TC Series Brakes

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Eaton® Axle and Brake Service Manual, EB and ES Models, Publication number BRSM-0033: April 1997.

Webb® Wheel Products, Inc. Installation, Service and Safety Instructions Manual, Publication number IM-298 (Supercedes IM-494).

Webb® Wheel Products, Inc. Torque Specifications, and Publication number SD-012: Revised April 1997.

Multiple loose-leaf instruction pages provided by Crewson Brunner®, Inc. on installing and maintaining Automatic Slack Adjusters, no publication number.

Holset® Air Compressor Field Service Manual, no publication numbers or dates.

MGM Brakes Model TR – Tamper Resistant Spring Brakes, © MGM 12/92, Form Number 5026-MGM.

Midland™ EL1300 and EL1600 Air Compressor Service Procedures, Publication Number L30002, Rev. 9-93, © Midland-Grau Heavy Duty Systems.

Allied Signal Bendix® Brakes Air Brake Handbook, Components, Maintenance and Troubleshooting, © AlliedSignal TBS Co. 9/1996, Publication numbers BW5057.

Allied Signal Bendix® Brakes TU-FLO 550 Compressor Service Data SD-01-333, © AlliedSignal 4/1996, Publication number BW1639.

Allied Signal Bendix® Brakes WS-20 Antilock Wheel Speed Sensor Service Data SD-13-4754, © Allied Signal TBS Co. 11/1996, Publication numbers BW1662.

Allied Signal Bendix® Brakes M-21 and M-22 Antilock Modulator Assembly Service Data SD-13-4793, © AlliedSignal TBS Co. 11/1996, Publication numbers BW1664.

Allied Signal Bendix® Brakes EC-17 Antilock Traction Controller Service Data SD-13-4788, © AlliedSignal TBS Co. 2/1998, Publication number BW1910.

Allied Signal Bendix® Brakes AD-9 Air Dryer Service Data SD-08-2412, © AlliedSignal TBS Co. 5/1996, Publication numbers BW1627.

Allied Signal Bendix® Brakes Push-Pull Type Control Valves Service Data SD-03-3611, © AlliedSignal TBS Co. 4/1996, Publication numbers BW1578.

Allied Signal Bendix® Brakes E-6 and E-10 Dual Brake Valves Service Data SD-03-817, © AlliedSignal 6/1996, Publication numbers BW1427.

Allied Signal Bendix® Brakes R-12 and R-14 Relay Valves Service Data SD-03-1064, © AlliedSignal 6/1996, Publication number BW1431.

List of Figures

Safety

Safety is always a primary concern. Remember to bleed system pressure, chock wheels and disable starting system prior to performing maintenance procedures to the vehicle.

When working with fluid under pressure, make sure you wear a face shield or protective goggles and clothing that covers exposed parts of the body. Pressurized fluid that escapes can penetrate exposed areas of the body. Be sure to relieve pressure before disconnecting pressurized lines.

Warnings and Cautions

You must adhere to the WARNINGS and Cautions to work safely.

WARNING

DEATH OR SERIOUS PERSONAL INJURY CAN RESULT IF THE WARNING INFORMATION INSTRUCTIONS ARE NOT FOLLOWED.

Caution

Always block vehicle wheels. Stop engine when working under vehicle. Keep hands away from chambers as they may activate when system pressure drops.

Never connect or disconnect a hose or line containing pressure; it may whip. Never remove component, pipe or plug unless all system pressure has been depleted.

Never exceed recommended pressure and always wear safety glasses.

Never attempt to disassemble a component until you have read and understand recommended procedures. Some components contain powerful springs and injury can result if component is not properly disassembled.

Use only genuine Blue Bird replacement components. Only components, devices and mounting and attaching hardware specifically designed for use in hydraulic brake systems should be used. Replacement hardware, tubing hose, fittings, etc. should be the same size, type and strength as the original equipment.

Devices with stripped threads or damaged parts should be replaced. Repairs requiring machining of components should not be attempted.

Caution

Equipment damage can result if the caution instructions are not followed.

Hydraulic Brake Systems are power assisted. Braking capacity is reduced without engine assist. Do not move the bus with dead engine.

WARNING

DO NOT DRIVE THE BUS WHEN THE ELECTRICAL BACKUP PUMP DOES NOT OPERATE. IN THE CASE OF A LOSS OF POWER ASSIST, THERE WILL BE REDUCED BRAKE CAPACITY WITHOUT THE ELECTRICAL BACKUP.

Caution

When one circuit of the dual system fails, the following conditions will exist:

Bus stopping distance will increase. (Drive the bus only with extreme caution. Service immediately).

The brake pedal will be softer to push.

Caution

The brake pedal will travel further, even as far as the floorboard. These conditions exist because only one axle will be stopping the bus.

Put only brake fluid in the brake fluid reservoir and power steering fluid in the power steering system. Failure to use the proper fluids could result in loss of braking or steering.

WARNING

IMPROPER ADJUSTMENT OF THE PARKING BRAKE CAN SIGNIFICANTLY REDUCE THE HOLDING ABILITY OF THE PARKING BRAKE SYSTEM. THIS COULD RESULT IN THE VEHICLE MOVING WHEN UNATTENDED.

Caution

The parking brake is designed to hold on a 20 % grade, clean , dry and smooth road surface. Parking on wet, ice or snow covered grades is not recommended. Chocking of the wheel(s) is recommended when parking on any grade.

WARNING

EXTREME CAUTION SHOULD BE EXERCISED WHEN THE DRIVE SHAFT IS REMOVED ON A UNIT EQUIPPED WITH HYDRAULIC BRAKES. THE PARKING BRAKE BECOMES INOPERATIVE WHEN THE DRIVE SHAFT IS DISCONNECTED. DO NOT LEAVE THE BUS UNATTENDED UNTIL APPROPRIATE MEASURES HAVE BEEN TAKEN TO PREVENT VEHICLE MOVEMENT.

Description of Operation

The basic principle in automotive brake systems is to develop friction between rotating and stationary components to stop a vehicle. The friction developed between the brake pad and rotor or brake shoe and brake drum are the primary elements used to develop this friction. As the friction increases, so does heat, so rotating brake components are designed with cooling fins to dissipate heat rapidly.

The air brake system utilizes modulated air under pressure to overcome spring force, which, in the absence of air pressure, forces the rotating and stationary members together. Compressed air is developed by an engine driven, twin piston air pump (G).

As the air is compressed and cools, moisture condenses and must be removed from the system. Moisture is removed to prevent system contamination and components from rusting and binding. The compressed, moisture laden air is passed through an air dryer that removes moisture before being utilized in the system. The compressed dry air is temporally stored in the wet tank (P) and can be diverted for use by additional accessories. Several valves and sensors are added to the wet tank to monitor system pressure and warn the operator in case of a system malfunction.

Air pressure is then routed through two single check valves and into the front and rear storage tanks (A, and Y). The storage tanks store air pressure for their respective front or rear circuits as needed. These air tanks are required to store air pressure for two reasons:

Successive stops would deplete the air supply directly from the compressor if a storage tank were not used.

Using two storage tanks provides a margin of safety in the event one of the two-brake circuits malfunction.

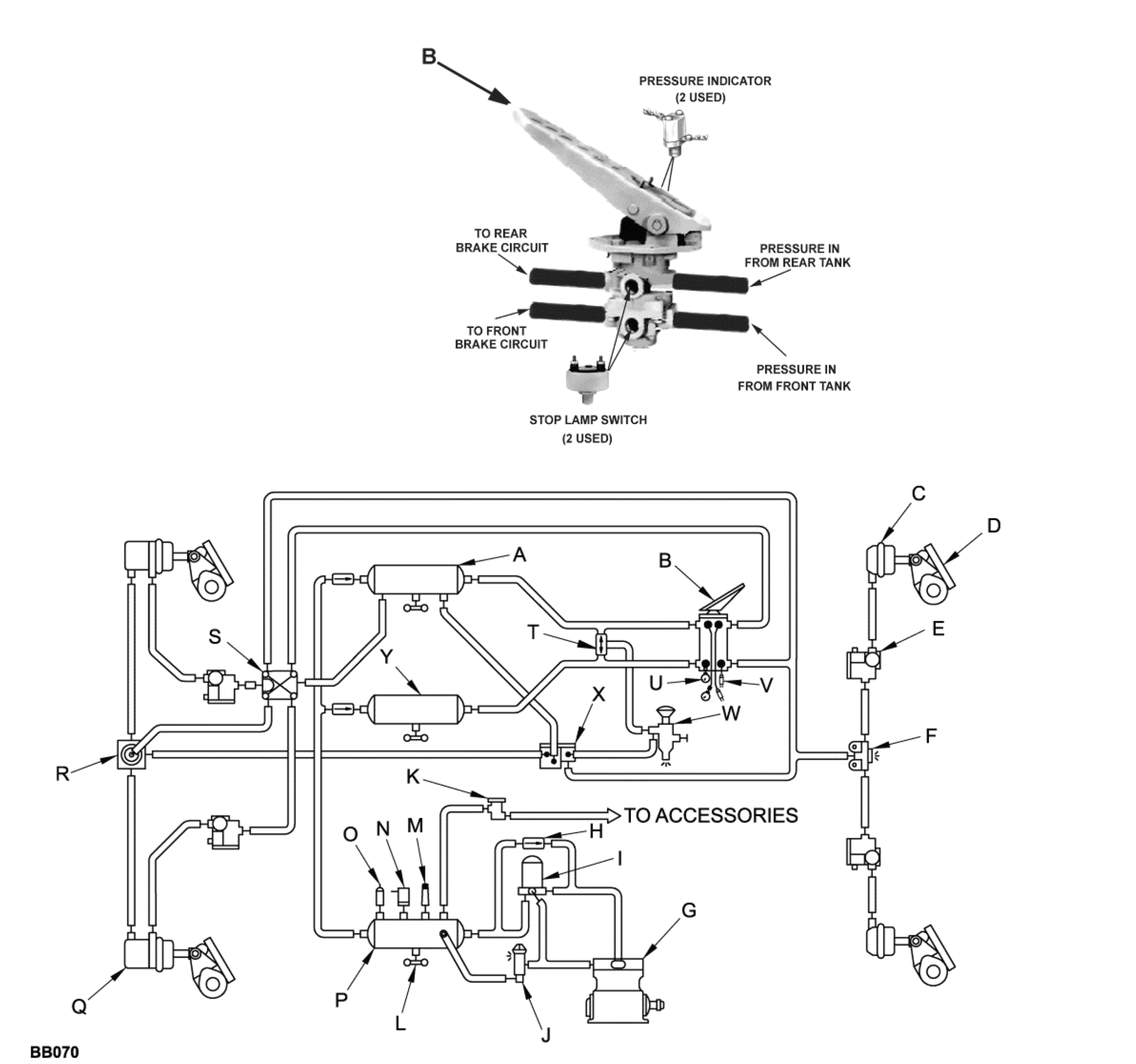
The double check valve (T) provides spring brake valve (W) and spring break (Q) with the highest pressure from either front or rear storage tank.

The brake valve (B) is controlled by the operator and modulates the air pressure to both the front and rear brake circuits. Provisions for monitoring brake pressure (U) and mounting location for brake light switch (V) is facilitated at the brake valve.

Modulated air from the brake valve is directed to the quick release valve (F) and the antilock modulator assembly. The brake chambers (Q) are spring applied pressure released, sealed, dual chambers.

The modulated air pressure enters the chamber and works against spring pressure to combine spring force and modulated air pressure to a longitudinal force.

The automatic slack adjusters (D) convert the longitudinal force to a rotational force. A cam action is then used to apply friction between rotating and stationary components to slow and stop the vehicle.



Air Brake System Diagram with ABS (Bluebird Specific)

Legend

A. Primary or Rear Service Tank
B. E-6 (Brake Valve)
C. Front Air Chamber
D. Slack Adjusters (4 used)
E. M-22 (ABS Antilock Modulator Assembly) (4 used)
F. QR-1C (Quick Release Valve) (3 used)
G. Air Compressor
H. Check Valve
I. Air Dryer
J. Governor
K. Pressure Protection Valve
L. Drain Valve (3 used)
M. Schrader Valve
N. Low Pressure Indicator Switch
O. Safety Valve
P. Wet Tank
Q. Rear Brake Chamber (2 used)
R. Quick Release Valve
S. R-12 Relay Valve with Double Check
T. Double Check Valve
U. Pressure Gauge (2 used)
V. Brake Light Switch (2 used)
W. PP-1 (Push Pull Control Valve)
X. SR-1 (Spring Brake Valve)
Y. Secondary or Front Tank

Description

Safety Valve

The safety valve (Figure 1) protects the air brake system against excessive air pressure buildup. It must be installed in the same reservoir that the compressor discharge line is connected to. Safety valves are available in both adjustable and non-adjustable styles, in various pressure settings, and with either 1/4" or 3/8" NPT.

Figure 1—Safety Valve

Governor

The governor (Figure 2) operates in conjunction with the compressor unloading mechanism and maintains reservoir air pressure between a predetermined maximum and minimum pressure. The governor is an adjustable piston-type valve available in various pressure settings. A non-adjustable pressure range between specified cut-in and cutout pressures is designed into the governor.

Provisions are made for direct mounting to the compressor, or for remote mounting, if desired. The governor is available in weatherproof and high temperature versions for special installations.

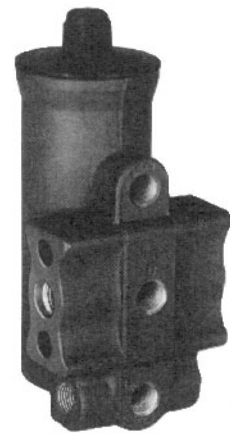


Figure 2—Governor

Air Dryers

The air dryer (Figure 3) is a desiccant type in-line filtration system that removes both liquid and water vapor from the compressor discharge air before it reaches the air brake reservoirs. This results in only clean, dry air being supplied to the air brake system, aiding in the prevention of airline freeze ups.

The air dryer uses a replaceable desiccant material, that has the unique ability to strip water vapor from moisture laden air.

The desiccant material is regenerative in that its adsorptive properties are renewed each time the compressor is unloaded.

The air dryer end cover is equipped with an automatic drain valve, controlled by the air system governor, and is equipped with an integral heating element, and is available for either 12 or 24-volt systems.

The air dryer is equipped with an integral storage of dry air for the purge cycle.

Figure 3—Air Dryer

Low Pressure Indicator

Low pressure indicators (Figure 4) are pressure operated electro-pneumatic switches. These switches are designed to complete an electrical circuit and activate a warning light and buzzer for the driver in the event air pressure in the service brake system is below a safe minimum for normal operation. The low-pressure indicator is available in various pressure settings, is not adjustable, and is generally used in conjunction with a dash mounted warning lamp or warning buzzer, or both.

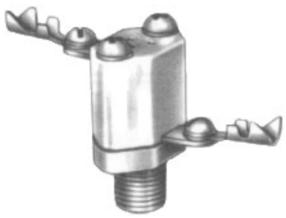


Figure 4—Low Pressure Indicator

Dual Circuit Brake Valve

Dual circuit brake valves (Figure 5) use two separate supply and delivery circuits for service and secondary braking. The first circuit is mechanically operated through the action of the treadle/pedal and plunger. The second circuit normally operates similar to a relay valve, with control air delivered from the first, or primary circuit. In the emergency mode (failure of the primary supply), the secondary inlet valve is mechanically opened by a push through mechanical force (from the driver's foot via the treadle/pedal, plunger and primary piston). The brake valve provides the driver with graduated control for applying and releasing the vehicle brakes. A rubber spring provides the driver with the correct feel.

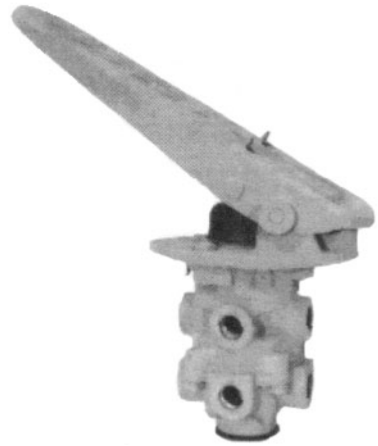


Figure 5—Dual Circuit Brake Valve

Automatic Slack Adjuster

Automatic slack adjusters function the same as manual adjusters, except that the automatic slack adjusters compensate for lining wear. The entire slack adjuster operates as a unit (rotating as a lever with the brake camshaft) as the brakes are applied or released.

Service Quick Release Valve

The function of the quick release valve (Figure 6) is to speed up the exhaust of air from the air chambers. It is mounted close to the chambers it serves. In its standard configuration, the valve is designed to deliver within one psi of control pressure to the controlled device; however, for special applications the valve is available with greater differential pressure designed into the valve. The quick release valve has a die cast body and diaphragm but does not employ a spring or spring seat.

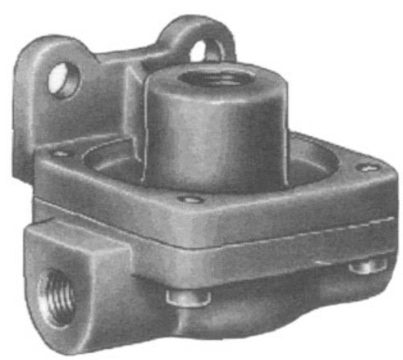


Figure 6—Service Quick Release Valve

Brake Chamber

The brake chamber (Figure 7) is a sealed non-repairable unit designed to receive modulated air pressure to apply the service brakes. Both sides of the diaphragm are connected via porting to allow internal air from the chamber being compressed to enter the chamber expanding.

1. End Cap
2. Release Tool
3. Steel Head
4. Sealed Spring Chamber
5. Power Spring
6. Push Rod
7. Piston and Guide
8. Service Piston Seal
9. Push Rod Seal
10. Stroke Alert Indicator
11. Center Hole Shield

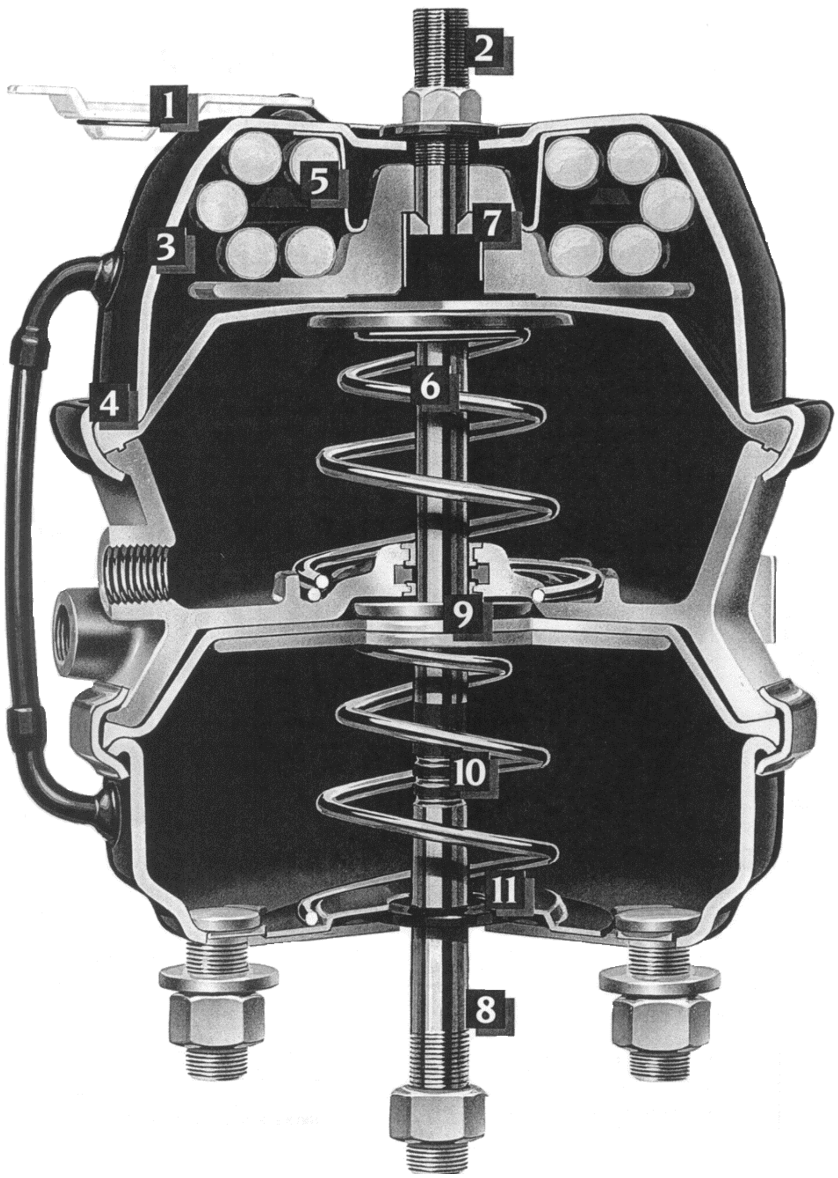


Figure 7—Brake Chamber

Double Check Valves

A double check valve (Figure 8) is used in the air system when a single function or component must be controlled by either of two sources of pressure. The double check valve will always transmit the higher of the two pressure sources to the outlet port. Double check valves are available in both disc and shuttle types and in various configurations for various applications. It is recommended that double check valves be mounted so that the shuttle operates horizontally.

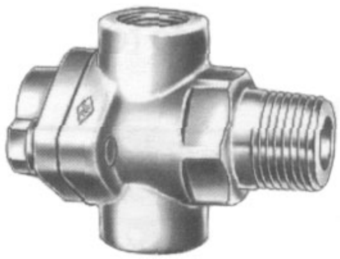


Figure 8—Double Check Valve

Stop Lamp Switches

The stop lamp switches (Figure 9) are pressure sensitive electro-pneumatic switches installed in the service application system. They operate the vehicle stop lamps, completing an electrical circuit and lighting the stop lamps each time a brake application is made.

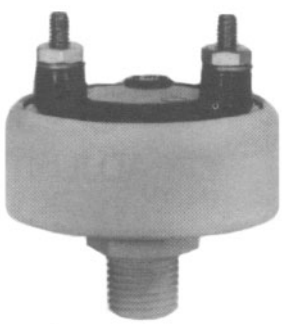


Figure 9—Stop Lamp Switches

Parking Quick Release Valve

The parking quick release valve (Figure 10) is a dual function valve. The valve's primary function is to serve the emergency side of a spring brake actuator as a quick release valve. In addition, it functions as an anti-compound device.

The double check valve prevents a service and emergency brake application from occurring simultaneously.

Figure 10—Parking Quick Release Valve

Relay Valve

Relay valves (Figure 11) are primarily used on long wheel base vehicles to apply and release rear axle(s) service or parking brakes. The valve is air operated, graduating control valves of high capacity and fast response. Upon signal pressure from the service brake valve, hold or release air pressure from the chambers they are connected to. The valve is generally mounted close to the chambers they serve. Relay valves are available in both remote and reservoir mount designs and feature inlet/exhaust valve cartridge replacement without line removal.

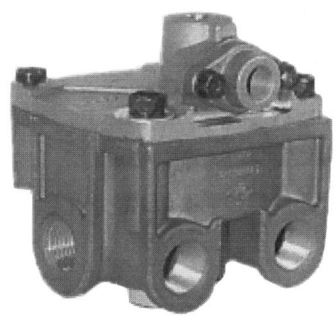


Figure 11—Relay Valve

Spring Brake Valve

The spring brake valve (Figure 12) is used in FMVSS 121 dual circuit brake systems and serves two functions. During normal operation, it limits hold-off pressure to the spring brakes to 90 or 95 psi. Should a loss of pressure occur in the rear service brake service supply, it will provide a modulated spring brake application proportional to service braking pressure delivered to the front axle.

Figure 12—Spring Brake Valve

Push Pull Control Valves

Push-Pull control valves (Figure 13) are most often mounted on the vehicle dashboard and are used for a variety of control applications. The valves are pressure sensitive, normally closed, on/off control valves, that automatically return to the exhaust (button out) position when supply pressure is below the required minimum. They may be manually operated to either position when pressure is above the required minimum. Pressure settings and button configuration and lettering may vary, depending on application. The valves are commonly used to control parking and emergency brakes.

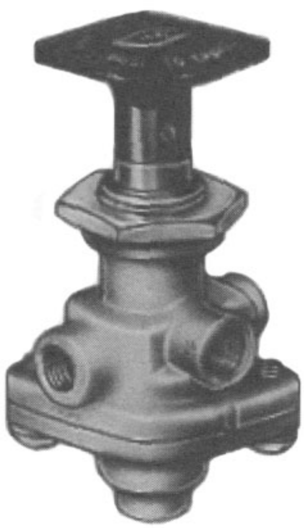


Figure 13—Push-Pull Control Valve

Pressure Protection Valve

The pressure protection valve is normally a closed pressure sensitive control valve. These valves can be used in many different applications but are typically used to protect or isolate one reservoir from another, by closing automatically at a preset pressure. The valve is also commonly used to delay the filling of auxiliary reservoirs until a preset pressure is achieved in the primary or braking reservoirs.

Pressure protection valves allow air to be "shared" between two reservoirs above the closing setting of the valve. The sharing ceases when pressure drops below the closing pressure off valve and the reservoirs are then isolated from each other.

Air Compressor

The function of the air compressor (Figure 14) is to provide and maintain air under pressure to operate devices in the air brake and/or auxiliary air systems. The Tu-Flo 550 compressor is a two cylinder single stage, reciprocating compressor with a rated displacement of 13.2 cubic feet per minute at 1250 RPM.

The compressor assembly (Figure 15) consists of two major subassemblies, the cylinder head and the crankcase. The cylinder head is an iron casting that houses the inlet, discharge, and unloader valves. (See Figure 14) The cylinder head contains the air inlet port and is designed with both top and side air discharge ports.

Three water coolant ports provide a choice of coolant line connections. Governor mounting surfaces are provided at both the front and the rear of the cylinder head.

The head is mounted on the crankcase and is secured by six cap screws. The Tu-Flo 550 compressor is designed so the cylinder head can be installed in one of two positions 180° apart.

The crankcase houses the cylinder bores, pistons, crankshaft and main bearings, and provides the flange or base mounting surface.

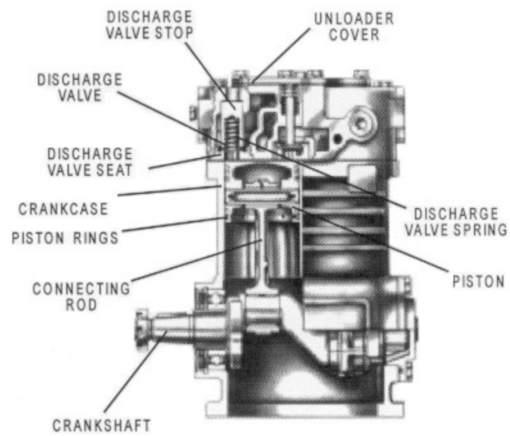


Figure 14—Air Compressor Bendix

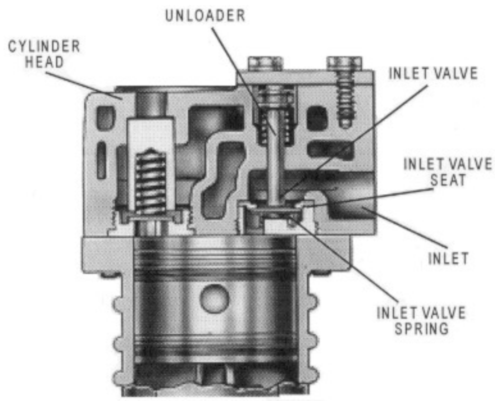


Figure 15A—Air Compressor Major Assemblies

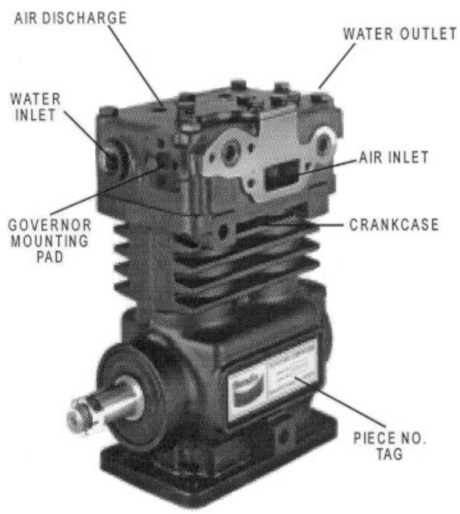


Figure 15B—Air Compressor Major Assemblies

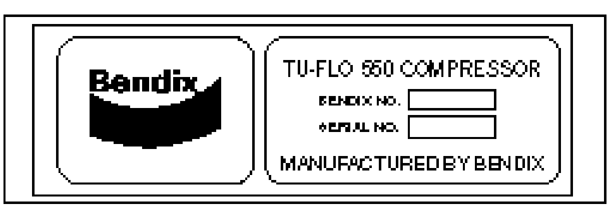


Figure 16—Nameplate

A nameplate identifying the compressor piece number and serial number is attached to the side of the crankcase. Reference Figure 16 Nameplate.

The Holset air compressor is an engine driven, piston-type compressor that supplies compressed air to operate the service brakes and other air powered devices. The compressor operates or turns continuously but has loaded and unloaded operating modes. Operation is controlled by a pressure-activated governor and compressor unloading assembly.

- **Unloading**

When the air system reaches “cut-out” pressure, the governor applies an air signal to the air compressor unloader assembly, causing the unloader valve to close and stopping compressed air from flowing into the system.

The unloader intake valve remains closed during the unloaded mode. This, in conjunction with back pressure on the exhaust valve, causes air inside the compressor cylinder to become trapped.

As the compressor rotates, the energy developed during the compression stroke is in turn released during the down stroke. The compressor effectively becomes an air spring.

This action nearly eliminates pumping losses during non-demand operation. Additional benefits include reduced oil passage, cooler exhaust air temperatures and unlimited turbo boosting capability.

- **Loading**

As the air in the air system is depleted, system pressure drops. At cut-in pressure, the governor exhausts the air signal to the compressor unloader assembly, allowing the compressor to again pump compressed air into the system.

Due to the unique unloading technique of the Holset compressor, a positive pressure must be maintained at the exhaust port or excessive oiling will occur. This can be checked at the air dryer inlet line.

Air Compressors Major Difference Unloading

In the unloading mode, the Holset unloads as the governor applies a pressure to CLOSE the intake valve, creating an air spring, effect while the Bendix and Midland compressors OPEN the intake valve. Due to the unique unloading technique of the Holset compressor, a positive pressure must be maintained at the exhaust port or excessive oiling will occur. This is a result of a vacuum being created on the down or intake stroke. Oil is then drawn past the rings of the piston and into the compressed air system.

Antilock Systems Component Description

Antilock Systems

Brake antilock systems and components are designed to provide improved vehicle stability by reducing wheel lock during aggressive braking.

While all antilock systems provide this basic benefit, there are several different systems and components offered. Each is designed to meet the specific needs.

Each modulator controller assembly model represents a different method of vehicle control and, in most cases, a different level of system performance.

All antilock controllers feature digital electronics with self-test and diagnostic circuitry that continuously monitors operation of the entire antilock system, including wiring continuity.

The condition of specific antilock components is provided to maintenance personnel by a series of labeled, Light Emitting Diodes (LEDs) displayed through a diagnostic window in the controller housing.

No special tools or equipment is required to read or interpret the diagnostics window. It should be noted that the diagnostics display is separate from the antilock condition lamp on the dash.

Feature conditions are stored in the controller memory and are not cleared by loss of power to the unit.

Wheel Speed Sensor

The wheel speed sensor (Figure 18) is an electromagnetic device used to obtain vehicle speed information for the antilock controller. The sensor is mounted on the axle and works in conjunction with an exciter, or tone wheel, mounted in the wheel hub.

When the wheel rotates, the exciter with its notched surface rotates across the face of the sensor, generating a simple AC signal.

The sensor is connected to the antilock controller that analyzes the signal and issues antilock commands accordingly. Specifically, the speed sensor consists of a coil, pole piece and magnet.

The exciter is a steel ring, or gear-like device, that has regularly spaced high and low spots called teeth.

The sensor is mounted in a fixed position, while the exciter is installed on a rotating member so that its teeth move, in close proximity, past the tip of the sensor.

Figure 18—Wheel Speed Sensor

Wheel Speed Sensor Operation

The sensor magnet and pole piece form a magnetic field. As an exciter tooth passes by the sensor, the magnetic field is altered, generating AC voltage in the sensor coil. Each time an exciter tooth and its adjacent space move past the tip of the sensor, an AC voltage cycle is generated.

The number of AC cycles per revolution of the vehicle's wheel depends on the number of teeth in the exciter that is programmed into the antilock controller. Using the programmed data, the controller can calculate vehicle speed by analyzing the frequency of AC cycles sent by the speed sensor. (The frequency of AC cycles is directly proportional to wheel speed.) AC voltage is also proportional to speed, but voltage is not used to determine speed. It is only an indication of AC signal strength.

The amount of AC voltage generated by a specific speed sensor depends on the distance, or gap, between the tip of the sensor and the surface of the exciter. Voltage increases as the sensor gap decreases.

The WS-20 is installed in a mounting block that is affixed to the axle housing. See Figure 19. A spring loaded retainer bushing provides a friction fit between the mounting block bore and the WS-20.

The friction fit allows the WS-20 to slide back and forth under force but to retain its position when force is removed. This feature allows the WS-20 to self adjust after it has been installed in the mounting block and the wheel is installed.

When the WS-20 is inserted all the way into the mounting block and the wheel is installed on the axle, the hub exciter contacts the sensor, that pushes the sensor back. In addition, normal bearing play will bump the sensor away from the exciter. The combination of these two actions will establish a running clearance or air gap between the sensor and exciter.

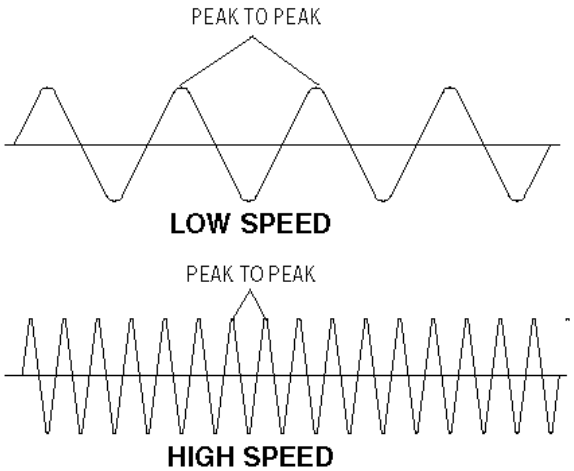


Figure 19—Wheel Speed Sensor Output

Antilock Modulator Assembly

The antilock system modulators (Figure 20) are high capacity, on/off air valves that incorporate a pair of electrical solenoids for control. The solenoids provide the electro-pneumatic interface or link between the antilock controller and the air brake system.

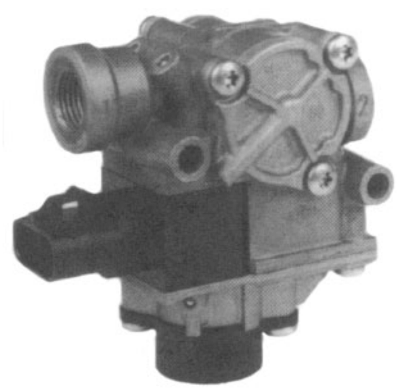


Figure 20—Antilock Modulator Assembly

Antilock-Traction Controller

The EC-17 is an electronic antilock controller. It is the base component in a family of full vehicle wheel control antilock systems. In addition to the antilock function, the EC-17 can be assembled and programmed to provide an optional traction control feature. Figure 21 shows the basic controller.

