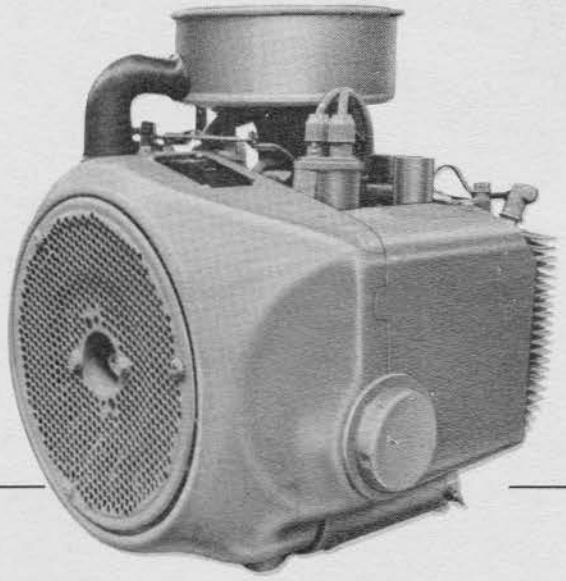
McGRAW-EDISON

Onan

Service and Parts Manual

BG Engine



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Safety Precautions

It is recommended that you read your engine manual and become thoroughly acquainted with your equipment before you start the engine.

WARNING ***This symbol is used 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.

Safety Codes

- All local, state and federal codes should be consulted and complied with.
- This engine is not designed or intended for use in aircraft. Any such use is at the owner's sole risk.

General

- Provide appropriate fire extinguishers and install them in convenient locations. Use an extinguisher rated ABC by NFPA.
- Make sure that all fasteners on the engine are secure and accurately torqued. Keep guards in position over fans, driving belts, etc.
- If it is necessary to make adjustments while the engine is running, use extreme caution when close to hot exhausts, moving parts, etc.

Protect Against Moving Parts

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

Batteries

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

Fuel System

- DO NOT fill fuel tanks while engine is running.
- DO NOT smoke or use an open flame in the vicinity of the engine or fuel tank. Internal combustion engine fuels are highly flammable.
- Fuel lines must be of steel piping, adequately secured, and free from leaks. Piping at the engine should be approved flexible line. Do not use copper piping for flexible lines as copper will work harden and become brittle enough to break.
- Be sure all fuel supplies have a positive shutoff valve.

Exhaust System

- Exhaust products of any internal combustion engine are toxic and can cause injury, or death if inhaled. All engine applications, especially those within a confined area, should be equipped with an exhaust system to discharge gases to the outside atmosphere.
- Do not use exhaust gases to heat a compartment.
- Make sure that your exhaust system is free of leaks. Ensure that exhaust manifolds are secure and are not warped by bolts unevenly torqued.

Exhaust Gas is Deadly!

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

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

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

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

Cooling System

- Coolants under pressure have a higher boiling point than water. DO NOT open a radiator pressure cap when coolant temperature is above 212° F (100° C) or while engine is running.

Keep the Unit and Surrounding Area Clean

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

TABLE OF CONTENTS

TITLE	PAGE
General Information	2
Specifications	3
Dimensions and Clearances	4
Assembly Torques and Special Tools	4
Engine Troubleshooting	5
Oil System	6
Fuel System	8
Ignition and Battery Charging	12
Starting System	17
Engine Disassembly	19
Engine Wiring Diagram	31

GENERAL INFORMATION

This manual contains proper information for the servicing and overhaul of your Onan engine. Use the *PARTS CATALOG* in the rear portion of this book to help you with disassembly and assembly procedures.

Flywheel end of engine is considered the front. Left and right sides are determined looking at front of engine.

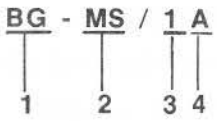
If it is necessary to contact your dealer or the factory about this engine, always supply the complete MODEL and SPEC NUMBER as well as the SERIAL NUMBER shown on the engine nameplate. The engine nameplate is located on left side of blower housing (end opposite oil filter).

Refer to the *TROUBLESHOOTING GUIDE* for assistance in locating and correcting troubles which may occur. If a major repair or overhaul becomes necessary, the engine should be carefully checked and necessary repairs made by a competent mechanic. Maintain factory limits and clearances as shown, replacing worn parts when necessary.

ENGINE MODEL REFERENCE

Identify your model by referring to the MODEL and SPEC (specification) NO. as shown on the unit nameplate. Always use this number and the engine serial number when making reference to your engine.

How to interpret MODEL and SPEC NO.



1. Factory code for general identification purposes.
2. Specific Type:
   S—MANUAL STARTING
   MS—ELECTRIC STARTING
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

This manual contains SI metric equivalents that follow immediately in parentheses after the U.S. customary units of measure.

Engine Manufacturer	Onan
Engine Design	Four Cycle, Air-Cooled, Two Cylinder
Horsepower (3600 rpm)	18
Displacement (cubic inches)	49.8 (816.22 cm^3)
Bore	3-1/4 (82.55 mm)
Stroke	3 (76.20 mm)
Compression Ratio	7.0:1
Crankshaft	Horizontal, Ductile Iron
Valves	Mechanical, Poppet
Bearings (Main and Rod)	Sleeve
Oil Capacity with Filter Change	4 Pints (1.89 litres)
Oil Capacity Without Filter Change	3.5 Pints (1.66 litres)
Battery Charging System	12 Volt, 15 Amp Flywheel Alternator

TUNE-UP SPECIFICATIONS

Tappets (Cold) Intake	.008 (0.20 mm)
Exhaust	.013 (0.33 mm)
Breaker Point Gap (Full Separation and Engine Cold)	.021 inch (0.53 mm)
Spark Plug Gap	.025 inch (0.64 mm)
Ignition Timing (Cold, Static Setting)	21° BTC

DIMENSIONS AND CLEARANCES

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

	Minimum	Maximum
CAMSHAFT AND CRANKSHAFT		
Crankshaft Main Bearing Journal to Bearing Clearance	0.0025	0.0038
*Crankshaft End Play	0.006	0.012
Camshaft Bearing to Camshaft	0.0015	0.0030
Camshaft End Play	0.003	
*Crankshaft Rod Journal to Rod Bearing	0.0020	0.0033
Connecting Rod End Play	0.002	0.016
Timing Gear Backlash	0.002	0.003
Oil Pump Gear Backlash	0.002	0.005
PISTON AND CYLINDER		
Piston Pin in Piston	0.0002	0.0004
Piston Pin in Rod	0.0002	0.0007
*Piston Ring Gap in Cylinder	0.010	0.020
Piston Clearance in Cylinder—Measured .10 Below Oil Control Ring, 90° from Pin	.004	.006
Cylinder Bore—Standard Size	3.249	3.250
Crankshaft Main Bearing Journal—Standard Size	1.9992	2.0000
Crankshaft Rod Bearing Journal—Standard Size	1.6252	1.6260
TAPPETS AND VALVES		
*Valve Seat Width	1/32	1/8
*Valve Face Angle	44°	44°
*Valve Seat Angle	45°	45°
Valve Stem to Guide—Intake	0.0010	0.0025
Valve Stem to Guide—Exhaust	0.0035	0.0040
Tappet to Cylinder Block Clearance	0.0015	0.0030
Tappet Adjustment (Cold)		
*Intake	0.007	0.009
*Exhaust	0.012	0.014

* - Frequently used overhaul values.

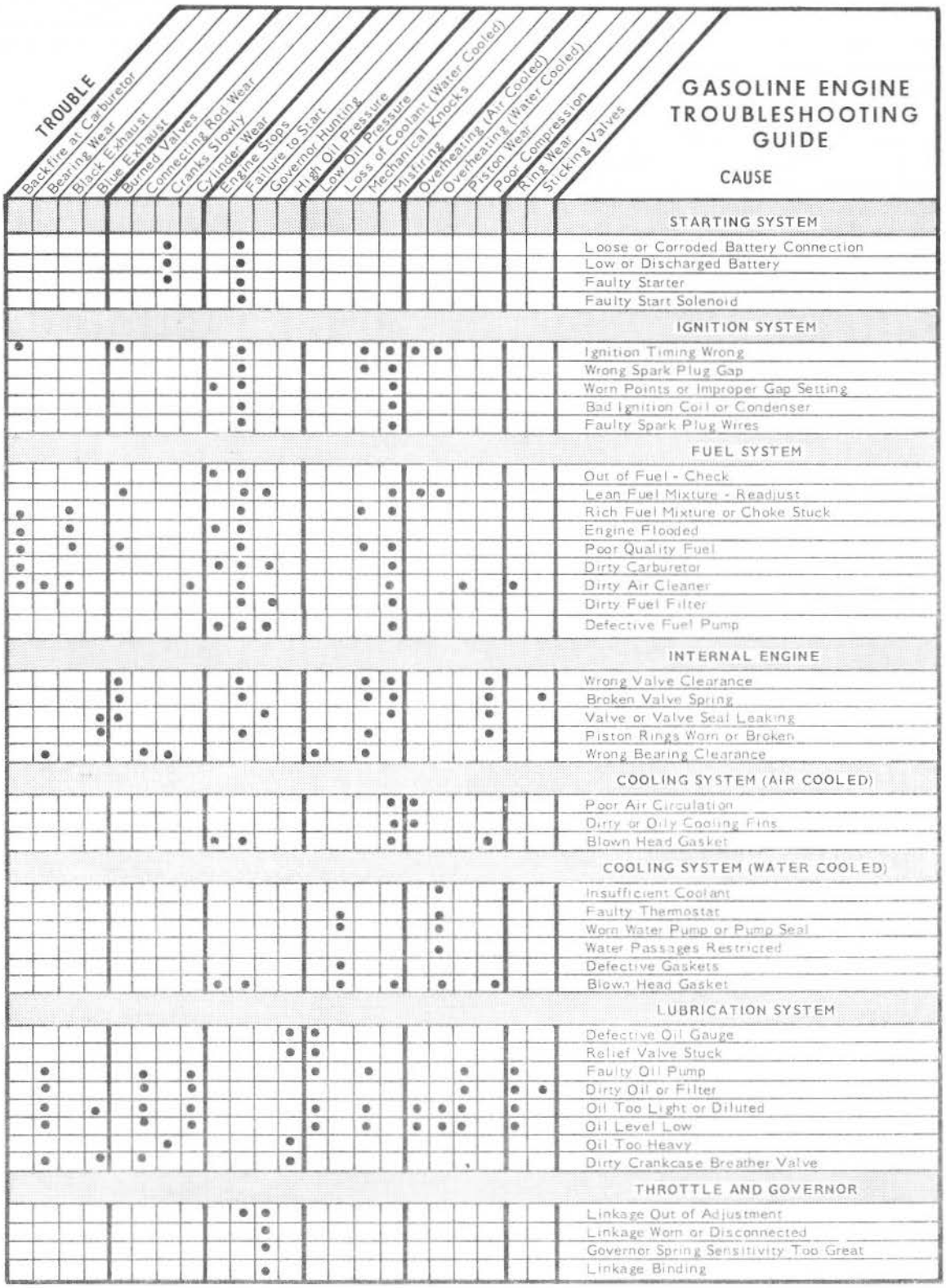
ASSEMBLY TORQUES AND SPECIAL TOOLS

BOLT TORQUE	FT.-LB.
Gearcase Cover	8 - 10
Cylinder Head Bolts (Cold)	14 - 16
Rear Bearing Plate Screws	25 - 27
Starter Mounting Bolts	18 - 20
Connecting Rod Bolt	14 - 16
Flywheel Cap Screw	35 - 40
Other 5/16" Cylinder Block Stud and Nuts	8 - 10
Oil Base	18 - 23
Manifold Mounting Screws	6 - 10
Oil Pump	7 - 9

The following special tools are available from Onan. For further information see *TOOL CATALOG 900-0019.*

Valve Seat Driver
Valve Guide Driver
Oil Guide and Driver
Combination Bearing Remover (Main and Cam)
Combination Bearing Driver (Main and Cam)
Flywheel Puller

ENGINE TROUBLESHOOTING



OIL SYSTEM

CRANKCASE OIL

Change crankcase oil every 50 operating hours and only when engine is warm. *(Exception:* Drain initial oil fill at 25 operating hours.*)*

To drain, remove the 1/2-inch pipe plug on the rear corner of the oil base. After oil drains, replace the pipe plug and refill crankcase with 3-1/2 pints (4 pints if changing filter) of a good quality detergent oil. Oil must meet or exceed the API (American Petroleum Institute) designation SE or SE/CC. See Figures 1 and 2. For temperatures above 30° F, use SAE 30 oil; for temperatures below 30° F, use 5W30 or 10W.

In extremely dusty conditions or in very cold weather, change oil at least every 25 hours of operation.

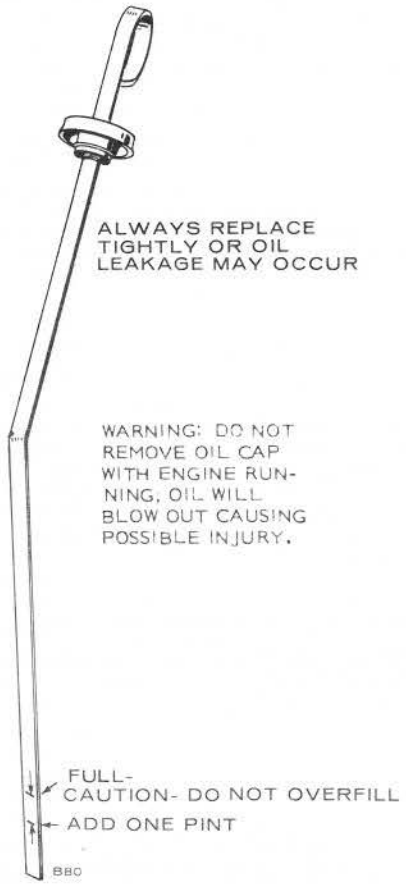


FIGURE 1. CRANKCASE OIL FILL

CAUTION **Do not overfill crankcase. Do not use service DS oil. Do not mix brands nor grades of motor oil. Engine damage could result from mixing non-compatible oils.**

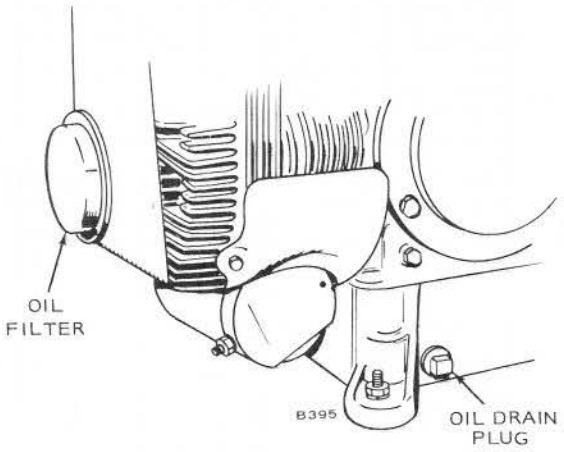


FIGURE 2. OIL DRAIN LOCATION

OIL FILTER

Change the crankcase oil filter every 100 hours; change more frequently in extremely dusty conditions. Remove the filter by turning counterclockwise with a filter wrench. Before installing a new filter, coat the gasket on the filter base with a light film of new oil. Install by turning clockwise until a light friction is noted, then turn an additional 1/2 turn.

Crankcase Breather

This engine uses a crankcase breather valve for maintaining crankcase vacuum. If the crankcase becomes pressurized as evidenced by oil leaks at the seals, clean baffle pack and valve in a suitable solvent. See Figure 3.

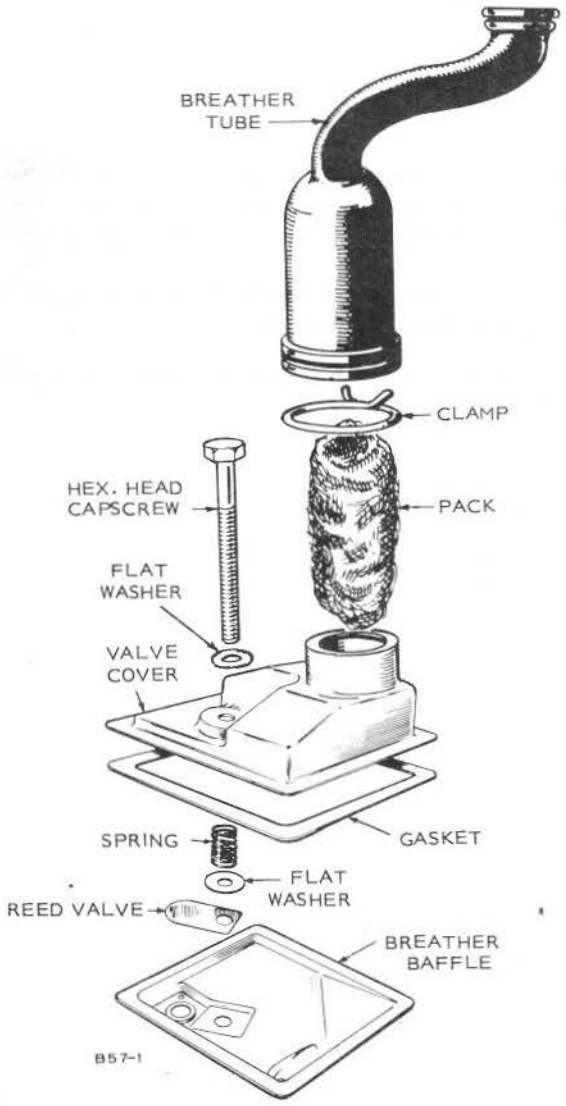


FIGURE 3. CRANKCASE BREATHER

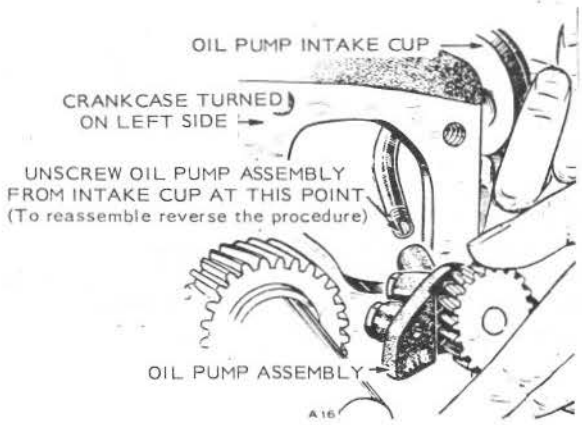


FIGURE 4. OIL PUMP ASSEMBLY

PRESSURE LUBRICATION

Pressure lubricated engines use an oil pump to lubricate engine parts. If oil pressure is low, the pump should be checked.

To remove the oil pump, it is necessary to detach the intake cup assembly, as illustrated in Figure 4.

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

If new oil pump gaskets are installed, they should be the same thickness as those removed. A gasket kit with various thickness gaskets is available.

OIL BY-PASS VALVE

The by-pass valve (located to the right and behind gear cover), controls oil pressure by allowing excess oil to flow directly back to the crankcase. Normally the valve begins to open about 30 psi.

The valve is non-adjustable and normally does not need maintenance. To determine if valve is not working correctly, caused by a sticky plunger, inspect as follows:

1. Remove the 3/8 x 24 x 1 cap screw located behind gear cover and under governor arm.
2. Remove spring and plunger with a magnet tool. Clean plunger and spring with a suitable solvent and reinstall.

FUEL SYSTEM

CARBURETOR CLEANING AND INSPECTION

To clean the carburetor, soak all components thoroughly in a good carburetor cleaner, following the manufacturer's instructions. Be sure to remove all carbon from carburetor bore, especially in the area of the throttle valve. After soaking, clean out all passages with filtered, compressed air.

Check the adjusting needles and nozzle for damage. If float is loaded with fuel or damaged, replace it. The float should fit freely on its pin without binding.

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

Carburetor repair and gasket kits are available from your nearest Onan Parts Center.

