13

Gauges, Warning Devices, and Driver Information System Operation

LEARNING OBJECTIVES

Upon completion and review of this chapter, you should be able to:

- Identify and explain the operation of electromagnetic instrument circuits, including gauges and sending units.
- Explain the operation of malfunction indicator lamps (MIL).
- Explain the operation of a simple mechanical speedometer.
- Identify and explain the operation of driver information systems (electronic instrument circuits).
- Explain the operation of the head-up display (HUD).

KEY TERMS

Air Core Gauge
Bimetallic Gauge
D'Arsonval Movement
Driver Information Center (DIC)
Driver Information System (DIS)
Gauges
Ground Sensor
Head-up Display (HUD)
Instrument Panel Cluster (IPC)
Malfunction Indicator Lamp (MIL)
Menu Driven
Nonvolatile RAM
Three-Coil Movement
Vacuum Fluorescent Display (VFD)
Warning Lamps

INTRODUCTION

This chapter covers the operation and common circuits of gauges, warning devices, and driver information systems. These systems include cooling fans, electromagnetic instrument circuits (sending and receiving gauges), and electronic instrument circuits (driver information systems).

ELECTROMAGNETIC INSTRUMENT CIRCUITS

Gauges and warning lamps allow the driver to monitor a vehicle's operating conditions. These instruments differ widely from car to car, but all are analog. Digital electronic instruments are explained in the "Electronic Instrument Circuits" section in this chapter. **Warning lamps** are used in place of gauges in many cases because they are less expensive and easier to understand, although they do not transmit as much useful information as gauges do. The following paragraphs explain the general operation of analog gauges, lamps, and the sending units that control them.

Gauge Operating Principles

Common gauges use one of the following three operating principles:

- Mechanical
- Bimetallic (thermal-type)
- Electromagnetic

Mechanical gauges are operated by cables, fluid pressure, or fluid temperature. Because they do not require an electrical circuit, they do not fit into our study. The cable-driven speedometer is the most common mechanical gauge.

Bimetallic Gauges

A **bimetallic gauge** works by allowing current to flow through the bimetallic strip and heat up one of the metals faster than the other, causing the strip to bend. A typical gauge (Figure 13-1) has U-shaped bimetallic piece anchored to the gauge body at the end of one arm. The other arm has a high-resistance wire (heater coil) wound around it. Current flow through the heater coil bends the free bimetallic arm. Varying the current changes the bend in the arm. A pointer attached to the moving arm can relate the changes in current to a scale on the face of the gauge.

Ambient temperature could affect the gauge, but the U-shape of the bimetallic strip provides temperature compensation. Although ambient temperature bends the free arm in one direction, the fixed arm is bent in the other direction and the effect is cancelled.

Electromagnetic Gauges

The movement of an electromagnetic gauge depends on the interaction of magnetic fields. The following kinds of movements are commonly used:

- D'Arsonval movement
- Three-coil or two-coil movement
- Air core design

A **D'Arsonval movement** has a movable electromagnet surrounded by a permanent horseshoe magnet (Figure 13-2). The electromagnet's field opposes the permanent magnet's field, causing the electromagnet to rotate. A pointer mounted on the

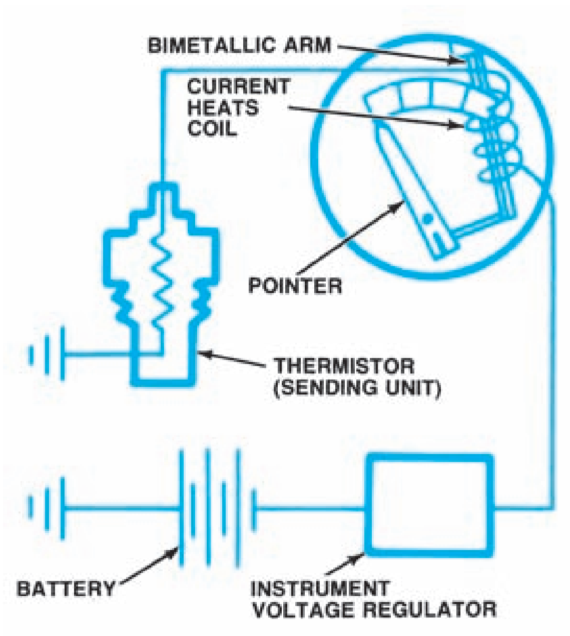

Figure 13-1. The bimetallic gauge depends upon the heat of current flow bending a bimetallic strip. (DaimlerChrysler Corporation)

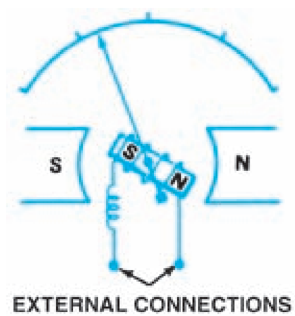

Figure 13-2. The D'Arsonval movement uses the field interaction of a permanent magnet and an electromagnet.

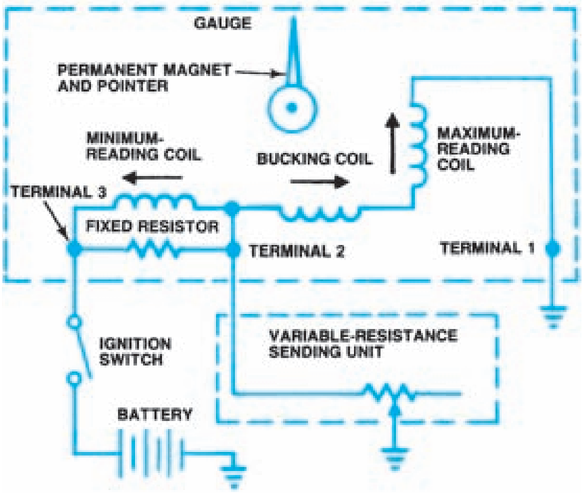

Figure 13-3. In a three-coil gauge, the variable resistance-sending unit affects current flow through three interacting electromagnets. (GM Service and Parts Operations)

electromagnet relates this movement to a scale on the face of the gauge. The amount of current flow through the electromagnet's coil determines the electromagnet's field strength, and therefore the amount of pointer movement.

A **three-coil movement** depends upon the field interaction of three electromagnets and the total field's effect on a movable permanent magnet. This type of gauge is used in GM and some late-model Ford vehicles.

The circuit diagram of a typical three-coil movement (Figure 13-3) shows that two coils are wound at right angles to each other. These are the minimum-reading coil and the maximum-reading coil. Their magnetic fields will pull the permanent magnet and pointer in opposite directions. A third coil is wound so that its magnetic field opposes that of the minimum-reading coil. This is called the bucking coil.

The three coils are connected in series from the ignition switch to ground. A fixed resistor forms a circuit branch parallel to the minimum-reading coil. The variable-resistance-sending unit forms a circuit branch to ground, parallel to the bucking and minimum-reading coils.

When sending resistance is high, current flows through all three coils to ground. Because the magnetic fields of the minimum-reading and the bucking coils cancel each other, the maximum-reading coil's field has the strongest effect on the permanent magnet and pointer. The pointer moves to the maximum-reading end of the gauge scale.

As sending unit resistance decreases, more current flows through the minimum-reading coil and the sending unit to ground than flows through the bucking and maximum-reading coils. The minimum-reading coil gains a stronger effect upon the permanent magnet and pointer, and the pointer moves to the minimum-reading end of the gauge scale.

Specific three-coil gauges may have slightly different wiring, but the basic operation remains the same. Because the circular magnet is carefully balanced, it will remain at its last position even when the ignition switch is turned off, rather than returning to the minimum-reading position, as does a bimetallic gauge.

The design of two-coil gauges varies with the purpose for which the gauge is used. In a fuel gauge, for example, the pointer is moved by the magnetic fields of the two coils positioned at right angles to each other. Battery voltage is applied to the E (empty) coil and the circuit divides at the opposite end of the coil. One path travels to ground through the F (full) coil; the other grounds through the sender's variable resistor. When sender resistance is low (low fuel), current passes through the E coil and sender resistor to move the pointer toward E on the scale. When sender resistance is high (full tank), current flows through the F coil to move the pointer toward F on the scale.

