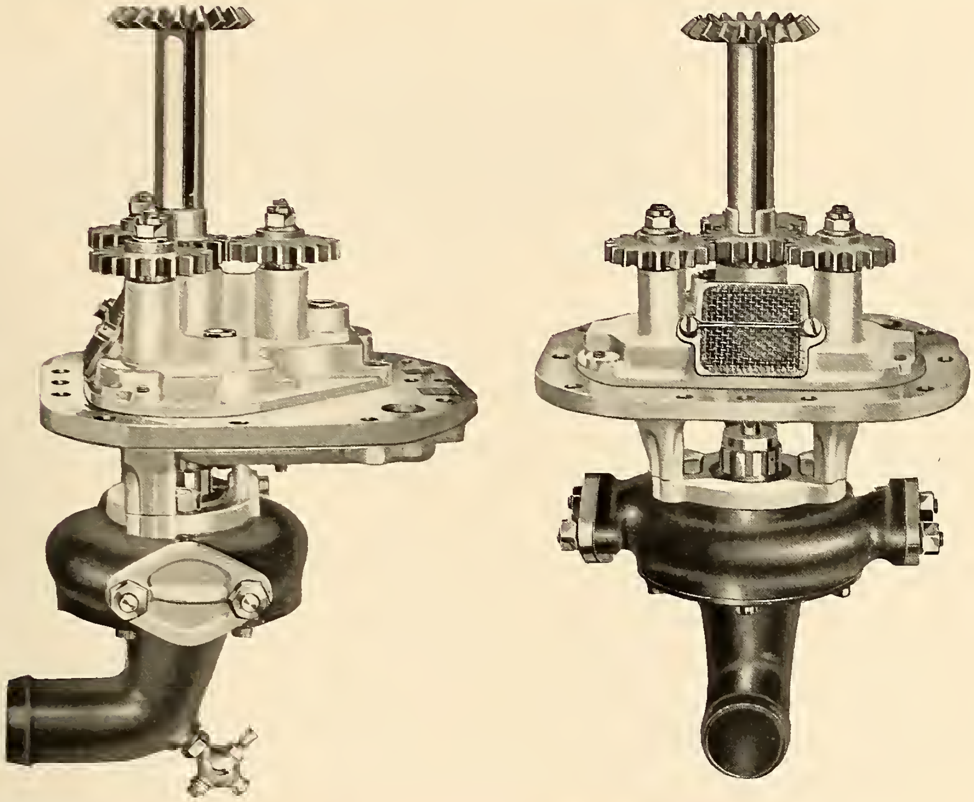
H-3 piston has plug type piston pin retainers similar to E-2; but is otherwise the same as H-2 piston.



Type of ring grooves on H-2 and H-3

Piston pin plug on later E, I *and H and H2*





Model E-2 oil and water pump assembly

bushing oil reaches the crankshaft, and passing on through holes in the shaft completely fills the inside thereof, passing out again through other holes which lead to the lower ends of the connecting rods. Further holes in the inner connecting rod member lead oil to the outer rod bearing. Piston and wrist pin lubrication is performed by the oil spray exuding from all bearings.

Camshaft and valve lubrication is obtained by taking oil from the groove around the front end main bearing and leading it up through two small steel pipes, one attached to each cylinder block. These lead to holes in the aluminum registering with holes in the front end camshaft bearings. Thence the oil enters the camshaft itself, which is hollow from end to end, small holes drilled in each cam allowing lubricant to be discharged directly upon the tappets. These holes are on the opening face of the cam and so oil the tappet head just as the cam begins to lift. The excess not only lubricates the valves themselves but flows into the bearings supporting the upper vertical shaft. Here it obtains access to the space inside the tube inclosing the vertical shaft, falls down this, lubricates the lower vertical shaft bearings and returns to the crankcase. Every bearing and gear is thus taken care of in proportion to its requirements.

Thrust Bearing Oiling

For lubrication of the main thrust bearing on the front end of the crankshaft the methods used on models E-2 and H-2 differ slightly. In the former there is a lead drilled in the crankcase which connects the main channel to the thrust bearing, the hole being small enough to prevent so great a flow of oil as to cause a drop in pressure. On Model H-2 the bearing is not connected with the pressure line, but directly above it is a pipe which attaches through a rubber hose to the vent of the external oil tank.

On Models A, E, I, H and H-3 the thrust bearing is taken care of by the general spray from other bearing.

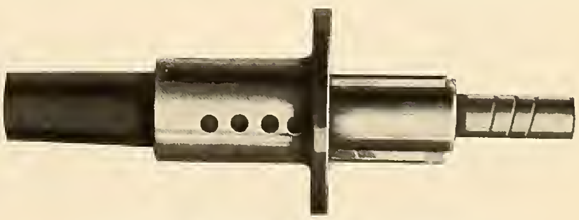
When the front end of the engine is at a lower level than the rear end, as when diving or climbing according as to whether the ship is a tractor type or not, there is a tendency for oil to collect in the front end of the valve cover. Here, if too great an accumulation occurs, valve fouling may result. To guard against this on Model E-2 a small pipe is taken out of the valve chamber at the front end and run back to the crankcase. This overflow line is made up alongside the pressure line from crankcase to camshaft.

Oil Pump System Models H, E-2, H-2 and H-3

There are in all three oil pumps of which one is the feed pump and two are the suction pumps. The feed pump draws its oil from an external tank and forces it through a screen into the main feed line. The two suction pumps take oil from the two ends of the crankcase and deliver it to the external tank, an oil radiator usually being placed between the pumps and the tank although tank and radiator are sometimes combined in a single unit.

The object of this triple pump system is to keep the crankcase dry at all times. If the engine is steeply inclined so that all the oil escaping from the bearings runs to one end of the crankcase, then one alone of the suction pumps will operate; the other, as it will be drawing air instead of oil, merely idles until such time as the plane changes its inclination.

All three pumps are made in a single unit, mounted



Old type oil pump with shaft and vanes half withdrawn on a base plate. In the bottom of the crankcase there is a large orifice into which the pump assembly fits, being held in place by a number of studs and located exactly by a pair of dowels. There is a single casting forming the body for all three pumps and a single spur gear drives all three. This gear is situated centrally and its shaft has a slot in the upper end which engages with the tongue on the lower end of the pump drive, mentioned on page 4, the dowels in the crankcase and base plate ensuring alignment. The base plate is perfectly flat on its upper surface to which the pump body is attached, but it is a cored casting containing all the intake and outlet oil passages for the three pumps.

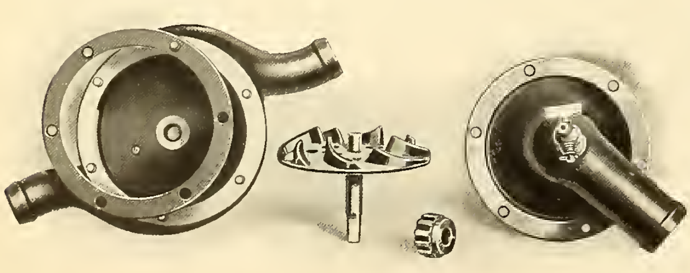
Running in various directions in a horizontal plane, these cored passages lead to a number of holes in the surface of the base plate, which holes correspond with similar holes in the crankcase, in turn leading to the various lines which comprise:

- Main pressure line.
- Suction line from the front end of the crankcase.
- Common external outlet from both suction pumps which is piped to the radiator.
- External suction for the pressure pump which is piped to the tank.

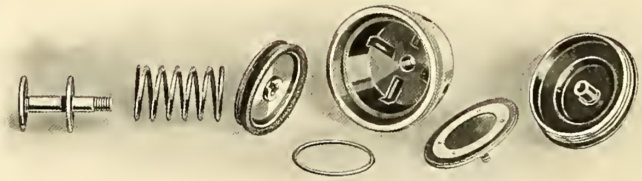
The intake for the suction pump which cares for the rear end of the crankcase has no line of course, but is merely an opening in the pump body covered with a coarse screen for the purpose of excluding particles of solid matter which might be in the oil and be large enough to injure the pump gears.

Thus except for the two external connections to radiator and tank, all the oil lead junctions are made automatically when putting the pump assembly in place.

There is a difference between the E-2 and H-3 in that the former has the suction line to the front end of the crankcase cast inside the case, while the latter has an external line. Also there is a difference in the form of the oil screen, this being cylindrical in the case of E-2 and removable from the side of the crankcase, while on H-2 it is hemispherical and is removed from beneath. There are also some detail differences in the pump construction, but the principle remains the same. In both motors there is an oil pressure relief valve situated on the side of the crankcase and communicating with the filter screen chamber, on the delivery side of the screen.



Body, rotor, and packing nut of water pump



Parts of air pressure pump

It may be remarked that the whole of the oil system as just described is different from that used on earlier models, the lubrication of which is dealt with in the supplements on old models, pages 11 to 18.

Water System All Models

The water pump is a simple centrifugal type with two outlets. It is placed directly beneath the oil pump and is attached to the underside of the oil pump base plate, thus forming an integral part of the oil pump assembly. The main oil pump driveshaft extends right through the casing and has a square hole in its lower end into which a squared end of the water pump shaft fits. A rather unusual and effective detail is that the gland nut on the water pump is recessed so as to catch any oil that may escape down the drive shaft and conduct it to the packing. The two water pump outlets connect by separate pipes to the outer, rear corners of the cylinder jackets, and the hot water issues from the upper, front corners to the radiator.* E-2 and H-3 engines are built with copper water pipes attached from pump to cylinder intakes.

Carburetion

A Stromberg carburetor has been used since the early Summer of 1918. It is described in detail on pages 20 to 24. There are two intake flanges on each cylinder block connected together by cast aluminum pipes and these lie close against the blocks. Above the carburetor there is a water jacketed aluminum casting having two outlets on the sides and two underneath. To the latter the two outlets on the duplex carburetor connect, the side outlets attaching to the center of each intake branch. On one side the connection is by a flange bolting solidly in place, and on the other side there is a short intermediate piece provided with a gland, allowing for expansion. This layout with the double form of carburetor is equivalent to two separate carburetors and intake systems, one for each block.

Air Pump

Since gasoline is fed to the carburetor by air pressure in many installations, the left hand valve cover carries a small air pump which comprises a bronze cylinder and

* This applies to a tractor installation, the connections are, of course, reversed for a pusher.

a piston with a cup leather. The piston is driven from the rearmost exhaust cam, its suction stroke being given by a spring that is compressed on the working stroke of the pump. The pump is not adjustable and supplies air at a higher degree of compression than is ever likely to be required. Various regulating devices for controlling the pressure in the fuel tank are in use but these are not part of the engine.

Accessory Drive

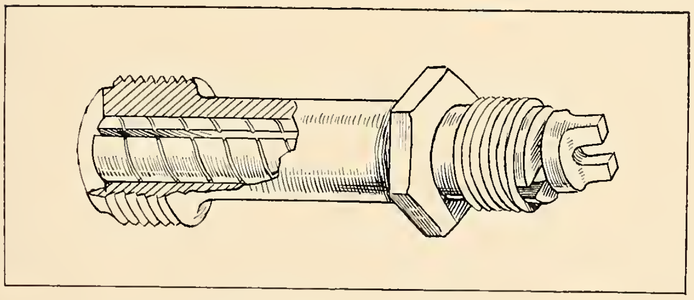
The rear end of each valve cover is provided with a threaded boss and each camshaft has a screwdriver slot in the rear end. In all installations a tachometer or motor speed indicator is used and the flexible shaft for driving this instrument is attached to a special connection supplied with the engine. This consists of a short brass body, screwing in the boss on the valve cover and containing a short shaft meshing with the camshaft slot and arranged at the outer end to take the standard form of flexible shaft connection. The tachometer can be attached to either camshaft, the hole in the end of the other valve cover being plugged.

Camshaft turns half the speed of crankshaft in opposite direction so tachometer must be geared 2 to 1 to read correct engine speed.

Propeller Hub

The propeller hub fits on the taper at the front end of the crankshaft and is not an interchangeable part in the ordinary sense of the word. Each hub is lapped by hand till it is a perfect fit on the taper and the key only performs part of the function of taking the drive, since the hub is drawn very tightly on the shaft. If the hub is not a perfect fit too much stress comes on the key and the hub is liable to "work" on the shaft. This will tear the shaft and hub and perhaps make it impossible ever to remove the hub.

The hub is locked in place by two nuts, of which one screws on the end of the crankshaft and the other into the nose of the hub itself. These two nuts fit one within the other and are free to turn relatively. That threaded *into* the hub has a finer thread than the one threaded *on* the shaft. In putting on the propeller the hub is drawn up by the inner nut, the outer being left a few threads unscrewed. When the inner nut is completely tightened it is locked by pulling up the outer nut and the two are then double locked by a clip wire. The purpose of the use of two threads of different pitches is seen when the propeller is to be removed, for then, after taking off the wire clip, *both* inner and outer nuts are undone simultaneously. The differential action of the two threads then gives great pulling power, which is necessary to break the hub free of the taper. Model A has a different form, described page 33.



Tachometer drive connector

Dimensional Data

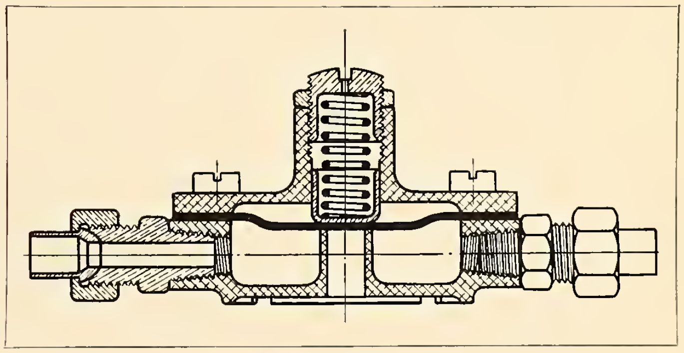
It may have been observed that in this description no dimensional details have been given. All such will be found on pages 76 to 77 under the heading "Tabulated Data." This covers all models of Wright engines and enables ready comparison to be made.

Fuel Pump Model E-2

On model E-2 provisions have been made for attaching a Fuel Pump. This is attached directly to the bottom of the magneto bracket, taking its drive from a short vertical shaft and another bevel gear meshing with the magneto driving gear.

Air Pressure Relief Valve

The Air Pressure Relief Valve is not supplied with motor equipment, but due to its positive operation, we recommend same to be used in connection with all models using air pressure for the fuel system. The valve as

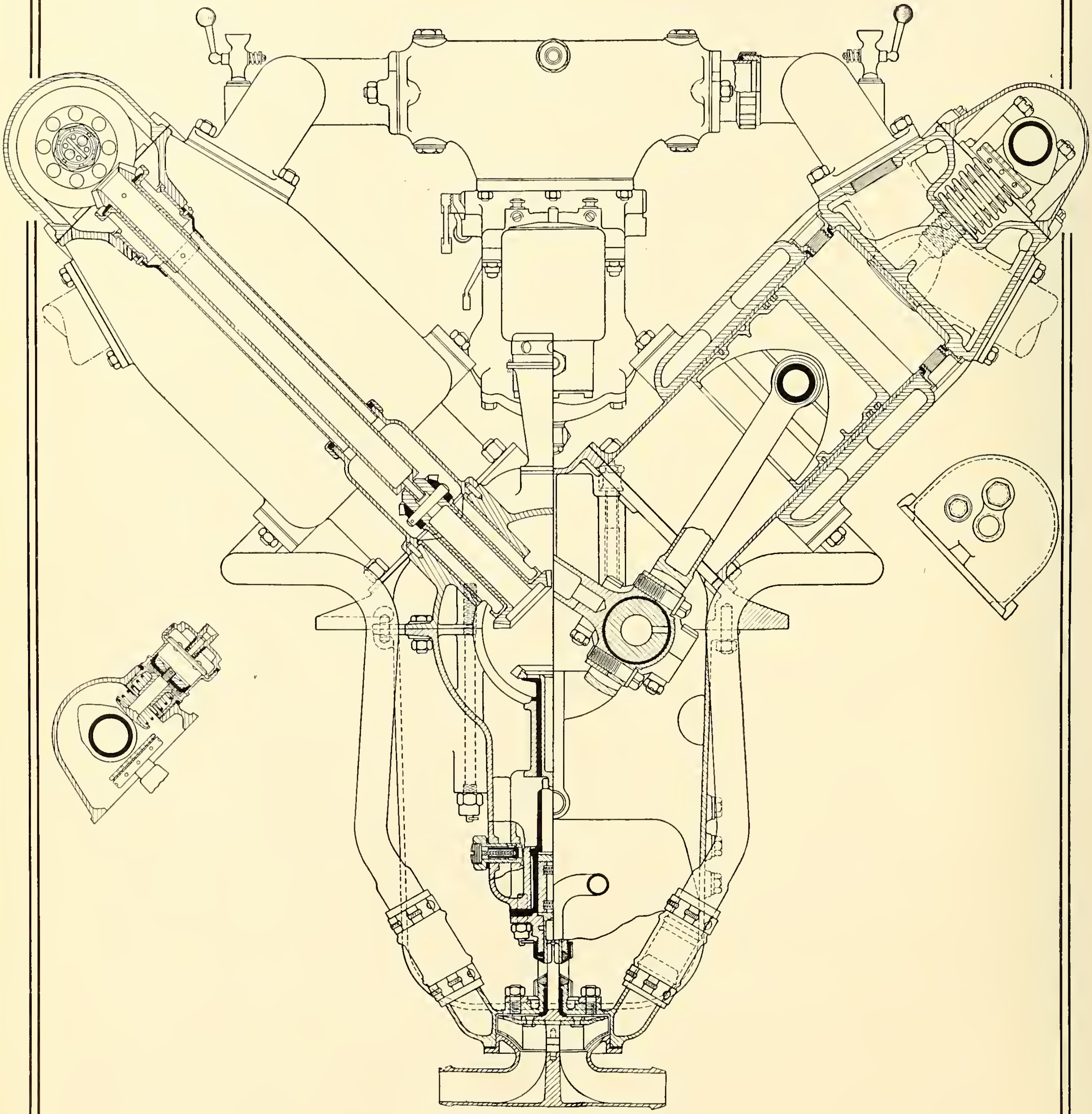


Air pressure relief valve

shown in cut consists of a leather plunger diaphram with the air under pressure on one side of the diaphram being balanced by a spring on the other side of diaphram. The spring is adjusted by small plug to desired pressure and locked by nut to prevent variation.

The valve can be assembled any way with reference to inlet and outlet lines. When excessive pressure is reached, the spring releases and allows air to pass out of line by means of several relief holes just beneath air pocket. The leather diaphram seats tightly maintaining pressure without leaks.

MODEL A WRIGHT ENGINE



Showing the piston and connecting rod construction peculiar to model A
Also the double intake on the water pump

MODEL A—SPECIAL POINTS IN DESIGN

Model A Was the Original Wright, Almost Identical With French Hispano-Suiza Motor

THE most conspicuous differences between the design of Model A and all the other models is the connecting rod construction.

As for all models these rods have hollow, round section shanks, but the lower end design is entirely different. Instead of the bronze box attaching to the forked end of the inner rod, it is the outer rod that is forked. There is thus a divided cap on the lower end of the outer rod, with a space between. After fitting this cap it is ground internally, just like the single end of the outer rod in the other designs.

Model A inner rod is forged with a lower end of very much the conventional gasoline engine type, but this lower end is not only bored but is turned on the outside also. It is split, and the cap attached by one pair of centrally located bolts. The bore of the inner rod is made larger than the crankpin and the outside is smaller than the internal diameter of the outer rod ends. This leaves quite a thin section of metal in the lower end of rod and cap, and this is drilled all over with small holes for babbitting.

By means of special tool equipment this lower end is then covered with babbitt both inside and out; the inside is fitted to the crankpin, the outside to the outer rod lower end. It should be particularly observed that this babbitting can only be performed successfully with complete factory equipment of an elaborate nature. The model A rod construction is slightly lighter than the marine type used on all the other models, but it is less durable, owing to the extreme difficulty of making a sound job of the babbitting, to the impossibility of refitting a bearing with ordinary tools, and to the fact that the thinner sections cause the bearing to run hotter.

Pistons

Model A pistons have thinner heads and a number of internal ribs or webs to support the heads. The wrist pin is fixed in the piston by a lock screw which threads into one of the piston bosses and passes right through the wrist pin.

Magneto Mounting

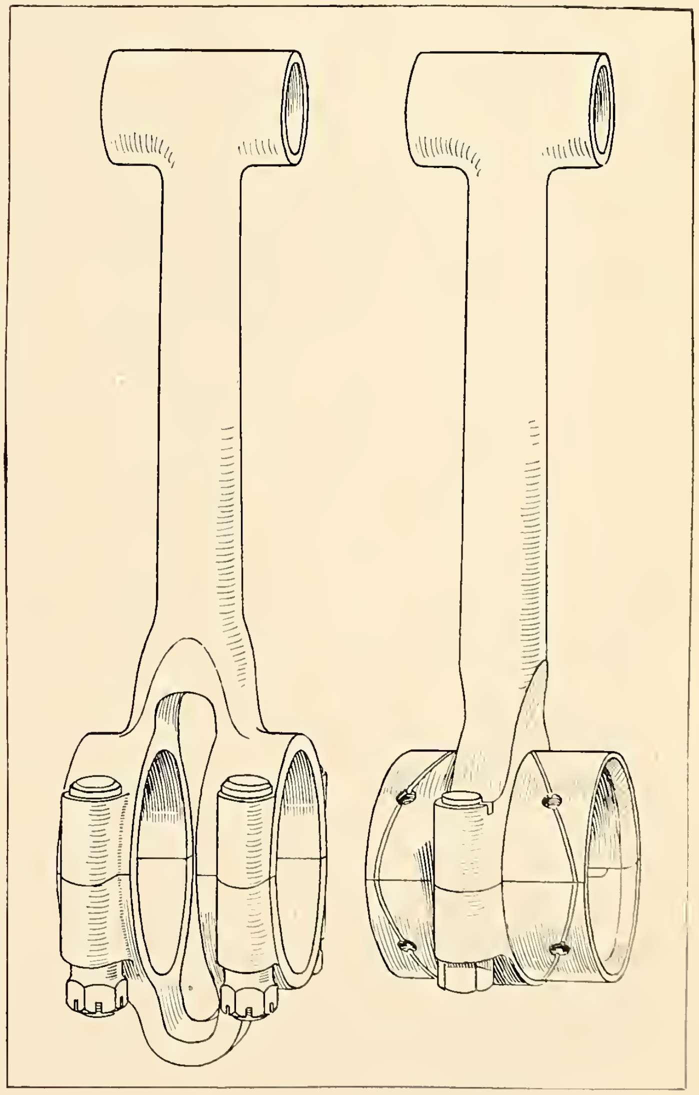
Instead of being a separate assembly altogether, the magnetos on Model A are attached to platforms located behind each cylinder block and cast integrally with the crankcase.

On the upper end of each of the lower vertical shafts there is a bevel pinion, and a corresponding pinion is attached directly to each magneto armature shaft. When the magneto is bolted down on its platform the pinions mesh; the drive being thus direct without any joint giving universal motion, wherefore the location of the magnetos has to be very accurate.

For timing, the pinion attached to the magneto armature has a flange mating with a similar flange on the part which is keyed to the shaft. Three bolts in slotted holes secure the two flanges together, thus allowing for adjustment.

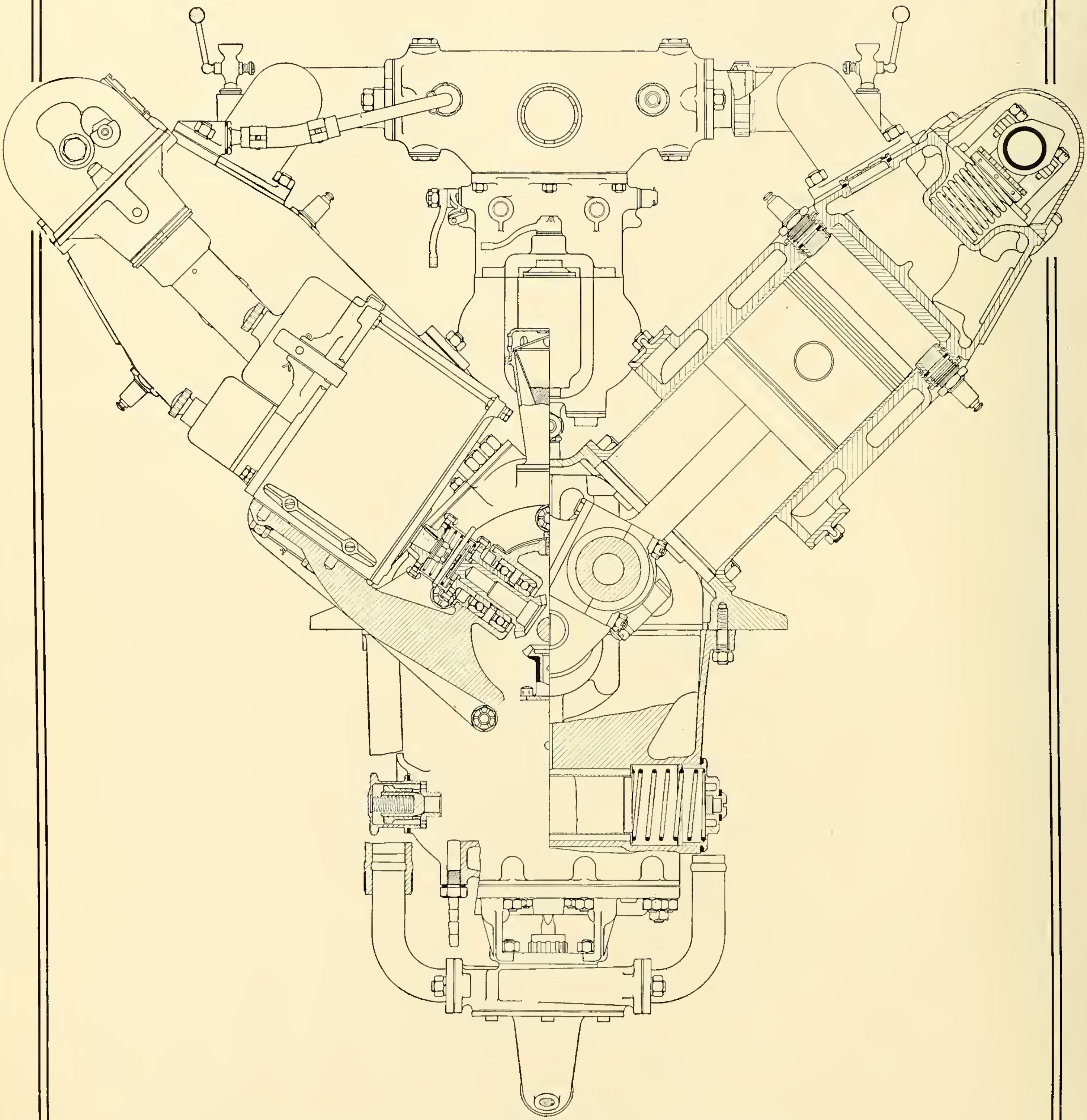
Lubrication System

The original Model A was designed to operate without an oil radiator or external tank, the whole supply being carried in the crankcase, automobile fashion. This, however, caused considerable trouble from overheated oil and radiators where usually fitted.



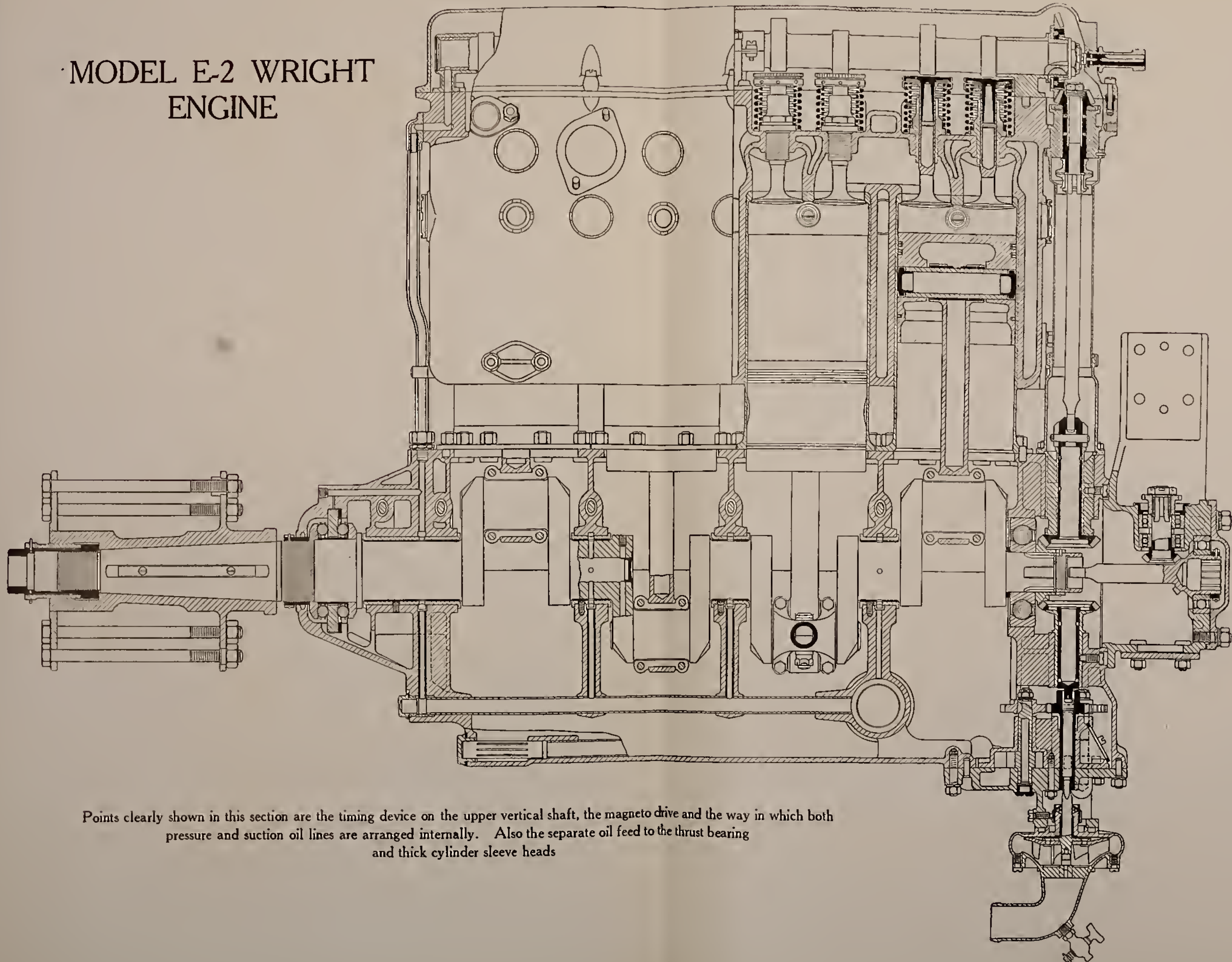
Model A connecting rod

MODEL E-2 WRIGHT ENGINE

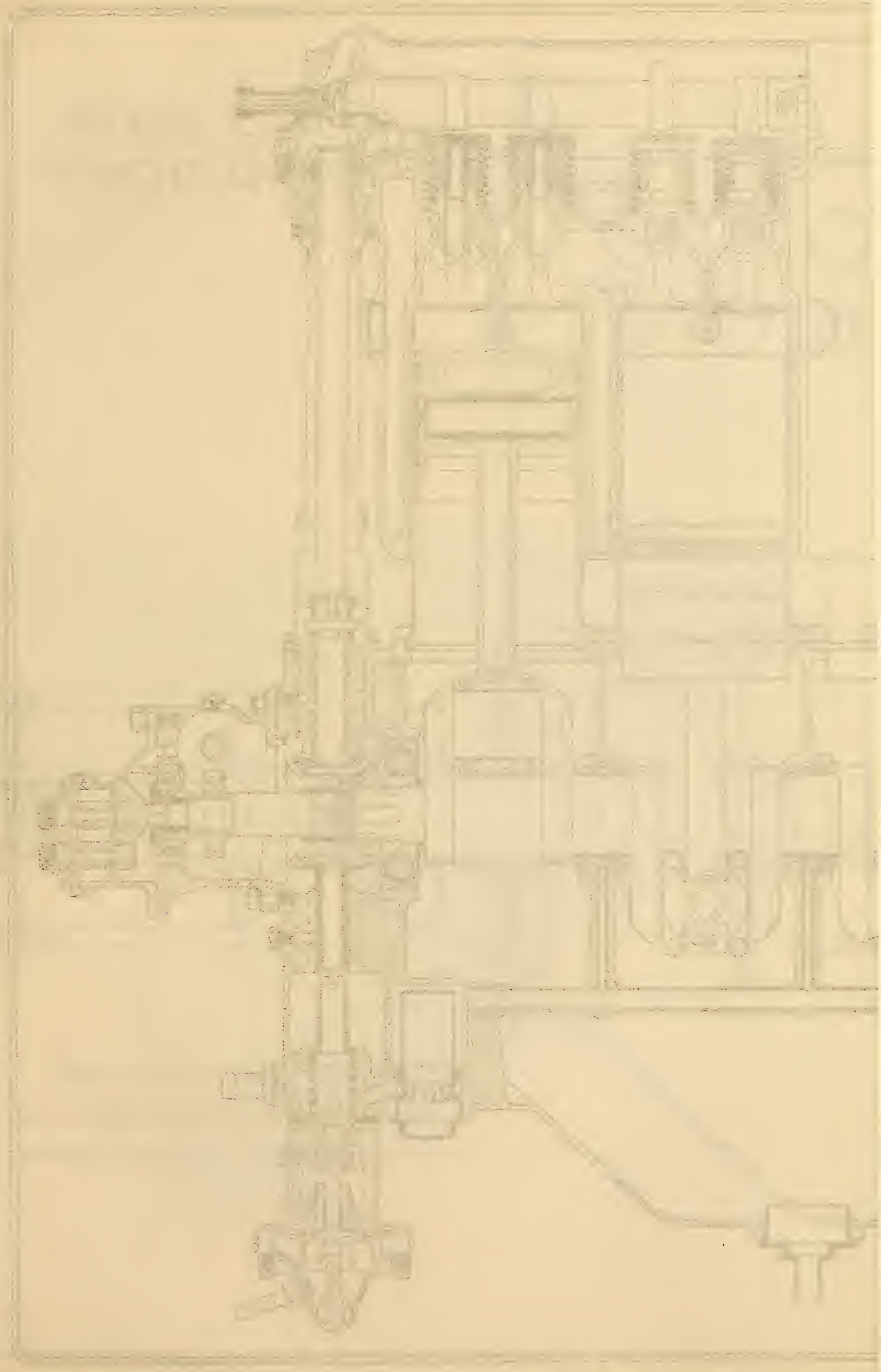


Showing the inclined magneto position and also the oil strainers and pressure release valve

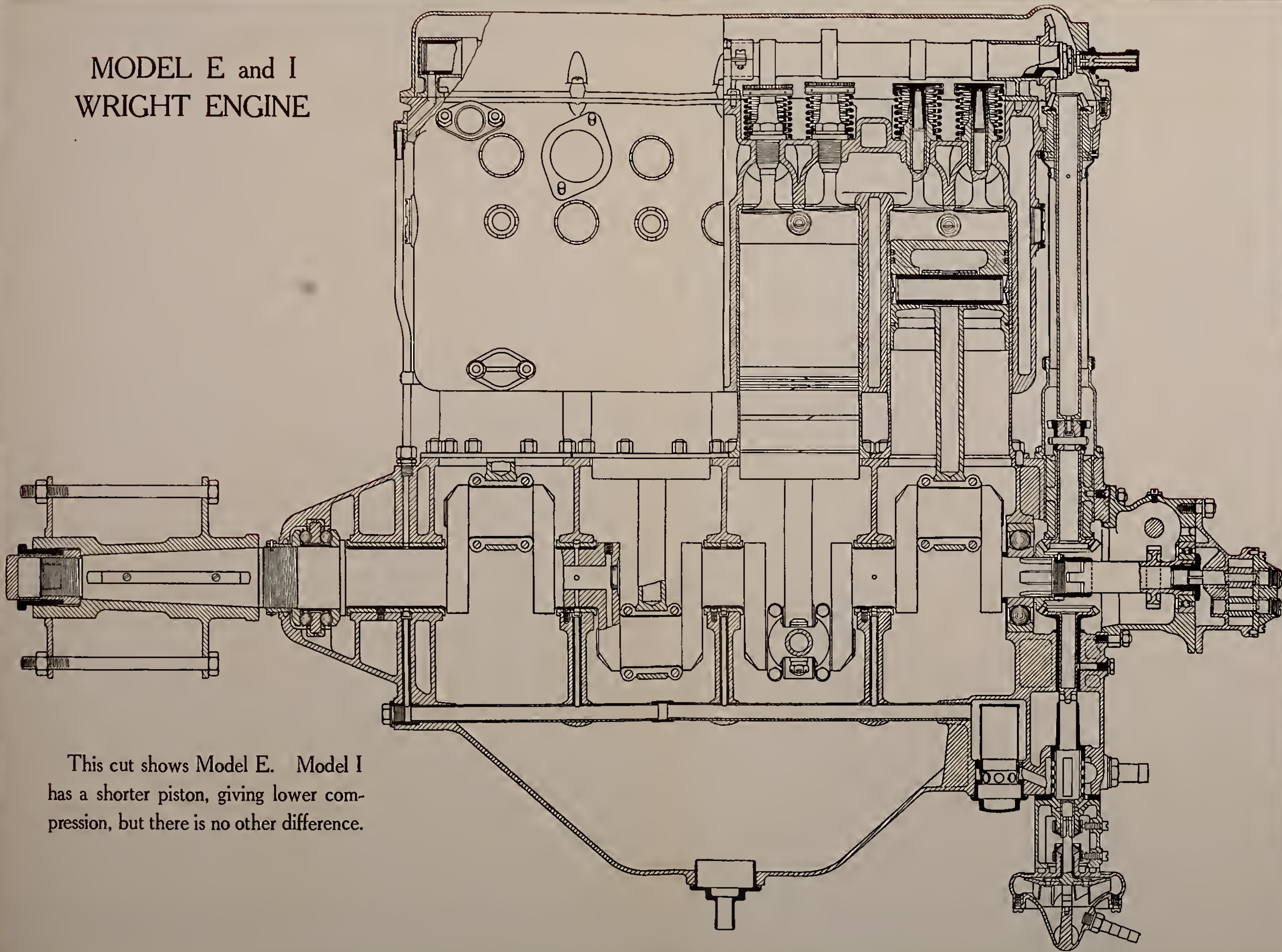
MODEL E-2 WRIGHT ENGINE



Points clearly shown in this section are the timing device on the upper vertical shaft, the magneto drive and the way in which both pressure and suction oil lines are arranged internally. Also the separate oil feed to the thrust bearing and thick cylinder sleeve heads



MODEL E and I WRIGHT ENGINE



This cut shows Model E. Model I has a shorter piston, giving lower compression, but there is no other difference.

The general circulation outward from the feed side of the pressure pump is the same for all models with the difference that model A has:

1. No feed to the thrust bearing on the crankshaft.

2. No drain pipes from the front end of the valve chambers.

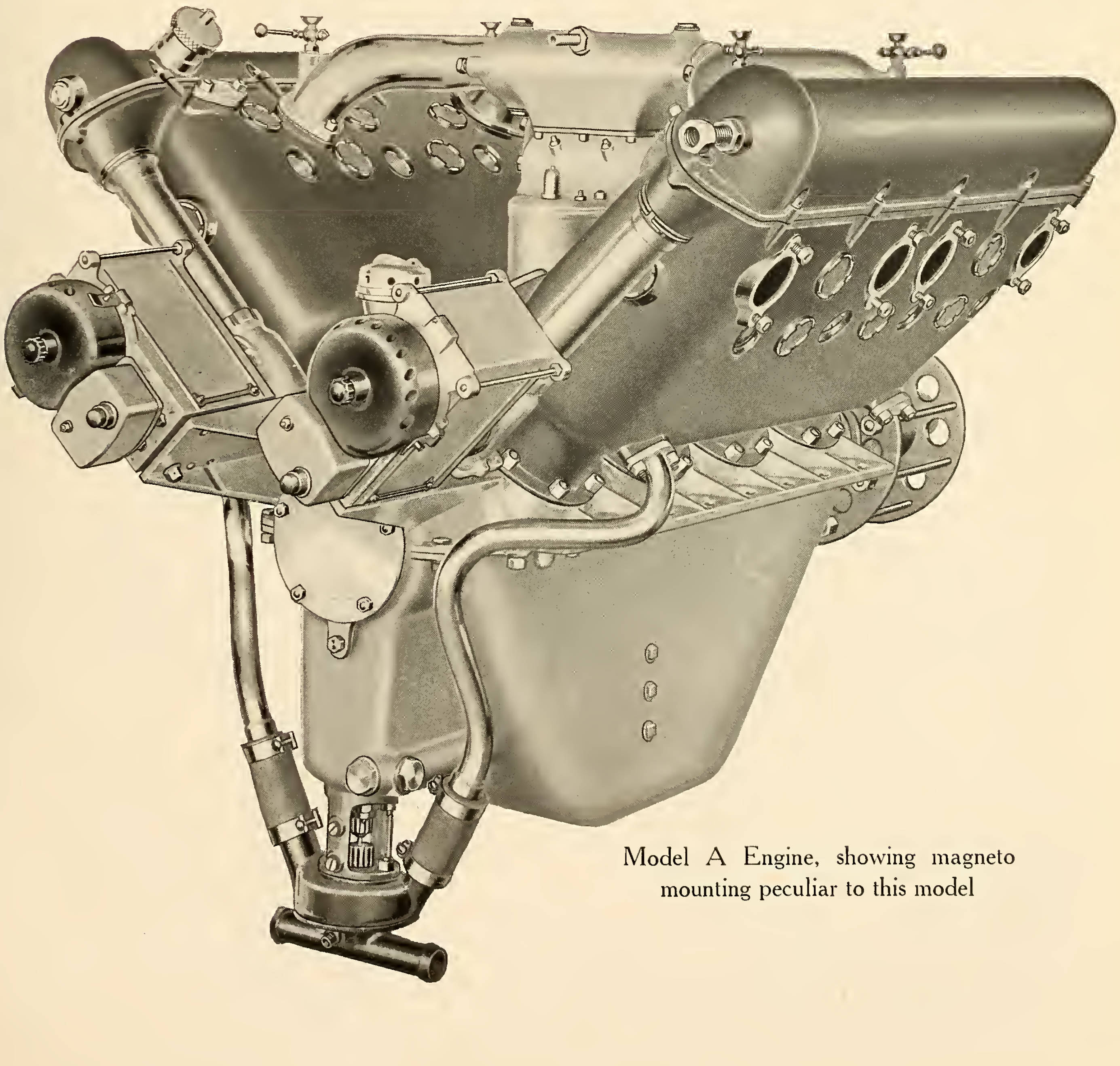
Model A has only a single oil pump, which circulates oil in one of two ways:

1. From the crankcase sump, through the system and back to the sump.

2. From a radiator and small tank placed directly beneath the engine, through the system, back to the crankcase, and thence by gravity down into the radiator, etc.

