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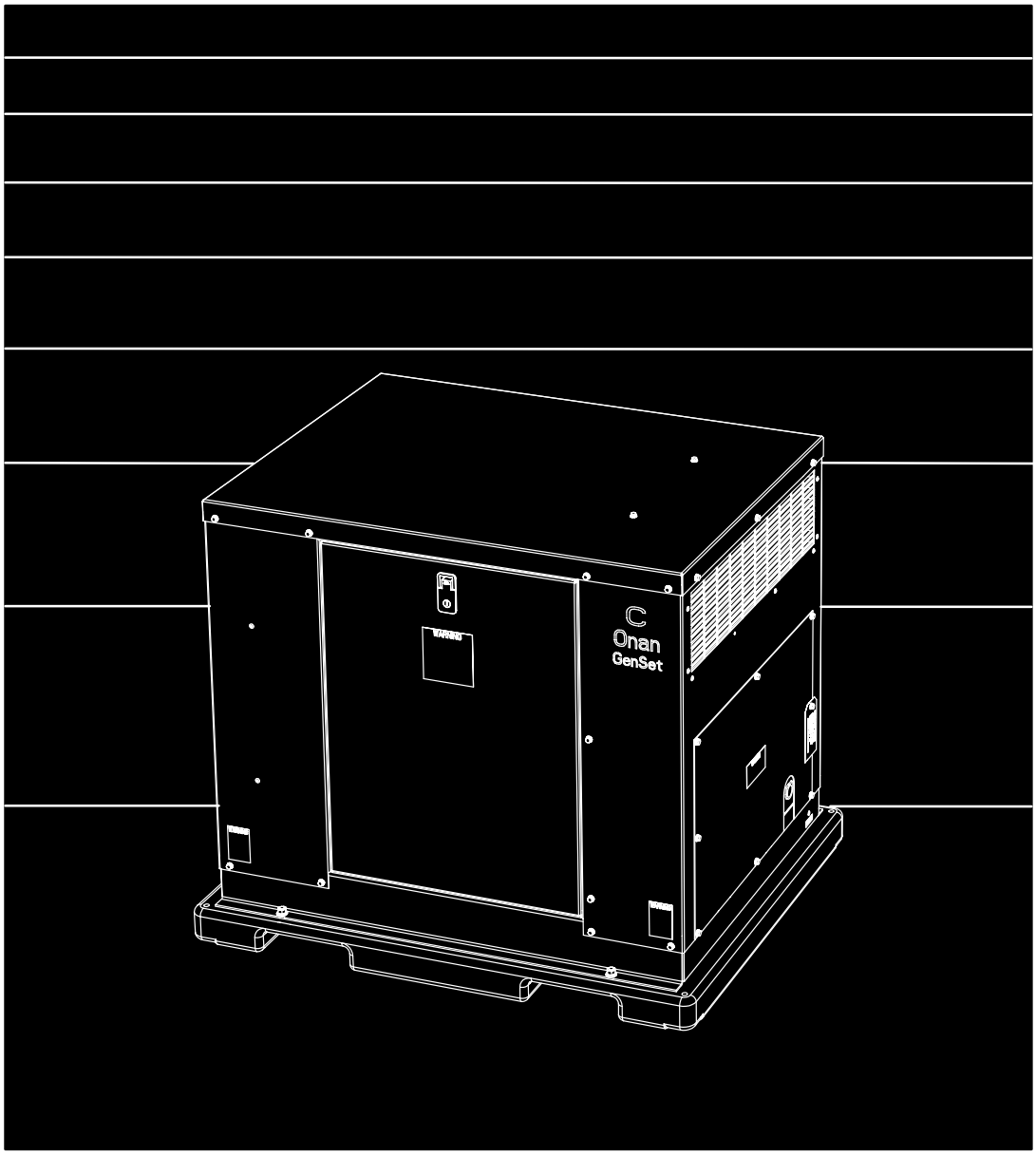
Service Manual

GHAB



Printed in U. S. A.

965-0503B
11-99

WARNING:

The engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects or other reproductive harm.

Table of Contents

Safety Precautions

Thoroughly read the OPERATOR'S MANUAL before operating the genset. Safe operation and top performance can be obtained only when equipment is operated and maintained properly.

The following symbols in this manual alert you to potential hazards to the operator, service person and equipment.

⚠ DANGER ***alerts you to an immediate hazard which will result in severe personal injury or death.***

⚠ WARNING ***alerts you to a hazard or unsafe practice which can result in severe personal injury or death.***

⚠ CAUTION ***alerts you to a hazard or unsafe practice which can result in personal injury or equipment damage.***

Electricity, fuel, exhaust, batteries and moving parts present hazards which can result in severe personal injury or death.

GENERAL PRECAUTIONS

- Keep ABC fire extinguishers handy.
- Make sure all fasteners are secure and torqued properly.
- Keep the genset and its compartment clean. Excess oil and oily rags can catch fire. Dirt and gear stowed in the compartment can restrict cooling air.
- Before working on the genset, disconnect the negative (**-**) battery cable at the battery to prevent starting.
- Use caution when making adjustments while the genset is running—hot, moving or electrically live parts can cause severe personal injury or death.
- Used engine oil has been identified by some state and federal agencies as causing cancer or reproductive toxicity. Do not ingest, inhale, or contact used oil or its vapors.
- Do not work on the genset when mentally or physically fatigued or after consuming alcohol or drugs.
- Carefully follow all applicable local, state and federal codes.

GENERATOR VOLTAGE IS DEADLY!

- Generator output connections must be made by a qualified electrician in accordance with applicable codes.
- The genset must not be connected to the public utility or any other source of electrical power. Connection could lead to electrocution of utility workers and damage to equipment. An approved switching device must be used to prevent interconnections.
- Use caution when working on live electrical equipment. Remove jewelry, make sure clothing and shoes are dry and stand on a dry wooden platform.

FUEL IS FLAMMABLE AND EXPLOSIVE

- Keep flames, cigarettes, sparks, pilot lights, electrical arc-producing equipment and switches and all other sources of ignition well away from areas where fuel fumes are present and areas sharing ventilation.
- Fuel lines must be secured, free of leaks and separated or shielded from electrical wiring.
- Leaks can lead to explosive accumulations of gas. Natural gas rises when released and can accumulate under hoods and inside housings and buildings. LPG sinks when released and can accumulate inside housings and basements and other below-grade spaces. Prevent leaks and the accumulation of gas.

ENGINE EXHAUST IS DEADLY!

- Learn the symptoms of carbon monoxide poisoning in this manual.
- The exhaust system must be installed in accordance with the genset Installation Manual.
- Do not use engine cooling air to heat a room or compartment.
- Make sure there is ample fresh air when operating the genset in a confined area.

BATTERY GAS IS EXPLOSIVE

- Wear safety glasses and do not smoke while servicing batteries.
- When disconnecting the battery cables, always check for a battery charger and disconnect it first then disconnect the negative (**-**) battery cable.
- When reconnecting battery cables, always reconnect the negative (**-**) battery cable after the positive (+) cable, then rereconnect the battery charger to reduce arcing.

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not wear loose clothing or jewelry near moving parts such as fans.
- Keep hands away from moving parts.
- Keep guards in place over fans.

1. Introduction

ABOUT THIS MANUAL

This is the Service Manual for the Series GHAB generator sets (gensets). Read and carefully observe all of the instructions and precautions in this manual. For quick reference, this manual includes *Operation* and *Periodic Maintenance*, which are also covered in the Operator's Manual.

See the Parts Catalog for part identification numbers. Genuine Onan® replacement parts are recommended for best results. When contacting Onan for parts, service or product information, be ready to provide the model number and the serial number, both of which appear on the genset nameplate (Figure 1-1. (The serial number is in the row marked "S/N", just below the model number. The last character of the model number is the specification letter, which is important for obtaining the right parts.)

⚠WARNING ***Improper service or parts replacement can lead to severe personal injury or death and to damage to equipment and property. Service personnel must be qualified to perform electrical and mechanical service.***

⚠WARNING ***Unauthorized modifications or replacement of fuel, exhaust, air intake or speed control system components that affect engine emissions are prohibited by law in the State of California.***

See the Installation Manual for important recommendations concerning the installation and for a list of the installation codes and standards for safety which may be applicable.

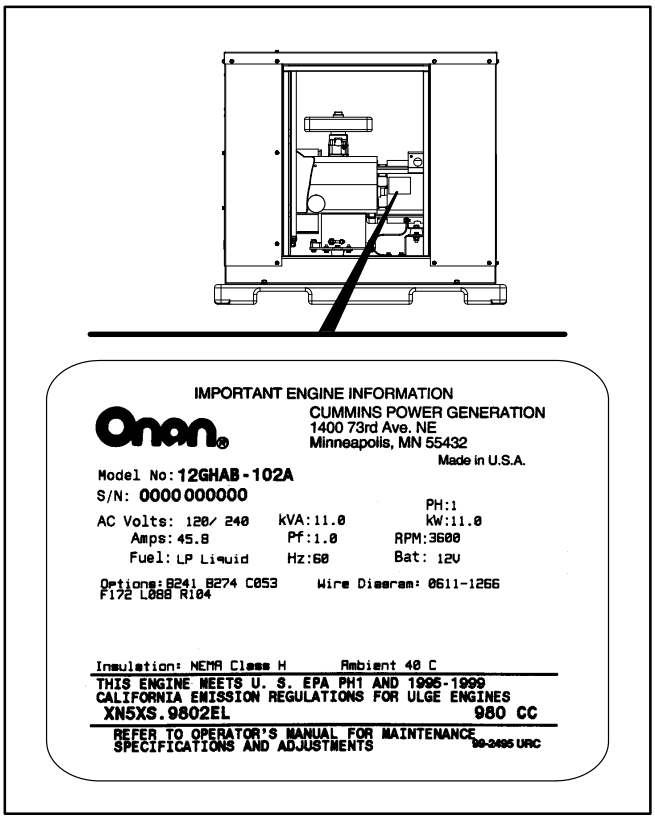


FIGURE 1-1. TYPICAL NAMEPLATE

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2. Specifications

GENERATOR SET GHAB:			
Fuel Type	Natural Gas	LP Vapor	LP Liquid
Rated Power	10 kW	11 kW	10 kW
Frequency	60 Hertz		
Voltage	120/240 volts		
Circuit Breaker Rating	2-Pole, 50 amperes		
Speed	3600 RPM		
FUEL CONSUMPTION:			
No-load Half-load Full-load	100,000 BTU/hr 150,000 BTU/hr 239,000 BTU/hr	46.3 ft.^{3}/hr 46.7 ft.^{3}/hr 85.0 ft.^{3}/hr	0.96 gal/hr (3.6 l/hr 1.18 gal/hr (4.41/hr) 2.41 gal/hr (9.1 l/hr)
Natural Gas Supply Pressure	7-15“ WC (water column) (178-381 mm)		
LP Supply Pressure (vapor)		7-15” WC (water column) (178-381 mm)	
LP Supply Pressure (liquid)			30-300 psi (207-2070 kPA)
Gas Supply Connection	3/4 inch NPT	3/4 inch NPT	1/4 inch NPT
ENGINE: Onan Performer P224, 1,000 cc. High Motor Starting Reserve			
Bore	3.653 inch (90 mm)		
Stroke	3.000 inch (76 mm)		
Displacement	60 inch^3 (980 cc)		
Compression Ratio	7.0 : 1		
Minimum Cylinder Compression Test Pressure	75 psi (517 kPa)		
Oil Capacity (with filter)*	3.5 quart (3.3 liter)		
Intake Valve Clearance (Cold)	0.005 inch (0.13 mm)		
Exhaust Valve Clearance (Cold)	0.013 inch (0.33 mm)		
Spark Plug Gap	0.025 inch (0.64 mm)		
Spark Plug Tightening Torque	8 lb-for (10 N-m)		
Ignition Timing (electronic ignition)	20° BTDC (non-adjustable)		
CRANKING SYSTEM:			
Nominal Battery Voltage (BCI, GP 26)	12 volts		
Battery Cranking Capacity	530 CCA @ 0° F (-17° C)		
Nominal Battery Charging Output	18 amperes		
Fuse F1 (control B+ input circuit)	20 amperes		
ENCLOSURE:			
Control Features	Lighted Run-Off-Auto Switch, Running Time Meter, 50 Amp UL Listed Circuit Breaker, DC Control Fuse. Large User Connection Area		
Enclosure Features	Sound Attenuated Drip-Proof Design, less than 70 dBA at 23 ft. (7M), Easy Service Access, Internal Starting Battery Tray and Tie-Down, Heavy Duty Exterior High Performance Fluoropolymer Finish Coat System		
Exhaust Silencer	Fully Enclosed Exhaust Silencer, Insulated Heat Shield, Ultra-Low Noise		
Installation Features	Pre-Mounted UV Resistant Plastic Installation Base, Convenient Electrical and Gas Supply Connections, Ground Anchor System for Base Included		
Unit Dimensions	45 in (1143 mm) Length, 34 inch (864 mm) Width, 39 inch (986 mm) Height (Including installation base)		
Weight	600 Pounds (272) kg)		
Sound Level at Full Load	Less than 70 dBA at 23 ft. (7 m)		

* See *Periodic Maintenance* for oil filling instructions.

ENGINE PART TOLERANCES AND CLEARANCES	
All dimensional tolerances and clearances are in inches (millimeters) unless otherwise indicated	
CYLINDER BLOCK	
Cylinder Bore Honed Diameter	3.5625-3.5635 (90.49-90.51)
Maximum Allowable	
Taper	0.003 (0.08)
Out-of-Round	0.003 (0.08)
Main Bearing Inside Diameer (Without bearing)	2.1870-2.1880 (55.55-55.58)
Main Bearing Inside Diameter (Installed)	2.0015-2.0040 (50.84-50.90)
Camshaft Bearing vbore (Bearing Installed)	1.3757-1.3787 (34.94-35.02)
CRANKSHAFT	
Main Bearing Journal Diameter	1.9992-2.0000 (50.78-50.80)
Main Bearing clearance	0.0024-0.0042 (0.061-0.107)
Connecting Rod Journal Diameter	1.6252-1.6260 (41.28-41.30)
Crankshaft End Play	0.0060-0.0120 (0.152-0.305)
CONNECTING ROD	
Large Bore Diameter (Without bearing installed and rod bolts properly torqued)	1.7505-1.7510 (44.46-44.48)
Connecting Rod Side Clearance	0.0020-0.0160 (0.051-0.406)
Piston Pin Bushing Bore (Without bushing)	0.8115-0.8125 (20.61-20.64)
Piston Pin Bushing Bore (Finished bore)	0.7504-0.7508 (19.06-19.07)
Bearing to Crankshaft Clearance	0.0020-0.0033 (0.051-0.084)
CAMSHAFT	
Bearing Journal Diameter	1.3740-1.3745 (34.90-34.91)
Bearing Clearance	0.0015-0.0030 (0.038-0.076)
End Play	0.0110-0.0480 (0.279-1.219)
Lobe Height	
Intake	1.1670 (29.64)
Exhaust	1.1570 (29.39)
PISTON	
Clearance in Cylinder	
Measure 90° to pin 1.187 inch below top of piston	0.0070-0.0090 (0.178-0.229)
Piston Pin Bore	0.7502-0.7506 (19.06-19.07)
Ring Groove Width	
Top compression Ring	0.0800-0.0810 (2.032-2.057)
Middle Compression Ring	0.0800-0.0810 (2.032-2.057)
Bottom Oil control Ring	0.1880-0.1890 (4.775-4.801)
PISTON PIN	
Clearance in Piston	0.00004-0.00064 (0.001-0.016)
Clearance in Connecting Rod	0.0002-0.0008 (0.005-0.020)
Diameter	0.7500-0.7502 (19.05-19.06)
PISTON RINGS	
Clearance	
Top Groove	0.0020-0.0080 (0.051-0.203)
Ring End Gap in Cylinder	0.0100-0.0200 (0.254-0.508)
INTAKE VALVE	
Stem Diameter	0.3425-0.3430 (8.700-8.712)
clearance (Stem to Guide)	0.001-0.0025 (0.025-0.064)
Valve Face Angle	44°

ENGINE PART TOLERANCES AND CLEARANCES (CONT.)	
All dimensional tolerances and clearances are in inches (millimeters) unless otherwise indicated	
INTAKE VALVE SEAT	
Seat Cylinder Head Bore Diameter	1.5645-1.5655 (39.74-39.76)
Seat Outside Diameter	1.5690-1.5700 (39.85-39.88)
Valve Seat Width	0.0310-0.0470 (0.787-1.194)
Valve Seat Angle	45°
EXHAUST VALVE	
Stem Diamter	0.3410-0.3420 (8.661-8.687)
Clearance (Stem to Guide)	0.0025-0.0040 (0.064-0.102)
Valve Face Angle	44°
EXHAUST VALVE SEAT	
Seat Cylinder Head Bore Diameter	1.2510-1.2520 (31.78-31.80)
Seat Outside Diameter	1.2550-1.2560 (31.88-31.90)
Valve Seat Width	0.0310-0.0470 (0.787-1.194)
Valve Seat Angle	45°
VALVE GUIDE	
Intake Inside Diameter	0.3440-0.3460 (8.738-8.788)
Exhaust Inside Diameter	0.3440-0.3460 (8.738-8.788)
TAPPET	
Body Diameter	0.7475-0.7480 (18.99-19.00)
Bore Diameter	0.7500-0.7515 (19.05-19.09)
Clearance in Bore	0.0020-0.0040 (0.051-0.102)
VALVE SPRINGS INTAKE AND EXHAUST	
Valve Spring Free Length (Approx.)	1.662 (42.21)
Valve Spring Length	
Valve Open	1.125 (28.58)
Valve Closed	1.375 (34.93)
Spring Load (Valve Open Length)	71 lb. (32 kg)
Spring Load (Valve Closed Length)	38 lb. (17 kg)
GEAR BACKLASH	
Timing Gear	0.0010-0.0050 (0.025-0.127)
Oil Pump Gear	0.0010-0.0080 (0.025-0.203)

THREAD TORQUES	
Bolt torques are in lb-ft (N-m)*	
Cylinder Head Nuts (Cold, with compression washers)	15-17 (20-23)
Connecting Rod Bolts	27-29 (37-39)
Rear Bearing Plate Screws	25-27 (34-37)
Flywheel Mounting Capscrews	50-55 (67-75)
Oil Base Screws	18-23 (24-31)
Oil Pump	7-9 (10-12)
Valve Cover	4-8 (5-11)
Gearcase Cover	8-10 (11-14)
Spark Plug	7-9 (9-12)
Exhaust Manifold Mounting Screws	9-11 (12-15)
Intake Manifold Mounting Screws	20-23 (27-31)
Starter Mounting Screws	19-21 (25-28)
Other 1/4” Cylinder Block Stud and Nuts	7-9 (10-12)
Other 5/16” Cylinder block Stud and Nuts	8-10 (11-14)
Other 3/8” Cylinder Block Stud and Nuts	18-23 (24-31)
Rotor Through-Bolt	49-56 (60-76)
Stator Feet to Base	16-20 (22-27)
Adapter-Engine Mounting Screws	25-29 (34-39)
Adapter-Generator Mounting Screws	25-35 (34-47)
Rear Vibration Isolators Center Screw Flange to Drip Tray Screws	 30-35 (41-47) 16-20 (22-27)
Front Vibration Isolators Center Screw Flange to Oil Base Screws	 30-35 (41-47) 16-20 (22-27)
* - Use engine oil as a lubricant for all threads EXCEPT for spark plug and rotor through-bolt threads.	
Engine to Mounting Plate	30-35 (41-47)
Skidbase to Pallet	16-22 (22-27)

3. Operation

ENGINE OIL RECOMMENDATIONS

Use premium quality motor oil. Look for the API (American Petroleum Institute) classification and use Class SG or SH oil (also SG/CD, SG/CE, SH/CD, or SH/CE). Also look for the SAE (Society of Automotive Engineers) viscosity grade. Referring to Table 3-1, choose the viscosity grade appropriate for the ambient temperatures expected during the period of time until the next scheduled oil change.

Single-grade SAE 30 oil is preferable when temperatures are consistently above freezing. Multigrade oils are better when wide temperature variations are expected.

Synthetic oil is recommended in regions with temperature extremes when you only change oil once a year.

TABLE 3-1. OIL VISCOSITY VS. TEMPERATURE

EXPECTED AMBIENT TEMPERATURES	SAE VISCOSITY GRADE
32°F (0°C) and higher	30
10°F to 100°F (-12°C to 38°C)	15W-40 (OnaMax)
0°F to 80°F (-18°C to 27°C)	10W-30 10W-40
-20 °F to 50°F (-28°C to 10°C)	5W-30

STARTING BATTERY

This genset has a 12 VDC starting battery and control system. See *Specifications* in Section 2 for minimum battery requirements for genset cranking.

FUEL RECOMMENDATIONS

⚠WARNING ***Fuels are flammable and explosive and can cause severe personal injury or death. Do not smoke if you smell gas or are near fuel tanks or fuel-burning equipment or are in an area sharing ventilation with such equipment. Keep flames, sparks, pilot lights, arc-producing equipment, switches, and all other sources of ignition well away. Keep a type ABC fire extinguisher handy.***

NFPA Standard No. 58 requires all persons handling and operating LP to be trained in proper handling and operating procedures.

When natural gas is the required fuel, use commercially available natural gas fuel having a methane content of at least 90 percent (by volume).

When LP (liquified petroleum) is the required fuel, use grade HD-5 or equivalent consisting of at least 90 percent propane. Commercial LP may contain more than 2.5 percent butane, which can result in poor fuel vaporization and poor engine starting in ambient temperatures below 32° F (0° C).

Satisfactory performance requires that fuel be supplied at a pressure within the range indicated in *Specifications*.

⚠WARNING ***High gas supply pressure can cause gas leaks which can lead to fire and severe personal injury or death. Gas supply pressure must be adjusted to Specifications in Section 2 by qualified personnel.***

FUEL SELECTION

The natural gas/LP vapor genset leaves the factory set up for natural gas. If the genset is to be run on LP vapor it must be converted for use with LP vapor. See NG/LP Vapor Fuel System in Section 6.

A genset purchased to use natural gas or LP vapor cannot be converted to use LP liquid, and one that is purchased to use LP liquid cannot be converted to use natural gas or LP vapor.

⚠CAUTION ***Wrong fuel selection can result in hard starting, poor genset performance, and fault shutdown.***

GENSET CONTROL

Figure 3-1 shows the genset control panel. The control features are as follows:

Control Switch - This is a three-position **Run-Off-Auto** switch with a status/diagnostics light. The **Run** and **Off** positions are for manual starting and stopping of the genset. The **Off** position is also used for resetting the controller following a fault shutdown. The **Auto** position is for remote start or transfer switch control.

Status/Diagnostics Light - This is an LED (light emitting diode) in the control switch. It blinks rapidly during cranking. It blinks in a coded fashion to indicate the nature of a genset shut down or of maintenance required to keep the genset running. See *Troubleshooting* in Section 11.

Hour Meter - The hour meter records the total running time of the genset. It cannot be reset.

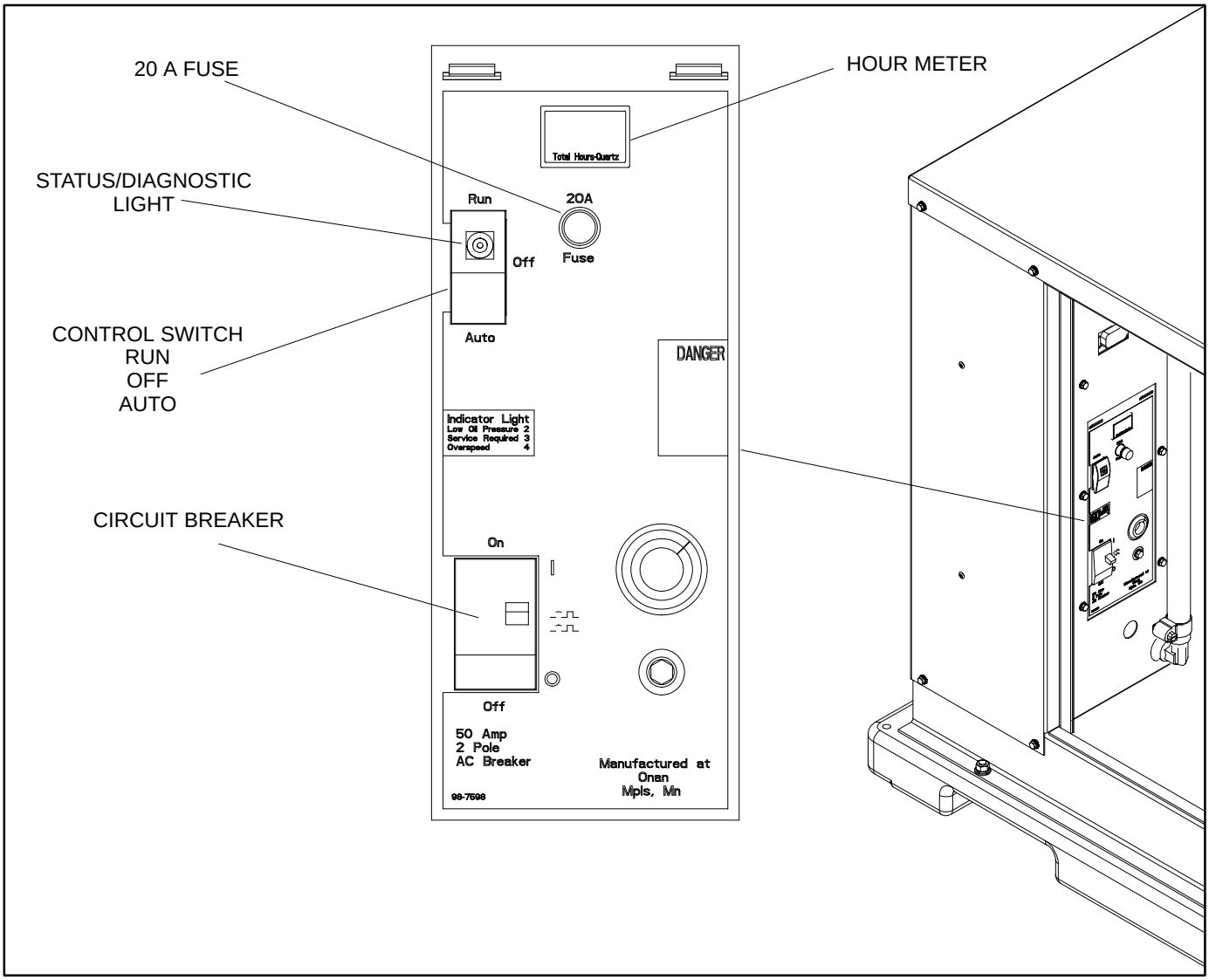

FIGURE 3-1. GENSET CONTROL

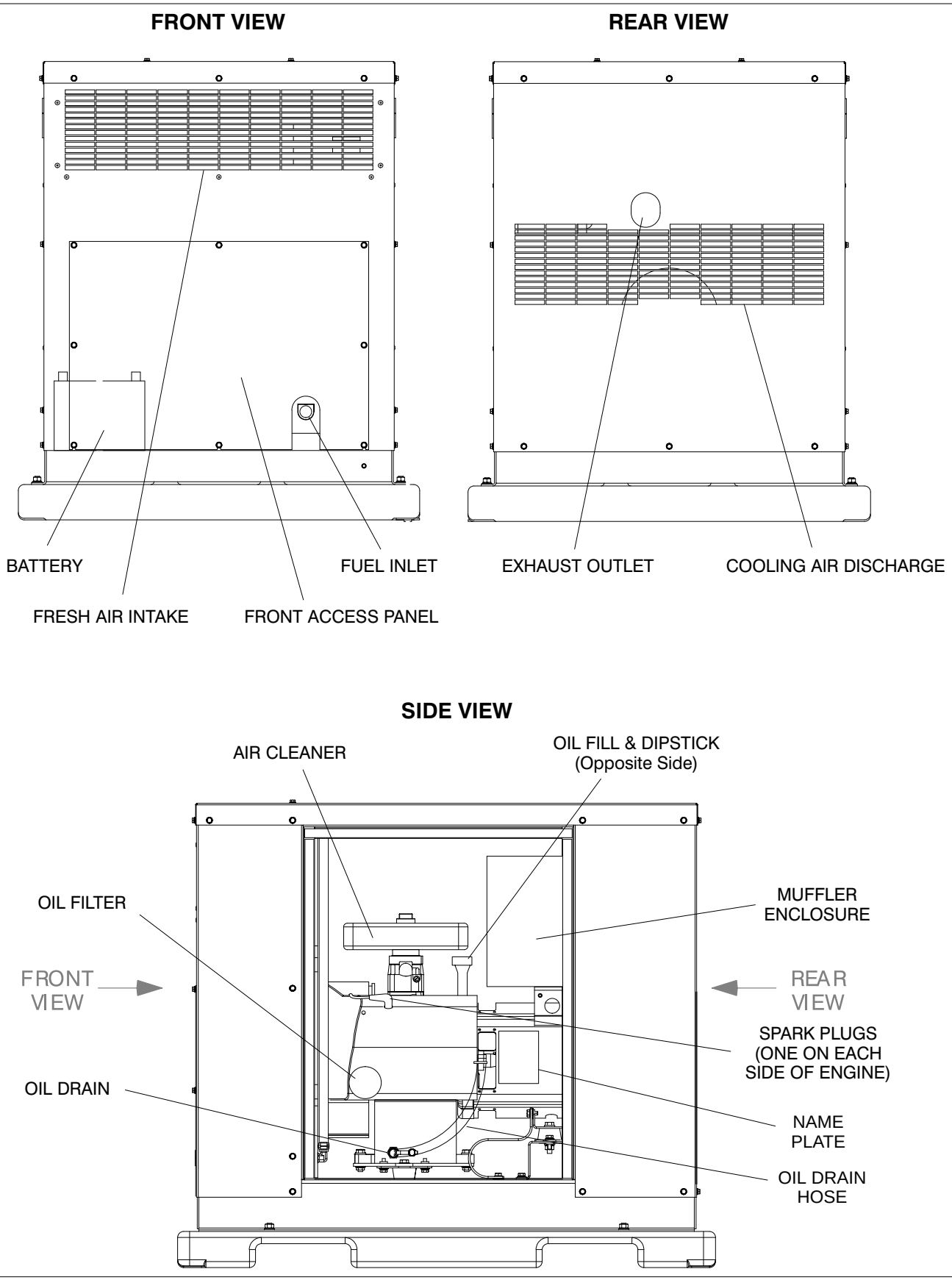

FIGURE 3-2. GHAB GENSET

⚠WARNING ***EXHAUST GAS IS DEADLY!***

All engine exhaust contains carbon monoxide, an odorless, colorless, poisonous gas that can cause unconsciousness and death. Symptoms of carbon monoxide poisoning include

- ***Dizziness***
- ***Headache***
- ***Weakness and Sleepiness***
- ***Nausea***
- ***Vomiting***
- ***Inability to Think Coherently***

IF YOU EXPERIENCE ANY OF THESE SYMPTOMS, GET INTO FRESH AIR IMMEDIATELY. If symptoms persist, seek medical attention. Shut down the genset and do not operate it until it has been inspected and repaired.

The exhaust system is an integral part of the genset. Do not modify the exhaust system. Make sure there is ample fresh air when operating the genset in a confined area.

STARTING AND STOPPING THE GENSET

Pre-start Checks

Perform the maintenance checks instructed in *General Inspection* (see page 4-2). Service the genset and make repairs as required if a fault shutdown code displays (see *Troubleshooting* in Section 11). Also, see *Genset Break-In* and *Genset Storage* in this section before placing in service a new or rebuilt genset or one that has been in storage.

Manual Starting

Push the control switch to **Run**. The engine should crank, start, and run up to governed speed in a few seconds. The starter disconnects automatically as the status light stops blinking.

If the engine does not start (after 20 seconds of cranking), the starter disengages. See *Troubleshooting* in Section 11 if the engine does not start.

Check for fuel and exhaust leaks. Stop the genset immediately if there is a fuel or exhaust leak and have it repaired before continuing operation.

Whenever possible, allow the engine to warm up for a few minutes before connecting the electrical loads.

Manual Stopping

Push the control switch to **Off**. Whenever possible, allow the engine to cool down with the electrical loads disconnected for a few minutes before stopping the genset.

⚠CAUTION ***Failure to push the control switch to AUTO before leaving the genset renders the genset unavailable for automatic standby service.***

Automatic Starting and Stopping

Push the control switch to **Auto** for remote, automatic starting and stopping (transfer switch).

⚠WARNING ***Automatic startup of the genset while performing maintenance or service can cause severe personal injury or death. Push the control switch to Off and disconnect the negative (-) battery cable from the battery to keep the genset from cranking and starting while working on it.***

POWERING EQUIPMENT

Genset Loading

How much electrical equipment (system load) can be connected at one time depends upon how much power is available from the genset (see *Specifications*, Section 2) and the type of load being supplied. If the genset is "overloaded," its circuit breaker trips or its controller shuts it down or both.

Determine how much equipment can be operated at one time by adding the power consumption ratings of the individual system loads that are likely to be used at the same time. Compare the sum of the loads to the kW (kilowatt) rating of the genset. Note that 1 kW = 1000 watts. See Table 3-2 for power consumption of typical residential appliances.

Note that when a genset is loaded nearly to full power and one of the large motor loads (such as an air conditioner) "cycles on," an undervoltage or under frequency fault shutdown (Code Numbers 13 and 15) could occur. The reason is that for a brief moment, at startup, motors can draw up to three or more times their rated power consumption. You may, therefore, have to consider shutting off some loads at times when large motor loads are "On." When powering large motor loads (such as an air conditioner) it is recommended that the total load should not exceed 80% of the genset kW rating.

Operating at High Altitude or High Temperature

Air density is less at higher altitudes, resulting in less available engine power. Power decreases approximately 3.5 percent of rated power each 1000 feet (305 meters) of increase in elevation above sea level. Power also decreases approximately 1.5 percent each 10°F (5.5°C) increase in ambient temperature above 77°F (25°C).

TABLE 3-2. TYPICAL APPLIANCE POWER CONSUMPTION

Appliance	Typical Watts	Basic Loads	Loads Chosen
Basic Needs			
Electric Lighting - N=Number of 100 W Bulbs	N 100 W Bulbs	N x 100 =	
Furnace - Gas	750		
Electric Heat (See Heater Nameplate)	2000-5000		
Well Pump - 1/2 HP	1000		
Well Pump - 1 HP	2000		
Refrigerator - 20 Cu. Ft.	800		
Heat Pump	5000		
Electric Water Heater	5000		
Security System	20		
Freezer - 20 Cu. Ft.	550		
Sump Pump 1/3 HP	500		
Garage Door Opener - 1/3 HP	500		
Garage Door Opener - 1/2 HP	720		
Typical Discretionary Loads			
Microwave Oven - 800 Watt	1200		
Microwave Oven - 1000 Watt	1500		
Coffee Maker	900		
Dishwasher	1400		
Toaster	900		
Computer	250		
Electric Range - Two Burners	2900		
Electric Range - Oven	7500		
TV - 13” Color	70		
TV - 32” Color	170		
VCR	60		
Stereo System	140		
Electric Iron	1100		
Electric Clothes Dryer	6000		
Gas Clothes Dryer	720		
Washing Machine	1000		
Electric Hair Dryer	1600		
Air Conditioner - 1 Ton	2000		
Air Conditioner - 2Ton	3000		
Air Conditioner - 3 Ton	4500		
Window A/C - 17,800 BTU	2000		
Ceiling Fan	100		
Vacuum Cleaner	780		
Central Vacuum	1750		
Total Basic Loads:			
Total Chosen Loads:			
Total Power Requirement:			

How To Use the Table

Table 3-2 lists the typical power consumption of some common household appliances. The value in the table is a typical value, check the value on the nameplate of your appliance for the most accurate value. Also, you may want to use appliances that are not listed in the table. In that case, use the value on the nameplate of the appliance for its power consumption. For the most accurate genset loading, substitute the values from the nameplates on the appliances for all calculations.

Select the appliances that satisfy your basic needs and write the power consumption in the Basic Loads column. Add the power consumption of all Basic Loads and place it in the Total Basic Loads box at the bottom of the table.

Compare the Basic Loads Total with the rated output of the genset. If the genset still has additional capacity (that is the Basic Loads Total is less than 80% of the genset capacity), you can select additional loads from the list. Write the power consumption of these additional loads in the Loads Chosen column. Add the power consumption of all Chosen Loads and place it in the Total Chosen Loads box at the bottom of the table. You can add loads to the Basic Loads until you reach 80% of the genset capacity.

Example

Using the chart on the previous page for a genset rated at 10 kW. Select a total load less than 8kW (8000 watts) in order to operate within the 80% limit.

Well Pump (1/2 HP)	1000
Refrigerator	800
Air Conditioner (2 ton)	2000
10 100 watt Bulbs	1000
Sump Pump (1/3 HP)	500
Microwave Oven (1000 W)	1500
Coffee Maker	900
Total	**7700**

This example uses 7700 watts. You could still safely use a TV, a small appliance, or even your computer before you exceed the 80% limit.

Remember that some loads are intermittent. For example your refrigerator does not run constantly. However, as it starts it requires considerably more current than when it is running. For the sake of the calculation from the table assume that all loads are constant. If total power consumption exceeds genset power output, the genset may shut down. In this case, you may have to operate some loads in sequence, one after another, rather than all at the same time.

If the load on the genset exceeds the rated capacity of the genset, the genset shuts down. If the genset shuts down under load, remove loads by turning off appliances, press the switch on the control to OFF and back to AUTO to allow automatic remote restarting.

Restarting The Genset

If the genset shuts down because it is overloaded, disconnect or turn off as many loads (appliances) as possible and try to restart the genset as instructed in *Starting and Stopping* in this section. Reconnect the loads one by one up to 80% of the genset rating.

Resetting Circuit Breakers

If a circuit breaker in the main power distribution panel or on the genset (see Figure 3-1) trips, there is either a short circuit or too many loads operating at the same time. Note that the genset continues to run after a circuit breaker trips.

If a circuit breaker trips, disconnect or turn off as many loads (appliances) as possible and reset the circuit breaker. If the circuit breaker trips right away, either the main distribution system has a short or the circuit breaker is faulty.

If the circuit breaker does not trip, reconnect the loads, one by one, up to 80% of the genset rating. If a circuit breaker trips right away when a load is connected, the load probably has a short.

Connecting The System To Utility Power

An approved device such as an automatic transfer switch must be provided to keep the genset and utility from being interconnected. The automatic transfer switch automatically reconnects the utility when service is restored.

⚠WARNING ***Interconnecting the genset and the public utility (or any other power source) can lead to the electrocution of utility workers and damage to equipment and fire. An approved switching device must be used to prevent interconnections.***

VARYING OPERATING CONDITIONS

Cold Weather

Perform maintenance due according to *Periodic Maintenance* in Section 4. See *Engine Oil Recommendations* in this section.

An optional thermostatically controlled heater for the battery is recommended for more reliable starting in ambient temperatures down to -20° F (-28.8 °C).

Hot Weather

Perform maintenance according to Table 4-1 of *Periodic Maintenance*. Make sure nothing blocks airflow to and from the genset. Keep the cooling fins clean.

High Altitude

See *Powering Equipment* in this section for information on how altitude affects the maximum power output of the genset.

Dusty Conditions

Keep the cooling fins clean. Perform air cleaner maintenance and change engine oil and oil filter more often than usual. See *Periodic Maintenance* in Section 4.

GENSET BREAK-IN

Proper engine break-in on a new genset or on one with a rebuilt engine is essential for top engine performance and acceptable oil consumption. For proper break-in, run the genset at 1/2 rated power for the first 2 hours and then at 3/4 rated power for 2 more hours. Avoid light load or no load operation during break in. See *Powering Equipment* in this section.

