

OPERATOR'S/ SERVICE MANUAL

**SERIES
CCKB
INDUSTRIAL ENGINES**



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SAFETY PRECAUTIONS

The following symbols in this manual signal potentially dangerous conditions to the operator or equipment. Read this manual carefully. Know when these conditions can exist. Then, take necessary steps to protect personnel as well as equipment.

WARNING Onan uses this symbol throughout this manual to warn of possible serious personal injury.

CAUTION This symbol refers to possible equipment damage.

Fuels, electrical equipment, batteries, exhaust gases and moving parts present potential hazards that could result in serious, personal injury. Take care in following these recommended procedures.

- **Use Extreme Caution Near Gasoline. A constant potential explosive or fire hazard exists.**

Do not fill fuel tank near unit with engine running. Do not smoke or use open flame near the unit or the fuel tank.

Be sure all fuel supplies have a positive shutoff valve.

Fuel lines must be of steel piping, adequately secured and free of leaks. Use a flexible section of fuel line between generator set and stationary fuel line in the vehicle. This flexible section must be 100% NON-METALLIC to prevent electrical current from using it as a conductor.

Have a fire extinguisher nearby. Be sure extinguisher is properly maintained and be familiar with its proper use. Extinguishers rated ABC by the NFPA are appropriate for all applications. Consult the local fire department for the correct type of extinguisher for various applications.

- **Guard Against Electric Shock**

Remove electric power before removing protective shields or touching electrical equipment. Use rubber insulative mats placed on dry wood platforms over floors that are metal or concrete when around electrical equipment. Do not wear damp clothing (particularly wet shoes) or allow skin surfaces to be damp when handling electrical equipment.

Jewelry is a good conductor of electricity and should be removed when working on electrical equipment.

Always use an appropriately sized, approved double-throw transfer switch with any standby generator set. **DO NOT PLUG PORTABLE OR STANDBY SETS DIRECTLY INTO A HOUSE RECEPTACLE TO PROVIDE EMERGENCY POWER.** It is possible for current to flow from generator into the utility line. This creates extreme hazards to anyone working on lines to restore power.

Use extreme caution when working on electrical components. High voltages cause injury or death.

Follow all state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician.

- **Do Not Smoke While Servicing Batteries**

Lead acid batteries emit a highly explosive hydrogen gas that can be ignited by electrical arcing or by smoking.

- **Exhaust Gases Are Toxic**

Provide an adequate exhaust system to properly expel discharged gases. Check exhaust system regularly for leaks. Ensure that exhaust manifolds are secure and not warped.

Be sure the unit is well ventilated.

- **Keep The Unit And Surrounding Area Clean**

Remove all oil deposits. Remove all unnecessary grease and oil from the unit. Accumulated grease and oil can cause overheating and subsequent engine damage and may present a potential fire hazard.

Do NOT store anything in the generator compartment such as oil cans, oily rags, chains, wooden blocks etc. A fire could result or the generator set operation may be adversely affected. Keep the floor clean and dry.

- **Protect Against Moving Parts**

Avoid moving parts of the unit. Loose jackets, shirts or sleeves should not be permitted because of the danger of becoming caught in moving parts.

Make sure all nuts and bolts are secure. Keep power shields and guards in position.

If adjustments *must* be made while the unit is running, use extreme caution around hot manifolds, moving parts, etc.

Do not work on this equipment when mentally or physically fatigued.

GENERAL INFORMATION

This manual contains installation, operation, maintenance, adjustment and repair information required for proper care of the engine. Since the first and most important part of repair work is the correct diagnosis of the trouble, a troubleshooting chart is included.

Study and follow the instructions carefully. Proper service and maintenance will result in longer engine life and better performance.

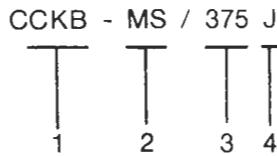
The flywheel end of the engine is considered the front. Left and right are determined when facing the front of the engine.

When instructions in this manual refer to specific models of industrial engines, identify the model by referring to the *MODEL* and *SPECIFICATION NO.* as shown on the unit nameplate.

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How to interpret MODEL and SPEC NO.



1. Factory code for general identification purposes.
2. Specific Type:
 - S* — *MANUAL* starting with stub shaft power take off.
 - MS* — *ELECTRIC* starting with stub shaft, starter and generator.
3. Factory code for optional equipment supplied.
4. Specification (Spec letter) advances with factory production modification.

WARNING

TO AVOID POSSIBLE PERSONAL INJURY OR EQUIPMENT DAMAGE, AN AUTHORIZED SERVICE REPRESENTATIVE MUST PERFORM ALL SERVICE.

SPECIFICATIONS

	MANUAL START CCKB-S/1	ELECTRIC START CCKB-MS/1
Nominal Dimensions		
Height	20.25 in (514 mm)	22 in (559 mm)
Width	20.50 in (520 mm)	20.50 in (520 mm)
Length	15 in (381 mm)	15 in (381 mm)
Weight in Pounds (approximate)	152 (69 kg)	172 (78 kg)
Fuel (standard)*	Gasoline**	Gasoline**
Number of Cylinders.....	Two	
Cylinder Bore	3.25 in (83 mm)	
Cylinder Stroke.....	3.0 in (76 mm)	
Displacement (cu. in.)	49.8 (816 cm ³)	
Compression PSI (sea level)	100-120 (689-827 kPa)	
Maximum BHP at 3900 rpm	20 (15 kW)	
Cooling Air Volume (cfm) at 3600 rpm (Pressure Cooled)	975 (27.6 m ³ /min)	
Governor Type	Adjustable, mechanical flyball	
Fuel Pump Type.....	Diaphragm	
Fuel Pump Lift	4 feet (1.2 m)	
Lubrication System	Full Pressure	
Oil Capacity (U.S. quarts).....	3 (2.8 litre)	3.5 (3.3 litre)
Optional Oil Filter Capacity (U.S. quarts)	0.5 (0.47 litre)	
Standard Power Take-Off Shaft Dimensions		
Length	2.75 in (69.9 mm)	
Diameter	1.5 in (38.1 mm)	
Keyway Length.....	2.13 in (54.1 mm)	
Keyway Depth.....	0.38 in (9.7 mm)	
Keyway Width	0.38 in (9.7 mm)	
Ignition	Magneto	Battery

* Gaseous fuel optional.

** Non-leaded or regular grade gasoline. See *OPERATION* section for special instructions.

Tune-Up Specifications

Breaker Point Gap (Full Separation)	0.020 in (0.51 mm)
Spark Plug Gap	
Gasoline	0.025 in (0.64 mm)
Gaseous	0.018 in (0.46 mm)
Ignition Timing	
Battery Ignition.....	20° BTC
Magneto Ignition, Engine Stopped—Hand Start	1° ATC—5° BTC
Magneto Ignition, Engine Running—Hand and Electric Start	24° BTC
Magneto Ignition, Engine Stopped—Electric Start	5° BTC
Gaseous	24° BTC
Carburetor Float Clearance (between float bowl gasket and float)	0.13 - 0.19 in (3.18 - 4.76 mm)

DIMENSIONS AND CLEARANCES

All clearances given at room temperature of 70° F.
All dimensions in inches unless otherwise specified.

	Minimum	Maximum
Valve Tappet to Cylinder Block Clearance	0.0150 (0.38 mm)	0.0030 (0.08 mm)
Valve Stem in Guide—Intake	0.0010 (0.03 mm)	0.0025 (0.06 mm)
Valve Stem in Guide—Exhaust	0.0025 (0.06 mm)	0.0040 (0.10 mm)
Valve Seat Interference Width	1/32	1/32
Valve Face Angle	44°	44°
Valve Seat Angle	45°	45°
Valve Interference Angle	1°	1°
Crankshaft Main Bearing	0.0025 (0.06 mm)	0.0038 (0.10 mm)
Crankshaft End Play	0.006 (0.15 mm)	0.012 (0.30 mm)
Camshaft Bearing	0.0015 (0.04 mm)	0.0030 (0.08 mm)
Camshaft End Play	0.003 (0.08 mm)	—
Rod Bearing (Forged Rod)	0.0005 (0.01 mm)	0.0023 (0.06 mm)
Connecting Rod End Play (Ductile Iron)	0.002 (0.05 mm)	0.016 (0.41 mm)
Timing Gear Backlash	0.002 (0.05 mm)	0.003 (0.8 mm)
Oil Pump Gear Backlash	0.002 (0.05 mm)	0.005 (0.13 mm)
Piston to Cylinder, Strut Type (Measured below Oil — Controlling Ring—90° from Pin) Clearance0025 (0.06 mm)	0.0045 (0.11 mm)
Piston Pin in Piston	Thumb Push Fit	Thumb Push Fit
Piston Pin in Rod	0.001 (0.0025 mm)	0.0006 (0.0152 mm)
Piston Ring Gap in Cylinder	0.010 (0.254 mm)	0.023 (0.584 mm)
Crankshaft Main Bearing Journal—Standard Size	1.9992 (50.779 mm)	2.000 (50.8 mm)
Crankshaft Rod Bearing Journal—Standard Size	1.6252 (41.280 mm)	1.6260 (41.300 mm)
Cylinder Bore—Standard Size	3.2490 (82.525 mm)	3.2500 (82.550 mm)
Valve Tappet Clearance		
Exhaust	0.015 (0.38 mm)	0.017 (0.43 mm)
Intake	0.006 (0.15 mm)	0.008 (0.20 mm)

WARNING

ENGINE EXHAUST GAS (CARBON MONOXIDE) IS DEADLY!

Carbon monoxide is an odorless, colorless gas formed by incomplete combustion of hydrocarbon fuels. Carbon monoxide is a dangerous gas that can cause unconsciousness and is potentially lethal. Some of the symptoms or signs of carbon monoxide inhalation are:

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

If you experience any of the above symptoms, get out into fresh air immediately.

The best protection against carbon monoxide inhalation is a regular inspection 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.

ASSEMBLY TORQUES

	LB.-FT.	N•m
Blower Housing Screws	10-15	(13.8-20.3)
Connecting Rod Bolts	27-29	(36.6-39.3)
Cylinder Head Screws	29-31	39.3-42.0)
Exhaust Manifold Screws	15-20	(20.3-27.1)
Flywheel Mounting Screws	35-40	(47.5-54.2)
Fuel Pump Mounting Screws	5-6	(6.8-8.1)
Intake Manifold Screws	15-20	(20.3-27.1)
Oil Base Screws	43-48	(58.3-65.1)
Oil Pump Mounting Screws	7-9	(9.5-12.2)
Rear Bearing Plate Capscrews	20-25	(27.1-33.9)
Spark Plugs	15-20	(20.3-27.1)
Timing Gear Cover Screws	10-13	(13.6-17.6)
Valve Cover Nut	4-8	(5.4-10.9)
Magneto Stator Screws	15-20	(20.3-27.1)
Starter Mounting Bolts	30-45	(47.5-54.2)

SPECIAL TOOLS

Bearing Clearance Guide (Plasti-Gage)	
.002" to .006"	420-0256
.004" to .009"	420-0257
Combination Bearing Remover -	
Main and Cam	420-0325
Combination Bearing Driver -	
Main and Cam	420-0324
Crankshaft Gear Puller	420-0072
Gear Puller Ring	420-0248
Flywheel Puller	420-0100
Carburetor Adjustment Wrench	420-0169
Continuity Tester	420-0290
Series Circuit Tester	420-0288
Torque Wrench - 1/2 Inch Drive	
0 to 100 Ft-Lb	420-0222
Valve Seat Driver	420-0071
Valve Guide Driver	420-0300
Valve Spring Compressor	420-0119
Valve Lock Replacer	420-0105
Valve Guide Honing Set	420-0305
Ridge Reamer	420-0260
Cylinder Hone	420-0304
Cylinder Wall Micro-Finishing Brush	420-0320
Ring Compressor	420-0214
Ring Spreader	420-0146
Piston Groove Cleaner	420-0332
Oil Seal Guide and Driver	
Bearing Plate	420-0181
Gear Cover	420-0313
Timing Advance Mechanical	
Cover Driver	420-0296

ENGINE TROUBLESHOOTING

TROUBLE														GASOLINE ENGINE TROUBLESHOOTING GUIDE																					
Backfire at Carburetor	Bearing Wear	Black Exhaust	Blue Exhaust	Burned Valves	Connecting Rod Wear	Cylinder Rod Wear	Engine Slowly	Engine Stops	Failure to Start	Governor Hunting	High Oil Pressure	Low Oil Pressure	Loss of Coolant (Water Cooled)	Mechanical Knocks	Misfiring	Overheating (Air Cooled)	Overheating (Water Cooled)	Piston Wear	Poor Compression	Ring Wear	Sticking Valves	CAUSE													
																						STARTING SYSTEM													
																						Loose or Corroded Battery Connection													
																						Low or Discharged Battery													
																						Faulty Starter													
																						Faulty Start Solenoid													
																						IGNITION SYSTEM													
																						Ignition Timing Wrong													
																						Wrong Spark Plug Gap													
																						Worn Points or Improper Gap Setting													
																						Bad Ignition Coil or Condenser													
																						Faulty Spark Plug Wires													
																						FUEL SYSTEM													
																						Out of Fuel - Check													
																						Lean Fuel Mixture - Readjust													
																						Rich Fuel Mixture or Choke Stuck													
																						Engine Flooded													
																						Poor Quality Fuel													
																						Dirty Carburetor													
																						Dirty Air Cleaner													
																						Dirty Fuel Filter													
																						Defective Fuel Pump													
																						INTERNAL ENGINE													
																						Wrong Valve Clearance													
																						Broken Valve Spring													
																						Valve or Valve Seal Leaking													
																						Piston Rings Worn or Broken													
																						Wrong Bearing Clearance													
																						COOLING SYSTEM (AIR COOLED)													
																						Poor Air Circulation													
																						Dirty or Oily Cooling Fins													
																						Blown Head Gasket													
																						COOLING SYSTEM (WATER COOLED)													
																						Insufficient Coolant													
																						Faulty Thermostat													
																						Worn Water Pump or Pump Seal													
																						Water Passages Restricted													
																						Defective Gaskets													
																						Blown Head Gasket													
																						LUBRICATION SYSTEM													
																						Defective Oil Gauge													
																						Relief Valve Stuck													
																						Faulty Oil Pump													
																						Dirty Oil or Filter													
																						Oil Too Light or Diluted													
																						Oil Level Low													
																						Oil Too Heavy													
																						Dirty Crankcase Breather Valve													
																						THROTTLE AND GOVERNOR													
																						Linkage Out of Adjustment													
																						Linkage Worn or Disconnected													
																						Governor Spring Sensitivity Too Great													
																						Linkage Binding													

STARTING

PRE-STARTING

Preparations for the initial and each additional starting operation should include careful checks of the oil, fuel, cooling, and electrical systems. The cylinder air housing door should be closed with all air shrouds in place.

Crankcase Oil: Be sure the crankcase has been filled with oil to the "FULL" mark on the oil level indicator, Figure 1. Use oil with the API (American Petroleum Institute) designation SE or SE/CC. Do not use an oil with the designation CD unless it is also designated SE and the oil manufacturer certifies it will perform satisfactorily in gasoline engines.

For gaseous operation, use an ashless or low-ash detergent oil specifically made for gaseous-fueled engines.

OIL CAPACITIES

Electric Start

- 3-1/2 qts. (3.31 litre)
- 4 qts. (3.8 litre with filter)

Manual Start

- 3 qts. (2.8 litre)
- 3-1/2 qts. (3.3 litre with filter)

Engine oil should always be drained when the engine is warm. Remove pipe plug to drain engine oil.

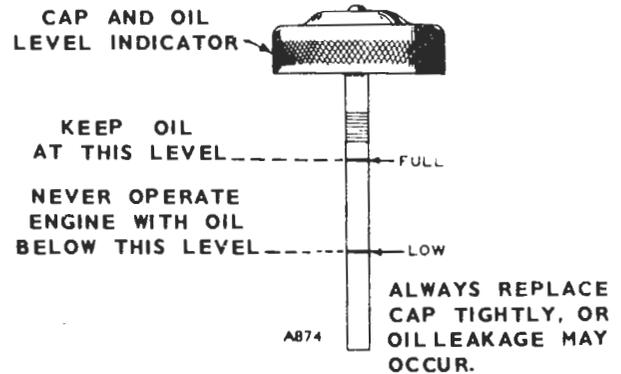
Recommended Fuel: Use clean, fresh, regular grade, automotive gasoline. Do not use highly-leaded premium types.

For new engines, the most satisfactory results are obtained by using nonleaded gasoline. For older engines that have previously used leaded gasoline, heads must be taken off and all lead deposits removed from engine before switching to nonleaded gasoline.

CAUTION If lead deposits are not removed from engine before switching from leaded to nonleaded gasoline, preignition could occur causing severe damage to the engine.

WARNING Never fill the fuel tank when the engine is running as fumes may cause explosion.

Open the fuel line valve (when used) and operate primer to assure fuel supply after filling an empty tank.



WARNING Never check oil level while engine is running. Hot oil discharged from the engine could cause personal injury.

FIGURE 1. OIL LEVEL INDICATOR

STARTING

Electric Start

1. Move the ignition switch to ON.
2. Push the START button to crank the engine.

Manual Start

1. Engine priming before starting is shown in Figure 5 (manual start only).
2. Pull the choke control about 3/4 of the way closed or as necessary according to temperature conditions.
3. Pull the start rope with a fast, steady pull to crank the engine. Do not jerk or let rope snap back under its own power.
4. As the engine warms up, adjust the choke gradually to its fully open position.

APPLYING LOAD

Apply load to a new or reconditioned engine gradually in about four steps; not less than 30 minutes running time for each step. Start with 1/4 load, then 1/2, 3/4 and full-load.

STOPPING THE ENGINE

When possible, disconnect all load before stopping the engine. Engines equipped with battery ignition are stopped by setting the ignition switch to the *off* position.

Engines equipped with magneto ignition are stopped by pushing the *stop* button (located on the blower housing). Hold in until engine completely stops.

INSTALLATION GUIDELINES

VENTILATION

The engine must be provided with a supply of fresh air for cooling and for combustion. Figure 2.

Pressure Cooled Engine: Position the air inlet opening directly in front of the engine and as close to the engine blower wheel as possible. The area of the inlet should be not less than 65 square inches (419 cm²). If louvers or grill work are used, increase the area to compensate for the reduced air flow. Provide extra ventilation if the driven load generates heat during operation.

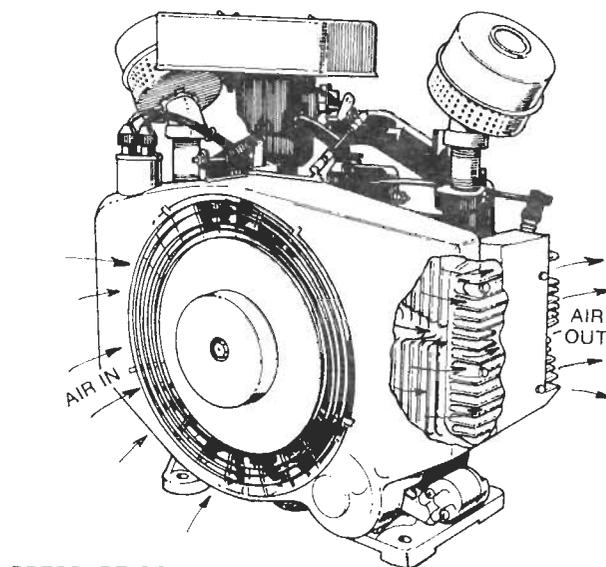
The heated air outlet must allow the heated air to escape freely and prevent recirculation with the cooling air. A duct between the compartment air inlet and the engine blower housing may be necessary. Locate the air outlet opposite the intake or at least at a 90 degree angle. The area of the outlet should be at least 15 percent larger than that of the inlet. Allow sufficient room on all sides to permit access for servicing.

Open Air Installation: For installations where the engine is operated outside, ventilation will be no problem. However, in protecting the engine from the elements, see that nothing obstructs the flow of air around the engine.

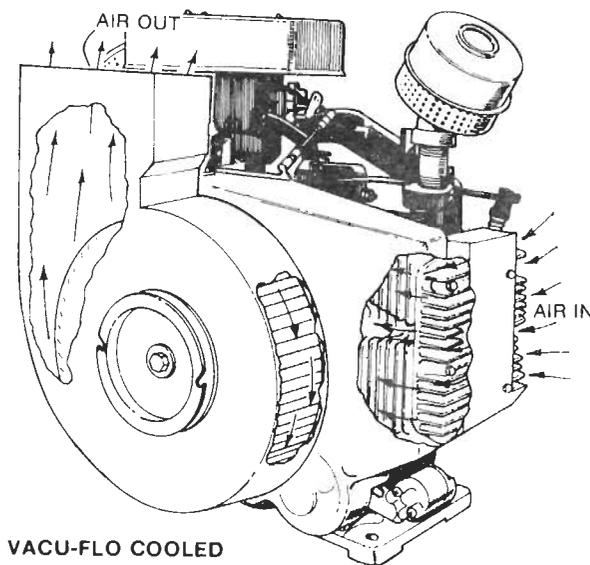
Vacu-Flo Cooled Engine: The Vacu-Flo equipped engine uses separate flywheel and a blower wheel to pull cool air into the engine shroud and over the cooling fins and surfaces of the engine, Figure 2. The heated air is directed through an air tight scroll which encases the blower. The scroll may be positioned to discharge heated air in the 12 o'clock or 3 o'clock direction, (Figure 3). The scroll outlet has a mesh-type screen for safety.

CAUTION The outlet of the vacu-flo scroll must not be restricted or overheating will result. Engine overheating can cause troubles ranging from vapor lock to scored pistons and cylinders.

The area of the air inlet must be at least 140 square inches (903 m²). If a filter, grille, or louvers are used, the inlet opening must be increased accordingly. The air outlet opening should be located as close to the engine as possible.



PRESSURE COOLED



VACU-FLO COOLED

FIGURE 2. AIRFLOW THROUGH ENGINES

If the duct length exceeds 5 feet (1.5 m), increase duct size 30 percent. Use no more than two 90 degree radius-type (not square-type) elbows if it is necessary to change air flow direction. When a duct is used between the scroll discharge and the outlet vent, its unobstructed airflow area must be at least as large as the scroll discharge. The cross-sectional area of the duct must be increased if air flow is restricted by bends, long runs, screens or the exhaust pipe. Exhaust pipes running inside Vacu-Flo ducts should be covered with asbestos tape.

CAUTION

The safety screen used to cover vents must be 1/4-inch (6.35 mm) mesh or larger to permit sufficient air flow. All screens and guards must comply with industrial safety standards that apply to hazardous moving parts to avoid personal injury.

Provide a short canvas section between the engine air outlet and the external duct or opening, to absorb vibration. If operation in cold weather is likely, installing a shutter in the air outlet is advisable. Cold weather can cause overcooling if air flow is not regulated.

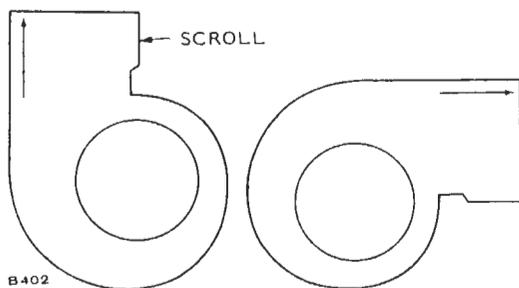


FIGURE 3. VACU-FLO SCROLL POSITIONS

Should a vacu-flo engine chronically overheat, the most likely sources of the problem are:

1. Air inlet is obstructed or too small to allow proper ventilation.
2. Air discharge opening is partially blocked by external ducts or exhaust systems.
3. Recirculation of heated air into fresh air inlet.

EXHAUST SYSTEM

Inspect the exhaust system regularly. Locate leaks in muffler and piping while the engine is operating. Repair all leaks immediately after they are detected for personnel safety.

WARNING

Leaky exhaust systems emit noxious carbon monoxide fumes which are a potential safety hazard in enclosed areas. Exhaust leaks in enclosed areas create health hazards that can result in personal injury or death to exposed personnel.

Use a length of flexible tubing between the engine exhaust outlet and any rigid piping to absorb engine

vibration. Shield the line if it passes through a combustible wall or partition. If turns are necessary, use sweeping type (long radius) elbows. Increase one pipe size (from manifold outlet size) for each additional ten feet in length. Locate the outlet away from the air intake.

CARBURETOR AIR INTAKE

Proper engine efficiency depends upon a supply of fresh air to the carburetor. Under special conditions, it may be necessary to move the air cleaner off the engine, using a longer connection hose as necessary. For extremely dusty or dirty conditions, install a special heavy duty air cleaner.

MOUNTING

There are several acceptable methods of mounting the engine. Among factors to be considered are: location, method of coupling the engine to the load, type of foundation or support, etc. The engine should be mounted on a level surface if possible. Maximum operation angle is 15 degrees sideways, 30 degrees front to rear tilt. If the engine is to operate at an angle, be sure to re-mark the oil level indicator to compensate for the tilt.

The type of installation can affect the life of the engine, the cost of operation and the frequency of necessary service. Plan the installation carefully to ensure the best performance.

Because of the great variety of uses, and the many variations of the engine, these installation instructions are typical or general in nature. Use the installation recommendations given as a general guide.

CHECKING FOR FUEL AT CARBURETOR

WARNING Do not permit any flame, cigarette, or other igniter near the fuel system. Gasoline is highly flammable and potentially explosive in confined spaces.

1. Look for one or more shutoff devices.
2. Disconnect fuel line at carburetor.
3. If fuel is present at carburetor, check ignition system or other engine malfunctions.
4. Reconnect fuel line.

CONNECTING TO THE LOAD

The dimensions of various power takeoff shafts are as follows.

SHAFT	DIAMETER	LENGTH	KEY SIZE
STD	1-1/2 (38.1 mm)	2-3/4 (69.8 mm)	3/8 (9.5 mm)
Rockford Clutch	1-7/16 (36.51 mm)	3-1/2 (88.9 mm)	3/8 (9.5 mm)
Gear Reduction	1-1/4 (31.75 mm)	2-3/4 (69.85 mm)	1/4 (6.35 mm)

Belt Drive: V-belts are preferable to flat belts. Consult a reliable belting supplier for recommendations regarding size of pulleys, number of belts, etc. required. A typical belt drive installation is shown in Figure 4.

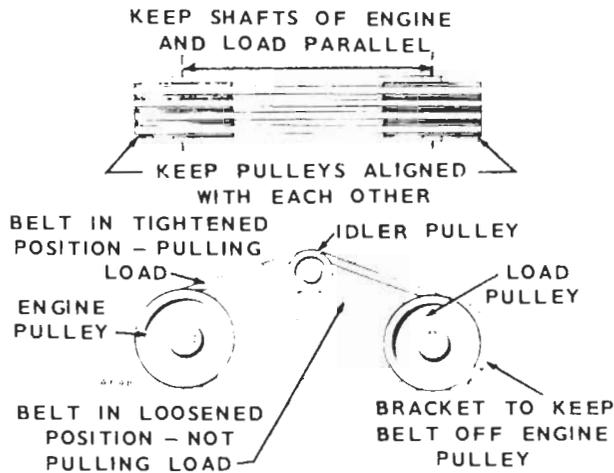


FIGURE 4. DRIVE BELT INSTALLATION

Comply with the following installation requirements:

1. The shafts of the engine and the load must be parallel with each other.
2. The pulleys of the engine and the load must be in alignment.
3. Mount the engine pulleys as close to the engine as possible.
4. If the installation permits, belts should run horizontally.
5. Some method of disconnecting the load for starting is recommended. If a clutch is not used, a belt-tightener idler arrangement can be used.

Flexible Coupling. If a flexible coupling engine-to-load drive is used, the load shaft must be in line and centered with the engine shaft (Figure 5).

Reduction Gear Drive: Reduction gear drives are mounted at the factory (when ordered). The method of connecting the load is the same as when connecting directly to the engine shaft.

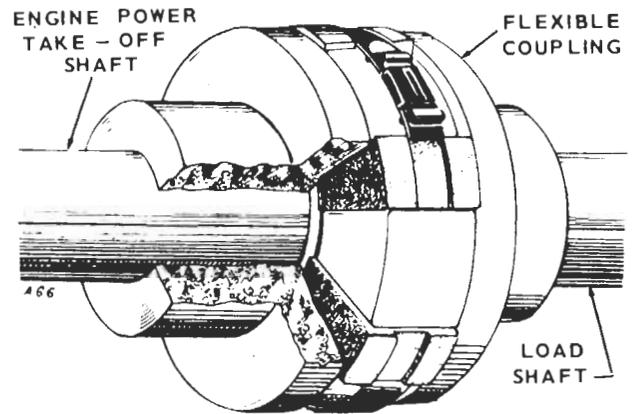


FIGURE 5. FLEXIBLE COUPLING

Drain the gear box after the first 100 hours of operation and refill with fresh lubricant of the recommended grade. Repeat this procedure every six months thereafter, or every 100 hours.

Use only SAE 50 motor oil or SAE 90 mineral gear oil. Do not use lubricants commonly known as extreme pressure lubricants, hypoid lubricants, etc.

Maintain the proper oil level between changes. Overfilling will cause foaming, which can lead to an oil leak due to overheating. Remove the filler plug on top of the case and the oil level plug from the face of the gear case. Fill the case until the oil just begins to flow from the oil level plug hole. Gear box holds 1/2 pint U.S. measure (.24 litre). Replace both plugs.

Clutch Installation: A Rockford Clutch can be installed at the factory or in the field. Install the clutch according to the following instructions and Figure 6.

Provide room for the clutch adapter casting by plugging the wet holes with a 3/8-16 x 1/2-inch slotted headless set screw. Apply sealing compound to the threads and install screw flush with the cylinder block.

Drill a 13/64-inch (5.16 mm) hole (or filed slot) in the crankshaft for the clutch set screw. Locate center of hole 11/32-inch (8.73 mm) from the end and directly opposite the keyway in the crankshaft.

Install the clutch adapter, with drain slot downward, using two cap screws 3/8-16 x 2-inches on the lower and one cap screw 3/8-16 x 1-3/4-inch on the upper #2 cylinder side (cylinder nearer clutch). Install the 3/8 x 3-7/8 or 4-inch stud through the adapter into the engine block upper remaining hole. Use a lock washer on each assembly screw. Use a flat washer and a lock washer under the stud nut.

Install the crankshaft key. Remove the clutch set screw. Install the clutch assembly (less housing) to the crankshaft, driving it on carefully with a soft-faced hammer until set screw hole is aligned. Install set

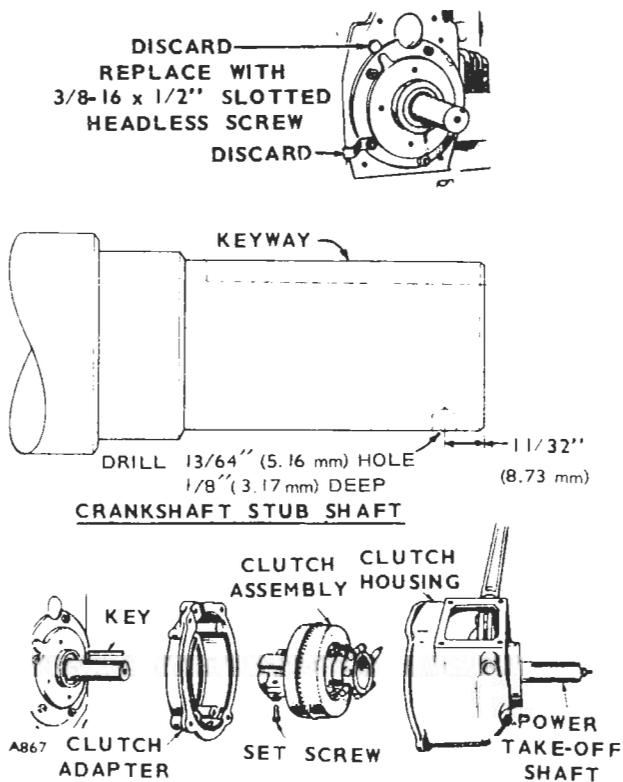


FIGURE 6. CLUTCH INSTALLATION

screw to bottom in crankshaft hole, then back it out one full turn. Tighten clutch retaining screws until clutch is clamped securely to crankshaft. Lock the screws and tighten the set screw.