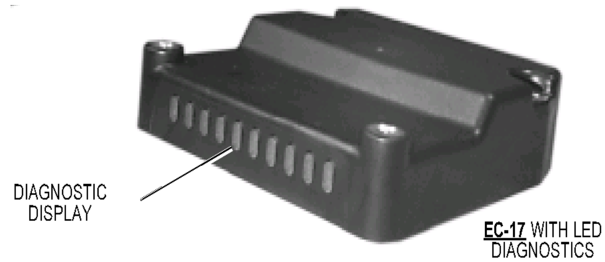


Figure 21—Antilock Traction Controller

Designed to minimize the potential of brake lock up on all wheels during aggressive braking, the controller based antilock system provides the vehicle with a high degree of stability and steer-ability during braking. In most cases, vehicle stopping distance is also reduced.

The antilock portion of the controller based system minimizes wheel skid during hard or aggressive braking. By controlling wheel skid at all wheels on the vehicle, optimum steering control and stopping distance is obtained.

Traction control, an optional feature in the full vehicle wheel control antilock system, helps improve vehicle traction during acceleration in adverse road conditions.

Integrated with antilock logic, traction control monitors wheel speed information from the sensors during acceleration, as well as braking. The system helps maintain vehicle stability on hazardous road surfaces and improves drive-ability and safety.

The controller contains a self configuring or learning feature that allows it to be configured by the user when installed on the vehicle. Because of this feature, all controllers contain all the features and options available, and will activate the specific features required for the vehicle it is installed on.

The controller is installed on vehicles with only antilock or vehicles using the traction control feature. The procedure for activating the self-configuring feature is contained in the section entitled Configuring the EC-17.

To provide full vehicle wheel control antilock, the controller is used in combination with the following components:

- Four or six wheel speed sensors
- Four air pressure modulator valves
- One dash mounted antilock condition lamp
- One service brake relay valve

When programmed to provide traction control in addition to antilock, the following components are added:

- One traction solenoid (incorporated into the relay valve)
- One dash mounted traction condition lamp
- Serial connection to engine control module for vehicles programmed for torque limiting feature
- Traction disable wiring and switch

Physical

The EC-17 electronics are contained in a non-metallic housing and are environmentally protected by an epoxy compound.

The design of the digital electronics is intended to provide a high degree of protection from radio, electromagnetic and environmental interference.

The patented optional light emitting diode (LED) display and magnetically actuated reset switch is incorporated in the housing for troubleshooting and diagnostic purposes.

Two electrical connectors, located in the controller housing opposite the diagnostic display (if so equipped), connect the EC-17 to antilock and traction system components: one 30 pin and one 18 pin connector.

Dual Brake Valve Operation

Normal Operation – Primary Circuit Portion

When the brake treadle (Figure 22 and Figure 23) is depressed, the plunger exerts force on the spring seat, graduating spring and primary piston. The primary piston that contains the exhaust valve seat closes the primary exhaust valve. As the exhaust valve closes, the primary inlet valve is moved off its seat, allowing primary air to flow out the primary delivery port.

Normal Operation – Secondary Circuit

When the primary inlet valve is moved off its seat, air is permitted to pass through the bleed passage and enters the relay piston cavity. The air pressure moves the relay piston that contains the exhaust seat and closes the secondary exhaust valve. As the secondary exhaust valve closes, the secondary inlet valve is moved off its seat allowing the secondary air to flow out the secondary delivery port.

Because of the small volume of air required to move the relay piston, action of the secondary circuit of the valve is almost simultaneous with the primary circuit portion.

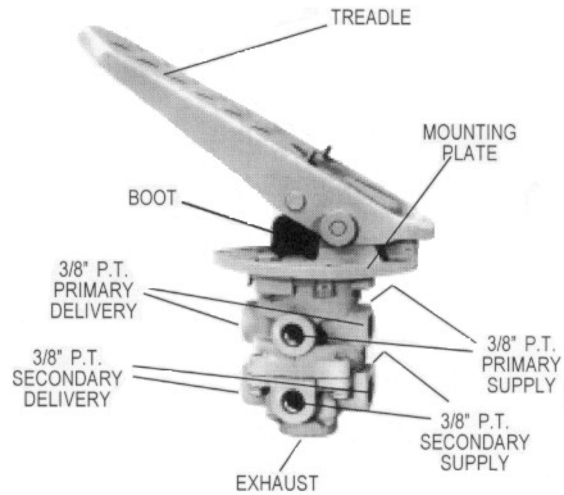


Figure 22—Dual Brake Valve

Loss of Air in the Secondary Circuit

Should air be lost in the secondary circuit, the primary circuit will continue to function as described above under “Normal Operation—Primary Circuit Portion.”

Loss of Air in the Primary Circuit

Should air be lost in the primary circuit, the function will be as follows: As the brake treadle is depressed and no air pressure is present in the primary circuit supply and delivery ports, the primary piston will mechanically move the relay piston.

This allows the piston to close the secondary exhaust valve and open the Secondary inlet valve, and allows air to flow out the secondary delivery port.

Balanced Primary Circuit

When the primary delivery pressure acting on the piston equals the mechanical force of the brake pedal application, the primary piston will move and the primary inlet valve will close, stopping further flow of air from the primary supply line through the valve. The exhaust valve remains closed preventing any escape of air through the exhaust port.

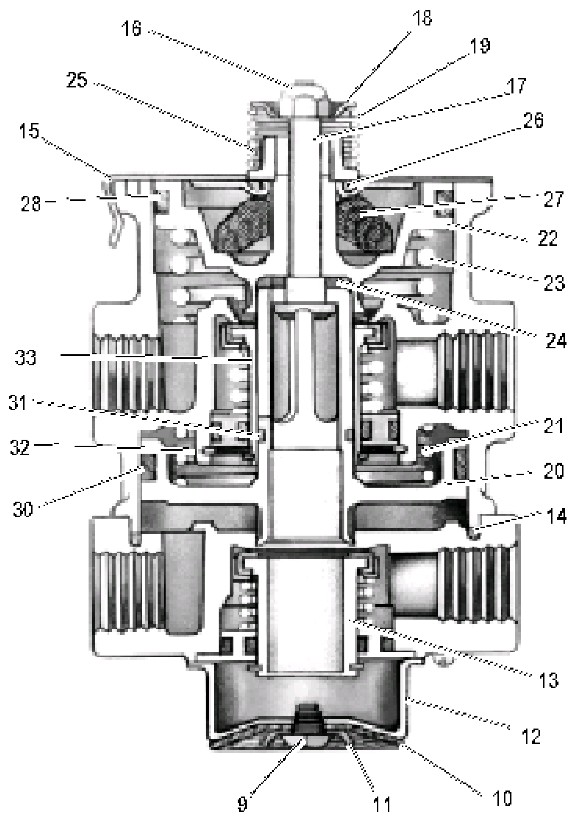


Figure 23—Dual Brake Valve Cross Section

Balanced Secondary Circuit

When the air pressure on the secondary side of the relay piston approaches that being delivered on the primary side of the relay piston, the relay piston moves, closing the Secondary inlet valve and stopping further flow of air from the supply line through the valve.

The exhaust remains closed as the secondary delivery pressure balances the primary delivery pressure.

When applications in the graduating range are made, a balanced position in the primary circuit pressure on the delivery side of the primary piston equals the effort exerted by the driver's foot on the treadle.

A balanced position in the secondary portion is reached when air pressure on the secondary side of the relay piston closely approaches the air pressure on the primary side of the relay piston.

When the brake treadle is fully depressed, both the primary and secondary inlet valves remain open and full reservoir pressure is delivered to the actuators.

Releasing Primary Circuit

With the brake treadle released, mechanical force is removed from the spring seat, graduating spring and primary piston. Air pressure and spring load moves the primary piston, opening the primary exhaust valve, allowing air pressure in the primary delivery line to exhaust out the exhaust port.

Releasing Secondary Circuit

With the brake treadle released, air is exhausted from the primary circuit side of the relay piston. Air pressure and spring load move the relay piston, opening the secondary exhaust valve allowing air pressure in the secondary delivery line to exhaust out the exhaust port.

Air Dryer Operation

Operation of the AD-9 Air Dryer

The AD-9 air dryer alternates between two operational modes or cycles during operation: the charge cycle and the purge cycle. The following description of operation is separated into these cycles of operation.

Charge Cycle

When the compressor is loaded compressing air along with oil, oil vapor, water and water vapor flows through the compressor discharge line to the supply port of the air dryer end cover.

As air travels through the end cover assembly, its direction of flow changes several times, reducing the temperature, causing contaminants to condense and drop to the bottom or sump of the air dryer end cover.

After exiting the end cover, the air flows into the desiccant cartridge. Once in the desiccant cartridge, air first flows through an oil separator, that removes water in liquid form as well as oil, oil vapor and solid contaminants.

Air exits the oil separator and enters the desiccant drying bed. Air flowing through the column of desiccant becomes progressively dryer as water vapor adheres to the desiccant material in a process known as adsorption. The desiccant cartridge using the adsorption process typically removes 95% of the water vapor from the pressurized air.

The majority of dry air exits the desiccant cartridge through its integral single check valve to fill the purge volume between the desiccant cartridge and outer shell. Some air will also exit the desiccant cartridge through the purge orifice adjacent to the check valve.

Dry air flows out of the purge volume through the single check valve assembly and out the delivery port to the first (supply) reservoir of the air system. The air dryer will remain in the charge cycle until air brake system pressure builds to the governor cutout setting.

Purge Cycle

When air brake system pressure reaches the cutout setting of the governor, the compressor unloads (air compression stopped) and the purge cycle of the air dryer begins. See Figure 24—Air Dryer Operation Cycle.

When the governor unloads the compressor, it pressurizes the compressor unloader mechanism and line connecting the governor unloader port to the AD-9 end cover control port.

The purge piston moves in response to air pressure causing the purge valve to open to atmosphere and (partially) closing off the supply of air from the compressor. This will be further discussed in the section covering the turbo cut-off feature.

Contaminants in the end cover sump are expelled immediately when the purge valve opens. Also, air that was flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected by the oil separator are removed by air flowing from the desiccant drying bed to the open purge valve.

The initial purge and desiccant cartridge decompression lasts only a few seconds. The actual reactivation of the desiccant drying bed begins as dry air flows from the purge volume through the desiccant cartridge purge orifice and into the desiccant drying bed. Pressurized air from the purge volume expands after passing through the purge orifice; its pressure is lowered and its volume increased. The flow of dry air through the drying bed reactivates the desiccant material by removing the water vapor adhering to it. Generally 15-30 seconds are required for the entire purge volume of a standard AD-9 to flow through the desiccant drying bed.

The end cover single check valve assembly prevents air pressure in the brake system from returning to the air dryer during the purge cycle. After the 30-second purge cycle is complete, the air dryer is ready for the next charge cycle to begin.

The purge valve will remain open after the purge cycle is complete and will not close until air brake system pressure is reduced and the governor signals the compressor to charge.

Turbo Cut-Off Feature (Figure 25)

The primary function of the turbo cut-off valve is to prevent loss of engine turbocharger air pressure through the AD-9 in systems where the compressor intake is connected to the engine turbocharger. The turbo cut-off valve also reduces the "puffing" of air out the open exhaust when a naturally aspirated, single cylinder compressor equipped with an inlet check valve is in use. At the onset of the purge cycle, the downward travel of the purge piston is stopped when the turbo cut-off valve (tapered portion of purge piston) contacts its mating metal seat in the purge valve housing. With the turbo cut-off valve seated (closed position), air in the discharge line and AD-9 inlet port is restricted from entering the air dryer. While the turbo cut-off effectively prevents loss of turbo charger boost pressure to the engine, some seepage of air may be detected under certain conditions of compressor engine and turbo charger operation.

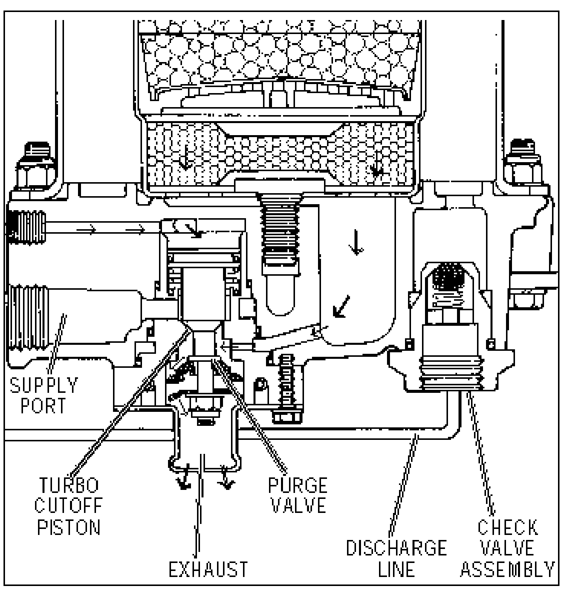


Figure 25—Turbo Cut-Off Feature

Relay Valve Operation

Application (Figure 26)

Air pressure delivered to the service port enters the small cavity above the piston and moves the piston down. The exhaust seat moves down with the piston and seats on the inner or exhaust portion of the inlet/exhaust valve, sealing off the exhaust passage. At the same time, the outer or inlet portion of the inlet/exhaust valve moves off its seat, permitting supply air to flow from the reservoir, past the open inlet valve and into the brake chambers.

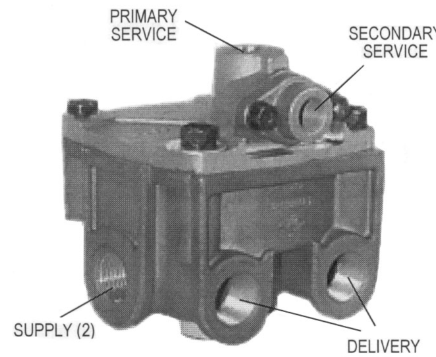


Figure 26—Relay Valve Ports

Balance

The air pressure being delivered by the open inlet valve also is effective on the bottom area of the relay piston. When air pressure beneath the piston equals the service air pressure above, the piston lifts slightly and the inlet spring returns the inlet valve to its seat. The exhaust remains closed as the service line pressure balances the delivery pressure. As delivered air pressure is changed, the valve reacts instantly to the change, holding the brake application at that level.

Exhaust or Release

When air pressure is released from the service port and air pressure in the cavity above the relay piston is exhausted, air pressure beneath the piston lifts the relay piston and the exhaust seat moves away from the exhaust valve, opening the exhaust passage. With the exhaust passage open, the air pressure in the brake chambers is then permitted to exhaust through the exhaust port, releasing the brakes.

Air Compressor

The function of the air compressor is to provide and maintain air under pressure to operate devices in the air brake and/or auxiliary air systems.

The compressor assembly consists of two major subassemblies, the cylinder head and the crankcase. The cylinder head is an iron casting which houses the inlet, discharge, and unloader valving. The cylinder head contains the air inlet port and is designed with both top and side air discharge ports. Three water coolant ports provide a choice of coolant line connections. Governor mounting surfaces are provided at both the front and the rear of the cylinder head. The head is mounted on the crankcase and is secured by six cap screws. The crankcase houses the cylinder bores, pistons, crankshaft and main bearings, and provides the flange or base mounting surface.

Intake and Compression of Air (Loaded)

During the down stroke of the piston, a slight vacuum is created between the top of the piston and the cylinder head, causing the inlet valve to move off its seat and open.

Note

The discharge valve remains on its seat. Atmospheric air is drawn through the air strainer and the open inlet valve into the cylinder (See Figure 28).

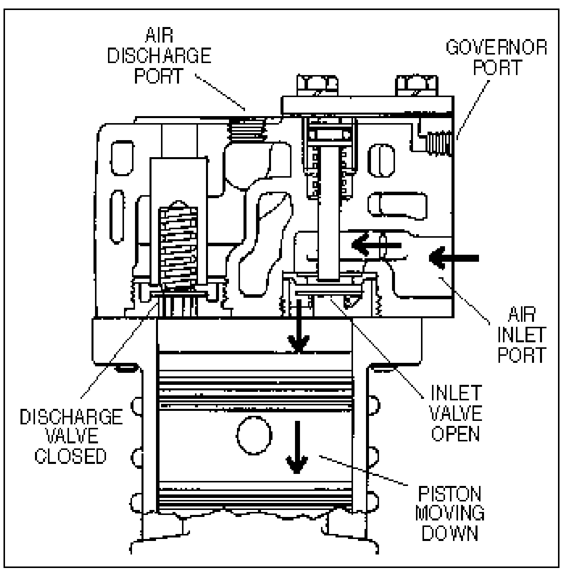


Figure 28—Operational-Loaded (Intake)

As the piston begins its upward stroke, the air that was drawn into the cylinder on the down stroke is being compressed. Air pressure on the inlet valve, plus the force of the inlet spring, returns the inlet valve to its seat and closes. The piston continues the upward stroke and compressed air pushes the discharge valve off its seat and air flows by the open discharge valve, into the discharge line and to the reservoirs (see Figure 29).

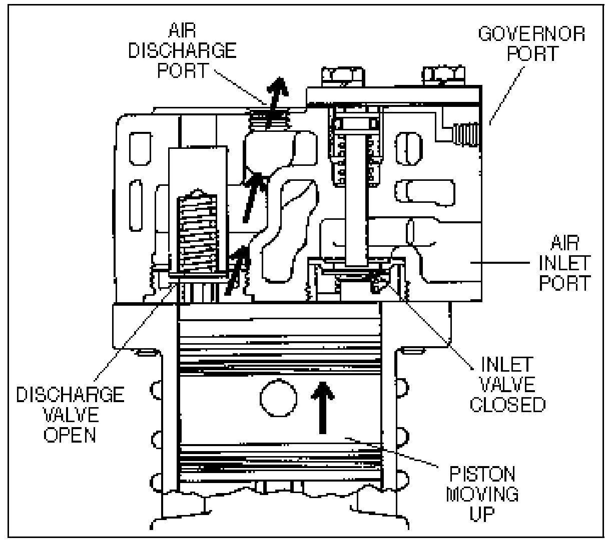


Figure 29—Operational-Loaded

As the piston reaches the top of its stroke and starts down, the discharge valve spring and air pressure in the discharge line returns the discharge valve to its seat.

This prevents the compressed air in the discharge line from returning to the cylinder bore as the intake and compression cycle is reseated.

Non-Compression of Air (Unloaded)

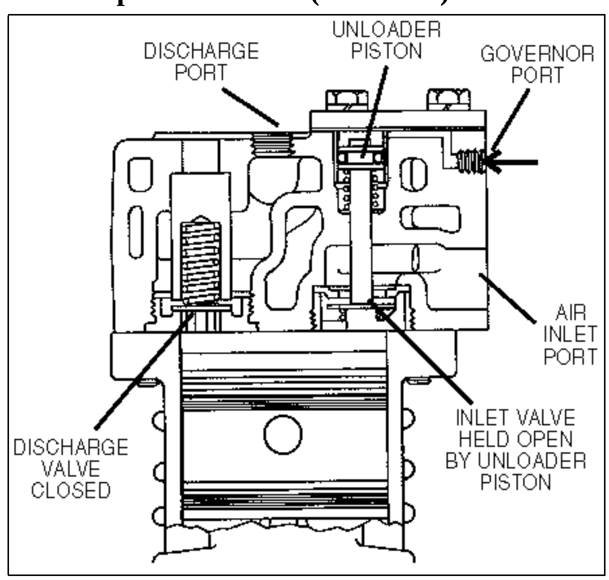


Figure 30—Operational-Unloaded

When air pressure in the reservoir reaches the cut-out setting of the governor, the governor allows air to pass from the reservoir, through the governor and into the cavity above the unloader pistons.

The unloader pistons move down holding the inlet valves off their seats (see Figure 30.) With the inlet valves held off their seats by the unloader pistons, air is pumped back and forth between the two cylinders, and the discharge valves remain closed.

When air pressure from the reservoir drops to the cut-in setting of the governor, the governor closes and exhausts the air from above the unloader pistons.

The unloader springs force the pistons upward and the inlet valves return to their seats. Compression is then resumed.

Lubrication

The vehicle's engine provides a continuous supply of oil to the compressor (see Figure 32). Oil is routed from the engine to the compressor oil inlet. An oil passage in the compressor crankshaft allows oil to lubricate the connecting rod crankshaft bearings.

Connecting rod wrist pin bushings and crankshaft ball bearings are spray lubricated. An oil return line connected from the compressor drain outlet to the vehicle engine crankcase allows for oil return.

On flange mounted models the oil drains back directly to the engine through the mounting flange.

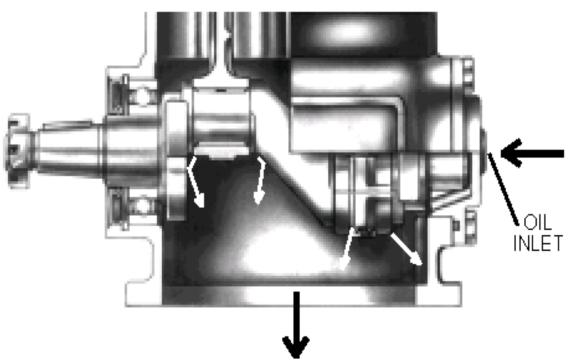


Figure 31—Lubrication

Air Induction

There are three methods of providing clean air to the compressor:

1. Naturally aspirated - Compressor utilizes its own attached air strainer (polyurethane sponge or pleated paper dry element).
2. Naturally aspirated - Compressor inlet is connected to the engine air cleaner or the vacuum side (engine air cleaner) of the supercharger or turbocharger.

Cooling

Air flowing through the engine compartment from the action of the engine's fan and the movement of the vehicle assists in cooling the compressor. (See Figure 32)

Coolant flowing from the engine's cooling system through connecting lines enters the head and passes through internal passages in the cylinder head and is returned to the engine.

Note

Proper cooling is important in maintaining discharge air temperatures below the maximum recommended 400° Fahrenheit.

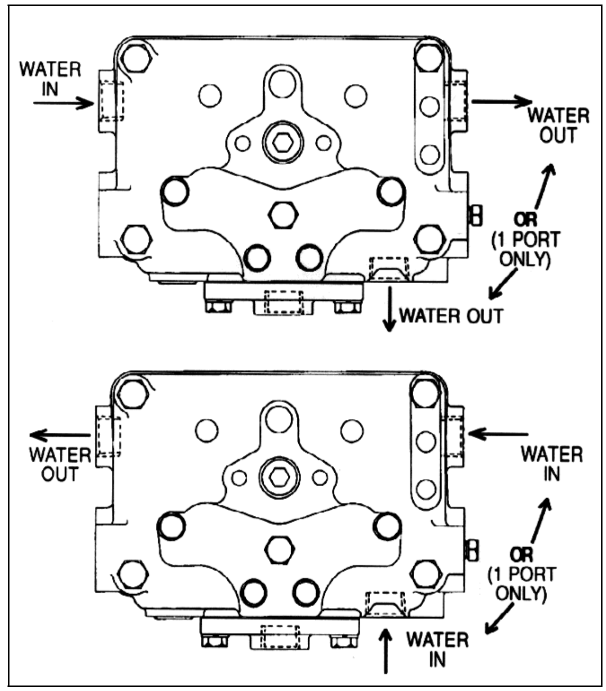


Figure 32—Cooling

3. Pressurized induction - Compressor inlet is connected to the pressure side of the supercharger or turbo-charger.
4. If a previously non-turbocharged compressor is being turbo-charged, it is recommended that the inlet cavity screen (238948) be installed with an inlet gasket (291909) on both sides of the screen.

Compressor Turbo Charging Parameters

Air entering the compressor inlet during the loaded cycle must not exceed 250° F (121° C). A metal inlet line is recommended.

Note

The following compressor crankshaft rotational speed and inlet pressure relationships may not be exceeded.

Crankshaft Maximum Compressor

RPM Inlet Pressure
2200 RPM 21.0 PSI (145 kPa)

2600 RPM 25.0 PSI (172.5 kPa)

Troubleshooting and Diagnostics

Brake System Troubleshooting

Test 1-Governor Cut-Out/Low Pressure Check List

1. Warning/Pressure Build-Up Vehicle Parked, Wheels Chocked.
2. Drain all reservoir to 0 PSI.
3. Start engine (run at fast idle)
4. Low pressure warning should be on.

Note

On some vehicles with anti-lock, a warning light will also come on momentarily when ignition is turned on.

5. Low pressure warning dash warning light should go off at or above 60 PSI.
6. Build up time pressure should build from 85-100 PSI within 40 seconds.
7. Governor cut-out, cuts out at correct pressure check manufacturers recommendations; usually between 100-130 PSI.
8. Governor cut-in reduce service air pressure to governor cut-in. The difference between cut-in and cut-out pressure must not exceed 25 PSI.

Make All Necessary Repairs Before Proceeding To Test 2; See Check List 1 For Common Corrections.

Governor Cut-Out/Low Pressure Check List

- **If the low pressure warning light or buzzer does not come on**
  - Check wiring.
  - Check bulb.
  - Repair or replace the buzzer, bulb or low pressure warning switch(s).
- **If governor cut-out is higher or lower than specified by the vehicle manual**
  - Adjust the governor using a gauge of known accuracy.
  - Repair or replace governor as necessary after being sure compressor unloader mechanism is operating correctly.
- **If low pressure warning occurs below 60 PSI**
  - Check dash gauge with test gauge known to be accurate.
  - Repair or replace the faulty low pressure indicator.
- **If build up time exceeds 40 seconds or is considerably greater than the permanent record figure:**
  - Examine the compressor air strainer and clean or replace.
  - Check for restricted inlet line if compressor does not have strainer, repair or replace as necessary.
  - Check compressor discharge port and line for excessive carbon. Clean or replace as necessary.
  - With system charged and governor compressor in unloaded mode, listen at the compressor inlet for leak.
  - If leak can be heard apply a small amount of oil around unloader pistons. If no leak is indicated, then leak is through the compressor discharge valves.
  - Check the compressor drive for slippage.

Note

Retest To Check Out All Items Repaired Or Replaced

Test 2-Leak Reservoir Air Supply Full Pressure, Engine Stopped, Parking Brakes Applied

1. Allow pressure to stabilize for at least 1 minute.
2. Observe the dash gauge pressures for 2 minutes and note any pressure drop.

3. Pressure Drop: (A 2 PSI drop within 2 minutes is allowable for either service reservoir)

Note

Make All Necessary Repairs Before Proceeding To Test 3; See Check List 2 For Common Corrections.

Check List 2

If there is excessive leak in the supply side of the pneumatic system, one or more of the following devices could be causing the problem:

1. Supply lines and fittings (tighten)
2. Wet tank
3. Front air tank
4. Rear air tank
5. Single check valves
6. Double check valve
7. PP-1 (push pull control valve)
8. E-6 brake valve
9. SR-1 spring brake valve
10. QR-1C Quick release valves
11. M-22 ABS antilock modulator assemblies
12. Front air chambers
13. Rear brake chambers
14. Safety valve
15. Low pressure indicator switch
16. Schrader valve
17. Drain valves
18. Pressure gauges
19. Governor
20. Compressor discharge valve

Note

A leak detector or soap solution will aid in locating the faulty component.

Retest To Check Out All Items Repaired Or Replaced

Test 3-Leak (Service Air Delivery) Full Pressure, Engine Stopped, Parking Brakes Released

Make and hold 80-90 PSI brake application. (A block of wood can be used to hold the foot valve down during these tests)

Allow pressure to stabilize for 1 minute; then begin timing for 2 minutes while watching the dash gauges for a pressure drop.

Pressure Drop: (A 4 PSI drop within 2 minutes is allowable for either service reservoir)

Check the angle formed between the brake chamber push rod and slack adjuster arm. (It should be at least 90° in the fully applied position)

Note

Make All Necessary Repairs Before Proceeding To Test 4; See Check List 3 For Common Corrections

Check List 3

If there is excessive leak in the service side of the pneumatic system, one or more of the following devices could be causing the problem.

1. Service lines and fittings (tighten)
2. E-6 brake valve
3. SR-1 spring brake valve
4. Brake light switch
5. R-12 relay valve with double check valve

If the angle between the brake chamber push rod and slack adjuster arm is less than 90°, then adjust slack adjuster arm to obtain desired setting. If brake chamber push rod travel exceeds the allowable tolerance, then adjust adjuster arm to obtain desired setting.

Note

Retest To Check Out All Items Repaired Or Replaced

Test 4-Automatic Emergency System Full Pressure, Engine Stopped

Drain front axle reservoir to 0 PSI.

- **Rear axle reservoir should not lose pressure.**

With no air pressure in the front axle reservoir make a brake application.

- **Rear axle brakes should apply and release**
- **The stop lamps should light**

1. Slowly drain rear axle reservoir pressure.
2. Spring brake push pull valve should pop out between 35 and 45 PSI.

3. Close drain cocks, recharge system and drain rear axle reservoir to 0 PSI.

- **Front axle reservoir should not lose pressure**

With no air pressure in the rear axle reservoir, make a brake application.

- **Front axle brakes should apply and release**

Check List 4

If the vehicle fails to pass the tests outlined, then check the following components for leak and proper operation.

1. Fittings
2. Kinked hose or tubing
3. PP-1 push pull control valve
4. E-6 brake valve
5. SR-1 spring brake valve
6. Retest To Check All Items Repaired Or Replaced Function Correctly.

Test 5-Brake Balance Test

1. Test drive vehicle approximately 10-15 minutes applying brakes frequently.
2. Park in a safe suitable location to perform brake test.
3. Take a temperature reading at each wheel drum using a thermocouple and note reading.
4. Compare the two front wheel drum temperature readings and compare the two rear wheel drum temperature readings.
5. Temperature range must be within ±50° for each two front drums and each two rear drums.

If temperature range is within limits, vehicle is in proper brake balance.

If temperature is out of range, see Check List 5 for common corrections.

Check List 5

If the brake balance test failed, one or more of the following devices could be causing the problem.

1. Worn brake shoes.
2. Worn return springs.
3. Brake actuating components binding.
4. Incorrect adjustment of slack adjuster.
5. Inoperative self-adjusting slack adjuster.

Compressor Troubleshooting

Symptom	Cause	Remedy
Compressor passes excessive oil as evidenced in system or by presence of oil at exhaust ports of valves or seeping from air strainer.	Restricted air intake	Check engine or compressor air cleaner and replace if necessary. Check compressor air inlet for kinks, excessive bends and be certain inlet lines have the minimum specified inside diameter.
---	Restricted oil return (to engine)	Oil return to the engine should not be in anyway restricted. Check for excessive bends, kinks and restrictions in the oil return line. **Return line must constantly descend** from the compressor to the engine crankcase. Make sure oil drain passages in the compressor and mating engine surfaces are unobstructed and aligned. Special care must be taken when sealant is used with, or instead of gaskets.
---	Poorly filtered inlet air.	Check for damaged, defective or dirty air filter on engine or compressor. Check for leaking, damaged or defective compressor air intake components (e.g. induction line, fittings, gaskets, filter bodies, etc.). The compressor intake should not be connected to any part of the exhaust gas re-circulation (EGR) system on the engine.
Compressor passes excessive oil as evidenced in system or by presence of oil at exhaust ports of valves or seeping from air strainer.	Contaminants not being regularly drained from system reservoirs.	Check reservoir drain valves to insure that they are functioning properly. It is recommended that the vehicle should be equipped with functioning automatic drain valves, or have all reservoirs drained to zero (0) psi daily, or optimally to be equipped with a desiccant-type air dryer prior to the reservoir system.

Table 1—Compressor Troubleshooting

Symptom	Cause	Remedy
---	Compressor runs loaded an excessive amount of time.	Vehicle system leak should not exceed industry standards of 1 psi pressure drop per minute without brakes applied and 3 psi pressure drop per minute with brakes applied. If leak is excessive, check for system leak and repair.
---	Excessive engine crankcase pressure.	Test for excessive engine crankcase pressure and replace or repair ventilation components as necessary. (An indication of crankcase pressure is a loose or partially lifted dipstick.)
---	Excessive engine oil pressure.	Check the engine oil pressure with a test gauge and compare the reading to the engine specifications. If not to specification check the following: Check oil level and condition. Replace if necessary (see specifications for engine oil viscosity). Defective oil pump. Replace oil pump. For further diagnostics, see Engine Troubleshooting.
---	Malfunction of the turbo cutoff piston in the air dryer, resulting in a loss of back pressure on the compression exhaust port of compressor during unload mode (Holset Only).	Warn or defective turbo cutoff piston. Replace end cover check valve assembly of AD-9 Air Dryer.
---	Malfunctioning check valve in wet tank air supply line to compressor exhaust port causing a lack of back pressure during the unload mode (Holset Only)	Replace check valve.
---	Faulty compressor.	Replace or repair the compressor only after none of the preceding installation defects exist.

Table 1—Compressor Troubleshooting continued

Symptom	Cause	Remedy
Noisy compressor operations.	Loose drive gear or Pulley.	Inspect the fit of the drive gear on pulley on the compressor crankshaft. The pulley on gear must be completely seated and the crankshaft nut must be tight. If the compressor crankshaft surface or the keyway is damaged, it is an indication of loose drive components. If damage to the compressor crankshaft is detected, replace the compressor. When installing the drive gear or pulley, torque the crankshaft nut to the appropriate torque specifications. Do not back off the crankshaft nut to align the cotter pin and castellated nut. (Some compressors do not use castellated nuts.) Do not use impact wrenches.
---	Excessively worn drive couplings or gears.	Inspect drive gear and couplings and engine for excessive wear. Replace as necessary. (Nonmetallic gears should be replaced when the compressor is changed.)
---	Compressor cylinder head or discharge line restrictions.	Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, check for proper cooling to the compressor. (See Symptom number 1. For Insufficient compressor cooling.) Inspect the discharge line for kinks and restrictions. Replace discharge line as necessary.
---	Worn or burned out bearings.	Check for proper oil pressure in the compressor. Check for excessive oil temperature; should not exceed 240° Fahrenheit.
---	Faulty compressor.	Replace or repair the compressor after determining none of the preceding installation defects exist.

Table 1—Compressor Troubleshooting continued

Symptom	Cause	Remedy
Excessive build-up and recover time. Compressor should be capable of building air system from 85-100 psi in 40 seconds with engine at full governed rpm. Minimum compressor performance is certified to meet federal requirements by the vehicle manufacturer. Do not downsize the original equipment compressor.	Dirty induction air filter	Inspect engine or compressor air filter and replace if necessary.
	Restricted induction line.	Inspect the compressor air induction line for kinks and restrictions and replace as necessary.
	Restricted discharge line or compressor discharge cavity.	Inspect the compressor discharge port and line for restrictions and carbon build-up. If a carbon build-up is found, check for proper compressor cooling. Replace faulty sections of the discharge line.
	Slipping drive components.	Check for faulty drive gears and couplings and replace as necessary. Check the condition of drive belts and replace or tighten, whichever is appropriate.
	Excessive air system leak.	Test for excessive system leak and repair as necessary. Use the following as a guide: Build system pressure to governor cutout and allow the pressure to stabilize for one minute. Using the dash gauge, note the system pressure and the pressure drop after two minutes. The pressure drop should not exceed 2 psi in each reservoir.
	Sticking unloader pistons or valves.	Check and clean the operation of the unloading mechanism. Lube mechanism with high temperature grease. Check the proper operation of the compressor air governor. If the governor is operating properly, replace the unloader mechanism. Inspect for bent, kinked or blocked tubing leading to or from the governor.
	Gauge defective	Replace gauge.
	Faulty compressor.	Replace or repair the compressor after determining none of the preceding installation defects exist.