When a two-coil gauge is used to indicate coolant temperature, battery voltage is applied to both coils. One coil is grounded directly; the other grounds through the sending unit. Sender resistance causes the current through one coil to change as the temperature changes, moving the pointer.

In the **air-core gauge** design, the gauge receives a varying electrical signal from its sending unit. A pivoting permanent magnet mounted to a pointer aligns itself to a resultant field according to sending unit resistance. The sending unit resistance varies the field strength of the windings in opposition to the reference windings. The sending unit also compensates for variations in voltage.

This simple design provides several advantages beyond greater accuracy. It does not create radiofrequency interference (RFI), is unaffected by temperature, is completely noiseless, and does not require the use of a voltage limiter. Like the three- and two-coil designs, however, the air-core design remains at its last position when the ignition switch is turned off, giving a reading that should be disregarded.

Instrument Voltage Regulator

On early-model cars and imported vehicles, except for the air core electromagnetic design, gauges required a continuous, controlled amount of voltage. This is usually either the system voltage of 12 volts or a regulated 5–6 volts. An instrument voltage regulator (IVR) supplied that regulated voltage. The IVR can be a separate component that looks much like a circuit breaker or relay; it can also be built into a gauge. Its bimetallic strip and vibrating points act like a self-setting circuit breaker to keep the gauge voltage at a specific level. Gauges that operate on limited voltage can be damaged or give inaccurate readings if exposed to full system voltage.

Warning Lamp Operating Principles

Warning lamps alert the driver to potentially hazardous vehicle operating conditions, such as the following:

- High engine temperature
- Low oil pressure
- Charging system problems
- Low fuel level
- Unequal brake fluid pressure
- Parking brake on
- Seat belts not fastened
- Exterior lighting failure

Warning lamps can monitor many different functions but are usually activated in one of the following four ways:

- Voltage drop
- Grounding switch
- Ground sensor
- Fiber optics

The first three methods are used to light a bulb or an LED mounted on the dash panel. Fiber optics is a special application of remote light.

Voltage Drop

A bulb will light only if there is a voltage drop across its filament. Warning lamps can be installed so that equal voltage is applied to both bulb terminals under normal operating conditions. If operating conditions change, a voltage drop occurs across the filament, and the bulb will light. This method is often used to control charging system indicators, as we learned in Chapter 8.

Grounding Switch

A bulb connected to battery voltage will not light unless the current can flow to ground. Warning lamps can be installed so that a switch that reacts to operating conditions controls the ground path. Under normal conditions, the switch contacts are open and the bulb does not light. When operating conditions change, the switch contacts close. This creates a ground path for current and lights the bulb.

Ground Sensor

A **ground sensor** is the opposite of a ground switch. Here, the warning lamp remains unlit as long as the sensor is grounded. When conditions change and the sensor is no longer grounded, the bulb lights. Solid-state circuitry generally is used in this type of circuit.

Fiber Optics

Strands of a special plastic can conduct light through long, curving runs (Figure 13-4). When one end of the fiber is installed in the instrument panel and the other end is exposed to a light, the driver will be able to see that light. Changing operating conditions can cause the fiber to change from light to dark, or from one color to another. Fiber optics are usually used for accessory warning lamps, such as coolant level reminders and exterior bulb monitors.

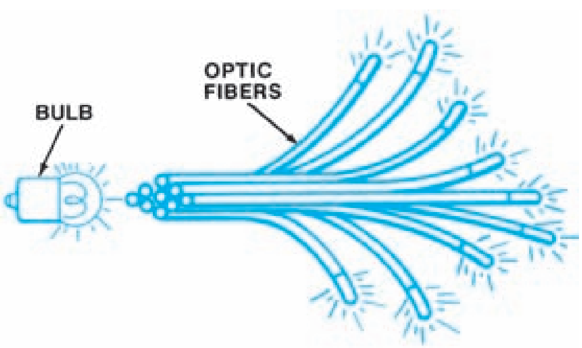

Figure 13-4. Light-carrying fibers can be used in accessory instruments.

Specific Instruments

Many different instruments have appeared in automobiles, but certain basic functions are monitored in almost all cars. Normally, a car's instrument panel will contain at least the following:

- An ammeter, a voltmeter, or an alternator warning lamp
- An oil pressure gauge or warning lamp
- A coolant temperature gauge or warning lamp
- A fuel level gauge

The following paragraphs explain how these specific instruments are constructed and installed.

Charging System Indicators

Ammeter, voltmeter, and warning lamp installations are covered in Chapter 8. Ammeters usually contain a D'Arsonval movement that reacts to field current flow into the alternator and charging current flow into the battery. Many late-model cars have a voltmeter instead of an ammeter. A voltmeter indicates battery condition when the engine is off, and charging system operation when the engine is running. Warning lamps light to show an undercharged battery or low voltage from the alternator. Lamps used on GM cars with a CS charging system will light when the system voltage is too high or too low.

Chrysler rear-wheel-drive (RWD) cars from 1975 on that have ammeters also have an LED mounted on the ammeter face. The LED works independently to monitor system voltage and lights when system voltage drops by about 1.2 volts. This alerts the driver to a discharge condition at idle caused by a heavy electrical load.

Oil Pressure Gauge or Warning Lamp

The varying current signal to an oil pressure gauge is supplied through a variable-resistance sending unit that is exposed to engine oil pressure. The resistor variation is controlled by a diaphragm that moves with changes in oil pressure, as shown in Figure 13-5.

An oil pressure-warning lamp lights to indicate low oil pressure. A ground switch controls the lamp as shown in Figure 13-6. When oil pressure decreases to an unsafe level, the switch diaphragm moves far enough to ground the warning lamp circuit. Current then can flow to ground and the bulb will light. Oil pressure warning lamps can be operated by the gauge itself. When the pointer moves to the low-pressure end of the scale, it closes contact points to light a bulb or an LED.

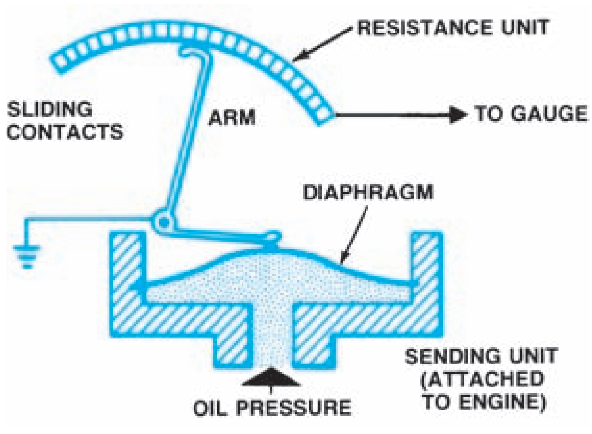

Figure 13-5. The oil pressure sending unit provides a varying amount of resistance as engine oil pressure changes.

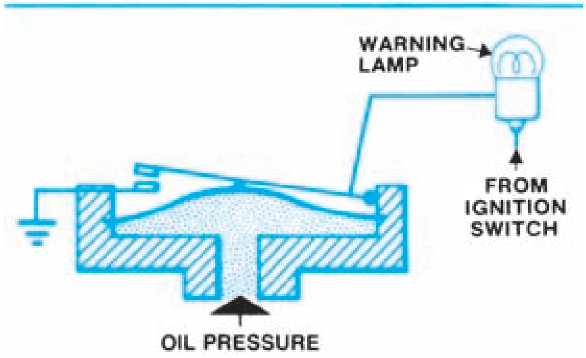

Figure 13-6. This oil pressure grounding switch has a fixed contact and a contact that is moved by the pressure-sensitive diaphragm.