Apply grease to splined power takeoff shaft. Position the clutch throw-out to align the grease fitting with the hole in the housing (#1 cylinder side, horizontal). Pull the throw-out collar outward to remove tension.

Install the clutch housing so that the clutch throw-out fork engages the throw-out collar. Be sure the serrated shaft is properly meshed with the clutch plate. Use two cap screws 7/16-14 x 2-inches on the lower and one cap screw 7/16-14 x 1-3/4-inch on the upper #2 cylinder side. Install the stud washer and nut. Lubricate the two grease fittings just until grease appears.

BATTERY CONNECTIONS (Engines with Automotive Type Separate Starter)

Connect the 12 volt battery positive cable to the engine start switch terminal. Connect the battery negative cable to the ground point on the engine oil base (Figure 7).

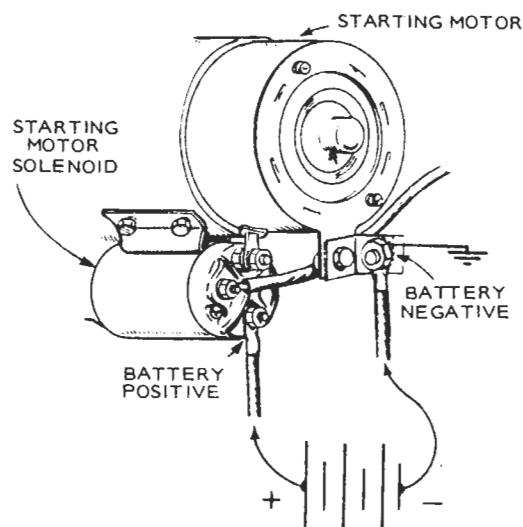


FIGURE 7. BATTERY CONNECTIONS

PROTECTION FOR EXTENDED OUT-OF-SERVICE PERIOD

Protect an engine that will be out-of-service for more than 30 days as follows:

1. Run engine until thoroughly warmed up.
2. Turn off fuel supply and run until engine stops from lack of fuel.
3. Drain oil from oil base while still warm. Attach a warning tag to refill before operation.
4. Remove each spark plug. Pour one ounce (two tablespoons) of rust inhibitor (or SAE #50) oil into cylinder. Crank engine over a few times to distribute oil film on cylinder walls and rings. Reinstall each spark plug.
5. Service air cleaner per maintenance schedule.
6. Lubricate governor linkage. Protect against dust, etc. by wrapping with a clean cloth.
7. Plug exhaust outlet to prevent entrance of bugs, moisture, or dirt.
8. Wipe entire unit clean. Coat parts likely to rust with a light film of grease or oil.
9. Provide a suitable cover for entire unit.
Disconnect battery and follow standard battery storage procedure.

CAUTION Discharged batteries are subject to severe damage if exposed to freezing temperatures. Store all batteries in a fully charged condition and maintain charge during storage.

RETURNING THE SET TO OPERATION

1. CHECK SERVICE IDENTIFICATION TAGS to properly service the engine.
2. Uncover and remove all storage seals from engine. Remove any dust, dirt, or foreign matter.
3. CHECK fuel supply tanks. CHECK lubricating oil for moisture or contamination (drain if necessary). CHECK fuel line connections, all wiring connections, and exhaust line connections.
4. Service air cleaner per maintenance schedule.
5. Check tag on oil base and verify that oil viscosity is still correct for existing ambient temperature.
6. Clean and check battery. Measure specific gravity (1.260 at 25° C [77° F]) and verify level to be at

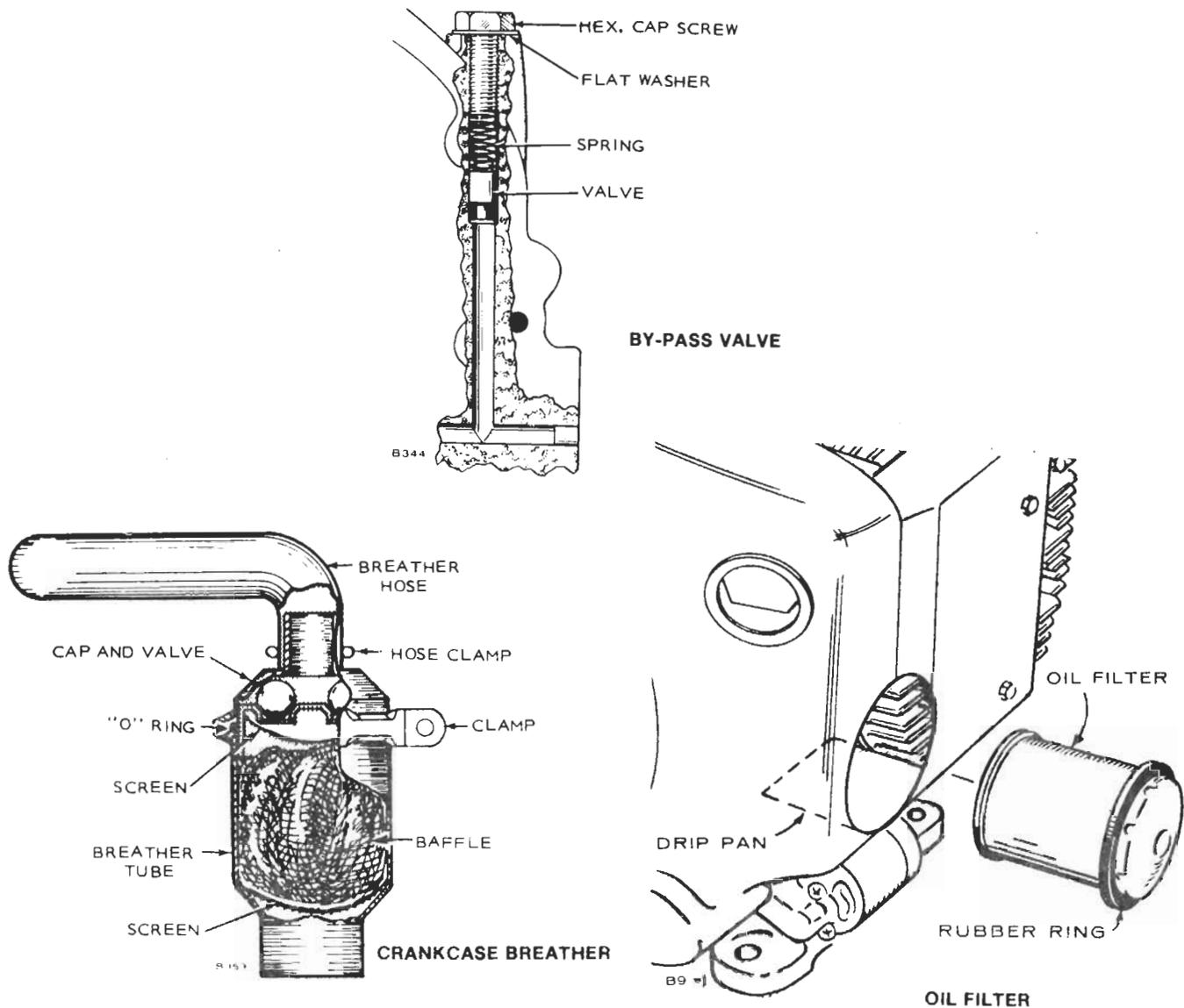
split ring. If specific gravity is low, charge until correct value is obtained. If level is low, add distilled water and charge until specific gravity is correct. DO NOT OVERCHARGE.

WARNING

Do not smoke while servicing batteries. Explosive gases are emitted from batteries in operation. Ignition of these gases can cause severe personal injury.

7. Check engine for fuel or oil leaks. Correct leakage as required.
8. Install fully charged batteries.
9. Start engine and check while running for leaks, battery charge rate, and proper cooling.

After engine has started, excessive blue smoke will be exhausted and the engine will run rough until the rust inhibitor or oil has burned away.



Clean or replace crankcase breather baffle periodically. Be sure baffle material doesn't come apart and work into the manifold.

FIGURE 10. OIL SYSTEM COMPONENTS

CRANKCASE BREATHER

The crankcase breather maintains a partial vacuum in the crankcase during operation to control oil loss and ventilate the crankcase, Figure 10.

To disassemble, remove the rubber cap from the crankcase tube and pry the valve out of the cap. Wash the valve in fuel at regular intervals and, if defective, replace it. Also, pull the baffle out of the breather tube and clean it. Install the valve with the perforated disk toward the engine.

OIL FILTER (OPTIONAL)

The full-flow filter (Figure 10) is mounted on the filter plate at the left front corner of the crankcase. Replace normally after every 200 hours of operation. Remove the filter by turning counterclockwise. Lubricate the gasket on the new filter with engine oil. Install the filter until the gasket touches the base and tighten 1/2 turn; do not overtighten.

GOVERNOR SYSTEM

CONSTANT SPEED GOVERNOR

The standard governor for the CCKB is a constant speed governor, Figure 11. A variable speed governor is shown in Figure 12. If the following checks don't remedy erratic governor operation, install a new governor spring. Check the governor arm, linkage, throttle shaft and lever for binding or excessive 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 shut off. Replace parts as needed.

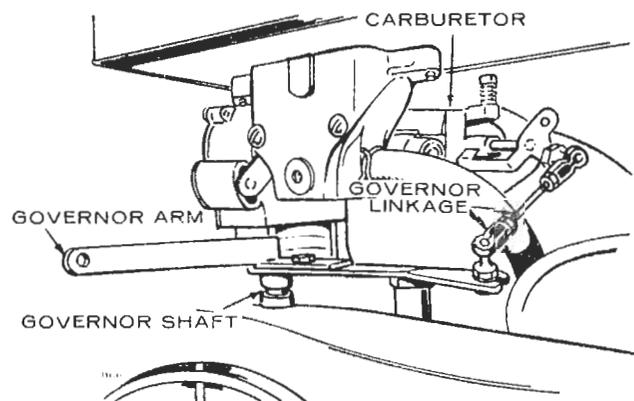


FIGURE 12. VARIABLE SPEED GOVERNOR

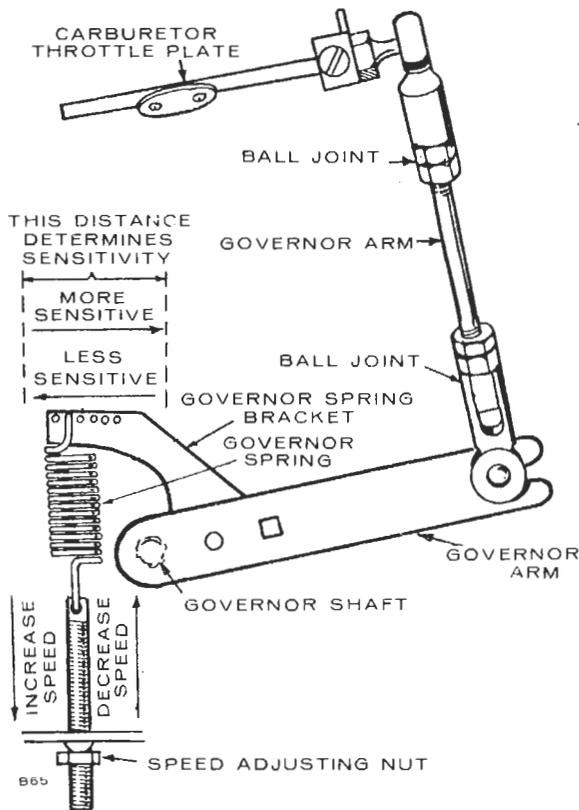


FIGURE 11. GOVERNOR ADJUSTMENT LINKAGE

GOVERNOR ADJUSTMENTS

Where engine speed is governor controlled, the governor is set at the factory to allow a nominal engine speed of 2400 rpm at no-load operation (unless another speed is specified when the engine is ordered). Proper governor adjustment is one of the most important factors in maintaining the power and speed desired from the engine, Figure 11.

Before making governor adjustment, run the engine about 10 minutes to reach normal operating temperature. Be sure carburetor main load and idle needles are properly adjusted before checking or adjusting governor system. For an accurate governor adjustment, a reliable instrument, tachometer for example, is required.

If the following checks don't remedy erratic operation, install a new governor spring. Springs become fatigued with age.

Linkage

Check the governor arm, linkage, throttle shaft and lever for a binding condition or excessive slack and wear at connecting points, Figure 11. 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. Replace parts as needed.

The engine starts at wide open throttle. The length of the linkage connecting the governor arm to the throttle arm is adjusted by rotating the ball joint. Adjust length so with the engine stopped and tension on the governor spring, the carburetor throttle lever is wide open. This setting allows immediate control by the governor after starting and synchronizes travel of the governor arm and the throttle shaft.

The adjustable governors use the same procedure for sensitivity adjustment, but the speed adjustment for the variable speed governor (Figure 13) is different. If engine has variable speed governor as shown, proceed to Variable Speed Governor Adjustment.

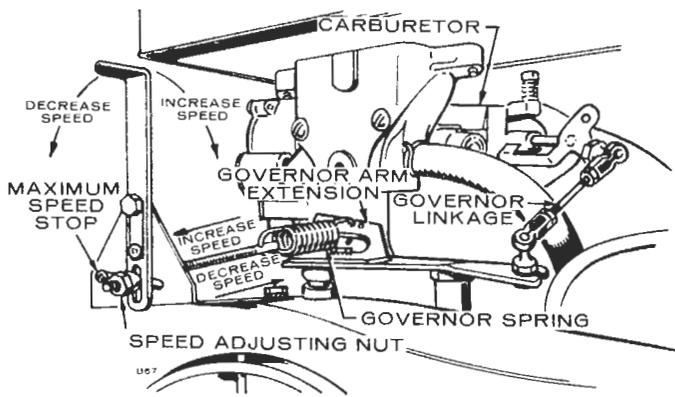


FIGURE 13. VARIABLE SPEED GOVERNOR

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. The no-load speed of the engine should be slightly higher than the speed requirements of the connected load. For example, if the connected load is to turn at 2310 rpm, set the no-load speed of the engine at about 2400 rpm. Check speed with a tachometer. If a speed adjustment is needed, turn the speed adjusting nut in to increase the speed or out to decrease the speed (Figure 11).

Sensitivity Adjustment

The engine speed drop from no load to full load must be within 100 rpm. Check the engine speed with no load connected and again after connecting a full-rated load.

The sensitivity of the governor depends upon the position of the arm end of the governor spring. A series of holes in the governor arm provides for adjustment. To increase sensitivity, move the governor spring toward the governor shaft. To decrease sensitivity, move the governor spring toward the linkage end of the governor arm.

A too-sensitive setting will result in a surging speed (hunting) condition, an alternate increase and decrease in engine speed. An opposite setting will result in too much speed variation between no-load and full-load conditions.

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.

Variable Speed Governor Adjustment

These governors are adapted for use where a wide range of speed settings is desired. Engine speed is controlled at any given point between minimum and maximum by simply shifting the speed lever on the blower housing until the desired speed is reached.

The adjustable governors use the same procedure for sensitivity adjustment, but the speed adjustment for the variable speed governor (Figure 13) is different.

The design of the variable speed governor gives an automatic decrease in sensitivity when the speed is increased and the result is good stability at all speeds.

Adjust the governor as follows:

1. Make sure carburetor is adjusted correctly (see *FUEL SYSTEM* section).
2. Adjust idle speed screw on carburetor for a 1500 rpm minimum idling speed.
3. Adjust tension on governor spring for minimum speed (Figure 13) with lever at slow speed position.
4. Adjust sensitivity for smooth no load to full load by moving the governor spring as shown in Figure 11. Move spring toward governor shaft for more sensitivity, away for less sensitivity.

If the setting is too sensitive, a hunting condition (alternate increase and decrease in engine speed) will result. If the setting is not sensitive enough, the speed variation between no-load and full-load conditions will be too great.

5. Apply a full load and shift the lever until the engine speed reaches the desired maximum speed. Set the screw in the bracket slot to stop lever travel at the desired maximum full load speed position. A full-load speed of 3600 rpm is the recommended maximum for continuous operation. The speed must agree with the load requirements.

FUEL SYSTEM

GENERAL

Satisfactory engine performance is largely dependent upon correct fuel system adjustments. However, adjustments cannot fully compensate for low engine power due to wear, etc. If trouble develops, follow an orderly procedure to determine the cause before making any adjustment.

Adjusting the carburetor is a means of obtaining the correct fuel-to-air mixture for smooth, efficient operation. Always adjust in two steps, first the load adjustment and then the idle adjustment.

GASOLINE AND GAS-GASOLINE CARBURETORS

Before adjusting the carburetor, be sure the ignition system is working properly and the governor is adjusted. Allow the engine to warm up before starting carburetor adjustments.

If carburetor is completely out of adjustment so the engine will not run, open both valves 1 to 1-1/2 turns off their seats to permit starting. Do not force the needle valves against their seats. This can bend the needle.

Gasoline Carburetor Adjustments

1. With no load, turn idle adjustment out until engine speed drops slightly below normal, Figure 14. Then turn needle in until speed returns to normal.
2. Apply a full load to engine.
3. Carefully turn main adjustment in until speed drops slightly below normal. Then turn needle out until speed returns to normal.

Alternate Method (No load adjustment possible)

1. Start engine and allow it to warm up.
2. Push in on governor mechanism to slow unit down to about 400 to 500 rpm.
3. Set idle adjustment screw for even operation so engine is firing on both cylinders and running smoothly.
4. Release governor mechanism to allow engine to accelerate. If the engine accelerates evenly and without a lag, the main adjustment is correct. If not, adjust the needle outward about 1/2 turn and again slow down the engine and release the mechanism. Continue until the engine accelerates evenly and without a time lag after releasing the governor.

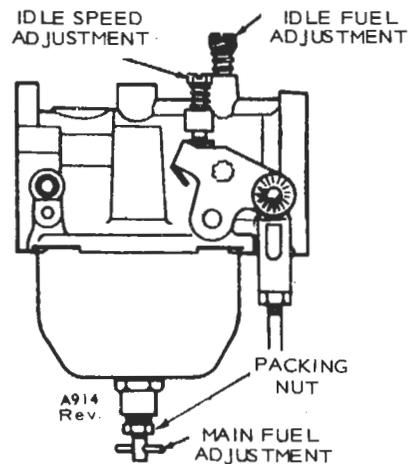
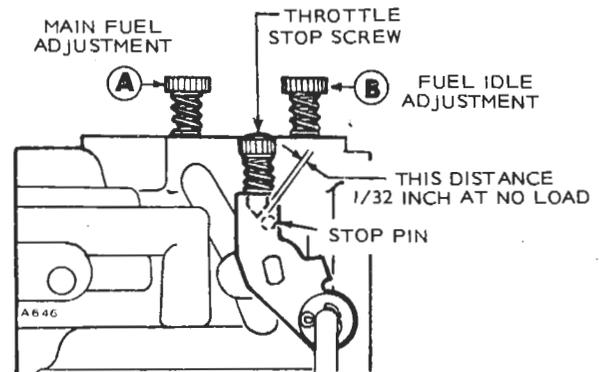


FIGURE 14. GASOLINE CARBURETORS

Gas-Gasoline Carburetor Adjustments

When operating on gasoline, use the adjustment procedures described under *Gasoline Carburetor Adjustments*. Be sure the choke lock wire (Figure 15) is removed. These carburetors are factory set for gas rated approximately 1000 BTU. If fuel rating is substantially different, a readjustment of the fuel mixture is required.

1. Turn idle fuel adjusting screw out until engine speed drops slightly (Figure 15). Then turn screw in until speed returns to normal.
2. Apply a full load to engine.
3. Turn in gas main adjustment screw until engine speed drops. Then turn out screw until engine speed returns to normal.

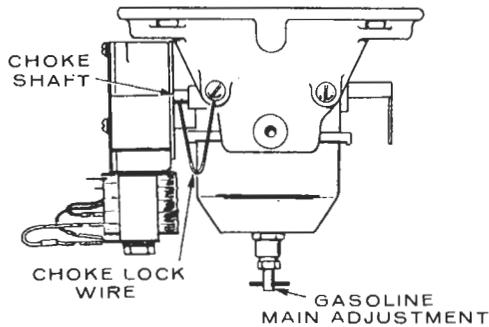
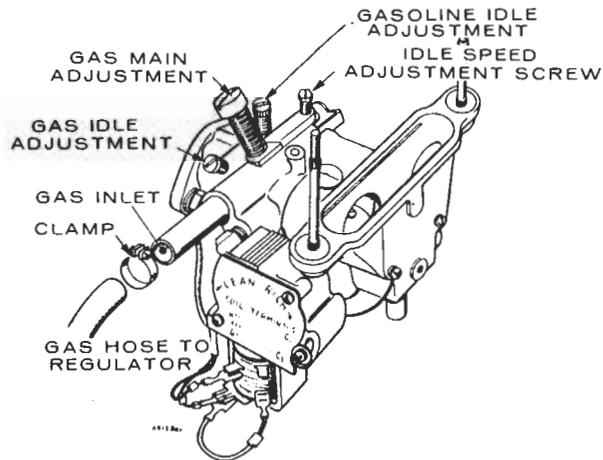


FIGURE 15. GAS-GASOLINE CARBURETOR

Alternate Method (No load adjustment possible)

1. Start engine and allow it to warm up.
2. Push in on governor mechanism to slow engine down to about 400 to 500 rpm.
3. Set idel fuel adjustment screw for even operation so the engine is firing on both cylinders and running smoothly.
4. Release governor mechanism to allow engine to accelerate. If engine accelerates evenly and without a lag, the main adjustment is correct. If not, adjust the screw outward about 1/2 turn and again slow down the engine and release the mechanism. Continue until the engine accelerates evenly and without a time lag after releasing the governor.

Gas-Fueled Carburetor

Allow the engine to warm up if preliminary adjustments are satisfactory for initial startup. If the engine won't start, set the idle fuel adjustment screw (Figure 16) two turns off seat and main adjusting screw approximately three turns (six turns for only 800 BTU gas). These settings should be adequate for starting.

1. Turn idle fuel adjustment screw out until engine speed drops, then turn in until speed increases to maximum.

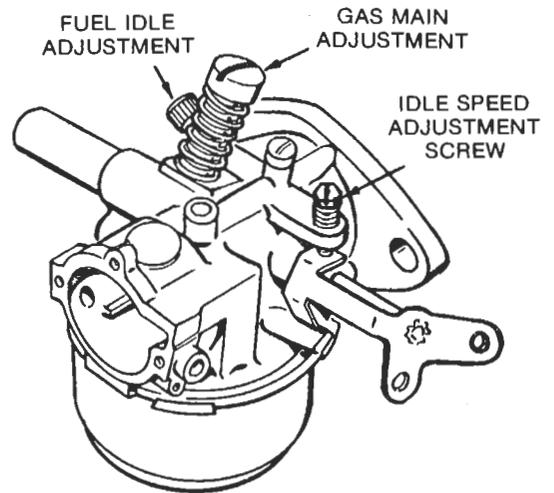


FIGURE 16. GAS CARBURETOR

2. Apply a full load to engine.
3. Turn main gas adjusting screw in until engine loses power. Slowly back out screw until engine carries full load smoothly.
4. Check setting with varying loads.

CARBURETOR DISASSEMBLY (Gasoline and Gas-Gasoline Only)

1. If engine is equipped with an automatic choke, remove two screws that fasten the choke to the carburetor and remove assembly.
2. Remove main jet assembly and bowl.
3. Remove float pin and float. See Figure 17.
4. Lift out fuel inlet valve and unscrew valve seat.
5. Remove no-load adjusting needle.
6. Remove throttle plate screws and plate and pull out throttle shaft.
7. Remove choke plate screws and plate and pull out choke shaft.

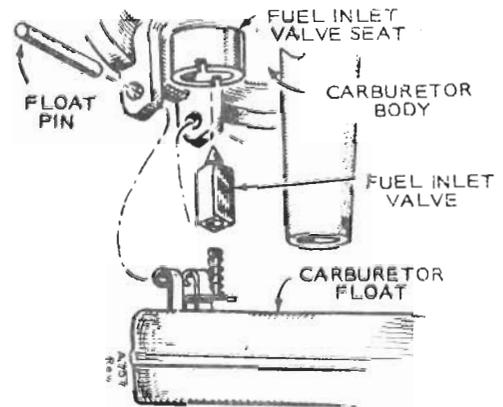


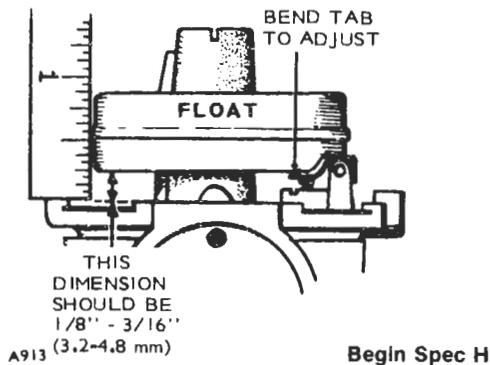
FIGURE 17. FLOAT ASSEMBLY

Cleaning and Repair

To clean the carburetor, soak all components thoroughly in a good carburetor cleaner following the cleaner manufacturer's instructions. Be sure all carbon is cleaned from the carburetor bore, especially in the area of the throttle valve. Blow out the passages with compressed air. If possible, avoid using wire to clean out the passages.

Check the adjusting needles and nozzle for damage. If the float is loaded with fuel or damaged, replace it. The float should fit freely on its pin without binding. Invert the carburetor body and measure the float level (Figure 18). If necessary, bend the small lip that the intake valve rides on to adjust float level.

Check the choke and throttle shafts for excessive side play and replace if necessary.



CARBURETOR ASSEMBLY (Gasoline and Gas-Gasoline Only)

1. Install throttle shaft and plate, using new screws and lockwashers. Install with bevel mated to the carburetor body. On plates marked with the letter C, install with the mark on the side toward the idle port when viewed from the flange end of the carburetor. To center plate, back off top screw, close throttle lever and seat plate by tapping it with a small screwdriver. Then tighten the two screws.
2. Install choke shaft and plate. Center plate in same manner as the throttle plate (step 1). Use new screws and lockwashers.
3. Install fuel inlet valve seat and valve.
4. Install float, float pin and float spring (begin Spec H). Center pin so float bowl does not ride against it.
5. Check float level with the carburetor casting inverted. See Figure 18.
6. Install bowl ring gasket, bowl and bowl nut. Make sure that the bowl is centered in the gasket, the float spring is in place (begin Spec H), and tighten the main jet assembly securely. Turn in until it seats and back out 1 to 1-1/2 turns.
7. Install the idle adjusting screw finger tight. Then back out 1 to 1-1/2 turns.
8. Install automatic choke (if used).

THERMAL MAGNETIC CHOKE (Optional)

This choke uses a heating element and a heat sensitive bimetal spring to open the choke plate. The choke solenoid, actuated during engine cranking only, closes the choke plate according to ambient temperature. During gaseous fuel operation, the choke plate is locked in the full open position by the choke lock wire, Figure 15.

If adjustment is required, use the following instructions. Choke bimetal spring must be at ambient temperature. Allow engine to cool at least one hour before setting. Adjust choke by turning the choke body, which engages a link connected to a bimetal choke spring.

Remove air cleaner and adapter to expose the carburetor throat. Loosen the screw which secures the choke body. Rotate choke body clockwise to increase choke and counterclockwise to decrease choke action (leaner mixture). Refer to Figure 19 for correct choke setting according to ambient temperature. Use drill rod or shank of drill bit to measure choke opening.

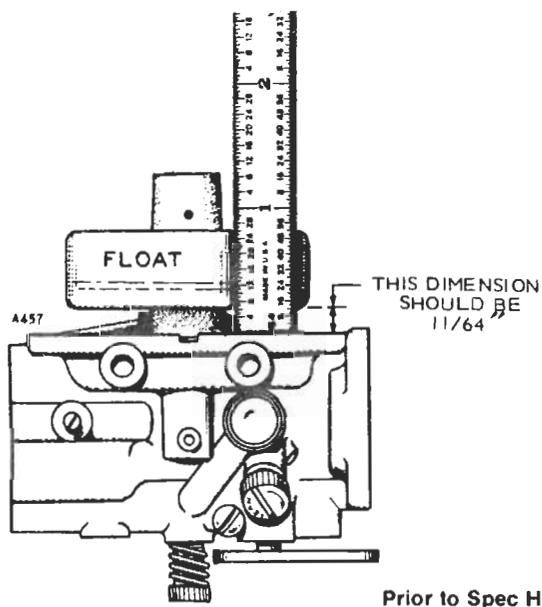


FIGURE 18. CHECKING FLOAT LEVEL

AMBIENT TEMP. (°F)	60	65	70	75	80	85	90	95	100
CHOKE OPENING (Inches)	1/8	9/64	5/32	11/64	3/16	13/64	7/32	15/64	1/4



FIGURE 19. THERMAL MAGNETIC CHOKE SETTINGS

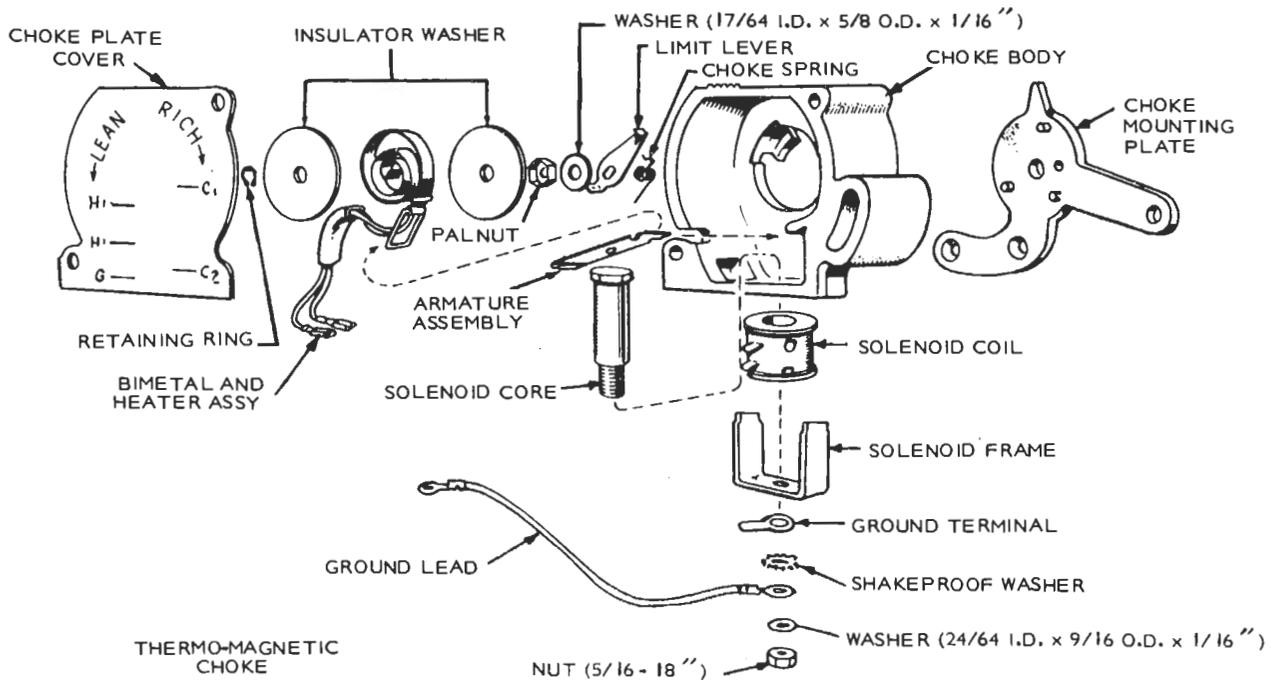


FIGURE 20. THERMAL MAGNETIC CHOKE ASSEMBLY

Disassembly and Repair

If the choke will not operate or will not retain an adjustment, disassemble it for repair. For disassembly, refer to Figure 20.

