

SECTION 06: ELECTRICAL

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1. GENERAL DESCRIPTION

This vehicle uses a dual voltage system to obtain two different voltages (12 and 24 volts) for various electrical controls and accessories. The main power source incorporates four maintenance-free "Delco" model 1150 batteries connected in a parallel-series configuration. All batteries are kept uniformly charged by means of a 100 amp battery equalizer (standard), giving a maximum possible output supply of 100 amps on the 12 volt system. Both the 12 and 24 volt systems are controlled through individual main battery relays. One or two 24 volt self-rectified alternators are belt driven from the engine, and can be reached through the engine compartment door.

1.1 WIRING DIAGRAMS

A master wiring diagram of the electric circuits, covering standard and optional accessories and systems, is located in the technical publications box. Usually, a separate wiring diagram page is provided for each major function or system. In some cases, more than one circuit may appear on one wiring diagram page; when this occurs, each circuit covered in this page is listed in the wiring diagram index. Moreover, a circuit may appear on several pages; in such case, the number(s) at the extremity of the diagram title will indicate the sheet reference number. Refer to the "*Wiring Diagram Index*" to ensure that the correct diagram is being used to trace the circuit in question.

1.1.1 Wiring Diagram Keys

Various symbols are used on the wiring diagrams to depict different types of electrical components. It is essential to become familiar with these symbols in order to understand the diagrams. The major symbols shown on the diagrams are identified under "*Wiring Diagram keys*" (page **K** of wiring diagrams).

1.1.2 Using Wiring Diagrams

Two methods are used to "*work*" with electric wiring diagrams.

Situation: You have identified the defective part (breaker, diode, relay, etc.), and you wish to locate its corresponding circuit.

Problem: Circuit breaker #56 is released (open circuit) and you don't know which circuit is affected.

- a) Refer to wiring diagram index, and look for "*Circuit breaker code*", pages **F**.
- b) At item CB #56, in the first column, you will find the page on which to find the corresponding diagram, in the second column the breaker ampere rating, and in the third column, the Prévost number. The other columns give you the location and the function of the breaker.
- c) Refer to page 4, keeping in mind the function of the breaker, i.e. emergency exit lights.
- d) When you have located "*emergency exit lights*", follow the wiring until you come across CB #56 and its circuit.

Situation: You have a problem with a specific system and you want to find the corresponding diagram.

Problem: The last three (3) speakers on the R.H. side of vehicle are inoperative and you must trace the electric circuit.

- a) Refer to wiring diagram index and look for "*Sound system*".
- b) You will find on page 26 the components as well as the electric wiring, thus providing you with a complete understanding of this circuit.

1.1.3 Testing Circuits

A careful study of the wiring diagrams should be made to determine the source and flow of current through each circuit. When a circuit is thoroughly understood, a point-to-point check can be made with the aid of the applicable wiring diagrams. Any circuit can be tested for continuity or short circuits with a multimeter or a suitable voltmeter.

All electrical connections must always be kept clean and adequately tight. Loose or corroded connections can result in discharged batteries, difficult starting, dim lights and improper

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functioning of other electric circuits. Inspect all wiring connections at regular intervals. Make sure knurled nuts on all amphenol-type plugs are securely tightened. Knurled nuts on the plastic amphenol-type connectors will click into a detent when properly tightened. Line connectors, who have the side locking tabs, must have the locks latched in place to ensure a proper electrical connection.

1.2 WIRE SIZES AND COLORS

Each wire in the electrical system has a specific size as designated on the wiring diagram. When replacing a wire, the correct size must be used. Never replace a wire with one of a smaller size.

The vehicle electrical system is provided with different voltages. The insulation on each wire is distinctly colored in order to determine visually the wiring voltage and to assist in making connectors. The wires are color coded as follows:

Red	24 volt system
Yellow	12 volt system
Black	grounded wire
Blue	110 V ac system (live)
White	110 V ac system (neutral)
Green	110 V ac system (ground)
Orange	speakers (+)
Brown	speakers (-)
Grey	spare wire

Note: Wires are identified at each 4-6 inch (10-15 cm) intervals by a printed number.

Each wire on a diagram is patterned to assist in tracing and testing circuits. The wire number identifies the voltage rating, the wire identification number and the basic wire gauge as illustrated in figure 1.

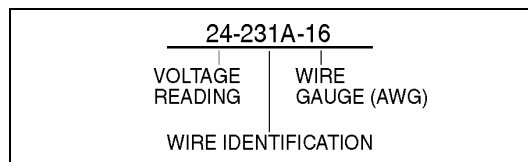


FIGURE 1: WIRE IDENTIFICATION

1.3 SPARE WIRES

When the vehicle leaves the factory, and even in the case of a fully-equipped vehicle, an important number of unconnected spare wires are routed between the junction boxes. Consequently, for any connection of an additional accessory, refer to page D "Spare wires" in master

wiring diagram to determine the number, the gauge and location of these wires.

Note: Spare wires are identified by a wire identification number and by the letters "SP", to designate "spare".

1.4 CLEANING CONNECTORS

When the pins and sockets of connectors become dirty, clean them with a good quality solvent containing HFC 134A refrigerant as its active ingredient. HFC 134A has two qualities that recommend it. First, it does not conduct electricity and therefore, will not cause shorting between connector pins and sockets. Second, it evaporates quickly, eliminating the possibility of condensation within the connectors.

Always shake out or gently blow out any excess HFC 134A before assembling a connector to its mating connector or hardware. HFC 134A trapped in the connector can affect the connector seal.

Warning: HFC 134A is toxic. HFC 134A bases compounds should always be used in a well-ventilated area, never in a confined space. Use outdoor whenever possible.

1.5 CIRCUIT BREAKERS

Most electric circuits are protected by circuit breakers of the "Manual Reset" type. The main circuit breakers, as well as those protecting the A/C system, are located in the main power compartment, on R.H. side of the vehicle, figure 2.

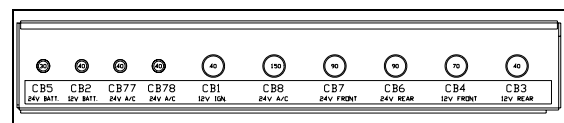


FIGURE 2: MAIN BREAKERS

CIRCUIT BREAKERS			
CB1	Ignition	12 volts	40 amps
CB2	Hot Wire	12 volts	40 amps
CB3	Rear Junction Box	12 volts	40 amps
CB4	Front Junction Box	12 volts	70 amps
CB5	Hot Wire	24 volts	30 amps
CB6	Rear Junction Box & Starter Relay	24 volts	90 amps

CIRCUIT BREAKERS			
CB7	Front Junction Box & Inverter Compartment	24 volts	90 amps
CB8	A/C Junction Box & Evaporator Fan	24 volts	150 amps
CB77	Condenser Fan Motor RH	24 volts	40 amps
CB78	Condenser Fan Motor LH	24 volts	40 amps

The smaller circuit breakers are accessible in front and L.H. rear electrical compartments. This type of circuit breaker deenergizes the circuit without disconnecting any wire. Simply press down the red tab on breaker to open the circuit, repair defective circuit, and afterwards depress black button in center of breaker to close the circuit.

1.6 RELAYS

Relays are used to automatically energize or deenergize a circuit from a remote location. The relay draws a very low current to energize its coil. Once the coil is energized, it develops a magnetic field that pulls a switch arm closed or open, to either energize or deenergize a given component. As the control current required for the coil is very low, the relay allows a remote station to control a high energy circuit without running great lengths of costly high capacity cable, and also eliminates the need for high amperage switches and heavy connectors.

Many systems on this vehicle are provided with control relays, which are all, located in or on the junction boxes, figure 3.

Note: Each relay is identified with “12 V” or “24 V” printed on its casing in order to identify the coil operating voltage.

Caution: The magnetic relays for the starting motor, evaporator and both condenser motors and condenser speed controls should have the 5/16” stud nuts torqued to $50 \pm 5 \text{ in}\cdot\text{lbf}$ ($5,5 \pm 0,5 \text{ N}\cdot\text{m}$).

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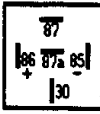
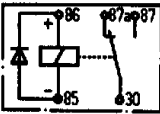
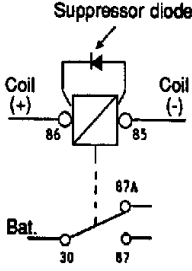
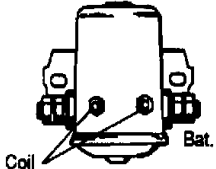
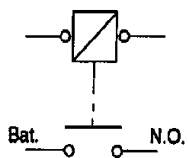
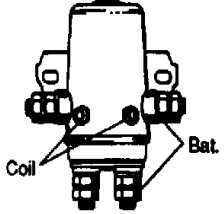
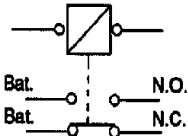
	Configuration on base	Key printed on casing	Key used on wiring diagram	Example
<p>Cubic relay (Steel or plastic casing) Type: S.P.D.T.</p> 				R #5
<p>NOTE: This relay is provided with an internal suppressor diode; never reverse wiring terminals #85 and 86 at base as a direct short circuit will result.</p> <p>The relay coils connected to the alternator "relay terminal" should never be provided with a suppressor diode as the output current at this terminal is not rectified, thus rendering relay inoperative.</p>				
<p>Magnetic relay (Round steel casing) Type: S.P.S.T.</p> 	None	None		R #4
<p>Magnetic relay (Round steel casing) Type: D.P.D.T.</p> 	None	None		R #40
<p>LEGEND</p> <p>Bat. Battery N.O. Normally Open N.C. Normally Closed S.P.D.T. Single Pole Double Throw S.P.S.T. Single Pole Single Throw D.P.D.T. Double Pole Double Throw</p>				

FIGURE 3: TYPES OF RELAYS

2. ELECTRICAL COMPARTMENTS AND JUNCTION BOXES

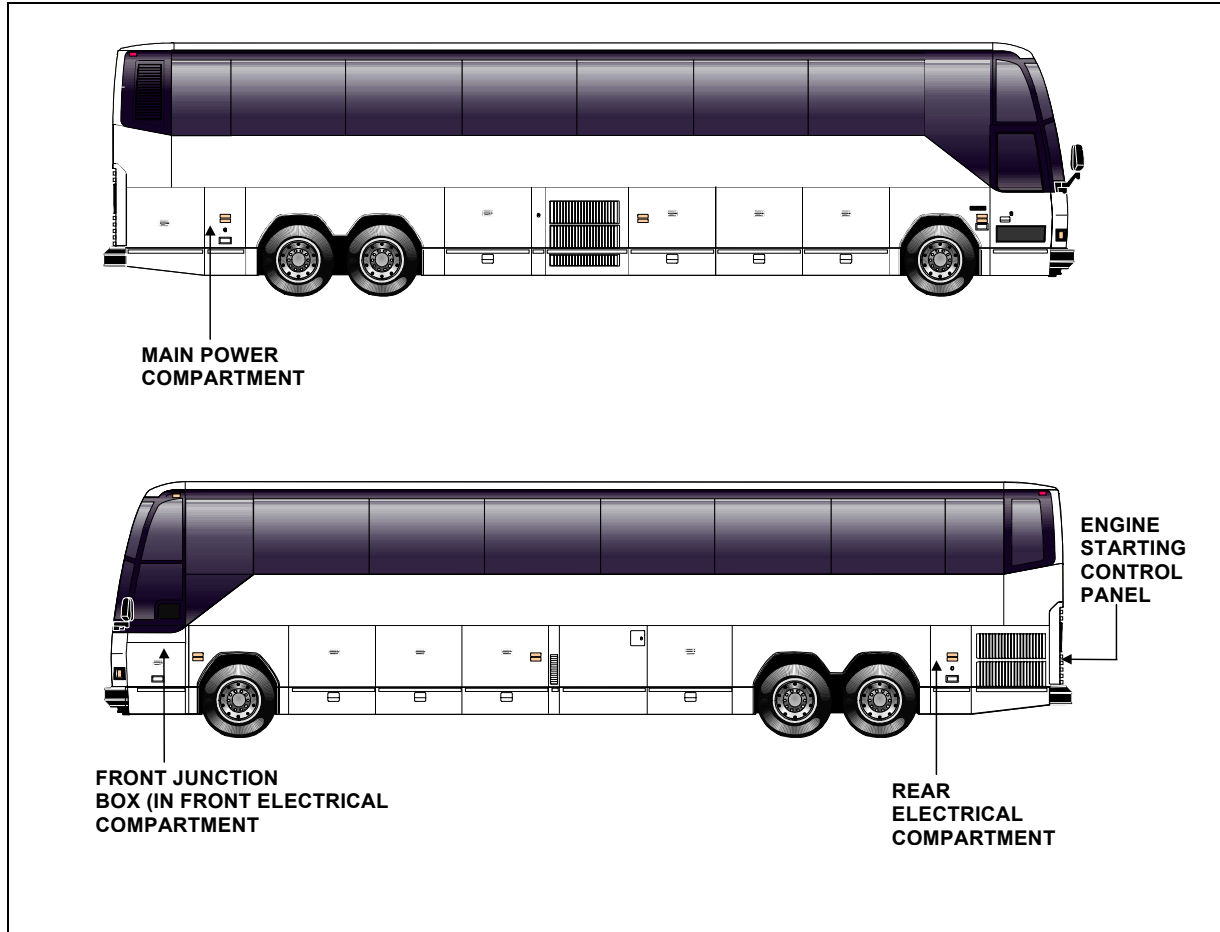


FIGURE 4: ELECTRICAL COMPARTMENTS

2.1 MAINTENANCE

A Cortec VCI-238 corrosion inhibitor has been sprayed in all electrical compartments to protect components from corrosion. The life expectancy of this product is five years, so it is recommended to reapply it every five years. It is also recommended to spray it on new components when added or replaced.

Warning: Use VIC-238 in a well ventilated area. Do not smoke. Avoid prolonged contact with skin and breathing of spray mist. Harmful or fatal if swallowed. Do not induce vomiting. Call physician immediately.

2.2 MAIN POWER COMPARTMENT

The main power compartment is located on rear R.H. side of vehicle aft of the rear wheelhousing. This compartment contains the following components (Fig. 5 and 6):

- Four 12 volts batteries;
- Main circuit breakers;
- Voltage regulator;
- Battery equalizer;
- Electric system monitor;
- Main battery relays (safety switch);
- Battery booster block.

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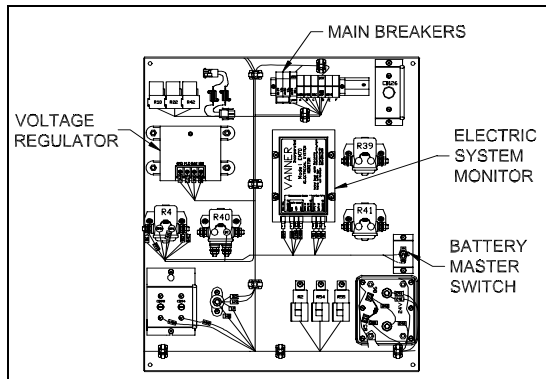


FIGURE 5: MAIN POWER COMPARTMENT

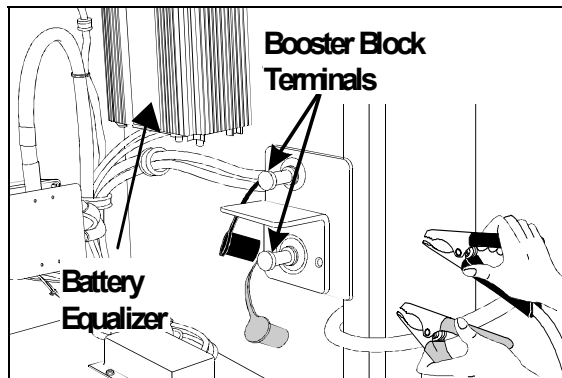


FIGURE 6: MAIN POWER COMPARTMENT

2.3 REAR ELECTRIC COMPARTMENT AND JUNCTION BOX

The rear electric compartment is located on L.H. side of vehicle aft of the rear wheelhousing (Fig.4). It contains the rear junction box with the following components (Fig. 7 and 8):

- ECU (Electronic Control Unit) for Allison World Transmission;
- Vehicle interface module;
- Secondary circuit breaker;
- Relays;
- Programmable speed switch.

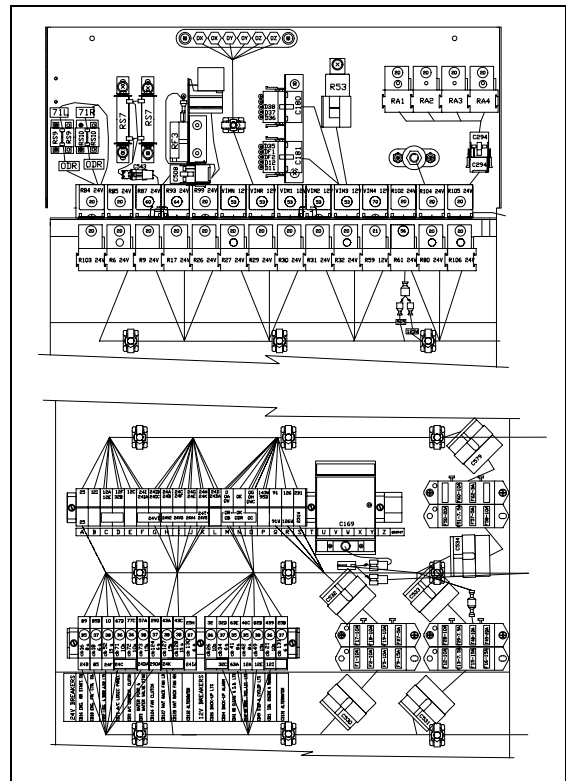


FIGURE 7: REAR ELECTRIC COMPARTMENT

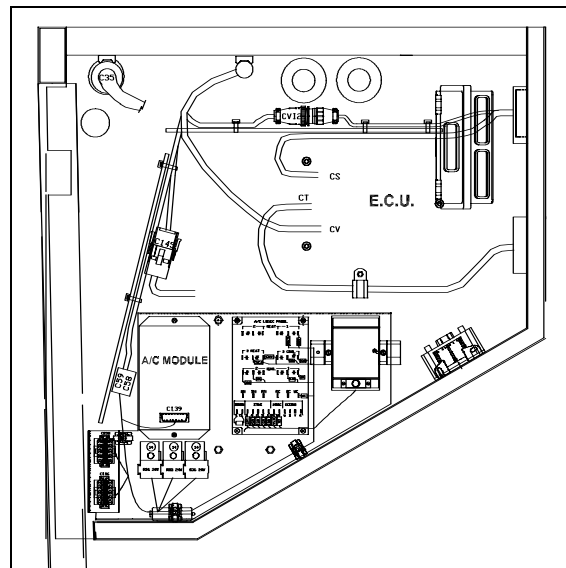


FIGURE 8: REAR ELECTRIC COMPARTMENT

2.4 FRONT ELECTRIC AND SERVICE COMPARTMENT

The front electric and service compartment is located on front L.H. side of vehicle. It contains the front junction panel with the following components (Fig. 9 and 10).

- Circuit breakers
- Resistors
- Pulse regulator (upper wiper)
- Electric flasher
- Fuses
- Relays
- Alarm
- Junction blocks

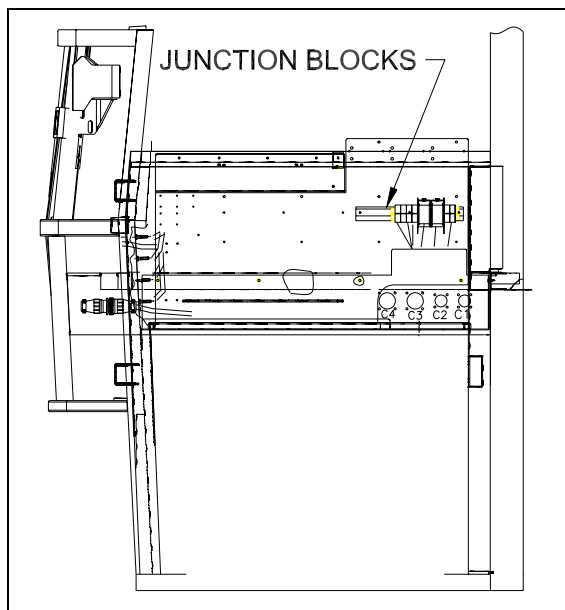


FIGURE 9: FRONT ELECT. & SERVICE COMPARTMENT

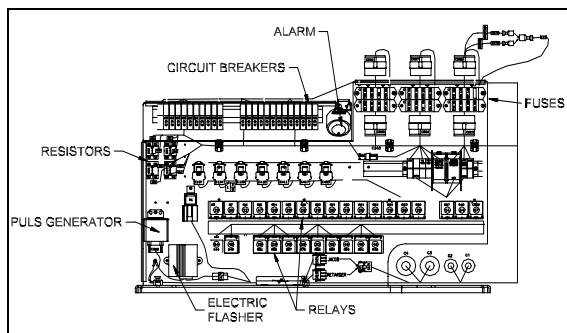


FIGURE 10: FRONT ELECT. & SERVICE COMPARTMENT

2.5 ENGINE STARTING CONTROL PANEL

This control panel is located in the R.H. side of engine compartment near the engine oil reserve tank. This control panel includes the engine starter selector switch, as well as the rear start push button switch to start engine from engine compartment.

2.6 A/C AND HEATING CONTROLS

The following components are located in the rear electric compartment (see Fig. 8). They are located on the front wall or the L.H. side wall, when facing the compartment:

- A/C module
- A/C Logic panel (W973B module)
- Electronic transmitter (T7067B)
- Relay R34 – A/C logic panel
- Relay R35 – Water booster pump
- Relay R36 – A/C compressor clutch
- Relay R38 – A/C liquid solenoid valve
- Diodes

Each component is well identified to facilitate its location (Fig. 11).

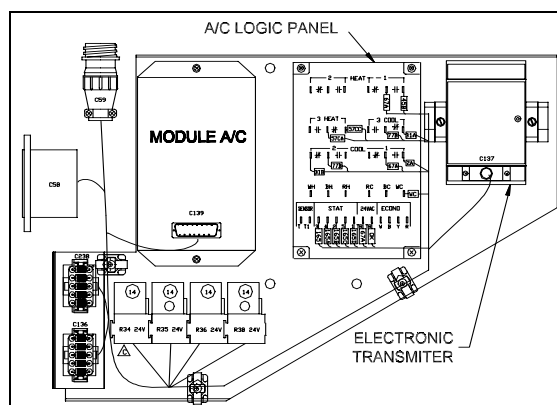


FIGURE 11: A/C AND HEATING CONTROLS

The following relays are located in the main power compartment. They are mounted on the control panel located on the back wall when facing the compartment:

- R39 – Condenser fan motor
- R40 – Condenser speed control HI

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- R41 – Condenser speed control HI

Each relay is identified to facilitate its location (Fig. 12).

Note: It is important when checking the A/C and heating system to keep the condenser compartment door closed in order to avoid faulty readings.

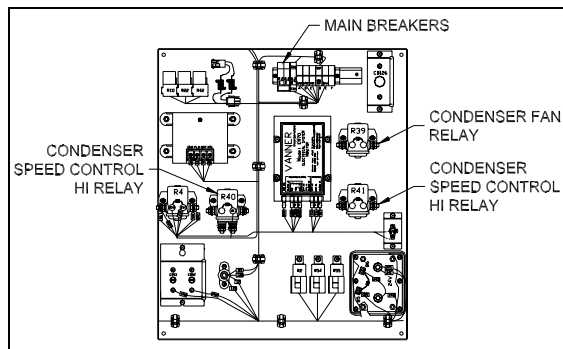


FIGURE 12: MAIN POWER COMPARTMENT

3. BATTERIES

The vehicle is provided with four (4) maintenance-free 12 volt heavy-duty batteries connected in series-parallel (Fig. 13). The top-mounted negative and positive terminals are tightly sealed to prevent leaks. Water never needs to be added to this type of battery. There are no filler caps in the cover. The battery is sealed, except for small vent holes in the cover. The vents must not be restricted as they allow small amounts of gases produced in the battery to escape. The special chemical composition inside the battery reduces gassing to a very small amount at normal charging voltages. Besides reducing gassing, the special chemistry greatly reduces the possibility of overcharge damage.

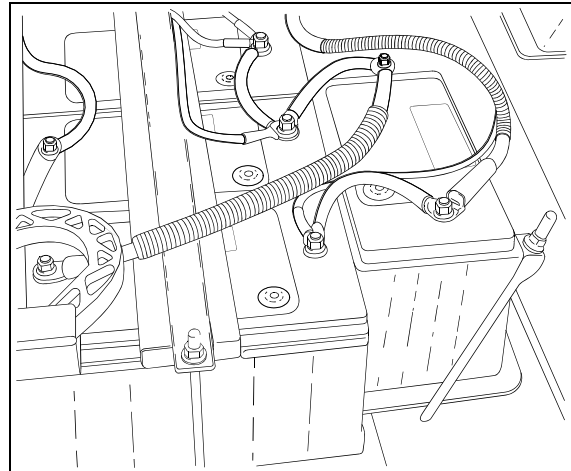


FIGURE 13: BATTERIES

The vents require keeping the battery in an upright position to prevent electrolyte leakage. Tipping the battery beyond a 45° angle in any direction can allow a small amount of electrolyte to leak out of the vent holes.

Warning: DO NOT tip battery by more than 45° when carrying or installing the battery.

Note: Evidence of electrolyte leakage does not necessarily mean the battery is defective.

With special cables properly attached to batteries, the metal surfaces that carry the current are completely sealed from the atmosphere. This prevents terminal oxidation and corrosion that may cause starting and charging problems. If new cables are required, sealed terminal cable replacements should be used to retain the reliability of the original maintenance-free connections.

Warning: All lead-acid batteries generate hydrogen gas, which is highly flammable. If ignited by a spark or flame, the gas may explode violently, causing spraying of acid, fragmentation of the battery, which may result in severe personal injuries. Wear safety glasses and do not smoke when working near batteries. In case of contact with acid, flush immediately with water.

The battery has four (4) major functions:

1. Providing a source of current for starting the engine.
2. Stabilizing the voltage in the electrical system;

3. Supplying current for a limited time, when electrical demands of the equipment exceed the power output of the alternator;
4. Providing a limited source of power for connected accessories, when the engine is not running.

3.1.1 Main Battery Relays

Main battery relays (12 V. and 24 V.) are provided for this vehicle. The relays are located in the main electrical compartment. The 24 volt battery relay is actuated by two master switches connected in series, the first one located in the main power compartment (refer to fig. 5), and the second one located on the dashboard.

When the main battery relays are turned to the *OFF* position, all electrical supply from the batteries is cut off, with the exception of the following items.

- Battery equalizer check module;
- ECM;
- ECU power (World transmission);
- Preheater electronic timer;
- Preheater and water recirculating pump;
- Sedan entrance door;
- Radio memory
- Cluster memory.

3.2 BATTERY REMOVAL AND INSTALLATION

1. Remove the two screws at the bottom of the plastic protective cover. Unscrew the two quarter turn nuts to remove the protective cover.
2. Remove supports. Unscrew terminal nuts of each defective battery.

Note: Battery main relays should be in the “Off” position before disconnecting cables from the batteries.

3. Remove battery cables from the batteries.

Note: When the battery cables have been removed from the batteries, wrap the battery terminals and cable ends with electric tape to prevent accidental grounding. The ground cables should always be disconnected first and replaced last.

4. Remove batteries.

5. Installation is the reverse of removal.

Note: In replacing batteries, only batteries of the same specification should be used. Refer to “Specifications” at the end of this section for further details.

Caution: Ensure that connections are not reversed when reinstalling batteries, since damage to electrical system components will result.

When reinstalling batteries, battery connections must be tightened to 10-15 ft-lbf (13-20 N•m) and the nut on top of sliding tray to 45-55 in-lbf (5-6 N•m). A torque wrench is required to ensure an accurate tightening torque.

Warning: To prevent possible electric shock or sparking, the battery main relays must be set to the “Off” position before tightening an electrical connection.

Note: A protective silicone free, coating should be applied on all terminals that have been disconnected. We recommend the use of Cortec VCI-238 (Prévost #682460) on all electrical connections.

3.3 BATTERY RATING

Each of the 12 volt batteries used on the vehicle has the following rating:

- Reserve capacity: 180 minutes
- Cold cranking (amps): 625 @ 0°F (-18°C)
- Cold cranking (amps): 490 @ -20°F (-29°C)
- Weight (filled): 59 lb. (26,7 kg)

The reserve capacity is defined as the number of minutes a new, fully charged battery at 80 F (26,6 C) can be discharged at 25 amperes and maintain a minimum of 1.75 volts per cell (10.5 volts total for one 12 volts battery). This rating can be used as a basis for determining how long a vehicle might run after an alternator failure.

Section 06: ELECTRICAL

The cold cranking rating is defined as the minimum discharge current a battery will deliver in amperes for 30 seconds at 0 F (-18 C) while maintaining a minimum of 1.2 volts per cell (7.2 volts total for one 12 volts battery). This rating can be used as a basis for comparing starting performance.

3.4 BATTERY TESTING

The maintenance-free battery has a strong ability to withstand the damaging effects of overcharge. The test indicator in the cover is used only to determine if the battery can be tested in case of a cranking problem.

The test indicator in the battery cover is to be used with accepted diagnostic procedures only. It must not be used to determine if the battery is good or bad, charged or discharged. The test indicator is a built-in hydrometer in one cell that provides visual information for battery testing (Fig. 14).

It is important when observing the test indicator, that the battery be relatively level and has a clean indicator top to see the correct indication. Some lighting may be required in poorly lit areas. Under normal operation, two indications can be observed.

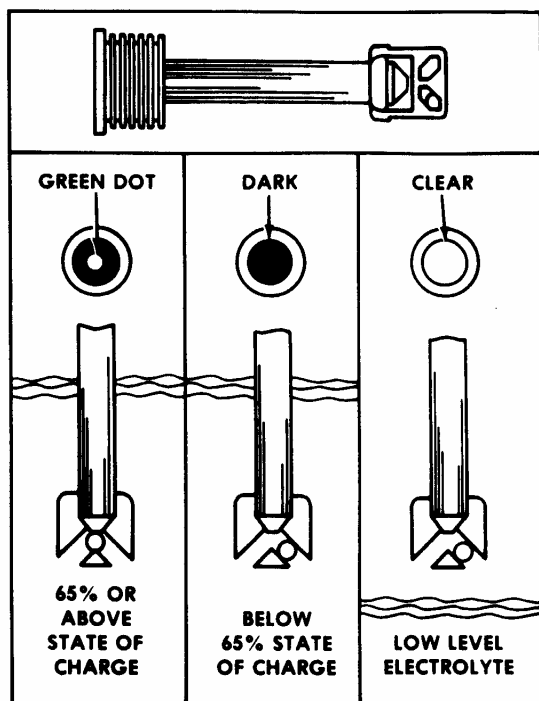


FIGURE 14: TEST INDICATOR

Green Dot Visible

Any green appearance is interpreted as a "green dot", and the battery is ready for testing. On rare occasions, following prolonged cranking, the green dot may still be visible when the battery is obviously discharged. Should this occur, charge the battery as described under "Charging Procedure" in "Battery Charging" later in this section.

Dark - Green Dot Not Visible

If there is difficulty cranking the engine, the battery should be tested as described in this section. On rare occasions, the test indicator may turn light yellow. In this case, the integral charging system should be checked. Normally, the battery is capable of further service; however, if difficult start has been reported, replace the battery. **DO NOT CHARGE, TEST, OR JUMP-START.**

3.4.1 Visual Inspection

1. Check the outside of the battery for a broken or cracked cover or case that could permit loss of electrolyte. If obvious physical damage is noted, replace the battery.
2. Check for loose terminal posts, cable connections, damaged cables, and for evidence of corrosion. Correct conditions as required before proceeding with tests.

3.4.2 Removing Surface Charge

Disconnect cables from the battery and attach alligator clamps to the contact lead pad on the battery as shown in figure 16. Connect a 300 ampere load across the terminal for 15 seconds to remove surface charge from the battery.

3.4.3 Load Test

This test is one means of checking the battery to determine its ability to function as required in the vehicle.

To make this test, use test equipment that will withstand a heavy electrical load from the battery, such as a carbon pile resistor or other suitable means.