The oil pump itself is located in the same position as for other models, connecting for drive with the short bevel driven vertical shaft by means of the same sort of tongue and slot. It is not a gear pump, however, but is what is known as a vane type and operates as follows: The pump body is cast iron and is cylindrical inside and outside. It fits into a bored chamber in the crankcase, the bottom of the body being flanged and secured by studs.

The pump shaft passes right through the body but slightly eccentric to its bore. Through the shaft is a slot, and in this slot fit two bronze vanes or paddles, held apart by small coil springs, which force the vanes out against the walls of the pump body. Owing to the eccentricity the vanes slide through the slot in the shaft as the latter revolves. In the body, on the side furthest from the shaft, are holes connected to the suction line, while directly opposite are the pressure outlets. The vanes in



Model A Engine, showing magneto mounting peculiar to this model sweeping over the walls "wipe" the oil from the suction side and compress it into the delivery side. Very high pressures can be pumped provided the vanes are fitted accurately.

On the pressure side of the pump there is a cylindrical screen contained in a cavity in the crankcase, and removable from beneath. There is a pressure relief valve similar to that used for the other engines and located on the side of the crankcase.

The lower half of the crankcase is much deeper in the center than at the ends and a suction line is cast in the case, ending at the bottom of the sump, where there is a large plug. When using an oil radiator this plug is removed and is replaced by a hollow outlet connected by a short hose to the radiator. The suction line inside the case is closed by a brass plug and suction connection is made by a line taken from a normally plugged hole in the rear end of the crankcase.

Timing Camshafts

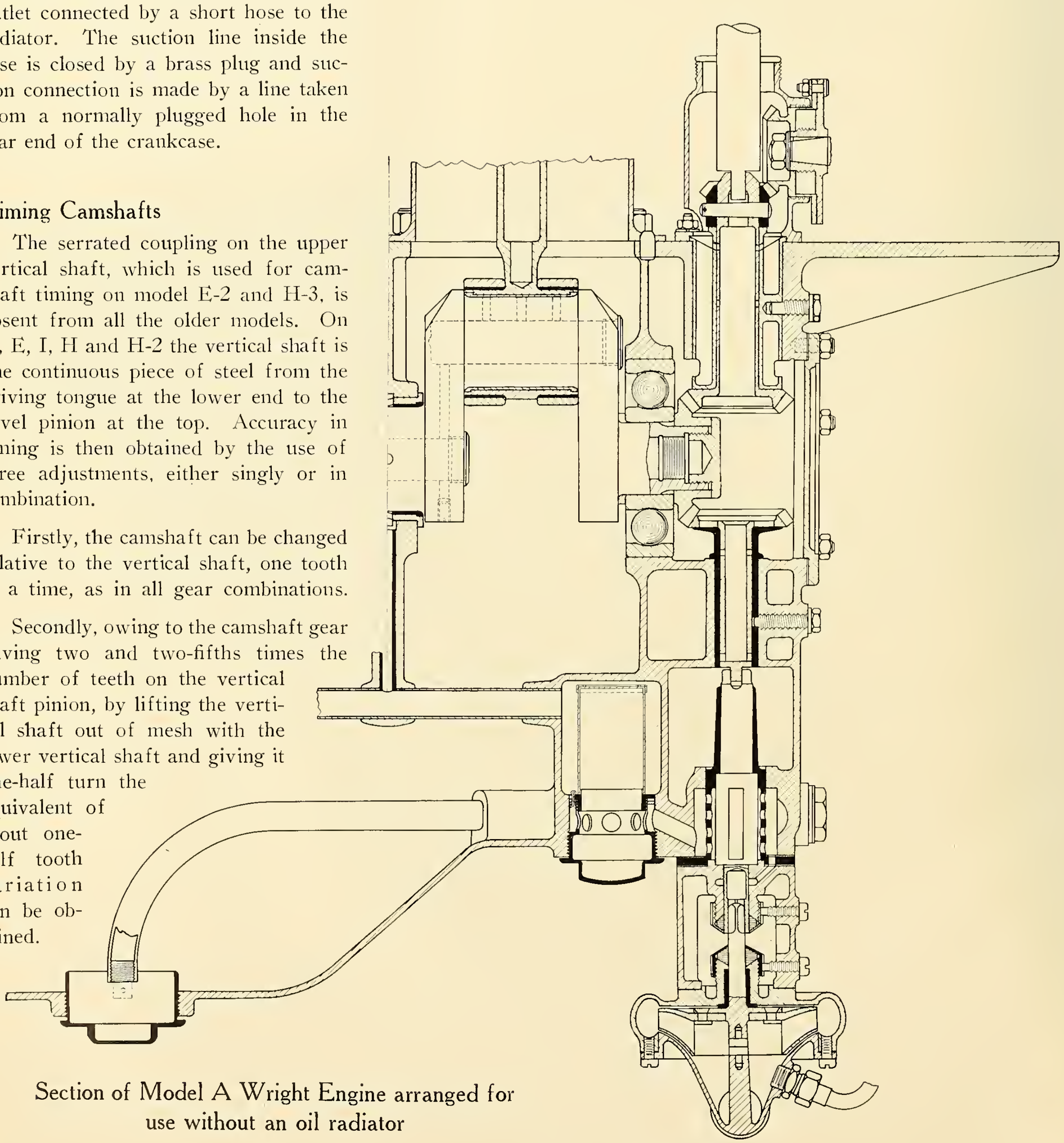
The serrated coupling on the upper vertical shaft, which is used for camshaft timing on model E-2 and H-3, is absent from all the older models. On A, E, I, H and H-2 the vertical shaft is one continuous piece of steel from the driving tongue at the lower end to the bevel pinion at the top. Accuracy in timing is then obtained by the use of three adjustments, either singly or in combination.

Firstly, the camshaft can be changed relative to the vertical shaft, one tooth at a time, as in all gear combinations.

Secondly, owing to the camshaft gear having two and two-fifths times the number of teeth on the vertical shaft pinion, by lifting the vertical shaft out of mesh with the lower vertical shaft and giving it one-half turn the equivalent of about one-half tooth variation can be obtained.

Thirdly, the camshaft gear, which has 36 teeth, has one keyway only cut in it, but the shaft end has five keyways. Thus by removing the gear and changing the placing of the key in the shaft we shift the gear relative to the shaft 72 deg. But there being 36 teeth in the gear each tooth covers 10 deg. Thus shifting the key back 72 deg. and then going seven teeth forward in the meshing gives the effect of a two degree retardation.

The propeller nut is attached by a single nut on which are two different threads on this nut, a coarser internal thread and a finer external; consequently the nut screws onto the shaft faster than into hub. This gives the differential action necessary to force the hub on the taper tightly.



Section of Model A Wright Engine arranged for use without an oil radiator

MODELS E AND I—SPECIAL POINTS IN DESIGN

These Models Marked the First Large Departure From French Designs, Having the Marine Type Connecting Rods

THE difference between models E and I is very slight indeed. By using a different proportion of piston the compression on model E is higher than on model I and the former is intended to run at a higher speed, thereby developing more power from the same piston displacement. This affects certain details of the magneto timing, etc., which are covered in the Table of Specifications and in the instructions for adjustment and overhaul. The description of the points in design which follows applies to both models E and I. Except for the points covered herein the design is the same as that of models E-2 and H-3 dealt with in pages 1 to 10.

Pistons

These are without ribs under the head, the head being thick enough both for strength and the rapid conduction of heat away from the center. The wrist pins float, being free to turn in either the small end of the connecting rod or in the piston bosses. On early E and I engines, to prevent the ends of the pin from scoring the cylinder walls there is a special, thin section piston ring in a groove which passes diametrically across the piston bosses. The later model E engines have had the wrist pins retained by aluminum caps like the piston of model H-2.

There are four compression rings placed in pairs in two grooves and a scraper ring, as well as the ring which secures the wrist pin, the latter not being thick enough to touch the cylinder wall.

Magneto Mounting

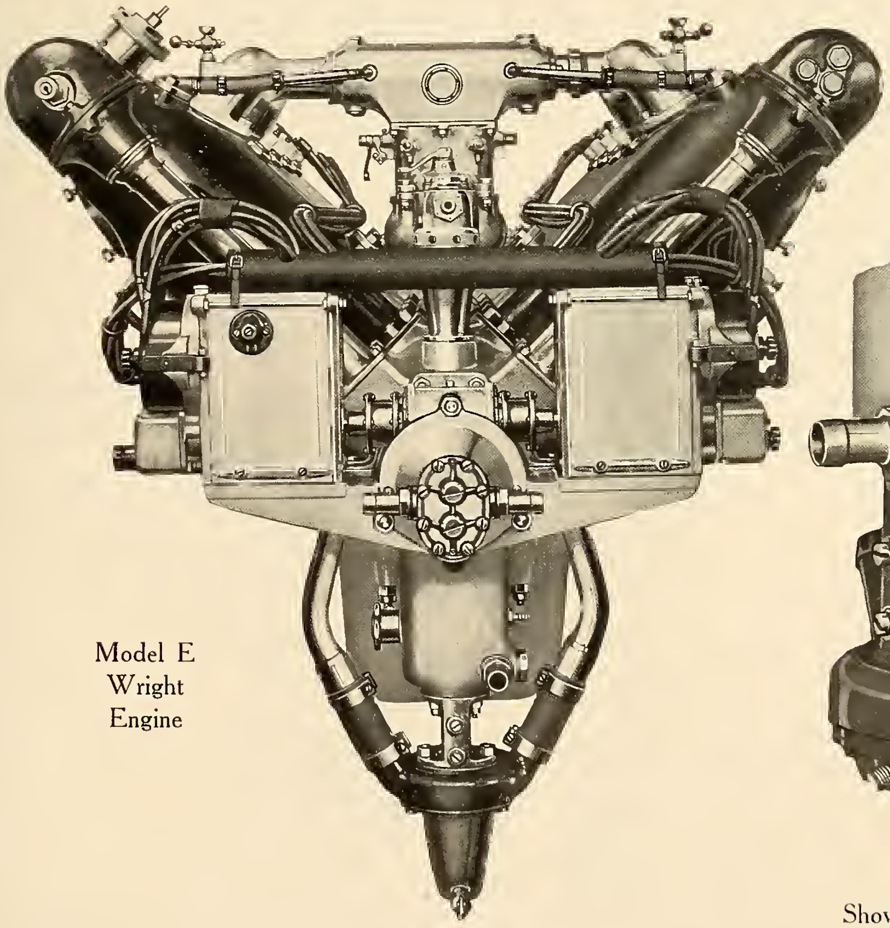
At the rear end of the crankcase a bracket is attached which carries the magnetos in much the same way as on models E-2 and H-2. However, instead of the magnetos being tilted upward, they set with their bases horizontal, on a level a little above that of the crankshaft center.

There is a centrally located driveshaft connecting with the crankshaft precisely as for models E-2 and H-3, but instead of carrying a bevel pinion it has a spiral gear upon it. With this gear there meshes a companion pinion on a cross shaft mounted in ball bearings in the bracket, and to the outside ends of this shaft are attached the magneto couplings of the identical design of models E-2 and H-3. Since both magnetos are thus driven off *opposite* ends of a common shaft they rotate in *opposite* directions, which means that one right hand and one left hand magneto is necessary instead of two right hand instruments.

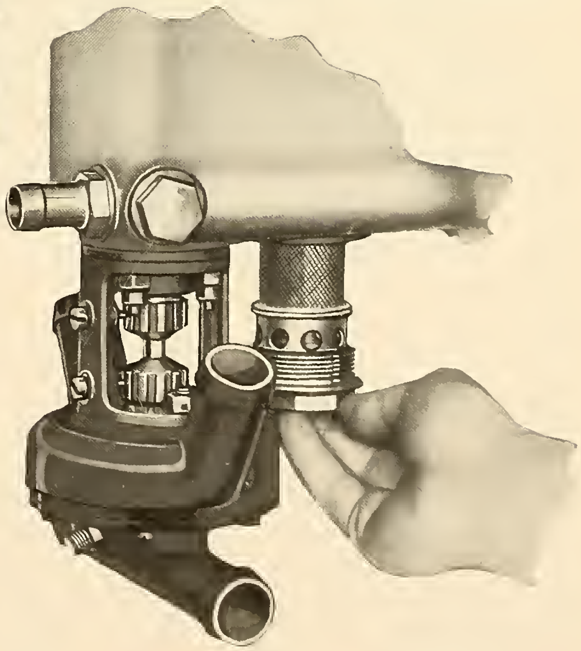
Lubrication System

The primary motion magneto driveshaft is carried out through the back of the magneto bracket somewhat as in models E-2 and H-3, but instead of being used for the application of a starting device, it operates small gear type pump.

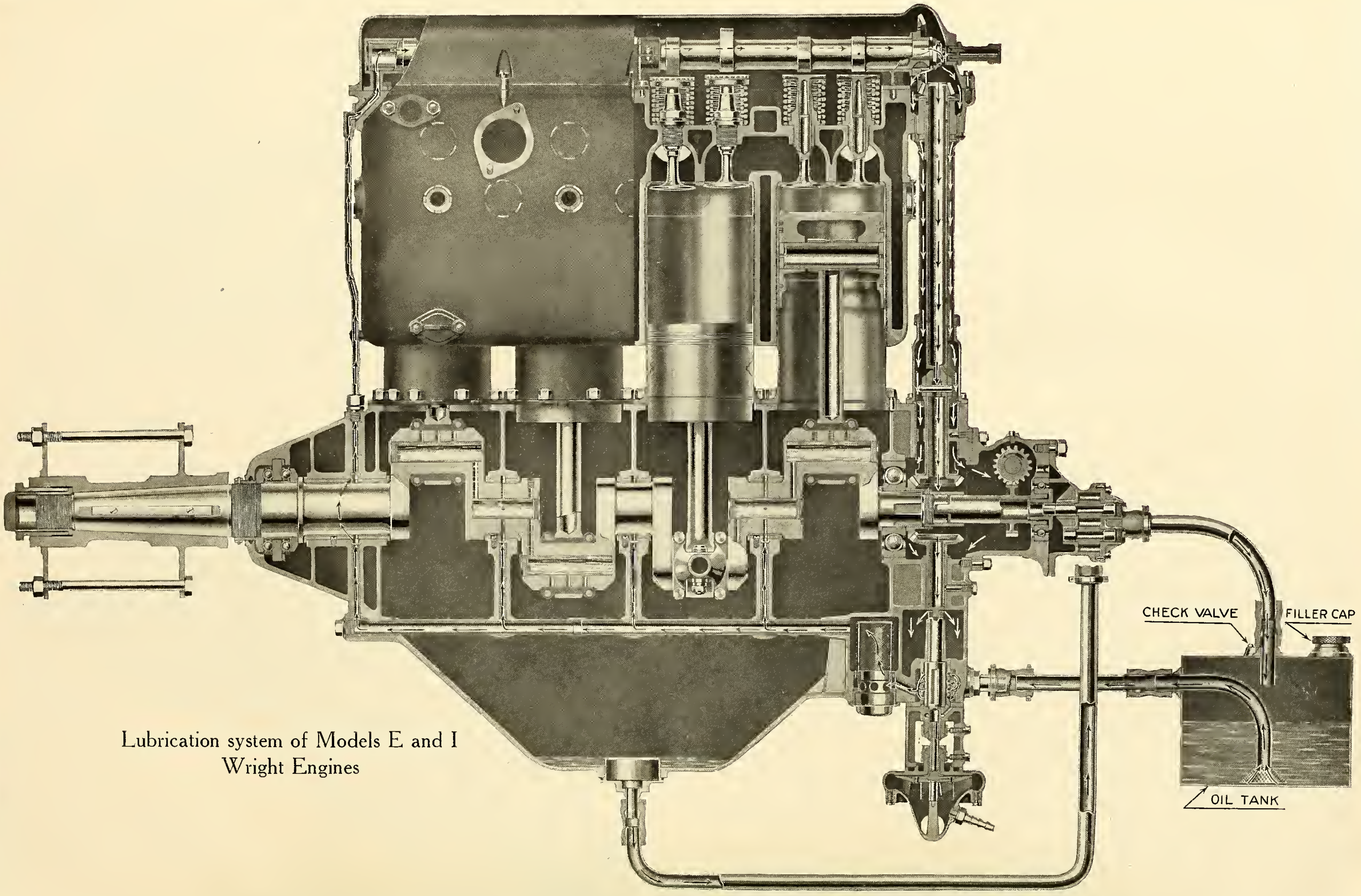
The pressure pump is exactly like that of model A (see cuts pages 7,



Model E Wright Engine

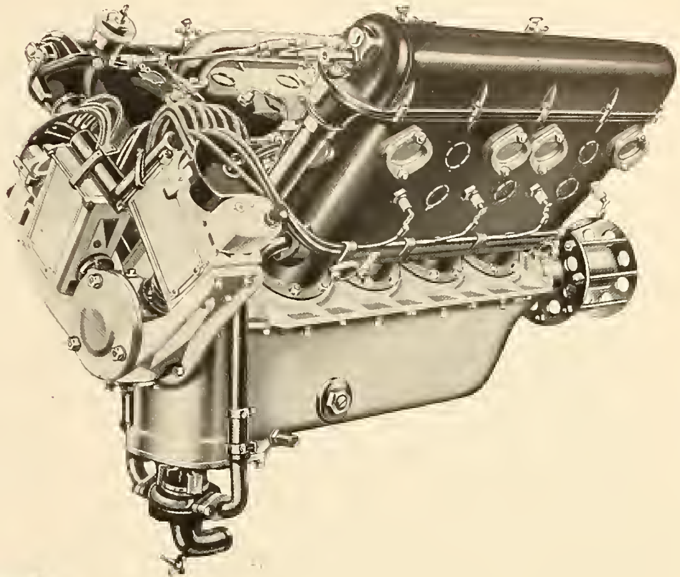


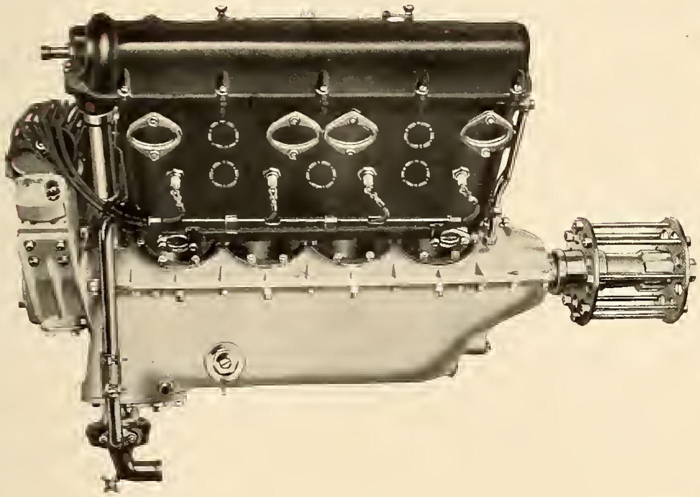
Showing location of oil strainer on Model E engine

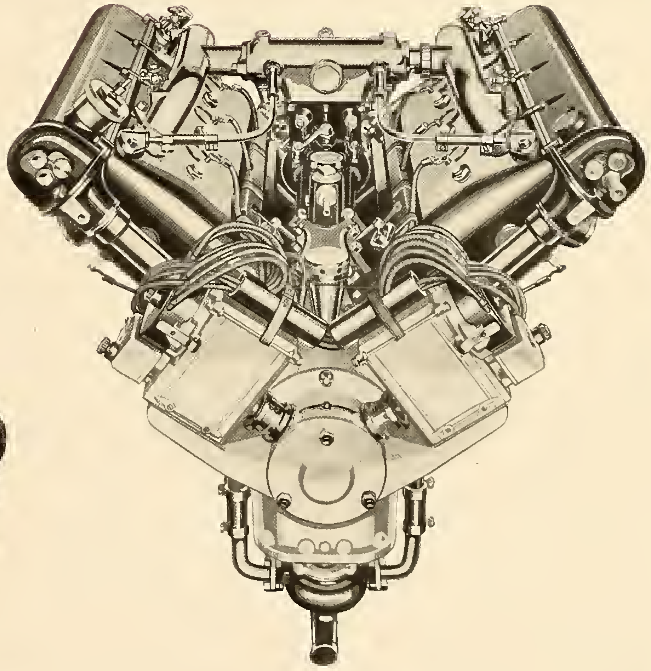


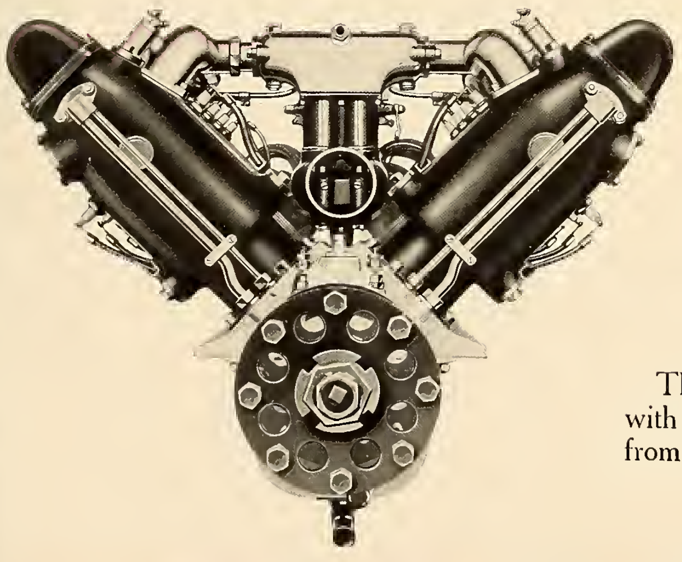
Lubrication system of Models E and I
Wright Engines

MODEL E-2 WRIGHT ENGINE

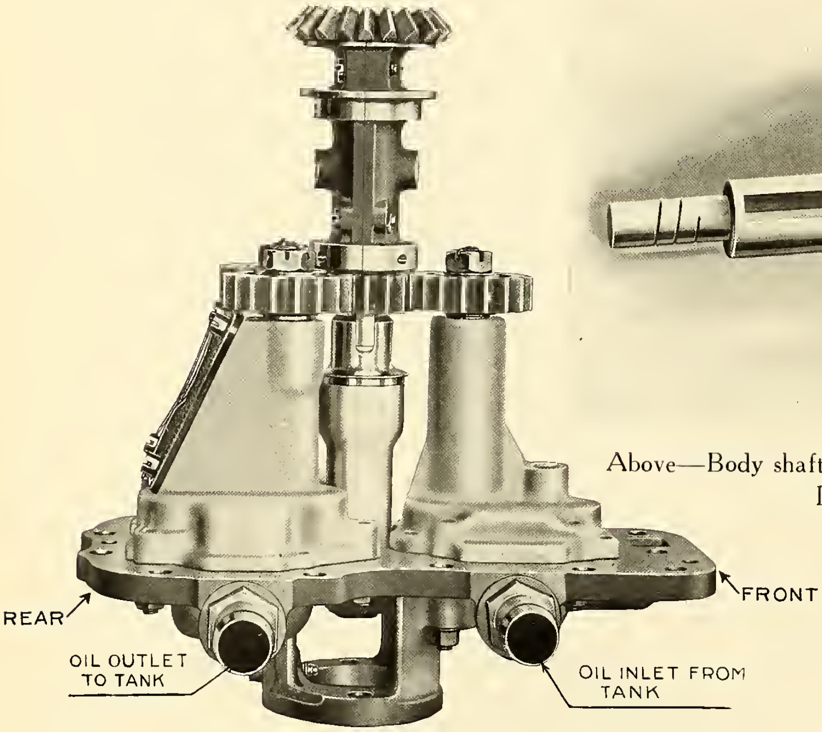


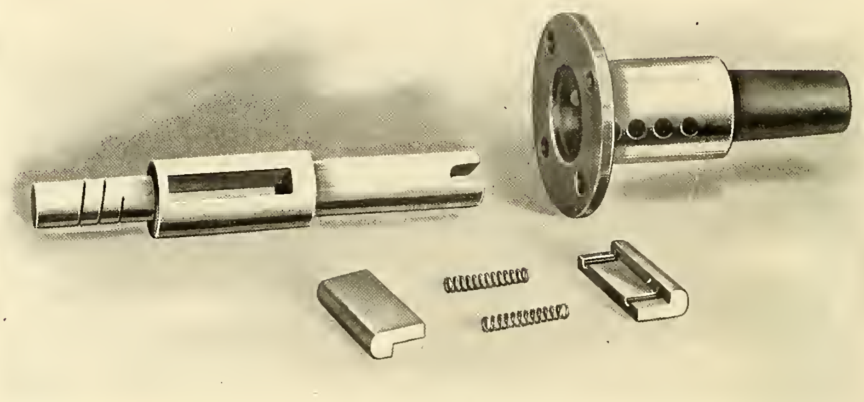






These views show the Model E-2 Wright Engine with the complete standard equipment, as sent out from the Wright plant.





Above—Body shaft and vanes of oil pump used on Models A, E and I.
Left—Oil pump assembly of Model H.

14 and 18), but with the difference that there is no suction line inside the crankcase. The lower half of the case is deepest at the center, and oil escaping from the bearings runs out through a hose connection plug in the middle of the sump. Thence it passes to the suction side of the little gear pump driven off the end of the magneto drive-shaft, which in turn delivers it through the oil radiator to a main tank. It is from this latter that the pressure pump draws its supply.

This layout gives the same dry sump effect that is obtained with models E-2 and H-2, but the pump arrangement is much less compact and more external piping is required.

MODEL H—SPECIAL POINTS IN DESIGN

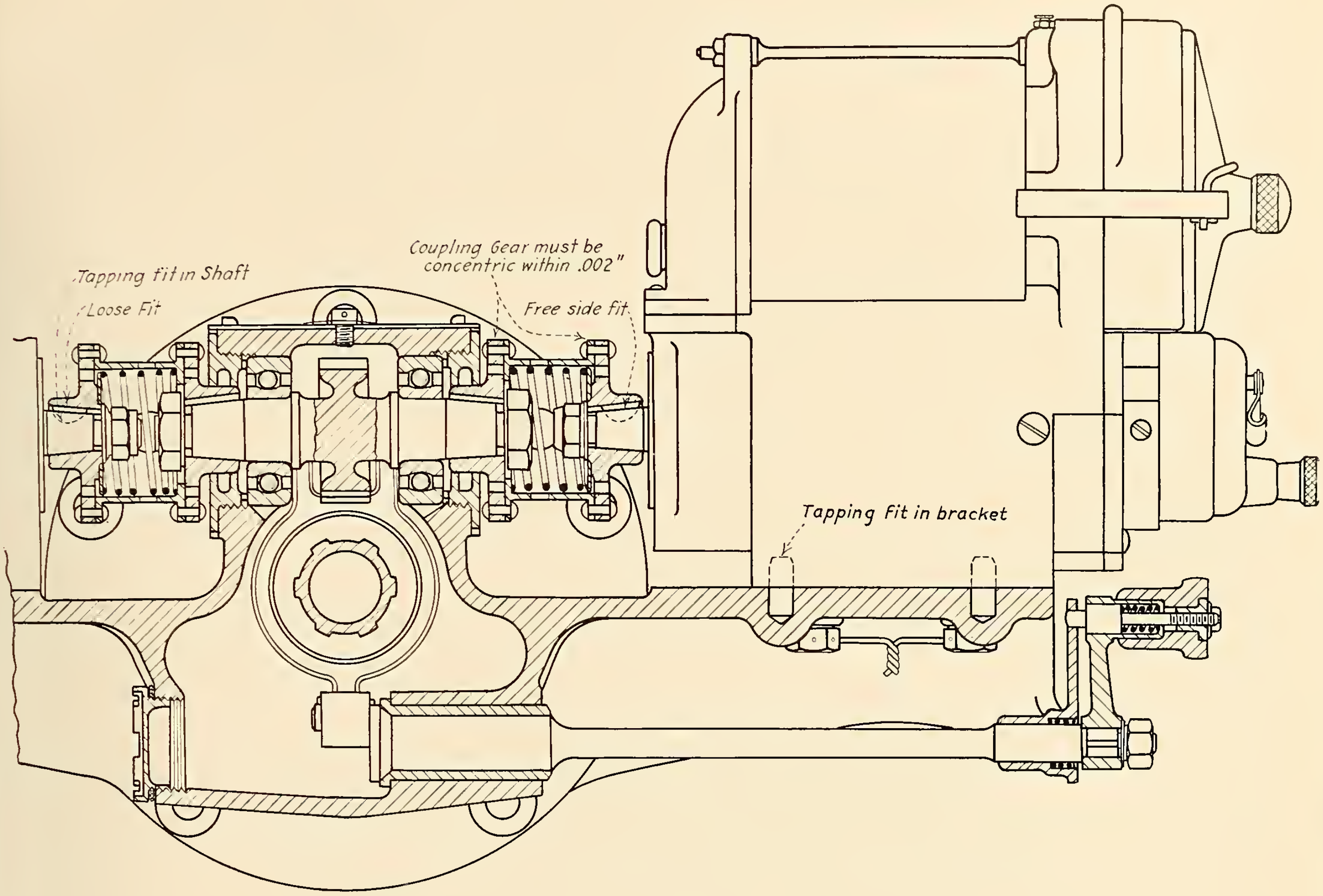
This Model Was Designed With Many Differences From the French 300 H.P. Engine, Notably the Triple Oil Pump System

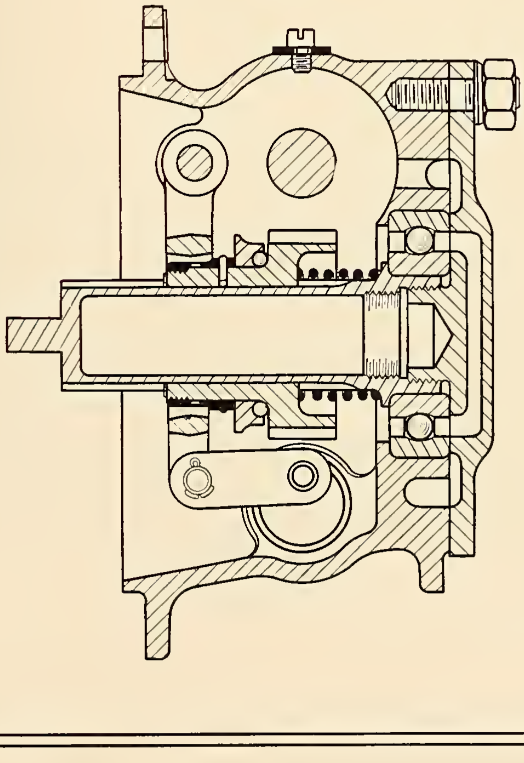
THE design of model H is in all general respects similar to that of models E and I, having only one really important point of difference, this being the lubrication system.

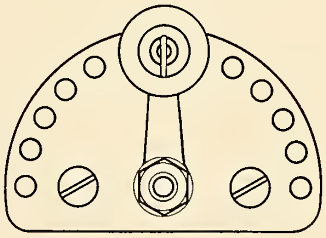
This is the same as for models E-2 and H-3 (see description, page 7) except that the detail design of the triple oil pump is different. The pump fits into the crankcase as a complete assembly in just the same way and the circulation is exactly the same.

Instead of having an internal suction line for withdrawing oil from the front end of the crankcase there is a pipe attached externally underneath the crankcase. Also there is no separate feed for the thrust bearing on the crankshaft, this being lubricated by the same spray which cares for pistons and wrist pins. With these reservations the description, page 7, applies throughout.

The model H pistons are unlike the early models E and I in that the method for retaining the floating wrist pin consists of aluminum caps instead of an additional piston ring. Model H piston is exactly like that of model H-2 (described page 5).







Magneto mounting details of Model H Wright engine
(See page 37)

CARBURETORS OF WRIGHT ENGINES

Describing the Principle of Action of the Stromberg Used on Present Models and the Zenith Used on the Original Model A

ON the original model A Wright engine the carburetor was a Zenith D.C.48. On models E, I and E-2 it is a Stromberg NA-D4. On models H, H-2 and H-3 it is a Stromberg NA-D6. The principle of the two Stromberg instruments is identical, in fact they are almost identical in all respects except size.

A slight change in the size and number of the holes in the accelerating well has been made for the H-3 and the carburetor called NA-D6A.

In the following pages the principle and design of, first the Stromberg and then the Zenith carburetors, is described. For instructions regarding the overhaul of carburetors see page 71.

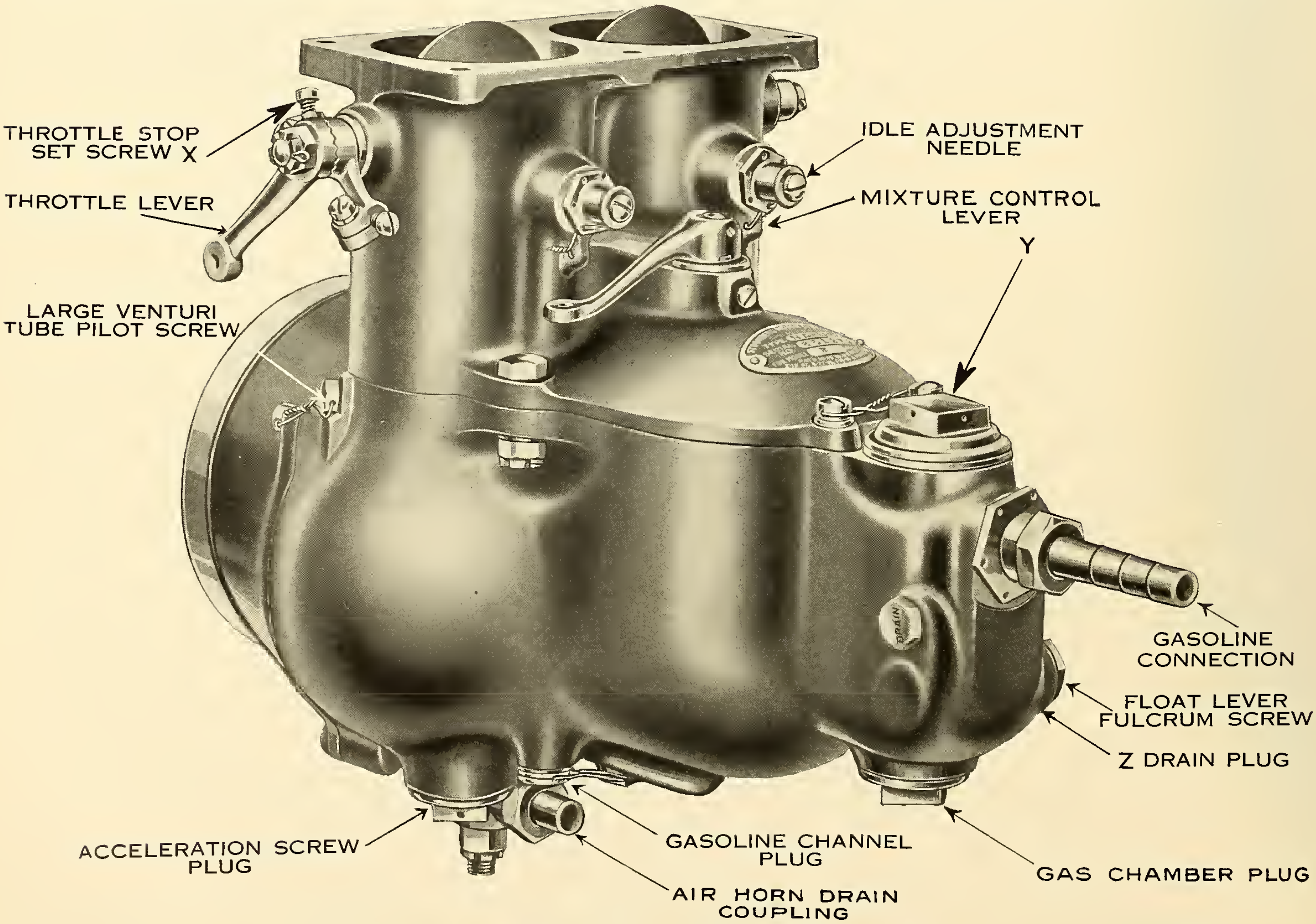
Stromberg Principle

A prominent feature of Stromberg carburetors is the use of two venturi, a small one within a larger one. The main gasoline discharge nozzle stands vertically in the center of the small venturi and the two venturi are concentric, the upper edge of the small one standing just a trifle higher than the smallest diameter of the large one. Air entering the large venturi thus has an ejector action on the small one, accelerating the velocity of the air passing through the latter; the object being to subject the main discharge nozzle to high velocity air which is most effective in atomizing the gasoline.

Thus the small venturi discharges a highly atomized spray of air and fuel at high velocity, into the body of air coming through the large venturi at a lower speed. This gives a two-stage mixing of the gasoline with the air; resulting in a more even mixture than would be obtained from a single venturi. Also the two-stage system, by ensuring a high velocity around the discharge nozzle at comparatively low engine speeds, enables a good, combustible mixture to be produced at partial throttle openings.

Idling

From the main gasoline supply channel between the float chamber and the main discharge nozzle a small tube is carried vertically upward to a fine, vertical slot



Stromberg Aviation Engine Carburetor used on Wright Engines cut in the carburetor body in such a position that the edge of the throttle disk lies against the slot when closed. Immediately behind this slot is a small adjustable orifice communicating with the atmosphere. Thus, when the throttle is closed there is suction through the portion of the slot exposed on the engine side of the throttle disk. This suction draws gasoline up the vertical pipe; and air through the orifice. As the throttle is opened through its first few degrees of movement it uncovers more and more of the slot, thereby increasing the supply of mixture to the engine.

Owing to the air orifice being very small the amount of gasoline drawn in increases, as the throttle starts to open, more rapidly than the amount of air, but since air is then beginning to flow up the venturi and past the throttle disk, this condition just meets the requirements.

