Manual Part No. 85680

SERVICE MANUAL

NP and IM Series

RECREATIONAL VEHICLE & INDUSTRIAL MOBILE AC GENERATORS

Liquid-Cooled
Diesel Engine Models

GENERAC CORPORATION

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Issued- 01/04/93

Printed in U.S.A.

IMPORTANT SAFETY NOTICE

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.

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 improper methods or practices from being used which could damage equipment or render it unsafe. These DANGER, CAUTION and NOTE blocks are not exhaustive. Generac could not possibly know, evaluate and advise the recreational vehicle trade of all conceivable ways in which operations described in this manual might be accomplished, or the possible hazardous consequences of each way. Consequently, Generac has not taken any such broad evaluation. Accordingly, anyone who uses any troubleshooting, testing or service procedure that is not recommended by Generac must first satisfy himself that neither his nor the equipment's safety will be jeopardized by the procedure or method he selects.

SERVICE MANUAL

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RECREATIONAL VEHICLE & INDUSTRIAL MOBILE AC GENERATORS

Liquid-Cooled
Diesel Engine Models

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Part 1
THE REVOLVING FIELD AC GENERATOR

NP and IM Series

RECREATIONAL VEHICLE & INDUSTRIAL MOBILE AC GENERATORS

Liquid-Cooled Diesel Engine Models

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Section 1.1
INTRODUCTION

Service Manual Familiarization

This SERVICE MANUAL is divided into six (6) PARTS. Each PART consists of two or more SECTIONS. In turn, each SECTION is divided into SUB-SECTIONS.

At the front of the manual is a main TABLE OF CONTENTS divider page which lists the titles of Parts 1 through 6.

Each PART of the manual is also identified by a divider page which identifies the SECTIONS that make up that PART.

Pages are numbered so as to identify the PART and SECTION, as well as the specific page number. For example, "Page 2.1-3" indicates Page 3 of Part 2, Section 1. This type of numbering system permits individual Sections of the manual to be kept current without affecting the entire manual.

Contents of Manual

Identifying Units By Stator Diameter

Throughout the Manual, generators are identified as having either a "15 inch" or a "10 inch" stator. These numbers refer to the DIAMETER of the stator can laminations. See Figures 1 and 2 on next page.

In addition to the diameter and construction of the stator assembly, the following differences exist between units with 10 inch stator and those having a 15 inch stator:

1. Units with 15 inch stator laminations are equipped with a Part No. 67680 Voltage Regulator.
   a. This type of Voltage Regulator mounts three advisory lamps (LED's) which greatly simplify troubleshooting.
   b. The 67680 Regulator requires a sensing voltage of 240 volts AC. To provide the required 240 volts, a step-up transformer (120 to 240 VAC) is used.

2. Units with 10 inch stator laminations are equipped with a Part No. 81918 Voltage Regulator.
   a. The 81918 Regulator mounts a single lamp (LED) which remains on as long as sensing voltage is available.
   b. The 81918 Regulator requires a sensing voltage of 120 volts AC and the step-up transformer is NOT required.

Three Different Engine DC Control Systems

The NP/IM series generators may be equipped with any one of three different kiinds of engine DC control systems. For convenience, the three different DC systems have been arbitrarily identified as Type 1, Type 2 and Type 3.

Refer to Part 5, "ENGINE ELECTRICAL SYSTEM", for a description Type 1, 2 and 3 DC control systems.

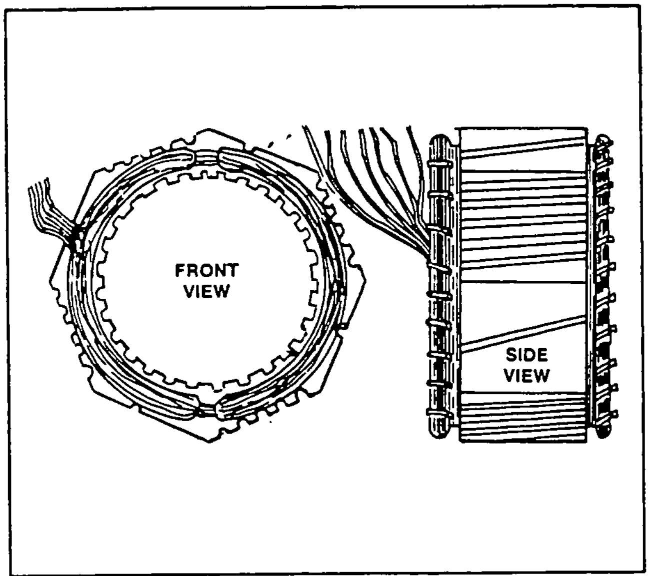


Figure 1. Typical 15 Inch Stator

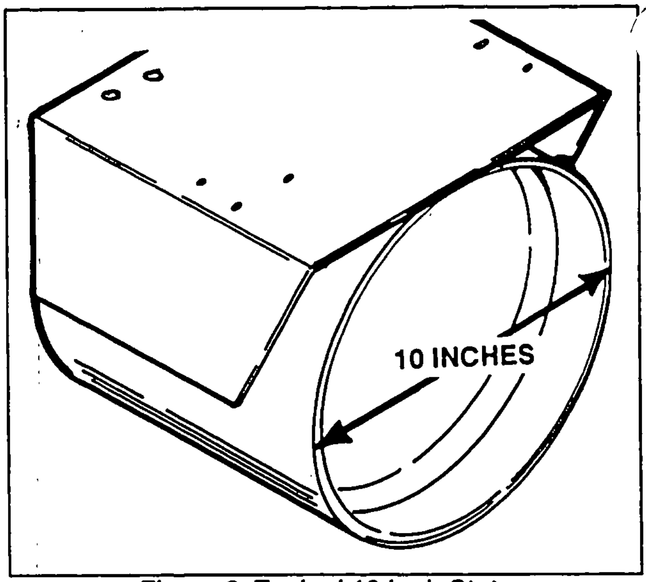


Figure 2. Typical 10 Inch Stator

Section 1.2

HOW A GENERATOR WORKS

General

It has long been known that a relationship exists between magnetism and electricity. The revolving field generator (or alternator) depends on this relationship for its operation. In order to diagnose problems and repair a generator, the service technician must understand this relationship.

Why Generators Produce Electricity

Generators produce an electrical current flow because of the following laws of magnetic induction:

- ☐ When a magnetic field is moved so that it cuts across a conductor, a voltage and current flow are induced into the conductor.
- ☐ When current flows through a conductor, a magnetic field is created around that conductor.

MAGNETIC FIELD CREATES A VOLTAGE:

See Figure 1. When a wire, or coil of wire, is moved through a magnetic field, an electromotive force (EMF) or voltage is induced into the wire. Conversely, movement of the magnetic field so that its lines of flux cut across the wire will induce a voltage into the wire. If the ends of the wire are connected to form a complete circuit, current will flow in the wire. The direction in which the current flows depends on the polarity of the magnetic field and the direction in which the magnet is moved.

CURRENT FLOW CREATES A MAGNETIC FIELD:

See Figure 2. Current flow through a wire or coil of wire will create a magnetic field around the wire. The strength of the magnetic field depends on the amount of current flow and the number of loops or coils in the wire. The direction (polarity) of the magnetic field depends on the direction of current flow through the wire.

A Simple AC Generator

See Figure 3. In the simple generator shown, the revolving magnetic field (Rotor) is a permanent magnet. As the magnet rotates, its magnetic lines of flux cut across a stationary coil of wire called a STATOR. If the stator circuit is completed (by adding a load such as the light bulb), current will flow through the circuit.

A More Sophisticated Generator

In Figure 4, direct current (DC) is delivered to the ROTOR coil through CARBON BRUSHES and SLIP RINGS, to create a magnetic field around the ROTOR. The greater the current flow through the ROTOR windings, the stronger the magnetic field around the ROTOR. The ROTOR's magnetic field cuts across the stationary STATOR windings, to induce a voltage into those windings, with the induced voltage proportional to the strength of the ROTOR's magnetic field.

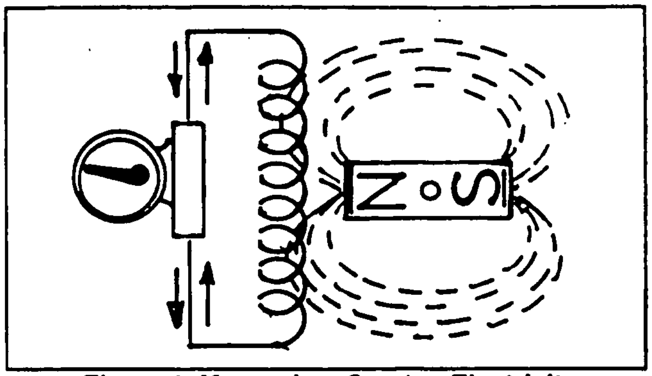


Figure 1. Magnetism Creates Electricity

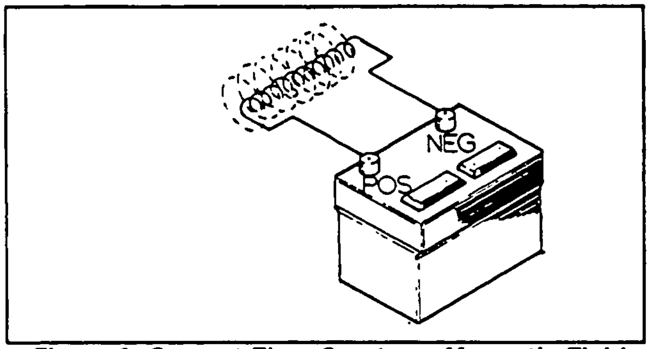


Figure 2. Current Flow Creates a Magnetic Field

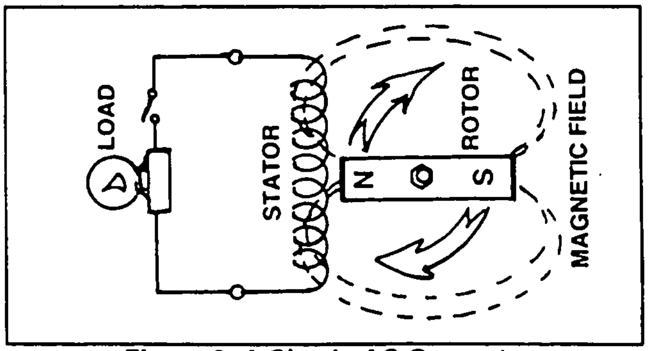


Figure 3. A Simple AC Generator

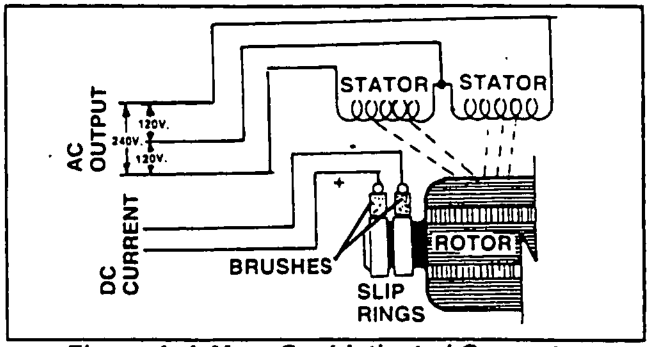


Figure 4. A More Sophisticated Generator

Operational Analysis- Units with 10 Inch Stator Laminations

***NOTE:** See "IDENTIFYING UNITS BY STATOR DIAMETER" on Page 1.1-1.*

Generator Operation may be briefly described as follows:

- ☐ The ROTOR is attached to the engine PTO shaft and rotates at the same speed as the engine.
- ☐ As the Rotor turns, its magnetic lines of flux cut across the stationary coils of (a) a stator excitation winding and (b) dual stator AC power windings. A voltage is induced into these stationary windings.
- ☐ Current flow from the Stator excitation winding is delivered to the Voltage Regulator as unregulated alternating current.
- ☐ Current flow from the Stator AC power windings is delivered to connected electrical loads.
- ☐ Sensing leads deliver a signal of ACTUAL power winding output voltage to the Voltage Regulator, from the Stator AC power windings.
- ☐ The Voltage Regulator electronically compares the ACTUAL power winding voltage to a REFERENCE voltage which was pre-set.
- ☐ If the ACTUAL power winding voltage is less than the Regulator's REFERENCE voltage, Regulator action will (a) change the excitation winding output to direct current (DC), and (b) increase the excitation current flow to the Rotor.
- ☐ If the ACTUAL power winding voltage is more than the Regulator's REFERENCE voltage, regulator action will (a) change the excitation current to direct current, and (b) decrease excitation current to the Rotor.
- ☐ The regulated direct current flow to the Rotor is delivered via brushes and slip rings.
- ☐ A regulated voltage is induced into the Stator AC power windings as the Voltage Regulator acts to maintain an ACTUAL voltage as close as possible to an adjusted REFERENCE voltage.

A = EXCITATION WINDING
B = STATOR AC POWER WINDING
C = STATOR AC POWER WINDING
CB1 = MAIN CIRCUIT BREAKERS
CB4 = EXCITATION CIRCUIT BREAKER
TP = THERMAL PROTECTOR
5 = THERMAL PROTECTOR BYPASS LEAD

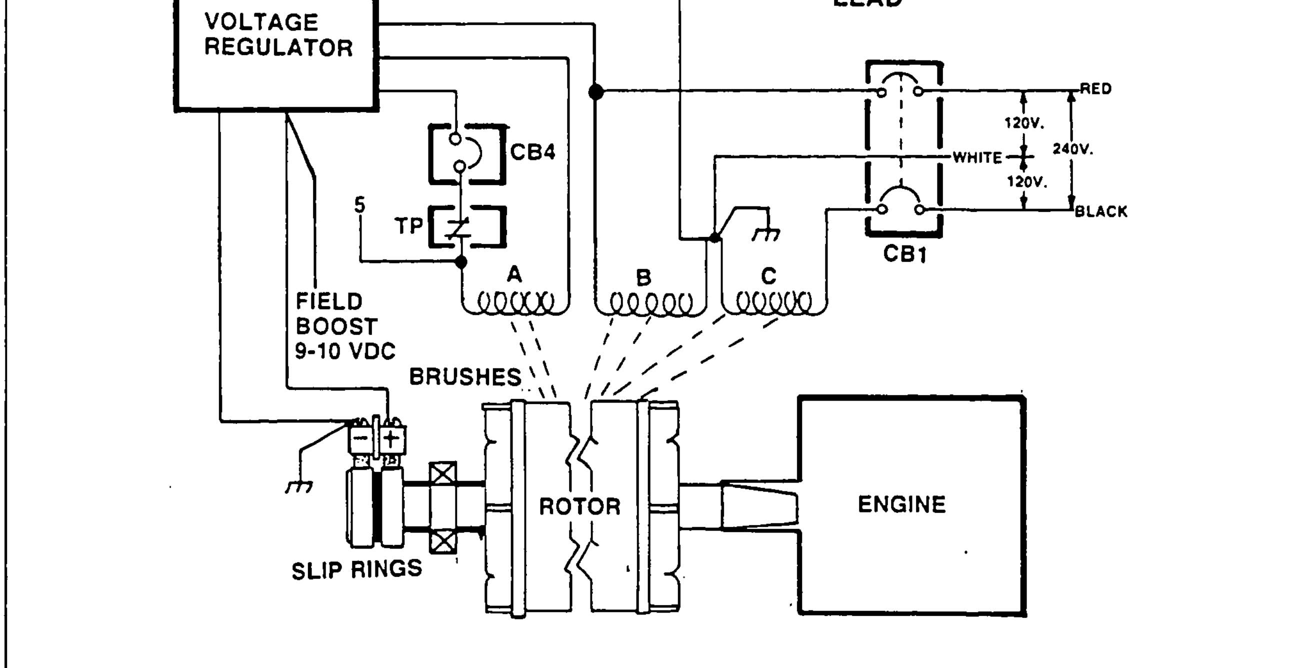


Figure 5. Operating Diagram- Units with 10 Inch Stator Laminations

Operational Analysis- Units with 15 Inch Stator Laminations

Some differences exist between generator models having a 10 inch diameter stator and those with a 15 inch diameter Stator. You may wish to review "IDENTIFYING UNITS BY STATOR DIAMETER" on Page 1.1-1.

Figure 6 is an Operating Diagram for NF eries
generators with a 15 inch diameter stator. T units
are equipped with a Part No. 67680 voltag re-
which requires 240 volts AC sensing. Th ram,
SENSING TRANSFORMER serves to tor's
stator's line-to-neutral sensing voltage to 24 ts.

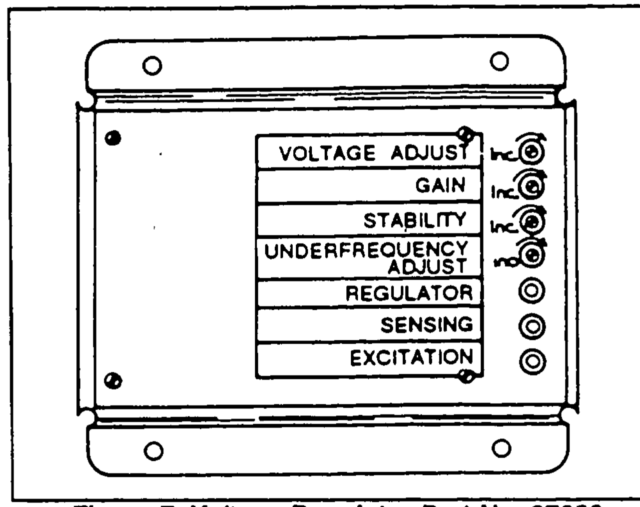
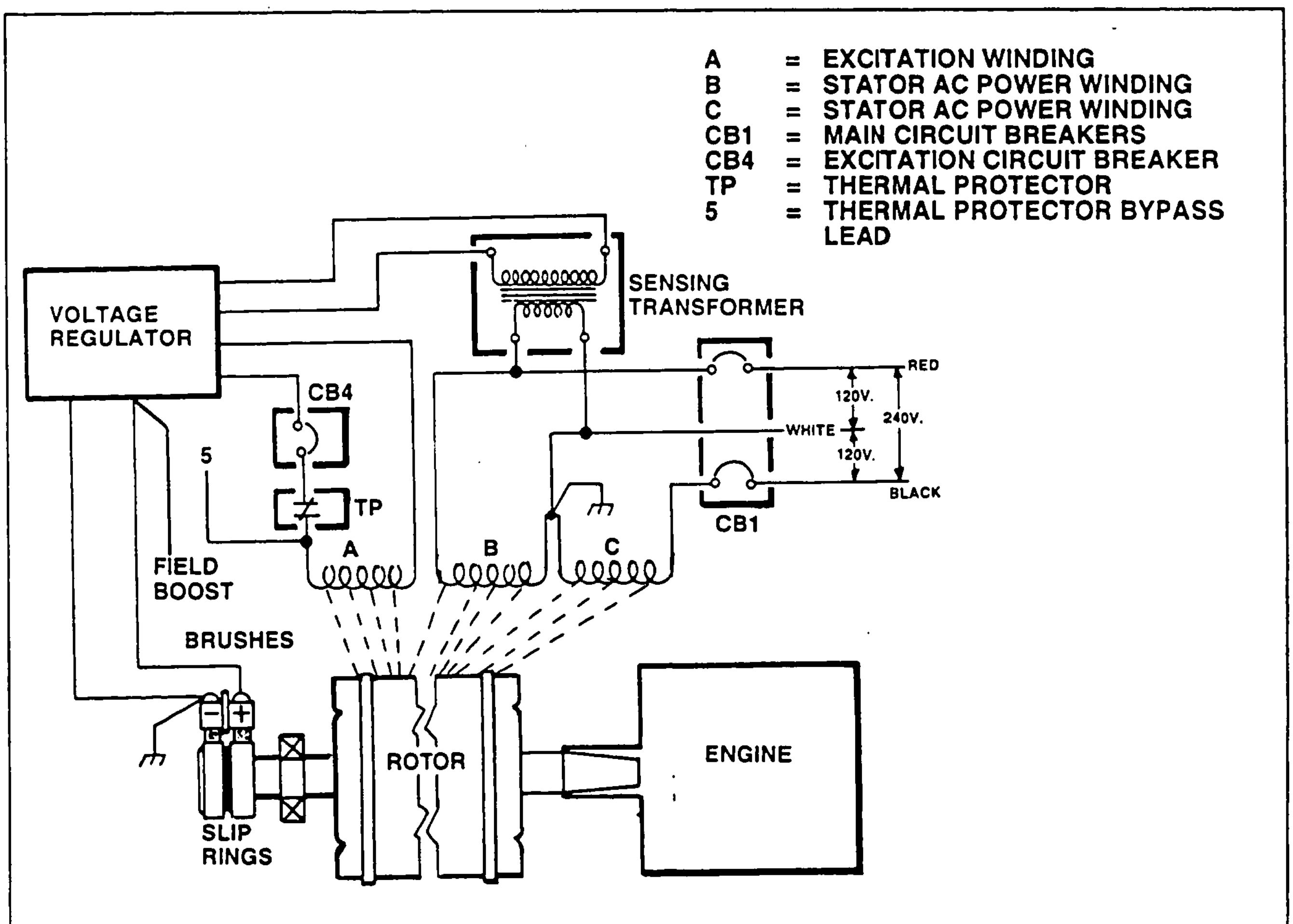


Figure 7. Voltage Regulator Part No. 67680



Operating Diagram- Units with 15 Inch Diameter Stator Laminations

Section 1.3
MAJOR COMPONENTS
(UNITS WITH 15 INCH DIAMETER STATOR)

ITEM	QTY	DESCRIPTION	ITEM	QTY	DESCRIPTION
1	4	Taptite Screw	21	1	Battery Cable Boot
2	4	Taptite Screw	22	1	Starter Motor
3	4	Stud	23	1	Engine Adapter
4	1	Rear Bearing Carrier	24	4	Hex Head Capscrew
5	1	Rotor Bearing	25	2	Vibration Isolator
6	1	Rotor Assembly	26	2	Flatwasher
7	1	Stator Assembly	27	8	Lockwasher
8	10	Hex Head Capscrew	28	2	Hex Head Screw
9	6	Lockwasher	29	8	Hex Nut
10	4	Hex Head Flanged Bolt	30	4	Brush
11	4	Screw	31	2	Brush Holder
12	4	Lockwasher	32	4	Screw
13	1	Flexible Coupling	33	2	Brush Cover
14	1	Fan Ring	34	4	Stud
15	1	Flywheel	35	4	Flanged Nut
16	4	Hex Head Capscrew	36	1	Red Starter Cable
17	1	Air Ring Baffle	37	1	Lockwasher
18	4	Vibration Mount	38	1	Hex Nut
19	6	Flatwasher	39	4	Lockwasher
20	2	Socket Head Capscrew	40	2	Hex Head Capscrew

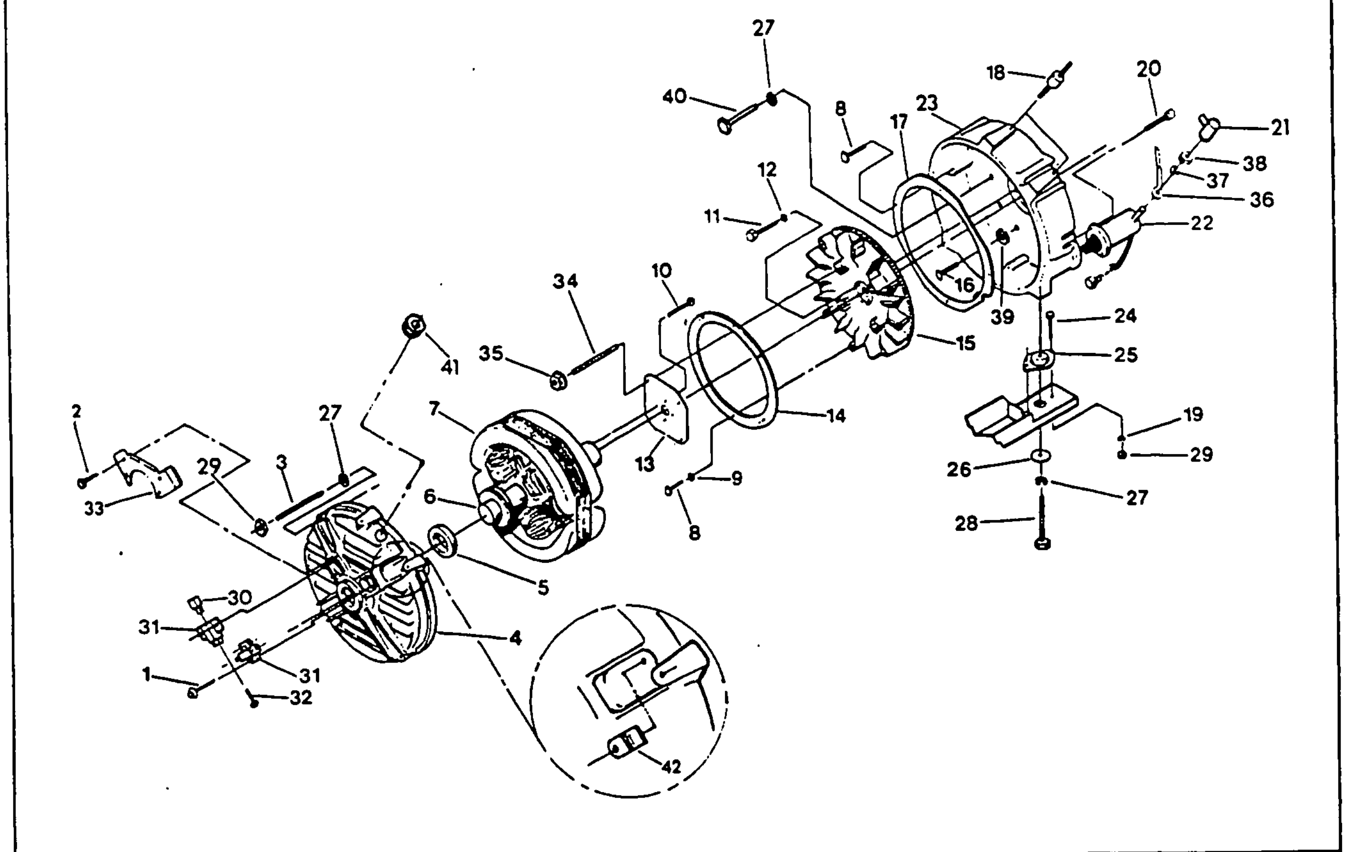


Figure 1. Exploded View of AC Generator with 15 Inch Stator

AC Generator Disassembly

BRUSH ACCESS AND REMOVAL Figures 1 & 2):

See Figure 1. Remove the TAPTITE SCREWS (Item 2) that retain the two BRUSH COVERS (Item 33) to the REAR BEARING CARRIER (Item 4). Remove the BRUSH COVERS (Item 33) to gain access to the BRUSH HOLDERS (Item 31).

See Figure 2, below. Remove Wires No. 1 and 4 from the BRUSHES in both BRUSH HOLDERS. Remove the TAPTITE SCREWS that retain the BRUSH HOLDERS to the REAR BEARING CARRIER. Remove both BRUSH HOLDERS, along with the BRUSHES

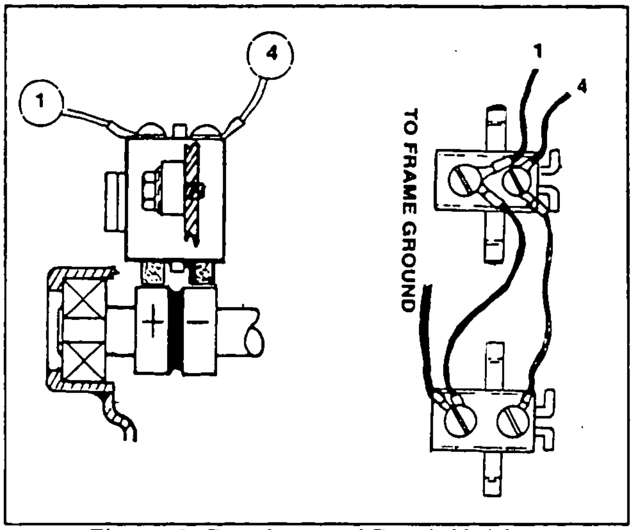


Figure 2. Brushes and Brush Holders

REAR BEARING CARRIER REMOVAL (Figure 1):

Remove HEX NUTS (Item 29), LOCKWASHERS (Item 27) and STUDS (Item 3) that retain the REAR BEARING CARRIER (Item 4). To free the REAR BEARING CARRIER (Item 4) from the ROTOR BEARING (Item 5), use a soft mallet to tap around the outer periphery of the BEARING CARRIER. Continue tapping until the BEARING CARRIER is free of the bearing.

STATOR REMOVAL (Figure 1):

The STATOR (Item 7) is "sandwiched" between the ENGINE ADAPTER (Item 23) and the REAR BEARING CARRIER (Item 4). Carefully remove the STATOR (Item 7). DO NOT PERMIT THE STATOR TO DROP OR BUMP THE ROTOR DURING REMOVAL.

ROTOR REMOVAL (Figure 1):

Remove the four FLANGED NUTS (Item 35) from STUDS (Item 34). The ROTOR (Item 6), with FLEXIBLE COUPLING (Item 13) attached, can now be pulled free of the FLYWHEEL (Item 15).

To remove the FLEXIBLE COUPLING (Item 13) from the ROTOR (Item 6), remove four HEX HEAD FLANGED BOLTS (Item 10).

FLYWHEEL REMOVAL (Figure 1):

Remove four SCREWS (Item 11) and LOCKWASHERS (Item 12). Then, remove FLYWHEEL (Item 15). If desired, the FAN RING (Item 14) can be removed by removing HEX HEAD CAPSCREWS (Item 8) and LOCKWASHERS (Item 9).

ENGINE ADAPTER REMOVAL (Figure 1):

To remove AIR RING BAFFLE (Item 17), remove CAPSCREWS (Item 8) that retain it to the ENGINE ADAPTER (Item 23).

Support the engine and remove all fasteners that retain the ENGINE ADAPTER to the BASE ASSEMBLY. Remove HEX HEAD CAPSCREWS (Item 40) and LOCKWASHERS (Item 27). Finally, remove the ENGINE ADAPTER.

Components Inspection and Testing

GENERAL:

Following disassembly, generator components should be cleaned, dryed and inspected or tested. Never reassemble a generator having defective parts. Keep major parts separated and keep the mounting hardware along with the parts they are used with. Store parts in a clean, dry area where condensation, dirt, or moisture will not damage them.

REAR BEARING CARRIER:

The Rear Bearing Carrier (Figure 1, Item 4) is an aluminum casting. Clean the casting and blow dry with air. Inspect carefully for cracks, obvious damage. An insert has been pressed into the Carrier center bore, to accommodate the Rotor Bearing. Replace the Rear Bearing Carrier if the center bore diameter is not within the following dimensions:

BEARING CARRIER CENTER BORE
2.9527-2.9533 Inches (74.999-75.014mm)

ROTOR BEARING:

The rotor bearing is a prelubricated and sealed ball bearing that requires no additional lubrication for the life of the bearing. Spin the Rotor bearing by hand and check it for binding, seizing, roughness, etc. If the bearing is defective, it must be replaced.

The bearing may be removed from the Rotor shaft using a bearing puller. A new bearing can then be pressed onto the shaft. Exert pressing force on the bearing inner race only- NEVER on the bearing outer race.

Components Inspection and Testing (Continued)

ROTOR ASSEMBLY:

Clean the Rotor with dry, low pressure air (25 psi or less). If the slip rings are dirty or tarnished, clean them with fine sandpaper. Inspect the Rotor for damage.

Check the resistance of Rotor windings with a volt-ohm-milliammeter (VOM). Refer to Section 1.6, "TROUBLESHOOTING (UNITS WITH 15 INCH STATOR)".

Use an insulation resistance tester, megohmmeter, or Hi-Pot tester to test the resistance of Rotor insulation. See Section 1.8, "*INSULATION RESISTANCE TESTS*".

If the insulation resistance is low, dry the Rotor with warm, dry air. DO NOT EXCEED 185° F. (85° C.). If resistance is still low after drying, replace the Rotor Assembly.

STATOR ASSEMBLY:

Clean the Stator Assembly in the same manner as the Rotor was cleaned. Inspect ther Stator for damage.

Use a VOM to check Stator windings resistance (see Section 1.6).

Check the insulation resistance of Stator windings, as outlined in Section 1.8.

FLEXIBLE COUPLING:

Carefully inspect the Flexible Coupling (Figure 1, Item 13) for damage, cracking. Check mounting holes on coupling for elongation and damage. Replace the Coupling, if it is damaged.

FAN RING AND AIR RING BAFFLE:

Inspect the Fan Ring (Figure 1, Item 14) and the Air Ring Baffle (Item 17) for damage, cracking. Replace, if damaged.

FLYWHEEL:

Clean the flywheel. Inspect for damage, cracks, wear, etc. Replace, if necessary.

ENGINE ADAPTER:

Clean the Engine Adapter (Figure 1, Item 23). Inspect the Adapter carefully for damage, wear, cracking, etc. Replace, if necessary.

BRUSH HOLDERS AND BRUSHES:

Inspect Brush Holders and Brushes for damage, cracking, chipping, excessive wear, etc. Replace any defective or damaged part. Brushes must always be replaced in complete sets.

Generator Reassembly

Reassemble the generator in the reverse order of disassembly. The reassembly process requires a great deal of care. Components must be properly aligned and retained. Tighten all fasteners to the recommended torque values (see Part 6, "SPECIFICATIONS AND CHARTS"). Following reassembly, perform an operational test of the unit (Section 1.9).

Components In Generator Control Panel

INTRODUCTION:

Figure 3 (next page) is an exploded view of the generator control panel. The Panel houses or mounts several important AC generator components, as well as components that are part of the engine DC electrical systems.

ENGINE ELECTRICAL SYSTEM COMPONENTS:

The Control Panel houses the following components that are part of the engine electrical system. For information on these components, refer to Part 5 of this Manual, "ENGINE ELECTRICAL SYSTEM".

- ☐ The 14 and 30 amp Fuses (Items 4 and 5).
- ☐ The 10 amp DC Circuit Breaker (Item 6).
- ☐ The two 12 volts DC Relays (Items 7 and 8).
- ☐ The DC Voltage Regulator (Item 13).
- ☐ Engine Control Circuit Board (Item 39).
- ☐ Hourmeter (Item 23).
- ☐ Start-Stop Switch (Item 24).
- ☐ Preheat Switch (Item 25).

AC GENERATOR COMPONENTS:

The following components, housed in the control panel, are major generator components and will be discussed in this Section and Sub-Section.

- ☐ Excitation Circuit Breaker (Item 11).
- ☐ AC Voltage Regulator (Item 14).
- ☐ The Sensing Transformer (Item 15).
- ☐ AC Circuit Breaker (Item 16).

In addition to the above components, a THERMAL PROTECTOR is physically imbedded in the wire windings of the Stator Assembly. A discussion of this component will also be included in this Section.

EXCITATION CIRCUIT BREAKER:

The excitation circuit breaker is housed in the control panel and connected in series with the Stator Excitation winding output to the Voltage Regulator.

If this Breaker should open, loss of unregulated excitation current to the Regulator will occur. The Regulator will then shut down and loss of regulated excitation current to the Rotor will occur. Generator AC output will then be proportional to Rotor residual magnetism only (about 2-7% of rated voltage).

ITEM	QTY	DESCRIPTION
1	2	Snap Bushing
2*	1	FUSE HOLDER- 30 amp
3*	1	FUSE HOLDER- 14 amp
4*	1	30 AMP FUSE
5*	1	14 AMP FUSE
6*	1	10 amp DC Circuit Breaker
7*	1	12 volts DC RELAY
8*	1	12 volts DC RELAY
9	1	Solderless Lug
10	1	90° Conduit Clamp
11**	1	EXCITATION CIRCUIT BREAKER
12	1	Control Panel Box
13*	1	DC VOLTAGE REGULATOR
14**	1	AC VOLTAGE REGULATOR
15**	1	SENSING TRANSFORMER
16	1	AC CIRCUIT BREAKER
17	4	Pan Head Screw
18	4	Lockwasher
19	1	Lockwasher
20	1	Control Panel
21	1	Panel Decal
22	2	Pan Head Screw
23*	1	HOURMETER
24*	1	START-STOP SWITCH
25*	1	PREHEAT SWITCH
26	2	Hex Head Capscrew
27	2	External Lockwasher
28	10	Lockwasher
29	8	Flatwasher
30	8	Hex Head Capscrew
31	-	Customer Leads (Not Shown).
32	1	Pan Head Screw
33	8	Pan Head Screw
34	8	Lockwasher
35	8	Hex Nut
36	4	Self Tapping Screw
37	4	Spacer Nut
39*	1	ENGINE CONTROL CIRCUIT BOARD
40	6	Lockwasher
41	2	Hex Nut
42	2	Hex Head Capscrew
44	1	Panel Wiring Harness
45	1	Engine Wire Harness
46	4	Vibration Dampener
47	4	Hex Nut
48	4	Flatwasher

* See Part 5, "ENGINE ELECTRICAL SYSTEM".
** Part of AC generator circuit, included in this Section.

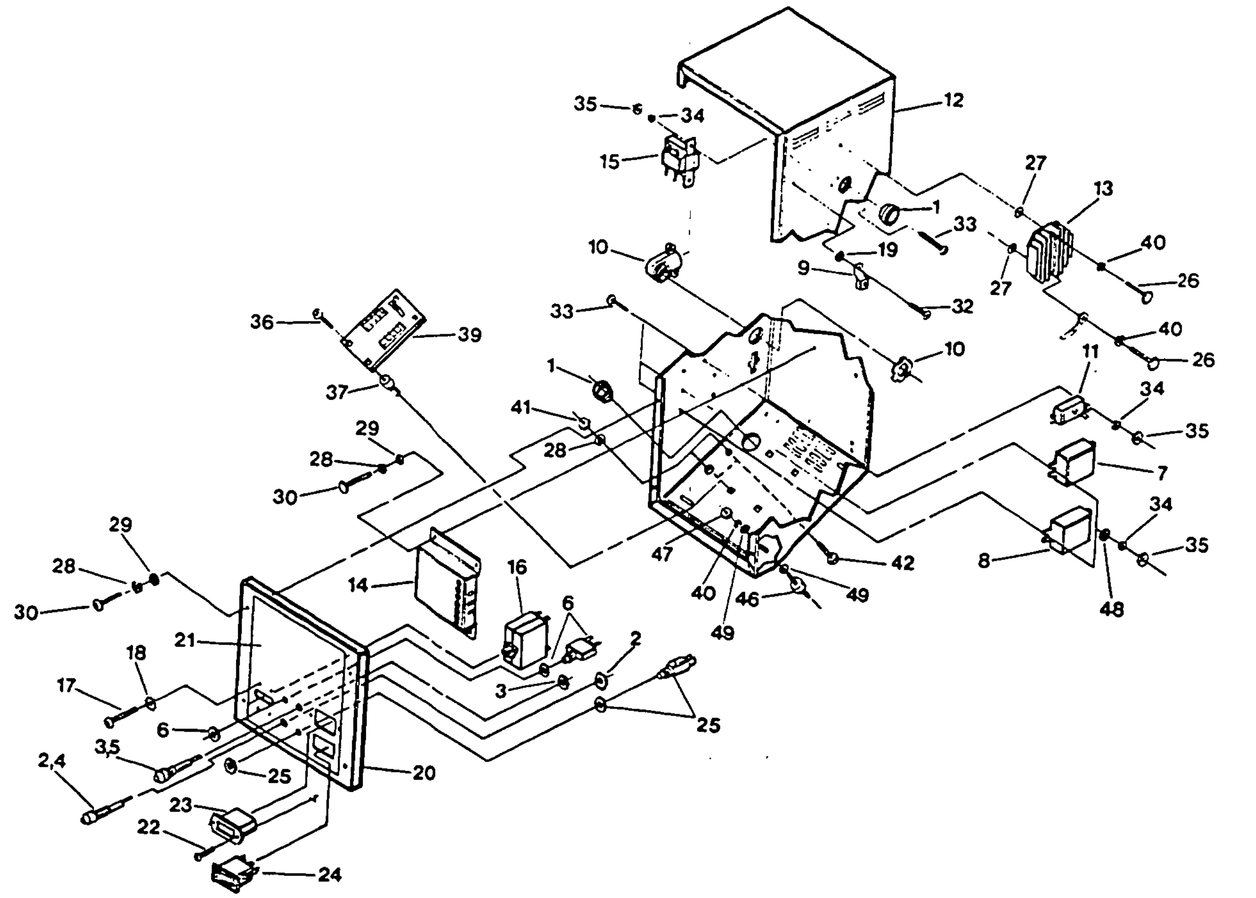


Figure 3. Exploded View of Control Panel

Components In Generator Control Panel (Continued)

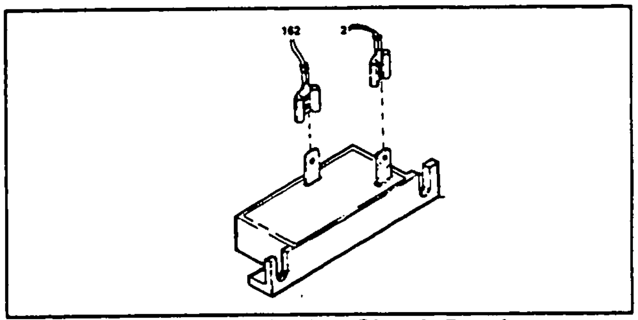


Figure 4. Excitation Circuit Breaker

AC VOLTAGE REGULATOR:

The Voltage Regulator is powered by stator excitation winding AC output. Approximately 4 to 8 volts is required from that power source to turn the regulator on.

The Regulator is equipped with three (3) lamps (LED's or "light emitting diodes). See Figure 5. These lamps are normally on during operation with no faults in the system. The green EXCITATION lamp and the red REGULATOR lamp are both turned on by stator excitation winding output. If, for any reason, stator excitation winding output were to be reduced, the two lamps would begin to dim. Finally, at some mid-point voltage and current, the two lamps will no longer glow visibly.

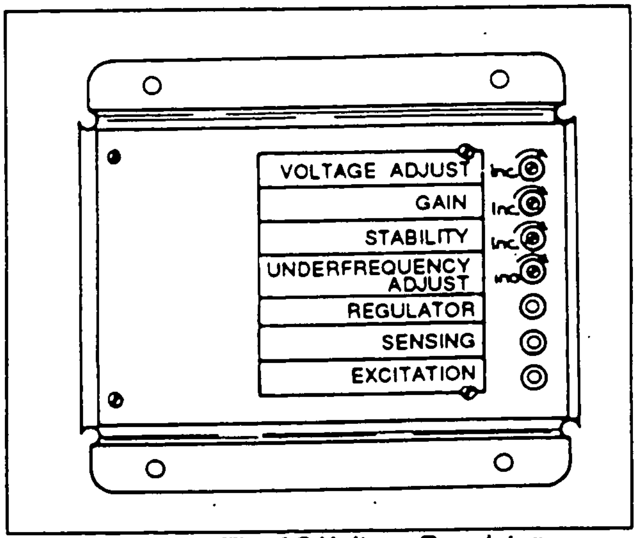


Figure 5. The AC Voltage Regulator

The yellow SENSING lamp is powered by sensing input to the Regulator from the stator AC power windings. The brightness of this lamp (LED) will depend on available sensing voltage..

NOTE: Sensing input to the Regulator is actually taken from line-to-neutral stator leads and is about 120 volts AC. However, this voltage is boosted to about 240 volts AC by the action of a sensing transformer.

The following facts apply to Voltage Regulator operation:

1. The Regulator will shut down on occurence of one or more of the following conditions:
   a. Loss of sensing voltage.
   b. Loss of stator excitation voltage input to the Regulator.
   c. Loss of circuit reference.

NOTE: The term "circuit reference" refers to voltage regulator settings. The Regulator "regulates" excitation winding current flow to the Rotor windings in order to maintain a sensing (actual) voltage that is commensurate with a preset "reference" voltage. The reference voltage is adjustable within a 20 percent range at the Regulator. Voltage regulation is accomplished by electronically maintaining an ACTUAL voltage that is very close to the Regulator's preset REFERENCE voltage.

2. During generator operation, all three Regulator lamps should be ON.
   a. REGULATOR lamp ON indicates the Regulator is functioning normally.
   b. SENSING lamp ON indicates that normal sensing voltage is available to the Regulator.
   c. EXCITATION lamp ON indicates that unregulated excitation winding output is available to the Regulator.
3. If the red REGULATOR lamp is OUT, a Voltage Regulator fault exists or the Regulator has shut down due to occurence of one or more Regulator shutdown conditions. See Step 1 above for conditions that will result in Regulator shutdown.
   a. Expect to see a generator AC output voltage that is commensurate with the Rotor's residual magnetism.
   b. Rotor residual magnetism will supply approximately 2 to 7 percent of the unit's rated voltage.

NOTE: "Residual" magnetism is that magnetism that is normally always present in the Rotor. The Rotor may be considered a "permanent magnet".

Components In Generator Control Panel (Continued)

AC VOLTAGE REGULATOR (CONT'D):

4. If the green EXCITATION lamp goes out, loss of stator excitation winding output to the Regulator has occured.
   a. Loss of excitation winding output will result in Regulator shutdown. The red REGULATOR lamp will then go out, as well.
   b. Under this condition, look for a generator AC output voltage that is commensurate with residual Rotor magnetism (about 2-7% of rated volts).
   c. When the REGULATOR and EXCITATION lamps are both out, the excitation circuit from the stator excitation windings to the voltage regulator is suspect (inclusive).
5. Should the yellow SENSING lamp go out, loss of sensing voltage to the Regulator has occured.
   a. Loss of sensing may cause the Regulator to shut down. Both the SENSING lamp and the REGULATOR lamp will then go out.
   b. Generator AC output voltage will then be commensurate with Rotor residual magnetism (2-7% of rated volts).
   c. Look for a fault in the sensing circuit.
6. If all three lamps go out, look for a fault that might cause both sensing and excitation to fail.
   a. Look for dirty or corroded slip rings, bad brushes, defective Rotor.
   b. Look for open circuit in Wires No. 1 and/or 4.
   7. If the red REGULATOR lamp flashes, the Regulator's STABILITY potentiometer requires adjustment.

SENSING TRANSFORMER:

The Part No. 67680 Voltage Regulator requires a "line-to-line" sensing voltage (240 volts) for proper operation. However, the sensing is taken from "line-to-neutral" Wires No. 11 and 22 (120 volts). For that reason, the primary coil of a sensing transformer is connected in series with the sensing leads. The sensing transformer is a "step-up" type. That is, 120 volts AC in its primary coil will induce 240 volts into its secondary coil. It is the secondary coil voltage that is delivered to the regulator as sensing voltage.

The sensing transformer is housed in the generator control panel and is used on generator's with the Part No. 67680 Voltage Regulator and with 15 inch diameter stator laminations.

The sensing transformer is shown pictorially and schematically in Figure 6.

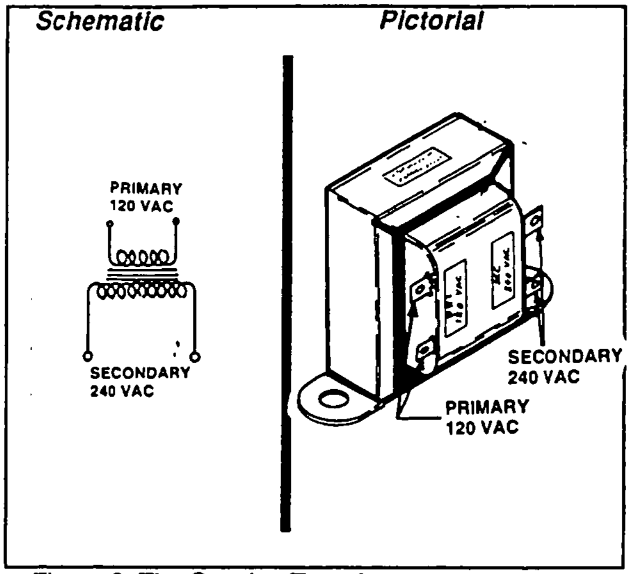


Figure 6. The Sensing Transformer

AC CIRCUIT BREAKER:

The AC circuit breaker protects the unit against current overload by opening the AC output circuit in the event the generator's current (amperage) capacity is exceeded. The amperage at which the breaker will trip (open) is the breaker's trip rating.

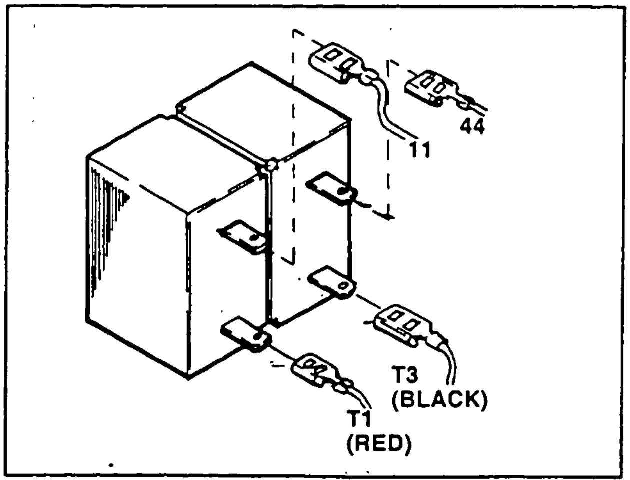


Figure 7. AC Circuit Breaker (Typical)

The AC circuit breaker used on any specific generator model will depend on the rated current (amperage) capacity of that model.

Thermal Protector

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

If the switch contacts should open, excitation winding AC output to the Voltage Regulator will be terminated and the Regulator's green EXCITATION lamp will go out. Since the Regulator cannot operate without excitation winding output, the red REGULATOR lamp will also go out. Generator AC output voltage will then drop to a value commensurate with the Rotor's residual magnetism.

If the Thermal Protector contacts open during operation due to a stator overtemperature condition, the cause of the overtemperature condition must be found and corrected. High internal stator temperatures can be caused by any one of the following:

- ☐ Insufficient cooling air flow into the generator interior. Look for blockage of cooling air inlet/outlet openings, air openings that are too small, ambient temperatures that are too high, etc.
- ☐ Exceeding the wattage/amperage capacity of the generator. If the unit is overloaded for a period of time, internal stator temperatures can rise quickly and cause the Thermal Protector contacts to open.
- ☐ A shorted condition in the generator stator windings or in an electrical load connected to the generator's AC output.

The Thermal Protector is not accessible and cannot be removed and replaced. If the device has failed open, it can be bypassed by connecting excitation lead No. 2 to a bypass lead (Wire No. 5). Once the device has been bypassed, stator overtemperature protection is no longer available.

Field Boost

When the generator engine is cranked, direct current (DC) is delivered to the Rotor windings. The current flow is provided by the action of an Engine Control circuit board housed in the control panel and is delivered to the Rotor via Wire No. 9, a Field Boost Resistor (R2), a Field Boost Diode (D2), Wire No. 4, and the brushes and slip rings. The direct current (approximately 9-10 volts DC) flows through the Rotor windings, the negative (-) slip ring and brush, and to ground.

Field boost current creates a magnetic field strength that is additive to the Rotor's residual magnetism. The increased magnetic field strength during engine cranking provides an early "pickup" voltage in the stator. The Regulator is turned on more quickly and AC output occurs sooner. In effect, field boost current "flashes the field" on every startup.

Failure of the field boost system may or may not result in a reduction of AC output to that produced by residual Rotor magnetism. If residual magnetism is adequate to turn the Regulator on and provide the required pickup voltage, the generator will operate normally with or without field boost. However, if residual magnetism is not adequate, generator AC output will not build and will be commensurate with Rotor residual magnetism.

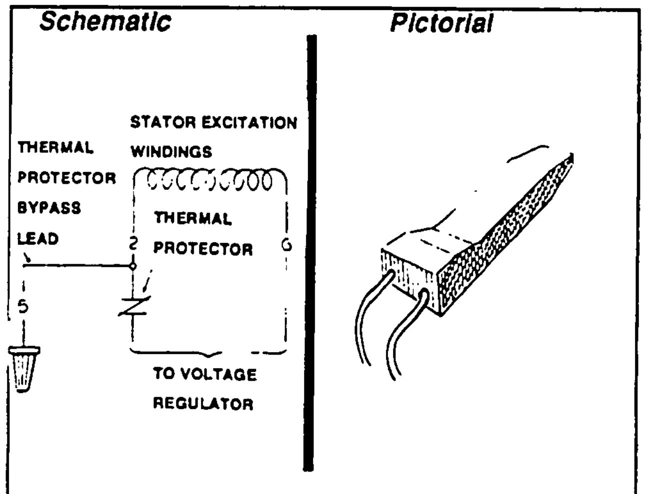
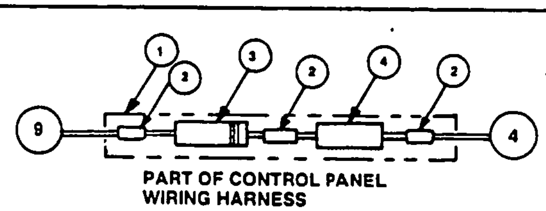


Figure 8. Thermal Protector



ITEM	DESCRIPTION
1	HEAT SHRINK
2	BARREL LUG
3	DIODE- 600V., 6 AMP
4	RESISTOR- 5 WATT, 10 OHMS

Figure 9. The Field Boost Circuit

Section 1.4

MAJOR COMPONENTS (UNITS WITH 10 INCH STATOR)

ITEM	QTY	DESCRIPTION	ITEM	QTY	DESCRIPTION
1	1	Rotor Assembly	23	9	Flatwasher
2	1	Drive Key	24	1	Engine Plate
3	2	Dowel Pin	25	3	Hex Head Capscrew
4	1	Blower Housing	26	10	Hex Head Capscrew
5	1	Air Outlet Screen	27	12	Hex Head Capscrew
6	4	Hex Head Capscrew	28	1	Flywheel
7	16	Lock Washer	29	6	Hex Head Capscrew
8	12	Flat Washer	30	1	Spacer
9	4	Vibration Dampener	31	1	Hex Head Capscrew
10	1	Stator Assembly	32	1	Lock Washer
11	1	Rear Bearing Carrier	33	1	Flexible Coupling
12	2	Brush Holder	34	6	Socket Head Capscrew
13	4	Hex Head Capscrew	35	1	Drive Hub
14	1	Bearing Carrier Gasket	36	1	Cooling Fan
15	1	Flame Arrestor	37	1	Starter Solenoid
16	1	Bearing Carrier Cover	38	6	Hex Head Capscrew
17	4	Bolt	39	2	Flat Washer
18	6	Lock Washer	40	2	Hex Nut
19	4	Capscrew	42	2	Hex Nut
20	1	Starter Assembly	43	2	Hex Head Capscrew
21	2	Socket Head Capscrew	44	1	DC Voltage Regulator
22	33	Lock Washer	45	1	Starter to Starter Solenoid Cable

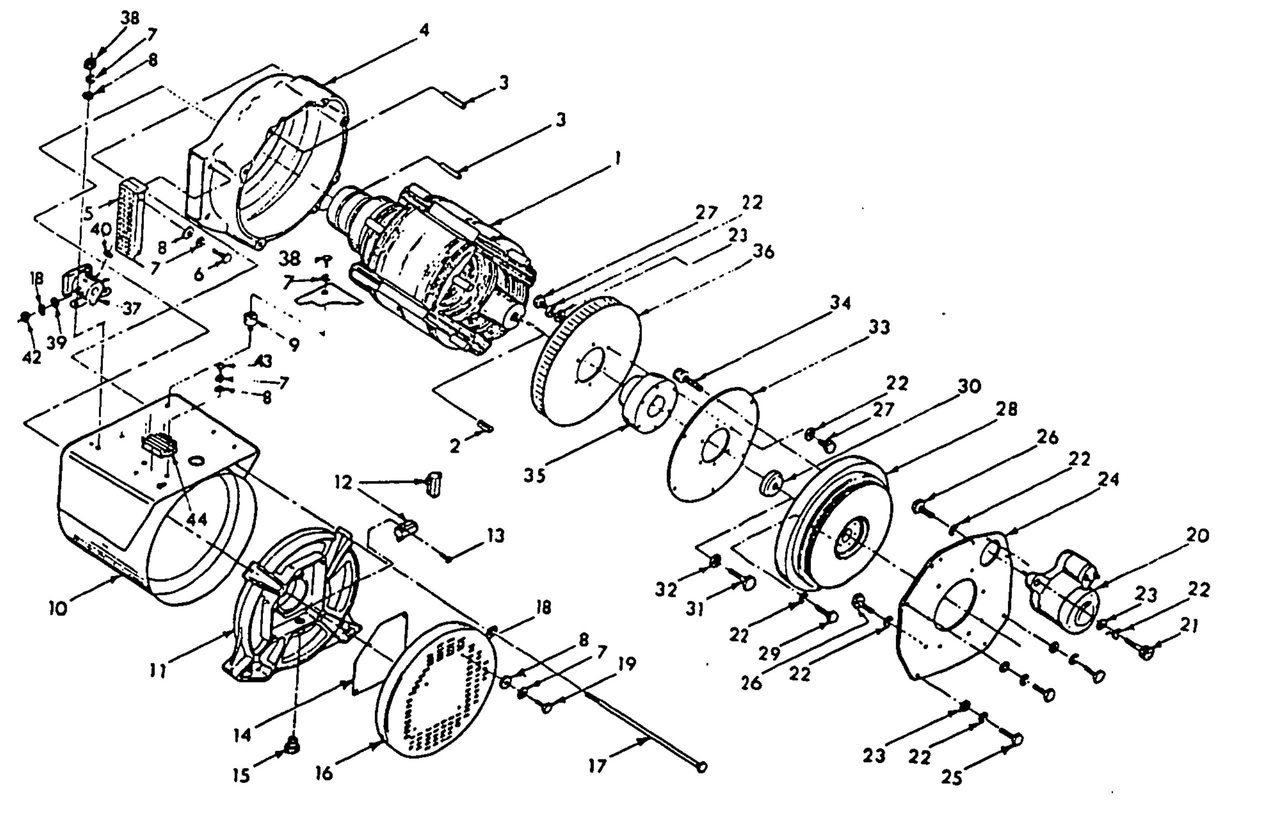


Figure 1. Exploded View of Generator with 10 Inch Diameter Stator

AC Generator Disassembly

BEARING CARRIER COVER:

Remove four (4) CAPSCREWS (Item 19), FLAT WASHERS (Item 8), and LOCK WASHERS (Item 7). Then, remove the BEARING CARRIER COVER (Item 16) and the BEARING CARRIER GASKET (Item 14).

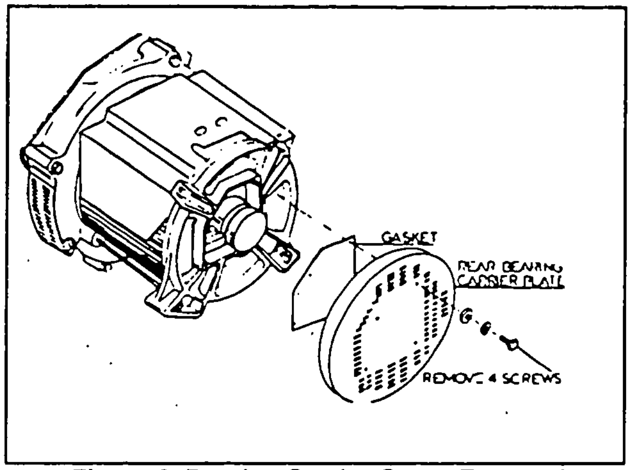


Figure 2. Bearing Carrier Cover Removal

BRUSH HOLDERS AND BRUSHES:

Remove wires from BRUSHES (Item 12). Remove SCREWS (Item 13) and remove BRUSH HOLDERS (Item 12) with brushes.

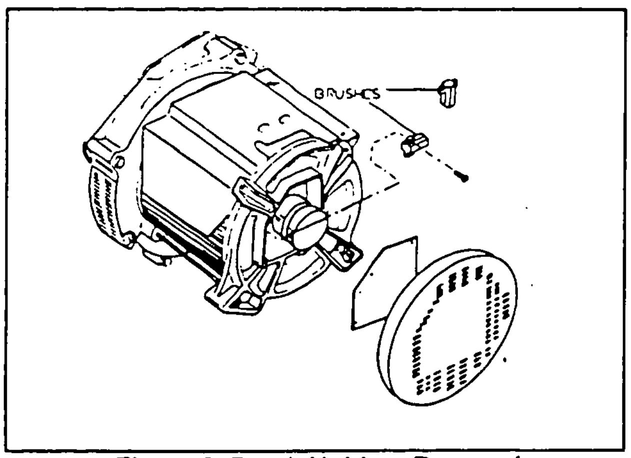


Figure 3. Brush Holders Removal

REAR BEARING CARRIER:

A bearing carrier puller (Figure 4) can be used to remove the Rear Bearing Carrier. Retain the puller to the Bearing Carrier using the same screws that originally held the Bearing Carrier Cover.

Remove fasteners that retain the Bearing Carrier to the mounting rail.

Remove all four long stator bolts along with washers.

Turn the large bolt at center of Bearing Carrier puller until end of bolts is flush with the puller. Retain the puller to the Bearing Carrier with original Carrier Cover screws. Turn the large center bolt of puller until the bearing carrier is free of the Rotor Bearing. Completely remove the Bearing Carrier.

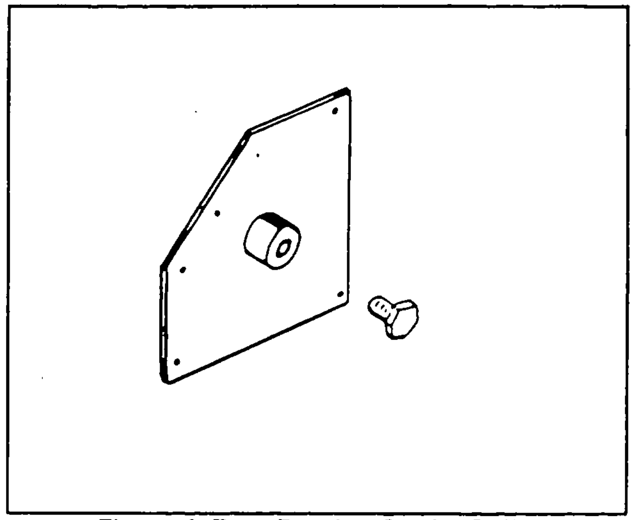


Figure 4. Rear Bearing Carrier Puller

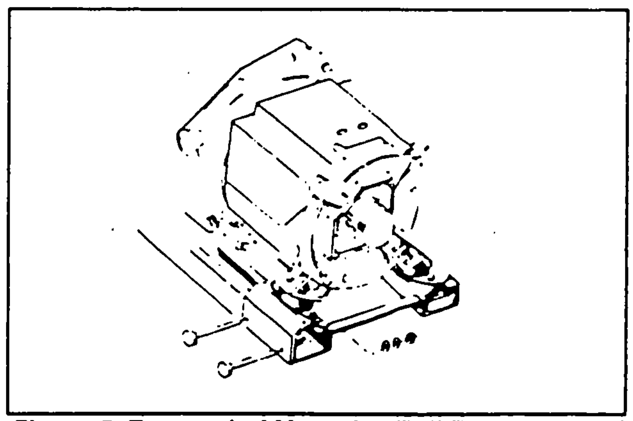


Figure 5. Removal of Mounting Rail Fasteners and Stator Bolts

STATOR REMOVAL:

CAUTION. Use care when removing the Stator. Do NOT allow it to drop or bump the Rotor during removal.

Free the Stator from the Blower Housing and remove. See Figure 6.

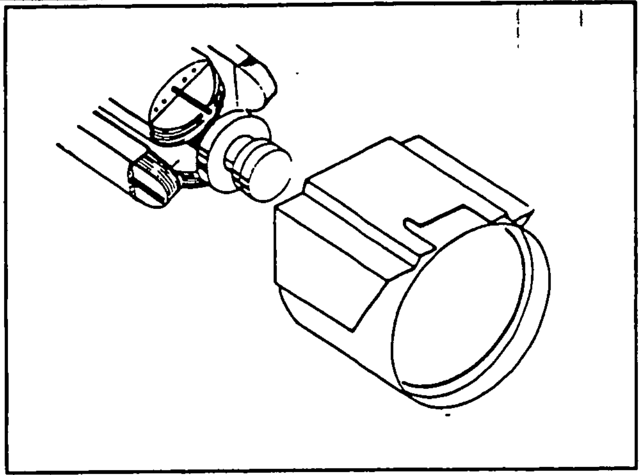


Figure 6. Stator Removal

BLOWER HOUSING REMOVAL:

Remove the capscrews that retain the Blower Housing to the Engine Plate, along with flat washers, lock washers and hex nuts. Note positions of longer and shorter screws, for reassembly.

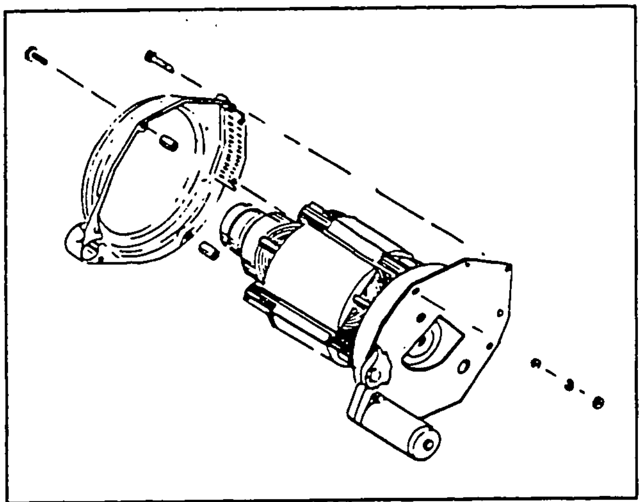


Figure 7. Blower Housing Removal

ROTOR REMOVAL:

Remove capscrews and washers that retain the Coupling Plate to the Ring Gear. Remove Rotor, Cooling Fan, Drive Hub and Coupling Plate as a unit.

If desired, the Cooling Fan, Drive Hub and Coupling Plate may be removed from the Rotor.

ENGINE PLATE REMOVAL:

Remove starter retaining bolts and remove starter. Remove bolts that retain the engine plate. Remove the engine plate.

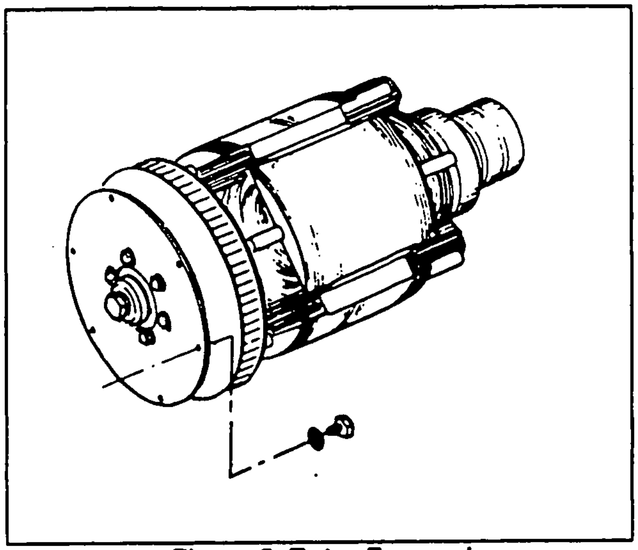


Figure 8. Rotor Removal

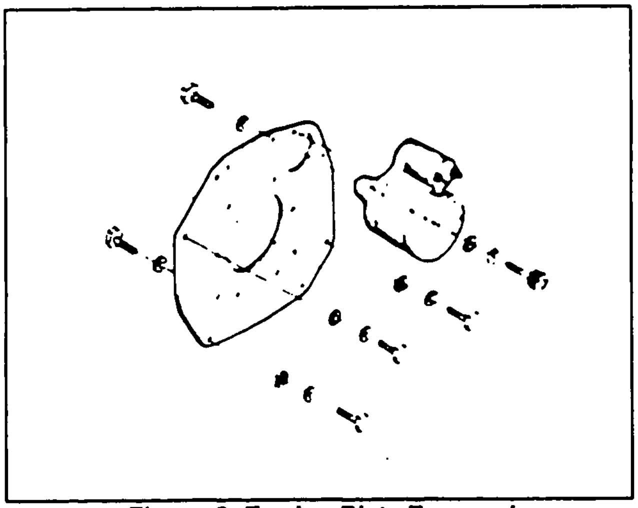


Figure 9. Engine Plate Removal

Components Inspection and Testing

GENERAL:

Following disassembly, generator components should be cleaned, dryed and inspected or tested. Never reassemble a generator with defective or damaged parts. Store parts in a clean, dry area.