1. Connect a voltmeter, ammeter, and a variable load resistance as illustrated in figure 15.

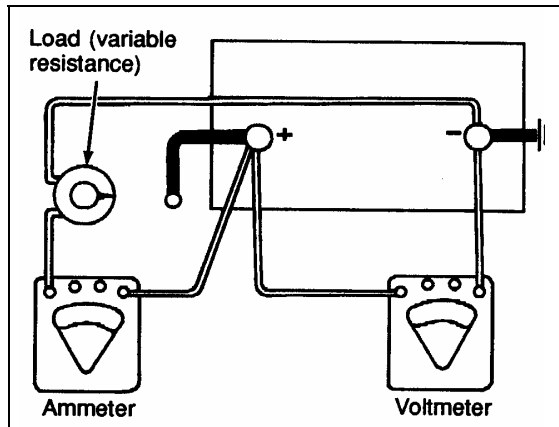


FIGURE 15: LOAD TEST

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Caution: Observe polarity of the meters and the battery when making connections, and select the correct meter range.

2. Apply a 290 amperes load to the battery for 15 seconds.
3. With an ammeter reading specified load, read voltage. The voltage should be at least 9.6 volts. Disconnect the load. If the voltmeter indicates 9.6 volts or more, the battery is good. If the voltmeter reading is less than 9.6 volts, replace the battery. This voltage is to be used for battery ambient temperatures of 70°F (21°C) and above. For temperatures below 70°F (21°C), refer to the following "Voltage and Temperature Chart".

Voltage and Temperature Chart

Ambient Temperature	Minimum Voltage
70°F (21°C) and above	9.6
60°F (16°C)	9.5
50°F (10°C)	9.4
40°F (4°C)	9.3
30°F (-1°C)	9.1
20°F (-7°C)	8.9
10°F (-12°C)	8.7
0°F (-18°C)	8.5

Note: The accuracy of this test procedure is dependent upon close adherence to the proper load, time and temperature specifications.

3.4.4 Testing Battery Cables

Check all cable ring terminals and connections to determine if they are in good condition. Excessive resistance, generally caused by poor connections, produces an abnormal voltage drop which may lower voltage at the starter to such a low value that normal operation of the starter will not be obtained. An abnormal voltage drop can be detected with a low-reading voltmeter as follows:

Warning: To prevent the engine from starting, the DDEC engine circuits, which are protected by breakers (CB-19, CB-20 and CB-21) located in the main power compartment, must be deenergized during these tests; afterward, depress black button to close circuit.

1. Check voltage drop between grounded (negative) battery terminal and vehicle frame by placing one prod of the voltmeter on the battery terminal and the other on a good ground (unpainted surface) on the vehicle. With the starter cranking the engine at a temperature of 70°F (21°C), voltage reading should be less than 0.3 volt. If the voltage reading exceeds 0.3 volt, there is excessive resistance in this circuit.
2. Check voltage drop between the positive battery terminal and the starter positive terminal stud while the motor is operated. If the reading is more than 2.5 volts, there is excessive resistance in this circuit.
3. Check voltage drop between the starter housing and a good ground on the vehicle. The reading should be less than 0.2 volt.

Note: If it is necessary to extend the voltmeter lead for this test, use a #16 (AWG) or larger wire.

Warning: Any procedure other than the following could cause personal injury or damages to the charging system resulting from battery explosion or electrical burns.

Section 06: ELECTRICAL

Wear adequate eye protection when working on or near the batteries. Ensure that metal tools or jumper cables do not contact the positive battery terminal (or a metal surface in contact with it) as a short circuit will result. Do not attempt to jump start a vehicle suspected of having a frozen battery because the battery may rupture or explode. Both the booster and discharged batteries must be treated carefully when using jumper cables. Follow exactly the procedure outlined later in this section, being careful not to cause sparks.

3.5 BATTERY CHARGING

Warning: During charging of the batteries, an explosive gas mixture forms in each cell. Part of this gas escapes through the vent holes and may form an explosive atmosphere around the battery itself if ventilation is poor. This explosive gas may remain in or around the battery for several hours after it has been charged. Sparks or flames can ignite this gas causing an internal explosion, which may shatter the battery.

1. Do not smoke near a battery which is being charged or which has been recently charged.
2. Do not break live circuits at battery terminals because a spark usually occurs at the point where a live circuit is broken. Care must always be taken when connecting or disconnecting booster leads or cable clamps on chargers. Poor connections are a common cause of electric arcs, which cause explosions.
3. The electrical system on this vehicle is negative ground. Installing the batteries with the positive terminals grounded or incorrect use of the booster battery and jumper cables will result in serious damage to the alternator, batteries and battery cables.

The batteries used on this vehicle can be charged either on or off the vehicle; however, when they are removed from the vehicle, it is recommended that an adapter kit, which is available from any "A/C DELCO" dealer, be used in charging sealed-terminal batteries. Use the booster block to charge the batteries when they are left on vehicle and **make sure that the main battery disconnect switch is set to the "On" position.**

The alligator clamps of the tester or charger must be placed between the terminal nuts and the lead pads of the terminal studs (Fig. 16) after the vehicle cables are detached. The alligator clamps should make firm contact with the lead pads.

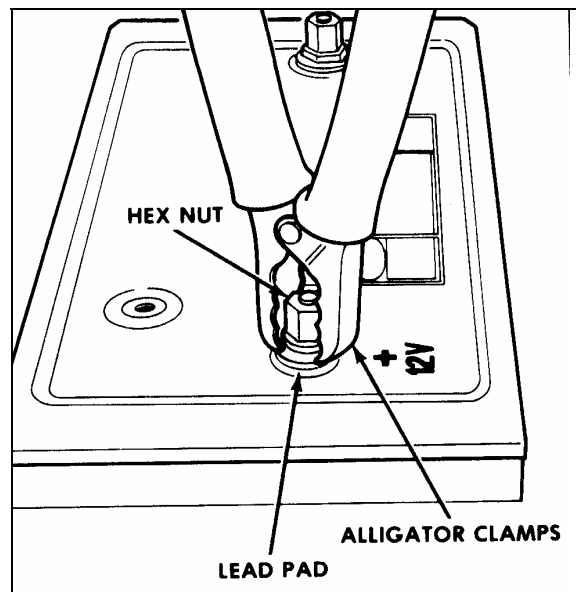


FIGURE 16: ALLIGATOR CLAMPS AND BATTERY 06065

Note: If this connection cannot be made because of the alligator clamp design, the load value for testing must be reduced from 290 to 260 amperes.

On rare occasions, such as those that occur following prolonged cranking, the green dot in the test indicator may still be visible when the battery is obviously discharged. Should this occur, a boost charge of 20 amperes-hour is recommended. Under normal operating conditions, do not charge battery if the green dot is visible. The battery should never be charged if the test indicator (hydrometer) is clear or light yellow. If this occurs, replace the battery.

A charge rate between 3 and 50 amperes is generally satisfactory for any maintenance-free battery as long as spewing of electrolyte does not occur or the battery does not feel excessively hot (over 125°F (52°C)). If spewing or violent gassing of electrolyte occurs or battery temperature exceeds 125°F (52°C), the charging rate must be reduced or temporarily stopped to allow cooling and to avoid damaging the battery.

Battery temperature can be estimated by touching or feeling the battery case. The battery

is sufficiently charged when the green dot in the built-in hydrometer is visible. No further charging is required. Shake or tilt the battery at hourly intervals during charging to mix the electrolyte and see if the green dot appears.

Warning: Always turn off the charger before connecting or disconnecting to a battery.

Note: The charge rate must be doubled when the batteries are charged by the booster block, because of the series-parallel circuit.

Battery charging consists of a charge current in amperes for a period of time in hours. Thus, a 25 ampere charging rate for 2 hours would be a 50 ampere-hour charge to the battery. Most batteries, whose load test values are greater than 200 amperes, will have the green dot visible after at least a 75 ampere-hour charge. In the event that the green dot does not appear, replace the battery.

3.5.1 Battery Charging Guide

Fast Charging Rate

- 20 amps @ 3-3/4 hours
- 30 amps @ 2-1/2 hours
- 40 amps @ 2 hours
- 50 amps @ 1-1/2 hours

Slow Charging Rate

- 5 amps @ 15 hours
- 10 amps @ 7-1/2 hours

The time required for a charge will vary according to the following factors:

Size of Battery

For example, a completely discharged large heavy-duty battery requires more than twice the recharging time of a completely discharged small passenger car battery.

Temperature

For example, a longer time will be needed to charge any battery at 0°F (-18°C) than at 80°F (27°C). When a fast charger is connected to a cold battery, the current accepted by the battery will be very low at first, then in time, the battery will accept a higher rate as it warms.

State of Charge

For example, a completely discharged battery requires more than twice as much charge than a half-charged battery. Since the electrolyte is nearly pure water and a poor conductor in a completely discharged battery, the current accepted is very low at first. Later, as the charging current causes the electrolyte acid content to increase, the charging current will likewise increase.

Charger Capacity

For example, a charger which can supply only 5 amperes will require a much longer period of charging than a charger that can supply 30 amperes or more.

3.5.2 Emergency Jump Starting With Auxiliary (Booster) Battery

Warning: Do not jump start vehicles equipped with maintenance-free batteries if the test indicator is light yellow.

Both booster and discharged batteries should be treated carefully when using jumper cables. A vehicle with a discharged battery may be started by using energy from a booster battery or the battery from another vehicle.

Warning: Jump starting may be dangerous and should be attempted only if the following conditions are met:

The booster battery or the battery in the other vehicle must be of the same voltage as the battery in the vehicle being started, and must be negative grounded.

If the booster battery is a sealed-type battery without filler openings or caps, its test indicator must be dark or a green dot must be visible. Do not attempt jump starting if the test indicator of the booster battery or the discharged battery has a light or bright center.

Warning: Follow the procedure exactly as outlined hereafter. Avoid making sparks.

1. Wear eye protection and remove rings, watches with metal bands and other metal jewelry.
2. Apply parking brake and place the transmission shift lever or push-button pads

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in Neutral (N) position in both vehicles. Turn off lights, heater and other electrical loads. Observe the charge indicator. If the indicator in the discharged battery is illuminated, replace the battery. **Do not** attempt jump starting when indicator is illuminated. If the test indicator is dark and has a green dot in the center, failure to start is not due to a discharged battery and the cranking system should be checked. If charge indicator is dark but the green dot does not appear in center, proceed as follows:

3. Connect one end of one red jumper cable to the positive (+) terminal of the booster power source and the other end to the positive (+) post of the booster power block, located in the main electrical compartment (refer to fig. 6).
4. Connect one end of the remaining negative jumper cable (black) to the negative (-) terminal of the booster power source, and the other end of the black jumper cable to the negative (-) post of the booster power block.
5. Make sure the clips from one cable do not inadvertently touch the clips on the other cable. Do not lean over the battery when making connections. The ground connection must provide good electrical conductivity and current carrying capacity.
6. Start the engine in the vehicle that is providing the jump start. Let the engine run for a few minutes, then start the engine in the vehicle that has the discharged batteries.
7. When removing the jumper cables, perform the above procedure exactly in reverse order, and replace protective caps on booster block terminals.

Warning: Any procedure other than the above could result in personal injury, property damage due to battery explosion, or damage to the charging system of the booster vehicle or of the boosted vehicle

Note: Jumper cables must withstand 500 cranking amperes. If cable length is 20 feet (6m) or less, use 2/0 (AWG) gauge wires. If cable length is between 20-30 feet (6-9m), use 3/0 (AWG) wires.

3.6 CLEANING AND INSPECTION

The external condition of the battery and the battery cables should be checked periodically. The top of the battery should be kept clean and the battery hold-down clamp bolts should be kept properly tightened. For best results when cleaning the battery, wash first with a diluted solution of ammonia or soda to neutralize any acid present, then wash out with clean water. The battery hold-down bolts should be kept tight enough to prevent the batteries from moving, but they should not be tightened to the point that excessive strain is placed on the battery hold-down cover (proper tightening torque: 45-55 in•lbf (5-6 N•m)).

To insure good contact, the battery cable ring terminals should be tight on the battery posts. If the posts or cable ring terminals are corroded, the cables should be disconnected and the posts and clamps cleaned separately with a soda solution and a wire brush. Install cable ring terminals on battery posts and tighten to a torque of 10-15 ft•lbs (13-20 N•m). Replace protective caps to prevent corrosion and sparks.

3.7 COMMON CAUSES OF BATTERY FAILURE

When a battery fails, the cause of failure may be related to something other than the battery. For this reason, when a battery failure occurs, do not be satisfied with merely recharging or replacing the battery. Locate and correct the cause of the failure to prevent recurrence. Some common external causes of battery failure are as follows:

1. A defect in charging system such as high resistance or a faulty alternator or regulator.
2. A malfunction within the 12 volts system (equalizer).
3. Overloads caused by a defective starter or excessive use of accessories.
4. Dirt and electrolyte on top of the batteries causing a constant drain.
5. Hardened battery plates, due to battery being in a low state of charge over a long period of time.
6. Shorted cells, loss of active material from plates.

7. Driving conditions or requirements under which the vehicle is driven for short periods of time.
8. A constant drain caused by a shorted circuit such as an exposed wire or water infiltration in junction boxes causing ground fault.
9. Extended operation of preheating system with engine not running.
10. Failing to close disconnect switches during the night.

3.8 TROUBLESHOOTING

If a battery is known to be good and then has not performed satisfactorily in service for no apparent reason, the following factors may reveal the cause of trouble:

1. Vehicle accessories and disconnect switches inadvertently left on overnight.
2. Defects in the charging system, such as high wiring resistance, faulty alternator, regulator or battery equalizer.
3. A vehicle electrical load exceeding the alternator (or battery equalizer) capacity, with the addition of electrical devices, such as CB radio equipment, a cellular phone or additional lighting systems.
4. Defects in the electrical system, such as shorted or pinched wires.
5. Extended driving at a slow speed while using many accessories.
6. Loose or poor battery cable-to-post connections, previous improper charging of a run-down battery, or loose hold-down clamp bolts.
7. High-resistance connections or defects in the cranking system.

4. ELECTRICAL SYSTEM MONITOR

This vehicle is equipped with an electronic device that monitors and detects abnormal alternator, voltage regulator, battery banks or battery equalizers conditions. The monitor is installed on back wall of the main electric compartment (refer to fig. 5). The "Battery

balance" and "Battery Hi/Lo" warning lamps connected to this module are mounted in the dashboard (refer to "Operator's Manual" for location). If a malfunction should occur, the monitor sends a signal to the driver through the warning light of the malfunctioning component. If the "Battery Hi/Lo" warning light is illuminated, check the 24 volt voltmeter to determine if the battery voltage is too high or too low.

Note: According to the battery charging condition, it is normal that "Battery Hi/Lo" warning light illuminates upon starting the engine and stays illuminated for a few seconds. This is caused by the normal voltage drop of the battery during starting.

4.1 TELLTALE LIGHT DEFINITIONS

Battery Hi/Lo

Voltmeter drops below 24 V dc

- Check alternator output.
- Check voltage regulator.
- Check battery connections.
- Check battery cells.
- Check battery equalizer connections.

Voltmeter exceeds 30 V dc

- Check alternator output.
- Check voltage regulator.
- Check battery connections.

Battery Balance

Note: Allow at least 15 minutes to balance batteries after any corrective measure has been taken.

1. Batteries out of balance (difference greater than 1.5 volts between the two battery banks).
 - Check battery equalizer connections.
 - Check equalizer cables for proper gauge.
 - Check battery connections.

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2. Demand for 12 volt power exceeding rated amperage output of battery equalizers causing batteries to go out of balance.

- Reduce 12 volt load or install additional battery equalizer(s).

"Battery" Warning Light

This warning light is not controlled by the electronic monitor, but by the "R" terminal of the alternator using the normally-closed contact of relay R-33. If a voltage drop should occur in the charging system, the "Battery" telltale light will immediately illuminate to warn the driver. The "Battery Hi/Lo" telltale light will illuminate if voltage drops below 24 V dc.

Refer to heading "Diagnosis of Charging System Problems" later in this section, to determine whether the alternator or the voltage regulator is defective. Should the "Battery" telltale light illuminate while the 24 volt voltmeter keeps on giving a normal reading and the "Battery Hi/Lo" telltale light does not illuminate, the relay R-33 or its wiring is probably defective.

Caution: The relay R-33 should never be replaced with a relay provided with a suppressor diode on its coil as the output current (between 12 and 14 volts) at the alternator "R" terminal is not rectified, thus rendering the relay inoperative.

Note: When the "Battery" warning light illuminates, the "A/C & Heating" system shuts off in order to prevent battery discharge.

5. BOSCH ALTERNATOR

One or two 24 volt 140 amp., self regulated, belt driven, air-cooled BOSCH alternators may be used in the 24 volt electrical system (instead of the DELCO 24 volt 270 amp. alternator). Refer to Bosh T1 Alternator Maintenance Manual Annexed at the end of this section.

6. DELCO ALTERNATOR

The 24 volt charging system consists of a belt driven, oil-cooled, brushless alternator, a 24 volt voltage regulator, an alternator relay and a 12 volt system that includes a 12 volt, 100 amp equalizer. The components used in this system are described under the applicable headings hereafter.

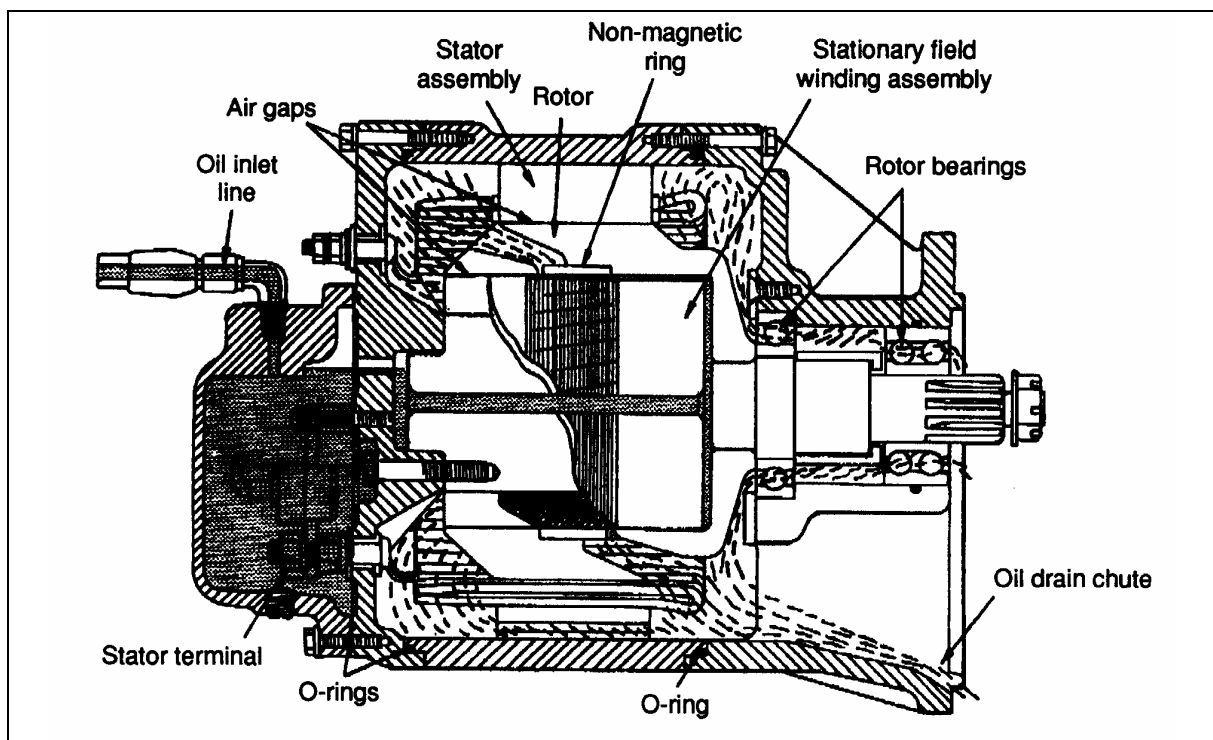


FIGURE 17: OIL CIRCULATION THROUGH ALTERNATOR

This oil-cooled alternator is self rectifying. All current carrying members, windings, built-in diodes, and field coils are stationary. The only moving component is the rotor. The alternator is a totally-enclosed unit, cooled and lubricated by engine oil. The oil inlet is on the diode end cover. The oil drains back into the engine crankcase through the drive end frame and drive adapter housing. This alternator should never

be operated with the oil supply line disconnected. A continuous flow of engine oil through the alternator lubricates the bearings and cools the assembly. Four terminals are used on this alternator: the DC output terminal, two field terminals, and a 12 volt relay terminal. The alternator output voltage is regulated by a separate 24 volt regulator that controls the alternator field current (Fig. 17 and 18).

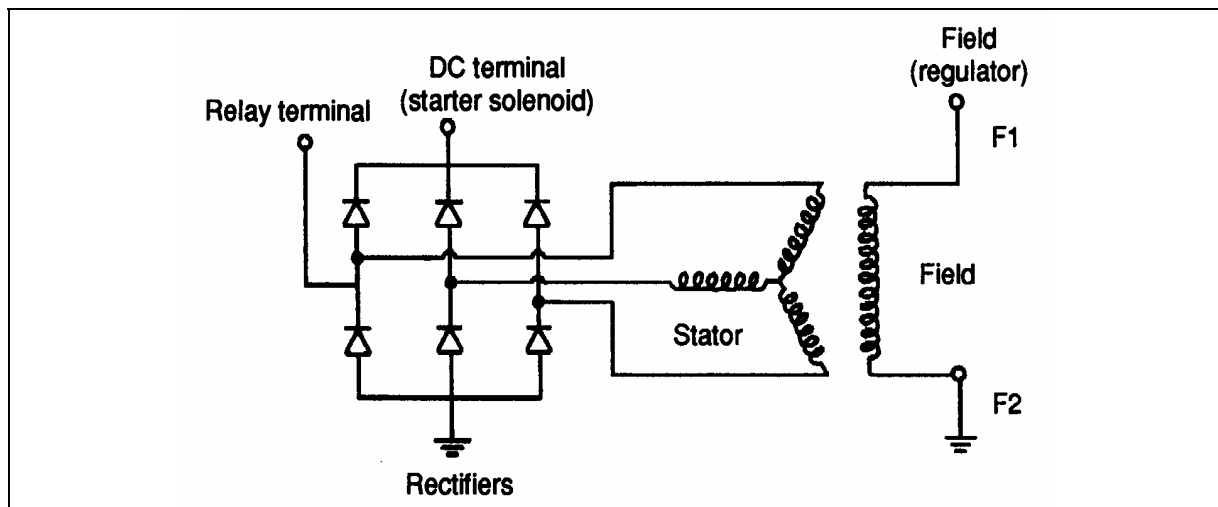


FIGURE 18: ALTERNATOR WIRING DIAGRAM (DELCO)

Note: The relay coils connected to the alternator “relay terminal” SHOULD NEVER BE PROVIDED WITH A SUPPRESSOR DIODE as the output current at this terminal is not rectified, thus rendering relay inoperative.

Caution: The electrical system is NEGATIVE GROUNDED. Connecting the batteries or a battery charger with the positive terminal grounded will endanger the alternator diodes and vehicle wiring by a high current flow. Burned wiring harnesses and burned “open” diodes will result. Always ensure that the alternator and battery polarities are matched prior to installation. THE ALTERNATOR WILL NOT REVERSE TO ACCEPT INVERSE POLARITY. Also, do not ground or short across any of the alternator or regulator terminals.

Since there are no brushes, slip rings, or rubbing seals, the alternator requires no periodic maintenance other than the following:

1. Check alternator-to-engine mounting bolts for looseness and tighten to the proper torque.

2. Check all electrical connections for tightness and corrosion. Clean and tighten connections as necessary. Be sure wiring insulation is in good condition and that all wiring is securely clipped to prevent chafing of the insulation.
3. With the engine running, listen for noise and check the alternator for vibration. If the alternator is noisy or vibrates excessively, it should be removed for inspection and repair.
4. Ensure that battery terminals are clean and tight.

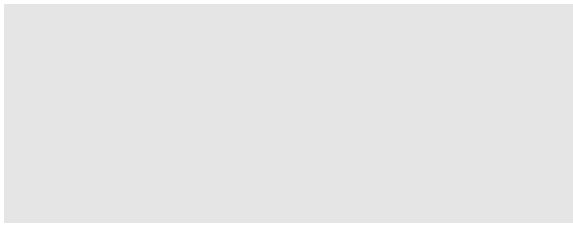
7. CHARGING SYSTEM TROUBLESHOOTING

The troubleshooting of the charging system is made easier by the use of a 12 and a 24 volt voltmeter, “Battery”, “Battery balance” and “Battery Hi/Lo” telltale lights mounted in the dashboard (for location refer to the “Operator’s Manual”). The definition of each warning light is explained under the “ELECTRICAL SYSTEM MONITOR”

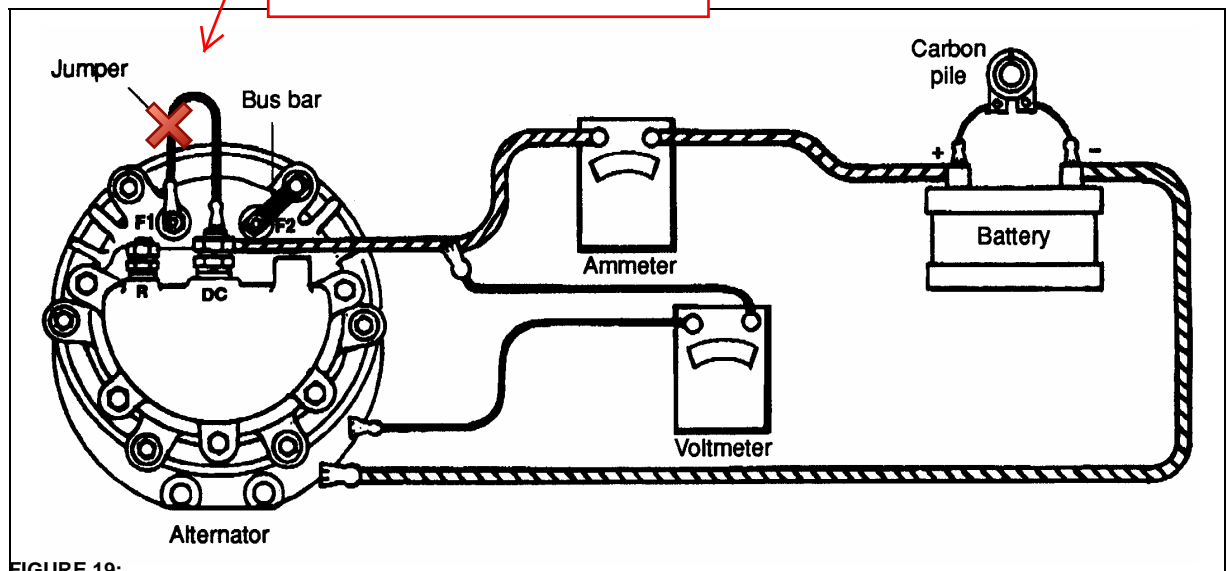
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7.1 ALTERNATOR OR VOLTAGE REGULATOR

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BAD PRACTICE. DO NOT JUMP F1 FIELD TERMINAL TO DC(+) TERMINAL



7.2 ALTERNATOR DIAGNOSIS

Caution: Before checking the alternator, TURN OFF the battery main disconnect switch.

It is not necessary to disassemble completely the alternator to make electrical checks. All electrical checks are made at the diode end of the assembly without having to remove the rotor, drive end frame or bearing. If the electrical components are not defective but bearing replacement is necessary, this can be done at the drive end without having to disassemble the diode end of the unit.

The components in the alternator that require electrical checks are the field winding, the six diodes, and the stator winding.

7.2.1 Diode Checks

Each diode may be checked for shorts and opens as follows:

1. Ensure the battery main disconnect switch is set to the "OFF" position.
2. Remove the pipe plug from underneath the end housing to drain the oil in the rectifier engine oil supply.
3. Remove the cap screws (7) and lock washers that attach the diode end cover to the end housing. Remove the end cover from the end housing.

Note: Do not operate the alternator unless this unit is completely reassembled.

4. Remove seal from the end housing, detach and remove "DC" and relay terminals, stud, insulating sleeves and O-rings.
5. Disconnect all diode flexible leads; i.e. three from the output terminal stud and three from the diode supports. See figure 20 for more details.

Each diode may be checked for short or open circuits with an ohmmeter.

Note: The ohmmeter polarity may be determined by connecting its leads to the voltmeter leads. The voltmeter will read up-scale when the negative leads are connected together and the positive leads are connected together. The polarity of the voltmeter leads may be determined by connecting the leads to the identified terminals on a battery.

Note: Use an ohmmeter with a single 1.5 volts cell. Most accurate reading will be determined when the 300 ohms value is calibrated to the center one-third of the scale. DO NOT USE high voltage, such as a 110 volts test lamp to check diodes.

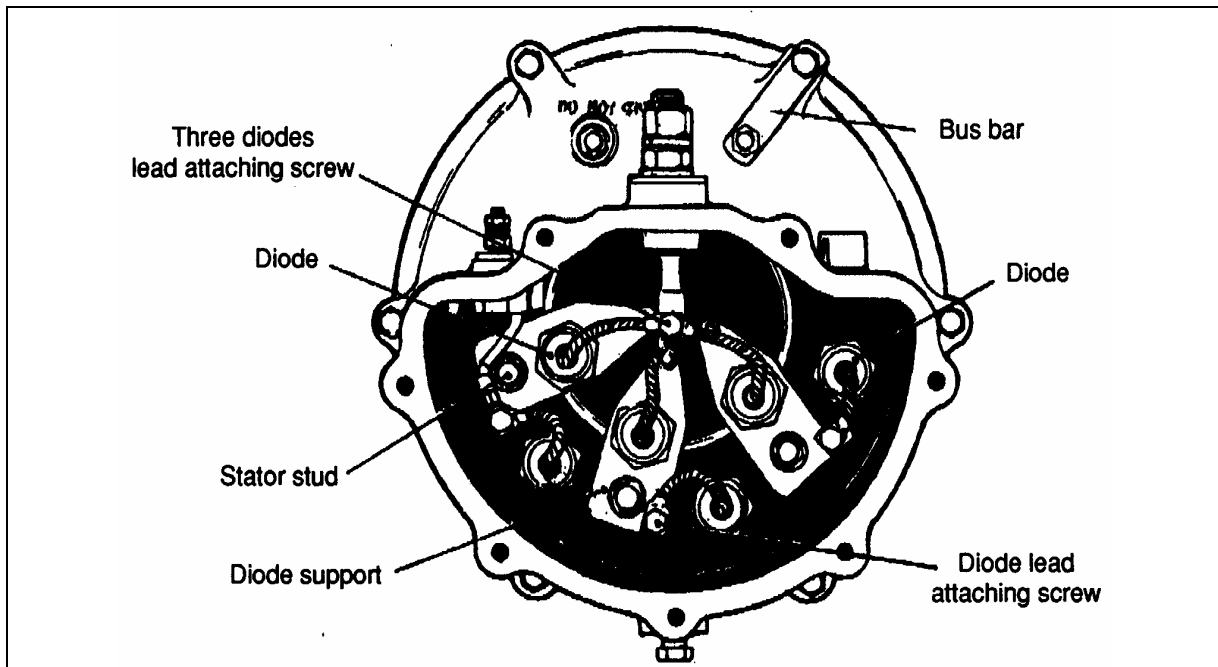


FIGURE 20: VIEW OF RECTIFIER END FRAME WITH COVER REMOVED

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To check diodes mounted in the supports for short fields, connect the positive ohmmeter lead to each diode lead and the ohmmeter negative lead to each support as shown in "A", "B", and "C" of figure 21. To check diodes mounted in the end frame for shorts, connect the ohmmeter positive lead to each diode lead and the ohmmeter negative lead to the end frame as shown in parts "D", "E", "F". The ohmmeter readings may vary considerably when checking diodes for shorts, but if the reading is 300 ohms or less, the diode is probably defective and should be replaced. A diode that reads 300 ohms or less will allow excessive reverse

current from the battery. Replace defective diodes as explained later in this section.