Table 1—Compressor Troubleshooting continued

Symptom	Cause	Remedy
Compressor fails to unload.	Faulty governor or governor installation.	Test the governor for proper operation and inspect air lines to and from the governor for kinks or restrictions. Replace or repair the governor or its connecting air lines.
---	Faulty or worn unloader pistons, valves or bores.	Inspect for worn, dirty or corroded unloader pistons, valves and their bores. Replace as necessary.
---	Gauge defective.	Replace gauge.
Compressor leak oil.	Damaged mounting gasket.	Check the compressor mounting bolt torque. If the mounting bolt torque is low, replace the compressor mounting gasket before re-torque of the mounting bolts.
	Cracked crankcase or end cover.	Visually inspect the compressor exterior for cracked or broken components. Cracked or broken crankcases or mounting flanges can be caused by loose mounting bolts. The end cover can be cracked by over-torque fitting or plugs installed in the end cover. Replace or repair the compressor as necessary.
	Loose end cover cap.	Check the cap screw torque and tighten as necessary.
	Loose oil supply or return line fittings.	Check the torque of external oil line fittings and tighten as necessary.
	Porous compressor casting.	Replace the compressor if porosity is found.
	Mounting flange or end cover, O-ring or gasket missing, cut or damaged.	Replace as necessary.
Compressor constantly cycles (compressor remains unloaded for a very short time).	Leaking compressor unloader pistons or valves.	Remove the compressor inlet air strainer or fitting. With the compressor unloaded (not compressing air), check for air leak. Repair or Replace as necessary.
	Faulty Governor.	Test the governor for proper operation and repair or replace as necessary
	Excessive system leak.	Test for excessive system leak, (See Test 2). Reduce leak wherever possible.
	Excessive reservoir Contaminants.	Drain reservoirs.

Table 1—Compressor Troubleshooting continued

Symptom	Cause	Remedy
---	Air dryer check valve leak.	Replace check valve with appropriate AD-9 End Cover Check Valve Replacement Kit.
Compressor leak coolant.	Improperly installed plugs and coolant line fittings.	Check torque of fittings and plugs and tighten as necessary. Over-torque fittings and plugs can crack the head or block casting.
	Freeze cracks due to improper antifreeze strength.	Test antifreeze and strengthen as necessary. Check coolant flow through compressor to assure the proper antifreeze mixture reaches the compressor.
Compressor head gasket failure.	Restricted discharge line.	Clear restriction or replace line.
---	Loose head bolts.	Tighten evenly to proper torque specifications.

Table 1—Compressor Troubleshooting continued

Electrical Circuits - ABS and Traction Control

Individual Circuit Diagrams

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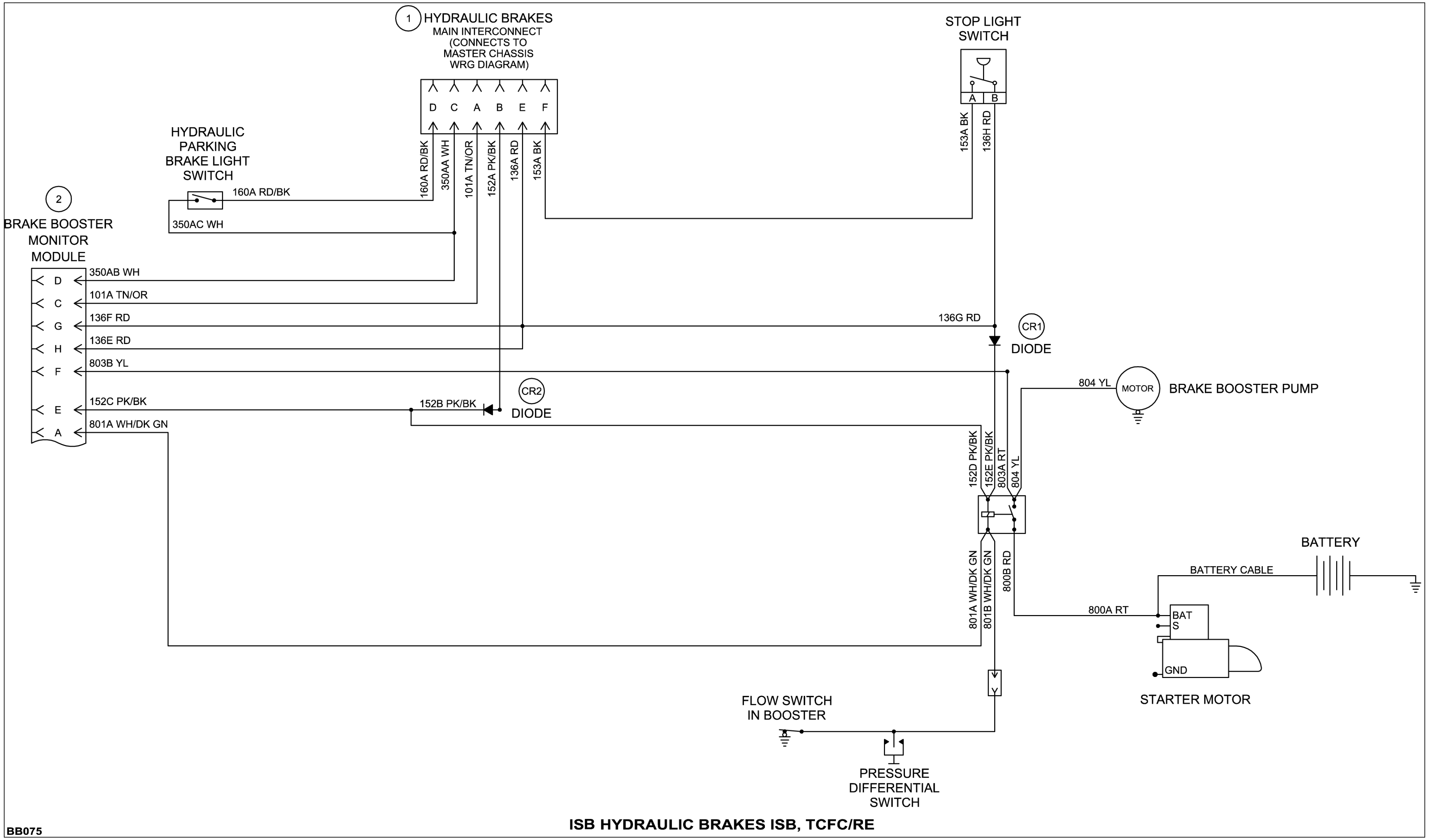

Figure 33—Hydraulic Brakes ISB, TC

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Ignition Voltage and Ground Circuits w/WT and AT/MT Transmission

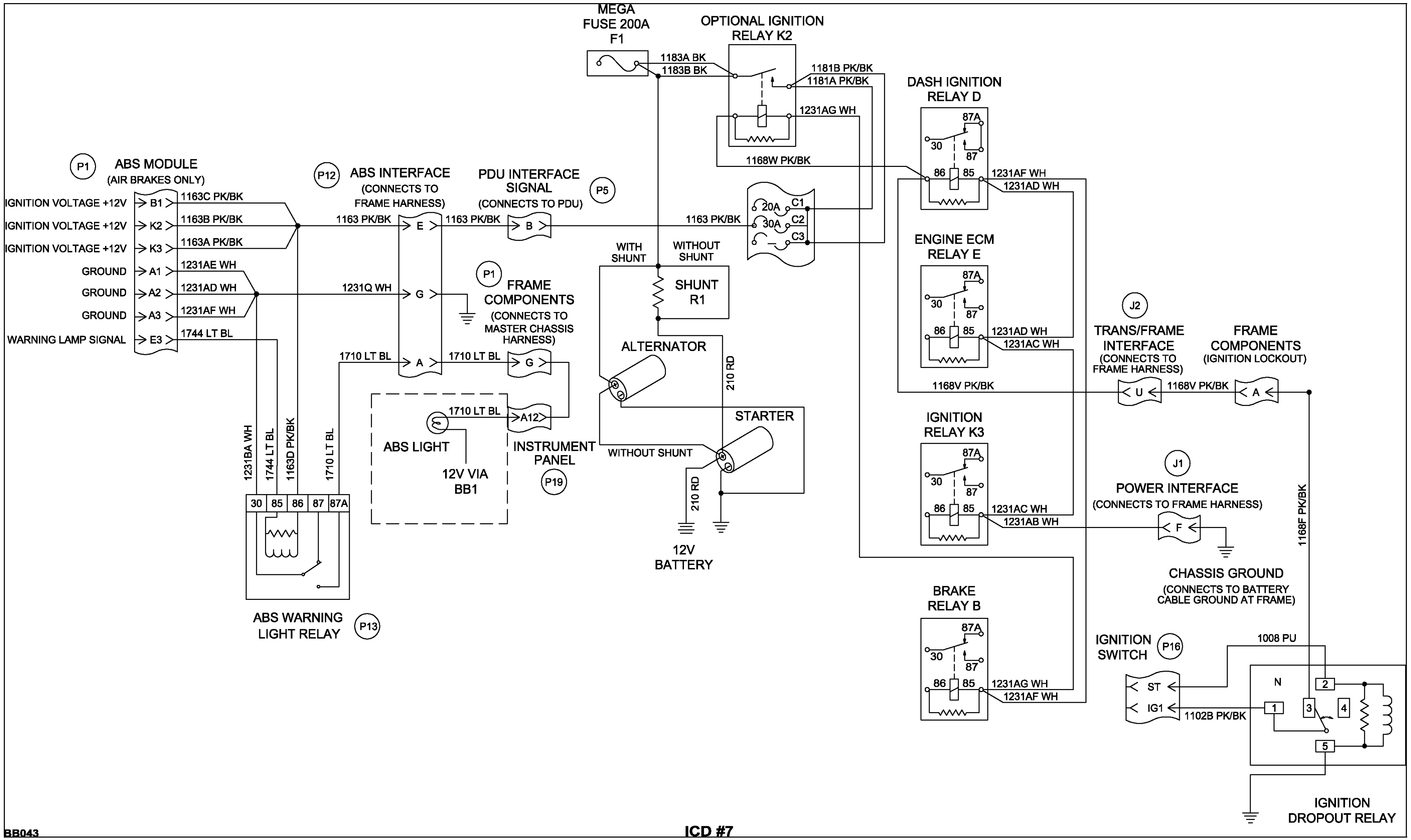

Figure 34—Ignition Voltage and Ground

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Diagnostic T1587 Serial Circuits with Cummins Engine

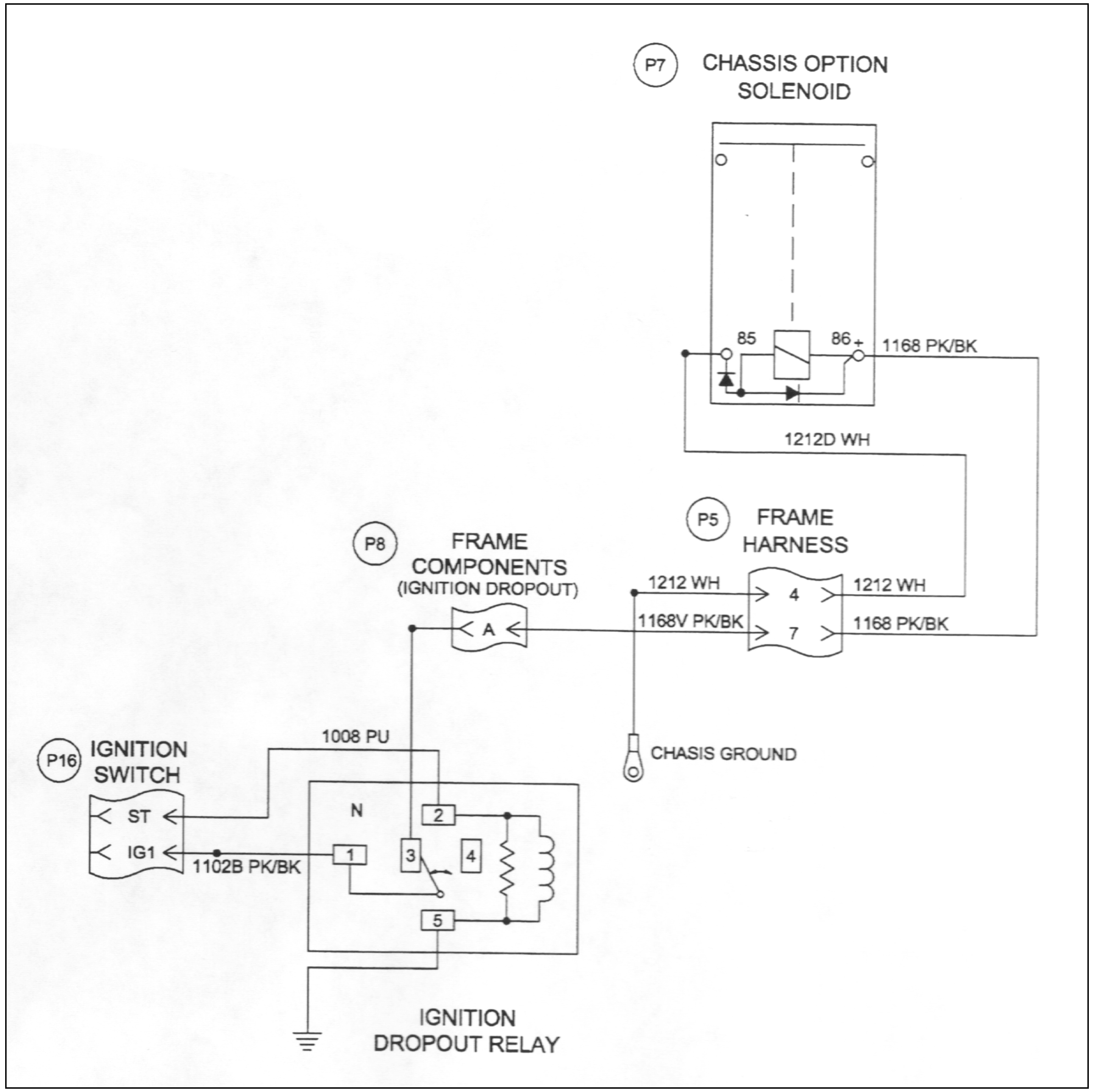

Figure 37—Diagnostic T1587 Serial Circuits with Cummins Engine

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ABS Signal Circuit for Cummins Engine w/WT

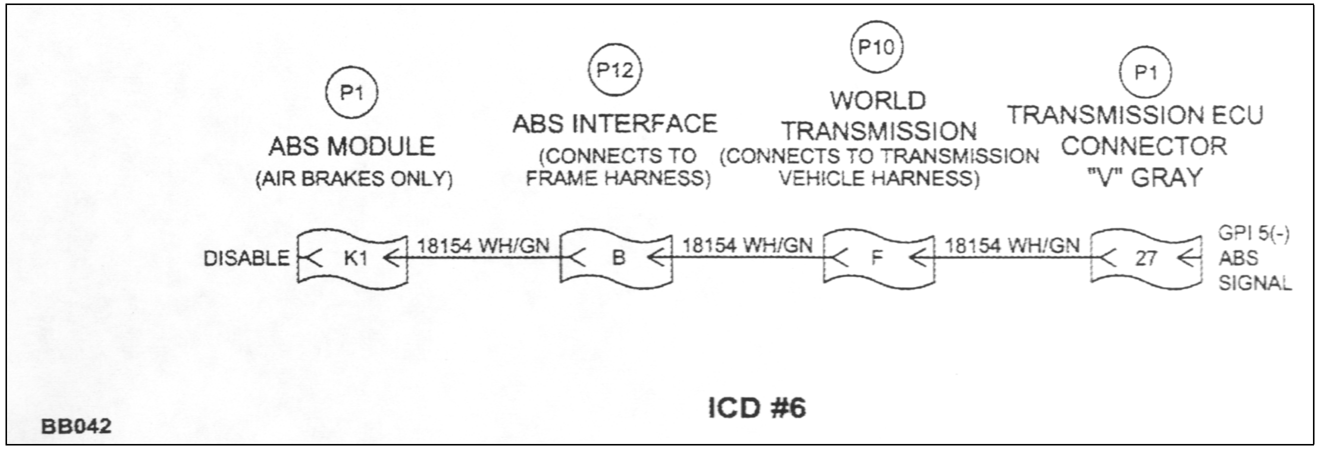

Figure 38—ABS Signal Circuit for Cummins Engine w/WT (TC)

ABS Signal Circuit w/AT/MT Transmission

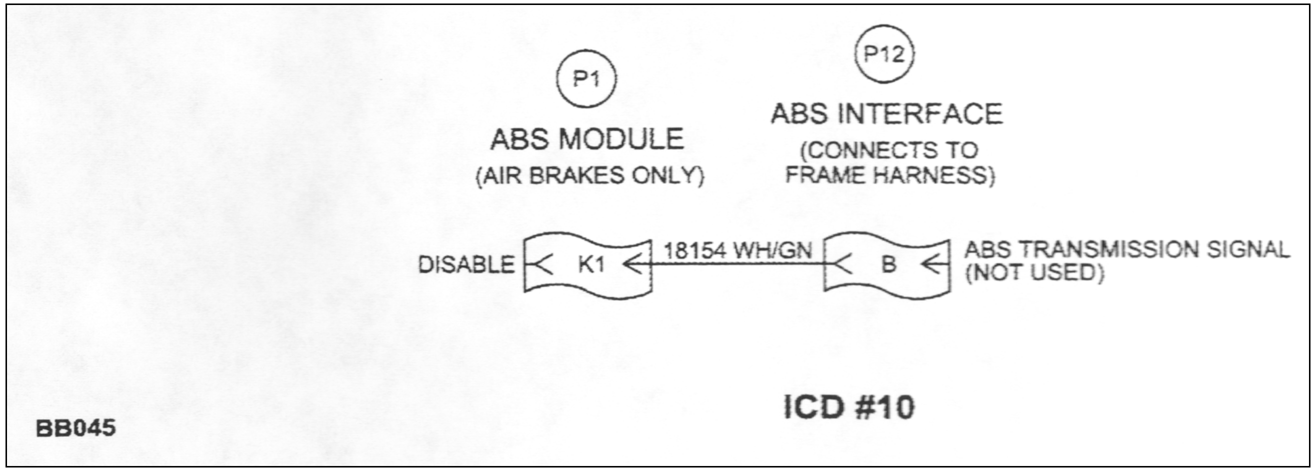

Figure 39—ABS Signal Circuit w/AT/MT Transmission

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Ground Circuit

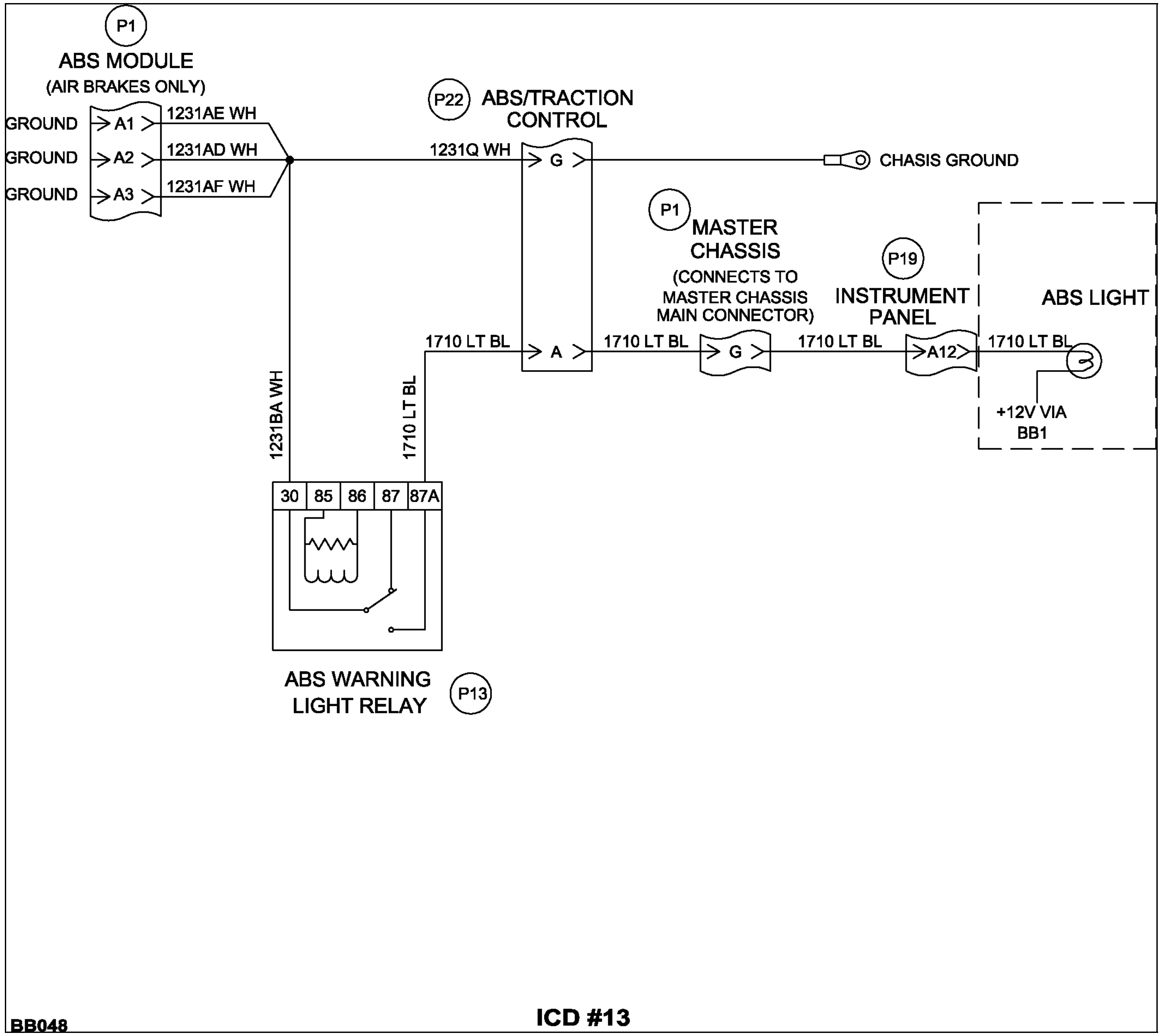

Figure 40—Ground Circuit

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Option Solenoid Circuit

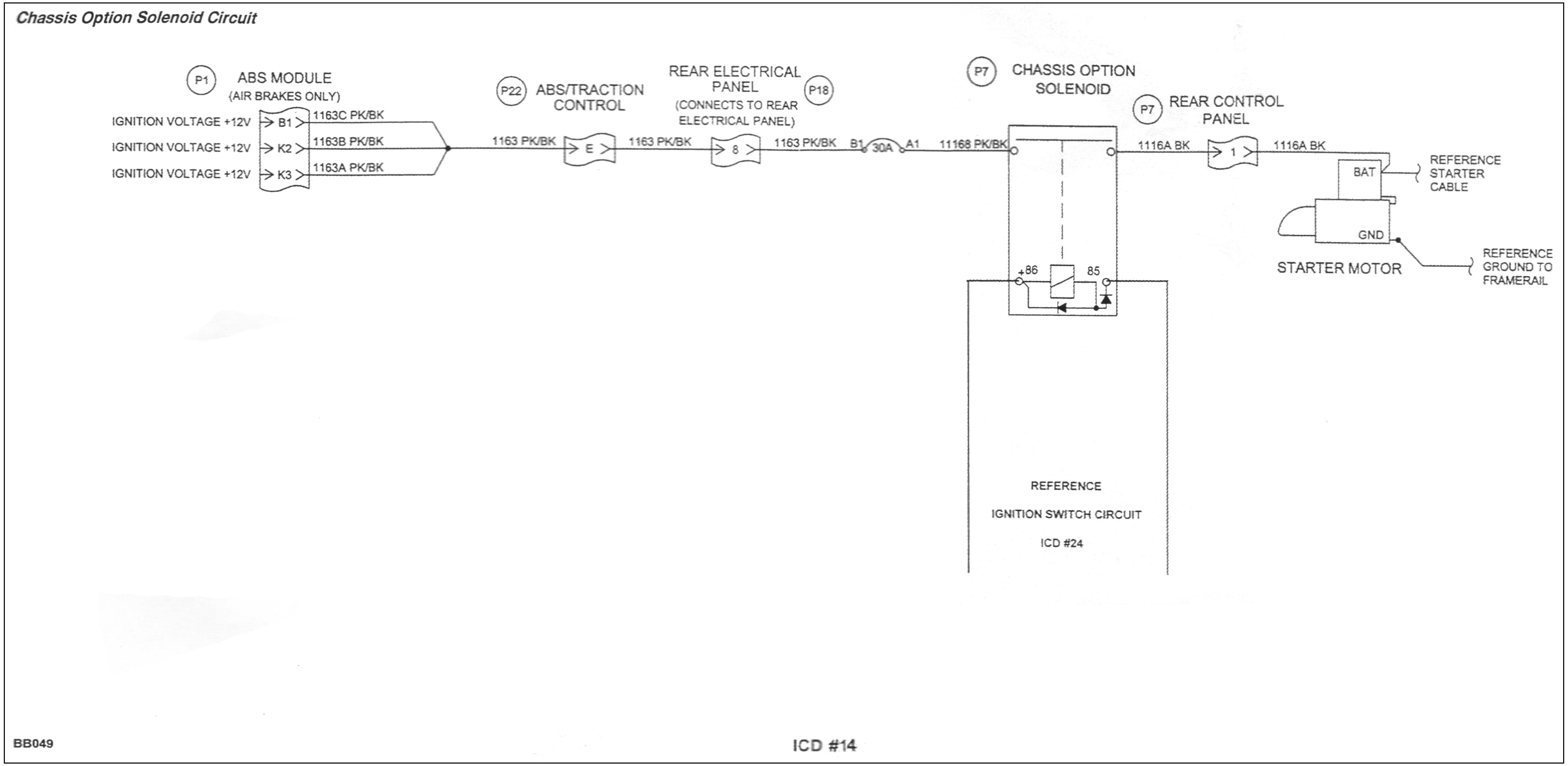

Figure 41—Chassis Option Solenoid Circuit

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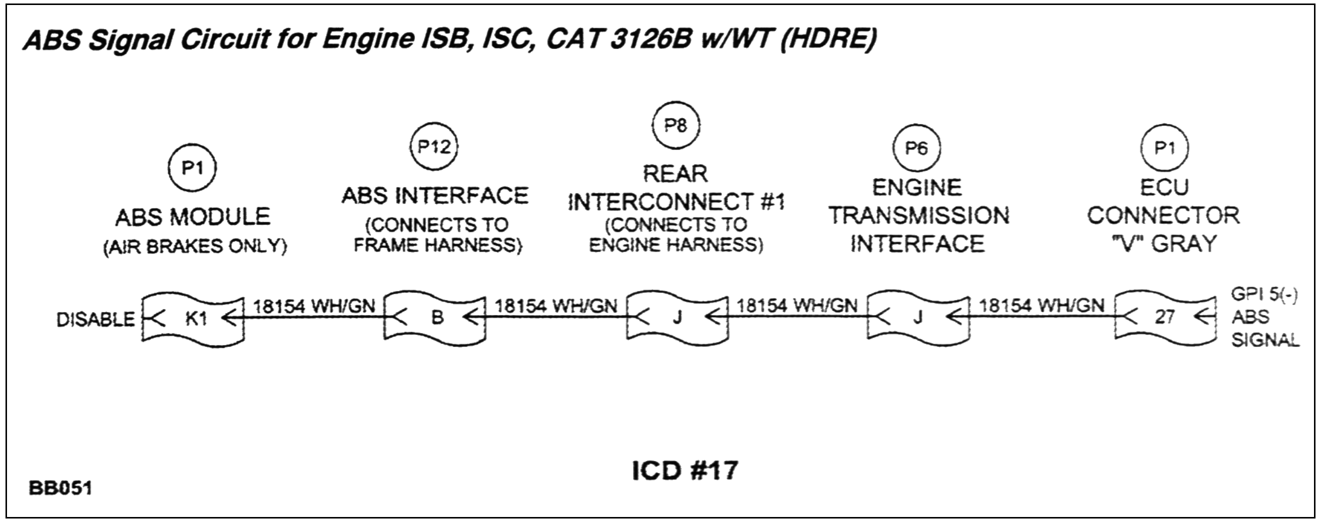

Figure 42—ABS Signal Circuit for Engine ISB

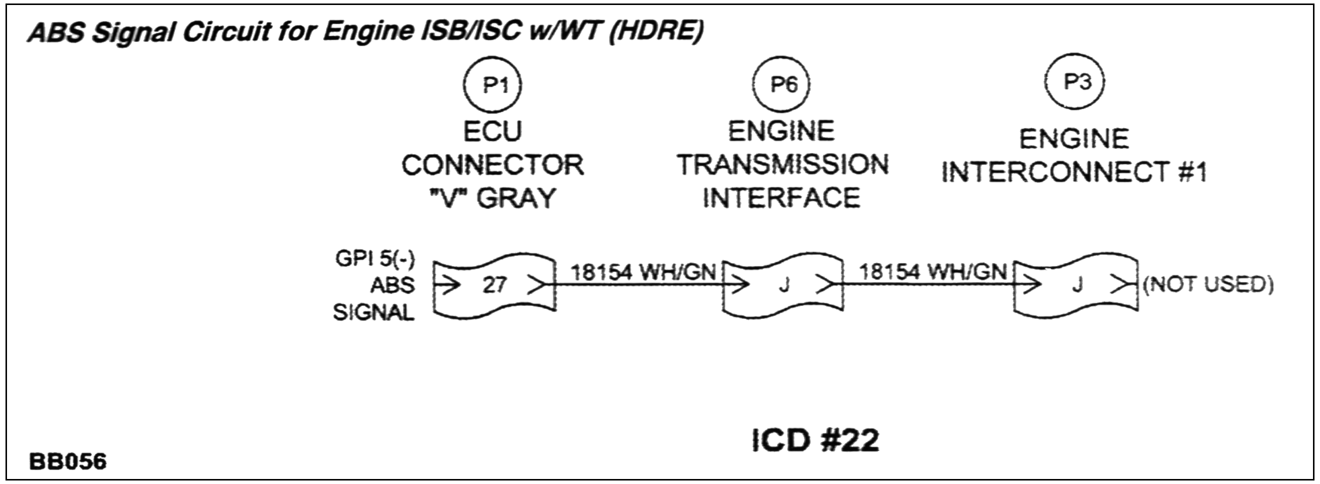

Figure 43—ABS Signal Circuit for Engine ISB

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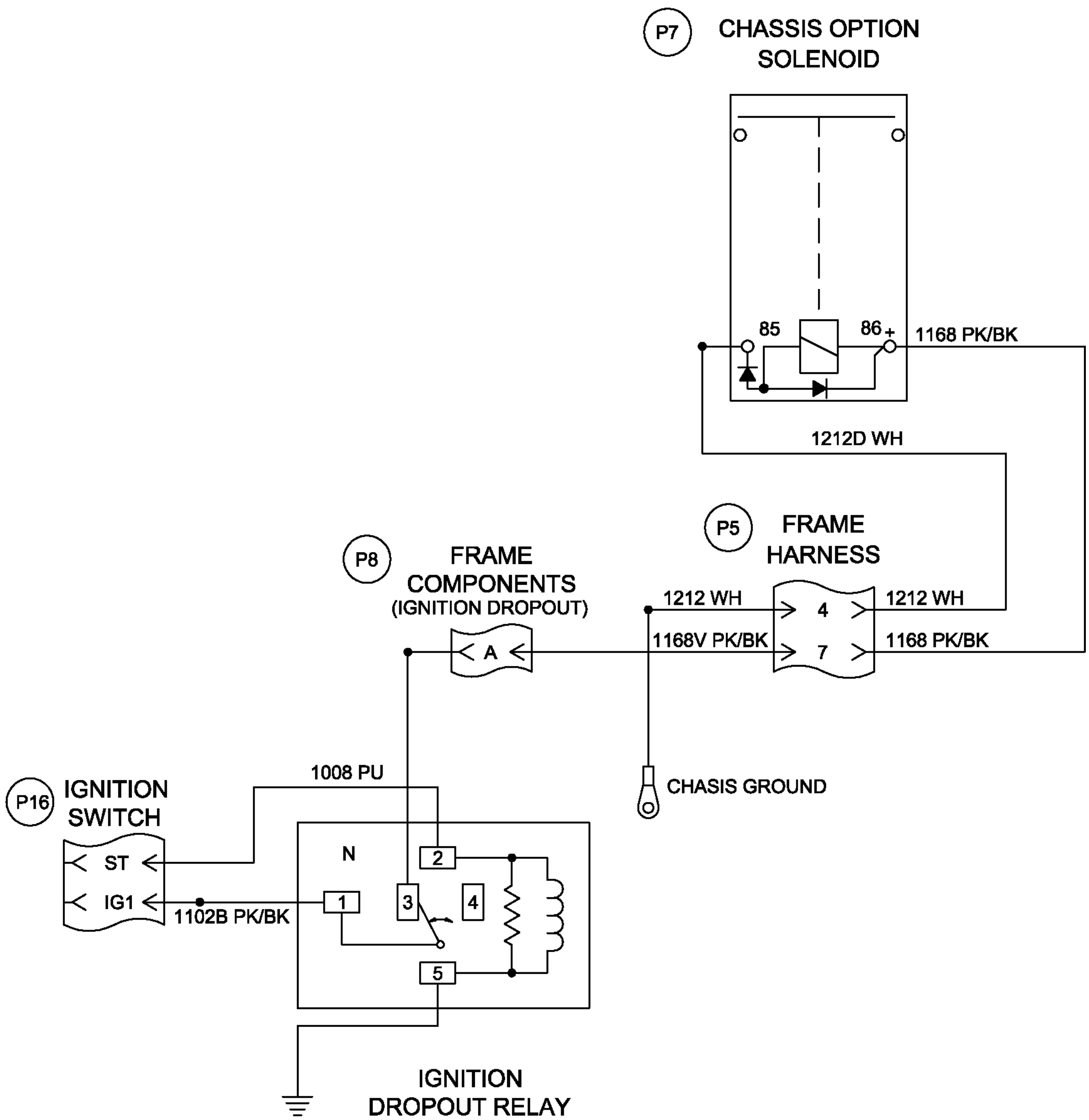
Ignition Switch Circuit



ICD #24

Figure 44—Ignition Switch Circuit

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Vehicle Speed In Circuits w/AT/MT Transmission

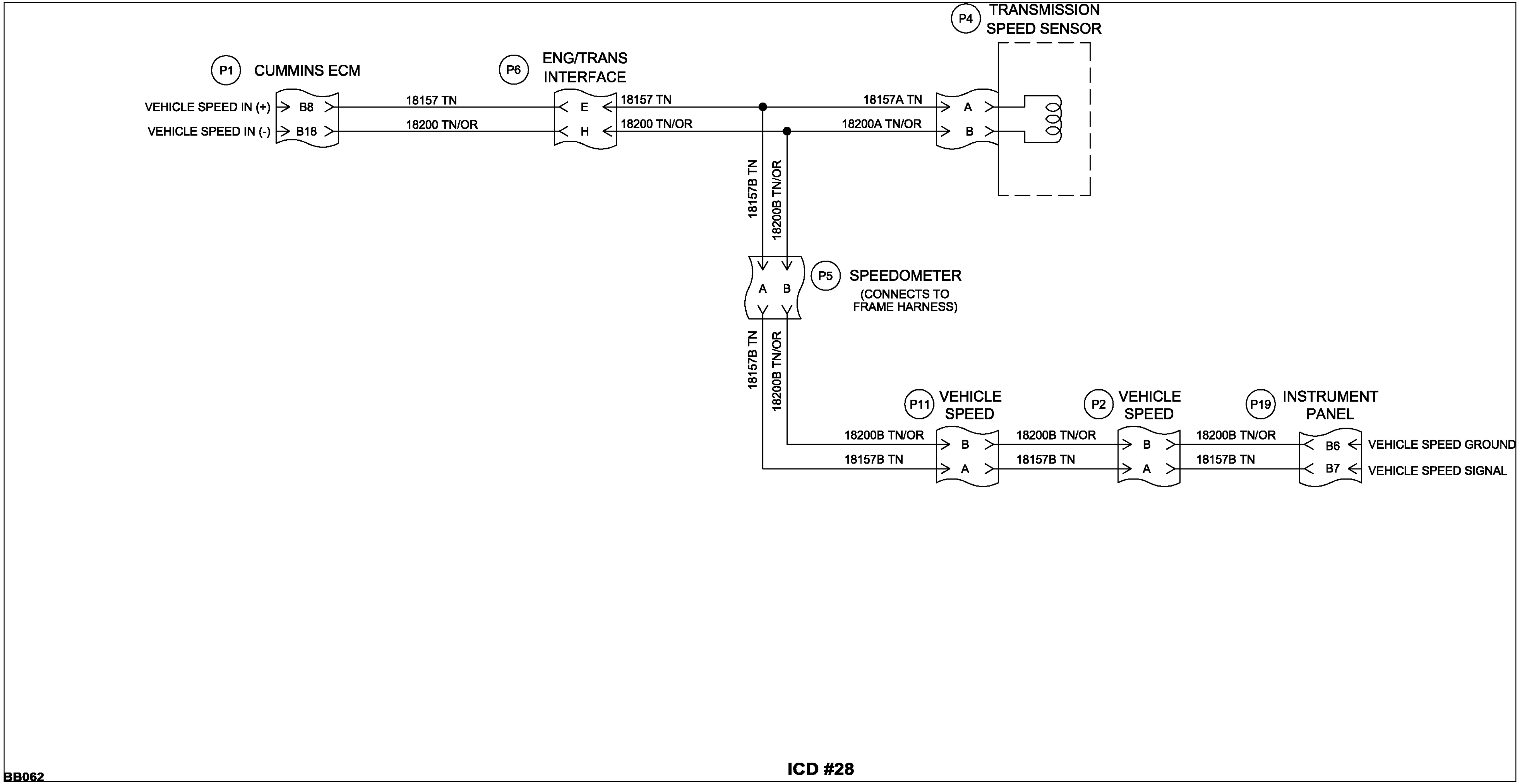

Figure 45—Vehicle Speed In Circuits w/AT/MT Transmission

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Vehicle Speed in Circuits w/WT Transmission