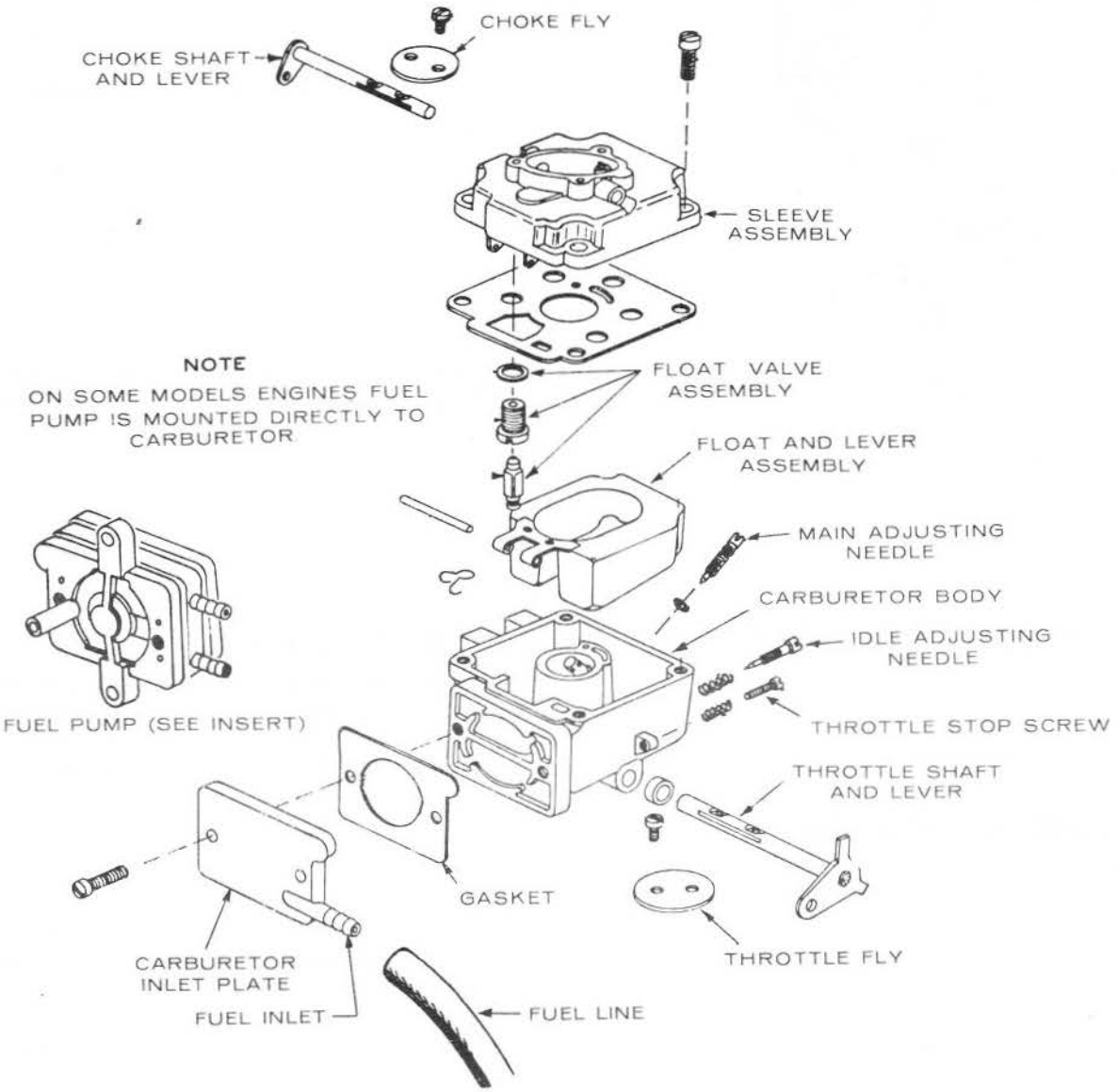


FIGURE 5. EXPLODED VIEW OF CARBURETOR

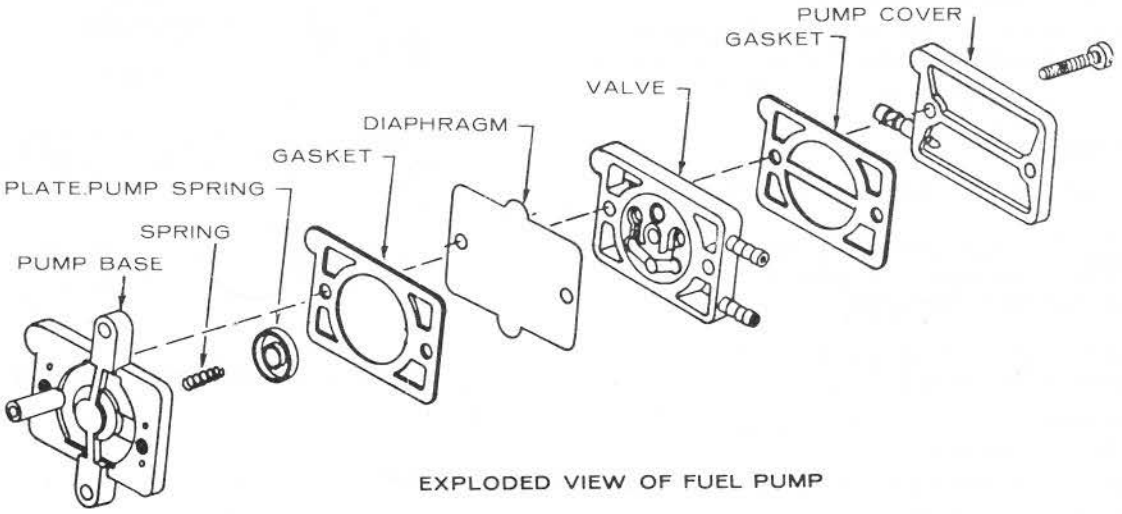


FIGURE 5A. EXPLODED VIEW OF FUEL PUMP

CARBURETOR DISASSEMBLY AND REPAIR (Figure 5)

Removal

1. Remove air cleaner and hose.
2. Disconnect governor and throttle linkage, choke control and fuel line from carburetor.
3. Remove the four intake manifold cap screws and lift complete manifold assembly from engine.
4. Remove carburetor from intake manifold.

Always work on carburetor in clean conditions.

Replacing Needle and Valve Seat

1. Remove four screws from top of carburetor and lift off float assembly.
2. Invert float assembly as shown in Figure 6.
3. Push out pin that holds float to cover.
4. Remove float and set aside in a clean place. Pull out needle and spring.
5. Remove valve seat and replace with a new one, making sure to use a new gasket.
6. Install new bowl gasket.
7. Clip new needle to float assembly with spring clip. Install float.

Carburetor Float Adjustment

1. Invert float assembly and casting.
2. With the float resting lightly against the needle and seat, there should be 1/8-inch clearance between the bowl cover gasket and the free end of float.
3. If it is necessary to reset the float level, bend float tangs near pin to obtain a 1/8-inch clearance (Figure 6).

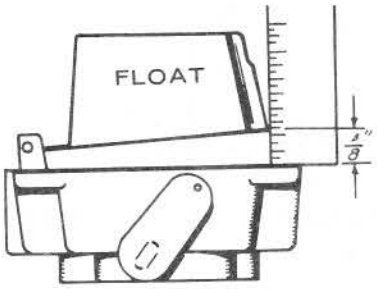


FIGURE 6. FLOAT ADJUSTMENT

Fuel Pump Disassembly (Figure 5A) When Used—Optional

1. Remove vacuum line and fuel line.
2. Remove the two fuel pump attaching screws.
3. Grasp pump and carefully pull apart. Diaphragm, plunger, return spring, pump body and mounting gaskets will now be loose.
4. Internal fuel pump parts are available in a repair kit. Check *PARTS CATALOG* for correct part number.
5. Ensure that clamps are replaced on fuel line.

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

CARBURETOR ADJUSTMENTS

The carburetor has a main fuel valve adjusting screw and an idle valve adjusting screw (Figure 7). A low speed adjustment screw is shown in Figure 8.

Initial Adjustment

1. Turn main fuel valve clockwise until it just closes.

CAUTION **Do not open main fuel jet more than 1/2 turn beyond the maximum power point as this could cause spark plug fouling, etc.**

2. Now open main fuel valve 1-1/8 turn counterclockwise from seat.
3. Close idle valve in same manner and open it one turn (counterclockwise).
4. This initial adjustment will permit engine to start and warm up prior to final adjustment.

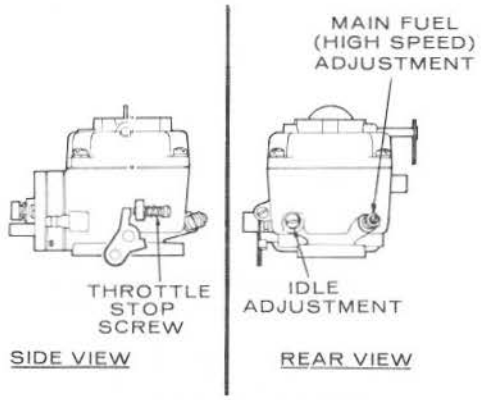


FIGURE 7. MAIN FUEL AND IDLE VALVE ADJUSTMENT

Final Adjustment

1. Turn main fuel valve in until engine misses (lean mixture), then turn it out past the point where engine runs smoothly until engine runs unevenly (rich mixture). Turn valve to mid-point between lean and rich so engine runs smoothly. (This should be 1-1/8 to 1-1/4 from seat.)
2. Hold engine at idle position and set low speed adjustment screw (Figure 8) until a fast idle is obtained (1200 rpm).
3. *Hold throttle in idle position* and turn idle adjustment valve in (lean) and out (rich) until engine idles smoothly.
4. Reset low speed adjustment screw so engine idles at 1200 rpm.
5. Release throttle—engine should accelerate without hesitation. If engine does not accelerate properly, readjust main fuel valve by turning out slightly.

Do not open more than 1/2 turn beyond maximum power point.

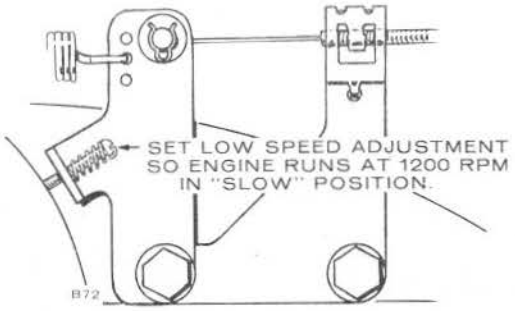


FIGURE 8. LOW SPEED ADJUSTMENT

GOVERNOR

These engines are adapted for use where a wide range of speed settings is desired (see Figure 9). Engine speed is controlled at any given point between minimum and maximum by simply shifting the throttle lever on the dash panel until the desired speed is reached.

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.

A reliable instrument for checking engine speed is required for accurate governor adjustment. Engine speed can be checked with a tachometer.

Check the governor arm, linkage, throttle shaft, and lever for binding condition or excessive slack and wear at connecting points. A binding condition at any point will cause the governor to act slowly and regulation will be poor. Excessive looseness may cause a hunting condition and regulation could be erratic. Work the arm back and forth several times by hand while the engine is idling to check for above conditions.

If the governor is hunting or not operating properly, adjust as follows and as shown in Figure 9.

1. Disconnect linkage (A) from one of holes (C).
2. Push linkage (A) and governor arm (B) as far back (toward carburetor) as they will go.
3. Holding linkage and governor arm toward direction of carburetor, insert end of linkage into whichever hole (C) in governor arm lines up the closest. If between two holes, insert in next hole out.

The governor control spring is factory set in the third hole of the governor arm (farthest from pivot). To increase sensitivity, move spring loop into hole nearest the pivot point or shaft. To decrease sensitivity, move spring outward. After the sensitivity has been set, adjust the low speed with adjustment screw on the control wire bracket. The spring will normally be in third hole from pivot.

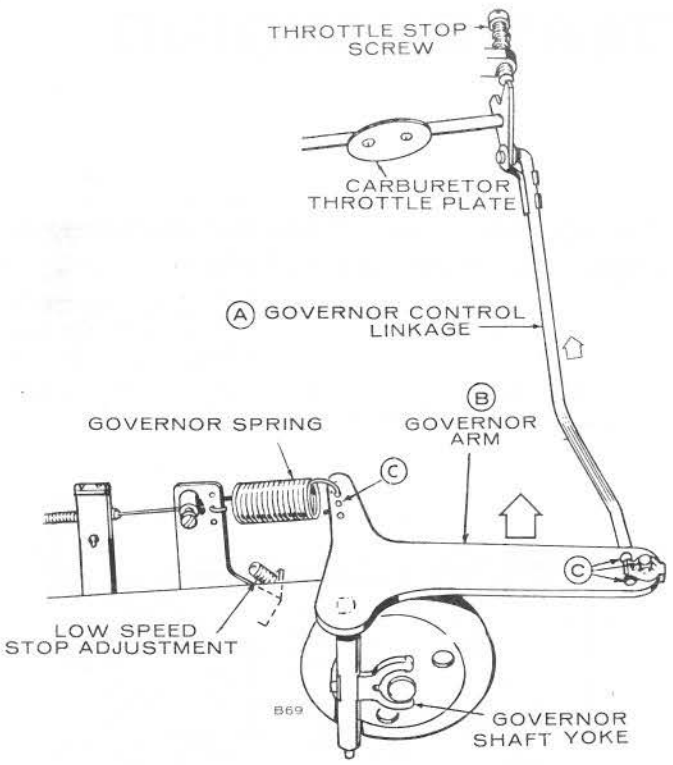


FIGURE 9. GOVERNOR ADJUSTMENTS

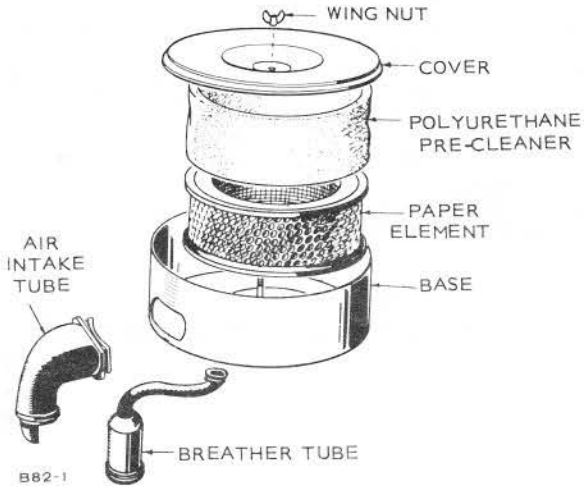
AIR CLEANER

CAUTION **If air cleaner becomes too dirty, engine will not receive sufficient air to run properly. Symptoms: Loss of power, flooding, hard to start and overheating.**

Engine is equipped with a paper element. If the engine is equipped with polyurethane precleaner, it must be removed, cleaned and oiled every 25 hours of operation, or more under extremely dusty conditions.

1. To clean precleaner, wash in water and detergent referring to Figure 10. Remove excess water by squeezing like a sponge and allow to dry thoroughly. Distribute three tablespoons of SAE 30 engine oil evenly around the precleaner. Knead into and wring excess oil from precleaner.
2. Depending on conditions in which the tractor is operating, the inner paper element should be replaced whenever it becomes excessively dirty or oily.

CAUTION **Never run engine with air cleaner removed. Dirt will enter engine and wear out rings causing excessive blow-by.**



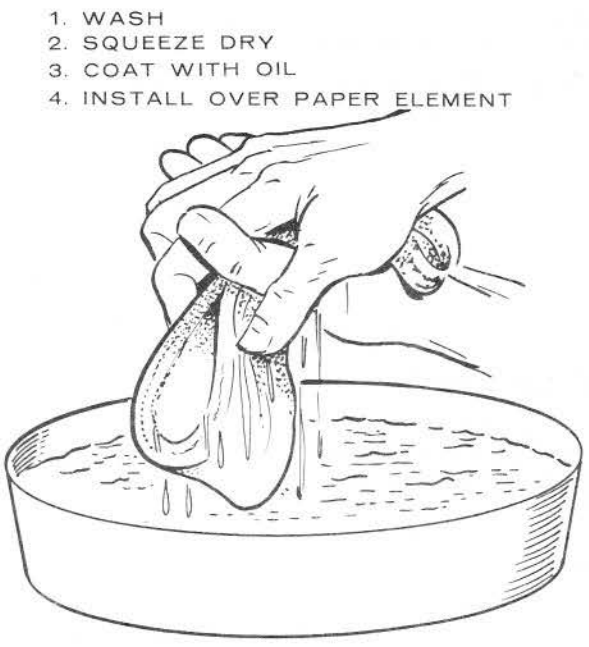


FIGURE 10. AIR CLEANER ASSEMBLY

IGNITION AND BATTERY CHARGING

BREAKER POINTS

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

1. Remove the two screws and cover on breaker box.
2. Remove the two spark plugs so engine can be easily rotated by hand. Check condition of spark plugs at this time.
3. Refer to Figure 11. Remove mounting nut (A) and pull points of the box just far enough so screw (B) can be removed and leads disconnected.
4. Remove screw (C) and replace condenser with a new one.
5. Replace points with a new set but do not completely tighten mounting nut (A).
6. Remove the air intake hose that connects to blower housing. This provides an access to view timing mark.
7. Rotate the engine clockwise (facing flywheel) by hand until the 21° BTC mark on gear cover aligns with mark on flywheel. Turn another 1/4 turn (90 degrees) to ensure points are fully open.
8. Using a screwdriver inserted in notch (D) on the right side of points, turn points until gap measures .020 to .023 inch with a flat thickness gauge. (Be sure feeler is clean.) Tighten mounting nut and recheck gap.
9. Check ignition timing as soon as possible using continuity test lamp.

IGNITION TIMING

The timing on the engine is preset at the factory. A non-movable breaker point box is used, however a slight timing change could be made by adjusting points.

The engine is equipped with an automotive type battery ignition system. Both spark plugs fire simultaneously, thus the need for a distributor is eliminated. Spark advance is set at 21° BTC (before top center) and should be maintained for best engine performance. Always check timing after replacing ignition points or if noticing poor engine performance. Proceed as follows:

Timing Procedure (Preferred Method) — Engine Not Running and Cold

1. Connect a continuity test lamp set across ignition breaker points. Touch one test prod to the breaker box terminal to which the coil lead is connected and touch other test prod to a good ground on the engine.

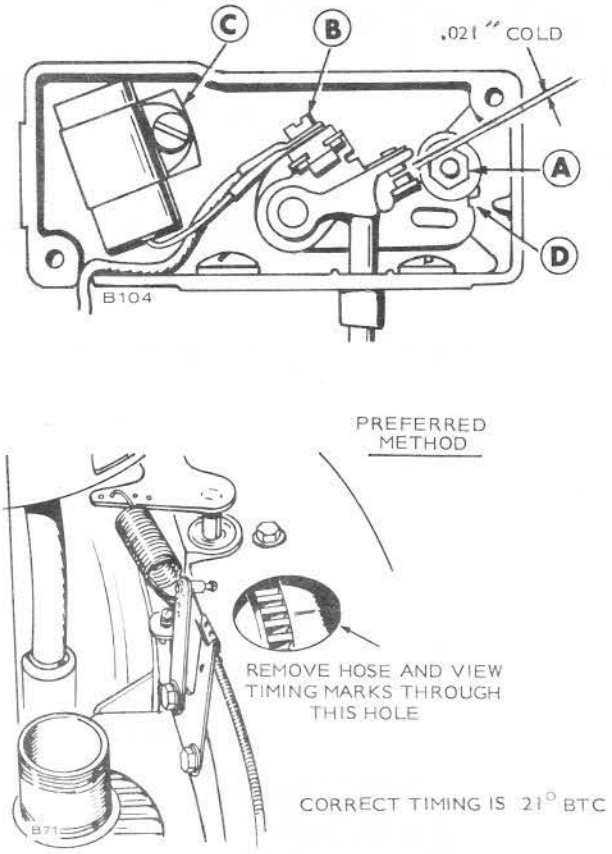


FIGURE 11. IGNITION AND TIMING ADJUSTMENT

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 which is the time at which ignition occurs (21° BTC).

