

INSTRUCTIONS No. 3200E

Fairbanks-Morse

Models 32E12 and 32E14
Stationary Diesel Engines



Price Two Dollars

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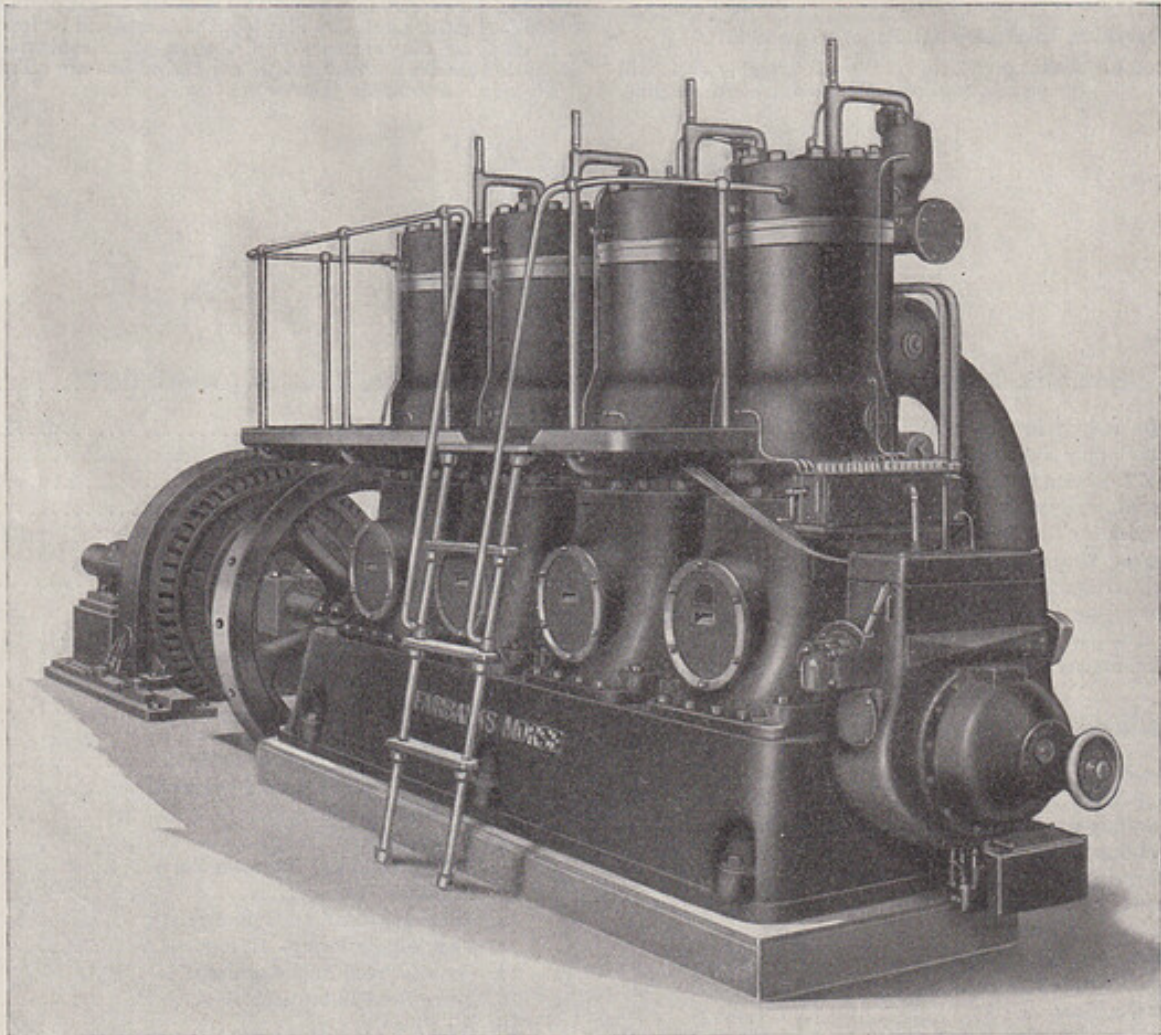


Instructions No. 3200E

Fairbanks-Morse

Stationary Diesel Engines

Models 32E12 and 32E14



4 Cyl. Model 32E14 Stationary Diesel Engine with Direct Connected Alternator

ENGINES COVERED

This instruction book covers the Model 32E12 Stationary Diesel Engines in 1, 2 and 3 cylinders, and the Model 32E14 Stationary Diesel Engines in 1, 2, 3, 4, 5 and 6 cylinders.

READ THE INSTRUCTIONS

Before attempting to operate the engine, read the instructions carefully. Familiarity with the engine and a thorough knowledge of the manner in which it operates is necessary to insure satisfactory and dependable operation.

INTRODUCTION

The material in this instruction book has been arranged into sections to make ready reference possible and to provide an organization of material which will suit the demands of the various persons interested in the engine.

I. Description and Operation. Pages 3 to 6, inclusive.

This section is indispensable to an operator who is interested in obtaining a thorough knowledge of the engine, and will be found valuable to others desiring a general knowledge of the engine and the manner in which it operates.

II. Installation Instructions. Pages 7 to 24, inclusive.

Complete instructions for installing the engine are contained in this section.

III. Operating Instructions. Pages 25 and 26.

The operator should study this section thoroughly as it will provide him with the necessary information to operate the engine.

IV. Inspection Routine. Page 27.

Both the owner and operator should read this section, and they should cooperate in establishing a suitable inspection routine for the particular installation.

V. Servicing Instructions. Pages 28 to 31, inclusive.

This section contains instructions which will enable the operator to perform minor adjustments and servicing.

VI. Repair Charts and List. Pages 33 to 71, inclusive.

This section contains an explanation of the repair list; instructions for ordering repair parts; an index of list divisions; an index of repair numbers; and the list divisions, each of which comprises one or more repair charts illustrating the parts furnished for repairs followed by a list of the repair parts found on the particular chart. In addition, the charts will be found useful in studying the construction of the engine. Repair numbers on charts that are underscored with a dotted line are numbers that are referred to in the instruction text.



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I. DESCRIPTION AND OPERATION

This section covers the description and operation of the several systems which make up the engine and complete installation.

1. Type and Cycle

Type and Cycle—These engines are of the valveless, airless fuel injection type, and are designed to use a wide variety of fuels. They operate on the two cycle principle in which two strokes of the piston (one complete revolution of the crankshaft), are necessary to complete the cycle.

Compression—The cycle begins with the upward movement of the piston from its lower dead center. After the piston has covered the exhaust ports, the air in the cylinder is compressed, and during the same upward movement of the piston, air is drawn into the crankcase through automatic suction valves.

Combustion and Expansion—As the piston nears upper dead center, fuel is injected into the combustion space where it burns and expands, forcing the piston downward. Expansion of the hot gases forms the greater part of the power stroke, and continues nearly to the end of the stroke. During this stroke, the air in the crankcase is slightly compressed.

Exhaust and Scavenging—Toward the end of the expansion or power stroke, the piston uncovers the exhaust ports, allowing the burned gases to escape to the atmosphere through the exhaust system. Immediately after the exhaust ports have been uncovered, when the pressure in the cylinder has dropped to atmospheric, the air inlet ports are uncovered by the piston, and the compressed air in the crankcase rushes through the air transfer passages into the cylinder, sweeping the exhaust gases out of the cylinder through the exhaust ports and filling the cylinder with fresh air for the next compression stroke.

2. Fuel Supply System

Supply System—The fuel system consists of the supply and injection systems. The supply system includes the fuel storage tank, suction and overflow pipes with the necessary fittings and valves, fuel supply pump, suction filter, and reservoir. When the fuel tank must be located above the level of the fuel reservoir, a gravity feed fuel regulator must be included.

Gravity Feed Fuel Regulator—The regulator consists of a water jacketed reservoir containing a float mechanism, see Fig. 11. This float operates a valve which controls the supply of fuel admitted to the regulator reservoir. The regulator is provided with an air vent in the cover which maintains atmospheric pressure on the fuel and indicates, by fuel leakage, that the float is inoperative. This air vent is arranged so that any fuel leakage flows into an open funnel and then into a vented tank outside of the building. With the open funnel, the operator can readily detect any leakage, and with the tank placed outside of the building, the fire hazard is greatly reduced.

Operation of Fuel Supply System—The supply pump draws fuel from the fuel storage tank or gravity feed fuel regulator through the suction filter and delivers it to the fuel reservoir where it is ready to be taken up by the individual injection pumps. Any excess fuel in this reservoir drains through the overflow pipe to the storage tank or gravity feed fuel regulator.

3. Fuel Injection System

Index to Diagrams—The following parts are indicated on Figs. 1 and 2 to illustrate the discussion of the fuel injection and governing system.

- (A) Fuel pipe leading to the injection nozzle.
- (B) Injection pump plunger.
- (C) Discharge valve.
- (D) Injection pump roller.
- (E) High point of injection cam.
- (F) Injection cam (in fixed relation to the crankshaft).
- (G) Crankshaft (shown in two sections).
- (H) Governor cam (loose on the crankshaft).
- (J) An increase in load will turn the governor cam H in the direction J, closing the suction valve P earlier, thus causing a greater amount of fuel to be injected into the cylinder.

(K) A decrease in load will turn the governor cam H in the direction K, closing the suction valve P later, thus causing a lesser amount of fuel to be injected into the cylinder.

(L) Leading high point of governor cam for reverse rotation.

(M) Leading high point of governor cam for standard rotation.

(N) Suction valve adjusting screw.

(O) Suction valve adjusting screw nut.

(P) Suction valve.

(Q) Injection pump suction lower push rod.

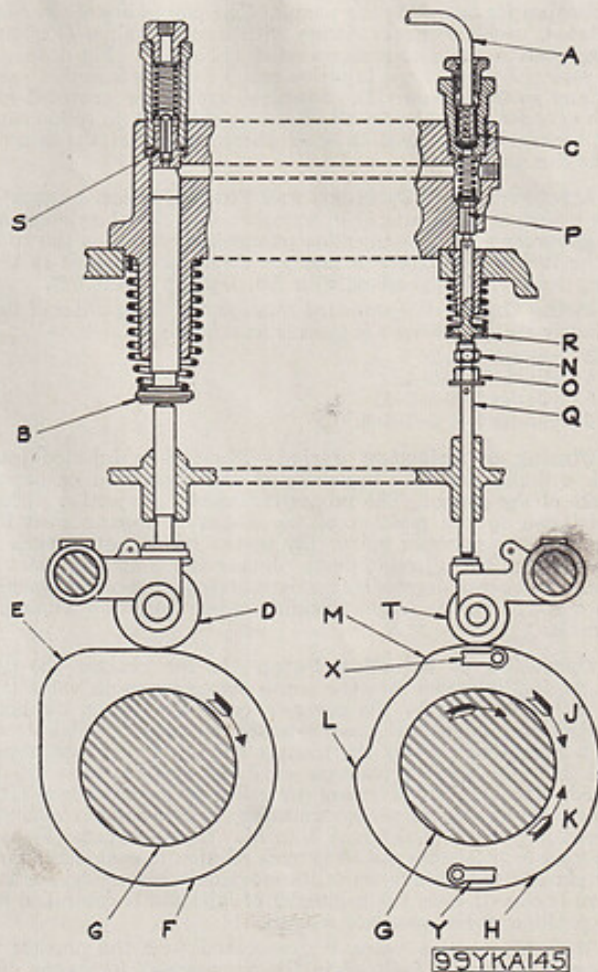


Fig. 1. Injection Pump and Governor Cam Diagram

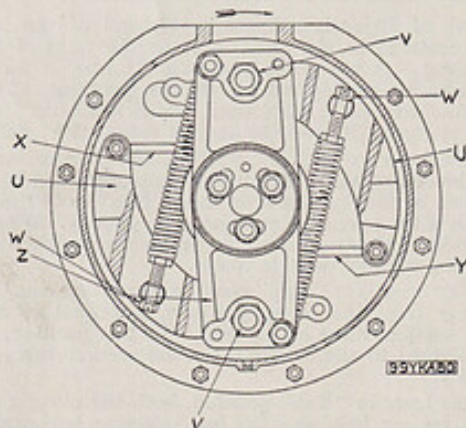


Fig. 2. Standard Rotation Governor Diagram

- (R) Injection pump suction upper push rod stem.
- (S) Relief valve.
- (T) Governor cam roller.
- (U) Governor weight; centrifugal force throws the weight out.
- (V) Pivot of the governor weight.
- (W) Governor spring adjusting screw; tighten to increase the speed and loosen to decrease the speed.
- (X) & (Y) Governor weight to governor cam pull rods.
- (Z) Governor spider, with governor weights, clamped in fixed relation to the crankshaft.

Fuel Injection System—The fuel injection system includes the individual injection pumps, fuel tubes, and differential fuel injection valves for each cylinder, also the driving and control mechanism for operating the pumps. The pumps are of the cam operated, constant stroke design with suction valves (P), discharge valves (C), and pressure relief valves (S). Fig. 1 shows the essential parts of one injection pump with the injection cam (F) and governor cam (H). Identical pumps are provided for each cylinder, but they are all driven by the same injection cam (F), rockers being placed at equal distances around the cam to make this possible.

Arrangement of Cylinders and Fuel Injection Pumps—The cylinders are arranged in sequence with No. 1 cylinder at the governor end. The injection pumps are located on the floor of the fuel supply reservoir and are arranged the same as the firing order of the cylinders, with No. 1 pump at the left.

Firing Order—For standard rotation the firing order of the cylinders on the different engines is as follows:

- 3 Cylinder 1-3-2.
- 4 Cylinder 1-3-2-4.
- 5 Cylinder 1-4-3-2-5.
- 6 Cylinder 1-4-5-2-3-6.

Timing of Injection Period—The fuel is injected into each cylinder near the beginning of the downward or power stroke of the piston. The proper timing of the injection period in relation to the position of the piston is accomplished by clamping the governor spider (Z) to the crankshaft in such a position that the injection pump plunger (B) is at high point a certain number of degrees before the corresponding piston reaches top center. This is fully explained under "Injection Timing," page 30.

Operation of Injection Pump—As the plunger (B) descends, fuel is drawn into the pump through suction valve (P) which is held open by the governor cam (H). When the high point of injection cam (E) moves under the roller (D) and pivots the rocker, thus moving the plunger (B) up, fuel is discharged back into the suction passages until the suction valve (P) is closed. The suction valves are controlled by governor cam (H), and are closed only when the cam roller (T) is in contact with the depressed portion of the cam L to M. Injection cam (F) and governor cam (H) are placed in such relation to each other that the plunger (B) always starts its movement before the suction valve is closed; thus, the beginning of injection is controlled by the position of the governor weights.

With the suction valve P closed, and with the plunger B rising, a pressure is built up in the pump which forces the discharge valve C off its seat. Fuel is then discharged through the injection tube A to the injection nozzle where it is thoroughly atomized and forced into the combustion space.

Control of Injection System—Control of the injection system is centered in the hand lever at the right of the fuel pump housing. It has three positions, "Prime," "Run," and "Stop" which are plainly marked on the quadrant. The hand lever is attached to a control shaft which has cams for lifting the pump plungers (B) and the suction valves (P). See Fig. 3.

With the lever in "Prime" position, the plungers are being lifted by the control shaft cams; thus the plunger can be worked up and down by moving the lever from "Run" to "Prime" positions which is the operation performed in priming. When priming a cylinder, the piston must be in such a position that the corresponding suction valve is closed.

When the lever is in "Stop" position, the lifting cam has been moved away from the pump plungers, and another cam has raised the suction valve off its seat. In this position, no fuel can be delivered to the cylinder, for the suction valve is open continuously.

With the lever in "Run" position, both the plunger and the suction valves are free, and the fuel injection is controlled by the governor mechanism.

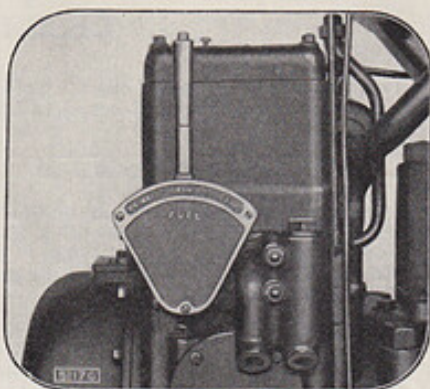


Fig. 3. Fuel Control Mechanism

4. Governing System

Governing System—The governing system includes the governor, injection cam (F), and governor cam (H). The governor is of the flyball type, and has two spring regulated weights (U) which pivot about points (V). The injection cam (F) is keyed to the governor spider (Z). The governor cam (H) is mounted on the governor spider too, but is free to rotate within certain limits, being held in position by the two links (X) and (Y) which are connected to the free ends of the governor weights.

The entire governing mechanism is clamped on the end of the crankshaft by means of three clamp nuts through the governor spider (Z). Slotted holes in the spider allow the shifting of the governor mechanism in relation to the crankshaft.

Operation of Governing System—With the crankshaft rotating, centrifugal force acts on the governor weights (U). With a decrease in load, the engine speed increases, and the governor weights swing out farther. Through links (X) and (Y), this movement is transmitted to the governor cam (H), which is retarded in relation to the injection cam (F). This causes the suction valves (P) to close later, and less fuel is delivered to the cylinders. With an increase in load the opposite is true; thus, the governor automatically controls the amount of fuel delivered between certain limits.

Description of Woodward Governor—The governor consists of a rectangular case approximately 1' square and 2½' high, containing the complete mechanism, including the oil pump, the relay cylinder for operating the fuel control equipment, flyballs for timing, and link mechanism, etc. This unit is mounted in the same place normally occupied by the standard stationary governor and is driven from the end of the crankshaft through a short splined shaft and a pair of bevel gears.

In the conventional (direct acting) Diesel engine governor, the flyballs do not only indicate speed, but also serve as a source of energy to move the engine fuel pump cam and suction valve and all intervening connections. Therefore, to make a corrective fuel change requires quite a sizeable frequency or speed change in order to produce the force required to overcome the friction of the governor head, fuel cam, suction valve and other connecting parts.

In the Woodward Diesel engine governor, the flyballs are very small by comparison with the conventional type and serve only to indicate speed. The flyballs transmit the speed indication to a small valve that is in perfect hydraulic balance, and it is this valve that controls the oil under pressure to move these mechanical parts required to relocate the fuel setting. Speed changes of less than 1/100 of one per cent will cause corrective movement of the fuel control mechanism.

The Woodward governor is stable, that is, it does not hunt when the load is added or taken off, which, in cases where accurate speed control is required, is very desirable. Tests show the governor capable of accepting full load from no load with a maximum speed reduction of 4% and returning to normal speed in approximately three seconds time. The same results are attained in the rejection of load from full load to no load.

This type of governor can be used on an engine, where there is only one engine in a plant, or where there are a number of engines in the same plant operating in parallel. Where there are several units operating in parallel, with one engine of sufficient capacity to handle the load changes, equipped with a Woodward governor, and all the other units equipped with a conven-

tional governor, the engine equipped with the Woodward governor will control the speed of all the other engines to check with that maintained by the engine equipped with the Woodward governor. For instructions on the operation of the Woodward governor see Woodward Bulletin W-2 for IC Type Governor.

5. Lubricating System

Automatic Lubrication—Each engine is equipped with an automatic lubrication and circulation system which requires no attention other than to keep an adequate supply of oil in the storage tank.

Main Part of System—The main parts of the system are the force feed lubricator, pressure type oil filter mounted on the clean oil storage tank, clean oil and used oil sumps each fitted with a reciprocating pump and strainer, oil rings and wells for each main bearing, oil reservoir in the governor case, and the connecting tubes and piping.

Lubrication of Pistons, Piston Pins, and Crankpin—In operation, the clean oil pump draws filtered oil through a strainer and delivers it to the force feed lubricator which supplies lubrication to the pistons, piston pins, and crankpin. Referring to Fig. 12 it will be noted that two of the lubricator feeds deliver to oil collectors located in the piston at each end of the piston pin. These collectors furnish lubrication to the piston pin. A third lubricator feed leads into the front or scavenge air transfer side of each cylinder for the lubrication of the piston, and the fourth feed supplies lubrication to the crankpin bearing by means of a ring oil collector bolted to the crank web. This collector is connected to a drilled passage in the crank web and pin which leads to the bearing. Each feed to the engine is an individual feed from the lubricator.

Used Oil Filtered and Returned to Tank—The used oil from the pistons, piston pins and crankpin bearings drains to the bottom of the respective crankcases and is drained through pipes to the used oil sump at the governor end of the engine. The used oil pump transfers this oil to the oil filter where it is thoroughly cleansed, and then delivers it to the clean oil storage tank where it is again ready for circulation. **Under no circumstances should oil ever be allowed to accumulate in the crankcases.**

Lubrication of Governor Mechanism—The clean oil pump delivers more oil than is required by the force feed lubricator, so the excess oil overflows to the governor case, lubricating the lubricator drive eccentric and rocker bearings. The 1, 2 and 3 cylinder engines, having fewer cylinders and bearings to lubricate, have a larger quantity of oil overflowing from the lubricator. This overflow is more than is required for the rocker bearings and lubricator drive eccentric so on the 1, 2 and 3 cylinder engines an overflow bypass is provided to return a portion of the oil directly to the clean oil sump. The oil level in the governor case is maintained at such a height that the splash created by the dipping of the governor spider thoroughly lubricates the governor mechanism, injection cam, push rods, etc. An overflow pipe permits any excess oil to flow back to the clean oil sump.

Lubrication of Main Bearings—The oil level in each of the crankshaft main bearing oil wells is automatically maintained by means of a cored passage between the governor case and the governor-end main bearing oil well and an equalizing pipe connecting this oil well to each of the other wells. Lubrication is supplied to the main bearings by means of oil rings which dip into the oil wells beneath. Operation of these rings can be observed and checked by opening the cover provided in the top of each bearing cap.

Oil Level Sight Gauges—All engines are equipped with a glass sight gauge at the governor end of the oil equalizer pipe for checking the oil level in the governor case and oil wells. The 4, 5 and 6 cylinder engines are provided with an additional gauge at the flywheel end of the equalizer pipe.

Floating Dredge Service—When the engine is to be used for floating dredge service where the crankshaft is not perfectly horizontal at all times, the main bearing oil well equalizing pipe must be omitted and an oil sight gauge be provided for each oil well. Also the cored passage between the governor case and the governor end main bearing must be plugged. When an order specifies that the engine is to be used for floating dredge service, this special oil well piping will be installed at the factory without extra charge.

The main bearing oil rings will function satisfactorily in this service as experience has shown that the engine may be slightly tilted end-wise without interfering with the action of the rings.

If the engine is to be direct connected to a direct current generator or magnetic clutch, brass oil rings must be used, as a

magnetic attraction is sometimes encountered which tends to make the steel rings stick. Brass oil rings will be furnished for special direct current installations without extra charge.

6. Cooling Water System

General—An adequate supply of cool soft water is essential to the satisfactory operation of an internal combustion engine. Only clean soft water or water which is free from scale forming ingredients, should be used in the cooling system. Even a thin layer of scale or dirt on the cylinder jacket walls will act as an insulator and cause overheating and possible breakage. If clean rain water is available, it is suitable for cooling purposes without previous treatment. Salt water should not be used for cooling, as it may cause corrosion in the water jackets. Any hard water containing lime or magnesia is almost certain to cause scale and must be treated. To prevent scale deposit, the best cooling system and the one recommended, is the closed system using only soft water in the engine jackets.

Cooling System—The cooling water system on these engines consists of the cooling water passages in the cylinders and heads, and the necessary equipment for circulating and cooling the water, such as pumps and heat exchangers.

The presence of combustion products in the cooling system, due to defective or loose cylinder head gaskets will form acids which will attack the metal surfaces. Gaskets must, therefore, be kept tight and in good repair. Pump glands should be well packed and tight to prevent infiltration of air and, wherever possible, positive pressure should be placed on the suction side of the pump.

7. Air Starting System

Air Starting System—Compressed air is used to start these engines. The air starting system consists of an air start mechanism on the engine for distributing and admitting the compressed air to the cylinders, an auxiliary air compressor, steel tanks for storing the compressed air, and the necessary piping and fittings.

Starting Mechanism—Fastened to the left side of the pump case housing is the air lever which controls the air start mechanism. See Fig. 4 in the next column. This lever is attached to a control shaft which has cams for raising or lowering the air valves and to which is fastened the disc shut off valve. The air lever has two positions "Start" and "Run." These are plainly marked on the quadrant.

Each cylinder head on those cylinders which receive starting air is provided with an air starting check valve. This valve is so arranged that it is opened by the compressed air during its admission to the cylinder, but is closed at all other times.

Operation of System—When the lever is moved to the "Start" position, the disc shut off valve is opened admitting compressed air to the distributor. At the same time the cams under the air starting valves are moved out of position, and the valves are lowered to their respective seats and brought into contact with the air starting cam. As the engine revolves, the air starting cam lifts the valves in the proper order, and air is admitted to the corresponding power cylinder during a portion of the downward stroke of the piston.

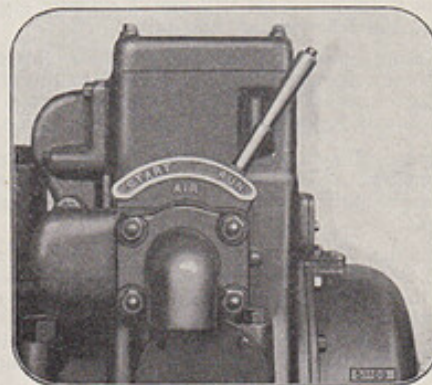


Fig. 4. Air Control Mechanism

When the engine has started, the air lever is moved to the "Run" position. In this position, the disc valve is closed, thus stopping the admission of air from the starting tanks, and the air starting valves are lifted off their seats. With this arrangement, the cam rollers do not come in contact with the cam while the

engine is in operation. The disc valve and the lifting cams are interlocked in such a manner that air cannot be admitted to the distributor while the starting valves are off their seats.

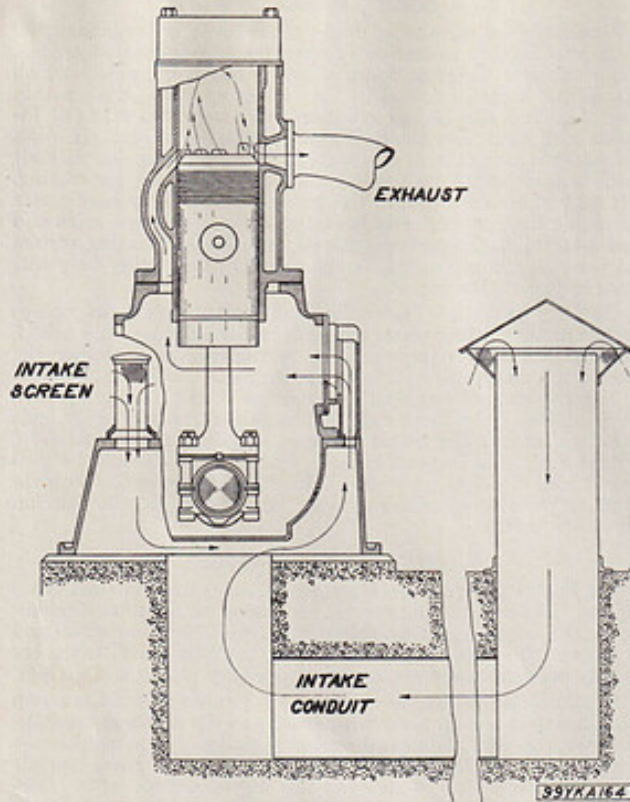


Fig. 5. Scavenging Diagram

8. Scavenging Air System

The scavenging air is supplied by the piston acting as a pump. During the upstroke of the piston, air is drawn into the engine in one of the following ways. (a) From outside the engine room through an underground conduit into the engine base. (b) From the engine room through a screen located on top of the engine base at the flywheel end.

When the air is supplied to the engine by method (a), which is the preferred arrangement, the intake opening on top of the base is shut off with a blind flange.

When the air is supplied to the engine by method (b), one intake screen is furnished on 1, 2 and 3 cylinder engines, and two on the 4, 5 and 6 cylinder engines.

After entering the engine base, the air is drawn into the crankcase through an automatic air valve during the upstroke of the piston, and is compressed on the downstroke. Arrows on Fig. 5 indicate the flow of scavenging air through the engine.

Air Filters—Many installations are made under conditions which require that the air supply be filtered before it enters the engine. Cement mill, flour mill, and rock crusher installations are examples.

The assembled filter usually consists of a steel box skeleton containing 2, 3 or 4 filter cells bolted to the vertical sides. The filter cell is a shallow steel box, with the filter media consisting of solid sheet steel plates scientifically graded and expanded. All surfaces exposed to the passing air are coated with a thin film of non-evaporating, non-inflammable, non-freezing, viscous fluid.

9. Exhaust System

General—In the discussion under "Type and Cycle," the manner in which the exhaust gases are expelled from the cylinders is explained. Since the satisfactory operation of any Diesel engine depends a great deal upon the arrangement for conducting these gases to the atmosphere, it is highly essential that the exhaust system conform to one of the approved arrangements as outlined

under "Installation Instructions." If any departure from these arrangements seems necessary, approval must be obtained from Fairbanks, Morse & Co.

Exhaust Temperature—Under normal full load operating conditions with the engine in good condition and proper adjustment and with an approved exhaust arrangement, the exhaust temperature should be approximately 390°F. to 420°F.

This should be determined for each individual installation. The temperature will vary to some extent with the temperature of the incoming air.

Exhaust Arrangements—In conducting the exhaust gases from the engine to the atmosphere, there are four approved arrangements as follows:

(a) **Underground Conduit**—This arrangement, as shown in Fig. 24, is preferred. It provides especially favorable exhaust and scavenging conditions under practically all field applications, and results in the most satisfactory engine operation together with the best appearance of the installation.

This arrangement consists of a reinforced concrete conduit extending lengthwise of and adjacent to the foundation. Individual pipes from each cylinder lead through expansion joints into this conduit which in turn is vented to the atmosphere through a stack. It is very important that the exhaust inlet and outlet connections to the conduit be at the extreme ends so that no dead spaces will exist, since under certain conditions such "dead ends" will seriously interfere with the engine exhaust.

The conduit must be provided with a drain connection, preferably so arranged that a fixed level of water can be maintained in the bottom. This will effectively quench all sparks brought in with the exhaust gases.

(b) **Exhaust Pot Arrangement**—This arrangement, shown in Figs. 25 and 26, is satisfactory for installations of more than one cylinder where it is permissible to run an exhaust pipe through a side wall or through the roof, or where the installation of an underground conduit is undesirable.

It is essential that individual exhaust stacks be installed with each exhaust pot, and where exhaust washing or silencing is required, an individual washer or silencer for each stack. For this reason, the arrangement will not be generally desirable for installations of 4, 5 and 6 cylinder engines where two or three exhaust pots are required.

(c) **Exhaust Manifold Arrangement**—This arrangement is used for engines with two or more cylinders where a single stack is necessary or desirable. An exhaust silencer may be installed if desired.

(d) **Dredge Individual Elbow Exhaust Arrangement**—This arrangement, shown in Fig. 27, is suitable only for dredge, drag line, and shovel installations where space requirements and weight must be kept to a minimum and where the noise of the exhaust is not particularly objectionable.

Single Cylinder Engine Standard—For the one cylinder engine either with or without a silencer, where a conduit cannot be used, a special exhaust adapter with an elbow and pipe support is provided. A support is necessary to hold up the weight of the piping and silencer if used. See illustration page 24.

10. Synchronizer

The synchronizer is furnished as special equipment and may be installed on the engine in the factory or in the field. For instructions on installing the synchronizer in the field, see page 24.

Purpose—When the engine is to be used in driving an alternator in parallel with other synchronous machinery, the no load speed must first be reduced to normal full load speed value before the alternator can be paralleled. This can be accomplished by means of a synchronizer as described below.

Description—The synchronizer consists of a mechanism which includes two coiled springs attached to the governor weights in such a manner that they oppose the action of the governor springs. A handwheel is provided by means of which the tension in the synchronizer springs can be varied. An indicator dial on the side of the synchronizer shows the position of the control at all times. The handwheel can be locked in any position by means of a knurled pin. The no load speed of the engine can be reduced approximately 25 r.p.m. by means of the standard synchronizer springs.

II. INSTALLATION INSTRUCTIONS

1. Layout of Plant

Floor Plan—Lay out the entire floor plan, carefully locating the exhaust and cooling water arrangements, foundations for auxiliaries, etc., before erecting the engine. Locate all auxiliary equipment so that the piping will be as short as possible. Leave plenty of space around the engine and auxiliaries, and provide for development and future extensions.

Engine Rotation—The standard rotation of the engine is clockwise, when facing the engine at the governor end. When

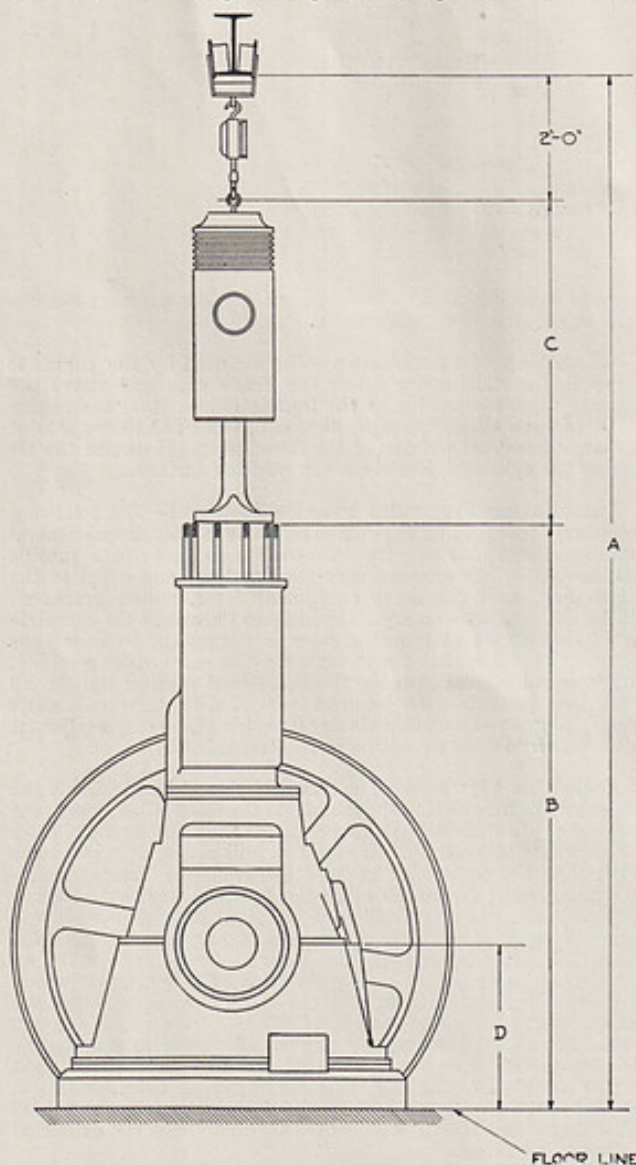


Fig. 6. Piston Removal Diagram (99YKA32)

HEAD ROOM REQUIRED FOR REMOVING PISTONS STANDARD LOW MOUNTED ENGINES

ENGINE SIZE	A	B	C	D
12"x15".....	13'-8"	7'-5½"	4'-2½"	22"
14"x17".....	15'-2"	8'-6¾"	4'-7¾"	2'-3"

SPECIAL HIGH MOUNTED ENGINES

12"x15".....	15'-1"	8'-10½"	4'-2½"	3'-3"
14"x17".....	16'-5"	9'-9¾"	4'-7¾"	3'-6"

specially ordered, the engine can be furnished for reversed rotation. Fig. 29 shows the engine with standard and reversed rotations.

Cylinder Position—The standard position of the cylinder is with the exhaust ports on the right-hand side when facing the engine at the governor end. See Fig. 29. When specially ordered, the engine can be furnished with the exhaust connections at the left-hand side.

Completely Reversed Engine—When specially ordered, the engine can be furnished with both reversed rotation and reversed cylinders.

Overhead Clearance for Removing Pistons—When laying out the plant it is important to provide a convenient means for removing the cylinder head, piston, etc., in order to facilitate cleaning or making repairs on these parts. Provide a suitable overhead hoist as illustrated in Fig. 6, keeping in mind that the hoist should travel, at least in the direction parallel with the axis of the engine crankshaft, and if possible, transversely as well. The overhead clearance required for removing the piston and connecting rod is shown in the table accompanying the diagram. The dimension given in the cut for the space occupied by the hoist is 2'-0", but this can be reduced several inches by the use of an army type hoist.

Size of Hoist—The following table indicates the size of hoist required when removing various parts of the engine. For general servicing work, a hoist of sufficient capacity to remove the cylinders will be suitable. For removing the crankshaft or flywheel, the size must be increased accordingly.

SIZE OF HOIST (TONS) REQUIRED TO REMOVE THE FOLLOWING PARTS

Engine Bore & Stroke	12"x15'			14"x17'					
	1	2	3	1	2	3	4	5	6
No. of Cylinders.....	1	2	3	1	2	3	4	5	6
Cylinders.....	1	1	1	1	1	1	1	1	1
Crankshaft.....	1	1½	2	1	2	3	3	3	4
Flywheel (Belted Commercial).....	1½	1	2	2	2	2	4	4	4
Flywheel (Belted Electric).....	3	1½	3	4	3	3	4	4	4
Flywheel (Dir. Con. Electric).....	4	2	2	5	4	4	4	4	4

Piping—To improve the general appearance of the plant, lay the fuel, water, and air pipes below the floor level wherever possible. Make a channel in the floor, to receive the pipes, and cover it with floor plates, or pack the channel with sand and cover the top with a thin layer of cement. If necessary to remove or repair the pipes, the thin layer of cement can be broken easily, the pipes repaired, and the cement readily replaced. It is not advisable to cement any pipe solidly into a wall or floor.

Lighting—Provide an abundance of light on all sides of the engine at all times. This is important from the standpoint of safety as well as economical operation. A well lighted engine room makes it possible for the operator to detect promptly, any slight irregularity of operation and to make the necessary adjustments before any serious results develop.

2. Foundation

Standard Mounting of Engine—The standard mounting for any 14"x17" engine is that in which the engine base is set upon a concrete foundation, projecting 7 inches above the floor line. On a 12"x15" engine, the foundation projects 4 inches above the floor line. For either size of engine, a pit must be provided for the flywheel and belt pulley, as shown on the foundation plan furnished for each engine. Drains should be provided for all pits.

Special Mounting of Engine—When specially ordered, a foundation plan will be prepared showing the engine mounted on a higher foundation with the flywheel and pulley above the floor line. With this mounting, no pit is required.

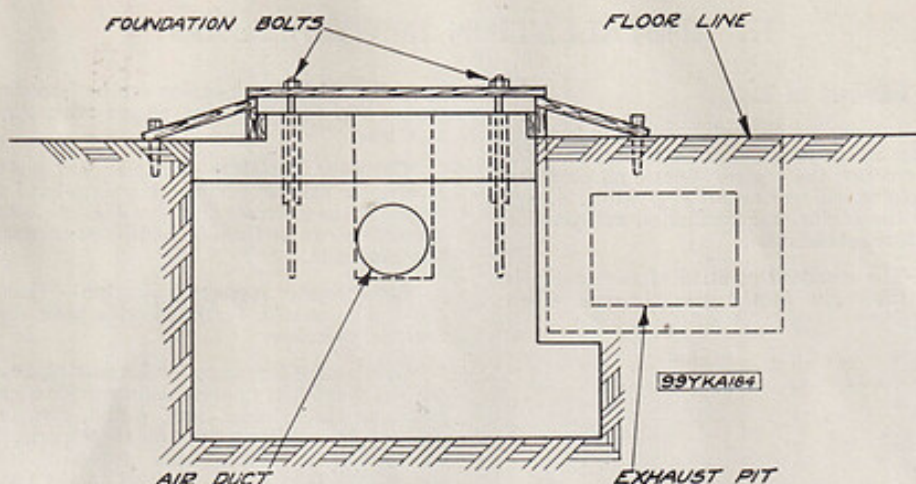


Fig. 7. Foundation from Governor End

Generator Mounting—On a direct connected outfit, the engine foundation is extended to support the generator, as shown on the foundation plan furnished for each engine.

Foundation Plan—Prepare the foundation in accordance with the foundation plan furnished for each engine. This plan gives the location of the foundation bolts, driving belt, exhaust equipment, and all outside dimensions. Follow the dimensions carefully.

Extend the foundation deep enough into the ground to secure a solid footing; that is, one that will not settle when the engine is mounted. The foundation plan shows a depth that is sufficient for solid ground, but Fairbanks, Morse & Company will not be responsible for the failure of a foundation. Provide a space of at least three feet all around the engine for easy access by the attendant.

Foundation Isolation—In all installations where engine vibrations are undesirable, such as in or near hotels, residences, offices, etc., it is recommended that the foundation be properly isolated. For information regarding such isolation, refer to the Manufacturing Division.

Isolate Exhaust Conduit—When an exhaust conduit is used, it should be isolated from the engine foundation. The usual practice is to place an inch board between the engine foundation and the exhaust conduit, and to leave this board in position after the remainder of the form is removed.

Foundation Bolts—Set the foundation bolts in tubes or boxes, extending from the top of the foundation well down into the concrete, with the ends of the foundation bolts extending above the foundation, the distance shown on the foundation plan. The object in using the tubes is to allow the foundation bolts to be sprung slightly, so as to enter the holes in the engine base. It is therefore important to exclude all concrete from the tubes while pouring the foundation, as the bolts cannot be sprung if imbedded in the concrete. Fill the tubes with a thin, rich grout at the time the finish grouting is poured.

Reinforcing Rods—The foundation may be strengthened by the addition of reinforcing rods, but their use is not considered necessary if the foundation is properly constructed.

3. Installing the Engine and Drive Equipment

Erector's Level—The erector should use a good level. It should be at least as accurate as the L. S. Starett No. 98 machinists' level and have a cross level in the base. Check it for each job by trying it on a smooth surface and noting the position of the bubble with respect to the graduations on the bubble tube. Reverse the level and again note the position of the bubble. If any variation exists, correct the error before attempting to level the engine. An 8 inch level is the longest that can be used on certain parts of the engine.

Examine Drain Pipes—Before the engine is set on the foundation, examine the drain pipes from the crankcase to the sump box to see that they have not been loosened or damaged in

transit. Also check the inter-connection pipes between bearing wells to see that these have not loosened.

Clean Top of Foundation—The air used by the engine is drawn in from the space below the crank case and above the concrete capstone portion of the foundation. Before the engine is set, remove all dust, chips, dirt, etc., from the under side of the lower base and the top of the foundation. If dirt in the air reaches the cylinders, it will cut the working surfaces.

Installation Procedure may be Modified—The following procedure for installing the engine and driven unit covers general conditions, and may require modification to apply to a specific installation. Some erectors may wish to level and grout in the engine first, and the drive equipment later, which procedure will be entirely satisfactory. Leveling and aligning the complete installation first and grouting later is suggested, because it is thought that by so doing any errors may be more easily rectified. Any procedure must produce the same final results; that is, all crankshaft journals must be dead level, and the extension shaft must be aligned so that there is no distortion of the crank adjacent to the flywheel in any position of the crankshaft.

Installing Flywheel—The flywheel should be placed on the crankshaft before setting the engine on the foundation, unless the flywheel pit is wide enough to permit placing the flywheel after the engine is in position. Wedge the hub apart, and place the flywheel on the crankshaft in the position shown on the foundation plan, being careful to align the flywheel keyway with the shaft keyway. In an installation using an extension shaft and outboard bearing, when the flywheel is in its proper location the crankshaft extends through the hub about $\frac{3}{4}$ inch. On an installation using an overhung flywheel, the wheel is moved closer to the main bearing and the shaft extends through the hub about $2\frac{3}{4}$ inches on the Model 32E12 engine and $2\frac{1}{2}$ inches on the Model 32E14 engines. Remove the wedges, and tighten the clamp bolts temporarily so that the flywheel will be tight on the shaft while the engine is being set on the foundation. Fit and drive the key. Lining up of the hub faces and final tightening of the clamp bolts should be done when the extension shaft is being fitted.

Set the Engine—The engine should now be placed on the foundation. Support it with leveling screws and steel bearing plates, allowing clearance for grouting according to the foundation plan furnished with the engine. The leveling screws should consist of $\frac{3}{4}$ inch by 5 inch, cup point, square head set screws. The steel bearing plates should be of such size and shape as to afford a suitable bearing surface and be installed in such a manner that they can be left in the grouting.

Level the Base—The base should be leveled first. On each side of every main bearing, scrape sufficient paint from the top of the lower base to provide a smooth bearing for the level. Place the level on each of the surfaces and adjust the leveling screws until an accurate crosswise and lengthwise level is obtained. In some cases, when leveling a base, it may be necessary to draw down on one or two of the foundation bolts.

Flywheel—If the flywheel has not been placed on the crankshaft, install it now.

Installing Bearing Pedestal, Sole Plate and Outboard Bearing—Before installing the outboard bearing, make certain that the lower shell is scraped to a good bearing surface throughout the entire length. In cases where it will not be necessary to remove the extension shaft after it is fitted, the bearing pedestal, sole plate and lower half of the outboard bearing should be placed in position before the shaft is bolted to the flywheel. The bearing should be placed low enough temporarily so that it will not interfere while the extension shaft is being fitted. Where there is sufficient clearance at the end of the shaft, the lower half of the bearing may be installed after the shaft is fitted, by sliding it lengthwise along the shaft.

Fitting Shaft Extension—The shaft extension should now be fitted to the engine. Loosen the flywheel hub clamp bolts and drive in a wedge lightly. Then bolt the shaft extension to the hub. This will line up the faces of the hub by pulling them up against the flange of the extension shaft. Remove the flywheel wedge and tighten the clamp bolts. It is essential to fit the hub faces accurately to a good contact over the entire bearing surface and so that the extension shaft will run true. Mark the flange and hub so that if the extension shaft must be removed it can be replaced in the original position.

Fitting Flexible Couplings—If the extension shaft is connected to the engine by means of a flexible coupling, instead of by a rigid flanged coupling, use the same care in aligning the flexibly coupled shaft as would be used in the case of a rigidly coupled shaft. Then the flexible coupling takes care of any misalignment due to expansion or to wear of the parts. The flywheels used with installations having a flexible coupling are so light that the bending effect on the crankshaft can be disregarded.

Aligning Outboard Bearing—When the extension shaft has been fitted, the outboard bearing should be aligned. All parts such as pulley or rotor and stator should first be in position. Then, with several shims between the bearing and sole plate, so that vertical adjustment can be made in both directions, adjust the position of the bearing to make the following conditions true. The journal next to the flywheel should be dead level, and the distance between the last two crank webs should be exactly the same when the crank is in the top and bottom positions. Measurements should be taken with an inside micrometer or an instrument equally accurate, preferably a Starrett #696 Crankshaft Distortion Gauge.

See Fig. 8 which illustrates incorrect and correct alignment. The two upper figures show the distortion of the crank next to the flywheel when the outboard bearing is placed on the same level as the main bearings. Dimensions "A" and "B" indicate the difference in the measurements for the two vertical positions of the crank. The lower figure shows the correct alignment. Dimension "C" will be the same for all positions of the crank.

Horizontal position of the outboard bearing may be checked by measuring the distance between the last two crank webs when the crank is in the two horizontal positions.

After the outboard bearing is installed and the extension shaft is fitted to the engine, place the distortion gauge between the cheeks of the cranks of all the cylinders. The distortion gauge should read very close to zero at all points. A deviation from a zero reading will indicate that the shaft is not bearing properly in the main bearing. Adjustment of the engine base leveling screws should be made until the deviation is corrected.

Filling Rail Jack Cutouts—After the engine is set fill the rail jack cutouts with ordinary concrete and allow to set before the grouting is poured.

Finishing Grouting—Re-check the alignment of the engine and extension shaft, then pour the finishing grouting. The foundation plan calls for finish grouting to be poured after the engine is carefully leveled and blocked in place. Grouting should also be poured under the outboard bearing sole plate and the generator stator foundation (if used). Make this finishing grouting from one part of cement and two parts of sand, with sufficient water added to make it flow freely. Build a board form around the top of the foundation to retain the grouting. Extend the grouting $\frac{3}{4}$ to 1 inch up on the base. When the grouting has

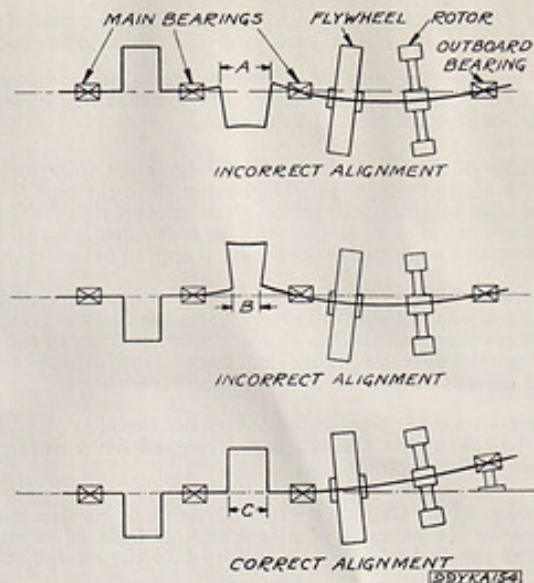


Fig. 8. Alignment Diagram
(This diagram is greatly exaggerated for illustrative purposes.)

set slightly, remove the form and cut away the excess grouting outside of the base. Pack the grouting in under the edge of the base, and finish the edge with a bevel. The grouting should flow over the whole surface of the foundation. To improve the appearance of the foundation above the floor, plaster it with a rich mixture of cement and sand.

After the grouting is hard make sure that the anchor bolt nuts are tight. Remove the leveling screws and fill each hole with a cork. The corks can be trimmed off flush and the base painted with engine paint.

Final Check of Alignment—When all work as outlined above has been completed, make a final alignment check of the entire installation before starting the engine.

4. Fuel Supply System

Since the fuel tank and the suction and overflow pipes (and the gravity feed fuel regulator, when used), are the only parts of the fuel supply system that are not incorporated in the engine, these parts are the only ones that need be considered under the installation of the system.

(a) Installation of System without Gravity Feed Fuel Regulator.

Fuel Tank Location—A galvanized steel fuel supply tank is required for each engine. Connect it to the engine with the suction pipe 3 and overflow pipe 4, as shown in Fig. 10. Locate the fuel tank outside of the building in a covered pit accessible for filling, and place it in a horizontal position so that the suction lift can never be greater than 10 feet. This applies when light fuels are used; for heavy fuels, use heaters, larger pipes or less suction lift.

Place unions close to the regulator, in all pipe lines entering it. Extend the pipe, connecting the overhead tank, with the regulator reservoir, about six inches into the tank to permit any sediment in the fuel to settle in the bottom of the tank so as to prevent any foreign matter from entering the fuel regulator. It is advisable to provide a gauge glass on the overhead tank to indicate the amount of oil in the tank and also to show any water that may accumulate in the bottom of the tank. This water should be drained off before it reaches the level of the top of the fuel outlet pipe.

Piping—When the tank is furnished by Fairbanks, Morse & Co., the proper connections for suction and overflow pipes are included. Use the size of pipe to fit these connections. In connecting the fuel tank with the engine, wash out every piece of pipe or joint with gasoline or kerosene to remove all scale and loose matter, which, if left in the pipes, would interfere with the

II. Installation Instructions—Fairbanks-Morse Diesel Engines

proper working of the valves. All tanks should be provided with drains for removing residue and water and for periodic cleaning.

When the piping is installed, three-way cocks should be placed in both the suction and overflow piping so that fuel consumption can be checked from time to time.

Joints—Make all fuel pipe connections carefully and use shellac to insure tight joints. Thoroughly clean the pipe threads with gasoline to remove all trace of oil before applying the shellac. Shellac will not stick to an oily surface, consequently an oil tight joint cannot be made unless the shellac is applied to clean threads.

Overflow Pipe—The engine is shipped with a union attached to the lower end of the overflow pipe from the fuel reservoir. To this union connect the return pipe and carry it down to the floor or through the floor as required, and back to the fuel tank with a gradual descent for the free return of surplus fuel.

Vent—A vent is provided in the side of the filler pipe. Care should be taken that the cap is not screwed down so far that this hole will be covered.

Storage Tank Capacity—It is advisable to install a storage tank having the capacity of a tank car, and placed at such a level that the fuel will flow by gravity into the smaller supply tank.

(b) Installation of System with Gravity Feed Fuel Regulator.

Gravity Feed Fuel Regulator—The gravity feed fuel regulator is special equipment and is necessary in installations where the fuel storage tank is located above the level of the injection pump. The function of the regulator is (1) to control the amount

of fuel supplied to the auxiliary fuel pump, (2) to provide for the overflow from the auxiliary fuel reservoir, (3) to provide for the overflow from the fuel pumps, and (4) to provide for the preheating of the fuel by means of the outlet water from the engine water jacket. Preheating is necessary only when the fuel is a very heavy oil or when it is exposed to low temperatures.

Clean Pipes and Connections—In connecting the regulator to the engine, carefully wash with gasoline or kerosene, each pipe and fitting used in order to remove all dirt or scale, which, if left in the piping, would seriously interfere with the operation of the valves.

Pipe Connections—All water and fuel pipe connections must be absolutely tight. Use shellac on fuel pipe joints and white lead on water pipe joints.

Arrangement of Equipment—Fig. 11 shows a typical arrangement of the regulator and piping. The regulator may be placed on a low bracket on the wall, on the floor, or in a pit below the floor level. Make dimension A about nine inches deep. In any case, the regulator must be placed below the unions B and C. Connect the overhead fuel tank to the regulator reservoir through the lower hole, tapped for $\frac{3}{4}$ inch pipe. Place a shut-off valve in this line and keep it closed when the engine is not operating. Connect the fuel overflow pipe on the engine to the upper hole, tapped for $\frac{3}{4}$ inch pipe, in the regulator reservoir. Connect the fuel suction pipe on the engine to the middle hole, tapped for $\frac{1}{2}$ inch pipe, in the regulator reservoir. Place a check valve in the suction line in order to keep the auxiliary fuel pump primed and a shut-off valve to prevent the loss of oil when disconnecting the fuel pipe at the union C. When valve E in the engine water outlet pipe is open, the water enters the regulator water jacket and heats the fuel but when the valve is closed, the water passes out through the engine water outlet pipe without circulating through the reservoir water jacket.

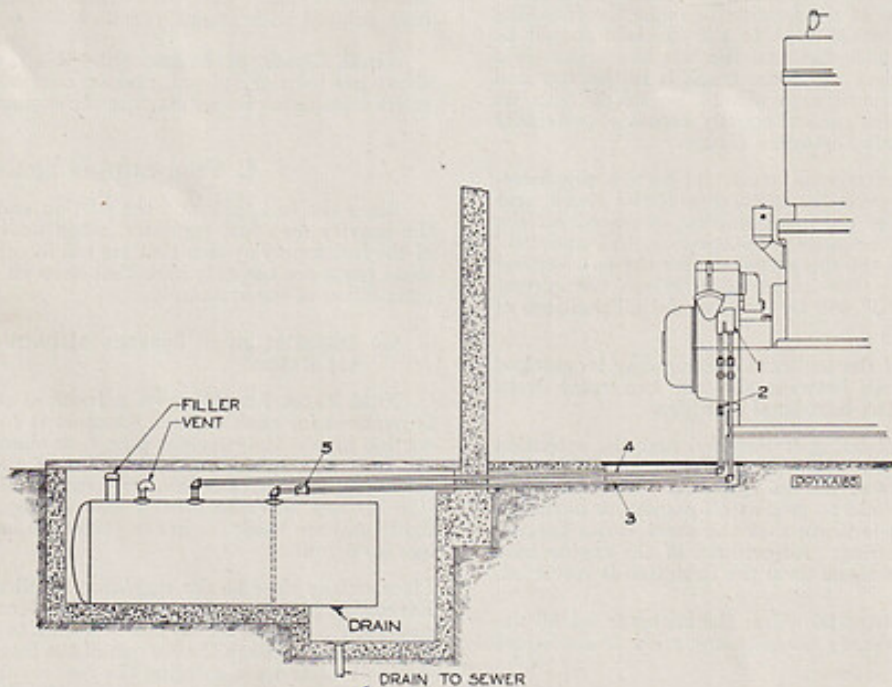


Fig. 10. Fuel Piping Diagram

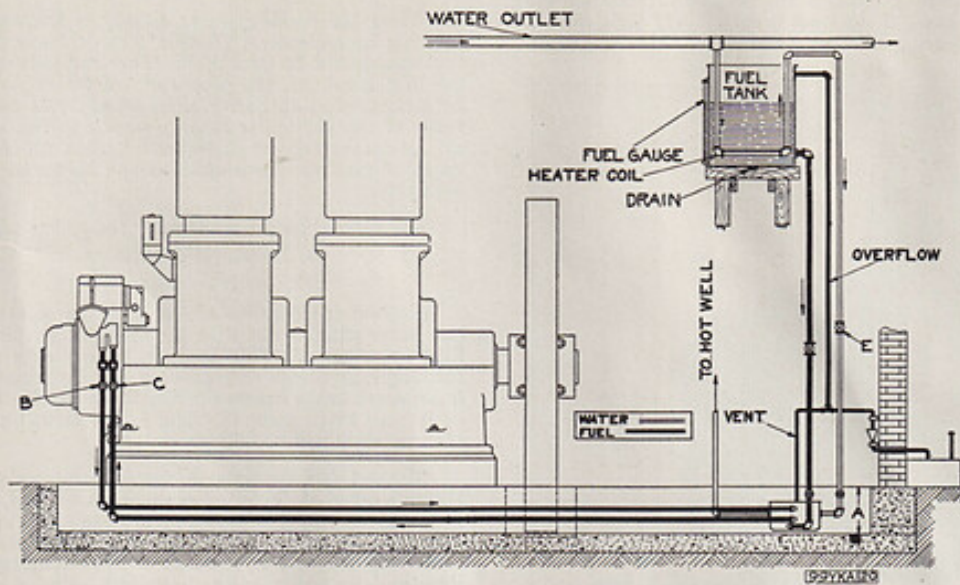


Fig. 11. Gravity Feed Fuel Regulator Diagram

5. Lubricating System

The pressure type oil filter and clean oil storage tank are mounted near the engine and connected to the clean and used oil sumps as shown in Figs. 12 and 13. All other parts are either attached to or incorporated in the engine itself; so installation work on the lubricating system requires only the proper setting and connecting of the filter and storage tank.