Temperature Gauge or Warning Lamp

In most late-model cars, the temperature gauge ending unit is a thermistor exposed to engine coolant temperature, as shown in Figure 13-7. As coolant temperature increases, the resistance of the thermistor decreases and current through the gauge varies.

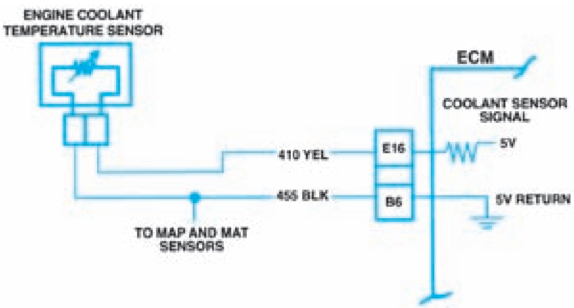

Figure 13-7. Coolant temperature gauge. (GM Service and Parts Operations)

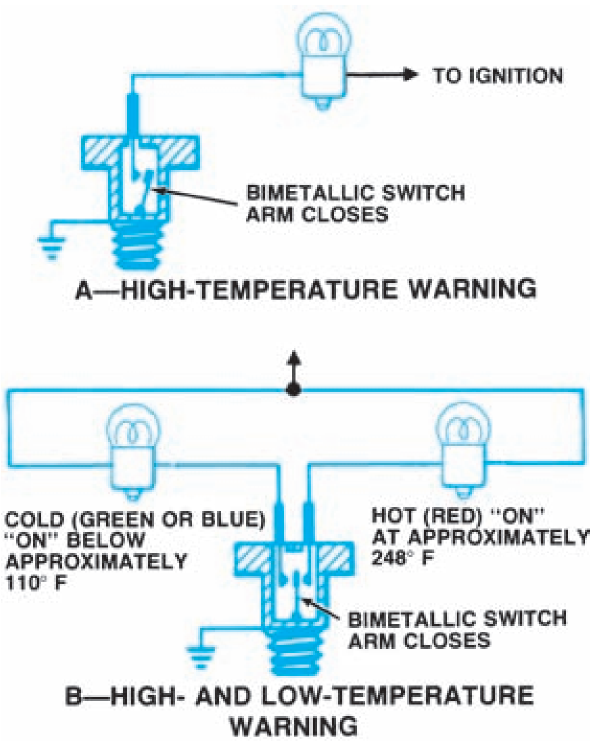

Figure 13-8. Temperature grounding switches expose a bimetallic strip to engine coolant temperature to light a high-temperature lamp or both high- and low-temperature warning lamps.

Temperature warning lamps can alert the driver to high temperature or to both low and high temperature. The most common circuit uses a bimetallic switch and reacts only to high temperature, as shown in Figure 13-8A. A ground switch has a bimetallic strip that is exposed to coolant temperature. When the temperature reaches an unsafe level, the strip bends far enough to ground the warning lamp circuit. If the circuit also reacts to low temperature, the bimetallic strip has a second set of contacts. These are closed at low temperature (Figure 13-8B) but open during normal operating temperature. The low-temperature circuit usually lights a different bulb than does the high-temperature circuit.

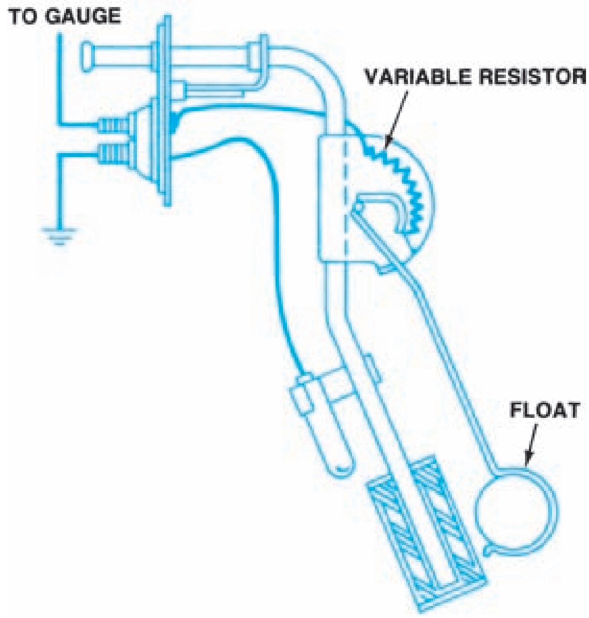

Figure 13-9. The fuel tank sending unit has a float that moves with the fuel level in the tank and affects a variable resistor.

A temperature warning lamp or an LED also can be lit by the action of the temperature gauge pointer, as explained for the oil pressure gauge.

Fuel Gauge or Warning Lamp

All modern cars have a fuel level gauge. Some have an additional warning lamp or an LED to indicate a low fuel level. A variable resistor in the fuel tank provides current control through the fuel gauge. The fuel tank sending unit has a float that moves with the fuel level, as shown in Figure 13-9. As the float rises and falls, the resistance of the sending unit changes. If a low-fuel-level indicator is used, its switch may operate through a heater or bimetallic relay to prevent flicker. Fuel-level warning lamps are operated by the action of the fuel gauge pointer, as explained for an oil pressure gauge.

Tachometer

In addition to the other instrument panel displays, some cars have tachometers to indicate engine speed in revolutions per minute (rpm). These usually have an electromagnetic movement. The engine speed signals may come from an electronic pickup at the ignition coil (Figure 13-10). Voltage pulses taken from the ignition system are processed by solid-state circuitry into signals to drive the tachometer pointer. The pointer responds to the frequency of these signals, which increase with engine speed. A filter is used to round off the pulses and remove any spikes.

Late-model vehicles with an engine control system may control the tachometer through an electronic module. This module is located on the rear of the instrument cluster printed circuit board and is the interface between the computer and tachometer in the same way the solid-state circuitry processes the ignition system-to-tachometer signals described earlier.

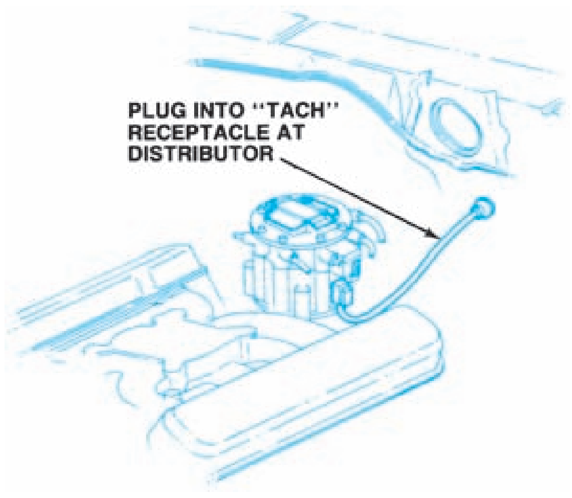

Figure 13-10. This GM HEI (high energy ignition) distributor has a special connector for a tachometer. (GM Service and Parts Operations)

MALFUNCTION INDICATOR LAMP (MIL)

Vehicles with electronic engine control systems generally have a computer-operated warning lamp on the instrument panel to indicate the need for service. In the past, this was called a Check Engine, Service Engine Soon, Power Loss, or Power Limited lamp, according to the manufacturer, as shown in the sample instrument cluster in Figure 13-11. To eliminate confusion, all domestic manufacturers now refer to it as a **malfunction indicator lamp (MIL).**

The MIL lamp alerts the driver to a malfunction in one of the monitored systems. In some vehicles built before 1995, the MIL is used to retrieve the faults or trouble codes stored in the computer memory by grounding a test terminal in the diagnostic connector. Like other warning lamps, the MIL comes on briefly as a bulb check when the ignition is turned on.

Seatbelt-Starter Interlocks

During 1974 and early 1975, U.S. federal safety standards required a seatbelt-starter interlock system on all new cars. The system required front-seat occupants to fasten their seatbelts before the car could be started. This particular standard was repealed by an act of Congress in 1975. Now, most interlock systems have been disabled so that only a warning lamp and buzzer remain.