To check the diodes mounted in the diode supports for open fields, connect the ohmmeter negative lead to each diode lead and the ohmmeter positive lead to each support as shown in parts "A", "B", and "C" of figure 22. To check the diodes mounted in end frame for shorts, connect the ohmmeter negative lead to each diode lead and the ohmmeter positive lead to the end frame as shown in parts "D", "E" and "F". An infinite resistance reading indicates an open diode. Diodes can be replaced by following the procedure outlined under "DIODE REPLACEMENT".

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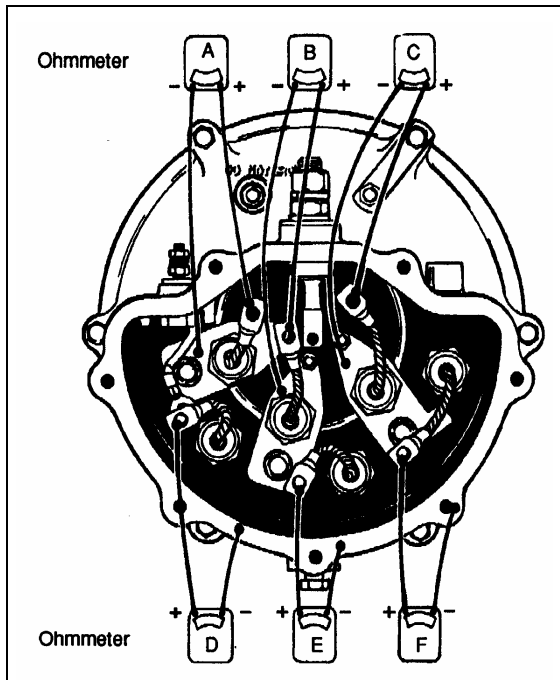


FIGURE 21: CHECKING DIODES WITH OHMMETER ON A TYPICAL OIL COOLED ALTERNATOR (END COVER REMOVED)

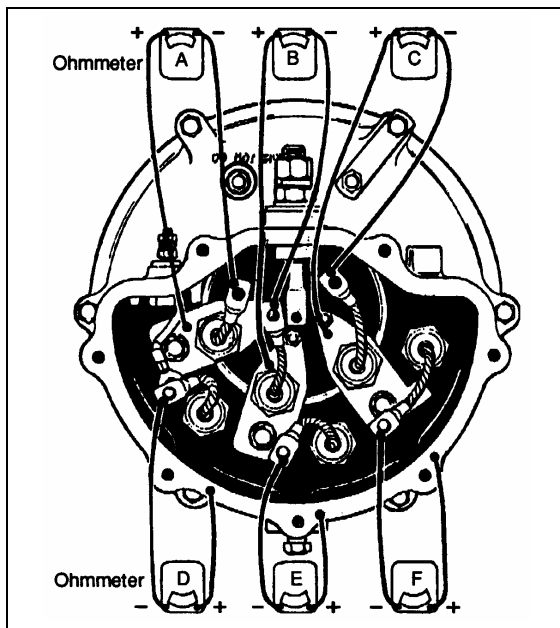


FIGURE 22: CHECKING DIODES WITH OHMMETER ON A TYPICAL OIL COOLED ALTERNATOR (END COVER REMOVED)

When reinstalling diodes, torque to 9-11 ft•lb (12-15 N•m). Re-stake next to the threads in an arbor press with an 1/8 inch (3,2 mm) round punch. Press the punch with gradual pressure. Do not strike as the shock may damage the diodes.

7.2.2 Field Winding Check

The field winding may be checked for shorts and opens with an ohmmeter. To check the field winding, connect the ohmmeter to field terminal and to ground. A resistance reading above normal indicates an open, and a reading less than normal indicates a short field. The normal resistance value is 3.0 to 3.3 ohms at 80°F (27°C). An alternate method of checking is to place a battery of specified voltage, and an ammeter in series with the field winding. The current should register 7.2 to 8.3 amperes at 24 volts. Coil resistance is approximately 3.1 ohms. Amperage readings, other than the above, indicate an open, grounded, or shorted field. A defective field coil can be replaced by removing the end frame on which the field terminal is located and then removing the four field coil mounting screws. See "FIELD REPLACEMENT" for a detailed procedure.

7.2.3 Stator Winding Check

The stator winding may be checked for open and short fields with an ohmmeter as follows:

Open Fields

Connect the ohmmeter leads to two pairs of diode supports as shown in parts "A", "B", and "C" of figure 23. Correct polarity of the leads must be observed. The ohmmeter should indicate a low resistance. If an infinite or a high resistance is measured in either one or both checks, the stator windings are open.

Ground

To check the stator windings for ground, connect an ohmmeter to the diode support and diode end frame as shown in part "C" of figure 23. The ohmmeter should indicate a very high or infinite resistance. If zero, or a very low resistance is measured, the windings are grounded.

Shorts

The stator windings are difficult to check for shorts without finely calibrated laboratory test equipment due to the very low resistance values of the windings. However, if all other alternator checks are satisfactory, yet the unit fails to perform to specifications, shorted stator windings are probable.

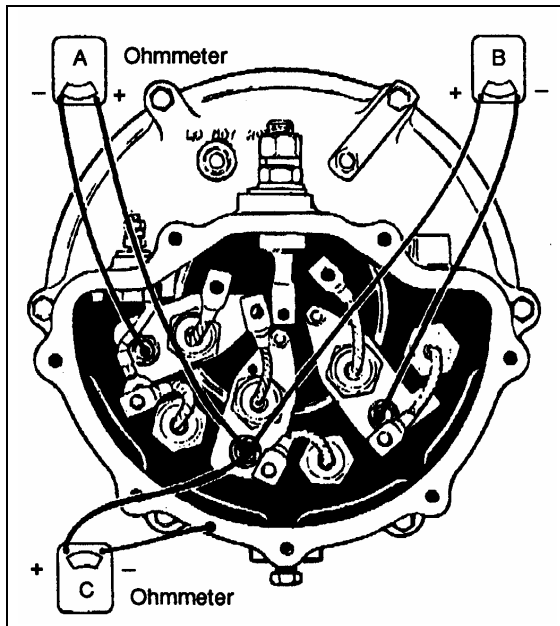


FIGURE 23: CHECKING STATOR WINDING FOR "OPEN" AND GROUND

7.3 DIODE REPLACEMENT

The following replacement procedures are based on the assumption that the diode end cover is still off and diode leads were disconnected as explained earlier in this section.

Note: When replacing a diode, make sure it is designed for a negative ground system. The diode can be identified by the symbol stamped on the diode case. The arrow must point toward the diode flexible lead.

To replace the three diodes that are mounted in the supports attached to the stator lead studs, it is necessary to remove the diode and support assembly. The two outer diode and support assemblies are identical and can be installed on either side. The center unit has a different support, with 2 inches (50,8 mm) between the mounting hole centers.

Note: The outer supports are provided with 2 1/4" (57,15 mm) center holes.

7.3.1 Diode Replacement (in Support)

1. Remove nut with lock washer attaching the diode support to the stator lead stud.
2. Remove nut, lock washer, and flat washer attaching support to the small stud in the end frame.

3. Remove the diode and support assembly. Then remove insert from small hole in support or from small stud in the end frame.
4. Remove nut and flat washer from diode mounting stud, then remove diode from the support.
5. Place a new diode in the support and install a flat washer and nut on the diode mounting stud. Hold the diode with a wrench placed over flats on the diode, while tightening nut on the mounting stud to a torque of 160-180 in•lbf (18-20 N•m).
6. Place diode and support assembly over the stator lead stud and the small mounting stud. Place insert over small stud inside the hole in the support. Install flat washer, lock washer, and nut on the small stud, and tighten to a torque of 22-25 in•lbf (2-3 N•m). Install nut with lock washer on stator lead stud and tighten firmly.

7.3.2 Diode Replacement (in End Frame)

To remove diode, use a thin 1 inch open end wrench on flats of the diode case to unscrew diode from the end frame. Thread the new diode into the end frame and tighten to a torque of 160-180 in•lbs (18-20 N•m). If no other parts are to be replaced, refer to "DIODE END COVER INSTALLATION" in this section.

7.4 FIELD REMOVAL

1. Remove three diode and support assemblies from the end frame to provide access to the two lower field to end frame bolts.
2. Remove nut with lock washer and flat washer from three stator lead studs.
3. Remove the six bolts and lock washers attaching the diode end frame to the stator frame.
4. Separate the end frame from the stator frame, and remove the end frame and field assembly from the rotor while pushing the stator lead studs out of the end frame.
5. Remove nut, lock washer, flat washer, and insulating washer which secure the field lead terminal stud in the end frame. Push the stud out of the end frame.

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6. Remove field terminal stud insulating bushing and seal from the end frame. Remove insulating sleeve from the field terminal stud.
7. Remove the four bolts and lock washers attaching the field to the end frame.
8. To separate the field from the end frame, install four 3/8-24 x 3 inch bolts in place of the 3/8-24 x 2 inch bolts removed in step 7. Thread bolts in to even heights. Support the end frame in an arbor press. Then, using a suitable press plate to exert pressure on all four bolt heads, press the field out of the end frame.

7.5 FIELD INSTALLATION

1. Position the field assembly on the end frame. Insert four 3/8-24 x 3 inch bolts through the end frame and thread into the field to keep holes aligned.
2. Support the end frame on an arbor press bed so that the diodes will not be damaged, and press the field into the end frame. Press in until shoulder on field coil bottoms against the end frame.
3. Remove the four guide bolts. Install four 3/8-24 x 2 inch bolts, using new lock washers to attach the field to the end frame. Tighten bolts securely.
4. Place insulating sleeve in inner side of the field terminal stud hole in the end frame, and insert the terminal stud through the sleeve. Place two O-rings and insulating bushing over the terminal stud and push into hole in the end frame. Install insulating washer, flat washer, toothed lock washer, and nut on terminal stud. Tighten firmly.
5. Install each stator lead stud in the end frame as follows: Place insulating washer over the stud and insert the stud through the end frame. Place the insulating bushing over the stud and position in end frame hole. Install flat washer, lock washer, and nut on the stud. Tighten firmly.
6. Install three diode and support assemblies on the end frame as previously directed under "DIODE REPLACEMENT".

7. Install a new seal in notch around end of the stator frame. Insert field into the rotor and position the end frame against the stator frame. Attach end frame to the stator frame with six bolts and lock washers. Tighten bolts firmly.
8. If no other parts require replacement, refer to "DIODE END COVER INSTALLATION" in this section to complete the assembly.

7.6 STATOR REPLACEMENT

If tests performed under "Stator Winding Checks" earlier in this section indicated an open circuit or short in the stator, the stator and frame assembly must be replaced.

7.6.1 Removal

1. Remove diode end frame and field assembly as previously directed in steps 1 through 4 under "Field Removal".
2. Remove the six bolts and lock washers attaching the stator frame to the drive end frame.
3. Separate the stator frame from the drive end frame and remove the stator frame from the end frame and rotor.

7.6.2 Soldering Stator Terminal Leads

1. Using a wire brush, thoroughly clean the wire and terminal.
2. Silver solder the stator lead to the terminal using a torch.
3. Thoroughly clean the silver solder connection with a wire brush.
4. Using a high grade energized rosin flux, coat the silver soldered connection with a 80-20 tin-lead solder or pure tin solder to prevent deterioration of the silver solder by engine oil.

Note: The silver solder will provide the required mechanical strength, which will not be affected by temperature. The tin-lead solder will protect the silver solder connection from deterioration by engine oil.

7.6.3 Installation

1. Position new seal in notch around the drive end of the stator frame.
2. Position the stator and frame assembly over the rotor against the drive end frame. Attach the stator frame to the drive end frame with six bolts and lock washers. Tighten bolts firmly.
3. Install diode end frame and field assembly as directed in steps 5, 6 and 7 under "installation".
4. Install rectifier end cover as directed later.

7.7 DIODE END COVER INSTALLATION

1. Make sure all diodes are properly installed and securely tightened. Leads from diodes threaded into the end frame must be securely attached to the diode supports. The relay terminal lead must also be attached to the left diode support.
2. Connect leads from the three diodes mounted in supports to the output terminal stud. Tighten the attachment screw firmly. Place insulating bushing over relay terminal stud.
3. Place a new seal in the diode end frame.
4. With the end cover in place against the end frame, install the cap screws and lock washers. Tighten the cap screws evenly and firmly.
5. Make sure the drain plug is installed in bottom of the end cover and securely tightened.

7.8 ALTERNATOR REMOVAL (DELCO)

1. Place "Starter Selector Switch" in engine compartment to the "OFF" position.
2. Place the battery main disconnect switch to the "OFF" position.
3. Remove alternator drive belt (see "ALTERNATOR DRIVE BELT").

Note: When reinstalling drive belt, it is important to set the belt tension correctly. (refer to the appropriate heading later in this section).

4. Scratch off protective sealer from electrical connections (relay, field and positive terminals). Refer to figure 24.

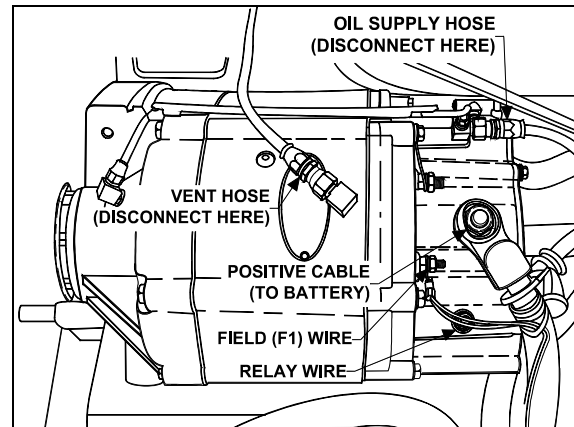


FIGURE 24: ALTERNATOR (HOSES AND WIRES) 06073

Note: After reconnecting electrical wires, it is important to cover terminals with protective sealer (Prévost #680745).

5. Disconnect wire #25 from the relay terminal, wire #107 from the field "F1" terminal and disconnect battery cable from the positive "+" terminal on the diode end cover. Tag wires removed to ease identification at time of installation. Refer to figure 24.
6. Disconnect oil supply line and vent hose from top of alternator (Fig. 24) and tape lines to prevent entry of foreign matter. Disconnect oil drain hose from bottom of alternator (Fig. 25) and tape line to prevent entry of foreign matter.
7. Remove the four bolts and lock washer retaining alternator (refer to fig. 25).

Warning: Alternator weights approximately 154 lbs (70 kg). Another person is required to take the alternator out of engine compartment.

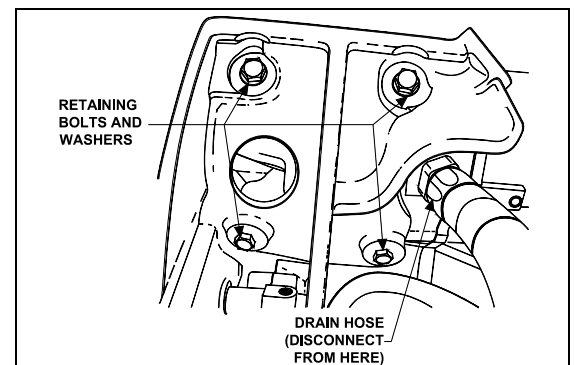


FIGURE 25: ALTERNATOR RETAINING BOLTS AND WASHERS

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7.8.1 Disassembly of Alternator

After diode, field and stator winding checks, the alternator can be disassembled to repair a faulty component, such as field or stator, or to proceed with bearing or rotor replacement. Perform the following steps to disassemble the alternator:

1. Remove nuts and washers from "DC" terminal on diode end frame.
2. Separate the diode cover plate from the diode end frame by removing the mounting screws.
3. Remove the washer, nut and lock washer attaching the diode supports to the end frame, the three screws connecting the diode leads to the diode supports, and the three nuts which attach the stator studs to the diode supports.
4. Separate the diode support assemblies from the diode end frame, and the three nuts that connect the studs to the diode end frame.
5. Mark the position of the drive end frame and diode frame with respect to the stator assembly so that the parts can be reassembled in the same position.
6. Detach the diode end frame and field assembly from the stator assembly by removing the attachment screws.
7. Separate the field assembly from the diode end frame by removing the four attachment screws.
8. Separate the rotor assembly and drive end frame from the stator assembly by removing the attaching screws.
9. Remove the shaft nut and washer, and the pulley. Press the rotor shaft out of the drive end frame.
10. Remove the retainer plate and pull the bearings from the drive end frame.

7.8.2 Alternator Cleaning and Inspection

Whenever the alternator is disassembled, it should be cleaned and inspected.

Cleaning

If sludge has accumulated on the stator, a light mineral oil should be used to clean it.

Inspection

When the alternator has been disassembled to the extent that the stator is exposed, the stator should be checked for the following:

- a) Adequate varnish.
- b) Proper spacing of conductors so that "near shorts" do not exist.
- c) Proper phase lead placement.
- d) Strong conductor and cross-over welds

7.8.3 Bearing or Rotor Replacement

Whenever the rotor and drive end frame are disassembled for any reason, the single-row ball bearing must be replaced with a new one due to the probability of damage during disassembly.

Removal and Disassembly

1. If the pulley was not removed from the rotor shaft at time of alternator removal, remove the nut and flat washer from the shaft and pull the pulley off the shaft.
2. Remove the six bolts and lock washers attaching the drive end frame to the stator frame. Separate the drive end frame from the stator frame. Remove the drive end frame and support assembly.
3. Support the drive end frame in an arbor press so that the rotor can be pressed down out of the end frame. Using a suitable adapter against the end of the rotor shaft that will pass through the inner race of the double-row ball bearing, press the rotor down out of the end frame and bearings. Since the single-row bearing outer race is held in the end frame by the retainer plate, and the inner race is a press fit on to the rotor shaft, the bearing will probably be damaged when the shaft is pressed out and need to be replaced with a new part.
4. Remove the six screws attaching the bearing retainer plate to the drive end frame. Remove the retainer plate, the single-row

bearing and the bearing spacer from the end frame.

5. Support the drive end frame in an arbor press with the double-row bearing down, so that the bearing can be pressed down out of the end frame. Using a suitable driver that will exert a force on the bearing outer race, press the bearing out of the end frame.
6. Remove the rubber bearing clamp from groove in the end frame.

Assembly and Installation

1. Install a new single-row ball bearing into inner side of the drive end frame. Install the bearing retainer plate and attach with six screws. Stake screws in place after tightening.
2. Position the rubber bearing clamp in the groove in bearing bore of the drive end frame. Lubricate the clamp to permit the bearing to be pressed in without dislodging or damaging the clamp.
3. Position the rotor in an arbor press with the shaft end up. Install the drive end frame and single-row bearing assembly over the rotor shaft. Using a driver over the rotor shaft, which will exert a force on the bearing inner race, press the bearing onto the shaft until it bottoms against the rotor.
4. Install bearing spacer over the rotor shaft. Position the double-row bearing over the rotor shaft at end frame bore. Using an adapter that will exert a force on both the inner and outer races of the bearing, press the bearing onto the shaft and into the end frame until the inner race bottoms against the bearing spacer.
5. Place a new seal around the drive end of the stator frame.
6. Insert the rotor between the stator and field, and position the drive end frame against the stator frame. Attach the end frame to the stator frame with six bolts and lock washers. Tighten the bolts to a torque of 5 to 5.4 ft•lbf (6-7 N•m).

Caution: When replacing the alternator on the vehicle, ensure that an alternator with the proper drive ratio is used. Installation of an alternator with any other drive ratio will result in severe and costly damage to the alternator and engine.

7.8.4 Alternator Reassembly

Reassembly is the reverse of disassembly.

Note: When tightening the outside nut on the "DC" output terminal, torque the nut to 30-35 ft•lbf (41-47 N•m). The lower nut should be supported while doing so.

When reinstalling diodes, tighten to a torque of 9-11 ft•lbf (12-15 N•m).

7.8.5 Output check

When removed from the engine, the alternator may be checked without circulating oil on a test bench, providing the output is limited to 100 amperes or less. The alternator may be bench tested without circulating oil at outputs exceeding 100 amperes, as long as the period of operation is limited to less than 15 seconds.

Caution: Operating the alternator at outputs greater than 100 amperes without adequate oil circulation for periods exceeding 15 seconds, will cause the alternator to overheat, resulting in damage to the winding and diodes.

If the alternator is to be operated at an output greater than 100 amperes for longer than 15 seconds, circulating oil must be provided. SAE 30 engine oil must be applied to the connection on the diode end cover at a pressure of 35 psi and at a temperature of 60°F to 220°F (16°C to 104°C). This will provide an oil flow of about one gallon per minute.

To check the alternator on a test bench, make electrical connections as shown in figure 22. Make sure the negative battery terminal is connected to the alternator frame.

7.9 ALTERNATOR DRIVE BELT

Removal

1. Insert a ¾ " socket drive into one of the tensioning arm opening (Fig. 26).
2. Twist the tensioning arm to slacken belt.
3. Remove belt.

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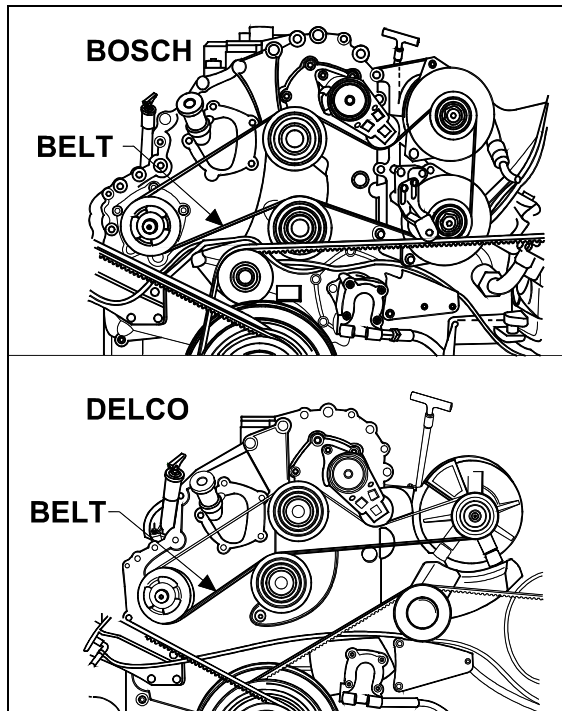


FIGURE 26: ALTERNATOR DRIVE BELT

Installation

Installation of the alternator drive belt is the reverse of removal.

7.9.1 Adjustment

Correct belt tension is required to maximize belt life. The tensioning arm maintains proper belt tension, no adjustment is required.

8. VOLTAGE REGULATOR (DELCO)

The 24 volt regulator (Delco) is located in the main electrical compartment.

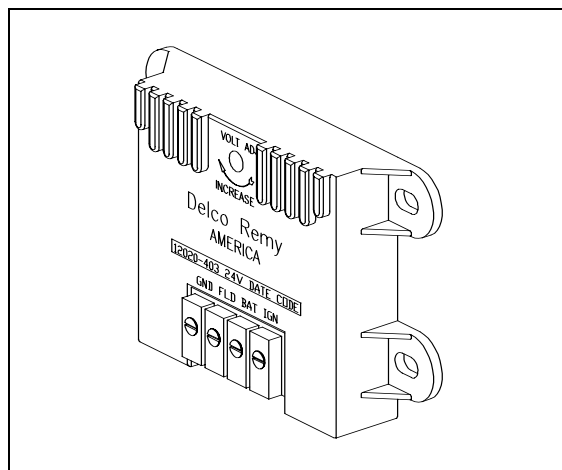


FIGURE 27: VOLT REGULATOR

The transistor regulator illustrated in figure 27 is an assembly mainly consisting of diodes, capacitors, resistors and transistors. These components are mounted on a printed circuit panel board to form a completely static unit containing no moving parts. Regulators of this type have only four terminals which are identified "GND." (ground), "FLD" (field) "BAT" (battery) and "IGN" (ignition).

The regulator components work together to limit the alternator voltage to the preset value by controlling the alternator field current. This is the only function that the regulator performs in the charging system.

The voltage at which the alternator operates is determined by the regulator adjustment. Once adjusted, the alternator voltage remains constant. The regulator is unaffected by length of service, changes in temperature, or changes in alternator output and speed.

A typical wiring diagram of a negative ground system is illustrated in figure 28. This diagram shows only the basic charging system components. It does not show any components such as the control relays. Refer to "Charging system" wiring diagram, in "Wiring diagrams" for the electric circuits and connections.

Voltage regulator maintenance

The voltage regulator is a service-free electronic unit. When it fails, it should be replaced. The following procedure must be used:

- Open the exterior panel of the R.H. side coach main electrical compartment in order to get access to the voltage regulator;
- Unscrew the electrical cable connectors;
- Unscrew the voltage regulator unit;
- Install a new voltage regulator by reversing the procedure.

Caution: Place the battery main disconnect switch to "OFF" position.

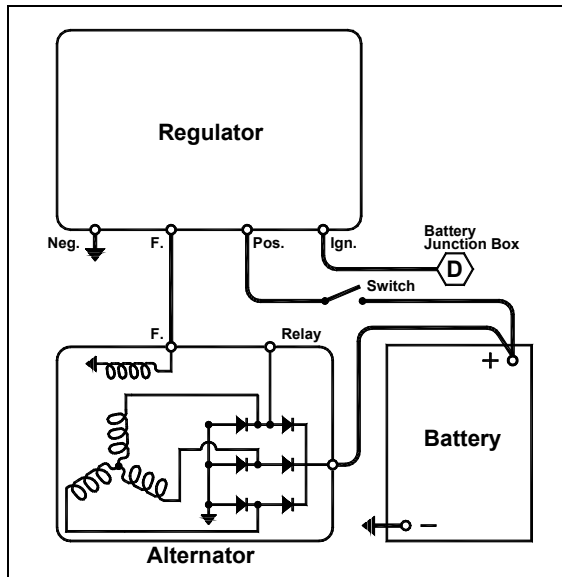


FIGURE 28: TYPICAL WIRING DIAGRAM OF A NEGATIVE GROUND SYSTEM

Note: For information about BOSCH alternator and voltage regulator, refer to technical publication "Repair and Testing Instructions for T1 Alternator 0120 689 552".

8.1 TROUBLESHOOTING PROCEDURES

Trouble in the electrical system will usually be indicated by one of two conditions: an undercharged or an overcharged battery. Either condition can result from an improper voltage regulator setting:

Checking Battery Voltage

The absence of gas production during the continuous appearance of the green dot in the battery's built-in hydrometer indicates that the voltage setting is satisfactory. Check the following conditions:

Checking Voltage Regulator Setting

1. To check the voltage setting, connect a voltmeter across the "POS" and "NEG" terminals on the regulator, and an ammeter to the "C" terminal on the alternator. Refer to figure 29.

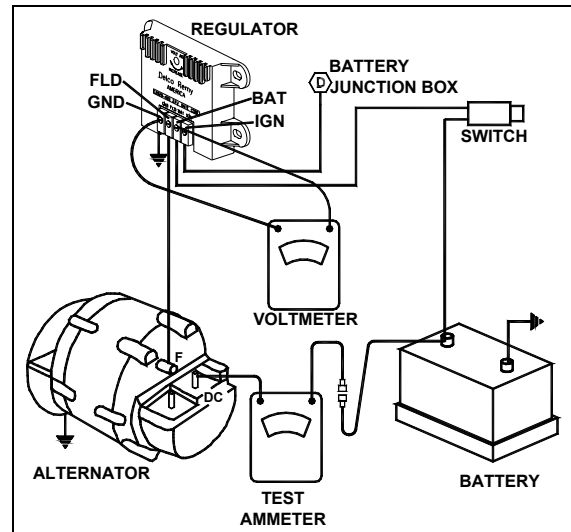


FIGURE 29: REGULATOR VOLTAGE TEST 06078

2. Operate the engine at approximately 1000 rpm (about 2300 alternator rpm), with accessories on, to obtain an alternator output of 20-200 amperes.
3. Note the voltage setting. It should be steady at 27.5 volts.
4. If not, the desired setting can be obtained by removing the plug from the voltage regulator cover and slightly turning the adjusting screw inside the regulator. Turn the adjusting screw clockwise to increase the voltage setting or counterclockwise to decrease it. See figure 30 for details.

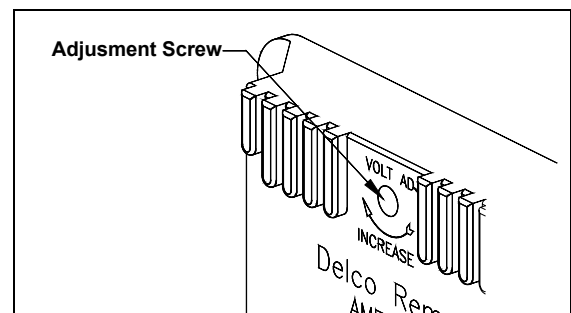


FIGURE 30: ADJUSTING REGULATOR VOLTAGE SETTING

Note: If regulator voltage cannot be adjusted to the specified setting, remove the regulator and repair or replace it as necessary.

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8.1.1 Undercharged Battery

If the voltage setting is steady and reasonably close to the specified value and the battery is undercharged, raise the setting by 0.3 volt, then check for an improved battery condition over a minimum service period of 48 hours. If the voltage cannot be adjusted to the desired value, the alternator should be checked as follows:

1. Stop alternator, turn off all accessories and disconnect battery ground cable.
2. Disconnect all leads from the regulator and from the alternator field. **Do not allow leads to touch ground.**
3. Connect a voltmeter and an ammeter in the circuit at the alternator "DC" terminal.
4. Connect a jumper lead from the alternator "DC" terminal to the alternator field terminal.

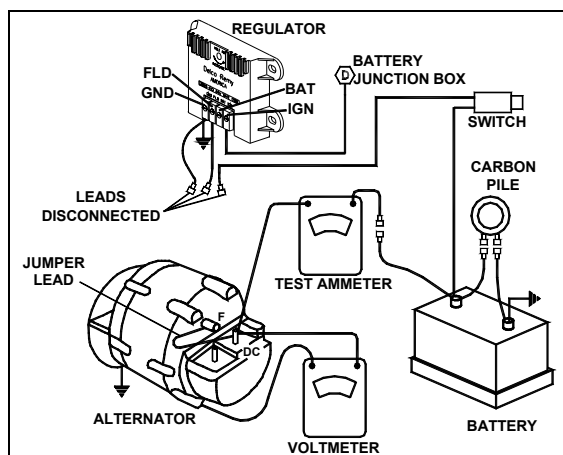


FIGURE 31: REGULATOR VOLTAGE TEST
(UNDERCHARGED BATTERY)

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5. Connect a carbon pile resistor load across the battery. Turn to the "Off" position.
6. See figure 31 for wiring connections.
Reconnect battery ground cable
7. Turn on all vehicle accessories.
8. Operate alternator and adjust carbon pile resistor load as required to check for rated output as given in Delco-Remy Service Bulletin 1G-187 or 1G-188.
9. Check the alternator field winding as follows: Disconnect the lead from the field terminal and connect an ohmmeter from the field terminal to ground. A resistance reading

above normal indicates an open field, and a resistance reading less than normal indicates a shorted or grounded field. The normal resistance can be calculated by dividing the voltage by the field current published in Delco-Remy Service Bulletin 1G-186, 1G-187, or 1G-188. The normal resistance value should be at or near midscale on the ohmmeter for accuracy. An alternate method of checking is to connect a battery of specified voltage and an ammeter in series with the field winding, and compare readings with published specifications in Delco-Remy Service Bulletin 1G-186, 1G-187, or 1G-188. An alternator is defective if it does not produce rated output or if field windings are faulty. If the alternator provides rated output, and field windings check satisfactorily, the regulator should be checked as covered under "Regulator Checks".

8.1.2 Overcharged Battery

If the voltage setting as checked above is steady and reasonably close to the specified value, lower the setting by 0.3 volt and check for an improved battery condition over a minimum service period of 48 hours. If the voltage cannot be adjusted to the desired value, proceed as follows: where the alternator field is grounded internally in the alternator as shown in figure 28 a shorted or grounded field or a defective regulator can cause an overcharged battery. The field winding can be checked as covered in paragraph "Undercharged Battery". If the field winding is found to be correct, the alternator is not defective, and the regulator should be checked as covered under "Regulator Checks".

8.2 REGULATOR CHECKS

Separate the cover from the base, and remove the panel assembly from the cover. Carefully note the location of all washers and lock washers.

The component parts are keyed to figure 28. Before making electrical checks, visually inspect the components and make sure all soldered connections are secure. Various electrical checks with an ohmmeter can be made to determine which components are defective.