Timing Procedure — Engine Running and Hot

1. To accurately check ignition timing, use a timing light when engine is running. Connect timing light according to its manufacturer's instructions. Either spark plug can be used as they fire simultaneously.
2. Remove the air intake hose that connects to blower housing to provide an access to view timing marks.

WARNING **Be sure tractor is in the neutral position before starting engine.**

3. Start the engine. When engine warms up check the ignition timing. The mark on the flywheel should line up with the 21-degree mark on the cover.
4. Replace hose, breaker box cover and any other hardware removed from engine.

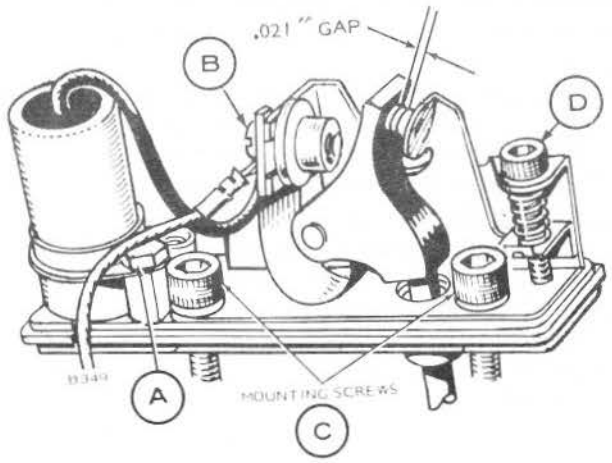


FIGURE 12. BREAKER POINT ADJUSTMENT

TOP ADJUST BREAKER POINTS— (Optional)

To maintain maximum engine efficiency, check the breaker points every 100 hours of operation and replace if necessary. Proceed as follows:

1. Remove spark plugs and rotate flywheel TC mark to 21° BTC (points open); then rotate it another 90 degrees clockwise to ensure points open fully.
2. Remove breaker box cover and unplug coil wire at coil (+) terminal.
3. Remove condenser (screw A) and detach condenser lead and coil lead (screw B).
4. Remove two Allen screws (C) and lift breaker assembly from engine.
5. Replace condenser and point assembly with new parts and reinstall using above procedure in reverse order of removal.
6. Using Allen wrench at screw (D) adjust point gap at .021 inch using a clean, flat thickness gauge.

Setting point gap accurately adjusts engine timing.

7. Replace breaker box cover and spark plugs.

If desirable, check ignition timing with a 12 volt test light or continuity tester.

TIMING (Top Adjust Points)

The timing on the engine is preset at the factory. A non-movable breaker point box is used, however a slight timing change could be made by adjusting points.

The engine is equipped with an automotive type battery ignition system. Both spark plugs fire simultaneously, thus the need for a distributor is eliminated. Spark advance is set at 21° BTC (before top center), and should be maintained for best engine performance. Always check timing after replacing ignition points or if noticing poor engine performance. Proceed as follows:

Timing Check—Engine Running and Hot

1. To accurately check the ignition timing, use a timing light with engine running at idle speed. Connect the timing light according to its manufacturer's instructions. Either spark plug can be used as they fire simultaneously.
2. Start the engine and check the timing. The pointer on the flywheel should line up with the 21-degree mark on the cover. The timing hole through the flywheel and the timing marks on the timing gear cover can be seen by looking through the flywheel blower screen. See Figure 13.

If timing marks do not line up, readjust point gap. To advance timing, slightly open gap on breaker points. To retard timing, slightly close gap on breaker points. Recheck timing and breaker point gap after making this adjustment.

Timing Check—Engine Not Running

If a timing light is not available, check the timing as follows:

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 which is the time at which ignition occurs (21° BTC).

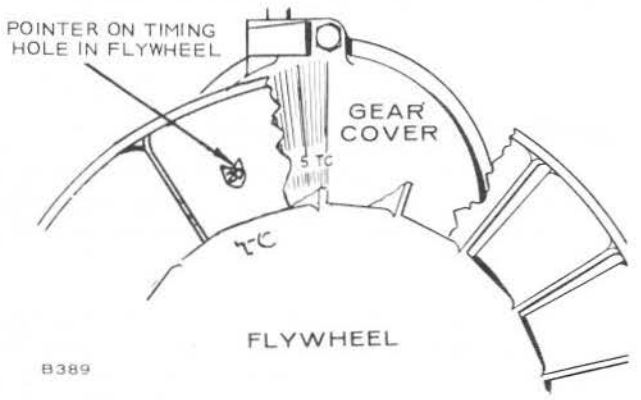


FIGURE 13. FLYWHEEL TIMING HOLE

SPARK PLUGS

Remove both spark plugs (see Figure 14) and install new ones every 100 hours. Use ONAN No. 167-0241 or Champion H-8. Check to be sure spark plug gap is set at .025-inch.

FIGURE 14. SPARK PLUG GAP

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 back 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 15). Secondary resistance should read 12,600 - 15,400 ohms.
4. If any of the above conditions are not met, replace coil. Refer to *PARTS CATALOG* for correct part number.

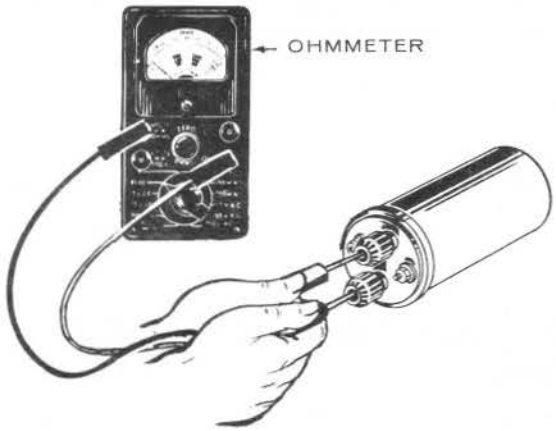


FIGURE 15. COIL TEST

CAUTION **This engine uses a 12 volt, negative ground system. Alternator must be connected to battery at all times when engine is running. Do not reverse battery cables. Damage to regulator or ignition coil could result if cables are reversed.**

Battery Inspection

Check battery cells with a hydrometer. The specific gravity reading should be approximately 1.280 at 80° F. (see Figure 16). If cells are low on water, add distilled water and recharge. If one cell is low, check case for leaks. 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 non-conductive grease to retard corrosion.

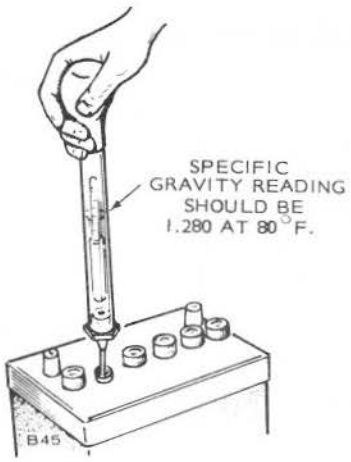


FIGURE 16. SPECIFIC GRAVITY TEST

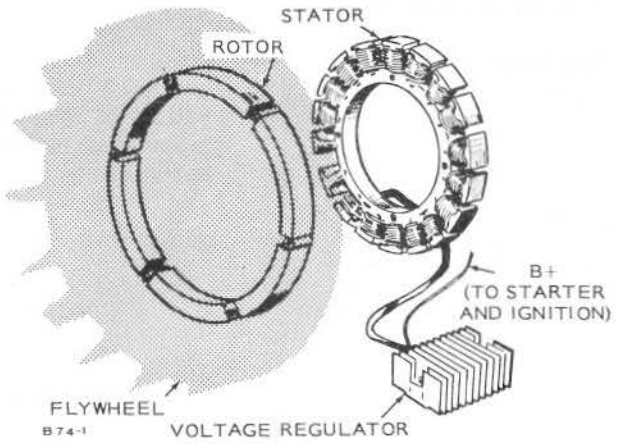


FIGURE 17. FLYWHEEL ALTERNATOR SYSTEM

FLYWHEEL ALTERNATOR

This unit is equipped with a permanent magnet flywheel alternator and solid-state voltage regulator-rectifier (output control). See Figure 17. As with all solid-state electrical units, precautions are necessary when servicing. Observe the following.

Precautions

1. Do not connect battery cables in the wrong polarity.
2. Do not short together alternator stator leads.
3. Do not run without a battery. Damage will occur to regulator and battery ignition coil.

Preservice Checks

1. Check for a good ground between equipment and regulator-rectifier case.
2. Be sure output control plug (connector) is properly inserted into stator receptacle. This means the plug must push in and solidly bottom in the receptacle to eliminate any resistance due to a poor connection. Keep it clean and tight.
3. Check battery and its connection to be sure it is serviceable.

Charging system tests require a fully charged battery for accuracy in isolating component malfunctions.

TESTING BATTERY CHARGING SYSTEM

TYPE OF FAILURE	TEST	RESULTS
No charge to battery.	1. With battery connected, check B+ to ground voltage with DC voltmeter. If voltmeter reads 13.8 volts or higher, place load (headlights) on battery to reduce battery voltage to below 13.6 volts. Observe ammeter.	
	a. If charge rate increases.	System okay. Battery was charged fully.
	b. If charge rate does not increase.	Check for defective stator or regulator.
	2. Disconnect plug from regulator-rectifier and test AC voltage at plug (two white wires, reading back into alternator).	
	Voltage reads much less than 28 volts AC.	Defective stator or magnet group.
Battery always charging at high rate.	1. Check B+ to ground voltage with DC voltmeter.	
	a. If over 14.7 volts DC	Regulator not functioning.
	b. If under 14.7 volts DC	Alternator system okay. Check battery charge—may be low.

STARTING SYSTEM

ELECTRIC STARTER

Normally the starter will require little or no service other than possible brush replacement. However, if through accident or misuse, the starter requires service or overhaul, the following information will provide the information necessary to perform this service.

STARTER DISASSEMBLY

1. Remove the through-bolts and separate the end cap, the housing and the armature (see Figure 18).
2. Disassemble the drive assembly and the drive end cap by loosening the self-locking nut.

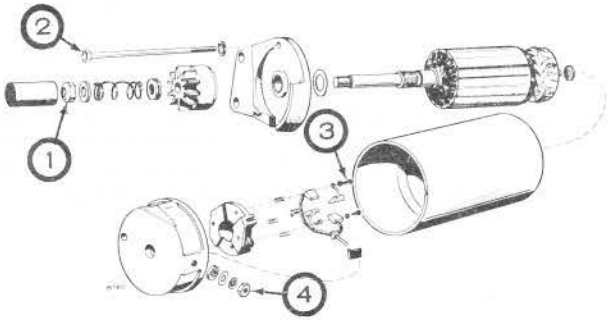


FIGURE 18. STARTER DISASSEMBLY

INSPECTION OF PARTS

1. **Testing Armature for Grounds:** Touch armature shaft or core and the end of each commutator bar with a pair of ohmmeter leads. If the ohmmeter reading is low, it indicates a grounded armature. Replace grounded armature. See Figure 19.
2. **Testing Armature for a Short Circuit:** Use a growler for locating shorts in the armature. Place armature in growler and hold a thin steel blade (e.g. hacksaw blade) parallel to the core and just above it while slowly rotating armature in growler. A shorted armature will cause the blade to vibrate and be attracted to the core. If armature is shorted, replace with a new one (Figure 20).
3. **Inspecting for an Open Circuit in Armature:** The most likely place to check for an open circuit is at the commutator riser bars. Inspect for loose connections on the points where the conductors are joined to the commutator bars.

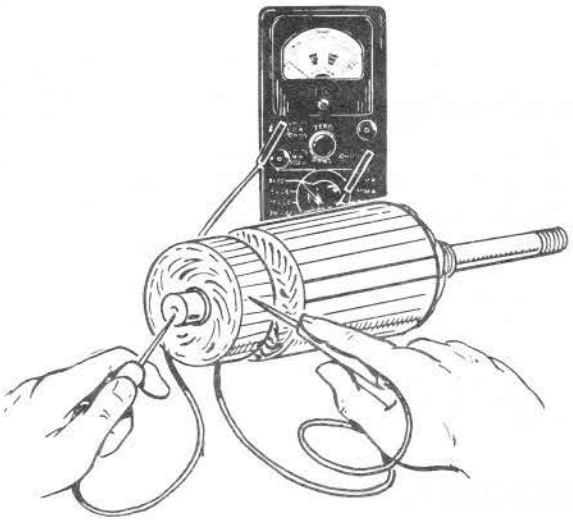


FIGURE 19. TESTING ARMATURE FOR GROUNDS

4. **Brush Inspection:** If brushes are worn shorter than 1/4 inch, replace them. Check to see that brushes move smoothly in the brush holders. See Figure 21.

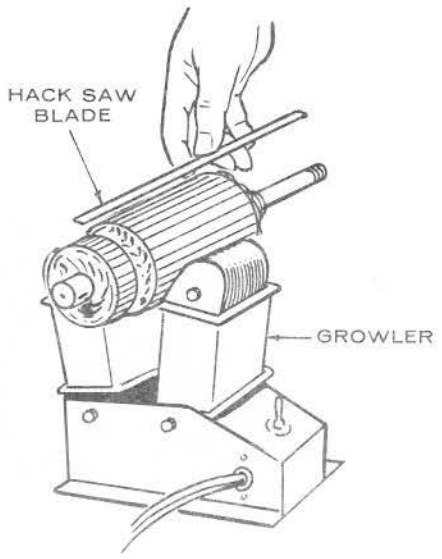


FIGURE 20. TESTING ARMATURE FOR SHORT CIRCUITS

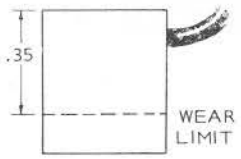


FIGURE 21. BRUSH WEAR LIMIT

STARTER ASSEMBLY

Reassembly is the reverse of disassembly. When reassembling, observe the following:

1. Wipe off any dirty parts with a clean cloth or blow clean using filtered, compressed air.

   Bearings must not be immersed in cleaning fluid. These parts should be cleaned with a brush dipped in clean engine oil.

2. Apply SAE 10W-30 oil on the armature shaft, spline and bearings.

REASSEMBLY

1. Assemble brushes so that chamfered side is away from the brush springs and position the brush shunts so that they will not contact the commutator or commutator end cap.
2. Torque bolts (Figure 18, item 3) to a value of 3 to 3-1/2 ft-lbs.
3. Torque nut (Figure 18, item 4) to a value of 4 to 5 ft. lbs.
4. Apply a thin film of grease to the commutator end of the armature shaft and to the portion of the shaft that contacts the bearings. Apply a generous film of Lubriplate "Aero" grease to the shaft thread.
5. Torque stop nut (Figure 18, item 1) to a value of 20 to 25 ft-lbs. Hold armature in a vise.
6. Torque thru-bolts (Figure 18, item 2) to a value of 4-/2 to 6 ft-lbs.

CAUTION **Do not exceed the rated voltage of the motor (12-VDC). Excessive voltage could demagnetize the motor permanent magnet field.**

INSPECTING REASSEMBLED STARTER

1. To ensure good electrical contact, make sure starter to engine mounting surfaces are free of dirt or oil.
2. When tightening attaching bolts and nut, starter gear should be held into ring gear to assure proper backlash.
3. Battery to starting motor wire must be tightened securely.

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.**

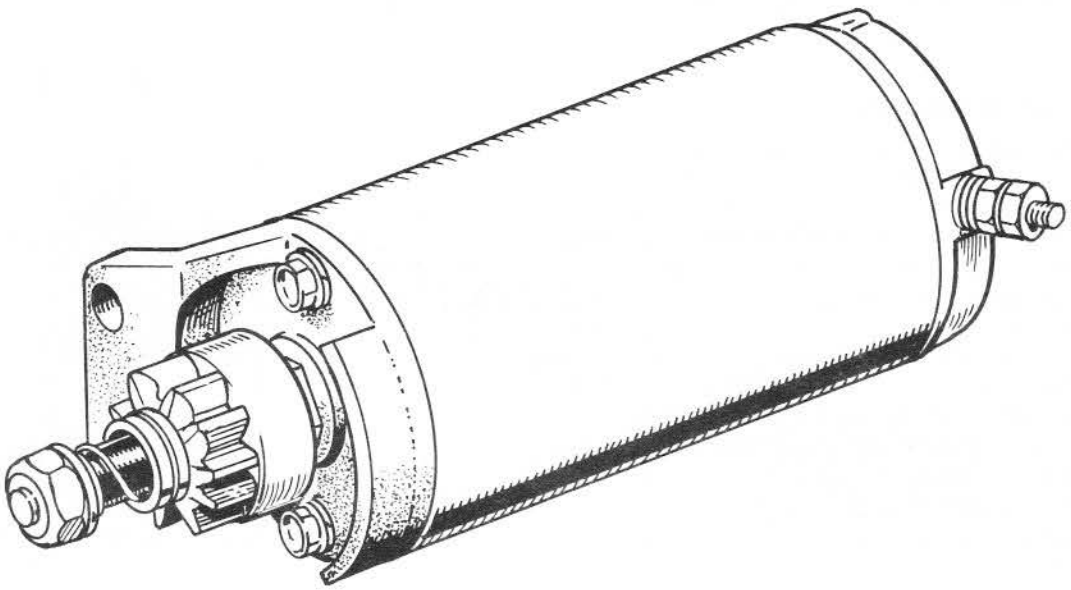


FIGURE 22. REASSEMBLED STARTER

ENGINE DISASSEMBLY

DISASSEMBLY/ASSEMBLY

General

When complete engine disassembly is necessary, first remove all complete assemblies. Individual assemblies such as fuel pump and carburetor can be disassembled and repaired at another time.

Suggested Disassembly Order

1. Drain crankcase.
2. Disconnect all exhaust lines and electrical lines.
3. Remove engine from its mountings and place on a suitable bench or work stand.
4. Remove all housings, shrouds, blower housings, etc.
5. Remove flywheel, using a puller or pry bar method.
6. Remove the gear cover, being careful to protect the oil seal from keyway damage.
7. Remove the crank gear, using a gear puller and ring.
8. Remove all accessories such as oil filter, starter, intake manifold, fuel lines, spark plugs, etc.
9. Remove breaker point box.
10. Remove oil base, oil pump and cylinder heads.
11. Remove valves, springs, lifters, etc.
12. Remove camshaft and gear assembly.
13. Remove connecting rods and pistons.
14. Remove rear bearing plate.
15. Remove crankshaft.
16. Remove front bearing.

Keep all parts in their respective orders. Keep valve assemblies together. Return rod caps to their respective pistons. Analyze the reasons for parts failure.

Suggested Assembly Procedure

Engine assembly is normally the reverse of the disassembly procedure, observing proper clearances and torques. Use a torque wrench to assure proper tightness. Coat the internal engine parts with oil as they are assembled. After the internal engine parts are assembled, the engine should turn over by hand freely. Use only genuine Onan parts and special tools when reassembling your engine.

1. Use the proper bearing driver to install front main bearing after coating it with a light film of oil.
2. Insert rear main bearing in rear bearing plate.
3. Install crankshaft and rear bearing plate.
4. Install pistons and connecting rods.
5. Install camshaft and gear assembly.
6. Install valve assemblies.
7. Install oil pump, oil base and cylinder heads.
8. Install breaker point box.
9. Install all accessories such as oil filter, starter, fuel lines and spark plugs.
10. Install crank gear, aligning crank gear mark with cam gear mark.
11. Install gear cover and oil seal.
12. Install flywheel.
13. Set breaker points to obtain proper timing.
14. Check valve clearance.
15. Install all housings and air cleaner.
16. Fill crankcase with oil.

Operation

Start engine and check oil pressure. Run for approximately 15 minutes to bring engine to operating temperature. Check for oil leaks, fuel leaks and exhaust leaks. Adjust carburetor and governor for speed and sensitivity.