Proper engine oil and oil level are especially critical during break-in because of the higher engine temperatures that can be expected. See *Engine Oil Recommendations* in this section. Check the oil level twice a day or every 4 hours during the first 24 hours of operation and change the oil after the first 25 hours of operation.

GENSET EXERCISE

If genset use is infrequent, it is recommended that the genset be exercised at least 1/2 hour, once a month, without load. Exercising the genset drives off moisture, re-lubricates the engine, and removes oxide from electrical contacts and generator slip rings, thereby promoting better starting, more reliable operation, and longer engine life.

An operator can exercise the genset by placing the control switch in the ON position. The genset would start and run at no load for a time determined by the operator. When the exercise period is finished, return the control switch to the AUTO position.

⚠ CAUTION ***Failure to push the control switch to AUTO before leaving the genset renders the genset unavailable for automatic standby service.***

When a transfer switch with an exerciser clock is available, set the clock to exercise the genset once a month for 1/2 hour at no load.

See the transfer switch operator's manual for instructions on how to adjust and activate the genset exerciser clock.

GENSET STORAGE

If the genset is to be stored for 120 days or longer, proper storage is essential for preserving top genset performance and reliability.

Storing the Genset

1. Push the genset line circuit breaker **OFF** (Figure 3-1).

2. Remove the air filter and start the genset. While the genset is running, spray an engine fogger (OnaGard™)[1] into the carburetor, following the instructions on the container label, and then stop the genset. (A fogger coats the intake, cylinder and exhaust systems with a protective coat of oil.)

3. Change the engine oil and oil filter. Also, change the air filter if it is dirty.

4. Disconnect the battery cables (negative [**-**] cable first) from the starting battery and store the battery according to the battery manufacturer's recommendations.

5. Close the fuel supply valve. If the genset is being removed from the premises, cap or plug any unused fuel line to prevent gas leakage if a fuel shutoff valve is opened inadvertently.

⚠WARNING ***Leaks can lead to explosive accumulations of gas. Natural gas rises when released and can accumulate under hoods and inside housings and buildings. LP vapor sinks when released and can accumulate inside housings and basements and other below-grade spaces. Prevent leaks and the accumulation of gas.***

1. OnaGard is a trademark of the Onan Corporation.

Returning The Genset To Service

1. Reconnect the starting battery (negative [**-**] cable last). See *Battery Care* in Section 4.

2. Open the fuel supply valve.

3. Inspect the genset. See General Inspection.

4. Start the genset at the genset control panel. The initial startup may be slow and there may be smoke and rough operation for a few minutes until the oil in the cylinders from the fogger burns off. If the engine does not start, clean or replace the spark plugs as they may have been fouled by the fogger.

5. Push the genset line circuit breaker to **Run** (Figure 3-1) and the control switch to **Auto** for remote, automatic starting and stopping (transfer switch).

⚠ CAUTION ***Failure to push the control switch to AUTO before leaving the genset renders the genset unavailable for automatic standby service.***

4. Periodic Maintenance

⚠WARNING ***Automatic startup of the genset while performing maintenance or service can cause severe personal injury or death. Push the control switch to Off and disconnect the negative (-) battery cable from the battery to keep the genset from starting while working on it.***

Periodic maintenance is essential for top performance and long genset life. Use Table 4-1 as a guide for normal periodic maintenance. Under hot or dusty operating conditions some maintenance operations should be performed more frequently, as indicated by the footnotes in the table. Keep a log of maintenance performed and the hours run. Recording maintenance helps you keep it regular and provide a basis for supporting warranty claims.

Maintenance, replacement, or repair of emission control devices and systems may be performed by any engine repair establishment or individual. However, warranty work must be completed by an authorized Cummins/Onan dealer or distributor.

TABLE 4-1. PERIODIC MAINTENANCE SCHEDULE

MAINTENANCE OPERATION	MAINTENANCE FREQUENCY					
	Every 8 Hours	Every Month	Yearly or Every		Every 500 Hours	Page
			100 Hours	200 Hours		
General Inspection	X					4-2
Check Engine Oil Level	X					4-3
Clean and Check Starting Battery		X				4-7
Change Engine Oil and Oil Filter			X[1, 2, 3]			4-4
Adjust Engine Valve Clearance (Lash)			X[5, 6]			6-2
Replace Engine Air Filter				X[1]		4-5
Replace Spark Plugs and Cables					X[4]	4-6
Clean Engine Cooling Fins					X[4, 5]	6-4

1. Perform more often when operating in dusty conditions.
2. Perform first time at 24 hours.
3. Perform more often when operating in hot weather.
4. Perform sooner if engine performance deteriorates.
5. Must be performed by a qualified mechanic (authorized Cummins/Onan dealer).
6. Perform first time at 50 hours then every 100 hours.

GENERAL INSPECTION

Inspect the genset according to the genset Periodic Maintenance Schedule.

Oil Level

Check the engine oil level as explained under *Checking Engine Oil Level* in this section.

Exhaust System

Look and listen for exhaust system leaks while the genset is running. Shut down the genset if a leak is found and have it repaired before operating the genset.

Fuel System

Check the fuel supply line and fittings for leaks while the genset is running. Check flexible fuel hose sections for cuts, cracks, and abrasions. Make sure the fuel line is not rubbing against other parts. Replace worn or damaged fuel line parts before leaks occur.

⚠WARNING ***Gaseous fuels are highly flammable and explosive and can cause severe personal injury or death. Shut down and repair leaks immediately.***

Battery Connections

Check the battery terminals for clean, tight connections. Loose or corroded connections have high electrical resistance which makes starting harder. Shut the genset off and disconnect corroded or loose battery cables (negative [**-**] cable first) and clean and reconnect them as instructed under *Battery Care* in this section.

⚠WARNING ***Batteries give off explosive gases that can cause severe personal injury. Do not smoke near batteries. Keep flames, sparks, pilot lights, electrical arcs and arc-producing equipment and all other ignition sources well away.***

Do not disconnect the battery charger or battery cables while the genset is cranking or running: the arcing can ignite the explosive battery gases.

Mechanical

Look for mechanical damage. Start the genset and look, listen, and feel for any unusual noises and vibrations.

Check to see that the genset air inlet and outlet openings are not blocked or clogged with debris.

Clean accumulated dust and dirt from the genset. Do not clean the genset while it is running or still hot. Always wear safety glasses when using compressed air.

⚠WARNING ***Always wear safety glasses when using compressed air to avoid severe eye injury.***

CHECKING ENGINE OIL LEVEL

Set the genset control to the Off position before checking the engine oil level.

1. Remove the oil fill cap/dipstick (see Figure 4-1), wipe it clean, screw the cap back on and then remove it again to check the oil level on the dipstick.

   ⚠WARNING ***Crankcase pressure can blow hot engine oil out the fill opening causing severe burns. Always stop the genset before removing the oil fill cap.***

2. Add oil as necessary until the full mark is reached. See *Engine Oil Recommendations* in Section 3. **Do Not Fill to a Level Above the Full Mark on the Dipstick**. Drain the excess oil if too much has been added.

   ⚠CAUTION ***Too much oil can cause high oil consumption, high operating temperatures and oil foaming. Too little oil can cause severe engine damage. Keep the oil level between the Full and Add marks on the dipstick.***

3. Secure the oil fill cap by turning 1/4 turn to prevent oil leakage.

Return the genset control to Auto when finished performing maintenance.

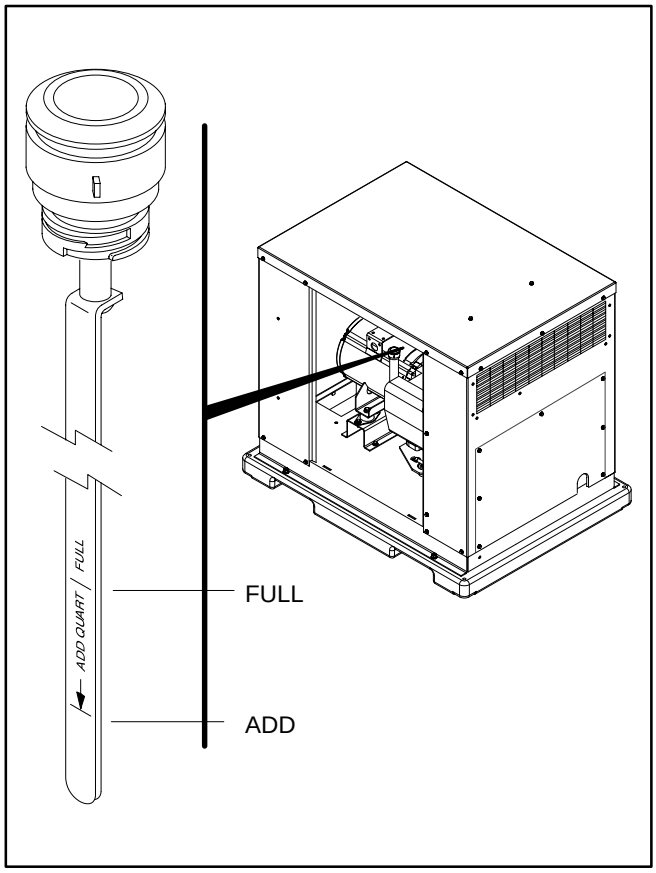

FIGURE 4-1. OIL LEVEL CHECK

CHANGING ENGINE OIL AND OIL FILTER

Refer to Table 4-1 for scheduled engine oil change. In hot weather and dusty conditions the oil should be changed more often.

Set the genset control to the Off position before changing engine oil.

⚠WARNING ***State and federal agencies have determined that contact with used engine oil can cause cancer or reproductive toxicity. Take care to limit skin contact and breathing of vapors as much as possible. Use rubber gloves and wash exposed skin.***

1. Place a pan under the oil drain hose. Run the engine until it is warm and then shut it off.

2. Remove the oil fill cap (see Figure 4-2), remove the hose plug, open the oil drain valve (grasp the hose near the engine, push in to stop, turn counter-clockwise to stop, and release) (see Figure 3-2), and allow all of the oil to drain from the engine.

3. Close the oil drain valve (grasp the hose near the engine, push in to stop, turn clockwise to stop, and release) and replace the hose plug.

4. Spin off the oil filter canister (see Figure 3-2) and catch the oil in the canister. Discard the oil filter according to local regulations.

5. Thoroughly wipe off the filter mounting surface. Make sure that the mounting surface is clean and free of filter particles (gasket from old filter is not stuck to surface).

6. Make sure the gasket is in place on the new filter canister and apply a thin film of oil to the gasket.

7. Spin on the new filter canister by hand until the gasket just touches the mounting pad and then turn it an additional 1/2 to 3/4 turn. Do not overtighten.

8. Refill with oil (see *Engine Oil Recommendations* in Section 3 and *Specifications* in Section 2) for oil capacity. Check oil level.

9. Secure the oil fill cap with a 1/4 turn to prevent oil leakage.

10. Used oil is harmful to the environment if it is not disposed of properly. Pour used oil into a sealed container and deliver it to the nearest recycling center or automotive service station.

Return the genset control to Auto when finished performing maintenance.

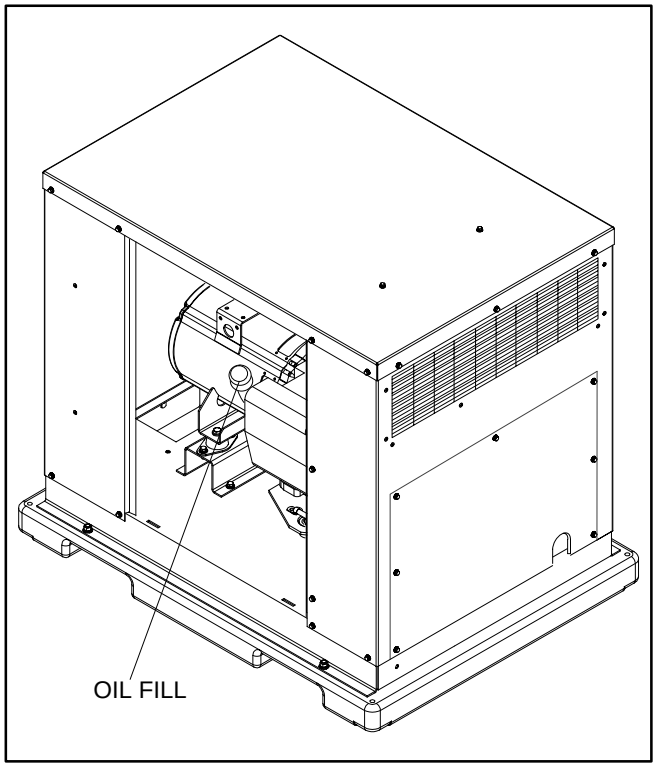

FIGURE 4-2. OIL FILL LOCATION

AIR FILTER

Refer to Table 4-1 for scheduled air filter replacement. In dusty conditions the air filter element and wrapper should be inspected and changed more frequently for best operation.

Set the genset control to the Off position before checking the air filter.

To change the air filter element and wrapper, remove the through-bolt and cover (Figure 4-3). Reassemble the air filter with a new air filter element and wrapper. ***Do not oil the filter or wrapper.*** Do not over-tighten the through bolt as that can distort the filter element or cover and lead to air leaks around the air filter element.

Return the genset control to Auto when finished performing maintenance.

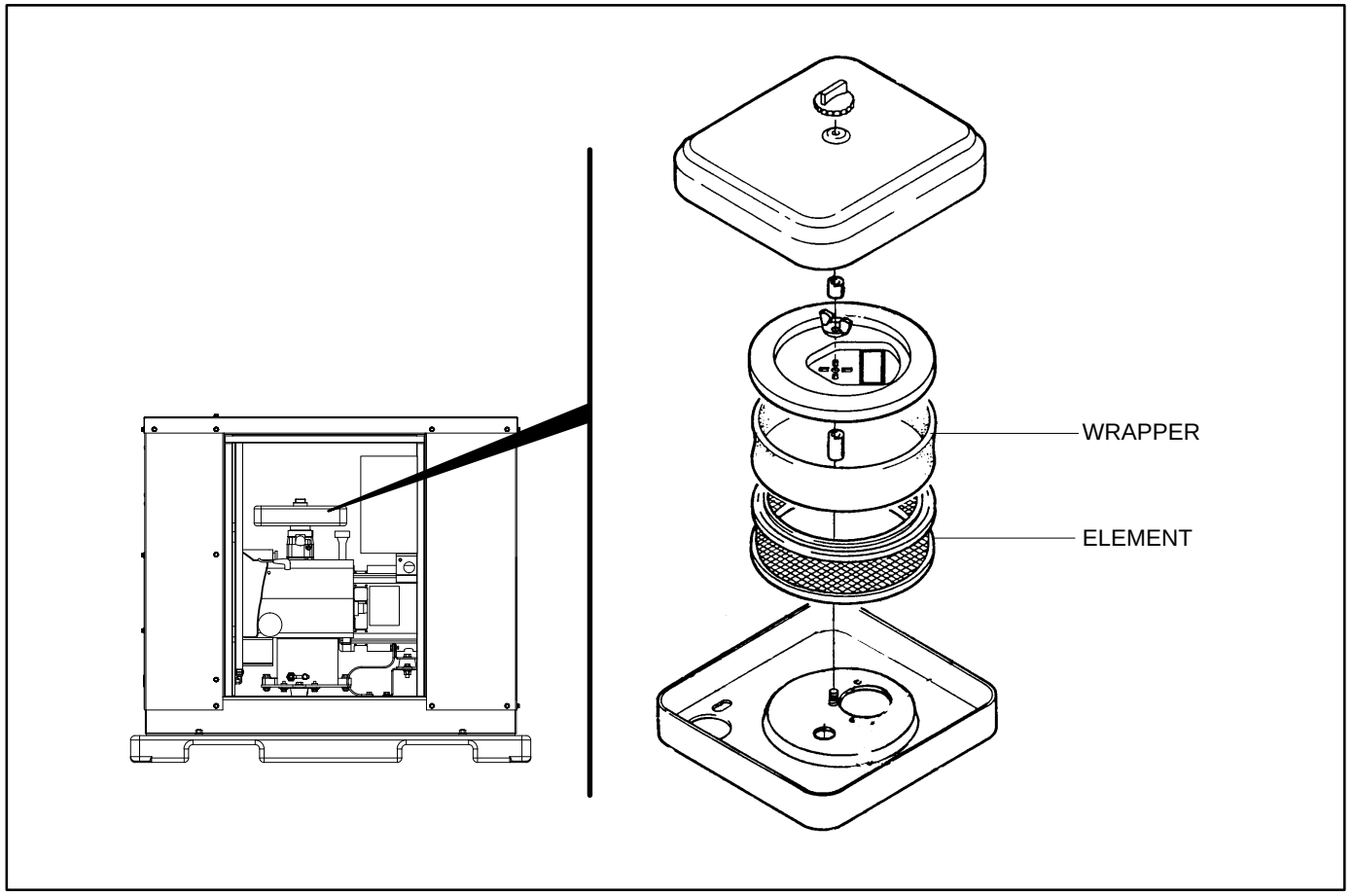

FIGURE 4-3. AIR FILTER ELEMENT AND WRAPPER

SPARK PLUGS

Set the genset control to the Off position before checking the spark plugs.

See Table 4-1 for scheduled spark plug replacement. (The genset has two spark plugs: one on each side of the engine, see Figure 4-3.) The spark plugs must be in good condition for proper engine starting and performance. A spark plug that fouls frequently or has heavy soot deposits indicates the need for engine service. See *Troubleshooting* in Section 11.

To prevent crossthreading a spark plug, always thread it in by hand until it seats. If the spark plug is being reused, turn it with a wrench an additional 1/4 turn. If the spark plug is new, turn it an additional 3/8 to 1/2 turn. If you have a torque wrench, tighten the spark plug to 8 lb-ft (10 N-m).

Return the genset control to Auto when finished performing maintenance.

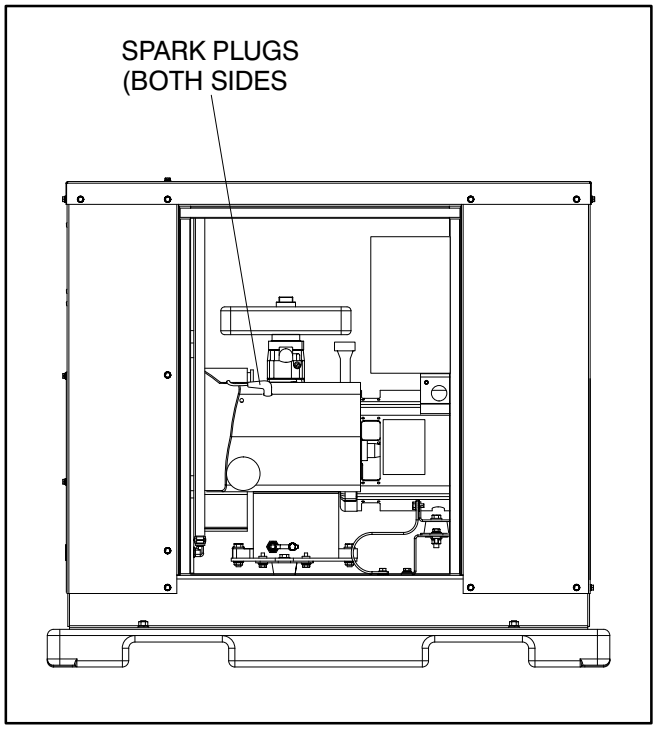

FIGURE 4-3. SPARK PLUGS

BATTERY CARE

See Table 4-1 for scheduled battery maintenance and to the battery manufacturer's recommendations and instructions for battery care.

Set the genset control to the Off position before checking the battery.

⚠WARNING ***Batteries give off explosive gases that can cause severe personal injury. Do not smoke near batteries. Keep flames, sparks, pilot lights, electrical arcs and arc-producing equipment and all other ignition sources well away.***

Do not disconnect the battery charger or battery cables while the genset is cranking or running: the arcing can ignite the explosive battery gases.

⚠WARNING ***Battery electrolyte can cause severe eye damage and skin burns. Wear goggles, rubber gloves and a protective apron when working with batteries.***

Maintain the battery as follows unless the battery manufacturer has other instructions and recommendations:

1. Keep the battery case clean and dry.

2. Make certain that the battery cable connections are clean and tight. Use a terminal puller tool to remove the battery cables.

3. Identify the cable as positive (**+**) or negative (**-**) before making the battery connections. Always remove the negative (**-**) cable first and connect it last, to reduce the risk of arcing.

4. To remove corrosion from the battery terminals, wash the terminals with an ammonia solution or a solution consisting of 1/4 pound (about 100 grams) of baking soda in 1 quart (about 1 liter) of water. Be sure the vent plugs are tight to prevent cleaning solution from entering the cells. After cleaning, flush the outside of the battery and the surrounding areas with clean water.

5. If the battery is not of the "maintenance-free" type, maintain the electrolyte level by adding distilled water. Fill each cell to the split-level marker in the battery. The water component of the electrolyte evaporates, but the sulfuric acid component remains. For this reason, add water, not electrolyte to the battery.

6. Use a battery hydrometer to check the specific gravity of the electrolyte in each battery cell (see Figure 4-4). Charge the battery if the specific gravity measures less than 1.215. Do not overcharge the battery. Stop charging the battery when the electrolyte specific gravity reaches 1.260, at approximately 80° F (27° C).

Return the genset control to Auto when finished performing maintenance.

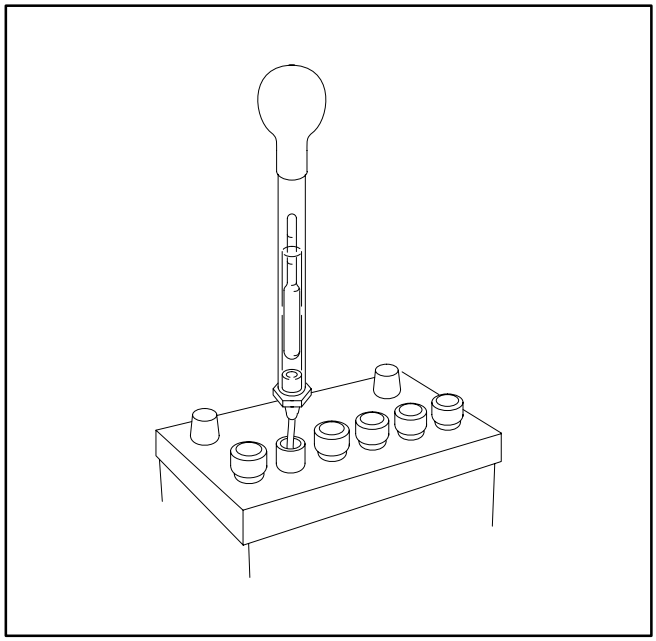

FIGURE 4-4. BATTERY CHECK WITH HYDROMETER

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5. Preparations for Service

SAFETY

There are hazards in servicing gensets. Study *Safety Precautions* and become familiar with the hazards listed in Table 5-1. Note the following safeguards and ways of avoiding hazards:

- ***Reduce the hazard:*** A safe, orderly workshop area and well-maintained equipment reduce the hazard potential. Keep guards and shields in place on machinery and maintain equipment in good working condition. Store flammable liquids in approved containers; away from fire, flame, spark, pilot light, switches, arc-producing equipment and other ignition sources. Keep the workshop clean and well lighted and provide adequate ventilation.
- ***Develop safe work habits:*** Unsafe procedures lead to accidents when using tools and machines. Be familiar with the equipment and its safe use. Use the correct tool for the job and check its condition before using it. Observe the warnings in this manual. Take special precautions when working around electrical equipment. Do not work alone, if possible. Do not take risks.
- ***Use personal protection:*** Wear appropriate protective safety equipment, such as safety shoes and safety glasses. Do not wear rings or jewelry and do not wear loose or damp clothing that might get caught in equipment or conduct electricity.
- ***Be prepared for an accident:*** Keep fire extinguishers and safety equipment nearby. Agencies such as the Red Cross and public safety departments offer courses in first aid, CPR and fire control. Take advantage of this information and be ready to respond to an accident. Learn to be safety-conscious and make safety procedures part of the work routine.

TABLE 5-1. HAZARDS AND THEIR SOURCES

Fire and Explosion	• Leaking fuel • Hydrogen gas from battery • Oily rags improperly stored • Flammable liquids improperly stored
Burns	• Hot exhaust pipes • Hot engine and generator surfaces • Electrical shorts • Jewelry touching electrical components
Poisonous Gas	• Operating genset where exhaust gases can accumulate
Electrical Shock	• Improper generator connections • Faulty wiring • Working in damp conditions • Jewelry touching electrical components
Rotating Machinery	• Fan and pulley guards not in place
Slippery Surfaces	• Leaking or spilled oil
Heavy Objects	• Mounting or removing genset

SPECIAL TOOLS

The following tools are necessary for servicing the genset:

Engine Tools

Torque wrench: 0-75 lb-ft (0-100 N-m)

Hole gauge: 0.300-0.400 inch (5-10 mm)

Outside micrometer set: 0-4 inch (0-100 mm)

Telescoping gauge set: up to 4 inch (100 mm)

Feeler gauge

Plasti-Gage bearing clearance guide

Spark plug gap gauge

Oil pressure gauge: 0-30 psi (0-200 kPa)

Manometer: 14 inch (350 mm) WC

Inclined Manometer: 1 inch (25 mm) WC range with 0.01 inch (0.1 mm) WC divisions

Cylinder compression tester

Flywheel puller

Crankshaft gear puller ring, bolts and puller (or special shoulder bolts and flywheel puller)

Snap ring pliers

Combination main and cam bearing remover

Combination main and cam bearing driver

Oil seal loader and driver

Cylinder ridge reamer

Piston ring spreader

Piston groove cleaner

Piston ring compressor

Cylinder hone

Valve spring compressor

Valve lock replacer

Valve seat cutter kit

Valve guide driver

Slide hammer

Lead or dead-blow hammer

Generator and Control Tools

Rotor removal tool (headless bolt) (approximately 13 3/8 inches long)

Commutator stone

Battery hydrometer

Digital multi-meter

Load test panel and leads

REMOVING AND INSTALLING THE HOUSING PANELS

Before removing housing panels (Figure 5-1) to access the genset for maintenance or service, perform the following steps.

⚠WARNING ***Gaseous fuels are flammable and explosive and can cause severe personal injury or death. Do not smoke if you smell gas or are near fuel tanks or fuel-burning equipment or are in an area sharing ventilation with such equipment. Keep flames, sparks, pilot lights, electrical switches and arc-producing equipment and all other sources of ignition well away. Keep a type ABC fire extinguisher handy.***

NFPA Standard No. 58 requires all persons handling and operating gaseous fuel to be trained in proper handling and operating procedures.

1. Close the fuel supply shut off valve. If the genset can be started, purge the fuel supply line and genset as much as possible by running the genset until it runs out of fuel with the shut off valve closed.
2. Press the control switch to **Stop**.
3. Remove the front access panel (Figure 5-1).

   ⚠WARNING ***This unit can start automatically. Accidental starting of the generator set while working on it can cause severe personal injury or death. Prevent accidental starting by disconnecting the negative (-) cable from the battery terminal.***

4. Disconnect the negative (**-**) battery cable from the battery to prevent accidental starting.

⚠WARNING ***Do not operate the genset without the housing panels secured in place. The panels guard against rotating parts and bare live electrical parts that can cause severe personal injury or death. The housing is also required for proper genset cooling.***

The housing consists of removable side doors and panels. The two side doors are secured by latches and the remaining panels are secured by screws.

To open the side doors, lift handle up and out, then turn counter-clockwise, swing the side door down, and lift out.

Begin by removing the two side doors and then the roof panel. (Remove all exposed screws from panel to be removed.) With the roof panel removed, the appropriate end panel can now be removed to access the control assembly, alternator or the engine for service.

Note that the rear panel is also secured by two screws located at the base of the divider panel (see Figure 5-1). Also, a panel hole cover that is attached to the divider panel (located directly below the exhaust pipe) must be removed to allow the panel to clear the exhaust pipe during removal.

Reassembly is the reverse of disassembly. To make sure that all of the panel screw holes will line up, wait to tighten the screws until all of the panels and screws are in place.

Lock unit to prevent unauthorized access.

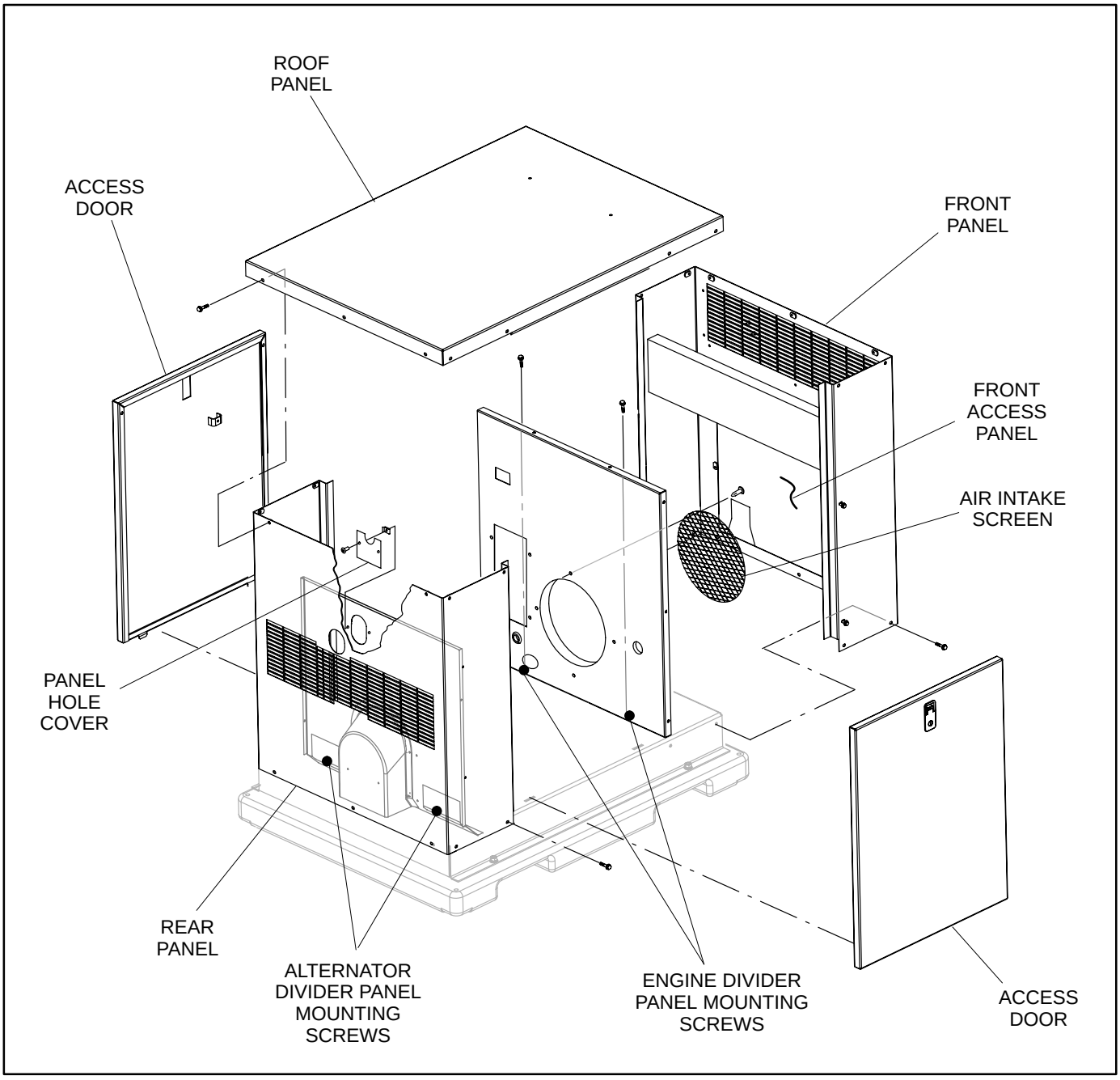

FIGURE 5-1. GENSET HOUSING

PREPARING ENGINE FOR SERVICE

The following procedure describes how to move the engine out from the engine divider panel for engine service. Engine repair procedures in this manual will reference this procedure when necessary.

1. Remove the rear panel of the housing (see *Removing and Installing the Housing Panels* in this section).

2. Remove B+ battery cable from starter and B- battery cable from engine.

3. Disconnect plugs P2 and P4 of the control harness (Figure 5-2).

4. Disconnect the five leads of the governor controller board (Figure 10-1).

5. Disconnect the B+ lead from the voltage regulator.

6. Disconnect the flexible fuel supply line from the carburetor for NG or LPG vapor fuel systems or from the LPG converter for LPG liquid fuel systems.

7. Remove the generator bond strap from the skid base.

8. Remove the two engine vibration isolator center-bolts.

9. Remove the four screws that secure the alternator support bracket to the skid base.

10. Slowly turn the engine/generator counterclockwise, taking care not too apply tension to the wires of the alternator harness.

11. Reassembly is the reverse of disassembly. Torque the center-bolts of the vibration isolators to 30-35 lb-ft (41-47 N-m) and the alternator support bracket screws to 25-35 lb-ft (34-47 N-m).

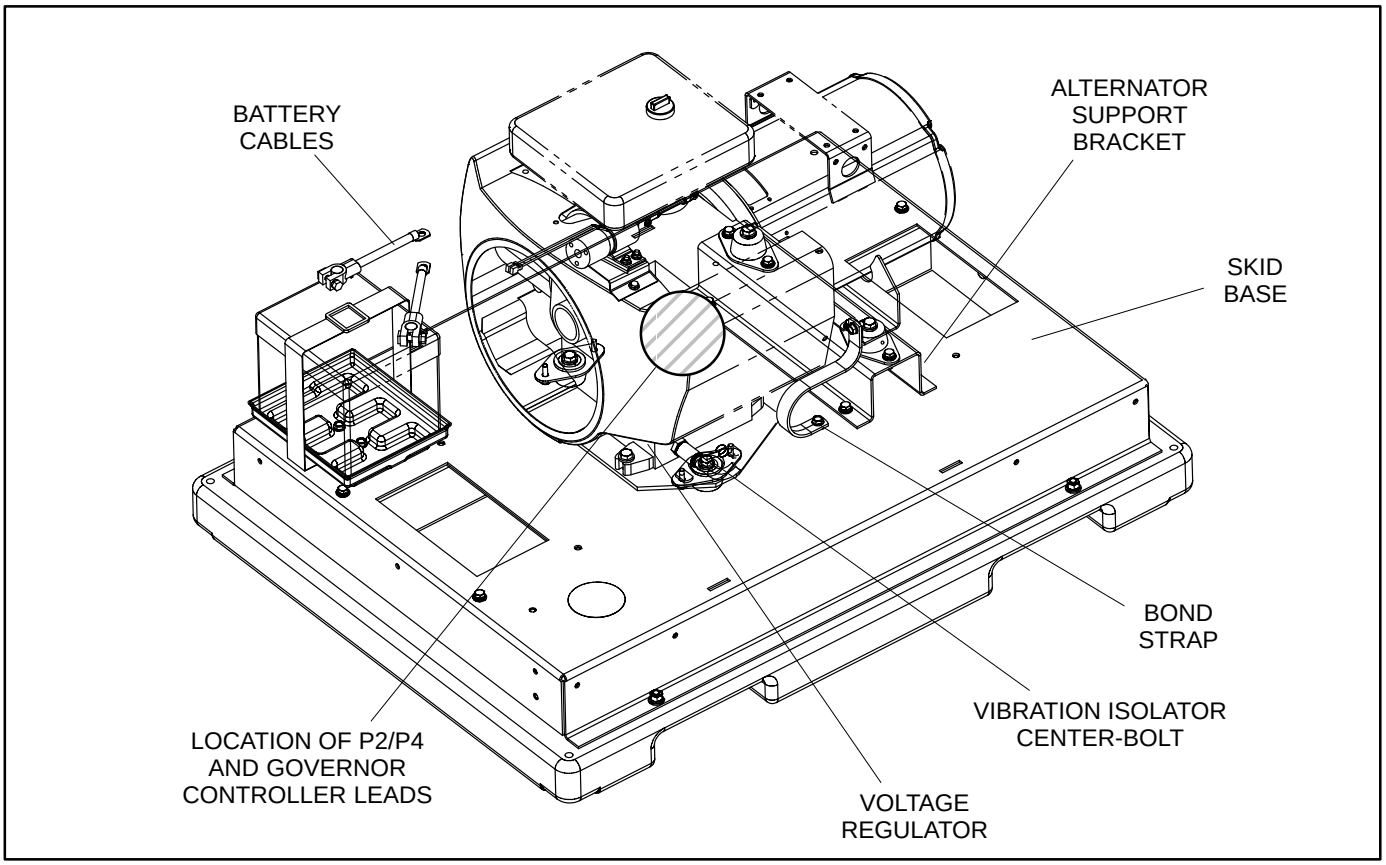

FIGURE 5-2. ENGINE/GENERATOR ASSEMBLY

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6. Engine Subsystems

These engine subsystems or service procedures do not require removal of the cylinder heads, gearcase or main bearings for access and may be serviceable without removing the engine from the cabinet.

CYLINDER COMPRESSION TEST

Examining the spark plugs and testing cylinder compression can tell much about the condition of the valves, piston rings and cylinders. Test cylinder compression as follows:

1. Start the genset and let it warm up.
2. Stop the genset and remove and inspect the spark plugs. See *Ignition System* in this section.
3. Insert the compression gauge nozzle into one of the spark plug holes, hold the throttle open and crank the engine. Note the pressure indicated by the gauge.
4. Repeat the test on the other cylinder.
5. See *Engine Block Assembly* in Section 7 if cylinder compression test pressures do not meet *Specifications.*

VALVE CLEARANCE (LASH) ADJUSTMENT

See Figure 6-1. The engine is equipped with adjustable valve tappets. Adjust the valve clearance only when the engine is at ambient temperature:

1. Remove the roof panel. See *Removing And Installing The Housing Panels* in Section 5.
2. Remove the intake manifold to access the valve tappets. See *Fuel System* in this section. When performing this procedure, it is not necessary to remove the air cleaner housing (Figure 6-11) from the carburetor or the carburetor from the intake manifold.
3. Remove the air intake screen from the engine divider panel (see Figure 5-1). To remove the four panel clips (screws) from air intake screen, turn out screw several turns and pull out panel clip. (Peel back foam insulation near air intake screen to expose panel clip screws.)
4. Remove the valve covers (use 7/16 inch socket).
5. Remove the spark plugs to make turning the engine easier (use 5/8 inch socket).
6. Place a 5/8 inch socket wrench on the flywheel capscrew and rotate the crankshaft in a clockwise direction. While rotating the crankshaft, observe the valve/tappet movement of both cylinders. When either valve/tappet of one cylinder begins to move, the opposite cylinder valve/tappets can be adjusted. Repeat for opposite cylinder.
7. When taking the clearance measurement, the feeler gauge should just pass between the valve stem and valve tappet.
   - Intake Valve Clearance (Cold)
     0.005 inch (0.13 mm)
   - Exhaust Valve Clearance (Cold)
     0.013 inch (0.33 mm)
8. To correct the valve clearance, use a 9/16 inch tappet wrench to prevent the tappet from turning during adjustment. Turn the adjusting screw as needed using a 7/16 inch tappet wrench. The screw is self-locking.
9. To adjust the valves on the left cylinder, turn the engine one complete revolution until the TC mark on the flywheel lines up again with the TC mark on the gear cover and then follow the same procedure as for the right cylinder.
10. Replace all parts removed. Tighten all screws securely. When installing intake manifold and valve covers, always use new gaskets. Torque all screws according to *Thread Torques*.