The ohmmeter **must** be accurate, and should be a scale-type meter with a 1.5 or 3 volt cell. Most digital ohmmeters cannot be used to check

semiconductors. However, some digital ohmmeters are specially designed to test semiconductors and can be used to test components in the regulator. Consult the ohmmeter's manufacturer for specifications concerning the capabilities of the ohmmeter.

It is important that all of the following checks be made. If a defective part is found, replace it before proceeding with the remaining checks. Be sure to make all the checks since more than one component may be defective.

A defective regulator can be repaired according to the following methods:

- A) By changing the printed circuit board in the regulator. Unscrew the retaining screws on the printed circuit and remove it. Install a new printed circuit board. This method is the most commonly used.
- B) By removing any retaining screws involved and unsoldering the connections. When resoldering, limit solder time to a minimum as excessive heat may damage the printed circuit board and component parts. However good soldered connections are essential for satisfactory operation. A resin core 63% tin 37% lead solder with a 360°F (182°C) melting point is recommended along with a soldering iron rated at 50 watts or less. Use extreme care to avoid overheating. Before checking the printed circuit board, remove transistor TR1, which must be checked separately. Connect the ohmmeter as shown in figure 31, and then reverse the ohmmeter leads to obtain two readings on the same component. Use the middle scale on scale-type meters on which the 300 ohm value should be within, or nearly within, the middle third of scale.

Capacitors C1 and C2 = The ohmmeter should read high and low on each capacitor. If not, replace capacitor.

Diodes D1, D2 and D3 = Each diode should give one high and one low reading. If not, replace diode.

Resistor R2 = Turn voltage adjustment screw (identified in figure 30) with ohmmeter connecting each way. Reading should change as slotted screw is turned. If not, replace R2.

Transistor TR1 = See figure 32. Use the low scale. Each of the three checks should read low and high. If not, replace TR1.

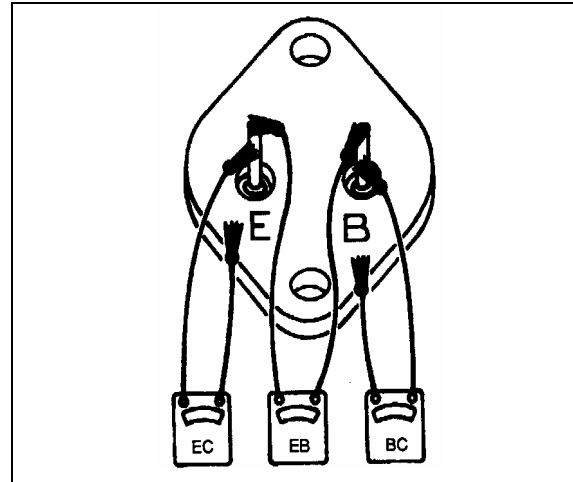


FIGURE 32: CHECKING TRANSISTORS TR1 06081

Transistor TR2 = Change the ohmmeter to use the low scale. EB should read low and high. BC should read low and high. EC should both read high. If not, replace TR2. See figure 33.

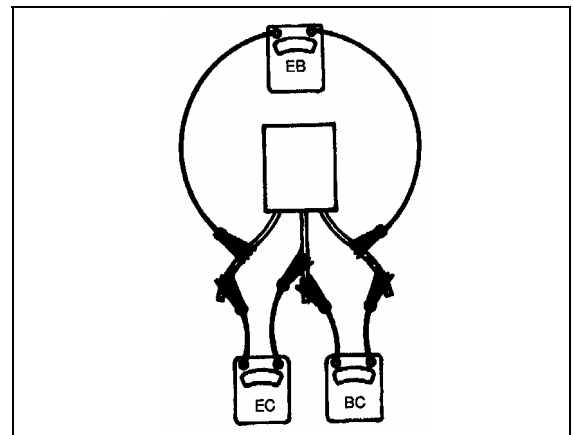


FIGURE 33: CHECKING TRANSISTORS TR2 06081

8.3 ADJUSTING VOLTAGE

After repair, the regulator must be adjusted to the desired voltage setting. Follow the procedure under "Checking Voltage Regulator Setting". Slowly turn the adjusting screw full range and observe the voltmeter to ensure that the voltage is being controlled, then, while still turning, slowly adjust to the desired setting.

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9. BATTERY EQUALIZER

Battery equalizer troubleshooting guide and owner's manual (50 and 100 amps) are annexed at the end of this section.

Refer to "Electrical Compartments and Junction Box" of this section, for location.

10. STARTER

The starter has a shift lever and solenoid plunger that are totally enclosed to protect them from exposure to dirt, icy conditions and splashing.

Positive lubrication is provided to the bronze bushing located in the commutator end frame, in the lever housing and in the nose housing, by an oil-saturated wick that projects through each bushing and contacts the armature shaft.

The clutch is a "Positork" drive type, that meshes with the ring gear by the action of the solenoid. Once engaged, the clutch will not disengage during intermittent engine firing. That prevents damage to pinion and ring gear teeth. The pinion remains engaged until starting is assured and the solenoid circuit is interrupted. Refer to figure 34 for more details.

10.1 MAINTENANCE

All wicks and oil reservoirs should be saturated with SAE 10 oil, and the splines underneath the clutch should be lubricated with a light coating of SAE 10 oil. Other than normal periodic lubrication and keeping cable connections clean and tight, the starter should require no periodic maintenance. However, under normal operating conditions, the starter should be disassembled, inspected, cleaned and tested at time of engine overhaul.

10.2 TROUBLESHOOTING

Failure of the starter to crank the engine at normal speed may be due to a defective battery, worn battery cables, poor connections in the cranking circuit, defective engine starting switch, low temperature, condition of the engine or a defective starter. To determine if the starter is the problem, it will first be necessary to check the batteries, the cranking circuit, the magnetic switch, the solenoid and the control switch.

To obtain full performance data on a starter, or to determine the cause of abnormal operation, the starter should be subjected to the following tests. These tests are performed with the starter removed from the engine. Check the armature for freedom of rotation by prying on the pinion with a screwdriver. Tight bearings, a bent armature shaft, or a loose pole shoe screw will prevent the armature from turning freely. Failure of the starter to perform according to specifications will require disassembly of the motor for further checks and adjustments. However, if the armature does rotate freely, the motor should be given a no-load test before disassembly.

Caution: *Never operate the starter more than 30 seconds at a time without pausing to allow it to cool for at least 2 minutes. Overheating, caused by excessive starting, will seriously damage the starter.*

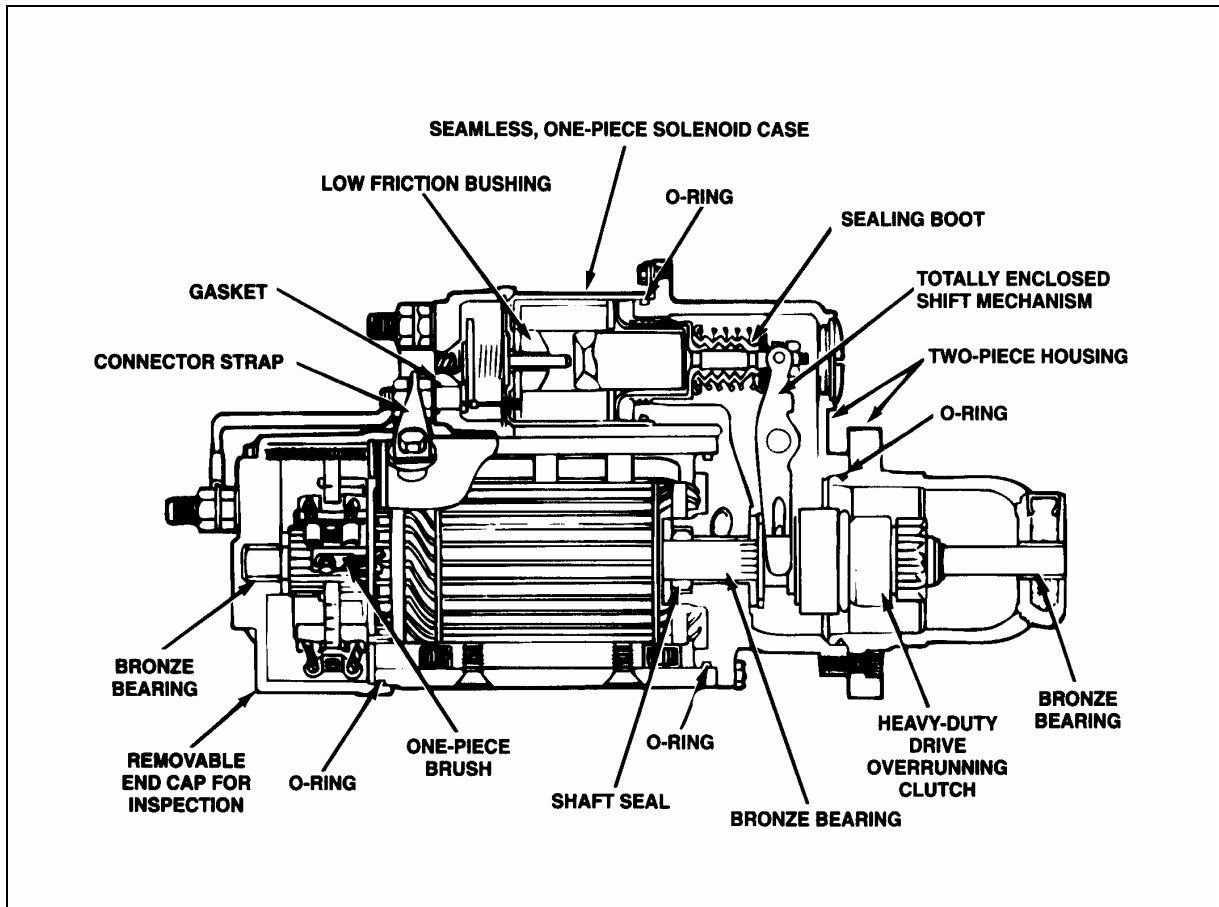


FIGURE 34: TYPICAL STARTER CROSS SECTION

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10.2.1 No-Load Test

Before disassembly of the starting motor, the following check of starting motor operation should be done to determine any condition that may require special attention during overhaul. Make test connections to the starting motor as in figure 35.

Connect the starting motor in series with fully charged batteries to give 24 volts, an ammeter capable of reading several hundred amperes and a variable resistance. Also connect a voltmeter as illustrated in figure 35 from the solenoid motor (M) terminal to the starter frame. A rpm indicator is necessary to measure armature speed. Proper voltage can be obtained by varying the resistance unit.

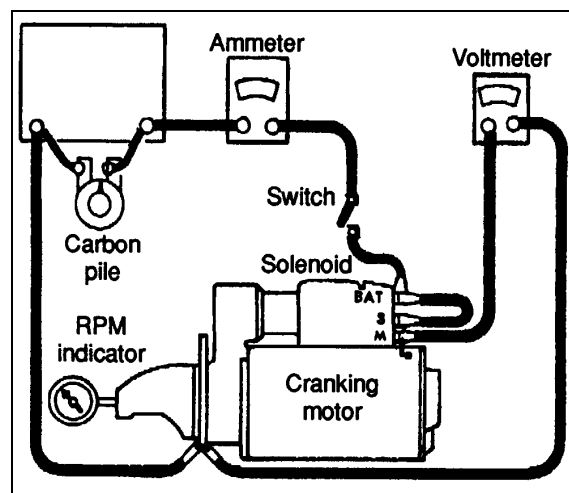


FIGURE 35: STARTING MOTOR TEST CONNECTIONS

No-load test results

1. Rated current draw and no-load speed indicate normal condition of the starter.

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2. Low free-speed and high current draw indicate the following:
 - a) Excessive friction. Tight, dirty, or worn bearings, bent armature shaft, or loose pole shoes allowing the armature to drag.
 - b) Shorted armature. This can be further checked on a growler after disassembly of the starter.
 - c) Grounded armature or fields. Check again after disassembly.
3. Failure of the starter to operate with high current draw indicates the following:
 - a) A direct ground in the terminal or fields.
 - b) "Frozen" bearings. This may be determined by turning the armature by hand.
4. Failure to operate with no current draw indicates:
 - a) Open field circuit. This can be checked after starter disassembly by inspecting internal connections and tracing circuit with a test lamp.
 - b) Open armature coils. Inspect the commutator for badly burned bars after disassembly.
 - c) Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.
5. Low no-load speed and low current draw indicate high internal resistance due to poor connections, defective leads, dirty commutator and causes listed previously in condition 4.
6. High free-speed and high current draw indicate shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.

10.2.2 Lock-Torque Test

A variable resistance with a high current capacity should be used. The starter should be securely mounted and brake arm hooked to the drive pinion. When specified current is applied, the torque can be computed from the reading on the scale. A one foot brake arm will directly indicate foot-pounds.

Warning: *This test requires extreme caution. Follow instructions carefully.*

10.3 DISASSEMBLY

Normally, the starter should be disassembled only far enough to make repairs or to replace the defective parts. As a precaution, it is suggested that safety glasses be worn when disassembling or assembling the cranking motor. Proceed as follows:

1. Note the relative position of the solenoid, lever housing, and nose housing so the motor can be reassembled in the same manner.
2. Disconnect field coil from the solenoid motor terminal, and lead from the solenoid ground terminal.
3. On motors with brush inspection plugs, remove the plugs and then remove the brush lead screws. This will disconnect the field leads from the brush holders.
4. Remove the attaching bolts and separate the commutator end frame from the field frame.
5. Separate the nose housing and field frame from the lever housing by removing attaching bolts.
6. Remove armature and clutch assembly from lever housing.
7. Separate solenoid from the lever housing by pulling apart.

10.3.1 Cleaning

The driving mechanism armature and fields should not be cleaned in a degreasing tank, or with grease dissolving solvents, since these would dissolve the lubricants in the drive mechanism and damage the insulation in the armature and field coils. All parts, except the drive, should be cleaned with mineral spirits and

a brush. The drive can be wiped with a clean cloth.

If the commutator is dirty, it may be cleaned with No. 00 sandpaper.

Caution: *Never use emery cloth to clean the commutator.*

10.3.2 Armature Servicing

If the armature commutator is worn, dirty, out of round, or has high insulation, the armature should be put in a lathe so the commutator can be turned down. The insulation should then be cut 1/32" (0,79 mm) wide and 1/32" (0,79 mm) deep, and the slots cleaned out to remove any trace of dirt or copper dust. As a final step in this procedure, the commutators should be sanded lightly with No. 00 sandpaper to remove any burrs left as a result of the undercutting procedures.

The armature should be checked for opens, short circuits and grounds as follows:

Open Circuit Test

Open circuits are usually caused by excessively long starting periods. The most likely place for an open circuit to occur is at the commutator riser bars. Inspect the points where the conductors are joined to the commutator bars for loose connections. Poor connections cause arcing and burning of the commutator bars as the starter is used. If the bars are not too badly burned, repair can often be performed by resoldering the leads in the riser bars (using rosin flux), and turning down the commutator in a lathe to remove the burned material.

Caution: *Do not undercut the insulation between the commutator segments after turning down the commutator.*

Short Circuit Test

Short circuits in the armature are located by means of a growler. When the armature is revolved in the growler with a steel strip such as a hacksaw blade held above it, the blade will vibrate above the area of the armature core in which the short circuit is located. Short circuits between bars are sometimes produced by brush dust or copper between the bars. These short circuits can be eliminated by cleaning out the slots.

Ground Test

Grounds in the armature can be detected by the use of a 110 volts test lamp and test points. If the lamp lights when one test point is placed on the commutator with the other point on the core or shaft, the armature is grounded. Grounds occur as a result of insulation failure, which is often brought about by overheating of the starter produced by excessively long starting periods, or by accumulation of brush dust between the commutator bars and the steel commutator ring.

10.3.3 Field Coil Checks

The field coils may be checked for grounds and opens by using a test lamp.

Grounds

If the motor has one or more coils normally connected to ground, the ground connections must be disconnected during this check. Connect one lead of the 110 volts test lamp to the field frame and the other lead to the field connector. If the lamp lights, at least one field coil is grounded, and it must be repaired or replaced.

Opens

Connect test lamp leads to ends of field coils. If lamp does not light, the field coils are open.

10.3.4 Field Coil Removal

Field coils can be removed from the field frame assembly by using a pole shoe screwdriver. A pole shoe spreader should also be used to prevent distortion of the field frame. Careful installation of the field coils is necessary to prevent shorting or grounding of the field coils as the pole shoe is tightened into place. Where the pole shoe has a long lip on one side and a short lip on the other, the long lip should be assembled in the direction of armature rotation so it becomes the trailing (not leading) edge of the pole shoe.

10.3.5 Reassembly

Reassembly is the reverse of disassembly. To reassemble the end frame with brushes on to the field frame, pull the armature out of the field frame just far enough to permit the brushes to be placed over the commutator. Push the commutator end frame and the armature back against the field frame.

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The recommended torque for the cross-slotted pole shoe screws is 25-35 ft•lbf (34-47 N•m). The electric cable connector is fixed with a nut tightened to 20 ft•lbf (27 N•m) and a jam nut tightened to 27 ft•lbf (37 N•m).

10.4 PINION CLEARANCE

Pinion clearance should be checked after reassembly of motor to ensure the clearance is within specifications. To check pinion clearance (starter off engine), first disconnect the motor field connector from the solenoid motor terminal. Connect 24 volt battery with the positive battery lead to the solenoid switch terminal (5), and the negative battery lead to the grounded (G) solenoid terminal. Momentarily flash a jumper lead from the solenoid motor terminal to the grounded (G) solenoid terminal. The pinion gear will now shift into cranking position and remain that way until the battery is disconnected. Push the pinion or drive back towards the commutator end to eliminate slack movement. Measure the distance between pinion and pinion stop. This should be $23/64" \pm 1/32"$ (9,5 mm \pm 0,79 mm). Pinion clearance is adjusted to these limits by turning the solenoid shaft nut after removing access plug in shift housing. See figure 36.

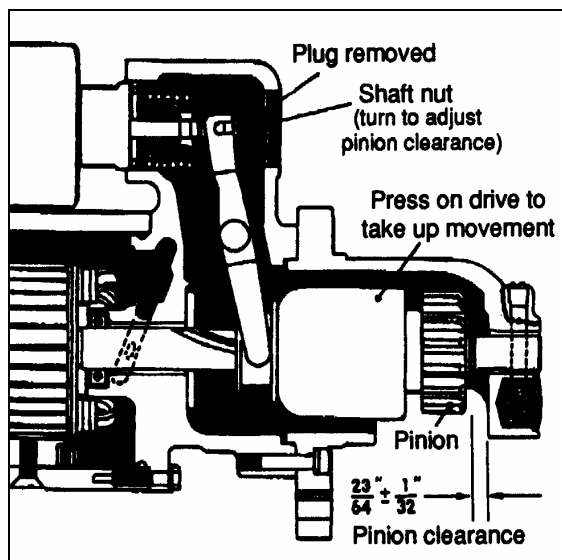


FIGURE 36: PINION CLEARANCE

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10.5 STARTER SOLENOID

The starter solenoid allows the starter pinion to mesh with the flywheel ring gear and also closes the electric circuit to energize the starting motor.

There are two windings in the solenoid: a pull-in winding and a hold-in winding. Both windings are energized when the external control switch is closed. They produce a magnetic field that pulls the plunger in so that the drive pinion is allowed into mesh, and the main contacts in the solenoid switch are closed to connect the battery directly to the starter. Closing of the main switch contacts shorts out the pull-in winding since this winding is connected across the main contacts. The magnetism produced by the hold-in winding is sufficient to hold the plunger in, and shorting out the pull-in winding reduces drain on the battery. When the control switch is opened momentarily, the pull-in winding and the hold-in winding are connected in series between the battery and common ground.

The polarity of the pull-in winding is reversed and opposes the magnetic pull of the hold-in winding. The magnetic holding force on the solenoid plunger is thus canceled. The return spring then quickly pulls the solenoid plunger back, opening the solenoid switch contacts and withdrawing the pinion gear from the meshing position at the same time. Proper operation of the switch depends on maintaining a definite balance between the magnetic strength of the pull-in and hold-in windings.

This balance is established in the design by the size of wire and the number of turns specified. An open circuit in the hold-in winding or attempts to start the motor with a discharged battery may cause the switch to chatter.

10.5.1 Disassembly

To disassemble the solenoid, remove nuts, washers, and insulators from the switch terminal and battery terminal. Remove the cover screws and cover. Take out the contact disk assembly.

10.5.2 Solenoid Maintenance

The solenoid requires no periodic maintenance other than keeping the terminals clean and tight. Always check the action of the solenoid if it has been removed. If the unit fails to function, first check wiring before condemning the solenoid. Solenoid windings can be checked for open or short circuit or current draw.

10.5.3 Solenoid Tests

Two tests must be made to determine the current draw of (1) both windings in parallel and (2) the hold-in winding alone. The solenoid windings can be tested with the solenoid either off or on the starter. However, when the solenoid is checked on the starter, it is necessary to disconnect both leads at the main solenoid terminals to prevent interference. The main solenoid terminal that is normally connected to the starter must then be grounded to the solenoid base by means of a jumper lead. For the first test, connect a source of variable voltage (battery and a variable resistance) in series with an ammeter between the solenoid base and the solenoid small switch terminal. Connect a voltmeter between the same two points. Slowly increase voltage and note the current draw. It should be 55-63 amps at 24 volts. Disconnect the jumper lead grounding the main solenoid terminal and readjust the variable resistance to obtain the specified voltage of 24 volts. It should not exceed 6.8 amperes.

When the solenoid has been removed from the starter for repair or replacement, the linkage must be adjusted to provide the correct pinion clearance when the solenoid is remounted on the starter. See "Pinion Clearance" earlier in this section for correct pinion clearance adjustment.

10.5.4 Recommendations

1. Tag each lead to ensure correct connections when the starter is reinstalled.
2. Tighten the 5/8"-11 starter attaching bolts to a torque of 137-147 ft•lbf (186-200 N•m).
3. Keep all the electrical connections clean and tight.
4. When installing wiring terminal leads to the starter and the solenoid switch, torque the No. 10-32 connections to 16-30 in•lbf (2-3 N•m) and the 1/2"-13 connections to 18-20 ft•lbf (24-27 N•m). For first nut and 24-27 ft•lbf (33-36 N•m) for the terminal one.

11. ENGINE BLOCK HEATER

The vehicle may be equipped with an engine immersion-type electric block heater to assist cold weather starting. The heater male electric plug is easily accessible through the engine oil reserve tank access door (Fig. 37). To use it, connect the female plug of an electrical

extension cord to the heater plug. Some converted vehicles may have the heater connected to the coach AC power system. The extension cord must be plugged into a 110-120 V AC power source only. The engine block heater should be used whenever the vehicle is parked for an extended period of time in cold weather and a suitable power source is available.

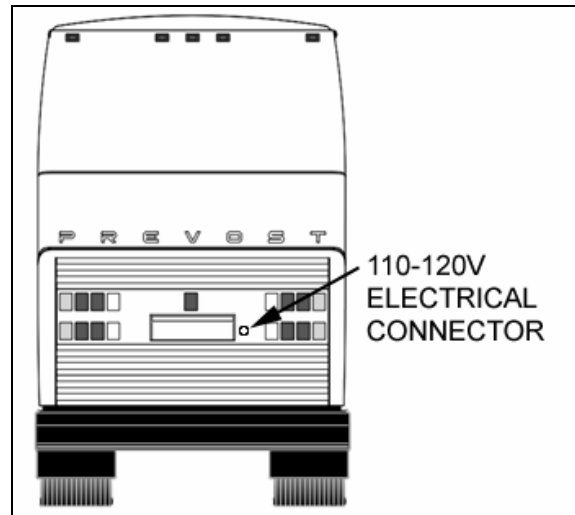


FIGURE 37: ELECTRIC HEATER PLUG LOCATION

11.1 MAINTENANCE

This heater is non-serviceable except for the cord, and if faulty, must be replaced as a unit.

12. EXTERIOR LIGHTING

The circuit for exterior lights, as well as their control switches, relays and circuit breakers are shown on the applicable wiring diagrams. Wiring diagrams are located in the technical publication box.

12.1 HEADLIGHTS

Each headlight assembly consists of two 12 volt halogen rectangular sealed-beam units. Outer lamps are double-filament units. Having high and low beams. Inner lamps are single-filament and operate with high beam of outer units. For identification purposes, outer units are molded with "2A1" and inner units are molded with "1A1" on top of the lens.

12.1.1 Headlight Beam Toggle Switch

The multifunction lever located on the steering column is used to select proper lighting. High beams or low beams can be selected by pulling

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the lever rearward. A high beam indicator on the central dashboard panel is illuminated when the high beam circuit is energized.

Note: Pulling the lever rearward while the lights are off will flash the headlights.

12.1.2 Maintenance

Clean headlights with soap and water and a good glass cleaner whenever dirty. For maximum illumination, headlight connections must be coated with a dielectric grease to prevent oxidation and proper voltage must be maintained. Low battery voltage, loose or dirty contacts in wiring system and poor ground contribute to a decrease in voltage. Check wiring and connections regularly and keep battery properly charged. When a headlight burns out, a new sealed-beam unit must be installed. Headlights must be properly aimed to provide maximum allowable road illumination. When using mechanical aiming devices, follow manufacturer's instructions.

Headlight aim should be checked after installing a new sealed-beam unit. Aiming can be performed without removing headlight bezels. Horizontal and vertical aiming of each sealed-beam unit is provided by two adjusting screws that move the mounting ring in the body against the tension of the coil spring (fig. 38). There is no adjustment for focus since the sealed-beam unit is set for proper focus during manufacturing assembly.

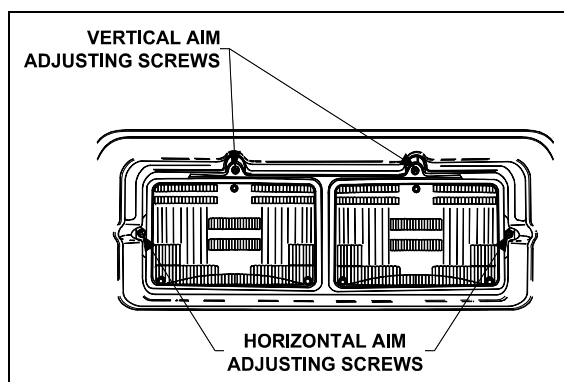


FIGURE 38: HEADLIGHT ASSEMBLY

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12.1.3 Headlight Adjustment

The following is a general procedure for headlight adjustment using a mechanical equipment, such as a "Bear 47-132 headlight

aligner". If your mechanical equipment is different, refer to the manufacturer's instruction manual.

Setting aligner according to slope

The floor level offset dial must match with slope to ensure a precise alignment.

1. Park vehicle on a level floor.
2. Fix one (1) calibration fixture to each aligner.
3. Install aligner in center of each wheel on one side of vehicle. Unit B must be installed beside the front axle wheel with its viewing port facing rearward, and unit A beside the drive axle wheel with its viewing port facing forward. See figure 40 for more details.

Note: Check that the three indicators on each module are set to zero.

4. Level each unit with the thumb adjusting screw on the fixture until level-vial bubble is centered.
5. Look through the top port hole of unit A, and turn horizontal knob until split images are aligned. See figure 39.

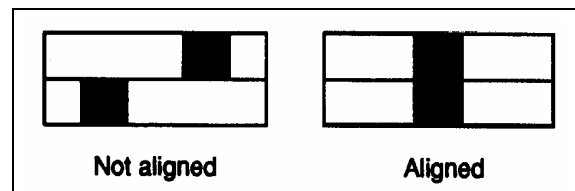


FIGURE 39: HEADLIGHT ALIGNER

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6. Set according to floor slope. Transfer positive (+) or negative (-) reading of horizontal dial to the floor level offset dial to offset floor slope on each aligner (Fig. 41). Push on the floor level offset dial to register reading.

7. Remove calibration fixture from each unit.

Note: If vehicle remains stationary during the headlight alignment procedure, it is not necessary to check floor slope each time.

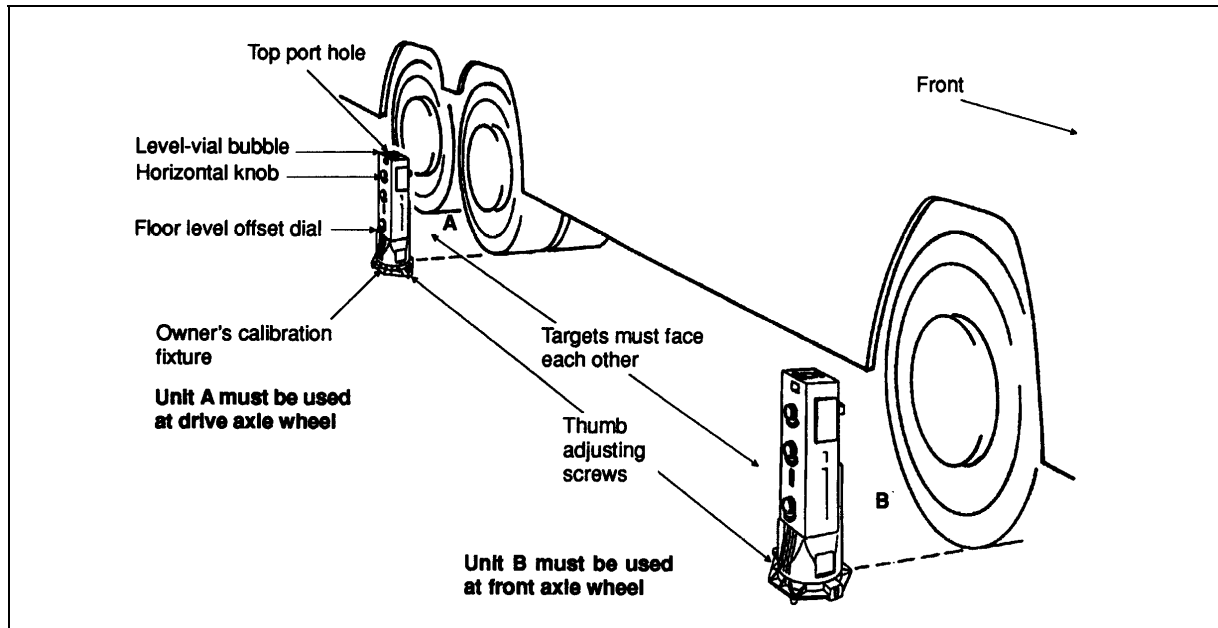


FIGURE 40: HEADLIGHT ALIGNER

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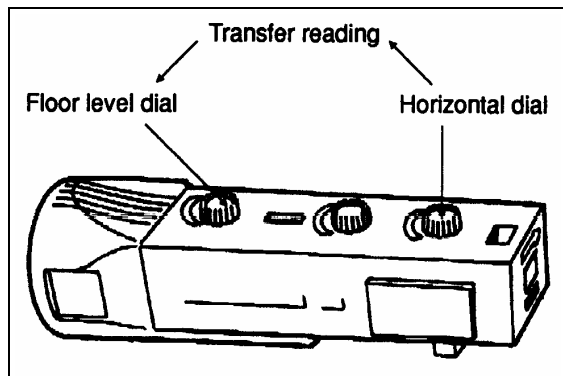


FIGURE 41: HEADLIGHT ALIGNER

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Headlight Alignment

The aligner is provided with adapters for different sizes of headlights that are always aligned in pairs.

1. Fix the adequate adapter on each headlight.

Note: The adapters are equipped with steel inserts, thus providing a good seating for precise headlight adjustment.

2. Install aligners on headlights (unit A on driver's side and unit B on other side with the sight openings facing each other) by pushing the handle forward to secure rubber suction disc. Pull handle until it locks. Refer to figure 42.

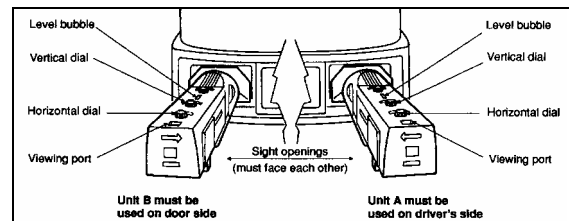


FIGURE 42: HEADLIGHT ALIGNER

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Note: Ensure that floor level offset dial is set correctly before aligning headlights.

