INSTRUCTION MANUAL

FOR

ONAN
INDUSTRIAL ENGINES
Two Cylinder, Air Cooled

Models

CK-S/35G
CK-S/35H
CK-S/35J
CK-S/35K
CK-S/259K
CK-S/259M
CK-S/259N

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Safety Precautions

Before operating the engine, read this manual and become familiar with it and the equipment. **Safe and efficient operation can be achieved only if the equipment is properly operated and maintained.**

The following symbols, found throughout this manual, alert you to potentially dangerous conditions to the operator, service personnel, or the equipment.

⚠ DANGER ***This symbol warns of immediate hazards which will result in severe personal injury or death.***

⚠ WARNING ***This symbol refers to a hazard or unsafe practice which can result in severe personal injury or death.***

⚠ CAUTION ***This symbol refers to a hazard or unsafe practice which can result in personal injury or product or property damage.***

Fuels, electrical equipment, batteries, exhaust gases and moving parts present potential hazards that can result in severe personal injury. Take care in following these recommended procedures. All local, state and federal codes should be consulted and complied with.

⚠ WARNING ***This engine is not designed or intended for use in any type of aircraft. Use of this engine in aircraft can result in engine failure and cause severe personal injury or death.***

GENERAL

- Provide appropriate fire extinguishers and install them in convenient locations. Use an extinguisher rated ABC by NFPA.
- Make sure that all fasteners on the engine are secure and accurately torqued. Keep guards in position over fans, driving belts, etc.
- If it is necessary to make adjustments while the engine is running, use extreme caution when close to hot exhausts, moving parts, etc.
- Used engine oils have been identified by some state and federal agencies as causing cancer or reproductive toxicity. When checking or changing engine oil, take care not to ingest, breathe the fumes, or contact used oil.
- Do not work on this equipment when mentally or physically fatigued, or after consuming any alcohol or drug that makes the operation of equipment unsafe.

BATTERIES

- Before starting work on the engine, disconnect batteries to prevent inadvertent starting of the engine. Disconnect negative (–) cable first.
- DO NOT SMOKE while servicing batteries. Lead acid batteries give off a highly explosive hydrogen gas which can be ignited by flame, electrical arcing or by smoking.
- Verify battery polarity before connecting battery cables. Connect negative (–) cable last.

PROTECT AGAINST MOVING PARTS

- Do not wear loose clothing in the vicinity of moving parts, such as PTO shafts, flywheels, blowers, couplings, fans, belts, etc.
- Keep your hands away from moving parts.

FUEL SYSTEM

- DO NOT fill fuel tanks while engine is running.
- DO NOT smoke or use an open flame in the vicinity of the engine or fuel tank. Internal combustion engine fuels are highly flammable.
- Fuel line must be of steel piping, adequately secured, and free from leaks. Piping at the engine should be approved flexible line. Do not use copper piping for flexible lines as copper will work harden and become brittle enough to break.
- Be sure all fuel supplies have a positive shutoff valve.
- Benzene and lead, found in some gasoline, have been identified by some state and federal agencies as causing cancer or reproductive toxicity. When checking, draining or adding gasoline, take care not to ingest, breathe the fumes, or contact gasoline.

EXHAUST SYSTEM

- Exhaust products of any internal combustion engine are toxic and can cause injury, or death if inhaled. When operating the engine in a confined area, make sure the ventilation system is operating properly.
- DO NOT use exhaust gases to heat a compartment.
- Make sure that your exhaust system is free of leaks. Make sure that exhaust manifolds are secure and are not warped by bolts unevenly torqued.

EXHAUST GAS IS DEADLY!

Exhaust gases contain carbon monoxide, a poisonous gas that can cause unconsciousness and death. It is an odorless and colorless gas formed during combustion of hydrocarbon fuels. Symptoms of carbon monoxide poisoning are:

- Dizziness
- Headache
- Weakness and Sleepiness
- Vomiting
- Muscular Twitching
- Throbbing in Temples

If you experience any of these symptoms, get out into fresh air immediately, shut down the unit and do not use it until it has been inspected.

The best protection against carbon monoxide inhalation is proper installation and regular, frequent inspections of the complete exhaust system. If you notice a change in the sound or appearance of exhaust system, shut the unit down immediately and have it inspected and repaired at once by a competent mechanic.

KEEP THE UNIT AND SURROUNDING AREA CLEAN

- Make sure that oily rags are not left on or near the engine.
- Remove all unnecessary grease and oil from the unit. Accumulated grease and oil can cause overheating and subsequent engine damage and present a potential fire hazard.

GENERAL INFORMATION

THIS INSTRUCTION BOOK CONTAINS INFORMATION FOR THE PROPER INSTALLATION, OPERATION AND MAINTENANCE OF YOUR EQUIPMENT. WE SUGGEST THAT THIS BOOK BE KEPT HANDY SO THAT IT CAN BE REFERRED TO WHEN NECESSARY.

THIS EQUIPMENT IS THE RESULT OF PROVEN ENGINEERING DESIGN, HIGHEST QUALITY MATERIALS, AND EXPERT WORKMANSHIP. THOROUGH INSPECTION AND TESTING ASSURES YOU THAT THIS EQUIPMENT WILL PERFORM AS EXPECTED.

IF YOU WISH TO CONTACT YOUR DEALER OR THE FACTORY REGARDING THIS EQUIPMENT, BE SURE TO SUPPLY THE COMPLETE MODEL AND SPEC. NO., AND THE FULL SERIAL NUMBER OF THE EQUIPMENT AS SHOWN ON THE NAMEPLATE. THIS INFORMATION IS NECESSARY TO IDENTIFY THE EQUIPMENT AMONG THE MANY BASIC AND SPECIAL OPTIONAL TYPES MANUFACTURED.

INTRODUCTION

This instruction manual applies to the engines listed below.

Always furnish the MODEL NO., SPECIFICATION NO., and the SERIAL NO. which appears on the engine nameplate, with each inquiry.

Characteristics peculiar to these engine are: Crankshaft with tapered power take-off; Four U.S. quart capacity oil base with four point mounting; Fuel Filter at carburetor; Mounted fuel tank (furnished as a separate item); Variable speed governor control; speed adjusted at 3100 rpm no load for WELDING operation; Ignition timed at 19° B.T.C. spark advance; Plastic shield on face of oil gauge; Special paint on muffler.

MODEL and / SPEC.	REASON FOR ADVANCE IN MODEL SPECIFICATION
CK-S/35G	Original Design, incorporating: Variable Speed Governor; Fuel Filter; Tapered End on Crankshaft; 4 quart Capacity Base; and Special Paint on Muffler.
CK-S/35H	Single 12 Volt Ignition Coil changed to: two 6 V."Autolite" coils installed in the Blower Housing. New adjustable quadrant on Variable Speed Control.
CK-S/35J	Changed to: Permatrol Pistons having split skirt and taking Connecting Rod with wider Pin Boss; New Ignition Breaker Box incorporating a Diaphragm on the Breaker Plunger; Forged Governor Yoke.
CK-S/35K	Changed to: Cast Iron Magneto Flywheel having Rope Sheave removable; New Magneto having Coil removable; .3 Mfd. Ignition Condenser; Molded Rubber Carburetor Air Inlet; Beginning with Serial No. 458109, New Fuel Pump having Priming Lever.
CK-S/259K	Added: Vacuum Speed-Booster; Throttle Lock. Larger Valve Compartment; Eliminated Gasket Under Exhaust Valve Guide.
CK-S/259M	Location of Governor Cup Stop Pin Changed from Cup to Gear Cover (Serial #512652). Breather Cap Hose Clamp Eliminated.
CK-S/259N	Changed to: Air Cleaner with Rain Shield and Metal Cup; Oil Intake Cup with 1/4" pipe thread; Oil Base with Fill Cap and Dip Stick; New Relief Valve.

The following recommended Engine Service Chart may be used as a guide for servicing ONAN Gasoline Engines.

The chart is based on favorable operating conditions.

SERVICE & PARTS REQUIRED	HOURS OF OPERATION																
	100	200	300	400	500	600	700	800	900	1000	1500	2000	2500	3000	3500	4000	4500	5000
Oil Change (Check oil level Daily)	X	X	X	X	X	X	X	X	X	X								COMPLETE RECONDITIONING
Clean and Adjust Spark Plugs ...	X	X	X	X	X	X	X	X	X	X								
*Service Air Cleaner	X	X	X	X	X	X	X	X	X	X								
Check Ignition Points		X		X		X		X		X								
					X					X	X	X	X	X	X	X	X	
†Clean Carbon and Lead Deposits..										X		X		X		X		
Clean Carburetor					X					X	X	X	X	X	X	X	X	
Check Tappets										X		X		X		X		
Grind Valves										X		X		X		X		
Remove and Clean Oil Base	X	X	X	X	X	X	X	X	X	X								
Clean Crankcase Breather										X		X		X		X		
Clean Engine	As Required																	
Replace Spark Plugs	As Required																	
Replace Valves	As Required																	
Replace Points	As Required																	
Replace Piston Rings																		

* Check the air Cleaner often. Thoroughly clean and put in fresh oil at least every 100 hours. Install a heavy duty air cleaner if necessary.

If it is necessary to remove parts for inspection and gaskets are disturbed they should be replaced with new ones.

Periodic Inspection: For Loose or Poor Connections, Fittings, etc.

Recommended Oil: Heavy Duty Detergent or its Equivalent. Use the proper SAE number oil for the lowest temperature at the engine as expected at the time of starting.

Above 90°F. (32°C.), for continous duty, use SAE 50
Between 30°F. and 90°F. (-1°C. and 32°C.) use SAE 30
Between 0°F. and 30°F. (-18°C. and -1°C.) use SAE 10W
Below 0°F. (-18°C) use SAE 5W

†Recommended fuel: Use Regular Grade Gasoline of at least 68 Octane - Do not use Premium Type. If a high lead content fuel is used, it will be necessary to remove the lead deposits more frequently.

Keep Engine clean.

PLANT RUNNING HOURS COMPARED TO AUTOMOBILE RUNNING MILES

The engine of your generating plant makes as many revolutions in one hour, as the average automobile engine does when the car travels a distance of 41 miles.

100 running hours' time on a generating plant engine is equivalent in total RPM to approximately 4100 running miles on an automobile.

However, do not conclude that the wear on the generating plant engine and the wear on the automobile engine would be the same. The generating plant engine is built much more ruggedly, (having larger main bearings, bigger oil capacity and has a heavier crankshaft proportionately per horsepower) than most automobile engines. Given the proper care and periodic servicing the generating plant engine will continue to give many more hours of efficient service than an automobile engine will after having been run the equivalent number of running miles.

Compare the running time of your generating plant engine with the number of miles traveled by an automobile. The oil in an auto is checked every one or two hundred miles (3 to 5 hrs. running time) and changed every 1000 to 1500 miles (28 to 42 hrs.) Whereas in a generating plant or stationary power engine, the oil should be checked every 6 to 8 running hours (250 to 350 miles) and changed every 50 to 100 operating hours (2000 to 4000 miles) depending on operating conditions.

About every 5,000 to 10,000 miles (120 to 250 hours), services have to be performed on an auto, such as checking ignition points, replacing spark plugs, condensers, etc. Similarly on your generating plant engine, these same services have to be performed periodically except the change period is reckoned in hours. 10,000 miles on an auto is equivalent to about 250 running hours on your plant engine.

To arrive at an approximate figure of comparative generating plant running hours as against automobile engine running miles, multiply the total number of running hours by 41 to find the equivalent of running miles on an automobile.

Your generating plant engine can "take it" and will give many hours of efficient performance provided it is serviced regularly.

Below is a chart showing the comparison between a generating plant engine running hours and an automobile running miles.

	GENERATING PLANT RUNNING HOURS	AUTOMOBILE RUNNING MILES
DAILY AVERAGE	1 Hr.	41 Miles
	4 "	164 "
	6 "	246 "
	8 "	328 "
WEEKLY AVERAGE	7 "	287 "
	28 "	1,148 "
	42 "	1,722 "
	56 "	2,296 "

	GENERATING PLANT RUNNING HOURS	AUTOMOBILE RUNNING MILES
MONTHLY AVERAGE	30 Hrs.	1,230 Miles
	120 "	4,920 "
	180 "	7,380 "
	240 "	9,840 "
YEARLY AVERAGE	365 "	14,965 "
	1,460 "	59,860 "
	2,190 "	89,790 "
	2,920 "	119,720 "

NOTE: Electric generating plants do not operate economically when used to power electric refrigerators and will add from 4 to 8 operating hours per day in addition to the regular lighting load.

All engines are test run before leaving the factory to assure that each engine will produce its rated output. Each engine is inspected before shipment. However, before placing your engine in service check it over thoroughly, it may have been damaged in shipment. Damaged parts must be repaired or replaced.

This special design engine is used to power an alternating current generator used for either welding or electric power.

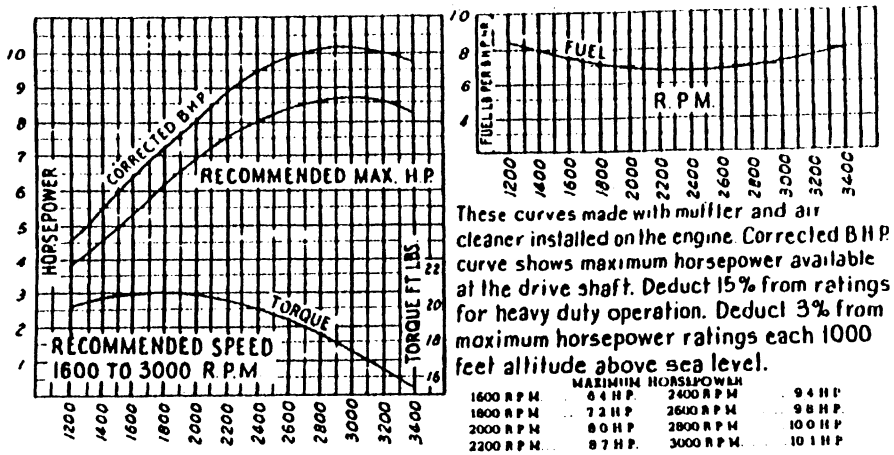
A speed control lever is used to change the nominal engine speed from 3100 rpm at no load, as desired for welding, to 1950 rpm at no load, as desired for electric power operation. The governor sensitivity adjustment is set to prevent a greater than 100 rpm speed drop when a full load is connected to the engine.

ENGINE DETAILS

TYPE: Opposed twin cylinders, 4-cycle, L-head, gasoline driven.
BORE: 3".
STROKE: 2-3/4".
COMPRESSION RATIO: 5.9 to 1.
HORSEPOWER RANGE: 6.5 to 10.1.
PISTON DISPLACEMENT: 38.8 cubic inches.
BASIC ENGINE CONSTRUCTION: Aluminum alloy.
IGNITION: Magneto.
FUEL SYSTEM: Fuel pump with primer, downdraft carburetor with adjustable main jet, oil bath type air cleaner, fuel filter.
LUBRICATION: Full pressure, gear driven, gear type oil pump.
OIL CAPACITY: 4 quarts U.S. Measure.
CRANKSHAFT: Extra heavy, fully counter-weighted and counter-balanced; tapered end for power take-off direct connection.
MAIN BEARINGS: Precision type, aluminum alloy, diameter 2", length 1-1/16".
CAMSHAFT BEARINGS: Steel backed, babbitt lined.
PISTONS: Aluminum alloy, 3 ring.
CONNECTING ROD BEARING SURFACE: Diameter 1-5/8", length 1-3/16".
COOLING: Air-cooled; axial flow turbine type fan.
STARTING: Hand cranking by pull rope.
GOVERNOR: Internal flyball; easily adjustable; with variable speed control attachment.
DIMENSIONS: See details on DIMENSIONAL OUTLINE herein.