If the choke will not close, check for binding, incorrect adjustment, or incorrect assembly of the bimetal and heater assembly. If the choke will not open after the engine starts, check for heating. The choke bimetal should be warm to the touch within a minute or two after starting.

If the heater assembly will not heat properly, check for broken heater wire, high resistance connections or

broken lead wires to the bimetal and heater assembly. With the element at room temperature, check the heater resistance with an ohmmeter. The resistance should be about 37.8 to 46.2 ohms for a 12-volt system. If the heater is defective, replace. There must be slack in the lead wires between the choke body and the bimetal and heater assembly. When the start button is engaged, the solenoid should cause the spring loaded lever to contact the solenoid core. If this does not occur, check for broken lead wires or a defective solenoid core.

The solenoid coil should have a resistance of 2.09 to 2.31 ohms in a 12-volt system.

Assembly

Refer to Figure 20. When assembling the thermomagnetic choke, connect the bimetal and heater assembly as follows:

1. Lead tagged 'G' to ground terminal in coil solenoid.
2. Lead tagged 'H' to either of the 'H' terminals on the solenoid core.

FUEL PUMP

A diaphragm-type fuel pump is used. If fuel does not reach the carburetor, check the fuel pump before dismantling it.

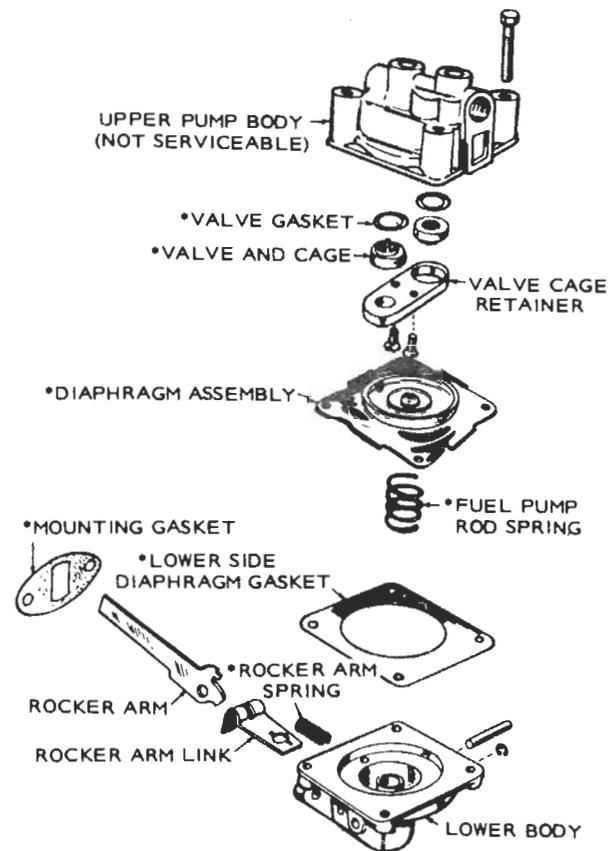
The pump can be checked by disconnecting the fuel line at the carburetor, cranking the engine slowly by hand, and observing whether fuel comes from the line at the carburetor. If there is enough fuel in the tank, and the line between the tank and the pump is open but the pump fails, repair or replace it. Failure of the pump is usually due to a leaking diaphragm, valve or valve gasket, a weak or broken spring, or wear in the drive linkage. If the operator chooses to repair the pump rather than install a new one, the use of a complete repair kit is recommended. Gasoline diluted oil may indicate a faulty fuel pump.

CAUTION Use care when reassembling pump; all parts must be perfectly aligned, or pump will leak, creating a fire hazard.

Fuel Pump Reconditioning (Figure 21):

1. Remove fuel lines and mounting screws holding pump to engine.
2. Make an indicating mark with a file across a point at the union of the fuel pump bolt and cover. This mark will assure proper reassembly. Remove assembly screws and remove upper pump body.
3. Turn pump body over and remove valve plate screw and washer. Remove valve retainer, valves, valve springs and valve gasket, *noting their position*. Discard valve springs, valves and valve retainer gasket.
4. Clean pump body thoroughly with solvent and a fine wire brush.
5. Holding the pump cover with the diaphragm surface up, place the new valve gasket into the cavity. Assemble the valve spring and valves in the cavity. Reassemble the valve retainer. Lock in position by inserting and tightening fuel pump valve retainer screw.
6. Place pump body assembly in a clean place and rebuild the lower diaphragm section.
7. Holding mounting bracket, press down on the diaphragm to compress spring under it, then turn bracket 90 degrees to unhook diaphragm so it can be removed.
8. Clean mounting bracket with a solvent and a fine wire brush.

9. Replace the diaphragm fuel pump rod spring, diaphragm gasket, stand new spring in casting, position diaphragm, compress spring and turn 90 degrees to reconnect diaphragm.
10. Hold bracket, then place the pump cover on it (make sure that indicating marks are in line) and insert the four screws. **DO NOT TIGHTEN**. With the hand on the mounting bracket only, push the pump lever to the limit of its travel and hold in this position while tightening the four screws. This is important to prevent stretching the diaphragm.
11. Mount the fuel pump on engine, using new mounting gaskets. Connect the fuel lines.



A320 Rev

* - PARTS INCLUDED IN REPAIR KIT.

FIGURE 21. FUEL PUMP ASSEMBLY

PULSATING DIAPHRAGM GASOLINE FUEL PUMP

Pulsating diaphragm fuel pumps use a combination crankcase and spring pressure to work a diaphragm thus pumping fuel. This pump may be mounted to the side of the carburetor or, in some tractor applications, on the upper right hand corner of the blower housing.

On the downstroke of the engine piston, when the crankcase pressure is greatest, the pump diaphragm is forced back against the diaphragm spring compressing it and drawing fuel into the pump intake chamber. The fuel then passes through the intake reed valve into the output chamber side of the pump. On the compression stroke, when crankcase pressure is the lowest, the diaphragm spring forces the diaphragm out pushing fuel through the pump output reed valve into the output chamber and into the fuel line.

Servicing Fuel Pump

1. Remove vacuum and fuel lines. Inspect lines for wear, cracking, etc.

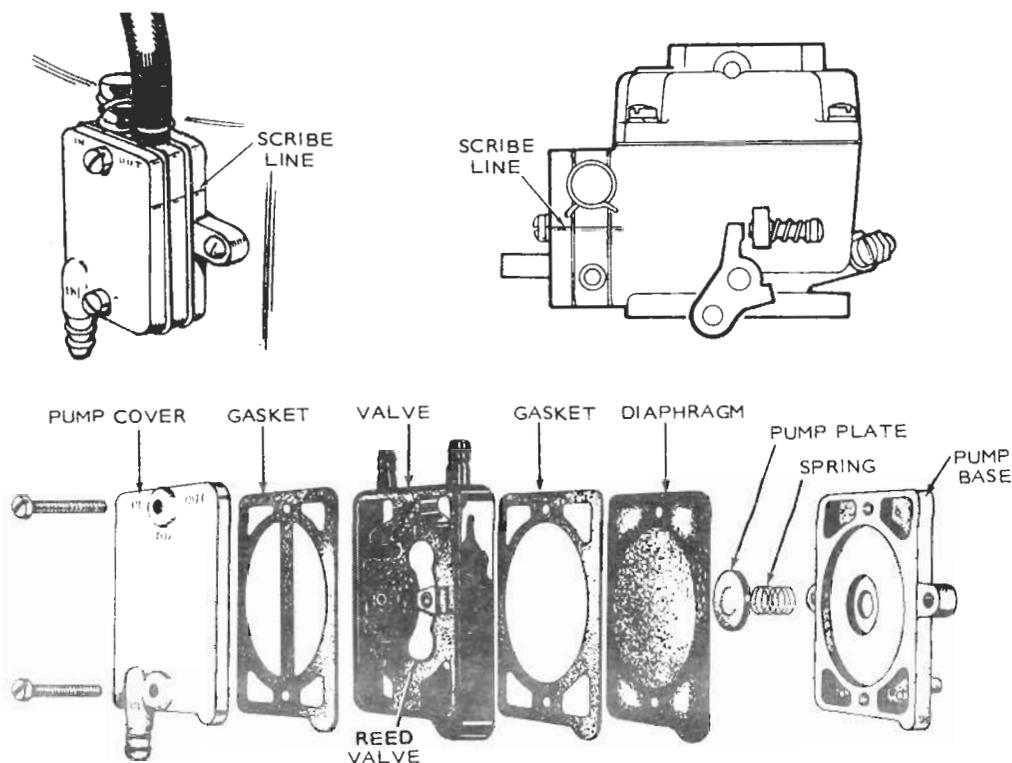
On models where the fuel pump is mounted directly to the carburetor, no output fuel line exists. The pump cover containing the input and output chambers of the pump is an integral part of the carburetor body.

2. Scribe two lines (one each on opposite ends of pump) across pump parts. This will ensure correct alignment of pump parts with each other and carburetor when pump is reassembled.
3. Remove fuel pump attaching screws.
4. Holding pump, carefully pull sections of the pump apart. The diaphragm, plunger, return spring and plate, pump body and gaskets will now be loose.
5. Check parts for wear and damage. Replace with new parts where necessary.
6. The air bleed hole in pump base must be unclogged to allow unrestricted movement of diaphragm.

CAUTION A clogged diaphragm air bleed hole can cause diaphragm wear and seal damage while inhibiting pump operation.

7. Replace gaskets and reassemble pump as shown in Figure.
8. Install pump and replace lines. Make sure fuel line clamps are replaced on fuel line.

WARNING Use care when reassembling the pump. All parts must be perfectly aligned or the pump will leak creating a fire hazard.



PULSATING DIAPHRAGM FUEL PUMP

SISSON CHOKE

This choke should not require any seasonal readjustment. If adjustment becomes necessary, pull choke lever up and insert a 1/16-inch (1.59 mm) diameter rod through shaft hole (opposite end from lever) and engage rod in notch of mounting flange, to lock shaft in place.

Loosen the choke lever clamp screw. With air inlet removed, adjust choke lever so carburetor choke plate is completely closed, or not more than 5/16-inch (7.94 mm) open. Tighten choke lever clamp screw and remove locking rod from shaft. See Figure 22.

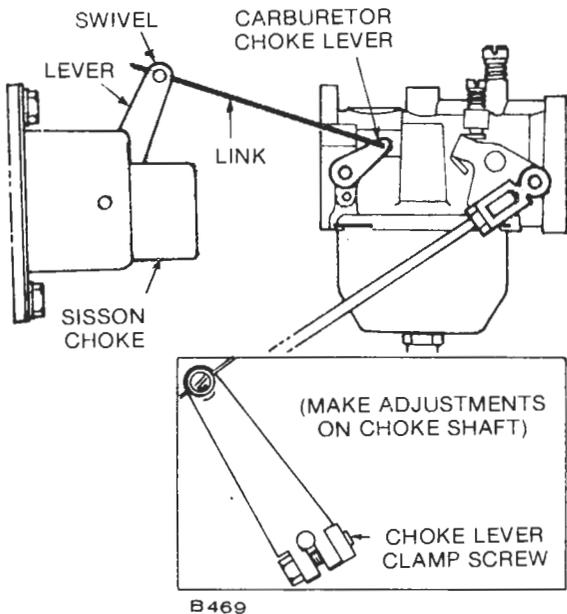


FIGURE 22. SISSON CHOKE

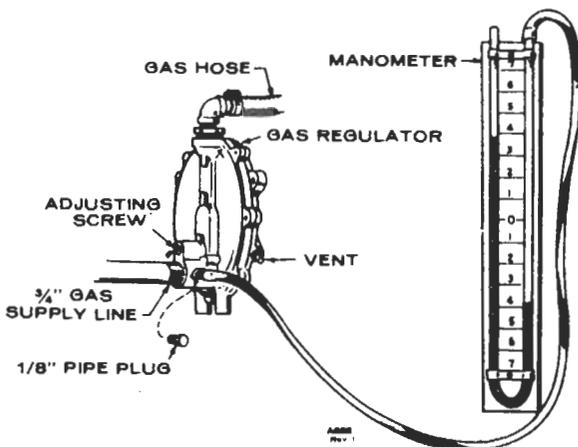


FIGURE 23. TESTING GAS REGULATOR

CAUTION

A soap bubble placed over the regulator outlet will not accurately test for regulator closing. The soap bubble's resistance when multiplied by the greater area of the regulator diaphragm is enough to shut off this very sensitive demand type regulator.

ADJUSTING THE GAS PRESSURE REGULATOR

The maximum allowable inlet pressure is 8 ounces; (3.45 kPa) minimum 2 ounces (0.86 kPa). If gas line pressure is greater than 8 ounces, install a primary regulator to reduce the pressure. The regulator has an adjustment to control the maximum pressure at which the regulator shuts off when there is no demand. To obtain maximum regulator sensitivity, adjust it to just shut off at your line pressure when there is no demand. Adjust the regulator for shut off when there is no demand to prevent gas leaks. The factory adjusted shutoff is between 2 and 4 ounces (0.86 and 1.72 kPa). If gas line pressure is between 4 and 8 ounces (1.72 and 3.45 kPa), readjust the screw Figure 23.

1. Use a manometer which reads up to 14 inches (355.6 mm) water column.

One ounce per square inch equals 1.73 inches (43.94 mm) water column. Likewise, one inch water column equals 0.58 ounce per square inch.

2. Shut off gas supply. Temporarily remove the 1/8-inch pipe plug at regulator inlet for testing pressure.
3. Connect manometer to read gas supply line pressure.
4. Open gas supply line valve. Without delay, alternately cover and uncover the regulator outlet with the palm of your hand. At the same time watch the manometer. If the regulator closes completely, as desired, the manometer will hold a steady reading.
5. If the manometer reading drops slightly each time you remove your hand, the regulator is leaking. Turn the adjusting screw inward just far enough so that the manometer reading remains constant when you repeatedly cover and uncover the regulator outlet with your hand.
6. Close the gas supply line valve. Remove manometer. Bleed air from gas supply line. Install test-hole plug in regulator. Open gas supply line valve.
7. See that vent fitting is installed in the regulator hole.
8. With a clamp on each end, secure the hose between the regulator outlet nipple and the carburetor inlet.
9. Operate the engine to assure quick starting results.

LPG VAPORIZER

The vaporizer-regulator consists of a high pressure regulator and a vaporizer in a single unit (Figure 24). Regulator portion of the vaporizer-regulator reduces LPG tank pressure to a uniform outlet pressure of 7 psi (48.3 kPa). The vaporizer section installed in the path of the engine cooling air system furnishes the heat required to offset the cooling effect produced as the LPG fuel is expanded and becomes gas.

The vaporizer reduces high pressure liquid fuel to low pressure gaseous fuel. Liquid fuel is admitted into the inlet part and passes through the fuel inlet orifice. With the engine running, the pressure to the right of the valve seat and retainer drops to open the valve, a mixture of partially vaporized fuel enters the center tube (first stage cold chamber) of the vaporizer. The droplets of fuel are sprayed out of the end plug holes into the staggered portions of the cast heat exchanger. The swirling action of the fuel ensures complete vaporization. Dry gas leaves the exchanger through the outlet port of 3 psi (20.7 kPa).

Vaporizer Adjustments: Adjust the vaporizer to a working pressure of 7 psi whenever the pressure adjusting screw is moved or the unit is overhauled.

1. Place the vaporizer in a vise or other suitable clamp. Attach an air hose from an air supply of approximately 75 psi (517.5 kPa) to the inlet, Figure 25.
2. Attach a pressure gauge capable of reading over 7 psi (48.3 kPa) to the outlet.
3. Back off the adjusting screw until only one or two threads are engaged. Apply air pressure to the unit.

4. Turn the pressure adjusting screw in slowly until a reading of 7 psi shows on the gauge.

To obtain an accurate gauge reading, it may be necessary to unscrew the gauge partially to bleed off some of the air. Then retighten the gauge and readjust for 7 psi (48.3 kPa). If the pressure reading remains steady, the valve is not leaking. If the pressure reading increases slowly, it indicates a leaking valve. Check the components of the vaporizer for correct assembly procedures. Replace defective parts.

5. Tighten the lock nut on the pressure adjusting screw. Turn off the air pressure and remove the gauge and air line.

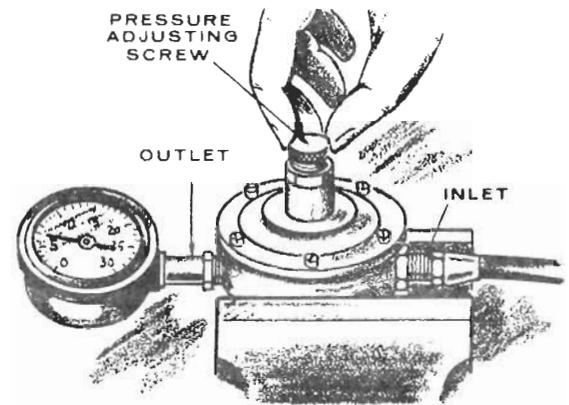


FIGURE 25. VAPORIZER ADJUSTMENT

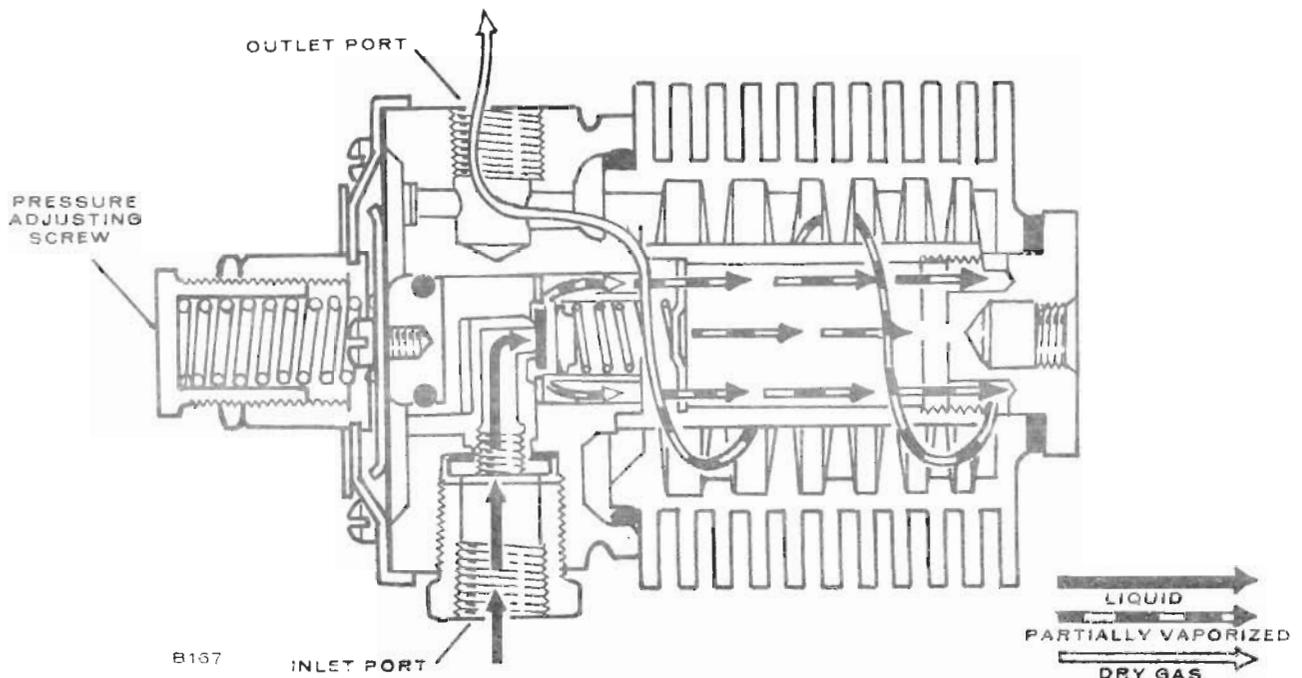


FIGURE 24. LPG VAPORIZER

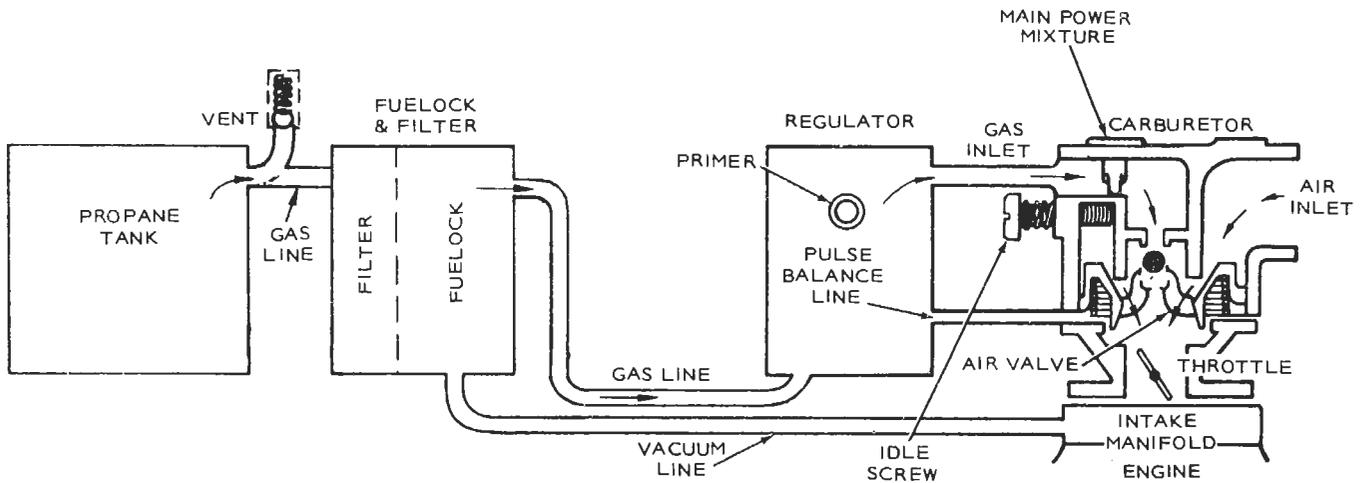


FIGURE 26. VAPOR WITHDRAWAL FUEL SYSTEM, BLOCK DIAGRAM

LPG VAPOR WITHDRAWAL SYSTEM

A typical vapor withdrawal LP gas fuel system consists of a vacuum fuellock and filter, a fuel regulator, and a gas carburetor connected by flexible hoses, Figure 26. A pulse balance line is needed for one and two cylinder engines between the carburetor and regulator. A vacuum line is needed between the intake manifold and the fuellock and filter. Some systems have a vacuum or solenoid operated fuel cutoff valve or both; the solenoid operated valve may be tied in with the ignition system.

FUEL

The engine and carburetor operate on propane (Liquefied Petroleum Gas-LPG). This discussion covers only systems and components used with propane vapor withdrawal applications.

FUELOCK AND FILTER

The IMPCO vacuum operated fuellock and filter is combined in one unit, Figure 27. It should be trouble-free and maintenance-free for extended periods. Normally, no adjustments or filter replacements are needed on a periodic basis, but repair kits and replacement filters are available for complete overhaul if a malfunction occurs. Each kit includes detailed and illustrated installation procedures and new replacement parts.

The fuel inlet and outlet take 1/4-inch NPT fittings. The vacuum connection takes a 1/8-inch NPT fitting for a 7/32-inch I.D. hose. The fuellock opens with 2-inches water column at normal tank pressure.

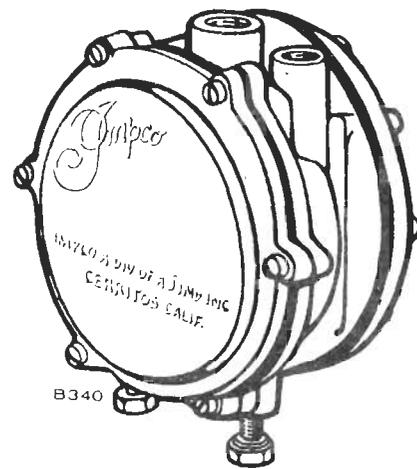


FIGURE 27. FUELOCK AND FILTER

The fuellock and filter unit replaces a separate line filter, an electric solenoid lockoff valve and a vacuum controlled switch required on earlier gas engine applications.

REGULATOR

The IMPCO pressure regulator is a two-stage regulator (LP Gas Converter) with a hand primer, Figure 28. It should be trouble and maintenance free for extended periods of operation. Repair kits are available for a complete overhaul if a malfunction occurs. The kit includes detailed and illustrated installation instructions. The secondary regulator lever assembly is subject to wear under heavy duty operation and may require replacement during an overhaul. The low pressure spring (blue) for vacuum control gives a negative 1-1/2-inch water column measurement on a manometer. The two vapor outlet ports and the LPG inlet have 1/2-inch pipe thread. The balance line connection is 1/8-inch pipe thread.

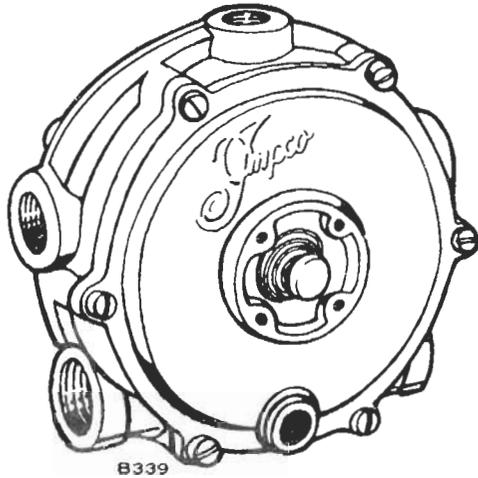


FIGURE 28. GAS REGULATOR

GAS CARBURETOR

The IMPCO carburetor or mixer employs a unique, moving venturi (air valve, metering valve and venturi combined) to measure airflow, to meter gas flow, and to mix the intake air and gas, Figure 29. The throttle controls engine speed and power in the same way as the carburetors on other gas or gasoline engines. An idle jet, a main jet (power mixture adjustment) and a throttle stop screw provide carburetor adjustments for maximum engine power and efficiency with low exhaust emissions.

CARBURETOR OPERATION

In operation, the moving venturi/air valve or air valve assembly opens in direct proportion to the breathing requirements of the engine to give optimum mixtures and good air/fuel distribution, Figure 30.

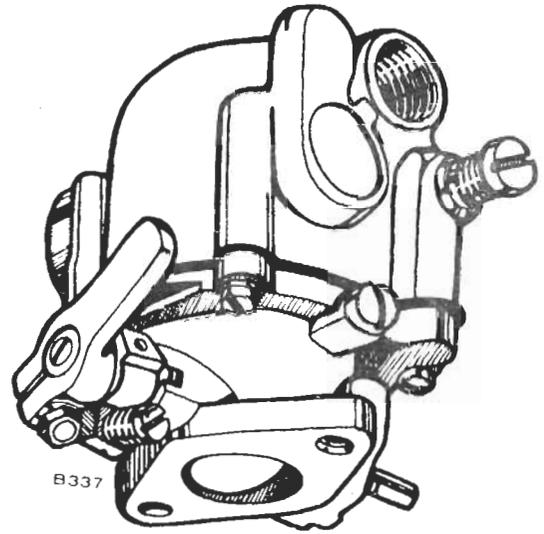


FIGURE 29. GAS CARBURETOR

The air valve assembly operates in an up-and-down, piston-like motion inside the cylindrical cavity of the throttle body assembly. When the engine is stopped, the air valve assembly is held in a closed position by a metering spring, Figure 30A. The gas passage in the throttle body is completely closed off by means of a synthetic rubber seat on the metering valve. When the engine is started, the air valve assembly moves downward off the gas passage inlet, allowing entry of gas into the venturi throat where it mixes with high-velocity intake air, Figure 30B. The higher the load demand, the greater the air and gas opening up to maximum throttle.

Carburetor vacuum provides a sufficiently strong metering signal (or metering force) to the fuel regulator. The better the signal, the less important precise pressure regulation of the fuel becomes.

Under heavy pulsing conditions with two-cylinder engines, oscillations of the air valve are reduced by a breather hole with a check valve in the plate that supports the air valve and spring. The check valve vents air allowing the air valve movement and relieves any pressure surges caused by backfire, without closing the air valve.

A constant depression spring positioned between the check valve and the air valve assembly provides constant tension against the air valve to keep the vacuum curve flat. This spring limits the vacuum signal transmitted from the intake manifold, holding it between 0.5- and 1.5-inches of mercury. The constant tension on the air valve assembly amplifies the signal at idle and limits it at full throttle. The air valve provides good breathing at top speed, eliminates flat spots at low speeds, and prevents lag in the pulse signal to the regulator. Therefore, throttle response is good with fast acceleration.

THROTTLE CLOSED
CUTAWAY VIEW

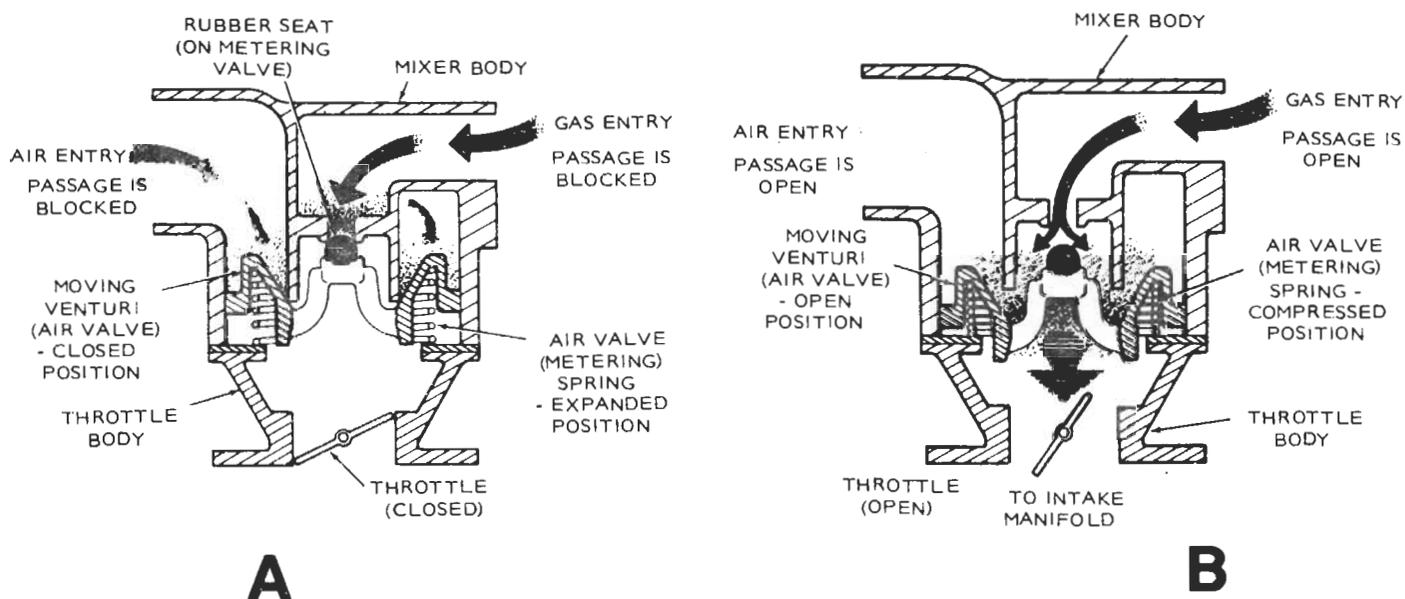
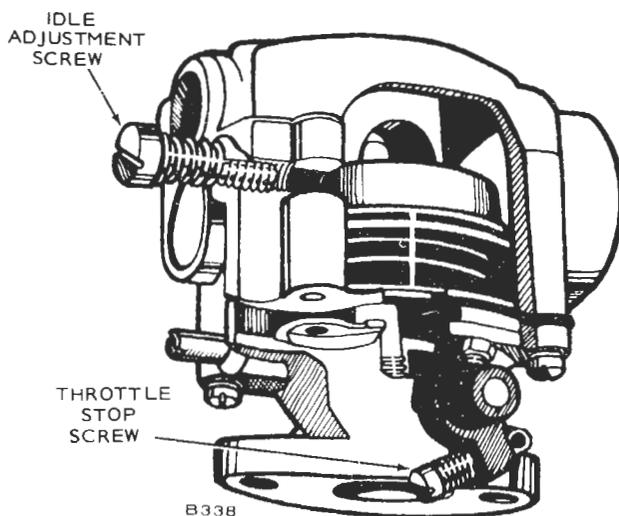


FIGURE 30. GAS CARBURETOR OPERATION

The idle adjustment/bypass system consists of an adjustable port for air through the air/fuel passage wall which bypasses the venturi to the throttle. At idle, the flow of air is past the idle adjustment screw into a port in the mixer body, past an idle cutoff piston in the throttle body where it enters the air/fuel passage. The idle cutoff piston is normally held in a closed position by a spring effectively blocking the passage of air through the idle port at less than 5 inches of vacuum. At idle, the piston is retracted allowing air to be metered by the idle adjustment screw. But during cranking and under heavy loads, the piston blocks the idle port enriching the fuel/air mixture for quick starts and acceleration. The idle mixture adjustment screw is tapped into the air bypass port in the throttle body. Turning the screw in or out meters the amount of air entering the port accordingly. Normally, only a very small opening past the screw is needed.