Horizontal Alignment

1. Reset horizontal dial to zero.
2. Check that split image is visible in the viewing port. If not, reposition aligner by turning it.
3. Turn the horizontal aim adjusting screw of each headlight until split image is aligned (Fig. 43).

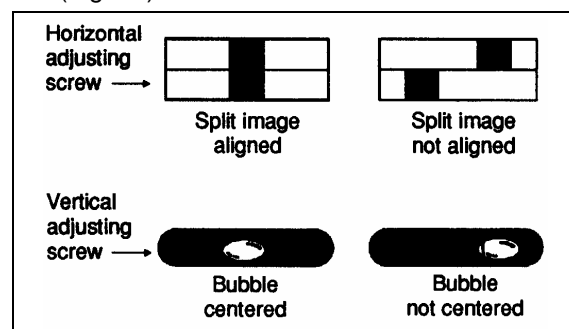


FIGURE 43: HEADLIGHT ALIGNER

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Vertical Alignment

1. Reset vertical dial to zero.
2. Turn the adjusting screw of the headlight vertical aim until bubble is centered (Fig. 43). Repeat operation on other headlight.
3. Recheck the horizontal alignment.

Remove aligners by pressing on vacuum release button.

Repeat the same procedure for the high beams.

If proper mechanical equipment is not available, perform adjustments as described below:

1. Park vehicle on level floor so headlights are 25 feet (7,6 m) from a smooth surface preferably of light color. A door or wall is suitable. Centerline of vehicle should be perpendicular to this vertical surface.
2. Draw a horizontal line on vertical surface at height of light center. Locate point on this horizontal line at which projected centerline of vehicle intersects. Measure distance between light centers and divide this distance equally on either side of center mark. Then draw two vertical lines directly ahead of each light center.
3. Switch on high beams and cover one headlight while adjusting the other.
4. When aiming headlights, beam may appear distorted. A new sealed-beam unit must be installed to correct this condition.
5. After headlight is properly aligned, cover it and proceed in the same manner as above with opposite headlight.

12.2 SEALED-BEAM UNIT REPLACEMENT

Removal

1. Remove screws attaching headlight bezel to front panel (10 "Phillips" screws) and remove bezel.
2. Remove four mounting screws attaching sealed-beam unit retaining ring to mounting ring.

Note: Do not disrupt headlight screw adjustment.

3. Remove sealed-beam unit and pull wiring connector off back of unit.

Replacement

1. Install wiring connector on back of sealed-beam unit. Position unit in mounting ring with molded lens number at top.

Note: Sealed-beam units with number "1A1" molded, on top of the lens must be used at inside light positions. Units with number "2A1" molded, on top of the lens must be used at outside light positions.

2. Position the retaining ring over the lens and secure it to the mounting ring with four screws.

Note: The headlight aim must be checked and adjusted even if it was properly adjusted before the sealed-beam unit was replaced, and adjusting screws were not removed.

3. After installing and adjusting the headlight assembly, install the headlight bezel.

12.3 FRONT TURN SIGNAL

The front turn signal is a part of the front headlight cluster. The turn signal lens is located on each front corner and shares a common bezel with the headlights. Turn signal is visible from both front and side.

12.3.1 Bulb Removal and Replacement

1. Remove the ten "Phillips" screws attaching the headlight bezel, then remove headlight bezel.
2. Remove socket from headlight bezel.
3. Remove the bulb by pushing and rotating it out of the socket.
4. Install the new bulb by reversing the previous procedure.

12.4 STOP, TAIL, DIRECTIONAL, BACK-UP, AND HAZARD WARNING LIGHTS

A combination stoplight, taillight, directional signal light and back-up light assembly is mounted at the rear, on each side of the vehicle. Furthermore, when braking, a center stoplight will illuminate simultaneously with the stoplights on the sides for increased safety.

The stop, tail, directional signal and back-up lights consist of individual bulbs mounted in a common housing, and each light is serviced individually as a complete unit and need only to be plugged into or unplugged from socket after removing proper light lens.

The hazard warning flashing system uses the front, side and rear directional lights simultaneously. This system is energized by a switch on the L.H. dashboard.

12.4.1 Bulb Removal and Replacement

1. Unscrew the retaining lens screws (2), then remove the lens.
2. Remove the bulb by pushing and then rotating it counterclockwise out of the socket.
3. Install the new bulb by pushing and rotating it clockwise, then replace the lens; the "Hella" inscription molded on the lens must be pointing upwards.

Note: *Lens must be installed in their original position.*

Note: *Taillights are provided with a different candle power bulb. Make sure appropriate replacements are used for any defective bulbs.*

12.5 LICENSE PLATE LIGHT

Two sealed units are mounted above the rear license plate(s) of vehicle. In case of burn out, the sealed unit must be changed according to the following procedure.

1. Pry out the rubber seal with a small screwdriver. Pull on the sealed unit and disconnect it.
2. Reconnect new sealed unit, place rubber seal, and press on it until it is seated in position.

12.6 CLEARANCE, IDENTIFICATION AND MARKER LIGHTS

The vehicle is equipped with marker, identification and clearance lights. The clearance lights are mounted at each corner of the coach near the top and the identification lights are in the upper center of rear and front sections. The rear clearance lights are red and the front ones are yellow.

The yellow marker lights are mounted along the sides of vehicle.

12.6.1 Marker Light Bulb Removal and Replacement

The side marker light is a sealed unit and should be replaced as an assembly in accordance with the following procedure:

1. Unscrew both "Phillips" light screws, then remove the light assembly.
2. Pull the connector to remove it from its socket.
3. Push the connector on the new light unit.
4. Position the light assembly and install the "Phillips" screws.

12.6.2 Clearance and Identification Light Bulb Removal and Replacement

The clearance and identification light bulb can be replaced in accordance with the following procedure:

1. Unscrew both "Phillips" lens screws, then remove the lens and housing.
2. Twist the bulb socket and pull out.
3. Pull the bulb straight out to remove it from its socket. Do not try to turn the bulb to remove it.
4. Install the new bulb by pushing it into the socket.
5. Position lens on housing, then install the "Phillips" screws.

12.7 DOCKING AND CORNERING LIGHTS

This vehicle is provided with two halogen headlights that serve as cornering lights. They are mounted on the vehicle as follows: one is mounted on the front L.H. side service compartment door, while the other is located between the front wheel and the entrance door on the R.H. side. The main function of these lights is to increase lateral visibility when turning a corner. These lights are energized simultaneously with the directional lights. On the V.I.P. model, a dashboard-mounted rocker switch may be actuated to cancel this system in special situations.

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Two additional halogen headlights are installed on rear electrical compartment doors. These lights are used as docking lights and both will illuminate automatically when reverse range is selected to facilitate back-up or docking procedure.

On the V.I.P. model, these lights do not operate automatically when the reverse range is selected, but by means of a dashboard-mounted rocker switch. When actuated, the docking as well as the cornering lights illuminate. Furthermore, a "Low docking" switch, also located on dashboard, allows the use of the docking and cornering lights at a lower intensity when the docking switch is actuated.

12.7.1 Lamp Removal and Replacement

Both docking and cornering headlights can be changed in accordance with the following procedure:

1. Remove the two "Phillips" screws attaching the retaining ring.
2. Disconnect the light unit connection.
3. Remove the lamp.
4. Position new lamp.
5. Connect and position the light unit.
6. Finally, install the retaining ring.

12.8 FOG LIGHTS

Optional halogen fog lights can be mounted on this vehicle to give the driver better visibility in foggy weather, or to improve the range of vision just ahead of the coach.

12.8.1 Bulb Removal and Replacement

1. Remove the protector cap on light unit (if so equipped). Remove the light unit retainer screw and slide the retainer upward.
2. Remove the light unit. Disconnect the light unit connection.
3. Remove retaining clip from its notches, then lift the retaining clip and remove the bulb.
4. Install the new bulb, then replace the retaining tab of clip to its position into the notches.

Caution: During this step, avoid contacting the bulb with your fingers. This could alter the bulb life.

5. Reconnect the light unit and replace in its proper position.
6. Replace the retainer.
7. Replace the light unit cover (if so equipped).

13. INTERIOR LIGHTING EQUIPMENT

13.1 CONTROL PANEL LIGHTING

The instrument gauges and switches mounted on all control panels are energized whenever the exterior light switch is pushed to the first position. A control dimmer located on the dashboard is used to vary the brightness of the panel gauges, switches and indicator lights.

The gauge lights, panel lights, switch lights and indicator lights have a different bulb arrangement. Thus, the procedure to change a defective bulb can vary according to the application.

13.1.1 Switch Lighting

1. Slightly pull the switch with a defective LED away from the control panel.
2. Disconnect the electric cable from the switch.
3. To install a new switch, reverse the procedure (Fig. 44).

Note: Switches are lighted by the use of LED. When lighting on a switch fails, replace defective switch as a unit.

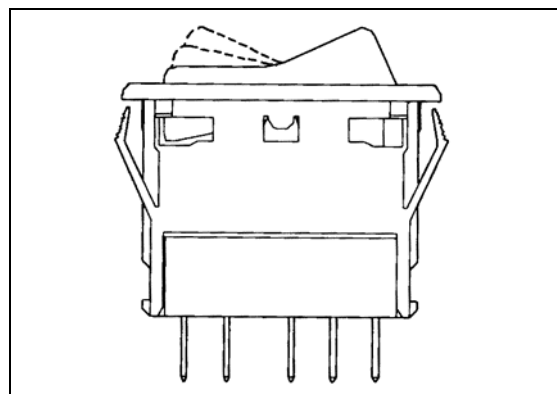


FIGURE 44: SWITCH

13.1.2 Telltale Light Replacement

Telltale module is non-serviceable and must be replaced as a unit.

1. Unscrew and remove the top dashboard panel.
2. Remove the telltale back wire electric connectors.
3. Unscrew and remove the telltale module.
4. To replace the telltale module, reverse the procedure.

13.1.3 Gauge Light Bulb Replacement

1. For any gauge light bulb replacement, the dashboard panel must be removed in order to have access to the rear of gauges.
2. Remove bulb socket from the gauge, turn the defective bulb counterclockwise and pull it out of the gauge.
3. Push a new bulb and socket ASM and turn clockwise to lock in place.
4. Replace the rear dashboard housing.

13.2 STEPWELL LIGHTS AND LAVATORY NIGHT-LIGHT

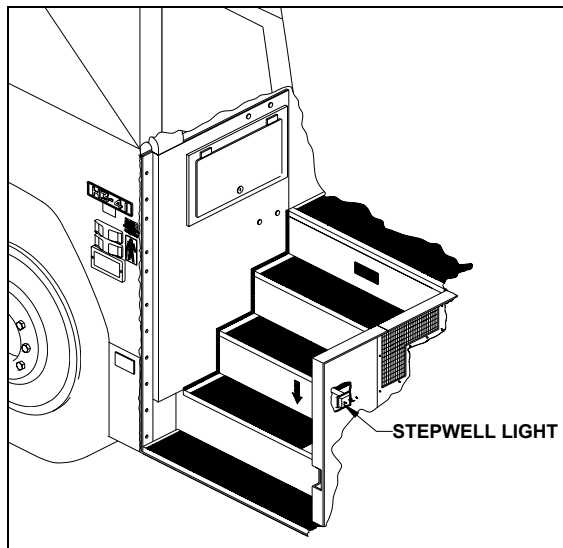


FIGURE 45: STEPWELL

Stepwell lights are illuminated when the door opening system is activated (Fig. 45).

The lavatory night-light is illuminated as soon as the ignition switch is set to the "ON" position.

13.2.1 Bulb Removal and Replacement

Proceed as follows to replace defective bulb:

1. Unscrew the two Phillips-head screws retaining the lens to the lavatory wall, and remove it.
2. With the light lens removed, pull bulb from the lamp while applying lateral pressure.
3. Install the new bulb into the lamp.
4. Position the light lens and install it.

13.3 DRIVER'S AREA LIGHTS

Two halogen ceiling lights are installed over the stepwell and the driver's area. These lights are frequently used for nighttime operation when passengers board or leave coach.

13.3.1 Bulb Removal and Replacement

1. Unsnap the lamp with a flat head screwdriver and remove it.
2. Pull the defective bulb out of the socket.
3. Install the new bulb by pushing it in position.
4. Replace the lamp by snapping it back in place.

Caution: Do not touch halogen bulbs with bare hands as natural oils on skin will shorten bulb life span.

13.4 PASSENGER SECTION LIGHTING

The passenger section of coach is lit by two types of fluorescent tube lamps installed on the parcel racks.

The aisle lights are located on front of parcel racks, and provide soft, indirect cabin lighting and parcel rack interior lighting. More powerful lighting for general and in-station applications is provided by fluorescent tubes located under the parcel racks, close to the windows. A dual power system is available for this lighting either from the 24 volt vehicle power supply or from a 110 volt outlet supply. In order to save batteries during extended periods of in-station lighting, no current is drawn from the batteries as soon as the 110 volt circuit is connected.

Moreover, adjustable reading lamps are installed under the parcel racks for passenger accommodation.

Section 6: ELECTRICAL

13.4.1 Fluorescent Tube Replacement

Indirect Fluorescent Light

1. Open the parcel rack access door, if so equipped, unscrew the two Phillips screws (one each end). Let the hinged cover down.
2. Remove fluorescent tube from light socket.
3. Install a new fluorescent tube.
4. Lift the hinged cover and replace the two retaining screws (Fig. 46).

Parcel Rack Interior Lighting

1. Open the parcel rack access door, if so equipped, unscrew the two Phillips screws (one each end). Pull the hinged cover down.
2. Push on the bulb, turn and then, pull it from the socket.
3. Install a new bulb.
4. Lift the hinged cover and replace the two retaining screws.

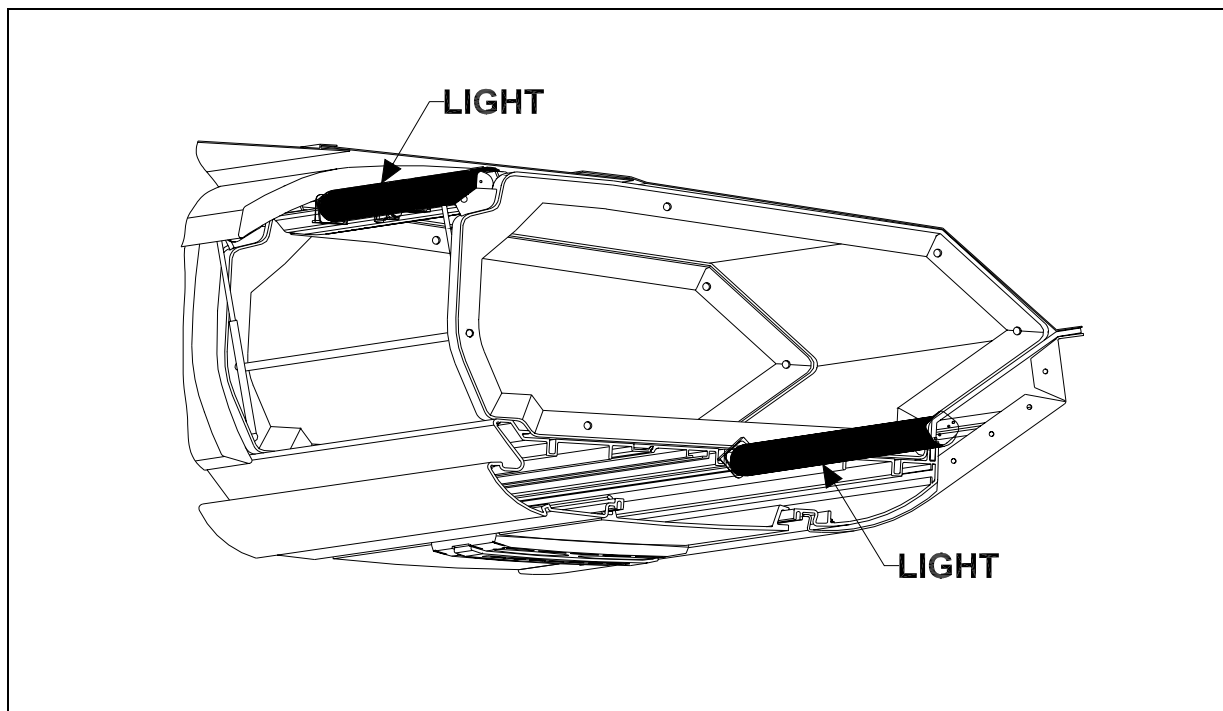


FIGURE 46: PARCEL RACK

06095

13.4.2 Removal and Replacement of In-Station Fluorescent Tubes

1. Start by pulling out the corner of the lens then delicately peeling it out of its seat.

Caution: *The lens is fragile. Be very careful when removing and handling.*

2. Rotate and pull the fluorescent tube from its sockets.
3. Install a new fluorescent tube, rotating the tube to secure it in the sockets.
4. Replace the screen lens by first inserting one side in the seat, then push the other

side in and snap it in place by running it in from one corner to the next.

13.4.3 Removal and Replacement of Reading Lamp Bulb

1. Engage the tool (#830164) over the lamp and turn one quarter turn counterclockwise. Then, remove the tool slowly.
2. Pull the bulb socket off the reading lamp unit.
3. Push and turn bulb counterclockwise, then pull it out of the socket.

4. Install new bulb in the socket, then push and turn clockwise to lock bulb in position.
5. Push the bulb socket in the reading lamp unit.
6. Position the reading lamp with the tool (#830164), turn one quarter turn clockwise.

13.5 ENGINE COMPARTMENT LIGHTING

Three lights illuminate the engine compartment upon opening of the engine door. Two are circular while the other is the same sealed unit as used to illuminate the license plate.

13.5.1 Circular Light

Each light is provided with one bulb that can be replaced as follows:

1. Remove the lens by prying out with a flat screwdriver.
2. Push and turn the defective bulb counterclockwise, then pull it out of the socket.
3. Install the new bulb in the socket, then push and turn clockwise to lock bulb in position.
4. Install the lens, and snap it in place.

13.5.2 Sealed Unit Light

In case of burn out, the sealed unit must be changed in accordance with the following procedure:

1. Pry the sealed unit out of its receptacle fixture by inserting a small flat screwdriver at one extremity, then pull on the sealed unit and disconnect it.
2. Reconnect new sealed unit, and press on it until seated in position.

13.6 LAVATORY LIGHT

The lavatory light is installed on ceiling and is provided with two fluorescent tubes. A microswitch, mounted in the door exterior frame, is activated by the door lock mechanism upon locking to energize the circuit. This switch is readily serviced by removing the two Phillips-head screws securing the mounting plate to the door exterior frame.

Section 6: ELECTRICAL

Proceed as follows to replace a fluorescent tube:

1. Press in side of lens (mirror side), free lens from its retaining groove, slide out other side and then remove lens.
2. Unsnap defective fluorescent tube by pushing both extremities simultaneously against felt discs.
3. Holding the fluorescent with one hand, push one of the pin receptacle steel plates inwards to free tube extremity, then remove tube from its fixture.
4. Reverse above procedure to install new fluorescent tube.

If ballast is defective or a wire feed voltage check is required, ballast cover may be removed by performing the previous first three steps and the following:

Warning: Be careful when checking the ballast feed voltage as its output voltage is 600 volts.

- a. Grasp and press both cover extremities inwards to free edges from the four rivets.
- b. Reverse previous steps to install cover, fluorescent tubes and lens.

14. LIGHT BULB DATA

When replacing a light bulb, special attention must be paid to the voltage rating (refer to light bulb date hereafter).

Note: All exterior lights are 12 volts and all interior lights are 24 volts, except for the "Check engine" and "Stop engine" warning lights and flasher indicator lights which are also on 12 volt system.

Application	Prévost part no.	Trade or SAE number	Watts or Candle Power	Volts	Qty
EXTERIOR LIGHTING					
Hi-beam	562690	H5051	50 W	12	2
Low-beam/Hi-beam	562689	H5062	40/55W	12	2
Docking & cornering	930319	H9415	37.5 W	12	4
Fog	561882	H3 (Osram)	55 W	12	2
License plate (sealed)	930266	---	---	12	2
Side directional	930301	Sealed	2 cp	12	6
Side marker	930304	Sealed	2 cp	12	2
	930301	Sealed	2 cp	12	4
Identification	562059	194	2 cp	12	6
Clearance	562059	194	2 cp	12	8
Front directional (hazard and marker)	561899	1157 NA	32/6 cp	12	2
Rear directional	561880	Hella	21 W	12	4
Stop	561880	Hella	21 W	12	4
Back-up	561880	Hella	21 W	12	4
Center stop	561880	Hella	21 W	12	1
Tail	561881	Hella	10 W	12	4
Exterior compartment (except engine)	562278	6429 (78207)	10 W	24	A R

Section 6: ELECTRICAL

Application	Prévost part no.	Trade or SAE number	Watts or Candle Power	Volts	Qty
Engine compartment	561917	1683	32 cp	24	2
	930209	---	---	24	1
INTERIOR LIGHTING					
Speedometer	560145	2721 M OSRAM	1 cp	24	2
Tachometer	560145	2721 M	1 cp	24	2
Turbo boost	561167	2721 M	3 W	24	1
Other instruments (1/unit)	560144	2721 MFX USRAM	1.6 cp	24	A R
Step	562278	6429	10 W	24	3
Lavatory	562278	6429	10 W	24	1
Parcel rack	560623	313	1.6 cp	24	A R
Driver's area	830151	Q35MR16	35 W	12	2
"EMERGENCY EXIT" decal	560601	456	2 cp	24	20
"LAVATORY OCCUPIED"	560144	1820	1.6 cp	24	2
"WATCH YOUR STEP"	560144	1820	1.6 cp	24	2
Aisle	560141	1251	3 cp	24	6
Reading	562519	5637	10W	24	A R
Fluorescent (In-Station)	830153	F32T8/SP41	32 W	---	A R
Lavatory fluorescent	830102	F15T8CW	15 W	---	2
Destination sign fluorescent	830080	F30T8CW4	20 W	---	1
Fluorescent (Indirect)	830152	F13T5/CW	13 W	---	---

Section 6: ELECTRICAL

15. SPECIFICATIONS

Battery

Make.....	Delco-Remy
Model.....	1150
Type	Maintenance-free
Terminal type	Top Stud
Group size.....	31
Volts	12
Load test amperage	290
Reserve capacity (minutes)	180
Cold cranking (in amps)	
-At 0°F (-18°C)	625 (each battery)
-At -20°F (-29°C)	490 (each battery)
Maximum dimensions (inches/mm)	
-Length (including flange)	13.0/330,2
-Width	6.8/172,7
-Height (including top posts)	9.4/238,8
-Approximate weight (lbs/kg)	60/27,2

❖ *Battery tester cable clamps should be between terminal nuts and lead pads of terminals. If not possible, load value should be 210 amperes.*

Torque specifications

Battery cable to post	10-15 ft-lbf (13-20 N·m)
Battery cover	45-50 ft-lbf (5-6 N·m)

Electrical system monitor

Make.....	Vanner
Model.....	EM-70
Input	24 V dc
System high	Greater than 30 V dc
System low	Less than 24 V dc
Trip level.....	+ 0.75 V dc
Prévost Number	562058

Alternator

Make.....	Delco Remy
Model Number.....	1117702
Series	50DN
Type	600

Section 6: ELECTRICAL

Field current at 80°F (27°C)

-Amperes..... 7.2 – 8.0
-Volts 24

Hot output

-Amperes.....270 at 80°F (27°C) ambient
-Volts 28
-Approximate rpm..... 3000
Ground negative
Prévost number..... 561723

Alternator

Make..... BOSCH
Model Number..... 0120689552
Series T1

Hot output

-Amperes..... 140 at 25°C (AMBIENT)
-Volts 28
-Approximate rpm..... 6000
Ground negative
Prevost Number 562752

Regulator

Make..... Delco-Remy
Model Number.....
Type Transistor
Voltage adjustment External screw
Prévost number 562775

Battery equalizer

Make..... Vanner
Model..... 60-50A
Amperes..... 50 amps
Prévost Number 561016

Section 6: ELECTRICAL

Battery equalizer

Make..... Vanner
Model..... 60-100D
Amperes..... 100 amps
Prévost Number 562542

Starter

Make..... Delco-Remy
Model Number..... 1990269
Series 50 MT
Type 400
Rotation (viewing drive end) CW
Brush tension 5 lbs (2,2 kg) Min.
Voltage 24

No-load test

-Volts 23
-Min. current draw 60 amperes
-Max. current draw 90 amperes
-Min. rpm 7000 rpm

Starter solenoid

Make..... Delco-Remy
Model Number..... 1115557
Current Draw 80°F(27°C)
-Hold-in winding 7.35 – 8.2 amps
-Pull-in winding..... 48 – 54.5 amps
Volts 24



Repair and Testing Instructions for T1 Alternator 0120 689 552



Modifications

Edition	Date	Name	Modifications
001	8/28/98	I. Serra	Original
002	12/4/98	I. Serra	Update 8.98 Instructions



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1 General

This manual contains repair and testing instructions with corresponding test specifications for the 0 120 689 5... series alternators.

T1 (RL) 28V 70/140A

Note: Alternator 0 120 689 543 was utilized in preparing these instructions.



2 Safety Precautions

2.1 Special Tool Usage



The use of incorrect or unsuitable tools and test equipment can lead to personal injury and may damage the alternator or its component parts. Only use tools that are specified in this instruction or meet the specification of the recommended tools.

2.2 Fire Risk



To provide radio interference suppression, the alternator is equipped with capacitors with a long storage time. Cleaning of alternator components may cause an electrical discharge when they are immersed in cleaning fluid. This discharge may cause combustible liquids to ignite.

2.3 Skin Protection



To avoid skin irritation when handling oils and greases, apply protective gloves or creams before starting work and wash off hands with soap and water when servicing has been completed.

2.4 Compressed Air



Only use compressed air regulated to a maximum of 4 Bar (60 PSI), and a clean cloth for cleaning of the armature, excitation windings and alternator plates.

2.5 Explosion Risk



Avoid exposure to fire, open flame and sparks. Thoroughly dry all cleaned parts as gases could form from the cleaning process and may cause an explosion.



3 Specifications

3.1 Electrical Test Specifications

Interference suppression capacitor	1.8 ... 2.6 μ F (microfarad)
Load current less than/equal to 10A	27.6 ... 28.4 V (volts, regulated)
Damping Resistance	3.1 ... 3.5 k Ω (kilohms)
Stator Resistance	0.036 Ω (-0/+10%) T1 (RL) 28V70/140A
Rotor Resistance	7.5 Ω (-0/+10%) T1 (RL) 28V70/140A

Power Output Test

Alternator	Speed (RPM)	Load Current - Inductive (A)	Test Duration (Min)
T1 (RL) 28V70/140 A	1500	76	30
	6000	136	10

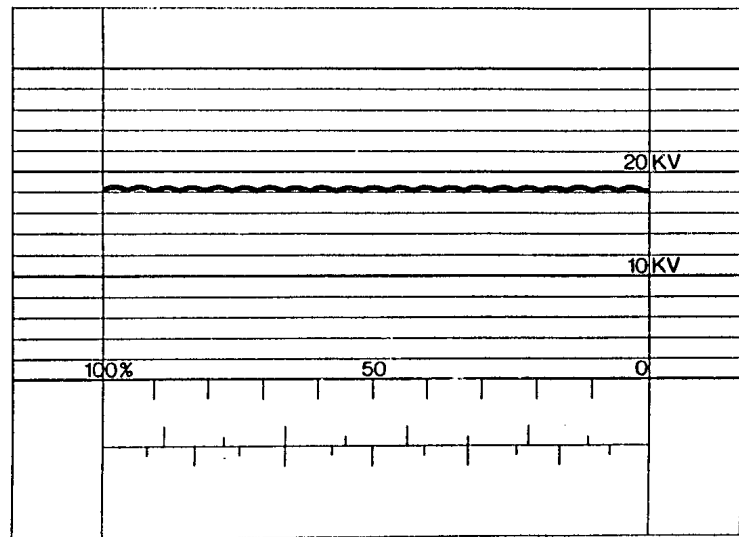
Following completion of the output test, allow alternator to run at 7000 rpm for one minute.

Oscilloscope Pattern

This image represents a properly functioning alternator. The D.C. voltage produced has a small harmonic wave.

Small spikes may be superimposed on the oscilloscope screen if the voltage regulator is regulating. Applying a load to the alternator output terminals can turn off the regulator.

In order to be able to compare oscilloscope images, the oscilloscope so the pattern fits between two vertical 10x divisions.



KME00052

Figure 1 Normal Oscilloscope Pattern



3.2 Mechanical Test Specifications

Rotor to Stator Air Gap (Between any side of stator and rotor)		Greater than 0.3 mm (0.012 in)
Eccentricity (Rotor mounted at bearing points)	Outer Diameter Of Rotor	0.05 mm (0.002 in) maximum
	Outer Diameter Of Collector Rings	0.03 mm (0.0012 in) maximum
Collector ring diameter	New	32.5 mm (1.279 in)
	Used	31.5 mm (1.240 in) minimum
Carbon Brush Projection	New	16.0 mm (0.630 in) minimum
	Used	7.0 mm (0.275 in) minimum

3.3 Tightening Torques

Item Number	Description	Metric (Nm)	SAE
55	Air Intake Stud	3.0 ... 3.4	26.5 ... 30.1 in. lbs.
66	D+ Terminal	2.4 ... 3.2	21.2 ... 28.3 in. lbs.
29	B+ Terminal, B- Terminal	10.0 ... 13.0	88.5 ... 115 in. lbs.
37	W Terminal	4.1 ... 5.5	36.3 ... 48.7 in. lbs.
15	Voltage Regulator	1.3 ... 1.7	11.5 ... 15.0 in. lbs.
43	Capacitor Mounting Screw	4.3 ... 5.7	38.0 ... 50.4 in. lbs.
23	Rectifier Mounting Screw	1.3 ... 1.7	11.5 ... 15.0 in. lbs.
21	Drive End Shield to Collector Ring Shield	7.2 ... 9.7	63.7 ... 85.9 in. lbs.
5	Drive End Shield Bearing Cover Plate	4.1 ... 5.5	36.3 ... 48.7 in. lbs.
52	Pulley Retaining Nut	135 ... 170	99.5 ... 125.4 ft. lbs.

