Chapter 7
Electrical System

Notes

Chapter 7 Electrical

The chassis' 12 volt electrical system is separate from the motor home "living" electrical system. The chassis system consists of a battery, the starting system, the charging system, and the instrument panel connectors from various transmitters, switches and senders. The coach builder provides the various gauges and lamps and connects them to the wiring during the construction of the coach body.

NOTICE
Procedures for repair and/or adjustment are intended for use on components which are NOT UNDER WARRANTY. Any unauthorized services performed on chassis components will negate all warranties concerning that component. Contact the Gillig Service Department for warranty service information or for questions regarding the warranties on your chassis components.

BATTERY

The storage battery is an electrochemical device which converts electrical energy into chemical energy, stores it, then reconverts it to electrical energy when a circuit across the terminal posts is closed. The battery does not actually store electricity, instead, it creates a difference of electrical potential between the terminal posts through the chemical action of the electrolyte upon the active materials in the positive and negative plates.

The battery has three major functions in the chassis electrical system. First, it is a source of electrical energy for cranking the engine to start it. Second, it acts as a voltage stabilizer for the electrical system. And third, it can, for a limited time, provide electrical energy when the load (demand) exceeds the output of the alternator.

Battery Hazards

A battery is not designed to last indefinitely, however, with proper care it will provide many years of service. There are four major hazards to the long life of a battery:

1. **Deep Cycling**
   This occurs when the battery is drained of all useful current and then recharged to its full value. In the process, the heat and stresses generated can cause plate warping and loss of active material. The extent of damage depends on the severity of the discharging and charging rates as well as how often deep cycling occurs.

2. **Sulfation**
   Sulfation results when the battery stands in a discharged state for a long period. The sulfate which normally forms in the plates becomes more dense and hard, eventually becoming impossible to remove through the process of recharging the battery.

3. **Overcharging**
   Overcharging is usually caused by a voltage regulator setting which is too high for the operating conditions or by high battery temperature. High water consumption by the battery is an indication of overcharging.

4. **Vibration**
   Vibration tends to shake the active material out of the plate, crack plate grids, loosen terminals and can even crack the battery case itself. Be sure batteries are clamped in their trays tight enough to hold them securely in place. Do not over-tighten. Over-tightening can distort and crack the battery cases.

Routine Maintenance

WARNING
Batteries produce explosive gasses, contain corrosive acid, and supply levels of electrical current high enough to cause burns. Precautions should be taken to protect yourself from injury.

The battery in your chassis is the conventional type, not the sealed type found in automobiles. Because the battery is not sealed, regular maintenance is required to ensure the proper operation of the electrical system and the long life of the battery:

1. The electrolyte level must be checked periodically and the cell topped off as needed with distilled or deionized water **(not tap water).**

2. If the motor home is to be placed into storage, or if it is to be left standing for extended periods of time, the electrical system should be protected by disconnecting the ground strap from the battery.

3. The external condition of the battery should be checked periodically for damage (i.e. cracked cover or casing, etc.). Also check the terminal area for loose or broken parts.

Battery Troubleshooting

If, after checking with a hydrometer, the battery tests "good" but fails to perform satisfactorily in service, the following are some of the more important factors which may indicate the cause of the dysfunction.

1. Accessories left on overnight.

2. Slow average driving speeds for short periods.

3. Vehicle electrical load greater than the alternator output. A major cause is the addition of aftermarket equipment, such as extra radio equipment, air conditioning, window defoggers, lighting systems, or voltage inverters.

4. Defects in the charging system, such as electrical shorts, slipping belts, a defective alternator, or a faulty voltage regulator.

5. Failure to keep the battery cable terminals clean and tight, or loose battery hold downs.

6. A battery stored in a motor home for long periods of time becomes discharged and sulfation occurs, reducing the batteries capability to accept a charge.

7. In operations under conditions of high ambient temperature, the electrolyte may become excessively hot, causing boil over and loss of electrolyte.

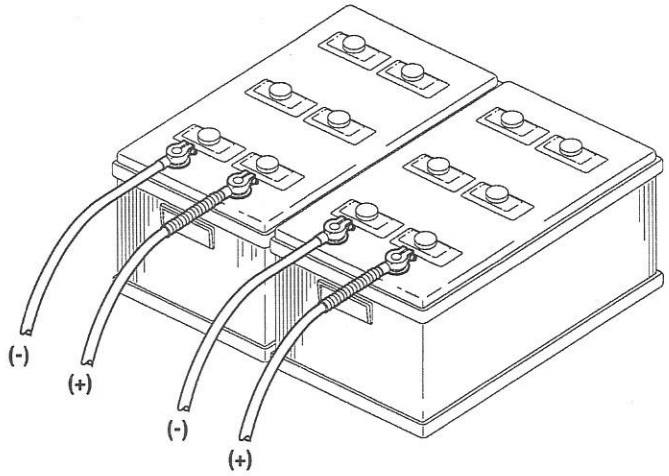


Figure 7.1. Battery Wiring

CA-09-362

Battery Precautions

WARNING
To decrease the possibility of personal injury when working near a battery, precautions 1 thru 4 should be observed.

1. **Always wear eye protection. Do not lean directly over a battery. Remove all metal jewelry, especially rings and chains.**

2. **Never expose a battery to open flames or electric sparks. Do not smoke near a battery.**

3. **Do not allow battery acid to contact eyes or skin. Flush any contacted area with water immediately and thoroughly. Get medical help.**

4. **Do not allow metal tools to contact both the positive (red, "+") battery terminal (or any metal connected to this terminal) and any other metal on the vehicle at the same time.**

Jump Starting With Booster Battery

CAUTION
Do not push or tow the motor home to attempt to start the engine. There are no provisions in the automatic transmission for engagement of the transmission to turn over the engine. Efforts to push or tow the vehicle to start it will have no effect, except possible damage to the transmission.