Components Inspection and Testing (Continued)

REAR BEARING COVER AND GASKET:

Clean the Bearing Cover in a suitable non-flammable commercial cleaner. Blow dry with compressed air. Inspect the Cover for obvious damage, clogged air slots, etc. Replace, if necessary. Inspect gasket, replace if damaged or defective.

REAR BEARING CARRIER:

The Rear Bearing Carrier is an aluminum casting. Clean the casting and blow dry with air. Inspect carefully for cracks, damage. An insert is pressed into the Bearing Carrier center bore, to accommodate the Rotor bearing. Use an inside micrometer to check the inside diameter of the insert. Replace the Bearing Carrier if the insert inside diameter is not within the following:

2.834-2.836 inches (71.996-72.012mm)

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 to test the resistance of Stator AC power and excitation windings. Use an insulation resistance tester (megohmmeter or Hi-Pot tester) to check condition of Stator insulation (see Section 1.8). If Stator insulation fails the test, the Stator may be dried 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.

BLOWER HOUSING:

Clean with a commercial solvent that is suitable for use with aluminum. Inspect the Housing carefully for cracks, damage, etc. Replace, if necessary.

ROTOR ASSEMBLY:

Clean with dry, low pressure air (25 psi maximum). Test Rotor winding resistance with an ohmmeter. Check Rotor bearing for binding, seizing, roughness. If the bearing is defective, replace the Rotor assembly. Inspect the keyway in the tapered shaft for wear, damage. If slip rings are dull or tarnished, clean with fine sandpaper. Use an insulation resistance tester (megohmmeter or Hi-Pot tester) to test for insulation breakdown (see Section 1.8). If resistance is low, dry the Rotor with dry, heated air for several hours. DO NOT EXCEED 185° F. (85° C.). If insulation resistance is still low after drying, replace the Rotor Assembly.

FAN AND RING GEAR ASSEMBLY:

The FAN, DRIVE HUB, COUPLING PLATE and RING GEAR are assembled and balanced as a unit. Clean and inspect parts, replace the entire assembly if necessary.

BRUSH HOLDER AND BRUSHES:

Inspect both brush holders and both sets of brushes. Look for cracks, excessive wear, cracks, chipping, etc. 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.

Generator Reassembly

Reassemble the generator in the reverse order of disassembly. The reassembly process requires a great deal of care. All components must be properly aligned and retained. Tighten all fasteners to the recommended torque values. Following reassembly, perform an operational test of the unit.

Components in Generator Control Panel

INTRODUCTION:

The following AC generator components are mounted on or housed in the generator control panel:

- ☐ Voltage Regulator Assembly.
- ☐ An AC Circuit Breaker (CB1 and CB2).
- ☐ Excitation Circuit Breaker (CB4).
- ☐ A field boost circuit.

In addition to the above AC generator components housed in the control panel, a THERMAL PROTECTOR is physically imbedded in the wire windings of the Stator Assembly.

Other components are housed in the control panel, as well. However, these components are part of the engine's DC control system and will be discussed in PART 5, *"ENGINE ELECTRICAL SYSTEM"*.

Components In Generator Control Panel (Continued)

THE AC VOLTAGE REGULATOR:

The Voltage Regulator used on units with 10 inch stator is shown in Figure 10. The Regulator has a single red lamp (LED) which will remain on during operation as long as stator AC power winding "sensing" voltage is available. Three sets of leads connect to the Regulator terminals as follows:

- ☐ Unregulated AC output from the stator excitation winding connect to the two terminals indicated by "DPE".
- ☐ Sensing (actual) voltage signals from the stator AC power windings are delivered to the Regulator terminals indicated by "SEN".
- ☐ Rectified and regulated (DC) current is delivered to the Rotor winding from Regulator terminals indicated by a "+" and "-".

The Regulator provides over-voltage protection. On loss of "sensing", the Regulator will shut down and regulated excitation current to the Rotor will terminate.

A single adjustment potentiometer permits the generator's AC output voltage to be adjusted. Perform this adjustment with the engine running at no-load and with AC frequency at 62 Hertz (1860 rpm). At 62 Hertz, set the line-to-neutral AC output voltage to 124 volts AC; or the line-to-line AC output voltage to 248 volts AC.

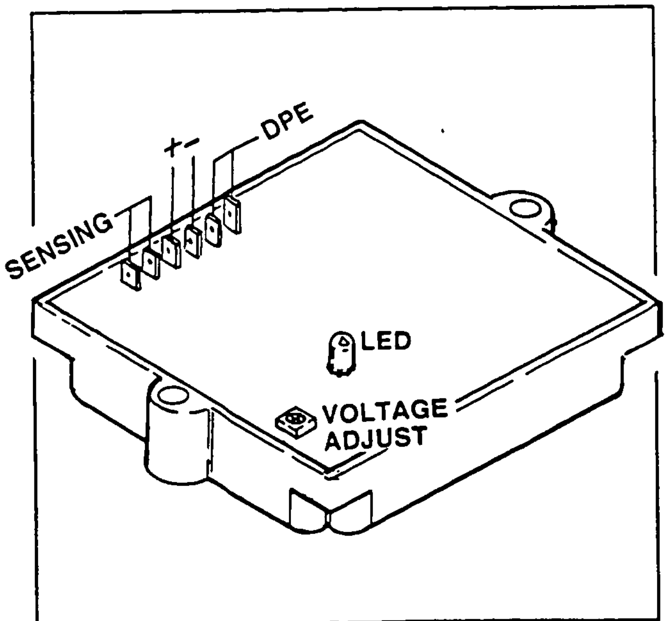


Figure 10. Voltage Regulator (Typical)

AC CIRCUIT BREAKERS:

Two AC output circuit breakers (CB1 and CB2) are provided, one for each line of the 240 volts AC output circuit. The trip rating of these breakers depends on the rated maximum amperage capacity of the generator. Units rated at 8000 watts (8.0 kW) are equipped with AC breakers rated at 35 amperes.

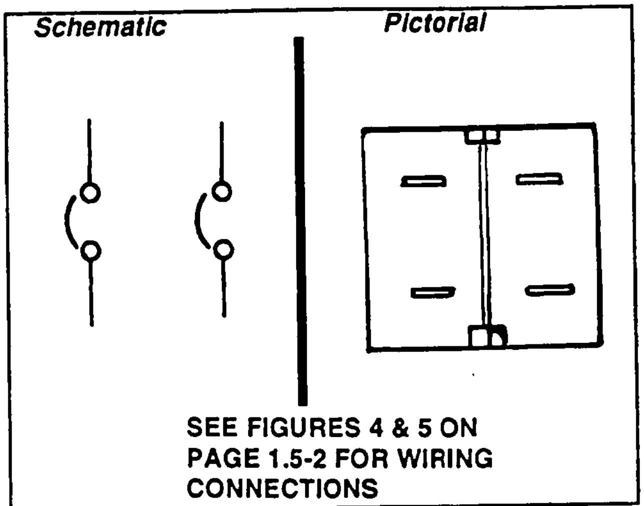


Figure 11. AC Output Circuit Breakers

EXCITATION CIRCUIT BREAKER (CB4):

An AC circuit breaker, rated 5 amperes, is electrically connected in series with Wires No. 2 and 2A between the stator excitation winding and the Voltage Regulator. If the breaker should trip (open) due to an overload, loss of excitation current to the Rotor will occur. Generator AC output voltage will then decrease to a value that is commensurate with Rotor residual magnetism (about 2 to 7% of the unit's rated voltage). The breaker is self resetting and cannot be reset manually.

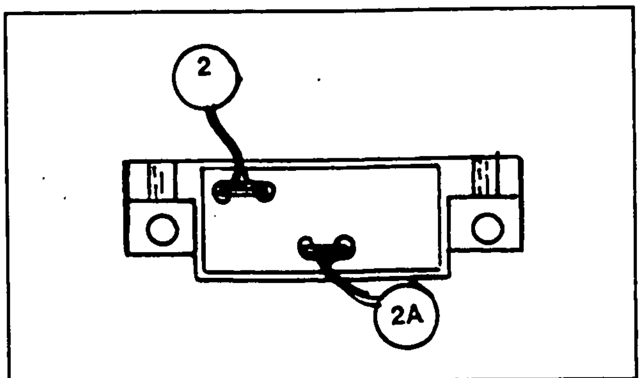


Figure 12. Excitation Circuit Breaker

Components In Generator Control Panel (Continued)

FIELD BOOST CIRCUIT

During engine cranking, an engine control circuit board delivers battery voltage to the Rotor windings. This "Field Boost" current is delivered to the Rotor via Wire 4A, a field boost resistor, and Wire 4. The Field Boost feature provides the following benefits:

- ☐ In effect, field boost current "flashes the field" on every engine startup. Thus, if Rotor residual magnetism was lost for any reason, it would be restored by the act of "flashing the field" during cranking.
- ☐ Approximately 4-8 volts AC output from the stator excitation winding is needed to turn the voltage regulator on. Field boost current builds Rotor magnetism early which, in turn, develops voltage early during startup. The result of field boost is an early "pickup" voltage in the stator windings.

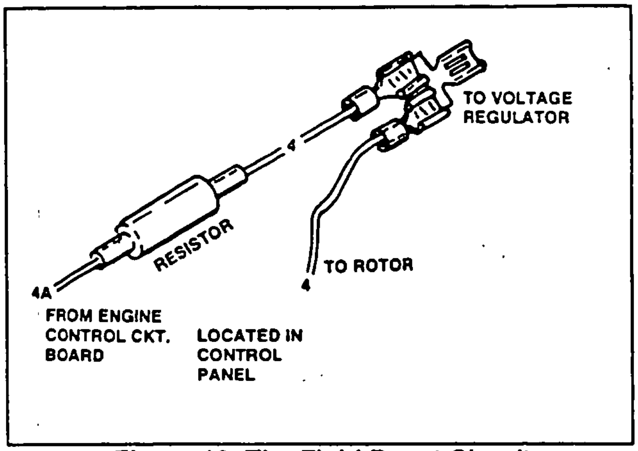


Figure 13. The Field Boost Circuit

THERMAL PROTECTOR:

Refer to "*THERMAL PROTECTOR*" on Page 1.3-7.

Section 1.5

INTRODUCTION TO TROUBLESHOOTING

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

Tools and Test Equipment

An RV generator service technician should have a well stocked tool box that is filled with a good selection of common hand tools. The tool box should contain combination wrenches and socket wrenches in both standard and metric sizes. Also, a good nut driver set is recommended.

The following test equipment is recommended:

- ☐ An accurate volt-ohm-milliammeter (VOM), preferably a precise digital type.
- ☐ A good AC frequency meter.
- ☐ An insulation resistance tester (megohmmeter or Hi-Pot tester).
- ☐ A load bank or some means of applying a known electrical load to the generator.

Volt-Ohm-Milliammeter (VOM)

If desired, three separate meters may be used, i.e., a voltmeter, ohmmeter and ammeter. Recommended is an accurate digital type VOM having a "Diode Check" mode.

The service technician must be familiar with his VOM and must know how to use it. He must also be familiar with generator electrical circuits and must be able to read electrical wiring diagrams and schematics.

Frequency Meter

The generator's AC output frequency must be known if engine governed speed is to be properly adjusted. See "ROTOR ROTATIONAL SPEED" in this section.

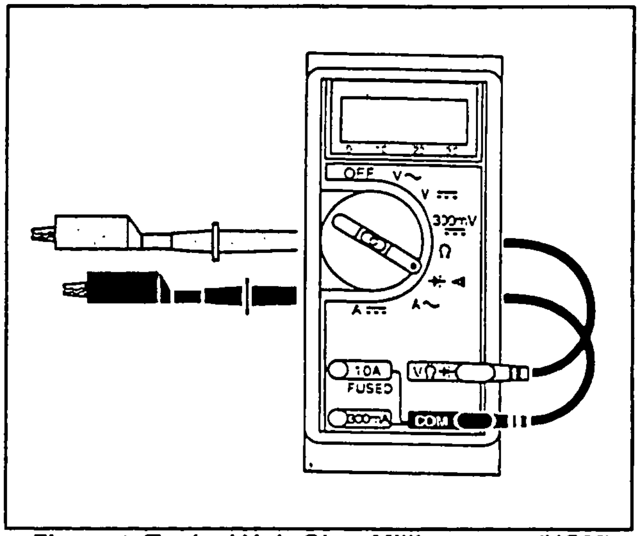


Figure 1. Typical Volt-Ohm-Milliammeter (VOM)

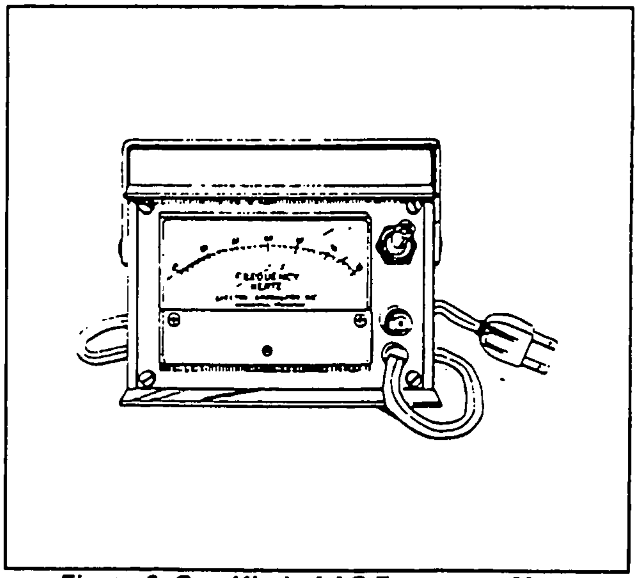


Figure 2. One Kind of AC Frequency Meter

Testing Insulation Resistance

Insulation resistance is a measurement of the integrity of the insulating materials that separate the electrical windings from the generator's steel core. This resistance can degrade over time due to contaminants such as dust, dirt, grease and especially moisture. Information on insulation resistance test can be found in Section 1.8, "*INSULATION RESISTANCE TESTS*".

Rotor Rotational Speed

"NP" series generators are equipped with a 4-pole Rotor. That is, the Rotor has two south magnetic poles and two north magnetic poles. A 4-pole Rotor must be operated at 1800 rpm to obtain a 60 Hertz AC output frequency. The following formulas apply when calculating frequency, rpm and number of Rotor poles:

$$\text{Hertz} = \frac{\text{RPM x No. of Rotor Poles}}{2 \times 60}$$

$$\text{RPM} = \frac{2 \times 60 \times \text{Hertz}}{\text{No. of Rotor Poles}}$$

$$\text{No. of Poles} = \frac{2 \times 60 \times \text{Hertz}}{\text{RPM}}$$

Voltage and Frequency

The generator's solid state Voltage Regulator will maintain an AC output voltage that is at a fixed ratio to frequency. For example, at a frequency of 60 Hertz, AC output voltage will be maintained at about 120/240 volts (plus or minus 2%). Should frequency drop to 30 Hertz, voltage will decrease proportionally to about 60/120 volts.

For generators rated 120/240 volts, the engine governor should be set to maintain a NO-LOAD frequency of about 60.5-63.5 Hertz. The Voltage Regulator should then be set to maintain a voltage of about 121-127 volts (line-to-neutral); or 242-254 volts (line-to-line).

Stator AC Connection Systems

1-PHASE, DUAL WINDING TYPE:

Some NP/IM series generators have dual AC power windings (Figure 3). Each winding supplies a 120 volts AC output. When the two windings are connected in series (Figure 4), a 240 volts AC output results.

When installed, the unit may have ben connected to supply a dual voltage output (120 and/or 240 volts). This is shown in Figure 4. A 3-wire connection system is used. Stator leads No. 11 and 44 form the two "hot" leads; the junction of stator leads 22 and 33 form the "Neutral" lead. Notice the "Neutral" line is grounded.

A second alternative is to connect the wiring to supply 120 volts AC only (Figure 5). When this connection method is used, a jumper wire must be connected between the two main circuit breakers (CB1 and CB2), as shown.

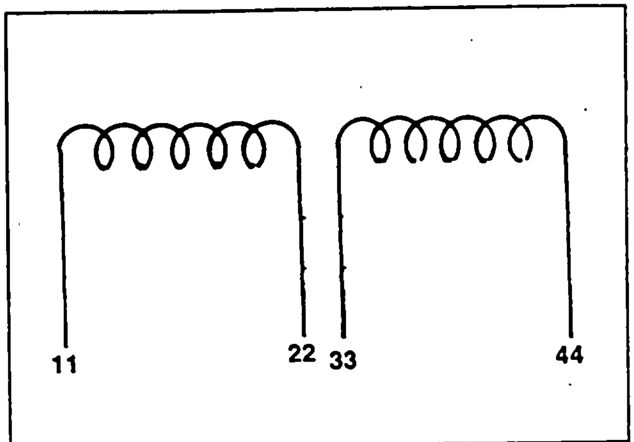


Figure 3. The Dual Stator AC Power Windings

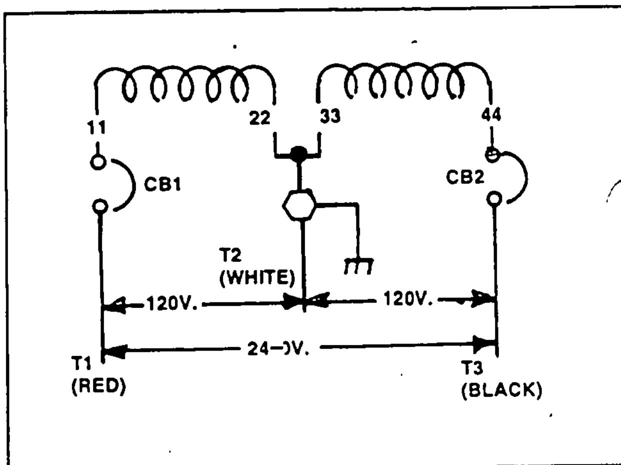


Figure 4. Connected for Dual Voltage AC Output

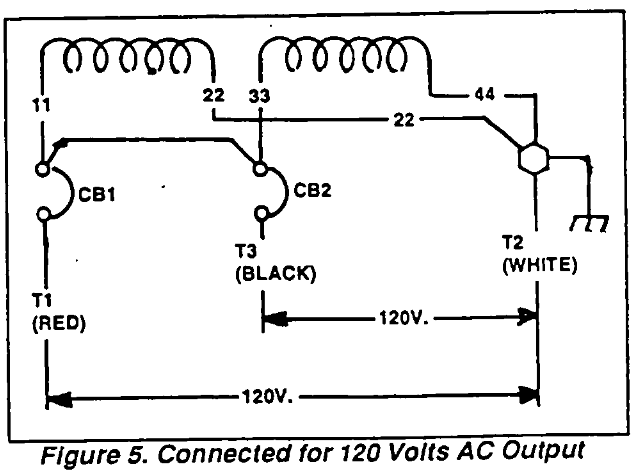


Figure 5. Connected for 120 Volts AC Output

Stator AC Connection Systems (Continued)

3-PHASE DELTA STATOR WINDING:

Some units may be equipped with a 3-phase delta type stator winding, shown in Figure 6. Phase rotation is L1-L2-L3. The "Neutral" line is designated as "L0". Generator Model No. 9422 uses this type of stator to deliver 120 volts AC (line-to-neutral); or 240 volts AC (line-to-line).

3-PHASE, WYE-CONNECTED SYSTEM:

Figure 7 shows a 3-phase Wye-Type stator which has 12 AC output leads that are reconnectable to supply several voltages. Generator Model 9318 uses this type of stator to supply 220/380 volts AC at 50 Hertz (i.e., 220 volts AC line-to-neutral; 380 volts AC line-to-line).

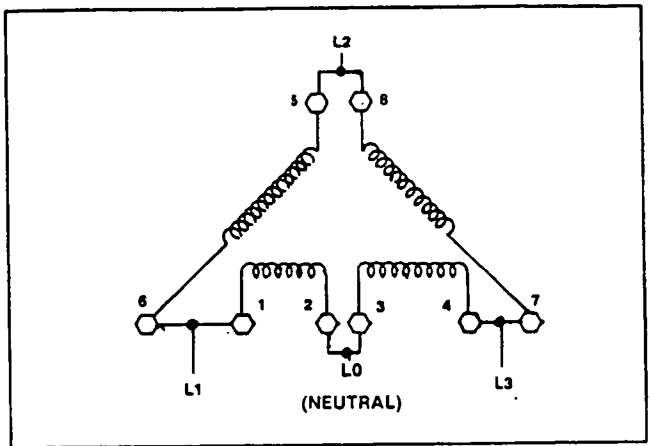


Figure 6. A 3-Phase Delta Stator

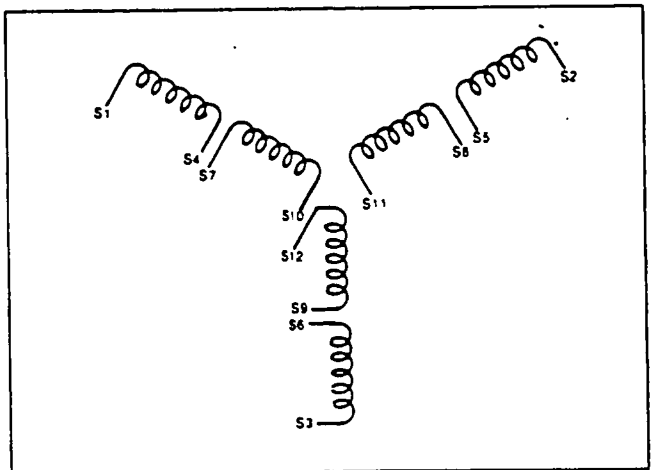


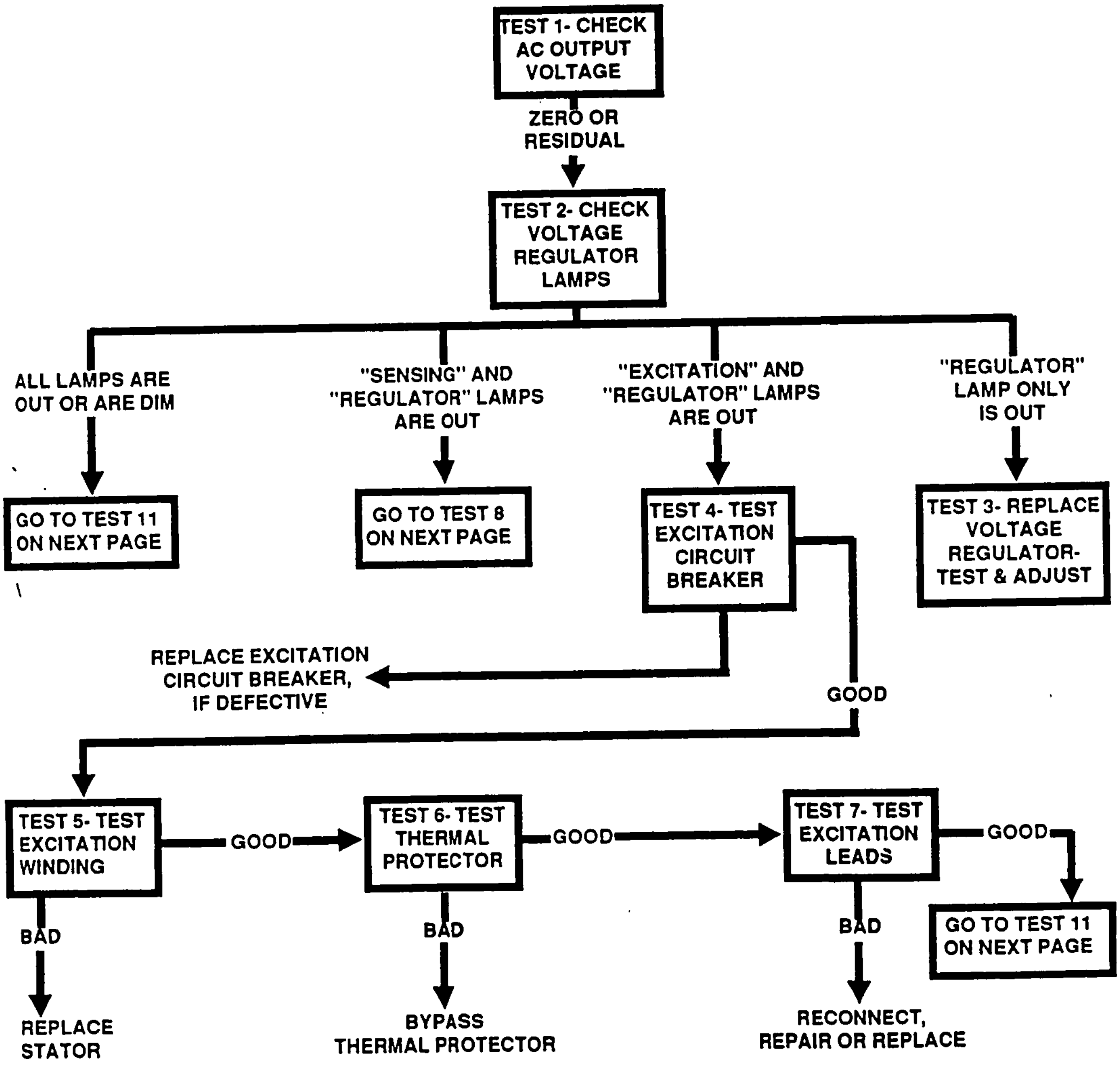
Figure 7. A 3-Phase, 12-Lead Stator

Section 1.6
TROUBLESHOOTING
(UNITS WITH 15 INCH STATOR)

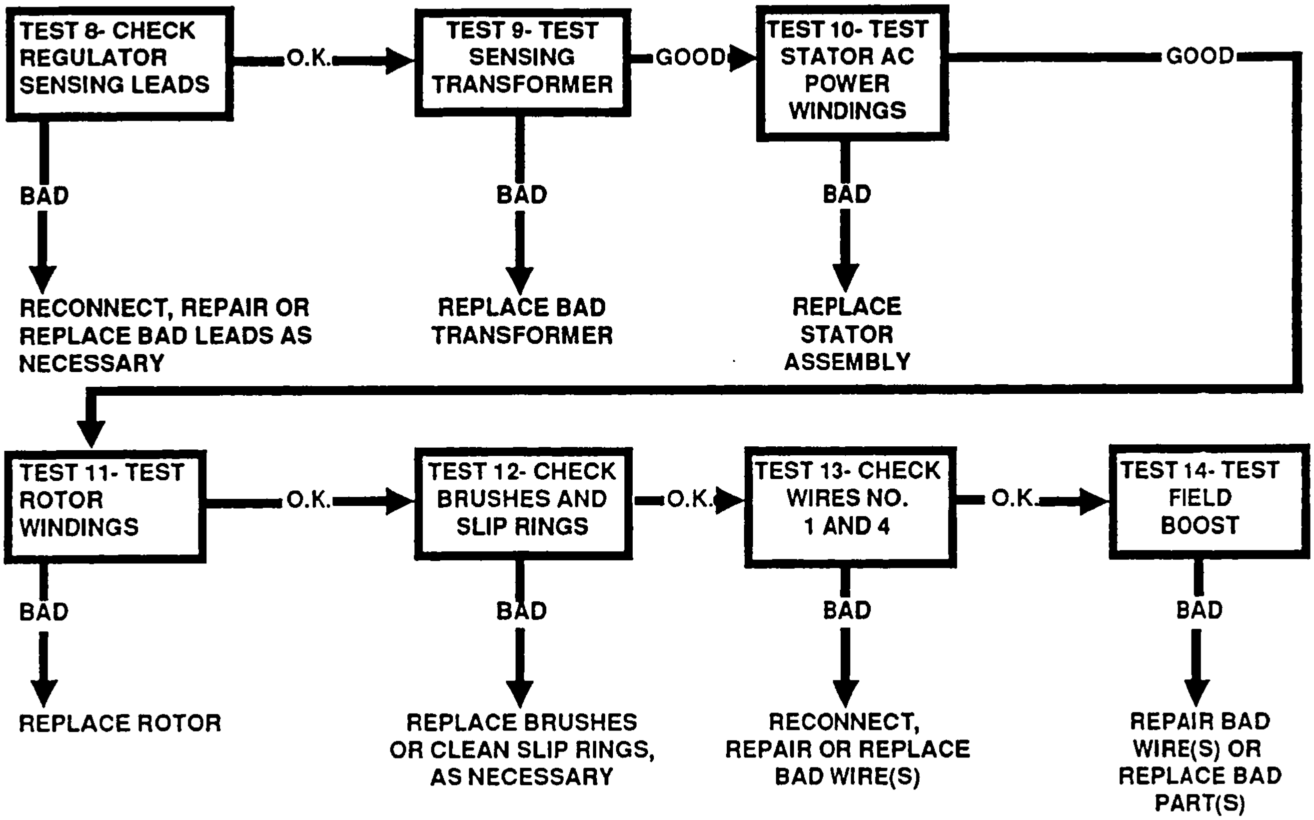
Introduction

The "Troubleshooting Flow Charts" that follow have been carefully formulated to help the technician find the cause of problems quickly and easily. Use the Charts as a guide in troubleshooting RV generator problems, to help avoid the unnecessary labor and expense of replacing parts needlessly. Test numbers in the Charts correspond to the numbered tests in the "DETAILED INSTRUCTIONS" that follow the Flow Charts.

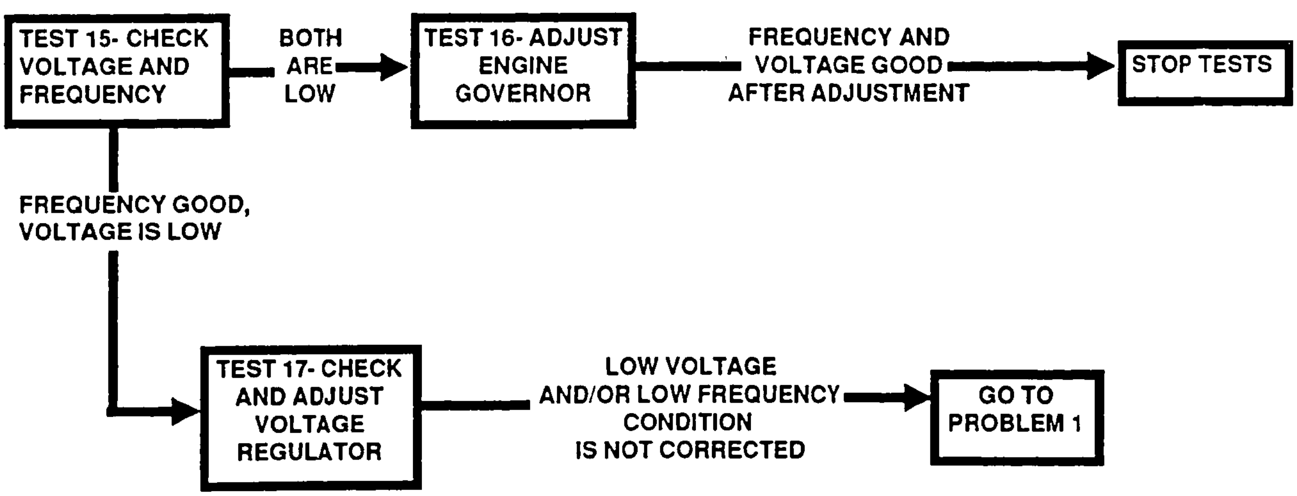
Problem 1- Generator Produces Zero or Residual Voltage at No-Load



Problem 1 - Generator Produces Zero or Residual Voltage at No-Load (Continued)

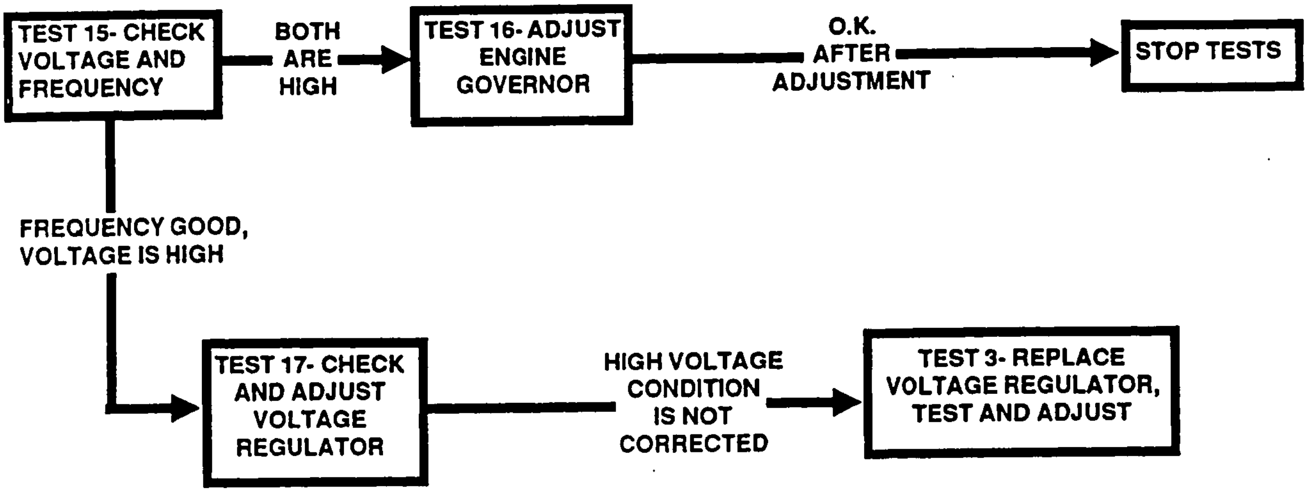


Problem 2- Generator Produces Low Voltage and Frequency at No-Load (Greater than Residual Voltage)

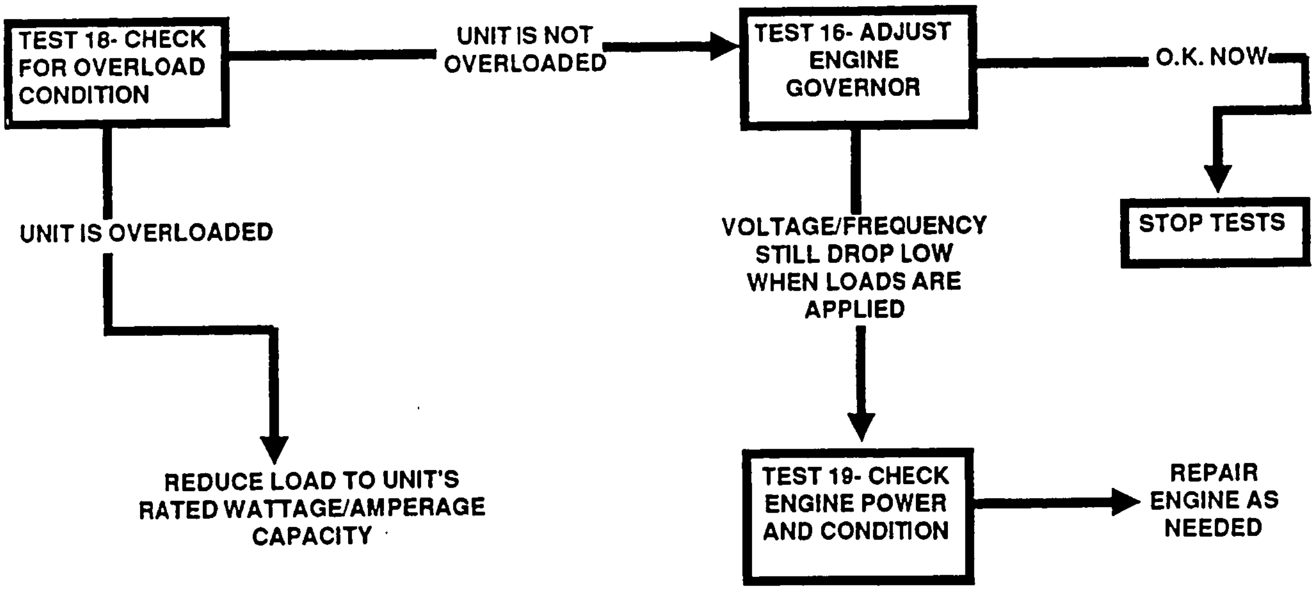


NOTE: A shorted stator winding can cause rpm, frequency and voltage to droop excessively in the same manner as when the unit's wattage/amperage capacity is exceeded.

Problem 3- Generator Produces High Voltage at No-Load



Problem 4- Voltage and Frequency Drop Low When Electrical Loads are Applied



Detailed Instructions

INTRODUCTION:

The following diagnostic test instructions are numbered to correspond with the numbered tests in the troubleshooting "Flow Charts" on Pages 1.6-1 through 1.6-3. Read the instructions carefully.

TEST 1- CHECK AC OUTPUT VOLTAGE:

Discussion: In order to identify the specific problem, it is necessary to measure the generator's AC output voltage. Some installations may include an optional AC meter package. Even when this is the case, it is a good idea to verify the AC voltage with an external meter. In some cases, the AC meter(s) on the optional package may be reading incorrectly.

Remember, some installed units may be connected for dual voltage AC output (120 and/or 240 volts). Some units may be connected for 120 volts AC output only. Also see "*STATOR AC CONNECTION SYSTEM*" on Page 1.5-2.

Procedure: An AC voltmeter or a volt-ohm-milliammeter (VOM) may be used to measure voltage. If the unit is installed in a vehicle, the meter may be connected to a convenient receptacle. For uninstalled units, connect the VOM across Wires No. T1 (red) and T3 (black) to obtain a line-to-line voltage reading (240 volts). For a line-to-neutral reading (120 volts), connect the VOM across line T1 (red) and T2 (white); or across line T3 (black) and T2 (white). With the unit runing at no-load, read the AC voltage. Voltage should be 121-127 volts (line-to-neutral); or 242-254 volts (line-to-line).

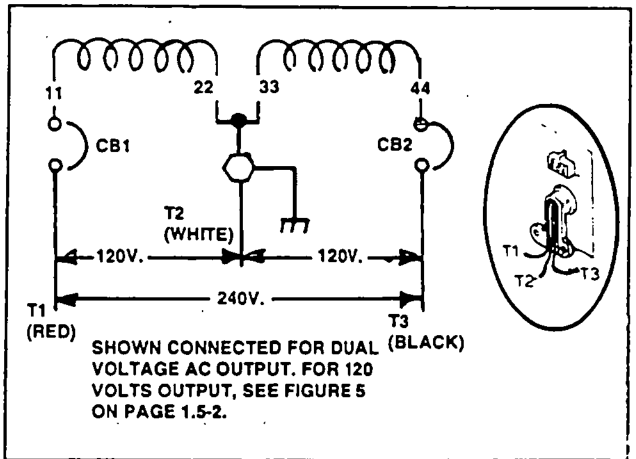


Figure 1. Stator AC Output Leads

NOTE: Line T1 (red) and T3 (black) are the two "hot" lines. Line T2 (white) is the "Neutral" line.

Results: Analyze the results of the AC output voltage test as follows:

1. If the reading is zero volts or residual volts, perform tests as indicated under Problem 1 of the Flow Charts.

NOTE: "Residual" voltage is that voltage produced as a result of Rotor residual magnetism only. It is equal to approximately 2 to 7 percent of the unit's rated voltage. For units rated 120/240 volts, residual voltage will be approximately 2.4-8.4 volts (line-to-neutral); or 4.8-16.8 volts (line-to-line).

2. If the voltage is low, but greater than residual, go to Problem 2 of the Flow Charts.
3. If AC output voltage is high, go to Problem 3 of the Flow Charts.
4. If AC output voltage is normal at no-load, but drops excessively when electrical loads are applied, go to Problem 4 of the Flow Charts.

Test 2- Check Voltage Regulator Lamps

Discussion: Refer to "AC VOLTAGE REGULATOR" on Pages 1.3-5 and 1.3-6.

Procedure: Gain access to the AC Voltage Regulator in the control panel. With the generator running at no-load, observe the condition of the Regulator lamps (LED's).

The Voltage Regulator lamps are normally ON during engine-generator operation. It is suggested that "AC VOLTAGE REGULATOR" on Pages 1.3-5 and 1.3-6 be read carefully. The REGULATOR lamp will go out if (a) a Regulator fault exists, or (b) if the Regulator has shut down due to occurence of one or more Regulator shutdown conditions. The EXCITATION lamp will go out on loss of stator excitation winding output to the Regulator. The SENSING lamp will go out on loss of sensing input to the Regulator.

Results:

1. If all lamps are out, go to Test 11.
2. If the "Sensing" lamp is out, go to Test 8.
3. If the "Excitation" lamp is out, go to Test 4.
4. If the "Regulator" lamp is out, go to Test 3.

Detailed Instructions

TEST 3- REPLACE REGULATOR, TEST/ADJUST:

Discussion: The Voltage Regulator lamps (LED's) are normally ON. If the "Regulator" lamp is OUT, the Voltage Regulator has shut down or has failed. A "Regulator" lamp ON condition indicates the Regulator's SCR's (silicone controlled rectifiers) are firing.

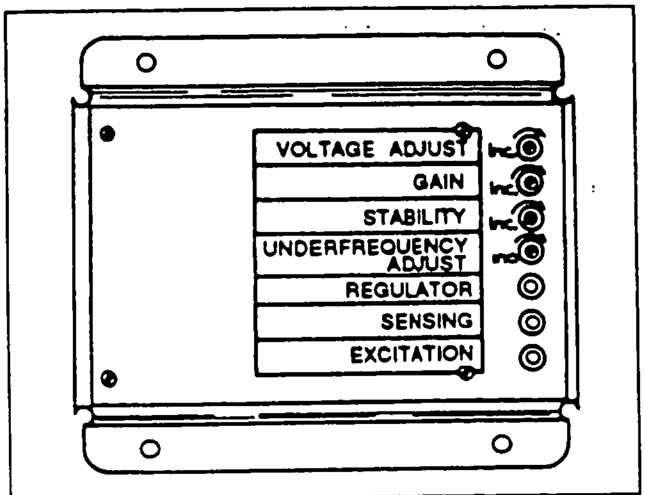


Figure 2. The Part No. 67680 Voltage Regulator

Procedure: Unplug the voltage regulator connector plug. Remove the screws, flatwashers and lockwashers that retain the regulator to the control panel. Remove the regulator. Install the new regulator, test and adjust as outlined in Section 1.9, "*OPERATIONAL TESTS AND ADJUSTMENTS*".

NOTE: Before attempting to adjust the voltage regulator, the engine governor must be properly adjusted to maintain a no-load frequency of 60.5-63.5 Hertz (1815-1905 rpm). Correct no-load AC output voltage setting is 121-127 volts AC (line-to-neutral), or 242-257 volts AC (line-to-line).

Results: If problem is corrected, discontinue tests. If problem still exists, continue troubleshooting as indicated in the "Flow Charts".

TEST 4- TEST EXCITATION CIRCUIT BREAKER:

Discussion: See Figure 3. The excitation circuit breaker is electrically connected in series with the stator excitation winding AC output to the voltage regulator. It is physically mounted in the control panel interior. Should the breaker fail open, loss of excitation winding output to the regulator will occur. Without excitation current, the regulator will shut down and generator AC output will drop to a voltage commensurate with Rotor residual magnetism. The breaker cannot be reset manually (it is normally self-resetting). If it has failed open, it must be replaced.

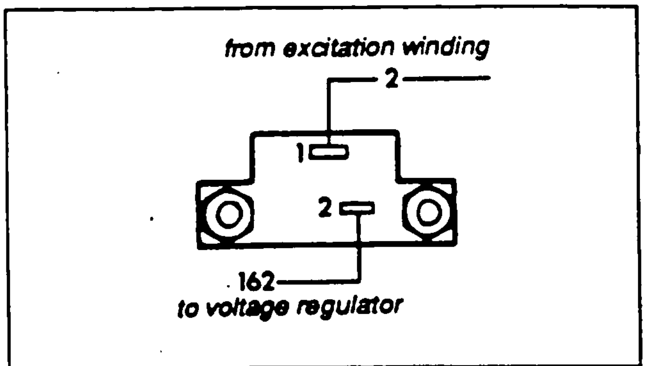


Figure 3. Excitation Circuit Breaker

Procedure: To prevent interaction, disconnect Wires No. 2 and 162 from the circuit breaker terminals. Set a VOM to its "Rx1" scale and zero the meter. Connect the VOM test probes across the two circuit breaker terminals. The meter should read "continuity".

Results:

1. If the meter displays any reading other than "continuity", replace the excitation circuit breaker.
2. If the VOM reads "continuity", go on to Test 5.

NOTE: When reading resistance across the circuit breaker contacts, a very small resistance reading is acceptable. An oxide film can build up on circuit breaker contact surfaces, causing the small resistance.

TEST 5- TEST STATOR EXCITATION WINDING:

Discussion: An open circuit in the stator excitation (DPE) winding will result in loss of excitation current to the Voltage Regulator. An excitation winding AC output of approximately 4-8 volts AC is required to turn the Voltage Regulator on. Thus, on loss of excitation winding output, the Regulator will shut down and regulated excitation current to the Rotor will terminate. Generator AC output voltage will then drop to a value commensurate with Rotor residual magnetism plus field boost current (about one-half normal no-load AC output voltage). An open winding will be indicated by a VOM reading of "infinity" or a very high resistance reading. A shorted excitation winding will be indicated by a very low resistance reading. In the following "Procedure", the excitation winding will also be tested for a grounded condition.

Procedure: See Figure 4, next page. In the control panel, locate unattached Wire No. 5. This is the thermal protector bypass lead. Remove the wire nut from end of Wire No. 5. Also locate Wire No. 6, connected to Pin 6 of the voltage regulator plug. On some units, a barrel lug may be used to connect Wire No. 6 between the voltage regulator and the stator excitation winding. Test the stator excitation winding for an open, shorted or grounded condition as follows:

Detailed Instructions (Continued)

1. Set a VOM to its "Rx1" scale and zero the meter.
2. Connect the VOM test probes across Wire No. 5 and Pin 6 of the Voltage Regulator. The meter should read the resistance of the stator excitation winding (about 0.53 ohm).
3. Now, set the VOM to a very high resistance scale such as "Rx10,000" or "Rx1K". Again, zero the meter.
   a. Connect one VOM test lead to bypass Wire No. 5, the other to a clean frame ground on the stator. The meter should indicate "infinity".
   b. Any reading other than "infinity" indicates a shorted condition and the stator should be replaced.
4. With the VOM still set to a high resistance scale, connect one VOM test probe to stator Wire No. 5, the other to stator ac output Wire No. 11 or 22. "Infinity" should be indicated.
5. Connect the VOM test probes across Wire No. 5 and stator AC output Wire No. 33. "Infinity" should be indicated.

Results:

1. If the stator excitation winding fails any part of the test, replace the stator assembly.
2. If the stator excitation winding checks good, go on to Test 6.

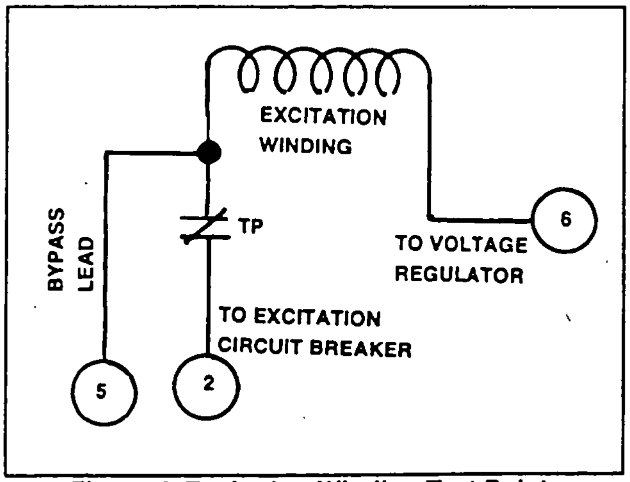


Figure 4. Excitation Winding Test Points

TEST 6- TEST THERMAL PROTECTOR:

Discussion: You may wish to review the information on the thermal protector. See Page 1.3-7.

Procedure: Set a VOM to its "Rx1" scale and zero the meter. Connect the VOM test probes across stator wires No. 2 and 6. See Table 1, Page 6.1-1 for nominal resistances.

Results:

1. If normal excitation winding resistance was indicated in Test 5, but "infinity" was indicated in Test 6, the thermal protector is open and must be bypassed.

2. If normal excitation winding resistance was indicated in both Tests 5 and 6, the thermal protector is good. Go on to Test 7.

TEST 7- TEST EXCITATION LEADS:

Discussion: An open or shorted condition in the stator excitation winding's output leads to the Regulator will cause complete or partial loss of the unregulated excitation current to the Regulator.

Procedure: Inspect Wires No. 2, 6 and 162, between the stator and the Voltage Regulator. Make sure they are properly connected and undamaged. Use a VOM to test the wires for "continuity".

Results:

1. Reconnect, repair or replace any damaged, disconnected or shorted wire(s).
2. If all excitation leads are good, go to Test 11.

TEST 8- CHECK REGULATOR SENSING LEADS:

Discussion: An open or shorted condition in the sensing leads to the Voltage Regulator will result in loss of sensing (actual voltage) signals to the Voltage Regulator. The Regulator's "Sensing" lamp will then go out.

Procedure: Carefully inspect Wires S15 and S16, between the Regulator and the sensing transformer. Also inspect Wires No. 11 and 22, between the sensing transformer and the stator. Use a VOM to test all wires for an open or shorted condition.

Results:

1. Reconnect, repair or replace any disconnected, damaged or defective wire(s).
2. If the sensing leads are good, go on to Test 9.

TEST 9- TEST SENSING TRANSFORMER:

Discussion: The Part No. 67680 Voltage Regulator requires a 240 volts AC sensing signal to operate properly. You may wish to review the information on the sensing transformer on Page 1.3-6.

Detailed Instructions (Continued)

Procedure: Gain access to the sensing transformer, inside the control panel. Use a volt-ohm-milliammeter (VOM) to test the sensing transformer as follows:

1. Disconnect Wires No. 11 and 22 from the transformer's PRIMARY terminals, to prevent interaction.
2. Connect the VOM test leads across the two PRIMARY (120 volts) terminals. Resistance of this winding should be approximately 120 ohms (plus or minus 2%).
3. Disconnect Wires No. S15 and S16 from the transformer SECONDARY (240 volts) terminals, to prevent interaction.
4. Connect the VOM test leads across the two SECONDARY (240 volts) terminals. Resistance should be approximately 950 ohms (plus or minus 2%).

Results:
1. If the transformer fails the test, it should be replaced.
2. If the transformer checks good, go on to Test 10.

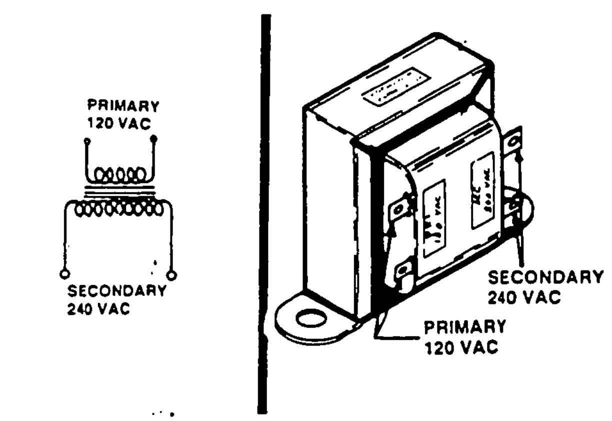


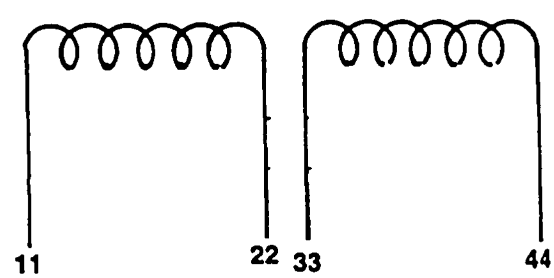
Figure 5. The Sensing Transformer

TEST 10- TEST STATOR AC POWER WINDINGS:

Discussion: An open condition in either of the dual stator AC power windings will result in loss of AC output from the affected winding. A shorted condition in those windings will cause a reduction in AC voltage that is commensurate with the number of shorted turns. A shorted condition can also impose such a heavy load on the engine that engine speed and AC frequency will also drop sharply. This test will check the stator AC power windings for (a) an open condition, (b) a shorted condition, and (c) a grounded condition.

Procedure: To test 1-phase, dual winding stators, proceed as follows:

1. Disconnect Wires No. 11, 22, 33 and 44 from the main circuit breaker (CB1) and from the unit grounding lug.
2. Set a VOM to its "Rx1" scale and zero the meter.
3. Test the windings as follows:
   a. Connect the meter test leads across Wires No. 11 and 22. Resistance reading should be approximately as listed in chart in Part 6.
   b. Connect the meter test leads across Wires No. 33 and 44. Resistance reading should be approximately as listed in chart in Part 6.
   c. Set the VOM to a very high resistance scale, such as "Rx10,000" or "Rx1K". Then, zero the meter.
   d. Make sure none of the stator leads are touching the generator or each other at any point. Connect one VOM test probe to Wire No. 11, the other test probe to Wire No. 33. The VOM should read "infinity". Any reading other than "infinity" indicates a short between the stator windings.
   e. Connect one VOM test probe to Wire No. 11, the other to a clean frame ground on the stator. VOM should read "infinity".
   f. Connect one VOM test probe to Wire No. 33, the other to a clean frame ground. Reading should be "infinity".



SEE SECTION 1.5, PAGE 1.5-3 FOR SOME OTHER STATOR CONFIGURATIONS. ALSO SEE PART 6, PAGE 6.1-1 FOR SOME RESISTANCE VALUES.

Figure 6. Stator Windings Schematic

TEST 11- TEST ROTOR WINDINGS:

Discussion: An open circuit condition in the Rotor windings means that excitation current cannot flow in the circuit. Field boost current will be unable to flow in an open circuit either.

Procedure: Use a VOM to check the resistance of Rotor windings. Connect the positive (+) VOM test probe to the positive (+) Rotor slip ring (nearest the Rotor bearing). Connect the common (-) VOM test probe to the negative (-) slip ring. The VOM should indicate approximately as listed in the chart in Part 6 (Page 6.1-1).

Remove both brush holders to prevent interaction. Set VOM to a high resistance scale and zero the meter. Connect the positive (+) test probe to the positive (+) slip ring (nearest the Rotor bearing); the common (-) test probe to a clean frame ground. "Infinity" must be indicated.

Detailed Instructions (Continued)

Results:
1. Replace the Rotor if it fails test.
2. If Rotor checks good, go to Test 12.

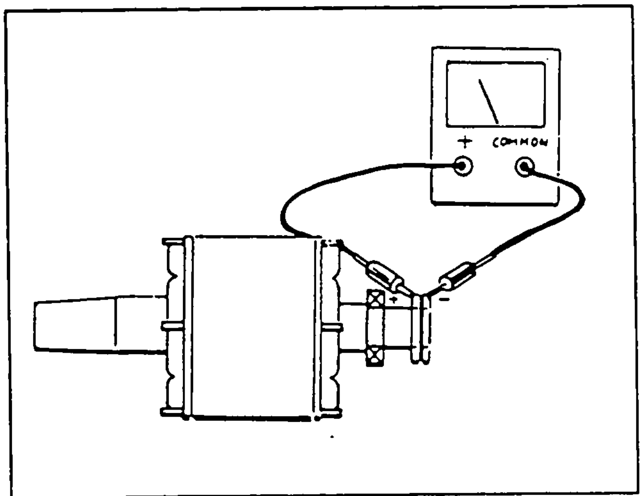


Figure 7. Rotor Assembly Test Points

TEST 12- CHECK BRUSHES AND SLIP RINGS:

Discussion: The brushes and slip rings are designed for long life and dependability. Problems with therse components are very infrequent. It is possible that, after a prolonged non-operating period, the slip rings can develop a corrossive film around their outer periphery. This film can separate the brushes from the slip rings and open the excitation circuit.

Procedure: Remove wires from the brushes. Remove the brush holders from the rear bearing carrier. Carefully inspect brushes, brush holders, wires and slip rings. Replace brushes that are chipped, cracked, or worn excessively. Replace brushes as complete sets. Replace any damaged brush holders. If the slip rings have a dull or tarnished appearance, they may be cleaned with fine sandpaper. DO NOT USE ANY METALLIC GRIT TO CLEAN SLIP RINGS. Polish the slip rings until shiny.

Results:
1. Replace any damaged brushes or brush holders. Clean and polish slip rings, if necessary.
2. If brushes and slip rings are good, go to Test 13.

TEST 13- CHECK WIRES NO. 1 AND 4:

Discussion: Wire No. 1 is routed from the negative (-) brush to the unit grounding lug; and from the grounding lug to Pin 1 of the Voltage Regulator. Wire No. 4 is routed from the positive (+) brush (nearest the Rotor bearing) to Pin 4 of the Voltage Regulator. Regulated excitation current (DC) is delivered from the Regulator to the Rotor via these wires.

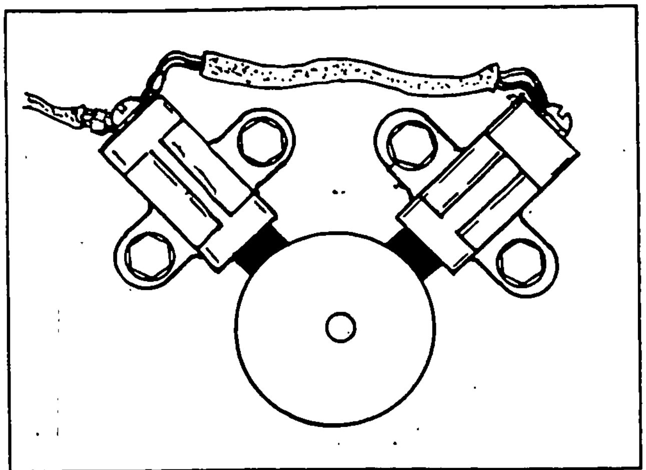


Figure 8. Brushes and Slip Rings

Procedure: Inspect Wires No. 1 and 4 along their entire length. Use a VOM to check the wires for an open or shorted condition. Make sure wires are properly connected.

Results:
1. Reconnect, repair or replace any damaged or defective wire(s).
2. If Wires are good, go to Test 14.

TEST 14- TEST FIELD BOOST:

Discussion: During engine cranking, the action of an engine control circuit board delivers battery voltage (12 volts DC) to the Rotor windings via Wire No. 9, a field boost resistor (R2), a field boost diode (D2) and Wire No. 4. Resistor (R2) reduces this voltage to approximately 7-10 volts DC. As soon as engine cranking stops, circuit board action terminates field boost current. Field boost current flow to the Rotor windings while cranking turns the Voltage Regulator on earlier and ensures that a "pickup" voltage is available to start the generation of electricity. Loss of field boost current may or may not affect generator AC output voltage. If Rotor residual magnetism is sufficient to provide the required "pickup" voltage in the stator, loss of field boost will have no affect. However, if Rotor residual magnetism is not adequate to produce the required "pickup" voltage, generator AC output voltage will build only to a value commensurate with Rotor residual magnetism (about 2-7% of rated voltage).

The field boost, in effect, flashes the field every time the engine is cranked and started. This test will check the field boost circuit to determine if it is functioning properly while the engine is cranking.

Detailed Instructions (Continued)

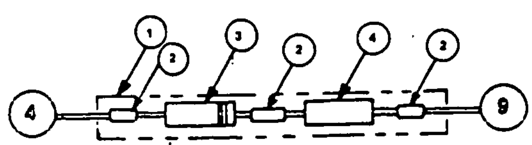
The field boost resistor, field boost diode, Wire No. 9 and Wire No. 4 are part of the control panel wiring harness. See Figure 9. The resistor and diode are connected in series with Wires No. 9 and 4, and are encased in heat shrink tubing.

Procedure: In the control panel, locate the voltage regulator and the engine control circuit board. Test field boost system operation as follows:

1. Unplug the 6-pin connector from the voltage regulator. This will prevent you from reading regulated excitation voltage during the test.
2. Set a VOM to read DC volts.
3. Field boost Wire No. 9 attaches to Terminal 8 of the engine control circuit board.
   a. Connect the positive (+) VOM test lead to Terminal 8 of the engine control circuit board.
   b. Connect the VOM common (-) test lead to frame ground.
4. Crank the engine and note the DC voltage reading. Meter should indicate approximately 12 volts DC while the engine is cranking.
5. Now, connect the VOM positive (+) test lead to Pin 4 of the regulator connector plug; connect the common test lead to a clean frame ground. Crank the engine and the meter should indicate 7-10 volts DC.

Results:
1. If no voltage is indicated in Step 4, a problem exists in the engine control circuit board, or in the engine DC control circuits. See Part 5, "*ENGINE ELECTRICAL SYSTEM*".
2. If no voltage is indicated in Step 5, an open circuit exists in Wire No. 9, the field boost diode, field boost resistor, or Wire No. 4 to the Regulator.

NOTE: By removing the heat shrink tubing around the diode and resistor, these two components can be tested individually. The defective part can then be removed and replaced. The resistor (Part No. 51980) is rated 5 watts, 10 ohms. The diode (Part No. 49903) is rated 600 volts, 6 amps.



ITEM	DESCRIPTION
1	HEAT SHRINK
2	BARREL LUG
3	DIODE- 600V., 6 AMP
4	RESISTOR- 5 WATT, 10 OHMS

Figure 9. Field Boost Part of Wiring Harness

TEST 15- TEST VOLTAGE AND FREQUENCY:

Discussion: The generator's AC output frequency is directly proportional to engine speed. Generator's having a 4-pole Rotor will produce a 60 Hertz frequency at 1800 rpm. Voltage is also proportional to AC frequency. The unit will supply 120 volts (line-to-neutral) or 240 volts (line-to-line) at 60 hertz; if frequency should drop to 30 Hertz, voltage output will decrease proportionally to 60/120 volts. It is apparent that a low governed speed will result in a reduced AC frequency and voltage. Conversely, a high governed speed will produce an increased frequency and voltage.

Procedure: See Test 1. Check AC output voltage as outlined (at no-load). Use an accurate AC frequency meter to check frequency (at no-load). The no-load frequency should be 62 Hertz. No-load AC output voltage should be 121-127 (line-to-neutral); or 242-254 volts (line-to-line).

Results:
1. If both frequency and voltage are low, go to Test 16.
2. If frequency is good, but voltage is low, go to Test 17.
3. If no-load voltage and frequency are both high, go to Test 16.
4. If frequency is good, but voltage is high, go to Test 17.

TEST 16- ADJUST ENGINE GOVERNOR:

Discussion: Refer to "*DISCUSSION*" under Test 15.

Procedure: See Section 1.9, "*OPERATIONAL TESTS AND ADJUSTMENTS*".

TEST 17- ADJUST VOLTAGE REGULATOR:

Discussion: Procedures for this test and adjustment are outlined in Section 1.9.

TEST 18- CHECK FOR OVERLOAD CONDITION:

Discussion: The rated maximum wattage/amperage capacity of the generator should not be exceeded for continuous operation. Overloading the unit will result in rpm, frequency and voltage droop. Excessive overloading will cause the AC circuit breaker(s) to trip.

Procedure: If an optional remote gauge panel is installed, load current can be checked by observing the AC ammeter on that panel. If such a panel is not available, a clamp-on ammeter can be used to check amperage.

Results:
1. If unit is not overloaded, go to Test 16.
2. If the unit is overloaded, reduce the total electrical load to the rated wattage/amperage capacity.

Detailed Instructions (Continued)

TEST 19- CHECK ENGINE POWER & CONDITION:

Discussion: Quite often excessive rpm, frequency and voltage droop that occurs when loads are applied is not the fault of the generator. An under-powered engine may be the cause of the problem.

Procedure: Refer to Sections of this manual pertaining to the diesel engine. The following tune-up checks are recommended:

1. Inspect engine air cleaner. A clogged air cleaner element can rob engine power.
2. Perform a compression test on engine cylinders.
3. Check for proper operation of the diesel fuel system.

Results: Repair engine as required to restore it to full power.