Necessity for Proper Oil Levels—As previously explained under the operation of the lubricating system, the oil in the governor case and each of the main bearing oil wells is maintained at a common level by means of equalizing connections. The level is maintained by the clean oil circulating pump, and is determined by the vertical overflow pipe leading to the clean oil sump. For best operation, the oil level in the governor case should coincide with the upper end of the overflow pipe. If the level in the engine is allowed to drop because of an insufficient

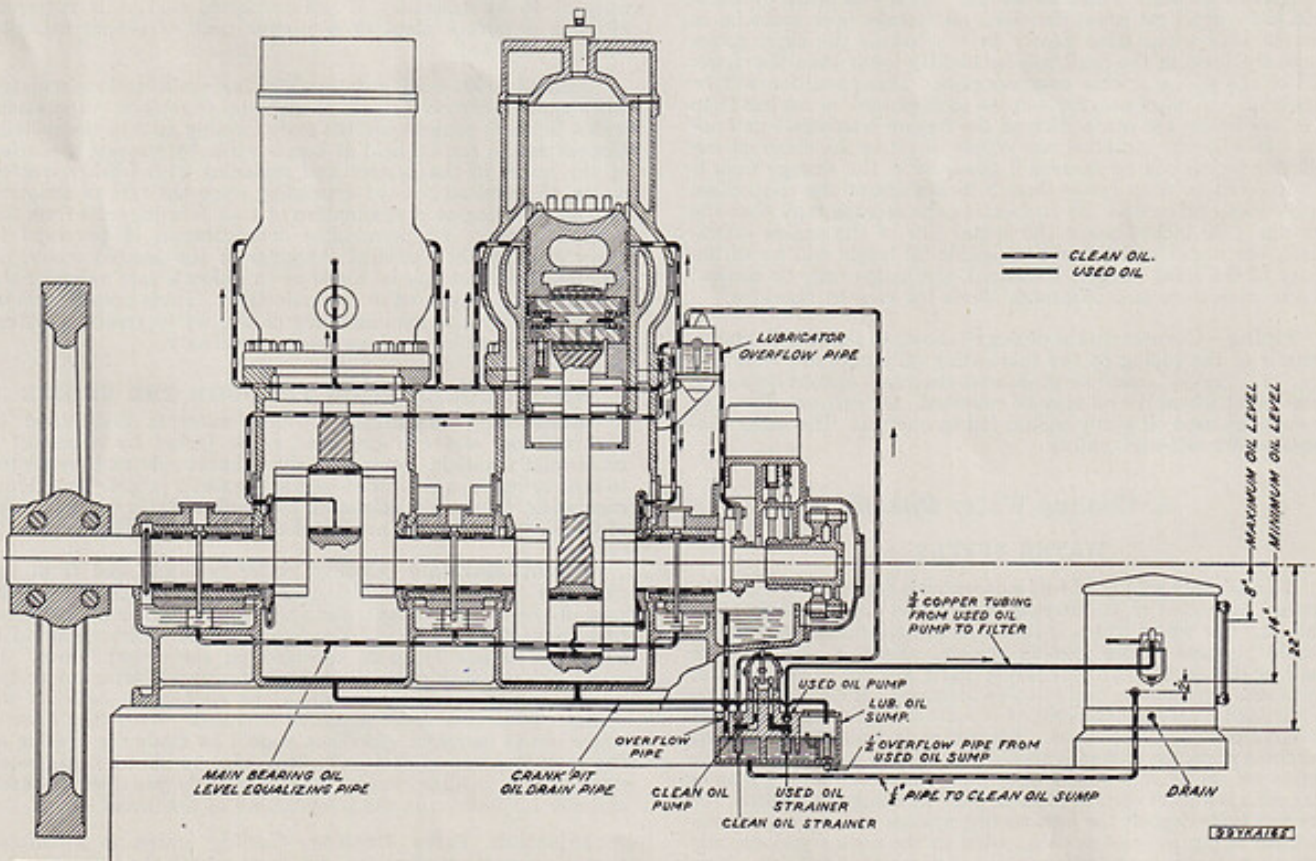


Fig. 12. Lubrication Diagram

supply to the clean oil pump, the governor spider and main bearing oil rings will swing clear of the oil and lubrication will cease. On the other hand, if the level is excessively high, oil will overflow from the bearing oil wells and flood the crankcases.

TREATMENT OF HARD WATER

When the cooling water supply is known to contain scale forming ingredients, a reliable manufacturer of water softening systems should be consulted. Two methods of water treatment are in general use, the proper one of which should be prescribed by a competent authority, after an analysis and survey has been made of the particular case in question. Such a diversity exists in the characteristics of water found in different localities that no intelligent recommendations can be given until all data are available.

The general methods of water treatment are:

- (a) Chemical Treatment.
- (b) Zeolite Treatment.

Method (a) consists of the addition of certain chemicals to the water which react with the salts, sulphates, carbonates, etc., held in solution. This reaction precipitates most of the scale forming ingredients so that they can be removed by settlement in separate tanks before putting the water in the cooling system, or it may leave some of them in solution, but so change them that no scale will be deposited.

Method (b) consists of forcing the water to be softened through a bed of "Zeolite" sand. This mineral, commonly known as the green sands of New Jersey, has the property of removing calcium and magnesium elements from the water and replacing them with sodium, or, in other words, changing the scale forming lime and magnesia salts to sodium salts, which are not scale forming. By properly regulating the flow of water through the "Zeolite" sand scale forming salts can be removed. After a certain amount of water has been treated, the active sodium in the Zeolite becomes so far exhausted that the water is no longer properly softened. The Zeolite is then rejuvenated by passing brine (made from common salt), through it. During this process, the lime and magnesia elements held by the Zeolite are exchanged for the sodium element in the salt, the lime and magnesia being carried away to waste as calcium and magnesium chlorides. After a short time, usually from 10 to 25 minutes, the Zeolite will have resumed its original state and the treatment can be stopped. Salt consumption and the frequency of regeneration will be governed by the hardness of the water and the amount to be treated. If uninterrupted service is required, either a duplicate plant or a storage tank of proper capacity must be installed.

Treated jacket cooling water which is recooled and recirculated will require a certain percent of make-up to replace evaporation, which tends to concentrate the scale forming salts in the system. Concentration can be held at a safe value by wasting a portion of the water in the system and replacing with freshly treated water, the amount wasted depending upon the rate of evaporation and the degree of elimination of scale forming salts from the treated water. As permissible concentration is governed in every case by the chemical character of the treated water, no general statement can be made as to either a safe value or the method to be employed in determining it. These points must be determined by the manufacturer of the water treating system in use and recommendations made accordingly.

WATER CIRCULATION THROUGH THE ENGINE

Main Inlet Manifold—Cooling water is distributed to each cylinder and cylinder head water jacket by means of a main inlet manifold located on the exhaust side and connected to each cylinder at the lowest part of the water jacket. Individual regulating valves for balancing the jacket water temperatures of the several cylinders are installed in the main inlet manifold.

Outlet Manifold—Cooling water is discharged from the cylinders through individual overflow pipes connected at the tops of the cylinder heads, and then flows into the outlet manifold connected to the cylinder heads. The outlet manifold is furnished in two types as specified on the order; "open," in which the overflow pipes discharge into funnels attached to the manifold, and "closed," in which the connection between the cylinder head and outlet manifold is closed. With the "closed" water outlet manifold, provision should be made for venting at the highest point of each cylinder. Fig. 14 shows a suggested method. A cooling water thermometer is provided at each cylinder for indicating the temperature of the outlet water.

Injection Valve Cooling—Cooling water is circulated through the injection valves. On engines with the "open" water outlet manifold, the injection valve cooling water outlet from

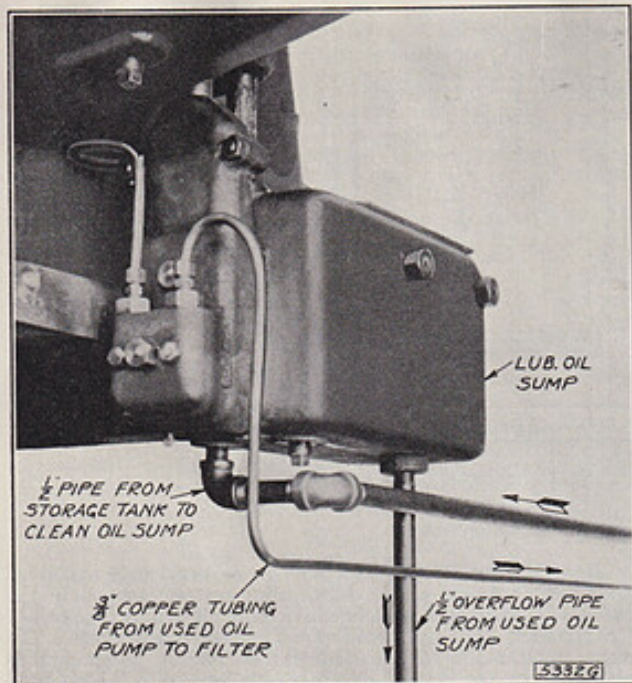


Fig. 13. Piping at Lubricating Oil Sump

Install Storage Tank at Proper Level—In order to maintain the correct oil level, the clean oil storage tank must be so located that when filled nearly to the top of the sight gauge glass, the level in the tank will be slightly lower than the upper end of the governor case overflow pipe. This condition will be met when the maximum level in the storage tank is not less than 8 inches below the center line of the engine crankshaft as indicated in Fig. 12. An adequate supply of oil to the clean oil circulating pump will be assured if the level in the storage tank is not allowed to drop lower than 2 inches above the connection to the clean oil sump. By so locating the storage tank that the bottom is 22 inches below the center line of the engine crankshaft, the upper and lower permissible oil levels will be within range of the sight gauge. If desired, the gauge may be marked at the maximum and minimum levels for ease in checking.

Piping—Connect up the piping as shown in the two diagrams. Details of the piping at the lubricating oil sump, are shown in Fig. 13. The $\frac{1}{2}$ " overflow pipe from the sump should be run to some point where the oil may be collected. Oil will overflow only in case the used oil pump should fail to operate. The other connections are self-explanatory.

6. Cooling Water System

WATER SUPPLY

An adequate supply of cool soft water is essential to the satisfactory operation of an internal combustion engine. Only clean soft water or water which is free from scale forming ingredients, should be used in the cooling system. Even a thin layer of scale or dirt on the cylinder jacket walls will act as an insulator and cause overheating and possible breakage. If clean rain water or distilled water is available, it is suitable for cooling purposes without previous treatment. Sea water is suitable for cooling purposes when the engine is specially equipped to resist corrosive action set up by salt water. Any hard water containing lime or magnesia is almost certain to cause scale and must be treated. To prevent scale deposit the best cooling system and the one recommended is the indirect system, using in the engine jackets only soft water which is cooled by means of raw water and some form of heat exchanger.

each valve is piped by means of copper tubing to each funnel. On engines with the "closed" water outlet manifold the outlet from each valve is piped to a header which must be piped separately to the hot well or drain. Connect each valve directly to the engine cooling water inlet header. This is necessary so that the valves will get the coolest water and at the highest pressure. This is indicated in Fig. 14.

COOLING WATER CIRCULATION RATES

The proper cooling of the cylinder, cylinder heads and pistons of a Diesel engine is one of the most important functions of Diesel engine operation. In the different types of engines, the amount of heat transferred from the engine to the cooling water is not the same and consequently the range of temperature from the outlet to the inlet is variable.

To avoid extremes of expansion and contraction between various parts of the engine, it is desirable to keep this temperature range small. Furthermore, air and steam accumulations must be rapidly removed. To accomplish this, a large amount of water must be circulated at a relatively high rate of flow.

The two kinds of systems used are:

- (a) Indirect
- (b) Direct

In (a) soft water is circulated through a closed system composed of the engine jackets, a water cooled heat exchanger or an air cooled radiator, an expansion tank and the necessary pump, piping and fittings. With this system a maximum cylinder outlet temperature of 160°F must not be exceeded. At full load, approximately 30 gallons of soft water per brake horsepower per hour must be circulated to maintain satisfactory cooling and with this condition a temperature range (outlet to inlet) not exceeding 15° must be maintained. A temperature range of from 5° to 7° is preferable. If the engine runs too cool it might be necessary to divert a portion of the warm outlet water to the pump suction. In indirect systems the flow of soft water should never be restricted. The engine temperature should be controlled by controlling the flow of raw water or air or by bypassing warm soft water from the engine outlet back to the engine inlet without going through the cooler or radiator.

The heat exchanger or the radiator should be large enough and the flow of raw water or air should be sufficient to maintain the temperature indicated for the soft water. It is not necessary to maintain the small temperature range in the raw water circuit as in the soft water circuit. The raw water used for the heat exchanger is recooled by means of a cooling pond or tower or it may be wasted. Systems of this sort are illustrated on pages 15, 16 and 17.

In (b) all the water used is circulated through the engine system which consists of the engine jackets, a cooling pond or tower (if used) and the necessary pump, piping and fittings. The water may be recooled by means of a cooling pond or tower as indicated and then recirculated or, if plenty of soft water is available, the water may be wasted (allowed to run back to the river or lake or other source from which it was obtained).

With a direct cooling system, using water in which the concentration of scale forming ingredients can never become harmful, a maximum cylinder outlet temperature of 140°F may be maintained but must not be exceeded.

With a direct cooling system, using raw water having a limited amount of scale forming ingredients, the maximum cylinder outlet temperature of 120°F must not be exceeded.

In all direct cooling systems the circulation rate must be approximately 20 gallons per brake horsepower per hour and the temperature range (outlet to inlet) of 5° to 15° should be maintained. To maintain this temperature range, it may be necessary to divert a portion of the warm outlet water to the suction of the circulating pump. Direct cooling systems are illustrated on pages 18, 19 and 20.

METHOD OF CIRCULATION

Positive Circulation—In any type of cooling system for these engines it is necessary to positively circulate the cooling water through the engine water jackets. Positive water circulation can be insured either by pumping the water directly through the water jackets or by pumping the water to an overhead tank and allowing the water to circulate by gravity.

Figs. 15, 16, 17, 19 and 20 show cooling water systems in which the water is circulated through the engine by gravity. Figs. 18 and 21 show cooling water systems in which the water is circulated through the engine by means of a pump.

CIRCULATING PUMPS

Pump Capacities—The capacity of the water pumps depends upon the type of cooling system installed. See above under "Cooling Water Circulation Rates."

Centrifugal Pumps—Centrifugal pumps are recommended for circulation of cooling water when the total dynamic head is within their range of performance. When the head is beyond this range or if a suction lift is imposed then positive displacement pumps must be used.

Positive Displacement Pumps—When positive displacement pumps are used they must be fitted for hot water. A pressure relief valve must be installed in the discharge line close to the pump without a shut-off valve between it and the pump. Set the relief valve 5 pounds per square inch higher than the discharge pressure.

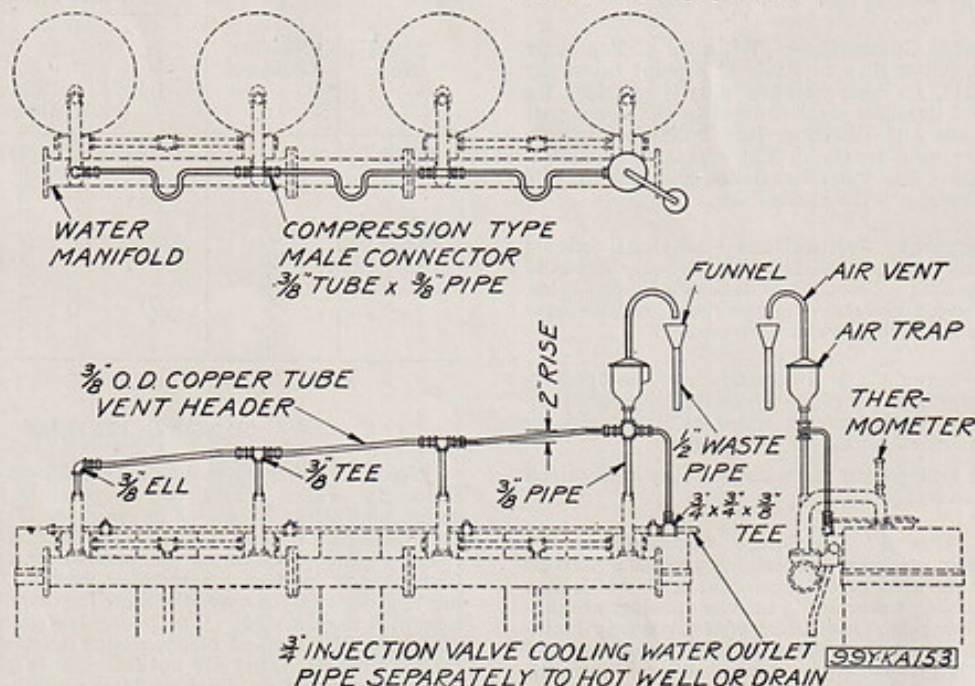


Fig. 14. Diagram of Vent Piping for "Closed" Discharge Connections with Single Vent Header and Air Trap

Location of Pumps—All centrifugal pumps should be located in such a position that the top of the pump is below the low water level.

**GENERAL INSTALLATION DATA
ON COOLING SYSTEMS**

Schematic Layouts—The cooling system diagrams shown on the pages immediately following are schematic layouts showing in a general way only, the method of connecting up the various types of cooling systems described later in the text.

Manifold Pipe Connections—Details of the manifold pipe connections are shown on the pipe connection plan which is furnished with each engine. Pipe sizes tabulated on this page refer to the main inlet and outlet pipes. The piping should be run down into a trench under the floor, by the shortest route; otherwise, run the pipes horizontally to the wall and then down, making the neatest and most convenient arrangement possible.

Emergency Cooling Water Connection—When running water under pressure or from a high tank is available, the piping should be so arranged that in an emergency, the regular cooling water supply can be shut off and the running water used instead. Such a precaution may eliminate costly shut downs, if repairs in the cooling water system should become necessary. The emergency inlet and outlet connections may be made at the opposite ends of the manifold from that used for the regular cooling water system, or the emergency supply may be run into the overhead tank.

Engine Control Valves—The inlet water manifold is equipped with control valves at each cylinder. These valves should be wide open when the engine is first started. After the temperatures have become constant, the valves on the cylinders having the lowest temperatures should be adjusted until the outlet temperatures of all cylinders are uniform.

Water Supply Valves—A valve should be placed in the main supply line as shown in the diagrams. This valve should not be used to regulate the flow of water to the engine, unless the rate is in excess of the recommended rate.

Water Inlet Valve—When the emergency cooling water connections are made at the opposite end of the manifold from the regular connections, a valve should be placed in each inlet line. With this arrangement, the emergency inlet will be closed when the regular inlet is being used, and vice versa.

"Open" Discharge Connections—When the cooling water outlet is piped to a hot well or to waste at a point below the water outlet manifold, an open overflow pipe is provided for each cylinder. These overflow pipes connect to the upper part of the cylinder heads and discharge into individual funnels attached to the water outlet manifold. This arrangement enables the operator to observe the water circulation and also permits any steam or air to escape to the atmosphere.

"Closed" Discharge Connections—Individual closed discharge connections are provided from the cylinder heads to the water outlet manifold. These pipes have two tapped holes, one for 3/8" pipe to accommodate a vent or riser, and the other for 1/2" pipe to take the cooling water thermometer.

Thermometer—Screw the thermometers into the openings provided in each water overflow pipe. These thermometers indicate the temperature of the cooling water as it leaves each cylinder, and their location should not be changed.

Inexpensive high temperature alarm devices may be obtained and are recommended equipment.

Venting for "Closed" Discharge Connections—On engines with the closed discharge connections, provision must be made for venting to the atmosphere any steam or air which may separate from the cooling water. 3/8" pipe tap openings are provided in each overflow pipe. Individual vent pipes may be installed in these openings, or the openings may be connected to a header pipe which is given a slight upward slope toward the outlet end and which may be connected to a high grade air trap located in the engine room, or to the overhead tank.

Pressure Relief Valve—On cooling systems using a displacement pump which discharges directly to the water jackets, a pressure relief valve must be installed near the pump discharge. This valve should be set to open at a pressure of 5 pounds per sq. in. higher than the working pressure in the system.

Pump Shut-off Valves—All water pumps should be equipped with valves on both the suction and discharge sides to allow the removal of the pump without draining the system.

Low Water Alarms—Low water alarms of a good commercial type should be installed in the overhead tank and hot well to warn the operator when the supply has reached the low level.

Overflow Connections—All tanks, hot or cold wells, catch basins, etc., should be provided with overflow pipes connected to some other part of the system or to the sewer.

Drains—The lower water manifold is provided with drain connections to which a drain pipe may be attached. Plugged openings are provided in the lower flange of each cylinder for completely draining the cylinders when there is danger of freezing or when the jackets are cleaned. On multi-cylinder engines, where frequent draining is necessary a drain header should be connected to these openings. All other low points in the system should be provided with proper drains.

Connections and Fittings—Make all water connection joints tight, using white lead. Avoid unnecessary bends, and use gate valves throughout the system to minimize pipe friction.

Cooling Water Pipe Sizes—The following pipe sizes are recommended in piping cooling water to the engine. They are based on a circulation of 30 gallons per rated engine horsepower per hour, and on a friction head corresponding to 100 feet of straight pipe. Should this value be exceeded by the length of run, or by the introduction of an excessive number of elbows in the line a correspondingly larger pipe size must be selected.

Anti-Freeze Solutions—Where there is a possibility of freezing, an anti-freeze solution may be used if desired. A reliable variety of anti-freeze material should be used and the strength of the solution must at all times be sufficient for adequate protection.

Cooling Water Pipe Sizes:

Model No.	Number Cylinders	Water Pipe Size, Inches		
		Inlet	Outlet	
			Closed Overflow	Open Overflow
32E12	1	1 1/2	1 1/2	2
	2	2 1/2	3	3
	3	2 1/2	3	3
32E14	1	2	2	2 1/2
	2	2 1/2	2 1/2	3
	3	3	3	4
	4	3	3	4
	5	4	4	5
	6	4	4	5

COOLING SYSTEMS

General—After the cooling water has been circulated through the engine water jackets, the temperature is raised, and the water must either be wasted or recooled. The choice of a cooling system will depend so much upon local conditions that only the most general of recommendations can be made for an installation without first taking a complete survey. The following outline and descriptions cover the more important points in connection with each system. The piping layouts show in a general way only, the method of connecting up the various types of cooling systems. They are not intended to give the exact location of equipment or piping, as local conditions must determine the most convenient and practical arrangement.

Outline of Cooling Systems—The following outline shows the principal cooling arrangements for stationary installations, in their order of desirability.

I. Closed Cooling System:

- a. Engine cooling water re-cooled by means of raw water and
 1. Commercial Heat Exchanger, or
 2. Pipe Coil Cooler.

In which system the raw water is either

- 1. Wasted or
- 2. Re-cooled by
 - (a) Spray Tower, or
 - (b) Cooling Tower, or
 - (c) Spray Pond

- b. Engine cooling water re-cooled by means of air and
 1. Radiator.

II. Atmospheric Cooling System:

Engine cooling water re-cooled by means of

- 1. Spray Tower, or
- 2. Cooling Tower, or
- 3. Spray Pond.

III. Running Water Cooling System:

Engine Cooling water circulated and run to waste.

- 1. Untreated water may be used when suitable.

In the outline of cooling arrangements above, the recooling systems are shown as preferable to running water systems because in a great majority of installations, the available water

supply is limited or if not limited, will not be suitable for cooling purposes on account of hardness. In localities where an unlimited supply of suitable water is available, the running water system is obviously preferable.

Indirect System—If a recooling system is used, either on account of scarcity or scale forming properties of the available water supply, an indirect cooling system is strongly recommended. In this system soft rain water or treated water is circulated continuously through the engine water jackets and is re-cooled by means of a heat exchanger. Raw water, used as the cooling medium, can either be wasted or re-cooled. The indirect cooling system is always to be preferred as the soft cooling water is not exposed to the atmosphere, and evaporation losses are negligible. For this reason, a small and inexpensive water softening plant will take care of all make-up water requirements.

Direct System—In case the installation of an indirect cooling system is undesirable, a direct cooling system using an atmospheric re-cooler such as a spray tower, cooling tower, or spray pond can be used. In this system, the engine cooling water is re-cooled both by exposure to the open air and by evaporation. The losses by evaporation and windage will average approximately 2 1/4%, which must be made up with raw water treated to "zero" hardness. Weekly samples of the water in the system should be submitted to the manufacturer of the water softening system to make sure that concentration is not taking place with resultant increase in hardness. A larger water treating plant will be required for treating make-up water than is necessary for the indirect or closed system. With this system it will be necessary to treat the jackets occasionally with acid, as there will be a gradual accumulation of scale due to imperfect manipulation of the treating system.

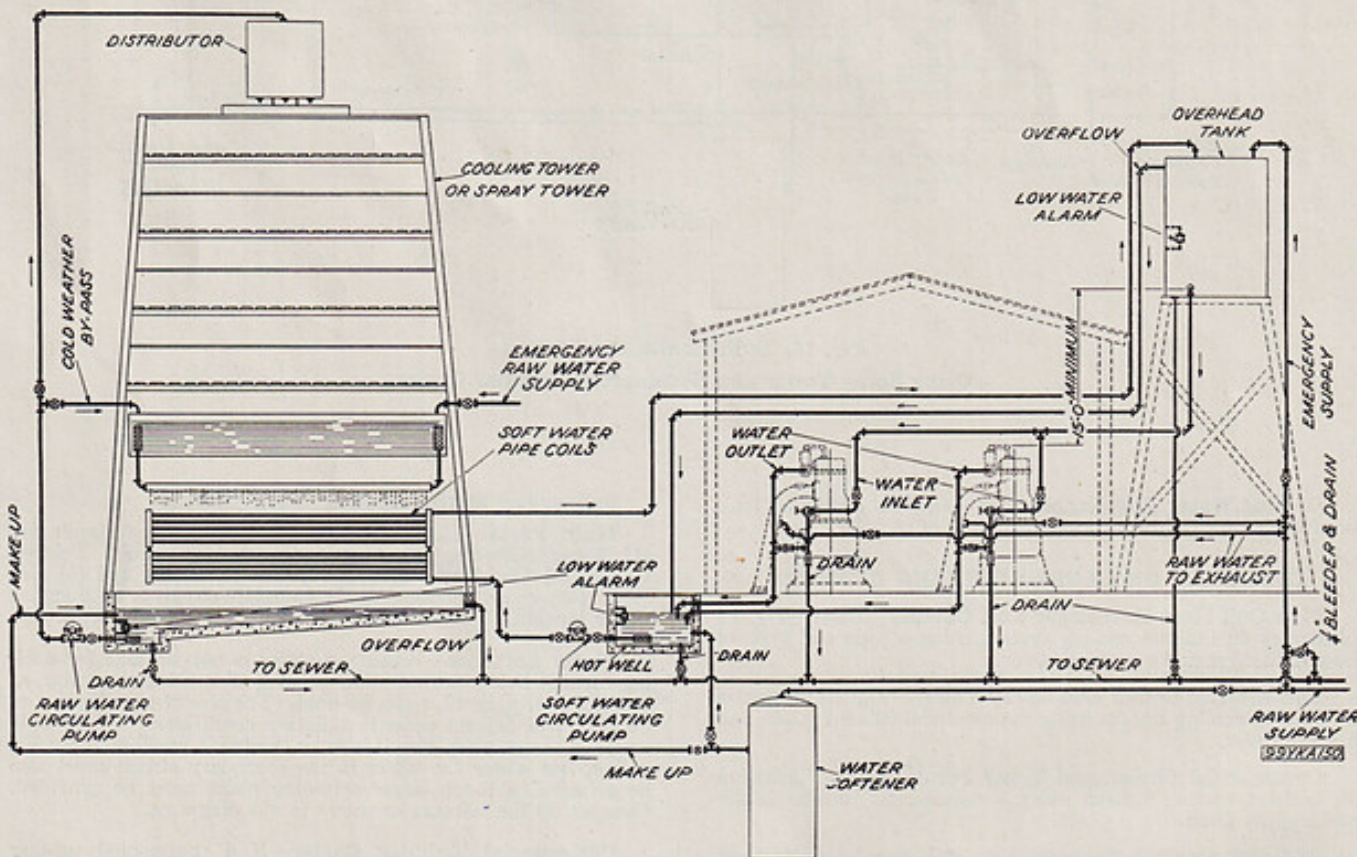


Fig. 15. Indirect Cooling System
Using Cooling Tower and Pipe Coils

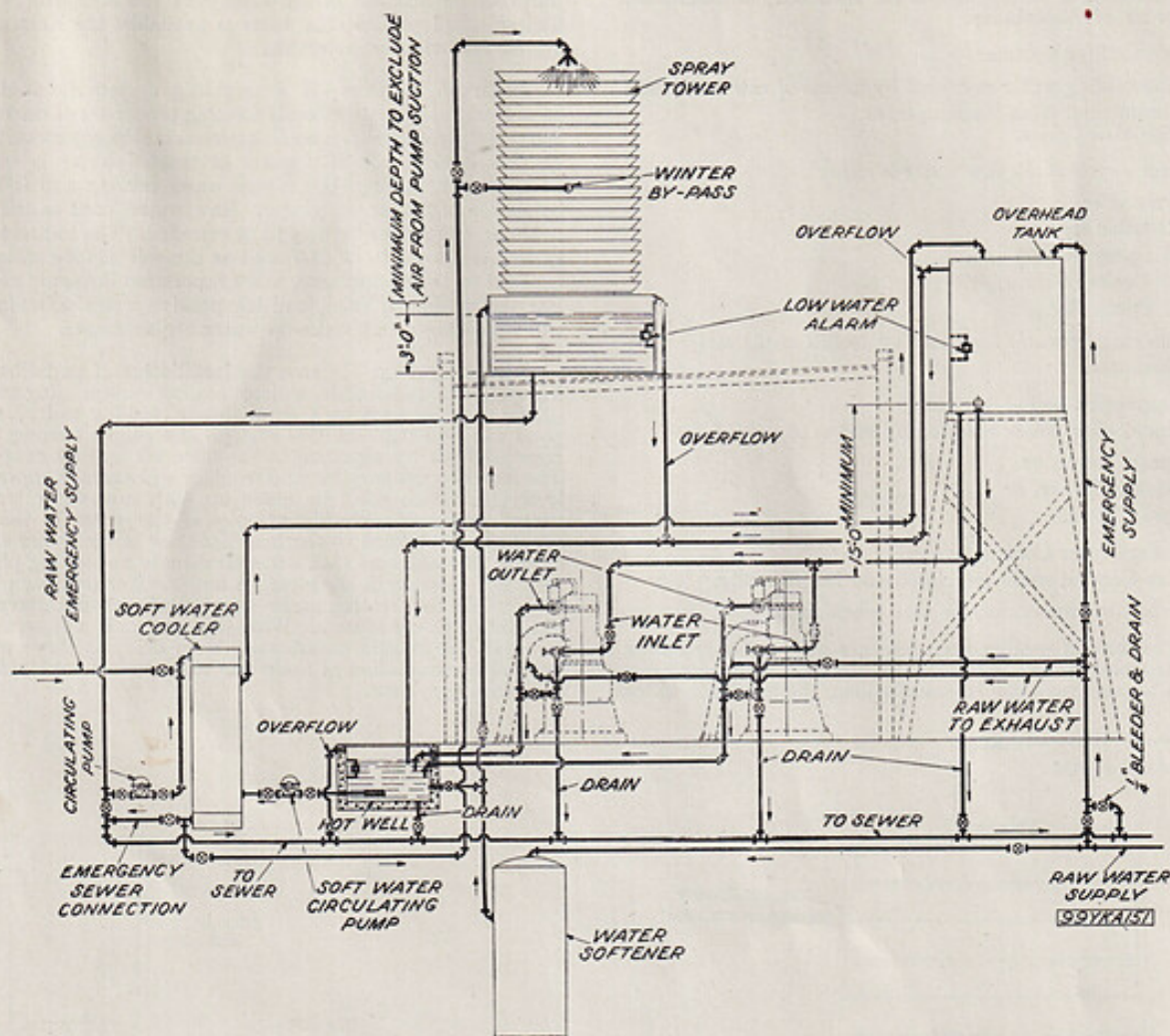


Fig. 16. Indirect Cooling System
Using Spray Tower and Commercial Tubular Cooler

Cooling Water Heat Exchangers—The heat exchanger may be either a pipe coil or a commercial type of recoler.

INDIRECT OR CLOSED COOLING SYSTEMS

Pipe Coil Heat Exchanger and Cooling Tower—Fig. 15 illustrates an indirect cooling system using a pipe coil type of heat exchanger and a cooling tower.

Commercial Cooler and Spray Tower—Fig. 16 illustrates an indirect cooling system using a commercial tubular cooler and a spray tower.

Commercial Cooler and Spray Pond—Fig. 17 illustrates an indirect cooling system using a commercial tubular cooler and a spray pond.

Radiator Cooling System—Fig. 18 illustrates an indirect cooling system using a radiator. This cooling system is somewhat different from the three systems listed above, and will be discussed separately on page 19.

Circuits Discussed Separately—Since the primary or engine cooling circuits in the three diagrams are somewhat similar, and the same is true of the secondary or raw water circuits, the two circuits will be discussed separately.

Primary or Engine Cooling Water Circuit

Main Parts—The main parts in the primary circuit are (1) Water Softener, (2) Pipe Coils or Commercial Tubular Cooler, (3) Circulating Pumps, (4) Gravity Tank, and (5) Hot Well. Other parts making up the complete circuit are the engine water jackets, piping, strainers, valves, low water alarms, etc.

Water Softener—When the water is not suitable for cooling without being treated, some method of treating the water, as described on page 12, must be used. The size of the softener to be used will depend upon installation conditions. Where only water in the primary circuit is to be treated, a small softener will suffice, but where the water in the secondary circuit must also be softened, a much larger softening plant must be provided. Connect up the softener as shown in the diagrams.

Commercial Tubular Cooler—If a commercial tubular cooler is to be used, it should be of a reliable make. Connect the cooler into the system as indicated in the diagrams.

Commercial coolers should be installed in a vertical position wherever possible as the tube bundle can be more readily removed and replaced when cleaning, and less floor space is required. The raw and soft water compartments must be vented at the highest points to avoid air pocketing.

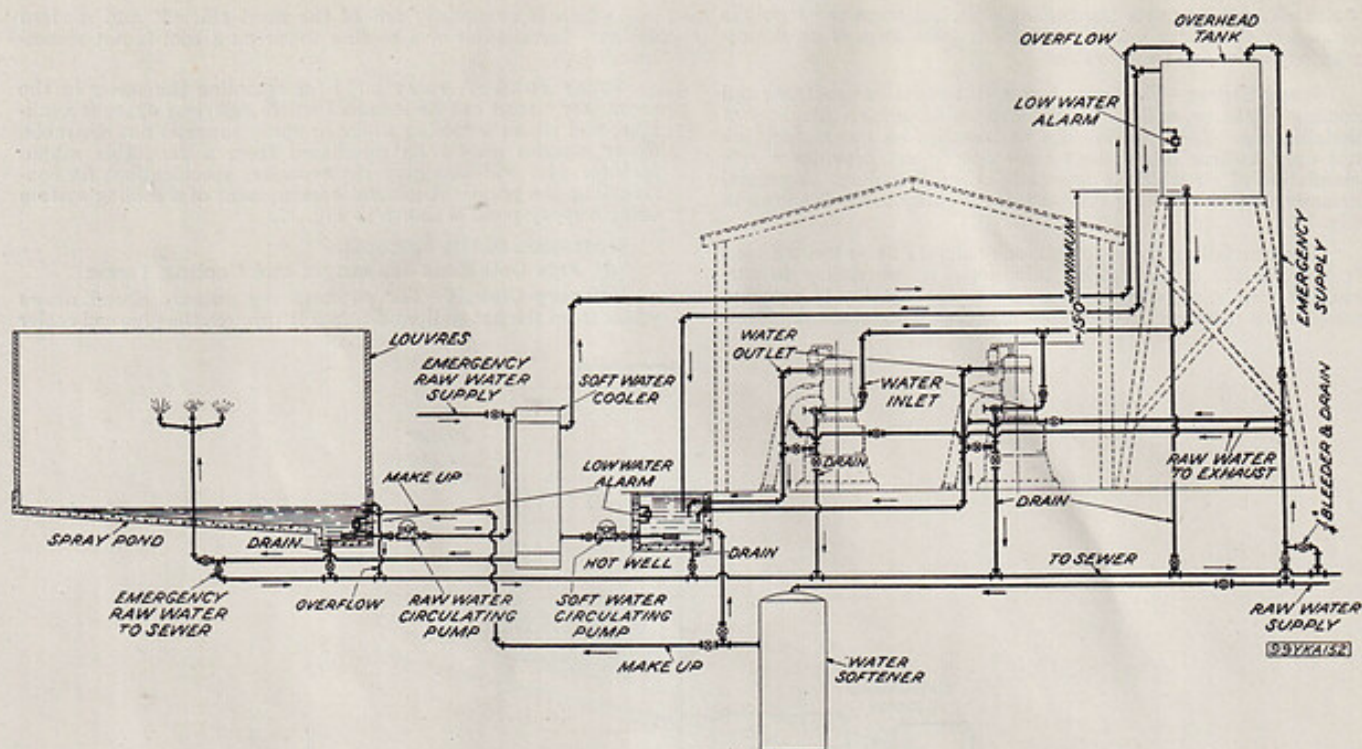


Fig. 17. Indirect Cooling System Using Spray Pond and Commercial Tubular Cooler

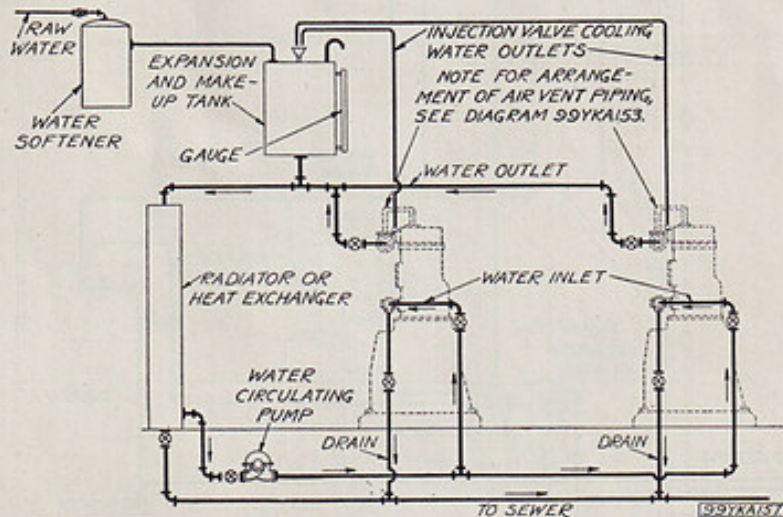


Fig. 18. Indirect Cooling System Using Radiator or Heat Exchanger with Pump Circulation

Note:—See Fig. 14 for diagram 99YKA153.

Pipe Coils—Pipe coil coolers should be purchased from a reliable manufacturer of such equipment. These manufacturers can ordinarily be expected to install the system so as to function most efficiently.

Overhead Tank—The overhead tank should have a capacity of from 2 to 5 gallons per rated horsepower and should be placed at a minimum height of 15'-0" above the highest point in the water jacket. The tank should be equipped with a low water alarm. Connect up the tank as shown in the diagrams.

Hot Well—The hot well in the primary circuit should have a minimum capacity of 6 gallons per rated engine horsepower, and preferably should have a capacity sufficient to allow draining of the engine water jackets and overhead gravity tank. A strainer

should be placed on the suction pipe, and a low water alarm should be installed in the well.

Pipe Sizes—The table on page 14 gives recommended pipe sizes for the various engines.

Secondary or Raw Water Cooling Circuit

Main Parts—The main parts of the secondary circuit are (1) Spray Tower, Cooling Tower or Spray Pond, (2) Water Softener, (3) Distributor, (4) Circulating Water Pump, and (5) Catch Basin.

Cooling Water—It is highly desirable that the cooling water for the secondary circuit be free from scale forming ingredients, for scale on the pipes or in the cooler will cause a marked reduction in their efficiency. If an unlimited supply of reasonably soft water is available for this purpose, the water may be run to

II. Installation Instructions—Fairbanks-Morse Diesel Engines

waste after passing over the cooling coils, but when the supply is limited or the water must be softened, some form of an atmospheric recoler will be desirable.

Spray Tower—The spray tower, due to its compactness and cooling efficiency, will be found most suitable for a majority of installations. These towers can be installed on the roof, which not only utilizes otherwise useless space, but provides a free circulation of air which is essential for rapid cooling. A general arrangement of a cooling system using a spray tower is shown in Fig. 16.

When installing spray towers, they should be so located that free circulation of air will be unhindered by proximity to surrounding walls, or, when several towers are installed in a group, a minimum distance between towers must be maintained. Mini-

but which is necessarily not of the most efficient and modern design. Installation of a cooling tower on a roof is not recommended.

Spray Pond—A spray pond for recooling the water in the secondary circuit can be installed where sufficient space is available, and where a cooling tower or spray tower is not desirable. Spray nozzles should be purchased from a reputable manufacturer who will also give the necessary specifications for constructing the pond. A general arrangement of a cooling system using a spray pond is shown in Fig. 17.

Operation of the Systems.

(d) Pipe Coil Heat Exchanger and Cooling Tower

Primary Circuit—The pump in the primary circuit draws water from the hot well, and forces it through the pipe coil cooler

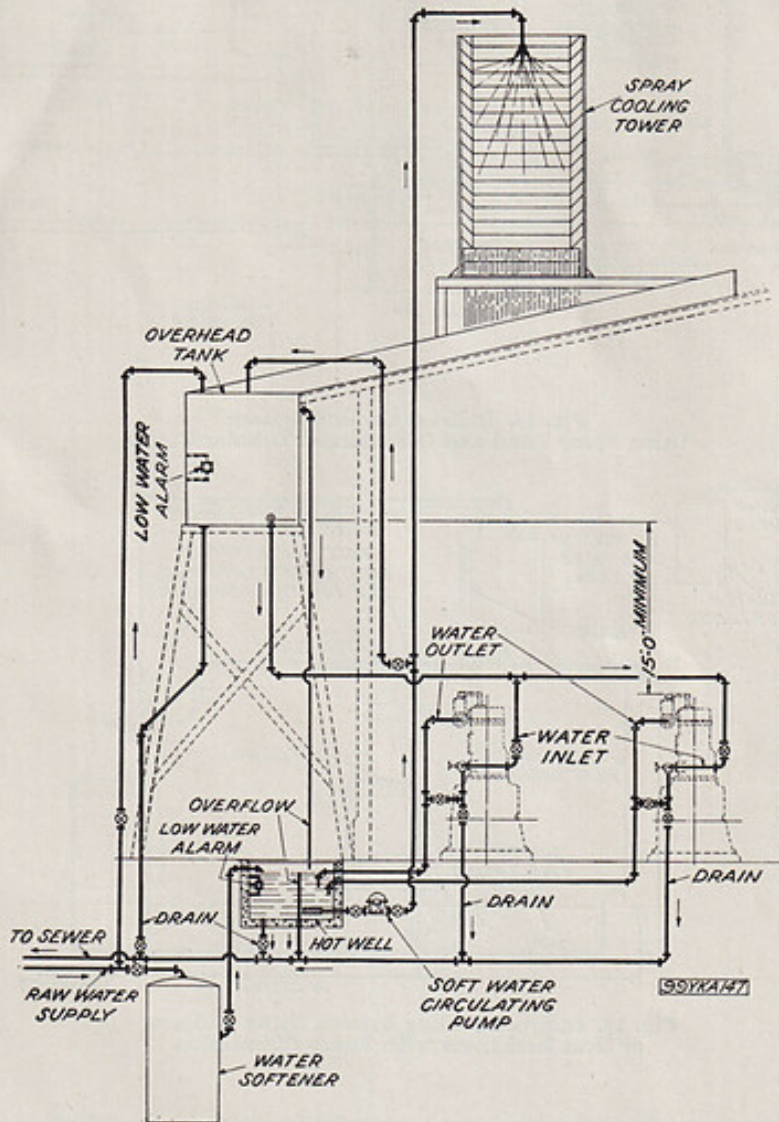


Fig. 19. Direct Cooling System Using Spray Tower

imum recommendations are 8 feet clear distance between towers and 20 feet clear distance between any tower and the nearest wall.

Cooling Tower—A cooling tower for recooling the water in the secondary circuit is shown in Fig. 15. If a cooling tower is to be installed, it is strongly recommended that a reputable manufacturer of cooling towers be consulted, so that the very best type of tower for any specific installation will be obtained. The Manufacturing Division is prepared to furnish working drawings for an efficient type of cooling tower particularly for single unit installations which is free from all patent interference

to the overhead tank. From this tank, the water flows by gravity through the engine water jackets and back to the hot well, where it is ready for circulation again.

Secondary Circuit—The pump in the secondary circuit draws water from the reservoir below the tower and delivers it to the distributor in the cooling tower. The cool water is then collected in a second reservoir above the pipe coils from which it is distributed over the pipe coils. The warm water is collected in the lower reservoir where it is again ready for circulation.

Temperature Control—The pumps should be regulated so that approximately 30 gallons of water per rated horse power per

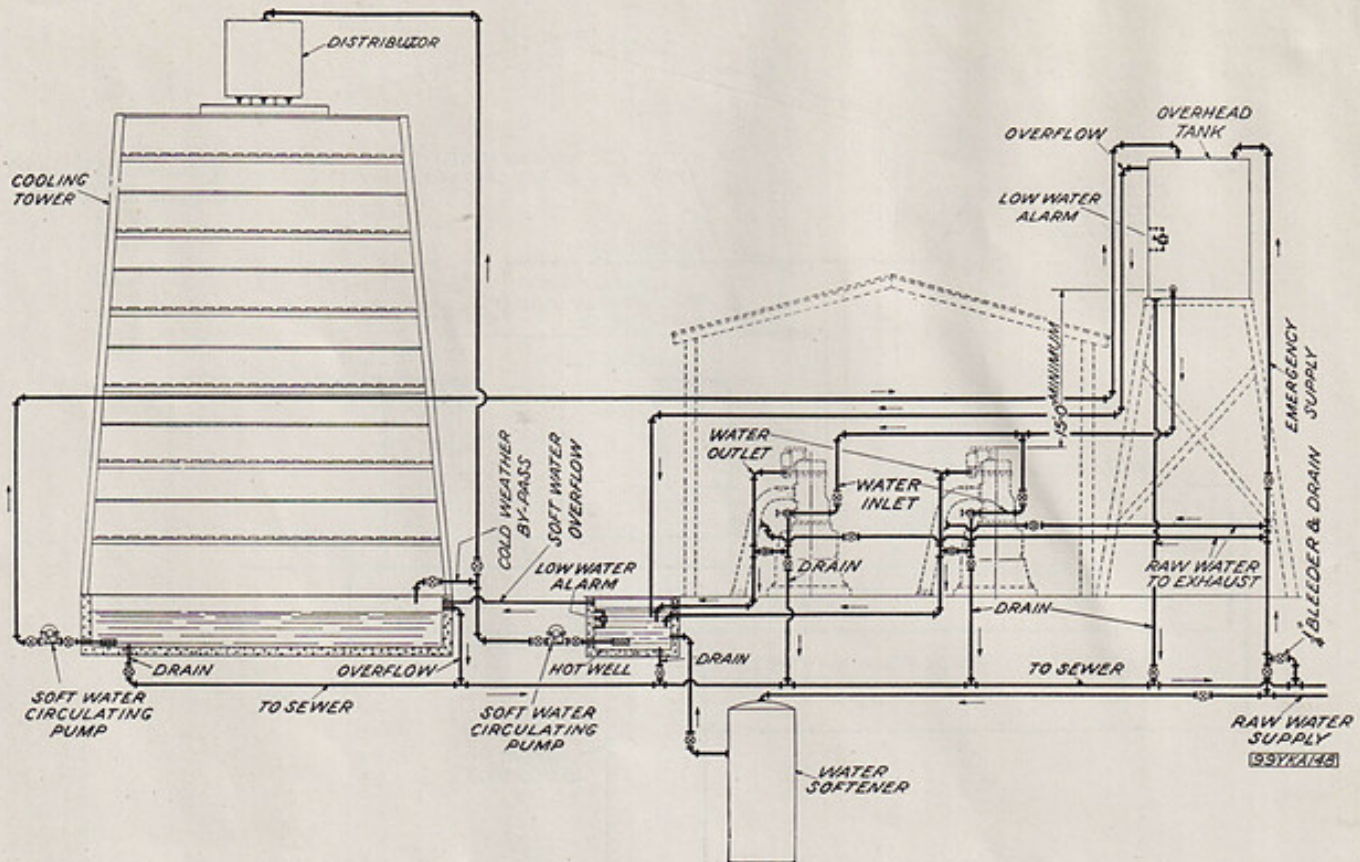


Fig. 20. Direct Cooling System Using Cooling Tower

hour are being circulated in each circuit. The jacket water temperature is controlled by adjusting a by-pass valve in the secondary circuit. In this way, some of the warm water may be diverted into the upper reservoir without going through the cooling tower, and the proper temperature may be easily obtained without varying the quantity of water circulated through the cooling water jackets.

(b) Commercial Cooler and Spray Tower

The operation of this system is similar to that of the pipe coils and cooling tower.

(c) Commercial Cooler and Spray Pond

The operation of this system is similar to that of the pipe coils and cooling tower.

Radiator Cooling System

Fig. 18 shows a radiator cooling system. With this system, the circulating pump forces the water directly through the cooling water jackets and into the radiator. A fan must be provided to force air through the radiator. A heat exchanger such as a commercial tubular cooler may be substituted for the radiator, but then a secondary or raw water circuit must also be provided as described on page 17.

DIRECT OR ATMOSPHERIC COOLING SYSTEMS

General—As explained previously, direct or atmospheric cooling systems are not generally desirable for direct cooling of the engine circulating water, due to the danger of concentration of scale forming salts through evaporation. By very careful treatment of the make-up water, satisfactory results can be obtained, but in the majority of cases the indirect or closed system will prove to be the most desirable.

Direct or Atmospheric Cooling Systems—The direct or atmospheric systems to be discussed are (a) Spray Tower System, (b) Cooling Tower System, and (c) Spray Pond System. Figs. 19 and 20 show these systems with gravity circulation.

Fig. 21 shows a direct cooling system with pump circulation to which a cooling tower, spray pond or spray tower may be applied.

(a) Spray Tower System

Schematic Diagram—Fig. 19 shows the general arrangement of a direct cooling system using a spray tower.

Where Suitable—Owing to the compact construction of the spray tower, it is especially suitable for installation in congested districts where ground space is at a premium. It can be installed on the roof, which not only utilizes otherwise useless space but also gives a free circulation of air, which is essential to rapid and efficient cooling.

Spray Tower Specifications—A reliable manufacturer of spray tower equipment should be consulted who will furnish specifications and will recommend the proper equipment. The recommendations should be based on a capacity of 20 gallons of circulating water per rated engine horsepower per hour.

Clearance Between Spray Towers and Buildings—When installing spray towers, they should be so located that free circulation of air will be unhindered by proximity to surrounding walls or when several towers are installed in a group, a minimum distance between towers must be maintained. Minimum recommendations are 8 feet clear distance between towers and 20 feet clear distance between any tower and the nearest wall.

Overhead Tank—The overhead tank should have a capacity of from 2 to 5 gallons per rated engine horsepower. This tank must be at an elevation of at least 15'-0" above the discharge level in the water manifold.

Hot Well—The hot well should have a minimum capacity of 6 gallons per rated engine horsepower and preferably should have sufficient capacity to allow draining the entire system.

Operation—The soft water circulating pump draws water from the hot well and forces it through the spray nozzles in the tower. The water, after being atomized, passes downward over the louvres, is cooled by evaporation and radiation, and is finally

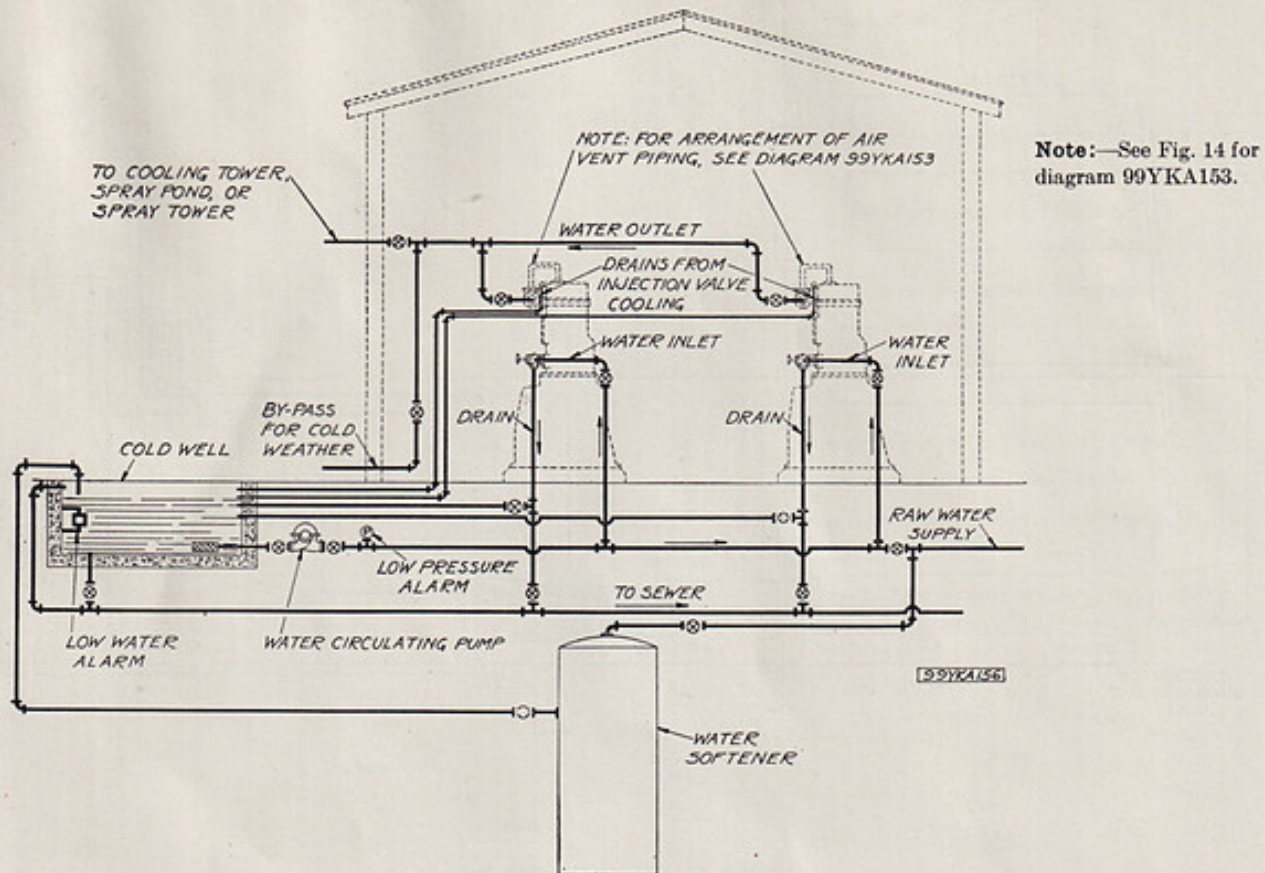


Fig. 21. Direct Cooling System with Pump Circulation

collected in the overhead tank. The water then flows by gravity through the engine water jackets and into the hot well where it is again ready for circulation.