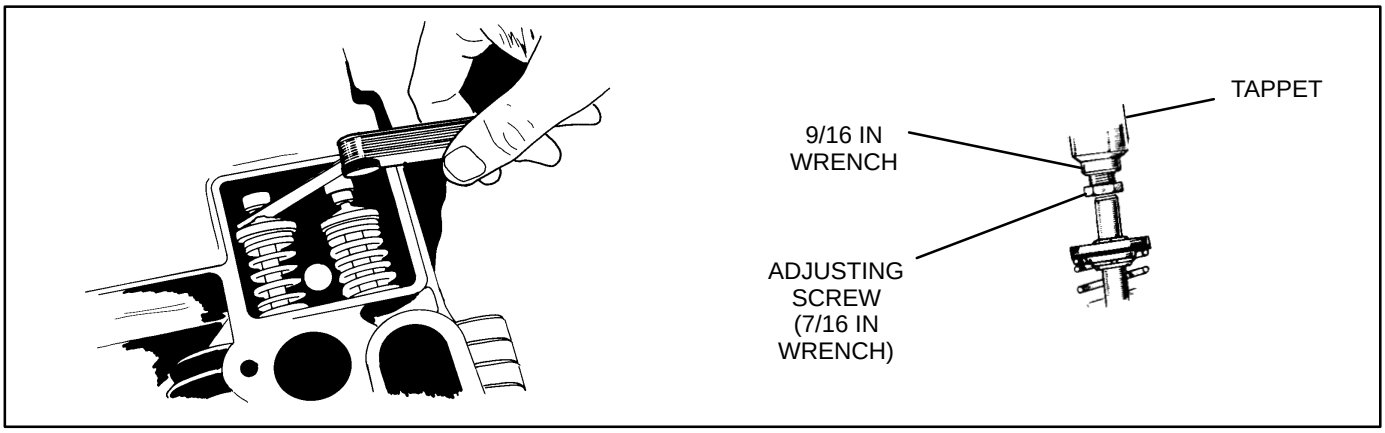

FIGURE 6-1. ADJUSTING VALVE CLEARANCE (LASH)

EXHAUST SYSTEM

See Figure 6-2. The exhaust system is a welded assembly that consists of two exhaust manifolds, muffler, and exhaust pipe. This welded assembly is mounted inside the heat shield assembly.

Always service a leaking exhaust system before running a genset. Never try welding a broken or leaky tailpipe, muffler or manifold.

⚠WARNING ***Exhaust gas is deadly. The exhaust system must not leak and must discharge all engine exhaust away from people, buildings and areas where exhaust can accumulate.***

Liability for injury, death, damage and warranty expense due to the use of an unapproved muffler or due to modifications becomes the responsibility of the person installing the unapproved muffler or performing the modifications. Use Onan approved exhaust system parts.

To inspect or remove the exhaust system for generator set maintenance, first remove the roof panel (see *Removing And Installing The Housing Panels* in Section 5).

Remove the four screws that secure the top cover of the heat shield assembly and remove cover to inspect muffler. With the top cover removed, perform the following procedure to remove the exhaust system.

1. Remove the two screws that secure the panel hole cover that is mounted directly below the exhaust pipe and remove panel hole cover (see Figure 5-1).

2. Remove the four screws that secure the muffler support bracket to the top of the generator.

3. Remove the two screws from the two exhaust manifold flanges and remove muffler from heat shield. Be sure to cover the openings in the block to prevent loose parts and dirt from entering the engine.

4. Remove the four screws that secure the bottom heat shield assembly to the top of the generator muffler support bracket.

5. Reassembly is the reverse of disassembly. When installing exhaust manifold, always use new gaskets. Torque all screws according to *Thread Torques*.

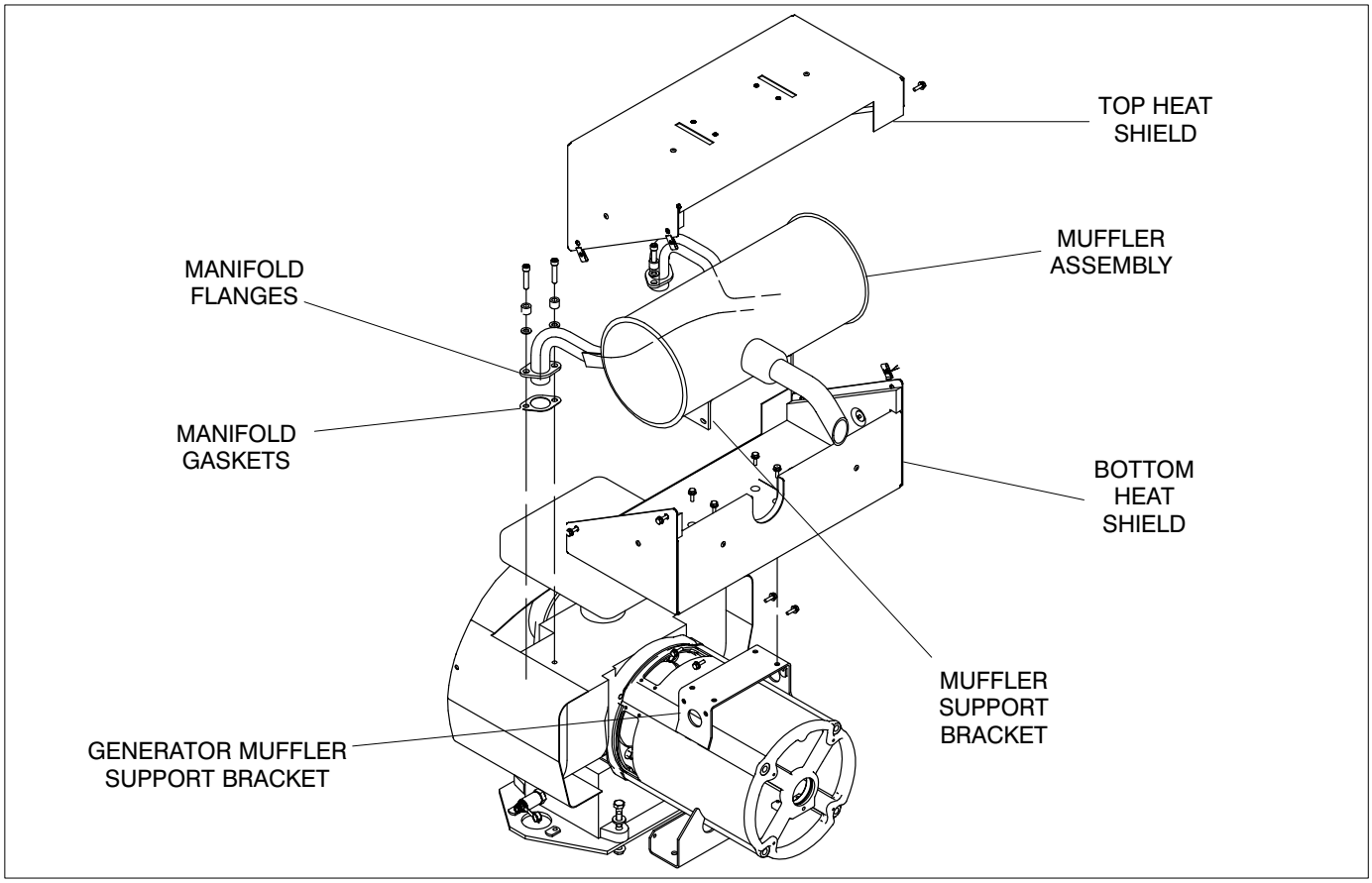

FIGURE 6-2. EXHAUST SYSTEM

ENGINE COOLING SYSTEM

These are air-cooled gensets. The centrifugal blower on the crankshaft blows cooling air across the fins on the engine cylinders and heads and discharges the warm air over and through the alternator divider panel and out the housing rear panel. Figure 6-3 shows the engine housing panels which direct the air flow.

⚠WARNING ***Do not run the generator set without all the panels in place. Contact with the rotating flywheel can result in severe personal injury or death.***

Engine Cooling System Disassembly for Engine Block Service:

1. Move engine out from engine divider panel. See *Preparing Engine for Service* in Section 5 for instructions and important safety precautions.
2. Remove air intake tube (see *Air Cleaner Assembly* in this section).
3. Remove ignition coil wires. Loosen coil mounting clamp and remove ignition coil.
4. Loosen wire clip that secures the ignition module wires and remove wires from clip.
5. Remove connector from voltage regulator.
6. Remove the clamp that secures the gas hose to the right cylinder air housing.
7. Remove the remaining screws shown in Figure 6-3 that secure the two air cylinder housings and the flywheel/blower housing to the engine.
8. Thoroughly clean the engine cooling fins.
9. Reassembly is the reverse of disassembly.

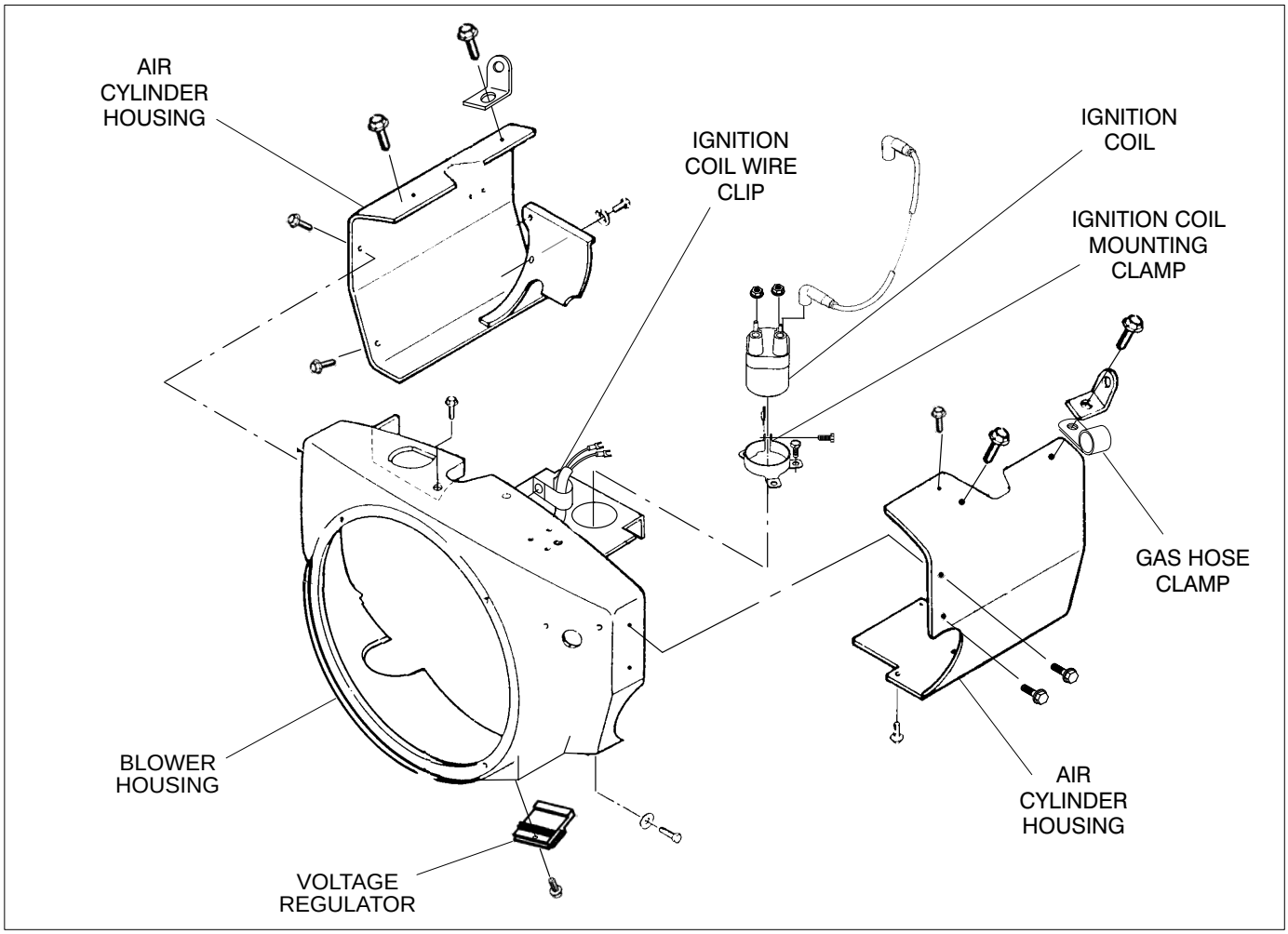

FIGURE 6-3. COOLING SYSTEM PANELS

Flywheel/Blower Removal

1. Remove the panels of the engine cooling system.

2. Loosen the blower hub capscrew and back it out several turns. See Figure 6-4.

3. Attach the puller tool to the blower hub. The tool has two jack screws that fit into the holes tapped in the hub. Tighten the puller center screw until the hub comes loose. Remove the puller, hub center screw and washer. Inspect the blower and replace it if any air vanes are missing, damaged or warped.

Flywheel/Blower Reassembly

Reassembly is the reverse of disassembly.

1. Make sure the woodruff key is in place when installing the blower hub. Use non-hardening sealer on the hub capscrew threads and tighten according to *Thread Torques.*

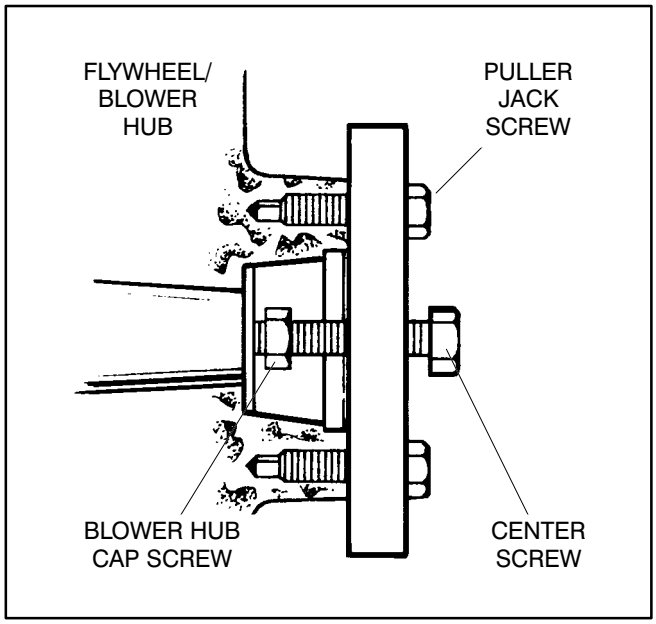

FIGURE 6-4. FLYWHEEL/BLOWER HUB REMOVAL

IGNITION SYSTEM

The genset is equipped with an electronic ignition system consisting of a trigger ring, module, coil, capacitor, spark plugs and associated wiring. Energy for ignition is supplied by the 12 volt cranking battery.

Module/Trigger Ring

See Figure 6-4. This engine is equipped with an electronic battery ignition system. Both spark plugs fire simultaneously, thus the need for a distributor is eliminated. The electronic ignition module is located on the engine gear cover behind the flywheel. The module receives a timing signal from magnets within the trigger ring which rotates with the engine crankshaft. The module contains no serviceable parts and normally should not require replacement.

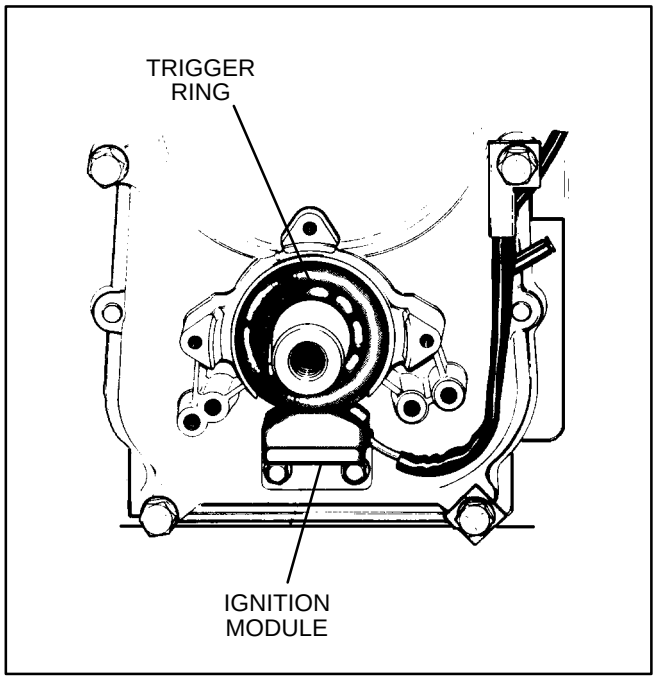

FIGURE 6-4. IGNITION ROTOR AND MODULE

Coil

See Figure 6-5. The ignition coil is a transformer that fires the spark plugs at roughly 20,000 volts each revolution when the ignition module opens the primary circuit causing the coil field to collapse.

⚠ CAUTION ***The leads connected at the low voltage terminals of the ignition coil (Figure 6-5) should not be routed so as to pass between the high voltage terminal posts. The result could be erratic operation due to false signals induced in the primary leads.***

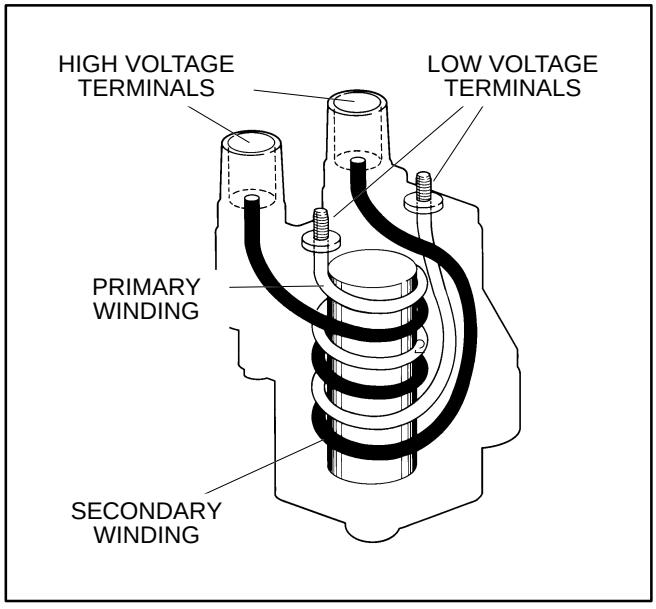

FIGURE 6-5. IGNITION COIL

Capacitor

The ignition capacitor is secured and grounded to the top of the generator-engine adaptor by one cap screw. The pig tail is connected to the positive (**+**) low voltage terminal of the ignition coil.

Spark Plugs

The genset has two spark plugs. The spark plugs must be in good condition and have the proper gap for top engine performance. See *Specifications.*

To prevent crossthreading a spark plug, always thread it in by hand until it seats. Then tighten the spark plug according to *Thread Torques.* Alternatively, if the spark plug is being reused, turn it with a wrench an additional 1/4 turn. If the spark plug is new, turn it an additional 3/8 to 1/2 turn.

If the engine misses or performance otherwise deteriorates, remove and examine the spark plugs for signs of the following problems:

Light tan, gray or reddish deposits - Normal

One spark plug fouled - Broken spark plug cable, low cylinder compression

Soot fouled - Wrong spark plug heat range (too cold), duty cycle too short for engine to reach normal operating temperature

Fuel fouled - Wrong spark plug heat range (too cold), faulty choke operation, overly rich fuel mixture, dirty air filter

Oil fouled - Malfunctioning crankcase breather, worn rings, worn valve guides or seals

Burned or overheated - Leaking intake manifold gaskets, lean fuel mixture

Worn - Spark plug service life used up.

Quick Ignition Test

If the engine misfires, test the ignition system as follows to quickly determine if the problem is in the ignition system. First recheck, clean and tighten the connections at the ignition coil terminals. See *Wiring Diagrams* for the proper connections at the "**-** " and "**+**" terminals.

⚠WARNING ***Gaseous fuels are flammable and explosive and can cause severe personal injury or death. Conduct this test only in a well ventilated area and make sure you cannot smell gas. Keep a Type ABC fire extinguisher handy.***

1. Open both access doors and wait several minutes and make sure you cannot smell gas before conducting this test.
2. Remove one of the spark plugs.
3. Reconnect the spark plug cable and lay the spark plug on bare engine metal to ground it.

   ⚠WARNING ***HIGH VOLTAGE. To prevent electric shock do not touch the spark plug or wire during this test.***
4. Crank the engine and observe the spark. A strong, consistent spark indicates that the ignition system probably is functioning properly and the problem is elsewhere. If no spark occurs or is weak or inconsistent, go to step 5.
5. Connect a jumper lead directly from the positive battery terminal to the positive (+) coil terminal (smaller diameter of the two threaded posts). Crank engine over while watching for spark. If spark occurs, the problem is in the low oil pressure cut out switch or in the circuitry bringing voltage to the coil (see *Wiring Diagram* in Section 12). If no spark occurs or is weak or inconsistent, service the ignition system as follows.

Spark Plug Cable Resistance Test

Remove both spark plug cables and check resistance across the ends with an ohmmeter. Replace a cable if resistance is not between 3,000 and 15,000 ohms.

Ignition Module Test

1. Remove the air intake screen from the engine divider panel (see Figure 5-1). To remove the four panel clips (screws) from air intake screen, turn out screw several turns and pull out panel clip.
2. Remove both spark plugs so that the crankshaft can be turned easily with a wrench.
3. Connect the positive (**+**) side of a voltmeter to the negative (**-**) terminal of the ignition coil (larger of the two screw terminals) and the negative (**-**) side of the voltmeter to engine ground.
4. Remove all leads from the positive (**+**) terminal of the coil.
5. Use a jumper to connect the red lead of the ignition module (the one just removed from the coil) to the battery positive terminal.
6. Place a socket wrench on the flywheel capscrew and rotate the crankshaft in a clockwise direction. If voltage does not jump from approximately 1 volt to approximately 12 volts and then back again each revolution, the rotor is broken or the module is faulty.

Ignition Coil Test

1. Remove all wires attached to the ignition coil.
2. Remove the coil from the engine.
3. Inspect the terminals for corrosion, looseness, cracks or other damage. Look for carbon runners around the high tension terminals indicating electrical leakage. Replace a damaged or leaking coil.
4. Clean the outside of the coil with a cloth dampened in parts cleaning solvent.
5. Measure primary coil resistance (across the positive [**+**] and negative [**-**] terminals). Replace the ignition coil if primary resistance is not between 2.90 and 3.60 ohms.
6. Measure secondary coil resistance (across the spark plug cable terminals). Replace the ignition coil if secondary resistance is not between 14,500 and 19,800 ohms. See Figure 6-6.

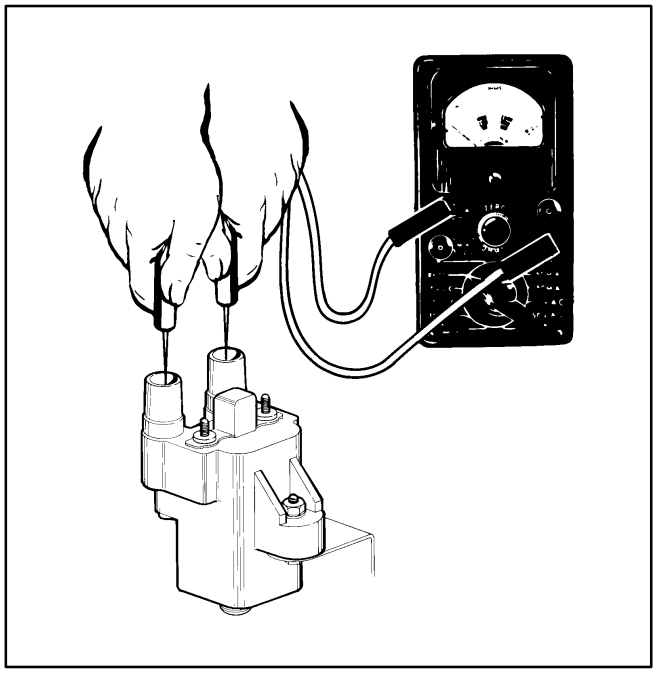

FIGURE 6-6. TESTING THE IGNITION COIL

CRANKCASE BREATHER ASSEMBLY

The crankcase breather is a ball valve assembly that opens to discharge crankcase vapors on the down-stroke of the piston and closes on the up-stroke, resulting in a negative pressure in the crankcase when the engine is running. The crankcase vapors (blowby gases, moisture, air) are routed to the carburetor for burning in the cylinders. A dirty or sticking valve can cause oil leaks, high oil consumption, rough idle, reduced engine power and sludge formation within the engine.

Disassembly: The breather assembly is serviced by disassembling it and cleaning all the parts in parts cleaning solvent. The assembly comes apart when the capscrew is removed.

Remove the breather cap and valve assembly and wash in a suitable solvent. Replace cap and valve assembly if balls do not move freely. Pull pack out and wash in solvent. To allow free operation of the valve, screens must be positioned as shown in Figure 6-7.

⚠WARNING ***Most parts cleaning solvents are flammable and corrosive and can cause severe burns and inflammation. Use only as recommended by the manufacturer.***

Reassembly: Reassemble using a new gasket. Torque the cover capscrew to 12-24 lb-in (1.3-2.6 N-m).

⚠CAUTION ***Over-tightening the capscrew can distort the cover allowing dirt and air to enter the engine.***

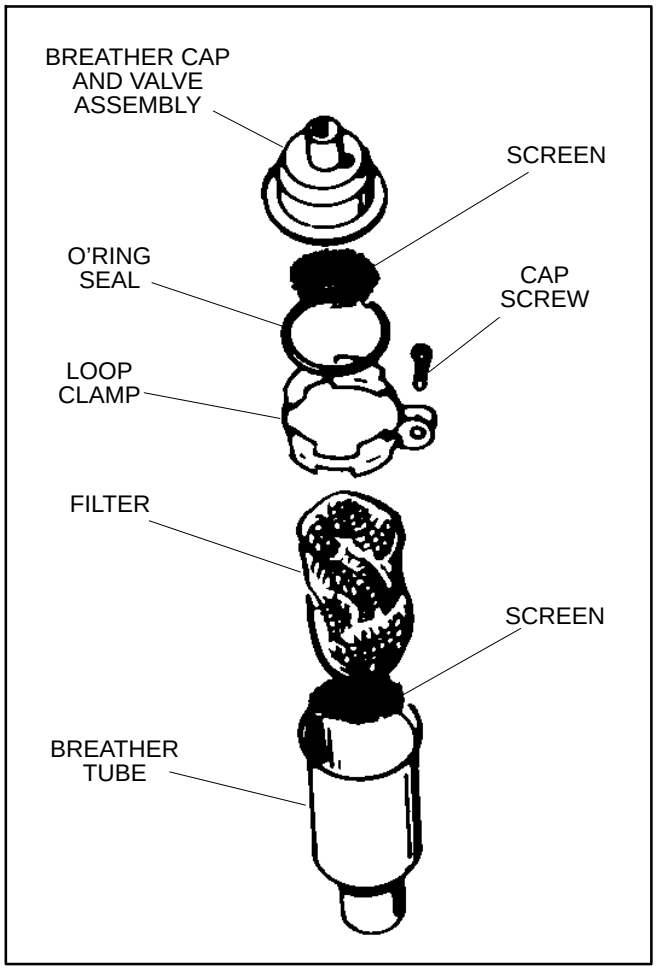

FIGURE 6-7. CRANKCASE BREATHER ASSEMBLY

LUBRICATION SYSTEM

An oil pump (refer to *Oil Pump Assembly* in Section 7) provides a constant flow of oil to the engine parts and a full-flow, spin-on filter keeps the oil clean. The oil collects in the oil base where it is picked up by the oil pump pick-up cup. An oil by-pass valve is used to control oil pressure.

Oil pressure should be at least at least 20 psi (138 kPa) when the engine is at normal operating temperature. If pressure drops below this value at governed speed, inspect the oil system for faulty components.

Oil Filter And Adapter

To remove the oil filter and adapter:

1. Open the oil drain valve and drain the crankcase oil.
2. Remove the filter by turning it counterclockwise with a filter wrench.
3. Loosen the two capscrews that secure the adapter to the engine block and remove the adapter and gasket. The low oil pressure cutoff switch is installed in a threaded hole in the filter adapter. See Figure 6-8.

To reassemble the oil filter and adapter, perform these steps in reverse order. Install a new adapter gasket so that the two small oil holes are aligned with the oil holes in the block. **This gasket should be installed dry**. Coat the threads of each capscrew with non-hardening sealer and torque to specifications.

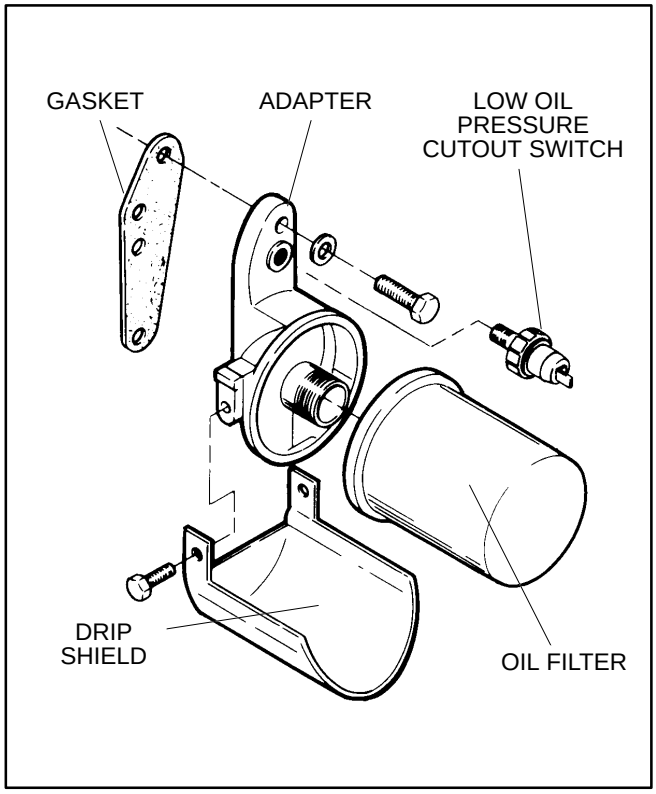

FIGURE 6-8. OIL FILTER AND PRESSURE SWITCH

Oil Bypass Valve

The bypass valve is located to the right and behind the gear cover (Figure 6-9). It controls oil pressure by allowing excess oil to flow back to the crankcase. It is non-adjustable and normally needs no maintenance. If it is suspected that it is the cause of high or low oil pressure, inspect it as follows:

1. Remove the 3/8 capscrew behind the gear cover and under the governor arm.
2. Remove the spring and plunger with a magnetic tool and clean them.
3. Replace the plunger if its diameter is not 0.3105-0.3125 inch (7.89-7.94 mm).
4. Replace the spring if its free length is not approximately 1 inch (25.4 mm) or if it does not take 2.4-2.8 pounds (10.7-12.5 N) to compress it 0.5 inch (12.7 mm).
5. Check the bore and valve seat and clean as necessary.

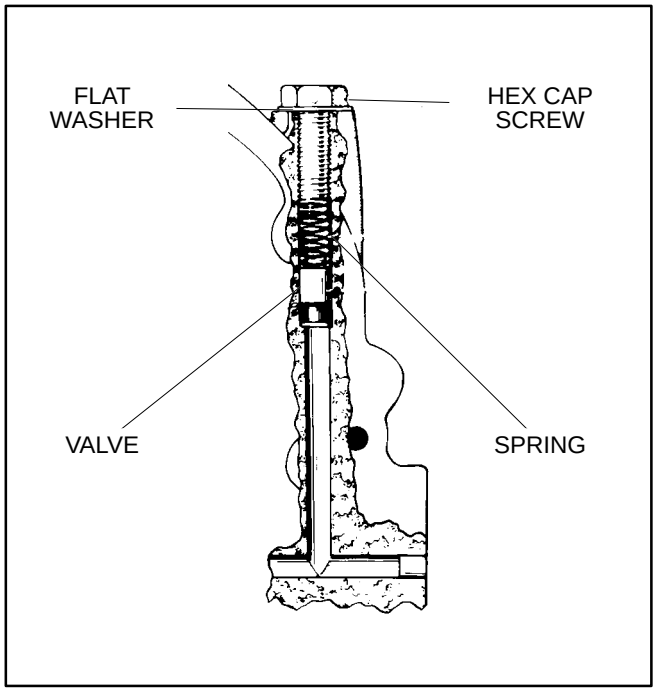

FIGURE 6-9. OIL BYPASS VALVE

GOVERNOR ROD AND ACTUATOR

See Figure 6-10. The genset controller operates the throttle by means of the governor rod and actuator to maintain a nearly constant engine speed (frequency) as the electrical load on the genset varies.

To determine if the governor actuator is defective, check the coil resistance with the two leads disconnected. Coil resistance should be 1.5 to 3.0 ohms. Also, with the leads disconnected, apply 12 VDC to the actuator. The actuator should open the carburetor to full throttle.

Replace the governor actuator if coil resistance is not between 1.5 and 3.0 ohms or if the coil is shorted to ground. The operation of the actuator can also be checked by disconnecting the actuator leads and applying 12 VDC to the actuator. The actuator should open the carburetor to full throttle.

Governor Rod Adjustment:

1. Unsnap the yoke from the ball joint on the throttle lever.

   Make sure ball joint is mounted in lower hole of throttle lever.

2. Loosen the yoke locknut shown in Figure 6-10.

3. While holding the throttle lever against the throttle stop screw, turn the yoke in or out to align the hole in the yoke to the end of the ball stud. Then turn the yoke two full turns to shorten the linkage and tighten the locknut.

4. Make sure yoke is perpendicular to face of throttle lever and then install yoke onto ball joint.

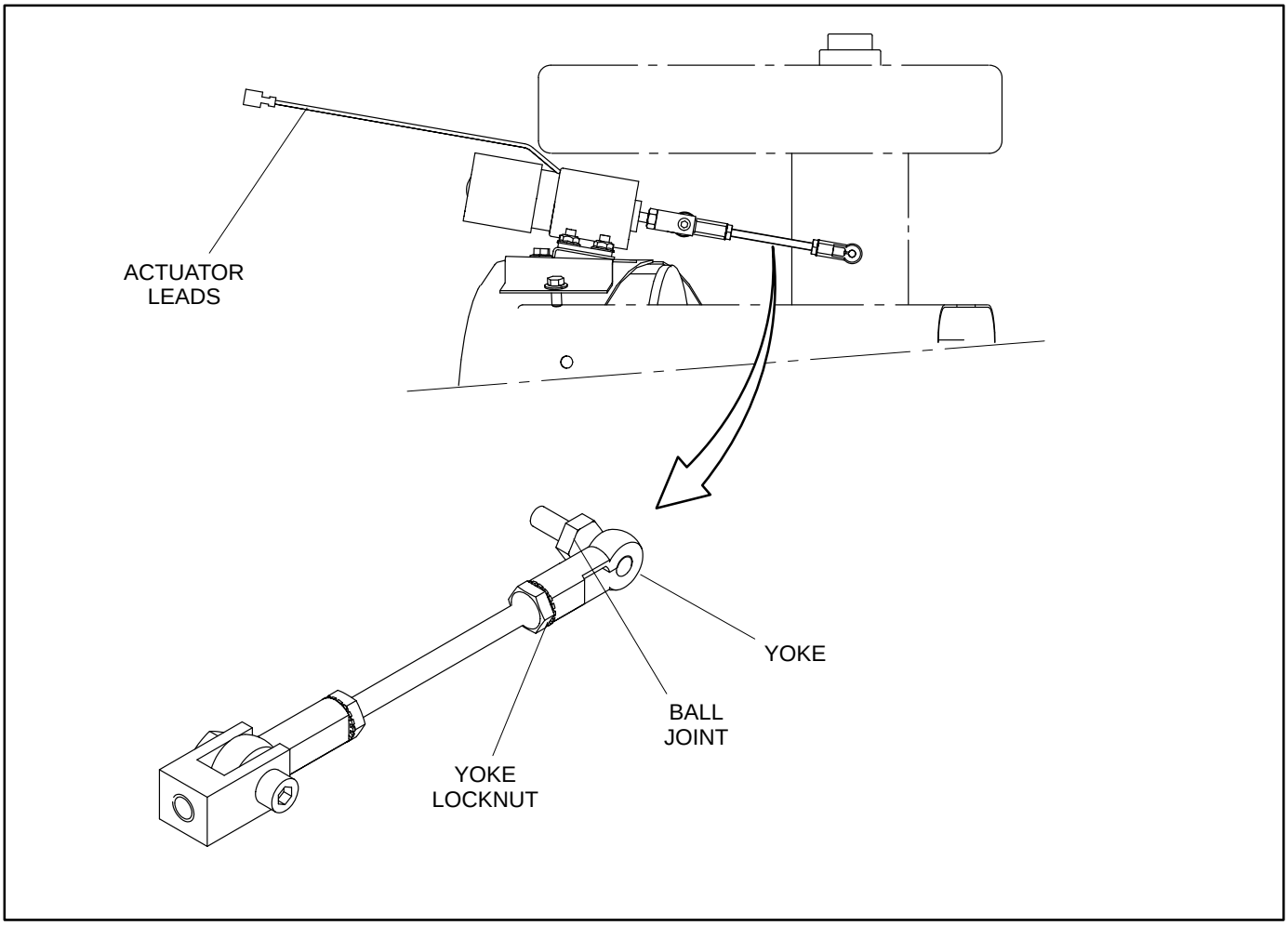

FIGURE 6-10. GOVERNOR ROD AND ACTUATOR

FUEL SYSTEM

The engine is equipped with a fuel system that is designed to run on either natural gas, LP vapor or LP liquid.

A genset purchased to use natural gas or LP vapor can not be converted to use LP liquid, and one that is purchased to use LP liquid can not be converted to use natural gas or LP vapor.

The genset leaves the factory set up for natural gas or LP liquid. If the genset uses LP vapor, a conversion kit was installed on a natural gas genset.

⚠WARNING ***Gaseous fuels are flammable and explosive and can cause severe personal injury or death. Do not smoke if you smell gas or are near fuel tanks or fuel-burning equipment or are in an area sharing ventilation with such equipment. Keep flames, sparks, pilot lights, electrical switches and arc-producing equipment and all other sources of ignition well away. Keep a type ABC fire extinguisher handy.***

NFPA Standard No. 58 requires all persons handling and operating gaseous fuel to be trained in proper handling and operating procedures.

⚠WARNING ***Gaseous fuel leaks into an inadequately ventilated space can lead to explosive accumulations of gas. Natural gas rises when released into the air and can accumulate under overhanging hoods and inside housings and buildings. LPG sinks when released into the air and can accumulate inside housings, basements and other below-grade spaces. Precautions must be taken to prevent gas leaks and the accumulation of gaseous fuel in the event of a leak.***

Air Cleaner Assembly

Disassembly:

1. Open the side access doors. (See *Removing and Installing the Housing Panels* in Section 5.
2. Remove the tool-less knob and lift off the air cleaner cover (Figure 6-11).
3. Remove the wing nut and lift off the air cleaner element assembly.
4. Remove the stud spacer and the five screws that secure air cleaner housing (two screws to the support bracket and the three screws to the carburetor) and remove housing.

Reassembly: Reassembly is the reverse of disassembly. Use a new gasket between the adapter and the carburetor.

Carburetor (Mixer) and Intake Manifold Assembly

The following procedure describes how to remove the carburetor and intake manifold (Figure 6-11) as an assembly without having to remove the exhaust assembly. (Adjustment procedures, such as valve clearance adjustment, requires the intake manifold to be removed but not the exhaust assembly.)

Disassembly:

1. Remove the air cleaner assembly.
2. Disconnect the fuel line and governor linkage from the carburetor (Figure 6-11).
3. Remove capacitor from intake manifold.
4. Loosen and remove the four intake manifold screws. Move the intake manifold left and right as necessary to remove screws from intake manifold from under exhaust pipes.
5. Move intake manifold left to right as necessary to lift one end of the intake manifold from under the exhaust pipes. Remove the carburetor and intake manifold as an assembly.
6. Remove the two intake manifold gaskets. Cover the intake ports to prevent loose parts from accidentally entering the ports.
7. Unbolt the carburetor from the intake manifold. Replace the carburetor if it is malfunctioning. There are no separately replaceable carburetor parts nor service adjustments.