Tappet Adjustment

The engine is equipped with adjustable valve tappets. The valve tappet clearance should be checked and adjusted, if necessary, at least every 150 operating hours or when poor engine performance is noticed. Adjust the valve clearance only when engine is at ambient temperature. Proceed as follows:

1. Remove ignition key to prevent accidental starting.
2. Remove all parts necessary to gain access to valve tappets.
3. Remove spark plugs to ease the task of turning the engine over by hand.
4. Use the engine flywheel to turn the engine over slowly by hand until the left hand intake valve opens and closes. Continue turning the flywheel until the TC mark is on the top and lined up with the TC mark on the gear cover. Both valves should be closed. 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 cylinder.

5. For the intake valve, a .007-inch thickness gauge should pass freely between valve stem and tappet; a thicker .009-inch gauge should not (Figure 24).
6. For the exhaust valve, a .012-inch thickness gauge should pass freely between the valve stem and the tappet; a thicker .014-inch gauge should not.
7. To correct the valve clearance, use a 7/16 inch open end wrench to turn the adjusting screw to obtain the correct clearance. The screw is self-locking and will stay where it is set. A 9/16-inch open end wrench is required to hold the tappet while turning the adjusting screw.
8. To adjust valves on the right hand cylinder, turn engine one complete revolution and again line up mark on the flywheel and the TC mark on the gear cover. Then follow adjustment procedure given for left hand cylinder.
9. Replace all parts removed in Step 2. Tighten all screws securely. Torque manifold bolts to specified torque.

VALVE SYSTEM

Properly seated valves are essential to good engine performance. The aluminum cylinder heads are 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 heads, piston tops, valves, guides, etc. If a valve face is burned or warped, or the stem worn, install a new one. Refer to Figure 23.

Worn valve stem guides may be replaced from inside the valve chamber. Valve locks are split, tapered type, of which the smaller diameter 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.

The valves should not be hand lapped, if at all avoidable, because the sharp contact may be destroyed. This is especially important where chrome cobalt 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-inch to 3/64-inch 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 testing tool. If such a tool is not available, make pencil 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 assemble all parts removed.

The positive type valve rotators prolong valve life and decrease valve repairs. When functioning properly, the valve is rotated a fraction of a turn each time it opens. While at open position, the valve must rotate freely, but in only one direction. If rotators are faulty, install new rotators.

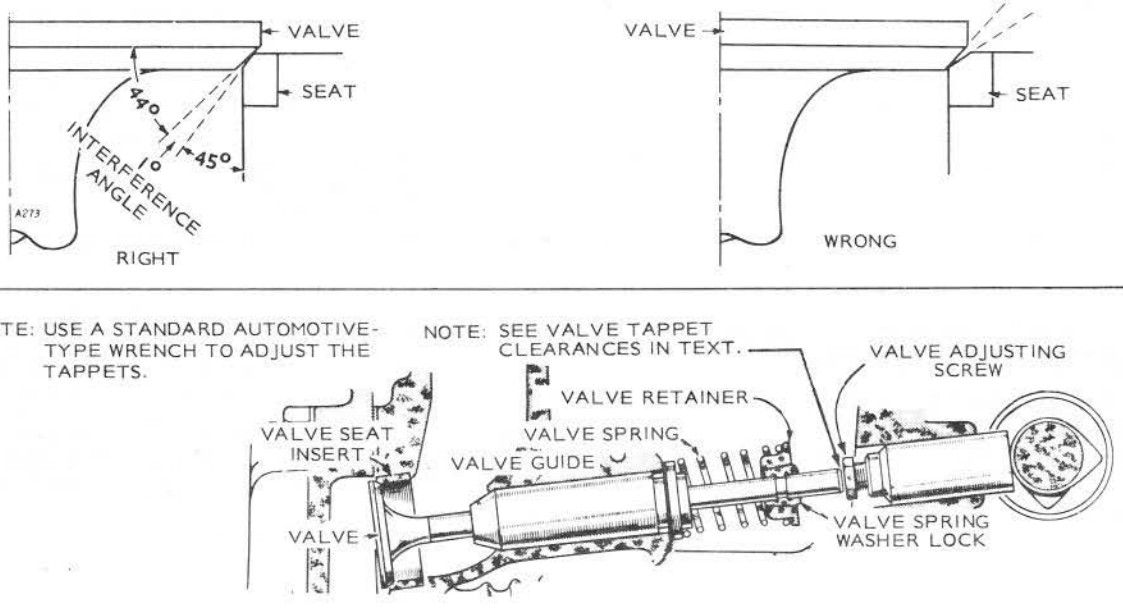


FIGURE 23. VALVE SYSTEM

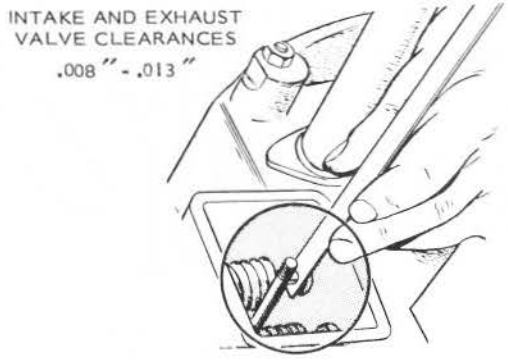


FIGURE 24. VALVE CLEARANCE

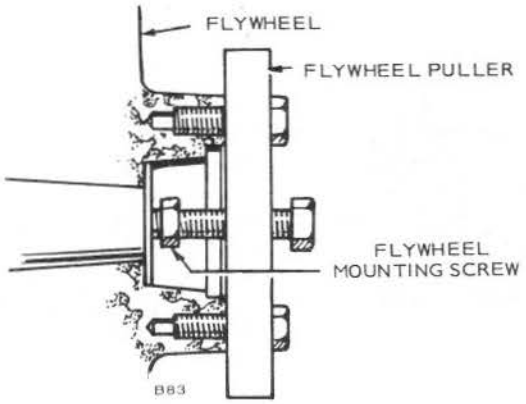


FIGURE 25. BLOWER WHEEL PULLEY

FLYWHEEL

Removing the flywheel is a relatively simple process, but the following procedure must be followed to avoid damage to the gear case and possible injury to the operator.

1. Turn the flywheel mounting screw outward about two turns.

WARNING **Do not remove the screw completely since it acts as a restrainer when the flywheel snaps loose. If the flywheel is not held by the screw, the spring action in the wheel will cause it to fly off with great force which can cause injury to the operator.**

2. Install a puller bar on the flywheel as shown in Figure 25.
3. Turn the puller bar bolts in, alternately, until the wheel snaps loose on the shaft.

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

4. Unscrew the puller from the flywheel, remove the flywheel mounting screw and washer and pull the flywheel off the shaft. Take care not to drop the wheel. A bent or broken fin will destroy the balance. Always use a steel key for mounting the flywheel.

GEAR COVER

After removing the mounting screws, tap the gear cover gently with a soft faced hammer to loosen it (see Figure 26).

When installing the gear cover, make sure that the pin in the gear cover engages the nylon lined (smooth) hole in the governor cup. Turn the governor cup so that the nylon lined hole is at the three o'clock position. Use a small amount of grease to assist in holding governor cup in 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.

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 27).

Replace with a new part any flyball which is grooved or has a flat spot; the ball spacer if its arms are worn or otherwise damaged; and the governor cup if the race surface is grooved or rough. The governor cup must be a free-spinning fit on the camshaft center pin, but without any excessive play.

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

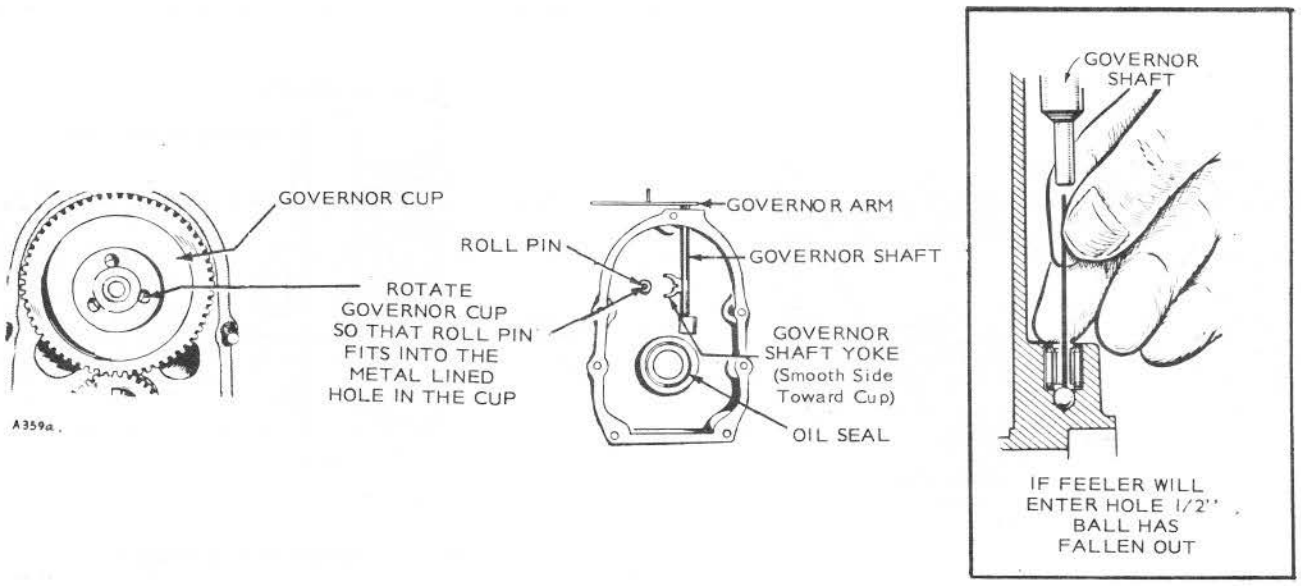


FIGURE 26. GEAR COVER ASSEMBLY

The camshaft center pin extends out 3/4 inch from the end of the camshaft. This distance provides an in and out travel distance of 7/32 inch for the governor cup, as illustrated. Hold the cup against the flyballs when measuring. If the distance is less (the engine will race especially at no load) remove the center pin and press in a new pin or 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.

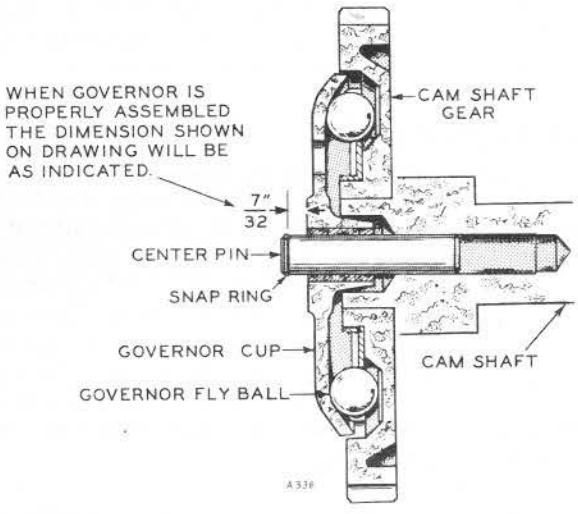


FIGURE 27. GOVERNOR CUP DETAIL

TIMING GEARS

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

To remove the crankshaft gear, first remove the snap ring and retainer washer, then attach the gear pulling ring using two No. 10-32 screws (Figure 28). Tighten the screws alternately until both are tight. Attach a gear puller to the puller ring and proceed to remove the gear.

The camshaft and gear must be replaced as an assembly. Before removing the camshaft and gear assembly, remove the cylinder head and valve assemblies. Then remove the operating plunger for the breaker points and tappets.

Each timing gear is stamped with "O" near the edge. The gear teeth must mesh so that these marks exactly coincide when the gears are installed in the engine. When installing the camshaft gear and shaft assembly, be sure that the thrust washer is properly in place behind the camshaft gear. Then install the crankshaft retaining washer and lock ring.

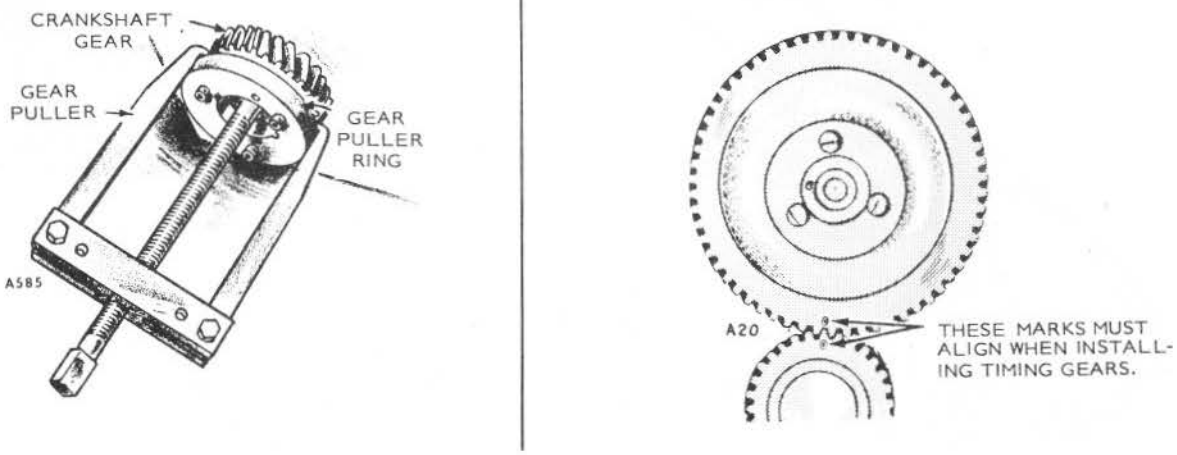


FIGURE 28. TIMING GEAR REMOVAL AND INSTALLATION

PISTONS AND CONNECTING RODS

Observe the following procedure when removing pistons and connecting rods from the engine.

1. Drain oil.
2. Remove the cylinder head and oil base pan from the engine.
3. Remove the ridge from the top of each cylinder with a ridge reamer before attempting piston removal (Figure 29).

CAUTION **Forcing the piston from the cylinder before reaming may cause damage to the piston lands and break rings.**

4. Turn the crankshaft until the piston is at the bottom of its stroke and remove the connecting rod nuts. Lift the rod bearing cap from the rod and push the rod and piston assembly out through the top of the cylinder using a hammer handle. Avoid scratching the crankpin and cylinder wall when removing the piston and rod.

Mark each piston and rod assembly so they can be returned to their respective cylinders after overhaul. Keep connecting rod bearing caps with their respective rods.

5. Remove the piston rings from the piston with a piston ring spreader as shown in Figure 30. Remove the piston pin retainer and push the piston pin out.

Remove dirt and deposits from the piston surfaces with an approved cleaning solvent. Clean the piston ring grooves with a groove cleaner or the end of a piston ring filed to a sharp point (Figure 31). Care must be taken not to remove metal from the groove sides.

CAUTION **Do not use a caustic cleaning solvent or wire brush for cleaning pistons. These materials will cause piston damage.**

When cleaning the connecting rods in solvent, include the rod bore. Blow out all passages with compressed air.

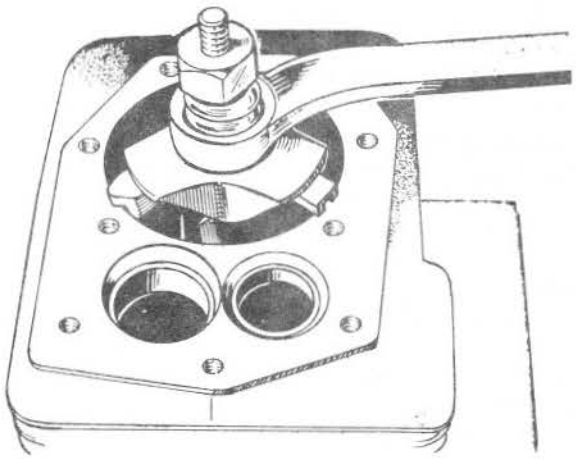


FIGURE 29. REMOVING RIDGE FROM CYLINDER

Inspection

The following text contains inspection procedures concerning pistons and connecting rods.

1. **Piston Inspection**
   a. Inspect the pistons for fractures at the ring lands, skirts and pin bosses. Check for wear at the ring lands using a new ring and feeler gauge as shown in Figure 32. Replace the piston when the side clearance of the top compression ring reaches 0.004 inch.

FIGURE 30. REMOVING PISTON RINGS

b. Replace pistons showing signs of scuffing, scoring, worn ring lands, fractures or damage from preignition. Excessive piston wear near the edge of the top ring land indicates preignition.

2. **Connecting Rod Inspection**
   a. Replace connecting rod bolts and nuts with damaged threads. Replace connecting rods with deep nicks, signs of fractures, scored bores or bores out of round more than 0.002 inch.
   b. Use a new piston pin to check connecting rod for wear. A push fit clearance is required and varies from engine to engine. If a new piston pin falls through a dry rod pin bore as a result of its own weight, replace the rod.
3. **Fitting Pistons**
   a. Proper piston tolerances must be maintained for satisfactory operation.
   b. Measure the piston to cylinder clearance as shown in Figure 33 to be sure the total clearance follows specifications.
4. **Fitting Piston Rings**
   a. Install the piston ring in the cylinder bore. Invert the piston and push the ring to the end of ring travel, about halfway into the bore, which trues the ring end gap. Check the gap with a feeler gauge as shown in Figure 34.
   b. The practice of filing ring ends to increase the end gap is not recommended. If the ring end gap does not meet specifications, check for the correct set of rings and the correct bore size. A cylinder bore that is 0.001 inch under size will reduce the end gap 0.003 inch.