SPEED-BOOSTER: Manifold-vacuum operated; supplements function of governor to sharpen speed regulation.

TABLE OF ENGINE OPERATION



These curves made with muffler and air cleaner installed on the engine. Corrected B H P. curve shows maximum horsepower available at the drive shaft. Deduct 15% from ratings for heavy duty operation. Deduct 3% from maximum horsepower ratings each 1000 feet altitude above sea level.

	MAXIMUM HORSEPOWER		
1600 R P M.	64 H P.	2400 R P M.	94 H P.
1800 R P M.	72 H P.	2600 R P M.	98 H P.
2000 R P M.	80 H P.	2800 R P M.	100 H P.
2200 R P M.	87 H P.	3000 R P M.	101 H P.

CONTROLS

These engines have magneto ignition and all controls needed for starting are supplied with the engine.

SPECIAL ACCESSORIES

MOUNTED FUEL TANKS. - Two gallon fuel tanks suitable for mounting on the engine are available in kit form. The kit contains shut-off brackets, fuel tank, fuel line, fuel strainer, and mounting hardware. The tank is to be mounted at the back of the engine.

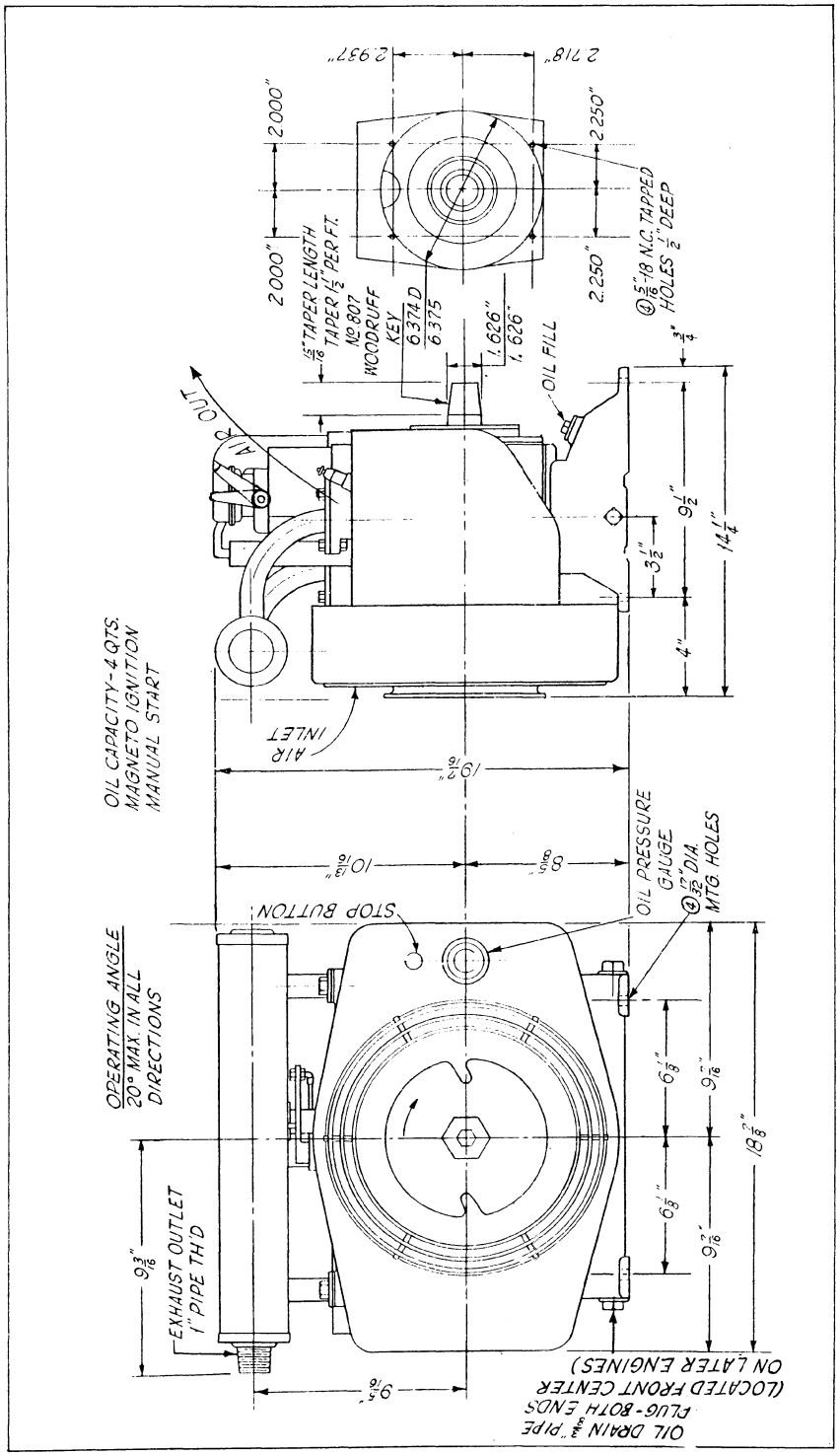
Too much emphasis cannot be placed on the importance of properly installing your engine. The life of the engine, its economy of operation, and the less frequent need for repairs and adjustments are a few of the factors that are dependent on proper installation.

Probably the most important factor in any installation is proper ventilation. An ample volume of fresh cool air must be supplied to the engine at all times for proper cooling. Where the engine is enclosed, recirculation of heated air within the enclosure must be prevented or engine troubles caused by overheating may occur.

The equipment of which this engine is a part is essentially portable. However, if this equipment is to be operated in an enclosure, several important factors should be performed. Conduct exhaust gases outside. Provide flexible exhaust tubing at the engine. Increase pipe size every 10 feet. Provide a condensation trap at each upward pitch. Shield and separate the line from inflammable material by at least 2 inches. Locate the equipment to allow access for servicing.

READI-PULL STARTER INSTALLATION. - Refer to the instructions given under the heading Starter, in the MAINTENANCE AND REPAIR section herein for installation of the self rewind manual rope starter.

DIMENSIONAL OUTLINE

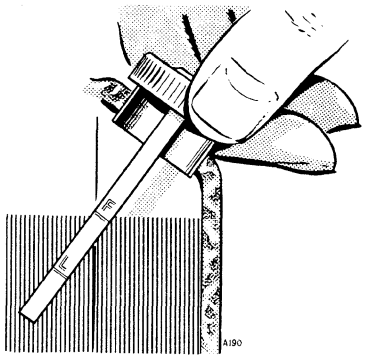


Do not attempt to operate your engine until it has been properly serviced with oil and fuel. Serious damage can result from running your engine even for just a minute or two without oil. Service as follows.

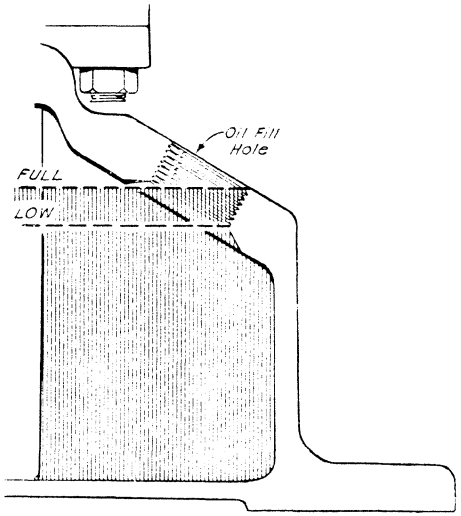
LUBRICATION

CRANKCASE. - Use detergent oils classified by the American Petroleum Institute as Service "DG" or, as marketed by most manufacturers, "MS/DG". The use of service "DS" is satisfactory, but its higher cost is not justified. Do not use a non-detergent oil unless unavoidable. Multiviscosity oils such as 5W-20 or 10W-30 are not recommended as the oil consumption increases greatly, in some cases consumption may be more than doubled.

The crankcase oil capacity of the engine is 4 quarts U.S. Measure. Use the SAE No. oil listed for the lowest temperature to which the engine will be exposed as given in the following table. Do not overfill as the connecting rods may strike the oil, causing it to foam, interfering with proper lubrication. Be sure to replace the oil filler plug or cap securely. Air leaking into the crankcase at this point may cause oil leakage.



BE SURE TO SCREW OIL FILLER CAP DOWN TIGHTLY.



- LATER MODELS - - EARLIER MODELS -

FIG. 1 - OIL LEVEL

LOWEST TEMPERATURE AT THE ENGINE	SAE NO. OIL
Above 90°F. (For continuous Duty) Above 32°C.	No. 50
Between 30°F. and 90°F. Between -1°C. and 32°C.	No. 30
Between 0°F. and 30°F. Between -18°C. and -1°C.	No. 10W
Below 0°F. Below -18°C.	No. 5 - Alternate No. 10 - 10W plus 10% kerosene.

Do not put oil diluted with kerosene into the crankcase until ready to start the engine. Mix well just before pouring into the crankcase.

Never run the engine when the oil level is below the low mark on the gauge. The oil level should be checked often until the operator is familiar with the natural oil consumption of the engine and as often thereafter as it is necessary to insure that the oil level never drops below the low mark.

GOVERNOR LINKAGE. - If available, use only powdered graphite on the governor ball joint to promote best performance and longest wear. Otherwise, use light oil on all governor joints.

AIR CLEANER. - Turn out the thumb screw on the underside of the air cleaner cup as far as it will go and remove the cup. Fill the cup to the level shown with oil of the same SAE No. as used in the engine crankcase. Replace the cup securely. See the illustration.

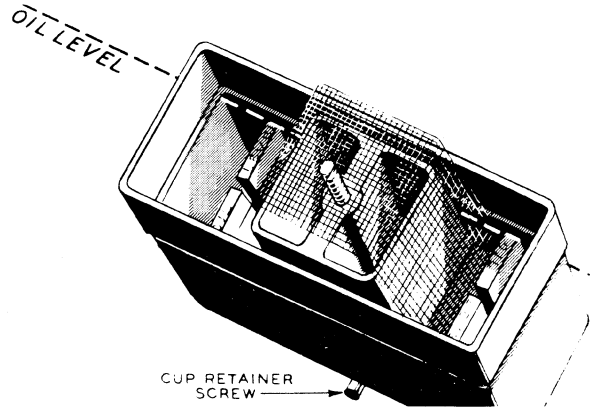


FIG. 2 - AIR CLEANER OIL LEVEL

FUEL (GASOLINE). - Fill the fuel tank nearly full with clean fresh regular gasoline of at least 68 octane. Do not use premium grade gasoline. Engine life will be greatest when fuel containing the smallest amount of lead is used. NEVER FILL THE FUEL TANK WITH THE ENGINE RUNNING. White gas may be used and is recommended providing you are sure that its octane rating is at least 68 and that the fuel is not what is commonly known as stove gas. DO NOT USE STOVE GAS UNDER ANY CONDITION.

GENERAL. - Before starting your engine be sure that the crankcase has been filled to the proper level with oil, the fuel tank filled with gasoline and that the shut-off valve in the fuel line is open. Recheck the installation carefully to see that everything is in good order. Be sure the load is disconnected from the engine where practicable. Then start the engine in the manner described.

STARTING THE ENGINE. - The fuel pump has a lever for hand priming. A short cable with a knob is attached to the priming lever. Before attempting to start the engine, work the knob in and out a few times to replace fuel probably lost from the carburetor by evaporation while the engine was not running. If the engine has stopped so that the lobe on the camshaft is lifting the fuel pump rocker arm, the engine must be cranked one revolution before the priming lever will be effective. Always LEAVE THE KNOB ALL THE WAY IN so that the priming lever does not prevent the normal operation of the fuel pump.

NOTE: Earlier engines did not have the hand priming feature. On those engines it is necessary to crank the engine to supply fuel to the carburetor. Be prepared for the starting of the engine because these engines have magneto ignition and will fire at a very low cranking speed. A fuel pump (top mounting) with the priming lever feature can be installed on earlier engines. The priming rod (cable) is available separately and must be mounted on one of the existing carburetor assembly screws. Refer to the parts catalog.

Insert the starting rope in a notch on the rope sheave and wind the rope in a clockwise direction around the sheave, leaving about six inches free at the handle end.

Pull the choke lever about 3/4 of the way closed.

Give a strong steady pull the full length of the rope. If the engine does not start at the first attempt, push the choke lever part way open and again crank the engine. Avoid overchoking. Overchoking causes oil dilution and excessive wear in internal parts.

After the engine starts, push the choke control lever open slightly until the engine runs smoothly. If the engine hunts (alternately gaining and losing speed), the mixture is too lean and needs a little more choking. If the engine sputters and is sluggish, the mixture is too rich and needs less choking. Allow the engine to warm up thoroughly. Open the choke slowly until it is all the way open and the engine continues to run smoothly. Always be sure the choke is fully open when operating the engine with load connected.

Continued failure of the engine to start readily usually points to trouble in the fuel or ignition system. Check each system thoroughly and make repairs or adjustments as needed. Failure of a new engine to start the first time may be caused by the inhibitor oil that was placed in the cylinders of the engine before shipment to prevent rust formation. To remedy, remove the spark plugs and clean them in gasoline. Then replace the plugs, being sure the gasket is in place.

APPLYING THE LOAD

When applying the load to a new or reconditioned engine, it should be applied gradually in about 4 steps; each step of not less than 30 minutes running time. Start with 1/4 load, then 1/2, 3/4 and finally full load. The maximum end thrust to the main bearings should not exceed 1000 pounds.

MAXIMUM HORSEPOWER AT VARIOUS SPEEDS

1600 R.P.M.	- 6.4 H.P.	2400 R.P.M.	- 9.4 H.P.
1800 R.P.M.	- 7.2 H.P.	2600 R.P.M.	- 9.8 H.P.
2000 R.P.M.	- 8.0 H.P.	2800 R.P.M.	- 10.0 H.P.
2200 R.P.M.	- 8.7 H.P.	3000 R.P.M.	- 10.1 H.P.

STOPPING THE ENGINE. - Disconnect all load before stopping the engine, where practicable.

The engine is stopped by pushing in firmly on the STOP button, located on the blower housing, until the engine completely stops running.

In an emergency, such as failure of the STOP button to work, the engine may be stopped by shutting off the fuel supply. Another way is to pull the choke control knob out to the limit of its travel. This method should be used only in extreme cases.

POINTS TO CHECK AFTER STARTING THE ENGINE. - Check the oil pressure and inspect the general operation.

