

SERVICE Manual

NP and IM Series

RECREATIONAL VEHICLE AND INDUSTRIAL MOBILE AC GENERATORS

Liquid-Cooled 1.2 Liter
Gas Engine Models

GENERAC

CORPORATION

♦ P. O. Box 8
♦ Phone: (414) 544-4811

♦ Waukesha, Wisconsin 53187
♦ FAX: (414) 544-4851

Foreword

PURPOSE OF MANUAL:

This Service Manual has been written and published by Generac Corporation to aid our Dealers' mechanics and company service personnel in the maintenance, servicing, troubleshooting and repair of the products described herein. All information, illustrations and specifications are based on the latest product information available at the time of publication.

Proper service and repair is important to the safe, economical and reliable operation of all recreational vehicle and industrial mobile generators. Troubleshooting, testing and servicing procedures recommended by Generac and described in this manual are effective methods of performing such operations. Some of these operations or procedures may require the use of specialized equipment. Such equipment should be used when and as recommended.

Generac could not possibly know of and advise the generator service trade of all conceivable procedures by which a service or repair might be performed or of the possible hazards and/or results of each method. We have not undertaken any such wide evaluation. Therefore, anyone who uses a service procedure, method or tool not recommended by Generac must first completely satisfy himself that neither his nor the product's safety will be endangered by the procedure or method selected.

USER'S RESPONSIBILITY:

It is assumed that service personnel are familiar with the servicing procedures of these products or like or similar products manufactured and marketed by Generac. It is further assumed that such personnel have been trained in the recommended servicing procedures for these products; and that such training includes the use of mechanic's common hand tools, special Generac tools, and tools from other suppliers.

SAFETY:

When working on this product, it must be remembered that the generator AC electrical system produces high and dangerous voltages that can cause severe electrical shock. Contact with high voltage terminals, bare wires, etc., can result in dangerous and even fatal injury.

To prevent accidental engine cranking and startup, always disconnect battery cables before working on or around the generator.

Cover all openings into the engine-generator, to prevent entry of foreign materials. Such materials could enter the engine cylinders and cause extensive damage when the engine is started.

It is important to note that the manual contains various DANGER, CAUTION and NOTE blocks. These should be read carefully in order to minimize the risk of personal injury or to prevent methods or practices from being used which could damage equipment or render it unsafe.

FASTENERS:

Replacement fasteners must have the same measurements and strength as the fasteners they will replace. Numbers on the heads of metric bolts and on surfaces of metric nuts indicate their strength. Customary nuts do not have strength markings. Mismatched or incorrect fasteners can cause damage, equipment malfunction or possible injury.

REPLACEMENT PARTS:

Many parts used on recreational vehicle generators and engines are designed and manufactured to comply with rules and regulations established by the Recreational Vehicle Industry Association (RVIA), American National Standards Institute (ANSI), and the National Fire Protection Association (NFPA). Strict compliance with such rules and regulations help to minimize the risk of fire or an explosion. Use of any replacement part that does not comply with such rules and regulations could result in fire or explosion hazard and should be avoided.

SERVICE MANUAL

NP and IM Series

RECREATIONAL VEHICLE & INDUSTRIAL MOBILE AC GENERATORS

1.2 Liter, Liquid-Cooled
Gas/Gasoline Engine Models

TABLE OF CONTENTS

PART	TITLE
1	THE AC GENERATOR
2	ENGINE MECHANICAL
3	ENGINE LUBRICATION SYSTEM
4	ENGINE COOLING SYSTEM
5	GASOLINE FUEL SYSTEM
6	GASEOUS FUEL SYSTEM
7	ENGINE SPEED CONTROL SYSTEM
8	ENGINE IGNITION SYSTEM
9	ENGINE DC ELECTRICAL SYSTEM
10	OPTIONS AND ACCESSORIES
11	SPECIFICATIONS & ELECTRICAL DATA

Part 1 THE AC GENERATOR

NP and IM Series
**RECREATIONAL
VEHICLE &
INDUSTRIAL
MOBILE
AC GENERATORS**
Liquid Cooled 1.2 Liter
Gas Engine Models

TABLE OF CONTENTS

SECTION	TITLE
1.1	How Generators Produce Electricity
1.2	Major Generator Components
1.3	Insulation Resistance Tests
1.4	Introduction to Troubleshooting
1.5	Troubleshooting Flow Chart
1.6	Troubleshooting Test Procedure

Manual Familiarization

This Service Manual has been divided into eleven (11) PARTS. Each PART consists of one or more SECTIONS. Each SECTION is divided into two or more SUBSECTIONS. Each SUBSECTION may be made up of one or more PARAGRAPHS.

A DIVIDER page separates each PART of the Manual. The DIVIDER page provides a TABLE OF CONTENTS which lists the SECTIONS that may be found in that PART.

Page numbers at the bottom of each page identify the PART number, SECTION number, and the specific page. For example, Page 2.3-4 indicates PART 2, SECTION 2.3, and Page 4 of that SECTION. This type of numbering system allows individual SECTIONS to be kept current without affecting page numbers in the entire Manual.

Section 1.1- HOW GENERATORS PRODUCE ELECTRICITY

Magnetic Induction

It has long been known that a relationship exists between magnetism and electricity. Revolving field AC generators depend on this relationship for their operation. If generator problems are to be properly diagnosed, the service technician must understand this relationship. Magnetism can be used to create an electrical voltage in a conductor. Conversely, electrical current flow through a conductor will create a magnetic field around that conductor.

See Figure 1, below. When a conductor is moved through a magnetic field, an electromotive force (EMF or voltage) is induced into the conductor. Movement of the magnetic field so that it cuts across the conductor will also create a voltage in the conductor. If the ends of the conductor are connected to form a complete circuit, current will flow through the conductor. The direction in which the current flows depends on the polarity of the magnetic field and the direction in which the magnetic field (or conductor) is moved. The amount of voltage induced into the conductor depends on the strength or concentration of the magnetic field, i.e., the stronger the magnetic field, the higher the induced voltage.

See Figure 2. When current flows through a conductor, a magnetic field is created around that conductor. The strength of the magnetic field depends on (a) the amount of current flow, (b) the number of turns or loops in the conductor. The polarity of the magnetic field depends on the direction of current flow through the wire. The following facts should be evident:

- ☐ If current flow through a conductor can be regulated, the strength of the magnetic field around the conductor can be regulated.
- ☐ If the strength of a magnetic field can be regulated, the amount of voltage induced into a conductor by such a magnetic field can also be regulated.

A Simple AC Generator

Figure 3 represents a simple AC generator, in which the rotating magnetic field (Rotor) is a permanent magnet. As the magnet rotates, its magnetic field cuts across a stationary coil of wires called a STATOR. When the magnet's North magnetic pole moves past the stator windings, current moves through the wire in one direction. As the South magnetic pole of the magnet passes the stator wires, current reverses itself and moves through the stator in the opposite direction.

In the simple generator shown, the strength of the magnet is fixed. That is, the magnetic field strength cannot be changed since a permanent magnet is used. Because the magnetic field strength is fixed, the voltage induced into the stator coil is constant.

If some method of regulating the magnetic field strength of the magnetic could be found, the voltage induced into the stator coil could be regulated as well.

Figure 1. Magnetism Creates Electricity

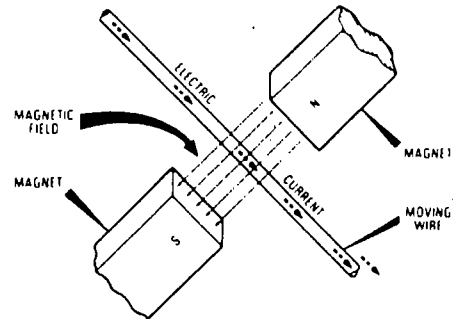


Figure 2. Current Flow Creates a Magnetic Field

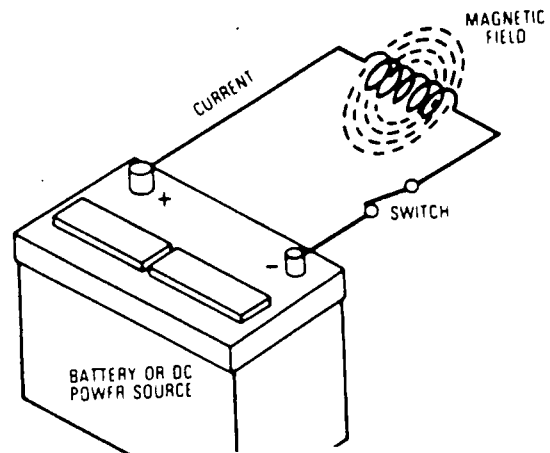
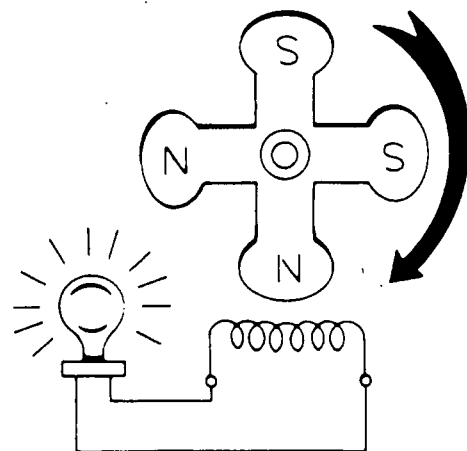
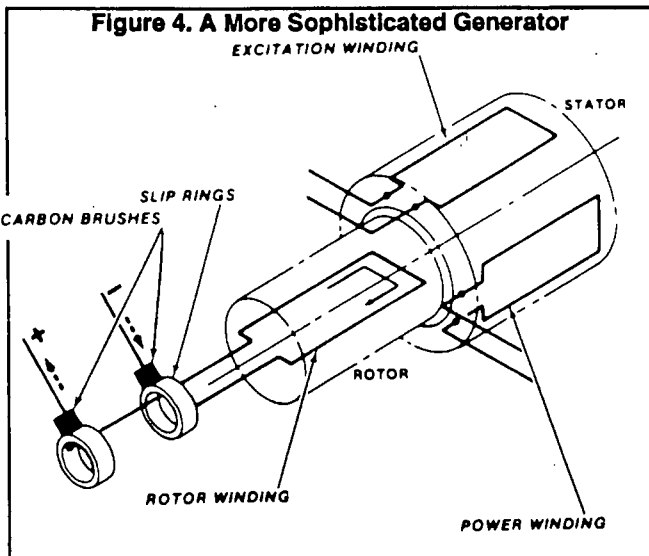


Figure 3. A Simple Revolving Field Generator



A More Sophisticated Generator

Figure 4 is a diagram of a more sophisticated generator. A regulated direct current (DC) is delivered to the rotating magnet (Rotor), via CARBON BRUSHES and SLIP RINGS. This creates a regulated magnetic field around the Rotor which cuts across the stationary Stator windings to induce a regulated voltage into those windings. When the Stator circuit is completed by connecting a load, current will flow through the Stator windings to the load.

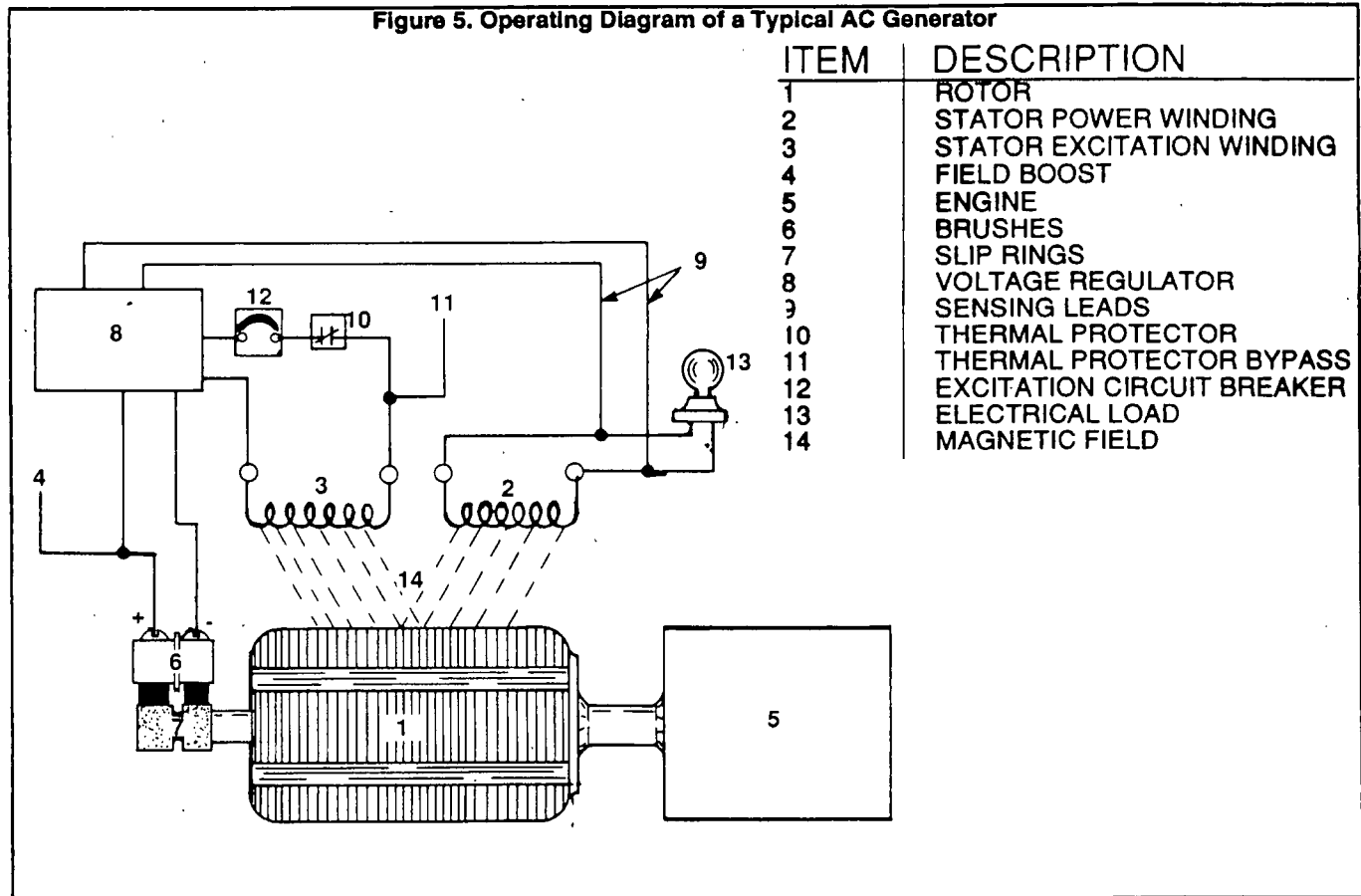


A Typical AC Generator

Figure 5, below, is an operating diagram of a typical AC generator. Operation of this typical generator may be briefly described as follows:

- ☐ The ROTOR is attached to the engine's power takeoff (PTO) shaft and turns at the same speed as the engine.
- ☐ As the ROTOR turns, its magnetic field cuts across the stationary coils of a STATOR EXCITATION WINDING and dual STATOR AC POWER WINDINGS. A voltage is induced into these stationary windings.
- ☐ Unregulated alternating current (AC) is delivered from the STATOR EXCITATION WINDING to the VOLTAGE REGULATOR, via an EXCITATION CIRCUIT BREAKER.
- ☐ "Sensing" leads deliver a signal of ACTUAL AC POWER WINDING voltage to the VOLTAGE REGULATOR.
- ☐ The VOLTAGE REGULATOR electronically compares the ACTUAL AC POWER WINDING voltage to a preset REFERENCE VOLTAGE and changes the STATOR EXCITATION WINDING output to direct current (DC).
- ☐ If ACTUAL POWER WINDING voltage is less than the REGULATOR's preset REFERENCE voltage, REGULATOR action will increase direct current flow to the ROTOR windings. The ROTOR magnetic field strength will then increase and the voltage induced into the STATOR AC POWER WINDINGS will then increase.
- ☐ When ACTUAL POWER WINDING voltage is greater than the REGULATOR's preset REFERENCE voltage, direct current flow to the ROTOR will be decreased by REGULATOR action to reduce ROTOR magnetic field strength.

Figure 5. Operating Diagram of a Typical AC Generator



- ☐ The VOLTAGE REGULATOR will continue to increase or decrease direct current flow to the ROTOR, in an attempt to maintain STATOR AC POWER WINDING voltage at the same value as the REGULATOR's preset REFERENCE voltage.
- ☐ When the STATOR AC POWER WINDING circuit is completed by connecting a load to the winding's AC output leads, current will flow through the windings and to the load.

Rotor Residual Magnetism

The Rotor may be considered a permanent magnet since some residual magnetism is always normally present in the Rotor windings. As a general rule, Rotor residual magnetism alone (without regulated excitation current and without field boost current) will produce a STATOR AC POWER WINDING output of approximately 2 to 7 volts.

Field Boost

When the engine is being cranked, direct current is delivered to the Rotor windings from a source other than the Stator excitation windings and Voltage Regulator. This direct current, in effect, "flashes the field" every time the engine is cranked. By applying field boost current to the Rotor during cranking, an early "pickup" voltage is induced into the Stator windings to turn the Regulator on sooner and provide AC output more quickly.

Failure of the field boost circuit may or may not result in loss or dropout of AC power winding output voltage, depending on the characteristics of the individual generator. The following general rules apply:

- ☐ If Rotor residual magnetism alone (without field boost) is sufficient to turn the Voltage Regulator on and provide the required pickup voltage, the generator will operate normally with normal AC output voltage.
- ☐ If Rotor residual magnetism alone (without field boost) is NOT sufficient to turn the Regulator on and provide the needed pickup voltage, generator AC output voltage will not build and will be commensurate with Rotor residual magnetism (about 2 to 7 volts AC).
- ☐ If regulated excitation current to the Rotor is lost, Stator AC power winding output voltage will drop to a value that is commensurate with Rotor residual magnetism (2 to 7 volts AC). The magnetic field strength created by field boost current cannot be considered since it is available only while cranking.

UNITS WITH GASOLINE FUEL SYSTEM:

See Figure 6. Units equipped with a gasoline fuel system use a choke module (CM) which closes and opens a choke solenoid (CS) during engine cranking to open and close the carburetor choke.

UNITS WITH LP GAS FUEL SYSTEM:

Units equipped with a gaseous fuel system do not require a carburetor choke and do not have a choke module. The field boost circuit for such units is shown in Figure 7. While cranking, battery voltage is delivered to Terminal No. 8 of an engine control circuit board, to Wire No. 9, a field boost assembly, Wire No. 4, and to the Rotor via brushes and slip rings.

The field boost assembly, shown in Figure 8, consists of a 100 ohm, 1 watt resistor (R2) and a 200 volt, 1 amp diode (D2). The diode ensures that current will flow in one direction only in the circuit. The resistor reduces the battery voltage (12 volts DC) to approximately 9-10 volts DC.

Figure 6. Field Boost Circuit (Gasoline Fuel System)

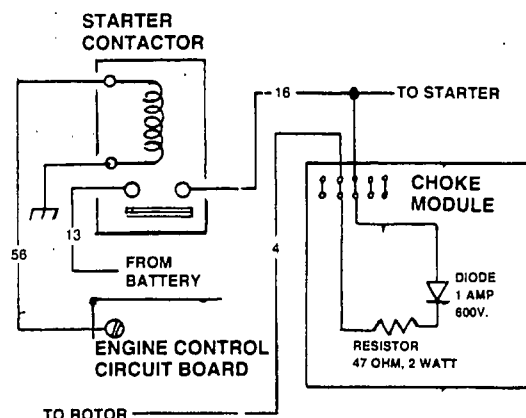


Figure 7. Field Boost Circuit (LP Gas Fuel System)

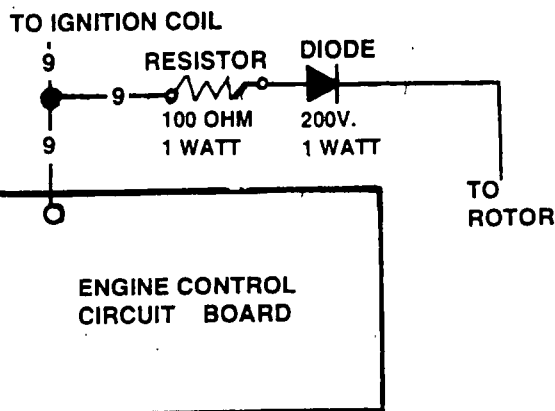
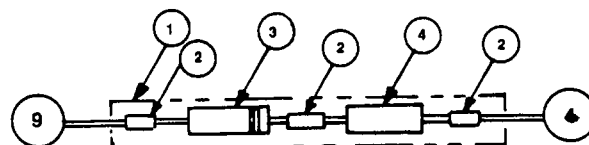


Figure 8. Typical Field Boost Assembly



ITEM
1
2
3
4

DESCRIPTION
Heat Shrink Tubing
Wire Connector
Field Boost Resistor
Field Boost Diode

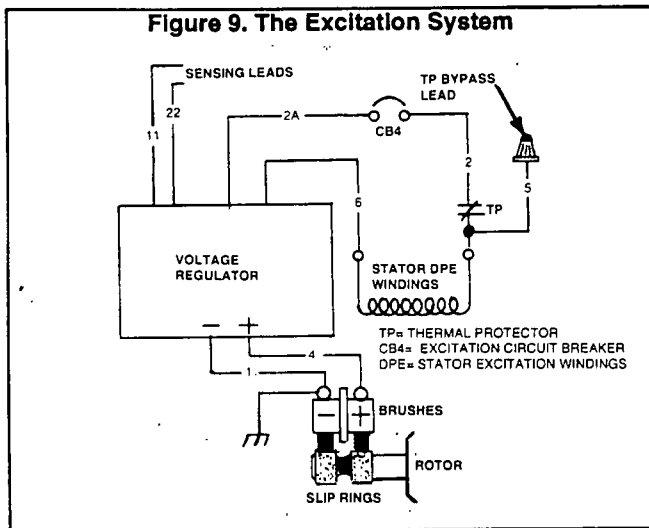
Excitation System

GENERAL:

The excitation system is shown schematically in Figure 9. During operation, unregulated AC current from the Stator excitation winding is delivered to the Voltage Regulator via a Thermal Protector, Wires 2 and 6, an excitation circuit breaker (CB4), and Wires 2A and 6. The Voltage Regulator rectifies and regulates the current flow, which is then delivered to the Rotor windings via Wires 4 and 1, and the brushes and slip rings. Major components of the excitation system include the following:

- ☐ Stator Excitation (DPE) Winding.
- ☐ Thermal Protector (TP).
- ☐ Excitation Circuit Breaker (CB4).
- ☐ AC Voltage Regulator.
- ☐ Brushes and Slip Rings.
- ☐ Rotor Assembly.

Figure 9. The Excitation System



THERMAL PROTECTOR:

A Thermal Protector (TP) is physically imbedded in the wire windings of the Stator assembly and electrically connected in series with the excitation winding AC output leads to the Voltage Regulator. The device is a normally-closed (N.C.), temperature sensitive switch. Should Stator temperatures exceed a preset level, the switch contacts will open. The switch is self-resetting. That is, its contacts will close when Stator temperatures decrease below a safe, preset level.

If the switch contacts open, excitation winding output to the Regulator will terminate and the Regulator will shut down. Generator AC output voltage will then drop to a value commensurate with the Rotor's residual magnetism (about 2 to 7 volts AC).

The thermal protector is NOT accessible and cannot be replaced. If it has failed open, it can be bypassed by connecting excitation lead No. 2 to a bypass lead No. 5. Once the switch has been bypassed, overtemperature protection is no longer available.

EXCITATION CIRCUIT BREAKER (CB4):

If this circuit breaker has failed open, the results will be the same as a Thermal protector that has failed open. That is, generator AC output will drop to about 2-7 volts AC (residual).

Figure 10. Thermal Protector

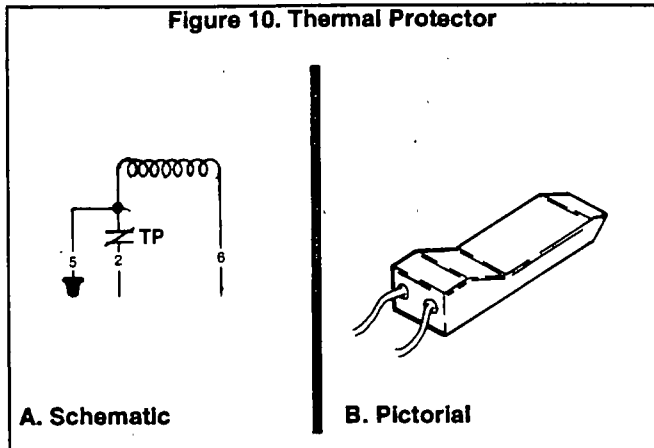
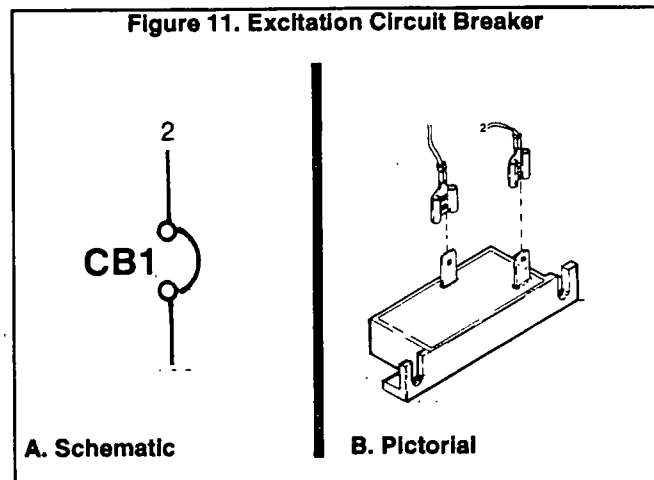


Figure 11. Excitation Circuit Breaker



AC VOLTAGE REGULATOR:

See Figure 12. Sensing leads deliver ACTUAL AC power winding voltage signals to the Regulator via Leads 11 and 22 and Regulator terminals 5 and 6. The Regulator electronically compares this ACTUAL signal to a preset REFERENCE voltage, then acts to maintain an ACTUAL voltage that is equal to the REFERENCE voltage.

If ACTUAL voltage is less than the preset REFERENCE voltage, the Regulator will increase excitation current flow to the Rotor. The Rotor's magnetic field will then strengthen and the AC output voltage will increase.

If ACTUAL voltage is greater than preset REFERENCE voltage, Regulator action will decrease excitation current flow to the Rotor. The Rotor's magnetic field strength will drop and ACTUAL voltage will decrease.

The typical AC Voltage Regulator shown in Figure 12 has a single adjustable potentiometer, used to establish the desired REFERENCE voltage.

BRUSHES AND SLIP RINGS:

The Brushes and Slip Rings (Figure 13) allow excitation current flow to be transmitted from a stationary member to a rotating member. The Slip Rings are actually a part of the Rotor assembly. As a general rule, the positive slip ring is the one nearest the Rotor bearing. Wire No. 4 is the positive brush lead; Wire No. 1 is the negative brush lead.

Figure 12. AC Voltage Regulator (Typical)

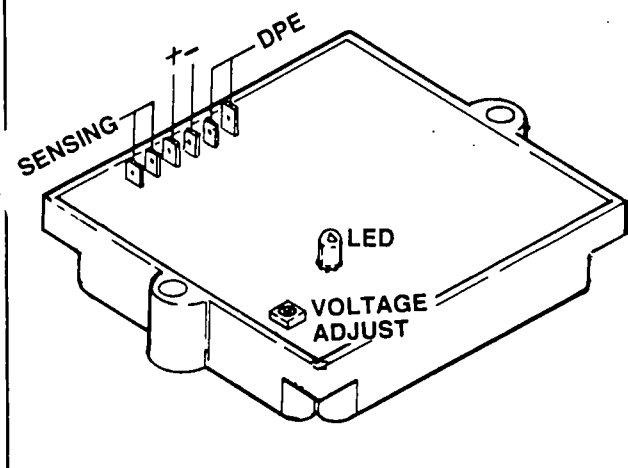
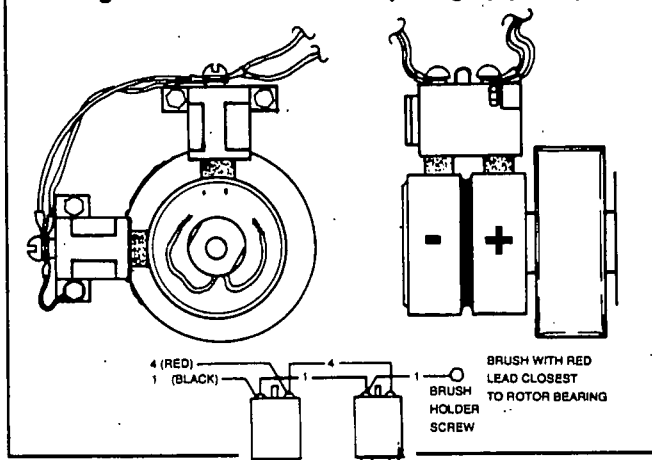


Figure 13. Brushes and Slip Rings (Typical)



Stator AC Power Connection Systems

GENERAL:

Any one of several different connection systems are used on NP and IM Series generators. These are (a) dual 1-phase, (b) 3-phase Delta, and (c) 3-phase Wye-Connected systems.

DUAL WINDING, 1-PHASE SYSTEM:

Figure 14 is a schematic representation of dual 1-phase Stator AC power windings. Each Stator winding can supply a 120 volts AC output. When the two windings are connected in series to form a 3-wire connection system, a 240 volts AC output results.

Connected for Dual Voltage Output: Some dual winding systems may have been connected to provide a dual voltage output (120 and/or 240 volts AC). See Figure 15. Stator AC output leads 11 (T1) and 44 (T3) form the two hot leads. The junction of Stator leads 22 and 33 form the "Neutral" line (T2).

Connected for Single Voltage Output: If desired, the Stator AC output leads can be reconnected for single voltage output only (Figure 16). When this is done, a jumper wire must be connected between the two main circuit breakers (CB1 and CB2).

NOTE: At the time this Manual was written, all NP/IM Series generators were equipped with the dual, 1-phase stator configuration. Some other possible stator configurations will be mentioned here to cover future possibilities.

Figure 14. Dual 1-Phase Stator Power Windings

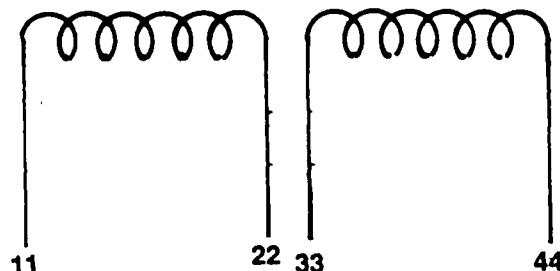


Figure 15. Dual 1-Phase Stator Connected for Dual Voltage Output

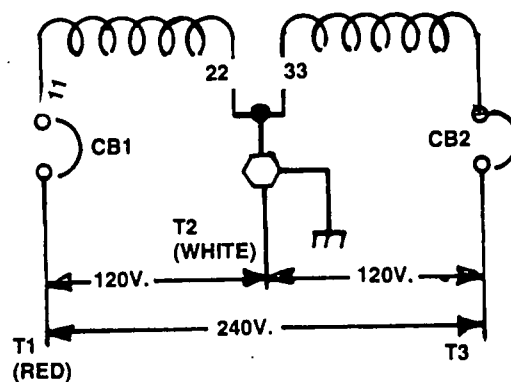
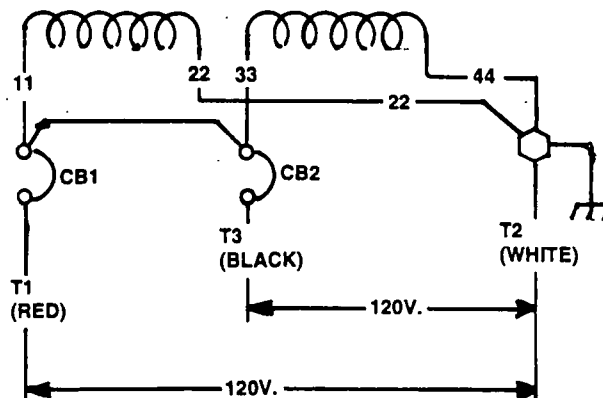


Figure 16. Dual 1-Phase Stator Connected for Single Voltage Output

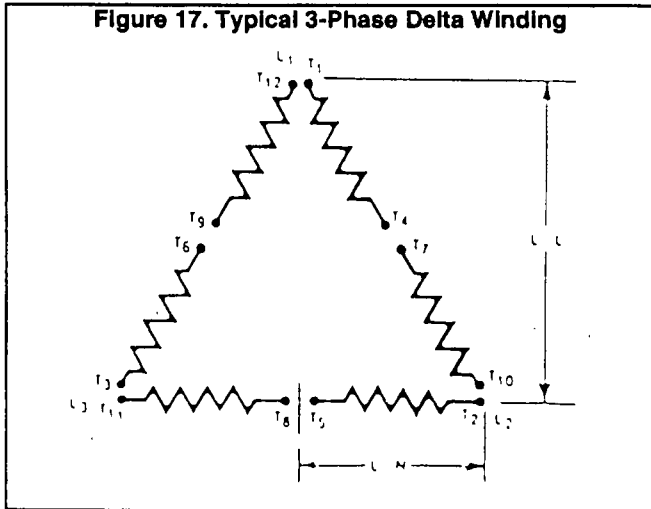


Stator AC Power Connection Systems (Continued)

3-PHASE DELTA STATOR SYSTEM:

Figure 17 is a schematic representation of a 3-phase Delta Stator configuration. Phase rotation is L1-L2-L3. The "Neutral" line is designated "L0".

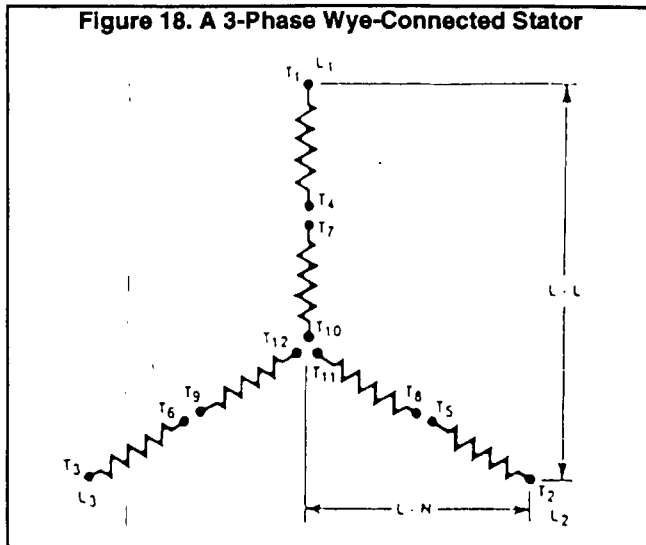
Figure 17. Typical 3-Phase Delta Winding



3-PHASE WYE-CONNECTED SYSTEM:

See Figure 18. This type of Stator consists of six (6) coils and twelve (12) leads coming out of the Stator. The twelve leads are reconnectable to supply several different voltages.

Figure 18. A 3-Phase Wye-Connected Stator



Section 1.2- MAJOR GENERATOR COMPONENTS

Introduction

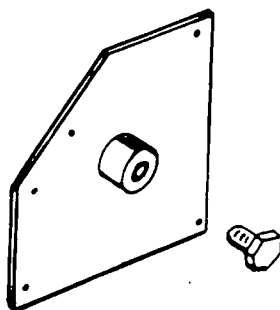
This section will discuss generator disassembly, inspection of components, and reassembly. See Figure 21 on Page 1.2-2.

Generator Disassembly

To disassemble the generator, proceed as follows. See Figure 21.

1. Remove the four capscrews, lockwashers and flatwashers (Items 22, 23 and 24) that retain the REAR BEARING CARRIER PLATE (Item 20) to the REAR BEARING CARRIER (Item 15). Remove the REAR BEARING CARRIER PLATE (Item 20).
2. Remove the Rear Bearing Carrier GASKET (Item 18).
3. Disconnect wires from BRUSH HOLDERS (Item 16).
4. Remove SCREWS (Item 17) that retain the BRUSH HOLDERS (Item 16) to the Rear Bearing CARRIER (Item 15). Remove the BRUSH HOLDERS (Item 16).
5. Remove hardware that retains the Rear Bearing CARRIER (Item 15) to the generator mounting base.
6. Remove the four long CAPSCREWS (Item 21), along with four LOCKWASHERS (Item 10).
7. A REAR BEARING CARRIER PULLER tool is available. See Figure 19. To order the tool, specify Part No. 74078.
 - a. Retain the PULLER TOOL to the Rear Bearing CARRIER (Item 15) using the same M6-1.00 x 8mm screws (Item 22) that were used to retain the Rear Bearing Carrier PLATE (Item 20).
 - b. Turn the center bolt on the PULLER TOOL (Figure 19) clockwise until the Rear Bearing CARRIER (Item 15) is free of the Rotor bearing.
 - c. Completely remove the Rear Bearing CARRIER (Item 15).
8. Free the STATOR ASSEMBLY (Item 14) from the BLOWER HOUSING (Item 2). Completely remove the STATOR ASSEMBLY (Item 14).

Figure 19. Rear Bearing Carrier Puller (Part #74078)



9. Remove the hardware that retains the STARTER (Item 40) to the ENGINE PLATE (Item 29). Remove the STARTER.
10. Remove all fasteners that retain the BLOWER HOUSING (Item 2). Remove the BLOWER HOUSING.
11. Remove CAPSCREWS (Item 33) that retain the FLEX PLATE (Item 28) to the FAN & RING GEAR (Item 25).

12. Remove the ROTOR ASSEMBLY (Item 1) with the FAN & RING GEAR (Item 25) attached.
13. Remove CAPSCREWS and LOCKWASHERS (Items 34 and 36) that retain the FLEX PLATE (Item 28) to the engine flywheel. Remove the FLEX PLATE (Item 28).
14. If the FAN & RING GEAR is to be removed from the ROTOR (Item 1), proceed as follows:
 - a. Remove CAPSCREW and LOCKWASHER (Items 30 and 31) that retain the FAN & RING GEAR to the ROTOR.
 - b. Remove the SPACER (Item 27).
 - c. Remove the FAN & RING GEAR (Item 25) from the ROTOR.

NOTE: The FAN & RING GEAR ASSEMBLY (Item 25) is retained to the ROTOR shaft by a KEY (Item 26).

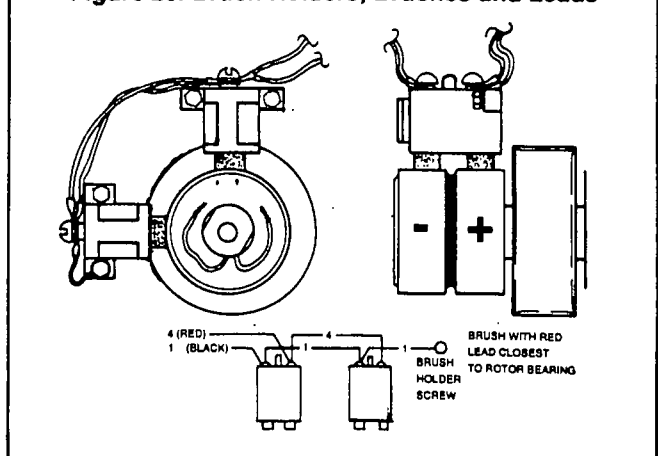
Inspection of Major Components REAR BEARING CARRIER PLATE:

Air slots in the Rear Bearing Carrier Plate allow cooling air to be drawn into the generator by fan action during operation. These air slots must be kept open and unobstructed. Clean the plate and check for cracks, obvious damage. Replace the Plate, if necessary.

BRUSHES:

Inspect both Brush Holders and their Brushes. Look for cracks, chipping, excessive wear. Replace any damaged Brush Holder. Brushes should be replaced as a complete set. Inspect Brush Leads No. 1 and 4, replace any damaged or defective Brush Lead.

Figure 20. Brush Holders, Brushes and Leads

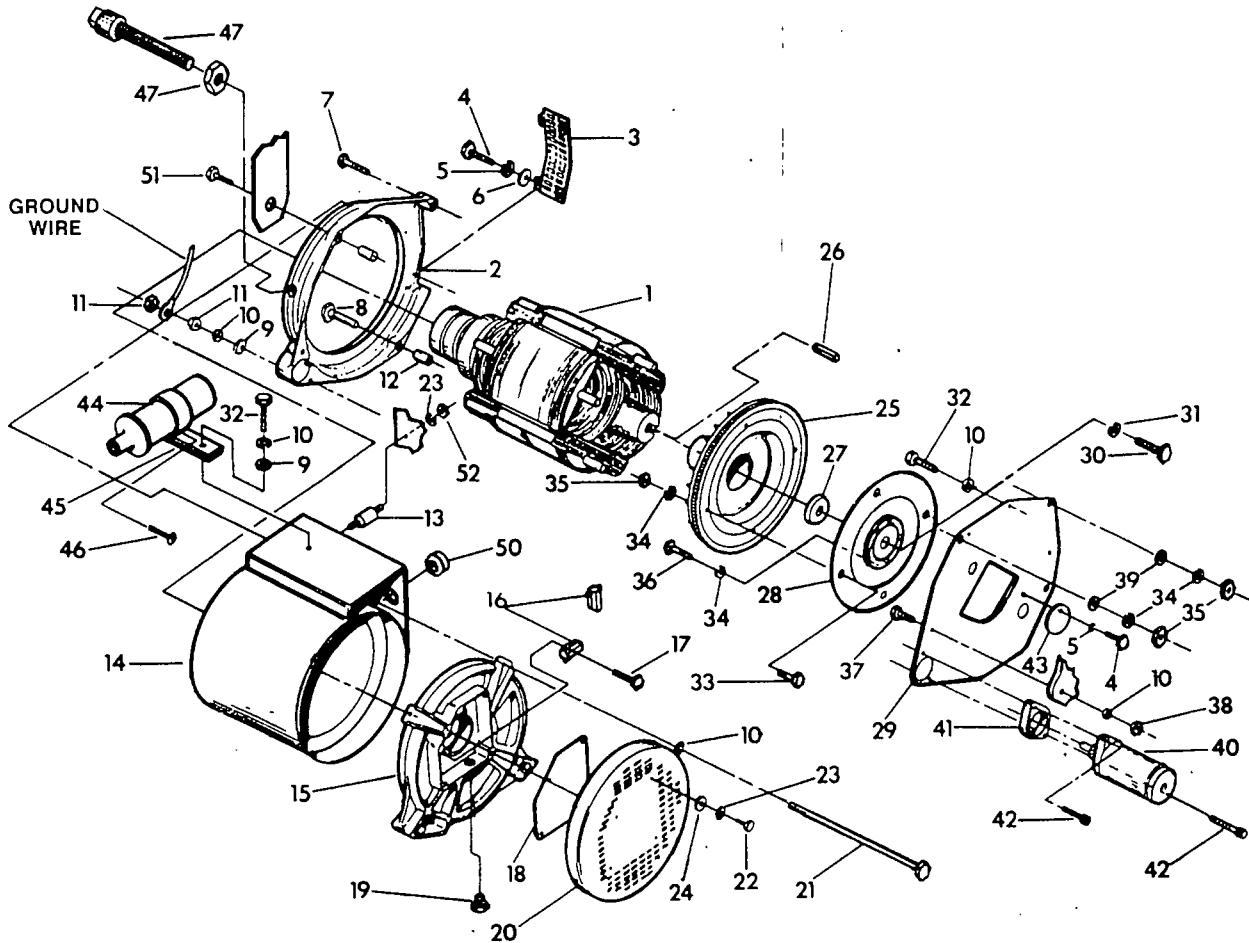


REAR BEARING CARRIER:

The Rear Bearing Carrier is an aluminum casting. Clean the casting and blow dry with compressed air. Inspect carefully for cracks, damage. An insert is pressed into the bearing carrier center bore, to accept the Rotor bearing. Use an inside micrometer to check the diameter of the insert. Replace the Rear Bearing Carrier if its insert's inside diameter (I.D.) is not within the following limits:

2.384-2.386 Inches (71.996-72.012mm)

Figure 21. Exploded View of AC Generator Assembly



ITEM	QTY	DESCRIPTION	ITEM	QTY	DESCRIPTION
1	1	Rotor Assembly	27	1	Spacer
2	1	Blower Housing	28	1	Flex Plate
3	1	Air Outlet Screen	29	1	Engine Plate
4	5	Pan Head Machine Screw	30	1	Hex Head Capscrew
5	5	Lockwasher	31	1	Lockwasher
6	4	Flatwasher	32	4	Hex Head Capscrew
7	1	Hex Head Capscrew	33	4	Hex Head Capscrew
8	1	Hex Head Capscrew	34	12	Lockwasher
9	2	Flatwasher	35	7	Hex Nut
10	9	Lockwasher	36	5	Hex Head Capscrew
11	3	Hex Nut	37	1	Hex Head Capscrew
12	2	Dowel Sleeve	38	1	Hex Nut
13*	4	Vibration Damper	39	3	Flatwasher
14	1	Stator Assembly	40	1	Starter Motor
15	1	Rear Bearing Carrier	41	1	Starter Adapter
16	2	Brush Holder	42	2	Hex Head Capscrew
17	4	Hex Head Screw	43	1	Fan Access Cover
18	1	Rear Bearing Carrier Gasket	44	1	Ignition Coil
19	1	Flame Arrestor	45	1	Ignition Coil Bracket
20	1	Rear Bearing Carrier Plate	46	1	Screw
21	4	Hex Head Capscrew	47**	1	Magnetic Pickup Assembly
22	4	Hex Head Capscrew	50	1	Rubber Grommet
23	8	Lockwasher	51	1	Hex Head Capscrew
24	4	Flatwasher	52	4	Hex Nut
25	1	Flywheel & Ring Gear Assembly			
26	1	3/8" square x 1" Key			

* Used to mount the generator control panel.

** Part of Engine Governor system.. See Part 7.

STATOR ASSEMBLY:

Clean the Stator can exterior surfaces with a soft brush or cloth. Use clean, dry, low pressure air (25 psi maximum) to clean the Stator.

Use an ohmmeter or a volt-ohm-milliammeter (VOM) to test the resistance of Stator AC power windings and excitation (DPE) windings. See Section 1.6.

Use an Insulation resistance tester (megohmmeter or hi-pot tester) to check the condition of stator insulation (see Section 1.3). If stator insulation is breaking down, dry the stator by blowing warm, dry air across it for several hours. Do NOT exceed 185° F. (85° C.). If insulation resistance is still low after drying, replace the stator assembly.

BLOWER HOUSING:

Clean the cast aluminum blower housing. Inspect the housing carefully for cracks, damage.

FLEX PLATE:

The flex plate is of 16 gauge steel. Clean the flex plate, then inspect it carefully for cracks, damage, wear. Check all holes for elongation and wear.

ROTOR ASSEMBLY:

Use clean, dry, low pressure air (25 psi maximum) to clean the rotor. Use a volt-ohm-milliammeter (VOM) to check the resistance of Rotor windings (Section 1.6).

Check the Rotor bearing for binding, seizing, roughness. The bearing is pre-lubricated and sealed; it requires no additional lubrication for the life of the bearing. If the bearing is defective, replace the Rotor assembly.

Check the keyway in the Rotor's tapered shaft for wear or damage. Also, inspect the drive key.

Inspect the slip rings. A dull or tarnished appearance indicates oxidation on the slip ring surface. If necessary, clean the slip rings with fine sandpaper. DO NOT USE ANY METALLIC GRIT TO CLEAN SLIP RINGS.

Use an insulation resistance tester (megohmmeter or hi-pot tester) to check the Rotor for insulation breakdown. If insulation resistance is low, dry the Rotor with heated, dry air. DO NOT EXCEED 185° F. (85° C.). If the insulation resistance is still low after drying, replace the Rotor assembly.

FAN AND RING GEAR ASSEMBLY:

During factory assembly, the ring gear is heated to 400° F. and the blower fan is installed. The entire assembly is then statically balanced. If the fan and ring gear must be replaced, replace it as an assembly.

Section 1.3- INSULATION RESISTANCE TESTS

Effects of Moisture and Dirt

The insulation in RV and IM generators is moisture resistant. However, prolonged exposure to moisture will gradually decrease the resistance of Stator and Rotor insulation. If moisture is allowed to remain in contact with generator windings, some of the moisture will be retained in cracks and voids of the insulation. This will result in a reduced insulation resistance and, eventually, the unit's AC output will be affected.

Dirt can make the problem worse since it tends to hold the moisture into contact with the windings.

Salt, as from sea air, can also worsen the problem since salt absorbs moisture from the air. When salt and moisture combine, they make a good electrical conductor.

Because of the detrimental effects of dirt and moisture, the generator should be kept as clean and dry as possible. Stator and Rotor windings should be tested periodically with an insulation resistance tester such as a megohmmeter or hi-pot tester. If the insulation resistance is excessively low, drying may be required to remove moisture. After drying, a second test of the insulation should be performed. If resistance is still low after drying, replacement of the defective windings may be necessary.

Insulation Resistance Testers

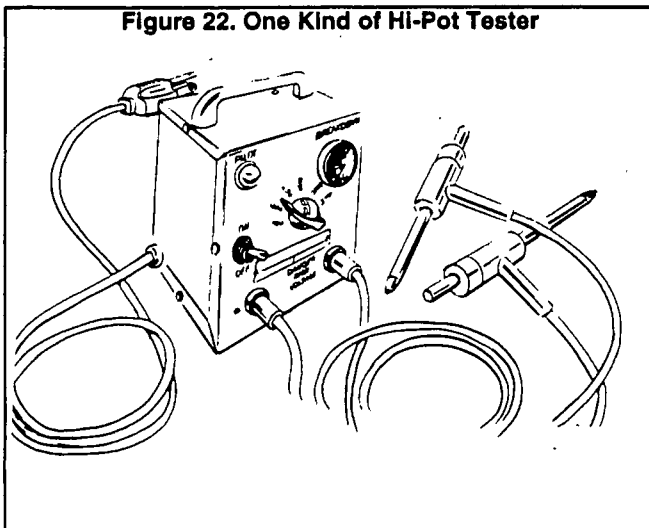
Figure 22 shows just one type of hi-pot tester. The tester shown is one of many brands that are commercially available. It has a "Breakdown" lamp which will glow to indicate insulation breakdown during the test.

Normally, the resistance of insulation is measured on the order of millions of ohms. It can be measured with a device called a "megger", which is a megohm meter (meg is for million) and a power supply. The power supply voltage varies but the most common is 500 volts. A megger voltage over 500 is NOT recommended.

When using a hi-pot tester or megger to measure insulation resistance, be sure to follow the manufacturer's instructions carefully.

CAUTION: Before attempting to measure insulation resistance in any winding, first disconnect any electronic components, regulators, diodes, surge protectors, protective relays, etc., from the circuit. Such components will be destroyed by the high voltages generated by a megger or hi-pot tester.

Figure 22. One Kind of Hi-Pot Tester



To measure insulation resistance, connect one tester lead to the leads for the winding to be tested and the other tester lead to the generator frame. Make sure no leads of the part being tested are touching any metal parts of the generator. If the "Neutral" is grounded, it must be disconnected. Follow the tester manufacturer's instructions and perform the resistance test.

Insulation Resistance- Main Stator

All stator leads (No. 11, 22, 33, 44, 2 and 6) must be isolated from ground and connected together. Connect one hi-pot or megger test lead to the main stator leads. Connect the other hi-pot or megger lead to the generator grounding stud. Set the hi-pot tester or megger voltage to "500". Follow the tester manufacturer's instructions and take the reading. Do not apply the voltage for longer than one (1) second.

If a hi-pot tester like the one shown in Figure 22 is being used, a "Breakdown" lamp on the tester will glow during the one second test to indicate an insulation breakdown.

If a megger is used to perform the test, the minimum acceptable value can be calculated using the following formula:

$$\text{Minimum Insulation Resistance (Megohms)} = \frac{\text{Generator Voltage} + 1}{1000}$$

Example: For a generator rated 240 volts AC:

$$\frac{240 + 1}{1000} = 1.24 \text{ Megohms}$$

If the reading is below the recommended value, the winding must be dried out.

Rotor Insulation Resistance

Before testing Rotor insulation, make sure the Rotor is completely isolated. This can be done by removing both brush holders with their brushes.

Connect one hi-pot tester or megger lead to the positive Rotor slip ring, the other test lead to a clean frame ground (such as the Rotor shaft). Set the tester to "500" volts and apply voltage - DO NOT APPLY VOLTAGE LONGER THAN ONE SECOND.

If a hi-pot tester is used, its "Breakdown" lamp will come on to indicate an insulation breakdown.

If a megger is used, the minimum acceptable value is 1.5 megohms.

If insulation is breaking down under the applied voltage, the Rotor must be dried out. After drying, retest the Rotor. If insulation still breaks down after drying, replace the Rotor assembly.

Cleaning the Generator

Greasy dirt or dirt that is caked may be loosened with a soft brush or a clean, damp cloth. A vacuum system may be used to clean up loosened dirt. Loose dust and dirt may also be blown away with clean, dry, low pressure air (25 psi maximum).

Drying the Generator

To dry the generator without disassembling it, proceed as follows:

1. Open the generator's main circuit breaker. NO ELECTRICAL LOADS MUST BE APPLIED TO THE UNIT WHILE DRYING.

Drying the Generator (Continued)

2. Disconnect Wires No. 4 from the Voltage Regulator.
3. Provide an external source to blow warm, dry air through the generator. DO NOT EXCEED 185° F. (85° C.).
4. Start the generator and let it run for 2 or 3 hours.
5. Stop the engine and retest Stator and Rotor insulation for breakdown.