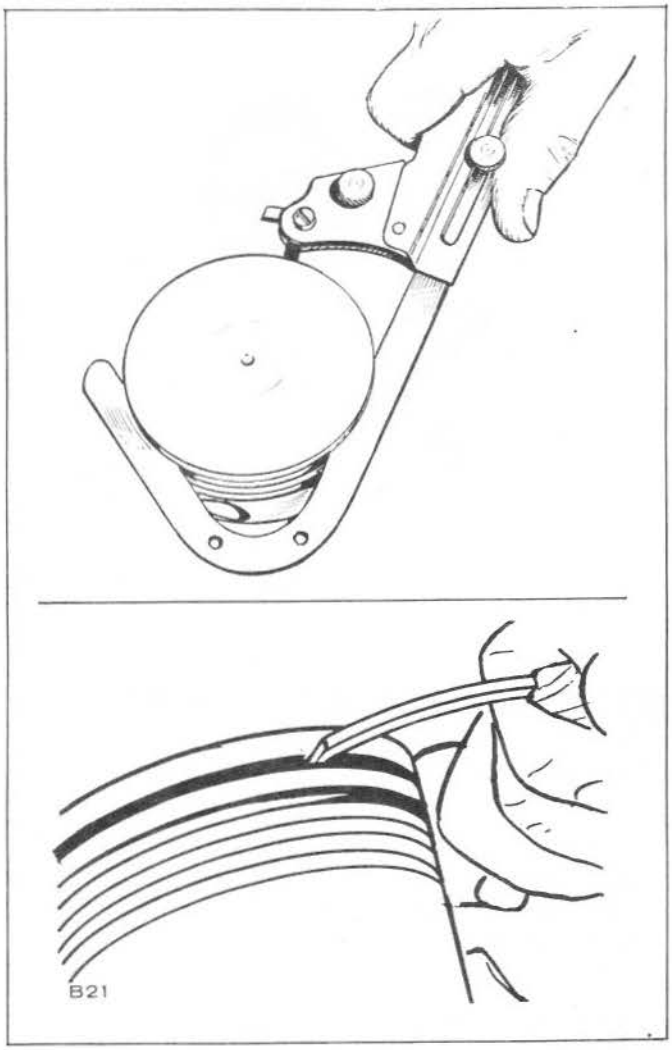


FIGURE 31. PISTON GROOVE CLEANING

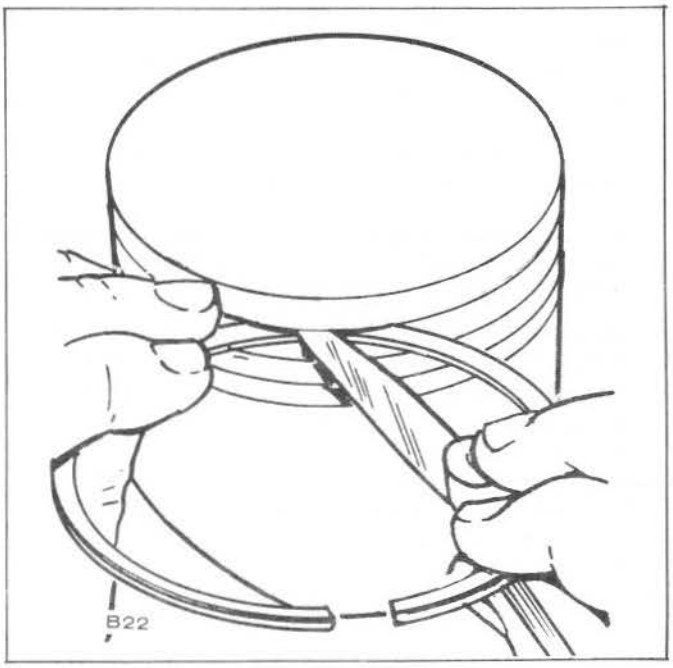


FIGURE 32. CHECKING RING SIDE CLEARANCE

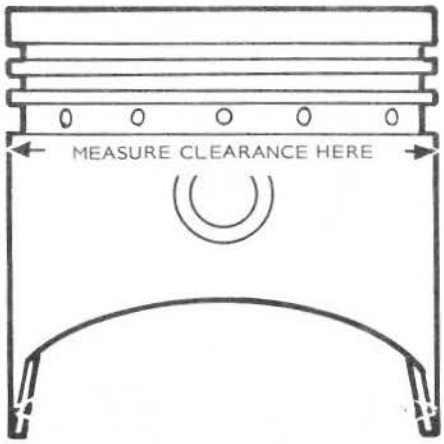


FIGURE 33. MEASURING PISTON CLEARANCE

CYLINDER BLOCK

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.
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 35). These measurements should be taken at four places—the top and bottom of piston ring travel.
4. Record measurements taken lengthwise at the top and bottom of the piston travel as follows:
   a. Lengthwise of the block, measure and record as "A" the diameter of the cylinder at the top of the cylinder where greatest ring wear occurs.
   b. Also, lengthwise of the block, measure and record as "B" the cylinder diameter at the piston skirt travel.
   c. Crosswise of the block, measure and record as "C" the diameter of the top of the cylinder at the greatest point of wear.
   d. Measure and record as "D" the diameter at the bottom of the cylinder bore and crosswise of the block.
   e. Reading "A" compared to reading "B" and reading "C" compared to reading "D" indicates cylinder taper.

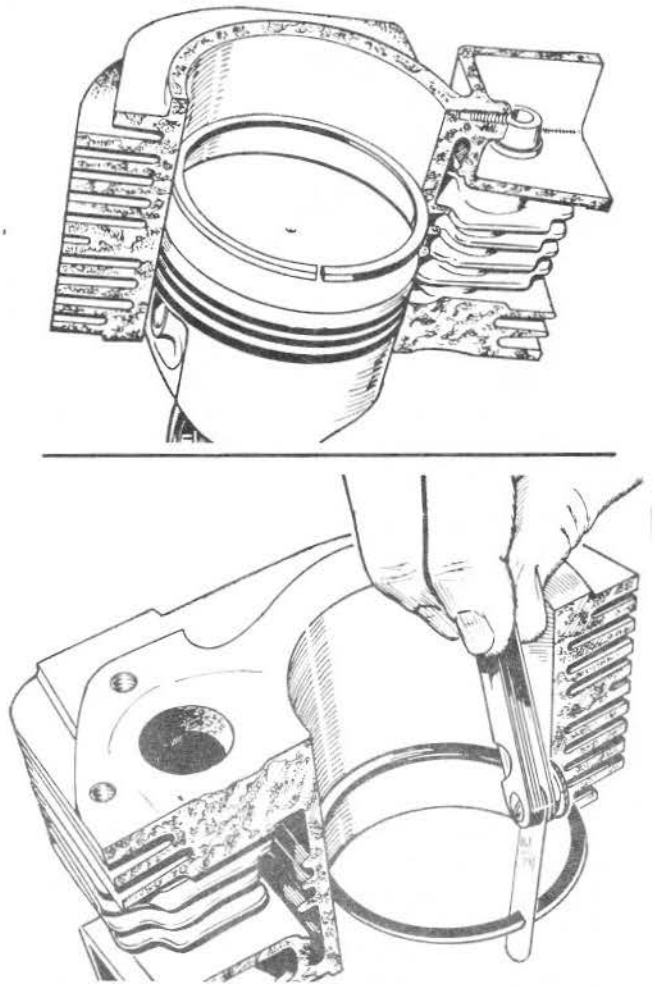


FIGURE 34. POSITIONING OF PISTON RING AND MEASURING OF END GAP

   f. If cylinder taper exceeds 0.005 inch, rebore and hone to accommodate the next oversize piston. Reading "A" compared to reading "C" and reading "B" compared to reading "D" indicates whether or not the cylinder is out of round. If the out of round exceeds 0.002 inch, the cylinders must be rebored and honed for the next oversize piston. A reboring machine is used when going to oversize pistons. The following repair data covers honing to oversize by use of a hone.

Repair

1. A hone can be used to refinish a cylinder.
2. Anchor the block solidly for either vertical or horizontal honing. Use either a drill press or heavy-duty drill which operates at approximately 250 to 450 rpm.

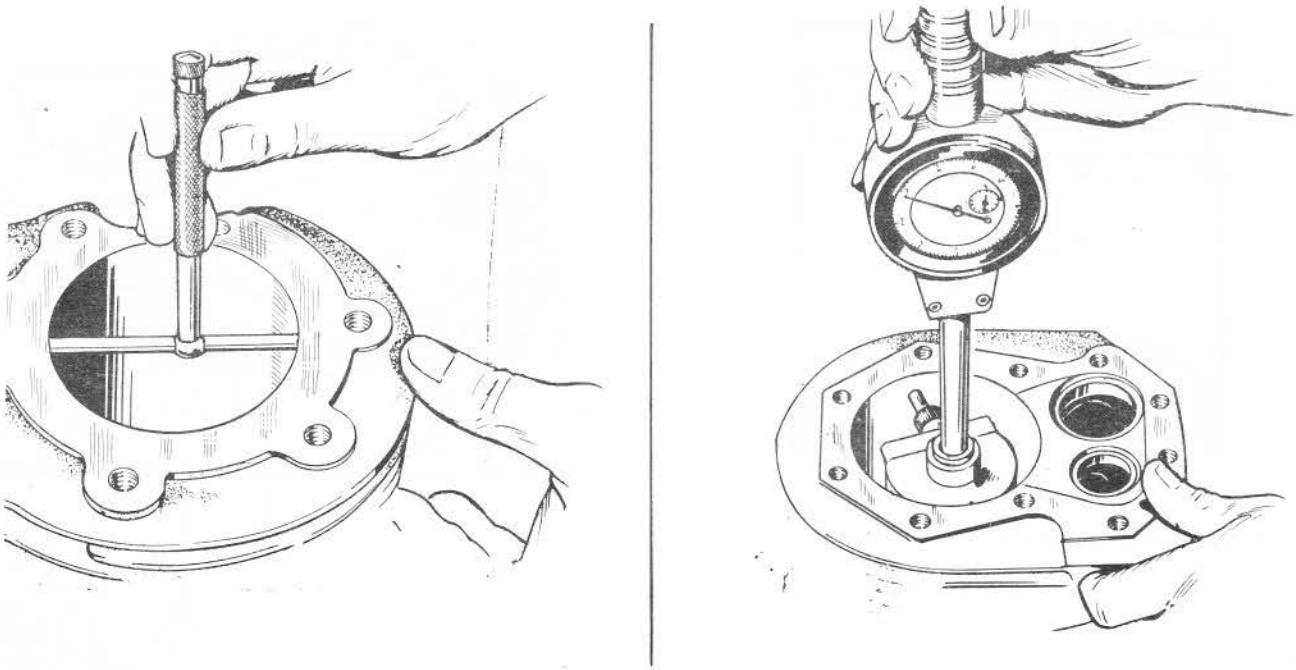


FIGURE 35. METHODS OF MEASURING THE DIAMETER OF A CYLINDER

3. Connect drill to hone and start drill. Move the hone up and down in the cylinder approximately 40 times per minute. Usually the bottom of the cylinder must be worked out first because it is smaller. Then when the cylinder takes a uniform diameter, move the 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.
4. Check the diameter of the 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 at 90-degree angles.
5. The crosshatch formed by the scratching of the stones should form an angle of 23 degrees. This can be achieved by moving the one up and down in the cylinder about 40 times per minute (Figure 36).
6. Clean the cylinder block thoroughly with soap, water and clean rags. A clean white rag should not be soiled on the wall after cleaning is complete. Do not use a solvent or gasoline since they wash the oil from the walls but leave the metal particles.
7. Dry the crankcase and coat it with oil.

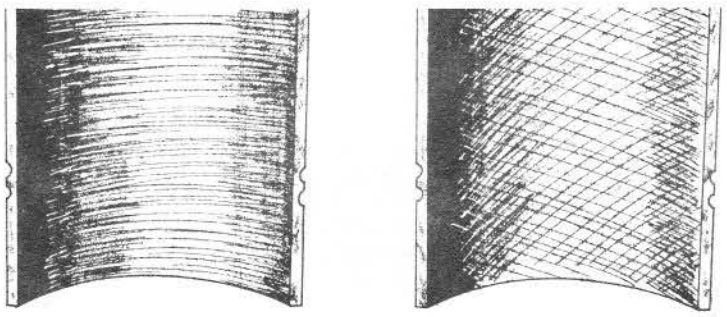


FIGURE 36. CROSSHATCHING

CRANKSHAFT

Inspect the bearing journals. If they are scored and cannot be smoothed out by dressing down, replace the crankshaft.

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

Removing camshaft or crankshaft bearings (Figures 37-39) 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.

New camshaft bearings are precision type which *do not* require line reaming or line boring after installation. Coat the bearing with SAE 20 oil to reduce friction. Place the bearing on the crankcase over the bearing bore with the elongated hole in proper position and narrow section facing out (except bores without oil holes install with bearing groove at the top). Be sure to start the bearing straight. Press the front bearing in flush with the bottom of counterbore which received the expansion plug (see Figure 37).

Crankshaft main bearings are precision type which do not require line reaming or line boring after installation. They are available in standard size and .002 inch undersize. Expand the bearing bore by placing the casting in hot water or in an oven heated to 200° F.

CAUTION **If a torch is used, apply only a little heat. Distortion will result from too much local heat.**

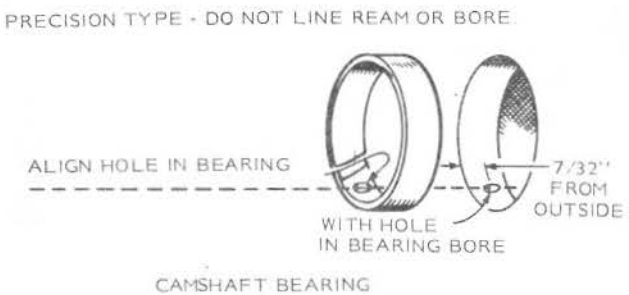


FIGURE 37. CAMSHAFT BEARING

To ease assembly, cool the precision bearing to shrink it. 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. Lubricate bearings with SAE 20 oil before installing. The cold oiled precision bearing should require only light taps to position it with a driving tool. If head of lock pin is damaged, use side cutters or Easy Out tool to remove and install new pin. Apply oil to thrust washer (one used with each bearing) to hold it in place while installing the crankshaft. Oil grooves in thrust washers must face the crankshaft and washers must be flat (not bent). The two notches on each washer must fit over the two lock pins to prevent riding on the crankshaft.

Original front bearing uses a separate thrust washer. Replacement front bearing is a one piece assembly with thrust washer part of the bearing. Do not use a separate thrust washer when installing this replacement part. See Figures 38 and 39.

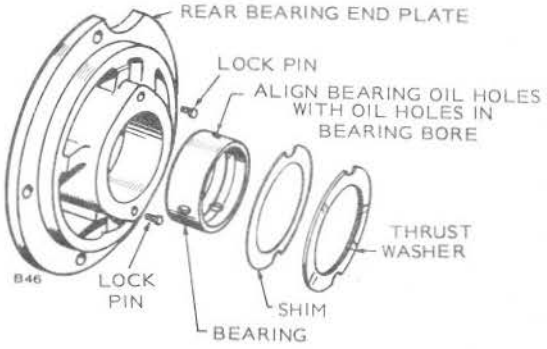


FIGURE 38. BEARINGS FOR REAR BEARING PLATE

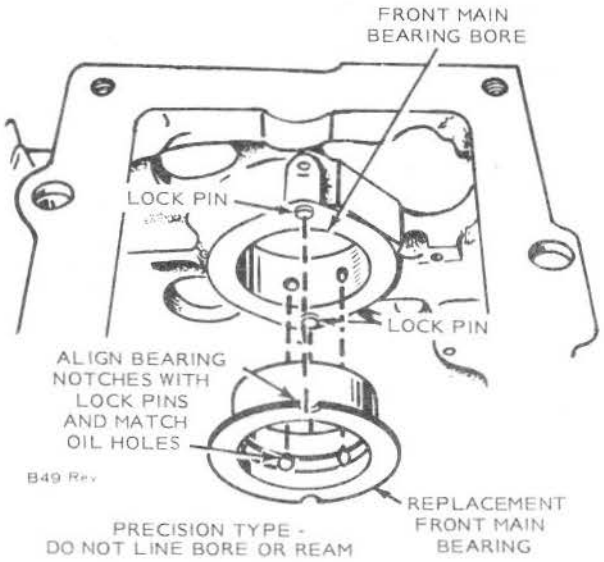


FIGURE 39. FRONT MAIN BEARING INSTALLATION

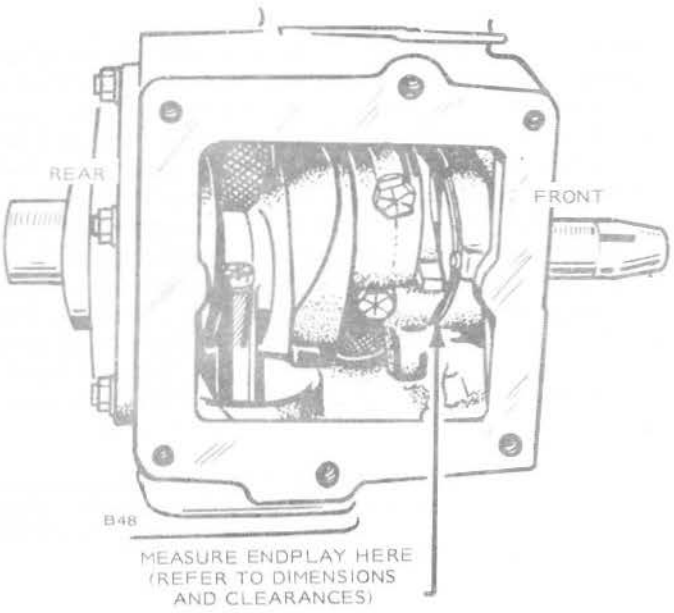


FIGURE 40. CRANKSHAFT ENDPLAY

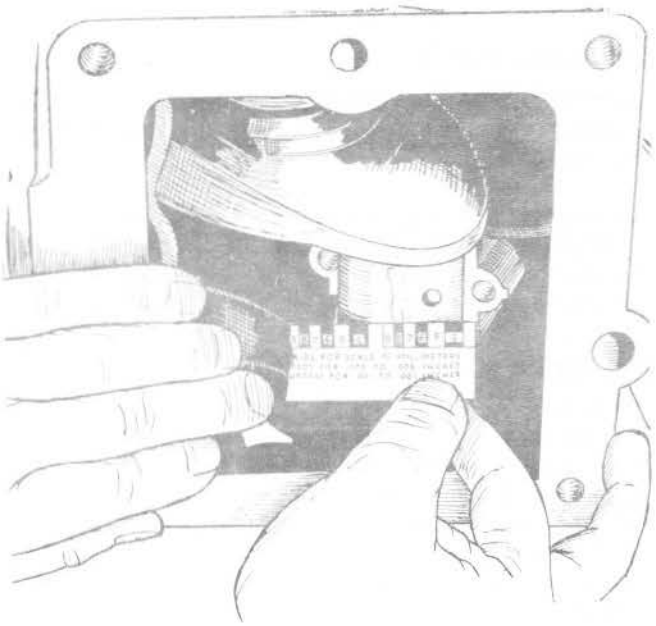


FIGURE 41. MEASURING BEARING CLEARANCE

CRANKSHAFT ENDPLAY

After the rear bearing end plate has been tightened using the torque recommended in *ASSEMBLY TORQUES*, check the crankshaft endplay as shown in Figure 40. If there is too much endplay (see *DIMENSIONS AND CLEARANCES* for minimum and maximum endplay), remove the rear bearing end plate and add a shim between the thrust washer and plate. Reinstall the end plate making sure the thrust washer and shim notches line up with the lock pins. Torque and recheck endplay of the crankshaft.

Checking Bearing Clearance with Plastigauge

1. Make certain that all parts are marked or identified so that they are reinstalled in their original positions.
2. Place a piece of correct size Plastigauge in the bearing cap the full width of the crankshaft rod surface about 1/4 inch off center (Figure 41).
3. Rotate the crank about 30 degrees from bottom dead center and reinstall the bearing cap; tighten the bolts to the torque specified in *ASSEMBLY TORQUES AND SPECIAL TOOLS*. Do not turn the crankshaft.
4. Remove the bearing cap. Leave the flattened Plastigauge on the part to which it has adhered and compare the widest point with the graduations of the Plastigauge envelope to determine bearing clearance.

OIL SEALS

The bearing plate must be removed to replace the oil seal (see Figure 42). Drive the oil seal out from the inside.

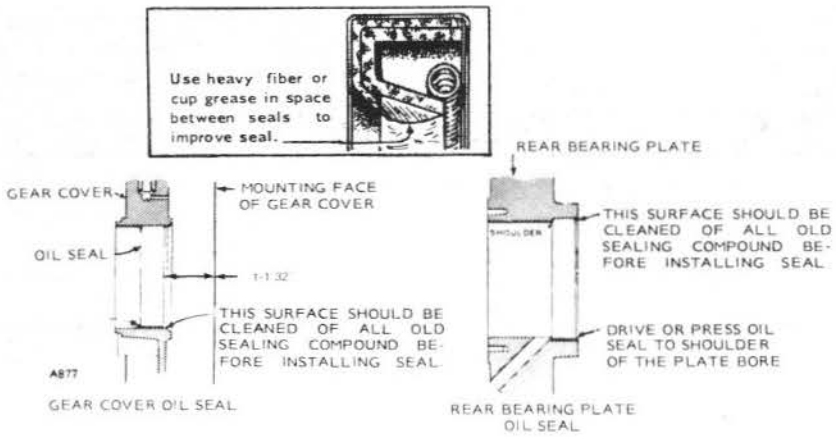


FIGURE 42. GEAR COVER AND REAR BEARING PLATE OIL SEALS

Before installing the seals, fill the space between lips with a multi-purpose grease. This will improve sealing.

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

When installing the bearing plate oil seal, tap the seal into the bearing plate bore to bottom against the 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.

ASSEMBLY

1. Lubricate all parts with engine oil.
2. Position piston on its respective rod and install the pin.
3. Install the rings on the pistons starting with the oil control ring (Figure 43). Use a piston ring spreader to prevent twisting or excessive expansion of the ring. Compression rings have a dot or the word "top" on one side of the ring to indicate which side faces the top of the piston. Unmarked piston rings can be installed either way. The oil control ring has an expander; install the expander first and then close until the expander ends butt. The joint should be 180 degrees from the gap of that ring. The second compression ring has an expander also.

