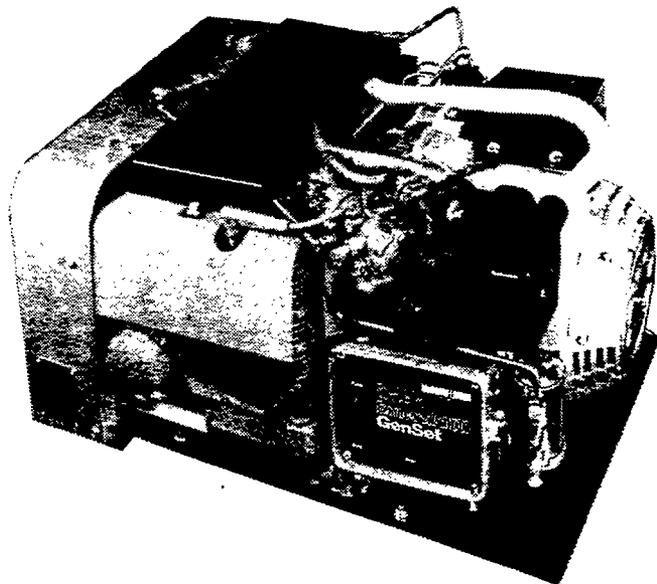


Onan

Service Manual NHE-NHEL GenSets

RV Electric Generating Set
(Spec A-C)



Safety Precautions

Before operating the generator set, read the Operator's Manual and become familiar with it and the equipment. Safe and efficient operation can be achieved only if the unit is properly operated and maintained. Many accidents are caused by failure to follow fundamental rules and precautions.

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

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

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

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

FUEL AND FUMES ARE FLAMMABLE. Fire, explosion, and personal injury can result from improper practices.

- DO NOT fill fuel tanks while engine is running. Fuel contact with hot engine or exhaust is a potential fire hazard.
- DO NOT SMOKE OR USE AN OPEN FLAME near the generator set or fuel tank.
- Fuel lines must be adequately secured and free of leaks. Fuel connection at the engine should be made with an approved flexible, non-conductive line. Do not use copper piping on flexible lines as copper will work harden and become brittle.
- Be sure all fuel supplies have a positive shutoff valve.

GASOLINE AND LPG FUEL MAY BE ACCIDENTALLY IGNITED BY ELECTRICAL SPARKS, presenting the hazard of fire or explosion, which can result in severe personal injury or death. When installing the generator set:

- Do not tie electrical wiring to fuel lines.
- Do not run electrical lines and fuel lines through the same compartment openings.
- Keep electrical and fuel lines as far apart as possible.
- Place a physical barrier between fuel lines and electrical lines wherever possible.
- If electrical and fuel lines must pass through the same compartment opening, make certain that they are physically separated by running them through individual channels, or by passing each line through a separate piece of tubing.
- DO NOT SMOKE while servicing batteries. Lead acid batteries emit a highly explosive hydrogen gas that can be ignited by electrical arcing or by smoking.

EXHAUST GASES ARE DEADLY

- Never sleep in the vehicle with the generator set running unless vehicle is equipped with an operating carbon monoxide detector.
- Provide an adequate exhaust system to properly expel discharged gases. Inspect exhaust system daily for leaks per the maintenance schedule. Ensure that exhaust manifolds are secure and not warped. Do not use exhaust gases to heat a compartment.
- Be sure the unit is well ventilated.

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Before starting work on the generator set, disconnect batteries. This will prevent accidental arcing.

- Keep your hands away from moving parts.
- Make sure that fasteners on the generator set are secure. Tighten supports and clamps, keep guards in position over fans, drive belts, etc.
- Do not wear loose clothing or jewelry while working on generator sets. Loose clothing and jewelry can become caught in moving parts. Jewelry can short out electrical contacts and cause shock or burning.
- If adjustment must be made while the unit is running, use extreme caution around hot manifolds, moving parts, etc.

ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Disconnect starting battery before removing protective shields or touching electrical equipment. Use rubber insulative mats placed on dry wood platforms over floors that are metal or concrete when around electrical equipment. Do not wear damp clothing (particularly wet shoes) or allow skin surfaces to be damp when handling electrical equipment.
- Use extreme caution when working on electrical components. High voltages can cause injury or death.
- Follow all state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician. Tag open switches to avoid accidental closure.
- DO NOT CONNECT GENERATOR SET DIRECTLY TO ANY BUILDING ELECTRICAL SYSTEM. Hazardous voltages can flow from the generator set into the utility line. This creates a potential for electrocution or property damage. Connect only through an approved device and after building main switch is open. Consult an electrician in regard to emergency power use.

GENERAL SAFETY PRECAUTIONS

- Have a fire extinguisher nearby. Maintain extinguisher properly and become familiar with its use. Extinguishers rated ABC by the NFPA are appropriate for all applications. Consult the local fire department for the correct type of extinguisher for various applications.
- Hot coolants under pressure can cause severe personal injury. DO NOT open a radiator pressure cap while the engine is running. Stop the engine and carefully bleed the system pressure.
- Benzene and lead, found in some gasoline, have been identified by some state and federal agencies as causing cancer or reproductive toxicity. When checking, draining or adding gasoline, take care not to ingest, breathe the fumes, or contact gasoline.
- Used engine oils have been identified by some state or federal agencies as causing cancer or reproductive toxicity. When checking or changing engine oil, take care not to ingest, breathe the fumes, or contact used oil.
- Remove all unnecessary grease and oil from the unit. Accumulated grease and oil can cause overheating and engine damage, which presents a potential fire hazard.
- DO NOT store anything in the generator compartment such as oil or gas cans, oily rags, chains, wooden blocks, portable propane cylinders, etc. A fire could result or the generator set operation (cooling, noise and vibration) may be adversely affected. Keep the compartment floor clean and dry.
- Do not work on this equipment when mentally or physically fatigued, or after consuming any alcohol or drug that makes the operation of equipment unsafe.

Date: 8-85

Insert with -

Title: NHE/NHEL Service Manual

Number: 940-0502

This supplement includes latest starter repair information for models NHE/NHEL RV gensets.

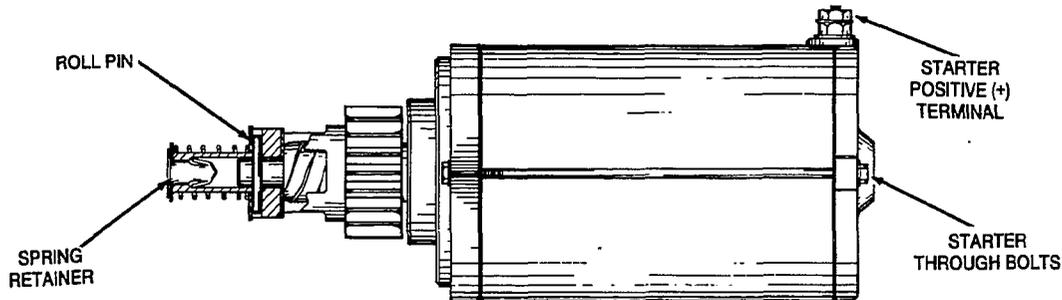


FIGURE 1. 191-1667 STARTER

ES-1608

ELECTRIC STARTER

The following procedures cover the disassembly and testing of electric starter.

Disassembly

Use the following procedure to remove and disassemble the starter.

1. Disconnect the generator set negative (-) battery cable from the set starting battery.
2. Disconnect the generator set positive (+) battery cable from the starter lug terminal.
3. Remove the starter mounting screws and then carefully disengage the starter from the stator housing.
4. Remove starter through-bolts and carefully separate the brush end cap housing and armature assembly.
5. Use a 1/8 to 5/32 inch nail set to remove roll pin. Remove return spring, gear and clutch assembly as required. When reassembling always use a new roll pin. See Figure 2.

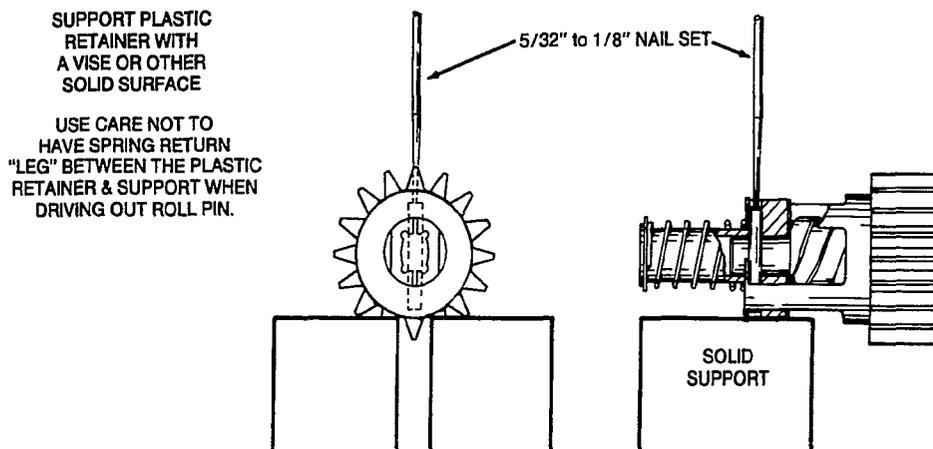


FIGURE 2. DRIVING ROLL PIN OUT

ES-1609

Testing Armature for Grounds: Touch one ohmmeter lead to a commutator bar and then touch the other lead to armature shaft and core laminations. A low resistance reading indicates a grounded armature. Replace grounded armature with a new part. See Figure 3.

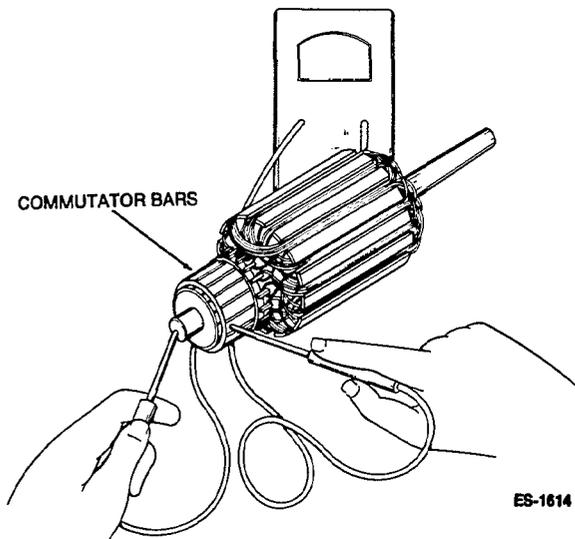


FIGURE 3. TESTING ARMATURE FOR GROUNDS

Testing for Shorts: Use a growler (Figure 4) for locating shorts in the armature. Place armature in growler and hold a thin steel blade (e.g. hacksaw blade) parallel to the core and just above the armature while slowly rotating armature in growler. A shorted armature will cause the blade to vibrate and be attracted to the core. Replace a shorted armature with a new part.

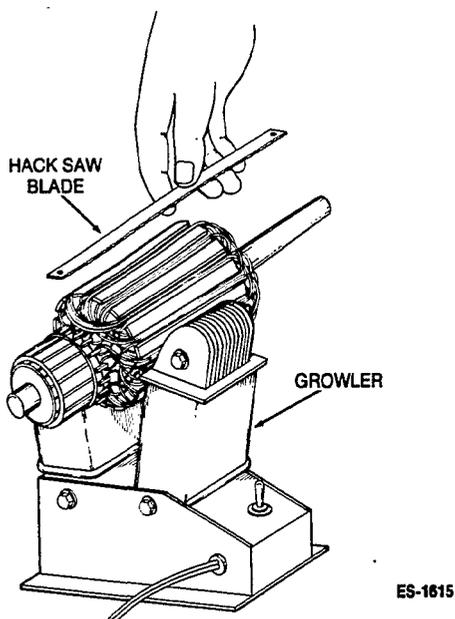


FIGURE 4. TESTING ARMATURE FOR SHORTS

Testing for Opens: Touch one ohmmeter lead to a commutator bar and then systematically touch the other lead to each of the remaining commutator bars. A high resistance reading indicates an open circuit between the commutator bars and armature windings. Replace an open armature with a new part.

Brush Inspection: Measure brushes (Figure 5) and replace if worn less than .425 inch (11 mm).

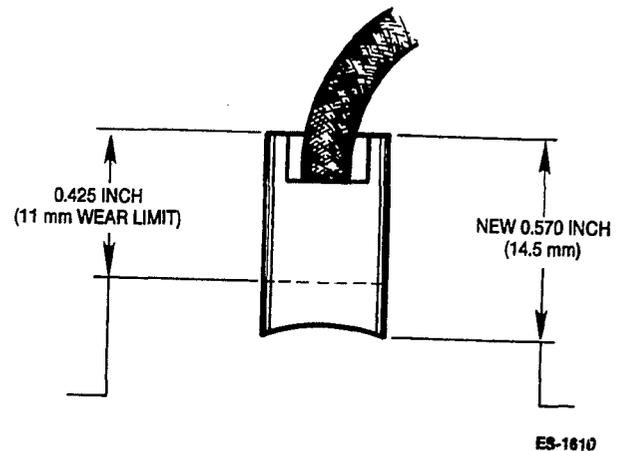


FIGURE 5. BRUSH INSPECTION

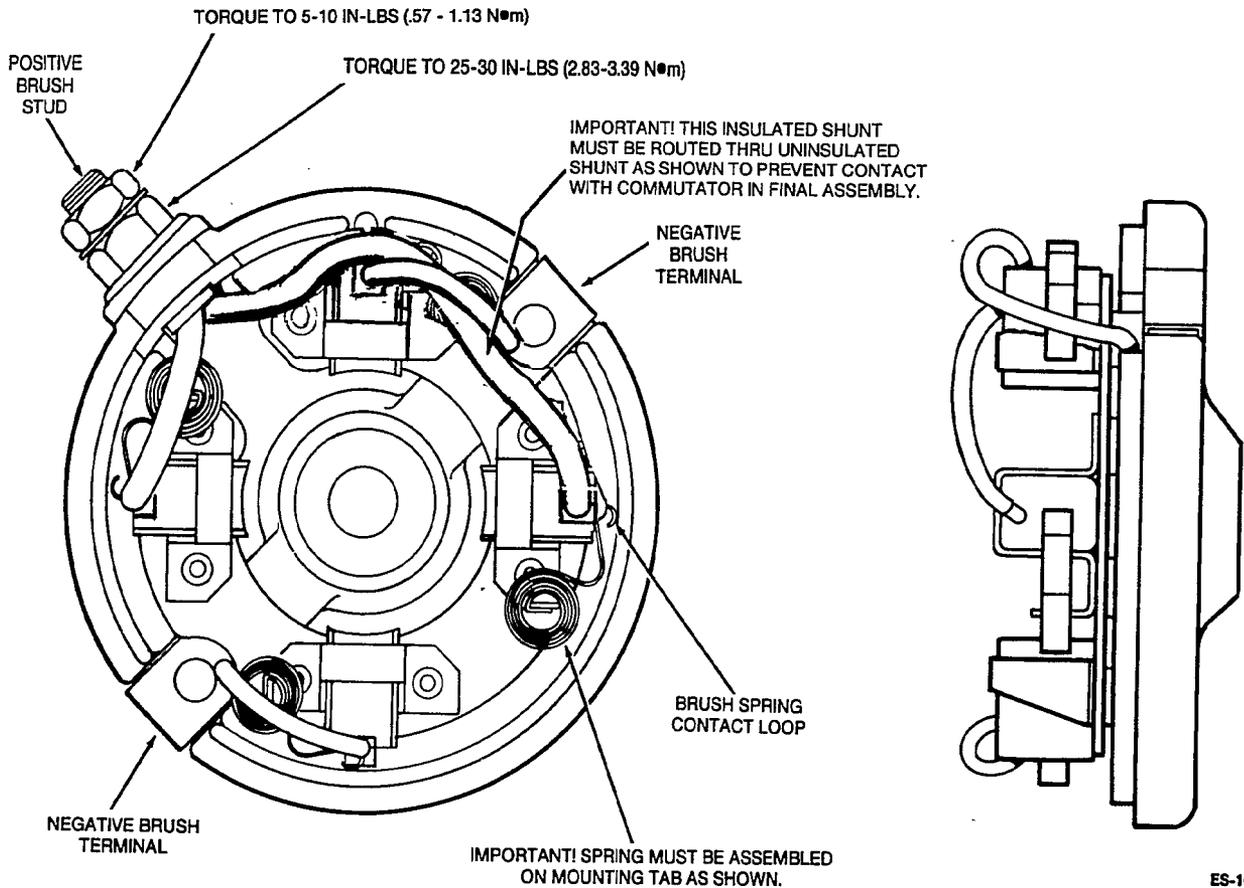


FIGURE 6. BRUSH ENDCAP

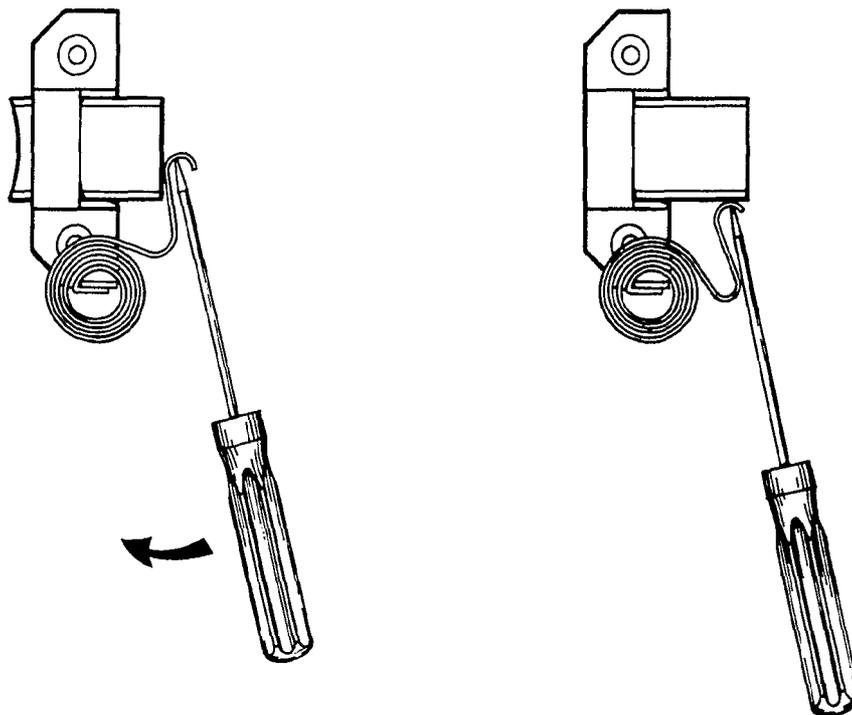
Assembly

1. Wipe off all dirt and oil from starter components using a clean cloth or blow off dirt with filtered, low pressure compressed air.

CAUTION *Oil on armature will damage starter. Do not immerse bearings in cleaning fluid. Use a brush dipped in clean engine oil for removing dirt from bearings. Avoid getting oil on brushes or commutator.*

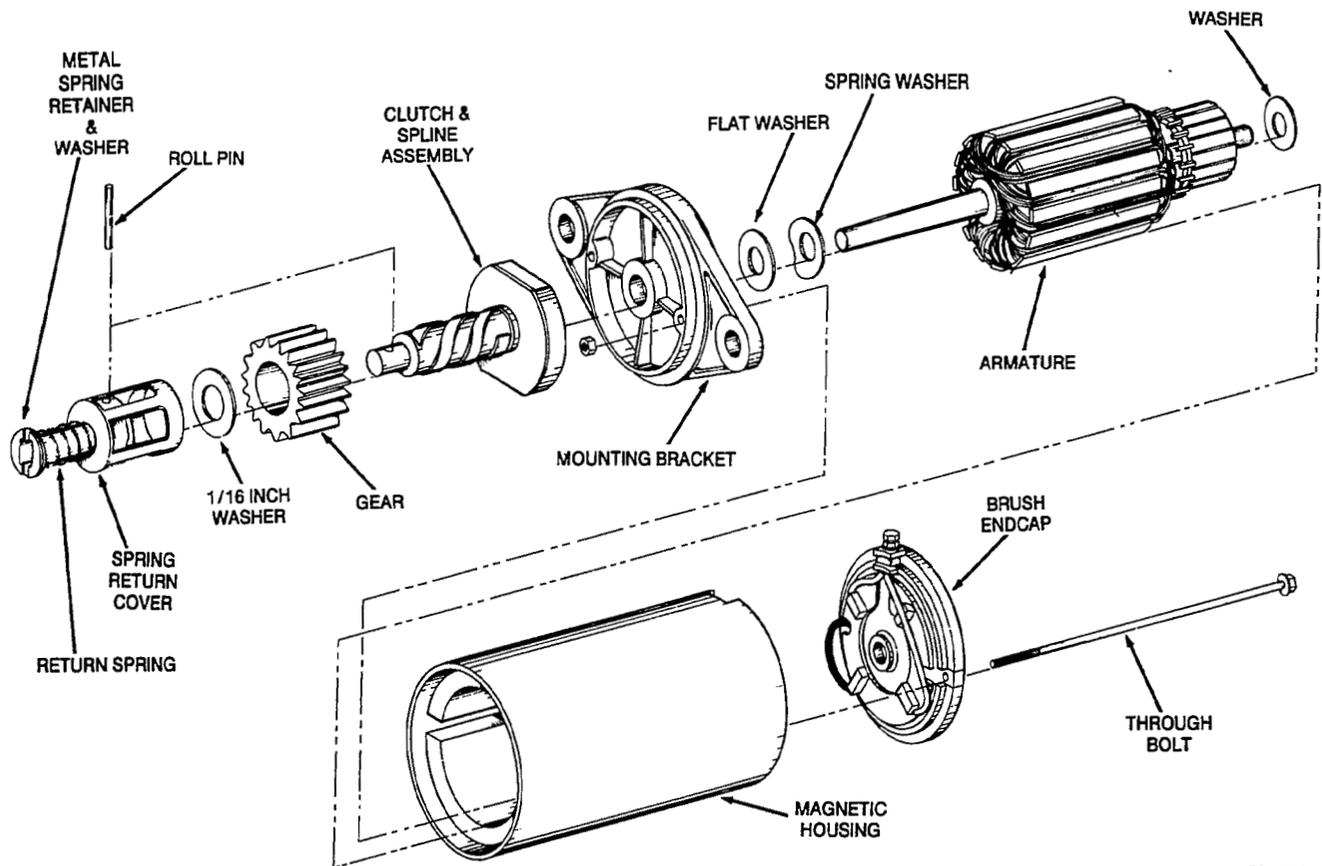
2. Mount brush springs on tabs as shown in Figure 6. Using a small screwdriver, turn spring counter-clockwise to torque so contact loop is inside of brush holder. Spring should be pushed down to mounting tab shoulder.
3. Push negative brush terminals over through-bolt holes on brush endcap.
4. Insert positive brush stud into hole and torque to 25-30 lb.-in. (2.83-3.39 N•m).
5. Using a small screwdriver inserted into brush spring contact loop, bend the spring back to allow each brush to be inserted into holder. Be sure all brush wires are facing up.

6. If the brushes are at least 0.430 inch (10.9 mm) long, rest the brush springs against the sides of brushes to keep them clear during armature installation. See Figure 7.
7. Place washer on commutator end of shaft and put armature into brush endcap. Push the four brushes toward commutator, making sure springs are properly positioned on brushes. Recheck to be sure spring is pushed all the way down on mounting tab.
8. Make sure all brush wires are clear of commutator and that uninsulated portions of insulated wires do not touch inside diameter of housing. Uninsulated portions of wires must also not touch adjacent brush boxes.
9. Place magnetic housing over armature. Use a nut driver over the end of shaft to hold down armature and endcap.
10. Place spring washer and flat washer on shaft as shown in Figure 8.
11. Place mounting bracket on motor with exposed end of sleeve bearing and through-bolt "lead-ins" to the inside of motor. The "flat" near one mounting hole should line up with the positive stud on end cap so through-bolts will line up.
12. Insert the through-bolts and torque to 35-45 lb. in. (3.96-5.09 N•m).
13. Wipe dust from helix and gear and apply a light coat of GE Versilube 322-L on outside diameter of helix, inside diameter of gear and unchamfered end of gear. Place clutch and helix assembly on motor shaft with flats engaged in clutch hole.



ES-1611

FIGURE 7. RESTING BRUSH SPRING ON BRUSH SIDE



ES-1613

FIGURE 8. STARTER ASSEMBLY

14. If Return Spring is Unassembled:

- A. Place 1-1/16 inch O.D. washer over end of shaft.
- B. With chamfered side of shaft hole up, place plastic retainer on shaft and line up hole with hole in shaft.
- C. Support the plastic retainer with a vise or other solid surface. Using a 5/32 to 1/8 inch nail set and hammer, drive in a new roll pin. The pin should be driven in about 1/10th of an inch (2.5 mm) from the edge of the plastic retainer or so its is evenly spaced from each side.

- D. Place spring cover over top of plastic retainer, then the return spring on top of the retainer.
- E. With washer placed over point of plastic retainer, push metal retainer into hole of plastic retainer as far as it will go.

15. Mount starter on generator stator housing using capscrews, lockwashers and nuts. Tighten mounting screws to 30-33 lb-ft (41-45 N•m).
16. Connect generator set positive (+) battery cable to starter terminal. Connect generator set negative (-) terminal to generator set starting battery.





Supplement 940-1042

Date: 11-86

Insert with -

Title: NHE-NHEL Service Manual

Number: 940-0502

PURPOSE

This supplement reflects the following manual updates:

Page 1 (for units equipped with a Nikki carburetor) - New throttle stop, mixture adjustment, and float setting; in reference to like information found on pages 6-13 to 6-16.

Nikki Carburetor - Throttle Stop, Fuel Mixture Adjustment, and Float Setting

Throttle Stop (Idle Adjust): Connect a frequency meter to generator set. Start the generator set and operate at no-load. Turn in the throttle stop screw (idle adjust) to contact the throttle lever tab. While adjusting screw, pull the governor linkage toward the engine and monitor the frequency meter. Adjust the screw to obtain the following setting:

- 60 Hz Model - 55 ± 1 hertz / 1650 ± 30 r/min.
- 50 Hz Model - 45 ± 1 hertz / 1350 ± 30 r/min.

Release governor linkage and check unit frequency and voltage. Refer to Governor Adjustments in section 6 of service manual. Perform necessary adjustments to achieve proper setting.

Mixture Screw Adjustments: If generator set voltage and frequency (r/min) cannot be satisfactory adjusted, and the generator set operation is erratic, stop the generator set and review the following idle and main fuel mixture screw adjustments.

A. Idle mixture screw adjustment:

- Carefully remove screw adjustment limiter cap.
- Using a screwdriver, carefully turn the idle mixture screw inward until lightly seated, and then back out exactly one (1) full turn.
- Carefully replace screw adjustment limiter cap over screw head, with limiter lever located at the LOW altitude position.

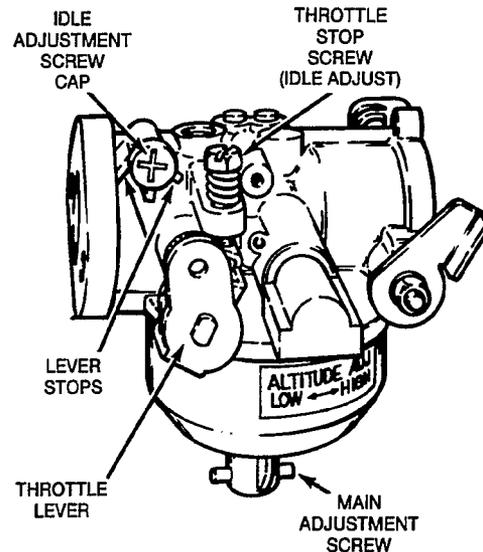
Take care not to change setting and confirm that limiter cap is fully seated over screw head.

B. Main mixture screw adjustment:

- Carefully remove screw adjustment limiter cap.
- Turn the main mixture screw inward until lightly seated, and then back out exactly one and one-quarter (1-1/4) full turns out.
- Carefully replace screw adjustment limiter cap over screw head, with limiter lever located at the LOW altitude position.

Take care not to change setting and confirm that limiter cap is fully seated over screw head.

Review Governor Adjustments in section 6. Add and remove a full load several times to make certain the generator set does not bog down or hunt. Stop generator set, remove meter(s) and tools, and close up generator set compartment.

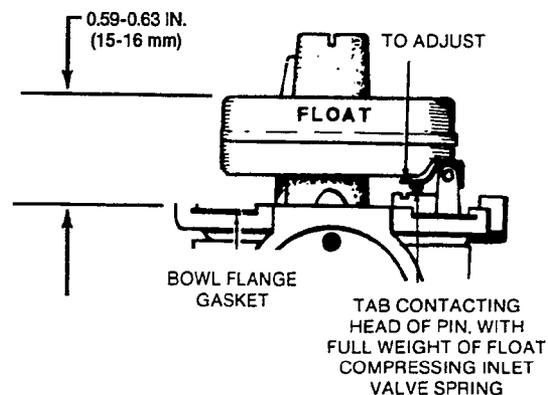


FS-1691

FIGURE 1. THROTTLE STOP, AND FUEL MIXTURE ADJUSTMENT SCREWS

Float Setting: To adjust the float, the carburetor must be removed from the generator set. Refer to Carburetor Overhaul - Removal, Cleaning, and Reassembly instructions in section 6 of the service manual.

Perform similar procedures to adjust the float; by bending the tab and checking proper float position. The Nikki carburetor float position is measured from the carburetor housing to the far side (bottom side) of the float. Proper float adjustment should reflect a measurement of .59 to .63 inch (15 to 16 mm).



FS-1611

FIGURE 2. FLOAT LEVEL

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Section 1 - Introduction

ABOUT THIS MANUAL

This manual provides complete service information for Onan NHE-NHEL series recreational vehicle generator sets, for the experienced serviceperson. Subjects covered include: troubleshooting, disassembly, repair, reassembly, and adjustments for engine, generator, and control. The serviceperson must possess thorough knowledge of internal combustion engine principles, and basic knowledge of electrical fundamentals. Refer to other Onan publications, such as Electrical/Mechanical Fundamentals (932-0408), Onan Generator Training Manual (932-0404), Operators Manual NHE GenSet (940-0122), and Installation Manual NHE GenSet (940-0622), for additional information.

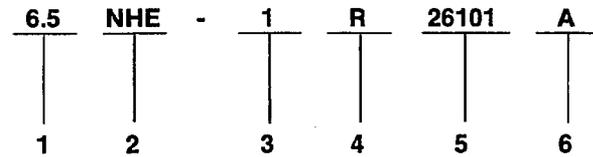
Read all service and procedures completely, observing all cautions and warnings, before beginning any repair work. The generator set installation must maintain compliance with the applicable recreational vehicle codes and standards. The most critical areas of concern are the exhaust system, fuel system, electrical wiring, compartment construction, and ventilation system. Improper servicing can create an unsafe installation that might cause serious personal injury or death, or damage to the vehicle or equipment.

MODEL IDENTIFICATION

Always supply the complete Model Number, Spec Number, and Serial Number as shown on the generator set nameplate (Figure 1-1) when contacting an Onan Dealer or Distributor. This information is necessary to identify your generator set when ordering replacement parts.

Always use genuine Onan replacement parts obtained from an authorized Onan Dealer or Distributor. Universal type replacement parts (usually intended for automotive use) often look similar but might not perform to Onan specifications. Only genuine Onan replacement parts are designed and tested for specific applications to ensure reliable service and dependable operation.

The model number consists of code segments which designate various features or options. The following typical model number is broken down to illustrate:



1. Kilowatt rating
2. Series identification
NHE - Gasoline fueled
NHEL - LPG fueled
3. Voltage code
1 - 120 volts
4. Starting method
R - Remote
5. Factory code for designating modifications, options, or special features.
6. Specification letter. Advances when the factory makes production modifications which affect all models.

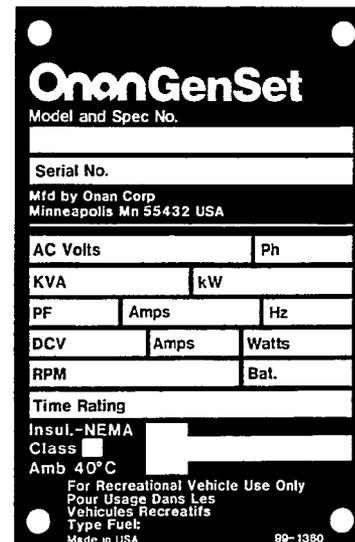


FIGURE 1.1. ONAN NAMEPLATE

⚠ WARNING

INCORRECT SERVICE OR REPLACEMENT OF PARTS CAN RESULT IN SEVERE PERSONAL INJURY AND/OR EQUIPMENT DAMAGE. SERVICE PERSONNEL MUST BE QUALIFIED TO PERFORM ELECTRICAL AND/OR MECHANICAL SERVICE.

Section 2 - Specifications

MODELS	NHE	NHEL
GENERAL		
Engine Design	Four Cycle, Air Cooled, Two Cylinder	
Generator Design	Revolving Field, Four Pole	
Output Ratings	Unity Power Factor	
Starting System	Automotive Type Starter, 12 Volts	
Engine Speed	1800 r/min	
Weight	262 lbs (119 kg)	
ENGINE DETAILS		
Displacement	60.0 In ³ (983.0 cm ³)	
Compression Ratio	7.0:1	
Bore	3.56 In. (90.42 mm)	
Stroke	3.00 In. (76.20 mm)	
Oil Capacity (With Filter)	4 Qt. (3.8 L)	
Ventilation (Free Area)	85 In. ² (548.4 cm ²)	
Fuel	Lead-Free or Regular Gasoline	LPG (Propane Liquid Withdrawal)
GENERATOR DETAILS		
Watts	6500	6300
Volts	120	
Amps at 120 Volts	54.2	52.5
Frequency (Hertz)	60	
Phase	Single	
Wires	2	
Battery Charge (fixed)	0-1 Amp	
TUNE-UP SPECS		
Check Spark Plug Gap	0.025 In. (0.64 mm)	0.025 In. (0.64 mm)
Point Gap	0.016 In. (0.41 mm)	0.021 In. (0.53 mm)
Valve Lash		
Intake	0.005 In. (0.127 mm)	
Exhaust	0.013 In. (0.330 mm)	

Section 3 - Dimensions/Clearances

Models	6.5 NHE AND 6.3 NHEL
CYLINDERS AND PISTON ASSEMBLY	Dimensions not in parentheses are INCHES
Cylinder Bore (Std. Size honed)	3.5625-3.5635 (90.488-90.513 mm)
Cylinder Taper (Max)	0.003 (0.076 mm)
Cylinder Out of Round (Max)	0.003 (0.076 mm)
Clearance in Cylinder	0.0070-0.0090 (0.178-0.229 mm)
Ring Gap	0.0100-0.0200 (0.254-0.508 mm)
Piston Ring #1 (top) Groove Width	0.080-0.081 (2.032-2.057 mm)
Piston Ring #2 Groove Width	0.080-0.081 (2.032-2.057 mm)
Piston Ring #3 Groove Width	0.188-0.189 (4.775-4.801 mm)
Piston Ring #1 (Top) Side Clearance	0.002-0.008 (0.051-0.203 mm)
Piston Pin Diameter	0.7500-0.7502 (19.05-19.06 mm)
Piston Pin Fit In Rod	0.00005-0.00055 (0.001-0.014 mm)
Connecting Rod Side Clearance	0.0020-0.0160 (0.051-0.406 mm)
Connecting Rod Bearing Clearance	0.0005-0.0028 (0.013-0.071 mm)
CRANKSHAFT AND CAMSHAFT	Dimensions not in parentheses are INCHES
Crankshaft Main Bearing Journal Diameter	1.9992-2.0000 (50.780-50.800 mm)
Crankshaft Rod Journal Bearing Diameter	1.6252-1.6260 (41.280-41.300)
Crankshaft Main Bearing Diameter	2.0015-2.0040 (50.838-50.902 mm)

Dimensions/Clearances (continued)

Models	6.5 NHE AND 6.3 NHEL
Crankshaft Main Bearing Clearance	0.0025-0.0038 (0.064-0.097 mm)
Crankshaft End Play	0.005-0.009 (0.13-0.23 mm)
Camshaft Journal Diameter	1.3740-1.3745 (34.900-34.912 mm)
Camshaft Bearing Diameter	1.376-1.377 (34.950-34.976 mm)
Camshaft Bearing Clearance	0.0015-0.0030 (0.038-0.076 mm)
Camshaft End Play	0.0030-0.0120 (0.076-0.305 mm)
VALVES AND LIFTERS	Dimensions not in parentheses are INCHES
Valve Spring Free Length	1.6620 (42.214 mm)
Valve Spring Compressed Length	1.3750 (34.925 mm)
Valve Spring Tension Open	71-79 lbs (32-36 kg)
Valve Spring Tension Closed	38-42 lbs (17-19 kg)
Valve Face Angle	44 degrees
Valve Seat Angle	45 degrees
Valve Stem Diameter (Intake)	0.3425-0.3430 (8.700-8.712 mm)
Valve Stem Diameter (Exhaust)	0.3410-0.3415 (8.661-8.674 mm)
Valve Guide Diameter	0.344-0.346 (8.738-8.788 mm)
Valve Stem Clearance (Intake)	0.0010-0.0025 (0.025-0.064 mm)
Valve Stem Clearance (Exhaust)	0.0025-0.0040 (0.064-0.102 mm)
Valve Lifter Diameter	0.7475-0.7480 (18.987-18.999 mm)
Valve Lifter Bore Diameter	0.7505-0.7515 (19.063-19.088 mm)

Dimensions/Clearances (continued)

Models	6.5 NHE AND 6.3 NHEL
Valve Lifter To Block Clearance	0.0015-0.0030 (0.038-0.076 mm)
Valve Seat Diameter (Intake)	1.5690-1.5700 (39.853-39.878 mm)
Valve Seat Diameter (Exhaust)	1.2550-1.2560 (31.877-31.902 mm)
Valve Seat Bore Diameter (Intake)	1.5645-1.5655 (39.738-39.764 mm)
Valve Seat Bore Diameter (Exhaust)	1.2510-1.2520 (31.775-31.801 mm)

Section 4 - Torque Specifications

Models	NHE AND NHEL	
TORQUE SPECIFICATIONS	Use engine oil as a lubricant for all threads EXCEPT the spark plug and rotor through-bolt threads	
	FOOT-POUNDS	(NEWTON-METRES)
Cylinder Head (Cold)	18-20	(24-27)
Connecting Rod	27-29	(37-39)
Rear Bearing Plate	25-28	(34-38)
Flywheel Mounting Screw	50-55	(68-75)
Oil Base	18-23	(24-31)
Gearcase Cover	8-10	(11-14)
Spark Plug	7-9	(9-12)
Exhaust Manifold	20-23	(27-31)
Intake Manifold	20-23	(27-31)
Other 3/8 Cylinder Block Nuts	18-23	(24-31)
Oil Pump	7-9	(10-12)
Rotor Through-Bolt	45-55	(61-75)
Starter Mounting Screws	30-33	(41-45)
Stator Clamp Screws	10-12	(11-16)
Adapter to Engine Mounting Screws	25-27	(34-37)
Adapter to Generator Mounting Screws	25	(34)
Rear Vibration Isolator - Center Screw	30-33	(41-45)
Flange to Drip Tray Screws	10-12	(11-16)
Front Vibration Isolator -Flange to Oil Base Screws	19-22	(26-30)

Section 5 - Preparing to Service

TROUBLESHOOTING

Before servicing the generator set, locate and isolate the problem using systematic troubleshooting procedures. To aid servicing, this manual divides the generator set into four logical groups and provides a separate section for each:

- Engine - Primary Systems
- Control
- Generator
- Engine - Block Assembly

This manual provides troubleshooting tables to help locate the cause of various malfunctions. Some malfunctions may have several causes. Thus, several likely problem areas may have to be investigated to isolate the source of the malfunction. Because of the complexity of the product, troubleshooting tables cannot list every malfunction and its cause. In some situations, the serviceperson will have to rely on experience and knowledge of the product to locate and correct the problem.

SPECIAL TOOLS

The following special tools may be required to service the generator set. Some of these tools can be purchased from Onan, while others must be purchased from outside suppliers. Tool Catalog #900-0019 (available from Onan Dealers or Distributors) lists all tools available from Onan.

Engine Tools

Torque wrench, 0-175 Ft-Lbs (0-240 N•m)
Feeler gauge
Pressure gauge
Spark plug gap gauge
Carburetor adjustment wrench
Points adjustment tool
Flywheel puller
Snap ring pliers
Gear puller with puller ring
Cylinder ridge reamer
Combination main and cam bearing remover
Combination main and cam bearing driver
Oil seal loader and driver
Piston ring compressor
Piston ring spreader
Cylinder hone
Valve seat cutter
Valve spring compressor
Valve lock replacer
Valve seat driver

Slide hammer
Piston groove cleaner
Outside micrometer set,
0-4 In. (1-102 mm)
Telescoping gauge set,
0.5-6 In. (12-154 mm)
Hole gauge,
0.300-0.400 In. (7.50-11.00 mm)
Plasti-gage bearing clearance guide

Generator and Control Tools

Lead or dead-blow hammer
Battery hydrometer
VOM multi-tester
Frequency meter
Armature growler
Jumper wires
Load test panel

SAFETY CONSIDERATIONS

Always consider the safety aspects of any service procedure. Generator sets present several hazards that the serviceperson must be aware of if the job is to be completed safely. Read through the safety precautions listed on the inside cover and familiarize yourself with the various hazards shown in Table 5-1. Once the hazards are known, approach the job with a safety conscious attitude. Being safety conscious is the most effective way to avoid injury to yourself or others. Reduce the chance that an accident will occur by adopting the following safeguards.

