

## SECTION VIII REPAIR

### 1. MAJOR REPAIRS

a. It is not recommended that the operator perform any repairs more complex than those covered under the maintenance section of this instruction book. If repairs of a major nature should become necessary, the engine should be serviced by an authorized Universal dealer or shipped direct to the Universal factory. However, should the operator prefer to make his own repairs, Tables 7 through 9 list proper clearances and torque wrench settings for all models covered by these instructions as an aid in making these repairs.

b. Only genuine Universal parts, specially designed for marine engines, should be used. Repair parts for all models of Universal engines up to 21 years old are available for immediate shipment from Universal dealers or directly from the Universal factory. When ordering parts it is essential that the following information be included with the order.

(1) Model and serial number of the engine.

(2) Part number or full description and sketch of part.

(3) Method of shipment desired: parcel post, express, truck, or rail freight. If freight shipment is desired, give name of truck line or railroad and specify closest freight station.

### 2. CONCLUSION

a. Our interest in you does not diminish after you have purchased our product. Our claims will always be made good. We agree to give you satisfactory service within the limits of our specifications and are ready at all times to assist you in obtaining satisfaction. Do not hesitate to come to us if you feel that we can be of any assistance. Your inquiries will be promptly answered and you will be advised with care in a manner easily understood. We want every UNIVERSAL owner to be a living, talking advertisement and a friend.

b. We feel that you are willing to do your part and that you will use care and judgment in the running of your engine. Do not expect the impossible, and remember that by using good quality lubricants, by careful attention to detect the first sign of trouble, and by prompt correction of troubles as they occur, the length of life and usefulness of your engine will be greatly increased.

Table 7  
VALVE AND PISTON DATA

MODEL NAME	PISTON CLEARANCE	PISTON RING GAP	VALVE SEAT ANGLE INTAKE AND EXHAUST	VALVE TAPPET CLEARANCE		VALVE STEM CLEARANCE IN GUIDE	
				INT.	EXH.	INTAKE	EXHAUST
Blue Jacket Twin	.0015"	.009 - .014"	45°	.008"	.010"	.0015 - .002"	.0015 - .002"
Atomic Four	.0015"	.007 - .015"	45°	.008"	.010"	.001 - .0015"	.0015 - .0025"
Utility Four	.002"	.008 - .013"	45°	.006"	.008"	.0015 - .002"	.0015 - .002"
Super-Four	.0015"	.010 - .015"	45°	.010"	.012"	.0015 - .002"	.0015 - .002"
Unimite Four	.003"	.015 - .020"	30°	.010"	.010"	.001 - .0015"	.0025 - .003"
Arrow	.0025 - .003"	.015 - .020"	30°	.010"	.014"	.0025 - .003"	.0025 - .003"
Bluefin	.0025 - .003"	.015 - .020"	30°	.010"	.014"	.0025 - .003"	.0025 - .003"
Marlin	.004 - .0045"	.015 - .020"	30°	.012"	.016"	.0025 - .003"	.0025 - .003"
Tarpon	.004 - .0045"	.015 - .020"	30°	.012"	.016"	.0025 - .003"	.0025 - .003"
Knight	.005 - .0055"	.015 - .020"	30°	.012"	.018"	.0025 - .003"	.0025 - .003"
Little King	.0006 - .001"	.010 - .020"	46°	.010" Hot	.020"	.001 - .0027"	.0017 - .0034"
Big King	.0011 - .0029"	.015 - .025"	30° Int. 45° Exh.	.020"	.022"	.001 - .0024"	.001 - .0024"

Table 8  
TORQUE WRENCH TENSION  
In Foot/Pounds

MODEL NAME	CYLINDER HEAD BOLTS OR NUTS	CONNECTING ROD NUTS	MAIN BEARINGS FRONT & INTER.	MAIN BEARINGS CENTER & REAR	MANIFOLD STUDS	SPARK PLUGS
Blue Jacket Twin	40	40	60	60	35	35
Atomic Four	35	33	60	60	35	30
Utility Four	40	25	60	60	40	35
Super-Four	55	50	100	100	45	35
Unimite Four	40	42	77	77	35	30
Arrow	60	39	70	60		30
Bluefin	60	39	70	60		30
Marlin	65	56	70	60		30
Tarpon	65	56	70	60		30
Knight	65	56	70	60		30
Little King	65	33	65	65	30	23
Big King	95-105	45-50	95-105	95-105	23-28	15-20

Table 9  
BEARING DATA

MODEL NAME	CONNECTING ROD CLEARANCE (Diameter)	CONNECTING ROD END PLAY	CRANKSHAFT MAIN BEARING CLEARANCE (Diameter)	CRANKSHAFT THRUST CLEARANCE AT THRUST BEARING	CAMSHAFT BEARING CLEARANCE (Diameter)
Blue Jacket Twin	.0015 - .0025	.002 - .003	.0015 - .0025	.002 - .003	.0025 - .003
Atomic Four	.001 - .0025	.004 - .008	.001 - .0025	.002 - .003	.002 - .0025
Utility Four	.0015 - .0025	.002 - .003	.0015 - .002	.002 - .003	.0025 - .003
Super-Four	.002 - .003	.002 - .003	.002 - .003	.003 - .004	.0025 - .003
Unimite Four	.001 - .0015	.005 - .010	.002 - .0025	.002 - .004	.0015 - .0025
Arrow	.0015 - .002	.005 - .010	.0015 - .003	.002 - .004	.0015 - .0025
Bluefin	.0015 - .002	.005 - .010	.0015 - .003	.002 - .004	.0015 - .0025
Marlin	.002 - .0025	.005 - .010	.0015 - .003	.002 - .004	.0015 - .0025
Tarpon	.002 - .0025	.005 - .010	.0015 - .003	.002 - .004	.0015 - .0025
Knight	.0025 - .003	.005 - .010	.0015 - .003	.002 - .004	.0015 - .0025
Little King	.001 - .004	(2).008 - .014	.001 - .004	.002 - .006	.0015 - .0035
Big King	.0006 - .0026	.005 - .015	.0009 - .0029	.004 - .008	.001 - .003