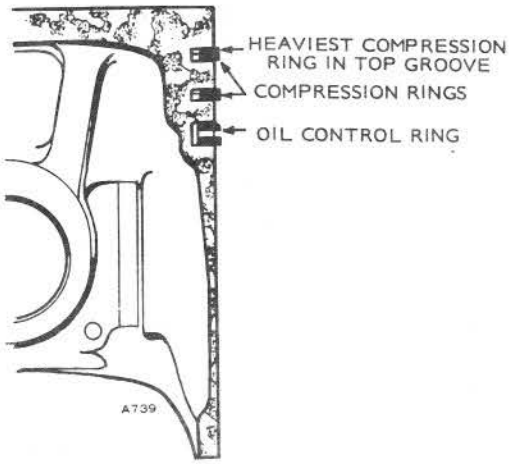


FIGURE 43. PISTON RINGS

INSTALLATION OF PISTON IN CYLINDER

1. Turn the crankshaft to position the number one rod bearing journal at the bottom of its stroke.
2. Lubricate the number one piston assembly and inside of the cylinder. Compress the rings with a ring compressor as shown in Figure 44.
3. Position the piston and rod assembly in the cylinder block.

Rod bolts are off-set toward outside of block.

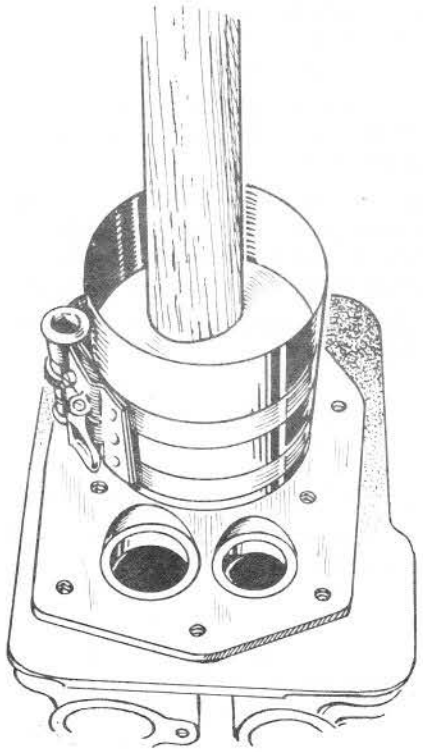


FIGURE 44. INSTALLING PISTON

4. Tap the piston down into the bore with the handle end of a hammer until the connecting rod is seated on the journal (Figure 44). Install the bearing cap on the rod with the stamped reference numbers matching the marks on the rod. Install and tighten the bolts evenly in steps to the specified torques.

   The bearing cap must be tapped to properly align it with the rest of the connecting rod. Clearance varies on the journal if this is not done.

   Install the remaining piston and rod in the same manner. Crank the engine over by hand to see that all bearings are free.

5. Install the oil base with a new gasket.
6. Install the cylinder heads and torque 14 - 16 ft. lb.
7. Replace oil and break-in engine.

CYLINDER HEADS

Remove the cylinder heads for cleaning each 200 hours or when poor engine performance is noticed.

1. Use a 1/2 inch socket wrench to remove cylinder head bolts. Lift heads off.

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

2. After removing heads, clean out all carbon deposits. Be careful not to damage the outer sealing edges where gaskets fit. The heads are made of aluminum and can be damaged by careless handling.
3. Use new head gaskets and clean both the heads and the cylinder block thoroughly where the head gaskets rest.
4. Place heads in position and follow head torque tightening sequence shown in Figure 45. Start out tightening all bolts to 5 ft - lb, then 10 ft - lb, etc., until all bolts are torqued 14 to 16 ft - lb.
5. Recheck torque before engine has run a total of 25 hours.

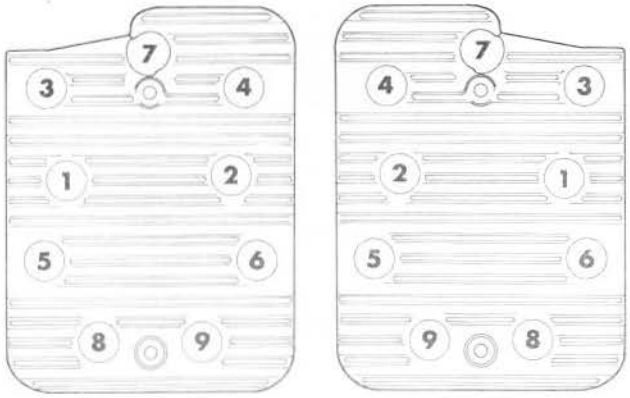
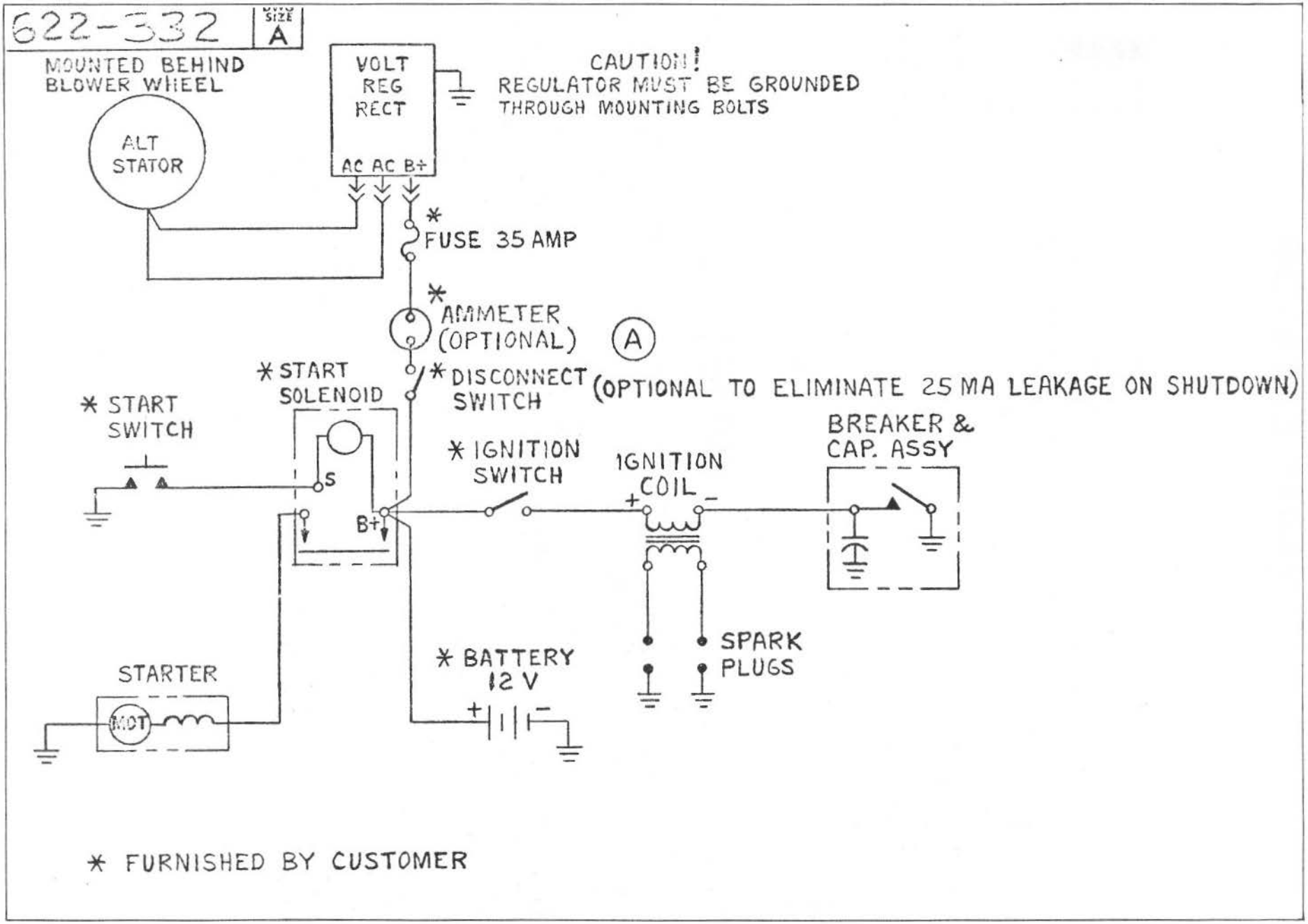


FIGURE 45. CYLINDER HEAD TORQUE SEQUENCE



PARTS CATALOG

This catalog applies to tractor application BG Engines. Parts are arranged in groups of related items. Each illustrated part is identified by a reference number corresponding to the same reference number in the parts list for that group. Parts illustrations are typical. Using the *Model* and *Spec No.* from the nameplate, select parts from this catalog that apply to your engine. Unless otherwise mentioned in the description, parts are interchangeable between models. Right and left sides are determined by facing the blower end (front) of the engine.

NOTICE!

ITEMS REFERENCED AS **OPTIONAL** INDICATE PART IS FACTORY INSTALLED AND MAY NOT BE APPLICABLE TO ALL MODELS. FOR FIELD CONVERSIONS ADDITIONAL PARTS ARE USUALLY REQUIRED.

GENERAL INFORMATION

INSTRUCTIONS FOR ORDERING REPAIR PARTS

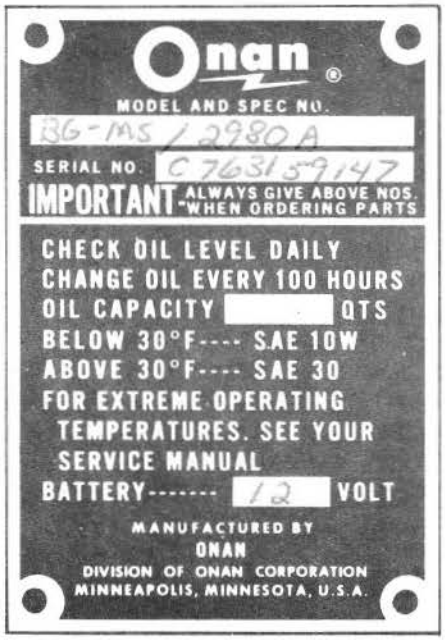
INFORMATION ON THIS PAGE INCLUDED FOR OWNERS WHO HAVE PURCHASED THIS CATALOG.

For parts or service, contact the dealer from whom you purchased this equipment or refer to your Nearest Authorized Onan Parts and Service Center.

To avoid errors or delay in filling your parts order, please furnish all information requested.

Always refer to the nameplate on your unit:

1. Always give the MODEL and SPEC NO. and SERIAL NO.



For handy reference, insert "YOUR" nameplate information in the spaces above.

2. Do not order by reference number or group number; always use part number and description.
3. Give the part number, description and quantity needed of each item. If an older part cannot be identified, return the part prepaid to your dealer or nearest AUTHORIZED SERVICE STATION. Print your name and address plainly on the package. Write a letter to the same address stating the reason for returning the part.
4. State definite shipping instructions. Any claim for loss or damage to your unit in transit should be filed promptly against the transportation company making the delivery. Shipments are complete unless the packing list indicates items are back ordered.

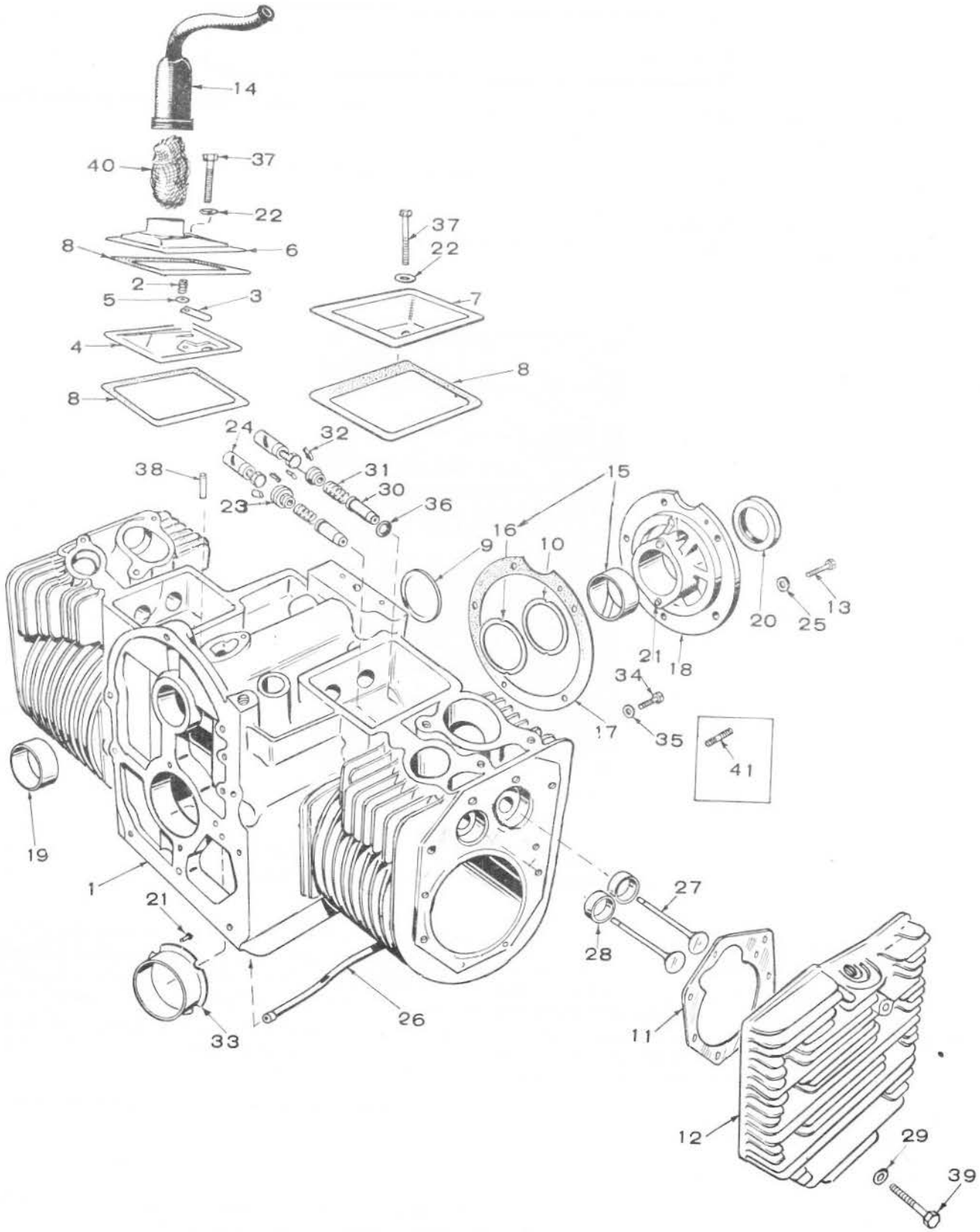
Prices are purposely omitted from this Parts Catalog due to the confusion resulting from fluctuating costs, import duties, sales taxes, exchange rates, etc.

For current parts prices, consult your Onan Dealer, Distributor or Parts and Service Center.

"En esta lista de partes los precios se omiten de proposito, ya que bastante confusion resulto de fluctuaciones de los precios, derechos aduanales, impuestos de venta, cambios extranjeros, etc."

Consiga los precios vigentes de su distribuidor de productos "ONAN".