Safeguards to Avoid Hazards

- Use Personal Protection-When the situation calls for it, protect your body by wearing the appropriate safety equipment. Protective clothing includes such items as safety shoes, gloves, safety glasses and hard hats. Leave rings and jewelry off and don't wear loose clothing that might get caught on equipment.
- Work to Reduce the Hazard - The workshop area and all pieces of equipment used can contribute to reducing the hazard potential. Keep guards and shields in place on equipment in good working condition. Store flammable liquids in approved containers away from open flame. Keep the workshop clean and well-lighted, and provide adequate ventilation. Keep fire extinguishers and safety equipment nearby and be prepared to respond to an emergency.

TABLE 5-1. HAZARDS AND THEIR SOURCE

<ul style="list-style-type: none">• Fire and explosions<ul style="list-style-type: none">-Leaking fuel<ul style="list-style-type: none">Gasoline vaporLP gas vapor-Hydrogen gas from charging battery-Oily rags improperly stored-Flammable liquids improperly stored• Burns<ul style="list-style-type: none">-Hot exhaust pipes-Hot engine and generator surfaces-Hot engine oil-Electrical short in DC wiring• Poisonous Gases<ul style="list-style-type: none">-Carbon monoxide from faulty exhaust-LP gas leaking into coach interior-Operating generator set where exhaust gases can accumulate	<ul style="list-style-type: none">• Electrical shock (AC)<ul style="list-style-type: none">-Improper load connections-Faulty RV wiring-Faulty electrical appliance-Faulty generator set wiring• Rotating Machinery<ul style="list-style-type: none">-Flywheel fan guard not in place• Slippery Surfaces<ul style="list-style-type: none">-Leaking or spilled oil• Heavy Objects<ul style="list-style-type: none">-Removing generator set from RV-Removing heavy components
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- Develop Safe Work Habits - Unsafe actions are identified as the cause of most accidents involving the use of tools and machines. Be familiar with the equipment and know how to use it safely. Use the correct tool for the job and check its condition before starting. Observe the warnings and cautions in this manual and take special precautions when working around electrical equipment. Don't work alone if possible and don't take risks.

Be prepared if an accident does occur. Numerous agencies such as the Red Cross and your local police and fire departments offer basic courses in first aid, mouth-to-mouth resuscitation, and fire control. Take advantage of these offerings so you are ready to respond when an accident happens. Learn to be Safety-Conscious and make safe practices a part of your work routine.

GENERATOR SET REMOVAL

Some service procedures will require that the generator set be removed from the coach. While there are many variations, generator set installations are generally classified as either conventional compartment mount or under floor mount. In a conventional compartment mount installation, a special compartment (see Figure 5-1) is built into the coach to house the generator set. The compartment is constructed with a vapor tight barrier that seals off the generator set from the coach interior. The generator set is usually fastened to the floor of the compartment which must be able to support the weight of the set. Access to the compartment is through a door located in the exterior of the coach.

In an under floor mount installation (see Figure 5-2), a special housing is used to suspend the generator set from the underside of the coach. The housing bolts to special support members that are built into the coach framework. The housing is mounted near the exterior of the coach and limited access is provided through a door located in the exterior of the coach.

Because of the wide variety of generator set installations, it is not possible to specify the exact removal procedures for each generator set. If, after examining the installation, a satisfactory method for removing the set cannot be determined, contact the RV coach manufacturer to obtain their recommendations before attempting to remove the set from the coach.

▲WARNING *Generator sets are heavy and can cause personal injury if dropped during removal. Use adequate lifting devices to provide sufficient support for the set. Keep hands and feet clear while lifting.*

Special fuel handling procedures are required when removing an LP gas (propane) powered set. The fuel system must be purged of LP gas before the set can be safely removed from the coach. Follow the purging procedure described in the next section before attempting to remove an LP gas powered set. If the generator set is powered by gasoline, proceed to the appropriate set removal section.

LP-Gas (Propane) Purging Procedure

To purge the LP gas from the set fuel system, close

the shut-off valve at the fuel tank and then start the generator set. Allow the generator set to operate until it runs out of fuel. Crank the set a few times after it stops to make sure the fuel system is completely purged of all LP gas fuel.

If the generator set cannot be operated, move the RV coach to an outdoor location that is well ventilated and is away from fire or flame. Disconnect both the vehicle negative (-) battery cable and the generator set negative (-) battery cable from their respective battery terminals. Close the fuel shutoff valves at the fuel tank for both the generator set fuel supply system and the appliance (stove, heater, etc) fuel supply system. In addition, close the fuel shutoff valves at each appliance.

▲WARNING *Fuel presents the hazard of fire or explosion which can cause severe personal injury or death. Eliminate all possible sources of ignition such as pilot lights or sparking electrical equipment before purging LP gas from the fuel system. Provide adequate ventilation to dissipate LP gas as it is released.*

Slightly open the fuel line (flexible section) at the solenoid valve just enough to allow the LP gas to slowly escape. Don't open the fitting too much or a large quantity of gas will be released.

Disconnect the fuel supply hose from the carburetor and hold it clear of the set. Press in and hold the primer button on the regulator to release LP gas from the set fuel system. When no more gas can be heard escaping from the open end of the fuel supply hose, reconnect the hose to the carburetor and proceed to the appropriate set removal section.

Disconnecting Set from RV Systems

Disconnect the following items from the generator set.

1. Disconnect the vehicle negative (-) battery cable at the battery terminal.
2. Disconnect the generator set negative (-) battery cable at the battery terminal.
3. Disconnect the generator set positive (+) battery cable from the start solenoid.
4. Disconnect the remote control wire plug from the generator set control.
5. Disconnect the generator load wires at the RV electrical system junction box. Tag the RV circuit wires if necessary for positive identification.
6. Loosen the conduit connector and pull the load wires and flexible conduit free of the junction box.
7. Disconnect the muffler from the exhaust manifold at the flange connection and disconnect any support brackets or hangers that connect the muffler to the set.

8. On gasoline fueled sets, turn off the fuel shutoff valve in the compartment and disconnect the fuel line at the fuel pump. Securely plug the end of the fuel line to prevent leakage or accumulation of explosive gasoline vapor.

▲WARNING *Fuel presents the hazard of fire or explosion which can cause severe personal injury or death. Make certain all fuel line openings are plugged to prevent gasoline vapor from accumulating.*

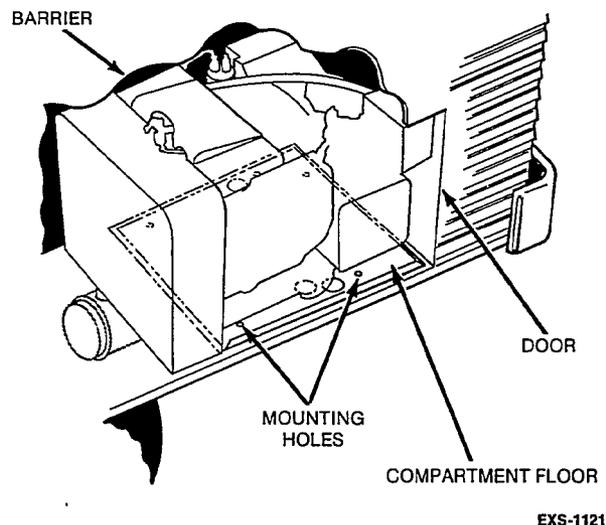
On LP Gas (propane) fueled sets, disconnect the fuel line (after purging) at the solenoid valve and plug end of the fuel line to prevent entrance of dirt.

Removing Conventional Compartment Mounted Set From RV

When the generator set has been disconnected from the electrical, exhaust, and fuel systems, examine the set mounting and support system. Locate all mounting bolts and support members for the set. In most installations, the generator set drip tray will be bolted to the coach framework. Depending on the installation, the set may be removable from the side, back, or bottom.

Verify that the generator set is adequately supported before loosening any of the mounting bolts or support members. The most satisfactory way to lift or move the generator set is to use a fork lift truck.

▲WARNING *The generator set is heavy and can cause severe personal injury if dropped during removal. Use the recommended removal techniques and keep hands and feet clear while removing mounting bolts.*



EXS-1121

FIGURE 5-1. TYPICAL CONVENTIONAL COMPARTMENT MOUNT INSTALLATION

Removing Underfloor Mounted Set From RV

When the generator set has been disconnected from the electrical, exhaust, and fuel systems, the set may be partially removed for limited service or completely removed from the RV for major service. The generator set is mounted on a support tray which serves as the bottom of the underfloor housing. The inner edge of the support tray is hinged to the rear panel assembly. The outer edge of the support tray is bolted to a support bracket. A front and rear panel assembly serve as sides to complete the housing.

The generator set is completely suspended underneath the RV coach by the housing assembly. To avoid dropping the set during removal, follow the recommended set removal procedures.

▲WARNING *The generator set is heavy and can cause severe personal injury if dropped during removal. Use the recommended removal techniques and keep hands and feet clear while removing mounting bolts.*

Partial Set Removal: Park the recreational vehicle on a level as possible surface (surface must support floor jack wheels). Then follow these instructions very carefully.

If generator set will be left in the down (tilted) position for more than 30 minutes, first drain the oil.

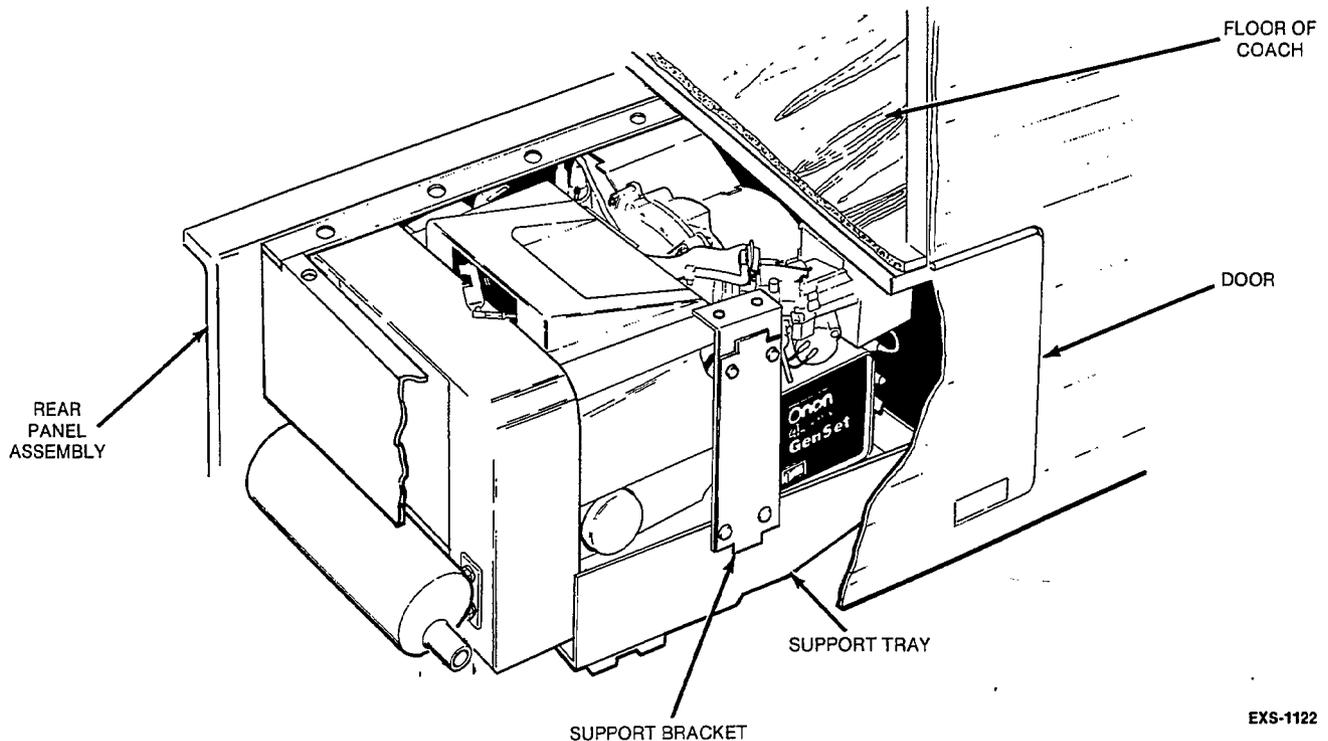
▲WARNING *Oil in the engine cylinders can cause engine damage during starting attempts. Oil can enter the engine cylinders when the generator set is in the lowered (tilted) position. Do not leave the generator set in this position for more than 30 minutes if the oil has not been drained.*

It is assumed that disconnecting the fuel, exhaust etc. if necessary has already been performed as described on the previous page.

1. Put the vehicle in its park position, lock the brakes, and remove the ignition key. Make sure no one moves the vehicle while performing this procedure.

▲WARNING *Dropping the generator set creates the hazard of severe personal injury or death. Make sure no one moves the vehicle during this procedure and that procedure is performed very carefully and only as instructed.*

2. Use a floor jack similar to the one shown in Figure 5-3, and position the floor jack under the reinforcement ribs of the drip tray as shown.
3. Raise the floor jack until it just makes contact with the drip tray, then just put a little upward pressure under the drip tray.
4. Remove the four bolts from the front support bracket, and remove the support bracket itself.



EXS-1122

FIGURE 5-2. TYPICAL UNDER-FLOOR INSTALLATION

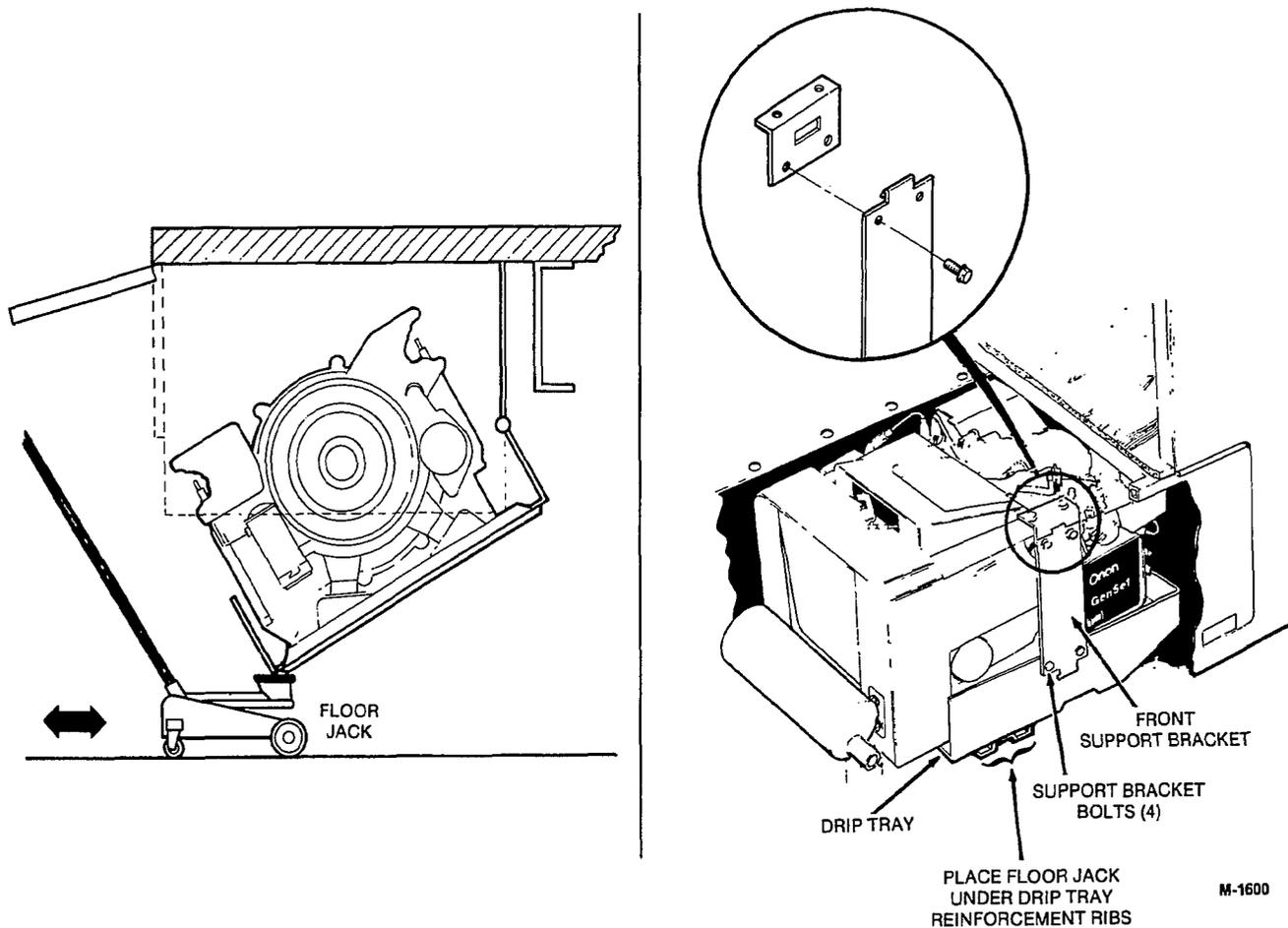


FIGURE 5-3. PARTIAL SET REMOVAL

This might require slight adjustment of the floor jack, either slight raising or lowering of the jack.

5. Once the support bracket is removed, all the weight of the generator set on that side is on the floor jack. Slowly lower the floor jack, being careful to allow the floor jack to roll as the generator set swings downward.
6. Onan suggests you put some wood blocks under the drip tray assembly so that you can remove the floor jack. This will allow you more access room for the maintenance or service procedure.

▲WARNING *Dropping the generator set creates the hazard of severe personal injury or death. Make sure generator set is resting securely before removing floor jack.*

Complete Set Removal: Park the recreational vehicle on a level surface. Then follow these steps very carefully.

It is assumed that disconnecting the fuel, exhaust, etc. has already been performed as described on the previous page.

1. Put the vehicle in its park position, lock the brakes, and remove the ignition key. Make sure no one moves the vehicle while performing this procedure.

⚠WARNING *Dropping the generator set creates the hazard of severe personal injury or death. Make sure no one moves the vehicle during this procedure and that the procedure is performed very carefully and only as instructed.*

2. Use a fork lift truck to support the generator set tray at the points shown in Figure 5-4. Place a wooden block on one fork so the set will remain level.

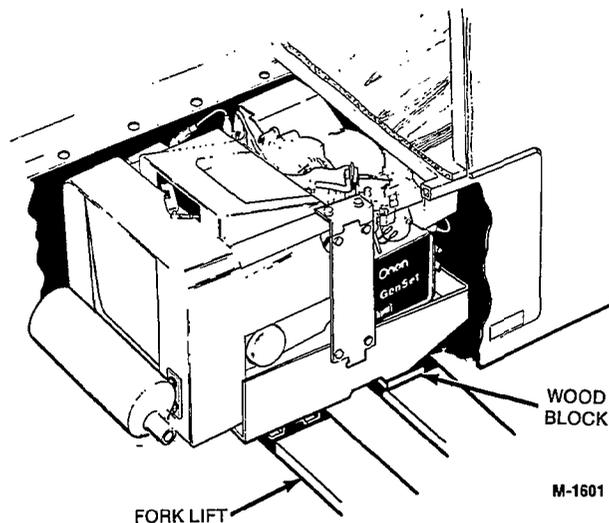


FIGURE 5-4. COMPLETE SET REMOVAL

3. Lift the fork lift just so it makes contact with the drip tray, then just put a little upward pressure under the tray. Verify the weight of the generator set supported by the forks before proceeding.
4. Remove the bolts that secure the side support to the drip tray and the underfloor bracket.
5. Lift generator up slightly until safety catch on side support is clear of tray. Pull support forward and upward until disengaged from tray and underfloor bracket.
6. Remove the side support to provide the clearance needed for lowering the set.
7. Remove the safety catch from the center of each hinge assembly and then remove the U-shaped hinge pin.
8. Slowly lower the generator until it is clear of all obstructions and can be moved out from under the recreational vehicle.

Section 6. Engine Primary Systems

INTRODUCTION

The engine primary systems include the following:

- Cooling System
- Exhaust System
- Ignition System
- Starter Motor
- Crankcase Ventilation System
- Governor
- Fuel System - Gasoline
- Fuel System - LP Gas Liquid Withdrawal

The engine primary systems can often be serviced without removing the generator set from the recreational vehicle and without major disassembly of the set. Use the following troubleshooting guide to help locate problems related to the engine primary systems. Refer to Troubleshooting Generator Set Control for problems related to starting the generator set.

TROUBLESHOOTING ENGINE PRIMARY SYSTEMS

Trouble	Possible Cause	Corrective Action
Engine Misfires	<ol style="list-style-type: none"> 1. Faulty ignition due to: <ol style="list-style-type: none"> a. worn or fouled spark plugs b. worn ignition points. c. incorrect ignition timing d. faulty ignition coil, or e. faulty plug wires. 2. Lean fuel mixture due to: <ol style="list-style-type: none"> a. incorrectly adjusted fuel mixture screws *b. incorrect float level c. dirt in carburetor d. vacuum leak. 3. *Contaminated fuel 4. *Carburetor icing <p>*Gasoline sets only</p>	<ol style="list-style-type: none"> 1a. Clean or replace spark plugs 1b. Replace breaker points 1c. Set breaker point gap 1d. Test coil and replace if necessary 1e. Test spark plug wires and replace if faulty 2a. Adjust carburetor main and idle adjustment screws 2b. Adjust carburetor float level 2c. Disassemble carburetor and clean all internal passages 2d. Locate leak and correct as required 3. Drain fuel tank and refill with fresh fuel 4. In cold weather, place air preheater in winter position
Engine Backfires	<ol style="list-style-type: none"> 1. Faulty ignition due to: <ol style="list-style-type: none"> a. incorrect ignition timing b. incorrect spark plug gap 2. Lean fuel mixture due to: <ol style="list-style-type: none"> a. incorrectly adjusted fuel mixture screws *b. incorrect float level c. dirt in carburetor 3. Mechanical damage to engine <p>*Gasoline sets only</p>	<ol style="list-style-type: none"> 1a. Adjust breaker point gap 1b. Reset spark plug gap 2a. Adjust carburetor main and idle adjustment screws 2b. Adjust carburetor float level 2c. Disassemble carburetor and clean all internal passages 3. See Engine Block Assembly

TROUBLESHOOTING ENGINE PRIMARY SYSTEMS

Trouble	Possible Cause	Corrective Action
Engine Lacks Power	<ol style="list-style-type: none"> 1. Faulty ignition due to: <ol style="list-style-type: none"> a. incorrect ignition timing b. incorrect spark plug gap 2. Dirty air cleaner 3. Restricted fuel flow due to: <ol style="list-style-type: none"> a. plugged fuel filter or b. faulty fuel pump 4. Incorrect fuel mixture due to: <ol style="list-style-type: none"> a. incorrect adjusted fuel mixture screws, *b. incorrect float level, or c. dirt in carburetor 5. Exhaust system blocked or restricted 6. Incorrect valve tappet clearance 7. Excessive engine wear or damage to engine 8. Carburetor air preheater set incorrectly *Gasoline Sets Only 	<ol style="list-style-type: none"> 1a. Adjust breaker point gap 1b. Reset spark plug gap 2. Replace air cleaner 3a. Clean fuel filter 3b. Test fuel pump and repair or replace if faulty 4a. Adjust carburetor main and idle adjustment screws 4b. Adjust carburetor float level 4c. Disassemble carburetor and clean all internal passages 5. Locate and remove cause of blockage. 6. Adjust valve tappets (see Engine Block Assembly section) 7. See Engine Block Assembly section 8. In hot weather, place air preheater in summer position
Engine	<ol style="list-style-type: none"> 1. Restricted airflow due to dirt or debris blocking air inlet or outlet 2. Dirt or oil covering engine cooling fins 3. Incorrect ignition timing 4. Lean fuel mixture due to <ol style="list-style-type: none"> a. incorrectly adjusted fuel mixture screws *b. incorrect float level or c. dirt in carburetor *Gasoline sets only 	<ol style="list-style-type: none"> 1. Clear away any debris that may restrict airflow to set. Do not use compartment for storage area. 2. Clean away all dirt and oil from engine cooling fins 3. Adjust breaker point gap 4a. Adjust carburetor main and idle adjustment screws 4b. Adjust carburetor float level 4c. Disassemble carburetor and clean all internal passages.
Black Exhaust	<ol style="list-style-type: none"> 1. Rich fuel mixture due to: <ol style="list-style-type: none"> a. dirty air cleaner. *b. choke sticking, c. incorrectly adjusted fuel mixture screws d. dirt in carburetor *Gasoline sets only 	<ol style="list-style-type: none"> 1a. Replace air cleaner 1b. Clean choke and choke linkage 1c. Adjust carburetor idle and main adjustment screws 1d. Disassemble carburetor and clean all internal passages

TROUBLESHOOTING ENGINE PRIMARY SYSTEMS

Trouble	Possible Cause	Corrective Action
Engine Hunts or Surges	<ol style="list-style-type: none"> 1. Sticking or binding governor linkage 2. Incorrect governor adjustment 3. Faulty governor spring 4. Incorrect fuel mixture due to: <ol style="list-style-type: none"> a. incorrectly adjusted fuel mixture screws, *b. incorrect float level, or c. dirt in carburetor 5. Governor mechanism worn excessively *6. Carburetor icing <p style="margin-left: 20px;">*Gasoline sets only</p>	<ol style="list-style-type: none"> 1a. Clean and lubricate governor linkage 2. Adjust governor speed and Replace governor spring 3. Replace governor spring 4a. Adjust carburetor main and idle adjustment screws 4b. Adjust carburetor float level 4c. Disassemble carburetor and clean all internal passages 5. See Engine Block Assembly section 6. In cold weather, place air preheater in winter position
High Oil Consumption (Note: New engines sometimes have high oil consumption during break-in)	<ol style="list-style-type: none"> 1. Oil viscosity too light or oil is diluted 2. Crankcase breather valve is dirty or defective 3. Oil leaks 4. Excessive engine wear 5. Light loading 	<ol style="list-style-type: none"> 1. Drain oil and refill with correct viscosity oil 2. Clean crankcase breather and replace if defective 3. Locate source of leak and repair as required 4. See Engine Block Assembly section 5. Don't run set at no load for long periods of time
Low Oil Pressure	<ol style="list-style-type: none"> 1. Oil viscosity too light or oil is diluted 2. Low oil level 3. Low oil pressure switch defective 4. Faulty oil bypass valve 5. Excessive engine wear or defective oil pump 	<ol style="list-style-type: none"> 1. Drain oil and refill with correct viscosity oil 2. Add oil as required. 3. Replace oil pressure switch (see Engine Block Assembly section) 4. Inspect oil bypass valve clean or replace as required (see Engine Block Assembly section) 5. See Engine Block Assembly section

EXHAUST SYSTEM

The condition of the exhaust system is extremely critical on RV generator sets because of the possibility of exhaust gases entering the coach.

The exhaust system must be serviced immediately if inspection reveals leaking joints or connections, loose fasteners, or broken or damaged components.

Always replace worn components with new original equipment replacement parts. Do not attempt to repair a broken exhaust pipe or manifold by welding and do not replace worn out components with parts that do not meet factory specifications.

⚠WARNING *Exhaust presents the hazard of severe personal injury or death. Modifying the exhaust system might allow poisonous exhaust gases to enter the coach. Use only original equipment replacement parts when servicing the exhaust system. Unauthorized modifications will also void the warranty and cancel the UL Listing/CSA Certification. Liability for injury or damages due to unauthorized modifications becomes the responsibility of the person making the change.*

Two basic exhaust systems are used with Emerald series generator sets. Figure 6-1 shows a typical exhaust system for conventional compartment mount generator set. Figure 6-2 shows a typical exhaust system for an underfloor mount generator set. Separate sections cover the service procedures for each exhaust system.

Compartment Mount Exhaust System

Compartment mount exhaust systems consist of the exhaust manifold, flange connector, muffler, muffler strap, hanger, clamps, and tailpipe. When service is required, disassemble and reassemble as specified in the following steps.

Disassembly

1. Loosen the front muffler clamp, muffler strap, and tailpipe hanger and remove the muffler and tailpipe assembly (see Figure 6-1).
2. Remove the screws that secure the flange connector to the exhaust manifold and remove the flange connector and asbestos gasket.

Completion of the remaining steps requires that the generator set be removed from the vehicle. Refer to the Preparing to Service section for the set removal procedures.

3. Remove the cooling system noise shield and scroll (see Cooling System in this section) to provide access to the exhaust manifold.
4. Remove the screw that secures the exhaust manifold outlet flange to the exhaust manifold support bracket.
5. Remove the four exhaust manifold screws and lift off the exhaust manifold and the two manifold gaskets.

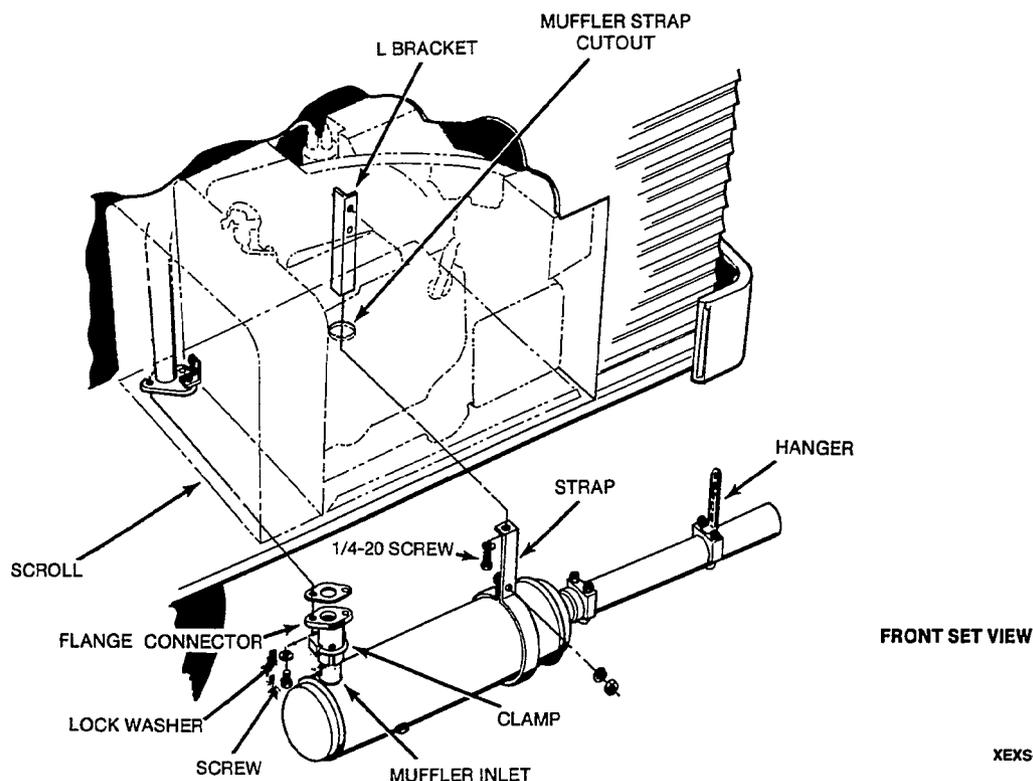


FIGURE 6-1. EXHAUST SYSTEM CONVENTIONAL COMPARTMENT

If set is LP-Gas fueled, the fuel vaporizer and regulator are attached to the exhaust manifold. Purge the fuel system of LP gas fuel before disconnecting the fuel line at the vaporizer. See FUEL SYSTEM - LP-GAS in this section for the recommended purging procedures.

Assembly: Obtain the required replacement parts and then proceed as indicated.

⚠WARNING *Exhaust gas presents the hazard of severe personal injury or death. To prevent exhaust leaks, install all gaskets, clamps, straps, and hardware as specified.*

1. Install the exhaust manifold using new gaskets and tighten the four manifold screws to the specified torque.
2. Install the 5/16-18 screw, lock washer, and nut that secure the manifold outlet flange to the manifold support bracket and tighten securely.
3. Install the cooling system scroll and noise shield (see Cooling System in this section).

If no other service is required, install the generator set in the vehicle before completing the remaining steps.

4. Install a new gasket between the exhaust manifold and flange connector and secure flange connector to manifold using 5/16-18 inch screws, lock washers, and nuts.
5. Attach the inlet of the muffler to the flange connector using a U-bolt type automotive muffler clamp ONLY. Make certain that muffler inlet pipe overlaps flange connector a minimum of 1-1/2 inches (38 mm).
6. Place muffler strap on muffler and position it below cutout in bottom of generator set drip tray. Fasten strap to set L-bracket using a 1/4-20 screw and lock washer. Tighten strap around muffler using a 1/4-20 screw, lock washer and nut.
7. If replacing the original tailpipe, refer to Tailpipe Recommendations in this section for selecting and locating the tailpipe. Attach tailpipe to outlet end of muffler and secure using a 1-1/2 inch U-bolt type automatic muffler clamp ONLY.
8. Support the tailpipe using a shock mounted support hanger with clamp.

⚠CAUTION *Angular mounting of muffler and tailpipe hanger brackets can result in exhaust system damage since excessive vibration transferred to the vehicle is caused by angular mounting. Mount muffler and tailpipe hanger brackets directly above the component supported, not at an angle.*

9. Run the generator set for five minutes and check entire exhaust system (visually and audibly) for leaks or excessive noise. Correct as required.
10. Clean spark arrester muffler every 100 hours of operation. Remove 1/8 inch pipe plug in bottom of muffler and run set for five minutes. Then

replace pipe plug. Inspect exhaust system (visually and audibly) for leaks daily (at least every eight hours of running time).

Underfloor Mount Exhaust System

Underfloor mount exhaust systems consist of the exhaust manifold, muffler, clamps, hanger (if required), and tailpipe. When service is required, disassemble and reassemble as specified in the following steps.

Disassembly:

1. Loosen the muffler clamp at the muffler inlet (see Figure 6-2) and remove the muffler support bracket screws.
2. Loosen tailpipe hanger (if used) and remove the muffler and tailpipe assembly.

Completion of the remaining steps requires that the generator set be partially removed from the vehicle. Refer to the Preparing to Service section for the set removal procedures.

3. Remove the cooling system scroll and noise shield (see Cooling System in this section) to provide access to the exhaust manifold.
4. Remove the four exhaust manifold screws and lift off the exhaust manifold and the two manifold gaskets.

If set is LP-Gas fueled, the fuel regulator/vaporizer must be removed along with the exhaust manifold. See FUEL SYSTEM - LP-Gas in this section for the vaporizer/regulator removal and replacement procedures.

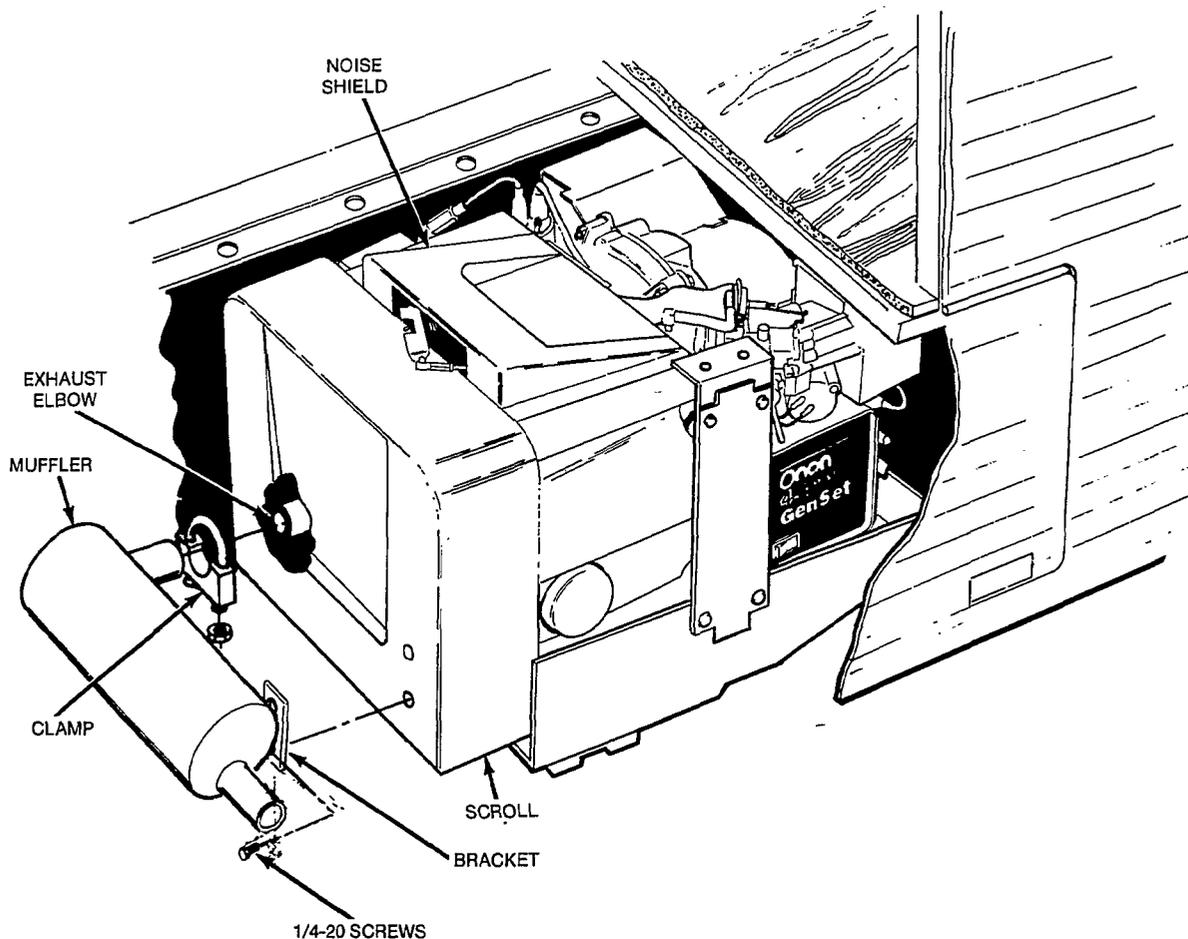
Assembly:

⚠WARNING *Exhaust gas presents the hazard of severe personal injury or death. To prevent exhaust leaks, install all gaskets, clamps, straps, and hardware as specified.*

1. Install the exhaust manifold using new gaskets and tighten the four manifold screws to the specified torque.
2. Replace the noise shield and scroll (refer to the Cooling System in this section).

If no other service is required, install the generator set in the vehicle before completing the remaining steps.

3. Place a U-bolt type automotive muffler clamp in position on the exhaust manifold (near elbow) prior to installing muffler.
4. Place muffler in position on set making certain that muffler inlet pipe overlaps exhaust manifold a minimum of 1-1/2 inches (38 mm).
5. Install the two 1/4-20 screws and lock washers that secure the muffler support bracket to the set and tighten muffler clamp.
6. If replacing the original tailpipe, refer to the Tailpipe Recommendations section for selecting and locating the tailpipe. Attach tailpipe to outlet end



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FIGURE 6-2. EXHAUST SYSTEM UNDERFLOOR MOUNT

of muffler and secure using a 1-1/2 inch U-bolt type automotive muffler clamp ONLY.

- Support the tailpipe using a shock mounted support hanger with clamp.

CAUTION *Angular mounting of muffler and tailpipe hanger brackets can result in exhaust system damage since excessive vibration transfer to the vehicle is caused by angular mounting. Mount muffler and tailpipe hanger brackets directly above component supported, not at an angle.*

- Run the generator set for five minutes and check entire exhaust system (visually and audibly) for leaks or excessive noise.
- Clean spark arrester muffler every 100 hours of operation. Remove 1/8 inch pipe plug in bottom of muffler and run set for five minutes. Then replace pipe plug. Inspect exhaust system (visually and audibly) for leaks daily (at least every eight hours of running time).

Tailpipe Recommendations

Tailpipes are supplied by the RV manufacturer and must meet several design specifications to ensure safe generator set operation. If replacing the tailpipe, make certain the replacement part is the same size and configuration as the original part. Refer to the following guidelines for selecting and locating the tailpipe.

WARNING *Exhaust gas presents the hazard of severe personal injury or death. Exhaust gases can enter the coach interior if the tailpipe is damaged, missing, or improperly installed. Follow the recommended exhaust system replacement procedures to ensure safe operation.*

- Use 1-3/8 inch ID, 18 gauge, rigid steel tubing for tailpipe. Do not use flexible exhaust tailpipe since it might break due to road shock and vibration.
- Install exhaust tailpipe at least 3 inches (76 mm) away from the fuel tank and any combustible

material. If 3 inches (76 mm) clearance cannot be maintained, install suitable heat shielding between tailpipe and combustible material or fuel tank to prevent excessive heating.

