THE CURTISS

STANDARD MODEL OX AERONAUTICAL MOTOR

HAND BOOK

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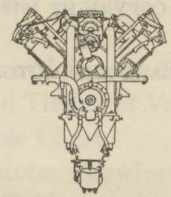
HAND BOOK



1918

ISSUED BY
CURTISS AEROPLANE AND MOTOR CORPORATION
BUFFALO, U. S. A.

THE CASLON PRESS, TOLEDO, OHIO

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OX MOTOR
GENERAL SPECIFICATIONS

Type	"Vee" 8 cylinder, 4 Stroke Cycle
Bore and Stroke	4 in. x 5 in.
Horsepower at 1400 R. P. M. (Rated)	90
Horsepower at 1400 R. P. M. (Brake)	93
Normal Speed	1400 R. P. M.
Cooling	Water
Weight (Complete with propeller hub)	390 lbs.
Ignition	8 cylinder High Tension Magneto
Lubrication	Force and Spray Feed
Carburetion, One duplex Carburetor to the rear of the Motor	
Fuel Consumption (normal), per H. P. Hour	0.60 lbs.
Oil Consumption (normal), per H. P. Hour	0.03 lbs.
Capacity of Oil Reservoir	924 cu. in.

INSTALLATION DIMENSIONS

Overall Length	$55\frac{3}{8}$ in.
Overall Width	$29\frac{3}{4}$ in.
Overall Depth	$31\frac{1}{2}$ in.
Width at Bed (Inside Supports)	$10\frac{7}{8}$ in.
Width at Bed (Center to Center of Bolts)	$12\frac{7}{8}$ in.
Height from Bed to Top	$17\frac{3}{4}$ in.
Depth from Bed to Bottom	$13\frac{3}{4}$ in.
Bed Bolts (Center to Center)	$12\frac{5}{32}$ in.

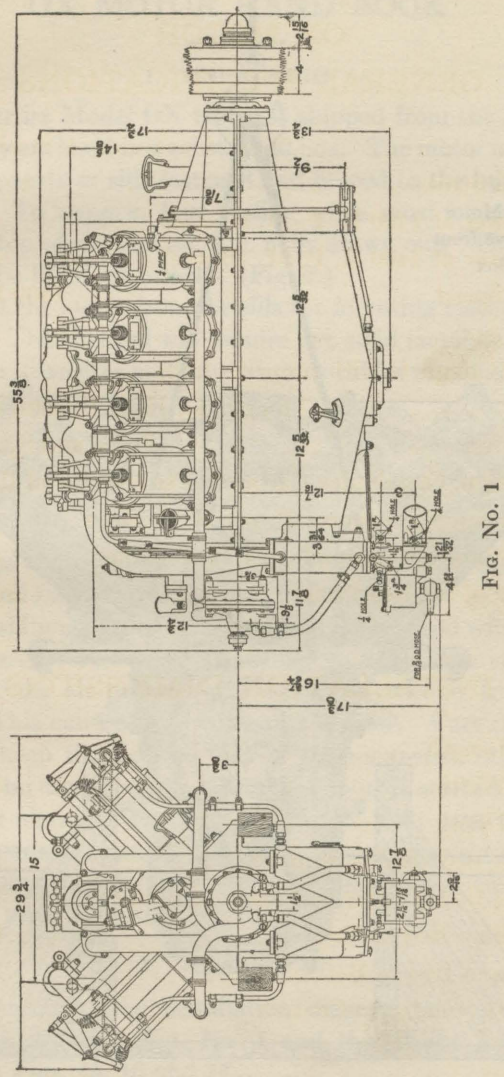


FIG. No. 1

Method of Slinging Motor to Remove from Engine Box

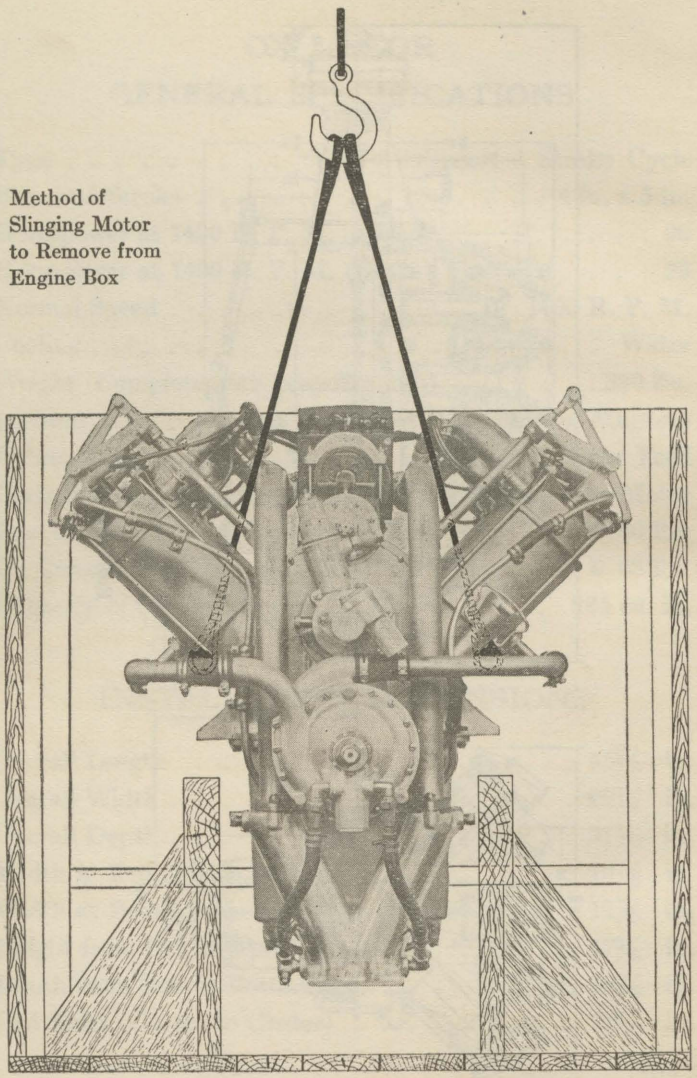


FIG. No. 2

OX MOTOR HAND BOOK

1. UNPACKING

The Curtiss Model OX motor is shipped from the factory completely enclosed in a substantial box. The motor is bolted to two supports or sills fastened and braced to the bottom of the box. To unpack, four sealing wires must be removed from the top of the box and the nails drawn out. The cover can then be lifted off intact. (Fig. 2.)

To hoist the motor from the sills the following method may be used. This method will require two solid metal bars of at least ¾-in. diameter and four wires or cables of equal length and with a loop on each end.

The two bars should be placed one on each side of the motor, bearing against the cylinder wall just under the water jacket. These bars are supported by the cables passing between the first two and last two cylinders on each side. The lower loops of the cables pass around the bar and the upper loops are all passed over the hoisting hook.

Before shipment the Curtiss motors are slushed with vaseline to prevent rusting or corroding en route. A spray of gasoline under air pressure will wash the vaseline from the motor. This can be done with an atomizer. Care must be taken to keep the gasoline out of the magnetos, otherwise there will be danger of fire when the motor is started.

DO NOT ATTEMPT TO EVEN PARTIALLY REST THE WEIGHT OF THE MOTOR ON THE LOWER HALF OF THE CRANK CASE, OR ON ANY PART OTHER THAN THE SUPPORTING ARMS. SEE THAT ALL ARMS BEAR EQUALLY.

2. SETTING UP

Study carefully the installation diagram shown on the installation drawing, Fig. No. 1 and the Motor Assembly Drawings, Figs. 15, 16 and 17.

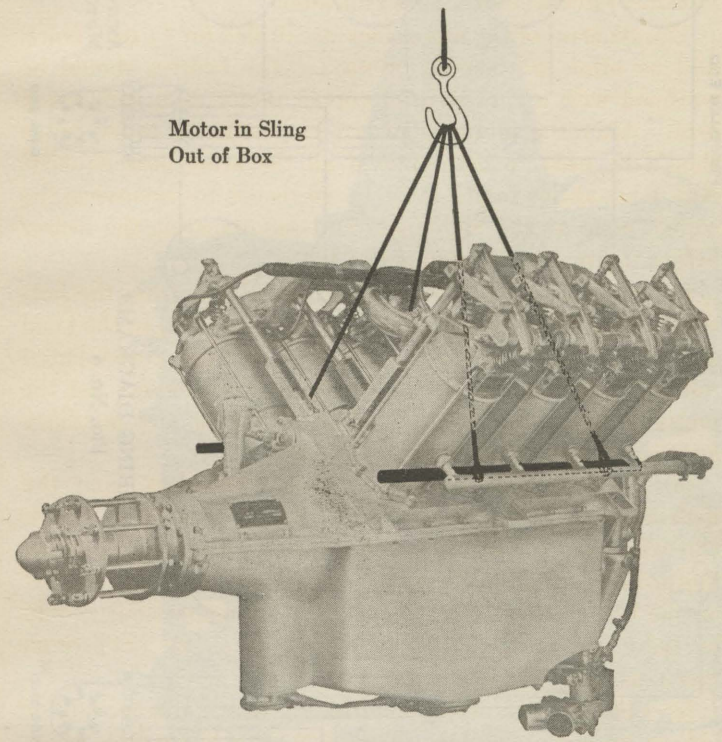
The bearers (96) should be 2 inches wide by 3 inches deep, preferably of laminated construction with hardwood upper and lower faces, and placed 10⅞ inches apart. They must be well and equally braced at forward and rear ends of the motor, to avoid undesirable vibration.

The six arms of the motor base are drilled for ⅜-inch bolts, and no other size should be used. The bearers should be wrapped with a thin strip of copper under each supporting arm. After the motor is placed in position a feeler gauge should be used to determine if all the arms bear equally. Any inequalities found must be corrected by removing the copper strip at the high spots and sandpapering the bearer before tightening the engine bed bolts.

(*a*) Anchoring the Motor: Put the bolts in from the bottom, with a large washer under the head of each, so the head cannot cut into the wood. On every bolt use a castellated nut and cotter pin so the bolt will not work loose. Set the motor in place and fasten, before attaching any auxiliary apparatus, such as carburetor (54), etc.