CARBURETOR ADJUSTMENTS

Gas engines with LPG carburetors maintain low exhaust emissions (Carbon Monoxide CO, Hydro Carbons HC, and Carbon Dioxide CO₂) as long as: the carburetor is adjusted properly, the engine remains in good service condition, and high temperature, low ash crankcase oil is used.

INITIAL START ADJUSTMENTS (At factory or after service or maladjustment)

1. Set main power mixture to position shown in Figure 31.
2. Turn idle screw in fully clockwise.
3. Turn idle screw out 2-1/2 to 3-1/2 turns counterclockwise.

4. Connect or turn on fuel supply to regulator.
5. Check (smell) for propane leaks.
6. Start engine—it should start within 20 seconds if fuel is available to carburetor.

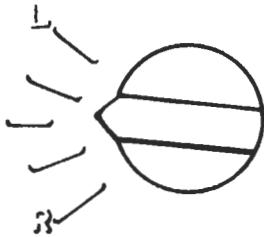


FIGURE 31. INITIAL START ADJUSTMENT

CHECKING FOR FUEL AT CARBURETOR

WARNING Do not permit any flame, cigarette, or other igniter near the fuel system. Propane gas is highly flammable and potentially explosive in confined spaces. Use your sense of smell to detect leaks.

1. Disconnect fuel line at carburetor.
2. Momentarily, press primer button; you should smell gas at end of fuel line. If not, check fuel lines back to supply tank.

With experience, you should be able to feel gas pressure on the regulator diaphragm when you press the primer button.

3. Look for one or more shutoff devices.
4. On vacuum operated shutoff valve systems, close throttle (fully) to aid engine starting with better vacuum.
5. If fuel is present at carburetor, check ignition system or other engine malfunctions.

CARBURETOR ADJUSTMENTS WITHOUT EXHAUST ANALYZER

1. Run new engine at least ten hours at normal service load. Avoid high loads before proper adjustments are made.
2. Run engine at maximum throttle and normal load for ten minutes, or set main power mixture near mark between L and R as shown in Figure 31.
3. Set main power mixture as lean as possible without noticeable loss in power output. If frost develops and remains on regulator for more than five minutes, check for propane leaks and ensure that vaporizer coil wraps tightly around exhaust pipe.
4. If engine functions properly but frost remains on regulator, the carburetor power mixture is too rich. Adjust for maximum efficiency.
5. Recheck head bolt torque and valve lash after carburetor is adjusted.

IDLE SCREW AND IDLE STOP

1. Run engine at idle speed (1200 rpm) for ten

minutes.

2. Adjust idle screw for maximum speed; maximum speed should be attained when idle screw is turned fully clockwise into carburetor.
3. Set idle stop screw speed at 1350 rpm.
4. Turn idle screw out until engine speed slows to 1200 rpm.

CARBURETOR ADJUSTMENTS WITH EXHAUST ANALYZER

Exhaust analyzers (with at least ± 3 percent accuracy) should be infra-red equipment, but flame ionization can be used for measuring hydrocarbon emissions which are n-hexane equivalent. All data is based on dry measurements which are obtained after removing all water vapor from the exhaust samples. A wet measurement will be about 15 percent less than for a dry measurement, if none of the water vapor is removed from the samples.

Main Power Adjustment:

1. Run engine at open throttle for normal maximum rpm for ten minutes or set main power mixture at mark between L and R as shown in Figure 31.
2. Adjust main jet for 1.0-plus 0.5-percent CO emission.
3. If frost develops and remains on regulator for more than five minutes, check for leaks and be sure vaporization coil wraps tightly around exhaust pipe.

When the fuel system functions properly, the regulator should be frost free after about five minutes running time.

Idle Screw Adjustment:

1. Run engine at 1200 rpm for ten minutes.
2. Using idle stop screw and idle mixture screw, set engine exhaust emissions for 0.2 ± 0.1 percent CO at 1200 rpm on richest mixture possible.

If this condition is met, the CO emission will exceed .5 percent when idle screw is turned one half turn counterclockwise from setting attained in step 2.

3. Return to 0.2 ± 0.1 percent CO idle screw setting.

At proper idle adjustment, the HC emission should be under 1000 ppm and CO₂ emission will be 8 to 10 percent.

THROTTLE STOP ADJUSTMENT

1. Adjust throttle stop clamp for maximum service load; throttle should be 20 degrees from vertical position at wide open throttle. Throttle travel from open to closed position should be 50 degrees.

CAUTION Do not change the throttle stop to increase the throttle opening. Increasing the throttle opening beyond this point does not increase the power output of the engine because the carburetor is designed for even larger engines. It may, however, adversely affect governor operation.

2. Check throttle linkage for freedom of movement.

SAFETY PRECAUTIONS WHEN WORKING WITH LPG

1. Always close the LPG tank shut-off valve when the engine is left unattended between use.
2. Be sure LPG tank shut-off valve is closed before disconnecting tank from system.
3. Ignition switch must be in OFF position prior to disconnecting any electrical wires.
4. Check fuel system regularly for leaks. Use soap to locate leaks and recheck with soap after repairing leaks.
5. Keep a fire extinguisher handy for immediate use. A dry powder or carbon dioxide (CO₂) type is recommended.
6. Never use LPG for cleaning parts.
7. Do not use LPG near open flame. Work in a well ventilated area.

LPG is heavier than air and settles in low places.

IGNITION SYSTEM

GENERAL

The CCKB engines use either a magneto ignition system or a battery ignition system. Each system and the spark advance mechanism are described in this section. Correct ignition timing is stamped on the crankcase near the breaker box (timing procedure given later). Spark advance is identified by a raised cup-shaped cover on the upper rear of the crankcase below the breaker box. Engines without spark advance use a flat cover which is flush with the crankcase. Figure 32 shows magneto ignition while Figure 34 shows the battery ignition system.

MAGNETO

The magneto coil assembly is mounted on the engine gear cover. The flywheel must be removed to expose it. The magneto coil assembly has only one set of mounting holes. Connect the smaller (ground) coil lead to the magneto coil assembly mounting screw, Figures 32 and 33. Connect the larger magneto coil assembly lead to the breaker box insulated terminal, Figure 32. The magneto coil used on engines with spark advance mechanism includes both the primary and secondary windings.

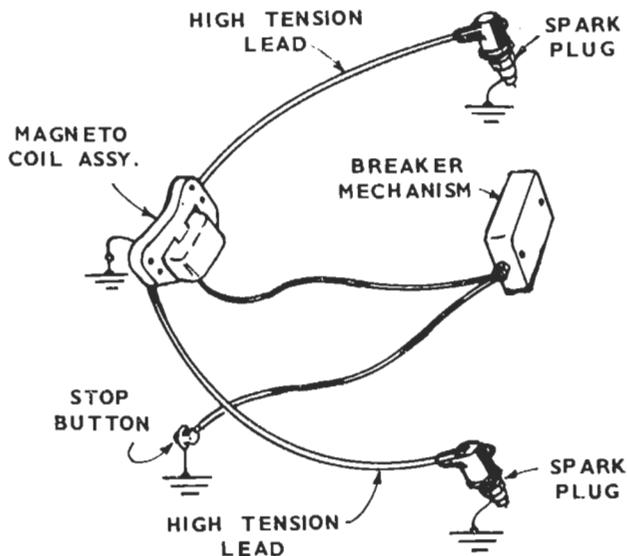
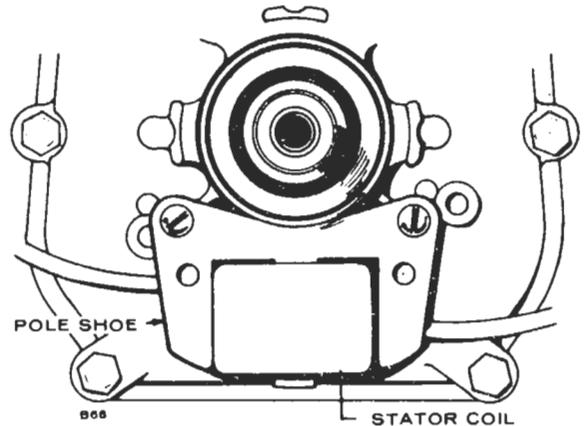


FIGURE 32. MAGNETO IGNITION SYSTEM



IF FLYWHEEL RUBS ON POLE SHOE LOOSEN POLE SHOE MOUNTING SCREWS, TAP POLE SHOE, AND RETIGHTEN MOUNTING SCREWS.

FIGURE 33. MAGNETO STATOR ASSEMBLY

BREAKER POINTS

To maintain maximum efficiency from the engine, change the breaker points every 200 hours of operation. Proceed as follows:

1. Remove the two screws and the cover on the breaker box.
2. Remove the two spark plugs so engine can be easily rotated by hand. If plugs have not been changed within the last 100 hours, replace them with new ones after setting the breaker points.
3. Remove the two mounting screws (A) and pull the points out of the box just far enough so screw (B) can be removed. See Figure 35. Replace points with a new set but do not completely tighten mounting screws (A).
4. Rotate the engine clockwise (facing flywheel) by hand until points are fully open. Turn screw (C) until point gap measures .020 inch (0.51 mm) with a flat thickness gauge.
5. Tighten mounting screws and recheck gap.
6. Proceed to *Ignition Timing*.

Each time new breaker points are installed, place a drop of oil on the point's pivot point (Figure 35).

IGNITION TIMING

Ignition Timing — Engine Running: Always check

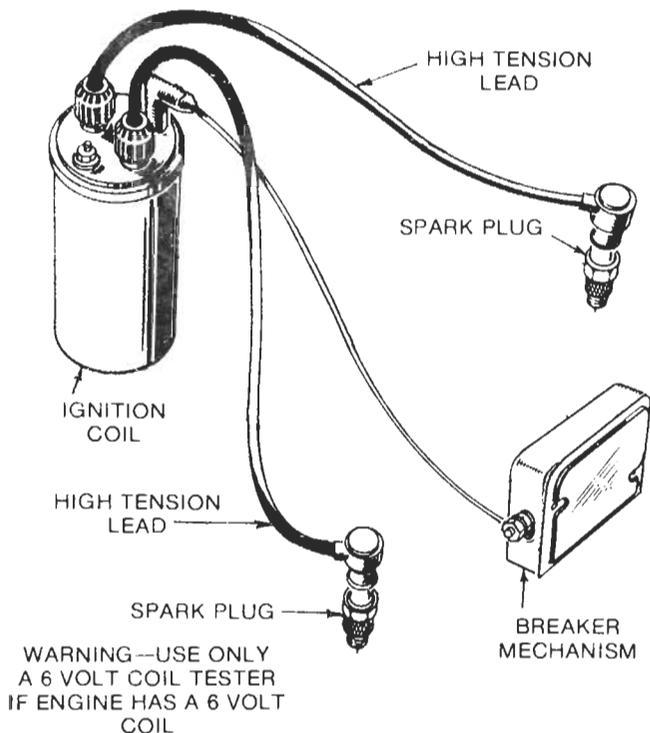


FIGURE 34. BATTERY IGNITION SYSTEM (12 VOLT)

timing after replacing ignition points or if noticing poor engine performance. Proceed as follows:

1. To accurately check the ignition timing, use a timing light when engine is running. Connect the timing light according to its manufacturer's instructions. Either spark plug can be used as they fire simultaneously.
2. Place a white chalk or paint mark on the timing mark.
3. Start the engine and check the timing.
4. If timing needs adjustment, loosen the mounting screws on breaker box and move it left to advance or right to retard the timing.
5. Tighten the screws on the breaker box and recheck timing.
6. Replace breaker box cover and any other hardware removed.

Ignition Timing — Engine Not Running

1. Connect a continuity test lamp set across the ignition breaker points. Touch one test prod to the breaker box terminal to which the coil lead is connected and touch the other test prod to a good ground on the engine.
2. Turn crankshaft against rotation (counterclockwise) until the points close. Then slowly turn the crankshaft with rotation (clockwise).
3. The lamp should go out just as the points break.
4. If timing needs adjustment, loosen the mounting screws on breaker box and move it left to advance or right to retard the timing.

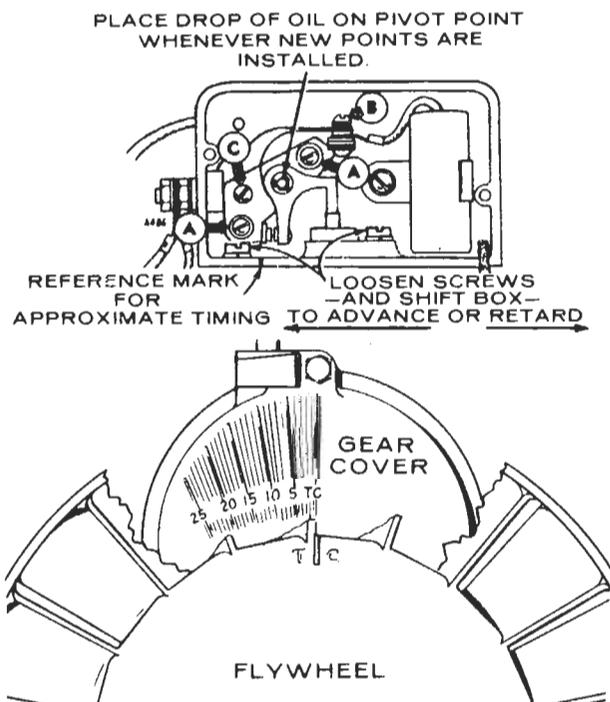


FIGURE 35. IGNITION TIMING

Spark Advance Mechanism (Figure 36): The spark advance mechanism is located on the rear of the camshaft and is standard on magneto models. It is operated by centrifugal force. As the engine speeds up, the weights rotate the cam and advance the spark. The cam returns to the retarded position as the engine speed is decreased. If the mechanism should become dirty or gummy, it would remain closed (retarded), causing the engine to lose power. If the mechanism remains open (advanced), the engine would possibly kick back on cranking. The cam advance must operate freely. Some units are snap acting. Should the engine fail to pick up speed or tend to alternately increase and decrease speed, the mechanism may require cleaning.

The spark advance mechanism can be reached for cleaning by either removing the cup shaped cover in the crankcase rear camshaft opening to expose the mechanism or by removing the camshaft from the engine. Do not indent the cup shaped cover as it will interfere with the weight mechanism.

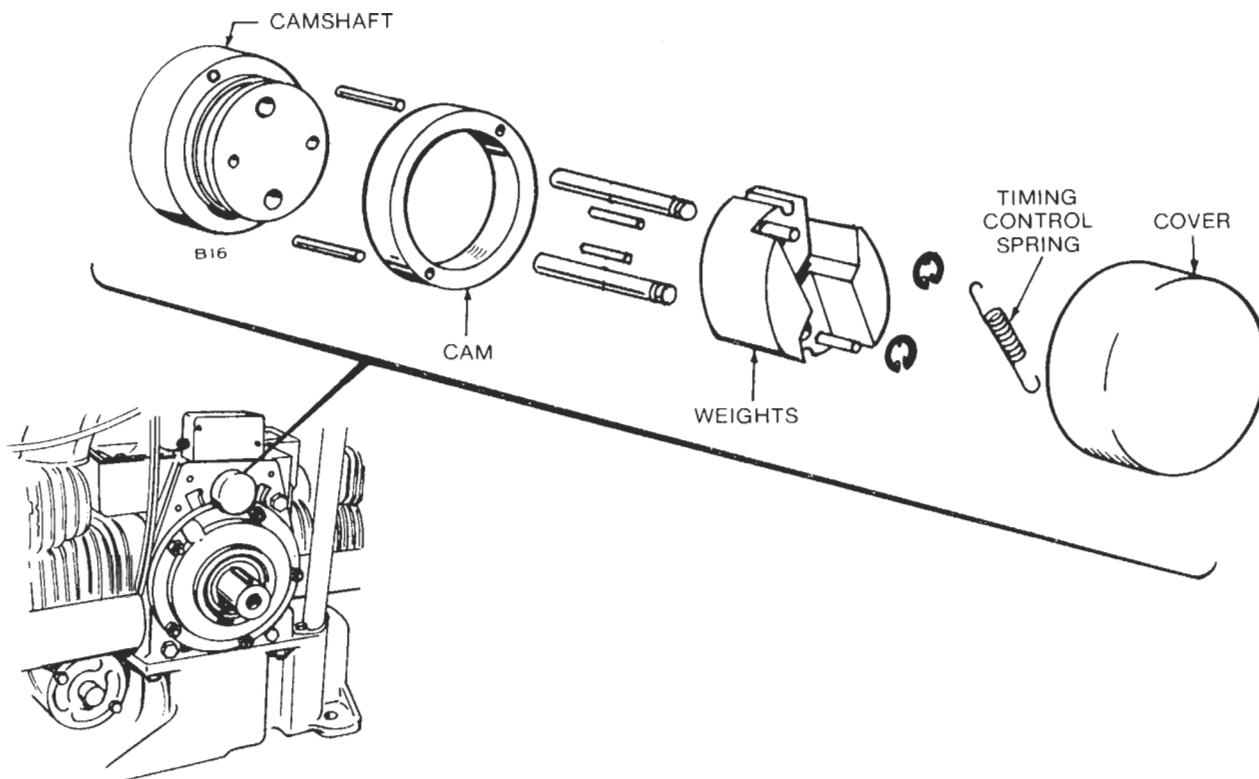


FIGURE 36. SPARK ADVANCE MECHANISM

Checking Advance Mechanism

1. The timing marks will be visible through the flywheel.
2. Connect timing light to spark plug.
3. Start engine and run at 1500 rpm or over.
4. View the timing marks using a timing light. The flywheel mark should align with mark on gear cover.
5. While watching the timing marks with the timing light, slow the engine down to as slow as possible (800 rpm). If the timing marks are not aligned but realign when the engine is brought back to speed, the mechanism is operating properly.
6. If the ignition advance mechanism DOES NOT REACT as described in step 5, remove, clean and/or replace as necessary.
7. Replace the cover.

IGNITION COIL

To test primary and secondary windings within the ignition coil proceed as follows:

1. Use a Simpson 260 VOM or equivalent.
2. Place black lead on ground (-) terminal of coil and red lead to positive (+) terminal. Primary resistance should read 3.87 - 4.73 ohms.
3. Change resistance setting on ohmmeter. Place ohmmeter leads inside of spark plug cable holes, Figure 37. Secondary resistance should read 12,600 - 15,400 ohms.

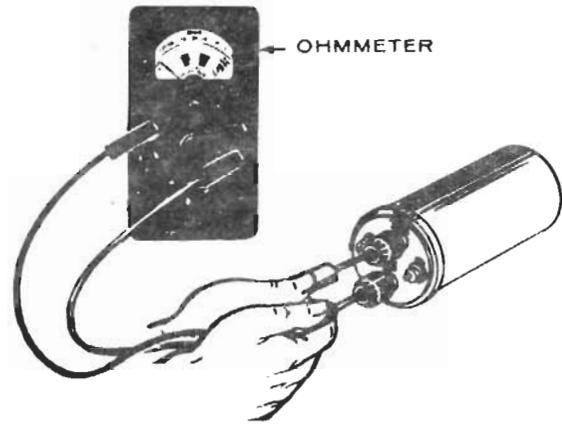
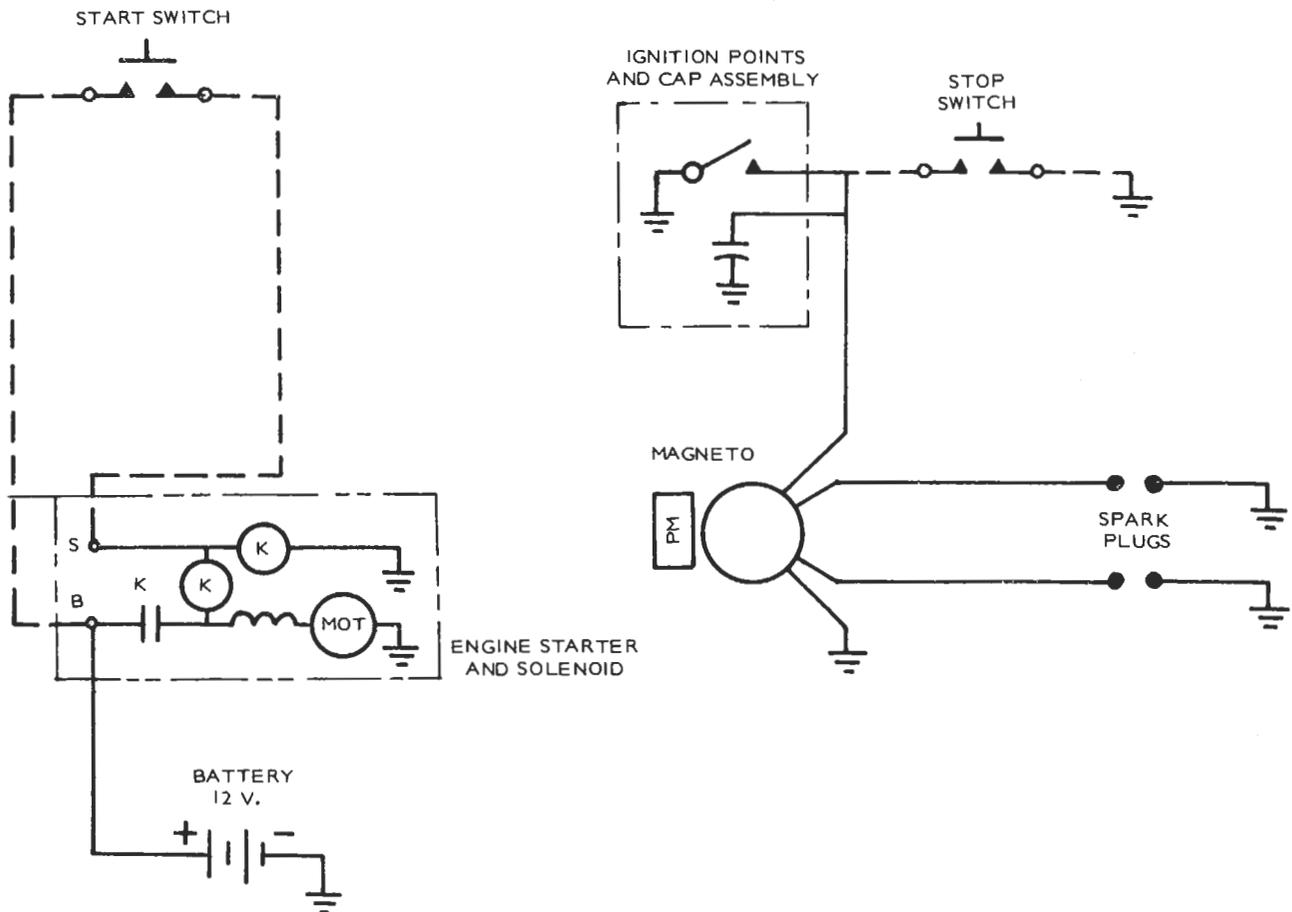


FIGURE 37. TESTING IGNITION COIL

SPARK PLUGS

The only service of spark plugs is cleaning, gapping or replacing. See the *Periodic Maintenance* section.



BASIC WIRING DIAGRAM FOR CCKB ENGINES

BATTERY CHARGING SYSTEM

BATTERY CHARGING, FLYWHEEL ALTERNATORS

The flywheel alternator is a permanent magnet alternator and uses a solid-state voltage regulator-rectifier for controlling output, Figure 38.

Weak ignition spark or a discharged battery indicate trouble in the charging system. But before testing the engine's charging system, always check the battery for serviceability.

Check battery cells to make sure they are filled to appropriate level adding distilled water as required. Check specific gravity in each cell. Specific gravity should be 1.265 at 80° F; if not, recharge battery to bring it up to this level.

Poor contact at the battery cable connections is often a source of trouble. Make sure battery cables are in good condition and that contacting surfaces are clean and tightly connected. Do not reverse battery leads. Use recommended battery tools when disconnecting leads to avoid mechanical battery damage.

Keep the battery case clean and dry. An accumulation of moisture will lead to a more rapid discharge and battery failure.

Keep the battery terminals clean and tight. After making connections, coat the terminals with a light application of petroleum jelly or grease to retard corrosion.

Keep these points in mind when testing or servicing the flywheel alternator:

1. Be sure the output control plug (connector) is inserted properly. The plug must bottom in receptacle — eliminates any resistance due to a poor connection. Keep clean and tight.
2. Make sure the alternator stator leads are not shorted together.
3. Be sure regulator-rectifier output control has a good ground connection. Mating surface for mounting must be clean and fasteners tightened properly.
4. Never reverse the battery leads.

Charging system tests require a fully charged battery.

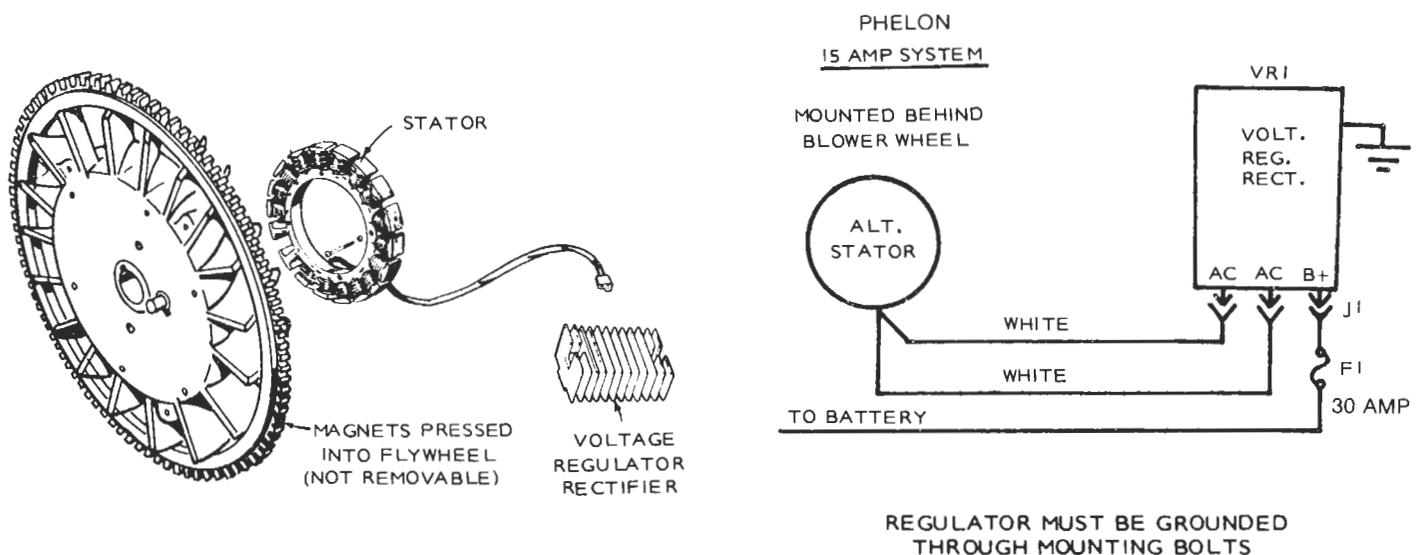


FIGURE 38. 15 AMP SYSTEM

TESTING PHELON 15 AMP SYSTEM

BASIC TEST	PROCEDURE	TEST VALUES
1. Battery	Battery Voltage - unit not running	12 VDC
2. Regulator	Battery Voltage after unit is running 3 to 5 minutes	13.6 to 14.7 VDC
3. Alternator Stator and Wiring with Fully Charged battery.	Ohmmeter reading from stator output - unit not running. Check at plug.	.11 to .19 Ohms
4. Alternator and Wiring	Measure AC open circuit stator voltage with unit running. Measure between two stator leads with plug disconnected and unit running at approximately 3600 rpm.	28 VAC

20 AMP FLYWHEEL ALTERNATOR SYSTEM

System Identification: Syncro flywheel alternator systems use a separate regulator and a separate rectifier. There are two black wires and one red wire coming from the stator assembly. For testing this system, use a voltmeter-ohmmeter such as a Simpson 270. Following are various alternator problems with individual test procedures.

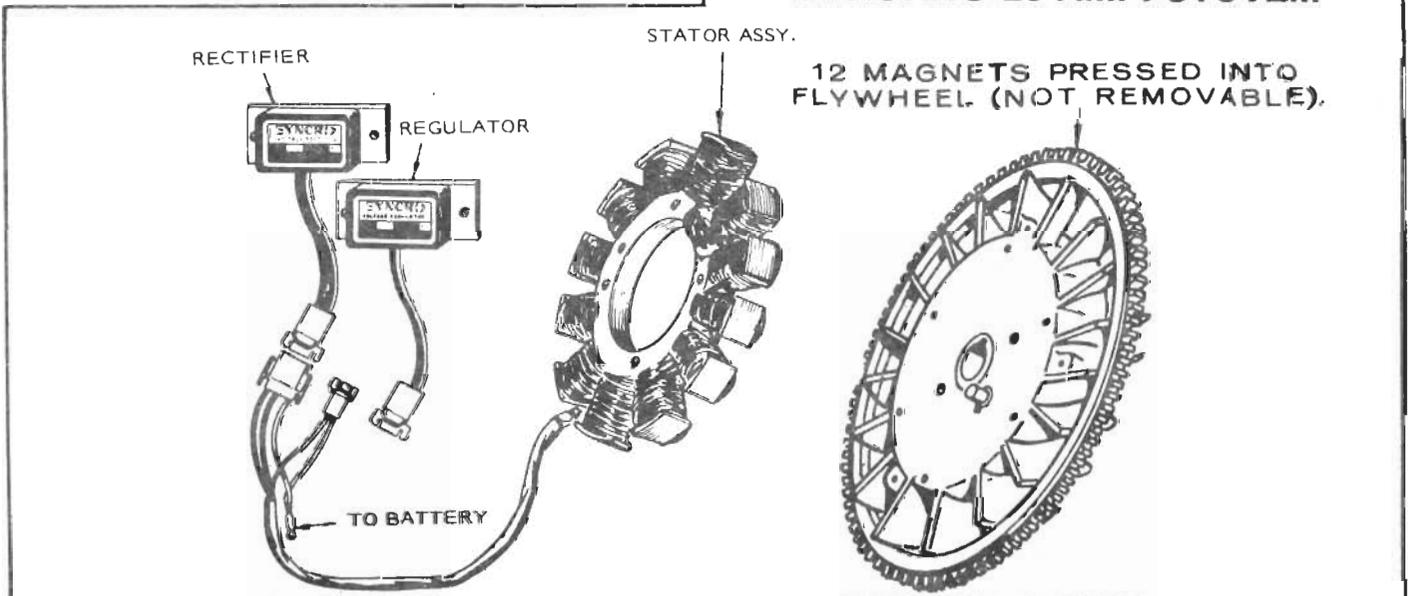
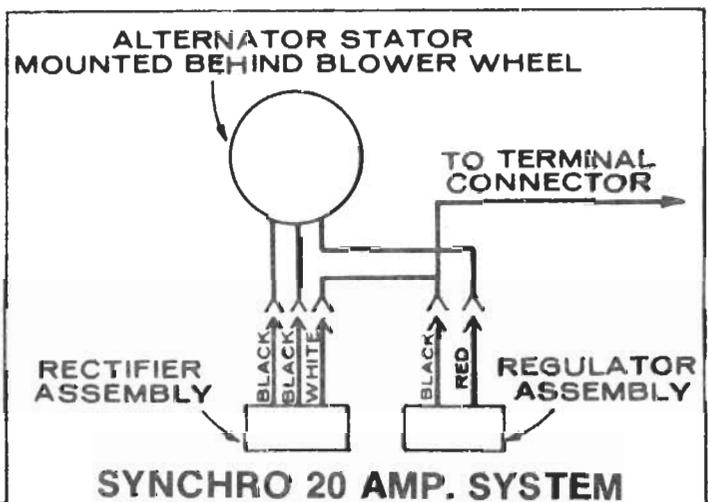
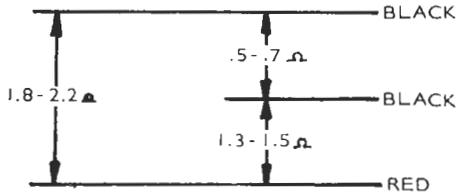


FIGURE 39. 20 AMP SYSTEM

TESTING 20 AMP SYNCHRO SYSTEM

DC TEST	VALUE
Battery voltage - unit not running	12 Volts DC
Battery voltage with unit running at 1800 r/min or more	14.2 - 14.8 Volt DC

Resistance values (Ohms) are as follows between wire pairs.