- Do **not** terminate the exhaust tailpipe:
 - A. Under a window, door, or any opening that might allow exhaust gases to enter the coach interior.
 - B. Ahead of or under the generator compartment air intake to prevent recirculation of exhaust gases. Terminate tailpipe to the **rear** of the compartment air intake.
 - C. Under the fuel tank fill spout to prevent spilled fuel from being ignited by a hot tailpipe.
 - D. Under the vehicle to prevent exhaust gases from entering the coach interior through small openings in the underside of the vehicle.

- Extend the tailpipe at least **one inch** (25 mm) beyond the perimeter of the vehicle. Direct exhaust gases **down** and **away** from the vehicle away from windows, doors, or compartment openings.

- Do not connect the generator set exhaust tailpipe to the vehicle exhaust system. Exhaust gases will be forced into the non-running engine and might be released through the carburetor air inlet. Water vapor from the exhaust might also damage the non-running engine.

COOLING SYSTEM

A constant airflow is critical for engine and generator cooling to prevent excessive heat build-up. All Emerald series generator sets use a Vacu-Flo cooling system to provide the required airflow. With Vacu-Flo cooling, a flywheel fan draws cool air in from the generator end of the compartment (see Figure 6-3). The cool air passes over the cooling fins on the engine and absorbs the heat. The heated air is then discharged through the opening in the bottom of the Vacu-Flo scroll.

⚠ WARNING *Discharged cooling air can contain poisonous exhaust gases which present the hazard of severe personal injury or death. Never use discharged cooling air for heating the coach interior.*

The generator compartment air inlet is sized (see Section 2 SPECIFICATIONS) to allow the required flow rate of air. The air inlet opening and the air discharge opening must be kept free of any obstructions to avoid restricting airflow. Dirt, dust, or other debris that may clog the air duct openings should be removed during periodic maintenance. Dirt might also become lodged between the cooling fins on the engine block and cylinder heads. If this happens,

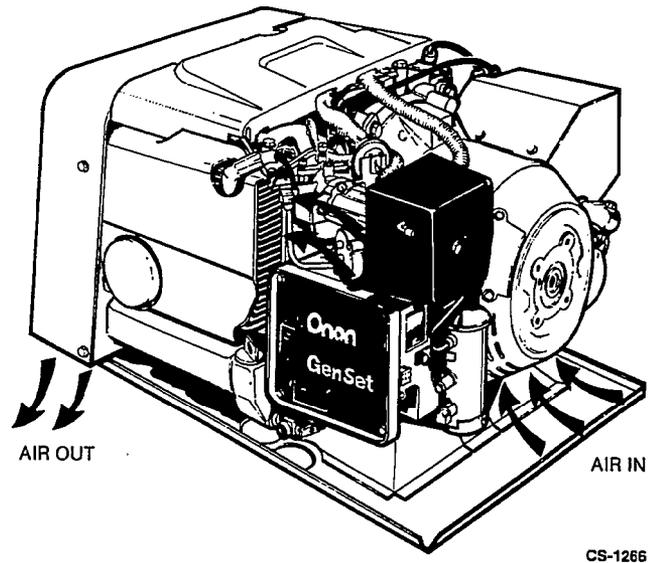


FIGURE 6-3. COOLING AIR FLOW

heat transfer is greatly reduced and overheating can occur if the fins are not cleaned.

The cooling system consists of the noise shield, cylinder air housings, scroll, flywheel, and scroll backplate. When service is necessary, disassemble and assemble the cooling system as specified in the following sections.

Disassembly: Remove the muffler and tailpipe assembly (see Exhaust System in this section) to provide access to the cooling system and then proceed as indicated.

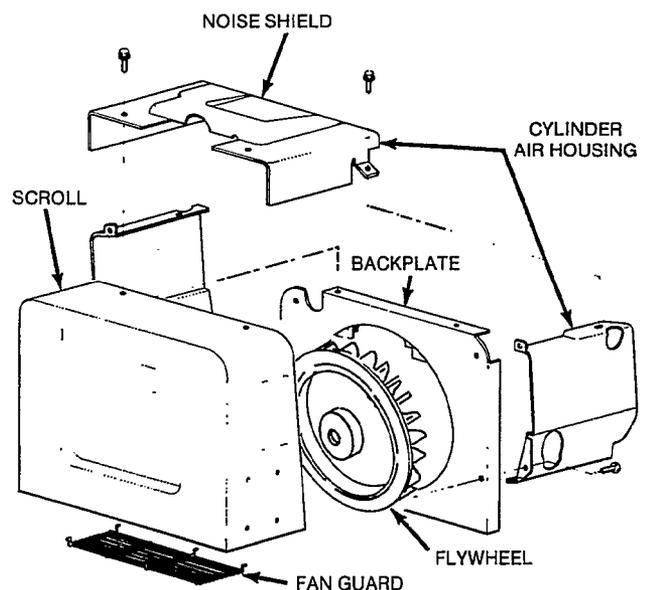


FIGURE 6-4. COOLING SYSTEM

1. Remove the capscrews that secure the noise shield (see Figure 6-4) to the engine and lift off the noise shield.
2. Remove the three nuts (located along the lower edge of the scroll) that fasten the flywheel guard to the scroll.
3. Remove the capscrews that fasten the scroll to the backplate and lift away from the scroll.
4. Remove the screws that fasten the cylinder air housings to the backplate and cylinder heads and lift off the air housings.
5. Loosen the flywheel capscrew and back it out several turns.
6. Attach puller tool to the flywheel as shown in Figure 6-5. The tool has two jack screws that fit into the tapped holes in the flywheel.
7. Tighten the puller center screw until the flywheel comes loose. Remove the puller, flywheel center screw, and washer. Inspect the flywheel and replace it if any air vanes are missing.
8. Remove the lead from the low oil pressure cut-off switch.
9. Remove the exhaust manifold as described in the Exhaust System section.
10. Remove the capscrews that secure the backplate to the engine and lift off the backplate.
11. Use a brush or low pressure compressed air to remove any dirt or debris that may be lodged on the engine cooling fins.

Assembly: Cooling system assembly is the reverse of disassembly. When installing the flywheel, align the keyway in the flywheel with the woodruff key on the crankshaft. Use non-hardening sealer on the flywheel capscrew threads and tighten to the specified torque. Refer to Exhaust System in this section when installing the exhaust manifold, muffler, and tailpipe.

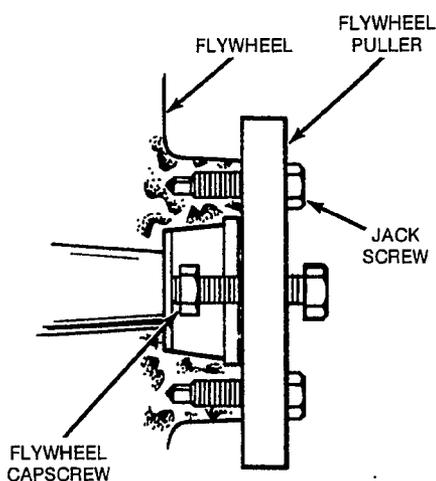


FIGURE 6-5. FLYWHEEL PULLER

CAUTION *Overheating can result in engine damage. To avoid overheating, never operate the generator set with any of the cooling system components removed.*

IGNITION SYSTEM

The ignition system consists of the breaker points, condenser, ignition coil, spark plugs, and wiring. For reliable generator set operation, the complete ignition system must be in good working order and properly adjusted. Many generator set "problems" can be traced to an improperly maintained ignition system. Refer to the following sections when servicing or making adjustments.

Breaker Points and Condenser

The breaker points and condenser mount on top of the engine block. A small plunger rides on an ignition cam at the end of the camshaft. The plunger actuates the points which can open and close twice with every revolution of the camshaft. Point opening is determined by the point gap setting. The exact timing of the ignition spark is dependent on when the points open.

It is important that the breaker points have the correct gap for easy starting, efficient operation, full power, and proper cooling. A retarded ignition will reduce efficiency while an advanced ignition will cause overheating.

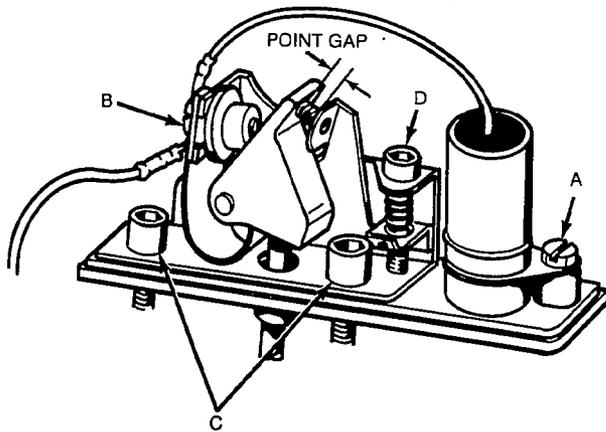
The condenser extends point life by preventing arcing across the opening breaker points. A defective condenser causes a weak spark and rapid point wear. Replace the condenser if defects are suspected. A new condenser is supplied with the engine tune-up kit.

Breaker Point Replacement and Adjustment: Inspect the breaker points at the interval specified in the Operators Manual and replace if pitted or burned. Filing of the points is not recommended. Use the following procedure to replace and adjust the points.

The ignition adjustments should be made with the engine in a static condition and cold.

1. Disconnect the negative (-) battery cable at the battery terminal.
2. Remove the breaker box cover clip and lift off the breaker box cover.
3. Remove the spark plugs to permit easy rotation of the engine and generator assembly. Using a hex-head socket and socket wrench, turn the rotor through-bolt in a clockwise direction until the breaker point gap is open the maximum amount.
4. Remove the condenser mounting screw (screw A) and disconnect the condenser and ignition lead wires (screw B). Lift out condenser (see Figure 6-6).

- Remove the breaker points mounting screws (screw C) and lift out the point assembly.



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FIGURE 6-6. BREAKER POINTS

- Replace the condenser and point assembly and install in reverse order of removal.
- Use an allen head wrench to adjust set screw D to obtain the gap setting specified in section 2, Specifications. Measure the point gap with a flat thickness gauge (see Figure 6-6). Clean points after adjusting.

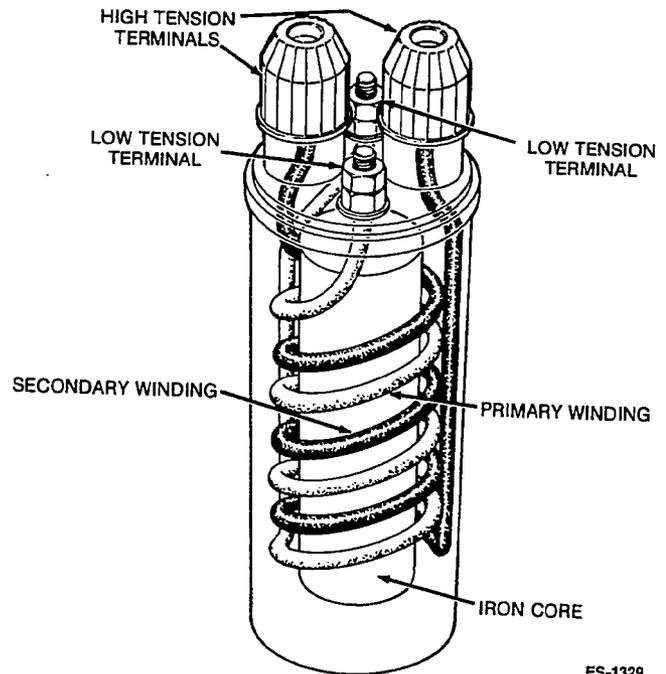
Make sure feeler gauge is clean and free of any grease, oil or dirt.

The timing is adjusted during initial engine assembly and is fixed by the point gap adjustment. No other adjustment or alignment is necessary.

- Replace the point box cover, spark plugs and spark plug leads.
- Connect negative (-) battery cable to negative battery terminal.

Ignition Coil

The ignition coil is a transformer that steps up the battery voltage to about 20,000 volts for spark plug firing. The coil is composed of a primary winding, secondary winding, sealing compound, bakelight cap, and the outside case and necessary terminals (Figure 6-7).



ES-1329

FIGURE 6-7. IGNITION COIL

Ignition coils do not normally require any service other than to keep all terminals and connections clean and secure. Also, check for loose seams, dents, punctures, and other mechanical damage. If poor ignition performance is evident and other ignition components are not at fault, the coil can be tested with the specified procedures. When replacing the coil, observe proper polarity. The negative (-) terminal connects to the breaker points and the negative (+) terminal connects to a battery (B+) source within the control.

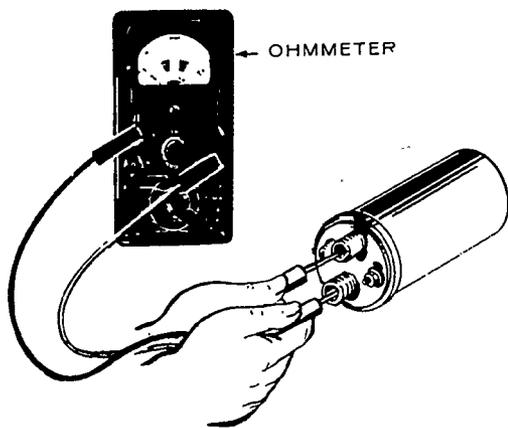
Ignition Coil Testing

A quick test of coil output can be made by checking the ignition spark. Remove one of the spark plugs. Reconnect the spark plug wire to the spark plug. Ground the spark plug to bare engine metal and crank the engine. A good spark should be observed between the plug center electrode and side electrode. If the spark is weak, the coil, points and condenser, or wiring is probably defective.

Direct Testing With Ohmmeter: To test a coil directly, remove all the wires connected to it. For easier access to the terminals, the coil may be removed from the engine. Use the following procedure to test.

- Inspect terminals for corrosion, looseness, cracks, dents or other damage. Look for evidence of electrical leakage around high tension terminals (indicated by carbon runners). Damaged or leaking coils should be replaced.
- Clean the outside of the coil with a cloth dampened in parts cleaning solvent.

3. To measure resistance in the primary circuit, connect one ohmmeter lead to the positive (+) terminal and the other to the negative (-) terminal on the coil. The resistance should be between 3.87 and 4.73 ohms. A high resistance value indicates an open circuit or poor connection inside the coil, and the coil should be replaced.
4. To measure resistance in the secondary circuit, connect the ohmmeter leads to the two high tension terminals (see Figure 6-8). The resistance measured should be between 12,600 and 15,400 ohms. A lower resistance value indicates a shorted secondary winding. A high resistance value indicates the coil has excessive internal resistance or an open circuit. Replace coil if not within specifications.



ES-1373

FIGURE 6-8. TESTING COIL SECONDARY

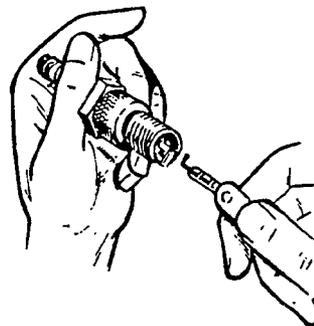
Spark Plugs

Remove and inspect the spark plugs at the intervals recommended in the Operators Manual. A careful examination of the plug can often pinpoint the source of an engine problem. The following covers some common spark plug conditions and the probable cause.

- One Plug Carbon Fouled — Check for an open ignition cable or low compression.
- Black Soot Deposits — Check for faulty choke operation, overly rich fuel mixture, or dirty air filter.
- Oil Fouled — Check for faulty crankcase breather, worn rings, or worn valve guides.
- Burned or Overheated — Check for leaking intake manifold gaskets, lean fuel mixture, or incorrect ignition timing. Be sure plug is not in wrong heat range.

- Chipped Insulator — Check for advanced timing. Bend only side electrode when setting gap.
- Splash Fouled — Check for accumulated combustion chamber deposits. See Cylinder Head in Section 6.
- Light Tan or Grey Deposits — Normal plug color.

Replace spark plugs that show signs of fouling for electrode erosion, with spark plugs of the recommended type. See Figure 6-9 on recommended method of checking plug gap.



ES-1374

FIGURE 6-9. CHECKING PLUG GAP

Wiring

Ignition system wiring includes (1) One positive (B+) wire which carries the low voltage current from the battery to the primary winding of the coil. (2) One negative (-) wire which carries low voltage to the points and condenser. (3) Two high tension wires that carry the high voltage current from the secondary winding of the coil to the spark plugs. The spark plugs and coil secondary are all grounded to the engine making a complete circuit for the voltage back to the battery. The ignition coil primary (low voltage side) is grounded when the breaker points close.

Check all low voltage wiring for loose connections and cuts or breaks in the insulation. Clean all terminals and connections and test for continuity with an ohmmeter. Use a megger to check for breaks in the spark plug wire insulation.

CRANKCASE VENTILATION SYSTEM

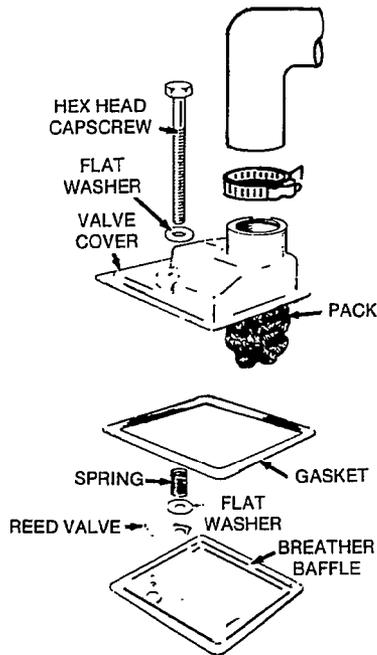
The crankcase breather prevents pressure from building up in the crankcase. It also prevents oil contamination by removing moisture or gasoline vapors and other harmful blow-by materials from the crankcase. These vapors are routed to the carburetor where they are mixed with incoming air and burned in the combustion chamber. A sticky breather valve can cause oil leaks, high oil compression, rough idle, reduced engine power and a rapid formation of sludge and varnish within the engine.

Crankcase Breather Service

If the crankcase becomes pressurized as evidenced by oil leaks at the seals, use the following procedures to service.

Remove the breather tube from the valve cover (see Figure 6-10). Remove the valve cover, pack, spring washer, reed valve, and breather baffle. Clean all parts in parts cleaning solvent.

⚠WARNING *Most parts cleaning solvents are flammable and can cause severe personal injury if used improperly. Follow the manufacturers recommendations when cleaning parts.*



C-1101

FIGURE 6-10. CRANKCASE BREATHER

The reed valve must be flat with no sign of a crease. Assemble using a new gasket. Do not overtighten valve cover capscrew.

Reed valve must be assembled as shown with washer on top and breather baffle on the bottom.

⚠CAUTION *Over tightening the valve cover can cause an air leak and allow dirt to enter the engine. Be careful not to distort the valve cover when tightening.*

GOVERNOR

The governor controls engine speed which directly affects the voltage output and frequency of the generator. An increase in engine speed will cause a corresponding increase in generator voltage and frequency. A decrease in engine speed will cause a corresponding decrease in generator voltage and

frequency. The governor maintains a constant engine speed under changing load conditions so that generator voltage and frequency do not vary.

Governor Adjustments

Before making governor adjustments, run the unit about 10 minutes under light load to reach normal operating temperature. If governor is completely out of adjustment, make a preliminary adjustment at no load to first attain a safe voltage and speed operating range.

An accurate voltmeter and frequency meter should be connected to the generator in order to correctly adjust the governor. A small speed drop not noticeable without instruments will result in an objectionable voltage drop.

A binding in the bearings of the governor shaft, in the ball joint, or in the carburetor throttle assembly will cause erratic governor action or alternate increase and decrease in speed (hunting). A lean carburetor adjustment can also cause hunting. Springs tend to lose their calibrated tension through fatigue after long usage.

If the governor action is erratic after all adjustments are made, replace the spring. If this does not improve operation, the problem is probably within the governor mechanism. Refer to Governor Cup Section 9 for service procedures.

Adjustments to the governor should be made in the following sequence.

1. The carburetor fuel mixture screws must be correctly adjusted before governor adjustments are made. If the carburetor needs adjusting, refer to Mixture Screw Adjustments in this section before making any adjustments to the governor.

⚠WARNING *Touching hot exhaust pipes or moving parts can result in severe personal injury. Use extreme caution when making adjustments while the engine is running.*

2. Adjust the length of the governor linkage and check for binding or excessive looseness. The length of the linkage connecting the governor arm to the throttle shaft assembly is adjusted by loosening the lock nut and rotating the ball joint (see Figure 6-11). Adjust this length so that with the engine stopped and tension on the governor spring, the stop on the throttle shaft assembly almost touches the stop on the side of the carburetor. (One more turn of the governor ball joint would allow the throttle shaft stop to touch the carburetor.) Tighten lock nut.
3. With the warmed up unit operating no no load, adjust the speed adjustment nut to obtain 62 hertz and 127.5 (± 4.5) volts for frequency and voltage.

4. Check the frequency and voltage first with a load applied and then with no load applied. The frequency and voltage should stay within the limits shown in Table 6-1.

**TABLE 6-1.
VOLTAGE AND SPEED CHARTS**

VOLTAGE CHART FOR CHECKING GOVERNOR REGULATION	1 PHASE 2 WIRE
Maximum No-Load Voltage	132
Minimum Full-Load Voltage	108

SPEED CHART FOR CHECKING GOVERNOR REGULATION	
Maximum No-Load Speed (Rpm) Hertz (Frequency)	1890 63
Minimum Full-Load Speed (Rpm) Hertz	1770 57

5. Adjust the governor sensitivity to give the closest regulation (least speed and voltage difference between no load and full load) without causing a hunting condition. To increase sensitivity (closer regulation), turn the sensitivity adjustment screw counterclockwise. To decrease sensitivity, turn the sensitivity adjustment screw clockwise.

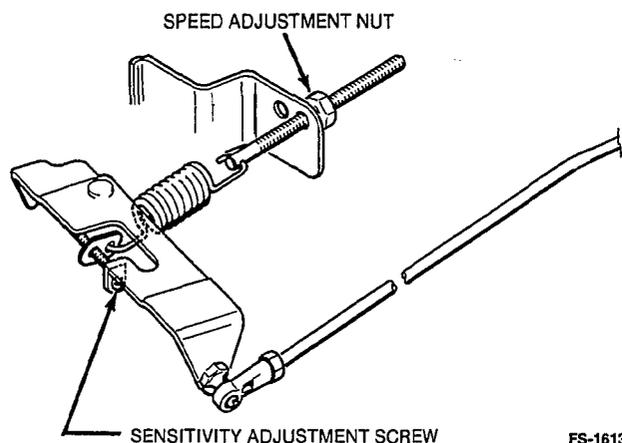


FIGURE 6-11. GOVERNOR ADJUSTMENTS

6. Recheck the speed setting made in step #3 and readjust if necessary.
7. Set the carburetor throttle stop screw as specified in the Fuel System section.

FUEL SYSTEM - GASOLINE

The fuel system must be in good condition and properly adjusted for efficient generator set operation. The main components of the fuel system are the air cleaner assembly, carburetor, choke, intake manifold, fuel filter, fuel pump, and air preheater. When servicing, disassemble, assemble, and adjust as specified in the following sections.

Air Filter Assembly

The air filter assembly consists of the air cleaner housing, air filter, air cleaner adapter, and choke assembly (See Figure 6-12).

Disassembly: Use the following procedures to remove and disassemble the air filter assembly.

1. Remove the crankcase breather hose and air preheater hose from the air cleaner housing.
2. Remove the air cleaner housing center capscrew and lift off the housing and air filter.
3. Remove the choke cover retaining nut and lift off the choke cover.
4. Disconnect the choke lead wires at the choke terminals.
5. Remove the three capscrews that secure the air cleaner adapter to the carburetor and lift off the adapter. Note that choke linkage must be disengaged from choke assembly as adapter is removed.
6. Remove the two capscrews that secure choke bracket to adapter and lift off choke assembly.

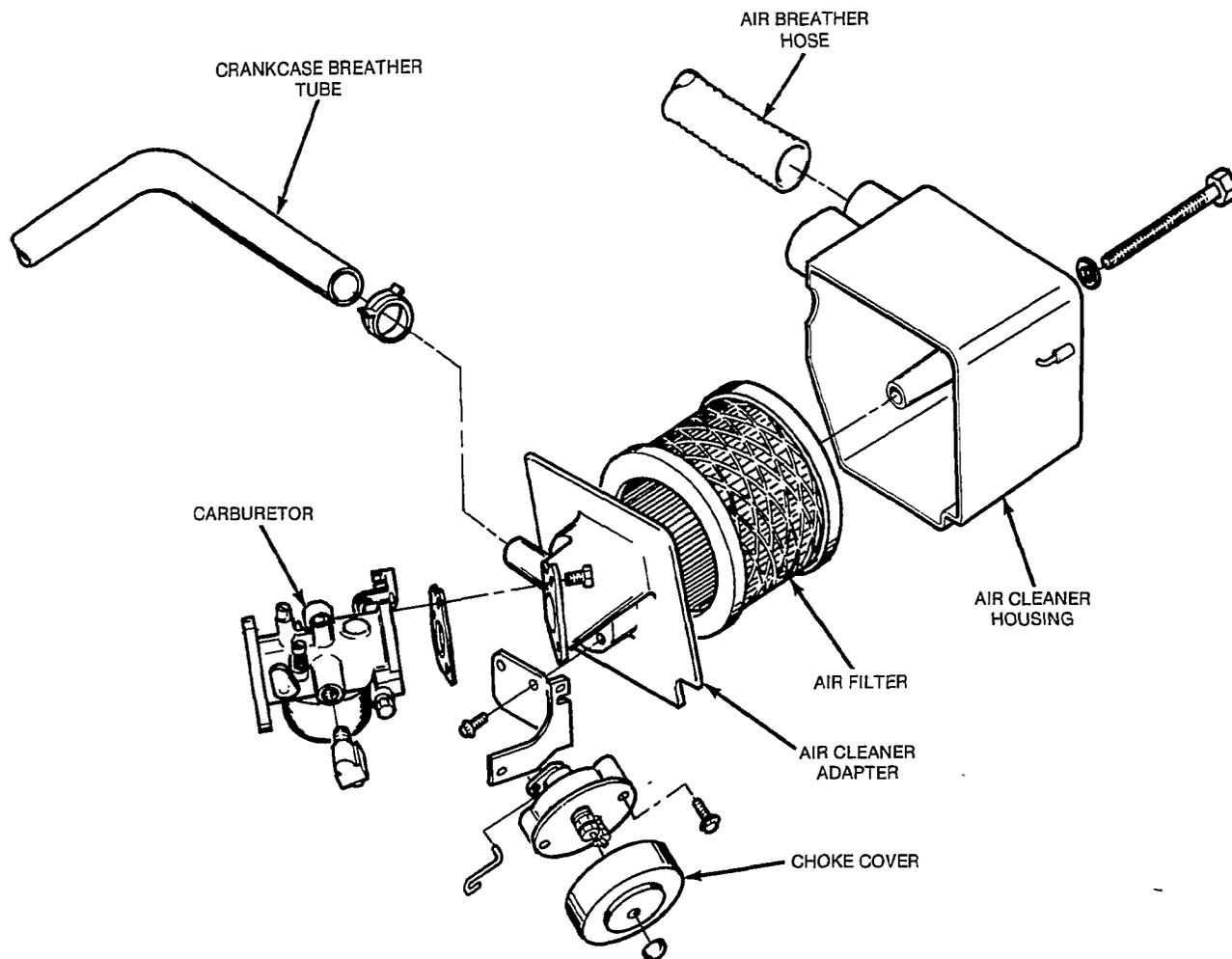
Assembly: Reverse order of disassembly. Use a new gasket between adapter and carburetor.

Carburetor and Intake Manifold Assembly

The carburetor and intake manifold assembly consists of the intake manifold, choke pull-off assembly, air preheaters, and carburetor (See Figure 6-13).

Disassembly: Use the following procedures to remove and disassemble the carburetor and intake manifold assembly.

1. Remove the air filter assembly as described in Air Filter Assembly in this section.
2. Disconnect the fuel line and governor control linkage from the carburetor.
3. Remove the intake manifold capscrews and lift off the carburetor air preheater. Lift off the carburetor and intake manifold as an assembly.



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FIGURE 6-12. AIR FILTER ASSEMBLY

4. Remove the two intake manifold gaskets and plug the intake ports with a rag to prevent loose parts from accidentally entering ports.
5. Remove the two capscrews that secure the carburetor and choke pull-off assembly to the intake manifold. Disengage the choke pull-off linkage from the carburetor and carefully separate the carburetor from the intake manifold.

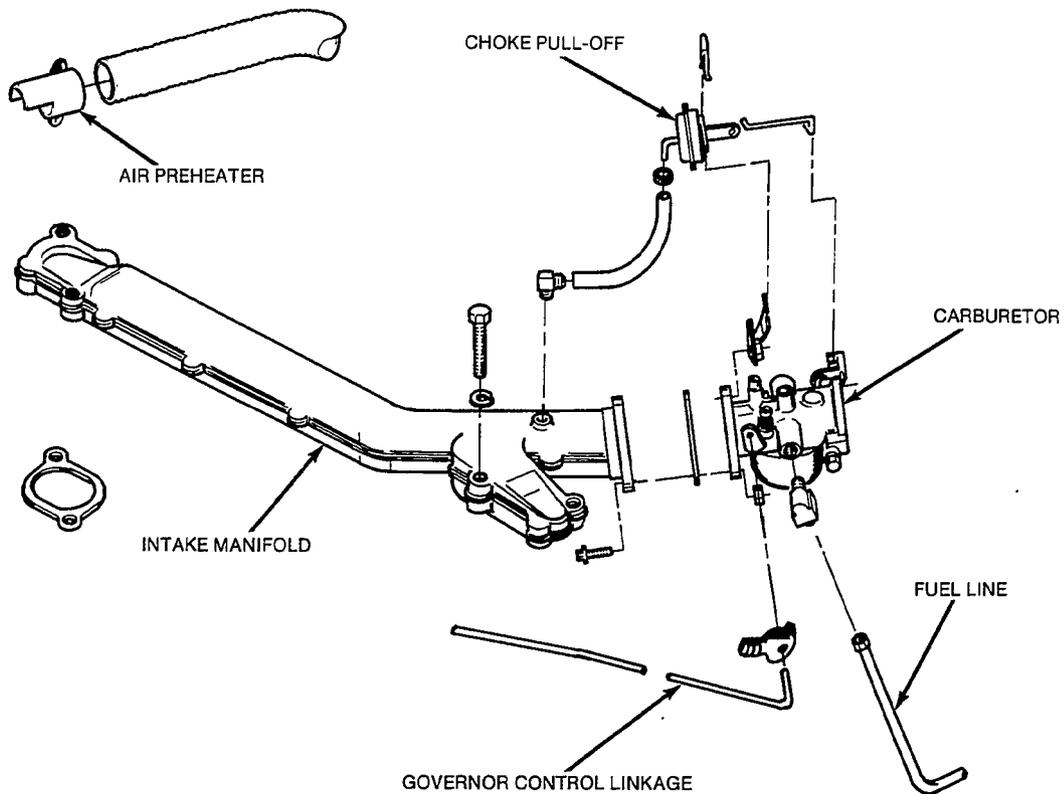
Assembly: Reverse order of disassembly. Use new gaskets between intake manifold and engine and between intake manifold and carburetor. Do not use any sealer on gaskets. Tighten intake manifold capscrews to specified torque.

Carburetor Mixture Screw Adjustments

The most common cause of poor carburetion is unsatisfactory adjustment of the idle or main mixture

adjustment screws. Significant variation from the correct settings may result in serious engine trouble. An overly rich mixture not only wastes fuel, but can increase engine wear by washing the lubricant from the cylinder walls and diluting the crankcase oil. An overly lean mixture results in a loss of power, flat spots in acceleration and a greater tendency to burn valves and spark plugs.

Mixture screw adjustment should be checked with every engine tune-up and whenever a carburetion problem is suspected. Before adjusting, be sure the ignition system is working properly and the governor is correctly set. If the carburetor is totally out of adjustment, use the mixture settings given in Table 6-2 as preliminary adjustments. Turn the mixture screws in until lightly seated, then turn out the specified number of turns.

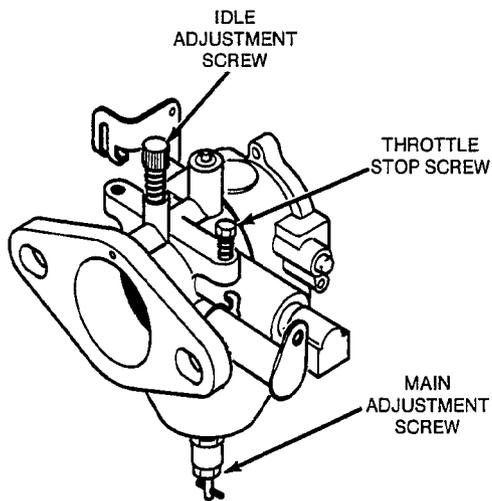


FS-1607

FIGURE 6-13. CARBURETOR AND INTAKE MANIFOLD ASSEMBLY

CAUTION Forcing the mixture adjustment screws tight will damage the needle and seat. Turn in only until light tension can be felt.

Start the engine and allow it to run for about 10 minutes. Refer to Figure 6-14 for location of the adjustment screws. Use the following procedure to adjust:



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FIGURE 6-14. MIXTURE ADJUSTMENT SCREWS - GASOLINE

1. Stop the set and connect a voltmeter, frequency meter, and load bank to the generator output leads.
2. Start the generator set and apply a full load. Verify that the frequency is within 59 ± 2 hertz and adjust the governor speed adjustment nut if necessary to obtain required frequency.
3. Turn the main adjustment screw inward until voltage or frequency drop again. Locate the point where the voltage and frequency are highest. From this setting turn the main adjustment screw out an additional 1/4 turn.
4. Remove the load and verify that frequency is within 62 ± 1 hertz. Adjust governor speed adjustment nut if necessary to obtain required frequency.
5. Turn the idle adjustment screw inward until voltage and frequency drop and engine begins to run rough or starts hunting. Back out idle adjustment screw as required for smoothest operation without hunting.
6. Pull the governor linkage toward the front of the set so that the throttle lever on the carburetor is resting against the throttle stop screw. Adjust the stop screw to obtain a setting of 55 hertz and 100 (± 4.5) volts.
7. Release the governor linkage and observe the stability of the set. Set the voltage and frequency

TABLE 6-2. CARBURETOR ADJUSTMENT SPECIFICATIONS

MODEL	MIXTURE SETTINGS		FLOAT* LEVEL
	IDLE	MAIN	
NHE	1 ± 1/4	2 ± 1/4	1/16 ± 1/32 in. (1.6 ± 0.8 mm)

*Measure between bowl gasket and end of float.

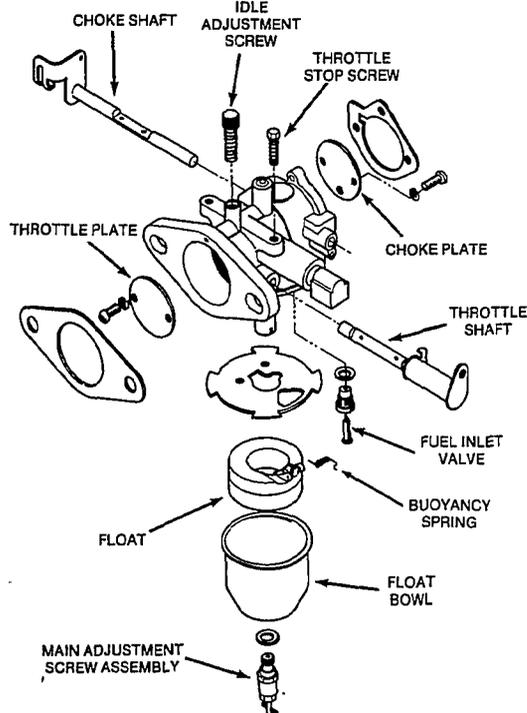
and adjust the sensitivity of the governor as specified in the Governor section. Add and remove a full load several times to make certain the set does not bog down or hunt.

Carburetor Overhaul

Carburetion problems not corrected by mixture or float adjustments are usually a result of gummed-up fuel passages or worn internal parts. The most effective solution is a complete carburetor overhaul.

In general, overhauling a carburetor consists of complete disassembly, a thorough cleaning, and replacement of worn parts. Carburetor repair kits are available that supply new gaskets and replacements for those parts most subject to wear.

General instructions for overhauling a carburetor are given below. Carefully note the position of all parts while removing to assure correct placement when reassembling. Read through all the instructions before beginning for a better understanding of the procedures involved. Carburetor components are shown in Figure 6-15.



XFS-1604

FIGURE 6-15. CARBURETOR OVERHAUL - GASOLINE

1. Remove the air cleaner adapter and the automatic choke assembly.
2. Remove throttle and choke plate retaining screws, then plates. Pull out throttle and choke shafts, being careful not to damage the teflon coating applied to some throttle shafts.
3. Remove main and idle mixture screw assemblies.
4. Separate the lower section of the carburetor (fuel bowl) from the upper section (fuel bowl cover) of the carburetor.
5. Carefully note position of float assembly parts, then slide out retaining pin and remove the float assembly, any springs or clips, and the needle valve.
6. Unscrew and remove needle valve seat.

Clean and Repair: When the carburetor is completely disassembled, clean and repair using the following procedure.

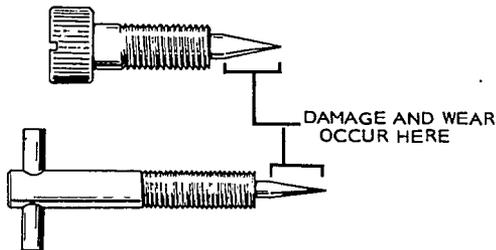
1. Soak all metal components not replaced by repair kit in carburetor cleaner. Do not soak non-metal floats or other non-metal parts. Follow the cleaner manufacturer's recommendations.

WARNING: Most parts cleaning solvents are flammable and can cause severe personal injury if used improperly. Follow the manufacturers recommendations when cleaning parts.

2. Clean all carbon from the carburetor bore, especially where the throttle choke plates seat. Be careful not to plug the idle or main fuel parts.
3. Blow out all passages with compressed air. Avoid using wire or other objects for cleaning that might increase the size of critical passages.
4. Check the condition of any needle valve not included in repair kit and replace if damaged (Figure 6-16). Replace float if loaded with fuel or damaged.
5. Check the choke and throttle shafts for excessive play in their bore and replace if necessary.
6. Replace old components with new parts included in repair kit.

Reassembly and Installation: When the carburetor parts are clean and dry, reassemble using the following procedure.

- Slide in throttle shaft and install throttle plate using new screws, if furnished in repair kit. Before tightening the screws, the plate must be centered in the bore. To do so, back off the throttle stop screw as necessary and completely close the throttle lever. Seat the plate by gently tapping with a small screwdriver, then tighten screws. Install the choke shaft and plate in the same manner.



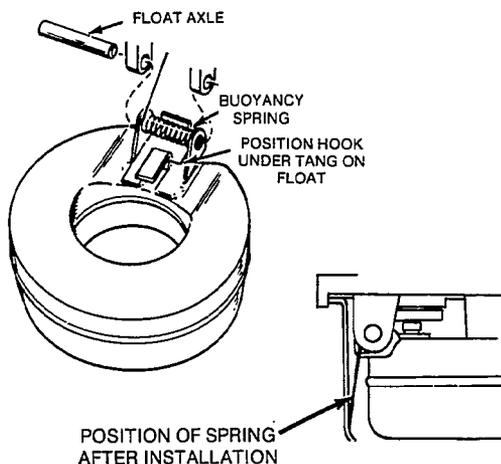
FS-1483

FIGURE 6-16. MIXTURE NEEDLE INSPECTION - GASOLINE

- Install idle mixture screw assembly. Turn in screw until lightly seated and then out the number of turns specified in Table 6-2.

CAUTION Forcing the mixture adjustment screws tight will damage the needle and seat. Turn in only until light tension is felt.

- Install needle valve and seat, fuel bowl gasket and float assembly. Make sure that all clips and springs are properly placed and that the float moves freely without binding. See Figure 6-17.



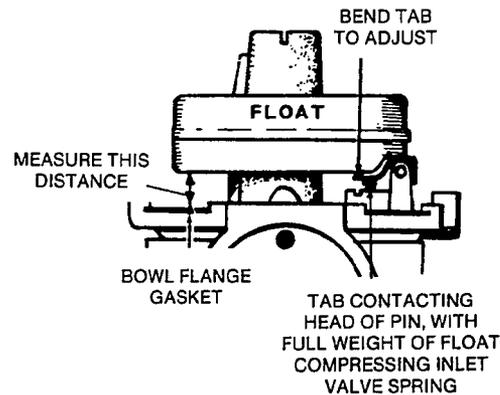
FS-1610

FIGURE 6-17. FLOAT INSTALLATION

- Invert the float and needle valve assembly and check float level by measuring between the float and gasket at the point shown in Figure 6-18. The full weight of the float should be resting on the needle valve and spring. The correct distance is

specified in Table 6-2. If the setting is incorrect, remove float and bend tab to adjust. Bend the float only at the point indicated.

CAUTION Attempting adjustments with the float assembly installed can damage the inlet needle and seat. Remove float assembly before making adjustments.



FS-1611

FIGURE 6-18. FLOAT LEVEL

- Install float bowl and main mixture screw assembly. Turn screw in until lightly seated and then turn out the number of turns specified in Table 6-2.