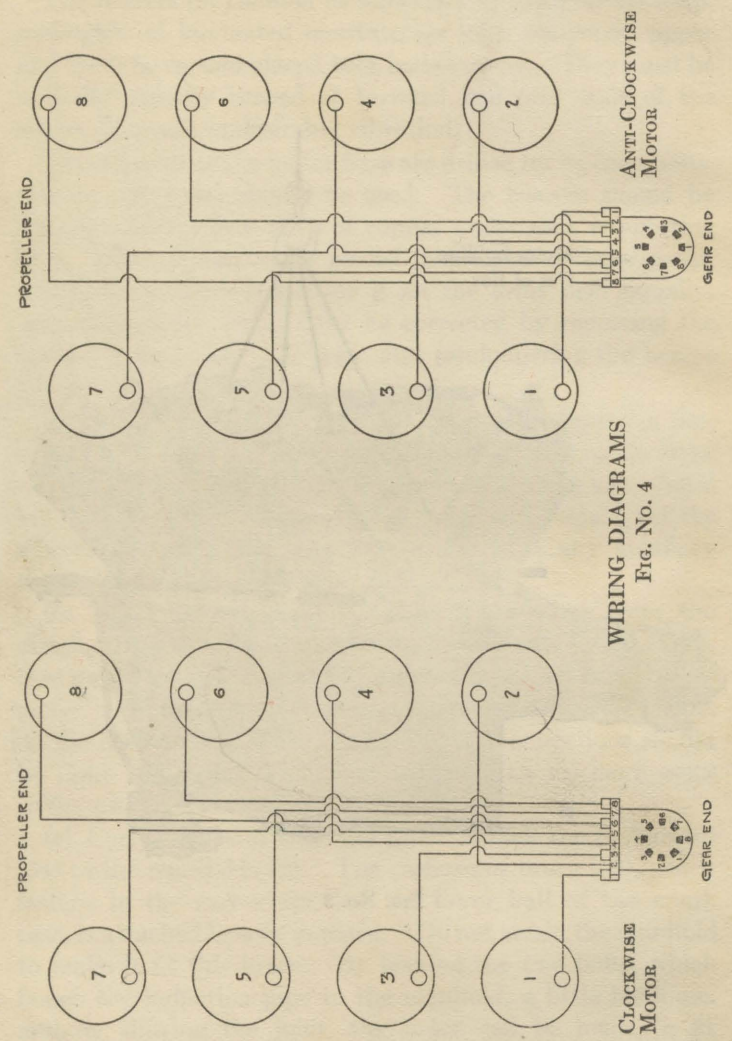
(*b*) Magneto and Wiring: Connect the wires from the distributor according to the wiring diagram shown in Fig. 4. One wire from the ignition switch should be connected to the motor body for ground connection and the other to the post on the breaker box of the magneto. All connections should be tight and firm. THE SWITCHES SHOULD BE LEFT OPEN UNTIL READY TO START THE MOTOR.

(*c*) Carburetor and Gasoline Line: Attach the carburetor (54) to the manifold (52). The carburetor brace (55), which fastens to the carburetor and the lower half of the crank case, is attached loosely in place. Do not strain the manifold to make it fit this brace. By leaving the two bolts, which fasten the induction pipe to the manifold, a little bit loose, and by shifting the joint, the brace can be made to fit easily.



Motor in Sling
Out of Box

FIG. No. 3



WIRING DIAGRAMS
FIG. No. 4

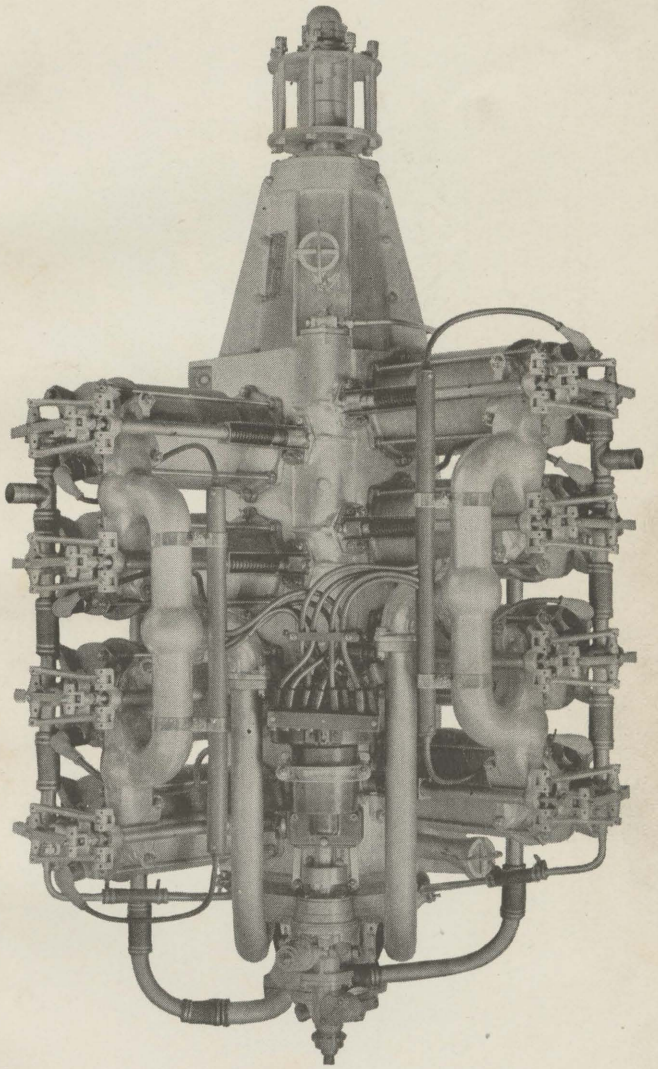


FIG. No. 5

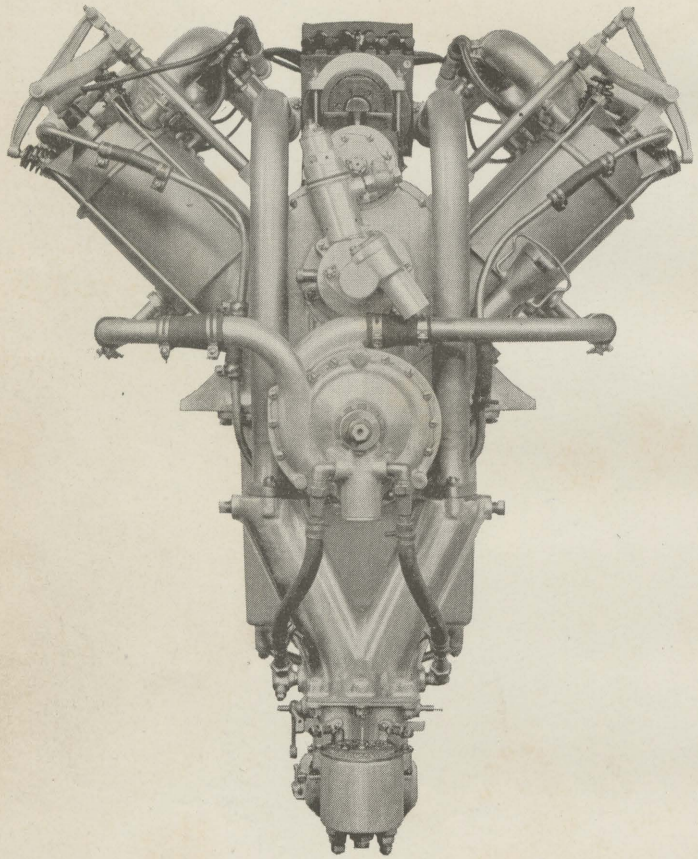


FIG. No. 6

When the throttle controls are attached to the carburetor the two lower case butterfly throttle valves should close simultaneously. Fuel connections from the fuel tank to the carburetor should be at least 3/16-in. inside diameter.

It is desirable that a satisfactory strainer and water separator be located between tank and carburetor. The gasoline line should be fitted with a spring loop to take up the vibration.

Fill the gasoline tank, open the valves connecting the tanks to the carburetors and inspect for leaks and for proper float action.

(*d*) Oiling: Connect up the oil line from the upper half of the crank case at the propeller end to the oil gauge on the instrument board. Fill the oil reservoir through the filler pipe located on the upper half of the crank case to the rear of cylinder No. 2. Use a light, high grade oil. The recommended lubricant is Mobil "A" oil or equivalent.

(*e*) Cooling System: Connect up the rubber hose connection from lower outlet of the radiator to the pump inlet and from the cylinder outlets at cylinders No. 7 and No. 8 to the radiator inlet pipes. Particular care should be taken to insure tight connections between radiator outlet and pump inlet as leakage here will permit air to be drawn in, displacing water and possibly causing overheating of the motor. Fill the cooling system with water through the radiator filler pipe and turn the crankshaft one or two revolutions to eliminate any air pockets.

(*f*) Oiling Exposed Parts: Oil all exposed parts, as rocker arms (31, 32), valve stems, etc. The oil holes in the rocker arms will hold oil enough to last for several hours' running.

3. STARTING THE MOTOR

Open the cock leading from the gasoline tank to the carburetor. With the ignition switch "OFF" turn the pro-

peller over one or two revolutions (in direction of rotation) to draw gasoline into the cylinders.

Turn on the ignition switch with the throttle partly open and give a quick, strong pull on the propeller.

(*b*) Let the motor run at about 500 revolutions per minute, for three to five minutes in order to establish oil circulation in all bearings. The pressure as indicated by the oil pressure gauge should be about 45 pounds at 500 R. P. M., and about 60 pounds at 1400 R. P. M.

(*c*) Warming up the Motor: As soon as all parts are performing properly the throttle may be opened gradually for warming up before flight.

NOTE: The auxiliary air valves on the carburetor barrels are for use in altitude flying and must be closed when running the motor on the ground.

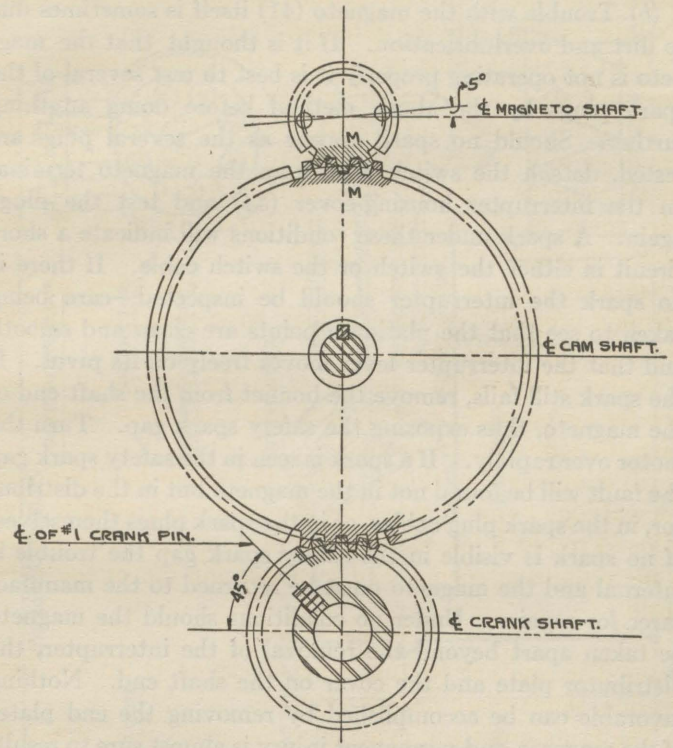
(*d*) Stopping the Motor: When the motor has been running at high power it should be slowed down gradually, then allowed to idle a few minutes before stopping. This insures a more uniform cooling and increases the life of the valve seats.