Temperature Control—The discharge of the pump should be regulated so that approximately 20 gallons of water per horsepower per hour are being circulated. The by-pass valve permits adjustment so that the desired amount of water may be by-passed into the overhead tank without being forced through the spray nozzles to be re-cooled. Thus, temperature control may be obtained without varying the pump capacity.

(b) Cooling Tower System

Schematic Diagram—Fig. 20 shows the general arrangement of a direct cooling system using a cooling tower.

Cooling Tower Recommendations—It is strongly recommended that a reputable manufacturer of cooling towers be consulted, so that the very best type of tower for any specific installation will be obtained. The Manufacturing Division is prepared to furnish working drawings for an efficient type of cooling tower particularly for single unit installations which is free from all patent interference, but which is necessarily not of the most efficient and modern design. Installation of a cooling tower on a roof is not recommended.

Overhead Tank—The overhead tank should have a capacity of from 2 to 5 gallons per rated engine horsepower. This tank must be at an elevation of at least 15'-0" above the discharge level in the water manifold.

Hot Well—The hot well should have a minimum capacity of 6 gallons per rated engine horsepower and preferably should have sufficient capacity to allow draining the entire system.

Operation—The pump with suction in the hot well draws water from the hot well and discharges it to the distributor at the top of the cooling tower. The water then drips down the tower where it is cooled, and finally collects in the catch basin below, from where the second pump discharges it to the over-

head tank. From this tank, the water flows through the engine water jackets and into the hot well where it is again ready for circulation.

Temperature Control—Both pumps should be regulated so that they are delivering approximately 20 gallons per rated horsepower per hour. Then by means of the by-pass valve warm water from the hot well may be diverted into the catch basin without going through the cooling tower. Thus regulation may easily be obtained without varying the pump capacity.

(c) Spray Pond System

Schematic Diagram—By substituting a spray pond in place of the cooling tower in Fig. 20, this diagram will apply.

Spray Pond Specifications—A reliable manufacturer of spray pond equipment should be consulted who will furnish specifications and will recommend the proper equipment. The recommendations should be based on a capacity of 20 gallons of circulating water per rated engine horsepower per hour.

Overhead Tank—The overhead tank should have a capacity of from 2 to 5 gallons per rated engine horsepower, and should be located at an elevation of at least 15'-0" above the discharge level in the water manifold.

Hot Well—The hot well should have a minimum capacity of 6 gallons per rated engine horsepower, and preferably should have sufficient capacity to allow draining the entire system.

Operation—The pump with suction in the hot well draws water from the hot well and discharges it through the spray nozzles, thus re-cooling it. The water collects in the spray pond from where the second pump draws and delivers it to the overhead tank. From this tank the water flows through the engine water jackets and into the hot well where it is again ready for circulation.

Temperature Control—Both pumps should be regulated so that they are delivering approximately 20 gallons per rated horsepower per hour. Then by means of the by-pass valve

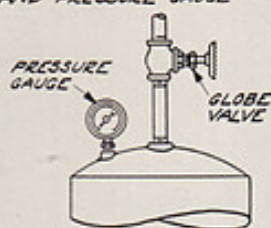
warm water from the hot well may be by-passed directly into the spray pond without going through the spray nozzles. Thus regulation may easily be obtained without varying the pump capacity.

Direct Cooling System with Pump Circulation—The cooling systems discussed in the paragraphs immediately preceding were provided with an overhead tank and gravity circulation through the engine. In some cases, however, due to extremely low temperatures or to the increased cost, this arrangement may not be desirable. An optional arrangement, shown in Fig. 21 in which the pump circulates water directly through the engine, may then be used.

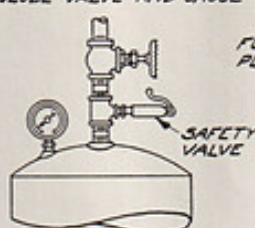
RUNNING WATER COOLING SYSTEM

In a running water cooling system, a reservoir should be provided, and the piping should be so arranged that part of the water may be by-passed back into the reservoir. With this arrangement, temperature control can be obtained by regulating the by-pass rather than by varying the pump capacity.

RECOMMENDED PIPING ARRANGEMENT AT TANK WHEN USING GLOBE VALVE AND PRESSURE GAUGE



OPTIONAL PIPING ARRANGEMENT AT TANK WHEN USING SAFETY VALVE IN ADDITION TO GLOBE VALVE AND GAUGE



OPTIONAL PIPING ARRANGEMENT AT TANK WHEN USING FUSIBLE PLUG IN PLACE OF THE SAFETY VALVE

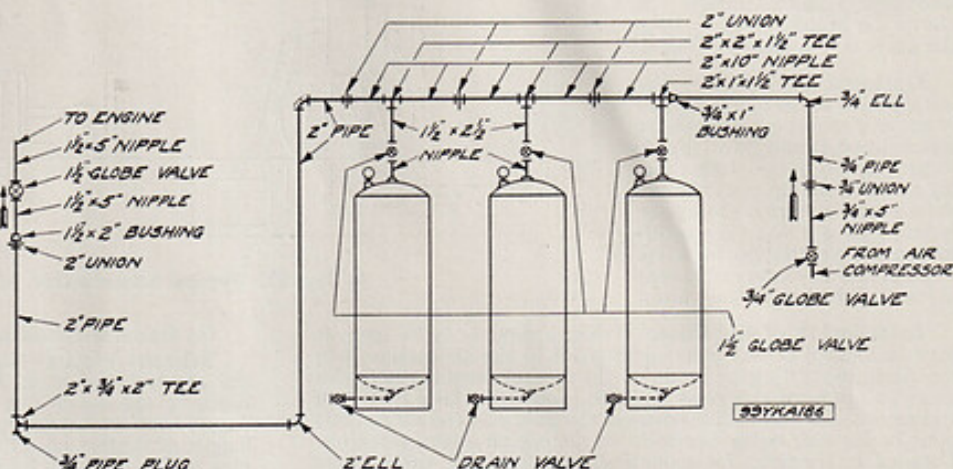
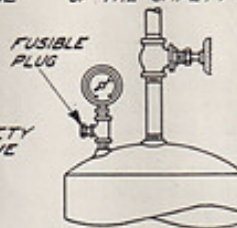


Fig. 22. Air Start Piping Diagram

7. Air Start System

Since the air starting mechanism is incorporated in the engine, installation work on the air starting system will consist of installing the air compressor, starting air tanks, and the piping from the tanks to the engine.

Air Compressor—The air compressor may be driven by a motor, an auxiliary engine, or by the engine for which it supplies the air. In the last arrangement, the drive pulley is fitted to the shaft extension. This last arrangement is not recommended unless a small independently driven auxiliary compressor is included; for, otherwise there would be no provision for supplying air for the initial start or in case of loss of air.

Air Tanks—Two 20"x60" air tanks are recommended for 1, 2, 3 and 4 cylinder engines, and three 20"x60" tanks for the 5 and 6 cylinder engines. Air tanks should conform to A.S.M.E. specifications and to the National Board requirements. Tanks conforming to such requirements may be purchased from Fairbanks, Morse & Co., Purchasing Dept., Chicago.

Pipe Fittings—Fittings used in the air line should be of the extra heavy pattern.

Air Line Valve—The air line valve should be a globe valve with lead composition disc, Jenkins Fig. 106A Spec. or equivalent make. Working pressure 250 lbs. gauge. May be ordered from Fairbanks, Morse & Co., Purchasing Dept., Chicago, on specification No. 21FM7F.

Pressure Gauge—Pressure gauge should conform to the following specifications. 1/2" male pipe thread, 4 1/2" dial, 0 to 300 lbs. per sq. in. Restricting screw with orifice .018" diameter to prevent oscillation of pointer. May be ordered from Fairbanks, Morse & Co., Purchasing Dept., Chicago, on specification No. 16FM4A2.

Air Pressure—The normal working pressure for the starting air is 225 pounds gauge pressure. In direct connected installations where the starting air must turn both the engine and the driven unit, the air should be maintained at this pressure to insure good starting.

Arrangement of Equipment—Fig. 22 shows a typical arrangement of air starting equipment. Drains should be provided for all tanks, and at the low point in the main pipe line. Either drain plugs or valves may be used in the line, but valves must be used for the tanks. Avoid all unnecessary joints, and make each connection carefully, using thick shellac or a mixture of litharge and glycerine.

Pipe Sizes—The following table gives pipe sizes for the air line depending upon the distance from the tanks to the engine

Model Numbers	Bore and Stroke	Air Pipe Sizes	
		Max. Length, Feet	Diameter
32	12x15"	25	2"
		50	2"
32	14x17"	25	2 1/4"
		50	2 1/4"

Pipe and Fittings—The following tabulation lists pipe and fittings with the exception of valves and pressure gauges, to cover an average installation. This equipment may be obtained through the Fairbanks, Morse & Co., Purchasing Dept., Chicago, or may be purchased locally.

Pipe and Fittings Required to Connect Air Starting System on Models 32E12 and 32E14 Stationary Diesel Engines

Quantity			Size	Material	Description
1 Tank	2 Tanks	3 Tanks			
2	4	6	1 3/4" x 2 3/4"	*W.I.	Nipple
1	1	1	2" x 1" x 1 1/4"	C.I.	Reducing Tee—Ex. Hvy.
1	1	2	2" x 2" x 1 1/2"	C.I.	Reducing Tee—Ex. Hvy.
1	3	5	2" x 10"	*W.I.	Nipple
2	3	4	2"	**	Union
2	2	2	2"	C.I.	Ell—Ex. Heavy
1	1	1	2" x 3/4" x 2"	C.I.	Reducing Tee—Ex. Hvy.
1	1	1	3/4"	C.I.	Pipe Plug
1	1	1	2" x 1 1/4"	C.I.	Pipe Bushing
1	1	1	1" x 3/4"	C.I.	Pipe Bushing
2	2	2	1 1/4" x 5"	*W.I.	Nipple
1	1	1	3/4"	**	Union
1	1	1	3/4"	*W.I.	Nipple
1	1	1	3/4"	C.I.	Ell—Ex. Heavy
1	1	1	3/4"	*W.I.	Pipe—Random Length
2	2	2	2"	*W.I.	Pipe—Random Length

*Standard wrought iron or steel pipe is satisfactory for 250 lbs. per sq. in.
**Forged steel unions or equivalent wrought iron R.R. unions may be used. Forged steel unions may be obtained through Fairbanks, Morse & Co., Purchasing Dept., Chicago, on specification No. 20FMSJ(Petro).

8. Scavenging Air System

Air Inlet Conduit—When the scavenging air is to be taken from outside the engine room, which is the recommended arrangement, make the conduit at the time the foundation is built. Specifications for this conduit will be found on the engine foundation plan. Provide a suitable covering and screen at the outer end to keep dirt from being drawn into the pipe, and extend the pipe above the ground level to keep the water out, as shown in Fig. 5.

Optional Air Inlets—For installations where both extremely hot and cold temperatures are encountered, it may be advisable to provide an optional scavenging air inlet; that is, one from the outside and one from the engine room. This will make it possible to provide ventilation in warm weather and to conserve the heat in the engine room in the winter.

Installation of Air Filter—When a filter is to be used, it may be located at any convenient point in the air suction line; that is, inside the engine room, on the roof, or outside the engine room wall in a suitable shed that will protect the filter from rain and snow. The connection between the filter and the air conduit must be kept air tight, especially on the engine side of the filter. Detailed instructions for mounting and operating these filters are furnished with each outfit by the filter manufacturer. Fig. 23 shows a typical filter installation.

9. Exhaust System

For the description and operation of the various exhaust systems that may be applied to these engines, read the material under "Exhaust Systems," page 6.

Recommendations for the various exhaust arrangements are given on the following pages. If any departure from these arrangements seems necessary, approval must be obtained from Fairbanks, Morse & Co. Also, any installation that varies from one of the recommended arrangements must be checked for back pressure. This can be done as follows: With the engine operating at approximately full load, remove the exhaust conduit manhole cover or the exhaust pot hand hole plate and note whether there is any change in the exhaust temperature or fuel consumption.

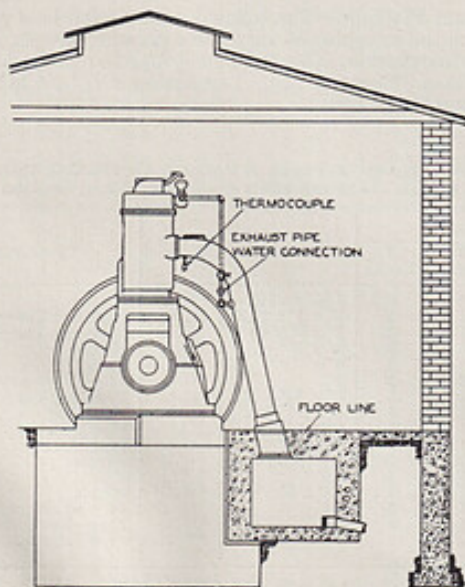


Fig. 24. Individual Exhaust Pipe and Underground Conduit Arrangement (99YKA62)

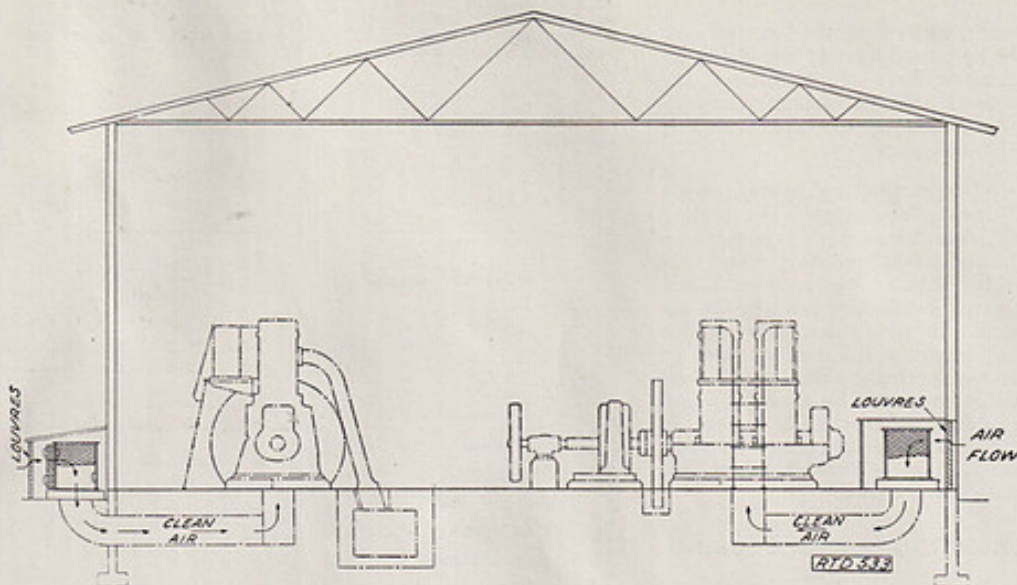


Fig. 23. Typical Installation of Filter Unit

(a) General Installation Data

Exhaust Piping—All exhaust piping should be installed in the shortest and most direct manner possible, avoiding sharp bends by the use of long sweep fittings. In order to protect the engine from undue strains, at least one expansion fitting or short length of flexible hose must be installed in the straight run of pipe adjacent to the engine and as close to the engine as practicable. It is recommended to use special fittings with cleanout flanges where the exhaust line is complicated and hard to dismantle.

Multiple Unit Installations—Do not combine the exhaust discharge in multiple unit installations. Under no circumstances will an installation be approved where the exhaust pipes from two or more engines are combined before reaching the atmosphere.

(b) Underground Conduit Arrangement.

Approved Exhaust Conditions—The following tabulation shows the recommended diameters and maximum lengths of exhaust piping when using a plain exhaust pipe or when using an exhaust silencer in the exhaust line.

Model Number	32E12	32E14	
Number Cylinders	1, 2 & 3	1, 2 & 3	4, 5 & 6
Plain Exhaust Stack; Conduit to Atmosphere:			
Diameter	18"	18"	20"
§Maximum length	60'-0"	60'-0"	200'-0"
Model Numbers	32E12	32E14	
Number Cylinders	1, 2 & 3	1, 2, 3 & 4	5 & 6
Exhaust Stack; Conduit to Exhaust Silencer:			
*Diameter	10"	12"	14"
Maximum length	6'-0"	6'-0"	6'-0"
Minimum length	12"	12"	12"
Exhaust Pipe; Exhaust Silencer to Atmosphere:			
*Diameter	10"	12"	14"
§Maximum length	12'-0"	12'-0"	12'-0"

§If a greater length is required, a ventilated stack must be installed.

*Use nominal pipe size corresponding to Exhaust Washer or Silencer connections.

§If a greater length is required, a ventilated stack must be installed having a minimum diameter of 18 in., and a maximum length of 200 ft.

Exhaust Diagram—Fig. 24 shows a typical exhaust system with underground conduit.

(c) Exhaust Pot Arrangement

Exhaust Pots—Fig. 25 shows the number of exhaust pots for each engine and the method of connecting them to the cylinders.

Exhaust Diagram—Fig. 26 shows a typical exhaust system using an exhaust pot.

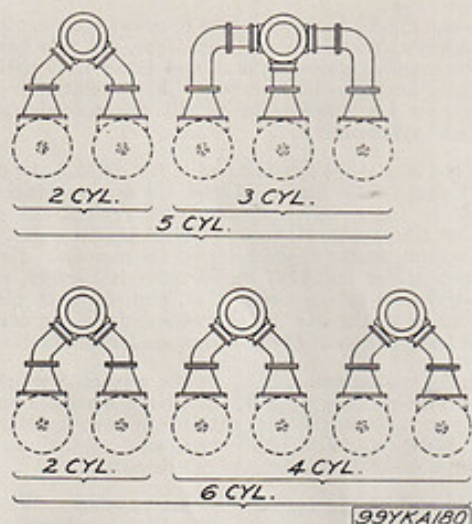


Fig. 25. Arrangements Using Exhaust Pots

Approved Exhaust Conditions—The following tabulation shows the recommended diameters and maximum lengths of exhaust piping for the various exhaust pot combinations.

Model Number.....	32E12		32E14	
	2 & 3	2, 3 & 4	5 & 6	
Number of Cylinders.....				
Exhaust Pipe; Engine to Exhaust Pot:				
Diameter.....	7"	8"	8"	
Minimum Length.....	•	•	•	
Plain Exhaust Stack; Exhaust Pot to Atmosphere:				
#Diameter.....	12"	12"	12"	
#Maximum length.....	12'-0"	12'-0"	12'-0"	
Exhaust Pipe; Exhaust Pot to Exhaust Silencer:				
§Diameter.....	10"	12"	△12"	
Maximum length.....	6'-0"	6'-0"	6'-0"	
Exhaust Pipe; Exhaust Silencer to Atmosphere:				
©Diameter.....	10"	12"	△12"	
**Maximum length.....	12'-0"	12'-0"	12'-0"	

*Connections regularly furnished with Exhaust Pot equipment are as follows: Model 32E12, 2 and 3 cyl., 3-4½"; Model 32E14, 2, 3, 4, 5 and 6 cyl., 3-10".

#This is the size and length of pipe listed for each Exhaust Pot equipment. If a greater length is required use 12 in. diameter pipe from 28 to 30 feet long (not more nor less) for all engines. For a still greater length, a ventilated stack must be installed.

§A special 12" pipe B.C. flange, tapped 10", for attaching the exhaust pipe to the exhaust pot, is required for the Model 32E12 engines. This can be furnished by Fairbanks, Morse & Co.

**If a greater length is required, a ventilated stack must be installed, having a minimum diameter of 18 in. and a maximum length of 200 ft. The ventilated stack is the preferred arrangement for all installations.

©Use nominal pipe size corresponding to connections at the exhaust silencer.

△A 12" silencer is used on 5 and 6 cylinder engines with exhaust pot arrangement.

(d) Dredge Exhaust Arrangement.

Approved Exhaust Conditions—With the dredge exhaust, an exhaust nozzle, the same as used with the exhaust pot arrangement, is bolted to the cylinder exhaust connection; a long sweep elbow is bolted to the nozzle, and a tapped flange is bolted to the elbow. On the 12"x15" engines, a 6"x6'-0" pipe is screwed into the flange and on the 14"x17" engines an 8"x8'-6" pipe is used.

Exhaust Diagram—Fig. 27 illustrates a typical dredge exhaust.

(e) Pyrometer Equipment.

Read Pyrometer Instructions—Before installing the pyrometer, read over carefully the instructions furnished by the manufacturer of the equipment.

Pyrometer Conduits—For the switchboard type of pyrometer, it is desirable to run the extension leads from the thermocouples to the switchboard in a conduit. The Manufacturing

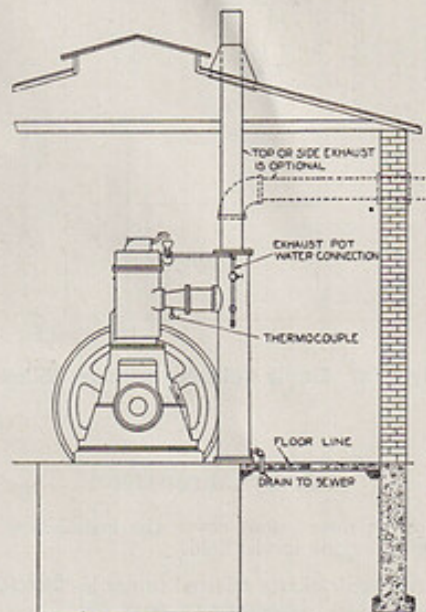


Fig. 26. Exhaust Pot Arrangement (99YKA63)

Division is prepared to furnish a special conduit which attaches to the exhaust side of the engine and has fittings for connecting to each thermocouple. The conduit extends to the governor end of the engine and is equipped with extension leads that project from the end of the conduit. Additional extension leads and conduit are required to connect to the switchboard.

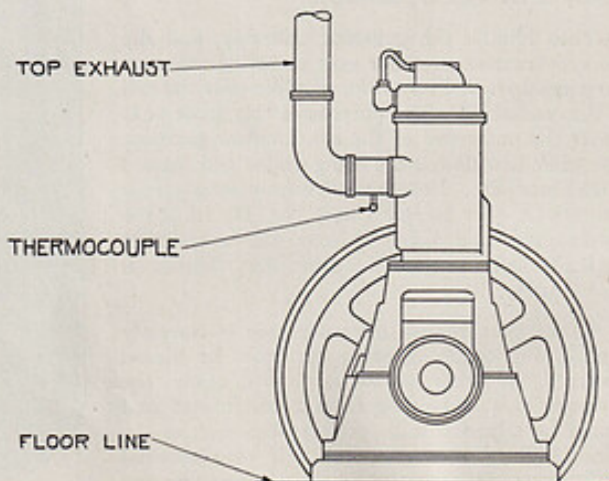


Fig. 27. Dredge Exhaust (99YKA60)

(f) Welded Exhaust Elbow

Single Cylinder Engines—The arrangement outlined here is for use only with the single cylinder engines, either with or without a silencer. The elbow outlet takes 10" pipe for the Model 32E12 engine and 12" pipe for the Model 32E14 engine.

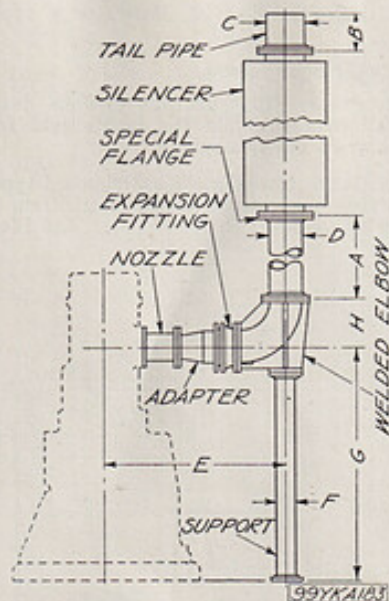


Fig. 27a. Single Cylinder Exhaust Elbow

10. Synchronizer

The following instructions cover the installation of a synchronizer on an engine in the field.

Note: All repair charts referred to are in "Section VI, Repair Charts and List" beginning on page 33.

Installation—Set No. 1 piston on its upper dead center. Remove the governor case 2341 (See Repair Chart No. 1), and the governor case dowels. Before touching the governor assembly, mark with a scratch awl or prick punch the position of the governor spider in relation to the crankshaft. This will make it possible to replace the governor spider exactly in its original position.

Then remove the governor assembly, and slip the synchronizer governor case centering arbor on the crankshaft and up to the shoulder near the end of the crankshaft. The purpose of this arbor is to center the outer end of the synchronizer governor case while new dowels are being drilled and reamed in the lower base. Detach the synchronizer governor case 2341A (See Repair Chart No. 17) from the synchronizer and place it over the studs that originally held the governor case; then tighten all nuts securely.

If the synchronizer governor case is correctly aligned, the centering arbor can now be turned easily; if the arbor cannot be turned easily, the governor case is binding from misalignment and should be adjusted until perfect alignment is obtained. This centering operation is very essential to the successful operation of the synchronizer and should be done accurately.

When the synchronizer governor case has been centered correctly and while the stud nuts still are tight, drill new dowel holes in the synchronizer governor case and lower base with a $\frac{3}{16}$ " drill, ream $\frac{1}{16}$ " and drive in the dowels. The synchronizer governor case may now be removed to permit the assembling of the governor and synchronizer.

Screw the long studs into the end of the crankshaft; drive the $\frac{1}{2}$ "x $1\frac{3}{8}$ " dowel (2533) furnished with the synchronizer into the dowel hole in the governor spider; then replace the governor assembly on the crankshaft in its original position, as shown by the prick punch marks made prior to its removal. Now place the governor spider hub 1767 on the governor spider, centering it on the governor spider dowel 2533, and clamp in place with the three studs in the end of the crankshaft, being careful not to disturb the position of the governor spider on the crankshaft.

Insert the spring posts 504A in the governor weights, and install the regulating springs 222A. Next assemble the speed regulator yoke 2538 in position with the speed regulator adjusting screw 1769, nut 1770, ball bearing and spider hub bearing retainer 2544, and tighten the stud nuts securely.

Bolt the synchronizer governor case in place. With No. 1 piston on its upper dead center, mark a "C" or other distinguishing mark on the governor spider hub dial 1767, under the governor case timing pointer 2344A.

Take out the flat head machine screws on the speed regulator dial 2546, and remove the pinion 2549. Assemble the adjusting screw housing 1771A complete with the handwheel, on the synchronizer governor case; then tighten the cap screws. Turn the handwheel 1602A in a clockwise direction until the regulating spring 222A has only a slight initial tension, then insert the indicator pinion with the hand 2547 pointing to zero on the dial 2546. Fasten the dial screws.

After refilling the synchronizer case with oil and pouring a small quantity of oil on the pinion through opening for plug 2545, the engine will be ready to start.

11. Checking Existing Installations

Importance of Proper Alignment—The importance of knowing that the proper alignment of the crankshaft and extension shaft is being maintained cannot be over-estimated. If an improper alignment is not corrected, serious damage to the engine may result. In checking over an existing installation, read very carefully the points covered in "3. Installing the Engine and Drive Equipment," pages 8 and 9.

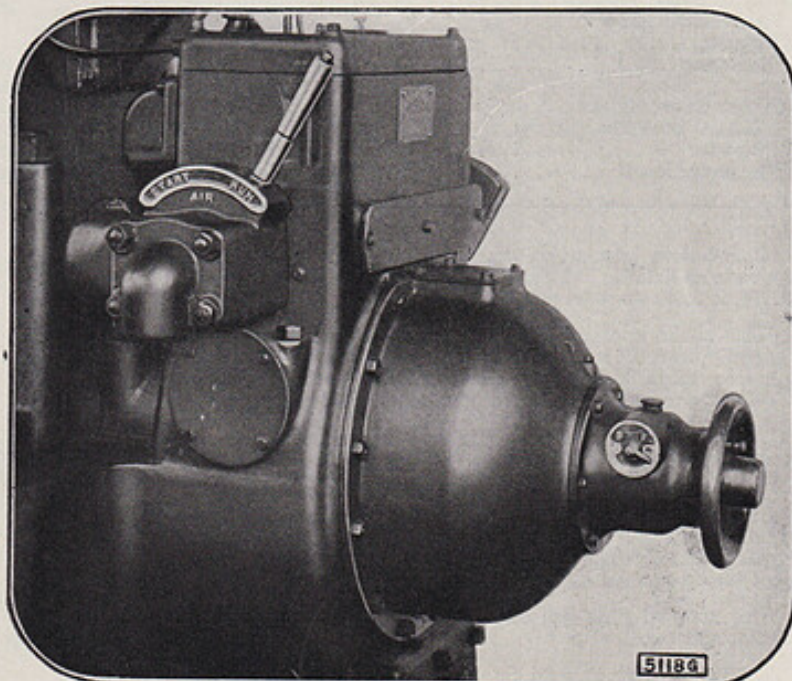


Fig. 28. Synchronizer with Hand Wheel and Indicating Dial

III. OPERATING INSTRUCTIONS

Note:—All repair charts referred to are in "Section VI, Repair Charts and List" beginning on page 33.

General—The following instructions refer particularly to a first start, or to a start after a long shut-down. Subsequent starts will not require such detailed preparation.

1. Before Starting the Engine

(a) Inspect the Engine.

Make a final check of the complete installation. See that the engine is properly lined up and fastened securely to the foundation. Open the compression relief valves and bar the flywheel over several complete revolutions to make certain that all parts move freely.

(b) Fuel System.

Clean Tanks and Piping—Before filling the fuel tank and other parts of the system, clean the tank and blow out or flush out the piping.

Fuel—Use an approved fuel oil. For cold weather operation, use a fuel oil that will flow readily at the atmospheric temperature in which the engine is to operate.

Fill Storage Tank and inspect for leaks.

Fill Gravity Feed Fuel Regulator, if one is used, and inspect for leaks.

Prime Fuel Supply System—Remove the cover (986D), on the fuel suction and overflow fitting and pour in strained fuel until the suction line and filter housing are full. Then replace the cover, and fill the fuel reservoir. (See Repair Chart No. 10).

Prime Fuel Injection Pumps and Valves—With the fuel system filled and ready for priming, proceed as follows:

Loosen the air vent plugs in the fuel injection valves and prime each injection pump, tube, and valve by moving the hand lever at the right side of the fuel reservoir back and forth from "Run" to "Prime" positions. Repeat until fuel free from air bubbles is forced out around the threads of the vent plugs. Then tighten the vent plugs. The normal injection pressure is such that the pump plungers cannot be operated manually to inject fuel through the valves. As the pump for each cylinder is primed, the engine must be turned so that the suction valve for that pump is closed.

(c) Lubricating System.

Study Diagram—Study the lubricating system shown in Fig. 12, and the description and operation of the system as explained on pages 4 and 5.

Lubricating Oil—Use a good grade of lubricating oil that has been recommended by a reputable oil company for use in a Diesel engine. The oil should check with Fairbanks, Morse specifications and should be free flowing for all temperature conditions in which the engine will operate.

Filling the System—Remove the lubricator filler cap and pour in oil until the level remains constant. (Surplus oil overflows to the clean oil sump). Disconnect the longest lubricator tube at its connection to the engine, and crank the lubricator until oil is discharged, then reconnect the tube. Crank the lubricator again for 30 or 40 turns so that all bearing surfaces supplied by the lubricator will have an ample supply for starting. Watch the oil level in the lubricator, and add more oil if necessary.

Fill the governor case and main bearing oil wells to the level of the overflow pipe.

Fill the oil filter storage tank to the maximum level.

Remove the crankcase covers. Spread the air seal rings from the crankcase webs, distribute lubricating oil over their bearing surfaces; then release the rings. Turn each crank down and with a hand oil can squirt oil into the crankpin oiler rings to insure lubrication to the crankpin bearings. Then replace the crankcase covers.

Do not, under any circumstances, pour oil into the crankcases.

Turn the flywheel several revolutions to distribute the oil.

(d) Cooling Water System.

Fill the cooling water system and inspect all joints for leaks, remedying them if any are discovered.

(e) Air Starting System.

Check the installation of the air starting system. Blow out all air lines before final connection is made at the engine to free them from dirt, scale, etc. Make the final connection of the air line, and charge the tanks to 250 lbs. per sq. in. Inspect the

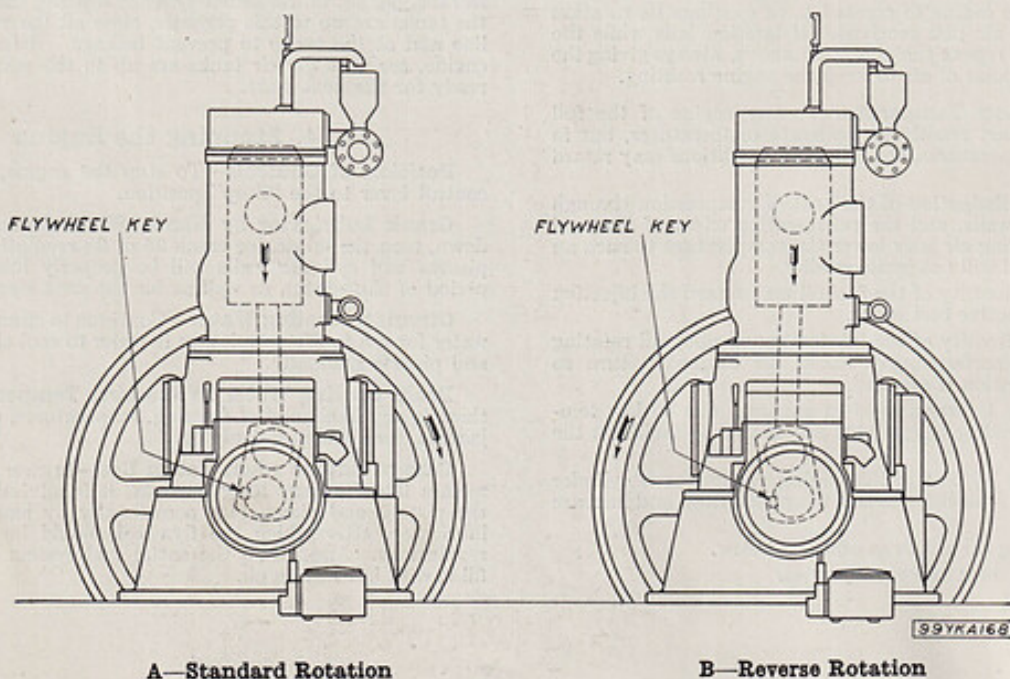


Fig. 29. Direction of Rotation and Position of Piston and Flywheel Key for Starting

lines for leaks and remedy them if any are found. Check the relief valves to make sure that they open at the proper pressure.

When the engine has been shut down for a period longer than one month, remove the air start valves 570B (See Repair Chart No. 14), from the fuel reservoir, and the air start check valves (853B), (See Repair Chart No. 7), from the cylinder heads and clean the stems with fine emery cloth. Lubricate the stems when replacing the valves.

(f) Position of Flywheel, Controls, Valves, etc.

Flywheel Position—Refer to Fig. 29. The standard direction of rotation is clockwise when looking at the engine from the governor end. See A in Fig. 29. With the relief valves in the cylinder heads open, turn the flywheel until the crank nearest the governor is about 10 degrees past the upper dead center. Determine the location of the crank in question by noting the location of the flywheel key.

Relief Valves—Close the compression relief valves.

Fuel System—Place the fuel control lever in "Run" position. Then open valves in the fuel line to place the system in operation.

Cooling Water System—Start the cooling water pumps, and check the operation of the system. Be sure that all water jackets are full.

Air Starting System—First place the air control lever in "Run" position, then open valves in the air line necessary to place the system in operation.

2. Starting the Engine

If the foregoing instructions have been carried out, the engine is now ready to start.

Starting Multi-Cylinder Engines—Throw the air control lever quickly to the "Start" position. This allows the starting air supply to rush into the cylinders and rotate the crankshaft. Ignition should occur as soon as the engine attains a good rotative speed. Return the air control lever to the "Run" position as soon as ignition occurs. Failure to fire is sometimes due to insufficient priming. To correct this condition, repeat the priming operation as outlined on page 25.

Starting Single Cylinder Engines—Single cylinder engines will generally start more promptly, especially in cold weather or when heavy oil is used for fuel, if the starting air supply is shut off as soon as the engine attains a good rotative speed. Therefore, after applying the starting air as described in the preceding paragraph, bring the air control lever back to the "Run" position, and allow the engine to coast; i.e., to continue its rotation on the impulse of air just received. If ignition fails while the engine is coasting, repeat the operation above, always giving the cylinder a new impulse of air to keep the engine rotating.

Starting in Low Temperatures—Any engine of the full Diesel type will start readily in moderate temperatures, but in extremely low temperatures, the following conditions may retard the start:

(a) The rapid dissipation of the heat of compression through the cold cylinder walls, and the refrigerating effect of the cold high pressure starting air may lower the temperature to such an extent that the fuel will not ignite readily.

(b) The high viscosity of the fuel oil may retard the injection and cause an ineffective fuel spray.

(c) The high viscosity of the lubricating oil upon all rotating and reciprocating surfaces may cause the engine to turn so slowly that combustion is affected.

When difficulty is experienced in starting, due to low temperatures, the following suggestions are offered to facilitate the start:

(a) Pour about $\frac{1}{2}$ pint of lubricating oil into each cylinder through the head. This helps to seal the piston rings and increase compression.

(b) Use starting cartridges as outlined below.

(c) If possible heat the engine room.

(d) Heat the jacket water.

(e) Use fuel oil with a low congealing point. In case it is impracticable to use fuel oil with a low congealing point, provide a fuel oil heater for regular operation, and run on light oil when starting and stopping.

(f) Use lubricating oil that will flow freely for all temperature conditions in which the engine will operate or heat the lubricating oil.

Gasoline or other highly volatile fuels must never, under any circumstances, be used for starting.

Using Starting Cartridges—If the engine does not start after several attempts, do not exhaust the supply of starting air. First make certain that fuel is being injected. Then remove one or two of the starting cartridge plugs in the cylinder heads on cylinders which do not receive starting air, insert and ignite the starting cartridges and replace the plugs. Then repeat the starting operation as outlined above.

3. After the Engine is Running

Position of Controls, Valves, etc.—As soon as several ignitions have occurred, and the engine has come up to speed, bring the air control lever to "Run" position, and close the valve in the air supply line. It may be necessary to move the fuel control lever toward the "Stop" position until the excess fuel, which has been injected for starting, has been burned; then bring it back to the "Run" position.

Check Fuel System—Determine if the fuel system is operating properly. Check the operation of the fuel supply pump by watching the fuel level in the reservoir gauge glass. The level should remain constant.

Check Lubricating System—Lift the cover of each of the main bearing caps, and see that all of the main bearing oil rings are running properly. See that the clean oil pump is maintaining the oil in the lubricator to the overflow level, and that the lubricator is functioning properly.

Check Cooling Water System—Determine if the cooling water system is operating properly. Adjust the controls so that the cooling water outlet temperature does not exceed 120°F. to 140°F. for direct cooling systems and 160°F. for indirect cooling systems. The maximum difference between the inlet and outlet temperatures must be restricted to 15°F., but it is recommended that a smaller difference be maintained. See "Cooling Water Circulation Rates" on page 13.

Charge Air Tanks—Pump up the air pressure in the air tanks. On installations where the air compressor is driven from the main engine, charge the tanks to the maximum pressure of 250 lbs. per sq. in. immediately after starting the engine. When the tanks are up to this pressure, close all the valves in the air line and at the tanks to prevent leakage. Before stopping the engine, see that the air tanks are up to the maximum pressure ready for the next start.

4. Stopping the Engine

Position of Controls—To stop the engine, bring the fuel control lever to the "Stop" position.

Crank Lubricator by Hand—While the engine is slowing down, turn the lubricator crank 25 or 30 revolutions, so that the pistons and cylinder walls will be properly lubricated for the period of shut-down, as well as for the next start.

Circulate Cooling Water—Continue to circulate the cooling water for ten to fifteen minutes in order to cool the hot cylinders and pistons gradually.

Drain Cooling Water in Freezing Temperatures—When there is any likelihood of freezing temperatures, drain the water jackets, manifolds, and piping.

Care of Engine when Not in Use—In case the engine is to remain idle for very long periods, it is advisable to lubricate the pistons and piston pins occasionally by hand cranking the lubricator, after which the flywheel should be turned several revolutions. Also, drain the entire fuel system of all fuel, and fill it with lubricating oil.

IV. INSPECTION ROUTINE

Note—All repair charts referred to are in "Section VI. Repair Charts and List" beginning on page 33.

Cleanliness—Keep the installation clean and in good order. It is our observation that when such is the case, little trouble is encountered with the machinery.

Caution—Do not use gasoline for any cleaning purpose.

Inspection—Inspect the engine and its equipment regularly. It is an excellent plan to have a regular inspection routine, and to assist owners and engineers in making up a suitable routine, the following suggestions are offered.

1. Daily Routine

- (a) Under "After the Engine is Running," page 26 will be found certain duties that should be performed after every start.
- (b) Inspect fuel level in storage tank.
- (c) Where a gravity feed fuel regulator is used, inspect for leakage through the vent.
- (d) Inspect water levels in cooling system tanks, hot wells, etc.
- (e) Inspect levels in the lubricating oil storage tank, lubricator and main bearing oil wells.
- (f) Check the feeds of the lubricator. See page 31.
- (g) Watch the drains from the crankcases. These drains discharge into the lubricating oil sump at the governor end of the base, and may be inspected after removing the sump cover. Be sure that the drains are open. **Under no circumstances should oil ever be allowed to accumulate in the crankcases.**
- (h) If an exhaust washer is used, blow out the drain pipes.
- (j) Readings of all instruments such as gauges, thermometers, meters, etc., should be taken at regular intervals as determined by the owner or engineer.

2. Weekly Routine

- (a) Remove drain plug in lubricator, and drain off any accumulated water.
- (b) Drain air storage tanks and piping of water and oil accumulations.
- (c) Clean the lubricating oil sump, strainers, etc., at the governor end of the engine. To drain the sump, remove the nipple (2316). (See Repair Chart No. 10.)
- (d) Clean the lubricating oil filter. See instruction card furnished with filter.
- (e) Check bearing temperatures by hand. Normal temperatures are such that the hand may be held on the bearing.
- (f) Remove upper base hand hole covers immediately after engine is shut down. Check connecting rod bearing temperatures by hand. Inspect pistons, cylinders, etc. for proper lubrication. Inspect crankpin oiler lubricator tubes. Examine connecting rod bearing bolts and cotter keys. Try connecting rod bearings with crowbar for looseness or wear. Replace hand hole covers.
- (g) Check water hardness.

3. Monthly Routine

- (a) Inspect and clean exhaust ports, exhaust nozzles, and points of thermocouples of accumulated carbon deposit.
- (b) Clean air suction valves.
- (c) Clean crankpits with kerosene. Reach well up into the scavenging air passages in the cylinders.
- (d) Drain water and sludge from lubricating oil and fuel oil storage tanks, using the drains provided for this purpose.
- (e) When the engine is in standby service, or is not in regular daily operation, remove all air starting valves (570B) (See Repair Chart No. 14) and air start check valves (853B) (See Repair Chart No. 7), and clean the stems with fine emery cloth. Lubricate the stems when replacing the valves.
- (f) Check and adjust injection valves.

4. Quarter Annual Routine

- (a) Remove cylinder inspection plates, and examine for scale. If any deposit is found, consult a reliable manufacturer of water softening systems for suitable treatment.
- (b) Inspect all valves in the fuel injection and fuel supply pumps.
- (c) Drain the entire lubricating system, and thoroughly wash out with kerosene all parts in which sediment might collect. This applies to the main bearing oil wells, governor housing, oil storage tank, force feed lubricator, oil pumps and piping.
- (d) Wash out fuel supply reservoir with kerosene.
- (e) Clean the exhaust system including conduit and stack.
- (f) Inspect the flywheel bolts for tightness.

5. Semi-Annual Routine

- (a) Pull pistons for inspection and cleaning. Remove any rings that are stuck and clean the rings and grooves. Wash off with kerosene. Examine connecting rod bearings.
- (b) Examine cylinder walls. When cleaning the cylinders and exhaust and intake ports, place a piece of cloth or canvas over the top of the cylinder, and then with a piston ring placed over the canvas, push both canvas and ring into the cylinder bore until they are well below the ports. This arrangement will provide a receptacle to catch all of the carbon, etc., which would otherwise fall into the crankcase. When the work is completed, the ring, canvas, and carbon may be withdrawn by pulling upward on the edges of the canvas. Clean the cylinder heads at this time, too.
- (c) Inspect the inner surface of the exhaust port bridges and of the cylinder wall adjacent to the ports. There is a tendency for the cast iron around the exhaust ports to grow due to the heat of the exhaust gases, and this surface must be kept even or slightly below the general bore of the cylinder. (See "6. Cylinder Exhaust Ports," page 29.)
- (d) Inspect and clean all water piping, circulating pumps, and cooling equipment.

6. Annual Routine

- (a) When pistons are removed for inspection, disassemble and clean the piston pin bearings. See "5. Pistons," page 28.
- (b) Check the crankshaft and engine for alignment; also, the driven apparatus.
- (c) Clean the main fuel tank with boiling water and washing soda.

V. SERVICING INSTRUCTIONS

Note:—All repair charts referred to are in "Section VI. Repair Charts and List" beginning on page 33.

1. Main Bearings

Main Bearing Adjustment—Adjustment of the main bearings is necessary when there is excessive clearance between the crankshaft and the upper main bearing shells. To determine the actual bearing clearance and make the proper adjustment, proceed as follows:

Remove the bearing cap and upper shell. Do not remove the shims. Place four pieces of pure lead wire over the exposed journal, one lengthwise and three crosswise. Replace the upper bearing shell and cap, and screw the nuts down to their original position. Then remove the cap and shell and with an outside micrometer, measure the thickness of the compressed wire. Then add or remove sufficient shims on each side of the bearing to give 0.004" to 0.007" clearance. After the adjustment is made, and the engine is in operation, note the bearing temperatures from time to time.

Main Bearing Removal—When the bearing cap, upper half of the bearing shell, shims, and the oil ring have been removed, the lower half of the bearing shell may be rolled out after first relieving it of the weight of the crankshaft by means of a small jack placed under the nearest crank web. Corrugations in the shell will assist in rolling it out.

New Bearing Shells—New bearing shells, which will interchange with those on the engine, can be furnished from the factory. It will be necessary to fit the lower shell to its bed in the lower base, and to fit the upper shell to the bearing cap. The shells must be fitted to give a good bearing surface, and special care must be taken in fitting the lower shell so that it receives its share of the load from the crankshaft. Adjust clearance as outlined above.

The lower shell is lined with "Bermax" babbitt and, for successful operation it must be fitted to a 100% bearing throughout an arc of at least 120°.

"Time Saver" should be used to produce a good bearing surface. "Time Saver" and instructions for its use may be obtained from Fairbanks, Morse & Co. or from Time Saver Products Co., 31 So. Desplaines St., Chicago, Ill.

2. Connecting Rod Crankpin Bearings

Connecting Rod Crankpin Bearing Adjustment—Adjustment of the connecting rod crankpin bearings is necessary when there is excessive clearance. To determine the clearance and make the adjustment, proceed as follows:

With a bar placed under the connecting rod crankpin bearing, pry up on the bearing to see if there is excessive clearance. **There should be no up and down movement of the bearing.** Should the bearing have excessive clearance take out 1 or 2 shims on each side of the bearing until there is no up and down movement. After shims have been taken out, draw the bolts up until they are tight and then place the bar at the side of the bearing and see that it is free to move sidewise on the crankpin. If the bearing will not move sidewise on the crankpin, then shims must be added until the bearing is free to move sidewise. When proper adjustment has been made see that the nuts are tight and **be sure to replace the cotter pins.** Examine the cotters before replacing them and if any show signs of cracking replace them with new **annealed** cotters.

Connecting Rod Crankpin Bearing Removal—With each engine, there are furnished two piston clamps (2600) (See Repair Chart No. 19), for supporting the piston and connecting rod in the cylinder while the connecting rod crankpin bearing is being removed. When a connecting rod crankpin bearing is to be removed, fasten these clamps to the lower end of the cylinder wall with the cap screws provided allowing the end of the clamp to project up into the cylinder bore. Remove the connecting rod bolts, bearing cap and shims; then, as the engine is barred over, the piston will rest on the clamps, and the bearing box may be removed as the engine is turned to the proper position. This manner of supporting the connecting rod and piston makes it unnecessary to remove the cylinder head and connecting rod when renewing the connecting rod crankpin bearing. **Be sure to remove the piston clamps** as soon as the connecting rod crankpin bearing is reassembled, otherwise serious damage will result to the piston and cylinder.

Connecting Rod Crankpin Bearing Renewal—The connecting rod crankpin bearing box and cap may be renewed if necessary. The bearing is lined with "Bermax" babbitt. For

successful operation it must be fitted to a 100% bearing throughout an arc of at least 120° on both the upper and lower bearings. The machining clearance of the bearing is 0.004" to 0.006". When the bearing is well lubricated there should be no up and down movement although it should be free to move sidewise. The bearing bolts must be tight when checking.

"Time Saver" should be used to produce a good bearing surface. "Time Saver" and instructions for its use may be obtained from Fairbanks, Morse & Co. or from Time Saver Products Co., 31 So. Desplaines St., Chicago, Ill. Always insert the cotter pins in the holes in the ends of the connecting rod bolts and spread the ends of the pins well apart.

There are two holes in the bolts for the cotter pins, either of which may be used, thus allowing a closer adjustment. When a new connecting rod crankpin bearing has been fitted to an engine, inspect it at intervals after the engine has been started, and apply the load gradually.

Wick Oiler—The crankpin bearing cap is fitted with a felt oil retainer which acts as an oil reservoir to furnish lubrication when the engine is first started.

3. Air Stop Ring

The air stop rings prevent the escape of air from the crankcases through the bearings. They are machined very carefully with the base to secure tight joints. All of the rings are of the split type and may be removed without dismantling the engine.

4. Crank Pin Oil Rings

These rings collect lubricating oil from the force feed lubricator tube and deliver it to the connecting rod crank pin bearings. They are of the split type, and can be removed or replaced without dismantling the engine.

5. Pistons

Removing Pistons—The pistons with connecting rods may be withdrawn after the cylinder heads and connecting rod bearings have been removed. Two $\frac{3}{4}$ " tapped holes are provided in the top of the piston so that eyebolts may be used for lifting the piston.

Piston Rings—During the periodic inspection of the piston, the rings should be examined. All piston rings should work freely in their grooves, for if they are allowed to stick fast, gases will blow past them, and combustion will be poor due to low compression. If any rings are stuck, they should be removed and the rings and grooves cleaned. Before removing a ring, mark it so that it can be installed again in the same position.

If the rings are gummed fast in the grooves, a hot solution composed of one pound of lye to three gallons of boiling water will assist in freeing them. Use this treatment only when the piston is removed from the cylinder. Wash off the solution after the parts are loosened. Clean all parts with kerosene or light lubricating oil, and lubricate them thoroughly before replacing in the engine.

Oil Scrapers—The oil scrapers, which provide lubrication to the piston pin, fit into recesses in the piston wall at each end of the piston pin.

Needle Roller Piston Pin Bearing—The piston pin bearing is of the needle roller type with three rows of needles (or rollers) fitted in the space provided between the hardened steel bushing and piston pin. Four retainers are used to maintain the three rows of needles in position. See Fig. 30. Bushings, piston pins, needle rollers and retainers may be renewed. The bushing fits tightly in the rod. When a bushing is to be replaced heat the end of the rod to 160°—180°F. in hot oil and then put the bushing in place.

Servicing Needle Type Piston Pin Bearings—Each piston pin bearing should be disassembled once a year and cleaned thoroughly. The needles should be rinsed in kerosene, and all oil holes in the piston pin should be cleaned out.

Disassembling the Bearing—In disassembling the bearing, proceed as follows: With the piston and connecting rod assembly removed from the engine, lay the piston on its side with the piston pin horizontal, or if a hoist is available for lifting the rod, stand the piston upside down. Take out the headless set screw, spring and dowel which hold the piston pin in the piston. See A, Fig. 30.

Place the piston pin sleeve in the piston against the small end of the piston pin as shown in A, Fig. 30, and push out the piston pin, at the same time following through with the piston pin sleeve. When the sleeve is in position in the connecting rod,

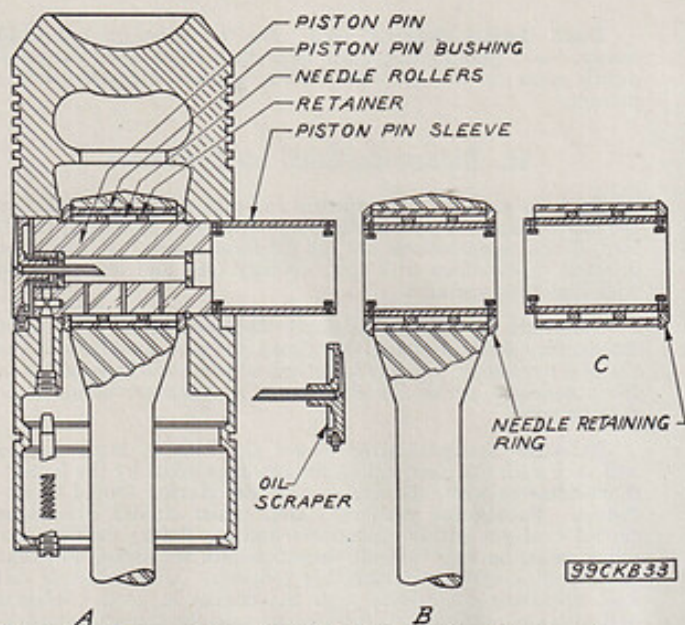


Fig. 30. Disassembling Needle Roller Piston Pin Bearing

the sleeve screws should be tightened against the two end retainers. The connecting rod with the piston pin bearing may then be removed from the piston as shown in B, Fig. 30, after which the complete bearing assembly may be slipped out of the connecting rod. See C, Fig. 30.

To further disassemble the bearing, slip off the piston pin bushing, whence the rollers and retainers may be removed. Take care not to lose any of the needle rollers. Each bearing on the 12x15 engines has 231 needle rollers, or 77 in each row. Each bearing on the 14x17 engines has 237 needle rollers, or 79 in each row. Rinse the parts in kerosene and clean out all oil holes in the piston pin.

Assembling the Bearing—1st Method—Install one retaining ring at one end of the piston pin sleeve and tighten the sleeve screws. Place the sleeve in the connecting rod and lay the rod on its side or lean it against a wall or post. Then insert the rollers in the space between the piston pin sleeve and the piston pin bushing until one row is complete. Push this row down by means of one of the retainers and add the second row of rollers. Repeat for the third row and install the other retaining ring and tighten the sleeve screws.

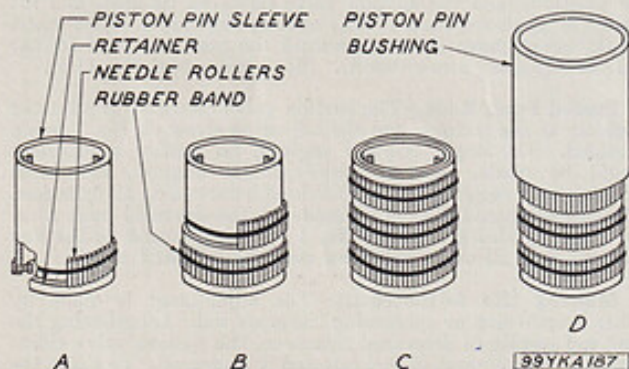


Fig. 31. Assembling Needle Roller Piston Pin Bearing

Assembling the Bearing—2nd Method—Install one retaining ring at one end of the piston pin sleeve and tighten the sleeve screws. Then stand the sleeve on end with the retaining ring at the bottom. Slip a rubber band around the sleeve where the first row of rollers will be, then place the rollers between the sleeve and the rubber band until a complete row has been built up. Place a retainer on the sleeve against the ends of the rollers. Add another rubber band for the second row of rollers and repeat the above procedure for the second and third rows. Then install the retaining ring on the top end and tighten the sleeve screws.

To assemble the bearing in the piston, reverse the procedure outlined in "Disassembling the Bearing"

6. Cylinder Exhaust Ports

When the pistons are pulled for the semi-annual inspection and cleaning or at any other time that the pistons are removed, the exhaust ports should be thoroughly cleaned and the cylinder walls carefully examined.