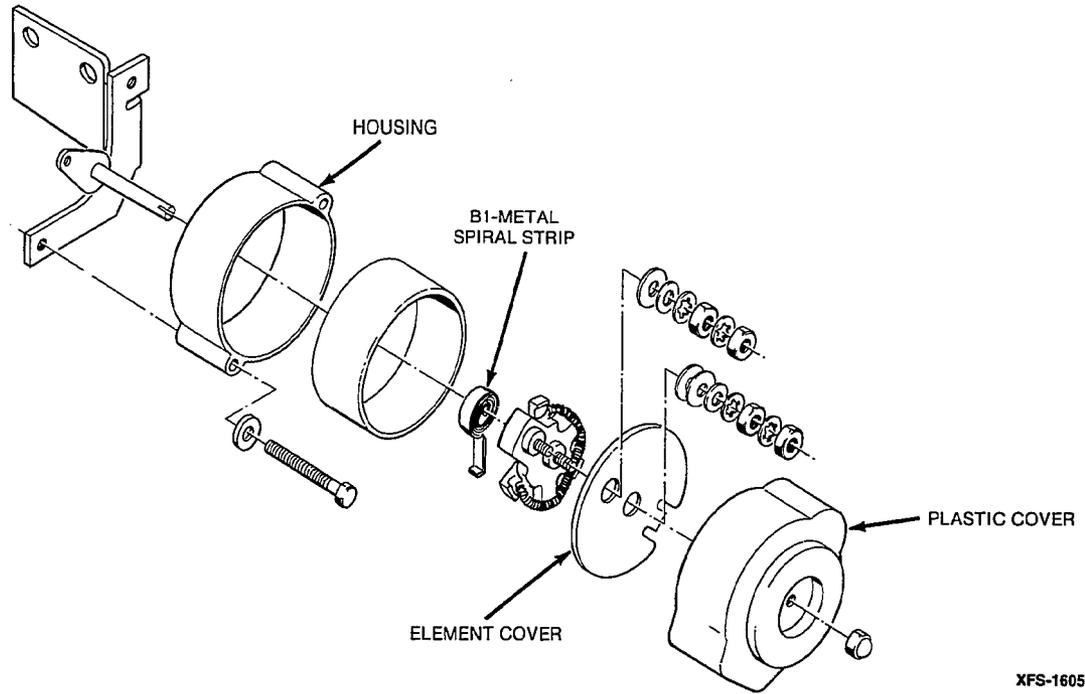
CAUTION Forcing the mixture adjustment screws tight will damage the needle and seat. Turn in only until light tension can be felt.

- When carburetor is installed on set, make final adjustments to mixture screws as described in Carburetor Mixture Screw Adjustments section.

Choke

The choke consists of a bi-metal, spiral strip, electric heating element, and choke pull-off diaphragm. The bi-metal coil is connected to the choke shaft and holds the choke plate nearly closed when the engine is cold. When the engine starts, vacuum from the intake manifold causes the pulloff diaphragm to pull in and partially open the choke. As the engine continues to run, electric current is supplied to the heating element. Heat from the element causes the bi-metal strip to coil. The coiling action of the bi-metal strip turns the choke shaft and gradually opens the choke plate. Heat from the element keeps the choke open while the engine is running.

WARNING The choke gets very hot during normal operation and can cause severe burns if touched. Do not remove choke cover while the set is operating.



XFS-1605

FIGURE 6-19. CHOKE ASSEMBLY

If the engine starts but runs roughly and blows out black smoke after a minute or two of operation, the choke is set too rich. If the engine starts but sputters or stops before it warms up, the choke is set too lean.

Choke Adjustment: Table 6-3 lists the choke settings for various ambient temperatures. Stop the set and allow it to cool down before making adjustments. Use

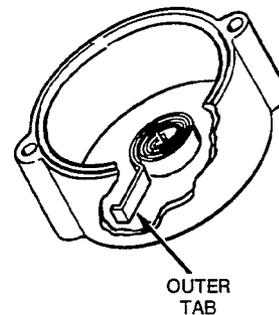
the following procedures to adjust.

1. Remove the protective plastic choke cover (see Figure 6-19) and loosen the heating element cover screws.
2. Rotate heating element until choke plate is about halfway open.
3. Slowly rotate cover counterclockwise (CCW) while tapping the carburetor choke lever and making the choke lever bounce. Continue rotation until tapping the choke lever no longer makes it bounce. This is the fully-closed position and becomes the reference position.

TABLE 6-3.
CHOKE ADJUSTMENTS

Ambient Air Temperature	Rotation From Reference Mark* (Fully Closed)
40° F (4° C)	0°
45° F (7° C)	4° CW
50° F (10° C)	8° CW
55° F (13° C)	12° CW
60° F (16° C)	16° CW
65° F (18° C)	20° CW
70° F (21° C)	24° CW
75° F (24° C)	27° CW
80° F (27° C)	32° CW
85° F (29° C)	35° CW
90° F (32° C)	39° CW
95° F (35° C)	43° CW
100° F (38° C)	47° CW

*Each mark on choke housing equals 5° angular rotation.



FS-1606

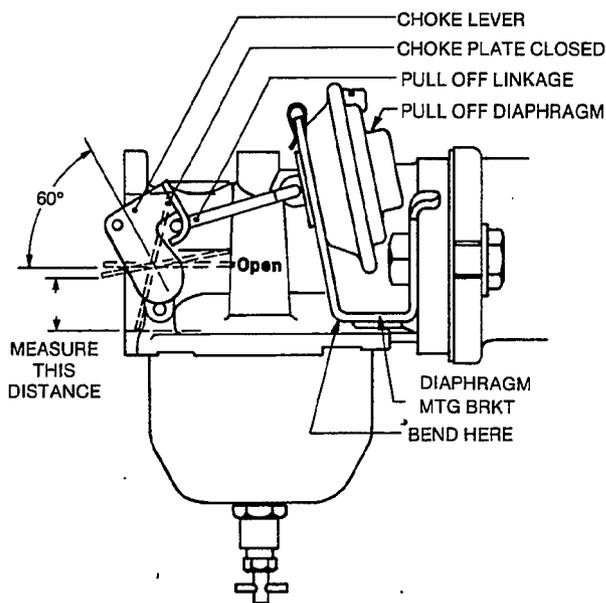
FIGURE 6-20. BI-METAL SPIRAL STRIP

4. Refer to Table 6-3 to determine the number of degrees element cover must be rotated (clockwise) from reference position. Marks on choke housing are spaced at 5° intervals.
5. Rotate element cover as specified and then tighten cover mounting screws.
6. Move choke lever back and forth to check for smooth operation. Lever should return automatically to the free position when released from the open position without sticking or binding.
7. Install plastic choke cover and tighten center mounting nut.

Choke Replacement: If the choke fails to open, remove the protective plastic cover and check to see if the heating element is working. The heating element cover should become hot after a few minutes of operation. If the element cover does not get hot, start the set and then use an AC voltmeter to check for voltage (approximately 20 VAC) at the element cover terminals. If voltage is not present, check for opens or shorts in the control wiring.

If the voltage is present at the heating element cover terminals, stop the set and remove the heating element cover. Inspect the heating element and replace if burned out or broken. Also inspect the bi-metal spiral strip and replace if damaged, deteriorated, or dragging in the housing.

When installing a new bi-metal strip, maintain the original direction of spiral (see Figure 6-20). The outer tab must point in a clockwise direction. Make sure the coil sets squarely in the housing and the inner end of the coil engages the slot in the choke shaft. When installing the element cover, make sure the slotted tang on the cover engages the bi-metal strip.



FS-1603

FIGURE 6-21. CHOKE PULL-OFF DIAPHRAGM

Choke Pulloff Diaphragm Adjustments: The choke pull-off diaphragm partially opens the choke plate following engine startup. This helps prevent flooding and provides for smoother engine operation as the set is warming up. Use the following procedure to adjust.

1. Remove the complete air filter assembly as specified in the air Filter Assembly in this section to provide access to the choke plate.
2. Disconnect diaphragm hose from intake manifold and apply 4 to 18 inches (102 to 457 mm) Hg vacuum to the diaphragm.
3. Apply light finger pressure against the choke lever to take up all freeplay in the pulloff linkage (see Figure 6-21).
4. Check alignment (as viewed from the top) of diaphragm stem, pulloff linkage, and slot in choke lever. Correct alignment as required.
5. Measure distance between choke plate and bottom of carburetor at the point indicated in Figure 6-21. If necessary, bend diaphragm mounting bracket to obtain 0.39 to 0.43 inches (9.9 to 10.9 mm) clearance.
6. Move choke lever back and forth to check for free movement. Verify that choke does not bind or stick.
7. Remove vacuum supply from diaphragm and install filter assembly on carburetor.

Fuel Pump

All gasoline fueled generator sets are equipped with an electric fuel pump. All fuel pumps have an integral shut-off valve that prevents fuel flow to the carburetor when the set is not in operation. If the pump malfunctions or insufficient fuel delivery is suspected, use the appropriate following procedure to test, and repair/replace the pump.

⚠ WARNING *Do not substitute automotive type electric fuel pumps for standard Onan supplied electric pumps. The output pressure is much higher and can cause carburetor flooding or fuel leakage, creating a fire hazard.*

Pump Test (for units built June 1986 and before): Test the fuel pump by checking the pump outlet pressure. Use the following procedure.

1. Remove the fuel line from the pump outlet and install a pressure gauge.
2. Press the START switch and hold it for several seconds until pressure reading is constant.
3. The pressure reading for a good pump should fall within 4 to 5 psi (27.5 to 34.4 kPa). The pressure should stay constant or drop off very slowly.

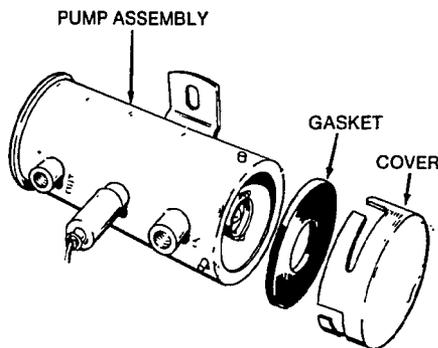
A low pressure reading with little or no pressure drop indicates a weak or broken diaphragm or diaphragm spring, worn linkage or leaky check valves. If pressure is above maximum, the pump diaphragm is too tight or the diaphragm (or plunger) return spring is too strong. Any of the above conditions are cause for repair or replacement of the pump.

Fuel Pump Repair (for units built June 1986 and before): Service of the fuel pump is limited to the bottom cover, plunger tube, and plunger assembly. All parts of the electric system are hermetically sealed in a gas atmosphere and are not serviceable. If electrical failure occurs, replace the pump.

CAUTION Do not tamper with the seal at the center of the mounting bracket on the side of the pump as it retains the dry gas which surrounds the electrical system. Electrical system components are not serviceable.

Use the following procedure for servicing the pump:

1. Using a gas pliers, loosen the pump cover, then remove by hand.
2. Remove the magnet and cover gasket (Figure 6-22).



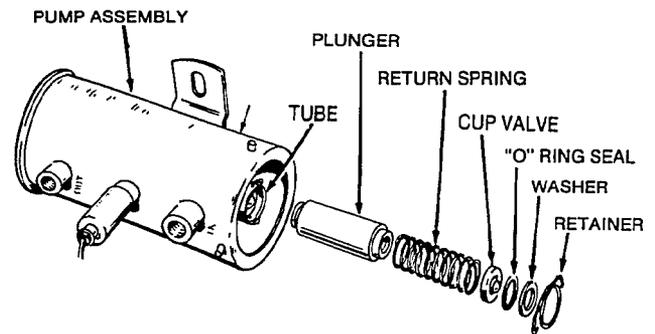
FS-1487

FIGURE 6-22. FUEL PUMP ASSEMBLY
(June 1986 and before)

3. Using a thin nose pliers, remove the retainer from the plunger tube. Remove the washer, "O" ring seal, cup valve, plunger spring and plunger from tube (Figure 6-23).
4. Wash all parts (except gasket and seal) in parts cleaning solvent. Blow out solvent and dirt with low pressure compressed air. Slosh the pump assembly in cleaning solvent, blow dry and swab the inside of the plunger tube with a cloth wrapped around a stick. If the plunger does not wash clean or has rough spots, gently clean the surface with crocus cloth.

WARNING Most parts cleaning solvents are flammable and can cause severe personal injury if used improperly. Follow the manufacturers recommendations when cleaning parts.

5. Insert plunger in tube, buffer spring end first. Check fit by slowly sliding the plunger back and forth in the tube. It should move fully without any tendency to stick. If a click cannot be heard as the plunger is slid from one end to the other, the internal pump assembly is not functioning properly and the pump should be replaced.



FS-1486

FIGURE 6-23. PLUNGER ASSEMBLY

6. Install plunger spring, cup valve, "O" ring seal and washer. Compress the spring and install the retainer with ends in the side holes of the tube.
7. Check cover gasket and replace if deteriorated. Place cover gasket in the bottom cover and install cover assembly on pump. Twist cover on by hand and tighten securely with a 5/8-inch wrench.

Pump Test (for units built June 1986 and after): Test the fuel pump by checking the pump outlet pressure. Use the following procedure.

1. Remove the fuel line from the pump outlet and install a pressure gauge.
2. Press the START switch and hold it for several seconds until pressure reading is constant.
3. The pressure reading for a good pump should fall within 3-1/2 to 5 psi (17.2 to 34.4 kPa). The pressure should stay constant or drop off very slowly.

- If pressure reading is below 3-1/2 psi (17.2 kPa), replace fuel pump.
- If pressure reading is at zero, stop engine cranking and check electrical connections. Press the START switch and recheck pressure reading.
- There are no serviceable components in the fuel pump. Replace if defective.

FUEL SYSTEM - LP-GAS

The fuel system must be in good condition and properly maintained for efficient generator set operation. The main components of the fuel system are the air cleaner assembly, carburetor, intake manifold, fuel filter, solenoid valve, vaporizer, and two-stage regulator. All LP-gas generator sets utilize a liquid withdrawal system and are intended to share the vehicle LP-gas fuel supply tanks. The LP-gas fuel supply tank must be designed with a dip tube to permit liquid fuel withdrawal. The following sections provide basic information about LP-gas fuel systems and specific service procedures for each fuel system component.

LP-Gas Fuel Systems

LP-gas liquid withdrawal fuel systems typically operate at pressures that range as high as 200 psi (1379 kPa) when the ambient temperature is 110°F (43.3°C). Because of the high pressures, special precautions must be taken to avoid releasing large quantities of highly flammable LP-gas when servicing the fuel system. Use the following procedure to purge the fuel system of LP-gas before servicing any fuel system components.

LP-Gas Purging Procedure: To purge the LP-gas from the set fuel system, close the shut-off valve at the fuel tank and then start the generator set. Allow the generator set to operate until it runs out of fuel. Crank the set a few times after it stops to make sure the fuel system is completely purged of all LP-gas fuel.

If the generator set cannot be operated, move the RV coach to an outdoor location that is well ventilated and is away from fire or flame. Disconnect both the vehicle negative (-) battery cable and the generator set negative (-) battery cable from their respective battery terminals. Close the fuel shutoff valves at the fuel tank for both the generator set fuel supply system and the appliance (stove, heater, etc.) fuel supply system. In addition, close the fuel shutoff valves at each appliance.

⚠ WARNING *Fuel presents the hazard of fire or explosion which can cause severe personal injury or death if accidentally ignited. Eliminate all possible sources of ignition such as pilot lights or sparking electrical equipment before purging LP-gas from the fuel system. Provide adequate ventilation to dissipate LP-gas as it is released.*

Slightly open the fuel line (flexible section) at the solenoid valve just enough to allow the LP-gas to slowly escape. Don't open the fitting too much or a large quantity of gas will be released.

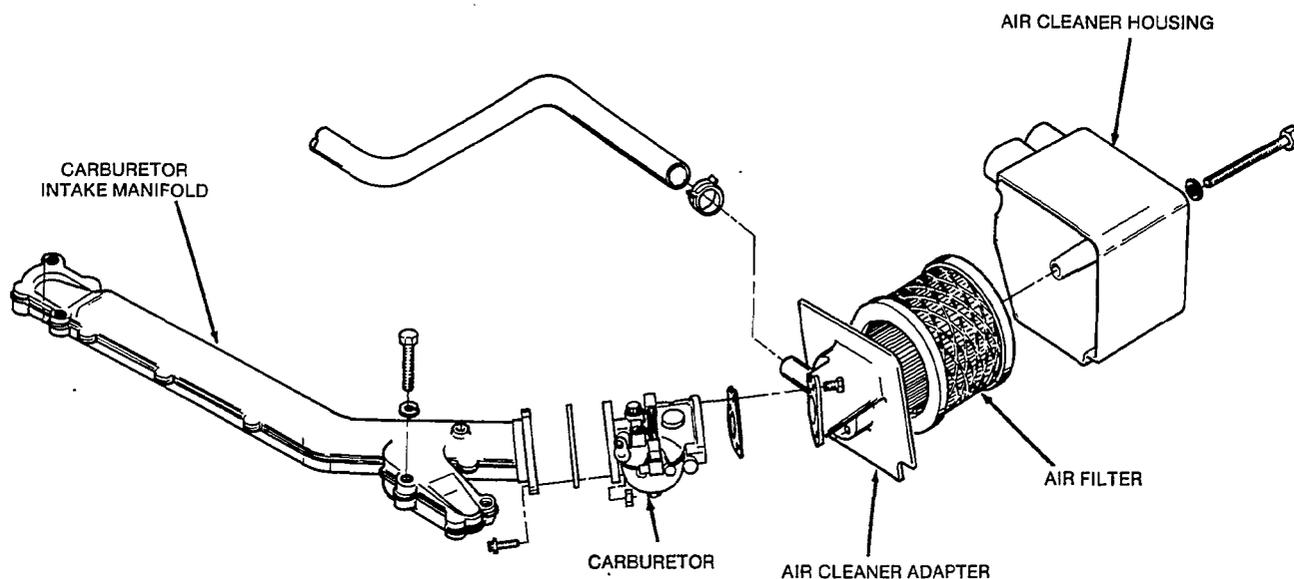
Disconnect the fuel supply hose from the carburetor and hold it clear of the set. Press in and hold the primer button on the regulator to release LP-gas from the set fuel system. When no more gas can be heard escaping from the open end of the fuel supply hose, reconnect the hose to the carburetor and proceed to the appropriate component service station.

Carburetor, Air Filter, and Intake Manifold Assembly

The carburetor, air filter, and intake manifold assembly consists of the air cleaner housing, air filter, air cleaner adapter, K5 relay assembly, carburetor, and intake manifold (see Figure 6-24).

Disassembly: Use the following procedures to remove and disassemble the carburetor, air filter, and intake manifold assembly.

1. Remove the crankcase breather hose from the air cleaner housing.
2. Remove the air cleaner housing center capscrew and lift off the housing and air filter.



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FIGURE 6-24. CARBURETOR, AIR FILTER, AND INTAKE MANIFOLD ASSEMBLY

3. Disconnect the lead wires from the K5 relay terminals.
4. Remove the three capscrews that secure the air cleaner adapter to the carburetor and lift off the adapter.
5. Remove the two capscrews that secure the K5 relay bracket to the adapter and lift off the relay assembly.
6. Disconnect the fuel hose and governor control linkage from the carburetor.
7. Remove the two capscrews that secure the carburetor to the intake manifold and lift off the carburetor.
8. Use the following procedures if it is necessary to remove the intake manifold.
 - A. Disconnect the flexible fuel supply line from the fuel vaporizer.
 - B. Remove the exhaust manifold as described in EXHAUST SYSTEM in this section to provide clearance for lifting off the intake manifold.

CAUTION *Bending the fuel vaporizer tubing will weaken the metal which might cause cracks to form. Do not bend the vaporizer tubing to remove the intake manifold.*

- C. Remove the intake manifold capscrews and lift off the intake manifold.
- D. Remove the two intake manifold gaskets from the block and plug the intake ports with rags to prevent loose parts from accidentally entering the ports.

Assembly: Reverse order of disassembly. Use new gaskets between the exhaust manifold and engine, the intake manifold and engine, and carburetor and intake manifold. Tighten exhaust and intake manifold capscrews to specified torque. Tighten fuel vaporizer fittings and check for leaks.

Carburetor Mixture Screw Adjustments

LP-gas carburetors have three adjustment screws that must be properly set for satisfactory operation. The throttle stop screw controls how much the throttle plate remains open when the throttle is pulled back to the closed position. The idle adjustment screw controls the fuel mixture when the set is operating at no load. The main adjustment screw controls the fuel mixture when the set is operating at full load. No other adjustments are required with an LP-gas carburetor since there are no float or choke adjustments.

Mixture screws should not be adjusted until the ignition system, governor, and other fuel system components have been checked for correct operation. If the carburetor is totally out of adjustment, turn the mixture screws in until lightly seated. For a preliminary adjustment turn the main adjustment screw out 2-1/2 ($\pm 1/4$) turns and the idle adjustment screw out 1 ($\pm 1/4$) turn.

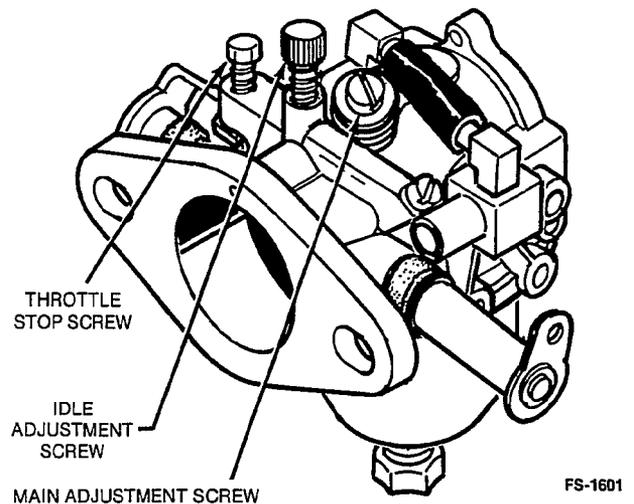


FIGURE 6-25. MIXTURE ADJUSTMENT SCREWS - LP GAS

CAUTION *Forcing the mixture adjustment screws tight will damage the needle and seat. Turn in only until light tension can be felt.*

Start the engine and allow it to run for about 10 minutes at light load. Refer to Figure 6-25 for location of the adjustment screws. Use the following procedure to adjust:

1. Stop the set and connect a voltmeter, frequency meter, and load bank to the generator output leads.
2. Start the generator set and apply a full load. Verify that the frequency is within 59 ± 2 hertz and adjust the governor speed adjustment nut if necessary to obtain required frequency.
3. Turn the main adjustment screw inward until voltage or frequency drop and then outward until voltage or frequency drop again. Set the main adjustment screw at the point where the voltage and frequency are highest.
4. Remove the load and verify that frequency is within 62 ± 1 hertz. Adjust governor speed adjustment nut if necessary to obtain required frequency.
5. Turn the idle adjustment screw inward until voltage and frequency drop and engine begins to run rough or starts hunting. Back out idle adjustment screw until engine runs smoothly without hunting.
6. Pull the governor linkage toward the front of the set so that the throttle lever on the carburetor is resting against the throttle stop screw. Adjust the stop screw to obtain a setting of 55 hertz and 100 (± 4.5) volts.
7. Release the governor linkage and observe the stability of the set. Set the voltage and frequency and adjust the sensitivity of the governor as specified under Governor in this section. Add and remove a half load several times to make certain the set does not bog down or hunt.

Carburetor Overhaul

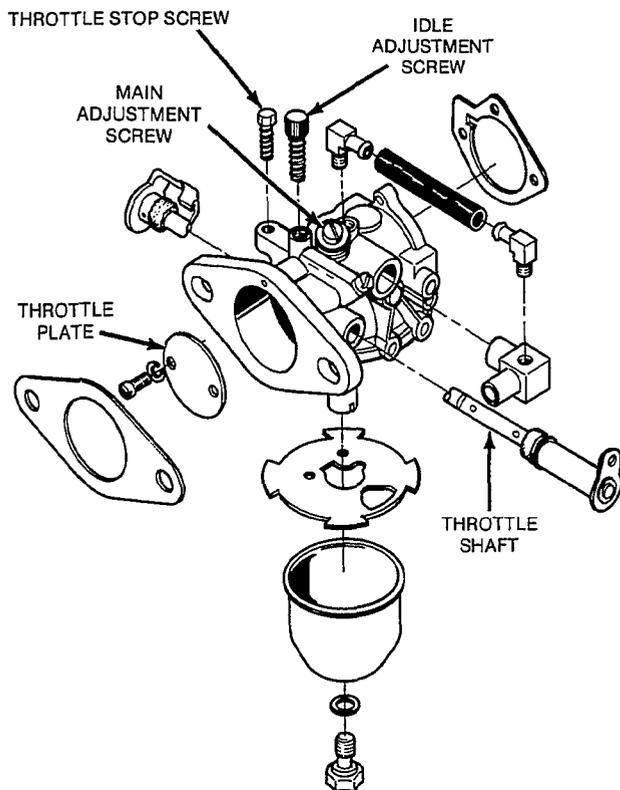
Carburetor problems not corrected by mixture adjustments may be caused by dirt in fuel passages or worn internal parts. Under normal conditions, the carburetor should seldom require cleaning since LP gas vaporizes complete before reaching the carburetor and leaves no residue. However, a bad fuel supply or inoperative fuel filter may allow dirt or oil to collect in the carburetor. This may require that the carburetor be cleaned to restore satisfactory operation.

Overhauling the carburetor includes complete disassembly, thorough cleaning, and replacement of worn parts. Carburetor repair kits are available that supply new gaskets and replacement parts for the components subject to wear.

Note the position of all components while removing to insure correct placement when reassembling. Refer to Figure 6-26 for component designations.

Removal and Disassembly: Remove the carburetor from the intake manifold as specified in Carburetor Air Filter, and Intake Manifold Assembly in this section. Use the following procedure to disassemble the carburetor.

CAUTION Most parts cleaning solvents are flammable and can cause severe personal injury if used improperly. Follow the manufacturers recommendations when cleaning parts.



FS-1602

FIGURE 6-26. CARBURETOR OVERHAUL

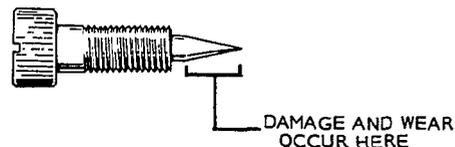
1. Remove the throttle stop collar and throttle stop lever from the end of the throttle shaft.
2. Remove the throttle plate retaining screws and throttle plate. Remove dust seals from throttle shaft and carefully pull out throttle shaft.
3. Remove main and idle mixture screw assembly.
4. Separate lower section (bowl) of carburetor from the upper section (bowl cover).

Clean and Repair: When the carburetor is completely disassembled, clean and repair using the following procedures.

1. Soak all metal components not replaced by repair kit in carburetor cleaner. Do not soak any non-metal parts or they may be damaged by the cleaning solution. Follow the cleaner manufacturer's recommendations.
2. Clean all carbon from throttle bore, especially where the throttle plate seats. Be careful not to plug the idle or main fuel parts.
3. Blow out all passages with low pressure (35 psi/ 241 kPa) compressed air. Do not use wire or other objects for cleaning that might increase the size of critical passages.
4. Check the condition of the mixture screws (see Figure 6-27) and replace if worn or damaged.
5. Replace all old components, seals, and gaskets with new parts included in the kit.

Reassembly and Installation: When the carburetor parts are clean and dry, reassemble using the following procedure.

1. Slide in throttle shaft and install throttle plate using new screws (if furnished in repair kit). Before tightening the screws, the plate must be centered in the throttle bore. To do so, move the throttle lever to the completely closed position. Seat the plate by gently tapping on it with a small screwdriver and then tighten the screws. Install seal, throttle stop lever, and collar on the throttle shaft end.



FS-1483

FIGURE 6-27. MIXTURE NEEDLE INSPECTION - LP GAS

2. Install the idle and main adjustment screws and turn in until lightly seated. For preliminary settings, turn the idle screw out 1 ($\pm 1/4$) turn and the main screw out 2-1/2 ($\pm 1/4$) turns.

CAUTION Forcing the mixture adjustment screws tight will damage the needle and seat. Turn in only until tension is felt.

3. Join the upper and lower sections of the carburetor and install bowl plug and washer.
4. When the carburetor is installed on set, make final adjustments to mixture screws as specified in Carburetor Mixture Screw Adjustments in this section.

Regulator

A two stage regulator (see Figure 6-28) is used to deliver vaporized LP gas fuel to the carburetor. The primary stage of the regulator receives LP gas at container pressure and reduces it to the low pressure required for set operation. The secondary stage of the regulator restricts fuel flow through the regulator until vacuum from the engine creates a demand for fuel. Fuel flows through the regulator only when the engine is cranking or operating and stops flowing when the engine is stopped.

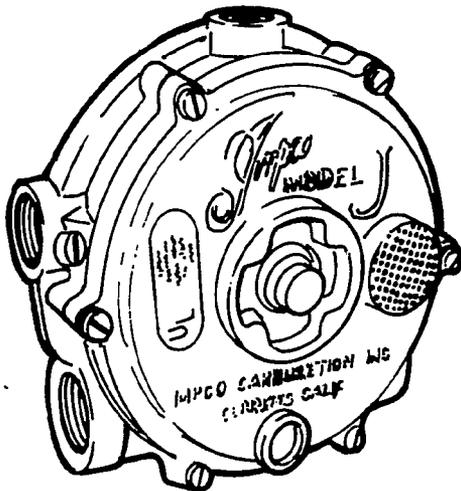
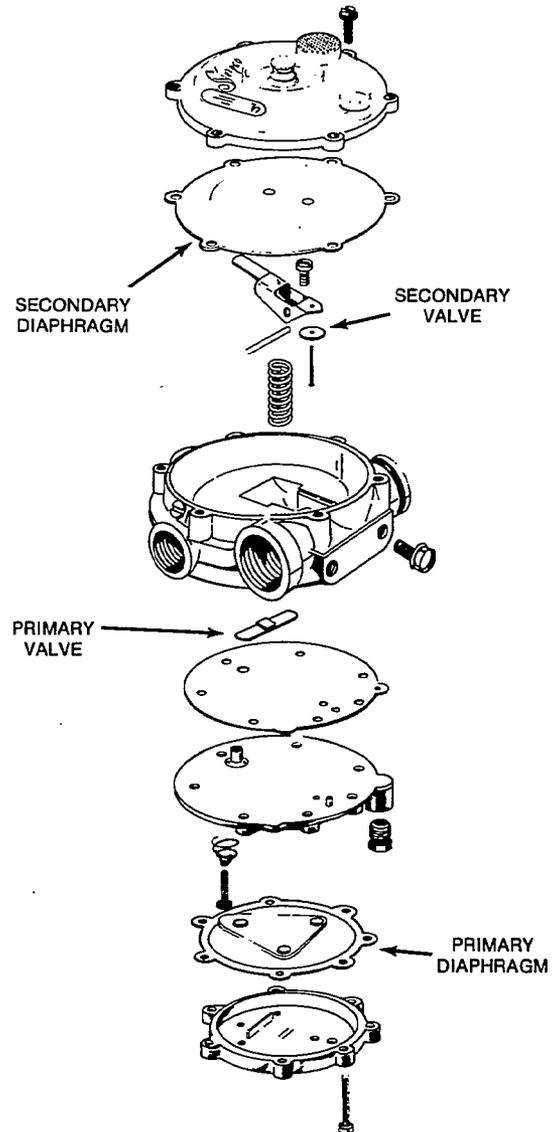


FIGURE 6-28. LP GAS REGULATOR

FS-1598

The regulator will normally require very little attention if the set is used on a regular basis and operated on clean high quality fuel. Most regular malfunctions can be traced to the following two sources:

- Hardened diaphragms and seats due to extended periods of non-operation.
- Dirt or foreign matter embedded on valves and valve seats.



XFS-1600

FIGURE 6-29. REGULATOR ASSEMBLY

A regulator that has been operated and then stored for any length of time may require rebuilding or replacement. Diaphragms and gaskets tend to dry, shrink, and harden as the lighter petroleum ends evaporate. Use the test procedure specified in the Regulator Test section to check regulator operation and then rebuild or replace as required. Repair kits include detailed and illustrated installation instructions.

A regulator that has granules of foreign matter embedded on the secondary seat may cause inconsistent starting or idling. These granules are seldom the result of insufficient filtration. The foreign matter

is dissolved in the liquid propane and forms into granules as the fuel is vaporized. Remove regulator front cover and diaphragm assembly (see Figure 6-29) to check for dirt or oil deposits. If granules are embedded in the Vitton rubber of the secondary valve, wash the valve and seat clean.

Regulator Test: The regulator may be bend tested using compressed air and a simple automobile fuel pressure gauge. Use the following procedure to test.

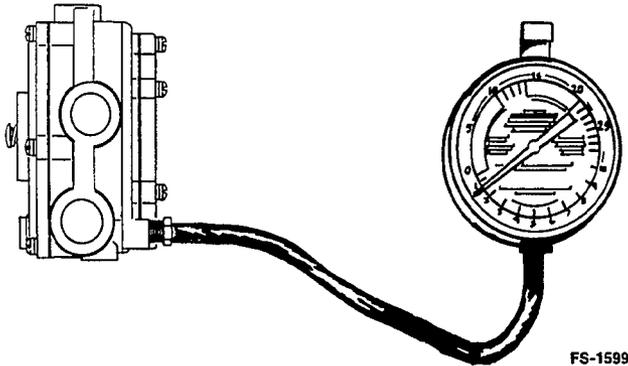


FIGURE 6-30. REGULATOR TEST

1. Attach the pressure gauge to the test port on the back of the regulator as shown in Figure 6-30.
2. Attach a pressure hose to the inlet opening and open the air pressure valve.
3. If the primary seal is sound, the gauge should read approximately 1-1/2 psi (10.3 kPa) and the pressure should remain constant. A fluctuating pressure reading indicates a bad primary seat.
4. Close the air pressure valve and observe the pressure gauge. The pressure should remain constant. If the pressure reading drops, the secondary seat is leaking.

If the regulator does not pass either test, it must be rebuilt or replaced.

Fuel Filter

The fuel filter (see Figure 6-31) removes solid impurities such as rust or scale from the LP-gas before they can clog the regulator or carburetor. A magnet within the filter housing traps iron or rust particles while a filter element traps non-magnetic particles. The fuel filter operates at container pressure and must be carefully assembled to prevent leakage. Use the following procedures to disassemble and clean:

1. Remove the four capscrews and lock washers that secure the filter bowl to the filter body.
2. Separate filter bowl from filter body and discard the O-ring seal.
3. Remove nut and washer from center stud and pull out the filter element.

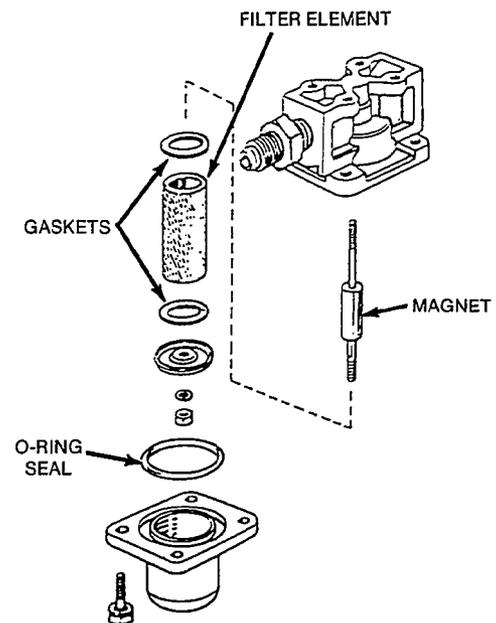
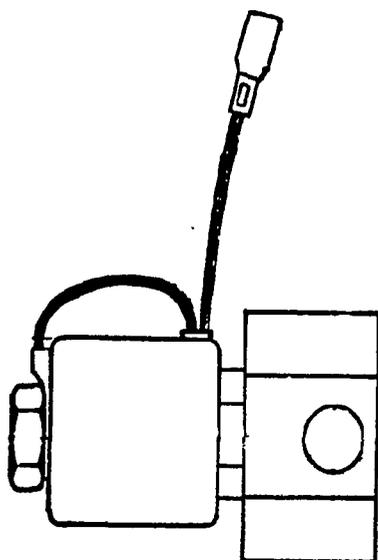


FIGURE 6-31. FUEL FILTER

4. If filter element is clogged, wash element in kerosene and blow dry with low pressure (35 psi/241 kPa) compressed air. Replace filter element if damaged.
5. Wipe the center stud magnet clean of any rust or scale particles that have collected.
6. Install clean filter element using two new gaskets and securely tighten center stud nut.
7. Place a new O-ring in the filter bowl sealing groove.
8. Align reference mark on filter bowl with reference mark on filter body and install four capscrews and four lock washers. Tighten capscrews to 56 to 74 in-lbs (6.5 to 8.3 N•m) torque. When fuel system is pressurized, check filter for leaks.



ES-1553

FIGURE 6-32. SOLENOID VALVE

Solenoid Valve

The solenoid valve (see Figure 6-32) provides a positive fuel shutoff whenever the generator set is stopped. The solenoid must be energized before fuel will flow to the regulator. Service is limited to replacing the complete valve assembly if it does not operate properly. The valve may be bench tested by connecting battery positive (B+) to the top terminal and battery negative (B-) to the grounded terminal. The plunger assembly should withdraw and open the valve when the solenoid is energized. Replace the solenoid valve if it does not operate properly.

Section 7 - Control

INTRODUCTION

The control system includes all functions that relate to starting, monitoring for fault conditions, instrumentation, battery charging, and stopping. This section covers how the control operates, where the components are located, and basic troubleshooting procedures. Separate control systems are used for the NHE and NHEL series generator sets. Each system is covered separately in this section.