4. IGNITION

(*a*) The ignition on this type of engine is by one high tension, single spark magneto system.

The firing order and cylinder arrangement is as shown on the Wiring Diagram, Fig. No. 4.

Ignition troubles are usually traced to faulty spark plugs (46). A common cause of spark plug failure lies in the burning away of the electrodes, due to intensity of the spark and the widening of the gap. This will cause missing at low speeds. The spark plug may be tested by connecting it up with its terminal and laying it on the motor for ground connection. A bright spark should jump across the terminals when the motor is turned over briskly. ALL GASOLINE LINES SHOULD BE CAREFULLY SHUT OFF BEFORE THIS OPERATION.



GEAR SETTING DIAGRAM

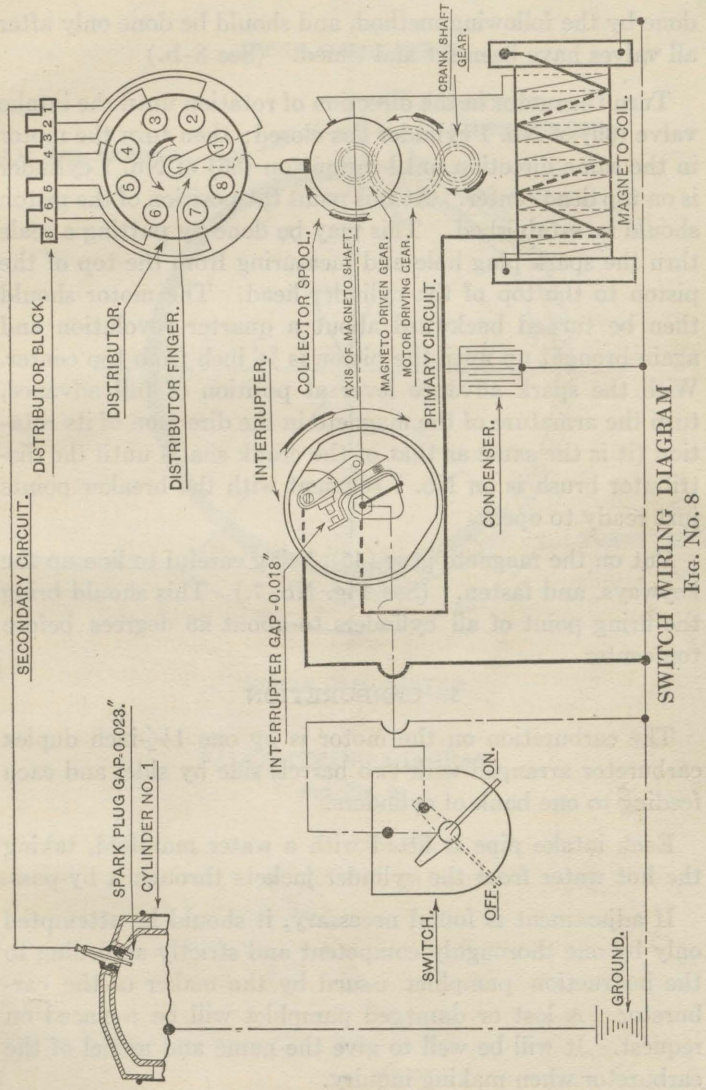
FIG. No. 7

(*b*) Trouble with the magneto (41) itself is sometimes due to dirt and overlubrication. If it is thought that the magneto is not operating properly it is best to test several of the spark plugs by the above method before doing anything further. Should no spark appear as the several plugs are tested, detach the switch wire from the magneto terminal on the interrupter housing-cover (44) and test the plugs again. A spark under these conditions will indicate a short circuit in either the switch or the switch cable. If there is no spark the interrupter should be inspected—care being taken to see that the platinum points are clean and smooth and that the interrupter lever moves freely on its pivot. If the spark still fails, remove the bonnet from the shaft end of the magneto, thus exposing the safety spark gap. Turn the motor over rapidly. If a spark is seen in the safety spark gap the fault will be found not in the magneto but in the distributor, in the spark plug cables, or in the spark plugs themselves. If no spark is visible in the safety spark gap the trouble is internal and the magneto must be returned to the manufacturer for repairs. Under no conditions should the magneto be taken apart beyond the removal of the interrupter, the distributor plate and the cover on the shaft end. Nothing favorable can be accomplished by removing the end plates of the magneto and permanent injury is almost sure to result.

The inside of the commutator should be kept clean and lubricated with cylinder oil, not in too large quantities, however. The lubricant recommended is a mixture of one-half Castor oil and one-half Mobil "A" oil. Graphite should never be used on the commutator.

Lift out the distributor plate occasionally without disarranging the wiring, and remove any accumulation of oil, dirt or moisture.

(*c*) The retiming or checking of the magneto should be



SWITCH WIRING DIAGRAM
Fig. No. 8

done by the following method, and should be done only after all valves have been set and timed. (See **8-b.**)

Turn the motor in the direction of rotation until the intake valve (39) of No. 1 cylinder has closed; then turn the motor in the same direction until the piston (86) of No. 1 cylinder is on top dead center. At this point the position of the piston should be established. This may be done by putting a scale thru the spark plug hole and measuring from the top of the piston to the top of the cylinder head. The motor should then be turned backward about a quarter revolution and again brought up until the piston is ⅜ inch from top center. With the spark advance lever at position of full advance, turn the armature of the magneto in the direction of its rotation (it is the same as that of the crank shaft) until the distributor brush is on No. 1 segment with the breaker points just ready to open.

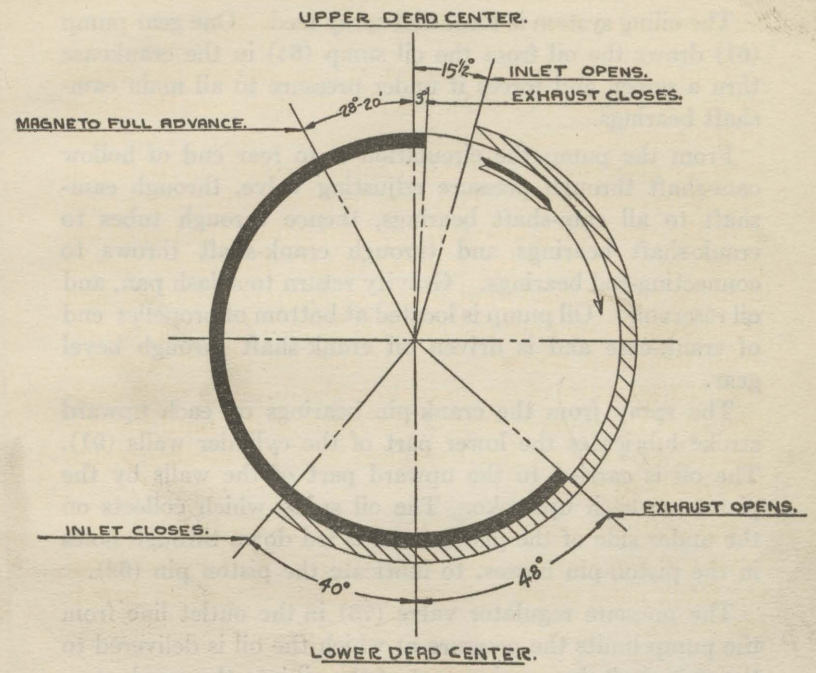
Put on the magneto gear (45), being careful to line up the keyways, and fasten. (See Fig. No. 7.) This should bring the firing point of all cylinders to about 28 degrees before top center.

5. CARBURETION

The carburetion on the motor is by one 1½-inch duplex carburetor arranged with two barrels side by side, and each feeding to one bank of cylinders.

Each intake pipe is fitted with a water manifold, taking the hot water from the cylinder jackets through a by-pass.

If adjustment is found necessary, it should be attempted only by one thoroughly competent and strictly according to the instruction pamphlet issued by the maker of the carburetor. A lost or damaged pamphlet will be replaced on request. It will be well to give the name and model of the carburetor when making inquiry.



VALVE TIMING DIAGRAM

FIG. No. 9

6. LUBRICATION

The oiling system is force and spray feed. One gear pump (61) draws the oil from the oil sump (64) in the crankcase thru a screen and forces it under pressure to all main cam-shaft bearings.

From the pump the circulation is to rear end of hollow cam-shaft through pressure adjusting valve, through cam-shaft to all cam-shaft bearings, thence through tubes to crank-shaft bearings and through crank-shaft throws to connecting-rod bearings. Gravity return to splash pan, and oil reservoir. Oil pump is located at bottom of propeller end of crank-case and is driven off crank-shaft through bevel gear.