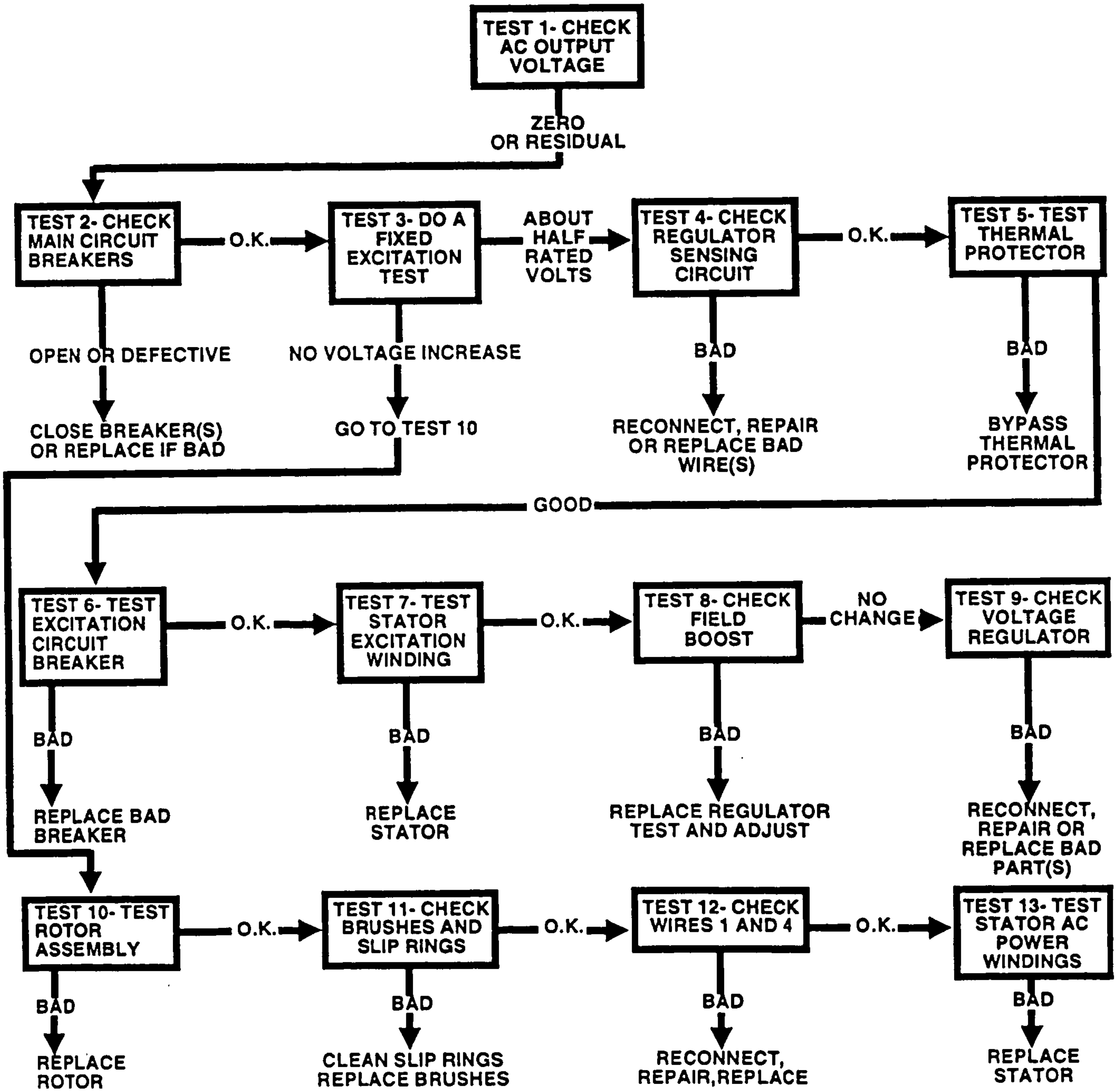
Section 1.7

TROUBLESHOOTING (UNITS WITH 10 INCH STATOR)

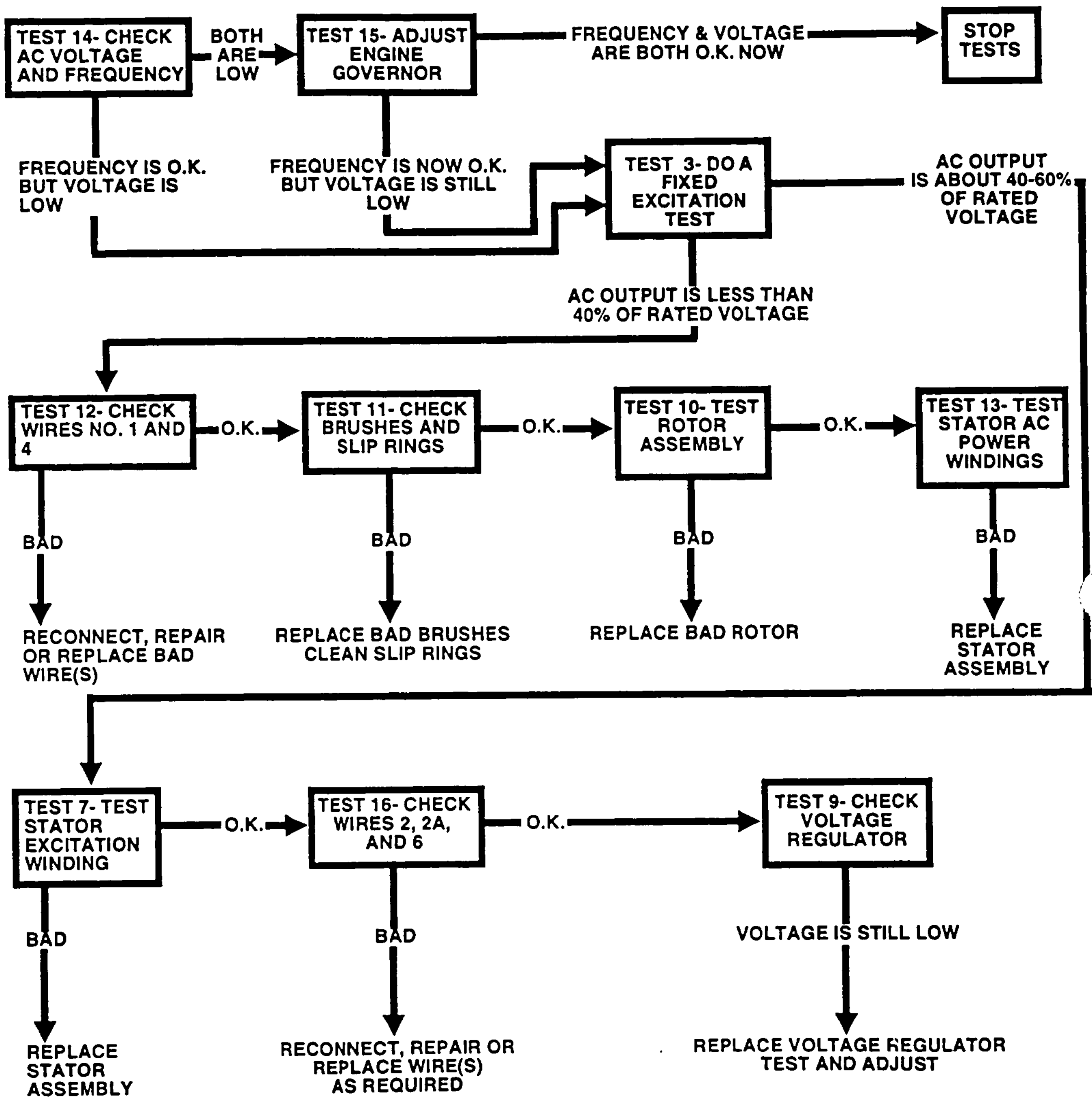
Introduction

The following "Troubleshooting Flow Charts" have been carefully formulated as an aid to the quick and accurate analysis of AC generator problems. Test numbers in the Flow Charts correspond to numbered tests in the "Detailed Instructions" that follow.

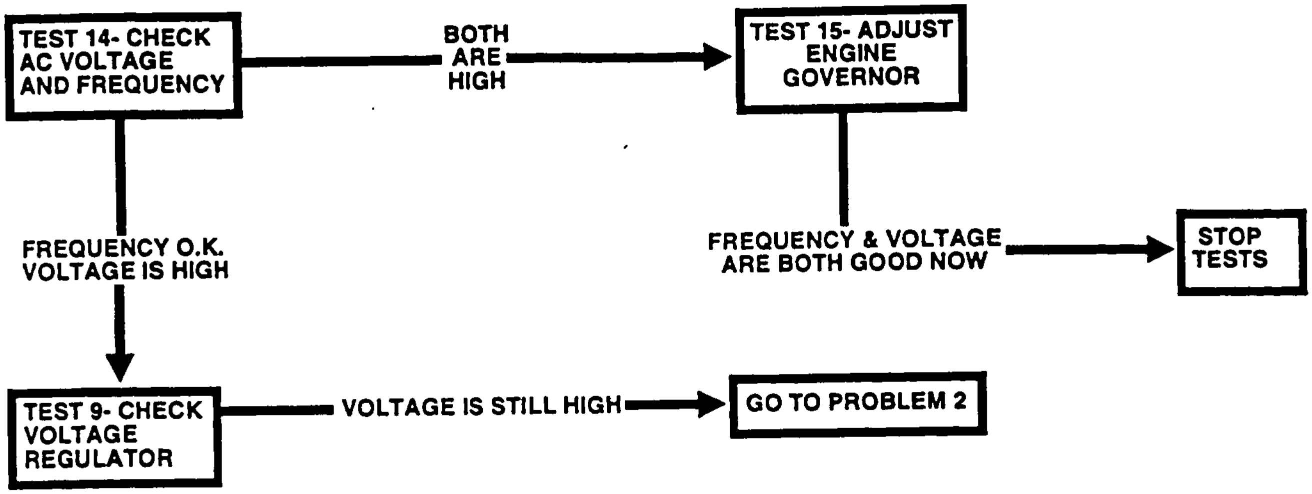
Problem 1- Generator Produces Zero or Residual Voltage at No-Load



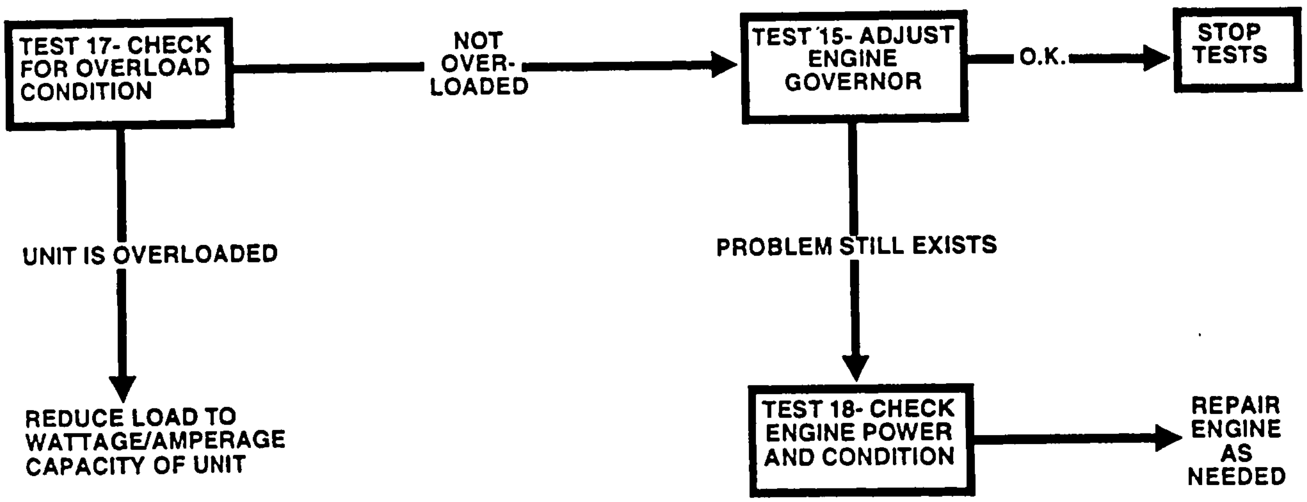
Problem 2- Generator Produces Low Voltage at No-Load (Voltage Is Greater Than Residual)



Problem 3- Generator Produces High Voltage at No-Load



Problem 4- Frequency and Voltage Drop Sharply When Load is Applied



Diagnostic Tests

INTRODUCTION:

The following "Diagnotic Tests" correspond to the numbered tests in the troubleshooting "Flow Charts" on Pages 1.7-1 through 1.7-3. When performing tests, it is recommended that the wiring diagram and/or electrical schematic for the appropriate generator model be referred to as often as necessary.

TEST 1- CHECK AC OUTPUT VOLTAGE:

Discussion: This test must be performed to help you determine if a problem exists and the exact nature of the problem. Some installed units will include an optional meter package, which includes an AC voltmeter. Even if such an optional package is installed, it is a good idea to check the voltage with an external meter such as a VOM. Using an external meter will help you determine if the AC voltmeter on the optional meter panel is accurate.

Procedure: If the generator is installed in a motor home, the VOM test probes can be inserted into a convenient AC outlet that is supplied by the generator. If uninstalled, connect the VOM test leads across AC outlet leads T1 (red), T2 (white) and T3 (black). See Figure 1.

NOTE: Remember, the unit may be connected for either single voltage (120 volts) or dual voltage (120/240 volts). See "STATOR AC CONNECTION SYSTEM" on Page 1.5-2.

Start the generator engine, let it stabilize and warm up. Read the line-to-line or line-to-neutral voltage from the VOM. Reading should be as follows:

Line T1 (red) to T2 (white) = 121-127 volts
Line T3 (black) to T2 (white) = 121-127 volts
Line T1 (red) to T3 (black) = 242-254 volts

Results:
1. If zero or residual voltage at no-load is indicated, go to Problem 1 of the "Flow Charts".
2. If the no-load voltage is low, but is greater than residual voltage, go to Problem 2 of the "Flow Charts".
3. If no-load voltage is high, go to Problem 3 of the "Flow Charts".

TEST 2- CHECK MAIN CIRCUIT BREAKERS:

Discussion: The generator is equipped with two main circuit breakers, designated CB1 and CB2, as standard equipment. If these circuit breakers are set to their "Off" or "Open" position, or if they have failed open, generator AC output voltage to the load(s) will not be available.

Procedure: Check the main circuit breakers, make sure they are set to "On" or "Closed". If the breakers are set to "On" or "Closed", but AC output voltage is not available, use a VOM to test the breakers as follows:

1. Shut the engine down.
2. Inspect the AC wiring connections carefully. Make sure wiring is properly connected for the correct voltage. See "STATOR AC CONNECTION SYSTEM" on Page 1.5-2.
3. Set the VOM to its "Rx1" scale and zero the meter. Then, test the breakers as follows:
   a. Connect the VOM test probes across circuit breaker CB1 terminals. When breaker is set to its "On" or "Closed" position, the VOM should read "continuity". When set to "Off" or "Open" position, "infinity" should be read.
   b. Repeat the above test for circuit breaker CB2. Results should be the same.

Results:
1. If circuit breakers are good, go to Test 3.
2. Replace any defective circuit breaker(s).

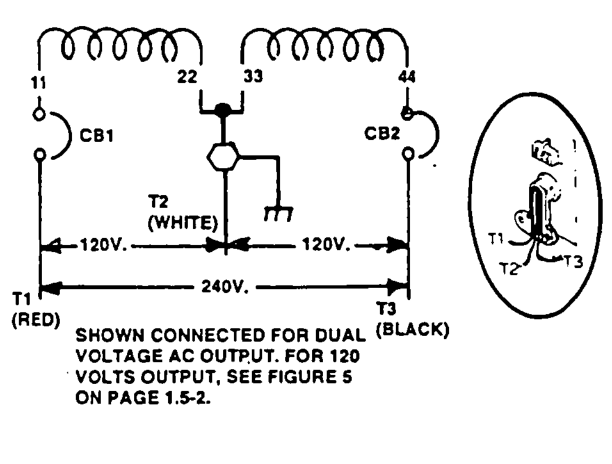


Figure 1. Stator AC Output Voltage

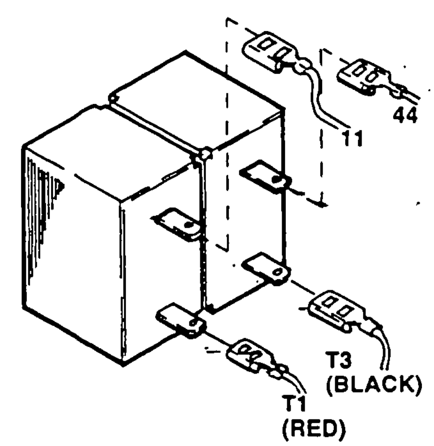


Figure 2. Main Circuit Breaker Test Points

Diagnostic Tests (Continued)

TEST 3- DO A FIXED EXCITATION TEST:

Discussion: This test will help you narrow the possible causes of zero, residual or low AC output voltage down to just a few possible causes.

The test consists of disconnecting regulated excitation current flow to the Rotor, but leaving the field boost circuit to the Rotor intact. With regulated excitation current disconnected, the generator's AC output voltage will be commensurate with Rotor residual magnetism plus field boost.

Procedure: Disconnect Wires No. 1 and 4 from the Voltage Regulator terminals, so that regulated excitation current is not available to the Rotor. Connect an AC Voltmeter across the generator AC output leads (T1, T2, T3). Start the engine, let it stabilize and warm up. The AC voltage reading should be commensurate with Rotor residual magnetism plus field boost, as follows:

1. Line-to-neutral voltage should be approximately 25-40 volts AC.
2. Line-to-Line voltage should be approximately 50-80 volts AC.

Results:

1. If line-to-neutral voltage is lower than 25-40 VAC, go to Test 10. If line-to-line voltage is less than 50-80 VAC, go to Test 10.
2. If 25-40 VAC line-to-neutral voltage is indicated (or 50-80 VAC line-to-line), go to Test 4.

TEST 4- CHECK REGULATOR SENSING CIRCUIT:

Discussion: The sensing circuit is the Regulator's ACTUAL voltage signal. The Regulator electronically compares the actual voltage with a pre-set REFERENCE voltage. If ACTUAL voltage is less than REFERENCE voltage, the Regulator will increase excitation current flow to the Rotor. If ACTUAL voltage is greater than REFERENCE voltage, it will decrease excitation current flow to the Rotor. In this manner, Rotor magnetic field strength and AC voltage are regulated.

If sensing (actual voltage) signals to the Regulator should be lost, the Regulator would interpret such a loss as "zero" actual volts. Regulator action would then increase excitation current flow to the Rotor until a "full field" condition existed. The result would be a high voltage condition. However, the Part No. 81918 Regulator will shut down automatically on loss of sensing voltage. With the Regulator shut down, excitation current to the Rotor will terminate and AC output voltage will drop to a value commensurate with the Rotor's residual magnetism plus field boost.

Procedure: Inspect Wires No. 11 and 22, between the Voltage Regulator and the engine control circuit board. These are the sensing (actual voltage) leads. Use a VOM to test the wires for "continuity".

Results:

1. Reconnect, repair or replace bad wire(s) as required.
2. If the sensing circuit is good, go on to Test 5.

TEST 5- TEST THERMAL PROTECTOR:

Discussion: You may wish to review "*THERMAL PROTECTOR*" on Page 1.3-7.

Procedure: To test the thermal protector, proceed as follows:

1. In the control panel, locate (a) Wire No. 5, (b) Wire No. 2, and (c) Wire No. 6. Wire No. 5 is unconnected and has a wire nut at its end. Wire No. 2 connects to the excitation circuit breaker. Wire No. 6 attaches to the Voltage Regulator plug.
2. Set a VOM to its "Rx1" scale and zero the meter.
3. Disconnect Wire No. 2 from the excitation circuit breaker. Unplug the Voltage Regulator plug. Remove the wire nut from Wire No. 5.
4. Connect one VOM test probe to Wire No. 5 and the other end to Pin 2 of the Regulator plug, to which Wire No. 6 attaches. The meter should read the resistance of the excitation winding (about 1.00 ohm).
5. Now, connect the VOM test probes across Wire No. 2 and Wire No. 6. Again, excitation winding resistance should be read.

Results:

1. If excitation winding resistance is indicated in Step 4, but not in Step 5, the thermal protector is open and must be bypassed.
2. If excitation winding resistance is indicated in both Steps 4 and 5, go on to Test 6.

TEST 6- TEST EXCITATION CIRCUIT BREAKER:

Discussion: This test will determine if the excitation circuit breaker has failed open. If the breaker is open, loss of excitation current to the Rotor windings will result and AC output will drop to residual voltage. The breaker is mounted in the control panel.

Procedure: Disconnect Wires 2 and 2A from the circuit breaker. Connect VOM test leads across the two breaker terminals. The VOM should read "continuity". If not, the breaker is open and should be replaced.

Diagnostic Tests (Continued)

Results:

1. Replace excitation circuit breaker if it fails the test.
2. If the circuit breaker tests good, go on to Test 7.

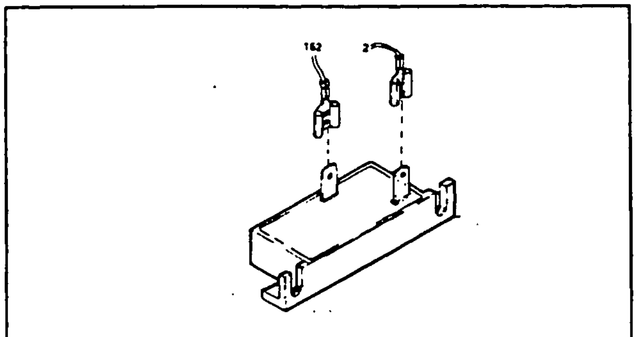


Figure 3. Excitation Circuit Breaker

TEST 7- TEST STATOR EXCITATION WINDING:

Discussion: An open or shorted stator excitation winding can seriously affect the generator's AC output. For example, an open condition will result in loss of loss of excitation AC output to the Regulator. Excitation current flow to the Rotor will then drop to zero and generator AC output voltage will drop to a value commensurate with residual magnetism plus field boost.

Procedure: Refer to Test 5. A VOM, connected across Wires No. 5 and 6, should read the resistance of the stator excitation winding (about 1.00 ohm). A reading of "infinity" indicates an open winding. A very low reading indicates a possible shorted condition. To test for a GROUNDED condition, proceed as follows:

1. Set a VOM to a very high resistance scale, such as "Rx10,000" or "Rx1K". Zero the meter.
2. Connect one VOM test probe to stator lead No. 5; connect the other test probe to a clean frame ground on the stator. The meter should read "infinity". Any reading other than "infinity" indicates a grounded condition.

Results:

1. If excitation winding is open, shorted or grounded, replace the stator assembly.
2. If excitation winding checks good, go to Test 8.

TEST 8- CHECK FIELD BOOST:

Discussion: Approximately 4 to 8 volts output from the stator excitation winding is required to turn the Voltage Regulator on. The field boost feature delivers additional current to the Rotor during engine cranking. The additional field boost current creates a Rotor magnetic field strength that is additive to the Rotor's residual magnetism. The end result of field boost is an early "pickup" voltage to build induced voltage into the stator windings early during startup.

It is normal for some residual magnetism to be present in the Rotor at all times. This residual magnetism can be lost under certain conditions. If Rotor residual magnetism has been lost, it will normally be restored by field boost current during engine cranking. However, if Rotor residual magnetism has been lost AND field boost does not "flash the field" during cranking, sufficient voltage to turn the Regulator on may not be developed. Loss of residual magnetism accompanied by loss of field boost current will likely result in a reduction of generator AC output to zero volts.

Field boost current is always available to the Rotor when the engine is running, by the action of an engine control circuit board housed in the control panel. Battery voltage is delivered to the Rotor via Terminal 8 of that circuit board, Wire 4A, field boost resistor, and Wire 4.

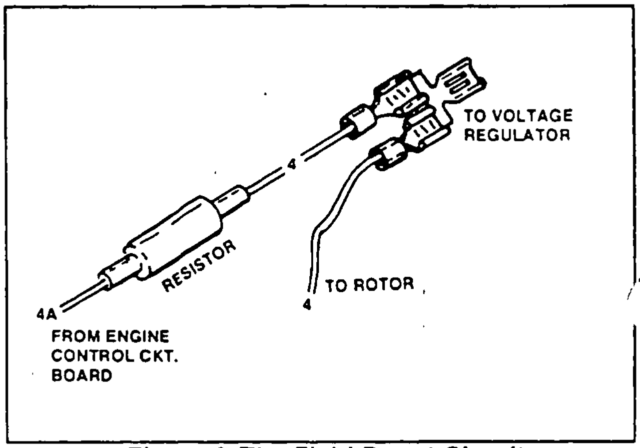


Figure 4. The Field Boost Circuit

Procedure: To test the field boost function, proceed as follows:

1. Disconnect Wires No. 4 from the Voltage Regulator. This is a "piggy-back" terminal with one Wire No. 4 routed to the brushes and one Wire No. 4 coming from the engine control circuit board. The latter wire, with in-line resistor, is the field boost circuit.
2. Connect a DC voltmeter across the terminal end of Wire No. 4 at the Voltage Regulator and Terminal 2 of the engine control circuit board (to which Wires No. 0 [ground] connect).
3. Crank the engine. During cranking, the meter should read approximately 9-10 volts DC, indicating that field boost voltage is available.
   a. If field boost voltage is indicated, end the test and go to Test 9.
   b. If voltage is NOT indicated, go to Step 4.
4. Connect the DC voltmeter across Terminal 8 (Wire No. 4A) of the engine control circuit board and Terminal 2 (Wire No. 0) of the circuit board. Crank engine and meter should read battery voltage (about 12-13 volts DC).

Diagnostic Tests (Continued)

Results:

1. If field boost voltage is NOT indicated in Step 4, a problem exists in the field boost wiring.
2. If field boost voltage is NOT indicated in Step 3, but IS indicated in Step 4, replace Wires 4, 4A and the field boost resistor.
3. If field boost voltage is indicated in Step 3, go to Test 9.

TEST 9- CHECK VOLTAGE REGULATOR:

Discussion: If you followed the troubleshooting "Flow Chart" carefully, the only remaining possible cause of zero, residual, low or high voltage is the voltage regulator.

Procedure: Try adjusting the voltage regulator as outlined in Section 1.9, "OPERATIONAL TESTS AND ADJUSTMENTS".

Results: If Regulator adjustment does not correct the problem, remove and replace the Regulator. Then, test the unit and adjust the Regulator.

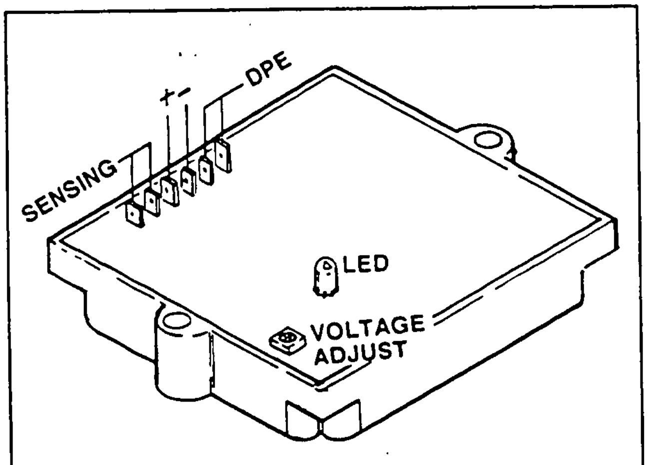


Figure 5. Voltage Regulator

TEST 10- TEST ROTOR ASSEMBLY:

Discussion: If fixed excitation voltage is applied to the Rotor and the generator's AC output voltage does not read about half rated voltage, the Rotor side of the voltage regulator circuit is suspect. This test will outline the procedure for testing the Rotor winding.

Procedure: To test the Rotor windings for an open, shorted or grounded condition, proceed as follows:

1. To gain access to the Rotor slip rings, remove the rear bearing carrier cover and gasket.
2. Disconnect Wires No. 1 and 4 from the brushes, then remove the brush holders with brushes to prevent interaction during the test.
3. Set a VOM to its "Rx1" scale and zero the meter.
4. Connect the positive (+) meter test probe to the positive (+) slip ring. This slip ring is the one nearest the Rotor bearing.
5. Connect the common (-) VOM test probe to the negative (-) slip ring. The meter should indicate the resistance of the Rotor windings.

Rotor Winding Nominal Resistance
Approximately 8.5 Ohms

NOTE: A reading of "Infinity" indicates an open circuit. A very high resistance indicates a partial open. A low reading indicates shorted turns.

6. Now, set the VOM to a very high resistance scale, such as "Rx10,000" or "Rx1K" and zero the meter. Then, check the Rotor for a grounded condition as follows:
   a. Connect the positive (+) VOM test probe to the positive (+) slip ring, nearest the Rotor bearing.
   b. Connect the common (-) VOM test probe to frame ground, such as the Rotor shaft.
   c. The meter should read "infinity". Any reading other than "infinity" indicates a grounded condition.

Results:
1. If the Rotor is good, go on to Test 11.
2. If Rotor is open, shorted or grounded, it must be replaced.

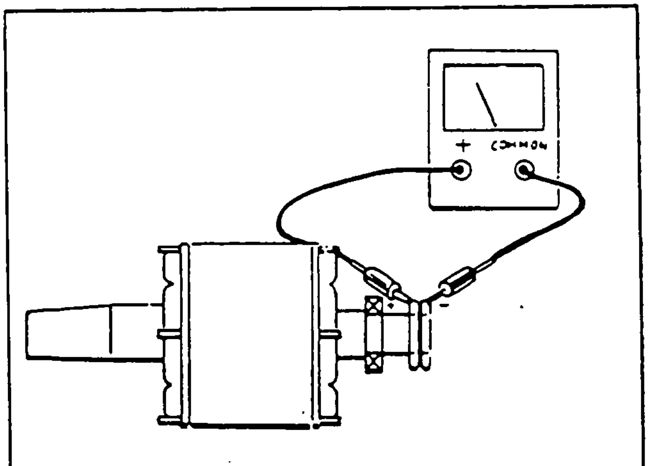


Figure 6. Rotor Test Points

TEST 11- CHECK BRUSHES AND SLIP RINGS:

Discussion: Refer to Test 12 in Section 1.6.

Procedure: See Test 12 in Section 1.6.

Results: Clean slip rings or replace brushes as necessary. Brushes should be replaced in completes sets. If brushes and slip rings are good but the problem persists, go to Test 12 on the next page.

Diagnostic Tests (Continued)

TEST 12- CHECK WIRES 1 AND 4:

Discussion: An open or shorted condition in Wires 1 and 4 will have the same result as an open or shorted Rotor winding.

Procedure: Carefully inspect Wires No. 1 and 4, between the Voltage Regulator and the Brushes. Look for improper connections, damaged insulation. condition of wire terminal ends, etc. Use a VOM to check the wires for an open or shorted condition.

Results:
1. Reconnect, repair or replace defective wire(s) as necessary.
2. If wires are good, go to Test 13.

TEST 13- TEST STATOR AC POWER WINDINGS:

Discussion: During the fixed excitation test, the generator's AC output voltage should have been approximately one-half rated voltage. If voltage was less than one-half rated voltage, one possible cause might be an open, shorted or grounded stator AC power winding. You may wish to review "*STATOR AC CONNECTION SYSTEM*" on Page 1.5-2.

Procedure: To test the stator's AC power winding, proceed as follows:

1. Disconnect and isolate stator leads 11, 22, 33 and 44. See appropriate wiring diagram.
2. Set an accurate VOM to its "Rx1" scale and zero the meter.
3. Check for an open circuit condition or for "turn-to-turn" shorts as follows:
   a. Connect the VOM test probes across stator leads 11 and 22. The resistance of the stator winding should be indicated, about 0.21 ohm.
   b. Connect the VOM test probes across stator leads 33 and 44. Reading should be approximately 0.21 ohm.
   c. A reading of "infinity" indicates an open circuit. A very high reading, indicates a nearly open circuit. A very low reading indicates "turn-to-turn" shorts.
4. Check for a short between parallel windings as follows:
   a. Set the VOM to a high resistance scale, such as "Rx10,000" or "Rx1K". Zero the meter.
   b. Connect one VOM test probe to stator lead 11, the other to stator lead 33. The meter should read "infinity".
5. Check for a grounded condition as follows:
   a. Set the VOM to a high resistance scale, such as "Rx10,000" or "Rx1K". Zero the meter.
   b. Connect one VOM test probe to stator lead 11, the other to a clean frame ground on the stator. The VOM should read "infinity".
   c. Now, connect one VOM test probe to stator lead 33, the other to a clean frame ground on the stator. The meter should read "infinity".

Results: Replace the stator if it is open, shorted or grounded.

TEST 14- CHECK AC VOLTAGE & FREQUENCY:

Discussion: You may wish to review "*ROTOR ROTATIONAL SPEED*", as well as "*VOLTAGE AND FREQUENCY*" on Page 1.5-2.

Procedure: Refer to Test 1, "CHECK AC OUTPUT VOLTAGE". Use an accurate AC frequency meter to check AC output frequency, as well. No-load voltage and frequency readings should be as follows:

Line-to-Neutral Voltage = 121-127 volts AC
Line-to-line Voltage = 242-254 volts AC
AC Output Frequency = 60.5-63.5 Hertz

Results:
1. If voltage and frequency are both correspondingly low or high, go to Test 15.
2. If frequency is good, but voltage is LOW, go to Test 3.
3. If frequency is good, but voltage is HIGH, go to Test 9.

TEST 15- ADJUST ENGINE GOVERNOR:

Discussion: See "Discussion" under Test 14, above.

Procedure: Check and adjust the engine governor as outlined in Section 1.9, "*OPERATIONAL TESTS AND ADJUSTMENTS*".

Results:
1. If voltage and frequency are now acceptable, stop tests.
2. If frequency is now acceptable, but voltage is low, go to Test 3.

TEST 16- CHECK WIRES 2, 2A, AND 6:

Discussion: Unregulated AC output voltage from the stator excitation windings is delivered to the voltage regulator via Wires 2, 2A and 6. An open condition in any part of this circuit will prevent excitation current from reaching the regulator and the Rotor.

Procedure: Refer to appropriate wiring diagram. Carefully inspect the wires for damage, incorrect connections, burned insulation, etc. Use a VOM to test each wire for an open or shorted condition.

Results: Reconnect, repair or replace any damaged or defective wire(s).

TEST 17- CHECK FOR OVERLOAD CONDITION:

Discussion: The generator should never be overloaded. That is, the total of all electrical loads connected at one time should not be greater than the unit's rated wattage/amperage capacity. If the generator is overloaded, rpm, frequency and voltage can drop sharply. In addition, the stator windings can heat up and cause the thermal protector to trip (open). If frequency and voltage drop excessively when electrical loads are applied, make sure the unit is not overloaded.

Diagnostic Tests (Continued)

Procedure: Add up the watts or amperes required to run all lights, appliances, motors, tools, etc., that will be powered by the generator at one time. This totatl should not be greater than the generator's rated wattage and/or amperage capacity. Rated wattage and amperage of the generator can be found on the unit's DATA PLATE.

Results:

1. If frequency and voltage drop excessively when load is applied, but unit is NOT overloaded, go to Test 15.
2. If unit is overloaded, reduce the total load to a wattage or amperage value that is within the unit's rated capacity.

NOTE: A badly shorted condition in the load circuit can also cause frequency and voltage to drop drastically when the load is applied.

TEST 18- CHECK ENGINE POWER & CONDITION:

Discussion: If the engine has lost power, AC output voltage and frequency will droop when the load is applied. The limit to AC output current (amps) is often established by available engine power. Loss of engine power can result from such things as a dirty air cleaner, burned valves, mechanical damage, out-of-time, etc.

Procedure: Inspect and test the engine. Look for anything that might cause the engine to lose power.

Section 1.8
INSULATION RESISTANCE TESTS

Effects of Dirt and Moisture on Generators

If moisture is permitted to remain in contact with the generator windings, some of it will be retained in voids and cracks of the winding insulation. This will cause a reduced insulation resistance and, eventually, generator AC output will be affected. Winding insulation used in "NP" and "IM" series generators is moisture resistant. However, prolonged exposure to water, high humidity, salt air, etc., will gradually degrade the resistance of winding insulation.

Dirt can make the problem even worse, since dirt tends to hold moisture into contact with the windings. Salt (as from sea air) will also worsen the problem, since salt tends to absorb moisture from the air. When salt and moisture combine, they make a good electrical conductor.

Because of the detrimental effects of moisture, dirt and salt, the generator should be kept as dry and clean as possible. Stator and rotor winding insulation resistance should be tested periodically. If insulation resistance is low, drying may be necessary. If resistance is still low after drying, replacement of defective windings may be required.

Insulation Resistance

Insulation resistance is a measurement of the integrity of the insulating materials that separate the electrical windings from the generator's steel core. Most winding failures are caused by a breakdown in the insulation system. In many cases, low insulation resistance is caused by moisture that has collected when the generator is shut down. The problem can often be corrected by drying out the windings.

Normally, the resistance of the insulation system is on the order of millions of ohms. It can be measured with a device called a "megger" or "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 greater than 500 is not recommended.

Another device used to check for insulation breakdown is called a "Hi-Pot Tester". See Figure 1. A typical Hi-Pot Tester has a "Pilot" lamp which turns on to indicate that power is available; and a "Breakdown" lamp which turns on if the insulation is breaking down under an applied voltage. The Hi-Pot Tester shown also has a "Voltage Selector" switch which allows the user to select the voltage that will be applied to the winding being tested.

DANGER: MEGGERS AND HI-POT TESTERS DELIVER A HIGH VOLTAGE TO WINDINGS BEING TESTED. DO NOT TOUCH THE GENERATOR, THE WINDING BEING TESTED, OR THE TEST LEADS WHEN PERFORMING TESTS. CARELESS USE OF SUCH TESTERS CAN RESULT IN DANGEROUS ELECTRICAL SHOCK.

To measure insulation resistance, connect one test lead to the leads of the winding to be tested. Connect the other test lead to the generator frame. Make sure the leads of the part being tested are not touching metal parts of the generator. If the "Neutral" line of a stator is grounded, it must be disconnected.

CAUTION: Before attempting to test insulation resistance, first disconnect all electronic components, regulators, diodes, surge protectors, protective relays, etc. The high tester voltages will destroy such components.

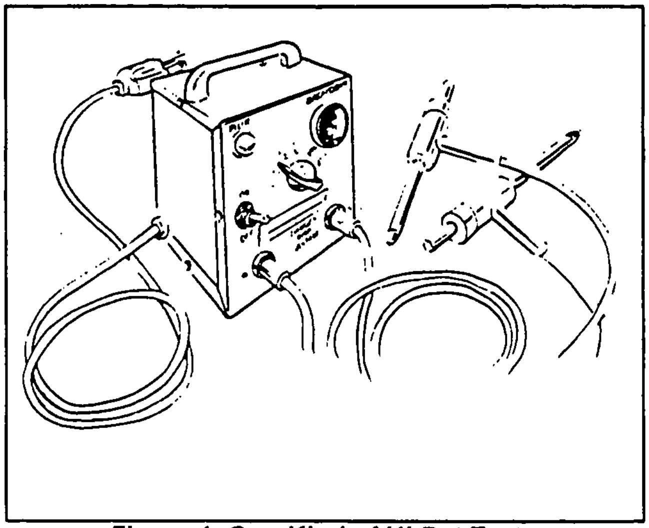


Figure 1. One Kind of Hi-Pot Tester

Using a Hi-Pot Tester

The Hi-Pot Tester shown in Figure 1 is one of many brands that are commercially available. Insulation breakdown tests outlined in this section use the tester shown in the illustration. The tester shown has a "Breakdown" lamp which turns on to indicate an insulation breakdown. If you are using another tester or megger, follow the manufacturer's instructions carefully. Do not exceed the voltages recommended in this manual.

All stator leads must be isolated from ground and connected together. On systems with a grounded neutral, the neutral can be isolated from ground and used as a test point.

CAUTION: Do not apply tester voltages to the stator or rotor windings longer than 1 second. Turn the tester switch "ON"; check that the Pilot lamp is "ON"; wait 1 second while observing the "Breakdown" lamp; turn the tester switch "OFF".

Testing Stator Insulation Resistance

To test the resistance of stator insulation, proceed as follows:

1. To test all stator leads to ground:
   a. Connect the ends of stator leads 11, 22, 33, 44, 2, 5 and 6 together. Make sure none of the wire terminal ends are touching any part of the generator.
   b. Connect the red test lead of the Hi-Pot Tester to the bunched terminal ends of Wires 11, 22, 33, 44, 2, 5 and 6.
   c. Connect the black test lead of the Hi-Pot Tester to a clean frame ground on the stator.
   d. Turn the Hi-Pot Tester Switch OFF.
   e. Plug the Hi-Pot Tester into a 120 volts AC wall receptacle.
   f. Set the Tester's Voltage Switch to "500" volts.
   g. Turn the Hi-Pot Tester switch ON. Check that the Tester's Pilot lamp is ON.
   h. Set the Tester Voltage Switch to "2000" volts and watch the "Breakdown" lamp. After 1 second, turn the Tester switch OFF and reset Voltage switch to "500" volts. **DO NOT APPLY VOLTAGE LONGER THAN 1 SECOND.**

2. To test between isolated windings:
   a. Connect the red Tester lead to terminal end of stator lead No. 2. Connect the black tester lead to terminal end of stator lead No. 11.
   b. Turn the Tester switch to ON (Pilot lamp should come ON).
   c. Set the Voltage Selector switch to "1500" volts. **APPLY VOLTAGE FOR ONE SECOND ONLY WHILE OBSERVING THE "BREAKDOWN" LAMP.**

   d. Turn the Tester switch to OFF and reset the Voltage switch to "500" volts.

3. To test between parallel windings:
   a. Connect the red tester lead to terminal end of stator lead No. 11; the black tester lead to terminal end of stator lead No. 33.
   b. Turn the tester switch to ON (pilot lamp should come ON).
   c. Set the Voltage Selector switch to "500" volts. **APPLY VOLTAGE FOR ONE SECOND WHILE OBSERVING THE "BREAKDOWN" LAMP.** After one second, turn the tester switch to "Off".

If the tester "Breakdown" lamp came on during any one second test, clean and dry the stator. Then, repeat the insulation breakdown test. If the "Breakdown" lamp illuminates during the second test, replace the stator assembly.

Testing Rotor Insulation

Before testing the Rotor, make sure brushes and brush holders are removed and Rotor is completely isolated from ground and from other components.

Disconnect excitation leads No. 1 and 4 from the brushes. Remove the brush holders with brushes. Make sure Rotor is completely isolated from frame ground.

CAUTION: Rotor must be completely isolated from the Voltage Regulator. Brush Wires No. 1 and 4 must not touch any part of frame during the test, or damage to the Regulator will result.

1. Connect the red test lead to the positive (+) slip ring. This is the slip ring nearest the Rotor bearing.
2. Connect the tester black lead to a clean frame ground on the Rotor.
3. Turn the Tester switch OFF.
4. Plug the tester into a 120 volts AC wall receptacle.
5. Set the Tester Voltage switch to "500" volts.
6. Turn the tester ON and check that the Pilot lamp is ON.
7. Set the tester Voltage switch to "1250" volts. Wait one (1) second, then turn the tester switch OFF. **DO NOT APPLY VOLTAGE LONGER THAN ONE SECOND.**

If the tester "Breakdown" lamp comes on during the one second test, cleaning and drying may be necessary. After cleaning and drying, repeat the insulation breakdown test. If "Breakdown" lamp comes on during the second test (after cleaning and drying), replace the Rotor.

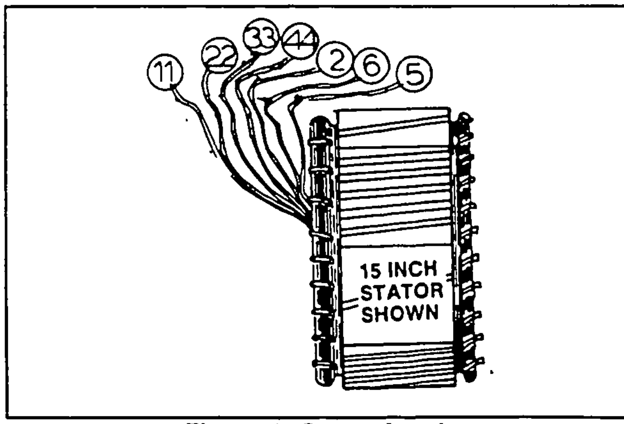


Figure 2. Stator Leads

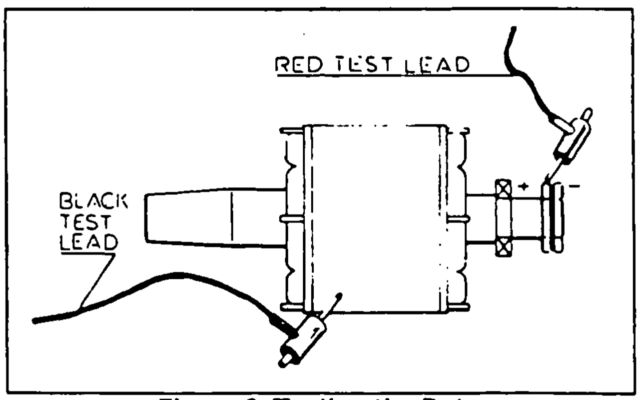


Figure 3. Testing the Rotor

Cleaning the Generator

Grease or caked-on dirt can be removed with a saoft brush or a clean, damp cloth. A vacuum system may be used to remove loosened dirt. Loose dust and dirt may also be blown away with clean, dry, low pressure air (25 psi maximum).

CAUTION: Do NOT use a forceful spray of water to clean the generator. Some of the water will be retained on generator windings.

Drying the Generator

To dry the generator, proceed as follows:

1. Open the generator's main circuit breakers or the main line switch. NO ELECTRICAL LOADS MUST BE APPLIED WHILE THE GENERATOR IS DRYING.
2. Disconnect the voltage regulator.
3. Provide an external source of warm, dry air. This air must be drawn through the generator's air inlet, blown over the rotor and stator, and must then exit through the cooling air outlet opening(s). DO NOT EXCEED 185° F. (85° C.).
4. Start the generator, let it run for about 2 to 3 hours.
5. After the recommended drying time of 2-3 hours, shut the engine down.
6. Retest the stator and rotor insulation for breakdown.

Section 1.9
OPERATIONAL TESTS AND ADJUSTMENTS

Introduction

Following major maintenance, an operational test of the generator should be conducted. Any required adjustments should be completed at this time. Operational testing may be accomplished on either an installed or uninstalled generator.

Preparation Before Operation

Before you attempt to crank or start the generator, be sure to check the following:

- ☐ Check engine oil level.
- ☐ Check engine coolant level.
- ☐ Check fuel supply.
- ☐ Check cooling air flow.

CHECK ENGINE OIL LEVEL:

Remove the engine dipstick and wipe end with a clean, lint-free cloth. Insert dipstick again and check oil level. Add the recommended oil, if necessary, to the dipstick "FULL" mark only. **DO NOT OVERFILL ABOVE THE "FULL" MARK. NEVER OPERATE THE ENGINE WITH OIL LEVEL BELOW THE "ADD" MARK.**

Engine oil capacity without oil filter change is 3.7 U.S. quarts; with oil filter change, capacity is 4.0 U.S. quarts.

Use a high quality detergent oil classified "For Service CC or CD". Detergent oils keep the engine cleaner and reduce carbon deposits. Use oil having the following SAE (Society of Automotive Engineers) viscosity rating, based on the ambient temperature range anticipated before the next oil change:

AMBIENT TEMPERATURE	RECOMMENDED SAE VISCOSITY
Above 100° F.	Use SAE 40 oil
40°-100° F.	SAE 10W-30 or SAE 30 Oil
Below 40° F.	SAE 5W-20 or 5W-30 Oil

CHECK COOLANT LEVEL:

Some generator models will be equipped with a remote mounted radiator, some models with a unit-mounted radiator. Before starting, be sure to check the coolant level in the radiator as well as the coolant recovery bottle.

Recommended coolant is a 50-50 mixture of ethylene glycol base anti-freeze and soft water. Use only a low silicate type anti-freeze. When adding coolant, always add the recommended 50-50 mixture.

CHECK FUEL SUPPLY:

Recommended fuel is a high quality, automotive type DIESEL fuel conforming to JIS No. 2D diesel fuel. The fuel supply must be kept CLEAN.

CHECK COOLING AIR FLOW:

If the generator is installed, make sure all cooling air inlet and outlet openings are open and unobstructed. Without adequate cooling air flow, the unit will quickly overheat and cause problems.

Starting the Engine

Before startup, turn OFF all electrical loads. Initial tests and adjustments are accomplished with the unit at no-load. To crank and start engine, hold the engine's start/stop switch at START. Release the switch when the engine starts. Let the engine stabilize and warm up.

Operational Tests

PRELIMINARY CHECKS:

When the engine has stabilized and warmed up, check all gauge and instrument readings available (oil pressure, coolant temperature, DC voltmeter, AC voltage, AC frequency).

NOTE: Some installations may include a gauge and meter panel. See Part 5, Section 5.8, "REMOTE PANELS AND CABLES".

Listen to the engine-generator while it is running. Unusual noises should be investigated and corrected. If the exhaust system is defective, shut down and complete the necessary repairs.

DANGER: ENGINE EXHAUST GASES CONTAIN DEADLY CARBON MONOXIDE GAS. CARBON MONOXIDE IS AN ODORLESS AND COLORLESS GAS THAT IS FORMED DURING THE COMBUSTION OF HYDROCARBON FUELS. DO NOT OPERATE THE GENERATOR IF ITS EXHAUST SYSTEM IS DAMAGED OR LEAKING. EXHAUST FUMES, IF BREATHED IN SUFFICIENT CONCENTRATIONS, CAN CAUSE UNCONSCIOUSNESS OR EVEN DEATH. PROVIDE ADEQUATE VENTILATION TO PREVENT THIS DANGEROUS GAS FROM ACCUMULATING.

Inspect the engine carefully for signs of oil, fuel or coolant leaks. No leakage should be permitted.

CHECK AC OUTPUT VOLTAGE & FREQUENCY:

With the engine running at no-load, use an accurate AC voltmeter and frequency meter to check voltage and frequency output. Record all readings for future reference. Frequency should be 60.5-63.5 Hertz. Line-to-neutral voltage should be 121-127 volts AC; line-to-line voltage should be 242-254 volts AC at no-load. Setting the no-load frequency slightly high helps prevent excessive rpm and frequency droop under heavy electrical loading.

Operational Tests (Continued)

If AC output voltage and frequency are not within the stated limits, some adjustments will have to be made as follows:

- ☐ If voltage and frequency are both correspondingly high or low, check and adjust the engine governor.
- ☐ If AC frequency is good, but voltage is high or low, try adjusting the Voltage Regulator.

NOTE: Do NOT attempt an adjustment if the engine is running rough. If engine runs rough or is hard to start, air may be present in the diesel fuel system. If necessary, bleed the fuel system as outlined in PART 4, "ENGINE FUEL SYSTEM".

NOTE: If problems are encountered, refer to the appropriate troubleshooting section in this manual. See Section 1.6 if troubleshooting units with 15 inch stator. See Section 1.7 for troubleshooting units with 10 inch stator.

CHECK OPERATION UNDER LOAD:

Turn on electrical loads equal to the generator's rated wattage and/or amperage capacity. Engine speed (frequency) may drop off momentarily when load is applied, but should recover within a short time. With the unit loaded to its rated capacity, frequency should not droop below about 58 Hertz.

Engine Governor Adjustment

You may wish to read Section 1.5, "*INTRODUCTION TO TROUBLESHOOTING*".

Initial adjustment of governed speed should be accomplished at no-load condition. Prior to engine startup, turn OFF all electrical loads by whatever means available (such as the generator main circuit breakers).

To adjust the engine governor, proceed as follows:

1. Connect an accurate AC frequency meter and voltmeter to the proper generator leads.
2. Start the engine, let it stabilize and warm up at no-load.
3. Read the no-load AC frequency and voltage from the previously connected meters.
   a. AC frequency at no-load should be 60.5-63.0 Hertz.
   b. Line-to-line voltage should be 242-254 volts.
   c. Line-to-neutral voltage should be 121-127 volts.
4. Analyze the voltage and amperage readings as follows:
   a. If frequency and voltage are both good, no adjustment is needed.
   b. If frequency is high or low, go on to Step 5 of this test.
   c. If frequency is good, but voltage is high or low, adjust the voltage regulator.
5. If no-load AC frequency is high or low, adjust the engine governor as follows Figure 1):
   a. Turn the GOVERNOR ADJUSTING SCREWS as required to obtain a no-load frequency as close as possible to 62 Hertz.
   b. With no-load frequency close to 62 Hertz, apply an electrical load as close as possible to the unit's rated load. If frequency drops below 58 Hertz, repeat Step 5(a), but set the no-load frequency slightly higher than 62 Hertz. DO NOT EXCEED 63.5 HERTZ.
   c. Again load to the unit to its rated load capacity. Frequency under load should not drop below 58 Hertz.
   d. Continue to check frequency at no-load and under rated load until frequency at rated load is 58 Hertz or more. DO NOT EXCEED A NO-LOAD SPEED OF 63.5 HERTZ.

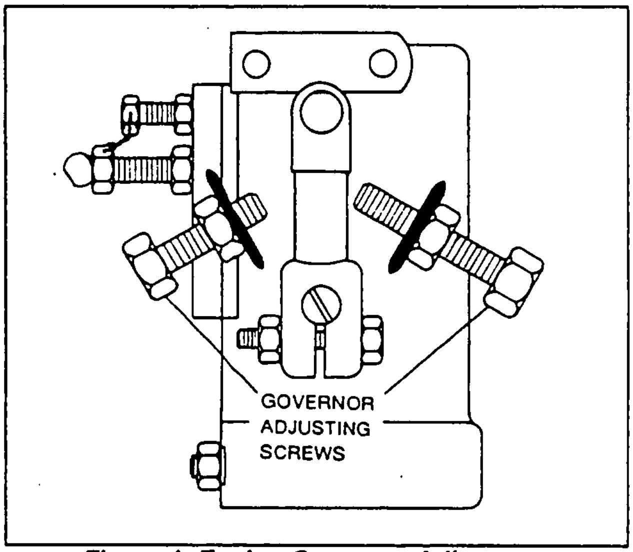


Figure 1. Engine Governor Adjustment

Voltage Regulator Adjustment

UNITS WITH 10 INCH STATOR:

To obtain correct AC voltage when frequency is correct, proceed as follows (Figure 2):

1. Make sure the unit's no-load frequency is correct. Readjust the engine governor, if necessary.
2. When frequency is correct, and with unit running at no-load, slowly turn the VOLTAGE ADJUST potentiometer on the voltage regulator until voltage is within the specified limits.
   a. Line-to-neutral voltage should be 121-127 volts.
   b. Line-to-line voltage should be 242-254 volts.

CAUTION: Do NOT force the Regulator's adjustment potentiometer past its stops or damage to the Regulator can result.

Voltage Regulator Adjustment (Continued):

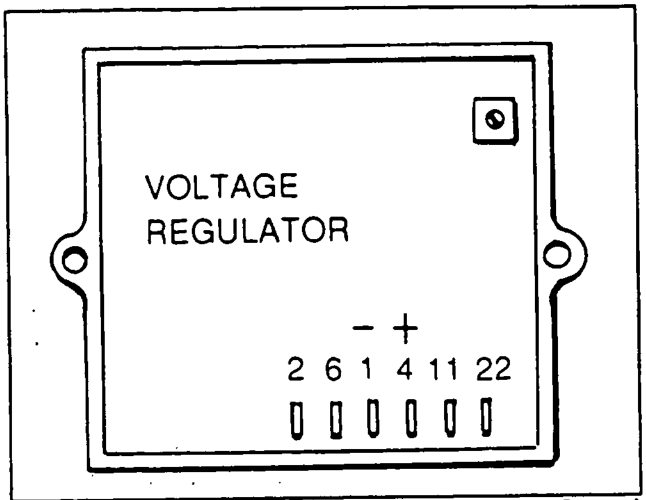


Figure 2. Voltage Regulator (Units with 10" Stator)

UNITS WITH 15 INCH STATOR:

The voltage regulator used on NP series units with 15 inch stator is shown in Figure 4. To adjust the regulator, proceed as follows:

1. Gain access to the voltage regulator in the generator control panel.
2. If a new replacement regulator is being installed, locate Switch "SW1" on the regulator circuit board. Set the switch to Position "2". Position "1" is used only for brushless generators.

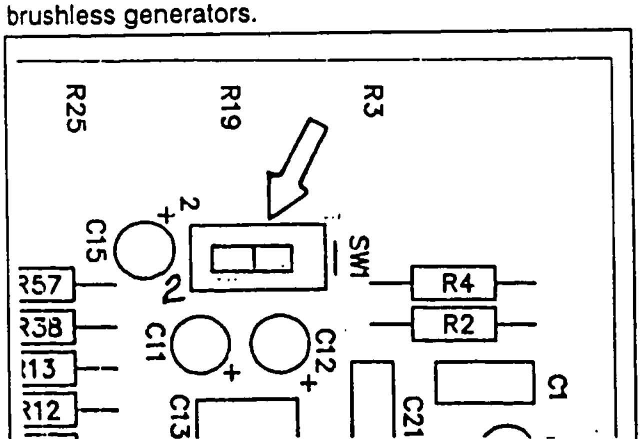


Figure 3. Location of Switch "SW1"

3. Connect an accurate AC voltmeter and frequency meter to the generator's AC output leads.
4. With unit shut down, set the voltage regulator potentiometers as follows:
   a. Turn the "Voltage Adjust" pot fully counterclockwise.
   b. Set "Gain" to its centered or mid-position.
   c. Set "Stability" to its centered or mid-position.
   d. Do NOT adjust the "Underfrequency Adjust" pot.
5. If so equipped, set the control panel's voltage adjust pot to its centered or mid-position.
6. Turn OFF all electrical loads. Startup and initial adjustments will be accomplished under a "no-load" condition.
7. Start the engine, let it stabilize and warm up at no-load.
8. Check the reading on the frequency meter.
   a. Frequency should be 60.5-63.5 Hertz.
   b. If necessary, adjust the engine governor to obtain a no-load frequency reading as close to 62 Hertz as possible. See adjustment procedure for governor.
   c. Do NOT proceed until governor is properly adjusted and frequency reading is correct.
9. Check the lamps (LED's) on the voltage regulator. All lamps should be ON. If any lamp is OUT, see appropriate troubleshooting section.
10. Turn the regulator's "Voltage Adjust" pot to obtain a line-to-line voltage of 242-254 volts; a line-to-neutral voltage of 121-127 volts. Try to get the voltage as close as possible to 124 volts (line-to-neutral); or 248 volts (line-to-line).
11. If the red "Regulator" lamp is flashing, turn the "Stability" pot either direction until the flashing stops.
12. Apply an electrical load and check engine speed recovery.
   a. Adjust the "Underfrequency Adjust" counterclockwise to unload the unit and reduce load voltage while the engine recovers.
   b. For flat regulation (no voltage decrease as frequency drops), turn the "Underfrequency Adjust" fully clockwise. Set point for this adjustment is 62 Hertz (counterclockwise) to 52 Hertz (clockwise).
   c. To obtain a constant voltage reduction as frequency drops, set "Underfrequency Adjust" fully counterclockwise.
13. With electrical load still applied, check the "Regulator" lamp for flashing. If lamp is flashing, adjust the "Stability" pot until flashing stops.
14. If better response is needed, adjust the "Gain" pot clockwise as needed. Then, if needed, correct for instability by adjusting the "Stability" pot.

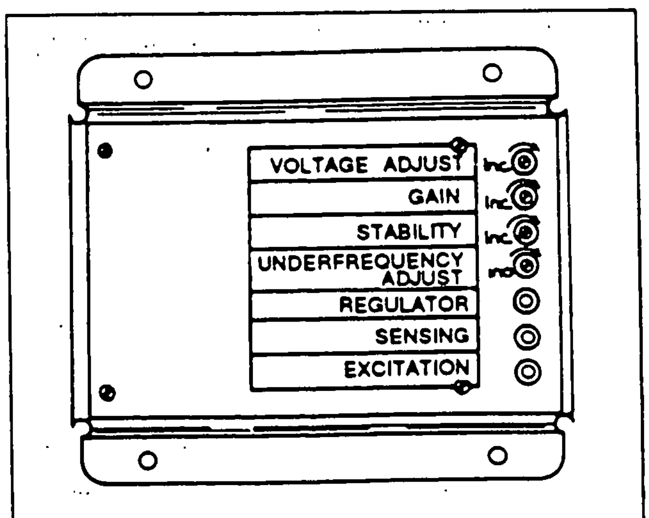


Figure 4. Voltage Regulator (Units with 15" Stator)

Voltage Regulator Adjustment (Continued)

UNITS WITH 15 INCH STATOR (CONT'D):

14. Turn OFF all electrical loads and check the voltage regulator lamps at no-load.
15. When all adjustments have been completed, let the engine run at no-load for a few minutes to stabilize internal engine-generator temperatures.
16. Shut the engine down.

Overspeed Shutdown Adjustment

GENERAL:

NP series generators are equipped with an automatic shutdown system which will stop the engine in the event of an overspeed. Shutdown will occur automatically when AC frequency (engine speed) exceeds approximately 69-71 Hertz (2070-2130 rpm). Adjustment of the overspeed shutdown setting is required when the unit's engine control circuit board is replaced.

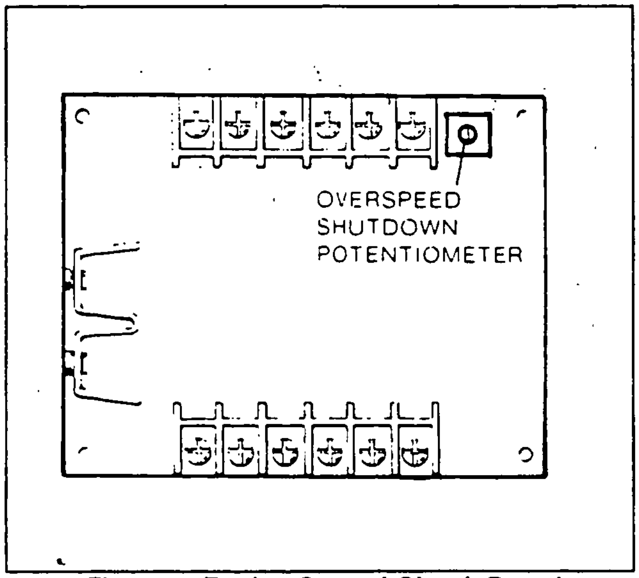


Figure 5. Engine Control Circuit Board

ADJUSTMENT PROCEDURE:

To adjust the overspeed shutdown setting, proceed as follows:

1. On the engine control circuit board, turn the OVERSPEED SHUTDOWN POTENTIOMETER 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.
4. Use the injection pump throttle lever to SLOWLY increase engine speed until the frequency meter reads 69-71 Hertz.
5. Hold the thrtottle at 69-71 Hertz and SLOWLY turn the OVERSPEED SHUTDOWN POT clockwise. When the engine shuts down, overspeed setting is correct.