The oil pressure of your engine should be between 15 and 25 pounds at normal operating temperature. The reading will be high until the engine is warmed up. If the pressure is not within the limits given, turn to the heading OIL PRESSURE RELIEF VALVE ADJUSTMENT in the Accessory Service section for instructions on adjusting.

Make a visual inspection of the entire installation. Check for fuel leakage, loose connections, loose bolts, nuts or screws, and anything else that might require attention. Make adjustments as needed.

VARIABLE SPEED GOVERNOR OPERATION. - These engines are equipped with a variable speed control on the governor. Engine speed can be changed by simply changing the position of the lever marked "INCREASE - DECREASE". The position of this lever determines the tension applied to the governor spring and engine speed is controlled at any given speed setting from idling speed to full throttle.

Later built engines have a metal plate (called a quadrant) with settings "WELDING" and "POWER" shown. The tension and position of the governor spring are adjusted for the speed desired at each of these lever positions. If readjustment is necessary refer to governor adjustment in the Accessory Service section.

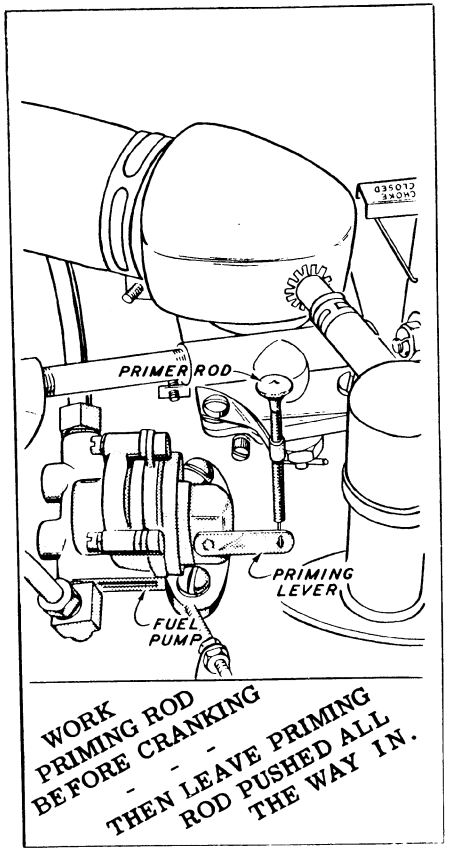


FIG. 3 - PRIMING THE FUEL PUMP

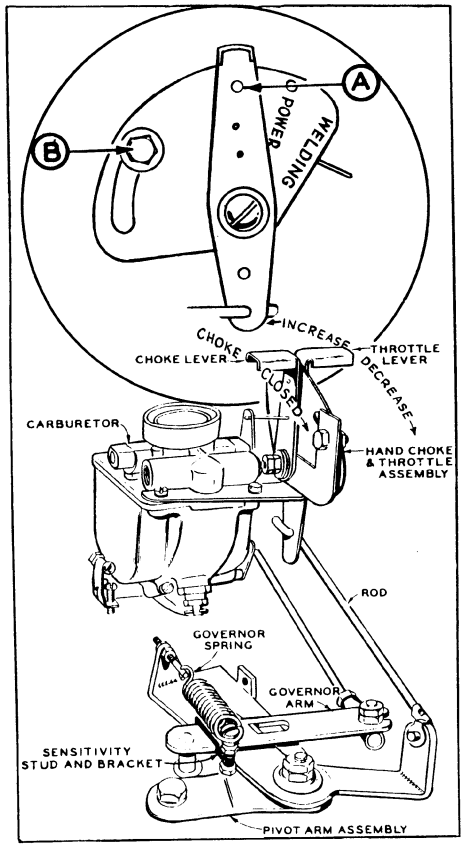


FIG. 4 - OPERATING SPEEDS

LOW TEMPERATURE

LUBRICATION. - If the engine is to be run at temperatures of 0°F. (-18°C.) or below and the crankcase oil has not already been prepared for engine operation at these temperatures, proceed as follows:

Remove the drain plug from the oil drain fitting and drain the old oil from the oil base while the engine is warm. Then replace the drain plug.

> CAUTION: Starting the engine at low temperature with heavy oil in the crankcase may cause serious damage through lack of lubrication. If the oil in the crankcase is heavier than SAE No. 10 and the engine has been standing idle in an unheated location, some means of heating the room in which the engine is located should be provided. The engine should be warm enough so the oil flows freely from the oil drain before attempting to start it. Then start the engine and run it for several minutes to warm it up before draining the oil. NEVER ADD KEROSENE ALONE TO THE CRANKCASE TO DILUTE THE OIL.

Refill the crankcase to the high mark with SAE No. 5 oil. Then start the engine immediately and run for at least 10 minutes to thoroughly circulate the oil. If SAE No. 5 oil is not available locally, thoroughly mix 1 pint of kerosene with 3-1/2 quarts (U.S. Measure) of SAE No. 10 or 10W oil and refill the crankcase to the full mark. Then start the engine and run it for at least 10 minutes to thoroughly circulate the mixture.

When using oil diluted with kerosene, change the oil every 50 hours of running time and check the crankcase oil level at least once every 6 to 8 hours of running time. Mix oil in the proportions given in LUBRICATION under Preparation when adding oil between changes.

AIR CLEANER. - Under certain weather conditions frost may form in the air cleaner or the oil may congeal, restricting the flow of air to the carburetor. Should either of these conditions exist, remove the air cleaner cup and body and clean them thoroughly in gasoline or other suitable solvent. Reassemble the air cleaner and use it without oil until temperature conditions permit the use of oil in the normal manner.

FUEL. - Keep the fuel tank nearly full to prevent condensation within the tank. Use only good fresh, regular grade, winter fuel of at least 68 octane. DO NOT USE PREMINUM GRADE GASOLINE. NOTE: A vapor lock may occur when using winter grade fuel if the engine is operated in an enclosed room where the temperature exceeds 70°F. When the engine is running, the blower supplies ample air to cool the fuel pump enough.

However, after the engine has been stopped for 10 to 20 minutes the fuel pump reaches its highest temperature and vapor lock is most likely to occur. If a vapor lock occurs, the ambient temperature at the engine is too high. Open existing building ventilators more, or provide additional ventilation.

VENTILATION. - The engine will usually operate more efficently if the air inlet and outlet openings are partially closed. Do not close them entirely. There must be a free circulation of cooling air around the engine and recirculation of heated air around the engine must be prevented. The radiated heat from the engine when it is running is usually enough to more than adequately heat the space in which the engine is located.

IGNITION SYSTEM. - Keep the ignition system properly adjusted. See that the spark plugs are clean and have the correct gap at the electrodes. Check the breaker points. Clean and adjust to the correct gap. Replace if necessary.

HIGH TEMPERATURES

LUBRICATION. - The oil level in the crankcase must be kept at or near the full mark on the gauge at all times. A low oil level may cause the engine to run hot and cause excessive wear on engine parts. Do not overfill the crankcase as too high an oil level will allow the connecting rods to strike the oil, causing it to foam, and parts which are normally oiled by spray are not properly lubricated.

Drain the oil from the crankcase and refill with the SAE No. oil recommended for the prevailing temperatures every 100 operating hours.

VENTILATION. - Keep the cooling surfaces of the engine as clean and free of dirt and grease as you can. If necessary provide more air inlet and air outlet openings to prevent recirculation of heated air to the engine and to keep the room temperature down.

IGNITION SYSTEM. - Keep the ignition system properly adjusted. A retarded ignition causes overheating. Advanced ignition reduces efficiency. Check all ignition wires and connections. Keep the spark plugs and breaker points clean and properly adjusted.

DUST AND DIRT

If your engine is to be run under adverse conditions such as near to other equipment where foreign matter is likely to be picked up by the air stream to the carburetor or is likely to foul cooling surfaces, check the engine and service more often as follows:

CLEANLINESS. - Keep the engine and accessories as clean as you can. Clean as often as needed.

FUEL AND OIL. - Keep supplies of fuel and oil in air tight containers. A piece of lint in the oil may plug an oil passage and burn out a bearing. Dirt in the fuel may plug one of the carburetor jets causing irregular running of the engine.

AIR CLEANER. - Check the air cleaner often. Clean the air cleaner and put in fresh oil as often as needed. Install a heavy duty air cleaner if necessary.

HIGH ALTITUDE

FUEL MIXTURE. - If the unit is to be operated at an altitude of 2,500 feet or more above sea level, adjust the carburetor main jet for a slightly leaner mixture to obtain maximum available power. The carburetor was factory adjusted for best performance at approximately 860 feet altitude. Because the air becomes less dense as the altitude increases, less fuel is required to maintain the proper air-to-fuel ratio. Consequently, any engine will develop less power at higher altitudes. The usual altitude de-rating amount is approximately 4 percent for each 1,000 feet above sea level.

The efficiency of your engine depends a great deal on the care and attention you give it. By following a definite schedule of inspection and service you can avoid engine failures caused by neglect. Service periods are based on hours of running time and are for normal operating conditions. For extreme conditions of load, dust, dirt, etc., service more often.

DAILY SERVICE

If the engine is to be run more than 8 hours daily, perform the following services at the end of each 8 hours of running time.

CRANKCASE OIL LEVEL. - Check the crankcase oil level. If necessary add proper oil to bring the crankcase oil level to the full mark. Never allow your engine to run when the oil level is below the low mark on the gauge. Do not overfill the crankcase as the connecting rods may strike the oil, cause it to foam, and interfere with proper lubrication. Always be sure the oil filler plug is securely tightened. Air leaking into the crankcase at this point may cause oil leakage.

FUEL. - Check the fuel supply. The amount of fuel used will vary due to load conditions, operating conditions, etc. Fill the fuel tank as often as needed to assure a continuous supply of fuel. Stop the engine when refilling the tank. Use good fresh regular gasoline of at least 68 octane. DO NOT USE PREMIUM GRADE GASOLINE.

AIR CLEANER. - Add oil, of the same SAE No. as used in the crankcase, as necessary to raise the oil to the level marked on the air cleaner cup. See also Abnormal Operating Conditions.

GENERAL. - Keep the cooling surfaces of your engine clean and free of dust, dirt, and grease. Wipe off any spilled oil from engine surfaces. Keep oily rags in metal containers or destroy them to limit fire hazard.

WEEKLY SERVICE

If the engine is to be run more than 50 hours weekly, perform the following services at the end of each 50 hours of running time.

CRANKCASE. - Check the oil level and add proper oil as needed to bring the oil level up to the full mark. Change oil if necessary. Run the engine until warm before draining the oil or drain the oil just after the engine has been in operation. Change oil every 100 hours of running time unless it has been necessary to use oil diluted with kerosene or to use highly leaded fuel, then change oil every 50 hours of running time.

GOVERNOR LINKAGE. - If available, use only powdered graphite on the governor ball joint to promote best performance and longest wear. Otherwise, use light oil on all governor joints.

AIR CLEANER. - Remove the oil cup by unscrewing the thumb screw at the bottom of the air cleaner. Clean the cup and screen in gasoline or other suitable solvent and dry thoroughly. Refill the cup to the level shown in the cup with oil of the same SAE No. used in the engine crankcase. Replace the cup and screen.

SPARK PLUGS. - Remove the spark plugs and clean them thoroughly with a stiff wire brush or with a regular plug cleaning machine. Check the electrode gap and reset to .025 inch if necessary. Then replace the plugs. If highly leaded fuels are used, the spark plugs will need cleaning more often.

MONTHLY SERVICE

If the engine is to be run more than 200 hours monthly, perform the following services at the end of each 200 hours of running time.

FUEL SYSTEM. - Close the fuel line shut-off valve and remove the sediment bowl and screen from the filter. Thoroughly clean the bowl and screen. Inspect the gasket. Replace it if necessary. If fuel does not flow freely from the tank, clean the strainer in the tank outlet. Reassemble the gasket, screen and bowl and open the fuel line shut-off valve. Inspect for leaks and correct any found.

IGNITION. - Remove the cover from the breaker box and inspect the breaker points. If the points are badly burned or pitted, install a new set of breaker points. If the points are still good, clean them up with a fine stone. Check the point gap and adjust to .020 inch if necessary. Complete instructions on timing the ignition are given in the Maintenance and Repair section.

Check the ignition condenser. The only sure way is to use a condenser tester. However, if the points continually burn over or the spark is weak and yellowish in color, it usually points to a defective condenser and the condenser should be replaced.

EXHAUST. - Inspect all exhaust connections. Tighten or replace all parts needing it.

VALVE GRINDING. - Valve grinding is a service that must be performed periodically if your engine is to continue operating efficiently. There is no set period for performing this service. Some engines may need a valve job more often than others due to load conditions, type of fuel used, etc. However it is recommended that the following tests be made at the end of each 250 hours of running time or whenever your engine begins to lose power or consume an excessive amount of fuel or oil.

Check the compression of each cylinder with a reliable compression gauge while the engine is still warm and as soon after stopping the engine as you can. The compression of each cylinder in a new engine at sea level is about 90 lbs. at hand cranking (105 lbs. elec. cranking) speed. Compression readings of the cylinders should be within 10 lbs. of each other and high enough to assure no loss of power. A low compression reading may point to either a poor valve condition or to worn or sticking piston rings, worn piston ring grooves, or worn cylinder walls. An excessively high compression reading may point to a heavy carbon formation within the cylinders.

Remove the spark plugs, pour only enough SAE No. 50 oil into each cylinder to seal the rings and again take compression readings. If the readings were low and remain about the same, the valves probably need servicing. However, if the readings have increased quite a bit, the valves are probably in good condition and loss of compression may be due to worn or sticking piston rings, worn piston ring grooves, or worn cylinder walls. Instructions for servicing these parts are given in the Maintenance and Repair section of this manual.

If a compression gauge is not available, check the compression of each cylinder by rocking the flywheel past the compression stroke while the engine is warm. If the compression is good, a lot of effort will be needed to rock the flywheel past the compression stroke. If the compression is poor, little effort is needed to rock the flywheel past the compression stroke.

CARBON REMOVAL. - Carbon should be removed from the engine about every 250 hours of running time. If a compression test shows that other work is necessary, combine carbon removal with the other work. Remove the cylinder air housings and the cylinder heads and clean the carbon from the cylinder heads, pistons, valves, valve seats and if necessary the valve guides. If highly leaded fuels are used, the carbon may have to be removed more often.

GENERAL. - Check the engine thoroughly for loose nuts, bolts, screws, connections, etc. Tighten or replace as needed.

CRANKCASE BREATHER. - Lift the rubber cap from the breather tube. Inspect the check valve in the breather tube. Frequently the breather valve will lift off with and remain inside the rubber cap. Pry it out. If the disc does not work freely, service as instructed under Accessory Service.

NOTE: On earlier built engines the carburetor air inlet adapter is metal instead of rubber. On those engines the carburetor air inlet adapter must be removed to service the breather valve.

SEMI-YEARLY SERVICE

If the engine is run more than 1200 hours semi-yearly, perform the following services at the end of each 1200 hours of running time.

IGNITION BREAKER. - Place a drop of light oil on the breaker arm pivot shaft to prevent the arm from sticking. See the illustration, Servicing the Ignition Breaker Points.