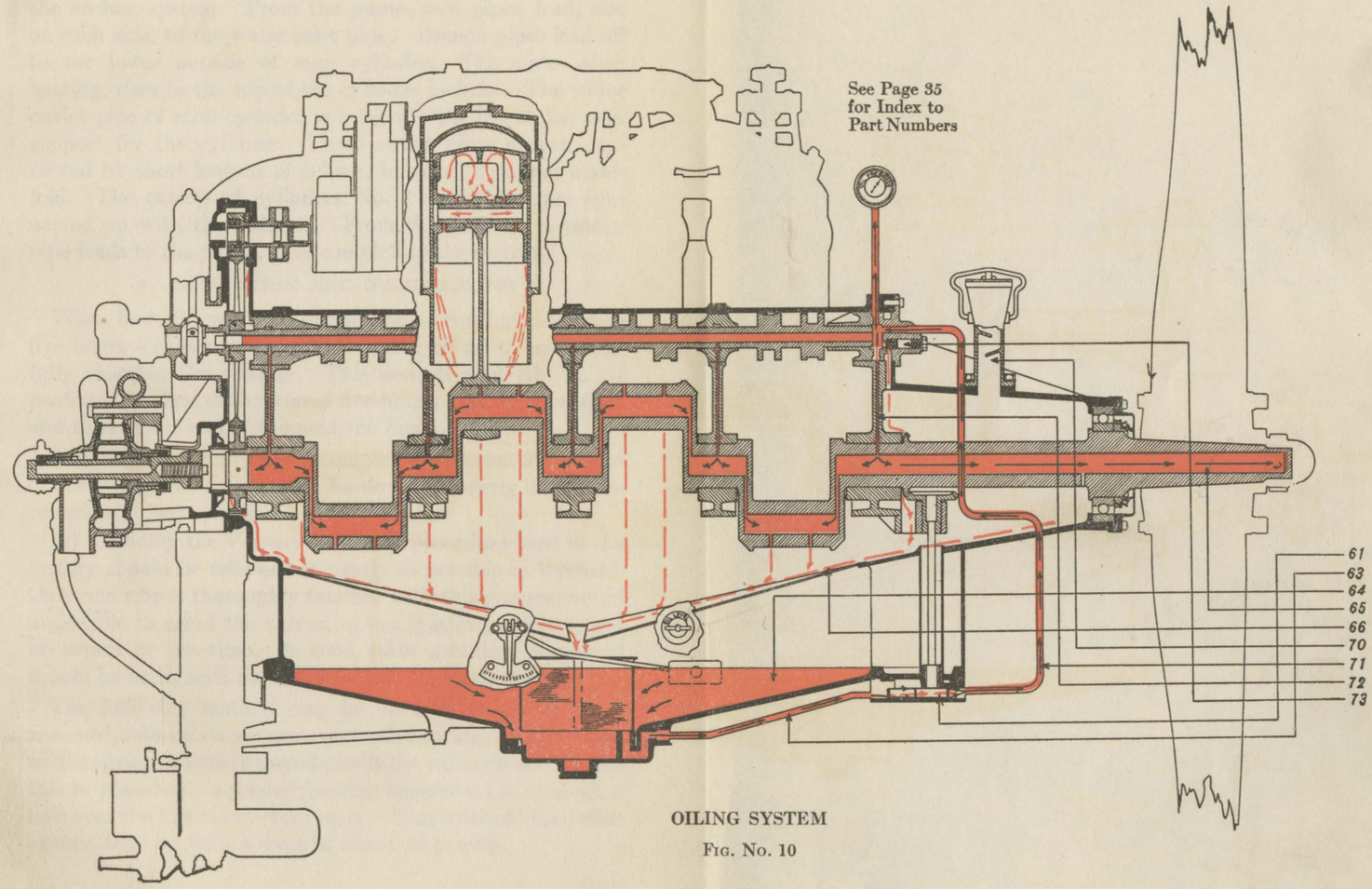
The spray from the crank-pin bearings on each upward stroke lubricates the lower part of the cylinder walls (91). The oil is carried to the upward part of the walls by the piston on each upstroke. The oil spray which collects on the under side of the piston head is led down through holes in the piston-pin bosses, to lubricate the piston pin (92).

The pressure regulator valve (73) in the outlet line from the pump limits the pressure at which the oil is delivered to the cam shaft, by passing part of the oil into the crank case. The pressure may be altered by changing the thickness of the fibre washer under the head of the screw which bears against the pressure regulating valve spring.

The lower half of the crankcase is so designed that its center is always its lowest point. This construction insures the oil remaining at this point at any flying angle, and prevents flooding the cylinders.

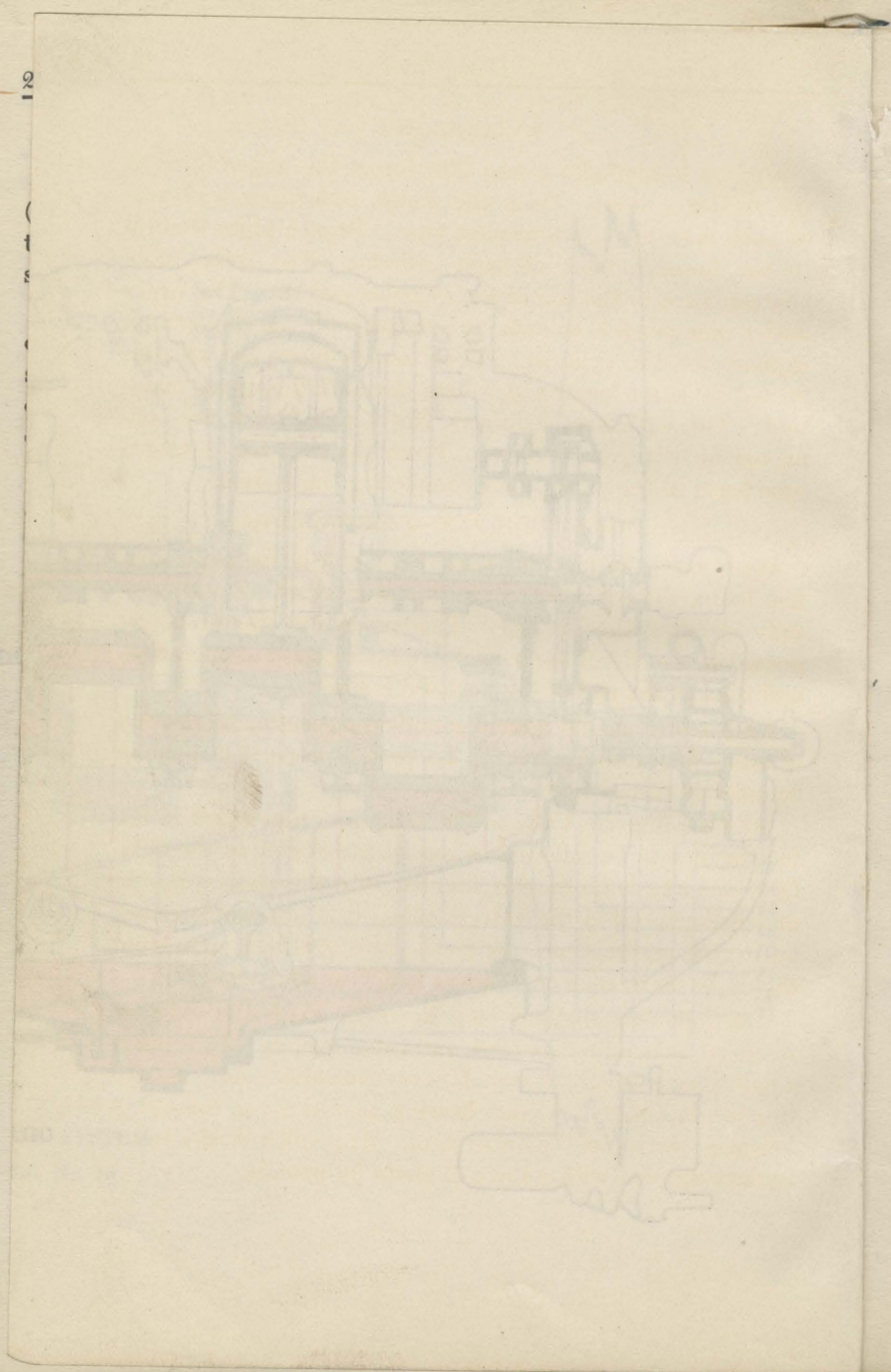
Inside the crankcase there is also an oil pan partition, which slopes down toward the center from each side. At the center a hole about a half-inch in diameter allows the returning oil to enter the oil sump.

See Page 35 for Index to Part Numbers



OILING SYSTEM

FIG. No. 10



7. COOLING

A single centrifugal pump (76) forces the water through the cooling system. From the pump, two pipes lead, one on each side, to the water inlet pipe. Branch pipes lead off to the lower outside of each cylinder. The water, after heating, rises to the top of the cylinder jackets. The water outlet pipe of each cylinder is integral with the rocker arm support for the cylinder. These outlet pipes are all connected by short lengths of tubing, forming the upper manifold. The outlets of cylinders No. 7 and No. 8 are connected up with the radiator. From the radiator, a return pipe leads to the pump, thus completing the system.

8. INSPECTION AND OVERHAULING

When new, the machine should not be run for more than five hours without thoroughly draining off all oil and carefully cleaning the strainer. This procedure should be repeated at the end of the second five-hour period of operation, and then at the end of the next ten hours.

Each motor should have a complete inspection at the end of every fifty running hours. To do this properly it must be completely dismantled.

(*a*) Grinding the Valves: The same procedure used in the factory should be followed as nearly as possible in the field. Only one who is thoroughly familiar with this process should undertake to grind the valves, unless it is impossible to get an expert at the time. A good valve grinding compound should be used, such as "Clover Leaf" or equivalent.

The following method may be used: With the cylinder removed, take off rocker arms and valve springs. Now place a light spring (about 10 pounds) over the valve stem. Fasten this in place with a washer bearing against a pin through a hole near the top of the valve stem. This will hold the valve against the seat with a force of about 10 pounds.

A socket wrench with a transverse hole, corresponding to the hole in the stem, or a fork which will straddle the stem, may be used. This tool should be fastened to the stem by means of the pin and by turning the tool, the valve may be rotated on the seat.

Clean the valve face and seat and test in three positions for gasoline leakage with the firing chamber full of gasoline. Lap in until gasoline tight in three positions and remove the shoulders caused by grinding. The valves must be lapped until perfectly tight.

(*b*) Setting and Timing the Valves: The valves are timed after the motor is completely assembled except for the camshaft gear (21) and the gear case cover.

Set the inlet tappet clearance (97) to .010 inches and the exhaust tappet clearance (98) to .010 inches. The clearance is adjusted by loosening the lock nut on the push rod and turning the rod.

Turn the crankshaft in the direction of rotation until No. 1 piston is on top dead center. Turn the camshaft in its direction of its rotation (opposite to that of the crankshaft) until the exhaust valve of No. 1 cylinder has just closed. Put on the camshaft gear, being careful to line up the keyways in gear and shaft and fasten. (See Fig. 7.)

Thus set and timed, the inlet valves will open 15½ degrees past top center and close 40 degrees after bottom center. The exhaust valves will open 48 degrees below bottom center and close 3 degrees past top center. These values refer to crankshaft rotation. A variation of 3 degrees from these values will not be detrimental.