   ⚠WARNING ***Unauthorized modifications or replacement of fuel, exhaust, air intake or speed control system components that affect engine emissions are prohibited by law in the State of California.***

Reassembly: Reassembly is the reverse of disassembly. Use new gaskets between the intake manifold and the engine and between the intake manifold and the carburetor. Do not use sealer on the gaskets. Tighten all fasteners according to *Thread Torques*.

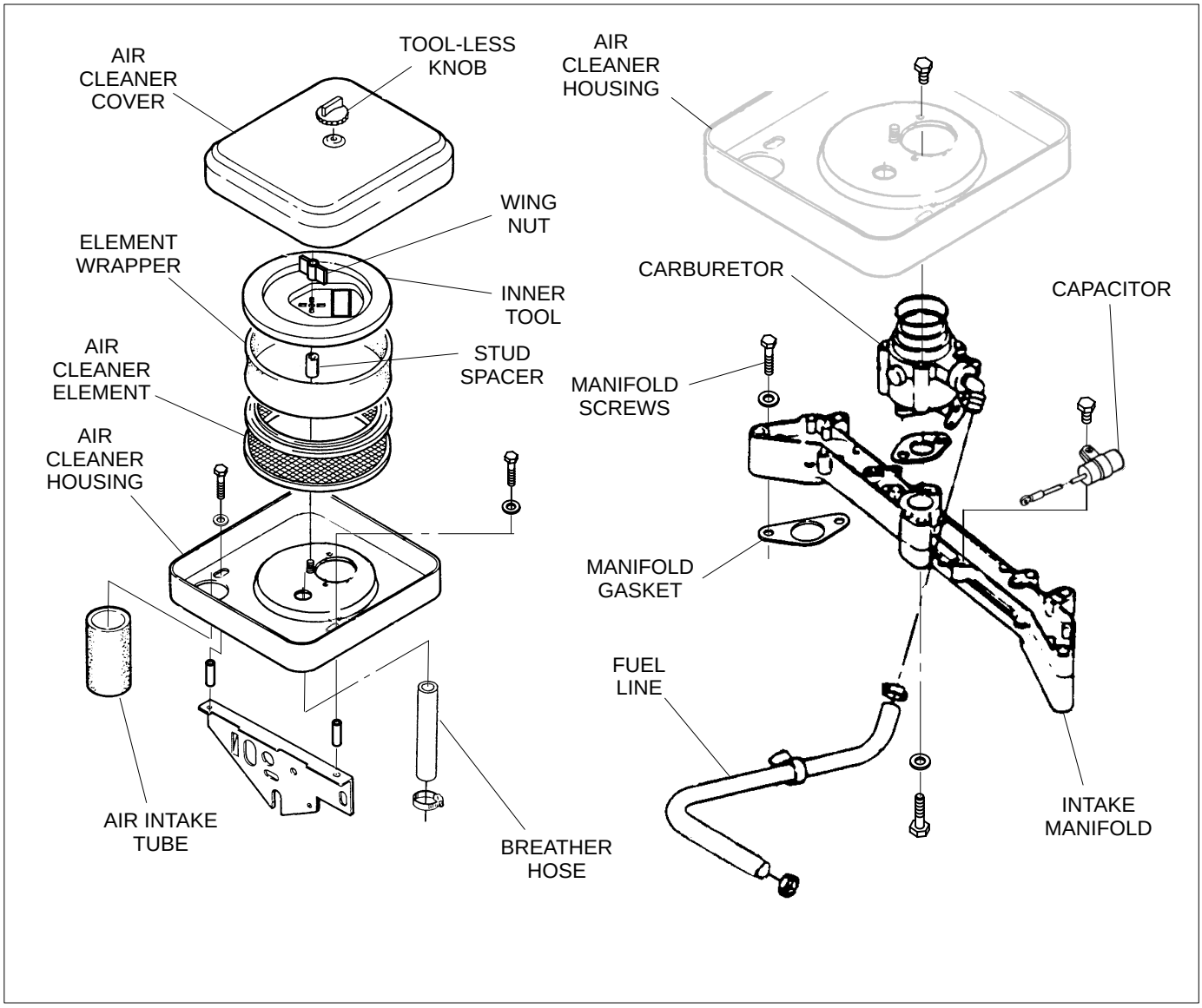

FIGURE 6-11. AIR CLEANER/INTAKE MANIFOLD

LP Liquid Fuel System

The fuel system for LP liquid consists of a solenoid valve and a LPG converter that are joined by a flex hose (Figure 6-12). There are no adjustments within the LP liquid fuel system.

Satisfactory performance requires that the LP liquid supply pressure at the genset must be within the range of 30 to 300 psi (20.7 to 2070 kPa).

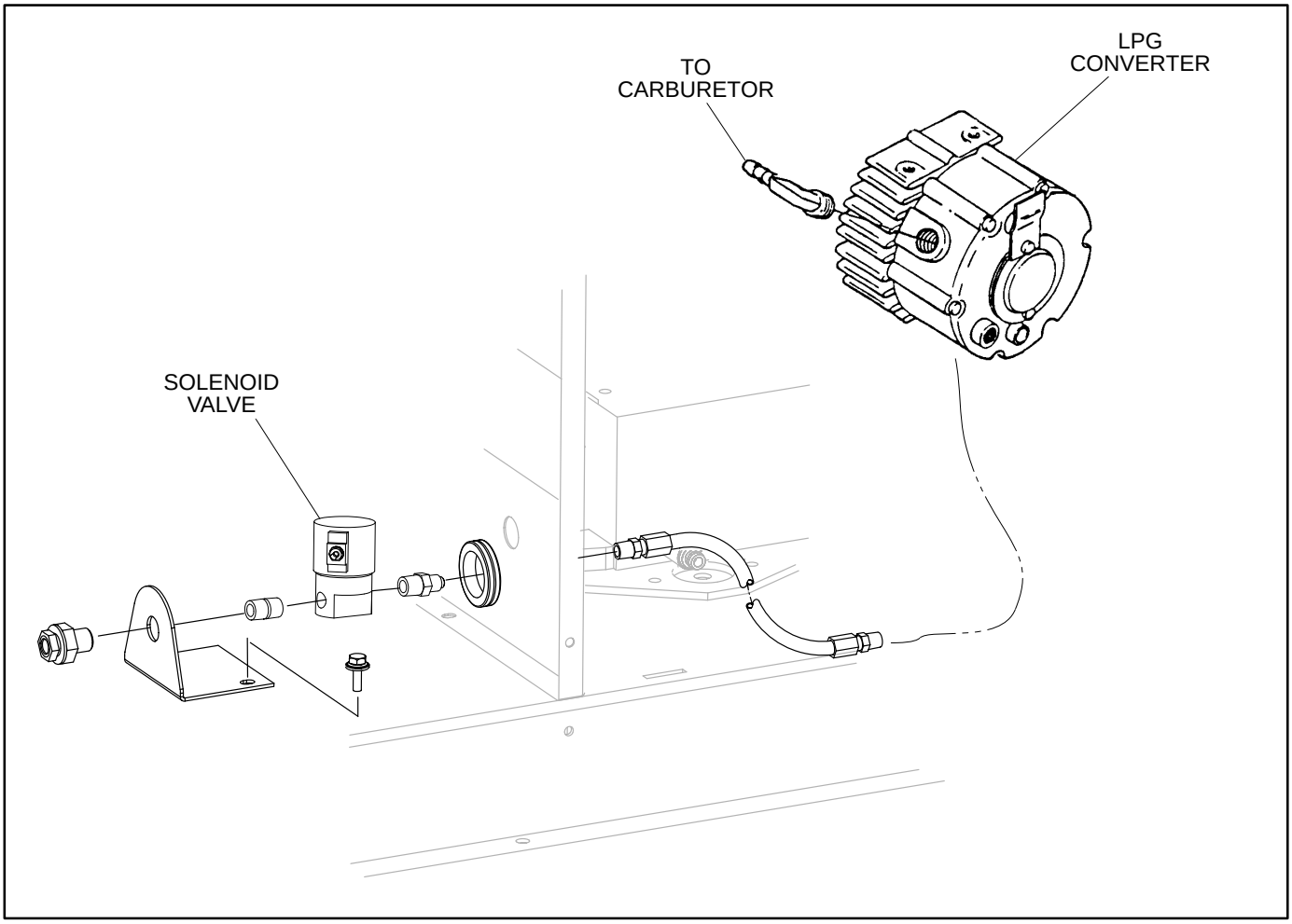

FIGURE 6-12. LP LIQUID FUEL SYSTEM

NG/LP Vapor Fuel System

The fuel system for NG or LP vapor consists of a gas pressure regulator and fuel solenoid that are joined by a pipe nipple. The assembly is mounted by means of a bracket to the base pan.

The only difference between the two fuel systems is that they require a different size fuel inlet opening to the carburetor. There are two styles of gas fittings that are used to convert between NG or LP vapor.

Style 1: The brass elbow contains an orifice that is required for LP vapor. (The orifice is removed for NG.) If the orifice is removed for fuel system repair, make sure that the smaller end of the orifice inserts into the elbow when installing the orifice.

Style 2: The brass elbow is manufactured for the fuel type used. If the brass elbow contains a colored dot, the fuel type is LP vapor. If no colored dot is visible, the fuel type is NG.

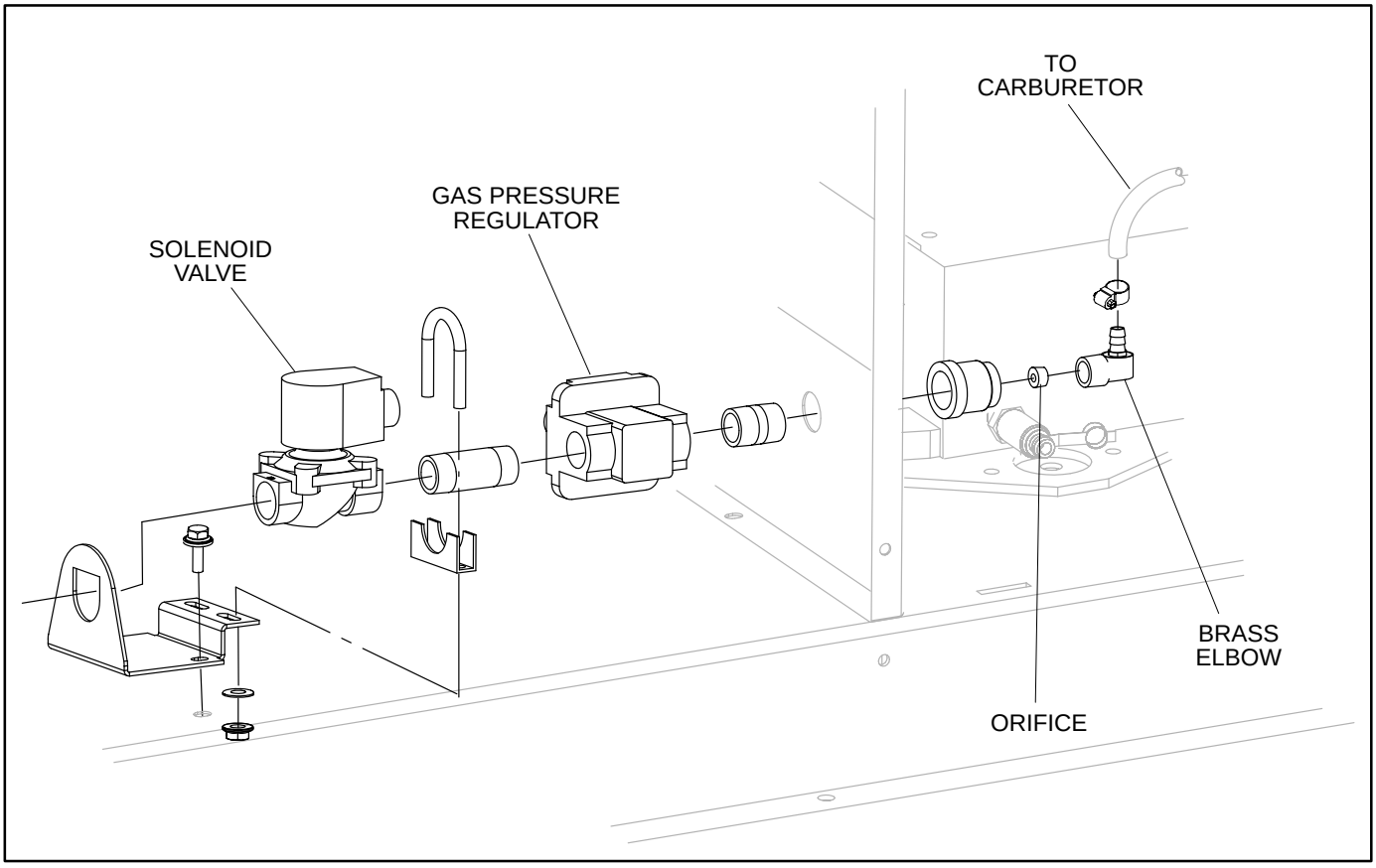

FIGURE 6-13. LP VAPOR/NATURAL GAS FUEL SYSTEM

Gaseous Fuel Adjustments: The carburetor has an idle adjust screw (Figure 6-13) that is adjusted for NG or LP vapor. (Once adjusted for either NG or LP vapor, it normally should not require future adjustment.)

When the carburetor is used for NG, the idle adjust screw is turned all the way in (clockwise). When used for LP vapor, adjust the screw so that the top of the screw is flush with the body of the carburetor as shown in Figure 6-14.

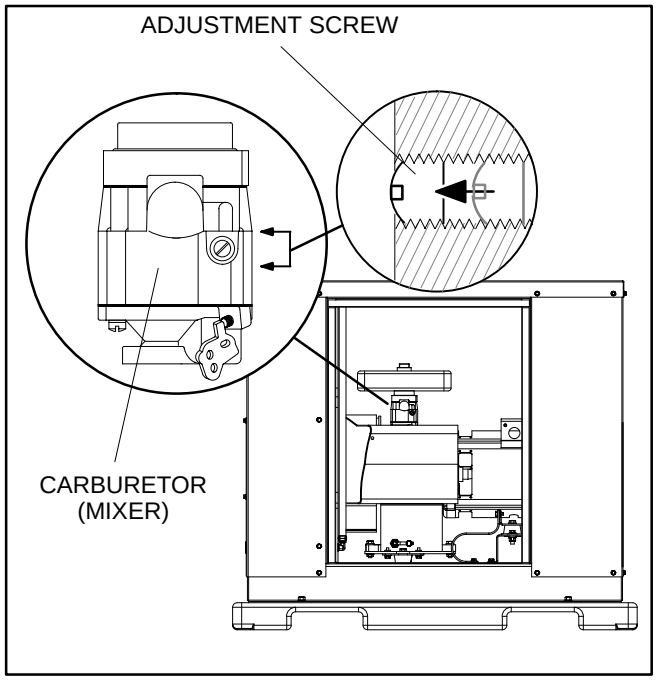

FIGURE 6-14. CARBURETOR ADJUSTMENT

Adjusting Gas Supply Pressure: The gas pressure regulator provides constant gas pressure at the carburetor under varying load conditions. There are pressure test ports on both sides of the gas pressure regulator for measuring supply and regulated fuel pressures. When measuring supply pressure, the most accurate reading would be on the input side that is connected to the solenoid valve.

NG or LP vapor gas supply pressure must be maintained at 9-13 inches (229-330 mm) water column (WC). Adjust the supply pressure as follows:

1. Close the gas supply shutoff valve.
2. Remove the 1/8 inch pipe plug from the regulator test port and connect a manometer calibrated in inches or mm WC having a scale range of at least 14 inches (350 mm).
3. Open the gas shutoff valve and try starting the genset.
4. While the genset is running at no load, check the manometer and adjust the gas supply pressure regulator to obtain 11 inches (279 mm) WC.
5. If the genset will not start, jumper the fuel solenoid to the battery cable connections on the genset so that it stays open (the regulator will keep gas from flowing) and then check and adjust the gas supply pressure.
6. If the genset is operable, check gas supply pressure under full load. If gas pressure drops below the required minimum, the gas supply piping may be too small. On an LPG supply system, the container may be too small to provide the rate of vaporization or it may not have enough fuel.
7. Disconnect any jumpers which may have been used to energize the fuel solenoid and thread in and tighten the pressure test port plug.

Fuel Solenoid Valve Tests

Replace a leaky fuel solenoid valve or one that fails to open.

To test for leakage use a test pressure of at least 11 inches (279 mm) WC and a soap bubble.

To test for opening, jumper the solenoid across the battery cable connections at the genset. The gas supply pressure manometer used for adjusting supply pressure can be used to indicate whether the valve opens.

FLYWHEEL ALTERNATOR

The engine is equipped with a permanent magnet flywheel alternator and solid-state voltage regulator-rectifier (Figure 6-15). As with all solid-state electrical units, precautions are necessary when servicing.

⚠ CAUTION ***Reversing positive and negative battery connections or allowing engine to run without being connected to the alternator will result in engine electrical system damage. Do not switch battery connections or allow engine to run without being connected to the alternator.***

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

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

1. Be sure engine is being run long enough to recharge battery after each start. Charging system tests require a full charged battery.

2. The regulator-rectifier has built in protection against open circuits or short circuits on the alternator output (B+) terminal. Either condition will cause the regulator-rectifier to shut off and appear as if it is not functioning. Prior to checking the regulator-rectifier, check all wiring between the regulator-rectifier B+ terminal and the battery positive (+) terminal to assure it is free of open circuits, resistances or short circuits. Also, if the battery is extremely discharged it may have insufficient power to "turn on" the regulator-rectifier.

3. Be sure regulator-rectifier plug (connector) is inserted properly. Plug must bottom in receptacle: this eliminates any resistance due to a poor connection. Keep clean and tight.

4. Make sure alternator stator leads are not shorted together.

5. Be sure regulator-rectifier has a good ground connection. Mating surface for mounting must be clean and fasteners tightened properly.

6. Never reverse the battery leads.

Connect a test ammeter to the charging circuitry and start the engine. If no charging is evident, proceed with the *Alternator Output Test*.

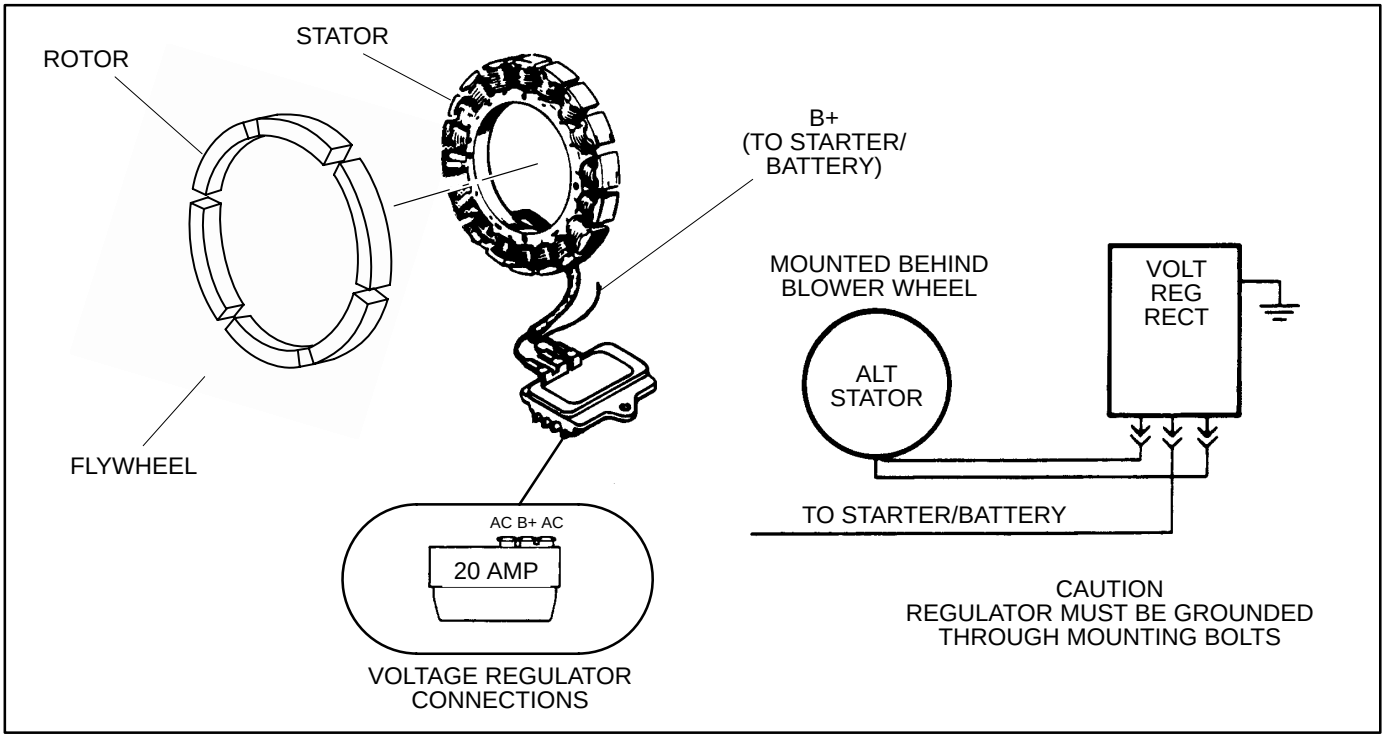

FIGURE 6-15. FLYWHEEL ALTERNATOR SYSTEM

ALTERNATOR OUTPUT TEST

A volt-ohmmeter is required for the following test.

1. Check battery voltage with unit not running. If not within 12 to 13 VDC, charge battery before proceeding to step 2.

2. With the engine running, check the battery terminal voltage (regulator output). Voltage output should be 13.6 to 14.7 VDC. If voltage is greater than specified, replace regulator-rectifier assembly. If voltage is less than specified, proceed to step 3.

3. Examine all wires for loose, corroded, or broken connections. Check fuses. Repair as needed to assure continuity between the regulator-rectifier B+ terminal to battery positive (+) terminal. Note that a 25 amp circuit breaker is contained in this circuit (see *Wiring Diagram* in Section 12). This inline circuit breaker automatically resets after reaching a preset cool-down temperature. Other than a short to ground, the circuit breaker can also trip if the battery contains a shorted cell.

   Also check ground path from battery negative(-) terminal to regulator-rectifier case. Make sure ground connections are clean and secure. If battery voltage remains low with engine running, proceed to step 4.

4. Disconnect both AC stator leads from the regulator-rectifier and test the AC voltage at the stator leads with engine running. If AC voltage reads more or less than 57 VAC, proceed to step 5. If AC voltage is as specified but DC voltage is low, replace regulator-rectifier.

5. Use the Rx1 scale on the ohmmeter for detecting an open or ground in the stator (unit not running). Disconnect both AC stator leads from the regulator-rectifier. Connect one ohmmeter test lead to a stator lead, connect the other test lead to ground. Reading should show an open(no continuity). If it doesn't, the stator must be replaced. If reading shows no continuity, measure the resistance of the stator winding by connecting one ohmmeter lead to each lead coming from the stator. If resistance is not 0.01 to 0.19 Ohms, replace the stator. If stator resistance readings are as specified and windings are not shorted or open, low AC voltage may be due to loss of magnetism. If so, blower wheel assembly must be replaced.

STARTER MOTOR

Starter Removal and Replacement

To remove the starter for service or replacement:

1. Move engine out from engine divider panel. See *Preparing Engine for Service* in Section 5 for instructions and important safety precautions.

2. Disconnect all wires and cables from the motor terminals.

3. Remove the two starter mounting bolts and remove the starter.

Replacement is the reverse of removal. Torque the mounting bolts to *Thread Torques*.

Starter Assembly and Disassembly

See Figure 6-16. Remove the starter from the genset. Remove the solenoid before disassembling the motor and remount if after assembling the motor. When mounting the solenoid make sure the plunger is hooked by the shift fork. The drive housing, motor frame and end bell are separable after the motor through bolts have been removed. Before loosening the through bolts, however, scratch register lines on the drive housing, motor frame and end bell so that these parts can be easily reassembled the same way relative to each other. While removing the end bell, be prepared to catch the brush springs, which tend to spring loose.

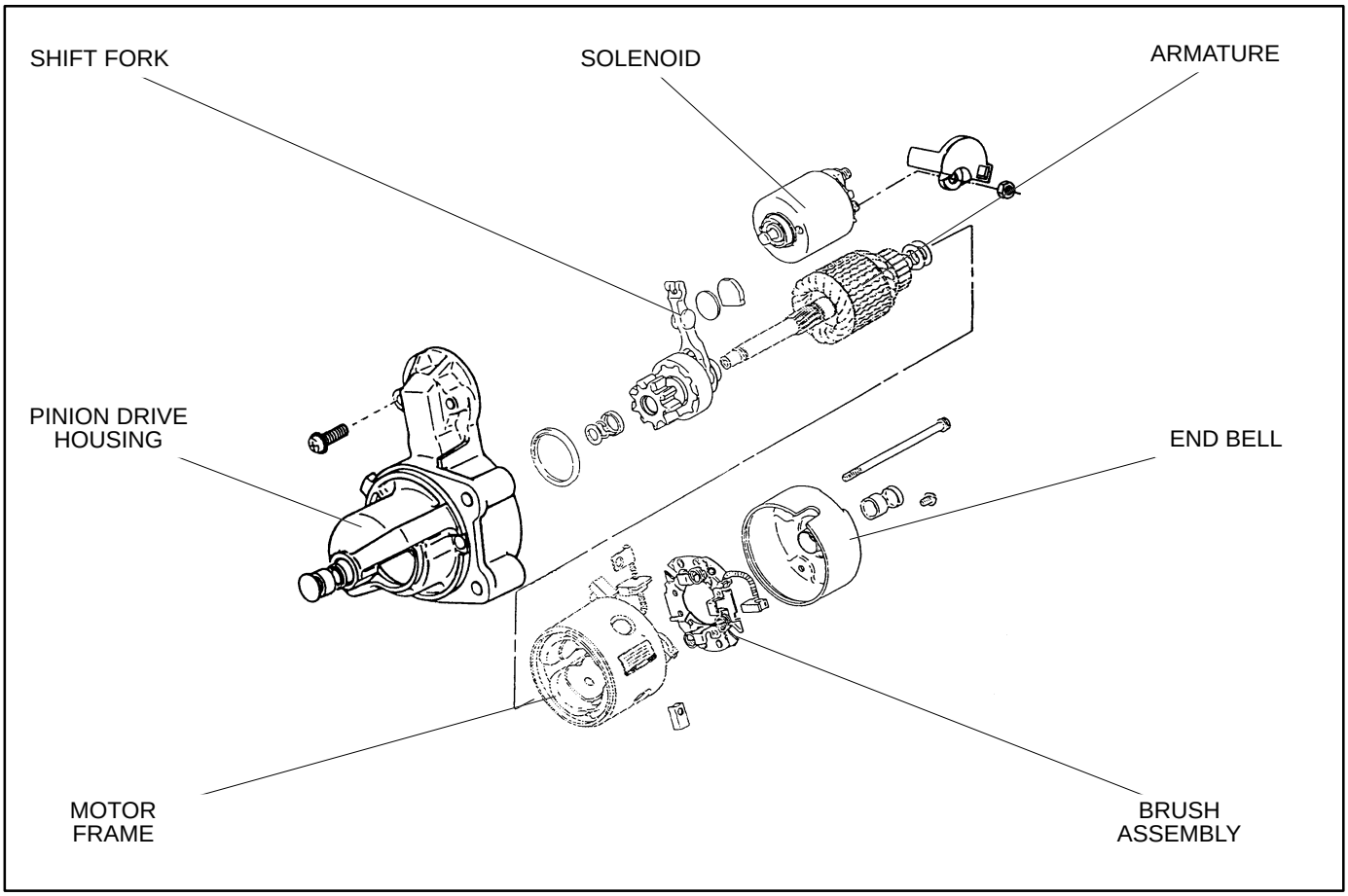

FIGURE 6-16. SOLENOID SHIFT STARTER

Solenoid

See Figure 6-17. Before replacing the solenoid, confirm that it is the cause of the starter not working by removing it from the starter assembly and conducting the following tests.

1. Connect **6 volt** battery positive (**+**) to solenoid terminal **S** and battery negative (**-**) to solenoid terminal **M**. The plunger should pull in and hold in strongly. If it does not, replace the solenoid.

2. Connect **6 volt** battery positive (**+**) to solenoid terminal **S** and battery negative (**-**) to the body of the solenoid. Push the plunger in and release it. The plunger should stay in. If it does not, replace the solenoid.

3. Connect **12 volt** battery positive (**+**) to solenoid terminal **M** and battery negative (**-**) to the solenoid body (reversed from normal polarity). Push the plunger in and release it. The plunger should push back out immediately. If it does not, replace the solenoid.

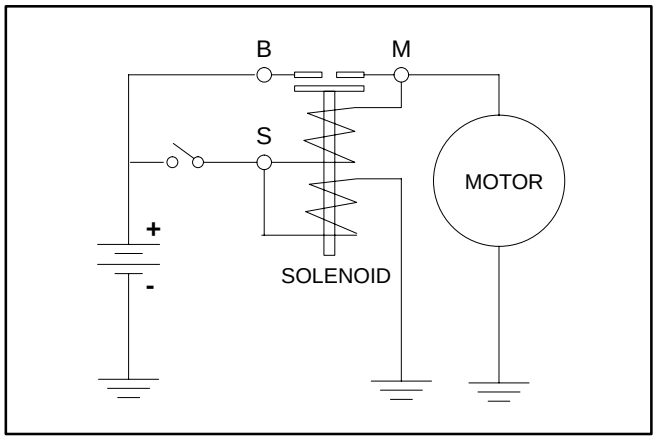

FIGURE 6-17. SOLENOID-MOTOR CIRCUITS

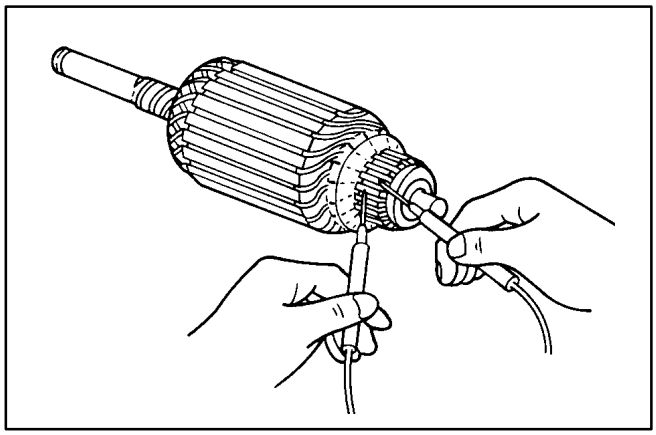

FIGURE 6-18. CHECKING WINDING INTEGRITY

Armature

Winding Integrity: See Figure 6-18. Use an ohmmeter to check for electrical continuity between pairs of commutator segments all the way around the commutator. Make sure each segment is checked. Replace the armature if a winding is open (high resistance) at any segment.

Winding Insulation: See Figure 6-19. Use an ohmmeter to check for winding insulation breakdown between the windings and the rotor laminations. Replace the armature if the ohmmeter does not indicate high resistance on its highest scale between any commutator segment and the rotor laminations.

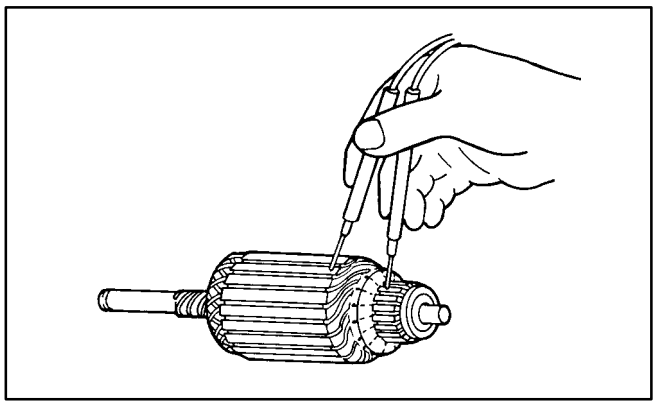

FIGURE 6-19. CHECKING WINDING INSULATION

Commutator: See Figure 6-20. Clean the commutator surface with sandpaper. Measure the diameter at several locations around the commutator. Turn the commutator in a lathe if it is not round or has deep pits. Replace the armature if it is necessary to turn the diameter of the commutator to less than 1-1/16 inch (27 mm).

Using a hacksaw blade, undercut the mica between the commutator segments by 1/32 inch and chamfer the edges of the segments slightly.

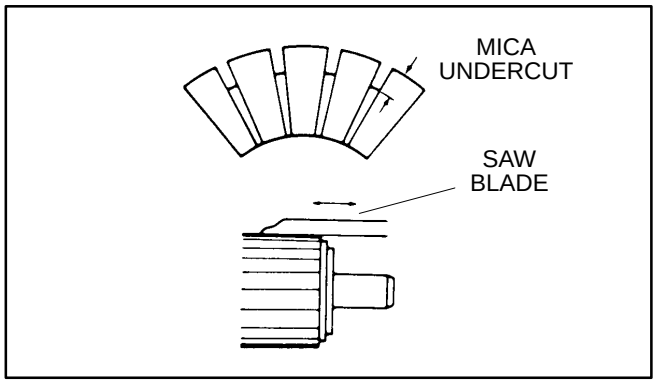

FIGURE 6-20. COMMUTATOR MICA UNDERCUT

Brush Assembly

Replace the motor frame and brush assembly if any brush is less than 0.43 inch (11 mm) long.

Motor Frame and Stator

See Figure 6-21. Two of the four brushes are connected directly to the stator windings, one to each pair of windings. The other ends of the two pairs of stator windings are crimped to the motor frame (grounded). To check the integrity of each winding pair, use an ohmmeter to check for continuity between its brush and the motor frame. Replace the motor frame if either winding pair is open (high resistance). (This test will not detect if a single winding of a pair is open. If the windings look burnt or smell bad, it is recommended that the motor frame be replaced.)

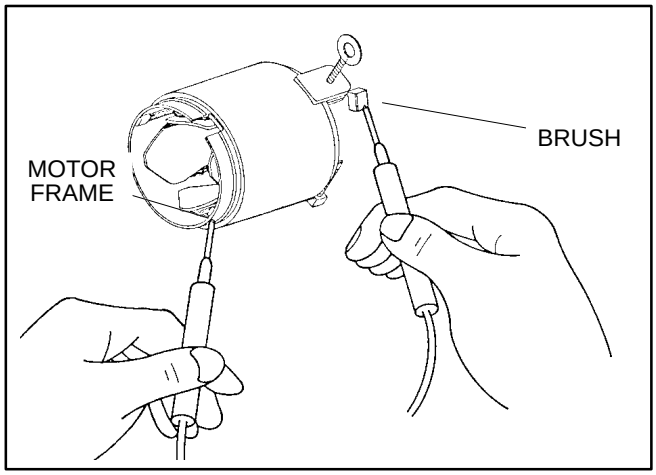

FIGURE 6-21. CHECKING MOTOR FRAME WINDINGS

Pinion

See Figure 6-22. Replace the pinion assembly if the pinion teeth and armature shaft splines are worn or damaged. Check the over-running clutch by rotating the pinion clockwise and counterclockwise. Replace the pinion assembly if it does not turn smoothly counterclockwise or lock clockwise.

⚠ CAUTION ***Do not clean the pinion overrunning clutch with any kind of cleaning solution, otherwise it may be damaged.***

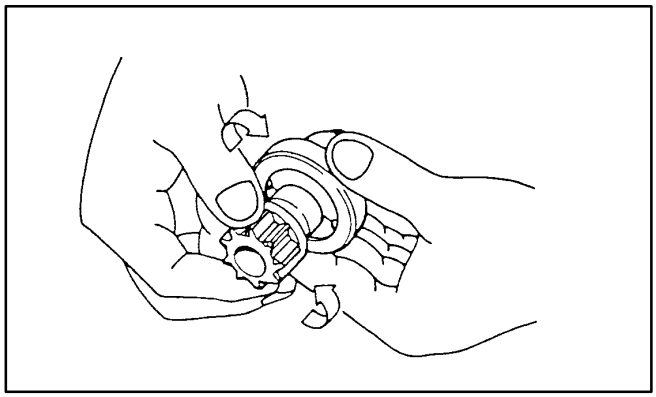

FIGURE 6-22. CHECKING OPERATION OF THE PINION OVER-RUNNING CLUTCH

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7. Engine Block Assembly

Performing major service on the engine block assembly requires removal of the engine divider panel be removed from the genset. See *Removing and Installing the Engine Divider Panel* in Section 5.

CYLINDER HEADS

See Figure 7-1. Remove and clean the cylinder heads as follows when poor engine performance is noticed:

1. Remove the cylinder head bolts by using a 1/2 inch socket wrench. Lift off the cylinder head.

   ⚠ CAUTION ***The heads may warp if they are removed while hot (above 100° F (20° C). Wait until the engine has cooled before removing the heads.***

2. After removing the heads clean out all carbon deposits. Be careful not to damage the outer sealing edges where the gaskets fit. The heads are made of aluminum and can be damaged by careless handling.

3. It is a good idea to also remove the valves and clean carbon deposits from the valves and the intake and exhaust ports. See *Valve System*.

4. Use new head gaskets and clean both the heads and the cylinder block thoroughly where the gaskets rest.

5. Place a head gasket on the cylinder head and align the stud holes in the gasket with the stud holes in the cylinder head. While holding the gasket against the cylinder head, carefully install the cylinder head on the engine. Do not attempt to slide the gasket over the studs without the cylinder head behind it or the gasket may tear.

6. Install a flat washer, two compression washers, and nut on each of the top six studs (Figure 7-2). When properly installed, only the outside edges of the compression washers will be in contact with each other. Install a flat washer and nut on each of the four bottom studs.

7. Torque the head bolts in steps of 5 lb-ft (7 N-m) in the numbered sequence shown in Figure 7-1 up to the specified torque of 15-17 lb-ft (20-23 N-m).

8. Retorque the head bolts before the engine has run a total of 25 hours.

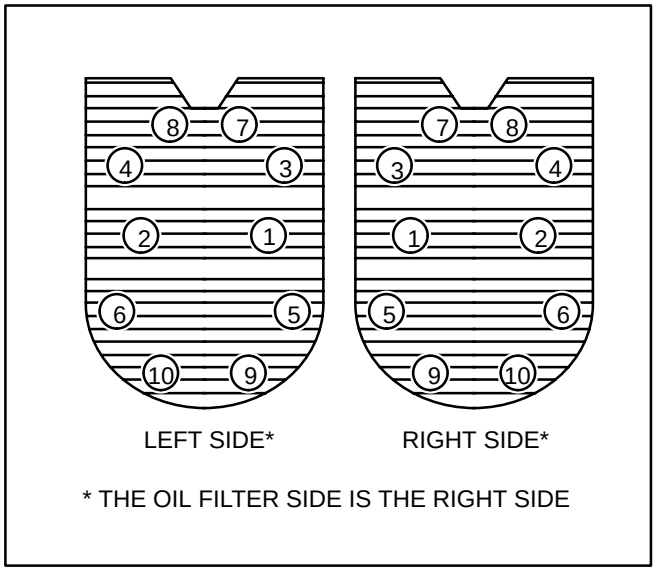

FIGURE 7-1. CYLINDER HEAD BOLT TORQUE SEQUENCE

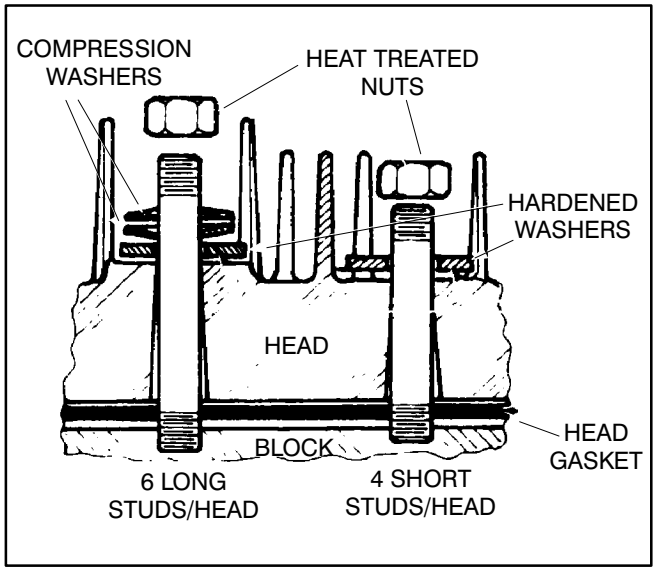

FIGURE 7-2. NHM CYLINDER HEAD WITH COMPRESSION WASHERS

VALVE SYSTEM

See Figure 7-3. This engine has a “side valve” type of valve system layout.