CARBURETOR. - Remove the air inlet from the carburetor and inspect the venturi. This is the tube or tunnel through which the air passes and mixes with the gasoline. If any carbon deposits are in evidence, the carburetor must be removed from the engine and thoroughly cleaned.

INTERNAL. - Drain the oil from the oil base and remove the oil base. Check all internal parts for wear or improper clearance. Repair, adjust or replace as needed. Clean the oil base and oil pump suction cup screen. Reassemble all parts and refill the crankcase with proper grade oil.

AIR CLEANER. - Clean the wire crimp (element) in the air cleaner. Remove the cleaner from the engine. Remove the oil cup. Immerse and agitate the cleaner in gasoline or suitable solvent. Dry and reoil the internal element.

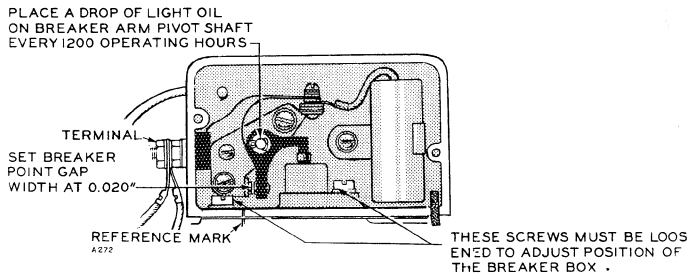


FIG. 5 - SERVICING THE IGNITION BREAKER POINTS

Instructions for making adjustments and servicing parts which may cause trouble if not properly adjusted or are not working right are contained in this section. Some of these parts are not necessarily of an accessory nature but are covered because they may require servicing from time to time. If trouble develops, follow an orderly procedure in determining the cause before making any adjustments. Turn to the section on Troubles and Remedies for help in checking causes of troubles which may occur.

CARBURETOR ADJUSTMENT. - The carburetor has adjustable main and idling jets. Refer to the illustration. It is simple in construction and normally requires little attention other than a periodic cleaning. If the engine runs unevenly at half or full load due to faulty carburetion, the main adjusting needle needs adjusting. Make the adjustment while the engine is running at normal operating temperature and with almost a full load connected to the engine.

Turn the main adjusting needle out about two full turns. Then turn it slowly in until the engine begins to lose power and speed. Then turn it out very slowly until the engine runs smoothly at full power and speed.

When adjusting the idle jet needle, the engine should be running at normal operating temperature and without a load connected. Turn the idle adjusting needle in until the engine loses considerable speed. Then turn it out until the engine runs smoothly. A hunting condition at no load can sometimes be corrected by an idle adjustment.

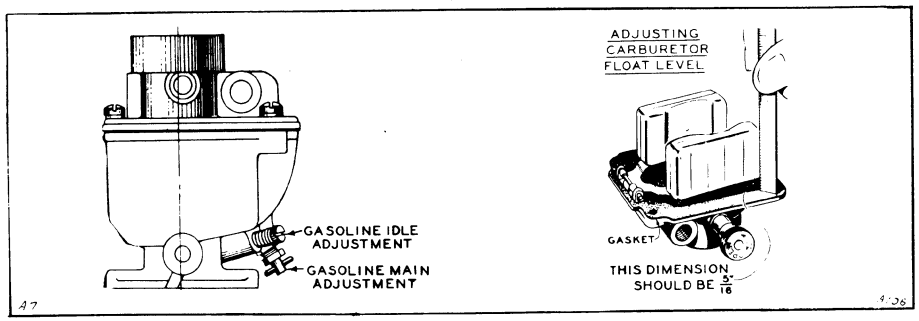


FIG. 6 - CARBURETOR ADJUSTMENTS

To adjust the carburetor float level, bend the float near the shaft as needed to obtain the correct level as shown.

If the engine speed is governor controlled and the engine develops a hunting condition (alternate increase and decrease of engine speed) try correcting by opening the main adjusting needle a little more. Do not open more than 1/2 turn beyond the maximum point of power. If this does not correct the condition, follow the instructions for regulating the sensitivity of the governor under GOVERNOR ADJUSTMENT.

SPARK PLUGS. - To clean carbon from the spark plugs, use a stiff wire brush or a regular plug cleaning machine. After cleaning, reset the electrode gap to 0.025 inch. Use Champion H-8 COMM (Type "A") or a comparable type made by another manufacturer when replacing spark plugs.

CRANKCASE BREATHER VALVE. - If the engine begins to leak oil, the valve in the breather tube may be sticking. Lift the rubber cap from the breather tube. Then lift out the valve and inspect it. Frequently the breather valve (check valve) will lift off with and remain inside the rubber cap. Pry it out. First soak then wash the valve in kerosene or suitable solvent so that the disc will work freely. Run the engine and hold the valve assembly in place to prove it opens and closes. Replace a faulty valve with a new one. If the metal mesh type baffle, used in the breather tube of later engines, is completely restricted by sludge, etc., lift it out with a hooked wire, clean and reinstall it or a new one, leaving only 2-1/4" of empty space in the top of the breather tube. Avoid crushing the baffle or allowing shreds to fall into the crankcase. An internal retainer ring stops the baffle from falling through. Reassemble the valve as illustrated.

NOTE: On earlier built engines the carburetor air inlet is metal instead of rubber. On those engines the inlet must be removed to service the breather valve.

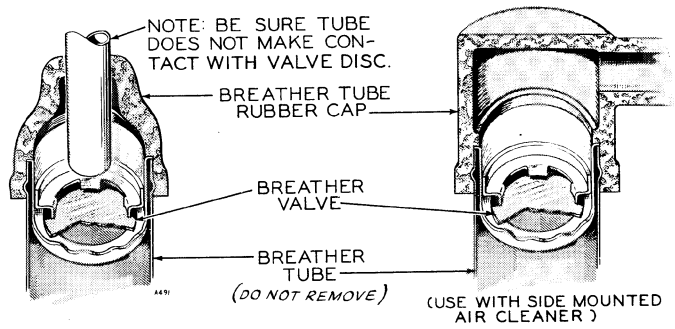


FIG. 7 - SERVICING THE CRANKCASE BREATHER

OIL PRESSURE RELIEF VALVE ADJUSTMENT. - Engine oil pressure is easily adjusted by means of the slotted stud and locknut located near the breather tube. See the illustration. Oil pressure readings when the engine is thoroughly warmed up should be between 15 and 25 pounds. To increase oil pressure, loosen the locknut and turn the stud inward. To decrease oil pressure, loosen the locknut and turn the stud outward. Be sure to tighten the locknut securely after making an adjustment. The spring and plunger can easily be removed and cleaned.

Low oil pressure may point to worn main or connecting rod bearings, improper clearance at these points, a weak or broken by-pass spring, an improperly adjusted by-pass or a defective gauge. Check the oil pressure gauge before making any other test, it may be defective.

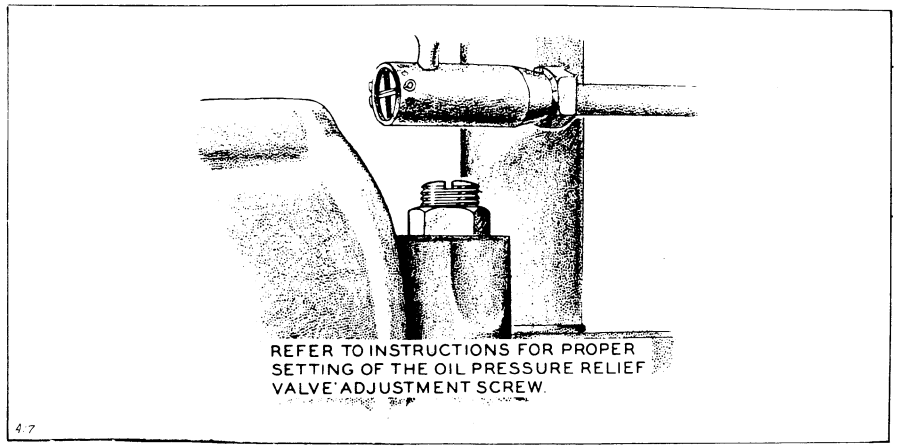


FIG. 8 - OIL PRESSURE RELIEF VALVE ADJUSTMENT

FUEL PUMP. - A diaphragm type fuel pump is used. If fuel does not reach the carburetor, check the fuel pump before dismantling it. The pump can be checked by disconnecting the fuel line at the filter, turning the engine over slowly by hand, and noting whether fuel comes from the line at the filter. If there is enough fuel in the tank, and the line between the tank and the pump is open but the pump will not operate, repair or replace it. Failure of the pump to operate is usually due to a leaking diaphragm, valve or valve gasket, a weak or broken spring or wear in the drive linkage. Repair kits for the fuel pump are available. See SERVICE KITS in the parts list.

NOTE: If the fuel pump has a hand priming lever, ALWAYS LEAVE THE PRIMING ROD KNOB ALL THE WAY IN so that the priming lever does not prevent the normal operation of the pump.

When installing a drive link or the rocker arm shaft, place it in position as shown in the illustration. Rotating the diaphragm 1/4 turn will disengage the drive link.

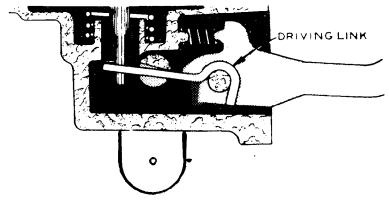


FIG. 9 - FUEL PUMP DRIVE LINK INSTALLATION

GOVERNOR ADJUSTMENT. - Proper governor adjustment is one of the most important factors in maintaining the power and speed desired from the engine.

Carefully study the related subjects in the following paragraphs and check each point in the order given before attempting adjustments on the governor:

1. GENERAL. - Before making governor adjustment, run the engine about 15 minutes to reach normal operating temperature.

If the engine is being run with the throttle wide open, either the governor is not properly adjusted or the engine is overloaded.

It is difficult to determine if after long usage the governor spring has become fatigued. If after properly making all other adjustments the regulation is still erratic, install a new spring.

A reliable instrument for checking engine speed is required for accurate governor adjustment. Engine speed can be checked with a tachometer. Another method is to check the frequency of a connected electrical output load.

Check the governor arm and linkage and the throttle shaft and lever for a binding condition and for excessive slack or wear at connecting points. A binding condition at any point will cause the governor to act slowly and regulation will be poor. Excessive looseness will cause a hunting condition and regulation will be erratic. Work the arm back and forth several times by hand while the engine is idle. If either of these conditions exist, find out where the trouble lies and adjust or replace parts as needed.

Tighten any loosened screws which mount the variable speed governor control levers before making any speed adjustment settings.

2. STEPS TO FOLLOW. - This gives the procedure only briefly. Refer to the details on each subject herein.

a. Adjust the carburetor main jet for the best fuel mixture at speed for POWER operation and full load connected.
b. Adjust the carburetor idle needle with no load connected.
c. Adjust the length of the governor linkage.
d. Check the governor linkage and throttle shaft for binding or excessive looseness.

e. Adjust the governor spring tension for engine speed for WELDING operation.
f. Adjust the governor sensitivity.
g. Recheck the speed adjustment.
h. Set the throttle quadrant for desired engine speed for electric POWER operation.
i. Set the carburetor throttle stop screw.
j. Set the vacuum speed-booster.

3. LINKAGE. - The engine starts at wide open throttle. The length of the linkage connecting the governor arm to the throttle shaft and lever is adjusted by rotating the ball joint. Adjust this length so that with the engine stopped and tension on the governor spring, the stop on the carburetor throttle shaft just contacts the underside of the carburetor bowl. This setting allows immediate control by the governor after starting. It also synchronizes the travel of the governor arm and the throttle shaft.

4. SPEED ADJUSTMENT. - The speed at which the engine operates is determined by the tension applied to the governor spring. Increasing spring tension increases engine speed. Decreasing spring tension decreases engine speed. Governor tension and thereby engine speed is controlled at any given point between minimum and maximum by simply shifting the lever marked INCREASE-DECREASE.

The lever is all the way toward INCREASE for WELDING operation. Shift the lever to WELDING position and adjust the spring tension by the adjusting nut so that the engine with no load connected runs at about 3100 rpm. Except for certain earlier models, speed limits are 3050 rpm. minimum to 3200 rpm. maximum. Lock the adjustment with the second nut.

NOTE: Certain earlier built engines did not have a speed adjusting nut, instead the spring attaching bracket must be bent.

5. SENSITIVITY ADJUSTMENT. - Refer to the illustration inset "D". The engine speed drop from no load to full load must be within 100 rpm. First, operate the engine with the variable-speed-governor-control lever at WELDING position (all the way INCREASE direction). Check the engine speed with no load connected and again after connecting a full load.

To increase sensitivity (reduce rpm drop between no load and full load) move the stud and bracket toward the governor shaft. An adjustment too close will cause hunting (alternate increase and decrease of engine speed). A fuel mixture too lean will also cause a hunting condition.

To decrease sensitivity move the sensitivity stud away from the governor shaft.

The correct position of the sensitivity stud will give the closest regulation without any hunting condition.

Always recheck the speed adjustment after a sensitivity adjustment. Increasing sensitivity will cause a slight decrease in speed and will require a slight increase in the governor spring tension.

6. THROTTLE QUADRANT. - Set the throttle quadrant to match with the throttle lever at electric POWER position. First move the throttle lever to run the engine at 1950 rpm with no load connected and with the booster (where used) disconnected. At this lever position, set the throttle quadrant so that the hole in the quadrant matches with the rivet head on the throttle lever.

NOTE: Certain earlier built engines do not have the quadrant.

7. THROTTLE STOP SCREW. - The throttle lever stop screw should be set at 1/32 inch distance from the manifold when the engine is operating at POWER speed with no load connected (approximately 1950 rpm). This setting will result in an idling speed of approximately 1275 rpm.

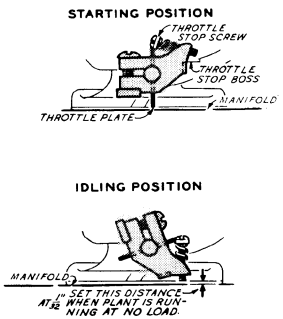


FIG. 10 - THROTTLE STOP LEVER POSITION

8. VACUUM SPEED-BOOSTER. - The speed-booster is operated by manifold vacuum. It will provide increased engine speed and better regulation when operating the **machine in the POWER** position. It does not affect performance when the machine is being used in the WELDING position.

To set the booster, first perform all engine governor speed and sensitivity adjustments while having the booster disconnected. Refer to the illustration "INSET E". Then set spring clip "A" so that there will be exactly zero spring tension when the engine is running at no-load in the POWER position. Apply a full electrical load to the "light-plant" side of the machine (21 amperes at 220 volts), and pull out the booster spring "E" until there is a minimum change in engine speed between no-load and full load. To increase the booster effect, pull out spring bracket "E". Booster failure may be due to an obstructed passage to the manifold (clean with a soft wire), to a leaky diaphragm or gasket, or to a fatigued spring (replace defective parts).