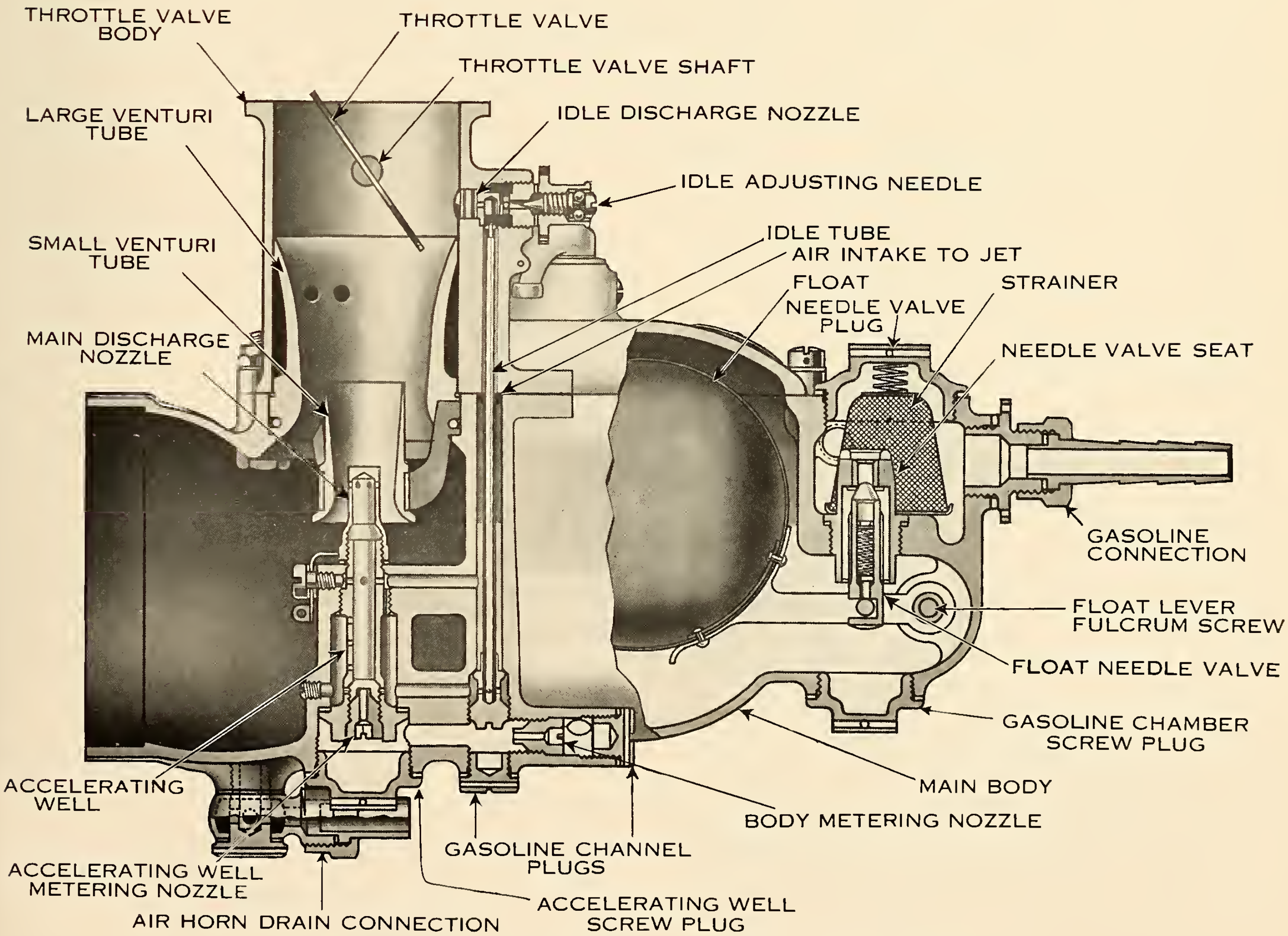
On the idling there is only one adjustment, that of the little needle valve which controls the admission of idling air. The precise relative positions of the slot and the edge of the throttle disk is very important and the throttle disk should never be removed. Adjustment of the air orifice by the "idle adjusting needle" is all that has to be done in service.

Acceleration Action

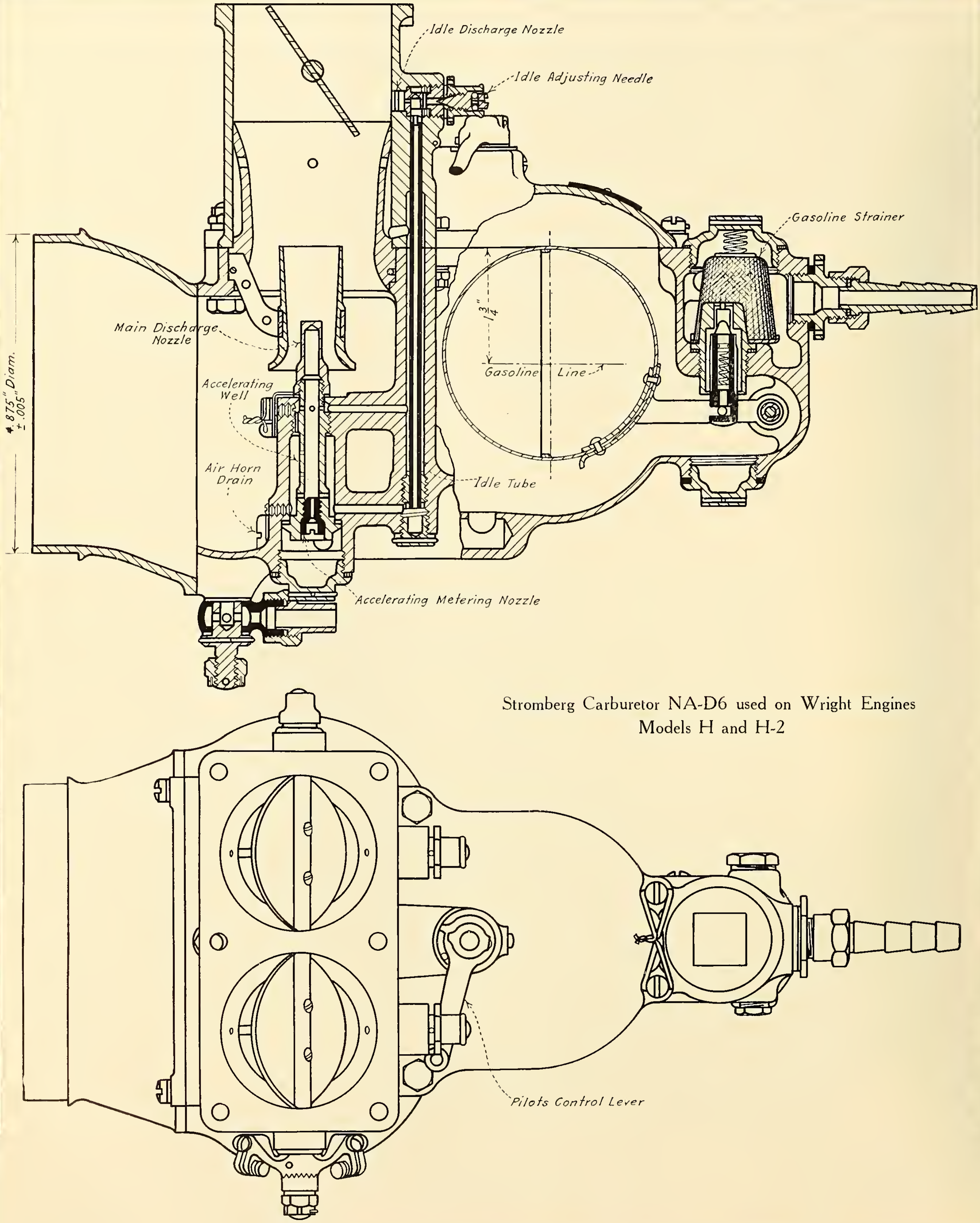
When the throttle disk edge is removed from the immediate proximity of the idling slot, suction on the latter falls to almost nothing and all the entering air comes through the venturi. If the throttle is opened quickly there is a pause before the gasoline in the main discharge nozzle begins to flow, owing to the inertia of the fluid. It is therefore necessary to give an extra supply of gasoline at the instant of throttle opening which will last just long enough to permit the main nozzle to get into action.

Now the main nozzle is a tube, standing in a small cylindrical chamber. Gasoline enters the nozzle from the bottom, passing through a small hole in a plug called the "acceleration metering nozzle," which will be referred to again later.

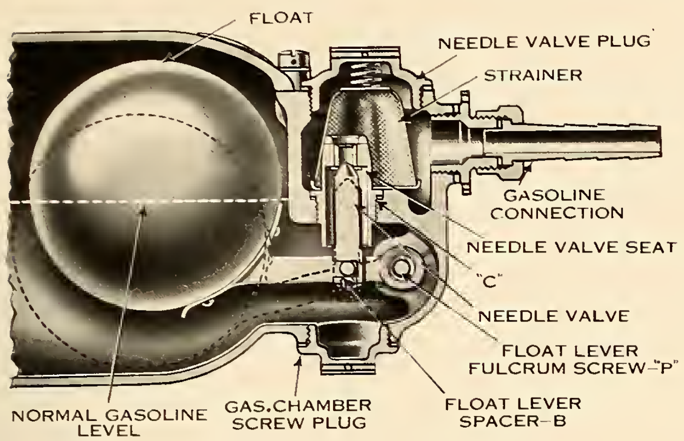
In the tube which forms the main discharge nozzle there are a few large holes at the top, forming the dis-



Sectional diagram of Stromberg Aviation Engine Carburetor NA-D4



Stromberg Carburetor NA-D6 used on Wright Engines Models H and H-2



Stromberg Float Mechanism

charge into the venturi, but lower down there are smaller holes which simply communicate with the cylindrical chamber around the nozzle. When idling, gasoline stands inside the main nozzle and flows out through the holes into the chamber, for it is from this chamber that the idling slot gets its supply of fuel.

Then, when the throttle is opened suddenly, suction on the idling slot stops and the gasoline in the cylindrical chamber at once flows back into the main nozzle tube. The size of the chamber is such that it contains just enough fuel to tide over the fraction of a second before the full flow starts through the accelerating metering nozzle.

Fully Open Action

From the description of the acceleration action just given it will be obvious that when the chamber around the main nozzle is emptied the small holes will be uncovered to the air in the chamber, although the inside of the nozzle will be full of gasoline. Now, when the chamber is empty, the pipe leading to the idling slot is also empty, and this means that the chamber is open to the atmosphere through the orifice which admits air for idling.

The effect of this is that the uprushing stream of gasoline draws in a little air with it and this air is carried along in the stream in the form of bubbles. As the gasoline passes out into the venturi these bubbles burst and are of important assistance in breaking up the liquid into fine spray.

High Speed Adjustment

It has already been said that the accelerating metering nozzle which screws into the bottom of the main discharge has a small hole through it. This hole is the *only* communication between the float chamber and the engine. It is by varying the size of this hole that the maximum gasoline flow is regulated. For any particular model of engine there is a correct size for this hole which *never* requires changing.

There is also a correct size of large venturi which is invariable once it has been determined for any given design of engine under no circumstances should it be changed.

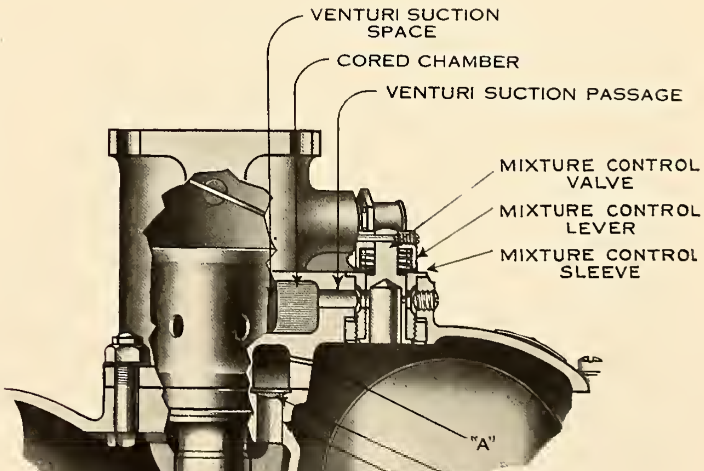
Mixture Control

As an airplane ascends the density of the air decreases, but that of the gasoline remains unaltered, so there is a tendency for the mixture to grow richer and richer. Now the actual power that forces the fuel out of the nozzles is the pressure of the atmosphere acting on the surface of the fuel in the float chamber. Therefore, it is possible to prevent the mixture growing richer with increase in altitude, by decreasing the atmospheric pressure in the float chamber.

Now, when the engine is running, the pressure inside the large venturi is always lower than that of the outside atmosphere. If the pressure above the fuel in the float chamber was the same as that inside the venturi there would be no flow of fuel. To get the correct flow of fuel it is necessary to have the correct *difference* in pressure between the two points.

The venturi size is chosen in the first place so that on the ground, with atmospheric pressure in the float chamber, the flow is correct. The cover of the float chamber is airtight and commmunication between the air space in the chamber and the outside atmosphere is through a quite small hole. In the side of the venturi are some small holes which communicate with a passage leading to a valve and thence to the air space in the float chamber.

Obviously then, if this valve is opened the suction in the venturi starts to draw air away from the float chamber, this being made up by air coming in through the fixed hole in the float chamber cover. The effect



Detail of mixture control mechanism of Stromberg Carburetor of opening the valve is, therefore, to rarify the air in the float chamber and so reduce its pressure on the fuel. The valve actually used gives great delicacy of action; when closed the mixture is rich and opening it makes the mixture grow leaner.

The holes in the venturi lead through a passage in the carburetor body to a small cylindrical chamber in the float chamber cover. Into this is set a steel sleeve with two holes in it opposite to each other, one larger than the other. There is an annular space between the sleeve and the chamber surrounding it. Inside the sleeve fits a hollow plug also with two holes in its sides. The lower end of the plug is open to the float chamber, the upper end is outside the carburetor and has the mixture control lever attached to it.

Now the holes in the plug are so placed that on turning the plug the small hole in the sleeve is first uncovered. When it is about half open the larger hole starts to uncover also. There is a small spring and a friction disk on the underside of the lever to make the action smooth, and to hold the position when set.

Float System

The float, although metal, is not the conventional cylindrical shape, but is like a ball with flattened sides. Attached to it is a lever pivoted on the side of the float chamber. As fuel enters, from the top of the float chamber, the lever lifts a small monel metal valve and shuts off the supply. The carburetor must always be fitted so that the air intake is forward and open to the direction of flight. Otherwise, when climbing the float level will be above that of the nozzles and the fuel flow will be excessive.

With the air intake forward the nozzles are below the float level only when diving, and since the throttle is then usually almost closed the loss of fuel will be very slight as the float cuts off the supply as soon as the small excess has spilled over and escaped throught the drain overboard.

When the conditions of flight are such that the pilot tends to fall away from his seat, the same force which is acting upon him is acting also on the float and therefore the float lifts and shuts off the fuel.

CARBURETOR ADJUSTMENTS

Possible Carburetor Troubles and How to Check Them

For Overhaul of Carburetor, See Page 73

A CARBURETOR which has been operating well can become out of order in only two ways. One, and this is far the most usual, is the presence of dirt in the fuel. The other is the loosening of some part, which should never occur if full advantage is taken of the locking wires and other devices when assembling.

Therefore adjustment, other than cleaning, should only be necessary only when the nature of the fuel is changed considerably. A great change in atmospheric temperature may call for adjustment of the idling screws.

Stromberg Instructions

If idling is irregular, before touching the carburetor remove all the spark plugs to see that they are clean and that the gaps are all set to 0.020 inch. Then see if ignition is regular when engine is speeded up.

If these two operations are performed and show that the ignition is correct, but leaves the idling still irregular, then, but not before, try adjusting the idling screws both together in order to find out whether it is excessive richness or weakness that is causing the trouble. Screwing the adjustment *in* makes it rich and unscrewing makes it *weaker*.

Too Rich on Idle

If this test shows that the idling adjustment was too rich do not merely readjust the idling screws, since the probability is that the excessive richness is caused by dirt stopping up the air bleeder holes. Clean these out thoroughly and then see if the original adjustment of the idling screws does not give correct idling.

To check one block of cylinders at a time to see that idling is even on both blocks open the pet cocks on the manifold belonging to the block it is desired to cut out.

Too Weak on Idle

If test of adjustment shows weakness there is a strong probability that air is leaking into the manifolds. Therefore see that all flange connections in the manifolds are tight, not forgetting the expansion gland on the tee, as this requires tightening occasionally.

In replacing the carburetor after overhaul it is easy to damage or displace the gaskets at either end of the tee, so look to these first.

If these tests do not disclose the trouble it is practically certain that dirt is the cause.

To Clean

Remove needle valve plug indicated in the cuts and small strainer will be found. If this is quite dirty the gas chamber screw plug should also be removed and the float bowl flushed out with gasoline in order to make sure that the needle valve and seat are clean.

Should indications of weakness continue after cleaning the screen, and if the screen was found very dirty, it will be necessary to remove the carburetor from the engine and take it apart for detail cleaning. See page 73.

Idle Adjustment

If idling is poor but acceleration satisfactory first see that all manifold flange joints are tight. Examine spark plugs for cleanliness and correct gap; also see that magneto breaker gap is set at from 0.015 to 0.020 inch. Check condition of the screen as described in the last paragraph and if found clean then, but not before, adjust for idle by means of the two idle adjusting screws shown in cut on page 21. Screwing these *in* makes the idling mixture richer, unscrewing them makes it weaker. *Never attempt to adjust for idling on a cold engine.*

Flooding

If flooding continues after cleaning screen and flushing out float chamber it will be necessary to take the carburetor apart for examination of the needle valve and seat. See overhauling instructions, page 73.

Cold Weather

Cold weather will usually call for a richer adjustment of the idling screws, but these should be set as lean as possible at all times. The table of carburetor settings on this page gives the normal requirements for the different models of Wright engines.

	Model I	Models E and E-2	Models H and H-2
Carburetor Type	N.A.D. 4	N.A.D. 4	N.A.D. 6
Venturi diam., in.	$1\frac{5}{16}$	$1\frac{1}{2}$	$1\frac{13}{16}$
Accelerating nozzle	No. 44	No. 30	No. 32
Body metering nozzle	No. 46	No. 42	None

Head from bottom of tank to carburetor must not be less than 18 inches, correct pressure for fuel supply is 2½ lbs.

MODEL A CARBURETION

Description of Zenith Carburetor D.C. 48 Used on Original French Engine and on Wright Model A Engines

THE Model A Wright engines were supplied with the Zenith D. C. 38 carburetor, which, like the carburetors of the later models, is a duplex instrument, having a single float chamber, but two venturi and two complete separate systems, one for each block of cylinders.

The unique feature of the Zenith is the construction of the main jet. This consists of a small central nozzle surrounded by a tube. Gasoline is supplied to both the inner tube and to the outer one, the two streams mixing together at the point of discharge.

The inner tube is connected directly to the float chamber, which means that the amount of fuel sucked through it will increase as the engine speed increases, and its size is such that it will supply just about enough for the *maximum* engine speed. Owing to the peculiar characteristics of the flow of liquids through nozzles, this means that at low engine speeds the fuel supply would be inadequate. Now the outer tube of the nozzle is also connected to the float chamber, but not directly, since between the two is a plug pierced by a very small hole. This hole limits the quantity of fuel that can pass from the float chamber to the outer tube.

Therefore at low speeds and low suction (low speed at open throttle, that is) fuel is sucked through both inner and outer tubes. Then, as the speed and suction increase, the supply through the outer tube soon reaches its maximum possible, and as speed increases still more the major part of the supply comes through the inner tube.

The idea of this construction is that the outer tube gives the correct flow for low speed but not enough for high. The inner tube gives enough for high speed but not enough for low. By proportioning the two correctly they compensate each other and so give the correct flow for all speeds. Changing the little plug between the float chamber and the outer tube of the nozzle alters the characteristic of the combination and this is one of the adjust-

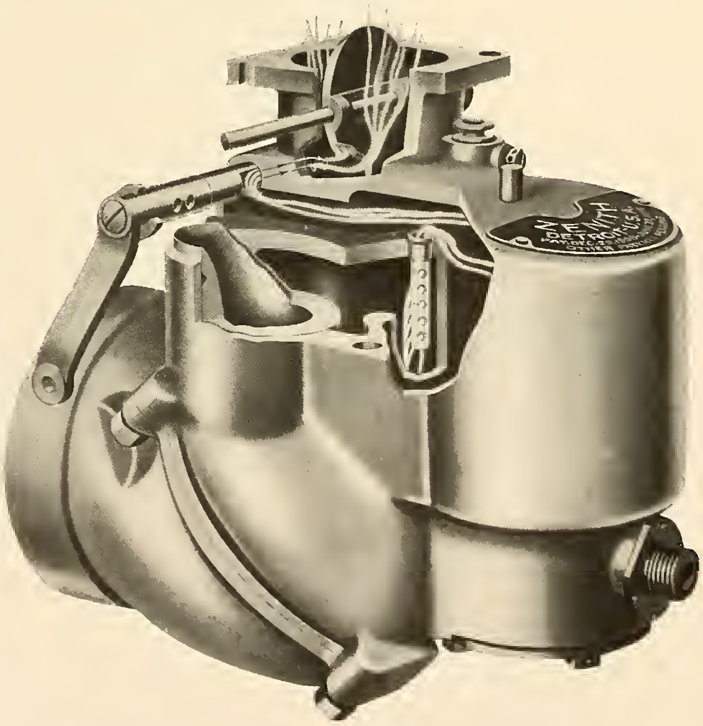


Diagram of mixture control action of Zenith D. C. 48 carburetor ments used in setting a carburetor to suit a particular design of engine.

Idling System

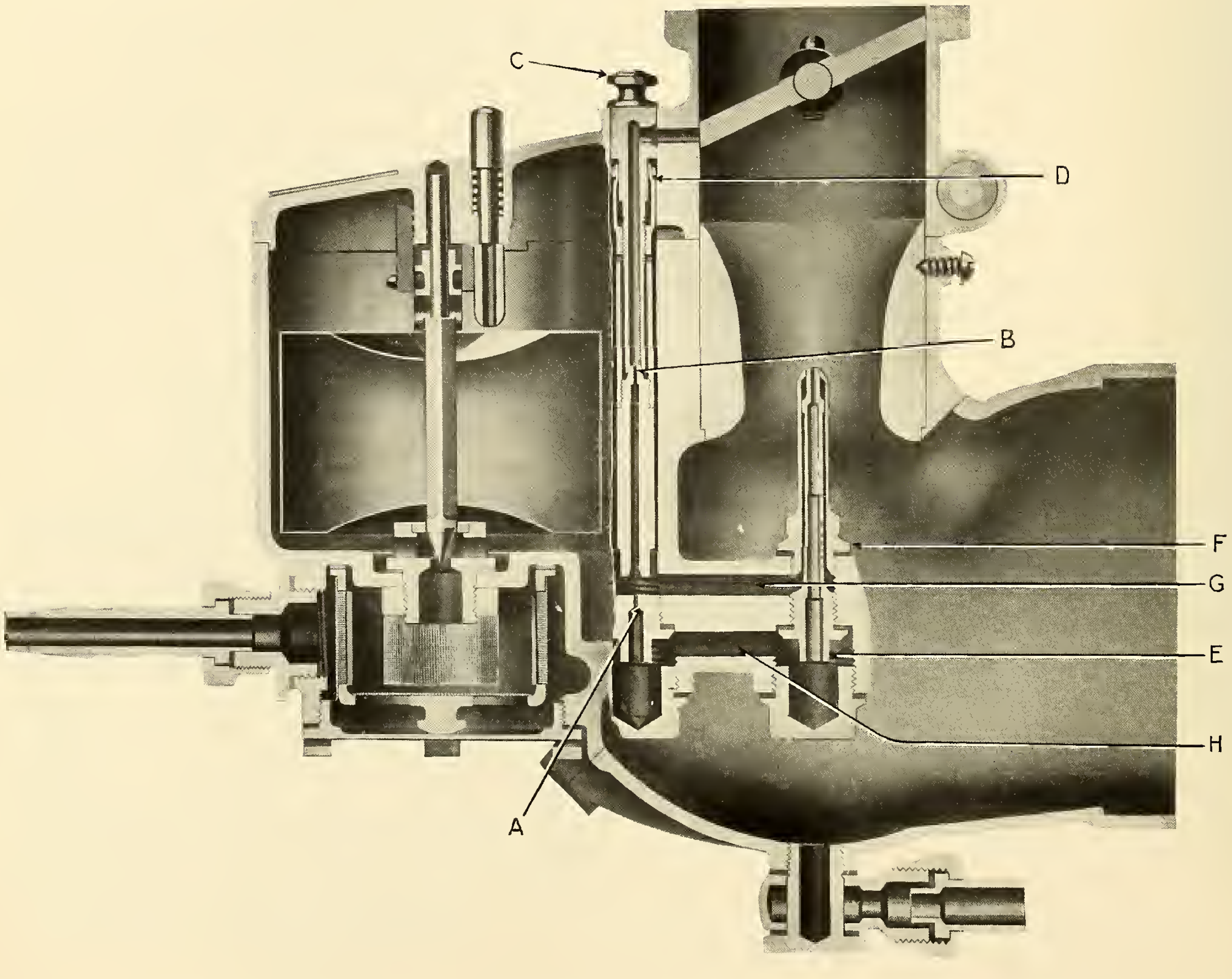
The compound nozzle just described takes care of open throttle running only. For idling there is a hole in the body of the carburetor which is covered and closed by the edge of the throttle disk when the throttle is shut. From this hole a small tube leads down into the gasoline duct between the float chamber and the outer tube of the main nozzle. Surrounding this tube is a "well" and at the top of the well there are some small holes through which air can enter.

When the engine is not running, fuel will stand at the same level in the well that it does in the float chamber. On starting, with the throttle nearly closed, fuel is sucked from the well through the idling tube, mixes with the small quantity of air coming around the throttle disk and so supplies the mixture.

Now the well, the idling tube and the outer tube of the main nozzle are all fed from the same passage, and this gets its supply of fuel through the compensating plug, which means that the total supply is limited. On opening the throttle, fuel immediately is sucked out of the main nozzle and, since there is no restriction between the well and the nozzle while there is the compensating plug between the well and the float chamber, the first effect is to empty the well. The throttle remaining open, gasoline will continue to come in through the compensating plug, but not fast enough to do more than supply the outer tube of the main nozzle, so the well remains empty. Through the small holes at the top of the well air will come in, and this mixes with the fuel, so that at high speeds the outer tube of the main nozzle supplies part gasoline and part bubbles of air, the latter being of great assistance in breaking up the fuel into a fine spray.

Mixture Control

The flow of fuel through the main nozzle is, of course, caused by suction, which is another way of saying that it is caused by the pressure of the atmosphere on top of the fuel in the float chamber being greater than the pressure of the air in the venturi around the tip of the nozzle. The



Section of Zenith D. C. 48 carburetor. A is the compensating plug. C is the idling jet, which is adjustable at points B and D. E and F are inner and outer members of main nozzle. G is the gasoline passage used for idling and acceleration, and H the main supply channel. This section is diagrammatic only.

richness of the mixture at any speed will depend upon the difference in pressure between these two places.

Connecting the top of the float chamber and the body of the carburetor just below the throttle disk is a passage having a cock set in it. If this cock is closed the carburetor operates in the conventional way, but if it is opened air is sucked away from the float chamber. Connection between the float chamber and the outer atmosphere is through a comparatively small screened opening, so that when the cock is open the suction establishes a partial vacuum in the float chamber. This decreases the difference in pressure between the float chamber and the tip of the nozzle and so reduces the flow of fuel. The cock is attached to a control, which the pilot uses to adjust the mixture richness either on the ground or during flight.

Adjustments

The general instructions for adjustment given on page 24 apply equally to the Zenith and Stromberg carburetors. The procedure for checking correctness of adjustment being just the same. In installation the carburetor must always be set with the air intake forward, facing the direction of travel, for the reasons given on page 24 under the head "Float Mechanism."

NA-V6 Stromberg Carburetor

The NA-V6 Stromberg Carburetor is used on some model H and H-3 engines by the U. S. Navy. The carburetor outlets are $2\frac{7}{16}$ inch diameter and are arranged on either side of the float chamber at 45 degrees from the vertical, instead of to the front as in other Stromberg carburetors. This allows the fuel jets to be placed on the lateral center line of the float, so that the fuel flow is not affected by fore and aft inclinations of the plane. The float mechanism is similar to other models and a similar double venture is used.

The mixture control is of greater range than the NA-D6. The mixture controlling suction is taken from a tube projecting up the center of the small venturi, where the suction is approximately equal to that on the full jets. The mixture control lever is concentric and above the throttle control lever. Provision has been made for a partial connection of their action in such a way that closing the throttle the last half of the way will positively move the control lever into the rich position.

The throttle lever is closed when toward the gasoline connection, and this is the rich position of the mixture control lever.

Bijur Electric Starter

A Bijur Electric Starting motor can be used on models E and I engines by using Inclined Magneto Bracket Part No. 12369 and Engine Starter Extension Part No. 15284.

On model E-2, H, H-2 and H-3 use Magneto Support Bracket Part No. 12331 and Engine Starter Extension Part No. 15284.

This Inclined Magneto Bracket assembly consists of a main drive shaft fitted with internal spline of standard design, which will fit Bijur Starting Motor drive shaft. Motor is attached direct to magneto bracket with a special extension and is held in position by studs supplied with same.

Hand Starting Crank

On some engine installations it is desirable to have a hand starter, particularly for flying boats and seaplanes. A hand starter can be supplied and attached to all models of Wright engines. The starting crank itself is geared down to the engines to facilitate cranking, the gear ratio being 7.35 to 1. It is attached directly to the back of the magneto bracket, the magneto drive shaft being prolonged and the end of the bracket flanged for this purpose.

The starting crank is lubricated by oil splashed from the lower vertical shaft gear. The starting crank shaft is equipped with a spring having a strong outward pressure which holds the dog out of mesh after engine starts. The dog at the front end of the shaft automatically frees itself when the engine starts. It is built with ball bearings and aluminum case.

There are three types of hand starters used, assembly 12370 for model E-2, assembly 11727 for model A and assembly 12268 for E and I with horizontal brackets.

To install crank on model E-2 using starting crank assembly 12370 with inclined magneto bracket 12331, remove magneto bracket and plate, saving the gasket. Remove wire lock and nut from magneto drive shaft, assemble threaded end of clutch dog to magneto drive shaft and lock with wire lock, then assemble starting crank bracket. On models E and I it is preferable to remove the horizontal bracket which carries the oil suction pump, replacing with inclined magneto bracket 12369 which has the geared oil pump below. Then attach starter 12370 as described for E-2. However, a starting crank assembly 12268 may be used on E and I without changing the horizontal magneto bracket.

To install starter on models H-2 and H-3 change to inclined bracket 12331 then use starting crank 12370. The installation is the same as for E-2. Note that if a sylphon pump is attached to the end of the crankshaft that no starter can be used. Model H must have the horizontal magneto bracket replaced with inclined bracket 12331, then proceed as with H-2 and H-3.

Model A used a different hand starter part 11727, which had a starting magneto geared to the hand crank, giving a hot spark as the engine was rotated by the hand starter.

Gasoline and Benzol

Use gasoline of approximately 68 degrees Baume, which has a specific gravity of .7447 and weighs 6.02 lbs. per gallon. Be careful it is clean and free from water. To exclude water strain through chamois, cotton moleskin or cotton twill. The gasoline used at the Wright plant for testing has gravity .73 to .76, initial evaporation 93 degrees C. or 200 degrees F., end point of evaporation 309 degrees C. or 590 degrees F.

Benzol may be added to the gasoline for any Wright engine without change of carburetor nozzles. A mixture of 20 per cent. benzol and 80 per cent. gasoline is used at the Wright plant for test runs. For compressions above 5.3 to 1 benzol should be used to prevent preignition. With a compression of 6½ to 1 it is advised to use 50 per cent. of benzol.

CAUTION IN USING BENZOL. Avoid use of rubber hose as benzol dissolves rubber and eventually the carburetor will be plugged with flakes of rubber. Where rubber hose must be used it should be fabric lined. *Reject any benzol having a white milky color.* White, milky benzol is apt to leave a precipitate which may clog carburetor.

Lubricating Oil

Care must be taken in the selection of lubricating oil. An unsuitable oil may cause expensive damage to the engine. The lubricating oil used must be a pure mineral hydrocarbon oil, free from acid or alkali, adulterants and impurities. The oil should meet the following specifications:

Flash Point Open Cup—465 degrees F. minimum.
Burning Point—520 degrees F.
Viscosity (Saybolt)—105 sec. at 210 degrees F. minimum.
Specific Gravity—.886 at 60 degrees F.
Baume Gravity—27.5 at 60 degrees F.
Cold Test—40 degrees F.
Free Acid—Nil.

We do not recommend any particular make of oil, but there are three oils which have given satisfactory service at such times as they have been graded to comply with the above specifications. We will upon request gladly advise you in regard to any particular oil or give more detailed advice on trade oils to purchase.

SECTION II.

Installation and Operation

INSTALLATION SUGGESTIONS

A Brief Resume of Some of the More Important Points Affecting the Performance of an Airplane

OWING to the extreme rapidity of aircraft development during the war period, there has been in the past less co-operation between airplane and aviation engine builders than there should have been. Many of the most successful fighting planes were little better than a makeshift combination of a good design of plane with a reliable engine. They could easily have been improved upon had time permitted.

Towards the end of the war co-operation was really beginning, but even then planes were being designed to take more than one engine, even to be adaptable for either an air cooled radial or an eight-cylinder water cooled Vee type motor.

This was an unavoidable war condition, but there is no excuse for its continuance. Recent performances have amply proved that the best results are obtained when engine and plane engineers work together.

Common Installation Troubles

While of little importance for the occasional stunt performance, it is vital for continued good operation that those parts of the engine which require attention should be accessible. The following parts of any engine need constant attention and their accessibility is vital to the reliability of the ship as a whole. They are:

The carburetor.	The oil strainer.
The spark plugs.	The water pump.
The magnetos.	The fuel pump.

It should be possible, without doing more than open doors in the engine housing, to completely remove the carburetor and all the spark plugs.

There should also be an opening large enough to let the oil strainer be removed and replaced, not forgetting that a fair-sized wrench has to be used for this operation.

The ends of the magnetos should have openings opposite to them through which the action of the breaker points can be observed directly and clearly. Also, in the case of Wright engines, it is desirable when possible to provide access to the rear end of the engine so that the magneto bracket with its two magnetos can be removed as a complete assembly, although, of course, this is much less important than access to the breaker boxes and distributor heads.

Radiation

The majority of airplane engines are under-cooled both as regards water and oil. The construction of radiators is improving rapidly and much useful data is now available as to the cooling requirements of different engines. This subject has not yet reached a stage of exactness, but in laying out a new airplane it is desirable to err on the side of over-cooling. It should not be overlooked that, while the desire to keep down the radiator dimensions is perfectly natural in so far as they affect head resistance, still the performance of the plane depends upon the power output of the engine at least as much as upon the resistance.

For E or E-2 engines the radiator should have not less than 150 square feet cooling surface for a nose radiator with 5-inch core and not less than 120 square feet cooling surface for a free air radiator with 9-inch core.

For H, H-2 and H-3 engines the radiator should have not less than 225 square feet cooling surface for nose with 5-inch core, nor less than 180 square feet for free air with 9-inch core.

This is assuming hex. end copper tubes .268-inch diameter with engine cowled, radiator in slip stream, cowling lowered at least 10 per cent. more than air area of core, and free water flow through radiator at least 25 per cent. in excess of pump capacity as shown in specifications sheets at back of book.

Oil tanks should be placed so as to be thoroughly air cooled.

Piping and Controls

Compactness in an engine installation generally makes for minimum weight, for accessibility and for reliability. It is easy to obtain in designing a new plane if consideration is given to every detail.

A good deal of trouble in the air has been caused by the loosening of pipe joints and connections either in gasoline, oil or water systems. If fuel, oil and water pipes are short and straight they are much less likely to give trouble than if they are long and sinuous. Often a slight change in the originally laid out position for, say the oil tank, will greatly simplify the piping.

It should also be remembered that practically all pipe joints have to be made after the engine is in position, and they should therefore be accessible.

It is believed that the raising of the magnetos on Wright engines so that the bed timbers can be carried straight back, to any length the plane designer desires, will be of very real assistance in simplifying installation.

To controls, which comprise the throttle and the mixture richness adjustment, those which are straightest and have fewest links are usually the best. Experience shows that the delicacy of control varies very much in different ships and it is urged that the pilot's levers be given ample travel to enable engine speed and mixture richness to be adjusted accurately and easily.

Control rods or links should also be so placed and proportioned that it is possible to remove the carburetor without breaking more than one link.

Propeller Data for Various Wright Engined Airplanes

Airplane	Engine Model	No. of Blades	Tractor or Pusher	Diameter	Mean Pitch (At 0.6 R)	Approximate Max. Speed M. P. H.	Airplane Performance Maximum Climb Ft./Min.
JN-4H	I	2	T	8′—6″	5.76′	(Estimated) 93	....
VE-7	E	2	T	8′—6″	6.04′	106	950
VE-7	E	2	T	8′—8″	6.20′	114	990
DH-4B	H	2	T	9′—2″	5.85′	115	1010
Ordnance Type D	H	2	T	8′—6″	7.10′	147	1450
Loening, M-8	H	2	T	9′—0″	7.29′	143.5	1520
Thomas-Morse, MB-3	H-2	2	T	8′—6″	8.10′	152	1970
V. C. P.-1	H	2	T	9′—0″	6.85′	154	1720
Bristol Fighter, 1918, Alt.	H	2	T	9′—2″	6.67′	116	1190
XB-1A	H-2	2	T	9′—0″	6.50′	133	1300

Pipes and controls should be placed so that there is no risk of their chafing against any part of the fuselage. This has been another frequent cause of forced landings and of fires.

Pusher Installations

Two important points have sometimes been overlooked in installations of the pusher type. One of these is that the carburetor air intake must face forward, in the direction of travel. This is essential in order that the nozzles give the proper supply of fuel under different flying conditions and is explained in detail in the carburetor description on page 24.

The other is that the water connections on the cylinders are changed so that the outlet to the radiator is situated at the magneto end of the engine, since this is the highest point during climbing, when maximum radiation is required.

Propellers

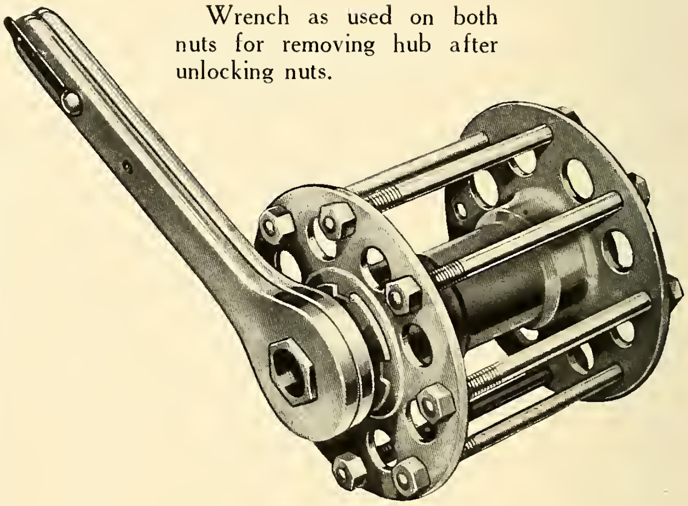
Since trial alone can as yet decide the best propeller combination for any particular airplane and engine it is not possible to offer any precise suggestions as to equipment for Wright engines.

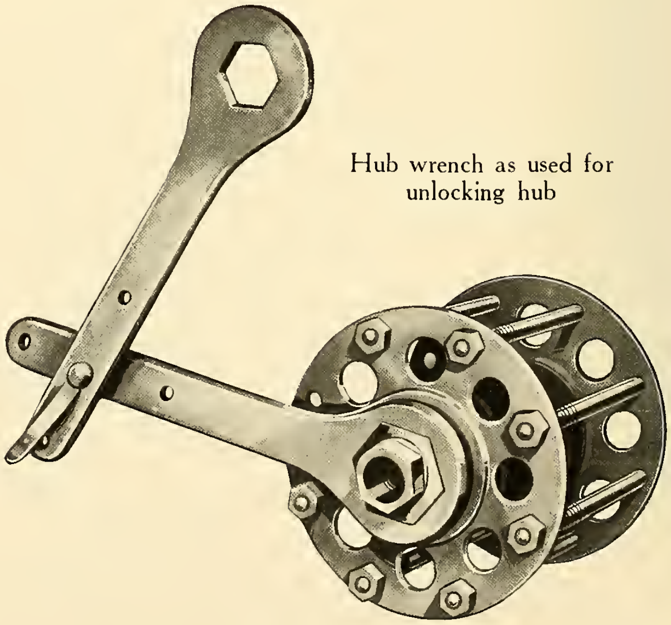
The table at the top of this page gives some slight particulars of propellers which have been found suitable in eleven different Wright engine installations and this may be of some use to desginers of new ships. More detailed information and more precise suggestion can be given by the Engineering Department of the Wright Aeronautical Corporation if the general characteristics and desired performance of a new design is known.

Co-operation

The Wright Aeronautical Corporation is always anxious to co-operate fully with designers of new airplanes and to place at their disposal complete details of installations which have proved particularly satisfactory. The company's engineers have given much time and study to this subject, believing that the success of both engines and planes depends to a very large extent indeed upon their entire suitability for each other.

Wrench as used on both nuts for removing hub after unlocking nuts.





Hub wrench as used for unlocking hub

Use of hub wrench

PROPELLER ATTACHMENT

Instructions for Care of Propeller Hubs and Mounting Propellers in Hubs

IN placing a propeller hub in a propeller, always put the keyway of the hub in the axis of the blades. Starting the engine by cranking is facilitated if the propeller is keyed in this position for "carrying over compression." Moreover, this recommendation is of vital importance since this position has been adopted for adjustment of the layout for firing the machine gun through the path of the propeller.