Section 1.4- INTRODUCTION TO TROUBLESHOOTING

Introduction

A revolving field RV/IM type generator does not have a large number of parts. However, the parts are expensive. For that reason, a "parts replacement" method of troubleshooting is not cost effective. A basic understanding of generators is required if one is to achieve effective troubleshooting and repair. The technician must understand why generators behave or don't behave as they should. This section is intended to introduce the service technician to some of the fundamentals of troubleshooting generator problems.

DANGER: RV AND IM TYPE GENERATORS PRODUCE EXTREMELY HIGH AND DANGEROUS VOLTAGES. CONTACT WITH LIVE WIRES AND TERMINALS MAY RESULT IN HAZARDOUS AND POSSIBLY FATAL ELECTRICAL SHOCK. ONLY PERSONNEL WHO HAVE BEEN TRAINED IN THE SERVICING AND REPAIR OF RV/IM GENERATORS SHOULD ATTEMPT TO TROUBLESHOOT, TEST OR REPAIR SUCH EQUIPMENT.

Tools and Equipment

The generator service technician should have a well stocked tool box having a good selection of common hand tools. Such a tool box should be equipped with wrenches in both english and metric sizes. A selection of nut drivers (english and metric) is also recommended. In addition to common hand tools, the following specialized equipment should be available:

1. Volt-Ohm-Milliammeter or VOM
 - a. An accurate VOM is necessary for testing, adjusting and troubleshooting.
 - b. Simply having a VOM is not enough- the technician must be familiar with electrical circuits, must be able to read wiring diagrams and electrical schematics, and must be able to use the VOM effectively.
 - c. An accurate digital type VOM is recommended.
2. Frequency Meter
 - a. Frequency meter reads alternating current (AC) frequency, in HERTZ or CYCLES PER SECOND.
 - b. Generator AC output frequency must be known in order to check and adjust engine-generator operating speed. See "ROTOR ROTATIONAL SPEED" in this section.
3. Insulation Resistance Tester
 - a. See Section 1.3, "INSULATION RESISTANCE TESTS".
 - b. This tester will allow the user to test Rotor and Stator Insulation for breakdown under an applied voltage.
4. Load Bank- will permit a known electrical load to be applied to the generator, i.e., for testing and adjustment of the generator under load.

Rotor Rotational Speed

The revolving field (Rotor) is directly connected to the engine crankshaft and will rotate at the same speed as the engine. Engine speed is held nearly constant by an engine governor. Some generator models utilize a constant speed, MECHANICAL governor; other models may be equipped with an ELECTRONIC governor. See Part 7, "ENGINE SPEED CONTROL SYSTEM".

Generators may be equipped with either a 2-pole or a 4-pole Rotor. A 2-pole Rotor has a single North magnetic pole and a single South magnetic pole. A 4-pole Rotor has two North magnetic poles and two South magnetic poles. The following apply to 2 and 4-pole Rotor assemblies:

Figure 23. A Typical Volt-Ohm-Milliammeter

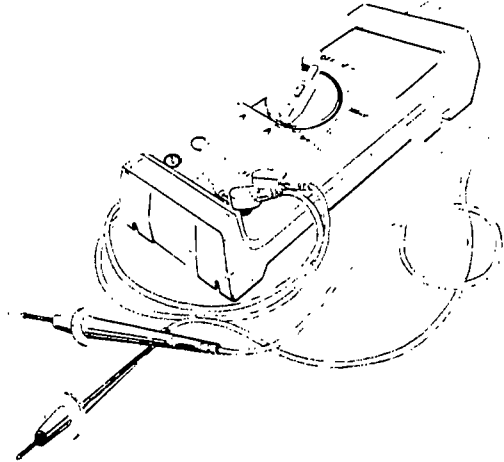


Figure 24. A Typical Frequency Meter

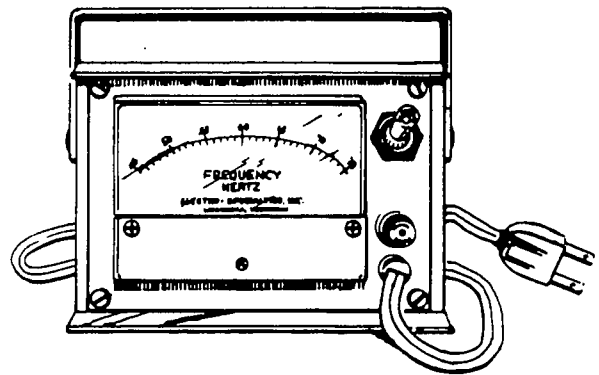
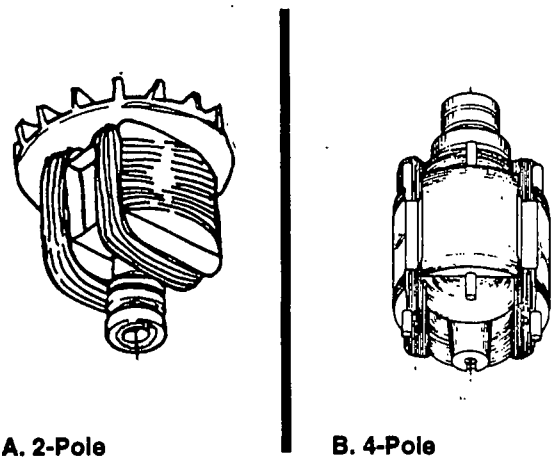


Figure 25. Typical 2 and 4-Pole Rotors



Rotor Rotational Speed (Continued)

1. A 4-Pole Rotor must be operated at 1800 rpm to supply a 60 Hertz AC output frequency; or at 1500 rpm for a 50 Hertz AC output frequency.
2. A 2-pole Rotor must be operated at 3600 rpm for a 60 Hertz AC output frequency; or at 3000 rpm for a 50 Hertz frequency.

The following formulas apply to (a) frequency, (b) rpm, and (c) number of Rotor poles:

FREQUENCY	=	$\frac{\text{RPM} \times \text{NO. OF ROTOR POLES}}{2 \times 60}$
RPM	=	$\frac{2 \times 60 \times \text{FREQUENCY}}{\text{NO. OF ROTOR POLES}}$
NO. OF ROTOR POLES	=	$\frac{2 \times 60 \times \text{FREQUENCY}}{\text{RPM}}$

Relationship of Voltage & Frequency

The generator's AC voltage regulator mounts a single adjustable potentiometer, used for adjustment of the Regulator's REFERENCE voltage (see "EXCITATION SYSTEM" on Page 1.1-4). The potentiometer is called simply a "Voltage Adjust Potentiometer" and is adjusted with the generator running at no-load and at a specific operating speed.

It is important that the engine speed governor be properly adjusted before the Voltage Adjust Potentiometer setting is attempted. The no-load AC frequency and voltage settings should be as follows:

1. For Units Rated 120/240 Volts at 60 Hertz: Set AC frequency to 60.5-63.5 Hertz and Voltage to 121-127 volts AC (line-to-neutral), or 242-254 volts AC (line-to-line).
2. For units rated 110/220 volts at 50 Hertz: Set AC frequency to 49-52 Hertz and voltage to 108-112 volts (line-to-neutral).

Visual Inspection

Quite often problems that occur in the generator can be detected by making a thorough visual inspection. Remove covers and look for any obvious problems. Burned windings, broken connections, leads, mounting brackets, etc., can usually be identified. Also look for loose or frayed insulation, loose or dirty electrical connections, broken wires.

Verify that the generator AC output leads are properly connected for (a) single voltage output, or (b) dual voltage output. See "STATOR AC POWER CONNECTION SYSTEMS" on Page 1.1-5.

Check for any foreign objects, loose nuts, bolts, and electrical connectors. Clear away paper, leaves, snow, building materials, etc., that might be sucked into the generator.

Constant Excitation Test

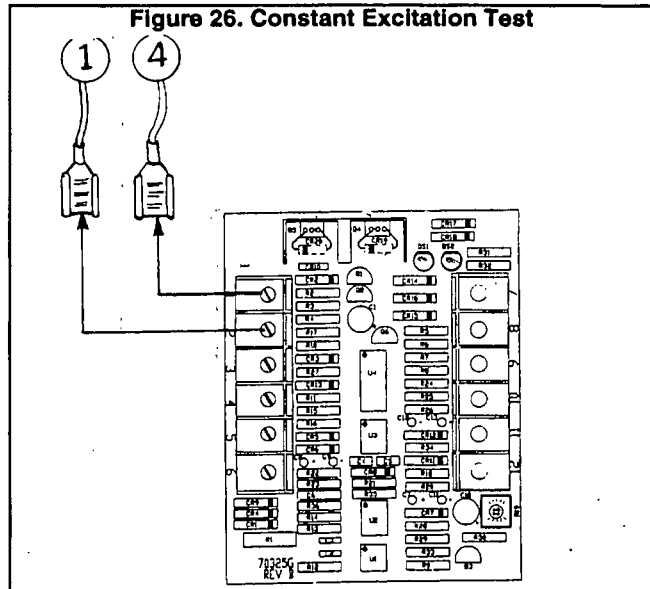
The generator's AC output voltage will vary with Rotor speed, generator design, connected loads, and excitation current to the Rotor. If the generator speed and excitation current to the Rotor are known, the no-load AC output voltage can be measured and compared to the design value. A problem can be isolated to (a) Stator Excitation (DPE) windings to Voltage Regulator circuit, including the Regulator, or (b) Voltage Regulator to Rotor circuit, excluding the Regulator, or (c) the Stator assembly. Perform the test as follows:

1. Shut the generator engine down.
2. Connect a voltmeter to the generator's AC output leads.
3. Disconnect Wires No. 4 and 1 from the Voltage Regulator.
4. Connect a jumper wire from terminal #1 (Wire #15) of the engine control circuit board to the terminal end of Wire #4 (just disconnected from the Regulator).
5. Connect a jumper wire from terminal #2 of the engine control circuit board (Wire #0, ground) and to the terminal end of Wire #1 (just disconnected from the Regulator).
6. Start the generator and let it run at no-load (main breakers open) and at its rated speed.
7. Read the generator's AC output voltage from the voltmeter connected in Step 2. Reading should be approximately one-half rated voltage (about 40-60 volts line-to-neutral or 80-120 volts line-to-line).
8. Shut the generator down.
9. Reconnect Wires No. 1 and 4 to the Voltage Regulator.

If voltage reading is normal in Step 7, the Wires #1 and 4 circuit, brushes and slip rings, Rotor and Stator are working satisfactorily. The problem is in the circuit that includes (a) stator excitation windings, (b) thermal protector, (c) excitation circuit breaker (CB4), (d) Wires 2 and 6, and (e) Voltage Regulator.

NOTE: Field boost current is available to the Rotor only while the engine is cranking. Loss of excitation current flow to the Rotor will result in a decrease in generator AC output voltage to a value commensurate with Rotor residual magnetism (about 2 to 7 volts AC).

Figure 26. Constant Excitation Test



Measuring Voltages

Quite often the service technician will want to measure a DC or AC voltage.

The DC voltage most often measured will be battery voltage (12 volts DC).

When measuring AC voltages, the generator will have to be running at rated speed and may have some of the protective guards and covers removed. BE CAREFUL. It is best to shut the unit down when connecting meters. Use the meter's instruction manual to verify its operation and limitations.

Measuring Current

Alternating current measurements can be taken with a "clamp-on" type ammeter. Amperage should never exceed the nameplate rating when running the intended electrical load(s).

Measuring Resistance

Resistance of the main stator windings is very low. Some meters are not able to read such a low resistance and, for that reason, use of a very sensitive digital type meter is recommended. A standard VOM can be used to check for continuity, shorts or grounded condition.

Effects of Engine Power

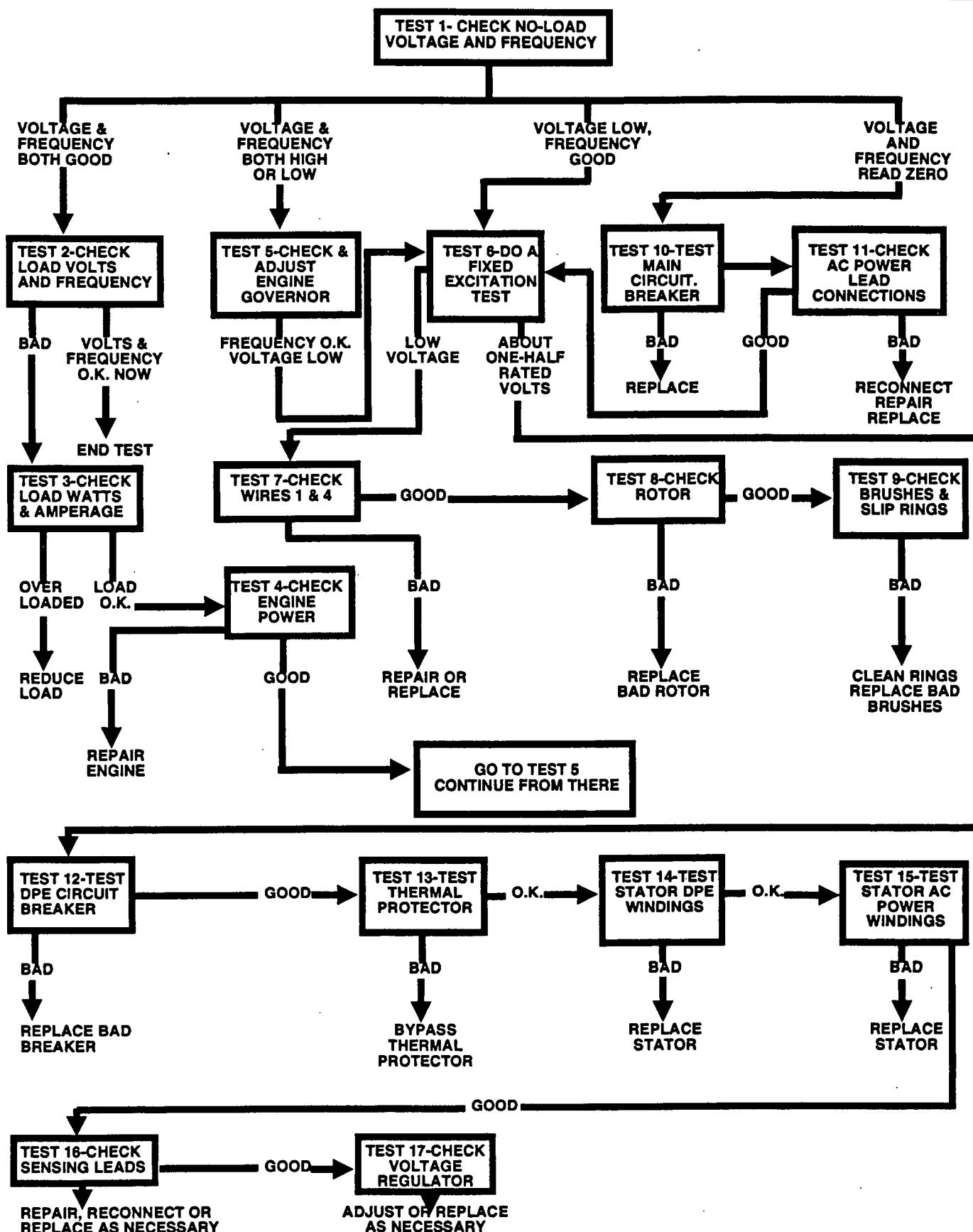
The generator engine must provide adequate power to operate the generator at rated load. The greater the load current (amperage) or load watts, the greater the engine power that is needed. As a general rule, approximately 2 engine horsepower is needed for each 1000 watts (1.0 kW) of generator power.

If the generator's wattage/amperage capacity is exceeded, engine power may not be sufficient to handle the increased load. The result will be a decrease in engine speed (rpm) and a corresponding reduction in AC output frequency and voltage.

A badly worn engine, one that has lost compression, or one with a mechanical problem may not be able to handle a load within the generator's rated capacity. Problems with generator AC output are often the direct result of an engine problem, rather than a generator problem.

If engine speed, AC frequency and voltage are normal when the generator is running at no load, but deteriorate when electrical loads are applied, an underpowered engine may be the cause of the problem.

Section 1.5- TROUBLESHOOTING FLOW CHART



Using the Troubleshooting Flow Chart

When a problem occurs with an RV/IM series generator set, the first step is to determine exactly what that problem is. The nature of the problem can usually be found by checking the unit's no-load AC output voltage and frequency. This is Test 1 in the Flow Chart. A check of the no-load voltage and frequency will usually end with one of the following results:

1. Voltage and frequency are both good. If this is the case, the next step is to check voltage and frequency with electrical load applied.
2. Voltage and frequency are both high or low, usually an engine governor problem, i.e., governed speed too high or too low.

3. Voltage is low, but AC frequency is good. The cause of this problem can often be found by performing a "Fixed Excitation" test.

4. Voltage and frequency read "zero".

Once the nature of the problem is defined, the cause of the problem can usually be found by following the explanations and arrows in the Flow Chart.

Use the "*TROUBLESHOOTING FLOW CHART*" in conjunction with test instructions in Section 1.6, "*TROUBLESHOOTING TEST PROCEDURES*".

Section 1.6- TROUBLESHOOTING TEST PROCEDURES

Introduction

The following numbered tests may be performed in conjunction with identically numbered tests in the "TROUBLESHOOTING FLOW CHART" (Section 1.5). The "FLOW CHART" has been carefully planned to prevent guesswork and to locate most common generator problems.

NOTE: Quite often the cause of a problem can be determined by completing a close visual inspection of the generator. See "VISUAL INSPECTION" on Page 1.4-2.

Test 1- Check No-Load Voltage and Frequency

DISCUSSION:

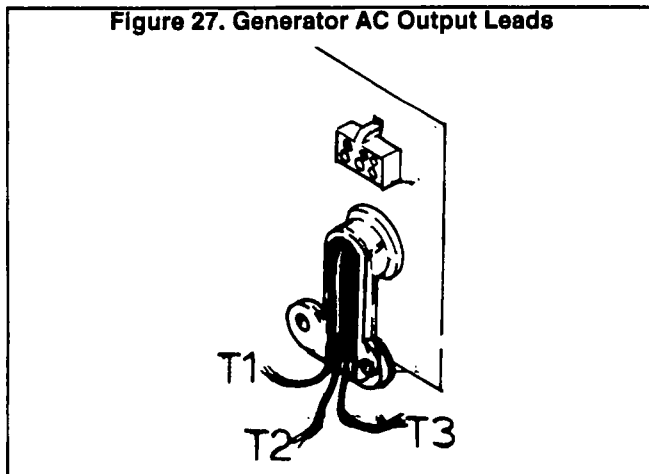
When a generator problem occurs, the first step is to identify the problem. This can usually be accomplished quickly by checking the no-load AC output voltage and frequency. Once the exact problem has been identified, the cause of the problem can usually be isolated by continuing orderly tests as shown in the "TROUBLESHOOTING FLOW CHART".

NOTE: You will have to determine whether the AC leads have been connected for single voltage output only (120 volts, 60 Hertz or 110 volts, 50 Hertz); or for dual voltage output (120/240 volts, 60 Hertz or 110/220 volts, 50 Hertz). See "STATOR AC POWER CONNECTION SYSTEMS" on Page 1.1-5.

PROCEDURE:

1. Connect an AC voltmeter and AC frequency meter across the generator's AC output leads. Open main circuit breaker.
 - a. If connected for single voltage AC output, connect the meters across leads T1 and T2.
 - b. If connected for dual voltage output, connect meters across leads T1 and T2 or T2 and T3 for a 120 volts, 60 Hertz (or 110 volts, 50 hertz) reading. For a 240 volts, 60 Hertz (or 220 volts, 50 hertz) reading, connect meter test leads across generator leads T1 and T3.
2. Start the generator engine, let it stabilize and warm up.
3. Read the AC output voltage and frequency. Readings should be as follows:
 - a. For units rated 120/240 volts, 60 hertz: readings should be 121-126 volts at 61-63 Hertz; or 242-252 volts at 61-63 Hertz.
 - b. For units rated 110/220 volts, 50 hertz: readings should be 111-113 volts at 51-53 Hertz; or 222-226 volts at 51-53 Hertz.

Figure 27. Generator AC Output Leads



RESULTS:

1. If the no-load voltage and frequency are good, go to Test 2.
2. If no-load voltage and frequency are both high or low, go to Test 5.
3. If frequency reads good but voltage is low, go to Test 6.
4. If voltage and frequency read "zero", go to Test 10.

Test 2- Check Load Voltage and Frequency

DISCUSSION:

Generator problems are sometimes caused by exceeding the wattage/amperage capacity of the unit. What appears to be a generator problem may, in fact, be caused by an engine that has lost power. The following facts apply:

- ☐ Quite often, the maximum wattage that can be supplied by a generator is limited by available engine power. When connected loads exceed a critical point, engine speed will drop. With a reduction in engine speed will come a voltage and frequency loss.
- ☐ It is possible that an engine can lose power to the extent that even normal rated generator output power can be achieved. Engine speed, frequency and voltage can then drop before a unit's rated maximum capacity has been reached.

PROCEDURE:

If no-load AC output voltage and frequency were within limits, but operational problems occur when electrical loads are applied, check the output voltage and frequency under load as follows:

1. Connect an AC voltmeter and frequency meter across the generator's AC output leads. Close the main circuit breaker.
2. Start the generator, let it stabilize and warm up.
3. Apply an electrical load to the generator equal to its rated maximum wattage/amperage capacity.
4. Read the voltage and frequency.
 - a. Units rated 120/240 volts, 60 Hertz: Readings should be at least 116 volts and 58 Hertz (or higher).
 - b. Units rated 110/220 Volts, 50 Hertz: Readings should be at least 107 volts, 48 Hertz (or greater).

RESULTS:

1. If load voltage and frequency are below limits, go to Test 3.
2. If voltage and frequency are good, discontinue tests.

Test 3- Check Load Watts and Amperes

DISCUSSION:

If the unit's AC output frequency and voltage drop below limits when electrical loading is applied, it is possible that the rated capacity of the generator has been exceeded.

PROCEDURE:

Add up wattage ratings of all electrical loads applied to the generator at one time. This total should not be greater than the unit's rated maximum wattage capacity. If desired, a clamp-on ammeter may be used to measure load current. The unit's rated maximum amperage capacity should not be exceeded.

Test 3- Check Load Watts and Amperes (Continued)

NOTE: The best way to check load wattage and amperage is to use a load bank. A load bank will allow the operator to apply a known wattage/amperage load to the generator and will permit voltage, frequency and amperage to be read directly from the load bank.

RESULTS:

1. If the generator is overloaded, reduce the load to the unit's rated capacity.
 - a. If voltage and frequency are excessively low at the unit's rated capacity or less, go on to Test 4.
 - b. If voltage and frequency are acceptable at the unit's rated capacity, discontinue tests.
2. If the load is within the unit's rated capacity, but load voltage and frequency are excessively low, go on to Test 4.

Test 4- Check Engine Power

DISCUSSION:

If excessive rpm and frequency droop occurs when electrical loads are applied, the engine may be underpowered due to a malfunction.

PROCEDURE:

Check the engine for (a) adequate air flow, (b) clogged air cleaner, (c) incorrect timing, (d) mechanical failure, etc.

RESULTS:

1. If engine problems are found, repair the engine as necessary.
2. If engine checks good, go on to Test 5.

Test 5- Check & Adjust Engine Governor

DISCUSSION:

If engine speed (and frequency) droop excessively under load, the engine governor may require adjustment.

PROCEDURE:

Refer to Part 7, "ENGINE SPEED CONTROL SYSTEM". Governor adjustment procedures for both the mechanical and electronic type governors can be found in Part 7.

RESULTS:

1. If, after governor adjustment, voltage and frequency output at no-load and under load are good, discontinue tests.
2. If, after governor adjustment, frequency is good, but voltage is excessively low, go on to Test 6.

Test 6- Do a Fixed Excitation Test

DISCUSSION:

See "CONSTANT EXCITATION TEST" on Page 1.4-2.

PROCEDURE:

See "CONSTANT EXCITATION TEST" on Page 1.4-2.

RESULTS:

1. If voltage is excessively low, go to Test 7.
2. If about 1/2 rated volts is indicated, go to Test 12.

Test 7- Check Wires 1 and 4

DISCUSSION:

The fixed or constant excitation test (Test 6) consisted of applying battery direct current to the Rotor windings (12 volts DC). With the normal excitation circuit disconnected, application of battery current should result in approximately one-half rated voltage output (about 60-80 volts AC).

If battery current is applied and AC output voltage is excessively low, a problem exists in Wires 1 and 4 from the Regulator, or the brushes and slip rings, or the Rotor or stator windings.

If the application of battery current results in an AC output of about one-half rated volts, but AC output voltage is low during normal operation, a problem exists in the stator excitation (DPE) windings, in the excitation circuit between the stator DPE windings and the Regulator, or in the Regulator itself.

PROCEDURE:

1. Visually inspect Wires 1 and 4, between the Voltage Regulator and the brushes.
2. Use a VOM to test Wire 1 (between the brushes and Regulator) for continuity.
3. Check Wire 4 (between the brushes and Regulator) for continuity.
4. Check that Wires No. 1 and 4 are properly connected at the Regulator and at the brushes.

RESULTS:

1. Repair, replace or reconnect wires 1 and 4 as necessary.
2. If Wires 1 and 4 are good, go to Test 8.

Test 8- Check Rotor

DISCUSSION:

Problems will be encountered if the Rotor is (a) open, (b) shorted, or (c) grounded. This test will determine if any of these problems exist in the Rotor.

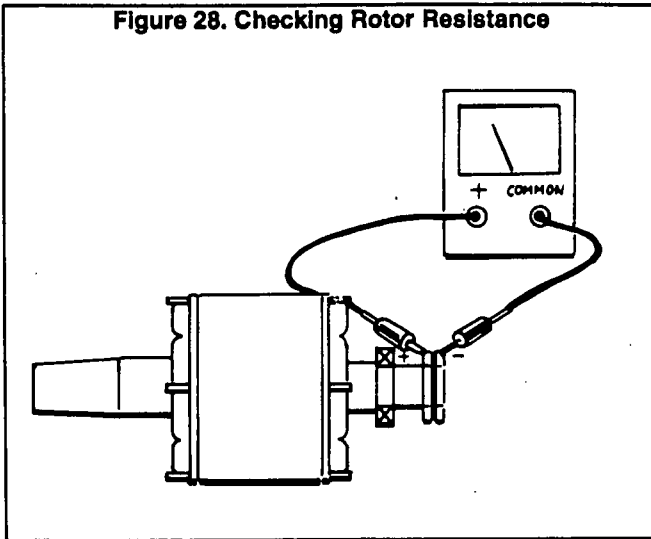
PROCEDURE:

1. If Rotor is installed, remove the bearing carrier cover to gain access to the Rotor brushes and slip rings.
2. Disconnect Wires 1 and 4 from the brushes, to prevent interaction.
3. Connect the positive test lead of an ohmmeter to the positive slip ring, the common test lead to the negative slip ring. The positive slip ring is the one nearest the Rotor bearing (see Figure 28). The meter should indicate the resistance of the Rotor windings, approximately 8.5 ohms (plus or minus 10%) for both 8 and 10 kW models.
4. Set a VOM to a very high resistance scale, such as "Rx10,000" or "Rx1K". Zero the meter. Connect the positive VOM test lead to the positive slip ring. Connect the negative VOM test lead to a clean frame ground, such as the Rotor shaft. The meter should read "infinity".

RESULTS:

1. In Step 3, a very high resistance or "infinity" indicates an open or partially open condition. Replace the Rotor.
2. In Step 3, a very low resistance indicates a shorted or grounded condition. Replace the Rotor.
3. In Step 4, any reading other than "infinity" indicates a grounded condition. Replace the Rotor.
4. If all Rotor readings are good, go to Test 9.

Figure 28. Checking Rotor Resistance



Test 9- Check Brushes and Slip Rings

DISCUSSION:

If the fixed (constant) excitation test did not result in an AC output voltage of approximately one-half rated volts, one possible cause of the problem might be defective brushes and/or slip rings.

PROCEDURE:

Remove Wires 1 and 4 from the brushes. Then, remove the brush holders from the rear bearing carrier. Inspect the brushes and brush holders. Replace, if cracked, damaged, worn excessively, etc.

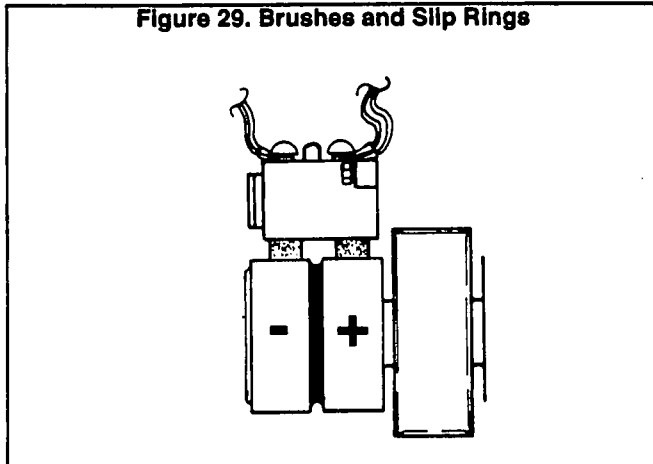
Inspect the slip rings. If they are dull or tarnished, they can be cleaned with fine sandpaper. DO NOT USE ANY METALLIC GRIT TO CLEAN SLIP RINGS. Use low pressure air (25 psi or less) to blow away cleaning residue.

Reassemble brushes and brush holders to rear bearing carrier. Make sure brushes are properly seated in brush holders and are contacting the slip rings properly. Reconnect Wires 1 and 4 to brushes. Rotate the Rotor several times to seat the brushes against the slip rings.

RESULTS:

Clean slip rings, replace bad brushes or brush holder(s) as necessary.

Figure 29. Brushes and Slip Rings



Test 10- Test Main Circuit Breaker

DISCUSSION:

If AC output voltage and frequency are "zero", one possible cause of the problem is an open or failed main circuit breaker.

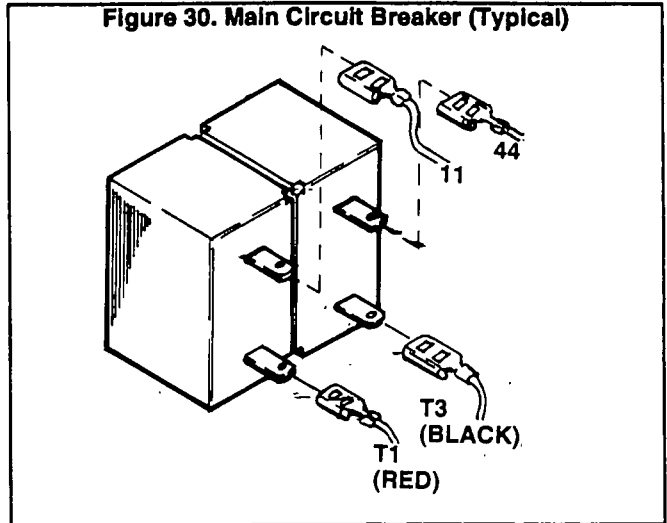
PROCEDURE:

Make sure the main circuit breaker is set to its "Closed" position. If the breaker is closed, check it for continuity.

RESULTS:

1. Replace main circuit breaker, if it is defective.
2. If main breaker is good, go to Test 11.

Figure 30. Main Circuit Breaker (Typical)



Test 11- Check AC Power Lead Connections

DISCUSSION:

The stator's AC output leads must be properly connected as outlined under "STATOR AC POWER CONNECTION SYSTEMS" (Page 1.1-5).

PROCEDURE:

Check that Stator AC output leads 11, 22, 33 and 44 (as well as T1, T2 and T3) are properly connected as shown in the appropriate wiring diagram/schematic. Reconnect wires as necessary.

RESULTS:

Reconnect, repair or replace stator AC output leads as necessary.

Test 12- Test DPE Circuit Breaker

DISCUSSION:

The excitation (DPE) circuit breaker is connected in series with lead 2 (or 2A) between the stator excitation (DPE) windings and the voltage regulator. If the breaker should open, excitation winding AC output to the Regulator will be lost and AC output from the generator will drop to a voltage that is commensurate with the Rotor's residual magnetism (about 2 to 7 volts AC). Application of fixed excitation current (Test 6) will result in an AC output voltage equal to approximately one-half rated voltage.

Test 12- Test DPE Circuit Breaker (Continued)

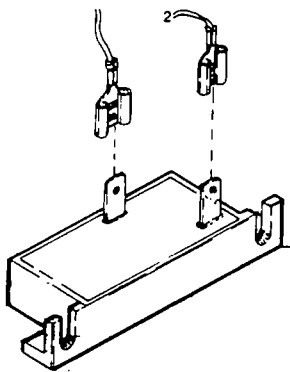
PROCEDURE:

1. With the generator shut down, disconnect the leads from the two breaker terminals, to prevent interaction. Then, connect the test leads of a volt-ohm-milliammeter (VOM) across the two circuit breaker terminals. The meter should read continuity or a very small resistance.
 - a. If meter indicates "continuity" or a small resistance, go to Step 2.
 - b. If the meter reads "infinity" replace the circuit breaker.
2. Reconnect the two leads to the circuit breaker terminals.
3. Start the generator engine.
4. Check the generator's AC output voltage (see Test 1).
 - a. If AC output voltage is excessively low, go to Step 5.
 - b. If AC output voltage is normal, discontinue tests.
5. Connect a jumper wire across the two terminals of the excitation (DPE) circuit breaker. Again, check the unit's AC output voltage.

RESULTS:

1. In Step 1, if the meter reads "infinity" it should be replaced.
2. If AC output voltage was excessively low in Step 4, but normal in Step 5, replace the excitation (DPE) circuit breaker.

Figure 31. Excitation (DPE) Circuit Breaker



Test 13- Test Thermal Protector

DISCUSSION:

Also see "THERMAL PROTECTOR" on Page 1.1-4. A thermal protector that has failed open will cause the same effects as an excitation circuit breaker that has failed open.

PROCEDURE:

1. Disconnect lead 2 from the excitation circuit breaker.
2. Disconnect lead 6 from the Voltage Regulator.
3. Locate lead 5. This lead is brought out of the Stator and is unattached. A wire nut covers its end.
4. Connect the test leads of a VOM across leads 5 and 6. The meter should read a small resistance (the resistance of the Stator excitation winding).
5. Now, connect the VOM test leads across leads 2 and 6. Again, the resistance of the Stator excitation windings should be indicated (about 0.73 ohm for 10 kW units; 1.00 ohm for 8 kW units).

RESULTS:

1. If the VOM indicated excitation winding resistance in Step 4, but read "infinity" in Step 6, the thermal protector will have to be bypassed as follows:
 - a. Cut Wire 2 as close as possible to the end of Wire 5.
 - b. Strip the insulation from the end of Wire 2 that goes to the excitation circuit breaker.
 - c. Strip the insulation from the end of Wire 5.
 - d. Connect the stripped ends of Wire 2 and 5, retain with the wire nut.
2. If the meter indicated excitation winding resistance in both Steps 4 and 5, go to Test 14.

Figure 32. Thermal Protector in the Circuit

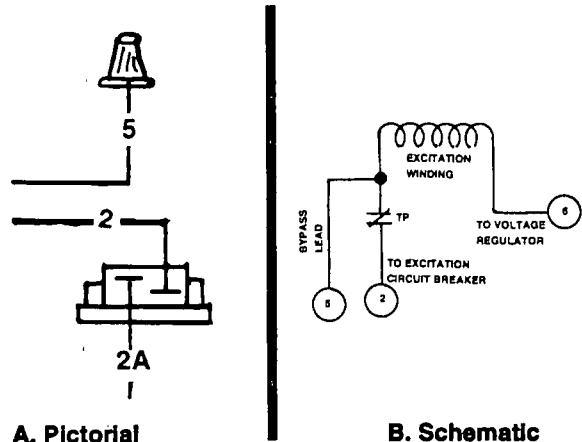
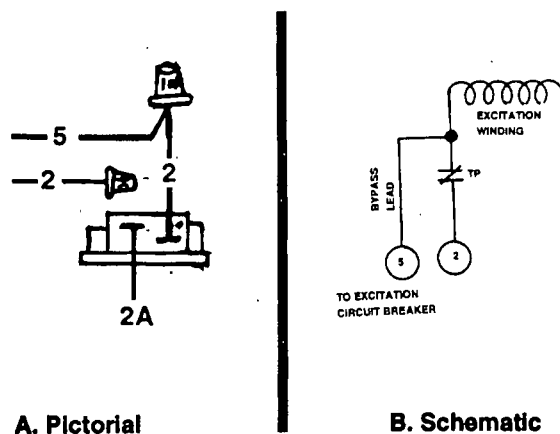


Figure 33. Thermal Protector Bypassed



Test 14- Test Stator DPE Windings

DISCUSSION:

An open condition in the stator excitation windings will result in loss of excitation output to the Voltage Regulator. The Regulator will then shut down and generator AC output voltage will drop to a value commensurate with Rotor residual magnetism (about 2-7 volts).

A grounded or shorted condition will also result in problems with generator AC output. This test will test the Stator excitation windings for (a) open condition, and (b) for a grounded condition.

NOTE: Before attempting to test the Stator excitation winding, be sure the thermal protector has not failed open. See Test 13.

PROCEDURE:

1. Disconnect Wire 2 from the excitation circuit breaker (CB4).
2. Disconnect Wire 6 from the Voltage Regulator.
3. Use a VOM to test the resistance of the excitation windings. Connect the VOM test leads across leads 2 and 6. The VOM should indicate the resistance of the excitation windings.
 - a. For 8 kW units, reading should be approximately 1.00 ohm (plus or minus 10%).
 - b. For 10 kW units, resistance should be approximately 0.73 ohm (plus or minus 10%).
4. Now, set the VOM to a high resistance scale such as "Rx10,000" or "Rx1K". Zero the meter. Connect one VOM test lead to Wire 6, the other test lead to a clean frame ground on the Stator. The meter should read "Infinity".

RESULTS:

1. If stator excitation windings fail the test, replace the Stator assembly.
2. If excitation windings check good, go to Test 15.

Test 15- Test Stator AC Power Windings

DISCUSSION:

An open or shorted condition in the Stator will adversely affect generator AC voltage output. This test will check the AC power windings for (a) open condition, (b) grounded condition, and (c) short between parallel windings.

PROCEDURE:

1. Disconnect and isolate Stator leads 11, 22, 33 and 44. Also disconnect and isolate Stator leads 5 and 6.
2. Set a VOM to its "Rx1" scale and zero the meter.
3. Connect the VOM test leads across stator leads 11 and 22.
 - a. For 8 kW units, the meter should read approximately 0.21 ohm.
 - b. For 10 kW units, the VOM should indicate approximately 0.14 ohm.

NOTE: The actual resistance will vary slightly with temperature, with a nominal variation as much as plus or minus 10 percent.

4. Connect the VOM test leads across stator leads 33 and 44. Resistance readings should be the same as in Step 3(a) and 3(b).
5. Now, set the VOM to a high resistance scale, such as "Rx10,000" or "Rx1K". Zero the meter. Connect one meter test lead to stator lead 11, the other test lead to stator lead 33.
 - a. The meter should read "infinity".
 - b. Any reading other than "infinity" indicates a short between parallel windings.
6. With VOM still set for a high resistance, connect one VOM test lead to stator lead 11, the other test lead to a clean frame ground on the stator. Repeat the test with one test lead attached to stator lead 33 and the other connected to a clean frame ground on the stator.
 - a. The VOM should read "infinity".
 - b. Any reading other than "infinity" indicates a grounded condition.

7. With the VOM still set for a high resistance, connect one VOM test lead to stator lead 11, the other to stator lead 5. Repeat the test with one VOM test lead connected to stator lead 33, the other to stator lead 5.

- a. In both cases, the meter should read "Infinity".
- b. Any reading other than "infinity" indicates a short between windings.

RESULTS:

1. If any reading is bad, replace the stator assembly.
2. If stator checks good, go to Test 16.

Test 16- Check Sensing Leads

DISCUSSION:

The Voltage Regulator must sense ACTUAL AC power winding voltage. It must then electronically "compare" the ACTUAL voltage to a REFERENCE voltage that is preset in the Regulator. The Regulator acts to maintain an actual voltage that is the same as the reference voltage by regulating excitation current flow to the Rotor.

If ACTUAL voltage sensing signals to the Regulator become lost for any reason, the normal reaction of most Regulators would be to "think" that ACTUAL voltage is too low. The Regulator would then increase excitation current flow to the Rotor in an attempt to increase the ACTUAL voltage. That is, the Regulator and Rotor would go to a "Full Field" condition and the generator's AC output voltage would go to a very high maximum value.

However, the Voltage Regulator used on RV/IM models is equipped with a "sensing loss cutout" feature. That is, when loss of sensing signals occurs, the Voltage Regulator will shut down. When the Regulator shuts down, a complete loss of excitation current flow to the Rotor will occur. The actual AC output voltage will then drop dramatically to a value commensurate with Rotor residual magnetism (about 2 to 7 volts AC).

PROCEDURE:

1. With the generator running, observe the red LED (light emitting diode) on the AC voltage regulator. If sensing voltage is available to the regulator, the light should be ON.
 - a. If the light is OUT, complete Step 2 below.
 - b. If the light is ON, go to Test 17.
2. Connect an accurate AC voltmeter across the Voltage Regulator sensing terminals (leads 11 and 22). The meter should indicate line-to-neutral voltage. If not, complete the following:
 - a. Carefully inspect sensing leads 11 and 22, between the engine control circuit board and the Voltage Regulator.
 - b. Inspect leads 11 and 22 between the engine control circuit board and the AC connection panel.
 - c. Use a VOM to check sensing leads 11 and 22 for an open or shorted condition.

RESULTS:

1. Reconnect, repair or replace any damaged, open, shorted or defective sensing leads.
2. If sensing leads are good, go to Test 17.

Test 17- Check Voltage Regulator

DISCUSSION:

The Voltage Regulator is discussed under Test 16 above, as well as on Page 1.1-4. The Regulator is equipped with two safety features, as follows:

Test 17- Check Voltage Regulator (Continued)

1. Sensing loss shutdown- if sensing is not available to the Regulator (sensing leads 11 and 22), the Regulator will shut down.

a. With the Regulator shut down, loss of regulated excitation current to the Rotor will occur.

b. The generator's AC output voltage will drop to a value commensurate with Rotor residual magnetism (approximately 2-7 volts AC).

c. The red LED (light emitting diode) on the Regulator is a sensing indicator. The light will go OUT when sensing signals to the Regulator (Wires 11 and 22) are not available. It should remain ON during operation, indicating that sensing voltage is available.

2. Voltage limiting- maximum AC output voltage is limited to a maximum of approximately 140-145 volts AC (line-to-neutral).

PROCEDURE:

If a zero or low AC output voltage condition exists and you have completed all previous tests indicated in the "Troubleshooting Flow Chart", you might try adjusting the Voltage Regulator. If attempts to adjust the Regulator do not produce positive results, replace the Regulator. Then, adjust the Regulator and test generator operation.

Part 2 ENGINE MECHANICAL

NP and IM Series
**RECREATIONAL
VEHICLE &
INDUSTRIAL
MOBILE
AC GENERATORS**
Liquid Cooled 1.2 Liter
Gas Engine Models

TABLE OF CONTENTS

SECTION	TITLE
2.1	Basic Engine Mechanical
2.2	Timing Belt
2.3	Cylinder Head
2.4	Oil Pan and Oil Pump
2.5	Oil Seal Replacement
2.6	Engine Overhaul

Section 2.1- BASIC ENGINE MECHANICAL

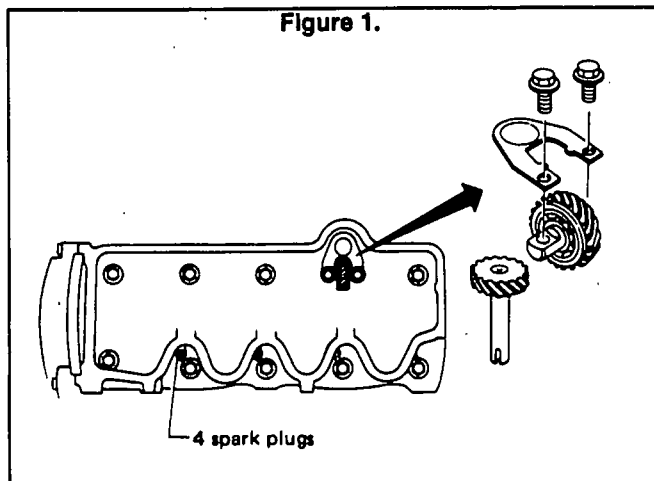
Introduction

This section covers some of the basic engine servicing tasks. Included in the Section are commonly used tightening procedures for cylinder head bolts, manifold nuts and carburetor bolts. Also covered are valve clearance adjustment and drive belt checking procedures.

Tightening Cylinder Head Bolts

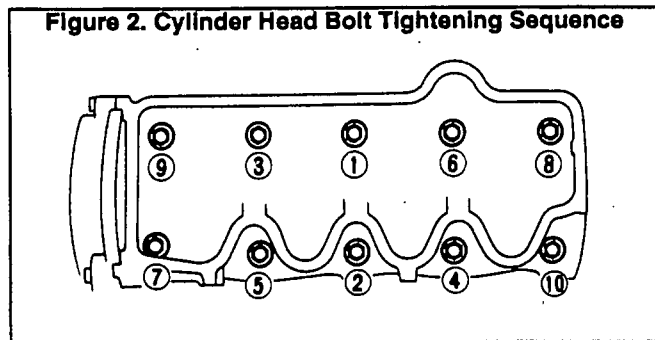
Retighten cylinder head bolts while the engine is cold, at approximately 68° F. (20° C.). Tighten the bolts as follows:

1. Remove all spark plugs, oil pump drive gears, retainer and bolts (Figure 1).



2. Tighten bolts to 47-51 foot-pounds (64-69 N-m) in the sequence shown below.

Figure 2. Cylinder Head Bolt Tightening Sequence



Tighten Manifold, Exhaust Manifold and Carburetor Fasteners

INTAKE MANIFOLD NUTS:

Tighten to 12-15 foot-pounds (16-21 N-m).

EXHAUST MANIFOLD NUTS:

Tighten to 12-15 foot-pounds (16-21 N-m).

CARBURETOR BOLTS:

Tighten to 4.3-5.8 foot-pounds (6-8 N-m).

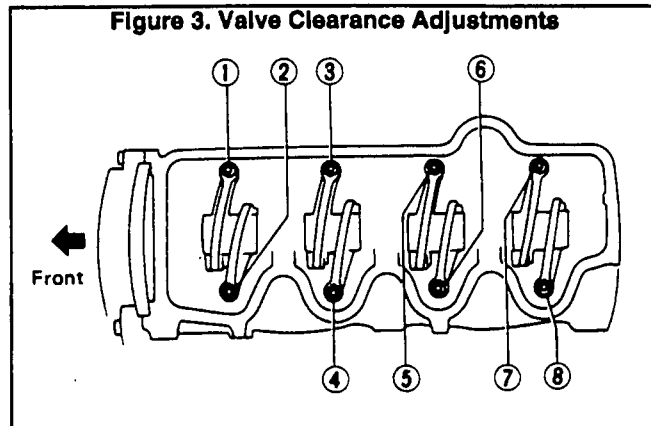
Adjusting Valve Clearance

Adjust valves while engine is warm, but not running, as follows:

1. Set No. 1 cylinder at top dead center (TDC) of its compression stroke. Then, adjust valve clearance 1, 2, 3 and 6.
2. Set No. 4 cylinder at top dead center (TDC) of its compression stroke and adjust valve clearance 4, 5, 7 and 8.
3. Set valve clearance as follows:

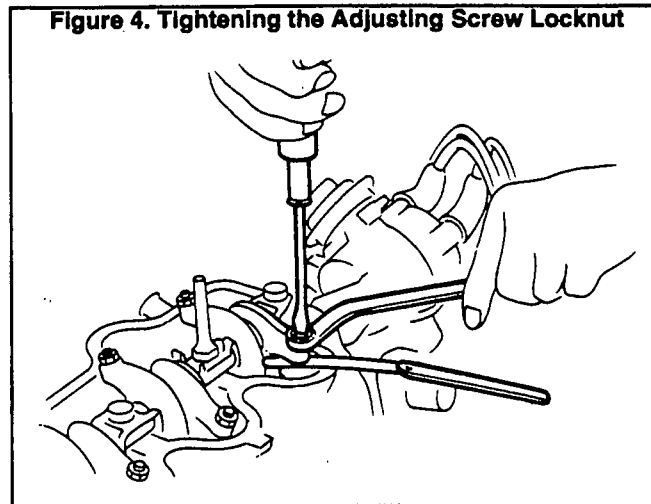
VALVE CLEARANCE HOT	
INTAKE =	0.010 inch (0.25mm)
EXHAUST =	0.012 inch (0.30mm)

Figure 3. Valve Clearance Adjustments



4. When valve clearances are properly set, tighten the adjusting screw locknut to 8-11 foot-pounds (11-15 N-m).

Figure 4. Tightening the Adjusting Screw Locknut



Checking Drive Belts

Inspect drive belts for cracks, fraying, wear, oiliness. Replace, if necessary. The belts should not touch the bottom of the pulley groove. To check belt tension, apply a force of approximately 22 pounds (10 kg) midway between pulleys. Belt deflection should be as follows:

NEW BELT =	0.59-0.75 inch (15-19mm)
USED BELT =	0.71-0.87 inch (18-22mm)

Measuring Compression Pressure

Warm up the engine. Then, shut down and remove all spark plugs. Use a standard automotive type compression gauge. Hold the throttle and choke valves on carburetor wide open,

Measuring Compression Pressure (Continued)

then crank the engine and read the compression pressure. The pressure reading should be as follows:

STANDARD = 192 psi (13.5 kg/cm²) at 350 rpm

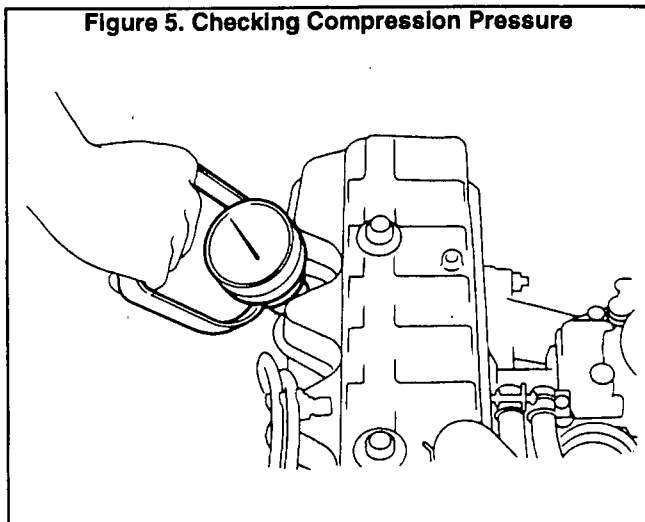
MINIMUM = 164 psi (11.5 kg/cm²) at 350 rpm

DIFFERENCE BETWEEN CYLINDERS SHOULD NOT EXCEED 14 PSI (1.0 kg/cm²)

If the compression reading is low in any cylinder, pour a small amount of clean engine oil into the cylinders through the spark plug opening. Then, retest compression and evaluate as follows:

- ☐ If compression pressure increased after adding the oil, check for worn or damaged piston rings or worn cylinder walls.
- ☐ If pressure did NOT increase after adding oil, valve(s) may be sticking or seating improperly.
- ☐ If compression in any two adjacent cylinders is low and adding oil did not increase compression, check for a leaking head gasket.

Figure 5. Checking Compression Pressure



Section 2.2- TIMING BELT

Timing Belt Precautions

Comply with the following precautions when removing, installing or inspecting the timing belt:

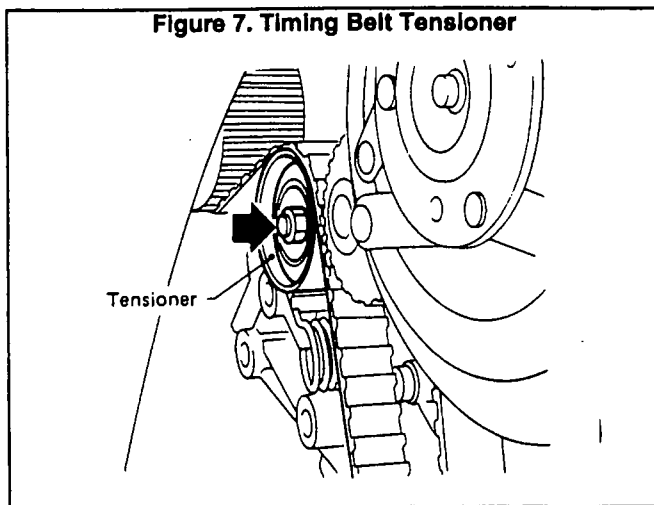
- ☐ Make sure the timing belt, pulleys and belt tensioner are free of oil and water.
- ☐ Prior to installing the timing belt, make sure that No. 1 cylinder is at top dead center (TDC) of its compression stroke.
- ☐ Align the arrow on the timing belt in the direction of engine rotation.
- ☐ Remove all spark plugs before adjusting timing belt tension.
- ☐ Once the timing belt has been removed, DO NOT rotate the crankshaft and camshaft separately, or the valves will strike the piston heads.
- ☐ Do NOT bend or twist the timing belt too tightly.

Timing Belt Removal

1. Drain the radiator.
2. Remove the radiator, fan guard and fan. See Part 4, "ENGINE COOLING SYSTEM".
3. Remove tension from the drive belt, then remove the drive belt.
4. Remove the crankshaft pulley.
5. Set No. 1 cylinder at top dead center (TDC) of its compression stroke. Then, remove upper and lower dust covers and gaskets.

6. Loosen timing belt tensioner and return spring, then remove timing belt.

Figure 7. Timing Belt Tensioner



Timing Belt Inspection

BELT IS BROKEN:

Caused by improper handling, poor belt cover sealing, coolant leakage at water pump.

Figure 8.