NHE CONTROL DESCRIPTION

The generator set control (see Figures 7-1 and 7-2) consists of the following components:

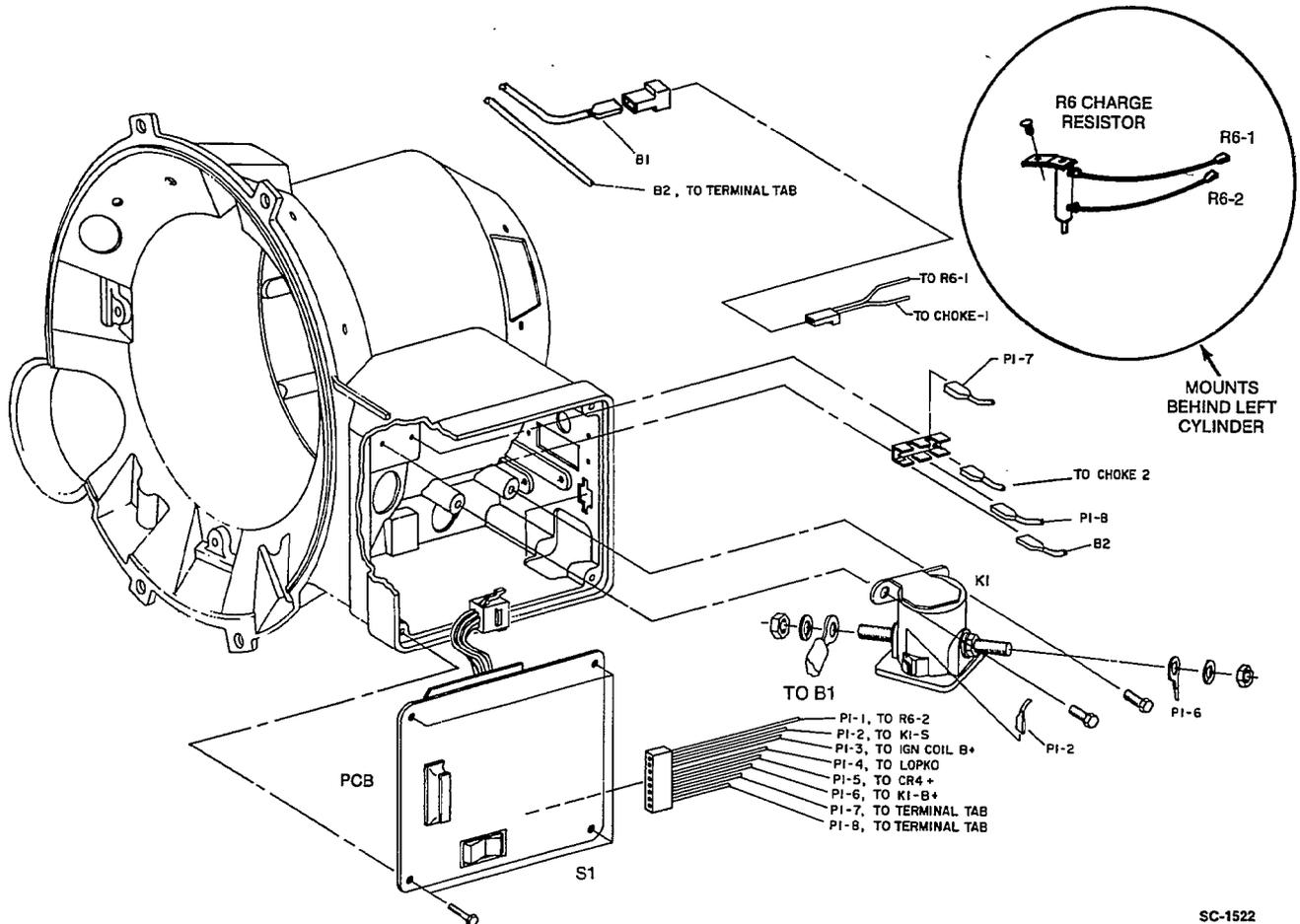
- Printed Circuit Board Assembly
- Panel Mounted Start/Run/Stop Switch (S1)
- Start Solenoid (K1)
- Battery Charge Resistor (R6)
- Optional Remote Start Control

A general description of each component and how it functions follows:

Printed Circuit Board Assembly

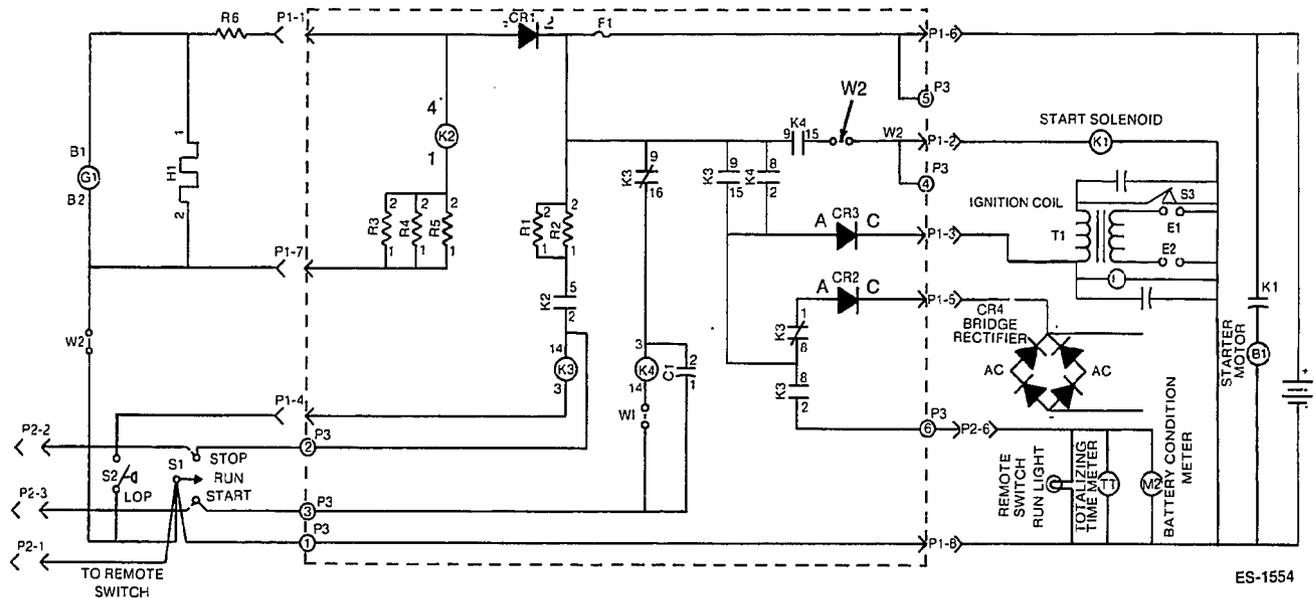
The printed circuit board assembly (see Figure 7-3) is the center of the generator set control system. The PC board circuitry controls the start, starter disconnect/run, stop, and battery charging functions. The primary components of the PC board include three relays, one power rectifier, two diodes, one capacitor, five resistors, and a five ampere fuse. The only serviceable component is the fuse which is removable from the front of the control panel. Connections to the PC board are made through an eight pin connector (P1) mounted on the board and through the four lead wiring harness. The PC board assembly mounts on the back of the control panel.

The PC board assembly is designed so that it will not be damaged by reversed battery polarity or by a short



SC-1522

FIGURE 7-1. NHE CONTROL



- | | |
|------------------------------------|----------------------------|
| S1-Start/Run/Stop switch | E1-Spark plug |
| S2-Low oil pressure cut-out switch | E2-Spark plug |
| S3-Breaker points | E3-Fuel pump |
| CR1-Power rectifier | R6-Battery charge resistor |
| CR4-Field rectifier | H1-Choke heater element |
| F1-Fuse | K1-Start solenoid |
| B1-Starter | K2-Generator relay (AC) |
| G1-Generator | K3-Run relay |
| | K4-Start relay |

FIGURE 7-2. TYPICAL CONTROL SCHEMATIC - GASOLINE

in the lead wires from the board or remote start control. The relays are sealed and filled with dry nitrogen for maximum contact life.

Start/Run/Stop Switch

The Start/Run/Stop switch (S1) is a single pole, double throw (SPDT) rocker type switch that is used for starting or stopping the generator set. Placing the switch in either the Start or Stop position will initiate the appropriate control function. The switch will automatically return to the center (Run) position when released. The switch is mounted on the control panel and is removable for service department.

Start Solenoid

The K1 start solenoid is used for opening or closing the circuit between the starter motor and the battery. Because of the high current loads imposed during starting, the start solenoid is designed with heavy duty contacts rated to withstand 300 amperes. A single small terminal provides a connection point for the 12 volt DC solenoid coil. Two large studs provide connection points for the battery cables. The solenoid is mounted inside the control.

Battery Charge Resistor

The battery charge resistor is a fixed value (2.5 ohm, 50 watts) resistor that limits the battery charge rate to no more than 1 ampere. The charge rate may not be altered. The resistor mounts between the left cylinder (as viewed from flywheel end) and the engine to generator adapter.

Optional Remote Start Control

The remote start control is an optional accessory that allows the generator set to be started, monitored, and stopped from a remote location. The deluxe control includes a running time meter and battery condition meter. Remote control panels are usually mounted on the vehicle dashboard.

NHE CONTROL OPERATION

This operation description applies to NHE series generator sets. The schematic diagram shown in Figure 7-2 is intended as an example to help follow the circuit description. Always refer to the specific wiring diagram that corresponds to the model and spec number of the generator set when troubleshooting problems.

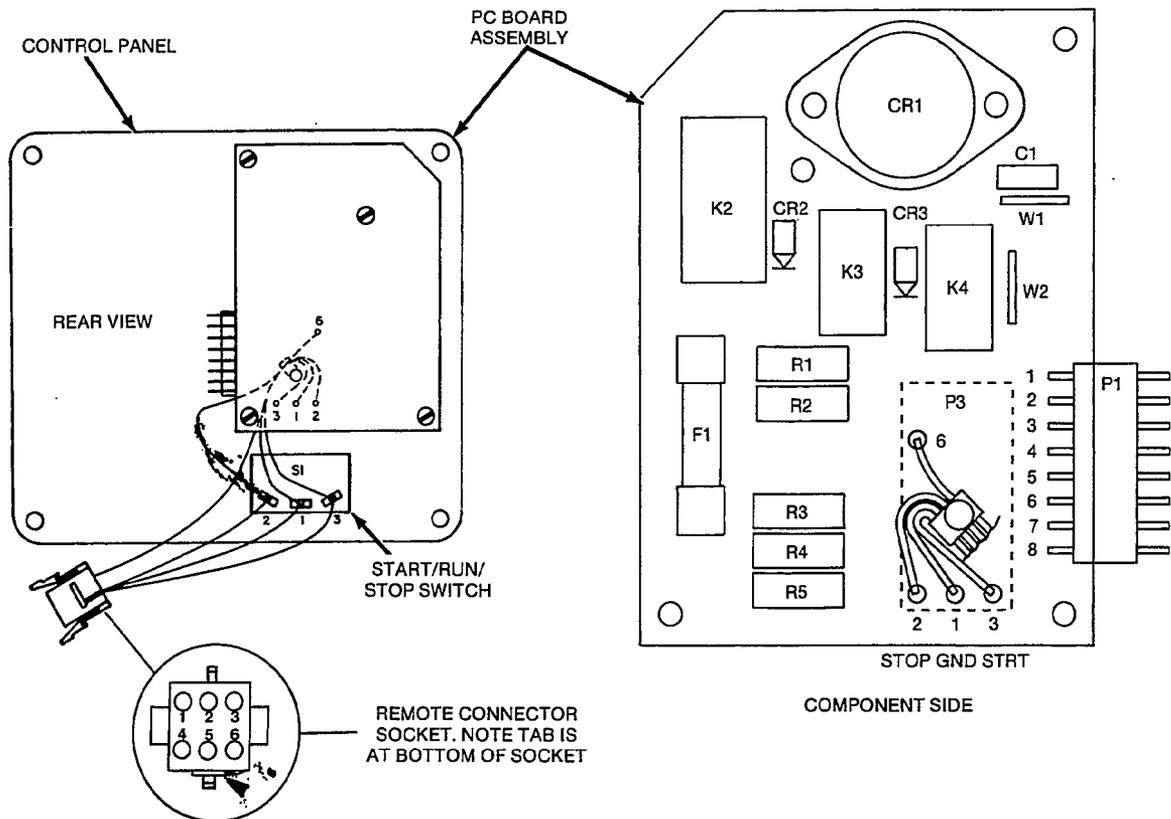


FIGURE 7-3. NHE CONTROL PANEL ASSEMBLY

SC-1521

Starting

Placing the Start/Run/Stop switch in the Start position connects battery ground (B-) to the K4 start relay. This energizes the K4 relay which closes two sets of contacts (K4-2,8 and K4-9,15) that connects battery positive (B+) to the generator field windings (CR4+), T1 ignition coil, E3 fuel pump, and K1 start solenoid. Connecting B+ as described produces the following control responses:

- Flashes the field to ensure that there is adequate residual magnetism to induce voltage build-up.
- Energizes the ignition coil (T1) so it can produce an ignition spark when the breaker points open and close.
- Energizes the fuel pump (E3) which begins pumping fuel to the carburetor.
- Energizes the K1 start solenoid to close the K1 contacts.

Closing the K1 start solenoid contacts connects B+ to the starter motor. This energizes the starter motor which begins to crank the engine to initiate starting.

Starter Lock-Out-Run

When the engine starts, the low oil pressure switch (S2) closes to connect battery ground (B-) to the K3 run relay. As the engine comes up to speed, AC output voltage from the generator is supplied to the choke heater element (H1) and to the K2 generator relay. This activates the heating element (which opens the choke) and also energizes the K2 relay. Energizing the K2 relay closes one set of contacts (K2-2,5) that connect B+ to the K3 run relay. This energizes the K3 relay which opens two sets of contacts to produce the following control responses:

- Closing the K3-9,15 contacts (which parallel the K4-2,8 contacts) provides an alternate pathway for supplying B+ to the T1 ignition coil and E3 fuel pump.
- Opening the K3-1,8 contacts disconnects B+ (CR4 positive terminal) from the generator field windings.
- Closing the K3-2,8 contacts connects B+ to run light, time meter, and battery condition meter.
- Opening the K3-9,16 contacts disconnects B+ from the K4 start relay causing it to de-energize.

De-energizing the K4 relay opens the K4-2,8 and K4-9,15 relay contacts. Opening the K4-2,8 contacts has no effect since they are in parallel with the closed K3-9,15 contacts which connect B+ to the ignition coil and the fuel pump. Opening the K4-9,15 contacts disconnects B+ from the K1 start solenoid. De-energizing the K1 start solenoid disconnects B+ from the starter motor which stops cranking.

When the S1 switch is placed in the RUN position, the engine continues to run. Relays K2 (generator relay) and K3 (run relay) are energized while relays K1 (start solenoid) and K4 (start relay) are de-energized. Generator voltage is rectified to DC by the CR1 power rectifier and supplied to the battery through the charge resistor (R6). This charges the battery at a constant rate (1 ampere maximum) during set operation.

Stopping

Placing the Start/Stop/Run switch (S1) in the Stop position grounds the K3 run relay. This de-energizes the K3 relay which opens the K3-2,8 and K3-9,15 relay contacts to disconnect B+ from the ignition coil, fuel

solenoid, run light, meters, and K5 solenoid. De-energizing the K5 relay closes the K5-30, 87A contacts which holds the K3 relay grounded. This prevents the set from restarting if the S1 switch is released from the Stop position.

Without ignition or fuel, the engine stops. As the generator output voltage drops, the K2 generator relay also de-energizes. All components return to their de-energized position following set shut-down. CR1 prevents the battery from discharging through the generator windings while the set is stopped.

NHE CONTROL TROUBLESHOOTING

Use the troubleshooting guide to help locate problems related to the NHE control. Figures 7-1 and 7-3 show the location of most of the control components. Refer to the wiring diagram in Figure 7-2 for location of all terminal connections.

The troubleshooting guide is divided into six sections. After identifying the problem, refer to the guide for the possible cause and the recommended corrective action.

TRUBLESHOOTING THE NHE CONTROL

Trouble	Possible Cause	Corrective Action
Engine Does Not Crank	<ol style="list-style-type: none"> 1. If engine cranks at set but not at remote control panel, fault is due to: <ol style="list-style-type: none"> a. open circuit in remote control b. remote start switch faulty 2. If engine cranks at remote control panel but not at set, fault is due to: <ol style="list-style-type: none"> a. open circuit in wiring between S1 switch and PC board, or b. faulty S1 switch 3. Insufficient voltage for cranking due to: <ol style="list-style-type: none"> a. Battery not charged, or b. Terminal connections loose or dirty 4. Control fuse (F1) is open 	<ol style="list-style-type: none"> 1a. Check for continuity and correct if circuit is open 1b. Replace remote start control switch 2a. Check for continuity and correct if circuit is open 2b. Replace S1 switch 3a. Check condition of battery and recharge or replace 3b. Clean and tighten all connections at battery, K1 start solenoid, and starter motor 4. Replace fuse (5 ampere) <p>⚠ WARNING <i>Short circuiting the battery cables can cause severe personal injury or death. Disconnect the negative battery (-) cable at the battery terminal before servicing.</i></p>

TROUBLESHOOTING THE NHE CONTROL

Trouble	Possible Cause	Corrective Action
<p>Engine Does Not Crank (cont.)</p>	<p>5. Connect a voltmeter between terminal S on the start solenoid and ground. Check for battery voltage when S1 is placed in Start position. If voltage is present, fault is due to:</p> <ul style="list-style-type: none"> a. K1 relay not grounded, b. defective K1 relay, or c. defective starter <p>6. If voltage is not present as described in step 5 test, fault is due to:</p> <ul style="list-style-type: none"> a. open circuit between K1 relay and control PC board, or b. defective control PC board. 	<p>5a. Tighten solenoid bracket mounting screw</p> <p>5b. Replace K1 start solenoid.</p> <p>5c. Refer to Electric Starter section for test and service procedures.</p> <p>6a. Check for continuity and correct if circuit is open.</p> <p>6b. Replace control PC board.</p>
<p>Engine Cranks But Does Not Start</p>	<p>1. Faulty ignition due to worn or fouled spark plugs, worn ignition points, incorrect ignition timing, or faulty plug wires.</p> <p>2. Faulty fuel system due to sticking choke, faulty fuel pump, or carburetor mixture screws incorrectly adjusted.</p> <p>3. Connect a voltmeter between positive (+) terminal on coil and ground. Check for battery voltage when S1 is placed in the Start position. If the voltage is not present, fault is due to:</p> <ul style="list-style-type: none"> a. open circuit between coil and control b. defective control PC board. 	<p>1. Refer to Ignition System section for test and service procedures.</p> <p>2. Refer to Fuel System section for test and service procedures.</p> <p>3a. Check for continuity and correct correct if circuit is open.</p> <p>3b. Replace control PC board.</p>
<p>Engine Starts But Stops When Start Switch is Released</p>	<p>1. Low oil pressure switch not closing due to:</p> <ul style="list-style-type: none"> a. low oil level b. open circuit between switch and control c. defective low oil pressure switch d. low oil pressure. <p>2. Output voltage from generator not being supplied to control due to:</p> <ul style="list-style-type: none"> a. defective charge resistor b. open circuit in wiring between generator and control. c. defective bridge rectifier d. no output voltage from generator. 	<p>1a. Check oil level and add oil if low.</p> <p>1b. Check for continuity and correct if circuit is open.</p> <p>1c. Replace low oil pressure switch.</p> <p>1d. Refer to Lubrication system section for test and service procedures.</p> <p>2a. Test R6 charge resistor (2.5 ohm) and replace if defective.</p> <p>2b. Check for continuity and correct if circuit is open.</p> <p>2c. Refer to Generator section for test and service procedures.</p> <p>2d. Refer to Generator section for test and service procedures.</p>

TROUBLESHOOTING THE NHE CONTROL

Trouble	Possible Cause	Corrective Action
Engine Starts But Stops When Start Switch is Released (cont.)	3. Defective control PC board.	3. Replace control PC board.
Engine Starts And Runs; Then Stops. Set Restarts Immediately or Set Restarts After Cooling Down	<ol style="list-style-type: none"> 1. Fuel level is below generator set fuel pickup tube or oil level is low. 2. Faulty choke operation due to sticking choke linkage, incorrect choke adjustment, open circuit in wiring between choke heater and generator, or defective choke heater. 3. Vapor lock due to: <ol style="list-style-type: none"> a. high ambient air temperatures b. faulty fuel pump. 4. Breaker points sticking. 5. Contaminated fuel. 	<ol style="list-style-type: none"> 1. Check fuel and oil levels and refill as necessary. 2. Refer to Fuel System section for testing and service procedures. 3a. Remove any objects or debris that may restrict airflow to and from the set. 3b. Refer to Fuel System section for test and service procedures 4. Replace breaker points. 5. Refill tank with fresh fuel.
Low Battery	<ol style="list-style-type: none"> 1. Weak or discharged battery. generator set charger will not recharge a battery that is in a very low state of charge. 2. Load connected to battery while set is turned off. 3. Disconnect the negative (-) battery cable at the battery and remove control lead P1-6 from the battery positive (+) terminal on the K1 start solenoid. Connect a DC ammeter and 5 ampere fuse in series between the P1-6 lead wire and the stud terminal on the K1 solenoid. With set running, the ammeter should read between 0 and 1 ampere. If meter shows battery is discharging, fault is due to: <ol style="list-style-type: none"> a. defective generator charge winding b. CR1 power rectifier open. 	<ol style="list-style-type: none"> 1. Connect a separate battery charger to bring battery up to full charge. 2. Turn off load. 3a. Refer to Generator section for testing and service procedures. 3b. Replace control PC board.

TROUBLESHOOTING THE NHE CONTROL

Trouble	Possible Cause	Corrective Action
Run Lamp, Time Meter, or Battery Condition Meter Does Not Operate	<ol style="list-style-type: none"> 1. Open circuit between terminal 6 or remote connector plug and terminal 6 on Start/Run/Stop switch. 2. Open circuit between ground terminals on lamp or meters and terminal 1 on remote Start/Run/Stop switch. 3. If battery condition meter works but time meter does not operate, time meter is defective. 4. If time meter works but battery condition meter does not operate, verify that jumper wire is connected between terminals 5 and 6 on remote start/stop switch. If jumper is in place, connect a voltmeter between the positive terminal on battery charge meter and ground. Use the following to determine fault: <ol style="list-style-type: none"> a. If reading equals battery voltage minus 10 volts, battery meter is defective. b. If reading does not equal battery voltage minus 10 volts, zener diode is defective. 	<ol style="list-style-type: none"> 1. Check for continuity and correct if circuit is open 2. Check for continuity and correct if circuit is open 3. Replace time meter 4a. Replace battery condition meter 4b. Replace zener diode

NHEL CONTROL DESCRIPTION

The NHEL generator set control (see Figures 7-4 and 7-5) consists of the following components:

- Printed Circuit Board Assembly
- Panel Mounted Start/Run/Stop Switch (S1)
- Start Solenoid (K1)
- Battery Charger Resistor (R6)
- Optional Remote Start Control
- Stop Relay (K5)
- Blocking Diode (CR5)

The first five components listed for the NHEL control are either the same or similar to the components in the NHE control. Refer to NHE Control in this section and Figure 7-6 for a general description of the printed circuit board assembly, panel mounted Start/Run/Stop switch,

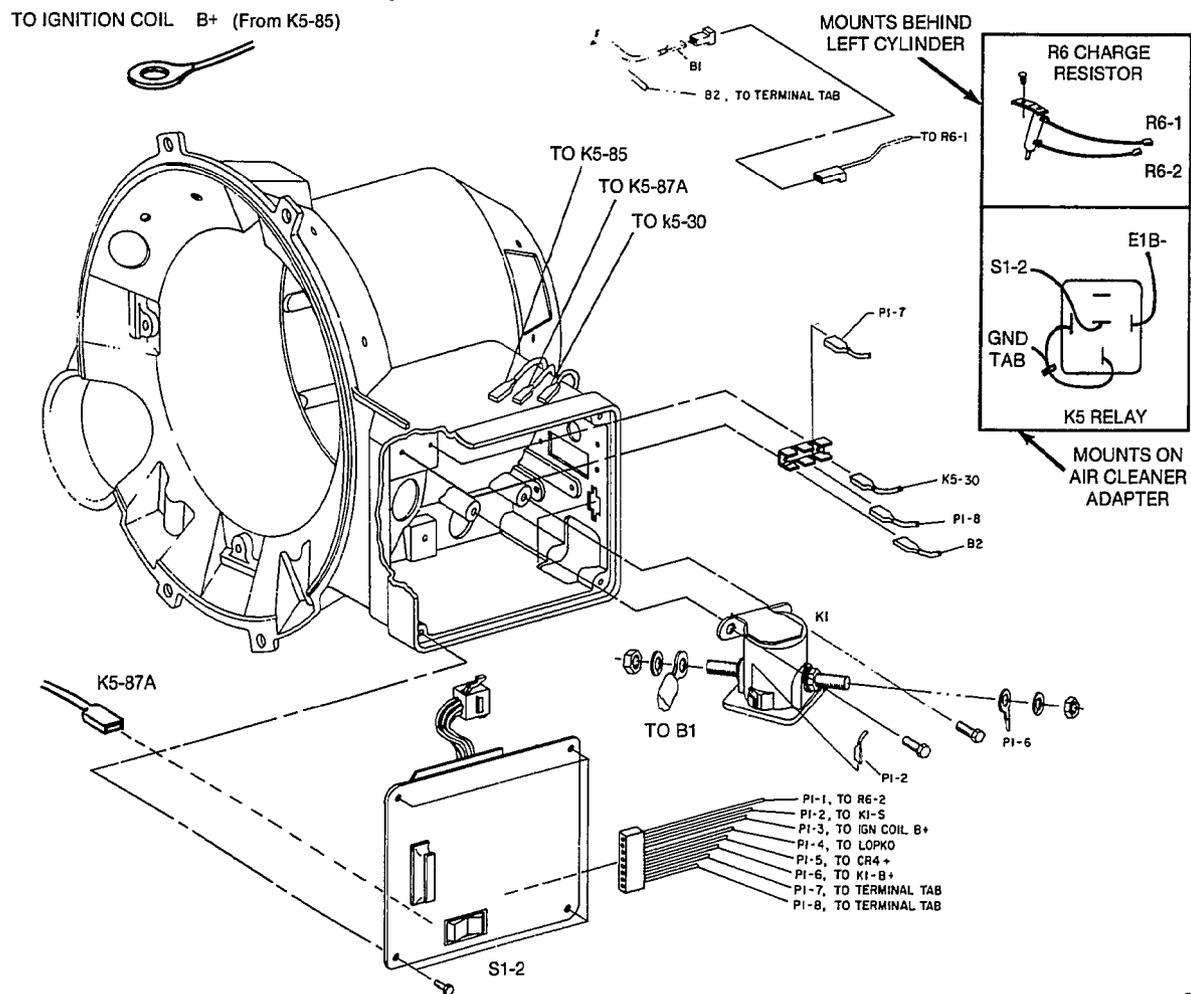
Stop switch, start solenoid, battery charge resistor, and remote start control. The following sections provide a description of the stop relay and blocking diode.

Stop Relay (K5)

The K5 stop relay is used to latch off the generator set when the Start/Run/Stop switch (S1) is placed in the Stop position. This prevents the set from restarting when the switch is momentarily placed in the Stop position and then released. The K5 relay mounts on the air cleaner adapter.

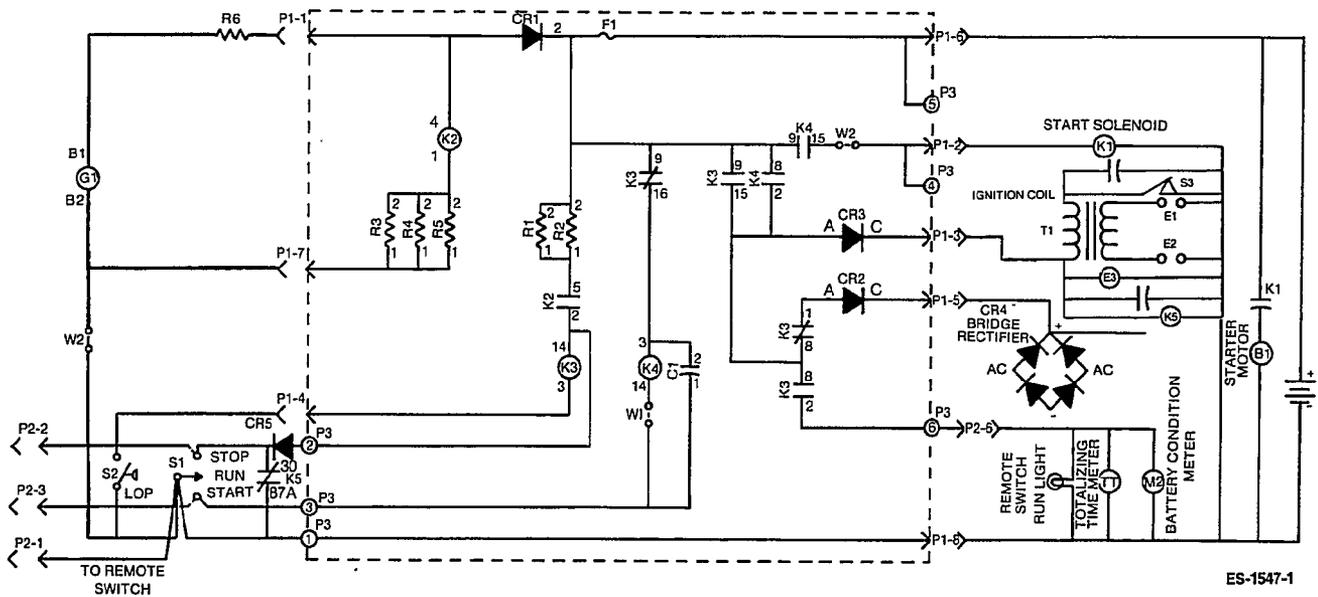
Blocking Diode (CR5)

The CR5 blocking diode is used to protect the control circuitry from reverse-flow transient currents. When the set is shut down, various magnetic fields within the generator collapse. This causes transient currents that can damage the control if not blocked. The CR5 diode is spliced into the control wiring harness between the circuit board assembly and Start/Run/Stop switch.



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FIGURE 7-4. NHEL CONTROL



- | | |
|------------------------------------|----------------------------|
| S1-Start/Run/Stop switch | E1-Spark plug |
| S2-Low oil pressure cut-out switch | E2-Spark plug |
| S3-Breaker points | E3-Fuel solenoid |
| CR1-Power rectifier | R6-Battery charge resistor |
| CR4-Field rectifier | K1-Start solenoid |
| F1-Fuse | K2-Generator relay (AC) |
| B1-Starter motor | K3-Run relay |
| G1-Generator | K4-Start relay |
| | K5-Stop relay |

FIGURE 7-5 TYPICAL CONTROL SCHEMATIC - LP GAS

NHEL CONTROL OPERATION

This operation description applies to NHEL series generator sets. The schematic diagram shown in Figure 7-5 is intended as an example to help follow the circuit description. Always refer to the specific wiring diagram that corresponds to the model and spec number of the generator set when troubleshooting problems.

Starting

Placing the Start/Run/Stop switch in the Start position connects battery ground (B-) to the K4 start relay. This energizes the K4 relay which closes two sets of contacts (K4 2,8 and K4-9, 15) that connect battery positive (B+) to the generator field windings (CR4+), T1 Ignition coil, E3 fuel solenoid valve, K5 stop relay, and K1 start solenoid. Connecting B+ as described produces the following control responses:

- Flashes the field to ensure that there is adequate residual magnetism to induce voltage build up.
- Energizes the ignition coil (T1) so it can begin producing an ignition spark when the breaker points open and close.

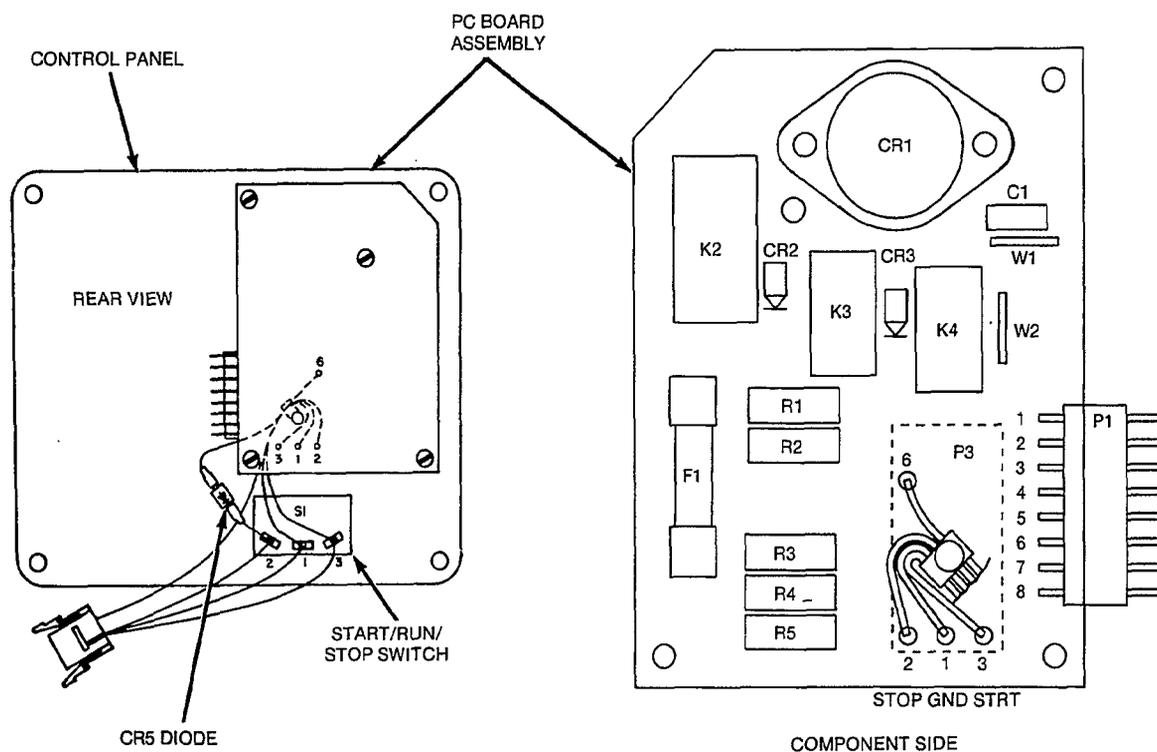
- Energizes the fuel solenoid valve (E3) which opens to allow fuel to flow to the carburetor.
- Energizes the K5 stop relay to open the K5 contacts.
- Energizes the K1 start solenoid to close the K1 contacts.

Opening the K5 stop relay contacts opens the circuit that holds the K3 run relay grounded. This allows the K3 relay to energize when connected to B+.

Closing the K1 start solenoid contacts connects B+ to the starter motor. This energizes the starter motor which begins to crank the engine to initiate starting.

Starter Lock-Out - Run

When the engine starts, the low oil pressure switch (S2) closes to connect battery ground (B-) to the K3 run relay. As the engine comes up to speed, AC output voltage from the generator is supplied to the K2 generator relay. This energizes the K2 relay which closes one set of contacts (K2-2,5) that connects B+ to the K3 run relay. This energizes the K3 relay which opens two sets of contacts and closes two sets of



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FIGURE 7-6 NHel CONTROL PANEL ASSEMBLY

contacts to produce the following control responses:

- Closing the K3-9,15 contacts (which parallel the K4-2,8 contacts) provides an alternate path way for supplying B+ to the T1 ignition coil and fuel solenoid valve.
- Opening the K3-1,8 contacts disconnects B+ (CR4 positive terminal) from the generator field windings.
- Closing the K3-2,8 connects B+ to the run light, time meter, and battery condition meter.
- Opening the K3-9,16 contacts disconnects B+ from the K4 start relay causing it to de-energize.

De-energizing the K4 relay opens the K4-2,8 and K4-9,15 relay contacts. Opening the K4-2,8 contacts has no effect since they are in parallel with the closed K3-9,15 contacts which connect B+ to the ignition coil and the fuel solenoid. Opening the K4-9,15 contacts disconnects B+ from the K1 start solenoid. De-energizing the K1 start solenoid disconnects B+ from the starter motor which stops cranking.

When the S1 switch is placed in the RUN position, the engine continues to run. Relays K2 (generator relay), K3 (run relay), and K5 (stop relay) are energized while relays K1 (start solenoid) and K4 (start relay) are de-energized. Generator voltage is rectified to DC by the CR1 power rectifier and supplied to the battery through the charge resistor (R6). This charges the battery at a constant rate (1 ampere maximum) during set operation.

Stopping

Placing the Start/Stop/Run switch (S1) in the Stop position grounds the K3 run relay. This de-energizes the K3 relay which opens the K3-2,8 and K3-9,15 relay contacts to disconnect B+ from the ignition coil, fuel solenoid, run light, meters, and K5 solenoid. De-energizing the K5 relay closes the K5-30, 87A contacts which holds the K3 relay grounded. This prevents the set from restarting if the S1 switch is released from the Stop position.

Without ignition or fuel, the engine stops. As the generator output voltage drops, the K2 generator relay also de-energizes. All components return to their de-energized position following set shut-down. CR1 prevents the battery from discharging through the generator windings while the set is stopped.

NHEL CONTROL TROUBLESHOOTING

Use the troubleshooting guide to help locate problems related to the NHEL control. Figures 7-4 and 7-6 show the location of most of the control components. Refer to the wiring diagram in Figure 7-5 for location of all terminal connections.

The troubleshooting guide is divided into six sections. After identifying the problem, refer to the guide for the possible cause and the recommended corrective action.

TRUBLESHOOTING THE NHEL CONTROL

Trouble	Possible Cause	Corrective Action
<p>Engine Does Not Crank</p>	<ol style="list-style-type: none"> 1. If engine cranks at set but not at remote control panel, fault is due to: <ol style="list-style-type: none"> a. open circuit in remote control wiring b. remote start switch faulty 2. If engine cranks at remote control panel but not at set, fault is due to: <ol style="list-style-type: none"> a. open circuit in wiring between S1 switch and PC board b. faulty S1 switch 3. Insufficient voltage for cranking due to: <ol style="list-style-type: none"> a. battery not charged b. terminal connections loose or dirty 4. Control fuse (F1) is open 5. Connect a voltmeter between terminal S on the start Solenoid and ground. Check for battery voltage when S1 is placed in Start position. If voltage is present, fault is due to: <ol style="list-style-type: none"> a. K1 relay not grounded, b. defective K1 relay c. defective starter 6. If voltage is not present as described in step 5 test, fault is due to: <ol style="list-style-type: none"> a. open circuit between K1 relay and control PC board b. defective control PC board 	<ol style="list-style-type: none"> 1a. Check for continuity and correct if circuit is open 1b. Replace remote start control switch 2a. Check for continuity and correct if circuit is open 2b. Replace S1 switch 3a. Check condition of battery and recharge or replace 3b. Clean and tighten all connections at battery, K1 start solenoid, and starter motor <p>⚠WARNING: <i>Short circuiting the battery cables can cause severe personal injury or death. Disconnect the negative battery (-) cable at the battery terminal before servicing.</i></p> <ol style="list-style-type: none"> 4. Replace fuse (5 ampere) 5a. Tighten solenoid bracket mounting screws 5b. Replace K1 start solenoid 5c. Refer to Electric Starter section for test and service procedures 6a. Check for continuity and correct if circuit is open 6b) Replace control PC board

TROUBLESHOOTING THE NHEL CONTROL

Trouble	Possible Cause	Corrective Action
<p>Engine Cranks But Does Not Start</p>	<ol style="list-style-type: none"> 1. Faulty ignition due to worn or fouled spark plugs, worn ignition points, incorrect ignition timing, or faulty plug wires. 2. Faulty fuel system due to carburetor mixture screws incorrectly adjusted, plugged fuel filter, faulty regulator, or faulty fuel solenoid. 3. Connect a voltmeter between positive (+) terminal on coil and ground. Check for battery voltage when S1 is placed in the Start position. If voltage is not present, fault is due to: <ol style="list-style-type: none"> a. open circuit between coil and control or b. defective control PC board. 	<ol style="list-style-type: none"> 1. Refer to Ignition System section for test and service procedures 2. Refer to Fuel System section for test and service procedures 3a. Check for continuity and correct if circuit is open. 3b. Replace control PC board.
<p>Engine Starts But Stops When Start Switch Is Released</p>	<ol style="list-style-type: none"> 1. Low oil pressure switch not closing due to: <ol style="list-style-type: none"> a. low oil pressure b. open circuit between switch and control, c. defective low oil pressure switch, d. low oil pressure. 2. K5 relay contacts not opening due to: <ol style="list-style-type: none"> a. K5 relay circuit open or b. defective K5 relay. 3. Output voltage from generator not being supplied to control due to: <ol style="list-style-type: none"> a. defective charge resistor. b. open circuit in wiring between generator and control, c. defective bridge rectifier, or d. no output voltage from generator 4. Defective control PC board 	<ol style="list-style-type: none"> 1a. Check oil level and add oil if low 1b. Check for continuity and correct if circuit is open 1c. Replace low oil pressure switch 1d. Refer to Lubrication system section for test and service procedures 2a. Check for continuity and correct if circuit is open 2b. Replace K5 relay 3a. Test R6 charge resistor (2.5 ohm) and replace if defective. 3b. Check for continuity and correct if circuit is open 3c,d. Refer to Generator section for test and service procedures. 4. Replace control PC board

TROUBLESHOOTING THE NHEL CONTROL

Trouble	Possible Cause	Corrective Action
<p>Engine Starts And Runs; Then Stops. Set Restarts Immediately or Set Restarts After Waiting Several Minutes</p>	<ol style="list-style-type: none"> 1. Oil level is low 2. Dirty fuel restricting fuel filter causing filter to freeze up. 3. Breaker points sticking 4. Contaminated fuel. 	<ol style="list-style-type: none"> 1. Check fuel and oil levels and refill as necessary 2. Clean fuel filter. Refer to Fuel System section for service procedures 3. Replace breaker points 4. Refill tank with fresh fuel
<p>Low Battery</p>	<ol style="list-style-type: none"> 1. Weak or discharged battery Generator set charger will not recharge a battery that is in a very low state or charge. 2. Load connected to battery while set is turned off. 3. Disconnect the negative (-) battery cable at the battery and remove control lead P1-6 from the battery positive (+) terminal on the K1 start solenoid. Connect a DC ammeter and 5 ampere fuse in series between the P1-6 lead wire and the stud terminal on the K1 solenoid. With set running, the ammeter should read between 0 and 1 ampere. If meter shows battery is discharging, fault is due to: <ol style="list-style-type: none"> a. defective generator charge winding or b. CR1 power rectifier open. 	<ol style="list-style-type: none"> 1. Connect a separate battery charger to bring battery up to full charge. 2. Turn off load. 3a. Refer to Generator section for testing and service procedures. 3b. Replace control PC board

TROUBLESHOOTING THE NHEL CONTROL

Trouble	Possible Cause	Corrective Action
<p>Run Lamp, Time Meter, or Battery Condition Meter Does Not Operate</p>	<ol style="list-style-type: none"> 1. Open circuit between terminal 6 or remote connector plug and terminal 6 on Start/Run/Stop switch 2. Open circuit between ground terminals on lamp or meters and terminal 1 on remote Start/Run/Stop switch 3. If battery condition meter works but time meter does not operate, time meter is defective. 4. If time meter works but battery condition meter does not operate, verify that jumper wire is connected between terminals 5 and 6 on remote start/stop switch. If jumper is in place, connect a voltmeter between the positive terminal on battery charge meter and ground. Use the following to determine fault: <ol style="list-style-type: none"> a. If reading equals battery voltage minus 10 volts, battery meter is defective. b. If reading does not equal battery voltage minus 10 volts, zener diode is defective. 	<ol style="list-style-type: none"> 1) Check for continuity and correct if circuit is open 2) Check for continuity and correct if circuit is open 3) Replace time meter 4a. Replace battery condition meter 4b. Replace zener diode

Section 8 - Generator

INTRODUCTION

The NHE and NHEL generator sets have a 4-pole, revolving field generator with transformer voltage regulation. All AC load connections are made through long generator lead wires that connect directly to a customer supplied junction box. A circuit breaker provides overcurrent protection for the generator and also functions as an on/off switch in the load circuit.