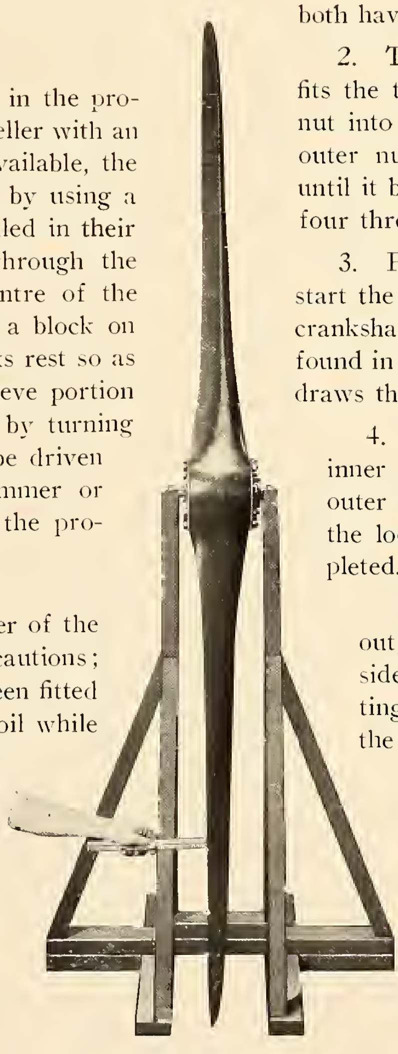
Location of keyway in propeller hub

Fit of Hub in Propeller

The hub should be a light press fit in the propeller. Hubs can be pressed in the propeller with an arbour press. If no arbour press is available, the hubs may be pressed into the propeller by using a large bolt and two block with holes drilled in their centre for the bolt. Place the bolt through the centre of the hub and through the centre of the propeller, also through the blocks with a block on each end of the bolt. See that the blocks rest so as to bring the strain directly over the sleeve portion of the hub. Draw down on the block by turning the nut on the bolt. Hubs should not be driven into propellers or removed with a hammer or mallet, as there is danger of splitting the propeller.

Mounting on Crankshaft

The mounting of the hub on the taper of the crankshaft requires very particular precautions; the hub supplied with each engine has been fitted to its taper by lapping with emery and oil while the key is removed. The hub and crankshaft taper is then thoroughly cleaned and the key replaced, making sure to lubricate the taper and hub with tallow or oil and graphite. This operation should be strictly adhered to each time a new hub or one that shows wear is placed on the crankshaft; always remembering that a bad fit rapidly develops play and if run in this condition will do great damage.

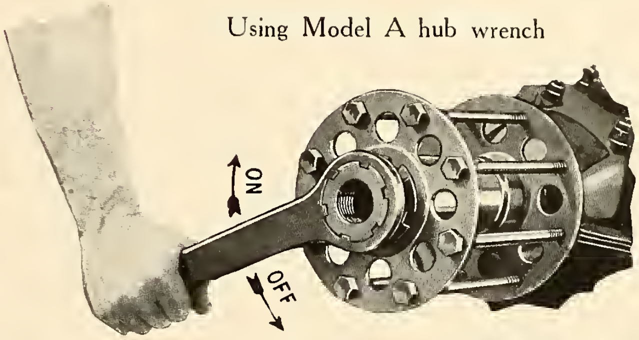


Tracking and balancing stand

Tightening the Hub Nuts I, E, E-2, H, H-2 and H-3

There is one inner propeller hub nut and one outer nut holding the propeller hub on the crankshaft, they being locked together with a lock wire.

To fasten the hub on the crankshaft taper:



Using Model A hub wrench

1. Insert the inner nut in the outer nut, so that both have their hexagon heads at the same end.

2. The thread on the outside of the outer nut fits the thread on the inside of the hub, screw the nut into the hub while the inner nut is still in the outer nut. This can be screwed all the way in until it bottoms and then backed off about three or four threads.

3. Place the hub on the crankshaft taper and start the inner nut on the thread on the end of the crankshaft by the aid of the wrench WA, which is found in the tool equipment; pull the nut home; this draws the hub on the crankshaft taper.

4. After the hub is drawn on the taper, the inner nut is locked in place by drawing up the outer nut, the nuts are then locked together by the lock spring wire, and the operation is completed.

Model A has one nut threaded inside and out, the outside thread fitting the hub, the inside thread fitting the crankshaft. Before putting the hub on the shaft screw the nut into the hub about 5 threads, then place hub on shaft and catch inner thread on shaft, screw home with wrench and safety wire.

Proper Balance

A faulty balance or fluttering of the propeller always causes vibration. As soon as this condition is encountered, correct the balance with care and also the pitch, using a tracking stand of the type shown on this page.

UNPACKING—ALL MODELS

TWO different forms of packing are used, one for domestic shipment and the other for export. The latter is, of course, the heavier style. The following tabulation gives the dimensions and approximate weights of engines packed both ways:

Domestic Shipping

	Models A, E, I, E-2	Models H, H-2 and H-3
Length	60 in.	60 in.
Width of case	38 in.	44 in.
Height	40 in.	44 in.
Weight	870 lbs.	950 lbs.
Displacement	52 cu. ft.	64 cu. ft.

Export Shipping

Length	55 in.
Width of case	38 in.
Height	40 in.
Weight	1040 lbs.
Displacement	53 cu. ft.

Unpacking

1. Remove front end of box by taking out wood screws.

2. Remove lag screws which hold in box a skid to which the engine is attached and pull skid and engine out.

3. Remove engine from skid, lifting it by two cables placed around cylinder blocks as shown in illustrations on pages 35 and 36. Lift with hoist.

Cleaning Engine

1. Remove paper wrapping from:
   Propeller hub.
   Water pump.
   Air pump.
   Magnetos.

Do not remove any other coverings for detail parts.

2. Wash off protecting coating of heavy oil. This is done most effectively by a spray of gasoline. If it is necessary to use gasoline dampened rags, be sure rags are clean and free from grit.

3. Remove all remaining wrappings and the fiber covers which are over all exhaust and water pipe flanges.

4. Remove spark plugs and turn engine over as fast as practicable in order to remove oil with which interior of cylinders is flushed before shipping.

NEVER REST ENGINE ON ANYTHING EXCEPT A PROPER ENGINE BED.

Preparation of Engines for Shipment or Storage

Drain the float chamber by running engine until it stops. Remove exhaust pipes and at least one plug in each cylinder. Rotate until engine is thoroughly slushed with oil. Thoroughly drain off all water. Remove the large 33 M/M plug on each camshaft cover to wipe off camshaft, etc.; then slush thoroughly and replace cover. Remove water pump covers, take out the impellers, wipe or blow dry with air. Blow compressed air through water jackets to carry away any slight amount of water. Grease water pump impeller with vaseline and replace. Pour one pint of cylinder oil of the grade used on engine in each cylinder. Remove cam covers and grease camshafts, valve tappets and gears with vaseline. Slush all exposed steel parts with E. F. Houghton's "Rust Veto Soft," applying with a brush, or by dipping, at a temperature of 110 degrees to 125 degrees F. Remove propeller hub assemblies and slush hub and shaft. Replace hub nuts hand tight. Wrap all exposed holes, such as cylinder water outlets, with oiled paper. Seal exhaust openings with a plate. After slushing, wrap the carburetor assembly, vertical shaft housings, propeller hub and magneto bracket assembly with oiled paper securely tied. In slushing the magneto couplings, care must be taken to cover all the surfaces. This can only be done by turning the engine over while it is being slushed.

Houghton's "Rust Veto Soft" was selected for use at the Wright plant in July, 1921, after careful experiments on 21 of the best-known slushing oils and compounds.

An engine treated in this manner should be free from danger of severe rusting for a moderate period, but if the engine is to be placed in storage, it should be immediately unboxed when received and torn down, and all parts, internal and external, thoroughly slushed.

Whether for long or short storage periods, it is recommended that the engines be stored out of the boxes or at least that the ends of the boxes be removed to insure thorough ventilation.

INSTALLING ENGINE IN FUSELAGE

Precise Instructions for Mounting Engine and Making Ready for Flight

Precautions to Be Taken in the Layout of Controls When Designing the Airplane Are Given on Page 31

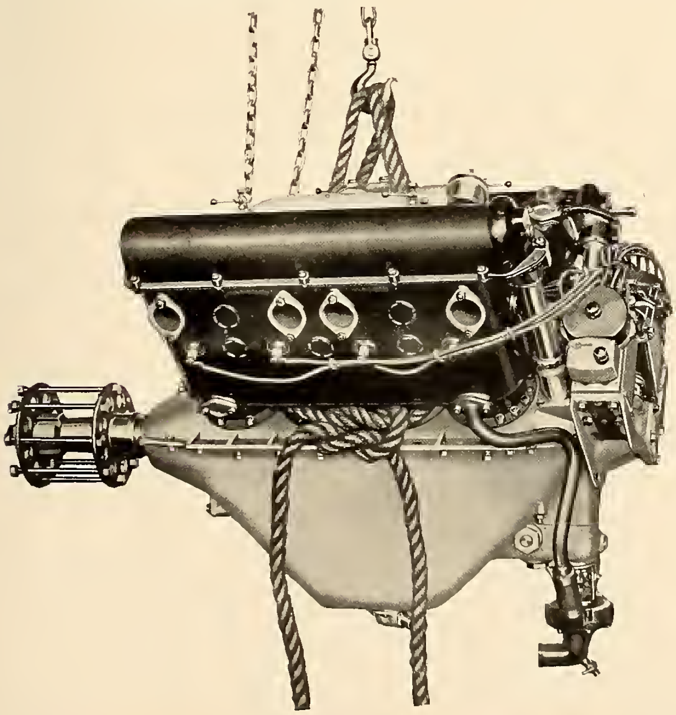
EASE of engine installation should be studied in airplane design, and general hints regarding this phase are given on page 31. The instructions following give in proper sequence the operations of installation and apply to practically all forms of aircraft.

Bolts Required

The bolts for holding the engine to its bed timbers should, of course, be of good quality steel. There are required: 16 bolts, ⅜-inch diameter; 32 hardened flat washers, 16 cotter pins, 16 castellated nuts.

Procedure for mounting is as follows:

1. Check distance between bed timbers and parallelism both for distance apart and for level. If the bed timbers are not perfectly true they must be made so or the crankcase will be strained in bolting down.
2. The holes in the bed timbers for the bolts should be a tight fit, so that the bolts require to be driven in. The spacing of the holes should be sufficiently accurate to allow the engine to set readily over the bolts.
3. Cut two fiber strips about $\frac{3}{32}$-inch thick. Mark off and drill clearance holes for bolts, and attach to bed timbers with a few flat head tacks.
4. Insert holding-down bolts from under side of bed timbers, placing one washer under the head.
5. Lower engine into place.



Showing proper method of attaching rope for lifting engine

6. Apply second washer and nut to all bolts.
7. Tighten down nuts gradually and in rotation. *Never* draw up any one nut much tighter than the next.
8. Apply cotter pins *of correct size* and make sure they are well spread.

Attaching Controls

After the engine is bolted down the exact procedure, of course, varies with the different installations. Hose connections are very important indeed, since should any of them loosen in flight a forced landing is inevitable. Therefore, in deciding procedure particular attention should be given to mounting radiators, tanks and so on in such sequence that hose connections are all capable of being made thoroughly well.

Making Hose Joints

The sizes of hose required for each model of engine will be found tabulated on page 76 under the two heads "Water System" and "Lubrication System." It is impossible to make a safe connection with hose that is either too large or too small.

The fit of the hose clamps on the outside of the hose, and the condition of the clamping bolts and nuts, should be checked before application.

Water Connections

On the water pumps there are three branches for hose. The larger is for the suction line and should be connected to the bottom of the radiator by a copper pipe, with hose connections. On the lower, outside, rear corners of the cylinder blocks are flanged holes to which are attached copper pipes which lead downwards to the water pump, being connected to the pump by short lengths of hose.

In some installations, instead of the copper pipes small aluminum castings have been attached to the cylinders and long rubber hose connections made to the pump. This, however, is not such good practice, as the long hose is liable to chafe against some part of the fuselage, while the copper pipes, having rigidity, can be bent in close to the crankcase and kept away from the fuselage.

The top of the radiator must be connected by copper pipes and hose to the two upper, front corners of the cylinder blocks. It is important that the water enter at the lower rear ends and escape from the upper front ends, as otherwise the cooling will be uneven and probably inadequate at some point.

Installing Pusher Type

Water pipe connections must be reversed when the engine is being used as a pusher. That is to say the connections from the water pump must go to the lower *front* end of the cylinders, and the outlet from the upper rear end; using the terms front and rear in accordance with conventional phrasing, which always calls the propeller end of the engine the front end.

Model A

Note that there are four connections on the Model A water pump instead of three, these being two outlets and two intakes.

Manifold Jacket

On E-2 and H-3 engines, the manifold jacket piping is carried from the upper front corners (propeller end) of the cylinder blocks by two connections to the jacket and from rear side of jacket by a single pipe to the intake side of water pump. This piping is furnished as part of the engine. On older models, two nozzles project horizontally from the upper rear corners of the cylinder blocks, and should be connected to nozzles on the rear of the manifold jacket by copper pipes with hose connections on each end. The jacket outlet should be connected to the intake side of water pump as on E-2 (drawing on request) and not to top of radiator as in past practice. This is in order to insure circulation.

Thermometer Connection

The maximum water temperature should be indicated by the thermometer on the instrument board, and to ensure this being the case the thermometer should be connected to the top of the radiator direct. Care must be taken that the bulb of the thermometer is actually in the *water* or it will not show the true temperature.

Oil Piping, Models H, H-2 and H-3

On these three models the oil pipe connections are as follows:

1. From pressure pump intake (located on right hand side of gear pump front) to bottom of oil tank.
2. From suction pump outlet (located on right hand side of gear pump at extreme rear end of engine) to oil radiator.
3. From oil radiator to top of oil tank.

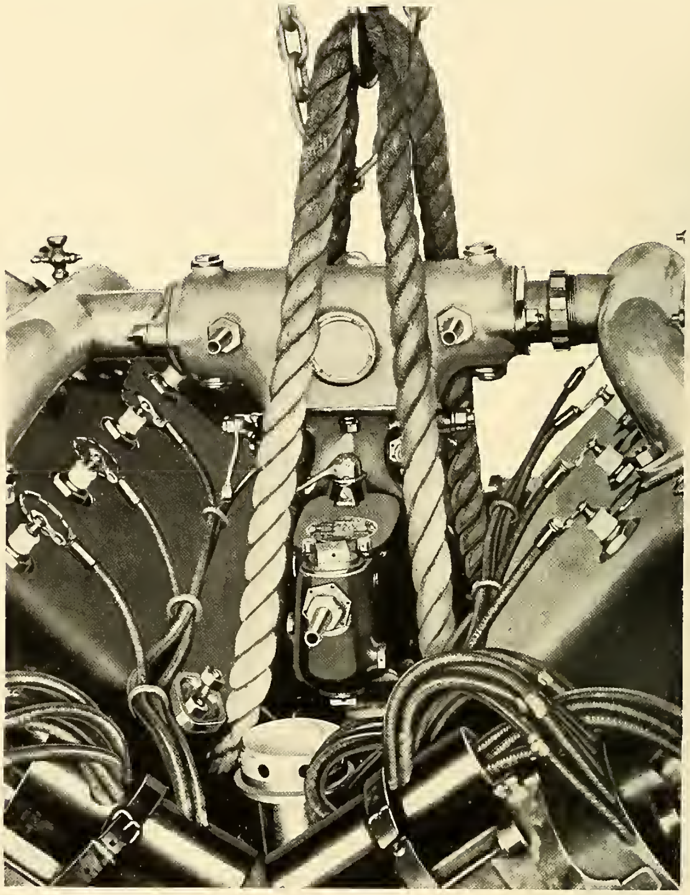
Oil Piping, Model E-2

On this model the oil pipe connections are as follows:

1. From pressure pump intake (located on left side of oil pump) to bottom of oil tank.
2. From suction pump outlet (located on right side of oil pump) to oil radiator.
3. From oil radiator to top of oil tank.

There are two nozzles for hose on the oil pump base, and the copper pipes leading to tank and radiator should be joined by pieces of hose.

For connection to the pressure gauge on the instrument board there is a nozzle on the right side of the crankcase low down toward the rear. Connection is made by small diameter copper pipe and hose.



Method of slinging engine

Oil Piping, Models E and I

On these two models the oil connections are as follows:

1. From pressure pump intake to bottom of oil tank.
2. From plug in bottom of crankcase to suction (left hand) side of gear pump at extreme rear end of engine.
3. From delivery side of gear pump to oil radiator.
4. From oil radiator to top of tank.

All the connections on the engine are nozzles suitable for rubber hose. All copper pipes should be made of short lengths joined by pieces of hose. For connection to the pressure gauge on the instrument board there is a nozzle on the right side of the crankcase, low down towards the rear. Connection is made by small diameter copper pipe and hose.

Oil Piping, Model A

In the rare cases where no oil radiator is used there is no external piping, but in the majority of Model A installations the oil radiator is situated directly beneath the crankcase and is connected thereto by a large diameter piece of hose. The radiator outlet is then connected to the pressure pump intake at the rear end of the crankcase, by copper pipe and hose.

There is no oil tank in Model A installations, unless it is entirely separate from the circulation system and merely contains a reserve supply which the pilot can admit to the crankcase by hand.

Pressure gauge connection on Model A is made by small diameter copper pipe and hose from a nozzle situated toward the *front* end of the crankcase. There is a nipple for a flanged copper pipe on the crankcase; this should be fitted with a short piece of pipe, over which the hose connection is made.

Gasoline Connections

Most of the carburetors which are on old Wright engines, and all those on newer models, have a nozzle on the carburetor to which the gasoline line is attached by a fabric hose. If the carburetor has a conventional pipe connection this should be provided with a very short length of copper pipe and a hose joint made as close as possible to the carburetor.

Although all carburetors are supplied with a fuel strainer, it is always unwise to rely upon this alone, partly because this screen is necessarily small and partly because it is almost always inaccessible. There are several excellent strainers made for airplane work, and one of these should be inserted in the gasoline line at some point where it is easy to get at for cleaning.

All carburetors are supplied with a drain which removes excess gasoline and prevents its accumulation in the air intake. Most of the carburetors have a nozzle for a hose connection and some have two such nozzles. A few of the older instruments have a conventional pipe joint instead of the nozzle and in such cases a hose "break" in the line should be made as close as possible to the carburetor.

Care must be observed in fitting the drain pipe or pipes, first to see that they have a continuous drop from carburetor to outlet, and second that the outlet is well back on the underside of the fuselage and as far as possible away from the exhaust pipes.

An air screen is usually fitted to the carburetor intake, but this is not a part of the engine. When used it should be large enough in area to insure that the intake is not choked. In most installations it consists of a cylindrical wire mesh screen about a foot long with a solid end, the opposite open end being clipped to the carburetor by a sort of hose clamp and the solid end furnished with lugs which can be attached to some point toward the end of the cylinders.

It is, however, more important to make sure that the carburetor drain operates properly, since it is only when there is an accumulation of gasoline in the intake that a flame of a dangerous sort can be caused to blow back.

Carburetor Controls

There are two controls on the carburetor, the throttle and the mixture control. No special instructions are necessary for connecting these to the pilot's control levers in the cockpit, except that they must be as straight and simple as possible. Make sure after installation that the throttle and mixture levers on the *carburetor* work smoothly and over their *whole* range.

Also make sure that to get the full range on the carburetor end the maximum amount of travel is also used at the cockpit end. If only part of the possible travel of the pilot's control levers is used to cause the whole travel on the carburetor, then the delicacy of the control is injured. Care should also be observed that there is as small as possible an amount of play or lost motion in the controls and that everything is thoroughly cotter-pinned.

Spark Control

Model H is the only engine to which a spark control is fitted. This is not connected to the cockpit and is only used for starting, access to it usually being obtained by a small opening in the side of the fuselage. It is not an essential control even on Model H and may be set permanently in the advanced position if desired. (Cut page 19.)

Tachometer Shaft

The tachometer drive connection, which is part of the engine, is described on page 9. In most installations it is placed on the left hand camshaft.

Before attaching the flexible shaft see that the little shaft in the adaptor has about 0.01 in end play.

Then see that the nut on the flexible shaft is a good fit on the adaptor.

Check the fit of the tongue on the end of the flexible shaft to see that it slides easily into the slot. If the adaptor has been removed from the camshaft cover into which it is screwed, great care must be taken in replacing it to make sure that little shaft engages properly with the camshaft end. If the tongue and slot inside do not meet squarely it is easy to damage the connection while screwing in the adaptor.

If the adaptor is changed from one side to the other, make sure that the plug which closes the unused hole is not forgotten.

Wiring

The cockpit switch should have three terminals, of which one is to be wired to a ground on some part of the *engine*, and the other two are connected to the respective terminals on the magneto breaker boxes. Be sure that all connections are thoroughly tight and, if metal covered wire is used, be sure that this is stripped back or taped far enough at the magneto terminal ends to make certain that vibration cannot cause an accidental ground.

Starting Magneto

This usually has two terminals, one of which must be firmly grounded to some part of the engine. The other is connected to the center of the distributor of *one* of the engine magnetos. If there is no ground terminal on the starting magneto, it is essential to run a wire from the body of the starting magneto to some part of the engine.

Note particularly that it is customary to wire the magnetos so that one of them fires all the plugs on the inner side of the cylinders (in the Vee) and the other all the outside plugs. Since the inside plugs are less liable to get oily, the starting magneto should always be attached to the right-hand magneto, which always fires the *inside* set of plugs. This is clearly shown in the wiring diagram.

STARTING ENGINE

Proceedings to Be Followed After Installing a New Engine and Precautions to Be Taken at Every Start

WHEN starting a new engine or an engine which has just been overhauled it is necessary to observe a few points which do not need to be watched so closely at every time of starting. In the following the instructions for starting a new engine, or one which has just been overhauled, are given first. Precautions to be taken at every start make a smaller list which succeeds.

Starting New Engine

1. Fill radiator and water system and inspect carefully for leaks. If any hose in the water system shows signs of leakage it should be made tight before doing anything further.

2. Fill oil tank. Turn engine over a few times by hand to make sure oil pumps and piping are full of oil. Inspect carefully for leaks. See that vent in oil tank is free and clear.

3. Remove gasoline supply line from tank and carburetor and blow or flush it out. In the case of installing an overhauled engine or a new engine in an old plane it is also wise to flush gas tank itself in order to be sure that gasoline system is free from dirt or water.

4. Replace gas line, fill tank and inspect for leaks.

5. Remove all spark plugs and check setting of points. Gap should be 0.020.

6. See that magneto ground wire connections are clean and tight; if they are not it may be impossible to properly switch off the ignition, making starting rather dangerous.

7. While plugs are out of cylinders check starting magneto action. If spark is weak look to ground wire, which should firmly connect the body of the starting magneto with some part of the engine itself.

8. Squirt a small quantity of oil in each cylinder. About one tablespoonful is the correct amount.

9. Replace spark plugs and connect wires.

Final Starting

The nine points described above are preliminary operations. Having checked over all of them the engine is ready to be started. It is very important that the remaining six actions listed hereunder be performed *as rapidly as possible*. Hesitation between one and another is likely to prevent a start from being obtained.

10. Prime through all four of the pet cocks on the intake manifolds. Practice is necessary to be sure that the engine is neither over nor under primed. The correct quantity is given if the cup on the cock is filled and emptied four times. As it is more convenient to use a squirt can, leaving the cock open and injecting through it, a trial should be made to see how many "squirts" correspond to the proper quantity. Correct priming makes all the difference between easy and quick starting and failure to start; so it is well worth while to take a little trouble to get the proper degree of prime. Do not over prime.

11. Close mixture control to rich position.

12. Open throttle slightly. The correct opening is given when the end of the throttle lever on the carburetor has moved one-eighth of an inch from the dead closed position.

13. See that ignition switch is in "off" position.

14. Turn engine over four or five *complete* revolutions as fast as possible and immediately step back, calling out at the same time.

15. Switch on and revolve starting magneto as fast as possible.

NOTE—It is essential to perform these last two operations as rapidly as possible. Pulling over the engine slowly, or pausing after the last pull and before spinning the starting magneto, is almost sure to result in failure to start.

Failure to Start

If engine does not start after several trials do not repeat priming until possible causes for failure have been checked over.

After Starting

Allow engine to run on very low throttle. *Never* open throttle wide immediately after starting, as this is certain to cause injury. Too rapid opening up is injurious to valves and pistons because it heats them up too quickly. It is also injurious to all the moving parts because the oil is not in good lubricating condition till it has warmed up and been thoroughly distributed throughout the system, a thing which takes some appreciable time.

A new or recently overhauled engine should never be flown till it has idled on the ground for at least fifteen minutes.

During the warming up period each three or four minutes the engine should be speeded up to 1,000 or 1,200 revolutions for the purpose of clearing the oil off the spark plugs. Such opening up should be of very short duration; just a second or two is sufficient for the purpose.

After the first five minutes of idling the speed may be increased little by little, till at the end of fifteen minutes the engine will be running steadily at 1,200 revolutions.

In cold weather be sure to cover water and oil radiators, as warming up will otherwise take altogether too long.

During the warming up run check ignition once or twice to see whether firing is regular on either of the two magnetos alone. Never leave the ground unless either magneto alone will fire perfectly.

Inspection for leaks in oil, gasoline and water lines should be made several times during the run, or at least before commencing a flight.

If gasoline is fed under air pressure and the engine has been a long time out of use it is possible that the leather in the air pump will require oiling. The air pressure regulating valve is also liable to need cleaning or adjustment.

After warming up the oil gauge should show at least 50 pounds pressure and not more than 100 pounds.

After warming up the water outlet temperature should be not less than 90 degrees F. or 32 degrees C., and not more than 110 degrees F. or 43 degrees C. Make sure that bulb of thermometer is actually in the water and not merely in the air over the water.

Before leaving the ground it is necessary to see that the mixture control is set to the leanest possible position. To check this the throttle should be opened wide and the mixture lever moved in the leaning direction till the engine just begins to slow down. Then richen slightly till maximum revolutions are again attained.

NORMAL STARTING

1. Fill with water, oil and gasoline.
2. Prime each of the four pet cocks, being sure to give the correct quantity, which is four times the contents of the cup on the cock. See No. 10 in instructions for starting a new engine.
3. Close mixture control to rich position.
4. Open throttle lever about one-eighth of an inch on end of carburetor throttle lever.
5. See that ignition switch is in off position.
6. Turn engine over two or three complete revolutions as rapidly as possible, and immediately stand clear and call.
7. Switch on and revolve starting magneto as fast as possible.

After Starting

Idle at from 800 to 1,200 revolutions till water outlet temperature is at least 32 degrees C. or 90 degrees F. and when warmed up see that oil pressure is not less than 50 pounds.

Open engine wide just before taking off and move mixture control toward the lean position till the motor just begins to slow down. Then richen slightly till maximum revolutions are attained.

Before taking off check ignition to see that either magneto alone will fire regularly.

Cold Weather Starting

Fill radiator and engine with hot water. Fill oil tank half full of hot oil.

Economy in Flight

Considerable saving in gas can be gained in cross country flight by careful regulation of mixture, keeping it as lean as possible. PARTICULARLY AT PART THROTTLE OPENING.

Steady Running

All makes of engines vibrate more at some speeds than at other speeds. The speed of maximum vibration in the air should be ascertained and then care should be taken to avoid running at that speed. Careful manipulation of the mixture control on Wright engines, at low altitudes and at part throttle opening, will prevent objectionable vibration.

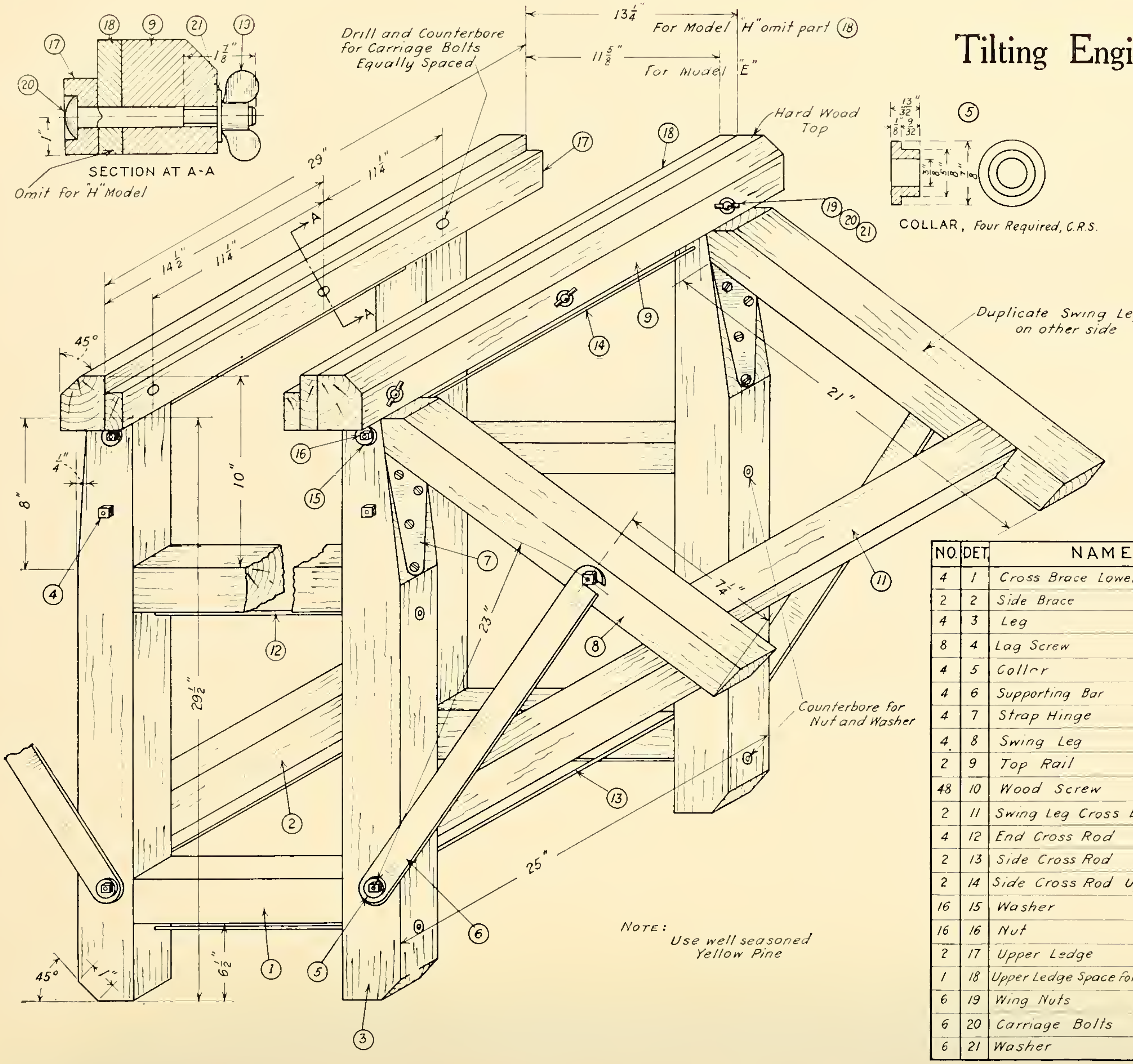
Failure to Start

1. Check air pressure in gas tank—there should be a minimum of 2 pounds.
2. Try flooding carburetor to see if lines are free.
3. Check starting magneto as to ground wire.
4. Check gap in spark plugs to see if points are not too wide or too close, should be .020 gap.
5. Look over breaker cam and points as to adjustments—points should have .020 clearance.
6. Look over brushes in distributors—see if they are dirty.

SECTION III.

Overhaul and Repair Instructions

Tilting Engine Stand



NO.	DET.	NAME	SIZE
4	1	Cross Brace Lower End	$2\frac{1}{2} \times 2\frac{1}{2} \times 18\frac{1}{4}$
2	2	Side Brace	$2\frac{1}{2} \times 2\frac{1}{2} \times 25$
4	3	Leg	$2\frac{1}{2} \times 2\frac{1}{2} \times 31$
8	4	Lag Screw	$\frac{3}{8}'' \times 2$
4	5	Collar	$\frac{7}{8}$ Dia $\times \frac{13}{32}$
4	6	Supporting Bar	$\frac{1}{4} \times 1\frac{1}{4} \times 24\frac{1}{8}$
4	7	Strap Hinge	6"
4	8	Swing Leg	$2\frac{1}{2} \times 2\frac{1}{2} \times 23$
2	9	Top Rail	$2\frac{1}{2} \times 3 \times 29$
48	10	Wood Screw	$\frac{3}{16}'' \times 1''$
2	11	Swing Leg Cross Brace	$2\frac{1}{2} \times 2\frac{1}{2} \times 25$
4	12	End Cross Rod	$\frac{3}{8} \times 17\frac{7}{8}$
2	13	Side Cross Rod	$\frac{3}{8} \times 28$
2	14	Side Cross Rod Upper	$\frac{3}{8} \times 27$
16	15	Washer	$\frac{3}{8}$ ID $\frac{7}{8}$ OD $\times \frac{1}{16}$
16	16	Nut	$\frac{3}{8}$ U.S. Std.
2	17	Upper Ledge	$\frac{7}{8} \times 2 \times 29$
1	18	Upper Ledge Space for Model "E" only	$\frac{5}{8} \times 3 \times 29$
6	19	Wing Nuts	$\frac{1}{2}$ U.S. Std.
6	20	Carriage Bolts	U.S.S. Thrd $\frac{1}{2} \times 5$ Long
6	21	Washer	$\frac{1}{2}$ Std.

ENGINE DISASSEMBLY

Complete Directions for Tearing Down Wright Engines in the Most Efficient Manner

THE sequence of operations given in the following directions has been chosen as the best and most efficient after experience gained on thousands of overhauls in many different base repair shops, as well as in the factory.

The procedure differs considerably from factory practice in that it eliminates as far as possible the use of special fixtures and of elaborate special tools.

It may be thought by the reader that too much stress is laid upon certain small points, but the greatest care has been taken to eliminate everything that is not really necessary. Where small points are emphasized it is because long experience has shown them to be of real importance.

Fits and Clearances

These are a case in point. In rebuilding an engine the clearances specified should be adhered to as carefully as possible. The power, durability and reliability of the engine depend upon them, and they have a great effect on the oil and fuel consumption. This is especially true of the valves and valve mechanism. The valves are always the weakest point of an aviation engine and the number of hours which can be flown without overhaul depends largely upon the accuracy of the valve fitting at assembly.

Special Tools

In addition to the few tools sent out with every engine there is a larger kit for each model of engine, which can be obtained from the Wright Aeronautical Corporation. This kit consists of tools designed specially for field service, is not expensive, and its use is advisable wherever frequent overhauling is done, as the special wrenches, etc., are not only quicker to use, but are less likely to do damage to motor parts, an ever present possibility with ordinary adjustable tools.

The kits comprise, first, a number of tools adaptable to all of the models of Wright engines, and then supplementary sets caring for parts peculiar to one model only. These tools are listed on page 78 in such a way that kits necessary for any one model or for any combination of two models can be found. In the overhauling instructions frequent mention is made of these tools and it is assumed they will be employed.

Cleanliness

Owing to the heavy pressures which prevail throughout an aviation motor in operation, the smallest amount of dirt in the oil is liable to do excessive damage. Thus complete overhaul should never be attempted anywhere but in a building that can be kept free from dust.

It is strongly recommended that the special system for washing parts (described on page 48) be used, for the cost of installing it will very soon be recovered in the longer life it will give the engines. Also, while the equipment may sound a little elaborate, it is quicker to clean parts with it than by haphazard methods.

Tearing Down

The instructions following refer primarily to models H-3 and E-2, but apply equally to the other models except where noted. In overhauling a Model A, E or I, follow the directions here and refer to the supplements when reference to them is encountered.

Mounting Engine

After removal from the plane the engine must be placed for overhaul on a stand which will support it on a bed similar to the plane bed. Far the most convenient stand to use is the wooden tilting stand illustrated on page 42. This can be made up by any carpenter and fits all models. To use it the engine is placed on the bed and held down by three or four clamps. It can be worked on thus for the first stages of disassembly, and when the removal of the cylinders is reached the whole stand, engine and all, is rocked over till it rests on the side legs, which brings one or the other of the blocks of cylinders into a vertical position. Blue prints of the details of the tilting engine stand can be obtained from the Service Department of the Wright Aeronautical Corporation.

Leave Parts Together

Throughout the tear-down replace all nuts and screws wherever possible. This is good practice always, but is particularly so with the close fits of an aviation engine. Nuts replaced on their threads immediately and so kept always on the same bolt or stud will always do up more easily on reassembly and the threads will last longer.

Disassembly

1. Remove carburetor. Loosen *but do not remove* four nuts holding central portion of intake manifold to cylinder branches. Remove support bracket underneath carburetor if there is such a part; it is not always employed.

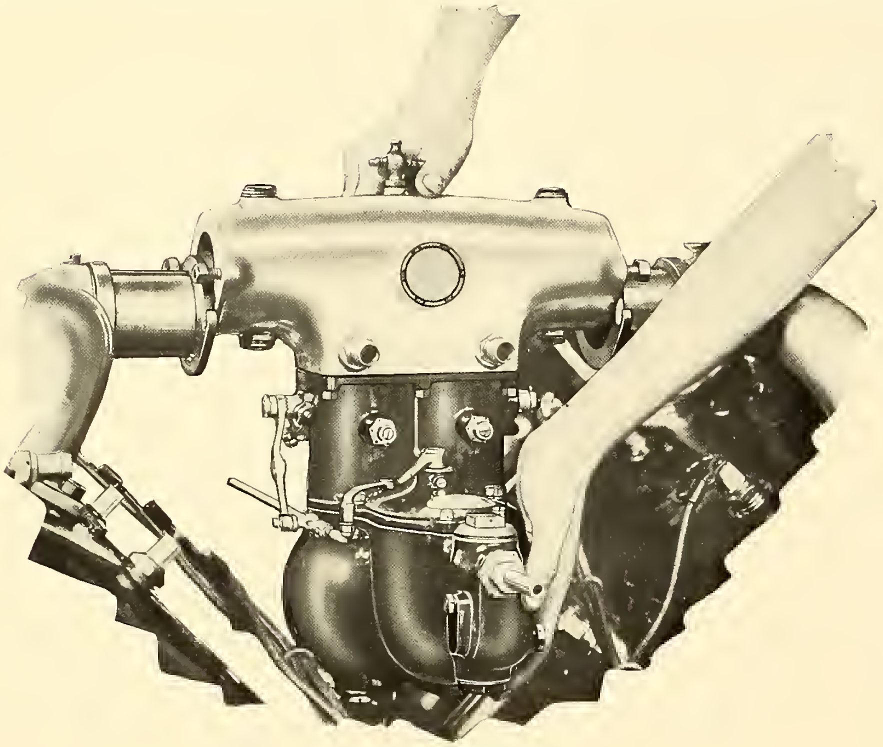
2. Lift carburetor directly upward as shown in the cut, loosening it by gentle tapping. Send the carburetor to carburetor department for cleaning. Instructions for carburetor overhaul are given on page 73.

3. Remove all spark plugs.

4. Remove magneto distributors and wire manifold with all wires intact.

5. Remove intake manifolds from cylinder blocks, leaving gaskets and nuts on the blocks.

6. *All models except model A.* Remove cotter pins from magneto couplings. Cut sealing wires and take out cap screws holding magnetos to their bracket. Slide back



Lifting out carburetor

pull down a nut too tight in reaching the cotter pin hole.

13. Detach connections between the oil pipes which are at the front end of the cylinder blocks and the crankcase.

14. Remove cylinder holding down nuts leaving in place two nuts on each block. These should be the uppermost nuts on cylinders one and three, that is the nuts nearest to the top of the crankcase. The special wrenches W A 52 or 92 are practically the only tools with which cylinder nuts can be removed easily.

15. Having all the nuts off, except the two to each block just mentioned; turn the crankshaft till the tongue and slot forming the connection between the upper vertical shaft and the lower shaft lies crosswise to the engine. This is to allow the cylinder block to be rocked to and fro to loosen it without risk of straining the vertical shaft.

coupling till the outer sleeve disengages with the gears and then lift off magnetos.

For model A magneto removal see page 47.

7. Take off magneto bracket by removing the nuts on the circular flange holding the bracket to the crankcase. The bracket can be loosened without breaking the gasket by gentle tapping with a rawhide hammer. *Never* attempt to pry off the bracket with a screwdriver. In the case of models E or I the scavenging oil pump should remain with the magneto bracket and be detached later.

8. Remove water connections between water pump and cylinders. Leave gaskets and nuts on the blocks.

9. When gun synchronizer attachment is fitted this should be removed at this stage, together with the bevel pinions which fit inside the casing at the crankcase end of the vertical shaft housing.

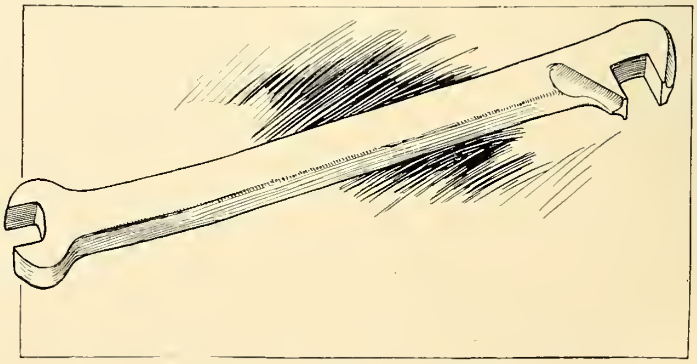
10. Remove the four nuts which hold each of the vertical shaft gear housings to the crankcase. Loosen these housings by gentle tapping; slide them up the tubes which inclose the vertical shafts and replace the nuts on their studs.

11. Remove camshaft covers.

12. Remove the four nuts from each of the *end* camshaft bearings. When these are free remove the nuts from the center bearing and lift shaft and bearings off the block. Note that it is important to free the end bearings first so that camshaft can rise up level under the valve spring pressure as the nuts on the center bearing are removed. Note also that each of the nuts and studs of the twelve that hold the camshaft bearings to the cylinder block are marked. This is because the cotter pin holes are drilled after the original assembly and if the nuts are not put back on their proper studs at reassembly there is great danger of straining the studs by trying to

Then remove the last two nuts and partly lift off the cylinder block. In rocking it to break the joint with the crankcase very little force should be used.