(*c*) Bearings: The crankshaft (5) and crank pin bearings (4) in these motors are made two or three thousandths of an inch larger than the shafts, although tests and experiences have proven that four-thousandths is not injurious, whereas

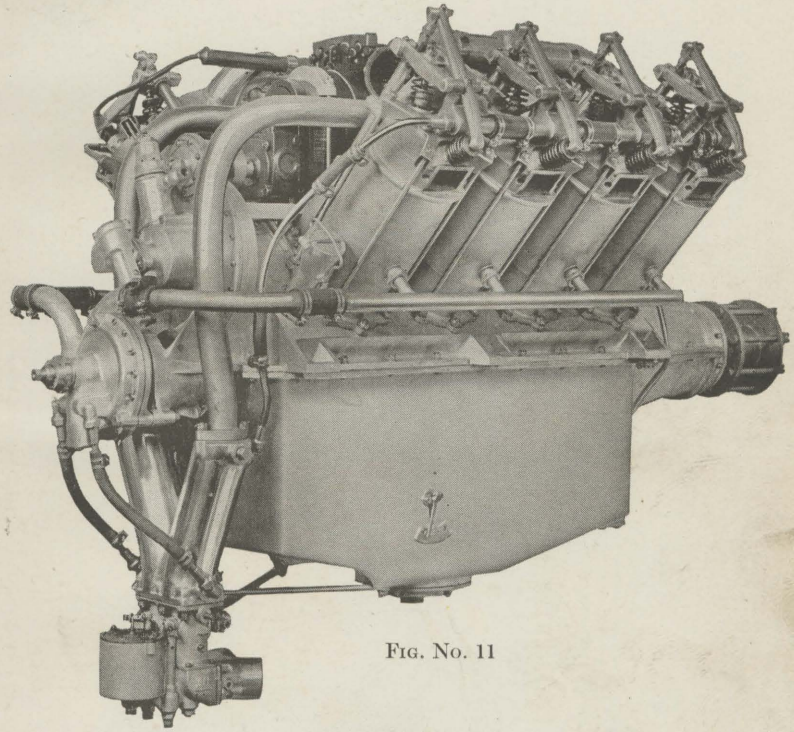


FIG. No. 11

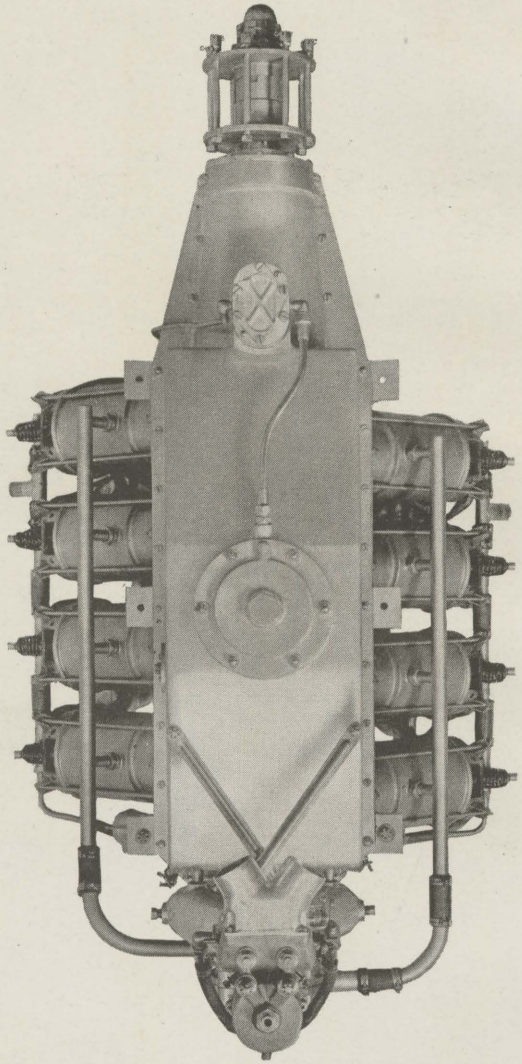


FIG. No. 12

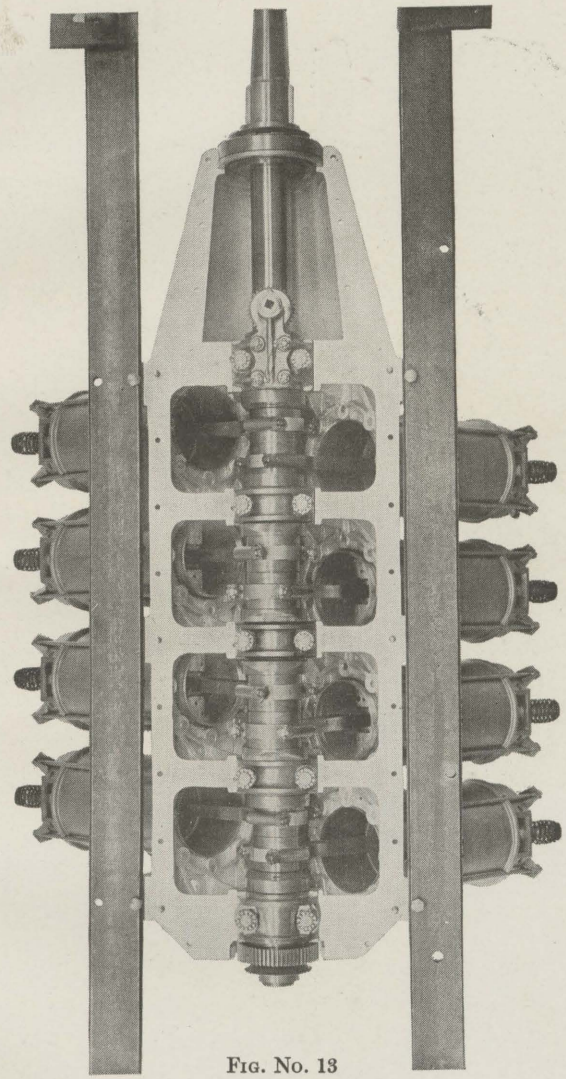


FIG. No. 13

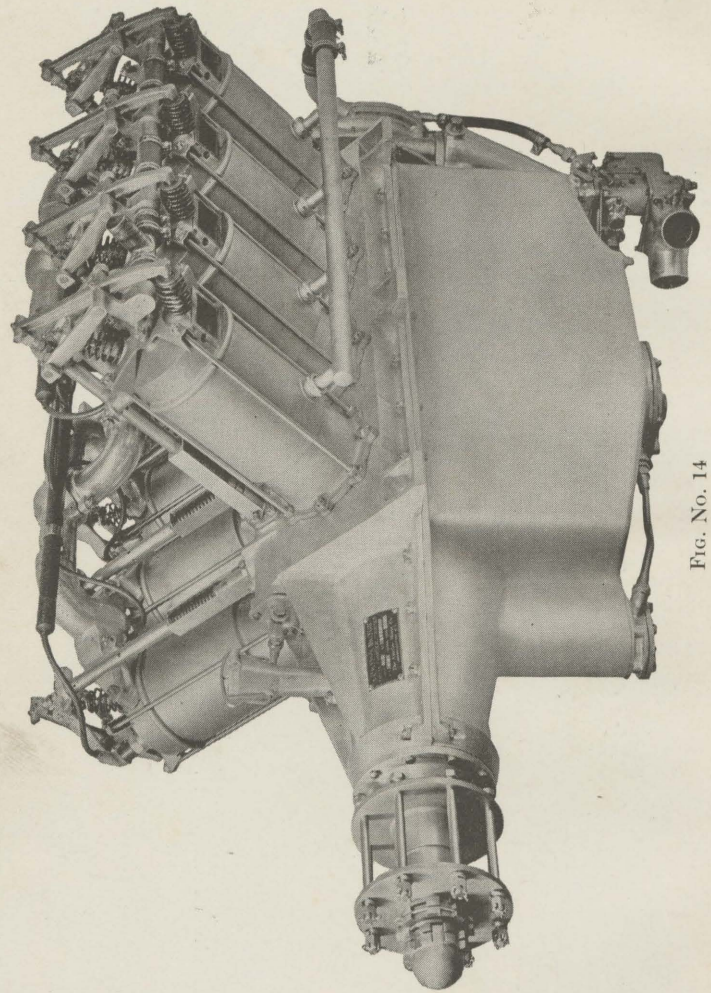


FIG. No. 14

one-thousandth clearance is not sufficient for the maintenance of a proper oil film. If the bearings show traces of dirt or the surface appears flaked, the dirt or flakes should be carefully cleaned off, without disturbing the body of the bearing. Do not undertake to refit the bearings tighter unless they are larger than the shaft by more than four-thousandths of an inch.

(*d*) Carbon Deposit: Any deposit of carbon on the piston head (86) should be carefully scraped off while the motor is disassembled. Be careful to clean off any carbon that may have fallen onto the cylinder wall or any bearing surface, before reassembling.

9. THE TROUBLE CHART

The trouble chart has been prepared to outline the various troubles and remedies in a form that will facilitate ready reference.

A general knowledge of motor troubles is necessary to use the chart as for instance, if the motor is "skipping" or "missing" the trouble should be found under the heading of "Skipping or Irregular Operation." If the motor fails to develop power the proper section is "Lost Power and Overheating." It is necessary to be able to recognize these main divisions in order to locate the remedy.

In a great many instances the trouble will be found in the auxiliary members of the power plant rather than in the motor. This chart, however, only undertakes to include the most common troubles of the motor itself.

On the index to the motor drawings Figs. 15, 16 and 17 the numbers of the parts on the drawing are found in the first three columns. The fourth column gives the part names. The fifth column contains figures which refer to the section in the trouble chart in which each motor part is concerned.

IMPORTANT DON'TS

1. Don't forget to inspect the motor thoroughly before starting.
2. Don't try to start without oil, water or gasoline; all three are vital.
3. Don't forget to see that the radiator is full of water.
4. Don't get dirt or water into the gasoline.
5. Don't get dirt or water into the oil.
6. Don't forget to oil all exposed working parts.
7. Don't try to start without turning on the switch.
8. Don't start the motor with throttle wide open.
9. Don't run the motor idle too long (it is not only wasteful but harmful).
10. Don't forget to watch the lubrication; it is most essential.
11. Don't forget that the propeller is the business end of the motor; treat it with profound respect, especially when it is in motion.
12. Don't cut off the ignition suddenly when the motor is hot; allow it to idle a few minutes at low speed before turning off the switch.
13. Don't fail to study the trouble chart in this book before you adjust anything about the motor.
14. Don't develop that destructive disease known as tinkeritis; when the motor is working all right let it alone.
15. Don't forget a daily inspection of all bolts and nuts; keep them well tightened.
16. Don't fail to study this instruction book thoroughly.

