SERVICE MANUAL SECTION

ANTILOCK AIR BRAKE SYSTEM: BENDIX

Vendor: BENDIX
Unit Code: 04AZA

S04023, Formerly CTS-5113

05/30/1996

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1. DESCRIPTION

1.1. ANTILOCK SYSTEM OPERATION OVERVIEW

During a brake stop, the maximum point of deceleration occurs just before wheel lock-up. When wheels lock up, stopping distances increase and loss of directional control may occur.

To reduce wheel lock-up, the antilock brake system monitors the rotational speed of the wheels using sensors mounted on the axle ends and exciter rings mounted on the wheel assemblies.

When the wheels rotate, an AC voltage pulse is generated by the sensors that is transmitted to the Electronic Control Unit (EC–15) (Component Identification Table) which is part of the CR–15 relay valve/ECU assembly. The ECU monitors the pulse rates. During a brake application, if a wheel(s) is about to lock up, the ECU sends a signal to the appropriate M–21 modulator valve(s).

Within a fraction of a second, the modulator valve responds by repeatedly exhausting air from the brake chamber(s) allowing the wheel(s) to speed up, and then automatically applying air (much like a driver pumping the brakes manually). The antilock system only operates when the ECU determines that a wheel is about to lock up.

A warning light on the instrument panel illuminates when the ECU detects a problem with the system. If the vehicle includes an engine brake, the ECU will dis–engage the engine brake when it senses a wheel lock–up is about to occur on the rear wheels.

1.2. FOUR–CHANNEL SYSTEM (CODE 04AZA)

The four–channel antilock brake system controls the rear axle brakes (both axles with 6x4) and the front (steering) axle. Wheel sensors are installed at each rear wheel (with 4x2), or with a 6x4, on one rear axle (one on each wheel end), and one sensor on each front axle wheel end.

The front axle has an M–21 modulator valve for each wheel, so that each front wheel/brake assembly is independently controlled by the CR–15 Relay Valve/ECU. The rear axle has separate a M–21 modulator valve for the right and left side of the vehicle. With a 6x4, the left modulator valve would control the forward rear and rear rear axle brakes on the left side, and the right side modulator valve controls the right forward rear and rear rear brakes. The CR-15 Relay Valve/ECU controls both front M–21 modulator valves and the two M–21 modulator valves for the rear axle(s).

Table 1 Component Identification

Component	Component Code
Electronic Control Unit	ECU or EC–15
Relay Valve	AR–1
Electronic Control Unit (ECU)/Relay Valve Assembly	CR–15
Modulator Valve	M–21
Quick Release Valve	QRV

2. OPERATION

2.1. OPERATION PHILOSOPHY

Rear Axle Brake Operation With 4x2 Chassis

Refer to Figure 1 for the following discussion. Also refer to COMPONENT LOCATIONS(See CIRCUIT DIAGRAM, page 65) for additional illustrations on system installations.

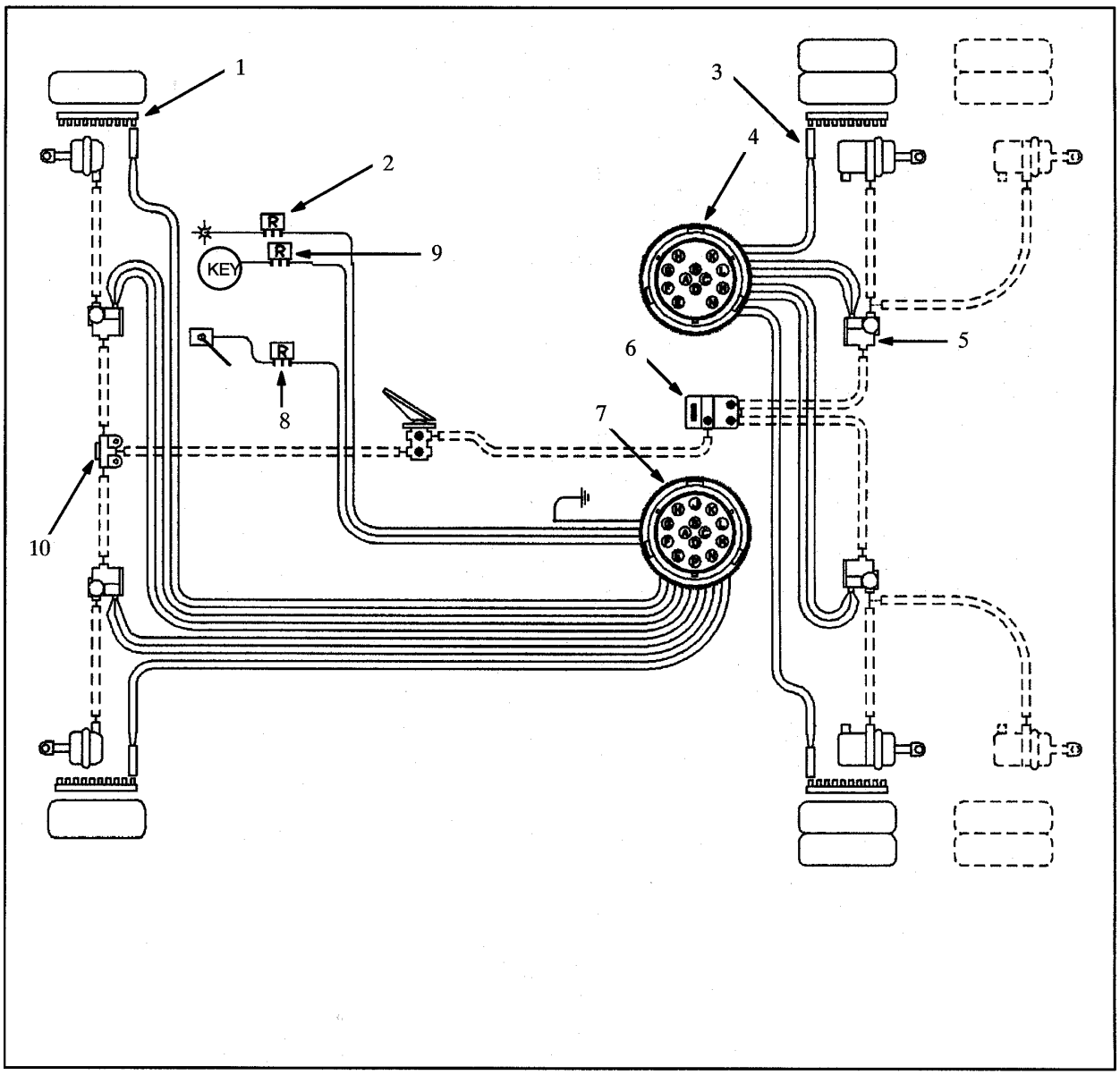


Figure 1 Typical Antilock Brake System

1. EXCITER RING (4 PLACES)
2. WARNING LIGHT RELAY
3. WHEEL SPEED SENSOR (4 PLACES)
4. C350 CONNECTS REAR HARNESS TO ITEM 6
5. M-21 MODULATOR VALVE (4 PLACES)
6. CR-15 RELAY VALVE/ECU CONTROLLER
7. C288 CONNECTS FRONT HARNESS TO ITEM 6
8. ENGINE BRAKE RELAY
9. CRANK RELAY (POWER SUPPLY TO CR-15)
10. QUICK RELEASE VALVE (QRV)

The antilock system provides individual wheel control by using a wheel speed sensor and modulator at each wheel to measure rotational speed. By monitoring the rate of deceleration during braking, and then modifying

the service brake application pressure at each wheel, the ECU is able to provide improved vehicle braking, while maintaining vehicle stability.

The rear axle brakes are controlled completely independent of each other and brake application pressure at an individual wheel is adjusted solely on the basis of its behavior on the road surface on which it is traveling.

Rear Axle Brake Operation With 6x4 Chassis

With vehicles equipped with tandem rear axles (6x2 or 6x4), the wheel speed sensors are installed at the wheels, located on the axle that is most likely to lose traction first. With a 4–spring suspension, the rear axle sensors are located on the Forward Rear axle. On an air suspension, sensors are located on the Rear Rear axle. A single modulator controls both left side rear axle brakes and another modulator controls both right side rear axle brakes. With this arrangement of wheel speed sensors and modulators, both brakes on one side of a tandem rear axle will be modulated as one, since they will most likely be on the same type of road surface.

Front (Steering) Axle Brake Operation

While each steering axle brake is under the control of an individual modulator valve, the ECU does not treat these brakes totally independent of each other. The ECU utilizes a modified individual control method for steering axle brakes. This is done to minimize "steering wheel pull" in the event that one front wheel is on dry pavement and the other is on a slippery surface, such as ice or snow. The ECU controls the braking force differences between the two brakes. The wheel on dry pavement is initially given less braking force and is brought up to optimum during the stop, while the wheel on ice attempts to maintain optimum braking during the entire stop.

2.2. NON–ANTILOCK BRAKE APPLICATION

Rear Axle(s)

During normal braking, control air pressure from the brake valve (foot valve) enters the service port of the service relay valve (part of the CR–15 Relay Valve/ECU assembly). The relay valve also receives air from the vehicle’s primary air reservoir. The service relay delivers air to, and through, the antilock modulators located near the braked wheel(s), and into the brake actuator. The service brakes are thus applied. If the wheel sensors do not find a beginning wheel lock-up, the ECU does not start any corrective action and the vehicle comes to a stop in a normal fashion.

Front Axle (Steering Axle)

During normal braking, air pressure from the brake valve (foot valve) is applied to the quick release valve (QRV). Air from the QRV is then sent to the right and left front M–21 wheel modulator valves. The M–21 antilock modulators then deliver the brake air pressure to the brake actuators, applying the service brakes. If the wheel sensors do not find a beginning wheel lock-up, the ECU does not start any corrective action and the vehicle comes to a stop in a normal fashion.

2.3. ANTILOCK CONTROLLED BRAKE APPLICATION — SYSTEM FULLY OPERATIONAL

IMPORTANT – The only way the driver will know the Antilock Brake System is not working properly is when the dash yellow warning light turns on. The driver will be able to give you little or no information to help you find the problem.

If a service brake application is made and the wheel speed sensors detect a wheel lock–up starting, the ECU will immediately begin changing the brake application using the M–21 antilock modulator(s) at the wheel(s) sensing a lock-up condition starting.

Solenoid valves contained in the modulator are rapidly energized and de-energized by the ECU to change the brake application. When a solenoid coil is energized, its shuttle moves, and depending upon the function of the specific solenoid, it either opens or closes, thereby causing the exhaust or re-application of air pressure to the brake actuator. By opening and closing the solenoid valves in the appropriate modulator, the ECU is actually simulating what the driver does when he "pumps the brakes." Unlike the driver, the ECU receives input on which wheel is approaching lock–up, and is able to pump each brake group on the vehicle independently and with far greater speed and accuracy.

2.4. ANTILOCK SYSTEM OPERATION – COMPONENT FAILURE

The ECU handles equipment failure using a conservative fail-safe philosophy. Any single electrical failure of an antilock system component results in two events happening at the same time. The two events are:

1. The yellow antilock warning light on the instrument panel will illuminate to alert the driver that the system has detected a malfunction.

2. The ECU will disable all or part of the antilock system.

When working with wheel equipment (modulator, wheel sensor/exciter ring or associated wire harness) failure, the ECU divides and separates the brakes diagonally. For example, if the modulator at the right front wheel has a broken wire lead, the ECU disables the antilock function for BOTH the right front and left rear wheels. The antilock will continue to function on the left front and right wheels and will continue to be controlled by the ECU.

NOTE – Right and left, and front and rear are determined from the driver's seat position. Left front would be the front corner closest to the driver.

Depending on the type of failure, and location of the failed component, the ECU will disable either the entire antilock system or only a portion of the antilock system, as previously described. An antilock system power failure (less than 10V) or failure of the ECU will cause the system to shut down, reverting to a standard braking system. Failure of two or more components will also cause the ABS system to shut down, and operate as a standard air brake system.

With the failed component approach previously described, a partially shutdown antilock brake system will still provide improved braking stability over a standard air brake system.

NOTE – With a partially shutdown antilock brake system, the driver will be alerted by the instrument panel warning light, and the portion of the antilock system disabled by the ECU reverts to a standard air brake system controlled by the relay valve (rear axles) or brake valve (front axle).

3. COMPONENT DESCRIPTION/OPERATION

Refer to circuit diagrams as needed for the following discussions.

3.1. WHEEL SENSOR

The wheel speed sensors are mounted on the axle ends (Figure 2 and Figure 3). The wheel sensors house a permanent magnet, which creates a magnetic field. When the field created by the sensor magnet is interrupted by the teeth of the exciter ring moving through it, an A.C. voltage is produced. The frequency of the voltage increases or decreases as the wheel speed increases or decreases. The sensor has a pigtail with a two-pin connector that connects to the ABS harness mating connector. The sensor signal goes from the sensor through the ABS harness and connects to the ECU, either with a 12-pin connector or a 14-pin connector, depending on the location of the wheel sensor. The left and right front wheel sensors connect to the 14-pin connector and the rear chassis sensors (2) connect to the 12-pin connector.

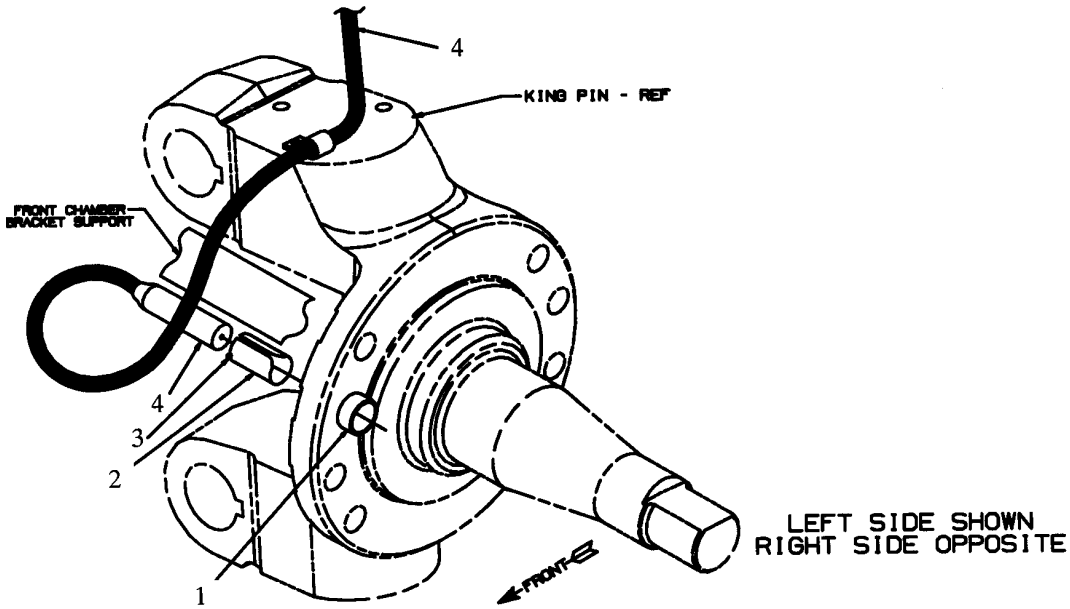


Figure 2 Typical Front Axle, Wheel Sensor Installation

1. SENSOR BUSHING (PART OF KNUCKLE ASSY)
2. SENSOR RETAINER
3. SENSOR RETAINER OUTSIDE TONGUES
4. SENSOR ASSEMBLY INCLUDES LEAD (CONNECTS TO CHASSIS ANTI LOCK HARNESS)

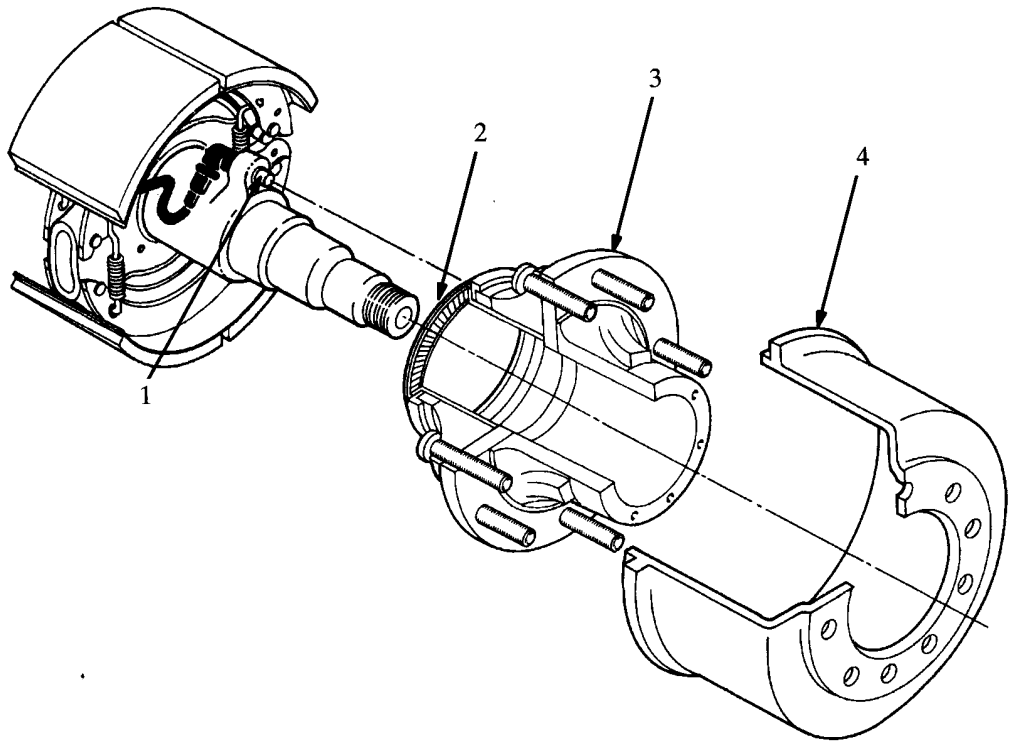


Figure 3 Exciter Ring Installed on Rear Wheel Assembly

1. WHEEL SENSOR
2. EXCITER RING
3. HUB
4. BRAKE DRUM

3.2. EXCITER RING

The exciter ring is machined to close tolerances and has 100 equally spaced teeth (Figure 3). The ring is heated and then installed onto the wheel assembly. Then as the exciter ring cools, it shrinks on the mating surface of the wheel hub. As the wheel rotates, the 100 teeth pass the sensor, each breaking the magnetic field creating the AC signal. One hundred cycles or pulses of the signal would indicate one revolution of the wheel. The signal is transmitted from the sensor to the ECU.

3.3. ANTILOCK WARNING (INDICATOR) LIGHT

Refer to Figure 48 for this discussion.

The antilock warning light is located on the instrument panel. When the vehicle is started, the "Initial Start-up Self Diagnostic Test" will be run. The test is fully explained in TROUBLESHOOTING. The yellow warning light also will turn on if, during operation, the ECU senses a system defect.

The yellow instrument panel warning light and the warning light relay control coil receive ignition power from fuse 299. With the relay in the open position (relay de-activated), the ground for the warning light is completed and the light is turned on.

The warning light relay control coil ground path is controlled by the ECU, which opens or closes the ground (activates or de-activates the relay) to turn the warning light ON or OFF. The warning light is ON whenever the relay is de-activated by the ECU.

During the Self Diagnostic Test when starting the vehicle or if a failure occurs in the antilock system, the ECU opens the ground path for the warning light relay coil causing it to de-energize, turning on the yellow instrument panel warning light.**If the antilock system is operating properly during normal operation, the lamp will not be on.**

The yellow antilock warning lamp, located on the instrument panel, receives ignition voltage from an in-line 10 amp fuse 299 through the cab harness to circuit 94F/94C/94B of the antilock cab harness. Voltage is present whenever the key switch is at IGN. The ground circuit to the warning light is circuit 94E through the warning light relay terminals 30 to 87A. The ground goes to circuits 94-GB/94-GC to 11-G and ground at G2.

When the warning light relay**is not energized**, the warning light will be on. Ignition voltage (the same source as the warning light) is present to the warning light relay control coil whenever the key switch is at IGN. The relay control coil ground circuit (94H) is connected through the cab and chassis harness to the ECU harness 14-pin connector at pin "K". The ECU opens (light ON) or closes (light OFF) the warning light relay in response to antilock system conditions as determined by the ECU.

3.4. CR–15 RELAY VALVE/ECU (WITH 4–CHANNEL SYSTEM 04AZA)

Refer to Figure 4 .

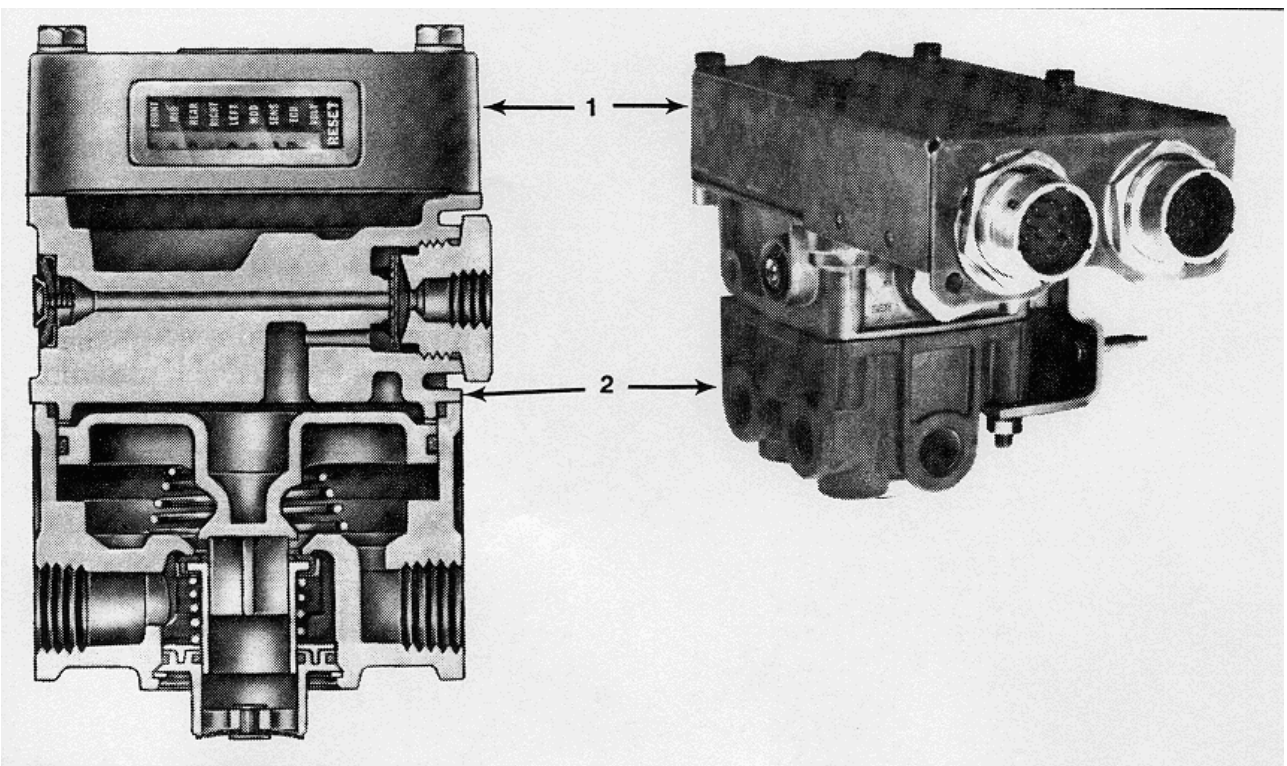


Figure 4 CR–15 Relay Valve/ECU Assembly

1. CONTROLLER (ECU)
2. AR–1 RELAY VALVE

The CR–15 Relay Valve/ECU assembly consists of a ECU controller mounted on an AR–1 antilock relay valve.

3.5. CONTROLLER (ECU)

The ECU controller houses the electronic control unit that regulates the antilock system. The ECU performs a system start-up self diagnostic test whenever the vehicle is started and then continues to monitor the antilock system during operation of the vehicle. The ECU uses the yellow instrument panel warning light and the warning light relay to communicate system performance to the driver. The ECU also incorporates a diagnostic LED window to provide additional system diagnostic information. See TROUBLESHOOTING.

The ECU controller mounts on the antilock relay valve with four capscrews. The ECU is electrically connected through a 12–pin and 14–pin connector to the wheel sensors, brake modulators, and the cab antilock wire harness. The antilock relay valve functions as a service brake relay valve and contains no electronics of its own.

The ECU assembly is supplied with electrical power by the vehicle electrical system. Refer to the Circuit Diagram for this discussion.

The ignition power source (Figure 5) to the ECU in the 8000 vehicle models is the J–1 battery feed stud. Ignition power is delivered from the J–1 battery feed stud on circuit 94 through a 30 amp in-line fuse (C298), and then to circuit 94A to the power relay (C283). The power relay is energized with the key switch turned to IGN. Voltage from the key switch uses circuit 13J to deliver power through an in–line 10 amp fuse (C299) to circuit 13K and through the power relay control coil and is grounded via circuit 94–GC and 11–G to G2. Once energized, the power relay allows ignition voltage to flow to the crank relay (C285) on circuit 94M.

Power from the crank relay flows to the ECU harness connector (C288) pin J on circuit 94K through connector C378, to circuits 94A and 94L. The ECU assembly harness includes a ground cable (circuit 94–G) that is grounded to the vehicle frame. When voltage from the start switch energizes the crank relay during engine cranking, power to the ECU is shut OFF. The crank relay control coil is grounded through circuit 94–GA, 94–GB, 94–GC, and 11–G to G2.

NOTE – During engine cranking, system voltage will on occasion drop below the operating limits of the ECU. The system avoids this by de–energizing the ECU using the crank relay.

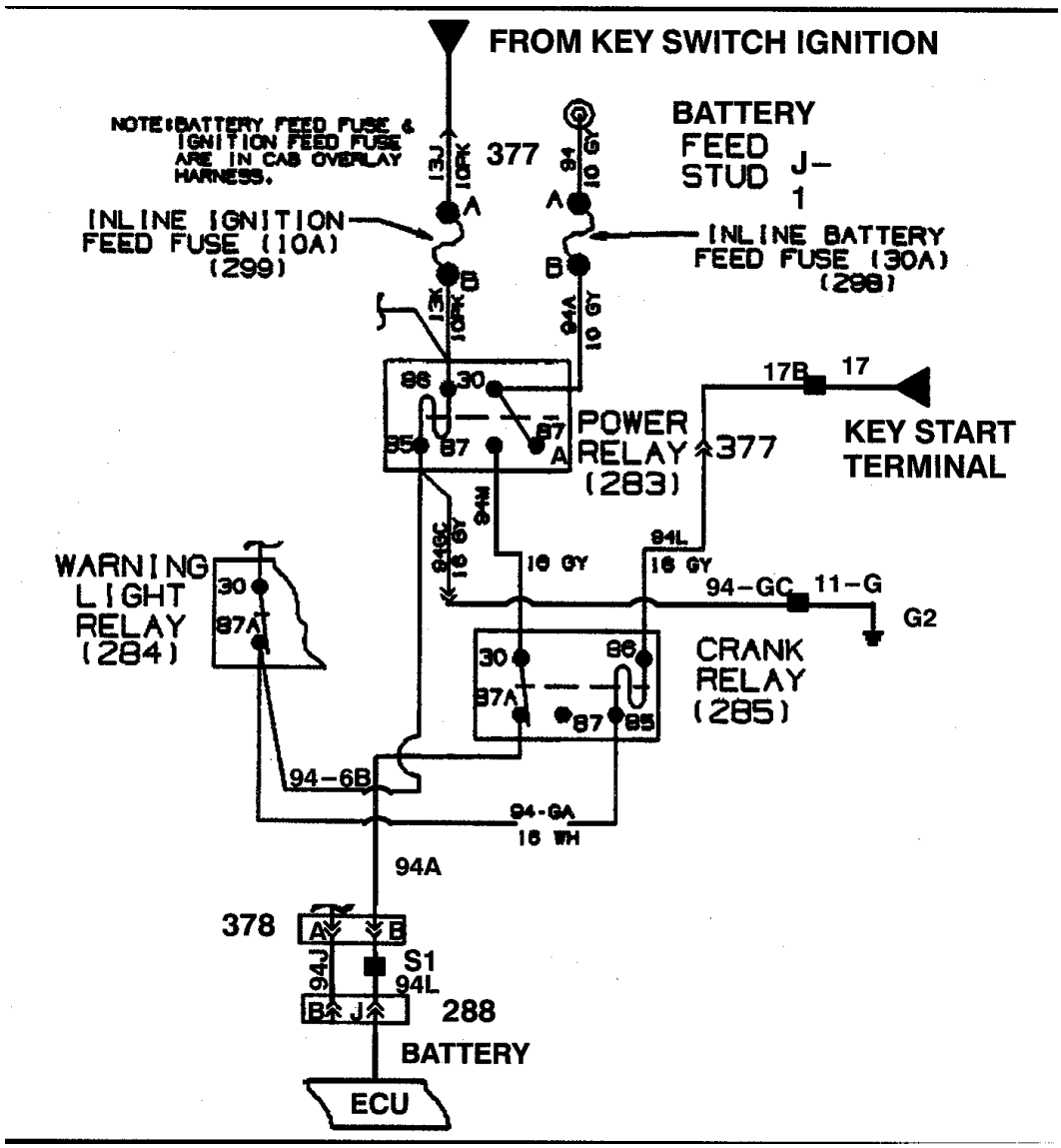


Figure 5 8000 ABS Power Circuit

3.6. AR–1 ANTILOCK RELAY VALVE

The AR–1 antilock relay valve is a specialized service brake relay valve. The AR–1 contains no electronic components and functions as a brake relay valve. The AR–1 is essentially an R–14 relay valve with a special cover that permits the direct attachment of the ECU controller. When the controller and relay valve are assembled together, the assembly is called a CR–15 Relay Valve/ECU.