Both the booster battery and the discharged battery should be treated carefully when using jumper cables. Follow the conditions and procedures outlined below, being careful not to cause sparks. **Departure from these conditions or procedures could result in serious personal injury (particularly to eyes) or property damage from such causes as battery explosion, battery acid, or electrical burns and/or damage to electronic components of either vehicle.**

1. Be sure the jumper cables and clamps do not have loose or missing insulation. **Do not proceed if suitable cables are not available.**

2. If either battery has filler caps, check the fluid level. **DO NOT CHECK WITH AN OPEN FLAME.** If low, fill to the proper level with electrolyte. Clear drinking water may be used in an emergency. Replace all caps before jump starting.

3. Do not route the cable (or attach the clamp) to or near pulleys, fans, or other parts that will move when the engine is started.

4. Set the parking brakes firmly and place the automatic transmission in NEUTRAL. Turn off the ignition, lights, and all other electrical loads.

5. Only 12 volt batteries can be used to start the engine because the starter (cranking) motor is a 12 volt motor.

6. Attach the end of one jumper cable to the positive (+) terminal of the booster battery and the other end of the same cable to the positive (+) terminal of the discharged battery. Do not permit the vehicles to touch each other; this may cause a ground connection which could cause sparks.

WARNING
Do not connect directly to the negative (-) terminal of the discharged battery.

7. Attach one end of the remaining cable to the negative (-) terminal of the booster battery and the other end to a solid engine ground (such as the chassis frame or an outrigger) at least 18 inches from the battery of the vehicle being started.

8. After turning off all accessories, start the engine of the vehicle which is providing the jump start and turn off all electrical accessories. Then start the engine in the vehicle with the discharged battery.

9. Remove the jumper cables in the reverse order of attachment. First disconnect the negative (-) cable from the engine which was jump started. Then disconnect the negative (-) cable from the booster battery. Next disconnect the positive (+) cable from the discharged battery, and, finally, disconnect the positive (+) cable from the booster battery.

Battery Removal and Replacement

When handling a battery, the following safety precautions should be observed:

1. Hydrogen gas is produced by the battery. A flame or spark near the battery may cause the gas to explode.

2. Battery fluid is highly acidic. Avoid spilling it on clothing or other fabric. Any spilled electrolyte should be flushed with large quantities of water and cleaned immediately.

3. To remove a battery, always disconnect the ground cable first, then the other cable. When replacing a battery, reverse the procedure. In most cases, the ground cable is marked with a negative sign (-). The ground cable is easily recognizable because it is attached directly to the engine or coach body. Torque the battery cable clamp bolts to 9 lb ft.

STARTING SYSTEM

The starter on your motor home does not require special maintenance. It will provide years of trouble free service if proper cranking procedures are used. When starting the engine, never engage the starter longer than 30 seconds at a time and then allow at least 15 seconds between starting attempts. This precaution keeps the starter motor from overheating and will prolong its life.

The function of the starting system is to rotate the engine crankshaft at a speed sufficient for fuel ignition and commencement of engine operation. This is done by the cranking circuit, which consists of a battery, starting motor, ignition switch, and other electrical wiring and components. In addition, the Gillig chassis has a neutral-start switch which prevents the engine from being started in any transmission selector lever position other than NEUTRAL. See Chapter 5 - Air System for instruction on starting the engine when air pressure has been lost.

When the ignition key is turned to START, electrical current flows from the battery through the key switch, the neutral start switch, and the starter relay to the starter solenoid, which closes the circuit between the battery and the cranking motor. The solenoid also moves the starter drive gear into contact with the crankshaft ring gear.

Cranking motors (starters) have the shift lever mechanism and the solenoid piston enclosed in the drive housing to protect them from exposure to dirt and moisture.

In the basic cranking circuit the solenoid is energized when the START switch is closed. The movement of the pistons engages the starter pinion gear with the flywheel ring gear and the main contacts in the solenoid close causing the starter motor to crank. When the engine starts, pinion overrun protects the starter armature from excessive speed until the ignition switch is opened. A return spring then disengages the pinion. To prevent excessive overrun, the key should be released immediately after the engine starts. While the cranking motor does not require routine maintenance, the system wiring should be inspected periodically for damage or corrosion. Inspect all connections to the cranking motor, solenoid, ignition switch, neutral start switch, relays, and battery, including all ground connections. Clean and tighten all connections as required.

If the engine is known to be functioning properly and there appears to be a problem with the cranking system, yet the battery, wiring relays and switches are in satisfactory condition, the vehicle should be taken to an authorized service facility for further diagnosis or testing.

Starting Problems in High Ambient Temperatures

Under conditions of high ambient temperatures, when the engine has been turned off and the vehicle allowed to set for 10 to 15 minutes, it is possible to encounter a problem with the starter. High resistance caused by heat reduces current flow and prevents activation of the starter motor and solenoid. After the engine has cooled sufficiently, the solenoid and starter motor should activate properly. In all cases where the engine cranks but does not fire, the problem is in the fuel system, not the electrical system, assuming power to the fuel solenoid is present.

CHARGING SYSTEM

The function of the charging system is to provide electrical power to the engine ignition system and the vehicle chassis accessories, and to restore power used from the battery.

Alternator

The primary component of the charging system is the alternator. The alternator assembly includes the rotor, stator, and rectifier subassemblies, as well as an internal voltage regulator. When the engine is operating and turning the rotor, an alternating current flow is induced in the stator assembly. This alternating current is changed into direct current in the rectifier through the use of diodes, which allow electrical current to flow in one direction only. The output of the alternator is controlled by the voltage regulator, which varies the strength of the electromagnetic field established in the rotor. The voltage regulator is located inside the rear cover of the alternator.