Occasionally, when an engine is operating under a very heavy load or possibly under an unfavorable exhaust condition, the bridges around the exhaust ports may have a tendency to grow and to extend into the cylinder. This condition should be checked with a straight edge when the cylinder is open and the extending metal removed by rubbing down or carefully grinding. It is unnecessary to relieve the surface beyond the surface of the cylinder.

7. Piston-Cylinder Head Clearance

Adjusting Clearance—The piston-cylinder head clearance may be adjusted by adding or removing shims at the joint between the foot of the connecting rod and the connecting rod bearing box. The connecting rod bolts must be removed to make the adjustment.

Checking Cylinder Head Clearance—1st Method—The preferred method of checking the clearance is to turn the crank to top dead center, loosen the connecting rod bolts and pry the rod up until the piston hits the cylinder head. Measure the amount of movement, which indicates the clearance. The movement should be $\frac{3}{4}$ " to $\frac{3}{8}$ ".

Checking Cylinder Head Clearance—2nd Method—A close check on the piston cylinder head clearance may be made as follows: With a cold engine, remove the injection valves on the cylinder to be checked. Bar the flywheel over until one of the pistons is near top dead center, and insert two pieces of lead wire through the opening in the cylinder head in such a manner that they will come between the head and the sloping portion at the top of the piston. Then bar the flywheel so that the piston passes over top dead center, remove the wires and measure their thickness, which will be the actual piston cylinder head clearance. The clearance at the closest point should be $\frac{3}{4}$ " to $\frac{3}{8}$ ". Repeat the process on the other cylinders.

Compression Pressures—The compression pressures should be taken while the engine is at operating temperature, and should be from 480 to 510 lbs. per sq. in. The firing pressure should be from 650 to 700 lbs. per sq. in. Check the pressures by means of an indicator. The indicator cocks should be installed in the holes provided in the cylinder heads. It is not necessary to connect up an indicator drive to obtain the pressure; pulling the indicator by hand will give the desired results.

8. Air Start Mechanism

Air Start Valves—The air start valves (570B) (See Repair Chart No. 14), located in the fuel supply reservoir casting just behind the fuel injection pumps should be inspected occasionally and resealed, if necessary. The plugs (903) must be removed before the valves can be taken out. The valves may be resealed in the usual manner. Be sure to replace the parts in their original position.

Air Starting Shut-Off Valve—The air starting shut-off valve (2294B) (See Repair Chart No. 14), is of the disc type and is held in position against the valve cage (2293E) by means of a spring. In the event of leakage between the valve and cage, reseat the valve to its seat on the cage by lapping or grinding.

Air Starting Check Valves—The air starting check valves in the cylinder heads should be removed and cleaned occasionally. If necessary regrind the valves to their seats.

9. Fuel Injection Pump

Reseating Injection Pump Valves—The injection pump valves must be resealed at intervals, for leaking valves will result in dark, smoky exhaust and irregular engine performance. Refer to Repair Chart No. 11B, when removing the valves for reseating. In grinding the valves, use a fine carborundum paste, flour of glass, or pumice stone mixed with oil. Never use emery compounds as even the finest grades are too coarse. After grinding, make sure that all traces of the grinding compound are removed from the valve and seat. Suction valves are provided with screw driver slots for rotating them while grinding. Discharge valves are cup shaped. A small stick shaped to fit into the valve may be used to rotate the valve.

10. Differential Fuel Injection Valve

For servicing information on the differential fuel injection valves, see Instructions No. 2769, latest edition. The injection valve should be checked in about 200 hours after the first start and at monthly intervals thereafter.

Whenever an injection valve is being installed in the cylinder head it must be clamped down very tightly and evenly as otherwise the extreme pressure of injection may disturb the location of the parts and cause unsatisfactory operation.

11. Injection Timing

The fuel injection is timed properly at the factory for best running conditions, and the parts are marked so that they may be reset to their original position. The cylinders are numbered 1, 2, 3, etc., with No. 1 cylinder at the governor end.

Method of Timing—The method of timing the injection is to clamp the governor spider (501B) (See Repair Chart No. 16), in such a position that the injection pump plunger of No. 1 injection pump is at high point a certain number of degrees before No. 1 piston reaches top dead center. With the timing correct for No. 1 cylinder, timing for the other cylinders will be correct automatically.

Injection Timing Marking—With No. 1 piston on top dead center, the mark on the governor spider designated by the letter "C" should register with the governor case timing pointer. (See Fig. 33.) This is the factory setting.

Injection Timing—Injection timing is properly set at the factory for best performance with an average fuel. For heavier or lighter fuels it may be necessary to adjust the setting. This can be determined from the full load firing pressures.

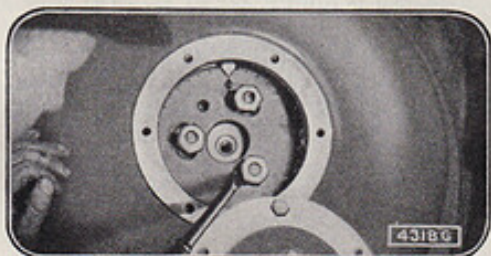


Fig. 33. Adjusting Injection Setting

Dead Center Setting—With No. 1 piston on top dead center, No. 1 pump plunger will be at high point when the prick punch mark on the governor spider registers with the timing pointer.

12. Balancing Load on Cylinders

Uniform exhaust temperatures indicate that approximately the same amount of fuel is being injected to all cylinders; therefore, if the temperatures are not uniform, more fuel should be injected to cylinders with low temperatures, and less to those with high temperatures.

Methods of Taking Exhaust Temperatures—The most satisfactory method of taking exhaust temperatures is with the use of a pyrometer which is furnished when ordered specially. In the absence of pyrometer equipment, an exhaust thermometer may be used.

Exhaust Temperatures—Since the exhaust temperatures will vary with the installation, the readings taken by the factory representative when the engine was first started should be obtained. Subsequent readings taken under similar conditions should conform within reasonable limits. Before making any adjustment, be sure that all thermocouples are clean, and that the injection system is operating properly. Under normal full load operating conditions, with the engine in good condition and with an approved exhaust arrangement the exhaust temperature should not exceed 420°F. The difference between the individual cylinders on an engine should not exceed 30°F. for full load or 60°F. for fractional loads to maintain the cylinders in balance.

Fuel Injected Determined by Suction Valve Closing—The amount of fuel injected depends upon the closing of the suction valve (P) (See Fig. 1), the earlier the valve is closed, the more fuel is injected, and the later the valve is closed, the less fuel is injected.

Suction Valve Closing Affected by Valve Clearance—The time of closing of the suction valve is affected by the amount of clearance between the upper push rod stem (R) and the suction valve (P) measured with the cam in low position. With a small clearance, the suction valve will be lifted farther off its seat, and will close later. With a large clearance, the opposite is true. Thus, if less fuel is to be injected into the cylinder, the clearance must be decreased, and if more, the clearance must be increased.

Suction Valve Clearance—The clearance between the suction valve and push rod should be from .015" to .050" on 12"x15" engines, and from .015" to .060" on 14"x17" engines with the governor cam in low position. To measure the clearance, remove the pump case housing cover (849A), the fuel reservoir cover (986A), and the injection pump discharge valve (91), spring (537), and suction valve spring (259). With the governor cam in low position, hold the suction valve down on its seat, and lift the upper push rod stem (642A) against the valve. Then insert the thickness gauge (feelers) between the push rod stem (642A) and the adjusting screw (626A). (See repair chart No. 11B.)

Sealed Push Rods—The suction valve clearance is adjusted correctly at the factory, and the adjusting screw on No. 1 pump is sealed. On single cylinder engines, no further adjustment should be made, but on multi-cylinder engines, occasional adjustment is required to keep the load balanced on all cylinders. Adjustment should always be made on the unsealed push rods. By following this procedure, No. 1 cylinder is used as the key cylinder, and all other cylinders must be adjusted to it.

Making the Adjustment—The adjustment is made by either lengthening or shortening the push rod. Lengthening the push rod results in decreased clearance, the suction valve closes later, and the amount of fuel injected is decreased. To make the adjustment, loosen the adjusting screw nut (O), and then while holding the push rod (Q) with a stiff wire or nail inserted through the hole in the push rod, turn the adjusting screw in the desired direction. (See Figs. 1 and 34.) Be sure to tighten the lock nut after the adjustment has been made. Start the engine and observe the exhaust temperature under full load. If one of the cylinders has more load than the others, its temperature will be higher. To balance the load, make further adjustments, until the pyrometer indicates exhaust temperatures all within a limit of 30°F. at full load.

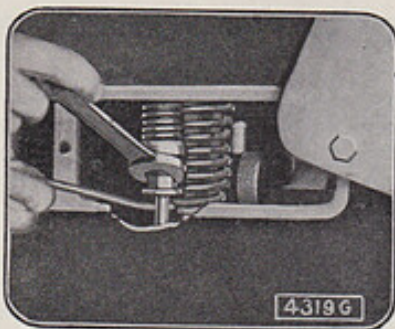


Fig. 34. Adjusting Push Rods

13. Fuel Supply Pump

Suction and Discharge Valves—The fuel supply pump should be inspected occasionally, and the suction and discharge valves (519A) reset, if necessary. (See Repair Chart No. 10.) To withdraw the valves, remove the fuel reservoir cover plug (2112), and cap (520A).

Strainers—The fuel suction strainers may be cleaned after removing the cover (986D) to which they are attached. Refer to the separate instructions furnished by the manufacturer of the strainers.

14. Gravity Feed Fuel Regulator

If fuel leaks from the vent in the reservoir cover, shut off the fuel supply to the regulator, drain and clean the reservoir by flushing with gasoline or kerosene. It may be necessary to grind the valve. There are also provided two drains—the lower drain for the water jacket and the upper for the fuel regulator reservoir. Drain the fuel regulator reservoir frequently to remove any accumulated water or sediment which might interfere with the operation of the engine.

15. Force Feed Lubricator

Drops per Minute—The lubricator should be adjusted to give the following number of drops per minute:

12"x15" Engines—360 r.p.m.	{ Cylinder feeds—16 drops. Crankpin feeds—24 drops.
14"x17" Engines—300 r.p.m.	{ Cylinder feeds—14 drops. Crankpin feeds—21 drops.

Checking Lubricator Feeds—To check the lubricator feeds, first count the number of impulses per minute made by the lubricator with the engine running at normal speed. Then divide the number of drops per minute (from above table), by the number of impulses per minute which will give the drops per impulse at which the lubricator should be set. With engine stopped, and while hand cranking lubricator, count the drops per impulse. If necessary, make the adjustment as outlined in the lubricator instruction book.

Cleaning Lubricator—See lubricator instruction book for method of cleaning.

16. Air Filter

Cleaning Filter—The filter should be cleaned every 4 to 8 weeks depending upon conditions. To clean, remove the cell from the frame, and thoroughly flush out with hot water or steam. Use a hose and flush from the back of the cell first. When the cell is dry, dip it in the treating fluid, then drain and install it in the frame. If hot water or steam is not available, use a washing tank three-fourths full of kerosene or washing soda. Hold the cell horizontally, and move vigorously up and down. It is not essential to have the cell perfectly clean as a light coating of dust has a tendency to increase the efficiency.

17. Exhaust Equipment

Necessity for Cleaning—Although the engine may be operating with a good exhaust condition under full load or less, flakes of carbon, tar, etc., will collect in the exhaust line unless

the exhaust is continually washed. If the formation is allowed to collect, it must be removed periodically. The frequency of cleaning depends upon many factors, but may be readily determined for each installation.

18. Crankshaft End Play

The end play of the crankshaft is adjusted by thin shims placed between the air stop ring and a shoulder on the crankshaft. The shims are made in halves for easy installation or removal, and are located to make all adjustments at one crank or bearing, the other cranks or bearings having slightly greater end-wise clearance. The shims may be ordered by Repair No. 577A for thick shims (used only for 14"x17" engines), and Repair No. 578A for thin shims.

Adjustment—If the end play becomes excessive, it may be reduced by adding shims, always adding two halves at a time. On engines of more than one cylinder, an equal thickness should be added to both points of adjustment, if possible. In making this adjustment, always allow .025" to .035" end play, and take especial care that all the other stop rings have greater clearance than the two taking the end thrust.

19. Changing Rotation

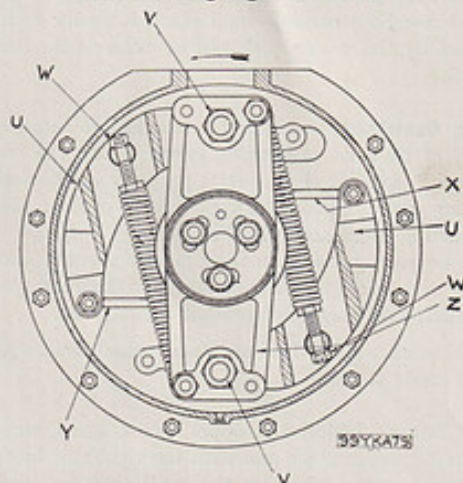


Fig. 35. Reverse Rotation Governor Diagram

Changing the rotation of the engine must be done by a competent mechanic, and to such a man it will be self-evident how to take the governor apart and reassemble it to the opposite hand. It is necessary to obtain from the factory a new governor spider with injection and governor cams, and also a new air starter cam. Reassemble the governor with the weights as shown in Fig. 35.

Note—Drawings will be furnished upon request, showing how to remachine the old parts in the field to obtain reverse rotation.

20. Changing Speed

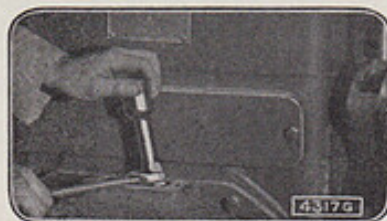


Fig. 36. Changing Speed

To increase the engine speed, tighten the governor springs by means of the adjusting screws W; to decrease the speed, reverse the operation. See Figs. 35 and 36. Adjust the two springs so that they have equal tension.

21. Woodward Governor

For instructions on adjusting Woodward governors see the Woodward Governor Co. Bulletin W-2 covering Type 1C governors.

12. INSTRUCTIONS FOR ASSEMBLING MODEL 32 ENGINES DISMANTLED FOR SHIPMENT

Export Shipments—Three different methods of boxing are used for shipping Model 32 engines on export orders. They are shipped:

1. Partially dismantled
2. Totally dismantled
3. Completely assembled

This section deals with a totally dismantled engine. If it is only partially dismantled the erector may finish assembling it, using only the instructions which cover the work yet to be done. The engine must be handled and assembled carefully in order that it may be kept clean and so that all parts will work freely. Study the repair charts while assembling the engine.

Setting Lower Base—When the foundation is ready the lower base may be set in place and assembly work started. Level the lower base carefully and block it firmly so it will not be disturbed by the work which will be done on it. See section 3 on page 8.

Laying Crankshaft—Clean the crankshaft thoroughly, removing all of the rust preventing grease. Lay the crankshaft in place and make sure that it rests properly in all of the lower main bearing shells. Put on the upper halves of the main bearing shells, adjusting them according to section 1 page 28. Be sure to put the bearing shells on in their proper position and replace the dowels and shims as they come from the factory. Check the crankshaft end play. See section 18, page 31.

Do not install the flywheel until after the bearings are tightened down ready to run.

Upper Bases—Install the upper bases, being sure to put each one in its proper place and with the right side to the front. The lower and upper bases on the multi-cylinder engines are plainly marked on the front side. The dowels for locating the upper base are shipped in place in the lower base. The gaskets are in a metal container.

Cylinders—Place the cylinders on the upper bases. Line them up so that the drilled spots at the joints line up exactly. There are no dowels between the cylinder and the upper base so the spots must be matched. The gaskets are in a metal container.

Pistons and Connecting Rods—The connecting rods and both halves of the connecting rod bearings are stamped with the cylinder number. The marks should all be toward the front of the engine. The shims between the upper and lower halves of the connecting rod bearing must be assembled in the same

relation as they are when they leave the factory. The shims between the connecting rod bearing and the bottom of the connecting rod are fastened to the upper stud for the hand hole cover on the front of each upper base. See sections 2, 5 and 7 on pages 28 and 29.

Piston-Cylinder Head Clearance—Be sure the cylinder heads are assembled properly. Each head is stamped on the front side with the cylinder number. To check the cylinder head clearance first turn the engine over by hand to see that all parts are free and then proceed as indicated in section 7 on page 29. Use the second method.

Governor—The governor is left on the crankshaft except in the case of the Woodward governor. For installing the Woodward governor see Instructions 2818. In this case it is not necessary to consider the section covering the removal of the standard governor.

Injection Pump—The injection pump housing is removed with all parts in place and the crankshaft is removed without disturbing the governor and then the injection pump housing is put back where it belongs. In the 4, 5 and 6 cylinder engines it is necessary to remove the rocker shafts for the lower rockers in order to lift the pump up past the cams. See repair chart 11B. These rocker shafts are put back in place for shipment and must be again removed in order to get the rockers down over the cams when the pump is replaced after laying the crankshaft. Then the rockers are reassembled for operation. To remove the rocker shaft, first remove the small lock plate at the outside end. Then push the shaft back a short distance and remove the split washer from the groove at the inside end. The shaft will slip out leaving the rockers free except for the small springs which hold them against the cam. To replace the rocker shafts reverse the procedure outlined above.

Manifolds and Piping—The installation of the water manifolding and the starting air and lubricator piping and the injection tubing is quite simple. The pipes are the right length and have the proper fittings attached to them. The air start piping and water manifolds are shown on pages 60 and 66. The injection tubes and some of the lubricator tubes run under the floor of the platform.

General—Too much care cannot be taken during the assembly of the engine to be sure that everything is clean and works easily and is free from leaks. When the assembly work is finished the engine may be installed in the normal manner. See the complete section on Installation beginning on page 7.

VI. REPAIR CHARTS AND LIST

Explanation of Repair List

Complete Assembly.—The complete assembly number shown in large bold face type and followed by the letter "C" (indicating complete) includes all items to the next horizontal line. A complete assembly may be ordered "less" any items unless the words "Not furnished separately" appear against those items.

Bracketed Assembly.—The bracketed assembly number shown in small bold face type includes all of the items in the

bracket. The main part of the assembly (in small bold face type) cannot be furnished except with all the parts in the bracket.

Individual Repair Parts.—Individual repair parts and unnumbered parts are furnished separately unless followed by the words "Not furnished separately."

Instructions for Ordering Repair Parts

Information Required.—To insure shipment of the proper repair parts, without delay, give the complete description of the part, or parts wanted as shown in the following example.

- Quantity of parts wanted, "one."
- Repair number, "1F."
- Name of part, "cylinder."
- Engine Model 32E14.
- Number of cylinders and model, "4 cylinder Model 32E14 Diesel."
- Engine serial number, "No. 876972."
- Specify AR1, AR2, AR3 or AR4 where found in list as with 422J on page 36. See Fig. 37 on page 34 to determine engine arrangement.

Sample Repair Order.—The repair order in this case should read: One "1F" cylinder for 14"x17" 4 cylinder Model 32E14 Diesel Engine serial number 876972.

Repair Number and Engine Serial Number.—The most important items of the above information are the Repair Number and the Engine Serial Number. The latter is stamped on the upper face of the lower base on the exhaust side of the engine at the governor end. The cylinders are numbered 1, 2, 3, etc., beginning at the governor end.

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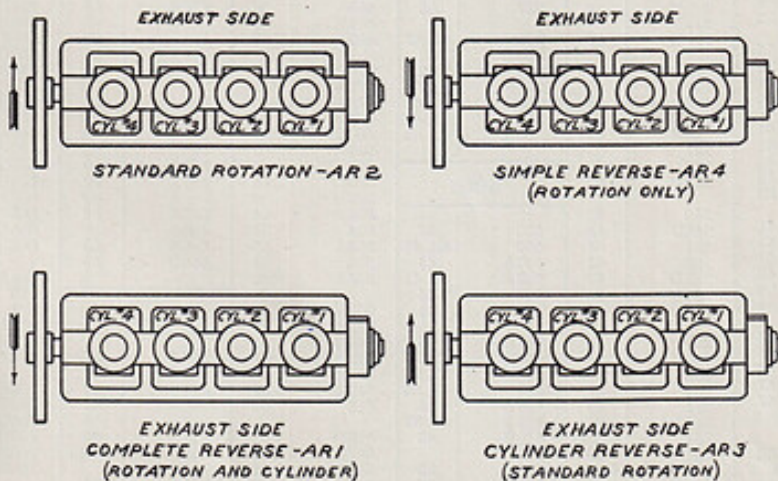
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Repair Number	Page No.	Repair Number	Page No.	Repair Number	Page No.	Repair Number	Page No.	Repair Number	Page No.	Repair Number	Page No.	Repair Number	Page No.	Repair Number	Page No.
1F	45	51B	64	193B	41, 42	311B	44	422H-A	60	525A	54	625F	51	701D	60
2F	37	52B	64	53	314A	44	422J	36	526A	54	625G	51	721E	67	
2H	37	55	54	195	36	314B	44	423H	36	528A	54	626A	57	755	55
2J	37	56	54	197B	38			423H-A	69	529A	54	626B	57	798A	66
2K	38	58	54	197D	38	315A	44	423J	36	531B	55	627A	57		
2L	37	58A	54	198B	45	317A	44			535B	55	627B	57		
3L	48	59	54	199A	37, 38, 59	319A	44	424H	36	536A	55				
						323	62	424H-A	69	537	55	632A	48		
						342	39	425G	36			642A	57		
4	46	60A	53	200		342A	39	425G-A	69	544	55	651B	57	805D	39
5G	46	66	67	205A	36	346	62	426F	36	546E	64	654Q	56	805E	39
6	46	70A	64	205B	36	346A	62	426G	36	552B	56	654R	56	806D	39
7D	46	75A	50	210A	36	349	46			553D	56	654S	56	806E	39
8B	46			210B	36	355B	39	427G	36	566A	64	654T	56	807D	39
8H	46	76	49, 50	214	36	362E	48	427G-A	69	566B	62	654U	56	807E	39
8K	46	76A	49	215A	58	363B	48	432	58	570B	54, 62				
		77A	50	215B	58	364B	48	451	58	572	54	656A	51	812D	38
13J	40	83A	64	216A	58	367	55	452	58			656B	51	812E	38
13K	40	85A	64	217D	58			454	58	573B	60	656D	51	813B	38
13L	40	90B	52					464B	54	573D	60	656E	51	813D	38
13M	41							469A	57	574	62	656F	51	814B	38
13N	41	91	55			392	41, 42			577A	43	657D	57	816E	42
14G	38	92A	36			393D	42			578A	43	658A	51, 61	816F	42
		92B	36	222	65	393E	42	470	52					816G	42
		96A	36	222A	65	393F	42	472A	57	591A	59	658B	41		
17D	47			225A	49	393G	41, 42	473A	56	592A	59	658D	62	817E	42
18F	47	138	41	225D	49	394	41, 42	501B	64	593A	59	659E	56	817F	42
18E	47	139	41	227	45	394A	41, 42	501F	62	595	65	659F	56	817G	42
20D	47	139A	41	229	49			501G	62	595A	59	659G	56	818E	42
20E	47	148	52	233B	59			502D	64	597A	59	659H	56	818F	43
21B	47	150	52					502E	62	597B	59	659J	56	818G	43
21D	47							503A	64	598A	59	665	50	819E	43
				240	62			504	64	598B	59	666	49	819F	43
25	69	164A	41	248B	48	400	67	504A	65	599A	59	668	49	819G	43
25B	41	165F	41	251	64	402	40, 41	505	64	599B	59				
25D	41	165H	42	253A	42	402A	41	505A	64			669A	66	820A	42, 43
26A	41	165J	42	253D	42	403A	40, 41					670	50	820B	42, 43
26B	41	165K	42	254A	38	404	45	507E	64			671	50	821E	43
26D	41	167A	64	256D	64	405	41	510A	57			674A	62	821F	43
								510B	68			674B	62	821G	43
32B	47	172	45	259	55	407B	66	511B-B	57	604A	37	674D	62	822E	43
32D	47	172A	45	260B	55	407D	66			608A	39			822F	43
33C	48	178	46	263	49, 50	409B	37, 38			611	50	700E	60	822G	43
34A	47	181	47	266	57	416	49, 50			615	49	700F	60	823G	42
39	54	181A	47	271	58	416A	45			616	49	700G	60	823H	42
		182B	37, 38	277A	66	419A	43, 67			617	49	700H	60	823J	42
				281	49, 50	419B	43	516D	52	618	49, 50	700I	60	823K	42
44D	47	187A	53	281A	49			517E	52			700K	60	823L	42
44E	47	189	46, 67	282	49, 50	420	36	518A	52	625A	51			823M	42
44G	47	189A	67	298B	38, 68	421G	36	519A	52	625B	51	701	60		
44H	47					421G-A	69	520A	52	625D	51	701A	60	825	38, 68
44J	47	191	41, 42	300A	52	421H	36	520B	69	625E	51	701B	60	825A	44
48A	64	192	41, 42	310A	44	422H	36	524A	54						

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Repair Number	Page No.	Repair Number	Page No.	Repair Number	Page No.	Repair Number	Page No.	Repair Number	Page No.	Repair Number	Page No.	Repair Number	Page No.	Repair Number	Page No.
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827H	42, 43	1012A	59	1322	36	1861	44	2319	53		3149B	66	5545	45	
827J	42, 43	1012B	59	1322A	36	1861A	44	2319A	53		3149D	66	5565	48	
827K	43	1013A	59			1861B	44	2320	39		3235	59	5565A	48	
827L	43	1014	59	1325	36	1898	64	2321	57		2533	65	5566	48	
827M	43	1015	59	1325A	36	1899	64	2321B	69		2534	65	5567	48	
830	39	1029A	58	1329A	59	1899A	65	2322	57		2535	62, 65	5601	65	
831F	43			1329B	59	1902	53	2322	66		2536	65	5601A	63	
831G	43	1030	58	1336A	38	1902A	54	2323	57		2537	65	5602	65	
831H	43	1031	58			1902D	69	2324	56		2538	65	5824	63	
831J	43	1031A	58	1379	57	1941B	57			2538A	63	3454	64		
831L	43	1039	52	1379	57			2326	56, 62	2540	65	3458	38		
831M	43	1081B	53	1380B	57	1977A	39	2326A	56	2541	65	3458A	38		
		1082D	53			1978	43	2326B	62	2543	65	3619	53		
833	43	1082E	69	1405	47	1988B	35	2326D	62	2544	65	3633	59		
833A	44	1084B	53	1406	47	1989A	39	2327	57	2545	65	3693	67		
833E	43	1085B	53	1407	47			2328	57	2546	65	3712	43		
836A	46	1086B	53	1423B	69	2058B	56	2329	57	2547	65	3713	43		
836D	46			1499	66	2059A	54	2331	51, 61	2548	65	3714	43		
836E	46	1088	53			2060E	56			2549	65	3716	43		
837A	46	1088A	53			2068	38			2551	65	3717	43		
838	46	1089A	53			2070	41, 59	2332	51, 61	2582	53	3718	43		
839A	46	1090	39			2073	69			2586B	67				
		1092A	58			2075D	47								
		1093A	53			2075E	47								
840	46			1500											
849A	57	1096D	67	1528	62	2108	55, 56	2333	51	2600	67	3818	57		
849B	62	1097A	53	1549	48	2108A	54	2333A	51	2601	60	4044	62		
849D	62			1550D	48	2108B	56	2334	54	2604	54	4045	39		
850	45	1189	62	1554B	58	2109	53	2335	54	2605	54	4103	47		
853B	48	1193D	47	1561	56	2110	53	2335A	62	2606	54	4120	46, 62		
854B	48	1193E	47	1561A	56	2111	53	2336	51	2605	54	4131	53		
856A	48	1193F	47	1581G	66	2112	52	2336A	51	2662	62				
858D	48	1193G	47	1581H	66	2113	48	2337	57	2679	55				
		1193H	47	1581P	66	2114	48			2749	69	4295	43		
896A	56					2115E	66	2338	57	2751	58				
903	54			1582B	66	2124	66	2338A	57	2763	37				
985A	52	1196E	61	1584A	66	2173A	57	2338B	57	2340	64				
985B	69	1196F	61	1584B	66			2340A	65	2766	42				
986A	53	1196G	61	1585A	66	2201A	57, 62	2341	64	2776	42				
986D	54	1199A	52	1586P	66	2202	57	2341A	65						
986F	69	1262	66	1593	65	2202A	62	2342	64						
		1262A	66	1596	65	2203	57			2777	42				
989	38, 44,			1599	65	2204	57, 62			2778	67				
	52	1300	35			2205	57, 62	2343	64	2780	49				
989A	68	1301	35	1602A	65	2257	57, 62	2343A	65	2789A	60				
990	38, 44,	1302	35	1614A	66	2258	69	2344	64	2790A	69				
	52, 68	1303D	35	1615	66			2344A	65	2791	69				
991A	52	1304	35	1616A	66	2270	53	2345	44	2792A	53				
991B	69	1304A	35	1617	59	2271	53	2346	44						
994B	67	1305D	35	1617A	66	2272	53	2360	57						
		1306A	35	1618B	66	2284	67	2361	57						
995	67			1620	67	2293E	62	2362	53						
996	67	1307A	35	1687B	66	2294B	62			2821	68				
997B	67	1309	35	1687D	66	2295A	62	2364	37, 38	2848	62				
998A	67	1310A	35	1687E	66	2296A	54	2366	52	2850	65				
		1310B	35			2297	54	2369	53	2976	51, 61,				
		1311	35	1767	65			2370	53		65				
		1314	35	1769	65	2302	69	2384	67						
		1314B	36	1770	65	2307	54	2387B	67						
1010B	59			1771A	65	2311	37, 38	2401	52						
1010D	58			1772	65	2312	53	2443	62						
1010E	58	1318B	36	1773	65	2313	53								
1010F	59	1319B	36	1786	39	2314	53, 58								
1011D	59	1320B	35	1786A	39	2316	53								
1011E	58	1320D	35	1796	53	2317	53								

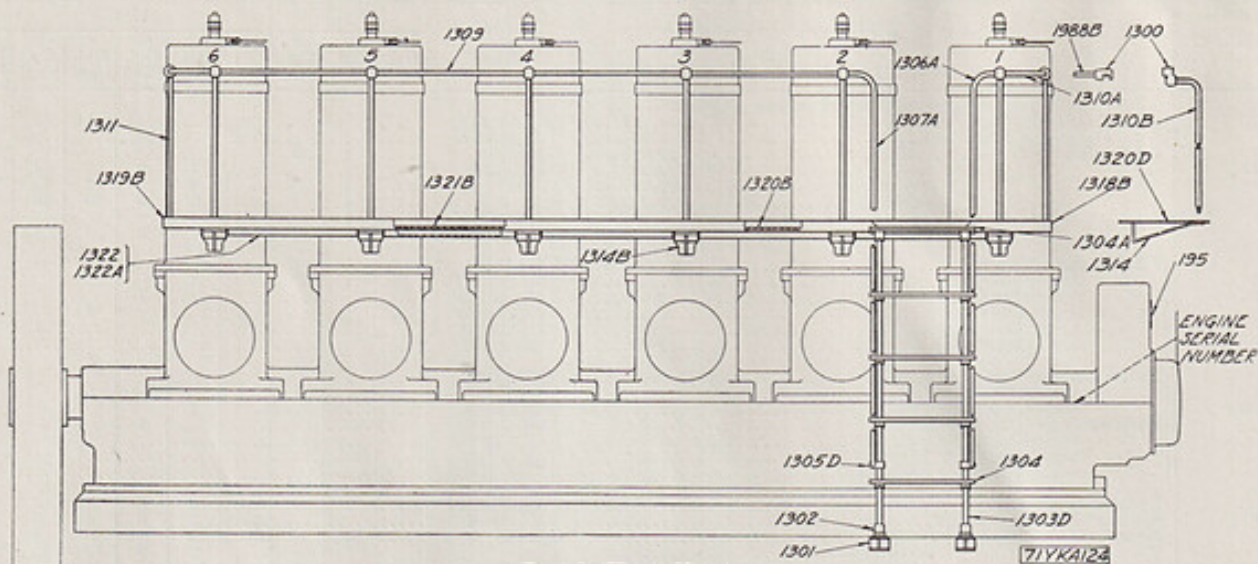
ALWAYS GIVE ENGINE SERIAL NUMBER



93YKAI66

Fig. 37. Arrangement Diagram

List Division No. 1. General Engine Parts and Platform



Repair Chart No. 1

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"						
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used	
1304A-C	Platform Stairs (Complete)			1	1		1	1	1	1	1	1
1304	Stair Step	YK1304A		4	4		4	4	4	4	4	4
1304A	Step (Top)	YK1304D		1	1		1	1	1	1	1	1
1305D	Rail Support	Y2KA1305A		2	2		2	2	2	2	2	2
1301	Stringer Floor Beam	YK1301B		2	2		2	2	2	2	2	2
1302	Lower Bracket	YK1302B		2	2		2	2	2	2	2	2
1303D	Stringer	Y2JA1303C		2	2		2	2	2	2	2	2
	Stringer	Y2K1303D					2	2	2	2	2	2
	Step Dowel	#631		10	10		10	10	10	10	10	10
	Top Step Flat Head Cap Screw	3/8"x1 3/4"		3	3		3	3	3	3	3	3
	Lockwasher	3/8"		3	3		3	3	3	3	3	3
	Nut	3/8"		3	3		3	3	3	3	3	3
	Stair Stringer Support Cap Screw	3/8"x1 3/4"		2	2		2	2	2	2	2	2
	Lockwasher	3/8"		2	2		2	2	2	2	2	2
1309-AC	Platform Railing (Complete)		1	1	1	1	1	1	1	1	1	1
	Front Hand Rail	Y3JA1309A			1							
	Rail	Y3KA1309B					1					
1309	Rail	Y4KA1309B						1				
	Rail	Y5KA1309A							1			
	Rail	Y6KA1309B									1	
1310A	End Hand Rail	Y2KA1310A					2	2	2	2	2	2
1310B	Hand Rail	YJA1310B		1								
1310A	Rail	YKA1310C			2	2						
1310B	Rail	YKA1310C										
1311	Rail Support	YK1311B1		4	5		4	5	6	7	8	
1300	Hand Rail End Bracket	YKA1300A		1	2	1						
	Bracket	Y3K1300B					2	2	2	2	2	2
1306A	Stair Hand Rail (R. H.)	Y2JA1306B			1	1						
	Rail (R. H.)	Y2KA1306C					1	1	1	1	1	1
1307A	Stair Hand Rail (L. H.)	Y2JA1307B			1	1						
	Rail (L. H.)	Y2KA1307C					1	1	1	1	1	1
1988B	End Hand Rail Extension	Y2JA1988C			2	2						
	Extension	Y2KA1988G					2	2	2	2	2	2
	Hand Rail End Bracket Stud	3/4"x3 1/4"		1	2	2	1	2	2	2	2	2
	Stud	3/4"x2"					2	2	2	2	2	2
	Nut	3/4"		1	2	2	1	2	2	2	2	2
	Lockwasher	3/4"		1	2	2	1	2	2	2	2	2
	Hand Rail End Bracket Hollow Set Screw	3/8"x1 1/2"		1	2	2	1	2	2	2	2	2
	Support Cap Screw	3/8"x1 3/4"		4	4		4	4	4	4	4	4
	Lockwasher	3/8"		8	10		8	10	12	14	16	16
	Cap Screw	3/8"x2 1/2"		4	6		4	6	8	10	12	12
	Set Screw	3/8"x1 1/2"		4	5		4	5	6	7	8	8
	Cap Screw Nut	3/8"x2"		8	10		8	10	12	14	16	16
	Stair Hand Rail Cap Screw	3/8"x2"		2	2		2	2	2	2	2	2
	Lockwasher	3/8"		2	2		2	2	2	2	2	2
	Nut	3/8"		1			1					
	Lockwasher	3/8"		1			1					
		C. P.										
		C. P.										
1320D-AC	Platform Floor (Complete)		1	1	1	1	1	1	1	1	1	1
	Floor Plate	Y2JA1320B			1							
	Plate	Y2KA1320D					1					
1320B	Plate	Y3JA1320A			1							
	Plate	Y3KA1320B						1				
	Plate	Y4KA1320B							1			
	Plate	Y6KA1320B								1	1	
1320D	Floor Plate, always with	YJA1320C		1								
	Plate, always with	YKA1320E					1					
1314	Platform Bracket	YKA1314A		1			1					
	to Floor Plate Rivet	3/4"x 3/4"		2			2					

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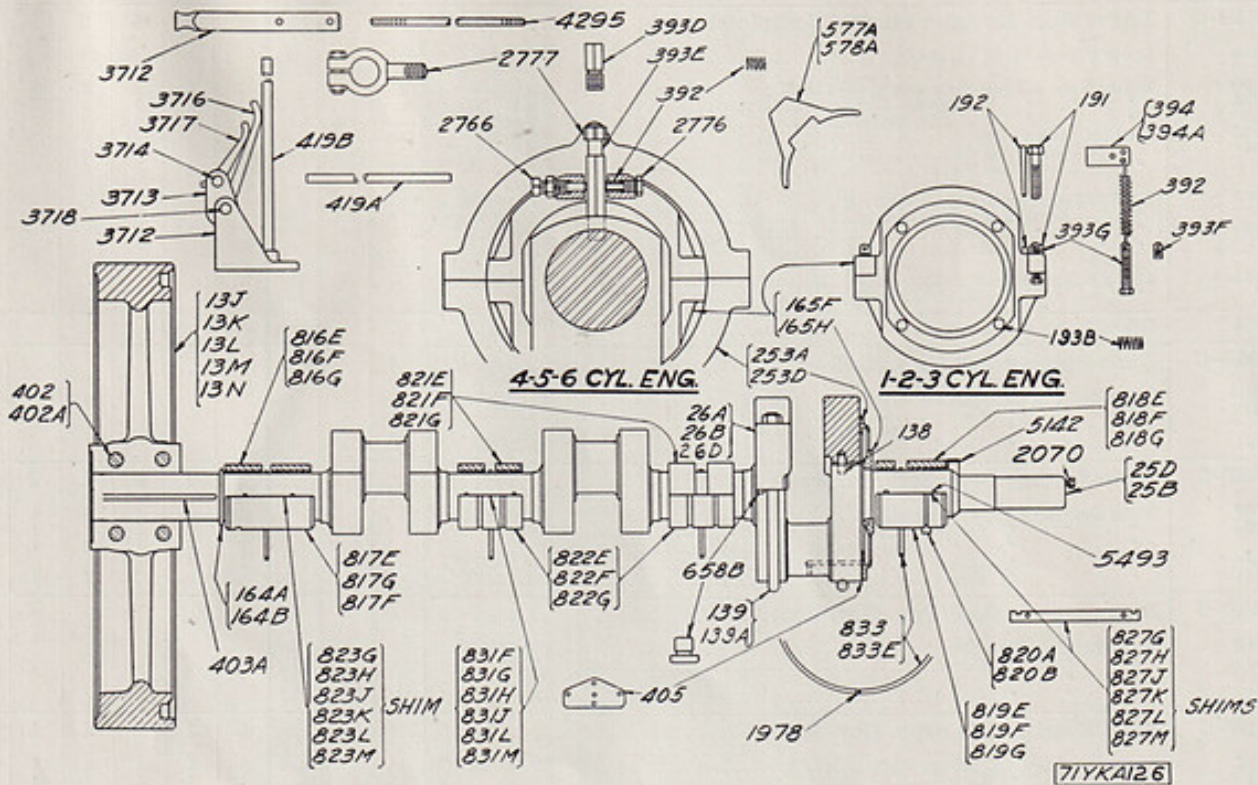
List Division No. 2. Upper and Lower Base (Continued)

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15'			14"x17'					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
2N-C 2N	Upper Base (Complete), Cyl. #1								1	1	1
	Upper Base, always with	YKA2Z							1	1	1
	Cylinder Stud	1 1/2"x5 3/4"							12	12	12
	Hand Hole Cover Stud	3/8"x2 3/4"							6	6	6
	Upper Base Oil Ring Pipe Plug	1/2"							3	3	3
	Air Valve Stud	3/8"x2 3/4"							6	6	6
	Upper Base Oil Ring Cover	YKA2311A							2	2	2
	2311 Gasket	YKA2364A							2	2	2
	2364 Cap Screw	3/8"x3/4"							8	8	8
	182B Upper Base Hand Hole Cover	YKA182C							1	1	1
199A Gasket	YK199							1	1	1	
2P-C 2P	Upper Base (Complete), Cyl. #2, #3, #4, #5, #6								1	2	3
	Upper Base, always with	YKA2Y1							1	2	3
	Cylinder Stud	1 1/2"x5 3/4"							12	24	36
	Hand Hole Cover Stud	3/8"x2 3/4"							6	12	18
	Air Valve Stud	3/8"x2 3/4"							6	12	18
	Upper Base Oil Ring Pipe Plug	1/2"							3	6	9
	Upper Base Oil Ring Cover	YKA2311A							2	4	6
	2311 Gasket	YKA2364A							2	4	6
	2364 Cap Screw	3/8"x3/4"							8	16	24
	182B Upper Base Hand Hole Cover	YKA182C							1	2	3
199A Gasket	YK199							1	2	3	
14H-C 14H	Lower Base (Complete)		1	1	1	1	1	1	1	1	1
	Lower Base, always with	YJA14K	1								
	Base, always with	Y2JA14L		1							
	Base, always with	Y3JA14H			1						
	Base, always with	YKA14Q2				1					
	Base, always with	Y2KA14J1					1				
	Base, always with	Y3KA14G2						1			
	Base, always with	Y4KA14G2							1		
	Base, always with	Y6KA14E2								1	
	Base, always with	Y6KA14G2									1
Upper to Lower Base Stud	1 1/2"x7 1/4"	4	8	12							
Stud	1 1/2"x4 1/2"	6	12	18	8	16	24	32	40	48	
Stud	1 1/2"x5 3/4"	4	8	12	4	8	12	16	20	24	
Main Bearing Stud (Gov. End)	1 1/2"x9 1/2"				2	2	2	2	2	2	
Main Bearing Stud	1 1/2"x8 1/2"	6	6	6							
Stud	1 1/2"x8"				4	4	4	4	4	4	
Stud	1 1/2"x6 1/4"				2	4	6	8	10		
Main Bearing Stud	1 1/2"x8"		2	4							
Governor Case Stud	1 1/2"x1 3/4"	6	6	6	6	6	6	6	6	6	
Lubricating Oil Sump Stud	1 1/2"x8 3/4"	2	2	2	2	2	2	2	2	2	
Governor Drain Pipe Plug	1/2"	1	1	1	1	1	1	1	1	1	
Crank Pin Oiler Bracket	YKA2068A1	1	2	3	1	2	3	4	5	6	
Cap Screw	3/8"x1"	2	4	6	2	4	6	8	10	12	
Lockwasher	3/8"	2	4	6	2	4	6	8	10	12	
254A Spout	YKA254A	1	2	3	1	2	3	4	5	6	
Lubricator Oil Tube Fitting	1/2" P.x 1/4" T.	1	2	3	1	2	3	4	5	6	
Tube Elbow	1/2" P.x 1/4" T.	1	2	3	1	2	3	4	5	6	
Tube	YJA1336A	1	2	3							
Tube	YKA1336A				1	2	3	4	5	6	
812D Main Bearing Shell Oil Stop	YJA812D	2	2	2							
812F " " " "	YKA812H1				2	2	2	2	2	2	
813B " " " "	YJA813C	2	2	2							
813D " " " "	YKA813C				2	2	2	2	2	2	
814B Main Bearing Shell Oil Stop (Center)	Y2JA814C		2	4							
814D " " " " Stop (Center)	Y2KA814E				2	4	6	8	10		
805D-C Bearing Cap (Gov. End)		1	1	1							
805E-C " " (Gov. End)					1	1	1	1	1	1	
806D-C " " (Opp. Gov. End)		1	1	1							
806E-C " " (Opp. Gov. End)					1	1	1	1	1	1	
807D-C " " Cap (Center)			1	2							
807E-C " " (Center)					1	2	3	4	5		
Main Bearing to Upper Base Capscrew	1 1/2" x 7 1/4"	4	8	12	4	8	12	16	20	24	
409D Dowel	YKA409C	4	8	12	4	8	12	16	20	24	
3458 Thrust Blocks (Gov. and Opp. Gov. End)	YKA3458B1	4	4	4							
3458A " " Blocks (Center)	YKA3458C1		2	4							
Taper Dowel	1/2"	1	1	1							
409A " " Taper Dowel	YKA409A	8	12	16							
Cap Screw	3/8"x2 3/4"	4	6	8							
298B-C Bearing Oil Gauge		1	1	1	1	1	1	2	2	2	
355B-C Lower Base Air Inlet		1	1	2	1	1	1	2	2	2	
2F-C Upper Base (Cyl. #1)		1	1	1							
2H-C " " Base (Cyl. #2, #3)			1	2							
2J-C " " Base (Cyl. #1)					1	1	1				
2L-C " " Base (Cyl. #1)								1	1	1	
2K-C " " Base (Cyl. #2, #3, #4, #5, #6)								1	4	5	
197B Upper to Lower Base Gasket	YJA197B	2	4	6							
Gasket	YKA197E				2	4	6	8	10	12	
197D Upper to Lower Base Gasket	YJA197D	4	8	12							
Gasket	YKA197D				4	8	12	16	20	24	
Bearing Oil Piping (Not Fur. Sep.)		1	1	1	1	1	1	1	1	1	
Oil Drain Piping (Not Fur. Sep.)		1	1	1	1	1	1	1	1	1	
Lower Base Pipe Plug	2 1/2"	4	6	8	4	6	8	10	12	14	
3/4" C. P. S. F. Nuts		4	8	12							
1 1/2" C. P. S. F. Nuts		16	28	40	12	24	36	48	60	72	
1 1/4" C. P. S. F. Nuts		4	8	12	6	8	10	12	14	16	
1 1/2" C. P. S. F. Nuts		1	1	1							
3/8" Plate Washer		1	1	1							
Governor Case Stud Nut	3/4"	6	6	6	6	6	6	6	6	6	
Lubricating Oil Sump Stud Nut	3/4"	2	2	2	2	2	2	2	2	2	
298B-C Main Bearing Oil Gauge (Complete)	YJA298A	1	1	1	1	1	1	2	2	2	
990 " " " " Glass Gasket	YK990	2	2	2	2	2	2	4	4	4	
825 " " " " Glass	YK825	1	1	1	1	1	1	2	2	2	
989 " " " " Plug	YK989	1	1	1	1	1	1	2	2	2	
Pipe Plug	1/2"	1	1	1	1	1	1	2	2	2	
Pipe Plug	1/2"	1	1	1	1	1	1	2	2	2	

List Division No. 2. Upper and Lower Base (Continued)

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
355B-C	Lower Base Air Inlet Flange (Complete)		1	1	2	1	1	1	2	2	2
355B	Lower Base Air Inlet Flange	YJA355A	1	1	2						
355B	Lower Base Air Inlet Flange, always with	YKA355B				1	1	1	2	2	2
1977A	Screen	YKA1977D				1	1	1	2	2	2
4045	Strip	YKA4045A				1	1	1	2	2	2
1989A	Air Inlet Screen Plate	YKA1989C				1	1	1	2	2	2
5874	Reinforcing Ring	YKA5874A				2	2	2	4	4	4
	Flange Cap Screw	1/4"x3"	3	3	6	3	3	3	6	6	6
1977A	Air Inlet Screen, always with	YJA1977B1	1	1							
4045	Screen, always with	Y3JA1977A			2						
	Seam	YJA4045A	1	1							
	Seam	Y3JA4045A			2						
1989A	Air Inlet Screen Plate	YJA1989B	1	1	2						
	R. H. M. Screw	1/4"x3/8"	8	8	16						
608A	Lower Step	YJA608A	1								
805D-C	Main Bearing Cap (Gov. End)		1	1	1						
805D	Main Bearing Cap, always with	YJA805G1	1	1	1						
830	Cover	YK830	1	1	1						
342	Hinge Pin	#455	1	1	1						
	Dowel	YJA342A	1	1	1						
805F-C	Main Bearing Cap (Governor End)					1	1	1	1	1	1
805F	Main Bearing Cap, always with	YKA805L2				1	1	1	1	1	1
830	Cover	YK830				1	1	1	1	1	1
342	Hinge Pin	#455				1	1	1	1	1	1
342A	Dowel	YJA342A				1	1	1			
	Dowel	Y5KA342A							1	1	1
806D-C	Main Bearing Cap (Opp. Gov. End)		1	1	1						
806D	Main Bearing Cap, always with	YJA806D1	1	1	1						
830	Cover	YK830	1	1	1						
342	Hinge Pin	#455	1	1	1						
	Dowel	YJA342A	1	1	1						
806F-C	Main Bearing Cap (Opp. Gov. End)					1	1	1	1	1	1
806F	Main Bearing Cap, always with	YKA806M				1	1	1	1	1	1
830	Cover	YK830				1	1	1	1	1	1
342	Hinge Pin	#455				1	1	1	1	1	1
342A	Dowel	YJA342A				1	1	1			
	Dowel	Y5KA342A							1	1	1
807D-C	Main Bearing Cap (Center)			1	2						
807D	Main Bearing Cap, always with	Y2JA807D1		1	2						
830	Cover	YK830		1	2						
342	Hinge Pin	#455		1	2						
	Dowel	YJA342A		1	2						
807F-C	Main Bearing Cap (Center)						1	2	3	4	5
807F	Main Bearing Cap, always with	Y2KA807K2					1	2	3	4	5
830	Cover	YK830					1	2	3	4	5
342	Hinge Pin	#455					1	2	3	4	5
342A	Dowel	YJA342A					1	2			
	Dowel	Y5KA342A							3	4	5
2320	Lubricating Oil Pump Rod Casing	YJA2320A	1	1	1						
	Casing	YKA2320A				1	1	1	1	1	1
1786	Upper Base Oil Deflector Plate	YJA1786A	2	2	2						
	Plate	YKA1786A				1	1	1			
	Plate	Y4KA1786A							1	1	1
A1786A	Upper Base Oil Deflector Plate (Center Br'g)	YJA1786B		2	4						
B1786A	(Center Br'g)	YKA1786C					2	4			
	(Center Br'g)	Y4KA1786C							6	8	10
C1786A	Upper Base Oil Deflector Plate	YKA1786D				1	1	1			
	Deflector Plate	Y4KA1786D							1	1	1
	Deflector Screw	#10 24" x 1/4"	6	12	18	6	12	18	24	30	36
5852N	Base Sump Nipple	YKA5852B				1	1	1	1	1	1
5852S	Nipple	Y2KA5852R				1					
A5852T	Nipple	Y2KA5852S					1	1	1	1	1
B5852T	Nipple	Y3KA5852A						1	1	1	1
C5852T	Nipple	Y4KA5852A							1	1	1
D5852T	Nipple	Y5KA5852A								1	1
E5852T	Nipple	Y6KA5852A									1
F5852T	Nipple	Y4KA5852A									1
G5852T	Nipple	Y3KA5852A				1	1	1			
A6844K	Base Sump Pipe	YKA6844G				1	1	1	1	1	1
B6844K	Pipe	YKA6844H					1	1	1	1	1
C6844K	Pipe	YKA6844J						1	1	1	1
D6844K	Pipe	YKA6844K							1	1	1
E6844K	Pipe	YKA6844L								1	1
F6844K	Pipe	YKA6844M									1
	Pipe	1/2" x 22"	1	1	1						
	Pipe	1/2" x 51"				1	1				
	Pipe	1/2" x 80"									
1090	Base Sump Pipe Clamp	Y3KA1090A			2			2	2	2	2
	Clamp	Y4KA1090A							2	2	2
	Clamp	Y6KA1090A								2	2
	Capscrew	1/2" x 2"						2	4	7	7
	Capscrew	1/2" x 2 1/4"									7
	Nut	1/2"							2	4	7
	Lockwasher	1/2"							2	4	7
	Pipe Elbow	1/2"	1	2	3	1	2	3	4	5	6
5851A	Drain Plug	YKA5851D	1	2	3	1	2	3	4	5	6

List Division No. 3. Crankshaft, Flywheel and Bearings



Repair Chart No. 3

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15'			14"x17'					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
13J-C	Flywheel (Complete) (Belted Commercial) Note:—Rims drilled for straight pulling bar.		1	1	1	1	1	1	1	1	1
13J	Flywheel 66"x 7", always with.....	YJA13V	1								
	" 66"x 6", always with.....	Y3JA13G		1							
	" 66"x11", always with.....	Y2JA13Z			1						
	" 76"x 8", always with.....	Y6KA13U				1	1	1			
	" 78"x10", always with.....	Y4KA13H							1	1	1
402	Flywheel Hub Bolt.....	YKA402A	4	4	4	4	4	4	4	4	4
	" Nut.....	2 3/4" C. P.	8	8	8	8	8	8	8	8	8
	" Extension Shaft Stud.....	1 1/2"x3 3/4"	6	6	6	6	6	6	6	6	6
	" Nut.....	1 1/2" C. P.	6	6	6	6	6	6	6	6	6
403A	Flywheel Key.....	YKA403A	1	1	1	1	1	1	1	1	1
13K-C	Flywheel (Complete) (Direct Connected) Note:—For Barring Device.		1	1	1	1	1	1	1	1	1
13K	Flywheel 66"x13", always with.....	YJA13U	1								
	" 66"x11", always with.....	Y2JA13Y		1	1						
	" 80"x14", always with.....	YKA13AA				1					
	" 78"x10", always with.....	Y2KA13Z					1	1			
402	Flywheel Hub Bolt.....	YKA402A	4	4	4	4	4	4	4	4	
	" Nut.....	2 3/4" C. P.	8	8	8	8	8	8	8	8	
	" Extension Shaft Stud.....	1 1/2"x3 3/4"	6	6	6	6	6	6	6	6	
	" Nut.....	1 1/2" C. P.	6	6	6	6	6	6	6	6	
403A	Flywheel Key.....	YKA403A	1	1	1	1	1	1	1	1	1
13L-C	Flywheel (Complete) (Direct Connected) Note:—Rims drilled for straight pulling bar.		1	1	1	1	1	1	1	1	1
13L	Flywheel, 66"x13", always with.....	YJA13W	1								
	" 66"x11", always with.....	Y2JA13Z		1	1						
	" 80"x14", always with.....	YKA13AB				1					
	" 78"x10", always with.....	Y2KA13AA					1	1			
402	Flywheel Hub Bolt.....	YKA402A	4	4	4	4	4	4	4	4	
	" Nut.....	2 3/4" C. P.	8	8	8	8	8	8	8	8	
	" Extension Shaft Stud.....	1 1/2"x3 3/4"	6	6	6	6	6	6	6	6	
	" Nut.....	1 1/2" C. P.	6	6	6	6	6	6	6	6	
403A	Flywheel Key.....	YKA403A	1	1	1	1	1	1	1	1	1

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 3. Crankshaft, Flywheel and Bearings (Continued)