GENERATOR DESCRIPTION

The generator (see Figure 8-1) consists of the following major components:

- Stator and Housing
- Rotor
- Voltage Regulating Transformer
- Field Current Rectifier
- Brushes
- Wiring Harness

Stator and Housing

During generator set operation, AC current is produced in the windings of the stator. All stators have two AC output windings (T1-T2 and T3-T4) for powering the load and a separate winding (B1-B2) for battery charging. All stators also have two lead wires (S1 and S2) that are used with the voltage regulating transformer.

The stator mounts inside the generator housing and is held in position with four clamps and four cap-screws. A series of air-intake openings in the end of the housing allow cool air to be drawn inside the housing for generator cooling. The housing also provides a mounting point for the starter, rear bearing, brushes, control, fuel pump, and voltage regulating transformer. The complete stator and housing assembly bolts to the engine-to-generator adapter.

Rotor

The 4-pole rotor provides the rotating magnetic field that is required for generating an AC voltage potential in the stator windings. The DC current required for field excitation is supplied through two slip rings that mount on the rotor shaft.

The inner end of the rotor is connected directly to the engine crankshaft using a tapered seat shaft coupling and through-bolt. The slip ring end of the rotor is supported by a single bearing. The bearing fits inside the generator housing bearing.

Cooling airflow for the generator is provided by a centrifugal fan that mounts on the inner end of the rotor shaft. The fan also serves as a mount for the stator ring gear.

Voltage Regulating Transformer

The voltage regulating transformer (see Figure 8-2) helps to provide stable generator output voltage under varying load conditions. Voltage transformers are constructed with two primary windings and a single secondary winding. Each primary winding (H1-H2 and H3-H4) is connected in series with one of the generator AC output windings. The transformer secondary winding is connected in series with the field current circuit. Taps on the secondary allow for field current adjustments.

The voltage regulating transformer mounts on the outside of the generator housing and is enclosed with a special cover. The cover must be in place during operation for transformer cooling.

Field Current Rectifier (CR4)

The CR4 rectifier is a full wave bridge rectifier that is used to rectify a portion of the generator AC output voltage to DC for field excitation. The positive and negative terminals of the rectifier are connected to the generator brushes. The rectifier mounts inside the generator set control and may be accessed by removing the control panel.

Brushes

The brush block assembly consists of a single brush block with two brushes. The brush block mounts inside the generator housing and can be accessed by removing the small plate at the rear of the housing.

Wiring Harness

A separate wiring harness is provided for connecting the generator set to the RV electrical system. All lead wires are stranded copper wire to withstand vibration. The lead wires must be protected with flexible conduit which must be provided by the RV manufacturer. A 3/4 inch conduit elbow is provided to facilitate installation. The load wire conductors are black, the neutral conductors are white, and the ground conductor is green. The exit point for the wiring harness is near the voltage regulating transformer.

GENERATOR OPERATION

Generator operation involves the control, stator, rotor, voltage regulating transformer, brushes, and full wave bridge rectifier. The schematic shown in Figure 8-3 is intended as an example to help follow the generator operating description. Always refer to the specific schematic that corresponds to the model and spec number of the generator set when troubleshooting problems.

When the Start/Run/Stop button is placed in the Start position, the rotating field (rotor) is connected to battery

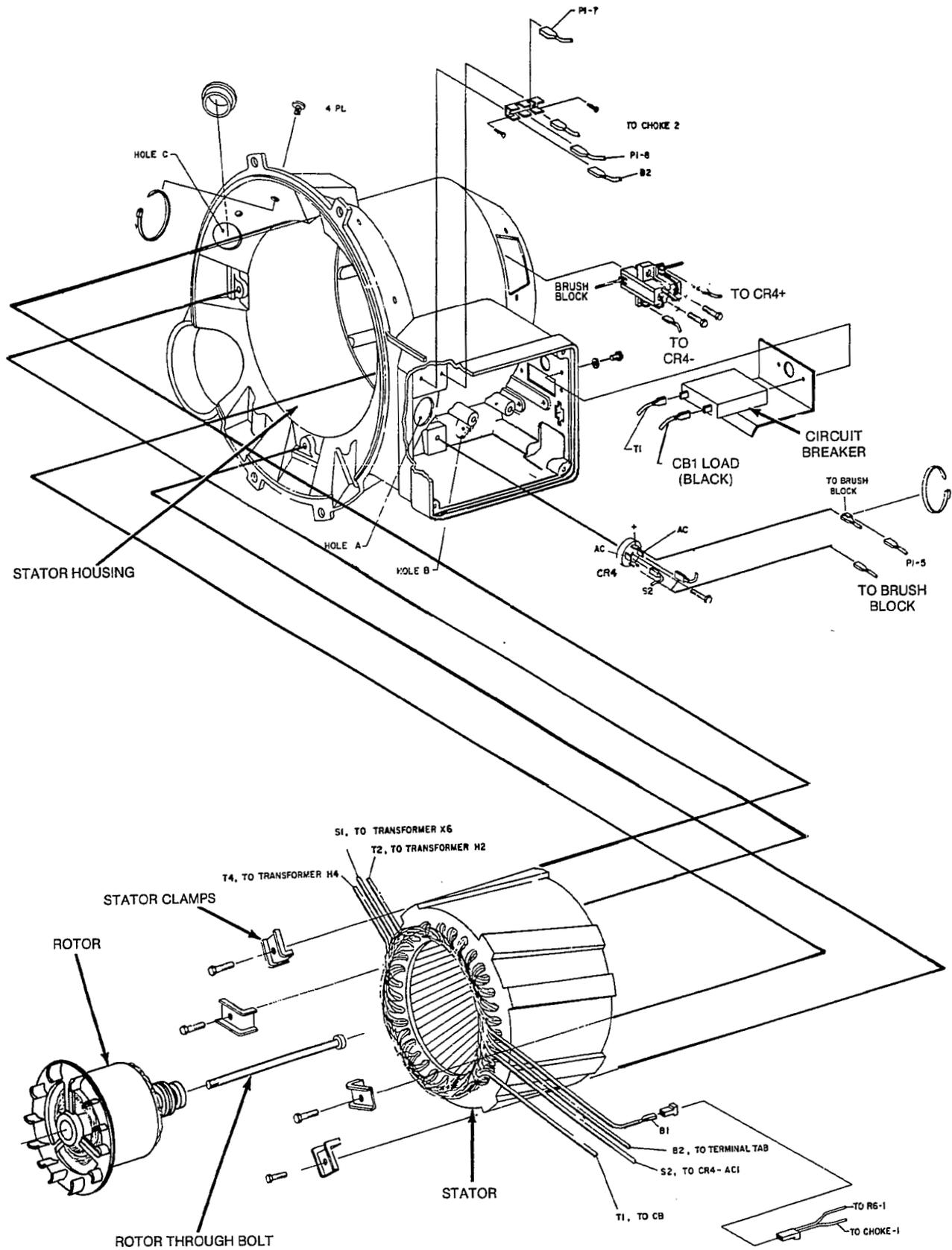


FIGURE 8-1. GENERATOR

positive (B+) to ensure adequate residual magnetism to voltage build-up. As the engine starts and speed increases, the rotating field induces a voltage build-up in the stator windings. A portion of the AC current generated in the stator windings is rectified to DC by the CR4 bridge rectifier. The DC current is supplied to the rotating field windings to create the strong magnetic field required for generating the rated current. The AC voltage build-up stabilizes at approximately 128 volts when the engine reaches governed speed.

To prevent an excessive voltage drop when a load is applied to the generator, a method for regulating the AC output voltage is required. The voltage regulating transformer allows the generator to provide a stable AC output voltage under varying load conditions. Each transformer primary winding (H1-H2 and H3-H4) is connected in series with one of the stator AC output windings. The full AC output current produced by the generator flows through these two primary windings. The secondary winding produces a corresponding increase or decrease in the primary current produced in the secondary winding. The secondary winding is connected in series with the circuit that supplies AC current for rectification to DC field current.

During operation, adding load increases the current flow through the transformer primary windings which causes a corresponding increase in the current output from the

transformer secondary winding. This boosts the DC field current to a higher level to offset the voltage drop that would normally occur when a load is applied. In the same manner, decreasing the load reduces the DC field current to offset the voltage rise that would normally occur when a load is removed. Continuously adjusting the field current as the load changes is how voltage regulation is achieved.

GENERATOR TROUBLESHOOTING

Use the following troubleshooting guide to help locate problems related to the generator. Figures 8-1 and 8-2 show the location of most of the generator components. Refer to the wiring diagram in Figure 8-4 for the location of all terminal connections. The troubleshooting guide is divided into four sections. After identifying the problem, refer to the guide for the possible cause and the recommended corrective action.

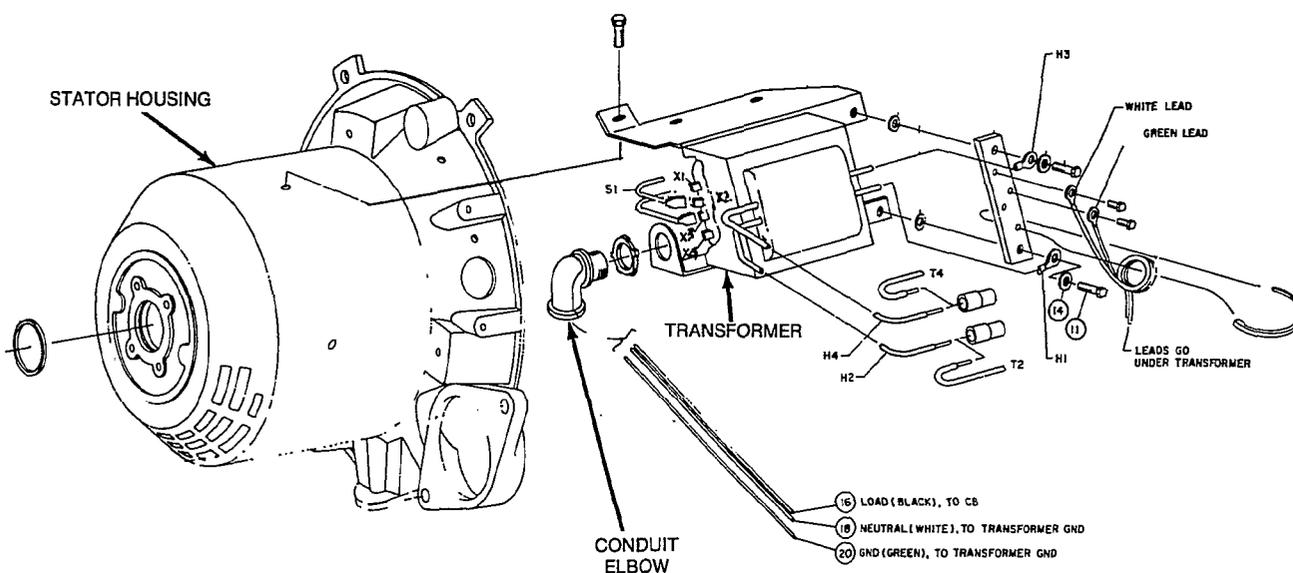
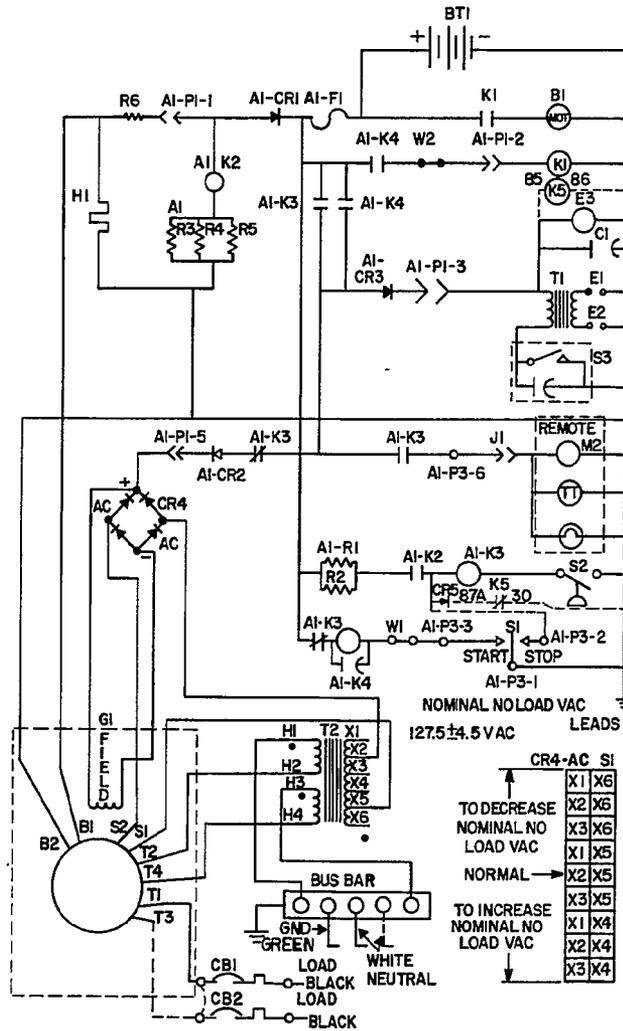


FIGURE 8-2. VOLTAGE REGULATING TRANSFORMER

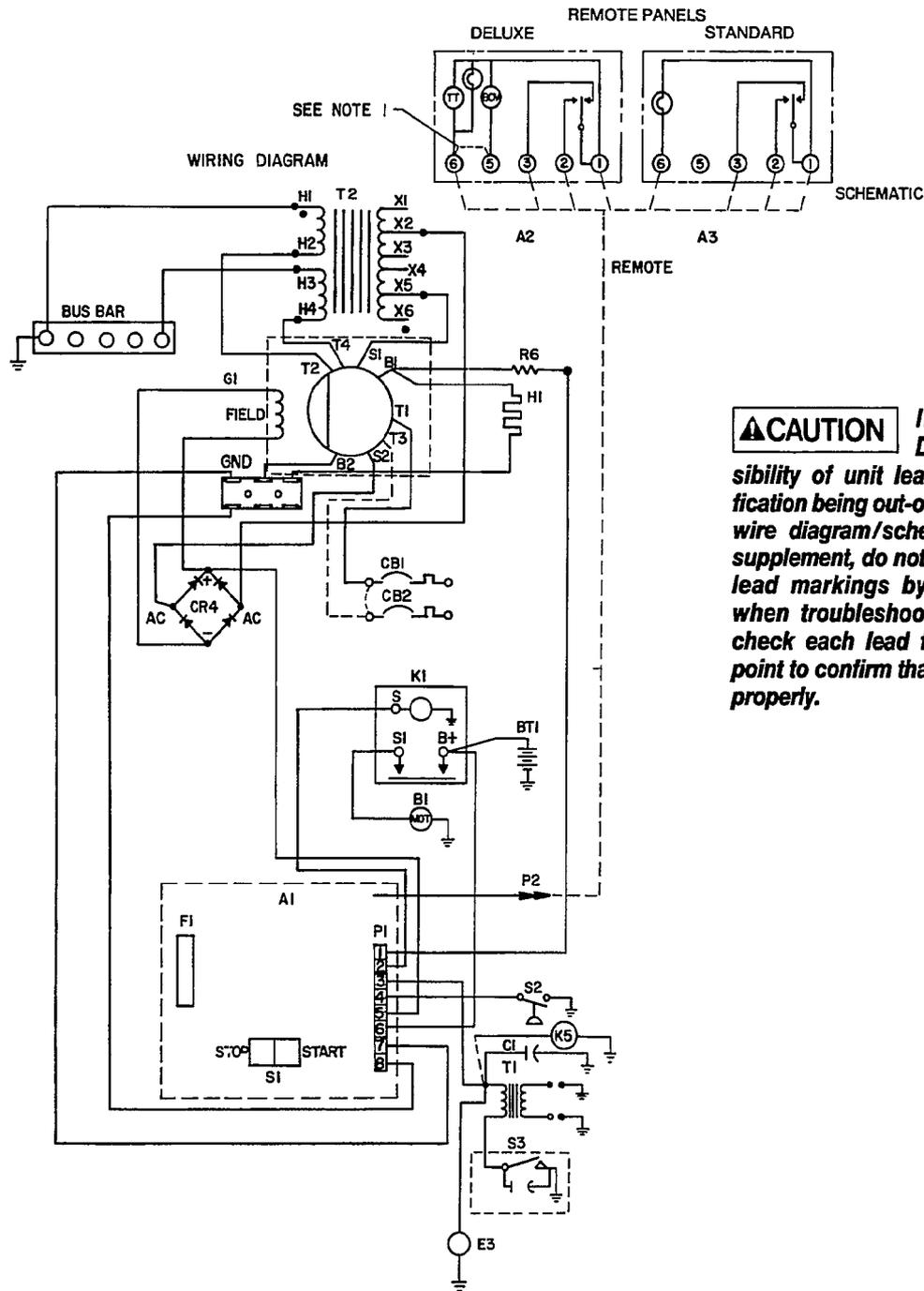


CAUTION **IMPORTANT!**
 Due to the possibility of unit lead end identification being out-of-date with the wire diagram/schematic of this supplement, do not rely solely on lead markings by transformer when troubleshooting. Instead, check each lead from point-to-point to confirm that unit is wired properly.

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- | | | | |
|----|---------------------------------|-------|--------------------------------|
| T2 | TRANSFORMER | E3 | FUEL PUMP/OR FUEL SOLENOID |
| T1 | IGN COIL | E1,2 | SPARK PLUG |
| S3 | IGN POINTS | CB1,2 | CIRCUIT BREAKERS (AC OUTPUT) |
| S2 | SWITCH - LOW OIL PRESSURE | CR4 | BRIDGE RECTIFIER |
| S1 | SWITCH - START STOP | CR5 | RECTIFIER - USED WITH LPG ONLY |
| R6 | RESISTOR - BATTERY CHARGE | C1 | CAPACITOR |
| K5 | RELAY - USED WITH LPG ONLY | BT1 | BATTERY 12V |
| K1 | START SOLENOID | B1 | STARTER |
| H1 | CHOKE - USED WITH GASOLINE ONLY | A3 | STANDARD REMOTE CONTROL |
| G1 | GENERATOR | A2 | DELUXE REMOTE CONTROL |
| F1 | FUSE | A1 | CONTROL ASSY. |

FIGURE 8-3. TYPICAL SCHEMATIC



CAUTION **IMPORTANT!**
 Due to the possibility of unit lead end identification being out-of-date with the wire diagram/schematic of this supplement, do not rely solely on lead markings by transformer when troubleshooting. Instead, check each lead from point-to-point to confirm that unit is wired properly.

611-1174

NOTES:

1 JUMPER IS NEEDED FOR BATTERY CONDITION METER

- | | | | |
|----|---------------------------------|-------|------------------------------|
| T2 | TRANSFORMER | E3 | FUEL PUMP/OR FUEL SOLENOID |
| T1 | IGN COIL | E1,2 | SPARK PLUG |
| S3 | IGN POINTS | CB1,2 | CIRCUIT BREAKERS (AC OUTPUT) |
| S2 | SWITCH - LOW OIL PRESSURE | CR4 | BRIDGE RECTIFIER - |
| S1 | SWITCH - START/STOP | C1 | CAPACITOR |
| R6 | RESISTOR - BATTERY CHARGE | BT1 | BATTERY 12V |
| K5 | RELAY - USED WITH LPG ONLY | BT | STARTER |
| K1 | START SOLENOID | A3 | STANDARD REMOTE CONTROL |
| H1 | CHOKE - USED WITH GASOLINE ONLY | A2 | DELUXE REMOTE CONTROL |
| G1 | GENERATOR | A1 | CONTROL ASSY |
| F1 | FUSE | | |

FIGURE 8-4. TYPICAL WIRING DIAGRAM

TROUBLESHOOTING THE GENERATOR

Trouble	Possible Cause	Corrective Action
<p>No AC Output Voltage</p> <p>Note: This condition may cause the generator set to stop when the Start switch is released.</p>	<ol style="list-style-type: none"> 1. Open circuit breaker 2. Open circuit between brush block and CR4 rectifier. 3. Brushes stuck in holder or not making good contact with slip rings 4. Defective CR4 bridge rectifier 5. Open, grounded, or short circuit in rotor, stator, or transformer 	<ol style="list-style-type: none"> 1) Locate cause of overload and correct as required. Reset breaker 2) Check for continuity and correct if circuit is open 3) Release brushes if jammed in holder. Clean slip rings if dirty. 4) Test rectifier and replace if defective 5) Test each component for open, grounded, or shorted windings and replace if defective.
<p>AC Output Voltage Too Low Or Too High</p>	<ol style="list-style-type: none"> 1. Engine governor incorrectly adjusted *2. Open diode in CR4 bridge rectifier *3. Brushes worn or not making good contact with slip rings 4. If generator frequency is within specified limits but voltage is incorrect, transformer is incorrectly connected or defective. *5. Open, grounded, or short circuit in rotor, stator, or transformer <p>*causes low AC output voltage</p>	<ol style="list-style-type: none"> 1) Refer to Governor section 2) Test CR4 rectifier and replace if defective 3) Check length of brushes and replace if worn excessively. Clean or replace slip rings. 4) Adjust tap connections on transformer secondary windings to obtain correct voltage. Replace transformer if voltage cannot be corrected with adjustments. 5) Test each component for open, grounded, or shorted windings and replace if defective.
<p>Noisy Generator</p>	<ol style="list-style-type: none"> 1. Loose brush holder 2. Worn generator end bearing 3. Rotor and stator rubbing together due to: a) varnish lumps, or b) rotor misaligned with crankshaft 	<ol style="list-style-type: none"> 1) Tighten brush holder 2) Replace end bearing 3a) Check for varnish lumps between rotor and stator and remove as required 3b) Follow specified assembly procedures to correct rotor to crankshaft alignment.

TROUBLESHOOTING THE GENERATOR

Trouble	Possible Cause	Corrective Action
Generator Overheats	<ol style="list-style-type: none">1. Generator overloaded due to defective circuit breaker2. Airflow restricted due to dirt or debris covering vent openings in stator housing3. Stator windings covered with oil or dirt4. Open, grounded, or short circuit in rotor, stator, or transformer	<ol style="list-style-type: none">1) Remove part of load and replace circuit breaker.2) Clear away all dirt or debris as required3) Clean stator windings4) Test each component for open, grounded, or shorted windings and replace if defective.

GENERATOR SERVICE

This section covers generator disassembly and assembly procedures. Refer to Figures 8-1 and 8-2 to locate and identify the various generator components described in each sub-section.

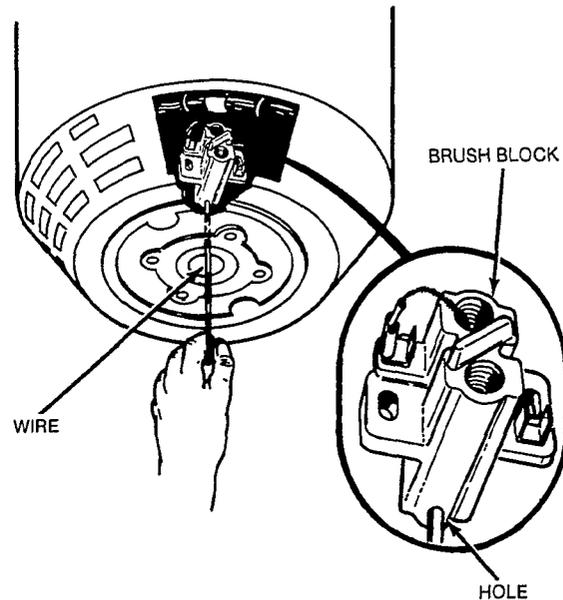
Generator Disassembly

Use the following procedures to disassemble the generator:

1. Drain the engine oil while the generator set is still mounted in the vehicle.
2. Remove the generator set from the vehicle and place it on a sturdy work bench. Refer to Set Removal in Section 5 for the recommended set removal procedures.
3. Remove the flywheel guard (from scroll opening) and the noise shield.
4. The carburetor and intake manifold must be removed to provide clearance for lifting the generator stator assembly. Disconnect the choke heater lead wires, throttle linkage, fuel line, crankcase breather hose, and preheater tube. Remove the intake manifold as an assembly. Refer to Fuel System in Section 6 for detailed removal procedures.
5. Disconnect the lead wires from the charge resistor (quick-disconnect type connections), the low oil pressure cutoff switch, and the B+ terminal on the ignition coil.
6. Remove the brush block cover and disconnect the B+ (outboard) and B- (inboard) lead wires from the brush block terminals.
7. Pull each brush outward from the holder and at the same time insert a piece of stiff wire into the small hole in the end of the stator housing (see Figure 8-5). Carefully guide the wire through the brush block and then release each brush. Verify that each brush is held off the slip rings by the wire.

CAUTION *The brushes will be damaged during disassembly if not held off the slip rings. Make certain wire is in place before removing stator assembly.*

8. Remove the transformer cover and if the set is LP gas fueled, disconnect the fuel line at the vaporizer coupling.
9. Attach the special lifting plate (see Figure 8-6) to the end of the stator housing using four 5/16-18 x 1 capscrews.
10. Place a pad in front of the engine to cushion and protect the scroll. Attach a hoist or other suitable lifting device to the lifting plate. Lift the set as shown in Figure 8-6 until it is completely vertical and resting on the scroll. Remove lifting plate when complete.
11. Remove the capscrew and two EIT lock washers that secure the ground strap to the drip pan.
12. Remove the three vibration isolator center screws from the underside of the drip pan and lift away from

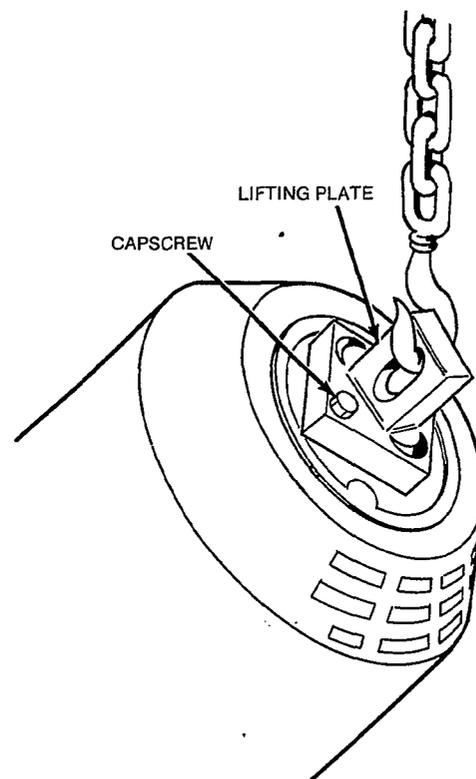


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FIGURE 8-5. BRUSH BLOCK

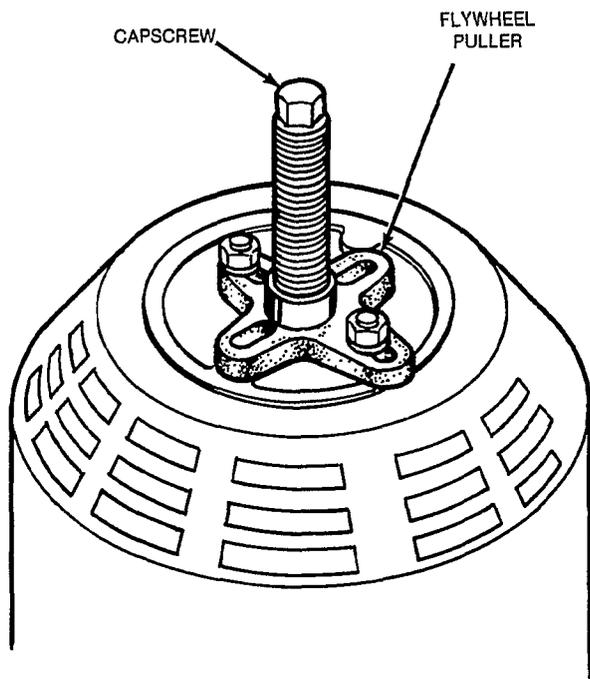
the drip pan.

13. Remove the four capscrews, lock washers, and nuts that secure the stator housing to the engine-to-generator adapter.
14. Install a puller on the end of the stator housing as



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FIGURE 8-6. GENERATOR SET LIFT



G-1177

FIGURE 8-7. STATOR ASSEMBLY REMOVAL

shown in Figure 8-7. Use two 5/16-18 x 1 capscrews to secure the puller to the housing. Tighten puller center screw against rotor through-bolt until housing lifts free of rotor and end bearing. Remove puller when complete.

15. Carefully lift the stator assembly straight up until it clears the rotor.

CAUTION Careless handling of the stator can damage the insulation on the stator windings. Do not brush the stator windings against the rotor as it is lifted clear.

16. Place a 3/8 inch allen wrench in the head of the rotor through-bolt. Using a rubber mallet, sharply strike the allen wrench so the through-bolt is driven in a counterclockwise (viewed from generator end) direction. Several sharp taps should break loose the through-bolt.
17. Remove the rotor through-bolt and in its place install the tool shown in Figure 8-8. Use a screwdriver to turn the rotor tool in a clockwise direction until it bottoms. Install a 9/16-12 x 2 capscrew in the end of the rotor shaft and tighten until rotor breaks loose from crankshaft. Remove capscrew from end of rotor when complete.
18. Carefully lift the rotor assembly off the end of the engine crankshaft and remove rotor tool.
19. Remove the brush block mounting screws and carefully lift out the brush block assembly.

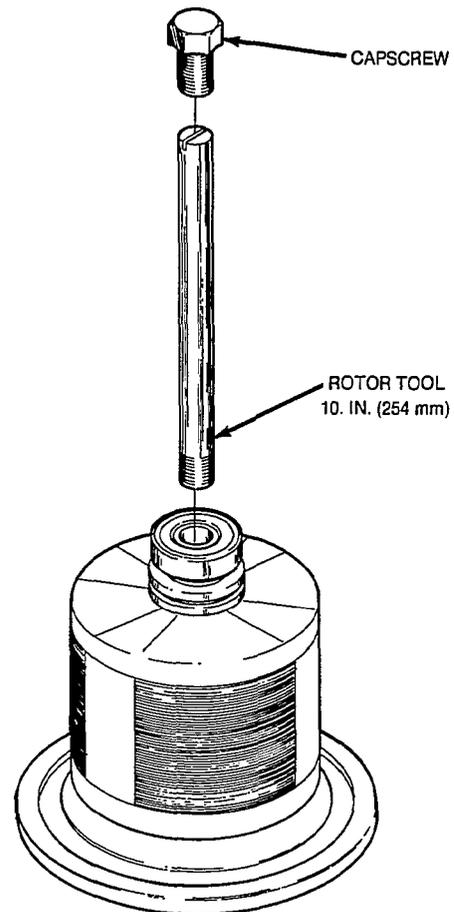
20. Use the following procedure to remove transformer from housing:

- A. Remove the braided insulating material from the transformer primary lead wire (T2-H2 and T4-H4) connections.
- B. Cut off the crimped barrel connectors and separate the transformer primary leads from the stator leads.
- C. Disconnect the lead wires from the transformer secondary taps.
- D. Remove the four screws that secure the transformer to the stator housing and lift off the transformer assembly.

CAUTION The transformer air gap can be altered if the mounting bracket is removed from the transformer. Do not loosen or remove any screws that pass through the transformer laminations.

21. Use the following procedure to remove the stator from the stator housing.

- A. Remove stator lead wires from the transformer primary leads and secondary taps as described in steps 20A through 20C.



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FIGURE 8-8. ROTOR TOOL

- B. Cut off the wire ties that secure the stator lead wires to the inside of the housing.

Cut only wire ties, not the tie supports.

- C. Remove the four stator clamps and capscrews.
- D. Carefully lift the stator straight up until it clears the stator housing.

CAUTION Careless handling of the stator can damage the insulation on the stator windings. Do not brush the windings against the housing as it is lifted clear.

Use the following procedures to assemble the generator:

- 1. If the stator was removed from the housing during disassembly, use the following procedures to install the stator in the housing:

- A. Position the stator so the output leads are oriented as shown in Figure 8-1; then carefully lower the stator into the stator housing.

CAUTION Careless handling of the stator can result in damage to the stator windings. Do not brush the stator windings against the housing as it is lowered into position.

- B. Install the four clamps and capscrews that secure the stator to the housing. Tighten capscrews to specified torque.
- C. Route stator lead wires through holes in stator housing as specified in Figure 8-1. Fasten wiring harness to inside of housing using wire ties.

- D. If transformer was not removed during disassembly, follow step 2c through 2e to connect stator output leads to transformer.

- 2. If the transformer was removed from the stator housing during disassembly, use the following procedures to install the transformer on the stator housing.

- A. Hold transformer in position for mounting on the stator housing. Install the two mounting screws and tighten securely.

- B. Connect the CR4-AC lead wire to the transformer X2 tap and the S1 lead wire to the transformer X5 tap. Note: This is a preliminary connection that may require adjustment to obtain the correct generator output voltage. See Transformer Voltage Adjustment section.

- C. Strip off 1/2 inch (13 mm) of insulation from the ends of transformer primary leads H2 and H4 and from stator leads T2 and T4.

- D. Twist each stator lead around the end of the corresponding transformer primary lead (T2 to H2 and T4 to H4). Place a #6 uninsulated barrel connector over the lead ends and crimp tightly using a #6 staking tool.

CAUTION Wire nuts or other non-crimp type connectors can loosen during set operation. Use only the specified connector and crimping tool when connecting stator leads to transformer primary tools.

- E. Slide a 2-1/2 inch (64 mm) long piece of braided insulation over each connection as shown in Figure 8-9. Use a wire tie to hold

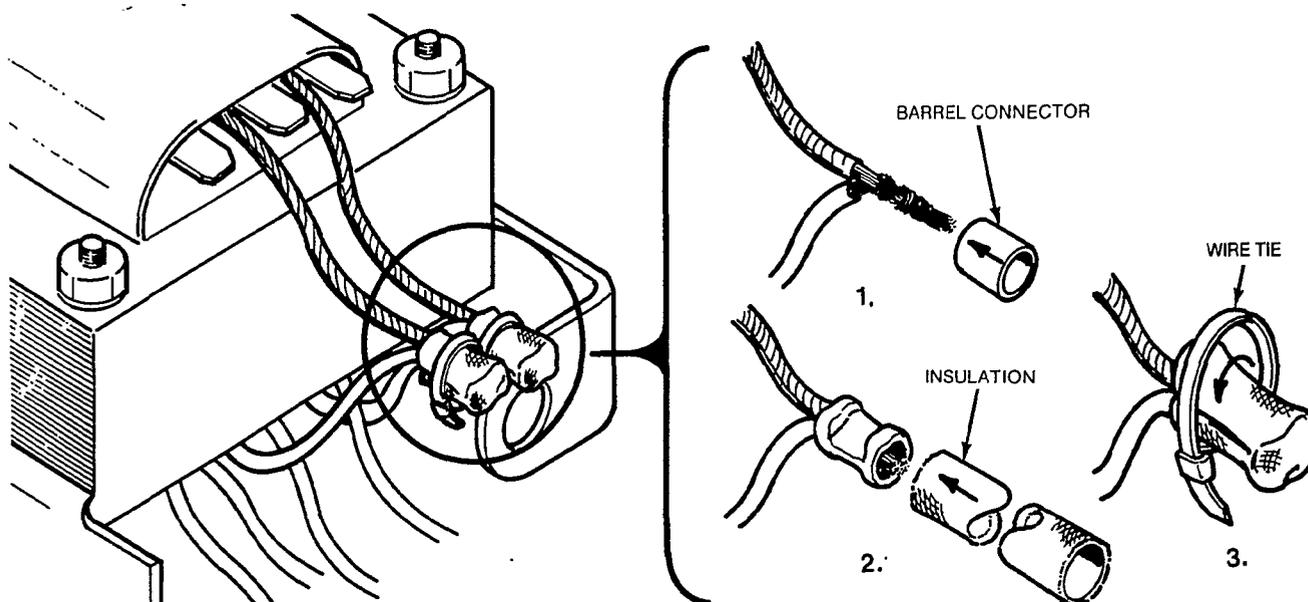


FIGURE 8-9. BRAIDED INSULATION

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insulation securely in place.

3. Pull each brush outward from the brush holder and at the same time insert a stiff piece of wire through the small holes in the base of the holder. The wire holds the brushes off the slip rings during assembly. Install brush block in housing and tighten mounting screws.
4. Place the rotor in position for mounting on the end of the crankshaft and install rotor through-bolt. Tighten through-bolt just enough to hold rotor in place.

▲CAUTION *Tightening the rotor through-bolt to specified torque before the stator assembly is installed can cause rotor shaft misalignment. Follow recommended installation procedures to avoid any possibility of shaft misalignment.*

5. Carefully lower the stator assembly over the rotor and into position for assembly to the engine. The rotor end-bearing should fit snugly into the bearing bore hole.

▲CAUTION *Careless handling of the stator can result in damage to the stator windings. Do not brush the stator windings against the rotor as it is lowered into position.*

6. Install the four nuts, locking washers, and capscrews that secure the stator housing to the engine-to-generator adapter. Tighten capscrews to specified torque. Note that each locking washer is installed under capscrew head.
7. Tighten the rotor through-bolt to the specified torque.
8. Hold the drip pan in position for mounting to the underside of the set and install the three vibration isolator center screws. Tighten the rear (generator end) center screws to the specified torque.
9. Secure ground strap to drip tray using a capscrew and two EIT locking washers. Note that ground strap is installed between locking washers to insure a good electrical connection.
10. Attach the special lifting plate (see Figure 8-6) to the end of the stator housing using four 5/16-18 x 1 capscrews.
11. Attach a hoist or other suitable lifting device to the lifting plate. Carefully tilt the set back until it is resting on the drip tray. Remove lifting plate when complete.
12. Remove the piece of wire that is holding the brushes off the slip rings. Check the brushes to verify that they are centered on the slip rings. If brushes are not centered, loosen the brush block mounting screws and adjust. Retighten mounting screws when complete.
13. Connect the B+ lead wire to the outboard brush terminal and the B- lead wire to the inboard brush

terminal. Install brush block cover and tighten cover mounting screws.

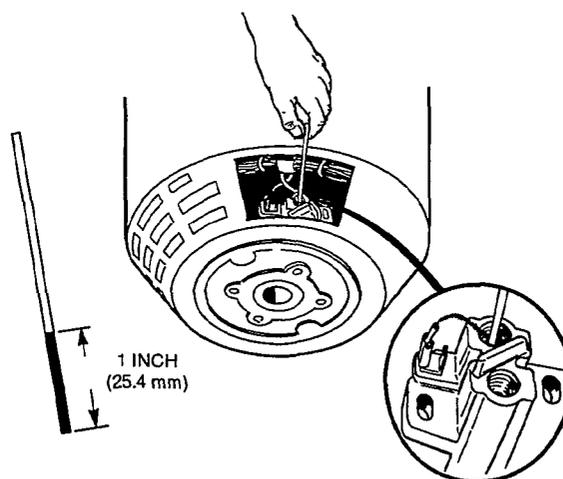
14. Connect the appropriate lead wires to the charge resistor, low oil pressure cut-off switch, and ignition coil B+ terminal.
15. Place new intake manifold gaskets on the engine block and install the carburetor and intake manifold assembly. Tighten the intake manifold screws to the specified torque. Connect the pre-heater tube, crankcase breather hose, fuel lines, throttle linkage, and choke heater wires. Refer to Fuel System Section 6 for detailed assembly procedures.
16. Install the noise shield, flywheel guard, and transformer cover.
17. Install the generator set in the vehicle and securely fasten all mounting screws and hardware. Connect the fuel, exhaust, and electrical systems in reverse order of disassembly. Refer to Set Removal Section 5.
18. Fill crankcase with oil of the recommended classification and viscosity.

BRUSHES AND SLIP RINGS

This section covers brush replacement and slip ring service.

Brush Replacement

Remove the brush block cover and inspect the brushes and brush holder for burn marks or other damage. If the brushes appear to be in good condition, use a piece of wire (modified as shown in Figure 8-10) to check for excessive brush wear. Insert the wire into the hole above each brush. Make sure the wire is resting on the brush and not on part of the spring. If the painted part of the wire is **not**, brush is

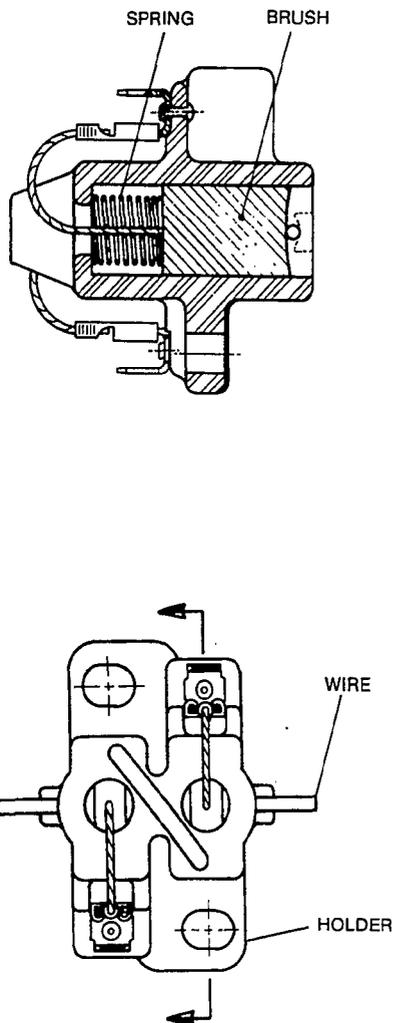


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FIGURE 8-10. CHECKING BRUSH WEAR

excessively worn and must be replaced. Always replace the brush springs when installing new brushes to insure that proper tension is maintained. Use the following procedure to replace the brushes.