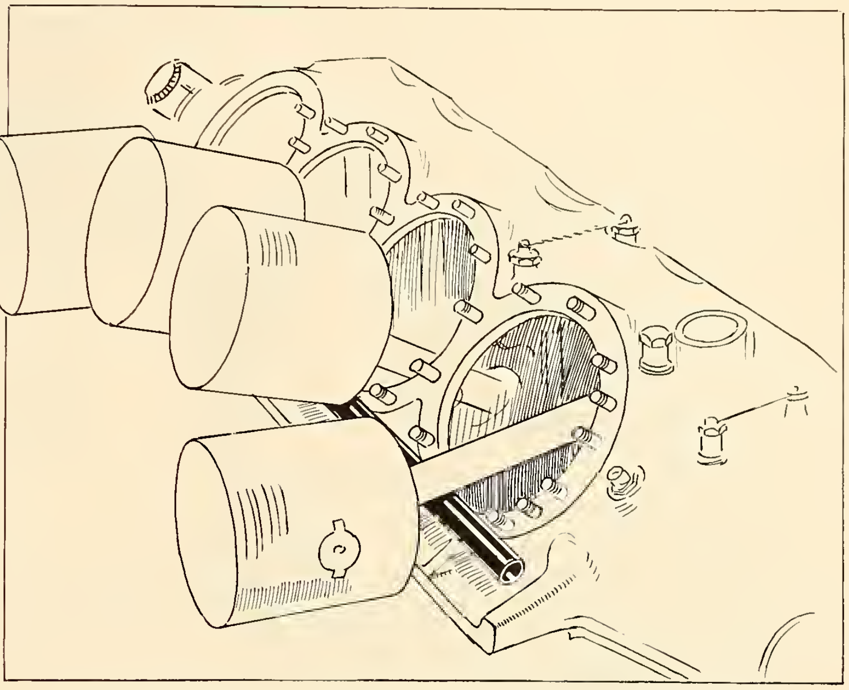
16. When the cylinder block is lifted a little way put in place the piston protector. This is shown on the next page. It is a copper tube as long as the cylinders and with either four or eight holes drilled in one side according to the model of the engine. A diameter of pipe about three-quarters of an inch is suitable. The holes are placed so that the pipe will slip over and so cover the ends of the lower cylinder holding down studs. Without this fixture, when the cylinder block is entirely removed, the pistons will fall against the lower studs with sufficient force to do damage. Even if care is taken to prevent this happening at the moment of cylinder removal, it is likely to happen afterwards and the time spent in making the fixture will be recovered in the overhaul of the first engine. Of course it is not essential to use copper pipe in precisely the way illustrated as long as the stud ends are covered. Another way used in some field shops is to cut short pieces of stout, small rubber hose and place them over the studs.



Wrench for cylinder holding nuts

17. Remove first cylinder block completely, and repeat all operations for other block. Before removing second block do not forget to see that the tongue and slot in its vertical shaft are transverse to the engine.

18. *Except for E-2 and H-3 models,* all recent models have pistons in which the wrist pins are floating and are prevented from endwise movement by aluminum caps which fit into the pistons. See cut on page 6. To remove these caps an 8 mm. bolt is necessary. Screw this into the tapped hole in the cap about two threads deep and the cap can be pulled off. All caps and pistons are marked and must be put back together in accordance with the marks, so keep the caps together with each piston.



Use of copper tube to protect pistons from injury by cylinder studs

Wrist pins have to be tapped out by using a drift. It is best to have two men for this job, one to drive and the other to hold the piston. If the job has to be done by one man he should hold the connecting rod as close up to the pistons as possible with the left hand and tap out the pin with the other. It is very important not to tap hard enough to put any side stress on the connecting rod, as the latter is easily sprung.

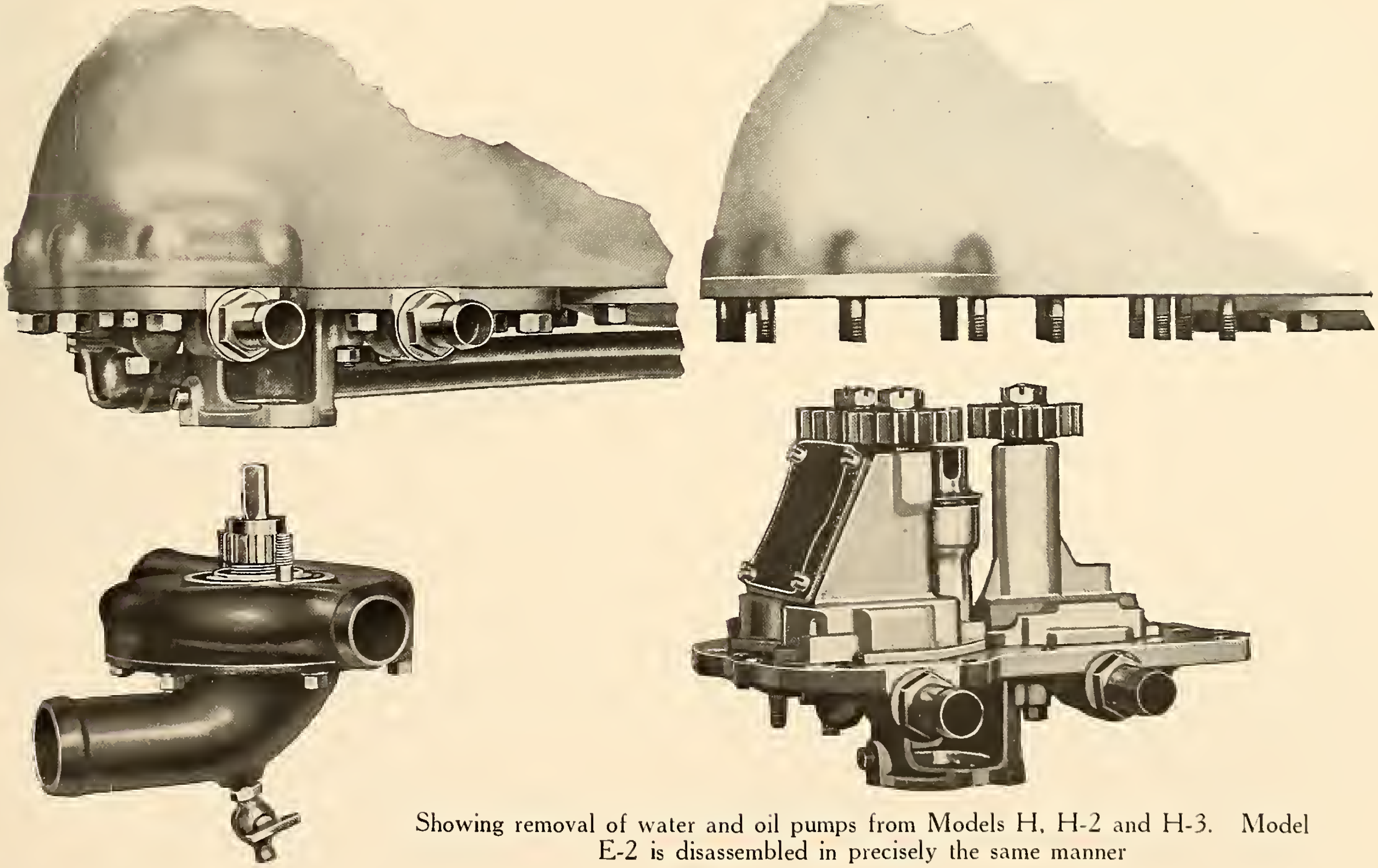
Do not drive wrist pins right out, merely far enough to allow pistons to be removed.

If the work is done in a cold shop the pistons should be heated before attempting to drive out the wrist pins.

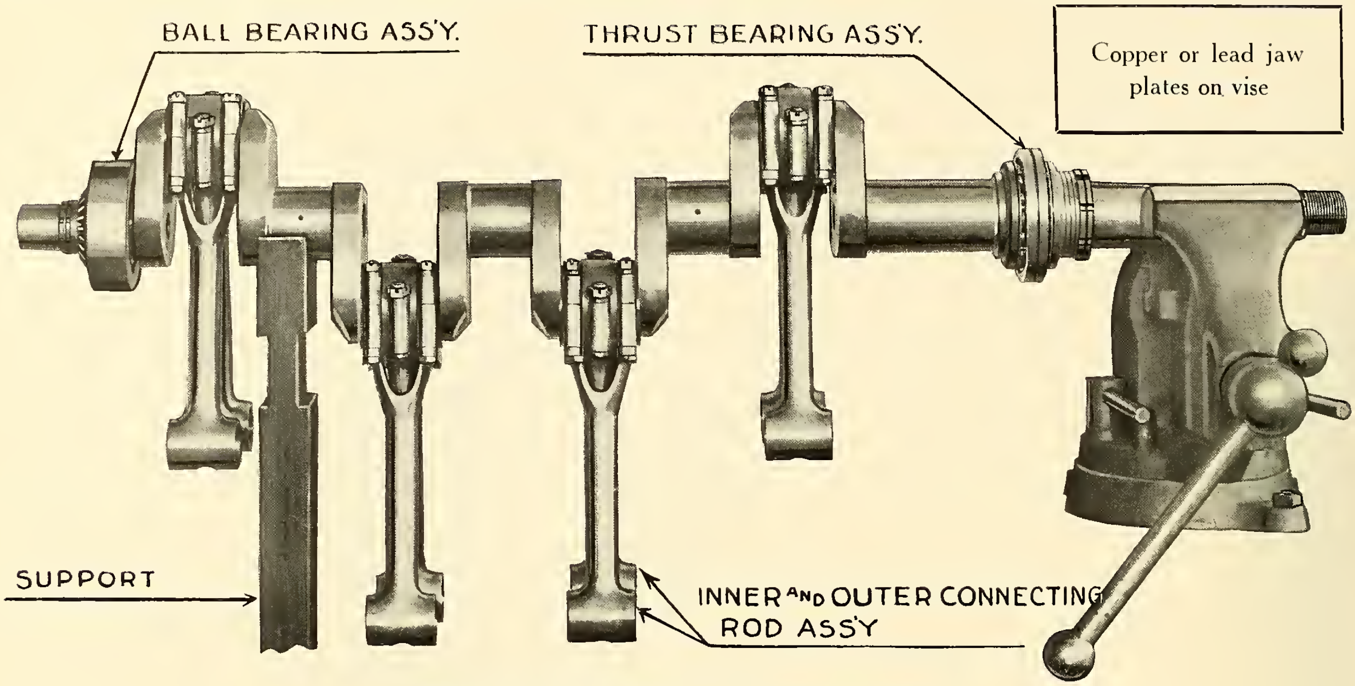
For removal of older model pistons see page 47.

Second Stage

This completes the first stage of the disassembly. The procedure up to this point covers the tearing down neces-



Showing removal of water and oil pumps from Models H, H-2 and H-3. Model E-2 is disassembled in precisely the same manner



Simple and secure support for crankshaft assembly

sary for a minor overhaul where valve grinding and general inspection are the objects. The second stage of disassembly covers the taking apart of the crankcase.

19. Remove the oil pressure gage hose connector from the side of the lower half of the crankcase. If not taken off now it is liable to be damaged in moving the case.

20. On the top of the crankcase there are ten nuts all locked by sealing wires. These are the nuts of the long bolts which hold together the two halves of the crankcase. Leave the four at the front end and the two in the center, but remove the other four.

21. Lift the crankcase out of the stand and lay it on its side.

22. Remove crankcase flange nuts, bolts and washers from the upper side of the case.

23. Remove oil and water pump assembly.

Models H, H-2 and H-3.

Detach external suction pipe at its front end flange connection with the crankcase. Remove nuts on pump base plate and lift off assembly. Take out strainer and oil pressure relief valve.

Models A, E and I.

Take off four nuts holding water pump bracket to crankcase. The water pump will then draw off and the inner member of the oil pump will follow it. As the oil pump shaft comes out grasp it firmly so that the pump vanes do not come out of their slot, as they may be damaged by falling. Directly the shaft is withdrawn tie a piece of wire round the vanes to hold them in position. Remove oil strainer and oil pressure relief valve.

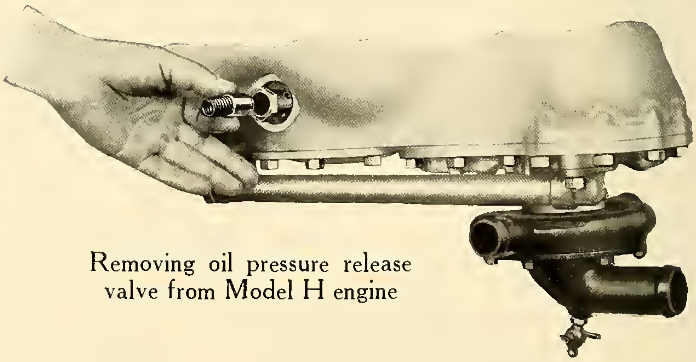
On Model E-2 after removing Pump Assembly the two stud bolt nuts at rear bearing inside of crank case must be removed. These can be reached through the pump opening.

24. Turn crankcase over on its other side and remove flange bolts, nuts and washers as before, from the other side.

25. Set the case back in its original position on the stand and remove remaining six nuts from the crankcase bolts.

26. Place the crankshaft so that the throws are horizontal. If this is not done the plugs in the crank throws will catch on the main bearings and prevent the separation of the upper from the lower half of the case.

27. Lift the case at one end about three inches off the stand and let it fall sharply back. The shock will



Removing oil pressure release valve from Model H engine

break apart the upper and lower halves of the case and the upper half can then be lifted off by raising it from each end simultaneously and being careful to keep it level.

28. Lift out the crankshaft and place it on a special stand as shown at the top of this page.

This completes the major disassembly.

DISASSEMBLING MODEL A

THE procedure for tearing down model A is almost exactly the same as that for models E and I. It differs in the magneto removal and in the taking off of the pistons.

Magneto Removal

1. Remove nuts from flange studs holding housing at bottom of vertical shaft to crankcase.

2. Cut locking wire on magneto holding down cap screws.

3. Remove holding down cap screws.

4. Lift up magneto and the housing, loosened in operation 1, together to clear dowels. Then draw back magneto, and pinion will slide out of housing remaining with magneto. During this operation be careful not to strain housing, which is rather delicate.

Piston Removal

1. Turn oil rings until the gap in the ring registers with the hole in which lies the head of the wrist pin lock screw cotter.

2. Straighten ends of cotter very carefully, grasp them with the pliers and tap back the pliers with a hammer till the head of the cotter projects enough to be grasped and pulled out.

3. Remove wrist pin lock screw, using the special model A tool W A 71. If this tool is not available a special socket wrench will have to be made. The screw has a square head and the socket requires a 7/32 in square hole.

4. Drive out wrist pins by same method as for other models.

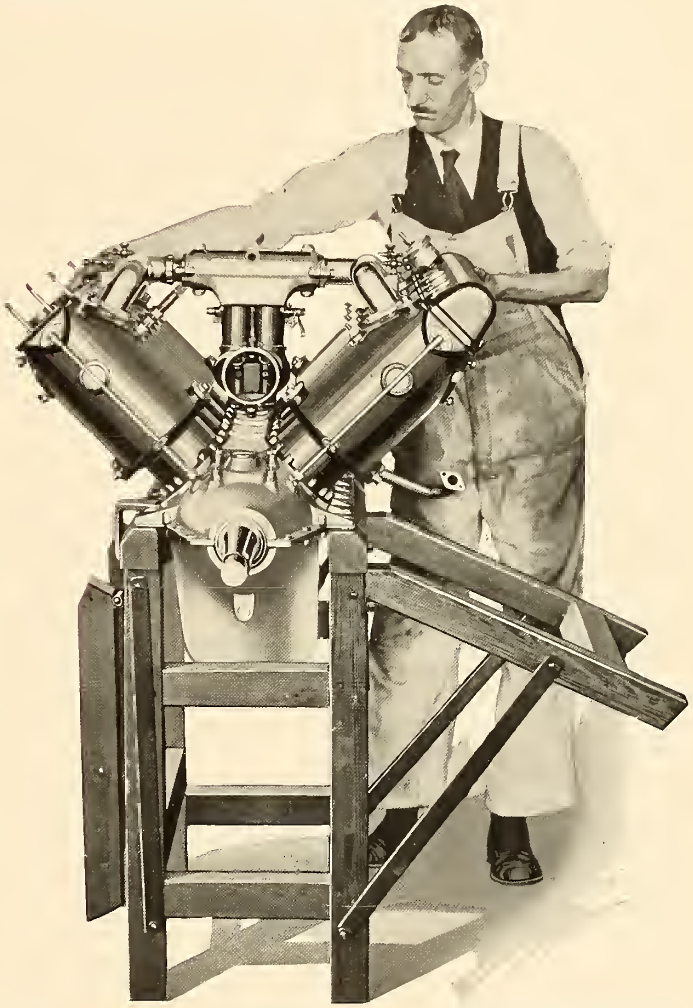
Connecting Rods

1. Remove the cotter pins and nuts from the four bolts of the bridged cap.

2. Remove the cap by very gentle tapping on the arch. This cap binds very easily and is easily injured.

3. Remove the cap screws from the inner rod and rod will be free.

4. In lifting off rod be careful not to strike against the plugs which close the hole through the crankshaft, as the babbitt can easily be burred by them.



Tilting engine stand in use, showing how operator should grasp engine in order to rock it over onto the side leg of stand

CLEANING ENGINE PARTS

Recommended Washing Equipment to Insure Absence of Dirt and Thereby Give Long Life to Motor

OWING to the close fits essential to an aviation engine, and to the very high bearing pressures extraordinary damage can be done by quite small amounts of dirt. Grit that would never be found in an automobile engine can easily be sufficient to heavily score bearings and pistons in an aviation motor.

The use of compressed air for blowing out parts dry is not enough; nor is it enough to wash them in a pail of more or less dirty gasoline.

THE MORE SCRUPULOUSLY CLEAN THE PARTS AT ASSEMBLY THE LONGER THE ENGINE WILL RUN WITHOUT OVERHAUL.

The best cleaning equipment consists of two tanks about four feet long, three wide and two deep.

These tanks should be placed close together on a wood stand which will raise them a foot off the ground. Each tank should have a drain cock in the bottom.

Inside each tank there should be a false bottom of wood slats raised about six inches from the actual bottom of the tank. The slats should be about an inch apart.

On either side of the tanks should be a sloping table draining into the tank and above and behind the tanks a shelf or two of slat construction.

Use of Equipment

The tanks should be filled with gasoline or kerosene to within about eight inches of the top. One tank should be used for the washing of dirty parts coming from dis-assembly, the other for clean parts, inspected and ready for final re-assembly.

Each part should be placed in the tank and left there soaking for at least five minutes. The false bottom supports the part below the surface of the gasoline and any heavy dirt, such as particles of babbitt, will drop through the slats to the bottom of the tank where they can do no further harm. The operator requires several bristle brushes and a squirt gun. Parts like a crankcase should be first soaked for five minutes, then lifted up and rested upon two pieces of wood laid across the top of the tank. In this position the brushes should be used, the case sluiced and the squirt gun employed for forcing gasoline through bolt holes, etc. Then the case should have a second, shorter soaking before being lifted out to drain.

A long soaking is advisable for crankcases, cylinder blocks and pistons. Shafts, gears and small parts generally require much less. Frequent use of the squirt gun to clear all small holes is important.

For cleaning out the oil holes inside the crankshaft the squirt gun is again used, but this operation calls for a helper who by covering the various holes with his fingers allows the operator to wash out one orifice at a time. This equipment should be situated in a building free from dust and with regard to fire risk it may be remarked that kerosene is practically as good as gasoline for cleaning.

There should be drying racks in the building and parts should never be sent to re-assembly until they are thoroughly dry. A point worth remembering is that soaking is more effective on old, caked oil than scrubbing, and it is sometimes economical of labor to soak crank-cases or pistons for as long as half an hour.

Owing to the opportunity for sediment to collect at the bottoms of the tanks, beneath the false floor, the kerosene or gasoline lasts a long time, as it only becomes unusable when it has taken up so much oil that its cutting properites have been lost. For this reason it is well to drain off all oil possible before washing. Where many parts have to be cleansed the amount of time and of gasoline saved by this equipment is substantial and the cost of the installation is thus rapidly recovered.

Experience has proved that cleaning parts of aviation engines to a degree that at first may appear ridiculous is actually highly economical. The number of hours a motor will fly without trouble is largely controlled by the amount of dirt remaining in the oil passages when it is put together. The total life of bearings and pistons is similarly affected.

OVERHAUL OF WRIGHT ENGINES

Instructions for Disassembly of Detail Parts, Their Inspection, Repair and Reassembly

WHERE reasonably frequent overhaul of Wright engines has to be made the use of the cylinder holding fixture illustrated on pages 50 and 51 is recommended strongly. A blue print of this fixture will be supplied on request to the company.

This fixture holds one cylinder block at a time, so that it can be rotated on the pivots, and the lock pin holds it any way up that the operator requires it. It is composed of lumber, flat steel strip and two standard iron pipe flanges and can be made up with the simplest tools. It is adjustable to suit either the E or the H series of engines.

Together with this stand four pieces of wood are required of a size and length which roughly fits the inside of the cylinder. One such piece is placed inside each bore and all four are held in place by a strip of flat stock cut to the length of the block and drilled so that it can be held in place by a bolt through each of the end cylinder flanges. These blocks of wood, held up in this way, support the valves and prevent them from lifting when the springs are held down for the removal or replacement of a tappet.

Procedure on the cylinder block after its removal from the engine is as follows:

1. Place block in holding fixture and attach wood blocks to hold up valves.

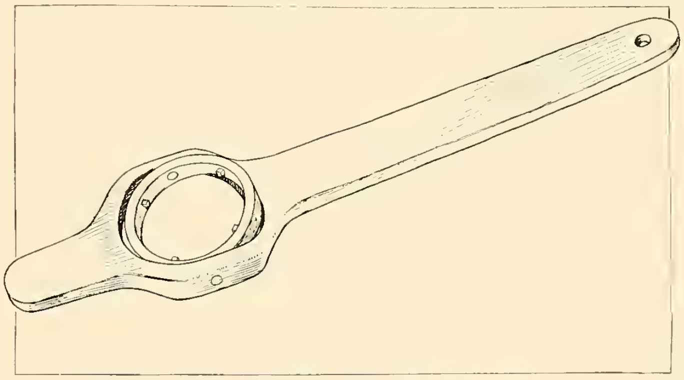
2. Set block vertically with valves on top and attach valve lifting fixture. This is the fixture illustrated in use, in the cut on this page. It can easily be made up from this illustration or a blue print can be obtained from the company. The two end pieces of the frame of this fixture are held down by putting two nuts on the end studs of the camshaft bearing studs. It is necessary to make up a frame for the E series and another for the H series of motors, since although an adjustable frame could easily be devised it would hardly be worth while.

3. Insert the short end of valve assembling lever (tool W A 15) below the back bar of the frame. Move the lever till the two pins slip through opposite notches in a tappet head. Then press down on the lever and the valve spring washer will be forced clear of the tappet.

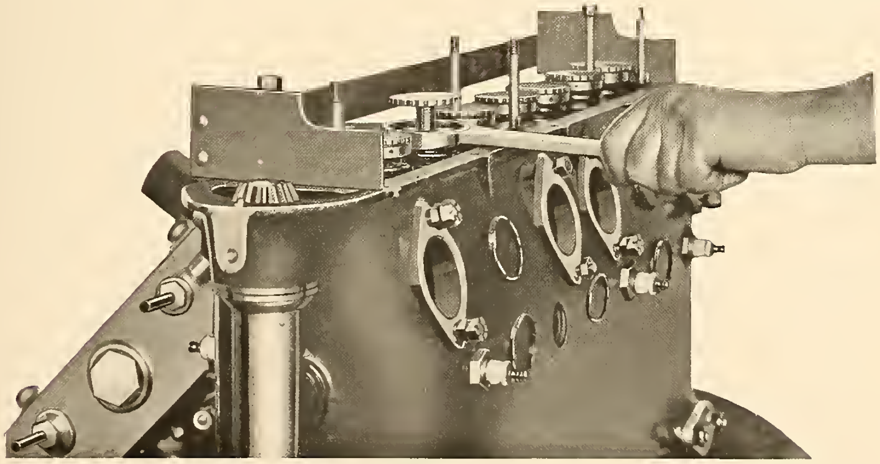
4. Unscrew the tappet. If this is more than finger tight use the socket wrench (tool W A 19).

5. As the tappets are removed and valve springs and washers lifted off, be sure to place them in order on the bench from number one to number eight.

6. Turn block over on its pivots and remove the blocks of wood holding up the valves. Remove valves one by one and *immediately* replace the washer and tappet belonging to each. Keep the valves in arranged order or check to see that each is marked. Even when marked be careful not to get the valves from right and left hand cylinder blocks confused.



Valve tappet lifting tool used for removing valves

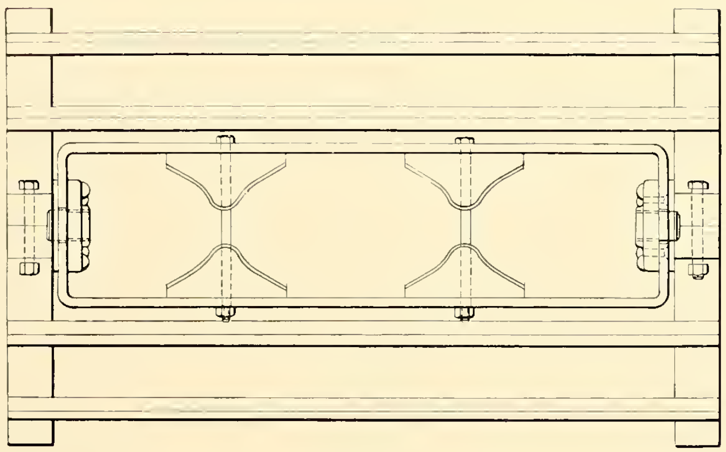


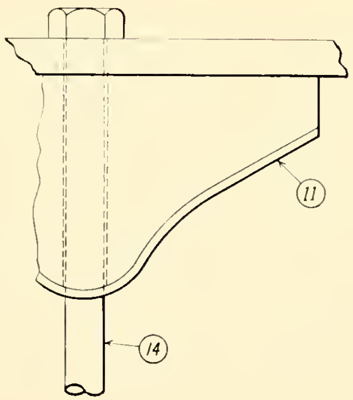
Shows fixture for removing valves in use. The frame is held by the end camshaft bearing studs and the tappet washer depressed by the lever. The tappet can then be unscrewed by hand.

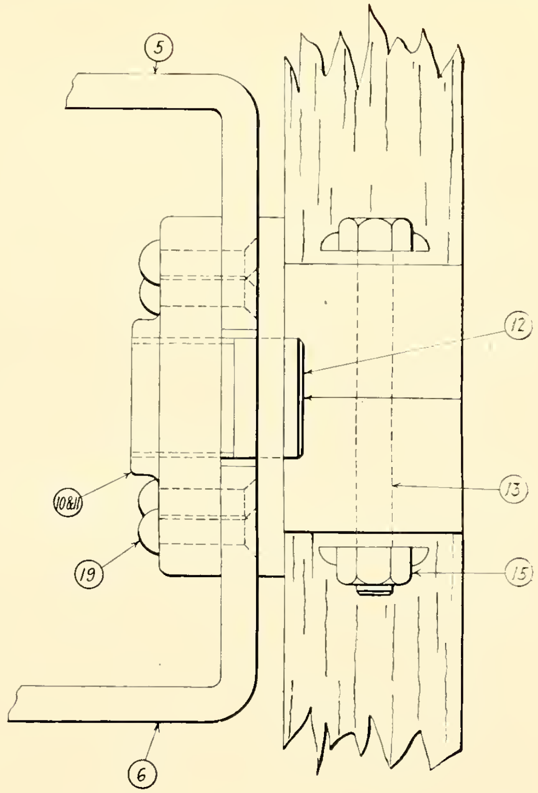
7. Using spark plug bushing wrench (tool W A 12) test each spark plug bushing for tightness. If any are found loose they should be removed and replaced, using a new copper ferrule gasket on the nose of the steel bushing. The use of a new gasket is very important, to tighten up a loosened bushing on an old gasket is very liable to leave a slight water leak.

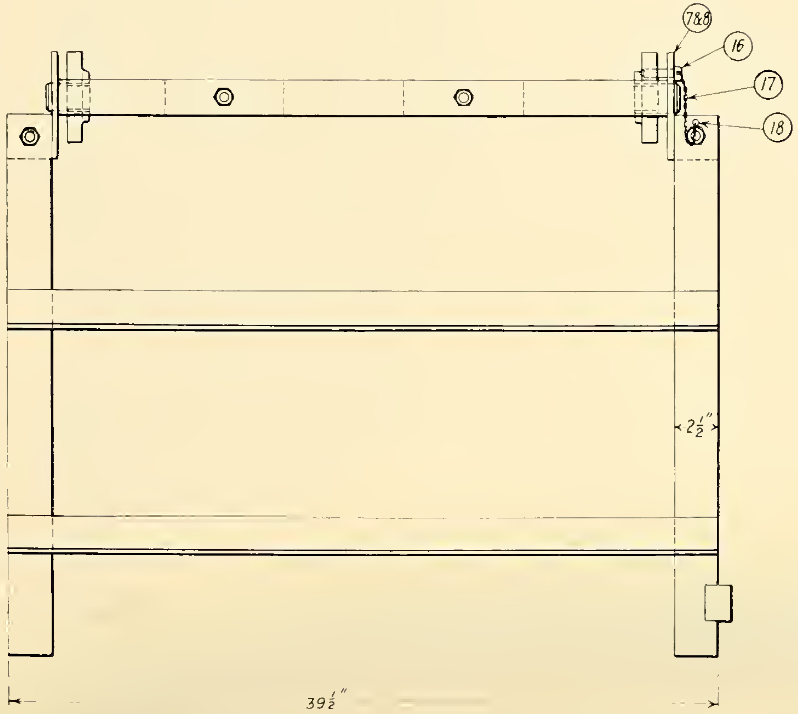
Spare spark plug bushings are sent out tapped a little undersize. *After*

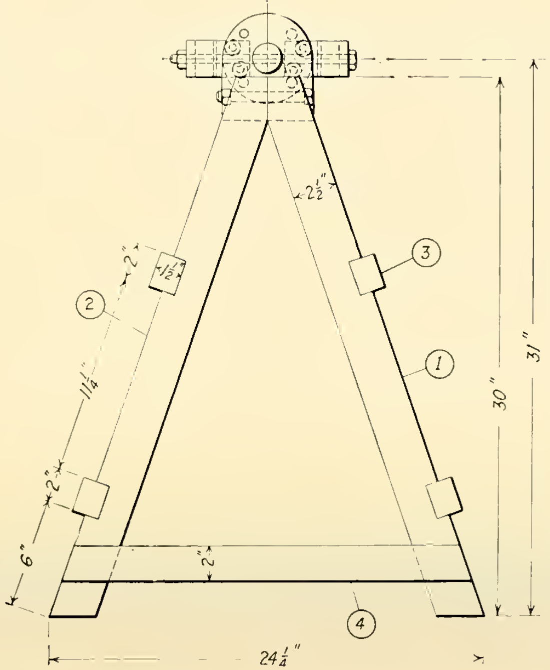
Assembly of Cylinder Holding Fixture



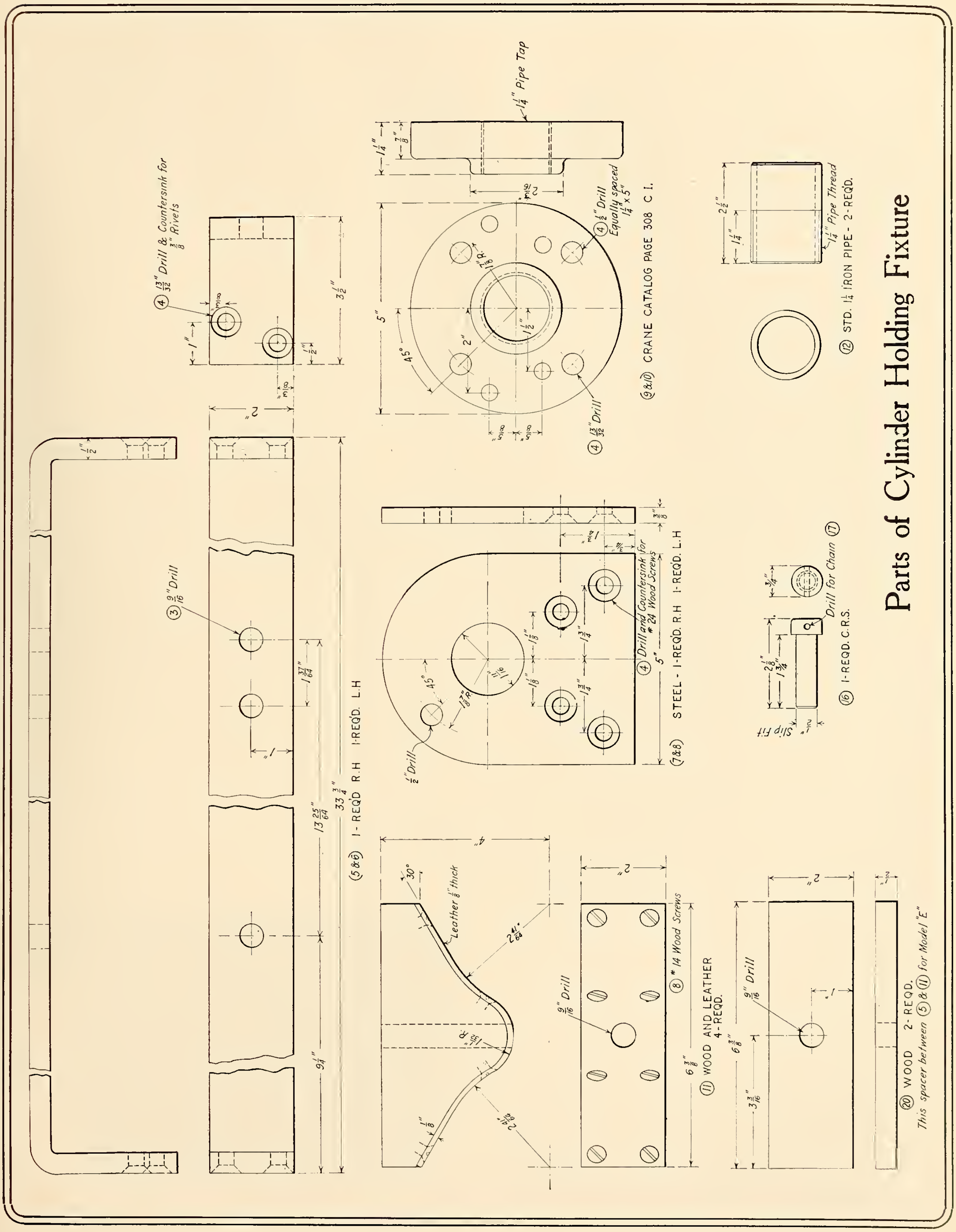




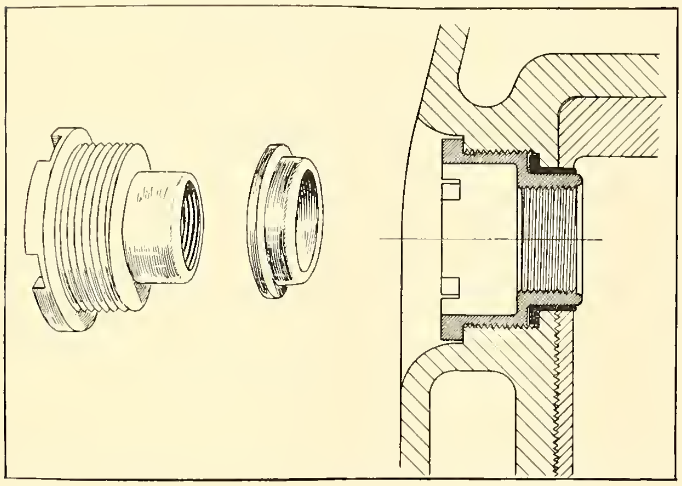




DET.	NO.	NAME	SIZE
1	2	End Support R.H.	$2\frac{1}{2}$" x $2\frac{1}{2}$ x $32\frac{1}{2}$ Wood
2	2	End Support L.H.	$2\frac{1}{2}$ x $2\frac{1}{2}$ x $32\frac{1}{2}$
3	4	Side Braces	$1\frac{1}{2}$ x 2 x 39
4	2	End Brace	$1\frac{1}{2}$ x 2 x 23
5	1	Holding Strap R.H.	Steel
6	1	Holding Strap L.H.	Steel
7	1	Bearing Plate L.H.	Steel
8	1	Bearing Plate R.H.	Steel
9	1	Tilting Flange L.H.	Commercial
10	1	Tilting Flange R.H.	Commercial
11	4	Clamping Blocks	
12	2	Pivot	$1\frac{1}{4}$ Pipe $2\frac{1}{2}$ long
13	2	Bolt	$\frac{1}{2}$ x $4\frac{5}{8}$ USS Hex
14	2	Bolt	$\frac{1}{2}$ x $9\frac{3}{4}$ USS Hex.
15	4	Nuts	$\frac{1}{2}$ U.S.S. Hex.
16	1	Locating Pin	
17	1	Chain	Length and size to suit
18	1	Eye Screw	Commercial
19	8	$\frac{3}{8}$ C.sunk Hd. Rivets	Length to suit Flng
20	2	Spacer Block	$\frac{1}{2}$ x 2 x $6\frac{3}{4}$



Parts of Cylinder Holding Fixture



Spark plug bushing and ferrule

putting in a new bushing an 18 mm. tap should be run through it.

Cylinder block is now ready for inspection.

Inspecting Cylinders

After washing and drying (see instructions for cleaning, page 48) cylinder blocks should be inspected for superficial defects such as cracks in the water jackets.

It is important to observe the condition of the top surface on which the camshaft cover rests, as this must be quite smooth and flat. The bronze bushes into which the cover screws go sometimes loosen. See that they are all tight and level with or below the surface of the aluminum. If it is necessary to do any smoothing work the cover and block should be gone over together, using blue and scraping high spots so as to get the best possible oil tight join between the two parts.

Cylinder Sleeves

These should be inspected internally for scores or scratches. Roughness due to a score should be removed with a half round Arkansas stone of fine grain. A deep scratch need not, in fact should not, be completely stoned out, as this is liable to distort the bore too much. If all rough or sharp edges are stoned out the score itself will do little harm provided, of course, that it is not too large.

Inspect for roundness carefully. A cylinder sleeve which is much out of round will cause serious loss of power and heavy oil consumption. If over .006 out of round it is recommended the block be returned for re-sleeving.

In case it is necessary to reject a cylinder sleeve for deep scores or for out of round the cylinder block *with the camshaft cover in position* must be returned to the Wright Aeronautical Corporation for the insertion of a new sleeve. New sleeves can be put in easily with the factory equipment, but without it the job is very difficult and uneconomical. The camshaft cover should be put back before shipping in order to protect the top surface of the block and to prevent the studs for the camshaft bearings from being injured. Outside of cylinder walls should be thoroughly slushed with a high grade slushing oil to prevent rust during shipment.

In cases where a cylinder bore is scratched up a good deal by grit, but none of the scratches are deep, it is a good plan to lap with an old piston and new piston rings, using plenty of oil and a very fine abrasive, preferably crocus. Note particularly that before lapping a block of wood must be put in the cylinder thick enough to prevent the piston from striking the inwardly projecting nose of the spark plug bushing. A slight blow on this is almost certain to cause a water leak.

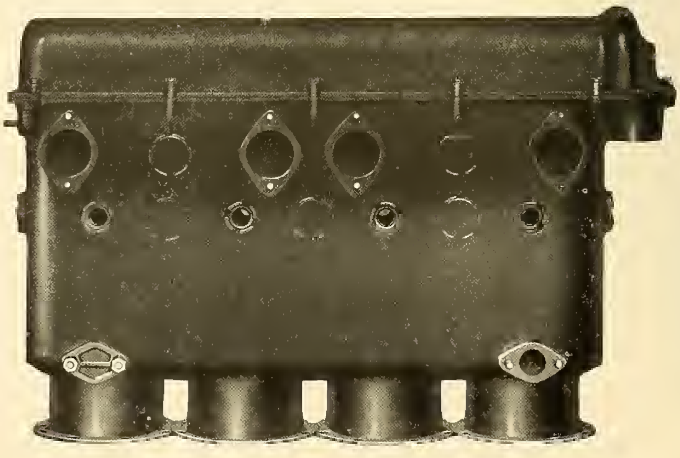
Valve Seats

The valve seats are usually glazed after an ordinary length of use and have a very hard skin. Using an old valve and coarse grinding compound this glaze should be broken, but never grind more than enough to break the glaze, the less grinding done the better.

The glaze being broken, the seat should be reamed with tool W A 7. This tool consists of a handle and two cutters, each cutter being complete with its pilot fitting in the valve guide bushing. There are two cutters because the valve guides are reamed to different sizes and care must be used to see that the intake cutter is used for the intake valve and the exhaust cutter for the exhaust valve seat. The pilot of the exhaust valve cutter will not go into the intake valve guide, but the intake valve pilot *will* go in the exhaust guide. It is, however, so loose a fit that a true seat could be reamed only with great care.