In the antilock brake system, the AR–1 relay valve (Figure 6) serves as a relay station to speed the application and release of the rear service brakes. Incorporated within the AR–1 relay valve is a quick release valve next to the service port, which provides for rapid exhausting of control air pressure from above the relay piston. All air connections on the relay valve are identified with cast, embossed letters for ease of maintenance. The letter identification of the air ports on the AR–1 is:

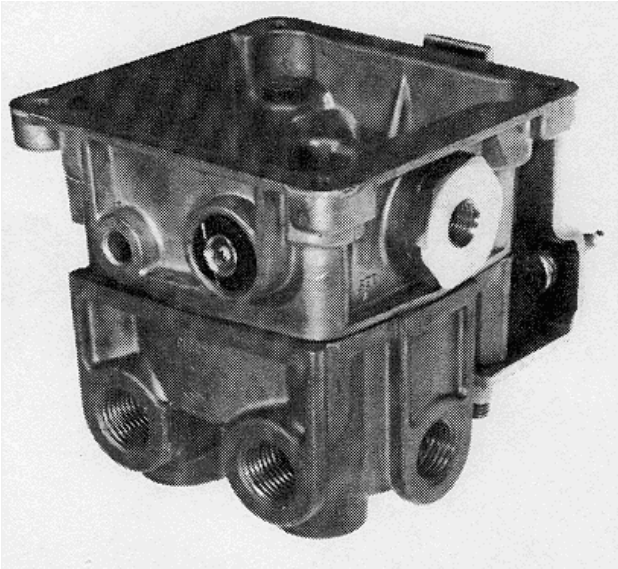


Figure 6 AR–1 Relay Valve

Table 2 AR-1 Air Port Identification

AR–1 AIR CONNECTION	EMBOSSED IDENTIFICATION
Supply (Primary reservoir to relay valve)	SUP
Delivery (To rear modulators)	DEL
Service (Brake valve to relay valve)	SER

For complete information on relay valve operation and maintaining the valve, refer to GROUP 04 - BRAKES in the CTS-5000 MASTER SERVICE MANUAL.

3.7. M–21 MODULATOR VALVE (WITH 4–CHANNEL SYSTEM 04AZA)

The M–21 antilock system modulator (Figure 7) is essentially a high capacity, ON/OFF air valve that incorporates a pair of electrical solenoids for control. The solenoids provide the electro-pneumatic link between the antilock controller electronics and the air brake system. The M-21 can be used to control the braking function (Figure 8) on an individual wheel or two service actuators (as with 6x4). The M-21 is the last control valve that air passes through on its way to the service brake actuator(s).

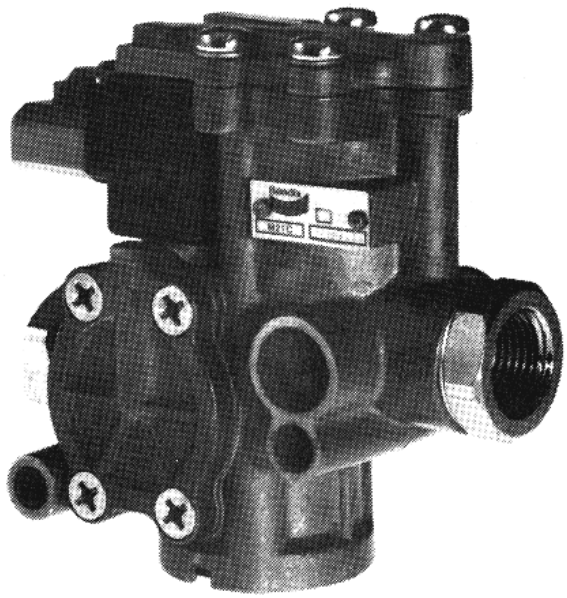


Figure 7 M–21 Modulator Valve

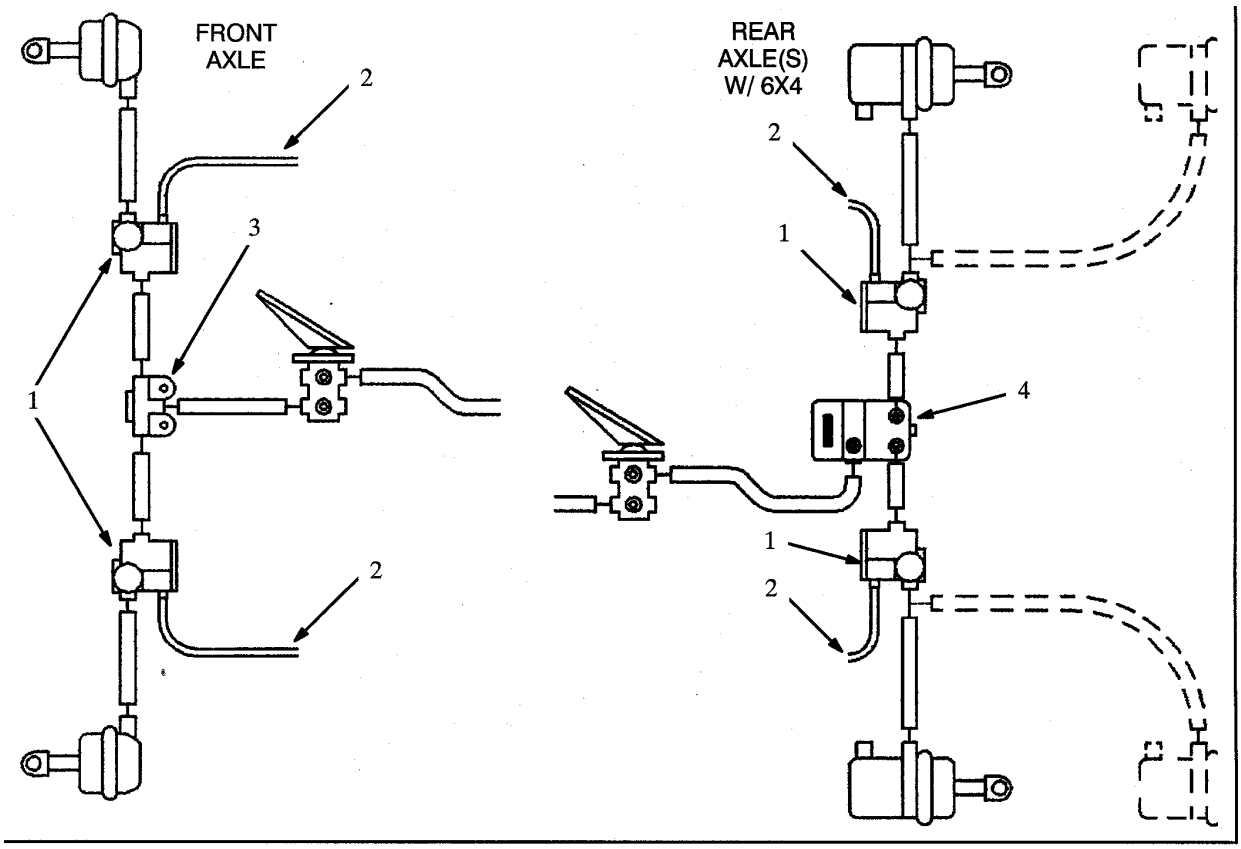


Figure 8 M–21 Air Flow Diagram

1. M–21 MODULATORS
2. ELECTRICAL CONNECTION TO EC–15 CONTROLLER
3. QRV
4. CR–15 RELAY VALVE/ECU

The M–21 modulator consists of a die cast aluminum body and a solenoid assembly, which contains one normally open (NO) solenoid, one normally closed (NC) solenoid, and two inlet and exhaust diaphragm valves. A Packard, three pin, 280 series weather resistant electrical connector is part of the M–21 solenoid assembly and carries control commands from the ECU to the M–21 modulator. The Supply, Delivery and Exhaust ports on the M–21 are identified with raised numerals for positive identification. They are:

Table 3 M-21 Valve Port Identification

M–21 MODULATOR VALVE	
IDENTIFICATION	**VALVE PORTING**
1	**Supply — Incoming air from brake valve through QRV (frt axle) or relay valve (rear axle).**
2	**Delivery — Air delivery to service actuators.**
3	**Exhaust — Air exhausted during antilock control.**

3.8. NON-ANTILOCK APPLICATION

Refer to Figure 9 .

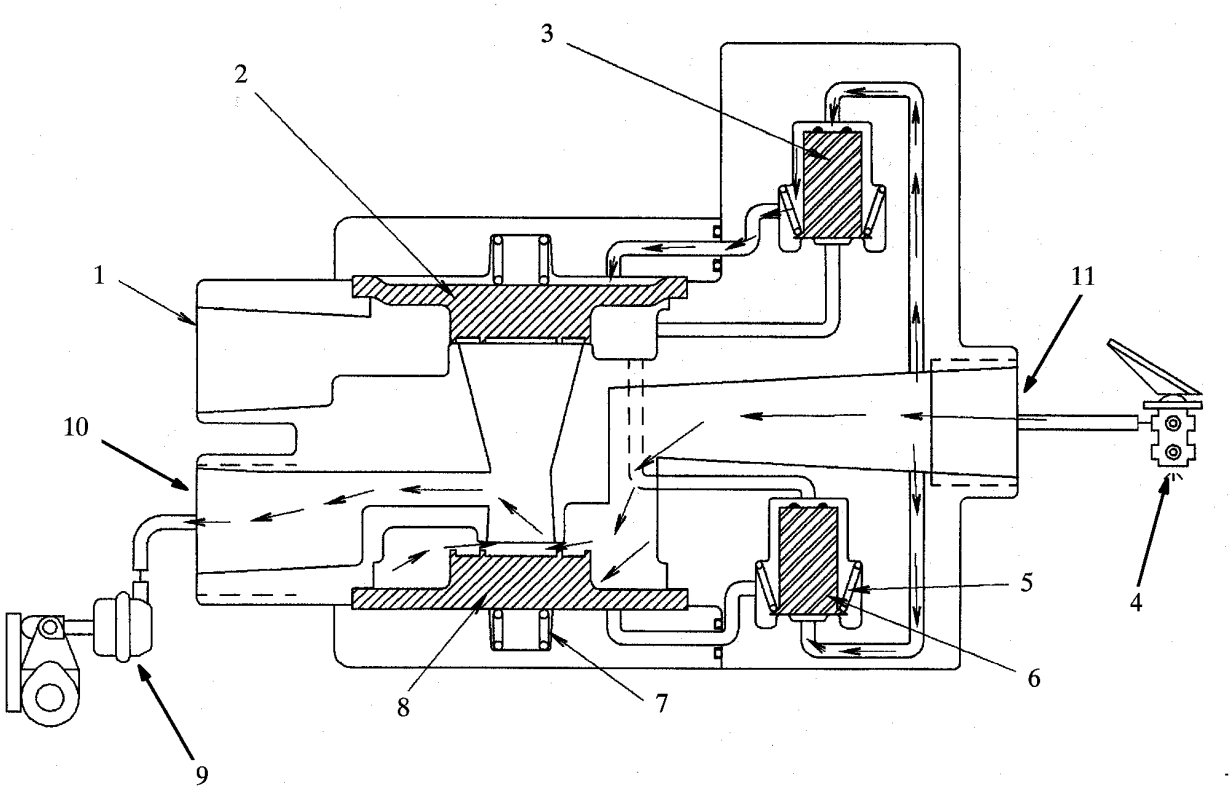


Figure 9 M–21 Application Of Service Brakes

1. EXHAUST PORT
2. EXHAUST DIAPHRAGM
3. EXHAUST SOLENOID
4. BRAKE VALVE
5. SPRING
6. SUPPLY SOLENOID
7. SPRING
8. SUPPLY DIAPHRAGM
9. BRAKE CHAMBER
10. DELIVERY PORT
11. SUPPLY PORT

During normal non–antilock braking, both solenoids are de-energized (no electrical power). Brake application air enters the Supply port of the M–21 and flows to, and through, the open exhaust solenoid then to the exhaust diaphragm. Air pressure, along with spring force, seats the exhaust diaphragm on the exhaust passage, thus preventing the escape of service air. Simultaneously, application air flows to the supply diaphragm and forces it away from its seat. Air flows past the open supply and out the M–21 delivery port to the service brake chambers.

3.9. NON–ANTILOCK HOLD

Refer to Figure 10 .

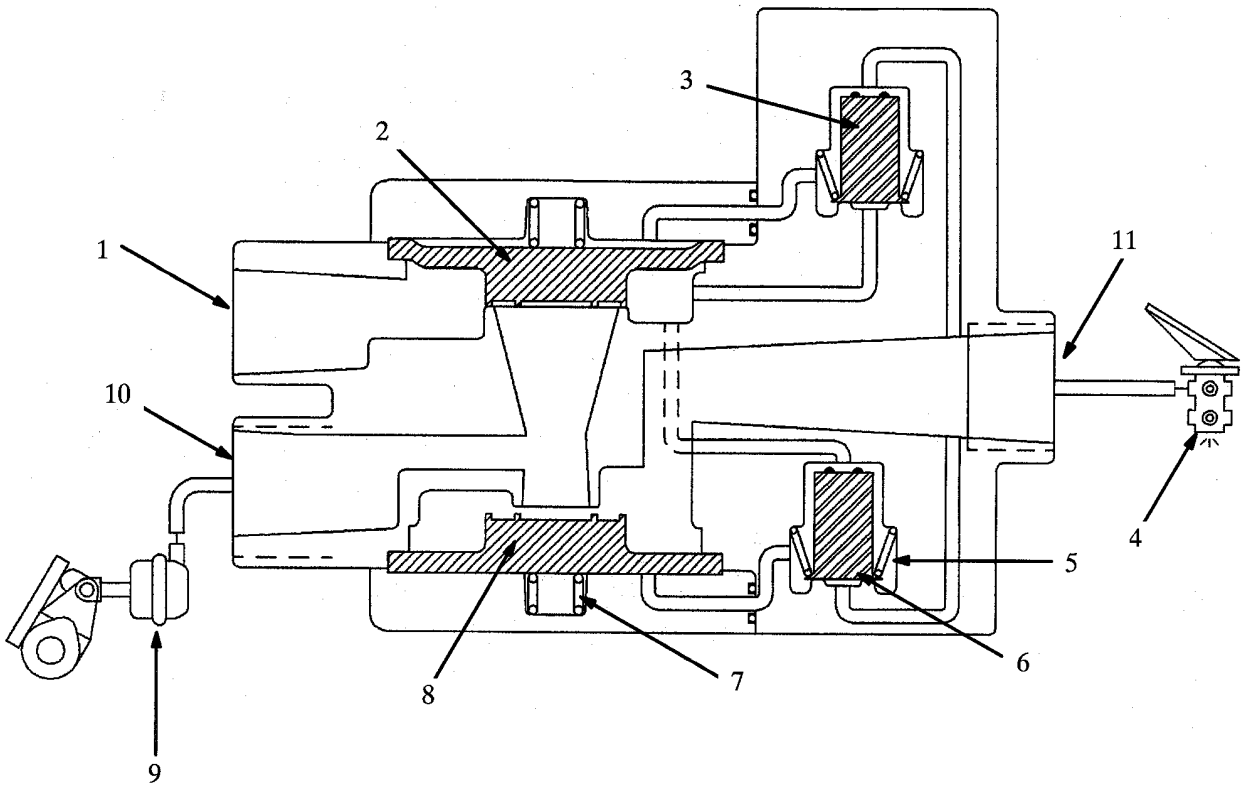


Figure 10 Non – Antilock Holding Position

1. EXHAUST PORT
2. EXHAUST DIAPHRAGM
3. EXHAUST SOLENOID
4. BRAKE VALVE
5. SPRING
6. SUPPLY SOLENOID
7. SPRING
8. SUPPLY DIAPHRAGM
9. BRAKE CHAMBER
10. DELIVERY PORT
11. SUPPLY PORT

When the desired air pressure is attained in the service brake chambers, the brake system is in the Holding position. In the Holding position, both solenoids in the M–21 remain de-energized and the balance of the internal components remain in the same position as they assumed during application.

3.10. NON–ANTILOCK EXHAUST

The manner in which air exhausts through the M–21 differs, depending upon how rapidly the brake application is released by the driver.

Normal Exhaust— Refer to Figure 11 . During a normal, relatively "slow" brake release, air moves back through the M–21 in the reverse direction as it flowed during application. The internal components of the M–21 will remain in the same position as they assumed during application until air pressure decreases to approximately one half psi, at which time the supply diaphragm will seat on the supply passage. Air will generally not be expelled from the M–21 exhaust port during normal brake release.

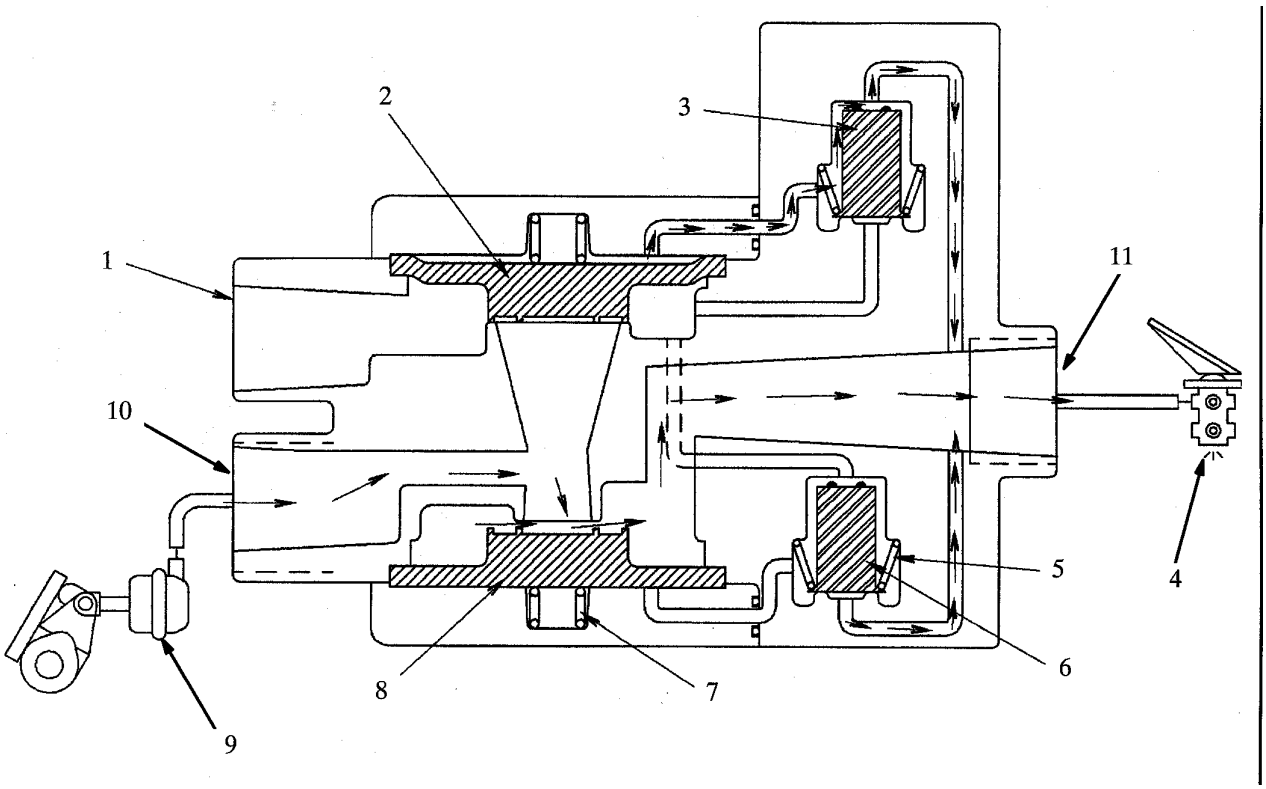


Figure 11 M–21 Non – Antilock Exhaust (Normal)

1. EXHAUST PORT
2. EXHAUST DIAPHRAGM
3. EXHAUST SOLENOID
4. BRAKE VALVE
5. SPRING
6. SUPPLY SOLENOID
7. SPRING
8. SUPPLY DIAPHRAGM
9. BRAKE CHAMBER
10. DELIVERY PORT
11. SUPPLY PORT

Rapid Exhaust —Refer to Figure 12 . The Rapid Exhaust operation described in the following text**only occurs when the M–21 is controlling two, type 30 (or larger) service chambers**. During a very rapid brake release, the M–21 will exhaust air in a different manner. An example of this would be if the driver made a severe brake application, then lifted his foot from the brake pedal (released foot valve). During a rapid brake release, air from the exhaust diaphragm flows back through the open exhaust solenoid and to the application device's exhaust. With pressure removed from the control side of the exhaust diaphragm, air, returning to the M–21 from the service chambers, opens the exhaust diaphragm. Returning air flows past the open

exhaust and out the the M–21 exhaust port. Air will also flow past the open supply diaphragm and back to the application device's exhaust.

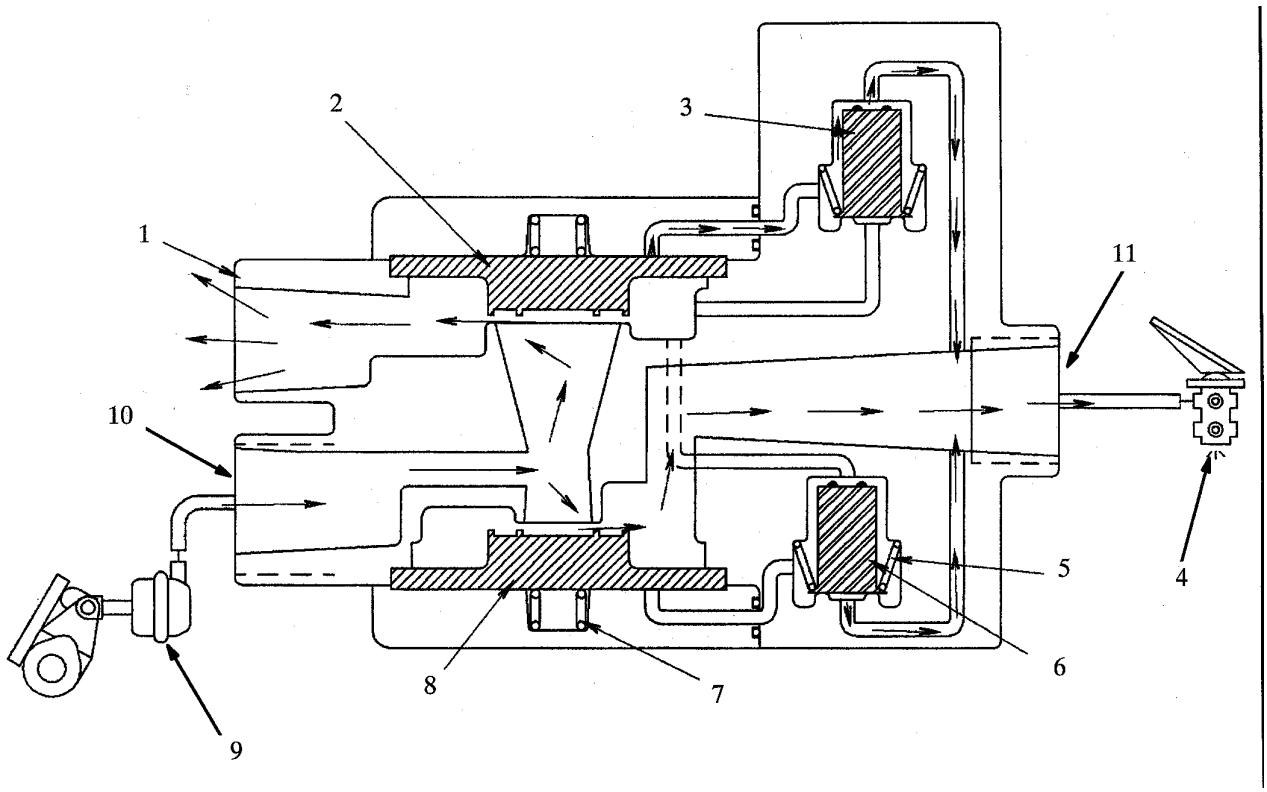


Figure 12 M–21 Non – Antilock Exhaust (Rapid)

1. EXHAUST PORT
2. EXHAUST DIAPHRAGM
3. EXHAUST SOLENOID
4 . BRAKE VALVE
5. SPRING
6. SUPPLY SOLENOID
7. SPRING
8. SUPPLY DIAPHRAGM
9. BRAKE CHAMBER
10. DELIVERY PORT
11. SUPPLY PORT

3.11. ANTILOCK OPERATION – GENERAL

If a service brake application is made and the antilock system finds a beginning wheel lock–up, the antilock controller will immediately begin modification of the brake application using the M–21 modulator.

In order to modify the brake application, the coils of the two solenoid valves contained in the M–21 are energized or de–energized in a pre–programmed sequence by the ECU. When a solenoid coil is energized, a shuttle within the solenoid moves, and depending upon the function of the specific solenoid, it either opens or closes, thereby causing the exhaust or re–application of air pressure to the brake actuator. The solenoids in the M–21 are controlled independently by the antilock controller. By opening and closing the solenoid valves in the M–21 modulators, the antilock controller is able to simulate what the driver does when he "pumps the

brakes." The antilock controller is able to "pump" each modulator, along with the brakes connected to it, independently and with far greater speed and accuracy.

3.12. ANTILOCK EXHAUST

Refer to Figure 13 .

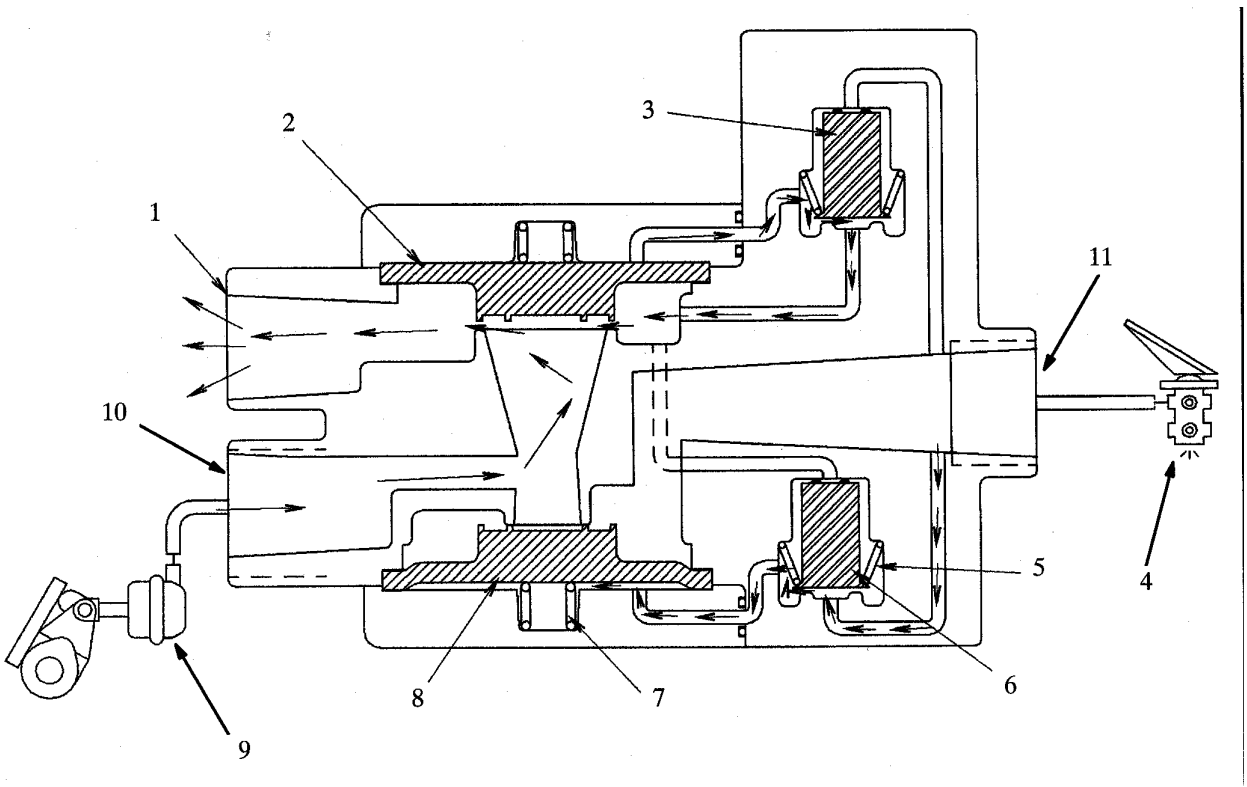


Figure 13 M–21 Antilock Exhaust

1. EXHAUST PORT
2. EXHAUST DIAPHRAGM
3. EXHAUST SOLENOID
4 . BRAKE VALVE
5. SPRING
6. SUPPLY SOLENOID
7. SPRING
8. SUPPLY DIAPHRAGM
9. BRAKE CHAMBER
10. DELIVERY PORT
11. SUPPLY PORT

When wheel lock-up is found, or about to happen, the antilock controller simultaneously energizes both the supply and exhaust solenoids in the M–21. Energizing the supply solenoid causes its exhaust to close and inlet to open. With the inlet of the supply solenoid open, application air is permitted to flow to the control side of the supply diaphragm. Air pressure acting on the supply diaphragm causes it to close the supply and prevent further delivery of air to the brake chamber.