ENGINE RPM	USE SIMPSON 260 FOR AC VOLTAGES		
	RED TO GND.	BLACK TO GND. (Either Lead)	BLACK TO BLACK
500	35	8.5	17
1000	60	15	30
2000	115	29	58
3000	160	40	80
3600	185	46	92

No Output — Stator Assembly: Examine leadwires for loose or broken connections at the regulator and rectifier. Use the Rx1 scale on the ohmmeter for detecting opens in the stator. Disconnect the three wires that come from alternator stator (two black, one red). Connect ohmmeter test leads to red leadwire and ground to check continuity. The ohmmeter reading should be approximately 2.0 ohms. See Figure 39.

Next, connect meter to black leadwires and ground. Approximately 0.1 ohm should be read from either black lead to ground. If no connection exists between ground and black leads, stator assembly should be replaced.

Checking Rectifier Assembly: Examine each of the two diodes for breakdown by connecting ohmmeter (Rx1 scale) from one black lead to white lead. Meter should read 10 ohms in proper polarity. A shorted diode would read zero resistance and would cause a short circuit through the lead winding when in operation. An open diode would read infinite in both directions indicating that replacement is necessary. See Figure 39.

Testing Regulator Assembly: To check for proper voltage regulation, attach a DC voltmeter to battery and operate engine at approximately 1800 rpm. Battery voltage will climb to the preset factory setting (14.2 to 14.8 volts).

Some installations may vary due to voltage drop in the length of ammeter harnesses. Other variations may stem from a loose connector in the harness or loose or corroded battery leads. Low voltage readings at the battery mean poor battery connections.

To test regulator, remove connector. Using the Rx10,000 scale of your ohmmeter, connect one meter lead to red leadwire and other meter lead to regulator base. No deflection should be noted on the ohmmeter in either polarity. Next connect meter to black leadwire and base of regulator. Meter will deflect fully in one polarity with no deflection in the other (Figure 39).

Full Charge — Will Not Regulate: Check for broken leads at connection to regulator plates. To be sure regulator winding operates properly, connect red lead to ground and start engine. A maximum of 4 amperes should be noted. This would indicate stator winding is satisfactory. If so, replace regulator.

No Charge: If alternator does not charge when load is applied to battery, shut off engine and disconnect one red leadwire from regulator terminal. Be sure lead is taped or isolated from conducting engine parts. Once again, start engine. Alternator should charge to full output; if it doesn't, replace stator assembly.

EXTERNAL BATTERY CHARGING ALTERNATOR (Optional)

This information is presented for field use only. If a major repair should become necessary, contact your local authorized dealer.

Brush Assembly Removal: Remove the three screws which fasten the voltage regulator to the alternator. Disconnect the regulator leads and remove the regulator.

Remove the two screws on the phenolic cover and lift out the cover and gasket. See Figure 40.

Pull the brush assembly straight up and lift out. Reverse the procedure for assembly.

Brush Assembly Tests: Connect an ohmmeter or test lamp (12 volts) to the field terminal and to the bracket. The test lamp shouldn't light or resistance reading should be high (infinite). If not, there is a short and the assembly must be replaced.

Now move the one ohmmeter lead from the bracket to the insulated brush. Use an alligator clip directly on the brush. Be careful not to chip it. Resistance reading should be zero (continuity).

Connect the ohmmeter leads to the grounded brush and the bracket. Resistance should be zero (continuity).

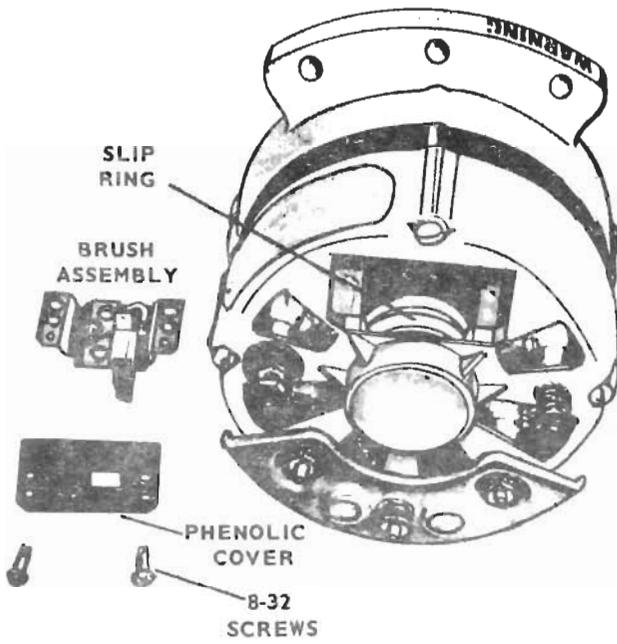


FIGURE 40. OPTIONAL, BATTERY CHARGING,
EXTERNAL ALTERNATOR

STARTING SYSTEM

ELECTRIC STARTING

Engines beginning with Spec J use the solenoid-shift starter shown in Figure 41. When the starter button is pushed, battery current energizes the start solenoid. The solenoid causes an arm to push the starter pinion into the flywheel ring gear. Simultaneously, the start solenoid contacts close and allow the starter motor to start turning. The starter remains engaged until the start button is released. An overrunning clutch protects the starter from damage before it can be disengaged from the flywheel.

Prior to Spec J, the starter motor on electric start engines was the gear drive starter shown in Figure 42.

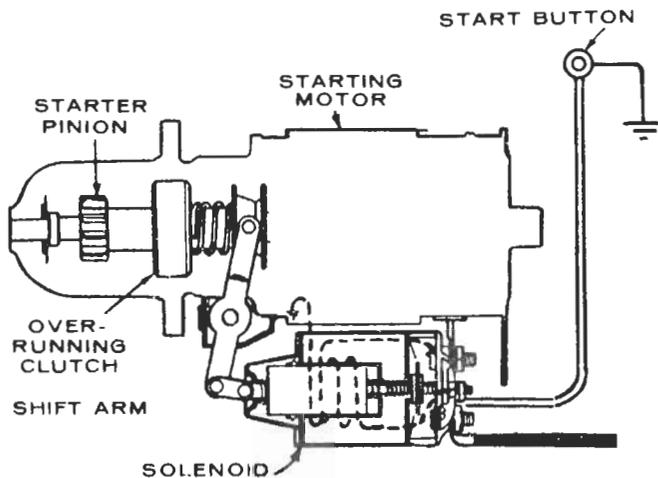


FIGURE 41. SOLENOID-SHIFT STARTER

The gear drive is mounted on a shaft which extends from the starter motor. When not running, the drive pinion gear is retracted so it clears the flywheel ring gear. When starting, a spiral spring through increasing speed forces the drive pinion to engage the flywheel ring gear. The pinion and flywheel ring gear teeth have beveled ends that ensure their engaging properly.

CAUTION Starter motors are not designed for continuous operation. Do not operate more than 30 seconds per "ON" cycle. Do not operate starter more than 10 seconds in a stall condition if engine will not rotate. Serious damage could result if these time limits are exceeded.

Maintenance: For proper cranking motor operation with a minimum of trouble, a periodic maintenance procedure should be followed. Periodic lubrication,

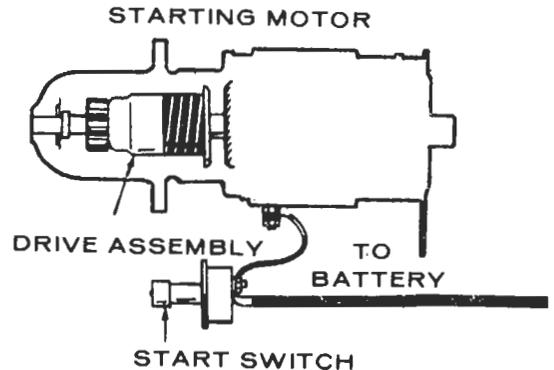


FIGURE 42. GEAR-DRIVE STARTER

and inspection of the brushes and commutator as described in this section will ensure long cranking motor life. Periodic disassembly (see *Disassembly*) of the cranking motor for a thorough overhaul is recommended as a safeguard against accumulations of dust, grease and parts wear.

Lubricate all oil-type bearings with 8 to 10 drops of light engine oil (SAE 20). All oil-less type bearings and bushings should be given a few drops of light oil. Lubricate the cranking motor drives with a few drops of light engine oil.

Never oil the commutator. Oil on the commutator reduces the cranking ability of the motor.

The commutator can be cleaned by using number 00 sandpaper. Never use emery cloth. If the commutator is out of round or has high mica, remove it from the cranking motor. Turn the commutator down on a lathe being careful to remove only enough material to true up the commutator and remove high mica.

It is not necessary to undercut mica on starter motor commutators.

Replace worn brushes. If brushes wear rapidly, check for excessive brush spring tension and roughness or high mica on the commutator.

Solenoid Shift: Periodically inspect solenoid and shift lever to make sure they are operating properly. Keep the solenoid shift lever free of dirt and excess grease.

The overrunning clutch is packed in a special high melting point grease and after its initial assembly, needs no further lubrication. This clutch prevents the engine from turning the starter motor at too high a speed once it is started. Do not subject the overrunning clutch to grease dissolving or high temperature cleaning methods. This may cause the clutch to lose some or all of its grease.

If the pinion does not turn freely in the clutch in the overrunning direction, or the clutch tends to slip in the opposite direction, replace the assembly. A worn clutch indicated by excessive looseness of the pinion requires replacement.

Never attempt to repair or relubricate a defective clutch.

The clearance between the pinion and the housing should be approximately 1/16- to 1/8-inch (1.6 - 3.2 mm) when the pinion is in the operating position, Figure 43.

Drive Pinion: The teeth of the drive pinion are chamfered on only one side and specially rounded and polished to make the automatic meshing with the flywheel ring gear more efficient. The drive is designed so if the ends of the pinion teeth meet end to end with the ring gear teeth (keeping in mind that the drive is freely mounted on the drive shaft), the drive assembly can move back slightly against the pressure of the driving spring. The longitudinal movement permits the pinion to turn slightly farther and enter the flywheel ring gear.

It is important the correct length of drive spring be used when making replacements. The length of the drive spring controls the longitudinal movement of the pinion (meshing and unmeshing of the pinion and flywheel ring gear).

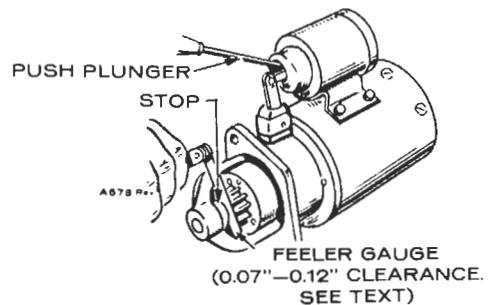
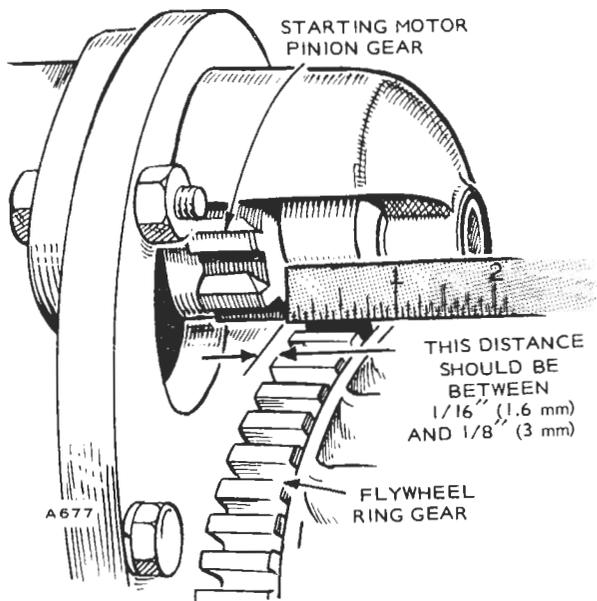
Keep the drive shaft free of rust, burrs or bends so the drive can move freely along it. A damaged pinion necessitates the replacement of the assembly.

Onan recommends replacement of faulty gear drive assemblies and provides no further service information concerning their repair. For further repair information, contact the manufacturer of your starter motor.

Disassembly:

1. Remove all wires to the starting unit. Tag each wire so it can be reconnected as originally.
2. Remove the solenoid (where applicable).
3. Remove the starter motor thru-bolts and divide the starter into three main assemblies — the front bracket, the housing and the rear bracket. On some model starters, short screws are used to hold the three starter sections together (Figure 44). The spacers on the solenoid starters are used for adjustment of the thrust gap of the armature shaft and are located between the rear bracket and the commutator shaft.

On the solenoid shift models, the steel spacing washer is on the commutator side.



STARTING MOTOR NEED NOT BE REMOVED FROM ENGINE TO MAKE THIS MEASUREMENT

FIGURE 43. PINION CLEARANCES (GEAR DRIVE)

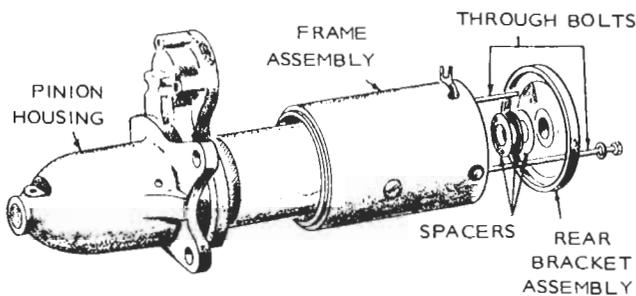


FIGURE 44. SOLENOID SHIFT STARTER (PRIOR TO SPEC J)

4. **Solenoid Starter Only:** The armature can now be removed from the front bracket. Be careful not to miss the small steel washer used in the end of the armature shaft. Remove the shift lever at the same time the armature is removed. The spring holder, lever springs and retainer can be removed prior to the lever Figure 45.

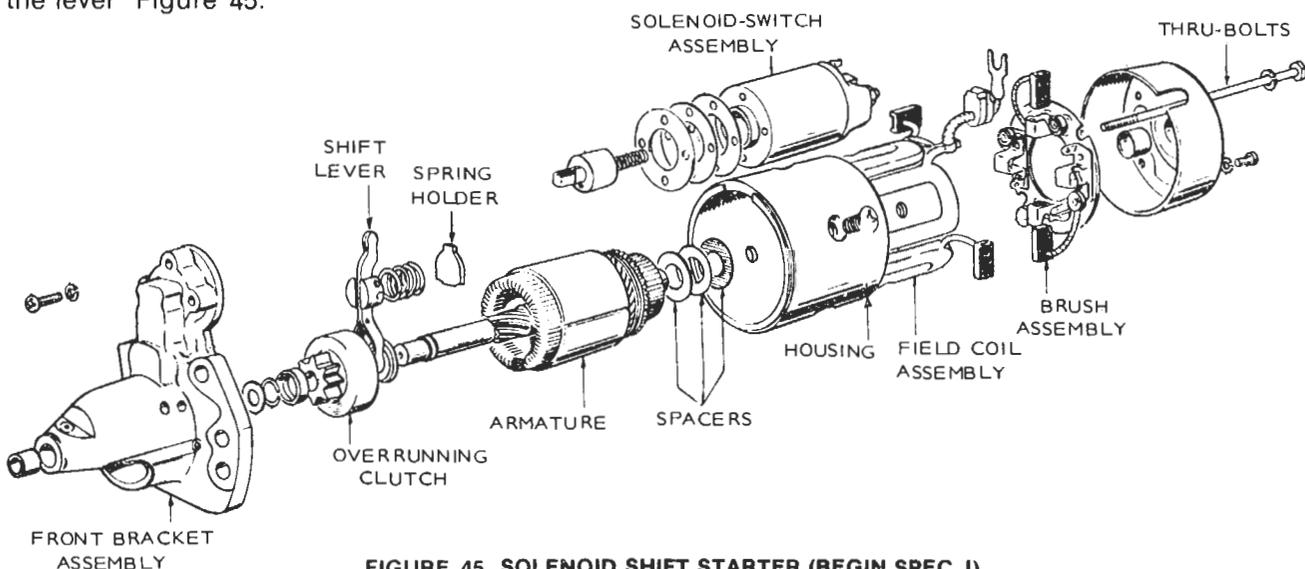


FIGURE 45. SOLENOID SHIFT STARTER (BEGIN SPEC J)

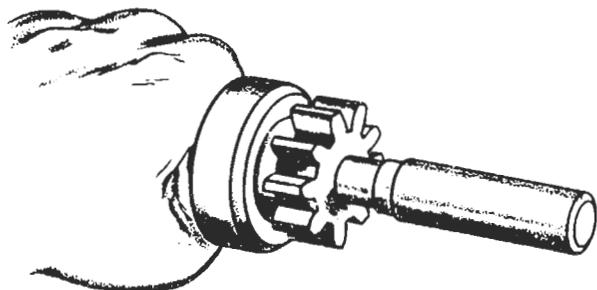


FIGURE 46. TOOL FOR DRIVING PINION STOPPER

5. **Solenoid Starter Only:** Remove the ring after driving the pinion stopper toward the pinion gear using a cylindrical tool (Figure 46). Remove the overrunning clutch and the pinion stopper at the same time.
6. **Gear Drive Starter Only:** The entire assembly is mounted on the armature shaft. When disassembling the starter, pay particular attention to the various parts and their positioning in the starter assembly, Figure 47. If the gears of the pinion are damaged, replace the entire pinion. Inspect the screw shaft for rust and burrs.
7. Remove the brushes from the brushholder and inspect them (inspection of brushes and brush springs discussed later).
8. Remove the pole shoes if necessary by removing the flathead machine screws which anchor them to the frame.

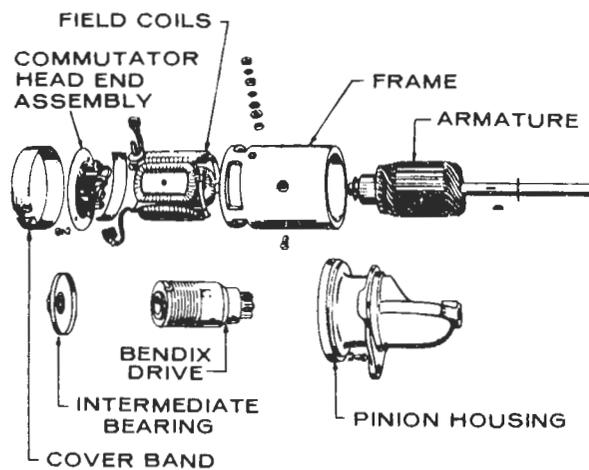


FIGURE 47. GEAR DRIVE STARTER (OPTIONAL)

ELECTRIC STARTER INSPECTION AND TROUBLESHOOTING

Testing the Armature for Shorts: Place the armature in the growler and hold a thin steel blade parallel to the core and just above it, while slowly rotating the armature in the growler, Figure 48. A shorted armature causes the blade to vibrate and move toward the core. A shorted armature must be replaced.

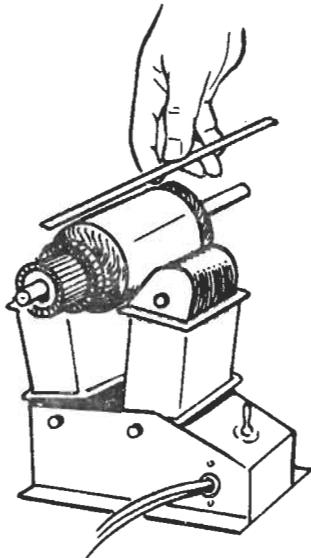


FIGURE 48. TEST FOR SHORTED ARMATURE

Testing Armature for Grounds: Touch armature shaft or core and the end of each commutator bar with a pair of ohmmeter leads, Figure 49. If the ohmmeter reading is low, it indicates a grounded armature. Replace grounded armature.

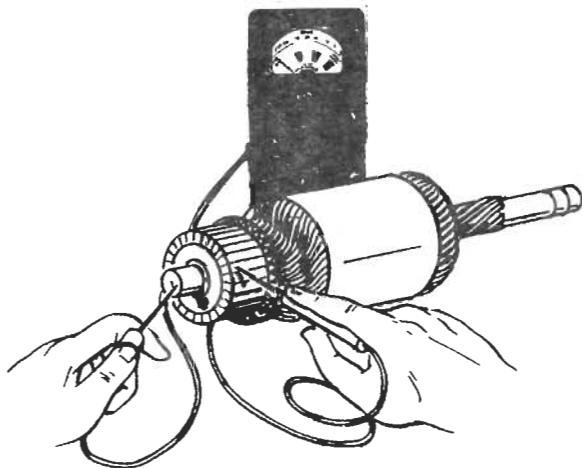


FIGURE 49. TEST FOR GROUNDED ARMATURE

Testing the Armature for Open Circuit: The most common place for an open circuit to occur is at the commutator riser bars. Inspect the points where the conductors are joined to the commutator bars for loose connections.

Testing Commutator Runout: Place the commutator in a test bench and check runout with a dial indicator (Figure 50). When commutator runout exceeds .004 inch, reface the commutator.

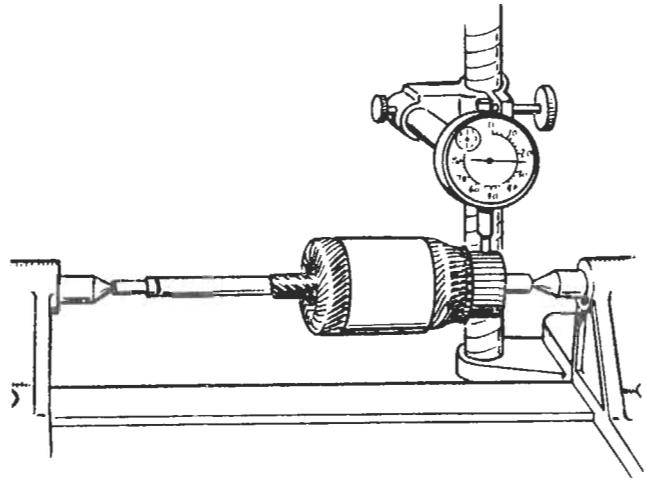


FIGURE 50. CHECKING COMMUTATOR RUNOUT

Testing Armature Shaft Runout: The armature shaft as well as the commutator may be checked. A bent armature can often be straightened, but if the shaft is worn, a new armature is required, Figure 51.

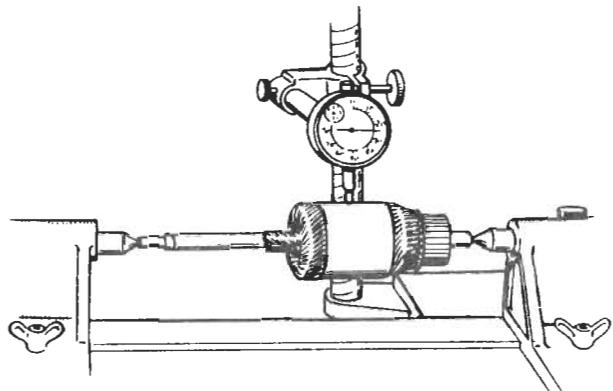
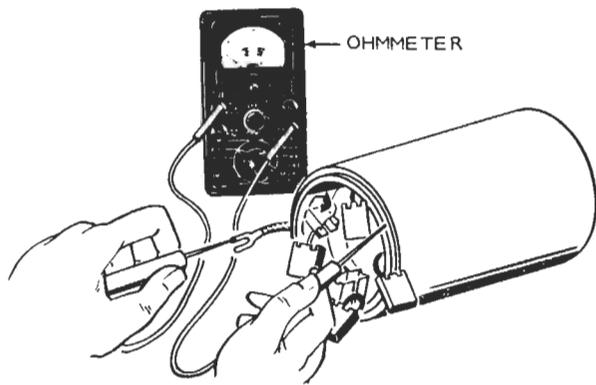


FIGURE 51. CHECKING ARMATURE SHAFT RUNOUT

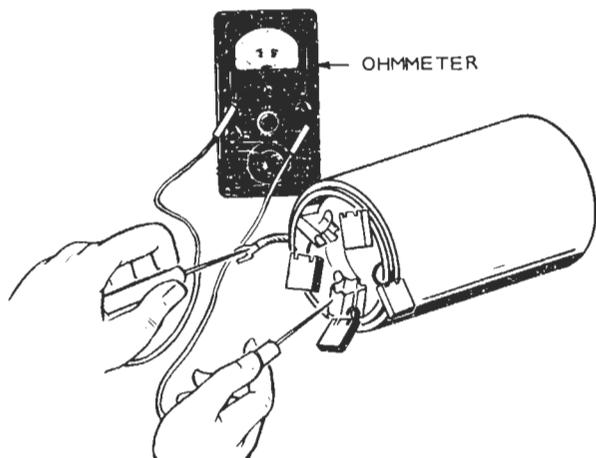
Testing Field Coils for Grounds: Place one test prod on the connector and the other on a clean spot on the frame after unsoldering shunt field coil wire. If the ohmmeter indicates continuity, the fields are grounded either at the connector or in the windings, Figure 52.



ONE PROD ON FIELD COIL LEAD. ONE PROD ON FRAME.

FIGURE 52. FIELD COIL GROUND TEST

Testing Field Coils for Open Circuit: Place one prod on the connector and the other on a clean spot on the brushholder, Figure 53. If continuity is good, the field coil is okay. Check all brushholders in the same manner.



ONE PROD ON FIELD COIL LEAD
ONE PROD ON BRUSH HOLDER.
SHOULD LIGHT.

FIGURE 53. TEST FOR OPEN FIELD COIL

Inspection of Brushes: When brushes are worn more than 0.3 inch (7.6 mm), replace them. Figure 54 shows the wear limit. See that the brushes move smoothly in the brushholders.

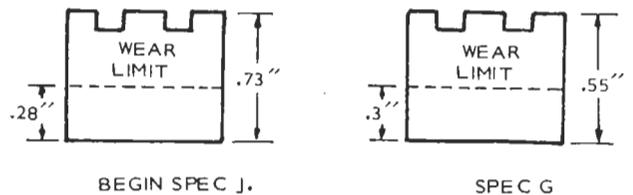


FIGURE 54. BRUSH WEAR LIMITS

Inspection for Brush Spring Tension: Measure brush spring tension with a tension meter, Figure 55. Push the brush into its holder and take the reading just as the brush slightly projects from the brushholder. On a new brush the spring tension should be 49 to 59 ounces (1.37-1.65 kPa) for engines begin Spec J, and 29 to 38 ounces (0.81 to 1.06 kPa) for Spec G engines.

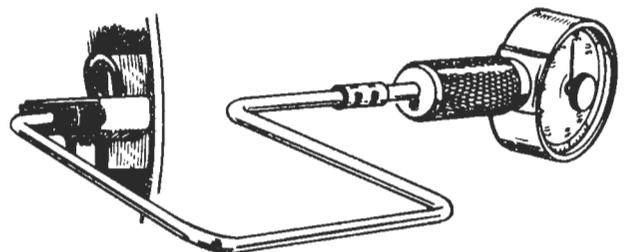


FIGURE 55. MEASURING BRUSH SPRING TENSION

Assembly: Reassembly is much the reverse of disassembly procedure. Follow a few precautions and procedures:

1. Clean all parts carefully with a dry cloth and compressed air if available.

CAUTION Do not immerse bearing equipped parts in cleaning fluid. Clean with a brush dipped in mineral spirits. Do not immerse the overrunning clutch in cleaning solvent.

2. Apply 20 weight oil to armature shaft and splines. Use grease sparingly for solenoid starter's shift lever pin, joint of shift lever and plunger, plunger and spacing washers at end of the shaft.
3. Use spacing washers to adjust armature end play of .004 to .020 inch (0.102 to 0.508 mm).
4. When assembling starter to engine oil base, do not draw the mounting bolts up tight. The gears should have .004- to .007-inch (0.103-0.178 mm) backlash. Tap the starter in or out from the oil base to adjust. Then tighten bolts securely.

MANUAL STARTER

READI-PULL STARTER

Refer to Figure 56 showing the Readi-Pull manual starter disassembled.

WARNING To prevent personal injury, be extremely careful when disassembling and reassembling the starter recoil mechanism. The recoil spring can uncoil violently if it is released.

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 four clamping screws.

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* (rivet 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.