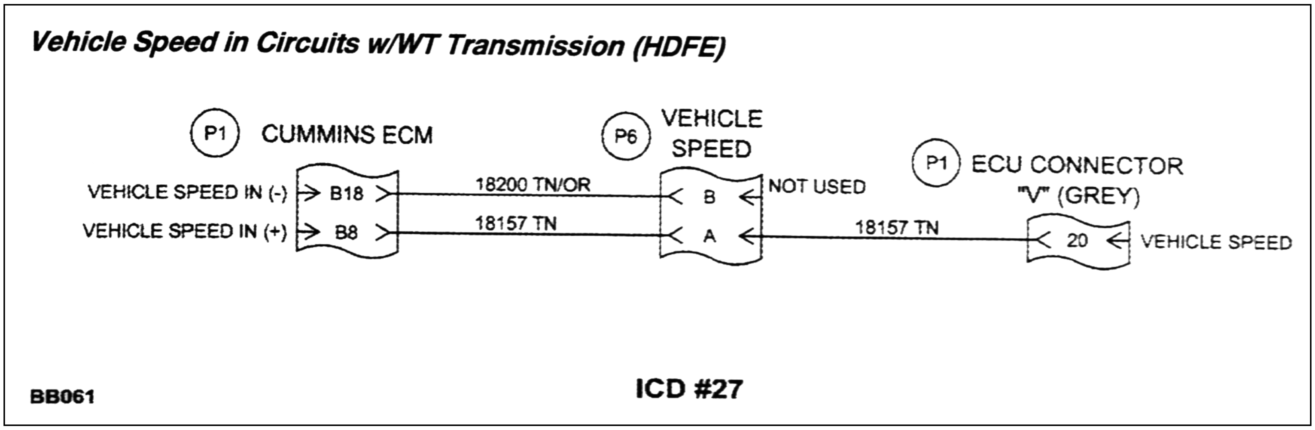

Figure 46—Vehicle Speed in Circuits w/WT Transmission

Vehicle Speed in Circuits w/AT/MT Transmission

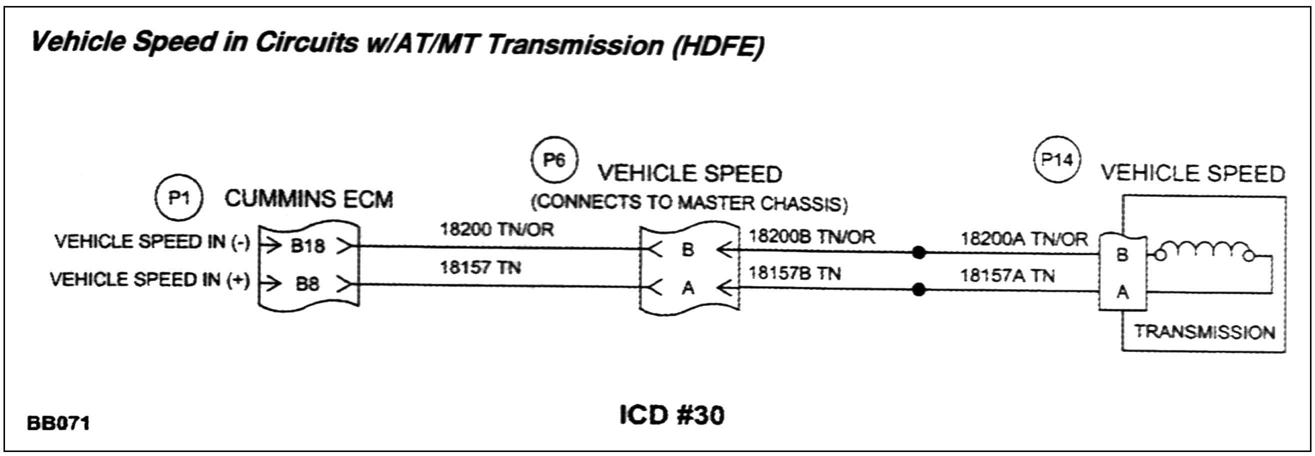

Figure 47—Vehicle Speed in Circuits w/AT/MT Transmission

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Serial Comm. Interface Circuits w/Throttle Diagnostic and Master Chassis

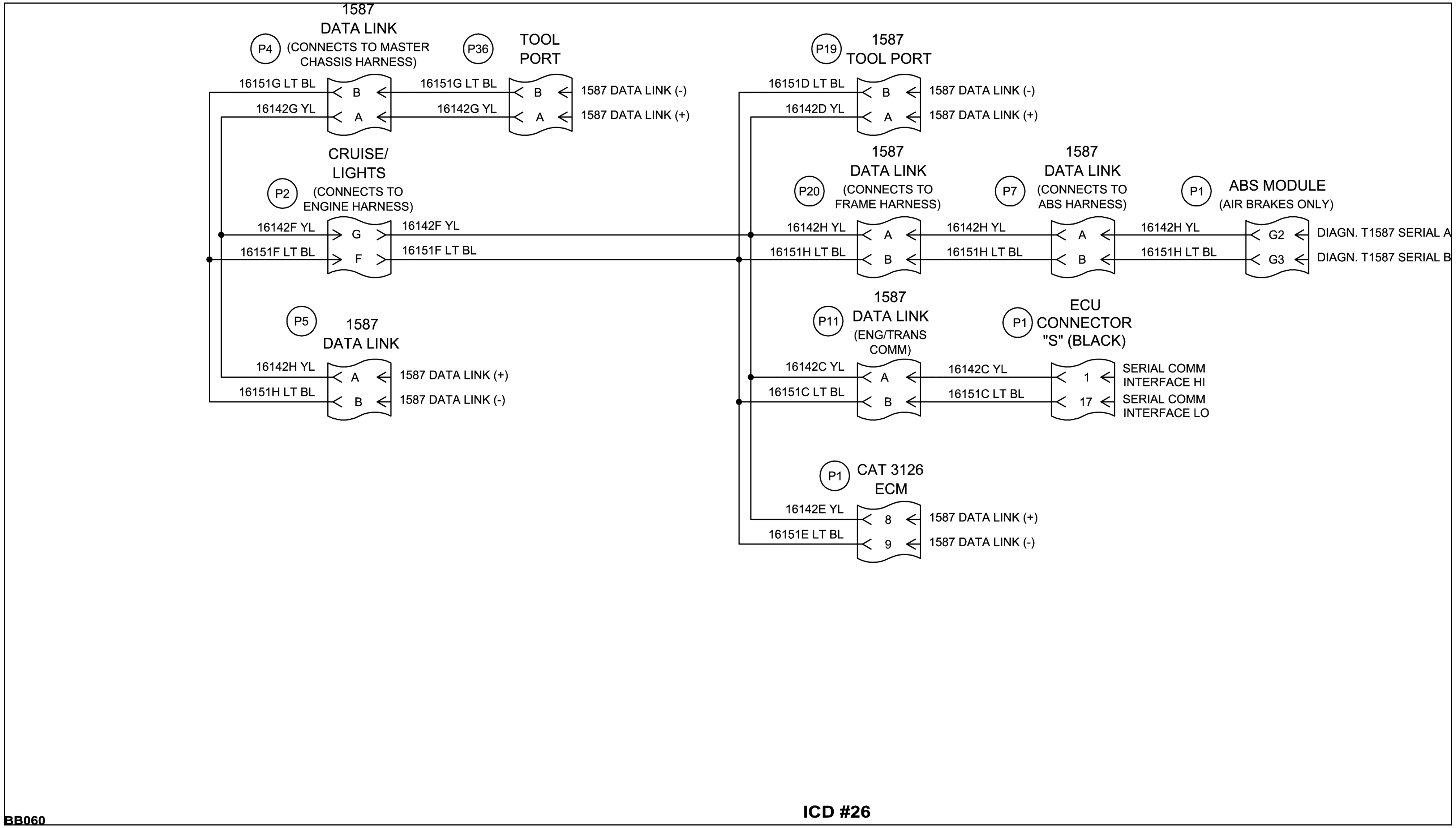

Figure 48—Serial Comm. Interface Circuits w/Throttle Diagnostic and Master Chassis

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Retarder Circuit (1 of 2)

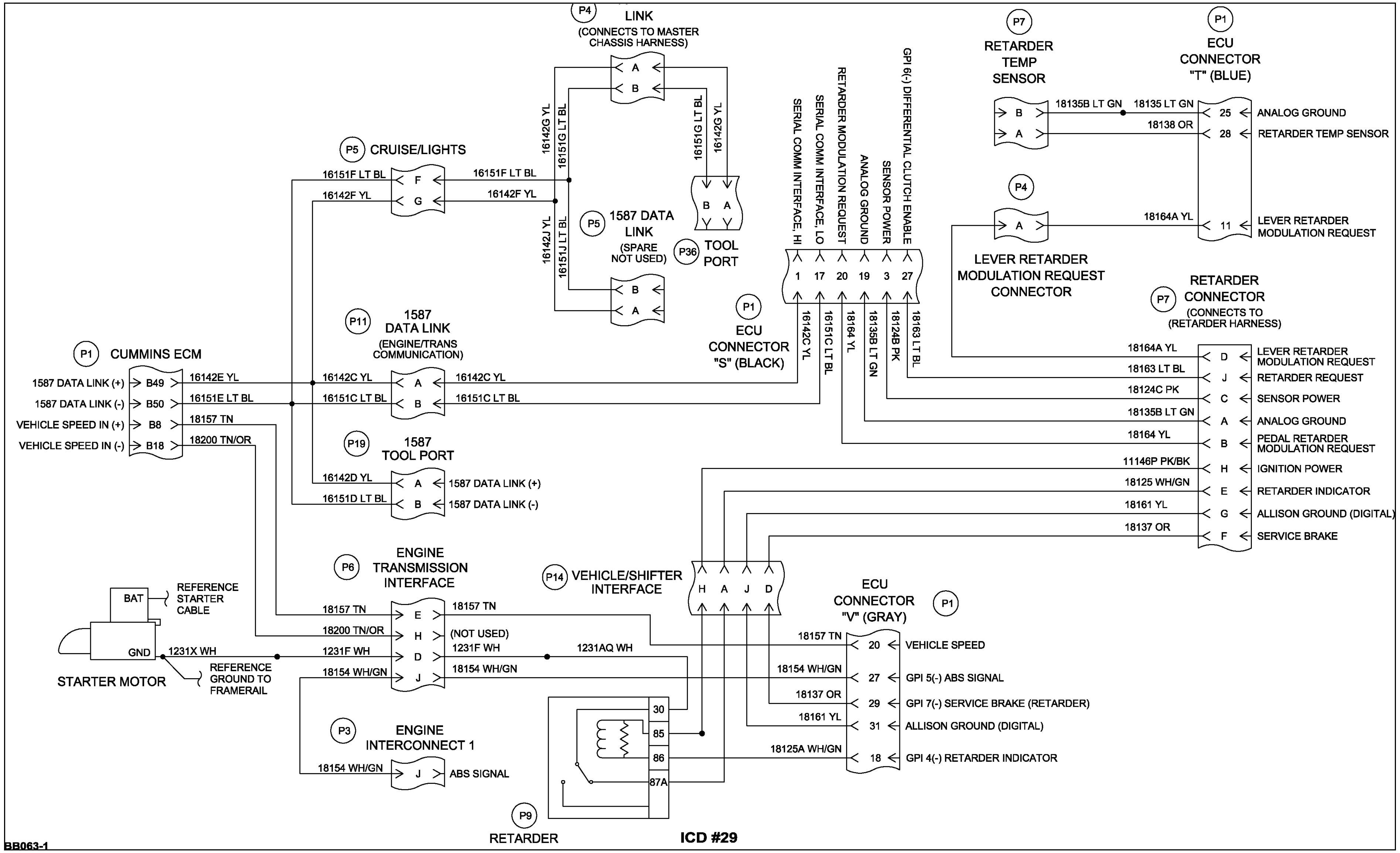

Figure 49—Transmission Retarder Circuit (1 of 2)

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Retarder Circuit (2 of 2)

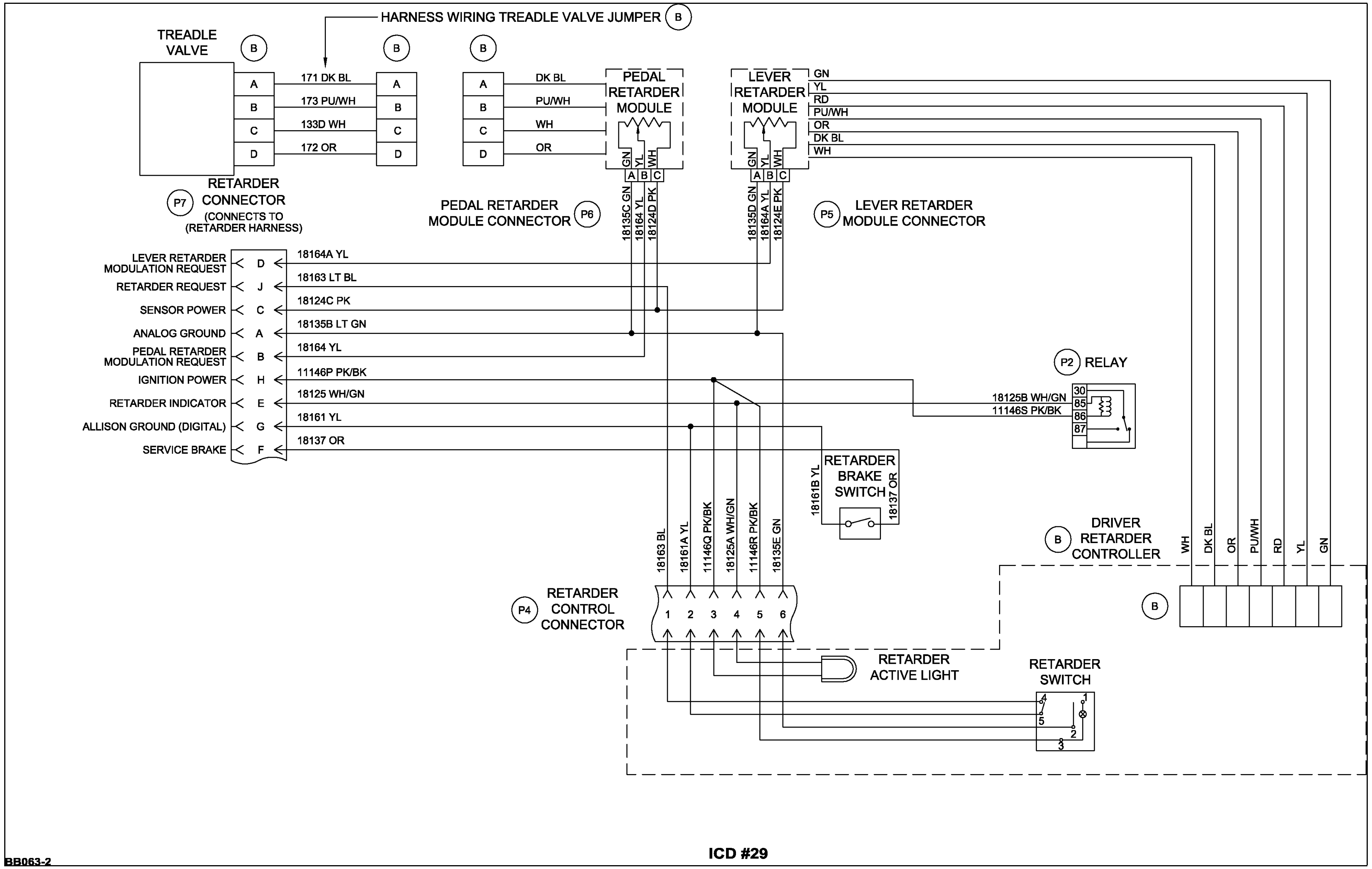

Figure 50—Transmission Retarder Circuit (2 of 2)

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Relay Circuit w/ISB/ISC and AT/MT Transmission

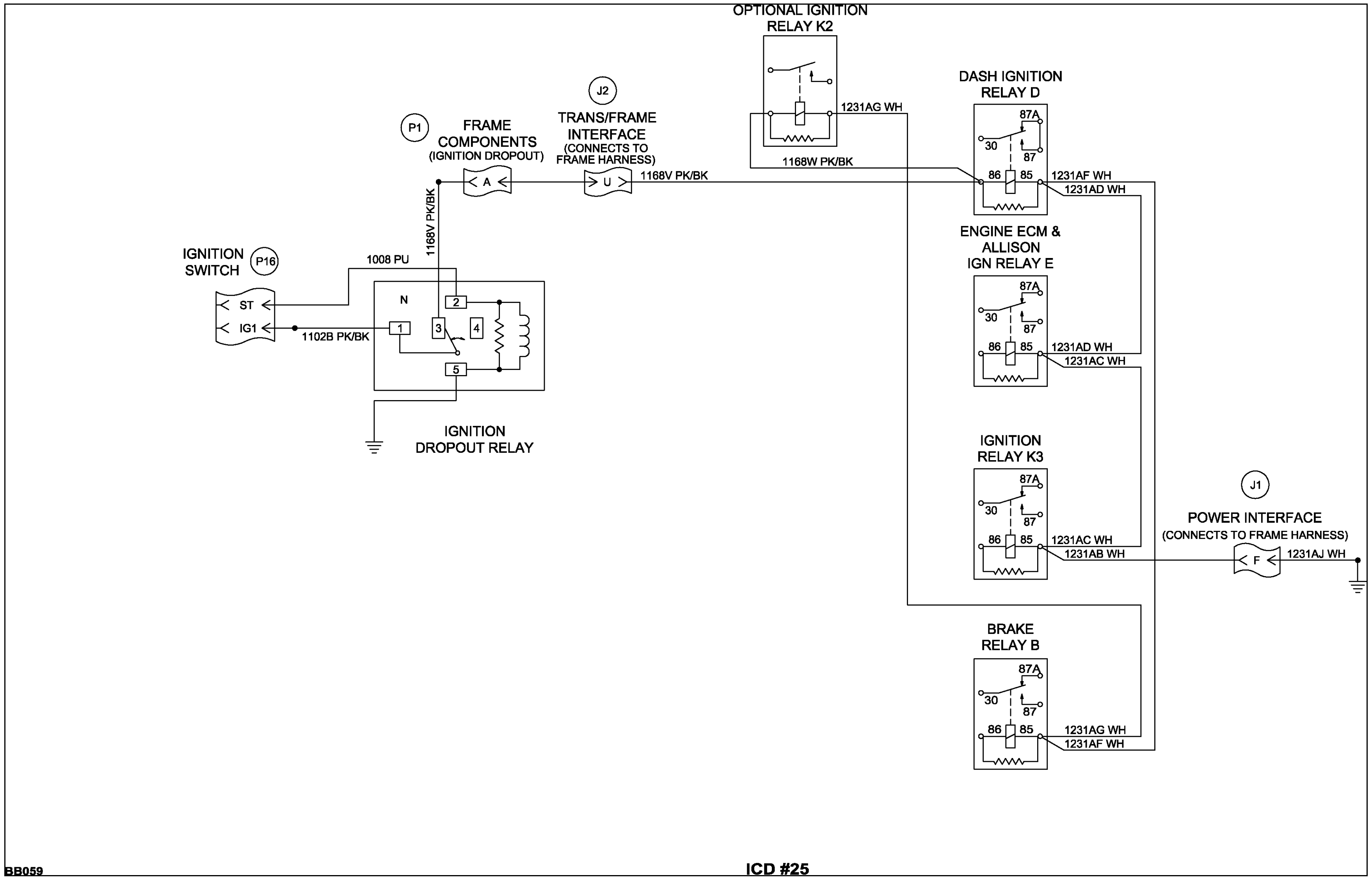

Figure 51—Relay Circuit w/ISB and AT/MT Transmission

Preventative Maintenance

Note

Review the warranty policy before performing any intrusive maintenance procedures. An extended warranty may be voided if intrusive maintenance is performed during this period.

Because no two vehicles operate under identical conditions, maintenance and maintenance intervals will vary. Experience is a valuable guide in determining the best maintenance interval for any one particular operation.

Note

When working on or around a vehicle, the following general precautions should be observed.

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. If the vehicle is equipped with air brakes, be sure to drain the air pressure from all reservoirs before beginning any work on the vehicle.
4. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.

Caution

When working in the engine compartment the engine must be shut off. Where circumstances require that the engine be in operation, extreme caution should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically charged components.

Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.

Never exceed recommended pressures and always wear safety glasses.

Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.

Use only genuine Blue Bird replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.

Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.

Prior to returning the vehicle to service, be sure all components and systems are restored to their proper operating condition.

Air Dryer

Every 900 operating hours or 25,000 miles or every three (3) months:

1. Check for moisture in the air brake system by opening reservoirs, drain cocks, or valves and checking for presence of water.

Note

If moisture is present, the desiccant may require replacement; however, the following conditions can also cause water accumulation and should be considered before replacing the desiccant.

2. An outside air source has been used to charge the system. This air did not pass through the drying bed.
3. Air usage is exceptionally high and not normal for a highway vehicle. This may be due to accessory air demands or some unusual air requirement that does not allow the compressor

to load and unload (compressing and non-compressing cycle) in a normal mode

4. Check for high air system leak.

Note

The air dryer has been installed in a system that has been previously used without an air dryer. This type system will be saturated with moisture and several weeks of operation may be required to dry it out.

Location of the air dryer is too close to the air compressor.

In areas where more than a 30 degree range of temperature occurs in one day, small amounts of water can accumulate in the air brake system due to condensation.

Under these conditions, the presence of small amounts of moisture is normal and should not be considered as an indication that the dryer is not performing properly.

A small amount of oil in the system may be normal and should not, in itself, be considered a reason to replace the desiccant; oil stained desiccant can function adequately.

5. Check mounting bolts for tightness. Re-torque to 270-385 inch-pounds.
6. Perform the Operation and Leak Tests in this publication.

Every 36 months or 300,000 miles or 10,800 hours:

- Rebuild the air dryer including the desiccant cartridge.

Note

The desiccant change interval may vary from vehicle to vehicle. Typical desiccant cartridge life is three years.

Relay Valve

Every 3 months or 25,000 miles or 900 operating hours:

Check for proper operation.

Every 12 months or 100,000 miles or 3,600 operating hours:

1. Disassemble valve.
2. Clean parts with mineral spirits.
3. Replace all rubber parts and any part worn or damaged.
4. Check for proper operation before placing vehicle in service.

Dual Circuit Brake Valve

Every 3 months, or 25,000 miles or 900 operating hours:

1. Clean any foreign material away from the heel of the treadle, plunger boot and mounting plate.
2. Lubricate the treadle roller, roller pin and hinge pin with light oil.
3. Check the rubber plunger boot for cracks, holes or deterioration and replace if necessary.
4. Check mounting plate and treadle for integrity.
5. Apply 2 to 4 drops only of oil between plunger and mounting plate.

Every year, or 100,000 miles, or 3,600 operating hours:

1. Disassemble parts.
2. Clean parts with mineral spirits.
3. Replace all rubber parts or any part worn or damaged.
4. Check for proper operation before placing vehicle in service.

Automatic Slack Adjuster

1. Lubricate automatic slack adjuster in accordance with maintenance schedule.
2. Visually inspect for cracks and loose or missing hardware.

Brake Chamber

1. Visually inspect brake chamber for cracks and loose or missing hardware.
2. Check air lines for cracks and loose fittings.

Push Pull Control Valves

Every 6 Months, or 50,000 miles or 1,800 operating hours:

- **Disassemble, clean and replace parts as necessary.**
-

Air Compressor

Every two months, 800 operating hours or 20,000 miles:

- **Compressor Inlet Line**

1. Air induction for the compressor comes from the engine intake.
2. Inspect hose from engine to compressor intake for kinks, abrasions, worn spots, and cracks. Replace as necessary.

- **Intake Adapter**

When the engine air cleaner is replaced.

Some compressors are fitted with compressor intake adapters that allow the compressor intake to be connected to the engine air induction system.

The compressor receives a supply of clean air from the engine air cleaner. When the engine air filter is changed, the compressor intake adapter should be checked.

If it is loose, remove the intake adapter, clean the strainer plate, if applicable, and replace the intake adapter gasket, and reinstall the adapter securely.

3. Check line connections both at the compressor intake adapter and at the engine.
4. Inspect the connecting line for ruptures and replace it if necessary.

Every 6 months, 1,800 operating hours or after each 50,000 miles:

- **Compressor Cooling**

Note

Minimum coolant line size is 3/8 inch ID.

1. Inspect the compressor discharge port, inlet cavity and discharge line for evidence of restrictions and carbon. If excessive buildup is found, thoroughly clean or replace the affected parts.
2. Re-inspect the compressor cooling system.
3. Check all compressor coolant lines for kinks and restrictions to flow.
4. Check coolant lines for internal clogging from rust scale. If coolant lines appear suspicious,
5. Check the coolant flow and compare to the tabulated technical data.
6. Inspect the air induction system for restrictions.

Every six months, 1800 operating hours or 50,000 miles:

- **Lubrication**

1. Check external oil supply and return lines for kinks, bends or restrictions to flow.
2. Supply lines must be a minimum of 3/16 inch ID and return lines must be a minimum of 1/2 inch ID.
3. Oil return lines should slope as sharply as possible back to the engine crankcase and should have as few fittings and bends as possible.

Every six months, 1,800 operating hours or 50,000 miles:

- **Compressor Drive**

1. Listen for noisy compressor operation that could indicate a worn drive gear coupling, a loose pulley or excessive internal wear. Adjust and/or replace as necessary.
2. If the compressor is belt driven, check for proper belt and pulley alignment and belt tension.
3. Check all compressor mounting bolts and retighten evenly if necessary.
4. Inspect for leak and proper unloader mechanism operation. Repair or replace parts as necessary.

Every 24 months, 7,200 operating hours, or after each 200,000 miles:

1. Inspect and, depending upon the results of inspection or experience, disassemble the compressor.
2. Clean and inspect all parts thoroughly
3. Replace all worn or damaged parts using only genuine Blue Bird replacements or replace the compressor with a genuine Blue Bird remanufactured unit.

Antilock Systems Preventative Maintenance

Wheel Speed Sensor

Every 3 months, 25,000 miles, 900 operating hours, or during the vehicle chassis lubrication interval:

Inspect speed sensor visually. Refer to Wheel Speed Sensor Service Check.

Every 12 months, 100,000 miles, or 3,600 operating hours:

Perform Wheel Speed Sensor Service Check in this manual.

Antilock Modulator Assembly

Perform the tests and inspections at the maintenance intervals.

If the modulator fails to function as described, or leaks are excessive, replace with a new or genuine Blue Bird remanufactured unit, available at any authorized parts outlet.

Every 3 Months, 25,000 Miles or 900 operating hours

1. Inspect visually the exterior for excessive corrosion and physical damage.
2. Remove any accumulated contaminates.
3. Inspect all air lines and wire harnesses connected to the modulator for signs of wear or physical damage. Replace as necessary.
4. Test air line fittings for excessive leak and tighten or replace as necessary.
5. Perform the antilock modulator assembly Operational and Leak Test described in this manual.

Service Checks

Air Dryer

Operation and Leak Tests

Test the outlet port check valve assembly by building the air system to governor cut-out and observing a test air gauge installed in the number 1 reservoir.

A rapid loss of pressure could indicate a failed outlet port check valve.

This can be confirmed by bleeding the system down, removing the check valve assembly from the end cover, subject air pressure to the unit and apply a soap solution to the check valve side. Leak should not exceed a 1 inch bubble in 1 second.

Check for excessive leaking around the purge valve. With the compressor in loaded mode (compressing air), apply a soap solution to the purge valve housing assembly exhaust port and observe that the leak does not exceed a 1 inch bubble in 1 second.

If the leak exceeds the maximum specified, service the purge valve housing assembly.

1. Close all reservoir drain cocks. Build up system pressure to governor cut-out and note that AD-9 purges with an audible escape of air. Fan the service brakes to reduce system air pressure to governor cut-in.
2. Check the operation of the safety valve by pulling the exposed stem while the compressor is loaded (compressing air). There must be an exhaust of air while the stem is held and the valve should reseat when the stem is released.
3. Check all lines and fittings leading to and from the air dryer for leaks and integrity.
4. Check the operation of the end cover heater and thermostat assembly during cold weather operation

- **Electric Power to the Dryer**

5. With the ignition or engine kill switch in the ON position, check for voltage to the heater and thermostat assembly using a voltmeter or test light.
6. Unplug the electrical connector at the air dryer and place the test leads on each of the pins of the male connector.

If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check to see if a good ground path exists.

- **Thermostat and Heater Operation**

Note

Some early models of the AD-9 will have resistance readings of 1.0 to 2.5 ohms for the 12 volt heater assembly and 4.8 to 7.2 ohms for the 24 volt heater assembly. If the resistance is higher than the maximum stated, replace the purge valve housing assembly, that includes the heater and thermostat assembly.

7. Turn off the ignition switch and cool the end cover assembly to below 40° Fahrenheit.
8. Check the resistance between the electrical pins in the female connector with a ohmmeter. The resistance should be 1.5 to 3.0 ohms for the 12 volt heater assembly and 6.8 to 9.0 ohms for the 24 volt heater assembly.
9. Warm the end cover assembly to over 90° Fahrenheit and again check the resistance. The resistance should exceed 1000 ohms. If the resistance values obtained are within the limits, the thermostat and heater assembly is operating properly.

If the resistance values obtained are outside the limits, replace the purge valve housing assembly, that includes the heater and thermostat assembly.

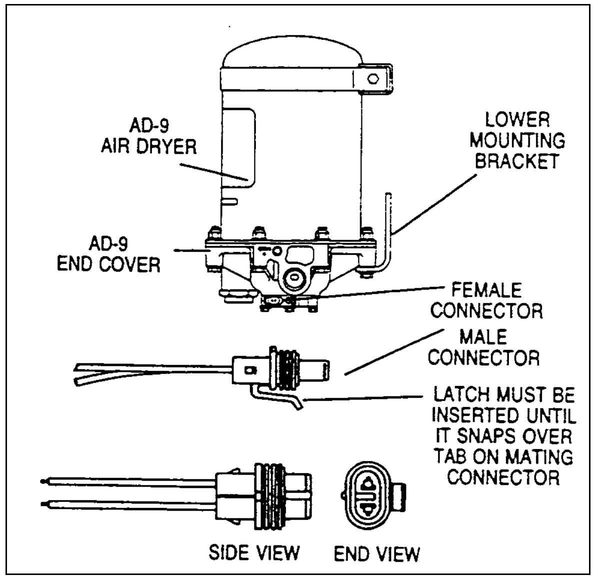

Figure 53—Air Dryer Connections

A two lead, 12 inch, wire harness (Figure 53) with attached weather resistant connector is supplied with all retrofit and replacement AD-9 Air Dryers.

10. Connect one of the two leads of the wire harness to the engine kill or ignition switch. The remaining lead of the wire harness must be connected to a good vehicle ground.
11. A fuse should be installed in the power carrying wire; install a 10 amp fuse for a 12 volt heater and a 5 amp fuse for a 24 volt heater.
12. Use 14 AWG wire if it is necessary to lengthen the wire harness provided.
13. Make sure all wire splices are waterproofed.
14. Tie wrap or support all electrical wire leading to the AD-9.

Relay Valve

Operational and Leak Test

1. Chock the wheels, fully charge air brake system and adjust the brakes.
2. Make several brake applications and check for prompt application and release at each wheel.
3. Check for inlet valve and O-ring leak.
4. Make this check with the service brakes released when the R-12 or R-14 is used to control the service brakes.
5. Make the check with the spring brakes applied (PARK) when the R-14 is used to control the spring brakes. Coat the exhaust port and the area around the retaining ring with a soap solution; a one inch bubble leak in 3 seconds is permitted.
6. Check for exhaust valve leak.
7. Make this check with the service brakes fully applied if the R-12 or R-14 controls the service brakes.
8. Make this check with the spring brakes fully released if the R-14 is used to control the spring brakes.
9. Coat the exhaust port with a soap solution; a 1 inch bubble in 3 seconds leak is permitted.
10. Coat the outside of the valve where the cover joins the body to check for seal ring leak; no leak is permitted.

Note

If the anti-compound feature is in use, the line attached to the balance port must be disconnected to perform this test.

If the R-14 is used to control the spring brakes, place the park control in the released position and coat the balance port with a soap solution. Check the diaphragm and seat. A leak equivalent to a one inch bubble in 3 seconds is permitted.

If the valves do not function as described above, or if leaks are excessive, it is recommended that the valves be replaced with new or remanufactured units or repaired with genuine Blue Bird parts, available at any authorized Blue Bird parts outlet.

Dual Circuit Brake Valve

Operating Check

1. Check the delivery pressure of both Primary and Secondary circuits using accurate test gauges.
2. Depress the treadle to several positions between the fully released and fully applied positions.
3. Check the delivered pressure on the test gauges to see that it varies equally and proportionately with the movement of the brake pedal.
4. After a full application is released, the reading on the test gauges should fall off to zero promptly.

It should be recorded that the Primary circuit delivery pressure will be about 2 PSI greater than the Secondary circuit delivery pressure with both supply reservoirs at the same pressure.

Caution

A change in vehicle braking characteristics or a low pressure warning may indicate a malfunction in one or the other brake circuit. Although the vehicle air brake system may continue to function, the vehicle should not be operated until the necessary repairs have been made.

Always check the vehicle brake system for proper operation after performing brake work and before returning the vehicle to service.

Leak Check

1. Hold a high pressure 80 psi application.
2. Coat the exhaust port and body of the brake valve with a soap solution.
3. A one inch bubble leak in 3 seconds is permitted If the brake valve does not function or leak is excessive, replace with a new or remanufactured unit, or repaired with genuine Bendix parts available at authorized Blue Bird parts outlets.

Automatic Slack Adjuster

Check the free stroke, push rod power stroke, and back torque. Refer to Group 030.2 Wheel End Components (Automatic Slack Adjuster).

Brake Chamber

Apply brakes and observe movement of all brake chamber rods.

Push Pull Control Valves

Operational and Leak Test

An accurate test gauge should be installed into the supply line and a means of controlling the supply pressure should be provided. Apply a 120 psi air source to the supply port. A small volume reservoir (e.g. 90 cu. in.) with a gauge should be connected to the delivery port.