Energizing the exhaust solenoid closes its inlet and opens its exhaust. By closing the exhaust solenoid inlet, application air is prevented from flowing to the control side of the exhaust diaphragm. Air pressure which was present on the control side of the exhaust diaphragm flows out the exhaust port of the M–21. With control air pressure removed from the exhaust diaphragm, brake application air forces the exhaust diaphragm to unseat, which allows it to flow out the M–21 exhaust port. The M–21 will remain in the Antilock Exhaust mode until the antilock controller senses that wheel speed has increased. The M–21 can enter the Antilock Hold or Re–apply mode from the Antilock Exhaust mode.

3.13. ANTILOCK HOLD

Refer to Figure 14 .

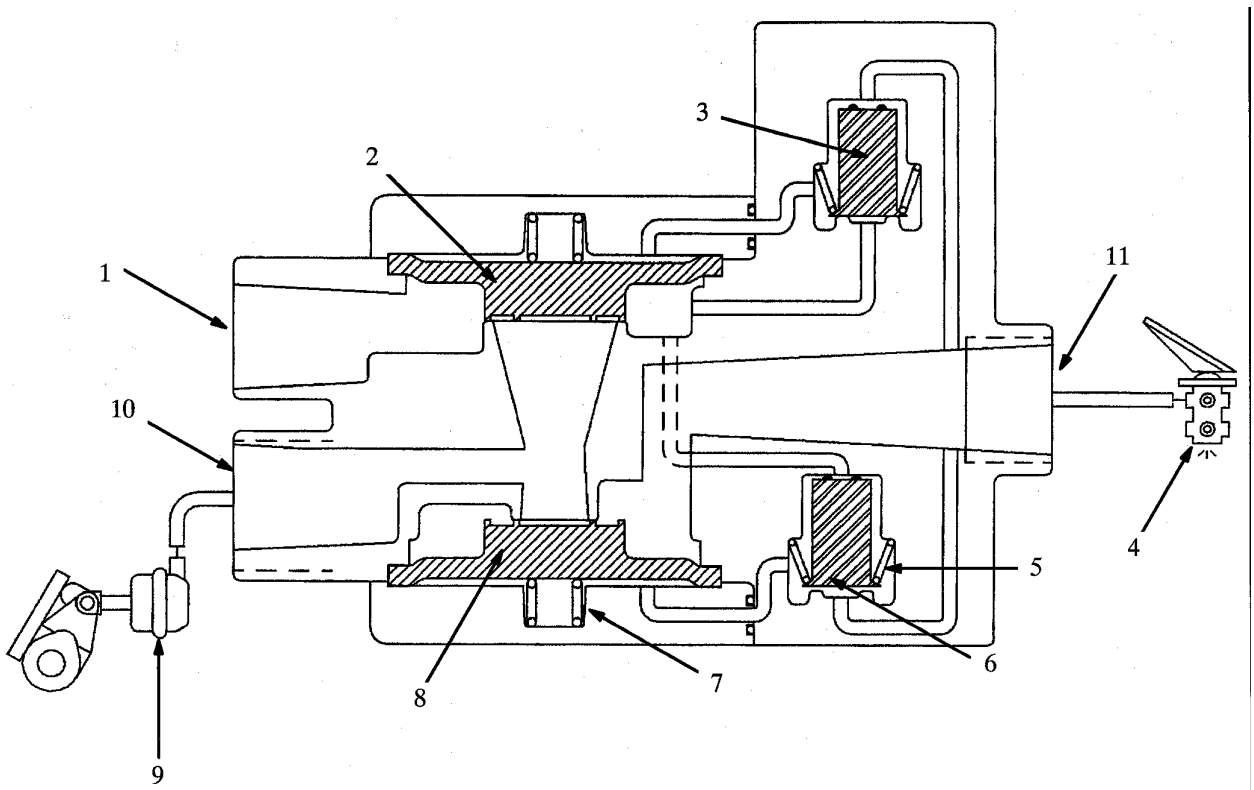


Figure 14 M–21 Antilock Holding Position

1. EXHAUST PORT
2. EXHAUST DIAPHRAGM
3. EXHAUST SOLENOID
4. BRAKE VALVE
5. SPRING
6. SUPPLY SOLENOID
7. SPRING
8. SUPPLY DIAPHRAGM
9. BRAKE CHAMBER
10. DELIVERY PORT
11. SUPPLY PORT

The antilock controller will place the M–21 in the Hold position when it senses that the correct wheel speed (braking force) has been reached. The antilock controller will also place the M–21 in the Hold position, prior to

entering the Re–Apply, when it finds recovery from a locked wheel condition. In this mode of operation, the M–21 supply solenoid remains energized, while the exhaust solenoid is de-energized.

De-energizing the exhaust solenoid opens its inlet and closes its exhaust. Opening the exhaust solenoid inlet allows application air to flow to the control side of the exhaust diaphragm, which then seals the exhaust passage. With the exhaust diaphragm seated, further exhaust of brake chamber air pressure is prevented. Because the supply solenoid remains energized, the supply diaphragm remains seated, thus preventing application air from flowing to the delivery port and out to the brake chamber. The M–21 can enter the Antilock Exhaust or Re–apply mode from the Antilock Hold mode.

3.14. ANTILOCK RE–APPLY

If the antilock controller senses that wheel speed has increased sufficiently to allow re–application of braking pressure, it de–energizes the supply and exhaust solenoids. With both solenoids de–energized, the M–21 re–applies air to the brakes in the same manner it did during a Non–Antilock Application.

4. MAINTENANCE AND SERVICE CHECKS

4.1. MAINTENANCE

IMPORTANT – Please Read

When you are working on, or near 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. Drain the air pressure from all reservoirs before beginning ANY work on the vehicle.

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

5. 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 released.

6. Never exceed recommended pressures and always wear safety glasses.

7. 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.

8. Use only International approved parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. must be designed specifically for such applications and systems.

9. 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 International Engineering.

10. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

11. Always turn the ignition key to OFF before disconnecting any of the antilock wiring or connectors. If the key is not OFF, the ECU controller will record the power interruption as a static fault.

CAUTION – Before you weld on a vehicle with an electronic control module for the engine, antilock brake system or other electronically controlled components, it is mandatory to remove all connectors going to the Electronic Control Unit (ECU). It is also mandatory to disconnect the positive (+) and negative (–) battery cables before connecting the welder.

Attach the welder ground cables as close as possible to the part being welded. Never connect the welder ground cables to an ECU or mounting bracket for the ECU.

5. M–21 MODULATOR VALVE

Perform the tests and inspections presented at the prescribed intervals. If the M–21 fails to function as described, or leakage is excessive, it should be replaced. Replace only with International-approved parts.

5.1. EVERY 3 MONTHS, 25,000 MILES OR 900 OPERATING HOURS

1. Remove any accumulated debris and contaminants, then visually inspect the outside of the modulator for excessive corrosion and physical damage. Replace if necessary.

2. Inspect all air lines and wire harnesses connected to the M–21 for signs of wear or physical damage. Replace as needed.

3. Test air line fittings for excessive leakage and tighten or replace as necessary.

4. Perform the OPERATION AND LEAKAGE TESTING described below.

5.2. OPERATION & LEAKAGE TESTS M–21 MODULATOR VALVE

Leakage 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. Make and hold a full service brake application.

   a. Apply a soap solution to the exhaust port of the M–21 modulator. Leakage should not exceed a one-inch bubble in less than 3 (three) seconds. If leakage exceeds the specified maximum, replace the M–21 modulator.

   b. Apply a soap solution around the solenoid assembly (top and bottom). Leakage should not exceed a one-inch bubble in less than 3 (three) seconds. If leakage exceeds the specified maximum, tighten the solenoid cap screws and re–test. If the leakage remains excessive after re–testing, replace the M–21 modulator.

c. Apply a soap solution around each diaphragm cover. Leakage should not exceed a one-inch bubble in less than 3 (three) seconds. If leakage exceeds the specified maximum, tighten the diaphragm cap screws and re-test. If the leakage remains excessive after re–testing, replace the M–21 modulator.

Operation Testing (Chuff Test) M–21 Modulator Valve

Each M–21 modulator contains (1)***exhaust solenoid***and (1)***hold solenoid***. During this test, the ECU controller will "fire" or energize each solenoid briefly in a test cycle making a "chuff" sound as the air exhausts. The exhaust solenoid will be "fired" for 10 milli–seconds, then a pause for only a few milli-seconds and the hold solenoid will "fire" for 20 milli–seconds. The two firing in rapid sequence will produce a "chuff" sound. The ECU will begin at the right front, then go to the left front, then right rear, and finish the cycle on the left rear. It will then repeat the cycle, making two complete cycles.

NOTE – Proper testing of the M–21 modulator operation requires 2 service technicians.

1. Park the vehicle on a level surface and block or chock the wheels. Release the parking brakes and build the air system to governor cut–out.

2. Turn the engine ignition key OFF, then make and hold a full brake application.

3. With the brake application held and a service technician posted at one of the M–21 modulators, turn the vehicle ignition key ON and note the following:
   a. A short burst of air pressure should be noted first at the RIGHT FRONT M–21 modulator exhaust.
   b. Then a short burst of air pressure should be noted at the LEFT FRONT M–21 modulator exhaust.
   c. Then a short burst of air pressure should be noted at the RIGHT REAR M–21 modulator exhaust.
   d. Last, a short burst of air pressure should be noted at the LEFT REAR M–21 modulator exhaust.
   e. The test cycle will be repeated one more time, repeating steps A through D.

If the air burst of the solenoids exhausting is not noted at one or more of M–21 modulators, perform the Electrical Tests located in TROUBLESHOOTING. Electrical testing ALWAYS WILL BEGIN WITH THE "INITIAL START–UP PROCEDURE."

5.3. REMOVE AND INSTALL M–21 MODULATOR VALVE

Valve Removal

1. Park the vehicle on a level surface and block the wheels and/or hold the vehicle by means other than the air brakes.

2. Drain the air pressure from all vehicle reservoirs.

3. Identify and mark or label all air lines and their respective connections on the valve to facilitate ease of installation.

4. Disconnect both air lines and the electrical connector.

5. Remove the valve from the vehicle.

Valve Installation

1. Install all air line fittings and plugs making certain thread sealing material does not enter the valve.

2. Install the assembled valve on the vehicle.

3. Reconnect both air lines to the valve using the identification made during VALVE REMOVAL step 3.

4. Reconnect the electrical connector to the M–21.

5. After installing the valve, test all air fittings for excessive leakage and tighten as needed.

5.4. SPECIFICATIONS

M–21 technical specifications are as follows:

Porting —1 Supply Port (from brake, relay or quick release valve)

1 Delivery Port (brake actuator)

Solenoid Voltage —12 Volts DC Nominal

Maximum Operating Pressure —150 psi Gauge

Operating Temp. Range —-40° to +185° Fahrenheit

Pressure Differential —1 psi maximum

6. EC–15 CONTROLLER (ECU)

6.1. EVERY 3 MONTHS, 25,000 MILES, OR 900 OPERATING HOURS

1. Check all wiring and connectors to ensure they are secure and free from visible damage.

2. Although the ECU controller incorporates self–check diagnostics, the LED display should be inspected to ensure that the LEDs are functional. With the vehicle ignition ON, a magnet (800 gauss; capable of picking up 3 ounces) held to the LED reset switch should cause all of the LED's to illuminate. If one or more of the LED's DO NOT ILLUMINATE and the antilock warning light on the dash indicates the system is functioning properly, the non–illuminated LED(s) should be noted for future reference. Although the diagnostic capabilities will be limited, the system will continue to function as designed.

NOTE – For the next step, 2 technicians are required: a vehicle driver and an observer.

3. Road test the vehicle by making an antilock stop from a vehicle speed of 20 miles per hour. When an antilock stop is made, the modulator solenoids pulsate and an audible burst of air can be heard from outside of the cab by an observer. The wheels should not enter a prolonged "lock" condition when vehicle speeds are above seven miles per hour.

6.2. REMOVE AND INSTALL EC–15 CONTROLLER (ECU)

Removal –ECU Mounted On Antilock Relay Valve

NOTE – Before disconnecting ANY electrical circuits in the antilock system, the ignition key must be OFF. If the key is not OFF, the EC–15 will record the open circuit(s) as a fault.

1. Identify and remove all air lines connected to the unit.

2. Identify and disconnect the electrical connector(s) from the ECU.

3. Note and mark the mounting position of the Controller/Relay valve assembly on the vehicle. Loosen, remove and save the mounting hardware attaching the CR–15 Relay Valve/EC–15 Controller assembly bracket to the vehicle. Remove the CR–15 Relay Valve/EC–15 Controller assembly from the vehicle.

4. Remove any dirt, grease, etc. from the cover of the ECU assembly.**Make sure you protect the open ports and connectors.**

5. Note and mark the position of the ECU controller relative to the antilock relay valve. Remove and keep the four capscrews that secure the ECU to the antilock relay valve. Carefully separate the ECU from the antilock relay valve making sure you don't damage the gasket between the two components. Peel the gasket from the the ECU or relay valve and keep for reuse (NOTE: Use a new gasket if the old gasket is damaged or if a new gasket is readily available).

Installation – EC–15 (ECU) Mounted On Relay Valve

1. After noting the relationship of the positioning marks made prior to disassembly, position the gasket on the ECU, then secure the ECU to the antilock relay valve using the four capscrews. Torque the capscrews to 50–80 lbs. in. (5.6–9.0 Nm).

2. Mount the assembled ECU and antilock relay valve on the vehicle and orient it in the position marked prior to removal.

3. Connect the air lines (as marked in removal) to the relay valve.

4. Connect the electrical connectors (as marked during removal) to the ECU.

5. Test the antilock relay valve for operation and leakage prior to placing the vehicle in service.

6. Perform the "Initial Startup Procedure" in the TROUBLESHOOTING Section to assure proper antilock system operation.

7. AR–1 ANTILOCK RELAY VALVE

Perform the tests and inspections presented at the prescribed intervals. If the AR–1 fails to function as described, or leakage is excessive, it should be repaired or replaced. Use only International–approved parts.

7.1. EVERY 3 MONTHS, 25,000 MILES OR 900 OPERATING HOURS

1. Clean the valve well and visually inspect the exterior for excessive corrosion and physical damage.

2. Inspect all air lines connected to the AR–1 for signs of wear or physical damage. Replace as necessary.

3. Test air line fittings for excessive leakage and tighten or replace as necessary.

4. Perform the Leakage Test described below.

7.2. EVERY YEAR, 100,000 MILES, OR 3,600 OPERATING HOURS

1. Perform the Operation and Leakage Tests that follow.

7.3. OPERATION AND LEAK TESTS – AR–1 ANTILOCK RELAY VALVE

Operation Test

NOTE – The following test requires 2 technicians.

1. Apply and release the brakes several times while a helper checks for prompt application and release at each wheel. If prompt reaction is noted at some,**but not all wheels**, test the antilock modulator between the AR–1 and the brake actuator for proper operation. If a "sluggish" response is noted at all wheels, inspect for a kinked or obstructed air line leading to or from the AR–1.

2. If some,**but not all,**brakes release completely, test the antilock modulator between the AR–1 and the brake actuator. If an incomplete release is noted at all wheels, inspect for a kinked or clogged air line leading to or from the AR–1.

3. During brake release, confirm that a slight "puff" of air exits at the AR–1's quick exhaust port in the cover. Air exiting at this exhaust port indicates the AR–1 integral quick release is functioning.

Leakage Test

1. Build the air system pressure to governor cut-out, and apply a soap solution to the exhaust port in body. The leakage noted should not exceed a one-inch bubble in less than three (3) seconds.

2. Make and hold a full brake application and apply a soap solution to the exhaust ports in the body, cover, and around the cover where it joins the body. The leakage noted should not exceed a one-inch bubble in less than three (3) seconds at any exhaust port.

7.4. REMOVE AND INSTALL AR–1 ANTILOCK RELAY VALVE

Remove

1. Park the vehicle on a level surface and block the wheels and/or hold the vehicle by means other than the air brakes.

2. Drain the air pressure from all vehicle reservoirs.

3. Identify, mark or label all air lines and wiring cables and their respective connections on the CR–15 Relay Valve/EC–15 Controller to facilitate ease of installation.

NOTE – Always turn key switch OFF before disconnecting any portion of the antilock wiring system. If circuits are disconnected with the key ON, the EC–15 controller will record the open circuit as a fault condition.

4. Disconnect all air lines and wiring.

5. Note and mark the mounting position of the relay valve/controller assembly on the vehicle. Remove and save the relay valve/controller mounting hardware, then remove the CR–15 Relay Valve/ECU Controller assembly from the vehicle.

6. Completely clean the case of the relay valve/controller assembly, making sure to protect the open ports and connectors.

7. Note and mark the position of the EC–15 controller relative to the AR–1 relay valve for later reassembly. Remove the 4 capscrews securing the controller to the relay valve. Carefully separate the controller from

the relay valve, making sure not to damage the gasket between the 2 components, if possible. Peel the gasket from the EC–15 or AR–1 and retain for use if it is not damaged.

NOTE – Use a new gasket if the old gasket is damaged or if a new gasket is readily available

NOTE – For disassembly of the relay valve, refer to GROUP 04 - BRAKES in the CTS-5000 Master Service Manual.

Installation

1. After noting the relationship of the positioning marks made in Step 7 of Removal, position the gasket on the EC–15, then secure the EC–15 to the AR–1 antilock relay valve using the 4 capscrews. Torque the capscrews to 50–80 Lb. In. (5.6-9.0 Nm).

2. Install all air line fittings and plugs (as marked during removal) making certain thread sealing material does not enter the valve.

3. Install the assembled CR–15 Relay Valve/ECU Controller on the vehicle in the position marked during Step 5 of Remove.

4. Connect all air lines and wiring cables to the valve and controller assembly using the identification made during Valve Remove Step 3.

5. After installing the valve and controller assembly, test all air fittings or excessive leakage and tighten as needed.

8. TROUBLESHOOTING

8.1. ANTILOCK WIRING

IMPORTANT – The only way the driver knows the Antilock Brake System is not working properly is when the yellow dash warning light turns on. The driver will not be able to give you any useful information to help you find the problem. It is important that you follow the Troubleshooting Charts step by step and use a copy of the Troubleshooting Record Sheet .

The antilock wire harnesses contain wires that are color-coded and have imprinted circuit numbers. CIRCUIT DIAGRAMS include the circuit numbers, wire colors, wire gauge and connector numbers. The connector numbers identify the various connectors by number. CONNECTOR END VIEWS display pin configuration and circuits that are attached for the various numbered connectors. Connectors are always viewed from the mating ends.

As you diagnose wiring in the antilock system, the following general rules should be followed where applicable:

1. It is generally best to replace a wire harness, rather than repair individual wires in the harness. If a splice repair must be made, it is important that the splice be properly soldered with a rosin flux (not acid-based) and made waterproof.

2. Do not pierce wire insulation when checking for continuity. Also, do not probe the ECU harness 12 and 14 pin connectors from the rear to check for continuity. The pins are sealed against moisture.**Check for power, ground or continuity only by disconnecting the connector(s) and testing the individual pins or sockets in the connector.**

3. Always refer to the Circuit Diagram Book for wire and connector identification. Individual wire identification will differ depending upon the type of connectors in use, the vehicle model, and the system features.

8.2. DIAGNOSING AND LOCATING A SYSTEM PROBLEM

Self–Diagnostics

The ECU contains self-test and diagnostic circuitry that continuously checks for proper operation of the entire antilock system, including wiring continuity. A yellow warning light located on the instrument panel, controlled by the ECU, advises the driver of the condition of the antilock system. The condition of specific antilock components is provided to the mechanic by a series of labeled, Light Emitting Diodes (LEDs) displayed through a window in the ECU.

No special tools or equipment are needed to read or interpret the ECU diagnostics window. It should be noted that the ECU diagnostics display is separate from the yellow antilock condition light on the dash. With this separation, the driver is only aware there is a problem.

A special feature of the ECU controller is the failure signal and diagnostic system. Off and on problems, particularly in the wheel speed sensing area, can be difficult to diagnose. When the controller senses a failure, whether in the controller electronics, the modulator or wheel speed sensing areas, it stores the information in the ECU, disables the antilock function, turns on the dash mounted antilock condition light and the appropriate diagnostic LEDs on the ECU.

Failure information is stored and is not lost because of loss of power to the ECU. The LEDs will re-light when power is restored and remain on until the failure is corrected. After the actual problem is corrected, you can clear or reset the ECU diagnostics by passing a small magnet over the RESET point in the diagnostics window.

Locating A System Defect

ALL TROUBLESHOOTING BEGINS BY OBSERVING THE**yellow**ANTILOCK WARNING LIGHT!

While the yellow antilock warning light on the instrument panel indicates a system defect, and the ECU diagnostic display locates a specific problem area, it is still necessary to confirm whether the problem is in the component, the wiring, or a faulty or mis-adjusted chassis component. Test procedure charts are provided to interpret the dash light self test, and the condition of the LEDs.

Troubleshooting Flow Charts

Troubleshooting Flow Charts are included for each test.**Troubleshooting always begins with Diagnosing The Initial Start-up Procedure.**It is the "Initial Start-up Procedure" that the ECU performs each time the key is turned to IGN and indicates a system defect. This procedure will direct you to the next test flow chart based on performance of the Dash Light and ECU LEDs.

Refer to the CIRCUIT DIAGRAMS while performing the tests. Also refer toCOMPONENT LOCATIONS(See CIRCUIT DIAGRAM, page 65)for specific locations for various components and connectors. CONNECTOR COMPOSITES are also included for each multiple connector.

It must be stressed that ALL TROUBLESHOOTING BEGINS BY OBSERVING THE**yellow**ANTILOCK WARNING LIGHT located on the instrument panel. You should begin all troubleshooting by first performing the**Initial Start–up Procedure**and following the directions contained in it. The troubleshooting procedure DIAGNOSING THE "INITIAL START–UP PROCEDURE" narrows the problem to either the wiring or a specific antilock component.

Important Troubleshooting Tips

1. Record all findings and the action taken on a TROUBLESHOOTING RECORD SHEET. The Troubleshooting Record Sheet should be filed in the vehicle maintenance folder for future reference.

2. **No voltage or resistance tests are ever performed into the EC–15.**All voltage and resistance tests are performed by beginning at the vehicle antilock wire harness(s) side of the EC–15 pigtail connectors and moving AWAY from the EC–15 toward an antilock system component (Modulator, Wheel Speed Sensor, etc.)**NO tests are performed "into" the EC–15 controller.**

8.3. DIAGNOSTIC LEDS

There are nine LEDs, plus a magnetically actuated reset switch in the EC–15 diagnostic window (Figure 15). The first five LEDs locate a problem to a specific area of the vehicle, while the last four indicate the problem component or its wiring. The LEDs are software driven and are either ON or OFF depending upon their monitor function.

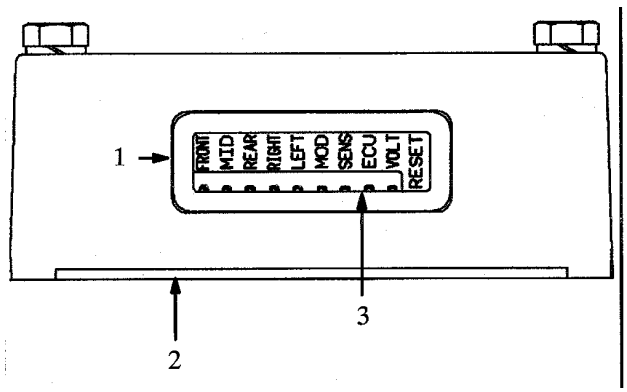


Figure 15 EC–15 LED Window

1. LED WINDOW
2. EC–15 CONTROLLER
3. LEDs

NOTE – Right and left, front and rear are determined from the driver's seat. Left front is therefore the corner closest to the driver.

'FRONT' LED

This Red LED turns ON and stays ON to indicate the location of a problem component or its wiring. This LED (when ON) indicates a defect in either the right or left front modulator or sensor circuits. The defect may be either the wiring or components. The FRONT LED lights at the same timeas either the RIGHT or LEFT LEDand either the MOD or SENS LED.

'MID' LED

This Red LED is not used in troubleshooting the ECU and should only turn on when a magnet is held on the RESET switch.

'REAR' LED

This Red LED turns ON and stays ON to indicate the location of a problem component or its wiring. This LED (when ON) indicates a defect in either the right or left rear modulator or sensor circuits. The defect may be either the wiring or components. The REAR LED illuminates at the same timeas either the RIGHT or LEFT LEDand either the MOD or SENS LED.

'RIGHT' LED

This Red LED turns ON and stays ON to indicate the location of a problem component or its wiring. This LED (when ON) indicates a defect on the right side (passenger) of the vehicle. The defect is in either the modulator or sensor circuits. The defect may be either wiring or the components. The RIGHT LED turns on at the same timeas either the FRONT or REAR LEDand either the MOD or SENS LED.

'LEFT' LED

This Red LED turns ON and stays ON to indicate the location of a problem component or its wiring. This LED (when ON) indicates a defect on the left side (driver side) of the vehicle. The defect is in either the modulator or sensor circuits. The defect may be either wiring or the components. The LEFT LED illuminates at the same timeas either the FRONT or REAR LEDand either the MOD or SENS LED.

'MOD' LED

This Red LED turns ON and stays ON to indicate a permanent or intermittent open or short circuit in the solenoids of one of the four modulators or the wiring connecting a modulator to the system. When this LED is on,either the RIGHT OR LEFT LEDand either the FRONT OR REAR LED will also turn on to identify the defect location.

'SENS' LED

This Red LED turns ON and stays ON to indicate permanent or intermittent failure. The failures indicated are: open or shorted wheel speed sensor, open or shorted wheel speed sensor wiring, wheel speed signal not present or is not proper. When this LED is ON,either the RIGHT OR LEFT LEDand either the FRONT OR REAR LED will also be ON to identify the defect location.

'ECU' LED

This Red LED, when ON, indicates that the controller itself has failed. It stays ON for all ECU failures, except low voltage. For voltages less than 9V DC, this LED turns on to indicate the controller is inoperative; however, when the voltage again exceeds 9V DC, the LED will TURN ITSELF OFF.

'VOLT' LED

This Green LED turns ON and stays ON during vehicle operation to indicate that vehicle power is reaching the controller. If vehicle power is out of range for proper operation (below 11 vdc or above 17 vdc) this LED will flash until power returns to the proper operating range.

'RESET'

Beneath the RESET area of the window display is a magnetically sensitive switch that is used to reset the diagnostic system. The device will respond to a magnet (magnet strength must be capable of picking up 3 ounces). With the vehicle key at IGN, holding a magnet against the RESET will cause all LEDs to turn on as long as the magnet is held against it. Resetting can only be done with the key at IGN.