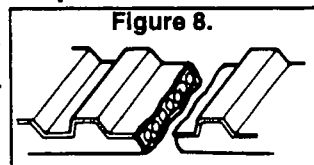
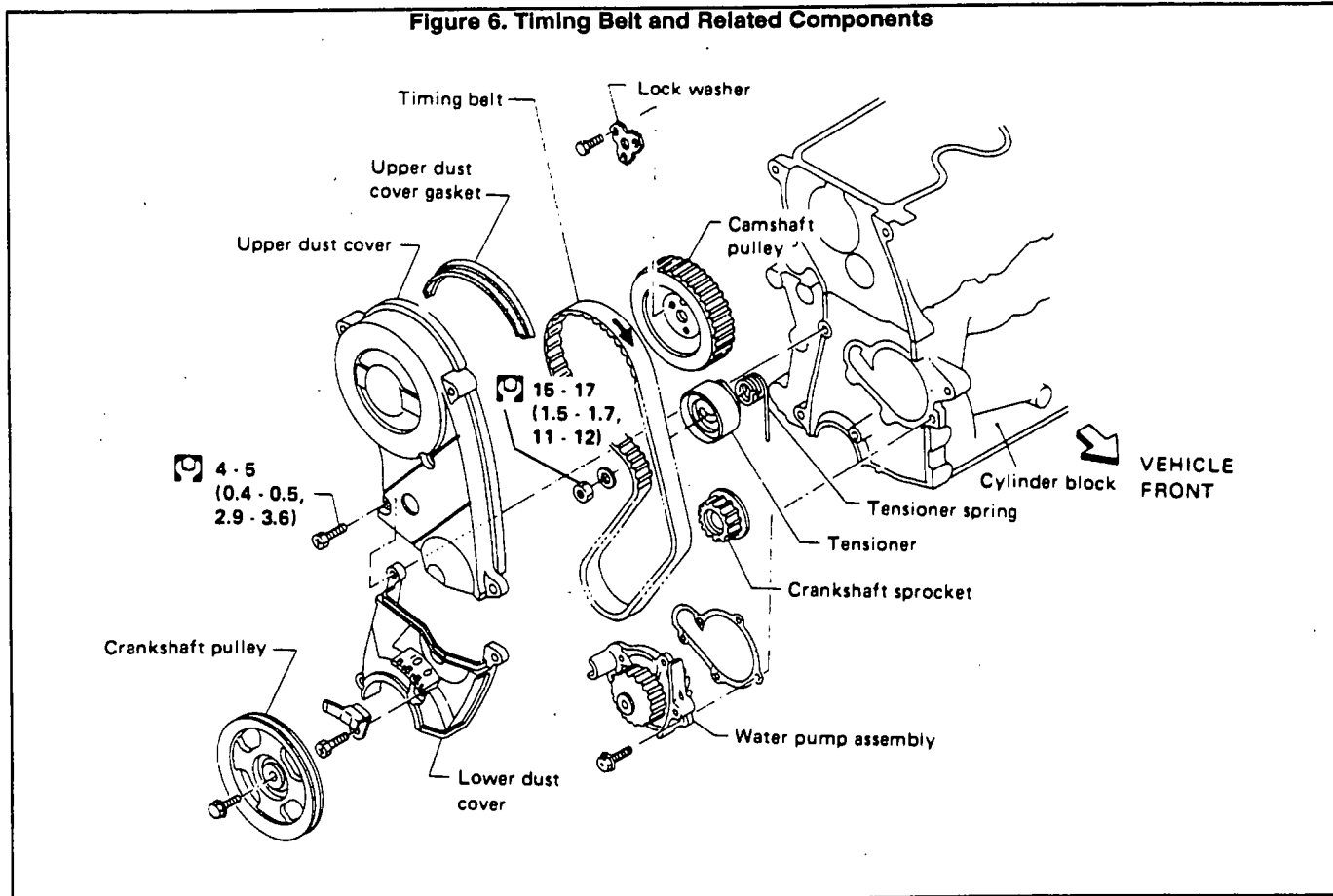


Figure 6. Timing Belt and Related Components

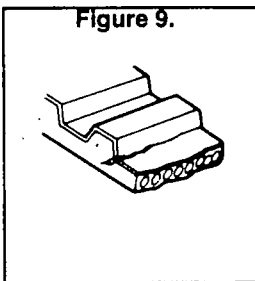


Timing Belt Inspection (Continued)

TOOTH BROKEN OR TOOTH ROOT CRACKED:

Caused by camshaft jamming, distributor jamming, damaged crankshaft or camshaft oil seal.

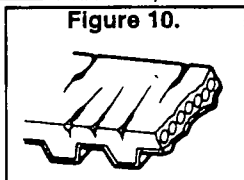
Figure 9.



BACK SURFACE CRACKED OR WORN:

Caused by tensioner jamming, overheated engine, interference with belt cover.

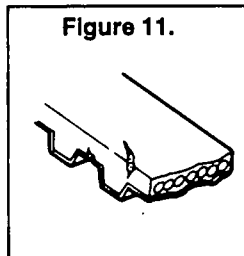
Figure 10.



SIDE SURFACE WORN:

Caused by improper belt installation, defective crank pulley and/or timing belt plate.

Figure 11.

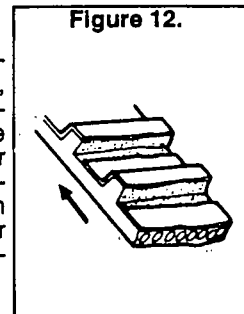


NOTE: Replace the timing belt if (a) side surface is worn to such an extent that cutoff performed during the manufacturing process cannot be seen, (b) belt corners are worn or rounded, or (c) belt fibers are frayed and coming out.

BELT TEETH ARE WORN:

Caused by poor belt cover sealing, coolant leakage at water pump, defective camshaft, defective distributor, excessive belt tension. Some problems that might be found under "Belt Teeth are Worn" include (a) canvas on tooth face worn, (b) canvas on tooth is fluffy, (c) rubber layer worn or faded white, or (d) web worn or invisible.

Figure 12.



Timing Belt Installation

1. Check that No. 1 cylinder is at top dead center (TDC) of its compression stroke. Align the camshaft and crankshaft pulley marks. See Figure 13.
2. See Figure 14. Install tensioner and return spring. Hook the return spring to its stopper.
3. Slide the tensioner to the left and tighten the lock nut temporarily (Figure 15).
4. Check that the water pump and tensioner pulleys can be rotated smoothly and with no evidence of binding. Then, install the timing belt.

CAUTION: The timing belt must be clean and free of oil and water. Do NOT bend the belt. Arrow on belt must point in normal direction of rotation.

Figure 13. Align Camshaft & Crankshaft Pulley Marks

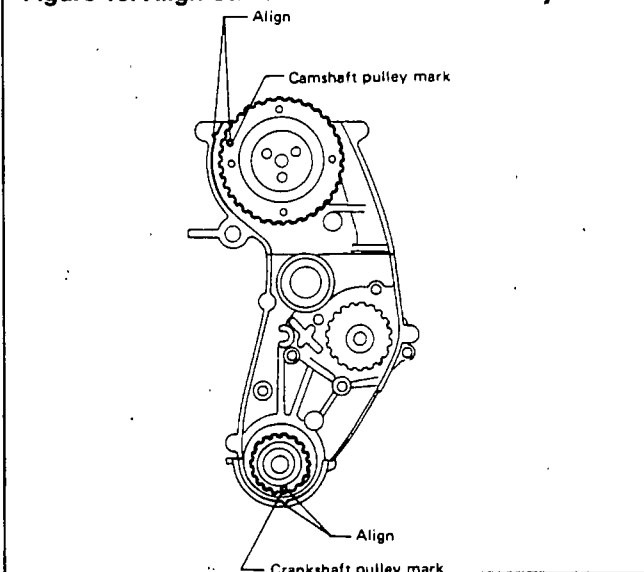


Figure 14. Tensioner and Return Spring

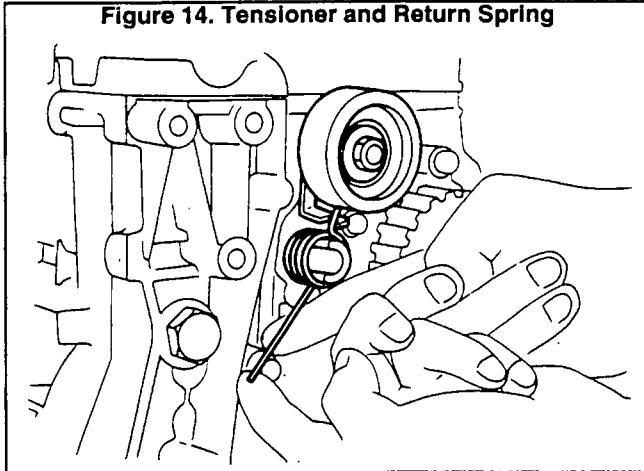
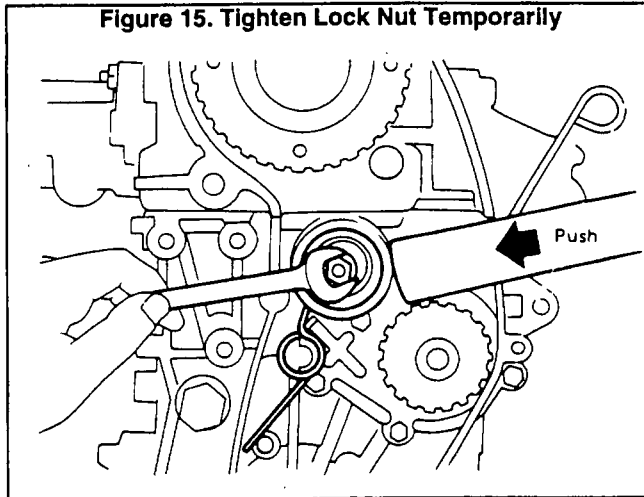


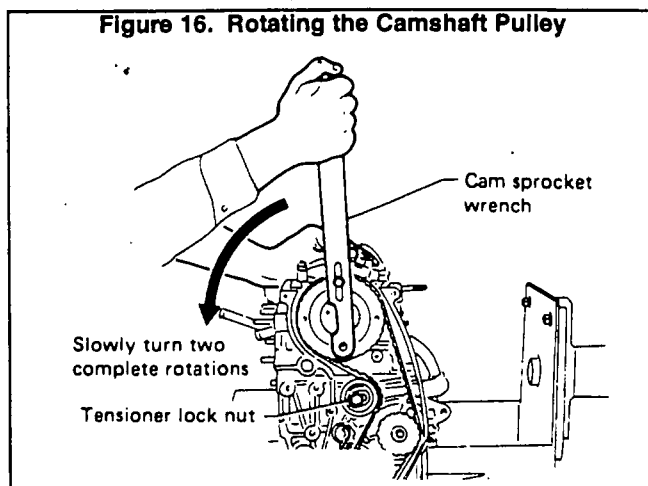
Figure 15. Tighten Lock Nut Temporarily



Timing Belt Installation (Continued)

5. Loosen the tensioner lock nut. With all spark plugs removed, rotate the camshaft pulley two full turns counterclockwise. Tighten the tensioner lock nut.
6. Check belt tension. With a force of 1.06-1.28 pounds applied, the belt should deflect about 0.08 inch (2mm).
7. Tighten the tensioner lock nut to 11-12 foot-pounds (15-17 N-m).

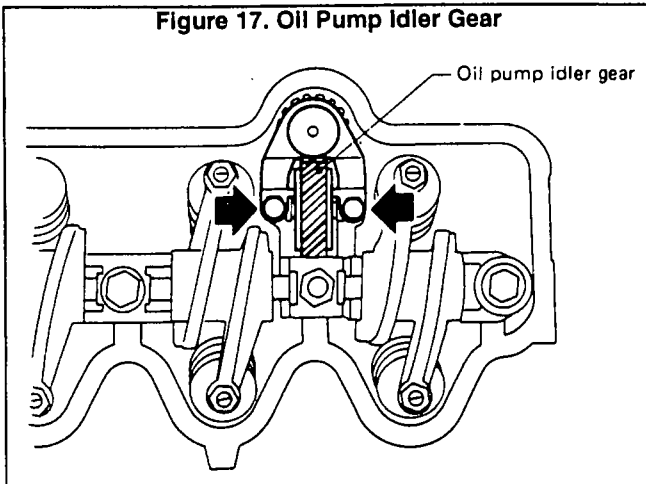
Figure 16. Rotating the Camshaft Pulley



Section 2.3- CYLINDER HEAD

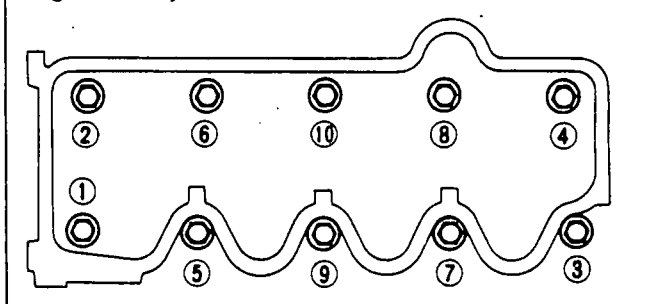
Cylinder Head Removal

Figure 17. Oil Pump Idler Gear



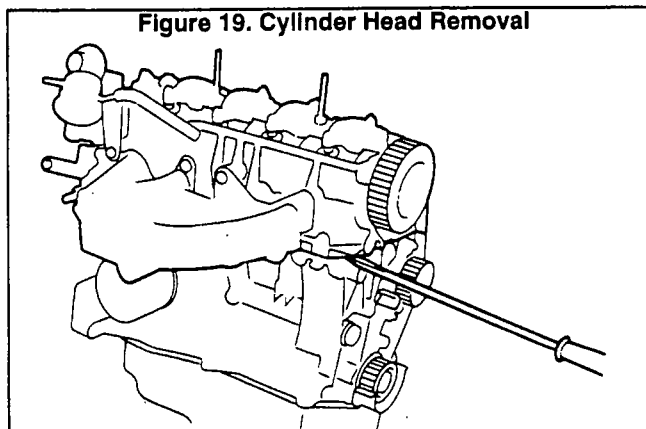
1. Remove timing belt (Section 2.2). Then, remove OIL PUMP IDLER GEAR.

Figure 18. Cylinder Head Bolts Loosening Sequence



2. Remove the cylinder head. Loosen bolts in 2 or 3 stages, in the sequence shown above.

Figure 19. Cylinder Head Removal



3. If the cylinder head is difficult to separate, pry with a screwdriver.
4. Remove the Camshaft (Figure 20).
5. Remove valve components parts (Figure 21).
6. Use a suitable puller to remove valve oil seals (Figure 22).

Checking Cylinder Head Distortion

Use a thickness gauge and a straightedge to measure cylinder head distortion. See Figure 23 (next page). Lay the

Figure 20. Camshaft Removal

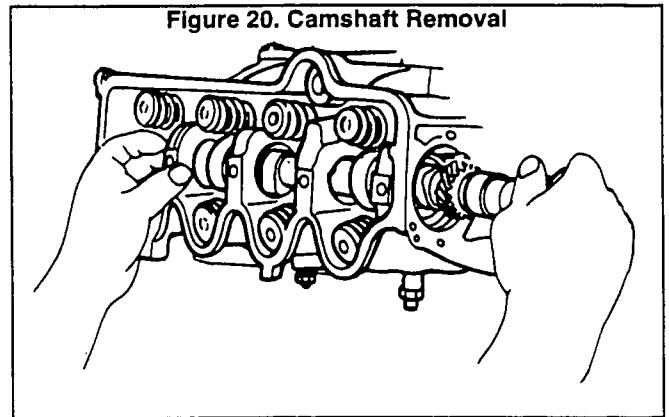


Figure 21. Remove Valve Component Parts

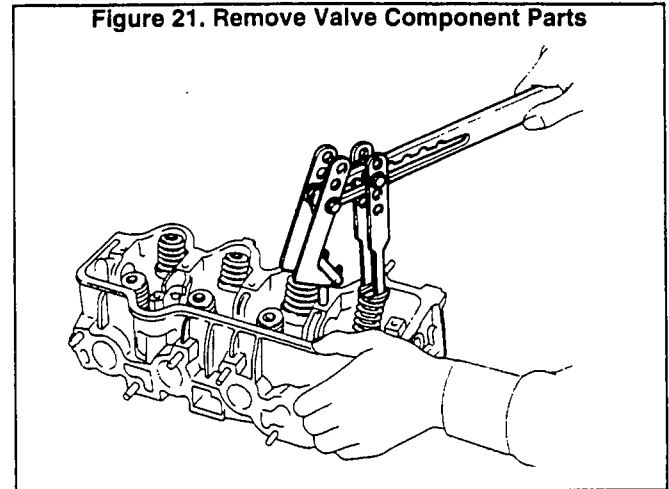
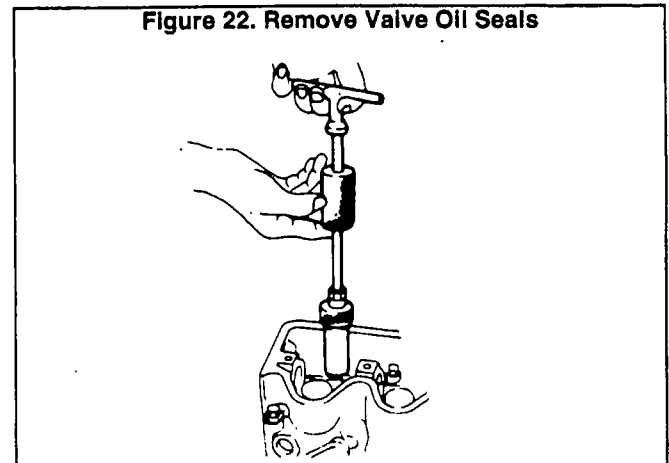


Figure 22. Remove Valve Oil Seals



straightedge across the cylinder head surface as shown. Surface warpage must not exceed 0.004 inch (0.1mm). If the cylinder head exceeds the stated value, it must be replaced.

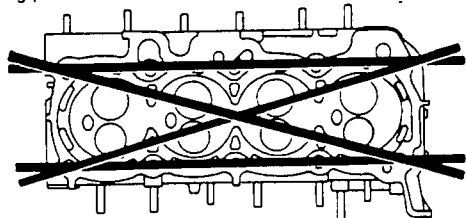
Resurfacing Limit: The amount of resurfacing that can be done on the cylinder head depends on the amount of resurfacing on the cylinder block. If the amount of HEAD surfacing is "A" and the amount of BLOCK surfacing is "B", the maximum limit is as follows:

Checking Cylinder Head Distortion (Continued)

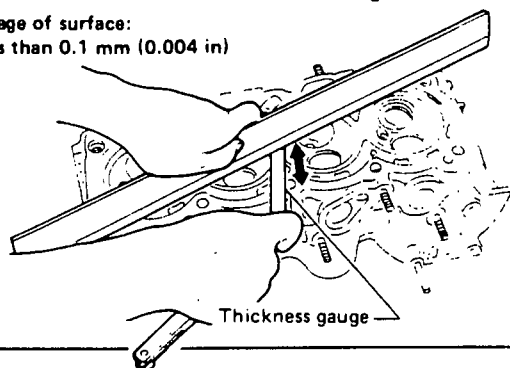
$$A + B = 0.008 \text{ inch (0.2mm)}$$

Figure 23. Checking Cylinder Head Distortion

Measuring points



Warpage of surface:
Less than 0.1 mm (0.004 in)



Valve Guide Clearance

Use a suitable dial indicator to measure valve stem to guide clearance. The valve should be moved parallel to the rocker arm, since most of the wear occurs in this direction. See Figure 24.

Figure 24. Valve Guide Clearance

Stem to guide clearance:

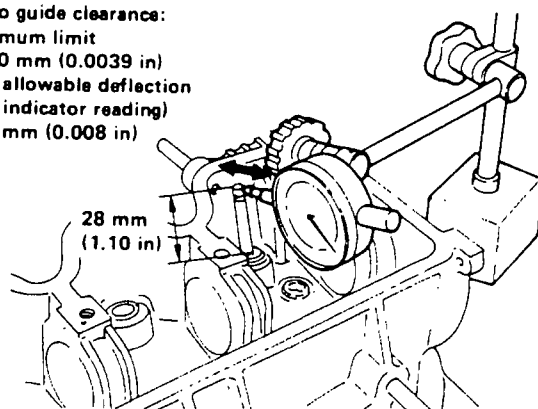
Maximum limit

0.10 mm (0.0039 in)

Max. allowable deflection

(Dial indicator reading)

0.2 mm (0.008 in)



Valve Guide Replacement

If valve guides must be replaced, proceed as follows:

1. Heat the cylinder head to 302°-320° F. (150°-160° C.) in an oil bath (Figure 25).
2. Use a press exerting a 2.2 U.S. ton (20 kN) force to remove valve guides. If a press is not available, use a hammer and a suitable driving tool (Figure 26).

Figure 25. Heating the Cylinder Head

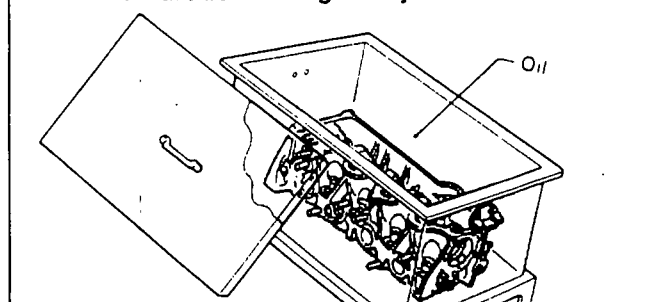


Figure 26. Valve Guides Removal

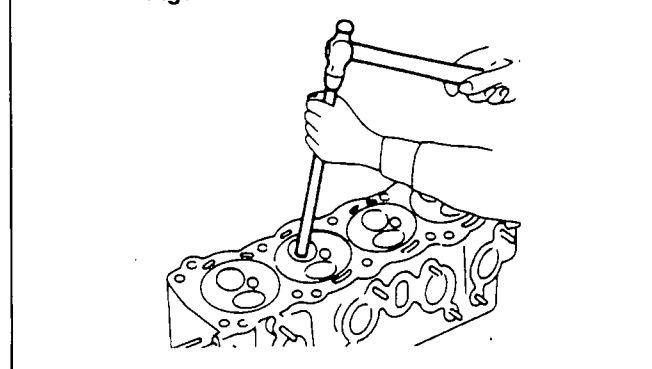
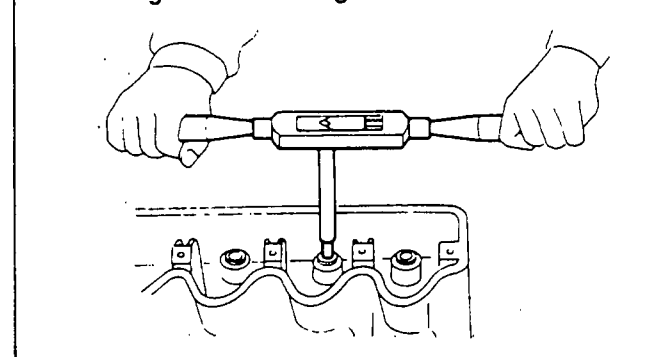
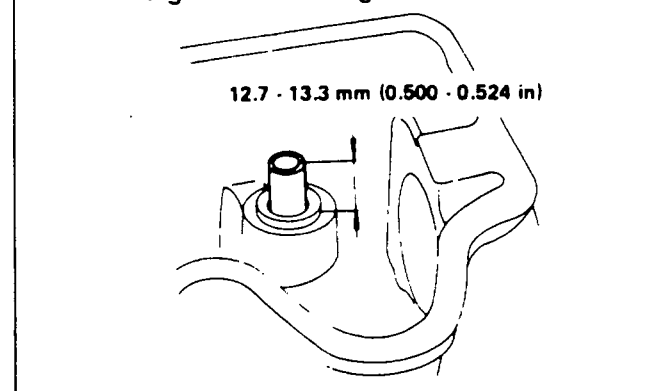


Figure 27. Reaming the Valve Guides



3. Ream the cylinder head's valve guide hole (Figure 27).

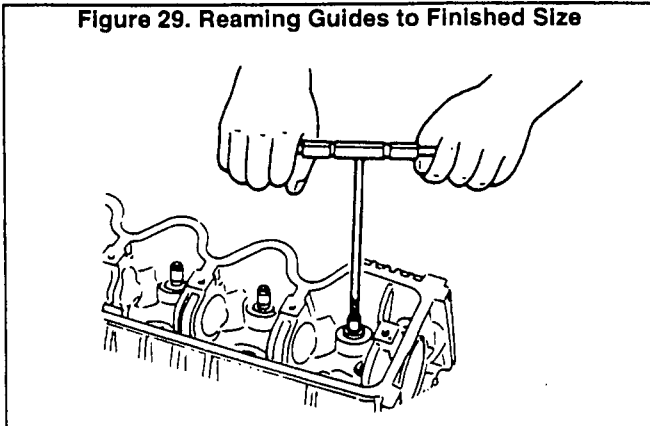
Figure 28. Installing Valve Guides



4. Heat the cylinder head to 302°-320° F. (150°-160° C.), then press service valve guide onto cylinder head (see Figure 28).

5. Ream the valve guides to a finished size of 0.2758-0.2764 inch (7.005-7.020mm).

Figure 29. Reaming Guides to Finished Size

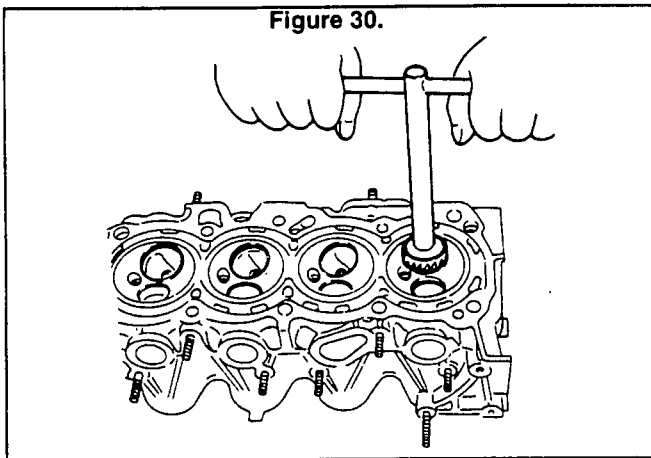


Valve Inserts

Inspect valve inserts for evidence of pitting at valve contact surfaces. Reseat or replace, if worn or pitted excessively. The following rules apply:

- ☐ When repairing valve inserts, first check the valve and valve guide for wear. If worn, replace them. Then, correct the valve seat.
- ☐ When cutting, use both hands for more uniform cutting.

Figure 30.



If necessary, replace valve inserts as follows:

1. Ream the cylinder head recess.
2. Heat the cylinder head to 302°-320° F. (150°-160° C.).
3. Install the insert. Make sure it bends at bottom face of its recess and caulk at more than 4 places.
4. Use a suitable tool to grind newly fitted valve seats. Grind the seats to the specifications listed in the applicable SPECIFICATIONS chart.
5. Apply a small amount of valve grinding compound to the valve contacting face and place valve into guide.

Camshaft Bearing Clearance

Check camshaft bearing clearance (Figure 31). Check both the bore and the bearing outside diameter (O.D.). The difference between the two measurements is the bearing clearance. Maximum bearing clearance is shown below:

MAXIMUM CAMSHAFT BEARING CLEARANCE
0.0059 Inch (0.15mm)

Figure 31. Checking Bearing Bore

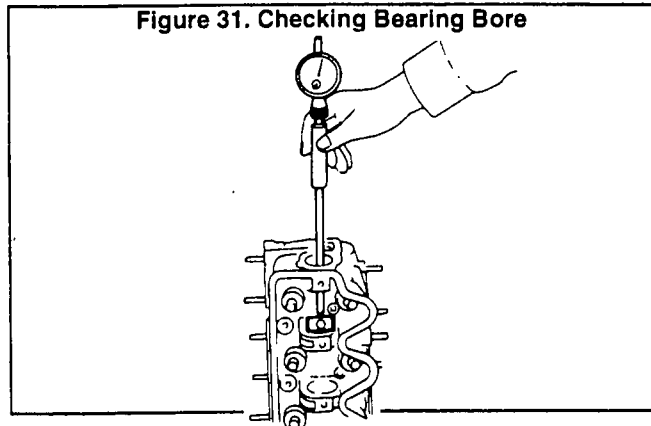
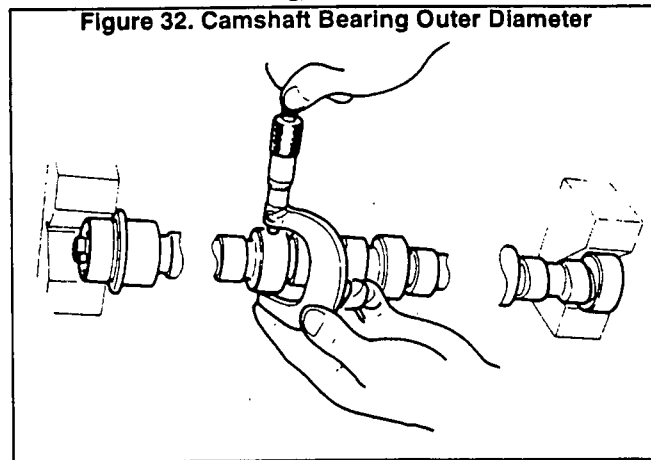


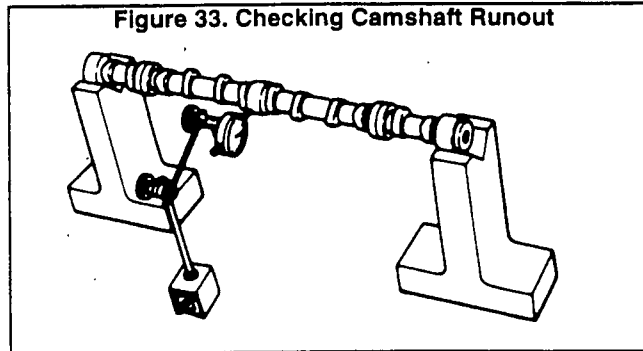
Figure 32. Camshaft Bearing Outer Diameter



Camshaft Runout

Use a suitable measuring device to check camshaft runout (Figure 33).

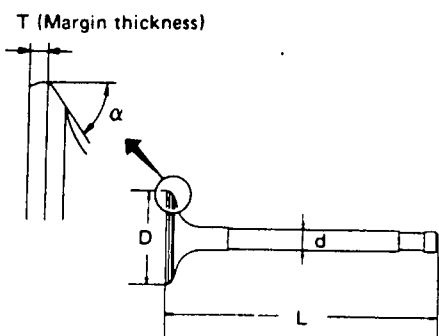
Figure 33. Checking Camshaft Runout



Valve Dimensions

Check dimensions of all valves. Refer to the appropriate SPECIFICATIONS chart.

Figure 34. Valve Dimensions

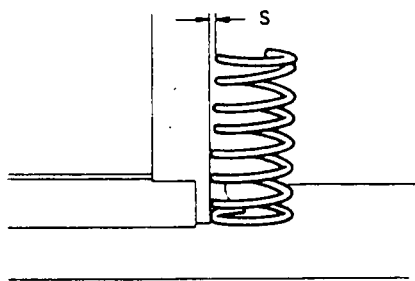


NOTE: When the valve head is worn to 0.020 inch (0.5mm) margin thickness, replace the valve. Grinding allowance for valve stem end surface is 0.008 inch (0.2mm) or less.

Valve Spring Squareness, Free Length and Tension

Valve spring out-of-squareness must not exceed 0.079 inch (2.0mm). Refer to appropriate SPECIFICATIONS chart for spring free length and tension.

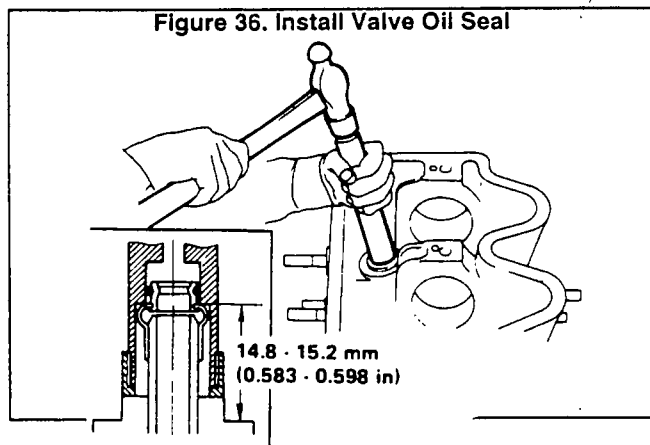
Figure 35. Valve Spring Squareness



Cylinder Head Assembly

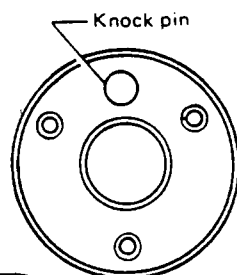
1. Install valve oil seal. Then, install valve component parts. Apply engine oil to camshaft oil seal and install the seal.

Figure 36. Install Valve Oil Seal



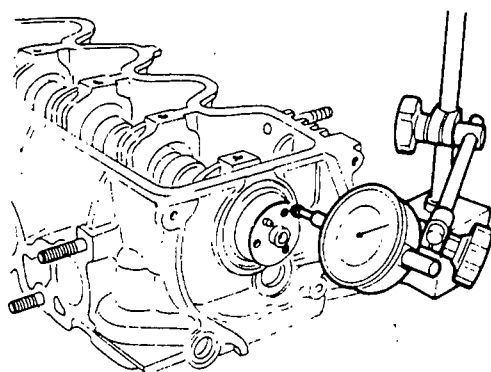
2. Install camshaft assembly. Note positioning of camshaft front face when No. 1 cylinder is at top dead center (TDC) of its compression stroke.

Figure 37.



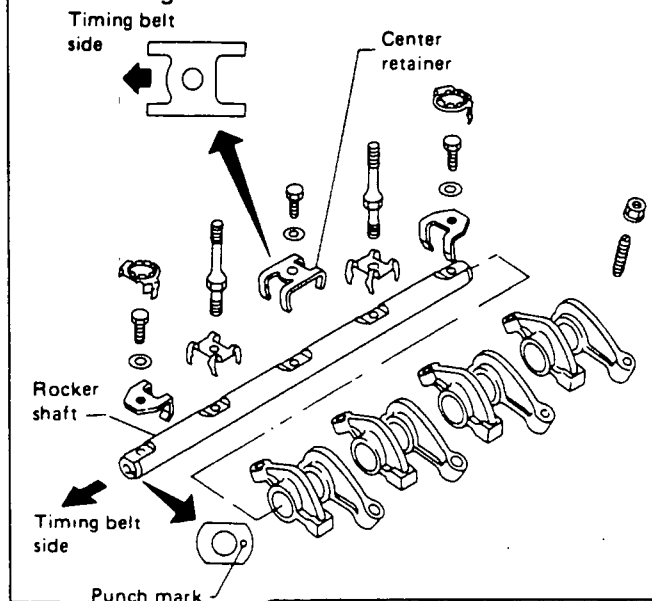
3. Measure camshaft end play with thermostat housing and gasket installed.

Figure 38. Checking Camshaft End Play



4. Install rocker shaft with rocker arms.

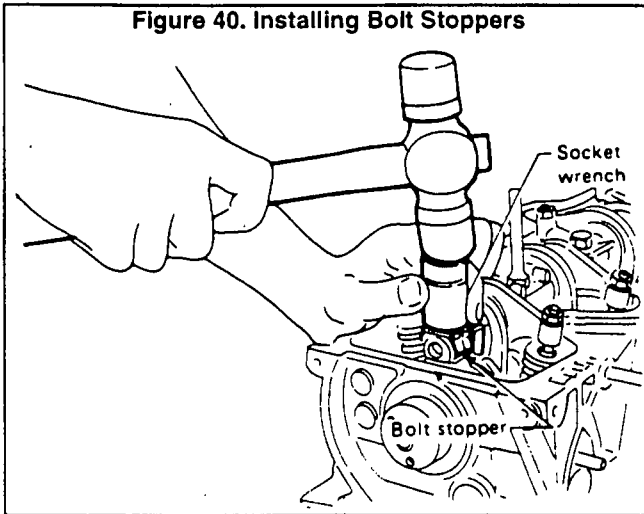
Figure 39. Rocker Shaft and Arms



5. Install bolt stoppers. Always use NEW bolt stoppers. See Figure 40, next page.

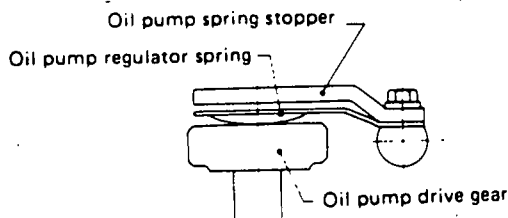
Cylinder Head Assembly (Continued)

Figure 40. Installing Bolt Stoppers



6. Install oil pump idler gear and oil pump regulator spring. Make sure the spring faces in the proper direction.

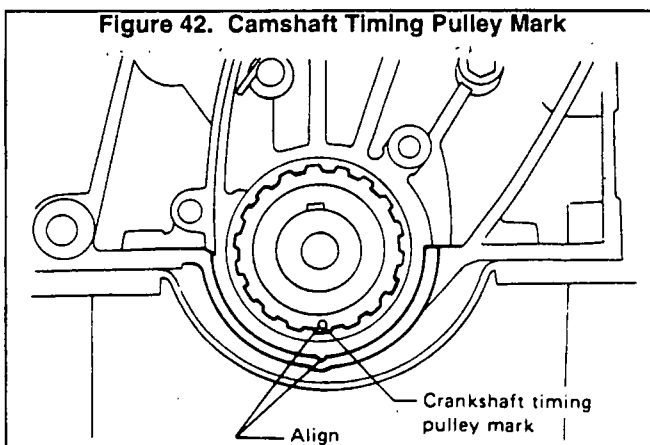
Figure 41.



Installation

1. Set No. 1 cylinder head at top dead center (TDC) of its compression stroke by first aligning the CAMSHAFT TIMING PULLEY MARK with mark on the main bearing cap.

Figure 42. Camshaft Timing Pulley Mark

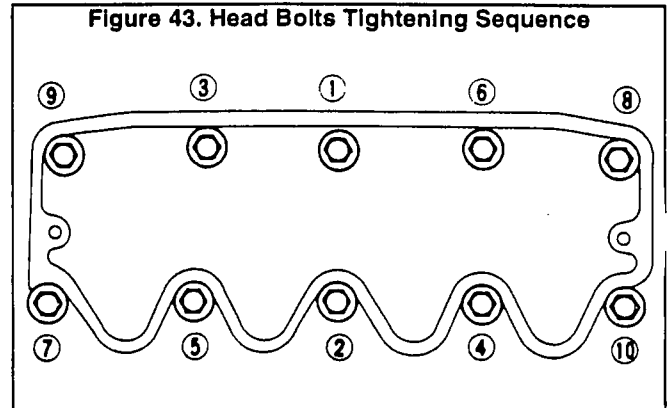


CAUTION: DO NOT rotate crankshaft and camshaft separately or valves will hit the piston heads.

2. Install cylinder head with a new gasket. The following rules apply:

- ☐ Always use a new cylinder head gasket.
- ☐ Before tightening the cylinder head bolts, check that the oil pump drive gear can be turned freely by hand.
- ☐ Always install washers between bolts and head.
- ☐ Tighten cylinder head bolts in the sequence shown in Figure 43.

Figure 43. Head Bolts Tightening Sequence



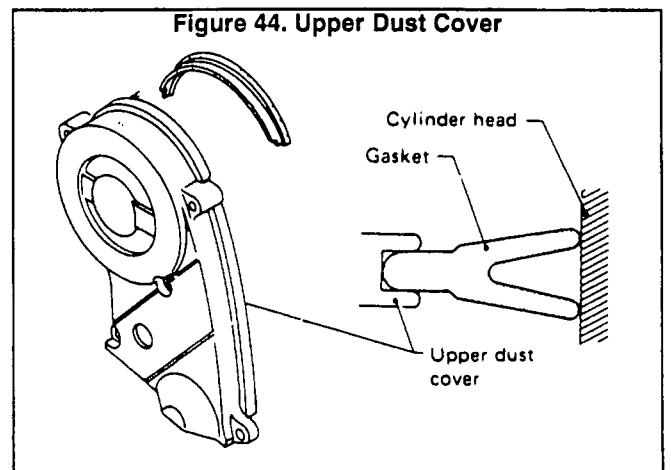
3. Tighten cylinder head bolts as follows:

- a. First, tighten all bolts to 22 foot-pounds (29 N-m).
- b. Then, tighten all bolts to 47 foot-pounds (64 N-m).
- c. Loosen all bolts completely.
- d. Tighten all bolts to 22 foot-pounds (29 N-m).
- e. Tighten all bolts to 47-51 foot-pounds (64-69 N-m).

NOTE: When RETORQUING cylinder head bolts for normal periodic maintenance, first loosen all bolts slightly. Then (with engine COLD), tighten all bolts in correct sequence to 47-51 foot-pounds (64-69 N-m).

4. Install timing belt. Install oil pump idler and oil pump regulator spring (make sure spring direction is correct). Install upper dust cover, making sure its gasket mates with cylinder head properly.

Figure 44. Upper Dust Cover



Installation (Continued)

5. Tighten upper dust cover bolts to 2.9-3.6 foot-pounds (4-5 N-m) (Figure 45).

6. Install spark plugs and tighten to 14-22 foot-pounds (20-29 N-m).

Figure 45. Tighten Dust Cover Bolts

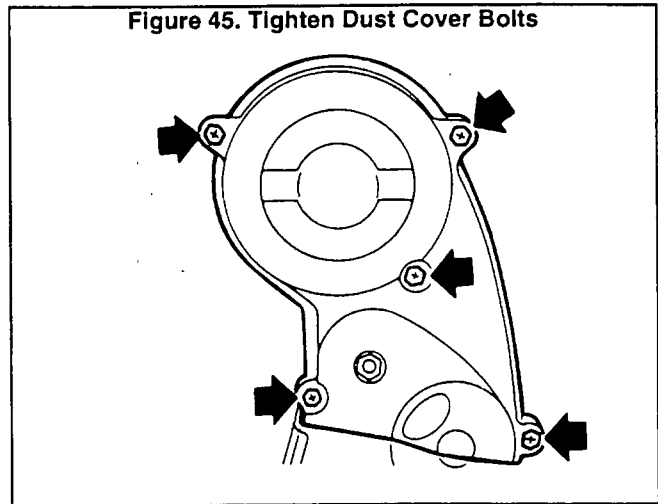
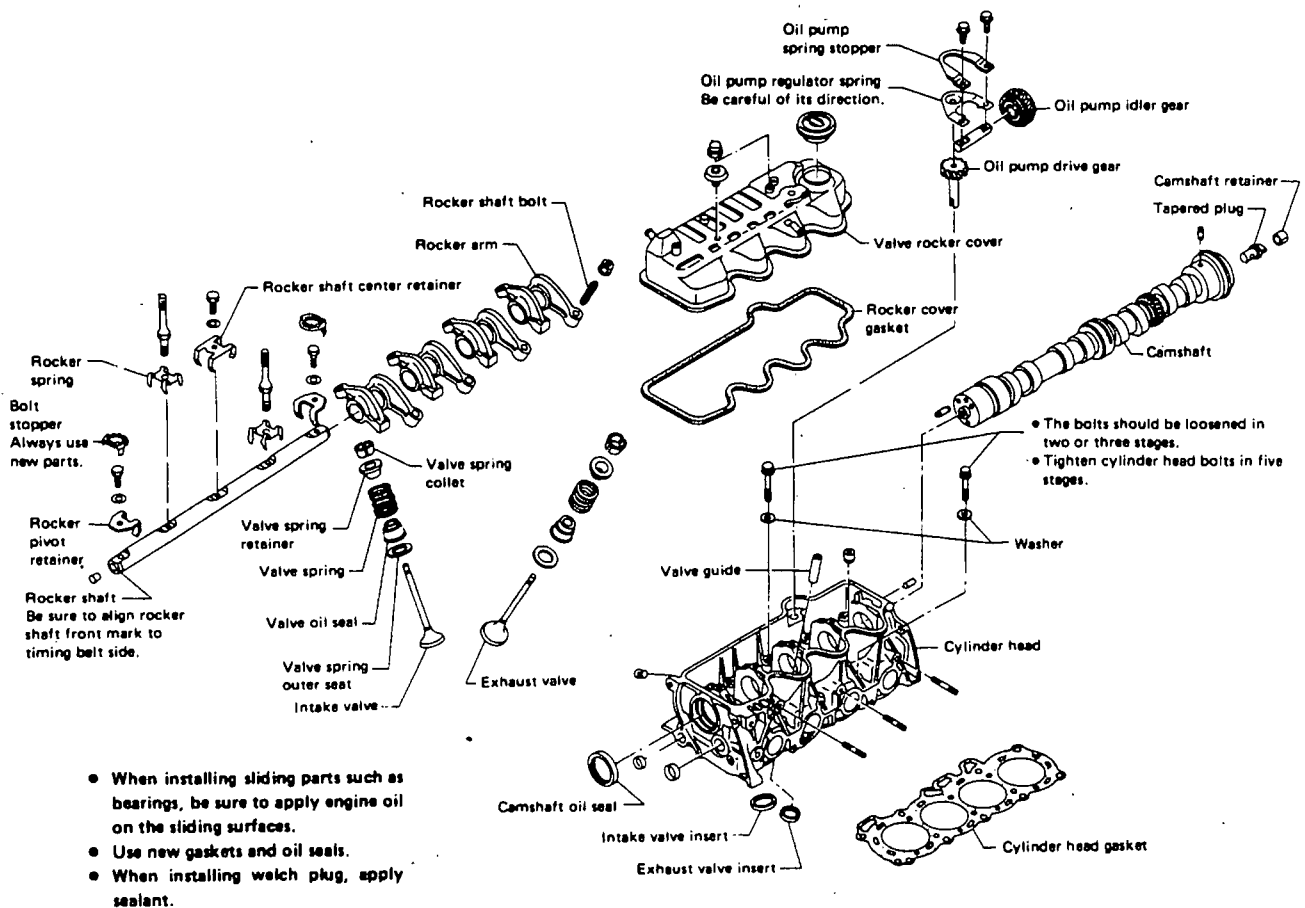


Figure 45A. Engine Cylinder Head Assembly



Section 2.4- OIL PAN AND OIL PUMP

Oil Pump Removal

Drain engine oil. Then, remove oil pump assembly with oil strainer. BE CAREFUL NOT TO DROP THE OIL PUMP DRIVE SHAFT.

Inspection

Refer to Part 3, "ENGINE LUBRICATION SYSTEM".

Installation

1. Install the oil pump assembly and tighten to 13-16 foot-pounds (18-22 N-m).

CAUTION: Before tightening the oil pump assembly, rotate the oil pump drive gear to make sure that the pump drive shaft does not interfere with inner wall of cylinder block.

2. Apply RTV gasket sealant to oil pan as shown in Figure 47.

3. Install oil seals. Apply RTV sealant to upper and lower surfaces of gaskets as shown (Figure 48).

4. Install gaskets and oil pan. Tighten bolts to 2.9-3.6 foot-pounds (4-5 N-m).

Figure 46. Oil Pump Removal

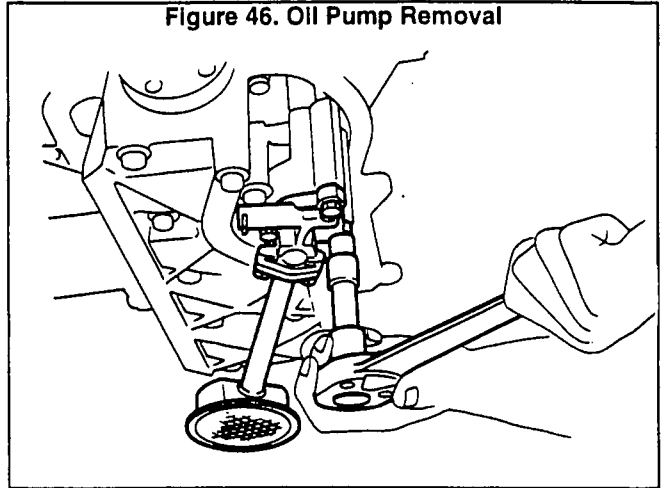


Figure 47. Apply RTV Gasket Sealant

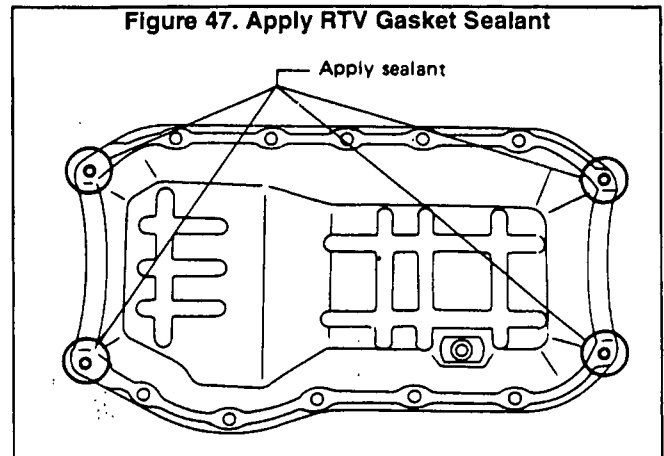
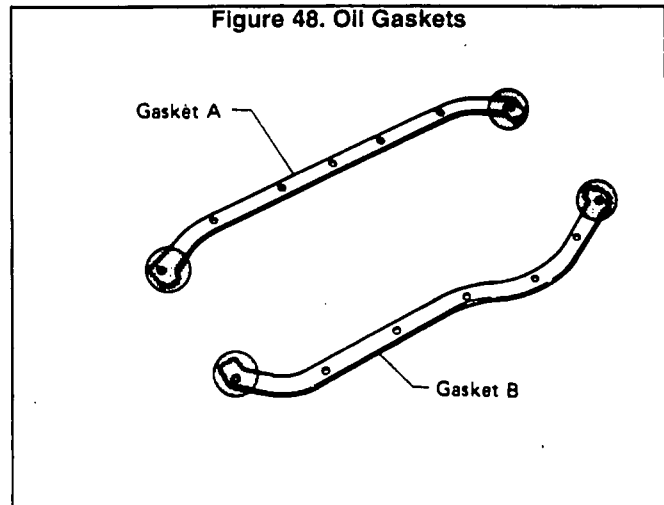


Figure 48. Oil Gaskets

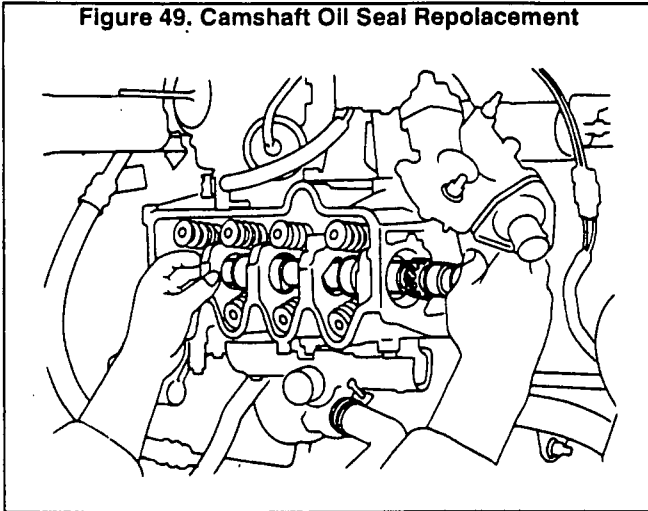


Section 2.5- OIL SEAL REPLACEMENT

Camshaft Oil Seal Replacement

Remove timing belt, oil pump idler gear. Remove bolt stoppers and rocker shaft with rocker arms. Remove camshaft. Remove camshaft oil seal. Apply engine oil to new camshaft oil seal and install.

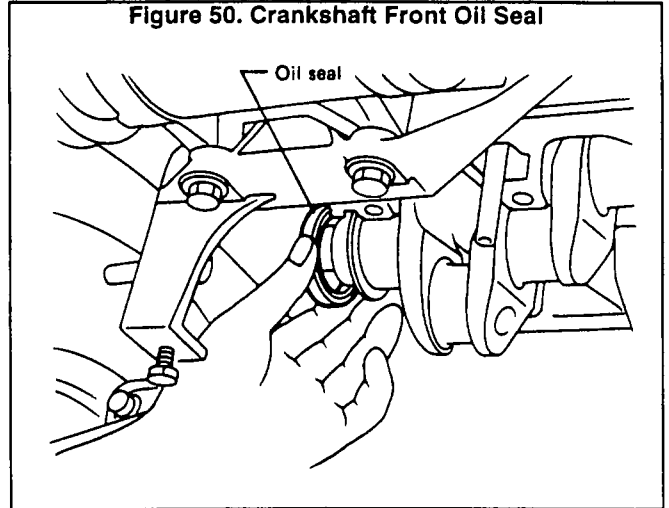
Figure 49. Camshaft Oil Seal Replacement



Crankshaft Front Oil Seal Replacement

Remove Timing Belt and Cover. Remove oil pan. Remove main bearing caps. Remove crankshaft oil seal. Apply engine oil to new crankshaft front oil seal and install.