1. Apply 120 psi supply pressure and pull button for exhaust position. A leak at the exhaust port should not exceed a one inch bubble in five seconds. Likewise,a leak at the plunger stem should not exceed a one inch bubble in five seconds.
2. There should be no leak between upper and lower body.
3. Push the button in (applied position). Any leak at the exhaust port or at the plunger should not exceed a one inch bubble in 3 seconds; at the plunger a one inch bubble in three seconds.
4. Reduce the supply pressure. At a pressure from 60 to 20 psi, depending on the spring installed, the button should pop out automatically, exhausting the delivery volume. (This does not apply to some PP-1's).

Air Compressor

Operating Tests

Vehicles manufactured after the effective date of FMVSS 121, with the minimum required reservoir volume, must have a compressor capable of raising air system pressure from 85-100 psi in 25 seconds or less.

This test is performed with the engine operating at the maximum recommended governed speed. The vehicle manufacturer must certify this performance on new vehicles with appropriate allowances for air systems with greater than the minimum required reservoir volume.

Air Leak Tests

Compressor leak tests are not performed on a regular schedule. These tests should be performed when it is suspected that discharge valve leak is substantially affecting compressor build-up performance, or when it is suspected that the compressor is "cycling" between the load and unloaded modes due to an unloader piston leak.

These tests must be performed with the vehicle parked on a level surface, the engine not running, the entire air system completely drained to 0 PSI and the inlet check valve detail parts removed, if applicable.

Unloader Piston Leak

- **The unloader pistons leak check**

1. Remove the cylinder head from the compressor.
2. Cover securely the inlet flange, apply 120 psi of air pressure to the governor port.
3. Listen for an escape of air at the inlet valve area. An audible escape of air should not be detected.

Discharged Valve Leak

Unloader piston leak must be repaired before this test is performed. Leak past the discharge valves can be detected.

1. Remove the discharge line and apply shop air back through the discharge port.
2. Listen for an escape of air at the compressor inlet cavity. A barely audible escape of air is generally acceptable.

If the compressor does not function as described above, or if the leak is excessive, it is recommended that it be returned to the nearest authorized Blue Bird distributor for a factory remanufactured compressor.

If a return to an authorized Blue Bird distributor is not possible, the compressor can be repaired using a genuine Blue Bird cylinder head maintenance kit. Retest the cylinder head after installation of the kit.

Antilock Systems Service Check

Wheel Speed Sensor Service Check

Check all wiring and connectors. Make sure connections are free from visible damage.

Examine the sensor. Make sure the sensor, mounting bracket, and foundation brake components are not damaged. Repair or replace as necessary.

Antilock Modulator Assembly

Operational and Leak Test

- **Leak Testing**

1. Park the vehicle on a level surface and block or chock the wheels. Release the parking brakes and build the air system to full pressure.
2. Turn the engine OFF and make 4 or 5 brake applications and note that the service brakes apply and release promptly.
3. Build system pressure to governor cut out and turn the engine OFF.
4. Hold a full service brake application.
5. Apply a soap solution to the exhaust port of the modulator. Leak should not exceed a one inch bubble in less than 3 three seconds. If leak exceeds the specified maximum, replace the modulator.
6. Apply a soap solution around the solenoid assembly (top and bottom). Leak should not exceed a one inch bubble in less than 3 three seconds.

If leak exceeds the specified maximum, tighten the solenoid cap screws and re-test. If the leak remains excessive after re testing, replace the modulator.

7. Apply a soap solution around each diaphragm cover. Leak should not exceed a one inch bubble in less than three seconds.

If leak exceeds the specified maximum, tighten the diaphragm cap screws and re test. If the leak remains excessive after re testing, replace the modulator.

Operation Testing

Note

To properly test the function of the modulator will require 2 service technicians.

1. Park the vehicle on a level surface and block or chock the wheels.
2. Release the parking brakes and build the air system to governor cut out.
3. Turn the engine ignition key to the OFF position then make and hold a full brake application.
4. Apply brakes and hold.
5. Post a service technicians posted at one of the modulators, turn the vehicle ignition key to the ON position.
6. One or two short bursts of air pressure should be noted at the modulator exhaust.
7. Repeat the test for each modulator on the vehicle. If at least a single burst of exhaust is not noted or the exhaust of air is prolonged and not short, sharp and well defined, perform the Electrical Tests below.

- **Electrical Tests**

Before testing the solenoid assembly of a suspect modulator, its location on the vehicle should be confirmed.

Proceed to the modulator in question and inspect its wiring connector. Disconnect the connector and test the resistance between the pins on the modulator. Refer to Figure 54.

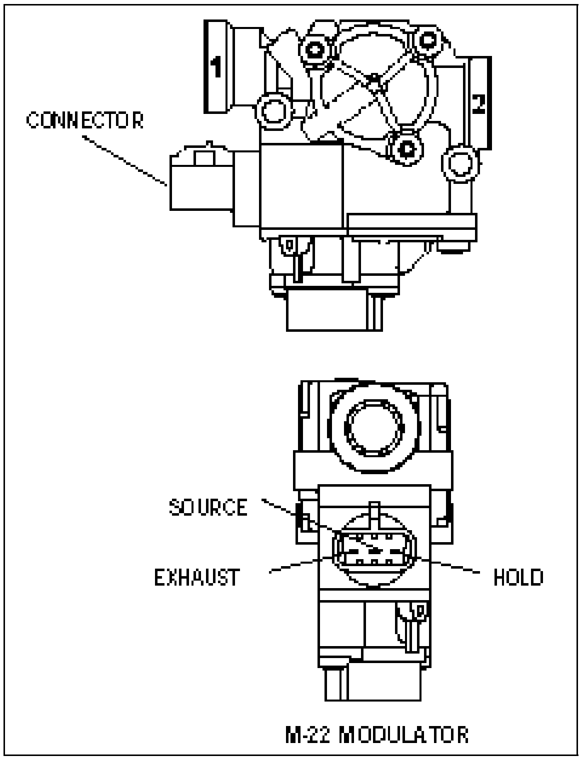

Figure 54—Modulator Test

HOLD to SOURCE: Read 3.5 to 5 OHMS

EXHAUST to SOURCE: Read 3.5 to 5 OHMS

EXHAUST to HOLD: Read 7 to 10 OHMS

Individually test the resistance of each pin to vehicle ground and note there is no continuity.

If the resistance readings are as shown, the wire harness leading to the modulator may require repair or replacement.

Before attempting repair or replacement of the wire harness, refer to Troubleshooting procedures specified for the antilock controller.

If the resistance values are not as shown above, replace the modulator.

Diagnosing and Locating a System Fault

General

The EC-17 contains self test and diagnostic circuitry that continuously checks for proper operation of the entire antilock/traction system, including wiring continuity.

The EC-17 is programmed at the factory to accommodate the needs of the vehicle and the customer's desires.

The EC-17 controller can be reconfigured by the end user to include traction control. A vehicle equipped with traction control can generally be identified by noting the presence of a dash mounted condition lamp, a disable switch (for the traction control system) and a traction solenoid located above the relay valve.

Separate dash lamps, controlled by the EC-17, advise the driver of the condition of the entire antilock/traction system.

When the controller senses an erroneous condition, it stores the condition in memory, illuminates the dash mounted condition lamp and, after certain criteria are met, it disables the antilock or traction control function.

The fault condition is truly stored and is not cleared by loss of power to the antilock system.

The optional LEDs will illuminate when power is restored and remain illuminated until the failure is corrected.

After the actual issue is corrected, maintenance personnel can clear or reset the EC-17 diagnostics through the SAE J1587 diagnostic link or the optional magnetic RESET point in the diagnostics display (Figure 55).

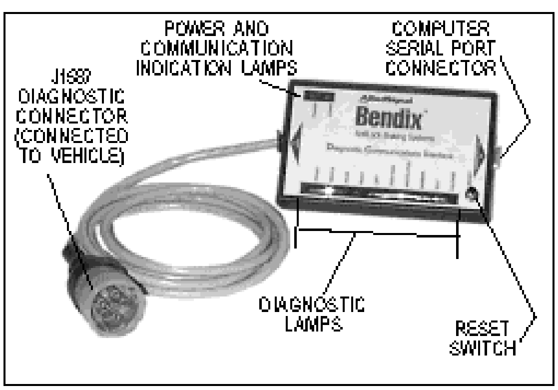

Figure 55—DCI Tool

Diagnostic Communication Interface

The DCI is a dual level electronic diagnostic tool for either the EC-17 antilock controller. It can either be used as a stand alone diagnostic tool or with AlliedSignal's A Com For Windows software.

In order to use the DCI, the vehicle must be equipped with a J1587 diagnostic link connector as illustrated in Figure 56. This connector is generally located on the driver's side, in the lower portion of the dash or under the dash panel.

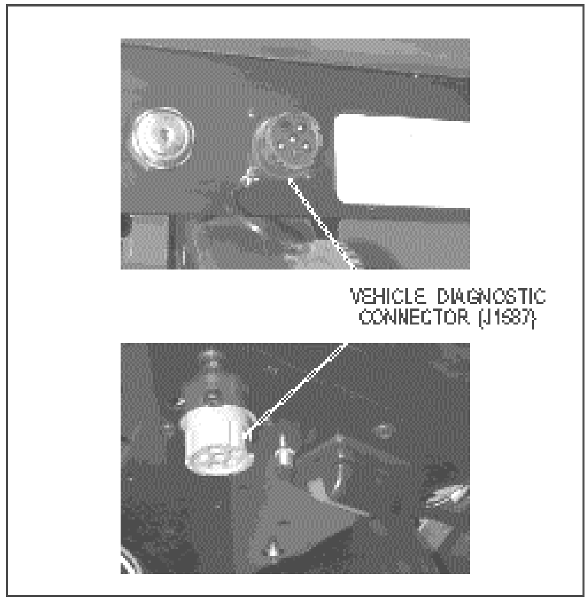

Figure 56—Diagnostic Connector

Used with its Microsoft Windows based software and a personal computer, the DCI is able to provide the technician with a high level of diagnostic information and antilock fault history (Figure 57).

This is particularly useful when attempting to determine the source of intermittent fault indication from the antilock dash condition lamp.

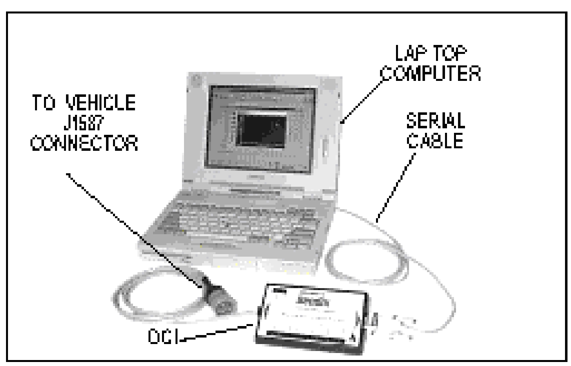

Figure 57—DCI Tool with PC

When using the DCI's LED display for system diagnosis or controller self configuration, the descriptions and procedures presented in this manual can be used. When connected to a PC, use the instructions and documentation packaged with the DCI to troubleshoot or reconfigure the EC-17 controller.

For more information on the Allied Signal Bendix, Diagnostic Communication Interface, see your local authorized AlliedSignal Bendix parts outlet or call 1-800-AIR-BRAK (1-800-247-2725).

Optional Diagnostic LED and RESET

The condition of specific components is provided by a series of labeled, light emitting diodes (LEDs) in the EC-17 housing.

No special tools or equipment are needed to read or interpret the EC-17 diagnostic display. It should be noted that the EC-17 diagnostics display is separate from the antilock and traction condition lamps on the dash Table 1.

With this separation, the driver is aware of any issues that occur but is not confused by diagnostic information.

There are ten LEDs plus a magnetically actuated reset switch.

The first six LEDs locate an issue to a specific area of the vehicle, and the next three indicate the component or its wiring. The LEDs are software driven and are either ON or OFF, depending upon their monitor function.

Note

Right and left, front and rear are determined from the driver's seat.

- **FRT Red LED**
- **MID Red LED**
- **RER Red LED**
- **RHT Red LED**
- **LFT Red LED**
- **TRC Red LED**
- **MOD Red LED**
- **SEN Red LED**
- **ECU Red LED**
- **VLT Green LED**
- **RESET + No LED**

Note

The MID LED is used with some but not all vehicles.

When six speed sensors are not installed this LED is not used in the diagnostic process.

However, it will light when a magnet is placed on the RESET switch in the diagnostic display.

- **FRT (Front) LED**

This Red LED illuminates in order to indicate the location of a faulted component or its wiring. It will light in conjunction with either the RIGHT or LEFT LED and the MOD or SENS LED.

- **MID (Middle Axle) LED**

This Red LED is not used in all installations. On those vehicles that have six speed sensors installed, this Red LED illuminates to indicate the location of a faulted speed sensor or its wiring. The "MID" LED should not illuminate with the "MOD" LED.

- **RER (Rear) LED**

This Red LED illuminates in order to indicate the location of a faulted component or its wiring. It will light in conjunction with either the RIGHT or LEFT LED and the MOD or SENS LED

- **RHT (Right) LED**

This Red LED illuminates in order to indicate the location of a faulted component or its wiring. It will light in conjunction with either the FRONT or REAR LED and the MOD or SENS

- **LFT (Left) LED**

This Red LED illuminates in order to indicate the location of a faulted component or its wiring. It will light in conjunction with either the FRONT or REAR LED and the MOD or SENS LED.

- **TRC (Traction) LED**

This Red LED illuminates to indicate a permanent fault in the traction control system. It may be illuminated with the MOD LED or may illuminate by itself.

Note

If a fault exists with the wiring to the engine control module (ECM), this LED will go on.

- **MOD (Modulator) LED**

This Red LED illuminates to indicate an open or short circuit in the solenoids of one of the four modulators or the wiring connecting them to the system. When indicating a fault with a modulator this LED will be illuminated with two positioning LEDs (RHT/LFT + FRT/RER).

Note

The MID positioning LED should not be illuminated with this LED. This LED is also used to indicate a fault with an ATR 1, antilock Traction Relay, solenoid. When illuminated for attraction system fault, the TRC LED will also be on.

- **SEN (Speed Sensor) LED**

This Red LED illuminates to indicate an open or short circuit in one of the speed sensors or the wiring connecting them to the system. The "SEN" LED will be illuminated with two positioning LEDs (RHT/LFT + FRT/MID/RER).

- **ECU (Electronic Control Unit) LED**

This Red LED, when illuminated, indicates that the controller itself has failed. Before controller replacement is considered, always check vehicle voltage to the controller.

- **VLT LED**

This Green LED illuminates and remains ON during vehicle operation to indicate that vehicle power is reaching the controller. If vehicle power is out of range (below 10 VDC or above 18.0 VDC) this LED will flash until power is brought into range.

- **RESET**

Beneath the RESET area of the display is a magnetically sensitive switch that is used to reset the diagnostic system. The device will respond to a magnet that has strength sufficient to lift a three ounce weight.

Momentarily holding a magnet against the RESET will cause ALL LEDs to light during the time the magnet is against it.

Holding a magnet against the RESET longer than 20 seconds will cause the EC-17 to initiate the self configuration feature.

Torque Limiting & Differential Braking		Torque Limiting Only		Differential Braking Only		
ANTILOCK DASH LAMP	TRACTION DASH LAMP	ANTILOCK DASH LAMP	TRACTION DASH LAMP	ANTILOCK DASH LAMP	TRACTION DASH LAMP	
ON	ON	ON	ON	ON	ON	Both the Antilock & Traction dash lamps are ON during the system self test.
OFF ON	OFF ON	OFF ON	ON ON	OFF ON	OFF ON	This is the first blink occurrence of the Antilock dash lamp. Compare and note the traction lamp's reaction to the Antilock lamp.
OFF ON	OFF ON	OFF ON	OFF ON	OFF ON	ON ON	This is the second blink occurrence of the Antilock dash lamp. Compare and note the traction lamp's reaction to the Antilock lamp.
OFF	OFF	OFF	OFF	OFF	OFF	Both dash lamps are OFF and remain OFF at the end of the powerup sequence.

Table 2—Lamp Configuration

EC-17 Controller Configuration

Caution

The following information and procedure applies to the EC-17 controller equipped with the optional LED diagnostic display and magnetic RESET switch.

Controllers without this option (EC-17N) must use the J1587 diagnostic link and the DCI with its related computer programs to reconfigure the controller.

EC-17 Configuration Display

Turn the ignition ON.

All LEDs will illuminate, then go out.

The number of active sensors will be displayed by the momentary illumination of the red SEN (sensor) LED and two or more of the red locating LEDs. No other LEDs will be on.

SEN + FRT (front) + RER (rear) = A four sensor con figuration (all systems must have at least a 4 sensor configuration)

SEN + FRT + MID (middle) + RER = A six sensor configuration

The red TRC LED will momentarily illuminate by itself if traction control torque limiting is active. If not, then the display will go to the condition described in number 5.

The red TRC and MOD LEDs will momentarily illuminate if traction control differential braking is active. If not, then the display will go to the condition described in number 6. No other LEDs will be on.

The diagnostic display will return to its normal operational status. Assuming no faults exist in the antilock or traction system, all red LEDs will be off and the single, green, VLT LED is illuminated.

EC-17 Self Configuring Process

Caution

Three aspects of the antilock and traction system are influenced by the self configuring feature of the EC-17.

- **Speed Sensors**

The number of speed sensors connected to the EC-17 will be detected during the self configuration process. The EC-17 will check the MID SEN (mid axle speed sensor) locations on its connector to determine if a sensor is connected to it and will default to a six sensor configuration if it detects even one sensor connected. If mid axle speed sensors are not detected, the EC-17 will default to a four sensor configuration. (Two front and two rear)

- **Electronic Engine Control**

If the EC-17 is connected to the control module of an electronic engine, the torque limiting feature of traction control will be activated during the self configuring process.

- **Antilock Traction Relay Valve**

If the solenoid assembly in the ATR valve is connected to the EC-17, the differential braking feature of traction control will be activated during the self configuring process.

- **Traction Disable Switch**

The traction disable switch must be in the correct position for the Self Configuration process.

No method is available to disable the Self Configuration Process feature.

Due to the extended period of time the magnet must be held on the RESET to initiate the self configuration process (20 seconds), it is unlikely that a self configuration would occur accidentally.

Basic, four speed sensor, antilock operation can not be removed during the self configuration process. This is a minimum configuration for all EC-17 controllers.

If a speed sensor is connected to either wheel on the mid axle, the EC-17 will configure for six sensors. If no mid axle speed sensor is detected, the EC-17 will configure for four sensors.

Any disconnected speed sensor(s) will register as a failure on the diagnostic display at the end of the EC-17 self test.

All or part of traction control can be lost during self configuration by;

Not connecting one of the wire harnesses (engine control module for torque limiting and ATR valve solenoid for differential braking)

A missing or inoperative traction control enable disable switch.

Not toggling the traction control enable/disable switch in the “traction enabled” after power up, but prior to the self configuration.

The operator can tell that the traction features are lost by noting the absence of the traction lamp flash upon power up. The operator should note the flashing of the antilock condition lamp, and the traction lamp if traction equipped, upon every power up. Observing the dash lamps is one method the operator has to verify the system operation.

The EC-17 can be reprogrammed up to 10,000 times.

When a replacement EC-17 is installed on a vehicle that does not have one or more of the pre-programmed features, a failure will be registered on the dash lamp(s) and on the EC-17 diagnostic display. For this reason it is necessary to perform the Self Configuration Process.

Some configuration information is available by observing the reaction of the dash condition lamps on vehicles configured with traction control and equipped with the self configuring EC-17.

When the ignition is switched ON, the EC-17 self test is begun. During the self test the dash lamps will flash on and off together as indicated in the chart, depending upon the type and amount of traction control configured into the EC-17.

Self Configuration Process

In order to successfully complete the self configuring process follow the steps presented.

Connect all antilock and traction control wire harnesses.

Make sure that all the speed sensors present on the vehicle are connected (H2, H3, J1, J2 on the 30 pin connector and E2, E3, F2, F3, B2, B3, C2, C3 on the 18 pin connector).

If the vehicle has an electronic engine and traction control torque limiting is desired the engine control module must be connected (B2 and B3 on the 30 pin connector for J1922 or C3, D2, and D3 on the 30 pin connector for J1939).

If the vehicle is equipped with either an ATR 1 or ATR 2 valve, the solenoid connection must be made to the EC-17 (D2 and D3 on the 18 pin connector) in order to obtain traction control differential braking.

If the vehicle is to be configured with traction control, it must have a traction control dash lamp and a traction control enable/disable switch. Both the lamp and switch must be functional.

Turn the ignition ON, toggle the traction control enable/disable switch back and forth then hold a magnet on the RESET position of the EC-17 diagnostic display until the LEDs begin to flash then remove the magnet.

If the magnet is not removed during the LED flashing a second self configuration may be initiated. The magnet may have to be held on the RESET for as long as 20 seconds.

When the self configuration process is complete the EC-17 will automatically go through a self test.

During the self test the diagnostic display will indicate the new configuration as described under the section entitled EC-17 CONFIGURATION DISPLAY.

Note

If the EC-17 is being configured with Traction Control (either torque limiting, differential braking or both), the traction control condition dash lamp, will be illuminated as well as the appropriate LEDs on the EC-17 diagnostic display.

The traction control dash lamp will be illuminated until the traction control enable/disable switch is placed in the traction control enabled position (traction control operative).

Place the traction control enable/disable switch in the traction control enabled position (traction control operative), the traction control dash lamp should be off.

Before placing the vehicle in service, verify the configuration and the system condition by turning the ignition OFF then ON while observing the EC-17 diagnostic display.

The diagnostic display should indicate the desired configuration as described under the section entitled EC-17 CONFIGURATION DISPLAY and no red LEDs should be illuminated at the end of the self test.

If the configuration appears correct but the diagnostic LEDs indicate a failure somewhere in the system, refer to the EC-17 Controller Configuration section and use the Troubleshooting section of this manual to locate and repair the fault.

If the configuration is incorrect, the process can be repeated as required. One common error is performing the self configuration without toggling the traction control enable/disable switch. This will prevent any traction features from being activated.

Note

The traction switch must be toggled to configure traction, but must be placed in the enable position to allow the traction lamp to flash.

Troubleshooting

Caution

Determine if the vehicle is equipped with traction control. The presence of a traction condition lamp on the dash can be used.

Some vehicles are equipped with a traction control" disabling switch." If so equipped, enable the traction system before beginning the Troubleshooting. The traction control must be disabled for dynamic testing.

If the vehicle is equipped with traction control and is a tandem axle unit, note the number of drive axles. The "MID" diagnostic LED is used only on 6x4 vehicles.

General

While the EC-17 diagnostic display locates a specific fault area, it is still necessary to confirm whether the fault resides in the component itself or the wiring. All troubleshooting should begin by first performing the "Initial Start up Procedure" and following the directions contained in it.

Troubleshooting Help

Begin by observing the dash condition lamp(s) and performing the Initial Startup Procedure.

The troubleshooting technician should record all findings and the action taken during the troubleshooting process.

No voltage or resistance tests are performed into the EC-17. All voltage and resistance tests are performed by beginning at the wire harness half of the connector and moving away from the EC-17 toward an antilock traction system component (modulator, wheel speed sensor, etc.)

Diagnostic Display

This index (Figure 58) is troubleshooting Bendix full-vehicle wheel control antilock with traction control. It provides a quick reference to specific sections that provide testing procedures and values.