A properly functioning valve system is essential for top engine performance.

See *Valve Clearance (Lash) Adjustment* in Section 6 for instructions on how to adjust valve clearance.

Inspecting the Valve System

The valve system is accessible by removing the cylinder heads and the valve covers on top of the engine. Use a valve spring compressor (Figure 7-4) to remove and replace the valves from the cylinder block. Make sure to first plug the breather hole in the Number 1 cylinder valve box (opposite oil filter side) to prevent the valve keepers from falling into the gear case.

Valve Face: See Figure 7-5. Check the valve face for evidence of burning, warping, out-of-roundness and carbon deposits.

Burning and pitting are caused by the valve failing to seat tightly. This condition is often caused by overheating, weak valve springs, insufficient tappet clearance, valve warpage and misalignment.

Warping occurs chiefly in the upper stem because it is exposed to intense heat. Out-of-roundness results from warping when the seat is pounded by a valve whose head is not in line with the stem. If a valve face is burned or warped, or the stem is worn, install a new valve.

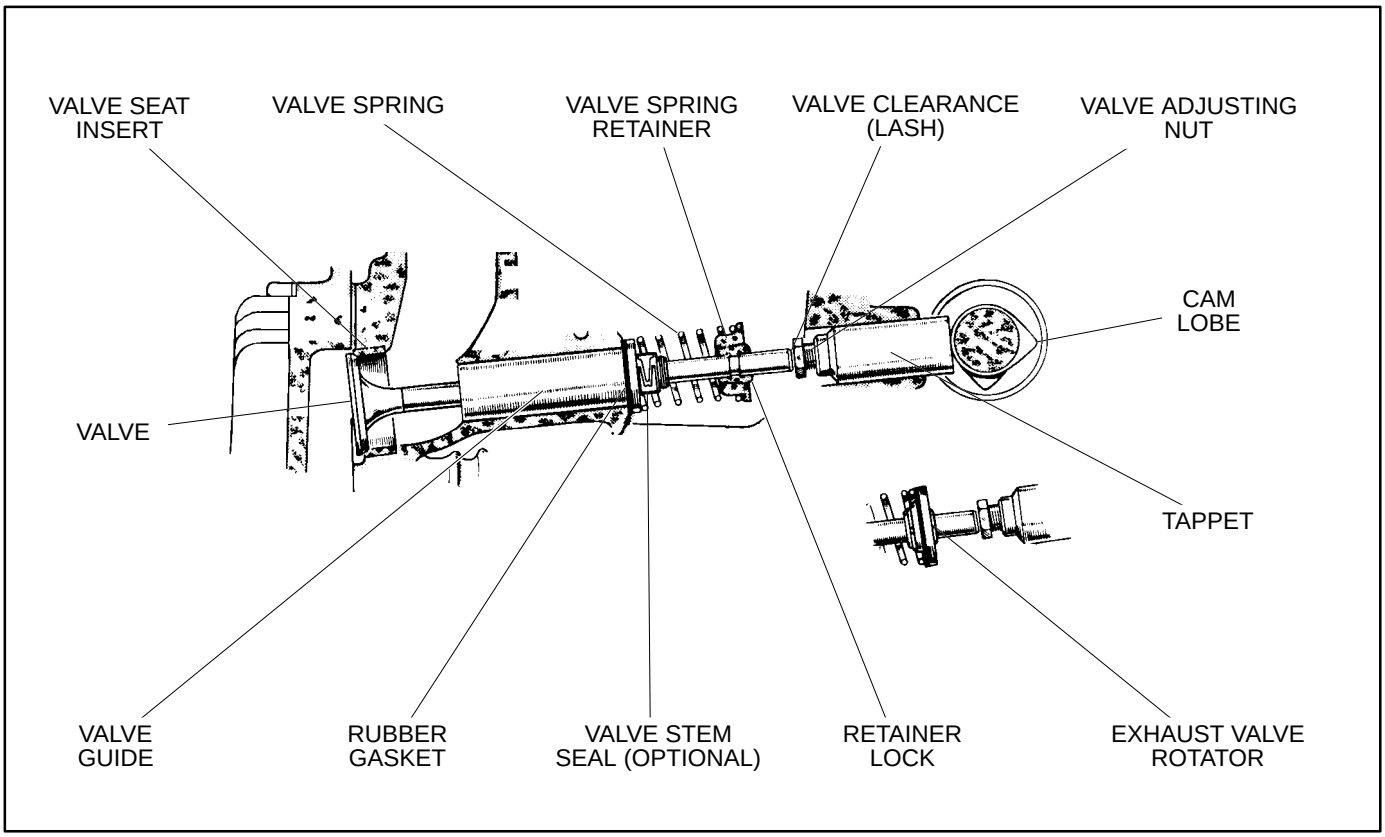

FIGURE 7-3. VALVE SYSTEM

Excess clearance in the intake guide admits air and oil into the combustion chamber, upsetting carburetion, increasing oil consumption and making heavy carbon deposits. Carbon prevents heat dissipation. Clean metal is a good heat conductor, but carbon insulates and retains heat. This increases combustion chamber temperatures, causing warping and burning.

Unburned carbon residue gums valve stems, causing them to stick in the guide. Deposits of hard carbon with sharp points projecting become white-hot, causing pre-ignition and “pinging”.

Valve Stems and Guides: See Figure 7-6. Check valve stems and guides for wear. Use a hole gauge to measure the valve guide bore diameter. When valve clearance with the stem exceeds the original clearance by 0.002 inch (0.05 mm), replace either the valve or guide or both, as necessary. Always regrind the seat to make it concentric with the newly installed guide.

Valve Stem Seal: A valve stem seal is used on the intake valve guides. This seal must be replaced each time the valve is removed.

Valve Springs: Check the valve springs for free-height, squareness, end wear and tension. If the spring ends are worn, check the valve spring retainer for wear. Check for height and squareness by placing the spring on a flat surface next to a square. Rotate the spring against the square edge to measure its distortion. Check the spring tension at the installed height in both the valve open and closed positions, using a valve spring tester. Replace a weak, broken, worn or distorted spring.

Valve Rotators:: The engine uses positive type valve rotators on the exhaust valves (Figure 7-3). When functioning properly, the valves are rotated a fraction of a turn each time they open. While in the open position, the valves must rotate freely. There is no easy way to determine if a valve rotator is good or bad. Onan recommends that valve rotators be replaced at each major overhaul or if a build up of carbon is noted on valve face and valve seat.

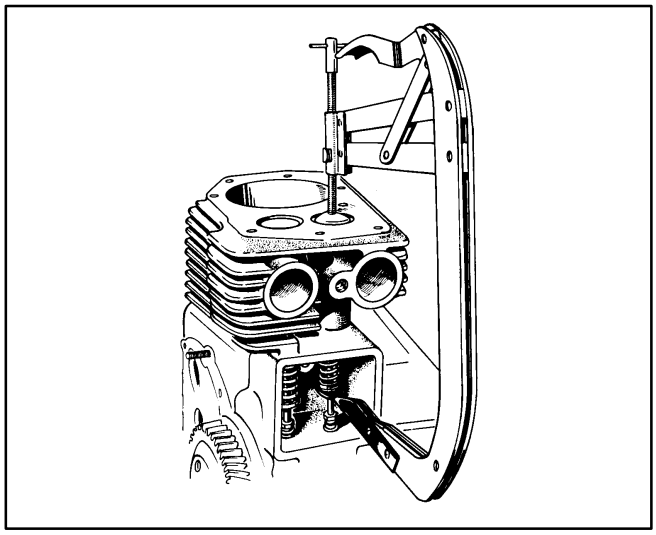

FIGURE 7-4. VALVE SPRING COMPRESSOR

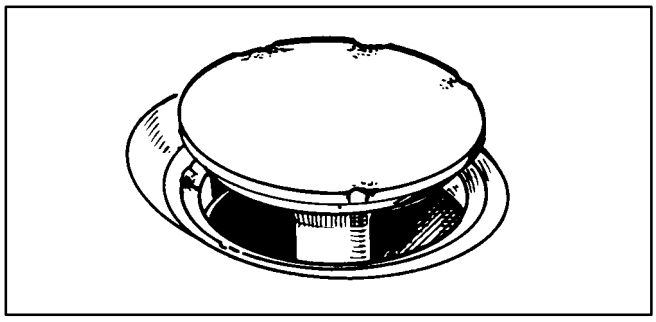

FIGURE 7-5. BURNED VALVE FACE

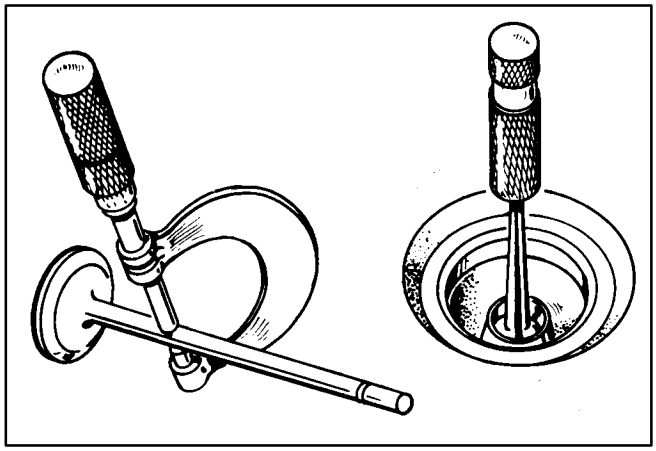

FIGURE 7-6. VALVE STEM AND VALVE GUIDE BORE DIAMETERS

Reconditioning Valves and Valve Seats

See Figure 7-7. The interference angle method of valve seating is used on these engines. 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 valves must not be hand lapped, because the sharp contact between the valve and the seat will be destroyed. This is especially important where chrome cobalt faced valves and seats are used. Valve faces must be finished to 44 degrees, in a machine.

Each valve must have a minimum of 1/32 inch (0.8 mm) margin (Figure 7-8). If the valve has less margin than this, it will heat up excessively. It will retain this heat during the compression stroke and pre-ignite the mixture, causing loss of power and economy. This valve is also susceptible to warping and breakage.

Not all valves can be reconditioned. A badly warped valve must be replaced, because the amount of grinding required to make it seat correctly removes its margin. To make a valve gas-tight, remove all pitting from the valve face and seat. Deeply pitted or cut valves must be replaced, because grinding removes the margin.

Check each valve for a tight seat. Make several marks at regular intervals across the valve face using machinist's bluing. The marks should rub off uniformly when the valve is rotated a quarter-turn against the seat, indicating even contact all the way around. The line of contact should be at the center of the valve face.

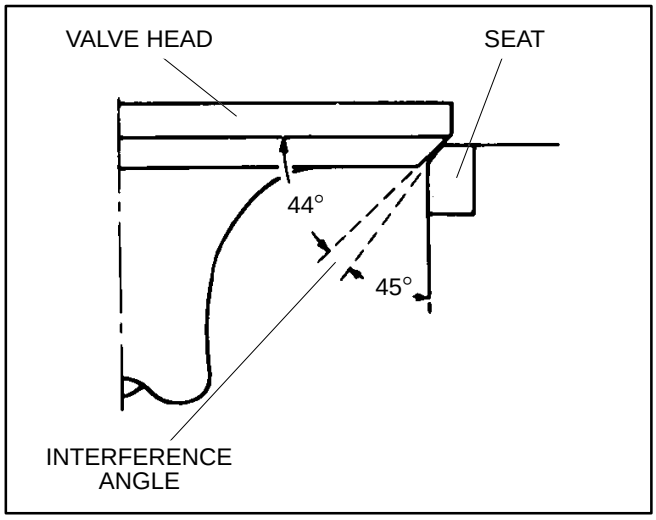

FIGURE 7-7. VALVE INTERFERENCE ANGLE

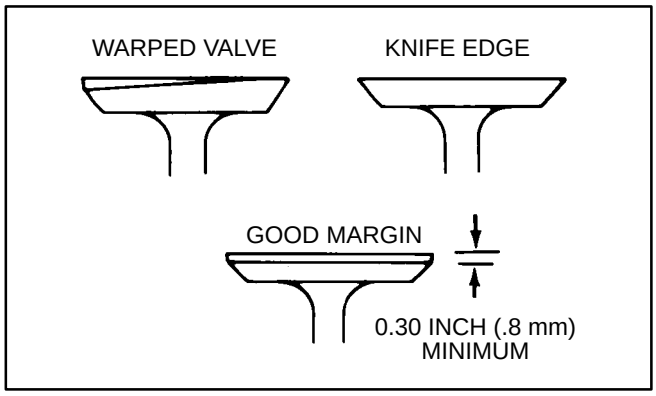

FIGURE 7-8. VALVE MARGIN

Replacing the Valve Guides

Worn valve stem guides can be replaced from inside the valve chamber. The smaller diameter of the tapered valve guides must face toward the valve head.

Removal:

1. Before removing the valve guides, use an electric drill with a wire brush to remove carbon and other foreign material from the top surface of the guides. Failure to do this may result in damage to the guide bores.

2. Drive the guides out with a hammer and a valve guide driver.

   ⚠ CAUTION ***Driving out the old valve guides can damage the tappet bores. Be careful not to strike the bores with the driver.***

Installation:

1. Run a small polishing rod with crocus cloth through the valve guide holes, to clean out carbon and other foreign materials.

2. Place a new gasket on the intake valve guide and coat the outer edge of each new guide with anhydrous lanolin (available at the drugstore).

3. Place the guide, notch up, in the cylinder block and press it in until the shoulder of the guide rests against the cylinder block (Figure 7-9).

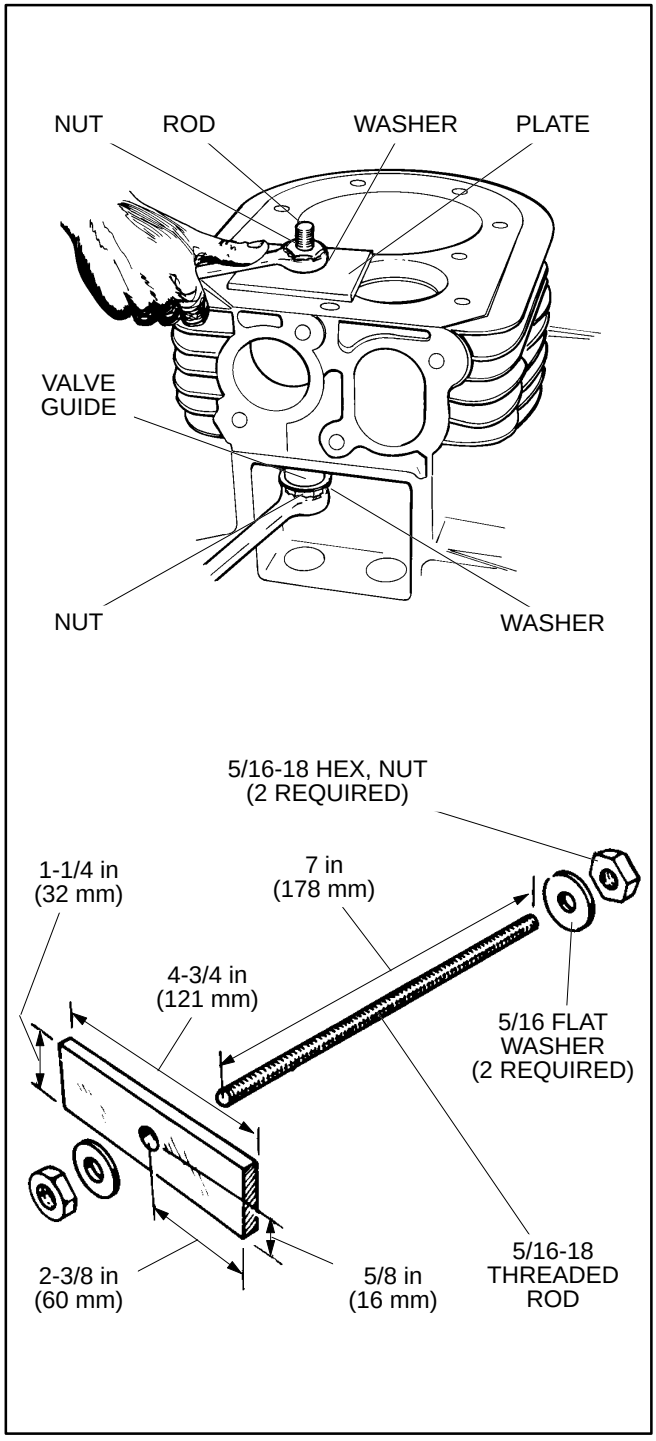

FIGURE 7-9. SUGGESTED TOOL FOR INSTALLING THE VALVE GUIDES

Valve Seat Removal Procedure

1. Remove carbon and combustion deposits from the valve seat.

2. Select the proper size puller (determined by the inside diameter of the valve seat). The puller jaws must expand into the cylinder block at the point where the bottom of the valve seat insert rests on the cylinder block (Figure 7-10).

3. Using the new seat insert as a guide, adjust the puller depth. Position the puller on the valve seat and tighten its hex nut. Clamp the cylinder block to a solid bench. Attach a slide hammer to the puller. Between blows with the slide hammer, tighten the hex nut.

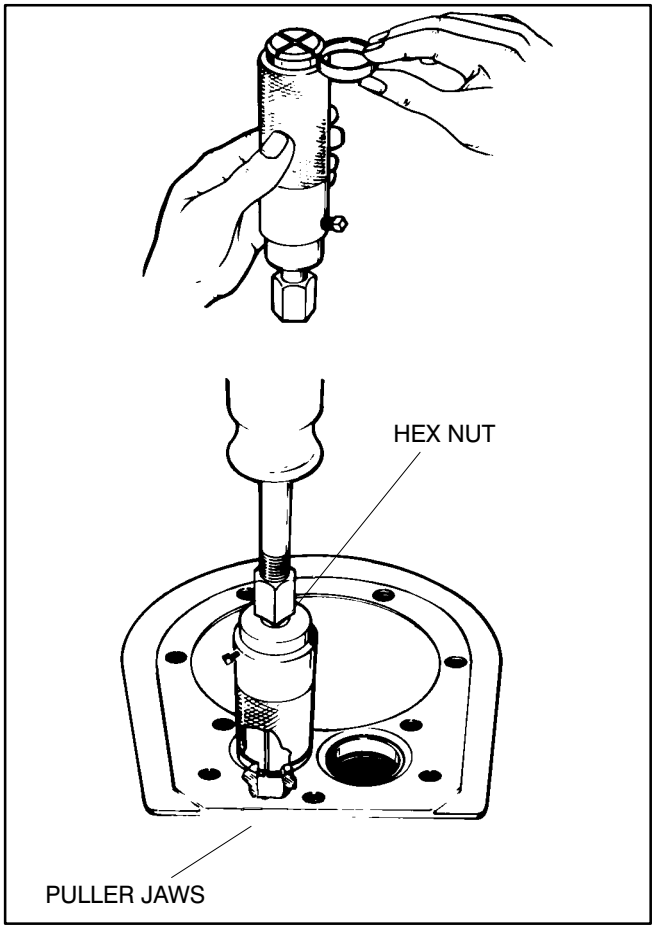

FIGURE 7-10. VALVE SEAT REMOVAL

Valve Seat Installation Procedure

1. After the old seat has been removed, clean out carbon and metal burrs from the seat insert recess. Use a valve seat insert driver and a hammer to install the insert.

2. Insert the pilot of the driver into the valve guide hole in the cylinder block. Quickly drive the valve seat insert in, so that the insert goes evenly to the bottom of the recess in the cylinder block. Make certain that the valve seat insert rests solidly on the bottom of the recess all the way around its circumference (Figure 7-11).

3. Insert a valve seat staker into the cylinder block valve guide hole. Rotate the staking tool until it drops to the original stake marks. Rotate the staking tool another 60° (1/6 turn). Using a lead hammer, strike the staking tool a sharp blow to wedge the new valve seat securely in place. The valve seat must be staked to ensure a tight fit and eliminate the danger of its loosening in the bore. Before installing the valves, refinish the valve seat inserts.

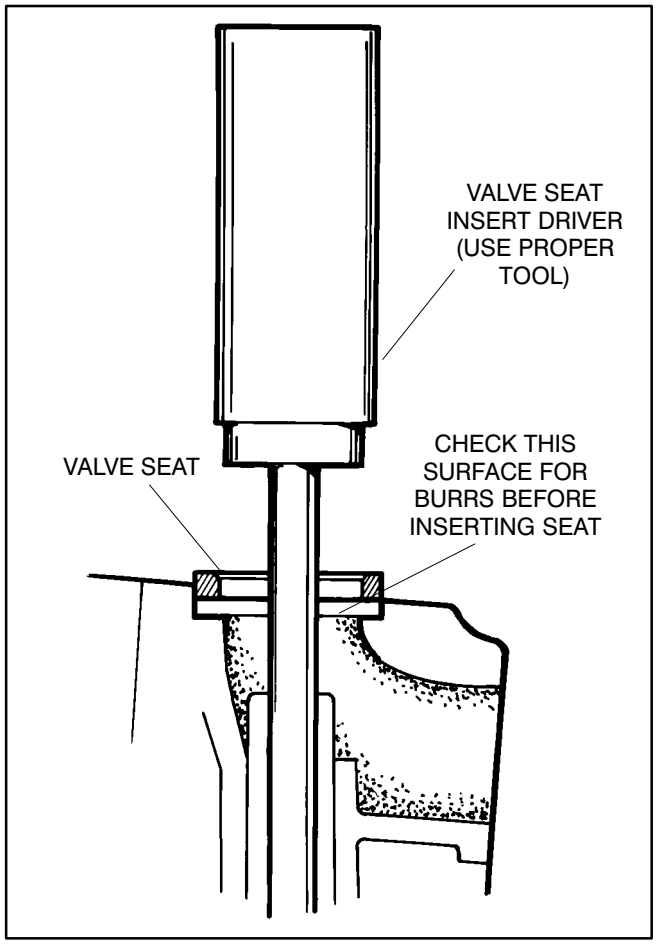

FIGURE 7-11. INSERTING NEW VALVE SEAT

PISTON ASSEMBLY

The piston assembly consists of the piston, rings, piston pin and connecting rod. Inspect for damage and wear before replacing parts.

Removal and Disassembly

1. Remove the ridge at the top of the cylinder with a ridge reamer before attempting to remove the piston (Figure 7-12).

   ⚠ CAUTION ***Improper use of a ridge reamer can damage the cylinder bore. Use this tool with extreme care.***

2. Turn the crankshaft until a piston is at the bottom of its stroke.

3. Remove the bearing caps from the connecting rods and push the rods and pistons out the top of the cylinders. Be careful not to scratch the crankpin or the cylinder wall when removing these parts.

4. Mark each piston, rod and bearing cap so that they can be reassembled together in the same cylinder.

5. The pistons are fitted with two compression rings and one oil control ring. Remove these rings from the piston using a piston ring spreader (Figure 7-13).

6. Remove the piston pin retainer from each side and push the pin out.

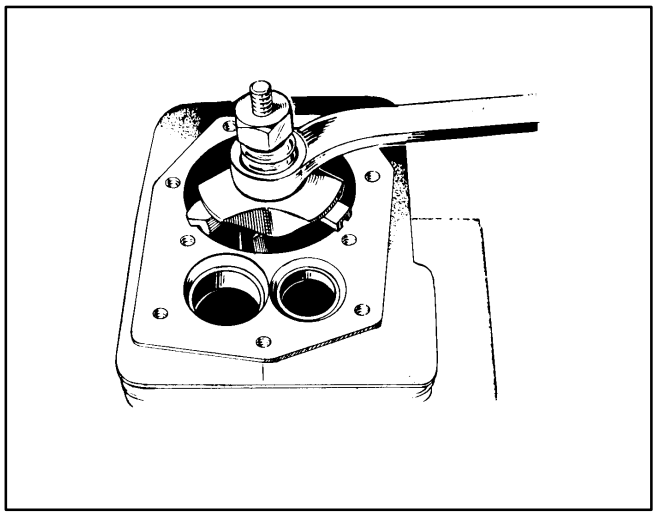

FIGURE 7-12. CYLINDER RIDGE REAMER

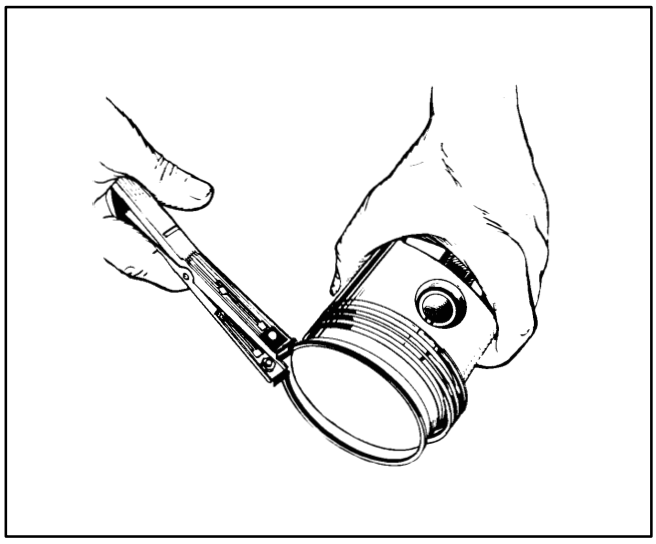

FIGURE 7-13. PISTON RING SPREADER

7. Remove deposits from the piston surfaces with an approved cleaning solvent. Clean the piston ring grooves with a groove cleaner or with the end of a piston ring filed to a sharp point (Figure 7-14). Take care not to remove metal from the sides of the grooves.

   ⚠ CAUTION ***Caustic cleaning solvents and wire brushes can damage pistons. Use parts cleaning solvent to clean pistons.***

   When cleaning the connecting rods in solvent, make certain to include the rod bore. Blow out all passages with low-pressure compressed air.

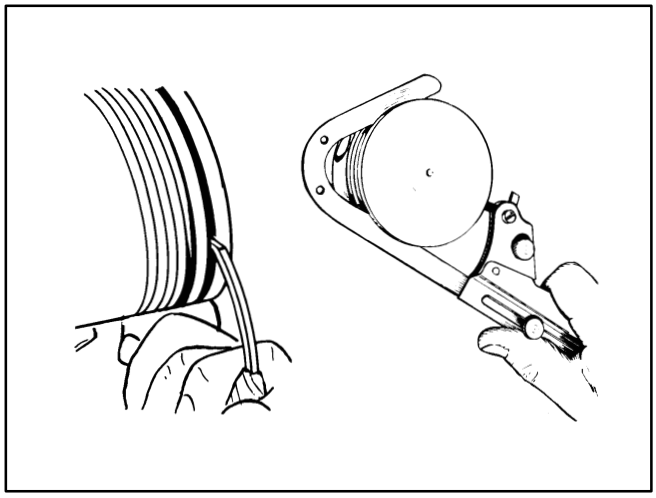

FIGURE 7-14. PISTON RING GROVE CLEANER

Piston and Connecting Rod Inspection

Piston Inspection: 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 (Figure 7-15). Replace the piston if the side clearance of the top compression ring is 0.008 inch (0.20 mm) or more.

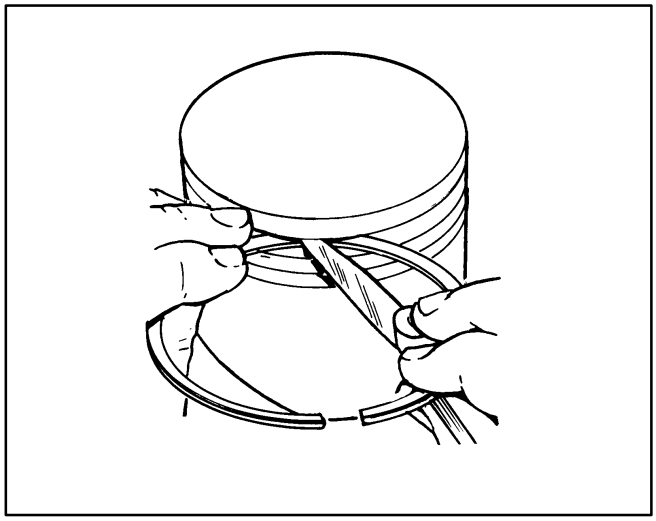

FIGURE 7-15. CHECKING RING LAND

Improper ring width or excessive ring side clearance can result in ring breakage. New rings in worn ring grooves do not make adequate contact with the cylinder wall (Figure 7-16).

Replace pistons showing signs of scuffing, scoring, worn ring lands, fractures or damage from pre-ignition.

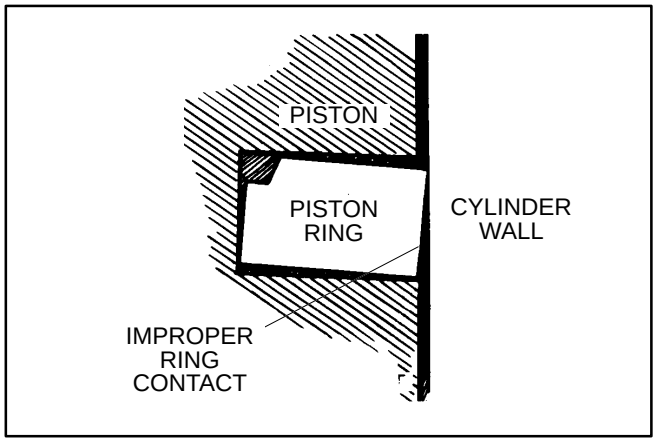

FIGURE 7-16. NEW RING IN WORN RING GROVE

Connecting Rod Inspection: Replace connecting rod bolts and nuts having damaged threads. Replace connecting rods with deep nicks, signs of fracture, scored bores or bores out of round more than 0.002 inch (0.05 mm).

Use a new piston pin to check the connecting rod for wear. A push-fit clearance is required; this 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 or bushing, as required.

Piston Pin Inspection: Replace piston pins that are cracked, scored, or out of round more than 0.002 inch (0.05 mm).

Bearing Inspection: Inspect bearings for burrs, breaks, pits and wear. Replace bearing inserts which are scored, show fatigue failure, are badly scratched or which have their overlay wiped out,. If a bearings appears serviceable, check for proper clearance.

Piston Clearance

Correct piston tolerances must be maintained. Use a micrometer to measure the piston diameter at the point shown in Figure 7-17. When the cylinder bore is measured (see *Cylinder Block*), subtract the piston diameter from the cylinder bore diameter to obtain the piston-to-cylinder wall clearance. See *Tolerances and Clearances* in Section 2.

Piston Ring Gap

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 (Figure 7-18). The gap should be 0.010-0.020 inch (0.25-0.50 mm).

Do not file the ring ends to increase the end gap. If the ring end gap does not meet the specifications, check the correctness of ring and bore sizes. A cylinder bore that is 0.001 inch (0.03 mm) undersize will reduce the end gap 0.003 (0.08 m).

Rings that are 0.010, 0.020, 0.030 and 0.040 inch (0.25, 0.51, 0.76 and 1.02 mm) oversize should be used on corresponding oversize pistons.

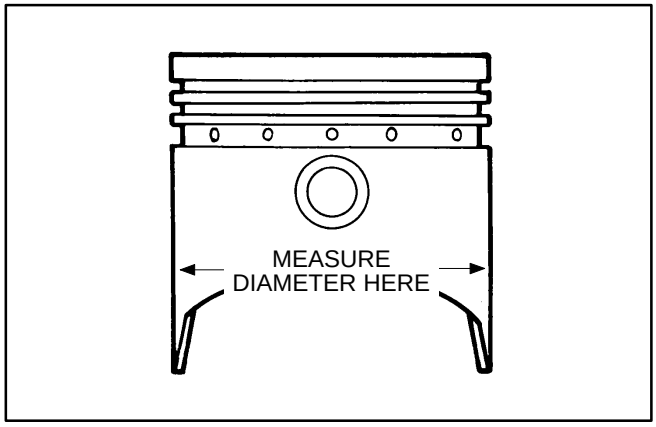

FIGURE 7-17. MEASURING PISTON DIAMETER

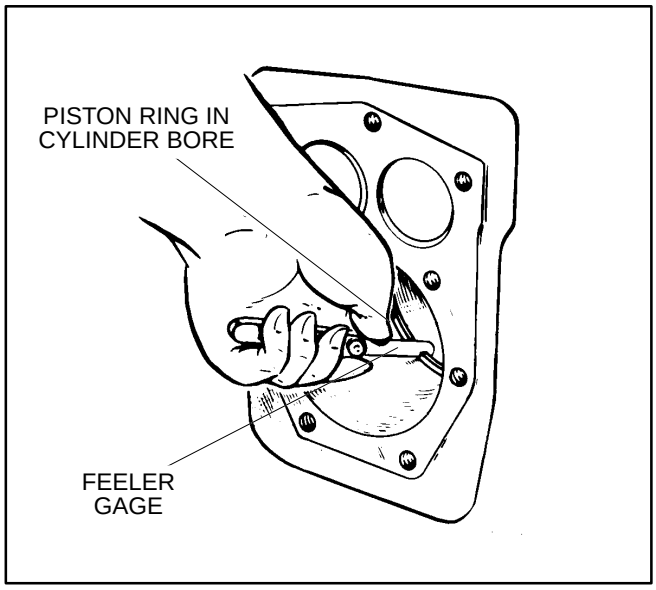

FIGURE 7-18. CHECKING RING GAP

Piston Assembly

1. Lubricate all parts with clean engine oil.

2. Line up the piston and connecting rod and insert the piston pin. The piston pin is a full-floating type kept in place by a lock ring on each side. Push the lock rings in by thumb pressure or pry them in with a small screwdriver. Make sure they are properly seated.

   ⚠ CAUTION ***Wear safety glasses and hold your thumb over the lock ring to keep it from flying out and getting lost or causing personal injury.***

3. Refer to Figure 7-19. Use a piston ring spreader to install the piston rings to prevent twisting or excessive expansion. Follow the instructions in the ring kit exactly. Note which ring goes in which groove and which side of the ring is "up". Also note that the oil control ring is an assembly.

Piston Installation

1. The crankshaft must be in place and should have been serviced already if crankshaft service was required. See *Crankshaft*.

2. Turn the crankshaft to position the Number 1 rod bearing journal (side opposite oil filter side) at the bottom of its stroke.

3. Lubricate the Number 1 piston assembly and cylinder with engine oil. Compress the rings with a ring compressor as shown in Figure 7-21. Install the bearing insert in the piston rod.

4. Position the piston and rod assembly in the cylinder block with the connecting rod oil hole facing towards camshaft (Figure 7-20).

5. Tap the piston into the bore with the handle end of the hammer until the connecting rod is seated on the crankshaft journal (Figure 7-21). If the crankshaft has been reground and/or new rods are being installed, check the bearing clearance with Plasti-gage as instructed below under Rod Bearing Clearance.

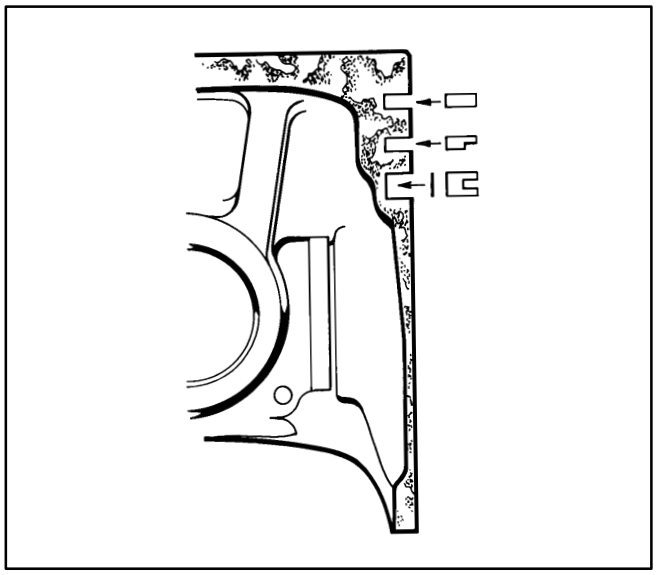

FIGURE 7-19. PISTON RINGS

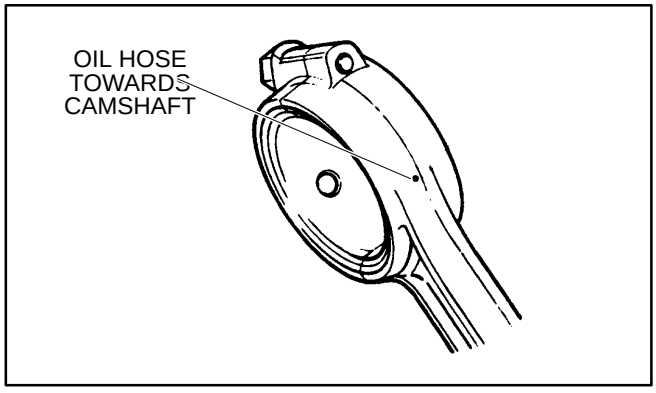

FIGURE 7-20. CONNECTING ROD OIL HOLE

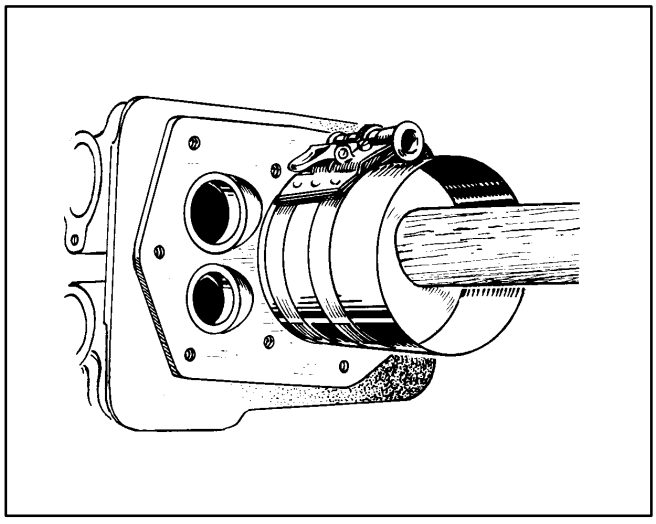

FIGURE 7-21. INSERTING PISTON

6. Install the rod bearing cap as follows:

   A. Lubricate the cap bolts with engine oil and torque to 5 lb-ft (7 N-m).

   B. Strike the cap/rod joint using a hardwood block and a leather or plastic mallet to remove any misalignment (Figure 7-22).

   C. Torque the cap bolts to 27-30 lb-ft (37-39 N-m). Recheck the torque on each bolt after both bolts have been torqued.

⚠ CAUTION ***Failure to align the rod and cap can result in high engine oil temperature and failure of the rod.***

7. Install the other piston assembly and crank the engine by hand to see that all bearings are free.

Connecting Rod Bearing Clearance

1. Wipe all parts clean of oil and grease.

2. Select Plasti-gage that corresponds to the connecting rod bearing clearance specification (0.0020-0.0033 inch [0.051-0.084 mm]). Place the piece of Plasti-gage across the full width of the bearing cap, about 1/4 inch (6 mm) off-center (Figure 7-23).