Figure 50. Crankshaft Front Oil Seal

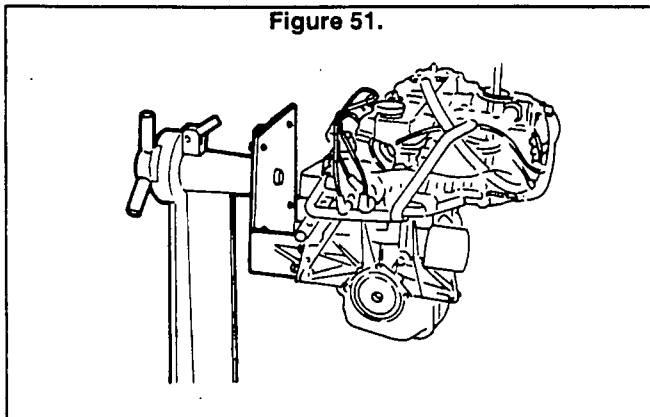


Section 2.6- ENGINE OVERHAUL

Disassembly

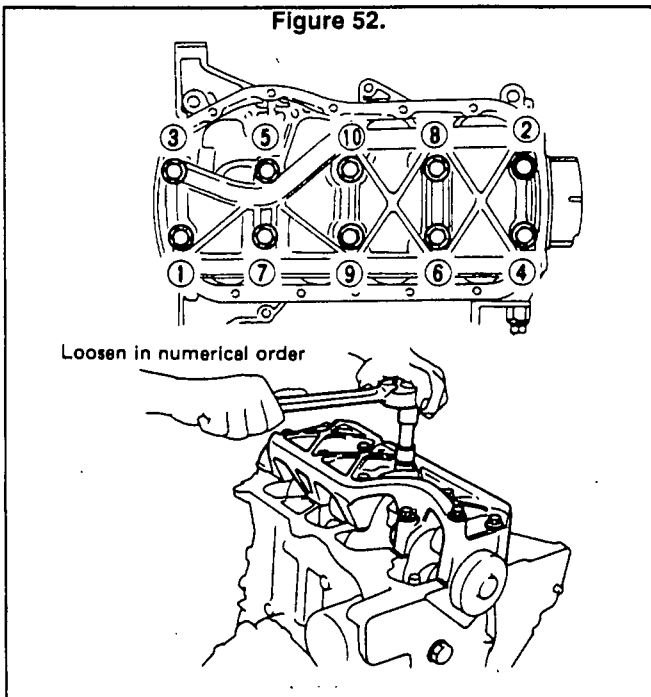
1. Place engine on workstand. Remove timing belt cover and timing belt. Remove cylinder head and oil pan. Remove pistons.

Figure 51.



2. Remove crankshaft rear oil seal retainer. Remove bearing caps. Remove the crankshaft.

Figure 52.



Inspection

1. Slide piston pin into piston pin bore. At room temperature, pin must slide smoothly into bore, without side play and without binding. See Figure 53.

PISTON PIN TO PISTON CLEARANCE
0.0003-0.0005 inch (0.008-0.012mm)

2. Check piston ring to groove side clearance (Figure 54). Clearance should not exceed the maximum stated limit.

RING TO GROOVE SIDE CLEARANCE MAXIMUM LIMIT

Top Ring = 0.0016-0.0029 inch (0.040-0.073mm)
2nd Ring = 0.0012-0.0025 inch (0.030-0.063mm)
Maximum
Tolerance=0.008 inch (0.2mm)

Figure 53. Checking Piston Pin Fit

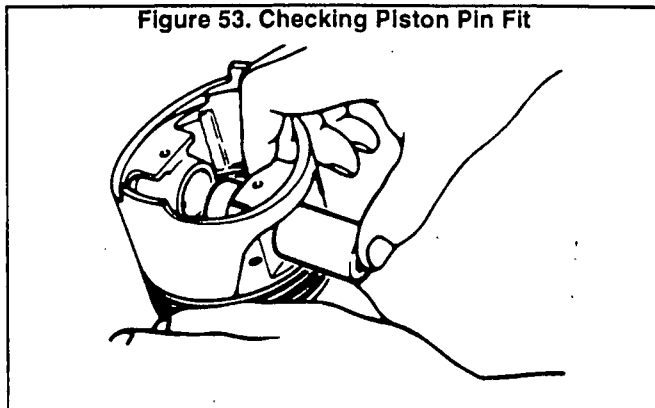
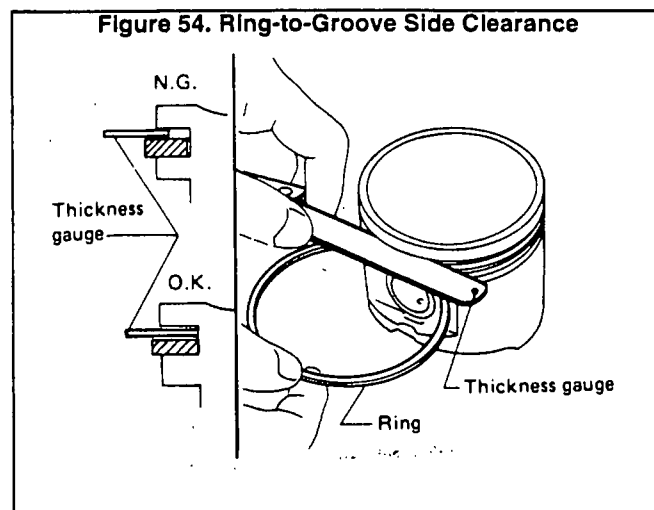


Figure 54. Ring-to-Groove Side Clearance



3. Check piston ring gap as shown (Figure 55).

TOP RING

No. 1 Grade= 0.0083-0.0118 inch (0.21-0.30mm)
No. 2 Grade= 0.0071-0.0118 inch (0.18-0.30mm)
No. 3 Grade= 0.0071-0.0118 inch (0.18-0.30mm)

2ND RING= 0.0059-0.0154 inch (0.15-0.39mm)

OIL RING= 0.0079-0.0311 inch (0.20-0.79mm)

4. Use Plastigage[®] to check bearing clearance (Figure 56). Comply with the following:

Inspection (Continued)

- DO NOT turn the crankshaft or connecting rod when Plastigage[®] is being inserted.
- When bearing clearance exceeds the specified limit, check that the correct bearing has been installed. If excessive clearance still exists, use a thicker main bearing or an undersize bearing to obtain correct clearance.

BEARING CLEARANCE

Main Bearing = 0.0012-0.0020 Inch (0.03-0.05mm)

Limit = 0.0030 inch (0.075mm)

Connecting

Rod Bearing = 0.0008-0.0024 Inch (0.02-0.06mm)

Limit = 0.0047 inch (0.12mm)

Figure 55. Checking Ring Gap

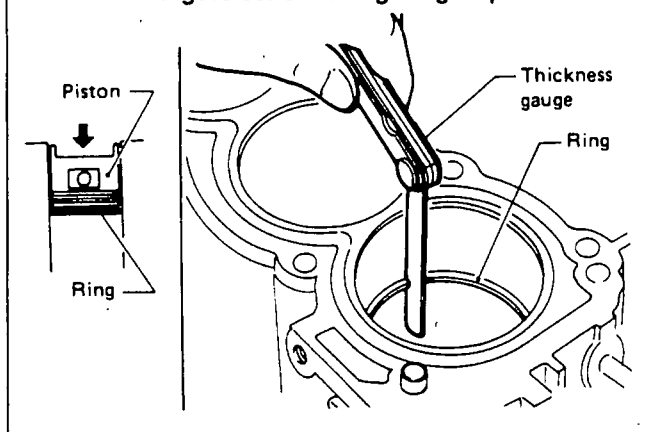
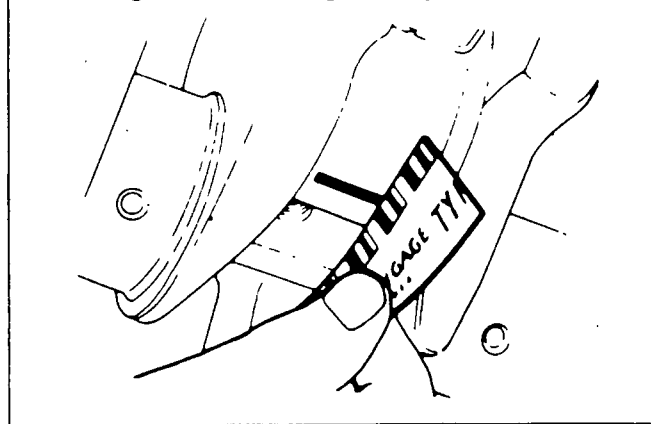


Figure 56. Checking Bearing Clearance

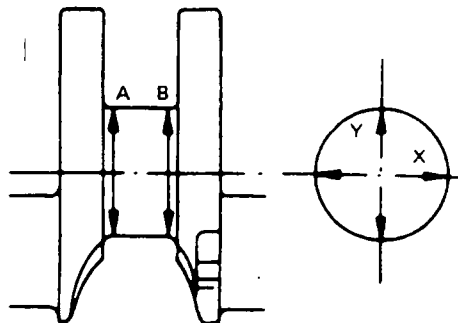


- Inspect crankshaft journals for scoring, bias, wear or cracks. Minor defects can be corrected using fine crocus cloth. Use a micrometer to check journals for taper and out-of-round. See Figure 57.

Out-of-Round (X-Y) = 0.0004 Inch (0.01mm)

Taper (A-B) = Less than 0.0008 Inch (0.02mm)

Figure 57. Checking Crankshaft Journals

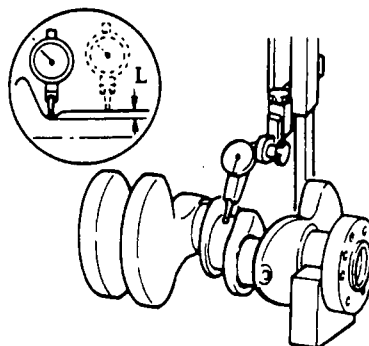


- When regrinding crankpin journal, measure the "L" dimension in the fillet roll (Figure 58). The measured value must exceed the specified limit. If measurements are within the specified limit, DO NOT grind.

"L" = Greater than 0.0051 inch (0.13mm)

NOTE: DO NOT grind off the fillet roll. Refer to applicable SPECIFICATIONS chart for regrinding crankshaft and available service parts.

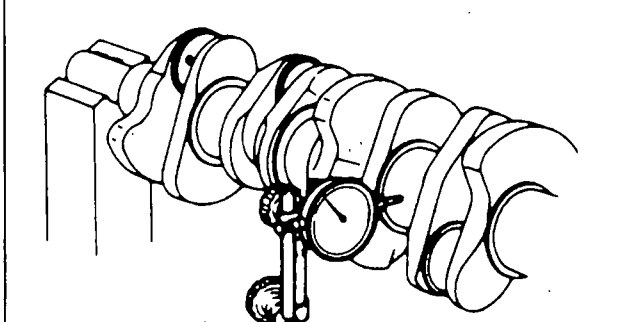
Figure 58. "L" Dimension



- Check crankshaft runout. "T.I.R." stands for "Total Indicator Reading".

T.I.R. = Less than 0.0031 inch (0.08mm)

Figure 59. Crankshaft Runout

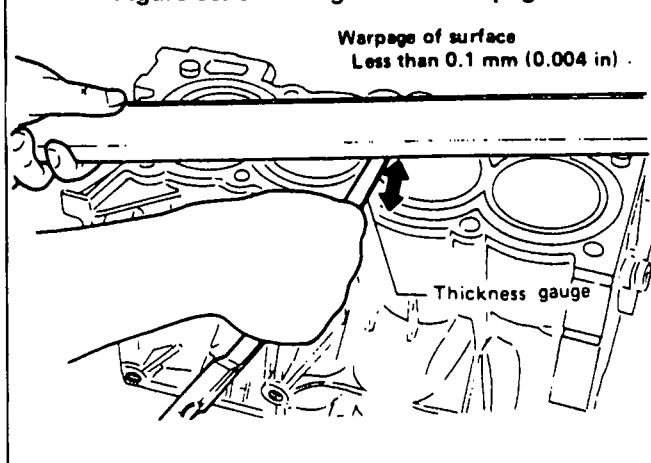


8. Surface warpage must be less than 0.004 inch (0.1mm). If beyond the specified limit, resurface the cylinder block. Resurfacing limit of the cylinder block is determined by the amount of resurfacing done on the cylinder head. If the amount of resurfacing on the cylinder head is "A" and the resurfacing on the cylinder block is "B", the maximum limit is as follows:

$$A + B = 0.008 \text{ Inch (0.2mm)}$$

CAUTION: When resurfacing, use care not to cut off the punched piston grade number.

Figure 60. Checking Surface Warpage



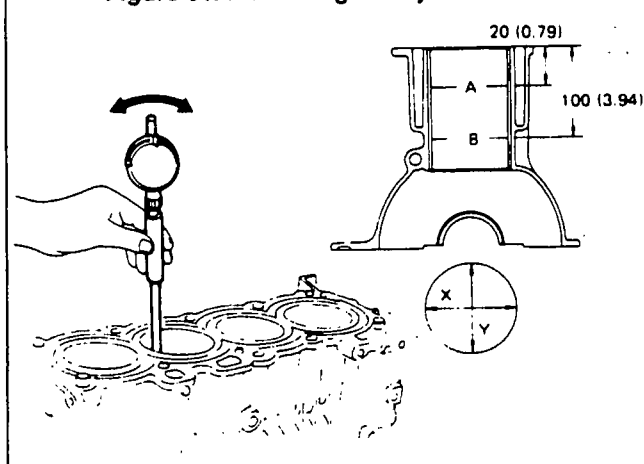
9. Use a bore gauge to measure the cylinder bore for wear, taper or out-of-round. Inspect for scratches or seizure. Hone the bore as necessary.

STANDARD INSIDE DIAMETER
2.7953-2.7965 Inch (71.00-71.03mm)

OUT-OF-ROUND (X-Y) LIMIT
0.0008 Inch (0.02mm)

TAPER (A-B) LIMIT
0.0008 Inch (0.02mm)

Figure 61. Measuring the Cylinder Bore



10. Use a micrometer to measure the piston skirt diameter (Figure 61). The measuring point for checking piston skirt diameter is 0.35 inch (9mm) as shown in Figure 63 (Point "L").

STANDARD PISTON SKIRT DIAMETER
2.6759-2.6770 Inch (67.967-67.997mm)

Piston clearance must be within the stated specifications.

PISTON CLEARANCE
0.0009-0.0017 Inch (0.023-0.043 mm)

Figure 62. Piston Skirt Diameter

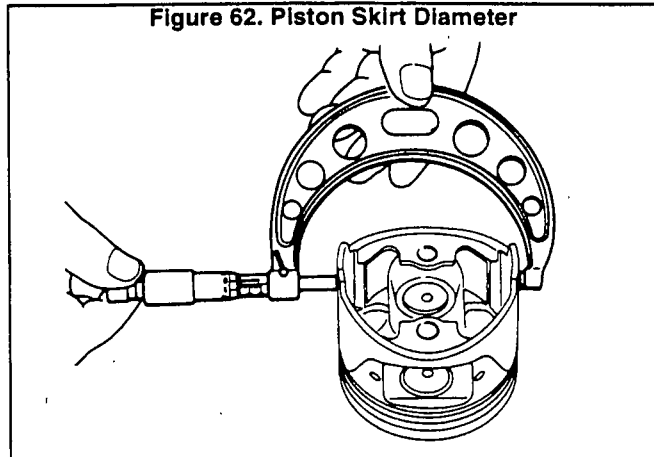
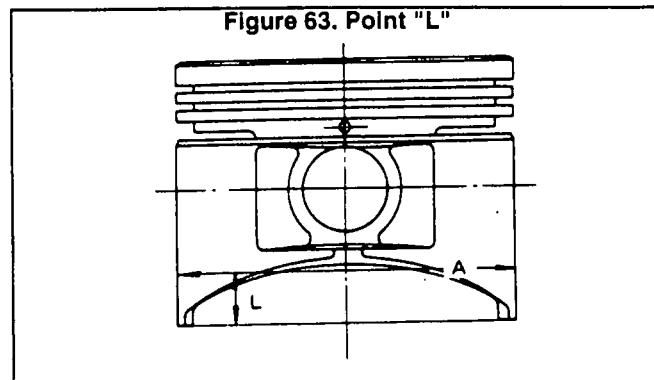


Figure 63. Point "L"



11. To measure piston clearance, use a 0.0016 inch (0.04mm) feeler gauge, inserted between the piston and the cylinder bore (Figure 64). The force required to remove the feeler gauge should be as follows:

REMOVAL FORCE
1.1-3.3 pounds (0.5-1.5kg)

12. Check flywheel runout (Figure 65). Total indicator reading (T.I.R.) should be less than the value specified below.

T.I.R. RUNOUT
Less than 0.0059 Inch (0.15mm)

Inspection (Continued)

Figure 64. Measuring Piston Clearance

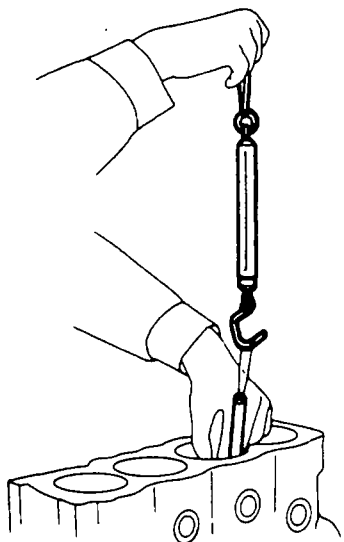
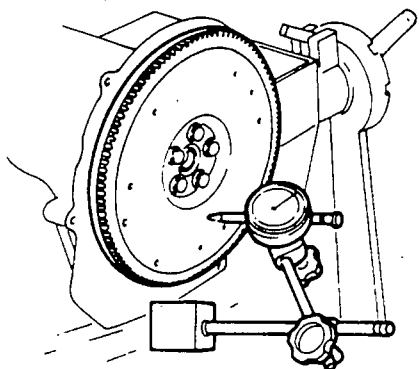


Figure 65. Checking Flywheel Runout



Assembly

PISTON:

Numbers that correspond to the cylinder number are stamped on connecting rods and connecting rod caps. Pistons, connecting rods, connecting rod caps and bearings should be installed only in the correct cylinder. **DO NOT COMBINE PARTS FROM DIFFERENT CYLINDERS.** When pressing the piston pin into the connecting rod (Figure 66), apply oil to the pin and to small end of connecting rod.

CRANKSHAFT:

Place main bearings in their proper position on the cylinder block. If the crankshaft, cylinder block and main bearings are to be replaced, you must select proper main bearing thicknesses.

When either the crankshaft, cylinder block or main bearings are to be re-used, it is necessary to measure main bearing thickness with Plastigage[®].

Numbers are stamped on the engine which indicate cylinder block main journal. Measure each bore separately.

Each crankshaft has stamped numbers which indicate main journal dimensions. Each journal is measured separately.

Select the correct main bearing thickness and order from the parts breakdown.

Figure 66. Piston Pin Installation

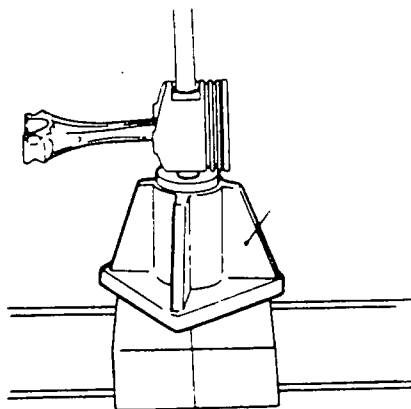
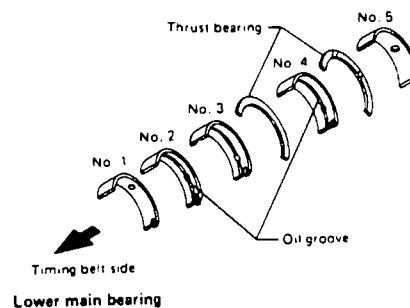


Figure 67. Crankshaft Main Bearings

Upper main bearing



Lower main bearing

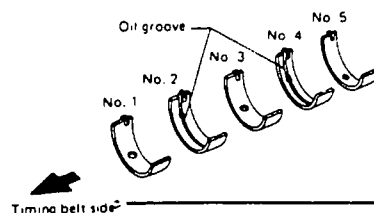
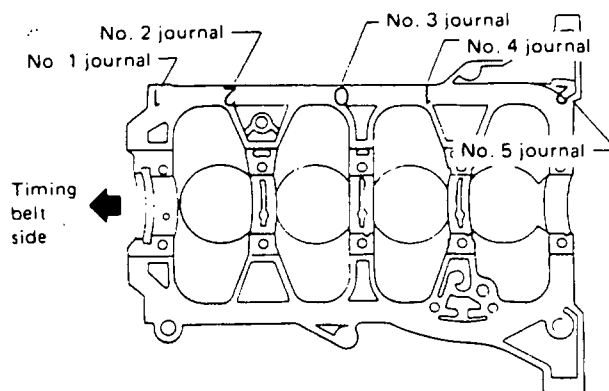
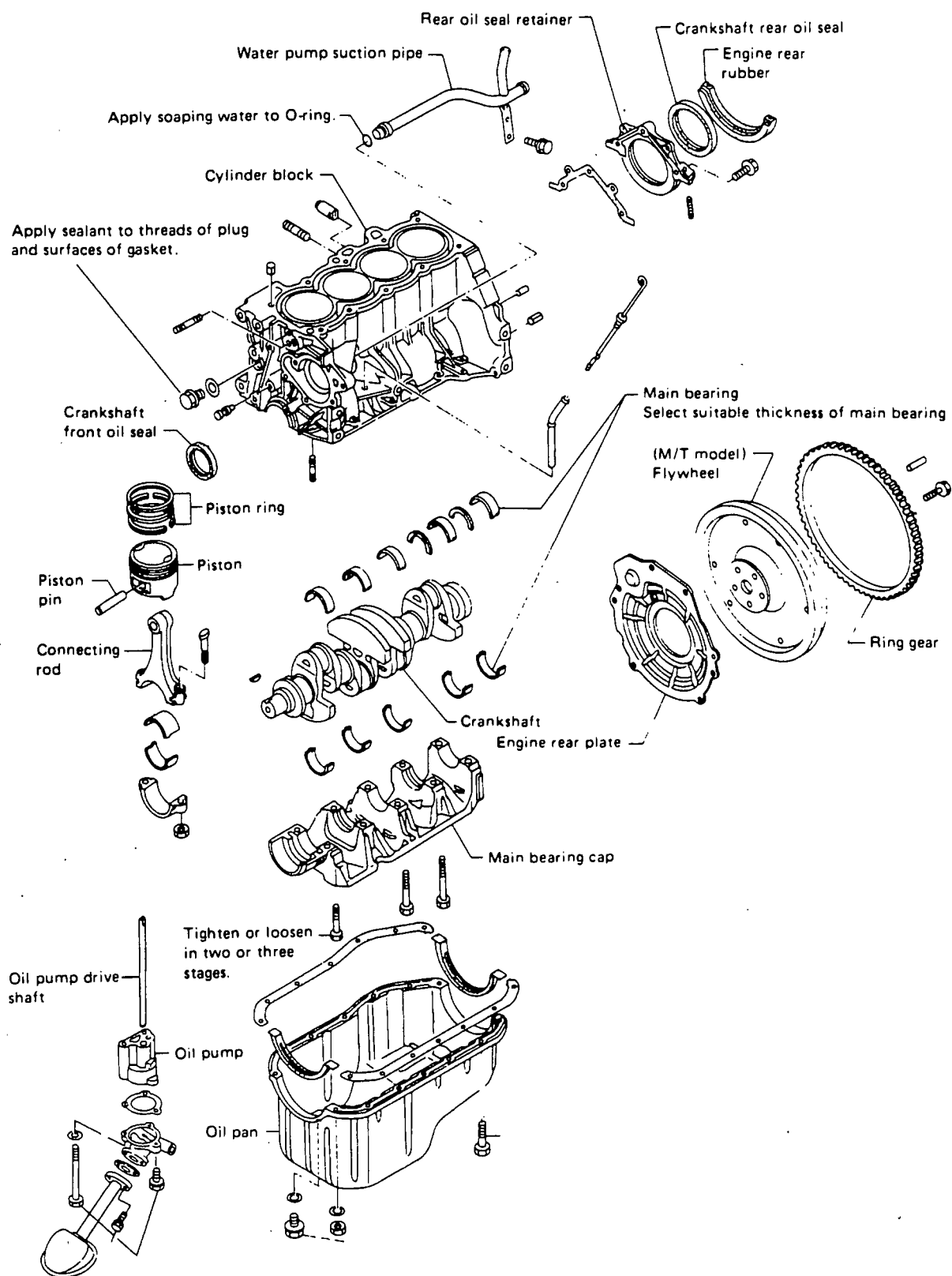


Figure 68. Journals



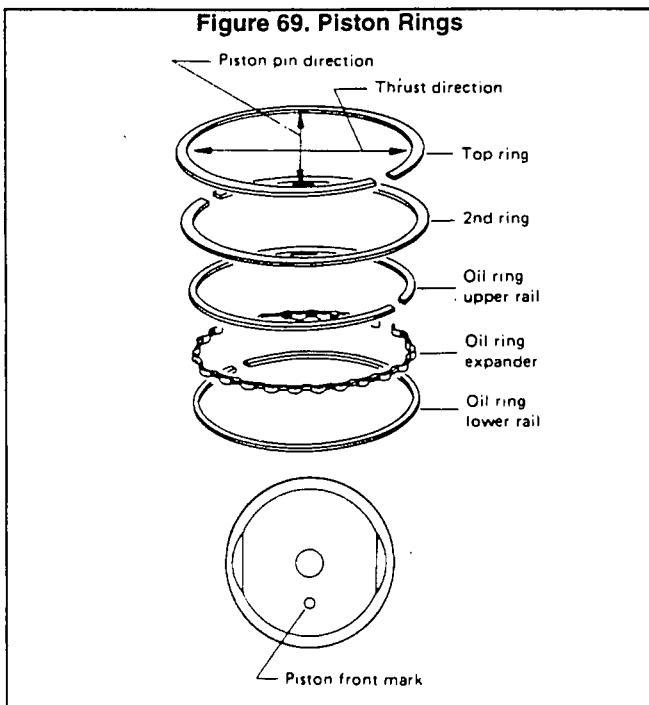
Cylinder Block, Crankshaft and Piston



Assembly (Continued)

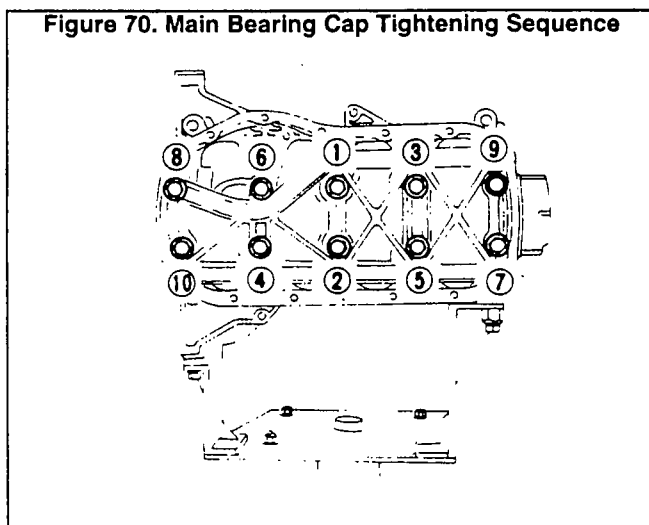
INSTALL PISTON ASSEMBLY:

1. Install piston rings as shown in Figure 69.



MAIN BEARING CAPS:

Install main bearing caps and tighten bolts to 34-38 foot-pounds (46-52 N-m). Tighten the caps in 2 or 3 stages and in the sequence shown in Figure 70. Before tightening the bearing cap bolts, place caps in proper position by shifting the crankshaft axially. After tightening the bearing cap bolts, check that the crankshaft turns smoothly by hand.



CRANKSHAFT FREE END PLAY:

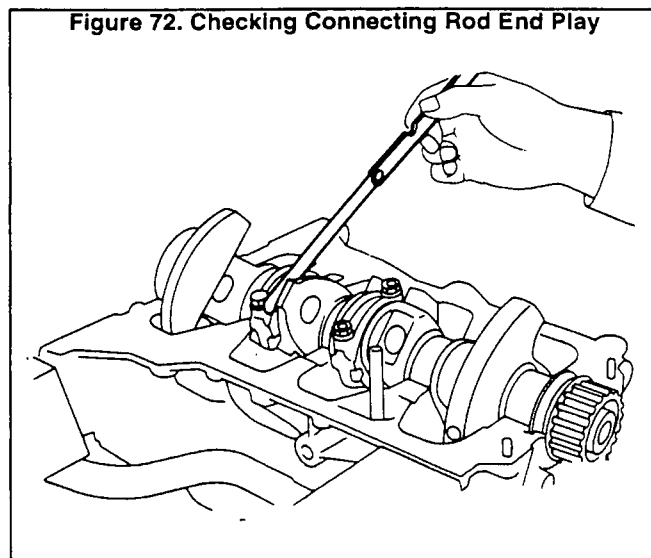
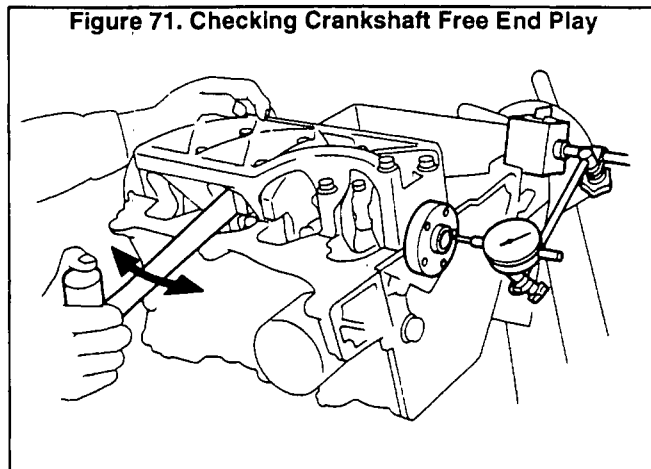
Measure crankshaft free end play at the center bearing (Figure 71). Nominal end play and wear limit are as follows:

CRANKSHAFT FREE END PLAY
 End Play = 0.0024-0.0087 inch (0.06-0.22mm)
 Wear Limit = 0.0197 inch (0.50mm)

CONNECTING ROD END PLAY:

Connecting rod end play should be within the following limits:

CONNECTING ROD END PLAY
 0.0039-0.0146 inch (0.10-0.37mm)



Part 3
ENGINE
LUBRICATION
SYSTEM

NP and IM Series
RECREATIONAL
VEHICLE &
INDUSTRIAL
MOBILE
AC GENERATORS
Liquid Cooled 1.2 Liter
Gas Engine Models

TABLE OF CONTENTS

SECTION	TITLE
3.1	Lubrication System Familiarization
3.2	Engine Oil Pump

Section 3.1- LUBRICATION SYSTEM FAMILIARIZATION

Engine Lubrication Circuit

Figure 1, below, shows the engine lubrication circuit in block diagram form and pictorially.

Recommended Oils

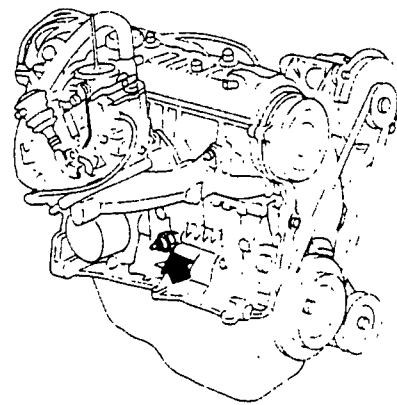
Use a high quality detergent oil classified "For Service SC, SD, SE or SF". Detergent oils keep the engine cleaner and reduce carbon deposits. Use oil having the viscosity rating listed in the chart below, based on the ambient temperature range anticipated before the next oil change.

TEMPERATURE	OIL GRADE
Above 88° F.	Use SAE 40 oil
32° to 85° F.	Use SAE 30 oil
Below 32° F.	Use SAE 20W oil
All Seasons	Use SAE 10W-30 oil

Low Oil Pressure Shutdown

The engine is equipped with a low oil pressure switch, which is exposed to oil pressure in the engine's main oil gallery. The pressure switch contacts are normally-closed (N.C.), but are held open by oil pressure during startup and running conditions. Should oil pressure drop below approximately 12-15 psi, the switch contacts will close and an automatic engine shutdown will occur.

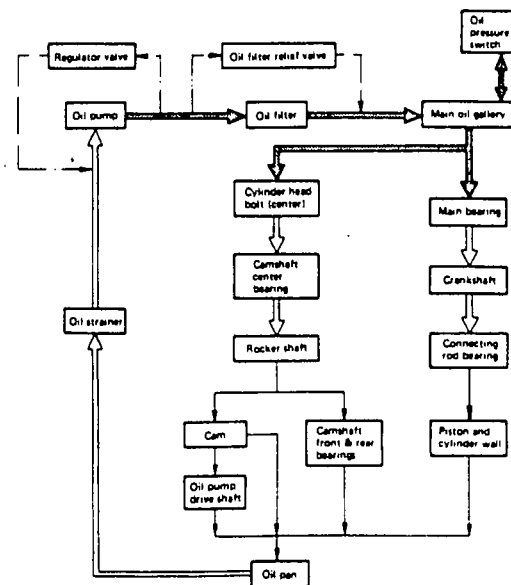
Figure 2. Low Oil Pressure Switch



Checking Low Oil Pressure Shutdown

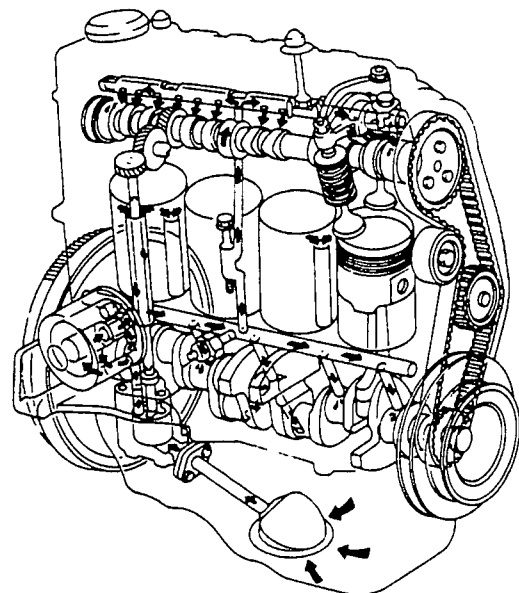
To test the operation of low oil pressure shutdown, start the engine. Let the engine run at no-load, i.e., with all electrical loads disconnected from the generator. Disconnect wire from oil pressure switch terminal and hold the wire terminal end against a clean frame ground on the engine. After a very short delay, the engine should shut down.

Figure 1. Engine Lubrication Circuit



Note
 Oil passage
 Oil gallery in cylinder block
 By-pass passage

A. Block Diagram

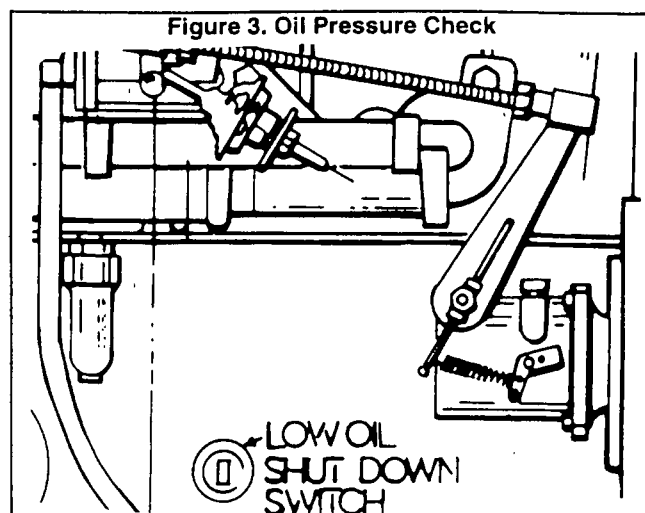


B. Pictorial

Oil Pressure Check

Warm up the engine. Then, shut down and remove the oil pressure switch. Install a direct reading pressure gauge in the oil pressure switch port. Start the engine and check oil pressure with the engine running at no-load condition, i.e., no electrical loads connected to generator.

Oil Pressure reading should be approximately 40-46 psi (2.8-3.2 kg/cm²) at 1860 rpm.



Section 3.2- ENGINE OIL PUMP

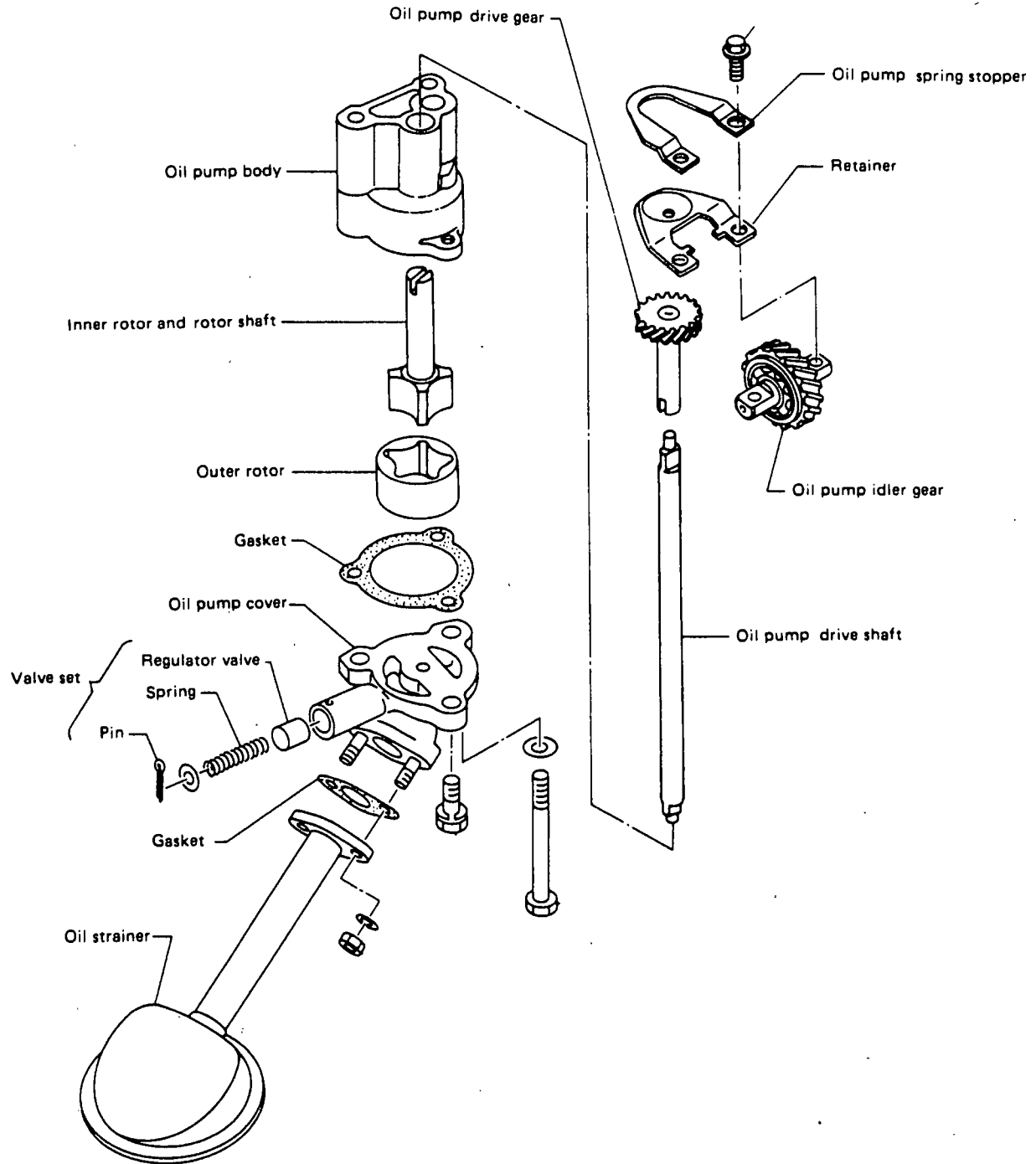
Oil Pump Disassembly

When removing the oil pump, be careful not to drop the oil pump drive shaft. When installing the pump, apply engine oil to the drive gear and shaft. The inner rotor and shaft cannot be disassembled.

Oil Pump Inspection

Visually inspect oil pump parts for wear and damage. Inspect the oil pressure regulator valve sliding surfaces and valve spring. Replace the valve seat, if damaged. Use a feeler gauge to check (a) rotor tip clearance, (b) outer body to body clearance, and rotor to straight edge clearance. See Figure 5.

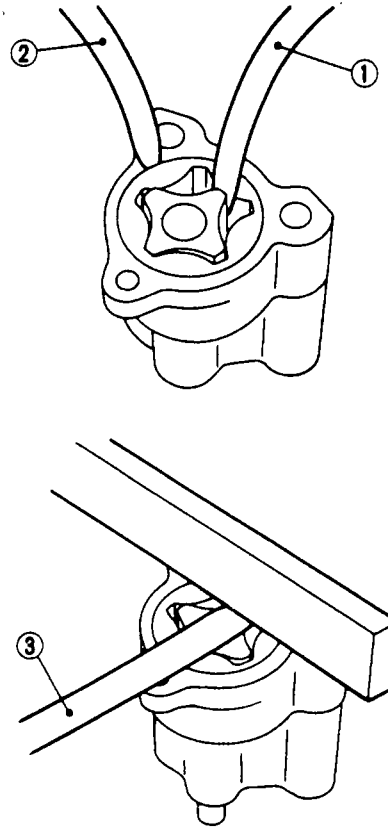
Figure 4. Oil Pump Assembly



Oil Pump Inspection (Continued)

ROTOR TIP CLEARANCE Less than 0.008 inch (0.2mm)
OUTER ROTOR TO BODY CLEARANCE Less than 0.008 inch (0.2mm)
ROTOR TO STRAIGHT EDGE CLEARANCE Less than 0.008 inch (0.2mm)

Figure 5. Oil Pump Inspection



Part 4 ENGINE COOLING SYSTEM

NP and IM Series

RECREATIONAL VEHICLE & INDUSTRIAL MOBILE AC GENERA- TORS

Liquid Cooled 1.2 Liter
Gas Engine Models

TABLE OF CONTENTS

SECTION	TITLE
4.1	Cooling System Familiarization
4.2	Water Pump and Thermostat
4.3	Cooling and Ventilating Air
4.4	Optional Remote Radiator Fan
4.5	Optional Heat Recovery System

Section 4.1- COOLING SYSTEM FAMILIARIZATION

Introduction

The generator cooling system is of the closed recovery type. Major cooling system components consist of (a) radiator, (b) cooling fan, (c) coolant recovery bottle, (d) engine water pump, (e) thermostat, and (f) interconnecting hoses.

Recreational vehicle generators are typically housed in a compartment. An adequate flow of cooling, combustion and ventilating air must be provided for these compartments.

Some models are equipped with unit-mounted radiators. Other models may have remote mounted radiators.

At least one IM (Industrial Mobile) generator model is equipped with a heat recovery system.

Recommended Coolant

Recommended is a 50-50 mixture of low silicate ethylene glycol base anti-freeze and soft water for all-weather protection. If desired, a high quality rust inhibitor may be added to the recommended mixture. When adding coolant to the radiator or to the coolant recovery bottle, always add the recommended 50-50 mixture.

NOTE: Cooling system capacity for models with unit-mounted radiator is approximately 2.5 U.S. gallons (9.5 liters). Use only **SOFT** water and **LOW SILICATE** anti-freeze. For installations equipped with a remote-mounted radiator, cooling system capacity will depend on radiator hose lengths.

CAUTION: The use of any "chromate" base inhibitor is NOT recommended. When chromate base rust inhibitor is used with ethylene glycol base anti-freeze, chromium hydroxide is formed in the cooling system. Chromium hydroxide is visible to the eye as a "green slime" which can cause reduced heat transfer and possible overheating. Any cooling system that has been operated with a chromate base inhibitor must be chemically cleaned before adding ethylene glycol base anti-freeze. Use of any high silicate anti-freeze boosters or additives is NOT recommended. In addition to the preceding, the use of any soluble oil rust inhibitor is NOT recommended.

The switch contacts should close and switch should read "continuity" at about 225°-235° F. (107°-113° C.).

Figure 1. High Coolant Temperature Switch

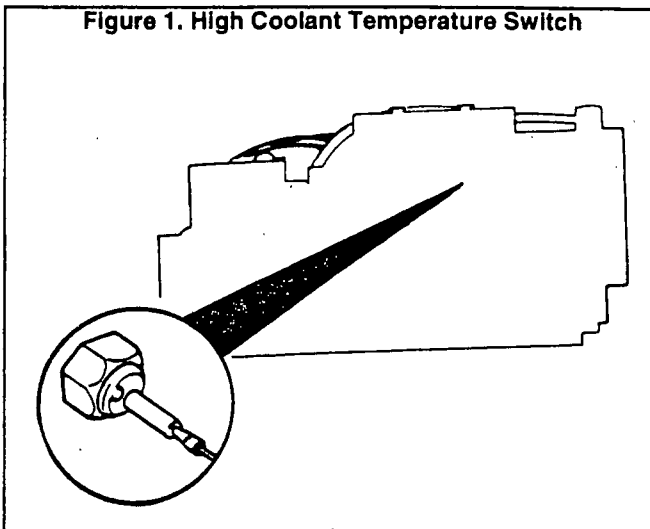
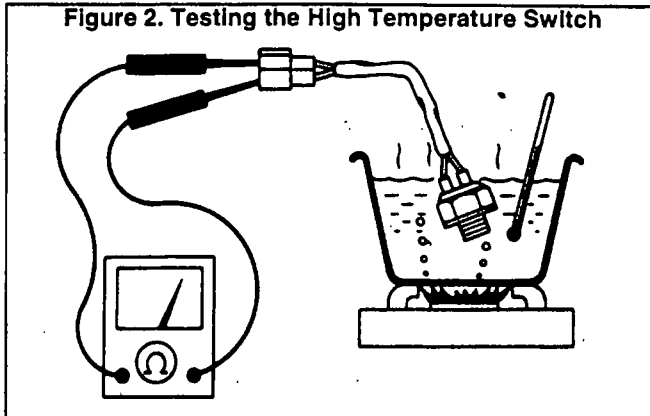


Figure 2. Testing the High Temperature Switch



High Coolant Temperature Switch

DESCRIPTION:

The engine mounts a normally-open (N.O.) thermostatic switch (Figure 1). The sensing tip of the switch is normally immersed in engine water jacket coolant. Should coolant temperature exceed approximately 230° F. (110° C.), the switch contacts will close and the engine will shut down automatically.

TESTING HIGH TEMPERATURE SHUTDOWN:

To test the high temperature shutdown feature, first disconnect Wire No. 85 from the switch terminal. Start the engine, let it stabilize and warm up at no-load. Hold the terminal end of Wire No. 85 into contact with a clean frame ground on the engine. After a short delay, the engine should shut down.

TESTING THE SWITCH:

Remove the switch. Check the switch closing temperature with an ohmmeter (Figure 2).

Section 4.2- WATER PUMP AND THERMOSTAT

Water Pump

The engine water pump (Figure 3) cannot be disassembled and must be replaced as a unit. Check the pump for excessive end play and smoothness of rotation. Bolt holes are drilled through the water jacket in the cylinder block. Use a sealant and tighten the bolts to the recommended torque. After installation, operate the engine and check for leaks.

Thermostat

Check the thermostat for proper seating at ambient temperature. It should seat tightly. Check its opening temperature and lift.

VALVE OPENING TEMPERATURE
190° F. (88° C.)

MAXIMUM VALVE LIFT
0.31 Inch at 212° F. (8mm at 100° C.)

After installing the thermostat, run the engine and check for leaks.

Figure 4. Thermostat

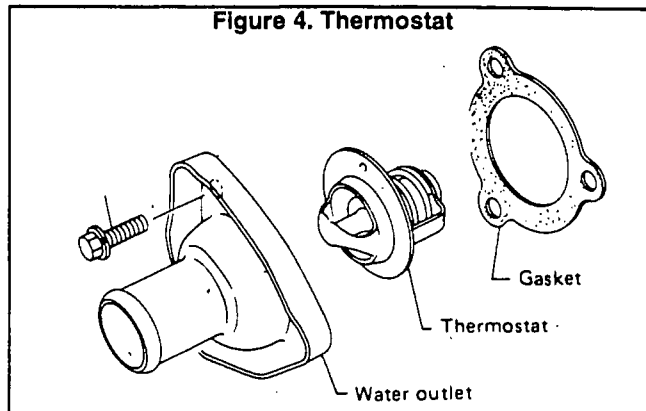


Figure 5. Testing the Thermostat

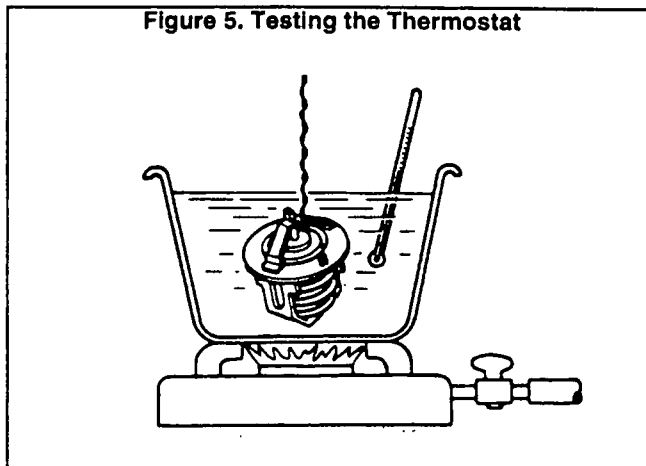
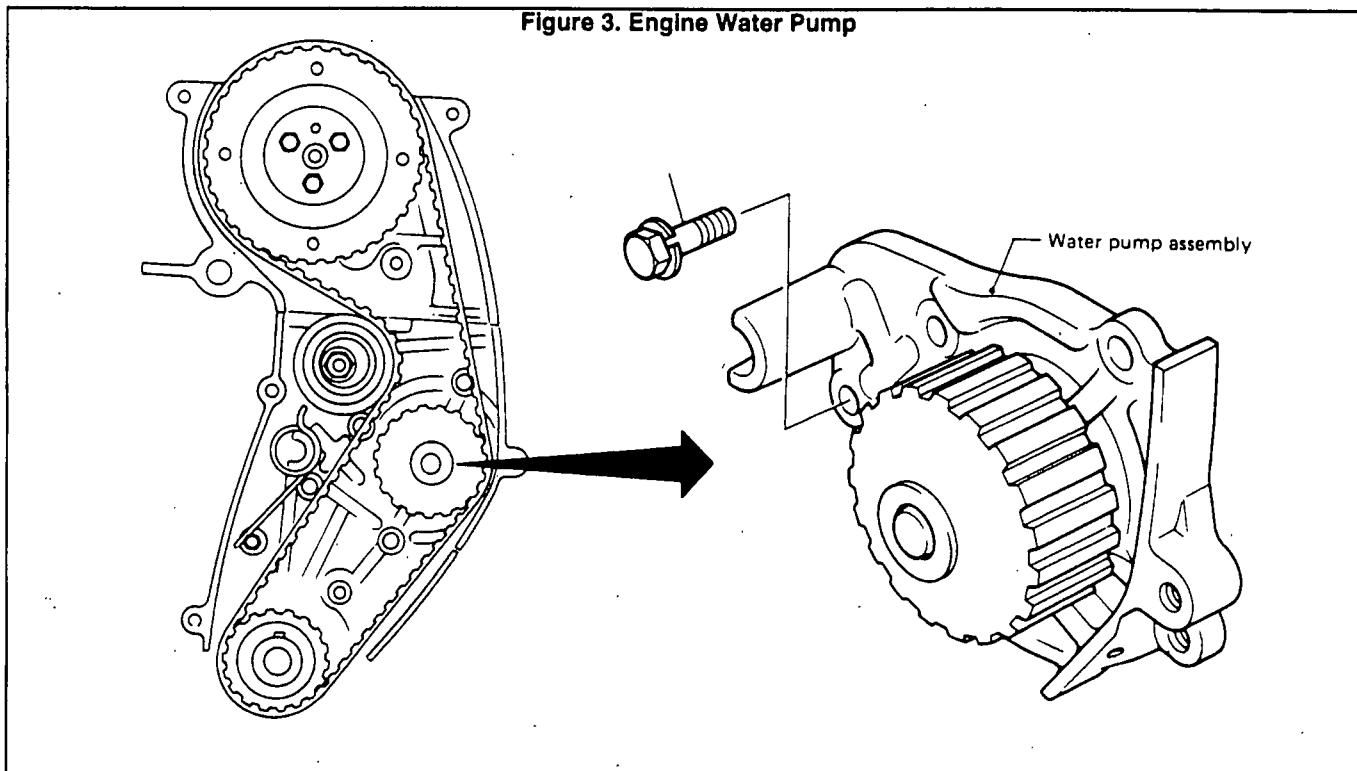


Figure 3. Engine Water Pump



Section 4.3- COOLING AND VENTILATING AIR

General

Service technicians who work on the Series NP (recreational vehicle) and IM (industrial mobile) generators should be familiar with air flow requirements for these units. Adequate air flow for cooling, ventilation and combustion MUST be provided or serious problems will result.

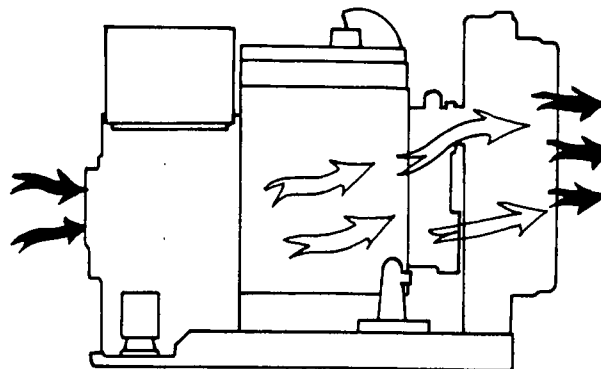
Types of Cooling Fans

Engine-generators may be equipped with either (a) a **PUSHER** type fan, or (b) a **SUCTION** type fan. The suction type fan used on some models is a "squirrel cage" fan.