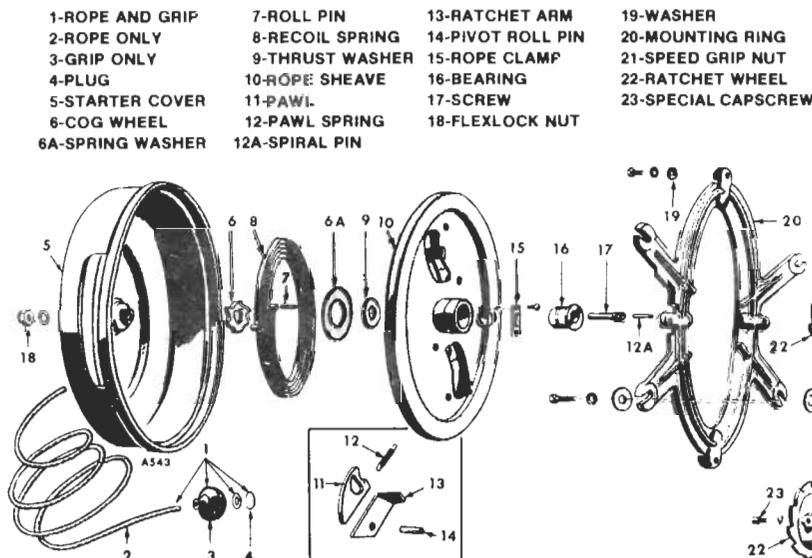


FIGURE 56. READI-PULL STARTER

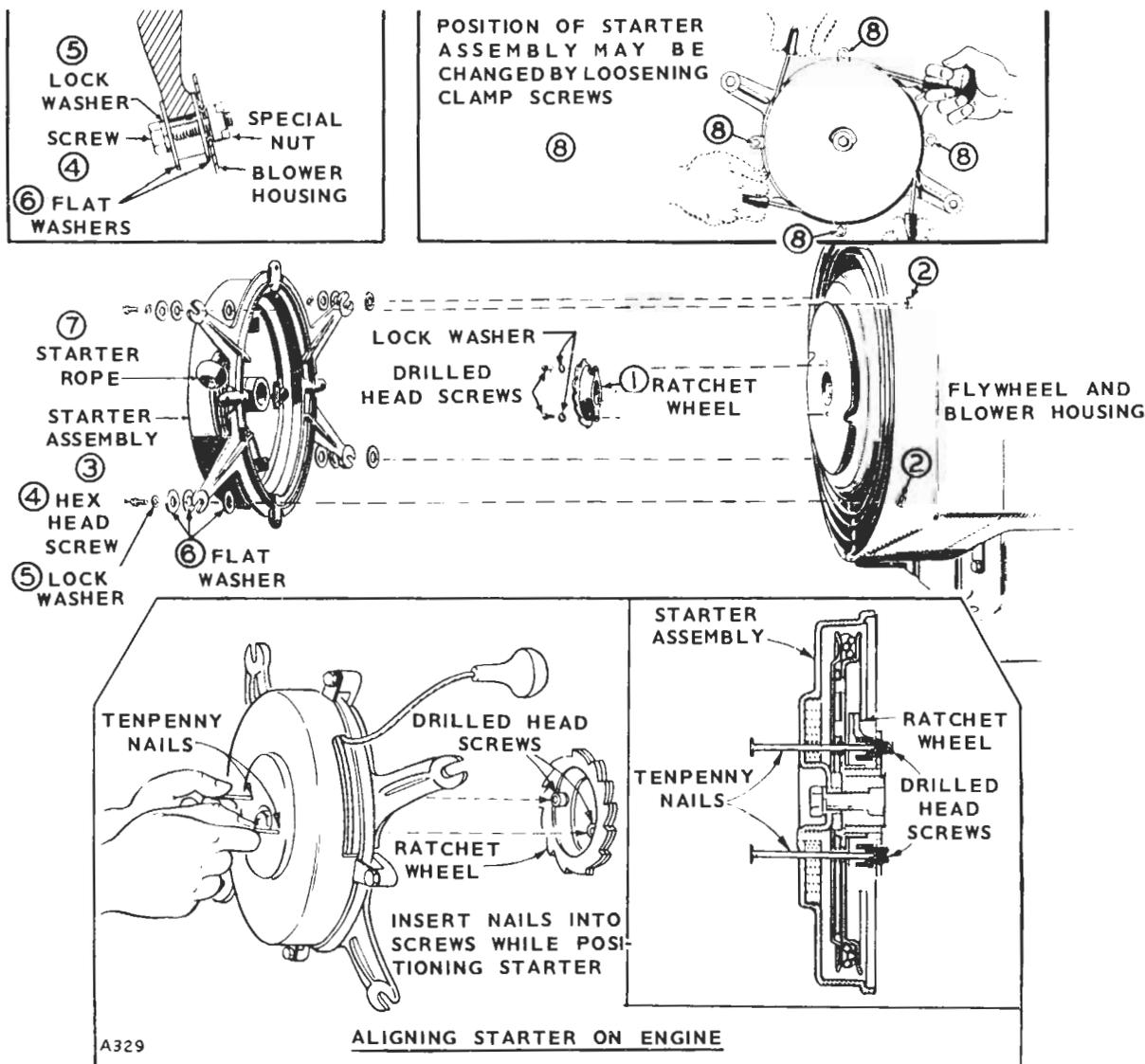


FIGURE 57. UNITS PRIOR TO SPEC E

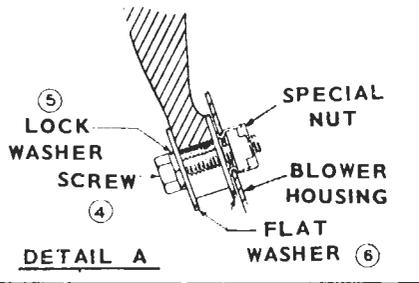
INSTALLING THE STARTER

Units Prior to Spec E: Refer to Figure 57. 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 tow 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.



POSITION OF STARTER ASSEMBLY MAY BE CHANGED BY LOOSENING CLAMP SCREWS (8)

DETAIL B

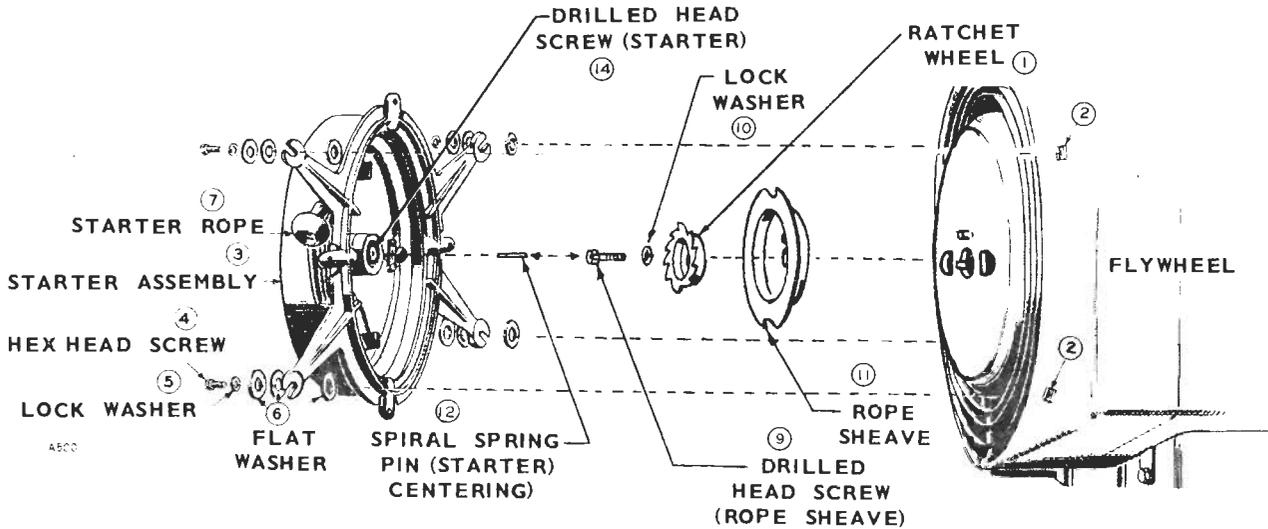
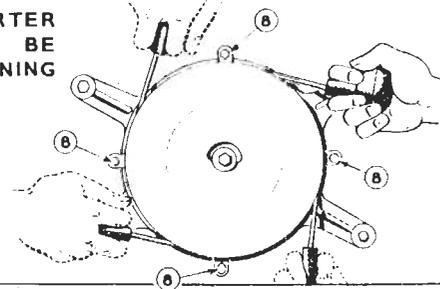


FIGURE 58. UNITS BEGINNING SPEC E

While holding in position, mount the starter, using a hex head screw (4), lock washer (5), and two 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. Occasionally 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.

1. Install the new ratchet wheel (1) against rope sheave (11) using lock washer (10) and flywheel mounting screw (9). Discard the large flat washer from engines so equipped. Engage drive hole with flywheel boss.
2. Four special nuts are supplied for mounting the starter to the blower housing. If the housing is not already fitted with similar nuts, remove the blower housing and install the nuts as shown in detail A. Reinstall the blower housing, tightening securely in place.
3. Install centering pin (12) in starter center screw (14) allowing 3/8-inch to protrude. For reinstalls, adjust pin depth.
4. Center the starter assembly over the ratchet wheel with the centering pin engaging the center hole of the flywheel mounting screw. While holding in position, mount the starter, using a hex head screw, lock washer, and two flat washers at each mounting arm as shown in detail A. Tighten the mounting screws securely.
5. 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 rope will not rub against one of the clamping screws.

Units Beginning Spec E: See that the engine blower housing is in good condition. If the mounting holes are worn or if the blower housing is otherwise damaged, replace it with a new one, Figure 58.

ENGINE DISASSEMBLY

If engine disassembly is necessary, first remove all the complete assemblies (e.g., manifold with carburetor and cartridge air cleaner). Individual assemblies, as the carburetor, can be removed and serviced later, if necessary. Any special assembly instructions for a particular group are included in the applicable section. When reassembling, check each section for these special assembly instructions or procedures.

Keep all parts in their respective order . . . valve assemblies, rod caps for respective rod and piston assemblies, etc.. Analyze reasons for parts failures. Use new gaskets for assembly.

FLYWHEEL

To remove the flywheel, turn the flywheel mounting screw outward about two turns and use Onan puller 420-0100 to pull the flywheel, Figure 59.

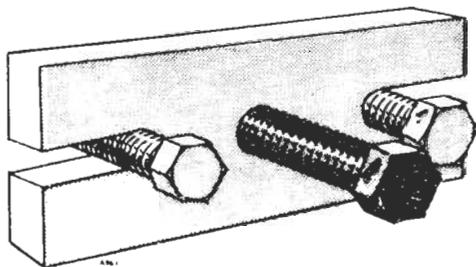


FIGURE 59. ONAN FLYWHEEL PULLER

CAUTION Do not use a screwdriver or similar tool or pry behind the flywheel against the gearcase. The gearcase cover is die-cast material and will break if undue pressure is applied in this manner.

Do not drop the flywheel. A broken fin will destroy the balance. Always use a steel key for mounting the flywheel.

A magneto flywheel which has lost its magnetism can be remagnetized. The spark should jump a 3/16-inch gap with ease, as tested by holding the spark plug wire away from a clean metal part of the engine while cranking.

GEAR COVER

After removing the flywheel key and mounting screws, tap the gear cover gently with a soft-faced hammer to loosen it.

CAUTION When installing the gear cover, make sure that the pin in the gear cover engages the governor cup correctly, Figure 60.

Turn the governor cup so that the metal lined hole is at the three o'clock position. The smooth side of the governor yoke must ride against the governor cup. Turn the governor arm and shaft clockwise as far as possible and hold in this position until the gear cover is installed flush against the crankcase. Be careful not to damage the gear cover oil seal. Adjust the roll (stop) pin to protrude to a point 3/4 inch from the cover mounting surface. See Figure 60.

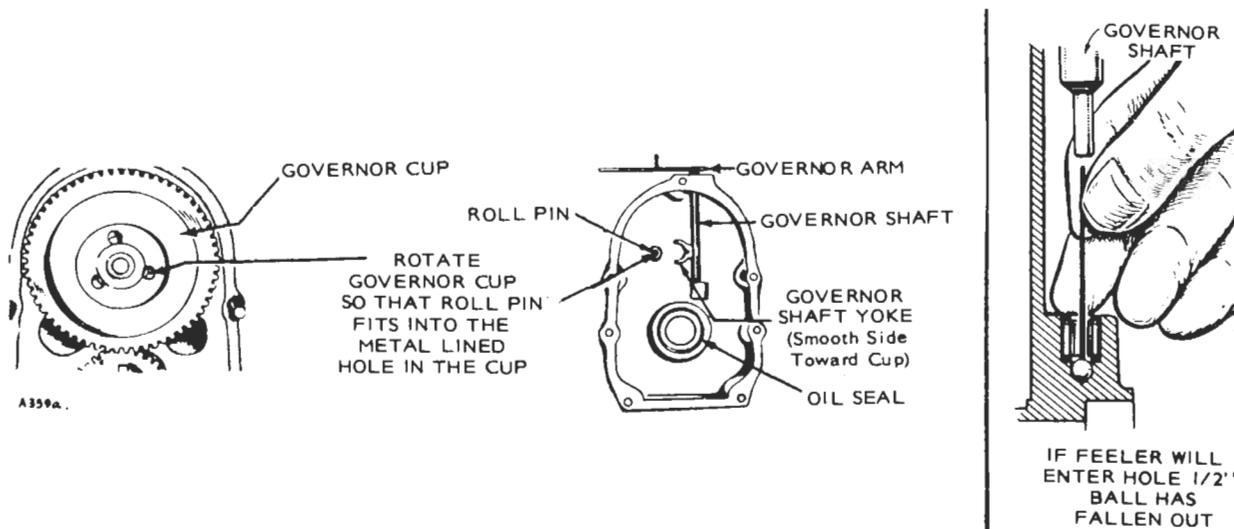


FIGURE 60. GEAR COVER ASSEMBLY

GOVERNOR CUP

With the gear cover removed, the governor cup can be taken off after removing the snap ring from the camshaft center pin. Catch the flyballs while sliding the cup off, Figure 61.

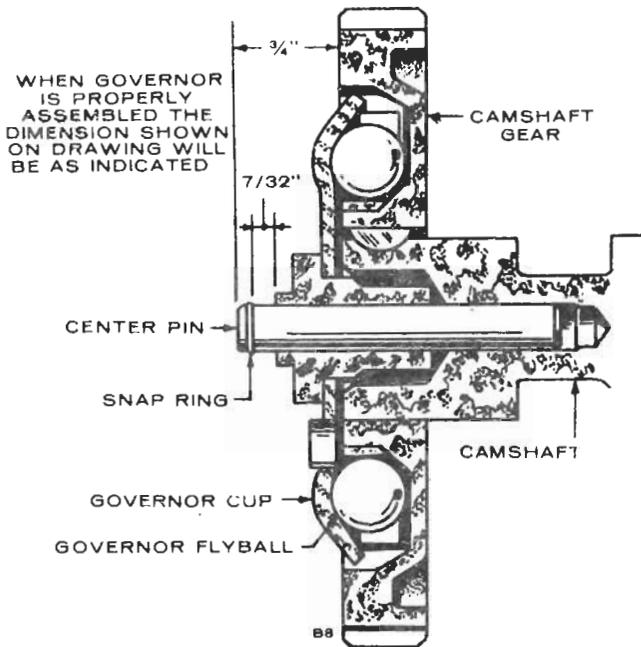


FIGURE 61. GOVERNOR CUP

Replace any flyball that is grooved or has a flat spot. If the arms of the ball spacer are worn or otherwise damaged, replace the entire timing gear set. The governor cup must spin freely on the camshaft center pin without excessive looseness or wobble. If the race surface of the cup is grooved or rough, replace it with a new one.

When installing the governor cup, tilt the engine so the gear is up, put the flyballs in place and install the cup and snap ring on the center pin, Figure 61.

The camshaft center pin extends out 3/4 inch (19 mm) from the end of the camshaft. This distance provides an in and out travel distance of 7/32 inch (5.6 mm) for the governor cup, as illustrated. Hold the cup against the flyballs when measuring. If the distance is less (the engine may race, especially at no load), remove the center pin and press a new pin in only the required amount. Otherwise, grind off the hub of the cup as required. The camshaft center pin cannot be pulled outward or removed without damage. If the center pin extends out too far, the cup will not hold the flyballs properly.

TIMING GEARS

If replacement of either the crankshaft gear or the camshaft gear becomes necessary, install both gears

new, never one only. Use a gear pulling ring (number 420-0248) to remove the crankshaft gear. Be sure to remove the snap ring first.

The camshaft gear is pressed on and keyed to the camshaft. The camshaft and gear must be removed as an assembly after first removing the crankshaft gear lock ring and washer. Before removing the camshaft and gear assembly, remove the cylinder head and valve assemblies. Remove the operating plunger for the breaker points. Remove the fuel pump and tappets.

The camshaft may be pressed out of the gear by use of a hollow tool or pipe which will fit over the camshaft center pin. Do not press on the center pin or damage it in any way. The governor ball spacer is a press fit to the camshaft gear.

When pressing a camshaft gear onto the camshaft, be sure the gear is started straight and that the key is properly in place. When replacing the cam gear on units having automatic spark advance mechanisms, remove the spark advance mechanism and put blocks beside the pins to avoid damage when pressing on cam gear. Install the governor cup assembly before installing the camshaft and gear in the engine.

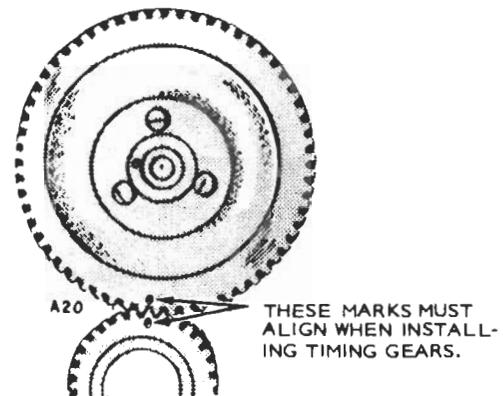
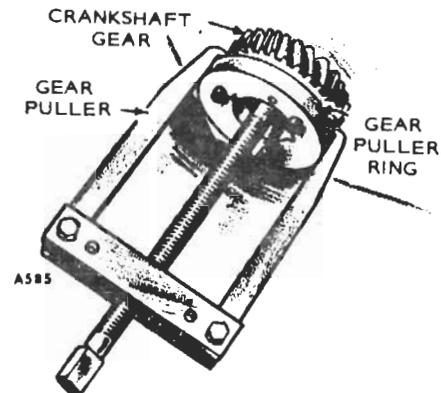
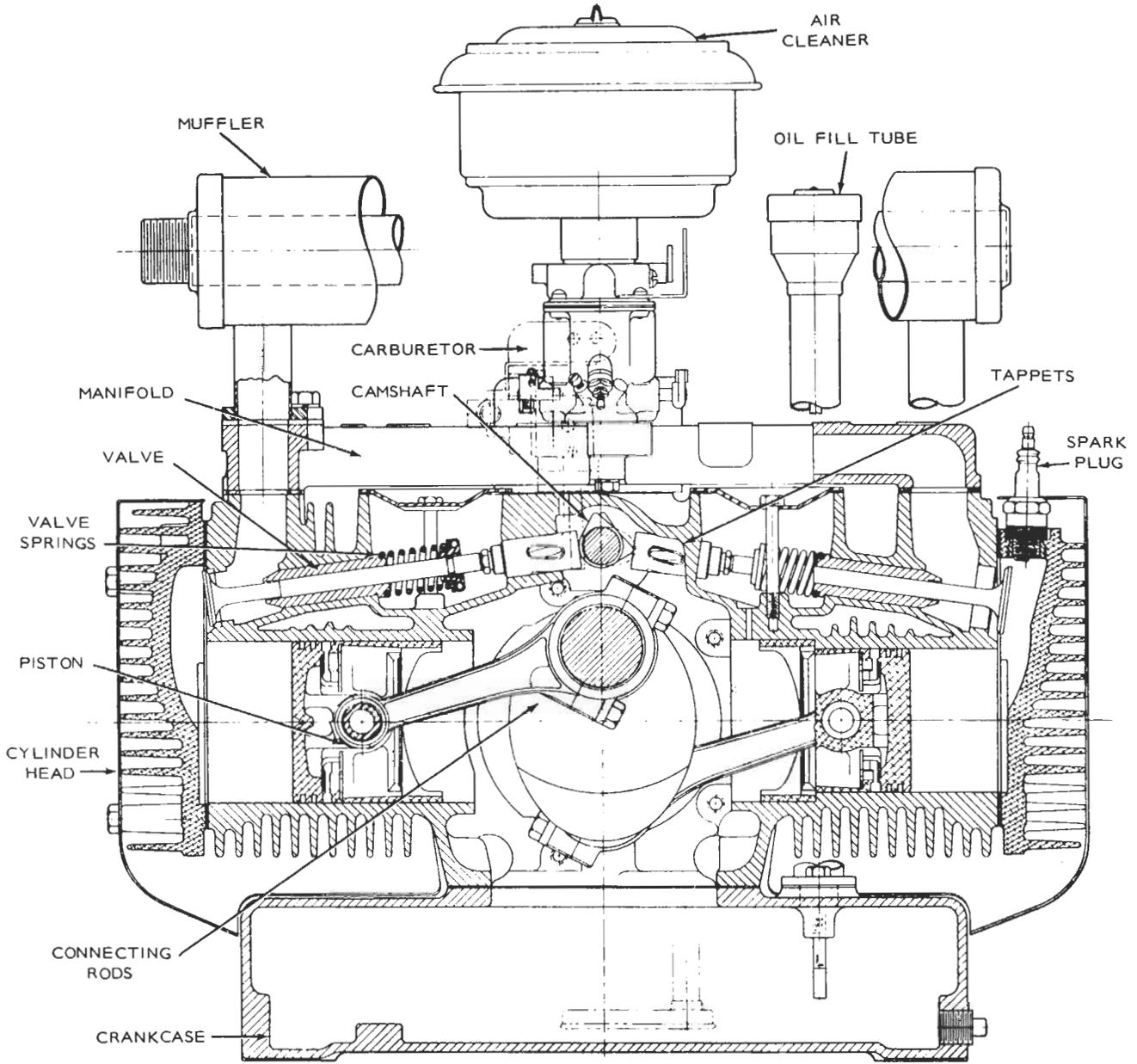


FIGURE 62. TIMING GEAR REMOVAL AND INSTALLATION



TYPICAL ENGINE (CROSS SECTION)

NOTE: Carburetor, manifold, and muffler not CCKB.

Each timing gear is stamped with an 0 mark near the edge. The gear teeth must mesh so that these marks coincide exactly when the gears are installed in the engine, Figure 62. Be sure, when installing the camshaft gear and shaft assembly, that the thrust washer is properly in place behind the camshaft gear. Replace the camshaft retaining washer and lock ring to the crankshaft.

CYLINDER HEADS

The cylinder head should be tightened in the order designated per Figure 63 to a torque of 5 foot-pounds, then 10 foot-pounds, etc., until all are torqued to 29 to 31 foot-pounds (7 then 14, 21, to 39-42 N•m).

CAUTION Do not remove heads when they are hot. Warpage may occur.

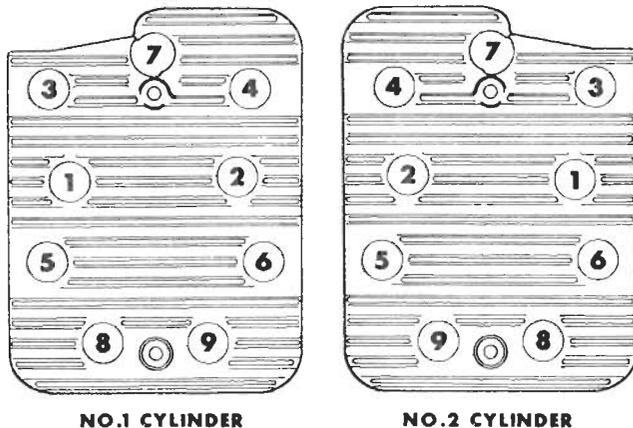


FIGURE 63. HEAD BOLT TIGHTENING SEQUENCE

VALVES

Properly seated valves are essential to good engine performance. The cylinder head is removable for valve servicing. Do not use a pry to loosen the cylinder head. Rap sharply on the edge with a soft-faced hammer, taking care not to break any cooling fins. A conventional type valve spring lifter may be used when removing the valve spring locks, which are of the split type. Clean all carbon deposits from the cylinder head, piston top, valves, guides, etc. If a valve face is burned or warped, or the stem worn, install a new valve.

Worn valve stem guides may be replaced from inside the valve chamber. See Figure 64. A seal is provided behind the intake valve guides only. The smaller diameter of the tapered valve guides must face toward the valve head.

Tappets are also replaceable from the valve chamber, after first removing the valve assemblies.

The valve *face* angle is 44 degrees. The valve *seat* angle is 45 degrees. This 1-degree 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, Figure 65.

The valves should not be hand lapped, if at all avoidable, since the sharp contact may be destroyed. This is especially important where stellite faced valves and seats are used. Valve faces should be finished in a machine to 44 degrees. Valve seats should be ground with a 45 degree stone and the width of the seat band should be 1/32 to 3/64 of an inch (0.79 to 1.2 mm) wide. Grind only enough to assure proper seating.

Remove all grinding compound from engine parts and place each valve in its proper location. Check each valve for a tight seat, using an air pressure type testing tool. If such a tool is not available, make pencil

NOTE - USE A STANDARD AUTOMOTIVE TYPE WRENCH TO ADJUST THE TAPPETS.

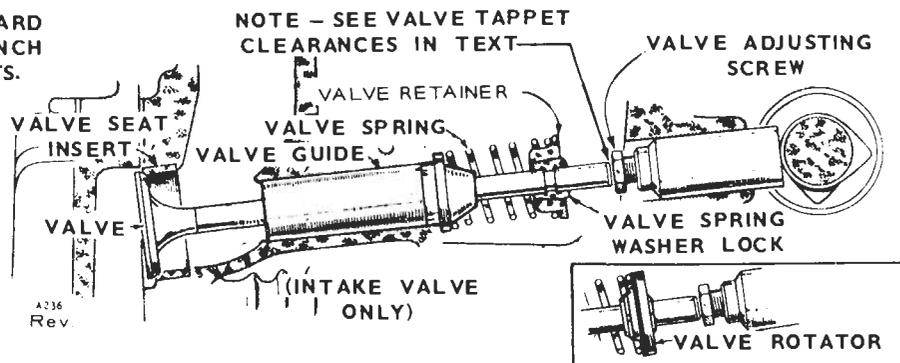


FIGURE 64. CCK AND CCKA VALVE SYSTEM

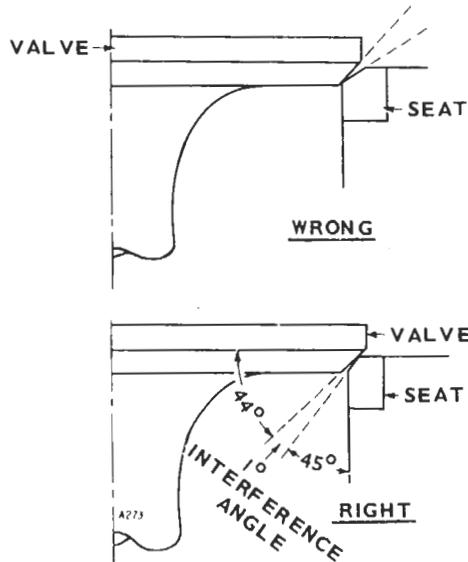


FIGURE 65. VALVE FACE AND SEAT ANGLES

marks at intervals across the valve face and observe if the marks rub off uniformly when the valve is rotated part of a turn against the seat.

Lightly oil the valve stems and reassemble all parts removed. Adjust the valve clearance (see *Tappet Adjustment*).

The positive type valve rotocoils serve to prolong valve life and decrease valve repairs. Check the rotocoils periodically by removing the cylinder heads and cranking the engine. When functioning properly, the valve is rotated a fraction of a turn each time it opens. If rotocoils are faulty, install new ones.

TAPPET ADJUSTMENT

The engine is equipped with adjustable tappets. To make a valve adjustment, remove the valve covers. Crank the engine over slowly by hand until the left hand intake valve, when facing the flywheel, opens and closes. Continue about 1/4 turn until the correct timing marks align. This should place the left hand 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 are shown in *Dimensions and Clearances* section. For each valve, the gauge should just pass between the valve stem and valve tappet, Figure 66.

To correct the valve clearance, turn the adjusting screw as needed to obtain the right clearance. The screw is self-locking.

To adjust the valves on the right hand cylinder, crank the engine over one complete revolution and again line up the correct timing marks. Then follow the

INTAKE AND EXHAUST VALVES
(SEE TABLE OF CLEARANCES)

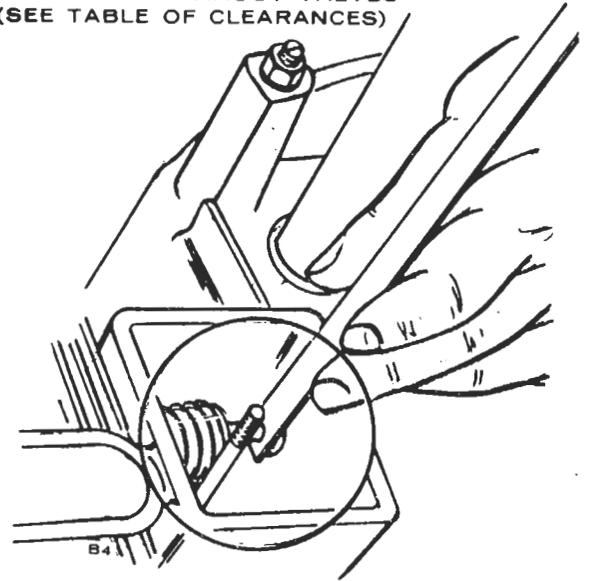
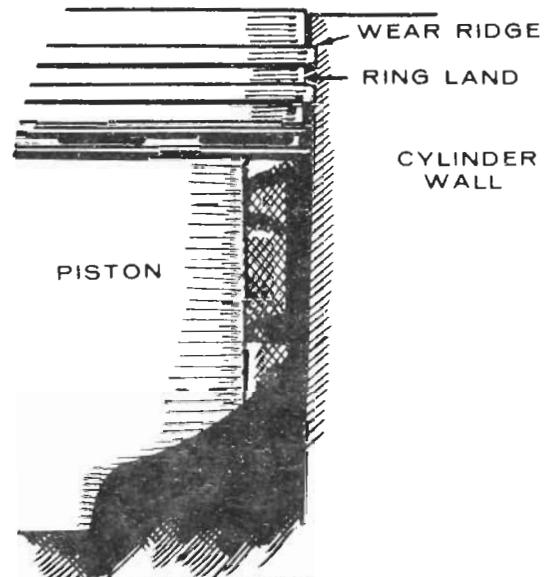


FIGURE 66. ADJUSTING TAPPETS



REMOVING PISTON WITH LARGE WEAR RIDGE COULD BREAK RING OR RING LAND.

FIGURE 67. WEAR RIDGE ON CYLINDER WALL

adjustment given for the valves of the left hand cylinder.

PISTONS AND RINGS

Whenever there is a noticeable wear ridge at the top of each cylinder, remove the ridge with a ridge reamer before removing the pistons. If not, the rings can catch the ridge when pushing out the pistons and cause a ring land fracture, Figure 67.

To remove the piston and connecting rod assemblies, turn the crankshaft until a piston is at the bottom of the stroke. Remove the nuts from the connecting rod bolts. Lift the rod bearing cap from the rod and push the rod and piston assembly out the top of the cylinder with the handle end of a hammer. Be careful not to scratch the crankpin or the cylinder wall when removing these parts.

Keep the connecting rod bearing caps and bearings with their respective rods.

The pistons are fitted with two compression rings and one oil control ring with an expander. Remove these rings from the piston using a piston ring spreader.

Clean the piston ring grooves with a groove cleaner or the end of a broken ring filed to a sharp point. See Figure 68. All passages should be cleaned with a non-caustic solvent. Clean the rod bore and the back of the connecting rod bearings thoroughly.

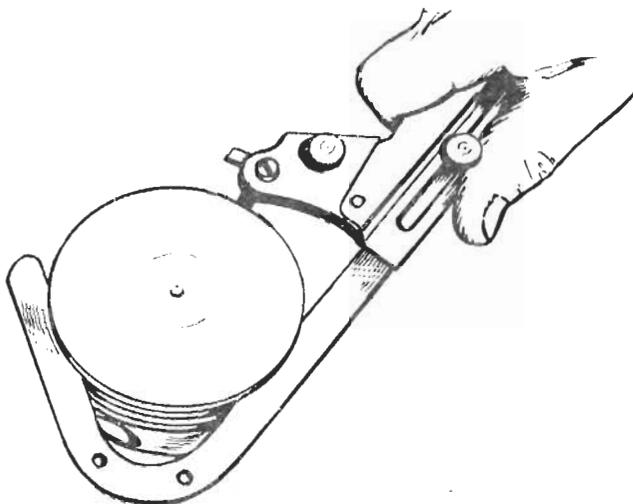
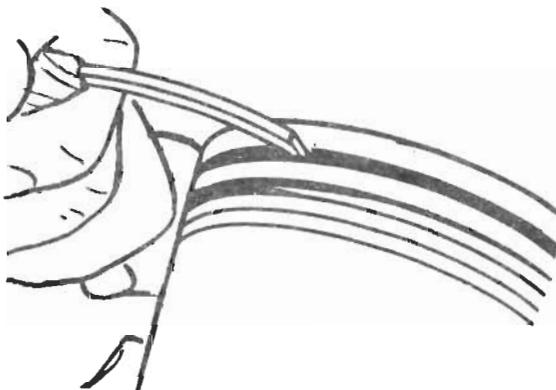


FIGURE 68. CLEANING RING GROOVES



Mark each piston to make sure the rod will be assembled on the piston from which it was removed. Remove the piston pin retainer from each side and push the pin out.