PART 2
ENGINE
MECHANICAL

NP and IM Series

RECREATIONAL VEHICLE & INDUSTRIAL MOBILE AC GENERATORS

Liquid-Cooled
Diesel Engine Models

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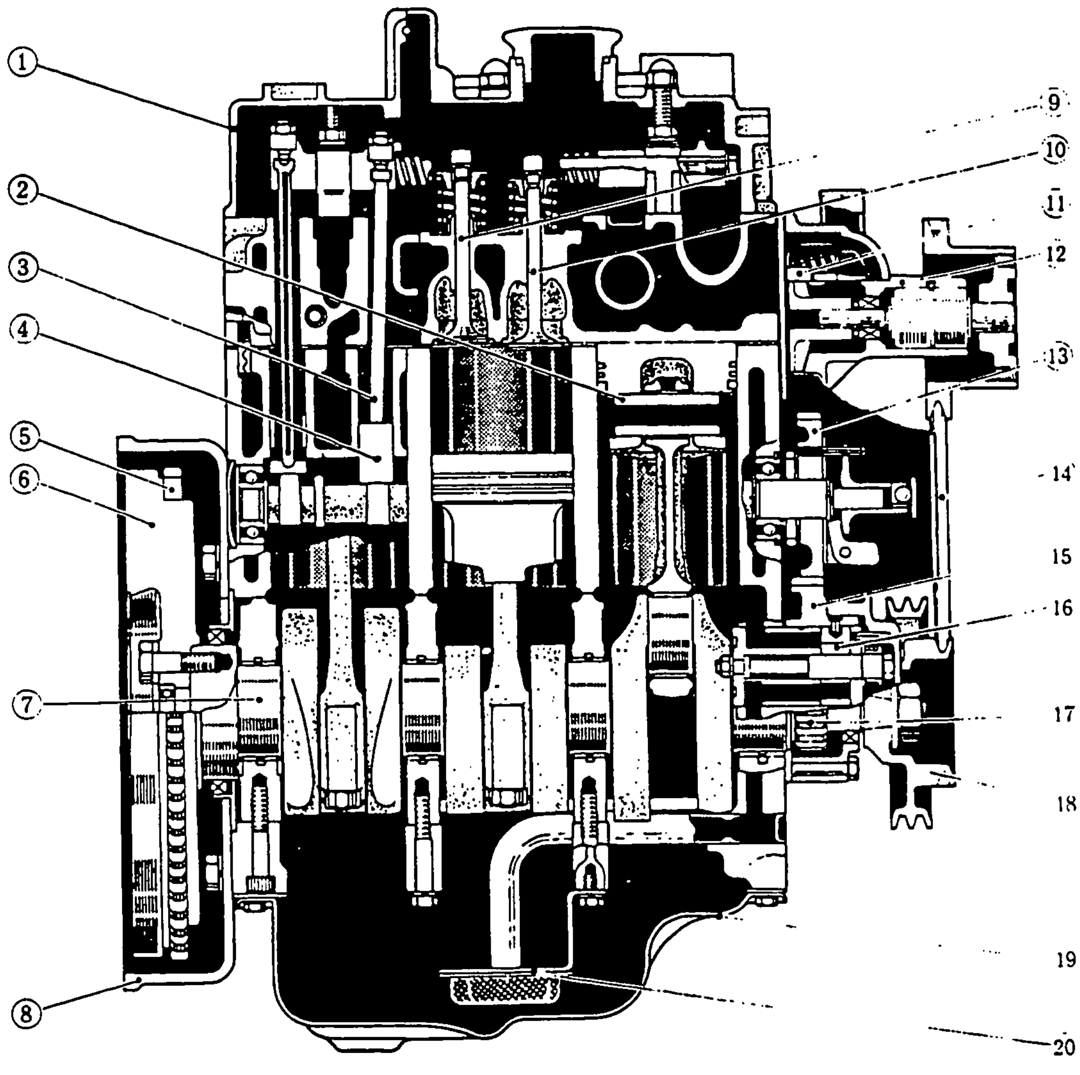
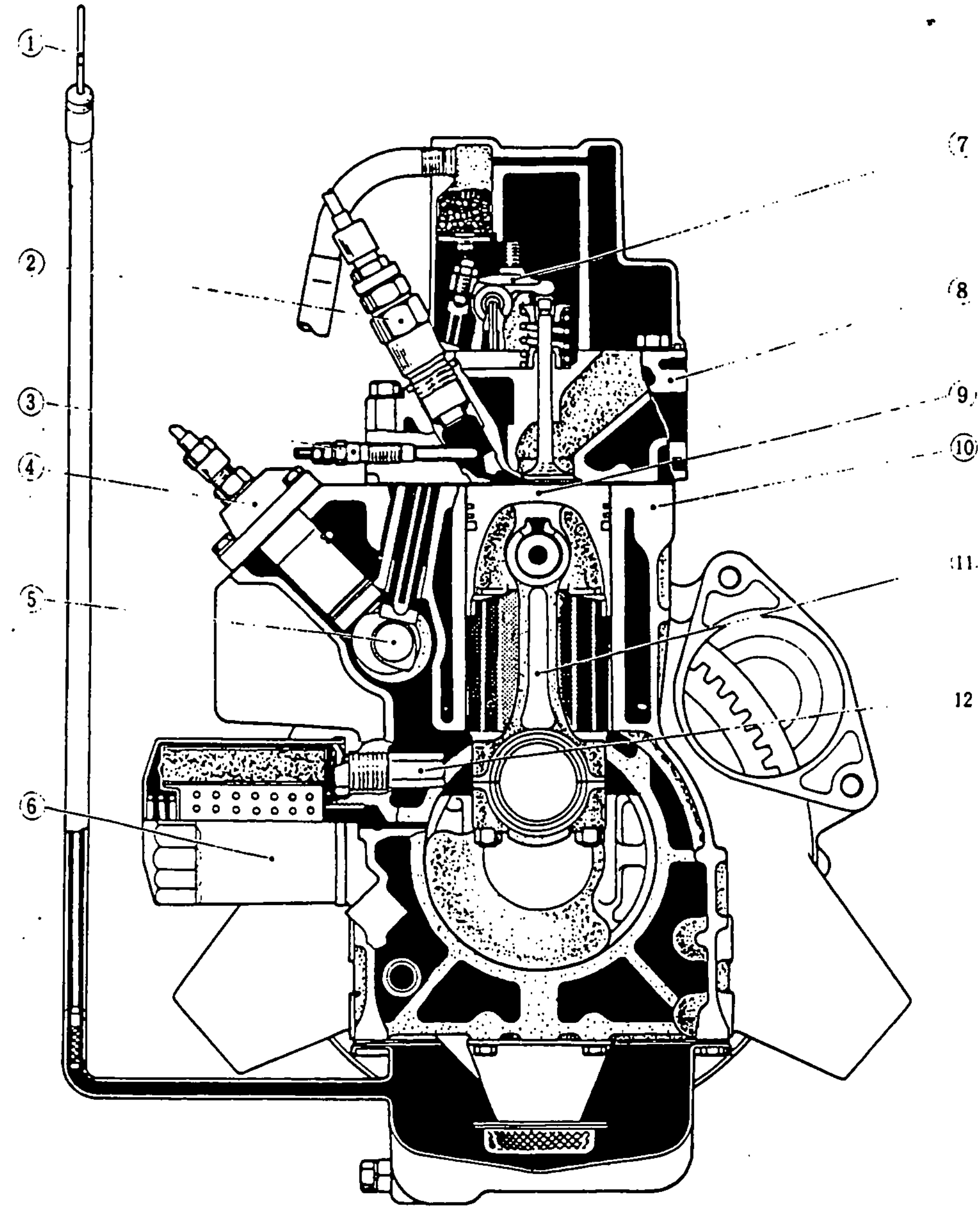
Section 2.1
ENGINE SPECIFICATIONS & CHARTS

Engine Cross Section- Side View



1. Head cover
2. Piston pin
3. Push rod
4. Tappet
5. Ring gear
6. Fly wheel
7. Crank shaft
8. Fly wheel cover
9. Exhaust valve
10. Intake valve
11. Thermostat
12. Water pump
13. Camshaft gear
14. V belt
15. Idle gear
16. Oil pump
17. Crankshaft gear
18. Crankshaft pulley
19. Oil pan
20. Suction filter

Engine Cross Section - Frontal View



1. Level gauge
2. Nozzle and holder
3. Glow plug
4. Injection pump
5. Camshaft
6. Oil filter
7. Rocker arm
8. Cylinder head
9. Piston
10. Cylinder block
11. Connecting rod
12. Relief valve

General Engine Specifications

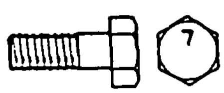
Type of Engine . . . . .4-cycle diesel
Cooling Method . . . . .Water-Cooled
Cylinder Arrangement . . . . . .Vertyical In-Line
Combution Chambers . . . . . .Special Swirl Type
Number of Cylinders 3
Bore x Stroke . . . . .2.95 x 2.83 Inches
Total Displacement . . . . .954 cc
Compression Ratio . . . . .23 to 1
Fuel Injection Pump . . . . .Bosch Type
Injection Nozzles . . . . .Throttle Type
Recommended Fuel . . . . . . .JIS No. 2D Diesel

Oil Pump . . . . Trtochold Type
Oil Filter . . . . Full-Flow Spin-On
Crankcase Oil Capacity
With Filter Change . . . . . . 4.0 U.S. Quarts
Without Filter Change . . . 3.7 U.S. Quarts
Oil Pressure . . . . 28-71 psi (196-490 kPa)

Torque Values for Metric Bolts

SIZE OF SCREW	CLASS.	COARSE THREAD		FINE THREAD	
		PITCH (mm)	TIGHTENING TORQUE	PITCH (mm)	TIGHTENING TORQUE
M6	4T	1.00	3.6-5.0 Ft.-Lbs. (0.50-0.70 m-kg)	-----	-----
	7T		5.8-9.4 Ft.-Lbs. (0.80-1.30 m-kg.)	-----	-----
	8T		7.2-10.0 Ft.-Lbs. (1.00-1.40 m-kg)	-----	-----
M8	4T	1.25	10-13 Ft.-Lbs. (1.00-1.40 m-kg)	1.00	11.5-16.5 Ft.-Lbs. (1.6-2.3 m-kg)
	7T		17.3-21.7 Ft.-Lbs. (2.4-3.0 m-kg)		18.8-26.7 Ft.-Lbs. (2.6-3.7 m-kg)
	8T		19.5-24.6 Ft.-Lbs. (2.7-3.4 m-kg)		
M10	4T	1.50	19.5-24.6 Ft.-Lbs. (2.7-3.4 m-kg)	1.25	20.0-28.0 Ft.-Lbs. (2.8-4.0 m-kg)
	7T		34.0-39.0 Ft.-Lbs. (4.7-5.5 m-kg)		36.0-46.0 Ft.-Lbs. (4.9-6.5 m-kg)
	8T		39.0-45.0 Ft.-Lbs. (5.3-6.3 m-kg)		40.0-52.0 Ft.-Lbs. (5.5-7.2 m-kg)
M12	4T	1.75	29.0-33.0 Ft.-Lbs. (3.9-4.7 m-kg)	1.25	31-41 Ft.-Lbs. (4.3-5.7 m-kg)
	7T		52.0-58.0 Ft.-Lbs. (7.1-8.1 m-kg)		56.0-68.0 Ft.-Lbs. (7.7-9.4 m-kg)
	8T		57.0-65.0 Ft.-Lbs. (7.9-9.1 m-kg)		62.0-75.0 Ft.-Lbs. (8.6-10.04 m-kg)
M14	4T	2.00	49.0-56.0 Ft.-Lbs. (6.8-7.8 m-kg)	1.50	52.0-63.0 Ft.-Lbs. (7.2-8.8 m-kg)
	7T		81.0-92.0 Ft.-Lbs. (11.2-12.8 m-kg)		90.0-105.0 Ft.-Lbs. (12.4-14.6 m-kg)
	8T		97.0-109.0 Ft.-Lbs. (13.3-15.1 m-kg)		107.0-124.0 Ft.-Lbs. (14.8-17.2 m-kg)
M16	4T	2.00	67.0-77.0 Ft.-Lbs. (9.5-11.5 m-kg)	1.50	69.0-83.0 Ft.-Lbs. (9.5-11.5 m-kg)
	7T		116.0-130.0 Ft.-Lbs. (16.0-18.0 m-kg)		120.0-137.0 Ft.-Lbs. (16.5-19.0 m-kg)
	8T		130.0-145.0 Ft.-Lbs. (17.9-20.1 m-kg)		140.0-158.0 Ft.-Lbs. (19.4-21.9 m-kg)
M18	4T	2.50	88.0-99.0 Ft.-Lbs. (12.2-13.8 m-kg)	1.5	100.0-116.0 Ft.-Lbs. (13.8-16.1 m-kg)
	7T		150.0-167.0 Ft.-Lbs. (20.8-23.3 m-kg)		178-198.0 Ft.-Lbs. (24.5-27.5 m-kg)
	8T		175.0-193.0 Ft.-Lbs. (24.2-26.8 m-kg)		202-231.0 Ft.-Lbs. (28.0-32.0 m-kg)
M20	4T	2.50	109.0-130.0 Ft.-Lbs. (15.0-18.0 m-kg)	1.5	133.0-149.0 Ft.-Lbs. (18.3-20.7 m-kg)
	7T		186.0-205 Ft.-Lbs. (25.7-28.3 m-kg)		206.0-240.0 Ft.-Lbs. (28.5-33.5 m-kg)
	8T		214-249.0 Ft.-Lbs. (29.5-34.5 m-kg)		246.0-289.0 Ft.-Lbs. (34.0-40.0 m-kg)

4T..... SS41 or S20C material
(Standard bolt)
7T..... S45C
8T..... SCr2 – 3 or
SCM2 – 3 material
(Special bolt)



Engine Tolerances and Fits

CYLINDER HEAD:

Compression Pressure:

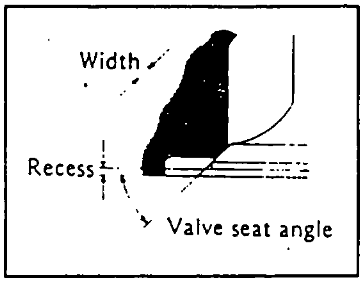
Standard Value .... More than 426.6 psi
Repair Required if .... Less than 284.4 psi
Check Pressure at .... 200 rpm

Maximum Cylinder Head Face Distortion:

Standard Value .... Less than 0.0020 inch
Repair if .... More than 0.005 inch

Valve Seat (Intake and Exhaust):

Standard Recess .... 0.033 inch
Repair if Greater than ...... 0.070 inch
Valve Seat Standard Width . 0.047-0.059 inch
Repair Width if More Than .. 0.079 inch
Valve Seat Angle .... 45°



Cylinder Head Tightening Torque:

Torque Value .... 32.5-36.0 Ft-Lbs

CYLINDER BLOCK:

Type .... Wet, Single Piece

Cylinder Block Bore:

Standard Dimension .... 2.95 inches
Standard Value .... 2.9527-2.9535 inches
Repair if More Than .... 2.9606 inches
Allowable Limits .... 3.000 inches
Oversize .... 0.020, 0.040 inch

Maximum Distortion of Cylinder Block Upper Face:

Standard Value .... 0.0020 inch
Repair if More Than .... 0.005 inch

MAIN REVOLVING SYSTEM:

Piston Skirt Maximum Diameter:

Standard Dimension .... 2.9527 inches
Standard Value .... 2.9134 inches
Allowable Limit .... 2.9409 inches
Oversize .... 0.020, 0.040 inch

Clearance to Cylinder:

Standard Value .... 0.003-0.004 inch
Allowable Limit .... 0.010 inch
Measure at .... 20° C.

Inside Diameter of Piston Pin:

Standard Dimension .... 0.827 inch
Standard Value .... 0.8267-0.8269 inch

Piston Pin Hole to Pin Clearance:

Standard Value .... -0.00008 to +0.0003
Allowable Limit .... 0.0008 inch

Piston Pin Outer Diameter:

Standard Dimension .... 0.8268 inch
Standard Value .... 0.8266-0.8268 inch
Allowable Limit .... 0.8260 inch

Small End Bushing to Pin Oil Clearance:

Standard Value .... 0.0006-0.0012 inch
Allowable Limit .... 0.003 inch

Piston Ring Gap:

No. 1 Ring Standard Value .. 0.008-0.014 inch
No. 2 Ring Standard Value .. 0.006-0.012 inch
Oil Ring Standard Value .... 0.008-0.014 inch
Allowable Limit (All Rings) .. 0.039 inch

Piston Ring Groove to Ring Clearance:

No. 1 Ring Standard Value .. 0.002-0.004 inch
No. 2 Ring Standard Value .. 0.002-0.012 inch
Oil Ring Standard Clearance .... 0.002-0.004 inch
Allowable Limit (No. 1, 2) ... 0.001 inch
Allowable Limit (Oil Ring) ... 0.006 inch

Piston Ring Width:

No. 1 Ring Std. Dimension .. 0.079 inch
No. 1 Ring Std. Value ...... 0.0776-0.0783 inch
No. 2 Ring Std. Dimension .. 0.059 inch
No. 2 Ring Std. Value ...... 0.0579-0.0587 inch
Oil Ring Std. Dimension .... 0.1575 inch
Oil Ring Std. Value .... 0.1563-0.1571 inch
Oversize Rings Available ... 0.020, 0.040 inch

Connecting Rod:

Allowable Twist Between Small and large End Holes (Per 3.94 inches) Not to Exceed .... 0.008 inch
Front to Rear Play Between Conecting Rod and Crankpin Allowable Limit .... 0.028 inch

Engine Tolerances and Fits (Continued)

MAIN REVOLVING SYSTEM (CONT'D):

Connecting Rod (Continued):

Connecting Rod to Crankpin Oil Clearance Allowable Limit .... 0.008 inch
Connecting Rod Bolt Torque .... 22-25 Ft.-Lbs.

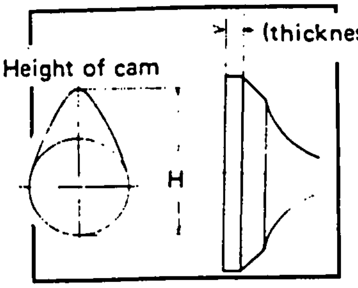
Crankshaft:

Standard Diameter of Main Journal .... 1.8110 inch
Standard Tolerance of Main Journal .... 1.8096-1.8100 inch
Allowable Limit of Main Journal .... 1.7874 inch
Main Journal Undersize .... 0.010, 0.020 inch
Crankpin Standard Diameter .... 1.5354 inch
Crankpin Standard Tolerance .... 1.5340-1.5344 inch
Allowable Crankping Limit .. 1.5118 inch
Crankpin Undersize .... 0.010, 0.020 inch
Standard Crankshaft Deflection .... Less than 0.001 inch
Maximum Allowable Crankshaft Deflection ..... 0.002 inch
Standard Axial Crankshaft Play .... 0.002 inch
Maximum Allowable Axial Crankshaft Play .... 0.020 inch
Standard Thickness of Thrust Washer .... 0.079 inch
Standard Tolerance of Thrust Washer .... 0.077-0.079 inch
Maximum Allowable Thickness of Thrust Washer .... 0.071 inch
Tolerance of Oil Clearance Between Crankshaft Journal and Center Bearing .... 0.0015-0.0036 inch
Maximum Allowable Oil Clearance Between Crankshaft Journal and Center Bearing . 0.0078 inch

VALVE SYSTEM:

Camshaft:

Standard Height of Cam Tolerance for Intake & Exhaust .... 1.0413-1.0433 inch
Minimum Allowable Cam Height for Intake & Exhaust ...... 1.0276 inch
Standard Cam Height for Injection Pump .... 0.9425-0.9472 inch
Minimum Allowable Injection Pump Cam Height .... 0.9370 inch
Standard Cam Height for Feed Pump .... 1.0590-1.0630 inch
Minimum Alowable Cam Hieght for Feed Pump .... 1.0236 inch
Standard Cam Gear Backlash .... 0.003 inch
Maximum Cam Gear Backlash .... 0.012 inch

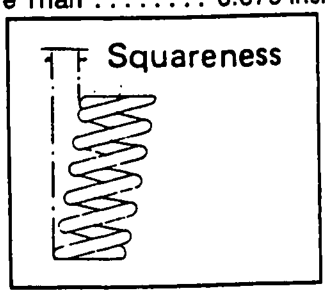


Valves:

Standard Diameter of Intake Valve Stem .... 0.2744-0.2738 inch
Maximum Allowable Diameter of Intake Valve Stem ...... 0.2713 inch
Standard Diameter of Exhaust Valve Stem .... 0.2740-0.2736 inch
Maximum Allowable Diameter of Exhaust Valve Stem ..... 0.2693 inch
Standard Clearance Between Intake Valve Stem and Valve Guide .... 0.001-0.002 inch
Maximum Clearance Between Intake Valve Stem and Valve Guide .... 0.0079 inch
Standard Clearance Between Exhaust Valve Stem and Guide .... 0.0016-0.0026 inch
Maximum Clearance Between Exhaust Valve Stem and Guide .... 0.010 inch
Valve Standard Thickness .. 0.039 inch
Valve Thickness Standard Tolerance .... 0.036-0.042 inch
Maximum Allowable Valve Thickness .... 0.020 inch
Valve Clearance- Intake & Exhaust (When Cold) ...... 0.008-0.020 inch

Valve Springs:

Force Required to Compress Springs to a Length of 1.197 inch .... 17.86 pounds
Valve Spring Standard Free Length .... 1.3779 inch
Valve Spring Minimum Free Length .... 1.3189 inch
Standard Valve Spring Squareness .... Less than 0.047 inch
Replace Spring if Out-of-Square More Than .... 0.079 inch



Engine Tolerances and Fits (Continued)

VALVE SYSTEM (CONT'D):

Valve Timing:

Intake Valve
- Open .... 13° BTDC
- Closed .... 43° BTDC

Exhaust Valve
- Open .... 43° BTDC
- Closed .... 13° BTDC

Push Rods:
- Standard Overall Length ... 5.181 inch
- Overall Length Standard Tolerance .... 5.173-5.189 inch
- Push Rod Outer Diameter .. 0.248 inch

Rocker Arm:
- Rocker Arm Standard Diameter................. 0.459 inch
- Rocker Arm Standard Tolerance .... 0.4586-0.4594 inch
- Maximum Allowable Wear .. 0.4555 inch

FUEL SYSTEM:

Injection Pump:
- Diameter of Pump Plunger .. 0.1969 inch
- Pump Plunger Stroke ...... 0.2362 inch
- Fuel Injection Timing ...... 20°-21° BTDC

Injection Nozzle:
- Injection Pressure .... 1706.4-1848.6 psi
- Angle of Injection .... 12°

LUBRICATION SYSTEM:

Oil Pump:

Discharge Volume
- In Quarts .... Over 10.57/Minute
- Liters .... Over 10.00/Minute

- Relief Pressure .... 43-71 psi
- Pump Rotor to Vane Tip Clearance (Standard Tolerance) .... 0.0004-0.0059 inch
- Pump Rotor to Vane Maximum Allowable Tip Clearance .... 0.010 inch
- Pump Rotor to Cover Side Clearance (Standard Tolerance) .... 0.004-0.006 inch
- Pump Rotor to Cover Maximum Side Clearance .. 0.008 inch

Engine Special Torque Values

Connecting Rod Bearing Cap
- Foot-Pounds 22-25
- m-kg 3.0-3.5

Main Bearing Holders
- Foot-Pounds 18-22
- m-kg 2.5-3.0

Flywheel Cover
- Foot-Pounds 34-40
- m-kg 4.7-5.5

Flywheel
- Foot-Pounds 43-51
- m-kg 6.0-7.0

Suction Filter
- Foot-Pounds 7.0-9.0
- m-kg 0.9-1.3

Camshaft Plate
- Foot-Pounds 7-9
- m-kg 0.9-1.3

Crankshaft Pulley
- Foot-Pounds 72-80

Oil Pipe Eyebolts
- Foot-Pounds 7-9
- m-kg 1.0-1.3

Cylinder Head
- Foot-Pounds 33-36
- m-kg 4.5-5.0

Rocker Arm Assembly
- Foot-Pounds 15-18
- m-kg 2.0-2.5

Cylinder Head Cover
- Foot-Pounds 6-8
- m-kg 0.8-1.2

Fuel Injection Pipes
- Foot-Pounds 18-22
- m-kg 2.5-3.0

Injection Nozzle Holders
- Foot-Pounds 58-61
- m-kg 8.0-8.5

Section 2.2
GENERAL INFORMATION

Introduction

Read this section carefully before you attempt to repair the diesel engine. The section contains valuable tips pertaining to the repair and/or replacement of engine parts.

When Is Major Maintenance Required?

Major engine repairs are usually required as a result of excessively worn cylinders, pistons, rings and valves. Data that is gathered from periodic maintenance and inspections will indicate the need for major maintenance. Occurence of any one or more of the following will indicate a need for major repairs:

- ☐ Loss of compression pressure below the stated limit.
- ☐ An increase in oil consumption.
- ☐ Increase in fuel consumption.
- ☐ Engine won't start or starts with difficulty.
- ☐ Loss of engine power.
- ☐ Rough or noisy operation.
- ☐ Excessive blowby of combustion gases through the engine breather.

Some of the major causes of the symptoms listed above are (a) Weak battery or defective starter motor, (b) worn cylinders, pistons or rings, (c) incorrect valve clearance, (d) malfunctioning fuel injection pump, (e) incorrect injection timing, (f) defective injection nozzles.

General Rules of Repair

When performing maintenance on the engine, the following general rules should be complied with:

- ☐ Keep the work area neat and uncluttered. Arrange work table(s), engine stands, parts bins, etc., in a logical sequence of disassembly.
- ☐ Prior to disassembly, locate any alignment or reassembly marks on parts to be disassembled. If alignment marks cannot be found, place your own alignment marks on the parts.
- ☐ Pay close attention to the condition of parts during disassembly. Many defects will be evident prior to the actual disassembly of parts.
- ☐ Use the proper tools for each job.
- ☐ Use new gaskets, seals and o-rings during reassembly.
- ☐ Use a torque wrench to ensure that all fasteners are properly tightened.

NOTE: Some components require a special torque value which is given in the reassembly sequence in this manual. Parts not requiring a special torque value should be tightened to the value recommended in "TORQUE VALUES FOR METRIC BOLTS" on Page 2.1-3.

Section 2.3
ENGINE DISASSEMBLY

General

The following engine disassembly procedure covers complete disassembly of the engine. You may wish to disassemble only to the extent needed for repairs. Most disassembly is a matter of common sense and simple logic.

AC Generator Disassembly

Disassemble the AC generator and remove generator parts from the engine. Refer to either Section 1.3 or 1.4 of this manual as appropriate.

Drain Engine Fluids

Before starting the disassembly process, drain all fluids from the engine block.

- ☐ Drain oil completely from the engine crankcase. If complete disassembly will be required, remove the engine oil filter.
- ☐ Drain the engine cooling system and the engine water jacket.
- ☐ If complete disassembly is planned, remove engine cooling system and fuel system hoses.

NOTE: Some installations may be equipped with an attached radiator, others with a remote-mounted radiator.

Miscellaneous Parts

- ☐ Remove the engine fuel filter.
- ☐ Remove the oil dipstick tube and the dipstick.
- ☐ Remove engine v-belts.
- ☐ Remove fuel injection hoses, pipes and return pipes.
- ☐ Remove fuel injection nozzles and nozzle holders.
- ☐ Remove the engine water pump assembly and gasket.

Remove the Head Cover

Remove the cylinder head cover and gasket.

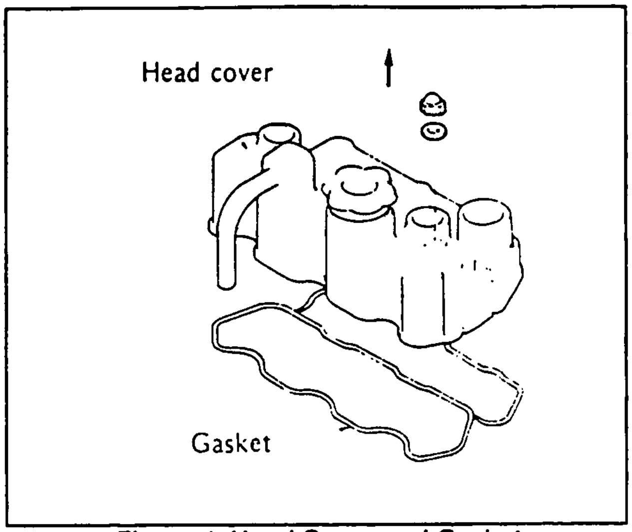


Figure 1. Head Cover and Gasket

Rocker Arm, Push Rod and Cap

Remove the rocker arm assembly and push rods. Remove caps from the intake and exhaust valves. Store all parts together in a safe place.

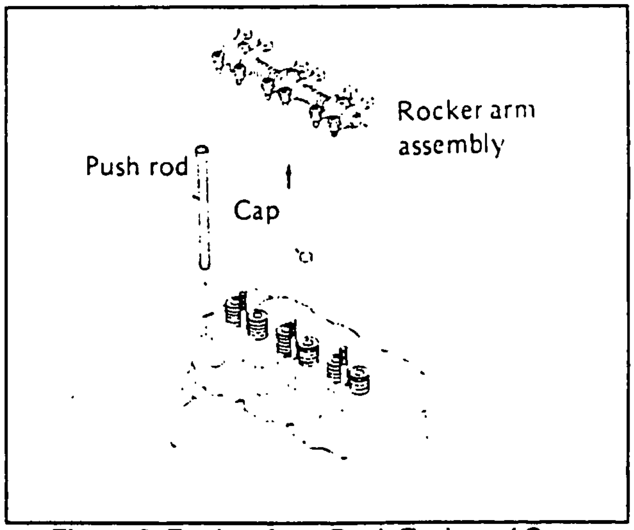


Figure 2. Rocker Arm, Push Rods and Caps

Cylinder Head Assembly

Remove the oil pipe bolts (head side). To remove the bolts, loosen them in about two or three increments. Finally, remove the glow plugs.

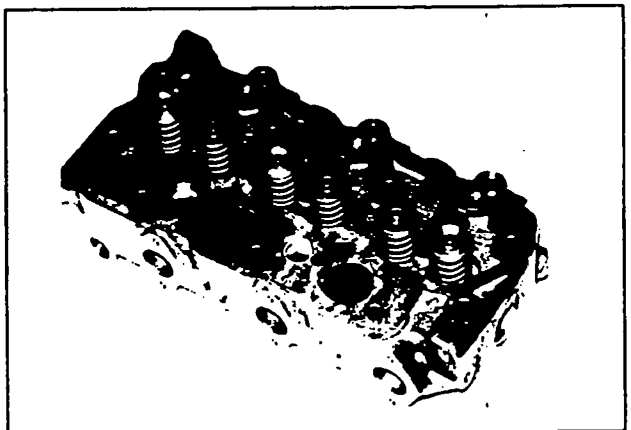


Figure 3. Cylinder Head Assembly

Remove the tappets by pulling them up from the cylinder block.

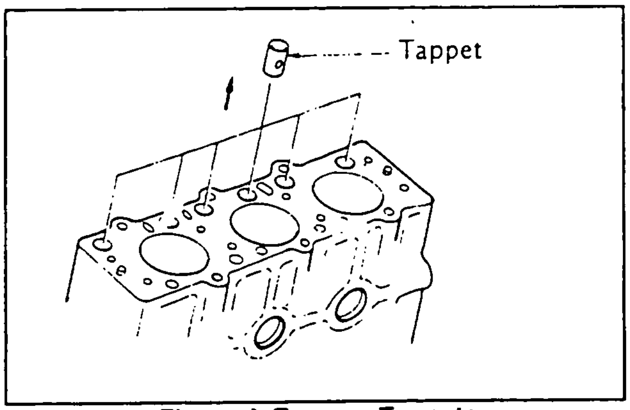


Figure 4. Remove Tappets

Remove Feed Pump Assembly

Remove the feed pump assembly.

Fuel Injection Pump Removal

Remove bolts and nuts that retain the fuel injection pump. Move the pump straight up and pull out the snap pin. Remove the link from the pump control rack. Finally, remove the injection pump.

NOTE: Injection timing is determined by SHIMS at the pump mounting face. Be sure to check and record the thicknes and number of shims to ensure proper installation of the pump.

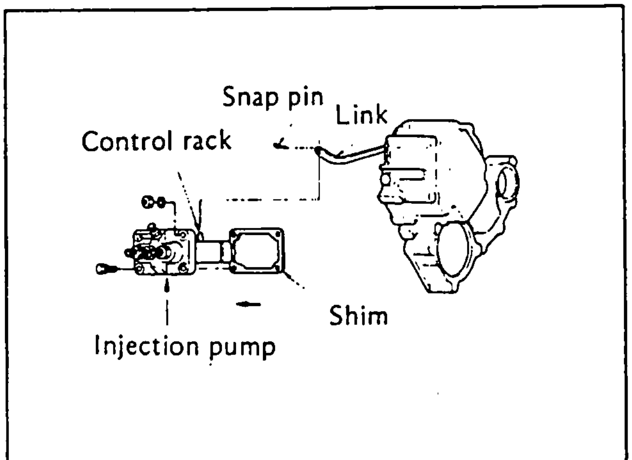


Figure 5. Fuel Injection Pump Removal

Oil Pipe Removal

Loosen the EYE BOLT and remove the OIL PIPE. See Figure 6.

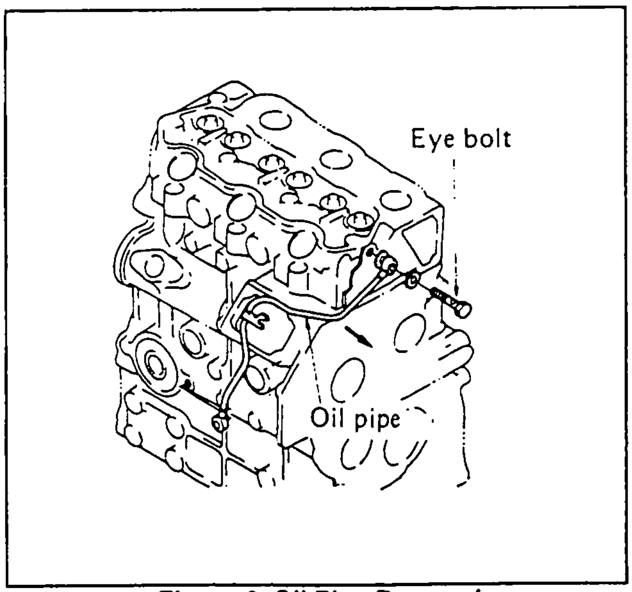


Figure 6. Oil Pipe Removal

Crankshaft Pulley

Remove the crankshaft pulley retaining nut and washer. Remove the crankshaft pulley and its key. See Figure 7.

Crankshaft Pulley (Continued)

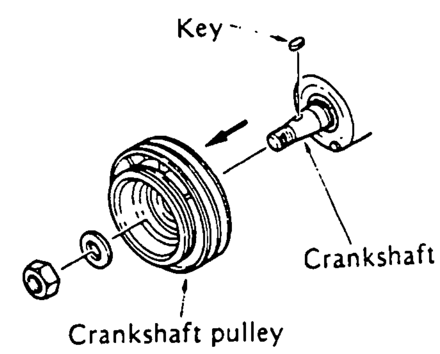


Figure 7. Crankshaft Pulley Removal

Timing Gear Assembly

Remove timing gear case and gasket (Figure 8).

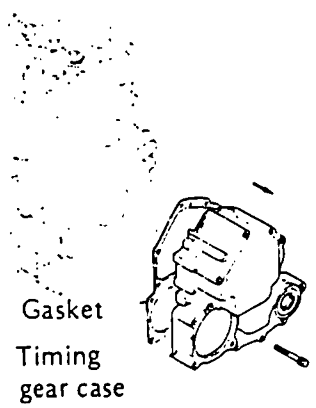


Figure 8. Timing Gear Case and Gasket

Idler Gear and Oil Pump Assembly

Remove the CLIP. Then, remove oil pump and IDLE GEAR. See Figure 9.

Camshaft Assembly and Plate

Remove two bolts that retain the PLATE. Remove the CAMSHAFT and PLATE. See Figure 10. Remove the FRONT PLATE and GASKET (Figure 11.

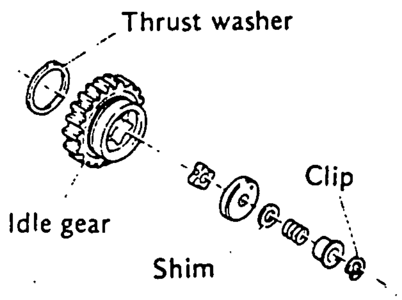


Figure 9. Idler Gear, Shim, Clip, Thrust Washer

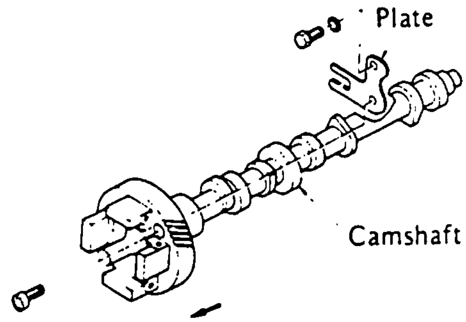


Figure 10. Camshaft Assembly and Plate

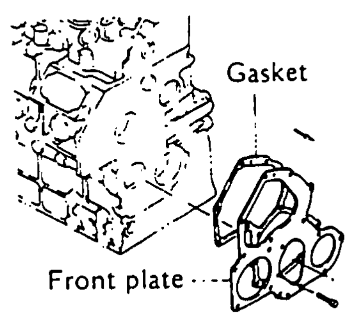


Figure 11. Front Plate and Gasket

Oil Pan Removal

Remove the oil pan screws, then remove oil pan. Remove the SUCTION FILTER and the SUCTION PIPE.

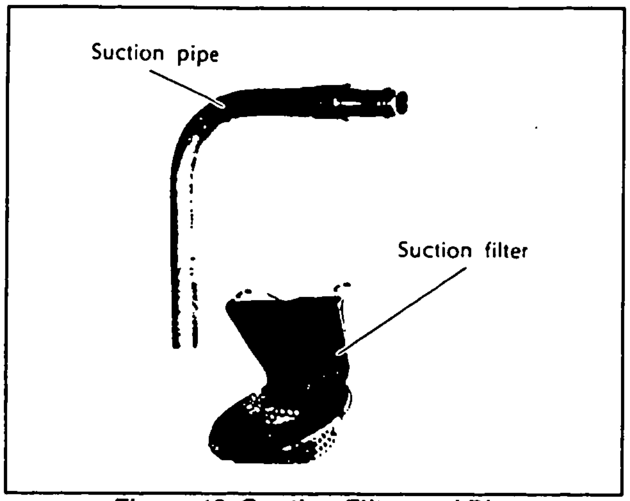


Figure 12. Suction Filter and Pipe

Connecting Rods and Pistons

CAUTION: Clean carbon from upper part of cylinder before removing the piston. Mark connecting rods, cap and bearings with the cylinder number upon removal.

See Figure 13. Loosen the connecting rod cap nuts and remove. Pull the piston, with connecting rod, from each cylinder. Remove all three pistons and connecting rods.

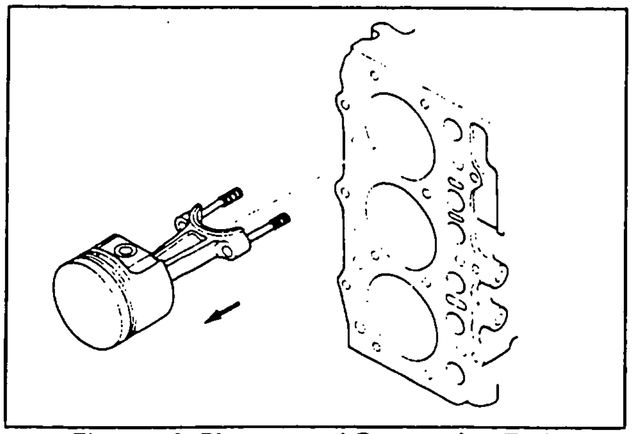


Figure 13. Pistons and Connecting Rods

Flywheel Cover and Oil Seal

Remove the flywheel cover. Then, remove the OIL SEAL (Figure 14).

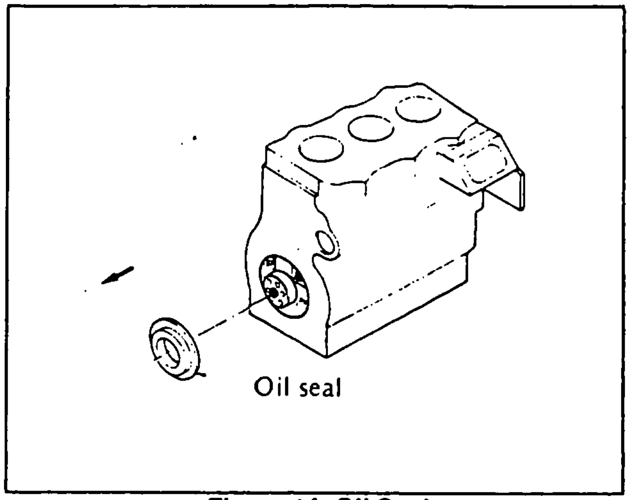


Figure 14. Oil Seal

Crankshaft and Bearing Holder

Remove the BOLTS that retain the bearing holder (Figure 15). Remove the crankshaft and the bearing holder by pulling out toward the flywheel.

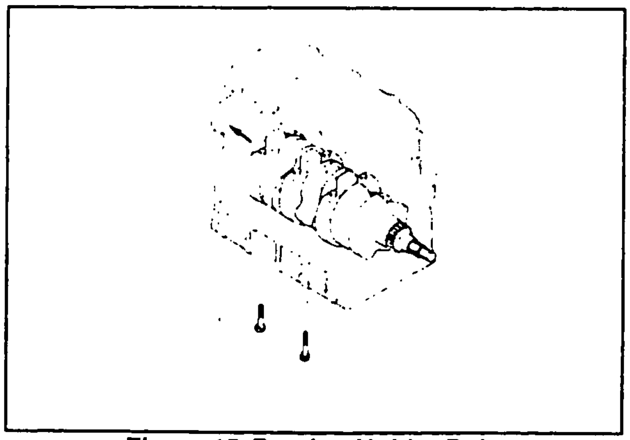
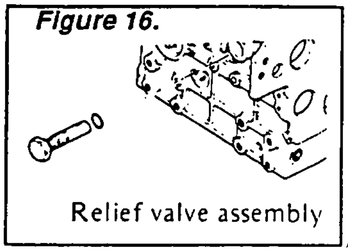


Figure 15. Bearing Holder Bolts

Relief Valve Assembly

Remove the RELIEF VALVE ASSEMBLY (Figure 16).

Figure 16.



Section 2.4

DISASSEMBLY AND INSPECTION

General

Before starting the disassembly and inspection procedure, check the folowing:

- ☐Carefully inspect the cylinder block and cylinder head for damage and evidence of water leakage.
- ☐Use pressure air to blow out all oil holes, make sure none of the holes are plugged.
- ☐Wash al parts to remove dirt, dust, dirty oil and carbon deposits.
- ☐Clean all carbon deposits from the piston, cylinder head and valves. Make sure these parts are not damaged. Pay special attention to aluminum alloy parts.
- ☐Place match marks on mating parts for correct reassembly.

Rocker Arm Assembly

Remove bolt at end of rocker arm shaft. Remove ROCKER ARM, ROCKER ARM BRACKET and springs. Pull out the spring pin from from the No. 1 cylinder ROCKER ARM BRACKET. Remove ROCKER ARMS, SPRINGS and BRACKETS.

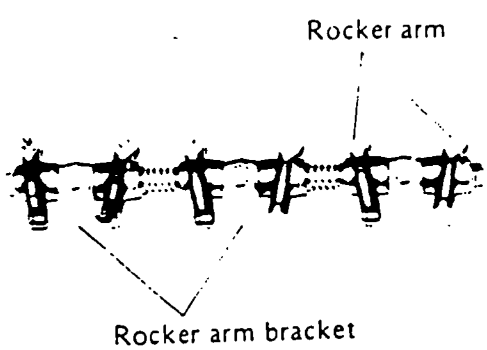


Figure 1. Rocker Arms and Rocker Arm Brackets

Use a micrometer to check the outside diameter of the rocker arm shaft. If allowable limits are exceeded, replace the rocker arm shaft.

Wear of rocker arm shaft(ϕ)

Standard dimension	Allowable limit
11.65 to 11.67 mm	11.57 mm

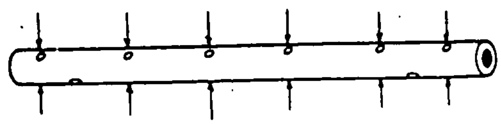
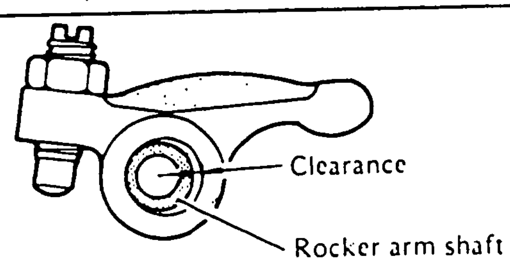


Figure 2. Wear Limits of Rocker Arm Shaft

Measure the inside diameter of the rocker arm. Calculate the clearance between the rocker arm and the rocker arm shaft. If allowable limits are exceeded, replace the part(s).



Rocker arm-to-shaft clearance

Standard clearance	Allowable limit
0.032 to 0.068 mm	0.2 mm

Figure 3. Rocker Arm to Shaft Clearance

Check the valve stem face for step wear or scoring. Slight wear or scoring may be corrected using an oil stone or grinder (Figure 4).

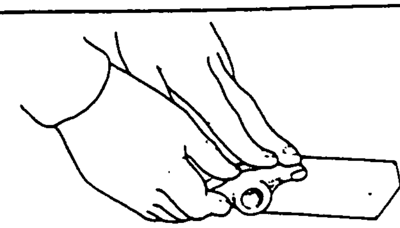


Figure 4. Removing Slight Wear or Scoring

Cylinder Head Assembly

VALVE PARTS:

Use a valve spring compressor to compress the SPRINGS. Then, remove the VALVE COTTER, RETAINER, SPRING and VALVE. Also remove the VALVE GUIDE SEAL.

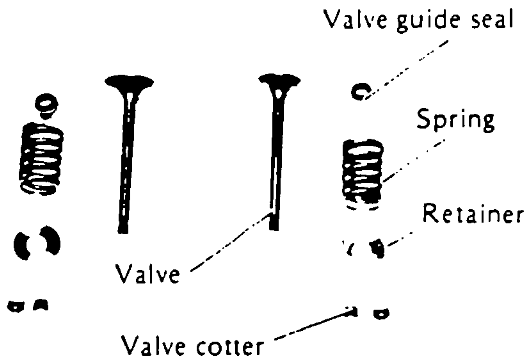


Figure 5. Valve Parts

CHECK CYLINDER HEAD WARP:

Use a straight edge and a thickness gauge to check warpage on the cylinder head lower face. Check with the straight edge at six (6) points, as shown in Figure 6. If warped excessively, correct with a surface grinder.

MAXIMUM CYLINDER HEAD WARP
STANDARD VALUE - LESS THAN 0.0020 INCH
REPAIR IF MORE THAN 0.005 INCH

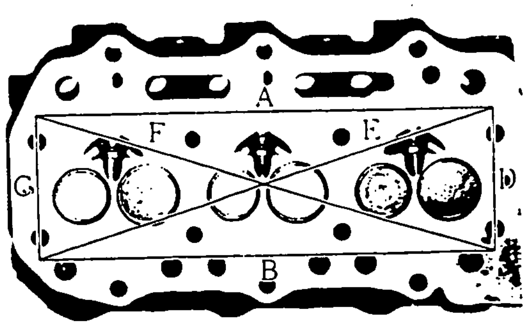


Figure 6. Check Points for Cylinder Head Warp

VALVE STEM:

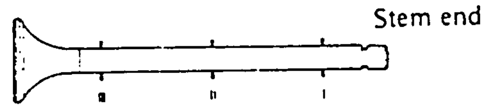
Inspect valve stem for damage and excessive wear. Replace if damaged or worn excessively. Use a micrometer to check valve stem diameters at locations I, II and III (Figure 7). If the stem is worn beyond limits, replace the valve. Also check valve head thickness (Figure 7), replace valve if worn excessively.

Intake Valve:

Standard Diameter	0.2740-0.2744 inch (6.955-6.97mm)
Allowable Limit	0.24 inch (6.09mm)

Exhaust Valve

Standard Diameter	0.2736-0.2740 inch (6.95-6.96mm)
Allowable Limit	0.2693 inch (6.84mm)



Thickness of Valve Head

Standard Thickness	0.036-0.042 inch (0.925-1.075mm)
Allowable Limit	0.0197 inch (0.5mm)

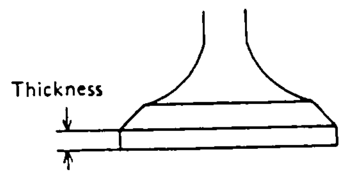
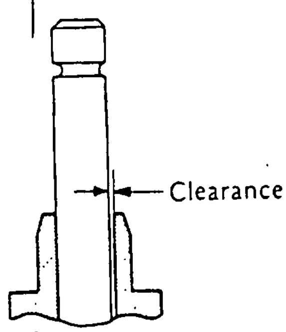


Figure 7. Valve Stem and Valve Head Inspection

VALVE TO VALVE GUIDE CLEARANCE:

Check clearance between valve and valve guide (Figure 8). If beyond limits, replace worn parts.



Intake valve

Standard clearance	Allowable limit
0.03 to 0.06 mm	0.2 mm

Exhaust valve

Standard clearance	Allowable limit
0.04 to 0.065 mm	0.25 mm

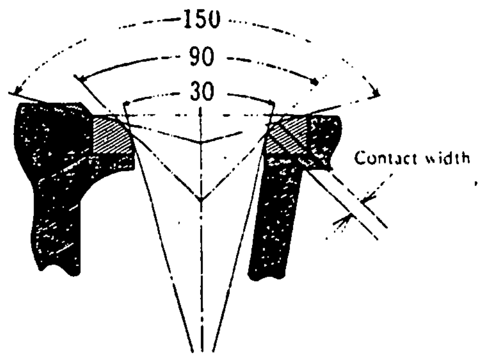
Figure 8. Valve to Valve Guide Clearance

VALVE SEAT:

Always check for valve guide wear before correcting valve seat. Use 15°, 45° and 75° cutters to correct the valve seat (Figure 9).

Cylinder Head Assembly (Continued)

VALVE SEAT (CONT'D):



Valve seat contact width

Standard width	Allowable limit
1.2 to 1.5 mm	2.0 mm

Figure 9. Correcting the Valve Seat

VALVE RECESS:

If the valve recess (Figure 10) exceeds allowable limits, replace the valve seat.

Recess of Valve Seat

Standard Recess	0.033-0.045 inch (0.85-1.15mm)
Allowable Limit	0.071 inch (1.8mm)

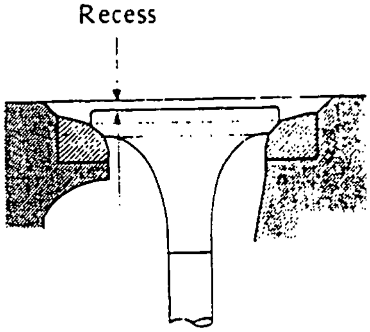


Figure 10. Checking Recess of Valve Seat

GRINDING VALVE SEAT:

See Figure 11. Use a valve seat grinder and valve grinding compound to grind valve seats. Check the valve contact face for correct contact and positioning.

NOTE: When installing a new cylinder head, use the valve seat cutter to obtain correct seat contact with recess of seat. Then, use lapping compound to lap the valve in.

VALVE SPRINGS:

Inspect valve springs for damage. Check spring squareness. Use a spring force tester to test for correctspring force and free length.

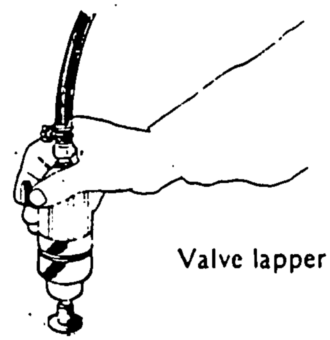


Figure 11. Grinding the Valve Seat

	Standard value	Allowable limit
Squareness (mm)	1.2	2.0
Free length (mm)	35	33.5
Spring force (30.4mm at compressioned) (kg)	8.1	7

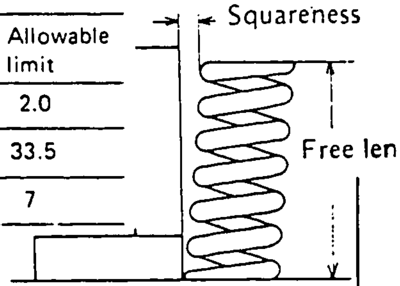


Figure 12. Valve Springs Inspection

CAP AND INSERT:

Remove CAP and INSERT from the cylinder. Inspect and clean the combustion chamber.

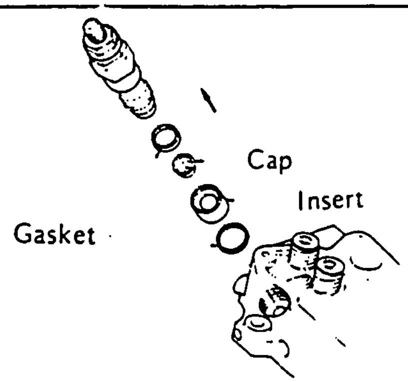


Figure 13. Cap and Insert Removal

Cylinder Head Assembly (Continued)

HEAD REASSEMBLY:

Reassemble all parts in the reverse order of disassembly. When assembling the VALVE SPRING, RETAINER and COTTER, use care to avoid damage to the VALVE GUIDE SEAL.

Cylinder Block

TOP FACE:

Inspect the cylinder block top face for damage, cracks, warpage. Use the same method that was used for checking the cylinder head warp (Figure 6, Page 2.4-2). Allowable warp limit is the same as for the cylinder head.

CYLINDER BORE:

Visual;ly inspect the cylinder bore. There should be no scoring, rust or corrosion. Measure thye cylinder bore at its upper, middle and lower areas, at positions A and B (Figure 14). If the bore diameter exceeds limits, rebore to the correct oversize dimension.

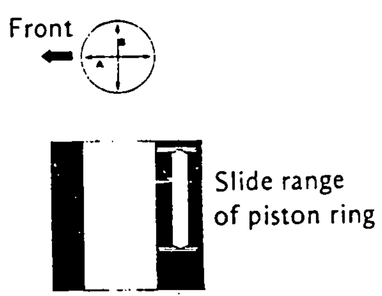


Figure 14. Checking Cylinder Bore

NOTE: In Figure 14, see "Slide Range of Piston Ring". The upper area corresponds to the top ring when the piston is at top dead center (TDC), or about 0.39 inch below the cylinder block top surface. The lower area corresponds to position of oil ring when the piston is at bottom dead center (BDC) or about 3.94 inches from cylinder block top surface.

Use a cylinder (inside diameter) gauge to measure the cylinder bore.

HONING THE CYLINDERS:

After boring is completed, hone the cylinder in two stages to obtain a diamond or "cross-hatch" finish. See Figure 15. The following specifications apply to honing:

- ☐ Use a rough finishing stone that corresponds to (a) Tokyo DIA, (b) SD120/140, (c) N100M (bronze series).
- ☐ Use finishing stone GC600JB.
- ☐ Use a grinding stone 100mm long by 4mm wide (3.94 x 0.157 inch).
- ☐ Drill speed should be 162 rpm.
- ☐ Feed should be 13m per minute (42.6 ft. per minute).
- ☐ Rough finishing gauge pressure should be 213 psi (15 kg per cm^2).
- ☐ Finishing pressure should be 71.12 psi (5 kg per cm^2).
- ☐ Perform the finishing strokes nine (9) times.
- ☐ Honing depths should be 0. 0015 inch (0.04mm).
- ☐ Cross hatch angles should be 40°.
- ☐ Surface roughness should be 2 to 4μ.

Standard bore	Allowable limit
ϕ 75 ~ 75.019	ϕ 75.2

First boring 0.5 mm ↓

Standard bore	Allowable limit
ϕ 75.5 ~ 75.519	ϕ 75.7

Second boring 0.5 mm ↓

Standard bore	Allowable limit
ϕ 76 ~ 76.019	ϕ 76.2

↓ Replace the block

Figure 15. Cylinder Boring Specifications

Piston and Piston Rings

Use a ring compressor to remove piston rings. Remove one snap ring, then remove the piston pin (Figure 16). With connecting rod and piston pin removed proceed with inspections as follows.

Pistons and Piston Rings (Continued)

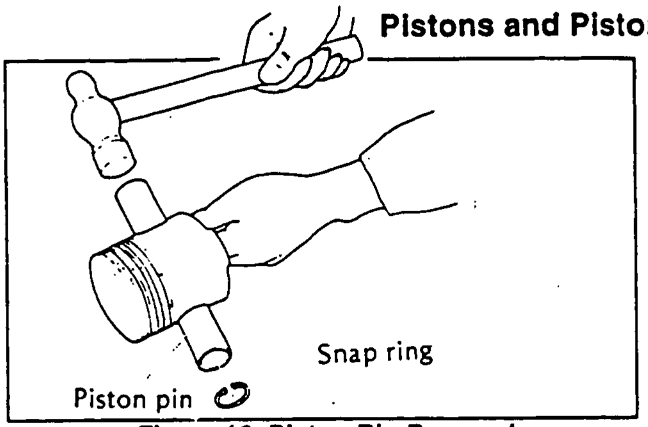


Figure 16. Piston Pin Removal

PISTON INSPECTION:

Inspect the piston, replace if damaged, cracked, scored, burned, etc. Check the diameter of the piston skirt, about 0.394 incvh (10mm) from bottom. Also check the inside diameter of the cylinder. Then, calculate the piston to cylinder clearance. If the clearance exceeds the allowable limit or if the piston diameter is less than the allowable limit, replace the piston. When a cylinder is oversized, use a correspondingly oversize piston. The following apply:

- ☐ **Standard piston to cylinder clearance is 0.003-0.005 inch (0.070-0.119mm). Allowable limit is 0.010 inch (0.25mm).**
- ☐ **Standard largest diameter of the piston skirt is 2.9488-2.9500 inch (74.900-74.930mm). Allowable limit is 2.9409 inch (74.7mm).**

PISTON	PART NO.	PISTON SKIRT DIAMETER*
Standard	214-70939	2.9488-2.9500 inches
0.5mm O.S	215-70939	2.9685-2.9697 inches
1.0mm O.S	216-70939	2.9882-2.9894 inches

* Largest diameter of piston skirt is given.

Figure 17. Checking Piston Fit

Check the diameter of the piston pin hole and the outside diameter of the piston pin. Calculate the clearance between the piston pin and piston pin hole. If clearance is greater than the allowable limit, replace the piston.

- ☐ **Standard piston pin hole to pin clearance is minus 0.00008-plus 0.0003 inch (-0.002-+0.008mm).**
- ☐ **Allowable hole to pin clearance limit is 0.0008 inch (0.02mm).**

PISTON RINGS:

Inspect rings, replace if worn or damaged. Install the rings into the cylinder skirt and check ring gaps with a feeler gauge. Replace rings if allowable limits are exceeded.

- ☐ **Standard gap of No. 1 Ring = 0.008-0.014 inch (0.2-0.35mm)**
- ☐ **Standard Gap of No. 2 Ring=0.006-0.012 inch (0.15-0.3mm)**
- ☐ **Standard Gap of Oil Ring=0.008-0.01 inch (0.2-0.35mm)**
- ☐ **Allowable Limit (All Rings) = 0.039 inch (1.0mm)**

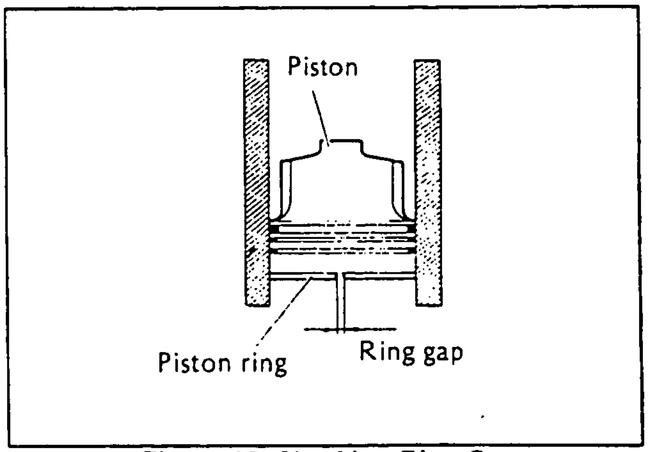


Figure 18. Checking Ring Gap

PISTON RING GROOVE TO RING CLEARANCE:

Measure the clearance between the piston ring groove and the ring. If allowable limits are exceeded, replace the ring.

- ☐ **No. 1 Ring Standard Clearance = 0.002-0.004 inch (0.06-0.1mm)**
- ☐ **No. 2 Ring Standard Clearance = 0.002-0.0035 inch (0.05-0.09mm)**
- ☐ **No. 1 and 2 Ring Allowable Limit = 0.010 inch (0.25mm)Oil Ring Standard Clearance = 0.0008-0.006 inch (0.02-0.06mm)**
- ☐ **Oil Ring Allowable Limit = 0.006 inch (0.15mm)**

Pistons and Piston Rings (Continued)

If the cylinder is oversized, use an oversized piston ring set.

- ☐ **Standard Piston Ring Set is Part No. 211-70939**
- ☐ **0.5mm O.S. Rings, Part No. 212-70939**
- ☐ **1.0mm O.S. Rings, Part No. 213-70939**

When installing the Piston Rings, install them as shown in Figure 19.

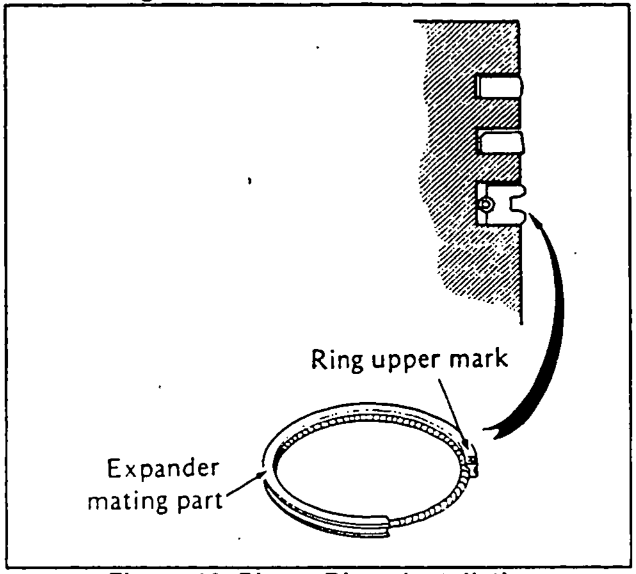


Figure 19. Piston Rings Installation

Connecting Rods

CHECK BENDING, PARALLELISM, DAMAGE:

Use a connecting rod alignment tool to check the connecting rod for bending and parallelism. If allowable limits are exceeded, replace the connecting rod.

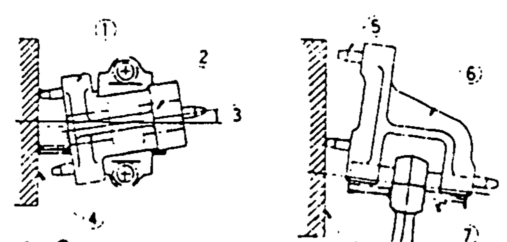


Figure 20. Checks of Connecting Rod

ROD BUSHING TO PISTON PIN CLEARANCE:

Measure the inside diameter of the connecting rod small end bushing. Also, measure the piston pin. Calculate the pin to bushing clearance. If clearance exceeds allowable limits, replace the connecting rod.

- ☐ **Standard Clearance = 0.0006-0.001 inch (0.015-0.03mm)**
- ☐ **Allowable Limit = 0.003 inch (0.08mm)**

ROD TO CRANKPIN CLEARANCE:

Assemble the connecting rod to the crankshaft and measure the play in the shaft direction. If play is greater than allowable limit, replace the connecting rod.

- ☐ **Standard Play = 0.004-0.012 inch (0.1-0.3mm)**
- ☐ **Allowable Limit = 0.028 inch (0.7mm)**

CONNECTING ROD BEARING:

Inspect the connecting rod bearing for peeling, cracks, etc. Replace, if defective. Use "plastigauge" to check bearing oil clearance as follows:

1. Remove oil and dirt from rod bearing and from crankpin.
2. Cut a length of plastigauge to the same length as the width of the bearing. Place it on the crankpin, parallel with the crankshaft. DO NOT PLACE OVER AN OIL HOLE. See Figure 21.
3. Assemble the connecting rod bearing and cap to the crankpin. Tighten to 22-25 foot-pounds (3.0-3.5 m-kg).

CAUTION: DO NOT rotate the connecting rod or crankshaft while plastigauge is installed.

4. Remove the connecting rod and bearing. Use the plastigauge scale to measure the oil clearance. Be sure to measure the widest area of the plastigauge.

Standard Clearance = 0.001-0.003 inch (0.35-0.83mm)
Allowable Limit = 0.008 inch (0.7mm)

5. If oil clearance exceeds the allowable limit, replace the bearing or grind the crankshaft pin and use the next undersize.

CRANKPIN BEARING	PART NO.	CRANKPIN OUTER DIAMETER
Standard	223-70939	1.5340-1.5344 inch (38.964-38.975mm)
0.25mm U.S	224-70939	1.5242-1.5246 inch (38.714-38.725mm)
0.50mm U.S	225-70939	1.5143-1.5148 inch (38.464-38.475mm)

PISTON & ROD ASSEMBLY:

Heat the piston to about 100° C. (212° F.). Then, assemble the piston to the rod by aligning the match marks shown in "A", Figure 22.

Connecting Rods (Continued)

Install the rings into piston with scribed marks at end of rings facing upward.

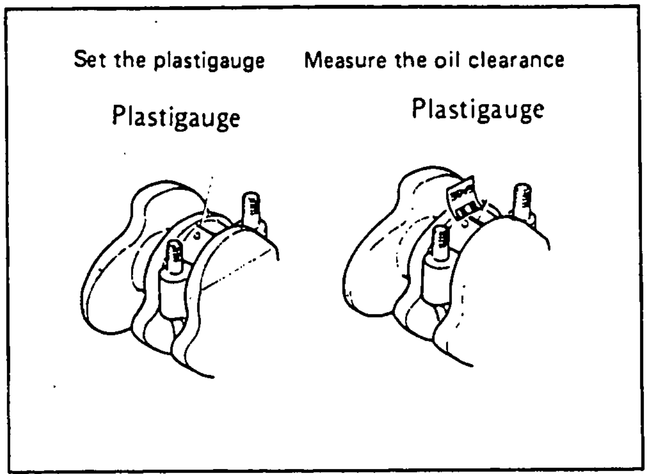


Figure 21. Measuring Oil Clearance

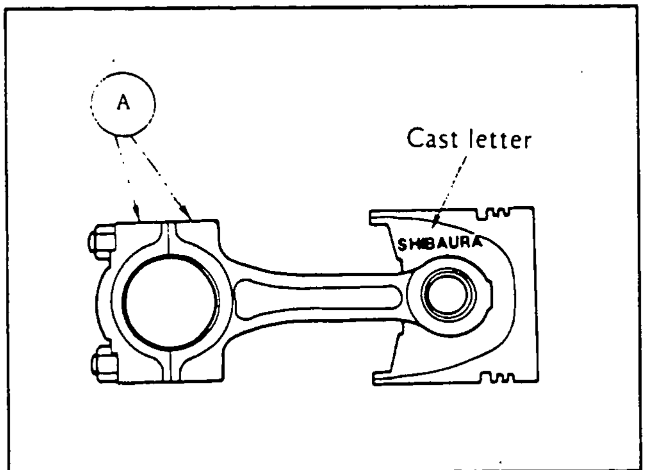


Figure 22. Piston and Rod Assembly

CAUTION: The difference in weight between cylinders of the assembled piston, piston pin, connecting rod and rings should not exceed 0.35 ounce (10 grams).

Main Bearing Holders

Remove the bearing holder and inspect for peeling, cracking, wear, etc. Replace holder, if defective. Use plastigauge to measure the oil clearance between the crankshaft center journal and the bearing. If oil clearance exceeds allowable limits, either replace the bearing or grind the crankshaft center journal and use an undersize bearing.

- ☐ **Standard Oil Clearance = 0.0015-0.0036 inch (0.039-0.092mm)**
- ☐ **Allowable Limit = 0.0078 inch (0.2mm)**

CRANKSHAFT JOURNAL DIA.	BEARING SIZE
1.8096-1.8100 inch (45.964-45.975mm)	Standard
1.7998-1.8002 inch (45.714-45.725mm)	0.25mm U.S.
1.7899-1.7903 inch (45.464-45.475mm)	0.50mm U.S.

Carefully inspect the THRUST WASHER for wear, poor contact, burning, other defects. Replace washer if it is damaged or defective.

- ☐ **Standard Thickness of Thrust Washer = 0.077-0.079 inch (1.95-2.0mm)**
- ☐ **Allowable Limit = 0.071 inch (1.8mm)**

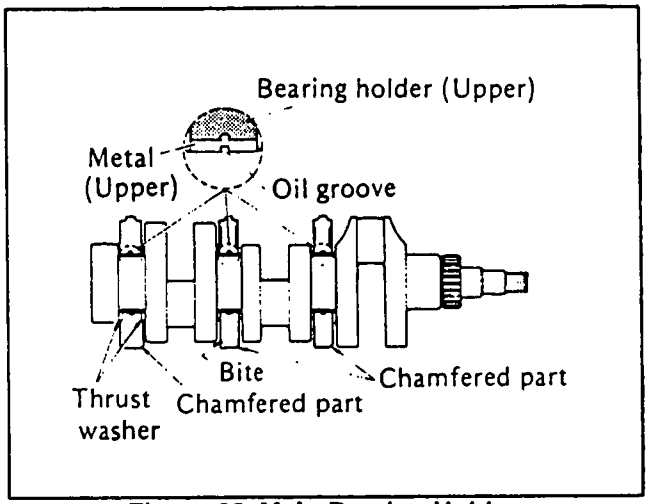


Figure 23. Main Bearing Holders

Reassemble the bearing holder, center bearing and thrust washer as follows:

1. Face the chamfered part of the bearing holder toward the front. Install the bearing holder which has reference bite at its center. Then, install the bearing holder which is to be mounted at the flywheel side.
2. Install the thrust washer. Face oil groove of thrust washer toward the thrust face of crankshaft.
3. Place the bearing with oil groove at the upper side. Place the bearing without oil groove at the lower side.

NOTE: Tightening torque of bearing holder is 18-22 foot-pounds (2.5-3.0 m-kg).

Crankshaft Bearing

INSPECTION:

1. Check crankshaft bearings for peeling, weld cracks, burning, poor contact, etc. Replace bearing(s), if defective.
2. Use a cylinder gauge and micrometer to measure oil clearance between the bearing and the crankshaft journal.

Crankshaft Bearing (Continued)

3. If oil clearance exceeds the allowable limit, replace the bearing or grind the crankshaft journal and use an undersize bearing.

- ☐ **Standard Oil Clearance = 0.0015-0.0024 inch (0.039-0.106mm)**
- ☐ **Allowable Limit = 0.0079 inch (0.2mm)**

CRANK JOURNAL O.D.	BEARING SIZE
1.8096-1.8100 inch (45.964-45.975mm)	Standard
1.7998-1.8002 inch 45.714-45.725mm)	0.25mm U.S.
1.7899-1.7903 inch (45.464-45.475mm)	0.50mm U.S.

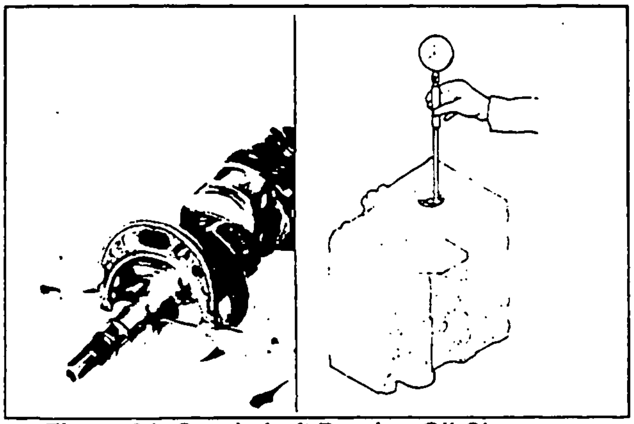


Figure 24. Crankshaft Bearing Oil Clearance

See Figure 25. Measure inside diameters at positions 1 and 2. At each of the positions, measure in directions A and B as shown.

NOTE: When changing the bushing, press fit using a press. If the crankshaft journal has been ground, check oil clearance before installing crankshaft.

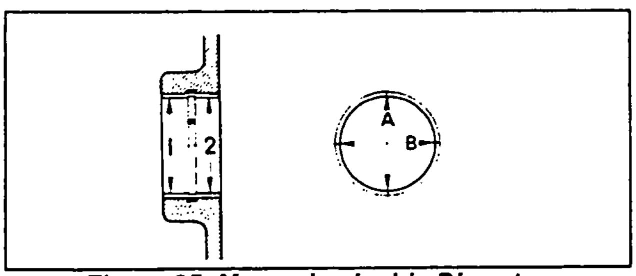


Figure 25. Measuring Inside Diameter

Crankshaft

1. Support the crankshaft on a V-Block. Then, check with a dial indicator as follows:

   a. Position the dial indicator on the crankshaft center journal. Then, turn the crankshaft slowly one full turn.
   b. If the gauge reading exceeds the allowable limit, replace the crankshaft.
   c. Inspect the oil seal contact face for damage or wear.
   d. Check for clogged oil holes.

- ☐ **Standard Deflection = 0.0012 inch (0.03mm) or less**
- ☐ **Allowable Limit = 0.0024 inch (0.06mm)**

2. See Figure 26. Inspect crankshaft journal and pin sections for damage, uneven abrasion, out-of-roundness, and axle diameter.

   a. Take measurements as shown in the illustration, at points 1 and 2 and in the directions A-A and B-B.
   b. Avoid the oil holes when measuring.