Air Flow- Pusher Fan Units

See Figure 6. A blower fan, attached to the generator Rotor, draws air into the generator interior to cool generator internal parts. The heated generator air is expelled through a blower air outlet duct on the side of the unit. The engine's "pusher" type cooling fan draws air around the unit, then forces the air through the radiator, outward and away from the unit.

Figure 6. Air Flow- Pusher Fan Units



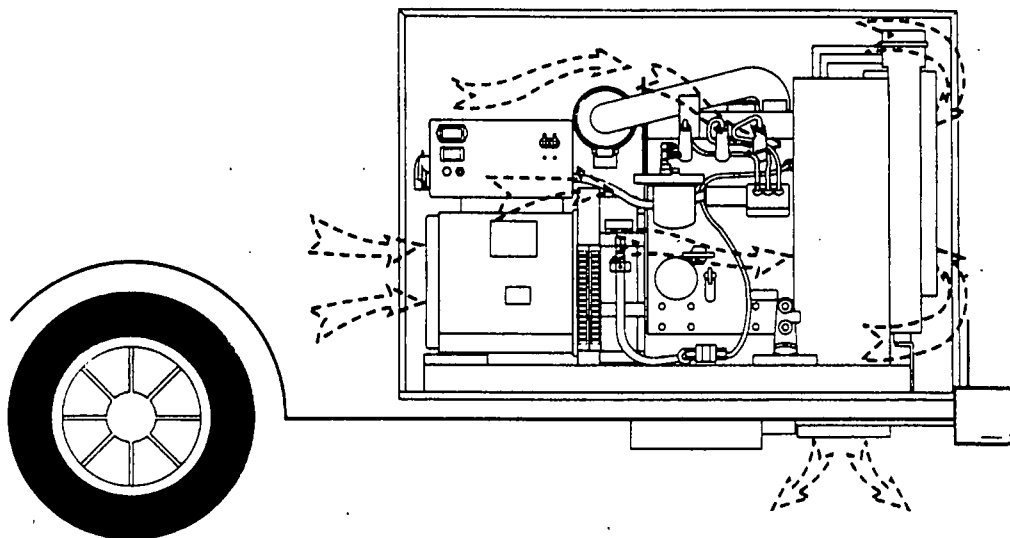
Air Flow- Suction Fan Units

Generator internal parts are cooled in the same manner as for "pusher" fan units. The suction type engine cooling fan is a high capacity, squirrel cage type. The fan draws air in and across the radiator, then directs the air downward and away from the unit through an air duct. See Figure 7.

Installation Manual

Additional information on cooling and ventilating requirements can be found in the "INSTALLATION MANUAL" for water-cooled RV generators. These manuals can be ordered from Generac Corporation.

Figure 7. Typical Installation- Unit with Suction Type Fan



Section 4.4- OPTIONAL REMOTE RADIATOR FAN

Some NP series engine-generators are not equipped with a unit-mounted radiator. The radiator on such units is mounted at a remote location in the vehicle that houses the generator. Such installations might require the following options:

An electrically operated RADIATOR FAN, along with a temperature sensor switch.

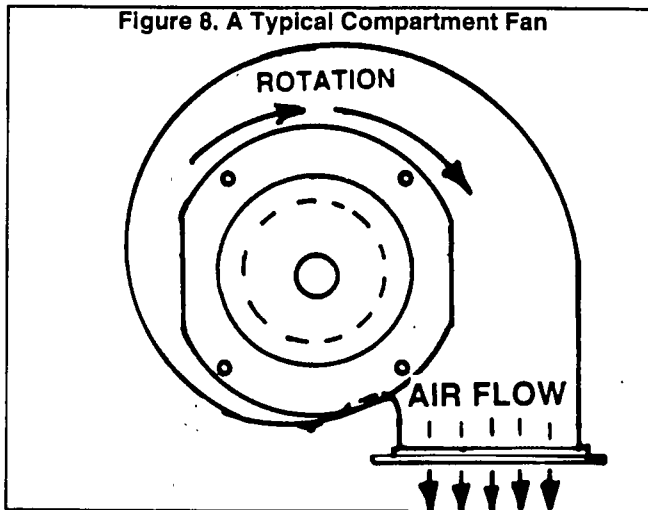
A squirrel cage type COMPARTMENT FAN which draws cooling and ventilating air through the compartment housing the generator.

Compartment Fan

The compartment fan (Figure 8) must be properly located during installation. When running, it must draw cooling and ventilating air through the generator compartment and expel the air to the outdoors. The compartment fan is needed, since an engine-driven fan is not provided.

The compartment fan motor is connected to generator AC output leads 11 and 22. When the generator is running and AC voltage is available, the fan will operate.

Figure 8. A Typical Compartment Fan



A Remote Radiator Assembly

COMPONENTS:

Major components of a typical remote radiator and fan include (a) the radiator, (b) the fan, (c) a thermostatic switch, (d) mounting hardware, and (e) wiring harnesses. See Figure 10 on next page.

OPERATION:

See Figure 9, below. Battery voltage for fan operation is always available to Terminal 30 of the Fan Relay (SR), via a 14 amp fuse and Wire 13A. However, the fan relay normally-open contacts are open and the fan is NOT running. On cranking and startup of the generator, an engine control circuit board delivers 12 volts DC to the Thermostatic Switch (TS) via Wire 14, Relay Coil, and Wire 243. If coolant temperature is below approximately 180° F., the thermostatic switch contacts will be open. As soon as coolant temperature increases above 180° F., the switch contacts close and Wire 243 is grounded. Fan Relay (SR) then energizes, its normally-open contacts close, and DC voltage is delivered to the FAN via Wire 244. The fan is now powered and will run.

Figure 9. Remote Radiator Fan Operating Diagram

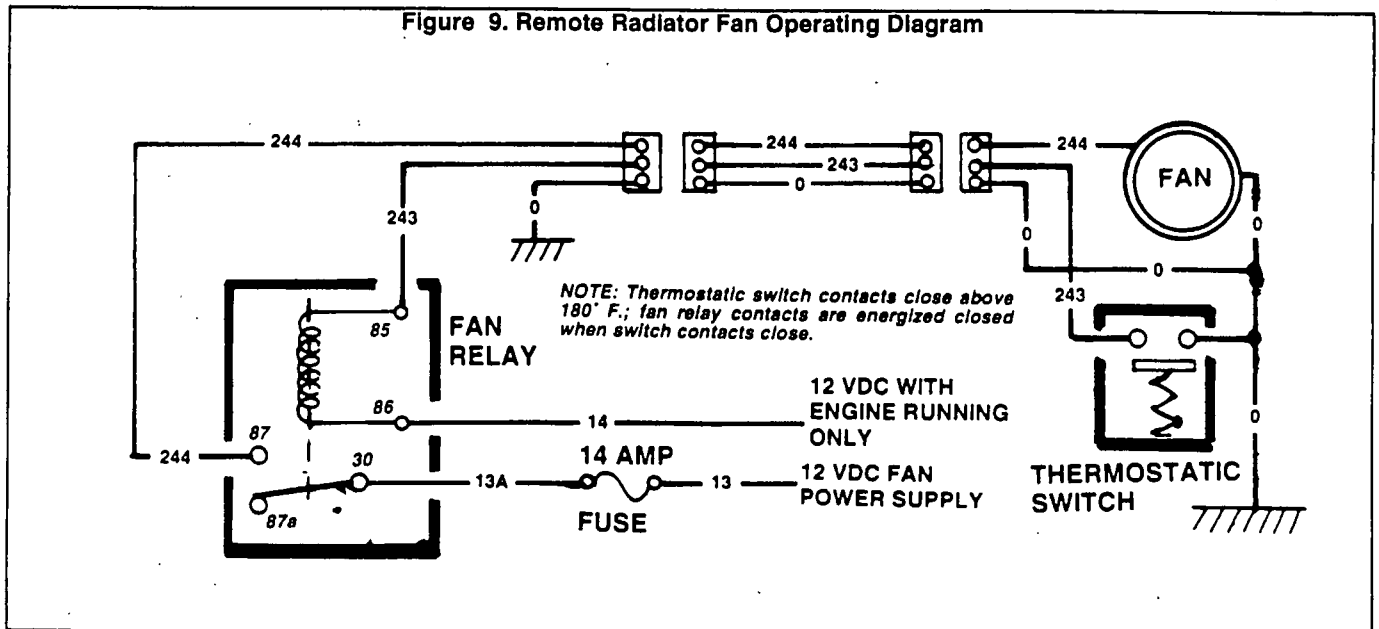
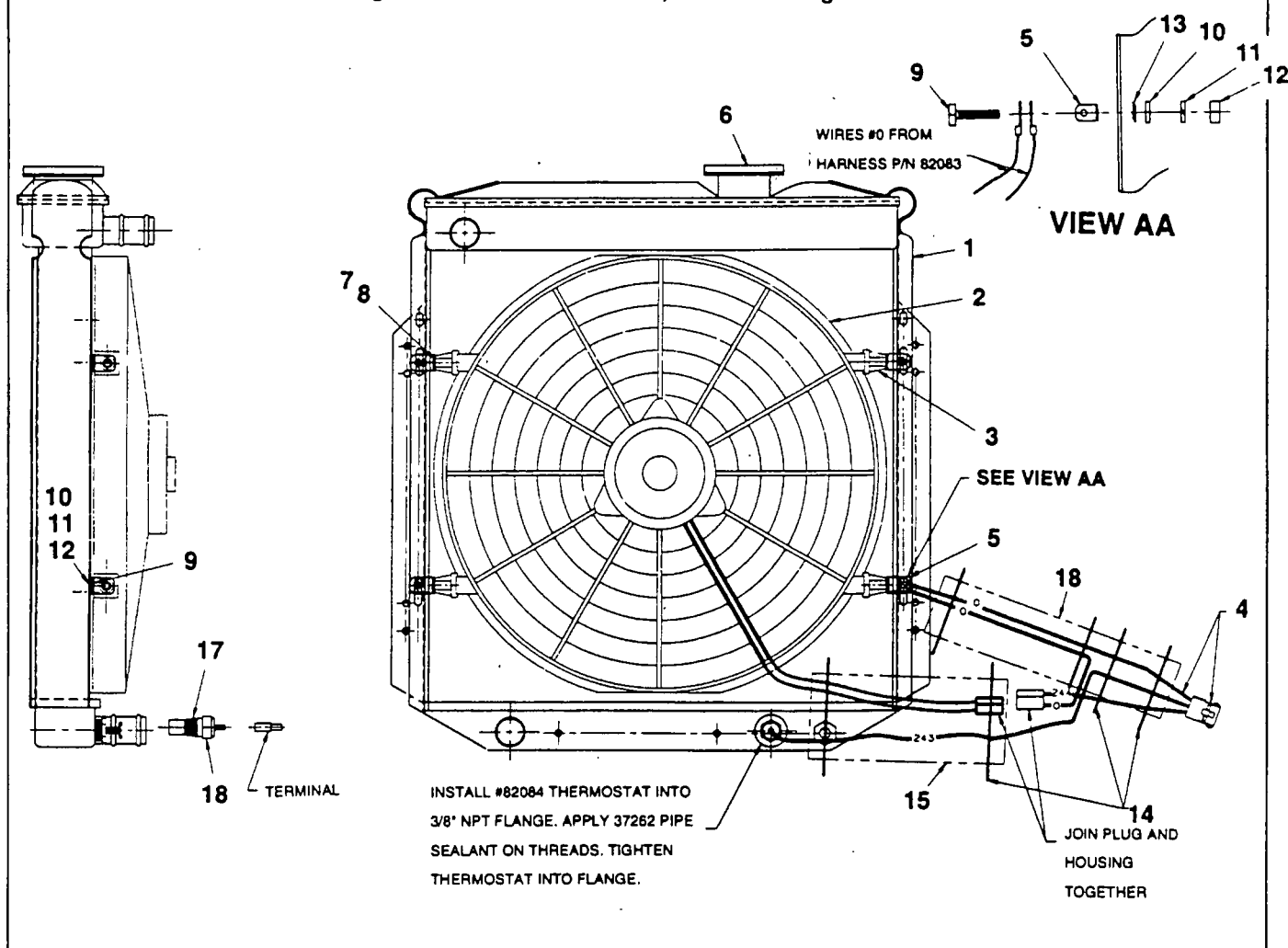


Figure 10. A Remote Radiator, Fan and Wiring Harness



ITEM	QTY	DESCRIPTION	ITEM	QTY	DESCRIPTION
1	1	Radiator Assembly	10	4	M6 Flatwasher
2	1	Radiator Fan	11	4	M6 Lockwasher
3	4	Fan Mounting Bracket	12	4	M6 Hex Nut
4	1	Remote Fan Harness	13	1	M6 Star Washer
5	4	Fan to Radiator Brackets	14	6	Tie Wrap
6	1	Radiator Cap	15	4 In.	Flex-Gard
7	4	M5-0.80 x 10mm Capscrew	16	6.5 In.	Flex-Gard
8	4	M5 Lockwasher	17	—	Pipe Sealant
9	4	M5-1.00 x 12mm Capscrew	18	1	Thermostatic Switch

Section 4.5- OPTIONAL HEAT RECOVERY SYSTEM

General

Some IM (Industrial Mobile) engine-generators are equipped with a heat recovery system. If desired, the customer can use this system to provide heated air while working in cold areas (such as a manhole).

Operation

Figure 1, below, is a schematic diagram of a heat recovery system. Factory installed components include (a) a heat exchanger, (b) a control valve, (c) a thermostat, (d) the engine radiator, and (e) interconnecting hoses and fittings. Operation may be briefly described as follows:

1. Coolant from the engine flows through the heat exchanger where it is heated by the engine exhaust, which also passes through the heat exchanger.

2. From the heat exchanger, coolant flows to a control valve (CV). The control valve can be positioned manually, as follows:

a. It can be actuated manually to direct coolant through a customer-supplied remote heater and then to a thermostat housing (TH).

b. It can be actuated manually to direct coolant to the thermostat housing (TH) and not to the customer's remote heater.

3. The thermostat (TH) either delivers the coolant back to the engine or to the unit radiator, as follows:

a. If coolant temperature is less than 192° F. (89° C.), additional cooling is not needed, and the coolant is delivered back to the engine.

b. If coolant temperature is greater than 192° F. (89° C.), additional cooling is needed, and the coolant is delivered to the unit radiator and then back to the engine.

Customer Remote Heater

This heater is usually supplied by the user, in conjunction with a fan or blower to extract the heat from the remote heater and deliver it to the desired work area(s). The user must ensure that the entire system has been properly filled with the recommended coolant mixture prior to use.

Exploded View of Heat Recovery System

Figure 12 (next page) shows a typical heat recovery system. Parts included in the drawing are listed below.

ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	Exhaust Manifold	20	Filler Neck
2	End Plate	21	Radiator Cap
3	Thermostat Hsng.	22	Exhaust Flange
4	Thermostat	23	Hose Clamp
5	Gasket	24	Upper Hose
6	Water Pump	25	Lower Hose
7	Lockwasher	26	Hose
8	Hex Nut	27	Hose
9	Stud	28	Hose
10	Fitting	29	Stud
12	Pipe Plug	30	Stud
13	Gasket	31	Stud
14	Gasket	32	Pipe Plug
15	Gasket	34	Hose
16	Fitting	35	Fitting
17	90° Fitting	36	Hose Clamp
18	Brass Fitting	37	Lifting Lug
19	Gasket	38	Lockwasher

Figure 11. Schematic Diagram- Engine Cooling and Heat Exchanger System

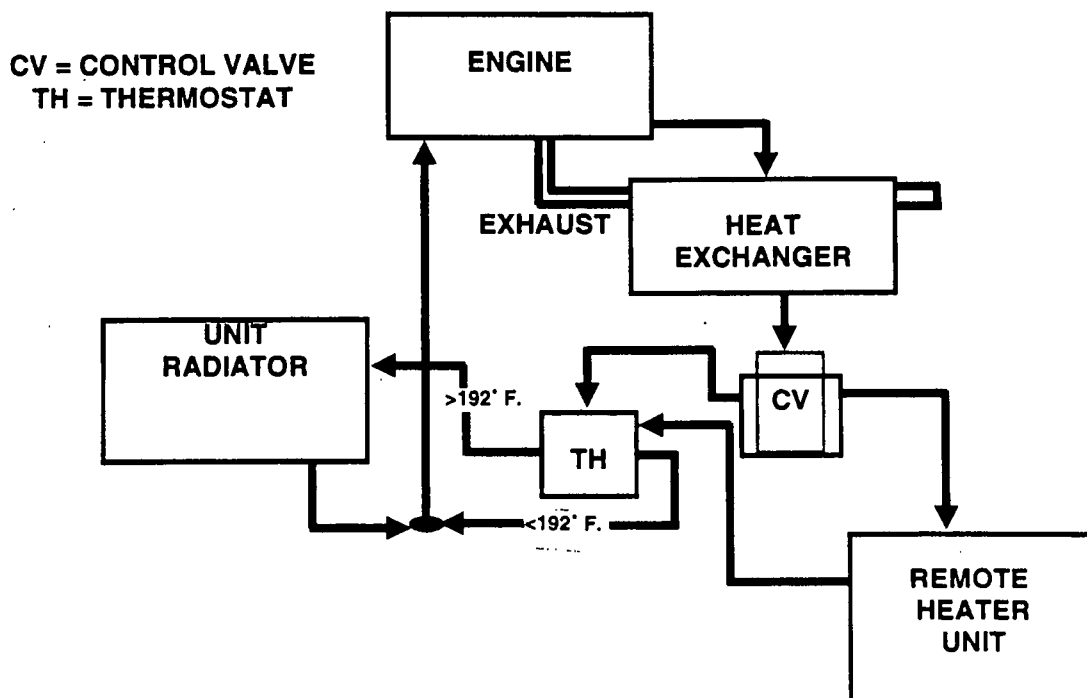
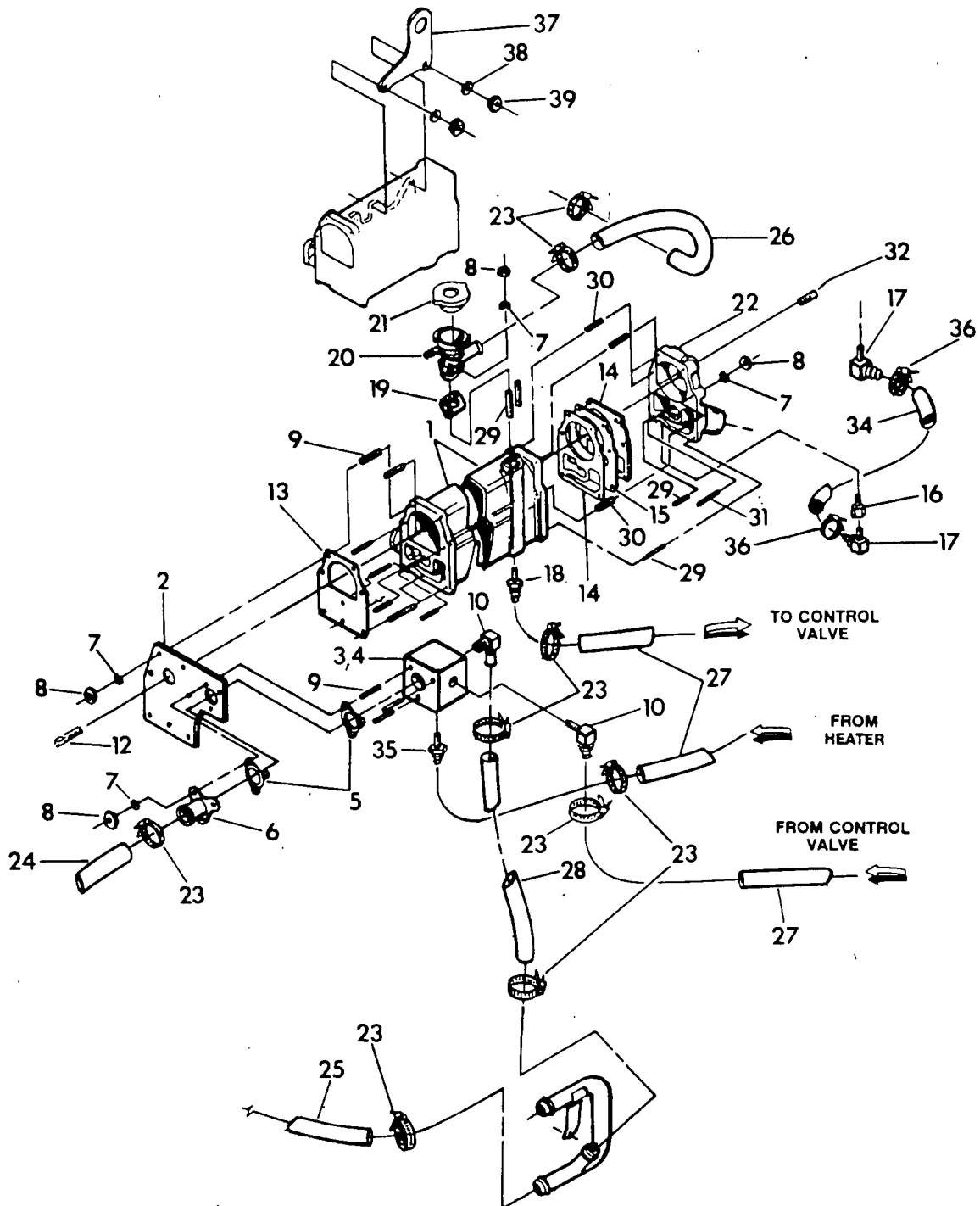


Figure 12. Exploded View of Heat Recovery System



Part 5 GASOLINE FUEL SYSTEM

NP and IM Series
**RECREATIONAL
VEHICLE &
INDUSTRIAL
MOBILE
AC GENERATORS**
1.2 Liter, Liquid-Cooled
Gas/Gasoline Engine Models

TABLE OF CONTENTS	
SECTION	TITLE
5.1	General Information
5.2	Fuel Pump
5.3	Carburetor

Section 5.1- GENERAL INFORMATION

Fuel Recommendations

Any high quality LEADED or UNLEADED regular grade gasoline having a minimum posted octane number of 86 (research octane number 90) is satisfactory for use with RV and IM generators.

Use of any gasoline containing alcohol (either methanol or ethanol) is **NOT RECOMMENDED**. Gasolines containing alcohol tend to absorb moisture from the air. Such absorption causes the water and alcohol to separate from the gasoline in the fuel tank. The adverse affects of alcohol increase in severity with methyl alcohol (methanol). In addition, the adverse affects worsen with increasing alcohol content. Use of gasoline containing alcohol may result in one or more of the following:

- ☐ Corrosion of metal parts.
- ☐ Deterioration of elastomer and plastic parts.
- ☐ Fuel permeation through flexible fuel lines.
- ☐ Wear and damage of internal engine parts.
- ☐ Starting and operating difficulties.

If the use of gasoline containing alcohol cannot be avoided, do not store the gasoline in fuel tank for long periods of time. Long periods of fuel storage create unique problems.

Fuel System Components

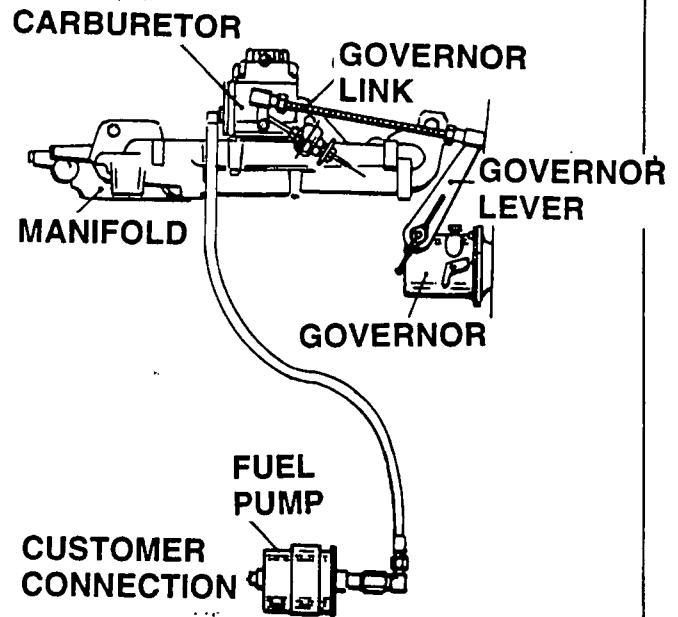
Major gasoline fuel system components include (a) a fuel pump, (b) the carburetor, and (c) interconnecting fuel lines. See Figure 1.

When the engine is cranked and started, the 12 volts DC electric fuel pump is turned ON. At the same time, a solenoid actuated fuel shutoff valve on the carburetor is opened to allow fuel flow to the carburetor.

The carburetor mounts an automatic electric choke which closes the carburetor choke valve while the engine is being cranked.

Carburetor throttle valve setting is established by the action of a constant speed governor. Most generator models utilize a mechanical, flyweight type governor. Some models, however, may be equipped with an electronic governor.

Figure 1. Gasoline Fuel System



Section 5.2- FUEL PUMP

General

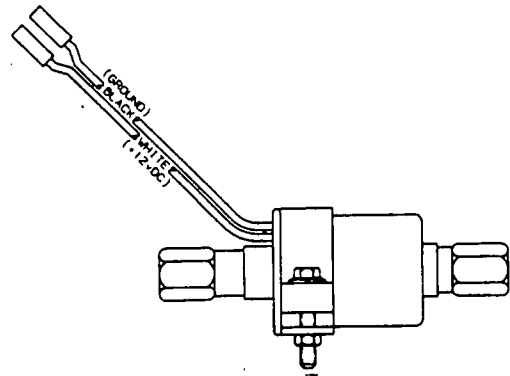
The fuel pump is energized ON during cranking and running when an engine controller circuit board delivers 12 volts DC power to a Wire No. 14 circuit. Circuit board action also energizes (a) a fuel solenoid, (b) a choke heater, and (c) the engine ignition system.

Testing the Fuel Pump

Use an ohmmeter or a volt-ohm-milliammeter (VOM) to test the pump windings for continuity.

To perform an operational test of the pump, disconnect fuel line from the pump outlet side and connect pump inlet side to a fuel supply. Connect a +12 volts DC power supply (such as a battery) to the pump WHITE wire and a -12volts DC power to the pump's BLACK wire. The pump should operate and pump fuel. Replace pump, if defective.

Figure 2. Electric Fuel Pump



Section 5.3- CARBURETOR

Removal

Remove carburetor air intake components as necessary to gain access to the carburetor. Disconnect the carburetor-governor link. Disconnect fuel line. Remove carburetor, carburetor adapter and gaskets.

Disassembly

See Figure 5 on next page. Disassemble the carburetor as follows:

1. Remove two screws and lockwashers, then remove FUEL INLET PLATE and GASKET.
2. Remove two screws and washers, then remove CHOKE SOLENOID ASSY.
3. Remove four screws and washers, then remove FLOAT BOWL COVER along with FLOAT BOWL GASKET, FLOAT, FLOAT SHAFT, SPRING, FUEL VALVE AND SEAT ASSY.
4. Remove FLOAT SHAFT, SPRING, FUEL VALVE and FLOAT.
5. Remove FLOAT BOWL GASKET.
6. Remove SEAT ASSY.
7. Remove two CHOKE PLATE SCREWS, then remove CHOKE PLATE.
8. If necessary for replacement, remove FUEL SOLENOID and seal.
9. Remove IDLE ADJUSTING NEEDLE & SPRING.
10. Clean all parts in clean gasoline.

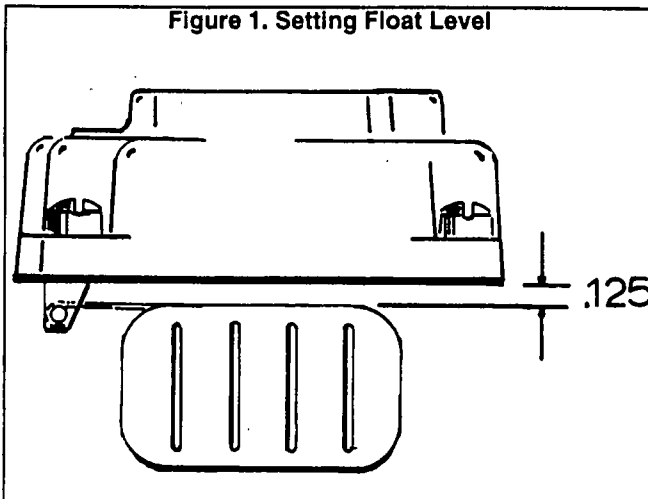
Reassembly

Reassemble all parts in the reverse order of disassembly. During the reassembly process, install new parts from carburetor repair kit. Pay close attention to the following:

- ☐ Open throttle plate slightly for idle speed.
- ☐ Set the idle adjusting needle 3/4 turn open.

With float bowl cover inverted and float bowl gasket installed, set float level 0.125 inch (3.175mm) from the float bowl gasket (see Figure 1).

Figure 1. Setting Float Level



Tighten air intake mounting screws. Make sure the throttle shaft rotates freely. Tighten the FUEL SOLENOID to 70 inch-pounds.

Insert short leg of CHOKE SHAFT SPRING into small hole in CHOKE SHAFT (Figure 2). Wind SPRING 1-1/2 turns counterclockwise, anchor on retaining screw boss.

Figure 2. Inserting Choke Spring

INSERT TO
SHORT
LEG OF
CHOKE
SPRING

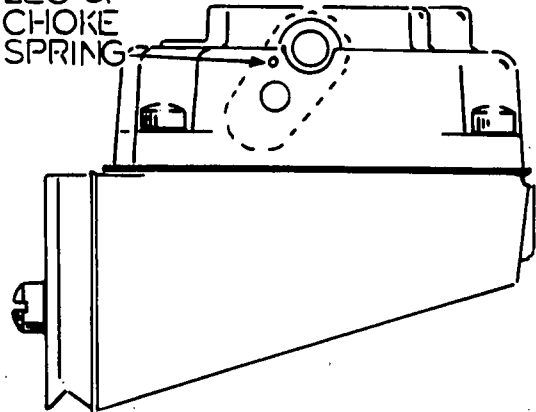
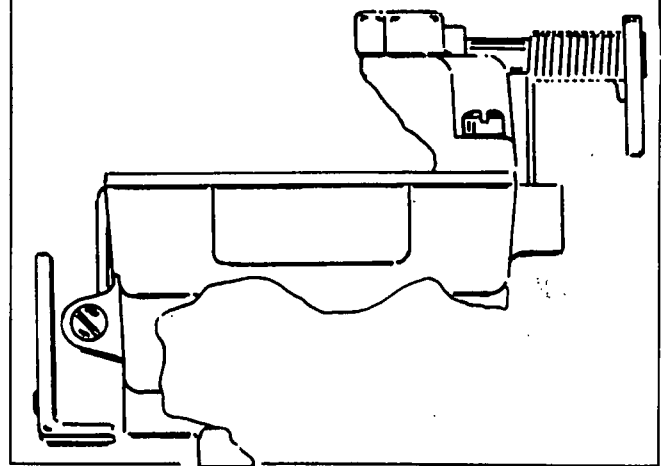


Figure 3. Installing Choke Shaft Spring



Installation

Install gasket, adapter, gasket and carburetor. Retain with socket head machine screws.

Automatic Choke Adjustment

Loosen CHOKE SOLENOID adjusting screws and adjust choke position so that, with the solenoid pulled in (energized), the choke plate is closed. With choke plate closed, tighten the adjusting screws. Then, with solenoid extended, bend tip of the bi-metal until choke plate is about 1/8 inch from vertical and towards the closed position.

Figure 4. Automatic Choke Adjustment

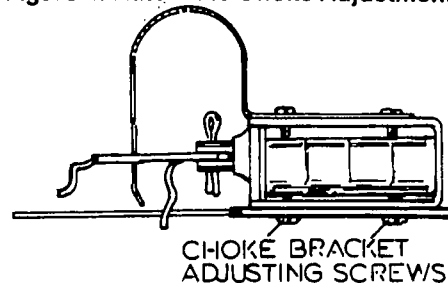
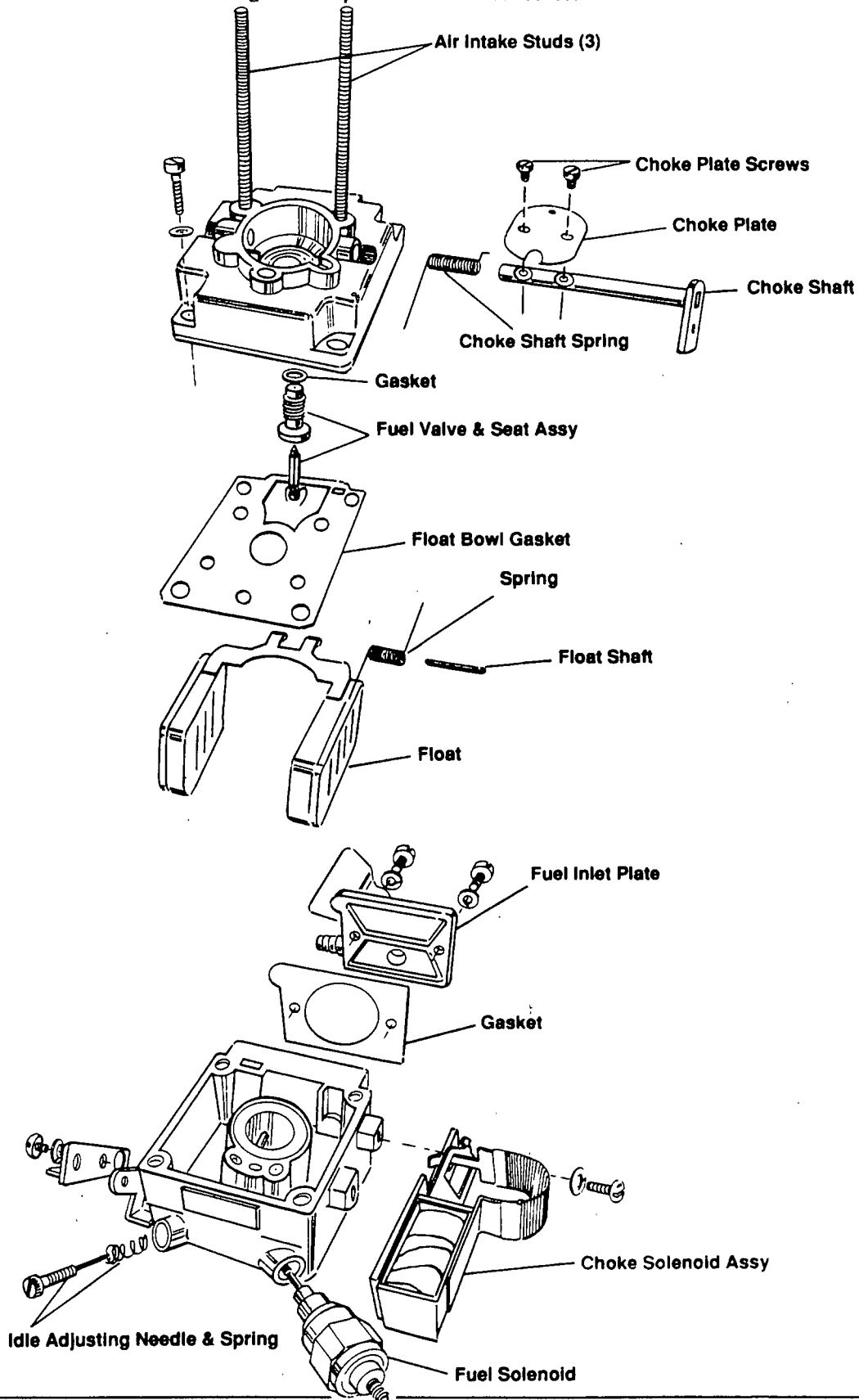


Figure 5. Exploded View of Carburetor



Part 6 GASEOUS FUEL SYSTEM

NP and IM Series
**RECREATIONAL
VEHICLE &
INDUSTRIAL
MOBILE
AC GENERATORS**
1.2 Liter, Liquid-Cooled
Gas/Gasoline Engine Models

TABLE OF CONTENTS

SECTION	TITLE
6.1	Introduction to Gaseous Fuel Systems
6.2	Major Components- Liquid Withdrawal System
6.3	Major Components- Vapor Withdrawal System

Section 6.1- INTRO. TO GASEOUS FUEL SYSTEMS

General

Some NP/IM series engine-generators may be equipped with optional LP (liquefied petroleum) gas fuel systems. This fuel is supplied as a liquid in pressure tanks.

LP gas is usually made up of (a) propane, (b) butane, or (c) a mixture of the two gases. The liquefied fuel must be converted to its vapor state before it enters the engine carburetor. Propane will vaporize at temperatures as low as 20° F. (-6.7° C.). Butane exists in its liquid state when temperatures drop below 32° F. (0° C.). In colder weather, fuel suppliers will usually increase the amount of propane in the fuel mixture for better vaporization. Under extremely cold conditions, butane gas may not provide sufficient vapor pressure to operate the engine.

- ☐ One gallon of butane liquid equals about 31.26 cubic feet of butane gas.
- ☐ One gallon of propane equals about 36.39 cubic feet of propane gas.

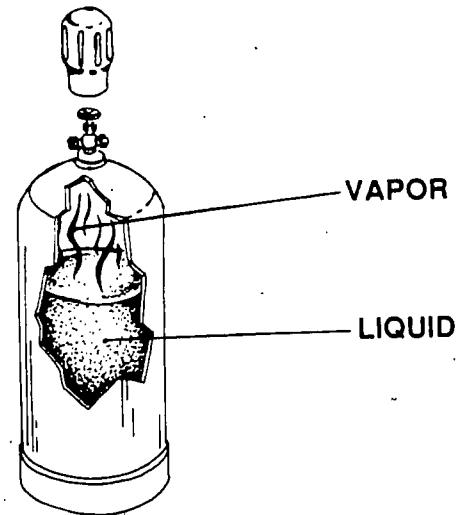
Vapor Withdrawal System

The LP gas fuel system may be either (a) a vapor withdrawal system or (b) a liquid withdrawal system.

The vapor withdrawal system utilizes the vapors that form above the liquid fuel in the supply tank. One typical vapor withdrawal supply tank is shown in Figure 1.

The vapor withdrawal system, because it uses gaseous fuel vapors, is much like a natural gas system. See Figure 2. The fuel vapors are delivered to a customer-supplied primary regulator which reduces the gas vapor pressure. The gas then goes to a fuel lockoff solenoid. Optimum gaseous pressure at the inlet to the fuel lockoff solenoid is about 11 inches (water column) and not to exceed 14 inches (water column). The function of the primary regulator is to provide this optimum fuel pressure to the solenoid. From the fuel lockoff solenoid, the gaseous fuel is delivered to the inlet of a pressure reducer valve. The pressure reducer valve receives the gas at the stated optimum pressure, reduces the gas pressure to a negative (vacuum) pressure of about -1 inch (water column). The gas is then delivered to the carburetor which meters the gas to the engine based on engine demand.

Figure 1. Typical Vapor Withdrawal Supply Tank

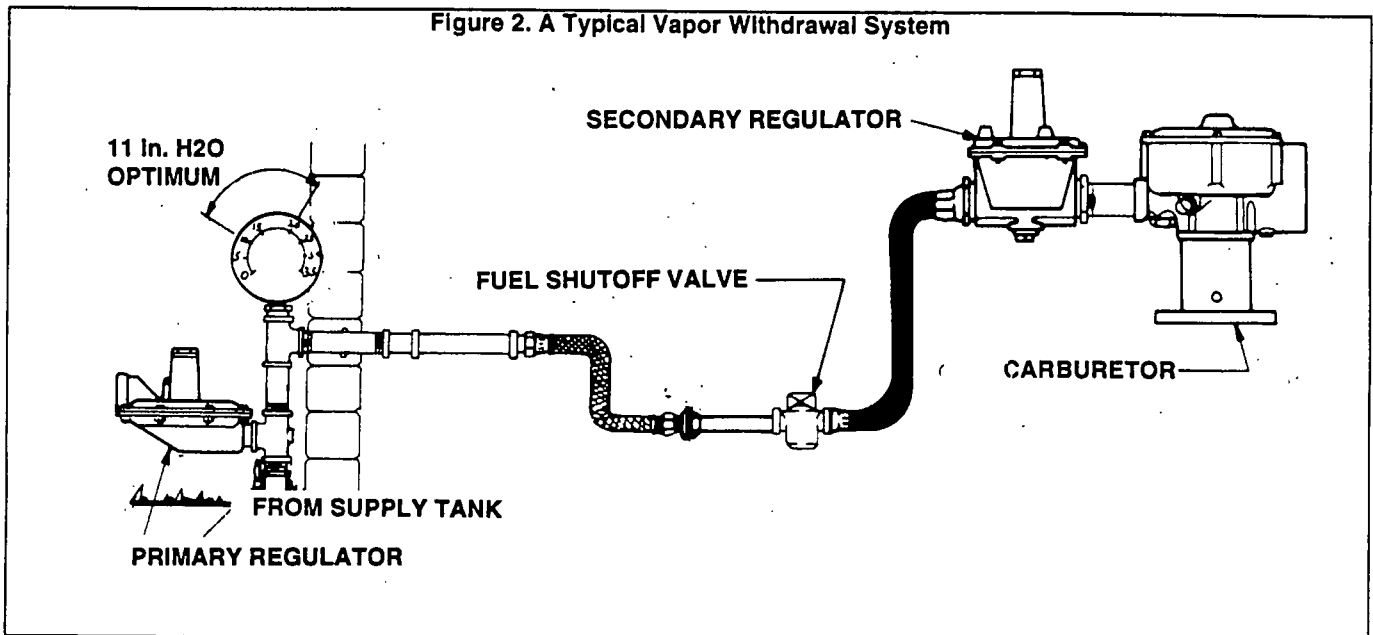


Liquid Withdrawal System

A typical liquid withdrawal fuel supply tank is shown in Figure 3 (next page). A pickup tube extends down into the tank. Vapor pressure on top of the fuel in the tank forces the fuel to flow through the pickup tube and to the engine-generator fuel system.

A typical liquid withdrawal type fuel system is shown in Figure 4 on the next page. From the fuel supply tank, liquid fuel flows to a fuel lockoff solenoid on the generator. The liquid fuel is then delivered to a vaporizer-regulator. Heated engine coolant also flows through the vaporizer-regulator, to heat the fuel and change it to its vapor state. The vaporized fuel is then delivered to the engine carburetor at greatly reduced pressure.

Figure 2. A Typical Vapor Withdrawal System



Liquid Withdrawal System (Continued)

Figure 3. Liquid Withdrawal Fuel Tank (Typical)

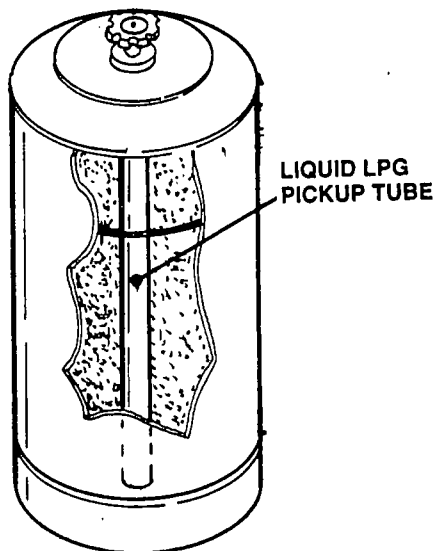
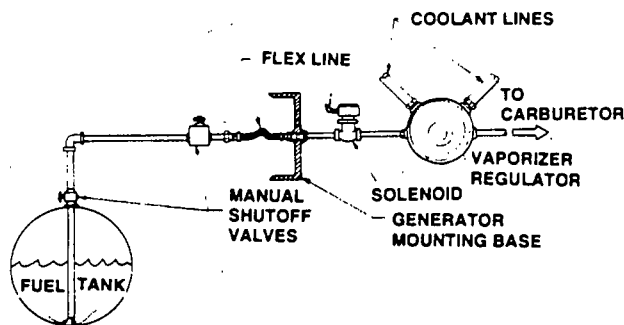


Figure 4. Typical Liquid Withdrawal Fuel System



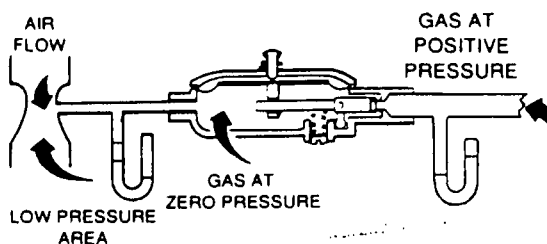
Gas Carburetion

See Figure 5. During the engine intake stroke, air is drawn into the engine. This air flows through a venturi in the carburetor and creates a vacuum at the venturi throat. The amount of vacuum created is proportional to the amount of air flow. That is, the greater the air flow through the venturi, the greater the amount of vacuum.

The vacuum created at the carburetor venturi throat acts on a diaphragm in the vaporizer-regulator (liquid withdrawal system) or pressure reducer valve (vapor withdrawal), to pull the diaphragm toward the source of vacuum. Diaphragm movement opens a metering valve and allows gas to flow to the carburetor.

As the throttle is opened wider, air flow increases through the carburetor venturi and the vacuum at the venturi throat increases proportionally. Diaphragm movement increases, the regulator metering valve opens further, and gas flow to the carburetor increases.

Figure 5. Gaseous Fuel Operating Diagram



The following facts apply to venturi type gas carburetion systems:

- ☐ The regulator must be properly adjusted so that it will stop the flow of gas when the engine is not running.
- ☐ The slightest vacuum should lift the regulator metering valve off its seat and allow gas flow to the engine.
- ☐ If diaphragm spring force is excessive, too much vacuum will be needed to open the regulator metering valve. This will result in a flat spot or sluggish progression off idle. Lean mixtures and power loss at full load may also result.
- ☐ If diaphragm spring force is too weak, fuel leakage after shutdown may result. Hard starting and the danger of fire exist.

DANGER: GASEOUS FUEL REGULATORS MUST BE PROPERLY ADJUSTED AND TESTED AT THE TIME OF INSTALLATION, TO PREVENT GAS LEAKAGE AND POSSIBLE FIRE OR EXPLOSION. INSTALLATION, ADJUSTMENT AND TESTING SHOULD BE ACCOMPLISHED ONLY BY QUALIFIED GAS SERVICE TECHNICIANS. THE GAS FUEL SYSTEM MUST COMPLY WITH ANSI 119.2/NFPA 501C, CHAPTER 2, "FUEL SYSTEMS AND EQUIPMENT". FOLLOWING INSTALLATION THE SYSTEM MUST BE PROPERLY PURGED AND LEAK TESTED. NO LEAKAGE IS PERMISSIBLE.

LP Gas Conversion Kit

An LP gas conversion kit is available for installation on NP and IM generators with 1.2 liter gas engine. Installation of the proper conversion kit will allow LP gas to be used as a fuel. The Model 9251 kit is a vapor withdrawal type; Model 9052 is a liquid withdrawal type. The kits do not include fuel supply tanks, nor do they include fittings, lines, etc., required to store the fuel and deliver the fuel to the fuel lockoff solenoid. Instructions are included with the kit. To order instructions only, specify manual Part No. 78360.

A primary regulator is required for vapor withdrawal systems. That regulator is not included in the kit.

Section 6.2- LIQUID WITHDRAWAL SYSTEMS

Introduction

Figure 8 (next page) is an Exploded View of a typical LIQUID WITHDRAWAL type gaseous fuel system. Major components of the system include the following:

- ☐ Fuel Solenoid Assembly.
- ☐ Vaporizer-Regulator Assembly.
- ☐ Carburetor Assembly.
- ☐ Air Cleaner Assembly.
- ☐ Interconnecting lines and fittings.

Fuel Solenoid Assembly

See Item 12, Figure 8. The electrically actuated fuel solenoid is energized open, de-energized closed. Maintenance on this part is generally limited to replacement of the entire solenoid assembly.

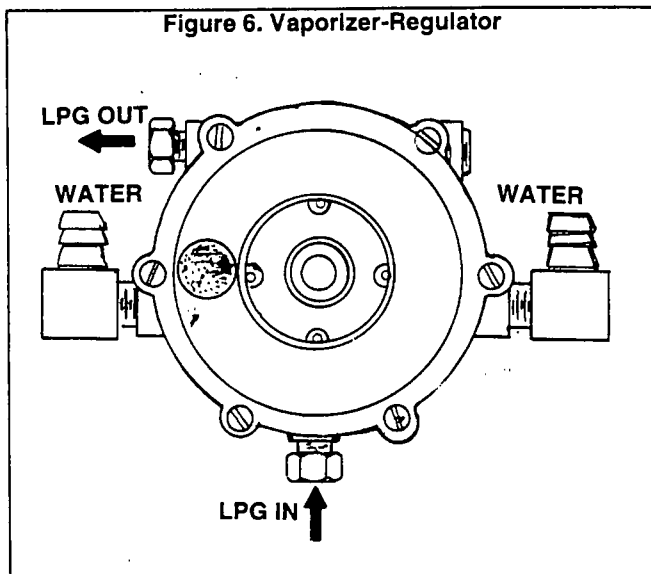
NOTE: If the fuel solenoid assembly must be replaced, use only an assembly that is useable with a liquid withdrawal system. Fuel solenoids are not interchangeable between liquid and vapor withdrawal systems. Fuel solenoids used on liquid withdrawal systems must be rated at a much higher pressure than vapor withdrawal solenoids.

Vaporizer-Regulator Assembly

The vaporizer-regulator included with the Model 9052 LP gas conversion kit is an IMPCO Model JB. The vaporizer-regulator must perform the following functions:

- ☐ It must positively stop the flow of gas when the engine is not running.
- ☐ At the slightest vacuum, the regulator metering valve must move off its seat and allow gas flow to the engine.
- ☐ Heated engine coolant, passing through the vaporizer-regulator, must vaporize the liquid fuel before it reaches the carburetor.

See Figure 6. Engine coolant lines connect to the vaporizer-regulator, as well as inlet and outlet lines for LP gas.



Carburetor Assembly

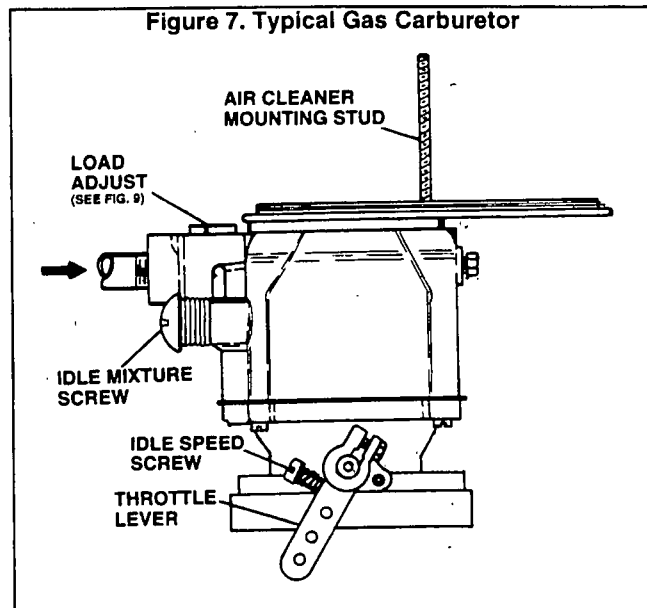
DESCRIPTION:

The carburetor assembly included with the Model 9052 gas conversion kit is an IMPCO Model CA50-506. See Figure 7.

Vaporizer-regulator and carburetor operation are described under "GAS CARBURETION" on Page 6.1-2.

The carburetor is equipped with (a) an idle mixture adjustment, and (b) a load adjustment.

Figure 7. Typical Gas Carburetor



ADJUSTMENTS:

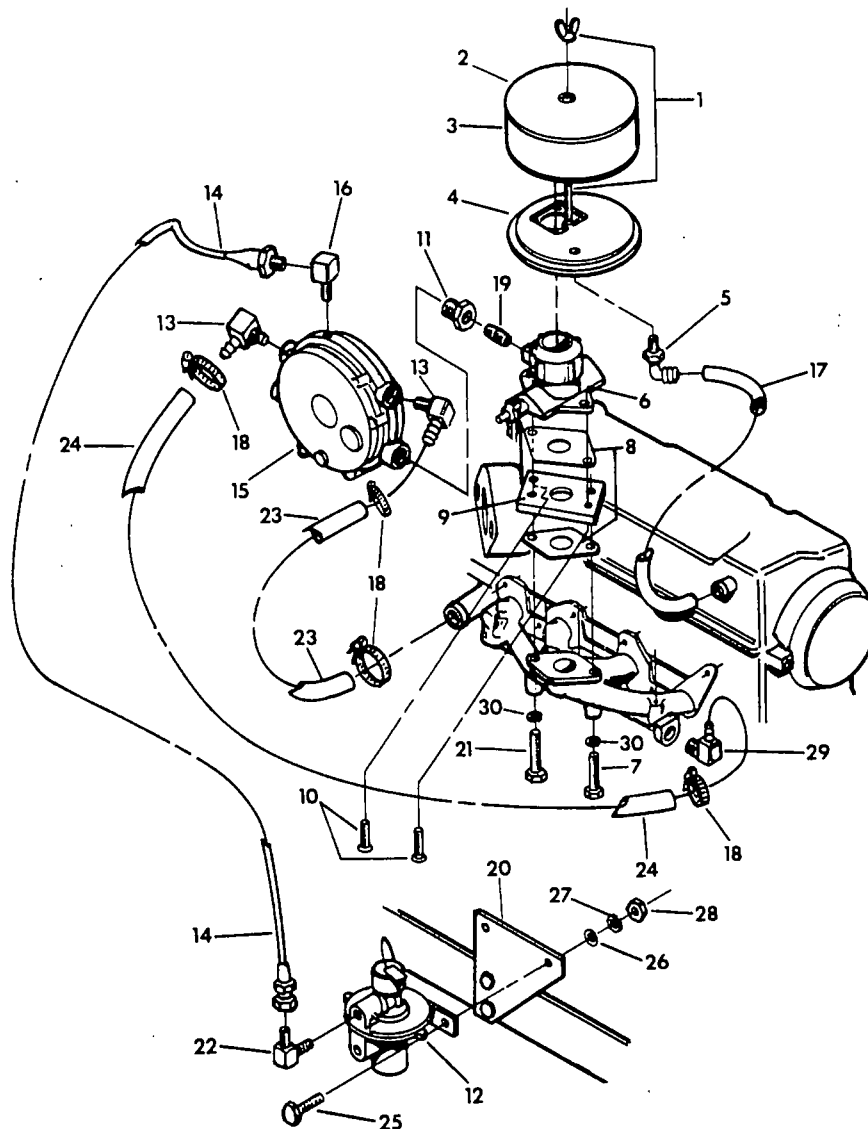
Idle Mixture: This adjustment affects fuel-air mixture only when the engine is running at idle speed. It has no effect on operation at the engine's normal rated speed of approximately 1800 rpm and, for that reason, adjustment is not required. However, if you wish to adjust idle mixture, proceed as follows:

1. Connect an AC frequency meter to the generator's AC power output leads.
2. Disconnect all electrical loads from the generator.
3. Start the engine, let it stabilize and warm up at no-load.
4. Reduce engine speed until frequency meter reads approximately 30-33 Hertz.
5. Slowly turn the idle mixture screw clockwise until engine starts to run rough. Then, turn the screw counterclockwise until engine again starts to run rough. Finally, turn the screw clockwise until smooth operation is obtained.