The white field wire to the alternator is used to initially activate the alternator by providing the current needed to establish the electromagnetic field in the rotor. The 10 ohm resistance, provided by either the alternator warning lamp or the resistance wire from optional gauges, is needed to protect the diodes in the rectifier assembly.

No periodic adjustments or maintenance of any kind are required on the entire alternator assembly. Belt tension, however, should be checked periodically and adjusted to specification as shown in **Appendix C.**

Noise from an alternator may be caused by a loose drive pulley or loose mounting bolts. These parts should be tightened as required. Other causes of alternator noise can be worn or dirty bearings, defective diode(s), or a defective stator. Such malfunctions require an overhaul.

Charging System Troubleshooting

If there is a problem in the charging system, the first action should be to check the state of charge of the battery and the condition of the wiring. An undercharged battery is indicated by low specific gravity of the fluid and slow cranking speed of the starter motor. An overcharged battery is indicated by excessive use of battery water.

The next check should be of the wiring and connectors. Look for dirty or loose connections and damaged or frayed wires. Repair, clean or replace wiring as necessary.

The final check should be of the alternator drive belts. Ensure they are properly adjusted in accordance with **Appendix C** and that the belts are in good condition.

If the problem is not located with the inspections above, proceed with the following steps:

1. With the engine off, connect an accurate voltmeter across the battery terminals. The reading should be from 12.3 to 12.6 volts.

2. Start the engine and increase the idle speed to approximately 1200 RPM. The voltmeter reading should increase to about 13.6 volts.

3. If the voltmeter rises excessively, the charging system is defective. However, it may only require an adjustment of the voltage regulator.

Regulator Inspection and Adjustment

1. With the engine off, connect a short jumper to the alternator POSITIVE output terminal and to the diode trio terminal for 2-3 seconds. This will restore the residual magnetism to the rotor. See figure 7.2.

2. Shut off all electrical accessories and run the engine at approximately 1200 RPM. Connect a voltmeter across battery terminals and measure voltage. Compare voltage reading with those recommended by Gillig for this coach. (The recommended regulator setting is 13.6 to 14.2 volts.) If voltage is outside of the values specified, continue with this adjustment process.

3. Shut off engine and disconnect battery ground cables.

4. Remove nut and lockwasher from regulator terminal and disconnect diode trio lead from diode trio terminal.

NOTICE
Before any adjustments are made, insure that the batteries, wiring, and alternator drive belt(s) are in good working condition and are properly tightened (Refer to Appendix C for Belt Tension Adjustment specifications.) Batteries must be at least 95 to 100% charged.

CAUTION
Use a magnetic tip screwdriver to avoid losing the small screws used for installing the voltage adjustment strap.

CAUTION
Recommended torque for the cross head screws used for securing voltage adjustment strap is 4-5 in lb. Over tightening these screws may cause them to break and the regulator would become unusable.

NOTICE
A digital voltmeter with 1/100 volt display should be used.

NOTICE (1)
Procedure (1) applies in positive and negative ground systems.

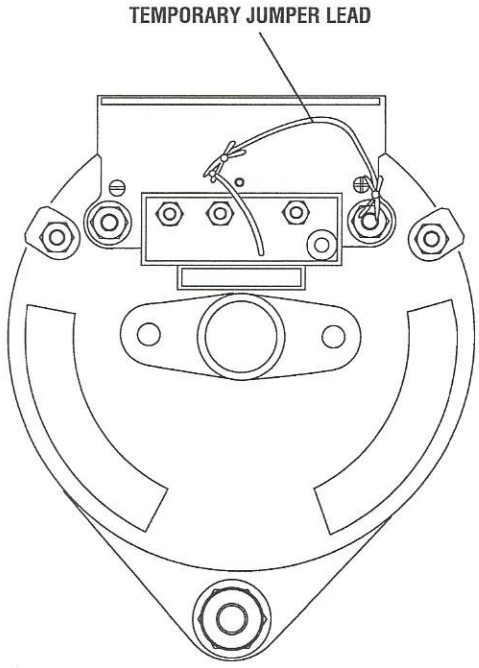


Figure 7.2. Regulator Inspection (CA-09-439)

5. Remove the four screws from the regulator cover. Lift regulator far enough to expose the voltage adjustment strap.

NOTICE (6)
In some cases, dirty or corroded pads can cause a low charge condition, and voltage adjustment may not be necessary.

6. Inspect the two regulator brush contact pads. If dirt or corrosion is noticed, clean pad with #600 (or finer) sand paper. Recheck voltage as recommended in procedure #2.

7. Remove, inspect, and reinstall brushes according to procedures in Regulator Removal section, procedure #5 and procedure #2 in the Regulator Installation section.

8. To adjust voltage, remove and reinstall voltage adjustment strap in any of the three positions available: A & B (Low), A & C (Medium), or C & B (High). See figure 7. 3.