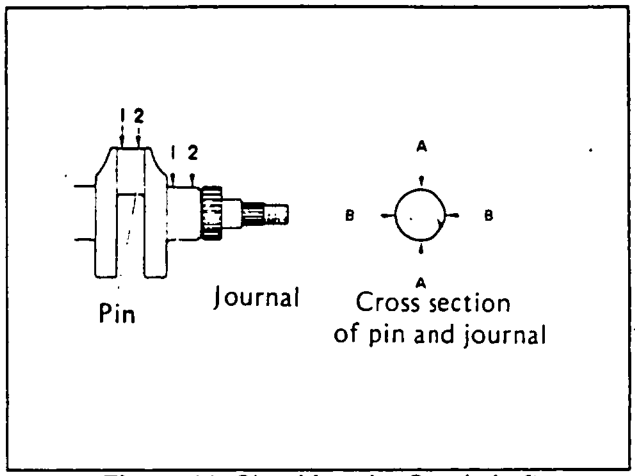


Figure 26. Checking the Crankshaft

SHAFT DIAMETER OF CRANKSHAFT JOURNAL		
BEARING SIZE	**STANDARD DIAMETER**	**ALLOWABLE LIMIT**
Standard	1.8096-1.8100 inch (45.964-45.975mm)	1.8070 inch (45.9mm)
0.25mm U.S.	1.7998-1.8002 inch (45.714-45.725mm)	1.7972 inch (45.65mm)
0.50mm U.S.	1.7899-1.7903 inch (45.464-45.475mm)	1.7874 in* (45.4mm)*

*** If crankshaft journal or crankshaft pin diameter is less than this value, replace the crankshaft.**

SHAFT DIAMETER OF CRANKSHAFT PIN		
BEARING SIZE	**STANDARD DIAMETER**	**ALLOWABLE LIMIT**
Standard	1.5340-1.5344 inch (38.964-38.975mm)	1.5315 inch (38.9mm)
0.25mm U.S.	1.5242-1.5246 inch (38.714-38.725mm)	1.5216 inch (38.65mm)
0.50mm U.S.	1.5143-1.5148 inch (38.464-38.475mm)	1.5118 inch* (38.40mm)*

Crankshaft (Continued)

3. When grinding the crankshaft, the following specifications apply (Figure 27):

A **Radius at Pin/Journal = 0.118 + 0.004 In. (3mm+0.1mm)**
B **Finish precision 1.6Z (∇∇∇)**
C **Radius around oil hole = 0.079 In. (2mm) max., 0.020 In. (0.5mm) min.**

NOTE: Use No. 400 sandpaper for final polishing.

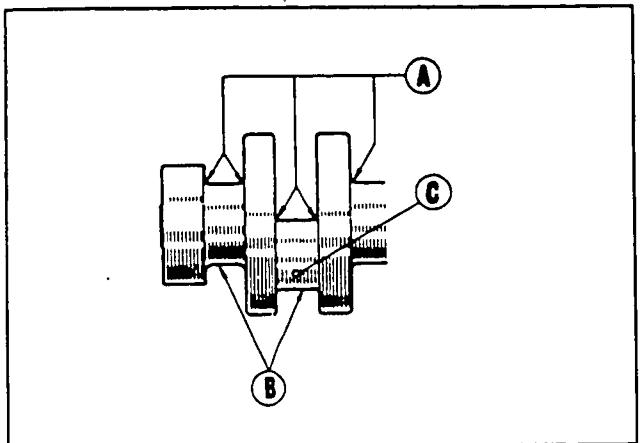


Figure 27. Crankshaft Grinding

Camshaft Assembly

Inspect the journals and cams for wear and damage. If allowable limits are exceeded, replace the camshaft.

See Figure 28. Cam height tolerances are as follows:

A INTAKE/EXHAUST VALVE CAM HEIGHT:

Standard Value: 1.0413-1.0433 Inch (26.45-26.50mm)
Allowable Limit: 1.0275 Inch (26.1mm)

B INJECTION PUMP CAM HEIGHT:

Standard Value: 0.9425-0.9472 Inch (23.94-24.06mm)
Allowable Limit: 0.9370 Inch (23.8mm)

C FUEL FEED PUMP CAM HEIGHT:

Standard Value: 1.0590-1.0630 Inch (26.9-27.0mm)
Allowable Limit: 1.0236 Inch (26.0mm)

Timing Gear

Inspect timing gears for wear or damage at their engaging areas. Replace if damaged or worn excessively. Use a thickness gauge or a dial indicator to measure gear backlash. If allowable limits are exceeded, replace the timing gears as a set.

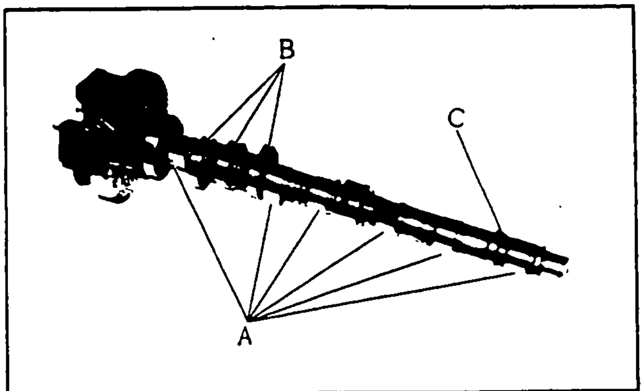


Figure 28. Camshaft Assembly

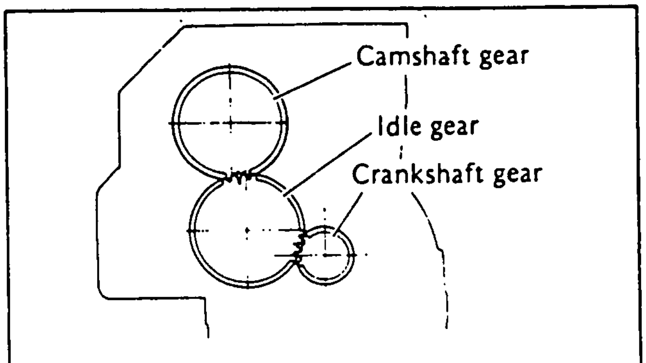


Figure 29. Timing Gears

BACKLASH OF TIMING GEARS:

Standard Backlash: 0.003 Inch (0.08mm)
Allowable Limit: 0.010 Inch (0.25mm)

Oil Pump

REMOVAL AND DISASSEMBLY:

1. See Figure 30. Remove the SNAP RING.
2. Remove COLLAR, SPRING and SHIM.
3. Remove IDLE GEAR, VANE and OIL PUMP COVER as a unit.
4. Rermove ROTOR and THRUST WASHER.
5. Remove OIL PUMP COVER from the IDLE GEAR.
6. Remove SPRING from the IDLE GEAR. Remove the KNOCK PIN.
7. Remove the VANE from the IDLE GEAR.

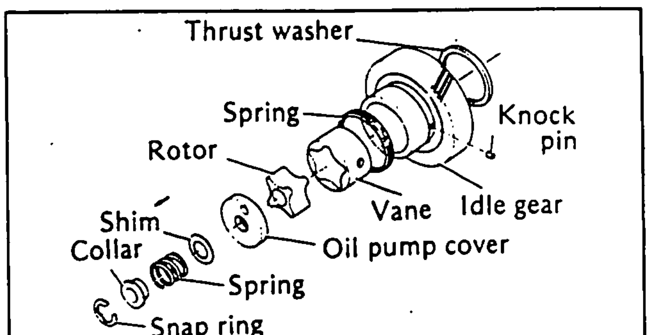


Figure 30. Oil Pump Assembly

Oil Pump (Continued)

INSPECTION AND REASSEMBLY:

1. Inspect the OIL PUMP COVER, ROTOR and VANE for wear. Replace if worn or damaged.

2. Check the clearance between the ROTOR and VANE. If clearance is excessive, replace parts.

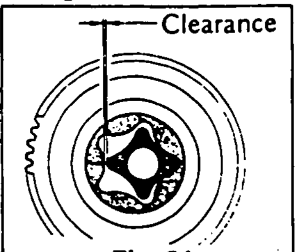


Fig. 31

3. Reassemble the oil pump in the reverse order of disassembly.
a. When reassembling, align the set marks on the crankshaft gear and the idle gear.
b. Adjust the side clearance between the rotor and vane to 0.0039-0.0059 inch (0.1-0.15mm).

Oil Filter

CONSTRUCTION AND FUNCTION:

The oil filter is a cartridge type. A SAFETY VALVE will open to bypass oil around the filter if the filter should become clogged. See Figure 32. Pressure oil from the oil pump enters at "A". The oil is filtered and then exits the filter at "B".

REPLACEMENT:

Replace the oil filter every 200 hours of operation. Prior to installing a new filter, coat its mounting face with clean oil. Tighten the filter with the hand only. Do not reuse the removed filter.

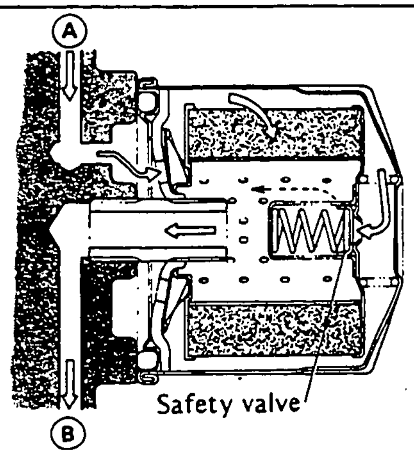


Figure 32. Oil Filter

Water Pump & Thermostat

Refer to Part 3, "*ENGINE LUBRICATION AND COOLING SYSTEM*".

Fuel Filter & Feed Pump

See Part 4 of this manual, "*ENGINE FUEL SYSTEM*".

Governor & Injection Pump

See Part 4, "*ENGINE FUEL SYSTEM*".

Nozzles and Holders

See Part 4, "*ENGINE FUEL SYSTEM*".

Section 2.5
ENGINE REASSEMBLY

General

This section provides instructions for the reassembly of the engine. Be sure to wash all parts prior to reassembly. In addition, be sure to coat all sliding and rotating surfaces with fresh, clean, new engine oil. Such surfaces as cylinder bores, pistons, bearings, bearing surfaces, etc., should be liberally coated with oil. Use new gaskets, seals and o-rings. Always tighten bolts to the recommended tightness. Never overtighten any fasteners that thread into aluminum.

Relief Valve

See Figure 16 on Page 2.3-4. Install a new o-ring onto the relief valve assembly. Install the relief valve and tighten to the recommended torque.

RELIEF VALVE TORQUE
43-51 Ft.-Lbs. (6-7 m-kg)

Crankshaft and Bearing Holder

1. Install bearing holder onto crankshaft and into bushing at front of cylinder block.
2. Align bolt holes at lower part of cylinder block with threaded holes on bearing holder, install and tighten bolts. Use two hex head bolts at flywheel side.

BEARING HOLDER TORQUE
18-22 Ft.-Lbs. (2.5-3.0 m-kg)

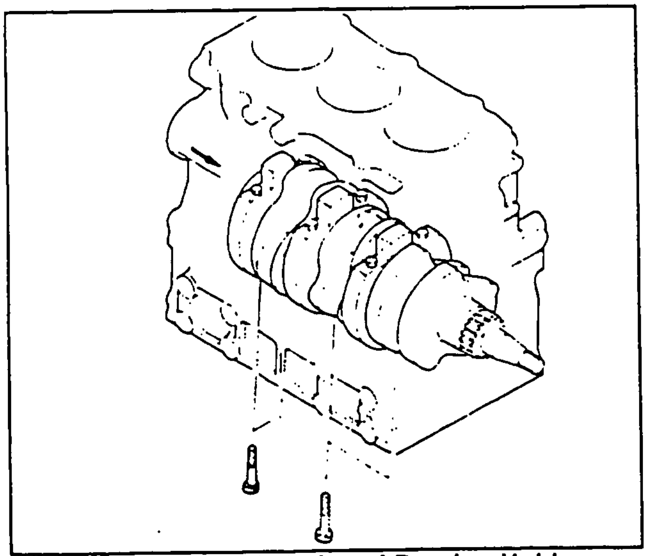


Figure 1. Crankshaft and Bearing Holder

3. Measure the crankshaft end play, in the direction of the crankshaft.

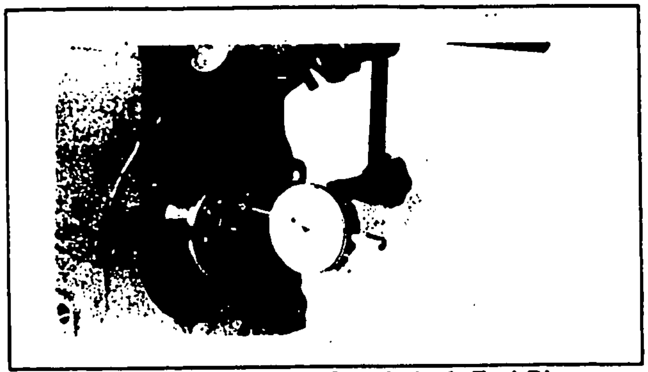


Figure 2. Checking Crankshaft End Play

CRANKSHAFT END PLAY
Standard = 0.0020-0.0118 Inch (0.05-0.30mm)
Allowable Limit = 0.020 Inch (0.5mm)

4. Install oil seal at flywheel end of crankshaft (Figure 3).

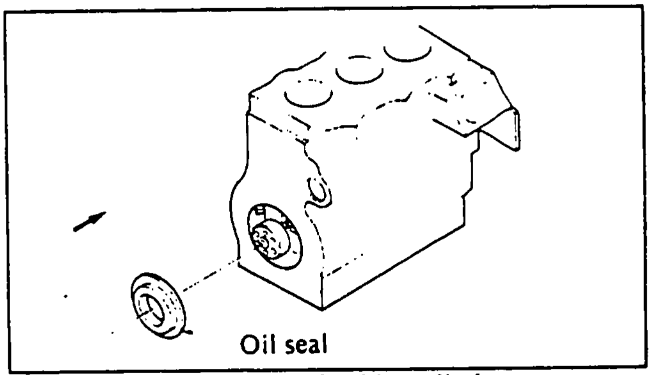


Figure 3. Oil Seal Installation

5. Install flywheel cover. Spread liquid packing over the M10 screw hole of the cylinder block flywheel cover face (Figure 4), then fit the flywheel over it.

FLYWHEEL TIGHTENING TORQUE
34-40 Ft.-Lbs. (4.7-5.5 m-kg)

6. Install the flywheel. Pay close attention to location of the alignment pin. Retain flywheel with bolts and lock ring. See Figure 5.

FLYWHEEL TIGHTENING TORQUE
43-51 Ft.-Lbs. (6-7 m-kg)

Crankshaft & Bearing Holder (Continued)

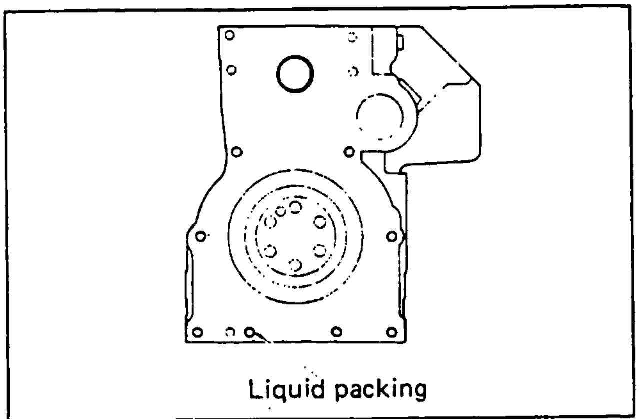


Figure 4. Liquid Packing

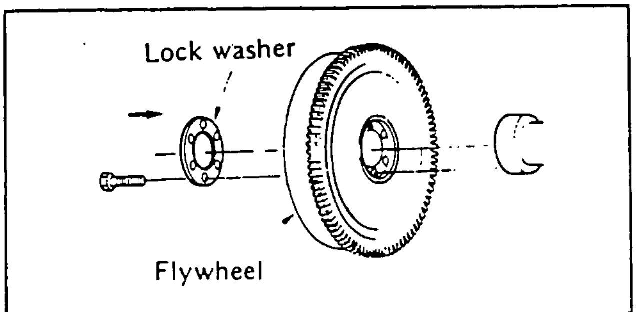


Figure 5. Flywheel Installation

Piston and Connecting Rod

1. Coat parts with clean engine oil. Move the piston rings around to provide plenty of oil in the ring grooves.
2. Set the ring gaps 90° apart from each other. However, do NOT place the ring gaps toward the piston pin or at right angles to the piston pin.
3. Use a ring compressor to compress the rings around the piston.
4. Face the alignment mark on the connecting rod toward the injection pump. Install the parts, starting at the front and moving toward the rear.
5. Tighten the connecting rod caps to their specified torque.

CONNECTING ROD CAP TIGHTNESS
22-25 Ft.-Lbs. (3.0-3.5 m-kg)

6. After installation, check that the crankshaft can move slightly the specified axial distance.

CRANKSHAFT AXIAL PLAY
0.004-0.012 Inch (0.1-0.3mm)

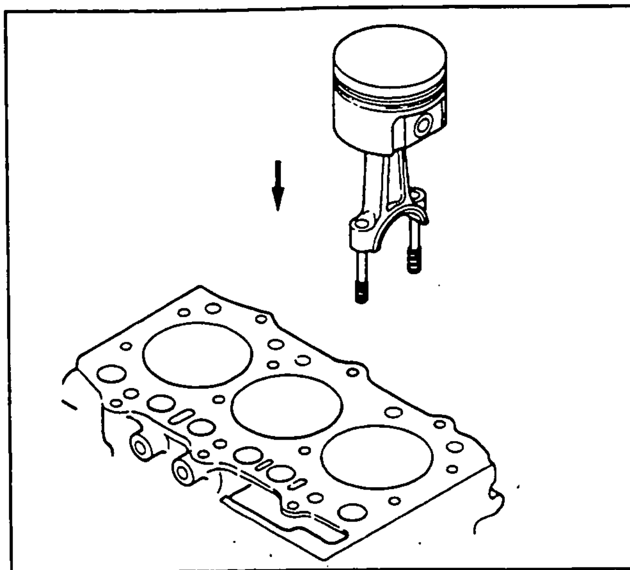


Figure 6. Piston and Connecting Rod

Suction Pipe and Filter

Install an o-ring onto the suction pipe. Install the pipe into the cylinder block. Install the suction filter.

SUCTION FILTER TIGHTNESS
7-9 Ft.-Lbs. (0.9-1.3 m-kg)

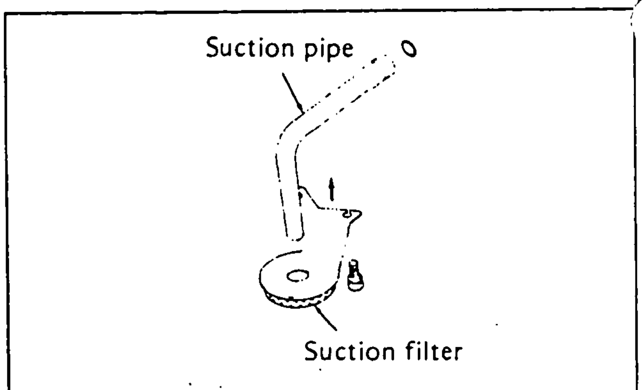


Figure 7. Suction Pipe and Filter

Oil Pan

Tighten oil pan boltsevenly and in diagonal increments. Install the front plate.

Camshaft Assembly

Install the camshaft assembly and plate. Tighten the plate to the specified torque. See Figure 8.

PLATE TIGHTENING TORQUE
7-9 Ft.-Lbs. (0.9-1.3 m-kg)

Camshaft Assembly (Continued)

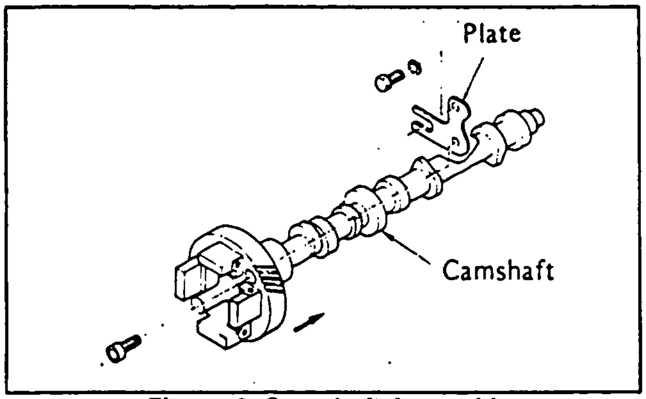


Figure 8. Camshaft Assembly

Idler Gear and Oil Pump

1. Install thrust washer onto the idler gear shaft. Assemble vane, knock pin and spring to the idler gear.

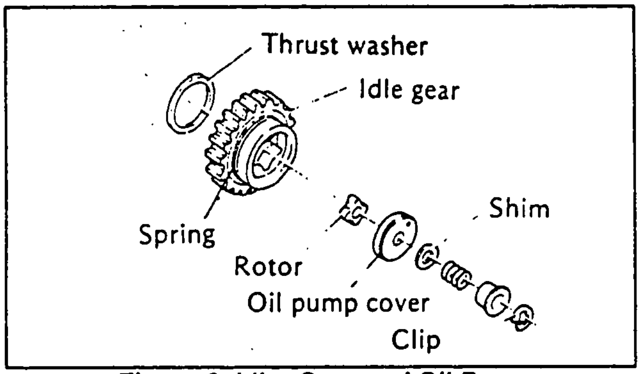


Figure 9. Idler Gear and Oil Pump

2. Align the timing marks of the idler gear, crankshaft gear and camshaft gear (Figure 10).

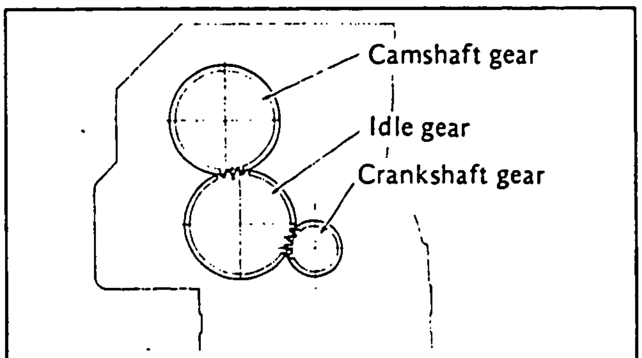


Figure 10. Idler, Crankshaft and Camshaft Gears

3. Install the oil pump rotor.
4. Install the oil pump cover, shim, spring and collar. Retain with snap ring. Adjust with shim so that side clearance between pump, rotor and vane is 0.004-0.006 inch (0.1-0.15mm).

CAUTION: Coat BOTH faces of the rotor and vane with grease prior to assembly. DO NOT ROTATE THE CRANKSHAFT UNTIL THE TIMING GEAR CASE IS MOUNTED.

5. Rotate the oil pump cover to place the spring pin insert hole to the center position. Then, assemble the gear case.

Timing Gear Case

Install the start spring. Insert the link into the cylinder block hole. Install the gasket. Install the timing gear case.

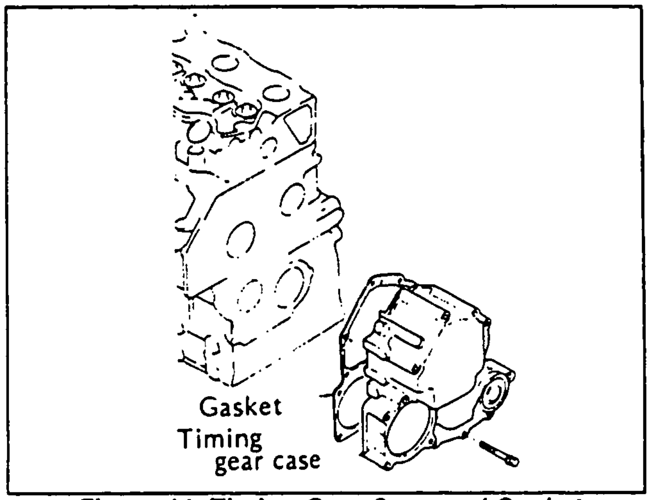


Figure 11. Timing Gear Case and Gasket

Crankshaft Pulley

Align pulley with key and install. Tighten to the recommended torque.

CRANKSHAFT PULLEY TORQUE
72-80 Ft.-Lbs. (10-11 m-kg)

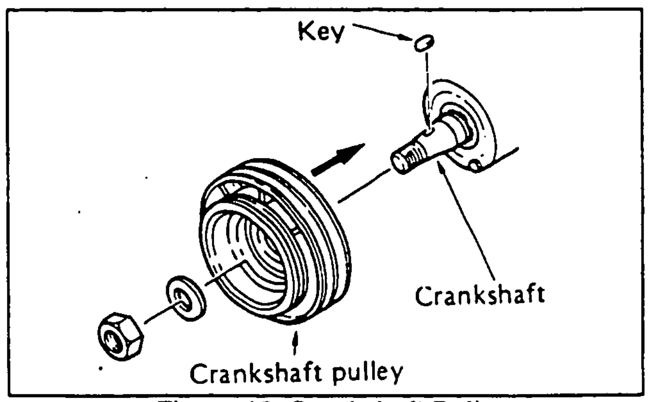


Figure 12. Crankshaft Pulley

Injection Pump Asembly

Install the injection pump, using the same shims that were removed during disassembly. Connect control rack of pump with LINK and retain with SNAP PIN. Retain pump with bolts and nuts.

NOTE: The pump shims establish the injection pump timing. When reinstalling the same injection pump that was removed, use the same shims that were removed. Fuel injection timing must be adjusted whenever (a) a new injection pump is installed, (b) a new camshaft is installed, or (c) a new cylinder block is used. See Part 4, "ENGINE FUEL SYSTEM" for timing adjustment procedure.

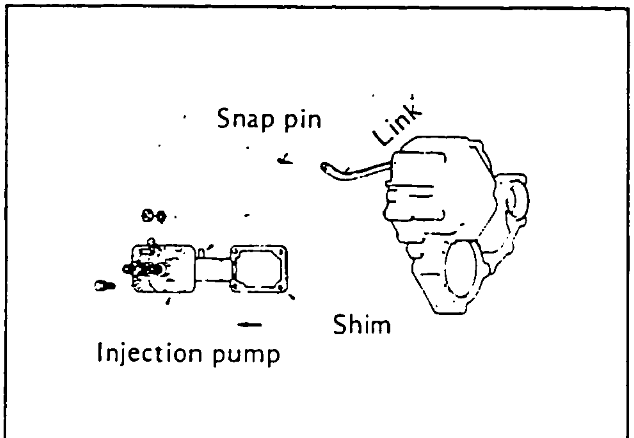


Figure 13. Injection Pump Installation

Oil Filter, Oil Pipe, Feed Pump and Tappets

1. Coat oil filter mounting face with light film of oil and install. Tighten by hand.
2. Install the feed pump assembly, using two bolts.
3. Coat tappets with oil and install.
4. Install the oil pipe (Figure 14).

OIL PIPE EYEBOLT TORQUE
7-9 Ft.-Lbs. (1.0-1.3m-kg)

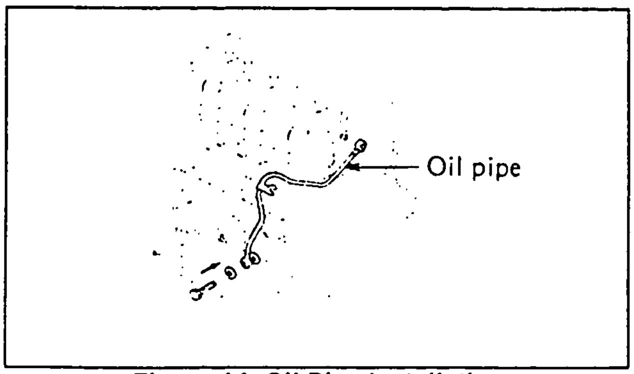


Figure 14. Oil Pipe Installation

Cylinder Head Assembly

1. Set each piston at top dead center (TDC), one at a time. When the pistons are at top dead center (TDC), measure their protrusion above the cylinder block with a depth gauge or a dial indicator. Measure the protrusion of all three pistons. Use the largest protrusion to select a cylinder head gasket having the correct thickness.

LARGEST PROTRUSION	GASKET PART NO.	GASKET THICKNESS
0.018-0.021 inch (0.45-0.55mm)		0.043 inch (1.1 mm)
0.022-0.026 inch (0.55-0.65mm)	158-70939	0.047 inch (1.2 mm)
0.026-0.029 inch (0.65-0.75mm)	159-70939	0.051 inch (1.3 mm)

NOTE: The thickness of the head gasket, when tightened, is stamped at top of gasket (as .1, .2, .3).

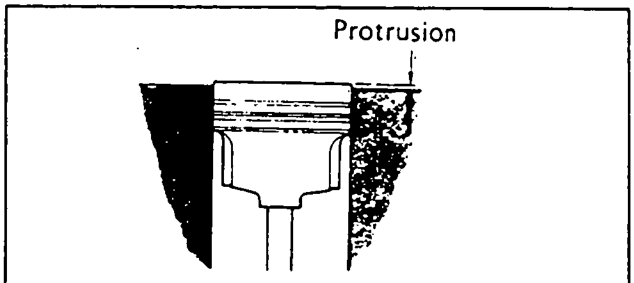


Figure 15. Piston Protrusion above Cylinder Block

2. Install the glow plugs.
3. Tighten the cylinder head bolts in three (3) phases and in the sequence shown in Figure 16. Alignment pins are provided for proper positioning. Coat all bolt threads with molybdenum disulphide grease.

CYL. HEAD FINAL TIGHTENING TORQUE
33-36 Ft.-Lbs. (4.5-5.0 m-kg)

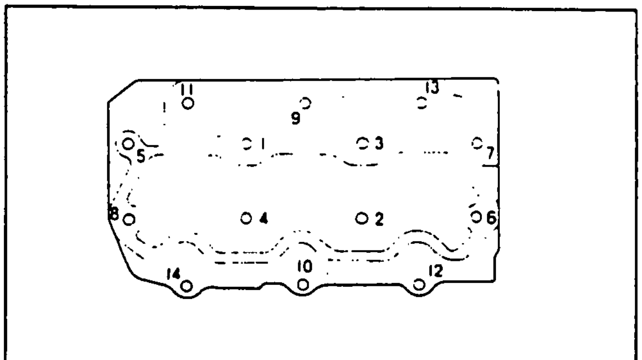


Figure 16. Cylinder Head Tightening Sequence

Cylinder Head Assembly (Continued)

4. Install CAPS on end of valve stems. Install the PUSH RODS and the ROCKER ARM ASSEMBLY.

ROCKER ARM TIGHTENING TORQUE
15-18 Ft.-Lbs. (2.0-2.5 m-kg)

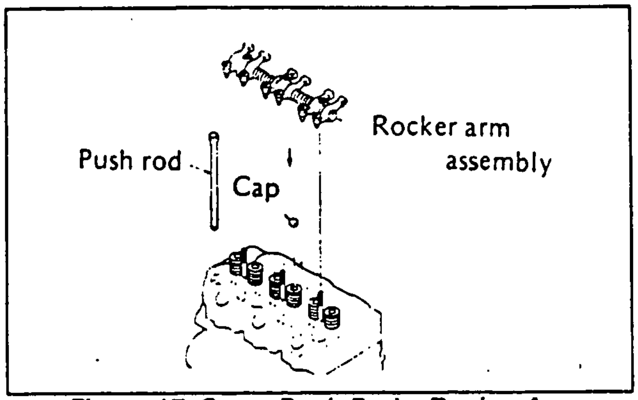


Figure 17. Caps, Push Rods, Rocker Arm

Valve Clearance Adjustment

See Figure 18. Loosen the NUT, then adjust intake and exhaust valve clearance to 0.008 inch (0.2mm) by turning the ADJUST SCREW. Use the following procedure:

1. Adjust valve clearance with engine cold.
2. Set No. 1 piston at top dead center (TDC), then adjust the intake and exhaust valves of No. 1 cylinder and the exhaust valve of No. 2 cylinder.
3. Turn the crankshaft 240° counterclockwise (as viewed from the front).
4. Adjust No. 3 cylinder intake and exhaust valves and the intake valve of No. 2 cylinder.

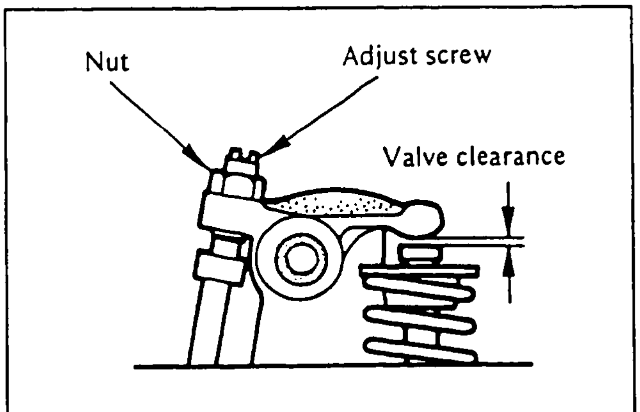


Figure 18. Adjusting Valve Clearance

Cylinder Head Cover

Install cover gasket and cover. Tighten the cover evenly to recommended torque.

CYLINDER HEAD COVER TORQUE
6-8 Ft.-Lbs. (0.8-1.2 m-kg.)

Water Pump Assembly

Install the water pump assembly, gasket and hose.

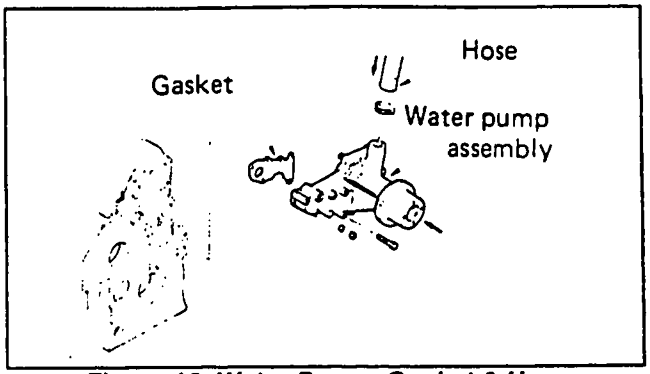


Figure 19. Water Pump, Gasket & Hose

Nozzles and Nozzle Holders

Install caps and gaskets. Install nozzle holders and tighten to specified torque. Install the return pipe and the injection pipes, tighten to specified torque.

NOZZLE HOLDER TIGHTENING TORQUE
58-61 Ft.-Lbs. (8.0-8.5 m-kg)

INJECTION PIPE TIGHTENING TORQUE
18-22 Ft.-Lbs. (2.5-3.0 m-kg)

Complete the Assembly

Install any remaining engine components.

Part 3
ENGINE LUBRICATION & COOLING SYSTEM

NP and IM Series

RECREATIONAL VEHICLE & INDUSTRIAL MOBILE AC GENERATORS

Liquid-Cooled Diesel Engine Models

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Section 3.1
ENGINE LUBRICATION SYSTEM

Oil Pump Removal

See "*Oil Pump*" on Page 2.4-9 (Part 2, Section 2.4).

Oil Pump Inspection & Reassembly

See "*Oil Pump*" on Page 2.4-10 (Part 2, Section 2.4).

Idler Gear & oil Pump Installation

Refer to "*Idler Gear and Oil Pump*" on Page 2.5-3 (Part 2, Section 2.5).

Oil Filter

The cartridge type oil filter is equipped with a SAFETY VALVE. Should the filter become clogged, the safety valve will open and allow unfiltered oil to flow to all parts of the engine.

See Figure 1. Oil enters the filter at "A", flows through the filtering element, then exits the filter at "B".

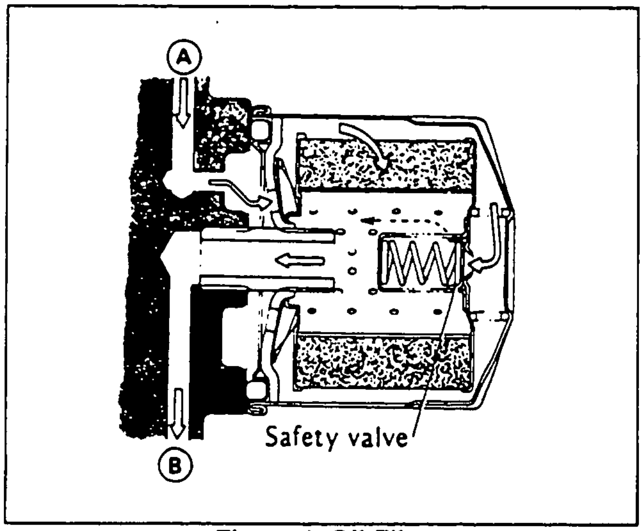

Figure 1. Oil Filter

Low Oil Pressure Shutdown

The diesel engine is equipped with a normally-closed low oil pressure switch (Figure 2). The switch is held open by engine oil pressure during engine cranking, startup and running operations. Should oil pressure drop below approximately 15 psi, the switch contacts will close to effect an automatic engine shutdown.

To test the low oil pressure shutdown feature, start the engine and let it run at NO-LOAD (electrical loads turned off). Remove the wire from the switch terminal. Hold the wire terminal end against a clean frame ground and the engine should shut down.

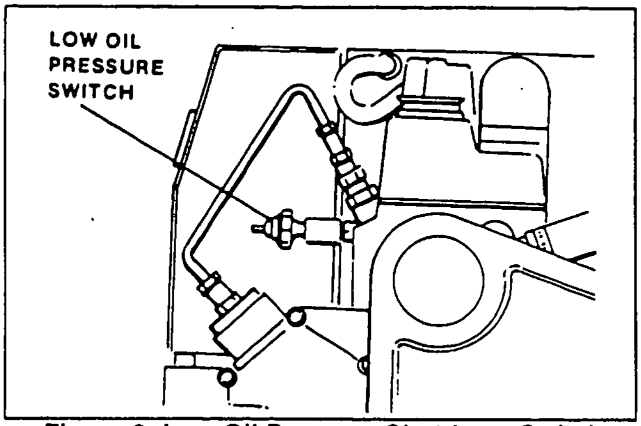

Figure 2. Low Oil Pressure Shutdown Switch

Section 3.2
WATER PUMP & THERMOSTAT

Water Pump

DISASSEMBLY:

1. Remove the SET SCREW and GASKET.
2. Remove the thermostat and spring.

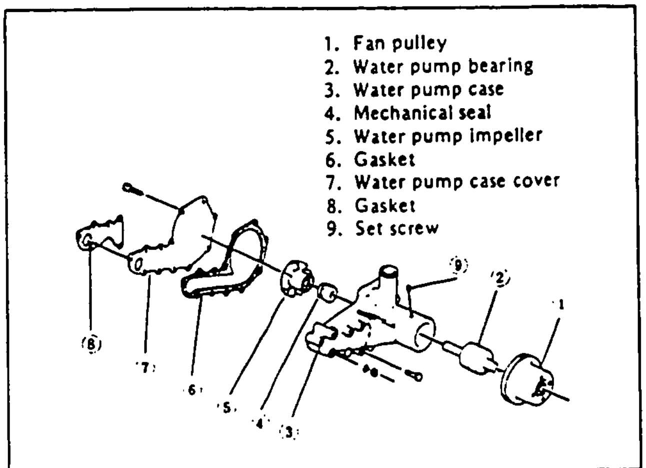

Figure 1. Water Pump Exploded View

3. Use a press to remove the bearing from the water pump (Figure 2).
4. See Figure 1. Remove the IMPELLER and MECHANICAL SEAL from the casing.
5. See Figure 3. Use a press to separate the bearing from the fan pulley.

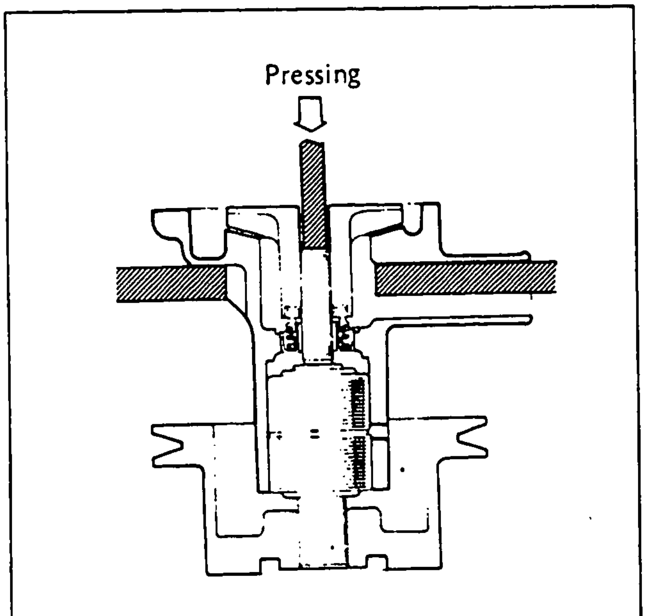

Figure 2. Bearing Removal from Pump

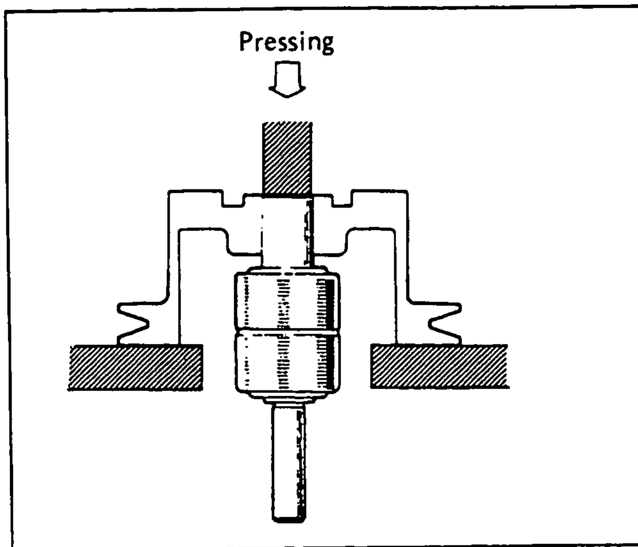

Figure 3. Separating Bearing from Fan Pulley

PUMP INSPECTION:

1. Inspect all parts of water pump for cracks, wear. damage. Replace any defective part(s).
2. Replace bearing if it rotates rough or if its conbtact with the casing is defective.
3. Replace the bearing if shaft play at end of shaft exceeds 0.008 inch (0.2mm).

WATER PUMP REASSEMBLY:

1. Apply liquid packing (Threebond 2) to the casing side of the mechanical seal. Press fit the seal into the casing.
2. Press fit the bearing into the casing.
3. Align the pump case end face with the bearing end face, as shown in Figure 4.

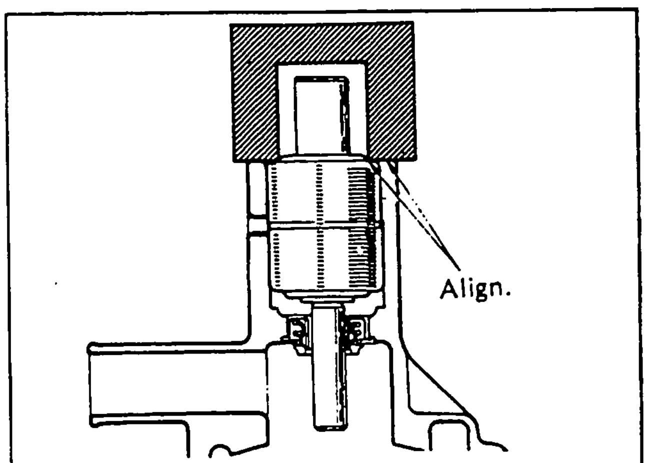

Figure 4. Pump Alignment

Water Pump (Continued)

REASSEMBLY (CONT'D):

4. Install a mechanical seal into the impeller by hand. Apply 4 or 5 drops of silicon oil to the contact surface of the mechanical seal.
5. Press the impeller into the casing until the impeller end is o.70 inch (17.8mm) from the end of the bearing. See Figure 5.

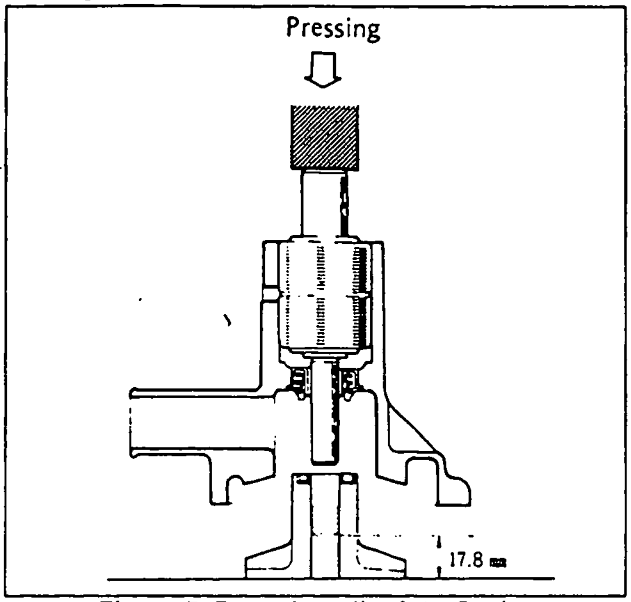

Figure 5. Press Impeller Into Casing

6. Use a SETSCREW to retain the bearing (Figure 6). Then, press the fan pulley into place until the bearing shaft end is aligned with the end face of the fan holder.

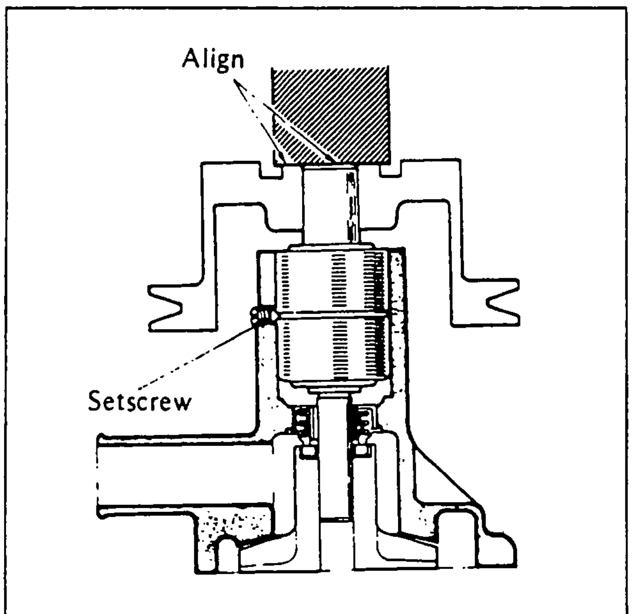

Figure 6. Fan Pulley & Setscrew Installation

7. Assemble the thermostat and spring to the water pump casing. Install gaskets, plate and cover. Retain with bolts.

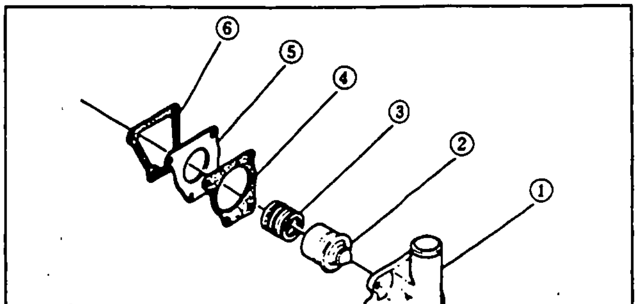

Figure 7. Thermostat Assembly

8. Rotate the fan pulley to ensure there is no interference.
9. Adjust fan belt tension to obtain a 0.20 inch (5mm) belt deflection when a 2.2 pound (1 kg) force is applied to center of belt.
10. Test run the engine until hot to confirm there are no water leaks.

Thermostat

To test thermostat operation, immerse it in water. Raise the water temperature gradually. Check the valve opening temperatures and the valve lift.

NOTE: About 3 to 5 minutes will be required before the valve starts to operate.

Starts to Open:	**158° F. (70° C.)**
Fully Open at:	**185° C. (85° C.)**
Valve Lift at Fully Open:	**0.31 inch (8.0mm)**

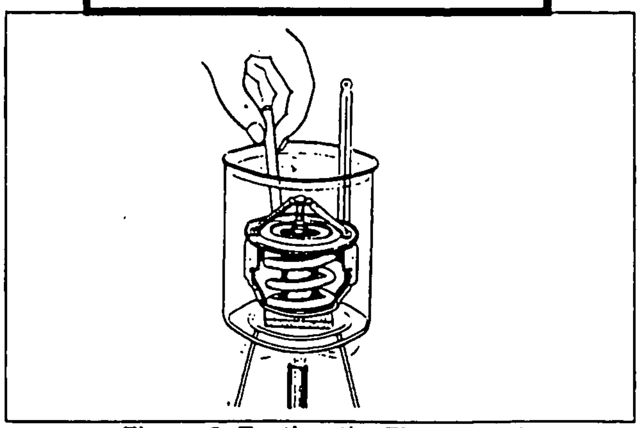

Figure 8. Testing the Thermostat

Section 3.3
COOLING & VENTILATING AIR

General

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

Types of Cooling Fans

Engine-generator sets may be equipped with either (a) a PUSHER type fan, or (b) a SUCTION type fan. The suction type (squirrel cage) fan may be installed on units with either a 10 or 15 inch stator. Pusher type fans are used primarily on units having a 10 inch stator.

Air Flow- Pusher Fan Units

See Figure 1 below. A blower fan attached to the generator rotor draws air into the generator interior to cool generator internal parts. The heated generator cooling air is expelled through a blower air outlet duct on the side of the unit. The engine's pusher fan draws air around the generator, forces it through the radiator, and outward, away from the unit.

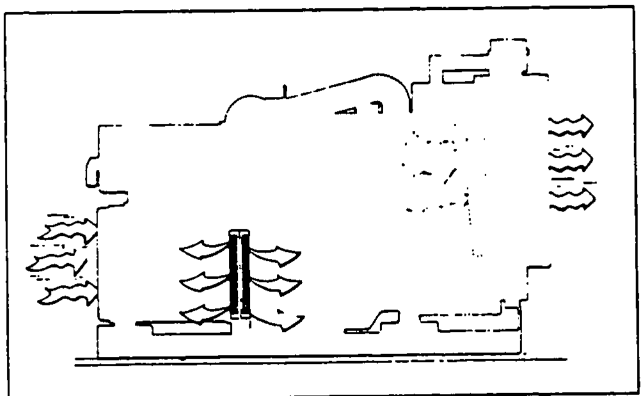

Figure 1. Air Flow- Pusher Fan Units

Air Flow- Suction Fan Units

A centrifugal blower fan rotates with the generator rotor to cool generator internal parts. The heated generator cooling air is expelled outward through a blower air outlet duct on the side of the generator.

The suction type fan is a high capacity "squirrel cage" type which draws air in, across the radiator, then directs the air downward and away from the unit through an air duct. See Figure 2.

Installation Manual

Additional information on cooling and ventilating requirements can be found in the "INSTALLATION MANUAL" for water-cooled recreational vehicle generators. Installation Manuals can be ordered from Generac Corporation.

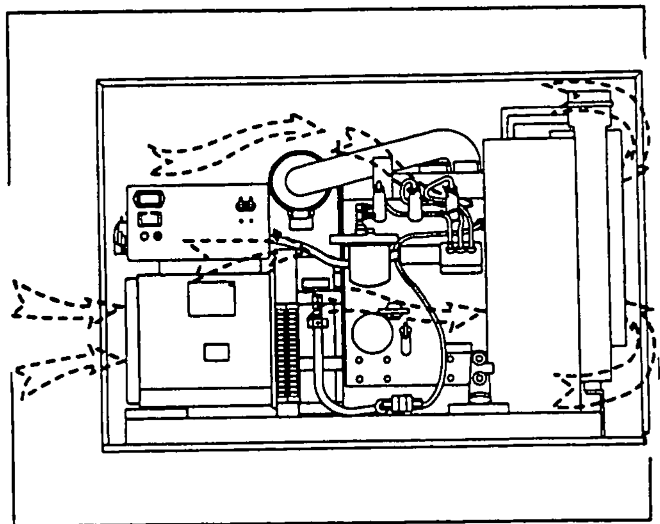

Figure 2. Air Flow Suction Fan Units

Air Inlet- Suction Fan Units

When the engine-generator is installed in a compartment (as in a recreational vehicle), the following rules apply to air inlet openings in the compartment:

- ☐ Ideally, the air inlet opening should be close to the generator's rear bearing carrier. This will allow air to circulate the full length of the compartment and around the entire generator.
- ☐ Unrestricted air inlet opening area must be at least 150 square inche (15 inch stator units); or 300 square inches (10 inch stator units).
- ☐ If louvers, screening or expanded metal are used to cover an air inlet opening, the restriction to air flow offered by such materials must be compensated for. This is done by making the actual air inlet opening size proportionally larger.

Other Rules for Suction Fan Units

Some installations provide a compartment, to house the generator set. In some installations, a floorless compartment or no compartment at all may be provided. The following rules apply:

- ☐ If a compartment is used, the unit radiator must not contact the compartment wall. A minimum of at least 3-1/2 inches (90mm) of clearance is recommended between the front and sides of the radiator and the compartment walls. Such clearance is required so the suction fan can draw air around the radiator edges.
- ☐ If a floorless compartment (or no compartment) is used, the generator must be protected against road splash and debris by such means as anti-splash baffles.

Compensating for Restrictions

Air openings may be covered with louvers, expanded metal or screening. These materials offer a restriction to the flow or air. Such restrictions must be compensated for by the installer.

To determine the actual air opening size required when an air opening is covered by some material, the material's "PERCENT OF FREE AIR INLET AREA" must be known. This value can usually be obtained from the manufacturer of the material. Some materials may provide only a 60 percent free air inlet area. Even the most efficient materials may offer only an 80-90 percent free air inlet area.

To calculate the actual air opening size required, divide the unrestricted air opening size required by the percent of free air inlet area of the material to be used.

EXAMPLE 1:

The recommended unrestricted air opening for units with 15 inch stator is 150 square inches. Air openings are to be covered with a material having a 70 percent free air inlet area. Divide "150" by "0.70" to obtain "214.28 square inches". In this case the actual air opening size should be about 215 square inches.

EXAMPLE 2:

The recommended unrestricted air opening for units with 10 inch stator is 300 square inches. Air openings are to be covered by expanded metal having an 80 percent free air inlet area. Divide "300 by 0.80" to obtain "375 square inches". The actual air opening size should be about 375 square inches.

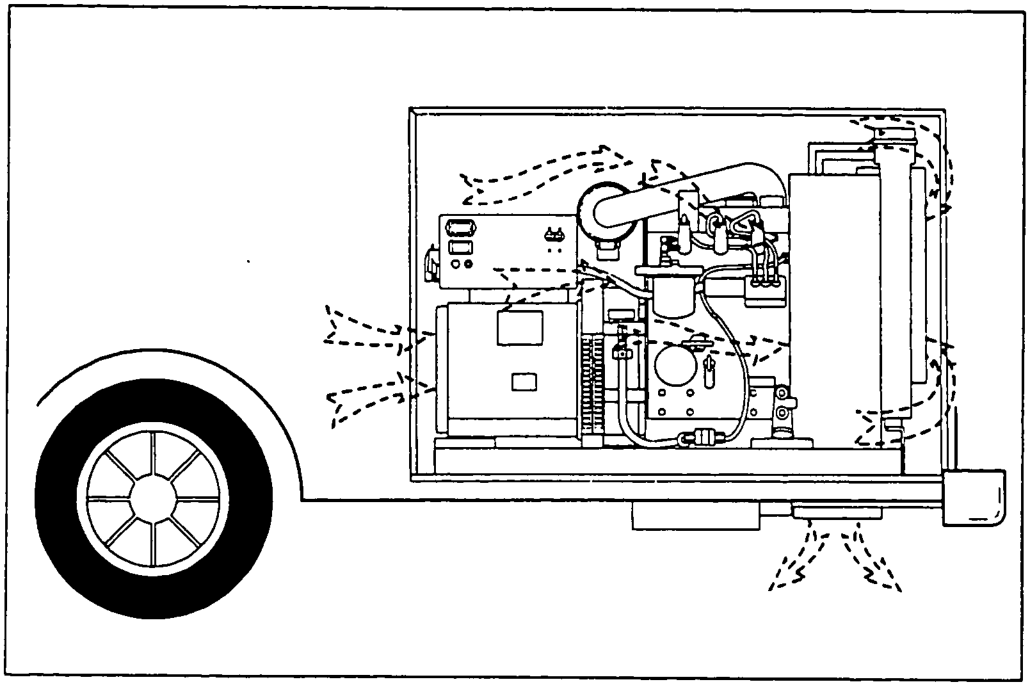

Figure 3. Typical Installation- Units with Suction Fan

Section 3.4
PERIODIC MAINTENANCE

Engine Oil System

OIL RECOMMENDATIONS:

Use a high quality detergent oil classified "For Service CC or CD". Detergent oils keep the engine cleaner and reduce carbon deposits. Use oil having the following SAE (Society of Automotive Engineers) viscosity rating, based on the ambient temperature range anticipated before the next oil change. Engine crankcase oil capacity is 3.7 U.S. quarts (3.5 liters) without oil filter change, or 4.0 U.S. quarts (3.7 liters) with oil filter change.

AMBIENT TEMPERATURE	SAE VISCOSITY
Above 100° F. (37.8° C.)	SAE 40 Oil
40°-100° F. (4.4°-37.8° C.)	SAE 10W-30 or SAE 30 Oil
Below 40° F. (4.4° C.)	SAE 5W-20 or SAE 5W-30 Oil

CAUTION: After refilling the crankcase with oil, check oil level on dipstick. NEVER OPERATE THE ENGINE WITH OIL LEVEL BELOW THE "ADD" MARK.

NOTE: On new engines, check oil level frequently during the break-in period (first 25 hours of operation). Add oil as required. It is normal for the engine to consume more oil than normal until the piston rings have seated properly.

OIL & FILTER CHANGE FREQUENCY:

Change engine oil and oil filter after the first 25 hours of operation. Thereafter, change oil and filter every six (6) months or every 250 operating hours, whichever occurs first.

Engine Cooling System

RECOMMENDED COOLANT:

Use a 50-50 mixture of low silicate, ethylene glycol base anti-freeze and soft water. Use only SOFT WATER and LOW SILICATE anti-freeze. If desired, a high quality rust inhibitor may be added to the recommended mixture.

CAUTION: DO NOT use any chromate base rust inhibitor with ethylene glycol base anti-freeze or the formation of chromium hydroxide (green slime) will result. Green slime in the cooling system will cause overheating. Engines that have been run with a chromate base inhibitor must be chemically cleaned before adding ethylene glycol type anti-freeze.

When adding coolant to the coolant recovery bottle, add only the recommended 50-50 mixture.

COOLING SYSTEM MAINTENANCE:

- ☐ Inspect the entire cooling system at least once every month or every 100 hours of operation, whichever occurs first. Check carefully for leaks, condition of hoses, tightness of clamps, etc.
- ☐ Every two (2) years, the cooling system should be drained, flushed and refilled with the recommended coolant.

Part 4
ENGINE FUEL SYSTEM

NP and IM Series

RECREATIONAL VEHICLE & INDUSTRIAL MOBILE AC GENERATORS

Liquid-Cooled Diesel Engine Models

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Section 4.1
INTRODUCTION TO THE DIESEL FUEL SYSTEM

General

The diesel engine does not require an electrical ignition system. The diesel fuel is ignited by heat which is created by extremely high pressures in the combustion chambers during the compression stroke. The compression ratio of the engine is 23 to 1, to provide a cylinder compression pressure of nearly 340 psi.

Fuel Recommendations

Diesel fuels are less volatile than gasoline and gaseous fuels. For that reason, diesel fuel is considered safer than the more volatile fuels. Because diesel fuels are safer, careless practices often result which can lead to serious problems with engine performance and reliability.

RECOMMENDED FUEL:

Use clean, fresh, No. 2D diesel fuel having a Cetane number of at least "40". Where the vehicle is equipped with a diesel engine, the vehicle fuel tank may also supply fuel to the NP series generator.

KEEP DIESEL FUEL CLEAN:

Dirt or water in the fuel system is a major cause of engine, injection pump or injection nozzle failure. Fuel must be kept clean and free of moisture.

DO NOT ALTER THE INSTALLATION:

When installed, the fuel system was in full compliance with applicable codes, standards and regulations. Do NOT make any changes that might render the system unsafe or in non-compliance with such codes, standards and regulations.

CHECK FOR LEAKS PERIODICALLY:

Fuel lines and fittings must be kept tight and must be maintained free of leaks. An improperly tightened fuel line might show no evidence of leakage, but may permit air to enter the fuel system. Air in the system will cause hard starting and rought operation.

NOTE: The diesel engine is self-bleeding and should never require hand priming or bleeding of air from the system.

Fuel System Components

See Figure 1, below. During operation, fuel is pumped from the fuel tank, to a 12 volts DC electric fuel pump, through a fuel filter, a fuel injector pump, fuel injectors, and into the engine combustion chambers.

The following facts apply to the various fuel system components:

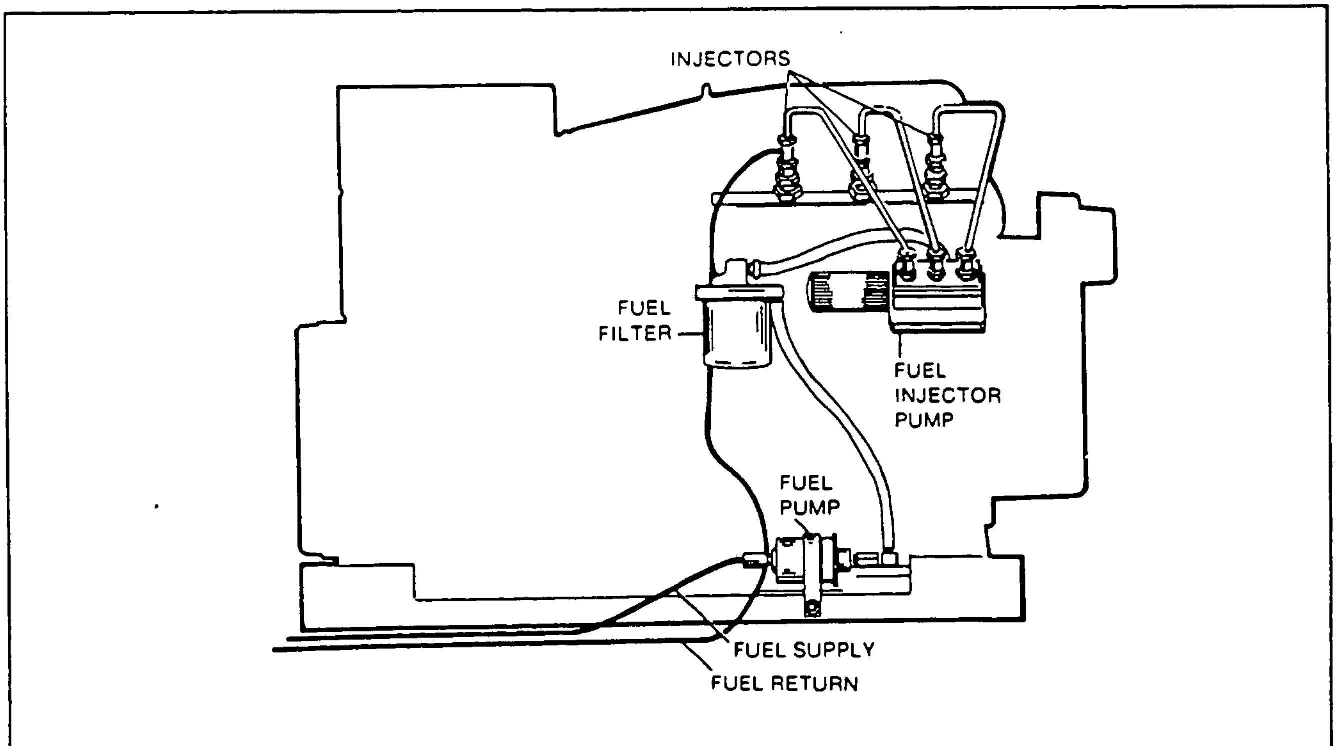


Figure 1. Engine Fuel System (Typical)

Fuel System Components (Continued)

- ☐ The FUEL INJECTOR PUMP must be properly timed, to deliver the required amount of fuel to each cylinder at the precise moment the fuel is needed. Firing order of engine cylinders is 1-2-3. Fuel injection occurs at 20°-21° BTDC.
- ☐ Injectors pressure is approximately 1707 psi (11,769 kPa).
- ☐ Rated lift of the electric fuel pump is approximately 9 to 10 feet (200 mm of Hg).
- ☐ Excess fuel is returned to the fuel tank, via one or more return lines.

Section 4.2
FUEL PUMP

General

The electric fuel pump is turned on by the action of an engine control circuit board, housed in the unit control panel. Power for pump operation is supplied via Wire No. 14 which is electrically hot only during engine running condition. Wire No. 14 also energizes a FUEL SOLENOID (FS) which then opens to supply fuel to the system.

NOTE: For additional information on the engine control circuit board, refer to Part 5 of this manual, "ENGINE ELECTRICAL SYSTEM".

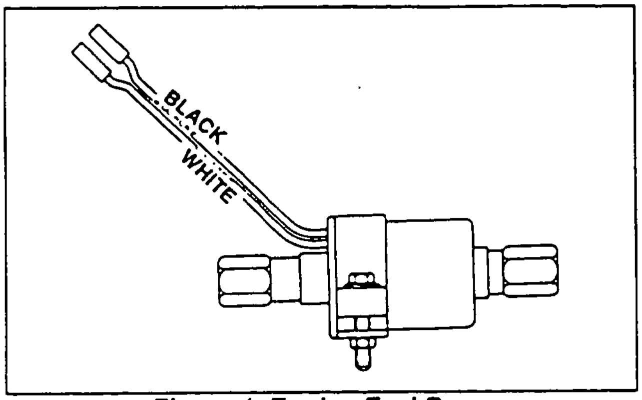


Figure 1. Engine Fuel Pump

Testing the Fuel Pump

An ohmmeter or a volt-ohm-milliammeter (VOM) may be used to test fuel pump windings for continuity.

To perform an operational test, disconnect the pump outlet line from the pump and connect the pump inlet line to a suitable fuel supply. Connect a 12 volts DC power supply to the white pump wire (+); a negative (-) DC power supply to the black wire (-). The pump should operate and pump fuel out of the outlet side. If not, replace the pump.

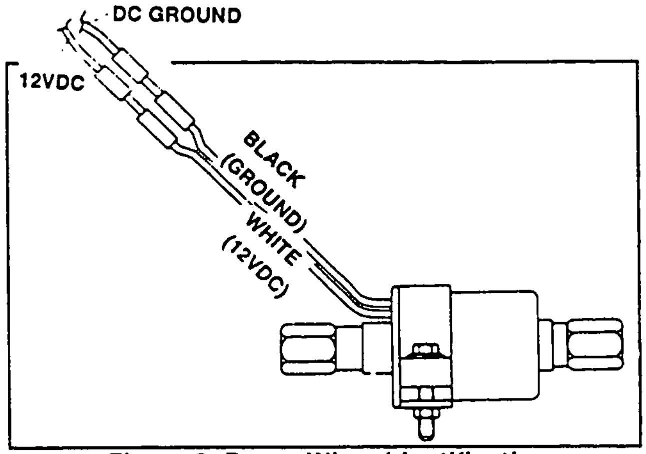


Figure 2. Pump Wires Identification

Section 4.3
GOVERNOR

General

A mechanical all-speed governor is used. It is housed in the gear case.

A flyweight assembly is mounted on the camshaft. Flyweight movement is transmitted to the injection pump control rack by way of the slider, control lever and link. A spring is attached to the arm complete and the tension lever. The spring regulates flyweight movement.