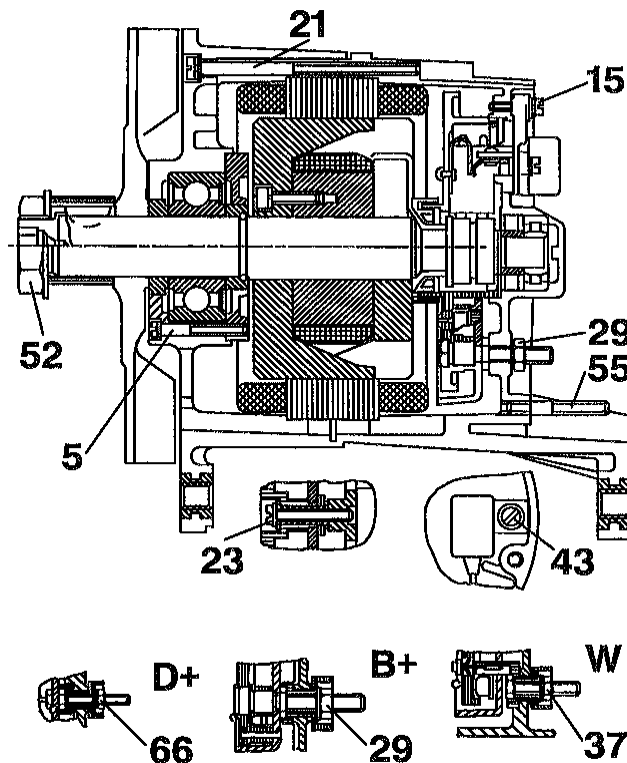
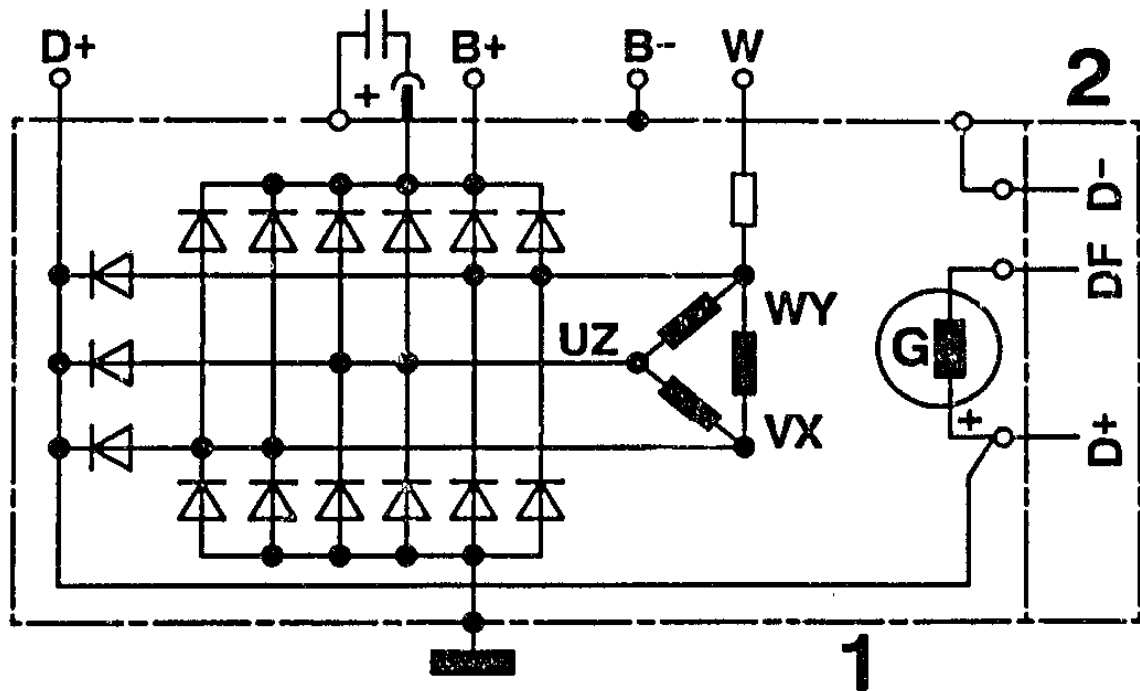


Figure 2 Fastener Torque Chart



4 Alternator Schematic



KME 00050

Figure 3 Alternator/Voltage Regulator Schematic

1 Alternator

- B+ Battery Positive
- B- Battery Negative
- D+ Dynamo + (Warning Lamp Output)
- W Tachometer Output

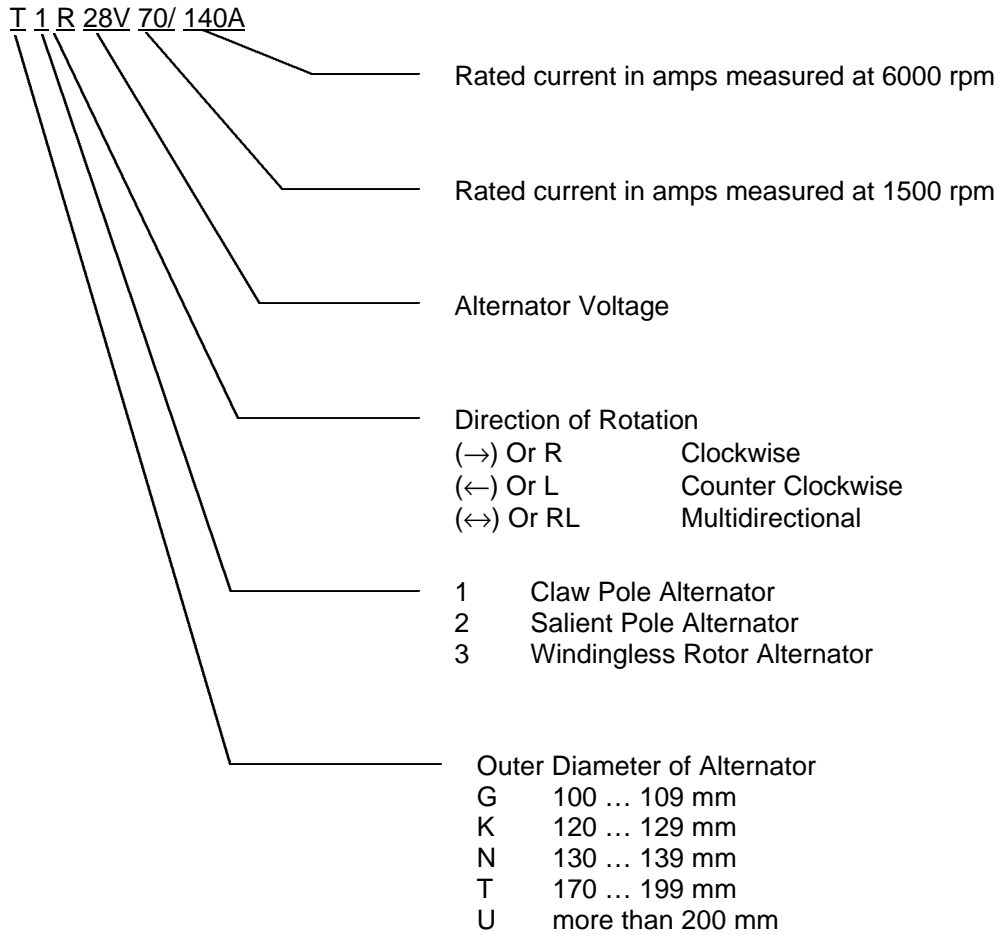
2 Voltage Regulator

- D+ Dynamo + (Alternator Output)
- DF Dynamo Field
- D- Dynamo -



5 Alternator Coding

T 1 R 28V 70/ 140A





6 Parts Cleaning



Caution: Fire Risk

To provide radio interference suppression, the alternator is equipped with capacitors with a long storage time. Cleaning of alternator components may cause an electrical discharge when they are immersed in cleaning fluid. This discharge may cause combustible liquids to ignite.

Alternator components with capacitors should only be cleaned with a non-combustible cleaner such as HAKU 1025/6.



Caution: Compressed Air

Only use compressed air regulated to a maximum of 4 Bar (60 PSI), and a clean cloth for cleaning of the armature, excitation windings and alternator plates.



Caution: Explosion Risk

Avoid exposure to fire, open flame and sparks. Thoroughly dry all cleaned parts as gases could form from the cleaning process and may cause an explosion.



7 Tools, Test Equipment Lubricants and Adhesives

7.1 Test Equipment

Description	Bosch Number	
Alternator Test Bench	Commercially Available	
Internal Short-Circuit Tester (Flash Tester)	KDAW 9978	0 986 619 110
Universal Multi-Meter	MMD 302	0 684 500 302
Alternator Tester	WPG 012.00	0 684 201 200

7.2 Special Tools

Description	Bosch Number	
Arbor Press	Commercially Available	
Soldering Iron	Commercially Available	
Universal Bearing Puller	Commercially Available	
V-Block <i>Note: 2 Required</i>	Commercially Available	
14mm Hex, 1/2" Drive Socket	Commercially Available	
Clamping Support	KDAW 9999	0 986 619 362
Die Spigot for Arbor Press (Used with KDLJ 6011, KDLJ 6012, KDLJ 6015)	KDLJ 6010	0 986 618 124
Bearing Remover	KDLJ 6009	0 986 618 121
Press Tool for Roller Bearing	KDLJ 6021	0 986 618 139
Bearing and Seal Installer	KDLJ 6011	0 986 618 125
Collector Ring Installer	KDLJ 6012	0 986 618 126
Drive End Shield Support Ring for Rotor Pressing	KDLJ 6013	0 986 618 127
Press Tool - Spacer Ring, Roller Bearing Inner Race and Collector Rings	KDLJ 6018	0 986 618 134
Alignment Pin - Drive End Shield and Collector Ring End Shield	KDLJ 6014	0 986 618 128
Removal Tool - Sliding Bushing	KDLJ 6015	0 986 618 129
Holding Tool - Sliding Bushing	KDLJ 6016	0 986 618 130
Inner Bearing Race Removal Tool	KDAW 9996	0 986 619 269
Puller Receiver Cup	KDAW 9995/0/1	0 986 619 214
Threaded Pin with Cone	KDAW 9995/14	0 986 619 250
Bearing Puller Spring Collet	KDAW 9995/6	0 986 619 233
Feeler Gauge 0.15 ... 0.6 mm (.005024 in) <i>Note: 4 required</i>	KDZV 7399	0 986 618 378
Dial Indicator	EFAW 7	1 687 233 011
Magnetic Indicator Stand	T-M 1	4 851 601 124



7.3 Lubricants and Adhesives

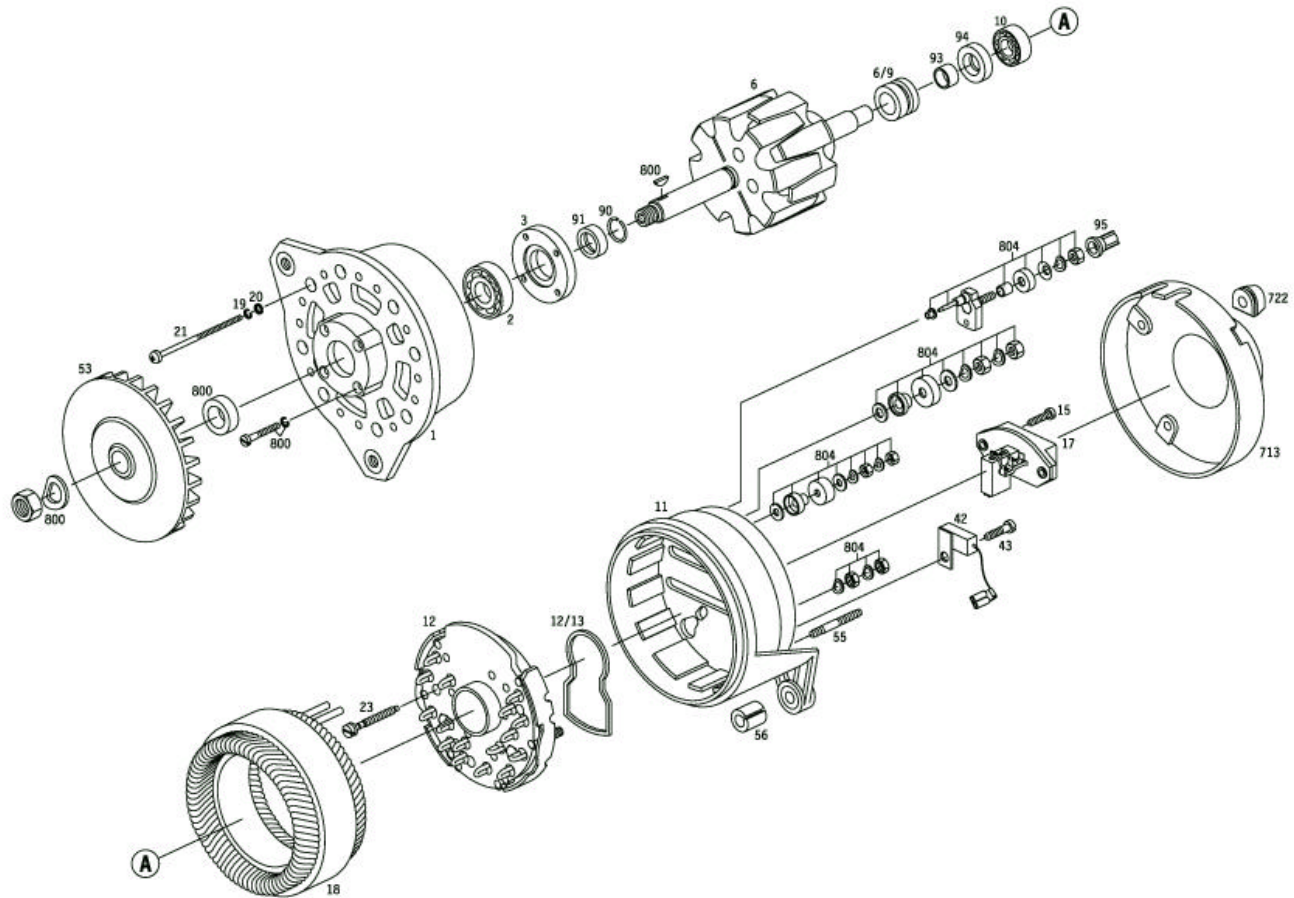
Description	Manufacturer Number	Bosch Number
Roller Bearing Grease	UNIREX N3	5 975 560 125
	Ft1 v 34	5 700 009 000
	VS 15164-Ft	5 975 560 000
Molycote Paste	Ft 70 v 1	5 700 040 000
Adhesive Dispersant	KK57v1	5 703 151 000
Silicon Paste	Ft2v4	5 700 083 005

7.3.1 Lubricant Quantities

Bottom of Roller Bearing	2 g (0.07 oz.)
Collector End Shield Radial Seal	2 g (0.07 oz.)
Roller Bearing	2...2.5 g (0.07...0.09 oz.)



8 Exploded View

**Figure 4 Alternator Exploded View**

<u>Item</u>	<u>Designation</u>	<u>Item</u>	<u>Designation</u>
1	Drive End Shield	20	Plain Washer
2	Ball Bearing	21	Oval-Head Screw
3	Cover Plate	23	Washer & Screw Assembly
6	Rotor	42	Suppression Capacitor
6/9	Collector Ring	43	Oval-Head Screw
10	Roller Bearing	53	Fan
11	Collector-Ring End Shield	55	Stud
12	Rectifier	56	Expansion Bushing
12/13	Seal	90	Retainer
15	Washer & Screw Assembly	91	Support Ring
17	Transistor Regulator	93	Spacer Ring
17/3/8	Compression Spring	94	Radial Seal
17/3/801	Carbon-Brush Set	95	Protective Cap
17/10	Gasket	713	Air-Intake Cover
18	Stator	722	Grommet
19	Spring Lock Washer		



9 Alternator Disassembly and Testing

9.1 Rear Cover Removal

1. Clamp alternator in clamping fixture KDAW 9999 (Bosch Number 0 986 619 362).
2. Remove four nuts holding on the air intake cover. (Figure 5)

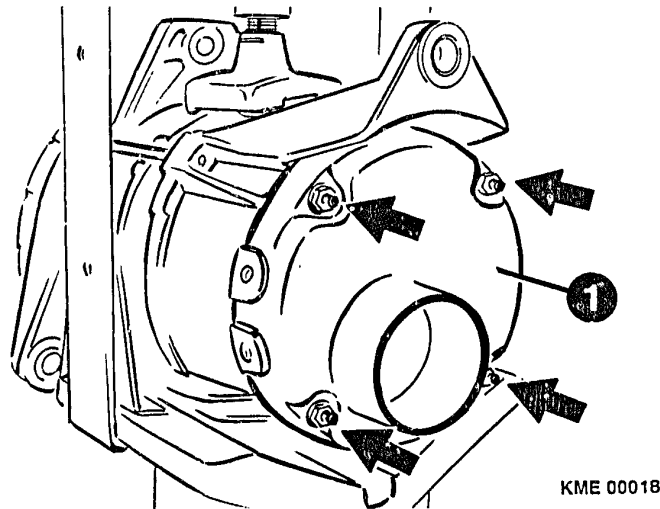


Figure 5 Air Intake Cover Removal (1)

Note: The voltage regulator must be removed before any further disassembly of the alternator takes place. The brushes of the regulator can break if the regulator is not removed before any other disassembly takes place.

9.2 Voltage Regulator Removal

1. Remove the three (3) screws that secure the regulator to the collector ring end shield. (Figure 6)
2. Carefully remove the voltage regulator from the collector ring end shield.

Note: The brushes of the regulator will break if the regulator is not removed before any other disassembly of the alternator takes place.

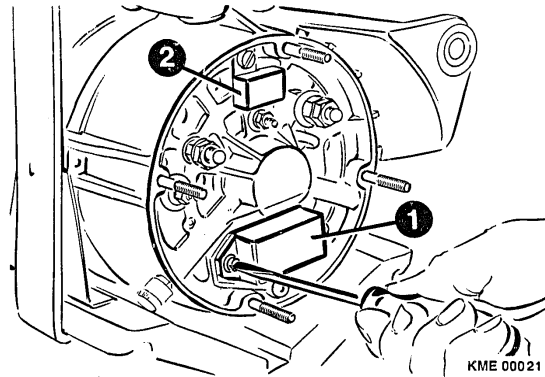


Figure 6 Voltage Regulator (1) and Suppression Capacitor (2)

9.2.1 Brush Replacement

1. The exposed length of the carbon brushes must be measured to determine if they require replacement. Measure the length of each brush. If the exposed brush length is less than 7 mm (0.276"), the brush must be replaced. (Figure 7)

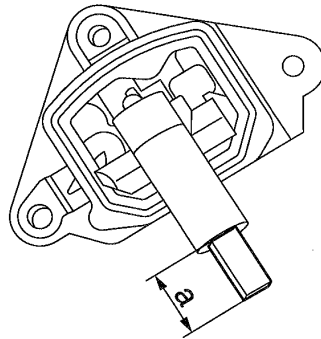


Figure 7 Brush Length Measurement

2. To replace the brushes, the brush lead must be unsoldered and the brush removed from the regulator.
3. Insert the new brush into the regulator and solder the brush lead to the regulator.

Note: Use only rosin-core solder to attached the brush lead.

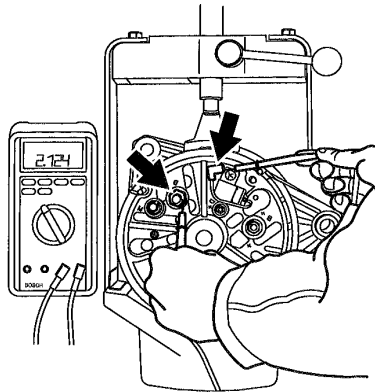
4. Check the brushes for freedom of movement after they are soldered.
5. Measure the exposed length of the new brushes. The exposed length should be 16 mm (0.630")

9.3 Noise Suppression Capacitor Testing and Removal

1. Disconnect the suppression capacitor from terminal B+.



2. Connect Multimeter MMD 302 (Bosch Number 0 684 500 302) or equivalent to the lead of the suppression capacitor and the B- terminal of the alternator. (Figure 8)

**Figure 8 Testing of Suppression Capacitor**

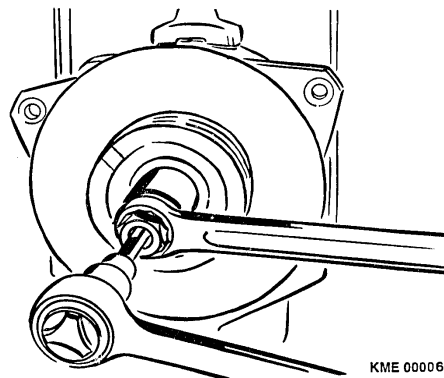
3. Measure the capacitance of the suppression capacitor. If the capacitance does not read between 1.8 and 2.6 μF (microfarad), the capacitor must be replaced.
4. Remove the screw that secures the suppression capacitor and remove capacitor.

Note: After removing the suppression capacitor from the alternator, the capacitor lead should be shorted to the capacitor-mounting strip to discharge the capacitor. Failure to do so may cause the capacitor to discharge while being cleaned.

9.4 Pulley and Fan Removal

1. Using a 14-mm hex socket to hold the rotor shaft. Loosen and remove pulley-retaining nut with a box wrench. (Figure 9)

Note: Do not use an air impact gun to remove the nut as the force of the impact may cause damage to the alternator bearings.

**Figure 9 Pulley and Fan Removal**

2. Remove the pulley and cooling fan from the alternator.

9.5 Separation of Drive Shield and Collector End Shield

Note: With a scribe, mark the relationship between the drive end shield and the collector ring end shield. This will assist in the realignment of the two shields upon reassembly.

1. Loosen and remove the four (4) outer Oval-head screws which hold the end shields together. (Figure 10)



2. Slide the drive end shield and rotor out of the collector end shield.

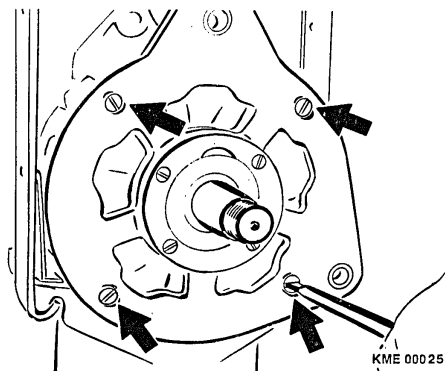


Figure 10 Drive End Shield Removal

9.6 Rectifier Assembly Testing

Note: The following testing of the rectifier is to be performed with the rectifier assembly installed and wired in to the stator.

1. With the rectifier assembly still installed in the collector end shield, testing of the rectifier is to be performed.
 - a. Using tester WPG 012.00 (Bosch Number 0 684 201 200) (Figure 11)
 - i) Connect the negative (black) lead of the tester to the collector end shield and the positive (red) lead to each of the stator connection solder joints.
 - ii) Connect the positive (red) lead of the tester to the B+ Terminal and the negative (black) lead to each of the stator connection solder joints.
 - iii) Connect the positive (red) lead of the tester to the D+ Terminal and the negative (black) lead to each of the stator connection solder joints.

The rectifier assembly is reusable if the tester remains in green zone. If the rectifier assembly fails any test, one or more of the diodes are defective and the whole assembly must be replaced.

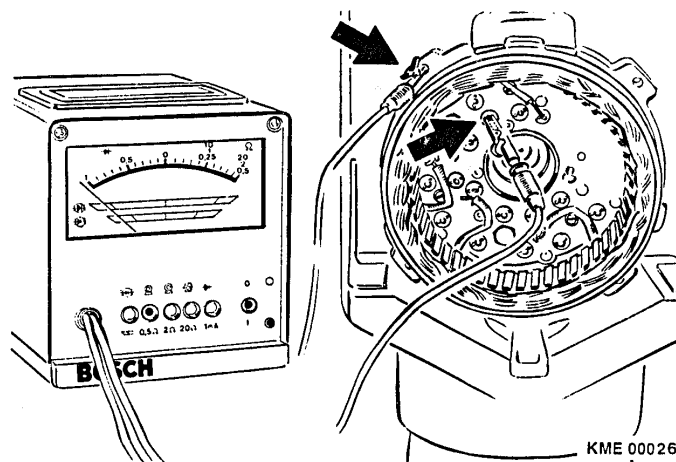


Figure 11 Testing of Rectifier Assembly

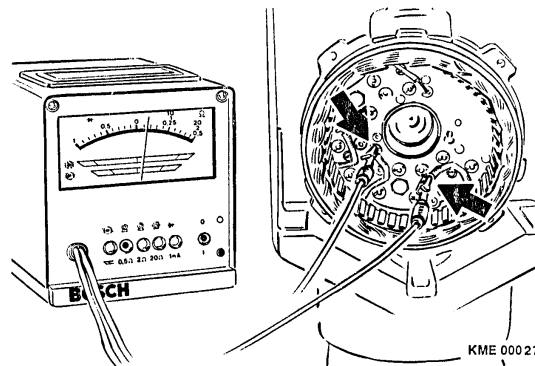
**b. Using a Diode Tester**

- i) Connect the negative (black) lead of the tester to the collector end shield and the positive (red) lead to each of the stator connection solder joints. No current should pass through the rectifier assembly.
- ii) Connect the positive (red) lead of the tester to the collector end shield and the negative (black) lead to each of the stator connection solder joints. Current should pass through the rectifier assembly.
- iii) Connect the positive (red) lead of the tester to the B+ Terminal and the negative (black) lead to each of the stator connection solder joints. No current should pass through the rectifier assembly.
- iv) Connect the negative (black) lead of the tester to the B+ Terminal and the positive (red) lead to each of the stator connection solder joints. Current should pass through the rectifier assembly.
- v) Connect the positive (red) lead of the tester to the D+ Terminal and the negative (black) lead to each of the stator connection solder joints. No current should pass through the rectifier assembly.
- vi) Connect the negative (black) lead of the tester to the D+ Terminal and the positive (red) lead to each of the stator connection solder joints. Current should pass through the rectifier assembly.

If the rectifier assembly fails any test, one or more of the diodes are defective and the whole assembly must be replaced.

9.7 Removal and Testing of Stator Assembly

1. With tester WPG 012.00 or Multimeter MMD 302 set to read 0 to 0.5 Ω , test the resistance of the stator while it is still attached to the rectifier assembly. Connect the test leads between the phase outputs of the stator. Repeat the test until all three phases of the stator has been tested. A good stator will read between 0.036 Ω and 0.040 Ω . (Figure 12)

**Figure 12 Stator Resistance Testing**

2. Unsolder the stator phase connections from the rectifier assembly with a soldering gun or iron.
3. Bend open any bent-over lead connections with a screwdriver or pliers and pull the stator leads from the rectifier eyelets.

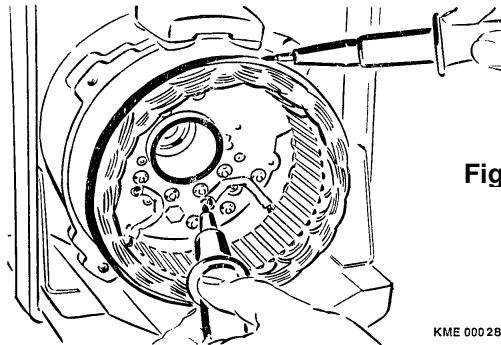


Note: The insulation tester applies a voltage of 80 VAC to the stator. Voltages of 80V can be fatal. When performing this test, observe care is used in handling the stator and any component or surface that is exposed to the stator. Use insulated gloves and do not touch the work surface until all tests are completed.



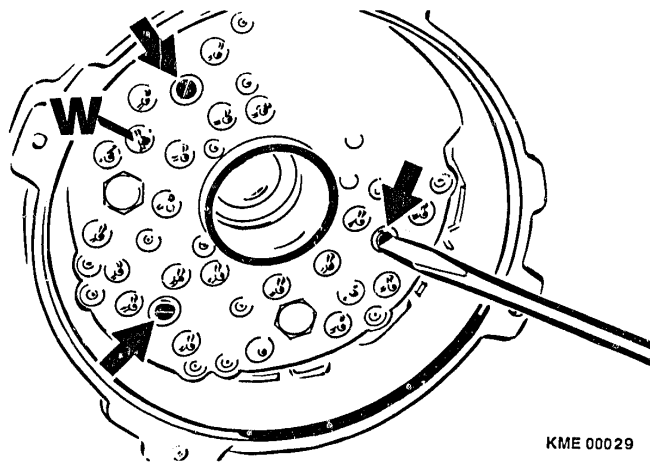
- Using insulation tester KDAW 9983 (Bosch Number 0 986 619 110) or equivalent, apply 80 VAC to each of the stator phase leads with one probe while the other probe is in contact with the exterior of the stator. (Figure 13)

No continuity should be present. Any continuity between the stator phase leads and the exterior of the stator indicates a breakdown of the stator insulation and a short to ground. If continuity is present, the stator must be replaced.

**Figure 13 Stator Insulation Testing**

9.8 Rectifier Assembly Removal

- Loosen and remove the three screws that hold the rectifier to the collector end shield. (Figure 14)
- Unsolder the W terminal from the rectifier assembly.

**Figure 14 Rectifier Assembly Removal**

- Remove the nuts holding terminals B+, B- and D+ to the collector end shield.

Note: Do not attempt to remove the studs from the rectifier assembly. Terminals B+, B- and D+ are permanently attached to the rectifier assembly. Terminal W is attached to the collector end shield. Do not loosen Terminal W.

- Remove the rectifier assembly from the collector end shield.



9.9 Dampening Resistor Testing and Removal

1. The W Terminal incorporates a dampening resistor. Using a Multimeter MMD 302, connect one lead to the exterior portion of the W terminal and connect the other lead to the other side of the W Terminal. The Multimeter should read between 3.1 and 3.5 k (kilohm). If the resistance is above or below this range, the W terminal is to be replaced as an assembly. (Figure 15)

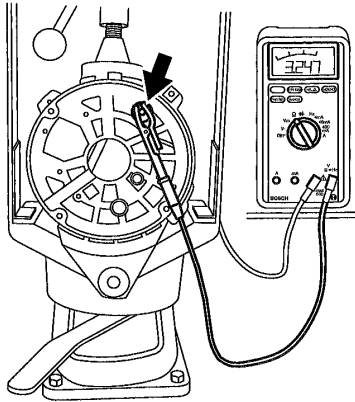
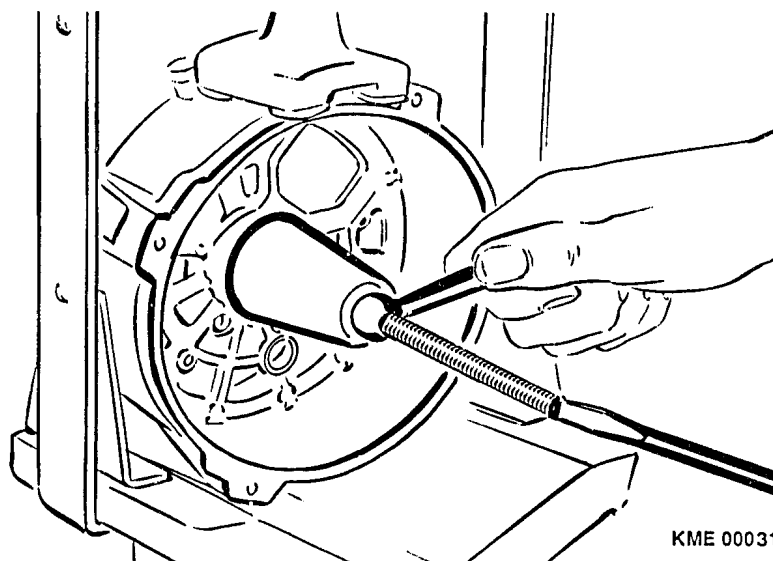


Figure 15 Testing of W Terminal Dampening Resistor

2. Loosen the nut retaining terminal W to the collector end shield.
3. Remove terminal W.

9.10 Removal of Collector End Shield Bearing and Seal

1. Insert extractor KDLJ 6009 (Bosch Number 0 986 618 121) into bearing.
2. Screw threaded rod KDAW 9995/14 (Bosch Number 0 986 618 214) into extractor KDLJ 6009.
3. Slide the receiver cup KDAW 9995/0/5 (Bosch Number 0 986 619 250) onto threaded rod.
4. Screw on the handle, rotate until the bearing, and seal come out of the collector end shield. (Figure 16)



KME 00031

Figure 16 Bearing and Seal Removal



5. If the roller bearing is stuck in end shield, proceed as follows:
 - a. Remove extractor KDLJ 6009 from the bearing.
 - b. Destroy the bearing cage with a screwdriver or similar tool.
 - c. Remove rollers from bearing.
 - d. Insert spring collet KDAW 9995/6 (Bosch Number 0 986 619 233) into bearing outer race.
 - e. Screw threaded rod KDAW 9995/14 into extractor KDAW 9995/6.
 - f. Slide the receiver cup KDAW 9995/0/5 onto threaded rod.
 - g. Screw on handle and rotate until the bearing race comes out of the collector end shield.

9.11 Removal of Sliding Bushing in Collector End Shield

1. Place collector end shield in an arbor press, support mounting/pivot boss on mandrel KDLJ 6016 (Bosch Number 0 986 618 130). (Figure 17)
2. Place bushing mandrel KDLJ 6015 (Bosch Number 0 986 618 219) on sliding bushing.
3. Press sliding bushing out of collector end shield into mandrel KDLJ 6016.