Table 11  
VALVE TIMING

MODEL NAME	INLET VALVE OPENS	INLET VALVE CLOSES	EXHAUST VALVE OPENS	EXHAUST VALVE CLOSES
Blue Jacket Twin	5° after TDC	45° after LDC	40° before LDC	TDC
Atomic Four	5° before TDC	50° after LDC	45° before LDC	10° after TDC
Utility Four	5° after TDC	45° after LDC	40° before LDC	TDC
Super-Four	5° after TDC	55° after LDC	50° before LDC	TDC
Unimite Four	5° before TDC	55° after LDC	45° before LDC	15° after TDC
Arrow	5° before TDC	55° after LDC	45° before LDC	15° after TDC
Bluefin	5° before TDC	55° after LDC	45° before LDC	15° after TDC
Marlin	5° before TDC	55° after LDC	45° before LDC	15° after TDC
Tarpon	5° before TDC	55° after LDC	45° before LDC	15° after TDC
Knight	5° before TDC	55° after LDC	45° before LDC	15° after TDC

TDC means TOP DEAD CENTER  
LDC means LOWER DEAD CENTER  
See Table 7 for Valve Tappet Clearance

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# OPERATION AND MAINTENANCE MANUAL FOR IX SERIES ENGINES

SERIAL NUMBERS { 400001 - 420000  
1250001 - 1300000  
2400001 - 2500000

## FIVE GEAR MODELS

MODEL	BORE	STROKE		NACC-H.P.	PISTON DISPL.
IX	2 $\frac{1}{2}$ "	x	4"	10	79
IXA	3"	x	4"	14.4	113
IXB <u>COUNT ENGINE</u>	3 $\frac{1}{4}$ "	x	4"	16.94	133

## THREE GEAR MODELS

IX-3	2 $\frac{1}{2}$ "	x	4"	10	79
IXF-3	2 $\frac{3}{4}$ "	x	4"	12.1	95
IXA-3	3"	x	4"	14.4	113
IXK-3	3 $\frac{1}{8}$ "	x	4"	15.89	123
IXB-3	3 $\frac{1}{4}$ "	x	4"	16.94	133

CB preceding model (CB-IXB) denotes counter-balanced crankshaft.

M or MM following model (IXAM or IXBMM) denotes Marine Engine.

C following model (IXAC-IXBC-IXBCM) denotes counter-clockwise engine.

## HERCULES MOTORS CORPORATION

CANTON, OHIO, U. S. A.

Cable Address HERCANO

## HERCULES MOTORS CORPORATION

CANTON, OHIO

Hercules Motors Corporation is a Member of the Internal Combustion Engine Institute and is pleased to warrant all Hercules products sold by it in accordance with the following Basic Warranty adopted by the Institute May 8, 1947, which is subject to further amendment without notice. This warranty is in lieu of any warranty expressed or implied by law and supersedes any different warranty in customer's purchase orders.

### BASIC WARRANTY

The Manufacturer warrants each new engine sold by the Manufacturer to be free from defects in material and workmanship for six (6) months from date of shipment, but not to exceed ninety (90) days of service, or such other period of time as may be agreed upon in respect to the application in which the engine is used. The obligation under this Warranty, statutory or otherwise, is limited to the replacement or repair at the Manufacturer's factory or at a point designated by the Manufacturer, of such part as shall appear to the Manufacturer, upon inspection at such point, to have been defective in material or workmanship.

This Warranty does not obligate the Manufacturer to bear the cost of labor or transportation charges in connection with the replacement or repair of defective parts, nor shall it apply to an engine upon which repairs or alterations have been made unless authorized by the Manufacturer.

The Manufacturer makes no Warranty in respect to trade accessories, such being subject to the Warranties of their respective Manufacturers.

The Manufacturer shall in no event be liable for consequential damages or contingent liabilities arising out of the failure of any engine or parts to operate properly.

No express, implied or statutory Warranty other than herein set forth is made or authorized by the Manufacturer.

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**New service parts are sold subject to the same warranty as new engines.**

# Introduction

The Hercules IX series engine is a four cylinder in line "L" head engine, four cycle, heavy duty, commercial type engine. The design is the result of years of development and field experience. Extensive tests have proven that these engines are adaptable to all purposes for which such sizes and types are required.

An effort has been made in this book to give sufficient information so that operators and maintenance crews can obtain the maximum efficiency and trouble free operation which may be expected of this engine.