Antilock Brake System (ABS) Warning Lamp

Vehicles with ABS have a computer-operated amber antilock warning lamp (Figure 13-12) in addition to the MIL and the standard red brake

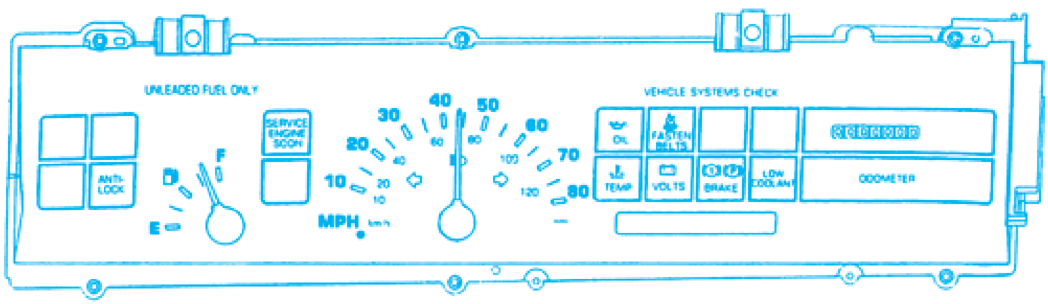

Figure 13-11. Malfunction indicator lamp in the instrument panel. (DaimlerChrysler Corporation)

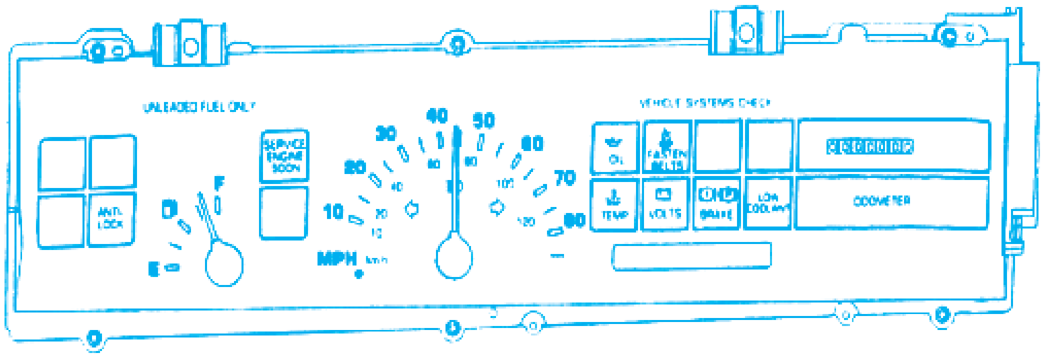

Figure 13-12. ABS lights. (DaimlerChrysler Corporation)

lamp. The antilock lamp serves the same functions for the ABS that the MIL lamp does for engine control systems as follows,

- Lights to warn of a system problem that inhibits ABS operation
- Retrieves trouble codes in the same way as the MIL lamp (specific vehicles only)
- Lights briefly at the beginning of an ignition cycle as a bulb check and to notify the driver that self-diagnostics are taking place

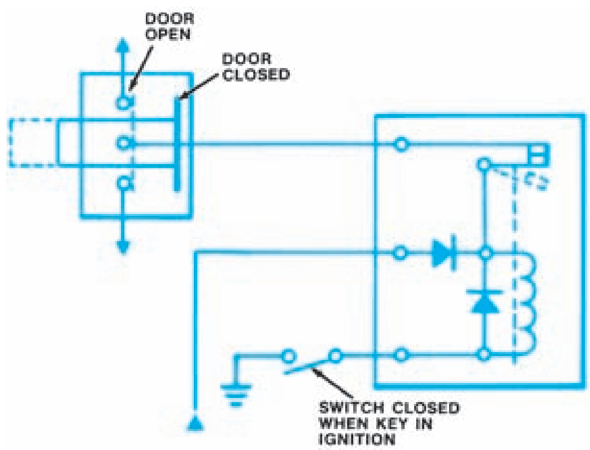

Figure 13-13. Current will flow through this warning buzzer only when both switches are closed—when the door is open and the key is in the ignition switch.

Buzzers, Tone Generators, Chimes, and Bells

Buzzers are a special type of warning device. They produce a loud warning sound during certain operating conditions, such as the following:

- Seatbelts not fastened
- Door open with key in ignition
- Lights left on with engine off
- Excessive vehicle speed

A typical buzzer (Figure 13-13) operates in the same way as a horn. Instead of moving a diaphragm, the vibrating armature itself creates the sound waves. In Figure 13-13, two conditions are required to sound the buzzer: The door must be open, and the key must be in the ignition. These conditions close both switches and allow current to flow through the buzzer armature and coil.

Most warning buzzers are separate units mounted on the fuse panel or behind the instrument panel. GM vehicles may have a buzzer built into the horn relay (Figure 13-14). When the ignition key is left in the switch and the door is opened, a small amount of current flows through

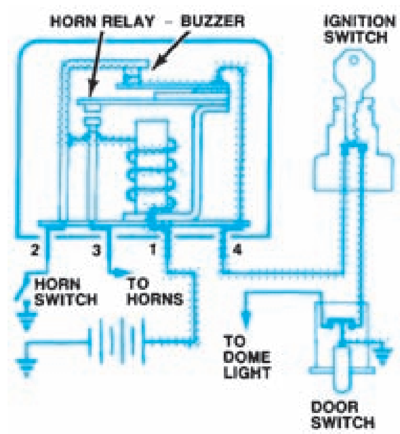

Figure 13-14. GM cars may have a buzzer built into the horn relay. Here, the buzzer is activated because both the door switch and the key switch are closed. (GM Service and Parts Operations)

the relay coil. The magnetic field is strong enough to operate the buzzer, but it is not strong enough to close the horn contacts.

Grounding switches usually activate buzzers. A timing circuit can be built into the buzzer by winding a heater coil around an internal circuit breaker (Figure 13-15) and connecting the heater coil directly to ground. When current flows to the buzzer, a small amount of current flows through the heater coil to ground. When the coil is hot enough, it will open the circuit breaker and keep it open. Current through the buzzer will stop even though the grounding switch is still closed.

Some typical buzzer warning circuits are shown in Figures 13-16 and 13-17. Figure 13-17 includes

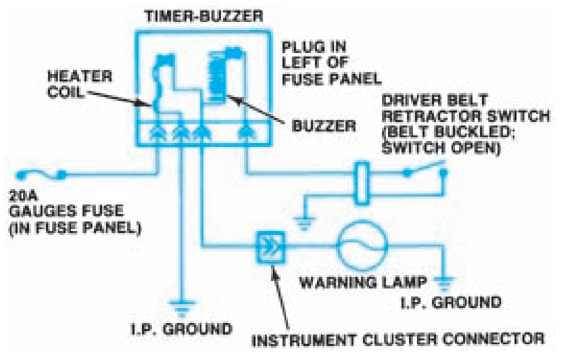

Figure 13-15. This buzzer will sound for only a few seconds each time it is activated, because of the circuit breaker and heater coil built into the unit. (GM Service and Parts Operations)

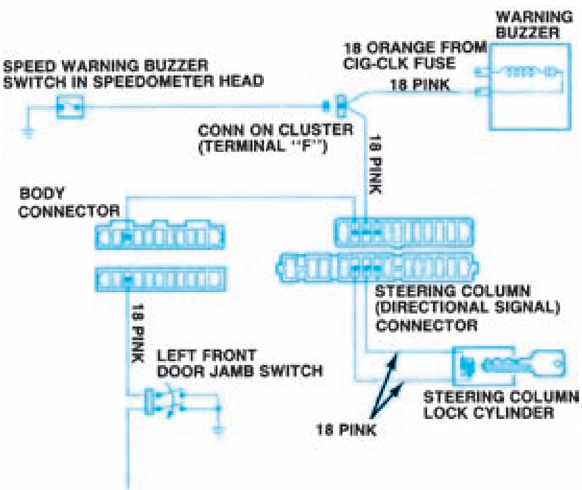

Figure 13-16. In this circuit, one buzzer responds both to excessive speed and to driver door position. (GM Service and Parts Operations)

a prove-out circuit branch with a manual-grounding switch that the driver can close to check that the bulb and buzzer are still working. Some prove-out circuits operate when the ignition switch is at START, to show the driver if any bulbs or buzzers have failed.