Load Adjustment: This is an adjustment of fuel-air mixture with the rated load of the unit applied. Complete the adjustment as follows:

1. Connect an AC frequency meter to the generator's AC power output leads.
2. Disconnect all electrical loads. This can be done by setting the main circuit breaker to "Off" or "Open".
3. See Figure 9. Turn the load adjustment as far as it will go toward the "R" (maximum rich).
4. Start the engine, let it stabilize and warm up at no-load.

Figure 8. Exploded View of Liquid Withdrawal Type Fuel System (Typical)



Parts List for Liquid Withdrawal Fuel System

ITEM	QTY	DESCRIPTION	ITEM	QTY	DESCRIPTION
1	1	Air Cleaner Stud	16	1	1/4" NPT Brass Elbow
2	1	Air Cleaner Cover	17	1	Ventilation Hose
3	1	Air Cleaner Element	18	4	Hose Clamp
4	1	Air Cleaner Adapter	19	1	3/8" NPT x 1-1/2" long Pipe Nipple
5	1	3/8" NPT x 1/2" Barbed 90° Fitting	20	1	Solenoid Mounting Bracket
6	1	Carburetor Assembly	21	1	M8-1.25 x 50mm Capscrew
7	1	M8-1.25 x 65mm Capscrew	22	1	1/4" NPT 90° Fitting (Brass)
8	2	Carburetor Gasket	23	1	5/8" ID x 11" long Hose
9	1	Carburetor Adapter (See Note 1)	24	1	5/8" ID x 20" long Hose
10	2	5/16"-18 x 1" Socket Head Capscrew	25	2	M6-1.00 x 25mm Capscrew
11	1	1" to 3/8" Reducer	26	2	M6 Flatwasher
12	1	Fuel Solenoid Assembly	27	2	M6 Lockwasher
13	2	3/8" NPT x 5/8" 90° Barbed Fitting	28	2	M6 Nut
14	1	LP Gas Fuel Line	29	1	1/2" NPT x 5/8" 90° Elbow
15	1	LP Gas Vaporizer-Regulator	30	2	M8 Lockwasher

NOTE 1: Carburetor adapter shown is for units with mechanical governor.

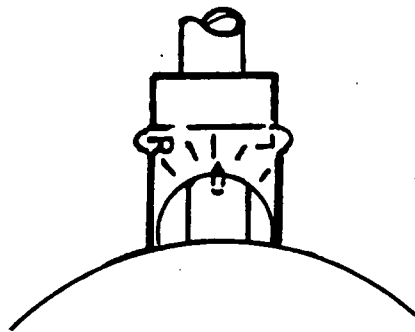
Carburetor Assembly (Continued)

ADJUSTMENTS (CONTINUED):

5. Apply an electrical load to the unit equal to the generator's rated maximum continuous wattage/ampere capacity.
6. Slowly turn the load adjustment toward the "L" (leaner) until the engine starts to run rough and frequency meter reading starts to decrease.
7. Slowly turn the load adjustment back toward "R" (richer) until engine starts to run rough and frequency meter reading again starts to decrease.
8. Turn the load adjustment toward the "L" (leaner) until smooth operation and highest frequency is obtained.
9. Turn off all electrical loads and check frequency reading. The no-load frequency should be 60.5-63.5 Hertz for 60 Hertz units; or 49-52 Hertz for 50 Hertz units.

NOTE: *If the no-load frequency reading is incorrect, adjustment of the engine governor may be required. See Part 7, "ENGINE SPEED CONTROL SYSTEM".*

Figure 9. Carburetor Load Adjustment



Section 6.3- VAPOR WITHDRAWAL SYSTEM

Introduction

Figure 10 (below) is an Exploded View of a typical VAPOR WITHDRAWAL type gaseous fuel system. Major components include the following:

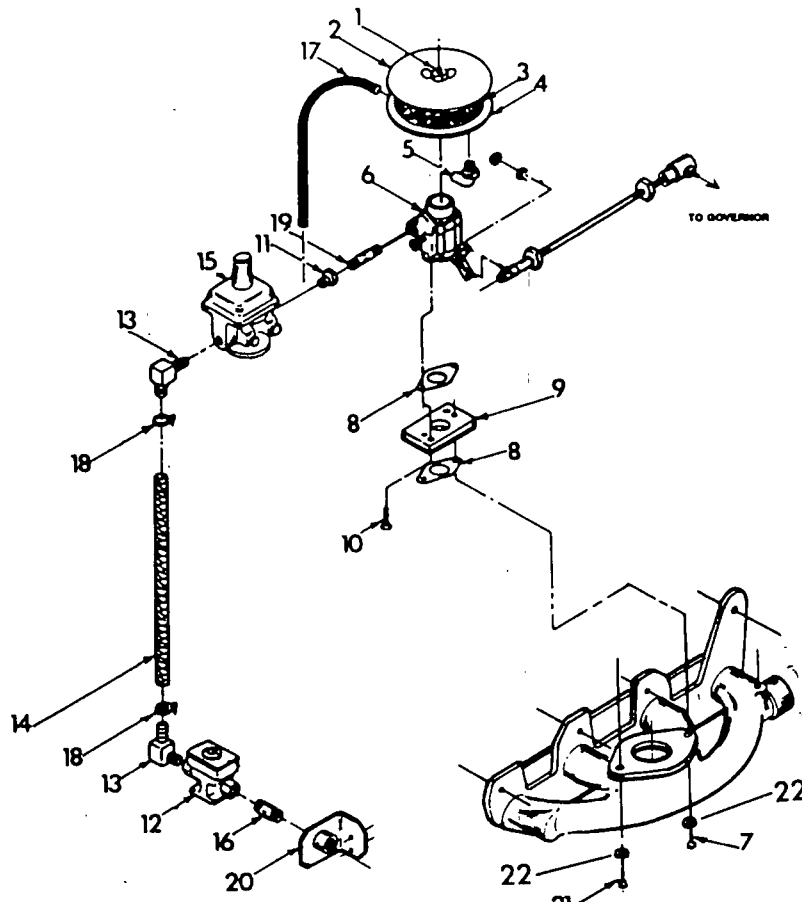
- ☐ Fuel Solenoid Assembly.
- ☐ Pressure Reducer Valve.
- ☐ Carburetor Assembly.
- ☐ Air Cleaner.
- ☐ Interconnecting lines and fittings.

Fuel Solenoid Assembly

The electrically actuated fuel solenoid is energized open, de-energized closed. Maintenance is generally limited to replacement of the solenoid assembly. When replacing the solenoid be sure to use the correct one for the system. Solenoids are not interchangeable between liquid and vapor withdrawal systems.

The solenoid is energized open by 12 volts DC during cranking and running. On shutdown, the solenoid must positively close to stop the flow of gas through the system.

Figure 10. Exploded View of Vapor Withdrawal Fuel System (Typical)



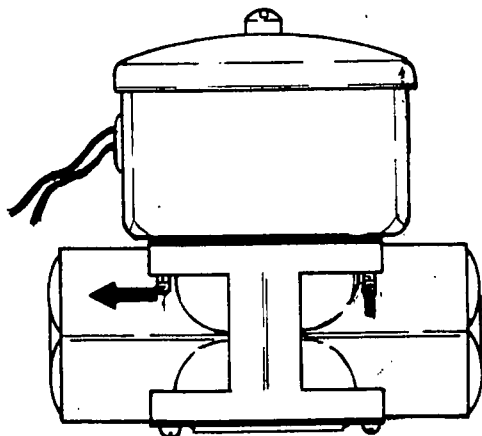
Parts List for Vapor Withdrawal Fuel System

ITEM	QTY	DESCRIPTION	ITEM	QTY	DESCRIPTION
1	1	Air Cleaner Stud	12	1	Fuel Solenoid Assembly
2	1	Air Cleaner Cover	13	2	3/4" NPT x 5/8" 90° Barbed Fitting
3	1	Air Cleaner Element	14	1	5/8" ID x 18-3/4" long Hose
4	1	Air Cleaner Adapter	15	1	Pressure Reducer Valve
5	1	3/8" NPT x 1/2" Barbed Fitting (90°)	16	1	3/4" NPT Nipple
6	1	Carburetor Assembly	17	1	Ventilation Hose
7	1	M8-1.25 x 65mm Capscrew	18	2	Hose Clamp
8	2	Carburetor Gasket	19	1	3/8" NPT x 1" long Pipe Nipple
9	1	Carburetor Adapter (NOTE 1)	20	1	Solenoid Bracket
10	2	5/16"-18 x 1" Socket Head Capscrew	21	1	M8-1.25 x 50mm Capscrew
11	1	3/4" to 3/8" Reducer	22	2	M8 Lockwasher

NOTE: Carburetor adapter shown is for units with mechanical engine governor.

Fuel Solenoid Assembly (Continued)

Figure 11. Vapor Withdrawal Fuel Solenoid

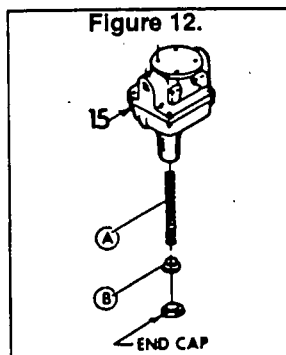


Pressure Reducer Valve

The pressure reducer valve used in the Model 9251 LP gas conversion kit is an IMPCO Model IMP-52. LP gas, in vapor form, is delivered to the valve inlet at approximately 11 inches (water column). Valve inlet pressure should not exceed 14 inches (water column). The pressure reducer valve provides a regulated pressure decrease down to approximately minus 1 inch (water column) and delivers this reduced (vacuum) pressure to the carburetor.

The pressure reducer valve is designed for both natural and LP gas fuel systems. For LP gas vapor withdrawal applications, it must be modified as follows (Figure 12):

1. Remove END CAP.
2. Remove ITEMS B and A.
3. Install and tighten END CAP.
4. Install the valve in the position shown (spring neck down).



Carburetor Assembly

The Models 9052 liquid withdrawal system and the Model 9251 vapor withdrawal system both utilize an IMPCO CA50-506 carburetor. Refer to "CARBURETOR ASSEMBLY" on Pages 6.2-1, 6.2-2 and 6.2-3.

**Part 7
ENGINE
SPEED
CONTROL
SYSTEM**

NP and IM Series
**RECREATIONAL
VEHICLE &
INDUSTRIAL
MOBILE
AC GENERATORS**
1.2 Liter, Liquid-Cooled
Gas/Gasoline Engine Models

TABLE OF CONTENTS

SECTION	TITLE
7.1	Mechanical Governor
7.2	Electronic Governor

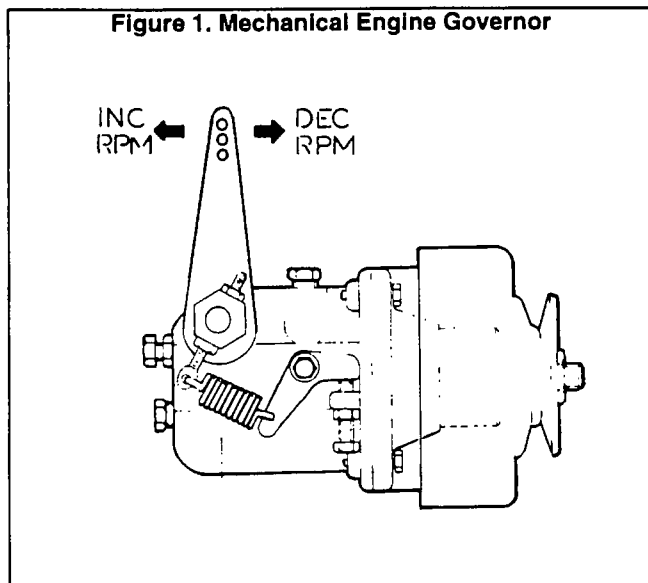
Section 7.1- MECHANICAL GOVERNOR

General Description

The mechanical engine governor utilizes the principle of spring tension versus centrifugal force to maintain a steady state engine speed, regardless of the applied load. When centrifugal flyweight force exceeds governor spring tension, the flyweights act on a yoke to rotate a rocker shaft. Rocker shaft rotation decreases carburetor throttle setting and engine speed decreases. As engine speed decreases, governor spring tension becomes greater than flyweight centrifugal force. The spring then increases carburetor throttle setting and engine speed increases. The governed speed is that rpm at which flyweight force and spring force are equal.

The governor flyweights are driven by an engine v-belt. The pulley which drives the flyweights also drives a DC alternator assembly, used to maintain battery state of charge during engine operation.

Figure 1. Mechanical Engine Governor



Governor Maintenance

Maintenance and repair of the governor is limited to the following:

- ☐ Removal and replacement of the DC alternator assembly.
- ☐ Removal and replacement of governor lever, links and springs.
- ☐ Removal, replacement and adjustment of governor to carburetor linkage.
- ☐ Adjustment of governed speed.

DC Alternator Removal

Refer to Figure 4 on next page. Remove the DC alternator assembly as follows:

1. Remove hex jam nut (Item 43), wave washer (Item 48), and pulley half (Item 44).
2. Remove the DC alternator Rotor (Item 44).
3. Remove socket head screws (Item 35) and lockwashers (Item 22).
4. Remove the Stator (Item 47).

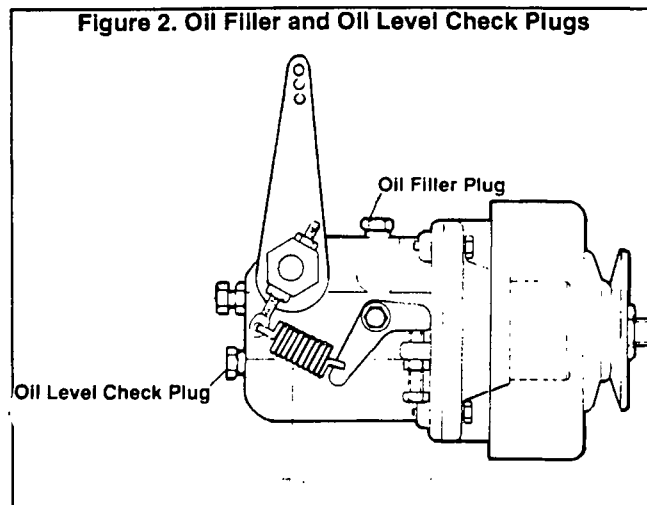
Reassemble the DC alternator in the reverse order of removal. Install socket head screws that retain the stator and tighten them to 5 foot-pounds (7 N-m). Tighten the hex jam nut to 35 foot-pounds (47 N-m).

Governor Lubrication

See Figure 2. To fill the governor with oil, proceed as follows:

1. Remove OIL FILLER PLUG and OIL LEVEL CHECK PLUG.
2. Add engine oil through FILLER PLUG until oil just starts to overflow the OIL LEVEL CHECK PLUG opening. Pour slowly.
3. When oil level is correct, install and tighten OIL FILLER and OIL LEVEL CHECK PLUGS.

Figure 2. Oil Filler and Oil Level Check Plugs



Engine Governor Adjustment

1. Connect an AC frequency meter across the generator's AC output leads.
2. Turn OFF all electrical loads. Initial adjustments will be accomplished at no-load.
3. Start the engine, let it stabilize and warm up.
4. Check the no-load AC frequency. Readings should be as follows:

Units Rated at 60 Hertz = 60.5-63.5 Hertz

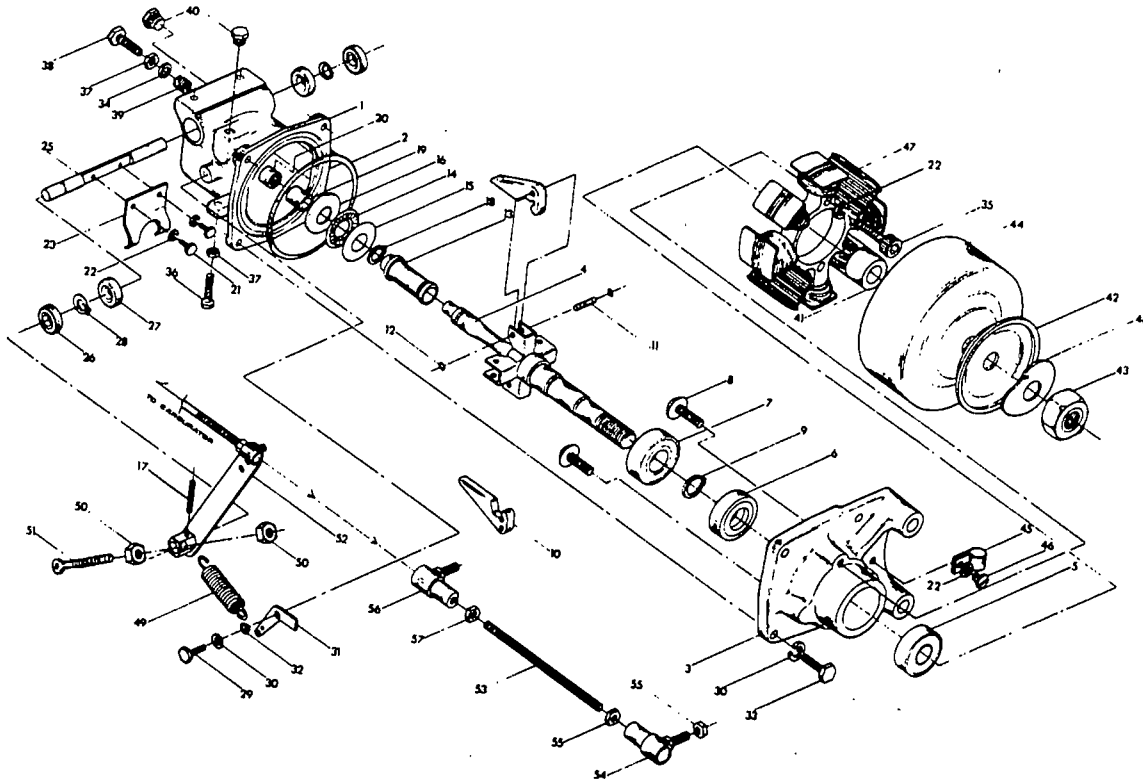
Units Rated 50 Hertz = 49-51 Hertz

5. **No-Load Governed Speed Adjustment:** If adjustment of no-load governed speed is required, proceed as follows (see Figure 3):

- a. Loosen the NO-LOAD BUMPER SCREW lock nut, then loosen the NO-LOAD BUMPER SCREW so the governor is not pre-loaded.
- b. Adjust the NO-LOAD SPEED ADJUST SCREW to obtain a frequency reading as close as possible to 61.5 Hertz for units rated 60 Hertz; or to 50.0 Hertz for units rated 50 Hertz.
- c. Adjust the NO-LOAD BUMPER SCREW to obtain a frequency of 62 Hertz (60 Hertz units); or 51 Hertz (50 hertz units).

6. **Adjustment Under Load:** Apply an electrical load to the generator equal to the rated wattage/ampere capacity of the generator. Then, proceed as follows:

Figure 4. Exploded View of Governor-DC Alternator Assembly



ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	Governor Housing	29	M6-1.00 Hex Screw
2	O-Ring Seal	30	M6 Lockwasher
3	Governor Flange	31	Tension Bracket
4	Drive Shaft Assembly	32	Tension Bracket Bushing
5	Ball Bearing	33	M6-1.00 Hex Screw
6	Oil Seal	34	Sealing Washer
7	Ball Bearing	35	M4-0.70 S/Wocket Head Capscrew
8	Truss Head Screw	36	M6-1.00 Hex Screw
9	Flyweight	37	M6-1.00 Nut
10	Flyweight	38	Bumper Screw
11	Dowel Pin	39	Compression Spring
12	External Retaining Ring	40	1/8" NPT Pipe Plug
13	Thrust Sleeve	41	Spacer
14	Needle Bearing	42	Pulley Half
15	Thrust Washer	43	Hex Jam Nut
16	Thrust Washer	44	DC Alternator
17	Roll Pin	45	Cable Clamp
18	External Retaining Ring	46	M4-0.70 Pan Head Screw
19	Inner Ring Bushing	47	DC Stator Assembly
20	Bearing Draw Cup	48	Wave Washer
21	M4-0.70 Hex Screw	49	Tension Spring
22	M4 Lockwasher	50	M6-1.00 Hex Nut
23	Yoke	51	M6-1.00 Screw
25	Rocker Shaft	52	Governor Lever
26	Oil Seal	53	Governor-Carburetor Link
27	Ball Bearing	54	Ball Joint
28	External Retaining Ring	55	No. 10-32 Flanged Lock Nut

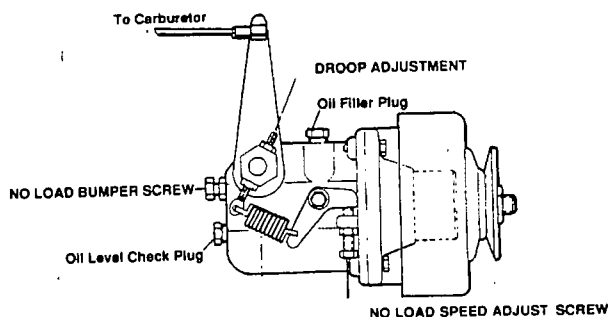
Engine Governor Adjustment (Continued)

- a. Check the AC frequency reading under load.
- b. If frequency drops below about 58 Hertz (60 Hertz units) or 49 Hertz (50 Hertz units) under load, adjust the DROOP ADJUSTMENT downward until application of the load results in the smallest possible AC frequency droop when maximum load is applied.

NOTE: If surging occurs when electrical load is removed, adjust the NO-LOAD BUMPER SCREW inward. If BUMPER SCREW adjustment changes the AC frequency reading, back the NO-LOAD BUMPER SCREW out until no-load frequency returns to 62 Hertz (60 Hertz units); or to 51 Hertz (50 Hertz units).

NOTE: With unit running at correct AC frequency, you may wish to check the generator's AC output voltage. If frequency reading is correct, but voltage reading is incorrect, adjustment of the AC voltage regulator may be required.

Figure 3. Governor Adjustment Points



Section 7.2- ELECTRONIC GOVERNOR

General

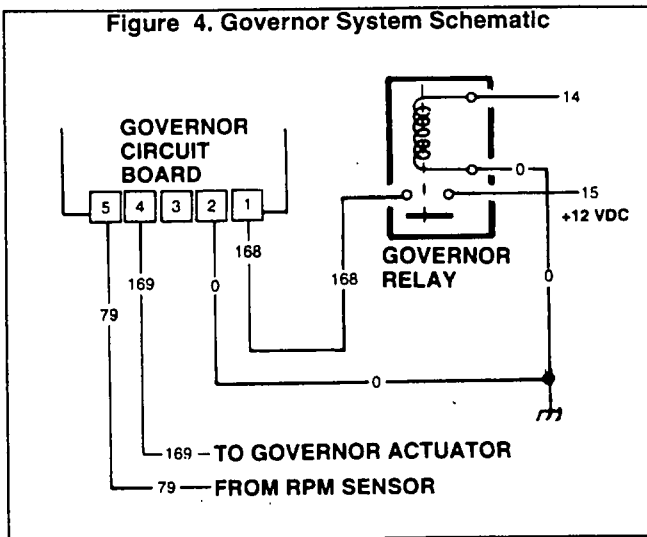
Some industrial mobile (IM) series generators may be equipped with an electronic engine governor system. The system consists of the following major components:

- ☐ A 12 volts DC Governor Actuator Relay (GAR).
- ☐ An Electronic Governor Actuator (EGA).
- ☐ An Electronic Governor Control circuit board (EGC).
- ☐ A Magnetic Pickup assembly (MPU).
- ☐ Interconnecting wiring.

Figure 4 is an operating diagram of the electronic governor system. Operation may be briefly described as follows:

1. During engine startup and running, an Engine Control circuit board delivers 12 volts DC to a GOVERNOR ACTUATOR RELAY (GAR) via Wire No. 14. The Relay energizes and its normally-open contacts close.
2. When the Relay contacts close, 12 volts DC is delivered to the ELECTRONIC GOVERNOR CONTROL (EGC) circuit board, to turn the governor system on.
3. Engine speed information is delivered to the ELECTRONIC GOVERNOR CONTROL (EGC) circuit board from a MAGNETIC PICKUP (MPU). This "actual" speed is electronically compared to a "reference" speed that has been preset on the circuit board.
4. If any difference exists between "actual" and "reference" speed, the ELECTRONIC GOVERNOR CONTROL (EGC) board sends speed correction signals to an ELECTRONIC GOVERNOR ACTUATOR (EGA).
5. The ELECTRONIC GOVERNOR ACTUATOR (EGA) is mechanically linked to the carburetor throttle valve.

Figure 4. Governor System Schematic



Governor Actuator Relay

DESCRIPTION:

See Figure 5. The Relay is housed in the generator control console. The Relay coil is energized when 12 volts DC is applied at its Terminal A and the circuit is completed through the coil to Terminal B and to ground.

TESTING:

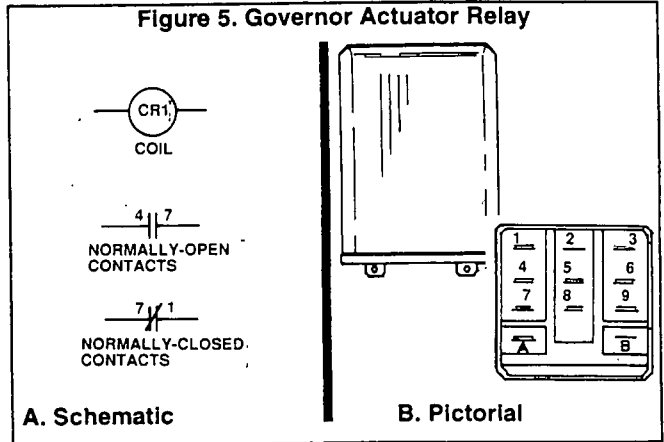
To test the Relay, apply +12 volts DC to Relay Terminal A and -12 volts DC to Terminal B. The Relay coil should

energize and normally-open Relay contacts 4 and 7 should actuate closed.

With the Relay coil energized, a VOM connected across Relay Terminals 4 and 7 should read "continuity".

With the Relay coil de-energized, a VOM connected across Relay Terminals 4 and 7 should read "infinity".

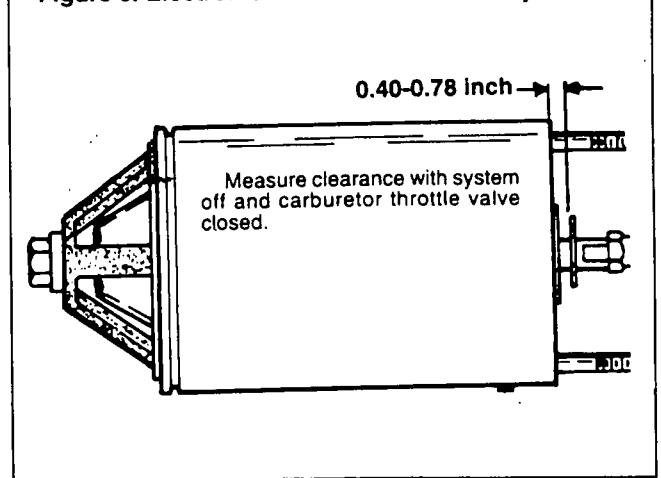
Figure 5. Governor Actuator Relay



Governor Actuator Adjustment

With the engine shut down, adjust the length of the Electronic Governor Actuator (EGA). With the carburetor throttle valve closed, adjust so that approximately 0.40-0.78 inch (1-2mm) of clearance exists between the EGA stop washer and the EGA body. See Figure 6.

Figure 6. Electronic Governor Actuator Adjustment



Electronic Governor Setup

The Electronic Governor Control (EGC) circuit board is housed in the generator control console (see Figure 7). All circuit board adjustments for new generators have been completed at the factory and no additional adjustment should be required. If the circuit board must be replaced, adjust the governing parameters as follows:

1. See Figure 7. Set the speed pot (R5) fully counterclockwise.
2. Set all other potentiometers (R12, R13, R22, R26) to their mid-point.

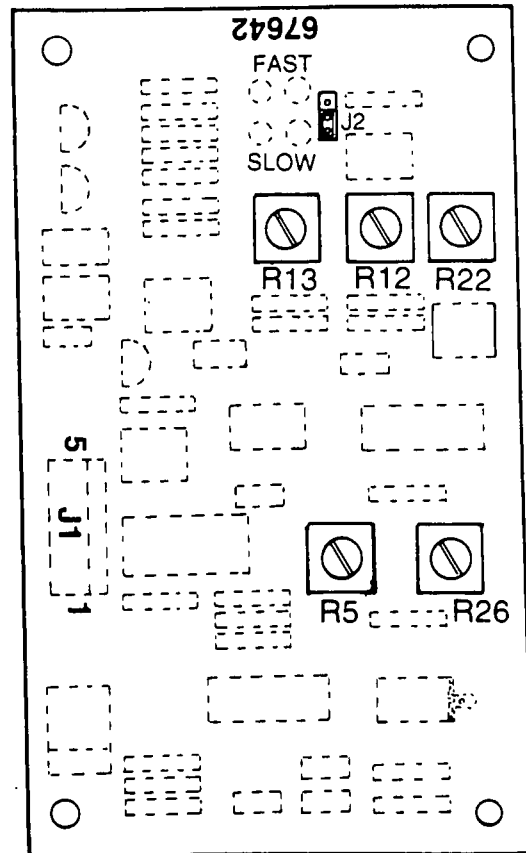
Electronic Governor Setup (Continued)

3. Set Jumper J2 to its "FAST" position.
4. Adjust Speed Pot R5 clockwise to obtain the correct AC frequency.
5. Check no-load stability. System stability can be improved by adjusting R12 and R13 clockwise.
6. Apply 25 percent of the unit's rated load. Then, check stability.
 - a. If undesirable oscillations are observed when the 25% load is applied, adjust R22 clockwise.
 - b. Adjusting R22 clockwise will dampen undesirable oscillations that occur when a load is applied.
7. Shut the engine down. Then, restart it and observe startup characteristics. If the overshoot that occurs during startup is higher than desired, adjust R26 clockwise (to reduce startup overshoot).
8. Apply rated block load to the generator. Observe the recovery from block load application and from load dump.
 - a. Adjusting R12 and R13 counterclockwise will improve recovery from block load application, but will tend to make the system less stable.
 - b. Adjusting R26 counterclockwise will improve recovery from load dump, but will allow more overshoot at startup.

Complete the preceding adjustments as required to obtain the best balance of all parameters. Basic guidelines for system operation are as follows:

- ☐ The system should reach stability at all load points with not more than four (4) oscillations.
- ☐ The system should recover to within one (1) Hertz of steady state in less than two (2) seconds for all load transients.
- ☐ No-load to full-load droop should be less than 0.5 Hertz steady state.

Figure 7. Electronic Governor Control Circuit Board



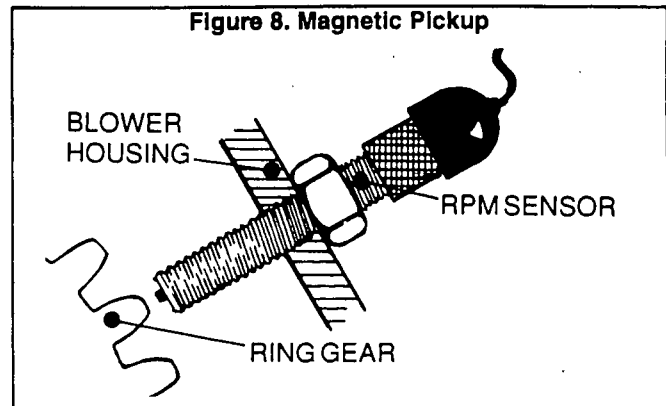
Magnetic Pickup

The Magnetic Pickup is installed into a threaded hole in the generator's blower housing and prevented from turning by a stop nut. The tip of the pickup lies directly over the flywheel's ring gear teeth.

To install and properly set air gap, thread the pickup in until its tip just contacts the ring gear. Then, back off about 1/2 to 3/4 turn and hold in that position while tightening the stop nut.

CAUTION: DO NOT rotate the engine during the above adjustment.

Figure 8. Magnetic Pickup



Part 8 ENGINE IGNITION SYSTEM

NP and IM Series
**RECREATIONAL
VEHICLE &
INDUSTRIAL
MOBILE
AC GENERATORS**
1.2 Liter, Liquid-Cooled
Gas/Gasoline Engine Models

TABLE OF CONTENTS

SECTION	TITLE
8.1	General Information
8.2	Tests, Checks and Adjustments

5

Service Data and Specifications

Firing Order 1-3-4-2
Distributor Rotation Counterclockwise
Breaker Point Gap 0.018-0.022 inch
Distributor Cap Insulation
Resistance Greater than 50 meg-ohms
Rotor Head Insulation
Resistance Greater than 50 meg-ohms
Distributor Cap Carbon
Point Length More than 0.012 inch
(3mm) protruded length

Ignition Coil Resistance

Primary Coil 1.3-1.5 ohms
Secondary Coil 8.7-11.7 k-ohms

Spark Plugs

NGKBPR6ES

CHAMPIONRN9YC

ACR42XLS

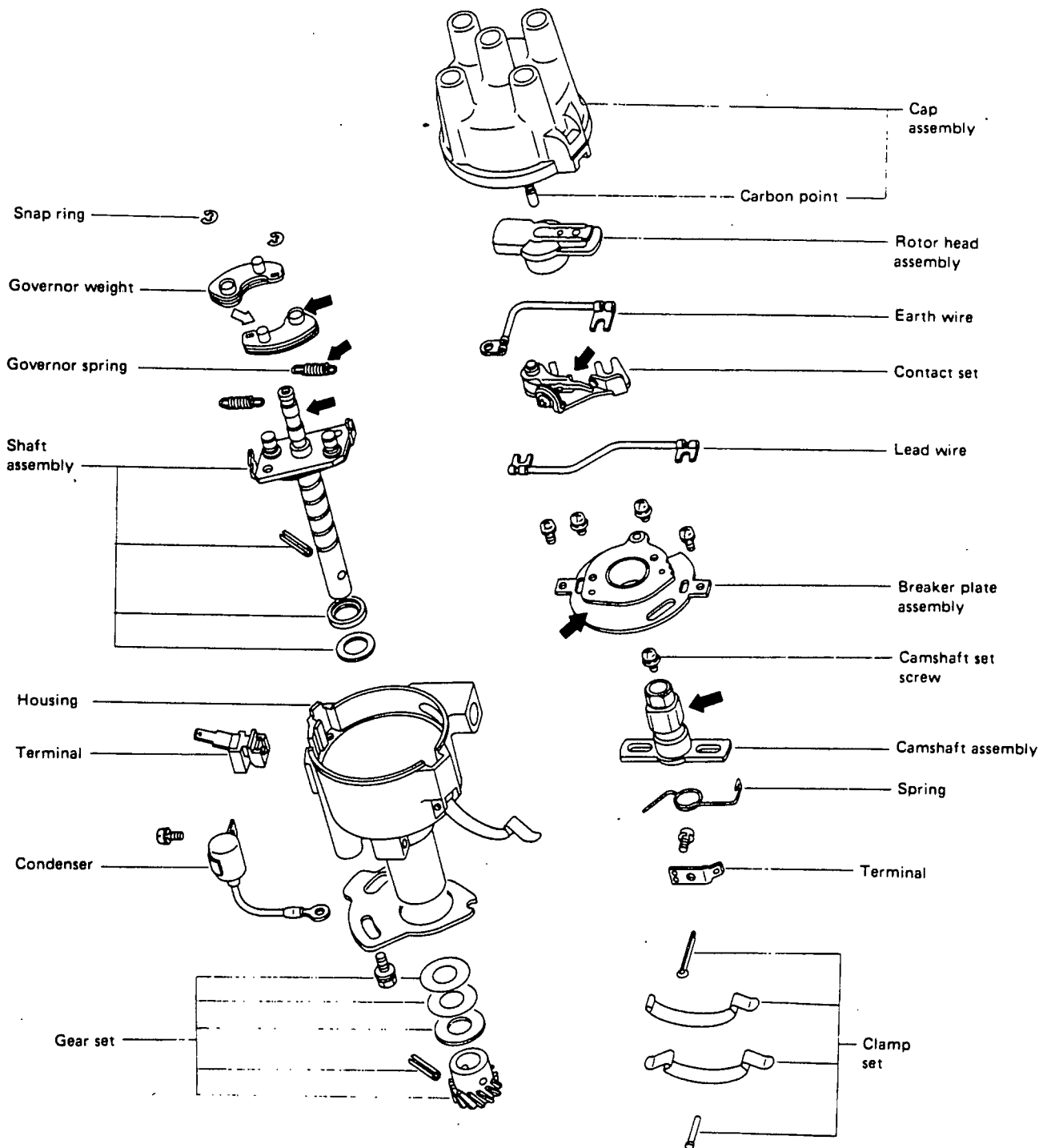
Spark Plug Gap 0.031-0.035 Inch

Condensor Capacity . . . 0.2-0.24 micro-farads

Figure 1. Ignition System Diagram

The diagram illustrates the electrical connections for an ignition system. A 15 DC VOLT source is connected to an ENGINE CONTROL CIRCUIT BOARD. The board has two output wires: one labeled 10 8 and another labeled 25. The 10 8 wire leads to a RESISTOR WIRE, which is connected to the primary winding of an IGNITION COIL. The 25 wire leads to a DISTRIBUTOR, which is connected to four SPARK PLUGS. The IGNITION COIL also has a secondary winding connected to the 25 wire. The DISTRIBUTOR is connected to the 25 wire. The SPARK PLUGS are connected to the 25 wire. The diagram also shows a 15 DC VOLT source connected to the ENGINE CONTROL CIRCUIT BOARD. The board has two output wires: one labeled 10 8 and another labeled 25. The 10 8 wire leads to a RESISTOR WIRE, which is connected to the primary winding of an IGNITION COIL. The 25 wire leads to a DISTRIBUTOR, which is connected to four SPARK PLUGS. The IGNITION COIL also has a secondary winding connected to the 25 wire. The DISTRIBUTOR is connected to the 25 wire. The SPARK PLUGS are connected to the 25 wire.

Figure 2. Distributor Components



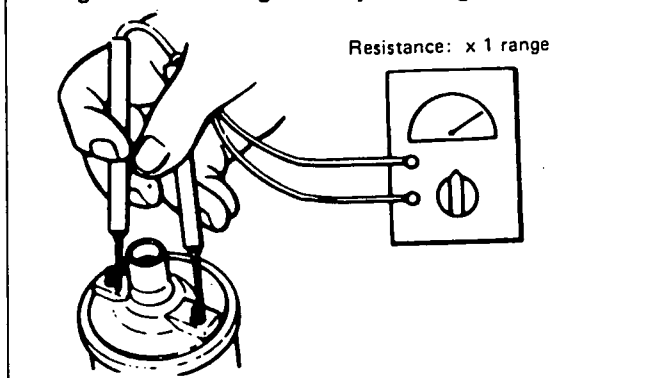
Section 8.2- TESTS, CHECKS AND ADJUSTMENTS

Ignition Coil

See Figure 3. Connect the test leads of an ohmmeter across the positive and negative terminals of the primary winding. Measure the resistance.

PRIMARY WINDING RESISTANCE
AT 68° F. (20° C.)
1.3-1.5 ohms

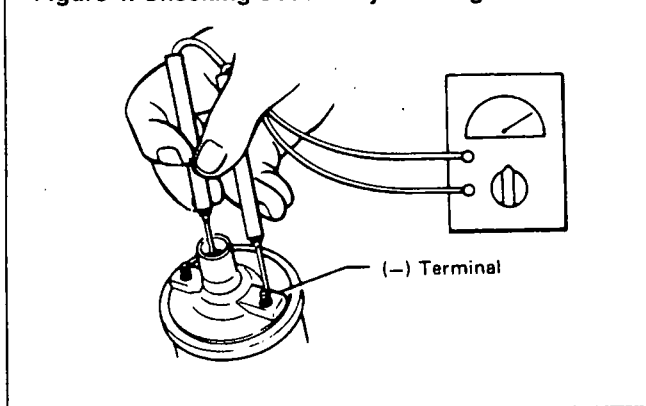
Figure 3. Checking Primary Winding Resistance



Connect the ohmmeter test leads across the secondary winding terminal and the primary winding negative terminal. Measure the resistance.

SECONDARY WINDING RESISTANCE
AT 68° F. (20° C.)
8700-11,700 ohms

Figure 4. Checking Secondary Winding Resistance

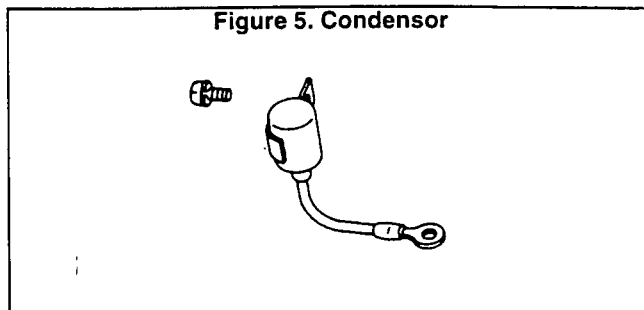


Checking the Condensor

Use a capacity tester to check the condensor. If a capacity tester is not available, a volt-ohm-milliammeter (VOM) may be used to test the condensor, as follows:

1. Set the VOM to a high resistance scale, such as "Rx1K" or "Rx10,000". Zero the meter.
2. Connect VOM test leads across the condensor. If the VOM needle swings violently, then moves back to "infinity" gradually, condensor is good. A reading of "zero" or a steady reading indicates the condensor has failed.

Figure 5. Condensor



Distributor Cap and Rotor Head

Inspect the cap and rotor head for dust, carbon deposits, cracks. Replace, if necessary.

Contact Set

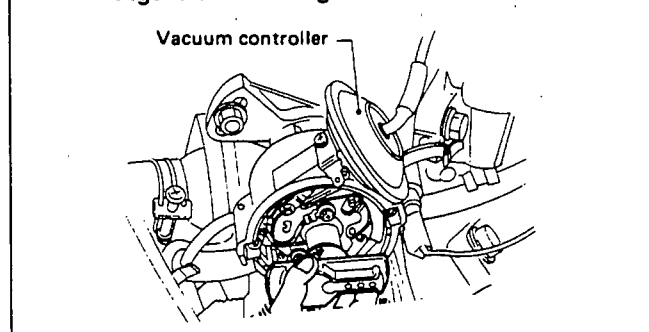
Inspect surfaces of the contact points. Irregularities may be removed with No. 500 or 600 sandpaper or with oilstone. Loosen the breaker point set screw and adjust gap with a feeler gauge.

BREAKER POINT GAP
0.018-0.022 inch (0.45-0.55mm)

Check Governor Advance

Turn the rotor shaft counterclockwise, then release it and check that it returns to the clockwise position. Also check that the rotor shaft is not excessively loose.

Figure 6. Checking Governor Advance



Spark Plugs

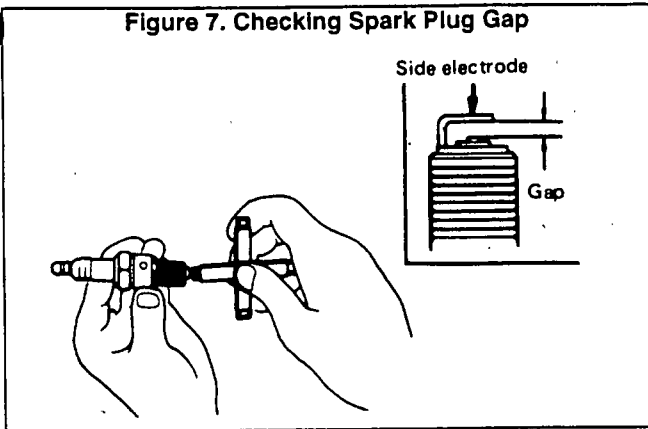
1. Grasp the spark plug wire boot to pull wires free of spark plugs. DO NOT PULL ON THE WIRES.
2. Use a spark plug wrench to remove spark plugs.
3. Clean the spark plugs in a sand blast cleaner. Inspect insulators for cracks, chipping. Inspect gasket. Check electrode for wear, burning or pitting. Replace plug(s) if defective.
4. Check spark plug gap (Figure 7).

SPARK PLUG GAP
0.031-0.035 inch

5. Install and tighten to 14-22 foot-pounds. Install wires.

Spark Plugs (Continued)

Figure 7. Checking Spark Plug Gap

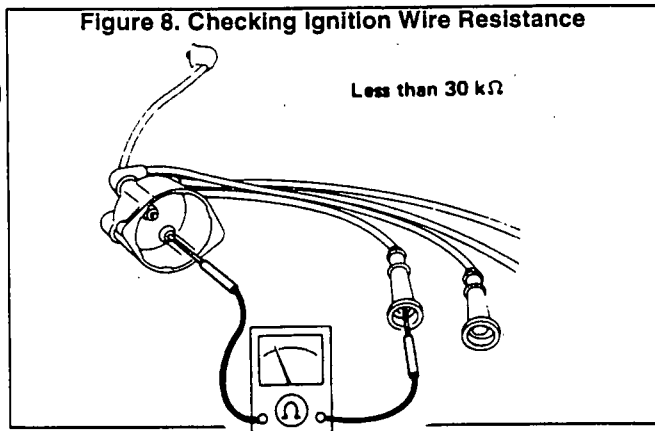


Checking Ignition Wires

Carefully inspect high tension leads for damage, cracks, burned terminals, proper fit. Measure the resistance of each wire (Figure 8). Shake the wires during the test.

IGNITION WIRE RESISTANCE
Less than 30,000 ohms

Figure 8. Checking Ignition Wire Resistance

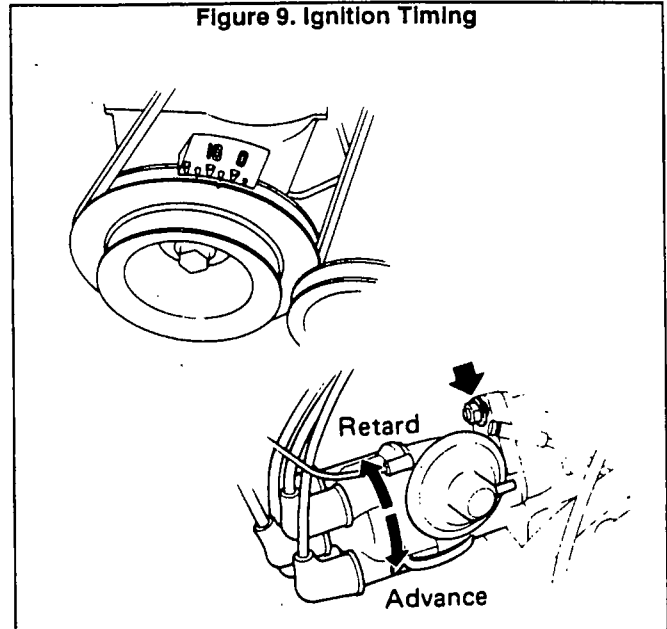


Ignition Timing

Use an automotive timing light to check and adjust ignition timing. A timing mark is provided on the crankshaft pulley and a degree indicator is also provided. Set timing with the engine running at no-load as follows:

IGNITION TIMING AT 1860 RPM
21° BTDC

Figure 9. Ignition Timing



Part 9
ENGINE
DC
ELECTRICAL
SYSTEM

NP and IM Series
RECREATIONAL
VEHICLE &
INDUSTRIAL
MOBILE
AC GENERATORS
1.2 Liter, Liquid-Cooled
Gas/Gasoline Engine Models

TABLE OF CONTENTS

SECTION	TITLE
9.1	Standard Battery Charging System
9.2	The "DELCO®" Charging System
9.3	Engine Cranking System
9.4	Engine Control Circuit
9.5	Troubleshooting Guide

Section 9.1- STANDARD BATTERY CHARGING SYSTEM

Components

A DC ALTERNATOR supplies charging current to the unit battery during engine operation, as regulated by a DC VOLTAGE REGULATOR. The circuit is protected by a 30 amp FUSE.

DC Alternator

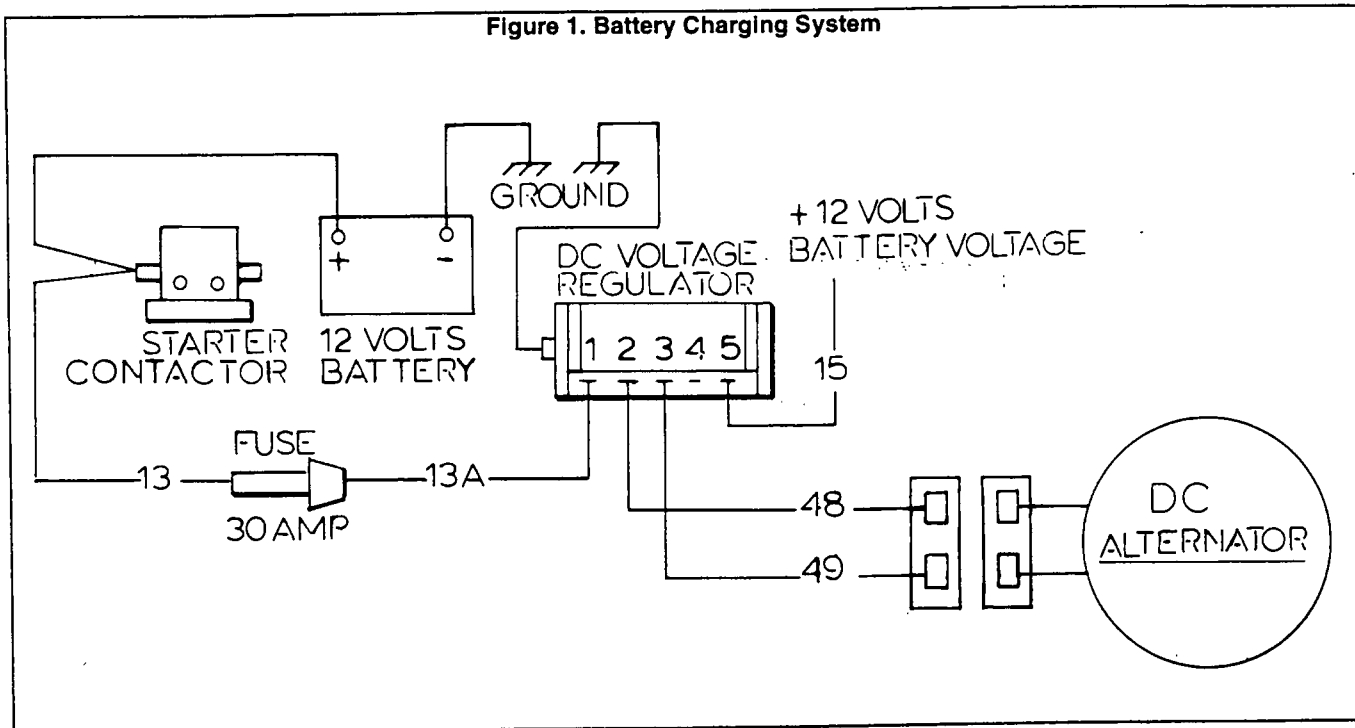
The belt driven, permanent DC alternator is part of the engine governor. Maintenance on the DC alternator is limited to replacement of defective parts. See Part 7, Section 7.1, "MECHANICAL GOVERNOR".

DC Voltage Regulator

The solid state DC voltage regulator is housed in an aluminum heat sink. All components are buried in an epoxy resin and the DC regulator is not repairable. DC regulator connector pins are numbered from left to right as follows:

- Pin 1= charging output to battery (12.5-14.5 volts DC)
- Pin 2= charging input from DC alternator.
- Pin 3= charging input from DC alternator.
- Pin 4= Not used (charging indicator lamp)
- Pin 5= sensing voltage from battery.

Figure 1. Battery Charging System



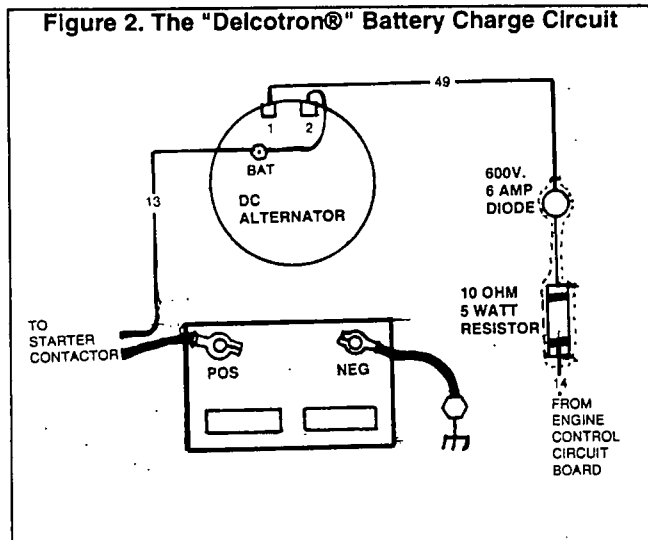
Section 9.2- THE "DELCO®" CHARGING SYSTEM

Introduction

Some industrial-mobile (IM) engine-generators may be equipped with a "Delcotron®" battery charging system. This system utilizes a belt driven DC alternator having an integral DC voltage regulator.