9. EC–15 DIAGNOSTIC STEPS

9.1. INITIAL START–UP SELF TEST PROCEDURE

For a vehicle**without any system defects**, the following information describes "normal behavior" during the engine start-up.

Normal Start–Up

NOTE – The ECU will begin start-up diagnostics when the key is turned to IGN. However, when the starter is engaged, the crank relay cuts power to the ECU during the engine cranking process. When the engine cranking process is ended, power is re–applied to the ECU and the "Initial Start-up Procedure" will start over.

Test Explanation — Each M–21 modulator contains (1)*exhaust solenoid*and (1)*hold solenoid*. During this test with service brakes applied, the ECU controller will "fire" or energize each solenoid briefly in a test cycle making a "chuff" sound as the air exhausts. The exhaust solenoid will be "fired" for 10 milli-seconds, then a pause for only a few milli-seconds and the hold solenoid will "fire" for 20 milli-seconds. The two firing in rapid sequence produces a single "chuff" sound. If the solenoids are wired incorrectly, or if only one is firing, the sound will be distinctly different. The ECU will begin at the right front, then go to the left front, then the right rear, and finish the cycle on the left rear. It will then repeat the cycle, making two complete cycles. The second cycle is a repeat of the first.

When the vehicle engine is started (or key switch turned to IGN), the ECU first runs the described series of modulator tests. The controller begins at the*right front*M–21 modulator and fires each of the (2) solenoids contained in the modulator, then moves to the*left front*modulator and fires each of the (2) solenoids in that modulator and moves to the*right rear*modulator, again firing both solenoids, and finally moves to the*left rear*and fires each of the (2) solenoids in that modulator. The cycle will be repeated one more time, in the same sequence.

After the modulator test is complete, the ECU will energize the "Engine Brake Relay" five or six times rapidly, causing a "chattering sound" from the relay (if vehicle is equipped with engine brake), then the yellow instrument panel warning light will flash twice and remain on until the vehicle speed is at least 7–10 mph for several seconds, then the warning light will "go out."

This indicates the antilock system is performing correctly. The ECU will continue to monitor system performance and turn on the warning light if there is a problem.

NOTE – If the vehicle is warm, and shut-off briefly, then restarted and quickly driven past the seven to ten miles per hour point, the system may not go through the diagnosis process of flashing twice, then staying on until the seven miles per hour is attained.

9.3. DIAGNOSING THE INITIAL START–UP PROCEDURE WITH DEFECT IN THE ANTILOCK SYSTEM (PART 1)

Refer to Figure 16, Figure 17, and Figure 18.

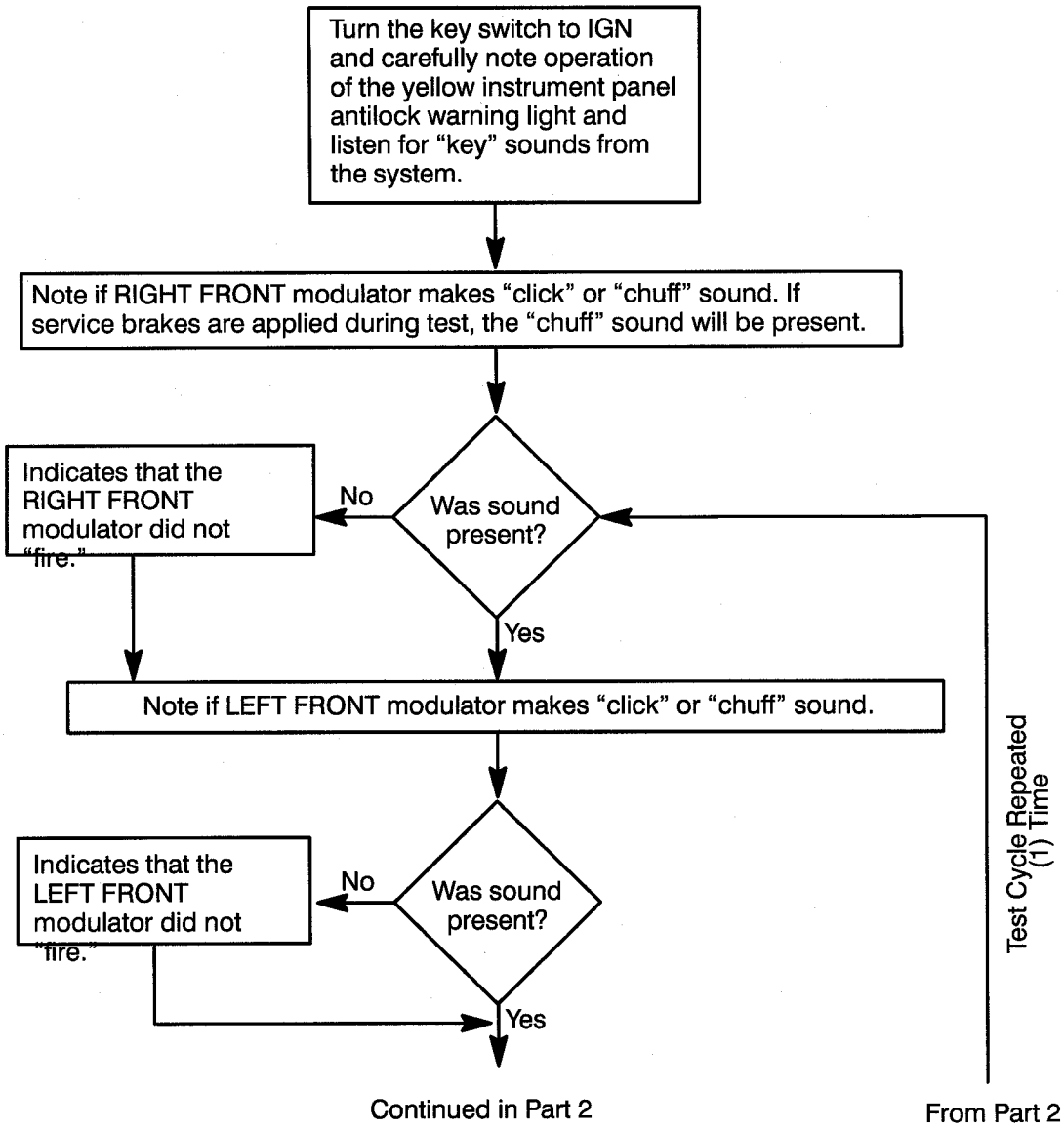


Figure 16 Diagnosing the Initial Start-Up Procedure With Defect in the Antilock System (Part 1)

NOTE – If the Initial Start–Up Procedure" is performed in a quiet area and you listen care fully, modulator click or chuff" and engine brake relay chattering can be heard. This will help you in your diagnosis.

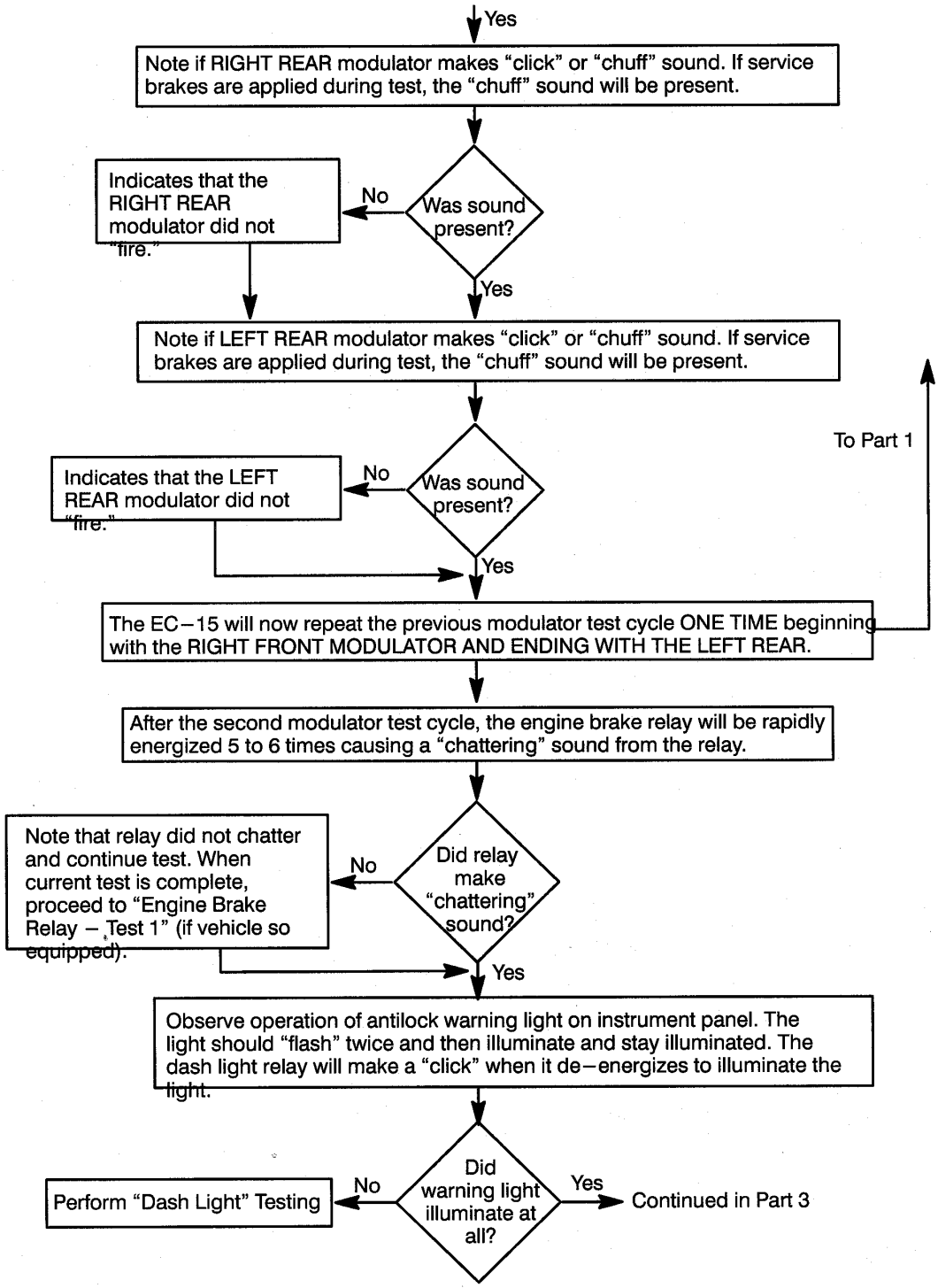


Figure 17 Diagnosing the Initial Start-Up Procedure With Defect in the Antilock System (Part 2)

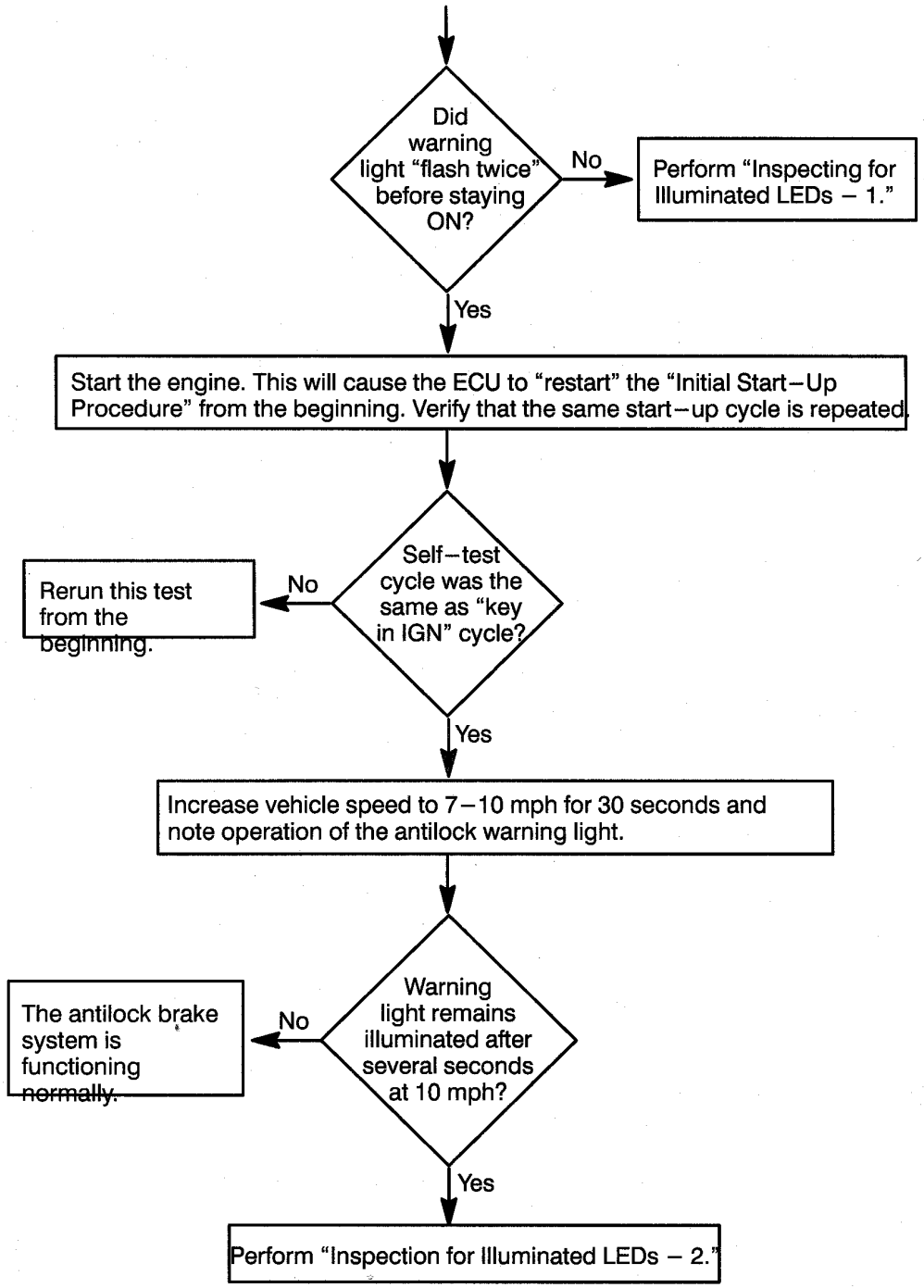


Figure 18 Diagnosing the Initial Start-Up Procedure With Defect in the Antilock System (Part 3)

9.4. ABS DASH WARNING LIGHT

Refer to Figure 19, Figure 20, and Figure 21.

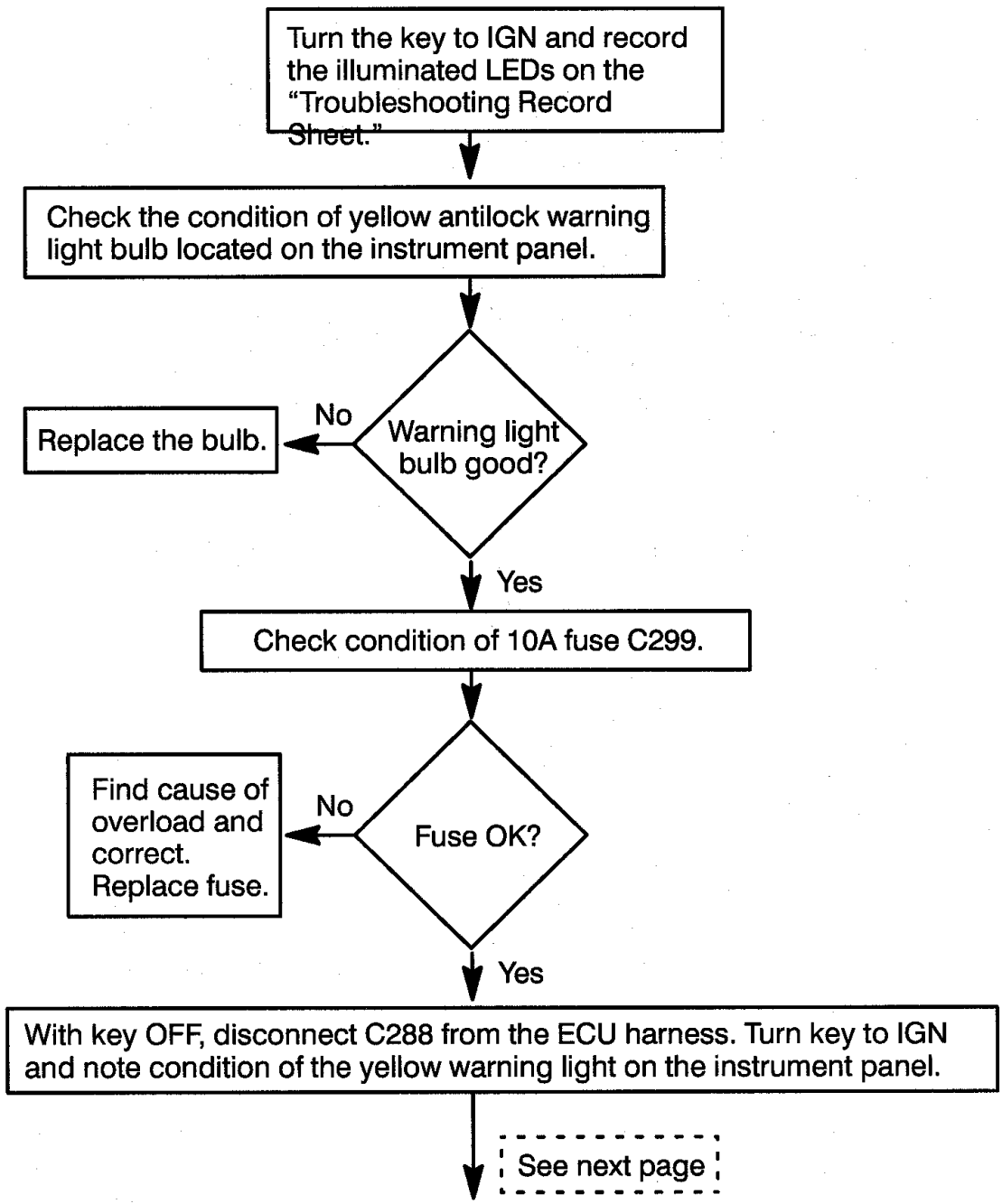


Figure 19 ABS Dash Warning Light

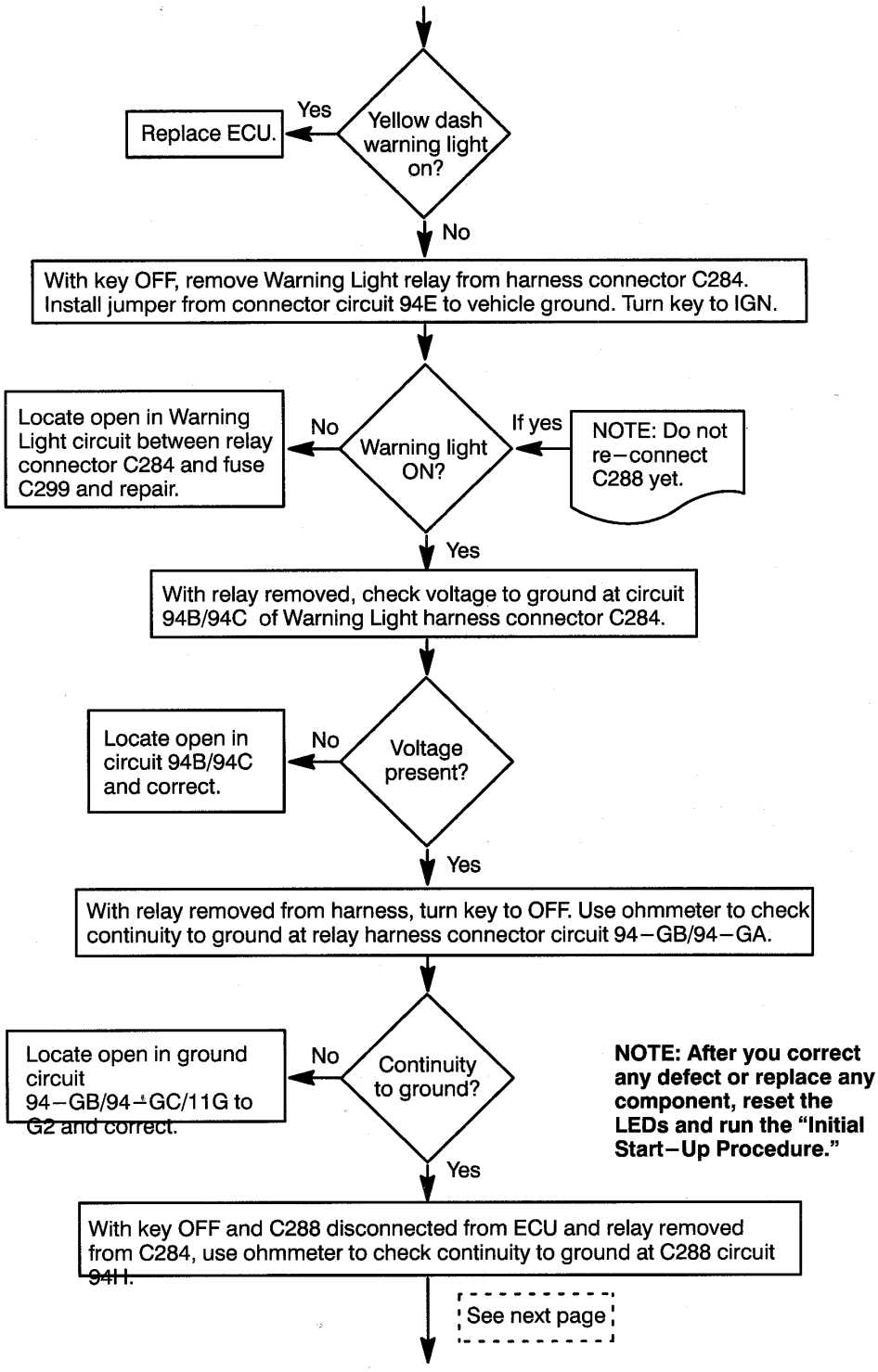


Figure 20 ABS Dash Warning Light (Cont.)

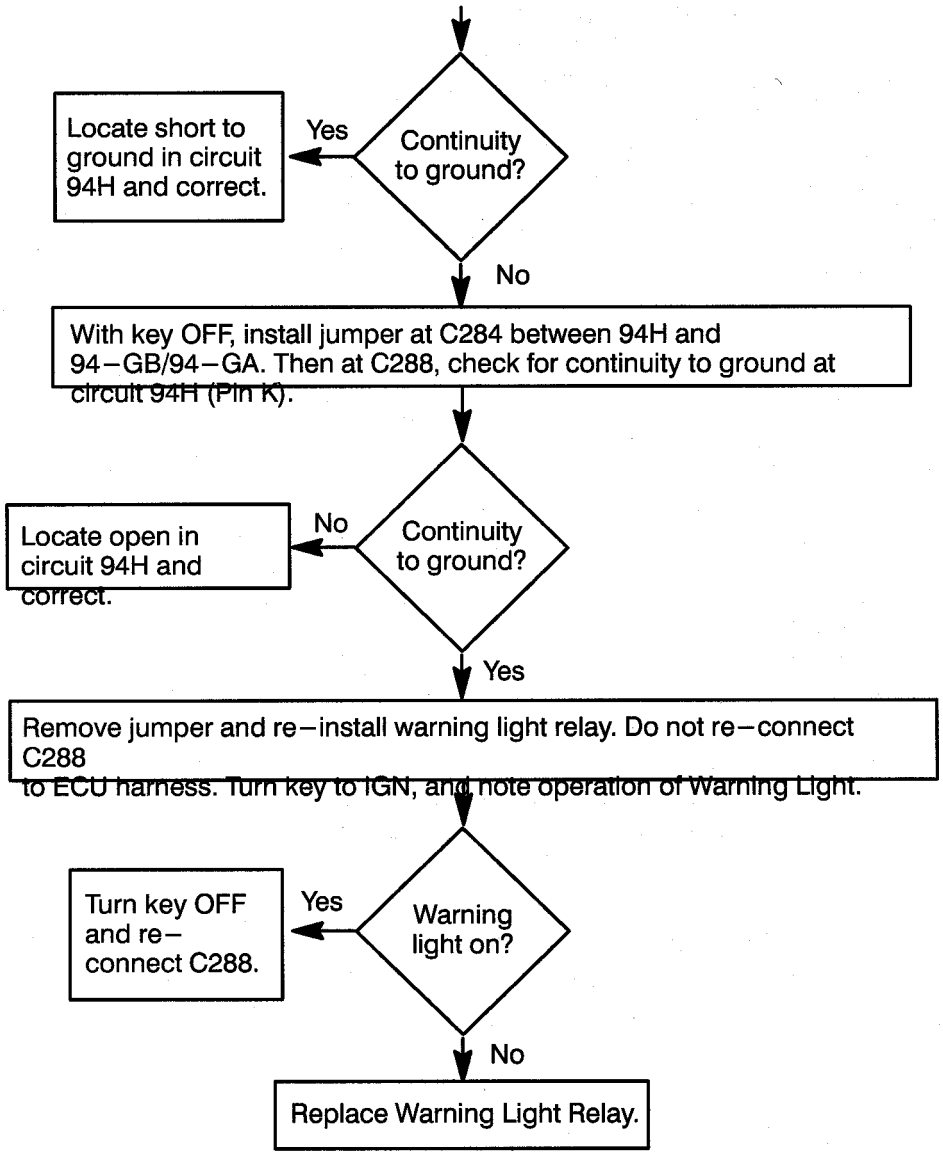


Figure 21 ABS Dash Warning Light (Cont.)

9.5. INSPECTION FOR ILLUMINATED LEDS

Refer to Figure 22, Figure 23, and Figure 24.