Good steady pressure is required on the handle of the seating tool, and the least possible amount of metal should be removed which will bring the seat smooth, as it is bad to cut away much. Too deep a reseating operation will "swallow" the head of the valve and so restrict the valve opening and cause excessive valve heating.

It may be observed that the teeth on the seating cutters are not radial, but are set at two different angles. This is done because it enables a smooth seat to be cut more easily. Cutters should be kept very sharp and great care taken to wash off all grinding dust before using the cutter.



Cylinder block with camshaft cover as it should be assembled if sent to factory for any kind of repair.

It should always be the desire to get a perfect seat with the cutter; the less grinding required afterwards the better.

Valve Guides

These should be tested with the guide plug gauges (see tool list page 78). If these are loose more than .005 new guides are required. New guides are supplied by the factory bored to one size. To fit a new guide, remove the old one with a socket wrench, and screw in the new one as tight as possible with a socket wrench and a bar about a foot long. Remember that the thread is fine and is cut in aluminum, so do not use too much force. Make sure that the collar on the guide seats flat against the faced lug on the cylinder block. If it does not do so, try another new guide before doing any scraping.

In fitting a new guide to a Model A for the first time it is necessary to do a small machine operation on the cylinder block. The cut shows, on the left, the design of the original Model A guide and cylinder and it will be seen that there is an upwardly projecting lug on the cylinder casting into which part of the valve guide slides, the guide not having a collar. On the right hand side of the illustration is shown the form of guide supplied for replacement—identical with the Model E guide. It is therefore necessary to machine off the lug from the cylinder block to suit the new design of guide. The illustration gives all necessary dimensions for this operation.

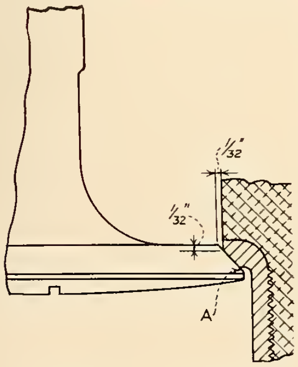
After inserting a new guide it must be reamed to size, using the expanding reamer and the intake and exhaust valve plug gauges (see tool lists for E and H series, page 78).

The new guide being reamed the valve seat must be trued with the reseating cutter, as it is practically impossible for the old seat to be true with the new guide.

Vertical Shaft Bearing

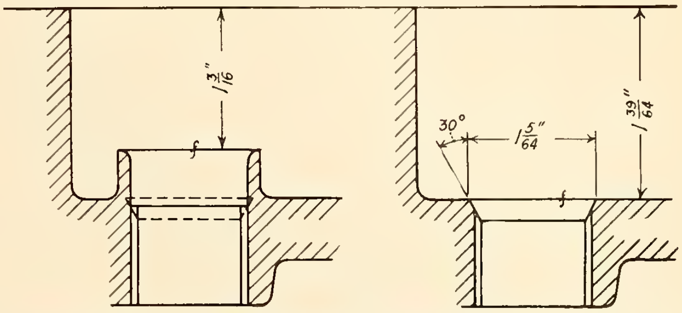
In an ordinary overhaul it is not necessary to remove the upper vertical shaft from the cylinder block, provided care is taken not to damage it during handling, especially during washing.

To remove it the tubular casing is taken off by unscrewing it at the top end and then driving up the bearing with a block of wood and a hammer as shown in the cut on page 55. Be sure to tag the shaft with its bearing and the tubular casing so that it is reassembled on the same cylinder block.



Correct valve seating
"A" must not be less than 1/64" and should be 1/32"

Inspect the vertical shaft for end and side clearance in accordance with the clearance chart, page 54. Also examine teeth of gear and reject gear if there is any sign of roughness on the tooth surfaces. In case it is necessary to fit a new vertical shaft bushing in the cylinder block one particular precaution should be taken, which is as follows: The tubular housing screws on the lower end of the bushing thus holding it in place, and there is a spring wire lock ring. If a new bushing or a new housing is fitted it will generally be necessary to drill a new hole for the turned in end of the lock ring. This hole *must not be drilled right through,* as, if it is it will cause an oil leak that is hard to find, but large enough to be a serious nuisance.



When fitting new valve guides to a Model A cylinder, the lug shown on left must be removed as shown on right

Valve Inspection and Seating

Various steels have been used for valves and some of them are only suitable for intake valve work; therefore, care must always be taken to observe the marking on the head of a valve, which shows whether it is an intake or an exhaust valve.

Valves after removal and cleaning should be chucked and examined for warping, but a valve should not be rejected for warp which can be corrected while regrinding the valve face, as an old valve if in generally good condition will usually retain its shape in service better than a new one.

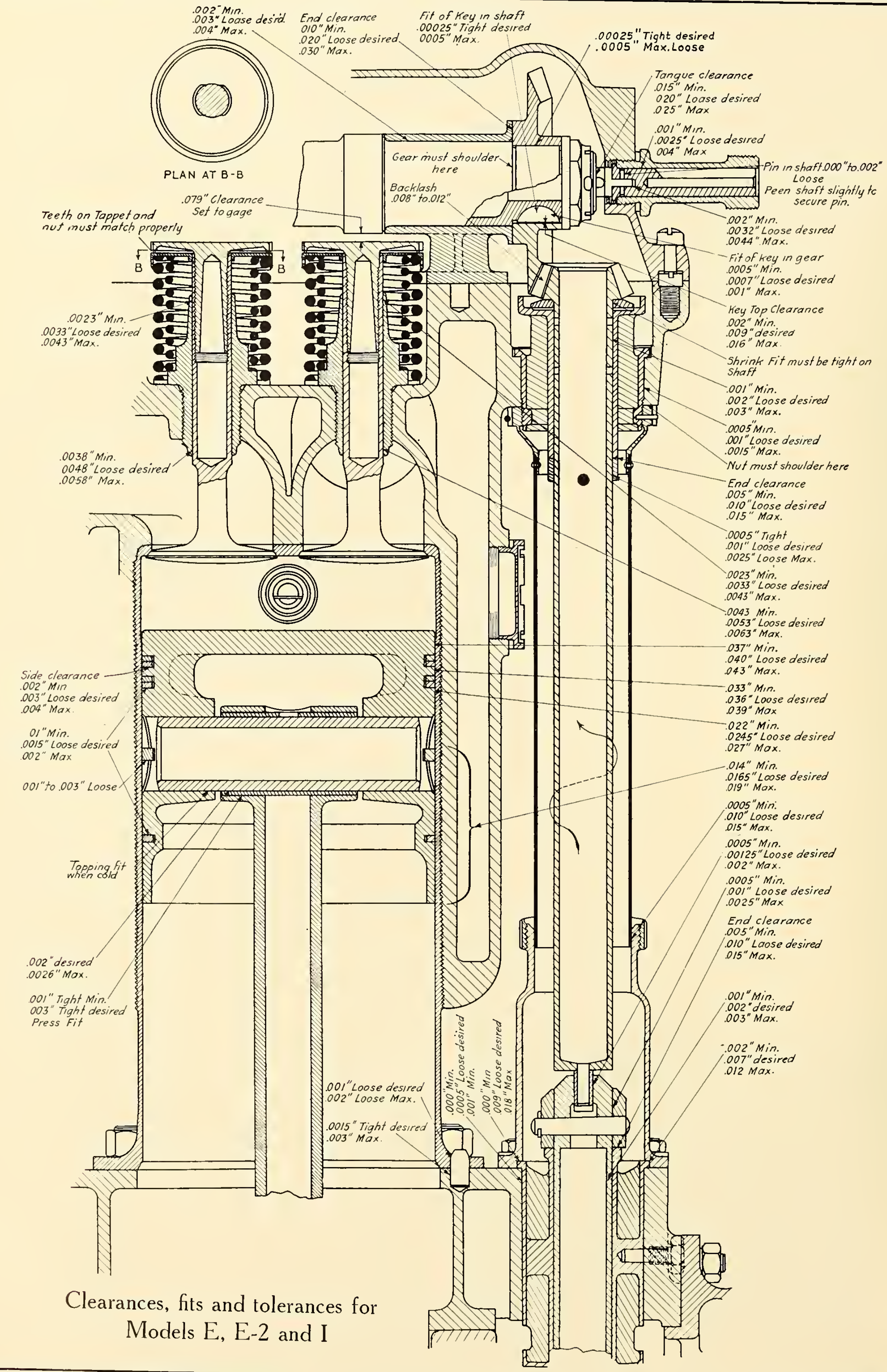
Always regrind the valves on a universal grinder or at least with the valve chucked by its stem. *Never* attempt to grind out pits or warp in the cylinder, as to do so will cause excessive wear on the cylinder seat and also give a poor seating. Remember that the ideally finished valve and cylinder seat require no grinding together and that the less grinding of valve in cylinder the better.

After setting up the grinding rig to reface the valves, do one and then try it in the cylinder. Use a little of the finest grade of grinding material and grind lightly *without pounding* for two or three minutes, not more.

This should show a seat of good width in accordance with the sketch on this page and should make the valve gasoline tight. In fact, five minutes at most should be enough.

If the first valve tried cannot be seated so easily, then change the setting of the grinding wheel so as to make the valve seat angle suit that of the cylinder better. Or possibly the trouble may be due to blunt reseating cutters, or to use of the wrong pilots in reseating.

Remember that the perfect seat on the exhaust valve should be not less than 3/32 inch wide and that it should



Clearances, fits and tolerances for Models E, E-2 and I be as little wider than this as is possible, so that when the engine is overhauled, there will be the maximum allowance for refacing. A very narrow seat is more easily made tight but warps easily. A very broad seat carries away heat better, but cuts down the allowance for refacing and carbonizes on the face more easily. A valve should be ground as little as possible to obtain a good seat. Much grinding never makes a proper set.

To spend a good deal of time in keeping the reseating cutters up to the mark, in properly chucking old valves for grinding, and thereby cutting down the conventional "grinding in" period, is the truest economy. The number of hours an engine will fly is directly dependent upon the perfection of the valve seat. Valve heads must not be "swallowed" in the cylinder seat, but a clearance of about 1/64 inch is enough. If the seat in the cylinder has been reamed out too large it is possible to save the sleeve by making a cutter with a thirty-degree angle and with this removing the corner of the seat so countersinking the actual valve seat till the head of the valve projects the necessary 1/64 inch.

Valve stems should be gauged and checked against the respective guides. If the intake valve stems are as much as 0.005 loose above called for dimensions, either valve or guide, or both, should be changed. This seems a small amount, but the unusual diameter of the stem means that a small excess clearance can cause quite a noticeable leakage of oil down the guide, quickly fouling the valve Exhaust valves are not quite so delicate since oil leaking down will burn off if the quantity is not too great.

Finally, remember that valves are the heart and lungs of an engine; if they are not *perfect* the engine as a whole cannot give any sort of satisfaction.

Valve Tappets

Reject valve and tappet when the tappet is a very easy fit on the threads, as in such case the threads are almost certainly damaged.

Reject tappet when it shows marks indicating that it has been revolving a great deal.

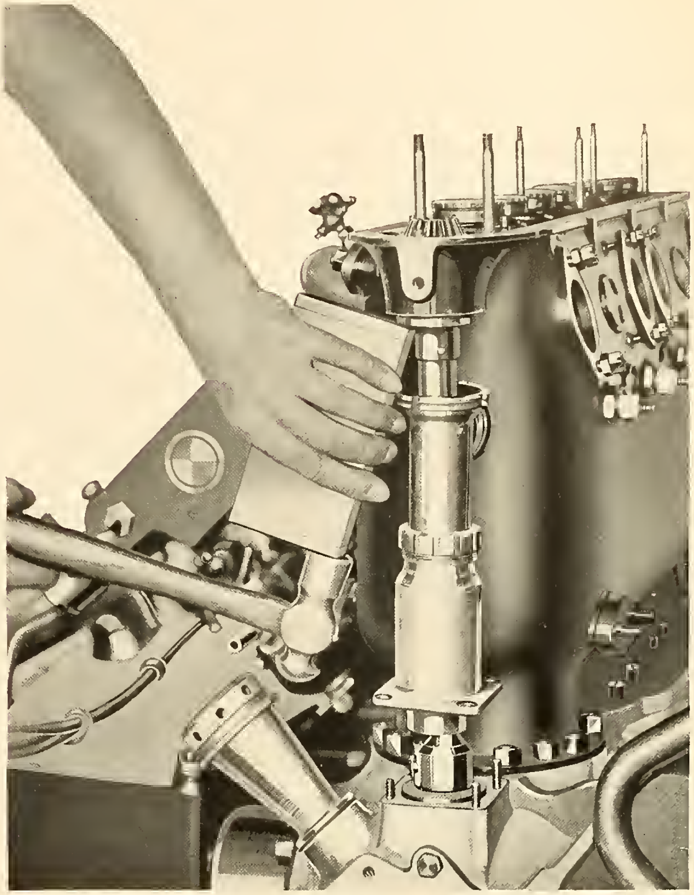
Stone out scratches on tappets otherwise in good condition, and stone tappet heads a little. The case is 0.020 thick or more, so considerable stoning can be done.

Valve spring washers sometimes strike against the top ends of the valve guides and are damaged. Examine for this and replace washers if necessary. If new guides are fitted check height of guides to make sure that there is plenty of clearance under the washer when the valve is lifted.

Check valve springs for strength in accordance with table, page 76.

Replacing Valves

After reseating valves and checking all points just covered, all parts must be again washed and dried before assembly. To assemble, place all valves in position with cylinder block in holding fixture. Insert blocks of wood described on page 49 to hold valves in place and turn over cylinders.



Driving out upper vertical shaft bearing, using block of wood faced with fiber

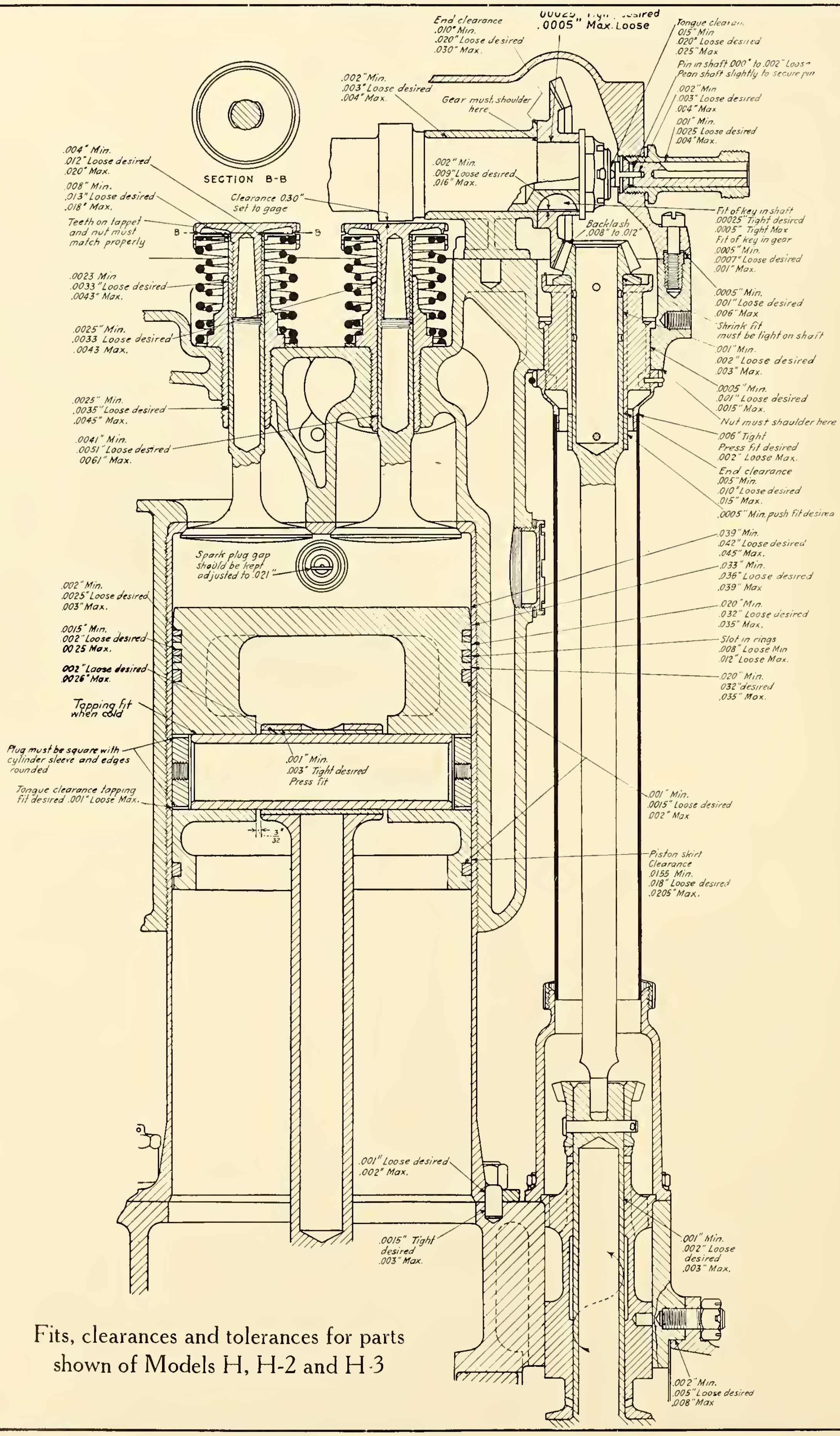
Attach the valve lifting fixture illustrated on page 49, and replace tappets by reversing the method used for their removal. Have a gauge made from sheet steel which will roughly check the height of the tappet above the top face of the cylinder block which should be $\frac{2}{3}\frac{1}{2}$ in. for all engines. Screw down the tappet till it is a trifle below the gauge.

Be sure that *intake valves* and *exhaust valves* are not mixed and that all valves go in their proper places. It is worth while to inspect this as a single error will cause the rapid burning out of a valve.

Camshaft Inspection

Unless there has been failure of the oil supply the camshaft bearings rarely require renewal. If they are damaged it is highly desirable to replace all three bearings, as they *must* be line reamed after bolting down in place. One new bearing *can* be fitted, of course, but only by much scraping and use of the camshaft bearing aligning bar (W. A. 2).

In fitting new bearings new cotter pin holes must be drilled in the studs or—which is better practice—the nuts filed down when the difference is not too great. The



Fits, clearances and tolerances for parts shown of Models H, H-2 and H-3 camshaft bearing studs are slender and the nuts must not be pulled down too tight or the studs will be strained dangerously. Before fitting a new bearing try a nut on an old one and so get the proper degree of tightness.

For reaming new bearings the special reamer (W. A. 1) fits both E and H series engines, as does the camshaft bearing aligning bar (W. A. 2). Before reaming make sure that the bearings are bolted down securely. If on trying the camshaft in the new bearings it appears tight, again see to it that the bearings are firmly bolted down, because if one is slightly loose it may feel tight on the shaft and yet be free when pulled down.

Follow the clearance chart on this page carefully in fitting new bearings, especially as regards end clearances.

Cam Faces

These should be looked over for scratches and may be polished with a fine stone. Scratches of any depth will inevitably score the tappets.

Clean out the inside of the camshaft very thoroughly indeed and, if it is to lie for a time before reassembly, plug all oil holes so that no dust will get inside.

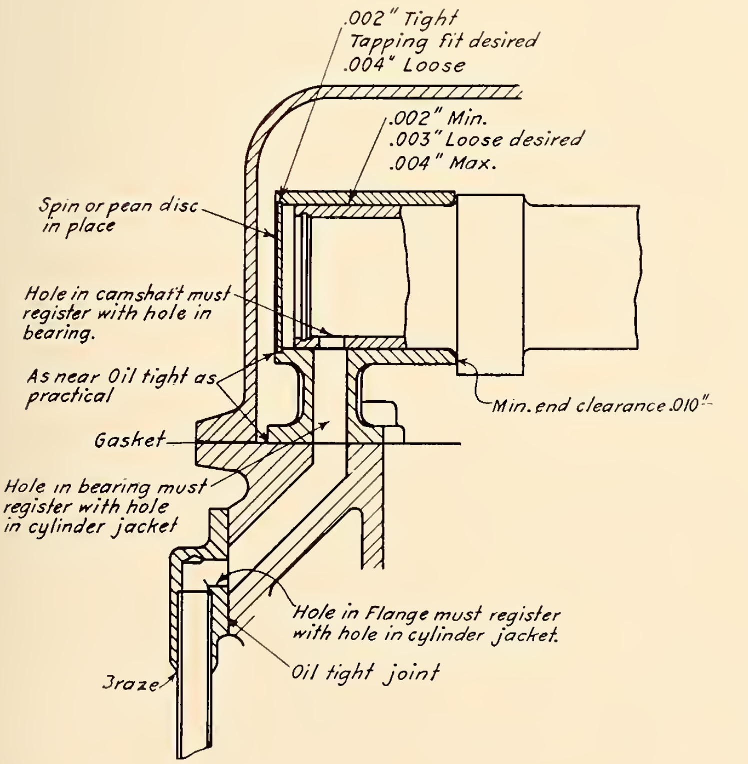
When remounting the camshaft check the backlash and clearances of the driving bevel gears and keep them to the amounts specified in the clearance charts. When testing backlash be sure to try it all around the gears and not only at one point. It is important that the backlash should not be too great, but still more important that there should be no really tight spots.

Crankshaft and Connecting Rods

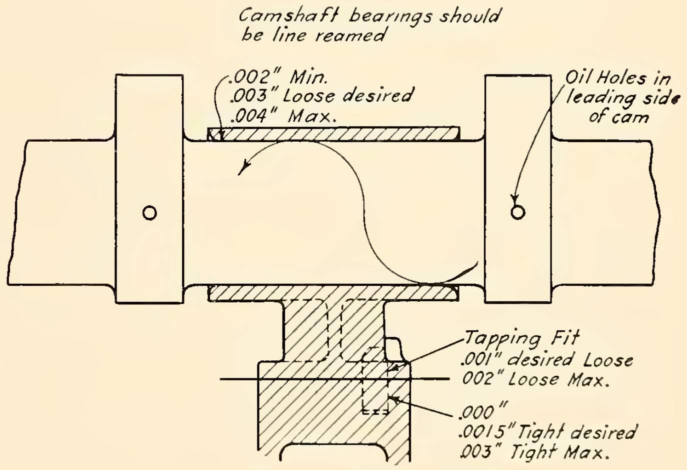
First, after removing all connecting rods and washing the shaft, test on vee blocks for straightness. A shaft should never be used that is more than 0.003 out on the taper end. If not more than 0.005 out straightening by springing is possible but is bad practice, as a shaft so straightened will seldom stay straight in service.

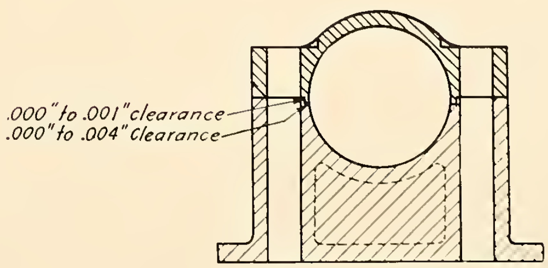
These amounts may seem very small, but experience has shown that a shaft that is not nearly perfect is really dangerous. Second, examine bearings for scores and if necessary polish with a stone and crocus powder used on a rawhide strap in the conventional way. Before stoning or using crocus *be sure* all oil holes are plugged with tallow, as fine grit inside the shaft is hard to clean out completely. A shaft is usually considered to be worn out and fit for rejection when the bearings are 0.005 undersize.

Third, examine the taper for signs of movement between shaft and propeller hub. If there are any signs of picking up, stone these out and then remove the key. Lap the hub, using fine grinding compound, and continue lapping till the very best possible contact is obtained. Great care must be taken that the hub does not ride on the top of the key. The key should be replaced if damaged,



Clearances, fits and tolerances for all models





CROSS SECTION OF CAMSHAFT B'R'G.

should be tight in the shaft, and the hub should be a good sliding fit. Hubs which are not perfectly bedded down to the taper end of the shaft will always "work" in service and this causes roughness to develop which may easily lock the two parts so tightly together that they will be impossible to separate.

Observe that crankshafts are match marked to their hubs and to their connecting rods. The shaft, hub and connecting rods make an assembly which is not interchangeable in detail after fitting.

Thrust Bearing

The condition of this bearing is important, as it carries a very heavy load. To remove it take off the lock spring and unscrew the nut with wrench (W. A. 9). Look for flat spots on the balls and for marks in the races; also for eccentricity on the ball path. If in any doubt about a thrust bearing renew it.

Try the bearing in both upper and lower crankcase halves. The bearing with its washers should be so tight in the case that it can just be turned by hand. If it is free so that it turns very easily a new washer must be fitted. In putting in a new washer, first make sure that it beds down against the back of the race so that a 0.0015 feeler cannot be inserted between them at any point; then grind or lap down the washer till the proper fit in the case is obtained.

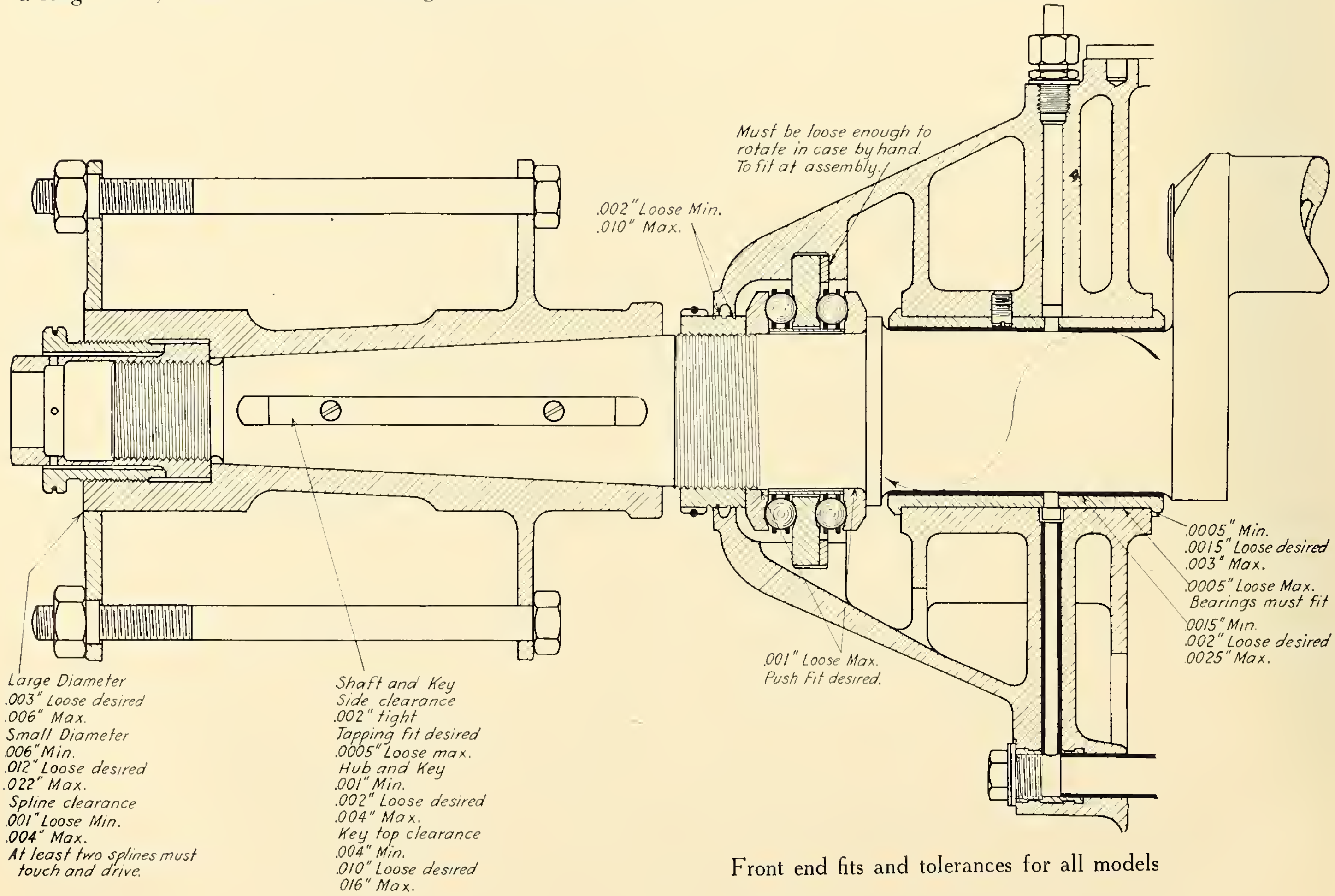
The spacer collar on the crankshaft should be of such a length that, when the nut is dead tight, the bearing will make not more than one or two revolutions when spun sharply by hand. If it is more free than this grind down the spacer.

Because the thrust on the crankshaft is always in one direction (the propeller pulls the shaft forward all the time) wear on the thrust bearing always allows the shaft to move forward relative to the crankcase. For this reason in fitting thrust bearing washers on A, I and E, the rear washer should be thinner than the front one, so that the clearance between the crankshaft webs and the main bearing flanges will be greater on the forward side than on the rear side. Wear then causes the shaft to work *towards* the central position. Models E-2, H, H-2 and H-3 have a single washer at rear end.

Next examine the ball bearing at the rear end of the shaft, but do not remove it unless it has more than 0.003 in vertical play, or shows signs of damage.

If it has to come off, a special puller is necessary owing to the small clearance behind it. Tool W. A. 6 is made specially for this job, but any puller of requisite span can be used by grinding down the ends till they will slip behind the bearing. The bearing should be a light drive fit on the crankshaft and if a new bearing is tight the shaft should be lapped down till the proper fit is obtained. The fit of the old bearing should be used as a guide for proper tightness.

The crankshaft bevel pinion should be examined for wear and replaced if the teeth are not in really good con-



Front end fits and tolerances for all models dition, as from this pinion all the supplementary shafts derive their drive.

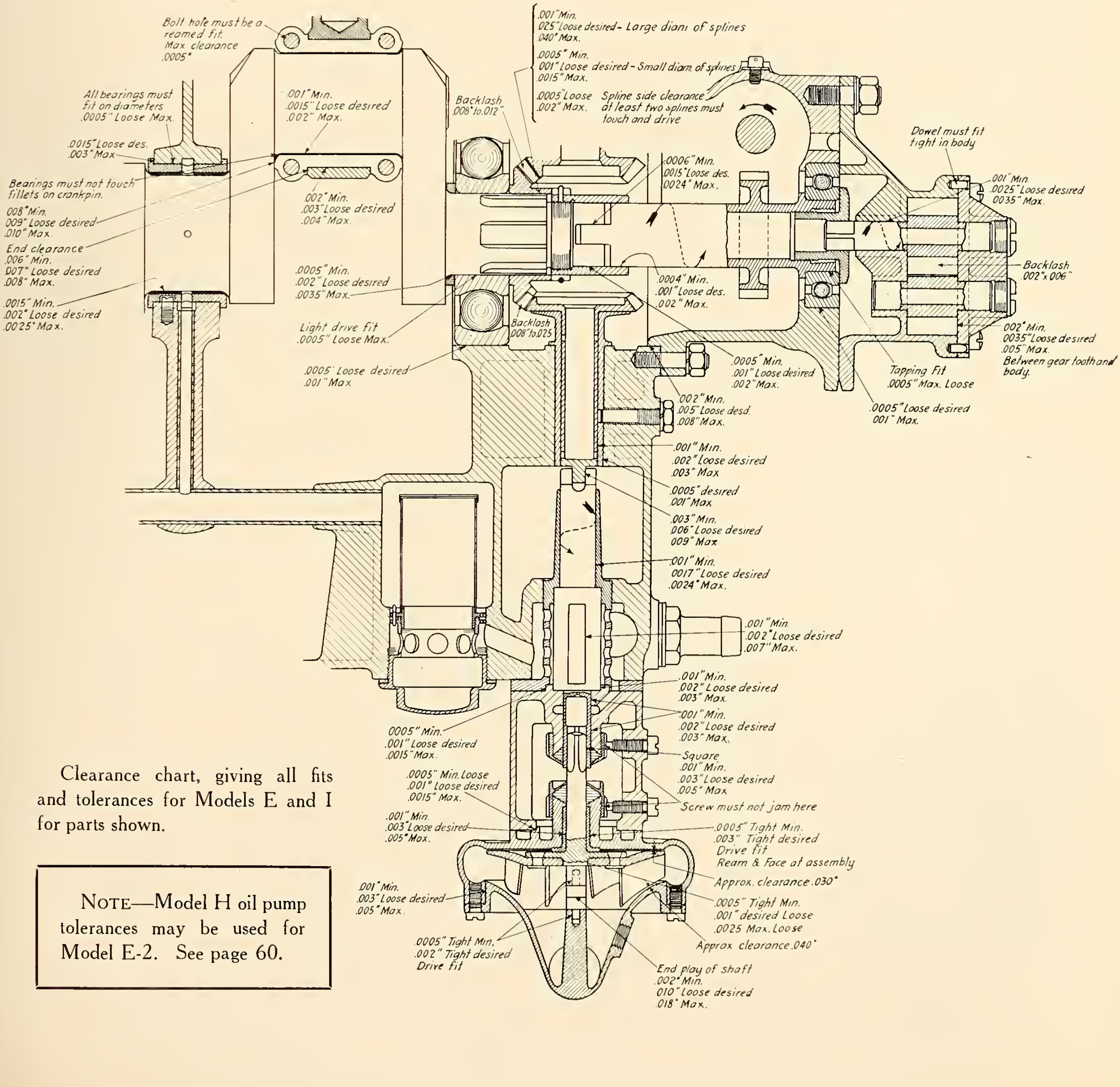
When a new pinion is fitted its mesh, with all the shafts it drives, must be checked against the clearances shown in the charts. The charts for models E and H are on pages 59 and 60 respectively. Adjustment of depth of mesh is obtained by lapping down the spacer washer behind the crankshaft pinion.

Connecting Rods

Connecting rods of the marine type as used on all the engines except Model A are easy to fit by conventional methods. If the babbitt inside the bronze box is much worn it can be replaced by conventional methods. Remember that in fitting the bronze box to the crankshaft the two bronze halves *cannot* be filed off so as to bring them closer together, as this would destroy the circularity of the outside on which the outer connecting rod works.

The inner babbit should be scraped to an 80 per cent. bearing and the babbitt *must be renewed* if the clearance between the crankpin and the bearing exceeds 0.006. On the other hand, a new bearing must not be fitted tight. The chart gives correct clearances and a rough test is that the rod, when the bolts are drawn tight and when oiled, should drop of its own weight, but should not oscillate pendulum fashion. In drawing up the bolts these should not be too tight, as it is possible to spring the box and strain the bolts.

The outer connecting rod and its cap are ground to size and cannot be tightened. If there is excessive wear the only possible thing to do is to renew the bronze box. In fitting a new bronze box to an outer rod the bronze



Clearance chart, giving all fits and tolerances for Models E and I for parts shown.

NOTE—Model H oil pump tolerances may be used for Model E-2. See page 60.

should be scrapped or lapped to the rod, not the other way around. A very fine flat file may be used on the bronze and in the hands of a skilful mechanic an excellent bearing obtained.

In fitting a new bronze box great care must be taken to maintain proper alignment. Scrape the box where the feet of the divided rod attach to it to get good contact and test for alignment by putting a bar 6 inches long through the wrist pin bushing. Rods must not be more than 0.002 inch out when tested on the ends of this bar; that is to say, not more than 0.002 inch out measuring 3 inches distant from the center line of the rod.

See that bearing clearances inside and outside the bronze box are between 0.003 and 0.005 and that end clearances of bronze on crankpin are between 0.014 and 0.018. End clearances of outer rod on bronze should be from 0.007 to 0.009 inch. It is desirable to burnish the babbitt after scraping.

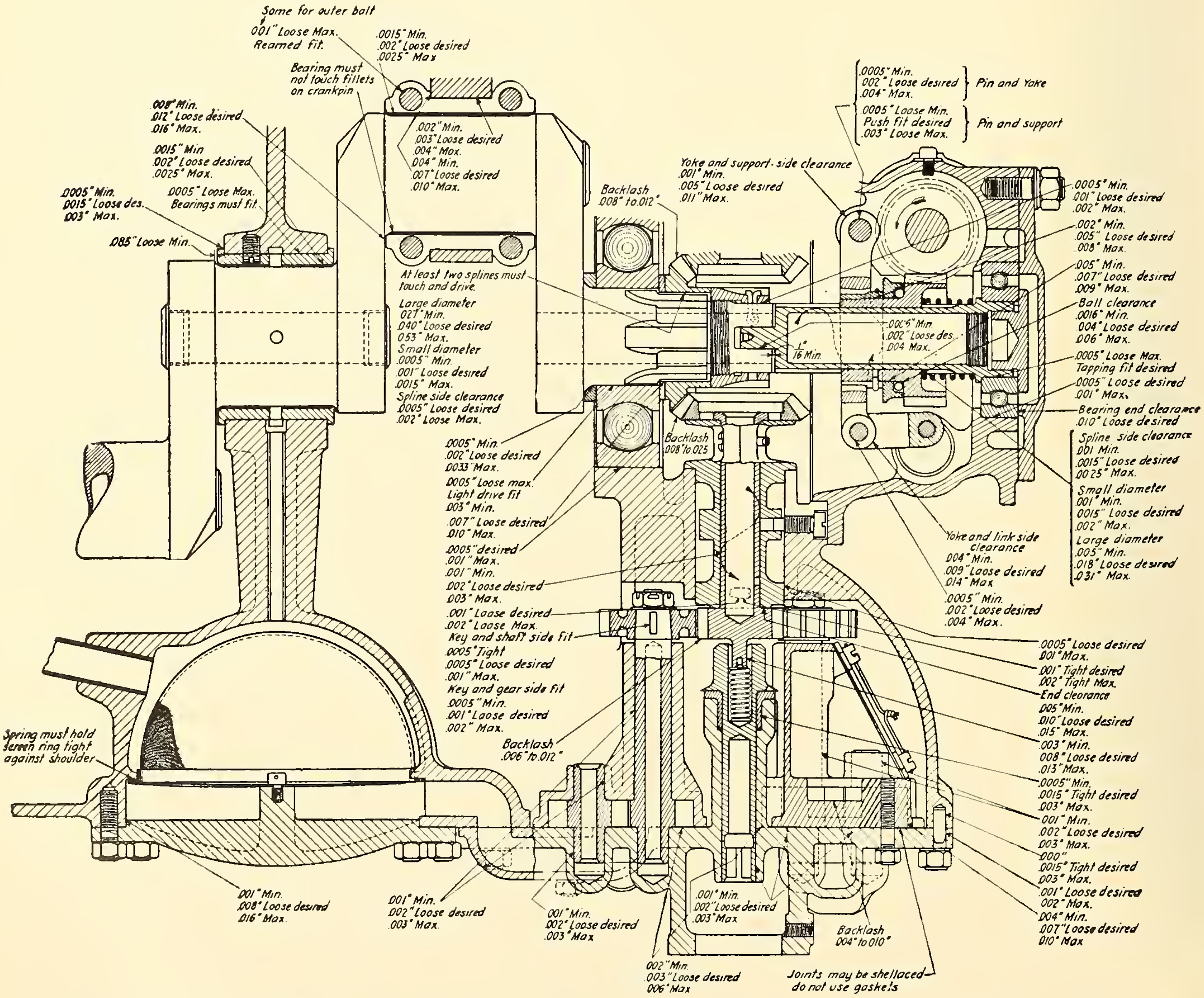
The proper wrist pin clearance is not more than 0.005 and if this is exceeded a new wrist pin bushing should be put in.

Special reamers are made for E and H series engines. After fitting a new wrist pin bushing check the rod for alignment as just described when speaking of fitting new bronze boxes.

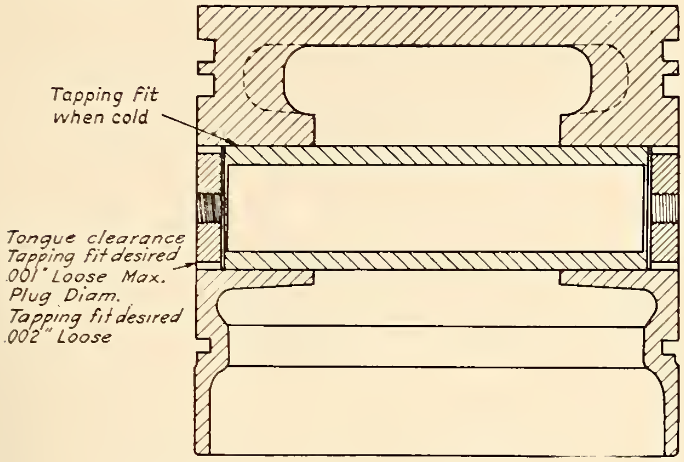
Type A Rods

Rods from a Model A engine should be inspected for condition of the babbitt. Slight cracks will do no harm, but if there is much sign of babbitt breaking away from the rod it must be sent to the Wright Aeronautical Company for rebabbitting.