1. Disconnect the negative (-) battery cable at the battery terminal.
2. Remove the air cleaner cover and air cleaner filter element.
3. Disconnect the B+ (outboard) and B- (inboard) lead wires from the brush block terminals.
4. Remove the brush block mounting screws and lift out the brush block.
5. Remove brushes and brush springs from holder and replace with new parts.
6. Pull each brush outward from the brush holder and at the same time insert (see Figure 8-11) a stiff wire through the small holes in the base of the



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FIGURE 8-11. BRUSH REPLACEMENT

holder. The wire holds the brushes off the slip rings during disassembly.

7. Install brush block in housing but do not tighten mounting screws.
8. Remove the wire that is holding the brushes off the slip rings by pushing it out through the hole in the end of the stator housing. Adjust brush block so that brushes are centered on the slip rings and then tighten mounting screws.
9. Connect the B+ lead wire to the outboard brush terminal and the B- lead wire to the inboard brush terminal.
10. Install brush block cover and tighten mounting screws.
11. Install air filter element and air cleaner cover.
12. Connect negative (-) battery cable to battery terminal.

Slip Ring Service

Remove the brush block cover and inspect the slip rings for grooves, pits, or other damage. If the slip rings are not in good condition, they may be refinished using a commutator stone. Use the following procedure to service:

1. Remove the air cleaner cover and air cleaner filter.
2. Disconnect the lead wires from the brush block terminals and then insulate the lead wire ends. Tie the lead wires to one side to allow clear access to the slip rings.
3. Remove the brush block mounting screws and lift out the brush block.
4. Remove K1-S lead wire from the S terminal on the K1 start solenoid. Connect a pushbutton type switch (normally open) in series between the K1-S lead wire and the S terminal on the K1 start solenoid.
5. Place a jumper wire between remote connector plug terminals 1 and 3.
6. Press the pushbutton switch to crank the engine and then release switch as soon as the engine starts.
7. Hold commutator stone (Onan tool #420-0259) against rotating slip rings until carbon is removed and all grooves or roughness is smoothed out.

⚠WARNING *Contact with rotating machinery can cause severe personal injury. Keep hands and fingers clear while servicing slip rings.*

8. Remove jumper wire from remote connector plug.
9. Remove insulating material from ends of brush lead wires and then install brush block. Follow steps 5 through 10 in Brush Replacement in this section.

TRANSFORMER VOLTAGE ADJUSTMENTS

The generator output voltage may be adjusted by changing the connections to the transformer secondary taps. This is necessary if the set voltage falls outside the recommended voltage range when operating at the specified frequency. Use the following procedures to adjust the generator output voltage:

1. Adjust the governor as specified in the Governor section before making adjustments to the transformer.
2. Check the generator voltage with the warmed-up set operating at no load and 62 hertz frequency. The nominal voltage should be 127.5 ± 4.5 volts AC.
3. Stop the set and adjust the transformer tap connections as shown in Table 8-1 to increase or decrease the voltage as required.
4. Repeat the voltage check and continue to make adjustments until voltage is within range specified.
5. Check the no load and full load voltage and frequency as specified under Governor in Section 6. Voltage and frequency should stay within the limits shown in Table 8-1.

GENERATOR TESTING

This section covers the test procedures for the stator, rotor, transformer, and CR4 bridge rectifier.

Field Voltage Test

To check the field voltage, remove the brush block cover and connect a DC voltmeter to the brush block terminals. Connect the positive lead to the B+ (outboard) terminal and the negative lead to the B- (inboard) terminal.

**TABLE 8-1.
TRANSFORMER TAP CONNECTIONS**

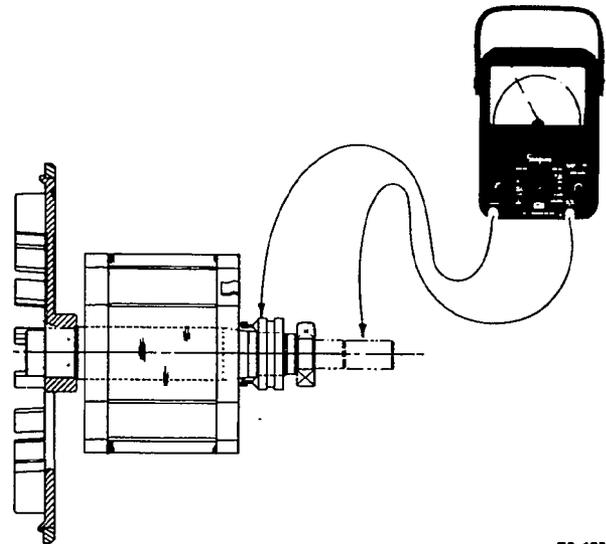
VOLTAGE ADJUSTMENT	CR4-AC TO	S1 TO
To Increase Voltage	X3	X4
	X2	X4
	X1	X4
	X3	X5
Standard Setting	X2	X5
To Decrease Voltage	X1	X5
	X3	X6
	X2	X6
	X1	X6

Start the generator set and allow it to stabilize. Measure the field voltage with no load applied and then with full load applied. Both readings should fall within a range of 18 to 60 volts DC. Remove test leads and replace brush block cover when test is complete.

Rotor Test

The rotor can be tested for grounded, open, or shorted windings using an ohmmeter. Figures 8-12 and 8-13 show the rotor removed from the generator for testing. However, it is possible to test the rotor without removing it from the generator. To obtain access to the slip rings, remove the brush block cover. Use a stiff wire to hold the brushes off the slip rings during testing. Refer to Brushes and Slip Rings in this section for the procedures to use for inserting the wire.

Ground Test: To test for grounds, set the ohmmeter for the highest resistance scale. Touch one test prod to the rotor shaft and hold it there. Touch the other test prod to one of the slip rings. A reading less than one megohm indicates the rotor is grounded. Replace a grounded rotor with a new rotor.



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FIGURE 8-12. TESTING ROTOR FOR GROUNDS

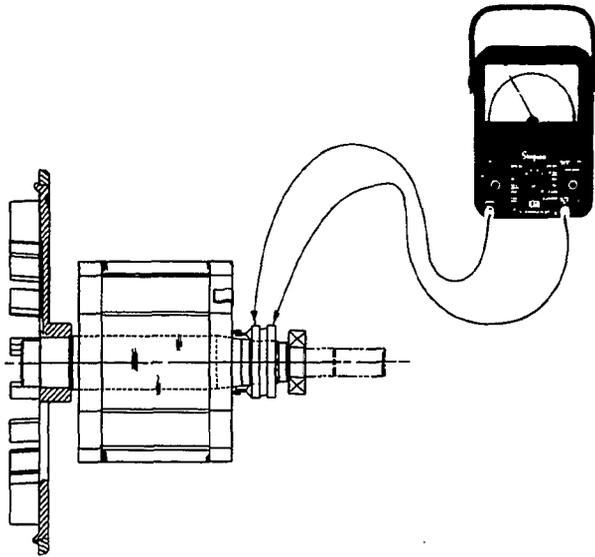
Open or Shorted Windings Test: To test for open windings, set the ohmmeter for the highest resistance scale. Place test prods on the slip rings as shown in Figure 8-12. Ohmmeter should indicate continuity between slip rings. A high resistance reading indicates a poor connection or an open winding. Check the connection between the slip rings and rotor lead wires. Replace rotor if rotor winding is open.

**TABLE 8-2
RESISTANCE VALUES FOR ROTORS**

KW	STACK LENGTH	RESISTANCE*
6.5	4.72 in. (120 mm)	10.6 ohm ($\pm 10\%$)

*At 77°F (25°C)

To test for shorted windings, set the ohmmeter for the lowest scale. Place the test prods on the slip rings as shown in Figure 8-12. A reading less than the value shown in Table 8-2 indicates shorted windings. Replace a rotor with shorted windings with a new rotor.



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FIGURE 8-13 TESTING ROTOR FOR OPENS OR SHORTS

Stator/Transformer Test

The stator and transformer can be tested for grounded or open windings using an ohmmeter. Testing for shorted windings requires a digital-type ohmmeter that can read to within 0.01 ohms.

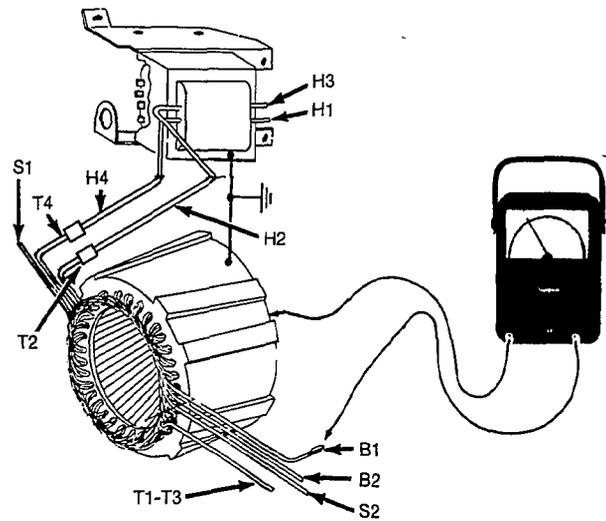
Figures 8-14 and 8-15 show the stator and transformer removed from the generator for testing. However, it is possible to test both components without removing them from the generator. Remove the control panel and transformer cover to obtain access to the specified lead wires during testing.

Ground Test: To test for grounds, disconnect the following transformer and stator leads.

- Stator lead S1 from tap X2
- Stator lead T1 from CB1
- Stator lead T3 from CB2 :
- Stator lead S2 from CR4-AC1

- Stator lead B1 from R6-1/H1-1 lead wire
- Stator lead B2 from ground tab
- Transformer lead H1 from ground
- Transformer lead H3 from ground
- CR4-AC2 lead wire from tap X5

Insulate or position the lead wire ends so they are not touching the generator set housing. Set the ohmmeter for the highest resistance scale and then connect one test prod to the generator housing. Touch the other test prod (see Figure 8-14) to the leads specified in Table 8-3. A reading less than one megohm indicates a ground.



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FIGURE 8-14. TESTING STATOR AND TRANSFORMER FOR GROUNDS

**TABLE 8-3
GROUND TEST FOR
STATORS AND TRANSFORMERS**

LEADS	LOCATION
T1	Stator
T3	Stator
B1	Stator
X1	Transformer

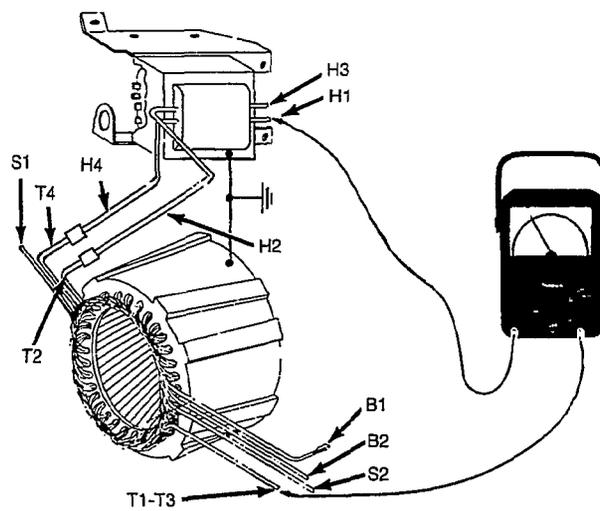
If the T1-T3 lead is grounded, the source of the ground could be either the stator windings or the transformer primary windings. To isolate, disconnect the transformer primary leads from the stator leads (T2 from H2 and T4 from H4). Touch the test prod to T1-T3, H2, and H4 to identify the grounded component. Replace a grounded stator or transformer with a new part.

Open or Shorted Windings: To test for opens, disconnect the transformer and stator leads as specified in the Ground Test section. Set the ohmmeter for the lowest resistance scale and then connect the test prods (see Figure 8-15) to the leads specified in Table 8-4. The ohmmeter should indicate continuity between lead ends. A high resistance reading indicates an open winding.

If the open circuit is between T1 or T3 and one of the transformer primary lead wires (H1 or H3), the source of the open could be either the stator windings or the transformer primary windings. To isolate, disconnect the transformer primary leads from the stator leads (T2 from H2 or T4 from H4). Test each winding separately as specified in Table 8 to locate the source of the open. Replace the stator or transformer if test indicates an open winding.

To test for shorted windings, use a digital-type ohmmeter that reads to within 0.01 ohms. Disconnect the transformer and stator leads as specified in Ground Test in this section. Connect the test prods (see Figure 8-15) to the stator/trans leads as specified in Table 8-4. A reading less than the value shown in Table 8-4 indicates shorted windings.

If the low reading is between T1-H1 or T3-H3, the source of the short could be either the stator windings or the transformer windings. To isolate, disconnect the transformer primary leads from the stator (T2 from H2 and T4 from H4). Test each winding separately as



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FIGURE 8-15. TESTING STATOR AND TRANSFORMER FOR OPENS OR SHORTS

specified in Table 8-4 to locate the short. Replace the stator or transformer if test indicates a shorted winding.

Due to the low resistance of the transformer primary windings, a milliohmmeter (or equivalent) must be used for accurate measurements.

CR4 Bridge Rectifier Test

The CR4 bridge rectifier can be tested using an ohmmeter. Remove the two AC leads and the positive (+) and negative (-) leads from the rectifier terminals. Connect one of the test prods to one of the AC terminals and the other test prod to the positive (+) terminal. Observe the reading on the ohmmeter and then reverse the test prod connections. Observe the second reading and compare with the first reading. A good rectifier will have a higher reading in one direction. If both readings are the same, the rectifier is defective and must be replaced. Repeat test procedure with test prod connected to other AC terminal and with test prod connected to negative (-) terminal. Replace lead wires when test is complete.

**TABLE 8-4
RESISTANCE VALUES
FOR STATORS AND TRANSFORMERS**

kW	STACK LENGTH	TEST WINDING	RESISTANCE* (± 10%)
6.5	4.61 IN (117 mm)	STATOR TRANS	
		T1 to H1	0.240 ohm
		T3 to H3	0.240 ohm
		B1 to B2	0.049 ohm
		X1 to X6	0.578 ohm
		STATOR ONLY	
		T1 to T2	0.240 ohm
		T3 to T4	0.240 ohm
		TRANS ONLY	
		H4 to H3	0.009 ohm
H2 to H1	0.009 ohm		

*At 77° F (25° C)

Section 9 - Engine Block Assembly

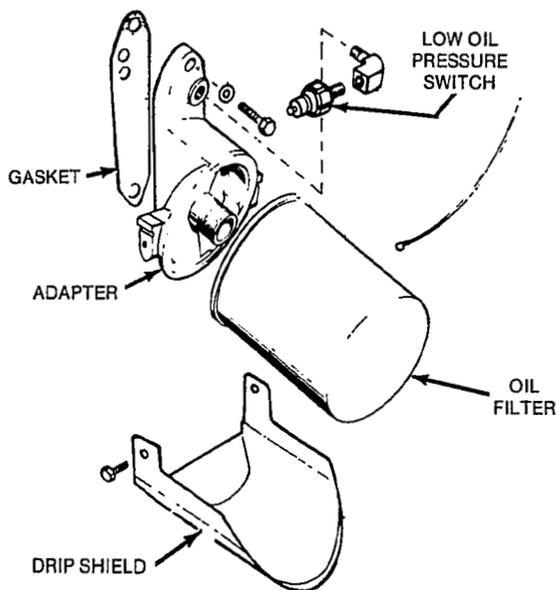
GENERAL

The engine block assembly includes the pistons and connecting rods, crankshaft, camshaft, valves and lifters, cylinder heads, lubrication system, timing gears, governor mechanism, bearings, and cylinder block. Performing any major service on the block assembly will require that the generator set be removed from the coach (see Set Removal in Section 5). In addition, to gain complete access to the block assembly, the control, generator, and all primary engine systems must also be removed. Refer to the previous sections for the disassembly and removal procedures.

OIL FILTER AND ADAPTER

Open the oil drain valve and drain the crankcase oil. Remove the filter (see Figure 9-1) by turning counter-clockwise with a filter wrench. The low oil pressure cut-off switch is installed in a threaded hole in the filter adapter and may be removed if required. Loosen the two capscrews that secure the adapter to the engine block and remove the adapter and gasket.

Assembly is the reverse of disassembly. Use a new adapter gasket and install so the two small oil holes are aligned with the oil holes in the block. Gasket should be installed dry. Coat the threads of each capscrew with non-hardening sealer and tighten to recommended torque.



LS-1111

FIGURE 9-1. OIL FILTER AND ADAPTER

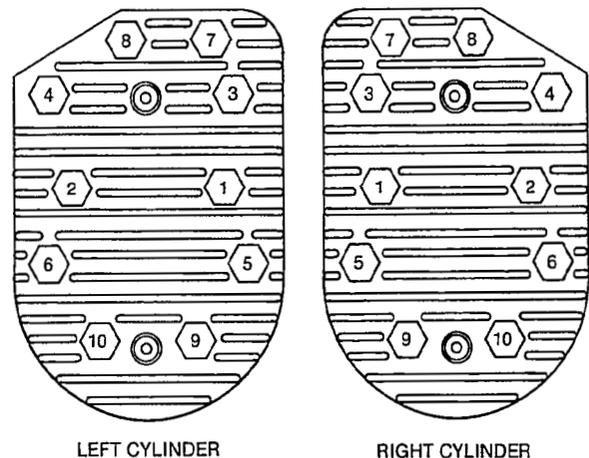
CYLINDER HEADS

Remove the cylinder heads for cleaning when poor engine performance is noticed. Use the following procedures to service.

1. Use a 1/2 inch socket wrench to remove the cylinder head bolts or stud nuts and lift off the head.

CAUTION *Warpage can occur if the heads are removed while hot. Wait until engine has cooled before removing heads.*

2. After removing heads, clean out all carbon deposits. Be careful not to damage the outer sealing edges where gaskets fit. The heads are made of aluminum and can be damaged by careless handling.
3. Use new head gaskets and clean both the heads and the cylinder block thoroughly where the head gaskets rest.
4. Place 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.
5. Place heads in position and follow head torque tightening sequence shown in Figure 9-2. Begin by tightening all nuts to 5 ft-lbs (7 N•m). Then, tighten all nuts to 10 ft-lbs (14 N•m), etc., until all nuts are tightened to the torque listed under Torque Specifications in Section 4.



LEFT CYLINDER

RIGHT CYLINDER

M-1479

FIGURE 9-2. CYLINDER HEAD TIGHTENING SEQUENCE

▲WARNING Asbestos gaskets contain fibers that when airborne harm your health. Use a respirator when handling and installing gaskets.

6. After the head nuts have been tightened once, it is necessary to tighten each head nut to the specified torque a second time. Follow the same sequence shown in Figure 9-2. Failure to re-torque could result in a blown head gasket.
7. Recheck torque before engine has run a total of 50 hours.

VALVE SYSTEM

A properly functioning valve system is essential for good engine performance. All generator sets utilize an L-head type valve design as shown in Figure 9-3. Access to the valve system can be obtained by removing the cylinder heads and the valve covers on top of the engine. A valve spring compressor must be used to remove valves (see Figure 9-4) from the cylinder block. Use the following procedures to inspect and service the valve system.

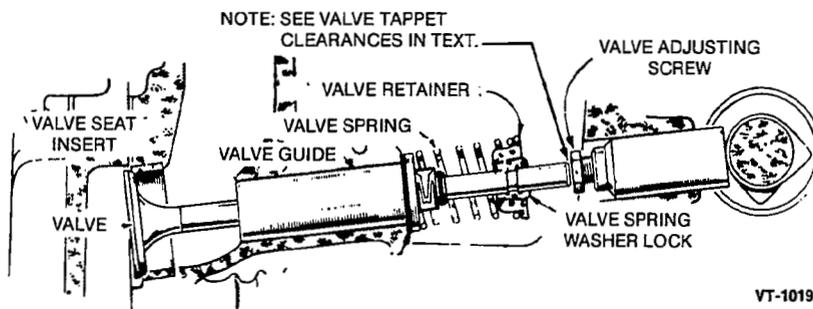


FIGURE 9-3. VALVE SYSTEM

Inspection

Valve Face: Check the valve face for evidence of burning, warpage, out-of-round, and carbon deposits (Figure 9-5).

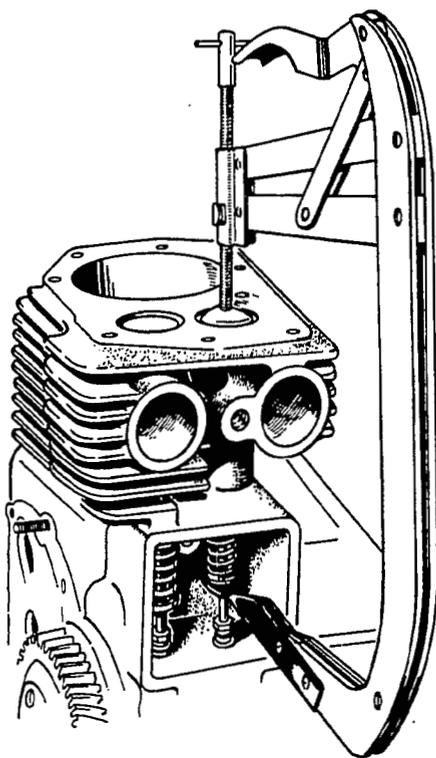


FIGURE 9-4. VALVE SPRING COMPRESSOR

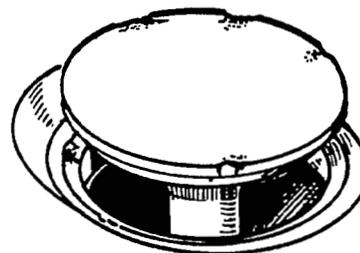


FIGURE 9-5. VALVE FACE

Burning and pitting are caused by the valve failing to seat tightly. This condition is often caused by hard carbon particles on the seat. It may also be due to weak valve springs, insufficient tappet clearance, warpage, and misalignment.

Warpage occurs chiefly in the upper stem due to its exposure to intense heat. Out-of-round wear follows when the seat is pounded by a valve whose head is not in line with the stem and guide. If a valve face is burned or warped, or the stem worn, install a new one.

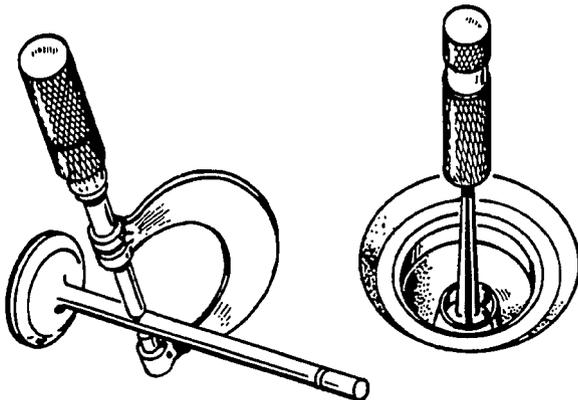
Too much clearance in the intake guide admits air and oil into the combustion chamber, upsetting carburetion, increasing oil consumption, and making heavy

carbon deposits. Carbon prevents heat dissipation. Clean metal is a good heat conductor but carbon insulates and retains heat. This increases combustion chamber temperatures which causes warping and burning.

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

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.

Stems and Guides: Always check valve stems and guides for wear as shown in Figure 9-6. Use a hole gauge to measure the valve guide. When clearance with stem exceeds original clearance by 0.002 inch (0.05 mm), replace either valve or guide or both, as may be necessary. Always regrind seat to make concentric with the newly installed guide.



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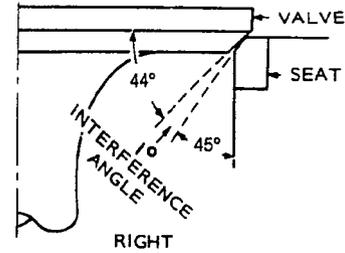
FIGURE 9-6. VALVE STEM AND VALVE GUIDE INSPECTION

Spring: Check valve springs for cracks, worn ends, distortion and tension. If spring ends are worn, check valve spring retainer for wear. Check for spring distortion by placing spring on a flat surface next to a square. Measure height of spring and rotate it against square edge to measure distortion. Check spring tension at the installed height for both the valve open and closed position using an accurate valve spring tester. Replace any valve spring that is weak, cracked, worn or distorted.

Reconditioning Valves and Valve Seats

The interference angle method of valve seating is used on all generator set engines. With this method, different seat and face angles are used and line contact between the valve face and seat occurs.

The valve face angle is 44 degrees. The valve seat angle is 45 degrees. This 1-degree interference angle results



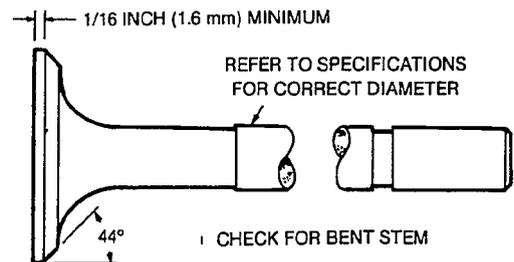
VT-1021

FIGURE 9-7. VALVE INTERFERENCE ANGLE

in a sharp seating surface between the valve and the top of the valve seat (see Figure 9-7).

The valves should not be hand lapped because the sharp contact will be destroyed. This is especially important where chrome cobalt faced valves and seats are used. Valve faces must be finished in a machine to 44 degrees.

Every valve must have a minimum of 1/16 inch (1.6 mm) margin, Figure 9-8. If the valve has less margin than this, it will heat up excessively. It will retain that heat during the compression stroke and preignite the mixture, causing loss of power and economy. This valve is also susceptible to warping and breakage.



VT-1022

FIGURE 9-8. VALVE MARGIN

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

Valve seats should be ground with a 45-degree stone and the width of the seat band should be 1/32-inch to 3/64-inch (0.79 to 1.2 mm) wide. Grind only enough to assure proper seating.

Place each valve in its proper location. Check each valve for a tight seat. Make several marks at regular intervals across the valve face using machinists bluing. Observe if the marks rub off uniformly when the valve is rotated part of a turn against the seat. The valve seat should

contact the valve face evenly at all points. The line of contact should be at the center of the valve face.

Valve Guide Replacement

Worn valve stem guides can be replaced from inside the valve chamber (a seal is provided behind the intake valve guides only). The smaller diameter of the tapered valve guides must face toward the valve head. Tappets are also replaceable from the valve chamber after first removing the valve assemblies.

Removal: Before removing valve guides, use an electric drill with a wire brush to remove carbon and other foreign material from top surface of guides. Failure to perform this operation may result in damage to the guide bores. Drive the guides out with a hammer and valve guide driver.

CAUTION Driving out old guides can damage the tapped bores. Be careful not to strike bores with driver.

Installation: Run a small polishing rod with crocus cloth through valve guide holes to clean out carbon

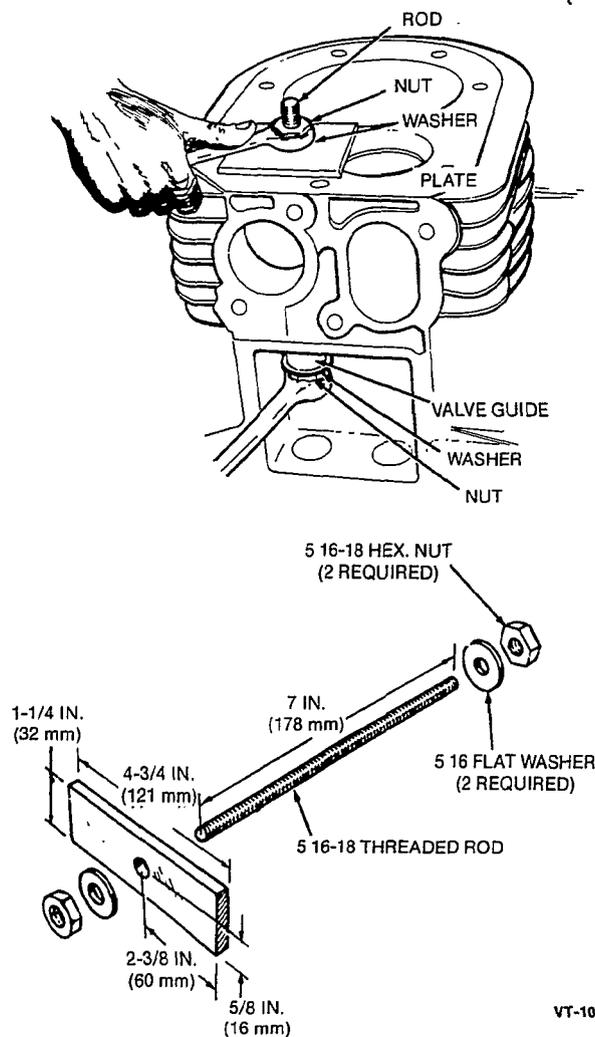


FIGURE 9-9. VALVE GUIDE INSTALLATION

and other foreign materials. Place a new gasket on the intake valve guide and coat the outer edge of each new guide with oil. Place guide, notch up, in cylinder block and press in until shoulder of guide rests against the cylinder block. A suggested method of installation is shown in Figure 9-9.

Valve Seats

Inspect valve seat inserts. If seats are loose, cracked, or severely pitted, new inserts must be installed. Remove valve seat inserts using a valve seat removal tool.

Removal: Remove carbon and combustion deposits from valve seat. 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 (see Figure 9-10). Using the new seat insert as a guide, adjust the puller depth. Position the puller on the valve seat and tighten hex nut. Clamp cylinder block to a solid bench. Attach slide hammer to puller. Between blows with the slide hammer, tighten the hex nut.

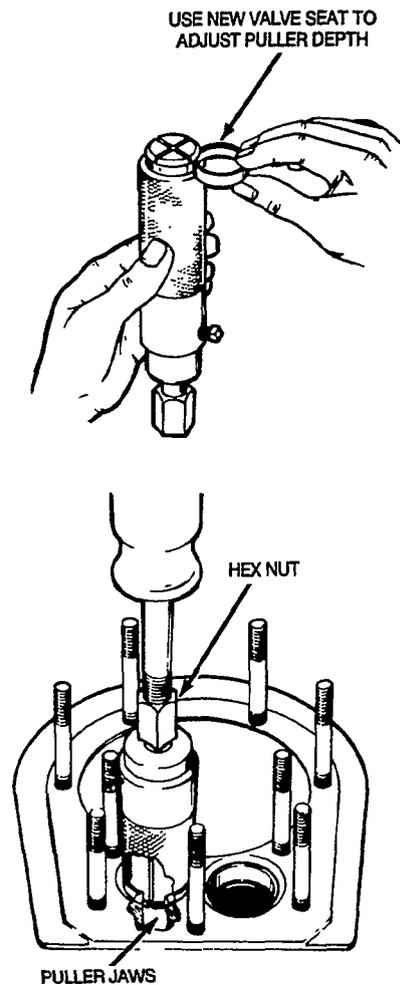


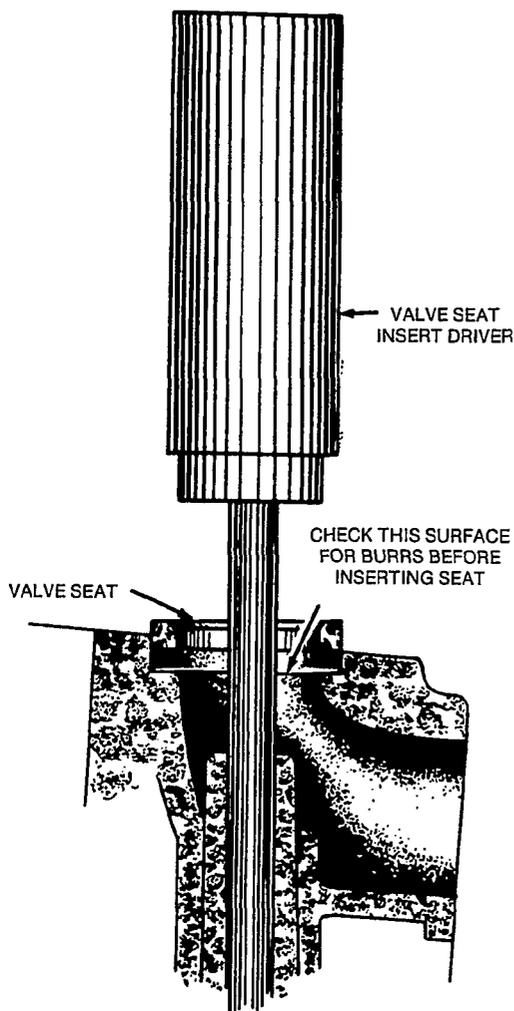
FIGURE 9-10 REMOVING VALVE SEAT

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

Insert the pilot of the tool into the valve guide hole in the cylinder block. Quickly drive in the valve seat insert 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 around its complete circumference (see Figure 9-11).

The valve seat must be staked to assure a tight fit and eliminate the danger of its loosening in the bore. Refinish valve seat inserts before installing valves.

Insert valve seat staker in the cylinder block valve guide hole. Rotate the staking tool until it drops to the original stake marks. Rotate staking tool another 60 degrees (1/6 turn). Using a lead hammer, strike the staking tool a sharp blow to wedge the new valve seat securely in place.



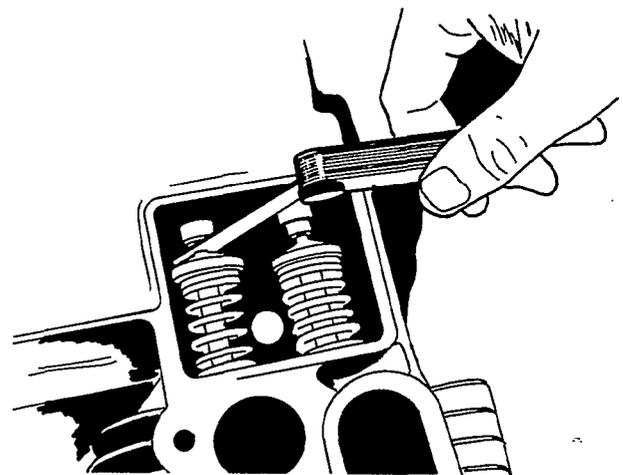
VT-1025

FIGURE 9-11. INSERTING NEW VALVE SEAT

Tappet Adjustment

The engine is equipped with adjustable valve tappets. Adjust the valve clearance only when engine is at ambient temperature. Proceed as follows:

1. Remove all parts necessary to gain access to valve tappets.
2. Remove spark plugs to make turning the engine easier.
3. Place a socket wrench on the flywheel capscrew and rotate the crankshaft in a clockwise direction until the left intake valve (viewed from flywheel end) opens and closes. Continue turning the crankshaft until the TC mark on the flywheel is lined up with the TC mark on the gear cover. This should place the left piston (#1) at the top of its compression stroke. Verify that the left intake and exhaust valves are closed and there is no pressure on the valve lifters.
4. Clearances are listed under Specifications in Section 2. For each valve, the gauge should just pass between the valve stem and valve tappet (see Figure 9-12).



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FIGURE 9-12. VALVE CLEARANCE ADJUSTMENT

5. To correct the valve clearance, turn the adjusting screw as needed to obtain the right clearance. The screw is self-locking.
6. To adjust valves on the right cylinder, turn engine one complete revolution and again line up mark on the flywheel and the TC mark on the gear cover. Then follow adjustment procedure given for left cylinder.
7. Replace all parts removed. Tighten all screws securely. Torque manifold bolts.

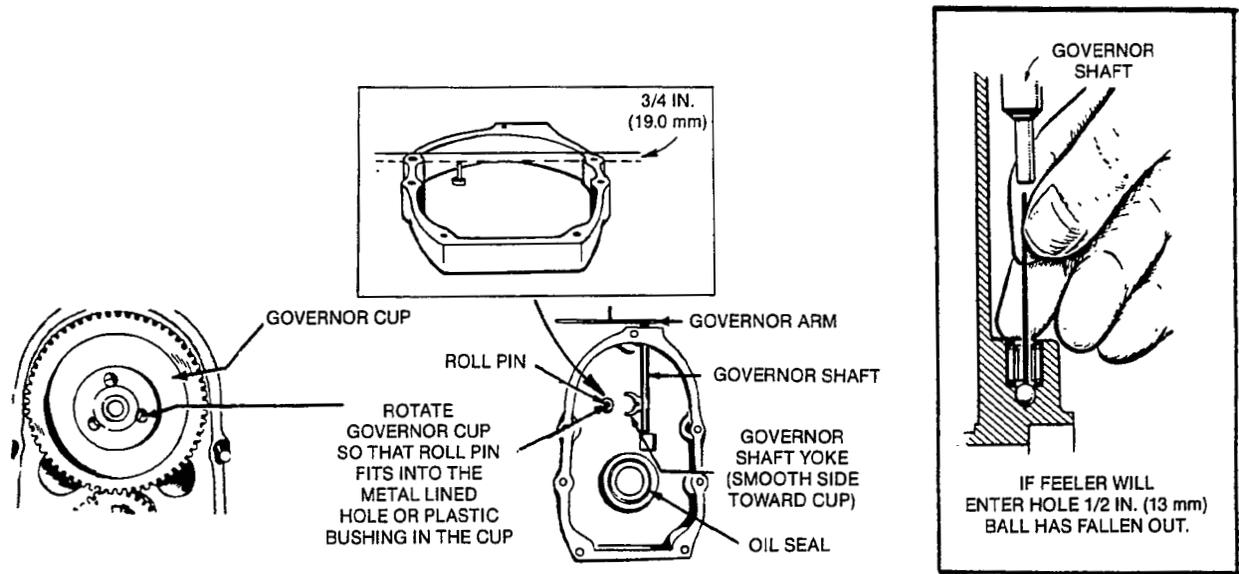


FIGURE 9-13. GEAR COVER ASSEMBLY

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GEAR COVER

Remove the flywheel key and gear cover mounting screws. Gently tap the gear cover with a plastic-faced hammer to loosen it (see Figure 9-13).

When installing the gear cover, make sure that the pin in the gear cover engages the nylon lined (smooth) hole in the governor cup. Turn the governor cup so that the nylon lined hole is at the three o'clock position. Use a small amount of grease to assist in holding governor cup in position. The rounded side of the governor yoke must ride against the governor cup. Turn the governor arm and shaft clockwise as far as possible and hold in this position until the gear cover is installed flush against the crankcase. Be careful not to damage the gear cover oil seal.

Refer to Oil Seals in this section if replacing the gear cover oil seal.

GOVERNOR CUP

With the gear cover removed, the governor cup can be taken off after removing the snap ring from the camshaft center pin, Figure 9-14. Catch the flyballs while sliding the cup off.

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

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

The camshaft center pin extends out 3/4-inch (19 mm) from the end of the camshaft. This distance provides an in and out travel distance of 7/32-inch (5.6 mm) for the governor cup, as illustrated. Hold the cup against the flyballs when measuring. If the distance is less, the engine may race, especially at no load. Remove the center pin and press in a new pin

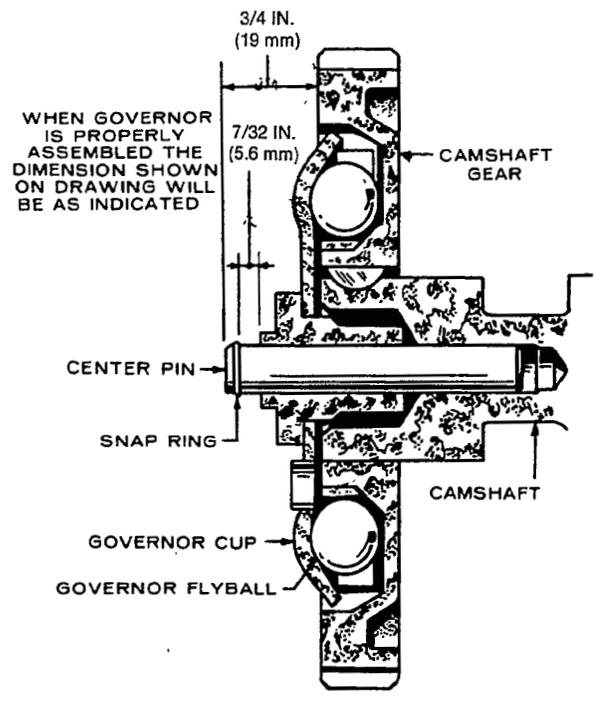


FIGURE 9-14. GOVERNOR CUP

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the specified amount. Do not hammer the new pin into place or it will be damaged. The camshaft center pin cannot be pulled outward nor removed without damage. If the center pin extends out too far, the cup will not hold the flyballs.

TIMING GEARS AND CAMSHAFT

If replacement of either the crankshaft gear or the camshaft gear becomes necessary, it is recommended that both gears be replaced.

To remove the crankshaft gear, first remove the snap ring and retainer washer; then attach the gear pulling ring using two No. 10-32 screws (Figure 9-15). Tighten the screws alternately until both are tight. Attach a gear puller to the puller ring and remove the gear.