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"						
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used	
13M-C	Flywheel (Complete) (Belted Electric)		1	1	1	1	1	1	1	1	1	1
	Note:—For Barring Device.											
13M	Flywheel 56"x16 ¹ / ₂ ", always with	YJA13R	1									
	" 56"x16" always with	Y2JA13W		1								
	" 56"x20" always with	Y3JA13J			1							
	" 67"x16" always with	YKA13X				1						
	" 67"x18" always with	Y2KA13V					1					
	" 67"x25" always with	Y3KA13P						1				
	" 78"x10" always with	Y4KA13G							1	1	1	1
402	" Hub Bolt	YKA402A	4		4	4	4	4	4	4	4	4
402A	" Bolt	YJA402B		4								
	" Nut	2 ³ / ₄ " C. P.	8	8	8	8	8	8	8	8	8	8
	Extension Shaft Stud	1 ¹ / ₂ "x3 ¹ / ₄ "	6	6	6	6	6	6	6	6	6	6
	" Nut	1 ¹ / ₂ " C. P.	6	6	6	6	6	6	6	6	6	6
403A	Flywheel Key	YKA403A	1	1	1	1	1	1	1	1	1	1
13N-C	Flywheel (Complete) (Belted Electric)								1	1	1	1
	Note:—Rims drilled for straight pulling bar.											
13N	Flywheel 78"x10", always with	Y4KA13H							1	1	1	1
	" Hub Bolt	YKA402A							4	4	4	4
	" Nut	2 ³ / ₄ " C. P.							8	8	8	8
	Extension Shaft Stud	1 ¹ / ₂ "x3 ¹ / ₄ "							6	6	6	6
	" Nut	1 ¹ / ₂ " C. P.							6	6	6	6
403A	Flywheel Key	YKA403A							1	1	1	1
25B-C	Crankshaft (Complete)					1	1	1				
25B	Crankshaft (8" Diam.), always with	YKA25C1				1						
	" (8" Diam.), always with	Y2KA25C2					1					
164A	Crankshaft Oil Throw Ring	Y3KA25B3						1				
26B	Counterweight	YKA164A				1	1	1				
26D	Counterweight	YKA26A				2	4					
138	" Dowel	Y3KA26C2						6				
139	" Bolt with Nut	YK138				2	4	6				
139A	" Bolt with Nut	YKA139A				2	4					
658B	" Mushroom	YKA139B						6				
	Governor Spider Stud	Y3K658				4	8	12				
	" Nut	3/8"x2 ¹ / ₄ "				3	3	3				
		3/8" C. P.				3	3	3				
2070	Crankshaft Governor Spider Stud Washer	YKA2070A				3	3	3				
405	Oil Ring to Shaft Gasket	YK405				1	2	3				
253A-C	Crank Pin Oil Ring					1	2	3				
165G-C	Air Stop Ring					2	4	6				
25D-C	Crankshaft (Complete)		1	1	1				1	1	1	1
25D	Crankshaft (7 ¹ / ₂ " Diam.), always with	YJA25B1	1									
	" (7 ¹ / ₂ " Diam.), always with	Y2JA25C2		1								
	Crankshaft (9 ¹ / ₂ " Diam.), always with	Y3JA25A2			1							
	" (9" Diam.), always with	Y4KA25H2							1			
	" (9" Diam.), always with	Y5KA25C1								1	1	1
	" (9" Diam.), always with	Y6KA25G1										
164A	Crankshaft Oil Throw Ring	YKA164A	1	1	1							
164B	Ring	Y6KA164B							1	1	1	1
26A	Crankshaft Counterweight	YJA26A	2	4								
26D	Counterweight	YJA26E			6							
138	" Dowel	YK138	2	4	6							
139	" Bolt	YJA139A	2	4								
139A	" Bolt	YJA139C			6							
	" Nut	1 ¹ / ₂ " C. P.	4	8	12							
	Mushroom	Y3K658	4	8	12							
	Crankshaft Governor Spider Stud	3/8"x2 ¹ / ₄ "	3	3	3				3	3	3	3
	" Nut	3/8" C. P.	3	3	3				3	3	3	3
2070	Crankshaft Governor Spider Stud Washer	YKA2070A	3	3	3				3	3	3	3
405	Crank Pin Oil Ring to Shaft Gasket	YK405	1	2	3				4	5	6	6
253A-C	" Ring		1	2	3							
253D-C	" Ring		1	2	3							
165H-C	Air Stop Ring		2	4	6				4	5	6	6
									8	10	12	12
165H-C	Air Stop Ring (Complete)					2	4	6				
165G	Air Stop Ring (Top), always with	YKA165E1				2	4	6				
	Ring (Bottom)	YKA165F1				2	4	6				
191	" Bolt	YK191A				4	8	12				
	" Lockwasher	3/8"				4	8	12				
192	" Lockwire	1/4"x3 ¹ / ₄ "				4	8	12				
	" Dowel	Y2J192				4	8	12				
393H	Back Lash Set Screw	YKA393C				4	8	12				
392	" Spring	YK392A				2	4	6				
394	" Clip	YK394				2	4	6				
394A	" Clip	YKA394A						6				
193B	Air Stop Ring Spring	YKA193A1				8	16	24				
	" Cap Screw	3/8"x2"				2	4	6				
	" Nut	3/8"x2 ¹ / ₄ "						6				
	Dog Point Set Screw Jam Nut	3/8" C. P.				2	4	6				
	Air Stop Ring Lockwasher	3/8" C. P.				6	12	18				
		3/8"				6	12	18				

List Division No. 3. Crankshaft, Flywheel and Bearings (Continued)

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
165H-C	Air Stop Ring (Complete)		2	4	6				8	10	12
165H	Air Stop Ring (Bottom), always with.....	YJA165F	2	4	6						
	Ring (Bottom), always with.....	Y6KA165E1							8	10	12
191	Ring (Top).....	YJA165E1	2	4	6						
	Ring (Top).....	Y6KA165F1							8	10	12
192	Air Stop Ring Bolt.....	YK191A	4	8	12				16	20	24
	Lockwasher.....	3/8"	4	8	12				16	20	24
392	Air Stop Ring Dowel.....	Y2J192	4	8	12				16	20	24
	Lockwire.....		4	8	12				16	20	24
393G	Air Stop Ring Back Lash Spring.....	YK392	2	4	6						
	Screw.....	YKA393B4	2	4	6						
393J	Screw.....	YKA393D1	2	4	6						
	Clip.....	YK394	2	4	6						
394A	Clip.....	YJA394B			6						
	Driving Stud.....	Y4KA393A1							4	5	6
393E	Oil Throw Ring Driving Stud.....	Y4KA393B1							4	5	6
	Driving Spring.....	Y4KA392B							8	10	12
2776	Plug.....	Y4KA2776B							8	10	12
	Air Stop Ring Spring.....	YKA193A1	8	16	24				32	40	48
193B	Driving Set Screw.....	Y4KA2766B							8	10	12
	Lockwasher.....	3/8"							16	20	24
2766	Jam Nut.....	3/8" C. P.							8	10	12
	Driving Clamp.....	Y4KA2777A1							4	5	6
2777	Cap Screw.....	3/8"x1 3/4"							4	5	6
	Lockwasher.....	3/8"							4	5	6
2777	Nut.....	3/8" C. P.							4	5	6
	Lockwasher.....	3/8"							4	5	6
2777	Nut.....	3/8" C. P.							4	5	6
	Lockwasher.....	3/8"							4	5	6
253A-C	Crank Pin Oil Ring (Complete)		1	2	3	1	2	3			
	Crank Pin Oil Ring, always with.....	Y4KA253A2	1	2	3	1	2	3			
253A	Ring, always with.....	Y4KA253B1	1	2	3	1	2	3			
	Cap Screw.....	1/2"x4 1/4"	2	4	6	2	4	6			
253A	Lockwasher.....	3/8"	2	4	6	2	4	6			
253D-C	Crank Pin Oil Ring (Complete)								4	5	6
	Crank Pin Oil Ring, always with.....	Y6KA253C							4	5	6
253D	Ring, always with.....	Y6KA253D							4	5	6
	Cap Screw.....	1/2"x4 1/4"							4	5	6
253D	Lockwasher.....	3/8"							4	5	6
816E-C	Main Bearing Shell (7 1/2" Diam.) (Opp. Gov. End)		1	1	1						
	Main Bearing Shell (2 pcs. 5 1/2" lg.), always with.....	YJA816D1	1	1	1						
816E	Shell (12 1/2" long) (Not Fur. Sep.).....	YJA817D3	1	1	1						
	Shim Dowel.....	CKB5493A	4	4	4						
820A	Main Bearing Shell Dowel.....	YJA820A	1	1	1						
	Shim.....	YJA823D1	6	6	6						
823G	Shim.....	YJA823E1	4	4	4						
	Shim.....	YJA823F1	6	6	6						
816F-C	Main Bearing Shell (8" Diam.) (Opp. Governor)					1	1	1			
	Main Bearing Shell (14 1/4" lg.), always with.....	YKA816D1				1	1	1			
816F	Shell (14 1/4" long) (Not Fur. Sep.).....	YKA817E				1	1	1			
	Shim Dowel.....	CKB5493A				4	4	4			
820A	Main Bearing Shell Dowel.....	YJA820A				1	1	1			
	Shim.....	YKA823K1				2	2	2			
823H	Shim.....	YKA823L1				4	4	4			
	Shim.....	YKA823M1				8	8	8			
816G-C	Main Bearing Shell (9" Diam.) (Opp. Gov. End)								1	1	1
	Main Bearing Shell (6 1/2", 6 5/8" long), always with.....	Y6KA816E1							1	1	1
816G	Shell (14 3/4" long) (Not Fur. Sep.).....	Y6KA817E3 #409							1	1	1
	Shim Dowel.....								4	4	4
820B	Main Bearing Shell Dowel.....	Y5KA820A							1	1	1
	Shim.....	Y4KA823A1							6	6	6
823L	Shim.....	Y4KA823B1							4	4	4
	Shim.....	Y4KA823C1							6	6	6
818E-C	Main Bearing Shell (7 1/2" Diam.) (Governor End)		1	1	1						
	Main Bearing Shell (2 3/4", 5 3/8" long), always with.....	YJA818D1	1	1	1						
819E	Shell (Not Fur. Sep.).....	YJA819D3	1	1	1						
	Shim Dowel.....	CKB5493A	4	4	4						
820A	Main Bearing Shell Dowel.....	YJA820A	1	1	1						
	Shim.....	YJA827G2	6	6	6						
827H	Shim.....	YJA827F2	4	4	4						
	Shim.....	YJA827E2	6	6	6						

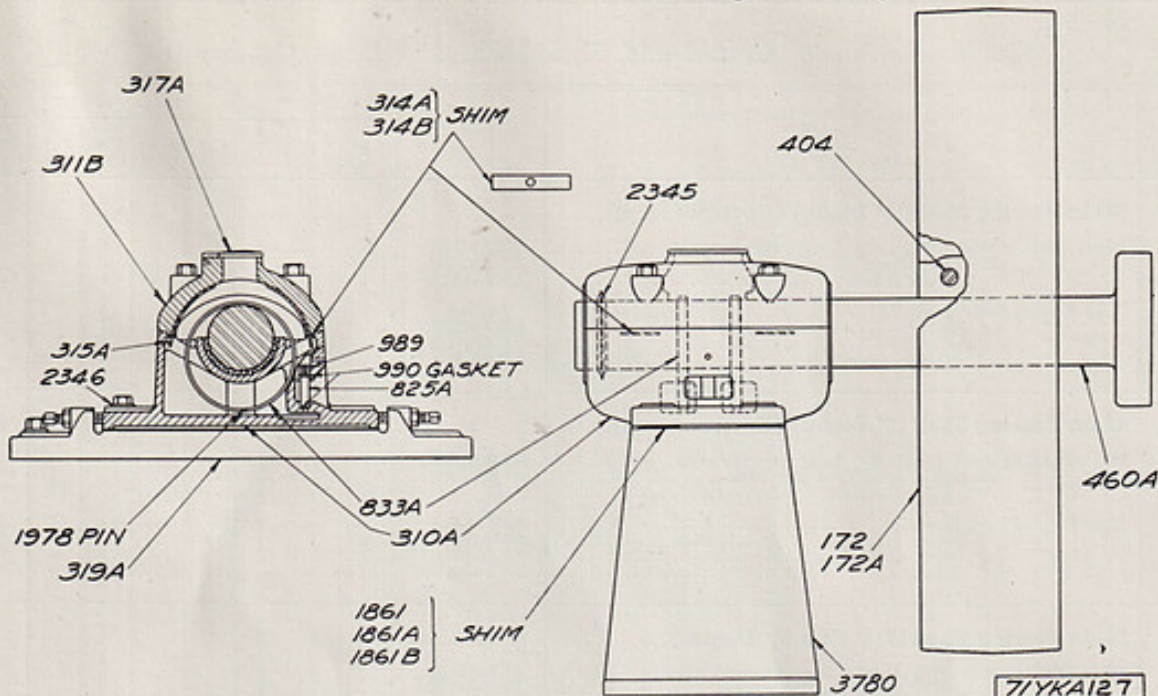
ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 3. Crankshaft, Flywheel and Bearings (Continued)

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"							
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used		
818F-C	Main Bearing Shell (8" Diam.) (Governor End)					1	1	1					
{ 818F 819F 5493	Main Bearing Shell (2 1/8", 4 1/8" long), always with.....	YKA818C1				1	1	1					
	Shell (8 1/4" long) (Not Fur. Sep.).....	YKA819D				1	1	1					
	Shim Dowel.....	CKB5493A				4	4	4					
820A	Main Bearing Shell Dowel.....	YJA820A				1	1	1					
827G	Shim.....	YKA827G2				2	2	2					
827H	Shim.....	YKA827H2				4	4	4					
827J	Shim.....	YKA827J2				8	8	8					
818G-C	Main Bearing Shell (9" Diam.) (Governor End)										1	1	1
{ 818G 819G	Main Bearing Shell (2 1/8", 4 1/8" long), always with.....	Y6KA818E1									1	1	1
	Shell (8 1/4" long) (Not Fur. Sep.).....	Y6KA819E3									1	1	1
	Shim Dowel.....	#409									4	4	4
820B	Main Bearing Shell Dowel.....	Y6KA820A									1	1	1
827K	Shim.....	Y4KA827A3									6	6	6
827L	Shim.....	Y4KA827B3									4	4	4
827M	Shim.....	Y4KA827C3									6	6	6
821E-C	Main Bearing Shell (7 1/2" Diam.) (Center)			1	2								
{ 821E 822E 5493	Main Bearing Shell (2 Pcs. 3 1/8" long), always with.....	Y2JA821E		1	2								
	Shell (8 1/4" long) (Not Fur. Sep.).....	Y2JA822E2		1	2								
	Shim Dowel.....	CKB5493A		4	8								
820A	Main Bearing Shell Dowel.....	YJA820A	2	3	4								
831F	Shim.....	Y2JA831D1		6	12								
831G	Shim.....	Y2JA831E1		4	8								
831H	Shim.....	Y2JA831F1		6	12								
821F-C	Main Bearing Shell (8" Diam.) (Center)							1	2				
{ 821F 822F 5493	Main Bearing Shell (10 1/4" long), always with.....	Y2KA821C						1	2				
	Shell (10 1/4" long) (Not Fur. Sep.).....	Y2KA822E						1	2				
	Shim Dowel.....	CKB5493A						4	8				
820A	Main Bearing Shell Dowel.....	YJA820A						1	2				
831F	Shim.....	Y2KA831B1						2	4				
831G	Shim.....	Y2KA831C1						4	8				
831H	Shim.....	Y2KA831D1						8	16				
821G-C	Main Bearing Shell (9" Diam.) (Center)										3	4	5
{ 821G 822G	Main Bearing Shell (2 Pcs. 4 1/8" long), always with.....	Y6KA821E									3	4	5
	Shell (10 1/4" long) (Not Fur. Sep.).....	Y6KA822F2									3	4	5
	Shim Dowel.....	#409									12	16	20
820B	Main Bearing Shell Dowel.....	Y6KA820A									3	4	5
831J	Shim.....	Y4KA831A2									18	24	30
831L	Shim.....	Y4KA831B2									12	16	20
831M	Shim.....	Y4KA831C2									18	24	30
577A	Crankshaft to Air Stop Ring Shim.....	YJA577A	4	8	12	4	8	12	16	20	24	24	24
578A	Shim.....	YJA578A	4	8	12	4	8	12	16	20	24	24	
833F	Main Bearing Oil Ring (Fur. in Pairs with #1978B).....	YKA833A1	2 Pr.	3 Pr.	4 Pr.	2 Pr.	3 Pr.	4 Pr.					
833G	Ring (Fur. in Pairs with #1978B).....	Y4KA833A1									5 Pr.	6 Pr.	7 Pr.
1978	Hinge Pin.....	YKA1978B	4	6	8	4	6	8	10	12	14	14	14
5142	Main Bearing Shell Oil Deflector.....	YJA5142A	1	1	1	1	1	1	1	1	1	1	1
	Shell Oil Deflector.....	YKA5142A											
5493	Main Bearing Shell Dowel.....	CKB5493A	8	12	16	8	12	16					
	Main Bearing Shell Oil Deflector Screw.....	3/8"-20 x 3/4"	4	4	4	4	4	4	4	4	4	4	4
	Screw.....	3/4"-20 x 5/8"											
3712-C	Barring Device (Complete)		1	1	1	1	1	1	1	1	1	1	1
3712	Barring Fulcrum.....	YJA3712B	1	1	1								
	Cap Screw.....	1"x4"	2	2	2								
3712	Bracket.....	YKA3712D				1	1	1	1	1	1	1	1
	Set Screw.....	5/8"x1 1/4"				2	2	2	2	2	2	2	2
3713	Socket.....	YKA3713B				1	1	1	1	1	1	1	1
	Set Screw.....	5/8"x1 1/4"				2	2	2	2	2	2	2	2
3716	Barring Pawl (Long).....	YKA3716A				1	1	1	1	1	1	1	1
3717	Pawl (Short).....	YKA3717A				1	1	1	1	1	1	1	1
3714	Bracket Socket Pin.....	YKA3714A				1	1	1	1	1	1	1	1
3718	Fulcrum Pin.....	YKA3718A				1	1	1	1	1	1	1	1
419A	Barring Bar.....	YKA19	1	1	1								
419B	Bar.....	YK419C				1	1	1	1	1	1	1	1
4295	Fulcrum Stud.....	YJA4295A	1	1	1								
	Nut.....	3/4" C. P.	3	3	3								

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 4. Outboard Bearing and Pulleys

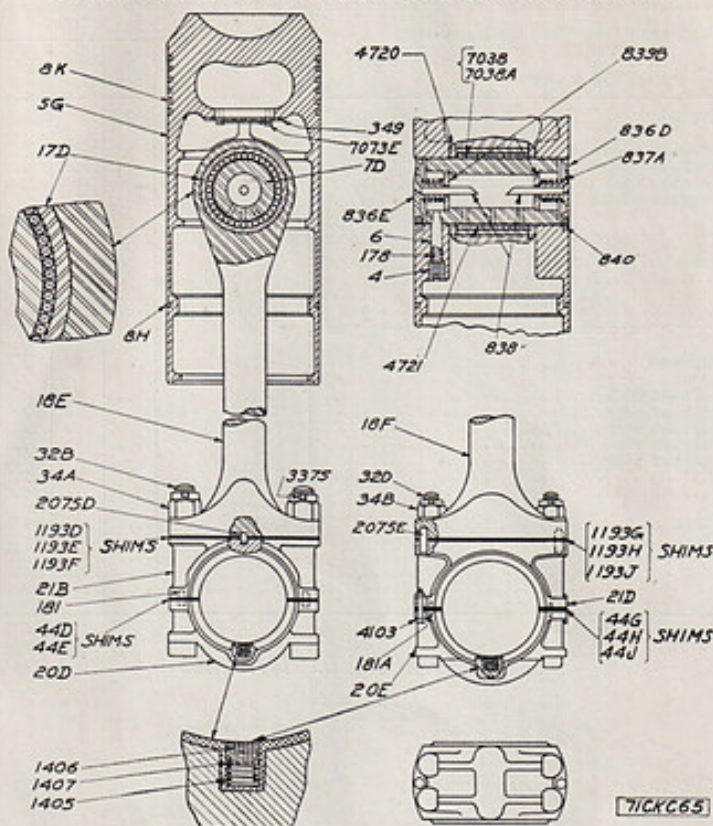


Repair Chart No. 4

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
310A-C	Outboard Bearing (Complete)		1	1	1	1	1	1	2	2	2
310A	Outboard Bearing Body, always with.....	YJA310A	1								
	Outboard Bearing Body, always with.....	YKA310B		1	1	1	1	1	2	2	2
	Outboard Bearing Body, always with.....	Y6KA310A								2	2
	Bearing Body Pipe Plug.....	3/4" C't's'k.	1								
	Plug.....	1" C't's'k.		1	1	1	1	1	2	2	2
	Drain Pipe Plug.....	3/4"	2	2	2	2	2	2	4	4	4
	Cap Stud.....	3/4" x 0"	4								
	Stud.....	1" x 7/8"		4	4	4	4	4	8		
	Stud.....	1" x 8/16"								8	8
	Nut.....	3/4" C.P.	4							8	8
Nut.....	1" C.P.		4	4	4	4	4	4	8	8	
311B	Bearing Body Cap (Not Furnished Separately).....	YJA311A	1								
	Cap (Not Furnished Separately).....	YKA311B		1	1	1	1	1	2	2	2
314A	Bearing Body Cap Shim.....	Y6KA311A									
	Shim.....	YJA314A	12								
314B	Bearing Body Cap Shim.....	YKA314A		12	12	12	12	12	24	24	24
	Shim.....	YJA314B	8								
317A	Bearing Body Cap Shim Dowel.....	YKA314B		8	8	8	8	8	16	16	16
	Bearing Oil Well Cover.....	#413	4	4	4	4	4	4	8	8	8
833H	Oil Ring (in Pairs) with 1978.....	YJA317A	1								
	1978.....	YKA317A		1	1	1	1	1	2	2	2
825A	Oil Ring (in Pairs) with 1978.....	#457	1	1	1	1	1	1	2	2	2
	1978.....	YG833D	2 Pr.	2 Pr.	2 Pr.						
989	Gauge Glass.....	YH833C				2 Pr.	2 Pr.	2 Pr.	2 Pr.		
	Gasket.....	YHA833B								2 Pr.	2 Pr.
990	Gauge Glass Plug.....	YK825	1								
	Gasket.....	YK989		1	1	1	1	1	2	2	2
315A	Horizontal Adjusting Set Screw.....	YK990	2	2	2	2	2	2	4	4	4
	Vertical Adjusting Set Screw.....	3/4"	1	1	1	1	1	1	2	2	2
2345	Horizontal Adjusting Set Screw.....	3/4" x 3"	4	4	4	4	4	4	8	8	8
	Vertical Adjusting Set Screw Jam Nut.....	3/4" x 2"	2	2	2	2	2	2	4	4	4
319A	Vertical Adjusting Set Screw Jam Nut.....	3/4"	4	4	4	4	4	4	8	8	8
	Bearing Oil Baffle.....	3/4"	2	2	2	2	2	2	4	4	4
1861	Bearing Oil Baffle Cap Screw.....	YJA315A		2	2	2	2	2	4	4	4
	Oil Throw Ring.....	YKA315A		2	2	2	2	2	4	4	4
1861A	Oil Throw Ring.....	3/4" x 3/4"	4	4	4	4	4	4	8	8	8
	Oil Throw Ring.....	YJA2345A	2								
1861B	Oil Throw Ring.....	YKA2345A		2	2	2	2	2	4	4	4
	Oil Throw Ring Felt.....	Y6KA2345A								4	4
2346	Oil Throw Ring Felt.....	3/4" x 1 1/4"	2								
	Bearing Sole Plate.....	3/4" x 1 1/8"		2	2	2	2	2	4	4	4
3780	Vertical Adjusting Shim.....	3/4" x 2 1/4"	1	1	1	1	1	1	2	2	2
	Shim.....	YKA319A		1	1	1	1	1	2	2	2
460A	Vertical Adjusting Shim.....	YKA1861A2	4	4	4	4	4	4	8	8	8
	Shim.....	YKA1861B1	2	2	2	2	2	2	4	4	4
365	Shim.....	YKA1861C1	2	2	2	2	2	2	4	4	4
	Sole Plate Cap Screw Washer.....	YKA2346A	4	4	4	4	4	4	8	8	8
366	Screw.....	1" x 3/4"	4	4	4	4	4	4	8	8	8
	Lock-washer.....	1"	4	4	4	4	4	4	8	8	8
366	Bearing Pedestal.....	DC155B							2	2	2
	Shim.....	DC158A							4	4	4
366	Extension Shaft (When ordering specify Engine Serial Number).....		1	1	1	1	1	1	1	1	1
	Thrust Collar.....	CC365A							2	2	2
366	Collar.....	CC366A								2	2
	Setscrew.....	3/4" x 1"							4	4	4

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 6. Piston and Connecting Rod



Repair Chart No. 6

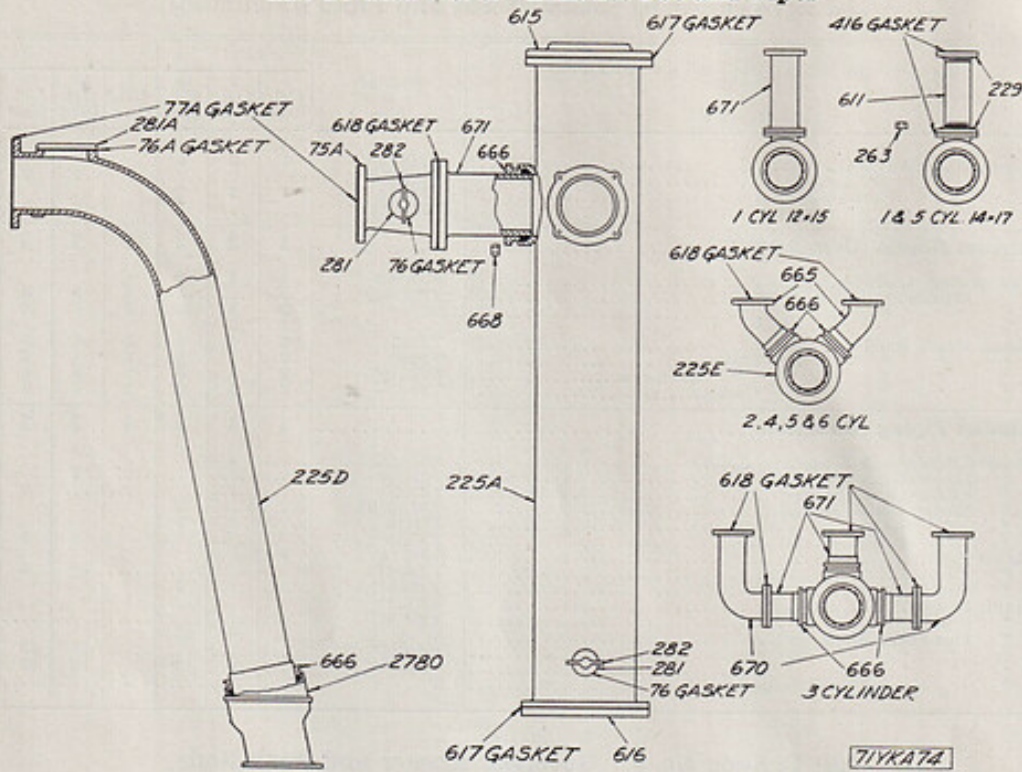
Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
5G-C	Piston (Complete)		1	2	3	1	2	3	4	5	6
5G	Piston } Always with.....	YJA5P3	1	2	3						
349	Piston } Baffle Plate.....	YKA5W7				1	2	3	4	5	6
7073E	Cap Screw Lockwire.....	YKA349A	1	2	3	1	2	3	4	5	6
6	Piston Pin Dowel.....	FM106C7	4	8	12	4	8	12	16	20	24
4	Cap Screw.....	3FM4A	1	2	3	1	2	3	4	5	6
178	Screw.....	YK6	1	2	3	1	2	3	4	5	6
8K	Spring.....	YK4	1	2	3	1	2	3	4	5	6
8K	Ring, Angle Step.....	YK178A1	1	2	3	1	2	3	4	5	6
8H	Ring, Angle Step.....	YJA8G1	6	12	18	6	12	18	24	30	36
8H	Ring, Oil Regulating.....	YKASH1	1	2	3	1	2	3	4	5	6
8H	Ring, Oil Regulating.....	YJAS8F	1	2	3	1	2	3	4	5	6
8H	Ring, Oil Regulating.....	YKA8G									
7D-C	Piston Pin Complete.....		1	2	3	1	2	3	4	5	6
7D-C	Piston Pin (Complete)		1	2	3	1	2	3	4	5	6
7D	Piston Pin } Always with.....	YJA7D2	1	2	3	1	2	3	4	5	6
7D	Pin }.....	YKA7K2				1	2	3	4	5	6
839B	Oil Scraper Pipe Guide.....	YJA839A	2	4	6	2	4	6	8	10	12
839B	Guide.....	YKA839B	1	2	3	1	2	3	4	5	6
836E	Scraper, Large } Always with.....	YJA836C1	1	2	3	1	2	3	4	5	6
836E	Scraper, Large }.....	YKA836H1	1	2	3	1	2	3	4	5	6
838	Oil Scraper Pipe, Not Furnished Separately.....	YJA838A	1	2	3	1	2	3	4	5	6
838	Pipe, Not Furnished Separately.....	YKA838A	1	2	3	1	2	3	4	5	6
840	Dowel.....	YK840	1	2	3	1	2	3	4	5	6
836D	Piston Pin Oil Scraper, Small } Always with.....	YJA836D1	1	2	3	1	2	3	4	5	6
836D	Scraper, Small }.....	YKA836J1	1	2	3	1	2	3	4	5	6
838	Oil Scraper Pipe, Not Furnished Separately.....	YJA838A	1	2	3	1	2	3	4	5	6
838	Pipe, Not Furnished Separately.....	YKA838A	1	2	3	1	2	3	4	5	6
840	Dowel.....	YK840	1	2	3	1	2	3	4	5	6
837A	Spring.....	YK837A	2	4	6	2	4	6	8	10	12
837A	Spring.....	YKA837A									
	Note: It is recommended that 7038-C set of needle bearings always be ordered and furnished with 7D or 7D-C.										
7038-C	Note: Separate needles should be furnished only to replace a few nearly new needles that have been lost. When needles are damaged or worn a full set should be furnished and the piston pin carefully inspected.										
7038	Needle Bearings (Set of 231 needles) 1/2"x1 3/4".....		1	2	3						
	• Bearings (Separate Needles) 231 Per Cylinder.....										
7038A-C	Needle Bearing (Set of 237 Needles).....					1	2	3	4	5	6
7038A	• Bearing (Separate Needles) 237 Per Cylinder.....										

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 6. Piston and Connecting Rod (Continued)

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"								
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used			
4721	Piston Pin Needle Retainer.....	YJA4721B2	2	4	6									
4721	" " " Retainer.....	YKA4721B1				2	4	6	8	10	12			
4720	" " " Ring.....	YJA4720B3	2	4	6									
4720	" " " Ring.....	YKA4720B4				2	4	6	8	10	12			
18E-C	Connecting Rod (Complete).....		1	2	3	1	2	3						
18E	Connecting Rod.....	YJA18E	1	2	3									
18E	" Rod.....	YKA18K				1	2	3						
17D	" " Piston Pin Bushing.....	YJA17E1	1	2	3									
17D	" " " Bushing.....	YKA17H2				1	2	3						
20D-C	" " Bearing Complete.....	YJA32A	1	2	3	1	2	3						
32B	" " Bolt.....	YKA32A	2	4	6				2	4	6			
32B	" " Nut.....	YJ34	2	4	6				2	4	6			
34A	" " " Nut.....	YK34A							2	4	6			
34A	" " " Nut.....	YJA3375A	2	4	6				2	4	6			
3375	" " Cotter.....	YKA3375A							2	4	6			
3375	" " Cotter.....	YJA1193D1												
1193D	Bearing to Rod Shim .031" Thick.....	YKA1193D1	As R equired.											
1193D	" " Shim .031" Thick.....	YKA1193D1												
1193E	" " Shim .062" Thick.....	YJA1193E1												
1193E	" " Shim .062" Thick.....	YKA1193E1												
1193F	" " Shim .015" Thick.....	YJA1193F1	As R equired.											
1193F	" " Shim .015" Thick.....	YKA1193F1												
18F-C	Connecting Rod (Complete).....								4	5	6			
18F	Connecting Rod.....	Y4KA18D												
17D	" " Piston Pin Bushing.....	YKA17H2										4	5	6
20F-C	" " Bearing Complete.....											4	5	6
32D	" " Bolt.....	CKC32A1										16	20	24
34B	" " Nut.....	CKC34A										16	20	24
	" " Cotter.....	11FM2A										16	20	24
1193G	Bearing to Rod Shim .031" Thick.....	CKC1193F1	As R equired.											
1193H	" " Shim .062" Thick.....	CKC1193G1												
1193J	" " Shim .015" Thick.....	CKC1193H1												
20D-C	Connecting Rod Bearing (Complete).....		1	2	3	1	2	3						
20D	Connecting Rod Cap } Always with.....	YJA20C	1	2	3									
20D	" " Cap }.....	YKA20J1				1	2	3						
18I	" " " Box Dowel.....	YKA181A	4	8	12	4	8	12						
21B	" " Box, Not Furnished Separately.....	YJA21D1	1	2	3									
21B	" " Box, Not Furnished Separately.....	YKA21L2				1	2	3						
44D	" " to Cap Shim .025" Thick.....	YJA44C	8	16	24									
44D	" " Shim .025" Thick.....	YKA44F				8	16	24						
44E	" " Shim .007" Thick.....	YJA44D	8	16	24									
44E	" " Shim .007" Thick.....	YKA44G				8	16	24						
1405	Cap Wick Support Spring.....	YK1405A	2	4	6	2	4	6						
1406	" Wick.....	YJ1406A	1	2	3									
1406	" Wick.....	YK1406A				1	2	3						
1407	" Support.....	YJ1407A2	1	2	3									
1407	" Support.....	YK1407A2				1	2	3						
2075D	Rod to Box Dowel.....	YJA2075D	2	4	6	2	4	6						
20E-C	Connecting Rod Bearing (Complete).....								4	5	6			
20E	Connecting Rod Cap.....	YKA20H1										4	5	6
181A	" " to Box Dowel.....	YK406A										16	20	24
21D	" " Box, Not Furnished Separately.....	YKA21K2										4	5	6
44C	" " to Cap Shim .006" Thick.....	YKA44A										40	50	60
44H	" " Shim .032" Thick.....	YKA44B										8	10	12
44J	" " Shim .064" Thick.....	YKA44C										8	10	12
1405	Cap Wick Support Spring.....	YK1405A										8	10	12
1406	" Wick.....	YK1406A										4	5	6
1407	" Support.....	YK1407A2										4	5	6
2075E	Rod to Box Dowel.....	CKC2075A										8	10	12
4103	Cap to Box Bolt.....	C3FC4103A1										8	10	12
	" " Nut.....	11FM29A										8	10	12
	" " Cotter.....	11FM2A										8	10	12

List Division No. 8. Exhaust Pot and Pipes



Repair Chart No. 8

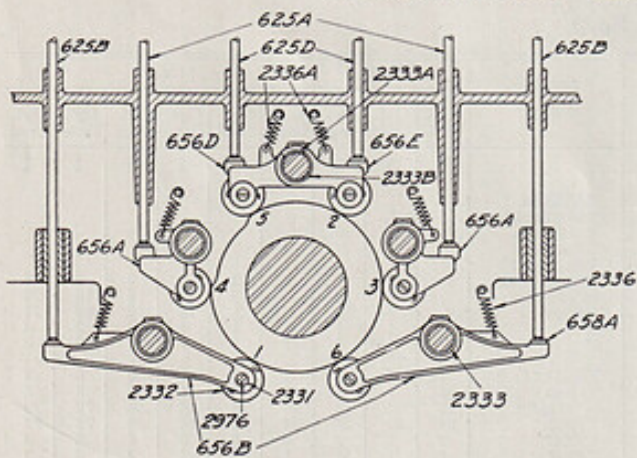
Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
225A-C	Exhaust Pot (Complete)		1	1	1	1	1	1	1	1	1
	Exhaust Pot, always with	YJA225A	1								
	" Pot, always with	Y2JA225A1		1							
225A	" Pot, always with	Y3JA225A			1						
	" Pot, always with	YKA225A				1					
	" Pot, always with	Y3KA225A1						1			
225E	Exhaust Pot, always with	Y2KA225A1									
	Stuffing Box Stud	5/8"x2 3/4"		8	12		8	12	16	16	24
	" Nut	Y2J668		8	12		8	12	16	16	24
668	" Pipe Plug	2"	1	1	1	1	1	1	2	3	3
	" Plug	2"	1	1	1	1	1	1	2	3	3
616	Exhaust Pot Bottom Plate	YK616A1	1	1	1	1	1	1	2	3	3
615	" Cover (Top)	Y3K615	1	1	1	1	1	1	2	3	3
	" Bolt	3/4"x3 3/4"	24	24	24	24	24	24	48	72	72
263	" Nut	YF263	24	24	24	24	24	24	48	72	72
617	" Gasket Top and Bottom	YK617	2	2	2	2	2	2	4	6	6
281	Hand Hole Cover	YF281	1	1	1	1	1	1	2	3	3
282	Hand Hole Cover Clamp (All in Bracket)	YF282	1	1	1	1	1	1	2	3	3
	" Set Screw	5/8"x2 3/4"	1	1	1	1	1	1	2	3	3
76	" Gasket	YF76	1	1	1	1	1	1	2	3	3
416	Exhaust Pot Flange Gasket	YG416	2								
229	" Flange	423				2				2	
618	" Flange Gasket	YK618				2				2	
	" Mach. Bolt	3/4"x3"	16								16
	" Bolt	3/4"x3 3/4"	16					16			16
263	" Nut	YF263	16					16			16
666	Stuffing Box Gland	YJA666A		2	3						
	" Gland	Y2K666				2	3	4	4	6	6
	Asbestos Wicking	3/4" Ball		3	5		3	5	6	6	9
225D-C	Exhaust Pipe (Complete)		1	2	3	1	2	3	4	5	6
	Exhaust Pipe, always with	YJA225C	1	2	3						
	" Pipe, always with	YKA225E				1	2	3	4	5	6
	" Plug	1 1/2"	1	2	3	1	2	3	4	5	6
	" Plug	1 1/2"	1	2	3	1	2	3	4	5	6
	Hand Hole Cover Stud	5/8"x2 3/4"	4	8	12	4	8	12	16	20	24
281A	Hand Hole Cover	YKA281B	1	2	3	1	2	3	4	5	6
	" Pipe Plug	1 1/2"	1	2	3	1	2	3	4	5	6
76A	" Gasket	YKA76B	1	2	3	1	2	3	4	5	6
	" Stud Nut	5/8" C. P.	4	8	12	4	8	12	16	20	24
2780	Conduit Thimble with Stud	YJA2780A1	1	2	3						
	" Stud	YKA2780B1				1	2	3	4	5	6
666	Conduit Thimble Gland	YJA666	1	2	3						
	" Gland	Y2K666				1	2	3	4	5	6
	Asbestos Wicking	1/2" Ball	2	3	3	2	3	5	6	8	9
668	Thimble Gland Stud Nut	Y2J668	4	8	12	4	8	12	16	20	24
	Exhaust Pot Gland to Thimble Stud	3/4"x4"	4	8	12	4	8	12	16	20	24

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 8. Exhaust Pot and Pipes (Continued)

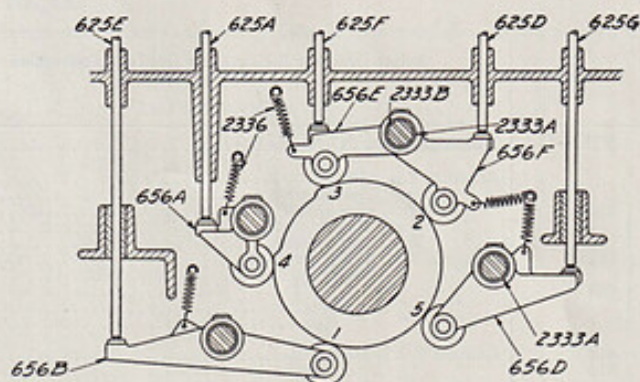
Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
77A	Cylinder Exhaust Pipe Gasket.....	YJA77A	1	2	3						
	" " Gasket.....	YKA77A				1	2	3	4	5	6
	" " Nozzle Gasket.....	YJA77A	1	2	3						
	" " Gasket.....	YKA77A				1	2	3	4	5	6
75A-C	Exhaust Nozzle (Complete).....		1	2	3	1	2	3	4	5	6
75A	Exhaust Nozzle, always with.....	YJA75D	1	2	3						
	Nozzle, always with.....	YKA75A				1	2	3	4	5	6
	" " Pipe Plug.....	1/2"	2	4	6	2	4	6	8	10	12
281	Exhaust Nozzle Hand Hole Cover.....	YF281	2	4	6	2	4	6	8	10	12
282	" " " " " " Clamp.....	YF282	2	4	6	2	4	6	8	10	12
	" " " " " " Set Screw.....	3/8"x2 3/4"	2	4	6	2	4	6	8	10	12
76	" " " " " " Gasket.....	YF76	2	4	6	2	4	6	8	10	12
665-C	Exhaust Piping (Complete).....		1	1	1	1	1	1	1	1	1
665	Exhaust Elbow (Single Flange).....	Y2JA665A		2							
	" " Elbow (Single Flange).....	Y2K665				2			4	4	6
670	" " Elbow (Double Flange).....	Y3K670						2			
	" " Elbow (Double Flange).....	Y3JA870A			2						
416	" " Gasket.....	YG416		2	5						
618	" " Gasket.....	YK618				2	5	4	4	6	
	Exhaust Pipe.....	YJ671A	1								
671	" " Pipe.....	Y3K671						3			
	" " Pipe.....	Y3JA671A			3						
611	Exhaust Nipple.....	YK611				1					
	" " Nipple.....	YK611C								1	
	" " Pipe Flange Mach. Bolt.....	1/4"x3"		16	40						
	" " Bolt.....	1/4"x3 1/4"				16	40	32	32	32	48
263	" " Nut.....	YF263		16	40		16	40	32	32	48
	" " Nipple Thread Protector.....	8"				2					2

List Division No. 9. Governor Rocker and Push Rods



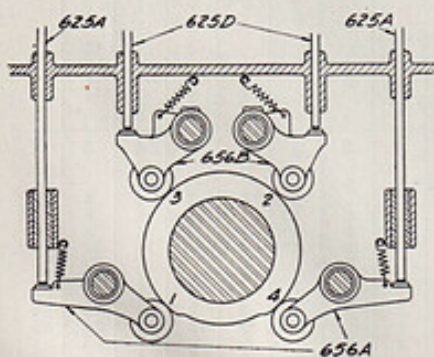
6 CYL. ENGINE

Repair Chart No. 9

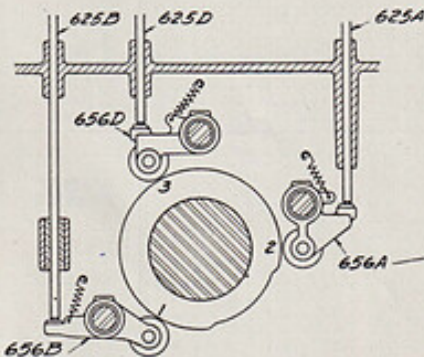


5 CYL. ENGINE

71YKA131

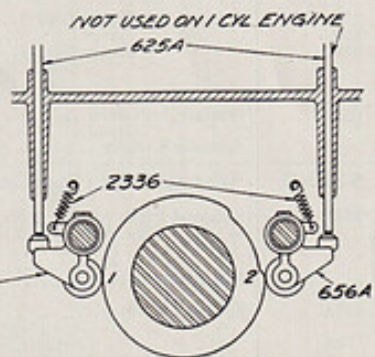


4 CYL. ENGINE



3 CYL. ENGINE

Repair Chart No. 9A



1 & 2 CYL. ENGINE

71YKA76

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 9. Governor Rocker and Push Rods (Continued)

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
656A-C	Governor Cam Rocker (Complete) Note:—6 Cyl. Engine. Used on Cyl. No. 3 and No. 4. 5 " Engine. " " Cyl. No. 4. 4 " Engine. " " Cyl. No. 1 and No. 4. 3 " Engine. " " Cyl. No. 2. 2 " Engine. " " Cyl. No. 1 and No. 2. 1 " Engine. " " Cyl. No. 1.		1	2	1	1	2	1	2	1	2
656A	Governor Cam Rocker, always with Rocker, always with	YKA656A2 Y4KA656A2	1	2	1	1	2	1	2	1	2
658A 2333	Governor Cam Rocker Mushroom Bushing	YKA658A YKA2333A	1	2	1	1	2	1	2	1	2
2331 2332 2976	Governor Cam Roller Pin Roller Dowel	YKA2331A YKA2332A1 YKA2976A1	1 1 2	2 2 4	1 1 2	1 1 2	2 2 4	1 1 2	2 2 4	1 1 2	2 2 4
656B-C	Governor Cam Rocker (Complete) Note:—6 Cyl. Engine. Used on Cyl. No. 1 and No. 6. 5 " Engine. " " Cyl. No. 1. 4 " Engine. " " Cyl. No. 2 and No. 3. 3 " Engine. " " Cyl. No. 1.				1			1	2	1	2
656B	Governor Cam Rocker, always with Rocker, always with Rocker, always with Rocker, always with	Y3KA656B2 Y4KA656B2 Y6KA656B2 Y5KA656B2			1			1	2		2
658A 2333	Governor Cam Rocker Mushroom Bushing	YKA658A YKA2333A			1			1	2	1	2
2331 2332 2976	Governor Cam Roller Pin Roller Dowel	YKA2331A YKA2332A1 YKA2976A1			1 1 2			1 1 2	2 2 4	1 1 2	2 2 4
656D-C	Governor Cam Rocker (All in Bracket) Note:—5 Cyl. Engine. Used on Cyl. No. 5. 3 " Engine. " " Cyl. No. 3.				1			1		1	
656D	Governor Cam Rocker, always with Rocker, always with	Y3KA656D2 Y5KA656D2			1			1		1	
658A 2333 2333A 2331 2332 2976	Governor Cam Rocker Mushroom Bushing Bushing Governor Cam Roller Pin Roller Rocker Dowel	YKA658A YKA2333A Y6KA2333A YKA2331A YKA2332A1 YKA2976A1			1 1 1 1 1 2			1 1 1 1 1 2		1 1 1 1 1 2	
656D-C	Governor Cam Rocker (Complete) Note:—5 Cyl. Engine. Used on Cyl. No. 5.										1
656D 658A 2333A	Governor Cam Rocker, always with Mushroom Bushing	Y6KA656D2 YKA658A Y6KA2333A									1 1 1
2331 2332 2976	Governor Cam Roller Pin Roller Rocker Dowel	YKA2331A YKA2332A YKA2976A1									1 1 2
656E-C	Governor Cam Rocker (Complete) Note:—6 Cyl. Engine. Used on Cyl. No. 2. 5 " Engine. " " Cyl. No. 3.									1	1
656E	Governor Cam Rocker, always with Rocker, always with	Y5KA656E2 Y6KA656E2								1	1
658A 2333B	Governor Cam Rocker Mushroom Bushing	YKA658A Y6KA2333B								1 2	1 2
2331 2332 2976	Governor Cam Roller Pin Roller Rocker Dowel	YKA2331A YKA2332A1 YKA2976A1								1 1 2	1 1 2
656F-C	Governor Cam Rocker (Complete) Note:—5 Cyl. Engine. Used on Cyl. No. 2.									1	
656F 658A 2333A	Governor Cam Rocker, always with Mushroom Bushing	Y6KA656F2 YKA658A YKA2333A								1 1 1	
2331 2332 2976	Governor Cam Roller Pin Roller Rocker Dowel	YKA2331A YKA2332A1 YKA2976A1								1 1 2	
625A	Inj. Pump Suct. Valve Lower Push Rod (9 3/4") " " " " " (12 1/4") " " " " " (Drilled) (9 3/4") " " " " " (Drilled) (12 1/4")	YKA625C Y4KA625D YKA625D Y4KA625F	1	1	1	1	1	1	1	1	1
625B	Inj. Pump Suct. Valve Lower Push Rod (14 1/4") " " " " " (13 1/4")	Y3KA625C Y6KA625B			1			1			2
625D	Inj. Pump Suct. Valve Lower Push Rod (6 1/4") " " " " " (6")	Y4KA625E Y3KA625D			1			1	2		2
625E 625F 625G	Inj. Pump Suct. Valve Lower Push Rod (14 1/4") " " " " " (9 3/4") " " " " " (11 3/4")	Y5KA625A Y5KA625B Y5KA625C								1 1 1	
2336 2336A	Gov. Cam Rocker Aux. Spring Spring Gov. Cam. Rocker Aux. Spring (Top)	YKA2336A2 Y5KA2336A YKA2336B	1	2	3	1	2	3	4	5	4 2

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 10. Fuel Reservoir, Oil Pump and Oil Sump (Continued)

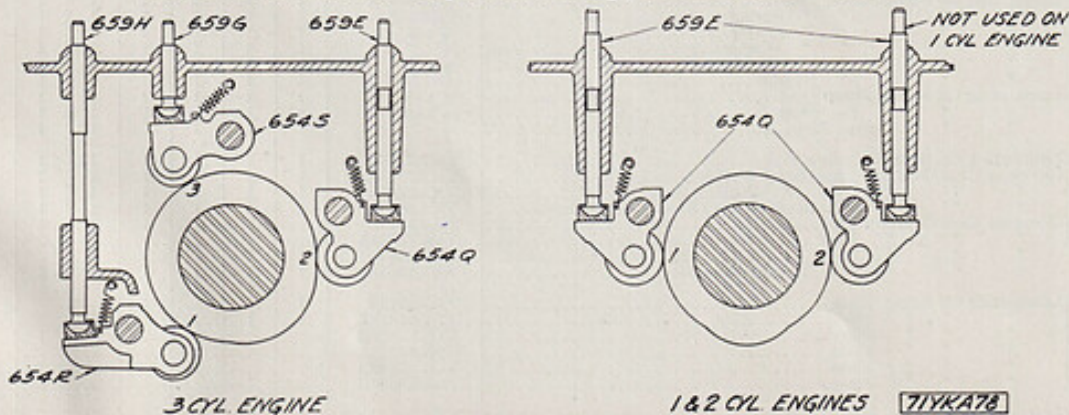
Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"						
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used	
986B-C	Fuel Reservoir Cover (Complete)		1	1	1	1	1	1	1	1	1	1
986A	Fuel Reservoir Cover, always with (See Chart 11B also)	YKA986A	1	1	1	1	1	1	1	1	1	1
	Cover, always with	Y4KA986A							1	1	1	1
60A	Cap	YKA60A	1	1	1	1	1	1	1	1	1	1
2313	Handle	YKA2313A	1	1	1	1	1	1	1	1	1	1
2362	Spring	YKA2362A	1	1	1	1	1	1	1	1	1	1
2270	Screw Collar	YKA2270A	1	1	1	1	1	1	1	1	1	1
	R. H. M. Screw	#10-24x1"	1	1	1	1	1	1	1	1	1	1
187A-C	Fuel Reservoir Cover Strainer (Complete)		1	1	1	1	1	1	1	1	1	1
1902	Fuel Reservoir Cover Gasket	YKA1902A	1	1	1	1	1	1	1	1	1	1
187A-C	Fuel Reservoir Cover and Oil Sump Strainer (Com.)		2	2	2	2	2	2	2	2	2	2
187A	Fuel Reservoir Cover Strainer Side, always with	YKA187A	2	2	2	2	2	2	2	2	2	2
2271	Strainer Flange (Not Fur. Sep.)	YKA2271A	2	2	2	2	2	2	2	2	2	2
2272	Bottom (Not Fur. Sep.)	YKA2272A	2	2	2	2	2	2	2	2	2	2
1369	Handle	YKA1369A	2	2	2	2	2	2	2	2	2	2
1084A-C	Lubricating Oil Pump Body (Complete)		1	1	1	1	1	1	1	1	1	1
1084A	Lubricating Oil Pump Body, always with	YKA1084A3	1	1	1	1	1	1	1	1	1	1
1085A	Plunger	YKA1085A	2	2	2	2	2	2	2	2	2	2
1093A	Lubricating Oil Pump Plunger Pin	YKA1093A	1	1	1	1	1	1	1	1	1	1
2111	Collar	YKA2111A	2	2	2	2	2	2	2	2	2	2
2110	Lubricating Oil Pump Discharge Connection	YKA2110A	2	2	2	2	2	2	2	2	2	2
	Valve Ball	1/4" Diam.	2	2	2	2	2	2	2	2	2	2
	Valve Ball	1/4" Diam.	2	2	2	2	2	2	2	2	2	2
1796	Plunger Pin Plug	YKA1796A	2	2	2	2	2	2	2	2	2	2
2369	Discharge Conn. Gasket	YKA2369A	2	2	2	2	2	2	2	2	2	2
3619	Set Screw	YKA3619A	2	2	2	2	2	2	2	2	2	2
	Wire	#16x5"	1	1	1	1	1	1	1	1	1	1
2582-C	Lubricating Oil Pump Strainer (Complete)		2	2	2	2	2	2	2	2	2	2
1097A	Lubricating Oil Pump Body Gasket	YKA1097A	1	1	1	1	1	1	1	1	1	1
2582-C	Lubricating Oil Pump Strainer (Complete)		2	2	2	2	2	2	2	2	2	2
2582	Lubricating Oil Pump Strainer Plug, always with	YKA2582A	2	2	2	2	2	2	2	2	2	2
1088	Side (Not Fur. Sep.)	YKA1088A	2	2	2	2	2	2	2	2	2	2
1088A	Bottom (Not Fur. Sep.)	YKA1088B	2	2	2	2	2	2	2	2	2	2
1086B-AC	Lubricating Oil Pump Rod (Complete)		1	1	1	1	1	1	1	1	1	1
1086B	Lubricating Oil Pump Rod, always with	YJA1086B	1	1	1	1	1	1	1	1	1	1
	Rod, always with	YKA1086B	1	1	1	1	1	1	1	1	1	1
	Nut	1/4" N. F.	1	1	1	1	1	1	1	1	1	1
2314	Lubricating Oil Pump Rod End	YKA2314A	1	1	1	1	1	1	1	1	1	1
6599	Umbrella	Y3JA6599A	1	1	1	1	1	1	1	1	1	1
2109	Lubricating Oil Pump Body Cover (Half)	YJA2109B	2	2	2	2	2	2	2	2	2	2
2792A	Lubricating Oil Pump Body Cover Gasket	YJA2792A	2	2	2	2	2	2	2	2	2	2
	Gasket	YKA2792A	2	2	2	2	2	2	2	2	2	2
1081D-C	Lubricating Oil Sump (Complete)		1	1	1	1	1	1	1	1	1	1
1081D	Lubricating Oil Sump, always with	YKA1081E	1	1	1	1	1	1	1	1	1	1
	Sump, always with	Y4KA1081E							1	1	1	1
1082D	Lubricating Oil Sump Cover	YKA1082D	1	1	1	1	1	1	1	1	1	1
	Cover	Y4KA1082D							1	1	1	1
6777	Lubricating Oil Sump Cover Pin	YKA6777A	1	1	1	1	1	1	1	1	1	1
193B	Spring	YKA193A	1	1	1	1	1	1	1	1	1	1
	Cotter	1/4"x3/4"	1	1	1	1	1	1	1	1	1	1
	Washer	1/4"	1	1	1	1	1	1	1	1	1	1
	Handle Stud	1/4"x1 1/4"	1	1	1	1	1	1	1	1	1	1
4131	Handle	CEA4131A	1	1	1	1	1	1	1	1	1	1
	Lubricating Oil Sump Pump Stud	1/4"x4 1/4"	1	1	1	1	1	1	1	1	1	1
	Stud	1/4"x3 1/4"	1	1	1	1	1	1	1	1	1	1
	Pipe Plug	1/2"	1	1	1	1	1	1	1	1	1	1
2316	Lubricating Oil Sump Overflow Pipe	YKA2316A	1	1	1	1	1	1	1	1	1	1
2370	Governor Case Overflow Pipe Gland Washer	YKA2370A	1	1	1	1	1	1	1	1	1	1
2317	Stuffing Box	YKA2317A	1	1	1	1	1	1	1	1	1	1
2318	Stuffing Box Gland	YKA2318A	1	1	1	1	1	1	1	1	1	1
2319	Governor Case Overflow Pipe	YKA2319A	1	1	1	1	1	1	1	1	1	1
	Pipe	Y4KA2319A							1	1	1	1
2319A	Pipe	YJA2319B	1	1	1	1	1	1	1	1	1	1
1089A	Packing Ring	YKA1089A	1	1	1	1	1	1	1	1	1	1
	Lubricating Oil Sump Plate	YKA2312B	1				1					
	Plate	Y2KA2312B		1				1				
	Plate	Y3KA2312B			1				1			
2312A	Plate	Y4KA2312B								1		
	Plate	Y5KA2312B									1	
	Plate	Y6KA2312B										1
3056	Lubricating Oil Sump Strainer Gasket	YKA3056A	1	1	1	1	1	1	1	1	1	1
	Gasket	Y4KA3056A								1	1	1
187A-C	Lubricating Oil Sump Strainer (Complete)		1	1	1	1	1	1	1	1	1	1

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 10. Fuel Reservoir, Oil Pump and Oil Sump (Continued)