All locations given as right hand (R.H.) or left hand (L.H.) have reference to observer's position when facing flywheel or clutch. The right hand side is the camshaft or manifold side, while the left hand side is the water pump or accessory side. The front of engine is the timing gear end. The flywheel and clutch end is the rear end of the engine. When the IX engine is used as a marine engine the power take off or reverse gear is usually attached to the timing gear or front end. Therefore, when reference is made to number one cylinder or front main bearing it is always the one nearest the timing gears. Cylinders, connecting rods, et cetera are numbered from the front or timing gear end of the engine. All dimensions are given in inches and fractions of inches except as otherwise noted. All weights and measures are in United States avoirdupois or liquid measure standards.

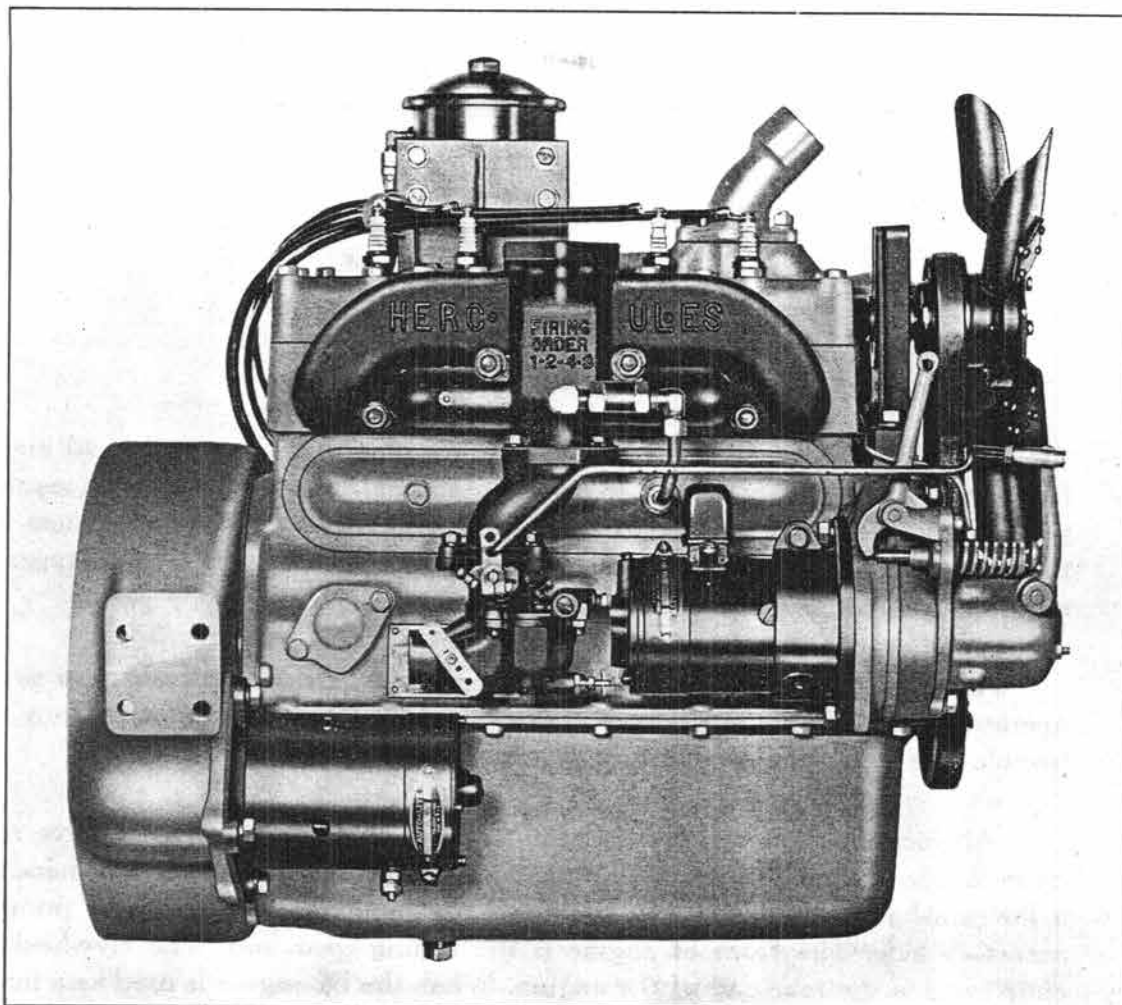
The book is divided into the following sections which appear in order named—Specifications, Operation, Lubrication, Trouble Shooting, Description and Maintenance, Clearances and Tools.

Where necessary to refer to accessories which are not furnished by Hercules Motors Corporation, information and comments given are general and may not apply to the specific accessory used.