SKIPPING OR IRREGULAR OPERATION

Part at Fault	Trouble	Effect	Remedy
1 Spark Plug	Loose binding at post	No spark	Tighten terminal
	Leak in threads	Low compression	Screw down tighter
	Defective gaskets	Low compression	Replace with new plug
	Cracked insulator	Short-circuit	Replace with new plug
	Points too close	No spark	Set points to .023″
	Points too far apart	No spark	Set points to .023″
	Carbon deposit	No spark	Clean off points and plug
	Plug too long	Pre-ignition	Change plug
2 Combustion Chamber	Carbon deposit	Pre-ignition	Remove carbon
3 Piston Head	Carbon deposit	Pre-ignition	Remove carbon
	Crack or blowhole (rare)	Pre-ignition	Replace with new piston
4 Valve Head	Warped or pitted on seat	Poor mixture	True up in lathe and grind to seat
		Low compression	Replace with new valve
5 Valve Stem	Binds in guide	Irregular valve action	Clean guide
	Sticks		Straighten stem
			Oil
6 Valve Spring	Weakened or broken	Irregular valve action	Replace with new
7 Exhaust Valve Seat	Scored or warped	Valve will not close	Use reseat reamer
	Dirty or covered with scale	Poor mixture	Clean off and grind to seat
		Poor compression	
8 Exhaust Valve Stem Guide	Warped or carbonized	Valve stem sticks	Clean guide
	Worn guide	Low compression	
		Poor seating	
		Poor mixture	
9 Valve Stem Clearance	Too little	Valve will not shut	Set inlet gap .010″
	Too much	Valve opens late and closes early	Set exh. gap .010″
10 Cam Shaft Bearing	Looseness or wear	Valves mistimed or valve lift short	Replace with new bushing
11 Cam	Worn contour	Valve lift short	Replace with new cam shaft
		Valves mistimed	

SKIPPING OR IRREGULAR OPERATION—Cont.

Part at Fault	Trouble	Effect	Remedy
12 Timing Gear	Not properly meshed Loose on shaft Worn or broken tooth	Valves mistimed Valves do not act	Time properly Fasten to shaft with key Replace with new gear
13 Cam Follower Guide	Loose on engine base Lock pin sheared off Worn in bore	Oil leaks Poor valve action	Fasten securely New pin New guide or bushing
14 Cam Follower	Loose in guide	Valves mistimed Oil leak	Replace with new guide or bushing
15 Inlet Valve	Closes late Opens early	Blow-back in carburetor	Time properly
16 Inlet Valve Seat	Warped or pitted Does not seat properly Carbon grain under seat	Blow-back in carburetor Low compression	Use reseat reamer Clean off and grind to seat
17 Inlet Valve Stem Guide	Worn	Poor mixture Low compression	Bush or replace with new cylinder
18 Carburetor	Weak mixture	Blow-back in carburetor	Adjust carburetor for richer mixture
19 Gas Manifold Pipe	Leak at joints Defective gasket Crack or blowhole	Poor mixture Poor mixture Poor mixture	Stop all leaks Replace with new Solder blowhole
20 Piston	Walls scored	Poor suction and leak of gas	Smooth up
21 Piston Rings	Loss of spring Loose in grooves Worn or broken Slots in line	Poor suction and leak of gas Poor compression	Peen rings or replace with new Loosen rings on piston
22 Cylinder Wall	Scored by wristpin Scored by lack of oil	Poor suction and leak of gas Poor compression	Lap in cylinder or new cylinder
23 Valve Spring Collar Key	Broken	Release spring No valve action	Replace with new key

LOST POWER AND OVERHEATING

Part at Fault	Trouble	Effect	Remedy
24 Manifold Connection	Poor mixture in one set of cylinders with good mixture in other set	Surging or pulsating	Tighten connections Put in new gaskets
25 Water Pipe Joint	Loose Defective gasket	Loss of water and overheating	Tighten bolts or Replace with new connection
26 Spark Plug	Loose in threads Defective gasket	Poor compression and overheating	(See No. 1) Screw down tight Replace with new
27 Combustion Chamber	Crack or blowhole Roughness Carbon deposit	Poor compression Pre-ignition Pre-ignition	Fill by welding or Replace with new Smooth up Remove carbon
28 Valve Head	Warped, scored or pitted Carbonized or covered with scale	Poor compression	True up in lathe and grind to seat Scrape off smooth with emery cloth
29 Valve Seat	Warped or pitted Carbonized or covered with scale	Poor compression or blow-back	Use reseat reamer Clean off and grind to seat
30 Piston Rings	Loss of spring Loose in groove Worn or broken Slots in line	Poor suction, leak of gas and overheating Poor compression	Peen rings or replace with new Loosen rings on piston
31 Piston Rings	Broken because too tight Insufficient opening	Scored cylinder walls, overheating in sump pan and poor compression	Replace scored cylinder if groove is deep Use new rings
32 Wrist Pin	Loose Scored cylinder	Poor compression	Fasten securely Replace scored cylinder if groove is deep
33 Piston Head	Carbon deposit Crack or blow-hole (rare)	Pre-ignition Poor compression	Remove carbon Replace with new
34 Piston	Binds in cylinder Walls scored or worn out of round	Overheating	Lap off excess metal Replace with new piston

LOST POWER AND OVERHEATING—Cont.

Part at Fault	Trouble	Effect	Remedy
35 Cylinder Wall	Scored Poor lubrication causes friction	Poor compression and overheating	Replace with new Lap in cylinder Repair oiling system
36 Cam Shaft Drive Gear	Loose on shaft Not properly meshed Worn or broken teeth	Irregular valve action	Fasten to shaft Time properly Replace with new
37 Crank Shaft	Scored or rough on journals Sprung	Overheating Overheating	Smooth up Straighten
38 Crank Pin Bearings and Main Bearings	Adjusted too tight Defective oiling	Overheating	Adjust to running clearance Clean out oil holes
39 Oil Sump	Insufficient oiling Poor oil Dirty oil	Overheating and burned-out bearings	Replenish supply Use best oil, Mobile "A" recommended Wash with kerosene Replace with new oil
40 Water Space and Water Pipes	Clogged with sediment or scale	Overheating	Dissolve and remove foreign material
41 Radiator Hose	Layer of hose obstructs opening	Overheating	Refit or replace with new
42 Water Pump	Impeller loose on shaft Dirty Broken	Overheating	Fasten to shaft Clean Replace with new

NOISY OPERATION

43 Spark Plug	Leakage	Hissing	Screw down tighter Replace with new
44 Cylinder Wall	Scored	Knocking	Smooth up or Replace with new

NOISY OPERATION—Cont.

Part at Fault	Trouble	Effect	Remedy
45 Manifold Pipe Joints	Leakage Defective gaskets	Sharp hissing	Tighten bolts Replace with new
46 Combustion Chamber	Carbon deposit	Knocking	Remove carbon
47 Cylinder	Retaining bolts loose	Sharp metallic knock	Tighten bolts
48 Cam	Worn contour	Metallic knock	Replace with new
49 Piston Head	Carbon deposit	Knock	Remove carbon
50 Wrist Pin	Worn Loose in piston	Dull metallic knock	Bush or replace pin
51 Connecting Rod	Worn at wrist pin or crank-shaft Side play in piston	Distinct knock	Adjust or replace Scrape and fit and oil
52 Main Crank Shaft Bearing	Loose Defective lubrication	Metallic knock Squeak	Fit caps close to shaft Clean out oil holes and oil
53 Connecting Rod Bearings	Loose Excessive play Binding	Intermittent metallic knock Knock and squeak	Refit Reline
54 Connecting Rod Bolts Main Bearing Bolts	Loose Stripped threads	Sharp knock	Tighten Replace bolts
55 Lower Half Crank Case Bolts	Loose Stripped threads	Knock and rattle	Tighten New bolts
56 Water Jacket	Covered with scale Clogged with dirt	Knock caused by overheating	Dissolve scale and flush out water space with water under pressure
57 Timing Gears	Loose Worn or broken teeth Meshed too deeply	Metallic knock Rattle Grinding	Fasten to shaft Replace with new gear
58 Cam Shaft Bearing	Loose or worn	Slight knock	Replace with new

NOISY OPERATION—Cont.

Part at Fault	Trouble	Effect	Remedy
59 Inlet Valve Seat	Warped or pitted Dirty	Rattle Poor compression Blow-back	Use reseat reamer Clean off and grind to seat
60 Inlet Valve Spring	Weak or broken	Blow-back in carburetor	Replace with new
61 Inlet Valve	Closes late Opens early	Blow-back in carburetor	Time properly
62 Valve Stem Guide	Worn or loose	Rattle or click	Replace with new guide
63 Cam Follower Guide	Loose	Rattle or click	Replace with new cylinder
64 Valve Stem Clearance	Too much Too little	Click Blow-back in carburetor	Set inlet gap .010″ Set exh. gap .010″
65 Push Rod Retention Stirrups	Nuts loose	Rattle Blow-back in carburetor	Tighten nuts
66 Crank Case Gaskets	Leak	Oil leak	Tighten bolts Replace with new
67 Cylinder or Piston	No oil Poor oil	Grinding and sharp knock	Repair oil system Use best oil
68 Piston	Binding in cylinder Worn oval causing side slap	Grind or dull squeak Dull hammer	Lap off excess metal Replace with new
69 Oil Sump	Insufficient oil Poor oil	Grind and squeak in all bearings	Replenish with best oil
70 Piston Rings	Defective oiling	Squeak, hiss, grind	Replace with new ring Repair oil system
71 Crank Shaft	Defective oiling	Squeak	Clean out oil holes use best oil Repair oil system
72 Engine Base	Loose on frame	Dull pound	Tighten bolts
73 Water Pipe	Leak Clogged Defective gaskets	Engine heats	Tighten connections Clean Replace with new gaskets

INDEX TO MOTOR DRAWINGS

Number on Fig. 15	Number on Fig. 16	Number on Fig. 17	Name of Part	Reference in Trouble Chart
			Crankshaft Section (1–10)	
3			Crankshaft Main Journal	37–71
4	4		Crank Pin	37–71
5			Crankshaft Bearing	52–38
6			Crank Gear	57–12
7			Main Bearing Cap	54
			Propeller Section (11–20)	
11			Propeller	
12			Crankshaft Taper	
13	13		Propeller Hub	
14	14		Propeller Hub Bolts	
15			Thrust Bearing	
			Camshaft Section (21–30)	
21			Camshaft Gear	12–36–57
22			Camshaft	
23	23		Exhaust Cam	11–48
24	24		Inlet Cam	10–58
25			Camshaft Bearing	14
	26		Cam Follower Guide	13–63
	27		Cam Follower	
			Valve Section (31–40)	
31	31	31	Exhaust Rocker Arms	
32	32	32	Intake Rocker Arms	
	33	33	Exhaust Valve Spring	23–6
	34	34	Intake Valve Spring	60–23–6
	35	35	Exhaust Push Rod	65
36	36	36	Intake Push Rod	65
	37	37	Exhaust Valve Cage	
	38	38	Intake Valve Cage	
	39	39	Intake Valve	4
	40	40	Exhaust Valve	
			Ignition (41–50)	
41	41	41	Magneto	
42	42	42	Distributor	
	43		Spark Advance Lever	
	44		Breaker Box	
45			Magneto Gear	
		46	Spark Plug	1–26–43

INDEX TO MOTOR DRAWINGS—Cont.