Tone generators, chimes, and bells are mechanical devices that produce a particular sound when voltage is applied across a sound bar. Various sounds are obtained by varying the voltage. Like buzzers, they are replaced if defective.

The circuit shown in Figure 13-18 is the circuit diagram for an electronic temperature gauge. The coolant temperature sensor is an NTC thermistor with high resistance at low temperatures and low resistance at high temperatures. When a cold engine is first started, the sensor's resistance is very high, resulting in a low voltage output to the gauge display, which translates into a low

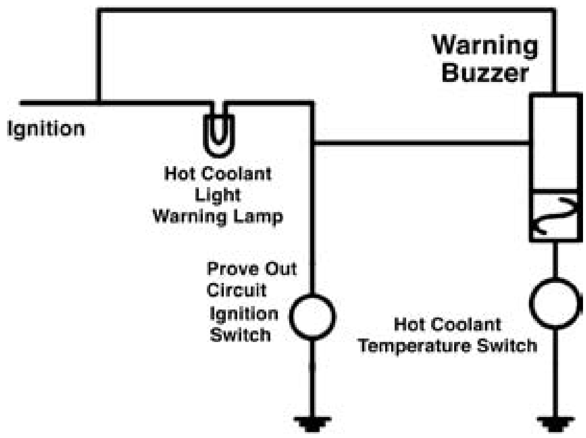

Figure 13-17. This warning buzzer will be activated if engine coolant temperature rises above a safe level.

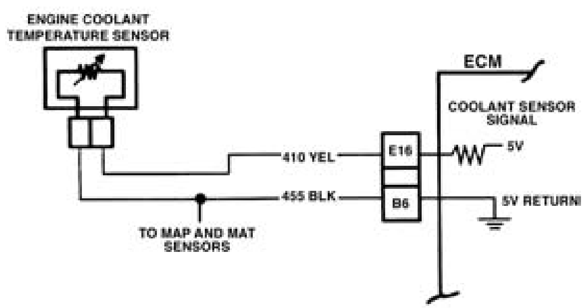

Figure 13-18. GM's electronic temperature gauge circuit is similar to that of an analog gauge. (GM Service and Parts Operations)

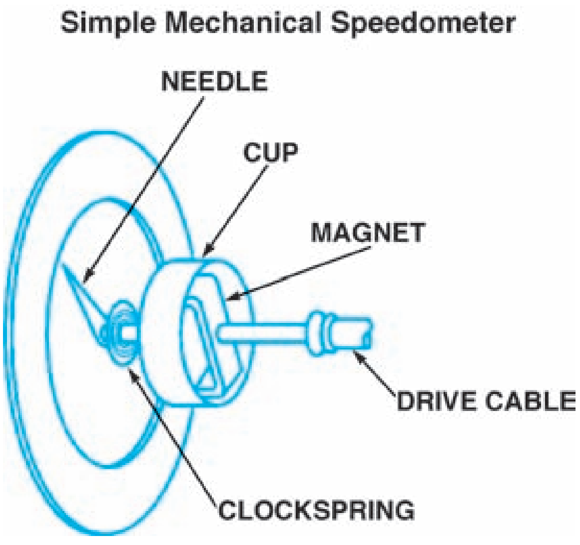

Figure 13-19. Mechanical speedometer.

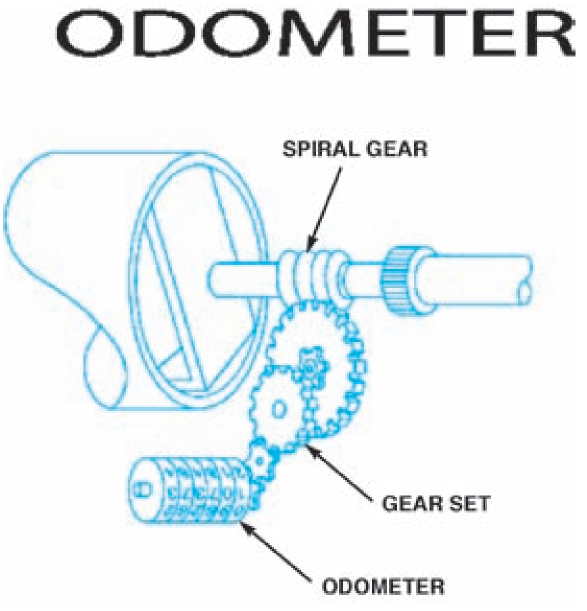

Figure 13-20. Mechanical odometer.

coolant temperature reading on the display. As coolant temperature increases, sensor resistance decreases. This results in a higher voltage output to the gauge display, which translates into a higher coolant temperature reading.

SPEEDOMETER

A mechanical speedometer uses a flexible cable, similar to piano wire, that is encased in an outer cover (Figure 13-19). One end of the cable connects to the transmission and the other end connects to the back of the speedometer. As the vehicle moves, the cable begins to rotate. The speed that the cable rotates is proportional to the speed of the vehicle; in other words, the faster the vehicle moves, the faster the cable will turn.

The indicator needle is attached to a metal drum in the speedometer. As the cable turns, so does a magnet inside the drum. The spinning magnet creates a rotating magnetic field around the drum, causing the drum to rotate and move the indicator needle along the scale. The faster the magnet spins, the more the drum moves. The speedometer gears drive a mechanical odometer. The gears are driven by a worm gear mounted on the same shaft as the permanent magnet of the speedometer (Figure 13-20). The gears reduce the speed of the odometer cable driven by the transmission.

ELECTRONIC INSTRUMENT CIRCUITS

Electronic instruments or **driver information system (DIS)** used on late-model cars have same purpose as the traditional analog instruments: The DIS displays vehicle-operating information to the driver and includes all guage and speedometer information. The primary difference between the DIS and traditional systems is the way in which the information is displayed. The **Driver Information Center (DIC)** is a type of DIS used by many of the automotive manufacturers. The DIS and DIC are basically the same item.

Digital instrumentation is more precise than conventional analog gauges. Analog gauges display an average of the readings received from the sensor; a digital display will present exact readings. Most digital instrument panels provide for display in English or metric values. Drivers select which gauges they wish to have displayed. Most of these systems will automatically display the gauge to indicate a potentially dangerous situation. For example, if the driver has chosen the oil pressure gauge to be displayed and the engine temperature increases above set limits, the temperature gauge will automatically be displayed to warn the driver. A warning light and/or a chime will also activate, to get the driver's attention.

Most electronic instrument panels contain self-diagnostics. The tests are initiated through a scan tool or by pushing selected buttons on the instrument panel. The instrument panel cluster also initiates a self-test every time the ignition switch is turned to ACC or RUN. Usually the entire dash is illuminated and every segment of the display is lighted; ISO symbols generally flash during this test. At the completion of the test, all gauges will display current readings. A code is displayed to alert the driver if a fault is found.

Like analog instruments, electronic instruments receive inputs from a sensor or a sending unit. The information is displayed in various ways. Depending upon the gauge function and the manufacturer's design, the display may be digital numbers or a vertical, horizontal, or curved bar (Figure 13-21). The following paragraphs give three examples of how electronic instruments function.

Electronic Speedometer

Figure 13-22A shows a GM speedometer that can be either a quartz analog (swing needle) display or a digital readout. The speed signal in this system originates from a small AC voltage generator with four magnetic fields called a permanent magnet (PM) generator. This device usually is installed at the transmission or transaxle speedometer gear adapter and is driven like the speedometer cable on conventional systems.