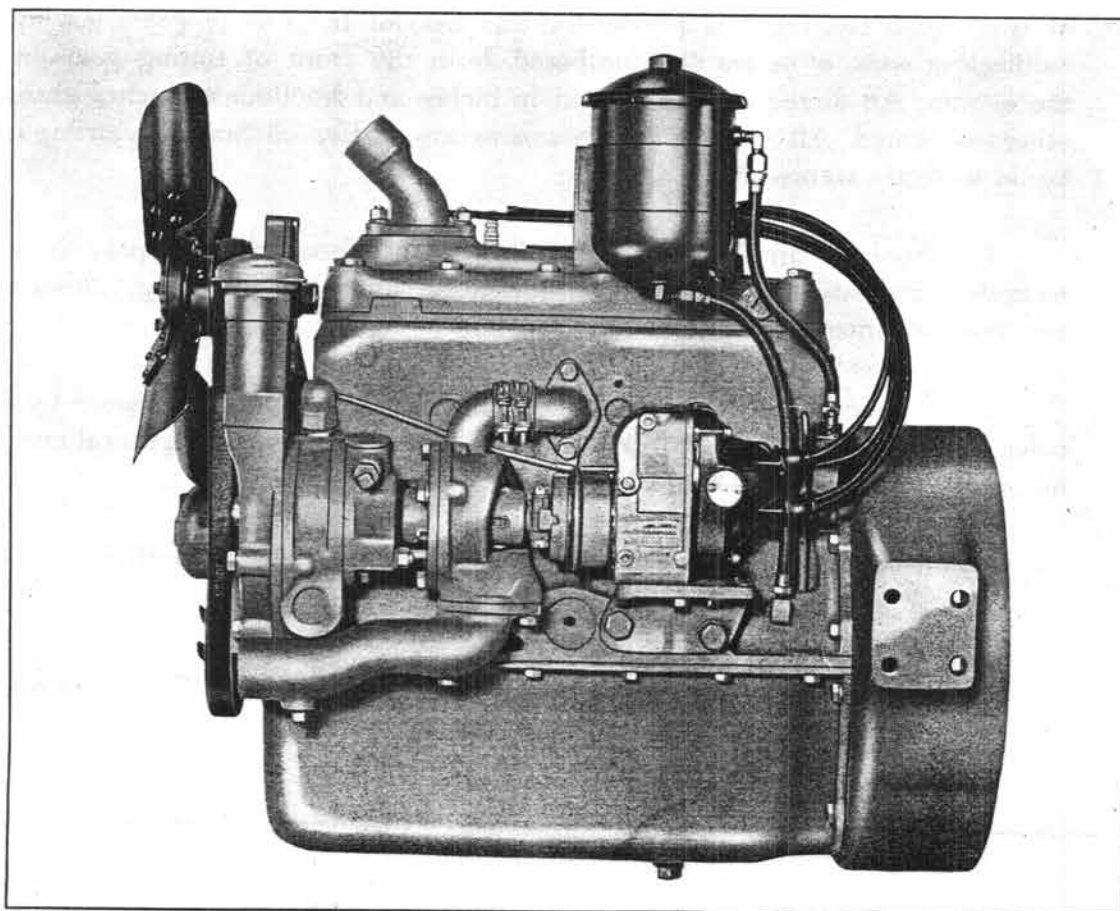
As an operator you owe it to yourself to read this book carefully.

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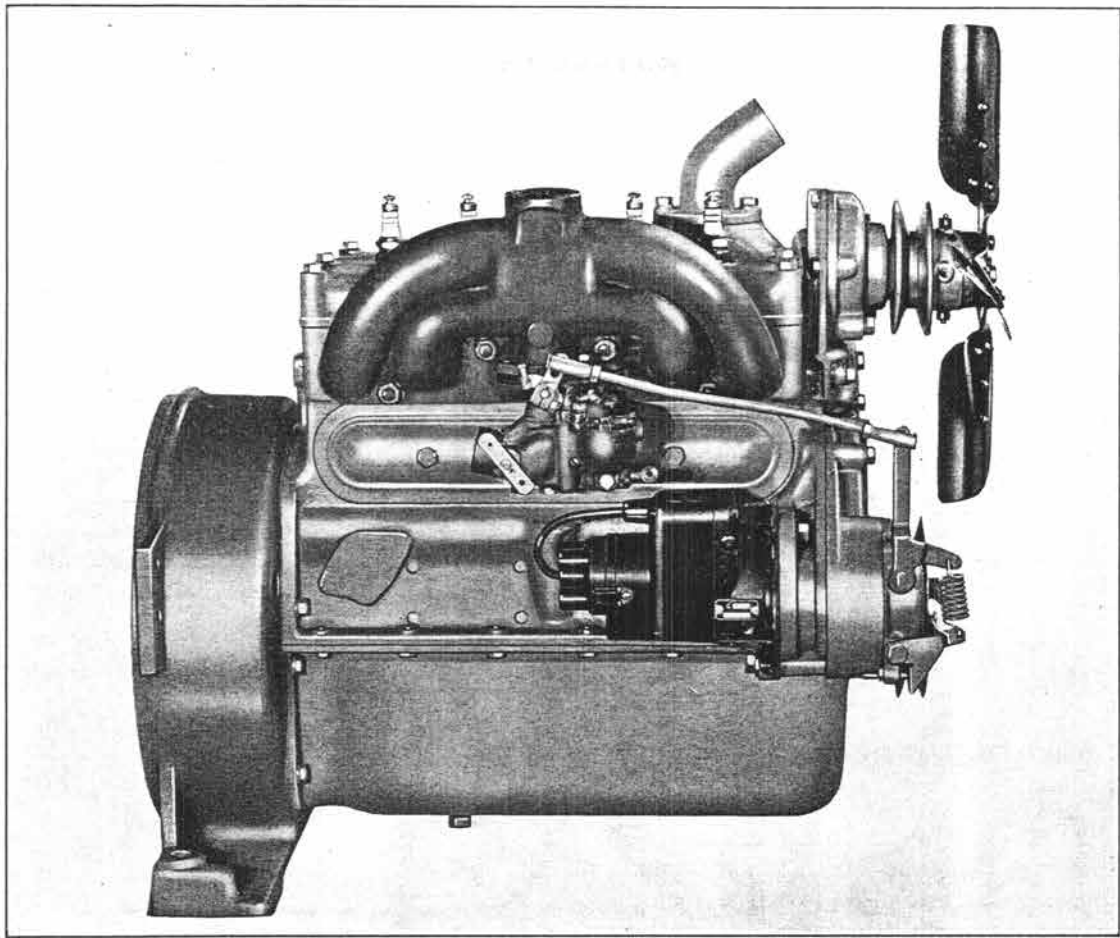