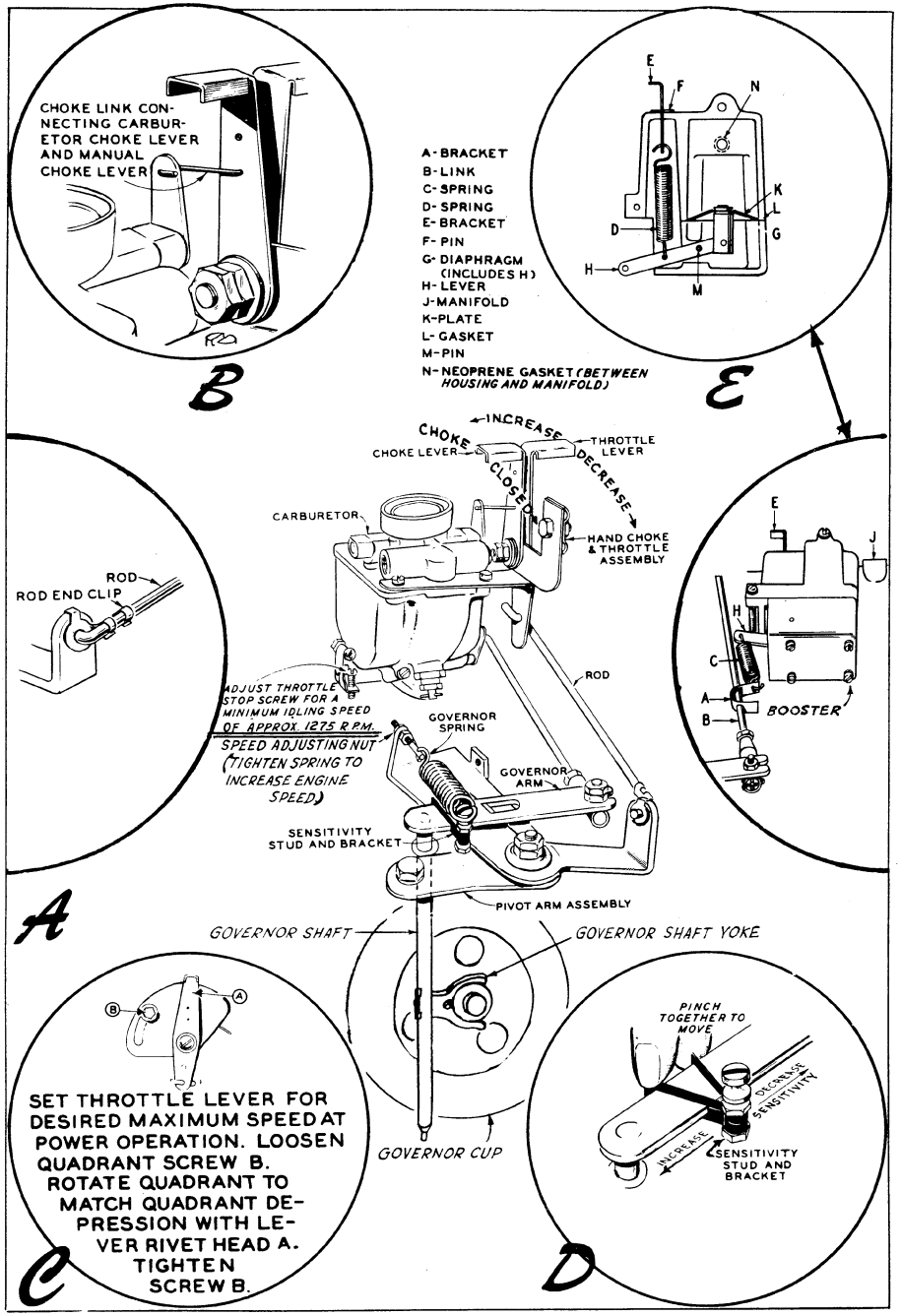


FIG. 11 - VARIABLE SPEED GOVERNOR ADJUSTMENTS

GENERAL. - Certain new engines when leaving the factory have an oversize cylinder bore. This oversize is indicated by the addition of a letter to the plant serial number. For example: Serial No. 48.382425E, the letter E indicating .005" oversize. Also the oversize is stamped on a flat metal surface near the left hand valve box. The piston oversize is stamped on top of the piston. If oversize valve seat inserts have been used, the actual oversize will be stamped on the cylinder block bevel just above the insert.

Pistons and rings are available in various oversizes for rebore jobs. See the parts list. Piston pins and valve seat inserts are also available in the oversizes shown in the parts list. Before ordering any repair parts that may be needed in an oversize, check the serial number of your plant and the positions of the oversize stampings as noted above.

ENGINE

CYLINDER BLOCK INSPECTION. - The need for major repairs to the engine can usually be determined, after draining the oil, by removing the oil base and feeling the fits of the working parts. Also by using a trouble lamp and carefully looking over the inside of the crankcase. If your experience with engines is limited, any competent mechanic should be able to help you decide on the need for repairs. Drain the oil whenever servicing bearings, timing gears, rods, rings, or pistons. Thoroughly clean the oil pump screen and oil base before replacing the base.

COMPRESSION READINGS. - Loss of power, failure of the engine to produce its rated output, may point to a loss of compression. See VALVE GRINDING under Periodic Service for testing compression. Loss of compression may be due to leaking spark plugs, spark plug gaskets, valves, cylinder head gaskets, carbon deposits on valve seats, worn cylinders, or piston rings. A compression leak past the piston rings may be heard at the oil filler opening. Compressed gases leaking past an exhaust valve can be heard at the exhaust outlet of the plant. If compressed gases are leaking past an intake valve, a hissing noise may be heard through the carburetor. If any valve is leaking, all valves should be serviced. Unusually high compression readings point to heavy carbon deposits on the cylinder heads and pistons. Remove the cylinder heads and scrape the carbon from the pistons, cylinder heads, and valves.

CYLINDERS. - When making major repairs to the engine, it is well to have the cylinders measured for wear. This requires the use of a micrometer. The standard cylinder bore size appears in the the Table of Clearances. If the new engine was bored to oversize originally, the bore will be .005 inch over. If the cylinder bore measures more than .005 inch out of true, the cylinders should be refinished

to use the next available oversize pistons. Pistons are available in .005", .010", .020", and .030" inch oversize. Piston rings are available in .010", .020", and .030" oversize. Some .005" oversize rings are available for use on .005" O.S. pistons; otherwise use standard size.

If the cylinder walls do not need refinishing, it is advisable to remove the ridge from the top of the cylinder sleeve before replacing the pistons and rings. Also read the following paragraph on PISTON AND PISTON RING SERVICE.

PISTON AND PISTON RING SERVICE. - Each piston has two compression rings and one oil control ring. Inspect the rings carefully for fit in grooves, for tension, and for seating on cylinder walls. If there is any doubt about the condition of the old piston rings, install new rings.

Inspect each piston. If the pistons are badly scored, very loose in the cylinders, have badly worn ring grooves, or otherwise are not in good condition, install new pistons. Install new pistons if the old ones are loose on the piston pins and .005 inch oversize piston pins will not correct it. Handle pistons carefully to avoid nicking the walls. Any raised surface of this type must be dressed down carefully with a fine stone.

CAUTION: When installing split skirt type pistons, the split must be installed so that it does not take the thrust on the power stroke of the engine. On the left hand (No. 1) cylinder (When facing the flywheel) the split in the piston skirt should be toward the manifold when in operating position. On the right hand (No. 2) cylinder the split in the piston skirt should be toward the oil base when in operating position.

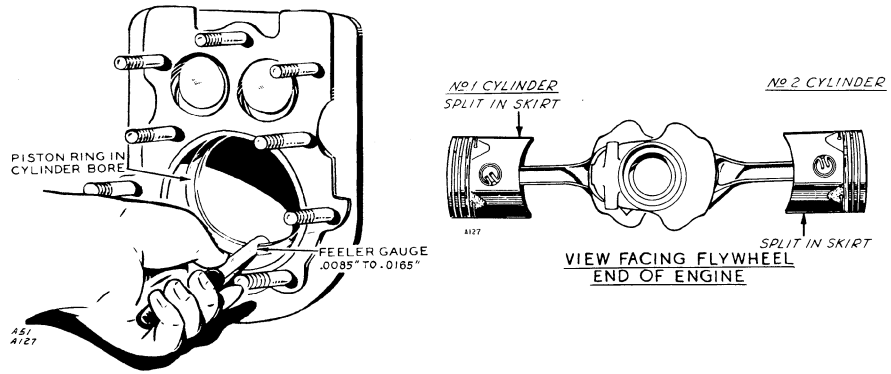


FIG. 12 - FITTING PISTON RINGS TO THE CYLINDER

When installing piston rings, fit each ring singly to its cylinder from the top. See Figure 12. The correct ring gap while in the cylinder is between .0085 and .0165 inch. Rings usually need some filing at the ends to obtain the right gap. Do not use rings that need a lot of filing as they will not seat properly on the cylinder walls. Install the rings on the pistons. Rings of the tapered type will be marked "TOP", or identified in some other manner, and this identifying mark must be placed nearer the top of the piston. Space each ring gap 1/3 of the way around the piston from each other, being sure no ring gap is directly in line with the piston pin.

CONNECTING RODS. - The connecting rods should be serviced at the same time the piston or piston rings are serviced as the rods must be removed with the piston. This requires draining the crankcase oil and removing the oil base, cylinder air housing and the cylinder heads. Rods are available in standard size or .020" undersize.

The connecting rod bearing surface is aluminum alloy and proper clearance between the rod bearing surface and the crankshaft journal surface is obtained by dressing the connecting rod cap. The correct clearance is between .002 and .003 inch. Place a sheet of (320 grit or finer) abrasive cloth on a smooth flat surface. Place the ends of the connecting rod cap on the abrasive material and carefully dress the ends down as needed. Be sure the cap is held perfectly straight. Remove all abrasive from the cap before installing it. Install the connecting rods and caps with the numbers facing toward the oil base, the rod and cap numbered "1" on the crankshaft journal nearest the timing gears. Coat the crankshaft journal bearing surfaces with oil before installing the rods. Turn the engine over by hand to see that the rods are free. If necessary, rap the connecting rod cap sharply with a heavy soft hammer to set the rod square on the journal.

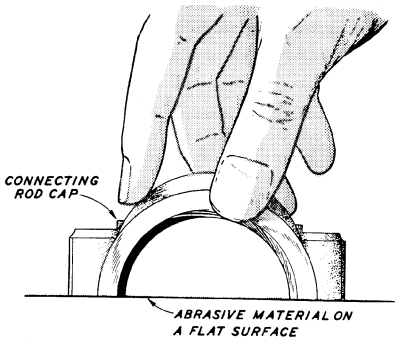


FIG. 13 - REDUCING CONNECTING ROD CLEARANCE

VALVE SERVICE. - The cylinder heads must be removed from the plant whenever servicing the valves. When removing the cylinder heads, rap sharply with a soft hammer to loosen. Do not use a pry. Remove the valves, valve springs, retainer washers, and valve guides. See Fig. 14.

Clean all carbon from the cylinders, cylinder heads, valves, valve seats, valve stems, valve faces, and valve guides. Check the valves carefully. Any valves that are badly burned must be replaced.

Correct valve SEAT angle is 45°. Correct valve FACE angle is 44°. This 1° interference angle results in a sharp seating surface between the valve and the top of the valve seat. The interference angle method of grinding valves minimizes face deposits and lengthens valve life. The valve should not be hand lapped, if at all avoidable, since the sharp contact may be destroyed. The finished seat must be between 3/64 and 5/64 of an inch wide. Before lightly grinding each valve to its seat, read the paragraph on VALVE ADJUSTMENT. Be sure to remove all grinding compound from engine parts. Locate each valve in its proper place when reassembling. The larger valves are the intake valves.

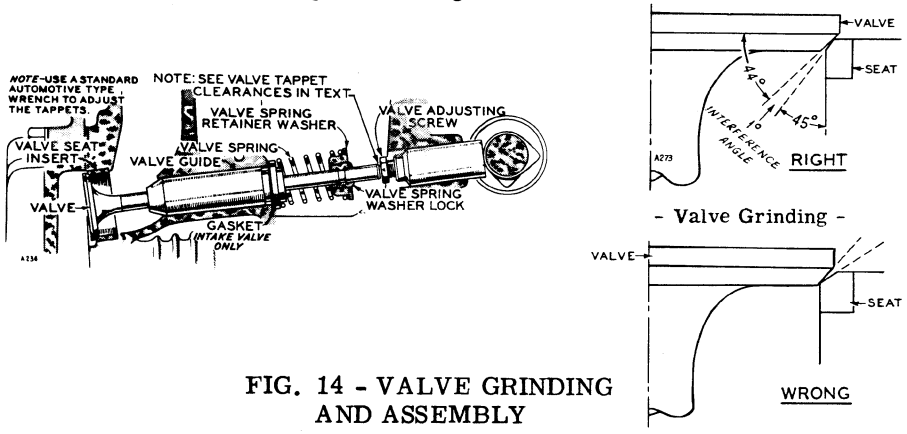


FIG. 14 - VALVE GRINDING AND ASSEMBLY

To correct the valve clearance of certain earlier built engines having non-adjustable tappets, either the valve stem, valve face or valve seat must be ground. An approved valve grinding machine should be used. Grind the valve face or seat to reduce valve clearance. Grind the valve stem to increase the valve clearance. If valve clearance can no longer be held within given limits, replace the valve. NOTE: Adjustable and non-adjustable valve tappets are interchangeable.

VALVE ADJUSTMENT. - To make a valve adjustment, remove the valve covers. Then crank the engine over slowly by hand until the left hand intake valve, when facing the flywheel, opens and closes and continue about 1/4 turn until the "TC" mark on the gear cover and the mark on the flywheel are in line. This should place the left piston at the top of its compression stroke, the position it must be in to get proper valve adjustment for the left hand cylinder. Clearances given are for room temperature, (72°F., 22°C.). Use .006 and .008 inch feeler gauges for the exhaust valves and .004 and .006 inch feeler gauges for the intake valves.

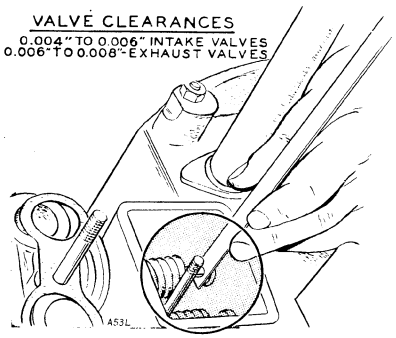


FIG. 15 - CHECKING VALVE CLEARANCE

In each case the thinner gauge should pass freely between the valve stem and valve tappet but the thicker gauge should not.

To correct the valve clearance, simply turn the tappet adjusting screw as needed to obtain the right clearance. The screw is self-locking and will stay where set.

If valve clearance can no longer be held within given limits, replace the valve.

To adjust the valves of the right hand cylinder, crank the engine over one complete revolution and again line up the "TC" mark on the gear cover and the mark on the flywheel. Then follow the adjustment given for the valves of the left hand cylinder.