Inspect the pistons for fractures at the ring lands, skirts and pin bosses. Check for wear at the ring land using new rings and a feeler gauge as shown in Figure 69.

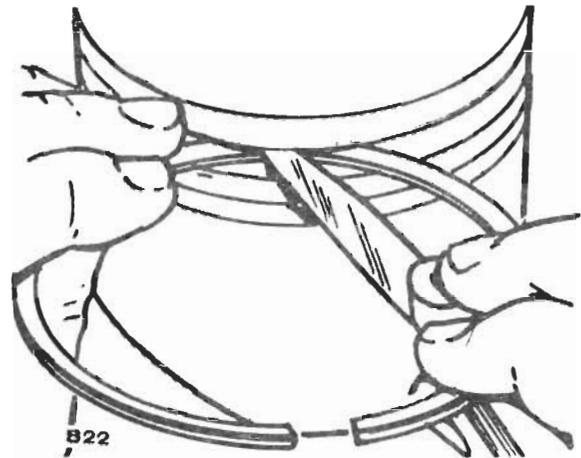


FIGURE 69. INSPECTING RING LANDS

Improper width rings or excessive ring side clearance can result in ring breakage. New rings in worn ring grooves do not have good cylinder wall contact, Figure 70.

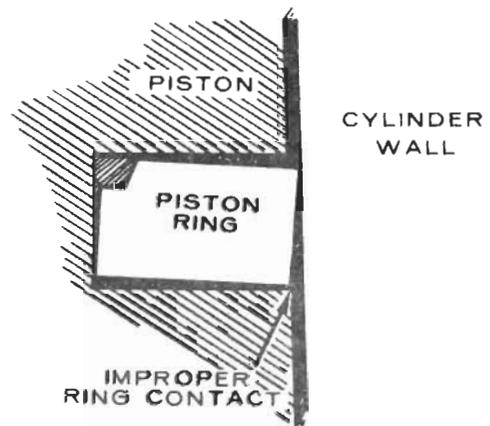


FIGURE 70. NEW RING IN WORN PISTON RING GROOVE

Replace pistons showing signs of bad scoring or burring, excessive skirt clearance, wavy or worn ring lands, fractures or damage from detonation. Replace piston pins showing fractures, scored bores or bores out of round more than 0.002 inch (0.051 mm).

Use a new piston pin to check the pin bushing in the connecting rod for wear. The clearance should be as shown in *Dimensions and Clearances* section.

Before installing new rings on the piston, check the ring gap by placing each ring squarely in its cylinder at a position corresponding to the bottom of its travel. See Figure 71. The gap between the ends of the ring is given in *Dimensions and Clearances* section. Rings which are slightly oversize may be filed as necessary to obtain the correct gap, but do not use rings which require too much filing. Standard size rings may be used on .005-inch oversize pistons. Other oversize rings must be used with corresponding oversize pistons. Rings of the tapered type are usually marked *top* on one side, or identified in some other manner and the ring must be installed with this mark toward the closed end of the piston.

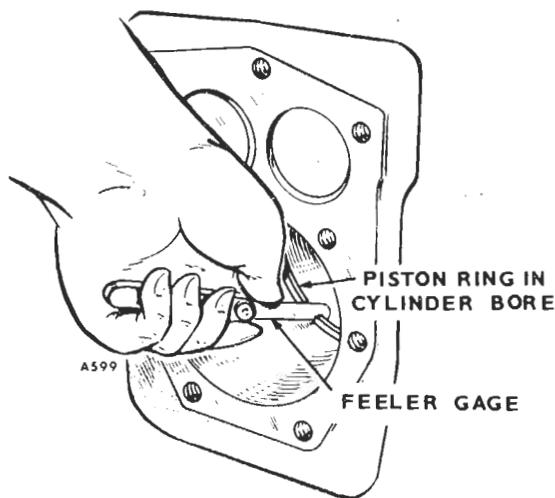


FIGURE 71. FITTING PISTON RINGS TO CYLINDER

Space each ring gap one third of the way around the piston from the preceding one, with no gap directly in line with the piston pin. The bottom piston ring groove should be fitted with an expander and an oil control ring and the two upper grooves fitted with compression rings. If a chrome faced ring is used, it will be in the top groove. The oil control ring is selected for best performance in regard to the correct unit pressure characteristics.

The piston is fitted with a full-floating type piston pin. The pin is kept in place by two lock rings in the piston, one at each side. Be sure these lock rings are properly in place before installing the piston and connecting rod in the engine. Refer to *Dimensions and Clearances* section for the correct piston-to-cylinder clearance.

CONNECTING RODS

The connecting rods should be serviced at the same time the pistons or rods are serviced. Rods must be

removed with the piston. Replaceable bushings and bearings are used. See *Parts Catalog 927-0404* for available undersize and standard size bearings.

Proper clearance is obtained by replacing the pin bushing and the bearings. The rod bearings are precision size and require no reaming.

Install the connecting rods and caps with raised lines (witness marks) aligned and with the caps facing toward the oil base. The rod and cap numbered 2 fits on the crankshaft journal nearest the bearing plate. Coat the crankshaft journal bearing surfaces with oil before installing the rods. Crank the engine by hand to see that the rods are free. If necessary, rap the connecting rod cap screws sharply with a soft-faced hammer to set the rod square on the journal.

Checking Bearing Clearance With Plastigauge: Make certain that all parts are marked or identified so that they are reinstalled in their original positions.

Place a piece of correct size Plastigauge in the bearing cap the full width of the bearing insert about 1/4 inch (6.35 mm) off center, Figure 72.

Rotate the crank about 30 degrees from bottom dead center and reinstall the bearing cap. Tighten the bolts to the torque specified in the *Assembly Torques and Special Tools* section. Do not turn the crankshaft.

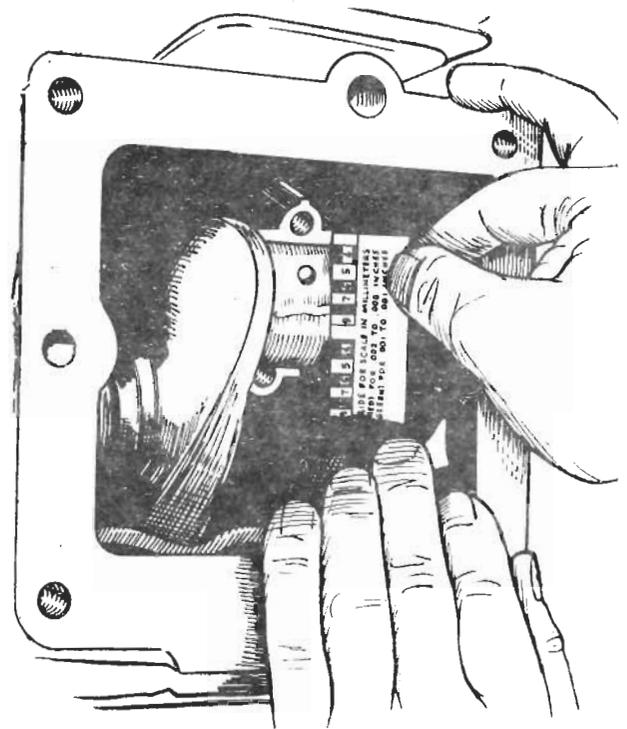


FIGURE 72. MEASURING BEARING CLEARANCE WITH PLASTIGAUGE

Remove the bearing cap. Leave the flattened Plastigauge on the part to which it has adhered and compare the widest point with the graduations on the Plastigauge envelope to determine bearing clearance.

CYLINDER BLOCK

Inspection:

1. Make a thorough check for cracks. Minute cracks may be detected by coating the suspected area with a mixture of 25 percent kerosene and 75 percent light motor oil. Wipe the part dry and immediately apply a coating of zinc oxide (white lead) dissolved in wood alcohol. If cracks are present, the white coating will become discolored at the defective area.

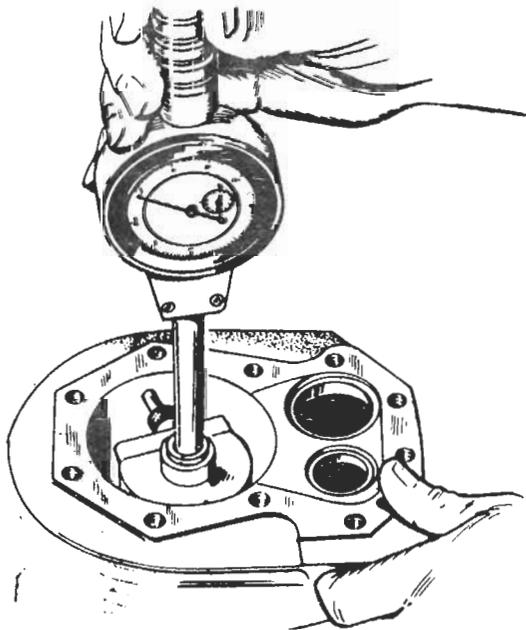
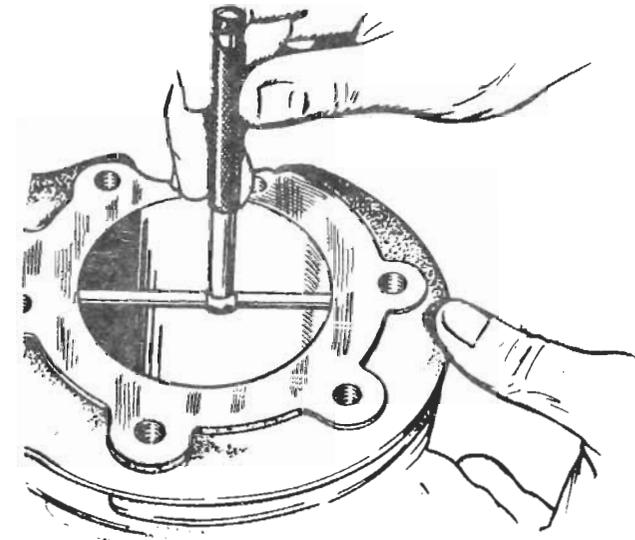


FIGURE 73. METHODS OF CYLINDER BORE INSPECTION

2. Inspect the cylinder bore for scoring. Check the Welsh plugs for a tight, even fit and the fins for breakage.
3. Check the cylinder bore for taper, out of round and wear with a cylinder bore gauge, telescope gauge or inside micrometer, Figure 73. These measurements should be taken at four places—two at the top and two at the bottom of piston ring travel.
4. Referring to Figure 74, measure cylinder diameter and record the readings as follows:
 - a. Measure reading A across top of cylinder where greatest piston ring wear occurs.
 - b. Measure reading B across cylinder at bottom of piston ring travel.
 - c. Measure reading C across top of cylinder where greatest ring wear occurs.
 - d. Measure reading D across cylinder at bottom of piston ring travel.
5. Compare reading A with reading B, then compare reading C with reading D to determine cylinder taper due to wear.

If taper exceeds 0.005 inch (0.127 mm), rebore and hone cylinder to accommodate the next oversize piston.

6. Reading A compared to C and reading B compared to D indicates whether or not the cylinder is out of round.

If cylinder is out of round 0.002 inch (0.051 mm), rebore and hone cylinders for next oversize piston.

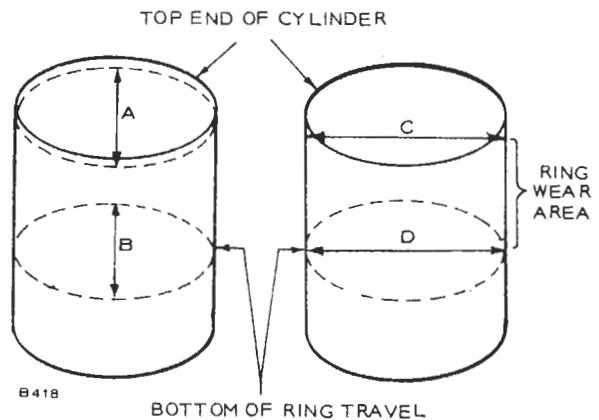


FIGURE 74. CYLINDER BORE MEASUREMENT

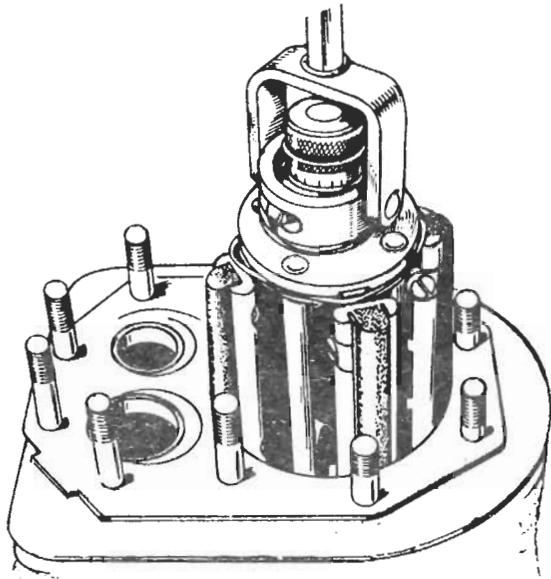


FIGURE 75. HONING CYLINDER

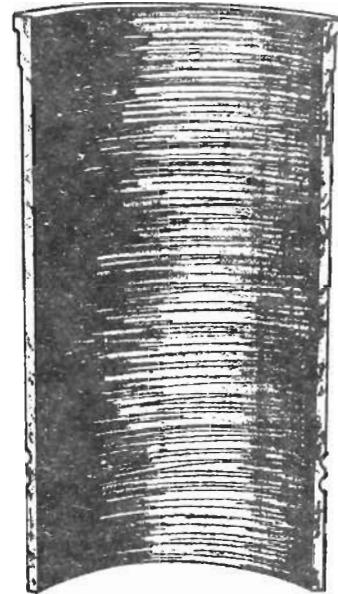
HONING PROCEDURE

1. A hone can be used to rebore a cylinder, Figure 75. Remove stock to 0.002 inch (0.051 mm) less than finished bore with coarse hone (100 grit), then complete honing with finish hones (300 grit).
2. Anchor block solidly for either vertical or horizontal honing. Use either a drill press or heavy-duty drill which operates at about 250 to 450 rpm.
3. Lower hone into cylinder until it protrudes 1/2 to 3/4 inch (13 to 19 mm) past end of cylinder. Rotate adjusting nut until stones come in contact with cylinder wall at narrowest point.
4. Loosen adjusting nut until hone can be turned by hand.
5. Connect drill to hone and start drill. Move hone up and down in the cylinder about 40 cycles per minute. Usually the bottom of the cylinder must be worked out first because it is smaller. When cylinder takes a uniform diameter, move hone up and down all the way through the bore. Follow the hone manufacturer's recommendations for wet or dry honing and oiling the hone.
6. Check diameter of cylinder regularly during honing. A dial bore gauge is the easiest method but a telescoping gauge can be used. Check the size at six places in the bore; measure twice at the top, middle and bottom of 90-degree angles.
7. When the cylinder is about 0.002 inch (0.051 mm) within the desired bore, change to fine stones and finish the bore. The finish should not be smooth but as shown in Figure 76. The crosshatch formed by the scratching of the stones should form an angle of 23 degrees. This can be achieved by moving the hone up and down in the cylinder about 40 cycles per minute.

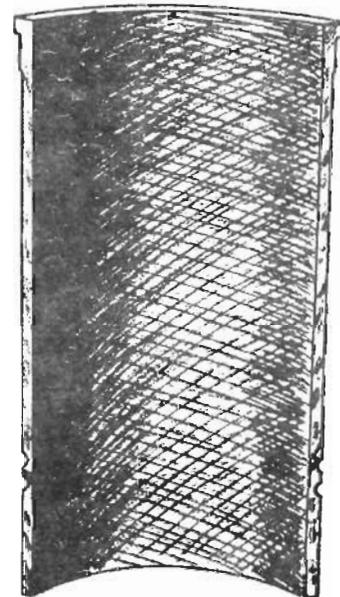
8. Clean cylinder block thoroughly with soap, water and clean rags. A clean white rag should not be soiled on the wall after cleaning is complete.

CAUTION Do not use a solvent or gasoline since they wash the oil from the walls but leave the metal particles.

9. Dry crankcase and coat it with oil.



AVOID THIS FINISH



PRODUCE CROSS HATCH SCRATCHES FOR FAST RING SEATING

FIGURE 76. CORRECT HONE FINISH

CRANKSHAFT

Inspect the bearing journals. If they are scored and cannot be smoothed out by dressing down, the bearing journals should be refinished to use nearest available undersize bearings or a new crankshaft should be installed. If a worn main bearing journal cannot be fitted with an available precision type undersize bearing, then refinish it to the next undersize. If a worn rod journal cannot be fitted by installing new bearing inserts (forged rod), then refinish it to take the corresponding undersize bearing insert available.

Whenever making major repairs on the engine, always inspect the drilled passages of the crankshaft. Clean them to remove any foreign material and to assure proper lubrication of the connecting rods.

BEARINGS

Removal of the camshaft or crankshaft bearings requires complete disassembly of the engine. Use a press or a suitable drive plug to remove the bearings. Support the casting to avoid distortion and avoid damaging the bearing bore during removal and installation. Use oil on the bearings to reduce friction when installing and again lubricate with oil after installing. See Figure 77. Use combination bearing driver 420-0324 to install the camshaft bearings.

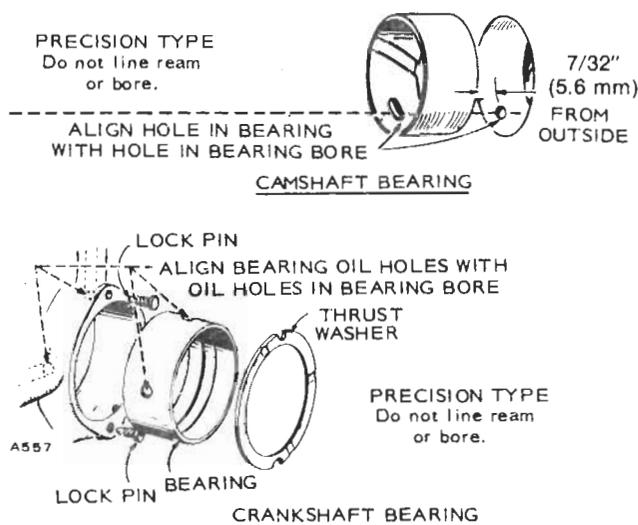


FIGURE 77. INSTALLATION OF CAM AND CRANKSHAFT BEARINGS

Camshaft: Replacement camshaft bearings are precision type which do not require line reaming or line boring after installation. Coat the bearing with lubricating oil to reduce friction. Place the bearing on the crankcase over the bearing bore with the lubricating hole (front only) in proper position. Be sure to start the bearing straight. Press the front

bearing in flush with the outside end of the bearing bore. Press the rear bearing in until past the ignition plunger hole.

Crankshaft: New crankshaft main bearings are precision type which *do not* require line reaming or line boring after installation. See *Parts Catalog 927-0264* for standard size and undersizes available.

Before putting in the main bearings, expand the bearing bore by placing the casting in hot water or in an oven heated to 200°F (93°C). If practical, cool the precision bearing to shrink it.

CAUTION If a torch is used to heat bearing bore, apply only a little heat evenly to prevent warpage and loss of temper in the steel.

For putting in either the front or rear main bearing, using instructions following, always align the oil hole(s) in the bearing with the oil hole(s) in the bearing bore. The oil passage must be at least 1/2 open. The cold oiled precision bearing should require only light taps to position it. Install the bearing flush with the inside end of the bore. If the head of a lock pin is damaged, use side cutters or "Easy-Out" tool to remove pin. Then install a new lock pin. Apply oil to the thrust washers to hold in place when the crankshaft is installed. The oil grooves in the thrust washer bearings must face the crankshaft. Be sure two notches fit over lock pins.

OIL SEALS

The bearing plate must be removed to replace its oil seal. Drive the oil seal out from the inside using bearing plate driver 420-0181 and gear cover driver 420-0313.

Before installing the seals, fill the space between seals with a fibrous grease or stiff cup grease. This will improve sealing. See Figure 78.

When installing the gear cover oil seal, tap the seal inward until rear (spring side) of casing is 1-1/32 inch (26.2 mm) from the mounting face of the gear cover.

When installing the bearing plate oil seal, tap the seal into the bearing plate bore to bottom against the shoulder in the plate bore. Use a seal expander, or place a piece of shim stock around the end of the crankshaft, when replacing the bearing plate to avoid damaging the seal. Remove the shim stock as soon as the plate is in place.

Engines equipped with some types of reduction gear assemblies do not use the rear oil seal. The reduction gear assembly is oiled directly from the engine crankcase. Refer to the instructions screened on the case of the reduction gear assembly.

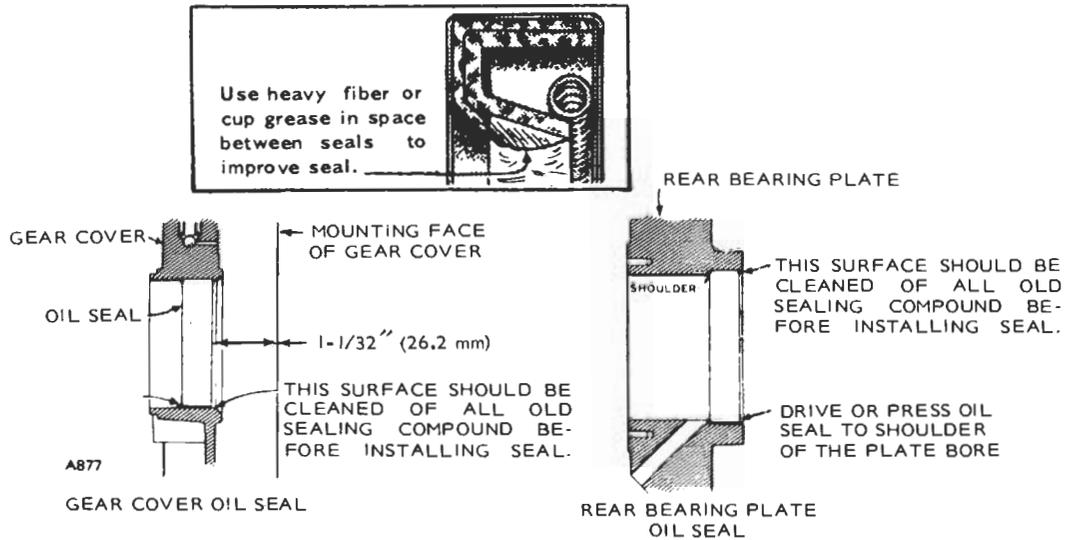


FIGURE 78. GEAR COVER AND REAR BEARING PLATE OIL SEALS

CRANKSHAFT ENDPLAY

After the rear bearing end plate has been tightened using the torque recommended in *Assembly Torques and Special Tools* section, check the crankshaft endplay as shown in Figure 79. If there is too much endplay (see *Dimensions and Clearances* section for minimum and maximum endplay), remove the rear bearing end plate and replace the gasket with a thinner gasket from the gasket kit. For too little endplay, remove the rear bearing end plate and

replace the gasket with a thicker one. Reinstall the end plate making sure the thrust washer notches line up with the lock pins. Torque and recheck endplay of the crankshaft.

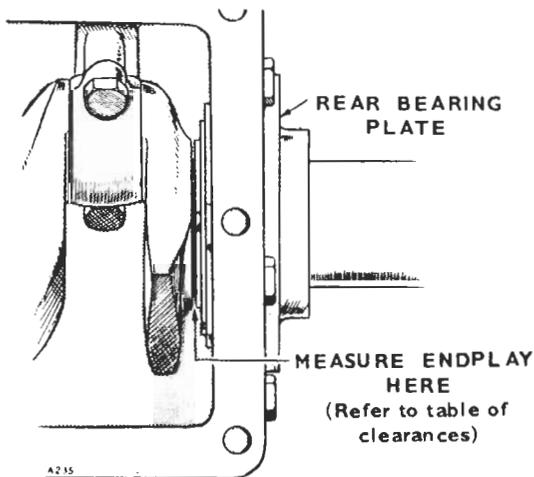


FIGURE 79. MEASURING CRANKSHAFT ENDPLAY

OIL PUMP

Check the oil pump thoroughly for worn parts. Oil the pump to prime it before reinstalling, Figure 80. Except for gaskets, the component parts of the pump are not available individually. The suction cup is available separately. Install a new pump assembly, if required.

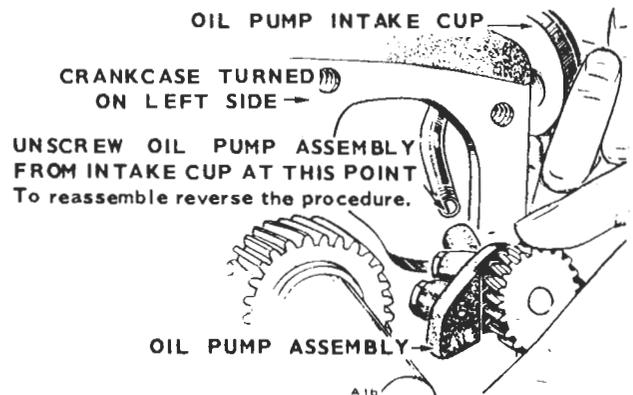


FIGURE 80. OIL PUMP

SPECIAL EQUIPMENT

ROCKFORD CLUTCH

With the engine stopped, the clutch released (disengaged lever position) and the top plate removed from the clutch housing, turn the adjusting ring (2) inward (clockwise facing power take-off shaft) until the toggles cannot be locked over center (Figure 81). Locking screw (1) may remain tightened.

Loosen the adjusting ring a notch or two at a time until the toggles can be locked over with a very firm pull on the engaging lever (3).

Start the engine and work the engaging lever back and forth several times, allowing the clutch to pick up load but not to lock over center. This is especially important with a new clutch plate as it knocks off high spots and fuzz.

Stop the engine and tighten the adjusting ring two or three notches for final adjustment.

Be sure the toggles lock over center at final adjustment with a firm pull on the engaging lever (clutch engaged).

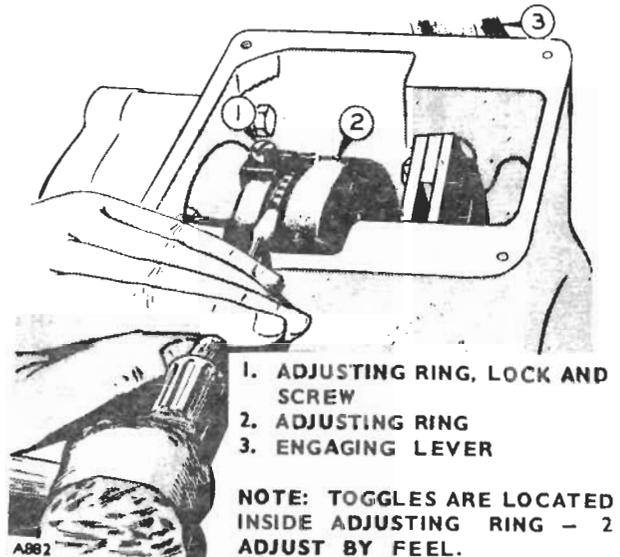


FIGURE 81. ROCKFORD CLUTCH

OPTIONAL REDUCTION GEAR DRIVE

Drain the gear box after the first 100 hours of operation and refill with fresh lubricant (SAE 50 motor oil or SAE 90 mineral gear oil). Repeat this procedure every six months thereafter or every 100 hours, whichever is first. Do not use lubricants commonly known as extreme pressure lubricants, hypoid lubricants, etc.

Maintain the proper oil level between changes. Overfilling will cause foaming, which can lead to an oil leak due to overheating. Remove the filler plug on top of the case and the oil level plug from the face of the gear case (Figure 82). Fill the case until the oil just begins to flow from the oil level plug hole. Gear box holds 1/2 pint U.S. Measure. Replace both plugs.

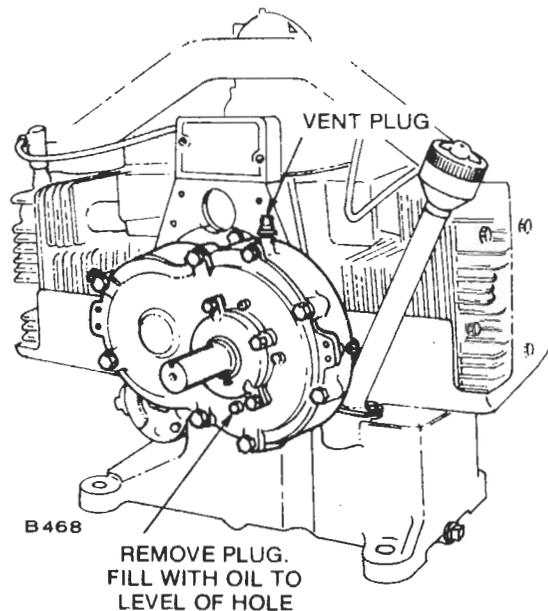
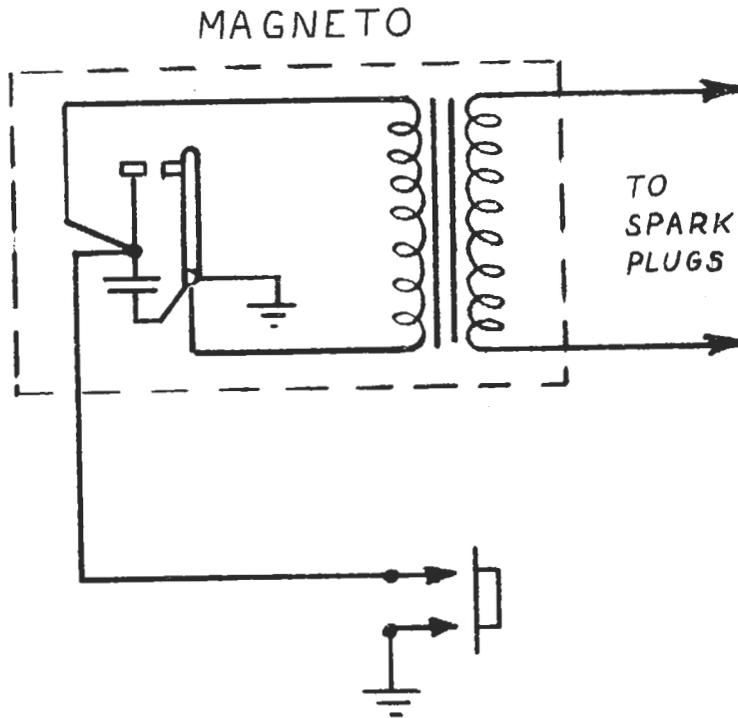


FIGURE 82. OPTIONAL REDUCTION GEAR DRIVE

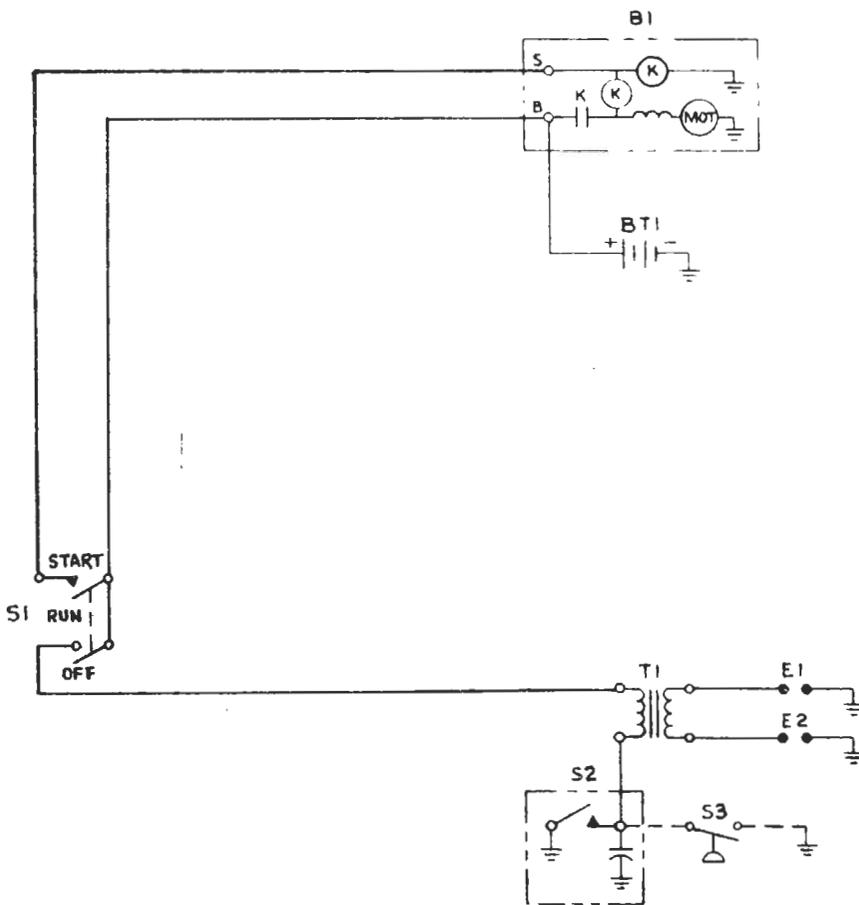
WIRING DIAGRAMS

The wiring diagrams on the following pages are typical and apply to standard engines with optional components added for connection details. Wiring diagrams for special models are available on request from the factory; send engine model, spec, and serial numbers with the request.