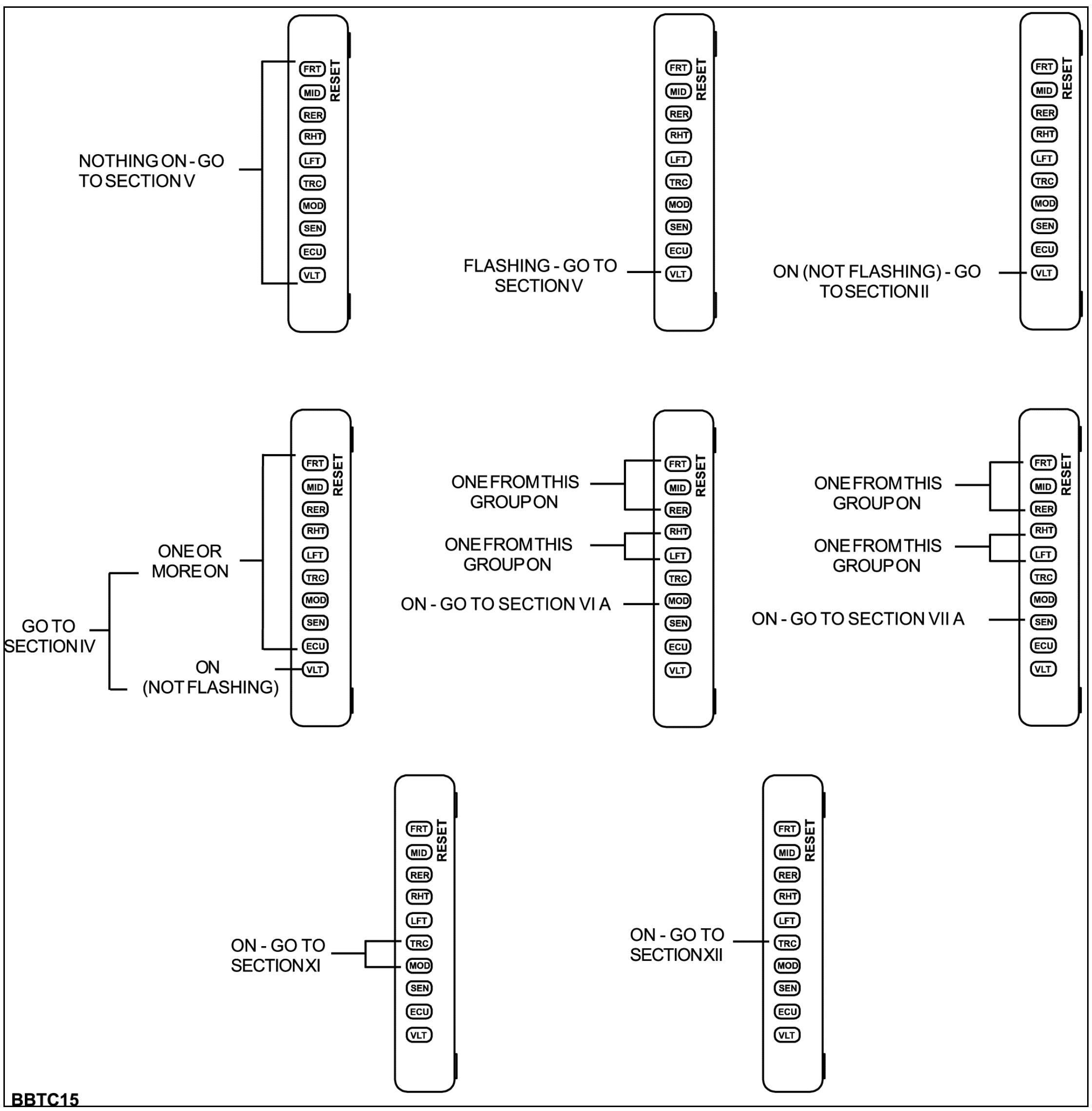

Figure 58—Diagnostic Display Quick Reference

Initial Startup Procedure

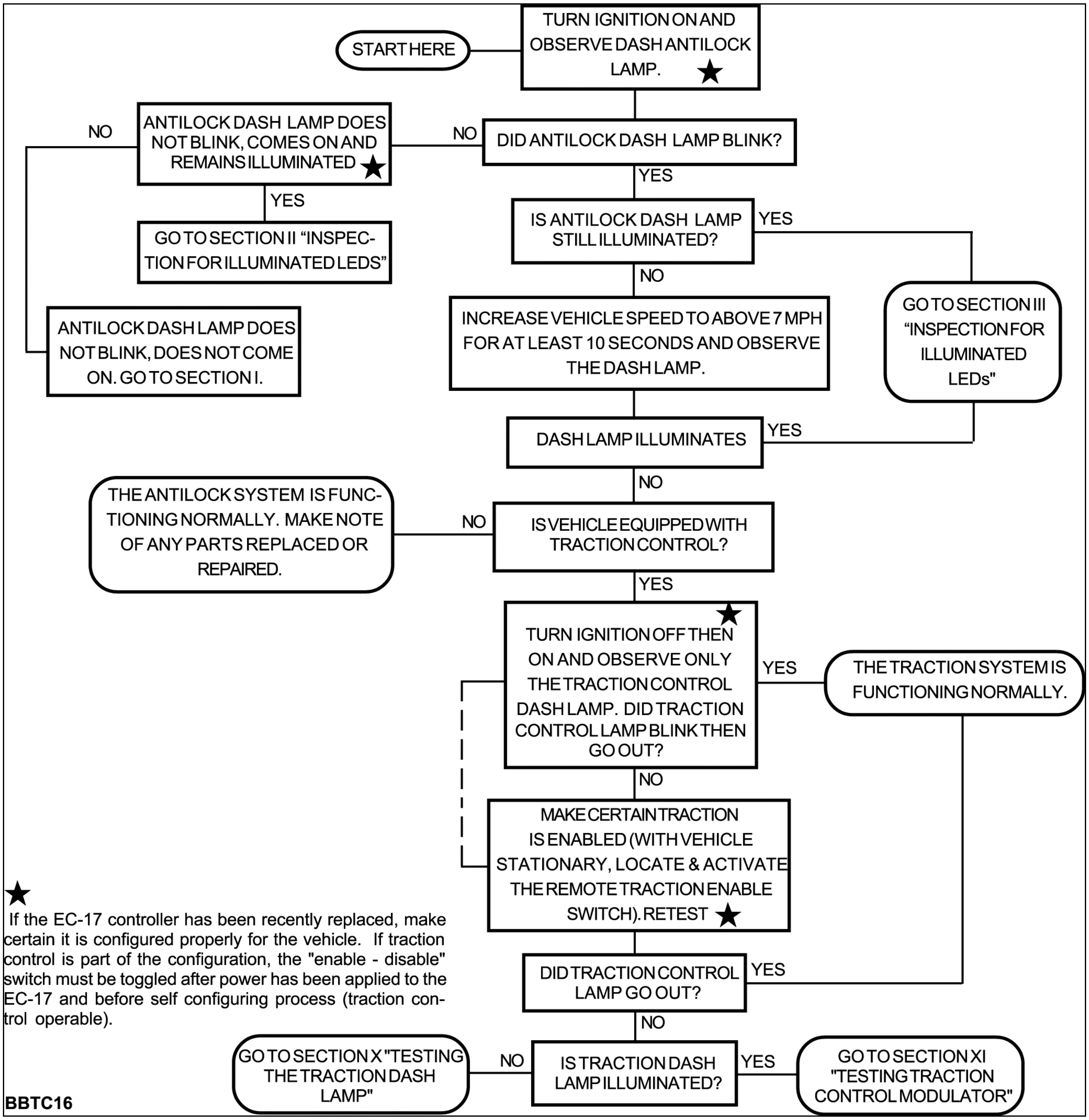

Figure 59—EC-17 Configuration

Section I – Antilock Dash Lamp Testing

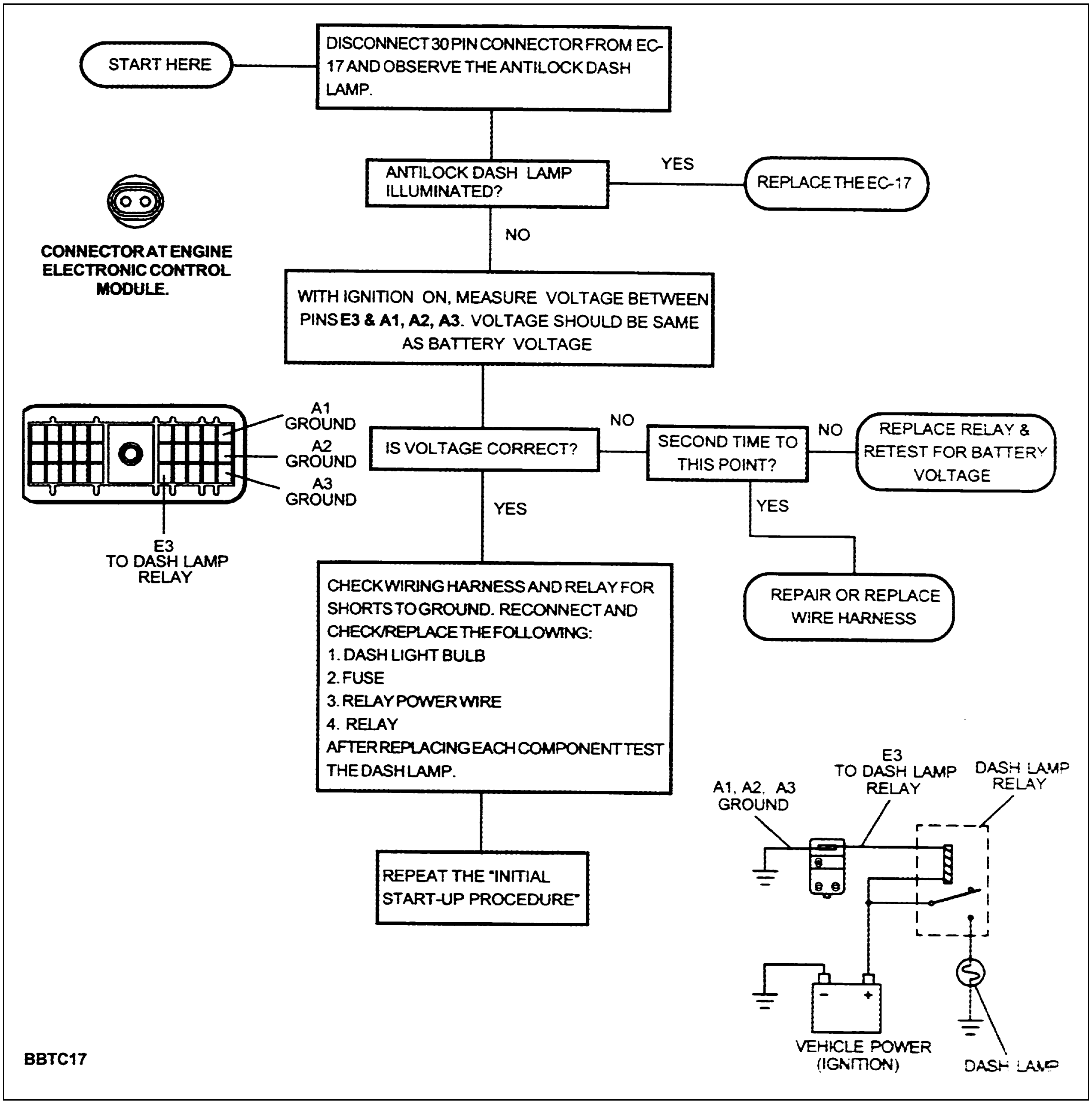

Figure 60—Antilock Dash Lamp Testing

Section II – Inspection for Illuminated LEDs

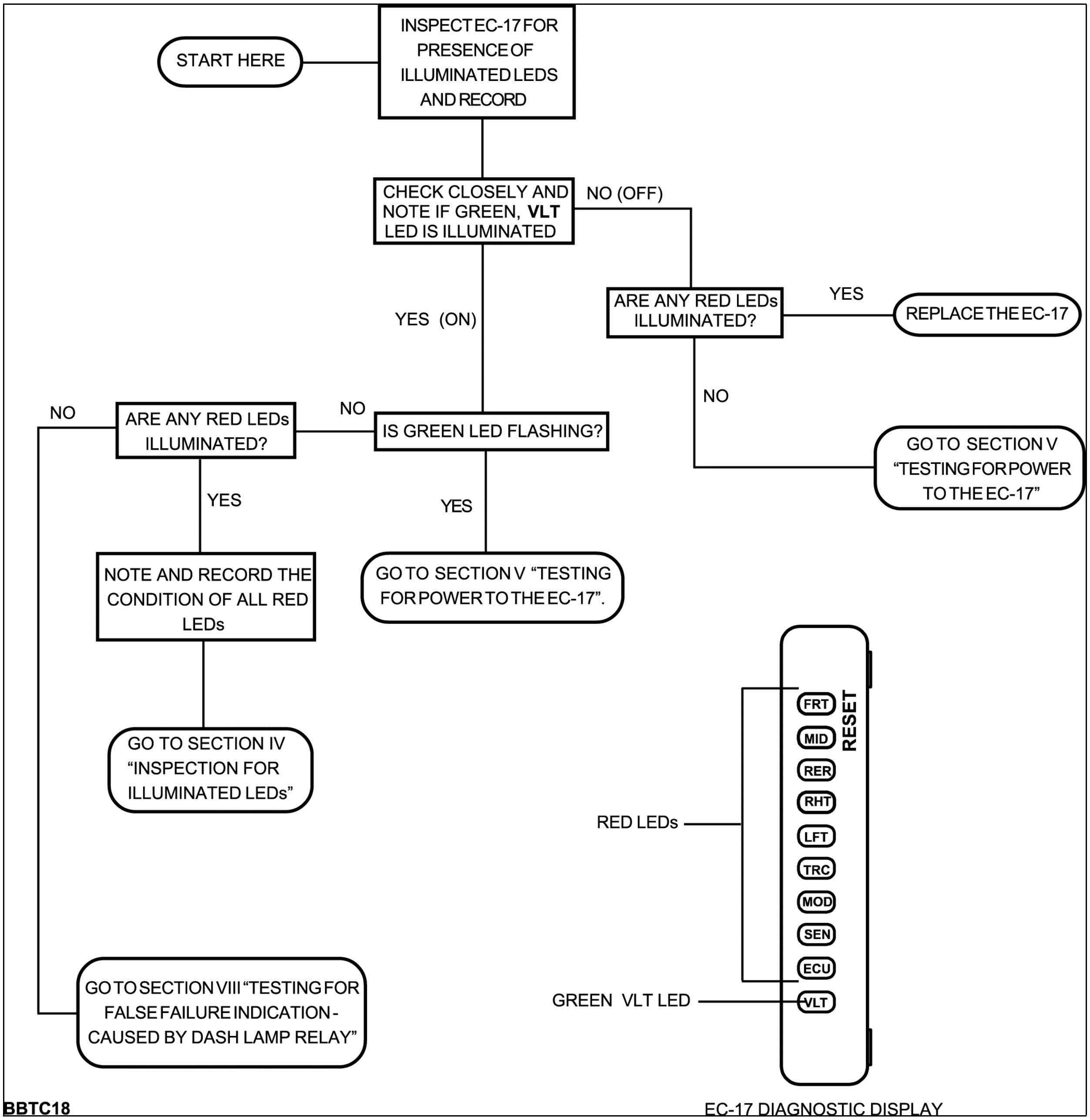

Figure 61—Inspection for Illuminated LEDs

Section III – Inspection for Illuminated LEDs

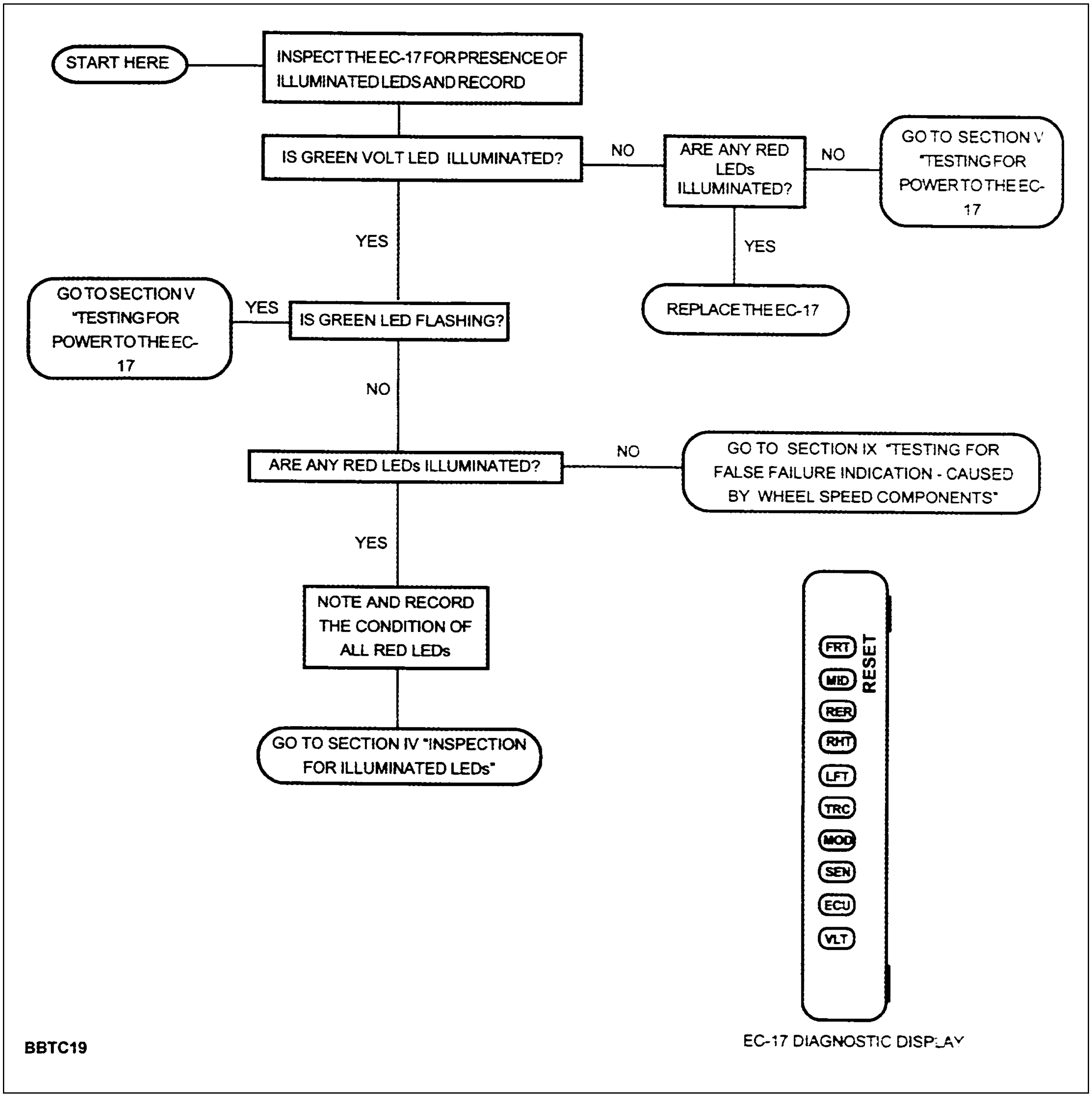

Figure 62—Inspection for Illuminated LEDs continued

Section IV – Inspection for Illuminated LEDs

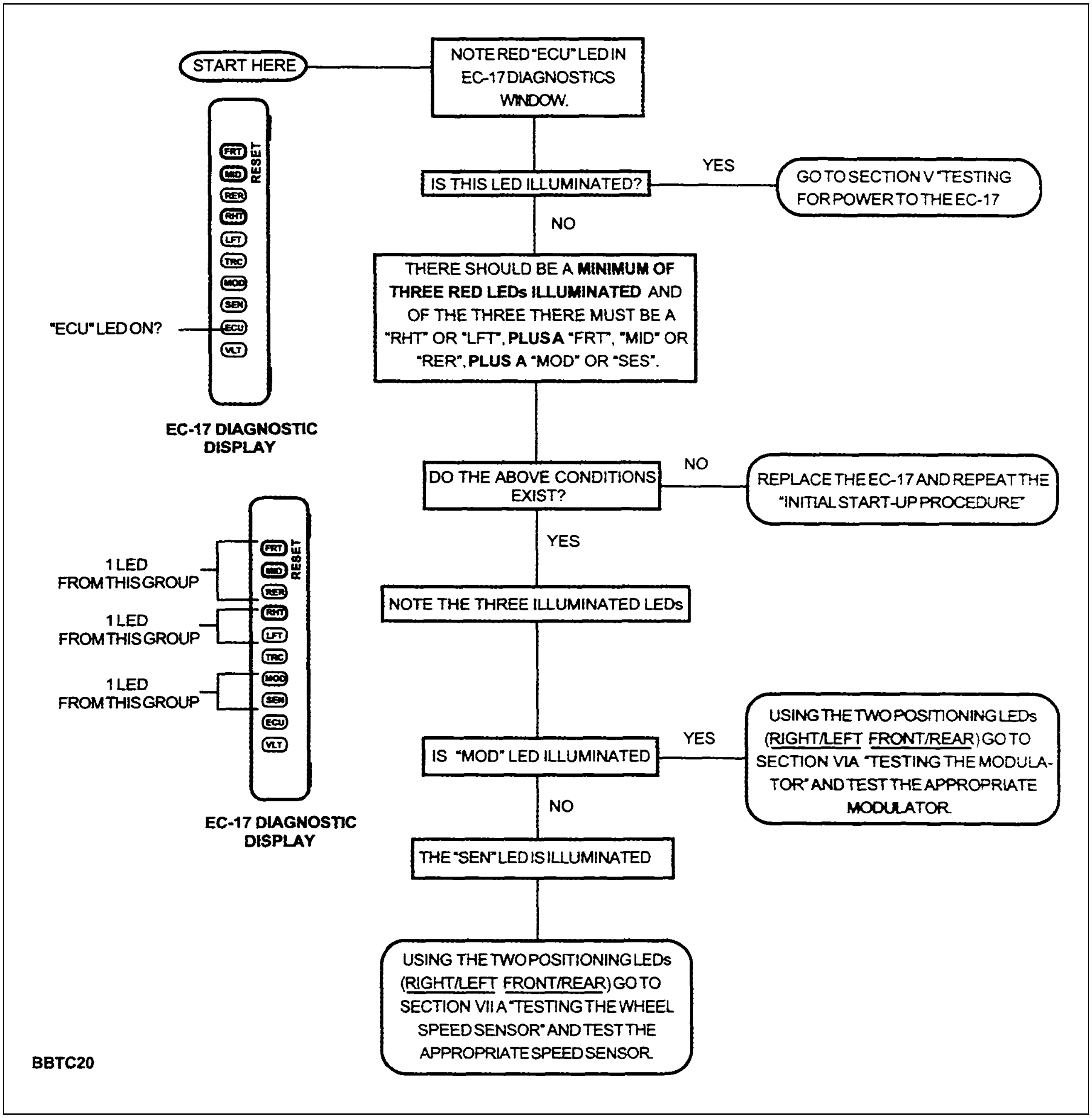

Figure 63—Inspection for Illuminated LEDs continued

Section V – Testing for Power to the EC-17

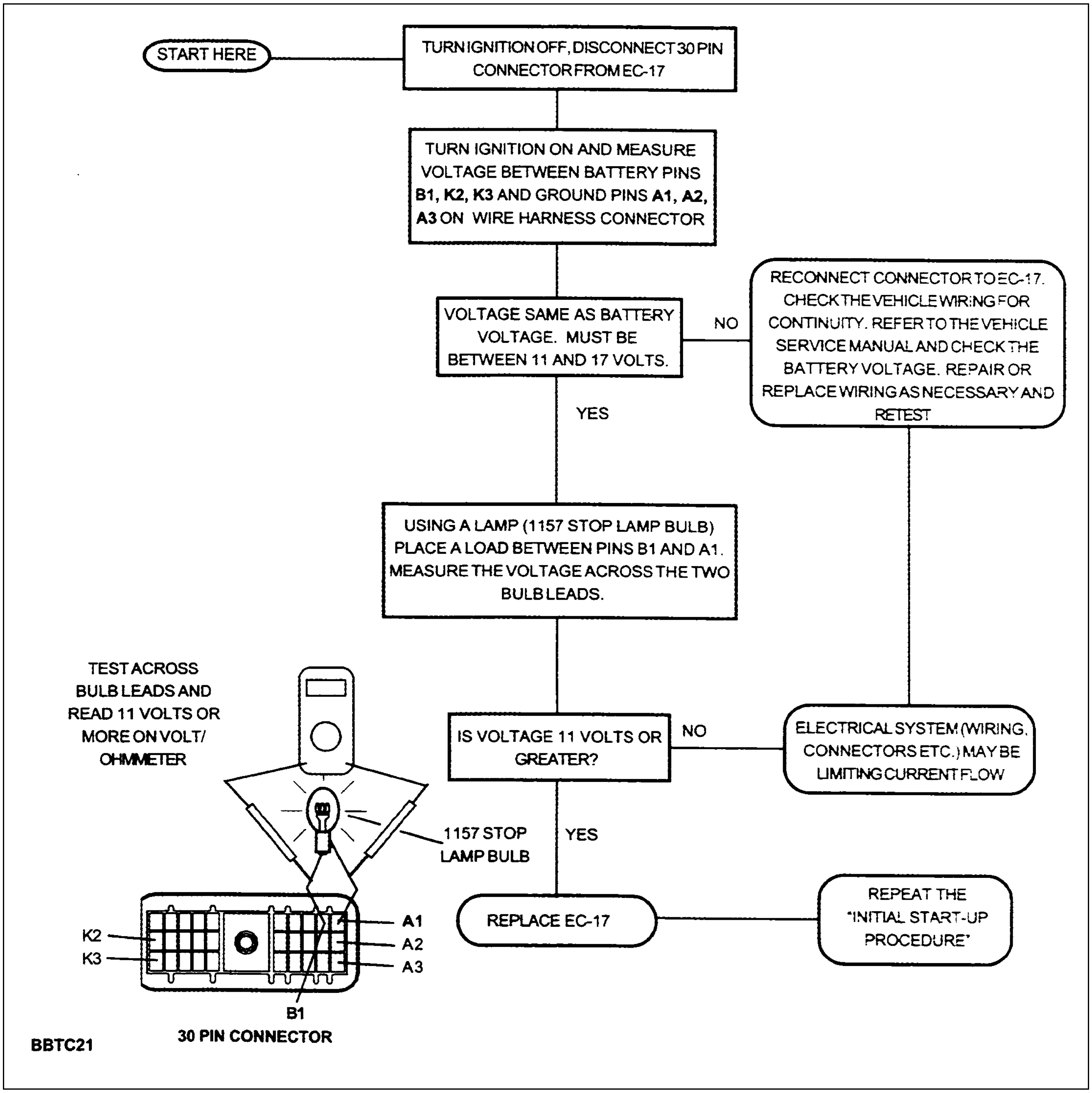

Figure 64—Power to EC-17

Section VI A - Testing the Modulator

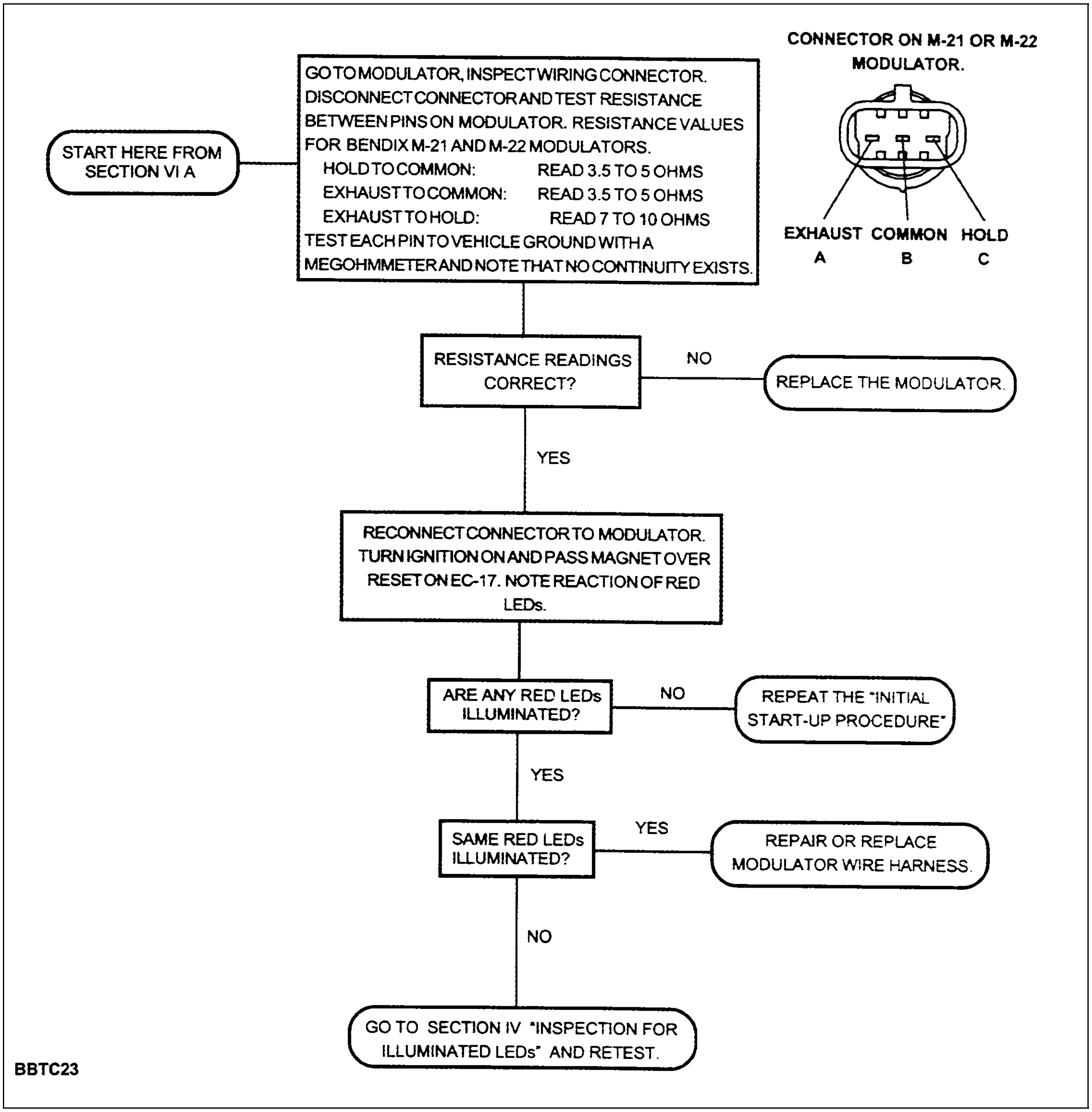

Figure 65—Testing Modulator

Section VI B - Testing the Modulator

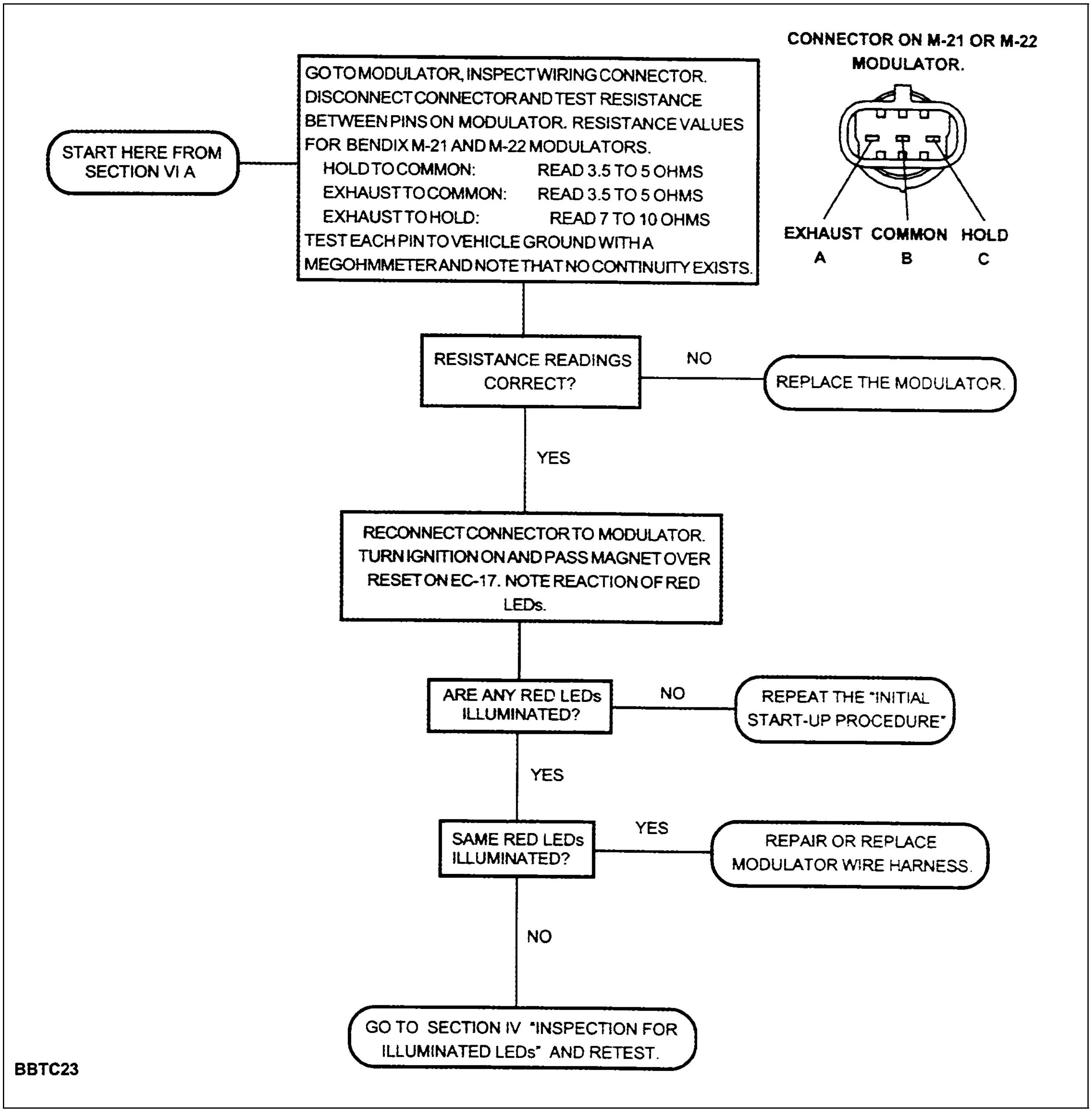

Figure 65—Testing Modulator continued

Section VII A - Testing the Wheel Speed Sensor

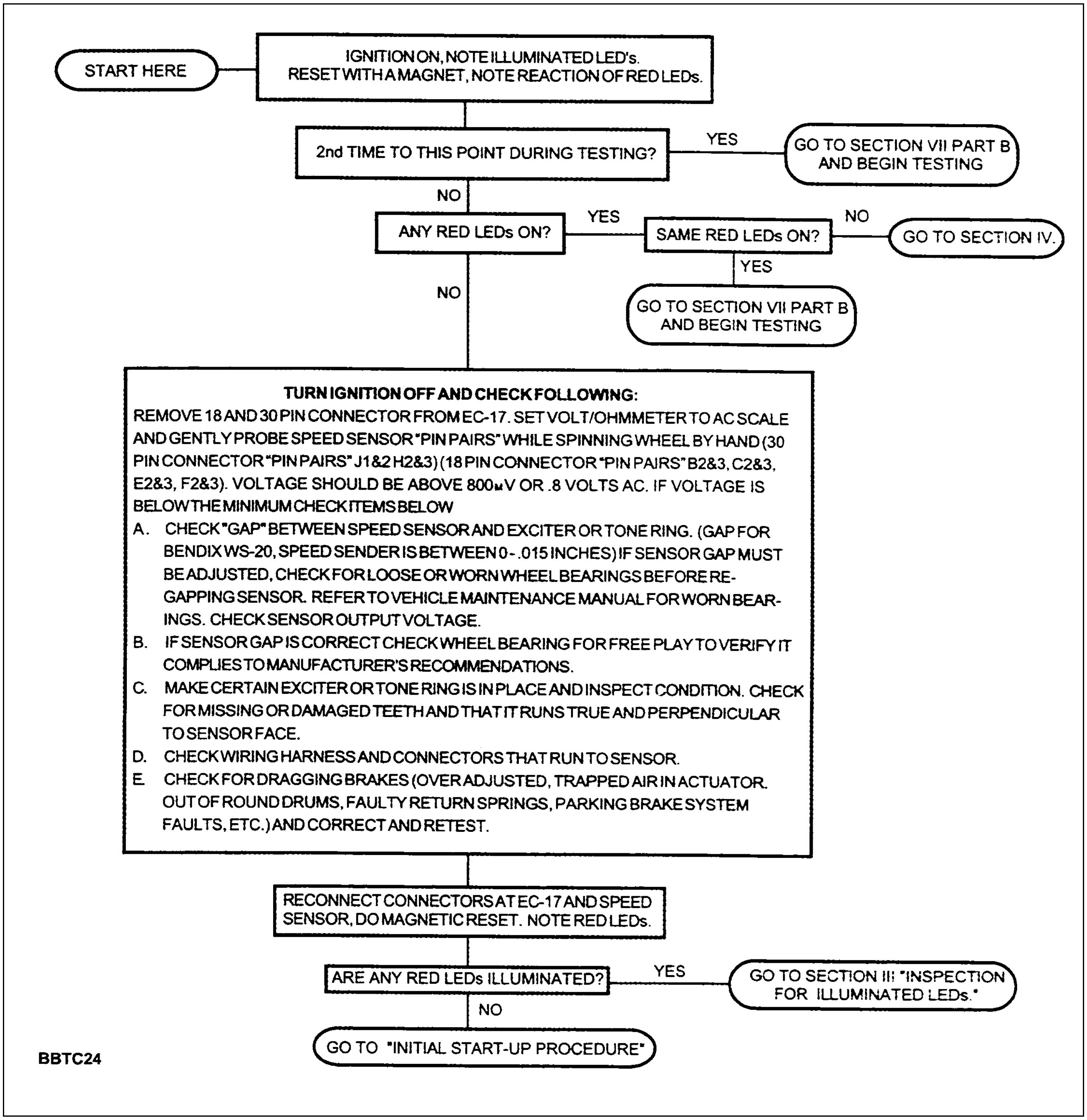

Figure 66—Testing the Wheel Speed Sensor

Section VII B - Testing the Wheel Speed Sensor

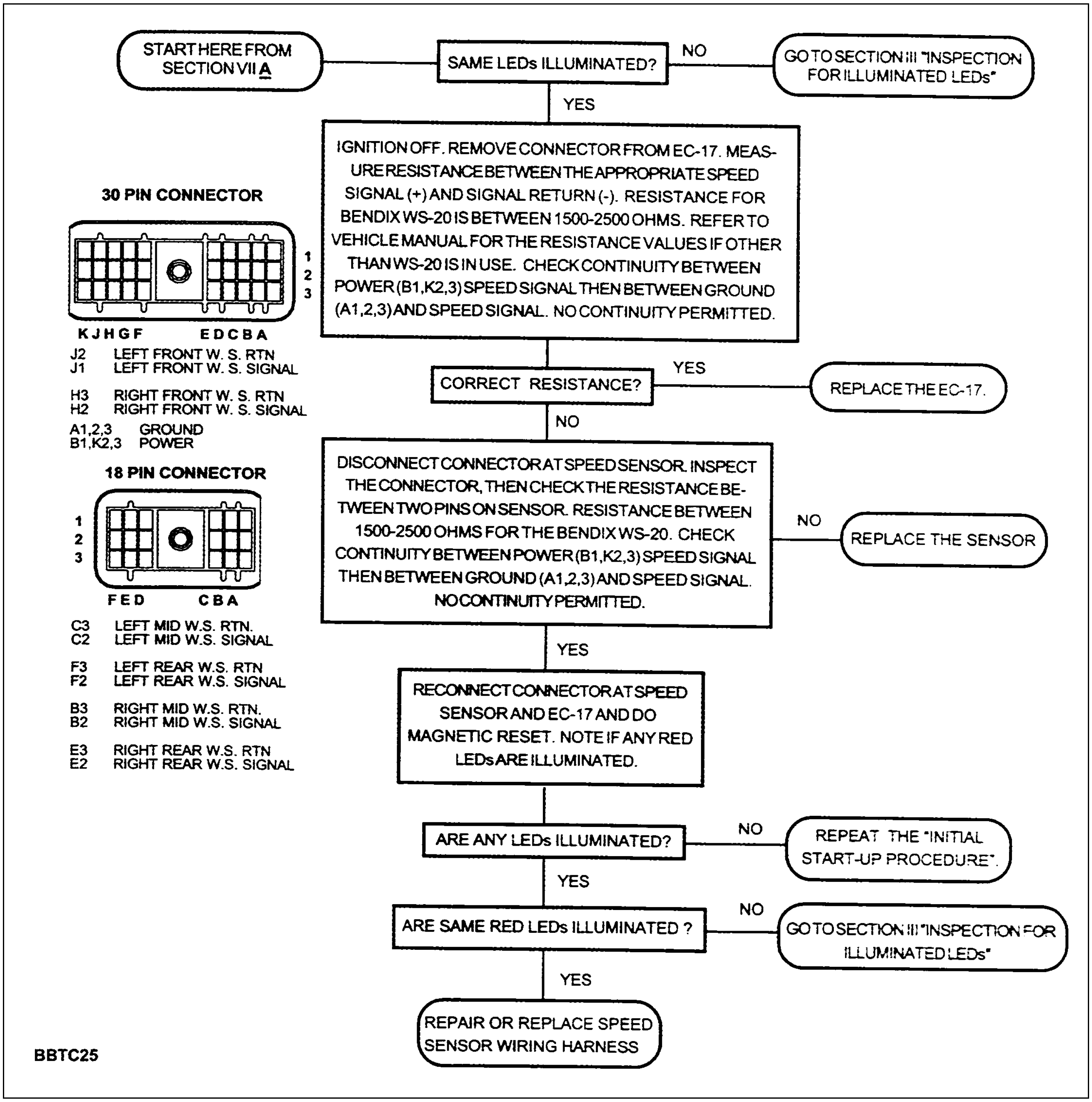

Figure 66—Testing the Wheel Speed Sensor continued

Section VIII - Testing for False Indication Caused by Dash Light Relay

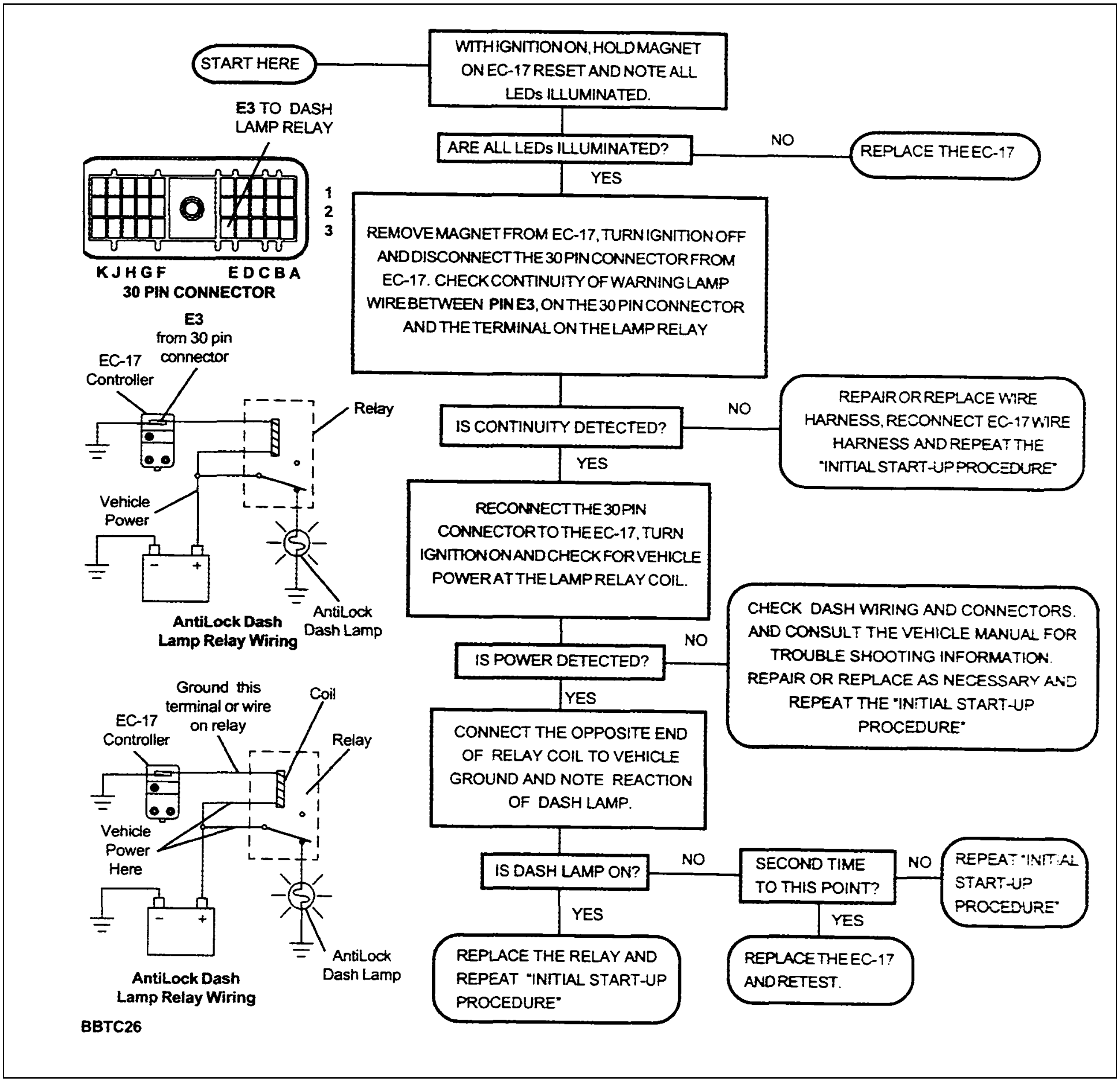

Figure 67—Testing for False Indication Caused by Dash Light Relay

Section IX - Testing for False Indication Caused by Wheel Speed Components

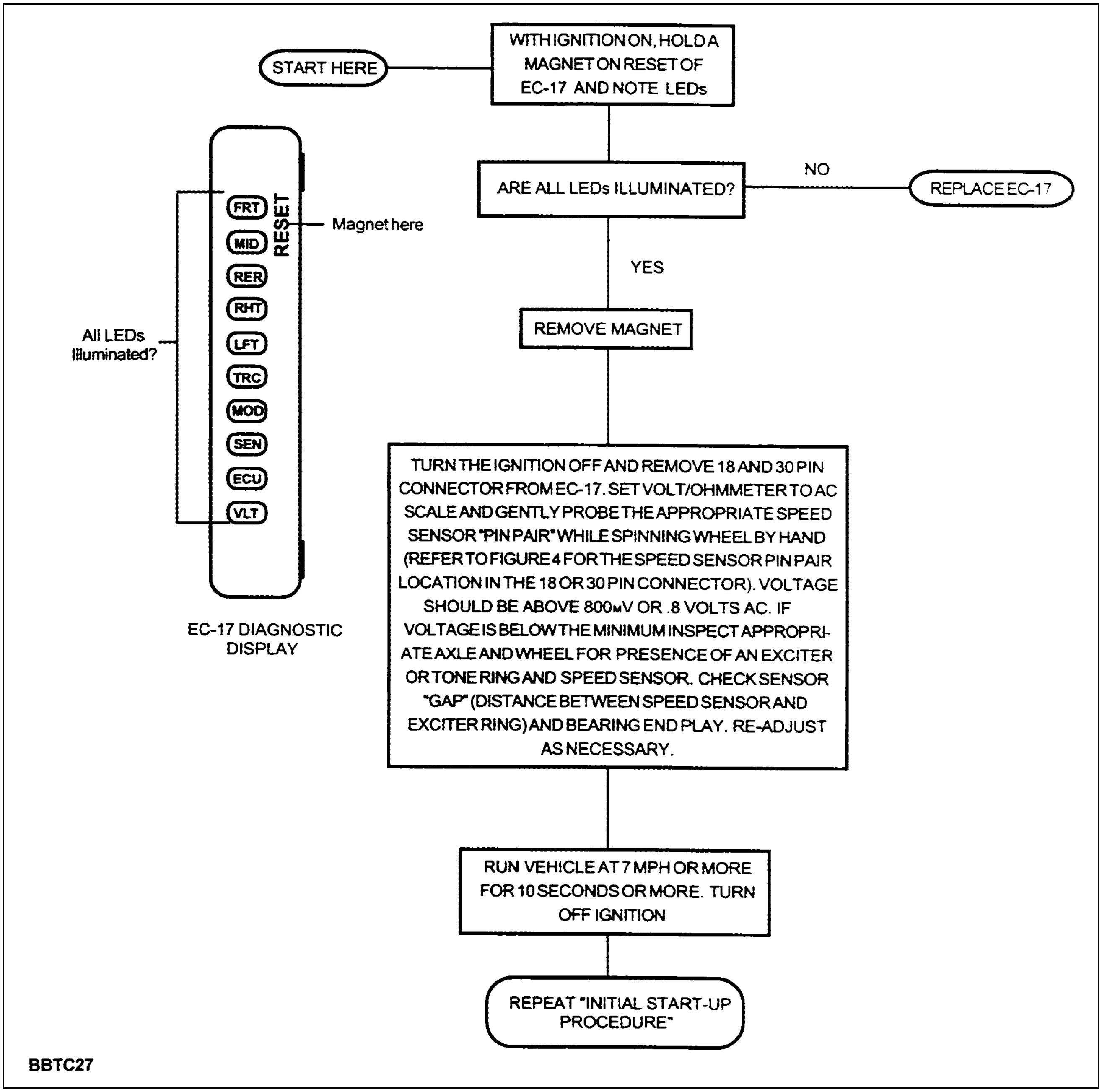

Figure 68—Testing for False Indication Caused by Wheel Speed Components

Section X - Testing Traction Control Dash Lamp

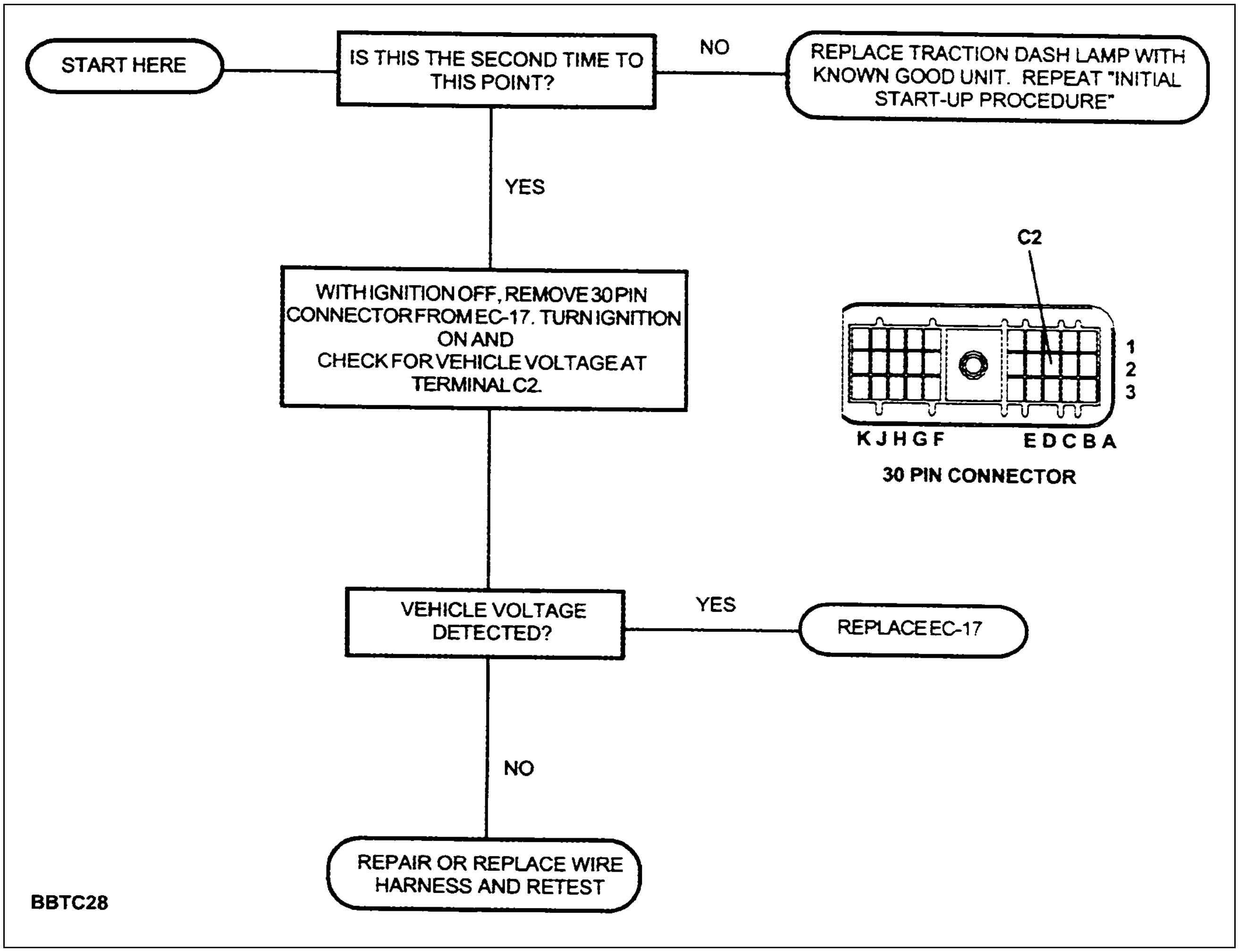

Figure 69—Testing Traction Control Dash Lamp

Section XI - Testing Traction Control Modulator

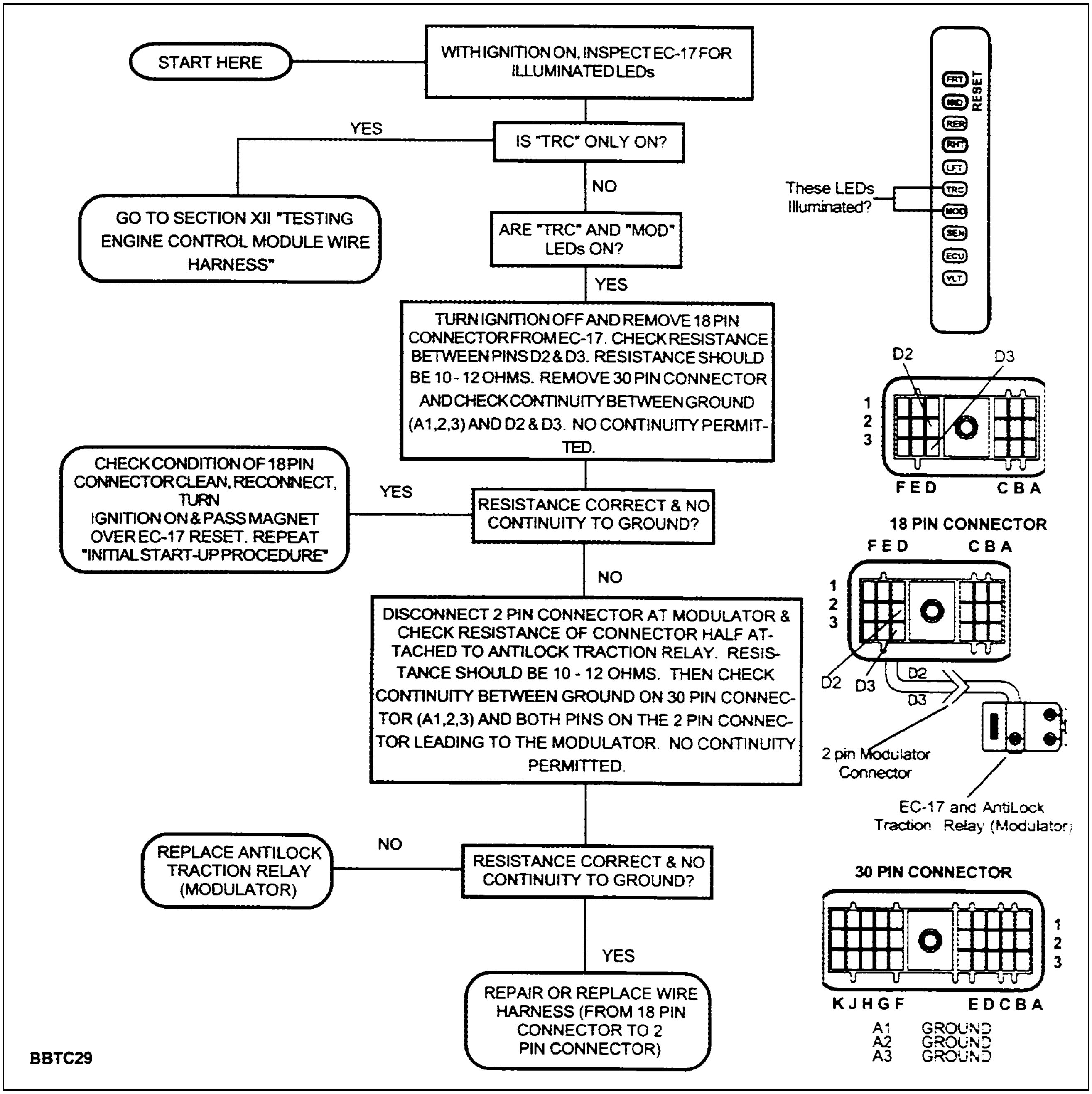

Figure 70—Testing Traction Control Modulator

Section XII - Testing Engine Control Module Wire Harness

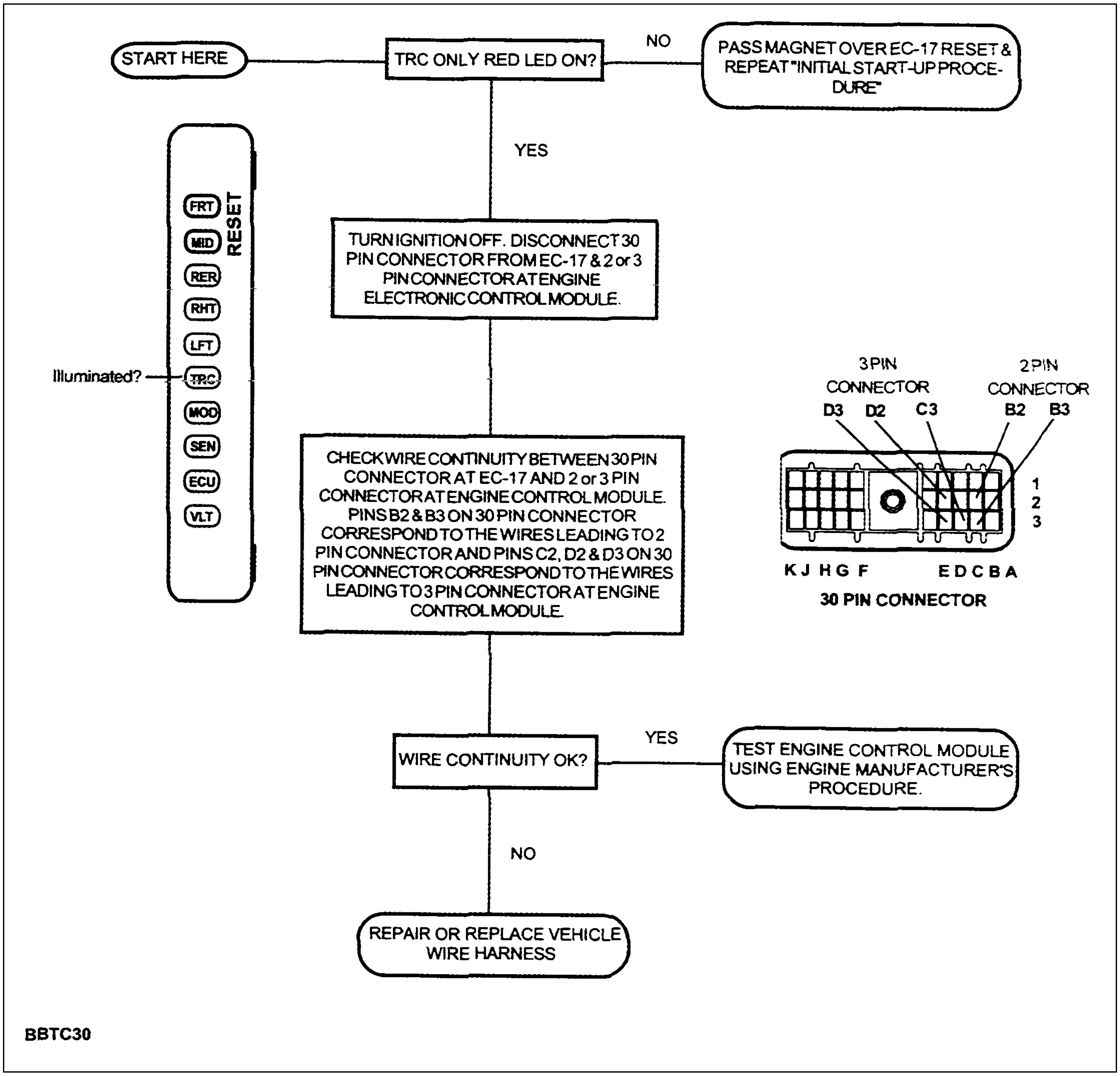

Figure 71—Testing Engine Control Module Wire Harness

Hydraulic Brakes

General

Dual hydraulic brake system receiving hydraulic boost from the vehicles power steering system incorporating an electric motor back-up boost in the event of a main system or engine failure.

Caution

Do not mix fluids in either the brake system or the boost system because premature brake system failure will occur.

The dual brake system gives the driver reasonable braking capacity in the event that either the front or rear brake circuit should fail. The brake system utilizes a glycol based hydraulic fluid (DOT), and the boost system utilizes power steering system fluid (DEXTRON).

The parking brake is a drum type brake installed on the output shaft of the transmission. Activated by a foot pedal and cable mechanism that rotates the bellcrank assembly that rotates the parking brake lever assembly that applies the brake shoes to the parking brake drum, that in turn locks the driveshaft preventing any further rear tire rotation. At this point, the parking brake is fully applied.

Routine Maintenance

Every three months, 25,000 miles or 900 operating hours whichever occurs first:

1. Check the brake fluid level of the master cylinder reservoir and replenish if necessary.
2. Check the Hydro-Max exterior and all the connecting lines for fluid leak. Remove dirt from the exterior of the Hydro-Max.
3. Check for the loose or disconnected electrical connections and damaged wiring.
4. Check the vehicle brake warning system (Reference Brake Booster and Warning System Troubleshooting) comparing the reaction of warning lights and buzzers to the vehicles handbook.
5. Check brake fluid level. The Bosch disc brakes self-adjust for lining wear. Brake fluid must be maintained to the correct level.

WARNING

FAILURE TO TIGHTEN HAND BRAKE LEVER LOCK SCREW MAY RESULT IN FAILURE OR DAMAGE TO THE PARK BRAKE. INCORRECT ADJUSTMENT COULD RESULT IN UNINTENTIONAL VEHICLE MOVEMENT.

Caution

Do not allow the cable to become twisted.

Note

Ensure that vehicle is on level ground with the wheels blocked to prevent rolling.

6. Loosen the lock screw located on the hand brake lever and relieve all tension on the cable by rotating the hand brake lever counter-clockwise.
7. Move the hand brake lever to the fully lowered position.
8. Disconnect and remove clevis from parking brake bellcrank assembly.
9. Perform maintenance (such as replacing shoes, drum, cable, or connecting linkage) as necessary.
10. Reconnect the cable to the bellcrank assembly and hold the brake lever in the full upright position bringing the shoes in contact with the drums.
11. Adjust the clevis on the cable to align the clevis holes with the brake lever hole. Insure minimum thread engagement.
12. Install clevis pin and cotter pin.
13. Raise the hand brake lever.
14. Adjust the cable at the hand brake handle. Turn the lever clockwise to obtain a peak resistance in the hand brake movement of 90 to 110 pounds (400 to 489N•m).
15. Tighten the lock screw located on the hand brake lever.

Brake Booster and Warning System Troubleshooting

Conditions	**Status**	**Fault**
Key Off-Brake Off	Motor Off	Normal
	Motor On	Relay stuck closed Stop light switch failed or out of adjustment. Pedal return spring out of adjustment or broken.
Key Off-Brake On	Motor On	Normal
	Motor Off	Blown stop light fuse Motor failed or disconnected Flow switch failed Stop light switch failed or out of adjustment Stop light switch diode bad.
	Warning Light /Buzzer Off	Normal
	Warning Light/Buzzer On	Ignition diode bad
Key On-Engine Off-Brake Off	Motor On Motor Off	Normal Motor faulty or disconnected. Relay faulty. Flow switch failed. Open in fusible link or relay feed from starter ignition diode bad.
	Warning Light/Buzzer On	Normal
	Warning Light/Buzzer Off	Booster module fault Buzzer and light both bad Buzzer fuse and light both blown. Ignition circuit fuse blown
	Light On/Buzzer Off	Buzzer bad Blown fuse Short in low coolant or Kysor® heater circuits.

Table 3—Brake Booster and Warning System Troubleshooting

---	Light Off/Buzzer On	Bulb burn out. Troubleshoot instrument cluster
KEY On-Engine On-Brake Off	Motor Off	Normal
---	Motor On	Low fluid flow Flow switch failed Pressure differential switch closed. Difference in front and rear system pressures. Switch failure. Relay faulty
	Warning Light /Buzzer Off	Normal