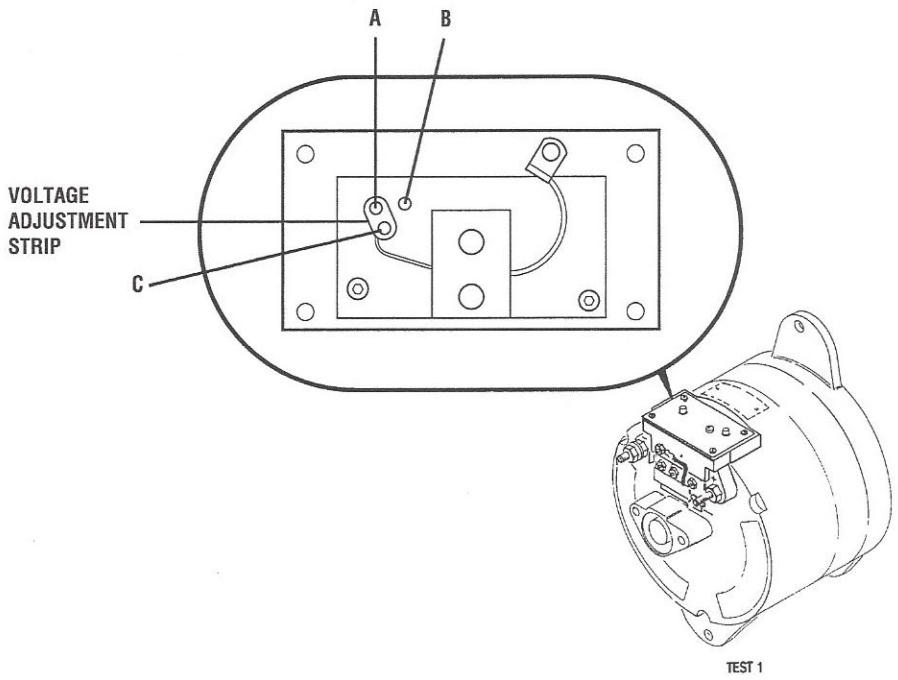


Figure 7.3. Voltage Regulator Adjsutment **CH-09-057d**

Each change in position of the adjustment strap will result in an INCREASE or DECREASE in voltage of approximately .4 volts.

9. Complete regulator installation as instructed in the Regulator Installation section.

10. Re-install battery ground cable and repeat steps #1 and #2 in this section to insure proper voltage.

If the charging system still delivers less than the required voltage to the battery, the problem is beyond simple diagnosis. The vehicle should be taken to an authorized service facility for detailed analysis and further testing.

Full Field Test

To determine whether the alternator or regulator is at fault, perform a full field test as follows:

1. Insert a short, stiff piece of wire, such as a paper clip, into the small hole in the end of the brush holder **SO THAT IT FIRMLY CONTACTS THE OUTER BRUSH TERMINAL.**

2. Connect a short jumper lead between the inserted wire and the negative alternator output terminal.

3. If the voltmeter reading now increases 0.3 volts or more with the engine at fast idle, the alternator is not defective and the problem is in either the regulator or the diode trio, or both.

4. If the voltage does not increase, the alternator is at fault and must be removed for repair or replacement.

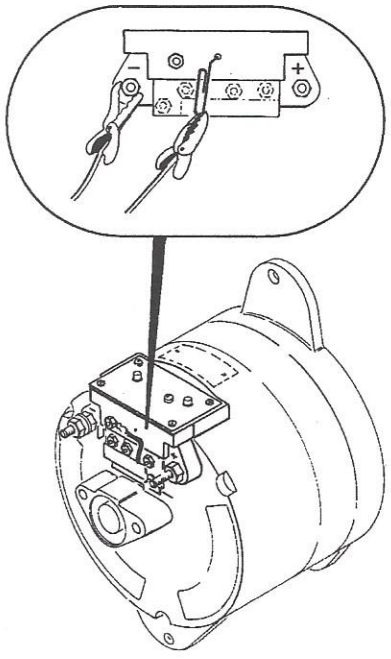


Figure 7.4. Full Field Test **CA-09-057b**

Diode Trio

The diode trio is the first component to check if the full field test has shown a voltage rise.

1. Remove the black diode trio lead from the outer brush housing.

2. Remove the three nuts and lift the diode trio assembly off the ATerminal studs.

3. The diodes should be checked with an ohmmeter having R times 1000 (R X 1,000) or R times 10,000 (R X 10,000) scales. Connect the negative lead of the ohmmeter to the diode trio output lead and touch the positive tester to each of the copper terminal pads, one after the other. The ohmmeter should indicate low resistance (voltage flow) at each copper terminal. Low resistance is indicated by full deflection of the needle on the ohmmeter.

4. Now connect the positive lead of the ohmmeter to the diode trio output lead and touch the negative tester lead to each of the three copper terminal pads again, one after the other. The ohmmeter should indicate infinite resistance (no voltage flow). Infinite resistance is indicated by little or no needle deflection.

5. Replace the diode trio if it does not pass ALL of the tests listed above.

6. After replacement of the diode trio, run the engine at 1,000 RPM and check for a voltage reading of approximately 13.6 volts. If a 13.6 volt reading is obtained, the system is now repaired. If the diode trio checked out or if the system still has a reading of approximately 12.5 volts at the regulator, the regulator is the defective component and should be replaced.

Regulator Removal

1. Disconnect battery ground cable.

2. Remove four mounting screws from regulator cover, and remove the nuts from the terminal located on the regulator holder to disconnect the diode trio lead. Tilt regulator up and remove the square head screw to disconnect regulator blue lead (also white with blue tracer).

CAUTION
All screws, nuts, and lock-washers that may fall in the regulator holder must be removed at this time to prevent them from falling in the slip ring cavity through the brush openings.

3. Remove the nuts (or crosshead screws) and lockwashers. Disconnect the red and the black leads from the regulator terminals. Note their position for reinstallation. They must not be reversed in reassembly. Remove the regulator.

4. Inspect the regulator. If it appears corroded, or if any circuitry is burned, it must be replaced. Burn damage is usually caused by reversing either the battery connection or the positive and negative alternator leads.

5. Remove the brushes and visually inspect them. If brushes appear burned, cracked, or damaged, they must be replaced. Inspect the springs and the shunt leads within the spring for damage. Replace brushes if necessary. Check brush lengths. If any brushes are worn to less than 3/16" in length, they should be replaced.

6. If the brushes or pigtails are burned or show evidence of overheating, check for a defective rotor coil in addition to the regulator check. Refer to the Regulator Installation section for brush replacement procedures.

7. Inspect the red and black leads which were removed from the regulator. If insulation is damaged and bare wires are noticeable the alternator should be serviced by an authorized facility or replace.
8. A defective regulator should not be serviced. It should be replaced with a new regulator following the procedures listed in Regulator Installation.