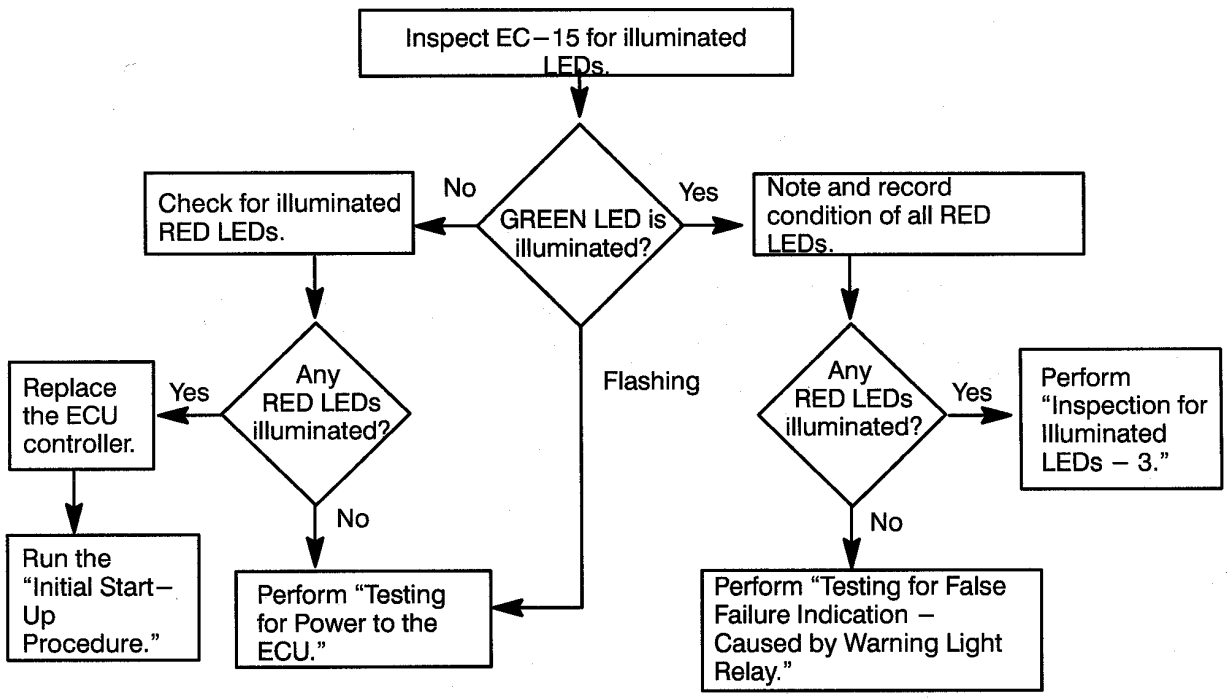


Figure 22 Inspection for Illuminated LEDs – 1

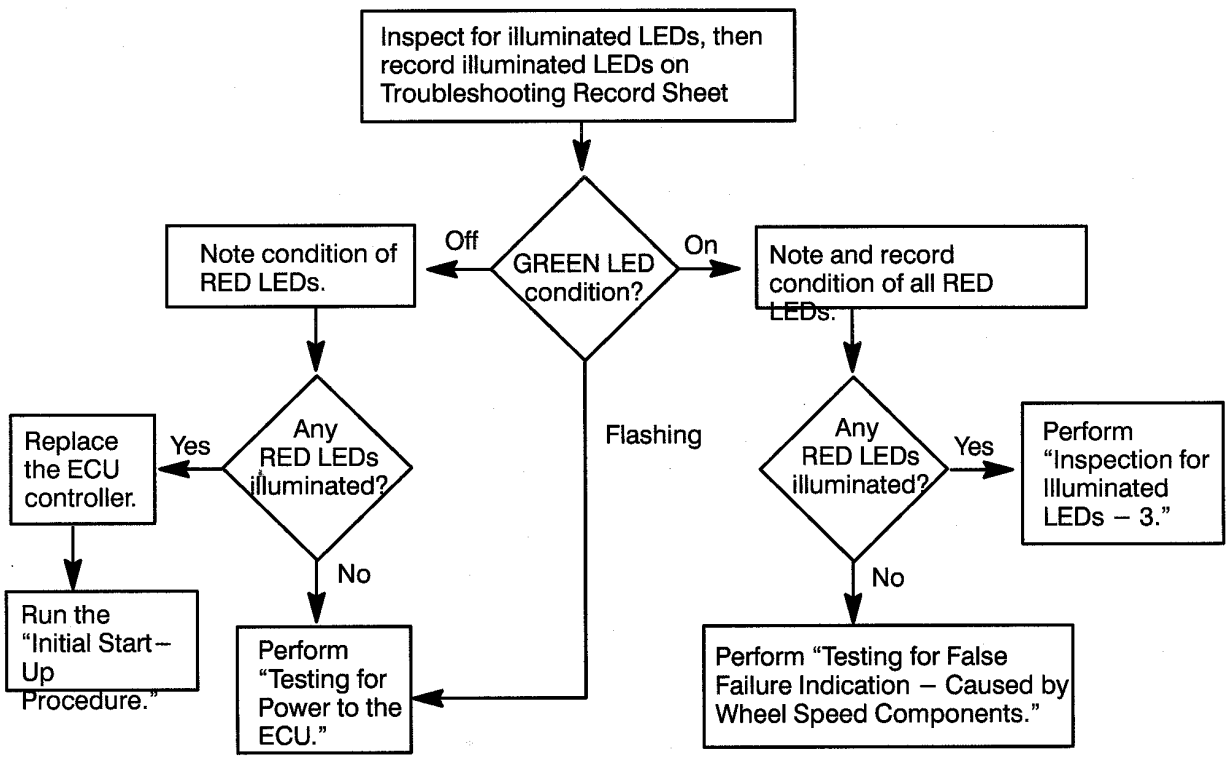


Figure 23 Inspection for Illuminated LEDs – 2

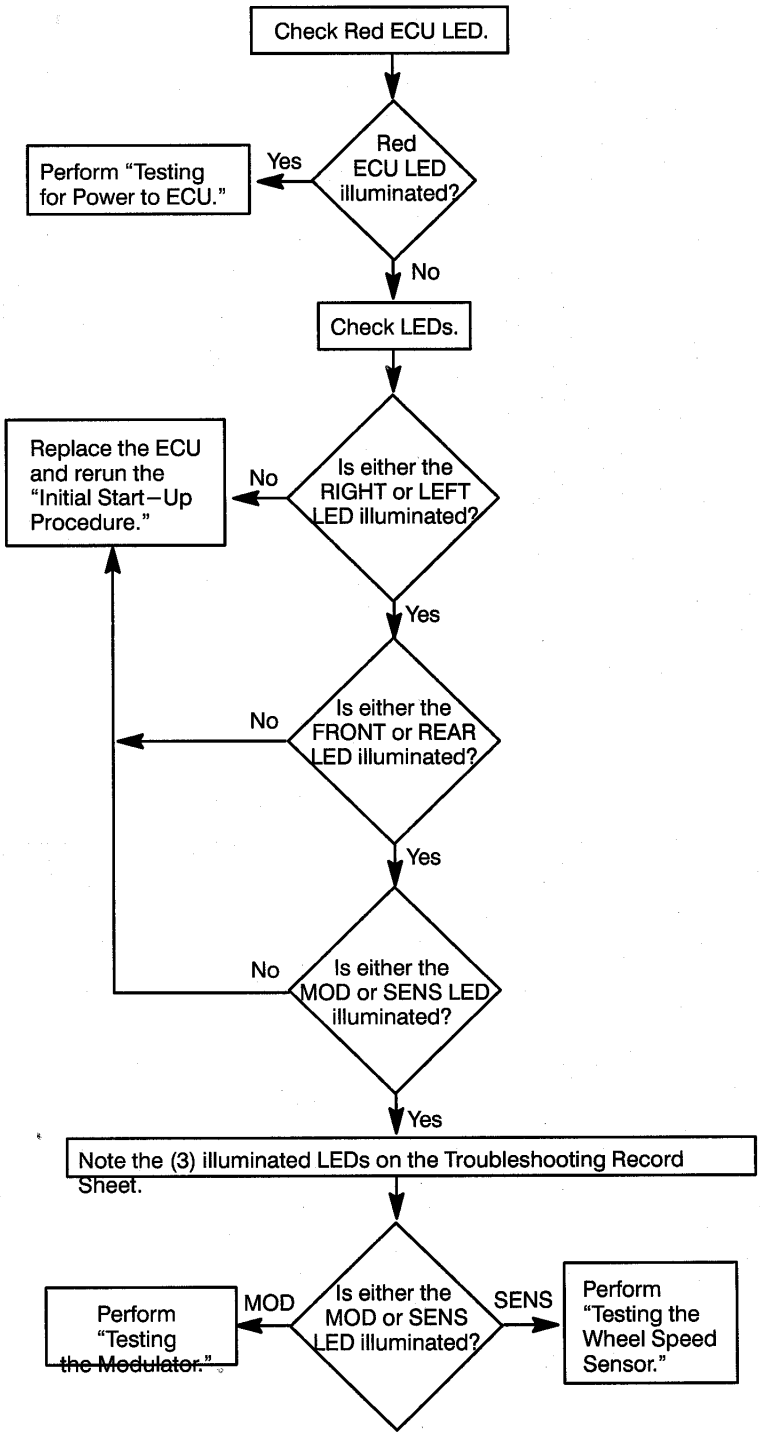


Figure 24 Inspection for Illuminated LEDs – 3

9.6. TESTING FOR POWER TO THE ECU

Refer to Figure 25 and Figure 26.

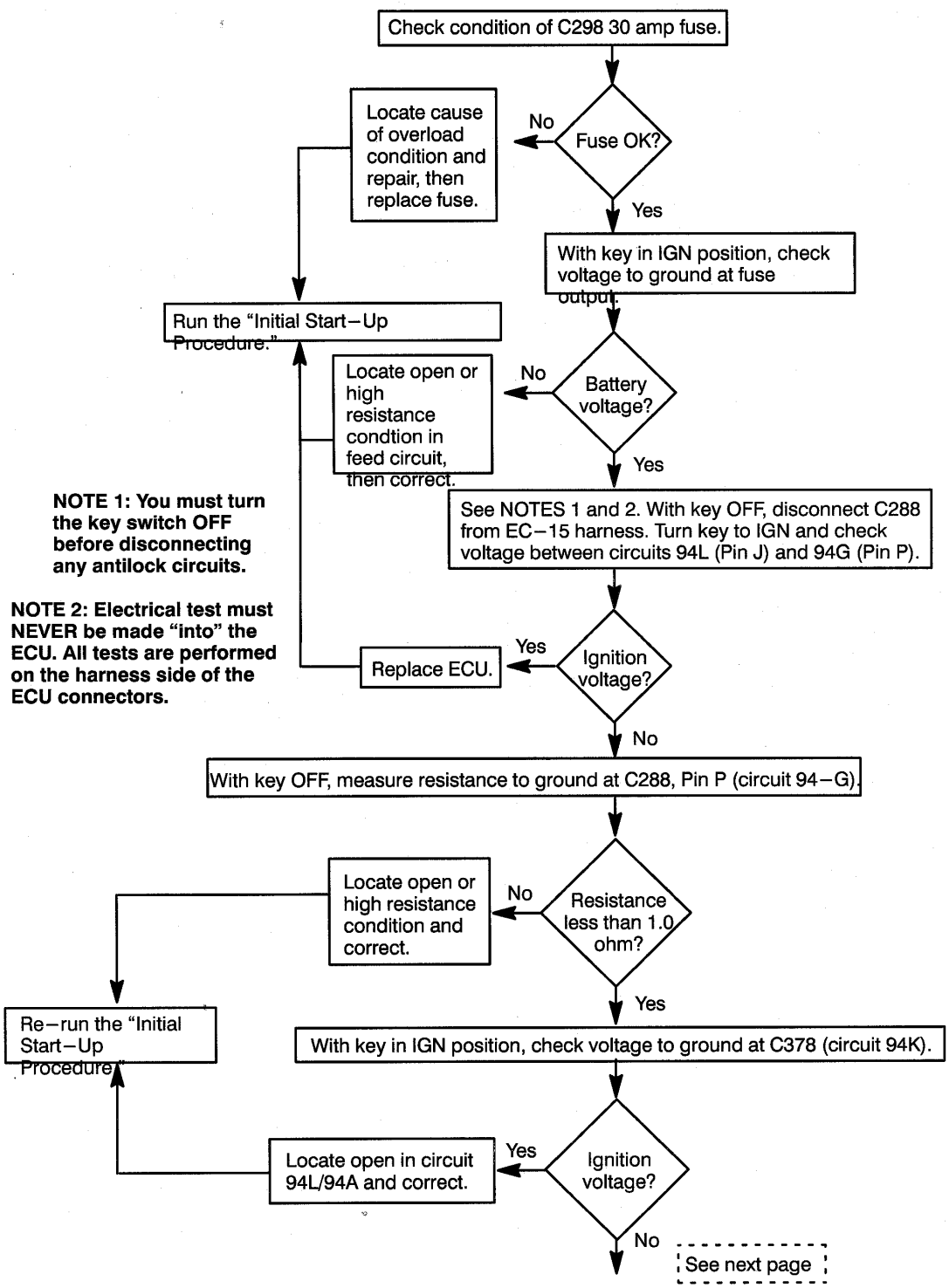


Figure 25 Testing for Power to the ECU

IMPORTANT – Vehicle batteries must be charged to perform this test. Check batteries for state–of– charge (less than 12 volts), correct condition.

NOTE – You must turn the key switch OFF before disconnecting any antilock circuits.

NOTE – Electrical test must NEVER be made "into" the ECU. All tests are performed on the harness side of the ECU connectors.

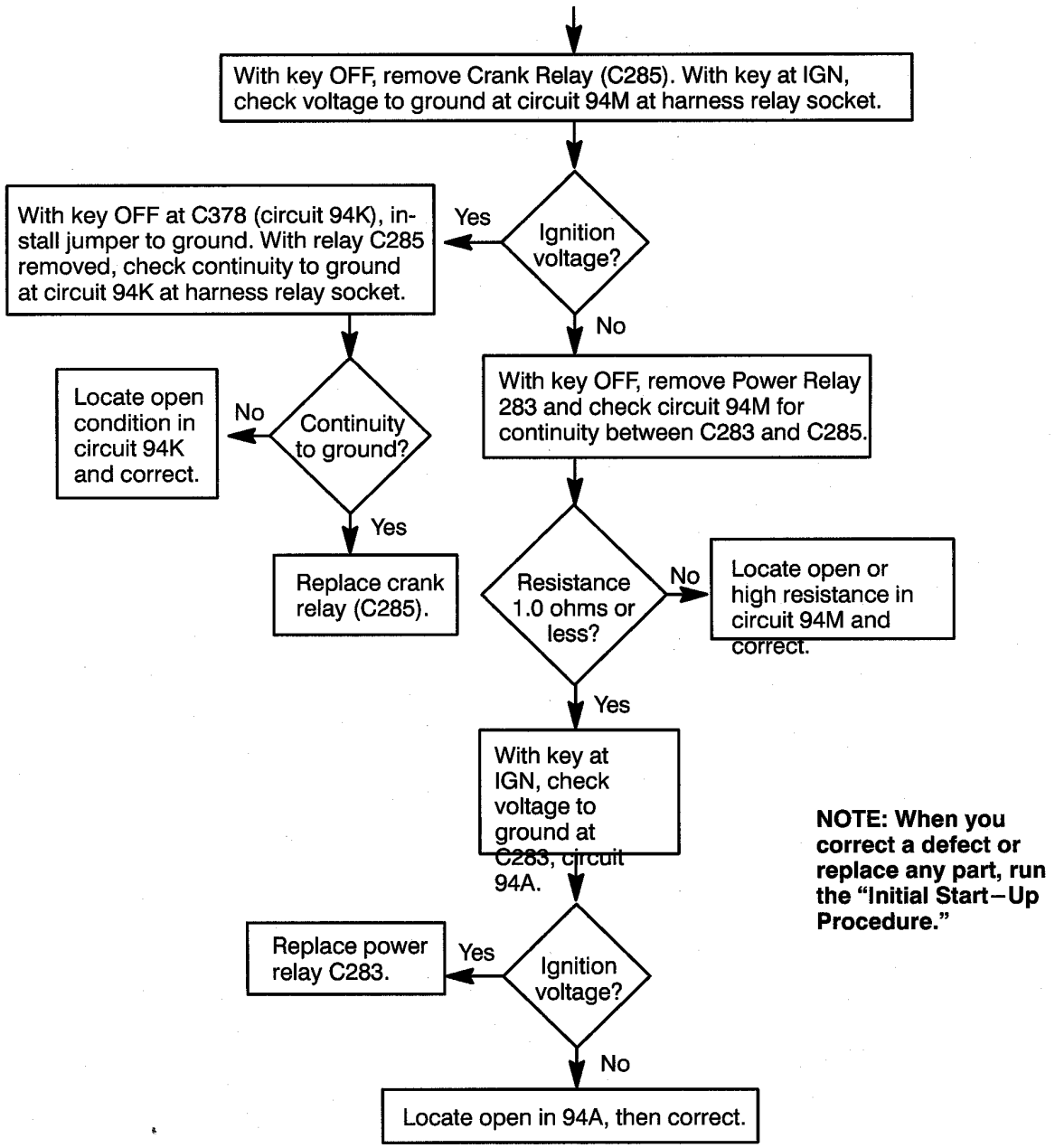


Figure 26 Testing for Power to the ECU (Cont.)

9.7. TESTING THE MODULATOR

Refer to Figure 27, Figure 28, Figure 29, Figure 30, and Figure 31.

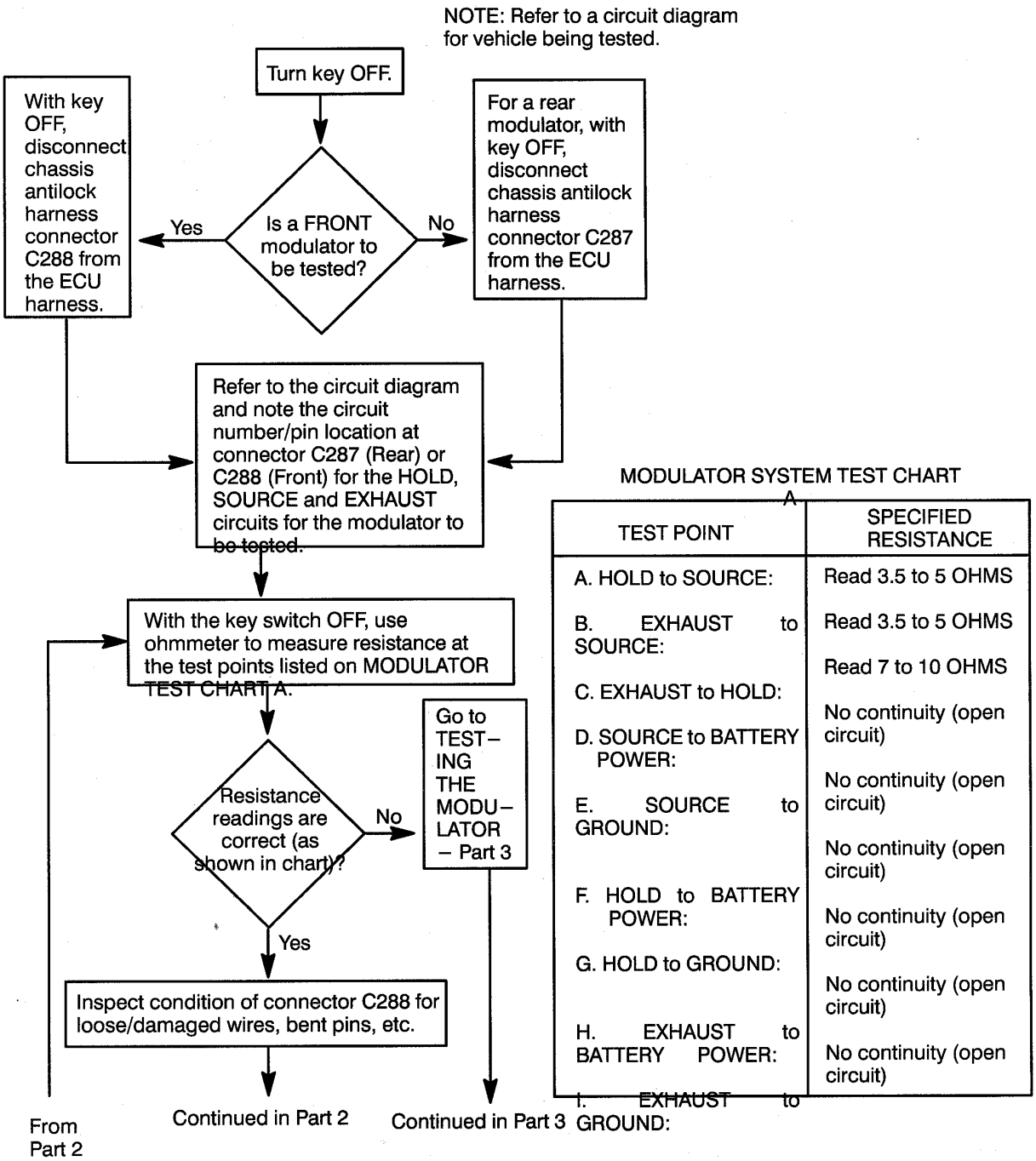


Figure 27 Testing the Modulator (Part 1)

NOTE – Record LEDs that are illuminated before starting the test. Also record ALL test steps and results on the Troubleshooting Record Sheet.

NOTE – Refer to a circuit diagram for vehicle being tested.

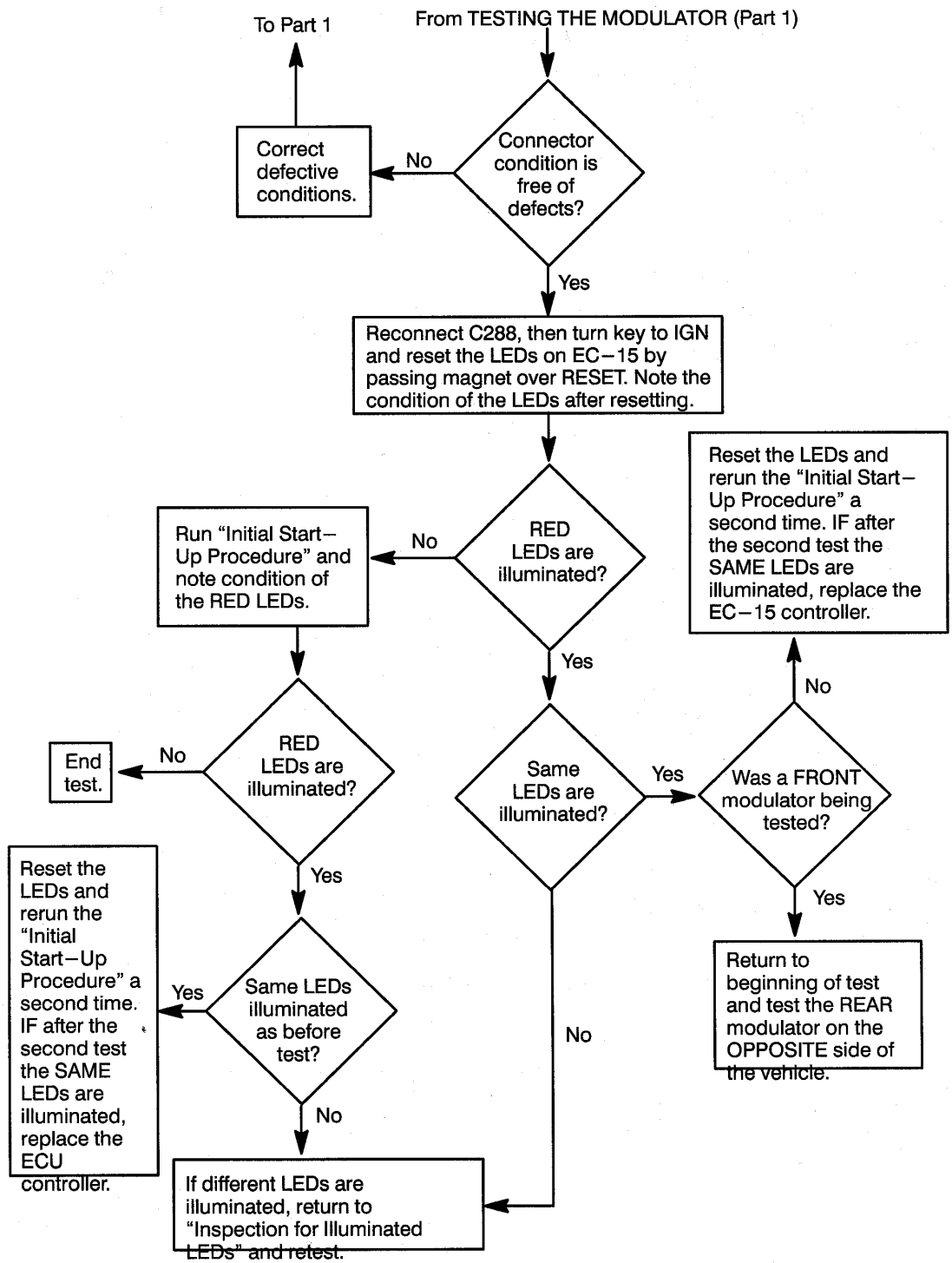
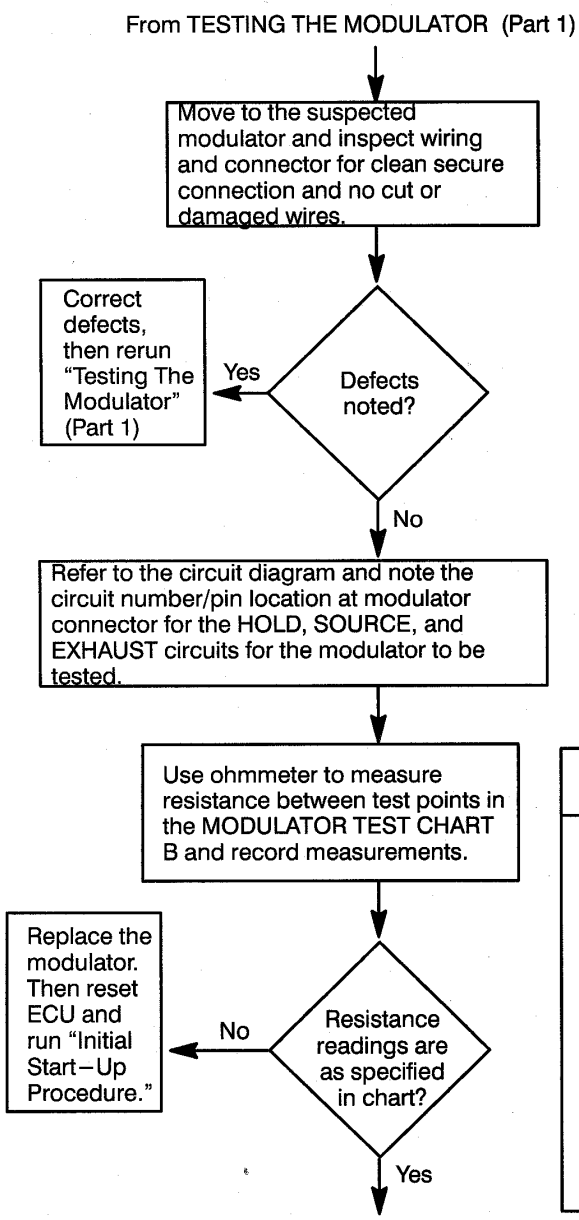


Figure 28 Testing the Modulator (Part 2)



MODULATOR SYSTEM TEST CHART B

TEST POINT	SPECIFIED RESISTANCE
A. HOLD to SOURCE:	Read 3.5 to 5 OHMS
B. EXHAUST to SOURCE:	Read 3.5 to 5 OHMS
	Read 7 to 10 OHMS
C. EXHAUST to HOLD:	Read NO continuity
D. HOLD to vehicle ground	Read NO continuity
E. EXHAUST to vehicle ground:	Read NO continuity
F. SOURCE to vehicle ground:	

Figure 29 Testing the Modulator (Part 3)

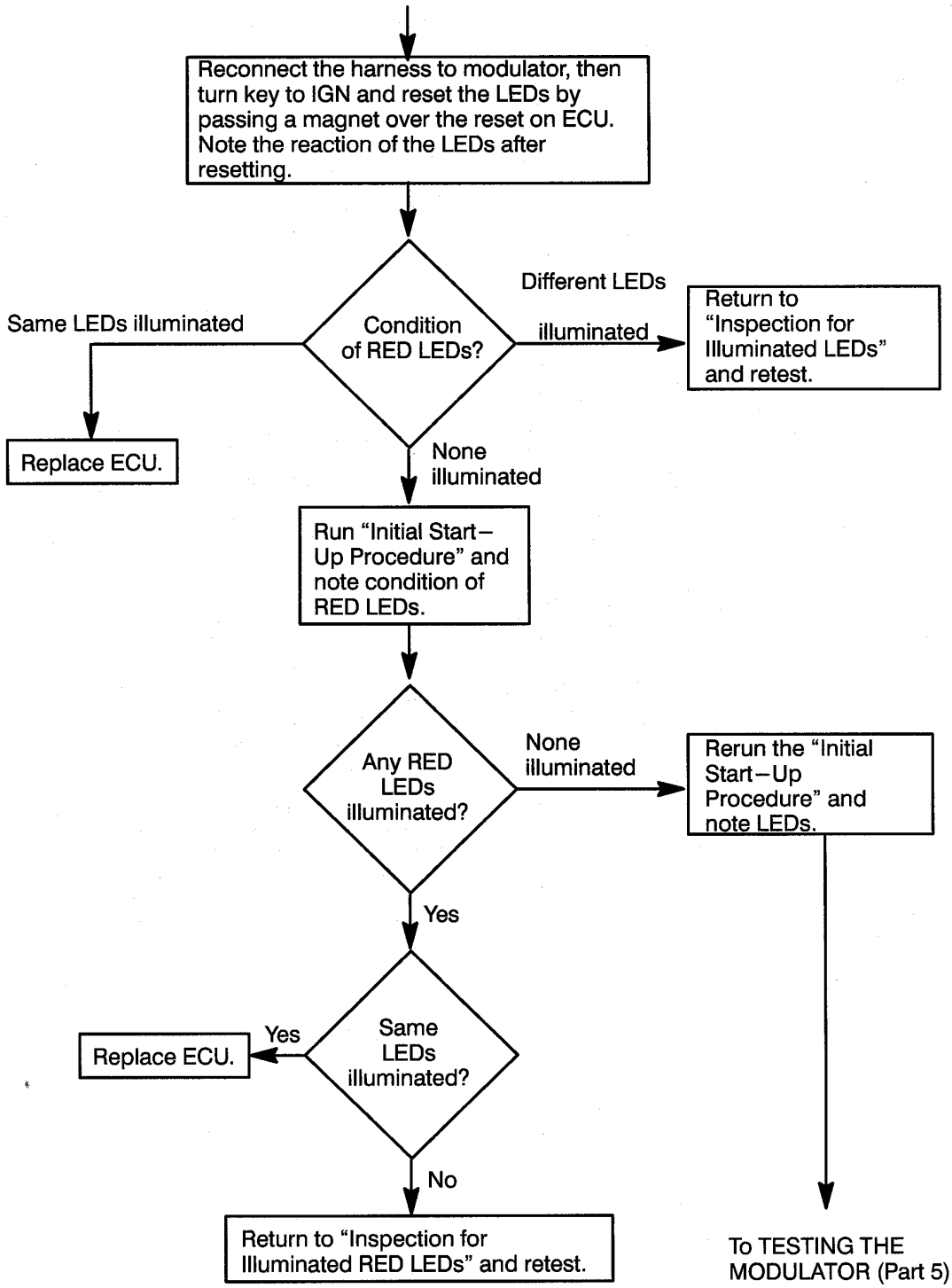


Figure 30 Testing the Modulator (Part 4)

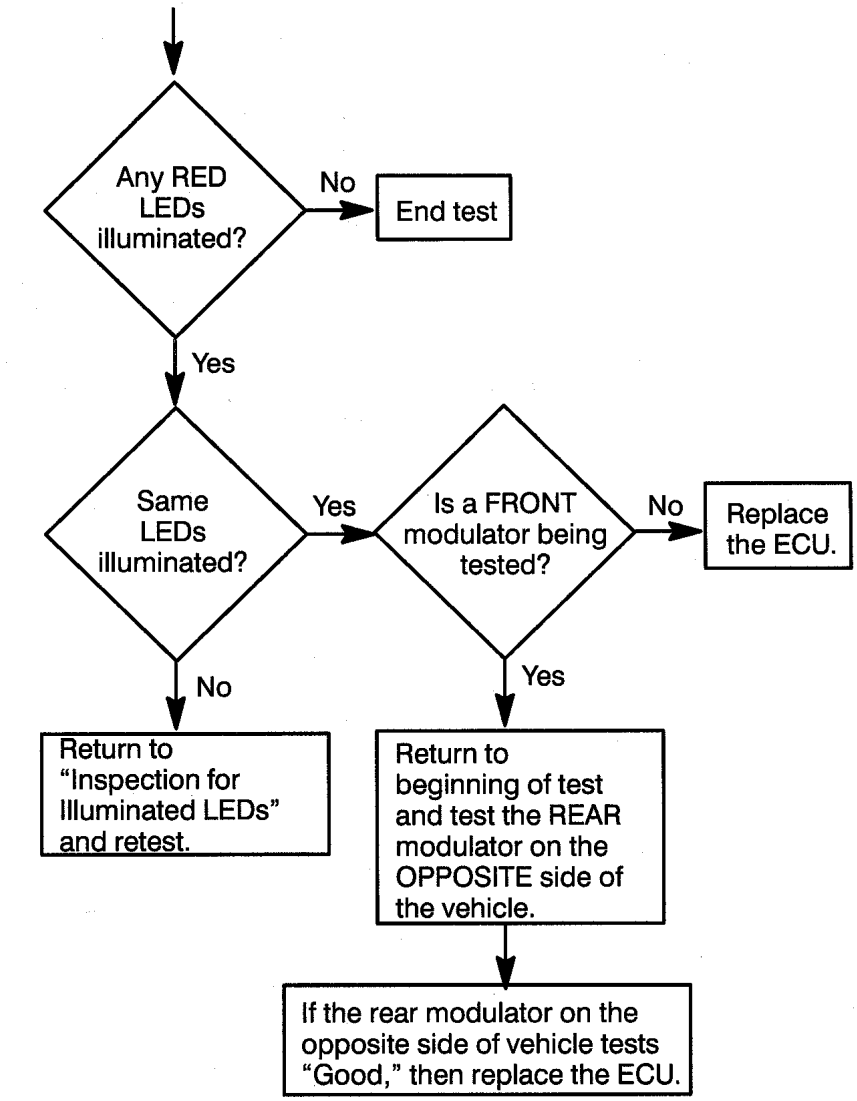


Figure 31 Testing the Modulator (Part 5)

9.8. TESTING THE WHEEL SENSOR

Refer to Figure 32, Figure 33, and Figure 34.