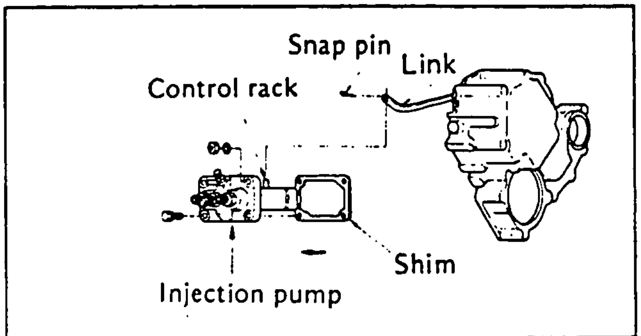


Figure 1. Governor to Pump Connections

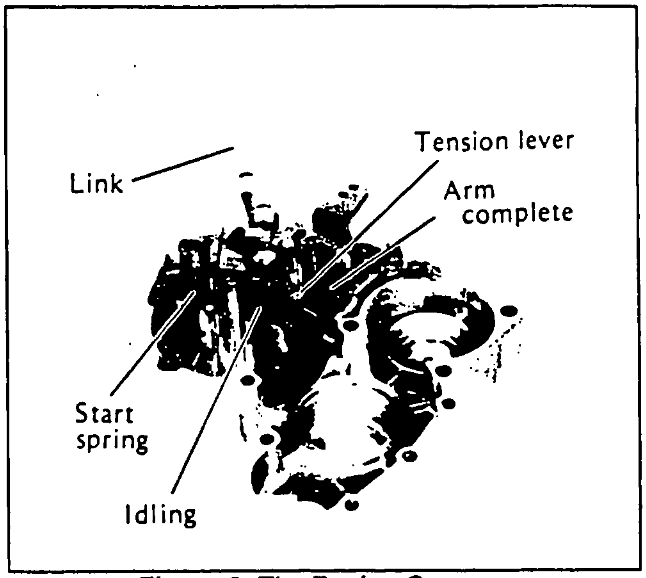


Figure 2. The Engine Governor

By changing the set angle of the governor lever. tension on the tension lever spring is changed. In this manner, engine speed can be regulated by the governor lever.

Governor Adjustment

Governor adjustment procedure may be found on Page 1.9-2 of this manual (Part 1, Section 9). Governed speed adjustment is accomplished by limiting the movement of the arm complete.

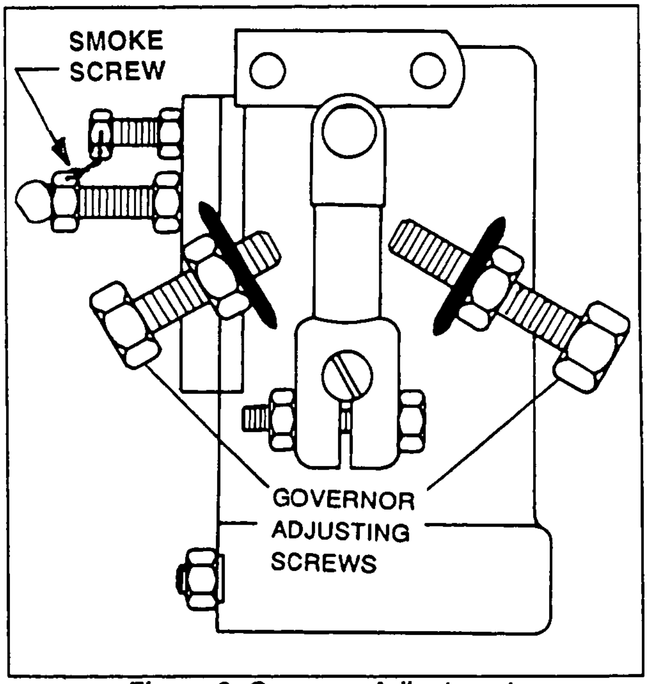


Figure 3. Governor Adjustments

Section 4.4
FUEL INJECTION PUMP

Injection Pump Removal

See Figure 1. Remove bolts and nuts that retain the pump. Move the pump straight up and pull out the snap pin. Remove the link from the pump control rack. Finally, remove the pump.

NOTE: Injection timing is determined by SHIMS at the injection pump mounting face. Be sure to check and record the thickness and number of shims to ensure proper installation of the pump.

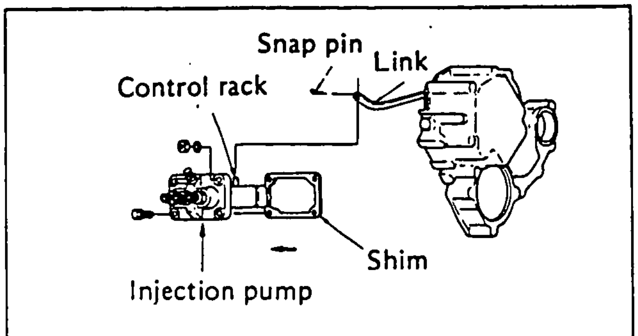


Figure 1. Injection Pump

Injection Pump Installation

Install the pump using the same shims that were removed during disassembly. Connect control rack of pump with link and retain with snap pin. Retain pump with bolts and nuts.

Fuel Injection Timing

If the same pump is to be reinstalled, always use the same number of shims that were removed. These shims establish the fuel injection timing.

Timing will have to be readjusted whenever one or more of the following components have been replaced:

- ☐ When the injection pump is replaced.
- ☐ When the camshaft has been replaced.
- ☐ When the cylinder block has been replaced.

To adjust fuel injection timing, proceed as follows:

1. Install the injection pump using a shim that is 0.5mm (0.020 inch) thick.
2. Remove the DELIVERY HOLDER at the front of the injection pump (Figure 2).
3. Remove the DELIVERY VALVE (IN). Reinstall the SPRING and the DELIVERY HOLDER.

NOTE: When reassembling the delivery holder, adjust the location of the delivery valve (OUT) with a wire.

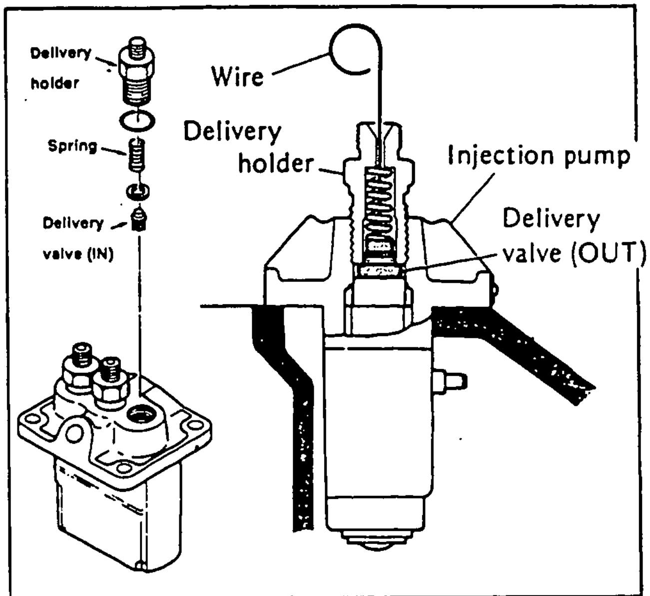


Figure 2. Delivery Holder, Spring, Delivery Valve

4. Move the governor control lever to its FULL INCREASE position, to deliver fuel with No. 1 piston ar around 25° BTDC of its compression stroke. Fuel will flow from the delivery holder at this time.
5. Slowly turn the crankshaft clockwise (CW) until fuel stops coming from the delivery holder. Check the piston position at this point.
   a. If the piston position is LATER than 16.5° BTDC, use a thinner shim.
   b. If the piston position is EARLIER than 17.5° BTDC, use a thicker shim.

INJECTION TIMING	PISTON POSITION
16.5°-17.5° BTDC	0.077-0.086 inch BTDC (1.95-2.19mm BTDC)

NOTE: When a shim is NOT required, use liquid packing to assemble the injection pump.

6. Assemble the DELIVERY VALVE (IN).

DELIVERY HOLDER TIGHTENING TORQUE
29-33 Ft.-Lbs. (4.0-4.5 m-kg)

NOTE: Injection timing shims are available in the following sizes: (a) 0.2mm (0.008 inch), (b) 0.3mm (0.012 inch), (c) 0.5mm (0.020 inch), (d) 1.0 mm (0.040 inch).

IMPORTANT: Disassembly and repair of the fuel injection pump should be attempted only at an authorized fuel injection pump repair facility.

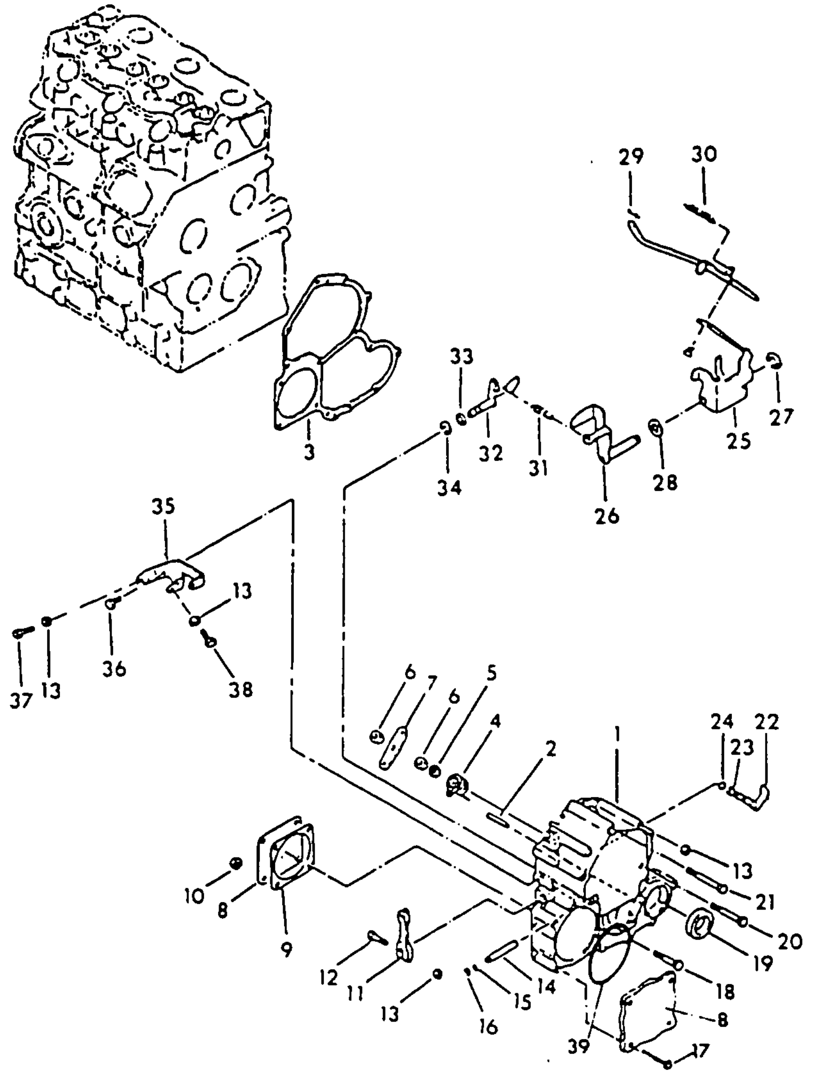


Figure 3. Timing Gear Case and Governor

ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	Timing Gear Case	25	Snap Ring
2	Spring Pin	26	Stay
3	Gasket	27	Bolt
4	Oil Seal	28	Bolt
6	Governor Lever Assembly	29	Arm Complete
7	Tension Lever Assembly	30	Snap Ring
9	Snap Ring	31	O-Ring
10	Washer	32	Spring
13	Snap Pin	33	Washer
14	Spring	34	Nut
15	Arm Complete	35	Stop Lever
16	O-Ring	40	Bolt
17	Snap Ring	41	Bolt
18	Governor Lever	42	Start Spring
19	Bolt	43	Cover
22	Nut	44	Gasket
23	Shaft		

Section 4.5

FUEL NOZZLES AND HOLDERS

General

Fuel, supplied by the injector pump, is delivered to the nozzle holder and to the nozzle body. When fuel pressure is sufficient to compress the spring, fuel is sprayed from the nozzle and into the combustion chamber.

1. Nut
2. Nozzle
3. Body
4. Shim
5. Spring
6. Rod
7. Piece
8. Nozzle Nut

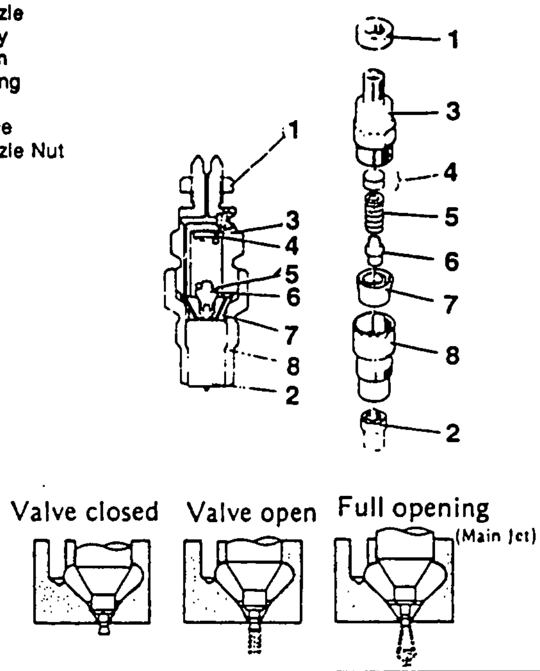


Figure 1. Injection Nozzle

Specifications

Needle Valve Diameter ....0.236 inch (6mm)
Pintle Diameter..........................0.039 inch (1mm)
Valve Opening Pressure ....1636-1778 psi
Adjusting Pressure ....1778-1849 psi
Spraying Angle ....12°

Check Injection Pressure

Use a nozzle tester to check injection pressure. Adjust the pressure at which fuel injection occurs by using shims, so that injection begins at 1707 psi (120 kg/cm^2).

NOTE: Injection pressure increases or decreases about 142.23 psi (10 kg/cm^2) for a shim 0.1mm (0.004 inch) thick.

Using the nozzle tester, check the spray pattern as follows:

- ☐ There should be no fuel droplets in the spray.
- ☐ The spray pattern should be a conical shape with respect to the nozzle axis.
- ☐ When sprayed at a distance of 11-12 inches (30cm) from a sheet of white paper, the spray pattern should be a conical shape.

Use the nozzle tester to increase nozzle pressure to 1422 psi (100 kg/cm^2). At that pressure there should be no leakage from the bozzle tip.

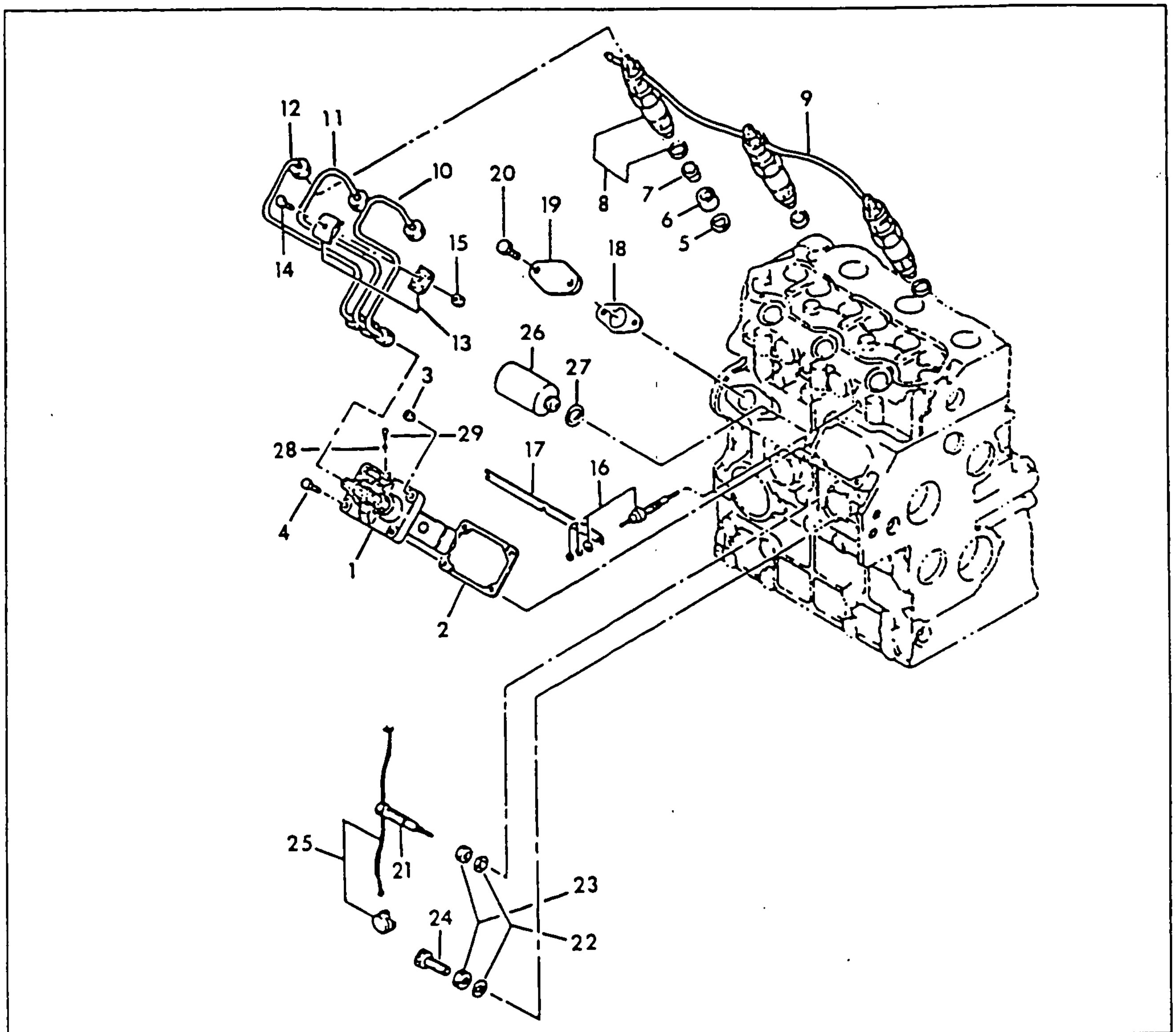


Figure 2. Fuel Injector Pump and Injectors

ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	Fuel Injector Pump	18	Bolt
2	Shim- 0.2mm	19	Nut
	Shim- 0.3mm	21	Glow Plug
	Shim- 0.5mm	22	Connector
	Shim- 1.0mm	23	Gasket
3	Nut	24	Cover
5	Bolt	25	Bolt
6	Gasket	26	Smoke Set Adjustment
7	Insert	28	Seal Washer
8	Cap	29	Nut
9	Injector Assembly	30	Bolt
10	Return Pipe	31	Lock Wire
14	Injection Pipe	32	Solenoid
15	Injection Pipe	33	Seal Washer
16	Injection Pipe	37	Seal Washer
17	Clamp	38	Screw

Part 5 ENGINE ELECTRICAL SYSTEM

NP and IM Series

RECREATIONAL VEHICLE & INDUSTRIAL MOBILE AC GENERATORS

Liquid-Cooled Diesel Engine Models

TABLE OF CONTENTS

*Use the "Troubleshooting Flow Charts" of Section 5.8 in conjunction with the "Troubleshooting Test Procedures" of Section 5.9. Test numbers assigned in Section 5.8 are identical to those used in Section 5.9.

Section 5.1
INTRODUCTION TO DC CONTROL SYSTEMS

General

Several different variations of the engine DC control system have been employed on the NP and IM series generators. These variations depend on (a) the date the engine control circuit board was manufactured, and (b) the type of starter used to crank the engine. To avoid confusion between these system variations, this manual arbitrarily identifies the DC control system as Type 1, Type 2 or Type 3.

TYPE 1 DC CONTROL SYSTEM:

The Type 1 DC control system applies to units having an earlier production engine control circuit board. These early circuit boards required that a crank relay (CR1) and a run relay (CR2) be employed to deliver operating power to the board during cranking and running, and to open the power circuit to the board for shutdown. Only the Type 1 system employs Relays CR1 and CR2.

The engine starter (Part No. 70954) used on these units is NOT equipped with a pull-in type starter solenoid. A starter contactor (SC) is used to deliver cranking current to the starter motor.

TYPE 2 DC CONTROL SYSTEM:

Type 2 DC control systems utilize an improved engine control circuit board. The crank (CR1) and run (CR2) relays that were used in Type 1 systems are not required, since the circuit board has taken over the function of the relays.

Like the Type1 systems, the engine starter (Part No. 70954) is NOT equipped with a pull-in type starter solenoid. A starter contactor (SC) is used to deliver cranking current to the starter motor.

TYPE 3 DC CONTROL SYSTEM:

The same improved engine control circuit board that is used on Type 2 systems is used on the Type 3 system. Crank relay (CR1) and run relay (CR2) are not used.

The engine starter on Type 3 units IS equipped with a pull-in type starter solenoid. A single starter relay (SR) is employed to energize the starter-mounted solenoid and initiate cranking.

Engine Control Circuit Board

The engine control circuit board is the electronic control center for engine cranking, starting, running and shutdown operations. The circuit board is housed in the generator control panel. Two terminal strips are provided on the board, with terminals numbered from 1 through 12. See Figure 1.

The circuit board is powered by 12 volts DC from the unit battery. Functions of the various terminals are listed in the following chart.

TERMINAL	WIRE	FUNCTION OF CIRCUIT
1	15B	Fused battery voltage (+)
2	0	Battery negative (grounded) side of power supply circuit
3	17, 17A	Start circuit, initiates startup when start/stop switch is set to "Start"
4	18	Shutdown circuit, initiates shutdown when start/stop switch is set to "Stop"
5	11	Engine speed (frequency) signal for overspeed shutdown
6	22	Engine speed (frequency) signal for overspeed shutdown
7	56	Engine cranking circuit
8	9	DC voltage to field boost
9	14	Engine run circuit is energized when engine is running
10	14	Same as Terminal 9
11	14	Same as Terminal 9
12	85	Provides automatic shutdown when circuit is grounded by closure of low oil pressure switch or high coolant temperature switch

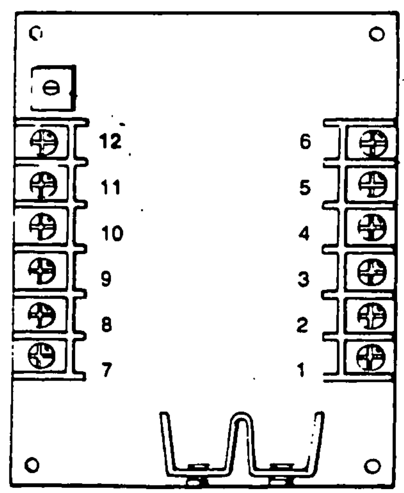


Figure 1. Engine DC Control Circuit Board

Operating Diagram- Type 1 DC Control System

See Figure 2, below. Operation of the Type 1 DC control system may be briefly described as follows:

ENGINE SHUT DOWN:

1. Battery voltage is available to the normally-open contacts of the starter contactor (SC), via Wire 13. However, SC is de-energized and the circuit is open.
2. Battery voltage is available to the normally-open contacts of crank relay (CR1) and run relay (CR2), via Wire 13, circuit breaker (CB3), and Wire 15. With CR1 and CR2 de-energized, the circuit is held open.

CRANKING:

Setting the start/stop switch to "Start" closes the Wire 17 and CR1 circuit to ground. Crank relay (CR1) energizes and its contacts close to initiate the following:

a. Battery voltage is delivered to Terminal 1 of the engine control circuit board, to turn the circuit board on.
b. Wire 17A from circuit board Terminal 3 is connected to ground. Circuit board action then delivers a DC voltage to the starter contactor (SC) coil, via Wire 56. SC energizes, its contacts close, and battery power is delivered to the starter (S) via Wire 16. The engine cranks.
c. Circuit board action delivers a DC voltage to Wires 14. Run relay (CR2) energizes. An hourmeter is turned on. A fuel pump (FP) and a fuel solenoid (FS) are energized by Wire 14 power and the engine starts.

RUNNING:

On startup, the start/stop switch is released. This opens the CR1 circuit and that relay de-energizes to terminate cranking. Relay CR2 remains energizes to sustain operation.

SHUTDOWN:

Setting the start/stop switch to "Stop" closes the Wire 18 circuit to ground. Circuit board action then opens the DC circuit to Wire 14. The fuel solenoid (FS) closes and the fuel pump (FP) shuts down. Fuel flow is terminated and engine shutdown occurs.

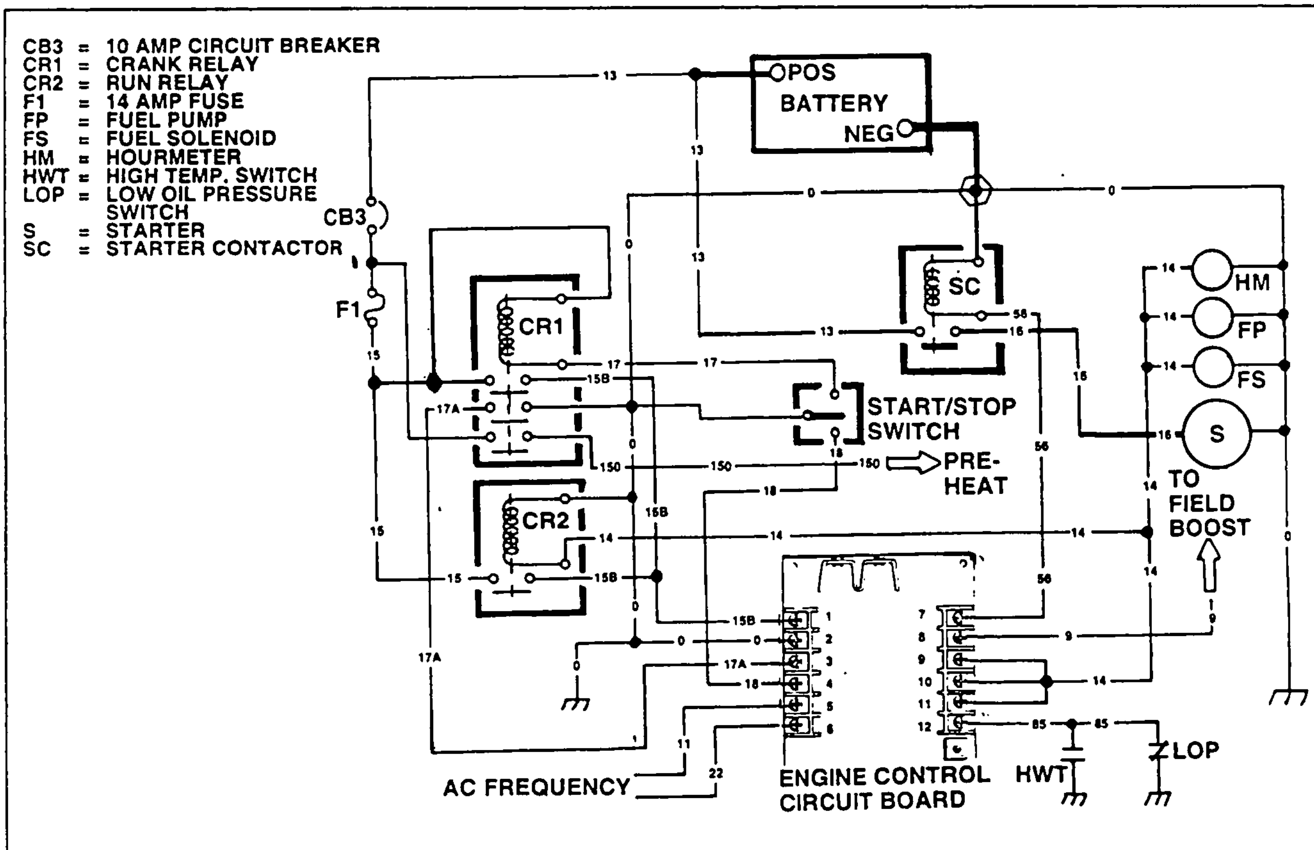


Figure 2. Operating Diagram- Type 1 DC Control System

Operating Diagram- Type 2 DC Control System

Operation of the Type 2 DC control system may be briefly described as follows:

SHUT DOWN:

Battery voltage is available to the engine control circuit board via Wire 13, a 10 amp circuit breaker (CB3), a 14 amp fuse (F1), and Wire 15. However, circuit board action holds this power circuit open.

CRANKING:

When the start/stop switch is set to "Start", Wire 17 from Terminal 3 of the circuit board is connected to ground. The circuit board responds by initiating the following actions:

- ☐ The circuit board delivers battery voltage through the starter contactor coil and to ground, via Wires 56 and 0. The starter contactor energizes, its contacts close, and battery voltage is delivered to the starter (S). The engine cranks.
- ☐ Circuit board action delivers battery voltage to the Wire 14 circuit, and to the hourmeter (HM), the fuel pump (FP), and the fuel solenoid (FS). The hourmeter runs. Fuel is delivered to the diesel fuel system and the engine can start and run.
- ☐ Battery voltage is delivered to the field boost circuit, via Wire 9.

RUNNING:

- ☐ When the engine starts, the start/stop switch is released, to open the Wire 17 circuit.
- ☐ Circuit board action opens the Wire 56 circuit and cranking ends.
- ☐ Circuit board keeps the Wire 14 circuit open. The fuel solenoid (FS) and fuel pump (FP) remain energized and the engine continues to run.

SHUTDOWN:

Setting the start/stop switch to "Stop" connects the Wire 18 circuit to ground. Circuit board action then opens the Wire 14 circuit. The fuel pump (FP) and fuel solenoid (FS) de-energize and engine shuts down.

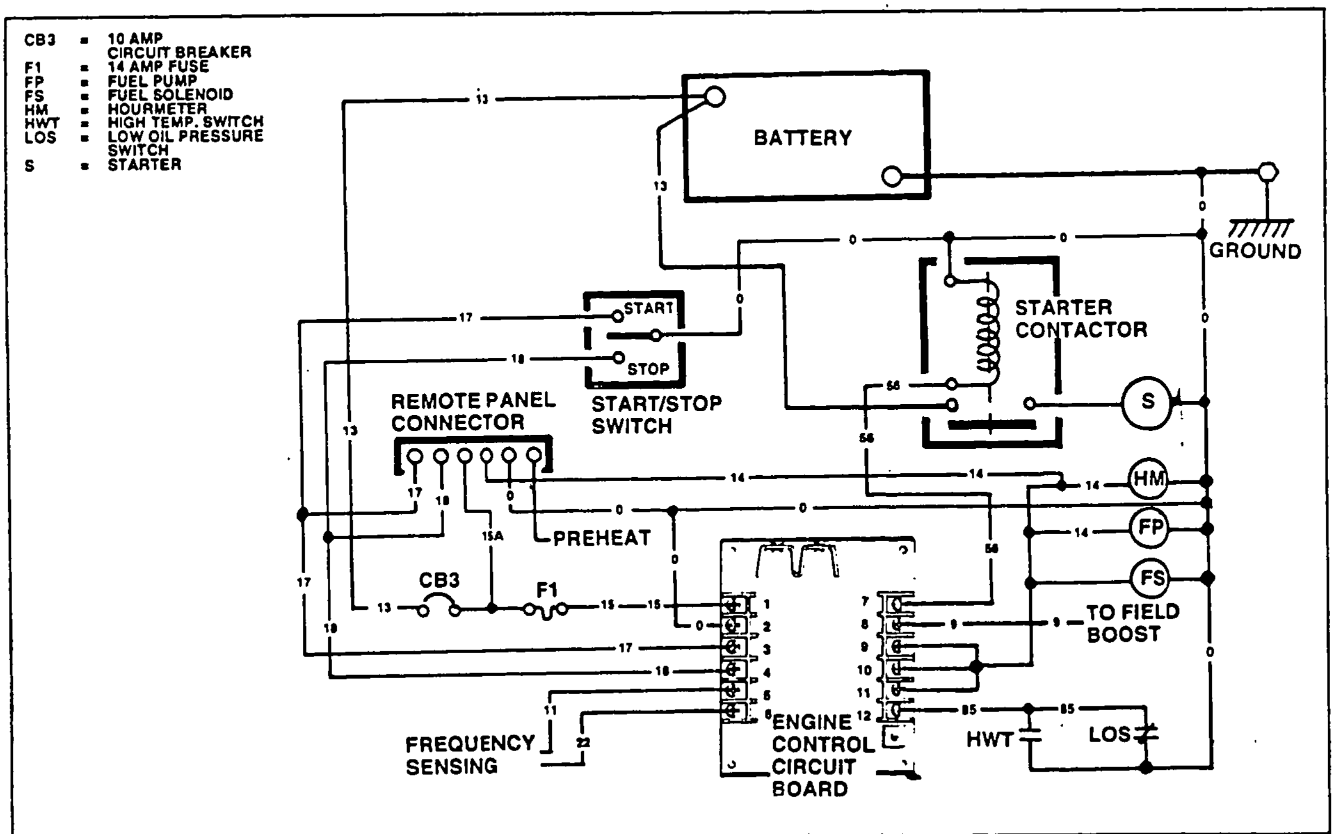


Figure 3. Operating Diagram- Type 2 DC Control System

Operating Diagram- Type 3 DC Control System

Operation of the Type 3 DC control system may be briefly described as follows:

SHUT DOWN:

Battery voltage is available to the starter relay and to Terminal #1 of the engine control circuit board, via Wire 13, 10 amp circuit breaker (CB3), 14 amp fuse (F1), and Wire 15. However, the starter relay is de-energized and its contacts are open. Engine control circuit board action also holds the circuit open.

CRANKING:

When the start/stop switch is set to its "Start" position, the following occur:

- ☐ Wire 17, from Terminal #3 of the circuit board, is connected to ground via the start/stop switch.
- ☐ Circuit board action delivers DC voltage to the starter relay actuating coil, via circuit board Terminal #7, Wire 56. The starter relay then energizes and its contacts close.
- ☐ On closure of the starter relay contacts, DC power is delivered to the starter solenoid. The solenoid energizes and the starter cranks the engine.
- ☐ Engine control board action delivers DC voltage to Terminal #8 and to the generator's field boost circuit, via Wire 4A.
- ☐ Circuit board action delivers DC power to (a) a fuel solenoid (FS); (b) a fuel pump (FP); and an hourmeter (HM). These devices turn on to deliver fuel to the engine and the engine starts.

RUNNING:

On engine startup, the start/stop switch is released. Circuit board action then terminates the DC current to the starter relay coil and cranking ends. Circuit board action continues to deliver DC voltage to the Wires 14 circuits and the engine continues to run.

SHUTDOWN:

When the start/stop switch is set to its "Stop" position, Wire 18 and circuit board Terminal #4 are connected to ground through the switch. Circuit board action then opens the circuits to Wires 14. The fuel pump (FP) and the fuel solenoid (FS) de-energize, fuel flow stops, and the engine shuts down. The hourmeter (HM) shuts down, as well.

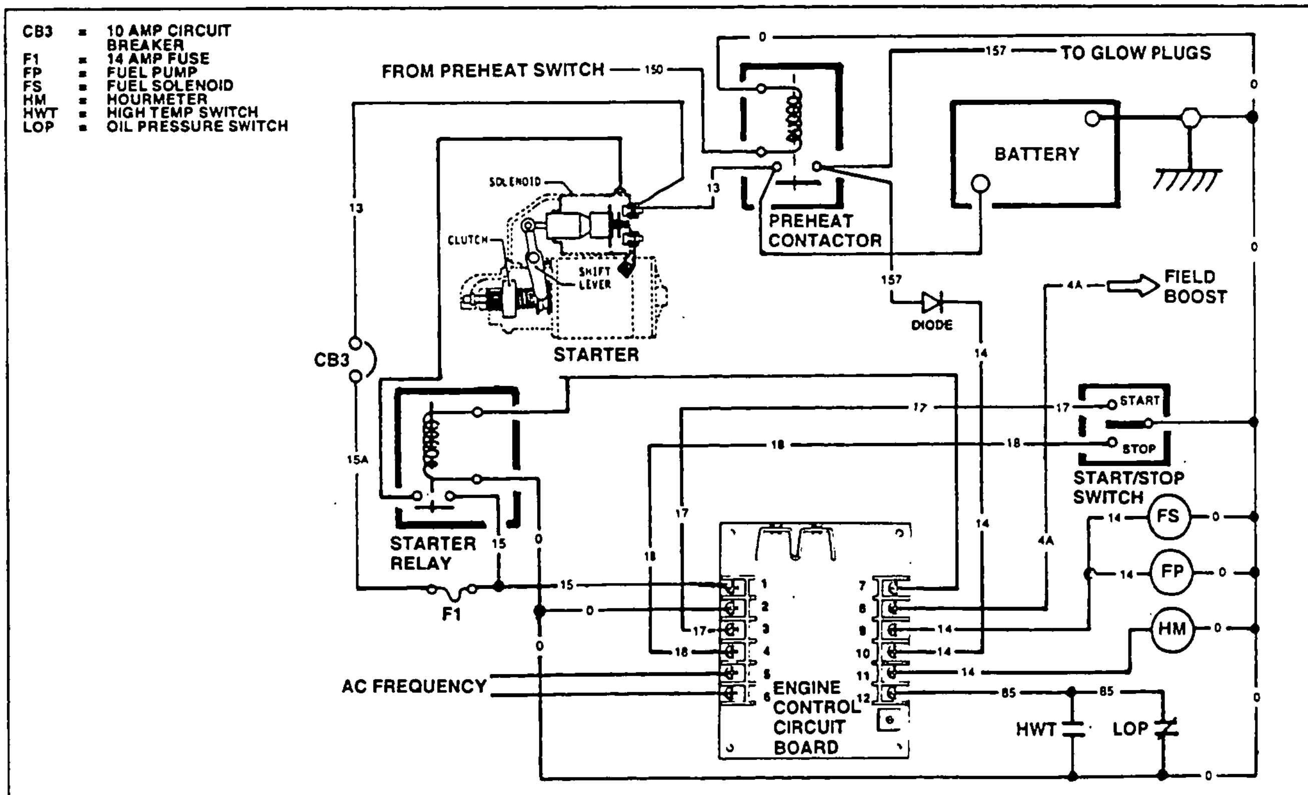


Figure 4. Operating Diagram- Type 3 DC Control System

Section 5.2
ENGINE CRANKING SYSTEM

Introduction

As explained in Section 5.1, the generator may incorporate any one of several different DC control systems. These systems were arbitrarily designated as Type 1, Type 2 or Type 3. The engine cranking system is a part of the DC control system. Each designated type will be discussed separately in this section. You may wish to familiarize yourself with the operation of each type by reading Section 5.1, "Introduction to DC Control Systems".

Type 1 Engine Cranking System

GENERAL:

The Type 1 engine cranking system was used in conjunction with early production engine control circuit boards. The system incorporates a crank relay (CR1) which, when energized by setting the start/stop switch to "Start", delivers battery voltage to the engine control circuit board. The energized circuit board then delivers battery voltage to a starter contactor (SC) coil (via a Wire 56 circuit). The starter contactor's normally-open contacts close to deliver battery power directly to a starter motor and the engine cranks.

COMPONENTS:

The following components are part of the Type 1 engine cranking system:

- ☐The 12 volts battery.
- ☐10 amp circuit breaker (CB3).
- ☐14 amp fuse (F1).
- ☐Crank Relay (CR1).
- ☐Engine Control circuit board.
- ☐Start/Stop switch.
- ☐Starter contactor (SC).
- ☐Starter (S).
- ☐Interconnecting wires.

THE BATTERY:

Recommended Battery: The battery used should be selected based on the following criteria:

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

2. When ambient temperature is below 32° F. (0° C.), use a 12 volts storage battery rated 95 amp-hours and having a cold cranking capacity of 450 amperes.

Battery Cables: Use of battery cables that are either too long or too small in diameter will result in excessive voltage drop. For best cold weather starting, voltage drop between the battery and the starter should not exceed 0.12 volts per 100 amperes of cranking current. Select the cables based on its length as recommended in the following chart:

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

** Distance from battery post to connection point on generator.*

Performing a Battery Capacity Test: The battery can be tested using a capacity tester, as shown in Figure 1. To test the battery, proceed as follows:

1. With the battery connected to tester as shown,. turn the load knob until a current draw equal to three (3) times the battery rating is selected. For example, if the battery is rated 70 amp-hours, set the load to 210 amps.

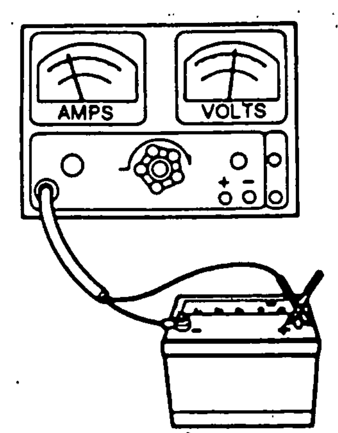


Figure 1. Battery Capacity Test

Type 1 Engine Cranking System (Continued)

THE BATTERY (CONT'D):

2. Hold the current draw for 15 seconds. Then, observe battery voltage. If the voltage remains at 9.6 volts or more, the battery is good. If battery voltage drops below 9.6, go to Step 3.
3. Connect the battery to a charger and set the charger to its fast charge rate. DO NOT EXCEED 40 AMPS. After three (3) minutes, check the voltmeter reading. If reading is greater than 16.5 volts, replace the battery.

If desired, the battery can be tested using an automotive type battery hydrometer. Check the battery for both (a) state of charge and (b) condition, as follows:

1. Follow the hydrometer manufacturer's instructions carefully. Draw a sample of the battery fluid from each battery cell, one cell at a time. Read the specific gravity of the fluid, then return the fluid to the cell from which it was drawn. As the specific gravity reading of the fluid from each cell is taken, write the reading down.
2. If the hydrometer being used does not have a "Percentage of Charge scale, compare the readings with the following:

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

3. If necessary, remove the battery and recharge it to a 100% state of charge.
4. If the difference in specific gravity between the highest and lowest reading cell is 0.050 (50 points) or more, the battery is nearing the end of its useful life and should be replaced.
5. If the highest reading obtained is less than 1.200, recharge the battery then retest specific gravity. If the difference between the highest and lowest reading is still more than 0.050 (50 points), replace the battery.

10 AMP CIRCUIT BREAKER (CB3):

General: The 10 amp circuit breaker (CB3) is physically mounted on the generator control panel. It is electrically connected in series with the battery power supply to the engine control circuit board. Should the circuit breaker trip open due to an overload, or if it is set to its OFF or OPEN position, engine cranking and startup cannot occur. In addition, the preheat function will not be possible when the breaker has opened.

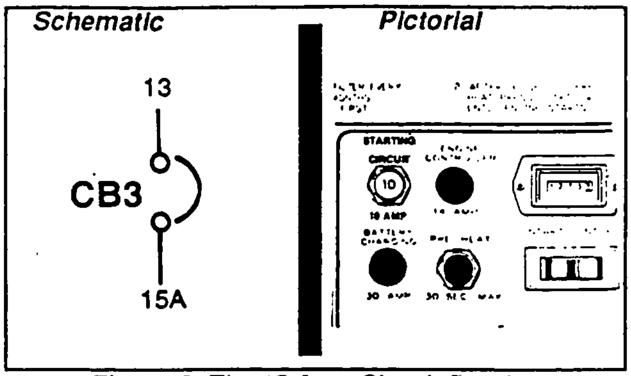


Figure 2. The 10 Amp Circuit Breaker

14 AMP FUSE:

Should the fuse element melt open due to an overload, engine cranking and startup will not be possible. If the fuse must be replaced, use only an identical 14 amp replacement fuse.

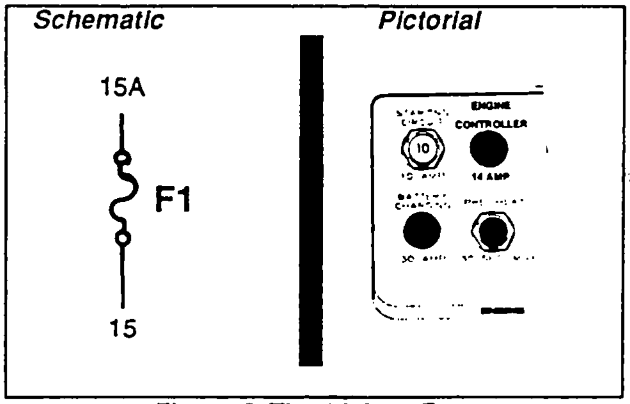


Figure 3. The 14 Amp Fuse

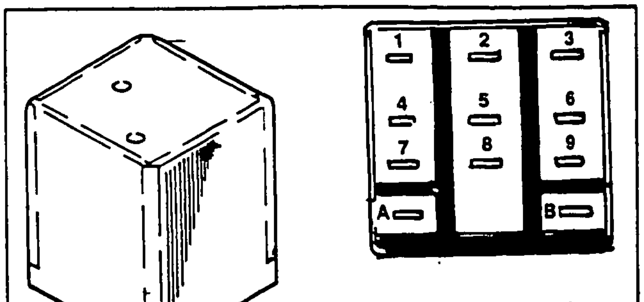
CRANK RELAY (CR1):

The crank relay (CR1) is energized by battery voltage when the start/stop switch is set to its "Start" position. When energized, the relay's normally-open contacts close to perform the following functions:

- ☐Deliver 12 volts DC to the engine control circuit board, for board operation while cranking.
- ☐Connect Terminal 3 of the engine control circuit board and Wire 17A to ground. The circuit board then responds by energizing a starter contactor to initiate engine cranking.
- ☐Deliver 12 volts DC to the engine preheat circuit.

Type 1 Engine Cranking System (Continued)

CRANK RELAY CR1 (CONT'D):



CONNECT WIRE NO.	TO TERMINAL
15	A
17	B
15B	4
150	5
17A	6
15	7
15A	8
0	9

Figure 4. Crank Relay (CR1)

ENGINE CONTROL CIRCUIT BOARD:

See "Engine Control Circuit Board" in Section 5.1 (Page 5.1-1). Type 1 systems utilized an early production circuit board which required an externally mounted crank relay (CR1) and run relay (CR2) for starting and running operations.

START/STOP SWITCH:

When set to "Start", the switch connects Wire 17 to frame ground. This energizes the crank relay (CR1) and initiates engine cranking.

When set to "Stop", the switch connects a Wire 18 circuit to ground and initiates engine shutdown.

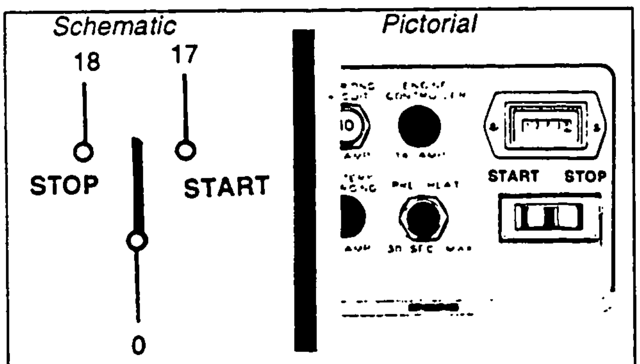


Figure 5. The Start/Stop Switch

STARTER CONTACTOR (SC):

When energized by battery voltage from the engine control circuit board (Wire 56), the starter contactor's normally-open contacts close to deliver full battery power to the starter motor. The engine is then cranked. The automotive type starter contactor is equipped with heavy duty contacts able to withstand high current.

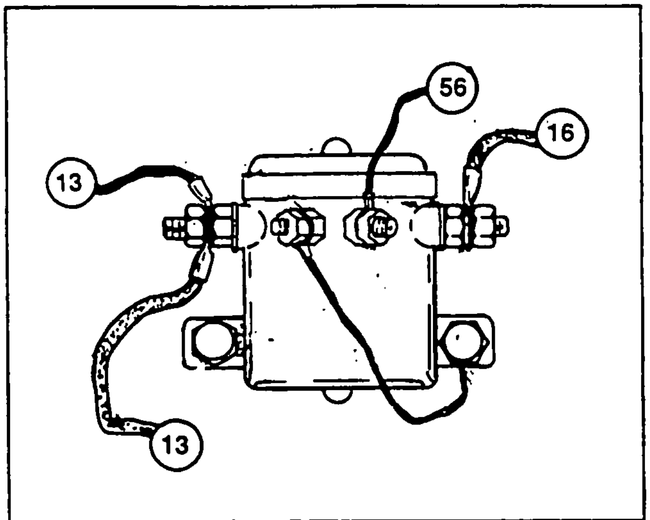


Figure 6. Starter Contactor (SC)

THE STARTER:

General: The Type 1 and 2 engine starter assembly is shown in Figure 7 on next page. The motor is rated 12 volts DC. Never exceed this rated voltage or magnets in the starter may become demagnetized.

Starter Performance Test: Starter performance can be tested using a fully charged 12 volts battery. Use a No. 10 (or larger) cable that is not more than 6 feet long. Connect the battery positive (+) post to the starter motor input stud; connect the battery negative (-) terminal to the starter motor housing. Maximum current draw and starter speed should be as follows:

32 amperes at 5600-7100 rpm

CAUTION: DO NOT operate the starter motor continuously for longer than about 30 seconds when testing.

Inspection: Check for excessive wear on all bearings, gears, shafts, etc. Check the spring washer for wear. Convex side of the spring washer should be next to the bearing. Add a drop of oil to the face of the bearing.

Thru-Bolts: Tighten thru-bolts to 75 inch-pounds of torque.

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.

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

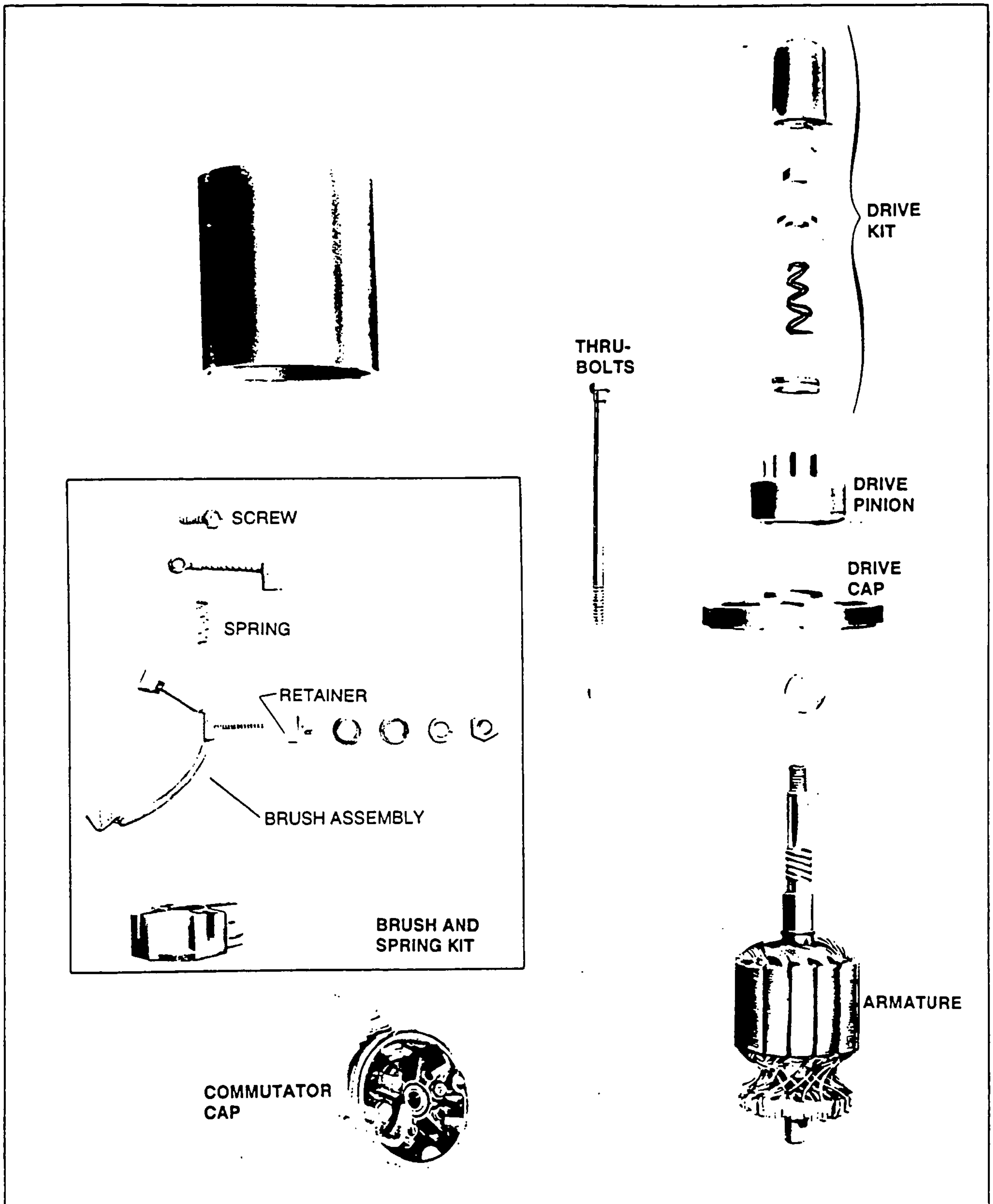


Figure 7. Starter Motor for Types 1 and 2 DC Control Systems

Type 1 Engine Cranking System (Continued)

THE STARTER (CONT'D):

Brush Assembly: Replace brushes and brush springs at every overhaul. Replace any brush that is (a) worn to 5/16 inch (or less) as measured on the short side of the brush; or (b) that has been in contact with grease, oil or cleaning fluid. When assembling brushes, place 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.

Type 2 Engine Cranking System

GENERAL:

Type 2 cranking systems employ a later production engine control circuit board. This circuit board has taken over the functions of a crank relay (CR1) and a run relay (CR2) that were required on Type 1 systems. The same starter motor is used on Type 2 systems that was used on Type 1 systems. Circuit operation is discussed and illustrated on Page 5.1-3 (Figure 3).

MAJOR COMPONENTS:

Major parts of the Type 2 engine cranking system include the following:

- ☐ 12 volts Battery.
- ☐ 10 amp circuit breaker (CB3).
- ☐ 14 amp fuse (F1).
- ☐ Engine Control circuit board.
- ☐ Start/stop switch.
- ☐ Starter contactor.
- ☐ Starter motor.

Crank relay (CR1) and run relay (CR2) are not required on Type 2 systems, since the circuit board has taken over their functions. Other system components are the same as on Type 1 systems.

Type 3 Engine Cranking System

GENERAL:

Type 3 DC control systems utilize the later production engine control circuit board and, for that reason, the externally mounted crank and run relays are not required. In addition, a pull-in type solenoid is an integral part of the starter. See "Operating Diagram- Type 3 DC Control System" on Page 5.1-4 (Figure 4).

MAJOR COMPONENTS:

Major components of the Type 3 cranking system are as follows:

- ☐ A 12 volts battery.
- ☐ Circuit Breaker (CB3) and fuse (F1).
- ☐ Engine control circuit board.
- ☐ Start/stop switch.
- ☐ Starter relay (SR).
- ☐ Starter.

NOTE: For information on the battery, circuit breaker, fuse and start/stop switch, refer to "Type 1 Engine Cranking System" (Pages 5.2-1 to 5.2-3). The engine control circuit board is briefly discussed in Section 5.1.

STARTER RELAY:

Battery voltage is always available to the normally-open contacts of the starter relay (SR). When the start/stop switch is set to "Start", Terminal 3 of the circuit board and Wire 17 are connected to ground. Circuit board action then delivers 12 volts DC to the starter relay (SR) coil, to energize the relay. The starter relay contacts close to deliver battery voltage to the starter solenoid on the starter. The solenoid energizes to (a) close the heavy duty solenoid contacts and (b) engage the starter with the engine flywheel by actuating the shift lever. With the heavy duty solenoid contacts closed, battery voltage is delivered directly to the starter motor and the engine is cranked.

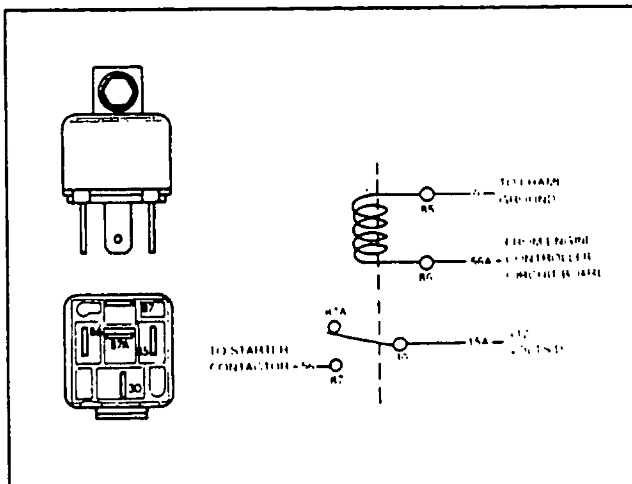


Figure 8. The Type 3 System Starter Relay

TYPE 3 STARTER ASSEMBLY:

An exploded view of the Type 3 starter assembloy is shown in Figure 9 on next page. The following apply:

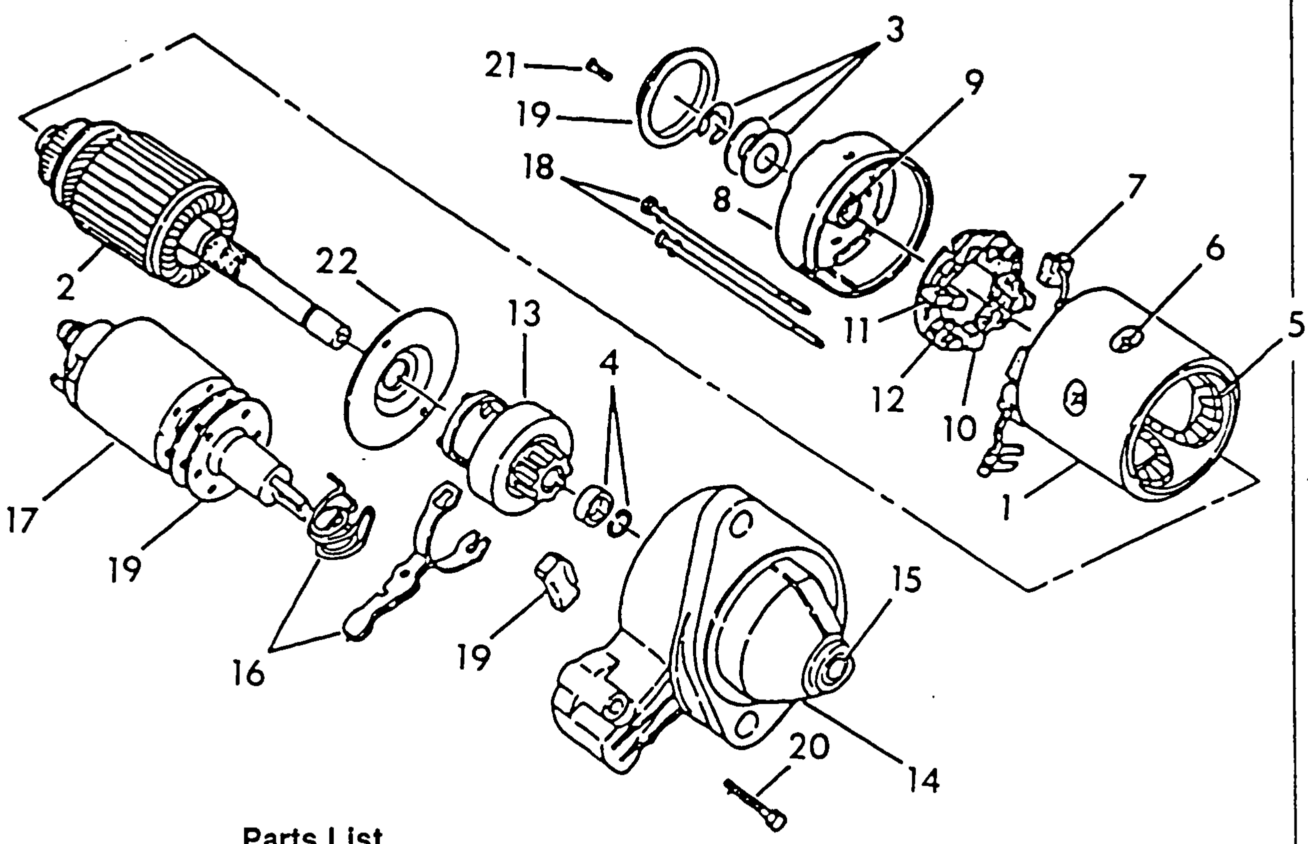
- ☐ Inspect for excessive wear on all bearings, gears, shafts, etc.
- ☐ Inspect the shift lever assembly for wear or damage, replace with new shift lever kit if necessary.
- ☐ Tighten thru-bolts to 75 inch-pounds.
- ☐ Replace brushes and brush springs at every overhaul. Replace any brush that is worn excessively or that has been in contact with grease, oil or cleaning fluid. Check that brushes ride properly on the armature when reassembling.
- ☐ Use a growler to check the armature for an open, shorted or grounded condition.

Type 3 Engine Cranking System (Continued)

TYPE 3 STARTER ASSEMBLY (CONT'D):

☐ Apply a thin film of non-conducting grease to commutator end of armature shaft and to portions of the shaft that contact the bearings.

To test starter operation, connect positive (+) post of a fully charged battery to the starter solenoid input stud (Wire 13 stud). Connect a jumper wire from the Wire 13 stud to the Wire 56 terminal. Solenoid should pull in and engine should crank.



Parts List

ITEM	QTY	DESCRIPTION
1	1	Starter Assembly
2	1	Armature
3	1	Thrust Washer Kit
4	1	Pinion Stopper Set
5	1	Field Coil Assembly
6	1	Pole Core Set Screw
7	1	Brush
8	1	Rear Cover Assembly
9	6	Bushing
10	6	Brush Holder Assembly
11	3	Brush
12	3	Brush Spring
13	2	Pinion
14	2	Gear Case Assembly
15	2	Bushing
16	1	Shift Lever Kit
17	3	Switch
18	3	Thru-Bolt
19	6	Dust Cover Kit
20	3	Bolt
21	3	Screw
22	6	Center Plate

Figure 9. Exploded View of Type 3 Starter Assembly

Section 5.3
BATTERY CHARGE SYSTEM

Components

See Figure 1, below. An engine driven ALTERNATOR delivers an AC output to the DC VOLTAGE REGULATOR. The REGULATOR senses battery voltage at its Terminal 5. The REGULATOR rectifies the ALTERNATOR output and regulates the direct current flow to the BATTERY.

The DC Alternator

A belt driven, permanent magnet type alternator is used. Alternator maintenance is limited to replacement of parts. The alternator is shown in Figure 3 on the next page. The alternator produces alternating current which is then rectified by the voltage regulator.

DC Voltage Regulator

The solid state voltage regulator (Figure 2) is housed in an aluminum heat sink. All parts are covered by an epoxy resin, making the unit non-repairable. Regulator connector pins are numbered from left to right as follows:

- ☐ Terminal 1: Charging output to battery (12.5-14.5 volts).
- ☐ Terminal 2: Wire 48, AC input from alternator.
- ☐ Terminal 3: Wire 49, AC input from alternator.
- ☐ Terminal 4: Not used (charging indicator lamp connection.
- ☐ Terminal 5: Wire 15, sensing input from battery.

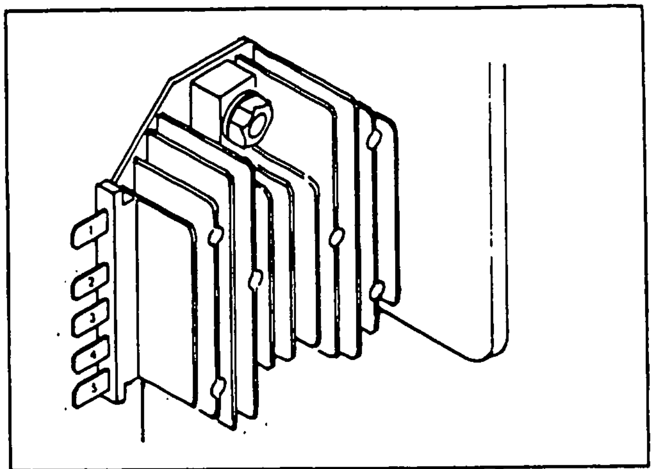


Figure 2. DC Voltage Regulator

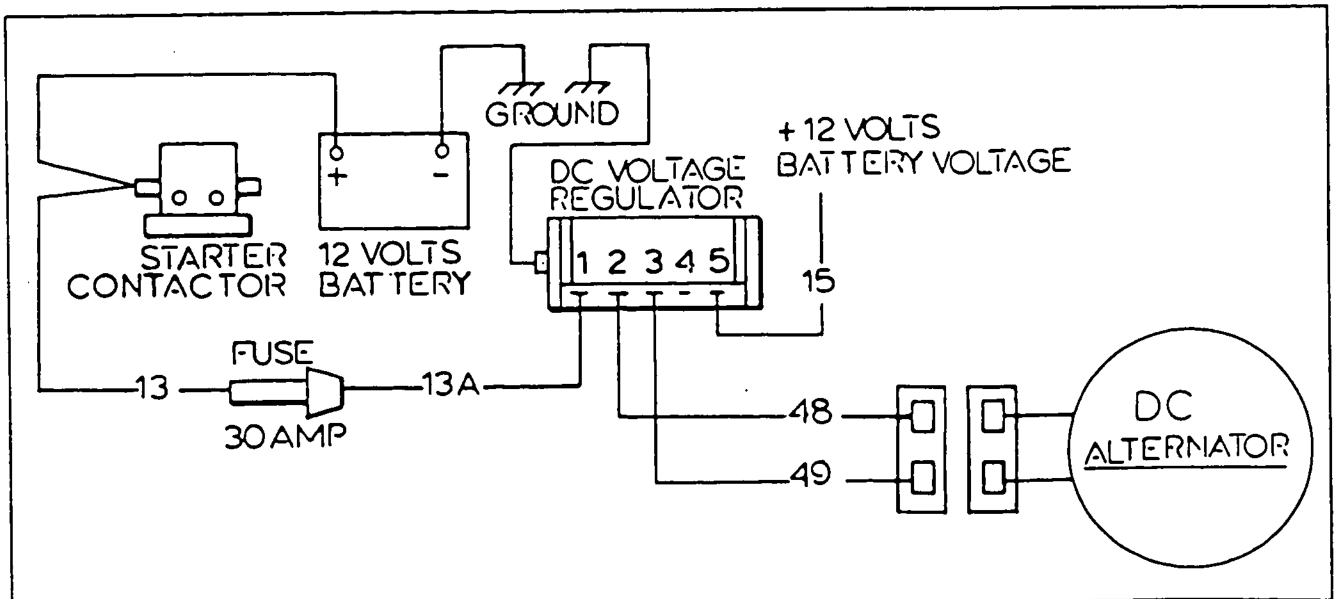


Figure 1. Battery Charge System Diagram

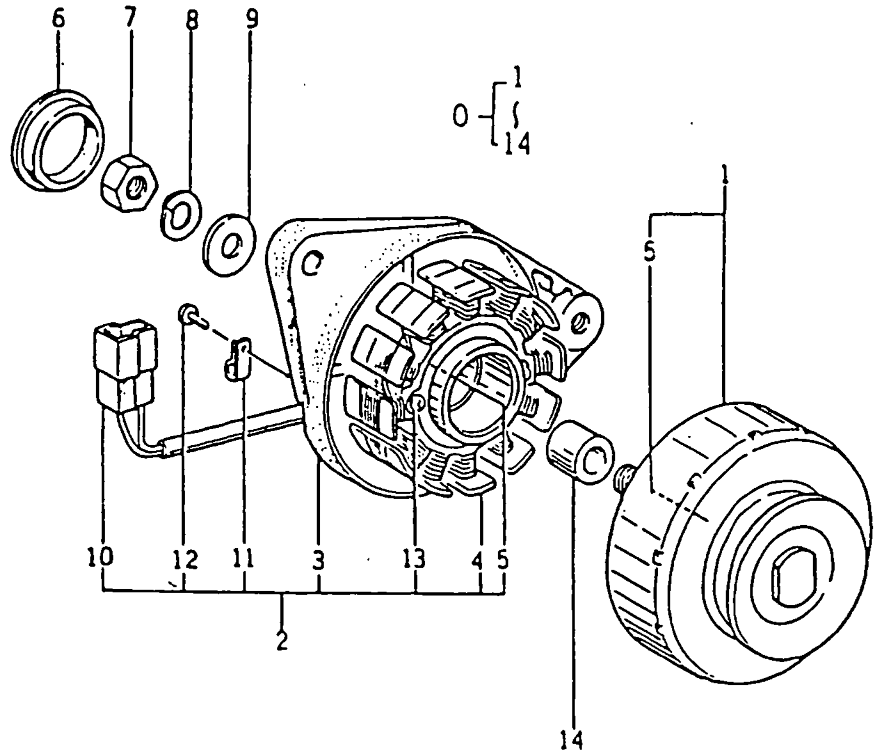


Figure 3. Exploded View of Battery Charge Alternator

Parts List for Figure 3

ITEM	QTY	DESCRIPTION
-----	1	Alternator Assembly
1	1	Flywheel- Complete
2	1	Plate- Complete
3	1	Plate
4	1	Stator- Complete
5	2	Bearing
6	1	Cap
7	1	Nut
8	1	Spring Washer
9	1	Washer
10	1	Coupler
11	1	Clamp
12	1	Screw
13	2	Screw
14	1	Collar

Section 5.4
PREHEAT SYSTEM

Introduction

The generator control panel mounts a PREHEAT switch. When actuated, this switch turns on a glow plug in each engine cylinder. The glow plug acts as a heating element to warm the engine combustion chambers and provide quicker, easier starts in cold weather.