FLYWHEEL. - The flywheel serves as a blower, a flywheel, and a magneto magnet. Before the flywheel can be removed, all parts necessary to expose the flywheel must be removed. Then turn the flywheel mounting screw out two full turns, insert a screwdriver between the flywheel and the gear cover to take up crankshaft end play, and strike a sharp endwise blow on the head of the cap screw with a heavy soft hammer. Remove the flywheel carefully to avoid damaging the magneto stator assembly. Do not drop the flywheel. A suitable puller can easily be made from a piece of bar steel and the flywheel removed with the aid of the puller, if so desired.

When replacing the flywheel be sure the key is in place on the crankshaft. Then install the flywheel. Install the mounting capscrew and tighten to 40 to 45 pounds feet torque. Replace other parts removed, reversing the order in which they are removed.

The zamak flywheel with its rope sheave integral, as used on earlier built engines, is not interchangeable with the cast iron flywheel with its rope sheave removeable, as used on later built engines. The magneto stator assembly and the ignition condenser used with each type of wheel are different.

GEAR COVER. - All parts necessary to remove the flywheel must be removed, including the flywheel, before the gear cover can be removed. Then disconnect the linkage and the spring from the governor arm, take out the gear cover mounting screws and remove the gear cover. Tap the gear cover gently with a soft hammer to loosen it.

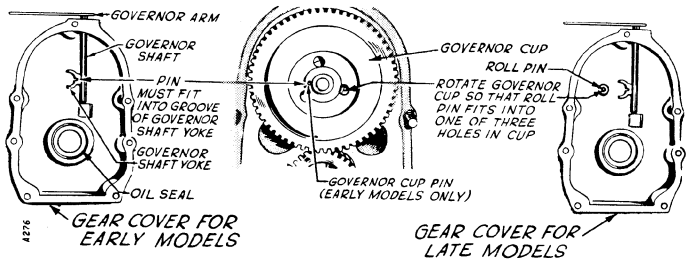


FIG. 16 - REPLACING THE GEAR COVER

When installing the gear cover, select the instructions which apply to the model in question. Don't lose the governor-shaft-end-thrust ball.

On models of the later design, position the governor cup so that one of its three large holes will admit the stop pin located on the gear cover.

On engines of the earlier design, the governor cup stop pin is located on the governor cup and must fit into the slot in the governor shaft yoke, as illustrated. Turn the governor cup to the position where its stop pin agrees with the 9 o'clock position on the face of a clock. Then turn the governor arm and shaft clockwise as far as it will go and hold it in this position until the gear cover is flush against the cylinder block. Turn the governor arm and shaft counterclockwise as far as it will go and hold or tie it in this position until the governor linkage is connected so that the governor stop pin will remain engaged with the yoke.

GOVERNOR CUP. - With the gear cover removed, the governor cup can be taken off by removing the snap ring from the camshaft center pin and sliding the cup off. Be sure to catch the flyballs as they will fall out when the cup is removed. When installing a new governor cup, tip the engine upward from the gear end, place all flyballs in their places, and install the governor cup on the center pin.

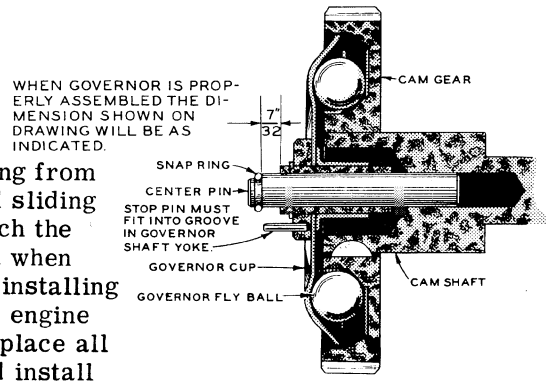


FIG. 17 - GOVERNOR CUP ASSEMBLY

Then install the snap ring on the camshaft center pin. The distance from the snap ring to the governor cup, when the cup is flush against the flyballs, must be exactly 7/32 of an inch if the governor is to operate as it should. See Fig. 17. If it is less than 7/32 of an inch, remove the cup and carefully dress down the face of the sleeve until this clearance is obtained. If more than 7/32 of an inch, the camshaft must be removed and the center pin carefully pressed in by means of an arbor press to allow 7/32 of an inch clearance. See Fig. 17. Leave the cup and snap ring on the pin to measure by. Be very careful not to bend the center pin as it is difficult to replace in the field.

CRANKSHAFT GEAR. - With the gear cover removed, the crankshaft gear is easily removed after taking off the snap ring and crankshaft gear washer. A suitable gear puller can be used or the gear can be removed by using two number 10-32 steel screws with hex. heads and turning them into the tapped holes in the gear until they butt up against the shoulder on the crankshaft and push the gear off. Turn each screw in a little at a time. If a puller is used and the gear is to be used again, apply the puller carefully to avoid damaging the teeth.

When installing the crankshaft gear, use a hollow pipe that will fit over the crankshaft but will not hit the teeth of the gear and press the gear on to the shoulder on the shaft. Be sure the Woodruff key is in place.

Should it become necessary at any time to replace the crankshaft gear, the camshaft gear must also be replaced as the gears are matched, and are sold only in sets.

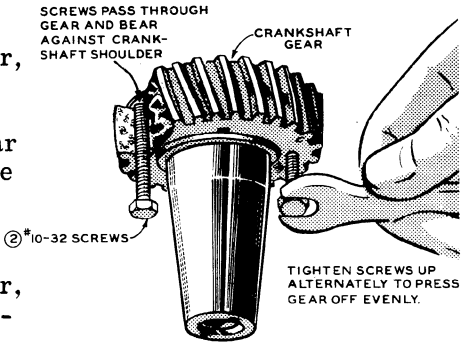


FIG. 18 - REMOVING THE CRANKSHAFT GEAR

CAMSHAFT GEAR. - The camshaft and gear should be removed from the engine as an assembly. Before this can be done, the gear cover, lock ring and washer on the crankshaft, the ignition breaker box and plunger, the valve stem locks and the fuel pump must be removed. Pull the valve tappets into the valve box. Then slide the camshaft and gear out as an assembly.

If the gear is to be removed from the shaft, remove the snap ring from the center pin and the governor cup and the flyballs from the gear. Then place the camshaft and gear in an arbor press and remove the gear. Be very carefull not to damage the center pin.

If the camshaft gear is to be replaced, the crankshaft gear must also be replaced as they are sold only as a matched set. When pressing the camshaft gear into place on the shaft, be sure the key is in place and the gear is straight on the shaft.

When installing the camgear and camshaft in the block, be sure the thrust washer is in place behind the cam gear. This thrust washer insures correct endplay. See Fig. 19. The timing mark on the camshaft gear must be lined up with the timing mark on the crankshaft gear as shown in Fig. 20 to assure correct engine timing.

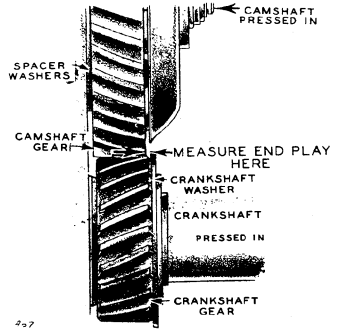


FIG. 19 - CHECKING CAMSHAFT GEAR ENDPLAY

TIMING GEARS. - The crankshaft gear and the camshaft gear serve to time the engine. These gears are matched and are sold only in sets. Should either gear need replacing, both gears must be replaced. When installing new timing gears or replacing the old timing gears, the timing marks must be aligned as shown in Fig. 20.

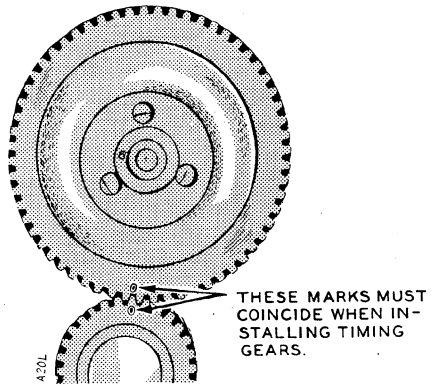


FIG. 20 - TIMING GEAR ASSEMBLY

CRANKSHAFT. - The unit must be completely disassembled to remove the crankshaft. Whenever making major repairs on the engine, always inspect the drilled passages of the crankshaft and if necessary, clean them to assure proper lubrication of the connecting rods. Also the bearing journals should be inspected. If they are scored and cannot be smoothed out by dressing down, the bearing journals should be refinished to use .020" undersize bearings or a new crankshaft should be installed.

When replacing the crankshaft, use gaskets as needed behind the bearing plate to assure endplay of .006 to .012 inch.

BEARINGS. - Removal of the camshaft and crankshaft bearings requires complete disassembly of the engine. Use a press or a suitable drive plug to remove the bearings. Drive or press the crankshaft bearings from the outside toward the inside of the cylinder block. Drive or press the camshaft bearings from the inside toward the outside of the cylinder block. Be very careful not to damage the bearing boss when removing a bearing.

The crankshaft main bearings must be installed from the inside of the cylinder block with the oil holes in the bearings aligned with the oil holes in the bearing boss. Replacement crankshaft main bearings are the precision type which DO NOT require line reaming or line boring after installation. Crankshaft bearings are available in standard size or,.002"or.020" undersize. The bearing stop pin used in earlier engines was the straight dowel type and must be replaced by the shoulder type pin which is furnished with the precision type new bearing. Using a press or drive plug to install the bearing in a cold cylinder block might result in damage to this type of bearing. Warm the bearing plate and cylinder block to expand the bearing bore size. Use hot water, a 200°F. oven, or in an emergency a low flame from a torch. Only a little heat is required. The cold precision bearing should then require only light taps to position it. The flange of the bearing must be against the inner end of the bearing boss. Use oil on the outer surface of the bearing to reduce friction and coat the inner surface before installing the crankshaft.

The oil groove of the front camshaft bearing must be centered at the top. The plunger notch in the rear camshaft bearing must be aligned with the hole in the bearing boss. Install both bearings from the outside. Press or drive the front bearing in flush with the bearing boss and the rear bearing in flush with the welch plug groove. Replace the welch plug of the rear bearing.

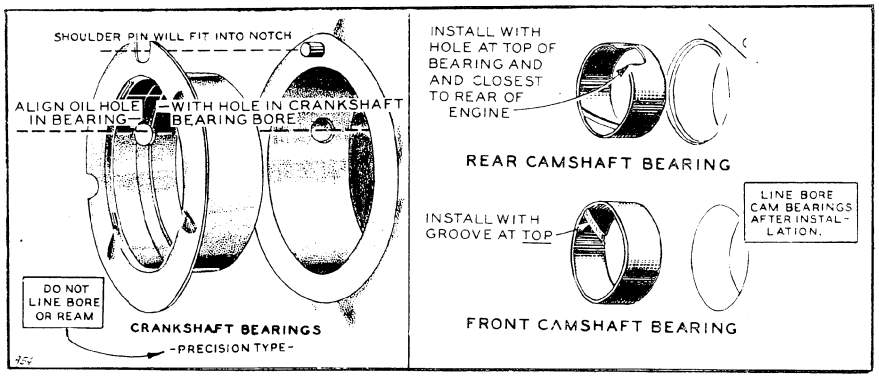


FIG. 21 - BEARING INSTALLATION

The camshaft bearings must be line bored or line reamed after being installed in the cylinder block, to allow a clearance of .001 to .003 inch. Any reliable machine shop should be able to perform this service. If equipment for the line boring or reaming is not available locally, see the dealer from whom you purchased your engine or return it to the factory for repairs.

OIL SEALS. - The gear cover must be removed to replace its oil seal. Drive the oil seal out from the inside of the gear cover. The bearing plate must be removed to replace its oil seal. Drive the oil seal out from the inside.

Oil seal installation is easier when using a tool for expanding and driving the seal. Otherwise, avoid damaging the seal by placing a piece of shim stock around the end of the crankshaft, then removing it after the seal is in place. Seal installing tools are available through the dealer.

When installing the gear cover oil seal, tap the seal inward until it is 31/32 of an inch from the mounting face of the cover.

When installing the bearing plate oil seal, tap the seal into the bearing plate bore to bottom against the plate bore shoulder. After the seal is in place, it is advisable to apply a thin coating of shellac or Permatex around the outer surface of the seal at the point where it comes in contact with the bearing plate boss.

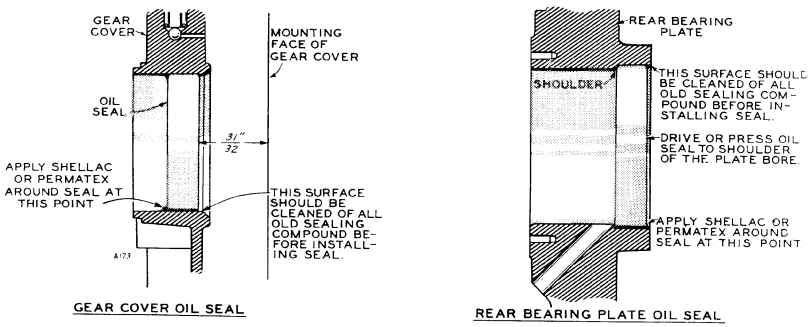


FIG. 22 - OIL SEAL INSTALLATION

OIL PUMP. - The unit must be completely disassembled to remove the oil pump. To remove the pump from the block follow Fig. 23, except on some engines the oil intake cup need not be detached from the pump body.

Check the oil pump thoroughly for worn parts. Should any parts need replacing, replace the entire pump assembly as the oil pump is sold only as a complete unit. See the parts list.

FUEL SYSTEM. - Instructions for adjusting and servicing the different parts of the fuel system are given under Periodic and Accessory Service.

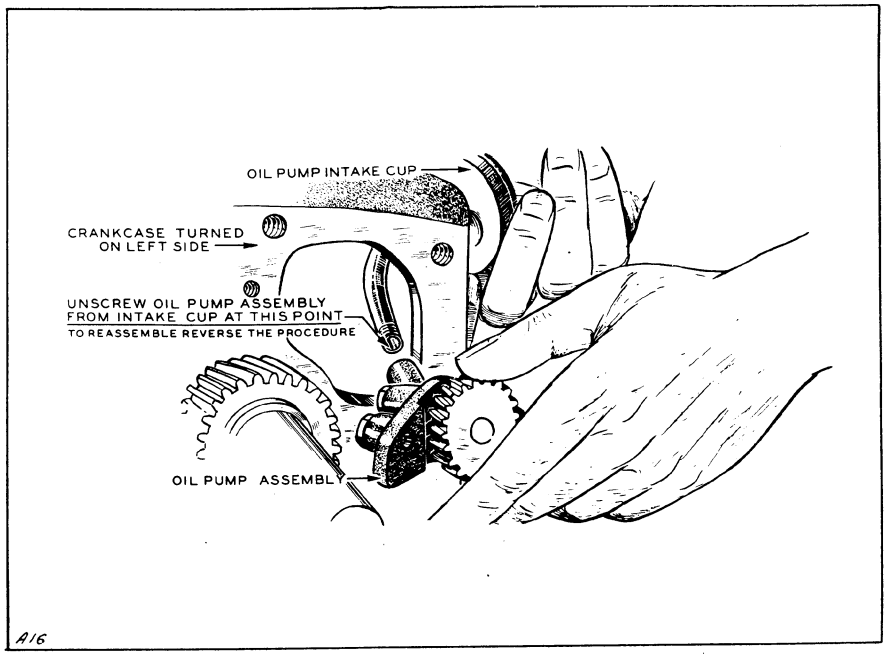


FIG. 23 - OIL PUMP REMOVAL

This view shows: Magneto Stator with coil NOT individually replaceable as used with zamak flywheel. Stator as used with cast iron flywheel has a replaceable coil. Be sure the coil is insulated from the pole shoe and is held snugly to the pole shoe.