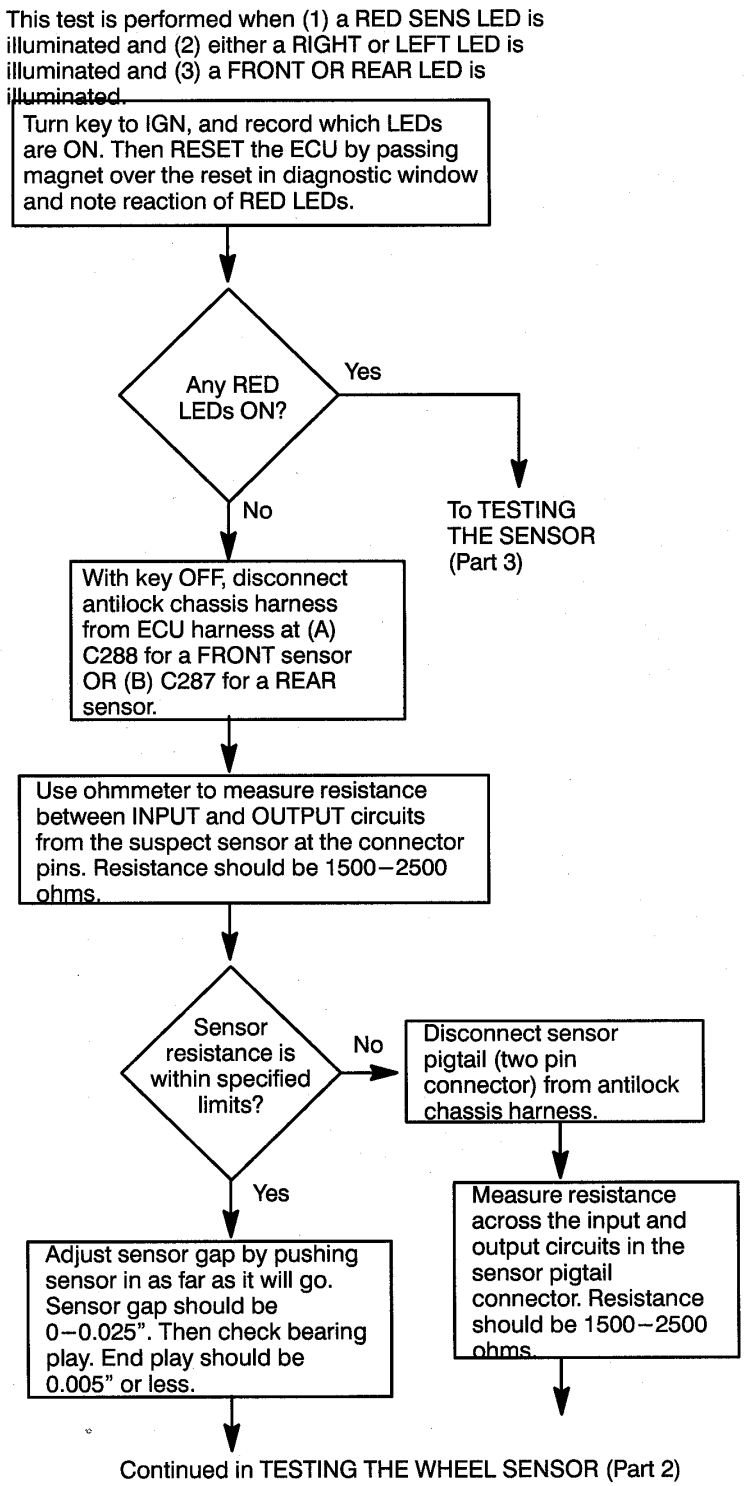


Figure 32 Testing the Wheel Sensor (Part 1)

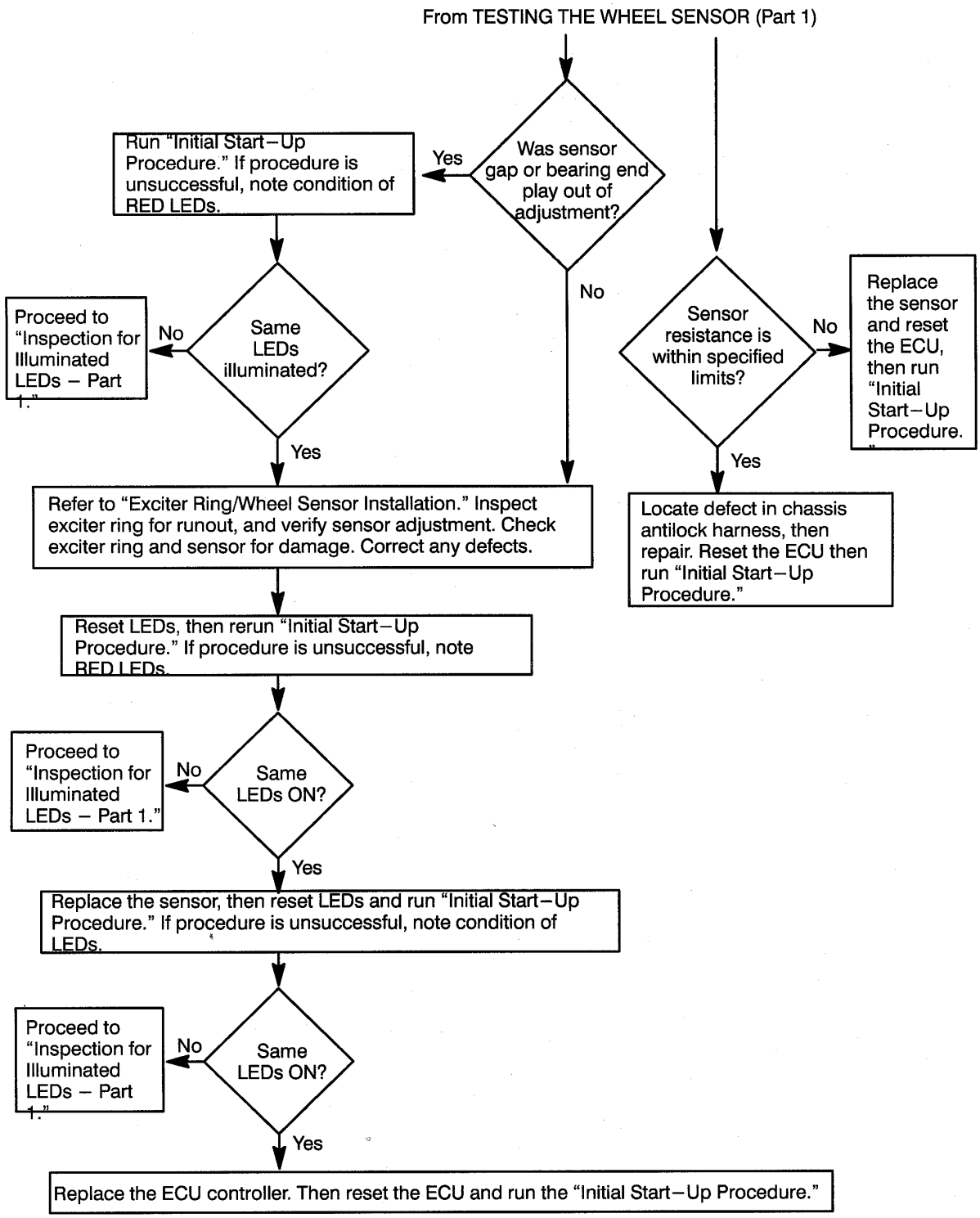


Figure 33 Testing the Wheel Sensor (Part 2)

Continued from TESTING THE WHEEL SENSOR (Part 1)

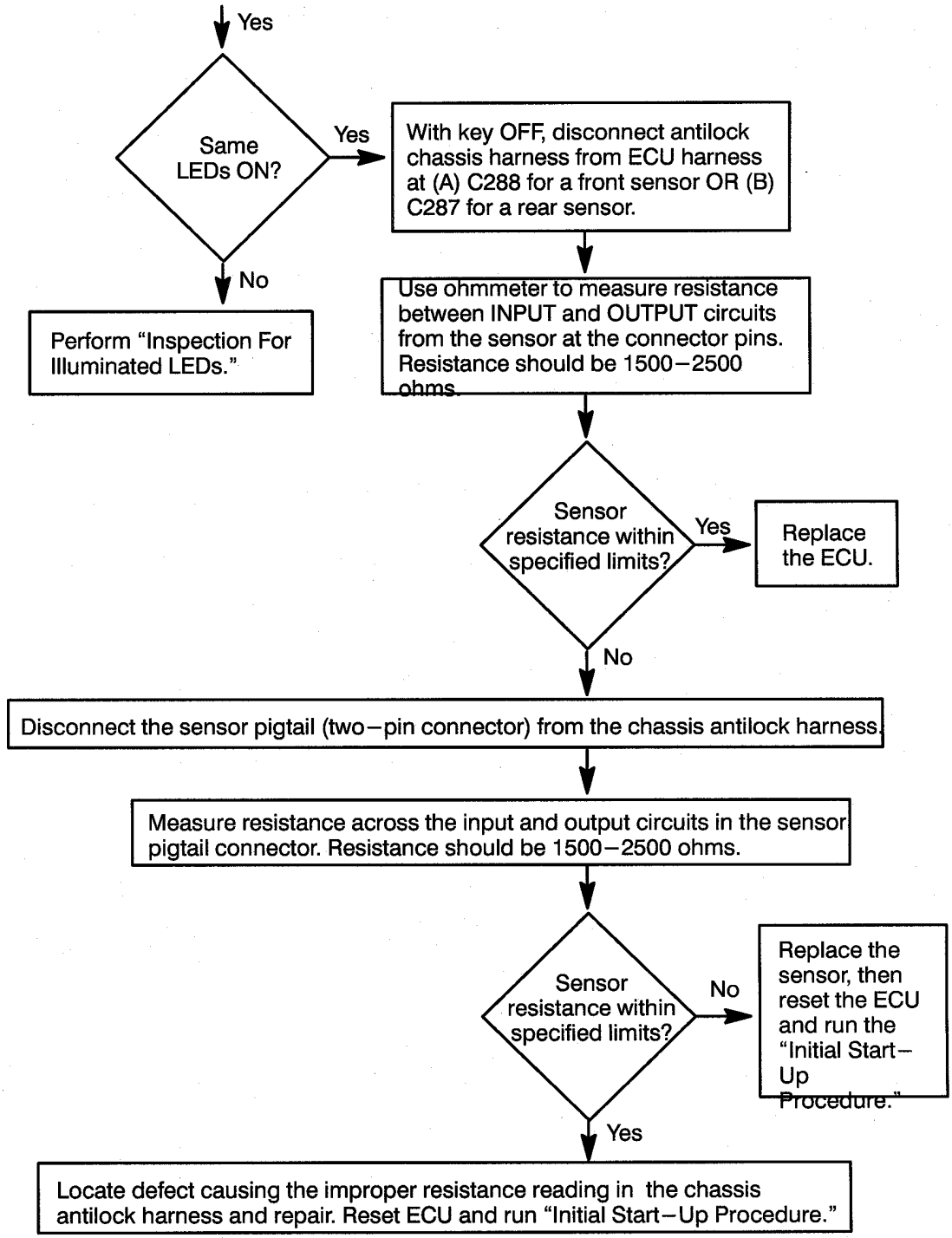


Figure 34 Testing the Wheel Sensor (Part 3)

9.9. TESTING FOR FALSE INDICATION – CAUSED BY DASH LIGHT RELAY

Refer to Figure 35 and Figure 36.

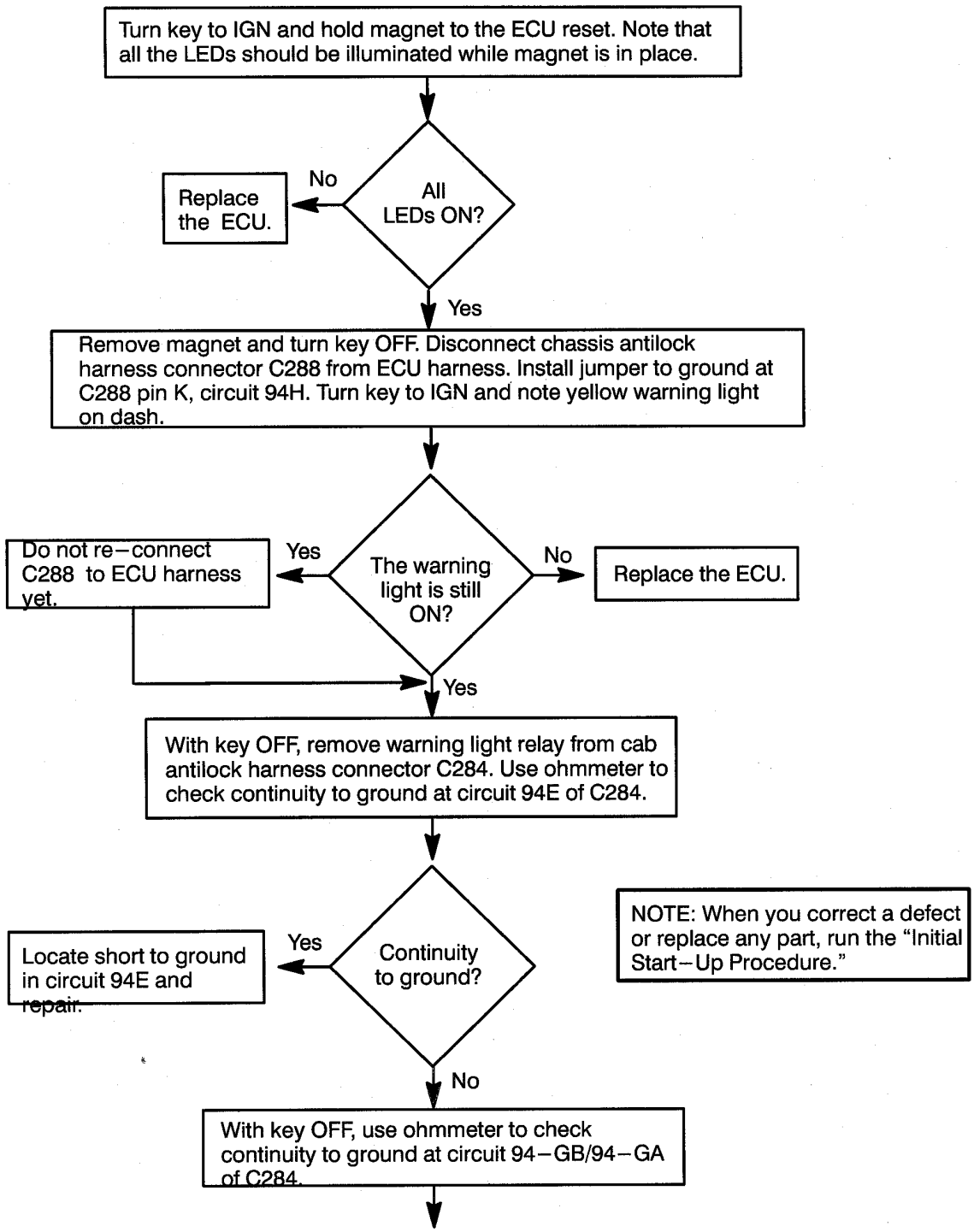


Figure 35 Testing for False Indication - Caused by Dash Light Relay (Part 1)

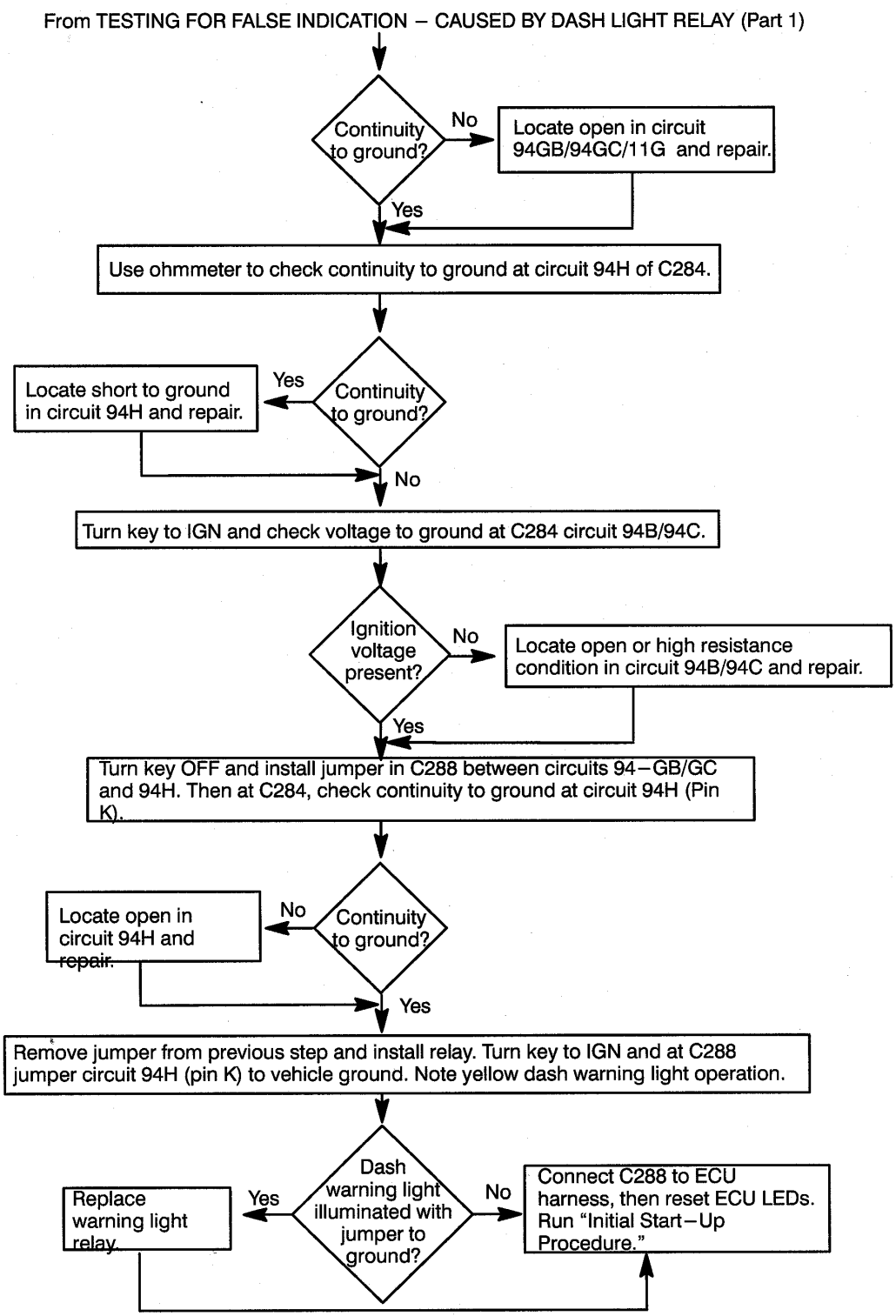


Figure 36 Testing for False Indication - Caused by Dash Light Relay (Part 2)

9.10. TESTING FOR FALSE FAILURE INDICATION – CAUSED BY WHEEL SPEED COMPONENTS

Refer to Figure 37.

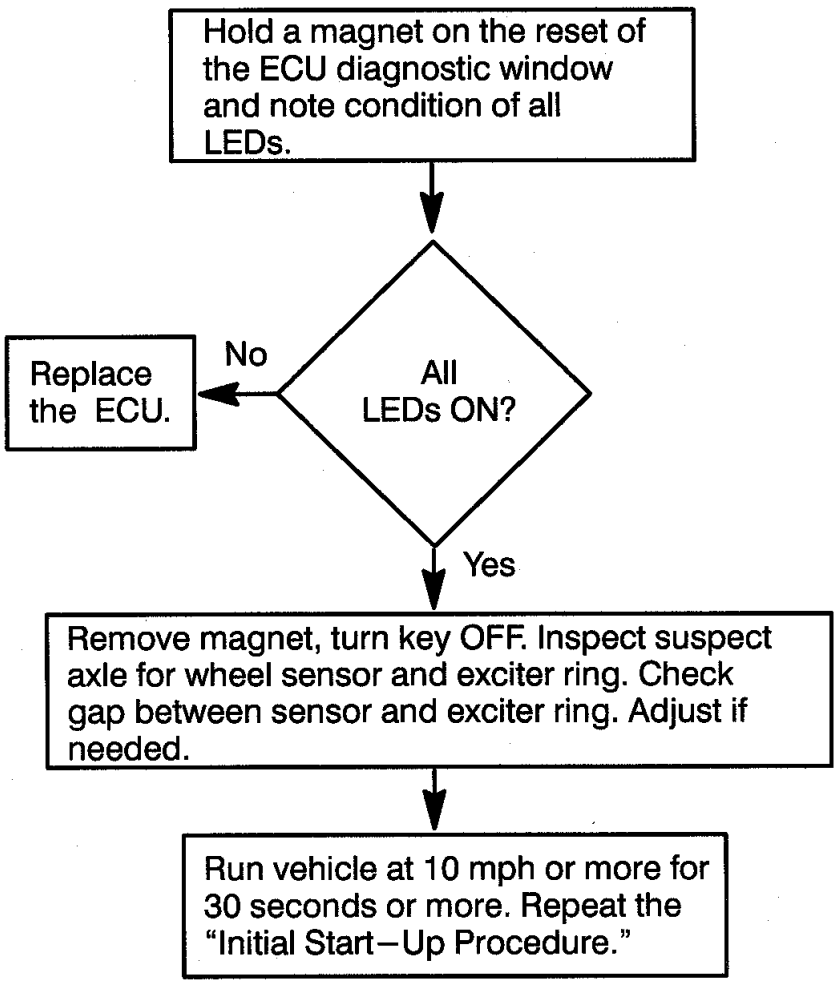


Figure 37 Testing for False Failure Indication - Caused by Wheel Speed Components

9.11. ENGINE BRAKE RELAY TEST

Refer to Figure 38 and Figure 39.