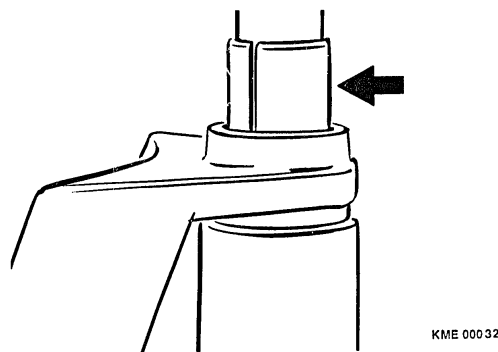


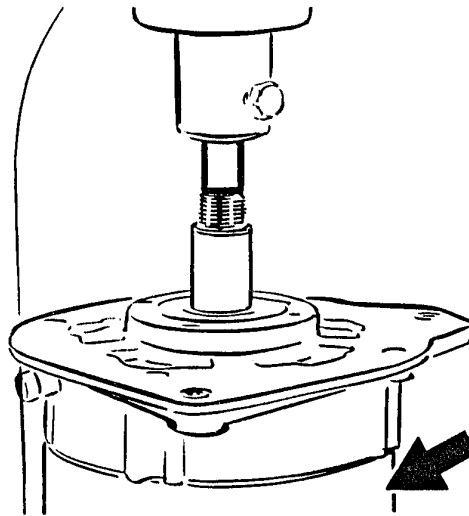
Figure 17 Sliding Bushing Removal

9.12 Removal of Rotor from Drive End Shield

1. Place drive end shield onto pressing ring KDLJ 6013 (Bosch Number 0 986 618 127).
2. Place pressing ring into an arbor press. (Figure 18)



3. Press out rotor.



KME 00033

Figure 18 Pressing out Rotor

4. Remove spacer ring from rotor shaft.

Notes: Protect the threads of the rotor from damage prior to pressing. Always replace the drive end bearing if the rotor has been pressed out. Therefore, only remove the rotor if;

- *the rotor is to be replaced*
- *the excitation winding of the rotor is to be replaced*
- *the drive end bearing/spacer ring is to be serviced*
- *the rotor collector rings are to be replaced*



9.13 Removal of Bearing and Seal from Drive End Shield

1. Loosen and remove the four (4) screws holding the bearing cover plate. (Figure 19)
2. Remove the spacer ring (Refer to arrow in Figure 19).
3. Remove the bearing from the drive end shield.

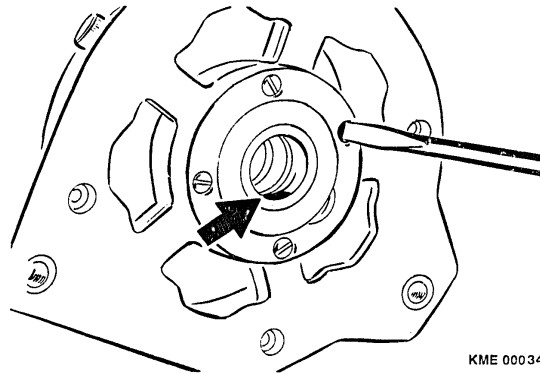


Figure 19 Drive End Bearing Removal

9.14 Removal of Collector Ring End Inner Bearing Race from Rotor

1. With a universal bearing puller, remove the inner race of the endshield bearing. (Figure 20)

Notes: Place jaws of the puller yoke behind the inner-bearing race and pull the bearing race only. Do not place the yoke behind the spacer ring. Pulling both the bearing and the spacer ring at the same time may damage the rotor. The inner bearing race must be replaced anytime the collector end shield bearing is replaced.

2. Reposition the puller and remove the spacer ring from the rotor shaft.

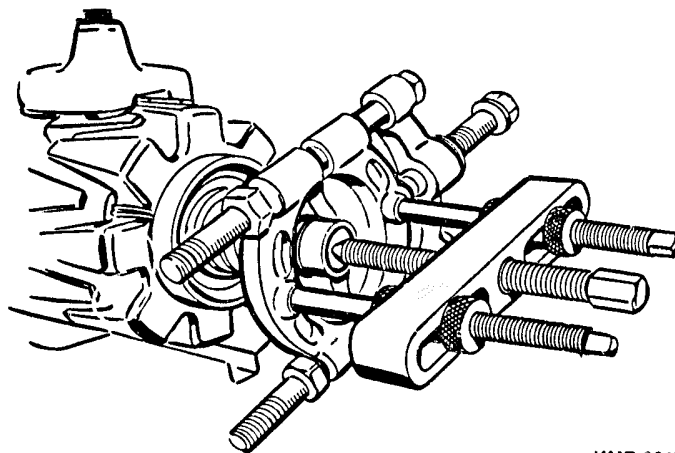


Figure 20 Inner Bearing Race Removal



9.15 Rotor Inspection

1. Using electric tester ETE 014.00 or Multimeter MMD 302, measure the resistance between the two collector rings of the rotor. The resistance measured should be between 7.5 and 8.3 Ω . (Figure 21)

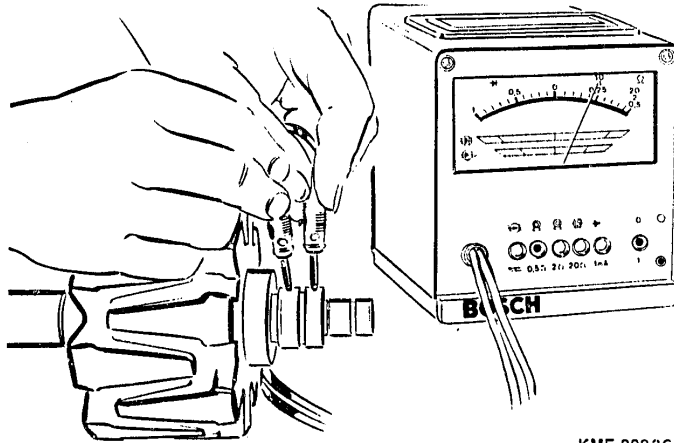


Figure 21 Rotor Resistance Testing

2. Using insulation tester KDAW 9983 or equivalent, apply 80 VAC to the rotor claw poles and each of the collector rings. If the insulation tester lights, there is a short to ground within the rotor. (Figure 22)

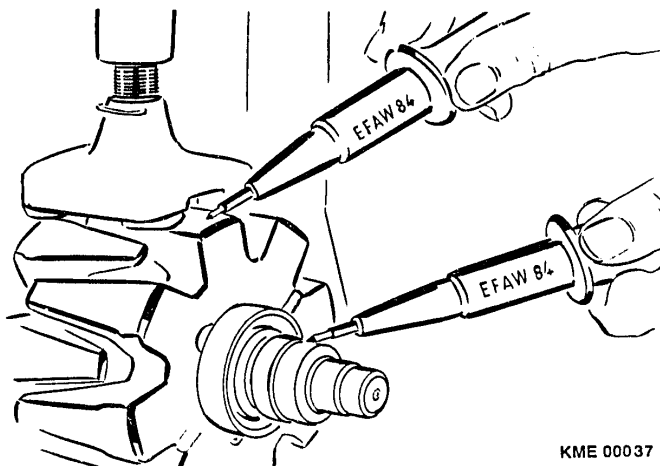


Figure 22 Rotor Insulation Testing

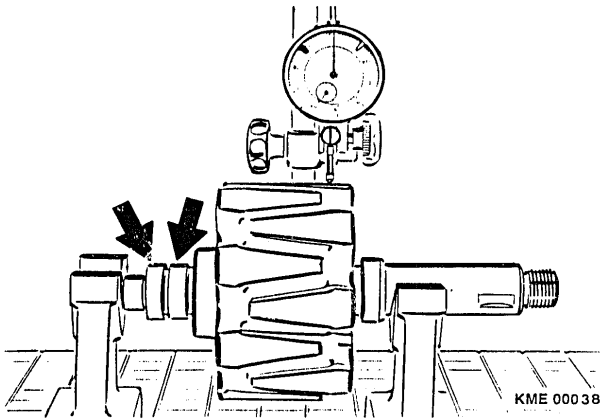


Note: The insulation tester applies a voltage of 80 VAC to the rotor. Voltages of 80V can be fatal. When performing this test, observe care is used in handling the rotor and any component or surface that is exposed to the rotor. Use insulated gloves and do not touch the work surface until all tests are completed.

3. Mount the rotor in a pair of V-Blocks at the rotor bearing points.



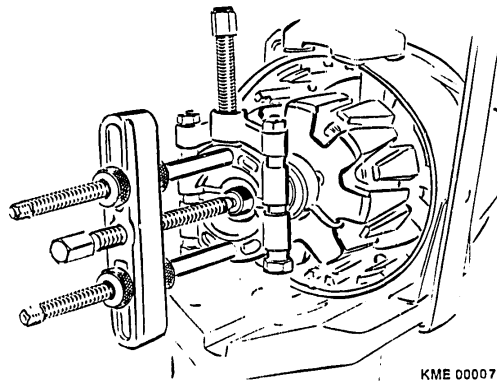
4. Position dial indicator (Magnetic Base T-M 1 (Bosch Number 4 851 601 124) and Dial Indicator EFAW 7 (Bosch Number 1 687 233 011)) to measure the concentricity of the rotor at:: (Figure 23)
 - a. Outer diameter of rotor, maximum run-out 0.05 mm (0.002 in). If the run-out of the rotor exceeds the maximum, the rotor must be replaced.

**Figure 23 Rotor Concentricity Measurement**

- b. Each collector ring, maximum run-out 0.03 mm (0.0012 in). If the run-out exceeds the maximum, the collector rings can be machined down to a minimum of 31.5 mm (1.240 in) diameter. If the required machining causes the collector ring diameter to drop below the minimum dimension, the collector ring(s) must be replaced.

9.16 Collector Ring Replacement

1. Before the collector rings can be removed, the spacer ring from the end of the rotor must be removed. Refer to Section 9.14 "*Removal of Inner Bearing Race from Rotor.*"
2. Unsolder the rotor leads from each collector ring.
3. With a universal bearing puller, remove each collector ring one at a time from the rotor. (Figure 24)

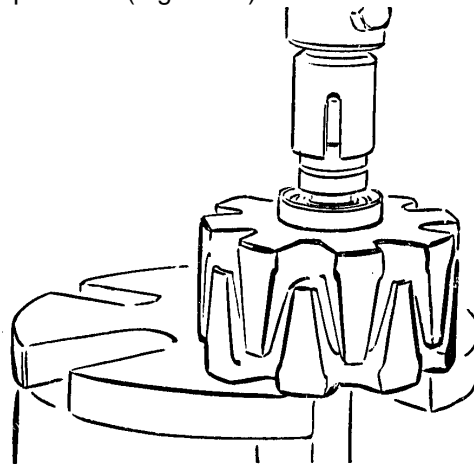
**Figure 24 Collector Ring Removal**



10 Alternator Assembly

10.1 Rotor Assembly

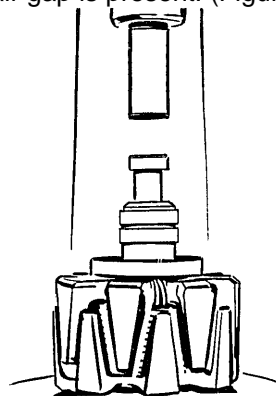
1. Position rotor in arbor press with the drive end pointing down.
2. Press the lead for the rotor winding into the slot of the rotor.
3. Slide the collector rings onto the rotor shaft as far as possible by hand. Make sure the lead for the rotor windings does not become damaged while sliding the collector rings over the lead.
4. Lining up the slot in tool KDLJ 6012 (Bosch Number 0 986 618 126) with the rotor lead, press the collector rings onto the rotor as far as possible. (Figure 25)



KME 00040

Figure 25 Pressing on Collector Rings

5. Solder each of the rotor winding leads to one of the collector rings with rosin core solder.
6. After soldering, touch up surface of collector ring to remove any excess solder from the brush contact surface.
7. Press on collector end shield bearing spacer ring with tool KDLJ 6018 (Bosch Number 0 986 618 134) until it contacts the stop on the rotor and no air gap is present. (Figure 26)



KME 00008

Figure 26 Spacer Ring



Note: Do not allow the spacer ring to twist while pressing onto the rotor.

8. Place the inner bearing race of the collector end shield bearing onto the rotor shaft.
9. Press the bearing onto the rotor shaft with tool KDLJ 6018. (Figure 26)

10.2 Drive End Shield Assembly

1. Insert sealed ball bearing into the drive end shield.
2. Align the holes of the bearing cover plate with the holes in the drive end shield.
3. Start the four screws which hold the bearing cover plate and tighten to 4.1 ... 5.5 Nm (36.3 ... 48.7 in. lbs.) (Figure 27)

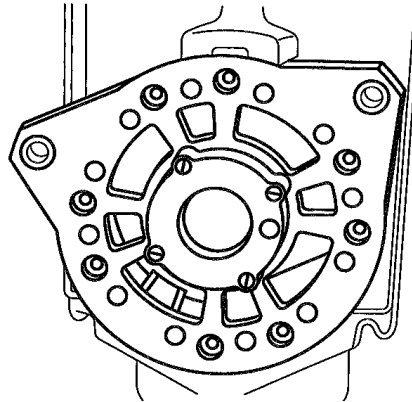
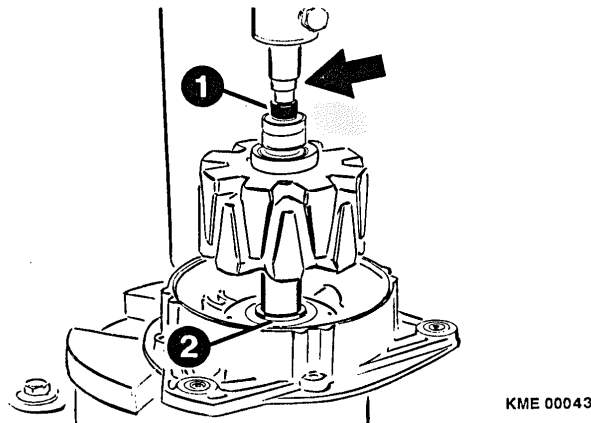


Figure 27 Drive End Bearing Retaining Screws

4. Insert bearing/fan spacer ring into the drive end shield from the fan side of the shield.
5. Place drive end shield on to an arbor press with the bearing/fan spacer ring pointed down. (Figure 28)
6. Slide support ring onto the drive end of the rotor. Make sure the under cut side of the ring faces the retaining ring on the rotor.



**Figure 28 Installing Rotor into Drive End Shield
(1) Tool KDLJ 6018 (2) Support Ring**



7. Place rotor into the drive end bearing.
8. Place tool KDLJ 6018 onto the end of the rotor and press the rotor into the drive end bearing until the bearing seats against the support ring.

10.3 Collector Ring End Shield Assembly

1. Pack the collector end roller bearing with 2 to 2.5 g (0.07 to 0.09 oz.) of UNIREX N3 grease.
2. Place the end shield on an arbor press.
3. Place tool KDLJ 6011 (Bosch Number 0 986 618 125) into bearing and press bearing into collector end shield. (Figure 29)
4. Pack the bottom of the collector end housing bearing bore with an additional 2 g (0.07 oz.) of UNIREX N3 grease.
5. Coat the sealing lip of the radial lip seal and pack the seal with 2 g (0.07 oz.) of UNIREX N3 grease.

Notes: Do not assemble the alternator with a dry radial seal as this will lead to seal failure and contamination of the brushes and collector rings.

Make sure there is no excess grease on the exterior of the seal before installation in the collector end shield. Excess grease on the exterior of the seal will cause contamination of the collector rings and brushes.

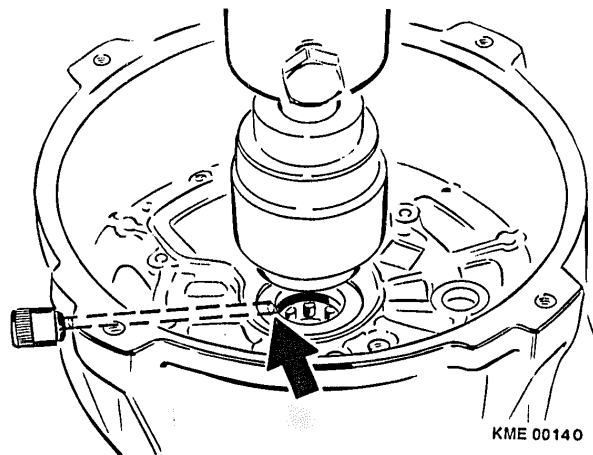


Figure 29 Installation of Bearing and Seal

6. Place seal onto tool KDLJ 6011 and press the seal into the collector end shield. (Figure 29)
7. Place collector end shield in an arbor press, support mounting/pivot boss on tool KDLJ 6016. (Figure 30)
8. Coat the inside of the collector end shield bore with Molycote.
9. Place sliding bushing into place on collector end shield.



10. With tool KDLJ 6015, press sliding bushing into end shield until the bushing is flush with the inner surface of the mounting/pivot boss. (Figure 30)

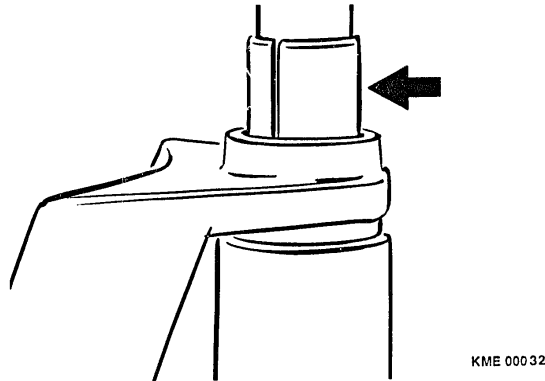


Figure 30 Sliding Bushing Installation

11. Insert terminal W into collector end shield in location marked W. Make sure the locating lug of the terminal assembly indexes the end shield correctly.
12. Place insulator and flat washer onto terminal W.
13. Install nut and torque to 4.1 to 5.5 Nm (36.3 to 48.7 in. lbs.)
14. Install protective cap onto terminal W. (Figure 31)

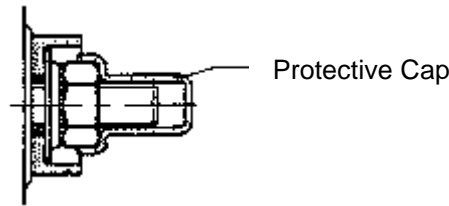


Figure 31 Terminal W Insulator, Washer, Nut and Cap

10.4 Rectifier Assembly

1. Place flat washer and insulator (a) onto terminal B+ and D+ studs of the rectifier assembly. (Figure 32)

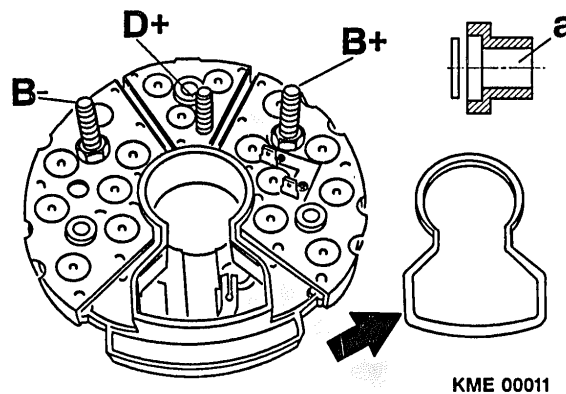
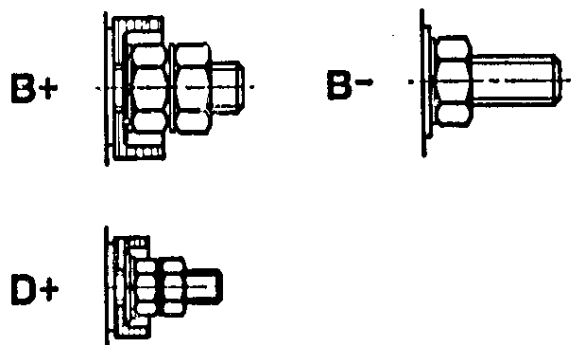


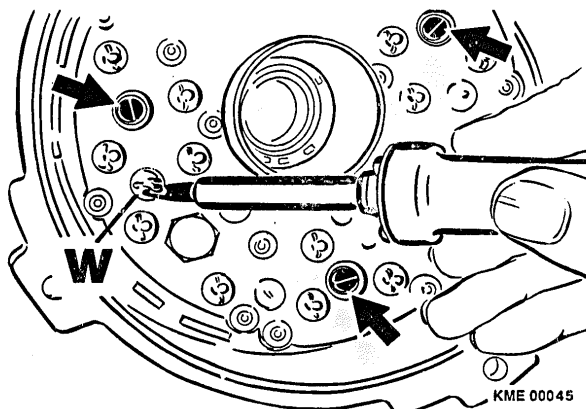
Figure 32 Rectifier Insulators and Seal



2. Coat the keyhole shaped surface of the rectifier with adhesive. (Figure 32)
3. Place the rectifier seal ring onto the keyhole shaped surface of the rectifier. Make sure the seal conforms to the shape of the keyhole.
4. Once the adhesive has cured, place the rectifier into the collector end shield. Make sure the solder lug of the W Terminal passes into the correct position of the rectifier assembly.
5. Install the insulating washer, flat washer and nut to terminal studs B+ and D+. (Figure 33)
6. Install flat washer and nut onto terminal stud B-. (Figure 33)
7. Check that the soldering lug of terminal W is still in the proper location of the rectifier assembly.

**Figure 33 Terminal B+, B- and D+ Assembly**

8. Torque terminal stud nuts B+, D+ and B- to:
 - a. Terminal B+ and B-..... 10 to 13 Nm (88.5 to 115 in. lbs.)
 - b. Terminal D+..... 2.4 to 3.2 Nm (21.2 to 28.3 in. lbs.)
9. Install the flat washer and second nut to terminal studs B+, D+ and B- and torque to:
 - a. Terminal B+ and B-..... 10 to 13 Nm (88.5 to 115 in. lbs.)
 - b. Terminal D+..... 2.4 to 3.2 Nm (21.2 to 28.3 in. lbs.)
10. Install the three (3) rectifier mounting screws and torque to 1.3 to 1.7 Nm (11.5 to 15 in. lbs.).
11. Solder the soldering lug of terminal W to the solder pad of the rectifier assembly with rosin core solder. (Figure 34)

**Figure 34 Rectifier Mounting and Soldering of Terminal W**



10.5 Stator Assembly

1. Position the stator on the collector end shield. The side of the stator with the winding leads should be closest to the collector end shield.
2. Line up the scribed mark of the stator with the scribed mark of the collector end shield. If either the stator or collector end shield was replaced, a new mark should be scribe across the new part using the replaced component as a reference.
3. Place each of the stator leads into a corresponding soldering lug of the rectifier assembly. After the lead is through the soldering lug, bend the lead so it forms a U around the lug. (Figure 35)

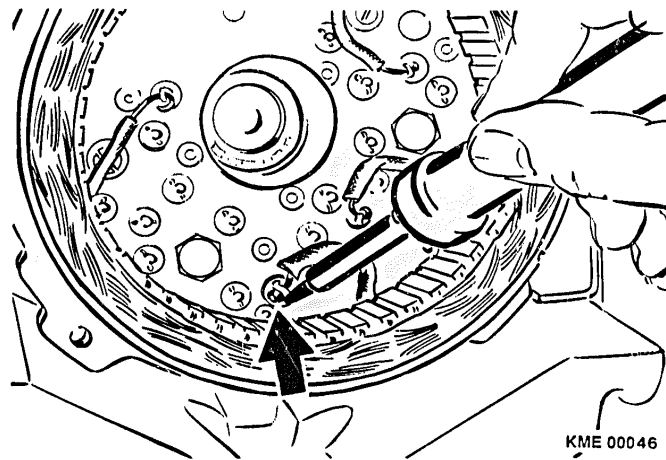


Figure 35 Soldering of Stator Leads

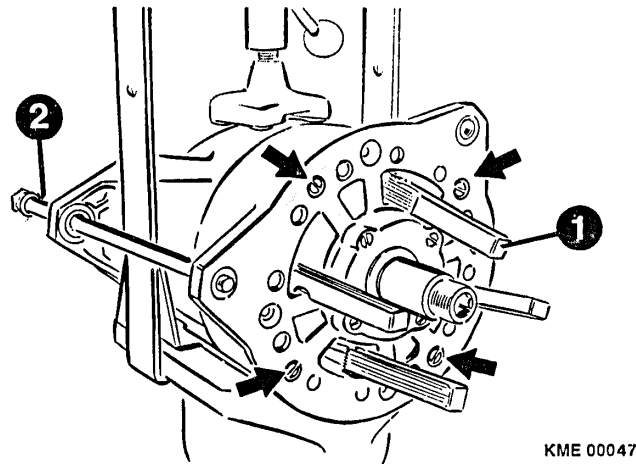
4. Solder each of the stator leads to the rectifier assembly with rosin core solder.

10.6 Rotor and Drive End Shield Installation

1. Place collector end shield and stator assembly on a suitable surface so the rotor and drive end shield assembly can be lowered into place
2. Guide the rotor and drive end shield assembly until the inner bearing race of the collector end bearing enters the roller bearing. Once the inner race enters the bearing, lower the assemblies completely into the collector end shield.
3. Insert guide pin KDLJ 6014 (Bosch Number 0 986 618 128) through the sliding bushing of the collector end shield and the bushing of the drive end shield. (Figure 36)
4. Start the four (4) drive end shield to collector end shield screws.
5. Place the alternator assembly into clamping fixture KDAW 9999.
6. Insert four (4) 0.3 mm (0.012 in) feeler gauges between the stator and the rotor. The feeler gauges should be place in four diametrically opposed positions. (Figure 36)
7. Torque the drive end shield to collector end shield screws to 7.2 to 9.7 NM (21.2 to 28.3 in. lbs.).



8. Remove the four feeler gauges from between the stator and rotor.
9. Turn the rotor by hand. The rotor should rotate freely by hand. If the rotor does not turn freely, loosen the drive end shield to collector end shield screws and repeat steps 6, 7, 8 and 9.
10. While rotating the rotor by hand, listen for contact between the rotor and the stator or stator leads. If any contact sound is heard, the rotor and drive end shield assembly must be removed, the cause determined and repaired before continuing. Once the problem has been corrected, start at step 1 of this section.



**Figure 36 Drive End Shield, Stator and Collector End Shield Assembly
(1) Feeler Gauge (2) Tool KDLJ 6015**

11. Remove the alignment pin KDLJ 6014 from the alternator.

10.7 Regulator and Capacitor Installation

1. Depress the carbon brush closest to the regulator into the regulator/brush holder.
2. Insert a straightened paper clip (1 to 1.3 mm dia. x 40mm) into the hole of the regulator until the pin holds the brush in place.
3. Pivot the regulator into the opening of the alternator. Once the brush holder is inside the alternator cavity, slowly remove the paper clip and allow the brushes to extend from the holder. (Figure 37)

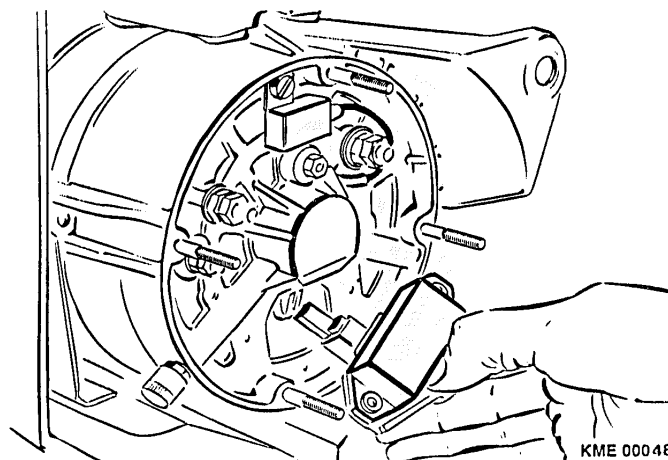


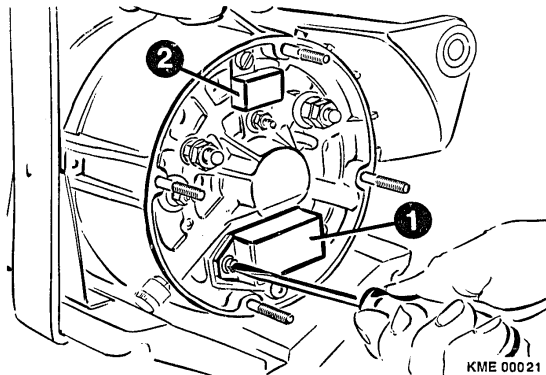
Figure 37 Regulator Installation



4. Align the mounting holes of the regulator to holes of the alternator housing.

Note: When aligning the mounting holes, pay attention to the force used as damage can occur to the brushes.

5. Install the three (3) regulator mounting screws and torque to 1.3 to 1.7 Nm (11.5 to 15 in. lbs.). (Figure 38)
6. Install capacitor on collector end shield and tighten mounting screw to 4.3 to 5.7 Nm (38.0 to 50.4 in. lbs.). (Figure 38)



**Figure 38 Capacitor Installation
(1) Voltage Regulator (2)**

7. Connect lead of capacitor to spade terminal +.
8. Install air intake cover onto alternator. Do not torque cover until it has been installed on the vehicle/engine.



11 Functional Testing

11.1 General Information

The functional testing of the alternator is broken into two categories, Power Output and Voltage Trace Evaluation. All of the tests describe here are performed with the voltage regulator installed on the alternator.

11.1.1 Power Output Tests

The power output tests verify the capability of the alternator to produce rated current and voltage at different speeds. This test requires a test bench of sufficient horsepower to turn a fully loaded alternator at a given speed. Additionally, the test bench must have the ability to inductively load the alternator to its rated amperage for an extended amount of time.

The power output test is to be performed anytime the alternator is suspected of being defective or if the alternator has been disassembled.

11.1.1.1 Test Bench Requirements

To perform the power output test of this series alternator, a test bench must meet the following minimum criteria.

Characteristic	Minimum Specification
Variable Speed Control	0 - 12,000 RPM
Drive Motor	4 kW (5.4 hp)
Load Bank Capability	170 A @ 28 V for 10 minutes 80 A @ 28 V for 30 minutes
Output Voltage Capability	28 V

11.1.2 Voltage Trace Evaluation

The voltage trace evaluation compares the output of the alternator as viewed on an oscilloscope to know oscilloscope patterns. The voltage trace evaluation is an important tool for diagnostics of an alternator that cannot meet the criteria of the power output test. Proper interpretation of the waveforms obtained can lead a technician to the defective component of a failed alternator. The voltage trace evaluation is done while the alternator is still mounted to the alternator test bench. Most any oscilloscope, which is capable of accepting the alternator voltage output, is useable for this evaluation.

11.2 Power Output Testing

11.2.1 Test Bench Mounting

1. Mount the alternator to the test bench per the operating instructions of the test bench manufacturer.
2. Connect the drive system of the test bench to the alternator as per the instructions of the test bench manufacturer.

Note: Only perform the power output tests with the fan pulley installed on the alternator. Failure to test the alternator with the correct fan installed can cause the alternator to overheat and damage the internal components of the alternator.



3. Connect the test leads of the test bench to the alternator as follows:

- a. Connect the +24 v lead of the test bench to the B+ terminal of the alternator.
- b. Connect the -24 v lead of the test bench to the B- terminal of the alternator.
- c. Connect the charging indicator lamp of the test bench to the D+ terminal of the alternator.

*Note: Refer to test bench manufacturers operating instructions for correct terminology of test leads
Refer to figure 39 for a schematic outline of alternator to test bench connections. Compare this schematic to the hook-up schematic of your test bench.*

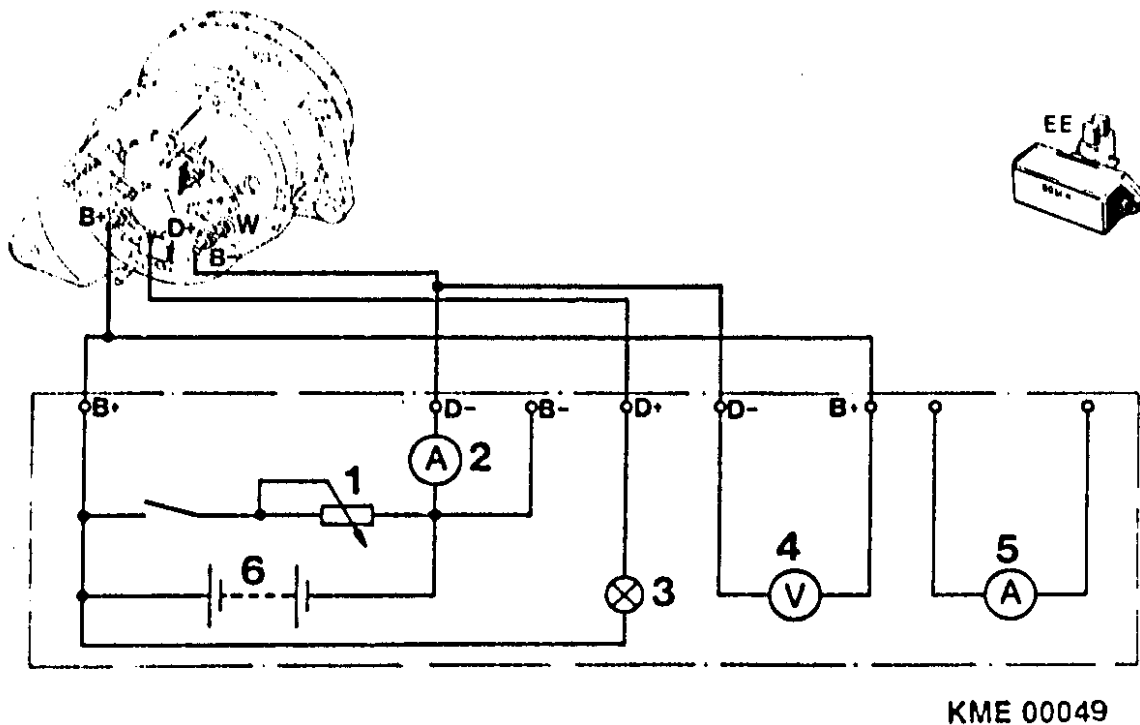


Figure 39 Alternator Test Bench Hook-up Schematic

- (1) Variable Load Resistor
- (2) Ammeter (Alternator Output)
- (3) Charging Indicator Lamp
- (4) Voltmeter (Regulated Voltage)
- (5) Ammeter
- (6) Test Bench Battery

4. Make sure the test bench is set for the correct voltage and rotation before starting tests.

11.2.2 Power Output Test

1. Start test bench and increase speed to 1500 rpm, alternator speed.
2. Increase inductive load on the alternator until 76A output is achieved. As load is increased, monitor test bench speed and correct if speed drops while applying load.