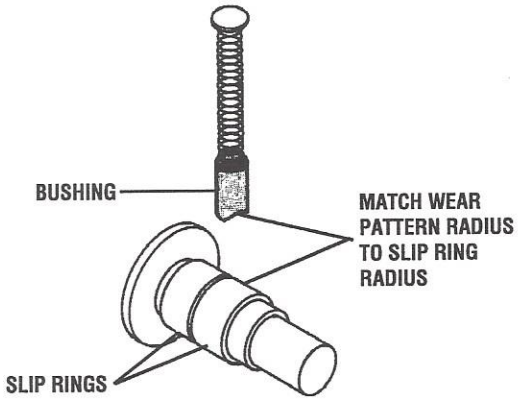


Figure 7.5. Slip Ring CA-09-440

Regulator Installation

1. Clean each of the brushes removed in procedure #5 of the Regulator Removal section with a spray electrical contact cleaner which DOES NOT contain silicone. Silicone attacks brushes and will cause short brush life. Clean brush contact caps with #600 (or finer) grade sand paper.

2. The brushes must be held in their housing prior to regulator installation. This is easily accomplished by compressing the springs and then inserting a wire through the hole in the back of the brush holder. A 1/16" drill bit, brazing wire, or a paper clip may be used to retain the springs.

NOTICE (2)
If the original brushes are being reused, the wear pattern of the brush must be matched with the radius of the slip rings as in Figure 7-5.

CAUTION (3)
Over tightening these screws may cause the screws to break, rendering the new regulator unusable.

NOTICE (5)
The temporary wire inserted in the brush holder to hold the brushes in place must be removed before the four regulator mounting screws are tightened.

3. Replace regulator and install voltage adjustment strap of the new regulator in the same position as the one on the original regulator. Recommended torque value for the crosshead screws is 4-5 in lbs.
4. Reconnect red and black leads.
5. Replace and tighten regulator mounting screws.
6. Reconnect battery cables.

ENGINE PROTECTION MODULE (EPM)

An Engine Protection Module (EPM) has been installed in your Gillig Chassis. Its purpose is to warn the operator of a condition which could damage the engine and to automatically shut the engine down if the dangerous condition is not corrected in the appropriate time interval. The EPM is wired into the chassis harness by the coach manufacturer during construction of the motorhome.

The EPM is a solid-state device which is connected to sensors on the engine. It monitors engine coolant temperature, engine oil pressure, air system pressure, and coolant level. If the module senses low engine oil pressure, low coolant level, or high engine temperature it will sound a horn and illuminate the appropriate dash-mounted indicator lamp. After 20 seconds it will shut the engine down to prevent damage. If the module senses low air pressure or low coolant level it will sound the horn and illuminate the appropriate indicator lamp. The module is sealed and is not separately serviceable; it must be replaced if defective.

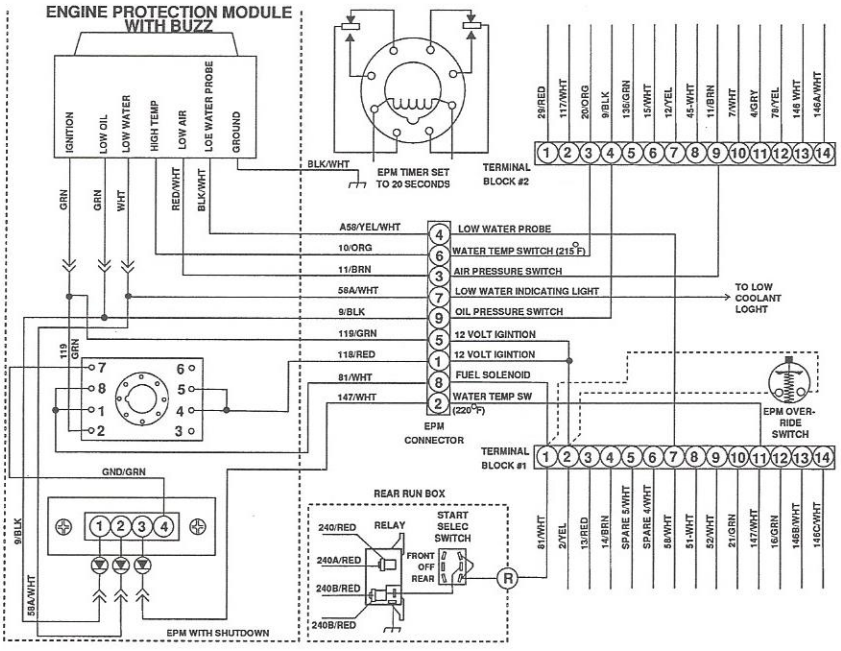


Figure 7.6. EPM Wiring Interface **PA-09-278**

Mounting

The EPM may be mounted in various locations in the coach. Figure 7.6 illustrates the wiring configuration on the rear engine block which controls switches, transmitters, and guages necessary to the functioning of the EPM unit.

Guage Transmitters

The oil pressure guage transmitters are bolted to a plate on the left side frame at the front of the transmission, forward of the external transmission oil filter and the heater booster pump. The yellow wire on the transmitter sends electrical current to the rear oil pressure guage; the orange wire transmits to the front dash oil pressure guage; the black wire is connected to the oil pressure switch and the EPM.

Temperature Switch

A temperature switch, mounted with the oil gauge transmitters, triggers the EPM in two (2) stages: first a warning with an audible alarm, then by shutting down the engine.

The early warning alarm signal, transmitted by white wire #147 is rated at 215°F and the engine shut down (location), orange wire #10, is rated at 220°F.

TDR Failure

NOTICE
If the TDR unit is not securely plugged into the TDR block, the starter solenoid will not receive power and the engine will crank but will not start. Check that it is plugged in firmly before proceeding.