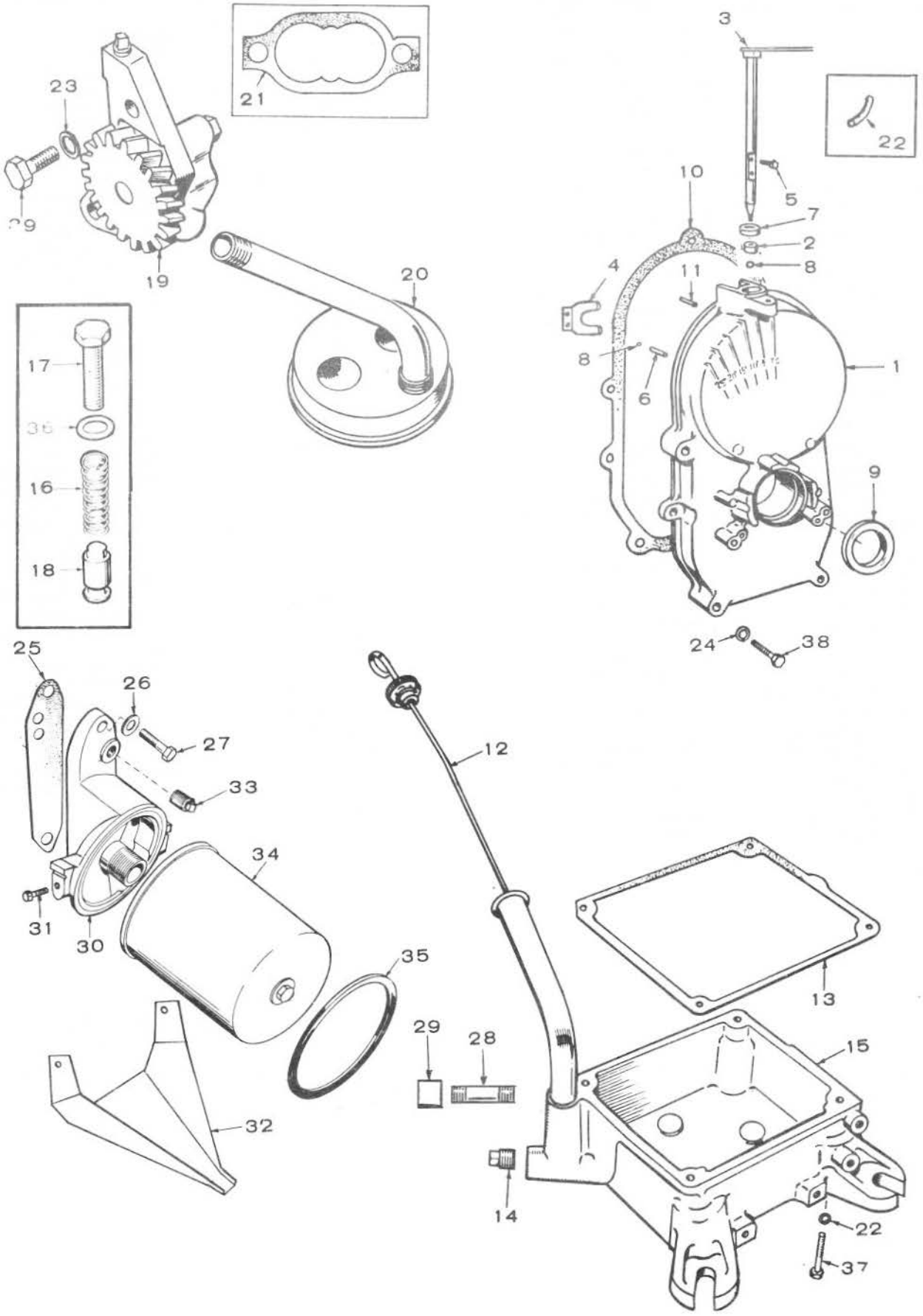
CYLINDER BLOCK GROUP



REF. NO.	PART NO.	QTY. USED	PART DESCRIPTION
1	110-2397	1	Block Assembly, Cylinder (Includes Parts Marked †)
2	123-1174	1	Spring, Breather Valve
3	123-1175	1	Valve, Breather
4	123-1173	1	Baffle, Breather
5	526-0018	1	Washer, Flat - Steel (17/64" I.D. x 5/8" O.D. x 1/16" Thick)
6	110-2274	1	Cover, Valve Compartment (L.H.)
7	110-1879	1	Cover, Valve Compartment (R.H.)
8	110-1921	3	Gasket, Valve Cover
9	517-0048	1	†Plug, Expansion - Camshaft
10	104-0776	As Req.	†Shim, Rear Bearing Plate (.005")
11	110-2287	2	Gasket, Cylinder Head
12	HEAD, CYLINDER		
	110-2273	1	Right Side (#2 Cylinder)
	110-2272	1	Left Side (#1 Cylinder)
13	800-0051	5	†Screw, Hex Head Cap - Steel (3/8-16 x 1-1/4")
14	123-1277	1	Tube, Breather
15	BEARING, CRANKSHAFT - REAR (INCLUDES THRUST WASHER)		
	101-0450	1	†Standard
	101-0450-02	1	.002" Undersize
	101-0450-10	1	.010" Undersize
	101-0450-20	1	.020" Undersize
	101-0450-30	1	.030" Undersize
16	104-0575	2	†*Washer, Crankshaft Bearing Thrust
17	101-0415	1	†Gasket, Bearing Plate
18	101-0439	1	†Plate, Bearing (Excludes Bearings)
19	101-0405	2	†Bearing, Camshaft (Precision)
20	509-0041	1	†Seal, Bearing Plate
21	516-0072	4	†Pin, Main Bearing Stop
22	526-0063	2	Washer, Flat - Copper (17/64" I.D. x 7/16" O.D. x 1/32" Thick)
23	110-0904	4	Rotocap, Valve
24	TAPPET, VALVE		
	115-0006	4	Standard
	115-0006-02	4	.002" Oversize
	115-0006-05	4	.005" Oversize
25	850-0050	5	†Washer, Lock (3/8")
26	120-0735	1	†Tube, Crankcase Oil
27	VALVE		
	110-1808	2	Intake
	110-1809	2	Exhaust
28	INSERT, VALVE SEAT		
			EXHAUST
	110-1824	2	†Standard
	110-1824-02	2	.002" Oversize
	110-1824-05	2	.005" Oversize
	110-1824-10	2	.010" Oversize
	110-1824-25	2	.025" Oversize
			INTAKE
	110-0197	2	†Standard
	110-0197-02	2	.002" Oversize
	110-0197-05	2	.005" Oversize
	110-0197-10	2	.010" Oversize
	110-0197-25	2	.025" Oversize
29	526-0122	18	Washer, Flat - Steel (11/32" I.D. x 23/32" O.D. x 10 Gauge)
30	110-1807	4	†Guide, Valve
31	110-0539	4	Spring, Valve
32	110-0639	8	Lock, Valve and Spring Retainer
33	*BEARING, CRANKSHAFT - FRONT (FLANGED)		
	101-0432	1	†Standard
	101-0432-02	1	.002" Undersize
	101-0432-10	1	.010" Undersize
	101-0432-20	1	.020" Undersize
	101-0432-30	1	.030" Undersize
34	800-0046	1	Screw, Hex Head Cap (3/8-16 x 3/4") - Cylinder Block Wet Hole
35	526-0066	2	Washer, Flat - Copper (25/64" I.D. x 9/16" O.D. x 1/16" O.D.)
36	110-0068	2	†Gasket, Valve Guide (Intake)
37	800-0010	2	Screw, Hex Head Cap (1/4-20 x 1-3/4")
38	149-1299	1	Tube, Fuel Pump Vacuum
39	SCREW, HEX HEAD CAP		
	800-0540	12	5/16-18 x 1-5/8"
	800-0541	6	5/16-18 x 2"
40	123-0865	1	Filter, Breather Tube
41	520-0820	1	Stud, Cylinder Block Wet Hole (Lower)

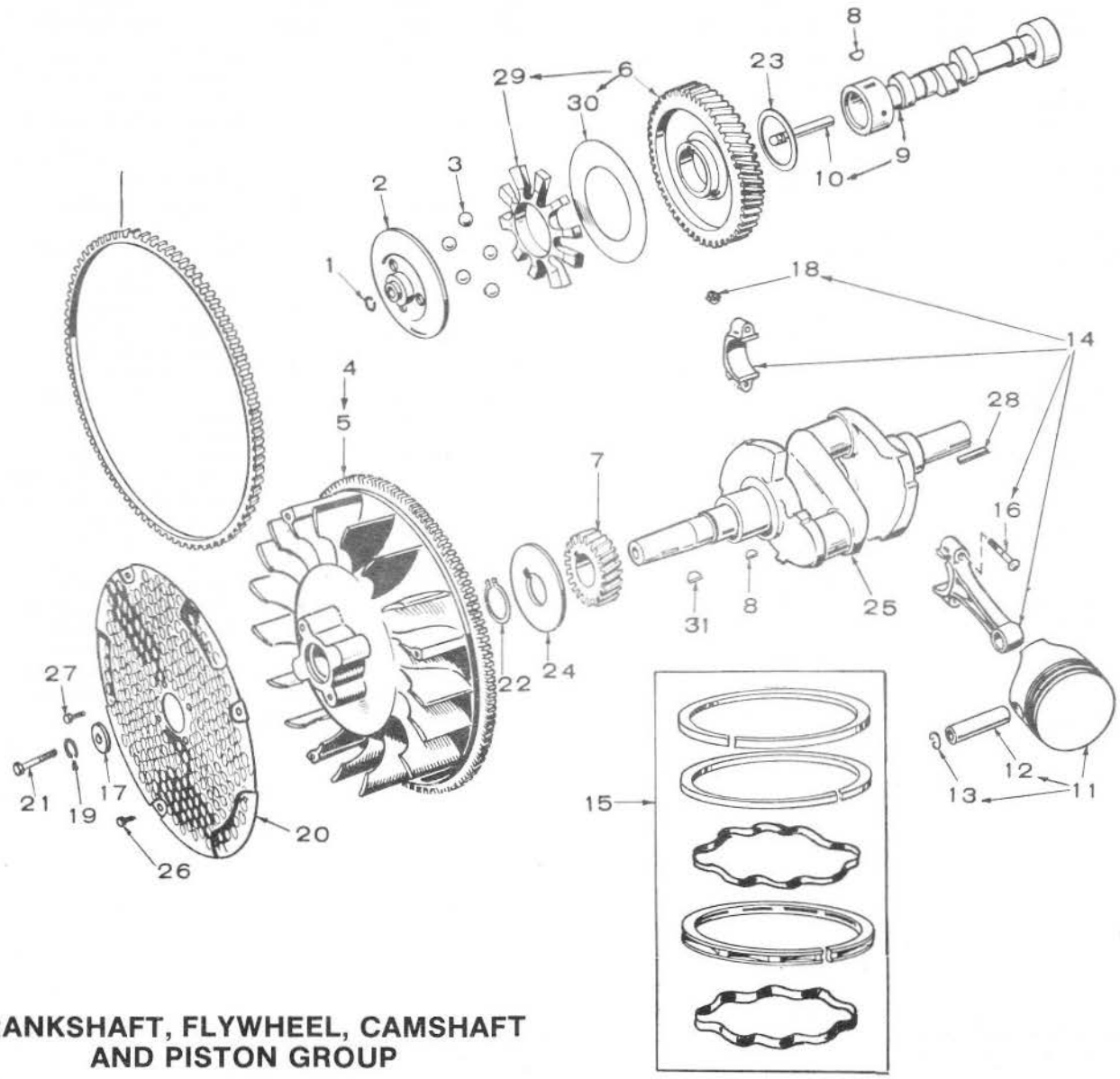
† - Included in 110-2397 Cylinder Block Assembly.
* - Replacement Front Flange Bearing replaces unflanged bearing and thrust washer.

GEAR COVER, OIL BASE AND OIL PUMP GROUP



REF. NO.	PART NO.	QTY. USED	PART DESCRIPTION
1	103-0498	1	Cover Assembly, Gear (Includes Parts Marked *)
2	510-0105	1	*Bearing, Governor Shaft
3	150-1470	1	*Shaft and Arm Assembly, Governor
4	150-1187	1	*Yoke, Governor Shaft
5	815-0046	2	*Screw, Yoke Retaining
6	516-0130	1	*Pin, Governor Cup Stop
7	509-0008	1	*Seal, Oil - Governor Shaft
8	510-0014	1	*Ball, Bearing - Governor Shaft
9	509-0040	1	*Seal, Gear Cover
10	103-0408	1	Gasket, Gear Cover
11	516-0141	2	Pin, Gear Cover Mounting (5/16 x 7/8")
12	123-1292	1	Cap and Indicator, Oil Fill
13	102-0693	1	Gasket, Oil Base Mounting
14	505-0056	1	Plug, Oil Drain
15	BASE, OIL		
	102-0741	1	For Engines With Extended Oil Drain
	102-0724	1	For Engines Without Extended Oil Drain
16	120-0140	1	Spring, Oil By-Pass Valve
17	801-0050	1	Screw, Hex Head Cap (3/8-24 x 1") - Oil By-Pass
18	120-0398	1	Valve, Oil By-Pass
19	120-0491	1	Pump, Oil - Complete (NOTE: Internal parts not sold separately)
20	120-0713	1	Intake, Oil Pump (Includes: Cup, Screen and Pipe)
21	120-0161	1	Gasket Kit, Oil Pump
22	850-0050	4	Washer, Spring Lock (3/8")
23	850-0040	2	Washer, Spring Lock (1/4")
24	526-0065	5	Washer, Flat - Copper (21/64" I.D. x 9/16" O.D. x 1/16 Thick)
25	122-0321	1	Gasket, Oil Filter Adapter
26	526-0065	2	Washer, Flat - Copper (21/64" I.D. x 9/16" O.D. x 1/16 Thick)
27	800-0028	2	Screw, Hex Head Cap (5/16-18 x 1")
28	505-0176	1	Nipple, Pipe - Oil Drain (1/2 x 3-1/2")
29	505-0158	1	Cap, Pipe (1/2")
30	122-0320	1	Adapter, Oil Filter
31	815-0194	2	Screw, Hex Head (#10-32 x 3/8")
32	122-0360	1	Drain, Oil Filter
33	502-0080	1	Plug, Oil Filter Adapter
34	122-0406	1	Filter, Oil
35	122-0347	1	Seal, Air - Oil Filter
36	526-0066	1	Washer, Flat - Copper (25/64" I.D. x 9/16" O.D. x 1/16" Thick) - By-Pass Valve
37	800-0056	4	Screw, Hex Head Cap (3/8-16 x 2-1/2")
38	800-0032	4	Screw, Hex Head Cap (5/16-18 x 1-3/4") - Gear Cover Mounting
38	800-0545	1	Screw, Hex Head Cap (5/16-18 x 2-3/4") - Gear Cover Mounting
39	800-0007	2	Screw, Hex Head Cap (1/4-20 x 1")

* - Included in Gear Cover Assembly.

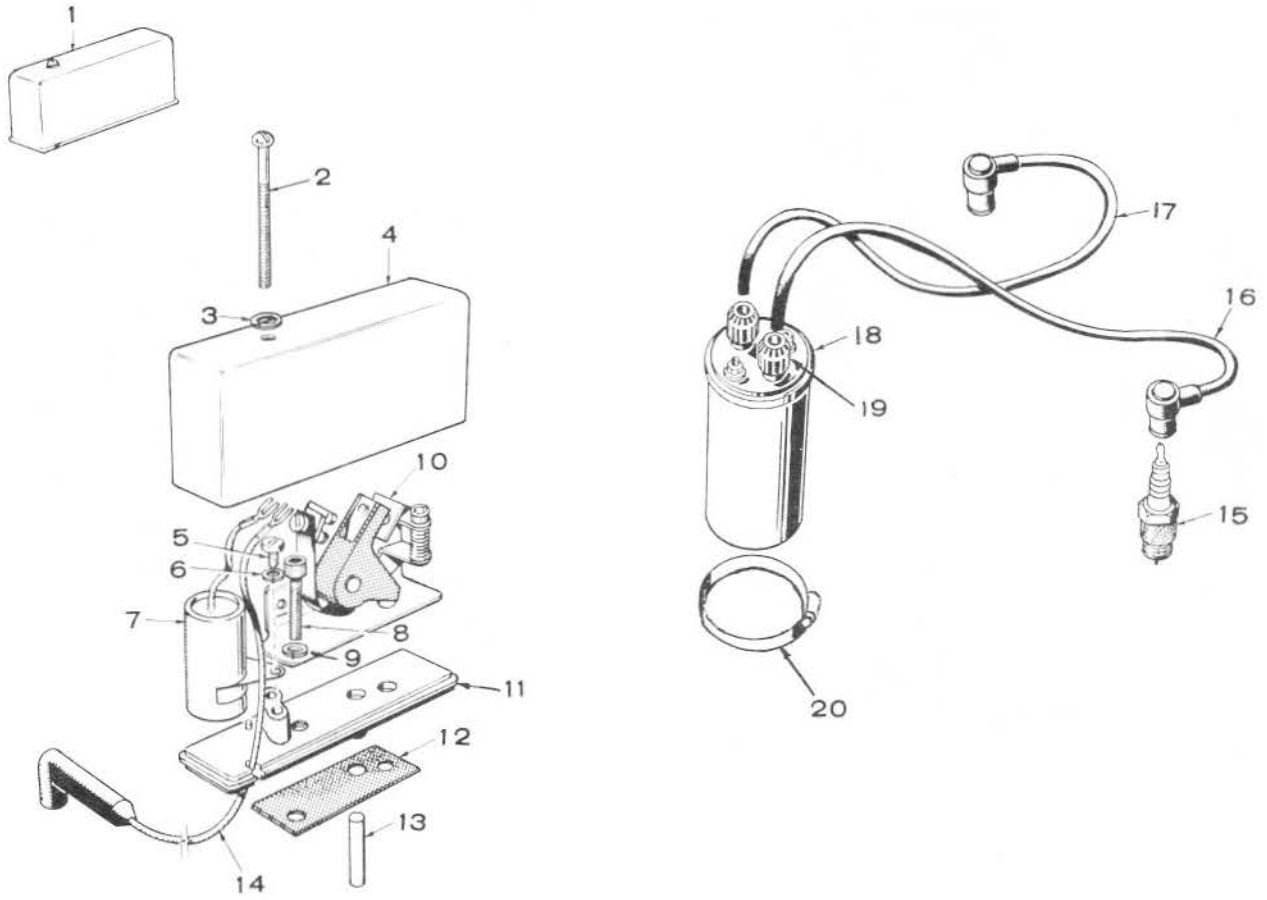


CRANKSHAFT, FLYWHEEL, CAMSHAFT AND PISTON GROUP

REF. NO.	PART NO.	QTY. USED	PART DESCRIPTION
1	150-0078	1	Ring, Camshaft Center Pin
2	150-1116	1	Cup, Governor
3	510-0015	5	Ball, Fly - Governor
4	104-0779	1	Gear, Ring - Flywheel
5	134-3209	1	Flywheel (Includes Ring Gear and Magnet Ring)
6	105-0332	1	Gear, Camshaft (Includes Flyball Spacer and Plate)
7	104-0032	1	Gear, Crankshaft
8	515-0001	2	Key (1/2" Diameter x 1/8")
9	105-0402	1	Camshaft (Includes Center Pin)
10	150-0075	1	Pin, Camshaft Center
11	PISTON AND PIN (INCLUDES RETAINING RINGS)		
	112-0143	2	Standard
	112-0143-05	2	.005" Oversize
	112-0143-10	2	.010" Oversize
	112-0143-20	2	.020" Oversize
	112-0143-30	2	.030" Oversize
	112-0143-40	2	.040" Oversize
12	112-0122	2	Pin, Piston
13	518-0311	4	Ring, Piston Pin Retaining

REF. NO.	PART NO.	QTY. USED	PART DESCRIPTION
14	ROD ASSEMBLY, CONNECTING		
	114-0247	2	Standard
	114-0247-10	2	.010" Undersize
	114-0247-20	2	.020" Undersize
	114-0247-30	2	.030" Undersize
15	RING SET, PISTON		
	113-0186	2	Standard
	113-0186-05	2	.005" Oversize
	113-0186-10	2	.010" Oversize
	113-0186-20	2	.020" Oversize
	113-0186-30	2	.030" Oversize
	113-0186-40	2	.040" Oversize
16	114-0228	4	Bolt, Special - Connecting Rod
17	526-0017	1	Washer, Flat - Steel (15/32" I.D. x 1-1/4" O.D. x 1/4" Thick)
18	870-0137	4	Nut, Locking - Connecting Rod Cap
19	850-0055	1	Washer, Spring Lock (7/16")
20	134-3212	1	Guard, Flywheel

REF. NO.	PART NO.	QTY. USED	PART DESCRIPTION
21	104-0170	1	Screw, Hex Head Cap (7/16-14 x 4")
22	518-0014	1	Ring, Retaining - Crankshaft Gear Washer
23	105-0004	1	Washer, Camshaft Gear Thrust
24	104-0043	1	Washer, Crankshaft Gear Retainer
25	104-0919	1	Crankshaft
26	821-0010	3	Screw, Hex Head Cap - Locking Flange (1/4-20 x 1/2")
27	821-0014	2	Screw, Hex Head Cap - Locking Flange (5/16-18 x 1/2")
28	515-0103	1	Key, Crankshaft Stub (1/4 x 1/4 x 2")
29	150-1257	1	Spacer, Governor Flywheel
30	150-0077	1	Plate, Governor Flyball
31	515-0227	1	Key Kit

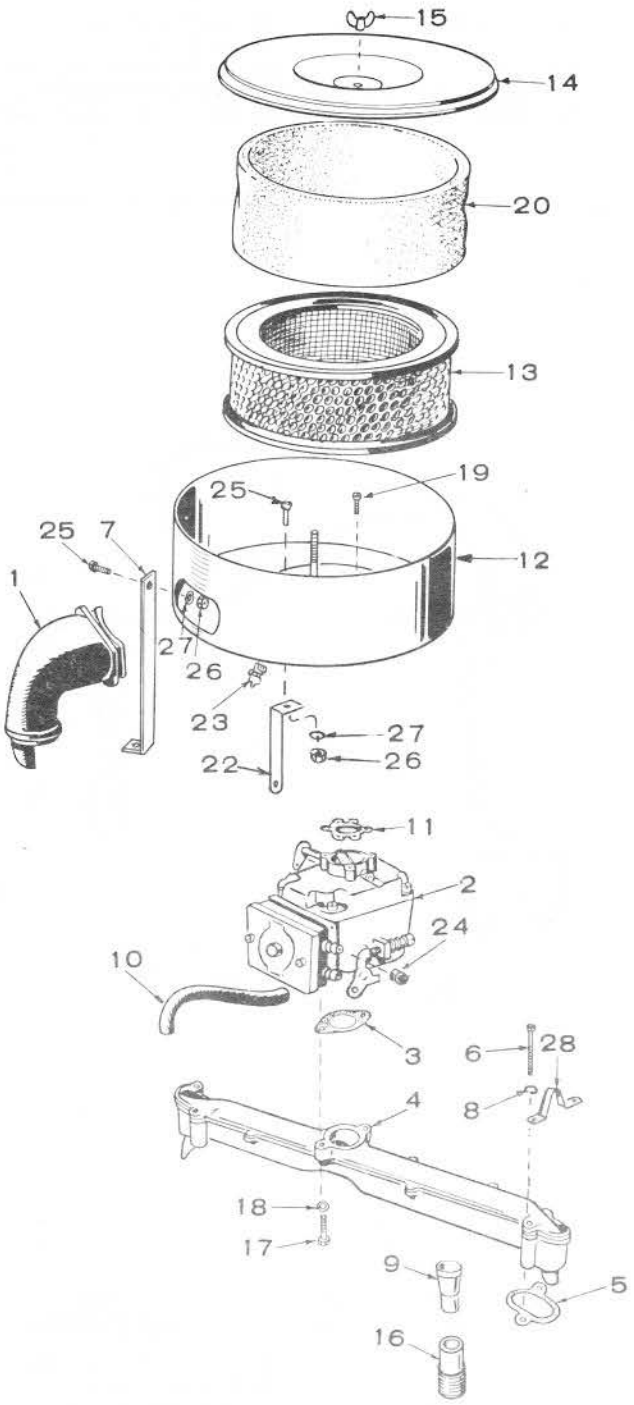


IGNITION GROUP

REF. NO.	PART NO.	QTY. USED	PART DESCRIPTION
1	160-1210	1	Box Assembly, Breaker (Includes Parts Marked *)
2	812-0108	1	*Screw, Machine - Round Head (#10-24 x 1-1/2")
3	526-0008	1	*Washer, Flat (13/64" I.D. x 7/16" O.D. x 1/32" Thick)
4	160-1176	1	*Cover, Breaker Box
5	815-0358	1	*Screw, Tapping - Hex Head (#8-32 x 5/16")
6	850-0025	1	*Washer, Lock - Spring (#8)
7	312-0196	1	*Condenser, Ignition
8	802-0034	2	*Screw, Cap - Socket Head (1/4-20 x 3/4")
9	850-0038	2	*Washer, Lock - Spring - High Collar (1/4")
10	160-1183	1	*Point Assembly, Breaker
11	160-1172	1	*Base, Breaker Box
12	160-1150	1	*Gasket, Breaker Box
13	160-1151	1	Plunger, Breaker Point Assembly
14	336-2132	1	Lead, Breaker Points to Coil
15	167-0241	2	Plug, Spark
16	167-1463	1	Cable, Spark Plug (19")
17	167-1462	1	Cable, Spark Plug (16-3/4")
18	166-0535	1	Coil, Ignition
19	166-0604	2	Nut, Coil Cable (Part of 166-0535 Coil)
20	503-0311	1	Clamp, Coil Mounting