Owing to the very heavy pressures in these bearings it is impossible to rebabbitt these rods without elaborate equipment, all the various heats having to be controlled by pyrometer. The job of rebabbitting looks easy and it



Fits, clearances and tolerances for parts shown of Models H and H-2; also for H-3 with exception of magneto bracket



Fits for piston pin of all engines and cap fits for Model H design

is easy to rebabbitt a Model A rod which will *appear* perfect. However, it has been proved again and again that rods rebabbitted without factory equipment are unreliable. There is no known method of testing a rod which will show how perfectly the babbitt is stuck to the steel, and if it is not in chemical contact all over, large pieces of babbitt will crack off in service. In fitting a rebabbitted rod the bearing clearances inside and outside should be not less than 0.0015 and not more than 0.005. End clearance on the inner rod should be from 0.008 to 0.012, and on the outer rod the same amount. Alignment of rod after fitting should be tested as described in dealing with the marine type of rods.

NOTE THAT ALL CONNECTING RODS ARE NUMBERED AND MUST BE REPLACED ON THEIR PROPER CRANK PINS. THAT CONNECTING ROD BOLTS ARE LIKEWISE NUMBERED AND MUST BE KEPT IN PLACE.

Pistons

Pistons should be examined for wear by checking the skirt diameter. Pistons may be used again which have a clearance of about 0.008 more than the chart clearance, which is the ideal, but should be discarded when worn more than this as otherwise there is danger of excessive oil consumption. Scores sometimes call for the discarding of a piston. Slight scores may be stoned out and a deep score may be smoothed with the stone without trying completely to remove it. If the ring grooves are not damaged a score is not likely to be serious.

The wrist pin must be a good fit in the piston bosses. It must not be possible to insert the pin by hand alone. If it can be pushed into place in a cold piston it will be so loose under working temperatures as to be unsafe. A wrist pin which shows more than 0.002 wear should be replaced and the piston replaced also if it is not a good tight fit on the new wrist pin.

The fit of the rings in the grooves is highly important. There should never be more than 0.003 side play which can easily be checked with a thickness gage and the end clearance at the ring joint should not exceed 0.025. Rings should be examined for wear on the face and discarded if there are signs of much leakage.

Fitting New Rings

When new piston rings have been installed the engine should be run in under its own power very carefully. The speed and load should be gradually increased, taking 3 hours to reach the full load. Neglecting this will cause considerable loss of power. In fitting new rings the side clearance should be kept carefully to the limits shown on the clearance chart, and the end clearance should be held between 0.008 and 0.012.

Oil scraper rings should be a tighter fit in the groove than the compression rings having a side clearance of 0.002 and an end clearance not exceeding 0.015 as an absolute maximum.

Magneto Assembly

It is seldom necessary to remove the magneto drive shafts or their bearings from the magneto bracket. After washing these parts should be given an inspection for accidental damage to bearings or gears due to particles of grit in the oil and for general wear.

Before replacing a magneto bracket assembly the face of the flange and the corresponding face on the crankcase should be looked over for burrs or scratches which might cause oil leakage.

In the event of its being necessary to replace any gears the clearances and backlash should be checked against the chart making sure that backlash is checked all round the gears and not only at one point.

Checking side clearance on piston rings

Oil Pump Assembly

In the case of models E-2, H, H-2 and H-3 the oil and water pumps can be removed from the crankcase as a unit, or the water pump may be detached first. It is always desirable to open up the water pump for inspection, as there is possibility of corrosion. Similarly the oil pumps should be examined for wear or damage due to grit.

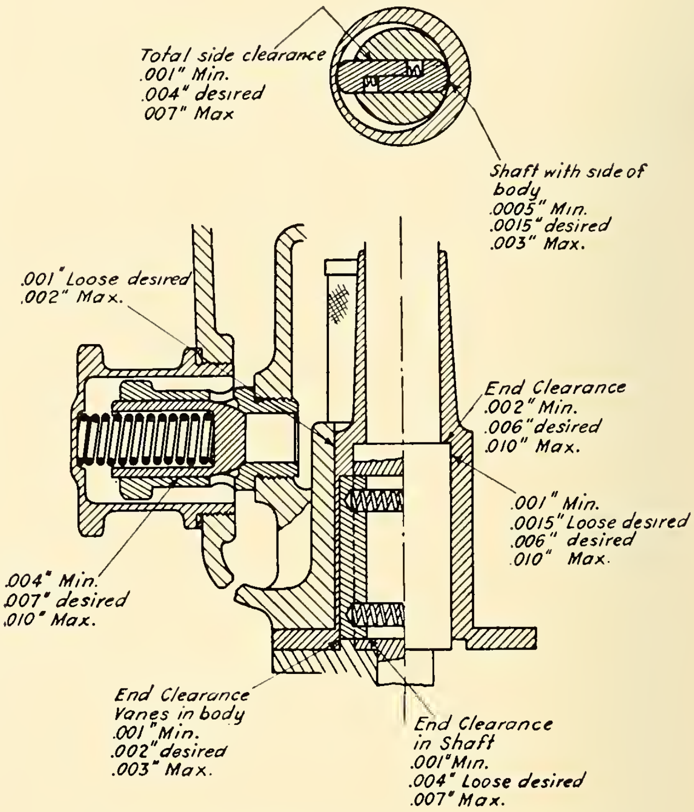
It must be remembered that the two halves of the oil pump body are lapped together and have no gasket. Therefore great care must be taken not to scratch the surfaces at the joint and in reassembling all parts must be perfectly clean and free from dust. The only parts of the oil pump assembly really liable to normal wear are the central drive shaft bushings of which there is one to each pump of the three in the assembly. If there is any suspicion of undue looseness the clearance should be checked against the chart and replacements made if necessary.

The water pump is subject to wear on the shaft and on the babbitt shaft bushing. This should be checked and also the clearances between the rotor and the pump body, which should be within the limits shown in the chart on this page. Examine carefully for cracks or corrosion.

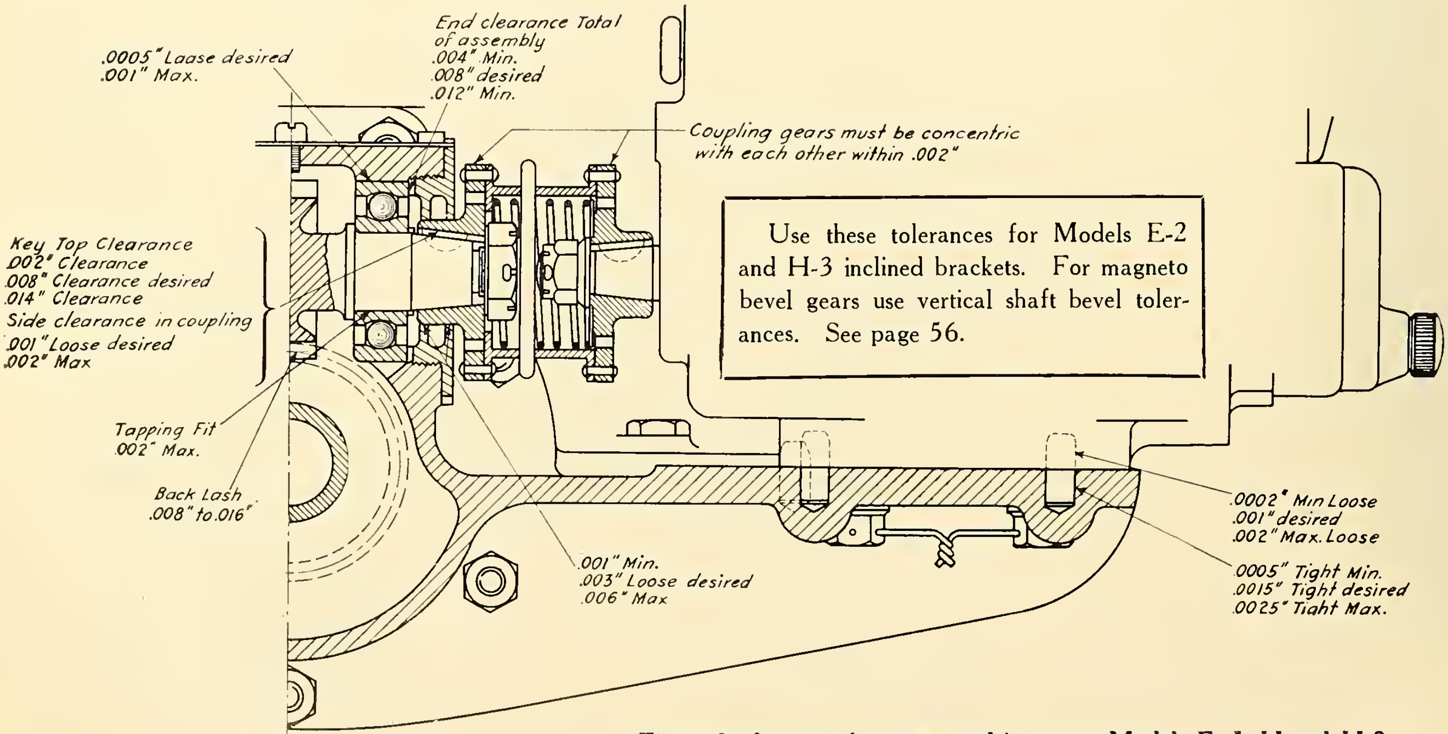
Model E and I Pumps

The vane type oil pump is more liable to wear and damage than the gear pumps of the later models and should, therefore, be examined more carefully. The oil pump body should be checked for looseness in the crankcase and for scratches on the inner surface. If there has been much internal cutting by grit a new pump body should be obtained.

The vanes should be examined for scratches and for wear. Slight damage may be removed with a very fine file. In fitting new vanes the greatest care must be taken to insure that they work through the slot in the shaft quite smoothly without shake. The two springs which



Oil pump and release valve fits for Models E and I



Fits and tolerances for magneto drive parts, Models E, I, H and H-2 separate the vanes should have approximately the same degree of tension. The efficiency of this type of pump is very good if the fitting is a first-class job but it is essential that the clearances given in the chart are not exceeded. It is well worth while to give considerable time to the fitting of any new parts. It must not be forgotten that the end clearance of the vanes in the pump body is very important.

No special instructions are required for the inspection of the gear type suction pump at the back of the magneto bracket on Models E and I.

Oil screens and release valves should always be removed from the crankcase, cleaned and examined. The oil release valves occasionally require grinding in with fine abrasive, but this should only be done if there is obvious pitting or wear.

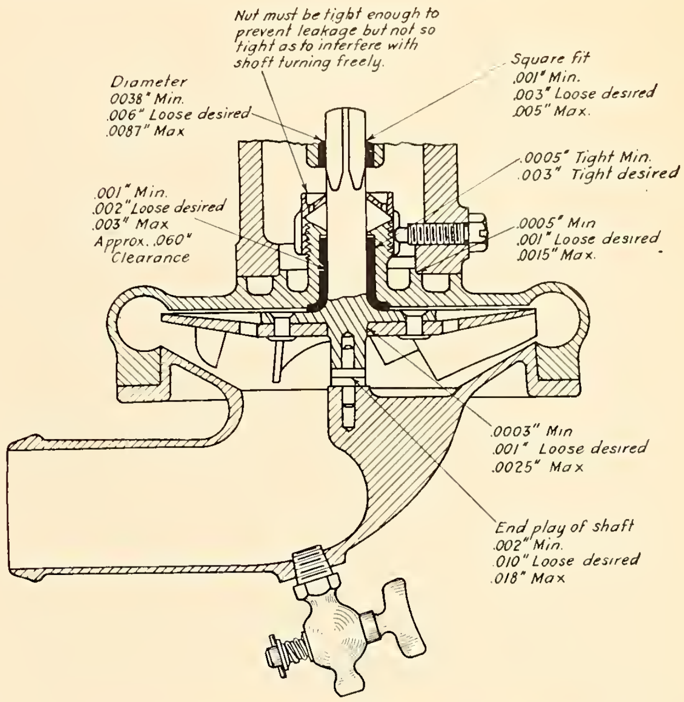
Crankcase

The upper half of the case requires the customary inspection for accidental damage and for condition of the cylinder holding down studs. It is not usually necessary to remove the lower vertical shafts, as they can readily be examined for condition of the bevel pinions and for fit in their bearings. Should any replacement be made, however, care should be taken to adhere to the clearances given in the chart, especially for the end play.

The condition of the thrust bearing grooves in both halves should be examined for wear due to the thrust washer having turned in the case. Instructions as to the proper fit bteween the bearing and the case have been given on page 58 under the heading "Thrust Bearing."

The seating of the ball bearing at the rear end should be examined for similar wear. It is almost sure to show some signs of the outside race having moved, but it is unlikely that the wear will be important unless there was a broken ball in the bearing.

In the lower half are all the oil connections, the pressure release valve and the oil screen. The condition of the threads, surfaces, etc., should be inspected with a view to detecting possible oil leaks. The connection for the



Fits and tolerances for water pump of all models

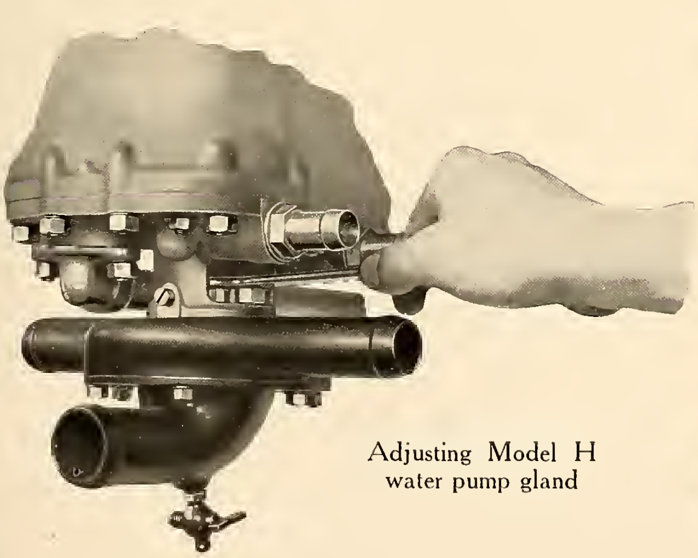
hose leading to the oil pressure gauge is rather liable to accidental damage, so the thread here should be given special attention.

If any lapped surfaces are scratched they must be redressed with extreme care, as a quite slight degree of damage may cause a serious oil leak.

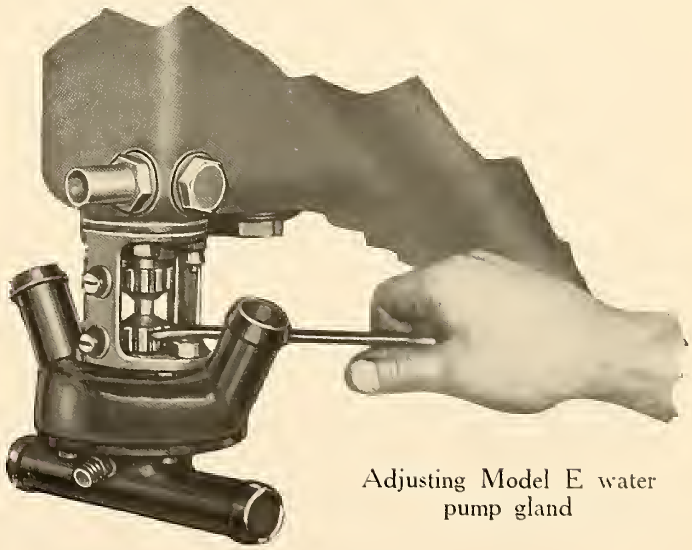
Main Bearings

Under usual circumstances the main crankshaft bearings will be in good condition and require only a little touching up and burnishing. Their clearance on the crankshaft should be checked, and renewal is necessary if this exceeds 0.006. Slight cracks in the babbitt will do no harm provided there are no large pieces.

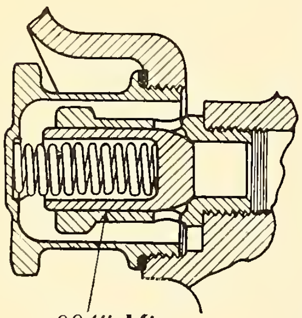
In fitting new bearings considerable time has to be given in scraping the outside of the bushes to the crank-



Adjusting Model H water pump gland



Adjusting Model E water pump gland



Oil release valve fits all models except A

case, because the oil is fed through grooves in the aluminum that encircle the bronze boxes, so that if the bronze does not bed down true and if the flanges do not bear against the crankcase bosses, there will be serious leakage.

The halves of the bronze boxes must be perfectly flush with the aluminum. In fitting new bearings to the crankshaft much labor is saved by using the expanding reamer which forms one of the special tools. Particular attention is called to the desirability of keeping closely to the clearances designated on the charts. These will give a fit that will appear distinctly loose to a mechanic who is a good hand at bearing fitting on other types of engines. It is highly uneconomical to fit new bearings entirely by hand as, while the special reamer is a somewhat expensive tool, the time saving consequent upon its use amounts to many hours on each occasion.

Before reassembling the crankcase finally the long studs which hold the halves together should be examined for stretch. Sometimes these have been known to elongate so that when the blind nuts are drawn down they bottom, instead of bearing against the case.

After assembling the crankshaft and putting the case together, it is advisable to attach the magneto bracket and then again check over the meshing of all the gears to make sure that there are no tight spots.

Small Parts

After tightening down all the main crankcase bolts, assemble the oil and water pumps, the release valve, oil screen and all crankcase attachments with the exception of the nozzle for the pressure gauge hose, which should be the very last part to be attached.

Pistons

Make a final check over the pistons to see that the proper equipment of right and left hand slotted rings has been used, and that the oil scraper rings have the bevel side uppermost. Warm the pistons till they can just be held in the hand, but only just, and then drive in the wrist pins.

In the case of pistons which have the aluminum caps to retain the wrist pins with tongues slotted into the pistons, it was stated in the disassembly instructions that these caps should be kept with the pistons to which they belong. They are match marked and if mixed should be sorted out. See that they tap down snugly into position and are neither too tight nor too loose.

E Piston Warning

The only precaution to be observed with Model E and I pistons having the central ring retaining the wrist pin is to see that the ends of the wrist pins are rounded off. If they are sharp they may cut the retaining ring.

Check the placing of the slots in the compression rings to make sure they are properly spaced and then coat the pistons with a good thick cylinder oil.

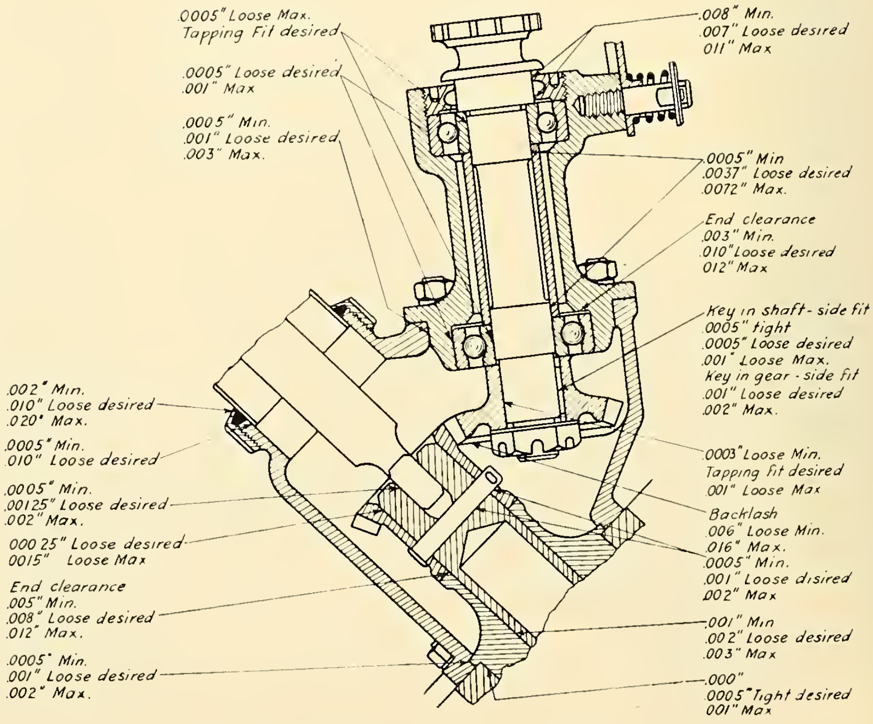
Reassembly

In a general sense the reassembly procedure is the reverse of the tearing down and it will therefore not be described in complete detail. However, there are several special points of importance. Assembly *must* take place in a building free from dust and all parts must be as clean as they can be made.

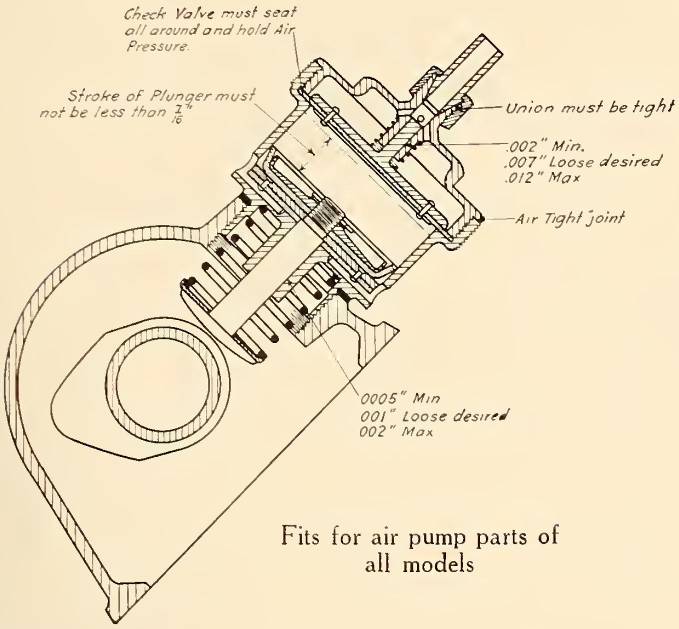
Crankshaft and Crankcase

After mounting the connecting rods check for alignment of the wrist pin ends. A bar which is just a nice fit in any one wrist pin bushing should pass freely through any three of the four on either side.

Before finally putting together the two halves of the crankcase, give the lapped surfaces a thin coat of shellac, being careful to avoid the bearings and oil channels, but being sure to cover the whole surface. A paper gasket must *never* be used.



Fits and clearances for gun synchronizer drive



Fits for air pump parts of all models

Cylinder Mounting

Tilt the engine stand to bring one set of pistons vertical and turn crankshaft till pistons 2 and 3 are at top of stroke, as it is easiest to place the block on by taking these two first. Much the easiest way to compress the rings is to make sheet steel clamping rings which can be closed with a pair of pliers. There is a special clamp used in the factory, which embraces all four pistons at once, but to use this properly requires two men to steady the clamp and one to lower the block into place so, while it gives maximum speed in the factory, it is not worth while for field use.

In replacing the cylinders the oil scraper rings are the most likely to slip out of place and are the easiest to injure, so they should be watched with particular care.

Cylinders are sometimes replaced without the camshafts, but it is better practice to mount the shafts first and to have the tappets adjusted to the proper clearance, so that nothing remains to be done after mounting the cylinders except to time the engine.

Do not forget that the upper vertical shaft housings must be mounted with the cylinder blocks and cannot be put on afterwards without removing vertical shaft and cam shaft. Mount the magnetos, but not their distributor heads, after bolting down the cylinders.

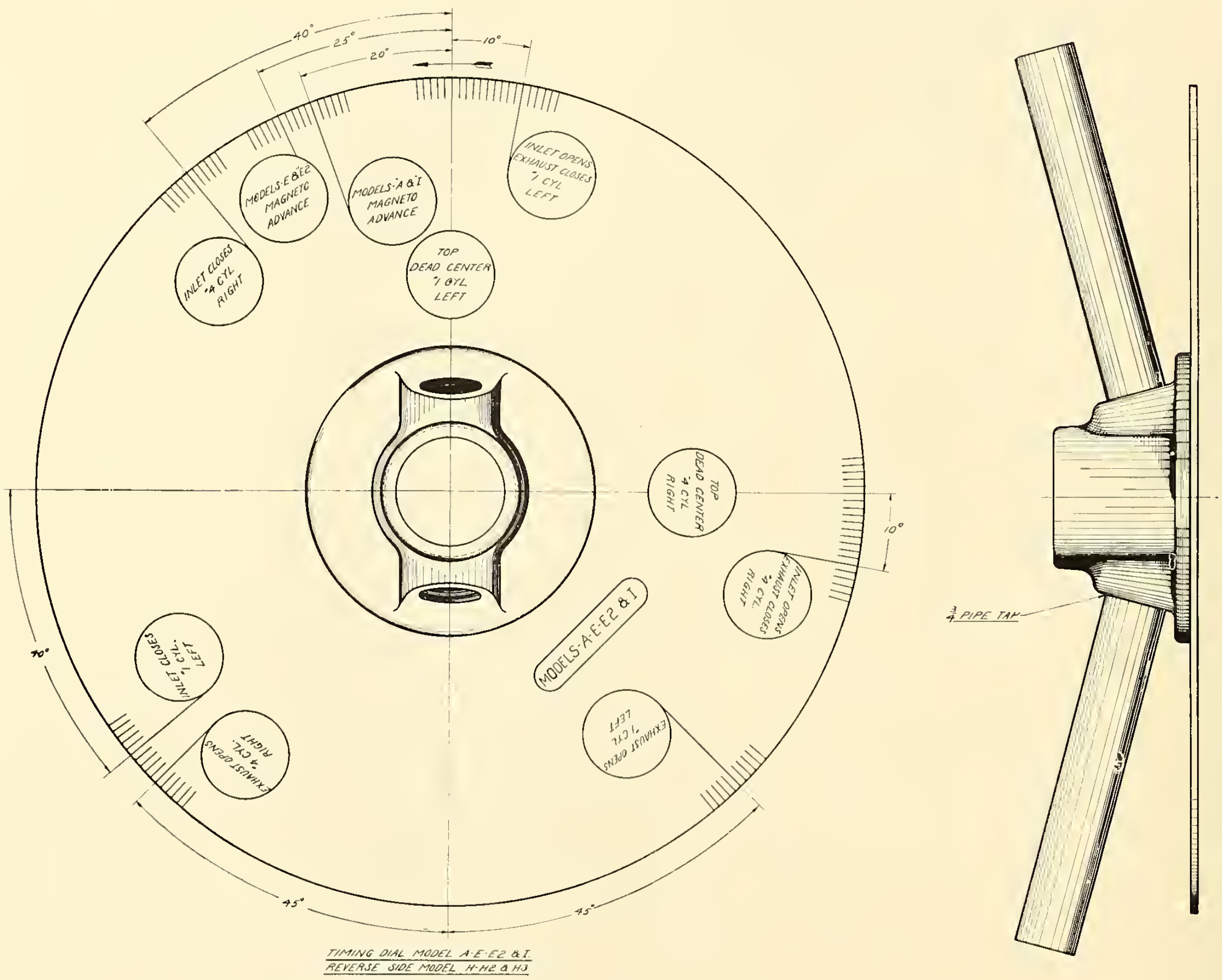
After timing (for which operation instructions are given on page 67) coat the camshafts with oil and put on the covers, using paper gaskets. Start all the holding down screws before finally tightening any one of them.

Carbureter Warning

A puzzling air leak can sometimes be caused by the expansion gland in the intake tee. Therefore, see that this is properly packed and tightened. Use new gaskets at all points on the intake system and, when putting the carburetor in place, observe that neither of the flange gaskets on either end is displaced. It is easy to push one or other of these a little out of position so that it partially blocks the intake.

Next attach the tachometer drive. To do this slide the shaft partly out of the bushing and, bearing on the outer end with a screwdriver, put it in place. The shaft being slid forward in this way it is possible to see that the tongue engages the camshaft properly. Still holding the shaft with the screwdriver, push the bushing forward and screw it home; finally, feel the shaft to check that it has proper end play.

Place about a tablespoonful of oil in each cylinder, put in spark plugs and, lastly, attach the wiring with the magneto distributor heads.



TIMING DISC FOR MODELS A I E AND E-2

The Timing Disc illustrated above is stencilled on one side with the valve setting degrees for Models A I E and E-2, and on the reverse side for Models H, H-2 and H-3. It is a steel disc with pipe handles which can be unscrewed for packing. The valve movements in degrees are shown for all models under items 25 to 30 in the table of Specifications at back of book. This is tool WA-13 part number TAM-864.

TIMING WRIGHT ENGINES

This Operation is Easy if Done Systematically but Difficult if Instructions Are Not Followed

FOR timing Wright engines it is necessary to be provided with a Wright timing disk. This consists of a false hub which fits on the crankshaft taper and embodies a pair of handles by which the crankshaft can be turned and a disk (see page 66) graduated with timing marks for all the different models. There is also a pointer of sheet steel, having a foot with holes drilled in it, so spaced that it fits on the locking wire lugs of the two front end blind nuts of the crankcase studs or into stud hole on E-2 and H-3.

The timing disk is attached to its hub by cap screws and has slotted holes, the purpose of which will appear directly. One side of the disk is graduated with timing for Models A, E, I and E-2, and the other side for Models H, H-2 and H-3.

Another essential tool is the dead center indicator, since it is essential to find the top dead center very accurately.

Procedure

Put the dead center indicator in number one cylinder (propeller end) of the left (left from magneto end) block. Mount the timing disk hub on the taper and drive it well home so that it is quite tight on the key. Loosen the cap screws so that the disk is free in the slotted holes. Put the pointer in place.

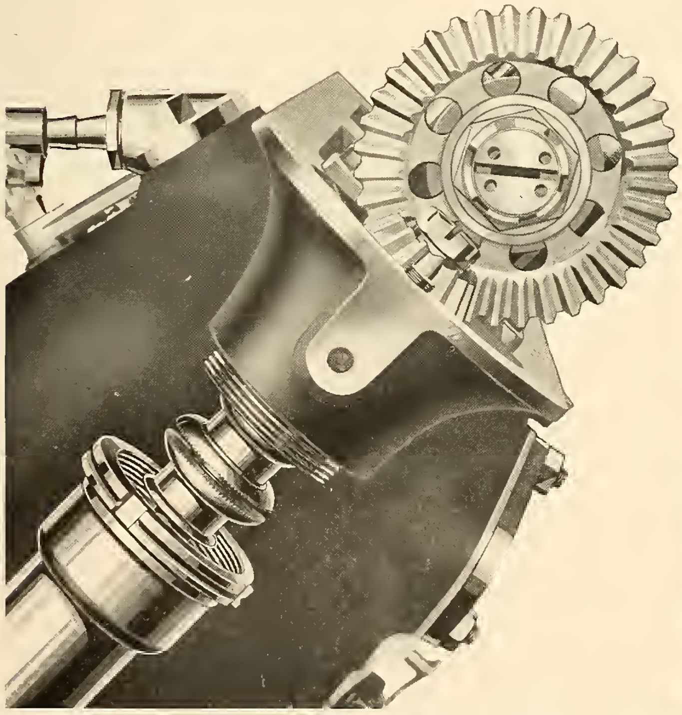
Find the approximate top dead center and set the timing disk so that it registers top dead center. Then move five degrees in one direction and observe the amount the dead center indicator has moved over its scale. Return to zero and move five degrees the other way, again observing the dead center indicator reading. If the indicator moves the same amount for five degrees on the timing disk either way, then the disk is correct, but if the indicator moves more one way than another the disk must be reset. This operation reads rather complicatedly, but is simple enough to perform.

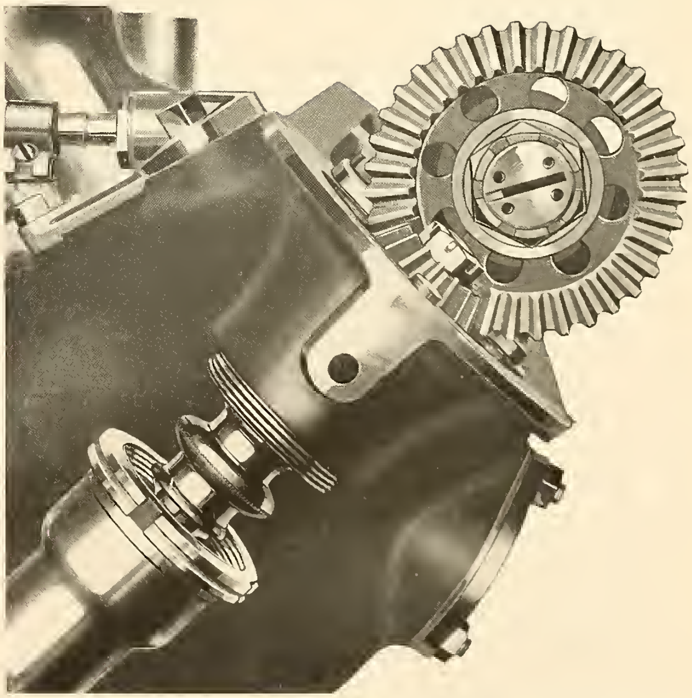
Model E-2 Valve Setting

Loosen nut on top of vertical shaft, that is just above the upper bevel pinion. Slip down housing of vertical shaft as far as it will go and then tap the loosened nut. This will separate the serrated coupling and free the camshaft from its drive.

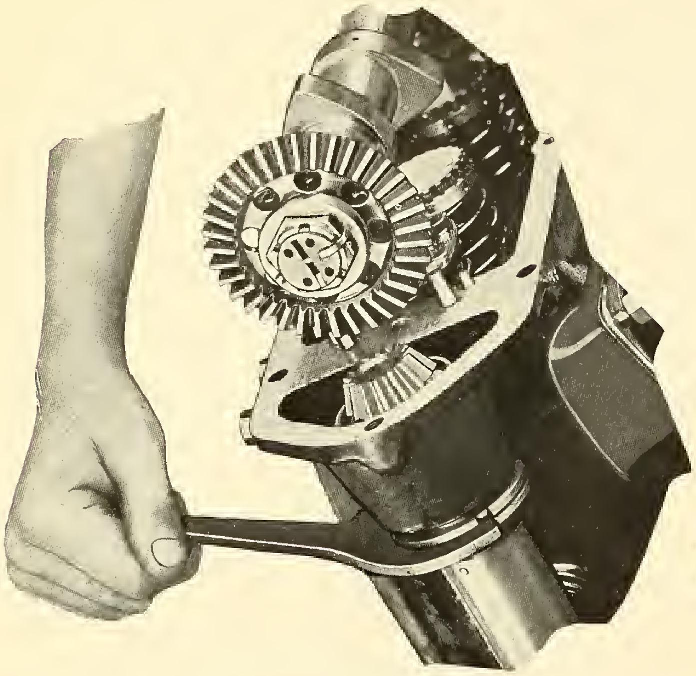
Turn camshaft till the cam of No. 1 left intake valve is just contacting with the tappet, having first checked the tappet clearance with the special gauge. Note that the thick end of the gauge is for use on all the smaller engines, the thin end being for Models H, H-2 and H-3 only.

Turn crankshaft till pointer registers with opening mark for No. 1 left and then tighten up nut drawing serrated coupling together. Check again before putting in cotter pin to make sure that the camshaft has not slipped



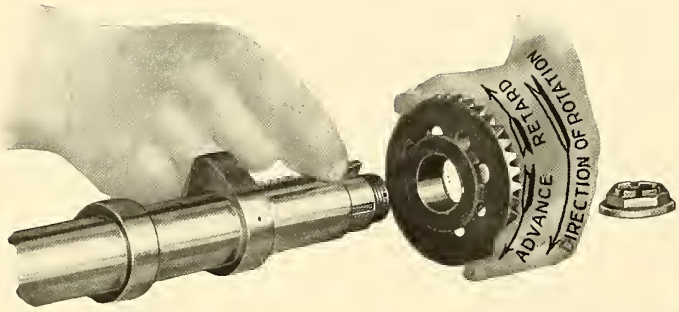


Timing device used on Models E-2 and H-3 engines. Left view shows coupling opened and right view closed in running position. Caution—When adjusting the timing device on vertical shaft always slip the housing down so you may see that the vertical coupling is in proper mesh



Loosening vertical shaft

Giving vertical shaft half turn



Changing placing of key in camshaft

Changing meshing of camshaft gear

during the tightening. Repeat the whole operation for the other block, using cylinder No. 4 right, the disk being graduated to suit.

Timing Older Models

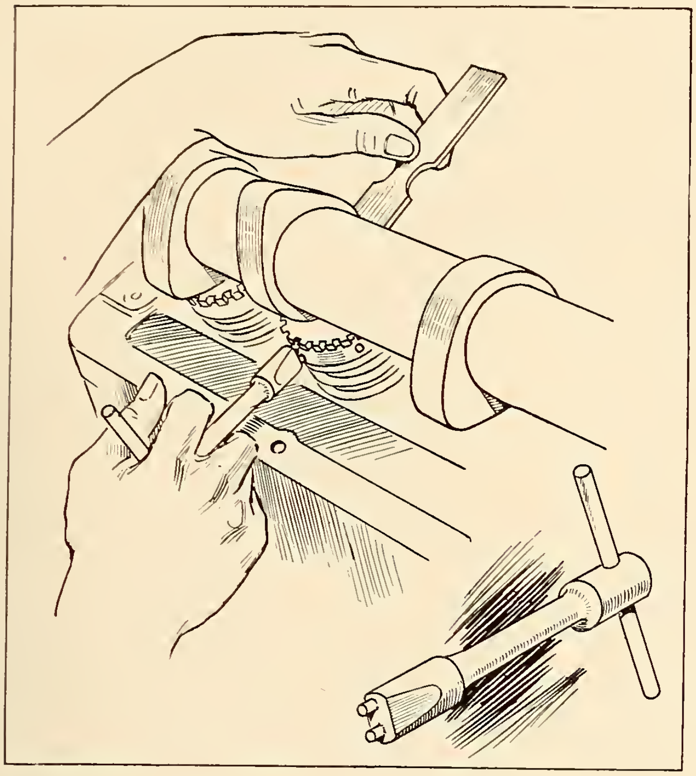
Owing to the absence of the serrated coupling this is a more difficult undertaking. The dead center of No. 1 left is first found and the disk set just as described above. Then, since there is no disconnecting coupling to free the camshaft, the next stage is to turn the crank round till the disk indicates the opening point for the intake valve on No. 1 left. If the camshaft is obviously far out of correct position, loosen its bearings, lift it up and set it as closely as possible. If set to the nearest tooth of the camshaft gear it will probably not be very far out. Now tighten down the camshaft bearings and turn the crank till the cam contacts with the tappet, having first checked the clearance at the back of the cam to the correct end of the gauge. The contacting of the cam is easiest tested by holding a piece of white paper behind and sighting between tappet and cam.

Now refer to the disk and read off the number of crankshaft degrees the shaft is out of time. *Note down this number* and also whether the camshaft is early or late.

Explanation of Timing Process

There are 36 teeth in the camshaft gear, so each tooth corresponds to 10 degrees of camshaft movement or 20 degrees on the crankshaft.

Now there are 15 teeth in the pinion at the top of the



Using the tappet adjusting tool and the clearance gauge to obtain proper gap between tappet and back of cam

vertical shaft, so a half turn of the vertical shaft causes 7½ teeth movement of the camshaft, or 75 degrees. Therefore, if we lift the camshaft out of mesh, loosen and drive up the vertical shaft, turn it 180 degrees and then put it back, we have changed the relative setting between crankshaft and camshaft by the equivalent of one-half tooth; 5 degrees on the camshaft or 10 degrees on the crankshaft. Thus if the camshaft is exactly 10 degrees late, as shown on the timing disk, we lift the camshaft and vertical shaft, turn the latter half a turn and advance the camshaft one tooth, which gives correct setting.

Next, to get finer adjustment in the camshaft there are five keyways and one key, while there is only one keyway in the camshaft gear. Five into 36 goes 7 1/5 times, so if we remove the camshaft gear, move the key to the next keyway and replace the gear, we have moved the gear relative to the shaft 7 1/5 teeth. One-fifth tooth equals 2 degrees on the camshaft or 4 degrees on the crankshaft. So by moving the key one keyway forward and then going back in the meshing 7 teeth we have the equivalent of a 4-degree advance.

The finest adjustment is 2 degrees on the crankshaft. Since the half turn of the vertical shaft gives ten degrees and each keyway 4 degrees, if we go forward three keyways we advance 12 degrees, and we can subtract 10 degrees from this by making a half turn of the vertical shaft; giving a final result of 2 degrees advance.

Of course an engine once having been properly set, if the gears are not moved on their shafts during overhaul, it ought to come to correct time by merely finding the right tooth, and the only other thing that could be wrong would be the half turn of the vertical shaft. However, in timing a motor with new gears, the correct setting can always be obtained at the first attempt if the table on this page is used.

First find out how much the timing is out, then refer to the table, make the adjustment as indicated and the timing will be correct within 2 degrees.

Error, Crankshaft Degrees	*Correction*
2	3 keyways, half turn vertical shaft
4	1 keyway
6	4 keyways, half turn vertical shaft
8	2 keyways
10	Half turn vertical shaft
12	3 keyways
14	1 keyway, half turn vertical shaft
16	4 keyways
18	2 keyways, half turn vertical shaft
20	1 tooth camshaft gear

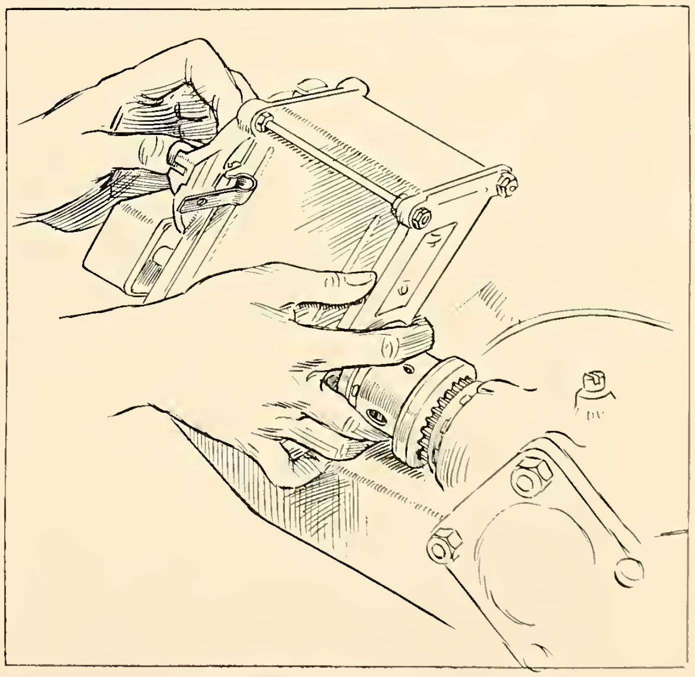
Of course, the two camshafts have to be timed separately by similar methods.