As the PM generator rotates, it generates an AC voltage of four pulses per turn, with voltage and frequency increasing as speed increases. The unit pulses 4,004 times per mile of travel (2,488 times per kilometer) with a frequency output of 1.112 oscillations per second (hertz) per mile per hour of travel (0.691 hertz per kilometer per hour of travel).

Since the PM generator output is analog, a buffer is used to translate its signals into digital input for the processing unit. The processing unit sends a voltage back to the buffer, which switches the voltage on and off and interprets it as vehicle speed changes. If the instrument cluster has its own internal buffer as part of the cluster circuitry, the PM generator signal will go directly to the speedometer.

On some systems, the buffer may contain more than one switching function, as shown in Figure 13-22B, as it handles the ECM and cruise control systems. These secondary switching functions run at half the speed of the speedometer switching operation, or 0.556 Hz/mph (0.3456 Hz/km/h).

If the instrument cluster uses a quartz analog display (Figure 13-23), the gauge is similar to the two-coil electromagnetic gauge discussed earlier. This type of gauge is often called a swing needle or air-core gauge and does not return to zero when the ignition is turned off. When the car begins to move, the buffered speed signal is conditioned

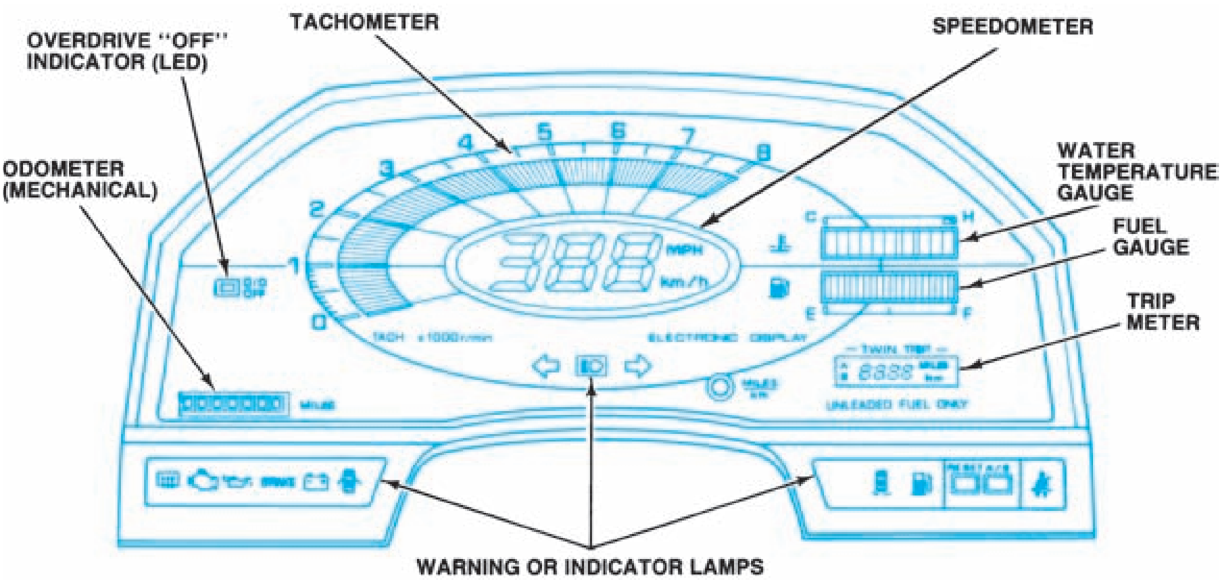

Figure 13-21. Toyota's electronic display is a digital combination meter, which uses a colored liquid crystal display (LCD) panel. (Reprinted by permission of Toyota Motor Corporation)

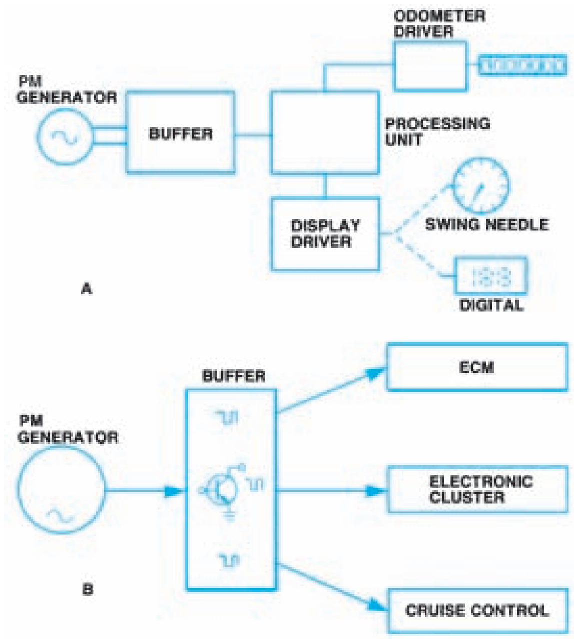

Figure 13-22. GM's electronic speedometer uses a permanent magnet (PM) generator instead of an optical sensor. In A, the buffer translates the PM generator analog signals into digital signals for the processor, which activates the display driver to operate an analog or a digital display. In B, the buffer toggles voltage on and off to interpret vehicle speed to the electronic cluster. (GM Service and Parts Operations)

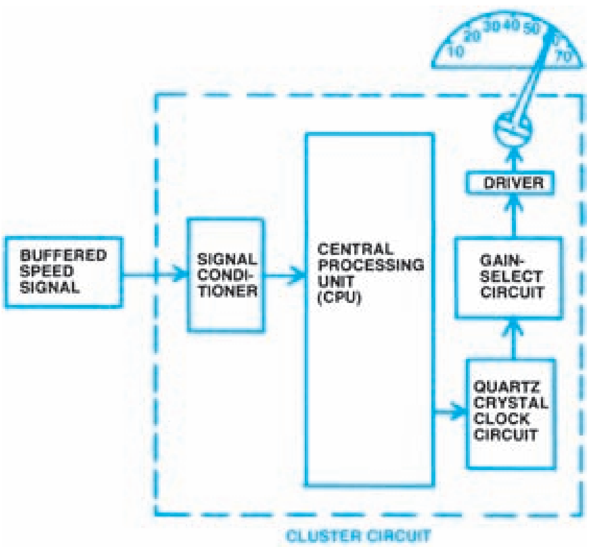

Figure 13-23. The buffered signal passes to a signal conditioner, which transmits it to the CPU where a quartz clock circuit ensures accuracy. After processing, the signal goes to a gain-select circuit, which sends it to the driver circuit for analog display.

and sent to the central processing unit (CPU). The CPU processes the digital input using a quartz-crystal clock circuit and sends it to a gain-select circuit, where it is transferred to a driver circuit. The driver circuit then sends the correct voltages to the gauge coils to move the pointer and indicate the car's speed.

Virtually the same process is followed when a digital display is used (Figure 13-24), with the following minor differences in operation:

- The CPU can be directed to display the information in either English or metric units. A select function sends the data along different circuits according to the switch position.
- The driver circuit is responsible for turning on the selected display segments at the correct intensity.

The odometer used with electronic speedometers can be electromechanical, using a stepper motor (Figure 13-25A), or an IC chip using **nonvolatile RAM** (Figure 13-25B).

The electromechanical type is similar to the conventional odometer, differing primarily in the way in which the numbers are driven. A stepper motor takes digital-pulsed voltages from the speedometer circuit board at half the buffered speed signal discussed earlier. This provides a very accurate accounting of accumulated mileage.