To warm the engine combustion chambers and provide quicker cold weather startup, push the panel PREHEAT switch in and hold for about 15-30 seconds. DO NOT EXCEED 30 SECONDS PREHEAT TIME.

NOTE: A PREHEAT switch is also included on the optional remote-mounted start/stop panels. See Section 5.7 (Part 5, Section 5.7).

Units with Type 1 DC Control System

Units with a Type 1 DC control system are equipped with a crank relay (CR1) and a run relay (CR2). The crank relay (CR1) remains energized only while the start/stop switch is held at its "Start" position (engine cranking). On Type 1 units, the preheat function occurs when CR1 is energized and its normally-open contacts are closed.

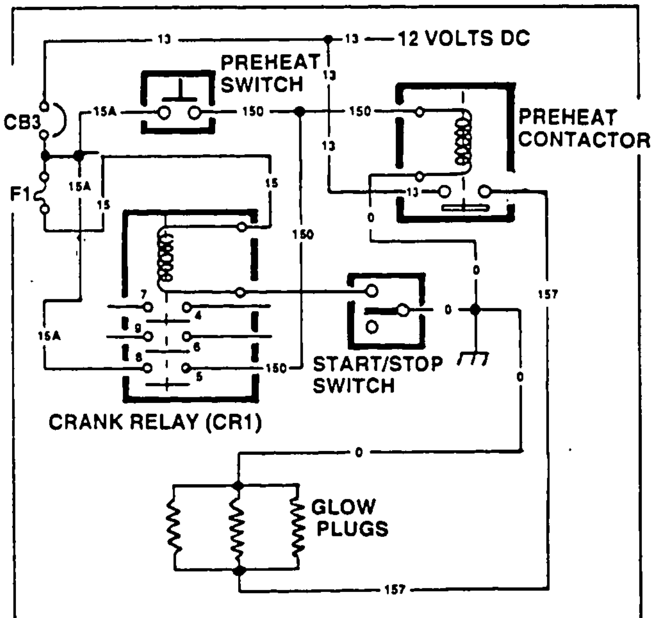


Figure 1. Preheat System- Type 1 DC Control

See Figure 1. Battery voltage is available to the preheat switch contacts. When the switch is closed, battery voltage is delivered to the preheat contactor coil. The coil energizes, the contacts close, and battery voltage is delivered to the glow plugs.

During cranking (CR1 energized), 12 volts DC is delivered across the closed CR1 contacts to the preheat contactor coil. Preheat occurs.

Units with Type 2 & 3 DC Control System

Figure 2 is an operating diagram of a typical preheat circuit on units with Type 2 and 3 DC control system. The preheat function will occur when the preheat contactor (PHC) is energized by actuating the preheat switch to its closed position.

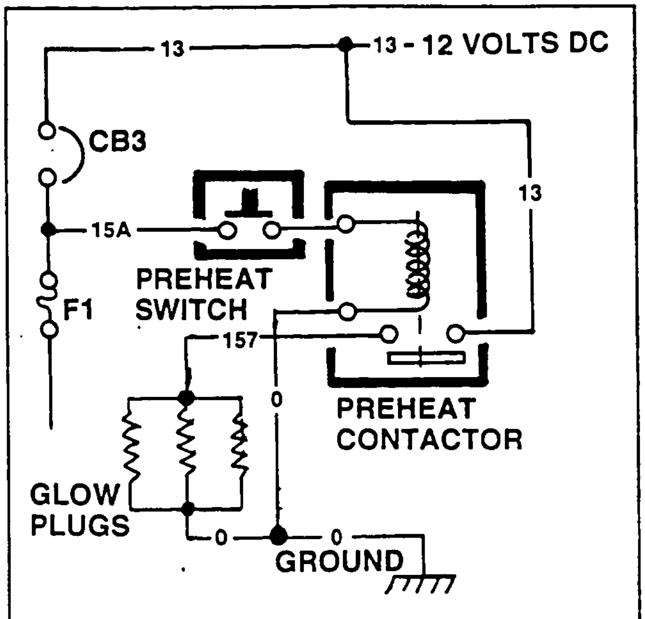


Figure 2. Preheat System- Type 2 & 3 DC Control

Glow Plug Construction

See Figure 3. A thin, coiled HEAT WIRE is encased in sintered magnesium oxide powder and enclosed by a stainless steel SHEATH. One end of the wire is welded to the SHEATH, the other end to the CENTER ELECTRODE. When voltage is applied to the HEAT WIRE, the wire is heated.

1. Heat Wire
2. Sheath
3. Asbestos
4. Body
5. Nut
6. Magnesium Oxide Powder
7. Insulating Bushing
8. Center Electrode

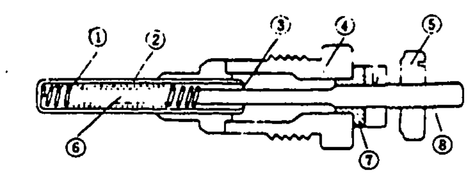


Figure 3. Glow Plug Construction

Glow Plug Testing

Glow plugs are connected in parallel. For that reason, if one plug fails open other plugs will continue to operate. However, loss of one plug will increase the possibility of the heat wire melting open in the remaining plugs.

To test each glow plug, remove the connector. Check each glow plug for continuity between the plug terminal and metal. If continuity is indicated, replace the glow plug.

Section 5.5
ENGINE PROTECTIVE DEVICES

General

The engine will shut down automatically in the event of any one or more of the following occurences:

- ☐ Low oil pressure.
- ☐ High engine coolant temperature.
- ☐ Engine overspeed.

System Operation

The engine mounts both a low oil pressure switch and a high coolant temperature switch. Both switches are connected to Terminal 12 of the engine control circuit board, via Wire 85. Either a low oil pressure condition or a high coolant temperature condition will cause Wire 85 and Terminal 12 to be connected to frame ground. Circuit board action will then initiate engine shutdown.

AC frequency signals are delivered to the engine control circuit board Terminals 5 and 6, via Wires 11 and 22. Should frequency exceed approximately 69-71 Hertz (2070-2130 rpm), an engine shutdown will occur after about four (4) seconds.

Low Oil Pressure Switch

DESCRIPTION:

The switch is normally-closed, but is held open by engine oil pressure during cranking and running. Switch contacts closure will occur when oil pressure drops below approximately 10-11 psi.

TESTING THE SWITCH:

With engine shut down, disconnect Wire 85 from the switch terminal. Set a VOM to its "Rx1" scale and zero the meter. Connect one VOM test probe to the switch terminal, the other test probe to a clean frame ground. The VOM needle indicate "continuity".

Now, start the engine. Again, connect the VOM test probes across the switch terminal and ground. The meter should read "infinity".

With the engine running at no-load condition, connect the terminal end of Wire 85 to a clean frame ground. The engine should shut down.

High Coolant Temperature Switch

DESCRIPTION:

This normally-open thermostatic switch has a sensing tip which is immersed in engine coolant. Should coolant temperature exceed approximately 245°-266° F. the switch contacts will close to ground Terminal 12 of the circuit board. Circuit board action will then effect an engine shutdown.

TESTING THE SWITCH:

To test the high coolant temperature switch, proceed as follows:

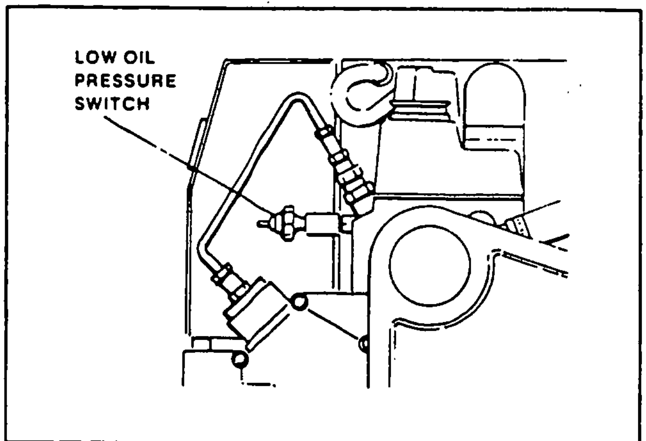


Figure 1. Low Oil Pressure Switch

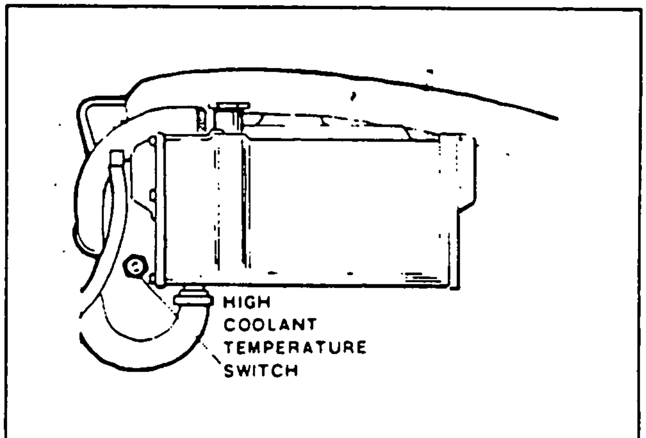


Figure 2. High Coolant Temperature Switch

1. **With Switch Installed:** With engine shut down, disconnect wire from switch terminal. Connect a VOM to the switch terminal and to frame ground. The meter should read "infinity". Any reading other than "infinity" is cause for switch replacement.
2. **Testing with Switch Removed:** Disconnect Wire 85, remove the switch and test as follows (see Figure 3):
   a. Immerse the switch in a 50-50 mixture of ethylene glycol base anti-freeze and water as shown.
   b. Set a VOM to its "Rx1" scale and zero the meter.
   c. Connect one VOM test probe to the switch wire terminal, the other test probe to the switch body. The meter should read "infinity".
   d. Place an accurate thermometer into the fluid mixture.
   e. Heat the fluid. At approximately 245°-266° F., the switch contacts should close anf the meter should read "continuity".
   f. With meter still connected, allow fluid to cool.

g. As the fluid temperature drops below about 245°-266° F., the switch contacts should open and the meter should indicate "infinity".

Replace the high temperature switch if it fails the test.

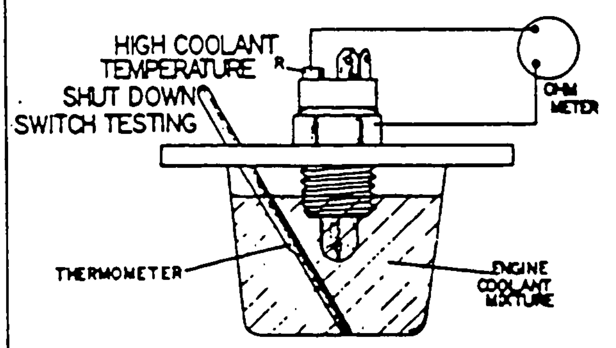


Figure 3. Testing Coolant Temperature Switch

Overspeed Protection

General: Generator AC frequency signals are delivered to Terminals 5 and 6 of the engine control circuit board, via Wires 11 and 22. Should engine-generator speed exceed approximately 69-71 Hertz (2070-2130 rpm), and should such an overspeed last longer than about four (4) seconds, circuit board action will cause an engine shutdown.

Testing Overspeed Shutdown: To test overspeed shutdown operation proceed as follows:

1. Connect an accurate AC frequency meter to Terminals 5 and 6 of the engine control circuit board (Wires 11 and 22).
2. Start the engine, let it stabilize and warm up. **DO NOT CONNECT ANY ELECTRICAL LOADS DURING THE TEST.**
3. Slowly increase engine speed until the frequency meter reads about 69 Hertz. Then, slowly increase speed to just slightly more than 71 Hertz. After a four (4) second delay, the engine should shut down.

Adjusting Overspeed Shutdown: To adjust the overspeed setting at which engine shutdown occurs, proceed as follows:

1. See Figure 4. Turn the OVERSPEED SHUTDOWN POTENTIOMETER all the way clockwise against its stop. DO NOT FORCE.
2. Start the engine, let it stabilize and warm up at no-load.
3. Connect an AC frequency meter across circuit board terminals 5 and 6 (Wires 11 and 22).
4. SLOWLY increase engine speed until the frequency meter reads about 70 Hertz. Hold that setting, then SLOWLY turn the OVERSPEED SHUTDOWN POTENTIOMETER counterclockwise (CCW) IN VERY SMALL INCREMENTS. Wait about four (4) seconds between each incremental adjustment. When engine shuts down, overspeed shutdown setting is correct.

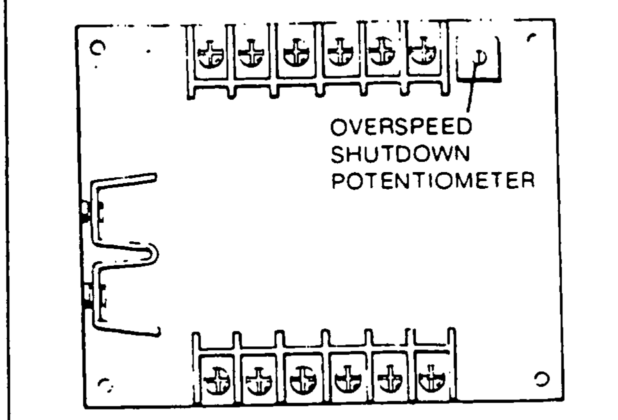


Figure 4. Engine Control Circuit Board

Section 5.6
REMOTE RADIATOR FAN

Introduction

Some NP series generators are not equipped with a unit-mounted radiator. The radiator on these units is mounted at a remote location in the vehicle that houses the generator. Generator models requiring a remote-mounted radiator, such as Model 9319, incorporate the following into their electrical system:

- ☐ An electrically operated RADIATOR FAN (RF), along with a temperature sensor switch (TS).
- ☐ A squirrel cage COMPARTMENT FAN (CPF) which draws cooling and ventilating air through the compartment that houses the generator.

Compartment Fan

The compartment fan must be properly located during installation so that, when running, it will draw cooling and ventilating air through the generator compartment and expel the air to the outdoors. The fan is required since an engine-driven cooling fan is not provided.

The 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.

The Remote Radiator Assembly

COMPONENTS:

Major components of the remote radiator and fan assembly include (a) the radiator, (b) the fan, (c) a thermostatic switch, (d) mounting hardware, and (e) wiring harnesses. See Figure 3 on next page.

Figure 2 (below) is an operating diagram of the remote radiator assembly.

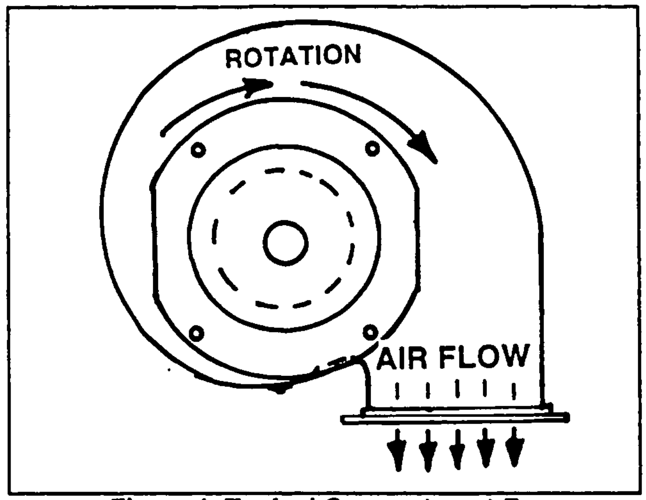


Figure 1. Typical Compartment Fan

OPERATION:

See Figure 2. 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, fan relay normally-open contacts are open and the fan is not running. On cranking and startup, the engine control circuit board delivers 12 volts DC to the thermostatic switch (TS) via Wire 14, the relay coil, and Wire 243. Coolant temperature is below 180° F. and the thermostatic switch contacts are open. When coolant temperature rises above 180° F., the switch contacts close and Wire 243 is grounded. The relay (SR) energizes, its normally-open contacts close, and DC voltage is delivered to the fan (RF) via Wire 244. The fan runs.

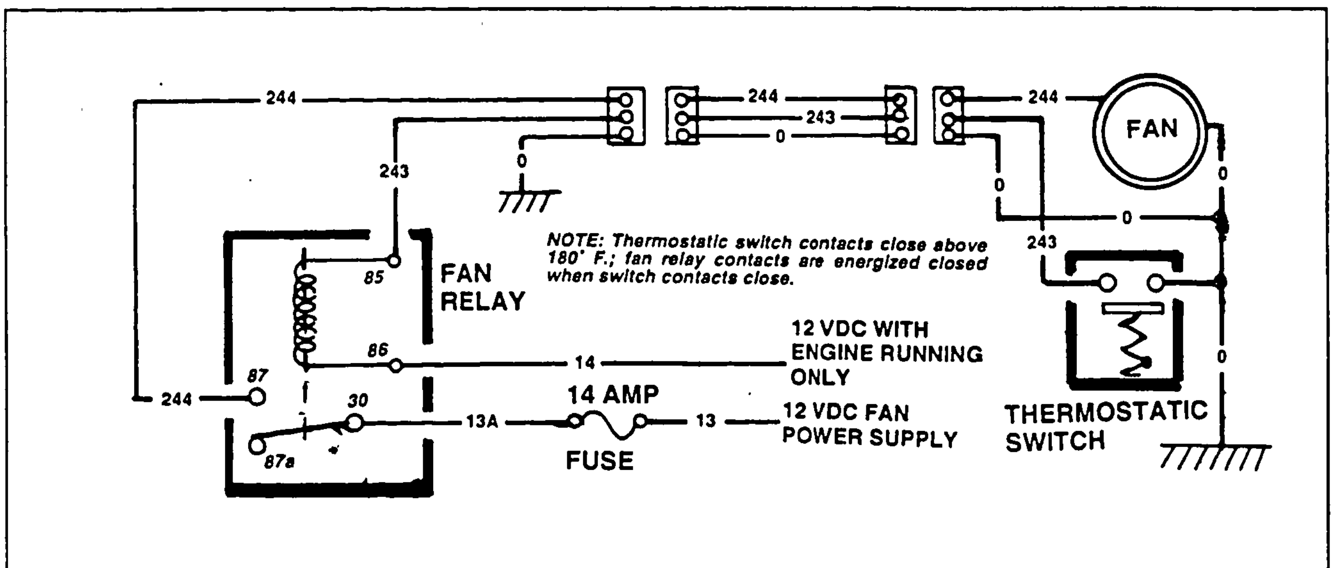


Figure 2. Remote Radiator Fan Operating Diagram

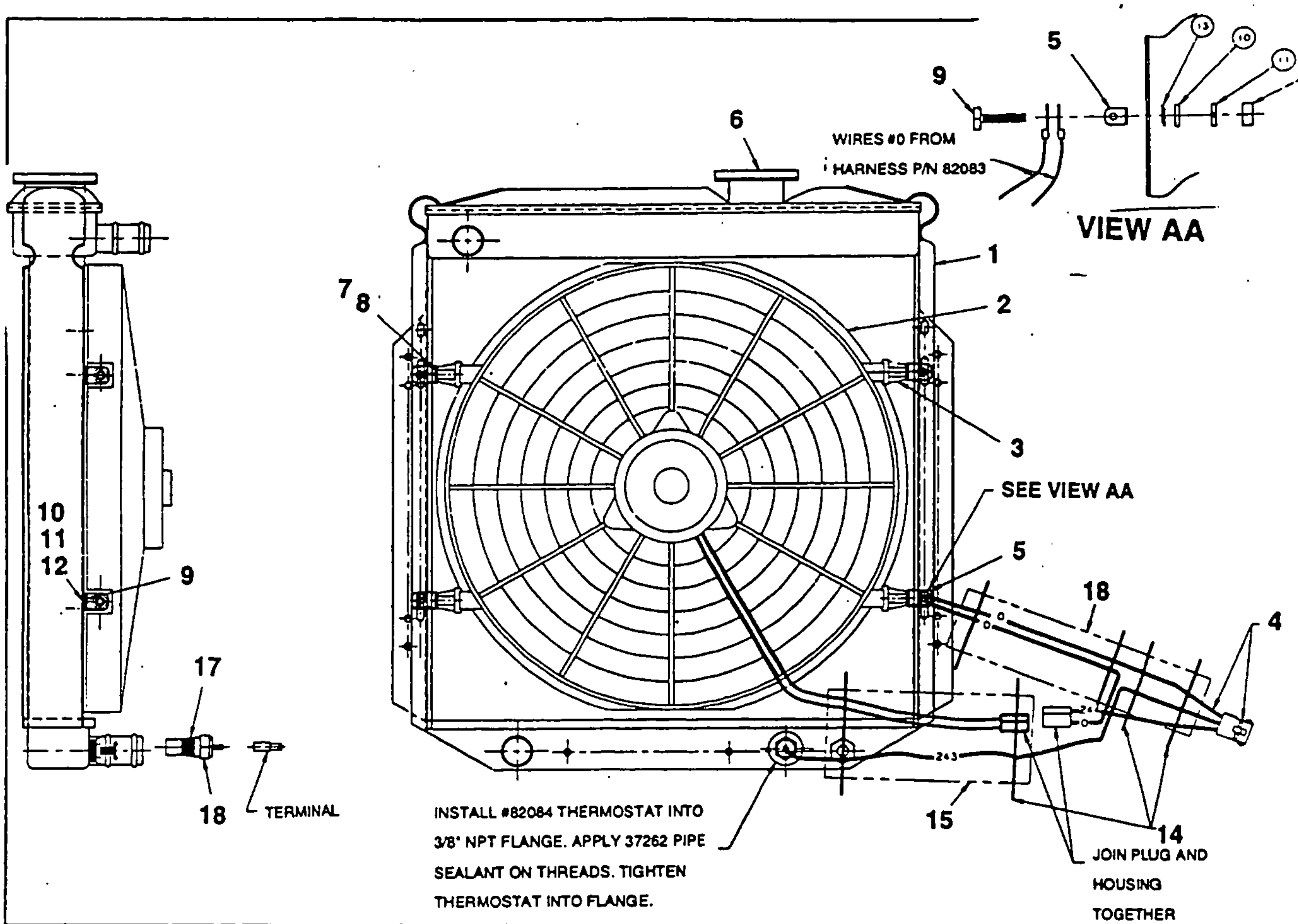


Figure 3. Remote Radiator, Fan and Wiring Harness

Parts List for Figure 3

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

Section 5.7
REMOTE PANELS

General

Optional panels are available which make it possible to start and stop the generator set from a remote location in the vehicle housing the unit. The following panels and wiring harnesses are available for use with water-cooled diesel engine units:

- ☐ Model 9044 start/stop panel. Panel features (a) a start/stop switch, (b) startup advisory lamp, (c) a preheat switch, and (d) a mounting plate.
- ☐ Model 9047 wiring harness. This 30 foot harness permits the Model 9044 start/stop panel to be connected to the generator.
- ☐ Model 9061 remote gauge panel. Panel mounts (a) a start/stop switch, (b) a preheat switch, (c) oil pressure gauge, (d) a DC voltmeter, (e) coolant temperature gauge, and (f) an hourmeter.
- ☐ Model 9118 wiring harness is 30 feet long. Harness permits the Model 9061 remote panel to be connected to the generator.

Model 9044 Start/Stop Panel

GENERAL:

The Model 9044 Remote Panel is shown in Figure 1, below. The panel includes (a) a stop/start switch, (b) a preheat switch, and (c) a generator run lamp.

PANEL MOUNTING:

The remote panel is designed to be flush-mounted to a wall in the vehicle that houses the generator. Figure 2 shows the wall cutout dimensions for mounting the panel.

OPTIONAL REMOTE WIRING HARNESS:

Use the Model 9047 wiring harness to install the Model 9044 remote panel. The 6-wire harness is 30 feet long and includes a connector plug which must be plugged into the generator's remote panel receptacle (Figure 3).

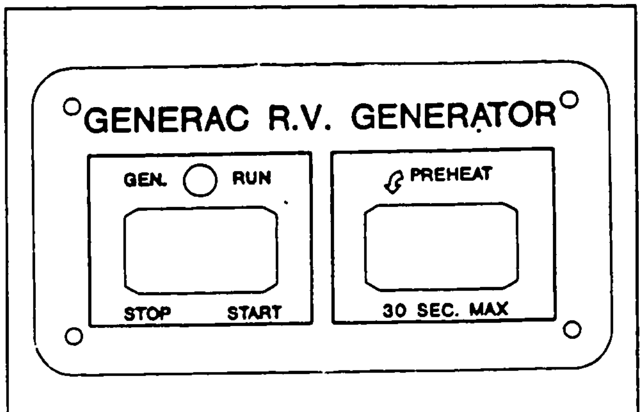


Figure 1. Model 9044 Remote Panel

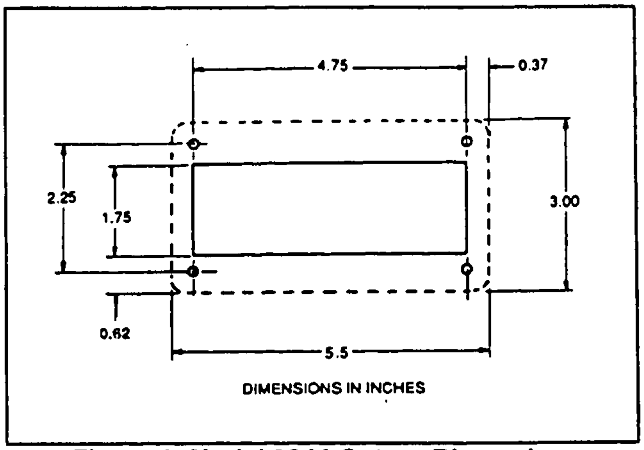


Figure 2. Model 9044 Cutout Dimensions

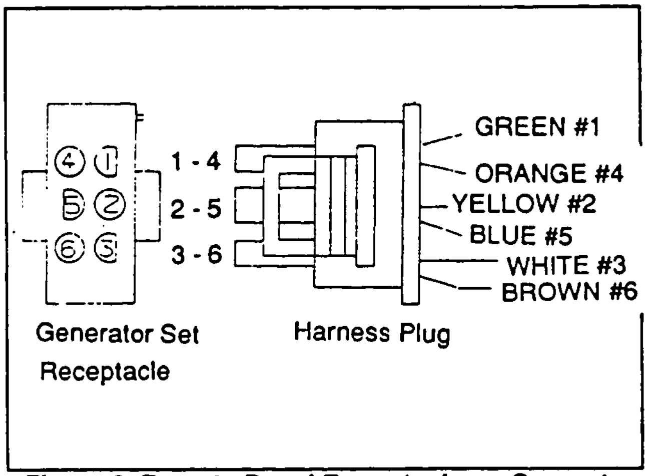


Figure 3. Remote Panel Receptacle on Generator

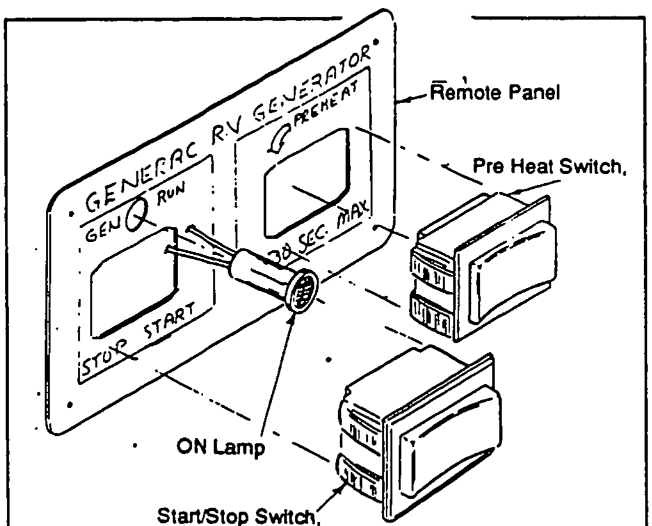


Figure 4. Model 9044 Panel Components

Model 9044 Start/Stop Panel (Continued)

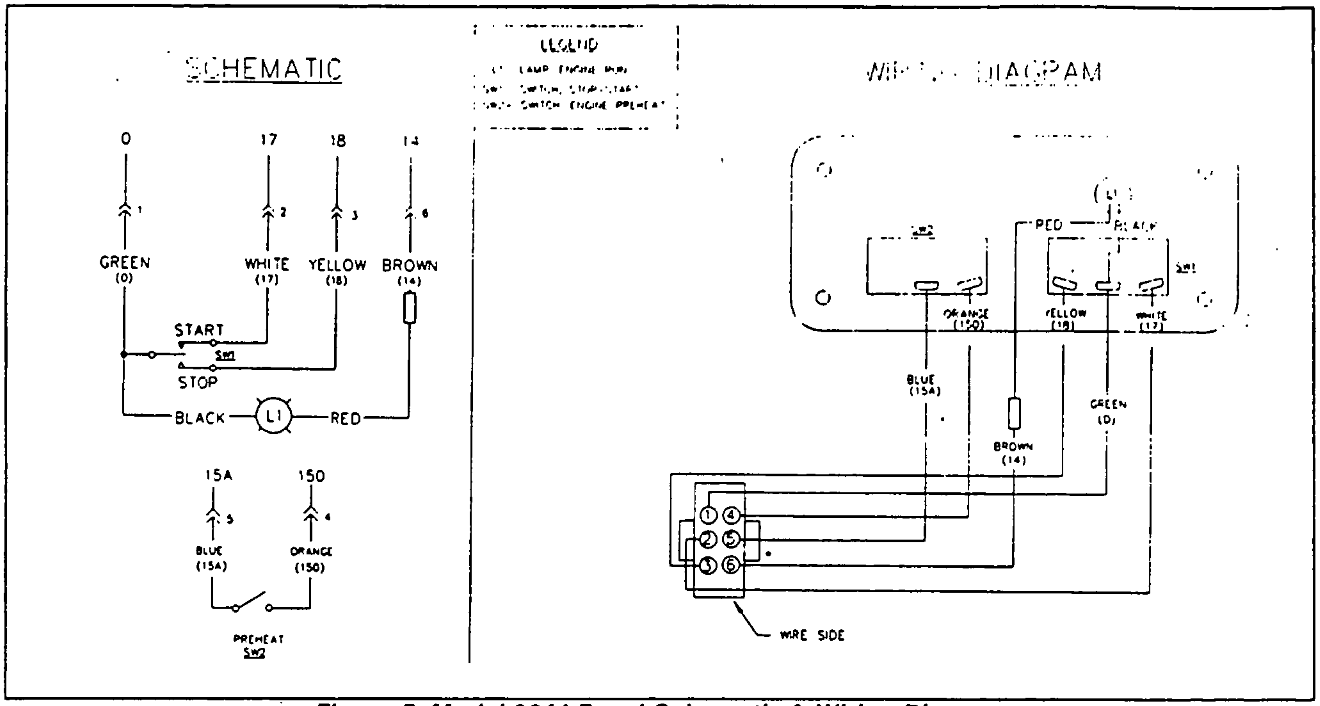


Figure 5. Model 9044 Panel Schematic & Wiring Diagram

Model 9061 Remote Gauge Panel

GENERAL:

The Model 9061 remote gauge panel is shown in Figure 6. The panel mounts the following components:

- ☐ An engine oil pressure gauge.
- ☐ A DC (Battery charge) voltmeter.
- ☐ An engine coolant temperature gauge.
- ☐ An hourmeter.
- ☐ A generator running advisory lamp.
- ☐ A start/stop switch.
- ☐ An engine preheat switch.

MODEL 9061 INSTRUCTIONS:

An *INSTRUCTIONS & PARTS* manual is shipped with each Model 9061 remote gauge panel kit. To order the Manual, specify Part No. 78253.

WIRING HARNESS:

Use the Model 9118 wiring harness when installing the Model 9061 remote gauge panel. The wiring harness is shown in Figure 7, next page.

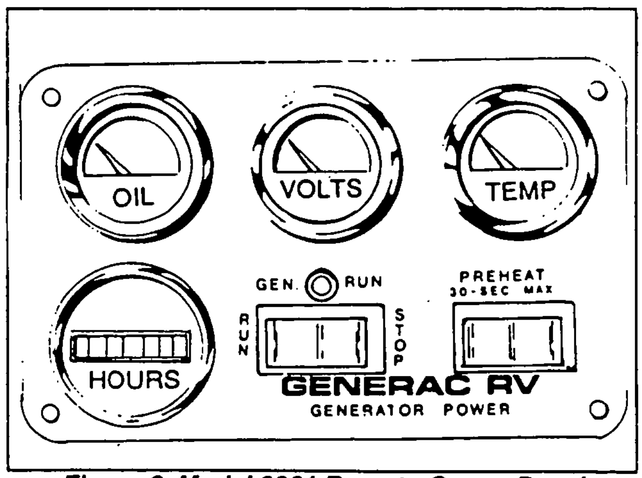


Figure 6. Model 9061 Remote Gauge Panel

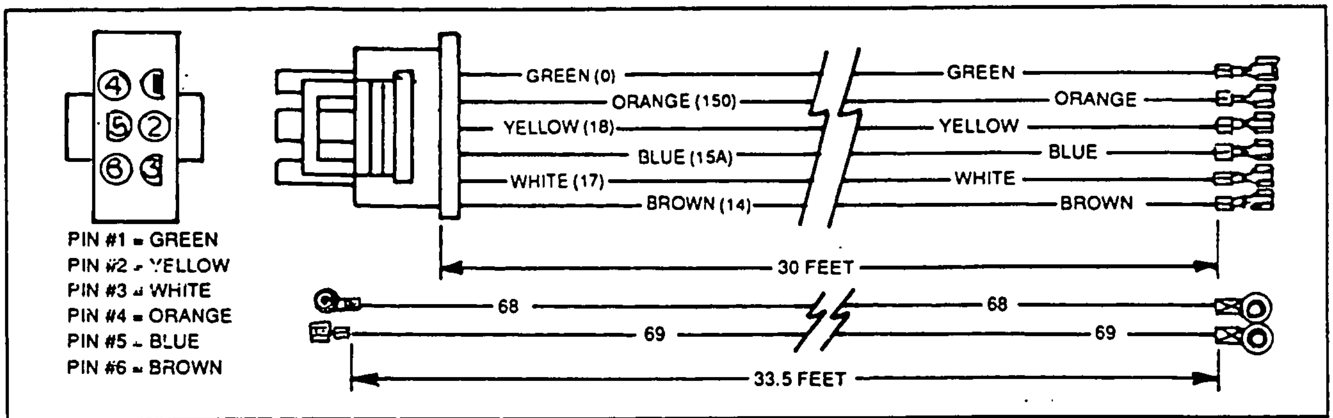
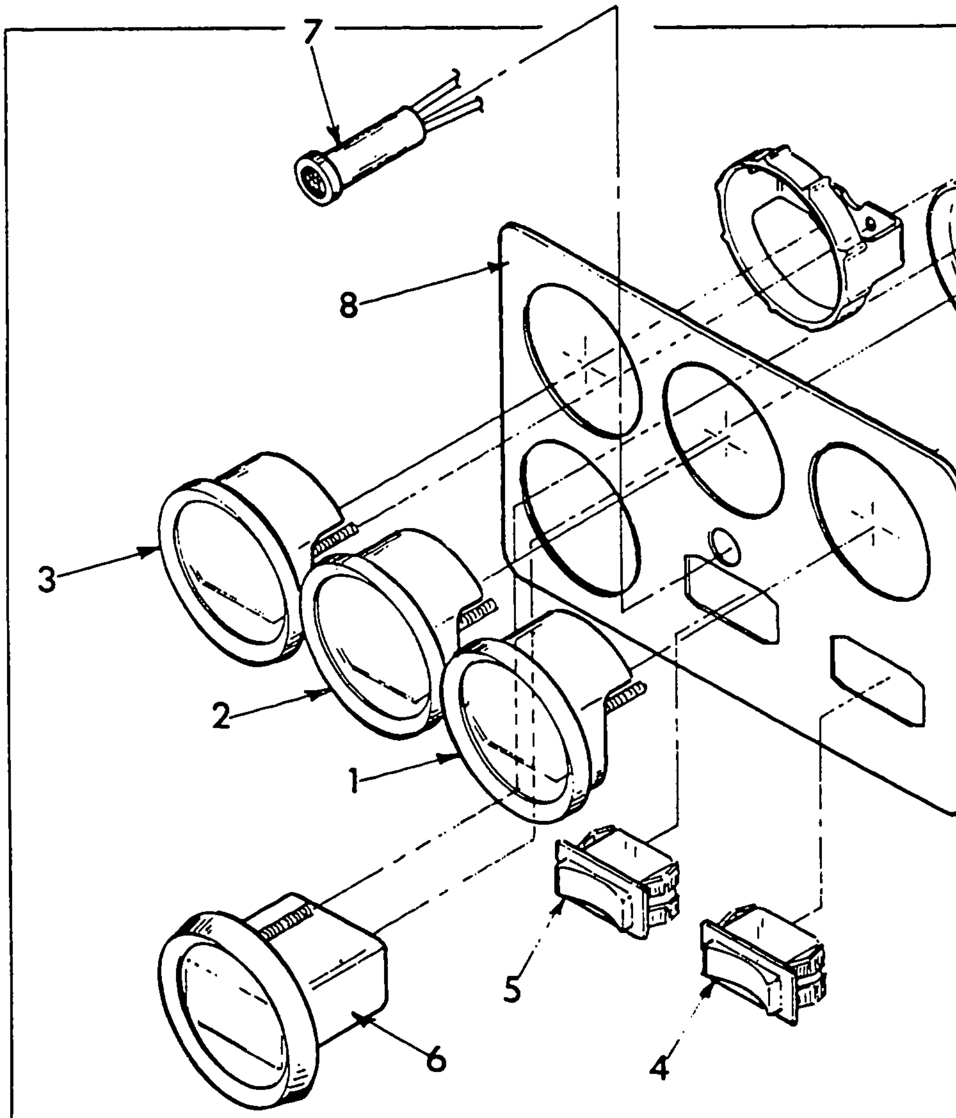


Figure 7. The Model 9118 Wiring Harness



ITEM	DESCRIPTION
1	Coolant Temp. Gauge
2	DC Voltmeter (8-18 VDC)
3	Oil Pressure Gauge
4	Preheat Switch
5	Start/Stop Switch
6	Hourmeter
7	Run Lamp
8	Panel

Figure 8. Exploded View of Model 9061 Remote Gauge Panel

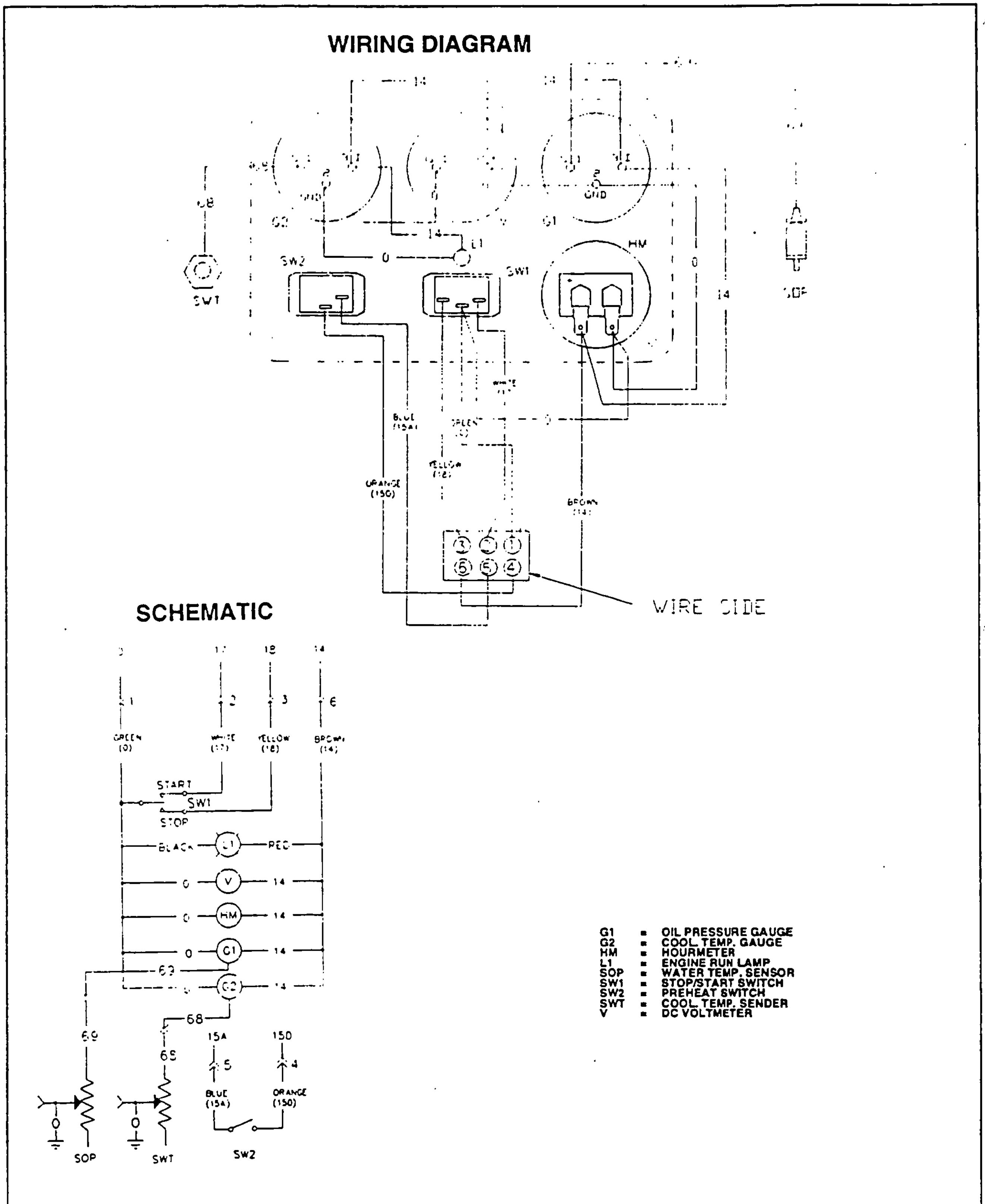


Figure 9. Wiring Diagram & Schematic- Model 9061 Remote Gauge Panel

Section 5.8

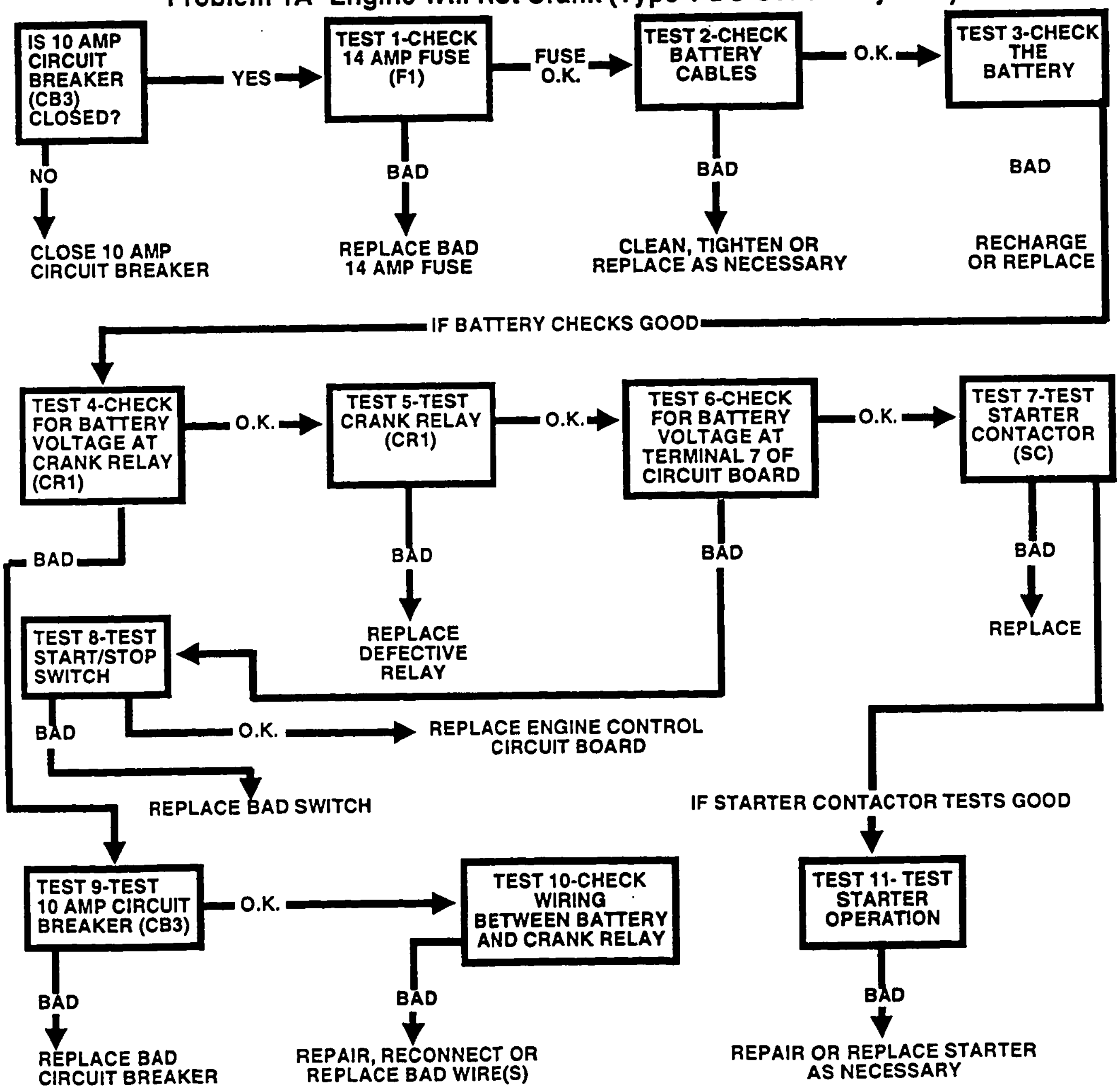
TROUBLESHOOTING FLOW CHARTS

Introduction to Troubleshooting

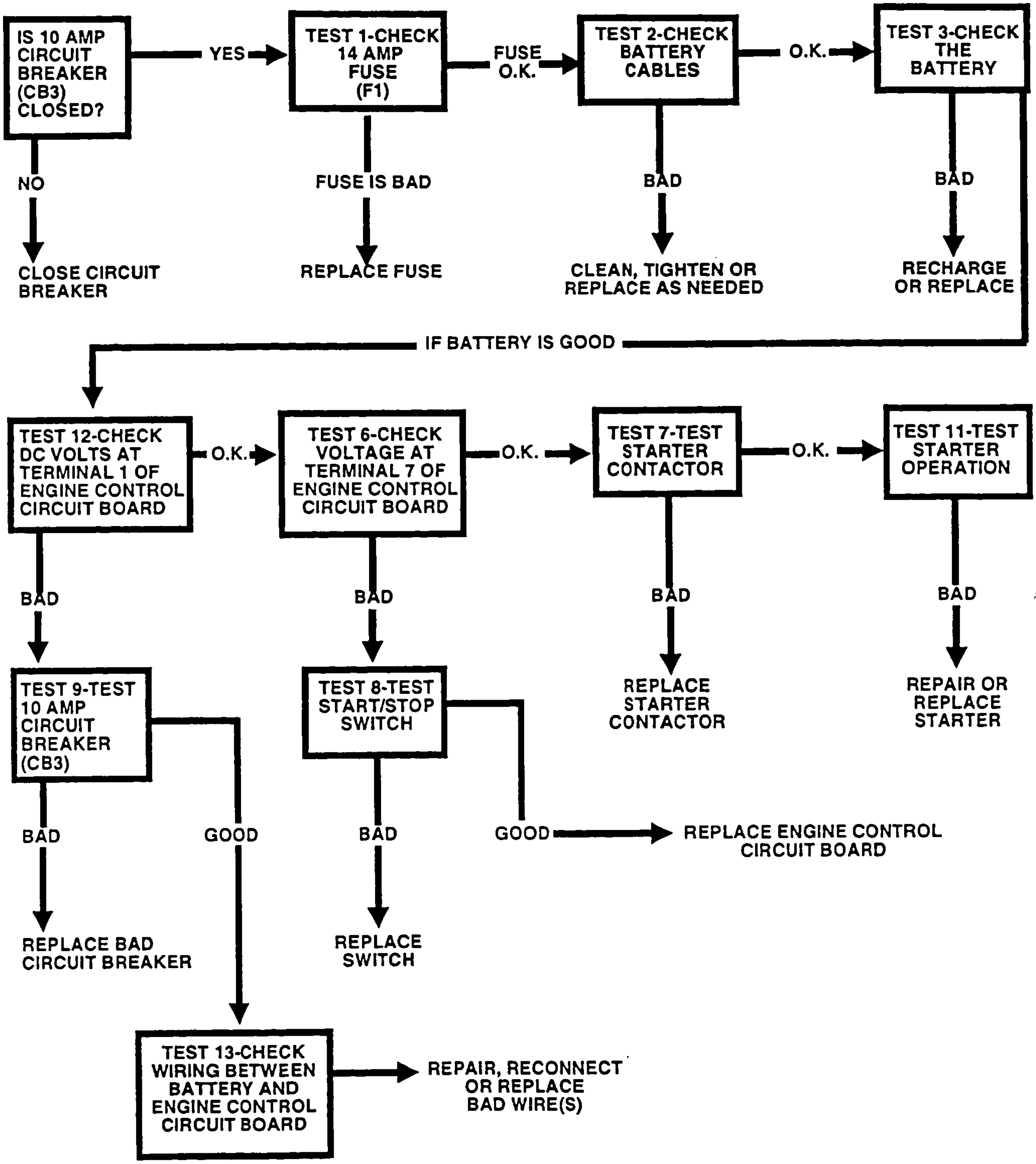
Use the TROUBLESHOOTING FLOW CHARTS in this section in conjunction with the test procedures outlined in Section 5.9. Test numbers in the FLOW CHARTS correspond with the numbered tests in Section 5.9.

It is suggested that you read Section 5.1 carefully. Three different DC control systems are covered by the FLOW CHARTS, arbitrarily designated as Type 1, Type 2 and Type 3. Section 5.1, *INTRODUCTION TO DC CONTROL SYSTEMS*, explains the differences between the three types of systems.

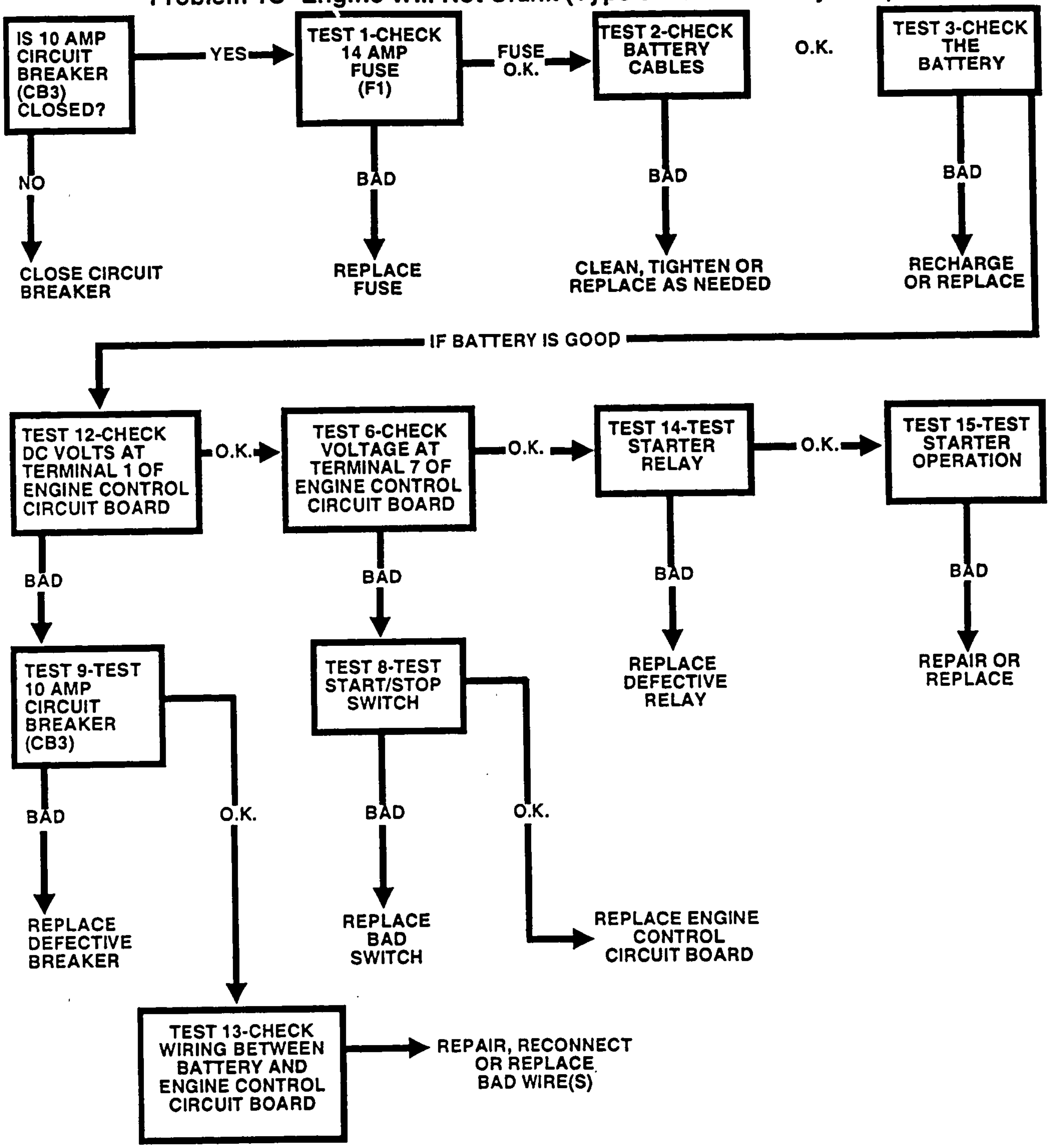
Problem 1A- Engine Will Not Crank (Type 1 DC Control System)



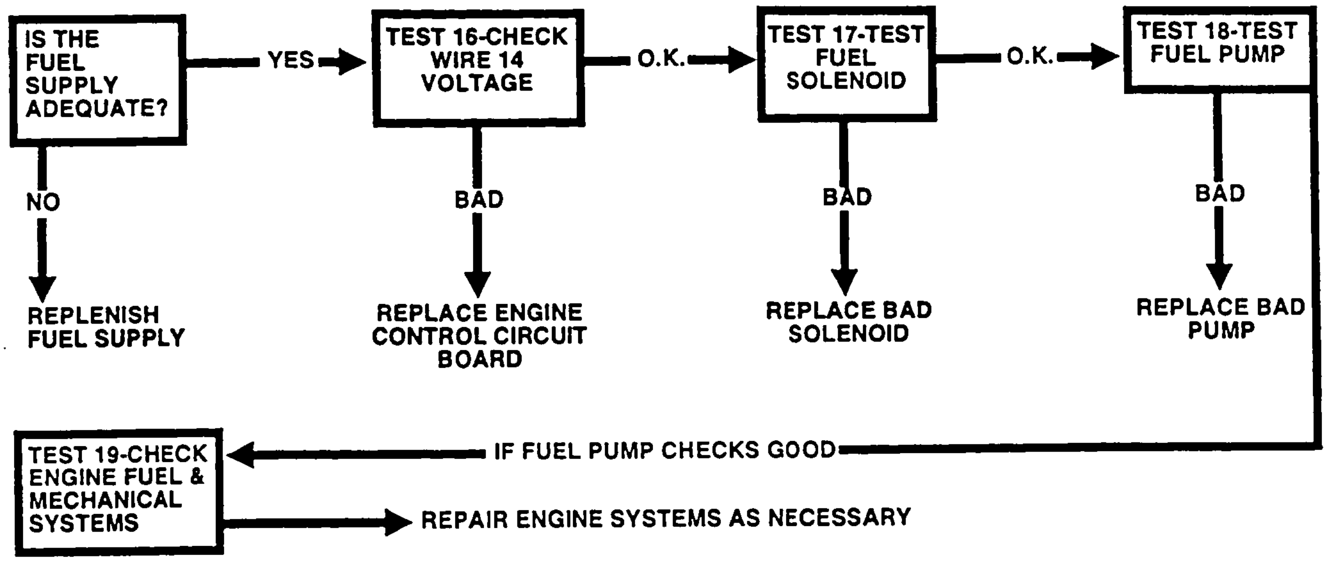
Problem 1B- Engine Will Not Crank (Type 2 DC Control System



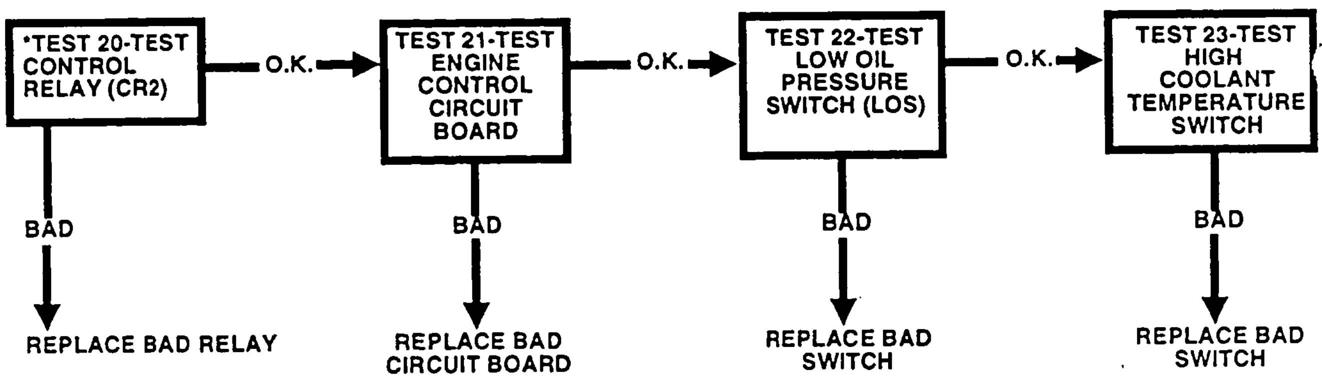
Problem 1C- Engine Will Not Crank (Type 3 DC Control System)



Problem 2- Engine Cranks But Will Not Start (All Types)



Problem 3- Engine Cranks, Starts, Shuts Down When Start/Stop Switch is Released (All Types)



* Test 20 applies only to units with a Type 1 DC control system.

Section 5.9
TROUBLESHOOTING TEST PROCEDURES

General

The test procedures that follow correspond to the numbered tests of Section 5.8, *TROUBLESHOOTING FLOW CHARTS.*

When performing diagnostic tests on the engine-generator, it is recommended that the WIRING DIAGRAM and ELECTRICAL SCHEMATIC for the particular model being tested be used. Some differences may exist between models and using the appropriate diagram and schematic will help prevent mistakes.

The writer has arbitrarily divided the different engine DC control systems into three types. Read Section 5.1 carefully to identify these types (Type 1, 2 and 3).

Test 1- Check 14 Amp Fuse (F1)

DISCUSSION:

The 14 amp fuse is physically mounted on the generator control panel. The fuse is electrically connected in series with the DC power supply to the engine control circuit board. A blown fuse will open the DC power supply to the circuit board, preventing engine cranking and startup.

PROCEDURE:

Push in on fuse holder cap and turn counterclockwise to remove. The fuse and cap will come off together. Use a volt-ohm-milliammeter to test the fuse for "continuity".

RESULTS:

1. A reading of "infinity" indicates the fuse element has melted open. Replace the fuse with an identical 14 amp fuse.
2. If the meter reads "continuity", go on to Test 2.

Test 2- Check Battery Cables

DISCUSSION:

Oxidation can form on battery cable terminals and clamps, as well as battery posts. The resultant film can result in an effective open-circuit, with the same results as a dead battery. Battery cable terminals and clamps, as well as battery posts, must be clean and free of corrosion.

PROCEDURE:

Inspect battery cable clamps and terminals, the cables themselves, and battery posts for evidence of corrosion. Clean as required. Reconnect the cables and make sure thay are tight.

RESULTS:

1. Clean, tighten or replace battery cables (including starter cable) as necessary.
2. If battery cables are not the cause of the problem, go on to Test 3.

Test 3- Check the Battery

DISCUSSION:

Storage batteries that are unused for any length of time can self-discharge. If the engine cranks too slowly, a discharged battery may be the cause of the problem. In some cases the battery may be too weak to crank the engine at all.

PROCEDURE:

See Section 5.2, ENGINE CRANKING SYSTEM. Two different methods of testing the battery are given in that section. These two methods are:

- ☐ A battery capacity test.
- ☐ Specific gravity tests using a battery hydrometer. \

RESULTS:

1. Recharge or replace the battery as necessary.
2. If battery is in good condition and properly charged, go on to Test 4.

Test 4- Check for Battery Voltage at Crank Relay (CR1)

DISCUSSION:

Crank relay (CR1) is used only on Type 1 control systems. These systems utilized early production engine control circuit boards and included both a crank relay (CR1) and a run relay (CR2). The crank relay, when energized by setting the start/stop switch to "Start" position, acts to initiate engine cranking and startup as follows:

- ☐ Connects terminal 3 (Wire 17A) of the engine control circuit board to ground. Circuit board action then delivers battery voltage to the starter contactor (SC) to initiate cranking.
- ☐ Delivers battery voltage to terminal 1 of the circuit board, to turn the board ON. Circuit board action then delivers battery voltage to a fuel solenoid and a fuel pump, so the engine can start and run.
- ☐ Closure of the crank relay contacts delivers battery voltage to a preheat contactor, for engine preheat.

If battery voltage is not available to the crank relay (CR1) for any reason, cranking cannot occur.

PROCEDURE:

The crank relay (CR1) is housed inside the generator control panel. See Figure 1, next page.

NOTE: Crank relay (CR1) and run relay (CR2) are mounted in the panel side-by-side. Crank relay (CR1) has a total of eleven (11) terminals; run relay (CR2) has eight (8) terminals.

Test 4- Check for Battery Voltage at Crank Relay (Continued)

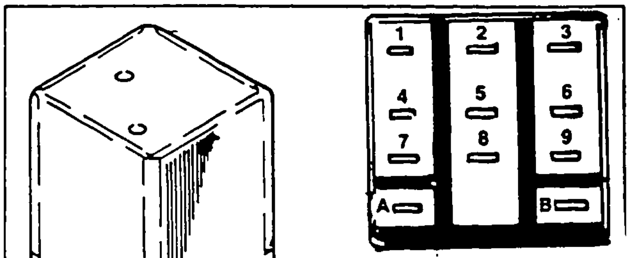
PROCEDURE (CONT'D):

Use a volt-ohm-milliammeter (VOM) or a DC voltmeter to check for the presence of battery voltage at relay terminals "A" and "7" as follows:

1. Set the meter to a scale that will permit battery voltage to be read.
2. Connect the positive (+) meter test lead to relay terminal "A"; connect the common (-) meter test lead to terminal 2 (Wire 0) of the engine control circuit board. The meter should read battery voltage.

RESULTS:

1. If battery voltage is indicated, go on to Test 5.
2. If battery voltage is NOT indicated, go to Tests 9 and 10.



CONNECT WIRE NO.	TO TERMINAL
15	A
17	B
15B	4
150	5
17A	6
15	7
15A	8
0	9

Figure 1. Crank Relay (CR1)

Test 5- Test Crank Relay (CR1)

DISCUSSSION:

The crank relay (CR1) is used only on Type 1 DC control systems.

The first step in testing the relay is to check for the presence of DC voltage at relay terminals "A" and "7". This has already been done (Test 4).

PROCEDURE:

To test crank relay (CR1) for proper operation, proceed as follows:

1. Set a volt-ohm-milliammeter (VOM) to read DC volts and to a scale high enough to read battery voltage.
2. With the relay de-energized, connect the meter test leads as follows. In each case, the meter should read zero volts.
   a. Connect the positive (+) VOM test lead to relay terminal 5; the common (-) test lead to terminal 2 of the engine control circuit board. Meter should read "zero".
   b. Connect the positive (+) meter test lead to relay terminal 6; the common (-) test loead to circuit board terminal 2. Meter should read "zero".
   c. Connect the positive (+) meter test lead to relay terminal 4; the common (-) test lead to circuit board terminal 2. Meter should read "zero".

DANGER: When crank relay (CR1) is energized in Step 3, the engine may crank and start. Stand clear of all moving parts during the test.

3. Now, connect a jumper wire from relay terminal "B" to terminal 2 of the engine control circuit board. The relay should energize. THE ENGINE MAY OR MAY NOT CRANK, DEPENDING ON THE PROBLEM. Test for closure of the relay contacts as follows:
   a. Connect the positive (+) VOM test lead to relay terminal 5; the common (-) test lead to terminal 2 of the engine control board. Battery voltage should be indicated.
   b. Connect the positive (+) VOM test lead to relay terminal 6; the common (-) test lead to circuit board terminal 2. Battery voltage should be read.
   c. Connect the positive (+) VOM test lead to relay terminal 4; the common (-) test lead to circuit board terminal 2. Battery voltage should be indicated.

RESULTS:

1. If the crank relay (CR1) tests good, go to Test 6.
2. Replace the crank relay if it fails any part of the test.

Test 6- Check for Battery Voltage at Terminal 7 of Circuit Board

DISCUSSION:

During cranking and with crank relay (CR1) energized, battery voltage is delivered to terminal 1 of the engine control circuit board. On relay contacts closure, circuit board terminal 3 is connected to ground via Wire 17A and the relay contacts. The circuit board should then react by delivering battery voltage to a starter contactor (SC), via circuit board terminal 7 and Wire 56. This test will determine if (a) battery voltage is available to circuit board terminal 1, and (b) if the circuit board is delivering battery voltage to the starter contactor.