See Figure 2. During cranking and running operations, an engine control circuit board delivers battery voltage to the DC alternator via Wire No. 14, a resistor (R1) and a diode (D1). This is DC alternator field excitation current. DC alternator output (charging) current is delivered to the battery via Wire No. 13.

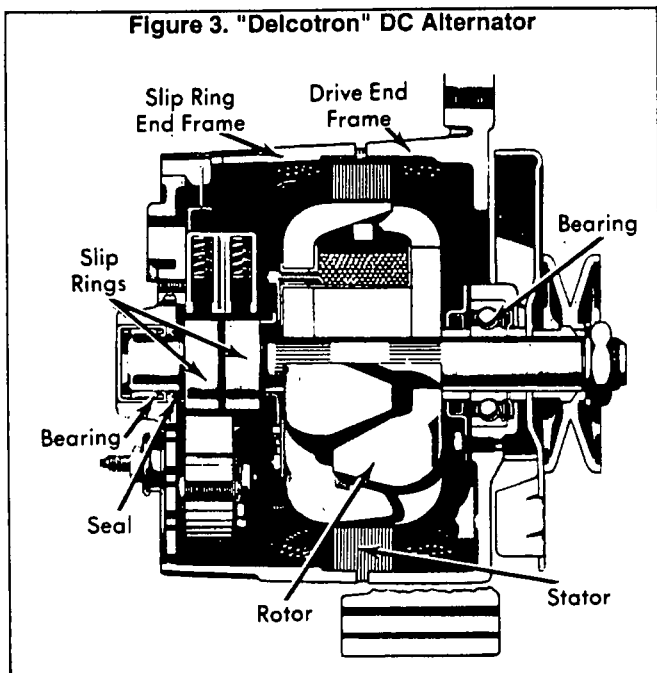
Figure 2. The "Delcotron®" Battery Charge Circuit



DC Alternator Specifications

Delcotron Series	10 SI
System Voltage	12
DELCO® Regulator No.	1116392
Ground Polarity	Negative

Figure 3. "Delcotron" DC Alternator



DC Alternator Description

See Figure 3. The DC alternator consists primarily of 2 end assemblies, rotor, stator, brushes, slip rings and diodes. The rotor is supported in the drive end frame by ball bearings and in the slip ring end frame by roller bearings. Bearings contain sufficient lubricant to eliminate the need for periodic lubrication.

DC Alternator Adjustments

No periodic adjustment or maintenance is required on the DC alternator assembly. Regulator voltage is preset and no regulator adjustment is needed.

CAUTION: Do NOT attempt to polarize the DC alternator. Do NOT short or ground any terminals except as instructed. Never operate the DC alternator with battery out of circuit or with output terminal open. The DC alternator and the battery must share the same ground polarity.

Testing

GENERAL:

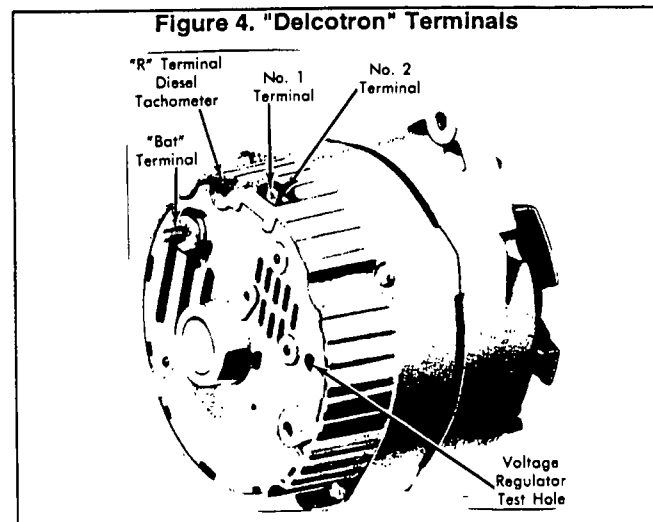
Before starting electrical checks, visually inspect all terminals for clean and tight connections. Check DC alternator mounting bolts and drive belt tension. Do NOT ground the No. 2 lead wire. Battery must be in good condition to test the charging system.

UNDERCHARGED BATTERY:

1. Connect a DC voltmeter from the DC alternator "BAT" terminal to ground (Figure 4). Crank the engine and note the meter reading. A "zero" reading indicates an open condition between the "BAT" connection and the engine control circuit board.

- If reading is "zero" on gaseous fuel unit, test Wire 49 between DC alternator and diode (D1) for open. Check diode (D1) and resistor (R1), as well as Wire 14 for open.
- If unit is a gasoline fueled unit and reading is "zero", check Wire 49, diode (D1), resistor (R1) and Wire 14 between DC alternator and carburetor fuel valve for open. Also check Wire 14, between carburetor fuel valve and engine control circuit board, for open.

Figure 4. "Delcotron" Terminals



Testing (Continued)

2. Disconnect the battery ground cable. Connect an ammeter in series at "BAT" terminal of DC alternator. See Figure 5. Reconnect the battery ground cable. Connect a carbon pile across the battery. Operate engine at 1860 rpm and adjust carbon pile as necessary to obtain maximum current output.

- If ampere output is within 10 amps of the rated output stamped on DC alternator case, the alternator is good.
- If output is NOT within 10 amps of rated output, ground the field winding tab by inserting a screwdriver into the end case test hole (Figure 6).

CAUTION: The field winding tab is within 3/4 inch of the casting surface. Do NOT force screwdriver deeper than 1 inch into end frame.

- With field winding tab grounded, run engine at 1860 rpm and again adjust carbon pile to obtain maximum current output. If output is now within 10 amps of rated output, check the field winding and check DC voltage regulator with tester. If output is NOT within 10 amps of rated output, check field winding, diode trio, rectifier bridge and stator.

OVERCHARGED BATTERY:

Connect a voltmeter from the DC alternator's No. 2 terminal to ground. If reading is "zero", No. 2 lead circuit is open. If the battery and the No. 2 lead circuit test good, but overcharge exists, overhaul the DC alternator. Check field windings for grounds and shorts. If defective, replace rotor and test regulator.

Figure 6. Grounding the Field Winding Tab

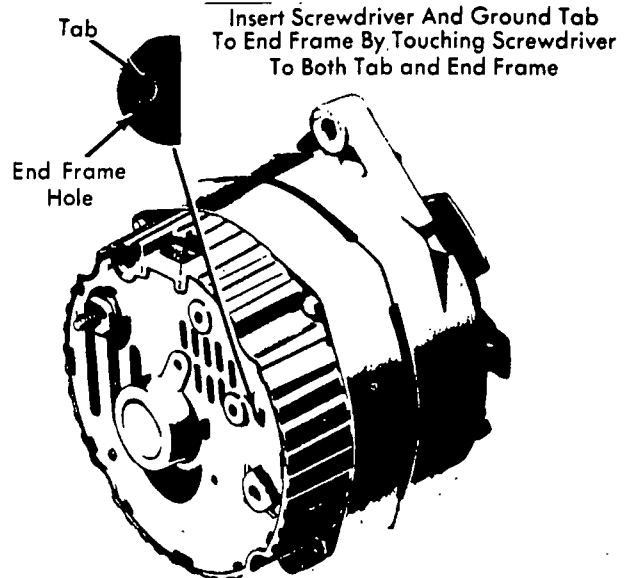
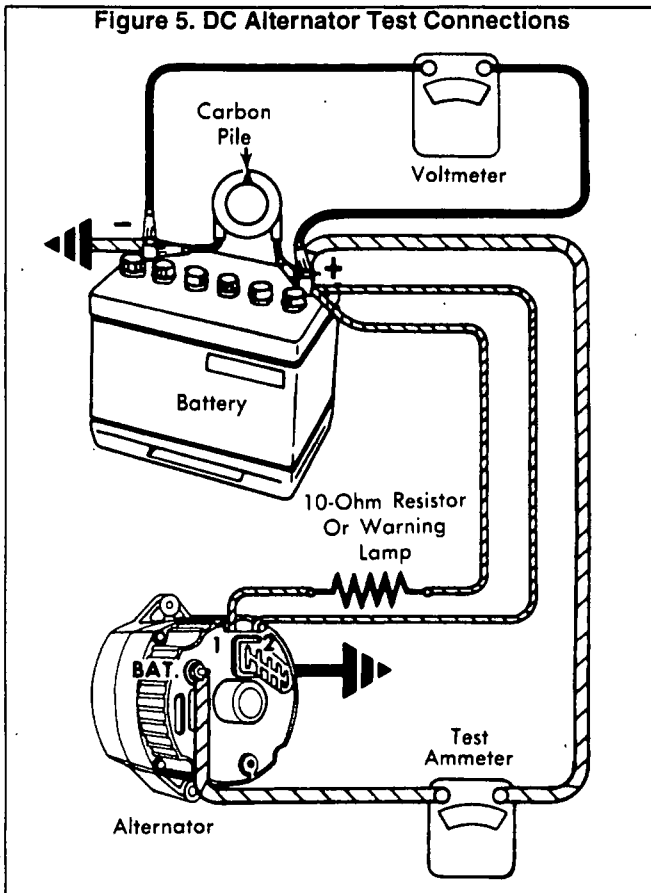


Figure 5. DC Alternator Test Connections



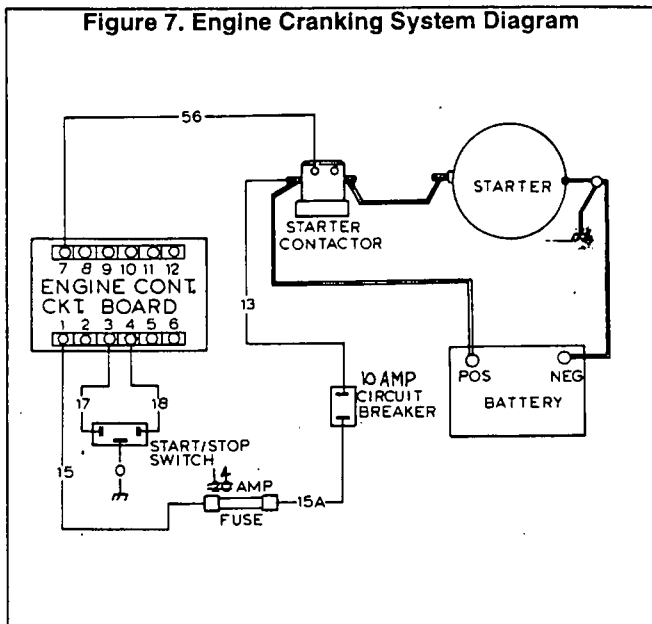
Section 9.3- ENGINE CRANKING SYSTEM

Cranking System Description

See Figure 7, below. Battery power is available to a large terminal stud of the STARTER CONTACTOR. However, the STARTER CONTACTOR contacts are normally-open. From the STARTER CONTACTOR, battery voltage is available to the ENGINE CONTROL circuit board, via Wire 13, a 10 amp CIRCUIT BREAKER, and Wire 15. Major components of the engine cranking system include the following:

- ☐ Engine control circuit board.
- ☐ Start-Stop switch.
- ☐ 10 amp Circuit Breaker.
- ☐ Starter Contactor.
- ☐ Starter.
- ☐ 12 volts Battery.

Figure 7. Engine Cranking System Diagram



Operational Analysis

Operation of the engine cranking system may be briefly described as follows (Figure 7):

1. Battery power is available to the STARTER CONTACTOR, via the positive battery cable. Battery power is also available to the ENGINE CONTROL circuit board, via Wire 13, a 10 amp CIRCUIT BREAKER, and Wire 15.
2. When the START-STOP SWITCH is set to "Start", Wire 17 and Pin 3 of the ENGINE CONTROL board are connected to ground. Circuit board action then delivers 12 volts DC to the STARTER CONTACTOR coil, via Wire 56. The STARTER CONTACTOR is energized and its contacts close.
3. On closure of the STARTER CONTACTOR contacts, 12 volts DC is delivered to the STARTER. The engine cranks.
4. When the engine starts, the START-STOP SWITCH is released and Wire 17 is no longer grounded. Circuit board action opens the 12 volts DC circuit to Wire 56 and cranking terminates.

Engine Control Circuit Board

See Section 9.4, "ENGINE CONTROL CIRCUIT".

Start-Stop Switch

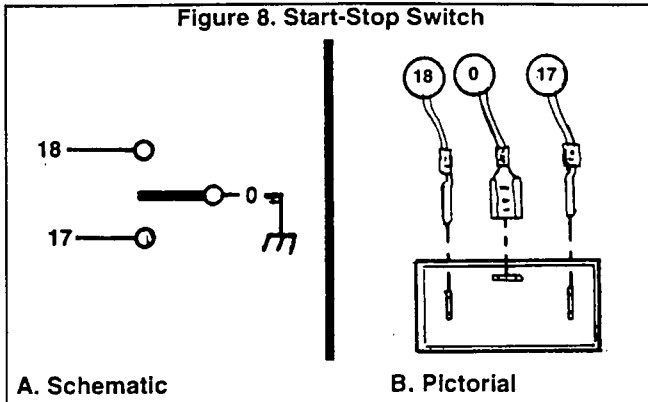
DESCRIPTION:

See Figure 8. Wires 17 (start), 18 (stop), and 0 (ground) connect to the start-stop switch terminals.

Setting the switch to "Start" connects the Wire 17 circuit to Wire 0 (ground). Engine control circuit board action then initiates engine cranking and startup.

Setting the switch to "Stop" connects the Wire 18 circuit to ground. The circuit board then opens its circuit to Wire 14 and engine shutdown occurs.

Figure 8. Start-Stop Switch



TESTING THE SWITCH:

The start-stop switch can be tested using a volt-ohm-millimeter (VOM). Set the VOM to its "Rx1" scale and zero the meter.

- ☐ Connect the VOM test leads across the Wire 17 and the Wire 0 terminal of the switch. With switch at "Start", the meter should read "continuity"; at "Stop", switch should read "infinity".
- ☐ Connect the VOM test leads across the Wire 18 and the Wire 0 terminals of the switch. Set switch to "Start" and meter should read "infinity". Set switch to "Stop" and it should read "continuity".

10 Amp Circuit Breaker

Refer to Section 9.4, "ENGINE CONTROL CIRCUIT".

Starter Contactor

DESCRIPTION:

The starter contactor (or starter solenoid) is attached to the engine-generator control panel. See Figure 9.

TESTING THE STARTER CONTACTOR:

If the engine will not crank, the starter contactor can be tested as follows:

1. Check for normal battery voltage at the large terminal stud to which the positive battery cable connects.
 - a. If battery voltage is zero or low, check the battery cable and the battery.
 - b. If normal battery voltage is read, go on to Step 2.

Starter Contactor (Continued)

2. Connect the positive VOM test lead to the large contactor terminal stud to which the starter cable attaches and the common VOM test lead to ground. Hold the start-stop switch at "Start" and battery voltage should be indicated.

a. If normal battery voltage is indicated, but engine does not crank, check the contactor to starter cable and the starter itself.

b. If normal battery voltage is NOT indicated when the start-stop switch is set to "Start", go to Step 3.

3. Check for battery voltage at the small starter contactor terminal to which Wire 56 attaches. When the start-stop switch is set to "Start" battery voltage should be indicated.

a. If battery voltage is indicated in Step 3 but was NOT indicated in Step 2, check the starter contactor ground wire. If ground wire is good, replace the starter contactor.

b. If battery voltage is NOT indicated in Step 3 when the start-stop switch is set to "Start", check the following:

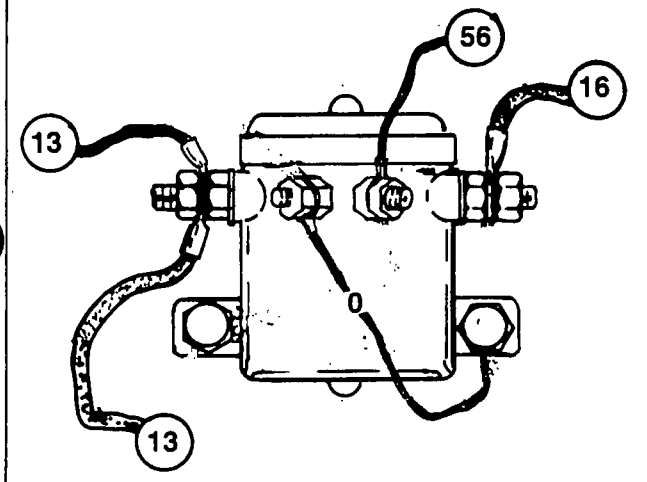
(1) Wire 56 between the starter contactor and the engine control circuit board.

(2) The start-stop switch.

(3) The 10 amp circuit breaker.

(4) Power supply to the engine control circuit board.

Figure 9. Starter Contactor (Typical)



Starter

DESCRIPTION:

The starter assembly is shown in Figure 10. It is rated 12 volts DC. Never apply any voltage in excess of rated voltage or magnets in the starter may become demagnetized.

STARTER MOTOR SERVICING:

1. **Inspection:** Check for adverse wear on all bearings, gears, shafts, etc. Check the spring washer for wear, convex side next to bearing. Add a drop of oil to face of bearing.

2. **Thru-Bolts:** Tighten thru-bolts to 75 inch-pounds.

3. **Drive Cap:** Apply a film of SAE #10 oil to the bearings in the drive cap. During reassembly, the insulating washer must be placed against the drive cap.

4. **Brush Assembly:** Brushes and brush springs should be replaced at each overhaul. Any brush that is worn to 5/16 inch or less, measured on short side of brush, or that has been in contact with grease, oil or cleaning fluid, must be replaced. Assemble brushes with their chamfered side away from the

springs. Tighten brush screw to 30-35 inch-pounds. Tighten the hot stud nut to 45-50 inch-pounds.

5. **Armature:** Check the armature for an open, shorted or grounded condition with a growler. Hold armature in a vise while installing or removing the drive assembly. Apply a thin film of non-conducting grease to the commutator end of the armature shaft and to the portions of the shaft that contact the bearings.

STARTER PERFORMANCE TEST:

CAUTION: DO NOT operate the starter continuously for longer than 30 seconds.

Use a fully charged, 12 volts battery to test the starter. Attach the battery's positive terminal to the starter motor input stud, and the battery negative terminal to the starter motor housing. Use a No. 10 (or larger) cable not more than 6 feet long. Maximum current draw and starter speed should be as follows:

MAXIMUM NO-LOAD CURRENT DRAW & SPEED
17 amps at 6000-7200 rpm

Battery

RECOMMENDED BATTERY:

When anticipated ambient temperature will consistently be above 32° F. (0° C.), use a 12 volts, automotive type storage battery rated at 70 amp-hours and capable of delivering at least 360 cold cranking amperes.

If ambient temperatures will be below 32° F. (0° C.), use a 12 volts battery rated 95 amp-hours and having a cold cranking capacity of 450 amps.

BATTERY CABLES:

Use of battery cables that are too small in diameter or too long will result in excessive voltage drop. For best cold weather starting, voltage drop between the battery and starter should not exceed 0.12 volt per 100 amperes of cranking current.

Select battery cables based on total cable length and prevailing ambient temperatures. Generally, the longer the cable and the colder the weather, the larger the required cable diameter. The following chart applies:

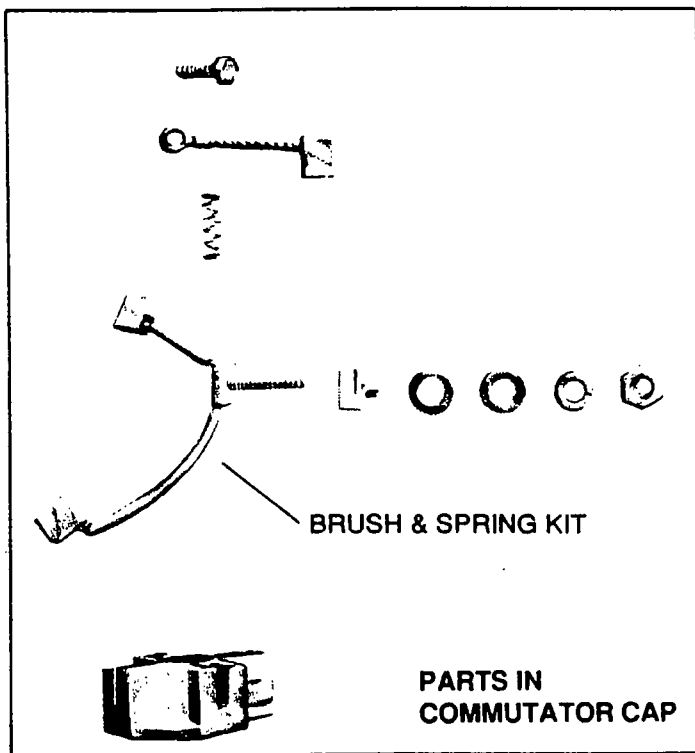
CABLE LENGTH (IN FEET)	RECOMMENDED CABLE SIZE
0-10	No. 2
11-15	No. 0
16-20	No. 000

EFFECTS OF TEMPERATURE ON BATTERY:

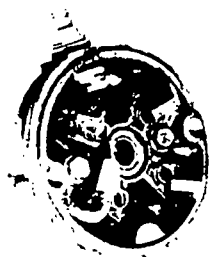
Battery efficiency is greatly reduced by a decreased electrolyte temperature, because such low temperatures have a decided numbing effect on the electrochemical action. Under high discharge rates (such as cranking), battery voltage will drop to much lower values in cold temperatures than in warm temperatures. The freezing point of battery electrolyte fluid is affected by the state of charge of the electrolyte.

SPECIFIC GRAVITY	FREEZING POINT
1.220	-35° F. (-37° C.)
1.200	-20° F. (-29° C.)
1.160	0° F. (-18° C.)

Figure 10. Starter Assembly



COMMUTATOR
CAP



THRU BOLTS



DRIVE KIT



DRIVE PINION



DRIVE CAP



ARMATURE
ASSEMBLY

Battery (Continued)

ADDING WATER:

Water is lost from the battery as a result of charging and discharging, and must be replaced. If the water is not replaced and the separator plates become exposed, they may become permanently sulfated. In addition, the plates cannot take full part in the battery action unless they are completely immersed in electrolyte.

CHARGING A BATTERY:

When charging a battery, an explosive gas mixture forms in each cell. Battery electrolyte fluid is an extremely caustic sulfuric acid solution that can cause severe burns. For that reason, the following precautions must be observed:

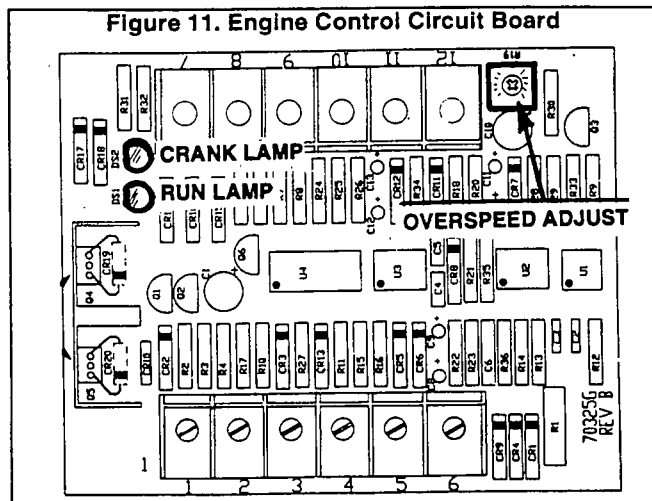
- ☐ The area must be well ventilated.
- ☐ Do NOT smoke or break a live circuit near the top of the battery- sparking could cause an explosion.
- ☐ Avoid spillage of battery electrolyte fluid. If spillage occurs, flush the affected area with clear water immediately.
- ☐ Wear eye protection when handling a battery.

Section 9.4- ENGINE CONTROL CIRCUIT

Engine Control Circuit Board

An engine control circuit board (Figure 11), housed in the generator control panel, controls engine starting, running and shutdown functions. A 12 volts DC power supply is delivered to the board for control of those functions.

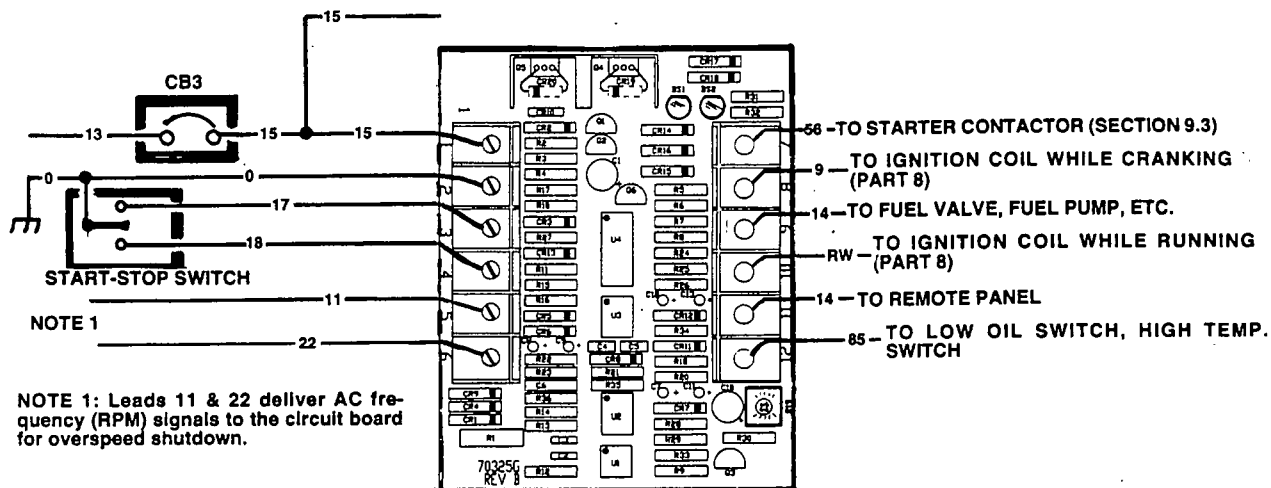
Figure 11. Engine Control Circuit Board



Circuit board terminals, connecting wires and a description (or function) of the wires is listed in the following chart:

TERMINAL	WIRE	DESCRIPTION OR FUNCTION
1	15	Breaker protected 12 volts DC power to operate engine control system.
2	0	Common ground.
3	17	Engine will crank when this circuit is grounded.
4	18	Engine will shut down when this circuit is grounded.
5 & 6	11, 22	Frequency (engine speed) signals from generator AC power leads for automatic engine shutdown.
7	56	Crank signal- starter contactor energizes when circuit board energizes Wire 56 circuit.
8	9	Delivers 12 volts DC to Ignition coil for engine cranking only.
9	14	Delivers 12 volts DC to carburetor fuel valve, fuel pump and DC alternator for running.
10	RW	Once cranking has ended, battery power is delivered to the Ignition coil via a resistance wire.
11	14	Delivers 12 volts DC to a remote panel only when the engine is running.
12	85	When this circuit is grounded by closure of either (a) a low oil pressure switch, or (b) a high coolant temperature switch, an automatic engine shutdown will occur

Figure 12. Engine DC Control Circuit



Engine Control Circuit Board (Continued)

See Figure 11 on previous page. The service technician should be aware of the following features on the engine control circuit board:

1. An adjustment potentiometer (R19) is provided to permit adjustment of the rpm at which an overspeed shut down will occur.
 - a. Automatic shutdown should occur when AC frequency (engine speed) exceeds approximately 69-71 Hertz (2070-2130 rpm).
 - b. Adjustment is required whenever the engine control circuit board is replaced.
2. The circuit board mounts a red crank lamp (LED) which should turn on when the engine is cranking.
 - a. A "Lamp On" condition indicates that (a) the Wire 17 circuit has been grounded by start-stop switch action, and (b) circuit board action has delivered battery voltage to the Wire No. 56 circuit to initiate cranking.
 - b. The lamp should go out when the start-stop switch is released and cranking has terminated.
3. The circuit board mounts a green run lamp (LED).
 - a. The run lamp should illuminate when circuit board action has delivered 12 volts DC to the Wire No. 14 circuit (to open the carburetor fuel valve, and turn on the fuel pump).
 - b. If the run lamp does NOT turn on during cranking, engine will not start.

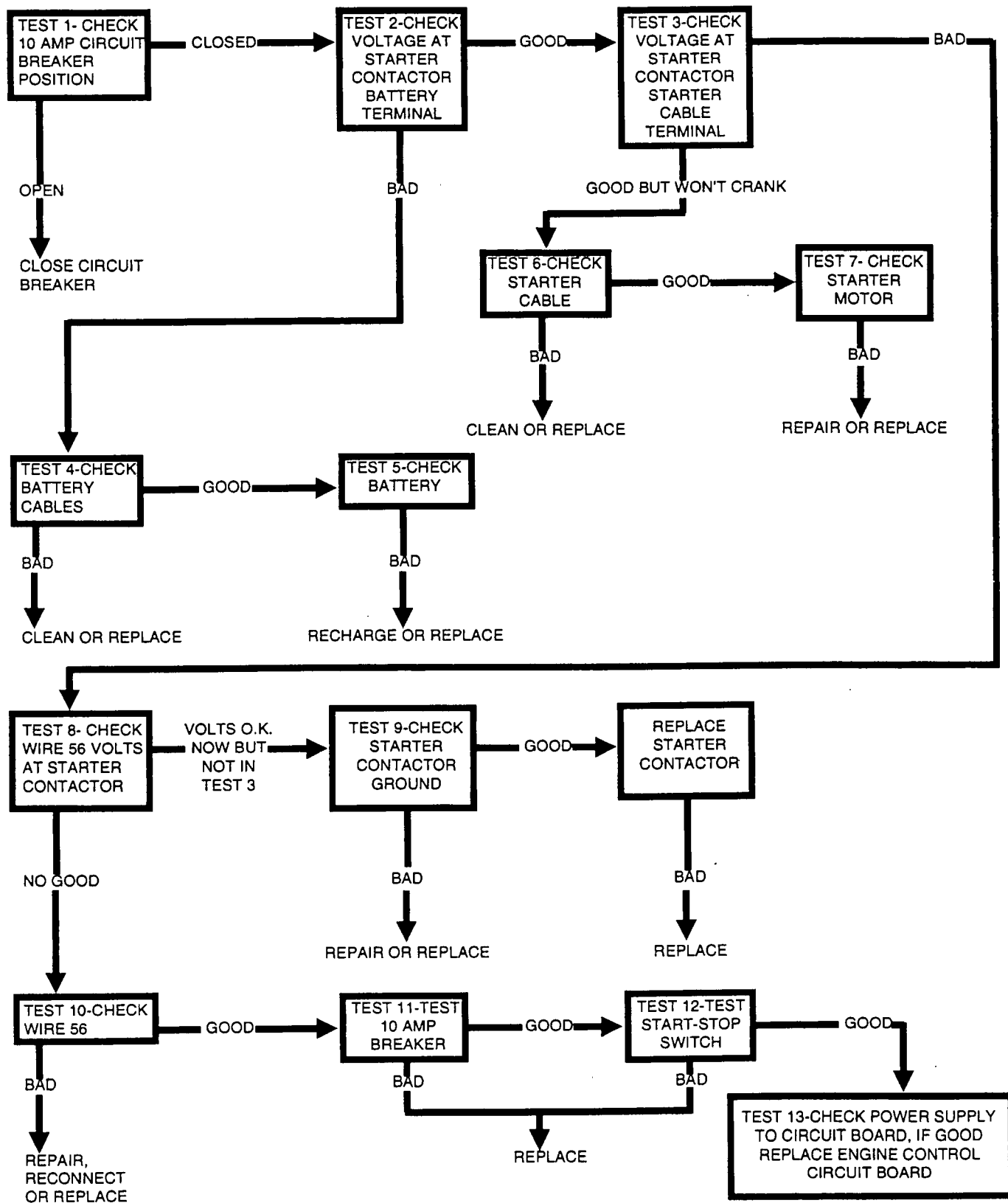
Overspeed Shutdown Adjustment

To adjust the overspeed shutdown setting, proceed as follows:

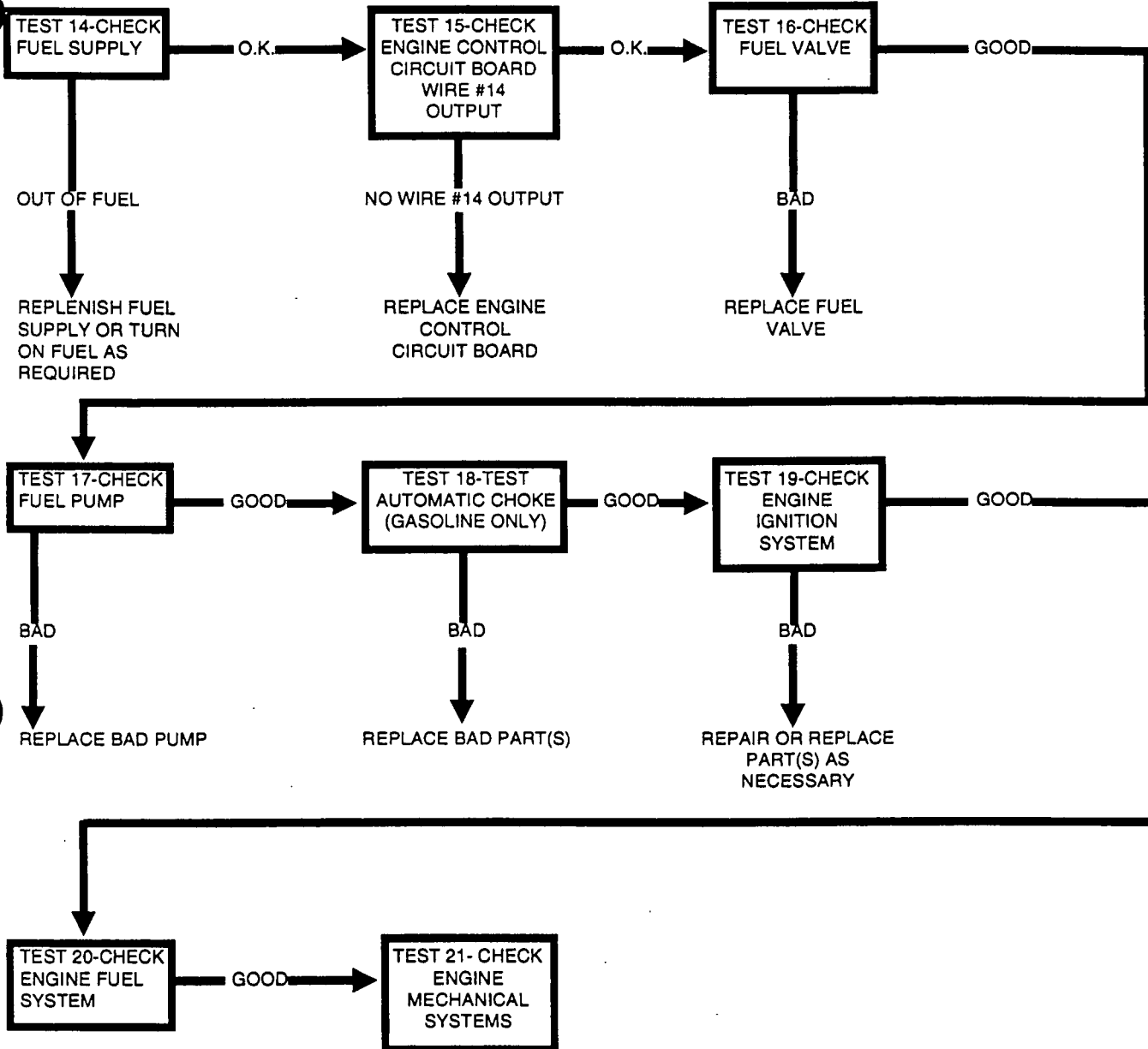
1. On the engine control circuit board, turn the OVERSPEED SHUTDOWN POT counterclockwise until it just contacts its stop. DO NOT FORCE.
2. Connect an accurate AC frequency meter across the generator's AC output leads.
3. Start the engine, let it stabilize and warm up at no-load.
4. SLOWLY increase engine speed until the frequency meter reads 69-71 Hertz.
5. Hold the throttle at 69-71 Hertz, then SLOWLY turn the OVERSPEED SHUTDOWN POT clockwise. When the engine shuts down, overspeed setting is correct.

Section 9.5- TROUBLESHOOTING GUIDE

Problem 1. Engine Will Not Crank



Problem 2. Engine Cranks But Will Not Start



Introduction

Test numbers in the test procedures that follow correspond to the numbered tests in the troubleshooting flow charts of Pages 9.5-1 and 9.5-2.

Test 1- Check 10 Amp Circuit Breaker Position

DISCUSSION:

Battery power must be available to the engine control circuit board in order for engine cranking to occur. This power is delivered to the circuit board via Wire 13, the 10 amp circuit breaker and Wire 15. If the 10 amp breaker is open, cranking will not be possible.

PROCEDURE:

Check if 10 amp breaker is set to "Off" or "Open". If it is set to "Off" or "Open", reset it to its "On" or "Closed" position.

RESULTS:

1. If the 10 amp breaker is set to "On" or "Closed", go on to Test 2.
2. If the 10 amp breaker is set to "Off" or "Open", reset it to its "On" or "Closed" position.

Test 2- Check Voltage at Starter Contactor Battery Terminal

DISCUSSION:

See "TESTING THE STARTER CONTACTOR" on Pages 9.3-1 and 9.3-2.

RESULTS:

1. If battery voltage is read at the starter contactor battery terminal, go on to Test 3.
2. If low or no voltage is indicated at starter contactor battery terminal, go on to Test 4.

Test 3- Check Voltage at Starter Cable Terminal

DISCUSSION:

See "TESTING THE STARTER CONTACTOR" on Pages 9.3-1 and 9.3-2.

RESULTS:

1. If low or no voltage is indicated at starter cable terminal stud of starter contactor when start-stop switch is held at "Start", go to Test 8.
2. If normal battery voltage is indicated at starter cable terminal stud of the starter contactor when start-stop switch is set to "Start", but the engine will NOT crank, go to Test 6.

Test 4- Check Battery Cables

DISCUSSION:

See "TESTING THE STARTER CONTACTOR" on Pages 9.3-1 and 9.3-2.

RESULTS:

Clean or replace battery cables as necessary. If battery cables are good, go to Test 5.

Test 5- Check Battery

DISCUSSION:

If the engine will not crank, the unit battery may be discharged or worn out.

PROCEDURE:

Use an automotive type battery hydrometer to test the battery for (a) state of charge and (b) condition. Follow the hydrometer manufacturer's instructions carefully.

State of Charge: If the hydrometer used does not have a "Percentage of Charge" scale, the following chart may be used:

SPECIFIC GRAVITY	PERCENTAGE OF CHARGE
1.260	100%
1.230	75%
1.200	50%
1.170	25%

Condition: If the difference in specific gravity between the highest and lowest reading cells is greater than 0.050 (50 points), the battery should be replaced.

RESULTS:

1. Recharge or replace battery as needed.

Test 6- Check Starter Cable

DISCUSSION:

When the start-stop switch is set to "Start", battery voltage should be available at the starter motor, indicating that the starter contactor has energized and its contacts have closed. If such voltage was available at the starter contactor (Test 3) but is NOT available to the starter motor terminal stud, the starter cable (between the contactor and the starter) is corroded or defective.

PROCEDURE:

Check for battery voltage at the starter motor terminal stud when the start-stop switch is set to "Start".

RESULTS:

1. Clean or replace starter contactor to starter motor cable as required.
2. If starter cable is good, go to Test 7.

Test 7- Check Starter Motor

DISCUSSION:

Refer to Section 9.3.

Test 8- Check Wire 56 Volts at Starter Contactor

DISCUSSION:

When the start-stop switch is set to "Start", engine control circuit board action should deliver battery voltage to the Wire 56 terminal of the starter contactor. The starter contactor should then become energized and the engine should crank. This test will determine if battery voltage is available to energize the starter contactor and initiate cranking.

Test 8- Check Wire 56 Volts at Starter Contactor (Continued)

PROCEDURE:

See "STARTER CONTACTOR" on Pages 9.3-1 and 9.3-2.

RESULTS:

1. If battery voltage is not indicated, go to Test 10.
2. If normal battery voltage is indicated in this test, but was NOT indicated in Test 3, go to Test 9.

Test 9- Check Starter Contactor Ground

DISCUSSION:

A ground wire connects to one of the smaller starter contactor terminals and to frame ground. If this wire is open or if a good ground connection is not available, the starter contactor will not energize.

PROCEDURE:

Test the starter contactor ground lead for "continuity".

RESULTS:

1. Repair, reconnect or replace the starter contactor ground wire as necessary.
2. If the ground lead is good, replace the starter contactor.

Test 10. Check Wire 56

DISCUSSION:

If Wire 56, between the engine control circuit board and the starter contactor, is open, cranking will not occur when the start-stop switch is set to "Start".

PROCEDURE:

Inspect Wire 56 between the starter contactor and the engine control circuit board. Test the wire for "continuity".

RESULTS:

1. Repair, reconnect or replace Wire 56 as required.
2. If Wire 56 is good, go to Test 11.

Test 11. Test 10 Amp Circuit Breaker

DISCUSSION:

Battery power must be available to the engine control circuit board or cranking cannot occur. If the 10 amp breaker has failed open, battery power will not be available to the circuit board.

PROCEDURE:

Test the 10 amp breaker for continuity with the breaker set to "On" or "Closed".

RESULTS:

1. Replace the 10 amp breaker, if it is defective.
2. If the 10 amp breaker is good, go to Test 12.

Test 12- Test Start-Stop Switch

DISCUSSION:

When the start-stop switch is set to "Start", switch action must connect Wire 17 to ground or cranking will not occur. In addition, when the switch is set to "Stop", Wire 18 must be connected to ground or engine shutdown will not occur.

PROCEDURE:

1. Connect VOM test leads across the Wire 17 terminal of switch and the Wire 0 (ground) terminal. Set Switch to "Start" and meter should read "continuity". Set switch to "Stop" and meter should read "infinity".
2. Connect the VOM test leads across Wire 18 terminal of switch and Wire 0 terminal. Set switch to "Start" and VOM should read "infinity". Set switch to "Stop" and meter should read "continuity".

RESULTS:

1. Replace the start-stop switch if it fails the test.
2. If switch is good, go to Test 13.

Test 13. Check Power Supply to Circuit Board

DISCUSSION:

In Test 8, battery voltage was NOT available to the Wire 56 terminal of the starter contactor. Wire 56 was checked in Test 10 and it was good. The 10 amp breaker was then tested, as well as the start-stop switch, and both were good. The engine control circuit board is left as a suspect.

PROCEDURE:

Connect a DC voltmeter across circuit board Pin #1 and ground. Battery voltage should be indicated.

RESULTS:

If battery voltage is indicated, replace the engine control circuit board.

NOTE: Perform Tests 14 through 21 if the engine cranks normally, but will not start.

Test 14. Check Fuel Supply

DISCUSSION:

Often, the most obvious cause(s) of a problem are overlooked when troubleshooting.

PROCEDURE:

If the engine cranks but will not start, check the fuel supply. Also make sure that any shutoff valve(s) in the fuel supply lines are open.

RESULTS:

1. Replenish fuel supply as necessary.
2. If fuel supply is good but engine will not start, go to Test 15.

Test 15. Check Engine Control Circuit Board Wire #14 Output

DISCUSSION:

During a startup attempt, when the start-stop switch is set to "Start", engine control circuit board action must deliver battery voltage to the Wire 14 circuit. Wire 14 voltage energizes a fuel solenoid open to allow fuel flow. On units with gasoline fuel system, Wire 14 turns on the fuel pump. And, on units with electronic governor, Wire 14 turns on the governor circuit.

The fact that the engine cranks when the start-stop switch is set to "Start" is adequate verification that battery power is available to the engine control circuit board.

PROCEDURE:

Use a VOM to check for battery voltage at terminal #9 (Wire 14) of the engine control circuit board when the engine is being cranked. Battery voltage should be indicated.

RESULTS:

1. If battery voltage is indicated, go to Test 16.
2. If battery voltage is NOT indicated, replace the engine control circuit board.

Test 16. Check Fuel Valve

DISCUSSION:

Units with gasoline fuel system are equipped with a fuel solenoid valve that is attached to the gasoline carburetor (see Part 5 of this Manual).

Units with gaseous fuel system have separately mounted solenoid valve (see Part 6).

The fuel valve MUST open if fuel is to be introduced to the engine carburetor.

PROCEDURE:

Gasoline Units: Remove the fuel valve from the engine carburetor. Hold the valve housing into firm contact with a clean frame ground and set the start-stop switch to "Start". The valve tip should pull in, indicating that it has been actuated to its open position.

Gaseous Fuel Units: Disconnect the inlet and outlet lines from the gaseous fuel valve. Apply 12 volts DC to the valve wires and the valve should open. Remove the 12 volts DC and the valve should close. Use your mouth to blow through the valve, to verify valve open and closed conditions.

CAUTION: If 12 volts DC is available to the gaseous system fuel valve, but valve does not appear to open, be sure to check gaseous fuel pressure before rejecting the valve. At pressures in excess of 14 inches water column (1/2 psi), the valve may not open.

RESULTS:

1. Replace fuel valve if it is defective.
2. If fuel valve checks good, go to Test 17.

Test 17. Check Fuel Pump

DISCUSSION:

This check applies to gasoline fuel systems only, since gaseous fuel systems do not require a fuel pump. The fuel pump MUST operate on these systems or the engine will not start.

PROCEDURE:

See Section 5.2 of this Manual.

RESULTS:

1. Replace fuel pump if defective.
2. If fuel pump is good, go to Test 18.

Test 18. Test Automatic Choke

DISCUSSION:

This test applies to gasoline fuel systems only, since gaseous fuel systems do not require a carburetor choke. The automatic choke on gasoline units actuates only during engine cranking. Choke operation is terminated at the same time that cranking ends.

PROCEDURE:

1. Crank the engine. During cranking, the choke solenoid should pull in about every 2 to 5 seconds.
 - a. If choke solenoid functions normally, go to Test 19.
 - b. If choke solenoid does NOT pull in while cranking, go to Step 2.
2. Try adjusting the choke. See "AUTOMATIC CHOKE ADJUSTMENT" on Page 5.3-1.
3. Inspect ground wire (No. 0) between choke module and start-stop switch.
4. Disconnect Wire 90 from choke module and hold it into firm contact with a clean frame ground. When engine is cranked, choke solenoid should pull in.

RESULTS:

1. Repair, replace or reconnect ground wire (Step 3) as necessary.
2. In Step 4, if choke solenoid pulls in when engine is cranked and Wire 90 is grounded but does NOT pull in otherwise, replace the choke module.
3. In Step 4, if choke solenoid does not pull in and does not actuate normally either, replace the choke solenoid.

Test 19. Check Engine Ignition System

DISCUSSION:

If engine cranks normally but won't start, the ignition system may be at fault.

PROCEDURE:

Test ignition system. See Part 8 of this Manual.

RESULTS:

1. Repair or replace defective ignition system parts as required.
2. If ignition system is functioning normally, go to Test 20.

Test 20. Check Engine Fuel System

DISCUSSION:

If the engine cranks normally but will not start, the fuel system may be the cause of the problem. Refer to Part 5 for information on gasoline fuel systems; or Part 6 for gaseous fuel systems.

RESULTS:

1. Repair or replace defective fuel systems components.
2. If fuel system is functioning properly, go to Test 21.

Test 21- Check Engine Mechanical Systems

DISCUSSION:

Failure of the engine to start may be the result of a mechanical problem in the engine.

PROCEDURE:

See Part 2, "ENGINE MECHANICAL". Check engine compression (see Page 2.1-1).

Part 10 OPTIONS AND ACCESSORIES

NP and IM Series
**RECREATIONAL
VEHICLE &
INDUSTRIAL
MOBILE
AC GENERATORS**
1.2 Liter, Liquid-Cooled
Gas/Gasoline Engine Models

TABLE OF CONTENTS	
SECTION	TITLE
10.1	Remote Start-Stop Panels
10.2	Remote Gauge Panel

Section 10.1- REMOTE START-STOP PANELS

General

Remote start-stop panels are available which, when properly installed and connected, allow the engine-generator to be started and stopped from a convenient remote location. Several different remote panel models are available. Wiring harnesses are also available which permit quick interconnection of the panel with the generator. The following remote panels and wiring harnesses are available:

1. **Model 9042** is a remote start-stop panel for gas generators. The panel mounts (a) a rocker type start-stop switch, and (b) a "Generator Run" advisory lamp.

2. **Model 9043** is a remote panel for gas units that includes (a) a start-stop switch, (b) a "Generator Run" lamp, and (c) an hourmeter.

3. **Model 9045** is a 10 foot long, 4-wire wiring harness that may be used to interconnect the Model 9042 and 9043 remote panels with the generator set.

4. **Model 9046** is a 30 foot long, 4-wire wiring harness that may be used to interconnect the Models 9042 and 9043 remote panels with the generator.

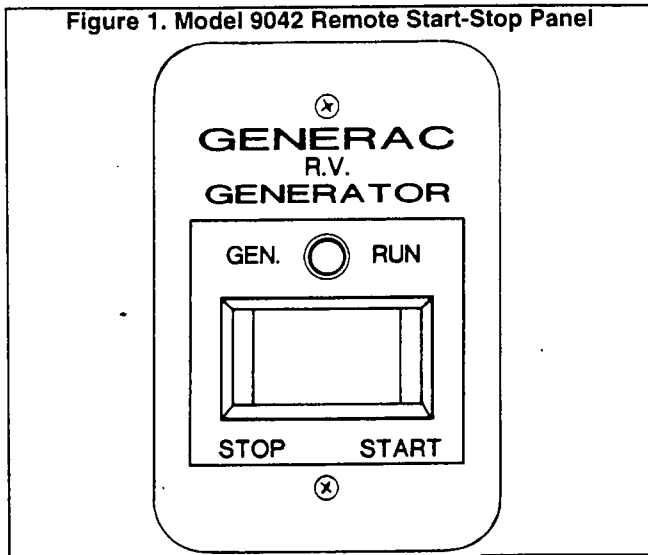
5. **Model 9060** is a remote gauge panel for use with gas engine generators. The remote gauge panel is discussed in Section 10.2.

Model 9042 Remote Panel

DESCRIPTION:

The Model 9042 remote panel is shown in Figure 1, below.

Figure 1. Model 9042 Remote Start-Stop Panel



MOUNTING:

The Model 9042 panel is designed for flush mounting to a wall or partition. Cutout dimensions for mounting the panel are shown in Figure 2.

CONNECTIONS:

A receptacle is provided on the generator for connection of the wiring harness. See Figure 3. Figure 4 is a connection diagram for the remote panel.

Figure 2. Model 9042 Cutout Dimensions

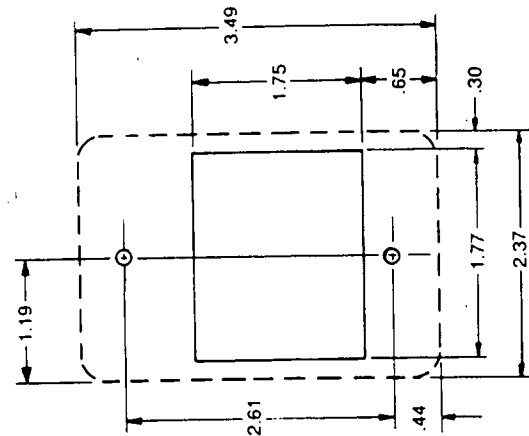


Figure 3. Generator's Remote Panel Receptacle

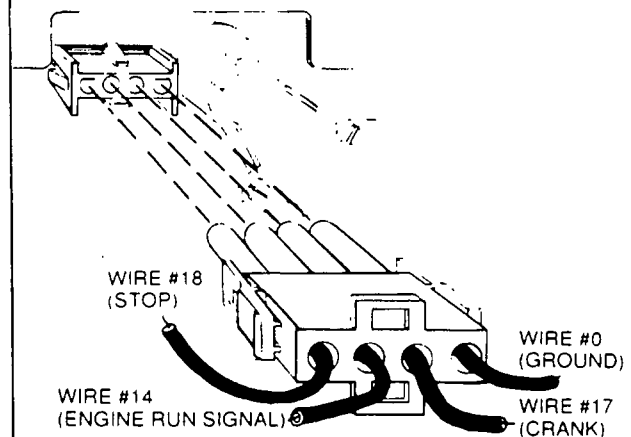
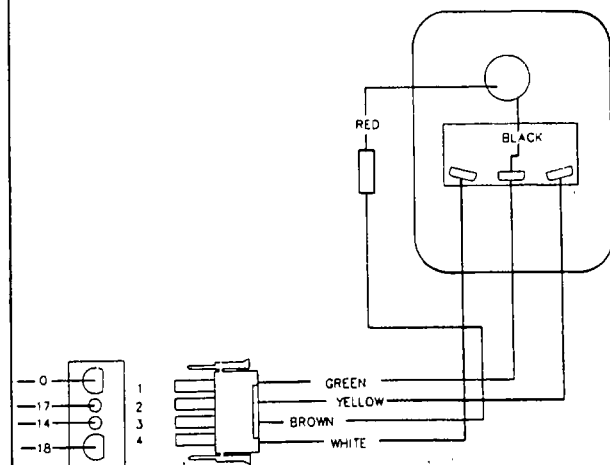


Figure 4. Model 9042 Connection Diagram

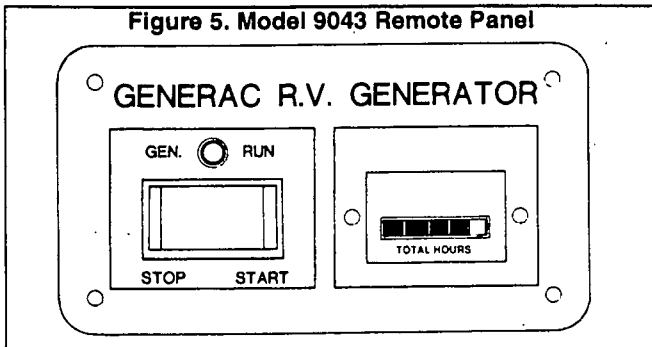


Model 9043 Remote Panel

DESCRIPTION:

The Model 9043 remote panel mounts a start-stop switch, a "Generator Run" lamp and an hourmeter.