	Warning Light/Buzzer On	Low fluid flow Flow switch failed Motor failed or disconnected Open in fusible link or relay feed from starter. Pressure differential switch closed Difference in front and rear system pressure. Switch failure Open in wire or fusible link between pin E of booster module and relay. Bad brake booster module
Key On-Engine On-Brake On	Motor Off	Normal
---	Motor On	Low fluid flow Flow switch failed Pressure differential switch closed Difference in front and rear system pressure. Switch failure Relay fault

Table 3—Brake Booster and Warning System Troubleshooting continued

---	Warning Light/Buzzer Off	Normal
---	Warning Light/Buzzer On	Low fluid flow Flow switch failed Motor failed or disconnected Pressure differential switch closed Difference in front and rear system pressure. Switch failure Open in wire or fusible link between pin E of booster module and relay. Bad brake booster module

Table 3—Brake Booster and Warning System Troubleshooting continued

Note

Where failed components are indicated, check the integrity before replacing that component. Check continuity of the circuitry (wires, connectors, etc.) leading to and from that component.

Theory of Operation

Hydro-Max General Description

The Hydro-Max is a hydraulically powered booster in conjunction with a mini master cylinder that provides a power assist for applying hydraulic brakes. Together, they form the hydraulic brake actuation unit. The unit reduces the pedal effort and the pedal travel required to apply the brakes as compared to a non-power system.

- **The hydraulic booster configuration**

An open center valve and reaction feed back mechanism, a large diameter boost power piston. A reserve electric motor pump, and an integral flow switch. It is powered by either the bus power steering pump or by a pump dedicated solely to the booster.

A reserve electric motor pump provides a redundant source for the hydraulic booster. The pump's use is signaled by the integral flow switch.

The mini master cylinder is a split system type with a separate brake fluid reservoir and pistons. The output ports for the front and rear brakes systems, or a single system master cylinder, may be used where regulations are not applicable.

Hydro-Max Power Brake System Components

1. A hydraulically powered booster
2. A reserve electric motor pump
3. A hydraulic master cylinder
4. An integral flow sensing switch and warning system

Hydraulic Pump Operating Components

The Hydro-Max booster is positioned in the vehicle's hydraulic circuit integrated with the power steering gear.

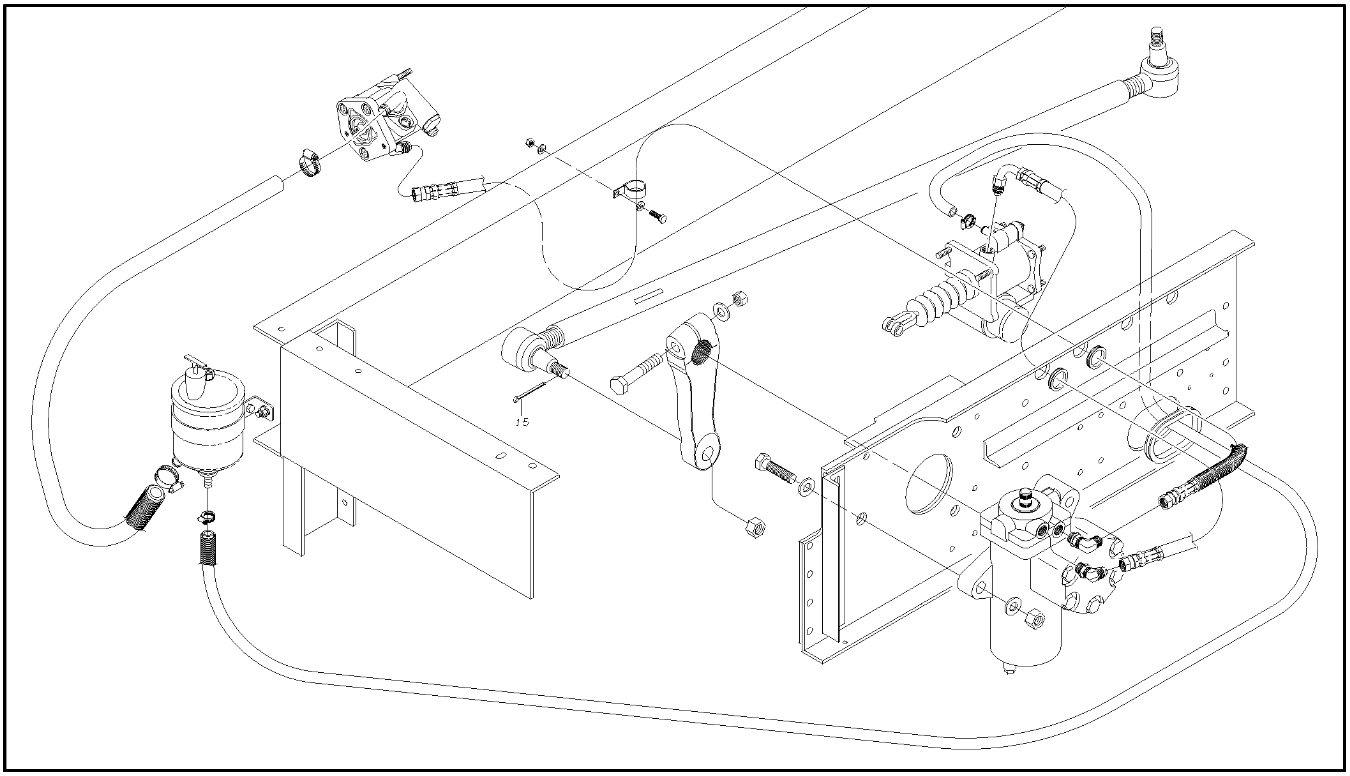

Figure 72—Hydraulic System Configuration

The Hydro-Max hydraulic booster operates in series with the power steering gear. The pressure demands during simultaneous steering and braking are additive (i.e., if steering requires 1200 psi and pump relief is 2100 psi, the booster will get 900 psi). See Figure 72—Hydraulic System Configuration.

The power steering gear must be balanced so that it can handle the pressures generated in the steering gear return line. It must also have an internal relief valve setting lower than pump relief. To allow the steering gear to relieve before the hydraulic pump does, it must also have an internal bypass to allow manual steering during reserve system operation.

The fluid flow path depicted is required to minimize the interaction between the power steering gear and the hydraulic booster.

The pressure line must be ½ inch flexible or rigid pressure line conforming to SAE J188 and be designed to run from the steering gear to the Hydro-max inlet.

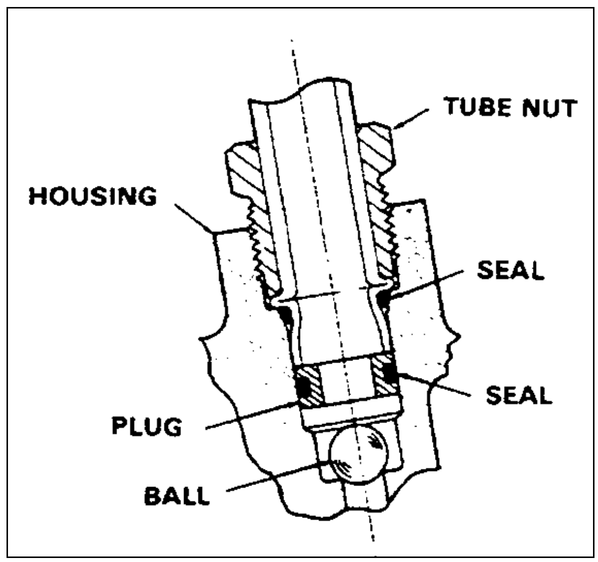

Figure 73—Hydro-Max Connections

The connections for the hose will consist of an adapter for the return side of the gear and the tube O arrangement for the Hydro-Max inlet. See Figure 73.

Electrical

1. A relay.
2. A 12 VDC battery.
3. A warning light for the pressure differential valve.
4. Electrical connectors and wiring.
5. Pedal activated brake light switch.
6. A buzzer.
7. A warning light for reserve motor.
8. A (optional) electronic monitor module.

Operation of the Hydro-Max Booster and Reserve Electric Motor Pump

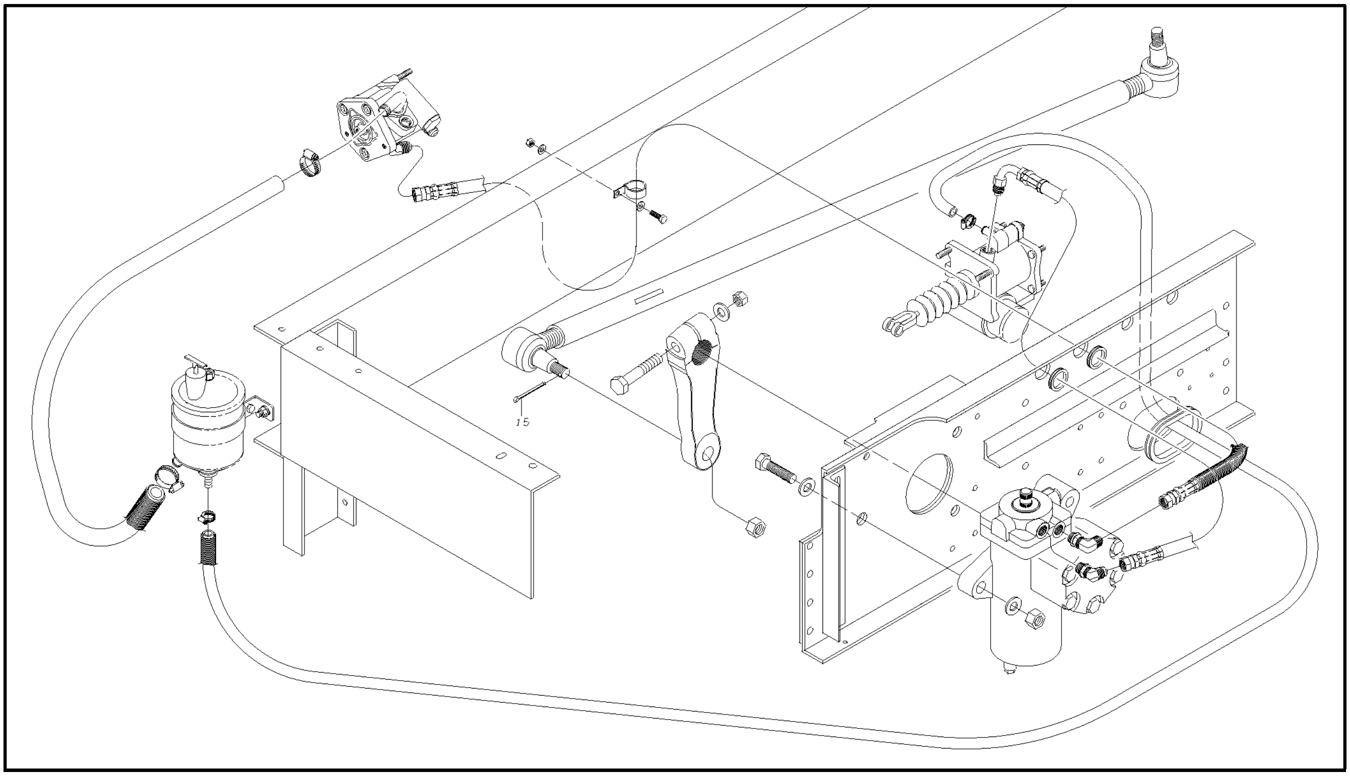

Figure 74—Booster Location

During normal system operation, fluid flow from a hydraulic power source (in the instance of the power steering pump), enters the inlet (pressure) port of the Hydro-Max booster, flows through the throttle valve and power piston, then through the flow switch and exits from the outlet (return) port (Figure 74).

Force applied to the brake pedal by the vehicle operator is multiplied by the lever ratio of the pedal mechanism to move the input pedal rod of the booster.

This movement activates the throttle valve, restricting flow through the power piston. The resulting pressure, acting on the power piston, applies a boosted force to the master cylinder primary piston.

A reaction piston, inside the power piston subassembly, provides the driver pedal feel during an application of the brake pedal.

Fluid flow through the flow switch opens the reserve motor pump electrical circuit during normal operation.

A separate check valve in the motor pump prevents back flow through the motor pump during normal applications.

In the event normal flow from the power steering is interrupted, the electric motor pump provides the power for reserve stops. Upon flow interruption, the integral flow switch closes, energizing a power relay, thereby providing electrical power to the motor pump.

During the reserve operation, fluid is retained within the booster by the inlet port check valve. The motor pump re-circulates fluid within the booster assembly with pressure built on demand via the throttle valve. The number of applications is limited only the electrical capacity of the vehicle.

Manual braking is also available in the event both the power and reserve systems are inoperative. Note the performance curve shown in Figure 75.

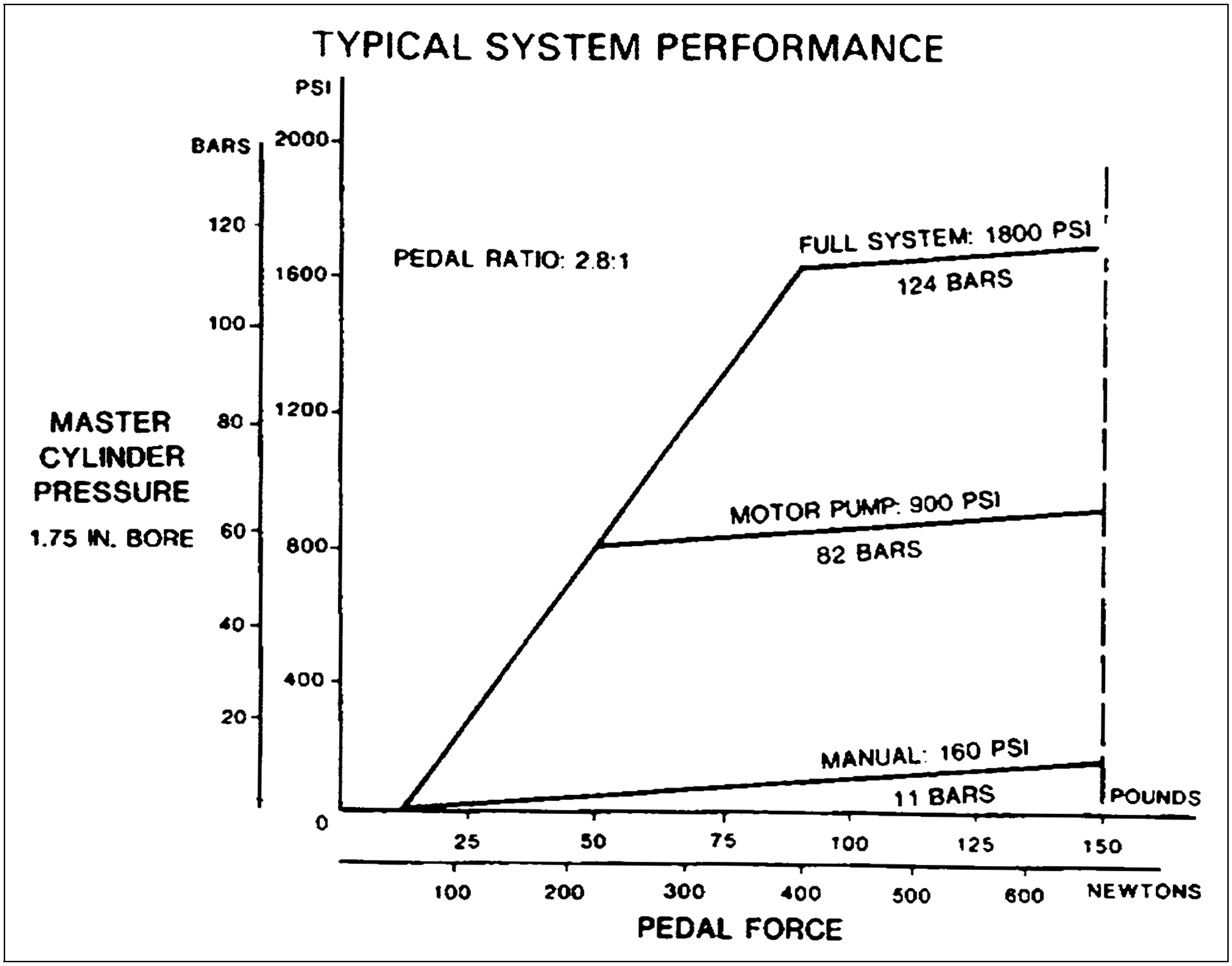

Figure 75—Performance Curve

Operation of the Mini Master Cylinder

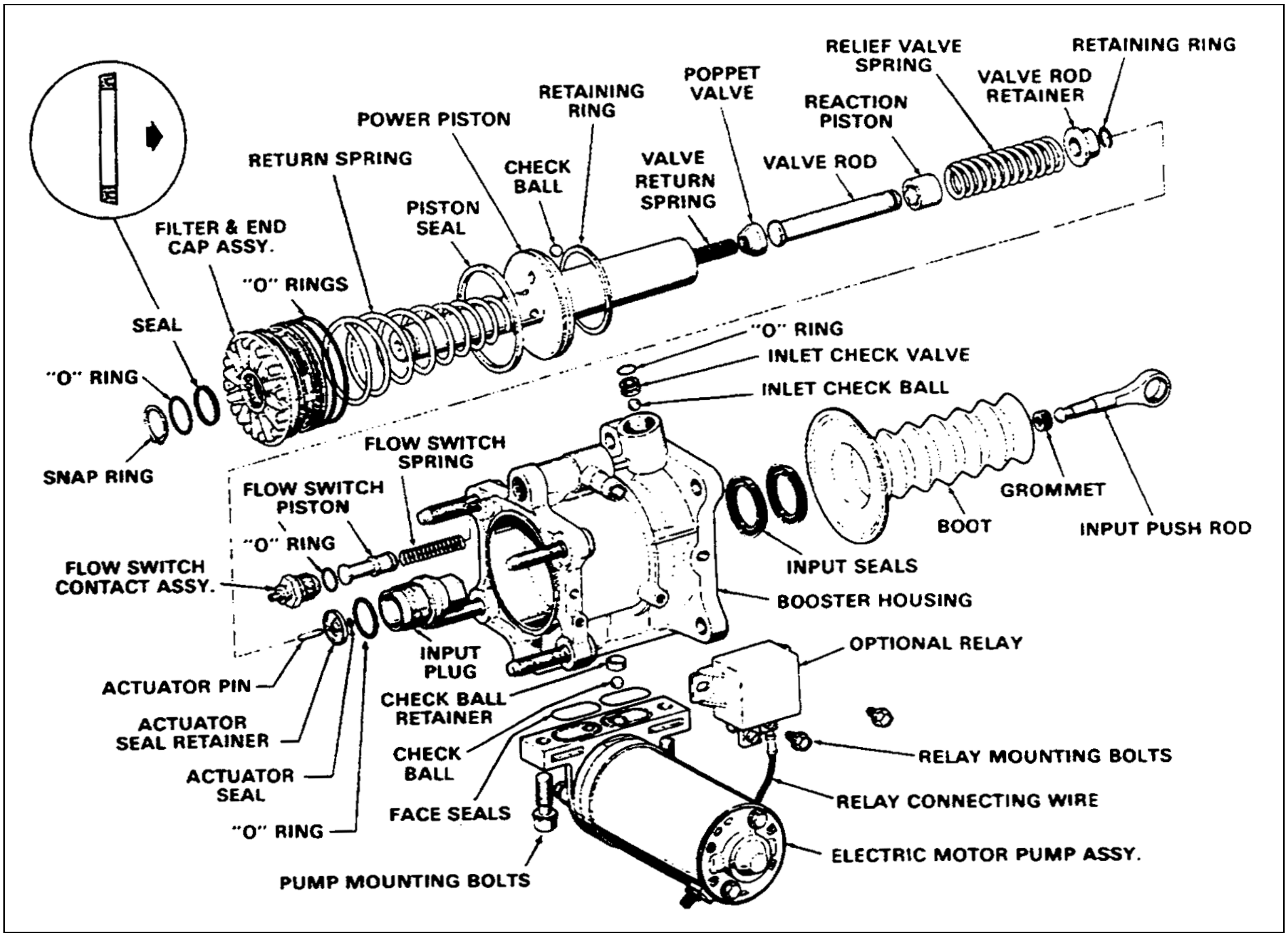

Figure 76—Master Cylinder Operation

Each pressure chamber has a piston/actuator subassembly containing a preload (caged) spring and a return spring (Figure 76). In the released position, actuators of both the primary and secondary pistons are in contact with their respective compensating valve stems, that project into the cylinder bore. This maintains the valves in an open position that allows hydraulic fluid in the reservoir to replenish any fluid displayed from the cylinder bore.