WARNING
The method provided below is intended for use to temporarily bypass the TDR unit to allow the coach operator time to safely park the vehicle. Continued operation of the engine could result in serious and permanent damage.

By diverting the red power feed wire (#118), the engine will no longer be protected from overheating or insufficient cooling. Extra attention must be paid to all temperature guages to prevent engine damage due to these malfunctions.

Should the Time Delay Relay (TDR) unit of the EPM fail, as an expedient field measure to allow for short term operation of the coach, the following method can be used to bypass the EPM:

1. Remove the TDR by unplugging the unit from the time delay relay block.
2. Remove the two (2) terminal connectors of red wire #118 (WYE) from terminal positions 4 & 5.
3. Connect the red #118 wire terminals to the white #81 wire terminals 1 & 8, leaving the #81 wires also connected.
4. Plug in the TDR unit.

REAR RUN BOX

The rear run box is mounted to the chassis frame to the right of the engine, making it possible to start the engine from the rear of the vehicle (Figure 7.7). To start the engine from the rear, set the switches to IGNITION ON and REAR START, then push the ENGINE START push button switch.

The IGNITION switch should be in the ON position **only** when starting the engine from the rear. It must be turned OFF when returning to normal operation.

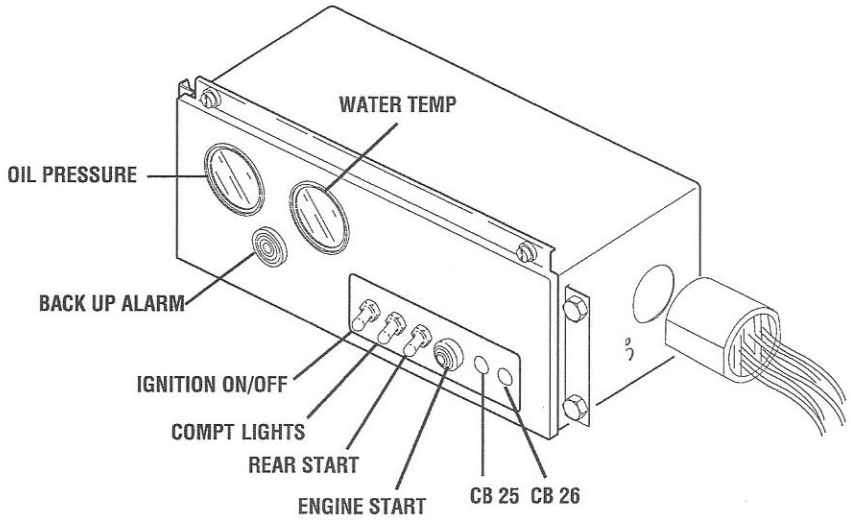


Figure 7.7. Rear Run Box **08-006-02**

ENGINE WIRING AND SENSORS

NOTICE
The engine wiring schematic seen in Figure 7.11 illustrates the system as delivered by Gillig to the motor home manufacturer. The system may have been modified by the manufacturer to include the addition of electrical isolators. If any maintenance or operational difficulties are encountered in this area, it may be necessary to refer to manufacturer provided schematics.

The engine and transmission have been fitted with several sensing or sending units which will drive gauges, dials, or indicator lamps in the dash panel of the completed motor home (Figure 7.8).

The electrical schematics are presented at Figures 7.9 through 7.11. Further information regarding the completed motor home, particularly the dash/control panels, can be obtained in the coach builders' operator manuals.

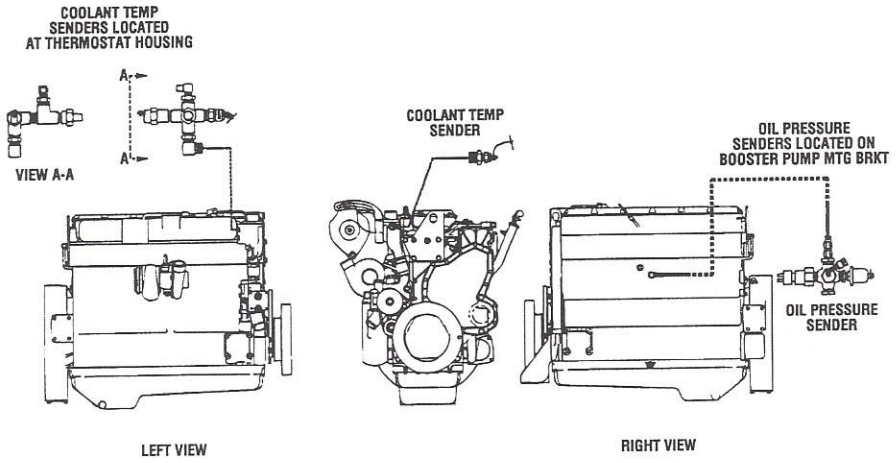


Figure 7.8. Sending Units

NEW ART

COLOR CODE:

1. Hazard - Purple
2. Right Front - Dark Blue
3. Stop Light - White
4. Left Front - Light Blue
5. Left Rear - Yellow
6. Right Rear - Dark Green
7. Horn - Black
8. Hazard Warning - Brown