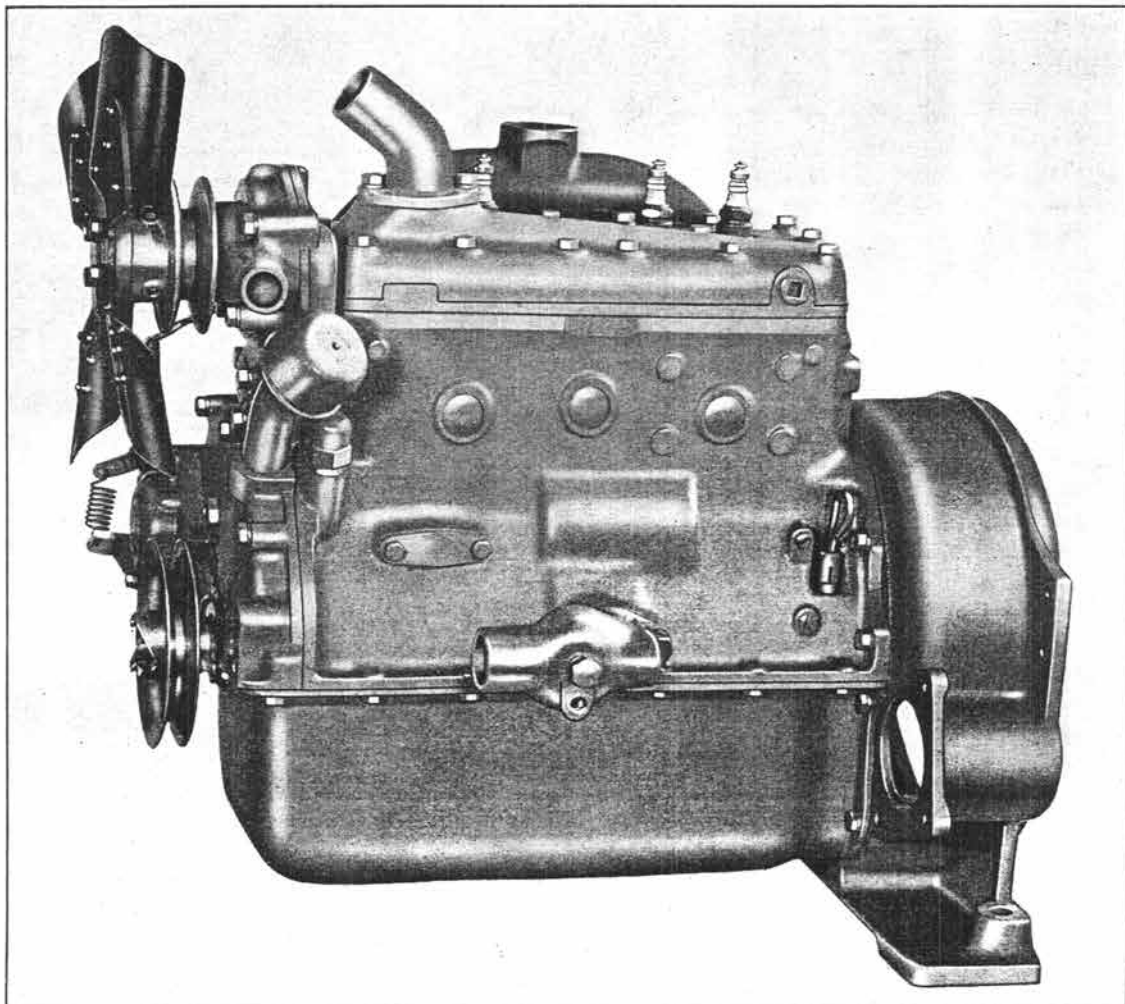
IX - 5 Right Hand Side



IX - 5 Left Hand Side



IX - 3 Right Hand Side



IX - 3 Left Hand Side

# SPECIFICATIONS

## IX SERIES ENGINE

### GENERAL DATA

Bore and Stroke .....	See Page 1
No. of Cylinders .....	4
N. A. C. C. Rated Horsepower .....	See Page 1
Piston Displacement .....	See Page 1
Rotation—Clockwise Standard, Looking at Cranking End.	
Firing Order 1-2-4-3	
Counter-Clockwise Rotation—Optional—Looking at Cranking End.	
Firing Order 1-3-4-2	

### MAIN BEARINGS (PRECISION TYPE)

Material—thin babbitt, steel or brass back shell.	
No. of Bearings .....	3
Bearing Diameter .....	2"
Bearing Length (Front) .....	1 $\frac{9}{16}$ "
Bearing Length (Center) .....	1 $\frac{5}{8}$ "
Bearing Length (Rear) .....	1 $\frac{5}{8}$ "

### CAMSHAFT

Material—Machined steel forging, case hardened.	
Drive .....	Helical Gear
No. of Bearings .....	4
Diameter of All Bearings .....	1 $\frac{7}{16}$ "
Length (Front) .....	1 $\frac{3}{16}$ "
Length (2 and 3) .....	$\frac{9}{16}$ "
Length (Rear) .....	1"
Location—Right Hand Side Looking at Flywheel.	