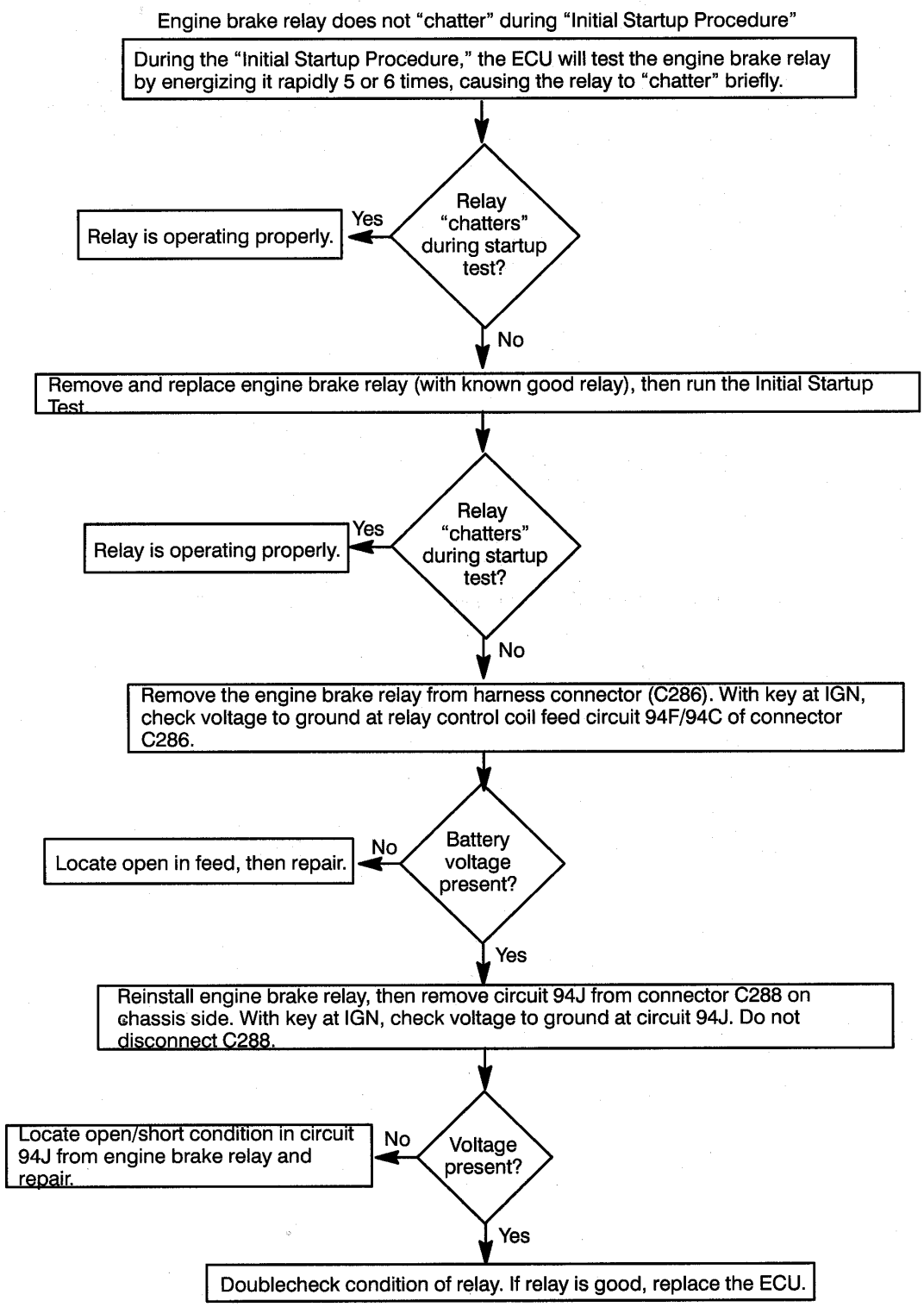


Figure 38 Engine Brake Relay Test 1 (With Vehicles Equipped)

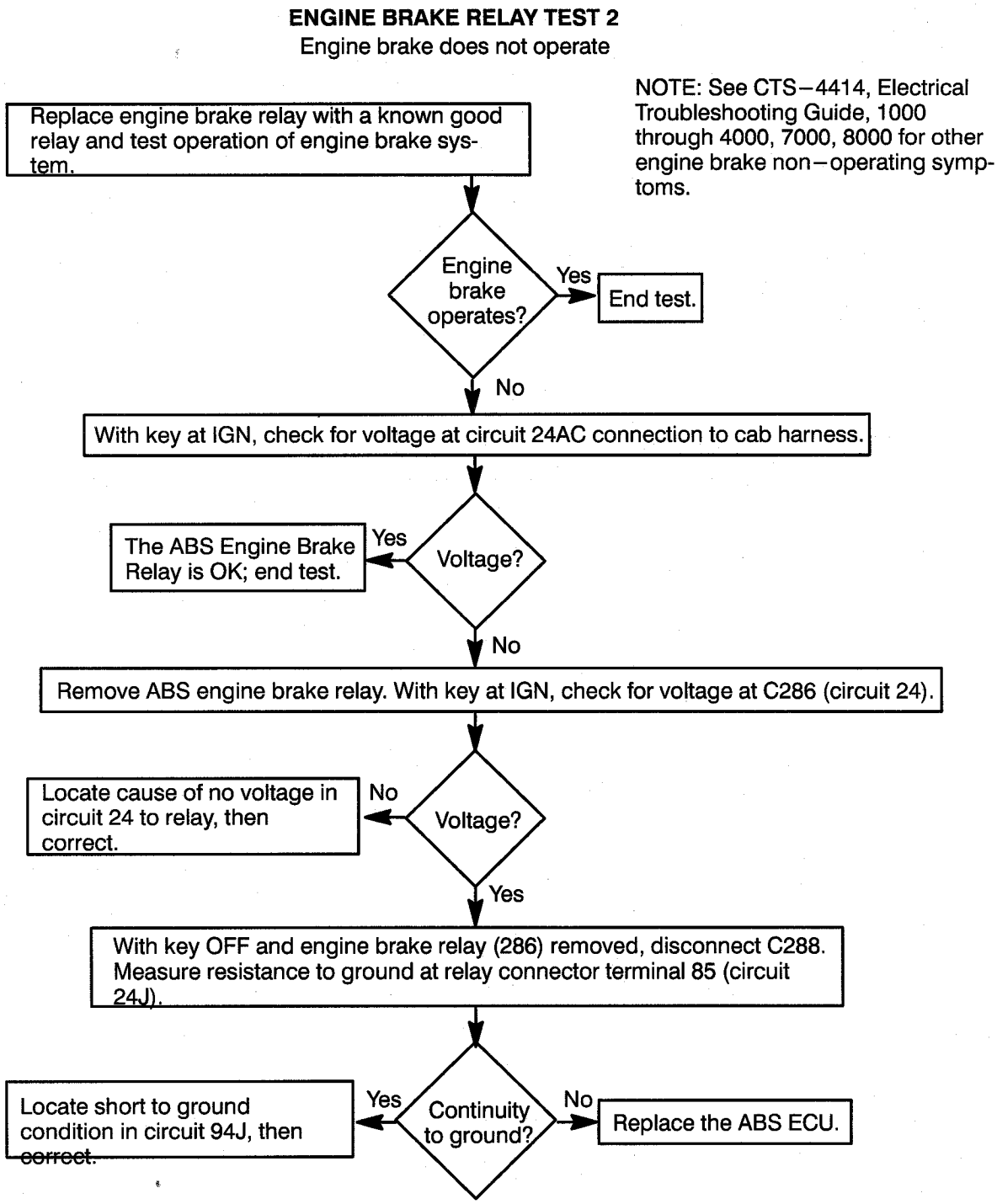


Figure 39 Engine Brake Relay Test 2

NOTE – See CTS–4414, Electrical Troubleshooting Guide, 1000 through 4000, 7000, 8000 for other engine brake non-operating symptoms.

9.12. EXCITER RING/WHEEL SENSOR

Adjustment

1. To adjust the wheel sensors, push the sensor into the bushing (on front axle) or into the mounting block (rear axle) as far as it will go. The sensor will bottom out against the exciter ring, then as the exciter ring rotates, the sensor will self-adjust. To adjust or check adjustment of the rear wheel sensor, the brake drum must be removed.

Inspection

1. The**front axle sensor**can be removed from the axle side of the steering knuckle by pulling the sensor out. Inspect the sensor lead, the connector and the sensor for damage. Replace if damaged. To install, push the sensor into the bushing as far as it will go.

2. The**rear axle sensor**removal requires removal of the wheels and brake drum. Inspect the sensor lead, the connector and the sensor for damage. Replace if damaged. To install, push the sensor into the bushing as far as it will go.

3. Inspect the**exciter rings**for damage by removing the brake drum from the wheel hub. If damaged, the exciter ring should be replaced. Observe the exciter ring, noting that it is properly seated on the wheel hub. To inspect for exciter ring runout with respect to the installed sensor, (with drum removed) push the sensor in against the exciter ring. Using a feeler gauge, slowly rotate the wheel hub observing the clearance between the exciter ring and the sensor. The gap must be between 0 and 0.025 inch for proper signal output.

Remove And Install

1. **Exciter Ring**— To remove the exciter ring, first remove the brake drum from the wheel hub. Then remove the hub from the vehicle. Lightly and evenly heat (about 200°F) the exciter ring. Use a suitable puller to remove it from the hub.

2. To install the exciter ring on the wheel, uniformly heat soak the exciter ring to a temperature of approximately 200°F. It is recommended that the exciter ring be heated by placing it in a 200°F (approximate) bath (water or oil) until the desired temperature is achieved. Then install the exciter ring onto the wheel hub, taking care to fully seat the exciter ring, then allow the exciter ring to cool and "shrink fit" on the wheel hub.**Do not heat with a torch as the exciter ring may develop hot spots, causing the exciter ring to distort.**

3. Install the hub to the axle (less the brake drum) and adjust the wheel bearings (refer to GROUP 17 in the CTS-5000 MASTER SERVICE MANUAL). The bearing end play should not exceed .005 inch. Install the sensor and then inspect for runout as described in step 3 of "Inspection." Install the brake drum after the inspection is complete.

4. **Sensor Retainers**— To replace the sensor retainer, remove old retainer and insert new retainer from axle side. Push into sensor bushing (front axle) or into sensor mounting block (rear axle) until retainer tongues are against the sensor bushing or mounting block.

5. **Front Sensor**— Install the sensor into the retainer and sensor bushing from the backside of the steering knuckle. Push the sensor as far as possible through the sensor bushing. Refer to Figure 40 . No further adjustment is necessary.

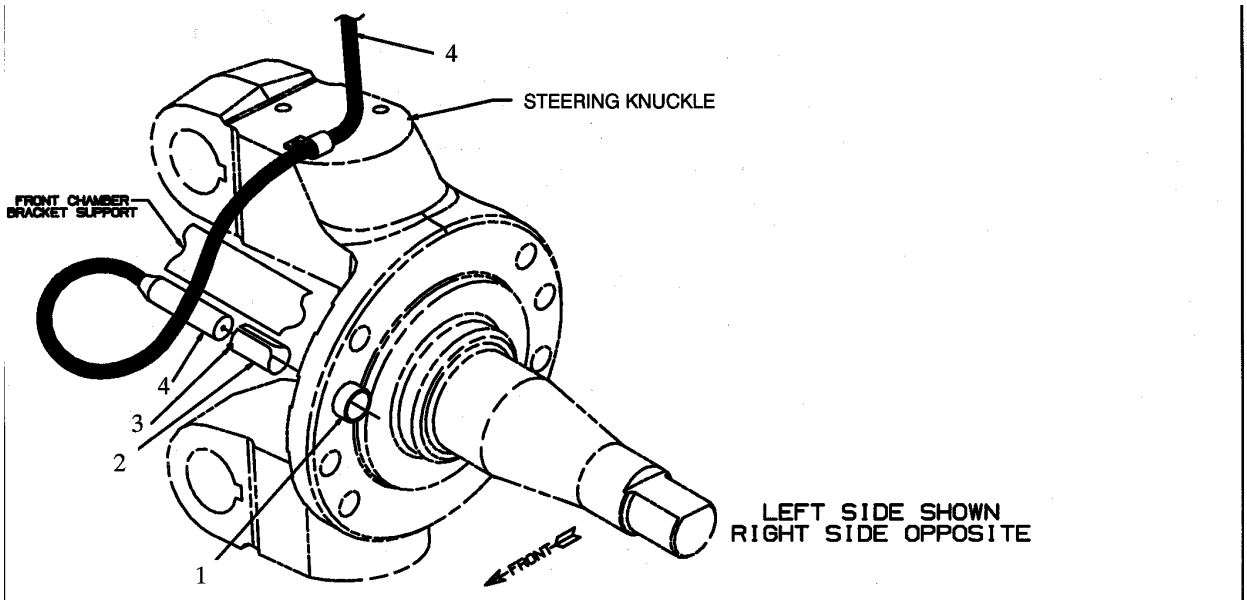


Figure 40 Typical Front Axle, Wheel Sensor Installation

1. SENSOR BUSHING (PART OF KNUCKLE ASSY)
2. SENSOR RETAINER
3. SENSOR RETAINER OUTSIDE TONGUES
4. SENSOR ASSEMBLY INCLUDES LEAD (CONNECTS TO CHASSIS ANTILOCK HARNESS)

6. **Rear Sensor**— Install the sensor into retainer and sensor mounting block from the axle side in a horizontal position with the "cable end" of the sensor positioned as shown in Figure 41 or Figure 42 , depending on suspension type. Push the sensor in as far as possible through the mounting block. No further adjustment is necessary.

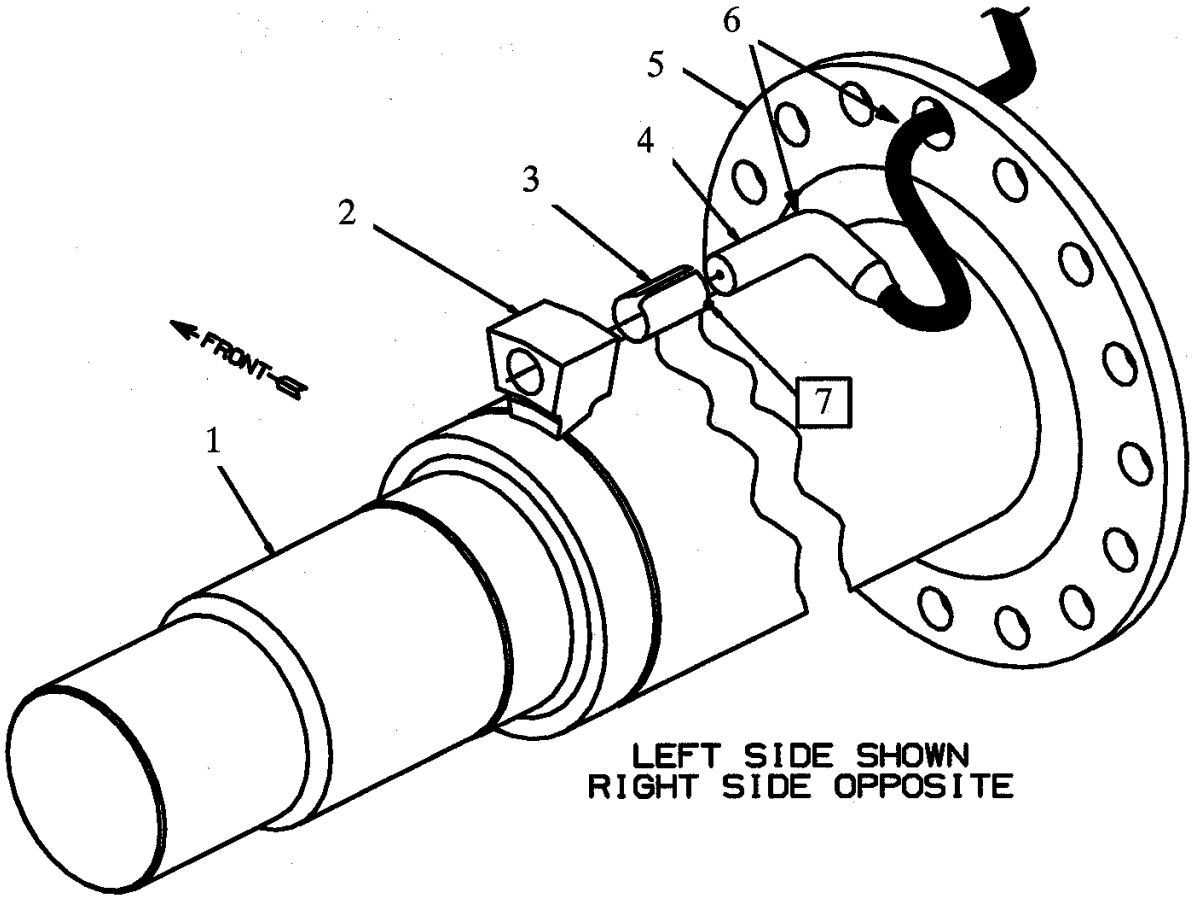


Figure 41 Typical Rear Sensor Installation With Air Suspension

1. REF – REAR AXLE
2. SENSOR MOUNTING BLOCK (PART OF AXLE)
3. SENSOR RETAINER (USE ONLY INTERNATIONAL RETAINER)
4. SENSOR SHOWN REMOVED
5. REF – AXLE FLANGE
6. SENSOR ASSEMBLY INCLUDES LEAD
7. RETAINER OUTSIDE TONGUES – REF

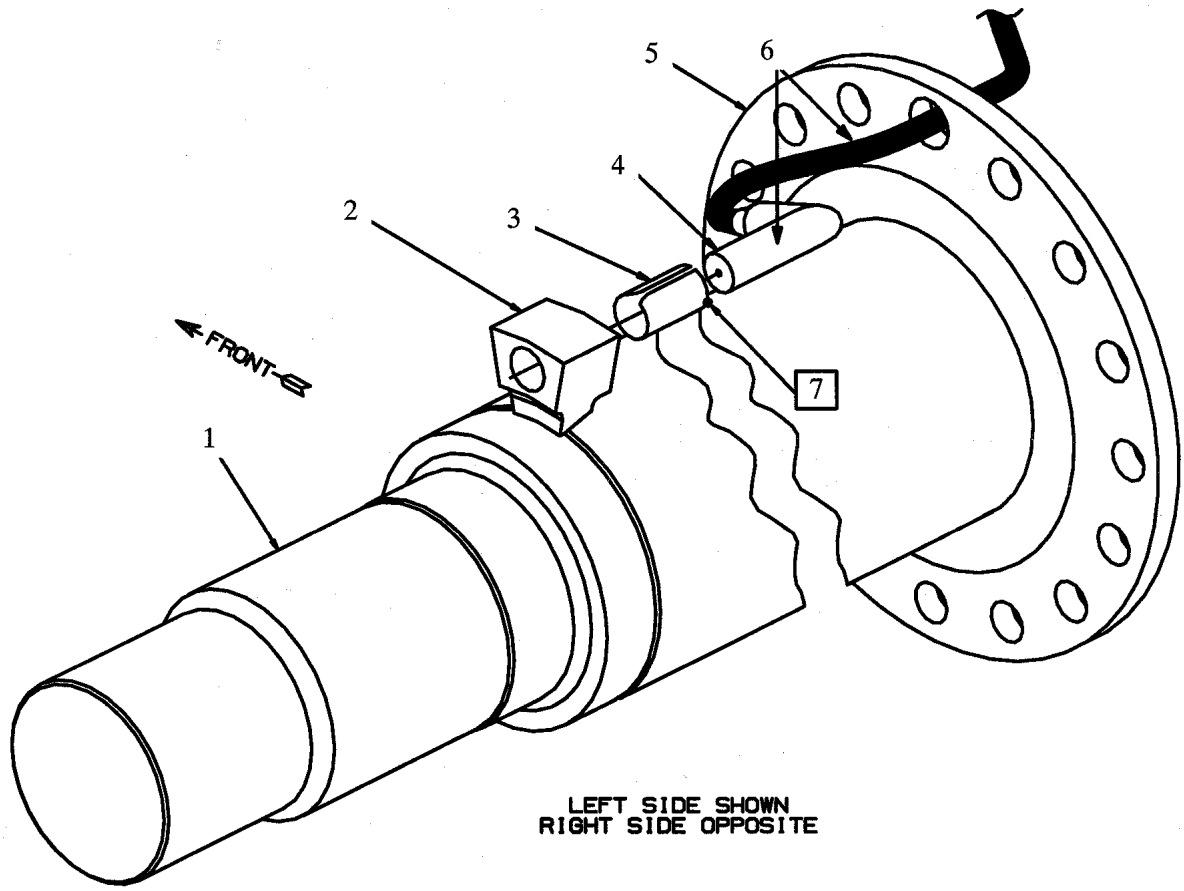


Figure 42 Typical Sensor Installation With 4 Spring Suspension

1. REF – REAR AXLE
2. SENSOR MOUNTING BLOCK (PART OF AXLE)
3. SENSOR RETAINER (USE ONLY INTERNATIONAL RETAINER)
4. SENSOR SHOWN REMOVED
5. REF AXLE FLANGE
6. SENSOR ASSEMBLY INCLUDES LEAD
7. RETAINER OUTSIDE TONGUES – REF

9.13. TROUBLESHOOTING RECORD SHEET

Technician's Name _____

Date _____ Time _____

Location_____

Vehicle Number _____

Vehicle Mileage _____Miles

Check LEDs illuminated:

__FRONT __MID __REAR __RIGHT __LEFT __MOD __SENS __ECU __VOLT

Steps Taken, Comments:

_____

_____

_____

_____

_____

Check LEDs illuminated:

__ FRONT __MID __REAR __RIGHT __LEFT __MOD __SENS __ECU __VOLT

Steps Taken, Comments:

_____

_____

_____

_____

_____

Check LEDs illuminated:

__ FRONT __MID __REAR __RIGHT __LEFT __MOD __SENS __ECU __VOLT

Steps Taken, Comments:

_____

_____

_____

_____

_____

10. COMPONENT LOCATIONS, CONNECTOR COMPOSITES AND CIRCUIT DIAGRAMS

10.1. COMPONENT LOCATION CHART

Table 4 Component Location Chart

ACCESSORY FEED STUD	TOP OF MAIN FUSE AND RELAY BLOCK
G–94 GROUND	LEFT REAR FRAME RAIL NEAR EC–15
G2 GROUND	LEFT COWL NEAR MAIN FUSE AND RELAY BLOCK
C298 FUSE	IN HARNESS NEAR THE MAIN FUSE AND RELAY BLOCK
C299 FUSE	IN HARNESS NEAR THE MAIN FUSE AND RELAY BLOCK
C283	RIGHT SIDE UNDER DASH ON RELAY BRACKET
C284	RIGHT SIDE UNDER DASH ON RELAY BRACKET
C285	RIGHT SIDE UNDER DASH ON RELAY BRACKET
C286	RIGHT SIDE UNDER DASH ON RELAY BRACKET
C287	AT ECU
C288	AT ECU
C289	NEAR FRONT MODULATOR VALVE
C290	AT FRONT ENGINE CROSSMEMBER
C291	AT FRONT ENGINE CROSSMEMBER
C292	NEAR FRONT MODULATOR VALVE
C293	NEAR REAR MODULATOR VALVE
C294	REAR OF CHASSIS NEAR CROSSMEMBER
C295	NEAR REAR MODULATOR VALVE
C296	REAR OF CHASSIS NEAR CROSSMEMBER
C377	RIGHT SIDE OF I/P BEHIND CLUSTER
C378	UNDER DASH NEAR CENTER

10.2. 8000 WIRING

Refer to Figure 43, Figure 44, Figure 45, Figure 46, and Figure 47.

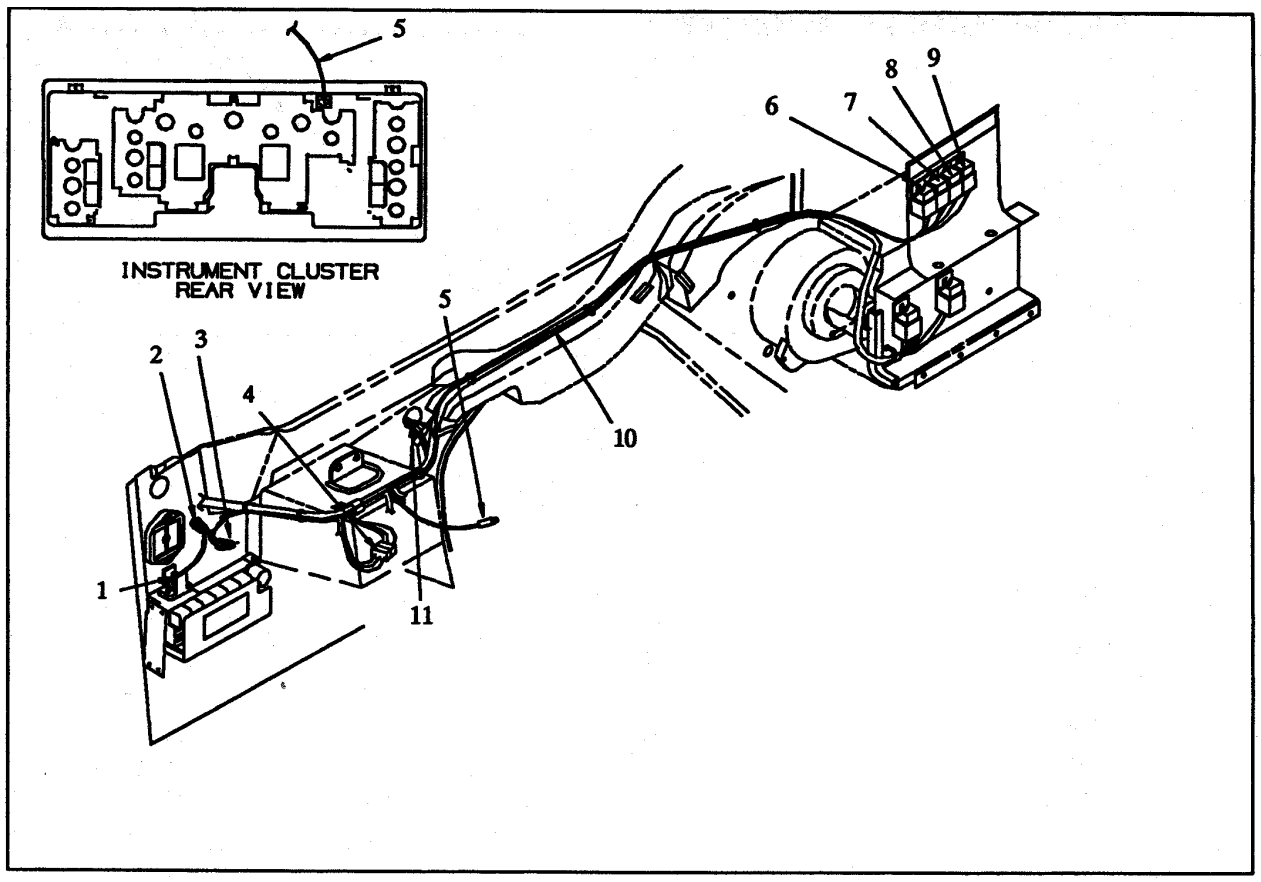


Figure 43 8000 Cab Wiring

1. ACCESSORY FEED STUD (J1)
2. C298 30 AMP FUSE
3. C299 10 AMP FUSE
4. C377 CAB HARNESS TO 8-WAY CONNECTOR, CIRCUITS 94-GC, 13J, 17B AND 24
5. C297 ABS WARNING LIGHT, CIRCUITS 94E AND 94B
6. C283 POWER RELAY
7. C284 WARNING LIGHT RELAY
8. C285 CRANK RELAY
9. C286 ENGINE BRAKE RELAY
10. ABS CAB HARNESS
11. ABS CHASSIS HARNESS, CIRCUITS 94H, 94J AND 94A

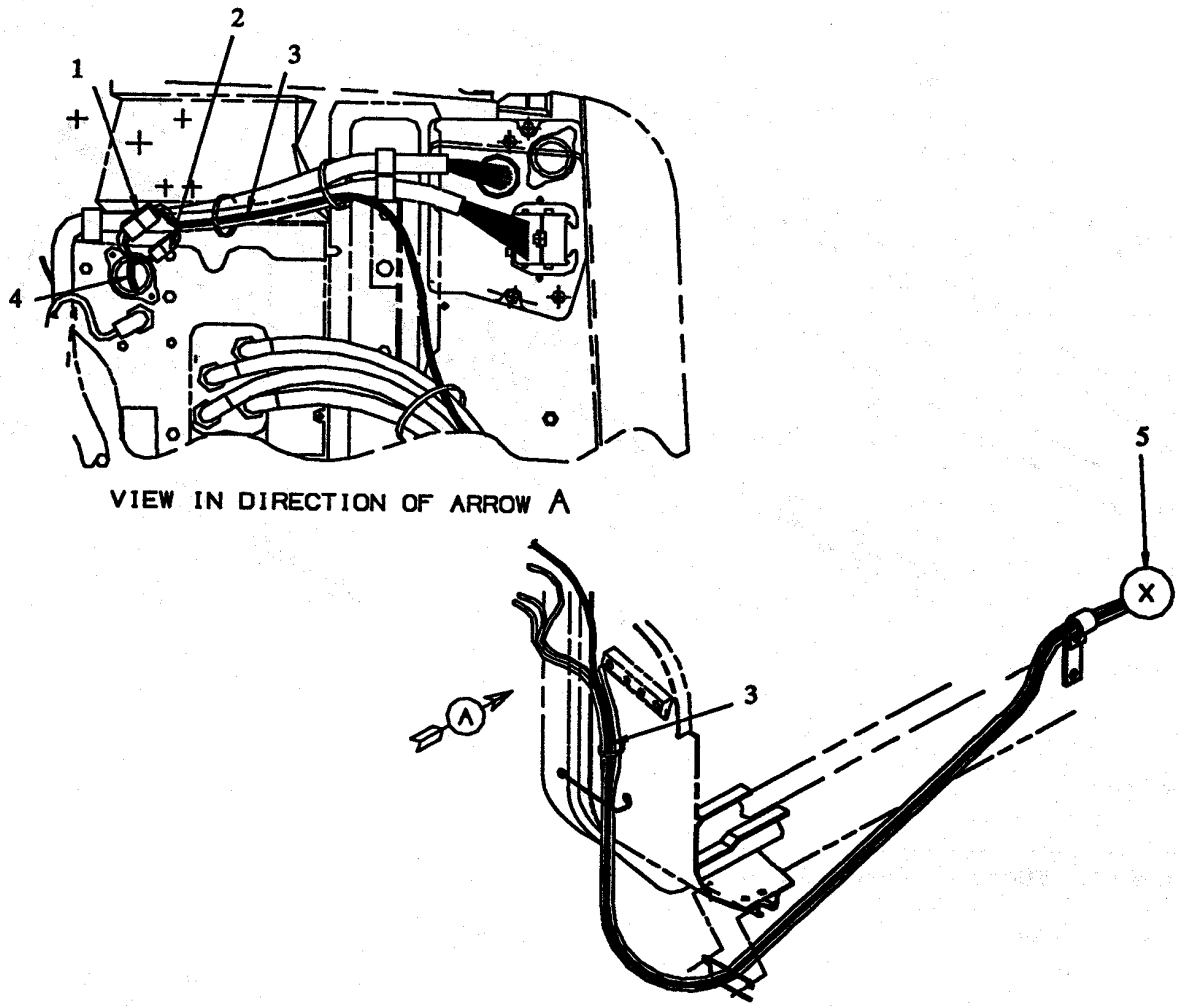


Figure 44 8000 Antilock Wiring at Front and Bottom Right of Cab

1. C378 CHASSIS TO CAB CONNECTOR, 97J AND 94A/94K
2. CIRCUIT 94H
3. CHASSIS ANTILOCK BRAKE HARNESS
4. CAB ANTILOCK BRAKE HARNESS
5. TO FIGURE 45