	PAGE
Magneto Ignition (Typical)	58
Battery Ignition - Basic, No Alternator (622-0315)	58
Side Mounted Alternator (35 Amp) - (622-0389)	59
Top Mounted Alternator (35 Amp) - (622-0384)	59
Flywheel Alternator 15 Amp (Phelon) - (622-0408)	60
Flywheel Alternator 20 Amp (Synchro) - (622-0413)	60
Top Mounted Control - 15 Amp Phelon Alternator (622-0410)	61
Top Mounted Control - 20 Amp Synchro Alternator (622-0383)	62
Battery Ignition - 12 Volt System with Side Mounted Alternator and 6 Volt Coil (191-0572)	62



TYPICAL WIRING DIAGRAM - FOR MAGNETO IGNITION ENGINES

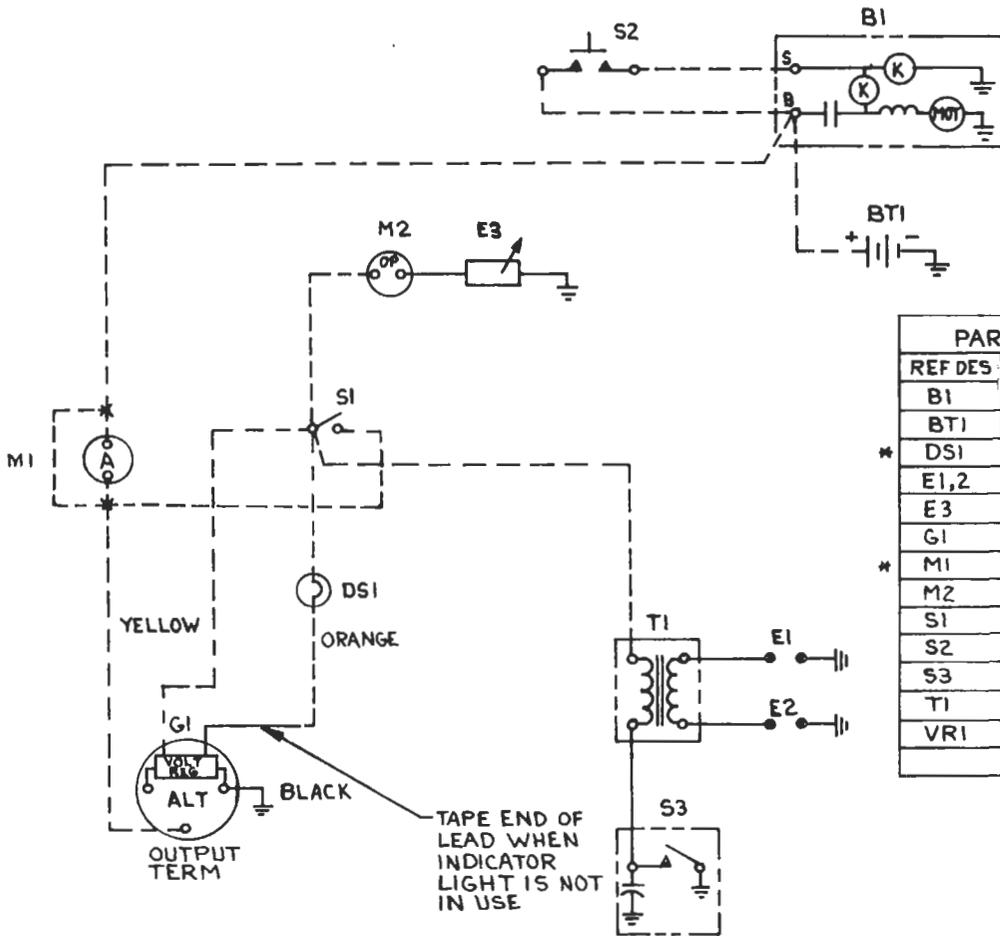


PARTS LIST (REF)		DESCRIPTION
REF	DES.	
B1		STARTER & SOLENOID - ENGINE
BT1		BATTERY
E1, 2		SPARK PLUG
S1		SWITCH - START, RUN, OFF
S2		BREAKER & CAP. ASSEMBLY
* S3		SWITCH - LOPKO
T1		COIL - IGNITION

* WHEN USED

622-0315

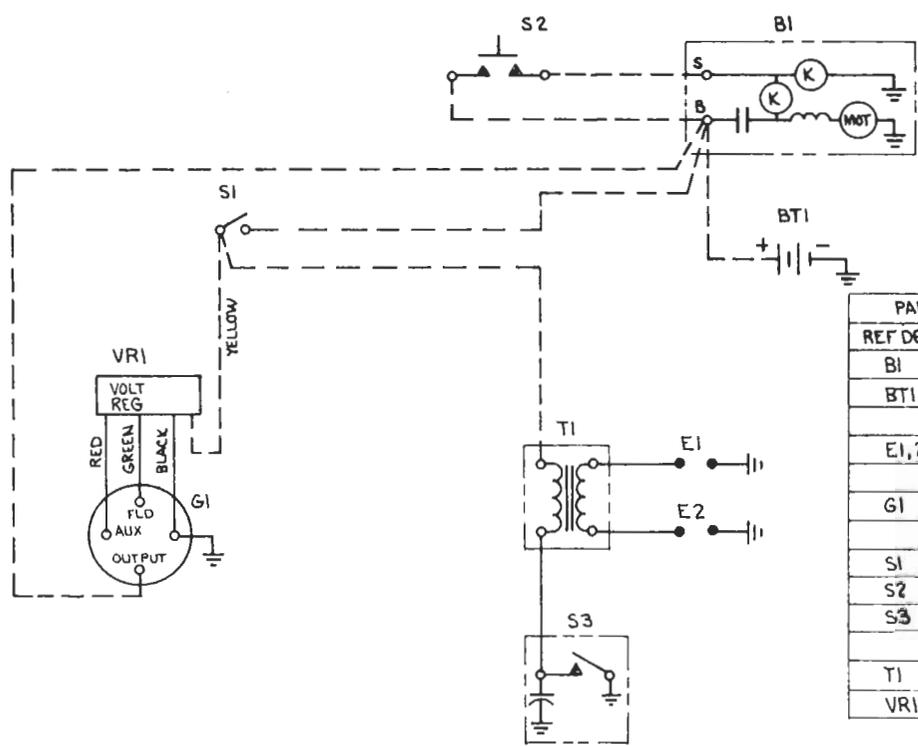
BATTERY IGNITION—BASIC, NO ALTERNATOR



PARTS LIST	
REF DES	DESCRIPTION
B1	STARTER, 12V
BT1	BATTERY, 12V
* DS1	LAMP-INDICATOR #57 OR EQUAL
E1,2	SPARK PLUG
E3	SENDER-OIL PRESSURE
G1	ALTERNATOR
* M1	AMMETER-CHARGE
M2	METER-OIL PRESSURE
S1	SWITCH-IGN
S2	SWITCH-START
S3	BREAKER & CAP ASSY
T1	COIL-IGN
VR1	REGULATOR-VOLTAGE

622-0389

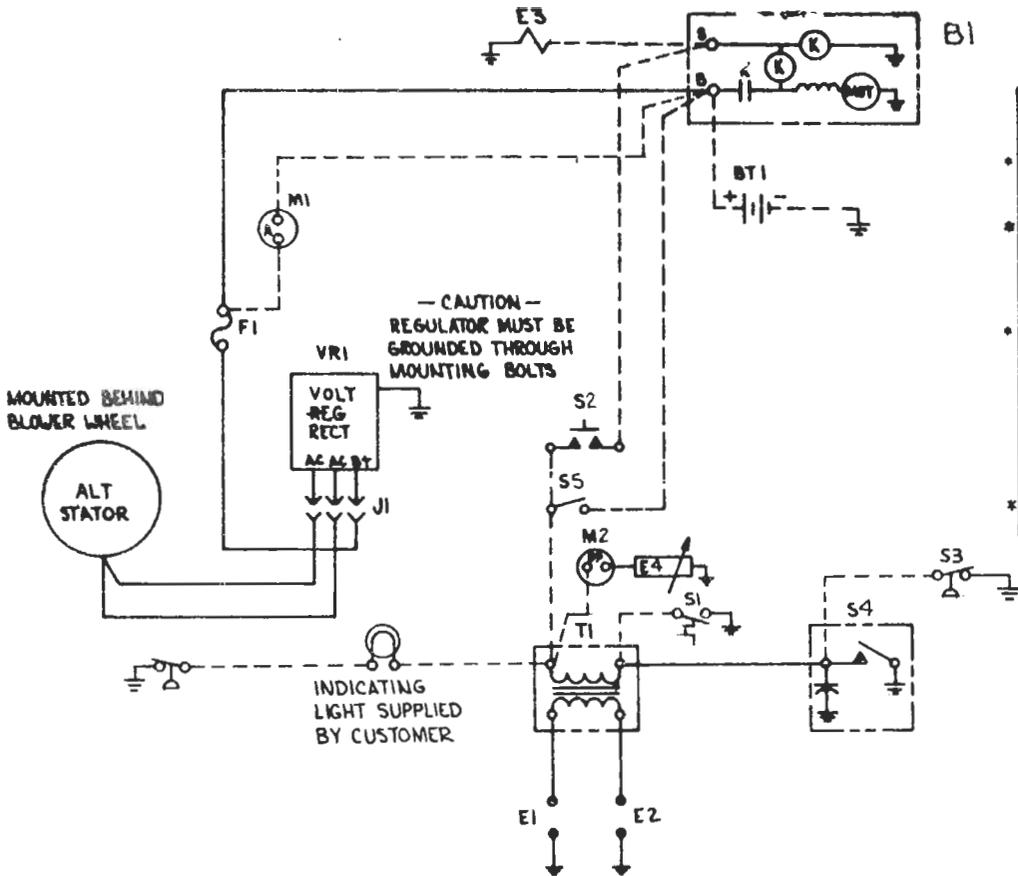
WIRING DIAGRAM FOR SIDE-MOUNTED ALTERNATOR



622-0384

PARTS LIST (REF)	
REF DES	DESCRIPTION
B1	STARTER & SOLENOID-ENGINE
BT1	BATTERY, 12V
E1,2	SPARK PLUG
G1	ALTERNATOR
S1	SWITCH-IGN
S2	SWITCH-START
S3	BREAKER & CAP ASSY
T1	COIL-IGN
VR1	REGULATOR-VOLTAGE

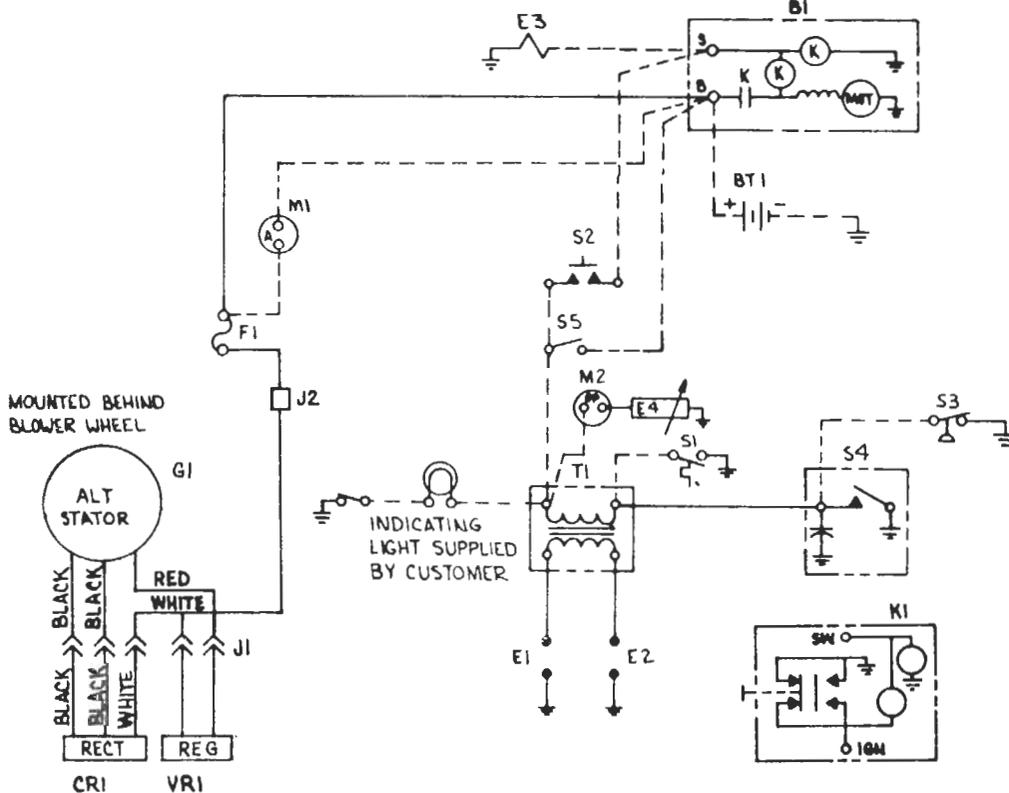
WIRING DIAGRAM FOR TOP-MOUNTED 35 AMP ALTERNATOR



PARTS LIST REF	
REF DES	DESCRIPTION
B1	STARTER & SOLENOID-ENGINE
BT1	BATTERY, 12 V
E1 & 2	SPARK PLUG
E3	CHOKE - SISSON
F1	FUSE, 15 AMP HOLDER-FUSE
G1	ALTERNATOR-FLYWHEEL 15 AMP
J1	CONNECTOR
S1	SWITCH - HATCO
S2	SWITCH-START
S3	SWITCH-LOPKO
S4	BREAKER & CAP ASSEMBLY
T1	IGNITION COIL-(ONAN)
VR1	REGULATOR-RECTIFIER-VOLTAGE
E4	SENDER - OIL PRESSURE
M1	AMMETER
M2	METER - OIL PRESSURE
S5	SWITCH - IGNITION

622-0408

WIRING DIAGRAM FOR FLYWHEEL ALTERNATOR (PHELON 15 AMP)



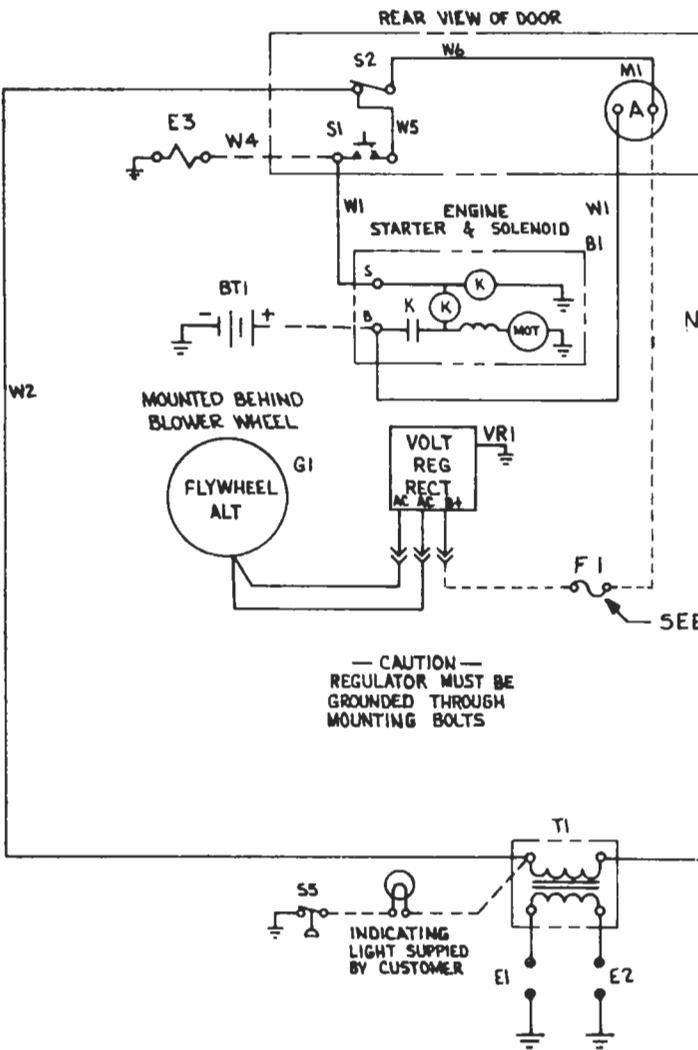
* PARTS FURNISHED BY CUSTOMER

PARTS LIST REF	
REF DES	DESCRIPTION
B1	STARTER & SOLENOID-ENGINE
BT1	BATTERY, 12 V
E1 & 2	SPARK PLUG
E3	CHOKE - SISSON
F1	FUSE 20 AMP HOLDER-FUSE
G1	ALTERNATOR
J1	CONNECTOR
S1	SWITCH - HATCO
S2	SWITCH-START
S3	SWITCH-LOPKO
S4	BREAKER & CAP ASSEMBLY
T1	IGNITION COIL-(ONAN)
VR1, CR1	REGULATOR-RECTIFIER-VOLTAGE
E4	SENDER - OIL PRESSURE
M1	AMMETER
M2	METER - OIL PRESSURE
S5	SWITCH - IGNITION
J2,	CONNECTOR
K1	SOLENOID - 2 SPEED GOVERNOR

622-0413

WIRING DIAGRAM FOR FLYWHEEL ALTERNATOR (SYNCHRO 20 AMP)

PARTS LIST	
REF DES	DESCRIPTION
B1	STARTER-ENG SOLENOID
BT1	BATTERY, 12V
E1,2	SPARK PLUG
* E3	CHOKE-SISSON
F1	FUSE 30 AMP (SUPPLIED BY CUSTOMER)
	HOLDER - FUSE
G1	ALTERNATOR - FLYWHEEL 15 AMP
J1	CONNECTOR
J2	CONNECTOR
M1	AMMETER-CHARGE 20-0-20
S1	SWITCH-START
S2	SWITCH-IGN
S3	BREAKER & CAP ASSY
Δ T1	IGN COIL
VR1	REGULATOR-RECTIFIER-VOLTAGE
W1	HARNES
W2	LEAD ASSY (-01 ONLY)
	LEAD ASSY (-02 ONLY)
	PANEL-CONTROL
* W4	LEAD ASSY
* Δ S4	SWITCH-LOPKO
* S5	SWITCH-OIL PRESSURE
W5	LEAD ASSY
W6	LEAD ASSY



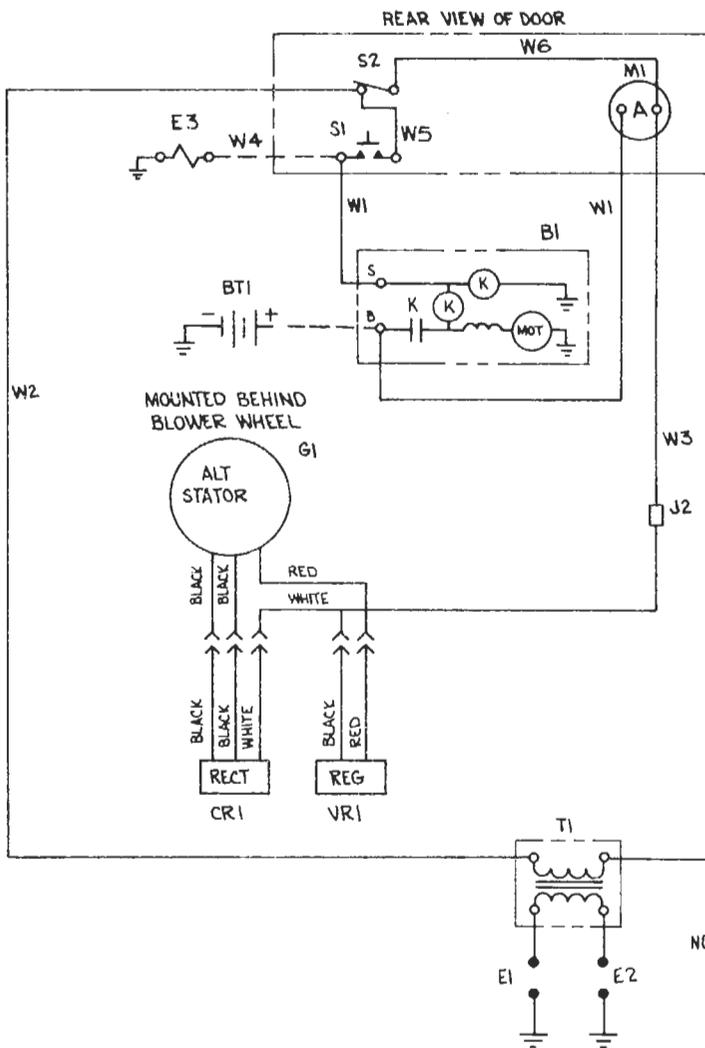
NOTES:
 1. PUT SWITCH (S2) IN UPPER 3/8 DIA. HOLE IN PANEL.
 2. LEAD & FUSE MUST BE CONNECTED TO RUN ENGINE.

SEE NOTE 2

— CAUTION —
 REGULATOR MUST BE GROUNDED THROUGH MOUNTING BOLTS

622-0410

**TOP MOUNTED CONTROL — 15 AMP
 PHELON ALTERNATOR**



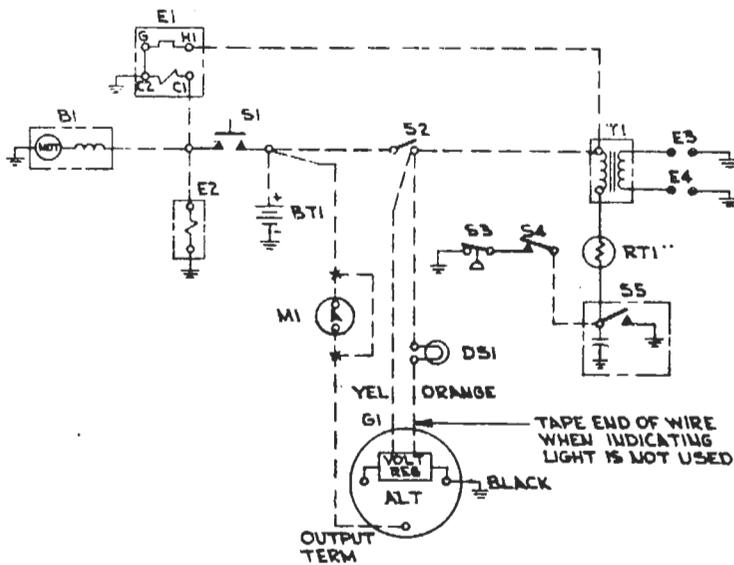
PARTS LIST	
REF DES	DESCRIPTION
B1	STARTER-ENG SOLENOID
BT1	BATTERY, 12V
E1,2	SPARK PLUG
E3	CHOKE-SISSON (-OZ ONLY)
G1	ALTERNATOR
J1	CONNECTOR
J2	CONNECTOR
M1	AMMETER-CHARGE 20-0-20
S1	SWITCH-START
S2	SWITCH-IGN
S3	BREAKER & CAP ASSY
T1	IGN COIL
VR1,CR1	REGULATOR-RECTIFIER-VOLTAGE
W1	HARNESS
W2	LEAD ASSY (-OZ ONLY)
W3	LEAD ASSY
W4	LEAD ASSY (-OZ ONLY)
	PANEL-CONTROL
W2	LEAD (-O1 ONLY)
W5	LEAD ASSY
W6	LEAD ASSY

622-0383

NOTE:

1. WHEN -O1 WIRING DIAGRAM IS USED, PUT SWITCH (S2) IN UPPER 3/8 DIA. HOLE IN PANEL. WHEN -O2 WIRING DIAGRAM IS USED, PUT SWITCH (S2) IN LOWER 3/8 DIA. HOLE.

WIRING DIAGRAM FOR FLYWHEEL ALTERNATOR (SYNCRO 20 AMP)

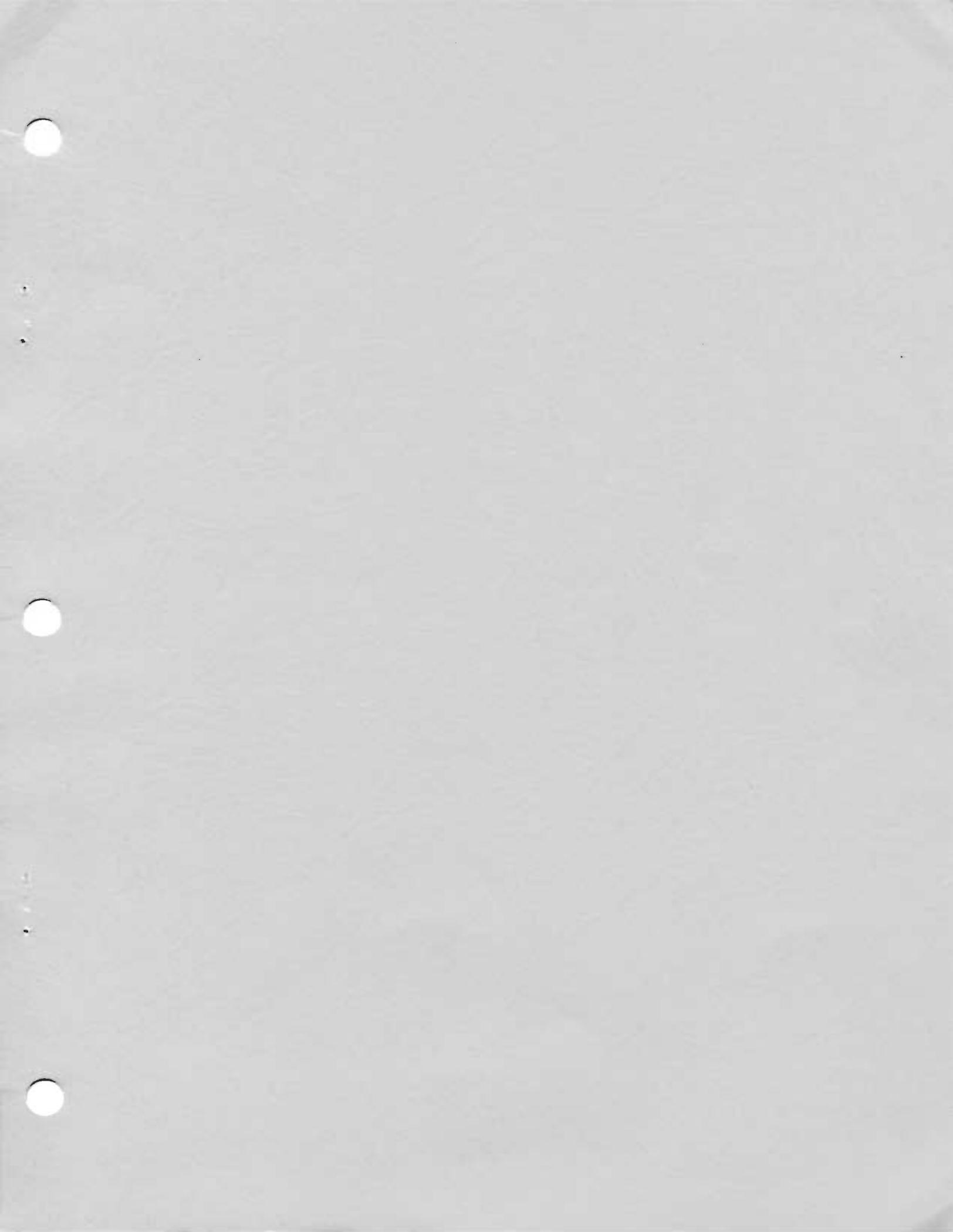


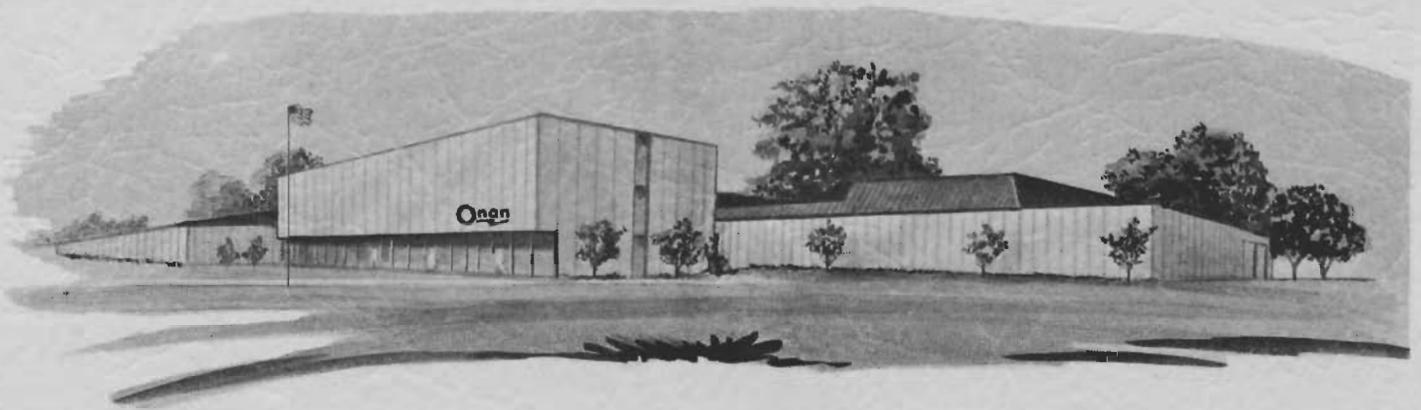
PARTS LIST (REF)			
REF DES.	PART NO.	QTY	DESCRIPTION
B1		1	STARTER - 12V
BT1		1	BATTERY - 12V
DS1		1	LAMP - INDICATOR #57 OR EQUAL
E1		1	CHOKE - THERMO MAG (CCMB)
E2		1	CHOKE - SISSON (CCK & CCKA)
E3,4		2	SPARK PLUG
G1		1	ALTERNATOR
M1		1	AMMETER - CHARGE
RT1	304A60	1	RESISTOR - HYTEMCO, 1.72Ω, 25W
S1		1	SWITCH - START
S2		1	SWITCH - IGN
S3		1	SWITCH - LOW OIL PRESS
S4		1	SWITCH - MON.
S5		1	SWITCH - CAP & BREAKER ASSY
T1		1	COIL - IGN

* WHEN USED

** Use with 6 volt coil only.

WIRING DIAGRAM FOR SIDE-MOUNTED ALTERNATOR (ONAN 191-0572)





ONAN 1400 73RD AVENUE N.E. • MINNEAPOLIS, MINNESOTA 55432
A DIVISION OF ONAN CORPORATION