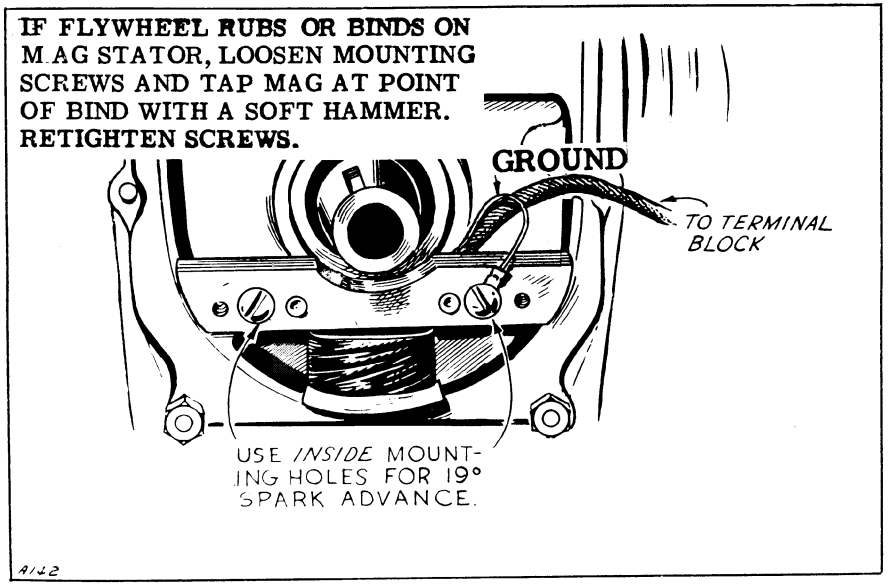


FIG. 24 - MAGNETO STATOR ASSEMBLY

MAGNETO STATOR INSTALLATION. - The magneto assembly is mounted on the gear cover and the flywheel must be removed to expose it. The degree of spark advance (either 19° or 25° Before Top Center) as stamped on the cylinder block near the breaker box is correct for the engine. With reference to the illustration, note that the inside mounting holes are for 19°spark advance and outside mounting holes are for 25°spark advance.

The ignition circuit is shown on the Wiring Diagram. Ground the small stator coil lead to the stator mounting screw (or to the lead clip screw on early engines). Connect the large lead to the breaker box terminal. A clip and grommet on the edge of the gear cover holds this lead in place.

TIMING THE IGNITION. - The spark advance is 19° before top center. Use the 19° mark and the "TC" mark on the gear cover and the mark on the flywheel and proceed as follows:

1. Remove the cover from the breaker box and check the witness marks on the crankcase and breaker box. If these marks are not in alignment, loosen the breaker box mounting screws and align these marks. See Fig. 5. This will give a nearly correct setting of the breaker box.

2. Adjust the ignition breaker point gap width to .020 inch at full separation.

3. Crank the engine over slowly by hand in the direction of crankshaft rotation until the "TC" mark on the gear cover and the mark on the flywheel are exactly in line. See Fig. 25.

4. Turn the flywheel to the left against crankshaft rotation, until the mark on the flywheel is about two inches past the 19° mark on the gear cover.

5. Turn the flywheel slowly to the right and note whether the ignition points just separate when the 19° mark on the gear cover aligns with the mark on the flywheel. If the marks align as the points break, timing is correct. If they do not, loosen the breaker box mounting screws and shift the whole breaker box assembly to the right (with crankshaft rotation) to advance the timing (points not breaking soon enough) or to the left to retard the timing (points breaking too soon). The witness marks on the cylinder block and breaker box may not be in alignment after this adjustment has been made but this is not important as these marks give only an approximately correct position of the breaker box. Tighten the breaker box mounting screws securely after making an adjustment.

6. Replace the breaker box cover.

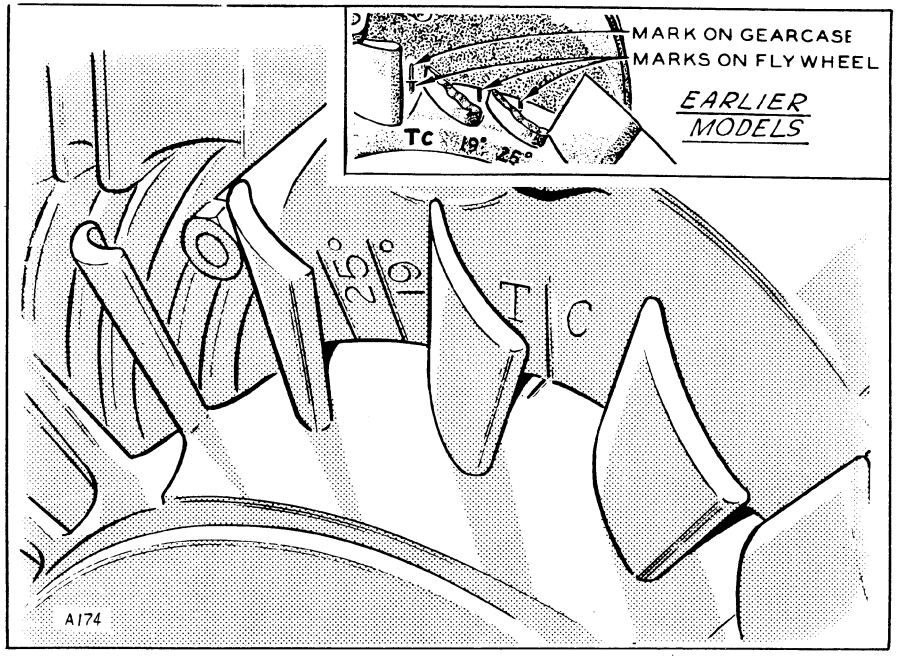


FIG. 25 - IGNITION TIMING MARKS

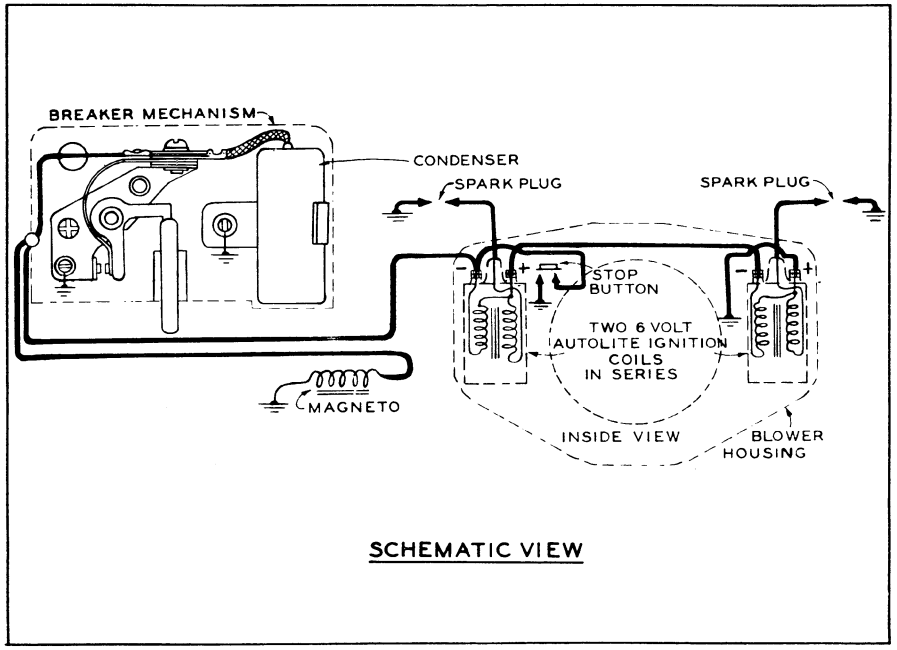


FIG. 26 - WIRING DIAGRAM

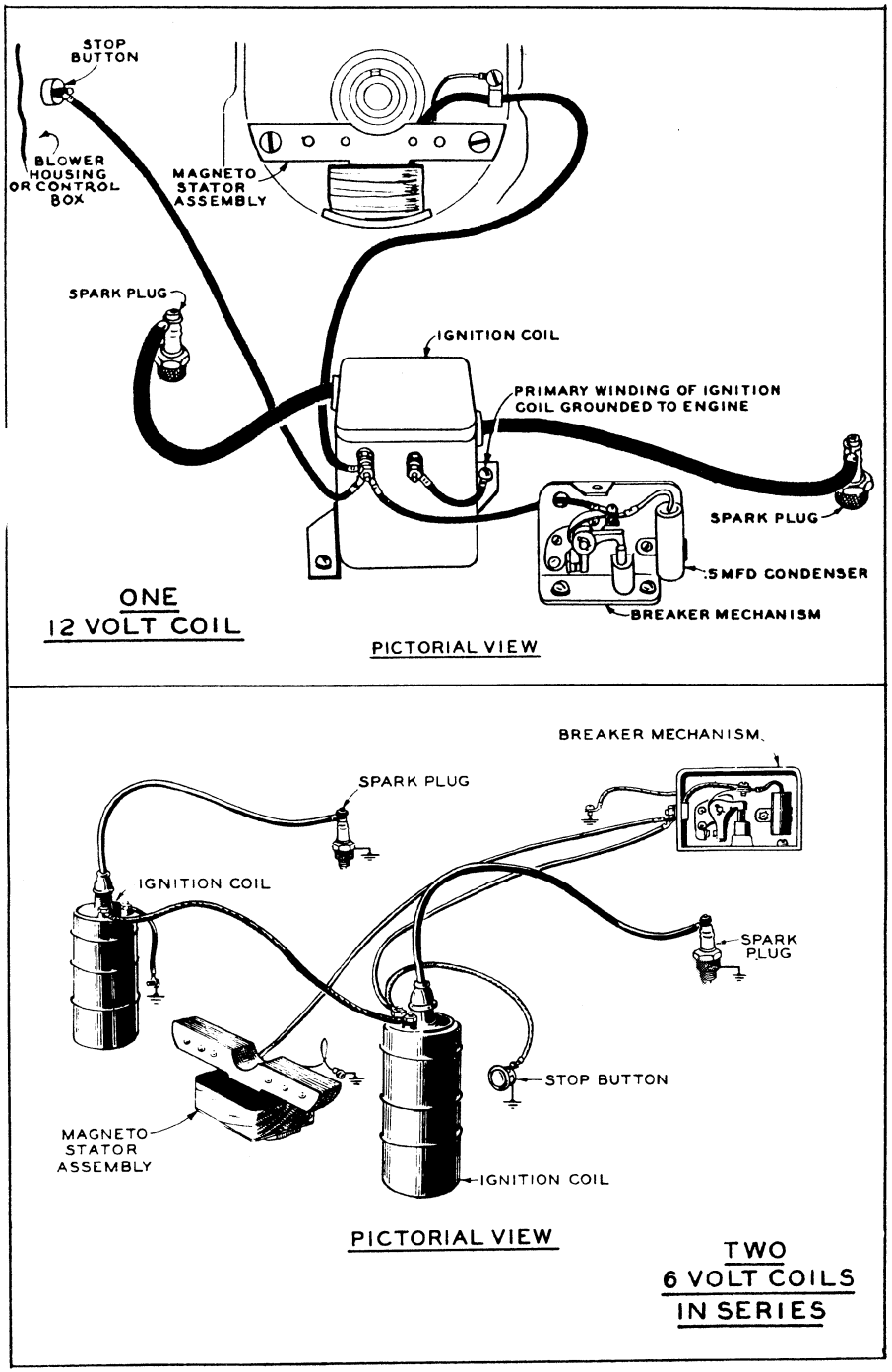


FIG. 27 - MAGNETO IGNITION CIRCUIT

GASKETS. - Always use new gaskets when replacing any part that requires a gasket. Thoroughly clean the surface that the gasket contacts before installing the gasket. Gaskets are listed singly in the Parts List and are also listed in kit form under SERVICE KITS.

DISASSEMBLY AND REASSEMBLY. - Carefully observe each part as it is removed to assure correct location when reassembling the engine. It is advisable to tag and mark such items as electrical leads before disconnecting to eliminate any possibility of a wrong connection.

Carefully inspect all gaskets exposed in disassembly. Clean all surfaces which gaskets contact. Reverse the order of disassembly when reassembling the unit.

Parts illustrations which appear in the parts catalog are a very helpful reference while repairing the engine.

RUN-IN OF RECONDITIONED ENGINE. - A thoroughly reconditioned engine should be treated in the same manner as new engine when placing it in service again. Check oil often as the rings will not be completely seated until the engine has been run for quite a few hours. Run the engine at no load or light load for the first 5 to 10 hours of running time. Then increase the load gradually as recommended under Operation.

ASSEMBLY TORQUES

Assembly torques as given here require the use of a torque wrench. These assembly torques will assure proper tightness without danger of stripping the threads. If a torque wrench is not available, you will have to estimate the degree of tightness necessary for the stud or nut being installed and tighten accordingly. Do not strip the threads. Check all studs and nuts frequently. Tighten as needed to prevent their working loose.

CYLINDER HEAD STUDS AND NUTS. - Tighten to 24 to 26 lbs. ft. torque.

OTHER 5 16 INCH CYLINDER BLOCK STUDS AND NUTS. - Tighten to 10 to 12 lbs. ft. torque. Tighten other studs and nuts just enough to assure tightness. Be careful not to strip the threads.

CONNECTING ROD BOLTS. - Tighten to 24 to 26 lbs. ft. torque.

FLYWHEEL CAPSCREW. - Tighten to 35 to 40 lbs. ft. torque.

TABLE OF CLEARANCES

	MINIMUM	MAXIMUM
Crankshaft Main Brg. Journal - Std. Size	1.9995"	2.000"
Crankshaft Rod Brg. Journal-Std. Size	1.6255"	1.6260"
Intake Valve Tappet Clearance at 72°F.	0.004"	0.006"
Exhaust Valve Tappet Clearance at 72°F.	0.006"	0.008"
Intake Valve Stem Clearance in Guide	0.001"	0.0025"
Exhaust Valve Stem Clearance in Guide	0.0025"	0.004"
Valve Seat Width	3 64"	5/64"
Crankshaft Main Bearing Clearance	0.002"	0.003"
Crankshaft End Play	0.006"	0.012"
Camshaft Bearing Clearance	0.0015"	0.003"
Camshaft End Play	0.003"	
Connecting Rod Bearing Clearance	0.002"	0.003"
Connecting Rod End Play	0.013"	0.038"
Timing Gear Backlash	0.002"	0.003"
Oil Pump Gear Backlash	0.002"	0.005"
Piston Clearance in Cylinder	0.0005"	0.0025"
Piston Pin Clearance in Piston at 72°F.	Thumb Push Fit	
Piston Pin Clearance in Rod at 72°F.	0.0001"	0.0006"
Piston Ring Gap in Cylinder	0.0085"	0.0165"
Breaker Point Gap at full Separation	0.020"	
Spark Plug Gap	0 025"	
Cylinder Bore - Standard Size	2 9985"	2.9995"

STARTER

SERVICING THE "MODEL D" READI-PULL STARTER. - Refer to the illustration showing the readi-pull starter (Model D) disassembled.