If battery voltage is available to circuit board terminal 1, but the board does not respond by delivering 12 VDC to terminal 7 and Wire 56, either the start/stop switch or the circuit board must be defective.

PROCEDURE:

1. Connect the positive (+) test lead of a volt-ohm-milliammeter (VOM) to terminal 1 of the engine control circuit board; the common (-) test lead to circuit board terminal 2 (ground).
2. Hold the start/stop switch at "Start". Crank relay (CR1) should energize and the VOM should read battery voltage.
   a. If battery voltage is NOT indicated, go to Test 8.
   b. If battery voltage is indicated, go on to Step 3.

Test 6- Check for Battery Voltage at Terminal 7 of Circuit Board (Continued)

PROCEDURE (CONT'D):

3. Now, connect the positive (+) VOM test lead to circuit board terminal 7; the common (-) test lead to circuit board terminal 2 (ground).
4. Hold the start/stop switch at "Start". Crank relay (CR1) should energize and the meter should indicate battery voltage.

RESULTS:

1. If battery voltage is NOT indicated in Step 4, go to Test 8.
2. If battery voltage IS indicated in Step 4, go to Test 7.

Test 7- Test Starter Contactor

DISCUSSION:

During a crank attempt, the crank relay (CR1) should energize and its contacts should close to (a) deliver battery voltage to circuit board terminal 1, and (b) connect circuit board terminal 3 (Wire 17A) to ground. The circuit board should then react by delivering battery voltage to a starter contactor coil. On closure of the starter contactor contacts, battery power should be delivered to the starter motor and the engine should crank. Failure of the starter contactor to energize or failure of its contacts to close will result in a failure of the engine to crank.

DANGER: Stand clear of all moving parts while performing this test. The engine could crank and start at any time during the test.

PROCEDURE:

1. Set a VOM to read battery voltage.
2. Connect the positive (+) meter test lead to the Wire 56 terminal of the starter contactor (see Figure 2). Connect the common (-) meter test lead to frame ground.
3. Hold the start/stop switch at "Start". USE CAUTION, THE ENGINE MAY CRANK. The meter should read battery voltage and the starter contactor should energize.
   a. If battery voltage was indicated in Step 4 of Test 6, but is NOT indicated now, Wire 56 (between the circuit board and the starter contactor) must be open. Repair, reconnect or replace Wire 56 as needed.
   b. If battery voltage is indicated, but engine did not crank, go on to Step 4 of this test.
4. Locate the large terminal lug on the starter contactor to which the battery cable (Wire 13) attaches. Use the VOM to make sure battery voltage is available to this lug.
   a. If battery voltage is NOT available or appears low, repeat Tests 2 and 3.
   b. If normal battery voltage is available, go on to Step 5 of this test.
5. Now, locate the large terminal lug on the starter contactor to which the starter cable connects. Test starter contactor operation as follows:
   a. Connect the meter's positive (+) test lead to the starter cable (Wire 16) terminal lug at the starter contactor; connect the common (-) test lead to frame ground.
   b. Hold the start/stop switch at "Start". The meter should indicate battery voltage and the engine should crank.

RESULTS:

1. In Step 5b, if battery voltage is indicated and the engine cranks normally, discontinue tests.
2. If battery voltage was indicated in Step 4, but is NOT available in Step 5b, replace the starter contactor.
3. If battery voltage was indicated in Step 5b, but the engine does not crank, go on to Test 11.

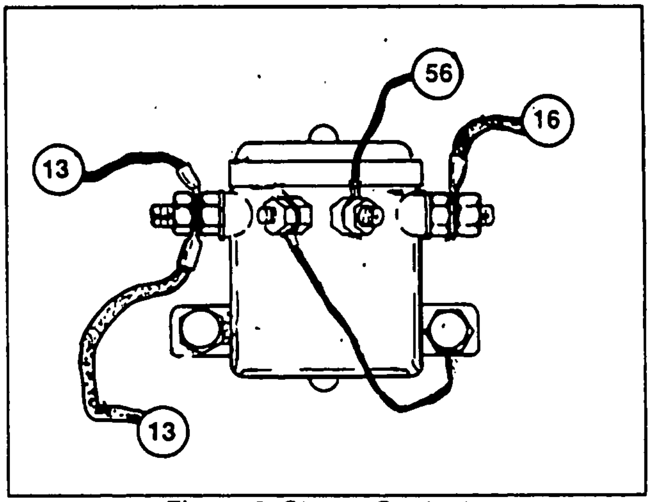


Figure 2. Starter Contactor

Test 8- Test Start/Stop Switch

DISCUSSION:

Cranking and startup is initiated when the start/stop switch is held at "Start" position. Setting the switch to "Start" connects crank relay coil to ground, to energize that relay. A defective start/stop switch can prevent the engine from cranking.

DANGER: Stand clear of moving parts while performing this test. The engine may crank and start at any time.

PROCEDURE:

Battery voltage should be available to the Wire 17 terminal of the start/stop switch at all times. Cranking is initiated when closure of the switch contacts connects Wire 17 to ground. To test the start/stop switch, proceed as follows (see Figure 3):

1. Use a VOM to check for the presence of battery voltage at the Wire 17 terminal of the start/stop switch. If not available, check Wire 17 between crank relay (CR1) and the start/stop switch.

Test 8- Test Start/Stop Switch (Continued)

PROCEDURE (CONT'D):

2. Test and inspect the grounding lead (Wire 0), between the start/stop switch and unit grounding stud. Make sure the wire is not open, shorted, damaged, etc. Wire must be properly attached.
3. Disconnect Wires 17 and 18 from the switch terminals. Then, test the switch as follows:
   a. Set VOM to its "Rx1" scale and zero the meter.
   b. Connect VOM test leads across the switch Wire 18 terminal and the Wire 0 terminal.
      (1) Set the switch to "Start". Meter should read "infinity".
      (2) Set the switch to "Stop" and meter should read "continuity".
      (3) Release the switch to its "Run" position. Meter should read "infinity".
   c. Connect the meter test leads across the Wire 17 switch terminal and the Wire 0 terminal.
      (1) Set the switch to "Start". Meter should read "continuity".
      (2) Set the switch to "Stop". Meter should read "infinity".
      (3) Release switch to its "Run" position. Meter should read "infinity".

RESULTS:

1. If no voltage was read at terminal 7 of the circuit board in Test 6 and the start/stop switch passed its tests, replace the engine control circuit board.
2. If switch tested bad, replace the switch.

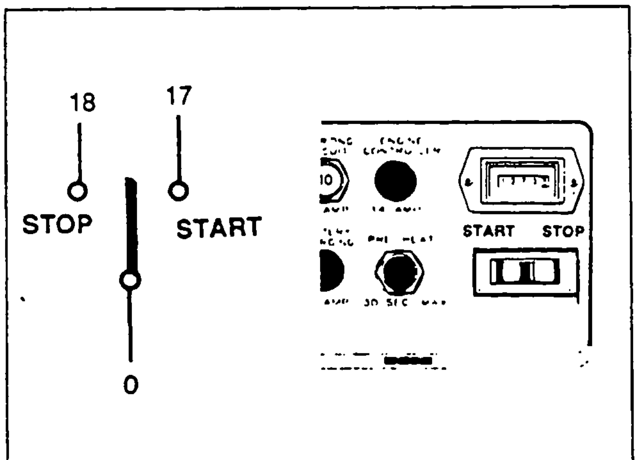


Figure 3. Start/Stop Switch

Test 9- Test 10 Amp Circuit Breaker (CB3)

DISCUSSION:

If battery voltage is NOT available to the crank relay (CR1), it is possible that the 10 amp circuit breaker is open or has failed open. The 10 amp circuit breaker is located on the generator control panel. If the breaker is open, cranking will not be possible.

PROCEDURE:

Make sure the circuit breaker is closed (push in to close). Use a VOM to determine if battery voltage is available to the circuit breaker's Wire 13 terminal. Then, check the Wire 15A terminal of the breaker. Battery voltage should be indicated at both terminals.

RESULTS:

1. If battery voltage is read at the Wire 13 terminal but not at the Wire 15A terminal, replace the start/stop switch.
2. If the circuit breaker is good, go to Test 10.

Test 10- Check Wiring Between Battery and Crank Relay

DISCUSSION:

In Test 4, if battery voltage was not available to the crank relay, it is possible that an open condition exists in the wiring circuit between the battery and the crank relay.

PROCEDURE:

Refer to the appropriate wiring diagram. Test and inspect wires between the battert and the crank relay.

RESULTS:

1. Repair, reconnect or replace open, shorted or damaged wire(s) as necessary.

Test 11- Test Starter Operation

DISCUSSION:

If Test 7 indicated that the starter contactor was functioning properly, but engine would not crank, the starter motor may be the problem.

PROCEDURE:

While holding the start/stop switch at "Start", check that battery voltage is available to the starter motor terminal. If battery voltage is available, but engine does not crank, the starter is probably defective.

To perform an operational test of the starter, see Section 5.2, *ENGINE CRANKING SYSTEM*.

RESULTS:

Repair or replace the starter as required.

Test 12- Check DC Volts at Terminal 1 of Engine Control Circuit Board

DISCUSSION:

This test applies to Types 2 and 3 DC control systems only. For Type 1 systems, use Test 4.

If battery power is not available to the engine control board, cranking will not be possible.

Test 12- Check DC Volts at Terminal 1 of Engine Control Circuit Board (Continued)

PROCEDURE:

1. Set a VOM to read DC volts.
2. Connect the positive (+) VOM test lead to terminal 1 of the engine control circuit board.
3. Connect the common (-) test lead to terminal 2 of the circuit board (ground). The meter should read battery voltage.

RESULTS:

1. If battery voltage is indicated, go to Test 6.
2. If battery voltage is NOT indicated, go to Test 9.

Test 13- Check Wiring Between Battery and Engine Control Circuit Board

DISCUSSION:

If battery voltage is NOT available to the engine control circuit board on Types 2 and 3 DC control systems, an open circuit must exists somewehere between the battery and the circuit board.

PROCEDURE:

Inspect and test wires between the battery and engine control circuit board. Refer to the appropriate wiring diagram/electrical schematic.

RESULTS:

Repair, reconnect or replace bad wire(s) as necessary.

Test 14- Test Starter Relay

DISCUSSION:

The starter relay (SR) is used only on units with a Type 3 DC control system. The Type 3 unit utilizes a starter assembly which includes a pull-in type starter solenoid.

The starter relay is energized when engine control circuit board action delivers DC power to the relay, via Wire 56A. The relay contacts then close to deliver battery voltage to the starter solenoid, via Wire 56. If the relay fails, engine cranking will not occur.

PROCEDURE:

1. See Figure 4. Disconnect Wire 56A from terminal 86 of the starter relay.
2. Set a VOM to read DC volts. Connect the positive (+) VOM test lead to terminal 87 of the starter relay; the common (-) test lead to frame ground.
3. Connect a jumper wire from relay terminal 30 (Wire 15) to relay terminal 86. The relay should energize. The VOM connected in Step 2 should read battery voltage.

RESULTS:

1. Replace starter relay if defective.
2. If relay is good, go to Test 15.

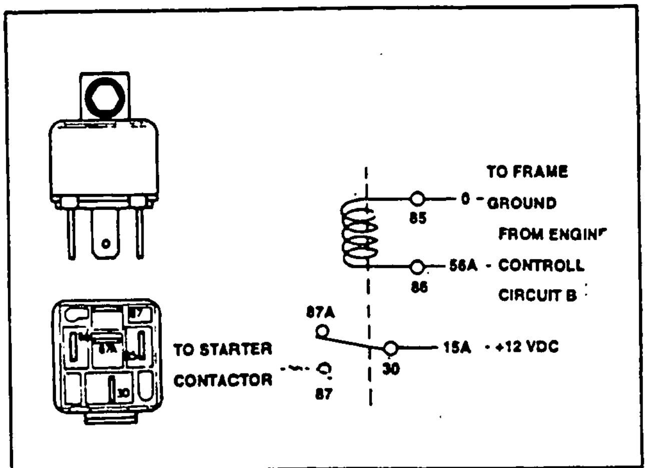


Figure 4. Starter Relay (Type 3 Units)

Test 15- Test Starter Operation

DISCUSSION:

The following procedure applies only to units with a Type 3 DC control system. Only the Type 3 system has a starter with a pull-in type starter solenoid mounted directly to the starter.

PROCEDURE:

See Section 5.2, ENGINE CRANKING SYSTEM.

RESULTS:

Repair or replace defective starter assembly, as required.

Test 16- Check Wire 14 Voltage

DISCUSSION:

During cranking and startup, engine control circuit board action delivers battery voltage to the Wire 14 circuits. Wires 14 connect to (a) a fuel solenoid, (b) a fuel pump, and (c) an hourmeter. With the fuel solenoid and fuel pump energized, fuel is delivered to the engine and the engine can start and run. Circuit board action will keep the Wires 14 circuits electrically hot after cranking has terminated.

NOTE: On units having a Type 1 DC control system, Wire 14 also delivers battery voltage to the actuating coil of run relay (CR2). The run relay energizes, its contacts close, and battery voltage to the engine control board is maintained even after the start/stop switch is released and cranking has terminated.

PROCEDURE:

1. Set a VOM to read DC volts.
2. Connect the positive (+) meter test lead to terminal 9 of the engine control board; the common (-) test lead to terminal 2 (ground).

Test 16- Check Wire 14 Voltage

PROCEDURE (CONT'D):

3. Crank the engine. The VOM connected in Step 2 should read battery voltage, indicating that the Wire 14 circuit is electrically hot.
4. Repeat Step 3 with the meter test leads connected across circuit board terminals 10 and 2.
5. Repeat Step 3 with the meter test leads connected across circuit board terminals 11 and 2.

RESULTS:

1. If no voltage is indicated at Wire 14, remove and replace the engine control circuit board.
2. If voltage tests are good, go to Test 17.

Test 17- Test Fuel Solenoid

DISCUSSION:

The fuel solenoid is a part of the fuel injection pump assembly.

PROCEDURE:

1. Set a VOM to read DC volts.
2. Connect the meter positive (+) test lead to the terminal of the fuel solenoid; the common (-) test lead to frame ground.
3. Crank the engine. The meter should read battery voltage and the solenoid should actuate.

RESULTS:

1. If the VOM reads battery voltage and the solenoid actuates, go on to Test 18.
2. Replace the fuel solenoid if battery voltage is indicated but it does not actuate.
3. If battery voltage is not indicated, check Wire 14 between the fuel solenoid and the engine control board for an open condition.

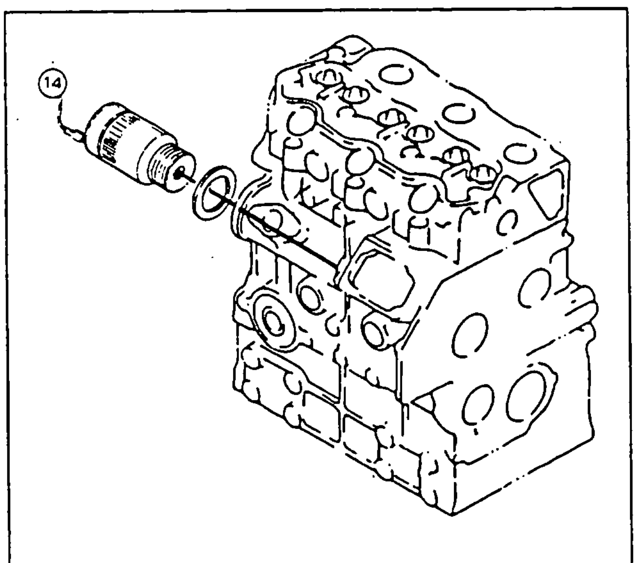


Figure 5. Engine Fuel Solenoid

Test 18- Test Fuel Pump

Discussion:

The electric fuel pump is turned on by Wire 14 during cranking and running operations.

PROCEDURE:

Refer to Part 4, Section 4.2, *FUEL PUMP.*

RESULTS:

1. Replace fuel pump if it is defective.
2. If fuel pump checks good, go to Test 19.

Test 19- Check Engine Fuel & Mechanical Systems

DISCUSSION:

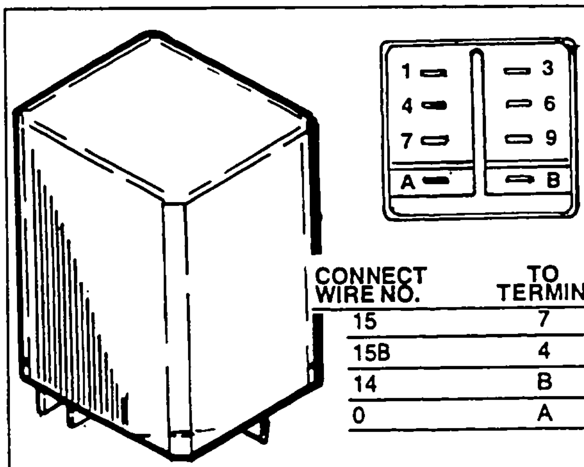
If the engine cranks normally but will not start, one possible cause might be a malfunctioning engine fuel system or mechanical system.

Refer to Part 2, "Engine Mechanical System" and Part 4, "Engine Fuel System".

Test 20- Test Control Relay (CR2)

DISCUSSION:

Control relay (CR2) is used on Type 1 DC control systems only. It acts as a "holding" relay. That is, while cranking, relay (CR1) delivers 12 VDC to the engine control circuit board. Circuit board action then delivers 12 VDC to the CR2 coil. CR2 energizes and its contacts close. When the start/stop switch is released to terminate cranking, 12 VDC is delivered to the engine control circuit board via the closed contacts of relay CR2.



CONNECT WIRE NO.	TO TERMINAL
15	7
15B	4
14	B
0	A

Figure 6. Run Relay CR2

PROCEDURE:

In the control panel, locate the run relay CR2, to which Wires 0, 14, 15 and 15B connect. Inspect all wires carefully. Compare wiring connections to the appropriate wiring diagram, make sure wires are properly connected.

Test 20- Test Control Relay CR2 (Continued)

PROCEDURE (CONT'D):

To test run relay CR2, proceed as follows:

1. Disconnect all wires from the relay terminals except Wire 0 (ground). Wire 0 must remain connected to relay terminal A.
2. Set a VOM to its "Rx1" scale and zero the meter.
3. Connect one VOM test lead to relay terminal #7, the other test lead to relay terminal #4. With the relay de-energized, the meter should read "infinity".
4. Wire 15 was previously disconnected from relay terminal #7. This wire is electrically hot. Connect Wire 15 to relay terminal #B.
   a. The relay should energize and its normally-open contacts should close.
   b. The VOM connected in Step 3 should read "continuity".

RESULTS:

1. Replace the run relay if it is defective.
2. If the relay tests good, go to Test 21.

Test 21- Test Engine Control Circuit Board

DISCUSSION:

The engine control circuit board cannot be repaired in the field. If the board is defective, it must be replaced.

PROCEDURE:

To test the engine control circuit board, proceed as follows:

1. Set a VOM to read battery voltage (12 VDC).
2. **Type 1 DC Control System:** Check that DC power is available to the circuit board as follows:
   a. Connect the meter's positive (+) test lead to Terminal #1 of the circuit board; the common (-) test lead to Terminal #2 (ground).
   b. Hold the start/stop switch at "Start". The meter should read battery voltage (indicating that crank relay CR1 has energized).
   c. If the engine starts, release the start/stop switch. The VOM should still read battery voltage (indicating that run relay CR2 has energized and is holding the power supply to the board).

Type 2 & 3 DC Control System: Check that DC power is available to the circuit board as follows:
   a. Connect the meter's positive (+) test lead to Terminal #1 of the circuit board; the common (-) test lead to Terminal #2 (ground).
   b. The meter should read battery voltage, indicating that fused battery voltage is available to the circuit board.

3. Now, connect the VOM positive (+) test lead to circuit board Terminal #7, to which Wire 56 connects; the common (-) test lead to Terminal #2 (ground). Set the start/stop switch to "Start" and the meter should read battery voltage.
4. Connect the positive (+) VOM test lead to circuit board Terminal #9; the common VOM test lead to Terminal #2 (ground). Set the start/stop switch to "Start" and battery voltage should be indicated. Release the start/stop switch and battery voltage should still be indicated.
5. Repeat Step 4 with the positive (+) VOM test lead connected to circuit board Terminal #10; the common (-) test lead connected to Terminal #2. Expect the same results as in Step 4.
6. Repeat Step 4 with the positive (+) VOM test lead connected to circuit board Terminal #11; the common test lead at Terminal #2. Expect the same results.

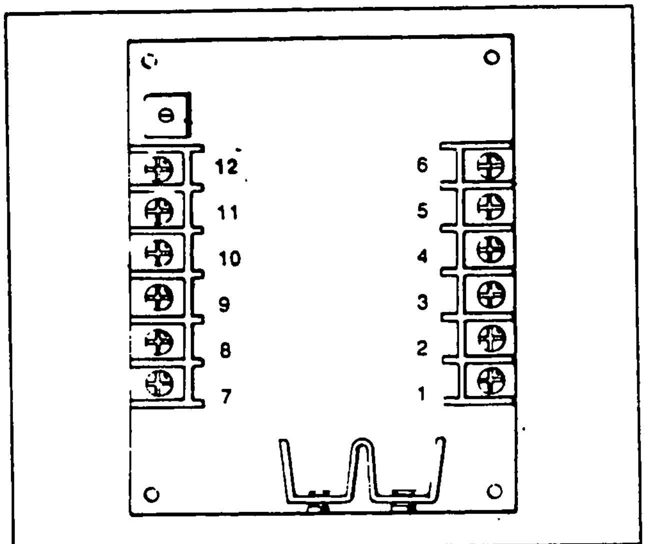


Figure 7. Engine Control Circuit Board

RESULTS:

1. Replace the engine control circuit board if defective.
2. If the engine cranks, starts and then shuts down when the start/stop switch is released, but the circuit board tests good, go to Test 22.

Test 22- Test Low Oil Pressure Switch

DISCUSSION:

If the engine cranks, starts and then shuts down when the start/stop switch is released, one possible cause of the problem is a defective low oil pressure switch. The switch is normally-closed, but is held open by engine oil pressure during cranking and running. Closure of the switch contacts will result in engine shutdown.

PROCEDURE:

If the engine will not start, unplug the connector from the low oil pressure switch terminal. Then, try a start. If engine starts with wire disconnected from switch terminal, but will not start when wire is connected, the low oil pressure switch must be defective.

Another way to test the pressure switch is with a volt-ohm-milliammeter (VOM). Test the switch with a VOM as follows:

Test 22- Test Low Oil Pressure Switch (Continued)

PROCEDURE (CONT'D):

1. Set a VOM to its "Rx1" scale and zero the meter.
2. Unplug Wire 85 from the switch terminal.
3. Connect one VOM test lead to the pressure switch terminal; the second test lead to frame ground. With engine shut down, the meter should read "continuity".
4. Crank and attempt to start the engine. As the engine cranks and attempts to start, the pressure switch contacts should open and the meter should read "infinity".

RESULTS:

1. Replace the low oil pressure switch if it fails the tests.
2. If the pressure switch checks good, go to Test 23.

Test 23- Test High Coolant Temperature Switch

DISCUSSION:

The high coolant temperature switch is connected in parallel, in the same circuit as the low oil pressure switch. Failure of the engine to start can be caused by a defective temperature switch.

PROCEDURE:

Refer to "*High Coolant Temperature Switch*" In Part 5, Section 5.5 (Page 5.5-1).

RESULTS:

Replace temperature switch if it is defective.

Part 6 ELECTRICAL DATA

NP and IM Series

RECREATIONAL VEHICLE & INDUSTRIAL MOBILE GENERATORS

Liquid-Cooled Diesel Engine Models

TABLE OF CONTENTS

Table 1. Resistances of Rotors & Stators (in ohms)

MODEL	9025-0	9055-0	9055-1	9318-0	9319-0	9343-0	9343-1	9344-0	9344-1	9410-0	9422-0	9510-0
ROTOR PART NO.	69888A	69888A	69888A	81956	69888A	81956	81956	81956	81956	69888A	83724	81956
ROTOR OHMS	8.5	8.5	8.5	7.4	8.5	7.4	7.4	7.4	7.4	8.5	8.5	7.4
STATOR* PART NO.	75675	75675	75675	83276	75675	81955	81955	81955	81955	75675	83371	81955
STATOR POWER WINDING OHMS	0.21 NOTE 1	0.21 NOTE 1	0.21 NOTE 1	0.51 NOTE 2	0.21 NOTE 1	0.23 NOTE 1	0.23 NOTE 1	0.23 NOTE 1	0.23 NOTE 1	0.21 NOTE 1	0.77 NOTE 3	0.23 NOTE 1
STATOR DPE WINDING OHMS	1.00	1.00	1.00	0.84	1.00	0.53	0.53	0.53	0.53	1.00	0.63	0.53

* See Section 1.5, "Stator AC Connection Systems" for stator power winding configurations.

NOTE 1: Measure stator power winding resistance across stator leads 11 and 22; 33 and 44. Measure DPE winding resistance across stator lerads 5 and 6.

NOTE 2: Stator Part No. 83276 is a 3-phase winding. Read power winding resistance across stator leads S1-S4; S2-S5; S3-S6; S7-S10; S8-S11; S9-S12. Check DPE winding resistance across stator leads 5-6.

NOTE 3: Stator Part No. 83371 is a 3-phase delta type. Check stator power winding resistance across leads L1-L2; L2-L3. Resistance across Leads L2-L0 is 0.39 ohm. Check DPE winding resistance across stator leads 2-6.

Table 2. Index to Wiring Diagrams & Electrical Schematics

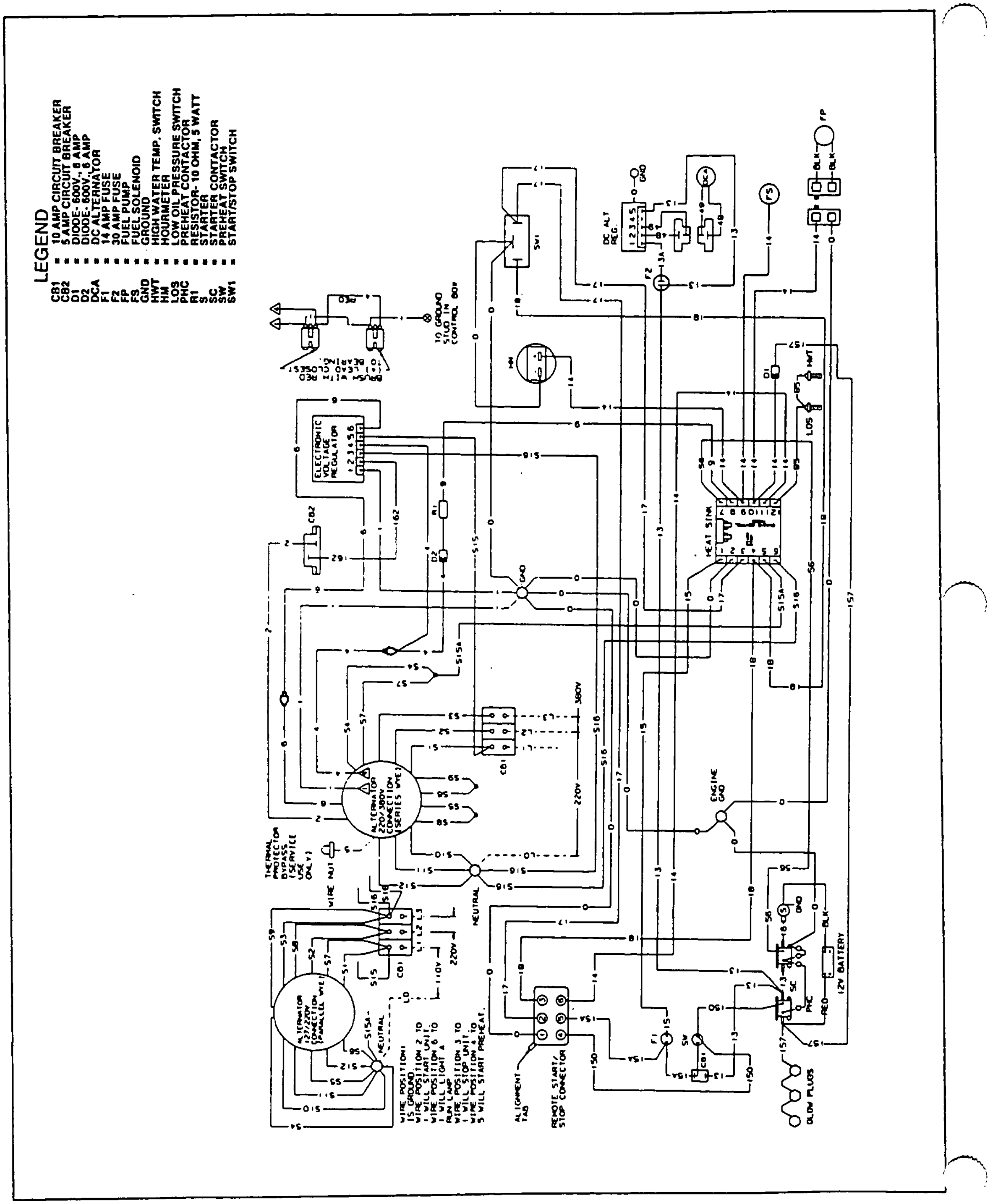
MODEL	9025-0	9055-0	9055-1	9318-0	9319-0	9343-0	9343-1	9344-0	9344-1	9410-0	9422-0	9510-0
WIRING DIAG.	74875	74875	74875	83154	82074	82615	83623	82615	83623	74875	83479	83623
ELEC. SCHEMATIC	*	*	*	83148	*	82616	83625	82616	83625	*	*	83625

* NO ELECTRICAL SCHEMATIC AVAILABLE FOR THESE MODELS.

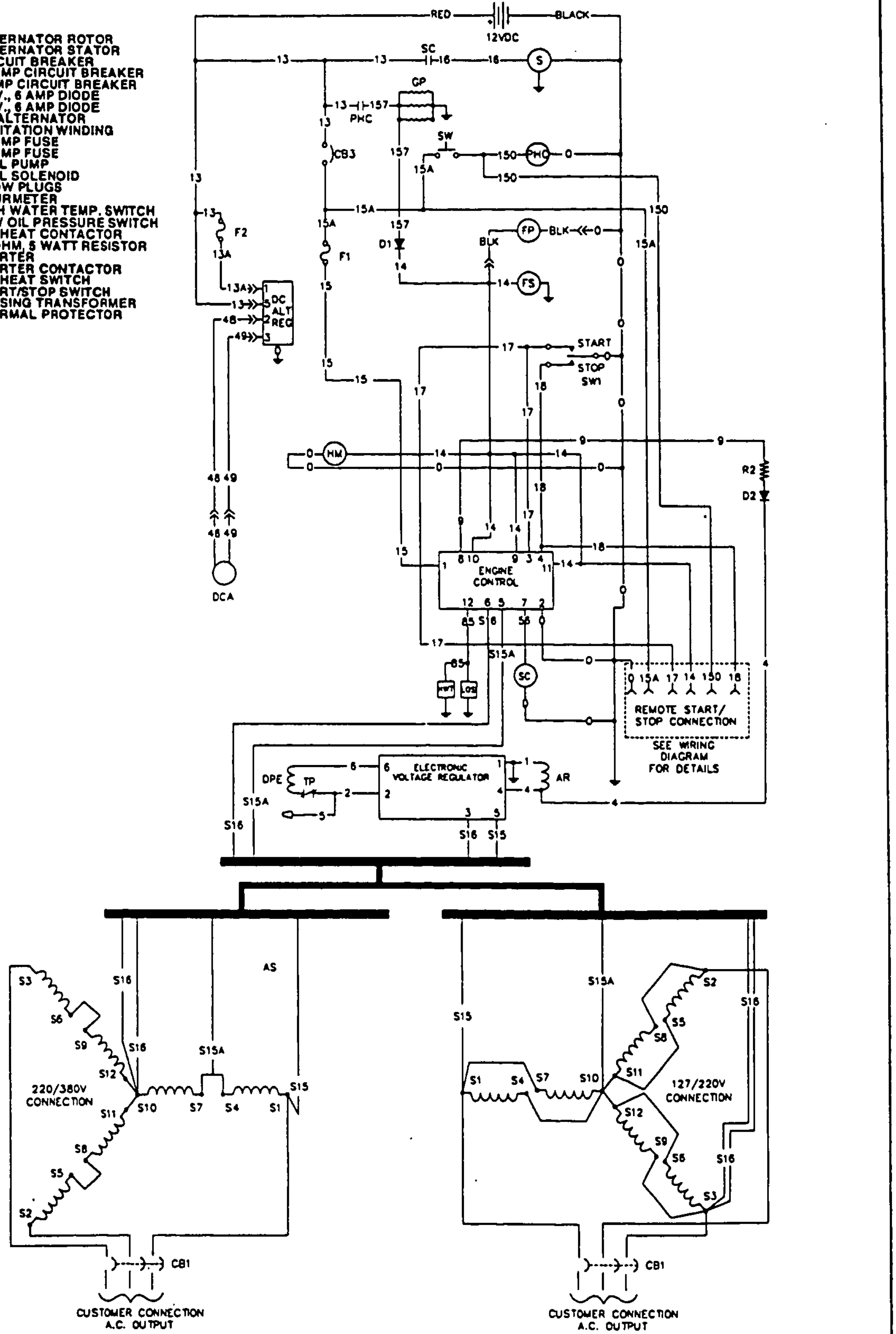
Owner's Manual with Parts List by Model Number

MODEL	9025-0	9055-0	9055-1	9318-0	9319-0	9343-0	9343-1	9344-0	9344-1	9410-0	9422-0	9510-0
MANUAL PART NUMBER	75695	75813	83530	83099	69879	81980	83861	83292	83874	83050	83451	83861

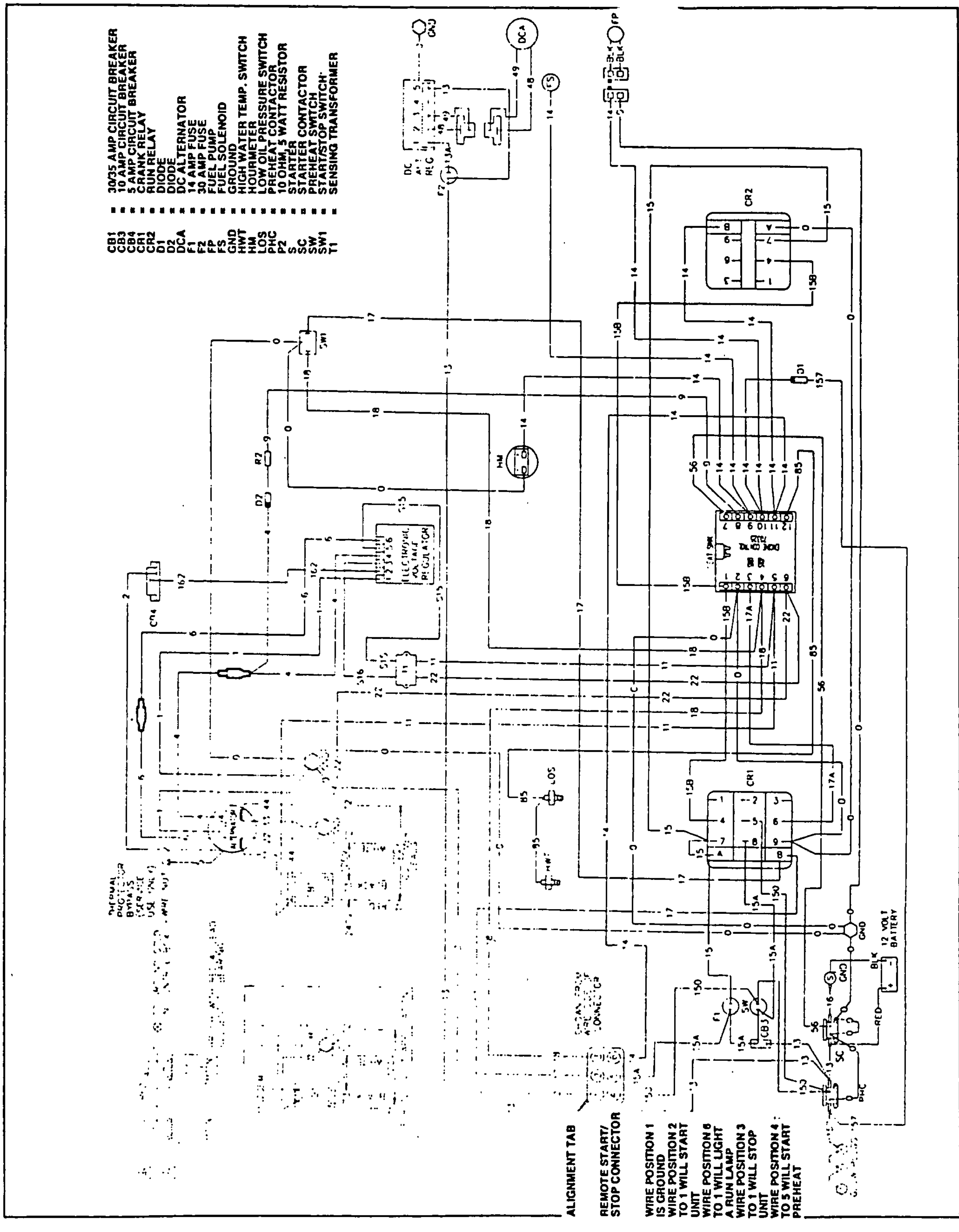
WIRING DIAGRAM
DRAWING NO. 83154

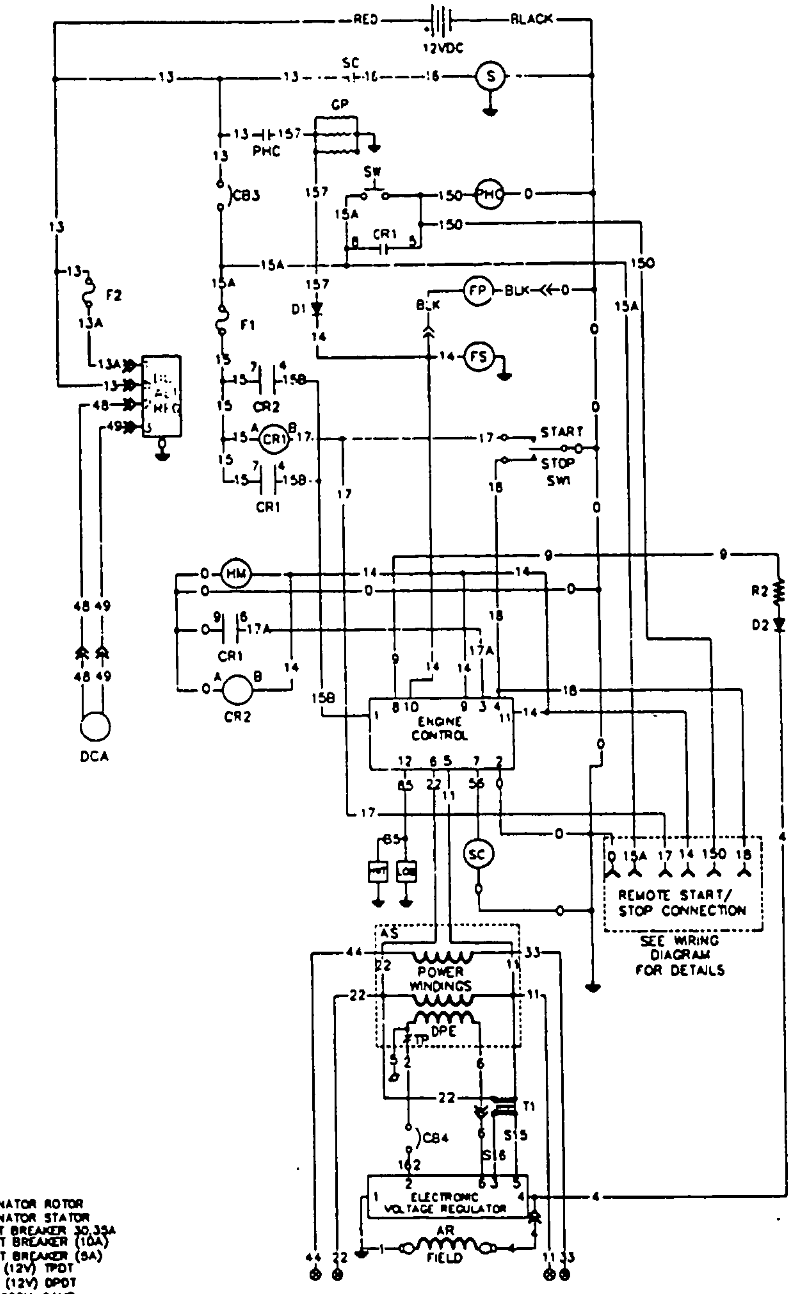


AR	=	ALTERNATOR ROTOR
AS	=	ALTERNATOR STATOR
CB1	=	CIRCUIT BREAKER
CB3	=	10 AMP CIRCUIT BREAKER
CB4	=	5 AMP CIRCUIT BREAKER
D1	=	600V., 6 AMP DIODE
D2	=	600V., 6 AMP DIODE
DCA	=	DC ALTERNATOR
DPE	=	EXCITATION WINDING
F1	=	14 AMP FUSE
F2	=	30 AMP FUSE
FP	=	FUEL PUMP
FS	=	FUEL SOLENOID
GP	=	GLOW PLUGS
HM	=	HOURMETER
HWT	=	HIGH WATER TEMP. SWITCH
LOS	=	LOW OIL PRESSURE SWITCH
PHC	=	PREHEAT CONTACTOR
R2	=	10 OHM, 5 WATT RESISTOR
S	=	STARTER
SC	=	STARTER CONTACTOR
SW	=	PREHEAT SWITCH
SW1	=	START/STOP SWITCH
T1	=	SENSING TRANSFORMER
TP	=	THERMAL PROTECTOR



WIRING DIAGRAM
DRAWING NO. 82615

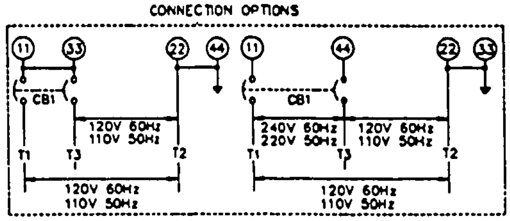




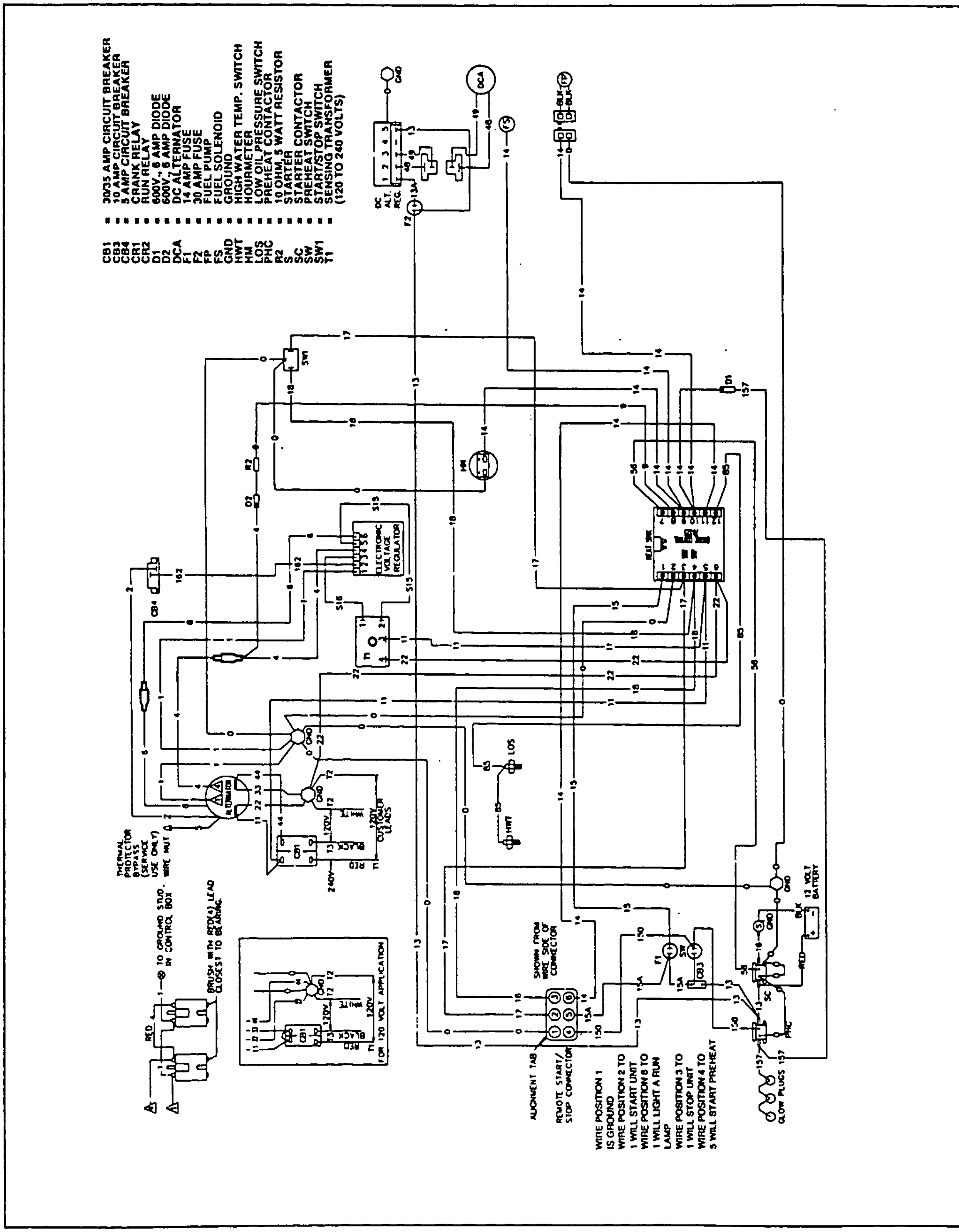
LEGEND

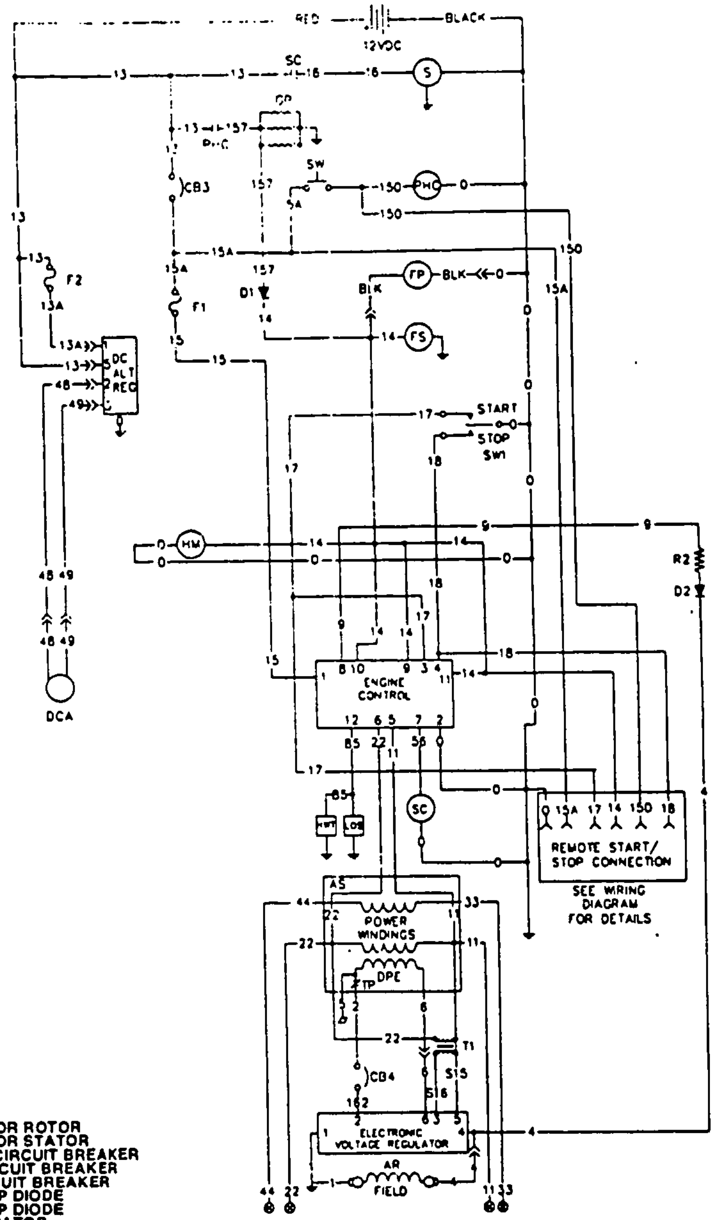
AR -ALTERNATOR ROTOR
AS -ALTERNATOR STATOR
CB1-CIRCUIT BREAKER 30,35A
CB3-CIRCUIT BREAKER (10A)
CB4-CIRCUIT BREAKER (5A)
CR1-RELAY (12V) TPDT
CR2-RELAY (12V) DPDT
D1 -DIODE 600V, 6AMP
D2 -DIODE 600V, 6AMP
DCA-DC ALTERNATOR
DPE -EXCITATION WINDING
F1 -FUSE 14AMP SFE
F2 -FUSE 30A
FS -FUEL SOLENOID
FP -FUEL PUMP
HM -HOURMETER
HWT-HIGH WATER TEMP SWITCH
LOS-LOW OIL PRESSURE SWITCH
PHC -PREHEAT CONTACTOR
R2 -RESISTOR 10 OHM, 5W
S -STARTER
SC -START CONTACTOR
SW -PREHEAT SWITCH
SW1 -SWITCH, START/STOP
T1 -SENSE TRANSFORMER
TP -THERMAL PROTECTOR

CONNECTION OPTIONS



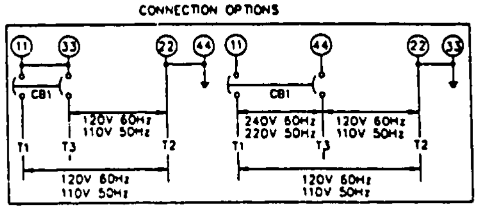
WIRING DIAGRAM
DRAWING NO. 83623



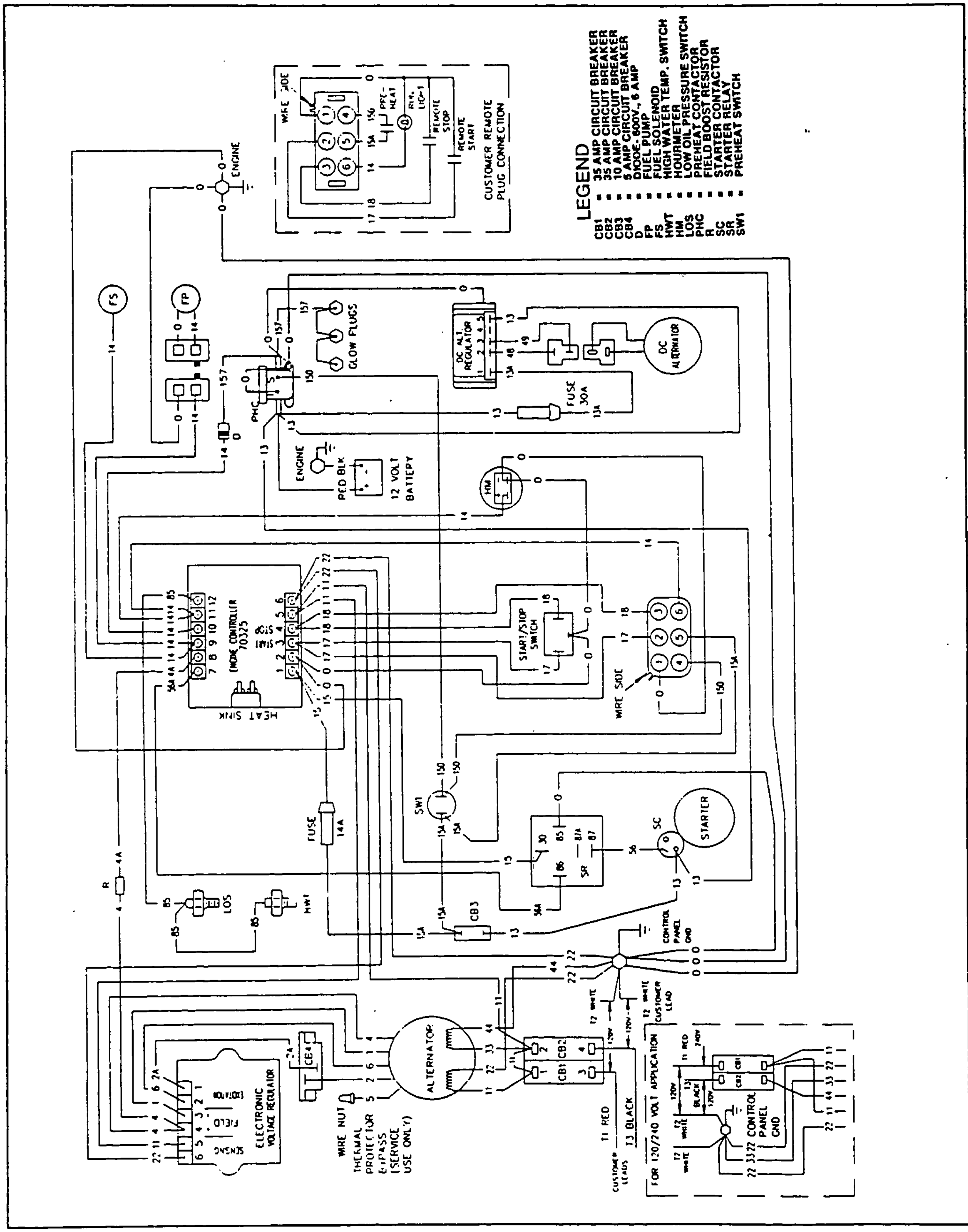


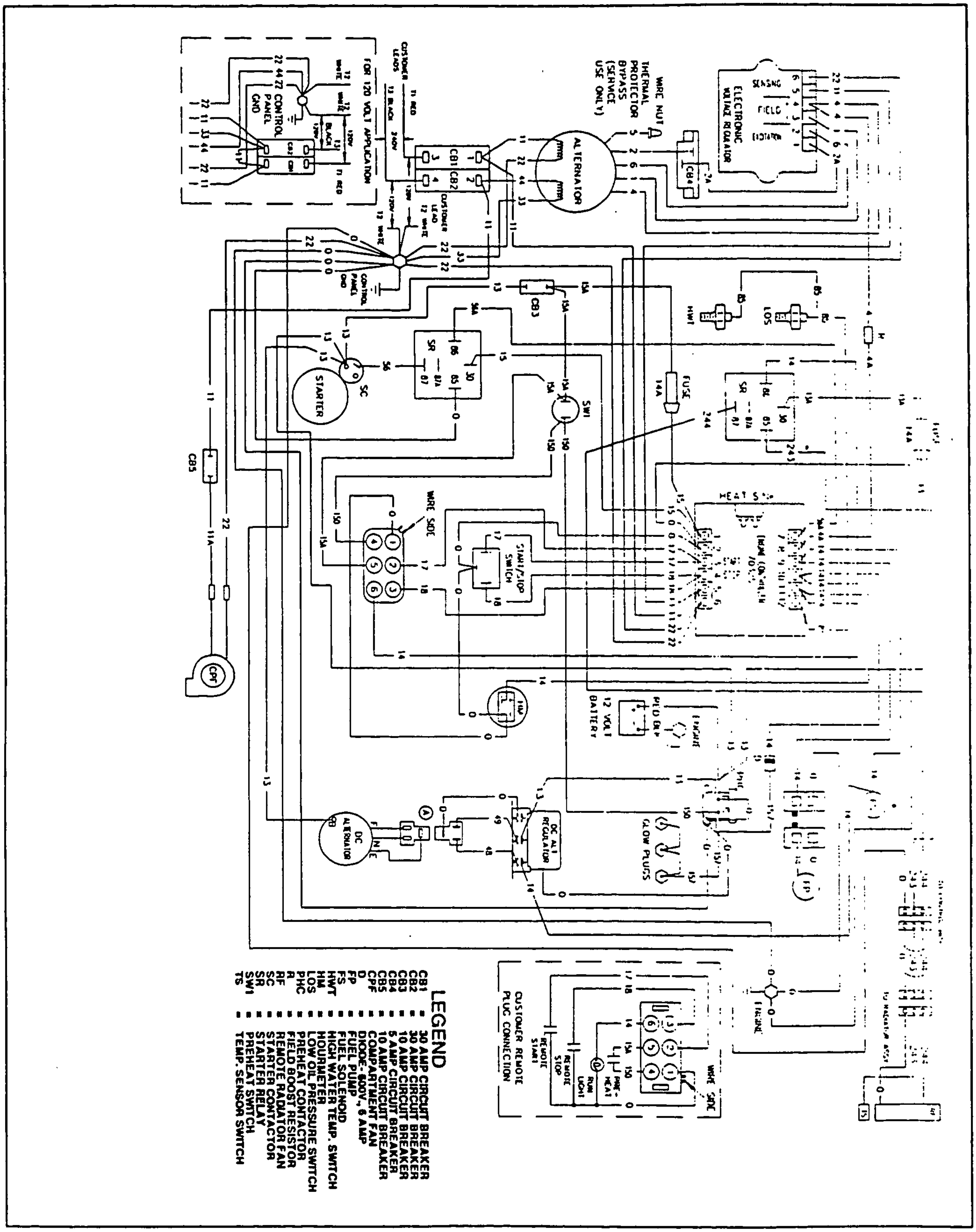
AR = ALTERNATOR ROTOR
AS = ALTERNATOR STATOR
CB1 = 30/35 AMP CIRCUIT BREAKER
CB3 = 10 AMP CIRCUIT BREAKER
CB4 = 5 AMP CIRCUIT BREAKER
D1 = 600V., 6 AMP DIODE
D2 = 600V., 6 AMP DIODE
DCA = DC ALTERNATOR
DPE = EXCITATION WINDING
F1 = 14 AMP FUSE
F2 = 30 AMP FUSE
FP = FUEL PUMP
FS = FUEL SOLENOID
GP = GLOW PLUGS
HM = HOURMETER
HWT = HIGH WATER TEMP. SWITCH
LOS = LOW OIL PRESSURE SWITCH
PHC = PREHEAT CONTACTOR
R2 = 10 OHM, 5 WATT RESISTOR
S = STARTER
SC = STARTER CONTACTOR
SW = PREHEAT SWITCH
SW1 = START/STOP SWITCH
T1 = SENSING TRANSFORMER
TP = THERMAL PROTECTOR

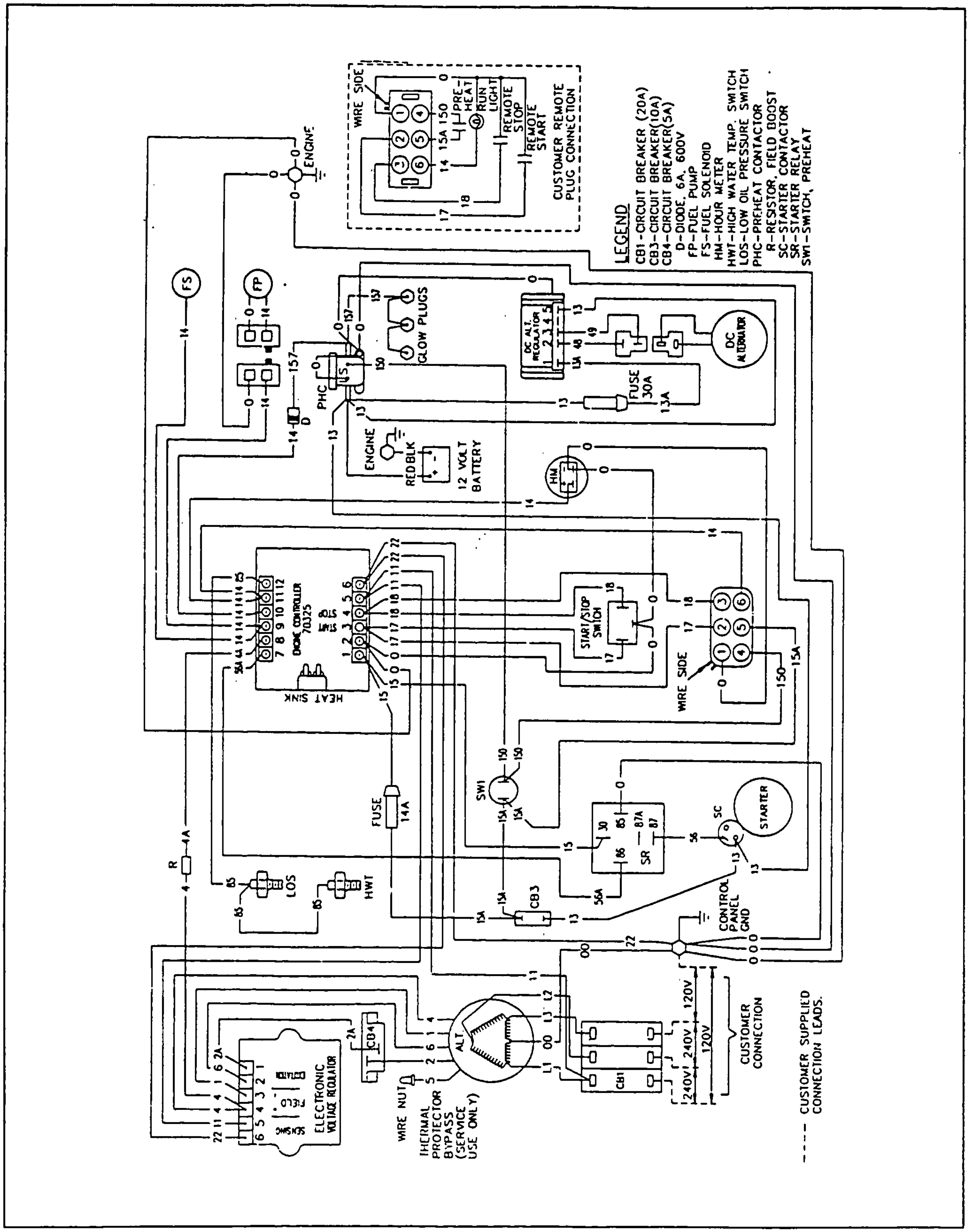
CONNECTION OPTIONS



WIRING DIAGRAM
DRAWING NO. 74875




LEGEND
CB1 = 30 AMP CIRCUIT BREAKER
CB2 = 30 AMP CIRCUIT BREAKER
CB3 = 10 AMP CIRCUIT BREAKER
CB4 = 5 AMP CIRCUIT BREAKER
CB5 = 10 AMP CIRCUIT BREAKER
CPF = COMPARTMENT FAN
D = DIODE-600V., 6 AMP
FP = FUEL PUMP
FS = FUEL SOLENOID
HWT = HIGH WATER TEMP. SWITCH
HM = HOURMETER
LOS = LOW OIL PRESSURE SWITCH
PHC = PREHEAT CONTACTOR
R = FIELD BOOST RESISTOR
RF = REMOTE RADIATOR FAN
SC = STARTER CONTACTOR
SR = STARTER RELAY
SW1 = PREHEAT SWITCH
TS = TEMP. SENSOR SWITCH
ALTERNATOR
STARTER
DC ALTERNATOR
DC ALT REGULATOR
GLOW PLUGS
12 VOLT BATTERY
CUSTOMER REMOTE PLUG CONNECTION
FOR 120 VOLT APPLICATION


WIRE SIDE
PRE-HEAT
RUN LIGHT
REMOTE STOP
REMOTE START
CUSTOMER REMOTE PLUG CONNECTION
LEGEND
CB1-CIRCUIT BREAKER (20A)
CB3-CIRCUIT BREAKER(10A)
CB4-CIRCUIT BREAKER(5A)
D-DIODE, 6A, 600V
FP-FUEL PUMP
FS-FUEL SOLENOID
HM-HOUR METER
HWT-HIGH WATER TEMP. SWITCH
LOS-LOW OIL PRESSURE SWITCH
PHC-PREHEAT CONTACTOR
R-RESISTOR, FIELD BOOST
SC-STARTER CONTACTOR
SR-STARTER RELAY
SW1-SWITCH, PREHEAT
ENGINE
GLOW PLUGS
DC ALT. REGULATOR
DC ALTERNATOR
FUSE 30A
PHC
12 VOLT BATTERY
RED BLK
HM
ENGINE CONTROLLER 70325
START
STOP
HEAT SINK
START/STOP SWITCH
FUSE 14A
SW1
SR
SC
STARTER
LOS
HWT
CB3
CONTROL PANEL GND
ALT.
CB1
CB4
ELECTRONIC VOLTAGE REGULATOR
SENSING
FIELD
EXCITATION
WIRE NUT
THERMAL PROTECTOR BYPASS (SERVICE USE ONLY)
CUSTOMER CONNECTION
CUSTOMER SUPPLIED CONNECTION LEADS.

Electrical Formulae

DESIRED DATA	ALTERNATING CURRENT 1-PHASE UNITS	ALTERNATING CURRENT 3-PHASE UNITS
KILOWATTS NOTE 1	$\frac{\text{Volts x Amps x P.F.}}{1000}$	$\frac{\text{1.73 x Volts x Amps x P.F.}}{1000}$
KVA NOTE 1	$\frac{\text{Volts x Amps}}{1000}$	$\frac{\text{1.73 x Volts x Amps}}{1000}$
HORSEPOWER NOTE 2	$\frac{\text{Volts x Amps x 100 x P.F.}}{\text{746 x Efficiency}}$	$\frac{\text{1.73 x Volts x Amps x 100 x P.F.}}{\text{746 x Efficiency}}$
AMPERES NOTE 3	$\frac{\text{H.P. x 746 x Efficiency}}{\text{Volts x 100 x P.F.}}$	$\frac{\text{H.P x 746 x Efficiency}}{\text{1.73 x Volts x 100 x P.F.}}$
AMPERES NOTE 4	$\frac{\text{Kilowatts x 1000}}{\text{Volts x P.F.}}$	$\frac{\text{Kilowatts x 1000}}{\text{1.73 x Volts x P.F.}}$
AMPERES NOTE 5	$\frac{\text{kVa x 1000}}{\text{Volts}}$	$\frac{\text{kVa x 1000}}{\text{1.73 x Volts}}$
FREQUENCY	$\frac{\text{RPM x No. of Rotor Poles}}{\text{2 x 60}}$	$\frac{\text{RPM x No. of Rotor Poles}}{\text{2 x 60}}$
NO. OF ROTOR POLES	$\frac{\text{2 x 60 x Frequency}}{\text{RPM}}$	$\frac{\text{2 x 60 x Frequency}}{\text{RPM}}$
RPM	$\frac{\text{2 x 60 x Frequency}}{\text{No. of Rotor Poles}}$	$\frac{\text{2 x 60 x Frequency}}{\text{No. of Rotor Poles}}$

NOTE 1: Refers to generator output or load input.
NOTE 2: Refers to engine output.
NOTE 3: If desired data is AMPERES when HORSEPOWER is known.
NOTE 4: If desired data is AMPERES when KILOWATTS are known.
NOTE 5: If desired data is AMPERES when KVA is known.

Efficiency in above formulae in PERCENT- such as 95%.

P.F. (Power Factor) in the above formulae is expressed as a decimal, usually 0.80.

VOLTS refers to line-to-line measurement.