### CONNECTING ROD

Material—Heat treated nickel chrome molybdenum steel.	
Connecting Rod Bearing Diameter .....	1 $\frac{3}{4}$ "
Connecting Rod Bearing Length .....	1 $\frac{1}{8}$ "
Connecting Rod Length, c to c .....	6 $\frac{9}{16}$ "

### MISCELLANEOUS

Cylinder and Crankcase—Cast Integral.
Cylinder Head—"L" type, detachable.
Crankshaft—Surface hardened by electric induction process.
Piston—Aluminum alloy or cast iron.
Piston Pin— $\frac{3}{4}$ " Dia. steel.

Specifications of other items will be found under "Description and Maintenance" section, starting on Page 26.

## GENERAL DESCRIPTION AND FEATURES OF DESIGN

### CYLINDER BLOCK AND CRANKCASE

The cylinder block and crankcase are cast in one piece in order to permit more efficient cooling by water jacketing the cylinders the full length of the bore. This construction also results in a very rigid unit, which provides a sturdy support for the crankshaft.

To help distinguish the "IX-3" cylinder block from the "IX-5" cylinder block refer to Illustration No. 1. Fig. 1 shows the front of the "IX-3" block without the idler gear shaft provision while Fig. 2 shows the "IX-5" cylinder block and crankcase with provision for driving the water pump on the left hand side of engine, necessitating an idler gear to drive the water pump drive gear. Otherwise the two "IX" cylinder blocks are similar.

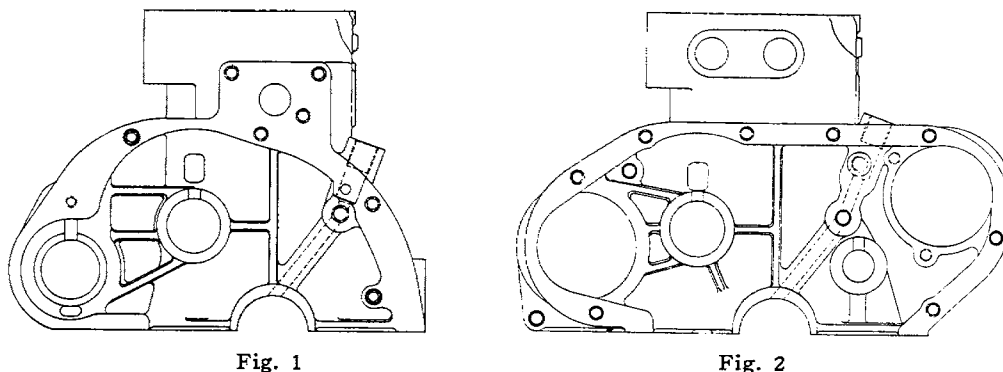


Illustration No. 1

### MAIN BEARINGS

The main bearing caps are each held in position by two alloy steel cap screws  $\frac{9}{16}$ " in diameter.

Precision or insert type bearings are now used and in this construction there is a removable shell in each cap as well as for the upper part. In this type of construction the upper shell is interchangeable with the lower shell for each bearing. These shells are completely finished before being put in place and no line reaming or scraping is required. This allows renewal of bearings to be easily accomplished. The shells each have a small ear or projection which fits into a recess which allows the ear to rest against the adjoining case or cap to prevent the shell from rocking or rotating. These shells are approximately  $\frac{1}{16}$ " thick and are not interchangeable with the upper shells used with the babbitted type caps. The bearing metals commonly used in the Precision shell type bearings are harder and have a higher melting point than ordinary babbitt metal and this requires the use of a hardened crankshaft.

### CYLINDER HEAD

The cylinder head is of the removable type, having the major part of the combustion space over the valves and is completely water jacketed. This construction permits easy removal of the cylinder head for cleaning carbon and grinding valves.

### CONNECTING RODS AND PISTONS

Like the main bearings the connecting rods have the Precision or insert type of bearing construction. In this type the cap and rod are split slightly below center so the split in the shells opposite the locking lugs does not match with the split in the forging. In some engines of this type the adjusting shims are placed on one side only, no shims being used on the side having provision for locking the shells, other engines do not have shims on either side.

The piston pin is clamped in the top end of the rod. The piston pin lock screw is prevented from working loose in early engines by a lock wire and in later engine by a "shakeproof" lock washer.

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When cast iron pistons are used they have bronze bushings for the piston pin. The aluminum pistons do not have bushings in the pin bosses as the alloy metal of the piston forms a suitable bearing for the pin. Each piston has two compression and one oil control ring.

### CAMSHAFT AND IDLER SHAFT

The camshaft is supported on four bearings in the crankcase. These bearings are of the removable babbitt lined type. At the center of the shaft is located the spiral gear which meshes with the gear attached to the oil pump shaft and drives the oil pump. There is a thrust washer placed between the cam gear and the crankcase. In the "IX-3" series there is no idler gear but in the "IX-5" the idler gear is supported by a shaft which is pressed into the gear. This shaft is supported by and turns in a babbitt lined bushing pressed into the crankcase. The idler gear is also supplied with a thrust washer between it and the case.