Initial forward travel of the primary piston moves the primary actuator away from its compensating valve counterpart permitting the valve to seat. Closure of this valve shuts off the passage between the primary pressure chamber and the reservoir section serving the primary chamber.

Further movement of the primary piston creates a pressure in the primary pressure chamber, causing the secondary piston and actuator to move. As the secondary piston and actuator move, the secondary compensating valve closes, shutting off the passage between the secondary pressure chamber and the reservoir section serving the secondary chamber. Additional movement of the primary piston causes both chambers to build pressure.

When the load on primary piston is removed, fluid pressure in each chamber, combined with return spring force, causes the primary and secondary pistons to return to their initial released positions. Each actuator opens its respective compensating valve, reopening the passage between the individual reservoir sections and its associated pressure chamber.

Should the rate or release be great enough to cause a partial vacuum in a chamber, the compensating valve will open to allow replenishment of fluid in the cylinder bore.

Any excess fluid remaining at the end of the stroke due to “pumping”, and/or volume change due to temperature fluctuation, is released as the compensating valve ports open.

Operation of Flow Switch and Warning Switch

The Hydro-max hydraulic booster has a reserve electric motor pump that will provide hydraulic boost for emergency operation.

The basic signal for operation of the electric motor pump comes from the integral flow switch (Figure 86) in the Hydro-max booster itself.

The interface of this electric motor with the vehicle's existing electrical system can be accomplished in at least two different ways.

The electric motor pump receives its power from the reserve system relay. The relay is in turn controlled by two dependent conditions.

First, the positive or power lead to the coil of the reserve system relay comes from the brake switch.

Second, the ground path for the coil of the relay is supplied by the Hydro-Max booster flow switch. When this switch is closed, a ground path is supplied to the relay coil. The flow switch senses flow through the booster. When the flow drops below a set point, the flow switch closes.

When power to the relay coil is available and the flow switch is closed, the relay energizes and supplies power to the reserve electric motor pump. Therefore, when the flow switch is closed and the brake pedal is depressed, the electric motor pump is operating and the reserve system is operational.

Operation of the Electronic Monitor Module

The electronic module receives power from two sources. The module is powered by the ignition switch; power is supplied when the ignition switch is in the run and start positions.

The second source of power for the module is received from the brake light switch. When the brake pedal is depressed and the brake switch closes, power flows to the brake lights and to the electronic module. Therefore, the module is powered anytime the vehicle ignition is turned on or anytime the brake pedal is depressed.

The Hydro-Max reserve system is powered by an electric motor pump. This electric motor receives its power from the reserve system relay.

The relay is in turn controlled by two dependent conditions. First, the positive or power lead to the coil of the reserve system relay from the electronic module. Second, the ground path for the coil of the relay is supplied by the Hydro-Max booster flow switch.

When this switch is closed, a ground path is supplied to the relay coil. This flow switch senses flow through the booster. When the flow drops below a set point, the flow switch closes.

Current is available to the coil of the relay whenever the module is powered.

When power to the relay coil is available and the flow switch is closed, the relay energizes and supplies power to the reserve electric motor pump.

Therefore, when the flow switch is closed and either the brake pedal is depressed or the ignition is on, the electric motor pump is operating and the reserve system is operational.

Brake Warning System

The brake warning system includes a buzzer and a dash mounted indicator. The light and buzzer will operate as a result of the following:

Engine is running, brakes not applied with a loss of electrical power to the electric backup pump motor.

Engine is running, brakes not applied with a loss of power assist from the power steering pump

Engine is running, brakes are applied and either the front or rear section of the system has failed. The backup pump buzzer and light will remain on even after the brake pedal has been released.

Engine is not running, brakes not applied, but ignition key is ON. This condition should happen every time the driver starts the bus. The bus should not be driven if the backup pump system is not working. The backup system should go off when the engine starts.

Note

With engine not running and ignition OFF, a depressed brake pedal will cause the backup to run with no light and buzzer.

Engine is running, brakes are applied, ignition is in ON or START position. This is a method for checking that the back-up pump system is not working. The backup system should go off when the pedal is released.

Without the assist of the power steering pump and without the assist of the backup pump, the master cylinder will allow the brakes to be applied. However, brake capacity will be very limited and the bus should not be driven under these conditions.

Parking Brake

The parking brake is designed to hold the loaded bus up to a 20% grade. The parking brake is not to be used as a normal service brake, but can be used to help stop in an emergency situation.

When the parking brake is applied, and the ignition switch is ON, a dash mounted yellow light labeled PARK will warn the driver that the brake is applied.

The bus should not be driven when the parking brake is applied.

Driving the bus when the parking brake is applied will prematurely wear the parking brake or damage other drive train components.

Remove Hydro-Max Booster

1. Park the bus on a level surface and prevent movement by means other than brakes.
2. Disconnect the negative terminal on battery.
3. Disconnect the Hydro-max input push rod from the brake pedal.
4. Detach the electrical power lead from the Hydro-Max pump motor.
5. Disconnect the electrical lead from the flow switch.
6. Disconnect the wires at the relay.

Caution

The master cylinder must be supported in some fashion so that the weight is exerted on the steel brake lines connected to the master cylinder.

Caution

Do not apply the brakes after removal of the input hose unless the reserve system is disconnected. Reserve boost pressure will blow the inlet check valve out of the booster.

7. Identify and remove the inlet and return hoses from the Hydro-Max.
8. Plug the ends of both hoses and the open ports of the Hydro-Max.
9. Remove the four cap nuts that secure the master cylinder to the Hydro-Max.
10. Support the master cylinder.
11. Remove the four bolts that secure the Hydro-Max to the bus and remove the Hydro-max.

Replace Hydro-Max Booster

1. Mount the Hydro-Max on the vehicle using four bolts.
2. Torque the mounting bolts to 18-25 pounds-ft (24.4-33.9 N·m).
3. Install the bus master cylinder on the Hydro-Max
4. Torque the four cap nuts to 25-30 pounds-ft (33.9-40.7 N·m).
5. Reconnect the vehicle inlet and return hoses to the Hydro-Max. Torque the inlet hose fitting to 16-25 pounds-ft (21.7-33.9 N·m). Do not over tighten the inlet hose. Stripping of the aluminum booster housing will result.
6. Reconnect the bus electrical power lead to the pump motor. Reconnect the vehicle electrical lead to the flow switch contact assembly. Reconnect the wires at the relay.
7. Reconnect the bus negative lead to battery.
8. Perform Refilling and Bleeding Hydro-Max. (See procedure in this group).
9. Perform Check Out Brake System. (See procedure in this group).

Refilling and Bleeding Hydro-Max

Caution

Do not use brake fluid. Use only clean power steering fluid. (Refer to Approved Hydraulic Fluids located in Group 120 Steering.)

1. Check hydraulic pump or power steering pump reservoir supplying Hydro-Max.

2. Fill with clean power steering fluid. (Refer to Approved Hydraulic Fluids located in Group 120 Steering.)
3. Crank engine several revolutions. (Do not start engine.) Check pump reservoir and refill if necessary.

Check Brake System

Before moving the vehicle, check the system for correct operation.

With engine off depress the brake pedal. The warning light and/or buzzer should come on and the electric motor should run, giving you some brake assistance.

Start the engine. Depress the brake pedal. No warning lights or buzzer or electric motor should come on. Check for leak.

Refer to Routine Maintenance (see procedure in this group) to perform a more comprehensive check of the systems integrity.

Stop the engine, check the fluid level in the power steering pump reservoir. Add fluid if necessary. (Refer to Approved Hydraulic Fluids located in Group 120 Steering).

Hydraulic Brake Components

The hydraulic brake system is comprised of hydraulic, electrical and mechanical components.

The hydraulic components consist of a fluid reservoir, master cylinder, Hydro-Max booster, and brake calipers.

The electrical components consists of a brake booster module, brake system relay, electric booster pump motor, flow switch, stoplight switches, engine brake warning buzzer, electrical wire harness, and electrical connectors.

The mechanical components are comprised of the parking brake system.

Remote Reservoir – The remote reservoir is connected to the master cylinder with two feed lines. When the brake pedal is activated, hydraulic fluid is compressed and activates the pistons in the brake calipers. The reservoir replenishes the displaced fluid.

- **Master Cylinder**

The master cylinder utilizes brake pedal effort to develop fluid pressure to activate the wheel cylinders.

- **Hydro-Max Booster**

The Hydro-Max booster assists the operator in providing reduced brake pedal effort and reduced travel required to apply the brakes. The friction developed between the rotor and brake pads provides the brake force required to stop the vehicle.

- **Brake Calipers**

When the operator presses on the foot pedal, hydraulic pressure is applied by the master cylinder to the pistons in the caliper, that press the brake pads against the rotor.

Electrical Components

- **Brake Booster Module**

Supplies power to the relay.

- **Brake System Relay**

Transfers power from the brake booster module to the electric booster pump motor.

- **Electric Booster Pump Motor**

Supplies hydraulic fluid to the Hydro-Max booster in case of hydraulic failure.

- **Flow Switch**

Senses hydraulic pressure

- **Stoplight Switch**

The stoplight switch senses pressure going to the brake calipers, and closes the circuit to illuminate stoplights.

- **Brake Warning Buzzer**

Activates a warning when hydraulic pressure is low.

- **Electrical Wire Harness**

Connects electrical components.

- **Electrical Connectors**

Connects electrical wire harness to electrical components.

Park Brake Components

The parking brake system is activated by a foot pedal that is attached to a cable. The cable is attached to the bellcrank assembly. That attaches to the parking brake lever by a parking brake yoke. The parking brake lever pushes the brake shoes against the parking brake drum.

Electrical Components

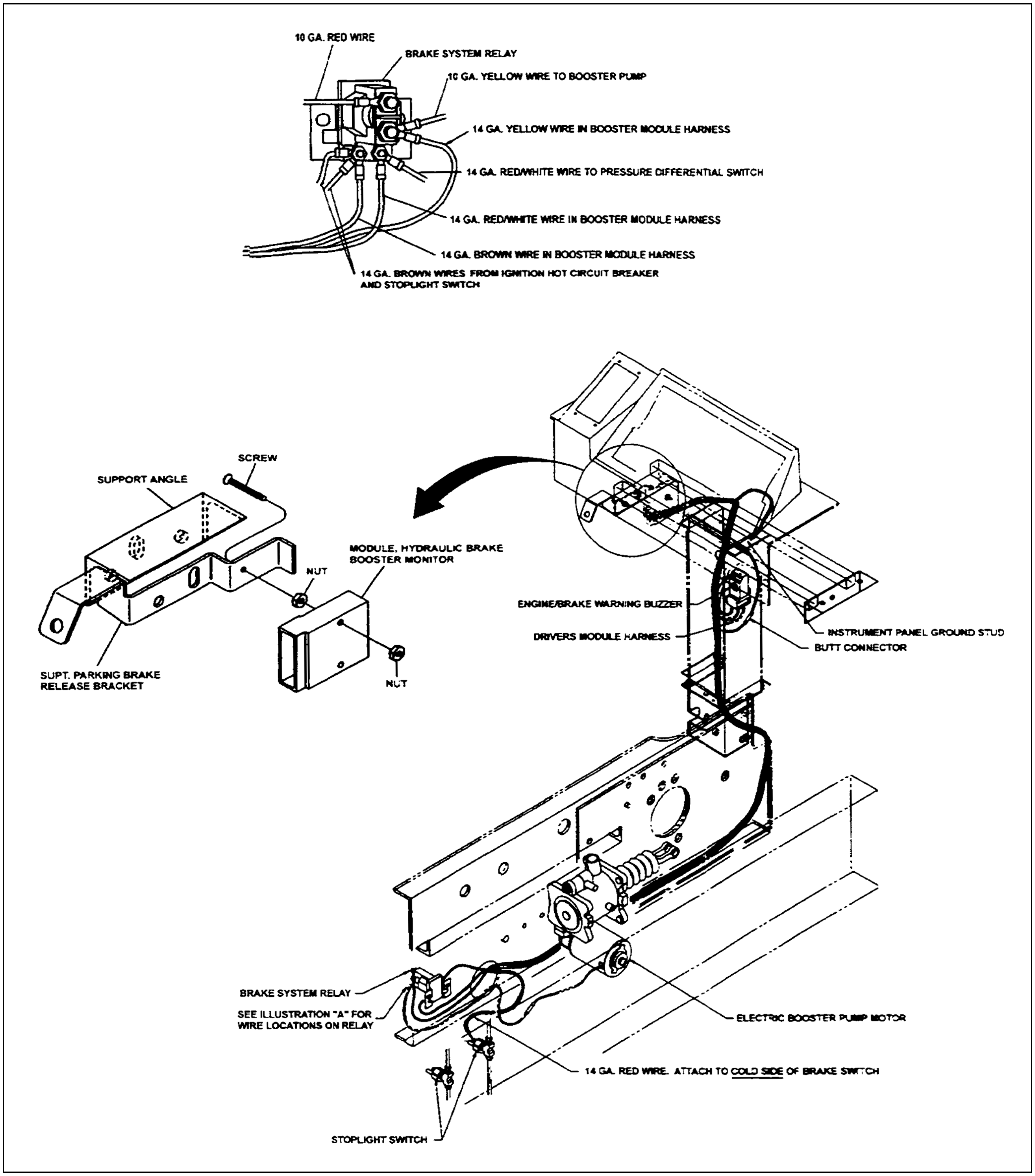

Figure 77—Brake Booster Electrical Components

Mechanical Components

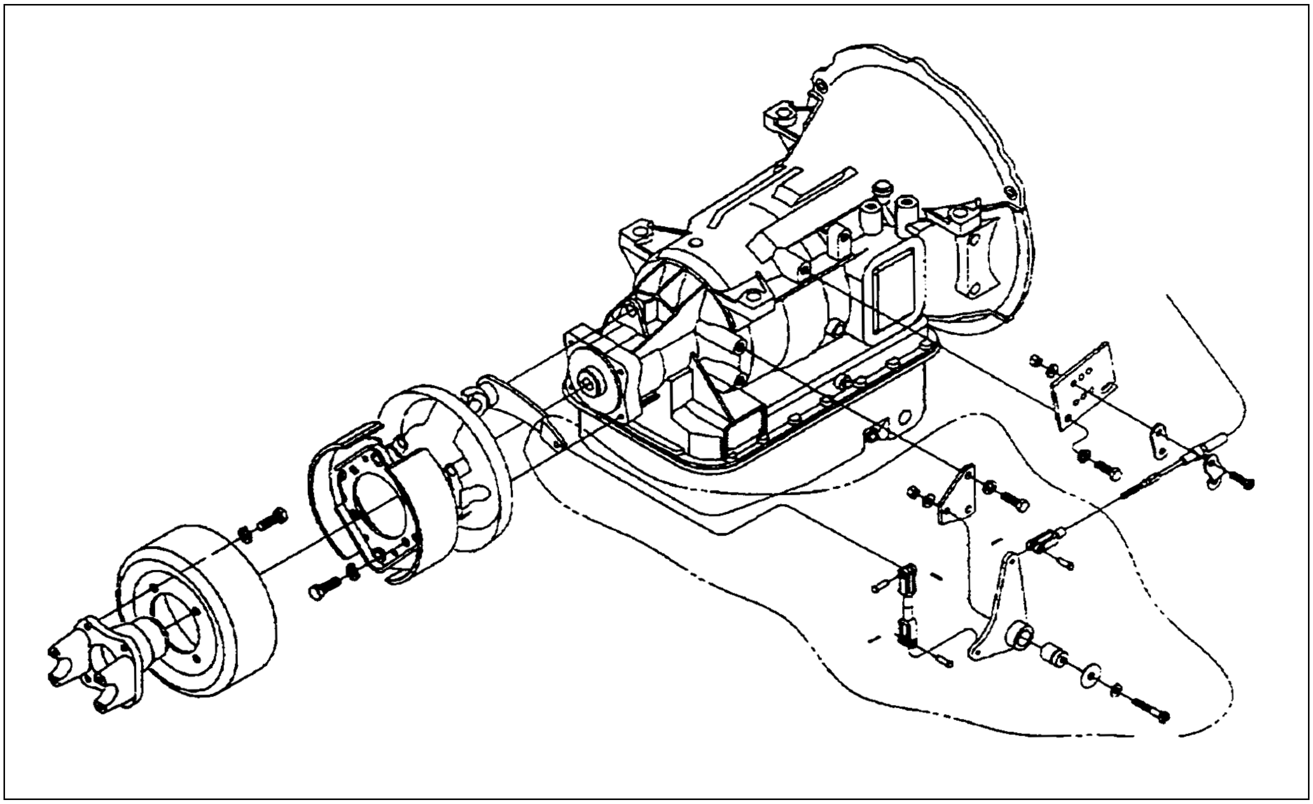

Figure 78—Park Brake Configuration

Troubleshooting and Diagnostics – Hydro-Max Power Brake System

Symptom	Cause	Remedy
Fluid leak between booster and master cylinder.	Worn or damaged master cylinder primary pressure seal or back-up ring.	Repair or replace master cylinder.
	Worn or damaged seals or O-rings in booster end cap assembly.	Repair or replace booster.
Fluid leak on booster or booster pump. (Power steering pump)	Damaged or missing seals at booster and electric motor pump mating surface.	Replace seals.
	Loose pump belt.	Tighten belt to specified tension.
	Excessive output pressure at pump.(Gauge at inlet line to booster pump reads 5515 kPa (800 psi) at least before pedal is hard.	Replace pump.
	Binding pedal rod linkage	Repair cause of restriction. Replace components as required.
	Worn or wet brake linings.	Repair or replace brake linings
Sluggish booster operation with little or no assist.	Slipping belt.	Replace belt if required. Tighten belt to specified tension.

Table 4—Troubleshooting and Diagnostics – Hydro-Max Power Brake System

---	Low fluid level in booster pump reservoir.	Refill to specified level.
	Binding pedal rod linkage.	Remove restriction. Replace components as required.
	Restricted hose or line.	Remove restriction in hose or line.
	Worn or damaged booster.	Repair or replace booster.
	Air in fluid.	Bleed system.
	Internal wear or damage in booster pump.	Replace booster pump.
	Motor pump check valve leaking in booster.	Check booster pump pressure at inlet with full brake application. Replace electric motor pump if low pressure is noted.
Electric motor pump does not operate with engine off, ignition off and brake pedal depressed.	Brake switch out of adjustment.	Adjust.
	Brake switch worn or damaged.	Replace switch.
Electric motor pump does not operate with engine off and ignition on.	Ignition switch or connecting wires.	Check condition of switch and wiring replace as necessary.
	Loose, disconnected or broken power lead wire at motor pump.	Repair or replace.
	Loose, disconnected or broken flow switch wire.	Repair or replace.
	Inoperative motor pump relay.	Repair or replace.
	Inoperative booster flow switch.	Repair or replace.
	Inoperative electronic monitor module.	Replace monitor module.
	Inoperative electric motor pump	Check operation and replace as required.
Electric motor pump runs continuously with ignition off and brake pedal NOT depressed.	Brake light switch.	Adjust, repair or replace.
	Inoperative, damaged motor pump relay.	Replace.
	Inoperative electronic monitor module.	Replace monitor module.

Table 4—Troubleshooting and Diagnostics – Hydro-Max Power Brake System continued

Premature lining wear/dragging brakes	Brake drag and associated premature lining wear is caused either by the brakes being applied when they shouldn't be, or the brakes not fully releasing after an application. Check the brake pedal to be sure it is fully released and is not binding. Check the position of the brake light switch. It should not interfere with brake pedal travel.	If binding repair or replace brake pedal mechanism and/or brake light switch.
---	On sliding-caliper disc brakes, make sure the calipers are free to slide on their pins or rails. On any type of disc brake, check the condition of the piston seals. A damaged, swollen or deformed seal can cause the piston(s) to hang up and not allow the pads to clear the rotor.	Replace piston seals.
---	Spin the front wheels to be sure they are free. With wheels spinning, start the engine but don't apply the brakes. When the wheels stop spinning, check for brake drag. If present, it's likely that the booster is defective	If brake drag is present, it's likely that the booster is defective, repair or replace booster.
Low or sinking pedal	Common cause is air in the hydraulic system. The fix may be as easy as bleeding the brakes. Check the hydraulic system: Pump the brakes several times with the engine off. Then hold steady pressure on the brake pedal. If the pedal sinks gradually.	If air in system bleed system.

Table 4—Troubleshooting and Diagnostics – Hydro-Max Power Brake System continued

---	If you can't find any signs of external leak anywhere, the internal seals in the master cylinder have failed.	Check wheel cylinders, lines, hoses and connections for external leak. Any detected repair or replace as needed. Replace seals in master cylinder.
Pulsing pedal	In any brake, friction material needs a smooth, flat rotor to rub against. Unfortunately, no rotor stays flat. Remember, a brake is a heat machine. It turns the energy of slowing a vehicle into heat, by way of friction. Heat, in turn, rearranges the molecules in metal, and warps occurs, making proper brake adjustment impossible. In a hydraulic system, the first indication of warping is a pulsing sensation felt through the brake pedal as the brakes are applied while the vehicle is moving (not to be confused with the pulsing induced by anti-lock brakes during a panic stop). The pulsing is generated as the linings or pads settle into a low spot in the drum or rotor, then are intermittently forced away by high spots as the wheel turns. Brake fluid is intermittently compressed and released in the wheel cylinder or caliper. The resulting pressure waves are transmitted back to the master cylinder and, ultimately, to the driver's foot.	The fix is to machine or replace the rotor. Remember, though, once a rotor is machined, valuable heat-absorbing metal has been removed and warping is likely to re-occur.

Table 4—Troubleshooting and Diagnostics – Hydro-Max Power Brake System

Repairing the Hydro-Max Brake Booster

After troubleshooting the brake system and if it is determined that the Hydro-Max booster is not functioning properly, replace the defective Hydro-Max assemblies with new or remanufactured assemblies rather than local repair. Use genuine Blue Bird maintenance kits.

Blue Bird seal bullet is used to install the power piston in the booster housing on units found on 1981 and earlier model year vehicles.

The bullet to install the power piston in the end cap and filter assembly on all Hydro-Max units must be fabricated. (Refer to Figure 79). Disassembly and assembly should not be attempted without a kit.

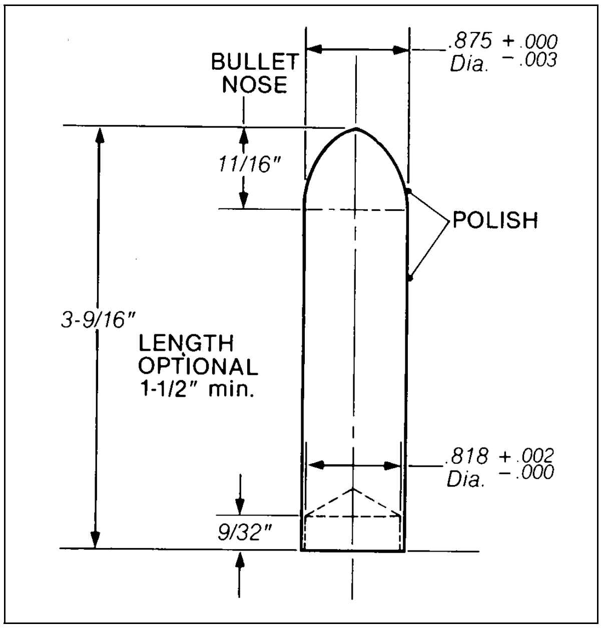

Figure 79—Power Piston Installation Tool

Hydro-Max Brake Booster Disassembly

1. Remove the cap screws securing the relay to the booster housing (if equipped). See Figure 80 and Figure 81.
2. Remove the two cap screws that secure the pump motor.

Note

Approximately three cups of oil will drain out of the booster when the pump is removed Avoid damaging the mating surfaces when removing the pump motor.

3. Remove and discard the two pump motor oval O-rings.
4. Remove the boot from the input push rod.
5. Push in on input push rod to force power piston assembly from booster. (Rotate end cap to ease piston removal).

Caution

During piston removal, pull straight out on piston to avoid scratching rear piston on external bore surface area. Handle piston with care. Aluminum surface will scratch easily.

6. Remove and discard the two power piston input seals from the rear of the booster housing.
7. Disassemble the flow switch. There are two types of flow switch assemblies. The flow switches are different in the method which the flow switch contact assembly is retained.

Threaded Contact Assembly

1. Remove the contact assembly.
2. Remove and discard the O-ring from the contact assembly.
3. Extract the flow switch piston and spring use a small magnet.

Snap Ring Contact Assembly

1. Press in on the contact assembly until tension is removed from the snap ring that retains the contact assembly.
2. Remove and discard the snap ring.
3. Remove the contact assembly.
4. Remove and discard the O-ring.
5. Extract the flow switch piston and spring use a small magnet.

Caution

Do not clamp onto power piston.

6. Clamp input push rod in vice.
7. Push against the filter and end cap assembly compressing the return spring ¼ - ½ inch.
8. Remove the snap ring, filter and end cap assembly and return spring.
9. Discard the snap ring.

Caution

Do not overtighten the vise.

10. Clamp the flat of the input plug in a vise.
11. Remove the input plug assembly, grasp the large diameter of the power piston by hand.
12. Rotate counterclockwise.

Note

Do not grip the piston surface with any tool. If additional leverage is required, a drift may be inserted through the flow holes in the output shaft.

Do not disassemble the valve rod and reaction piston assembly.

13. Remove the valve rod and reaction assembly, poppet valve and valve return spring from the power piston.
14. Pry the actuator seal retainer from the input plug and discard.
15. Remove actuator pin and discard actuator seal.
16. Remove and discard input plug and O-ring.
17. Remove and discard the O-ring and lip seal from the ID of the filter and end cap assembly.
18. Remove and discard both O-rings from the OD of the filter and end cap assembly.
19. Remove the inlet check valve and O-ring from the inlet port of the booster housing use a hooked piece of wire.
20. Discard O-ring and the inlet check ball.
21. Clamp the input plug flats in a vise.
22. Insert a 5/8-inch rod as a lever carefully pull the input push rod out of the input plug. A load up to a 100 pounds may be required to pull the rod from the plug.

Note

If the input plug is the blue plastic type, special care should be taken in clamping not to damage it. All rubber debris from the smeared grommet must be completely removed from the input rod and plug.

23. Remove and discard the grommet from the input push rod.

Cleaning

Use clean power steering fluid for cleaning and lubricating parts and seals.

Inspection

1. Inspect the piston input and output shaft surfaces for scratches or nicks.
2. Inspect the large piston seal surface is smooth without excessive wear.
3. If any defects are found, replace the power piston assembly.
4. Confirm that the check ball is in place and is cleaned free to move.
5. Confirm that the reaction piston bore and poppet seat surface inside the piston are clean and undamaged.
6. Inspect housing for grooves, scratches or nicks in the input bore area. If any are found replace the entire Hydro-Max assembly.
7. Inspect the input plug for wear in the actuator pin hole. Replace plug if wear is evident.

Note

The blue plastic input plug is not available for service replacement and is not interchangeable with the aluminum input plug.

8. Replace the filter end cap assembly if cracked or damaged. The 12 rib cage is interchangeable with the 4 rib cap.
9. Remove the three largest OD O-rings from the kit.

Note

Two of the three are identical in thickness with the third O-ring being noticeably thicker.

Does the filter end cap assembly have four or twelve ribs? If the cap is the four rib version, discard the thickest O-ring of the three.

10. Install the two identical O-rings in their respective grooves on the OD of the cap.
    - If the cap is the 12 rib version as illustrated, discard one of the two thin O-rings.
11. Install the thick O-ring in the OD groove closest the end cap ribs and the thin O-ring in the other OD groove.
12. Remove the one inch OD O-ring and the smallest of the three lip seals in the kit.
13. Lubricate and install the O-ring and lip seal in the appropriate grooves in the ID of the filter and end cap assembly.

Caution

Make sure that the lip of the lip seal faces the power piston when the filter and end cap assembly is installed on the power piston shaft. Incorrect orientation of the seal will allow pressurized fluid to leak from the interior of the Hydro-Max booster. Refer to Figure 66 for proper assembly.

14. Install the grommet on the input push rod.
15. Insert the input push rod into the plug. Ensure the grommet is completely seated in the input plug and is capable of retaining the input push rod.

Caution

If the input push rod is not properly installed, the push rod could become disconnected from the input plug. The result will be no brake condition.

Do not clean parts with brake fluid. Use only fresh clean steering fluid.

16. Lubricate and install the actuator seal (smallest seal in kit) in the recess inside of the input plug.
17. Lubricate and insert the actuator pin in the seal
18. Install the actuator seal retainer in the input plug with its flat side toward the input plug.
    - Of the O-rings remaining in the kit remove the two with the largest diameter.

Note

If the input plug assembly is aluminum, install the 1-3/16 inch OD O-ring and discard the remaining O-ring. The correct one is the thinner of the two. If the input plug assembly is blue plastic, install the 1-5/32 inch OD O-ring and discard the remaining O-ring. The correct one is the thicker of the two.

19. Remove the two remaining lip seals from the kit.
20. Lubricate and install both seals in the small ID of the booster housing bore. The lip of both seals should be face the interior of the booster housing.

Note

Of the three remaining O-rings in the kit two are identical in size with the third slightly larger in diameter.

21. Lubricate and install one of the small diameter O-rings in the groove of the inlet check valve.
22. Install the inlet check ball in the inlet port of the booster housing.
23. Lubricate and install the assembled inlet check valve and O-ring in the inlet port.
24. Push the inlet check valve in until it comes to rest.
25. Install the flow switch spring and then the flow switch piston in the booster housing.
26. Determine the type of flow switch contact assembly that is in use.

- **Threaded Contact Assembly**
    - If the contact assembly in use is threaded, lubricate.

27. Install the larger diameter of the two remaining O-rings on the contact assembly.
28. Install the contact assembly in the booster housing and torque to 20-40 pound-inch (2.-4 N•m).

Caution

Do not overtighten the contact assembly. A failed and leaking assembly will result.

Discard the remaining small diameter O-ring and the plain wire C type snap ring. Do not confuse the C ring with the Tru-Arc type snap ring that will be installed later on the power piston shaft.

Snap Ring Contact Assembly

1. If the contact assembly requires a snap ring to secure in the booster housing, lubricate and install the smallest of the two remaining O-rings on the contact assembly.
2. Install the contact assembly in the booster housing.
3. Install the C type snap ring to secure it. Be sure that the type snap ring is fully seated in its groove.
4. Discard the last remaining O-ring.
5. Install the return spring on the output shaft of the power piston, small end first.
6. Lubricate the lip seal and O-ring in the ID of the filter and end cap assembly.
7. Install on the piston shaft to prevent damage to the lip seal in the end cap assembly.
8. Install a fabricated seal bullet on the end of the shaft and depress the end cap onto the shaft until the snap groove on the piston shaft is exposed.
9. Install the Tru-Arc type snap ring on the piston shaft and make sure the snap ring is fully seated in its groove.

Note

It is strongly recommended that a fabricated seal bullet tool be used to install the filter and end cap assembly.

The tape must be applied in such away that it covers the snap ring groove and forms a smooth forcing surface for the lip of the seal.

10. Re-lubricate with clean power steering fluid. Install the poppet valve return spring in the hollow end of the power piston.
11. Install the poppet valve.

Note

Be sure the poppet valve is installed with coned shaped end toward the return spring. Refer to Figure 81 for proper assembly.

12. Install the valve rod and reaction piston assembly in the hollow end of the power piston.
13. Insert the reaction piston end in the power piston first.

Note

The next phase of assembly will depend upon the type of input plug in use on the power piston. If the aluminum plug is in use, proceed to step 17. If the input plug is blue plastic, proceed to step 19. The plastic and aluminum plugs are not interchangeable.

14. Screw the input plug and push rod assembly into the power piston and hand tighten. Clamp the input plug flats in a vise and firmly hand tighten the power piston and plug until seated. Do use tools to tighten.
15. Lubricate the exterior of the input plug and power piston input shaft.
16. Insert the power piston in the booster housing with a gentle twisting motion. Proceed to Step 21 of the assembly instructions.

Note

While it is strongly recommended that a seal bullet be used to install the power piston, in an emergency, the following alternate method may be of use.

17. Install a seal bullet (Bendix tool 74015) over the open end of the power piston input shaft and lubricate the bullet and shaft.
18. Install the power piston using the seal bullet to start the piston shaft through the two lip seals in the booster housing.
19. Install the blue plastic input plug in the hollow end of the power piston and tighten by hand.
20. Wrap plastic electrical tape around the input plug so that a smooth forcing surface is formed for the two lip seals in the booster housing.

21. Ensure that the tape is not wrapped on any portion of the major diameter of the plug or shaft.
22. Install the power piston.
23. Inspect the tape. If fragments of the tape are missing, remove the power piston from the booster housing. Remove all tape fragments and use a seal bullet to reinstall.
24. Install the blue plastic input plug and firmly hand tighten until seated. Do not use tools to tighten.
25. Lubricate and install the two oval face seals in the grooves of the electric motor pump assembly.

Note

Before installing the electric pump motor assembly on the booster housing, check to be sure that the motor pump check ball and retainer is present in the delivery port.

26. Secure the pump to the housing using two cap screws.
27. Torque the cap screws 18-25 foot-pounds (24-33 N•m).

Caution

The electrical pump motor assembly can be incorrectly installed. The pump motor must be installed with its delivery port closest to the input push rod end of the booster housing.

The position of the inlet and return ports on the booster housing should have the same relationship to the delivery and return of electric pump motor assembly.

A check ball is visible in the delivery port of the electric pump motor. Do not mar the mating surfaces when installing the pump motor on the booster housing. Install the boot on the input push rod.

If the optional electrical relay is in use, secure to the booster housing using two cap screws. Torque the cap screws to 35-50 pound-inch (4-5 N•m).

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