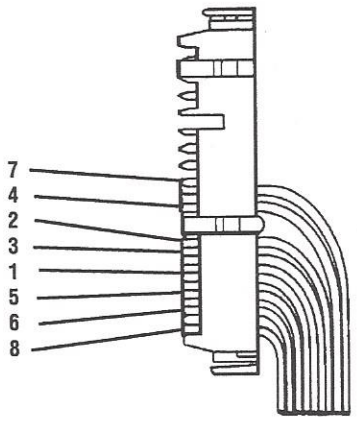


Figure 7.9. Turn Signal/Horn

CA-09-378

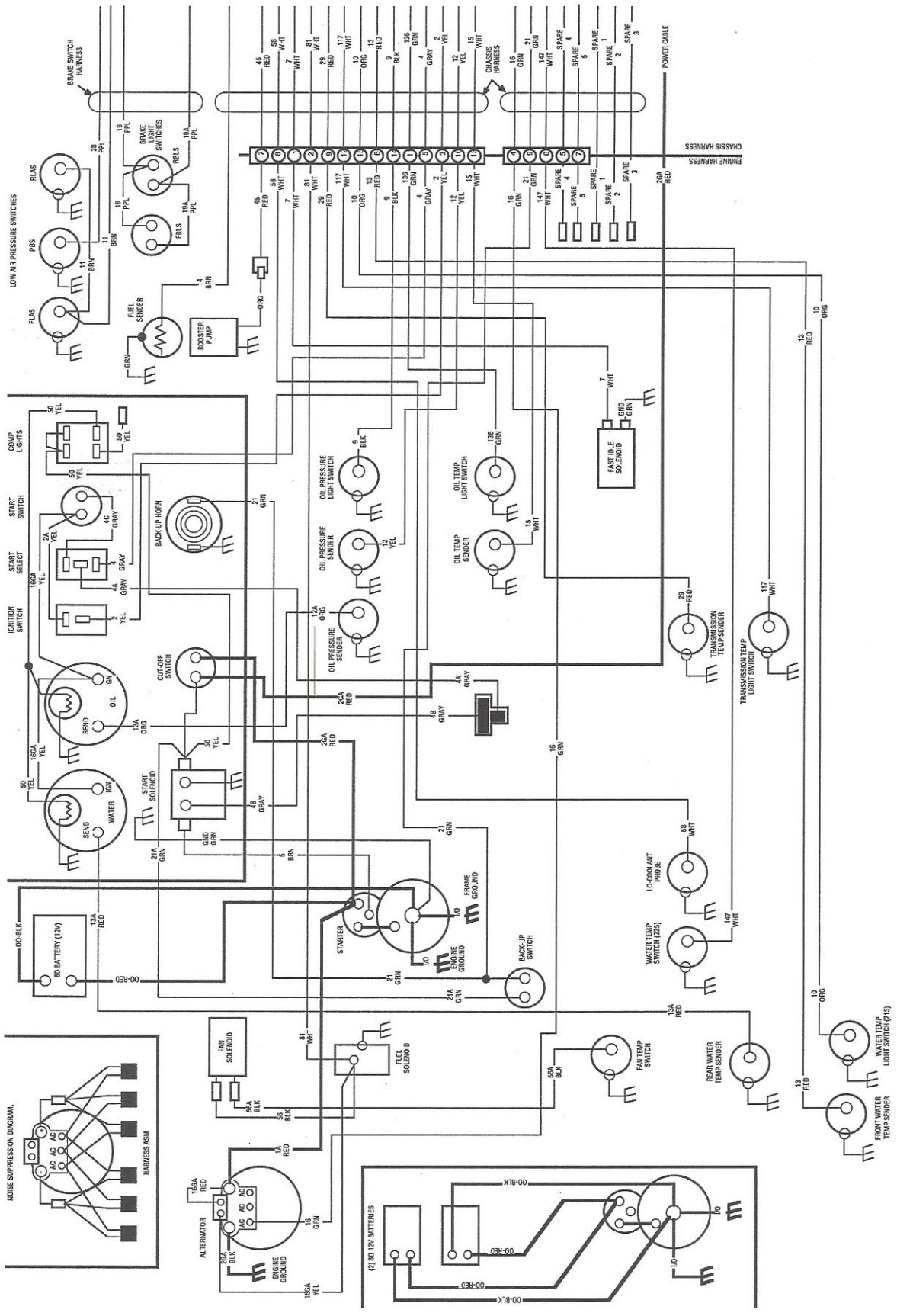


Figure 7.10. Electrical Schematic

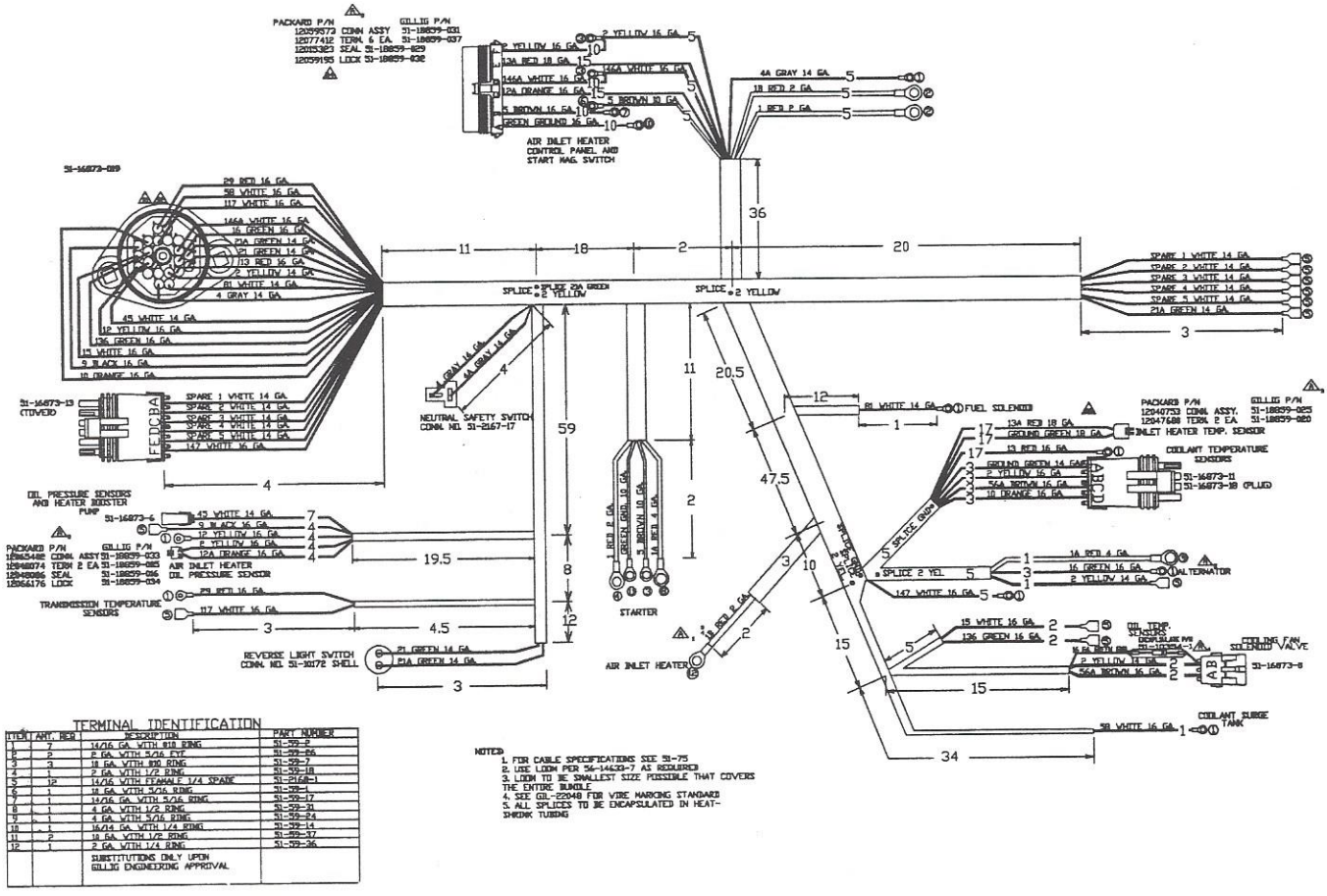
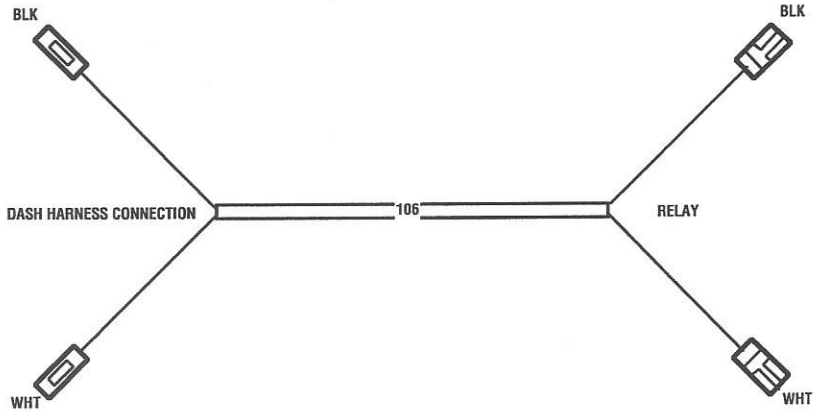