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

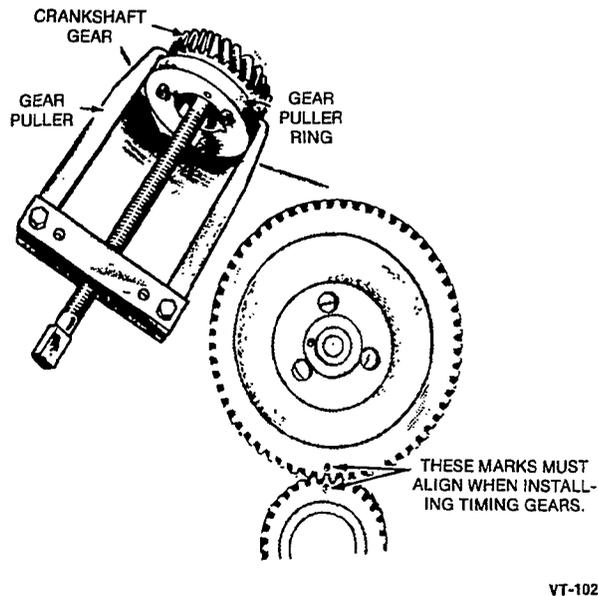


FIGURE 9-15. TIMING GEAR REMOVAL AND INSTALLATION

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

LUBRICATION SYSTEM

All generator set engines use an oil pump to provide a constant flow of oil to the engine parts. The oil supply collects in the oil base where it is picked up by the oil pump pick-up cup. A by-pass valve is used to control oil pressure. Drain the oil before removing the oil base and always use a new gasket when replacing the oil base.

Oil Pump

The oil pump (Figure 9-16) is mounted on the front of the crankcase behind the gear cover and is driven by the crankshaft gear. The inlet pipe and screen assembly is attached directly to the pump body. A discharge passage in the cover of the pump registers with a drilled passage in the crankcase. Parallel passages distribute oil to the front main bearing, rear main bearing and pressure control bypass valve.

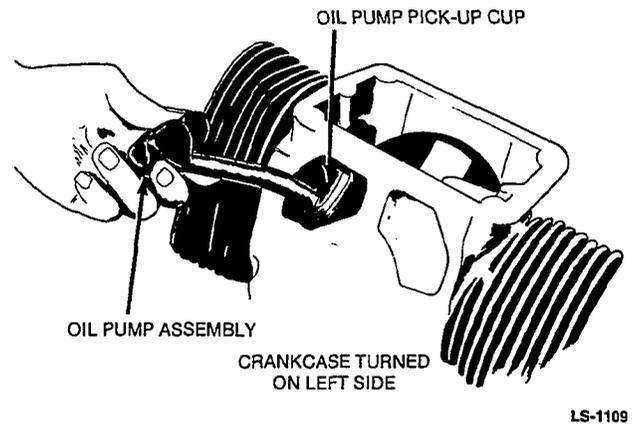


FIGURE 9-16. OIL PUMP ASSEMBLY

Circumferential grooves in the main bearings supply oil to the connecting rod bearings through drilled passages from each main journal. A drilled passage connects the front main bearing oil supply to the front camshaft bearing. The oil overflow from the bypass valve furnishes lubrication to the camshaft drive gears.

Normal oil pressure should be 30 psi (207 kPa) or higher when the engine is at normal operating temperature. If pressure drops below this value at governed speed, inspect the oil system for faulty components.

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

Oil By-Pass Valve

The by-pass valve (located to the right and behind gear cover, Figure 9-17) controls oil pressure by allowing excess oil to flow directly back to the crank-

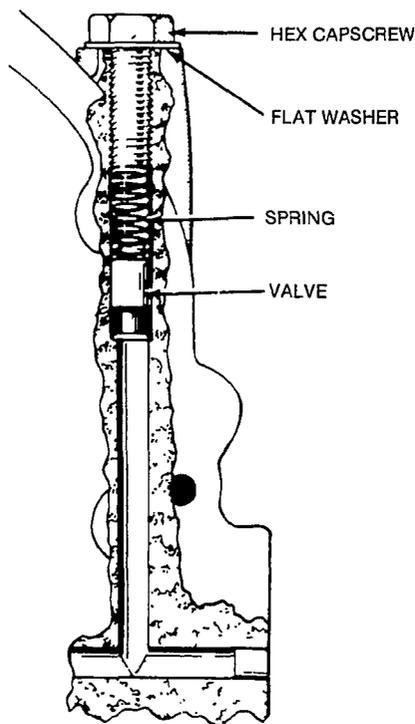


FIGURE 9-17. OIL BY-PASS VALVE

case. Normally the valve begins to open about 30 psi (207 kPa).

The valve is non-adjustable and normally needs no maintenance. To determine if abnormal (high or low) oil pressure is caused by improper valve operation inspect as follows:

1. Remove 3/8-24 x 1 in. capscrew located behind gear cover and under governor arm.
2. Remove spring and plunger with a magnet or magnetic tool.
3. Determine proper valve operation by checking the spring and plunger according to the following measurements.

Plunger Diameter..... 0.3105 to 0.3125 in.
(7.89 to 7.94 mm)

Spring
Free Length 1.00 inch (25.4 mm)
Load 2.6±0.2 lbs (11.6±0.9 N)
when compressed to 0.500 inch (12.7 mm)

4. Check the valve seat and clean away any accumulation of metal particles which could cause erratic valve action. Verify that the valve seat is concentric with the larger diameter valve bore.
5. Clean plunger and spring in parts cleaning solvent and install.

PISTON ASSEMBLY

The piston assembly consists of the piston, piston rings, piston pin, connecting rod assembly, and bearing. After removal from the engine, all parts must be carefully inspected for damage and wear before replacing.

Removal and Disassembly

Remove carbon from top of cylinder bore and check for a ridge. Remove ridge (see Figure 9-18) with a ridge reamer before attempting piston removal.

▲CAUTION *Improper use of a ridge reamer can damage the cylinder bore.*

▲CAUTION *Forcing the piston from the cylinder before reaming can damage the piston land or rings. Remove wear ridge before removing the piston.*

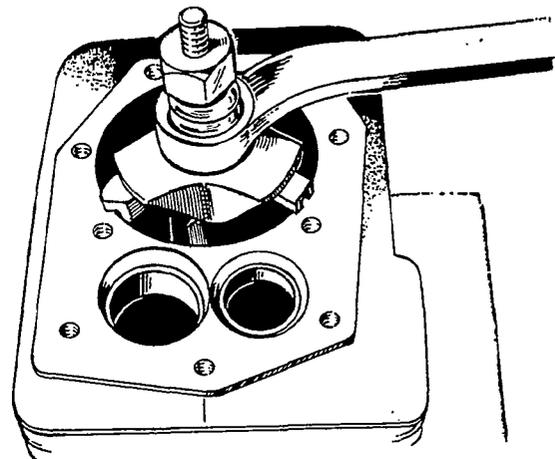


FIGURE 9-18. REMOVING WEAR RIDGE

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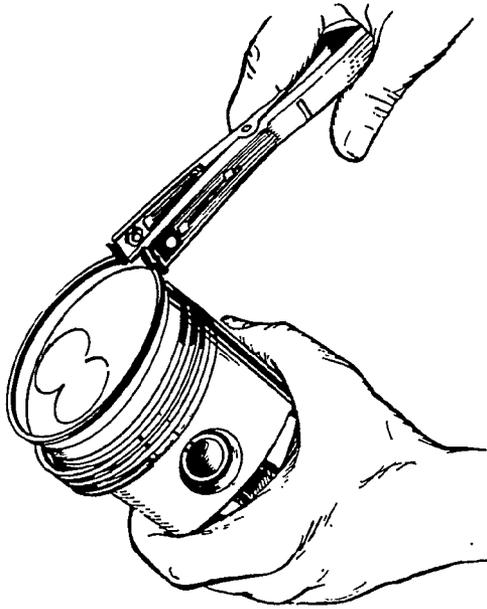
To remove the piston and connecting rod assemblies, turn the crankshaft until a piston is at the bottom of the stroke. Remove the nuts from the connecting rod bolts.

Lift the rod bearing cap from the rod and push the rod and piston assembly out the top of the cylinder with the handle end of a hammer. Be careful not to scratch the crankpin or the cylinder wall when removing these parts.

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

The pistons are fitted with two compression rings and one oil control ring. Remove these rings from the piston using a piston ring spreader as shown in Figure 9-19.

Mark each piston to make sure the rod will be assembled on the piston from which it was removed.



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FIGURE 9-19. REMOVING PISTON RINGS

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

Remove dirt and deposits from the piston pin surfaces with an approved cleaning solvent. Clean the piston ring grooves with a groove cleaner or the end of a piston ring filed to a sharp point (Figure 9-20). Care must be taken not to remove metal from the groove sides.

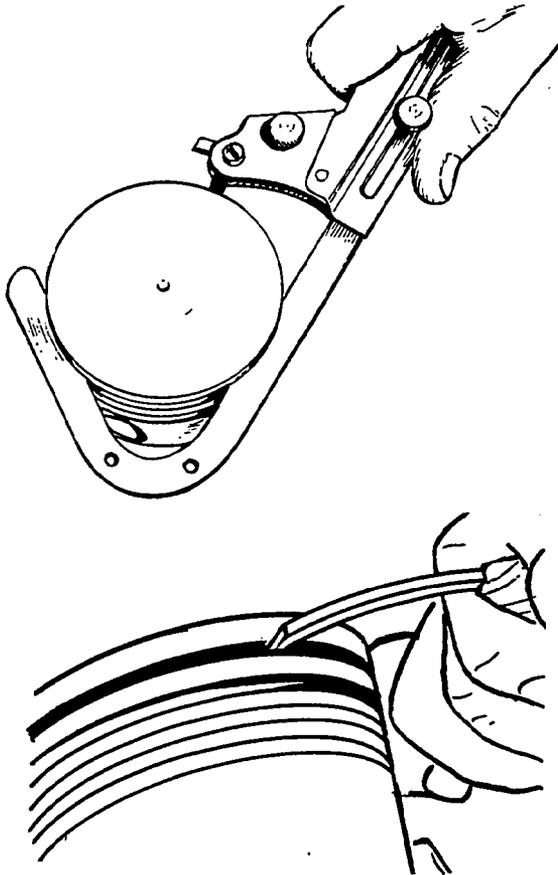
CAUTION *Using a caustic cleaning solvent or wire brush for cleaning pistons will cause piston damage. Use only parts cleaning solvent.*

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

Inspection

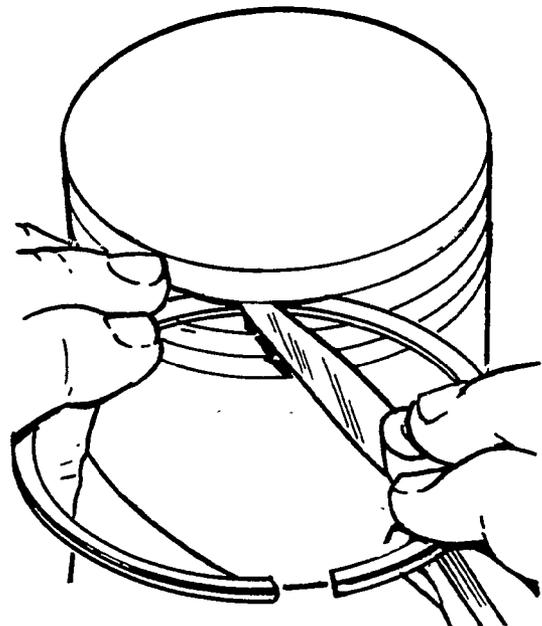
The following covers inspection procedures for pistons and connecting rods.

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 as shown in Figure 9-21. Replace the piston when the side clearance of the top compression ring reaches 0.008 inch (0.20 mm).



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FIGURE 9-20. CLEANING RING GROOVES



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FIGURE 9-21. CHECKING RING LAND

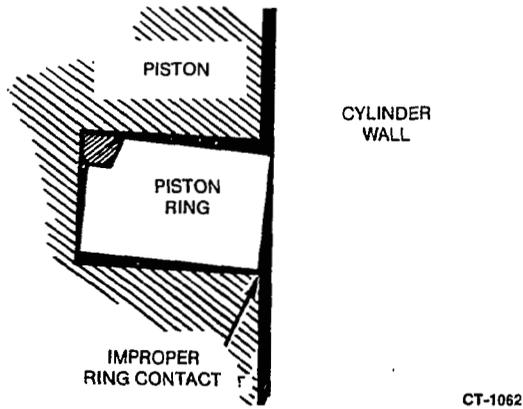


FIGURE 9-22. NEW RING IN WORN RING GROOVE

Improper width rings or excessive ring side clearance can result in ring breakage. New rings in worn ring grooves don't have good cylinder wall contact (Figure 9-22).

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

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

Use a new piston pin to check connecting rod for wear. A push fit clearance is required and varies from engine to engine. If a new piston pin falls through a dry rod pin bore as a result of its own weight, replace the rod 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, pitting and wear. Replace bearing inserts that are scored, have the overlay wiped out, show fatigue failure, or are badly scratched. If bearings appear to be serviceable, check them for proper clearance.

Piston Clearance

Proper piston tolerances must be maintained for satisfactory operation. Use a micrometer to measure the piston diameter at the point shown in Figure 9-23. When the cylinder bore is measured (see Cylinder Block in this section), subtract the piston diameter from the cylinder bore diameter to obtain the piston to cylinder wall clearance. Refer to Dimensions and Clearances in Section 3 for the recommended piston clearance.

Fitting Piston Rings

Before installing new rings on the piston, check the

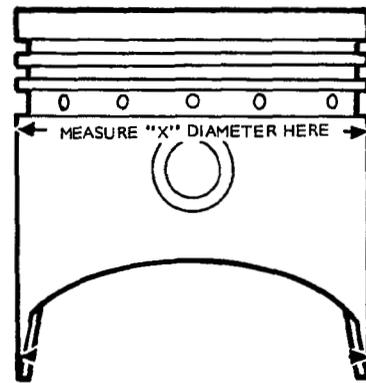


FIGURE 9-23. PISTON CLEARANCE MEASUREMENT

ring gap by placing each ring squarely in its cylinder, at a position corresponding to the bottom of its travel (Figure 9-24). The gap between the ends of the ring is given in Dimensions and Clearances in Section 3.

The practice of filing ring ends to increase the end gap is not recommended. If the ring end gap does not meet specifications, check for the 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 inch (0.08 mm).

Standard size rings may be used on 0.005 inch (0.13 mm) oversize pistons. Rings that are 0.010, 0.020, 0.030 and 0.040 inch (0.25, 0.51, 0.76 and 1.02 mm) oversize are to be used on corresponding oversize pistons. Rings of the tapered type are usually marked TOP on one side, or identified in some other manner. Install these rings with the identification mark toward the closed end of the piston.

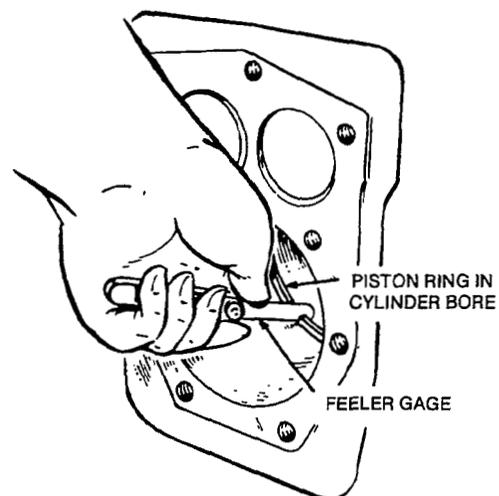


FIGURE 9-24. CHECKING RING GAP

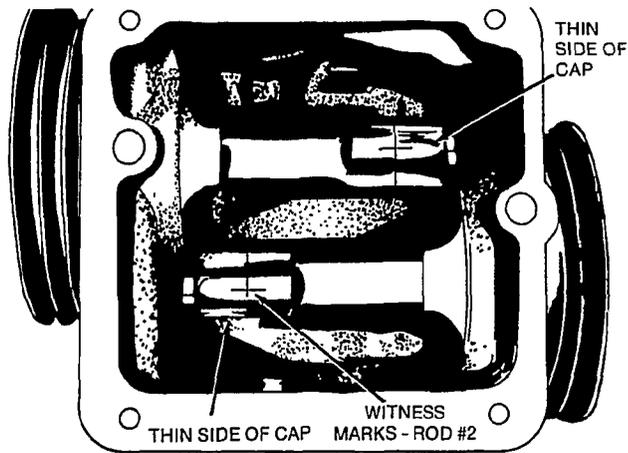


FIGURE 9-25. ROD CAP ALIGNMENT

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Piston Assembly Installation

Lubricate all parts with clean engine oil. Position the piston on the connecting rod. Install the piston pin. The piston pin is a full-floating type, and must be kept in place in the piston with two lock rings (one at each side). Install the two lock rings and ensure the lock rings are properly in place before installing the piston and connecting rod in the engine.

Install the rings on the piston beginning with the oil control ring. Use a piston ring spreader to prevent twisting or excessive expansion of the ring. Compression rings are marked with a dot or the word "top" on one side of the ring to indicate which side faces the top of the piston. Unmarked piston rings can be installed either way. The oil control ring has an expander; install the expander first and then close until the expander ends butt together. Locate the expander gap 180 degrees from the ring gap.

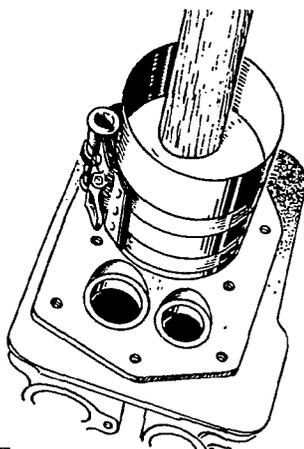


FIGURE 9-26. INSTALLING PISTON

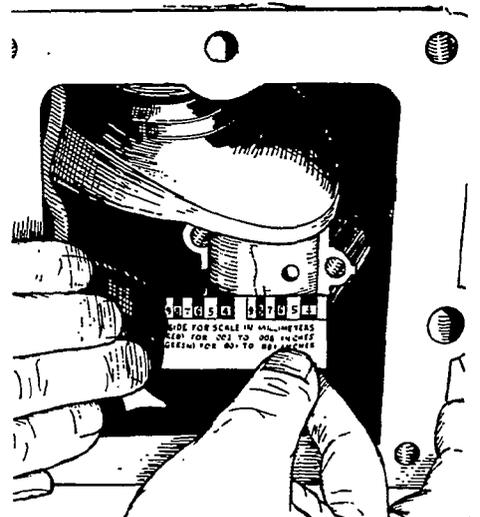
Installing Piston in Cylinder: When installing the piston assembly, the raised lines (witness marks - see Figure 9-25) on the rods and caps must be aligned. Also, note that the connecting rod bolt is offset to one side of the cap. When assembled on the crankshaft, the thin side of the cap should be next to the cylinder block. The rod and cap stamped #2 should be installed next to the bearing plate.

1. Turn crankshaft to position rod bearing journal at bottom of its stroke.
2. Lubricate piston assembly and inside of cylinder. Compress rings with a ring compressor as shown in Figure 9-26. Install bearing insert in rod.
3. Position the piston and rod assembly in the cylinder block with the connecting rod oil hole toward the camshaft.
4. Tap piston down into bore with handle end of hammer until connecting rod is seated on journal. Check bearing clearance before proceeding to step #5 (see Rod Bearing Clearance in this section).
5. Lubricate the rod bearing journal and install the connecting rod cap. Tighten connecting rod bolts to specified torque.

The bearing cap must be tapped several times to properly align it with the connecting rod. Clearance varies on the journal if this is not done. Install the remaining pistons and rods in the same manner. Crank the engine by hand to see that all bearings are free.

Rod Bearing Clearance

1. Mark all parts so they can be installed in their original positions; and wipe all parts clean of any oil or grease.
2. Place a piece of the correct size Plasti-Gage across the full width of the bearing cap about 1/4-inch (6 mm) off center.
3. Install the bearing cap and tighten to the specified torque. Do not rotate the crankshaft after the cap is in place.
4. Remove the bearing cap and leave the flattened Plasti-Gage on the part to which it adheres. Compare the widest point of the flattened Plasti-Gage with the graduations on the envelope (see Figure 9-27) to determine the bearing clearance.



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FIGURE 9-27. MEASURING BEARING CLEARANCE

CRANKSHAFT

To remove the crankshaft, loosen the rear bearing plate screws and remove the bearing plate, gasket, thrust washer, and shims. Turn the crankshaft so the crankthrow is aligned with the notch in the rear opening of the crankcase. Carefully slide the crankshaft out of the crankcase.

Inspection

Inspect the rod and main bearing journals. If they are worn or scored and cannot be smoothed out by polishing, either the journals should be reground to use one of the standard undersize bearings or the crankshaft should be replaced. Remove only as much metal as is required to restore the journal surface while maintaining the recommended bearing clearance.

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

Installation

Lubricate the front and rear main bearings with engine oil. Use oil or gear lubricant to hold the front thrust washer in place against the engine block. The flat side of the thrust washer goes against the block.

Position the crankshaft so the crank throw is aligned with the notch at the rear of the crankcase and install the crankshaft. Make sure the front thrust washer did not slip out of place during installation.

Place the oil seal loader on the oil seal guide and driver and insert into the rear bearing plate. Remove the seal guide and driver leaving the loader in the bearing plate. The loader prevents the seal from being cut on the crankshaft keyway during installation of the rear bearing plate.

Use oil or gear lubricant to hold the shim(s) and rear thrust washer in position on the rear bearing plate (see Figure 9-32). The shim goes against the bearing plate and the flat surface of the thrust washer goes against the shim.

Place the bearing plate gasket in position on the block, making sure the oil hole on the back of the block is exposed. Install the rear bearing plate and fasten with two nuts (or capscrews) tightened to the specified torque. Make sure the rear thrust washer and shim(s) did not slip out of place during installation. The crankshaft should turn freely by hand.

Checking Endplay

After tightening two rear bearing plate nuts (or capscrews) to the specified torque, check the crankshaft endplay at the point shown in Figure 9-28 using a feeler gauge. Lightly tap the front of the crankshaft with a plastic-faced hammer to take up the freeplay. Refer to Dimensions and Clearances Section 3 for the recommended crankshaft endplay. If necessary, remove the rear bearing and plate and add or remove shims as required. Install the end plate and tighten all nuts (or capscrews) to the specified torque. Make sure the shim and thrust washer are in place, and recheck crankshaft endplay. Verify that the crankshaft turns freely without binding.

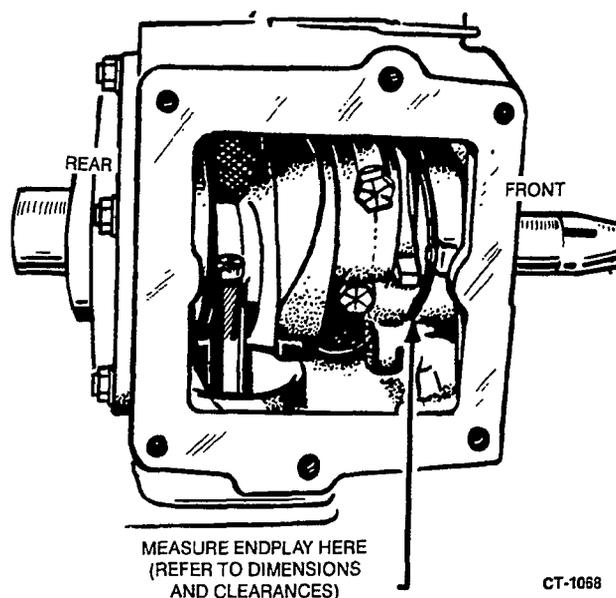


FIGURE 9-28. CHECKING ENDPLAY

CYLINDER BLOCK

The cylinder block is the main support for all other basic engine parts. Crankshaft and camshaft are supported by the block, assuring alignment of the crankshaft and cylinder bores.

Cleaning

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

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

Inspection

When rebuilding the engine, thoroughly inspect block for any condition that would make it unfit for further use. This inspection must be made after all parts have been removed and 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. 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 top of block for flatness with a straight edge and a feeler gauge.

Cylinder Bore Inspection: Inspect cylinder bores for scuffing, scratches, wear, and scoring. If cylinder bores are scuffed, scratched, scored, or worn, they must be rebored and honed for the next oversize piston.

When the appearance of cylinder bores is good and there are no scuff marks, check cylinder bore for wear or out of roundness as follows:

1. Check cylinder bore for taper, out-of-round, and wear with a cylinder bore gauge, telescope gauge, or inside micrometer. These measurements should be taken at four places, top and bottom of piston ring travel, parallel and perpendicular to axis of crankshaft.
2. Record measurements taken at top and bottom of piston travel as follows (see Figure 9-29).

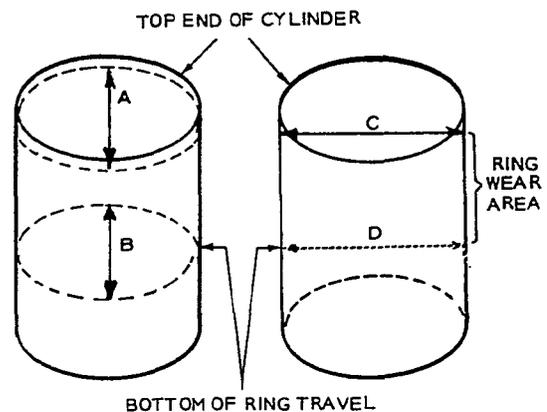
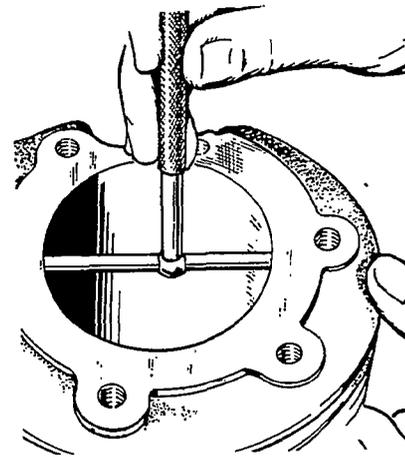


FIGURE 9-29. METHODS OF MEASURE
CYLINDER BORE DIAMETER

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- A. Measure and record as "A" the cylinder bore diameter (parallel to crankshaft) near the top of cylinder bore where greatest amount of wear occurs.
- B. Also measure and record as "B" cylinder bore diameter (parallel to crankshaft) at the bottom of piston travel.
- C. Measure and record as "C" cylinder bore diameter (perpendicular to crankshaft) near the top of cylinder bore where greatest amount of wear occurs.
- D. Also measure and record as "D" 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 cylinder taper.

If cylinder taper exceeds 0.003 inch (0.08 mm), rebore and hone cylinder to the next oversize.

- F. Reading "A" compared to reading "C" and reading "B" compared to reading "D" indicates whether or not cylinder is out-of-round. If 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 going to oversize pistons. The following repair data covers honing to oversize by use of a hone.

Reboring the Cylinder

Rebore and hone engine whenever cylinder bore is worn, damaged, out-of-round, or if cylinder taper exceeds specifications. A worn cylinder bore should be resized to the smallest standard oversize diameter at which it will clean up. The final finish and bore diameters should then be obtained by honing.

CAUTION *If boring bar is operated incorrectly, it will produce a rough cylinder surface that may not clean up even when honed. Boring should be done only by qualified service personnel who are careful in their work.*

After boring to the correct oversize cylinder bore dimension, piston and ring clearance should be appropriate. There is no need to adjust or "fit" pistons and rings.

When reboring cylinders, take the following precautions:

1. Make sure cutting tool is properly ground before using it.
2. Be sure top of engine block is smooth and deposit free.
3. Clean base of boring bar before bar is set up. Deposits under boring bar will cause it to tilt, and the cylinder will be distorted after boring.
4. Make an initial rough cut, followed by a finish cut. Then hone cylinder bore to the specified oversize.

Honing Cylinders (Using Precision Hones)

Refer to hone manufacturer's recommended grit size to produce specified surface finish of 20 to 40 RMS. Too rough of a finish will wear out the rings and too smooth of a finish can retard piston ring seating.

1. Position block solidly for either vertical or horizontal honing. Use either a drill press or heavy-duty drill which operates at approximately 250 to 450 r/min.
2. Follow hone manufacturer's instructions for the use of oil or lubricant on stones. Do not use lubricants with a dry hone.
3. Insert hone in bore and adjust stones to fit snugly to the narrowest section. When adjusted correctly, the hone should not shake or chatter in

cylinder bore but will drag freely up and down when hone is not running.

4. Connect drill to hone and start drill. Feel out bore for high spots, which cause an increased drag on stones. Move hone up and down in bore with short overlapping strokes about 40 times per minute. Usually bottom of cylinder must be worked out first because it is smaller. As cylinder takes a uniform diameter, move hone up and down all the way through cylinder bore.
5. Check diameter of the cylinder regularly during honing. A dial bore gauge is the easiest method, but a telescoping gauge can be used. Check size at six places in bore; measure twice at top, middle and bottom at 90-degree angles.
6. Crosshatch formed by the stones should form an included angle of 23 degrees. This can be achieved by moving the rotating hone (250 to 450 r/min) up and down in cylinder bore about 40 times per minute.
7. Clean cylinder bores thoroughly with soap, water, and clean rags. A clean white rag should not become soiled on wall after cleaning is complete. Do not use a solvent or gasoline, since they wash oil from the walls but leave metal particles.
8. Dry crankcase and coat it with oil.

Deglazing Cylinder Bores

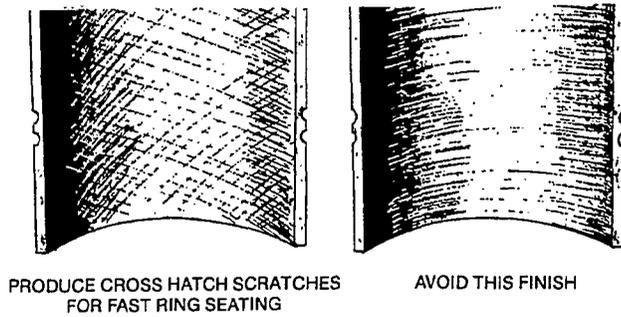
Deglaze the cylinder bores if there are no scuff marks and no wear or out of round beyond specifications before installing new rings. Deglazing gives a fine finish but does not enlarge cylinder diameter, so the original pistons with new rings may still be used.

The reason for deglazing a cylinder is to provide cavities to hold oil during piston ring break-in.

1. Wipe cylinder bores with a clean cloth which has been dipped in clean, light engine oil.
2. Use a brush type deglazing tool with coated bristle tips to produce a crosshatch pattern in the cylinder bore.
3. The deglazing tool should be driven by a slow speed drill. Move deglazing tool up and down in cylinder (10 to 12 complete strokes) rapidly enough to obtain a crosshatch pattern as shown in Figure 9-30.

CAUTION *Never use gasoline or commercial cleaners to clean cylinder bores after deglazing or honing. These solvents will not remove abrasives from the walls. Abrasives not removed from engine will rapidly wear rings, cylinder walls, and bearing surfaces of all lubricated parts.*

4. Clean cylinder bore thoroughly with soap, water, and clean rags. Continue cleaning until a clean white rag shows no discoloring when wiped through cylinder bore.



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FIGURE 9-30. CROSSHATCHING

BEARINGS

Removal of the camshaft or crankshaft bearings requires complete disassembly of the engine. Use a combination main and cam bearing removal tool and a press to drive out the bearings. Support the casting to avoid distorting or damaging the bearing bores.

Camshaft Bearings

Replacement camshaft bearings are precision type and do not require line reaming or line boring after installation. Coat the bearing with lubricating oil. Position the front bearing so the oil hole in the bearing is aligned with the oil hole (see Figure 9-31) in the block. Position the rear bearing so the elongated slot is aligned with the breaker point plunger hole in the top of the block.

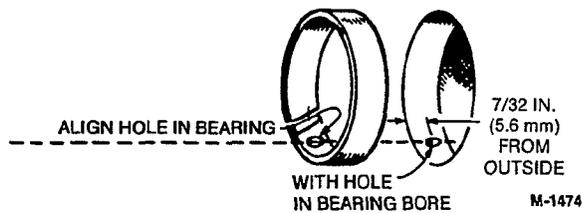


FIGURE 9-31. CAMSHAFT BEARINGS

Use the combination main and cam bearing driver and a press to install the front and rear cam bearings. Push in the bearings to the depth allowed by the flange on the driver.

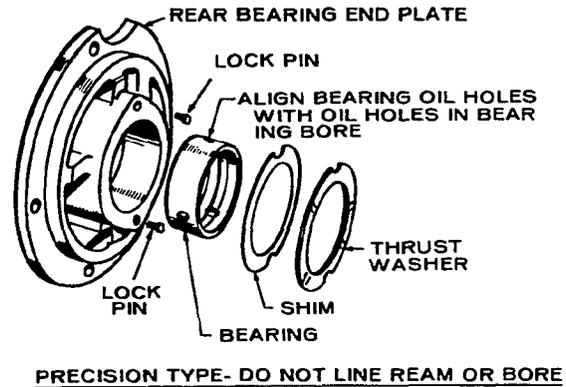
Crankshaft Bearings

New crankshaft main bearings are precision type which do not require line reaming or line boring after installation. They are available in standard size, 0.002, 0.010, 0.020 or 0.030 inch undersize.

For putting in either the front or rear main bearing, always align the oil hole(s) in the bearing with the oil

hole(s) in the bearing bore. The oil passage must be at least 1/2 open.

Rear Bearing: Use the combination main and cam bearing driver and a press to install the rear main bearing. Push the bearing into the bearing plate from the inner side (see Figure 9-32) to the depth allowed by the flange on the driver.

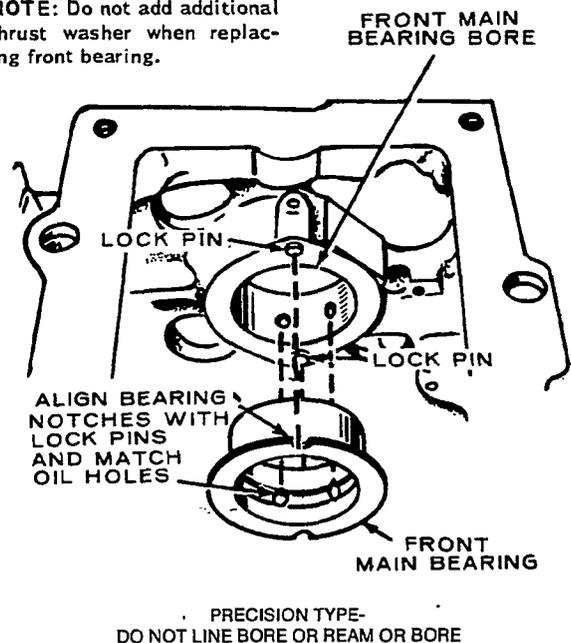


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FIGURE 9-32. REAR BEARING

Front Bearing: Locktite Bearing Mount is used when installing the front bearing (see Figure 9-33). Use the towelette furnished with the bearing kit to clean the outside of the bearing and the bearing bore in the

NOTE: Do not add additional thrust washer when replacing front bearing.



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FIGURE 9-33. FRONT BEARING

block. Apply the Loctite Bearing Mount to the mating surfaces of the bearing and bearing bore. Allow three to four minutes for drying.

WARNING Breathing vapor from towelette and prolonged contact with skin can cause severe personal injury. Be sure area is well-ventilated.

Use the combination main and cam bearing driver and a press to install the front bearing. Push in the bearing to the depth allowed by the flange on the driver. Wipe off any excess Loctite and allow one hour for hardening at room temperature.

Engines shipped from the factory have separate thrust washers and main bearings for both front and rear of engine. Front bearing replacement is one piece bearing (with attached thrust washer) as shown in Figure 9-33. Do not add an additional thrust washer to this front bearing.

OIL SEALS

Remove the rear bearing plate to replace the rear oil seal. Remove the gear cover to replace the front oil seal. Use an oil seal remover to pry out the front or rear oil seal.

Use an oil seal guide and driver to press or drive the rear seal into the rear bearing plate until it bottoms against the shoulder of the plate (see Figure 9-34). Press or drive the front oil seal into the gear cover until it is 0.97 ± 0.02 inch (24.6 ± 0.5 mm) from the mounting face of the cover.

Lubricate the lips of the replacement seal with a light coating of grease before installing the rear bearing plate or gear cover. This provides initial lubrication until engine oil reaches the seal. Refer to Crankshaft in this section for the rear bearing plate installation procedures. Refer to Gear Cover in this section for the gear cover installation procedures.

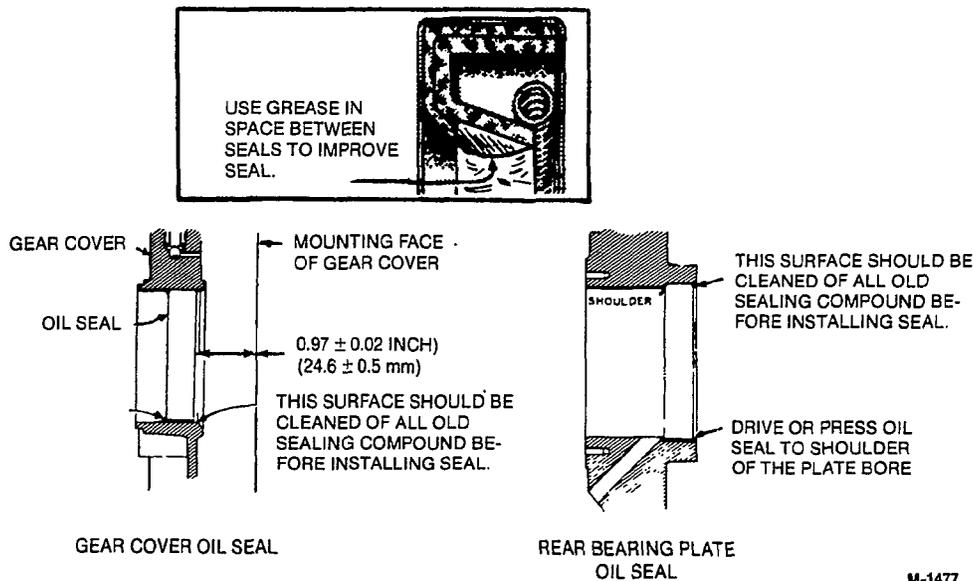


FIGURE 9-34. OIL SEALS

Section 10 - Service Checklist

After servicing, inspect and test the complete installation to confirm that the generator set will operate properly and will pull full rated load. Check each of the following areas before putting the set into service.

MOUNTING

Examine all mounting bolts and supporting members to verify that the generator set is properly mounted. All fasteners should be tightened securely to prevent them from working loose when subjected to vibration.

LUBRICATION

If the engine oil was drained, fill the crankcase with oil of the recommended classification and viscosity. Refer to the appropriate operator's manual for the specific recommendations and procedures.

WIRING

Verify that all wiring connections are tight and hooked up properly. Check each of the following:

- Load Wires
- Control Wires
- Ground Strap
- Battery Cables

INITIAL START ADJUSTMENTS

Adjust the carburetor idle and adjustment screw and main adjustment screw as specified in Fuel System in Section 6 to allow starting.

Start the set and immediately adjust the governor speed adjustment nut to obtain a safe no-load operating speed. With no load applied, listen for any unusual sounds or vibrations. When the choke is completely open, adjust the carburetor and governor as specified in Fuel System Section.

OUTPUT CHECK

Apply a full load to certify that the set will produce its full rated output. Use a load test panel to apply a progressively greater load until full load is reached.

EXHAUST SYSTEM

With the generator set operating, inspect the entire exhaust system including the exhaust manifold, muffler, and exhaust pipe. Visually and audibly check for leaks at all connections, welds, gaskets, and joints and also make sure the exhaust pipes are not heating surrounding areas excessively. If leaks are detected, correct immediately.

▲WARNING *Exhaust gas presents the hazard of severe personal injury or death. Inspect exhaust system audibly and visually for leaks daily. Repair leaks immediately.*

▲WARNING

EXHAUST GAS IS DEADLY!

Exhaust gases contain carbon monoxide, an odorless and colorless gas. Carbon monoxide is poisonous and can cause unconsciousness and death. Symptoms of carbon monoxide poisoning can include:

- Dizziness
- Nausea
- Headache
- Weakness and Sleepiness
- Throbbing in Temples
- Muscular Twitching
- Vomiting
- Inability to Think Coherently

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

Never sleep in vehicle with the generator set running unless the vehicle interior is equipped with an operating carbon monoxide detector. Protection against carbon monoxide inhalation also includes proper exhaust system installation and visual and audible inspection of the complete exhaust system at the start of each generator set operation.

FUEL SYSTEM

With the generator set operating, inspect the fuel supply lines, return lines, filters, and fittings for leaks. Check any flexible sections for cuts, cracks and abrasions and make sure they are not rubbing against anything that could cause breakage.



Leaking fuel creates a fire hazard which can result in severe personal injury or death if ignited. If leaks are detected, correct immediately.

CONTROL

Stop and start the generator set several times at the set control and remote control to verify that the control functions properly.

MECHANICAL

Stop the generator set and inspect for leaking gaskets, loose fasteners, damaged components, or interference problems. Repair as required. Inspect the generator set compartment and verify that there are no breaks or openings in the vapor-proof wall that separates the compartment from the coach interior. Seal openings as required. Make sure all soundproofing material is in place.





Cummins Power Generation
1400 73rd Avenue N.E.
Minneapolis, MN 55432
763-574-5000
Fax: 763-574-8087

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