Number Fig. 15	Fig. 16	Fig. 17	Name of Part	Reference in Trouble Chart
			Carburetion (51–60)	
	51	51	Combustion Chamber	46–2
52	52	52	Carburetor Induction Pipe	19
53		53	Intake Manifold Connection	45–24
54		54	Carburetor	18
55			Carburetor Braces	
			Lubrication (61-75)	
61			Oil Pump	
63	63		Oil Suction Pipe	69–39
64	64		Oil Sump	
65			Crankshaft Oil Tube	
66	66		Oil Pan Partition	
69	69		Oil Filler Pipe	
		70	Breather Pipe	
71			Oil Pressure Pipe	
72			Supporting Web Oil Tube	
73			Oil Pressure Valve	
			Cooling (76–85)	
76	76		Water Pump	42
	77		Outlet Water Pipe	40
			Outlet Water Pipe Connection	25–41
	79	79	Inlet Water Pipe	40
			Inlet Water Pipe Connection	25
81	81	81	Cylinder Water Jacket	40
			Piston (86–90)	
	86	86	Piston Head	68–3–20–33–49
			Cylinder and Connecting Rod (91–95)	
	91	91	Cylinder Wall	67–85–44–22
	92		Wrist Pin	50–32
93	93		Connecting Rod	51
94			Connecting Rod Bearing	53–38
			Miscellaneous (96–100)	
	96	96	Engine Bearers	
	97		Intake Valve Clearance	9–64
	98		Exhaust Valve Clearance	9–64
99	99		Crank Case Lower Half	55
	100		Engine Bed Bolts	

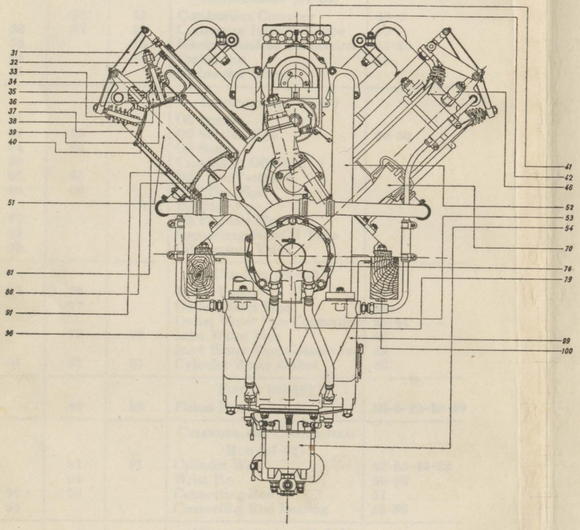


FIG. No. 15
MOTOR ASSEMBLY—GEAR END

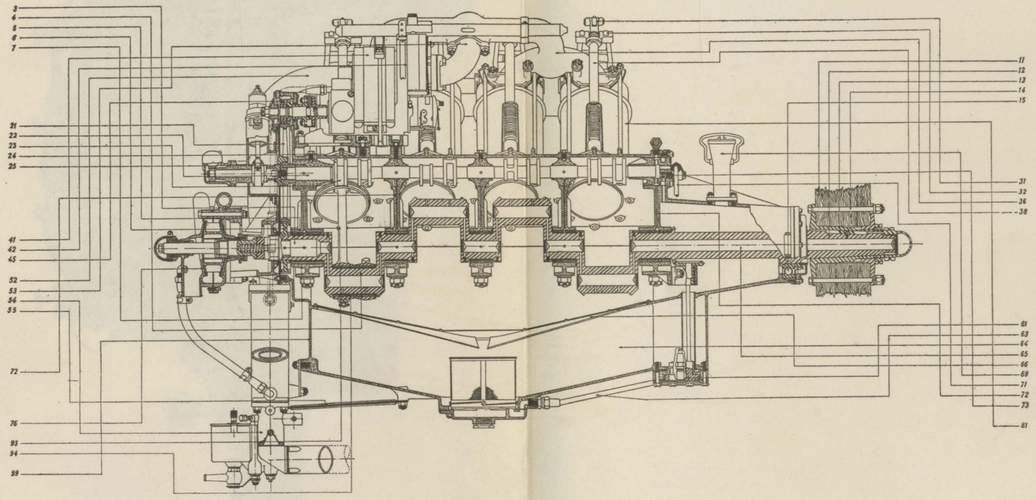


FIG. No. 16
MOTOR ASSEMBLY—SIDE VIEW

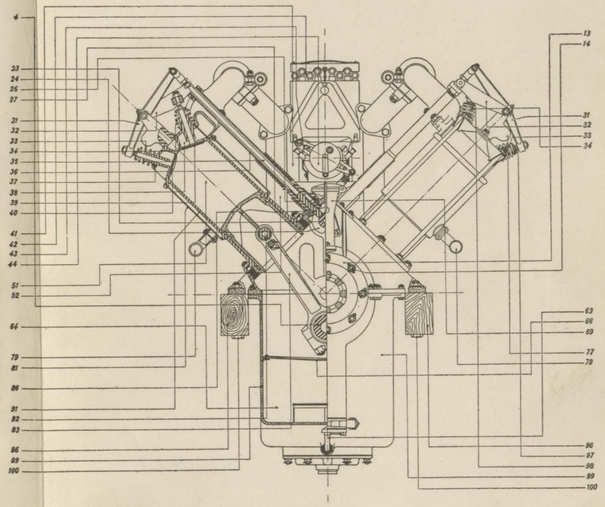


FIG. No. 17
MOTOR ASSEMBLY—PROPELLER END

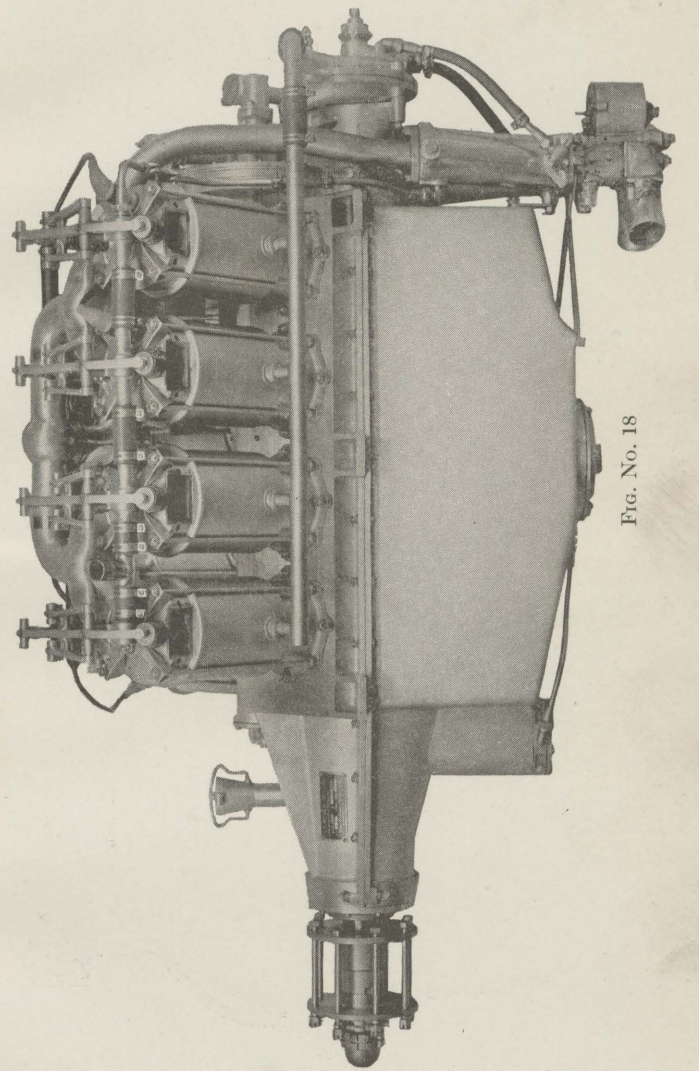


Fig. No. 18

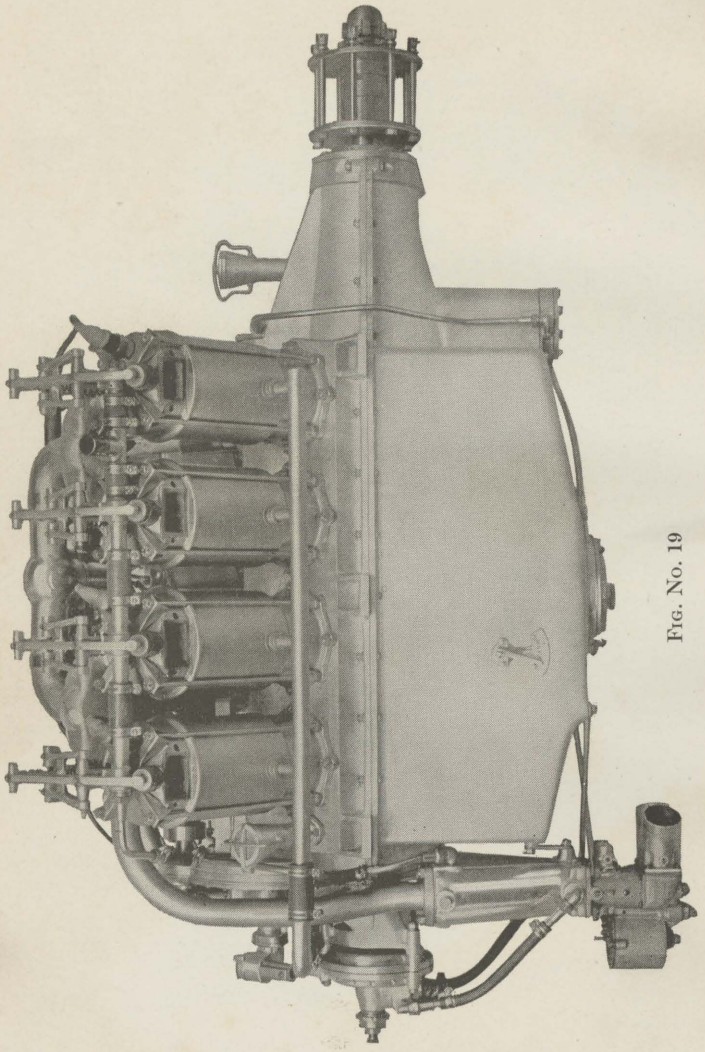


FIG. No. 19

SPECIFIC GRAVITY EQUIVALENTS FOR DEGREES BEAUMÉ FOR LIQUIDS LIGHTER THAN WATER

FORMULA: DEGREES BEAUMÉ $= \frac{140}{\text{SP. GR.}\frac{60°}{60°}\text{F.}} = 130$