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15'			14"x17'					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
6055	Base Sump Pipe Drain Fitting.....	YKA6055A	1	2	3	1	2	3	4	5	6
4645A	Gasket.....	YKA4645B	1	2	3	1	2	3	4	5	6
	Base Sump Pipe Reducer.....	1/2" x 1/2"	1	2	3	1	2	3	4	5	6
2312A	Lubricating Oil Sump to Base Shim.....	YKA2312A	As R	eq.	.....	As R	eq.	.....	.....	.....	.....
	Shim.....	Y2KA2312A	.....	As R	eq.	.....	As R	eq.	.....	.....	.....
	Shim.....	Y3KA2312A	.....	As R	eq.	.....	As R	eq.	.....	.....	.....
	Shim.....	Y4KA2312A	.....	As R	eq.	.....	As R	eq.	.....	.....	.....
	Shim.....	Y5KA2312A	.....	As R	eq.	.....	As R	eq.	.....	.....	.....
	Shim.....	Y6KA2312A	.....	As R	eq.	.....	As R	eq.	.....	.....	.....
39-C	Fuel Supply Pump Rocker (Complete)		1	1	1	1	1	1	1	1	1
39	Fuel Supply Pump Rocker.....	YKA39A	1	1	1	1	1	1	1	1	1
55	Pin.....	YKA55A	1	1	1	1	1	1	1	1	1
2307	Washer.....	YKA2307A	1	1	1	1	1	1	1	1	1
	Cap Screw.....	3/8" x 1/2"	1	1	1	1	1	1	1	1	1
	Set Screw.....	3/8" x 1/2"	1	1	1	1	1	1	1	1	1
	Lockwasher.....	3/8"	1	1	1	1	1	1	1	1	1
	Jam Nut.....	3/8"	1	1	1	1	1	1	1	1	1
56	Fuel Supply Pump Rocker Ecc. Pin.....	YKA56A	1	1	1	1	1	1	1	1	1
2605	Eccentric Pin Jam Nut.....	YKA2605A	1	1	1	1	1	1	1	1	1
	Lockwasher.....	3/8"	1	1	1	1	1	1	1	1	1
	Cotter.....	3/8" x 1/4"	1	1	1	1	1	1	1	1	1
58	Fuel Supply Pump Rocker Shaft.....	YKA58A							1	1	1
58A	Shaft.....	YKA58B	1	1	1	1	1	1			
59	Collar.....	YKA59A	1	1	1	1	1	1	1	1	1
2604	Screw.....	YKA2604A	1	1	1	1	1	1	1	1	1
	Lockwasher.....	1/2"	1	1	1	1	1	1	1	1	1
	Plug.....	1/2"	1	1	1	1	1	1	1	1	1
	Plug.....	1/2"	1	1	1	1	1	1	1	1	1
464B-C	Fuel Supply Pump Strainer and Overflow		1	1	1	1	1	1	1	1	1
464B	Strainer and Overflow Casing, always with.....	YKA464B	1	1	1	1	1	1	1	1	1
	Stud.....	3/4" x 2 1/4"	1	1	1	1	1	1	1	1	1
	Dowel.....	3/8" x 3/4"	1	1	1	1	1	1	1	1	1
	Pipe Plug (Solid).....	1/2"	1	1	1	1	1	1	1	1	1
	Plug (Solid).....	1/2"	1	1	1	1	1	1	1	1	1
986D	Strainer and Overflow Cover.....	YKA986B	1	1	1	1	1	1	1	1	1
1902A	Gasket.....	YKA1902C	1	1	1	1	1	1	1	1	1
2108A	Plug Gasket.....	YLA2108A	1	1	1	1	1	1	1	1	1
2296A	Plug.....	YKA2296B	1	1	1	1	1	1	1	1	1
5350E	Purulator Filters.....	X-153	3	3	3	3	3	3	3	3	3
2334	Casing Gasket.....	YKA2334A	1	1	1	1	1	1	1	1	1
570B-C	Air Starting Valve (Complete)		1	1	2	1	1	2	2	2	3
570B	Air Starting Valve (See Chart #14 also).....	YKA570A	1	1	2	1	1	2	2	2	3
572	Spring.....	YKA572A	1	1	2	1	1	2	2	2	3
903	Plug (See Chart #14 also).....	YKA903A	1	1	2	1	1	2	2	2	3
2335	Gasket.....	YKA2335A	1	1	2	1	1	2	2	2	3
524A-C	Air Starter Cam and Eccentric (Complete)		1	1	1	1	1	1	1	1	1
524A	Air Starter Cam and Eccentric.....	YKA524A	1	1	1	1	1	1	1	1	1
525A	Strap (Upper) always with.....	YKA525A1	1	1	1	1	1	1	1	1	1
526A	Strap (Lower).....	YKA526A1	1	1	1	1	1	1	1	1	1
2764	Stud.....	YKA2764A	2	2	2	2	2	2	2	2	2
2297	Cap.....	YKA2297A	1	1	1	1	1	1	1	1	1
528A	Air Starter Cam and Eccentric Strap Bolt.....	YKA528A	2	2	2	2	2	2	2	2	2
	Nut.....	1/2" N.F. Castle	2	2	2	2	2	2	2	2	2
	Cotter.....	3/8" x 1"	2	2	2	2	2	2	2	2	2
	Lockwasher.....	3/8"	2	2	2	2	2	2	2	2	2
	Stud Nut.....	3/8"	2	2	2	2	2	2	2	2	2
	Lockwire.....	.062" x 4 1/2"	2	2	2	2	2	2	2	2	2
529A	Air Starter Cam and Eccentric Key.....	YKA529A	1	1	1	1	1	1	1	1	1

List Division No. 11. Injection Pump, Rockers and Housing



Repair Chart No. 11

ALWAYS GIVE ENGINE SERIAL NUMBER

71YKA78

List Division No. 11. Injection Pump, Rockers and Housing (Continued)

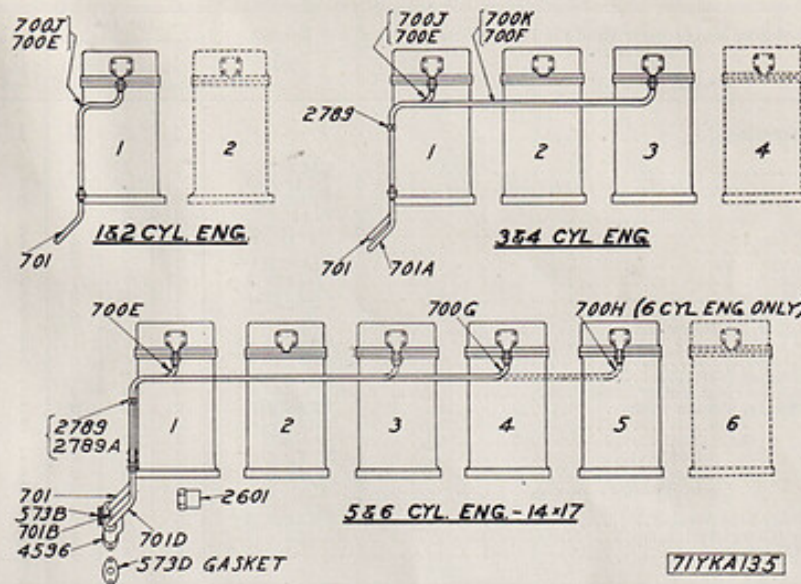
Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
6325-C	Injection Pump Relief Valve Cage (Complete)		1	2	3	1	2	3	4	5	6
6325	Injection Pump Relief Valve Cage	CKC6325A	1	2	3	1	2	3	4	5	6
2108	" " " " Gasket	YKA2108A	1	2	3	1	2	3	4	5	6
2058B	" " " " Seat	CKC2058A	1	2	3	1	2	3	4	5	6
2108B	" " " " Gasket	CJA2108A	1	2	3	1	2	3	4	5	6
2060E	" " " " Cage Plug	CKC2060A	1	2	3	1	2	3	4	5	6
6281A	Injection Pump Relief Valve	CKC6281A	1	2	3	1	2	3	4	5	6
6282	" " " " Spring Seat	CKC6282A	1	2	3	1	2	3	4	5	6
6283	" " " " Spring	CKC6283A	1	2	3	1	2	3	4	5	6
1561	" " " " Shim (.031")	CPE1561A	1	2	3	1	2	3	4	5	6
1561A	" " " " Shim (.015")	CPE1561B	1	2	3	1	2	3	4	5	6
2108B	" " " " Cage Plug Gasket	CJA2108A	1	2	3	1	2	3	4	5	6
473A	Injection Pump Body Gasket	YKA473A	1	2	3	1	2	3	4	5	6
654Q-C	Injection Pump Rocker (Complete)		1	2	1	1	2	1	2	1	2
	Note:—6 Cyl. Engine. Used on Cyl. No. 3 and No. 4. 5 " Engine. " " Cyl. No. 4. 4 " Engine. " " Cyl. No. 1 and No. 4. 3 " Engine. " " Cyl. No. 2. 2 " Engine. " " Cyl. No. 1 and No. 2. 1 " Engine. " " Cyl. No. 1.										
654Q	Injection Pump Rocker	YKA654C2	1	2	1	1	2	1		1	2
552D	Injection Pump Cam Roller	YKA552D3	1	2	1	1	2	1		1	2
553D	" " " " Pin	YKA553D3	1	2	1	1	2	1		1	2
2324	" " " " Rocker Dowel	YKA2324A1	2	4	2	2	4	2		2	4
654R-C	Injection Pump Rocker (Complete)				1			1	2	1	2
	Note:—6 Cyl. Engine. Used on Cyl. No. 1 and No. 6. 5 " Engine. " " Cyl. No. 5. 4 " Engine. " " Cyl. No. 2 and No. 3. 3 " Engine. " " Cyl. No. 1.										
654R	Injection Pump Rocker	Y3KA654E1			1			1			
	" " " " Rocker	Y4KA654F1							2		
	" " " " Rocker	Y5KA654D								1	
	" " " " Rocker	Y6KA654K									2
552D	" " " " Cam Roller	YKA552D3						1	2	1	2
553D	" " " " Pin	YKA553D3			1			1	2	1	2
2324	" " " " Rocker Dowel	YKA2324A1			2			2	4	2	4
654S-C	Injection Pump Rocker (Complete)				1			1		1	1
	Note:—6 Cyl. Engine. Used on Cyl. No. 5. 5 " Engine. " " Cyl. No. 3. 3 " Engine. " " Cyl. No. 3.										
654S	Injection Pump Rocker (Eye End)	Y3KA654F1			1			1			
	" " " " Rocker	Y5KA654C1								1	
	" " " " Rocker	Y6KA654H1									1
552D	" " " " Cam Roller	YKA552D3			1			1		1	1
553D	" " " " Pin	YKA553D3			1			1		1	1
2324	" " " " Rocker Dowel	YKA2324A1			2			2		2	2
654T-C	Injection Pump Rocker (Complete)									1	1
	Note:—6 Cyl. Engine. Used on Cyl. No. 2. 5 " Engine. " " Cyl. No. 2.										
654T	Injection Pump Rocker (Fork End)	Y6KA654J1									1
	" " " " Rocker	Y5KA654B1								1	
552D	Injection Pump Cam Roller	YKA552D3								1	1
553D	" " " " Pin	YKA553D3								1	1
2324	" " " " Rocker Dowel	YKA2324A1								2	2
654U-C	Injection Pump Rocker (Complete)									1	
	Note:—5 Cyl. Engine. Used on Cyl. No. 1.										
654U	Injection Pump Rocker	Y5KA654A								1	
552D	" " " " Cam Roller	YKA552D3								1	
553D	" " " " Pin	YKA553D3								1	
2324	" " " " Rocker Dowel	YKA2324A1								2	
659E	Injection Pump Plunger Push Rod (8.42")	YKA659C	1	2	1	1	2	1		1	2
659F	Injection Pump Plunger Push Rod (4.37")	Y5KA659B								1	
	" " " " Rod (13.15")	Y3KA659F			1			1			
	" " " " Rod (11.56")	Y4KA659F							2		
659G	Injection Pump Plunger Push Rod (5.02")	Y4KA659E							2		
	" " " " Rod (4.34")	Y3KA659G			1			1			2
	" " " " Rod (3.97")	Y5KA659C								1	
659H	Injection Pump Plunger Push Rod (12.30")	Y6KA659C									2
	" " " " Rod (13.05")	Y5KA659A								1	
659J	Injection Pump Plunger Push Rod (10.11")	Y5KA659D								1	
896A	Injection Pump Push Rod Shoe	YKA896B1	1	2	3	1	2	3	4	5	6
2326	Injection Pump Rocker Spring	YKA2326A4	1	2	2	1	2	2	4		5
	" " " " Spring	Y5KA2326A									5
2326A	Injection Pump Rocker Spring	YKA2326C			1			1			
	" " " " Spring	YKA2326B									
	Injection Pump Rocker Spring Pin	1/4"x1 1/2"			1			1			2

List Division No. 11. Injection Pump, Rockers and Housing (Continued)

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
2337	Rocker Spring Post (with 2 Holes)	Y2KA2337B	1	1	1	1	1	1	2	2	4
2338	" " Post (with 3 Holes)	YKA2338B2	1	1	2	1	1	2	2	1	1
2338A	" " Post (with Slot)	YKA2338D								1	1
2338B	" " Post (with 1 Hole)	YKA2338E								1	1
657D	Rocker Shaft (Short)	Y2KA657E4		1	1		1	1	2	2	2
1941B	Governor Cam Rocker Shaft	YKA1941E4	1	1	2	1	1	2	2	2	3
3378	" " Plug	CDA3378A	1	2	3	1	2	3	4	5	6
626A	Injection Pump Suction Valve Adj. Screw	YKA626B	1	1	2	1	1	2	3	4	5
626B	" " " " " " Screw	YKA626C	1	1	1	1	1	1	1	1	1
	" " " " " " Lockwire	.081"x1"		1	1		1	1	1	1	1
627A	" " " " " " Nut	YKA627A1	1	1	2	1	1	2	3	4	5
627B	" " " " " " Nut	YKA627B	1	1	1	1	1	1	1	1	1
2327	" " " " " " Rocker Spacer	YKA2327A1	3	6	9	3	6	9	12	12	18
511B-DC	Pump Case Housing (Complete)		1	1	1	1	1	1	1	1	1
511B-B	Pump Case Housing, always with	YKA511B4	1	1		1	1				
	" " " " " " Housing, always with	Y3KA511B5			1			1			
	" " " " " " Housing, always with	Y4KA511B5						1			
	" " " " " " Housing, always with	Y5KA511A5							1		
	" " " " " " Housing, always with	Y6KA511B6								1	
2361	Governor Case Stud.	1/2"x1 3/4"	6	6	6	6	6	6	6	6	6
2360	Pump Case Housing Plug	YKA2360A	1			1					
510A	" " " " " " Blank Flange	YKA510A	1	1	1	1	1	1	1	1	1
642A	Injection Pump Suct. Valve Push Rod Stem, With	YKA642A	1	2	3	1	2	3	4	5	6
651B	Push Rod Stem Bushing (Not Fur. Sep.)	YKA651A	1	2	3	1	2	3	4	5	6
2321	Pump Case Housing Fuel Reservoir Stud	YKA2321A	4	4	4	4	4	4	4	4	4
1379	Governor Push Rod Bushing	Y3KA1379A			1			1	2	2	2
6631A	Fuel Reservoir Stud	1/2"x3 3/4"	2	2	2	2	2	2	2	2	2
	Injection Pump Stud	YKA6631B	4	4	6	4	4	6	8	10	12
	Air Inlet Stud	3/4"x8 1/2"	4	4	4	4	4	4	4	4	4
	Overflow Casing Stud	3/2"x6"	2	2	2	2	2	2	2	2	2
1380B	Lubricating Rod Cover	YKA1380F	1	1	1	1	1	1	1	1	1
	" " " " " " Cover	YKA1380G									1
849A	Pump Case Housing Cover	YKA849C	1	1	1	1	1	1	1	1	1
	" " " " " " Cover	Y4KA849D									1
512A	" " " " " " Cap Screw	3/8"x3/4"	3	3	3	3	3	3	3	3	3
469A	" " " " " " Side Cover	YKA512A	2	2	2	2	2	2	2	2	2
	" " " " " " Gasket	YKA469A	2	2	2	2	2	2	2	2	2
	Lubricating Rod Cover Cap Screw	3/4"x3/4"	2	2	2	2	2	2	2	2	2
	Lubricator Rod Cover Cap Screw	3/4"x2"	1	1	1	1	1	1	1	1	1
	" " " " " " Lockwasher	3/4"	3	3	3	3	3	3	3	3	3
	Pump Case Housing Side Cover Cap Screw	3/4"x3/4"	8	8	8	8	8	8	8	8	8
266	Injection Pump Suction Valve Push Rod Spring	YKA266B	1	2	3	1	2	3	4	5	6
472A	Pump Case Housing Gasket	YKA472A	2	2	2	2	2	2	2	2	2
2322	" " " " " " Gasket	Y4KA472A							2	2	2
2328	Pump Case Housing Lower Base Tap Bolt	YKA2322A	4	4	4	4	4	4	4	4	4
2329	Fuel Hand Control Shaft Support	Y4KA2328A							1	1	1
	" " " " " " Dowel	Y4KA2329A							1	1	1
2173A-C	Fuel Hand Control (Complete)		1	1	1	1	1	1	1	1	1
2173A	Fuel Hand Control Shaft and Cam	YKA2173B	1	1		1	1				
	" " " " " " Cam	Y3KA2173B			1			1			
	" " " " " " Cam	Y4KA2173B							1		
	" " " " " " Cam	Y5KA2173A								1	
	" " " " " " Cam	Y6KA2173B									1
2203	Hand Control Quadrant Plate	YKA2203A	1	1	1	1	1	1	1	1	1
2202	Fuel Hand Control Lever Quadrant	YKA2202A	1	1	1	1	1	1	1	1	1
	Hand Control Quadrant R. H. M. Screw	3/4"x3/4"	3	3	3	3	3	3	3	3	3
2201A-C	Hand Control Lever (Complete)		1	1	1	1	1	1	1	1	1
2201A-C	Fuel Hand Control Lever (Complete)		1	1	1	1	1	1	1	1	1
2201A	Hand Control Lever	YKA2201B	1	1	1	1	1	1	1	1	1
2204	" " " " " " Latch Spindle	YKA2204A	1	1	1	1	1	1	1	1	1
2205	" " " " " " Latch	YKA2205A	1	1	1	1	1	1	1	1	1
2257	" " " " " " Spring	YKA2257A1	1	1	1	1	1	1	1	1	1
	" " " " " " Cap Screw	3/8"x1 1/4"	1	1	1	1	1	1	1	1	1
	" " " " " " Key	3/8"x3/4"x1"	1	1	1	1	1	1	1	1	1
3359	Rocker Shaft Plate	YKA3359A	1	2	3	1	2	3	4	5	6
3360	" " " " " " Cap Screw	YKA3360A	2	4	6	2	4	6	8	10	12
3818	" " " " " " Lockwasher	YKA3818A	2	2	4	2	2	4	4	5	6
	" " " " " " Screw Wire	#19x4"	1	2	3	1	2	3	4	5	6
6521	Injection Rocker Oil Pipe	Y4KA6521A							1		
	" " " " " " Pipe	YKA6521D								1	
	" " " " " " Pipe	Y6KA6521B									1
986B-C	Fuel Reservoir Cover (See also Chart #10)		1	1	1	1	1	1	1	1	1

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 13. Air Start Piping



← Gov. End

Repair Chart No. 13

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
700J	Air Start Pipe Cyl. #1, always with.....	Y3JA700J	1	1	1						
700K	" " Pipe Cyl. #3, always with.....	Y3JA700K			1						
700E	Air Start Pipe Cyl. #1, always with.....	YKA700E				1	1				
	" " Pipe Cyl. #1, always with.....	Y3KA700F						1	1	1	
	" " Pipe Cyl. #1, always with.....	Y6KA700E							1	1	1
700F	Air Start Pipe Cyl. #3, always with.....	Y3KA700G						1	1		
700G	" " Pipe Cyl. #4, always with.....	Y6KA700F								1	1
700H	" " Pipe Cyl. #5, always with.....	Y6KA700S								1	1
	Air Start Pipe R. R. Union.....	1 1/4"	1	1	2	2	2	4	4	4	6
	Close Nipple.....	1 1/4"x2 1/2"			1	1	2	2	2	2	3
701	Air Start Pipe (Lower) Cyl. #1.....	YJA701A	1	1							
	" " Pipe (Lower) Cyl. #1.....	YKA701A				1	1				
	" " Pipe (Lower) Cyl. #1.....	Y3JA701A			1						
	" " Pipe (Lower) Cyl. #1.....	Y3KA701A						1	1	1	
	" " Pipe (Lower) Cyl. #1.....	Y6KA701A									1
701A	Air Start Pipe (Lower) Cyl. #3.....	Y3JA701B			1						
	" " Pipe (Lower) Cyl. #3.....	Y3KA701B						1	1		
701B	" " Pipe (Lower) Cyl. #4.....	Y6KA701B								1	1
701D	" " Pipe (Lower) Cyl. #5.....	Y6KA701C									1
2789	Air Start Pipe Clamp (2 Pipes).....	Y4KA2789A			2			2	2	2	2
2789A	Clamp (3 Pipes).....	Y3KA2789B									2
4596	Air Start Distributor Body.....	YKA4596A	1	1		1	1				
	" " Body.....	Y3KA4596A			1			1			
	" " Body.....	Y4KA4596A							1		
	" " Body.....	Y6KA4596A								1	1
573B	Air Start Distributor Body Gasket.....	YKA573A	1	1		1	1				
	" " Gasket.....	Y3KA573A			1			1	1		
	" " Gasket.....	Y6KA573A								1	1
573D	Air Start Shut-off Valve Cage Gasket.....	YKA573B	1	1	1	1	1	1	1	1	1
2601	Air Start Distributor Body Stud Nut.....	Y6KA2601A								4	4

ALWAYS GIVE ENGINE SERIAL NUMBER

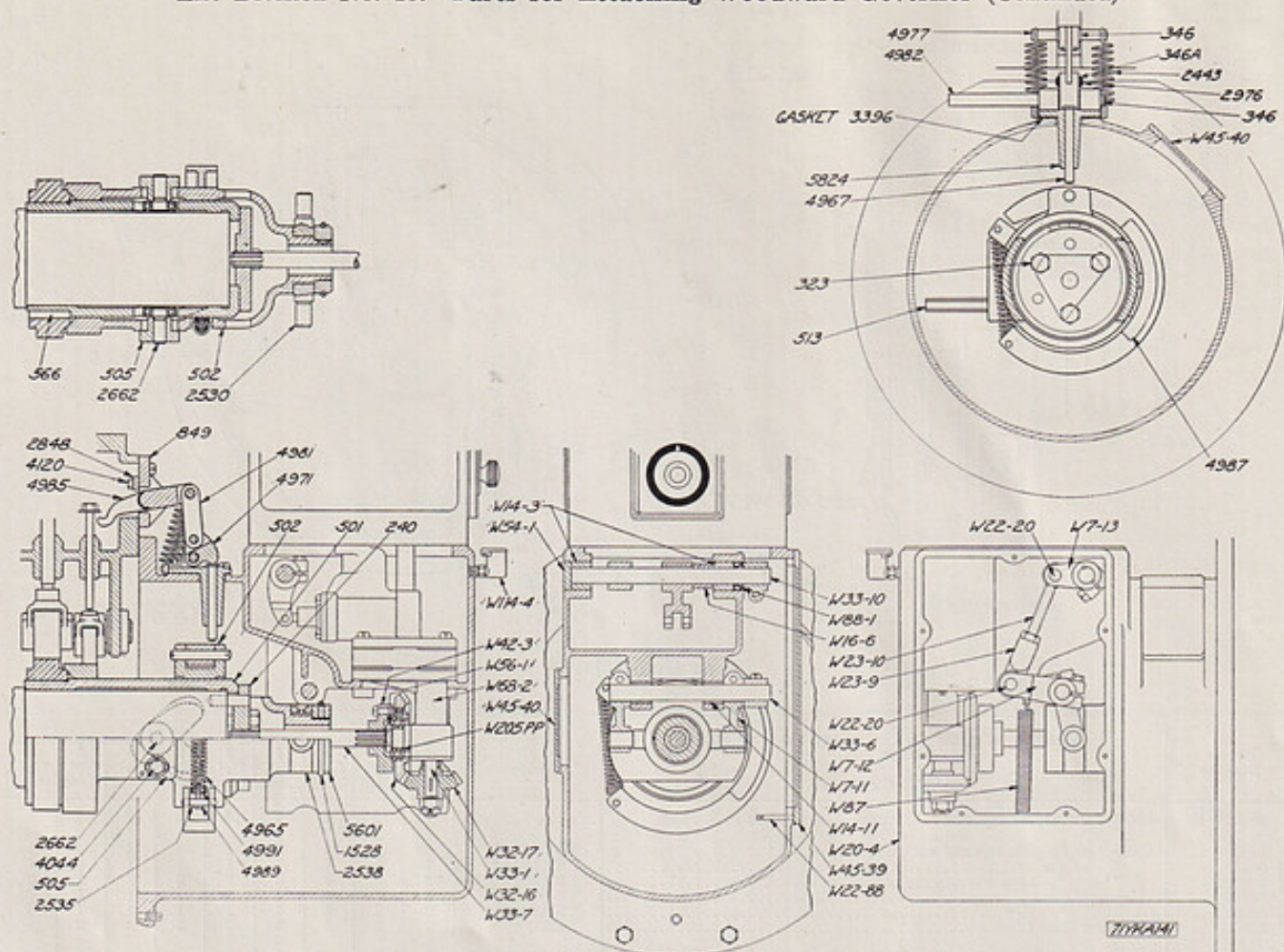
List Division No. 14. Air Start Rocker and Push Rods (Continued)

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"						
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used	
674A	Air Starter Push Rod (10" long)..... " " " Rod (15" long)..... " " " Rod (13 3/4" long).....	YKA674A Y3KA674A Y4KA674A	1	1	1	1	1	1	1	1	1	1
674B	Air Starter Push Rod (8 1/2" long)..... " " " Rod (6 1/2" long)..... " " " Rod (15" long).....	Y3KA674B Y4KA674B Y5KA674A			1			1		1		1
674D	Air Starter Push Rod (14" long).....	Y6KA674A										1
2326	Air Start Rocker Spring.....	YKA2326A4	1	1	2	1	1	2	2			2
2326B	" " " Spring.....	YKA2326D										1
2326D	" " " Spring.....	Y5KA2326B									2	
568D-C	Air Start Control (Complete)		1	1	1	1	1	1	1	1	1	1
568D	Air Start Hand Control Shaft and Cam..... " " " " " Cam..... " " " " " Cam..... " " " " " Cam..... " " " " " Cam.....	YKA568F Y3KA568F Y4KA568F Y5KA568A Y6KA568F	1	1	1	1	1	1		1		1
2202A	Hand Control Lever Quadrant.....	YKA2202C1	1	1	1	1	1	1	1	1	1	1
2201A-C	Air Start Hand Control Lever.....		1	1	1	1	1	1	1	1	1	1
2201A-C	Air Hand Control Lever (Complete)		1	1	1	1	1	1	1	1	1	1
2201A	Air Hand Control Lever.....	YKA2201B	1	1	1	1	1	1	1	1	1	1
2204	" " " Latch Spindle.....	YKA2204A	1	1	1	1	1	1	1	1	1	1
2205	" " " Latch.....	YKA2205A	1	1	1	1	1	1	1	1	1	1
2257	" " " Spring.....	YKA2257A1	1	1	1	1	1	1	1	1	1	1
	" " " Cap Screw.....	1/4"x1 1/4"	1	1	1	1	1	1	1	1	1	1
	" " " Key.....	3/8"x3/4"x1"	1	1	1	1	1	1	1	1	1	1
2293E-C	Air Starter Shut-off Valve (Complete)		1	1	1	1	1	1	1	1	1	1
2293E	Air Starter Shut-Off Valve Cage.....	YKA2293E	1	1	1	1	1	1	1	1	1	1
2294B	" " " Valve.....	YKA2294C	1	1	1	1	1	1	1	1	1	1
2295A	" " " Spring.....	YKA2295B	1	1	1	1	1	1	1	1	1	1
1189	" " " Retainer.....	YKA1189A	1	1	1	1	1	1	1	1	1	1
3143	Air Starter Shut-Off Valve Spring Guide.....	YKA3143A	1	1	1	1	1	1	1	1	1	1
574	" " " Inlet Elbow.....	YKA574B	1	1	1	1	1	1	1	1	1	1
2335A	" " " Gasket.....	YKA2335B	1	1	1	1	1	1	1	1	1	1
570B	Air Start Valve (See Chart #10 also).....	YKA570A	1	1	2	1	1	2	2	2	2	3
903	" " " Plug (See Chart #10 also).....	YKA903A	1	1	2	1	1	2	2	2	2	3

List Division No. 15. Parts for Attaching Woodward Governor

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"						
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used	
240	Governor Drive Flange.....	YKA240A	1	1	1	1	1	1	1	1	1	1
323	Crankshaft Governor Cap Screw..... " " " Lockwire.....	NW323A #16x12"	3	3	3	3	3	3	3	3	3	3
	Governor Spiral Sleeve Dowel..... " " " Cam Sleeve Dowel.....	#825 #825	1	1	1	1	1	1	1	1	1	1
346	Over-speed Governor Trip Lever Shaft Spring Ring..... " " " Pin Spring Ring.....	PCD346A PCD346A	1	1	1	1	1	1	1	1	1	1
346A	Over-speed Governor Trip Pin Spring Ring.....	ZBA346	2	2	2	2	2	2	2	2	2	2
501F	Governor Spiral Sleeve (Std. Rotation).....	YKA501H5	1	1	1	1	1	1	1	1	1	1
501G	" " " Sleeve (Rev. Rotation).....	YKA501J5	1	1	1	1	1	1	1	1	1	1
502E	" " " Cam Sleeve.....	YKA502C4	1	1	1	1	1	1	1	1	1	1
505A	" " " Ball Bearing Adj. Bracket.....	YKA505A	2	2	2	2	2	2	2	2	2	2
2751	" " " Adjusting Bracket Washer.....	YKA2751A	4	4	4	4	4	4	4	4	4	4
513	" " " Oil Throter..... " " " Adj. Bracket Lock Wire..... " " " Dowel.....	YKA513A1 #16"x10" #309	1	1	1	1	1	1	1	1	1	1
	" " " Roller Ball Bearing.....	#6203 SKF	2	2	2	2	2	2	2	2	2	2
566B	Injection Cam Key.....	YKA566B	1	1	1	1	1	1	1	1	1	1
849B	Valve Gear Housing Governor End Cover.....	YKA849E	1	1	1	1	1	1	1	1	1	1
849D	Valve Gear Housing Governor End Cover..... " " " Cover.....	Y4KA849E Y5KA849B							1			1
1528	Governor Trunnion Yoke Collar Lock.....	YKA1528A	1	1	1	1	1	1	1	1	1	1
2443	Over-speed Governor Trip Spring.....	YKA2443A	2	2	2	2	2	2	2	2	2	2
2535	Over-speed Governor Weight Spring Pin.....	YKA2535B	2	2	2	2	2	2	2	2	2	2
2538A	Governor Trunnion.....	YKA2538B	1	1	1	1	1	1	1	1	1	1
2662	Governor Roller Ball Bearing Pin.....	YKA2662A	2	2	2	2	2	2	2	2	2	2
2848	Over-speed Governor Cam Shaft Brg. Cap.....	YKA2848A	2	2	2	2	2	2	2	2	2	2
2976A	" " " Trip Pin.....	YKA2976B	1	1	1	1	1	1	1	1	1	1
3396	" " " Push Rod Guide Gasket.....	YKA3396A	1	1	1	1	1	1	1	1	1	1
4044	Governor Ball Bearing Adj. Bkt. Cap Screw.....	YLA4044A	3	3	3	3	3	3	3	3	3	3
4120	Over-speed Governor Cam Shaft Brg. Cap Screw..... " " " Wire.....	CEA4120A #20"x6"	2	2	2	2	2	2	2	2	2	2
4965	Over-speed Governor Weight Spring (257 R. P. M.).....	YKA4965A				1	1	1	1	1	1	1
4965A	" " " Spring (300 R. P. M.).....	YKA4965B2				1	1	1	1	1	1	1
4965B	" " " Spring (360 R. P. M.).....	YKA4965C1				1	1	1	1	1	1	1
4967	" " " Push Rod.....	YKA4967A	1	1	1	1	1	1	1	1	1	1
4971	Over-speed Governor Trip Lever.....	YKA4971A1	1	1	1	1	1	1	1	1	1	1
4977	" " " Pin.....	YKA4977A1	1	1	1	1	1	1	1	1	1	1
A4981	" " " Link.....	YKA4981A										
B4981	Over-speed Governor Trip Lever Link.....	YKA4981B										
C4981	" " " Link..... " " " Woodruff Key.....	YKA4981C #3										

List Division No. 15. Parts for Attaching Woodward Governor (Continued)

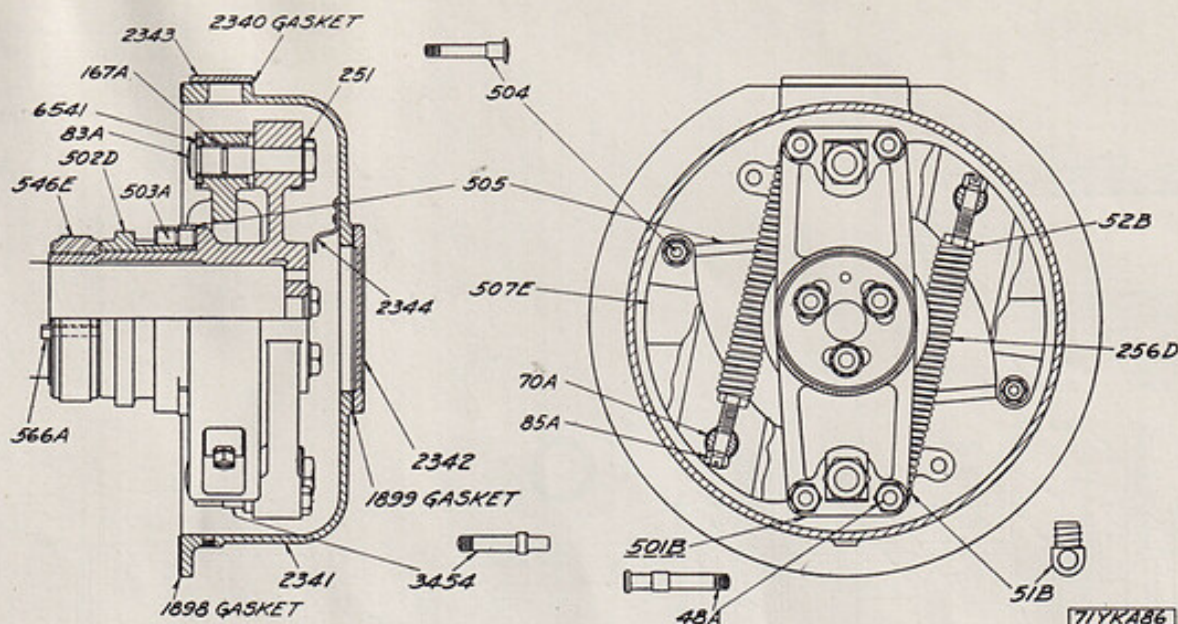


Repair Chart No. 15

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
4982	Overspeed Governor Trip Lever Pin	YKA4984A	1	1	1	1	1	1	1	1	1
	Shaft	YKA4982A1	1	1	1	1	1	1	1	1	1
4985	Overspeed Governor Cam Shaft	Y3KA4985A2	1	1	1	1	1	1	1	1	1
	Shaft	Y4KA4985A2							1		
	Shaft	Y5KA4985A2								1	
	Shaft	Y6KA4985A2									1
4987	Overspeed Governor Cam Shaft Cotter	YKA4987A1	2	2	2	2	2	2	2	2	2
	Overspeed Governor Weight	YKA4987A1	1	1	1	1	1	1	1	1	1
	Pin	#43C	1	1	1	1	1	1	1	1	1
	Cotter	1/4"x3/4"	2	2	2	2	2	2	2	2	2
4989	Screw	YKA4989A	2	2	2	2	2	2	2	2	2
4991A	Spring Plug	YKA4991B	2	2	2	2	2	2	2	2	2
5601A	Governor Trunnion Yoke Thrust Nut	YKA5601A	1	1	1	1	1	1	1	1	1
	Dowel	#309	1	1	1	1	1	1	1	1	1
5824	Overspeed Governor Push Rod Guide	YKA5824A	1	1	1	1	1	1	1	1	1
	Cap Screw	3/4"x3/4"	4	4	4	4	4	4	4	4	4
W7-11	Fuel Shaft Yoke Lever	7-11	2	2	2	2	2	2	2	2	2
W7-12	Drive Lever	7-12	1	1	1	1	1	1	1	1	1
W7-13	Terminal Shaft Lever	7-13	1	1	1	1	1	1	1	1	1
W14-3	Bushing	14-3	2	2	2	2	2	2	2	2	2
W14-11	Fuel Shaft Bushing	14-11	2	2	2	2	2	2	2	2	2
W16-6	Terminal Shaft Spacer	16-6	1	1	1	1	1	1	1	1	1
W20-4	Governor Case	20-4	1	1	1	1	1	1	1	1	1
W22-20	Fuel and Terminal Shaft Lever Pin	22-20	2	2	2	2	2	2	2	2	2
W22-88	Fuel Shaft Lever Spring Post	22-88	1	1	1	1	1	1	1	1	1
W23-9	Fuel to Terminal Shaft Rod End	23-9	1	1	1	1	1	1	1	1	1
W23-10	Fuel to Terminal Shaft Rod	23-10	1	1	1	1	1	1	1	1	1
W32-16	Governor Drive Gear	32-16	1	1	1	1	1	1	1	1	1
W32-17	Driven Gear	32-17	1	1	1	1	1	1	1	1	1
W33-1	Shaft	33-1	1	1	1	1	1	1	1	1	1
W33-6	Fuel Shaft	33-6	1	1	1	1	1	1	1	1	1
W33-7	Splined Shaft	33-7	1	1	1	1	1	1	1	1	1
W33-10	Terminal Shaft	33-10	1	1	1	1	1	1	1	1	1
W42-3	Governor Gear Coupling	42-3	1	1	1	1	1	1	1	1	1
W45-39	Case Cover—Large	45-39	1	1	1	1	1	1	1	1	1
W45-40	Case Cover—Small	45-40	2	2	2	2	2	2	2	2	2
W54-1	Governor Case Plug	54-1	1	1	1	1	1	1	1	1	1
W56-1	Drive Gear Ball Bearing Retainer	56-1	1	1	1	1	1	1	1	1	1
W58-2	Drive Bearing	58-2	1	1	1	1	1	1	1	1	1
W87	Fuel Shaft Lever Spring	#87	1	1	1	1	1	1	1	1	1
W88-1	Terminal Shaft Oil Seal	88-1	1	1	1	1	1	1	1	1	1
W114-4	Governor Case Oil Cup	114-4	1	1	1	1	1	1	1	1	1
W205PP	Drive Gear Ball Bearing	205PP	1	1	1	1	1	1	1	1	1

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 16. Governor

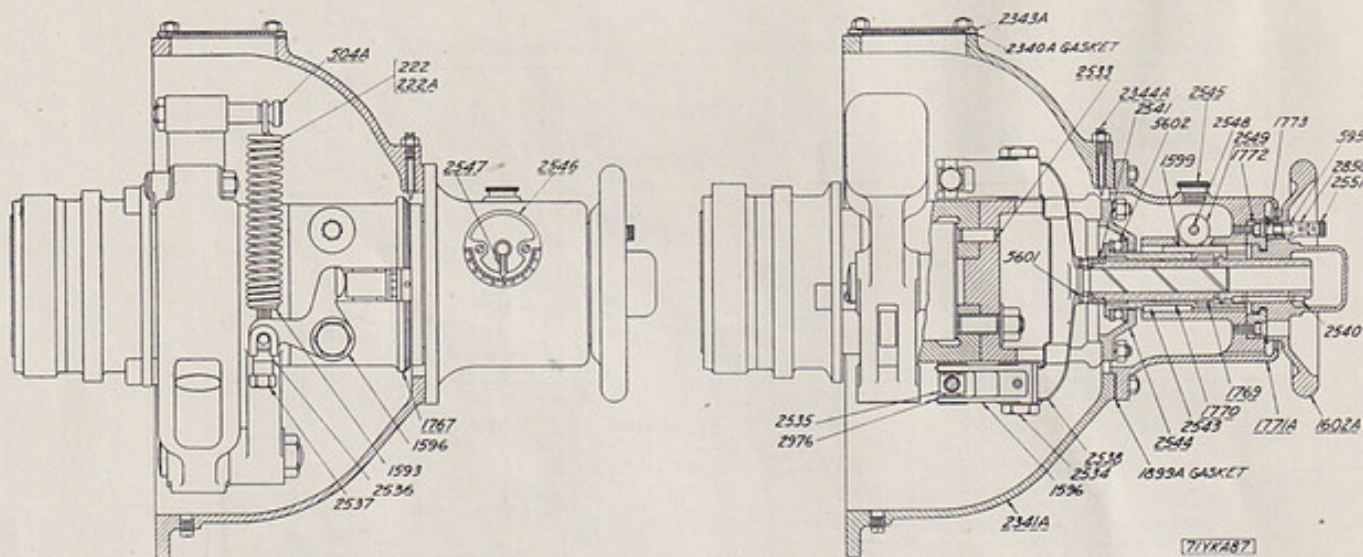


Repair Chart No. 16

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"						
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used	
501B-BC	Governor (Complete)		1	1	1	1	1	1	1	1	1	1
501B	Governor Spider, always with.....	YKA501C1	1	1	1	1	1	1	1	1	1	1
502D	" Cam.....	YKA502A2	1	1	1	1	1	1	1	1	1	1
503A	" Link Pin.....	YKA503A	2	2	2	2	2	2	2	2	2	2
546E	Injection Cam.....	YKA546A1	1	1	1	1	1	1	1	1	1	1
566A	" Key.....	YKA566A	1	1	1	1	1	1	1	1	1	1
505	Governor Cam Link.....	YK505	2	2	2	2	2	2	2	2	2	2
507E	Governor Weight, always with.....	YJA507E	2	2	2	2	2	2	2	2	2	2
167A	" Weight, always with.....	YKA507G	2	2	2	2	2	2	2	2	2	2
83A	" Bushing.....	YKA167A1	2	2	2	2	2	2	2	2	2	2
251	Governor Weight Pin.....	YKA83A1	2	2	2	2	2	2	2	2	2	2
3454	" " Nut.....	1"	2	2	2	2	2	2	2	2	2	2
504	" " Lock.....	YKA251A	2	2	2	2	2	2	2	2	2	2
48A	" " Stop Pin.....	YKA3454A	2	2	2	2	2	2	2	2	2	2
256D-C	Governor Weight Drag Spring.....	5/8" C. P.	2	2	2	2	2	2	2	2	2	2
504	" Link Pin.....	YKA6541B	2	2	2	2	2	2	2	2	2	2
48A	" Nut.....	YK504	2	2	2	2	2	2	2	2	2	2
256D-C	" Spring Pin.....	1/2" C. P.	2	2	2	2	2	2	2	2	2	2
256D-C	" Nut.....	YKA48A	2	2	2	2	2	2	2	2	2	2
256D-C	Governor Spring (Complete).....	5/8" C. P.	2	2	2	2	2	2	2	2	2	2
256D-C	Governor Spring (Complete)		2	2	2	2	2	2	2	2	2	2
256D	Governor Spring (360 R.P.M.), always with.....	YJA256E	2	2	2	2	2	2	2	2	2	2
52B	" " (300 R.P.M.), always with.....	YKA256J	2	2	2	2	2	2	2	2	2	2
51B	" Plug.....	YKA52C	2	2	2	2	2	2	2	2	2	2
51B	Governor Spring Eye Bolt.....	YKA51B	2	2	2	2	2	2	2	2	2	2
70A	Adjusting Screw Pin.....	YKA70A	2	2	2	2	2	2	2	2	2	2
85A	" Screw.....	YKA85A2	2	2	2	2	2	2	2	2	2	2
85A	" Cotter.....	1/2"x1 1/4"	2	2	2	2	2	2	2	2	2	2
2341-C	Governor Case (Complete)		1	1	1	1	1	1	1	1	1	1
2341	Governor Case, always with.....	YKA2341A1	1	1	1	1	1	1	1	1	1	1
	" End Plate Cap Screw.....	3/4"x1"	6	6	6	6	6	6	6	6	6	6
	" Hand Hole Plate Cap Screw.....	3/4"x3/4"	2	2	2	2	2	2	2	2	2	2
	" Pipe Plug.....	3/4"	1	1	1	1	1	1	1	1	1	1
1899	Governor Case Dowel.....	#613	2	2	2	2	2	2	2	2	2	2
2340	" End Plate Gasket.....	YKA1899A	1	1	1	1	1	1	1	1	1	1
2342	" Hand Hole Cover Gasket.....	YKA2340A	1	1	1	1	1	1	1	1	1	1
2343	" End Plate.....	YKA2342A1	1	1	1	1	1	1	1	1	1	1
2344	" Hand Hole Cover.....	YKA2343A	1	1	1	1	1	1	1	1	1	1
2344	" Timing Pointer.....	YKA2344A	1	1	1	1	1	1	1	1	1	1
1898	" R. H. M. Screw.....	YKA1898A	2	2	2	2	2	2	2	2	2	2
1898	Governor Case Gasket.....	YKA1898A	1	1	1	1	1	1	1	1	1	1

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 17. Synchronizer or Speed Regulator

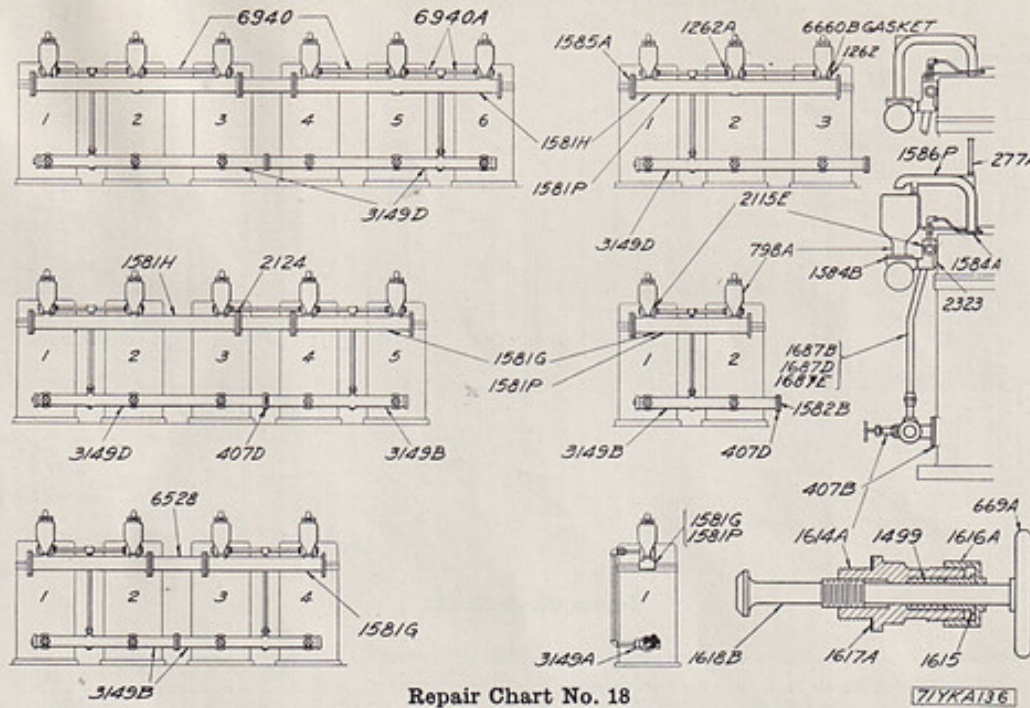


Repair Chart No. 17

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"						
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used	
222	(Speed Regulator Slow Down Spring (360 R. P. M.) Spring (300 R. P. M.)	YKA222F YKA222A1	2	2	2	2	2	2	2	2	2	2
222A	Synchronizer Spring	YKA222B1	2	2	2	2	2	2	2	2	2	2
504A	Speed Regulator Spring Post	YKA504A	2	2	2	2	2	2	2	2	2	2
505	Hand Wheel Stop Spring	YK505A1	1	1	1	1	1	1	1	1	1	1
1593	Speed Regulator Spring Plug	YKA1593A	2	2	2	2	2	2	2	2	2	2
1596	" " " " " " " " " " " "	YKA1596A1	2	2	2	2	2	2	2	2	2	2
1599	" " " " " " " " " " " "	YKA1599A	1	1	1	1	1	1	1	1	1	1
1602A	Hand Wheel	YKA1602M1	1	1	1	1	1	1	1	1	1	1
1767	Governor Spider Hub, always with Bearing Stud	YKA1767A 5/8"x1 1/2"	1	1	1	1	1	1	1	1	1	1
1769	Speed Regulator Adjusting Screw	YKA1769A	1	1	1	1	1	1	1	1	1	1
1770	" " " " " " " " " " " "	YKA1770A	1	1	1	1	1	1	1	1	1	1
1771A	" " " " " " " " " " " "	YKA1771K2	1	1	1	1	1	1	1	1	1	1
1772	Hand Wheel Retaining Ring	YKA1772A1	1	1	1	1	1	1	1	1	1	1
1773	" " " " " " " " " " " "	YKA1773A	1	1	1	1	1	1	1	1	1	1
1899A	Governor Case End Plate Gasket	YKA1899B	1	1	1	1	1	1	1	1	1	1
2340A	" " " " " " " " " " " "	YKA2340B	1	1	1	1	1	1	1	1	1	1
2341A	" " " " " " " " " " " "	YKA2341B1	1	1	1	1	1	1	1	1	1	1
2343A	" " " " " " " " " " " "	YKA2343B1	1	1	1	1	1	1	1	1	1	1
2344A	Injection Pointer	YKA2344B	1	1	1	1	1	1	1	1	1	1
2533	Governor Spider Hub Dowel	YKA2533A	1	1	1	1	1	1	1	1	1	1
2534	Speed Regulator Rocker Pin	YKA2534A	2	2	2	2	2	2	2	2	2	2
2535	" " " " " " " " " " " "	YKA2535A	2	2	2	2	2	2	2	2	2	2
2536	" " " " " " " " " " " "	YKA2536A	2	2	2	2	2	2	2	2	2	2
2537	" " " " " " " " " " " "	YKA2537A	2	2	2	2	2	2	2	2	2	2
2538	" " " " " " " " " " " "	YKA2538A	1	1	1	1	1	1	1	1	1	1
2540	Speed Regulator Adj. Screw Key	YKA2540A	1	1	1	1	1	1	1	1	1	1
2541	" " " " " " " " " " " "	YKA2541A	1	1	1	1	1	1	1	1	1	1
2543	" " " " " " " " " " " "	YKA2543A	1	1	1	1	1	1	1	1	1	1
2544	Governor Spider Hub Bearing Retainer	YKA2544A	1	1	1	1	1	1	1	1	1	1
2545	Adjusting Screw Housing Oil Plug	YKA2545A	1	1	1	1	1	1	1	1	1	1
2546	Speed Regulator Indicator Dial	YKA2546A	1	1	1	1	1	1	1	1	1	1
2547	" " " " " " " " " " " "	YKA2547A	1	1	1	1	1	1	1	1	1	1
2548	" " " " " " " " " " " "	YKA2548A	1	1	1	1	1	1	1	1	1	1
2549	" " " " " " " " " " " "	YKA2549A	1	1	1	1	1	1	1	1	1	1
2551	Hand Wheel Stop Pin Knob	YKA2551A	1	1	1	1	1	1	1	1	1	1
2850	" " " " " " " " " " " "	YKA2850A	1	1	1	1	1	1	1	1	1	1
2976	Speed Regulator Rocker Pin Dowel	YKA2976A1	2	2	2	2	2	2	2	2	2	2
5601	" " " " " " " " " " " "	16FM34A18	1	1	1	1	1	1	1	1	1	1
5602	" " " " " " " " " " " "	16FM34A19	1	1	1	1	1	1	1	1	1	1

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 18. Water Manifolds



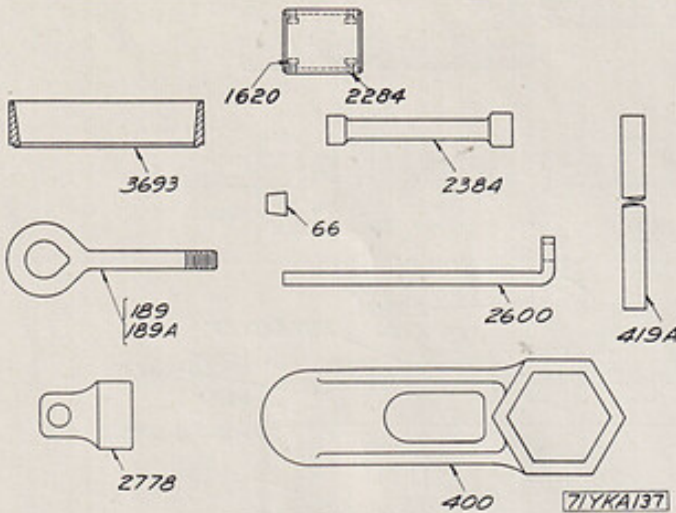
Repair Chart No. 18

7/YKA136

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"								
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used			
1581G	Water Overflow Manifold	YKA1581B				1								
1581H	" " Manifold	Y2KA1581H1					1			2	1			
6528	Water Overflow Manifold Spacer	Y4KA6528A							1		1	1		
1581P	Water Overflow Manifold	YJA1581M	1											
2124	" " Manifold	Y2JA1581N		1										
2115E	" " Manifold	Y3JA1581J			1									
2323	Air Start Pipe Flange Gasket	Standard (4")					1	1	3	3	3			
1262	Air Start Pipe Flange (Upper)	YKA2115G	1			1								
1262A	Air Start Pipe Flange (Upper)	YKA2115F		2	3		2	3	4	5	6			
6660B	Air Start Pipe Flange Plug (Solid)	1 1/4"		1	1		1	1	2	2	3			
1585A	Water Overflow Funnel	YKA2323A1	1	2	3	1	2	3	4	5	6			
798A	Air Start Pipe Flange Gasket	YKA1262A		2	2		2	2	4	4	4			
1584B	Air Start Pipe Flange Gland	YKA1262B		2	4		2	4	4	6	8			
277A	" " " Plug Gasket	YLA6660A		2	2		2	2	4	4	4			
1586P	" " " Candle Wicking	1/2"x10"		2	4		2	4	4	6	8			
1584A	" " Blind Flange	Y2KA1585B					1	1	1	1	1			
1584A	Water Overflow Funnel	YKA798C	1	2	3	1	2	3	4	5	6			
1584A	" " Gasket	YKA1584E	1	2	3	1	2	3	4	5	6			
1584A	Cooling Water Thermometer	16FM39C1	1	2	3	1	2	3	4	5	6			
1584A	" " Overflow Elbow	YKA1586R	1	2	3	1	2	3	4	5	6			
1584A	" " Gasket	YKA1584D	1	2	3	1	2	3	4	5	6			
6940	Upper Water Header Pipe	Y2JA6940A			1									
6940A	Upper Water Header Pipe	Y2KA6940A					1			1	2			
6940A	Upper Water Header Pipe	Y2JA6940B		2	2									
6940A	Upper Water Header Pipe	Y2KA6940B					2	2	4	4	4			
1687E	Upper to Lower Water Manifold Pipe	YJA3816A	1	1	1									
1687B	" " " Pipe	YKA3816A				1								
1687D	Upper to Lower Water Manifold Pipe	Y2KA3816A					1	1	2	2	1			
1687D	Upper to Lower Water Manifold Pipe	Y6KA3816A										1		
3149A	Lower Water Manifold (One Cyl. Opening)	YKA3149A1	1			1								
3149B	Lower Water Manifold (Two Cyl. Opening)	Y2JA3149C1		1										
3149B	Lower Water Manifold (Two Cyl. Opening)	Y2KA3149B2					1		2	1				
3149D	Lower Water Manifold (Three Cyl. Opening)	Y3JA3149C1			1									
3149D	Lower Water Manifold (Three Cyl. Opening)	Y3KA3149B2						1		1	2			
407B	Water Manifold to Cylinder Gasket	YKA407B	1	1	1	1	2	3	4	5	6			
407D	" " Gasket	YLA407B					1	1	1	1	1			
1582B	" " Flange	YLA1582D					1	1						
1617A	Regulating Valve Bonnet Gasket	NH665		2	3		2	3	4	5	6			
1618B-C	Cooling Water Regulating Valve (Complete)		2	3		2	3	4	5					
1618B	Water Regulating Valve (All in Bracket)	YLA1618A	2	3		2	3	4	5	6				
1614A	" " Bonnet	YLA1614A	2	3		2	3	4	5	6				
1499	" " Packing	CFA1499A2	12	18		12	18	24	30	36				
1615	" " Gland	CFA1615A1	2	3		2	3	4	5	6				
1615	" " Nut	YLA1616A	2	3		2	3	4	5	6				
1616A	" " Handle	YKA669A	2	3		2	3	4	5	6				
669A	" " Dowel	#205	2	3		2	3	4	5	6				