3. Install the rod bearing cap (Step 6, Piston Installation). Do not let the crankshaft rotate or the Plasti-gage will smear.

4. Remove the bearing cap, leaving the Plasti-gage on the part it sticks to. Check the widest part of the flattened Plasti-gage with the graduations on the envelope to determine the bearing clearance.

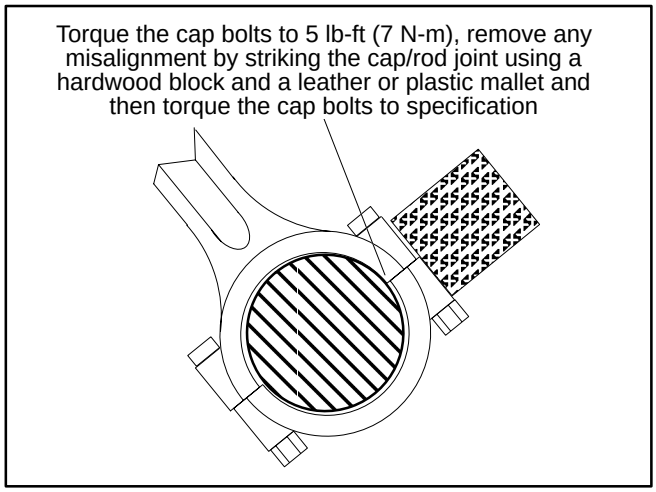

FIGURE 7-22. ALIGNING CONNECTING ROD CAP

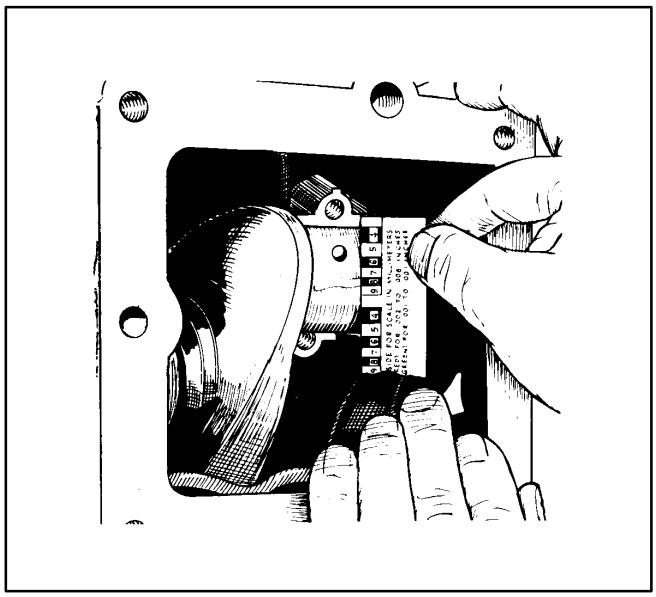

FIGURE 7-23. USING PLASTI-GAGE

GEAR COVER

Gear Cover Removal Procedure

1. Remove the flywheel key (see *Flywheel/Blower Rmoval* in Section 6.).

2. Remove the gear cover mounting screws (see Figure 7-26).

3. Gently tap the gear cover with a plastic-faced hammer to loosen it (see Figure 7-24).

Gear Cover Installation Procedure

NOTE: Electronic governor gensets may have the governor arm, shaft, etc. to consider when performing this step. These items are not used to govern the engine, but must be properly installed after gear cover removal.

1. Use new gaskets and apply thread sealant to the bolts when installing the gear cover. Make sure that the pin in the gear cover engages the nylon-lined (smooth) hole in the governor cup. See Figure 7-24.

2. Turn the governor cup so the nylon-lined hole is at the three o'clock position. Use a small amount of grease to help hold the cup in position. The rounded side of the governor yoke must ride against the governor cup.

3. 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.

See *Crankshaft Oil Seals* in this section if replacing the gear cover oil seal.

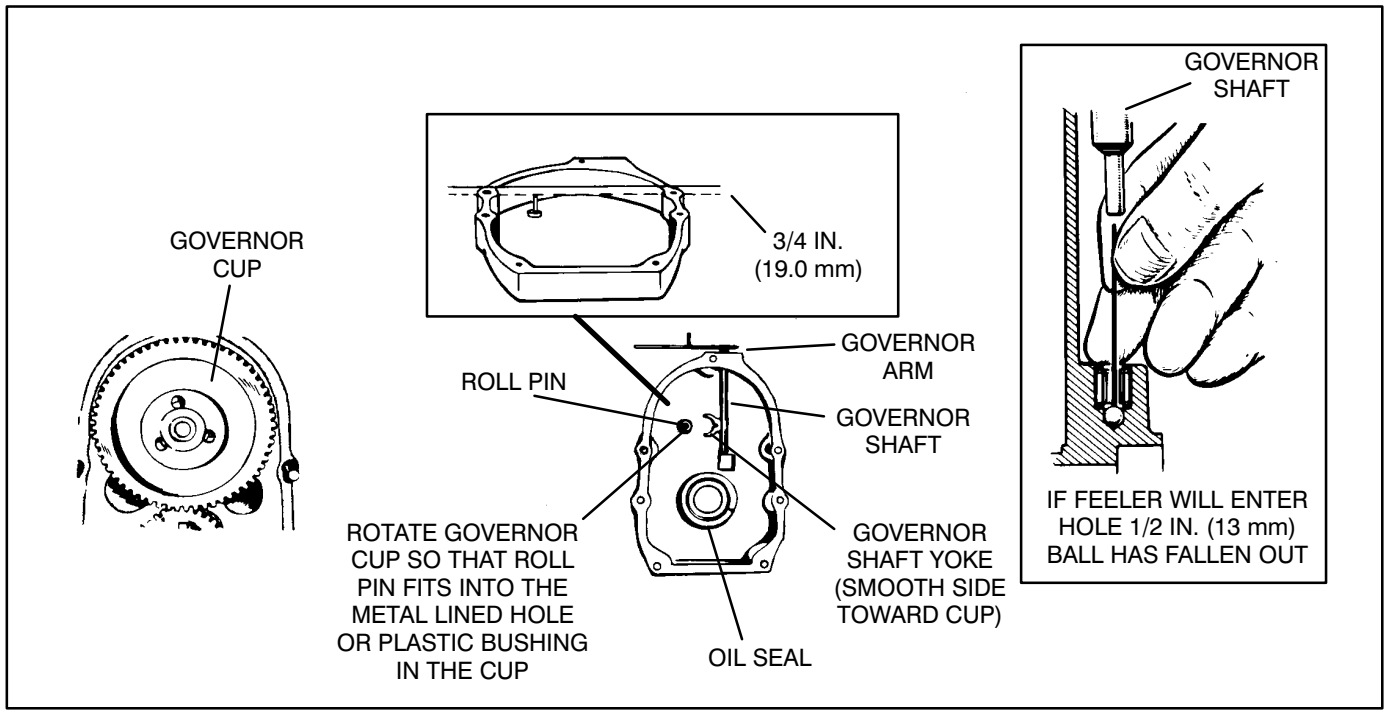

FIGURE 7-24. GEAR COVER ASSEMBLY

GOVERNOR CUP (MECHANICAL)

NOTE: Electronic governor gensets may have the governor cup installed. This assembly is not used to govern the engine but must be removed when rebuilding the engine.

Governor Cup Removal Procedure

1. Remove the gear cover, as described above.
2. Remove the snap ring from the camshaft center pin (see Figure 7-25).
3. Slide the governor cup off, making certain to catch the flyballs.

Governor Cup Installation Procedure

The governor cup and flyballs are easily installed when the camshaft assembly is removed from the engine. If necessary, the engine may be tilted up to install the cup and flyballs.

1. Put the flyballs between the spacer arms and install the cup on the center pin.
2. Lock the cup in place with the snap ring.

Camshaft Center Pin Installation Procedure

1. The camshaft center pin extends 3/4 inch (19 mm) from the end of the camshaft. This distance provides 7/32 inch (5.6 mm) travel for the governor cup, as illustrated in Figure 7-25. Measure this distance while holding the cup against the flyballs.
2. Remove the center pin and press in a new pin the specified amount. Do not hammer the new pin into place, or it will be damaged. The camshaft center pin cannot be pulled outward or removed without damage. If the center pin extends too far, the cup will not hold the flyballs properly.

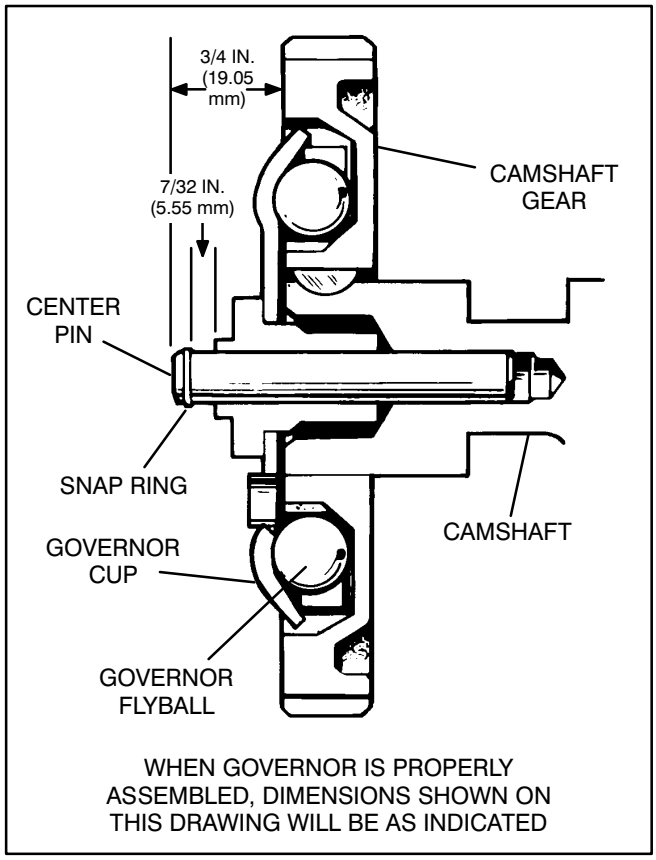

FIGURE 7-25. GOVERNOR CUP

TIMING GEARS AND CAMSHAFT

The camshaft and its timing gear are not separately replaceable. Also, if it is necessary to replace a timing gear, the gears should be replaced as a pair.

Removal

1. Remove the flywheel key (see *Engine Cooling System* in Section 6 to remove the flywheel/blower).
2. Remove the gear cover mounting screws (see Figure 7-26).
3. Remove the valve tappets so that the camshaft can be withdrawn.
4. Remove the snap ring and washer in front of the crankshaft timing gear.
5. Withdraw the camshaft.
6. Remove the oil pump.
7. Remove the crankshaft timing gear. Use a gear puller and ring bolted to the gear with 1/4-20x1 inch Grade 8 bolts (lesser grade bolts will snap off) (Figure 7-27), or the shoulder bolts and flywheel puller which are available.

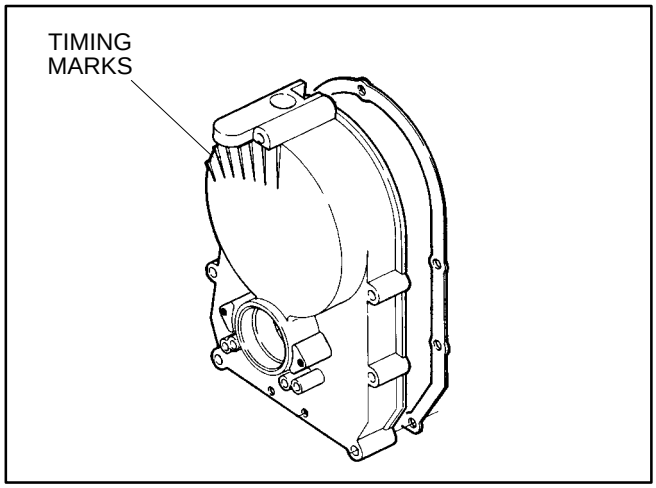

FIGURE 7-26. GEAR COVER AND GASKET

Installation

1. Install the camshaft bearings. See *Camshaft Bearings* in this section.

2. Install the crankshaft. See *Crankshaft*.

3. Preheat the crankshaft gear to 325° F (168° C).

4. Make sure the key is in place in the crankshaft and that the “0” mark is facing out and then tap the gear down to the shoulder on the crankshaft.

5. Install the camshaft, making sure the thrust bearing is in place between the gear and the block and that the “0” marks on the timing gears line up (Figure 7-27).

6. Install the oil pump assembly.

7. Install the retainer washer and snap ring in front of the crankshaft timing gear.

8. Replace the crankshaft oil seal in the gear cover and install the gear cover. See *Crankshaft Oil Seals* in this section.

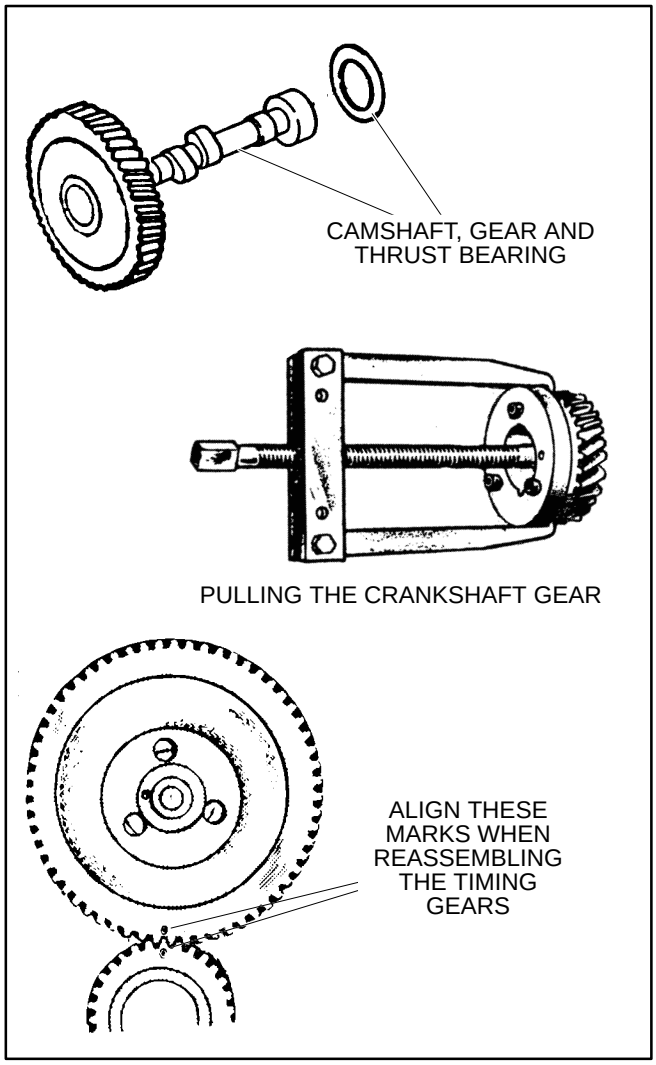

FIGURE 7-27. TIMING GEARS AND CAMSHAFT

OIL PUMP ASSEMBLY

See Figure 7-28. The oil pump is mounted behind the gear cover and is driven by the crankshaft gear. The pump discharges into a crankcase passage leading to the front main bearing via the oil filter. A groove in the front main bearing allows oil to cross over to a passage leading to the front camshaft bearing. A crossover tube carries oil to the rear main bearing. The connecting rod journals are lubricated through drilled passages from the main journals. The oil overflow from the bypass valve lubricates the camshaft drive gears.

Replace the oil pump if the crossover tube is tight and the oil bypass valve is functioning properly but the oil pressure is below specification. The gasket and pick-up screen are the only individually replaceable parts. Oil the pump generously when reassembling it so that it will prime faster when the engine is first started.

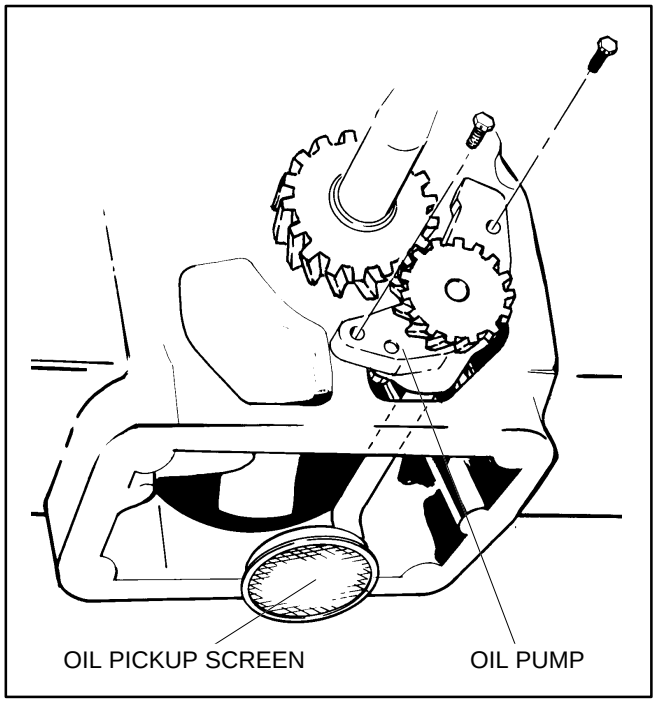

FIGURE 7-28. OIL PUMP ASSEMBLY

CRANKSHAFT

Removal

1. Remove the piston assemblies if they have not already been removed.

2. Remove the gear cover and camshaft timing gear. See *Timing Gears and Camshaft* in this section.

3. Remove the rear bearing plate. See *Main Bearings* in this section.

4. Turn the crankshaft so that the crank throw lines up with the notch in the crankcase and carefully slide the crankshaft out.

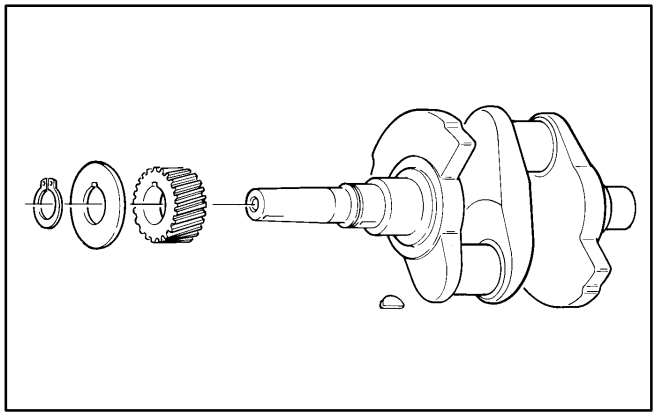

FIGURE 7-29. CRANKSHAFT AND TIMING GEAR

Inspection

Inspect the rod and main bearing journals. Replace the crankshaft or regrind the journals to the next undersize if the journals are worn or scored and cannot be smoothed by polishing. Make sure to clean out the drilled oil passages in the crankshaft.

Installation

1. Replace the main bearings in the block and rear bearing plate, if necessary. See *Main Bearings*.

2. Reinstall the original front thrust bearing if it is still usable or has not been replaced by the combination thrust/shell bearing (Figure 7-31). The flat side goes against the block and the notches should clear the lock pins. Liberally oil the thrust and shell bearing surfaces.
3. Orient the crankshaft so that the crank throw lines up with the notch in the crankcase and insert the crankshaft in the front bearing. Make sure the front thrust bearing does not slip out of place.
4. Grease the lips of the rear oil seal (mounted in the bearing plate) and insert the oil seal driver to keep the lips spread as the crankshaft passes through.
5. Place the rear thrust bearing and shim on the rear bearing plate with the shim between the bearing and the bearing plate. The flat side of the bearing goes against the shim and the shim and bearing notches should clear the lock pins. (Figure 7-32). Liberally oil the thrust and shell bearing surfaces.
6. Place the bearing plate gasket in position on the block, making sure the oil hole on the back of the block is exposed.
7. Mount the rear bearing plate making sure the thrust bearing does not slip out of place. To check crankshaft end play, secure the bearing plate with only two mounting bolts (on opposite sides) and tighten them to the specified torque (see *Thread Torques*).
8. Remove the oil seal driver.
9. Lightly tap the front of the crankshaft with a plastic-faced hammer to take up the crankshaft endplay. Check end play with a feeler gauge at the location shown (Figure 7-30). The endplay should be 0.006-0.012 inch (0.15-0.30 mm). Add or remove shims as necessary.
10. When crankshaft end play is within specifications, tighten all mounting screws to the specified torque. The crankshaft should turn freely by hand.

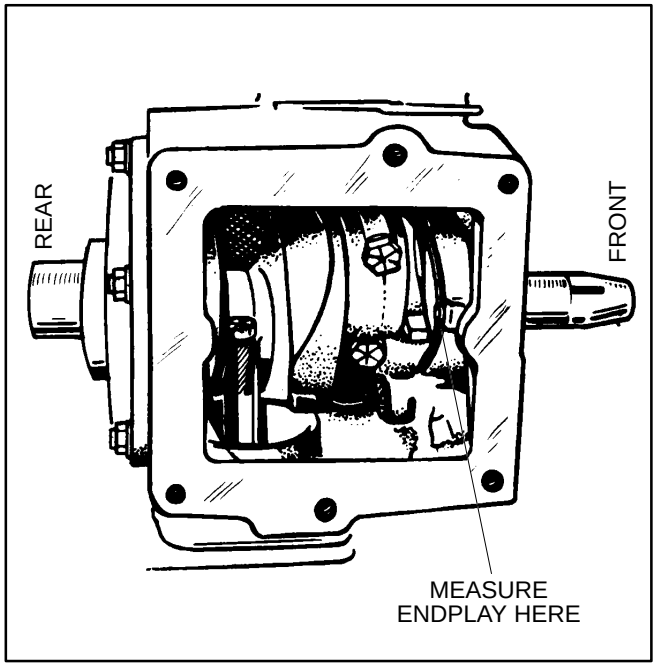

FIGURE 7-30. CRANKSHAFT ENDPLAY

MAIN BEARINGS

Use the special drivers available to drive out the old bearings and drive in the new. Support the engine casting so as not to cause distortion or damage to the bore or casting.

Crankshaft bearings are available in standard size and in 0.002, 0.010, 0.020 and 0.030 inch undersizes.

Front Bearing: See Figure 7-31. Use Loctite brand Bearing Mount or equivalent when installing the front bearing in its bore in the block. Use the towelette furnished with the bearing kit to clean the outside of the bearing and its bore in the block. Apply the Loctite to the outside of the bearing and to the mating surface of the bore in the block. Allow three to four minutes for drying.

⚠WARNING ***Skin contact with the Locktite towelette and inhalation of its vapors can be harmful. Use protective gloves and make sure the work area is well ventilated.***

Use the special driver available to drive the bearing into its bore in the block. Make sure that the oil holes in bearing and bore will line up so that the passage is at least half open and that the notches in the thrust bearing will clear the lock pins in the block. Push the driver in until it is stopped by its flange. Wipe off any excess Loctite and allow one hour for hardening at room temperature.

Note: Original bearings consist of separate thrust and shell bearings, front and rear. Replacement front bearings have one-piece thrust/shell construction. Install the front bearing without shims. Adjust crankshaft end play with shims behind the rear thrust bearing only. See Crankshaft.

Rear Bearing: See Figure 7-32. Use the special driver available to drive the rear main bearing into the bearing plate. Make sure the oil holes in bearing and bore will line up so that the passage is at least 1/2 open. Push the driver in until it is stopped by its flange.

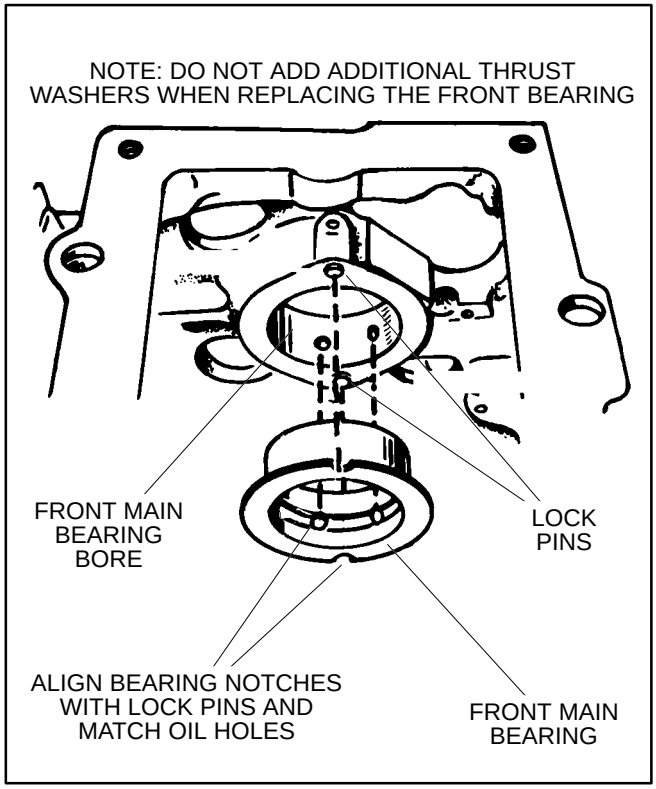

FIGURE 7-31. FRONT CRANKSHAFT BEARING

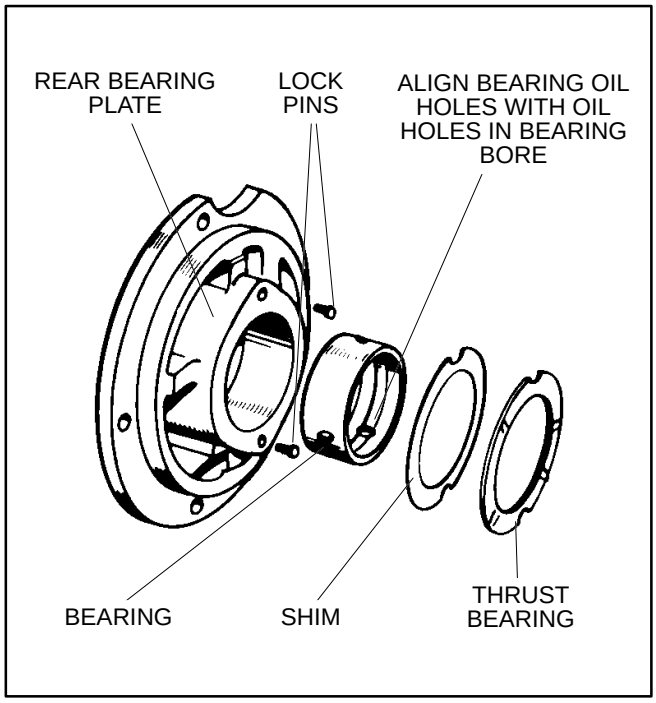

FIGURE 7-32. REAR CRANKSHAFT BEARING

CRANKSHAFT OIL SEALS

See Figures 7-33 and 7-34. The front crankshaft oil seal is located in the gear cover and the rear seal in the rear main bearing plate. Push the old seals out with the oil seal removal tool available and clean the bearing plate and gear cover bores of all old sealing compound before installing the new seals.

Use the appropriate installer to drive in the oil seal from the outside of the bearing plate or gear cover. Drive the tool in until it bottoms so that the seal is located correctly. Note the orientation of the seal lip and the location dimensions.

Coat the oil seal lips with grease to make it easier to push the end of the crankshaft through without damaging the lips and to provide initial lubrication until engine oil reaches the seal.

Rear Oil Seal: Leave the installer in place in the rear oil seal while mounting the bearing plate to keep the oil seal lips spread as the crankshaft passes through. See *Crankshaft* for the procedure for mounting the bearing plate.

Front Oil Seal: Take care that the oil seal lip does not bear down on the sharp edges of the crankshaft keyway while installing the gearcase. See *Timing Gears and Camshaft* for installing the gear cover.

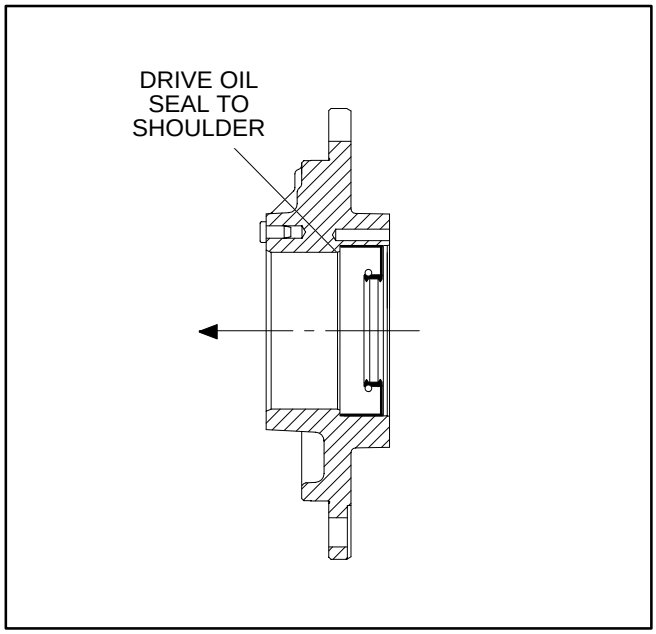

FIGURE 7-33. BEARING PLATE OIL SEAL

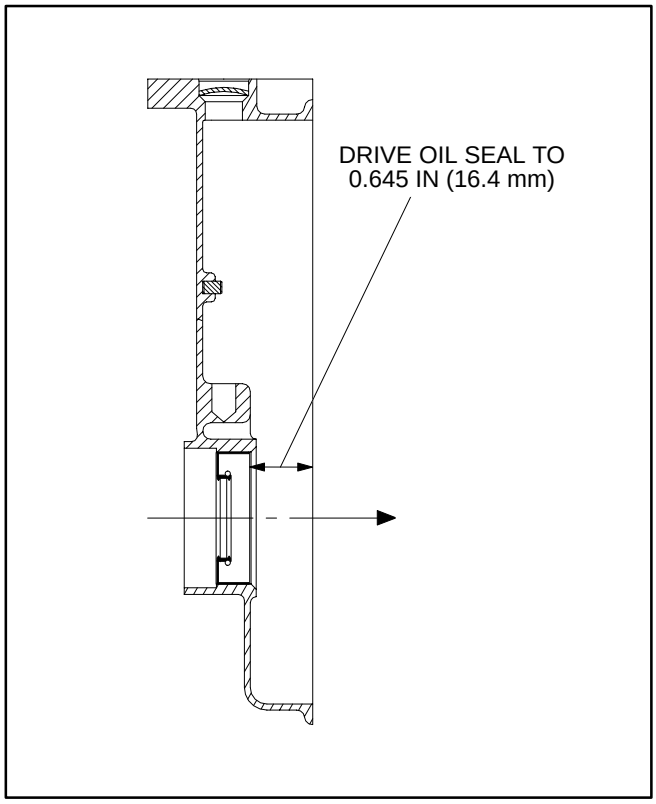

FIGURE 7-34. GEAR CASE OIL SEAL

CAMSHAFT BEARINGS

To replace camshaft bearings the engine must be completely disassembled. Use the special drivers available to drive out the old bearings and drive in the new. Support the engine casting so as not to cause distortion or damage to the bore or casting.

It should be noted that identical bearings are used for replacing the front and rear camshaft bearings and that they may look different from the old bearings.

Use Loctite brand Bearing Mount or equivalent to install the bearings. Use the towelette furnished with the bearing kit to clean the outside of the bearing and its bore in the block. Apply the Loctite to the outside of the bearing and to the mating surface of the bore in the block. Allow three to four minutes for drying before pressing the bearing into its bore.

⚠WARNING ***Skin contact with the Locktite towelette and inhalation of its vapors can be harmful. Use protective gloves and make sure the work area is well ventilated.***

Front Bearing: See Figure 7-35. Press the front bearing in so that the oil hole in the bearing lines up with the oil hole in the bore.

Rear Bearing: See Figure 7-36. Press the rear bearing in so that it is located 1/2 inch (12.7 mm) from the outside edge of the bore. There is no oil hole in the rear bore.

Coat the bearing surfaces with engine oil.

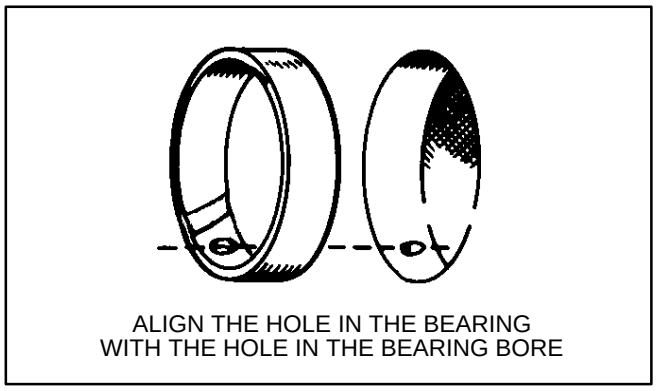

FIGURE 7-35. FRONT CAMSHAFT BEARING

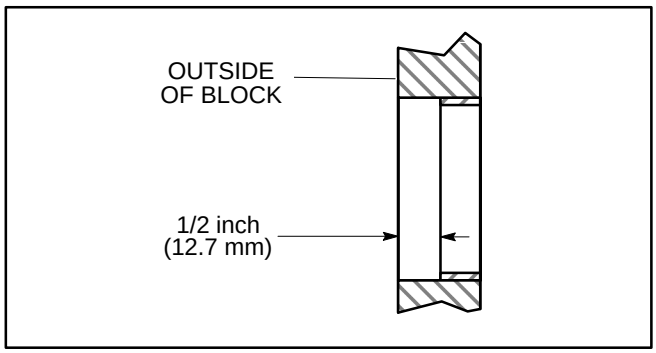

FIGURE 7-36. REAR CAMSHAFT BEARING

ENGINE BLOCK

The engine block is the main support for all other basic engine parts and subassemblies.

Cleaning

After removing the pistons, crankshaft, cylinder heads, etc., inspect the block for cracks and extreme wear. If it is still serviceable, prepare it for cleaning as follows:

1. Scrape all old gasket material from the block. Remove oil bypass to allow cleaning solution to contact inside of oil passages.
2. Remove grease and scale from the cylinder block by agitating in a bath of commercial cleaning solution or hot soapy washing solution.
3. Rinse the block in clean hot water to remove cleaning solution.

Inspecting the Block

When rebuilding the engine, thoroughly inspect the block for any condition that would make it unfit for further use. This inspection must be made after all parts have been removed and the block has been thoroughly cleaned and dried.

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. (Remove this coating after the test and before reassembly.) Always replace a cracked cylinder block.
2. Inspect all machined surfaces and threaded holes. Carefully remove any nicks or burrs from machined surfaces. Clean out tapped holes and clean up any damaged threads.
3. Check the top of the block for flatness with a straight-edge and a feeler gauge.

Inspecting the Cylinder Bores

Inspect the cylinder bores for scuffs, scratches, and wear. If these conditions exist, the cylinders must be rebored or honed for the next oversize piston.

See Figure 7-37. If the cylinder bores look good and there are no scuff marks, check the bores for wear and out-of-roundness as follows:

1. Check cylinder bore for taper, out-of-roundness and wear with a cylinder bore gauge, telescope gauge or inside micrometer. These measurements should be taken at four places: the top and bottom of piston ring travel, and parallel and perpendicular to the axis of the crankshaft.

2. Record the measurements taken at the top and bottom of the piston travel as follows:

   A. Measure and record as A the cylinder bore diameter (parallel to crankshaft) near the top of cylinder bore where the greatest amount of wear occurs.

   B. Measure and record as B the cylinder bore diameter (parallel to crankshaft) at the bottom of piston travel.

   C. Measure and record as C the cylinder bore diameter (perpendicular to crankshaft) near the top of cylinder bore where the greatest amount of wear occurs.

   D. Measure and record as D the cylinder bore diameter (perpendicular to crankshaft) at the bottom of piston travel.

   E. Reading A subtracted from reading B and reading C subtracted from reading D indicates the cylinder taper.

   F. 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 0.003 inch (0.08 mm), the cylinders must be rebored and honed to the next oversize. A reboring machine is used when changing to oversize pistons. The following repair data describes the honing procedure.

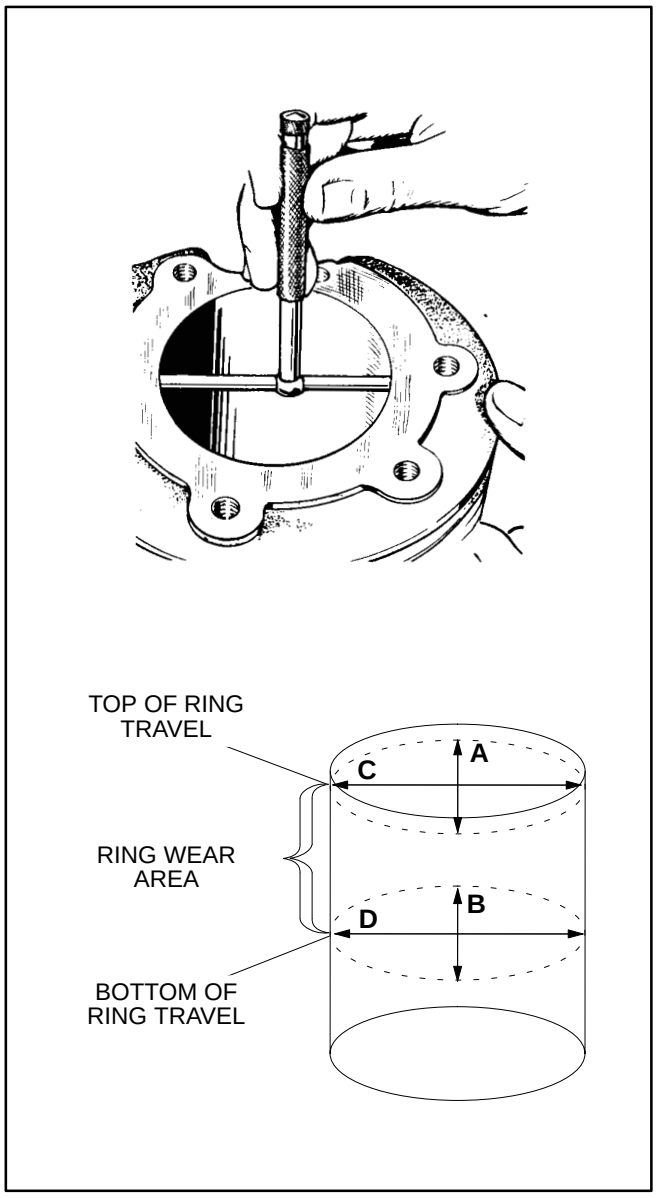

FIGURE 7-37. MEASURING CYLINDER BORE DIAMETERS

Machining the Cylinder Bores

The available oversize pistons and rings will fit with the required clearance in cylinders machined to the matching oversize (standard bore plus 0.005, 0.010, 0.020, 0.030 and 0.040 inch). There is no need to adjust or to “fit” pistons and rings. Piston and ring size should be checked as described below to confirm that they are correct for the standard bore oversize. Boring and honing must be accurate and remove just enough metal for the smallest oversize possible. The finish hone should leave a 20 to 40 micro-inch crosshatch finish having an included angle of 20 to 25 degrees. See Figure 7-38.

Clean the cylinder bore with hot, soapy water and a brush after machining. A clean white rag will not soil when the cylinder bore is clean. Dry the bores and coat them with oil.

⚠ CAUTION ***Do not use gasoline or commercial cleaning solvents to clean the cylinder bores after honing—they do not remove abrasives.***

Deglazing the Cylinder Bores

Deglaze the cylinder bores for fast piston ring break-in if the bores look good and there is not enough wear, taper and out-of-roundness to warrant machining. Deglazing should not increase the bore diameter, permitting the use of the original pistons (if they are good) with new rings. To deglaze the cylinder bores:

1. Wipe the cylinder bores with a clean cloth that has been dipped in light engine oil.
2. Use a brush-type deglazing tool with coated bristle tips.
3. Drive the tool with a slow-speed drill. Move the tool up and down in the cylinder bores fast enough to obtain the crosshatch pattern shown (Figure 7-38). Ten to twelve strokes should be sufficient.
4. Clean the cylinder bore with hot, soapy water and a brush after deglazing. A clean white rag will not soil when the cylinder bore is clean. Dry the bores and coat them with oil.