### VALVES

The intake valve head is larger in diameter than the exhaust valve head in order to increase the efficiency and insure more power. Both intake and exhaust valves are forged from special alloy steel and the exhaust valves in particular are of high heat resisting material. Valve tappets are of the mushroom type and each is provided with suitable screw and lock nut to allow adjustment of valve stem clearance. The valve guides as well as valve tappet guides are removable bushings pressed into the cylinder block.

NOTE: Two types of valve guides have been used on IX-5 engines, therefore, it is necessary to know the outside diameter of the valve guide before ordering. Valve guide 28214-A has a .485" O. D. while 27011-A has a .532" O. D. Engines with the latest type pressure regulator which is built into the cylinder block and not a separate assembly attached to the block have the small diameter (.485) valve guide 28214-A.

### ACCESSORY DRIVE

On the "IX-5" engines the accessory drive or water pump is located on the side opposite that on which the camshaft and valves are located and consists of a sleeve casting bolted to the front part of the crankcase. On the "IX-3" the water pump is mounted on the front of the cylinder block and has the fan mounted on the pump shaft. The distributor is mounted on the gear cover and is driven by a gear pressed into the front end of the camshaft.

### OILING SYSTEM

The oil pump is of the gear type and is fastened to the block so that the suction end is in the oil pan and needs no priming. The oil under pressure is delivered through suitable connections to a drilled passage in the crankcase and this drilled passage extends from front to rear of the engine on the side opposite the camshaft. This passage is closed at either end by means of suitable threaded plugs. Radial holes are drilled from the crankshaft bearing to meet this horizontal oil passage and this permits oil to be delivered under pressure to the main bearings and through drilled holes in the crankshaft to the connecting rod bearings. The cylinder bores, tappets and valve stems are lubricated by the mist of oil thrown off around the connecting rod bearings.

In the "IX-5" the idler shaft and gear are oiled by pressure to the bushing and through drilled holes lected in pockets. are supplied with oil by gravity feed from oil col- in the shaft and gear. All of the camshaft bearings

### OIL PRESSURE

See page 61 for oil pressure adjustment.

<p style="text-align: center;"><b>GOOD TOOLS</b> help Competent Mechanics do a better job.</p>
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# OPERATION

This section covers those items which are of particular interest to the operator and does not cover such work as might be required of a maintenance crew. This does not mean that an operator should not acquaint himself with the various subjects covered in other sections of this book.

## PRECAUTIONS

### READ BEFORE STARTING ENGINE

The following precautions, if followed, will help eliminate operating difficulties and abnormal wear.

1. **Filters**—keep them clean—they are the guardians of your engine—dirty filters cause rapid wear and low engine output. Read sections on Pages 27 and 60.
2. **Fuel**—keep it clean—do not use dirty container to handle it—insist on the fuel being clean and acid free when you get it. Procure it from reputable companies.
3. **Lubricating Oil**—keep it clean—drain crankcase often. Use best brands obtainable, having specifications as set forth on Pages 13 and 14.
4. Do not allow **Oil Level** to fall much below the 4/4 mark on the bayonet gauge. As the lubricating oil is the medium for removing the friction heat in the bearings, the larger the volume of oil the more heat it can absorb and dissipate. Do not fill above 4/4 or full mark.
5. **Do Not Run Engine** at any time without lubricating oil and cooling solution (water or anti-freeze mixture).
6. Do not use oil, fuel oil or kerosene in the cooling solution or as a cooling medium as these will be detrimental to the synthetic rubber water pump seal.
7. **Never Run Engine** with water or anti-freeze solution **boiling**. This allows lubrication to break down and may seriously damage engine.
8. Do not put cold water in an **Overheated Engine**. It may crack cylinder head, block, etc. An overheated engine shows negligence in operation.
9. Do not allow **Air Cleaners** to become clogged or to operate without all connections being tight. Keep them clean and properly serviced. These units protect your engine from undue wear only when they are given intelligent care.
10. Never allow your **Batteries** to run low or dry of water. The plates will warp and ruin the battery.
11. **Do Not Attempt Starting Engine** until lubricating oil, water and fuel supply has been checked and the engine properly prepared for starting. See section starting on Page 10.
12. **Do Not Run Engine** at high speed without load, as this will cause undue wear and shorten the engine's life.
13. **Do Not Idle Engine** for long periods as it is not only detrimental to the engine but also increases operating costs as you are using fuel without any benefit.
14. **Do Not Use Engine As A Brake** in intermediate or low gear. The high engine speeds possible when using low or intermediate gear descending steep grades will turn the engine much faster than the speed for which it is designed and damage will result unless vehicle speed is held to that used in same gears on the level.
15. **Never Allow engine to Run Without Oil Pressure** showing on the gauge. Damage from lack of lubrication will result.
16. Do not allow fuel in tank to run low as it may allow line to fuel pump to uncover long enough to fill the lines with air and cause the engine to stop, resulting in lost time taken for repriming.
17. Loss of power, erratic running and poor performance often results from **Air In The Fuel System or Vapor Lock**. Be sure there are no leaks in the fuel lines and filters which will allow this condition to exist.
18. Remember dirt, grit, water, lint or any foreign matter in the fuel and lubricating oil is detrimental to the engine and it is your duty as an operator to see that it does not get into the engine.