The IC chip retains accumulated mileage in its special nonvolatile RAM, which is not lost when

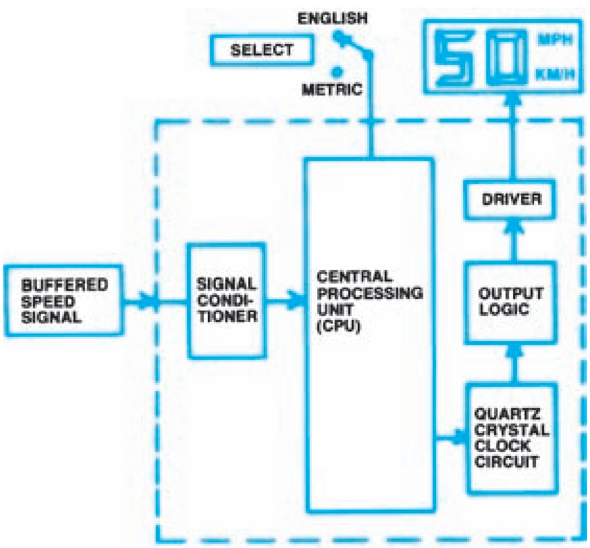

Figure 13-24. The digital cluster circuit is similar to the analog circuit, but an output-logic circuit is used instead of a gain-select circuit.

current is removed. Since its memory *cannot* be turned back, the use of this chip virtually eliminates one of the frauds often associated with the sale of used cars.

Electronic Instrument Panel

The GM electronic **instrument panel cluster (IPC)** contains the following indicators:

- The ABS indicator
- The Air Bag indicator
- The Brake indicator

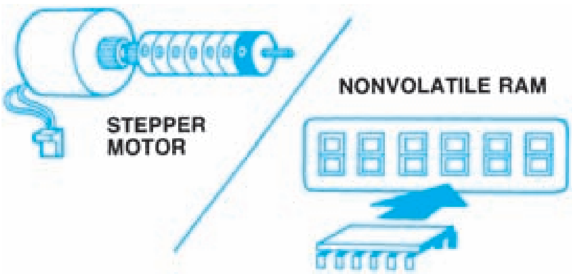

Figure 13-25. Electronic odometers may use a stepper motor or a nonvolatile RAM chip for mileage display. (GM Service and Parts Operations)

- The Cruise indicator
- The Charge indicator
- The Engine Coolant indicator
- The Engine Oil Pressure indicator
- The Fasten Belts indicator
- The Security indicator
- The Service Engine Soon indicator (MIL)

Indicators and Warning Messages

Average Fuel Economy

The average fuel economy is a function of distance traveled divided by fuel used since the parameter was last reset. When the average fuel economy is displayed in the IPC, pressing the Info Reset button on the DIC will reset the average fuel economy parameter. The average fuel economy parameter is only displayed on the DIC. The average fuel economy displays either miles or kilometers, as requested, by briefly pressing the Eng/Met button on the DIC.

Engine Coolant Temperature Gauge

The IPC displays the engine coolant temperature, as determined by the PCM. The IPC receives a Class 2

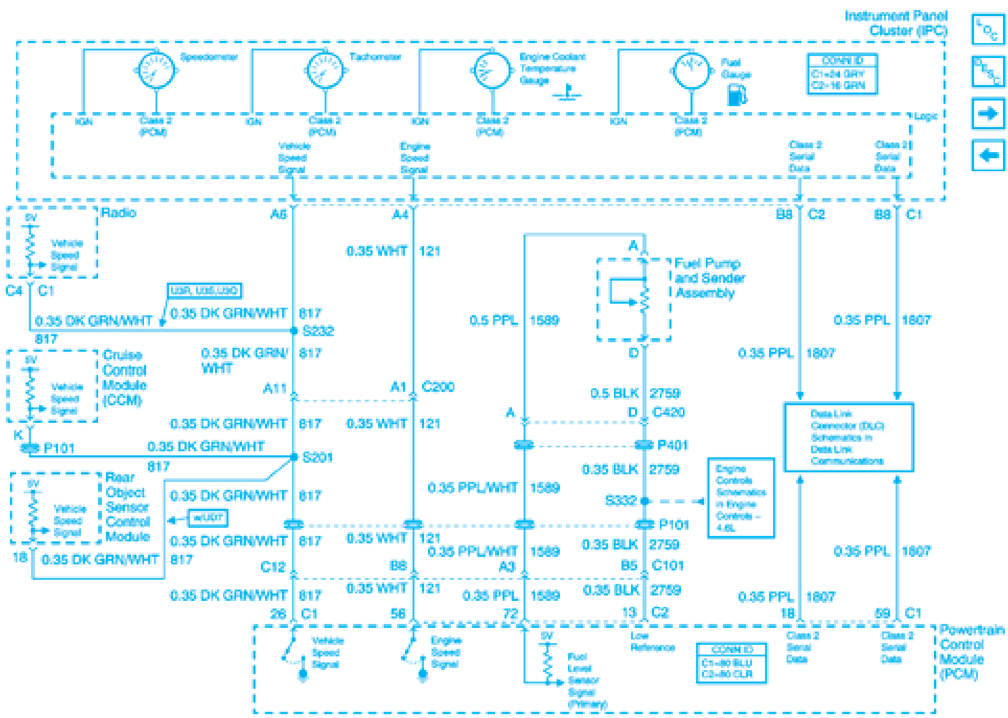

Figure 13-26. GM electronic instrument panel schematic. (Courtesy of GM Service and Parts Operations)

message from the PCM indicating the engine coolant temperature. The engine coolant temperature gauge defaults to C if the following is true:

- The PCM detects a malfunction in the engine coolant temperature sensor circuit.
- The IPC detects a loss of Class 2 communications with the PCM.

Fuel Gauge

The IPC displays the fuel level, as determined by the PCM. The IPC receives a Class 2 message from the PCM indicating the fuel level percentage. The fuel gauge defaults to empty if the following is true:

- The PCM detects a malfunction in the fuel level sensor signal circuit.
- The IPC detects a loss of Class 2 communications with the PCM.

Fuel Range

The fuel range is the estimated distance that the vehicle can travel under the current fuel economy and fuel level conditions. The driver cannot reset the fuel range parameter. “LO” is displayed in the fuel range display when the range is calculated to be less than 64 km (40 miles). The fuel range displays either miles or kilometers, as requested, by briefly pressing the Eng/Met button on the DIC.

Odometer

The IPC contains a season odometer and two trip odometers. The IPC calculates the mileage based on the vehicle-speed signal circuit from the PCM. The odometer will display “Error” if an internal IPC memory failure is detected. The odometer displays either miles or kilometers, as requested, by briefly pressing the Eng/Met button on the DIC. Pressing the Reset Trip A/B button for greater than 2 seconds will reset the trip odometer that is displayed.

PRNDL Display

The IPC displays the selected automatic transmission/transaxle gear position determined by the PCM, as sensed by the gear position selected by the driver. The IPC receives a Class 2 message from the PCM indicating the gear position. The PRNDL for the transmission gear position display blanks if the following is true:

- The PCM detects a malfunction in the transmission range switch signal circuit.
- The IPC receives a Class 2 message indicating the park position and the column park switch indicates a position other than park.
- The IPC detects a loss of Class 2 communications with the PCM.

Speedometer

The IPC displays the vehicle speed based on the information received from the PCM. The PCM converts the data from the vehicle speed sensor to a 4,000-pulses/mile signal. The IPC uses the vehicle-speed signal circuit from the PCM in order to calculate the vehicle speed. The speedometer defaults to 0 km/h (0 mph) if a malfunction in the vehicle speed signal circuit exists. The speedometer displays either miles or kilometers, as requested, by briefly pressing the Eng/Met button on the DIC.

The speedometer display configuration can be changed by using the Dspl Mode button. The speedometer can be configured in one of the following formats:

- Analog display only
- Analog and digital displays
- Digital display only

Tachometer

The IPC displays the engine speed based on information received from the PCM. The PCM converts the data from the engine to a 2-pulses-per-engine-revolution signal. The IPC uses the engine-speed signal circuit from the PCM to calculate the engine speed. The tachometer defaults to 0 rpm if a malfunction in the engine-speed signal circuit exists.

Voltmeter

The IPC displays the system voltage.

Driver Information Center (DIC)

The DIC vehicle information displays vehicle operation parameters that are available to the driver when the ignition is in the RUN position. On many applications, the driver can navigate through the various parameters displayed on the DIC using the Info Up and Info Down buttons. Some parameters can be reset by briefly pressing the Info Reset button.