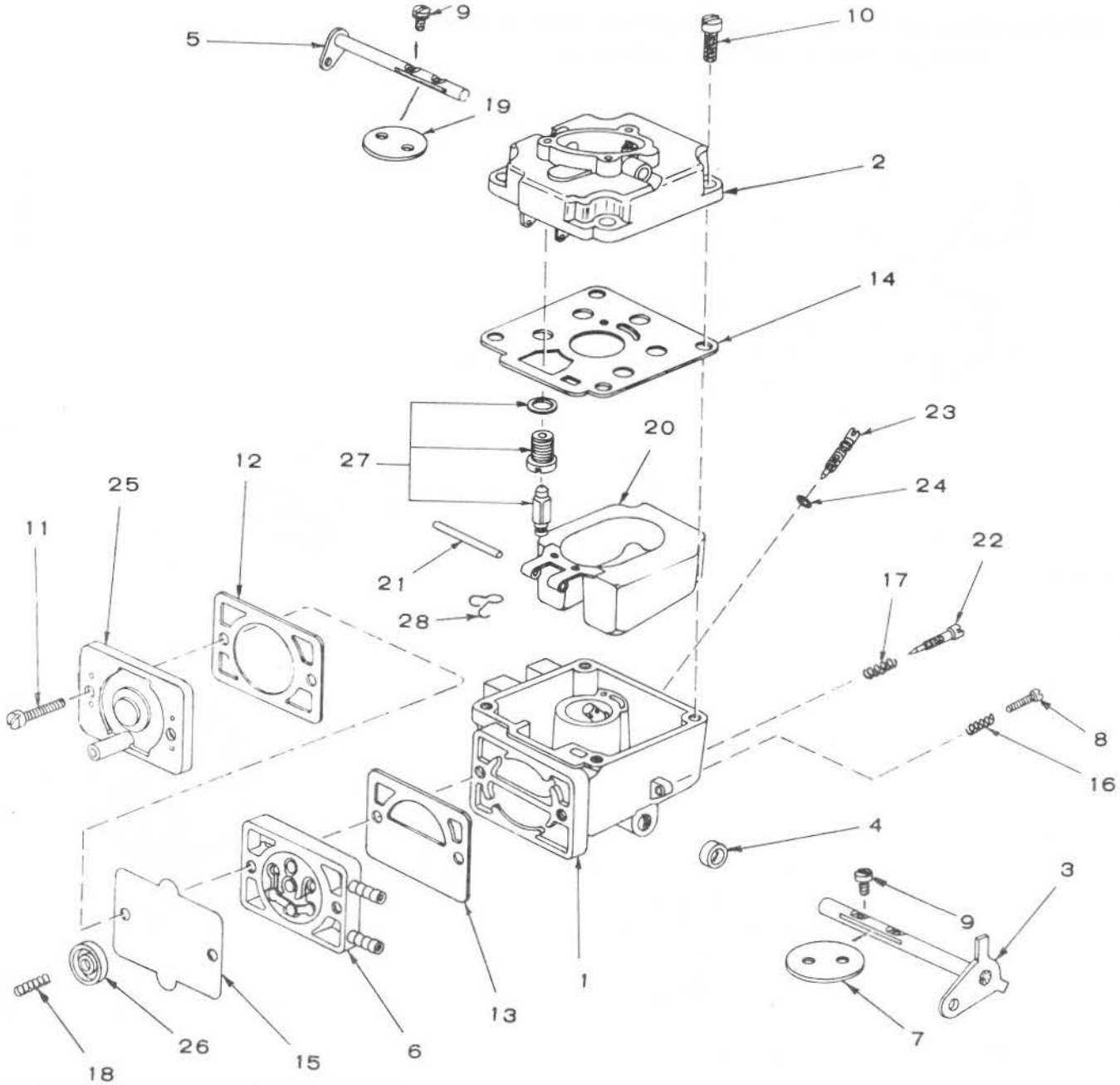
* - Parts included in 160-1210 Breaker Box Assembly.

FUEL SYSTEM GROUP



REF. NO.	PART NO.	QTY. USED	PART DESCRIPTION
1	140-1169	1	Tube, Air Intake (Air Cleaner to Blower Housing)
2	142-0568	1	†Carburetor, Gasoline (With Integral Fuel Pump)
3	145-0438	1	Gasket, Carburetor Mounting
4	154-1468	1	Manifold, Intake
5	154-1744	2	Gasket, Intake - Manifold
6	800-0034	4	Screw, Hex Head Cap (5/16-18 x 2-1/4")
7	140-1198	1	Support, Air Cleaner
8	850-0045	4	Washer, Spring Lock (5/16")
9	155-1365	2	Insert, Exhaust Pipe
10	503-0740	1	Hose, Fuel Pump Vacuum
11	140-1215	1	Gasket, Air Cleaner Mtg.
12	140-1213	1	Housing, Air Cleaner
13	140-1216	1	Element, Air Cleaner
14	140-1168	1	Cover, Air Cleaner
15	865-0020	1	Nut, Wing - Air Cleaner Cover (1/4-20)
16	505-0815	2	Nipple, Exhaust (1 x 3")
17	800-0023	2	Screw, Hex Head Cap (1/4-20 x 1-3/8")
18	850-0040	2	Washer, Spring Lock (1/4")
19	815-0377	3	Screw, Round Head with Nylon Seal (#10-32 x 3/8")
20	140-1259	1	Wrapper, Air Cleaner Element
22	140-1313	1	Bracket, Air Cleaner Support
23	518-0328	2	Clip, Bracket, Cable
24	149-1321	1	Cap, Fuel Pump
25	800-0003	2	Screw, Hex Head Cap (1/4-20 x 1/2")
26	862-0001	2	Nut, Hex - Steel (1/4-20)
27	853-0013	2	Washer, Lock - ET (1/4")
28	403-1021	2	Bracket, Lifting

† - See separate group for components.

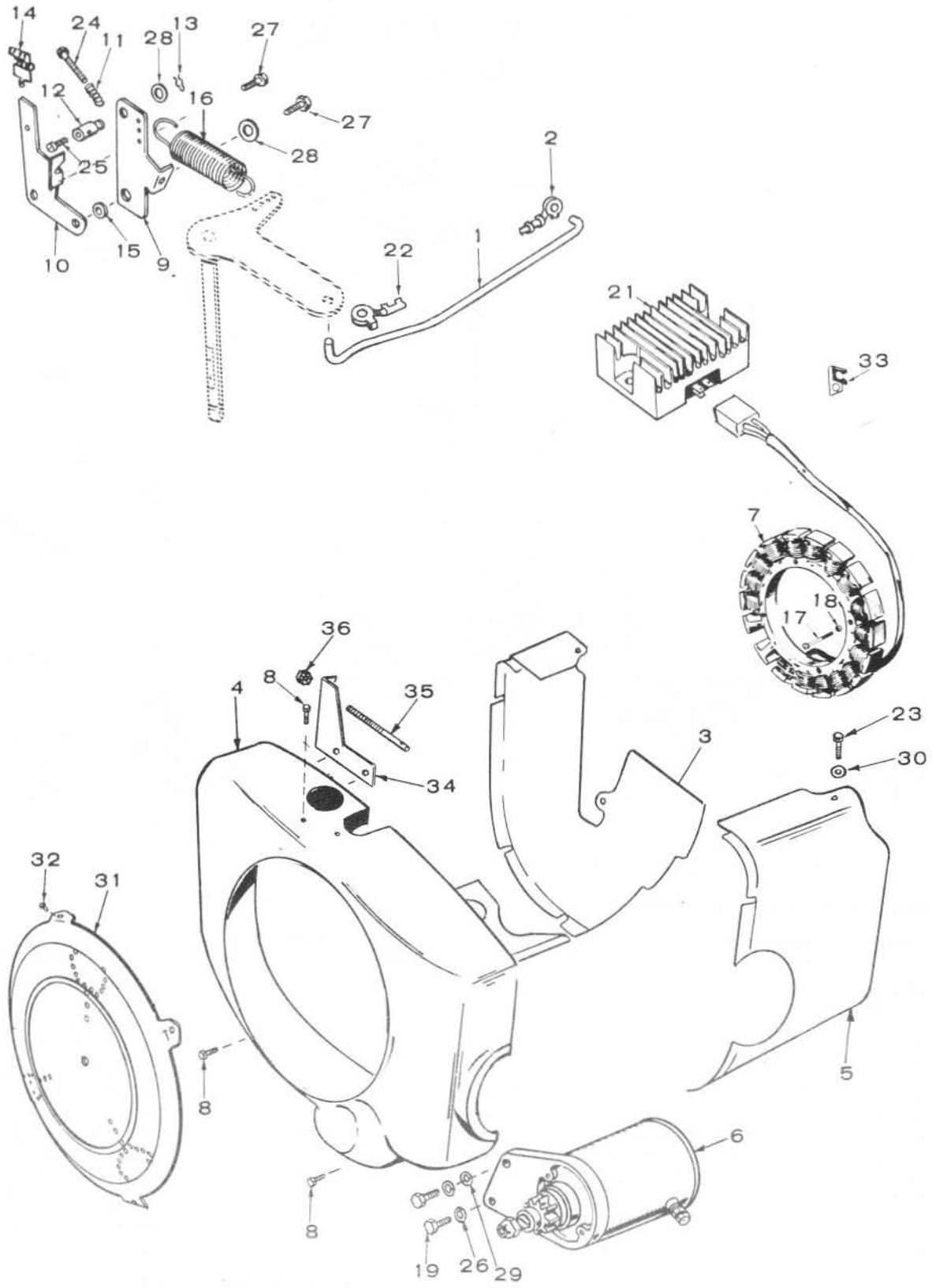


CARBURETOR PARTS GROUP

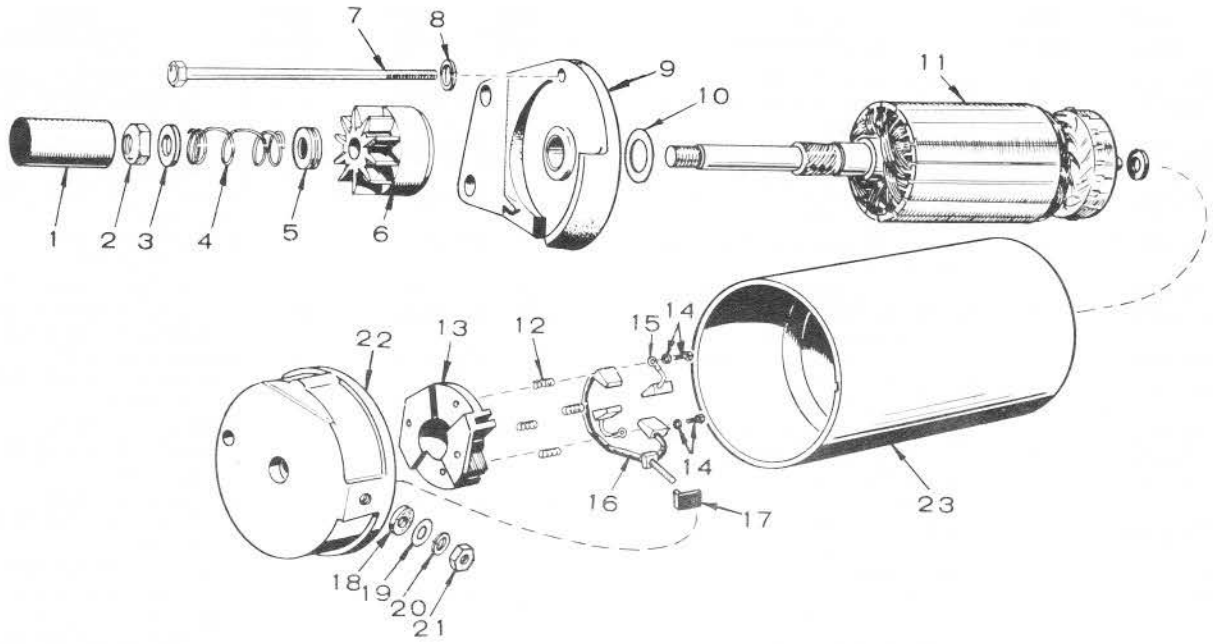
REF. NO.	PART NO.	QTY. USED	PART DESCRIPTION
	142-0568	1	Carburetor Assembly, Complete
1	142-0574	1	Body Assembly, Lower
2	142-0573	1	Sleeve Assembly
3	142-0534	1	*Shaft Assembly, Throttle
4	142-0535	1	†Packing, Shaft
5	142-0536	1	Shaft Assembly, Choke
6	142-0537	1	*Valve Plate Assembly
7	142-0538	1	Fly, Throttle
8	142-0064	1	Screw, Throttle Stop
9	142-0334	4	*Screw, Fly Mounting
10	142-0539	4	Screw, Bowl Cover Mounting
11	142-0540	2	Screw, Pump Cover
12	142-0541	1	†Gasket, Base to Diaphragm
13	142-0542	1	†Gasket, Plate to Base
14	142-0572	1	†Gasket, Sleeve Assembly to Base
15	142-0555	1	*Diaphragm, Pump
16	142-0544	1	Spring, Throttle Stop Screw
17	142-0282	1	*Spring, Idle Needle
18	142-0545	1	*Spring, Pump Diaphragm
19	142-0546	1	Fly, Choke
20	142-0547	1	Float and Lever Assembly
21	142-0548	1	*Shaft, Float Lever
22	142-0016	1	*Needle, Idle
23	142-0549	1	Needle Assembly, Power
24	142-0550	1	†Gasket, "O" Ring
25	142-0551	1	Cover, Pump
26	142-0552	1	*Plate, Pump Spring
27	142-0553	1	*Valve Assembly, Float
28	142-0554	1	Clip, Float Valve
	142-0571	1	*Gasket Set (Includes Parts Marked †)
	142-0570	1	Repair Kit (Includes Parts Marked *)

† - Included in 142-0571 Gasket Set.
* - Included in 142-0570 Repair Kit.

GOVERNOR, STARTER, CHARGING ALTERNATOR AND BLOWER HOUSING GROUP



REF. NO.	PART NO.	QTY. USED	PART DESCRIPTION
1	150-1350	1	Rod, Governor Control
2	518-0004	1	Clip, Governor Control Rod to Carburetor
3	134-2989	1	Housing, Cylinder Air - Left
4	HOUSING, BLOWER		
	134-2605	1	Engines With Remote Variable Speed Governor
	134-2991	1	Engines Without Variable Speed Governor
5	134-2988	1	Housing, Cylinder Air - Right
6	191-0933	1	Starter, 12 Volt (For Components see separate group)
7	191-1102	1	Stator, Charging Alternator
8	815-0261	3	Screw, Hex Head Cap (1/4-20 x 7/16")
9	150-1345	1	Arm, Governor Control
10	150-1343	1	Bracket, Governor Mounting
11	150-1398	1	Spring, Throttle Lever Adjusting Screw
12	152-0155	1	Swivel, Throttle Cable
13	516-0059	1	Pin, Cotter - Swivel Mounting
14	518-0176	1	Clip, Throttle Cable
15	150-1269	1	Bushing, Governor Control
16	150-1214	1	Spring, Governor
17	813-0108	3	Screw, Round Head - Steel (#10-32 x 1-1/2")
18	850-0030	3	Washer, Spring Lock (#10)
19	800-0512	2	Screw, Hex Head Cap (5/16-18 x 1")
20	526-0006	1	Washer, Flat - Steel (15/64" I.D. x 1/2" O.D. x 3/64" Thick)
21	191-0886	1	Regulator, Rectifier (Optional)
22	870-0278	1	Clip, Governor Control Rod to Governor Arm
23	815-0290	4	Screw, Hex Head Cap (1/4-20 x 5/8")
24	812-0068	1	Screw, Round Head - Steel (#6-32 x 3/4")
25	815-0104	1	Screw, Round Head (#8-32 x 5/16")
26	850-0045	2	Washer, Spring Lock (5/16")
27	821-0010	2	Screw, Hex Cap - Flange Locking (1/4-20 x 1/2")
28	526-0214	1	Washer, Flat - Steel (17/64" I.D. x 1/2" O.D. x 1/16" Thick)
29	526-0113	1	Washer, Flat - Steel (11/32" I.D. x 1" O.D. x 3/32" Thick)
30	526-0021	4	Washer, Flat - Steel (17/64" I.D. x 3/4" O.D. x 1/16" Thick)
31	134-3213	1	Guard, Blower Housing
32	815-0378	4	Screw, Ind. Hex Head w/ET (#14 x 1/2")
33	167-0188	1	Clip, Alternator Lead Support
34	150-1433	1	Bracket, Governor Control (Engines Without Variable Speed Governor)
35	150-1418	1	Stud, Governor (Engines Without Variable Speed Governor)
36	870-0131	1	Nut, Hex (#10-32) (Engines Without Variable Speed Governor)



STARTER PARTS GROUP

REF. NO.	PART NO.	QTY. USED	PART DESCRIPTION
	191-0933	1	Starter, 12 Volt (Complete)
1	191-1034	1	Cover, Dust
2	191-1045	1	Nut, Stop
3	191-1046	1	Washer, Stop Nut
4	191-1035	1	Spring, Anti-drift
5	191-1047	1	Spacer, Dust Cover
6	191-1036	1	Drive Assembly
7	191-1048	2	Screw, Hex Cap
8	850-0040	2	Washer, Lock
9	191-1037	1	Cap Assembly, Drive End
10	191-1038	1	Washer, Armature Thrust
11	191-1039	1	Armature
12	£	4	†*Spring, Brush
12	£	1	†Brush Holder
14	£	2	†Screw and Lockwasher
15	£	2	†*Brush, Ground
16	£	1	†*Stud and Brush Assembly, Input
17	£	1	†Bushing, Insulation - Input Stud
18	£	1	†Washer, Insulation - Input Stud
19	£	1	†Washer, Flat - Input Stud
20	£	1	†Washer, Lock - Input Stud
21	£	1	†Nut, Securing - Input Stud
22	191-1040	1	Cap Assembly, Commutator (Includes Parts Marked †)
23	£	1	Housing, Starter Motor
	191-1041	1	Repair Kit, Brush, Spring and Stud (Includes Parts Marked *)

† - Included in the 191-1040 Cap Assembly.
* - Included in the 191-1041 Brush, Spring and Stud Kit.
£ - Not Sold Separately.

SERVICE KITS AND MISCELLANEOUS

REF. NO.	PART NO.	QTY. USED	PART DESCRIPTION
	168-0131	1	Gasket Kit, Carbon Removal
	168-0130	1	Gasket Kit, Engine
	522-0277	1	Overhaul Kit

Onan Corporation
A Subsidiary of
McGraw-Edison Company
1400 73rd Avenue N.E.
Minneapolis, MN 55432

612 574-5000
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