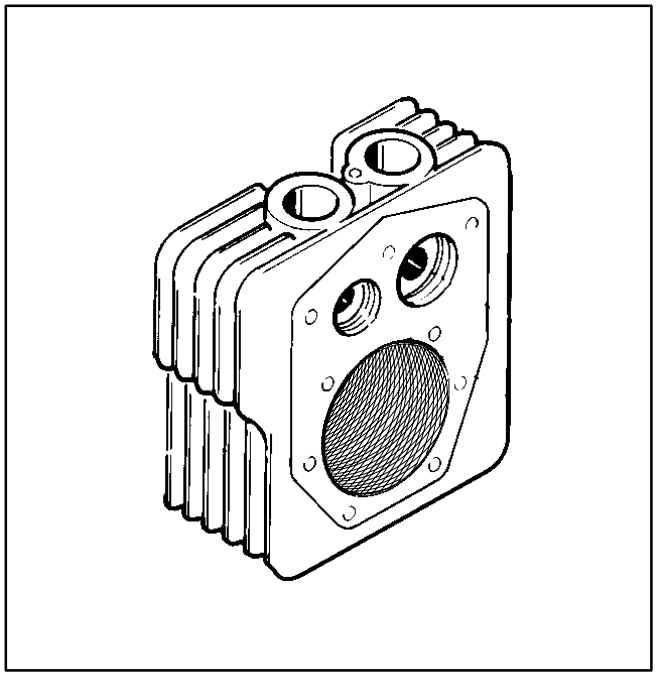

FIGURE 7-38. CROSSHATCH IN CYLINDER BORE

8. GENERATOR

GENERAL DESCRIPTION

The YVB generator (Figure 8-1) is a two-pole, revolving field, brush-type design with drip-proof construction. It is regulated by the microprocessor-based genset controller.

The generator rotor and engine crankshaft have a tapered coupling secured by the rotor through-bolt. The other end of the rotor is supported in a sealed, pre-lubricated ball bearing assembly. The cooling blower wheel is bolted to the rotor assembly

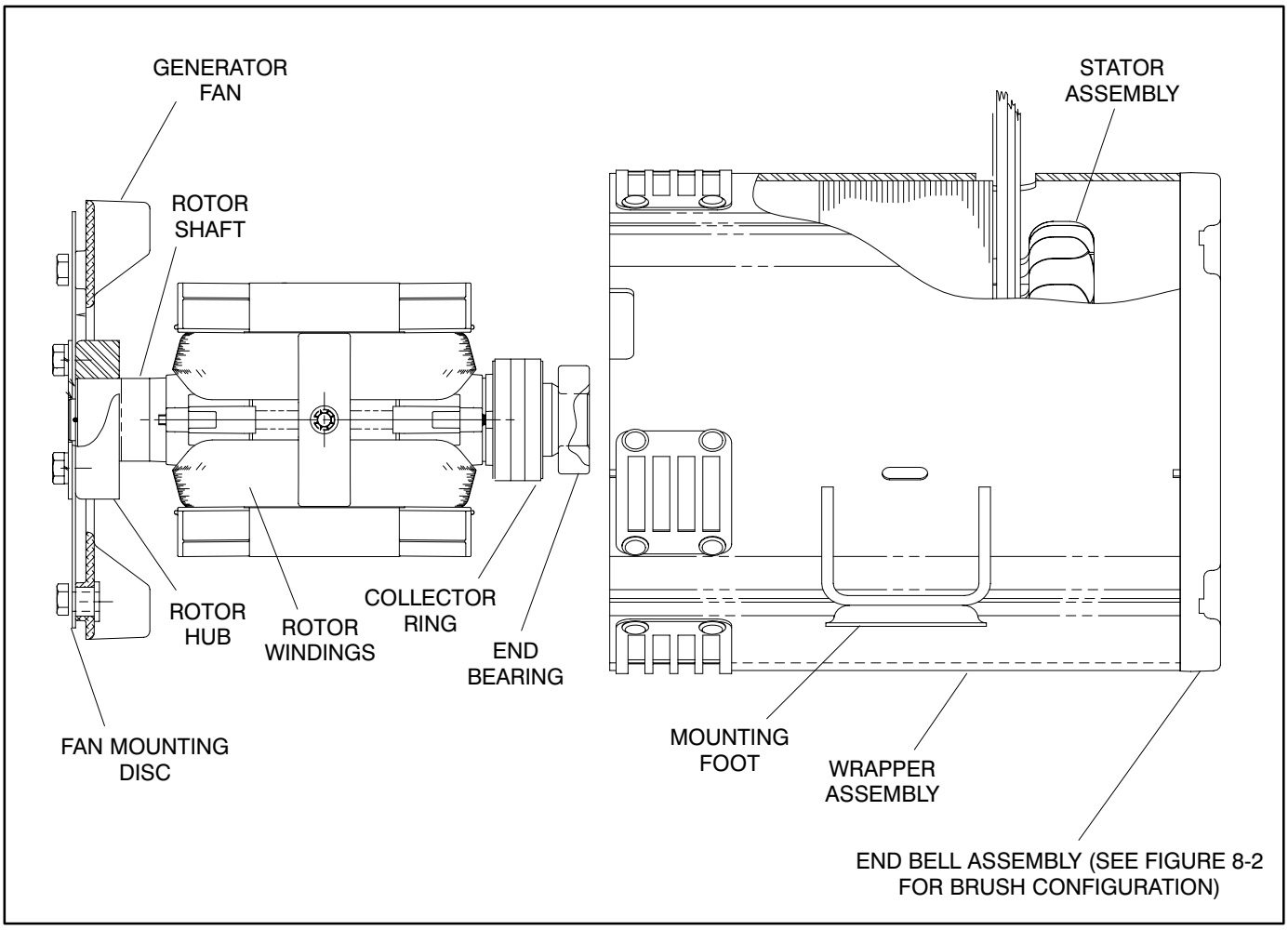

FIGURE 8-1. YVB GENERATOR

SERVICING BRUSHES AND SLIP RINGS

Remove the rear panel to access the generator brushes. See *Removing and Installing the Housing Panels* in Section 5.

Remove the brush block cover and inspect for burned brushes and grooved or pitted slip rings and other damage. (Turn the rotor to inspect all the way around the slip rings.)

If everything looks good, check brush wear with a piece of wire marked off as shown in Figure 8-2. Replace the brushes and brush springs if the wire can be inserted more than 1 inch (25 mm) into the hole in the brush holder. (Make sure the wire rests on top of the brush and not on part of the brush spring.)

If the slip rings are grooved or pitted try cleaning them up with a commutator stone. If the slip rings need to be replaced, see Removing and Replacing the Slip Ring Assembly under *Generator Assembly/ Disassembly* in this section.

To replace the brushes or to clean up the slip rings:

1. Disconnect the leads marked **F1** and **F2** from the brush block terminals.

2. Remove the brush block mounting screws and lift out the brush block assembly.

3. If the slip rings need to be cleaned up, insulate the ends of leads **F1** and **F2**, disconnect all leads from the positive (**+**) terminal of the ignition coil to keep the engine from starting, hold the commutator stone lightly against the slip rings and crank the engine for 3 to 6 seconds. Check the slip rings and repeat the procedure as necessary until the pits and groves have been removed.

4. Replace the brushes and brush springs with new parts. Connect each brush pigtail to the terminal on its side of the insulating divide (Figure 8-3).

5. Remount the brush block. Center the brushes on the slip rings before tightening the mounting screws.

6. Reconnect the lead marked **F1** to the outboard brush terminal and the lead marked **F2** to the inboard brush terminal and secure the cover and air cleaner.

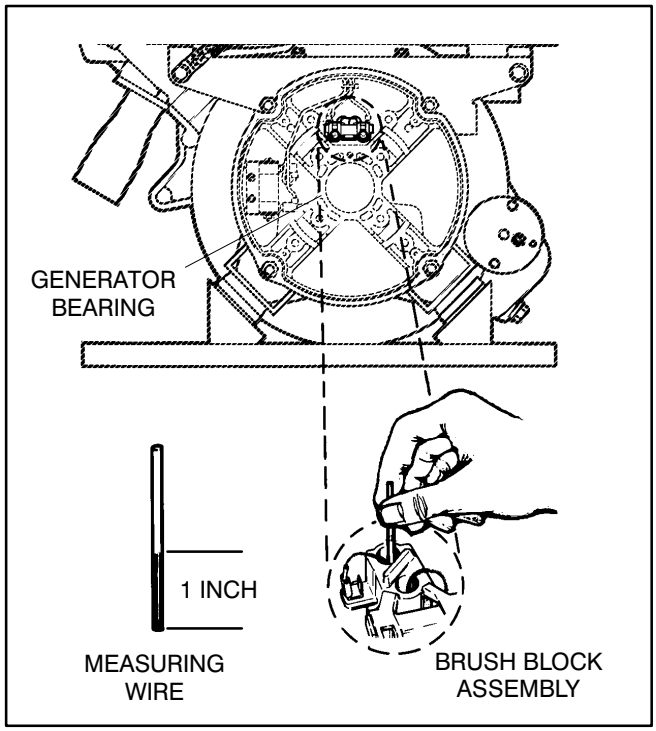

FIGURE 8-2. CHECKING BRUSH WEAR

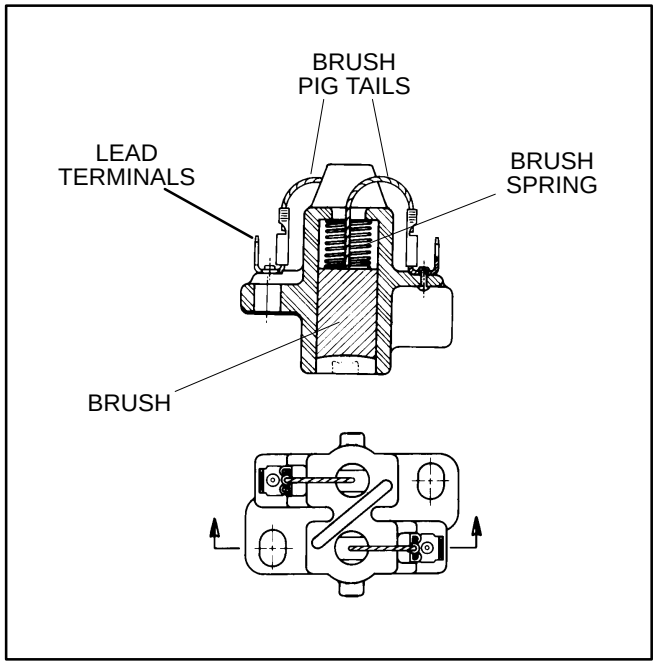

FIGURE 8-3. BRUSH BLOCK ASSEMBLY

GENERATOR DISASSEMBLY/ASSEMBLY

The following sections describe the disassembly and reassembly procedures for the generator. Figure 8-4 illustrates generator disassembly.

⚠WARNING ***Generator components are heavy and can cause severe personal injury if dropped during service. Be careful, use appropriate lifting techniques, keep hands and feet clear during service, and use the recommended service procedures.***

Disassembly

1. Remove the rear panel. See *Removing and Installing the Housing Panels* in Section 5.

   Check lead markings before disconnecting a lead. If the lead makings do not clearly identify reconnection, mark the leads with tape.

2. Remove the two harness clamps that secure the harness to the outside of the generator (Figure 8-4).
3. Remove the cover from the control box and disconnect stator leads T1 and T4 from the circuit breaker and T2 and T3 from the neutral terminal. Cut necessary cable ties to remove these leads from the harness sleeving up to the rear of the generator.
4. Disconnect leads Q1 and Q2. Connectors are located in the harness sleeving at the rear of the generator (Figure 8-4).
5. Disconnect leads F1 and F2 from the brush block terminals (Figure 8-3).
6. Remove the bonding strap from the generator mounting foot.
7. Remove the exhaust assembly (see *Exhaust System* in Section 6).

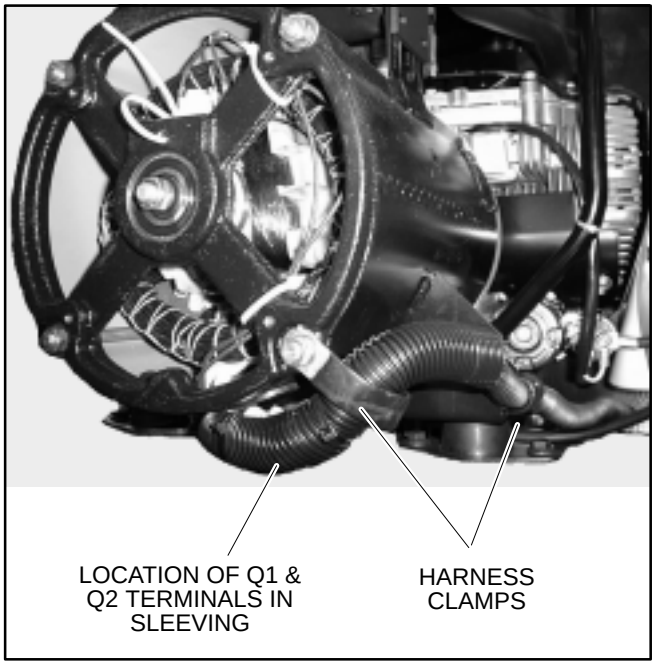

FIGURE 8-4. ALTERNATOR HARNESS

8. To keep from damaging the brushes and to keep them from interfering when remounting the stator, either:

   A. Remove the brush block assembly by disconnecting the leads marked **F1** and **F2** from the brush block terminals (Figure 8-3) and then removing the two mounting screws, **or**

   B. Insert a stiff wire into the small hole in the end of the stator housing to hold the brushes up and out of the way (Figure 8-5). To do this, first pull both brush pigtails to lift the brushes off the slip rings.

9. Remove the two generator vibration isolator center-bolts.

10. Place a piece of “two-by-four” lumber under the rear of the engine mounting plate to support the engine.

11. Remove four nuts and lock washers from the generator stud bolts. Pry the end bell free of the rotor bearing. Be careful not to damage the brush holder. (Figure 8-6).

12. Pull the stator/wrapper assembly off the rotor and away from the engine, taking care not to scrape stator windings. Set it aside.

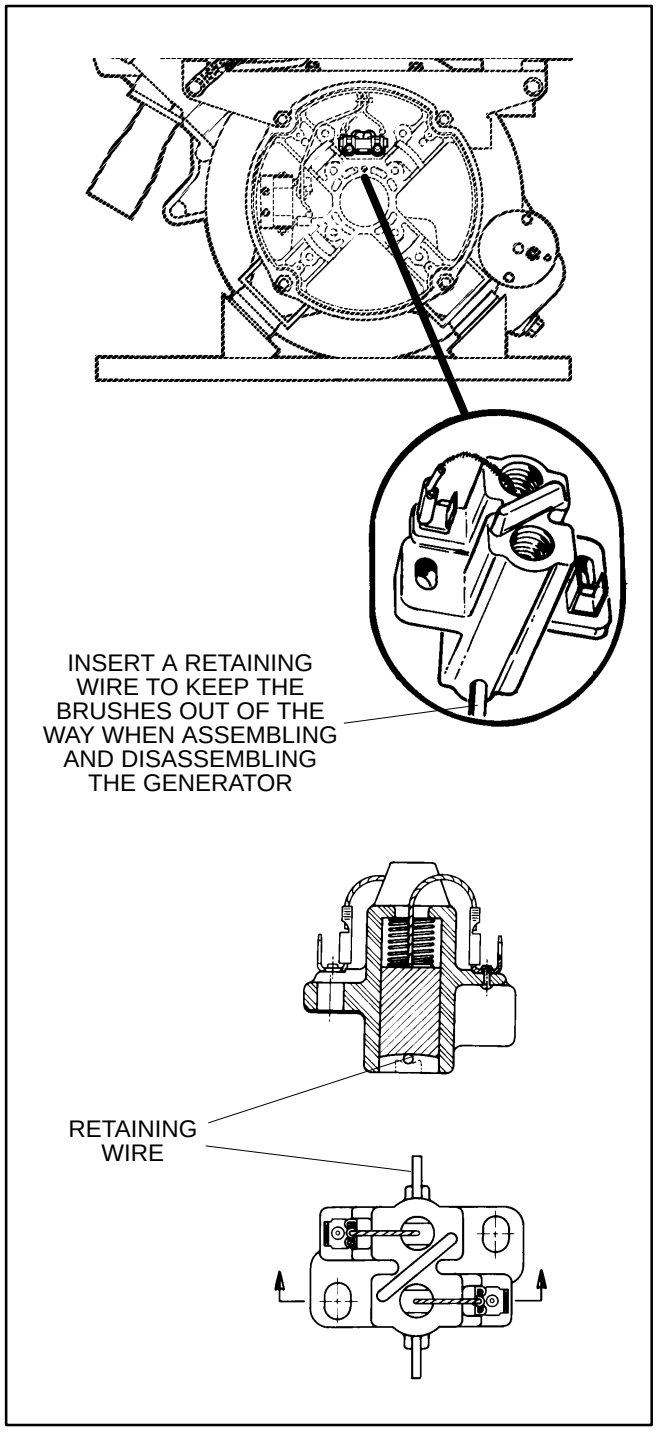

FIGURE 8-5. BRUSH BLOCK ASSEMBLY

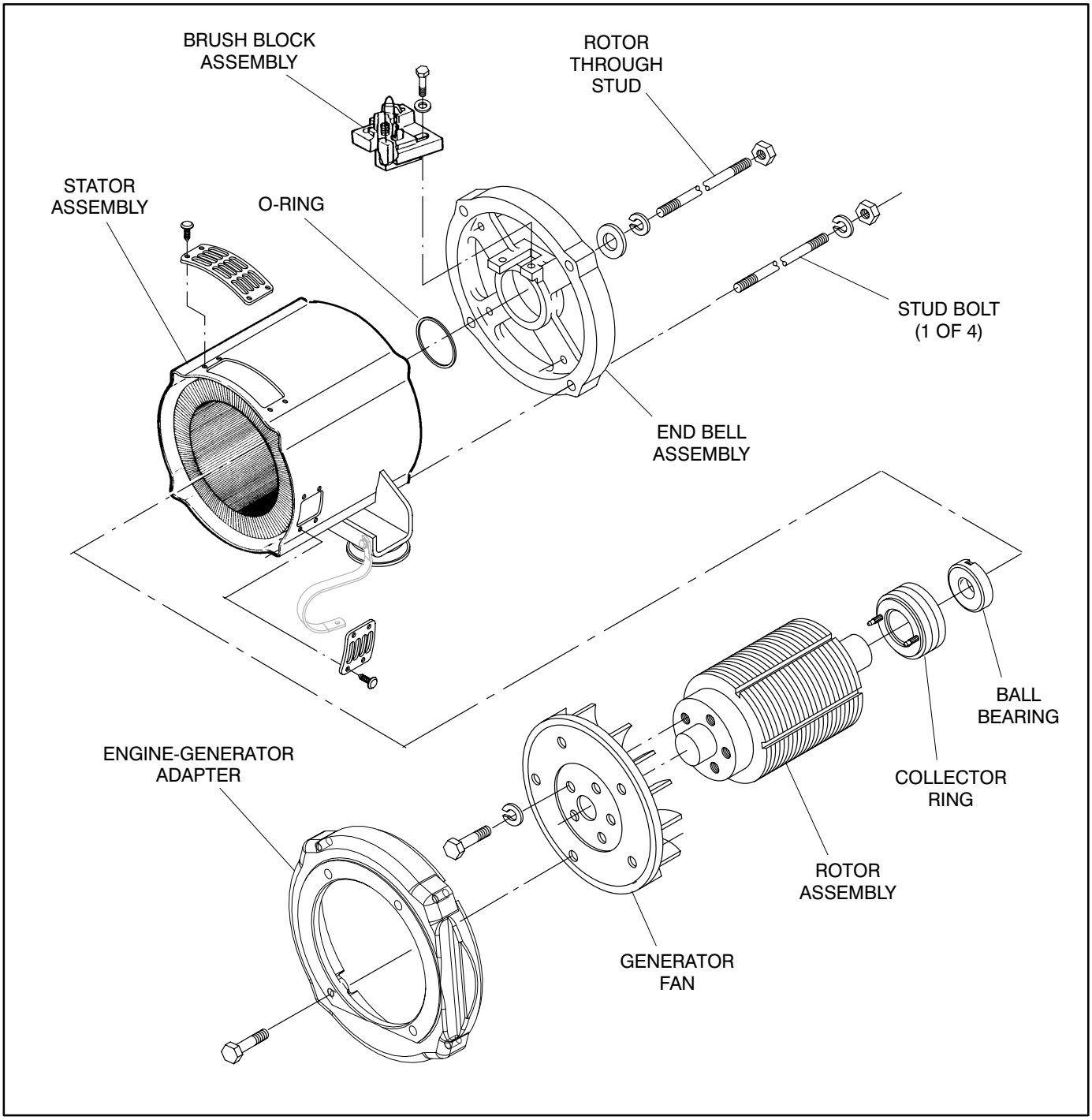

FIGURE 8-6. GENERATOR DISASSEMBLY/REASSEMBLY

Removing the Rotor

1. Remove the rotor through bolt. (Use two nuts locked together at the end of the rotor through bolt to loosen and remove bolt from crankshaft.)
2. Thread in the rotor removal rod (shorten rotor through bolt, Figure 8-7) and turn it with a screwdriver until it bottoms in crankshaft. Thread in and tighten a 9/16-12 x 1-3/4 inch bolt against the rod until the rotor breaks loose from the crankshaft.
3. If necessary, replace the bearing and the slip ring assembly as instructed in this subsection.

Remounting the Rotor

Replace the bearing and the slip ring assembly, if necessary, as instructed in this section. Use the rotor removal tool to guide the rotor on. Torque the through bolt to *Thread Torques*.

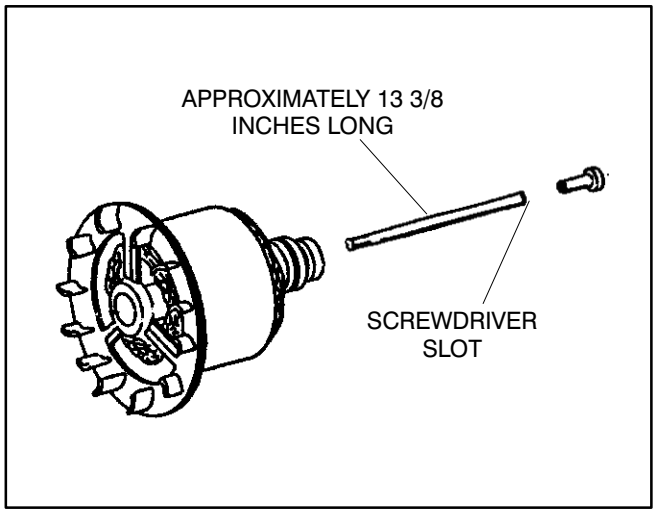

FIGURE 8-7. ROTOR REMOVAL TOOL

Remounting the Stator Housing

Remounting is the reverse of removal. Note the following:

1. Mount the rotor.
2. Make sure the brush block assembly has been removed or that the wire is holding both brushes up and out of the way.
3. Make sure the bearing O-ring is in place in the housing bearing bore.
4. Torque the generator housing, rotor through-bolt and vibration isolator center-bolts to *Thread Torques* in Section 2.
5. Make sure to secure the bonding strap to the generator mounting foot using one EIT (external and internal toothed) lock washer on each side of the strap terminal for a good electrical connection.
6. Reconnect or reassemble all other parts that were disconnected or removed.
7. Install the brush block assembly if it was removed. If it was left in place, pull the brush pig tails and remove the retaining wire. If necessary, loosen the brush block mounting screws, align the brush block so that the brushes are centered on the slip rings and retighten the mounting screws.
8. Connect the lead marked **F1** to the outboard brush terminal and the lead marked **F2** to the inboard brush terminal.
9. Replace all cable ties that were removed during this procedure.

Removing and Replacing the Rotor Bearing

Use a gear puller to remove the bearing from the rotor shaft if it or the slip ring assembly is to be replaced, otherwise leave it in place. If the bearing is to be reused, make sure the fingers of the gear puller bear on the inner race of the bearing only.

⚠ CAUTION ***The bearing will be damaged and become unusable if force is applied to the outer race either when pulling it off or pressing it on.***

Replace the bearing as follows:

1. Replace the slip ring assembly first, if necessary.
2. Press the bearing on with a press, making sure to bear down on the inner race only.

Removing and Replacing the Slip Ring Assembly

Unsolder the two rotor leads from the slip ring assembly and pull the slip ring assembly off with a gear puller. Tape the key to the shaft to keep from loosing it if a new assembly is not going to be installed right away.

Press on a new slip ring assembly with a press, making sure the key is in place and the assembly is aligned with the key. Solder the two rotor leads to the solder terminals on the slip ring assembly.

TESTING THE GENERATOR

The following tests and adjustments can be performed without disassembly of the generator.

⚠WARNING ***Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review safety precautions on inside cover page.***

Testing Field Flash Voltage

Field flash voltage can be tested at the brush holder terminals with a DC voltmeter. With the engine cranking, check for 12 VDC. If present, check for open windings in the rotor.

If not present, disconnect F1 and F2 leads. At lead terminals, check for 12 VDC while cranking engine. If present, check rotor for shorted windings or grounds between each slip ring and the rotor shaft. If not present, alternator harness or genset control (A11) PCB is defective.

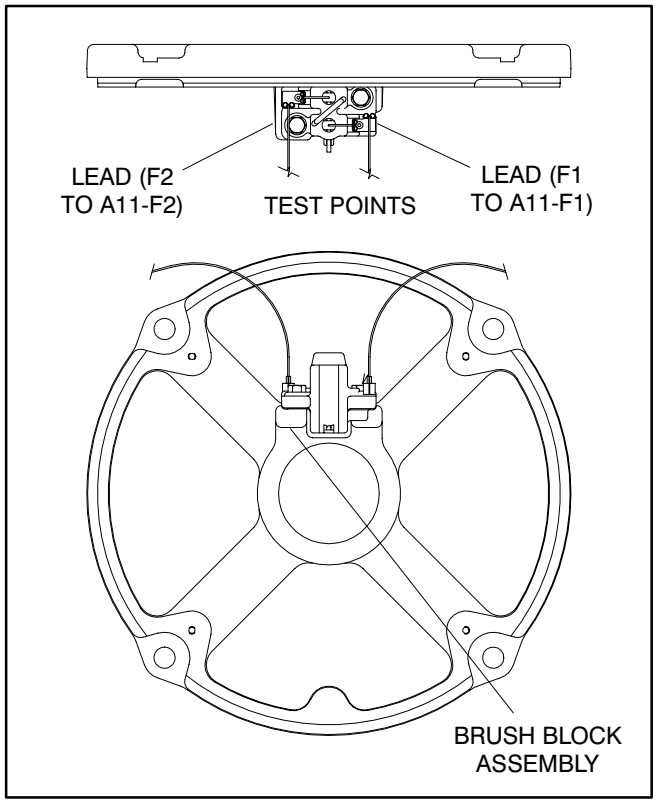

FIGURE 8-8. FIELD VOLTAGE TEST POINTS

Testing the Rotor

The generator circuits can be tested without having to disassemble the generator. It is recommended that an ohmmeter be used to check for open circuits and an insulation resistance meter for grounded circuits. An ohmmeter can be used to check for grounded circuits, but it may not be able to detect marginal insulation breakdown.

Testing for Grounds: Check for grounds between each slip ring and the rotor shaft, Figure 8-9. Use a Megger or insulation resistance meter which applies 500 VDC or more at the test leads. Perform test as follows:

1. Isolate the rotor windings by disconnecting the two leads to the brush holder.

2. Connect test leads between each ring and the rotor shaft in turn. Meter should register 100,000 ohms or greater.

3. If less than 100,000 ohms, rotor is questionable. Thoroughly dry the rotor and retest.

4. Replace a grounded rotor with a new identical part.

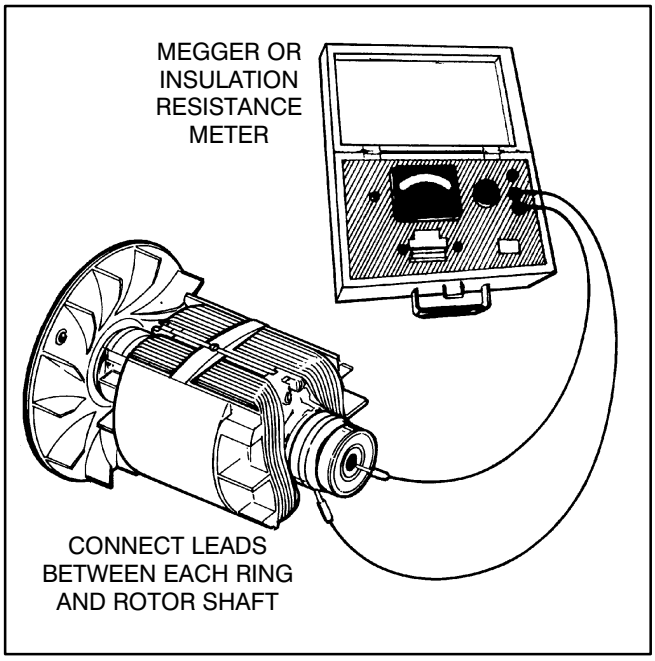

FIGURE 8- 9 TESTING ROTOR FOR GROUNDS

Testing for Open or Shorted Windings: Perform this test with an accurate meter such as a digital ohmmeter.

1. Isolate the rotor windings by disconnecting the two leads to the brush holder.

2. Using ohmmeter, check resistance between F1 and F2 leads (25.47 ohms ± 10%), Figure 8-10.

   If there is a large difference, replace the defective rotor with new, identical part.

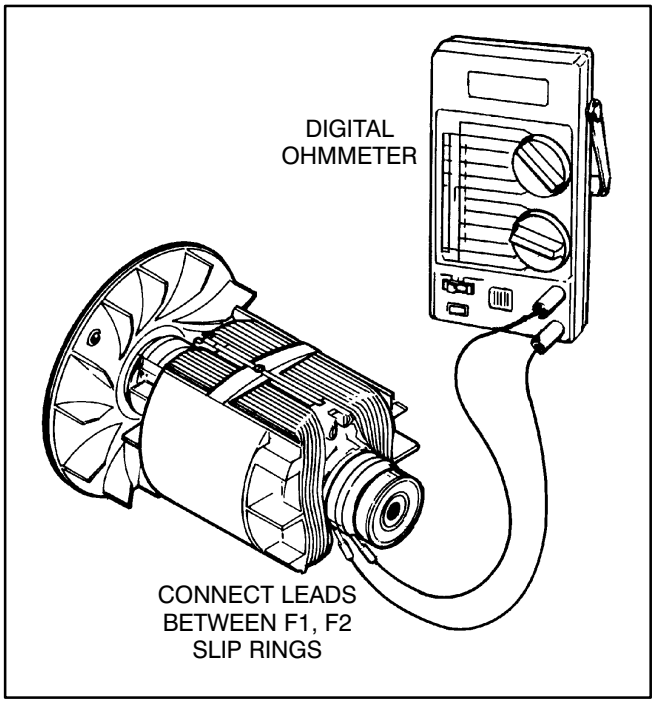

FIGURE 8-10. TESTING ROTOR FOR AN OPEN

Testing Generator Stator

Isolate the stator windings by disconnecting all six stator leads. Test for open circuits between T1-T2, T3-T4 and Q1-Q2, and for grounded circuits between T1, T3 and B1 and the stator laminations or other unpainted grounding point.

Using proper test equipment, check the stator for grounds, opens, and shorts in the windings.

Testing for Grounds: Some generators have ground connections to the frame. Check wiring diagram. All stator leads must be isolated for testing.

Use a megger or insulation resistance meter which applies not more than 500 VDC to the test leads (Figure 8-11). Test each stator winding for short to laminations. A reading less than 100,000 ohms indicates a questionable stator. Thoroughly dry the stator and retest.

Testing for Open or Shorted Windings: Test for continuity between coil leads as shown in Figure 8-12; all pairs should have equal resistance. Use an accurate instrument for this test such as a Wheatstone Bridge. Resistance should correspond to the values shown below.

- Resistance values (± 5%):
  T1-T2: 0.095 ohms
  T3-T4: 0.095 ohms
  Q1-Q2: 1.185 ohms

If a winding is shorted, open or grounded, replace the stator assembly. Before replacing the assembly, check the leads for broken wires or insulation.

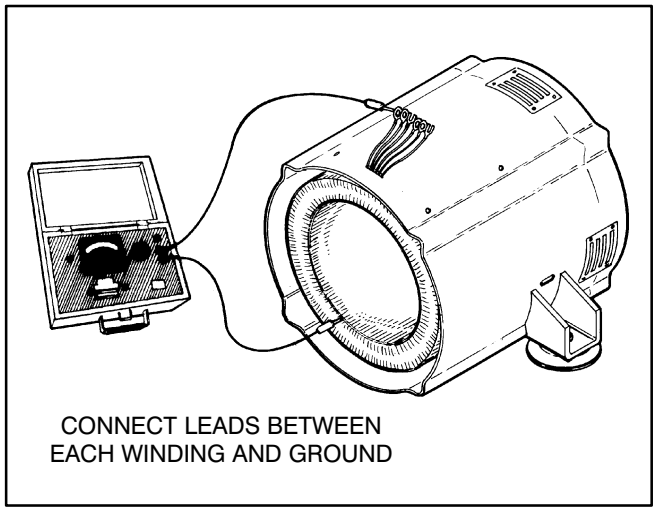

FIGURE 8-11. TESTING STATOR WINGING FOR GROUNDS

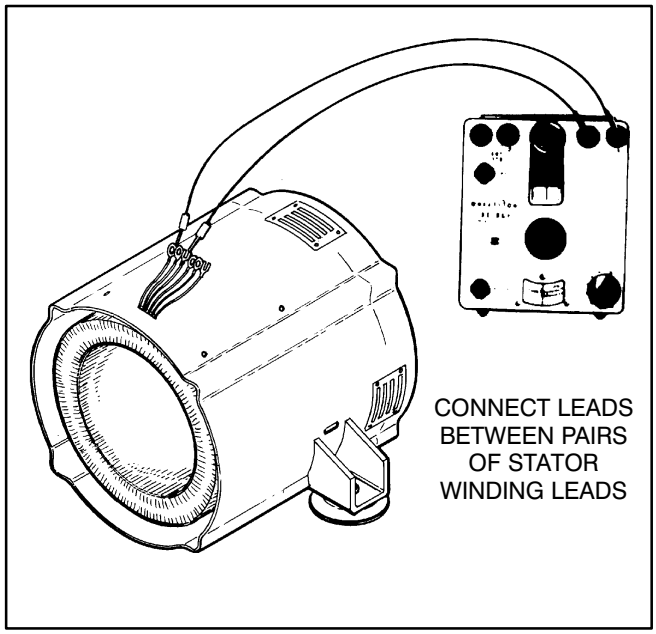

FIGURE 8-12. TESTING STATOR WINDING RESISTANCE

9. Genset Control PCB (A11)

The genset control PCB (A11) is a fully potted assembly with one connector (P1) and is mounted by one screw to the generator control assembly. A bracket is also used at the top of the control PCB for additional bracing for removing and installing the P1 connector. To remove the control PCB, perform the following steps.

3. Remove the front access panel and side access doors. (See *Removing and Installing the Housing Panels* in Section 5 for instructions and important safety precautions.)
4. Remove connector P1 from the control PCB (Figure 9-1). To remove connector, insert small blade screwdriver into slot of connector retainer tab. Move tab downward to release and remove connector.
5. Remove retainer screw from the base of the control PCB.
6. Loosen the lower two screws and remove the upper four screws that secure the control assembly panel to the engine divider panel.
7. Lightly pull back on the top of the control assembly until the connector on the back of the control PCB clears the cutout in the back of the engine divider panel.
8. With the control assembly tilted back, lift up on the control PCB to release the bracket from the control assembly and remove the control PCB.

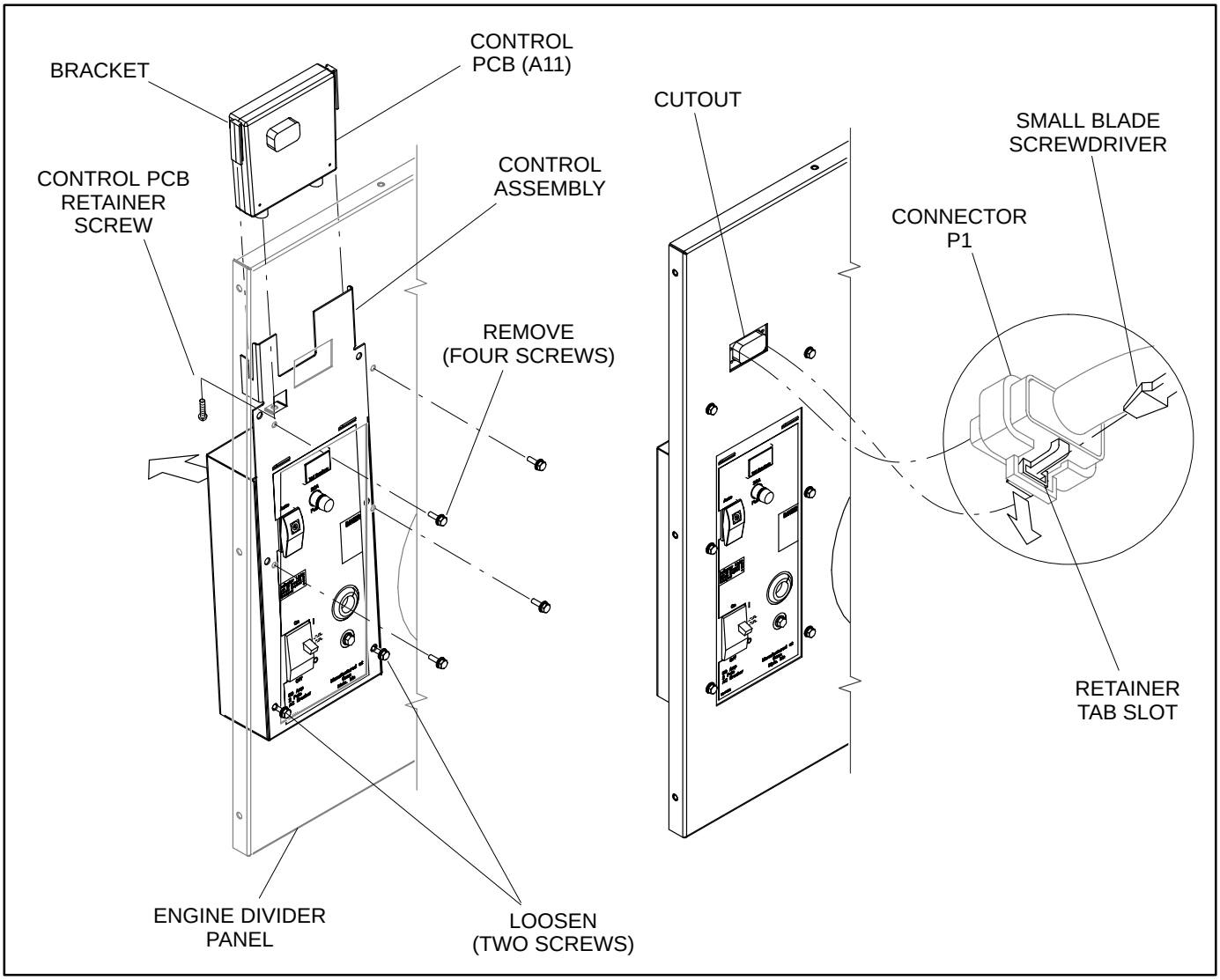

FIGURE 9-1. REMOVING CONTROL PCB

The control PCB uses a microprocessor with embedded software. The micro-controller supports the traditional functions of genset control along with voltage regulation and extensive diagnostics (see *Troubleshooting*, Section 11). Figure 9-2 is a block diagram of control PCB inputs and outputs.