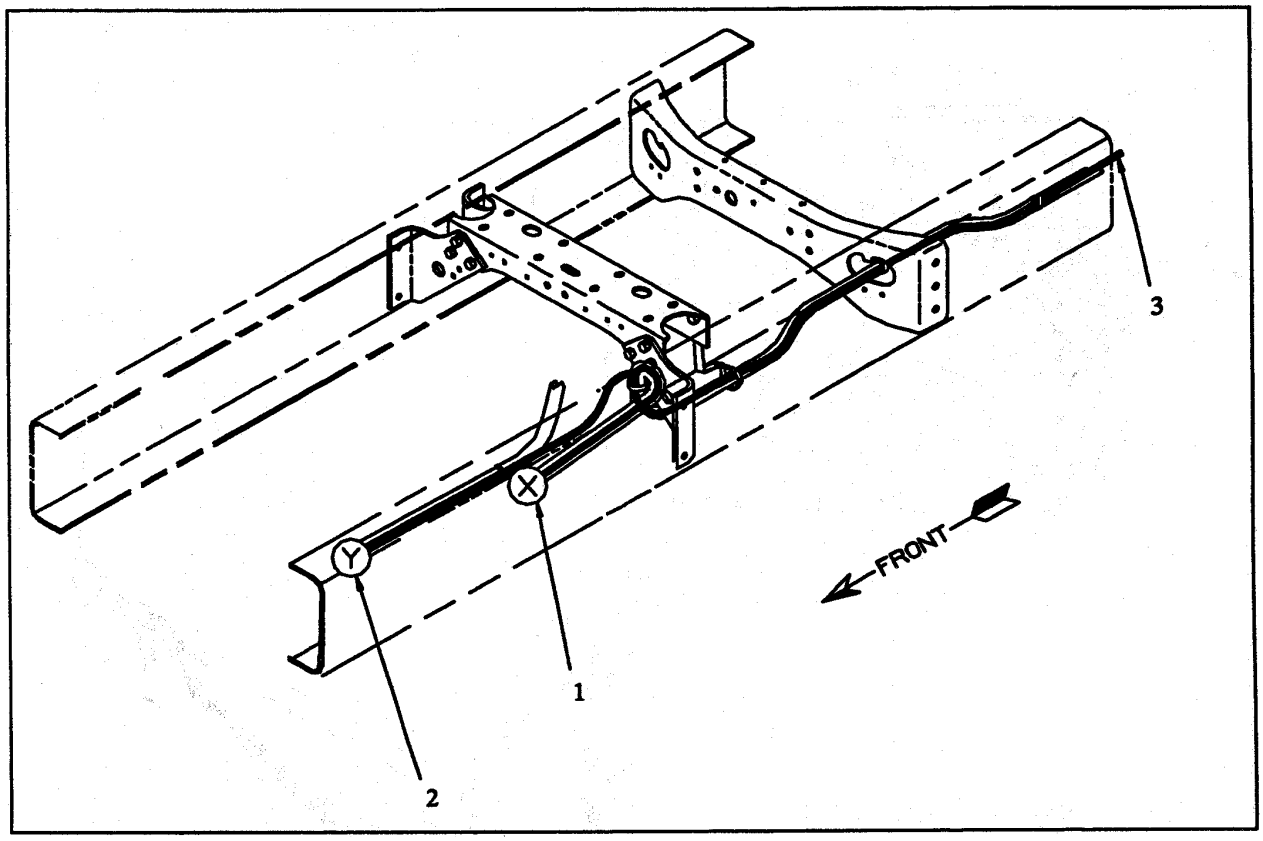


Figure 45 8000 ABS Chassis Wiring

1. TO FIGURE 44
2. TO FIGURE 46
3. TO FIGURE 47

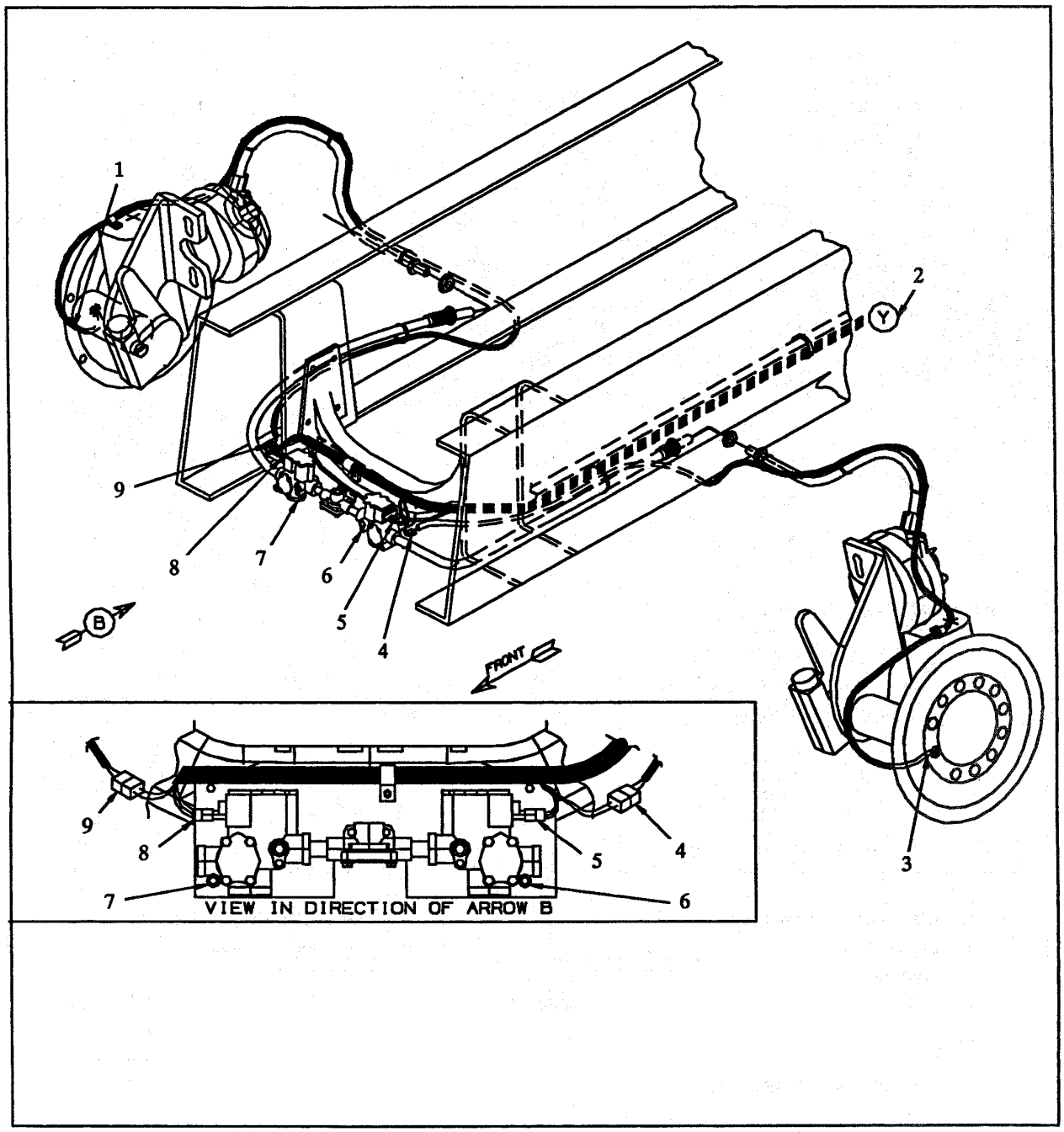


Figure 46 8000 Chassis Wiring, Front Axle Section

1. RIGHT FRONT WHEEL SENSOR
2. TO FIGURE 45
3. LEFT FRONT WHEEL SENSOR
4. C289, CIRCUITS 94M AND 94AN
5. C290, CIRCUITS 94AR, 94AP AND 94AS
6. LEFT FRONT MODULATOR
7. RIGHT FRONT MODULATOR
8. C291, CIRCUITS 94AV, 94AX AND 94AW
9. C292, CIRCUITS 94AU AND 94AT

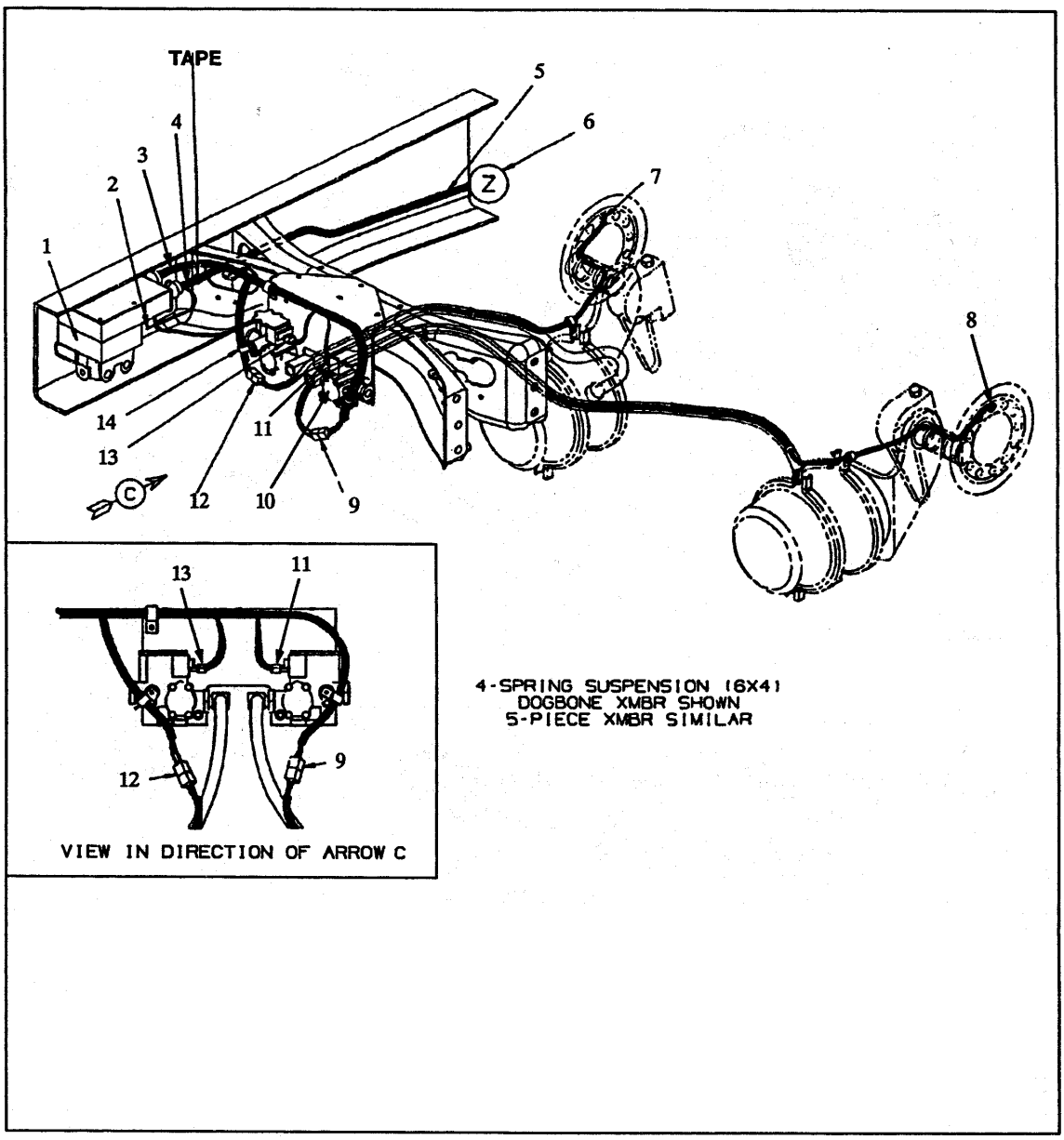


Figure 47 8000 Chassis Wiring, Rear Axle Section

1. EC–15 CONTROL UNIT (ECU)
2. GROUND 94–G
3. C287, REAR ANTILOCK CHASSIS HARNESS TO EC–15
4. C288, FRONT ANTILOCK CHASSIS HARNESS TO EC–15
5. FRONT ANTILOCK CHASSIS HARNESS
6. TO FIGURE 45
7. LEFT REAR WHEEL SENSOR
8. RIGHT REAR WHEEL SENSOR
9. C292, CIRCUITS 94AK AND 94AL
10. RIGHT REAR MODULATOR
11. C291, CIRCUITS 94AJ, 94AF AND 94AH
12. C293, CIRCUITS 94AA AND 94AB
13. C294, CIRCUITS 94AE, 94AC AND 94AB
14. LEFT REAR MODULATOR

11. CIRCUIT DIAGRAM

Refer to Figure 48.

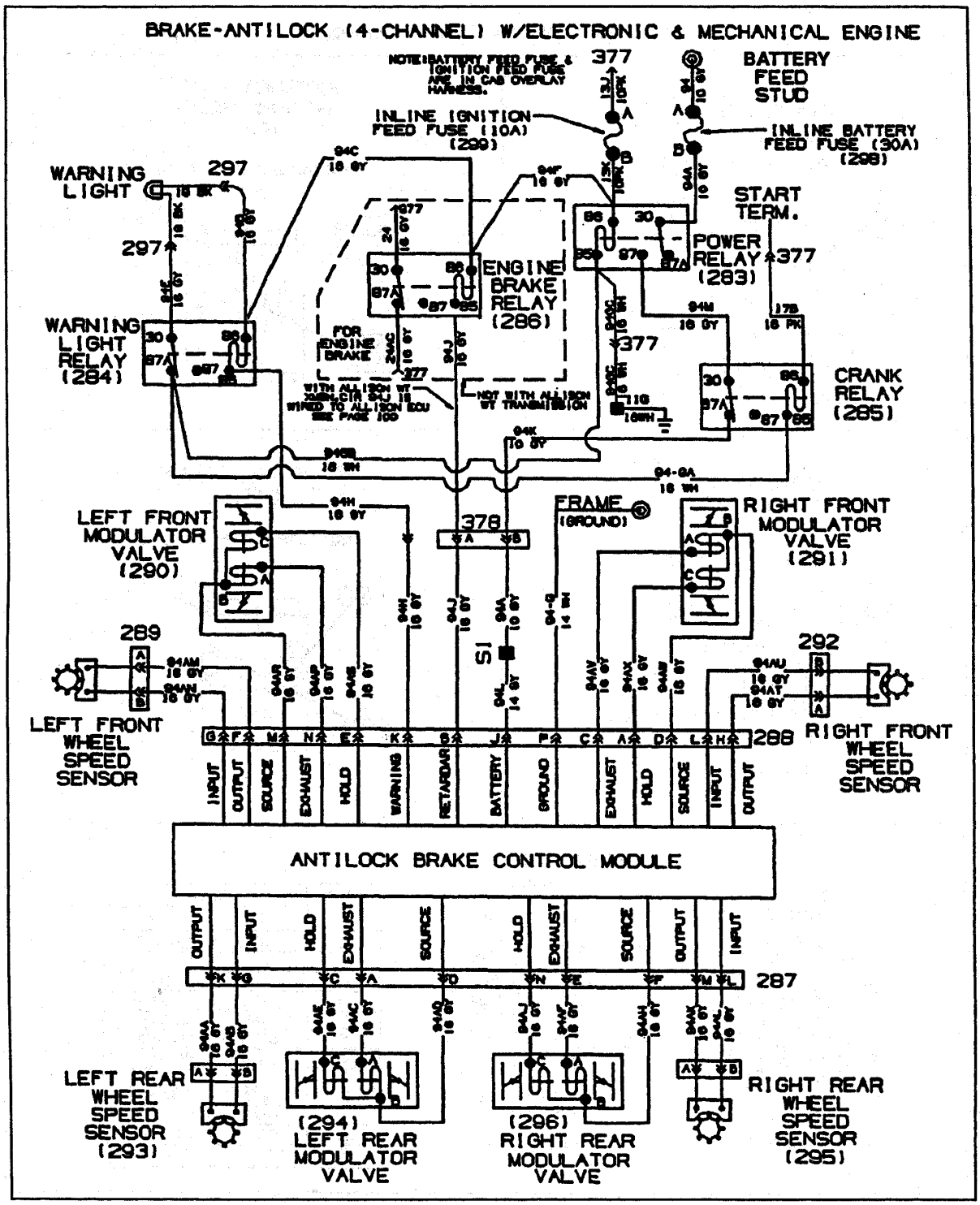
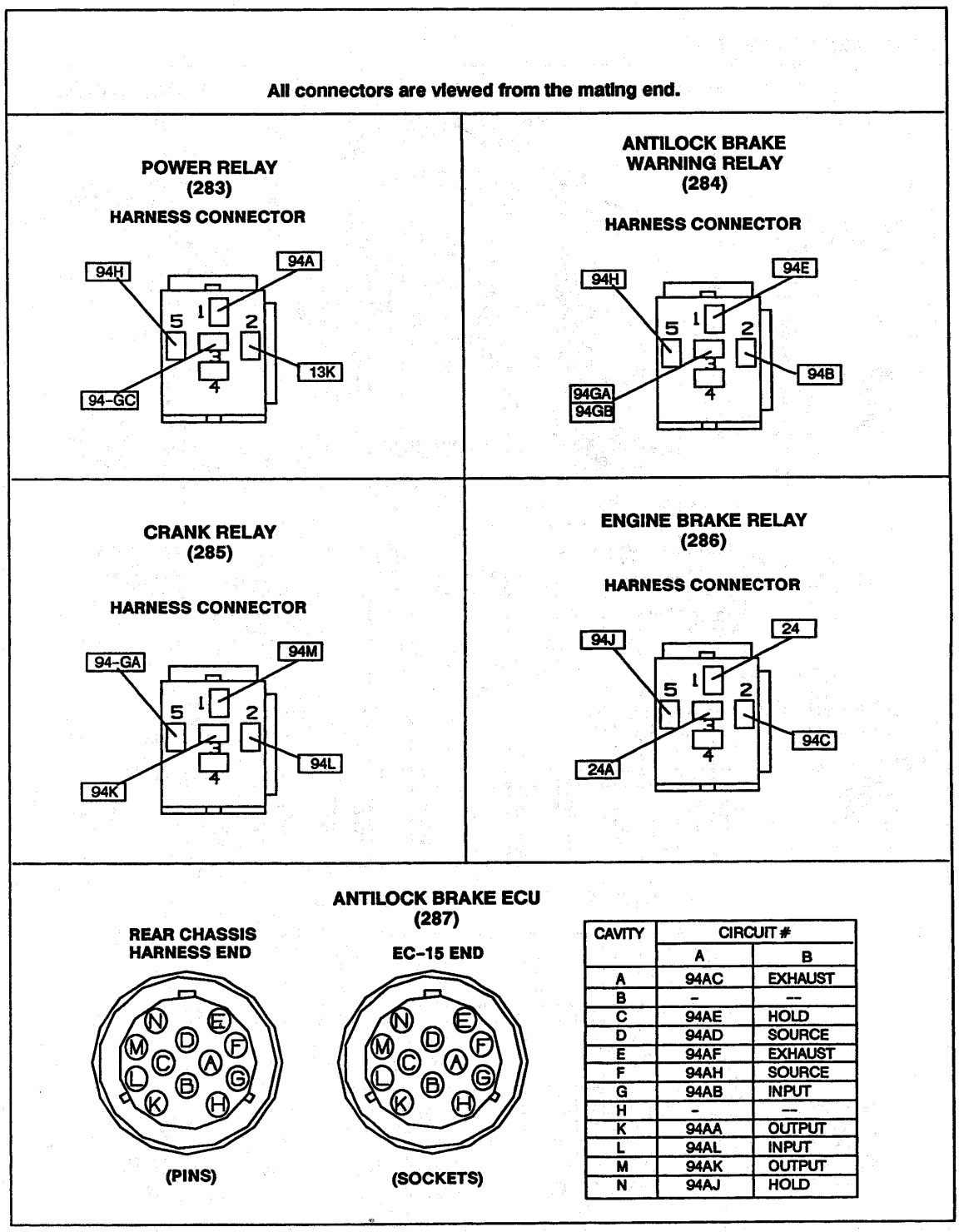


Figure 48 Circuit Diagram

12. CONNECTOR COMPOSITES

Refer to Figure 49, Figure 50, and Figure 51.



CAVITY	CIRCUIT #	
	A	B
A	94AC	EXHAUST
B	-	---
C	94AE	HOLD
D	94AD	SOURCE
E	94AF	EXHAUST
F	94AH	SOURCE
G	94AB	INPUT
H	-	---
K	94AA	OUTPUT
L	94AL	INPUT
M	94AK	OUTPUT
N	94AJ	HOLD

Figure 49 Connector Composites

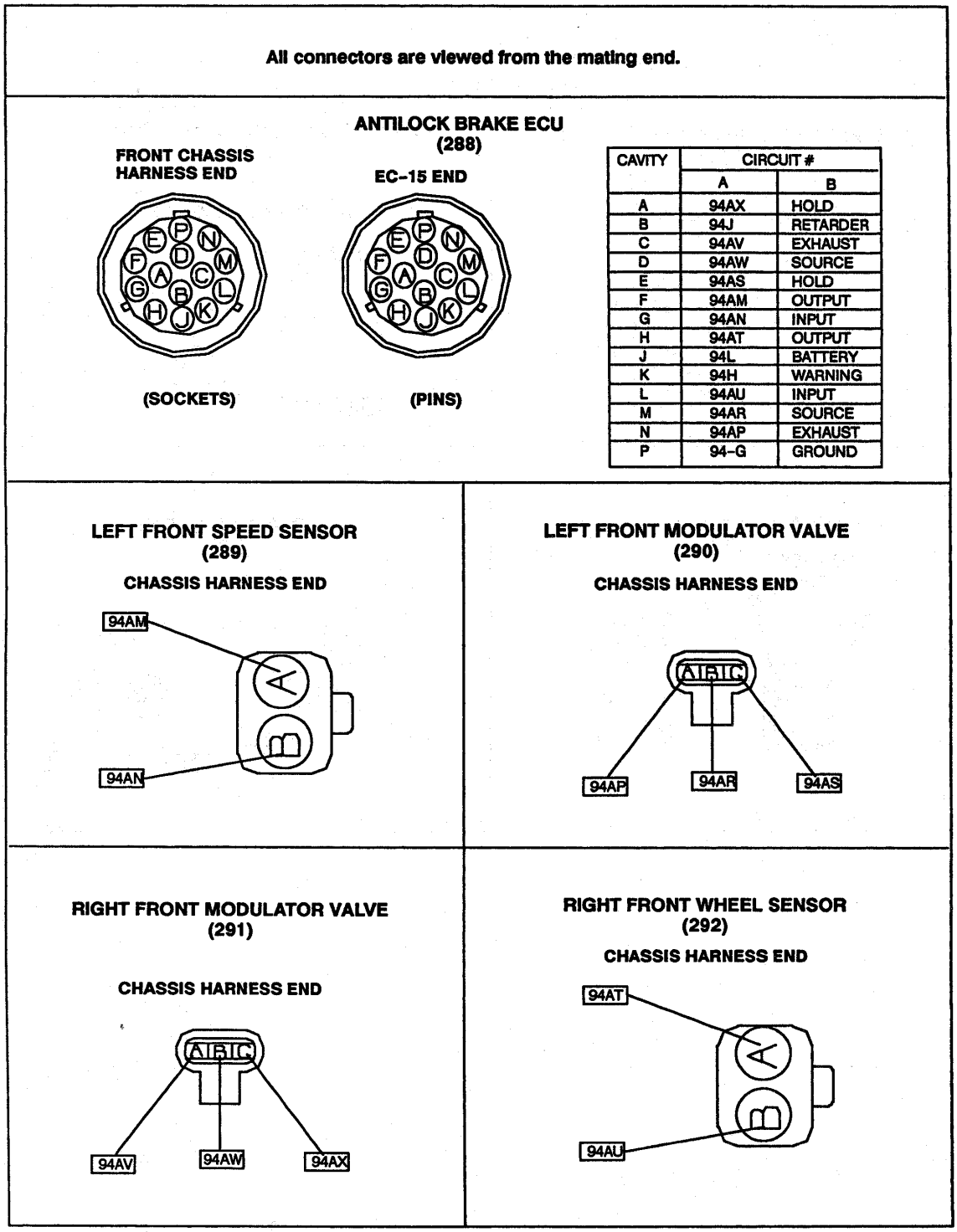


Figure 50 Connector Composites

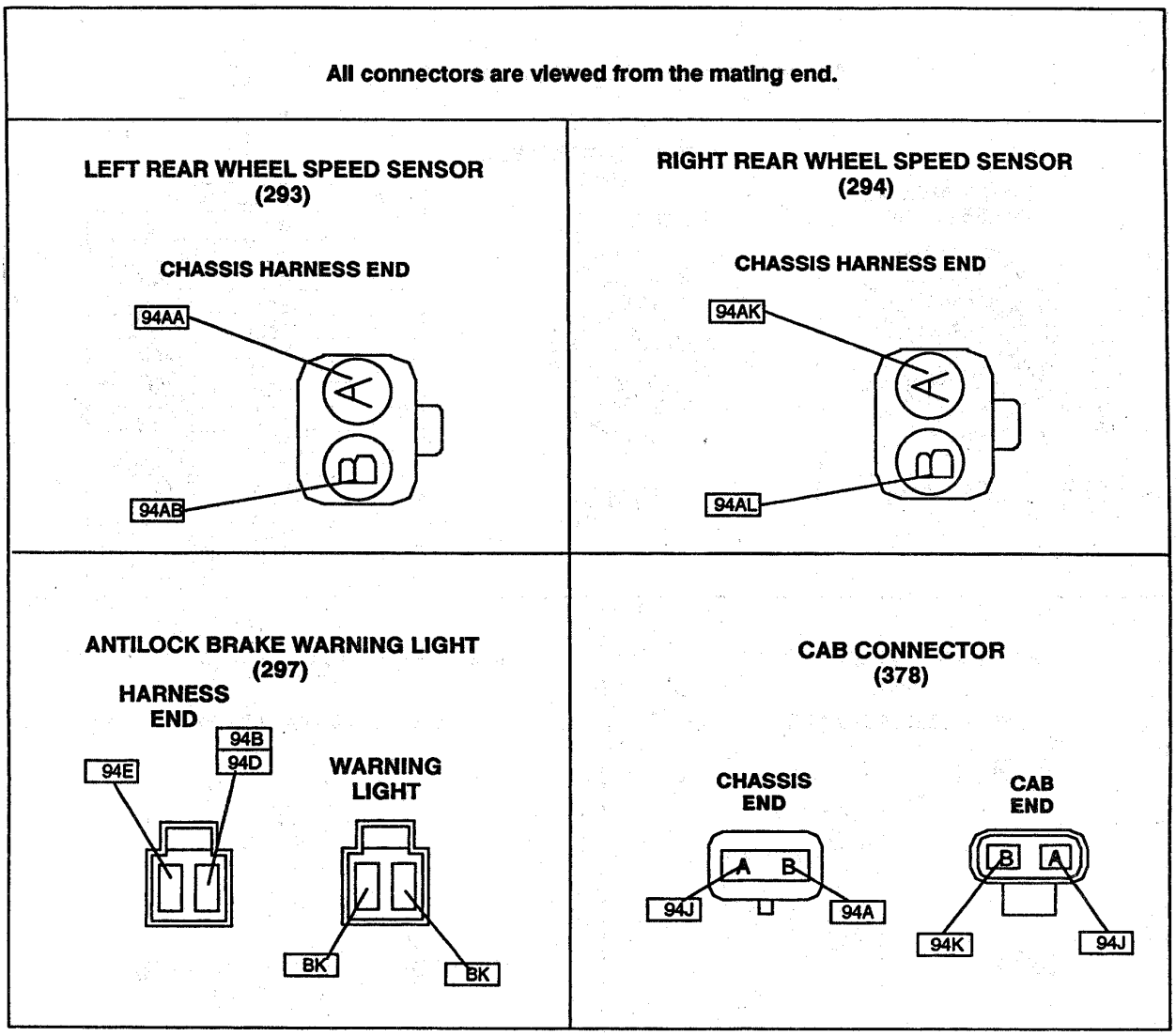


Figure 51 Connector Composites