19. Do not attempt to start engine in cold weather until you have read section covering "Cold Weather Starting," Page 11.
20. Some external heat will help starting in cold weather and saves the batteries.
21. Never run starting motor longer than 30 seconds at one time without a rest period of at least one minute before allowing it to run again. Failure to follow this procedure may result in a burnt out starting motor.
22. Do not attempt to start or operate this engine without first reading the instructions in this book carefully. As an operator you owe it to yourself.

### STARTING AND OPERATING SUGGESTIONS

1. Use a good brand of fuel.
2. Use only the best lubricating oil obtainable to specifications on Page 13.
3. An S.A.E. 30 oil is a good grade to start with (unless extreme cold weather is prevalent), from this the proper grade can be determined. See Page 13 for complete information relative to grade to use for climatic conditions encountered.
4. Fill cooling system with clean water (if in locality where water has a large percentage of dissolved minerals or is alkaline—use rain water). Allow sufficient time for water to seek lowest level, then complete filling. Run engine and recheck level.
5. Be sure the batteries are hooked up properly before pressing the starter button.
6. If possible, turn engine over three or four times by hand to be sure there is nothing sticking or water has not seeped into cylinder, as the starting motor has sufficient power to bend or break certain parts should anything be out of place.
7. Be sure all fuel line connections are tight and the fuel system properly primed.
8. Always follow starting instructions outlined below to eliminate difficulties.

### STARTING THE ENGINE

**First Time Engine Started** or starting engine after a long period of shut down.

1. Fill the fuel tank with suitable fuel.
2. Fill cooling system with clean pure water or if atmosphere is below freezing and engine is to stand or operate in these temperatures, use anti-freeze solution.
3. Fill crankcase with suitable lubricating oil to the 4/4 or full mark on the oil gauge rod. See lubricating oil specifications, Page 13 and Illustration No. 7.
4. If possible, turn engine over by means of hand crank three or four times to start oil circulation and distribute the oil already on the surfaces. This hand cranking also prevents possibilities of damage due to water having accumulated in the cylinders.
5. In addition to the procedure just described, check the lubrication of generator, starter, fan, water pump and any other accessories. Check air cleaners to make sure there are no obstructions, that they are properly installed, and are clean, and that they are properly filled with oil (if oil bath cleaners are used).
6. Check entire electrical system to be sure there are no loose connections and all component parts are properly connected together.
7. See that no loose bars, tools, parts, etc., are lying in or on any part of the engine as they could cause serious damage or wreckage of engine or bodily injury to anyone near.
8. Turn ignition switch to "On". Start engine by operating the starting motor switch. If all of the foregoing instructions have been properly followed and the proper grade and type of fuel has been used, the engine will start at once.
9. Allow engine to run for several minutes before load is applied to enable engine to properly warm up and insure proper lubrication. See Page 12 for instructions when engine is started.

## STARTING

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**Usual Routine Way of Starting Engine.** If the engine has been operating recently and nothing has been removed or repaired since it last operated, the following is all that is necessary to start:

1. Check fuel supply.
2. Check lubricating oil in engine base with gauge rod. Be sure oil is to 4/4 or full mark on rod. See Illustration No. 7.
3. Check cooling system.
4. Inspect installation to see all is in good order and tight and no loose tools, bars or parts are lying on engine.
5. Start engine by operating starter switch after turning ignition on.
6. Check engine as under "Operating Instructions After Starting," Page 12.

### COLD WEATHER STARTING

At extremely low temperatures difficulty may be encountered in starting the engine due to (a) battery charge or output being low due to temperatures or (b) gasoline with vapor pressure too low to readily vaporize.

In starting any engine and particularly a cold engine do not allow it to run up to governed speed or do not run the engine much over 800 or 1000 RPM until the oil has become warm enough to circulate and the water or cooling solution has become warm enough to take the chill off the cylinder block. This usually takes four or five minutes if the engine is equipped with a thermostat. A longer period is generally required for engines not so equipped and these engines should have the radiator covered for the first few minutes in order to allow the water or cooling solution to warm up. If the unit is not equipped with a thermo-gauge or thermometer this can be then checked by placing the hand on the cylinder block or cylinder head and as soon as the engine becomes warm enough can be run up to maximum speed. This is probably the most important phase of the engine operation as damage can result in the first few seconds of running if the engine is allowed to run maximum load and maximum speed before lubrication has been established and before parts have started to warm up normally.

### COLD WEATHER STARTING SUGGESTIONS

If ignition and carburetion are correct, starting in cold weather can be made less difficult by observing the following suggestions.

1. Late ignition timing causes hard starting. (Magneto impulse coupling should click or release on or slightly after top dead center.)
2. Never attempt to start with wide open throttle. Have throttle open not more than one-fifth of total opening.
3. Close carburetor choke and turn engine several times before ignition switch is closed if the engine is hand cranked.
4. Close ignition switch and keep choke closed nearly all the way and crank engine over in the same way as has been followed in warmer weather.
5. When engine starts to fire keep choke partially closed until engine warms up sufficiently to run normally.
6. Filling cooling system with hot water will assist starting.
7. Thin oil such as 10W or 20W will make cranking easier.
8. Cheap gasoline makes cold weather starting very difficult.
9. Be sure gasoline flows through the carburetor. Ice may have blocked gasoline due to water in gasoline.
10. If engine has been standing idle for several days remove spark plugs and dry out and at same time pour a tablespoon of oil in each spark plug hole.