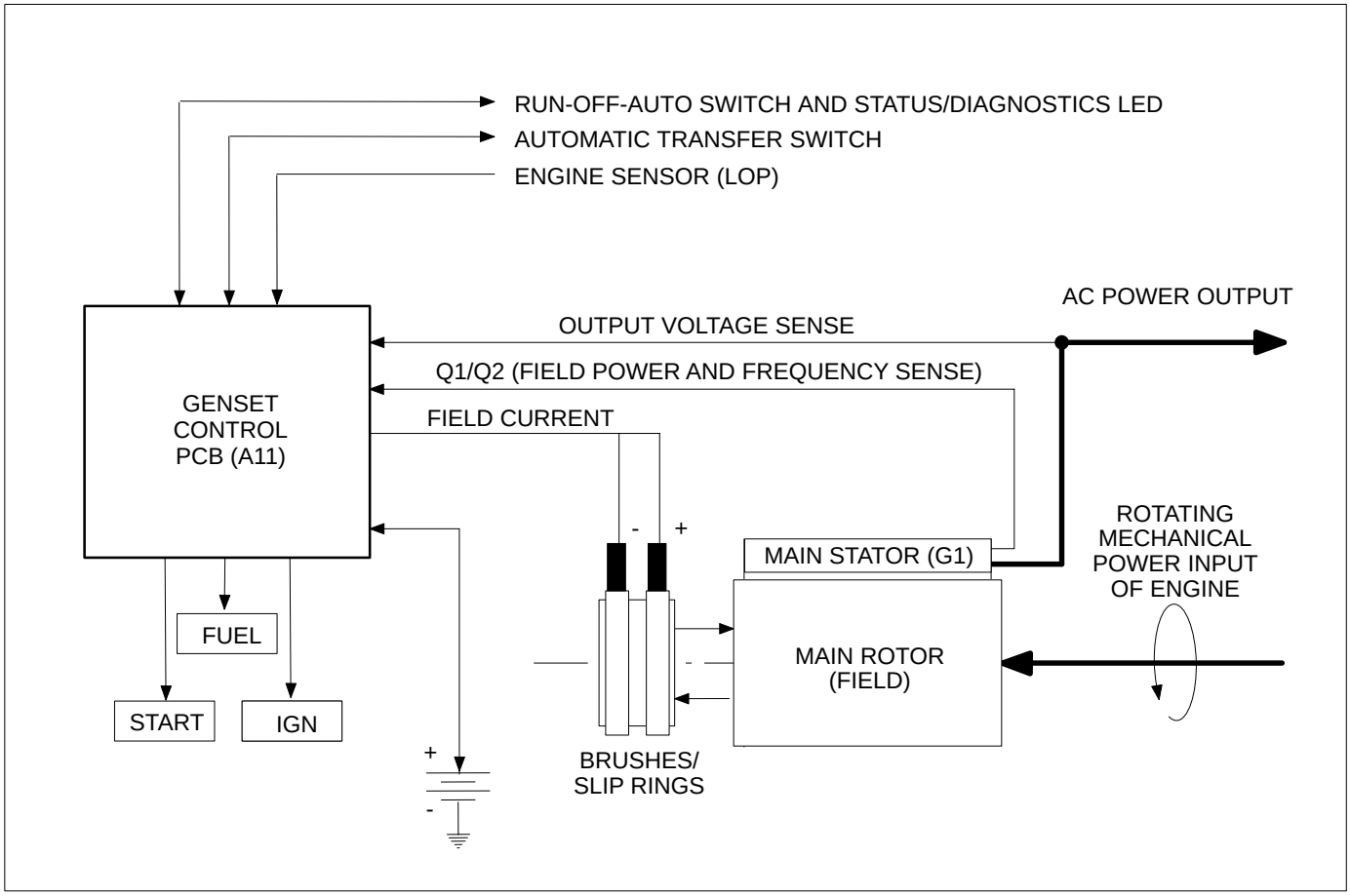

FIGURE 9-2. GENSET CONTROLLER INPUTS AND OUTPUTS

10. Governor Controller Board (A12)

The genset governor controller board (A12) is mounted on the engine divider panel, directly above the control PCB. It receives the governing control (tachometer) signal from the electronic ignition module and B+ from the control PCB.

The governor controller board outputs a DC voltage that drives the governor actuator, which in turn moves the carburetor throttle to maintain an engine speed of 3600 RPM (60 Hz). The input from the ignition module and B+ from the control PCB can signal the governor controller board to shut the engine off under the following adverse conditions:

- If power (B+) is lost to the control PCB
- Any control PCB shutdown fault
- If signal from the ignition module stops

Under all these circumstances, governor controller board shuts down the genset. The governor controller board is a non-serviceable component.

GOVERNOR CONTROLLER BOARD TROUBLESHOOTING

When starting the genset, the actuator should open the carburetor to full throttle. If not, first check the operation of the actuator and linkage (see *Governor Rod and Actuator* in Section 6) and also the ignition system (see *Ignition System* in Section 6) and then check the following to determine if the governor controller board is defective.

The status indicator on the governor controller board should light for 1 second, then off for 1 second and then remain on during cranking and genset operation. If the indicator flashes more than once, the governor controller board is defective.

If the indicator does not light, check all connections before replacing the governor controller board. Also check for +12 VDC at the ignition coil. If not present the controller PCB may be defective.

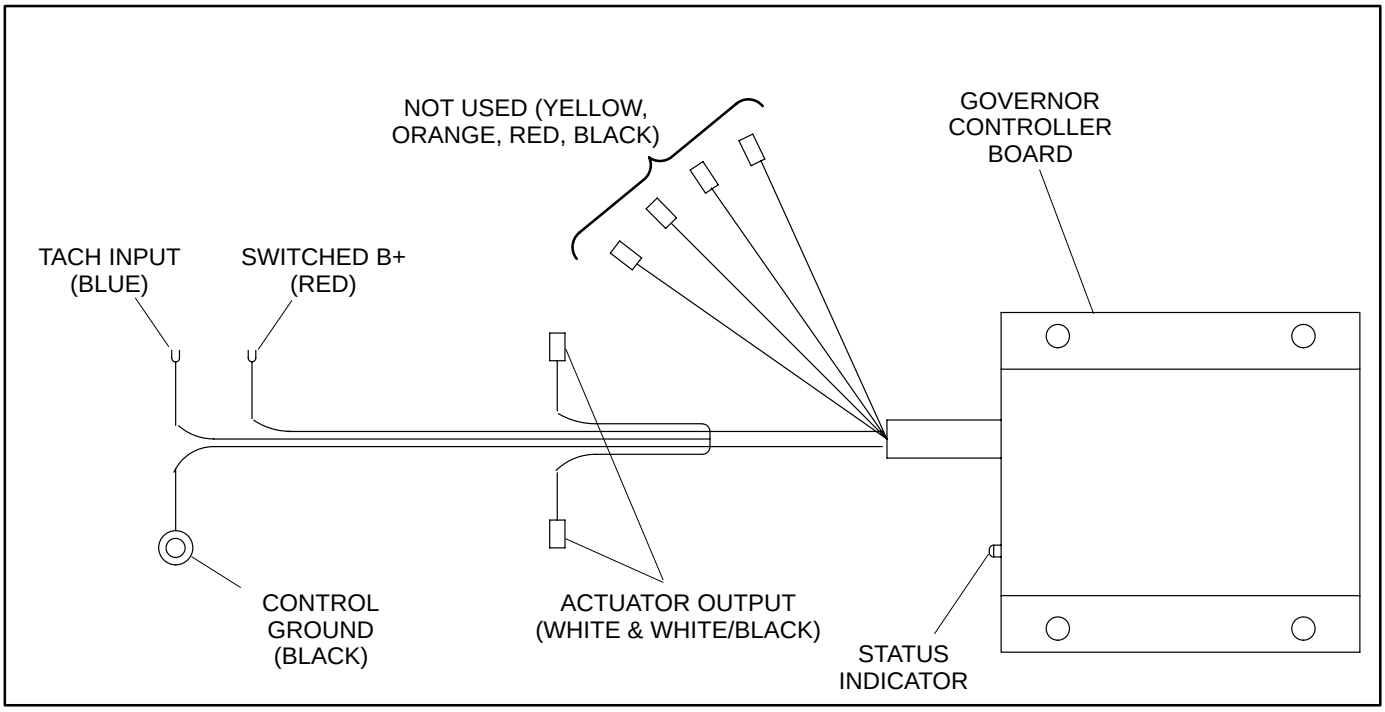

FIGURE 10-1. GOVERNOR CONTROLLER BOARD A12

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11. Troubleshooting

Table 11-1 provides troubleshooting guidance for a genset that fails to start or that shuts down. The genset controller has an extensive diagnostic capability and its fault codes are covered in numerical sequence in Table 11-1. *Gaps in the code numbers are for codes that do not apply to this genset.*

Most shutdowns can be prevented by proper maintenance and use of the genset—maintaining oil levels, keeping battery connections clean and tight, and not overloading the genset.

STATUS/DIAGNOSTICS LIGHT ON THE GENSET CONTROL SWITCH

The genset controller causes the status/diagnostics LED to indicate a fault code if there is a fault shutdown that requires maintenance or service. There are distinct (longer) pauses between repetitions of the code blink transmissions.

Single-Digit Fault Code - A single-digit fault code is indicated by a corresponding number of blinks. For example:

Code No. 4: blink-blink-blink-blink-long pause-repeat code

Two-Digit Fault Code - A two-digit fault code is indicated by two sets of blinks separated by a short pause. The first set corresponds to the tens digit and second to the ones digit. For example:

Code No. 32 - blink-blink-blink-*pause*-blink-blink-long pause-repeat code

FAULT CODE LEVEL

There are two levels of fault codes. *Level One* is a "single digit" fault code that indicates engine faults (possibly correctable by customer) or that there is a level two fault.

Level Two fault is a "two digit" fault code that requires repair by an authorized service representative.

DISPLAYING LEVEL ONE/TWO FAULT CODES

Immediately following a fault shutdown, the indicator light will blink a Level One fault code and will stop after five minutes. To restore and read this fault, perform the following:

9. Disconnect the remote start wire from the terminal block of the control assembly (TB1-5). This will prevent accidental starting of the genset by the transfer switch while performing this procedure.

10. Grasp the side of the Run/Off/Auto switch and toggle the switch three times between Off and Auto within five seconds.

11. The Level One fault code will be displayed. If a Level One fault code "3" is displayed, a Level Two fault has occurred. To display the Level Two code, toggle the switch one more time between Off and Auto.

12. See Table 11-1 for troubleshooting guidance of indicated fault code.

Note: The fault displayed is the last fault logged and will remain in memory even though the condition has been corrected and the genset is running normally.

⚠WARNING ***Automatic startup of the genset while performing maintenance or service can cause severe personal injury or death. Push the control switch to Off and disconnect the negative (-) battery cable from the battery to keep the genset from starting up while working on it.***

⚠WARNING ***Hot engine parts can cause severe burns. Always allow the engine time to cool before performing any maintenance or service.***

TABLE 11-1. TROUBLESHOOTING

⚠ WARNING ***Some genset service procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.***

NO RESPONSE WHEN THE CONTROL SWITCH IN THE RUN POSITION

(Marginal batteries, connections, or charging system)

Corrective Action:

1. Replace **Fuse F1** (B+) if blown.
2. Clean and tighten the positive (**+**) and negative (**-**) battery cable connections at the battery and genset.
3. Recharge or replace the battery. Refer to the battery manufacturer's recommendations.
4. Test the battery charging system and service as necessary. See *Flywheel Alternator* - Section 6.
5. Push the control switch to **Auto** and try starting the genset through the transfer switch control. Replace control switch **S2** if the genset can be operated remotely but not locally.
6. Resettable fuse on genset control PCB is open. Check for short to ground in the starter, fuel solenoid, ignition, field flash circuits.
7. Replace the genset control PCB (see Section 9).

NO POWER—GENSET RUNNING, RUN LIGHT ON

(Line circuit breaker OFF or tripped or faulty wiring)

Corrective Action:

1. Turn on or reset the line circuit breaker on the genset.
2. Turn on or reset the line circuit breakers on the main distribution panel.
3. Check for proper transfer switch function.
4. Check genset AC output connections at the equipment (transfer switch) and reconnect as necessary.
5. Attempt to reset the circuit breakers and measure electrical continuity across terminals. Replace a circuit breaker that does not close or that has measurable resistance across the contacts.
6. Check all AC wiring connections in genset.

LOW OIL FAULT—CODE NO. 2

(The controller sensed that the low oil pressure cutoff did not open within 10 seconds of starting or closed during operation)

Corrective Action:

1. Check engine oil level and add oil as necessary. Repair oil leaks.
2. Drain excess oil. (Excess oil leads to foaming and a consequent loss of oil pressure.)
3. Repair the low oil pressure cutoff switch (**S1**) wiring or replace defective switch.
4. Service a worn lubricating system and/or engine according to *Engine Subsystems* (Section 5) and/or *Engine Block Assembly* (Section 6).

TABLE 11-1. TROUBLESHOOTING (CONT.)

⚠ WARNING ***Some genset service procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.***

SERVICE CHECK FAULT—CODE NO. 3

(A Level Two fault occurred)

Corrective Action: Check the second-level fault code. See *Displaying Level One/Two Fault Codes* in this section.

OVERCRANK FAULT—CODE NO. 4

(Cranking exceeded 20 seconds without engine starting)

Corrective Action:

1. Open any closed fuel shutoff valves.
2. Check the governor linkage for binding and service as necessary (see *Governor Linkage and Actuator* in Section 6).
3. Fill the LPG fuel tank if less than half full. On cold days the LPG container may have to be kept at least half full to provide the rate of vaporization required to keep up with genset fuel demand. LPG with more than 2.5 percent butane will not vaporize below 32° F (0° C). Use HD-5 grade LPG.
4. Inspect/secure the spark plug cable on the spark plugs.
5. Service the air cleaner.
6. Check for a blocked exhaust system and service as necessary.
7. Check fuel solenoid valve operation (see *Fuel System* in Section 6).
8. Check the gas supply pressure and adjust as necessary (see *Fuel System* in Section 6).
9. Conduct the ignition system tests and service as necessary (see *Ignition System* in Section 6).
10. Check the governor controller board (see Section 10).
11. Conduct a cylinder compression test and service the engine if it is worn or malfunctioning.

OVERVOLTAGE FAULT—CODE NO. 12

(Controller not able to regulate to rated voltage)

Corrective Action:

1. Service the brushes and slip rings as necessary (see *Servicing Brushes and Slip Rings* in Section 8).
2. Replace the genset control PCB (see Section 9).

UNDERVOLTAGE FAULT—CODE NO. 13

(Controller not able to regulate to rated voltage)

Corrective Action:

1. Turn the genset line circuit breaker **OFF**. If the genset runs without shutting down, run the genset with fewer connected loads.
2. Check power factor. Disconnect loads that cause a power factor of 0.5 or less.
3. Service the brushes and slip rings as necessary (see *Servicing Brushes and Slip Rings* in Section 8).
4. Test the generator field, stator and guadrature windings for opens or shorts. Replace the generator rotor or stator assembly if winding resistance is not as specified in Section 8.
5. Replace the genset control PCB (see Section 9).

TABLE 11-1. TROUBLESHOOTING (CONT.)

⚠ WARNING ***Some genset service procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.***

OVERFREQUENCY FAULT—CODE NO. 14

(Controller not able to regulate to rated frequency)

Corrective Action:

1. Check the governor linkage for binding and service as necessary (see *Governor Linkage and Actuator* in Section 6).
2. Check the governor controller board (see Section 10).

UNDERFREQUENCY FAULT—CODE NO. 15

(Controller not able to regulate to rated frequency)

Corrective Action:

1. Turn the genset line circuit breaker OFF. If the genset runs without shutting down, run the genset with fewer connected loads.
2. Fill the LPG fuel tank if less than half full. On cold days the LPG container may have to be kept at least half full to provide the rate of vaporization required to keep up with genset fuel demand. LPG with more than 2.5 percent butane will not vaporize below 32° F (0° C). Use HD-5 grade LPG.
3. Inspect/secure the spark plug cable on the spark plugs.
4. Service the air cleaner.
5. Check fuel solenoid valve operation (see *Fuel System* in Section 6).
6. Check the gas supply pressure and adjust as necessary (see *Fuel System* in Section 6).
7. Conduct the ignition system tests and service as necessary (see *Ignition System* in Section 6).
8. Check for a blocked exhaust system and service as necessary.
9. Check the governor linkage for binding and service as necessary (see *Governor Linkage and Actuator* in Section 6).
10. Check the governor controller board (see Section 10).
11. Conduct a cylinder compression test and service the engine if it is worn or malfunctioning.
12. Replace the genset control PCB (see Section 9).

AC OUTPUT SENSE FAULT—CODE NO. 27

(Controller unable to sense output voltage)

Corrective Action:

1. Check AC sense circuitry (Voltage Sense Input signal to genset control PCB) for continuity. See *Wiring Diagram* in Section 12.
2. Check resistance of AC sense transformer:
   H1 to H2 - 309 ohms ±10%
   X1 to X2 - 391 ohms ±10%
3. Replace the genset control PCB (see Section 9).

TABLE 11-1. TROUBLESHOOTING (CONT.)

⚠ WARNING ***Some genset service procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.***

HIGH BATTERY VOLTAGE FAULT—CODE NO. 29

(Voltage across battery system greater than 17.5 volts)

Corrective Action:

1. Test the battery charging system and service as necessary. See *Flywheel Alternator* - Section 6.
2. Select a lower battery charge rate if applicable.

LOW CRANKING SPEED FAULT—CODE NO. 32

(Cranking speed less than 180 rpm for more than 2 seconds)

Corrective Action (When engine is cranking slowly):

1. Clean and tighten the positive (**+**) and negative (**-**) battery cable connections at the battery and at the genset.
2. Recharge or replace the battery. See the battery manufacturer's recommendations.
3. Replace the engine oil with oil of proper viscosity for the ambient temperature (p. 2-1). (High oil viscosity can slow cranking speed.)
4. Test the battery charging system and service as necessary. See *Flywheel Alternator* - Section 6.

Corrective Action (When engine appears to be cranking normally):

1. Disconnect genset control connector **P1** (refer to Section 9 to remove connector **P1**) and check for electrical continuity across pins **P1-1** and **P1-10** (field windings). If the circuit is open, service the generator brush block and slip rings and repeat the test. Service or replace the generator rotor if the circuit is still open (Section 8). (Speed sense signal is generated from this circuit.)
2. Disconnect genset control connector **P1** and check for electrical continuity across pins **P1-3** and **P1-9** (quadrature windings). Replace the generator stator assembly if the circuit is open (Section 8).
3. Replace the genset control PCB (see Section 9).

CONTROL CARD FAILURE FAULT—CODE NO. 35

(Microprocessor EEPROM error during self-test)

Corrective Action: Replace the genset control PCB (See Section 9).

TABLE 11-1. TROUBLESHOOTING (CONT.)

⚠ WARNING ***Some genset service procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.***

MECHANICAL FAULT—CODE NO. 36

(Engine stopped without command by controller)

Corrective Action:

1. Fill the LPG fuel tank if less than half full. On cold days the LPG container may have to be kept at least half full to provide the rate of vaporization required to keep up with genset fuel demand. LPG with more than 2.5 percent butane will not vaporize below 32° F (0° C). Use HD-5 grade LPG.
2. Inspect/secure the spark plug cable on the spark plugs.
3. Service the air cleaner.
4. Check fuel solenoid valve operation (see *Fuel System* in Section 6).
5. Check the gas supply pressure and adjust as necessary (see *Fuel System* in Section 6).
6. Disconnect genset control connector **P1** (refer to Section 9 to remove connector **P1**) and check for electrical continuity across pins **P1-1** and **P1-10** (field windings). If the circuit is open, service the generator brush block and slip rings and repeat the test. Service or replace the generator rotor if the circuit is still open (Section 8). (Speed sense signal is generated from this circuit.)
7. Conduct the ignition system tests and service as necessary (see *Ignition System* in Section 6).
8. Conduct a cylinder compression test and service the engine if it is worn or malfunctioning.
9. Replace the genset control PCB (see Section 9).

FIELD OVERLOAD FAULT—CODE NO. 38

(To many low power factor loads)

Corrective Action:

1. Reduce the number of appliances running at the same time, especially those with high motor starting loads such as air conditioners.
2. Have air conditioners and other appliances checked for proper operation. (A locked compressor rotor can cause very low power factor.)

GENERATOR ROTOR FAULT—CODE NO. 41

(Controller failed to sense field voltage)

Corrective Action:

1. Test rotor (see *Testing the Generator* in Section 8).
2. Replace the genset control PCB (see Section 9).

PROCESSOR FAULT—CODE NO. 42

(Microprocessor ROM error during self-test)

Corrective Action: Replace the genset control PCB (see Section 9).

TABLE 11-1. TROUBLESHOOTING (CONT.)

⚠ WARNING ***Some genset service procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.***

PROCESSOR FAULT—CODE NO. 43

(Microprocessor RAM error during self-test)

Corrective Action: Replace the genset control PCB (see Section 9).

SPEED SENSE FAULT—CODE NO. 45

(Controller failed to sense quadrature frequency)

Corrective Action:

1. Disconnect genset control connector **P1** (see Section 9 to remove connector **P1**) and check for electrical continuity across pins **P1-1** and **P1-10** (field windings). If the circuit is open, service the generator brush block and slip rings and repeat the test. Service or replace the generator rotor if the circuit is still open (Section 8).
2. Disconnect genset control connector **P1** and check for electrical continuity across pins **P1-3** and **P1-9** (quadrature windings). Replace the generator stator assembly if the circuit is open (Section 8).
3. Replace the genset control PCB (see Section 9).

FIELD SENSE LOST FAULT—CODE NO. 48

(Controller failed to sense field voltage)

Corrective Action: Replace the genset control PCB (see Section 9).

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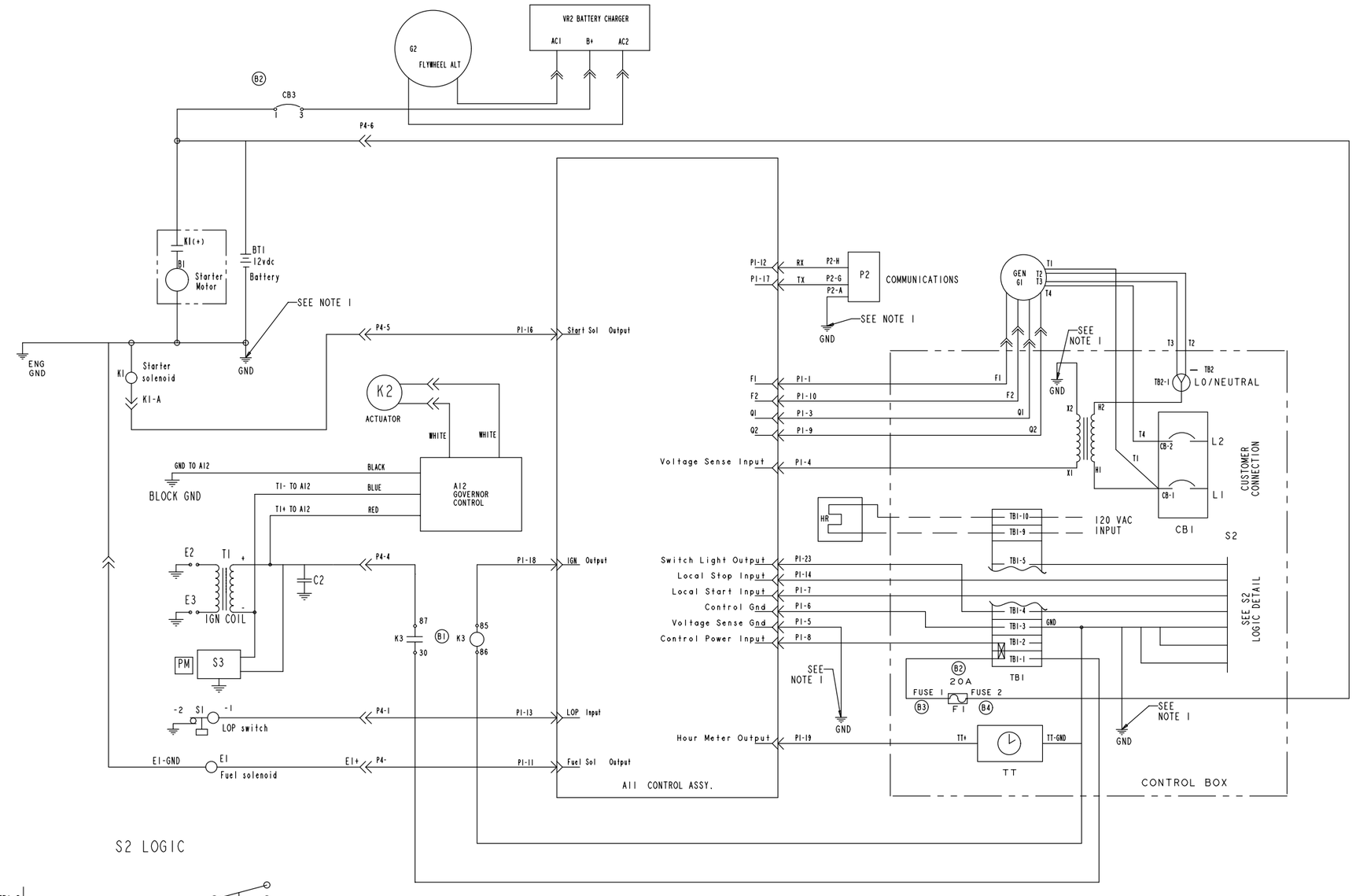
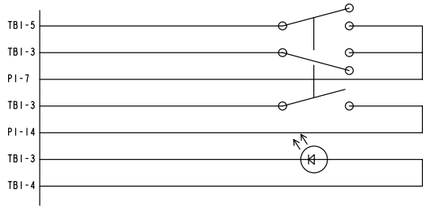
12. Wiring Diagrams

GENERAL

This section consists of the schematic and wiring diagrams referenced in the text. the following drawings are included:



S2 LOGIC



NOTES:

1. ALL NOTED GROUNDS ARE ATTATCHED AT ONE POINT.

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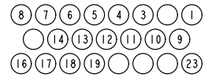
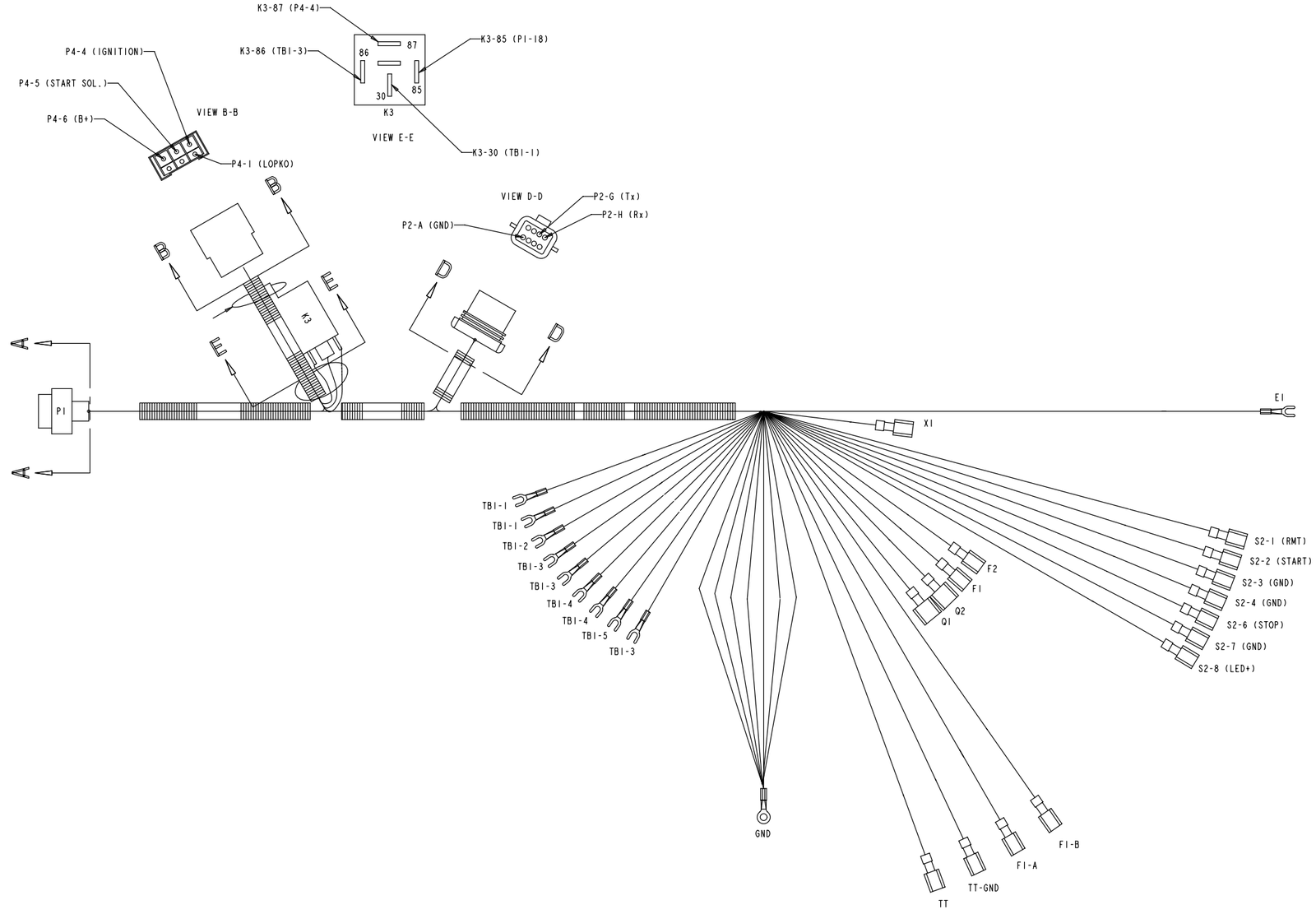
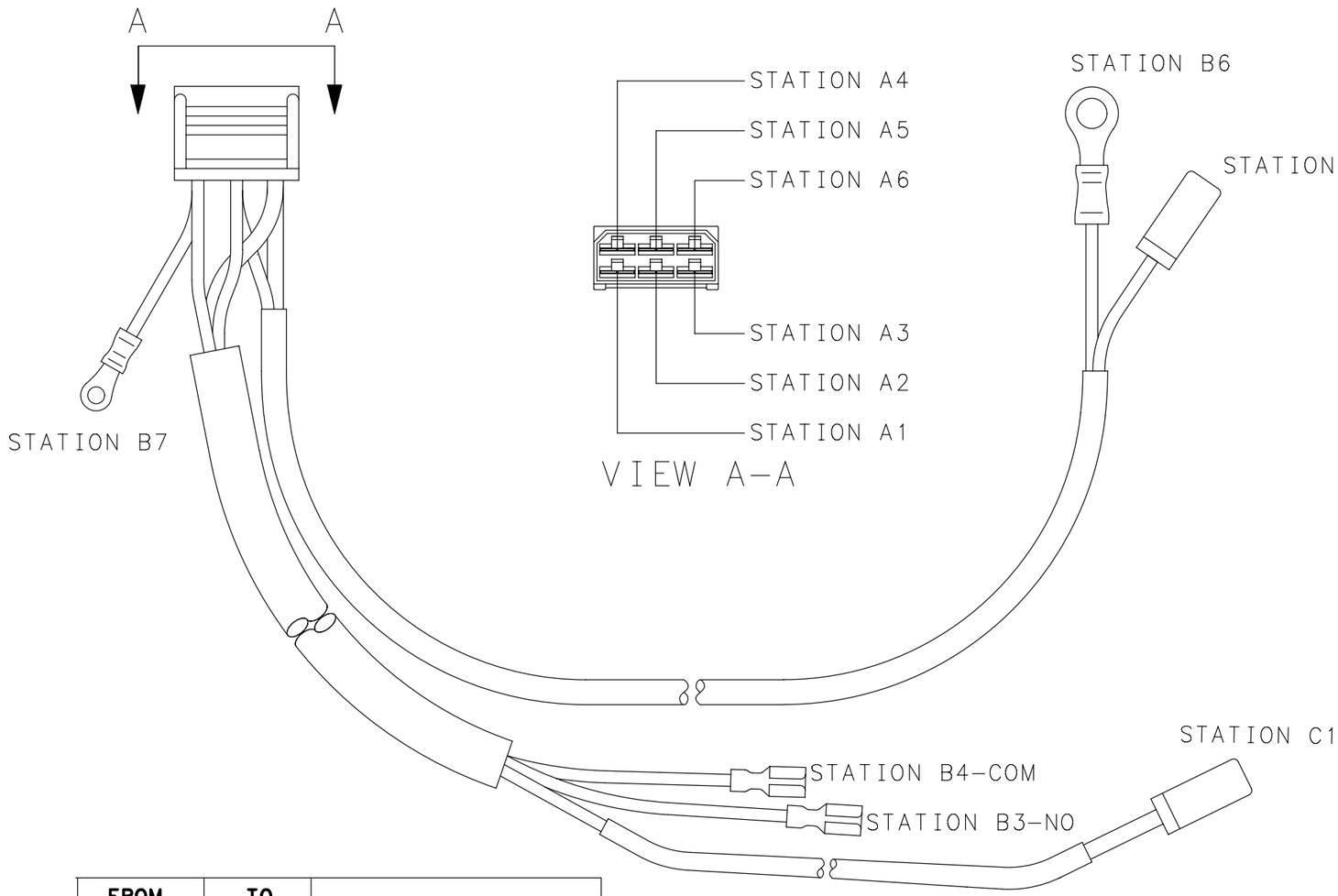


VIEW A-A
2X SCALE

FROM STATION	TO STATION	FUNCTION
P1-8	TB1-2	A11_B+
P1-6	TB1-3	A11_GND
P1-1	F1	ALT. FIELD (+)
P1-10	F2	ALT. FIELD (-)
TB1-1	K3-30	IGN-RELAY CONT.
P1-11	E1	FUEL SOLENOID
GND	P2-A	COM-GROUND
GND	S2-3	SW-GROUND
GND	S2-4	SW-GROUND
GND	S2-7	SW-GROUND
GND	TT-GND	HOUR METER GND
GND	TB1-3	CUST-GROUND
GND	P1-5	VR21-GND
P1-19	TT+	HOUR METER (+)
P1-18	K3-85	RELAY IGNITION
TB1-4	S2-8	LED (+)
P1-13	P4-1	LOPKO
P1-3	Q1	QUAD_1
P1-9	Q2	QUAD_2
TB1-5	S2-1	RMT START
P1-12	P2-H	Rx
P1-7	S2-2	START
F1-A	P4-6	STARTER B+
P1-16	P4-5	STARTER SOLENOID
P1-14	S2-6	STOP
P1-23	TB1-4	SWITCH LIGHT
P1-17	P2-G	Tx
P1-4	X1	VR21-SENSE
F1-B	TB1-1	BATTERY SUPPLY
K3-87	P4-4	IGNITION
TB1-3	K3-26	GND



No. 338-3825 sh 1 of 1
Rev. F Sys: ProE
Modified 8-99



FROM STATION	TO STATION	DESTINATION REF
A1	B3–NO	OIL PRESSURE SWITCH
A2	B4–COM	OIL PRESSURE SWITCH
A3	C1	VOLTAGE REGULATOR
A4	B7	IGNITION COIL
A5	C2	STARTER SOLENOID
A6	B6	STARTER B+

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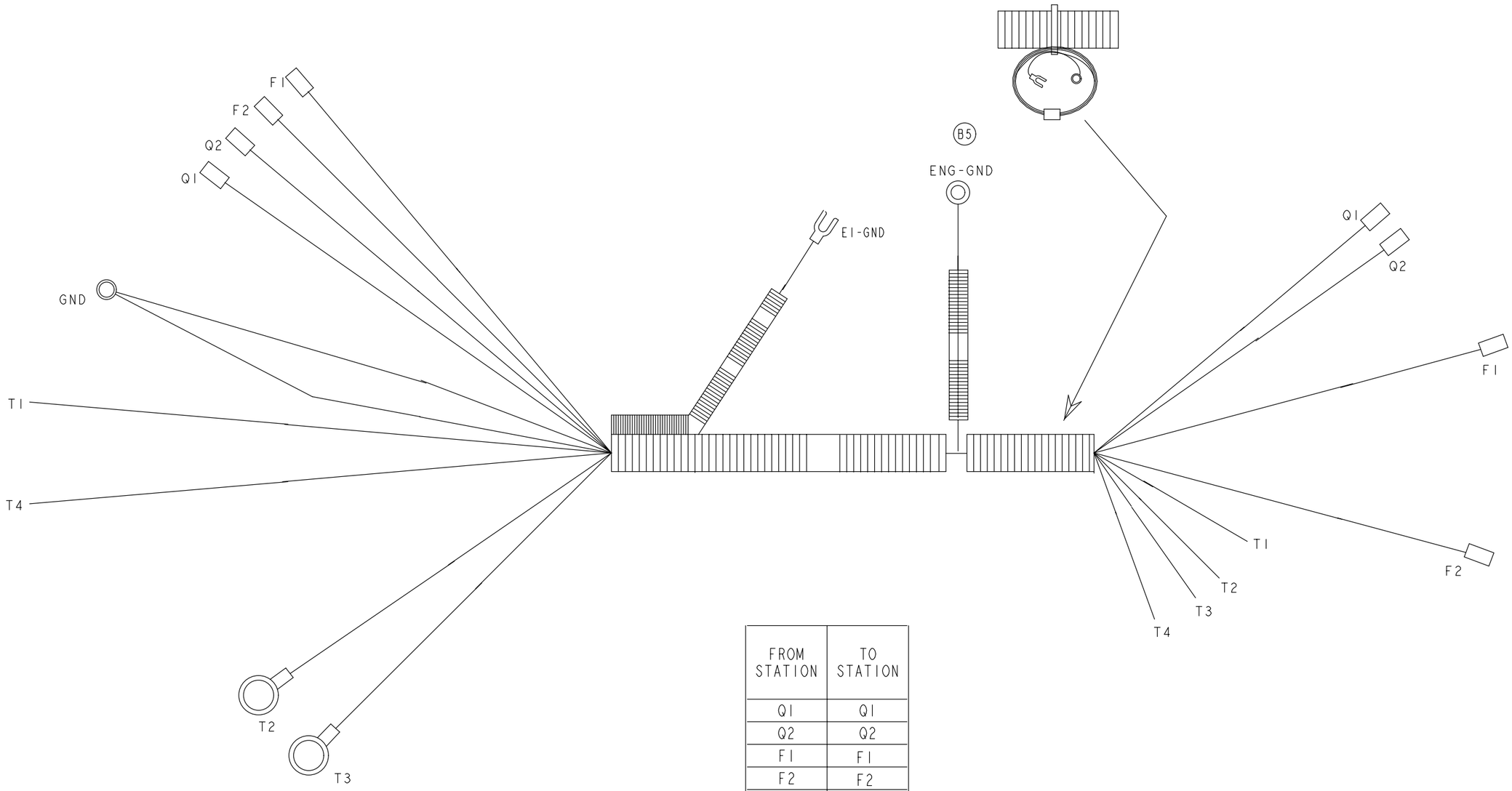
Rev. B Sys: Revisio
Modified 7-99



FROM STATION	TO STATION
Q1	Q1
Q2	Q2
F1	F1
F2	F2
ENG-GND	GND
E1-GND	GND
T1	T1
T2	T2
T3	T3
T4	T4

No. 338-3845 sh 1
Rev. F Sys: ProE
Modified 8-99

ALTERNATOR HARNESS

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