3. Hold test bench at this speed and load for 30 minutes. Monitor alternator output and speed during the test period.
4. Remove load and operate the alternator at 7000 rpm for one minute to allow the alternator to cool.
5. Refer to the test bench operating instructions and allow the load bank to cool the required amount of time before proceeding to the next test.
6. After the load bank has cooled, increase the test bench until the alternator has reached 6000 rpm.
7. Increase inductive load on the alternator until 136A alternator output is achieved. As load is increased, monitor test bench speed and correct if speed drops while applying load.
8. Hold test bench at this speed and load for 10 minutes. Monitor alternator output and speed during the test period.
9. Remove load and operate the alternator at 7000 rpm for one minute to allow the alternator to cool.
10. Refer to the test bench operating instructions and allow the load bank to cool the required amount of time before proceeding to the next test.
11. Apply a minimum load of 10A to the alternator.
12. Measure the regulated voltage of the alternator. The correct regulated voltage is between 27.6 and 28.4 volts.
13. If the alternator passes the three output tests, no further testing is required. If the alternator failed any of the three tests, proceed with the voltage trace evaluation.

11.3 Voltage Trace Evaluation

The voltage trace evaluation is a comparison of the voltage output of the alternator to know patterns. These know patterns will help identify different failed components.

11.3.1 Oscilloscope Hook-up

1. Following the manufacturer's instructions for your oscilloscope, connect the scope to the B+ and B- terminals of the alternator.
2. Adjust the oscilloscope to read 28 volts.
3. Turn on test bench and operate the alternator with a 10A load.
4. Compare oscilloscope display to the following test patterns.

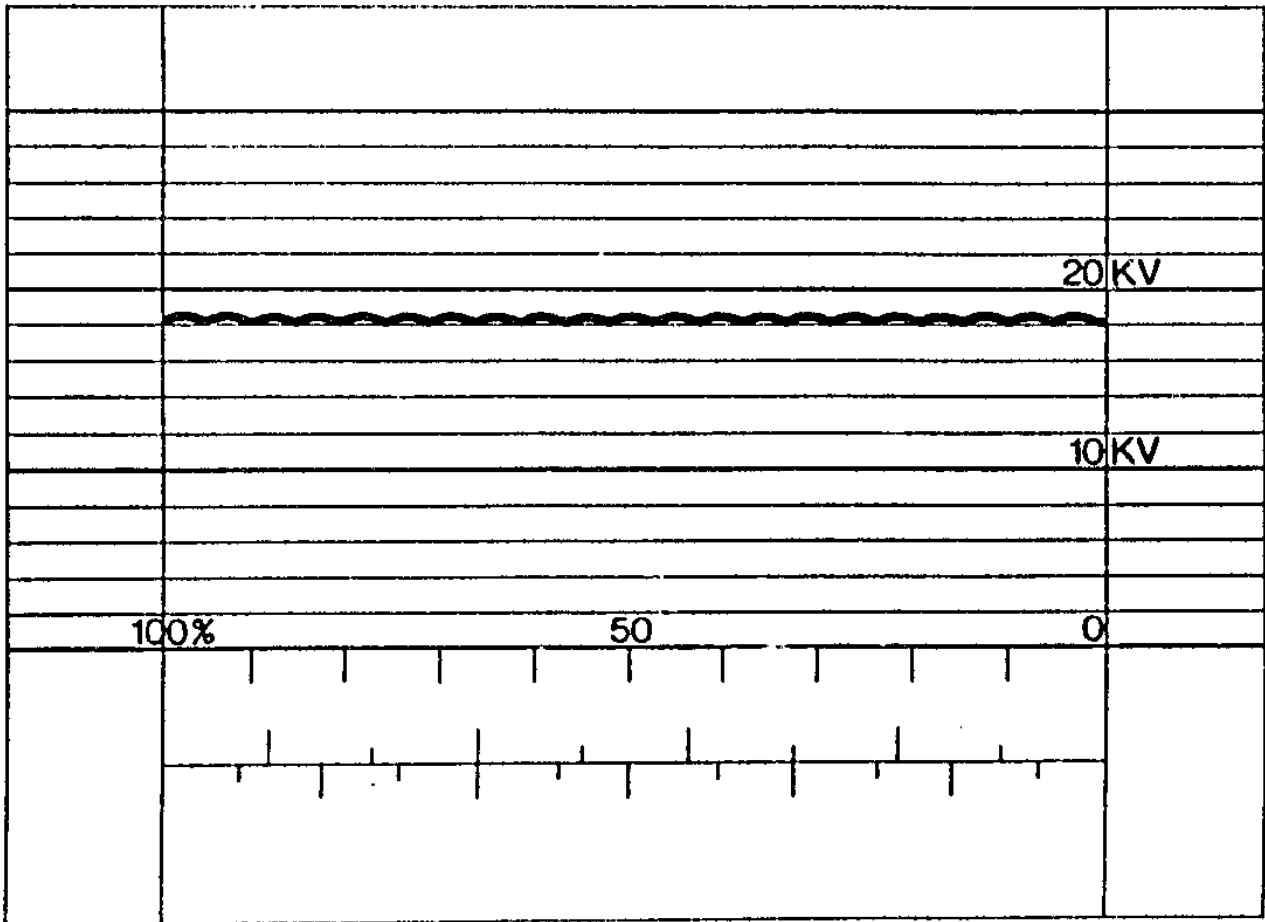


11.3.2 Normal Pattern

This image represents a properly functioning alternator. The D.C. voltage produced has a small harmonic wave.

Small spikes may be superimposed on the oscilloscope screen if the voltage regulator is regulating. Applying a load to the alternator output terminals can turn off the regulator.

In order to be able to compare oscilloscope images, the oscilloscope so the pattern fits between two vertical 10x divisions.



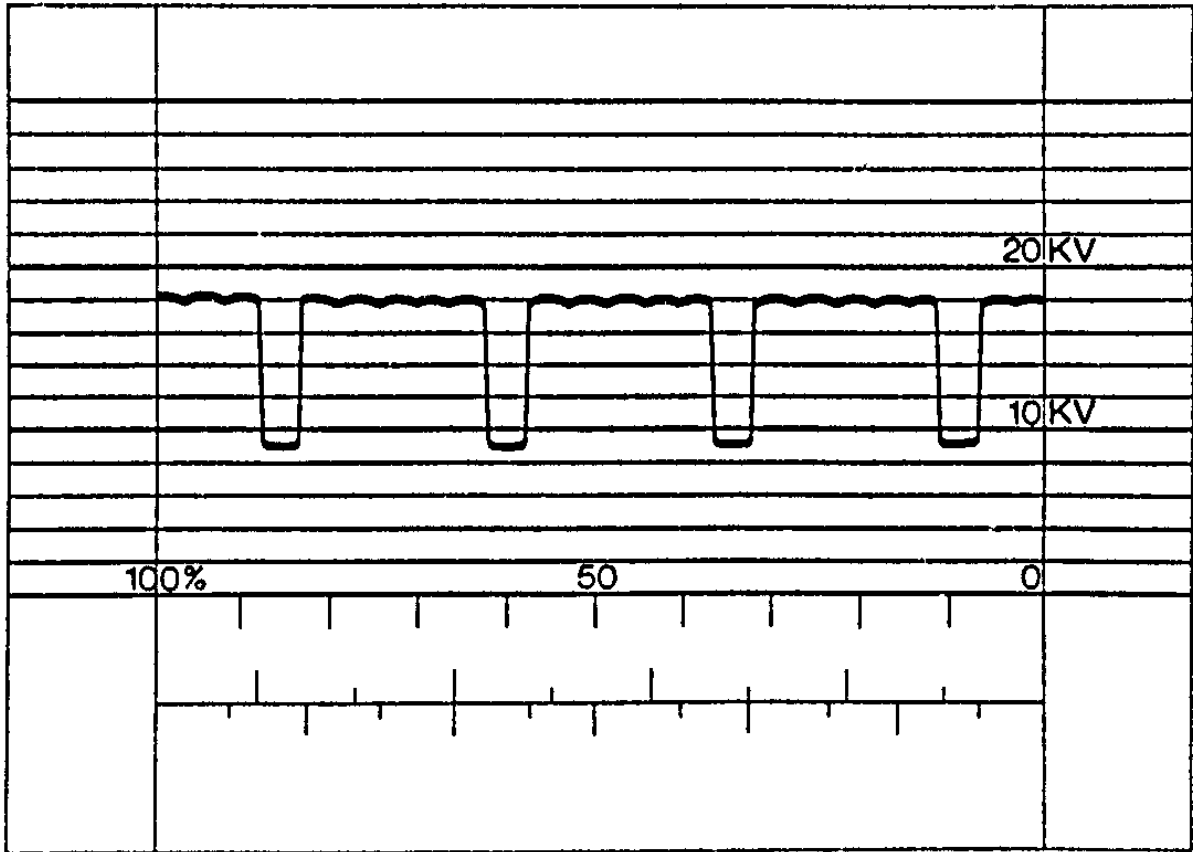
KME00052

Figure 40 Normal Pattern



11.3.3 Open Exciter Diode

This pattern displays a characteristic dip in the normally smooth wave characteristic of a defective exciter diode. This would require disassembly of the alternator and replacement of the rectifier assembly.



KME00053

Figure 41 Open Exciter Diode

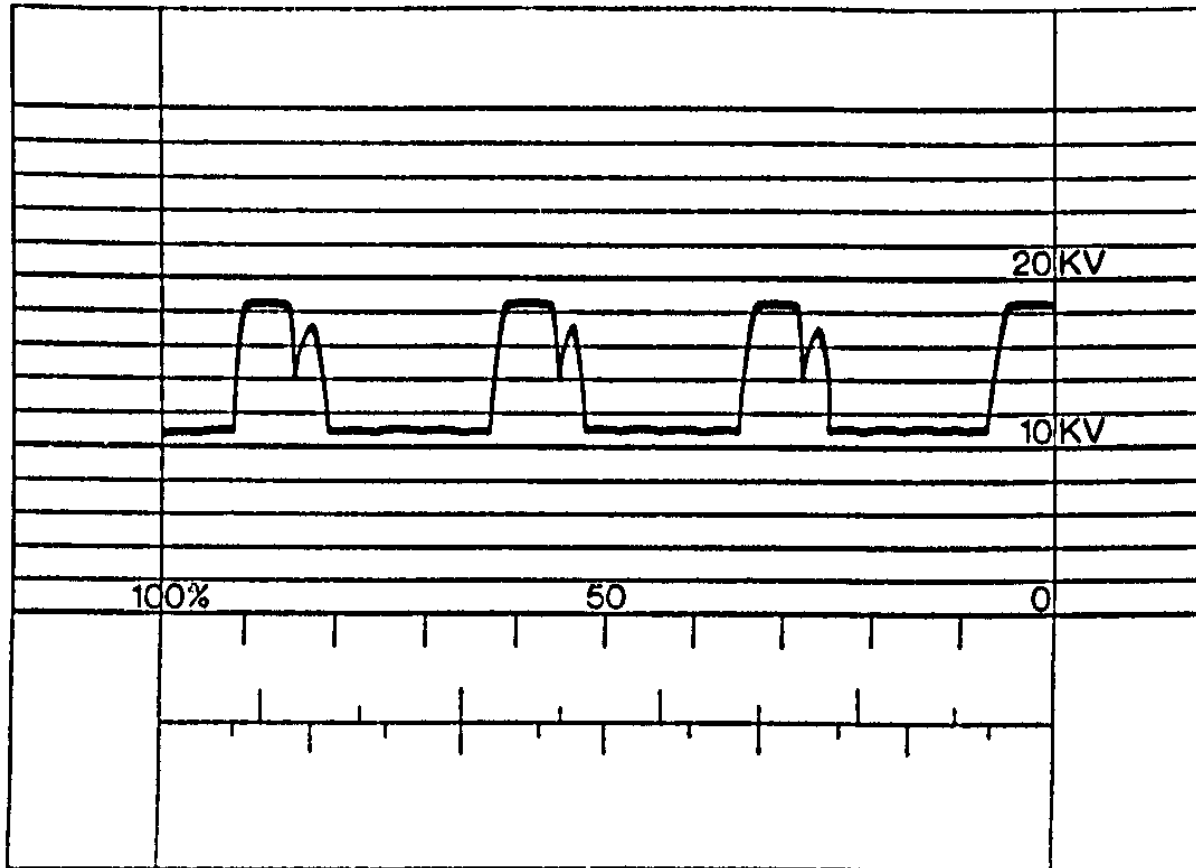


11.3.4 Open Positive Rectifier Diode

This pattern identifies an open positive rectifier diode. In the case of multiple diodes in parallel, all of the diodes on the circuit must be open. An example is:

There are two diodes in the rectifier for each phase of the stator. Both diodes must be open for this pattern to appear.

With this type of defect, the rectifier assembly must be replaced.



KME00054

Figure 42 Open Positive Rectifier Diode

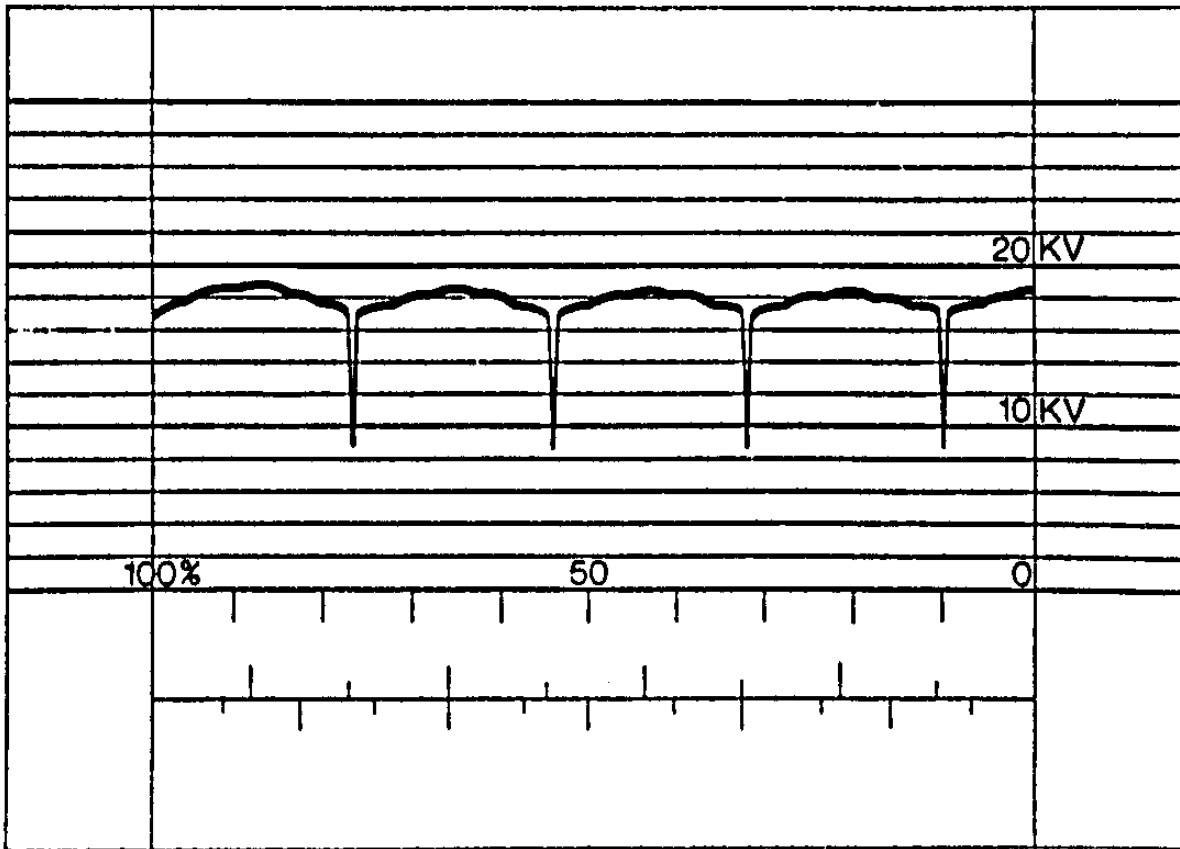


11.3.5 Open Negative Rectifier Diode

This pattern identifies an open negative rectifier diode. In the case of multiple diodes in parallel, all of the diodes on the circuit must be open. An example is:

There are two diodes in the rectifier for each phase of the stator. Both diodes must be open for this pattern to appear.

With this type of defect, the rectifier assembly must be replaced.



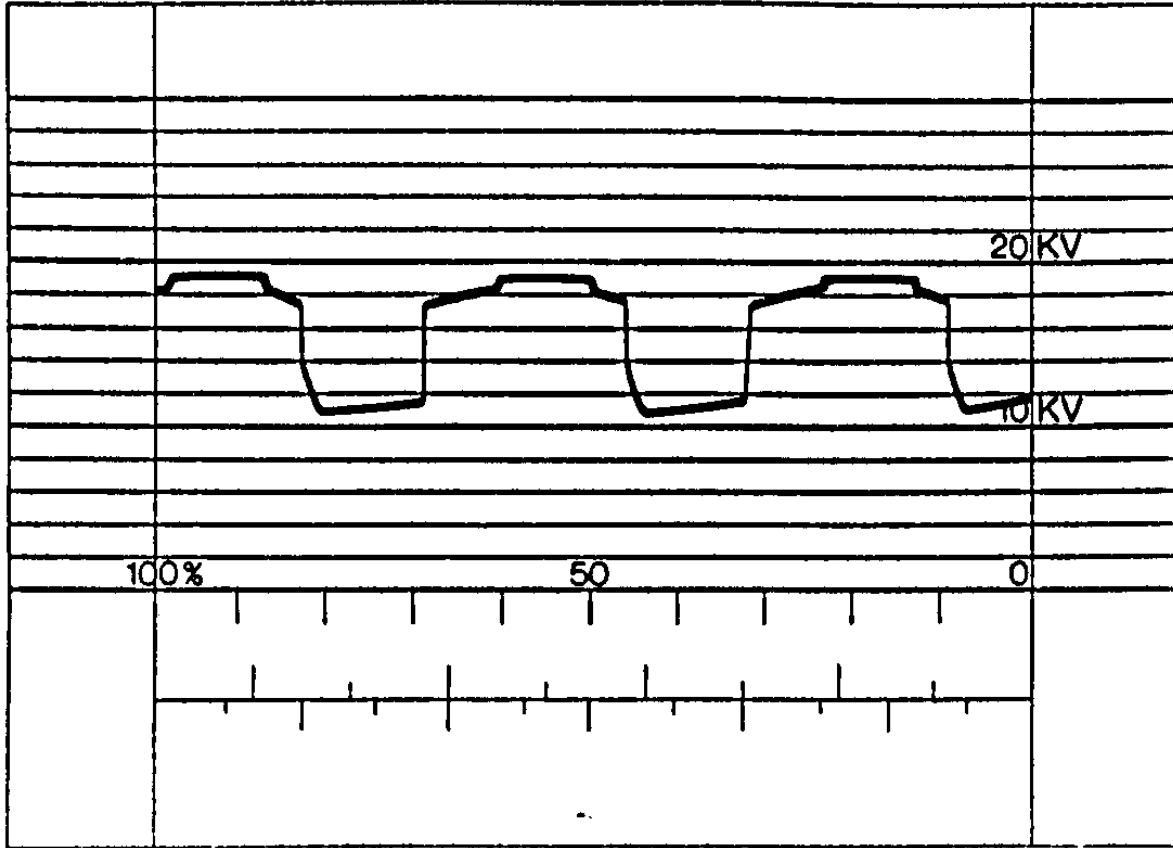
KME00055

Figure 43 Open Negative Rectifier Diode



11.3.6 Shorted Exciter Diode

This pattern identifies a shorted exciter diode. This would require disassembly of the alternator and replacement of the rectifier assembly.



KME 00056

Figure 44 Shorted Exciter Diode



11.3.7 Shorted Positive Rectifier Diode

This pattern identifies a positive rectifier diode that is shorted. This defect requires replacement of the rectifier assembly.

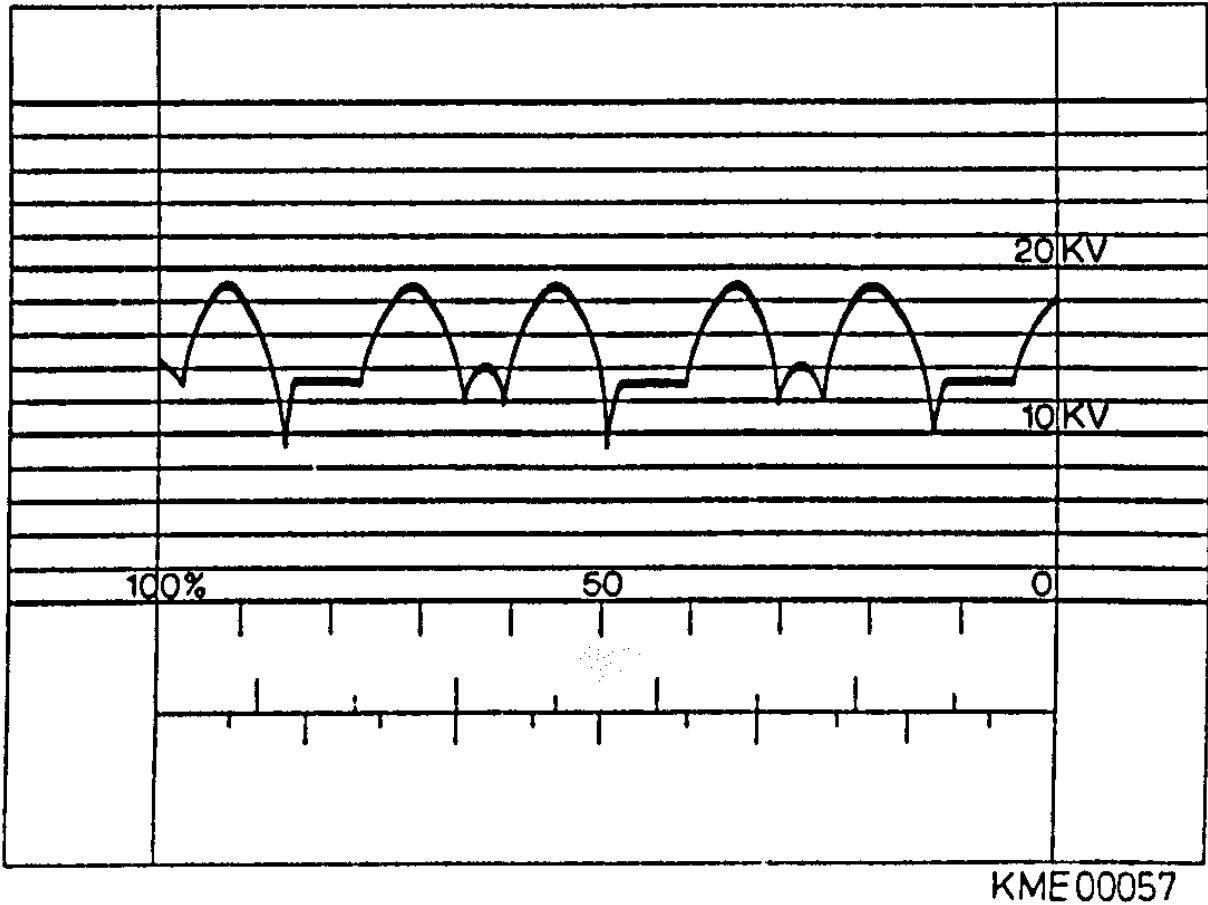
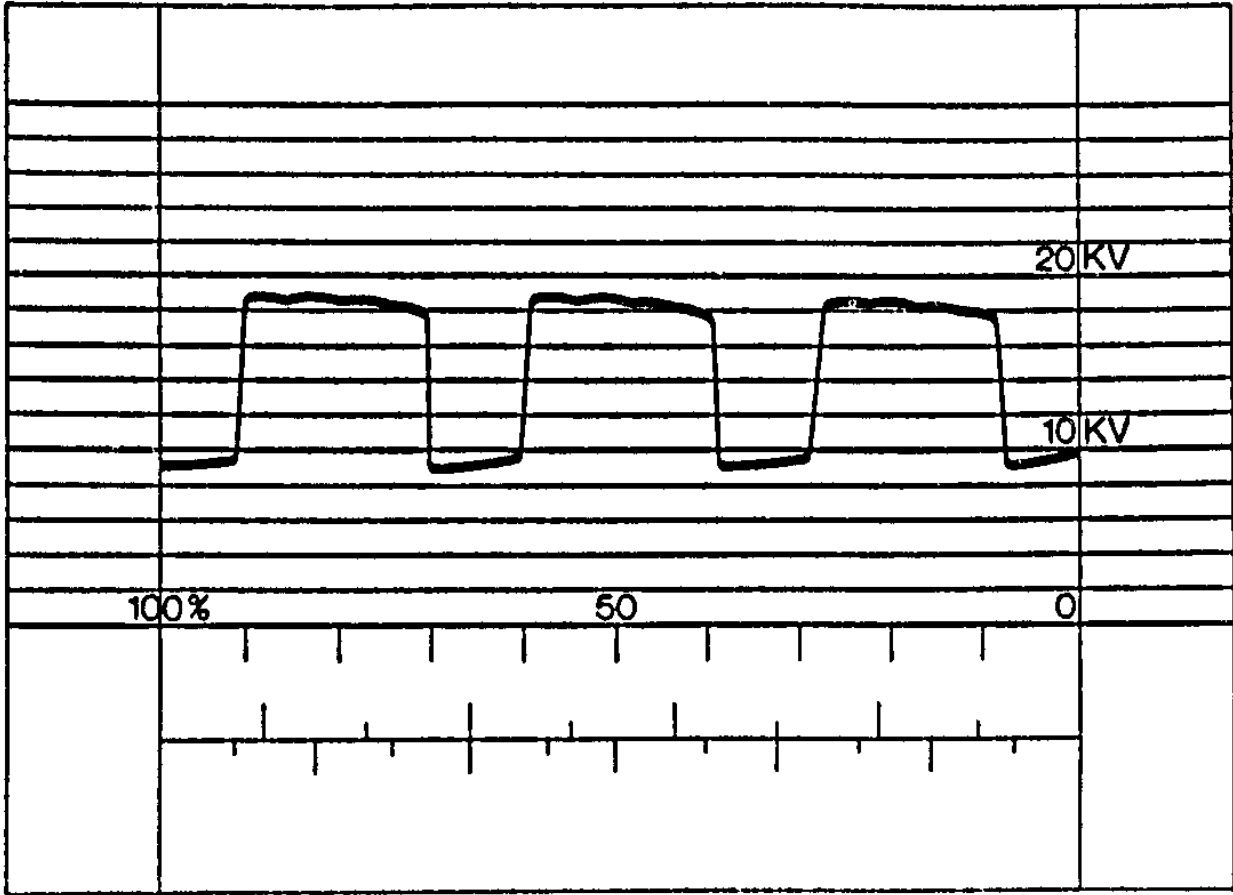


Figure 45 Shorted Positive Rectifier Diode



11.3.8 Shorted Negative Rectifier Diode

This pattern identifies a negative rectifier diode that is shorted. This defect requires replacement of the rectifier assembly.



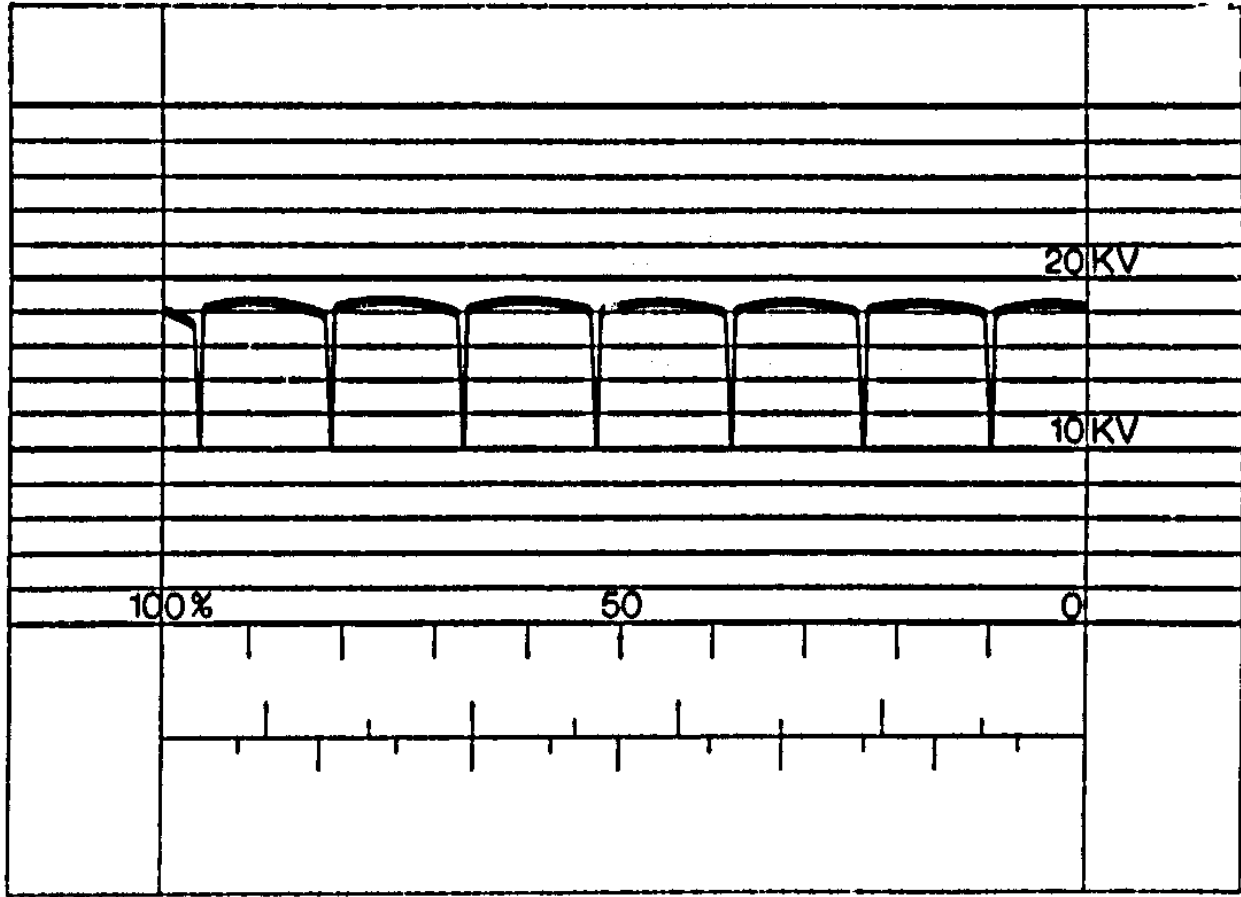
KME00058

Figure 46 Shorted Negative Rectifier Diode



11.3.9 Open Phase of Stator

This pattern illustrates a stator with an open phase winding. This type of defect would require replacement of the stator.



KME00059

Figure 47 Open Stator Phase