SP. GR. TAKEN AT 60°F. AND REFERRED TO DISTILLED WATER AT 60°F

Beaumé	Specific Gravity	Pounds Per Gallon	Beaumé	Specific Gravity	Pounds Per Gallon	Beaumé	Specific Gravity	Pounds Per Gallon
10	1.0000	8.33	37	.8383	6.98	64	.7217	6.01
11	.9929	8.27	38	.8333	6.94	65	.7179	5.98
12	.9859	8.21	39	.8285	6.90	66	.7143	5.95
13	.9790	8.16	40	.8235	6.86	67	.7107	5.92
14	.9722	8.10	41	.8187	6.82	68	.7071	5.89
15	.9655	8.04	42	.8139	6.78	69	.7035	5.86
16	.9589	7.99	43	.8092	6.74	70	.7000	5.83
17	.9524	7.93	44	.8046	6.70	71	.6965	5.80
18	.9459	7.88	45	.8000	6.66	72	.6931	5.78
19	.9396	7.83	46	.7955	6.63	73	.6897	5.75
20	.9333	7.78	47	.7909	6.59	74	.6863	5.72
21	.9272	7.72	48	.7865	6.55	75	.6829	5.69
22	.9211	7.67	49	.7821	6.52	76	.6796	5.66
23	.9150	7.62	50	.7777	6.48	77	.6763	5.63
24	.9091	7.57	51	.7735	6.44	78	.6730	5.60
25	.9032	7.53	52	.7692	6.41	79	.6698	5.58
26	.8974	7.48	53	.7650	6.37	80	.6666	5.55
27	.8917	7.43	54	.7609	6.34	81	.6635	5.52
28	.8861	7.38	55	.7568	6.30	82	.6604	5.50
29	.8805	7.34	56	.7527	6.27	83	.6573	5.48
30	.8750	7.29	57	.7487	6.24	84	.6542	5.45
31	.8696	7.24	58	.7447	6.20	85	.6511	5.42
32	.8642	7.20	59	.7407	6.17	86	.6481	5.40
33	.8589	7.15	60	.7368	6.14	87	.6451	5.38
34	.8537	7.11	61	.7329	6.11	88	.6422	5.36
35	.8485	7.07	62	.7292	6.07	89	.6392	5.33
36	.8433	7.03	63	.7254	6.04	90	.6363	5.30

METRIC CONVERSION TABLES

ENGLISH TO METRIC

English Units	Hundredths of an Inch to M/M	Feet to Meters	Miles to Kilometers	Gallons to Liters	Pounds to Kilometers
1	0.254	0.30480	1.6093	3.7853	0.45359
2	.508	.60960	3.2187	7.5707	.90718
3	.762	.91440	4.8280	11.3560	1.36078
4	1.016	1.21920	6.4374	15.1413	1.81437
5	1.270	1.52400	8.0467	18.9267	2.26796
6	1.524	1.82880	9.6561	22.7120	2.72155
7	1.778	2.13360	11.2654	26.4973	3.17515
8	2.032	2.43840	12.8748	30.2827	3.62874
9	2.286	2.74321	14.4841	34.0680	4.08233
10	2.540	3.04801	16.0935	37.8533	4.53592
11	2.794	3.35281	17.7028	41.6387	4.98552
12	3.048	3.65761	19.3122	45.4240	5.44311
13	3.302	3.96241	20.9215	49.2093	5.89670
14	3.556	4.26721	22.5309	52.9947	6.35029
15	3.810	4.57201	24.1402	56.7800	6.80389
16	4.064	4.87681	25.7496	60.5653	7.25748
17	4.318	5.18161	27.3589	64.3506	7.71107
18	4.572	5.48641	28.9682	68.1360	8.16466
19	4.826	5.79121	30.5776	71.9213	8.61826
20	5.080	6.09601	32.1869	75.7066	9.07185
21	5.334	6.40081	33.7963	79.4920	9.52544
22	5.588	6.70561	35.4056	83.2773	9.97903
23	5.842	7.01041	37.0150	87.0626	10.43263
24	6.096	7.31521	38.6243	90.8480	10.88622
25	6.350	7.62002	40.2337	94.6333	11.33981
26	6.604	7.92482	41.8430	98.4186	11.79340
27	6.858	8.22962	43.4524	102.2040	12.24700
28	7.112	8.53442	45.0617	105.9893	12.70059
29	7.366	8.83922	46.6711	109.7746	13.15418
30	7.620	9.14402	48.2804	113.5600	13.60777
31	7.874	9.44882	49.8898	117.3453	14.06137
32	8.128	9.75362	51.4991	121.1306	14.51496
33	8.382	10.05842	53.1085	124.9160	14.96855
34	8.636	10.36322	54.7178	128.7013	15.42214
35	8.890	10.66802	56.3272	132.4866	15.87573
36	9.144	10.97282	57.9365	136.2720	16.32933
37	9.398	11.27762	59.5458	140.0573	16.78292
38	9.652	11.58242	61.1552	143.8426	17.23651
39	9.906	11.88722	62.7645	147.6280	17.69010
40	10.160	12.19202	64.3739	151.4133	18.14370
41	10.414	12.49682	65.9832	155.1986	18.59729
42	10.668	12.80163	67.5926	158.9840	19.05088
43	10.922	13.10643	69.2019	162.7693	19.50447
44	11.176	13.41123	70.8113	166.5546	19.95807
45	11.430	13.71603	72.4206	170.3400	20.41166
46	11.684	14.02083	74.0300	174.1253	20.86525
47	11.938	14.32563	75.6393	177.9106	21.31880
48	12.192	14.63043	77.2487	181.6960	21.77244
49	12.446	14.93523	78.8580	185.4813	22.22603
50	12.700	15.24003	80.4674	189.2666	22.67962
100	25.400	30.48006	160.9347	378.5330	45.35924

METRIC CONVERSION TABLE

METRIC TO ENGLISH

Metric Units	M/M to Inches	Meters to Feet	Kilometers to Miles	Liters to Gallons	Kilograms to Pounds
1	0.03937	3.28083	0.62137	0.26418	2.2046
2	.07874	6.56167	1.24274	.52836	4.4092
3	.11811	9.84250	1.86411	.79253	6.6139
4	.15748	13.12333	2.48548	1.05671	8.8185
5	.19685	16.40417	3.10685	1.32089	11.0231
6	.23622	19.68500	3.72822	1.58507	13.2277
7	.27559	22.96583	4.34959	1.84924	15.4324
8	.31496	26.24667	4.97096	2.11342	17.6370
9	.35433	29.52750	5.59233	2.37760	19.8416
10	.39370	32.80833	6.21370	2.64178	22.0462
11	.43307	36.08917	6.83507	2.90595	24.2508
12	.47244	39.37000	7.45644	3.17013	26.4555
13	.51181	42.65083	8.07781	3.43431	28.6601
14	.55118	45.93167	8.69918	3.69849	30.8647
15	.59055	49.21250	9.32055	3.96266	33.0693
16	.62992	52.49333	9.94192	4.22684	35.2740
17	.66929	55.77417	10.56329	4.49102	37.4786
18	.70866	59.05500	11.18466	4.75520	39.6832
19	.74803	62.33583	11.80603	5.01937	41.8878
20	.78740	65.61667	12.42740	5.28355	44.0924
21	.82677	68.89750	13.04877	5.54773	46.2971
22	.86614	72.17833	13.67014	5.81191	48.5017
23	.90551	75.45917	14.29151	6.07608	50.7063
24	.94488	78.74000	14.91288	6.34026	52.9109
25	.98425	82.02083	15.53425	6.60444	55.1156
26	1.02362	85.30167	16.15562	6.86862	57.3202
27	1.06299	88.58250	16.77699	7.13280	59.5248
28	1.10236	91.86333	17.39836	7.39697	61.7294
29	1.14173	95.14417	18.01973	7.66115	63.9340
30	1.18110	98.42500	18.64110	7.92533	66.1387
31	1.22047	101.70583	19.26249	8.18951	68.3433
32	1.25984	104.98667	19.88384	8.45368	70.5479
33	1.29921	108.26750	20.50521	8.71786	72.7525
34	1.33858	111.54833	21.12658	8.98204	74.9572
35	1.37795	114.82917	21.74795	9.24622	77.1618
36	1.41732	118.11000	22.36932	9.51039	79.3664
37	1.45669	121.39083	22.99069	9.77457	81.5710
38	1.49606	124.67167	23.61206	10.03875	83.7756
39	1.53543	127.95250	24.23343	10.30293	85.9803
40	1.57480	131.23330	24.85480	10.56710	88.1849
41	1.61417	134.51417	25.47617	10.83128	90.3895
42	1.65354	137.79500	26.09754	11.09546	92.5941
43	1.69291	141.07583	26.71891	11.35964	94.7988
44	1.73228	144.35667	27.34028	11.62381	97.0034
45	1.77165	147.63750	27.96165	11.88799	99.2080
46	1.81102	150.91833	28.58302	12.15217	101.4126
47	1.85039	154.19917	29.20439	12.41635	103.6173
48	1.88976	157.48000	29.82576	12.68052	105.8219
49	1.92913	160.76083	30.44713	12.94470	108.0265
50	1.96850	164.04167	31.06850	13.20888	110.2311
100	3.93700	328.08334	62.13700	26.41776	220.4622

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