Warning

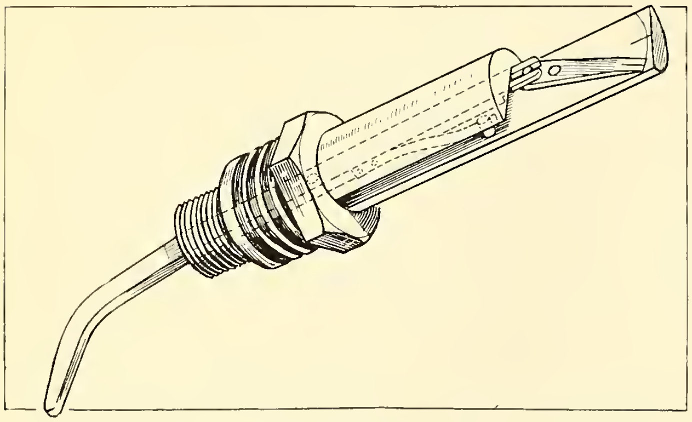
Cylinder No. 4 right fires next to No. 1 left, so care must be taken in setting the timing that this is remembered. It is easily possible to overlook this and set the right block one whole revolution out of time.

Ignition Timing

This is also marked on the timing disk. Set the crankshaft so that the pointer registers with the ignition



Operation of timing magneto



Wright dead center indicator, which screws in spark plug bushing

point, making sure that No. 1 left or No. 4 right, as the case may be, is on the compression and not on the exhaust stroke.

Remove the cotter pin from the magneto coupling and, taking hold of the coupling as shown in the cut on this page, slide it back till the magneto is free.

Holding the distributor with the other hand, turn it till the high tension brush registers with the proper cylinder and till the breaker has just broken.

Place a cigarette paper between the points and turn the magneto back again till the paper is just gripped. Then release the coupling and, taking care that the magneto does not slip, engage the coupling with the gears. Do not forget to replace the cotter pin and well spread the ends.

Model A Magneto Setting

Turn the crankshaft till the parallel surfaces of the cams of No. 1 left cylinder are on top and set the disc so that the piston is 20° and 20' before top center.

Shellac the bottom surface of the magneto gear housing and turn the magneto by hand until the breaker points just begin to separate, with the distributor brush in the first position to the left of top center. Hold the magneto in this position and slip the drive gear through the opening in the front of the housing. Then permit the magneto to slide down over the dowel pins and secure it with one of the magneto screws.

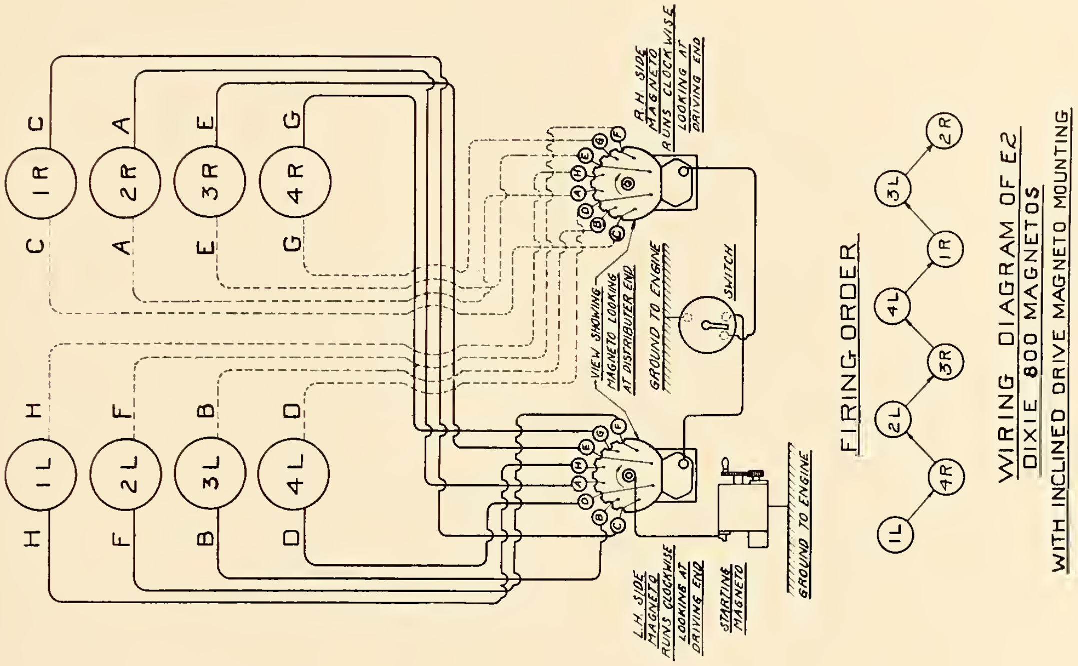
Bolt down the magneto gear housing with four 6 mm. nuts held by lock washers, and put in the remaining three magneto bolts.

Loosen the three bolts and slip the flanged coupling until the magneto points are exactly beginning to open.

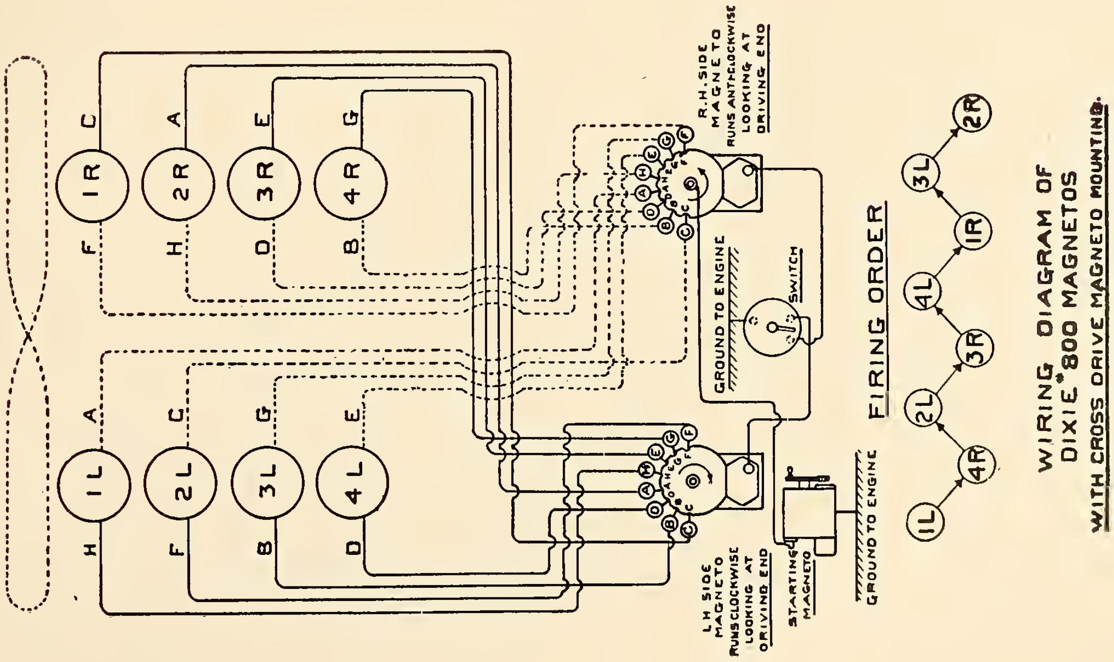
Tighten one bolt and test the point of opening by turning the crankshaft back and then forward, until a piece of tissue paper placed between the points is just released, being sure all backlash is held out of the gears during the operation. The other magneto is set in the same manner and the two must break at as nearly as possible the same instant, showing a variation of not over half a degree.

Firing Order
Model A, I, E, E-2
(See page 71)

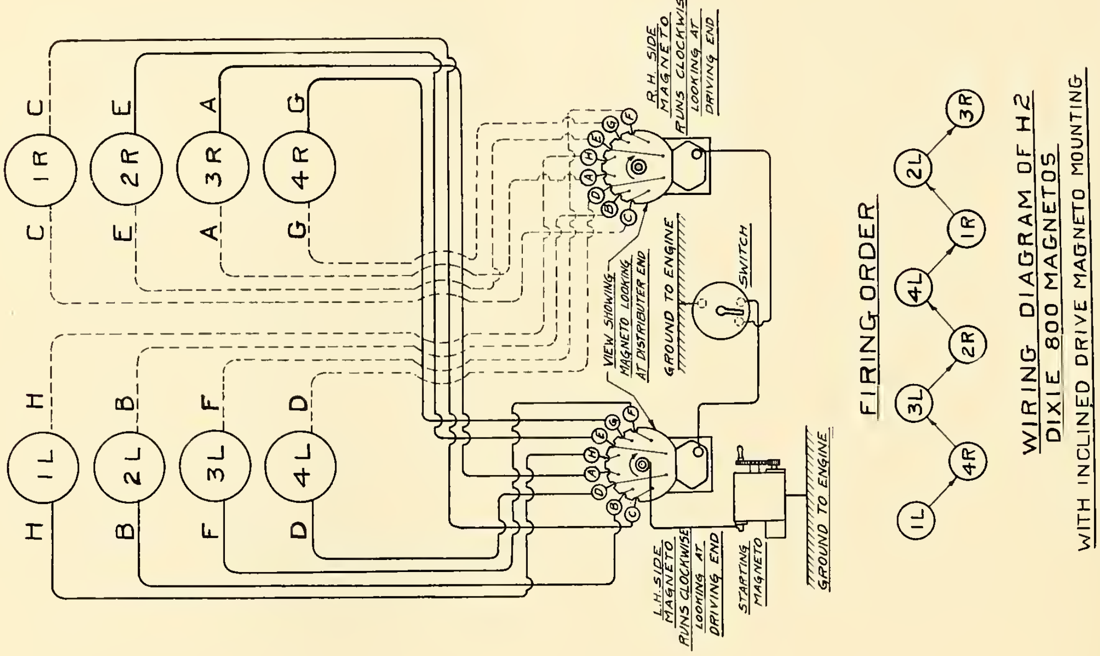
Firing Order
Model H, H-2, H-3
(See page 72)



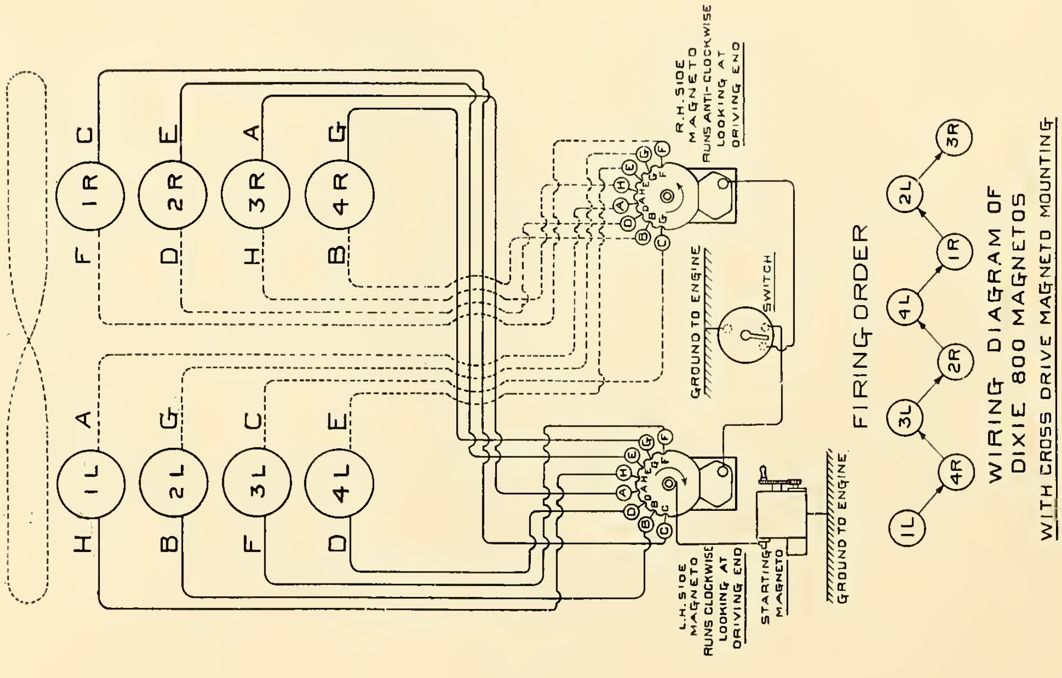
Model E-2



Model A, I and E



Model H-2 and H-3



Model H

CARBURETOR OVERHAUL

Instructions for Taking Apart Stromberg Carburetor Used on Wright Engines and for Inspection and Reassembly

When overhauling a carburetor of the twin type, that is, with two separate throttle disks, it is never wise to remove the disks. In the case of the Stromberg carburetors used on Wright engines it is doubly undesirable because the operation of the carburetor in idling and acceleration is affected by the *precise* setting of the throttle disks relative to the idling slots in the throat.

Remember that the usual object of overhauling a carburetor is to make sure that all parts are clean, that the float valve and seat are in good condition, and that no internal parts are loose. Therefore, it is seldom either necessary or advisable to completely disassemble an instrument.

Disassembly

Before starting to take a carburetor apart read the description of its action and adjustment on pages 20 to 27, as if this is not fully understood it will be difficult to judge the internal condition.

1. Remove the needle valve plug and the strainer.

2. Take out the three bolts and two cap screws holding the two halves of the body together.

Remember that the two idling tubes extend through both halves, so in separating the parts be careful not to bend the tubes. If the halves do not part readily, loosen the set screws which lock the venturi in place and tap the air entrance lightly with some soft substance. Try not to damage the gasket as the operation of the mixture control depends upon this being perfectly tight on reassembly.

3. Remove needle valve seat. In carburetors with a serial number after 753156 this is done from the top after taking out the needle valve plug. A special screwdriver is required as the seat is threaded in very tight. In carburetors with an earlier serial number the seat is screwed in from the underside of the body. It is then necessary to remove the plug, take out the float fulcrum pin, remove the float and then unscrew the seat with a special screwdriver.

Examine the seat for wear, also the needle valve plug. Wear is generally confined to the seat, which can be made good by grinding if only slightly worn, or may be replaced if badly pitted.

Whether the seat is removed from above or below be sure to preserve the gaskets under it, as the thickness of these determines the level of the fuel in the float chamber. In replacing the seat be sure that it is screwed right home.

There is usually no need to remove the float unless this be to get at the valve seat in one of the older carburetors. However, if the float is removed, in replacing the float lever fulcrum screw be sure that a 1/32 inch hard washer is put beneath the head. If this is left out the screw will sink in far enough to bind the float lever.

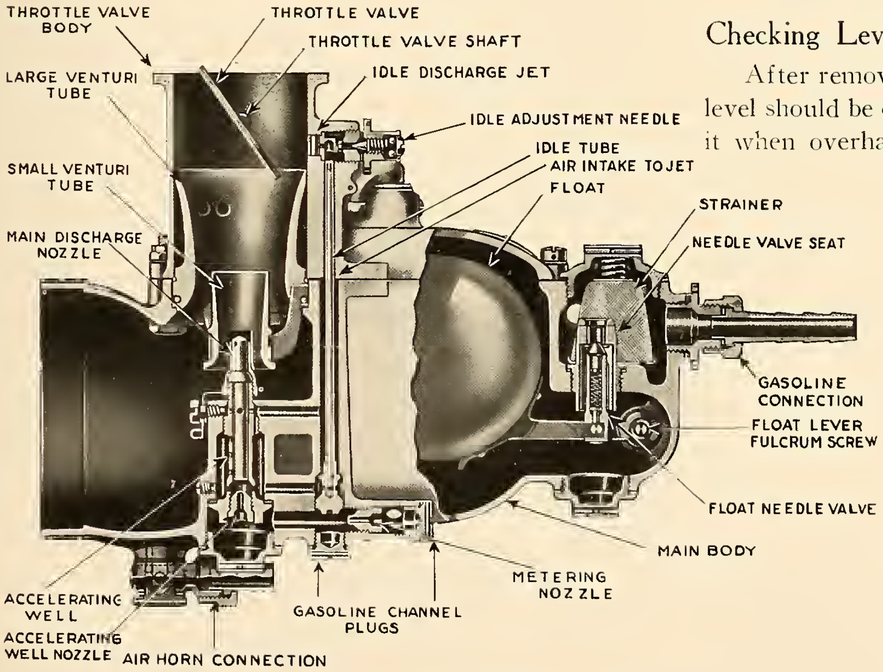
After replacing a float make sure that it operates freely.

Checking Level

After removing the float valve seat or the float the fuel level should be checked, and it is always advisable to check it when overhauling a carburetor. To do this take the lower half of the carburetor and set it up in a vise or on blocks with the top surface level, and all plugs, etc., in place. Then connect the fuel nozzle to a gasoline supply which *must* be under the same pressure as is used in the plane.

Using an ordinary scale measure the distance from the top surface of the float chamber to the surface of the gasoline, which should be 1⅜ in. for the NA-D4 carburetor and 1 9/16 for the NA-D6. A tolerance of 1/32 either way may be allowed.

If the level is too high—that is, if the scale reads less than 1⅜, the needle valve seat must be lowered so that



Section of Stromberg carburetor. See also larger cuts on pages 21 and 22 the valve will strike it sooner. This means changing the gasket under the seat so as to lower it. The amount the seat should be moved is one-quarter the error in level. Thus if the level is 1¼ below the top instead of the desired 1⅜, then the valve seat needs to be lowered 1/32 in.

If the level is too low, this means the valve cuts off too soon and the seat requires to be raised.

Nozzles

4. Remove the gasoline channel plugs and the accelerating well plug. Then take out the body metering nozzle and the idling tubes. It is not usually necessary to remove the main discharge nozzles since the gas passages can be thoroughly washed out without doing this.

5. From the upper half of the carburetor remove the idle adjusting screws so as to be able to blow out the passages. Before unscrewing these, screw them in as far as they will go, observing the number of turns for each. Note this down. On replacement, run the screws right home and then unscrew till the original adjustment has been obtained.

6. In replacing nozzles and plugs be sure they are all tight. It is recommended that for carburetor work the screwdrivers used should be of the proper sizes and be kept in good condition. Burrs on the nozzles can easily interfere with the flow of the fuel.

7. In reassembling the two halves of the carburetor see to it that the large venturi are properly seated in the lower half and that their lock screws enter the gap in the locking ring.

Check that the surfaces of the halves are undamaged and that the gasket is in good condition. Draw the halves together with the bolts and cap screws by tightening them gradually and in turn. The existence of a perfect joint between the halves is essential to the operation.

Mixture Control

Do not take apart the pilot's control valve if it is working freely, but merely wash it and blow it out with compressed air. Referring to the illustration of this part of the mechanism on page 23 there is a small hole A which should be examined to see if it is clear. Also there is a small screen A2 in the entrance to the passage AA and this must be clean.

Note that the NA-D4 and the NA-D6 carburetors are identical except that the NA-D6 has no body metering nozzle. The half tone cut on page 21 and the line drawings on page 22 can be compared to show this difference. The H-3 has NA-D6A carburetor, which differs slightly from the NA-D6 in the number and size of holes in the accelerating well.

MAGNETO OVERHAUL

Instructions for Inspection of Magnetos in Cases Where Expert Overhaul is not Available

As already stated, magnetos should never be handled by any but magneto specialists except for cleaning the distributor and adjusting the platinum breaker points. None the less a magneto should be taken apart for detail examination and cleaning by properly qualified men after 100 hours of service.

The directions which follow describe the taking apart and rebuilding of the Splitdorf magnetos used on Wright engines, and *are intended for the assistance of expert magneto hands only*. While any first-class mechanic *can* take apart a magneto and rebuild it, to do so is a useless procedure unless the man has the special knowledge enabling him to judge the condition of the parts.

Magneto Examination

Remove the two cotter keys which hold the distributor block clasps in position. Press forward the two clasps on either side of the block and spring them out, releasing the distributor block. Do not remove the wires from the distributor block. Remove binding post screw and breaker point cover. This is as much disassembly as will be necessary for a normal examination of the magneto, and, generally speaking, magnetos should not be further disassembled.

Magneto Disassembly

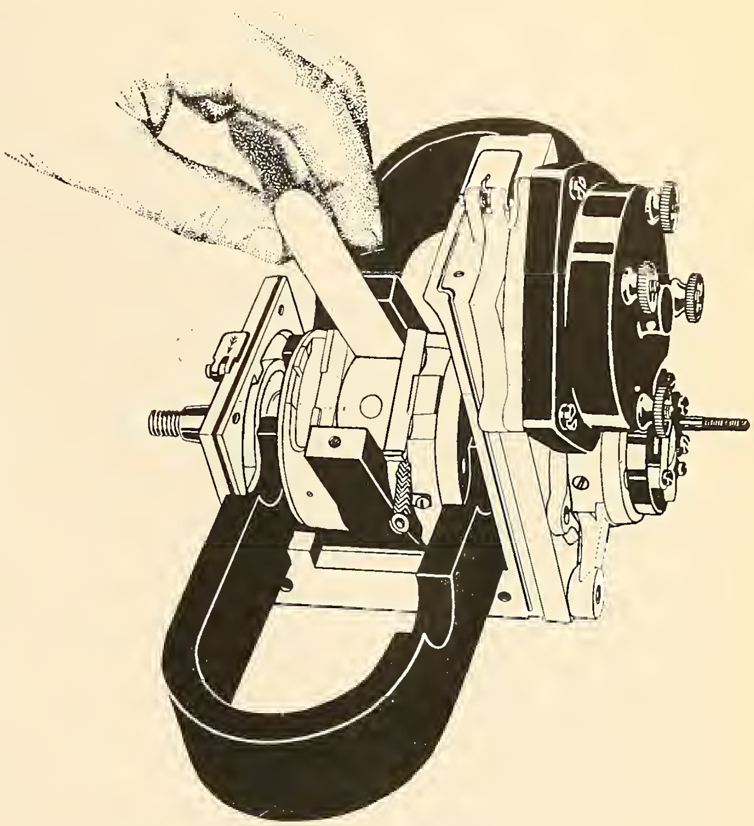
Loosen the four screws from the sides of the magneto near base and remove the two bars and the magneto cover plate.

To remove the magnets place a *soft iron* keeper against the magnet at the base. Remove two nuts and cotter from the end of steel strap at driven end of magneto and raise strap up. Slip magnet up vertically, then tilt out at bottom and slide down and out from behind magneto frame bolt. Repeat for other magnet. Magnets should never be removed without the use of a keeper and should either be stored separately with a keeper in place or placed end to end with semi-circular cuts on opposite sides.

Remove screw and disconnect primary winding cable where attached to breaker point arm and loosen small clip on rotor housing which holds the cable in position. Remove screw and loosen woven copper primary ground connection. Loosen four screws and slip the two clasps off the end of the coil core piece. Lift off coil, drawing flexible cable out of hole through magneto frame.

This will be sufficient to give the magneto a careful examination and test the strength of the magnets, to clear out any dirt which may have accumulated around the rotor and to dust the condenser.

Complete disassembly is accomplished by removing the double nuts and lock washers at the top of the magneto frame and the two other bolts at the bottom. Remove nut and drive gear from taper end of rotor shaft and pry the aluminum castings off of the two dowel pins which hold them at their base. Use great care in this operation, as the dowels are very tight, being put in place on an arbor press. Next remove the four screws which hold in place the rotor housing end plate and bearing support. After removing the special screw and the rotor cam, drive the rotor shaft back out of the housing (toward driven end). This is as far as the magnetos should ever be disassembled except when some part of the adjustable breaker frame may be actually broken. This frame is adjustable, being held by three screws which have special grooved heads provided with a permanent locking device. The timing of the magneto is correctly done at the factory before shipment and should never be tampered with except for the actual replacement of broken parts. In case it is loosened it will be necessary to retime the magneto.



Magneto opened up for inspection. Cut is diagrammatic only.

Inspection

Inspect the rotor member for signs of binding, either on the outer face of the soft iron members or on the ends of these members.

Inspect the flexible copper ground connection to see that it is clean and tight.

See that the inner-distributor rotor carbon brush is in good condition and makes good contact with the high tension winding. Examine the platinum points to see they are free from serious pits, have a smooth contact surface and are adjusted to 0.018 to 0.022 clearance when wide open.

Reassembly

Reassemble rotor shaft and ball bearings in rotor housing, using extreme care that all parts are entirely clean and that the ball bearings are packed in with a small amount of vaseline. Great care must be exercised that the two spacing washers on the rotating shaft are of such thickness that the shaft has 0.002 to 0.004 play, both between the collars on the shaft and between each collar and the opposite front or back plate. Also that the rotated member is in the center of the field structure so that a 0.003 feeler gauge can be passed completely around it in any position. If this rotor should bind at any point heat will be produced and it may eventually break the shaft.

Replace the drive coupling part and the cam with its lock screw. Also replace the magneto drive coupling part together with its nut and cotter pin at the driven end of the shaft.

Reassemble the coil, being sure that the winding clamp screws are tight and that their lock nuts are tight. Also that the wire connections are clean and tight.

Replace the magnets, being careful that the magneto support pieces are in place. Screw the magneto strap down tight and lock it by tightening the double nuts against lock washers. Replace magneto cover. Replace breaker cover and terminal screw. Thoroughly clean the inside of the distributor box of all free carbon and replace.

Table of Specifications Covering Wright Aviation Engines

GENERAL	A	I	E	E-2	H	H-2	H-3
1. Number of cylinders	8	8	8	8	8	8	8
2. Bore	120 mm. 4.724 in.	120 mm. 4.724"	120 mm. 4.724"	120 mm. 4.724"	140 mm. 5.51"	140 mm. 5.51"	140 mm. 5.51"
3. Stroke	130 mm. 5.118 in.	130 mm. 5.118"	130 mm. 5.118"	130 mm. 5.118"	150 mm. 5.9"	150 mm. 5.9"	150 mm. 5.9"
4. Piston displacement	11,762 cc. 718 cu. in.	11,762 cc. 718 cu. in.	11,762 cc. 718 cu. in.	11,762 cc. 718 cu. in.	18,475 cc. 1127 cu. in.	18,475 cc. 1127 cu. in.	18,475 cc. 1127 cu. in.
5. Compression ratio	4.72	4.72	5.33	5.5	5.4	5.5	5.5
6. Guaranteed brake horse-power sea level 29.27" at normal R. P. M.	150 H.P. 1450 R.P.M.	150 H.P. 1450 R.P.M.	180 H.P. 1800 R.P.M.	190 H.P. 1800 R.P.M.	320 H.P. 1800 R.P.M.	320 H.P. 1800 R.P.M.	320 H.P. 1800 R.P.M.
7. Direction of rotation of crankshaft (looking at magneto end of engine)	Clockwise for all models						
8. Direction of rotation of camshafts (looking at magneto end of engine)	Anti-clockwise for all models						
9. Tachometer shaft speed	Half crankshaft speed for all models						
10. Direction of rotation tachometer shaft (looking at magneto end of engine)	Anti-clockwise for all models						
11. Weight of engine complete *with* propeller hub flange and bolts, carburetor and two magnetos. *Without* water, oil, radiators, tanks, starting device, gasoline, supply system or propeller	432	472	472	480	625	617	620
12. Weight as in 11, but *with* cyl. jackets full of water. Water in radiator, etc., *not* included	473	513	513	520	680	672	672
13. Position of center of gravity of engine under conditions (11):							
Back from hub rear flange	19 13/32"	21 17/32"	21 17/32"	21 11/16"	23 13/32"	23 13/32"	23 13/32"
Up from center line of crank shaft	5"	5"	5"	5 11/32"	6¼"	6¼"	6¼"
14. Width requisite between engine bearers	11½	11½	11½	11½	13⅛	13⅛	13⅛
15. Width between engine holding bolt centers	13 5/32	13 5/32	13 5/32	13 5/32	14 5/16	14 5/16	14 5/16
16. Number of holding down bolts	16	16	16	16	16	16	16
17. Size of holding down bolts	⅜	⅜	⅜	⅜	⅜	⅜	⅜
Overall length from end to end of magneto	51¼	50 23/32	50 23/32	49⅛	51 15/32	52 9/32	52 9/32
Overall width outside of cam covers	33 7/16	33 7/16	33 7/16	33 7/16	38⅝	38⅝	38⅝
Height from engine bearer to highest point-top of pet cocks	18¾	18¾	18¾	18¾	23½	23½	23½
IGNITION							
18. Magneto type	Dixie 800	Dixie 800	Dixie 800	Dixie 800	Dixie 800	Dixie 800	Dixie 800
19. Direction of rotation of magneto R. h. (looking at drive coupling end) l. h.	Anti-clock Anti-clock	Anti-clock Clock	Anti-clock Clock	Clock Clock	Anti-clock Clock	Clock Clock	Clock Clock
20. Magneto speed	Crankshaft	Crankshaft	Crankshaft	Crankshaft	Crankshaft	Crankshaft	Crankshaft
21. Magneto breaker point gap	0.02"	0.02"	0.02"	0.02"	0.02"	0.02"	.02"
22. Spark plug point gap	0.02"	0.02"	0.02"	0.02"	0.02"	0.02"	.02"
23. Clearance between back of cam and tappet	2 mm. .078"	2 mm. .078"	2 mm. .078"	2 mm. .078"	0.03"	0.03"	.03"
24. Advanced spark occurs crankshaft degrees before top stroke	20°	20°	25°	25°	25°	25°	25°
VALVES AND TIMING							
25. Intake closes	50° late	50° late	50° late	50° late	60° late	60° late	60° late
Intake opens	10° late	10° late	10° late	10° late	10° early	10° early	10° early
26. Exhaust opens	45° early	45° early	45° early	45° early	61° early	61° early	61° early
Exhaust closes	10° late	10° late	10° late	10° late	26° late	26° late	26° late
27. Intake remains open (crankshaft deg.)	220°	220°	220°	220°	250°	250°	250°
28. Exhaust remains open (crankshaft deg.)	235°	235°	235°	235°	267°	267°	267°
29. Strength of outer valve springs, when compressed to length of	45 1 9/16	45 1 9/16	45 1 9/16	45 1 9/16	45 1 9/16	45 1 9/16	45 1 9/16
30. Strength of inner valve springs, when compressed to length of	35 1 7/16	35 1 7/16	35 1 7/16	35 1 7/16	35 1 7/16	35 1 7/16	35 1 7/16
For valve adjustment see page	49	49	49	49	49	49	49
Overhaul see page	55	55	55	55	55	55	55
31. Carburetor type	Zenith 48 D.C.	Stromberg N.A.D. 4	Stromberg N.A.D. 4	Stromberg N.A.D. 4	Stromberg N.A.D. 6	Stromberg N.A.D. 6	Stromberg N.A.D. 6A
32. Average fuel consumption per H. P. hour at normal R. P. M.	0.55 lb.	0.55 lb.	.50	.48	.52	.48	.48
33. Approximate consumption at sea level gallons per hour at normal R. P. M. and guaranteed H. P., 6.25 lbs. gas per gal.	13.2 gal.	13.2 gal.	14.3 gal.	14.5 gal.	26.6 gal.	24.6 gal.	24.6 gal.
34. Correct pressure on fuel supply	2.5 lb.	2.5 lb.	2.5 lb.	2.5 lb.	2.5 lb.	2.5 lb.	2.5 lb.
35. Diameter of venturi throat	30 mm.	1½"	1½"	1½"	1 13/16"	1 13/16"	1 13/16"
For carburetor adjustment see page	24	24	24	24	24	24	24
For carburetor overhaul see page	71	71	71	71	71	71	71

	A	I	E	E-2	H	H-2	H-3
LUBRICATION SYSTEM	8	8	8	8	8	8	8
36. Average oil consumption per H. P. hour	.022 lb.	.022 lb.	.018	.018	.022	.018	.018
37. Approximate consumption on ground gallons per hour	.45 gal.	.45 gal.	.44 gal.	.45 gal.	.96 gal.	.80 gal.	.80 gal.
At normal R. P. M.	1450	1450	1800	1800	1800	1800	1800
38. Correct oil pressure at normal R. P. M.	50 lb.	50 lb.	70 lb.	70 lb.	70 lb.	70 lb.	70 lb.
At recommended oil temperature	150° F.	150° F	150° F	150° F	150° F	150° F.	150° F.
39. Quantity oil circulated per min. under conditions of (38)	2.2 gal.	2.2 gal.	2.2 gal.	1.25 gal.	1.25 gal.	1.25 gal.	1.25 gal.
40. Minimum safe quantity of oil in whole system	1½ gal.	2 gal.	2 gal.	2 gal.	3 gal.	3 gal.	3 gal.
41. Maximum permissible temperature of oil under worst conditions	90° C 200° F	90° C 200° F	90° C 200° F	90° C 200° F	90° C 200° F	90° C 200° F	
42. Desired maximum oil temperature in normal operation	160° F	160° F	160° F	160° F	160° F	160° F	
43. Speed of oil pump	1.2 x crank	1.2 x crank	1.2 x crank	Crank	Crank	Crank	Crank
44. Direction of rotation of oil pump (looking at driving end of shaft)	Anti-clock	Anti-clock	Anti-clock	Clock	Clock	Clock	Clock
45. Hose connection required between engine and piping:							
Inside diameter	1 3/16"	¾"—¼"	¾"—¼"	¾"—¼"	¾"—¼"	¾"	¾"
Number of pieces	2	4—1	4—1	2—1	2—1	2	2
WATER SYSTEM							
46. Free delivery water pump in gallons at normal R. P. M. of engine	25	25	40	25	56	56	56
47. Speed of pump	1.2 crank	1.2 crank	1.2 crank	1.2 crank	1.2 crank	1.2 crank	1.2 crank
48. Direction of rotation of pump looking at driving end of spindle	Anti-clock	Anti-clock	Anti-clock	Anti-clock	Anti-clock	Anti-clock	Anti-clock
49. Desirable water temperature at cylinder outlets	110° F	110° F	110° F	110° F	110° F	110° F	110° F
50. Maximum permissible water temperature at cylinder outlets	80° C 190° F	88° C 190° F	88° C 190° F	88° C 190° F	88° C 190° F	88° C 190° F	88° C 190° F
51. Hose connections required between engine and piping:							
Inside diameter	1 3/16"	1 3/16"	1 3/16"	1 3/16"	1 3/16"	⅝"	13/16"
Number of pieces	4	4	4	2	6	5	7
Inside diamater				1½	1 9/16	1 9/16"	1 9/16"
Number of pieces				1	1	1	1
Inside diameter						1 3/16"	
Number of pieces						6	
PISTONS							
52. Permissible weight variation between piston assemblies in each set of four	1%	1%	1%	1%	1%	1%	1%
53. Number of compression rings per piston	4	4	4	4	4	4	4
54. Number of compression ring grooves per piston	2	2	2	2	4	4	4
55. Number of right hand rings required for one piston	2	2	2	2			
56. Number of left hand rings required for one piston	2	2	2	2			
57. Number of oil scraper rings required for one piston	1	1	1	1	1	1	1

WRIGHT ENGINE TOOL LIST

WRIGHT ENGINE TOOL LIST

LIST A

Tools common to all Models

Service No.	*Name*	*Tool No.*
WA 1	Camshaft Line Reamer	TA-11108-D-92
WA 2	Camshaft Bearing Aligning Bar	TAM-865
WA 3	Cylinder Holding Stand (supplied in blueprint only)	TAM-866
WA 4	Dead Center Indicator	12192-T-10
WA 5	Engine Stand, tilting (supplied in blueprint only)	TAM-863
WA 6	Gear and Ball Bearing Puller	12159-T-5
WA 7	Handle for Valve Seat Cutters	TAM-860
WA 8	High Speed Wrench Handle No. 6 and Sockets Nos. 16 to 28 inclusive	Billmont Wrenches
WA 9	Lock Nut Socket Wrench (Crankshaft)	TA-12159-T-15
WA 10	Magneto Driveshaft Gear Puller	11905-T-12
WA 11	Propeller Hub Wrench Assy.	12300
WA 12	Spark Plug Bushing Wrench Assy.	12066-E-7
WA 13	Timing Disk Assy.	TAM-864
WA 14	Valve Assembling Frame (supplied in blueprint only)	TAM-862
WA 15	Valve Assembling Lever	TA-12066-E-6
WA 16	Valve Clearance Gauge	TAM-855
WA 17	Valve Grinding Screwdriver	TA-12066-E-27
WA 18	Valve Guide Socket Wrench	Commercial 1" long socket
WA 19	Valve Tappet Socket Wrench	TA-12066-E-18
WA 20	Valve Tappet Adjusting Wrench	14072
WA 21	Water Pump Bracket Nut Wrench	TA-12066-T-82
WA 22	Water Pump Gland Wrench	14049
WA 23	Adjustable Hook Spanner Wrench	14050
WA 24	Adjustable Hook Spanner Wrench	14051
WA 25	Spark Plug Wrench and Handle	14052-14053
WA 26	Cylinder Stud Nut Wrench	Can use either 12066-T-72 or 14054 for all engines

LIST B

Additional Tools required for Models E and I

WA 51	Crankshaft Thrust Bearing Nut Wrench	TA-12066-T-65
WA 53	Main Bearing Reamer	TA-12045-C-2
WA 54	Piston Pin Bushing Reamer	10537-T-51
WA 55	Valve Guide Plug Gauge Exhaust	TA-11279-A-1
WA 56	Valve Guide Plug Gauge Intake	TA-10484-A-26
WA 57	Valve Guide Reamer	12075-C-8
WA 58	Valve Seat Cutter and Pilot Exhaust	TAM-857
WA 59	Valve Seat Cutter and Pilot Intake	TAM-856

NOTE—The handle for these cutters has formerly been duplicated and supplied with cutters TA-12066-T-89 and 90. The pin attaching handle to cutters should be changed so that the handle can be supplied with the tools common to all motors and the cutters interchanged on the one handle.

LIST C

Service No. *Name* *Tool No.*

Model A requires all the Tools in Lists A and B with the exception of Nos. 10 and 11.

It also needs the following:

WA 71	Piston Pin Lock Screw Wrench	12015-C-2
WA 72	Propeller Hub Nut Wrench	TA-12066-T-94

LIST D

Models H, H-2 and H-3 require all Tools in List A. Plus the following:

WA 91	Crankshaft Thrust Bearing Nut Wrench	12159-T-17
WA 93	Main Bearing Reamer	13263-T-37
WA 94	Piston Pin Bushing Reamer	11493-T-6
WA 95	Valve Guide Plug Gauge Exhaust	11485-T-2
WA 96	Valve Guide Plug Gauge Intake	11568-T-13
WA 97	Valve Guide Reamer	12128-T-12
WA98	Valve Seat Cutter and Pilot Exhaust	TAM-858
WA 99	Valve Seat Cutter and Pilot Intake	TAM-859

NOTE—These cutters are portions of 12104-T-1 and 12104-T-5. They should be supplied without the handle as they will fit Handle No. 7 in List A after pin is redesigned. Refer to note on valve seat cutters for Models A, E and I at foot of List B.

Tool Box. The following tools are supplied in Tool Box of each engine as it leaves the Wright Plant:

WA 11, 20, 22, 23, 24, 25.

If only one engine is being used, the following single engine tools will be sufficient to make most of the adjustment necessary in addition to the tools supplied in Tool Box:

Single engine tool list for Models I, E and E-2—

WA 3, 4, 5, 7, 8, 12, 13, 14, 15, 16, 17, 18, 19, 21, 26, 51, 58, 59.

Single engine tool list for Model A—

WA 3, 4, 5, 7, 8, 12, 13, 14, 15, 16, 17, 18, 19, 21, 26, 51, 58, 59, 71, 72.

Single engine tool list for Models H, H-2 and H-3—

WA 3, 4, 5, 7, 8, 12, 13, 14, 15, 16, 17, 18, 19, 21, 26, 91, 98, 99.

If several engines are at a station, a fuller complement of tools should be kept and the following list is suggested in addition to the tools supplied in Tool Box:

Several engine tool list for Models I, E and E-2—

WA 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 21, 26, 51, 54 55, 56, 57, 58, 59.

Several engine tool list for Model A—

WA 3, 4, 5, 7, 8, 9, 12, 13, 14, 15, 16, 17, 18, 19, 21, 26, 51, 54, 55, 56, 57, 58, 59, 71, 72.

Several engine tool list for Models H, H-2 and H-3—

WA 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 21, 26, 91, 94, 95, 96, 97, 98, 99.

For a base where many engines are to be overhauled and repaired, the entire list of tools should be obtained for the models of engines coming into the base. This would supply the base with some of the large tools such as reamers, aligning bars, etc., which would be seldom used if only a few engines are being served.