Figure 7.11. Harness Connector Pin Locations



CH-09-367

Figure 7.12. Dash Harness

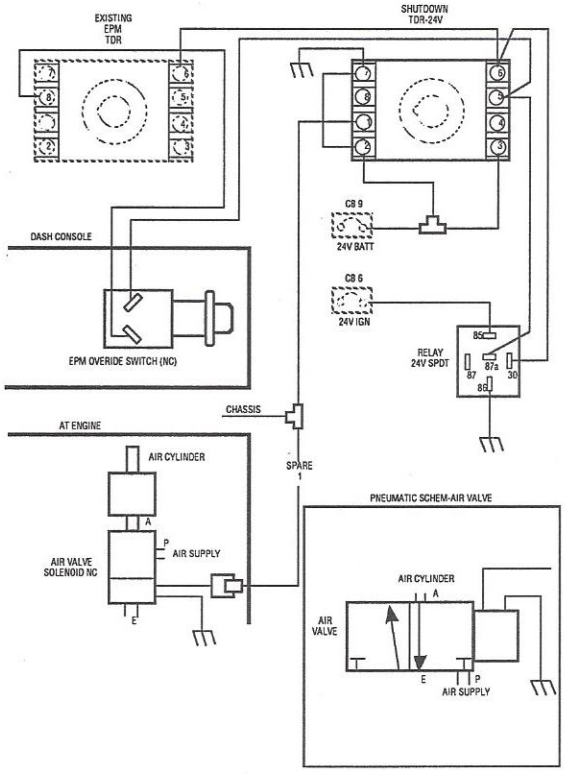


Figure 7.13. (EPM) Emergency Engine Shutdown CH-09-363

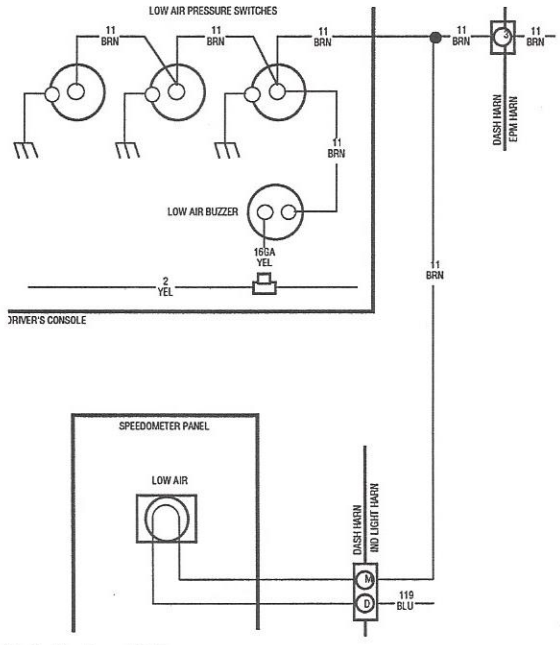


Figure 7.14. Low Air Indicator with Buzzer CH-09-364