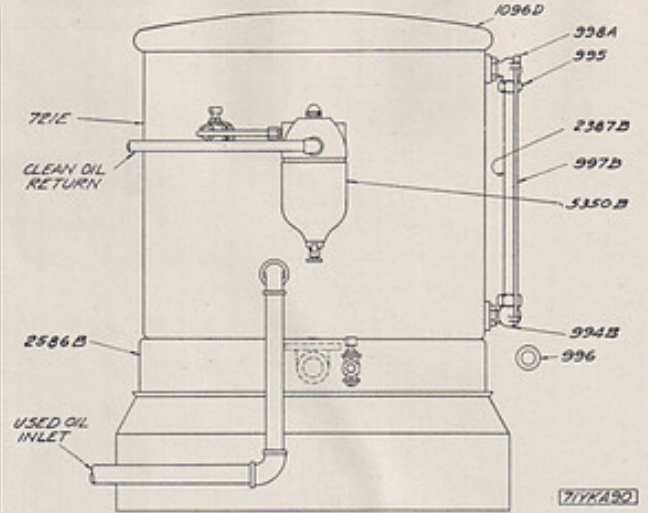
ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 19
Tools and Wrenches



Repair Chart No. 19

List Division No. 20
Oil Filter Storage Tank



Repair Chart No. 20

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"						
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used	
750B-C	Tools (Complete Set)		1	1	1	1	1	1	1	1	1	1
189A	Fuel Reservoir Eye Bolt.....	3/4"	2	2	2	2	2	2	2	2	2	2
189	Piston Lifting Eye Bolt.....	YKA189A	2	2	2	2	2	2	2	2	2	2
419A	Flywheel Turning Bar.....	YK419	1	1	1							
	Bar.....	YKA419A				1	1	1	1	1	1	1
2600	Piston Clamp, with (2) 3/4"x1" Cap Screws.....	YJA2600A	2	2	2							
	Clamp, with (2) 3/4"x1 1/4" Cap Screws.....	YKA2600A				2	2	2	2	2	2	2
3693	Piston Ring Guide.....	YJA3693A	1	1	1							
	Guide.....	YKA3693A				1	1	1	1	1	1	1
06	Air Start Cage Plug.....	ND66	1	1	1	1	1	1	1	1	1	1
	Open End Wrench 1 1/2" Nut.....	#13	1	1	1							
	" " Wrench 1 1/2" Nut.....	#14	1	1	1	1	1	1	1	1	1	1
	" " Wrench 1 1/2" Nut.....	#16				1	1	1	1	1	1	1
	" " Wrench 3/4" - 3/4" Nut.....	#27	1	1	1	1	1	1	1	1	1	1
	" " Wrench 3/4" - 3/4" Nut.....	#34	1	1	1	1	1	1	1	1	1	1
	" " Wrench 3/4" - 3/4" Nut.....	#39	1	1	1	1	1	1	1	1	1	1
	" " Wrench 1" - 1 1/4" Nut.....	#43	1	1	1	1	1	1	1	1	1	1
	" " Wrench 3/4" Cap Screw.....	#702	1	1	1	1	1	1	1	1	1	1
	" " Wrench 3/4" Cap Screw.....	#704	1	1	1	1	1	1	1	1	1	1
	Box Type Wrench 1 1/4" Nut.....	#812										
	Hollow Head Set Screw Wrench 3/4" Wrench.....	A5667	1	1	1	1	1	1	1	1	1	1
	" " Wrench.....	A5668	1	1	1	1	1	1	1	1	1	1
400	Flywheel Hub Bolt Wrench.....	YK400	1	1	1	1	1	1	1	1	1	1
2384	Governor Socket Wrench.....	YK2384A	1	1	1	1	1	1	1	1	1	1
2778	Main Bearing Socket Wrench.....	YJA2778A	1	1	1							
	" " Wrench.....	YKA2778A				1	1	1	1	1	1	1
2284	Piston Pin Sleeve.....	YJA2284B	1	1	1							
	" " Sleeve.....	YKA2284B				1	1	1	1	1	1	1
1620	Piston Pin Sleeve Screw.....	CFE1620A	4	4	4	4	4	4	4	4	4	4
	Upper to Lower Base Capscrew Socket Wrench.....	452A				1	1	1	1	1	1	1
	Upper to Lower Base Dowel Removing Tool.....	TD2273A				1	1	1	1	1	1	1
	" " Nut.....	TD2274A				1	1	1	1	1	1	1
721E-C	Oil Filter Storage Tank (Complete)		1	1	1	1	1	1	1	1	1	1
721E	Oil Filter Storage Tank, always with	CFB721C	1	1	1	1	1	1	1	1	1	1
	" " Bottom.....	CFB721B	1	1	1	1	1	1	1	1	1	1
	" " Coupling.....	PBD555A	3	3	3	3	3	3	3	3	3	3
	" " Elbow.....	YKA2794B	1	1	1	1	1	1	1	1	1	1
	" " Rivets.....	3/8"x3/4"	8	8	8	8	8	8	8	8	8	8
	" " Inlet Fitting.....	CFB4834A	1	1	1	1	1	1	1	1	1	1
	" " Filter Coupling.....	YKA5305C	1	1	1	1	1	1	1	1	1	1
	" " Coupling.....	YKA5305D	2	2	2	2	2	2	2	2	2	2
2586B	Oil Storage Tank Base.....	YKA2586D	1	1	1	1	1	1	1	1	1	1
1096D	" " Cover.....	CFB1096A	1	1	1	1	1	1	1	1	1	1
994B	Gauge Glass Arm.....	PBD994A	2	2	2	2	2	2	2	2	2	2
995	" " Gland Cap.....	PBD995A	2	2	2	2	2	2	2	2	2	2
996	" " Washer.....	PBD996A	2	2	2	2	2	2	2	2	2	2
2387B	" " Glass.....	YKA2387B	1	1	1	1	1	1	1	1	1	1
997B	Gauge Glass Guard Rod (All in Bracket).....	PBD997A	2	2	2	2	2	2	2	2	2	2
998A	" " End.....	PBD998A	2	2	2	2	2	2	2	2	2	2
	Oil Filter to Cover Flat Head Screw.....	3/8"x3/4"	3	3	3	3	3	3	3	3	3	3
	Drain Nipple.....	1/2"x10"	1	1	1	1	1	1	1	1	1	1
	Tee Handle Stop Cock.....	1 1/2"	1	1	1	1	1	1	1	1	1	1
5350B	Oil Filter (Purolator).....	G48WM5	1	1	1	1	1	1	1	1	1	1
1091E	Oil Filter Element (Purolator).....		1	1	1	1	1	1	1	1	1	1

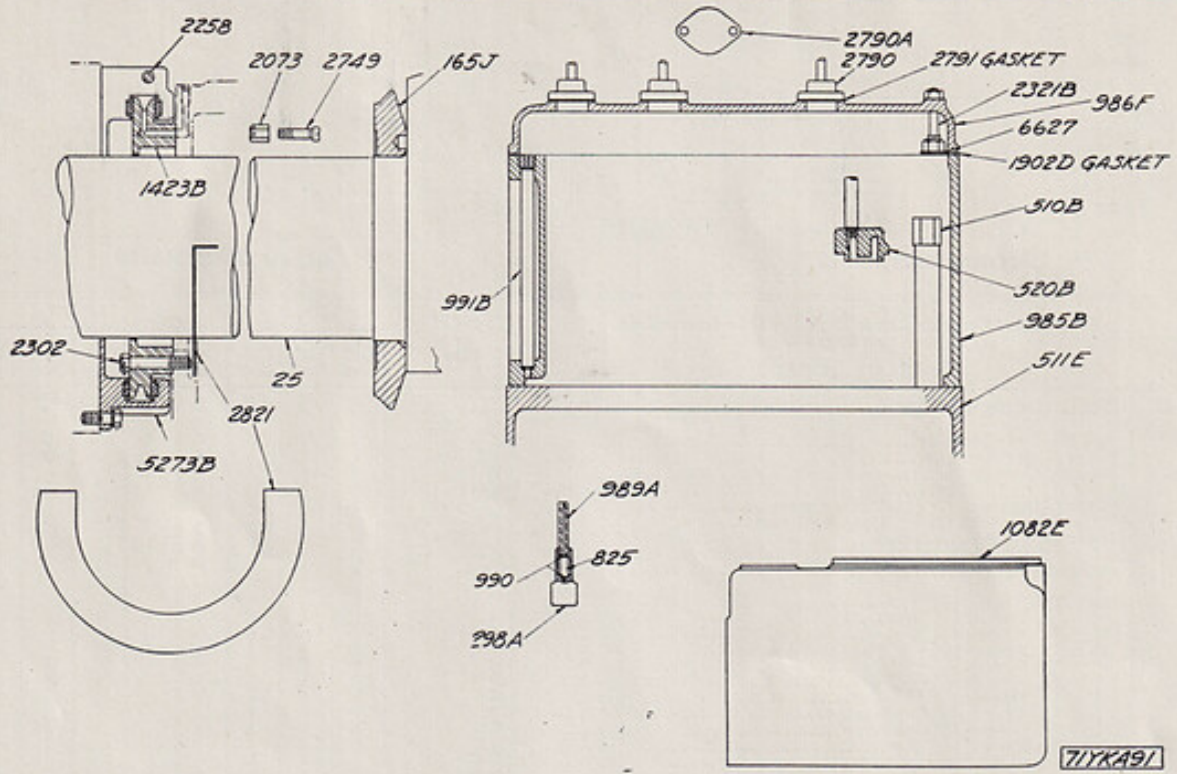
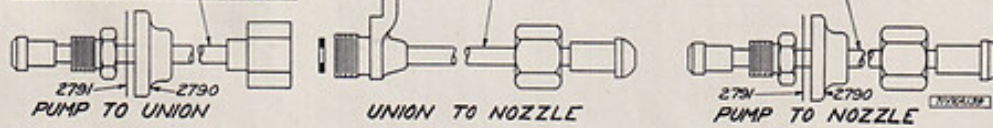
ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 21. Dredge Parts

- 422H-A FOR 2 CYL. ENGINE - 14"x17"
- 422J-A - 2 - - - - - 12"x15"
- 423H-A - 3 - - - - - 14"x17"
- 423J-A - 3 - - - - - 12"x15"
- 424H-A - 4 - - - - - 14"x17"
- 425G-A - 5 - - - - - 14"x17"
- 427G-A - 6 - - - - - 14"x17"

- 426F FOR 2, 3, 4, 5 AND 6 CYL. ENGINES - 14"x17"
- 426G FOR 2 AND 3 CYL. ENGINES - 12"x15"

- 421G-A FOR 1 CYL. ENGINE - 14"x17"
- 421H-A FOR 1 CYL. ENGINE - 12"x15"



Repair Chart No. 21

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"					
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used
298B-C	Main Bearing Oil Gauge (Complete)		1	2	3	1	2	3	3	4	5
298A	Main Bearing Oil Gauge, always with	Y2KA298A	1	2	3	1	2	3	4	5	6
825	" " " " Glass	YKS25	1	2	3	1	2	3	3	4	5
990	" " " " Gasket	YK990	2	4	6	2	4	6	6	8	10
989A	" " " " Vent Plug	YK989A	1	2	3	1	2	3	3	4	5
	" " " " Pipe Plug	1"	1	2	3	1	2	3	3	4	5
	" " " " Plug	1"	1	2	3	1	2	3	3	4	5
	" " " " Plug	1"	1	2	3	1	2	3	3	4	5
2821	Main Bearing Oil Baffle Plate	YKA2821A	1	1	1	1	1	1	1	1	1
165J	Air Stop Ring (Bottom), always with	YJA165G	2	2	2	2	2	2	2	2	2
	" " " (Bottom), always with	Y6KA165C									
	" " " (Bottom), always with	Y6KA165G									
	Air Stop Ring (Top)	YJA165H	2	2	2						
	" " " (Top)	YKA165D				2	2	2			
	" " " (Top)	Y5KA165B							2	2	
Air Stop Ring Bolt	Y6KA165H									2	
" " " Lockwasher	YK191A	4	4	4	4	4	4	4	4	4	
" " " Lockwire	1/2"x3/4"	4	4	4	4	4	4	4	4	4	
" " " Dowel	Y2J192	4	4	4	4	4	4	4	4	4	
511E-C	Pump Case Housing (Complete)		1	1	1	1	1	1	1	1	1
	Same as 511B-DC except use										
	Pump Case Housing	YKA511C3	1	1		1	1				
511E	" " Housing	Y3KA511C4			1			1			
" " Housing	Y4KA511C3								1		
" " Housing	Y5KA511B3									1	
" " Housing	Y6KA511E4										1
510B	" " Overflow Pipe	YKA510B	1	1	1	1	1	1	1	1	1

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 21. Dredge Parts (Continued)

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or size	12"x15"			14"x17"						
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used	
985B-C	Fuel Reservoir (Complete)		1	1	1	1	1	1	1	1	1	1
	Fuel Reservoir, always with.....	YKA985B4	1	1		1	1					
	" Reservoir, always with.....	Y3KA985B4			1			1				
985B	" Reservoir, always with.....	Y4KA985B4							1			
	" Reservoir, always with.....	Y5KA985A4									1	
	" Reservoir, always with.....	Y6KA985D4										1
	Fuel Reservoir Starting Valve Bushing.....	YKA1199A	1	1	2	1	1	2	2	2	2	3
991B	" Gauge Glass.....	YKA991B	1	1	1	1	1	1	1	1	1	1
	" " Plug.....	YK989	1	1	1	1	1	1	1	1	1	1
	" " Gasket.....	YK990	2	2	2	2	2	2	2	2	2	2
	Air Shut-Off Valve Fuel Res. Stud.....	5/8"x2 1/4"	2	2	2	2	2	2	2	2	2	2
	Air Start Valve Plug.....	Y5KA5141A									1	
975-C	Fuel Discharge Strainer (Complete) (See Reg. Eng. Rep. List).....		1	1	1	1	1	1	1	1	1	1
2321B	Pump Case Housing Fuel Res. Stud.....	YKA2321B	6	6	6	6	6	6	6	6	6	6
986F-C	Fuel Reservoir Cover (Complete)		1	1	1	1	1	1	1	1	1	1
	Fuel Reservoir Cover.....	Y2KA986C	1	1		1	1					
	" Cover.....	Y3KA986C			1			1				
986F	" Cover.....	Y4KA986E							1			
	" Cover.....	Y5KA986B									1	
	" Cover.....	Y6KA986D										1
2790A	" Blank Flange.....	YKA2790B	1			1						
2791	" Gasket.....	YKA2791A	1			1						
1902D	Fuel Reservoir Cover Gasket.....	Y2KA1902A	1	1	1	1	1	1				
	" " Gasket.....	Y4KA1902A							1			
	" " Gasket.....	Y5KA1902A									1	
	" " Gasket.....	Y6KA1902A										1
6627	Fuel Reservoir Cover Gasket Washer.....	YKA6627A	6	6	6	6	6	6	6	6	6	6
5273B-C	Thrust Bearing (Complete)		1	1	1	1	1	1	1	1	1	1
	Thrust Bearing Collar (Half).....	YKA1423J1	1	1	1	1	1	1				
1423B	" Collar (Half).....	YKA1423K1	1	1	1	1	1	1				
	" Collar (Half).....	YKA1423G1							1	1	1	
	" Collar (Half).....	YKA1423H1							1	1	1	
2749	Thrust Bearing Collar Bolt.....	YKA2749B1	2	2	2	2	2	2	2	2	2	2
2073	" Nut.....	YKA2073A	2	2	2	2	2	2	2	2	2	2
5273B	Thrust Bearing Housing (Half).....	YKA5273F1	2	2	2	2	2	2	2	2	2	2
	" (Half).....	YKA5273E1	2	2	2	2	2	2	2	2	2	2
2258	Thrust Bearing Housing Pipe Plug.....	1/4"	2	2	2	2	2	2	2	2	2	2
	" Bolt.....	YKA2258A	2	2	2	2	2	2	2	2	2	2
	" Lockwasher.....	1/2"	2	2	2	2	2	2	2	2	2	2
	" Nut.....	3/4" C. P.	2	2	2	2	2	2	2	2	2	2
520B	Fuel Supply Pump Discharge Valve Cap.....	YKA520B	1	1	1	1	1	1	1	1	1	1
1082E	Lub. Oil Sump Cover.....	YKA1082E	1	1	1	1	1	1				
	" Cover.....	Y4KA1082E							1	1	1	
2302	Thrust Collar to Base Cap Screw.....	YKA2302A	10	10	10	10	10	10	10	10	10	10
25	Crankshaft.....		1	1	1	1	1	1	1	1	1	1
Note:—When Crankshaft is ordered for Dredge Outfit engine number must be specified. The Standard Crankshaft is used on all outfits except 4 cylinder engine. The arrangement of Air Stop Rings differ and the 4 cyl. engine has special counterweights.												
Note:—When ordering injection tubes, specify AR1, AR2, AR3 or AR4 where found in list. See Fig. 37 on page 34 to determine engine rotation.												
421H-A	Injection Tube, Pump to Nozzle (81°), (Complete).....	YJA421L	1									
421G-A	Injection Tube, Pump to Nozzle (90°), (Complete).....	YKA421M				1						
*422J-A	Injection Tube, Pump to Union (89°), (Complete) AR2 and AR4.....	Y2JA422K		2								
	Tube, " (93°), (Complete) AR1 and AR3.....	Y2JA422L		2								
*422H-A	Injection Tube, Pump to Union (97°), (Complete) AR2 and AR4.....	Y2KA422N					2					
	Tube, " (99 1/2°), (Complete) AR1 and AR3.....	Y2KA422P					2					
*423J-A	Injection Tube, Pump to Union (113 1/4°), (Complete) AR2 and AR4.....	Y3JA423G			3							
	Tube, " (124°), (Complete) AR1 and AR3.....	Y3JA423H			3							
*423H-A	Injection Tube, Pump to Union (128°), (Complete) AR2 and AR4.....	Y3KA423N						3				
	Tube, " (111°), (Complete) AR1 and AR3.....	Y3KA423P						3				
*424H-A	Injection Tube, Pump to Union (174°), (Complete) AR2 and AR4.....	Y4KA424P								4		
	Tube, " (176°), (Complete) AR1 and AR3.....	Y4KA424Q								4		
*425G-A	Injection Tube, Pump to Union (209°), (Complete) AR2 and AR4.....	Y5KA425N									5	
	Tube, " (193 1/2°), (Complete) AR1 and AR3.....	Y5KA425P									5	
*427G-A	Injection Tube, Pump to Union (238 1/4°), (Complete) AR2 and AR4.....	Y6KA427N										6
	Tube, " (214 1/2°), (Complete) AR1 and AR3.....	Y6KA427P										6
426G	Injection Tube, Union to Nozzle (44 3/4°), (Complete) (See page 36).....											
426F	Tube, " (50 3/4°), (Complete) (See page 36).....											
Note:—Injection tubes are furnished complete with fittings as shown in Repair Chart No. 21. All fittings may be ordered separately. Fittings, with the exception of 2790 and 2791 which are listed below, are found on page 36.												
2790	Fuel Reservoir Cover Flange.....	YJA2790A	1	2	3							
	" Flange.....	YKA2790A				1	2	3	4	5	6	
2791	Fuel Reservoir Cover Flange Gasket.....	YKA2791A	1	2	3	1	2	3	4	5	6	

See Arrangement Diagram on page 34.

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 22. Springs and Gaskets

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"						
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used	
748D-C	Springs (Complete)		1	1	1	1	1	1	1	1	1	1
178	Piston Pin Dowel Spring	YK178A1	1	2	3	1	2	3	4	5	6	6
193B	Air Stop Ring Spring	YKA193A1	8	16	24	8	16	24	32	40	48	48
	Lubricating Oil Sump Cover Pin Spring	YKA193A1	1	1	1	1	1	1	1	1	1	1
256D	Governor Spring with Plug	YJA256E	2	2	2							
	Plug	YKA256J				2	2	2	2	2	2	2
259	Injection Pump Suction Valve Spring	YKA259A	1	2	3	1	2	3	4	5	6	6
260A	Plunger Spring	CKB260A	1	2	3	1	2	3	4	5	6	6
266	Suction Valve Push Rod Spring	YKA266B	1	2	3	1	2	3	4	5	6	6
300A	Aux. Fuel Pump Plunger Rod Spring	YKA300B	1	1	1	1	1	1	1	1	1	1
392	Air Stop Ring Backlash Spring	YK392A	2	4	6	2	4	6				
	Driving Spring	Y4KA392B							8	10	12	12
537	Injection Pump Discharge Valve Spring	YK537	1	2	3	1	2	3	4	5	6	6
572	Air Starting Valve Spring	YKA572A	1	1	2	1	1	2	2	2	3	3
595A	Air Valve Spring	YK595A1	20	40	60	20	40	60	80	100	120	120
837	Piston Pin Oil Scraper Spring	YKA837A	2	4	6	2	4	6	8	10	12	12
837A	Spring	YK837A	2	4	6	2	4	6	8	10	12	12
856A	Air Start Check Valve Spring	YKA856A	2	4	6	2	4	6	8	10	12	12
1405	Connecting Rod Box Cap Wick Support Spring	YK1405A	2	4	6	2	4	6	8	10	12	12
2257	Fuel Hand Control Lever Latch Spring	YKA2257A1	2	2	2	2	2	2	2	2	2	2
2295A	Air Start Shut Off Valve Spring	YKA2295B	1	1	1	1	1	1	1	1	1	1
	Air Start Rocker Aux. Spring	YKA2326A4	1	1	2	1	1	2	2	2	2	2
2326	Injection Pump Rocker Aux. Spring	YKA2326A4	1	2	2	1	2	2	4			5
	Spring	Y5KA2326A										5
2326A	Injection Pump Rocker Aux. Spring	YKA2326C			1			1				2
	Spring	YKA2326B										2
2326B	Air Start Rocker Aux. Spring	YKA2326D										1
2326D	Gov. Cam Rocker Aux. Spring	Y5KA2326B									2	4
2336	Gov. Cam Rocker Aux. Spring	YKA2336A2	1	2	3	1	2	3	4			4
	Spring	Y5KA2336A										5
2336A	Gov. Cam Rocker Aux. Spring	YKA2336B										2
2362	Fuel Reservoir Cover Cap Spring	YKA2362A	1	1	1	1	1	1	1	1	1	1
6283	Injection Pump Relief Valve Spring	CKC6283A	1	2	3	1	2	3	4	5	6	6
6541	Governor Weight Drag Spring	YKA6541B	2	2	2	2	2	2	2	2	2	2
749D-C	Gaskets and Packing (Complete)		1	1	1	1	1	1	1	1	1	1
33C	Cylinder Head Gasket	YKA33F	8	16	24	10	20	30	40	50	60	60
76	Exhaust Nozzle Hand Hole Cover Gasket	YF76	2	4	6	2	4	6	8	10	12	12
	Pot Gasket	YF76	1	1	1	1	1	1	1	2	3	3
76A	Exhaust Pipe Hand Hole Cover Gasket	YKA76B	1	2	3	1	2	3	4	5	6	6
	Exhaust Nozzle to Cyl. Gasket	YJA77A	1	2	3							
	Gasket	YKA77A				1	2	3	4	5	6	6
77A	Pipe " " Gasket	YJA77A	1	2	3							
	Gasket	YKA77A				1	2	3	4	5	6	6
197B	Upper-Lower Base Gasket	YJA197B	2	4	6							
	Gasket	YKA197C				2	4	6	8	10	12	12
197D	Upper-Lower Base Gasket	YJA197D	4	8	12							
	Gasket	YKA197D				4	8	12	16	20	24	24
198B	Cylinder-Upper Base Gasket	YJA198B	1	2	3							
	Gasket	YKA198B				1	2	3	4	5	6	6
199	Upper Base Hand Hole Cover Gasket	YJ199	1	2	3							
	Gasket	YK199				1	2	3	4	5	6	6
	Air Valve Seat Gasket	YJ199	1	2	3							
	Gasket	YK199				1	2	3	4	5	6	6
214	Injection Tube Union Gasket	YKA214A		2	3		2	3	4	5	6	6
405	Crank Pin Oil Ring Gasket	YK405	1	2	3	1	2	3	4	5	6	6
407B	Lower Water Manifold to Cyl. Gasket	YKA407B	1	1	1	1	2	3	4	5	6	6
	Section Gasket	YLA407B				1	1	1	1	1	1	1
416	Exhaust Pot Flange Gasket	YG416	2	2	5							
469A	Pump Housing Side Cover Gasket	YKA469A	2	2	2	2	2	2	2	2	2	2
470	Aux. Fuel Pump Discharge Cap Gasket	YKA470A	1	1	1	1	1	1	1	1	1	1
472A	Pump Housing Gasket	YKA472A	2	2	2	2	2	2	2	2	2	2
	Gasket	Y4KA472A							2	2	2	2
473A	Injection Pump Body Gasket	YKA473A	1	2	3	1	2	3	4	5	6	6
	Air Start Distributor Body Gasket	YKA573A	1	1		1	1					
573B	" " " " Gasket	Y3KA573A1			1			1	1			
	Gasket	Y6KA573A1								1	1	1
573D	Air Start Shut Off Valve Cage Gasket	YKA573B	1	1	1	1	1	1	1	1	1	1
617	Exhaust Pot Cover to Body Gasket	YK617	1	1	1	1	1	1	2	3	3	3
618	Flange Gasket	YK618				2	2	5	4	4	6	6
632A	Cylinder Head Counterbore Gasket	YJA632F	1	2	3							
	Gasket	YKA632F				1	2	3	4	5	6	6
858D	Air Start Valve Cage Gasket	CFE5877A	1	2	3	1	2	3	4	5	6	6
990	Main Bearing Oil Gage Glass Gasket	YK990	2	2	2	2	2	2	4	4	4	4
	Fuel Reservoir Gage Glass Gasket	YK990	1	1	1	1	1	1	1	1	1	1
1039	Aux. Fuel Pump Suction Valve Gasket	YK1039	1	1	1	1	1	1	1	1	1	1
1097	Lubricating Oil Pump Body Gasket	YKA1097A	1	1	1	1	1	1	1	1	1	1
1549	Air Start Valve Cage Gasket	YKA1549A	1	2	3	1	2	3	4	5	6	6
1584A	Water Overflow Pipe Gasket	YKA1584D	1	2	3	1	2	3	4	5	6	6
1548B	Funnel Gasket	YKA1584E	1	2	3	1	2	3	4	5	6	6
1617	Regulating Valve Bonnet Gasket	NH655		2	3		2	3	4	5	6	6
	Lubricator Overflow Pipe Bracket Gasket	YKA1617A	1	1	1	1	1	1	1	1	1	1

ALWAYS GIVE ENGINE SERIAL NUMBER

List Division No. 22. Springs and Gaskets (Continued)

Repair Number	Before Ordering Repair Parts Read the Instructions on Page 33. NAME OF PART	Symbol or Size	12"x15"			14"x17"						
			1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	1 Cyl. Used	2 Cyl. Used	3 Cyl. Used	4 Cyl. Used	5 Cyl. Used	6 Cyl. Used	
1898	Governor Case Gasket.....	YKA1898A	1	1	1	1	1	1	1	1	1	1
1899	End Plate Gasket.....	YKA1899A	1	1	1	1	1	1	1	1	1	1
1902	Fuel Reservoir Cover Gasket.....	YKA1902A	1	1	1	1	1	1	1	1	1	1
1902B	Aux. Fuel Suction Cover Gasket.....	YKA1902C	1	1	1	1	1	1	1	1	1	1
2108	Injection Pump Discharge Valve Cage Gasket.....	YKA2108A	1	2	3	1	2	3	4	5	6	6
	Relief Valve Cage Gasket.....	YKA2108A	1	2	3	1	2	3	4	5	6	6
	Main Bearing Oil Gauge Body Gasket.....	YKA2108A	2	2	2	2	2	2	4	4	4	4
2108A	Aux. Fuel Suction Cover Plug Gasket.....	YLA2108A	1	1	1	1	1	1	1	1	1	1
2108B	Injection Pump Relief Valve Cage Plug Gasket.....	CJA2108A	1	2	3	1	2	3	4	5	6	6
	Seat Gasket.....	CJA2108A	1	2	3	1	2	3	4	5	6	6
2323	Air Start Pipe Flange Gasket.....	YKA2323A1	1	2	3	1	2	3	4	5	6	6
2334	Aux. Fuel Suction Overflow Casing Gasket.....	YKA2334A	1	1	1	1	1	1	1	1	1	1
2335	Air Starting Valve Spring Plug Gasket.....	YKA2335A	1	1	2	1	1	2	2	2	3	3
2335A	Air Start Inlet Elbow Gasket.....	YKA2335B	1	1	1	1	1	1	1	1	1	1
2340	Governor Case Hand Hole Cover Gasket.....	YKA2340A	1	1	1	1	1	1	1	1	1	1
2364	Upper Base Oil Ring Cover Gasket.....	YKA2364A	2	4	6	2	4	6	8	10	12	12
2369	Lub. Oil Pump Discharge Conn. Gasket.....	YKA2369A	2	2	2	2	2	2	2	2	2	2
2401	Fuel Reservoir Housing Gasket.....	YKA2401A	1	1	.....	1	1	.....	.....	.....	.....	.....
	" " " Gasket.....	Y3KA2401A	.....	.....	1	.....	.....	1	.....	.....	.....	.....
	" " " Gasket.....	Y4KA2401A	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
	" " " Gasket.....	Y5KA2401A	.....	.....	.....	.....	.....	.....	.....	1	.....	.....
	" " " Gasket.....	Y6KA2401A	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
2792	Lub. Oil Pump Body Cover Gasket.....	YKA2792A	.....	.....	.....	2	2	2	2	2	2	2
2792A	" " " Gasket.....	YJA2792A	2	2	2	.....	.....	.....	.....	.....	.....	.....
4645	Base Sump Pipe Gasket.....	YKA4645A	1	2	3	1	2	3	4	5	6	6
5877	Cylinder Head Air Check Valve Gasket.....	YKA5877A	1	2	3	1	2	3	4	5	6	6
6660	Air Start Pipe Flange Plug Gasket.....	YKA6660A	.....	2	2	.....	.....	.....	.....	.....	.....	.....
	Injection Pump Plunger Cylinder Gasket.....	YKA6660A	1	2	3	1	2	3	4	5	6	6
6660A	Air Start Pipe Flange Plug Gasket.....	YLA6660A	.....	.....	.....	2	2	4	4	4	4	4
	Water Overflow Manifold Blind Flange Gasket.....	4"	.....	.....	.....	.....	1	1	1	1	1	1
	to Spacer Gasket.....	4"	.....	.....	.....	.....	.....	2	2	2	2	2
Packings												
1089	Governor Case Overflow Packing Ring.....	YKA1089A	1	1	1	1	1	1	1	1	1	1
1499	Regulating Valve Packing.....	CFA1499A2	.....	12	18	.....	12	18	24	30	36	36
	Air Start Pipe Flange Candle Wicking.....	1/4"x10"	.....	2	4	.....	2	4	4	6	8	8
	Cylinder Lub. Oil Pipe Packing.....	1/2"x 3/8"x4"	2	4	6	2	4	6	8	10	12	12
	Exhaust Pot Wicking.....	1/2 lb. Ball	.....	3	5	.....	3	5	6	6	9	9
	Indicator Cock Adapter Tube Packing.....	1/4"x9"	1	2	3	1	2	3	4	5	6	6
	Relief Valve Body Adapter Tube Packing.....	1/4"x9"	1	2	3	1	2	3	4	5	6	6

ALWAYS GIVE ENGINE SERIAL NUMBER

Instructions No. 2769D

Servicing

FAIRBANKS-MORSE

DIFFERENTIAL FUEL INJECTION VALVES

These instructions should be followed carefully in servicing the Differential Fuel Injection Valves used on Fairbanks-Morse Diesel engines employing the "Open Head" combustion principle.

Reference Charts

- 71YKA123 — Tools (page 4).
 99CFE30 — Present Style Standard Injection Valve (page 5).
 99CFE29 — Present Style Lever Adjustment Injection Valve (page 6).
 71YKA66B — Injection Valve Test Pump and Stand (page 7).

Service Equipment Necessary

Injection valve testing pump and stand complete—Chart 71YKA66B (page 7).

The following tools are illustrated on Repair Chart 71YKA123 (page 4).

- Valve grinding tool and bushing puller (6396).
 Valve tip cleaning drill (4324, 4324A, 4324B, 4324D and 4324E).
 Valve tip cleaning tool (747)
 Valve cage wrench (1641)
 Small drill vise (7044).

GENERAL INSTRUCTIONS

Cleanliness Essential — When servicing injection valves, exclusion of all dirt, grit and other foreign matter is absolutely essential.

Valve Marking — All injection valves are stamped on the body with a designation letter indicating the tip used, followed by a number which indicates the number of hundreds of pounds opening pressure for which the valve is set. The valve tip is also stamped with the designation letter.

With the exception of the lever adjustment feature on some of the valves, the only difference between the various valves is in the tip, the pressure setting and the lift adjustment. (See table on page 2.)

The following instructions are written to apply specifically to the standard injection valve not fitted with the hand lever (Chart 99CFE30) but reference to chart 99CFE29 will indicate that the general method of procedure is the same for the lever equipped valve except that it is necessary to use a special valve cage wrench (1641) to remove the part 6357D.

Repair Chart	Model No. of Engine Used On	Tip Used	Pressure Setting Lbs. Per Sq. In.	*Lift Adjustment
99CFE30 (Standard) Page 5	35HE8 $\frac{3}{4}$	F	2200	$\frac{1}{2}$ Turn
	42E8 $\frac{3}{4}$ S	F	2200	$\frac{1}{2}$ Turn
	44HD8 $\frac{3}{4}$	F	2200	$\frac{1}{2}$ Turn
	32E12	B	2200	$\frac{1}{2}$ Turn
	35E10S	B	2200	$\frac{1}{2}$ Turn
	44HD10	B	2200	$\frac{1}{2}$ Turn
	32E14	C	2200	$\frac{1}{2}$ Turn
	35E14	C	2200	$\frac{1}{2}$ Turn
	33E12	D	2200	$\frac{1}{2}$ Turn
	33D14	D	2200	$\frac{1}{2}$ Turn
	37D14	D	2200	$\frac{1}{2}$ Turn
	33D16	H	2200	$\frac{1}{2}$ Turn
37D16	H	2200	$\frac{1}{2}$ Turn	
33E16	J	2500	$\frac{1}{2}$ Turn	
37E16	J	2500	$\frac{1}{2}$ Turn	
99CFE29 (Lever Adjustment Type) Page 6	35E8 $\frac{3}{4}$	F	(3200) (1500)	.020"
	35E10M	B	(3200) (1500)	.020"
	37D10 $\frac{1}{2}$	B	(3200) (1500)	.020"
	37E12	D	(2200)	.020"

* When using heavy fuel, the lift may be increased slightly on those valves where a single adjustment is indicated. Where limits are shown, the lift may be increased to the high limit.

If the lift is too small, dangerous lengthening of injection may result, which can show up as higher exhaust temperatures. This also induces excessive stresses in the injection mechanism. If wire drawing occurs, it is a clear indication that the lift is not sufficient or that the fuel carries grit. Wire drawing is indicated by small grooves across the valve seat and end of the needle valve.

Testing — It is generally advisable to secure the injection valve in the testing fixture and test it with the injection valve testing pump before proceeding with any disassembling for cleaning and adjustment. This will help to indicate any adjustment discrepancies and serve as a comparison with the test to be made after servicing.

When installing the injection valve in the testing fixture be sure to tighten the holding down nuts evenly and very tightly. Back off the valve stop adjustment before tightening the nuts. If the valves are not tight and even they may not give satisfactory results. This also applies when the valves are installed in the engine.

Repair Chart 71YKA66B shows how this set-up is made for testing. Clean fuel oil should be poured into the test pump. If necessary, filter the fuel to remove any foreign matter. See valve testing procedure on page 3.

On injection valves shipped from the factory, the valve needle is coated with "3 in 1" oil to prevent corrosion. When testing one of these valves it will be necessary to pump approximately 50 strokes with the test pump before judging the operation, because "3 in 1" oil will produce different results from fuel oil.

Cleaning the Injection Valve

In the majority of cases, the valve may be put in first class condition by cleaning the needle, needle bushing, and tip. The tip should not be removed for this cleaning. The needle is not to be ground during this operation.

Disassembling — Standard Type — (See Chart 99CFE30). Loosen and back out the stop screw (6360D) slightly. Unscrew the assembled spring cage (6357E) and disassemble it, being careful not to lose or misplace any of the shims (6361D, E and F). The valve needle (202B), the retaining ring (6446) and the bushing (2409B) can next be removed. Push the grinding tool (6396) over the needle and use it to withdraw the needle. Screw the threaded end of the same tool into the top end of the bushing (2409B) in order to remove this part and the retaining ring.

Disassembling — Lever Type — (See Chart 99CFE29). Turn the lever (557A) to the low pressure position and then remove the capscrews which hold the lever bracket (6730B) to the valve body (201G). The lever bracket may be removed and with it the spring plunger (6360B), the needle stop pin (3890), the spring (203D) and the spring shims (6361D, E and F). After these parts are removed the spring cage (6357D) may be taken out with the spring cage tool (1641). This will also include the needle plunger (6694B). Then the needle (202B) and needle bushing (2409B) may be removed by the use of the grinding tool (6396).

Cleaning — With the parts removed as specified above, clean the tip, needle and bushing. Clean the spray passages in the tip with a cleaning drill (4324, 4324A, 4324B, 4324D, 4324E) held in the small drill vise. Use 4324 (.011" dia. on A, F, and B tips, 4324A (.016" dia.) on C tips, 4324B (.020" dia.) on D tips 4324D (.022" dia.) on H tips and 4324E (.024" dia.) on J tips. Then use the tip cleaning tool (747) to clean central passage in the tip, working down inside the valve body and turning the drill. Repeat this procedure several times to make sure that the holes are clean.

Wash the valve body in light fuel oil or kerosene. Also wash the needle valve and bushing, working the needle valve back and forth in the bushing while submerged in the cleaning fluid until both parts are perfectly clean.

Clean the Remaining Parts. To clean the filter (7018), remove the filter body (474E) and the filter element (7018). Rinse the filter in light fuel oil or kerosene, or blow out with compressed air.

Reassembling — Standard Type — When all parts have been cleaned as outlined above, the parts may be reassembled. Replace the bushing (2409B) and retaining ring (6446) spherical side up and screw the spring cage (6357E) into the valve body (201D) until the bushing and retaining ring are clamped securely. Now reassemble the remaining parts. Replace the valve needle

(202B), needle plunger (6694), spring (203D) and shims (6361D, E and F). Be sure that all of the shims are replaced. Screw in the cage nut (6730D), and turn the stop screw (6360D) until it seats against the plunger (6694) then back it off the fraction of a turn listed in the Lift Adjustment column in table on page 1. Lock the screw in position with the lock nut. Attach the fuel filter assembly to the injection valve body, making sure that gasket (6700A) is in place.

Reassembling — Lever Type — To reassemble the lever type valve replace the bushing (2409B) and retaining ring (6446) spherical side up and screw the spring cage (6357D) into the valve body until the bushing and retaining ring are clamped securely. Replace the valve needle (202B) and the needle plunger (6694B). Then the lever bracket sub-assembly may be replaced. If it has been disassembled be sure that it is reassembled the same as it was before.

On the latest lever adjustment valve as shown in chart 99CFE29 the valve lift is adjusted by varying the position of the hand lever pin (965A) until a thickness gauge of .020" can just be inserted between the top of stop pin (3890) and the body of the lever pin (965A). Tightening the nut on the end of lever pin secures it against turning. The valve is now ready to be tested in the test pump fixture. See page 7.

Grinding the Valve Needle

If the testing after the valve has been cleaned shows that the valve needle leaks, the valve needle may need regrinding, although this is not always a positive indication. See the last paragraph under "Valve Testing Procedure," page 3. If the leakage cannot be stopped in any other way, it will be necessary to regrind the valve needle. This should be done without removing the tip.

Proceed as follows: Remove and clean the parts as indicated under "Cleaning the Injection Valve." Dry the inside of the valve body thoroughly, using a long pointed stick split at the end to hold a small piece of cloth free from lint. This is necessary to prevent the grinding compound from being carried to other parts of the valve than the seat. Also make certain that the valve needle (202B) and bushing (2409B) are perfectly clean and thoroughly dry.

Replace the bushing (2409B) and retaining ring (6446) and screw the spring cage (6357E) into the valve body (201D) until the bushing and retaining ring are clamped securely.

At this stage in the reassembly, the valve needle (202B) is to be reground to its seat in the tip (204B). With the valve needle (202B) absolutely dry, place a **very small amount** of grinding compound on the polished surface at the tip of the needle. Use Carborundum Grinding Compound H40 Fine made by Carborundum Co. of Niagara Falls, N. Y. or a compound of similar grade. (Note: Since the valve tip must not be removed after the grinding operation, especial care must be taken to avoid excessive use of the grinding compound). Insert the valve needle (202B) in the end of the valve grinding tool and then insert in the valve body (201D) taking every precaution that none of the compound comes in contact with the bore of the bushing (2409B). If the valve needle (202B) and bushing (2409B) are perfectly clean and dry, the needle should enter the bushing quite easily. Grind the valve needle (202B) to its seat in the tip (204). Good results are obtained by rotating the grinding tool rapidly between the hands.

When the grinding operation is completed, the grinding compound on the valve seat must be removed. To do this, first remove the spring cage, retaining ring, and bushing. Then with a long pointed stick, split at the end to hold a small piece of cloth, clean every particle of grinding compound from the valve seat and the top surface of the tip.

Now reassemble the remaining parts as outlined under "Reassembling."

Grinding the Valve Needle after Replacing Parts

Where the valve needle is "wire-drawn" or where a large shoulder from grinding or wear appears on the valve needle, it will be impossible to put the injection valve in first class condition by ordinary grinding. In such cases, the injection valve should be returned to the factory where the valve needle and valve seat can be reground, or the valve needle and bushing and possibly the valve tip should be replaced. If the parts are to be replaced, proceed as follows:

Disassemble the parts as described under "Disassembling." In addition, the sleeve (6365B) and tip (204) must be removed. The pump stand is arranged so that it may be used as a puller to remove the sleeve. With the injection valve in place in the test stand, turn out the screws (6600), and then turn in the knurled head screws (furnished with pump stand) until their ends engage the holes in the sleeve. Then by unscrewing the lower nuts on the pump stand studs, the valve body may be drawn up and out of the sleeve. Then remove the sleeve from the test stand. On water cooled valves, remove any scale or sediment in the sleeve.

Remove the tip (204) by tapping carefully on a brass rod inserted through the top of the injection valve body. Be very careful not to mar the seat and fitting surfaces.

Clean the valve body thoroughly. Then replace the new tip (204) and sleeve (6365B) with the proper gaskets and draw them firmly into position in the testing fixture. See Chart 71YKA66B. Replace screws (6600).

Note: No pressure should be exerted on the point or the conical surface of the tip (204) when driving it into the valve body. Do not remove the valve from the fixture until complete assembly, adjustment and test has been made and the valve is ready for service.

Now proceed as under "Grinding the Valve Needle," except that the needle bushing must be seated in the body. Screw the combination valve grinding tool and bushing puller into the bushing to assist in seating the bushing. Be sure to remove all grinding compound and clean and dry the inside of the valve body and the bushing.

Valve Testing Procedure

Refer to Chart 71YKA66B on page 7.

Fill the test stand with clean filtered fuel oil so that the entire pump body is just submerged.

Note: It is very important that the fuel for testing be very clean. Drain the fuel from the test stand at intervals, and keep the test stand and pump well covered when it is not in use.

Secure the injection valve in the test stand, connecting up the tubing as indicated on the chart. The injection valve must be fastened down very tightly and evenly, as otherwise the operation will be unsatisfactory. See that the relief screw (4203) is closed tightly.

When testing standard valves (Chart 99CFE30) not yet overhauled, check to see that the lift adjustment is correct. (See table on page 1.)

At the start, open the air vent plug (6359A) on the injection valve until fuel free from air bubbles is forced out around the threads, then close the vent plug. In pumping the test pump, use very quick strokes so that the fuel is ejected in the form of a fine spray. The highest pressure indicated on the gauge is the pressure at which the valve opens and is the setting pressure referred to in the table on page 1.

When testing a valve that has been disassembled and cleaned as outlined above, it is good practice to loosen up slightly on the valve spring housing (6357E) and then to tighten again. With the spring pressure on the valve needle, this will tend to bring the bushing and needle into perfect alignment with the tip. It may be necessary to repeat this procedure several times.

Clogged Holes in Tip

While pumping, observe whether fuel is spraying out of all the spray holes. By holding one's hand 2" to 3" below the valve tip when pumping, a difference in the impact of any of the sprays will be readily felt if one of the holes is partially clogged. (Caution: Never hold hand closer than 2" to tip as spray may cause serious injury to the hand.)

Low Pressure Setting

If the pressure setting indicated on the gauge is lower than the standard setting for the particular valve being tested it is possible (1) the pressure setting is not adjusted correctly, (2) the valve needle is stuck open or (3) the spring is broken.

High Pressure Setting.

If the pressure setting indicated is higher than that desired it is possible (1) the pressure setting is not adjusted correctly, (2) the valve needle is stuck closed or (3) the holes in the tip are clogged.

Test for Leaky Needle Valve

Pump the pressure up to within 300 to 500 pounds below the opening pressure. Allow to stand a short time; if drops of fuel collect on the tip the needle valve leaks and probably needs grinding. It is advisable, however, to clean the valve thoroughly and test it again before grinding. Grinding is advised only after ever other method has failed. Field experience has shown that grinding is usually done too frequently.

Water Cooled Injection Valves

On water cooled injection valves, an adequate supply of cold water should be circulated through the valve. Decreased flow of cooling water discharging from the valve, or craters forming at the tip may indicate formation of scale in the sleeve (6365B), collection of sediment in the passages, or insufficient pressure on the water being circulated. The sleeve (6365B) must be removed to clear the passages of scale or other sediment. Forcing water through under high pressure will not clear the passages.

To remove the sleeve, first loosen nut (6730D) which will relieve the spring pressure on the valve needle. The sleeve (6365B) may then be removed without disturbing the tip. (See second paragraph under "Grinding the Valve Needle after Replacing Parts," page 2.) Scale will usually form inside of the sleeve (6365B) and should be removed either by scraping or with an acid solution.

Adjusting

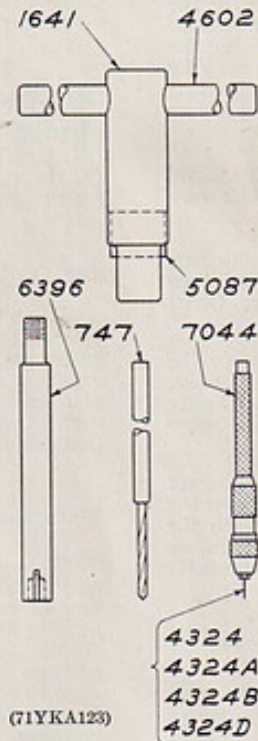
Refer to page 2 for procedure on disassembling and servicing of these valves.

The table on page 1 indicates the pressures for which the various valves are to be set when tested by the test pump. A variation of plus or minus 100 pounds is allowable.

Two pressures are given any valve fitted with "Hand Lever Adjustment." The valve should be adjusted for the higher pressure with the hand lever in a horizontal position so that marking "H.P." is on top. Then with the lever position reversed with marking "L.P." on top the lower pressure will be obtained.

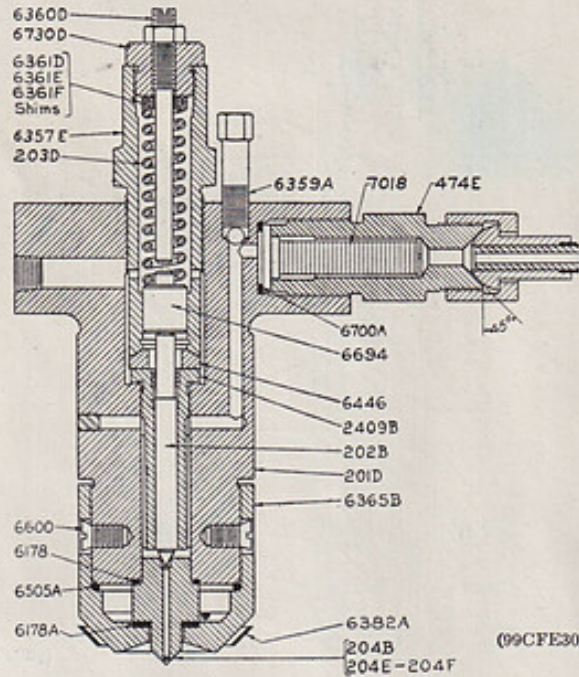
The pressure is adjusted by varying the number of shims (6361D, E and F) used. A $\frac{1}{64}$ " shim (6361F) will vary the pressure approximately 200 pounds.

It is very necessary that the pressure gauge on the test pump be checked frequently either at some laboratory where a gauge tester is available or by checking it against an injection valve known to be correctly set for certain pressure.



TOOLS FOR SERVICING FUEL INJECTION VALVES

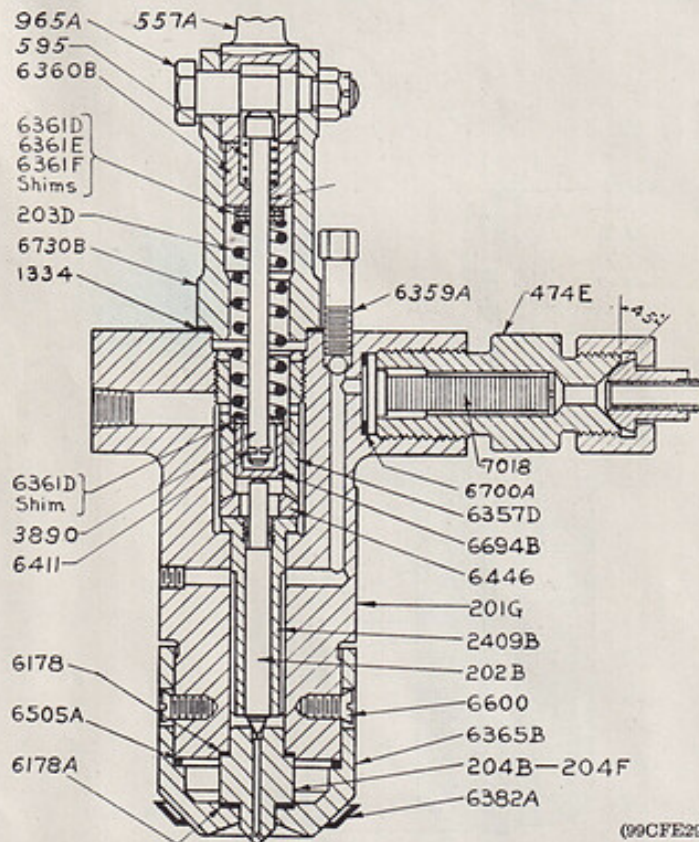
Repair No.	NAME OF PART	Symbol or Size	No. Used
747	Injection Valve Tip Cleaning Tool Handle, always with #42 Drill	YKA747A	1
1641	Injection Valve Spring Cage Wrench, always with Handle (4602) and Blade (5087)	YKA1641B1	1
4324	Injection Valve Tip Cleaning Drill (for use on tips stamped "A", "B", and "F")	YKA4324A	Set of 12
4324A	Injection Valve Tip Cleaning Drill (for use on tips stamped "C")	YKA4324B	Set of 12
4324B	Injection Valve Tip Cleaning Drill (for use on tips stamped "D")	YKA4324C	Set of 12
4324D	Injection Valve Tip Cleaning Drill (for use on tips stamped "H")	YKA4324E	Set of 12
4324E	Injection Valve Tip Cleaning Drill (for use on tips stamped "J")	YKA4324F	Set of 12
4602	Injection Valve Spring Cage Wrench Handle (Included in group 1641)	YKA4602A	1
5087	Injection Valve Spring Cage Wrench Blade (Included in group 1641)	YKA5087A1	1
6396	Injection Valve Needle Grinding Tool	YKA6396A1	1
7044	Injection Valve Tip Drill Vise (Starrett)	#162A	1



Present Style Standard Injection Valve 201E-C

Repair No.	NAME OF PART	Symbol or Size	No. Used Per Valve
201E-C	201E-C Injection Valve (Complete)		1
201D	Injection Valve Body	YKA201K1	1
203D	Injection Valve Spring	YKA203D	1
204B	Injection Valve Tip (Used only on Models 33E12, 33D14, 37D14 (Stamped "D"))	CKC204A	1
204B	Injection Valve Tip (Used only on Models 35E10S, 32E12, 44HD10) (Stamped "B")	CHC204B	1
204E	Injection Valve Tip (Used only on Models 35E14 and 32E14) (Stamped "C")	YKA204K1	1
204F	Injection Valve Tip (Used only on Models 44HD8 ³ / ₄ , 35HE8 ³ / ₄ , 42E8 ³ / ₄ S, (Stamped "F"))	CFE204B	1
204F	Injection Valve Tip (Used only on Models 33D16, and 37D16) (Stamped "H")	YLA204L1	1
204G	Injection Valve Tip (Used only on Models 33E16 and 37E16) (Stamped "J")	YLA204M	1
474E	Injection Valve Fuel Filter Body (45° Seat, Brazed Tubing)	YKA474C	1
2409B	Injection Valve Bushing, always with	YKA2409E2	1
202B	" " Needle (Not Furn. Sep.)	YKA202G	1
6178	" " Tip Gasket	YKA6178A	1
6178A	" " Tip Gasket	YKA6178B	1
6357E	" " Spring Cage	YKA6357H	1
6359A	" " Body Vent	YKA6359D	1
6359A	" " Body Vent Ball	1/4" 16FM18C	1
6360D	" " Stop Screw	YKA6360G	1
6360D	" " Stop Screw Nut	5/16"	1
6361D	" " Spring Shim (.0625")	YKA6361D	2
6361E	" " Spring Shim (.0312")	YKA6361E	2
6361F	" " Spring Shim (.0156")	YKA6361F	2
6365B	" " Body Sleeve	YKA6365D1	1
6446	" " Ring	YKA6446C	1
6505A	" " Body Sleeve Gasket	YKA6505A	1
6600	" " Body Sleeve Screw	YKA6600A	2
6694	" " Plug	YKA6694A	1
6700A	" " Fuel Filter Body Gasket	YKA2108B	1
6730D	" " Spring Cage Nut	YKA6730D	1
7018	" " Fuel Filter Element (Purolator)	16FM115D14	1
6382A	Injection Valve Body Gasket	YJA6382A1	1

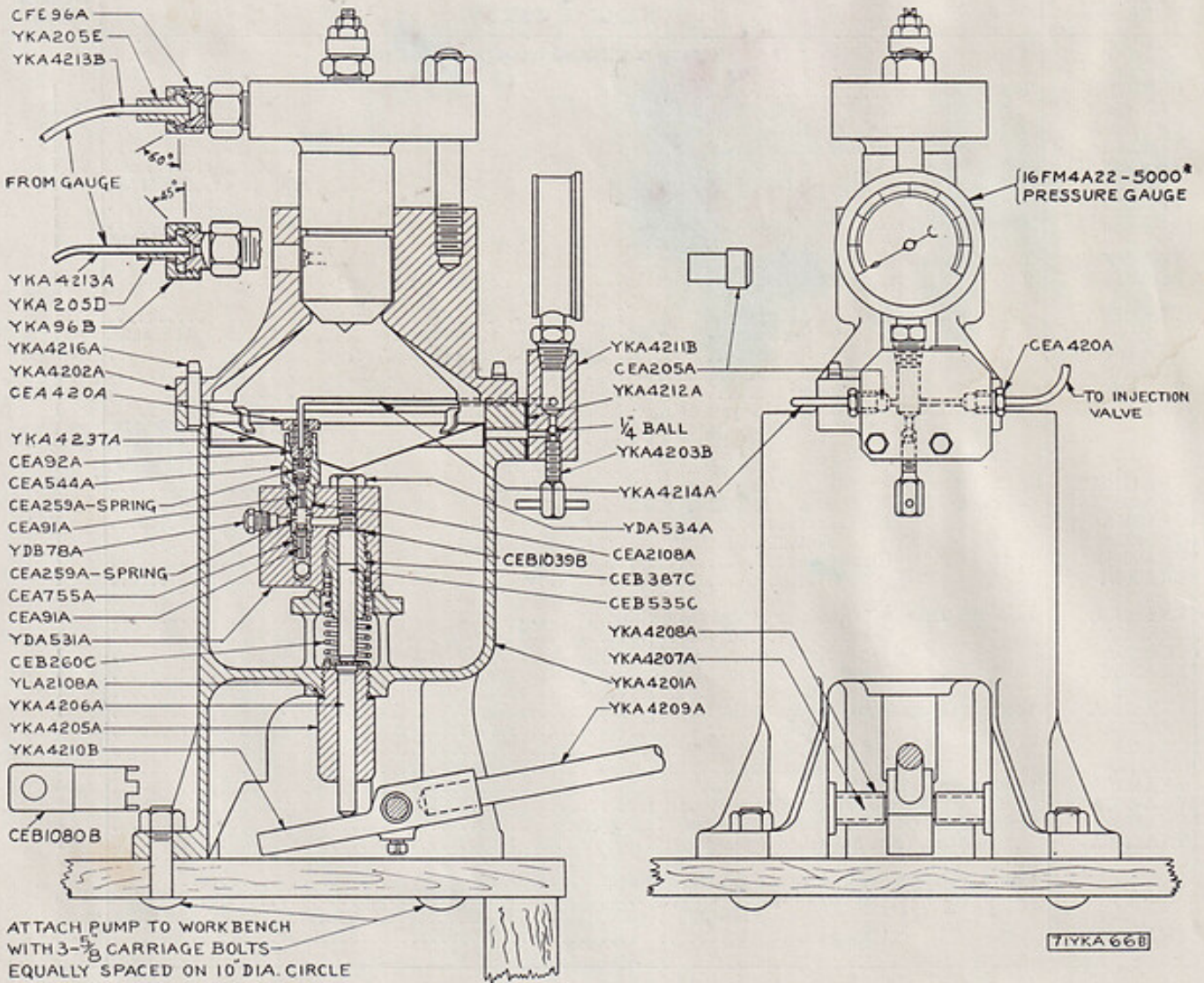
ALWAYS GIVE ENGINE SERIAL NUMBER



Present Style Lever Adjustment Injection Valve 201G-C

Repair No.	NAME OF PART	Symbol or Size	No. Used Per Valve
201G-C	201G-C Injection Valve (Complete)		1
201G	Injection Valve Body	YKA201J	1
2409B	Injection Valve Bushing, always with	YKA2409E1	1
202B	Injection Valve Needle (Not furn. sep.)	YKA202G	1
203D	" " Spring	YKA203D	1
204B	" " Tip (Used only on Model 37E12) (Stamped "D")	CKC204A	1
204B	" " Tip (Used only on Models 35E10M and 37D10½) (Stamped "B")	CHC204B	1
204F	" " Tip (Used only on Models 35E8 ¾) (Stamped "F")	CFE204B	1
474E	" " Injection Valve Fuel Filter Body (45° Seat, Brazed Tubing)	YKA474C	1
557A	" " Hand Lever	YKA557B	1
595	" " Needle Stop Pin Spring	YK595A1	1
965A	" " Hand Lever Pin	YKA965B	1
	" " Hand Lever Pin Nut	3/8"	1
	" " Hand Lever Pin Nut Cotter	3/8" x 3/4"	1
1334	" " Hand Lever Bracket Gasket	YKA1334A	1
3890	" " Needle Stop Pin, always with	YKA3890B	1
6411	" " Needle Stop Pin Snap Ring	CEB6411A	1
6178	" " Tip Gasket	YKA6178A	1
6178A	" " Tip Gasket	YKA6178B	1
6357D	" " Spring Cage	YKA6357G	1
6359A	" " Body Vent	YKA6359D	1
	" " Body Vent Ball	1/4" 16FM18C	1
6360B	" " Spring Plunger	YKA6360F	1
6361D	" " Spring Shim (.0625")	YKA6361D	2
6361E	" " Spring Shim (.0312")	YKA6361E	2
6361F	" " Spring Shim (.0156")	YKA6361F	2
6365B	" " Sleeve	YKA6365D1	1
6446	" " Ring	YKA6446C	1
6505A	" " Gasket	YKA6505A	1
6600	" " Sleeve Screw	YKA6600A	2
6694B	" " Needle Plunger	YKA6694D	1
6700A	" " Fuel Filter Body Gasket	YKA2108B	1
6730B	" " Hand Lever Bracket	YKA6730C	1
	" " Hand Lever Bracket Cap Screw	3/8" x 1 1/4"	2
	" " Hand Lever Bracket Cap Screw Lock Washer	3/8"	2
7018	" " Fuel Filter Element (Purolator)	16FM115D14	1
6382A	Injection Valve Body Gasket	YJA6382A1	1
6411	Injection Valve Needle Stop Pin Snap Ring	CEB6411A	1

ALWAYS GIVE ENGINE SERIAL NUMBER



Equipment M78—Injection Valve Test Pump and Stand for 2 Cycle Engines.