CAUTION: The recoil spring may unwind and cause injury if let fly wildly when starter is disassembled or reassembled.

The sheave hub bearing (16) has a recess which was packed full of grease at the factory. Normally no additional lubrication is required. However, if the starter is disassembled for some other reason, add grease to the bearing and to the spring pawls (11) where they contact the ratchet arm (13).

To install a new rope or internal parts remove the starter from its mounting ring by removing the 4 clamping screws (19).

To install a new rope, rotate the sheave (10) with crankshaft rotation direction to fully tighten the spring (8), back up only as necessary to align the hole in the sheave with the slot in the cover (5), clamp the rope to the sheave, then when released the rope will wind on the sheave.

To install a new recoil spring remove the sheave from the cover. Wind the spring, with its rivet heads outward, forming a coil small enough to be inserted in the recess of the starter cover. It may be necessary to tie the spring with a piece of wire to prevent its unwinding during installation unless other help is available. Place the spring in the cover recess in crankshaft rotation direction. Remove the tying wire if used. While holding the spring to prevent its unwinding install the inside end of the spring on the roll pin (7) in the cover. With the pull rope removed, install the sheave assembly in the cover so that the tab on the sheave enters the outside end loop of the recoil spring. Be sure the thrust washer (9) is in place. Then install the pull rope.

Spring breakage is much less common than spring fatigue due to long usage. In either case the spring should be replaced. Cleaning and lubricating the pawls, and ratchet arms in the rope sheave will improve a sluggish acting recoil. To temporarily extend the life of a fatigued spring, try rewinding it "inside out" (rivets heads inward).

To install a ratchet arm (13) in the sheave, the pawl (11) must first be removed. The ratchet arm will fit in only the correct position. The spring pawl must be installed with its flat edge against the ratchet arm.

The anti-back lash cogwheel (6) is an easy press fit on the starter cover.

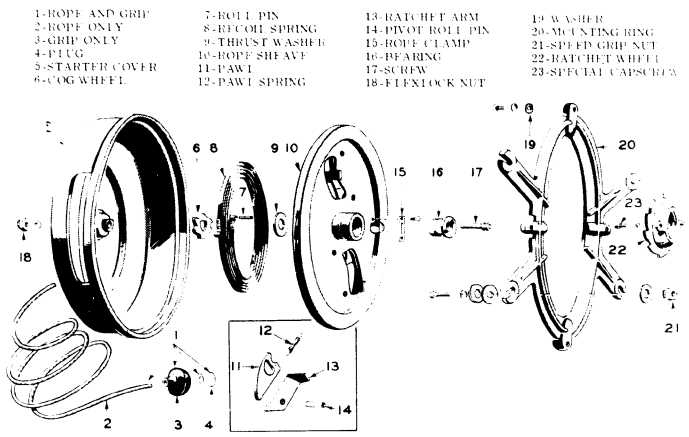


FIG. 28 - SERVICING (Model D) READI-PULL STARTER

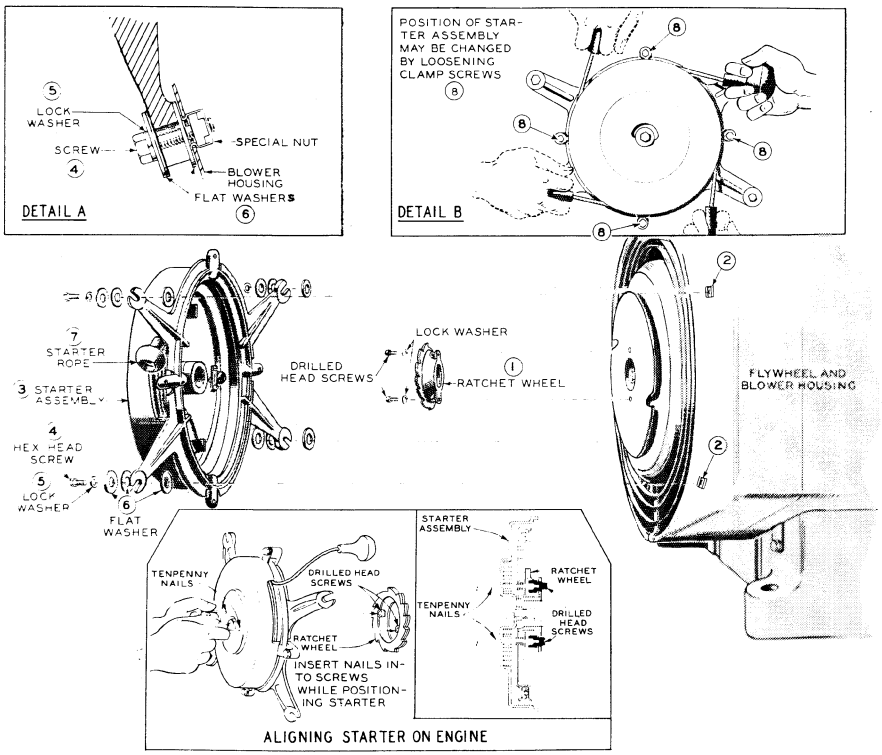


FIG. 29 - INSTALLING (Model D) READI-PULL STARTER

INSTALLING "MODEL D" READI-PULL STARTER. - For use with a Readi-Pull starter, the blower housing on the engine must be as rigid as possible. Examine the blower housing carefully. If the mounting holes are worn or if the blower housing is otherwise damaged, replace it with a new one. Proceed as follows to install the complete starter kit.

1. Refer to the installation drawing. Do not change the flywheel mounting screw. New screws (if furnished) are needed on other model engines only.

2. Install the new ratchet-wheel (1) to the blower wheel, using the two special head screws and lock washers provided. A 3/8 inch 12 point socket or closed end wrench fits these screws. Tighten securely.

3. Four special nuts are supplied for mounting the starter to the blower housing. If the blower housing is not already fitted with similar mounting nuts, remove the blower housing and install the nuts in the square holes (2) in the blower housing. See detail A. Reinstall the blower housing, tightening securely in place.

4. Note that there are two small holes drilled through the starter cover. See detail C. Pull slowly out on the starter rope while sighting through one of these holes. When the starter is turned a partial turn, the open-center roll pins in the starter rope sheave will align with these two holes. While holding in the aligned position, insert a ten penny common nail through each of the holes. Push the nails in up to their heads.

5. Install the starter assembly (3) to the blower housing, making sure that the nail ends enter the pilot holes in the ratchet wheel mounting screws. It will probably be necessary to turn the flywheel a partial revolution to allow proper alignment. While holding in position, mount the starter, using a hex head screw (4), lock washer (5), and three flat washers (6) at each mounting arm as shown in the detail drawing A. Tighten the mounting screws securely. Remove the nails.

6. The direction of pull on the starter rope is adjustable to fit the requirements of the individual installation. See detail B. To change the direction of pull, loosen the four clamp screws (8) and turn the starter in its mounting ring to the desired position. Tighten the four clamp screws securely. Try the starter several times, making sure that the pull rope will not rub against one of the clamp screws.

7. Ocassionally check the operation of the starter, making sure the starter is properly centered (step 5 above). See that the blower housing mounting screws are tight. If the blower housing tends to shift, its mounting holes may have become worn oversize. If the blower housing tends to weave or distort during starter operation, installation of a new housing is recommended.

POSSIBLE CAUSE	REMEDY
ENGINE CRANKS TOO STIFFLY	
Too heavy oil in crankcase.	Drain, refill with light oil. See PREPARATION
Engine stuck.	Disassemble and repair.
ENGINE WILL NOT START WHEN CRANKED	
Faulty ignition. Breaker point plunger sticking.	Clean, adjust, or replace breaker points, spark plugs, condenser, etc., or retime ignition.
Lack of fuel or faulty carburetion. Leaky carburetor float.	Refill the tank. Check the fuel system. Clean, adjust or replace parts necessary. Remove leaky section of float. Carburetor will function until new float can be installed. Check position of fuel pump priming lever (if used); push knob in.
Clogged fuel screen.	Clean.
Cylinder flooded.	Crank few times with spark plug removed. Ground spark plug cable.
Poor fuel.	Drain, refill with good fuel.
Poor compression.	Tighten cylinder heads and spark plugs. If still not corrected, grind the valves. Replace piston rings, if necessary.
Wrong timing.	Reset breaker points or retime ignition.
POWER DROPS UNDER HEAVY LOAD	
Engine lacks power.	See remedies for engine missing under heavy load.
Poor compression.	Tighten cylinder heads and spark plugs. If still not corrected, grind the valves. Replace piston rings, if necessary.

POSSIBLE CAUSE	REMEDY
POWER DROPS UNDER HEADY LOAD (CONT.)	
Faulty carburetion.	Check the fuel system. Clean, adjust or replace parts necessary.
Clogged carburetor air cleaner.	Clean.
Choke partially closed.	See that it opens wide enough.
Carbon in cylinders or in carburetor venturi.	Remove carbon.
Restricted exhaust line.	Clean or increase the size.
Governor not sensitive enough.	Adjust sensitivity.
ENGINE MISFIRES AT LIGHT LOAD	
Carburetor adjustment set wrong or clogged.	Adjust, clean if needed.
Spark plug gap too narrow.	Adjust to correct gap, .025".
Intake air leak.	Tighten or replace gaskets.
Faulty ignition.	Clean, adjust, or replace breaker points, spark plugs, condenser, etc.
Poor compression.	Tighten cylinder heads and spark plugs. If still not corrected, grind valves. Replace piston rings, if necessary.
ENGINE MISFIRES AT HEAVY LOAD	
Defective spark plug.	Replace. Use Champion H9 Com.
Faulty ignition.	Clean, adjust, or replace breaker points, spark plugs, condenser, etc.
Clogged carburetor.	Clean jets.
Clogged fuel screen.	Clean.
Defective spark plug cable.	Replace.

POSSIBLE CAUSE	REMEDY
ENGINE MISFIRES AT ALL SPEEDS	
Foulded spark plug.	Clean and adjust.
Defective or wrong spark plug.	Replace. Use Champion H9 Com.
Sticking valves.	Grind, or replace. See MAINTENANCE AND REPAIR.
Broken valve spring.	Replace.
Defective ignition wires.	Replace.
Defective or improperly adjusted points.	Adjust or replace breaker points.
LOW OIL PRESSURE	
Oil too light or diluted from leaking fuel pump diaphragm.	Drain, refill with correct oil. Repair or replace fuel pump.
Oil too low.	Add oil.
Badly worn engine.	Overhaul.
Sludge on oil screen.	Remove and clean.
Badly worn oil pump.	Replace.
Defective oil pressure gauge.	Replace.
HIGH OIL PRESSURE	
Oil too heavy.	Drain, refill with proper oil.
Clogged oil passages.	Clean oil lines and passages.
Oil relief valve stuck, spring broken or adjustment wrong.	Remove and clean, Replace worn or broken parts. Readjust.
Defective oil pressure gauge.	Replace.
ENGINE BACKFIRES AT CARBURETOR	
Lean fuel mixture.	Clean or adjust carburetor. See ACCESSORY SERVICE.

POSSIBLE CAUSE	REMEDY
ENGINE BACKFIRES AT CARBURETOR (CONT.)	
Clogged fuel screen.	Clean screen.
Air leaks at intake manifold.	Replace gaskets, tighten.
Poor fuel.	Refill with good, fresh fuel.
Spark too early.	Reset breaker points or retime ignition.
Intake valves leaking.	Grind or replace
EXCESSIVE OIL CONSUMPTION, LIGHT BLUE SMOKY EXHAUST	
Poor compression, usually due to worn piston, rings, or cylinder.	Refinish cylinder. Replace piston and rings. See MAINTENANCE AND REPAIR.
Oil too light or diluted from leaking fuel pump diaphragm.	Drain, refill with correct oil. Repair or replace fuel pump.
Too large bearing clearance	Replace bearings.
Engine misfires.	Refer to "Engine Misfires At All Speeds".
Faulty ignition.	Clean, adjust, or replace breaker points, plug, condenser, etc.
Engine operated at light or no load for long periods.	No remedy needed.
Too much oil.	Drain excess oil.
Worn intake valve guides or valve stems.	Replace worn parts.
Air leak at oil fill plug.	See that plug fits tightly.
Crankcase breather valve sticking.	Free up disc. Replace valve if necessary.
BLACK SMOKY EXHAUST, EXCESSIVE FUEL CONSUMPTION, FOULING OF SPARK PLUG WITH BLACK SOOT, POSSIBLE LACK OF POWER UNDER HEAVY LOAD.	
Fuel mixture too rich.	Adjust carburetor or choke. Install needed carburetor parts, adjust float level.
Choke not open.	See that choke opens properly.
Dirty air cleaner.	Clean, refill to proper level.

POSSIBLE CAUSE	REMEDY
LIGHT POUNDING KNOCK	
Loose connecting rod bearing.	Adjust or replace rod.
Low oil supply.	Add oil.
Oil badly diluted.	Change oil.
ENGINE STOPS UNEXPECTEDLY	
Fuel tank empty.	Refill.
Defective ignition.	Check the ignition system. Repair or replace parts necessary.
DULL METALLIC THUD, IF NOT BAD, MAY DISAPPEAR AFTER FEW MINTUES OPERATION. IF BAD, INCREASES WITH LOAD.	
Loose crankshaft bearings.	Replace, unless one of the next two remedies permanently corrects the trouble.
SHARP METALLIC THUD, ESPECIALLY WHEN COLD ENGINE FIRST STARTED	
Low oil supply.	Add oil.
Oil badly diluted.	Change oil.
PINGING SOUND WHEN ENGINE IS RAPIDLY ACCELERATING OR HEAVILY LOADED	
Carbon in cylinder.	Remove carbon.
Spark too early.	Reset breaker points or retime ignition.
Wrong spark plug.	Install correct spark plug, Champion H9 Com.
Spark plug burned or carboned.	Install new plug.
Valves hot.	Adjust tappet clearance. See VALVE SERVICE.
Fuel stale or low octane.	Use good fresh fuel.
Lean fuel mixture.	Clean and adjust carburetor. See ACCESSORY SERVICE.
TAPPING SOUND	
Valve clearance too great.	Adjust or replace. See VALVE SERVICE.
Broken Valve spring.	Install new spring.
HOLLOW CLICKING SOUND WITH COOL ENGINE UNDER LOAD	
Loose Piston.	If noise only slight and disappears when engine warms up, no immediate attention needed. Otherwise replace worn parts.

Cummins Power Generation
1400 73rd Avenue N.E.
Minneapolis, MN 55432
1-800-888-6266
763-574-5000 International Use
Fax: 763-528-7229

Power Generation