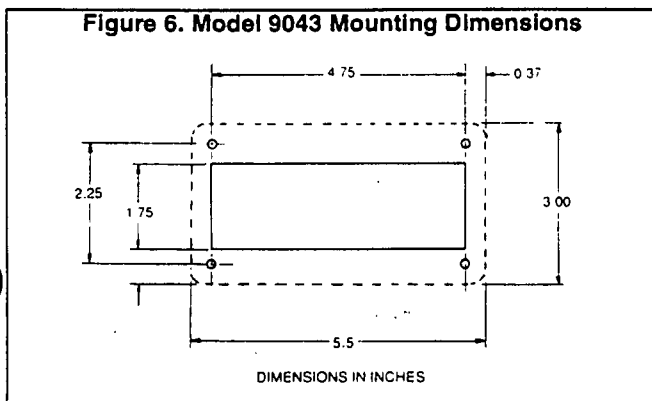
Figure 5. Model 9043 Remote Panel



MOUNTING:

The Model 9043 remote panel is designed for flush mounting to a wall or partition. Cutout dimensions are shown in Figure 6.

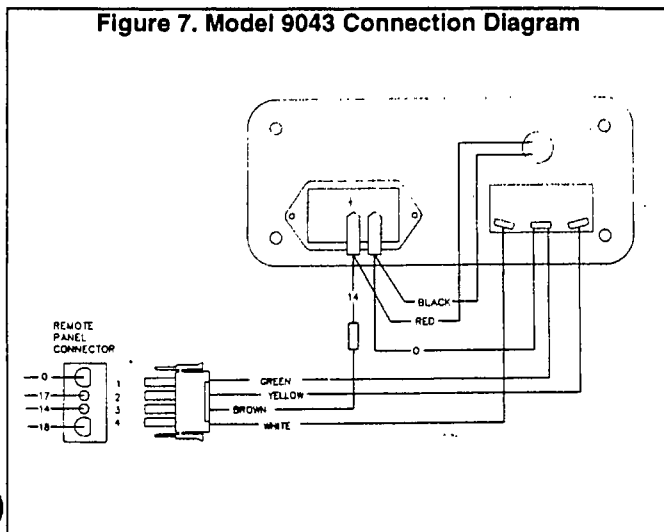
Figure 6. Model 9043 Mounting Dimensions



CONNECTIONS:

Connect the appropriate wiring harness to the generator's remote panel receptacle (Figure 3) and to the Model 9043 remote panel as shown in Figure 7.

Figure 7. Model 9043 Connection Diagram



Section 10.2- REMOTE GAUGE PANEL

Description

The Model 9060 remote gauge panel provides remote starting and stopping capability. The panel also mounts gauges and meters to allow engine operating parameters to be monitored by the operator.

A wiring harness (Model 9181) is available for easier connection of the gauge panel to the generator.

Installation

Complete installation instructions are included with the remote gauge panel kit.

Figure 8. Model 9060 Remote Gauge Panel

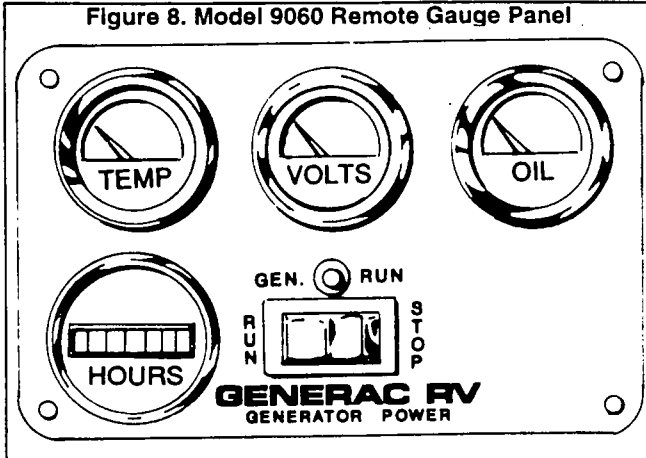
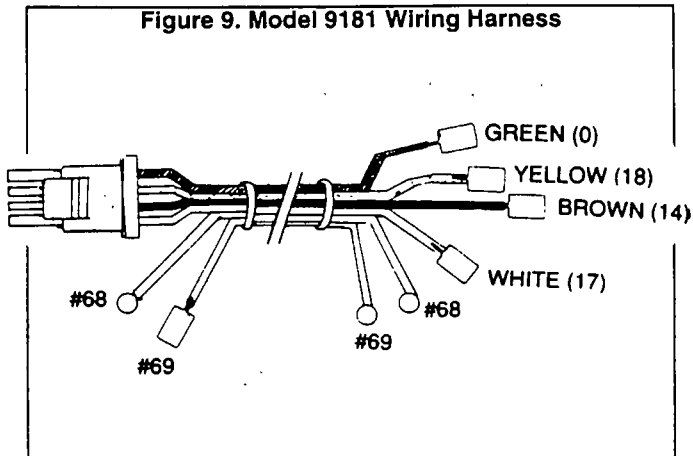


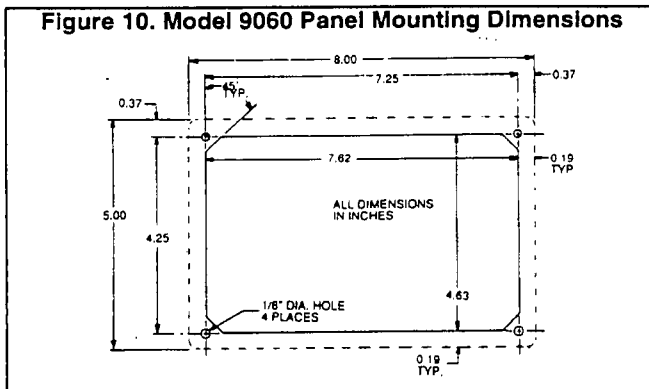
Figure 9. Model 9181 Wiring Harness



Panel Mounting

The Model 9060 remote gauge panel is designed for flush mounting to a wall or partition. Panel mounting dimensions are shown in Figure 10.

Figure 10. Model 9060 Panel Mounting Dimensions



Part 11 SPECIFICATIONS AND ELECTRICAL DATA

NP and IM Series
**RECREATIONAL
VEHICLE &
INDUSTRIAL
MOBILE
AC GENERATORS**
1.2 Liter, Liquid-Cooled
Gas/Gasoline Engine Models

TABLE OF CONTENTS	
TABLE	TITLE
11.1	Nominal Resistances of AC Generator Windings
11.2	General Engine Specifications
11.3	Tightening Torques for Engine Bolts
11.4	Tightening Torques for Standard Metric Bolts
11.5	Engine Service Data
11.6	Index to Electrical Schematics and Wiring Diagrams

Table 11.1- Nominal Resistances of AC Generator Windings

MODEL	ROTOR RESISTANCE	STATOR RESISTANCE	
		POWER WINDING	DPE WINDING
NP80G	8.8 ohms	0.21/0.21 ohm	1.00 ohm
NP100G	8.5 ohms	0.14/0.14 ohm	0.73 ohm
IM80G	8.8 ohms	0.21/0.21 ohm	1.00 ohm
IM100G	8.5 ohms	0.14/0.14 ohm	0.73 ohm

Table 11.2- General Engine Specifications

Engine Displacement1.2 liters (73 In.³)
 Type of CoolingWater-Cooled
 No. of Cylinders4, In-Line
 Bore2.8 Inches (71mm)
 Stroke3.07 Inches (78mm)
 Compression Ratio9 to 1
 No. of Main Bearings5
 Brake Mean Effective Pressure
 (B.M.E.P.)77

Table 11.3- Tightening Torques for Engine Bolts

Intake & Exhaust Manifold

Nuts 12-15 ft-lbs (16-21 N-m)
 Spark Plugs 18-22 ft-lbs (25-29 N-m)
 Water Pump Bolt 2.9-3.6 ft-lbs (4-5 N-m)
 Crankshaft Pulley Bolt 61-69 ft-lbs (83-93 N-m)
 Thermostat Housing Bolt ... 2.0-3.6 ft-lbs (4-5 N-m)
 Oil Pressure Switch 9.0-12.7 ft-lbs (13-17 N-m)
 Camshaft Pulley Bolt 6.5-8.7 ft-lbs (9-12 N-m)
 Connecting Rod Nut 22-25 ft-lbs (29-34 N-m)
 Cylinder Head Bolts See Page 2.1-1
 Cylinder Head Front Cover .. 2.9-3.6 ft-lbs (4-5 N-m)
 Flywheel Bolts 43-51 ft-lbs (59-69 N-m)
 Drive Plate Bolt 51-58 ft-lbs (69-78 N-m)
 Main Bearing Cap Bolts* 34-38 ft-lbs (46-52 N-m)
 Oil Pan Bolt 2.9-3.6 ft-lbs (4-5 N-m)
 Oil Pan Drain Plug 26-35 ft-lbs (35-47 N-m)
 Rocker Shaft Bolt 13-15 ft-lbs (18-21 N-m)
 Tensioner Lock Nut 11-12 ft-lbs (15-17 N-m)
 Rocker Cover Nut 2.2-3.6 ft-lbs (3-5 N-m)
 Rocker Arm Lock Nut 8-11 ft-lbs (11-15 N-m)
 Oil Pump Idler Gear Bolt 4.3-5.1 ft-lbs (6-7 N-m)
 Oil Pump Securing Bolt 12-16 ft-lbs (16-22 N-m)
 Water Pump Securing Bolt .. 2.9-3.6 ft-lbs (4-5 N-m)
 Water Outlet Securing Bolt .. 3.6-5.8 ft-lbs (5-8 N-m)

* Tighten or loosen main bearing cap bolts in 3 stages.

Table 11.4- Tightening Torques for Standard Metric Bolts

GRADE	SIZE	TORQUE	
		N-m	ft-lbs
4T	M6	3-4	2.2-2.9
	M8	8-11	5.8-8.0
	M10	16-22	12-16
	M12	26-36	20-27
	M14	46-62	34-46
7T	M6	6-7	4.3-5.1
	M8	14-18	10-13
	M10	25-35	19-26
	M12	45-61	33-45
	M14	76-103	56-76
9T	M6	8-11	5.8-8.0
	M8	19-25	14-18
	M10	36-50	27-37
	M12	65-88	48-65
	M14	109-147	80-108

Table 11.5- Engine Service Data

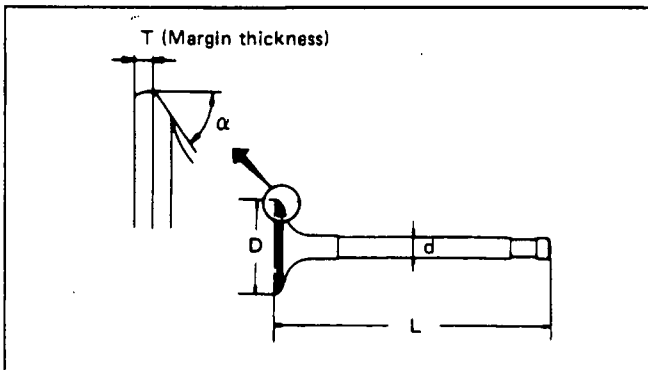
COMPRESSION PRESSURE (@ 350 RPM):

Standard	192 psi (13.5 kg/cm ²)
Minimum	164 psi (11.5 kg/cm ²)
Maximum Difference Between Cylinders	14.0 psi (1.0 kg/cm ²)

CYLINDER HEAD FLATNESS:

Standard	Less than 0.0020 inch
Limit	0.004 inch (0.1mm)

VALVE DATA:



Valve Head Diameter "D"

Intake	1.358 inch (34.5mm)
Exhaust	1.18 inch (30.0mm)

Valve Length "L"

Intake	4.2736-4.2854 inch (108.55-108.85mm)
Exhaust	4.2539-4.2657 inch (108.05-108.35mm)

Valve Stem Diameter "d"

Intake	0.2744-0.2750 inch (6.970-6.985mm)
Exhaust	0.2734-0.2740 inch (6.945-6.960mm)

Valve Seat Angle "a"

Intake and Exhaust 45° 15' -45° 45'

Valve Margin ("T") Limit 0.020 inch (0.5mm)

Valve Stem End Surface

Grinding Limit 0.008 inch (0.2mm)

Valve Clearance (Hot)

Intake 0.0098 inch (0.25mm)

Exhaust 0.0118 inch (0.30mm)

Valve Clearance (Cold)

Intake and Exhaust 0.009 inch (0.22mm)

VALVE SPRING:

Free Height 1.8386 inch (46.7mm)

Pressure Height 1.122 inch @ 36.4 lbs
(28.5mm @ 55.6kg)

Assembled Height 1.457 inches @ 36.4 lbs
(37.0mm @ 16.5kg)

Out-of-Square 0.079 inch (2.0mm)

VALVE GUIDE:

Standard O.D. 0.4340-0.4344 inch
(11.023-11.034mm)

Service Limit O.D. 0.4418-0.4423 inch
(11.223-11.234mm)

Valve Guide I.D. 0.2758-0.2764 inch
(7.005-7.020mm)

Cylinder Head Valve Guide Hole Diameter

Standard 0.4315-0.4322 inch
(10.960-10.978mm)

Service Limit 0.4394-0.4401 inch
(11.160-11.178mm)

Interference Fit of

Valve Guide 0.0018-0.0029 inch
(0.045-0.074mm)

Valve Stem to Valve Guide Clearance

Intake (Standard) 0.0006-0.0018 inch
(0.015-0.045mm)

Exhaust (Standard) 0.0018-0.0030 inch
(0.045-0.075mm)

Maximum Tolerance 0.004 inch (0.1mm)

Valve Deflection Limit . . . 0.008 inch (0.2mm)

CAMSHAFT & CAMSHAFT BEARING:

Camshaft Journal to Bearing Clearance

Standard 0.0012-0.0028 inch
(0.03-0.07mm)

Maximum Tolerance 0.0059 inch (0.15mm)

Camshaft Bearing I.D. 1.5748-1.5760 inch
(40.00-40.03mm)

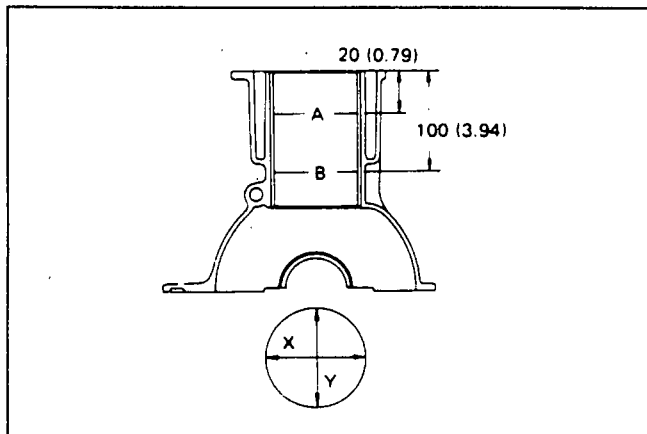
Camshaft Journal O.D. 1.5728-1.5736 inch
(39.95-39.97mm)

Camshaft Bend (Total Indicated Reading)
 Standard Less than 0.008 Inch
 (0.02mm)
 Maximum Tolerance ... 0.004 Inch (0.1mm)
 Camshaft End Play 0.0012-0.0122 Inch
 (0.03-0.31mm)

Cam Height
 Intake 1.3295-1.3394 Inch
 (33.77-34.02mm)
 Exhaust 1.3280-1.3378 Inch
 (33.73-33.98mm)
 Wear Limit of
 Cam Height 0.008 Inch (0.2mm)

CYLINDER BLOCK:

Surface Flatness
 Standard Less than 0.020 Inch
 (0.05mm)
 Limit 0.0039 Inch (0.10mm)
 Cylinder Bore Inner Diameter
 Standard 2.6772-2.6783 Inch
 (68.00-68.03mm)
 Wear Limit 0.0039 Inch (0.10mm)
 Cylinder Bore out-of-Round
 X-Y Less than 0.0008 Inch
 (0.02mm)
 Cylinder Bore Taper
 A-B Less than 0.0008 Inch
 (0.02mm)

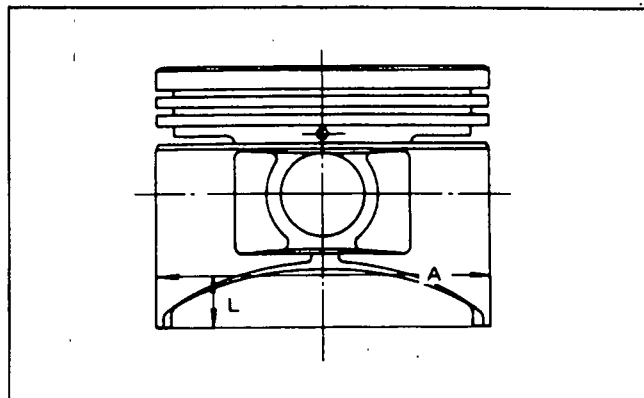


Main Journal I.D.
 Grade No. 0 1.9291-1.9293 Inch
 (49.000-49.004mm)
 Grade No. 1 1.9293-1.9294 Inch
 (49.004-49.008mm)
 Grade No. 2 1.9294-1.9296 Inch
 (49.008-49.012mm)
 Grade No. 3 1.9296-1.9298 Inch
 (49.012-49.016mm)

PISTON:

Piston Skirt Diameter "A"
 Standard 2.6759-2.6770 Inch
 (67.967-67.997mm)

"L" Dimension 0.35 Inch (9mm)
 Piston Pin Hole Diameter ... 0.6694-0.6698 Inch
 (17.003-17.012mm)
 Piston Clearance to
 Cylinder Block 0.0009-0.0017 Inch
 (0.023-0.043mm)



PISTON RINGS:

Side Clearance (Standard)
 Top 0.0016-0.0029 Inch
 (0.040-0.073mm)
 Second 0.0012-0.0025 Inch
 (0.030-0.063mm)
 Oil 0.0069 Inch (0.175mm)
 Side Clearance (All) ... 0.008 Inch (0.2mm)
 Piston Ring Gap (Standard)
 Top (No. 1 Grade) 0.0083-0.0118 Inch
 (0.21-0.30mm)
 Top (No. 2 and 3 Grade) 0.0071-0.0118 Inch
 (0.18-0.30mm)
 Second 0.0059-0.0154 Inch
 (0.15-0.39mm)
 Oil Ring 0.0079-0.0311 Inch
 (0.20-0.79mm)
 Piston Ring Gap Limit (All) .. 0.031 Inch (0.8mm)

PISTON PIN:

Outer Diameter 0.6663-0.6678 Inch
 (16.924-16.961mm)
 Pin to Piston Clearance ... 0.0003-0.0005 Inch
 (0.008-0.012mm)
 Interference Fit of Piston
 Pin to Connecting Rod 0.0007-0.0015 Inch
 (0.017-0.038mm)

CONNECTING ROD:

Center Distance 4.5079 Inch (114.5mm)
 Bend Limit per 3.94 Inch (100mm)
 Limit 0.0020 Inch (0.05mm)
 Piston Pin Bore Diameter ... 0.6678-0.6684 Inch
 (16.962-16.978mm)
 Big End Play
 Standard 0.0039-0.0146 Inch
 (0.10-0.37mm)
 Limit 0.020 Inch (0.5mm)

Table 11-5. Engine Service Data (Continued)

CRANKSHAFT:

Main Journal Diameter

Grade No. 0 1.7703-1.7705 Inch
(44.966-44.970mm)

Grade No. 1 1.7702-1.7703 Inch
(44.962-44.966mm)

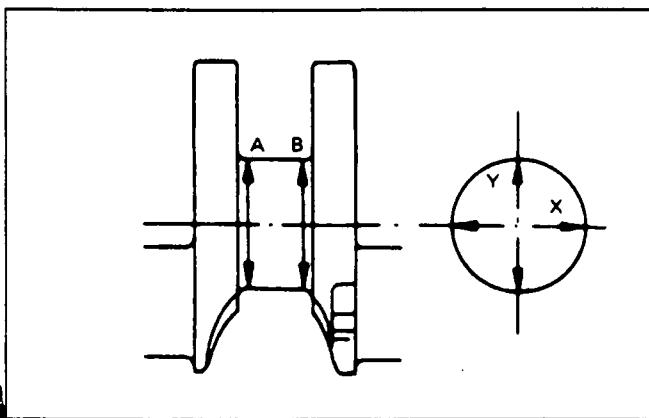
Grade No. 2 1.7700-1.7702 Inch
(44.958-44.962mm)

Grade No. 3 1.7698-1.7700 Inch
(44.954-44.958mm)

Pin Journal Diameter ... 1.5732-1.5736 Inch
(39.96-39.97mm)

Out-of-Round (X-Y) Less than 0.004 Inch
(0.1mm)

Taper (A-B) 0.0008 Inch (0.02mm)



Bend (T.I.R.) Less than 0.0031 Inch
(0.08mm)

Free End Play (Standard) ... 0.0024-0.0087 Inch
(0.06-0.22mm)

Free End Play (Limit) 0.0197 Inch (0.50mm)

BEARING CLEARANCE:

Main Bearing Clearance

Standard 0.0012-0.0020 Inch

Limit 0.0030 Inch (0.075mm)

Connecting Rod Bearing Clearance

Standard 0.0008-0.0024 Inch
(0.02-0.06mm)

Limit 0.0047 Inch (0.12mm)

AVAILABLE MAIN BEARINGS:

(with or without oil groove)

Grade No. 0

Thickness 0.0787-0.0789 Inch
(2.000-2.004mm)

Identification Color Black

Grade No. 1

Thickness 0.0788-0.0790 Inch
(2.002-2.006mm)

Identification Color Brown

Grade No. 2

Thickness 0.0789-0.0791 Inch
(2.004-2.008mm)

Identification Color Green

Grade No. 3

Thickness 0.0790-0.0791 Inch
(2.006-2.010mm)

Identification Color Yellow

Grade No. 4

Thickness 0.0791-0.0792 Inch
(2.008-2.012mm)

Identification Color Blue

Grade No. 5

Thickness 0.0791-0.0793 Inch
(2.010-2.014mm)

Identification Color Pink

Grade No. 6

Thickness 0.0792-0.0794 Inch
(2.012-2.016mm)

Identification Color Red

MAIN BEARING UNDERSIZE:

Crank Journal Diameter

Standard 1.7697-1.7705 Inch
(44.95-44.97mm)

Undersize:

0.0098 Inch (0.25mm) ... 1.7598-1.7606 Inch
(44.70-44.72mm)

CONNECTING ROD BEARING UNDERSIZE:

Crank Main Journal Diameter

Standard 1.5732-1.5736 Inch
(39.96-39.97mm)

Undersize:

0.0098 Inch (0.25mm) ... 1.5634-1.5638 Inch
(39.71-39.72mm)

FLYWEIGHT RUNOUT:

Total Indicator Reading Less than 0.0059 Inch
(0.15mm)

ENGINE LUBRICATION SYSTEM:

Oil Pressure

At 1200 rpm 28 psi (2 kg/cm²)

At 2000 rpm 43 psi (3 kg/cm²)

Oil Pump Clearances

Rotor Tip Less than 0.008 Inch
(0.2mm)

Outer Oil Pump Rotor

to Body Clearance Less than 0.008 Inch
(0.2mm)

Oil Pump Rotor to

Straightedge Clearance . Less than 0.008 Inch
(0.2mm)

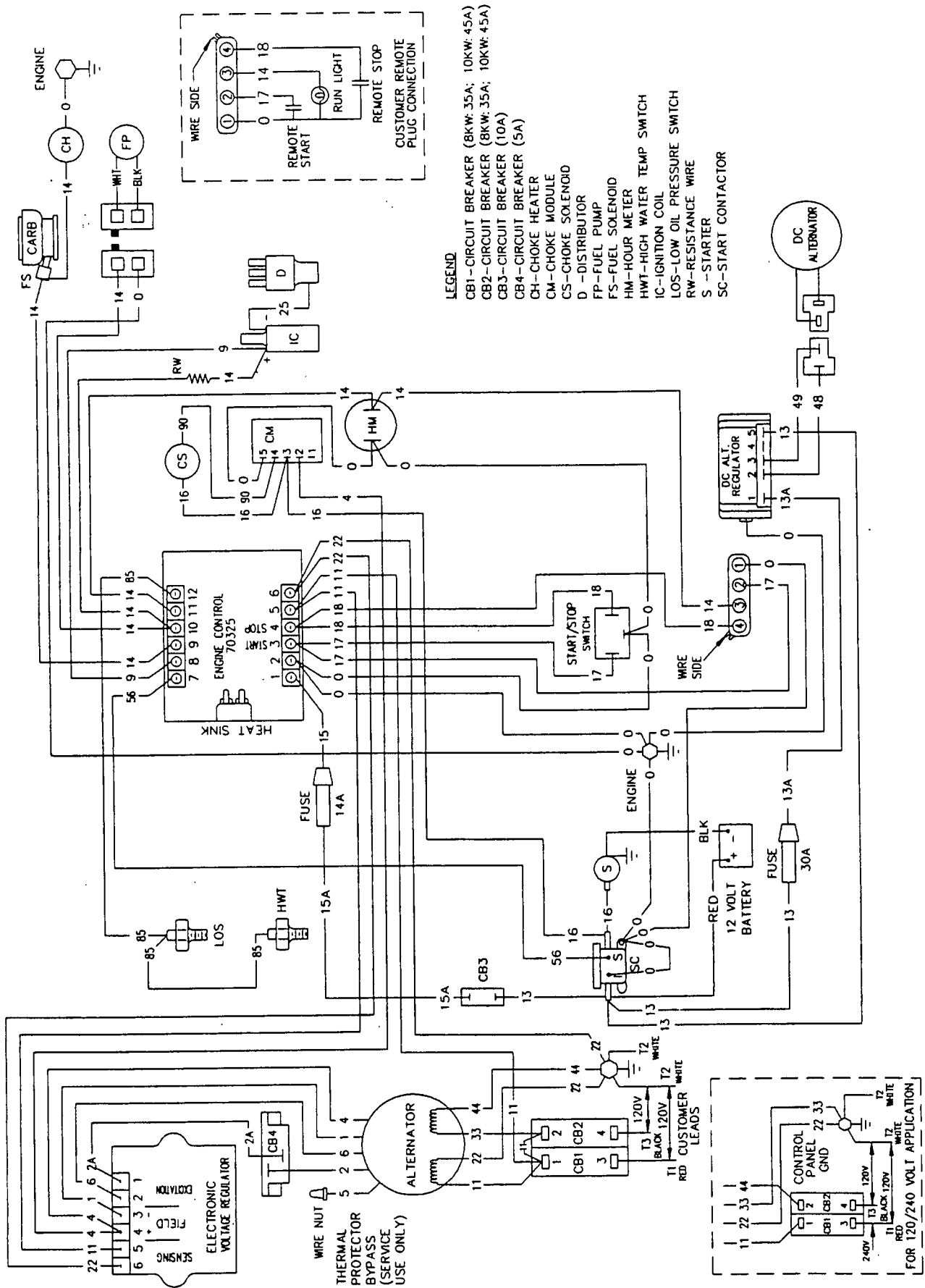
Table 11-6. Index to Electrical Schematics & Wiring Diagrams

MODEL	SERIES	RATED kW	WIRING DIAGRAM	ELECTRICAL SCHEMATIC	FUEL SYSTEM	PAGE
9049-0	NP	8	74874		GASOLINE	11-6
9050-0	NP	10	74874		GASOLINE	11-6
9254-0	IM	10	80897		LP GAS	11-7
9254-1	IM	10	80897		LP GAS	11-7
9260-0	IM	10	82134		LP GAS	11-8
9260-1	IM	10	82661	82663	LP GAS	11-9,-10
9260-3	IM	10	82661	82663	LP GAS	11-9, -10
9340-0	IM	10	82123	80771	GASOLINE	11-11,-12
9340-1	IM	10	82660	82662	GASOLINE	11-13,-14
9340-3	IM	10	82660	82662	GASOLINE	11-13,-14

Table 11-7. Electrical Formulas

VALUE	SINGLE PHASE	THREE PHASE
WATTS	$\text{Volts} \times \text{Amps} \times \text{P.F.}$	$\text{Volts} \times \text{Amps} \times \text{P.F.}$
KILOWATTS	$\frac{\text{Volts} \times \text{Amps} \times \text{P.F.}}{1000}$	$\frac{\text{Volts} \times \text{Amps} \times 1.73 \times \text{P.F.}}{1000}$
AMPERES	$\frac{\text{kW} \times 1000}{\text{Volts} \times \text{P.F.}}$	$\frac{\text{kW} \times 1000}{\text{Volts} \times \text{P. F.}}$
KILOVOLT AMPERES (KVA)	$\frac{\text{Volts} \times \text{Amps}}{1000}$	$\frac{\text{Volts} \times \text{Amps} \times 1.73}{1000}$
FREQUENCY (HERTZ)	$\frac{\text{No. of Rotor Poles} \times \text{RPM}}{120}$	$\frac{\text{No. of Rotor Poles} \times \text{RPM}}{120}$
RPM	$\frac{\text{Hertz} \times 120}{\text{No. of Rotor Poles}}$	$\frac{\text{Hertz} \times 120}{\text{No. of Rotor Poles}}$
NO. OF ROTOR POLES	$\frac{\text{Hertz} \times 120}{\text{RPM}}$	$\frac{\text{Hertz} \times 120}{\text{RPM}}$
POWER FACTOR	$\frac{\text{Actual Watts}}{\text{Volts} \times \text{Amps}}$	$\frac{\text{Actual Watts}}{\text{Volts} \times \text{Amps}}$
AMPERES (when kVA is known)	$\frac{\text{kVA} \times 1000}{\text{Volts}}$	$\frac{\text{kVA} \times 1000}{\text{Volts}}$

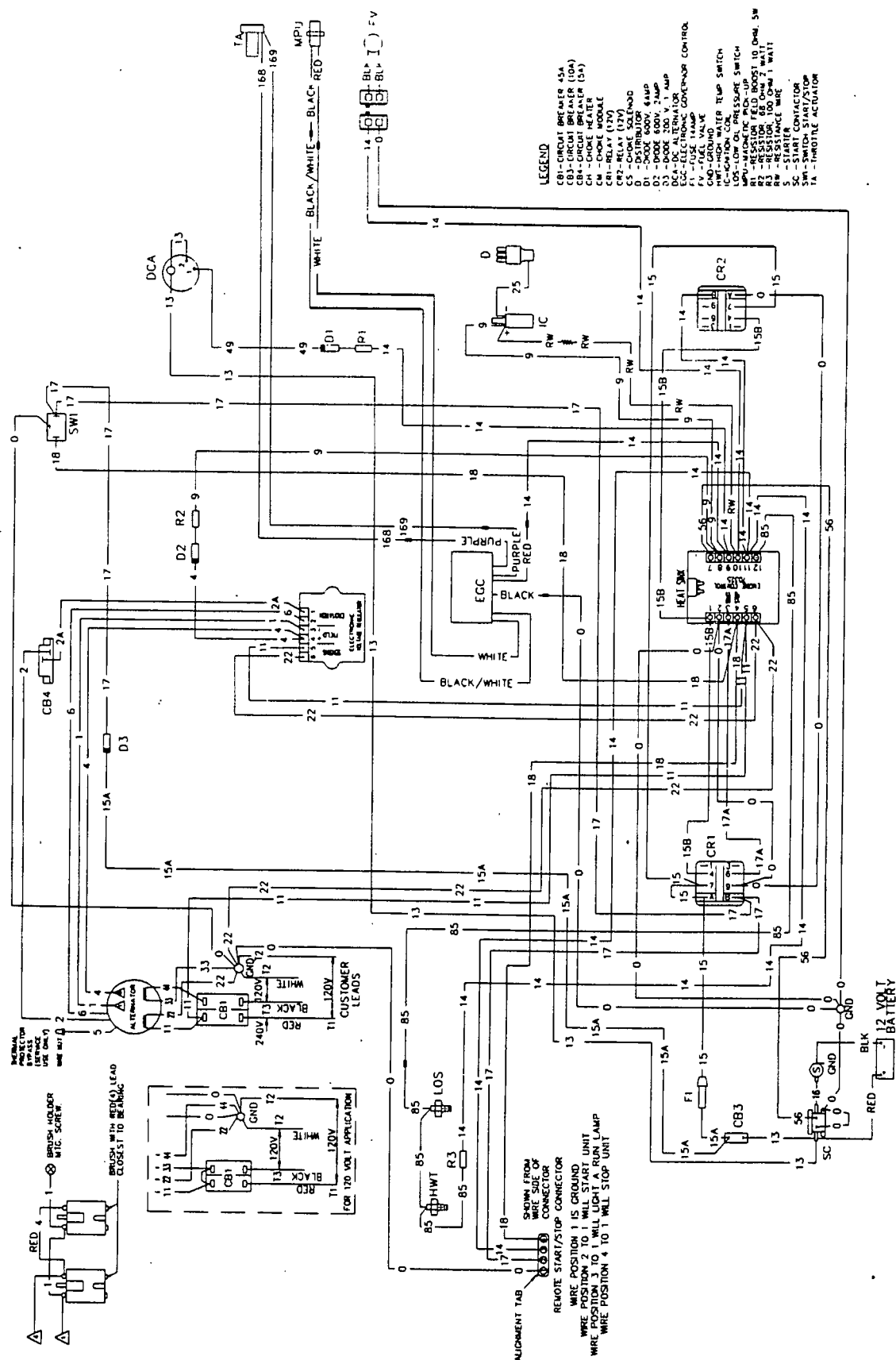
WIRING DIAGRAM (74874)



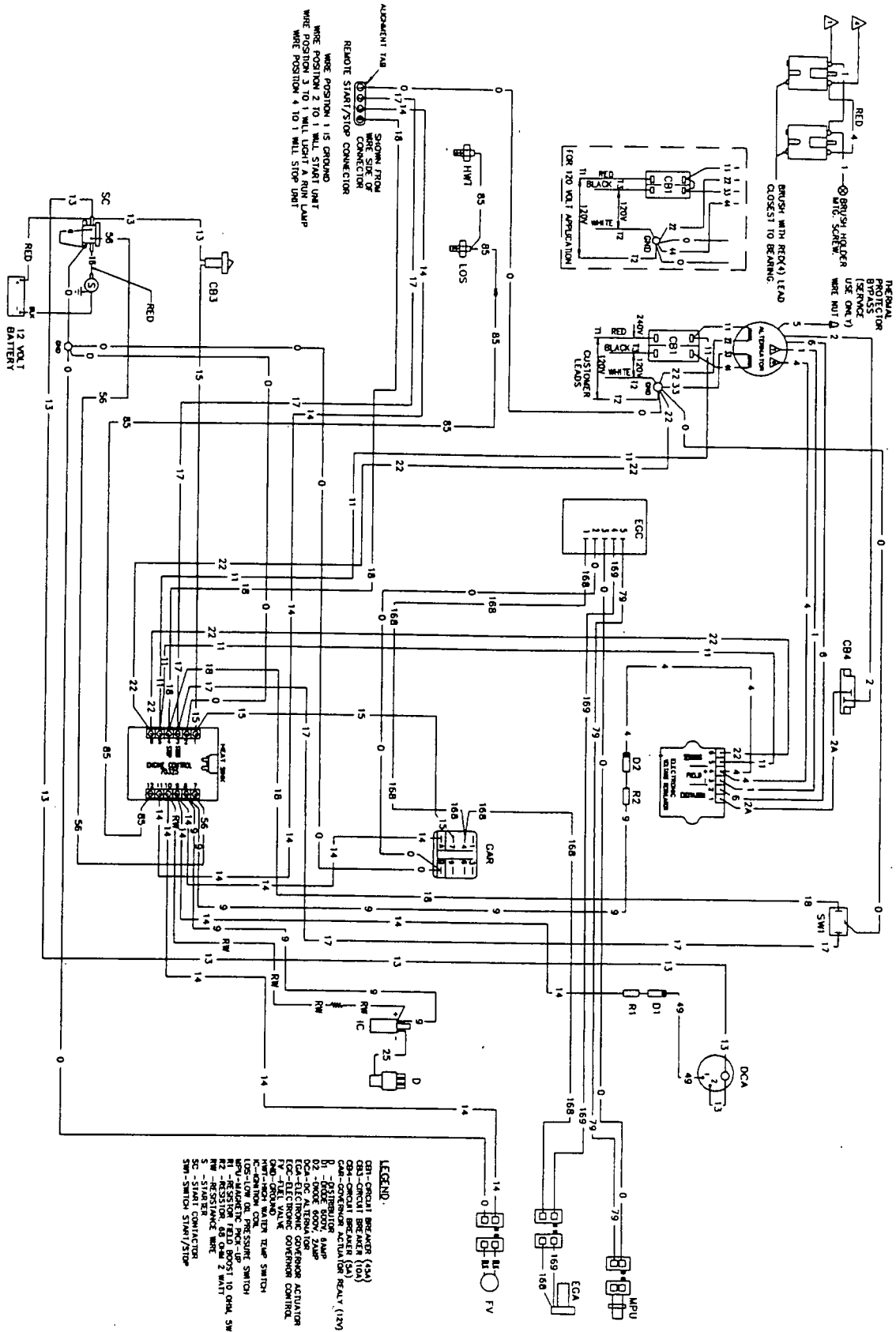
3



Page 11-8



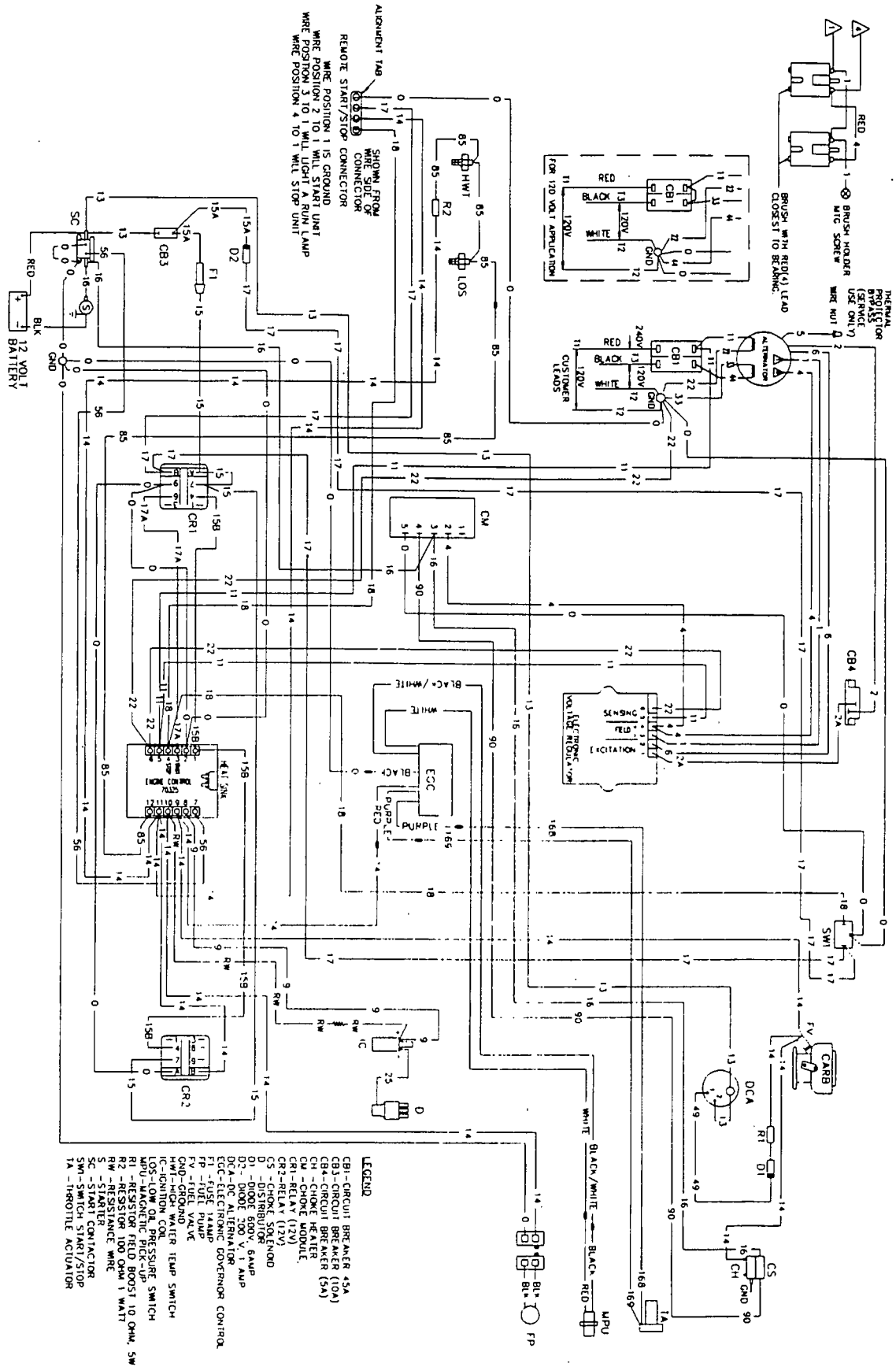
WIRING DIAGRAM (82661)



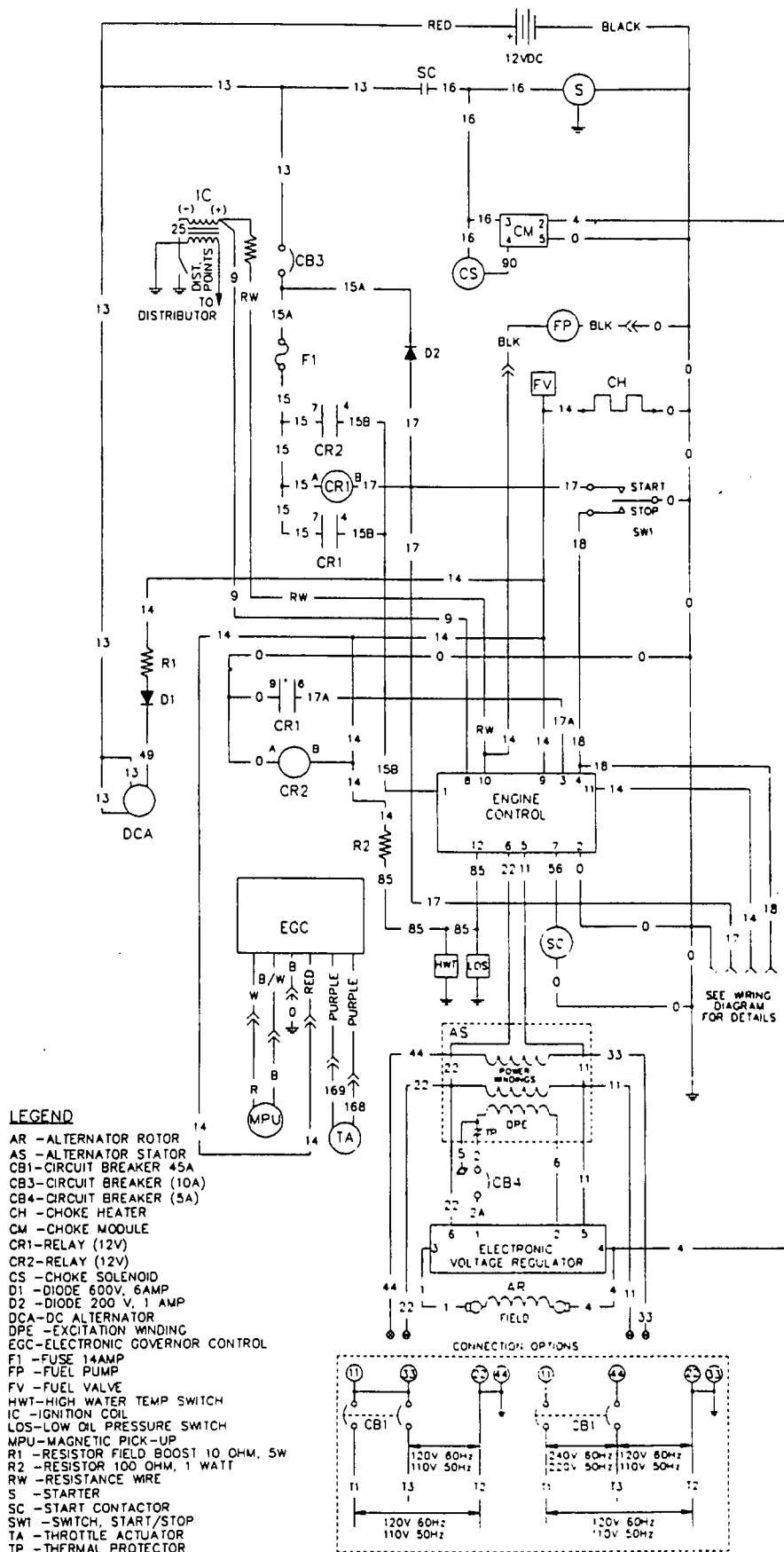
ELECTRICAL SCHEMATIC (82663)



- AR - ALTERNATOR ROTOR
AS - ALTERNATOR STATOR
CBI - CIRCUIT BREAKER 45A
CB3 - CIRCUIT BREAKER (10A)
CB4 - CIRCUIT BREAKER (5A)
GAR - GOVERNOR ACTUATOR RELAY (12V)
D1 - DIODE 600V, 6AMP
D2 - DIODE 200 V, 1 AMP
DCA - DC ALTERNATOR
DPE - EXCITATION WINDING
EGC - ELECTRONIC GOVERNOR ACTUATOR
EGG - ELECTRONIC GOVERNOR CONTROL
EWF - FUEL VALVE
HWT - HIGH WATER TEMP SWITCH
IG - IGNITION COIL
LOS - LOW OIL PRESSURE SWITCH
MPU - MAGNETIC PICK-UP
R1 - RESISTOR FELD BOOST 10 OHM, 5W
R2 - RESISTOR 100 OHM, 1 WATT
RS - RESISTOR WIRE
S - STARTER
SC - START CONTACTOR
SW1 - SWITCH, START/STOP
TP - THERMAL PROTECTOR



ELECTRICAL SCHEMATIC (80771)



2



⑤

ELECTRICAL SCHEMATIC (82662)

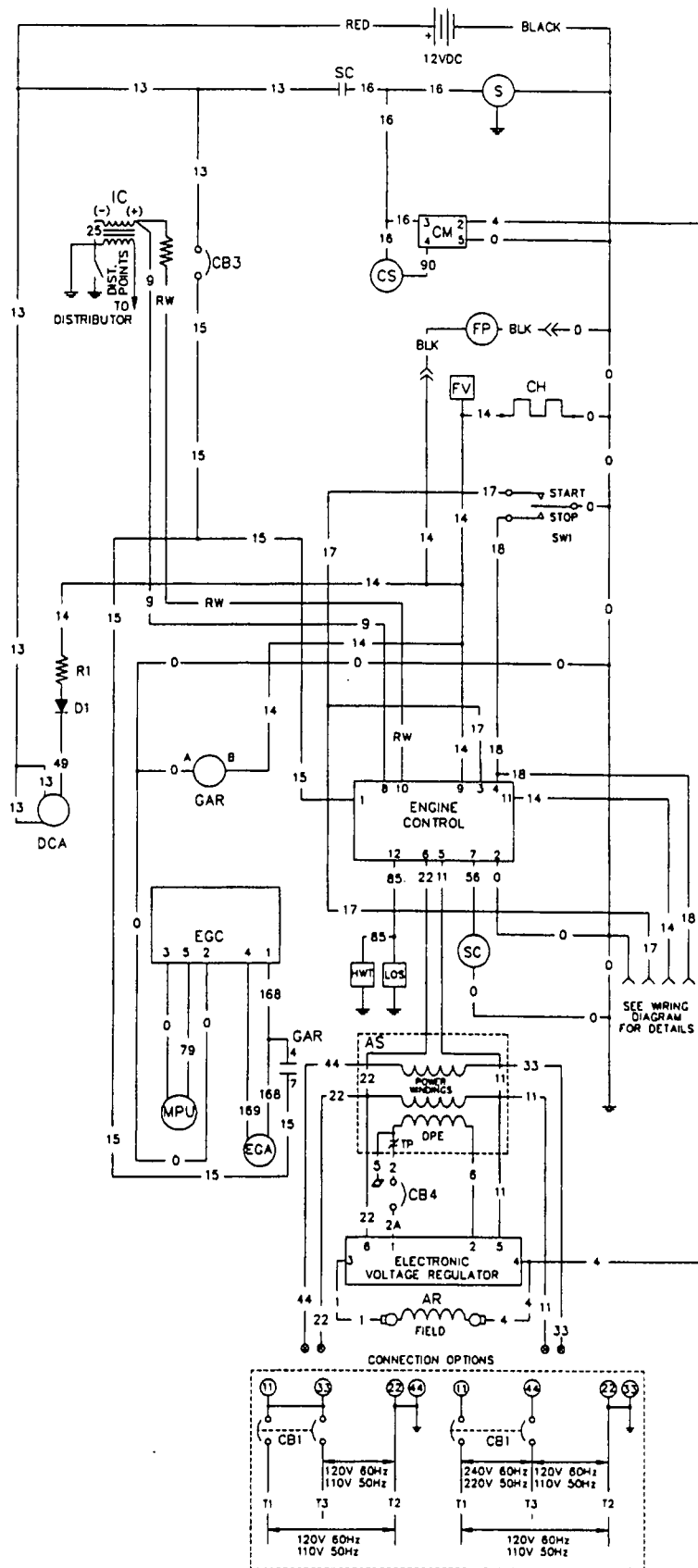


Table 11-8. Length Equivalents

UNIT	cm	Inch	feet	yard	meter	kilometer	mile
cm	0.3937	0.03281	0.01094	0.01	0.00001	-----	-----
Inch	2.54	1	0.0833	0.02778	0.0254	0.00003	-----
feet	30.48	12	1	0.33333	0.3048	0.00030	-----
yard	91.44	36	3	1	0.9144	0.00091	-----
meter	100	39.3701	3280.84	1.09361	1	0.001	0.00062
kilometer	100,000	39370.1	3280.84	1093.61	1000	0.62137	-----
mile	160,934	63,360	5280	1760	1609.34	1609.34	1

Table 11-9. Conversion Table- Units of Power

UNIT	HORSEPOWER	FT-LBS/MIN	WATT	KILOWATT	METRIC HP	BTU/MIN
HORSEPOWER	1	33,000	745.70	0.74570	1.014	42.456
FT-LBS/MIN	-----	1	0.0226	-----	-----	0.00128
WATT	0.00134	44.25	1	0.001	0.00136	0.05687
KILOWATT	1.34102	44,250	1000	1	1.35962	56.8690
METRIC HP	0.98632	32,550	735.498	0.73549	1	41.8271
BTU/MIN	0.02358	778.2	17.5843	0.01758	0.02391	1

Table 11-10. Units of Pressure and Head

UNIT	mm Hg mm of mercury	In. Hg Inches of mercury	In. H ² O Inches of water	ft. H ² O feet of water
mm Hg	1	0.03937	0.52525	0.0446
In. Hg	25.4	1	13.5954	1.13296
In. H ² O	1.86827	0.07355	1	0.08333
ft. H ² O	22.4193	0.88265	12	1
psi	51.7151	2.03603	27.6807	2.30673
kg/cm ²	735.561	28.9591	393.712	32.8094
bar	750.064	29.5301	401.474	33.4562
atmosphere	760	29.9213	406.794	33.8995
kPa	7.50064	0.29530	4.01474	0.33456

Table 11-11. Number of 20 Gallon Propane Cylinders Required at Various Indicated Temperatures when Kept at Least Half Full (Vapor Withdrawal Systems)

WITHDRAWAL RATE	LOWEST AVERAGE WINTER TEMPERATURE					
	32° F.	20° F.	10° F.	0° F.	-10° F.	-20° F.
10 CFH (25,000 BTU/Hour)	1	1	1	1	1	2
25CFH (62,500 BTU/Hour)	1	1	1	2	2	3
50 CFH (125,000 BTU/Hour)	2	2	3	3	4	5
100 CFH (250,000 BTU/Hour)	4	4	5	6	7	10

Table 11-12. Line Sizing Chart for Liquid Propane

LIQUID GAS FLOW (CFH)	GAS FLOW (GPH)	PIPE LENGTH IN FEET									
		1/4"		3/8"		1/2"		3/4"		1"	
		SCHEDULE 40	80	SCHEDULE 40	80	SCHEDULE 40	80	SCHEDULE 40	80	SCHEDULE 40	80
360	10	729	16								
540	15	324	185								
720	20	182	104	825	521						
1440	40	46	26	205	129	745	504				
2160	60	20	11	92	58	331	224				
2880	80	11	6	51	32	187	127	735	537		
3600	100	7	4	33	21	119	81	470	343		

HOW TO USE TABLE 11-12:

1. Determine the required flow of LP gas required to run the generator at its rated maximum capacity. Locate this flow in the left hand column. If the flow falls between two numbers, use the larger number.
2. Determine the total length of piping from source to point of use.
3. Read across chart from left (Required Flow) to right, to find the total length of pipe which is equal to or exceeds the distance from source to point of use.
4. From this point, read up to find the correct pipe size.