Repair Number	NAME OF PART	Number Used
YDB78A	Pump Body Plug.....	1
CEA91A	" Suction Valve.....	1
CEA91A	" Discharge Valve.....	1
CEA92A	Pressure Gauge Tube Gland, Pump End.....	1
CFE96A	Injection Tube Nut, Nozzle End.....	1
YKA96B1	" " Nut, Nozzle End.....	1
CEA205A	Pressure Gauge Tube Gland, Gauge End.....	1
YKA205D	Injection Tube Gland, Nozzle End.....	1
YKA205E	" " Gland, Nozzle End.....	1
CEA259A	Pump Suction and Discharge Valve Spring.....	1
CEB260C	" Spring.....	1
CEB387C	" Sleeve.....	1
CEA420A	Injection Tube Gland Nut, Gauge End.....	1
CEA420A	Pressure Gauge Tube Gland Nut.....	2
YDA531A	Pump Body.....	1
YDA534A	Pump Filling Plug.....	1
CEB535C	" Plunger.....	1
CEA544A	" Discharge Valve Cage.....	1
CEA755A	" Suction Valve Seat.....	1

(Group continued on the next page)

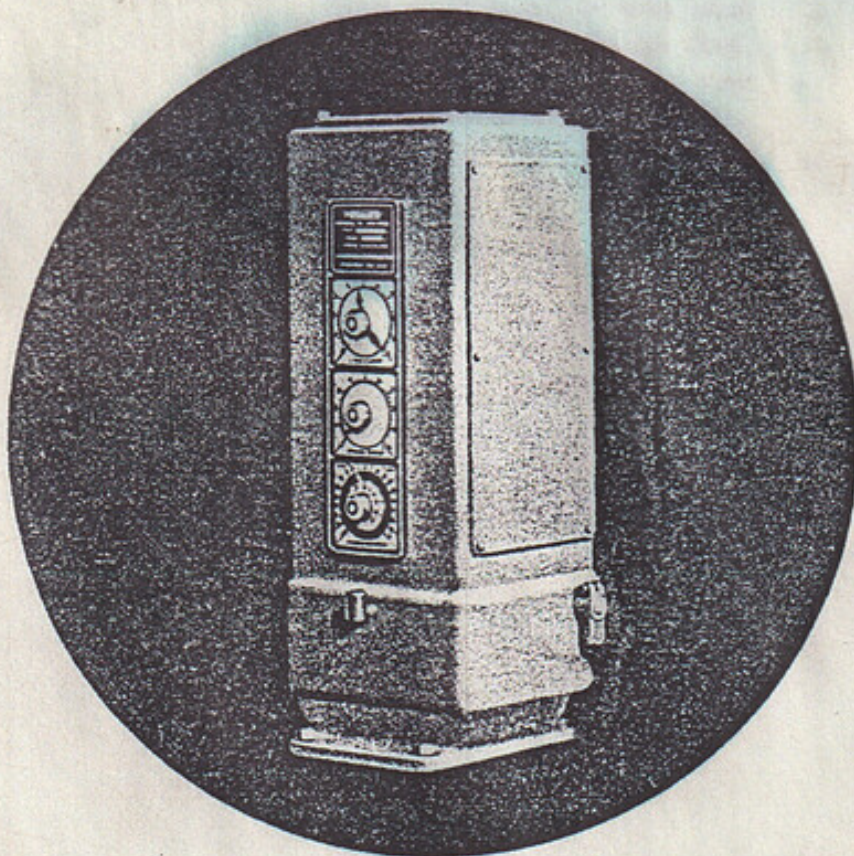
ALWAYS GIVE ENGINE SERIAL NUMBER

Repair Number	NAME OF PART	Number Used
(Group continued from preceding page)		
CEB1039B	Pump Gasket.....	1
CEB1080B	" Plunger Sleeve Wrench.....	1
CEA2108A	" Discharge Valve Gasket.....	1
YLA2108A	" Stand Push Rod Guide Gasket.....	1
YKA4201A3	" Stand.....	1
⊖	" " Pipe Plug— $\frac{1}{4}$ "..... 20FM7A.	1
YKA4202A1	" " Top.....	1
YKA4203B1	Pressure Gauge Vent Screw, Always with.....	1
⊖	Vent Screw Pin—#429..... 11FM41A	1
YKA4205A2	Pump Stand Push Rod Guide.....	1
YKA4206A	" " Plunger Push Rod.....	1
YKA4207A	" " Lever Rod, Always with.....	1
	" " " " Set Screw— $\frac{3}{8}$ " x $\frac{3}{8}$ "..... 11FM15A	1
YKA4208A	" " " " Spacer.....	2
YKA4209A1	" " " " Rocker Handle.....	1
YKA4210B1	" " " " Rocker.....	1
YKA4211B3	Pressure Gauge Vent Body, Always with.....	1
⊖	" " " " Plug— $\frac{1}{2}$ "..... 20FM7K	1
⊖	" " " " Cap Screw— $\frac{3}{8}$ " x $1\frac{3}{4}$ "..... 11FM7A	2
⊖	" " " " Ball— $\frac{1}{4}$ "..... 16FM18C	1
YKA4212A2	" " " " Gasket.....	1
YKA4213A	Injection Tube, $\frac{3}{8}$ " O. Dia. x 14", Always with.....	1
CEA205A	" " Gland.....	1
CEA420A	" " " Nut.....	1
YKA205D	" " Gland.....	1
YKA96B1	" " " Nut.....	1
YKA4213B	Injection Tube, $\frac{3}{8}$ " O. Dia. x 14", Always with.....	1
CEA205A	" " Gland.....	1
CEA420A	" " " Nut.....	1
YKA205E	" " Gland.....	1
CFE96A	" " " Nut.....	1
YKA4214A	Pressure Gauge Tube, Always with.....	1
CEA205A	" " Gland.....	1
CEA92A	" " " Gland.....	1
CEA420A	" " " Gland Nut.....	2
YKA4216A	Pump Stand Pin.....	4
YKA4237A	Test Pump Screen, Always with.....	1
YKA4238A	Screen Ring, (Not Furnished Separately).....	1
YKA4239A	" Hook, (Not Furnished Separately).....	1
⊖	Pressure Gauge, 5000#, 5 Iron Case, Brass Ring.....	1
⊖	Pump Stand Top Nozzle Stud— $\frac{3}{4}$ " x $5\frac{1}{4}$ "..... 11FM6A	2
	" " " " Nut— $\frac{3}{4}$ "..... 11FM25A	4
YKA6600B	" " " Screws.....	2

WOODWARD

TYPE IC GOVERNORS

BULLETIN 02002 A



WOODWARD GOVERNOR CO.
ROCKFORD, ILLINOIS

WOODWARD GOVERNORS

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WOODWARD GOVERNORS



WOODWARD GOVERNOR CO.
ROCKFORD, ILLINOIS

SECTION I

INSTRUCTIONS TO POWER PLANT OPERATORS

Your Woodward Governor is a precision instrument, but there is nothing mysterious about it. You don't have to be an engineer or a scientist to operate it and get the finest possible governing.

The illustration on the front cover shows the location of all the controls mentioned below. All of them may be adjusted while the engine is running.

STARTING ENGINE: With the knob on the top dial (LOAD-LIMIT) turn the red hand to a point just a little higher than where the black hand usually runs when the engine is idling (probably somewhere between 1½ and 4 on the dial). This prevents the engine from getting too much fuel and accelerating too rapidly. Start the engine.

When the engine is sufficiently warmed up, turn the red hand way over to 10. If for any reason you want to keep this engine from taking full load, set the red hand at a lower point. The black hand (which shows the fuel control position) can never go beyond the red hand.

If the engine carries any load other than an A.C. generator, the governor is now ready for load, so apply it when ready. You can adjust the speed of the engine by turning the synchronizer knob on the governor, or by operating the synchronizing switch on the switchboard. This switch controls a small electric motor inside the governor which turns the synchronizer knob. If your engine drives an A.C. generator, set the speed droop at about 5 and then synchronize in the usual way. After the unit is on the line, load can be picked up by turning the synchronizer toward FAST or dropped off by turning it toward SLOW.

THE FOLLOWING INSTRUCTIONS APPLY ONLY TO A.C. GENERATING PLANTS WHICH ARE OPERATING ALONE. THEY DO NOT APPLY IF YOUR PLANT IS TIED IN WITH OTHER PLANTS.

In order to maintain 60 cycle frequency most easily, adjust your governors as follows. These instructions should be followed unless the manufacturer of your engine has given you other instructions.

All but one of the governors on the line at one time should have speed droop. If you have any engines which do not have a Woodward Governor, they probably have from 3% to 5% speed droop. Therefore:

(a). Set the speed droop dials of all governors (except one) at about 3 on the dial if you have all Woodward Governors.

(b). If you have some engines that do not have Woodward Governors, set all (except one) of the speed droop dials at 5 or higher.

Set one governor on zero speed droop or as far to the left as the pointer will go. **THIS ENGINE WILL NOW TAKE ALL OF THE LOAD CHANGES WITHIN THE LIMIT OF ITS CAPACITY**, and when you have learned how to adjust it closely enough, it will hold the normal frequency to very close limits. You will have to adjust it only once a day or less to keep your electric clock correct within a few seconds a day. Turning the inner dial on the synchronizer one small division will make your electric clock change about 8 seconds a day.

You should watch your load on the watt meters or on the governor load indicators, and when you find that the engine whose governor has zero speed droop is almost to full load, **PICK UP MORE LOAD ON THE OTHER ENGINES**. If you find that it has almost no load, **TAKE SOME LOAD OFF THE OTHER ENGINES**. After you have run this way a while, you will learn what times during the day you will have to do this.

You adjust your speed or frequency (cycles) by means of synchronizer adjustment on the engine with zero speed droop, and you adjust load by changing speed (synchronizer) setting on the other engines.

THE FOLLOWING INSTRUCTIONS APPLY IF YOUR PLANT IS TIED IN WITH OTHER PLANTS.

Set the speed droop dial at about 5.

Start engine and synchronize as above.

If the engine tries to take too great a share of the load changes, set the speed droop higher. If it does not take its share, set it lower.

Pick up load in the usual manner by adjusting the synchronizer knob.

It may be that if your system is not too large and you have one unit that is large enough to take care of any load changes that may occur, you can set its governor on zero speed droop so it will do all the regulating for the system, just as though it were a single plant. The best way to find out if you can this is to try

it, first making sure that the load limit is set so that the engine cannot be overloaded.

STOPPING ENGINE: Take the load off the engine by turning the synchronizer knob toward SLOW.

After the unit has been taken off the line, shut it down in the usual way.

THE FOLLOWING INSTRUCTIONS APPLY IF YOUR ENGINE IS NOT DRIVING AN A.C. GENERATOR.

If your engine is driving a D.C. generator, pump, or anything but an alternating current generator, set the speed droop at zero on all engines. In direct current service, it is occasionally desirable to run with a little speed droop to aid in load division, particularly in cases where generator compounding is not identical.

TAKING CARE OF YOUR GOVERNOR

It will not take much care to keep your Woodward Governor running properly for many years.

OIL: Keep the governor oil level high enough so it can be seen in the filler cup. Your regular engine oil will be all right although SAE 20 to 30 is usually best. The oil should be acid-free and should not sludge or retain air. **IT MUST BE CLEAN AND NEW.** Wash your pail or oil can thoroughly with gasoline before you use it for governor oil.

The dashpot (inside the governor) must be kept full of Woodward dashpot oil up to the level of the filler cup. This should be checked every six months, say on February 1st and again on August 1st.

The connecting joints of levers, links, pins, etc. should be lubricated once a week with oil from the governor sump. This may be done by using a small new paint brush, which can be hung inside the governor where it will always be available and will be kept clean. If the governor is not provided with a ballhead oiler as shown on Page 9, write to us for information and price of this service kit.

MAINTENANCE AND REPAIRS

OIL LEAKAGE: When it becomes necessary to add oil frequently to maintain proper level, the oil seal 88-1 on the drive shaft should be replaced as follows: Remove governor from the engine, remove drive gear and key and the four cap

screws. Slip the sleeve 16-1 and bearing retainer 55-6 off the shaft. Press or knock out the old seal 88-1 and press in a new one; be certain the sealing lip will be upward when assembled. Slip the sleeve into the seal, using shim stock in the form of a cone to prevent damaging the sealing edge of the seal. If the shim and sleeve are turned, while inserting, the edge of the shim stock will not cut the seal. Inspect the drive bearing 203FF at this time.

REGISTER OF BLACK HAND (LOAD INDICATOR): If the load indicator goes below zero when the load limit (red hand) is turned all the way to the left, to shut down the engine, it may be reset as follows:

Unlock the nut and remove screw 36-12 in gear segment 32-4. The screw will usually be worn and it should be repointed by grinding it to a rounded end. Replace the screw and nut, adjusting it to obtain register of the pointer with the zero mark.

PARTS SUBJECT TO WEAR: The following parts should be inspected twice yearly and replaced if necessary, in order to maintain best performance: Ballhead assembly parts consisting of 200FF bearings, 22-4 ballarm pins, 90-3 ballarm blocks, 22-3 ballarm block pins, 14-1 bushing, 14-2 bushing, 68-11 bearing, 5205FF bearing, and 6-4 speeder rod.

The 200FF ballarm bearings must be perfectly free running. Any roughness or stickiness will cause poor operation and if bad enough will make it impossible to hold speed.

Twist the ballhead assembly around a few degrees to check the action of the spring drive laminations 98-2 and pin 22-52. Replace them if no spring action is felt or if it feels "rough".

The 90K pivot pins will wear if lubrication is neglected. Inspect them and replace if they are grooved.

EXCHANGE PLAN: When your governor becomes several years old and may require considerable repair and readjustment, write us for details of our exchange plan. Be sure to give us the serial number stamped on the nameplate.

ORDERING OF PARTS OR REQUESTING INFORMATION: When ordering any parts or requesting any information concerning your governor, be sure that you furnish us with the serial number of the governor.

SECTION II

INSTRUCTIONS TO ENGINE ERECTORS

You will not find it difficult to install and adjust a Woodward type IC Governor. If the governor was fitted on the engine at your factory, you will only have two simple things to do. If they are not done, the governor will not work properly, and your engine will not perform as well as other engines whose governors are correctly adjusted.

1. PUT IN OIL.

(a). Take off the side cover and fill the governor base with engine oil, so that the oil level shows in the filler cup on the front. This level should be maintained in service.

Use CLEAN, NEW ENGINE OIL. The pail or can used to carry oil to the governor should be thoroughly washed with gasoline before it is used.

(b). It is a good idea to roll the engine over slowly a few revolutions to fill the governor cylinder with oil. This is not necessary, but it will make the first start of the engine much smoother.

2. ADJUST THE COMPENSATION.

This is not as difficult as it sounds, and it is VERY IMPORTANT.

The adjustments made at your factory may not be satisfactory when the engine is installed in the field. You should go through the procedure indicated here, even though the governor appears to work all right. The fact that a governor does not hunt does not necessarily mean that it is correctly adjusted.

(a) First, check to see that the dashpot is full of oil up to the level of the filler cup. Nothing but Woodward dashpot oil should be used. Open the needle valve one turn and move the small plunger up and down two or three complete strokes. (This should be done before the engine is started.)

(b) Set the slider (pc. 28K) in about the center of the compensating crank.

(c) Close the needle valve by screwing it all the way in, then open it about $\frac{1}{2}$ turn.

(d) Start the engine.

(e) If the governor hunts, close the needle valve slowly until the hunting stops, or until it is only about $\frac{1}{8}$ turn open.

(f) If this does not stop the hunting, move the slider $\frac{1}{8}$ " farther out on the crank and open the needle valve again until it is $\frac{1}{2}$ turn open.

(g) Close the needle valve slowly until the hunting stops or until it is only $\frac{1}{8}$ turn open.

(h) Repeat this until the hunting stops.

(i) When the correct opening of the needle valve has been determined, lock it in place with the lock nut.

(j) If the hunting does not stop with the slider all the way out and the needle valve $\frac{1}{8}$ turn open, it is a good idea to check over the linkage from the governor to the fuel pumps (or other fuel metering device). The linkage should be entirely free from lost motion and binding.

(k) On some engines with very little flywheel effect, the above adjustments may not be sufficient to stop hunting. If this is the case, stop the engine, remove the screw 90K, and move the rod end 93K to the outer hole in lever 7-2.

(l) Now start all over again with the slider in the center of the crank as shown and the needle valve open $\frac{1}{2}$ turn, and repeat the above adjustments.

(m) It is not desirable to have the slider any farther out or the needle valve closed any farther than necessary, because this will tend to make the governor sluggish. If the needle valve is closed too far it will be almost impossible to divide load properly.

OPERATION: If you want to know how to operate the governor, read section I, "Instructions for Power Plant Operators."

SECTION III

DESCRIPTION OF GOVERNOR AND ITS METHOD OF OPERATION

SCHEMATIC OPERATION

Movements of the operating parts of the governor are actually proportional to the amount of speed change, but have been greatly exaggerated in the drawings to make them more visible.

Assume, for the purpose of explanation, that the prime mover is rotating at normal speed as shown on the speed indicator and carrying approximately half load as shown by the black hand. Assume, also, that the governor adjustments are all properly set and that speed droop is zero.

LOAD REDUCTION

Cut No. 1. The flyballs are in their normal position for normal speed and no speed droop. The load limit is set at about 9/10 load, as shown by the red hand. The pilot valve is central. The power piston is stationary. The larger or actuating compensating plunger is approximately central. The small or receiving compensating plunger is central.

Cut No. 2. A certain amount of load is thrown off the unit. The speed instantly starts to increase. As the speed increases, the flyballs move out, the speeder rod is forced down against the upward thrust of the speeder spring, pivot points "H", "I", "B" and "A" are forced down, the pilot valve plunger is forced down from its central position against the upward thrust of the pilot valve spring, and pressure oil is admitted from P-1 through the lower holes in the pilot valve bushing into port W-1 and on into the power cylinder where it starts moving the power piston to the right, which is the direction to reduce the flow of energy medium to the prime mover. Oil laying on the opposite side of the power piston is forced out through port Y-1, through the upper holes in the pilot valve bushing and into the discharge area D-1 and from there back into the sump tank.

Cut No. 3. As the power piston moves to the right, pivots "G", "M" and "L" are raised and the larger or actuating compensating plunger is raised. Since the compensating dashpot is filled with oil, the upward movement of the compensating actuating plunger sucks the smaller or receiving compensating plunger downward against the upward force of the tension-compression compensating spring, which attempts to keep the receiving plunger central at all times. The downward movement of the compensating receiving plunger pulls pivot "J" downward and as pivot "H" is temporarily stationary due to the fact that the flyballs are still in their outward position, it acts as a fulcrum, causing the downward movements of pivot "J" to raise pivots "I", "B" and "A" and consequently the pilot valve plunger. These various parts do not make a single, definite and

complete move but make short moves in sequence and the action is continued until the pilot valve plunger is raised to its central position, thus stopping the flow of pressure oil from P-1 to port W-1 and thus stopping the motion of the power piston.

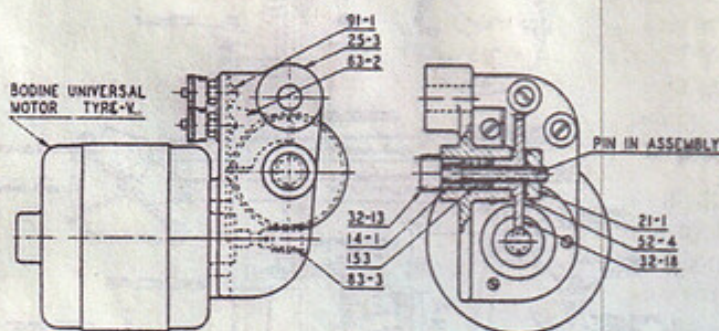
If the compensating adjustments have been properly made, the pilot valve plunger will be centered and the movement of the power piston will be stopped at a position corresponding to a flow of energy medium just sufficient to accommodate the reduced load on the unit. All that is necessary now is to hold the power piston stationary until the speed returns to normal or until a subsequent speed change occurs.

The upward movement of the actuating compensating plunger created a vacuum in the lower half of the compensating dashpot case, which caused the receiving plunger to be drawn downward. At the same time, oil from the upper part of the case began to flow through the compensating needle valve into the lower part of the case to break up the vacuum and allow the compensating spring to return the receiving plunger to its central position. The needle valve is small and consequently had little effect while the actuating plunger was in motion. Now, however, the movement of the actuating plunger has stopped and, therefore, the flow through the needle valve will allow the compensating spring to bring the receiving plunger back to normal at any pre-determined rate according to the setting of the needle valve. If the needle valve has been properly set, the receiving plunger will return to its central position in exact unison with the return of the prime mover speed to normal and consequently the return of the flyballs to their normal central position. Such being the case, pivot "J" will move upward in exact ratio to the upward movement of pivot "H" caused by the return of the flyballs to center. Pivot "I" will, therefore, remain stationary, the pilot valve plunger will not be disturbed, and the power piston will remain stationary.

Cut No. 4. The cycle has been completed, the speed is normal, the load is as shown by the black hand, the flyballs are central, the receiving compensating plunger is central, and the power piston is stationary. The only permanent changes that have resulted are the position of the black hand, which shows the new loading of the unit; the position of the power piston; and the position of the compensating actuating plunger.

LOAD INCREASE

The action when load is added to the unit is just the reverse. The speed starts to drop, the flyballs move in, pivots "H", "I", "B" and "A" are raised, the pilot valve plunger is raised, pressure oil is admitted from P-1 to Y-1, and the power piston moves to the left to increase the flow of energy medium. As the power piston moves



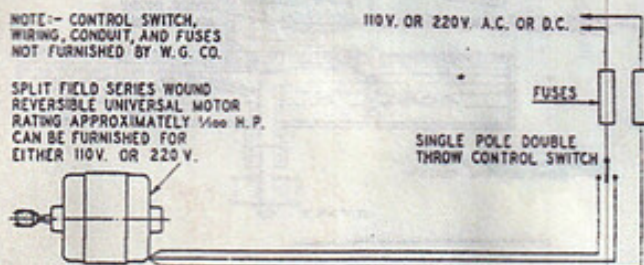
SYNCHRONIZING MOTOR BRACKET ASSEMBLY

THIS ASSEMBLY USED ON GOVERNORS TO AND INCLUDING SERIAL NO. 8367

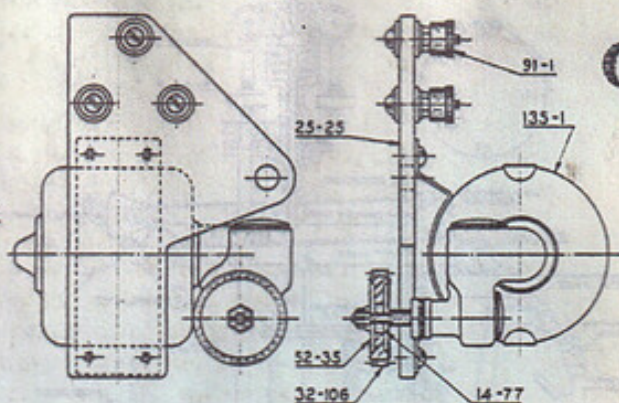
WIRING DIAGRAM FOR SYNCHRONIZING MOTOR

NOTE:- CONTROL SWITCH, WIRING, CONDUIT, AND FUSES NOT FURNISHED BY W. G. CO.

SPLIT FIELD SERIES WOUND REVERSIBLE UNIVERSAL MOTOR RATING APPROXIMATELY 1/200 H. P. CAN BE FURNISHED FOR EITHER 110V. OR 220 V.



02000-A-9



SYNCHRONIZING MOTOR BRACKET ASSEMBLY

This assembly used on governors beginning with Serial No. 8368. When used on governors preceding this serial number, the following parts are also required:

- 1 — No. 020186 Speeder Screw Assembly.
- 1 — No. 186265 Spacer Washer.

to the left pivots "G", "M" and "L" are lowered, the compensating actuating plunger is forced downward, the compensating receiving plunger is forced upward, raising pivot "J" and lowering pivots "I", "B" and "A" until the pilot valve plunger centers, stops the flow of pressure oil into port Y-1 and stops the movement of the power piston at the exact position corresponding to the increased load on the unit. As the energy medium flow is corrected, the speed of the unit returns to normal. In unison with the return of the speed to normal and consequently the return of the flyballs to their central position, the compensating receiving plunger, due to the flow of oil through the compensating needle valve and the centering action of the compensating spring, returns to its central position. The pilot valve plunger is not disturbed and the power piston remains stationary awaiting another change in speed resulting from a change in load.

THE LOAD LIMIT

The purpose of the load limit is to prevent the unit from taking on more load than that for which the red hand is set by mechanically preventing the pilot valve plunger from rising above center when a loading corresponding to the setting of the red hand has been reached. It also provides a means of shutting the unit down by merely turning the red hand to zero.

Action: Referring to the cuts, as the power piston moves to increase the flow of the energy medium, the compensating crankshaft is revolved clockwise and the load limit eccentric lowers the left end of the load limit lever, the right end being held stationary. The pivot "K" is forced downward as is the load limit rod. The finger on the lower end of the load limit rod is forced downward, and as the power piston reaches a position corresponding to the setting of the red hand, the finger contacts the top of the pilot valve plunger and prevents it from rising above center. The energy medium flow cannot, therefore, be further increased.

To reduce the load limit or to shut the unit down completely, revolve the red hand counter clockwise. The right end of the load limit lever will be forced downward, the load limit rod and the finger will be forced down and will force the pilot valve plunger below center. Pressure oil from P-1 will be admitted to port W-1, the power piston will move to the right, pivots "G" and "M" will be raised, the compensating crankshaft will be revolved counter clockwise, and the load limit eccentric will raise the left end of the load limit lever and thus raise pivot "K", the load limit rod and the pilot valve plunger so that the pilot valve plunger will center and stop the action just as the power piston reaches a position corresponding to the setting of the red hand.

SPEED DROOP

The purpose of speed droop is to cause all units operating in parallel to take their proportionate share of the total load.

Action: As shown in the cuts, pivot "P" is on exact center and consequently does not produce a drooping of the unit speed as the unit takes on load. In other words, the speed of the unit will remain the same regardless of the amount of load on the unit (within the capacity of the unit). But, revolve the speed droop knob clockwise and pivot "P" will be drawn toward the front of the governor and consequently away from exact center. The farther away from exact center it is drawn, the greater will be the droop in the speed.

With pivot "P" off center, assume that the power piston moves to the left to increase energy medium flow. The compensating crankshaft will be revolved clockwise and will move the upper end of the speed droop lever to the left. Pivot "P" will be raised, pivot "E" will be raised, pivots "D" and "C" will be lowered, pivot "A" will be lowered in respect to pivot "B", the pilot valve will be centered and the power piston stopped before it reaches a position corresponding to the original speed. In other words, the speed of the unit will not be returned to the speed at which it was operating but to a slightly lower speed of a percentage corresponding to the distance pivot "P" is off center.

If the power piston moves in the direction to decrease energy medium flow, the speed will rise a percentage corresponding to the distance pivot "P" is off center.

THE SYNCHRONIZER

The purpose of the synchronizer or speed adjusting mechanism is to permit varying the unit speed for synchronizing when the unit is being paralleled with other units. If the unit is operating in parallel on a system many times the capacity of the individual unit, an adjustment of the speed setting will result in a change of the system speed, but the change in speed may be so infinitesimal as to be unreadable on ordinary switchboard instruments. Practically, therefore, a change in the synchronizer setting merely changes the loading of the unit due to the small amount of influence the capacity of the unit has on the total capacity of the system.

Action: Revolve the synchronizer knob counter clockwise. Pivot "O" will be pulled toward the front of the governor, pivot "C" will be raised—permanently raising the left end of the lower floating lever. This will raise pivot "A" with respect to pivot "B". Pressure oil will be admitted from P-1 to port Y-1, the power piston will move to the left to increase energy medium flow, the unit speed will increase until the flyballs have changed their normal central position sufficiently to recenter the pilot valve plunger. The flyballs will then be slightly farther apart and this will be their normal central position until the synchronizer is again reset.

Revolving the synchronizer knob clockwise will cause a reversal of operation and the unit speed will be lowered.

WOODWARD TYPE IC GOVERNORS

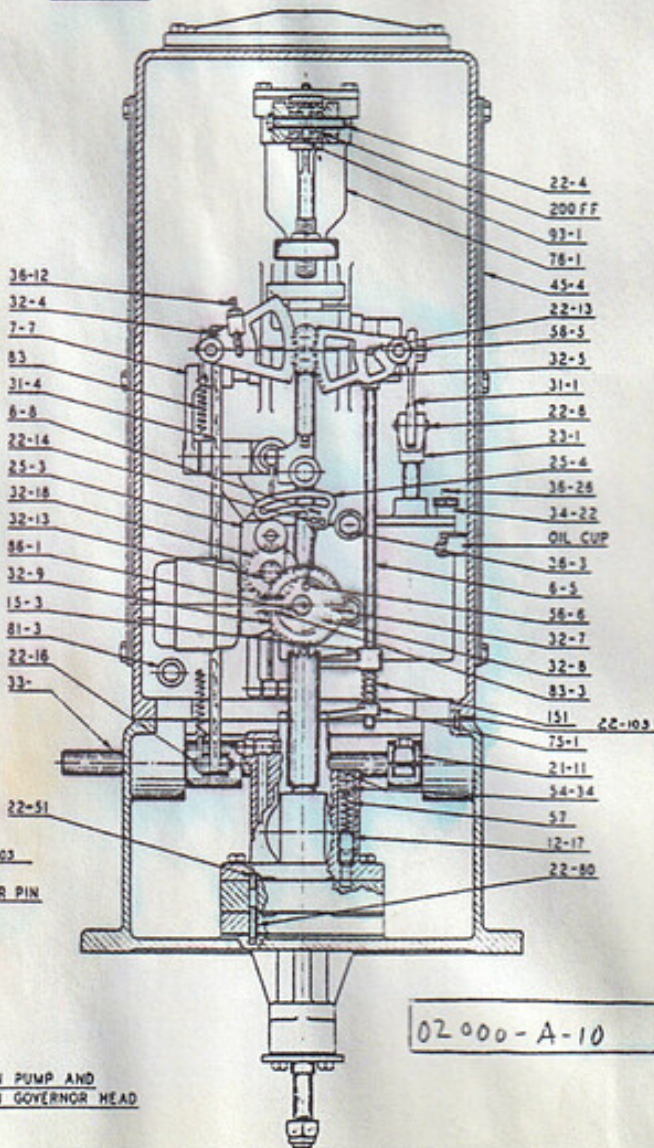
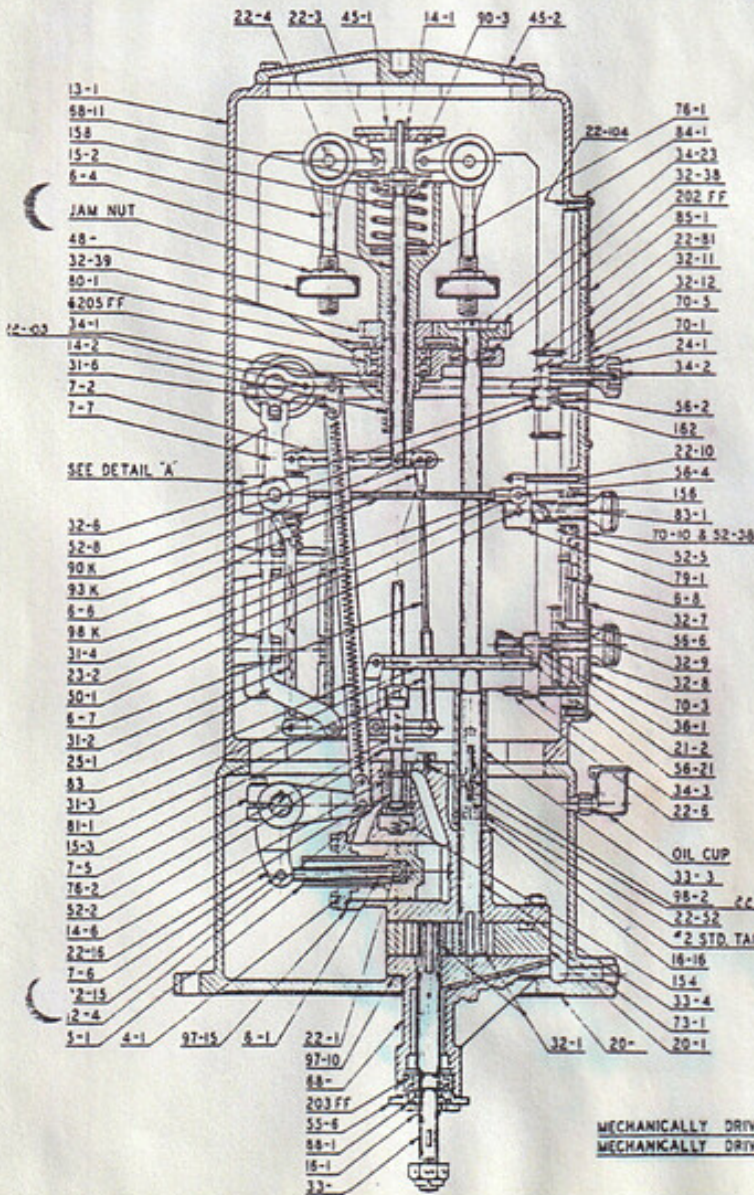
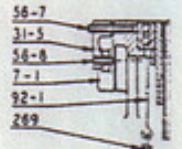
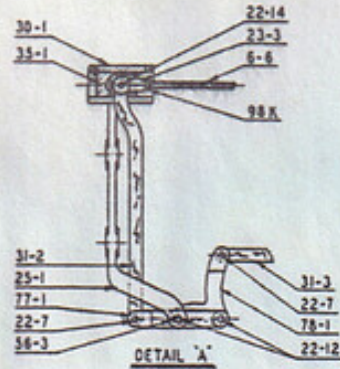
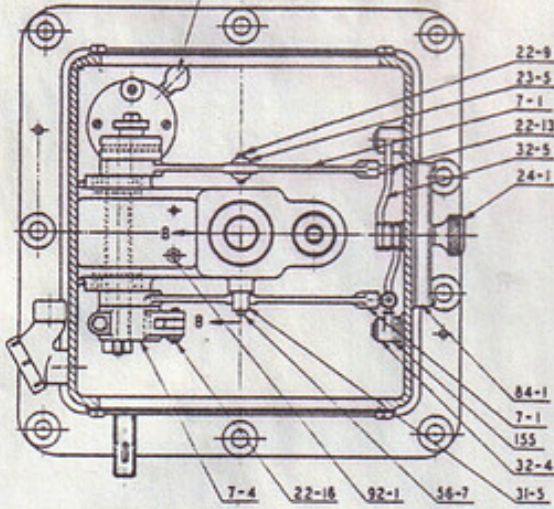
— PARTS LIST —

<i>Part No.</i>	<i>Description</i>	<i>Part No.</i>	<i>Description</i>	<i>Part No.</i>	<i>Description</i>
4-1	Cylinder Head	23-4	Rod End	56-4	Adjusting Rod Stud
5-1	Power Piston	23-5	Rod End	56-5	Segment Pivot Stud (2)
6-1	Connecting Rod	24-1	Knob (3)	56-6	Stop Rod Stud
6-4	Speeder Rod	25-1	Speed Droop Bracket	56-7	Pivot Link Stud
6-5	Limit Stop Rod	25-4	Guide Bracket	56-8	Load Indicator Pivot Stud
6-6	Speed Droop Adjusting Rod	25-25	Motor Bracket	56-9	Upper Compensating Lever Stud
6-7	Floating Lever Connecting Rod	27-3	Compensating Dashpot	56-21	Stud
6-8	Reducing Gear Stop Rod	30-1	Speed Droop Fulcrum	68-	Drive Bearing
7-1	Load Indicator Lever (2)	31-1	Dashpot Connecting Link	68-11	Speeder Rod Bearing
7-2	Upper Floating Lever	31-2	Connecting Link	70-1	Load Limit Pointer
7-3	Lower Floating Lever	31-3	Synchronizer Link	70-3	Synchronizer Vernier Pointer
7-4	Upper Compensating Lever	31-4	Compensating Connecting Link	70-5	Disc Pointer (Load Indicator)
7-5	Compensating Lever	31-5	Load Indicator Pivot Link	70-10	Disc Pointer (Speed Droop)
7-6	Power Lever	31-6	Spring Link (2)	73-1	Controlet
7-7	Speed Droop Lever	32-1	Pump Gear (2)	75-1	Limit Stop Rod Guide
9-1	Compensating Crank	32-4	Load Indicator Segment	76-1	Governor Head
11-1	Large Bonnet	32-5	Load Limit Segment	76-2	Pilot Valve Head
11-2	Small Bonnet	32-6	Load Limit Pinion	77-1	Walking Beam
12-1	Large Plunger	32-7	Internal Gear	78-1	Bell Crank
12-4	Pilot Valve Plunger	32-8	Synchronizer Reducing Gear	79-1	Speed Droop Adjuster
12-12	Small Plunger	32-11	Load Limit Pinion	80-1	Clamp Plate
12-17	Relief Valve Plunger	32-12	Load Indicator Pinion	81-1	Connecting Rod Sheath
13-1	Control Column	32-38	Gear	81-3	Electrical Conduit
14-1	Bushing (4)	32-39	Gear	83-1	Speed Droop Adjusting Worm
14-2	Bushing (4)	32-105	Synchronizer Gear	84-1	Control Panel
14-3	Terminal Shaft Bushing (2)	32-106	Synchronizer Gear	85-1	Control Dial
14-6	Pilot Valve Bushing	33-	Drive Shaft	86-1	Synchronizer Eccentric
14-77	Synchronizer Gear Bushing	33-	Terminal Shaft	86-2	Load Indicator Eccentric
15-2	Ball Arm	33-3	Upper Drive Shaft	88-1	Oil Seal (2)
15-3	Limit Stop Arm	33-4	Lower Drive Shaft	90-3	Ball Arm Block (2)
16-1	Spacer Sleeve	34-1	Lock Nut	91-1	Binding Post (3)
16-2	Crankshaft Bearing Spacer Sleeve	34-2	Knob Lock Nut (3)	92-1	Spring Anchor
16-16	Spring Drive Sleeve	34-3	Synchronizer Nut	93-1	Spacer Ring (2)
20-1	Pump Case	34-22	Lock Nut	97-10	Gasket
20-	Power Case	34-23	Shear Nut	97-15	Cylinder Head Gasket
21-2	Synchronizer Stop Collar	35-1	Speed Droop Slide	98-2	Spring Lamination (8)
21-11	Collar	36-1	Synchronizer Screw	135-1	Synchronizing Motor
22-1	Piston Pin	36-2	Connecting Link Screw	28K	Compensating Slide Block
22-3	Ball Arm Block Pin	36-3	Dashpot Screw (2)	90K	Pivot Pin (4)
22-4	Ball Arm Pin	36-12	Load Indicator Adjusting Screw	93K	Rod End
22-6	Guide Pin	36-26	Bypass Screw	98K	Nut (3)
22-7	Pin (3)	45-1	Governor Head Cover	57	Relief Valve Spring
22-8	Pin	45-2	Top Cover	83	Tension Spring
22-9	Pin	45-4	Side Cover	151	Limit Stop Rod Spring
22-10	Guide Pin	48-	Flyball (2)	154	Pilot Valve Spring
22-12	Pin (2)	50-1	Guide Key	155	Torsion Spring
22-13	Pin (2)	52-2	Oil Shield Washer	156	Speed Droop Friction Spring
22-14	Pin (2)	52-5	Speed Droop Friction Washer	158	Speeder Spring
22-15	Connecting Rod Pin	52-6	Compensating Crankshaft Washer	162	Load Limit Friction Spring
22-16	Pin (2)	52-8	Load Limit Friction Washer	269	Tension Spring
22-51	Dowel Pin (2)	52-35	Spring Washer (2)	298	Dashpot Spring
22-52	Spacer Pin	52-38	Washer	38	Ball Bearing (2)
22-80	Dowel Pin (2)	54-1	Power Case Plug	200	Ball Bearing (4)
22-81	Segment Stop Pin (2)	54-34	Adjusting Plug (2)	202	Ball Bearing
23-1	Rod End	55-6	Bearing Retainer	203	Ball Bearing (3)
23-2	Rod End	56-2	Load Limit Stud	5205	Ball Bearing
23-3	Rod End	56-3	Pivot Stud		

WOODWARD TYPE IC GOVERNORS

SECTIONAL VIEWS AND PART NUMBERS

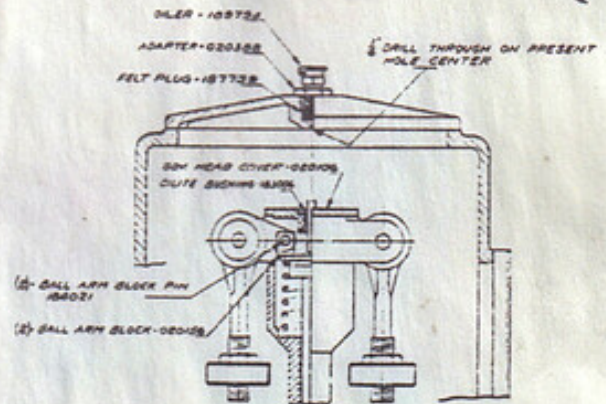
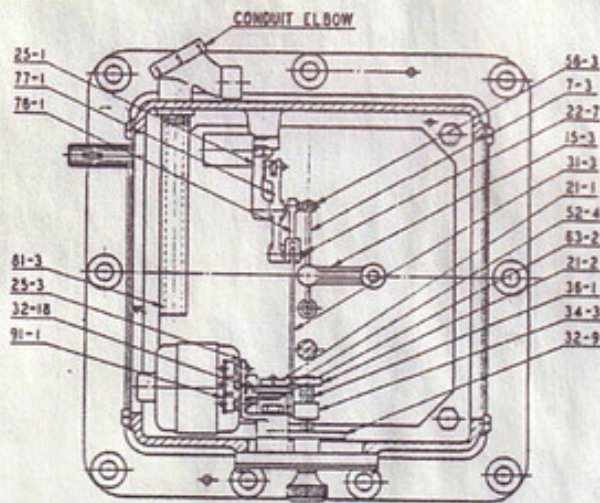
FILL DASHPOT WITH SPECIAL OIL
THROUGH FILLER CUP. SEE PAGE II.



02000-A-10

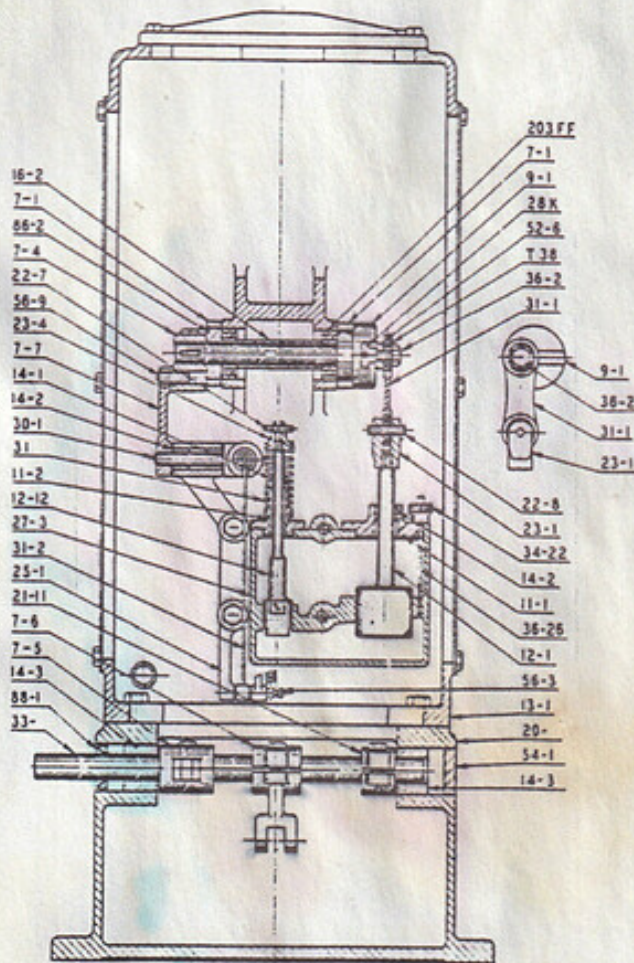
MECHANICALLY DRIVEN PUMP AND
MECHANICALLY DRIVEN GOVERNOR HEAD

WOODWARD TYPE IC GOVERNORS SECTIONAL VIEWS AND PART NUMBERS



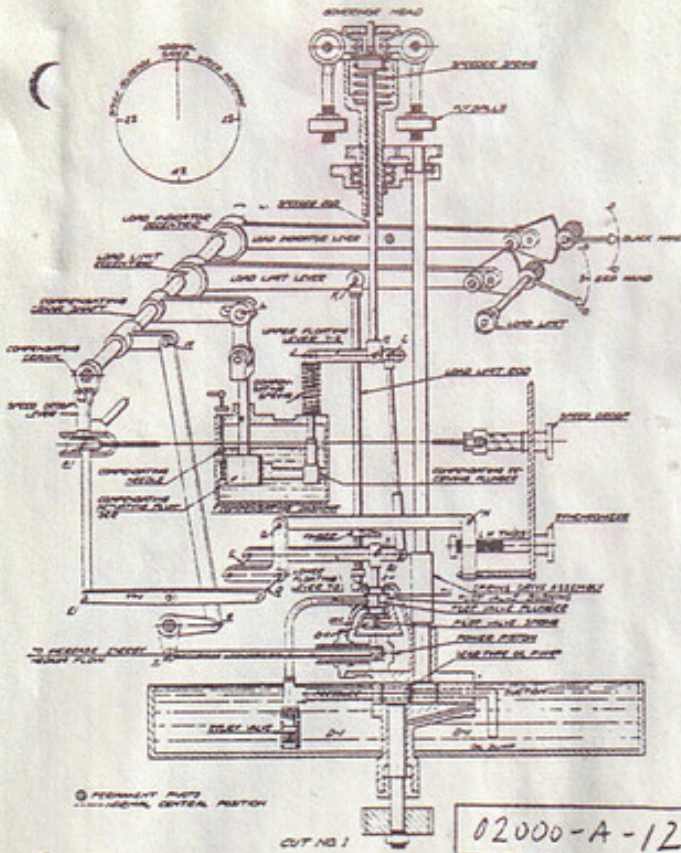
BALLHEAD OILER SERVICE KIT No. 175130

The parts shown directly above can be furnished for installation on IC Governors of any serial number. Oiling of the ballhead will reduce wear and improve performance. 45-2 Cover must be drilled when these parts are installed.

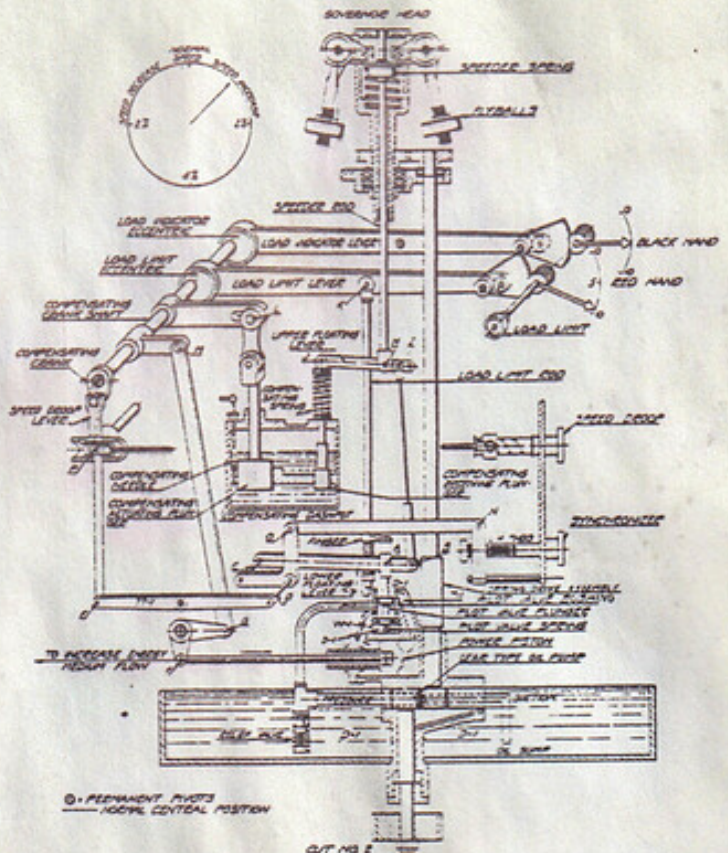


02000-A-9

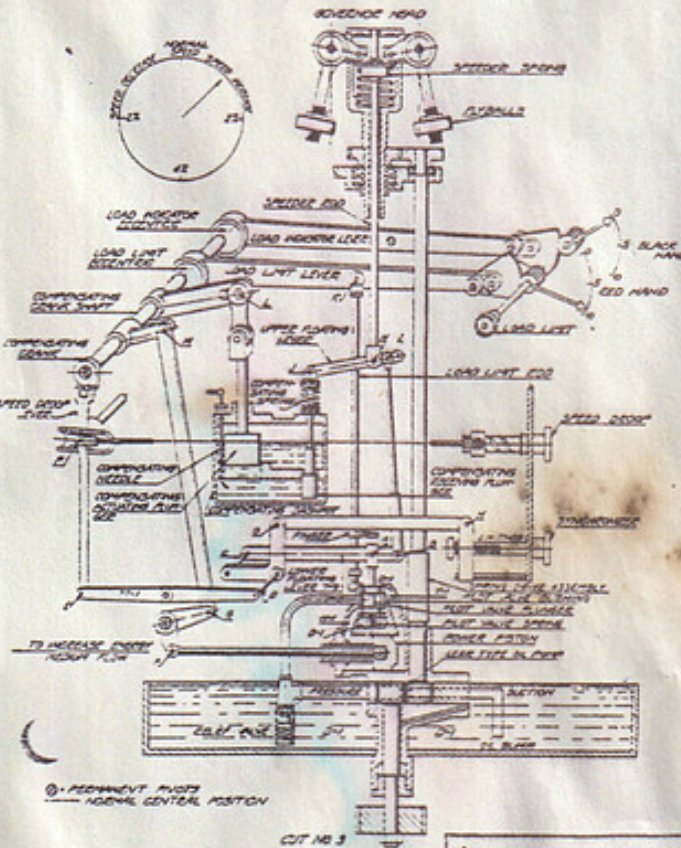
SCHEMATIC OPERATION VIEWS



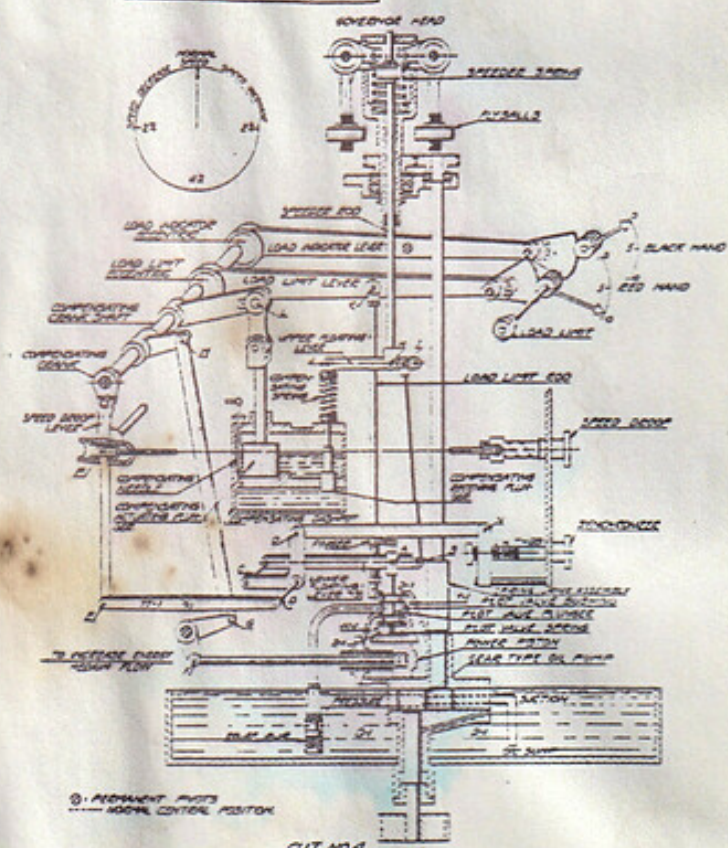
02000-A-12



02000-A-7



02000-A-11



02000-A-13