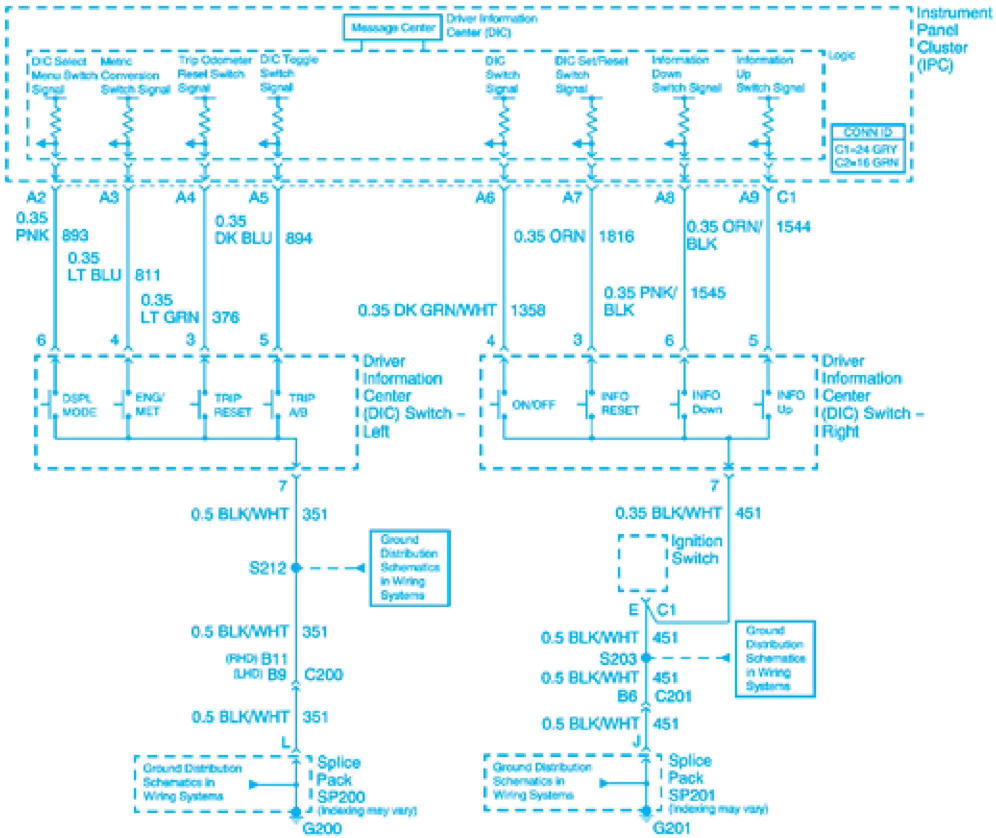

Figure 13-27. GM Driver Information Center (DIC) Schematic. (GM Service and Parts Operations)

NOTE: The Driver Information Center (DIC) is also know as a Driver Information System (DIS).

Some parameters require information from other modules. If the IPC has not received data for a parameter when the time has come to display the parameter, the IPC will blank the display on the DIC. If the IPC has determined that a Class 2 communication failure with one of the modules exists when the time has come to display the parameter, the IPC will display dashes on the DIC. The vehicle information display parameters are displayed in the following order:

1. OUTSIDE TEMP
2. RANGE
3. MPG AVG
4. MPG INST
5. FUEL USED
6. AVG MPH
7. TIMER
8. BATTERY VOLTS
9. TIRE PRESSURE
10. TACHOMETER
11. ENGINE OIL LIFE
12. TRANS FLUID LIFE
13. PHONE
14. FEATURE PROGRAMMING

When the Info Up button is pressed, the DIC will display the next parameter on the list. When the Info Down button is pressed, the DIC will display the previous parameter on the list.

Body Control Module (BCM) Computers

When more than one computer is used on a vehicle, it is often desirable to link their operations. The body control module (BCM) used on many

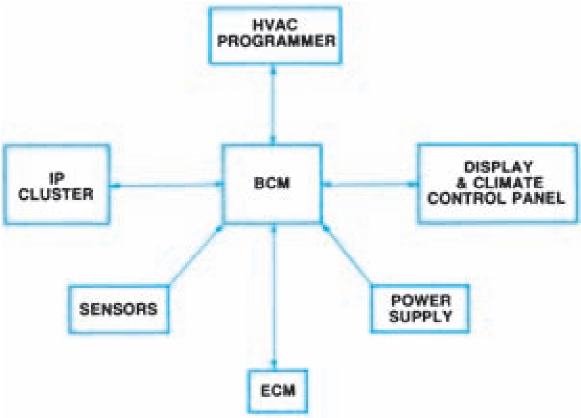

Figure 13-28. Sophisticated electronic systems are composed of several computers and use a central computer (GM calls it a body control module) to manage the system. (GM Service and Parts Operations)

GM cars is an example. The BCM manages the communications for the multiple computer system (Figure 13-28) using a network of sensors, switches, and other microprocessors to monitor vehicle-operating conditions. Certain components also provide the BCM with feedback signals; these tell the BCM whether the components are responding to the BCM commands properly. Like the powertrain control module (PCM), which operates the engine control system, the BCM has built-in diagnostics to help locate and correct a system malfunction.

Light-Emitting Diodes (LEDs)

The light-emitting diode (LED) is a diode that transmits light when electrical current is passed through it (Figure 13-29). An LED display is composed of small dotted segments arranged to form numbers and letters when selected segments are turned on. The LED is usually red, yellow, or green. LEDs have the following major drawbacks:

- Although easily seen in the dark, they are difficult to read in direct sunlight.
- They consume considerable current relative to their brightness.

Liquid Crystal Display (LCD)

A liquid crystal display (LCD) uses sandwiches of special glass containing electrodes and polarized fluid to display numbers and characters.

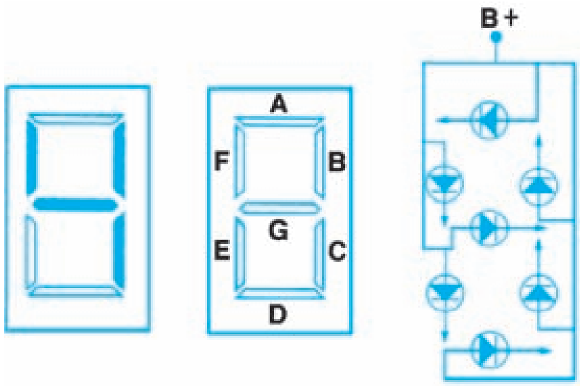

Figure 13-29. Selective application of voltage through the diodes composing a light-emitting diode (LED) results in an alphanumeric display. (GM Service and Parts Operations)

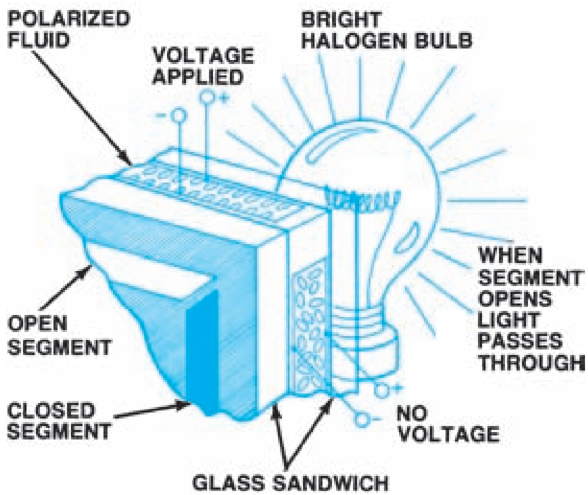

Figure 13-30. Light passes through polarized fluid to create the liquid-crystal display. (GM Service and Parts Operations)

Light cannot pass through the polarized fluid until voltage is applied. The display is very dense, however, and the various special filters used to provide colors create even more density. For this reason, halogen lights are generally placed behind the display (Figure 13-30). Although LCDs perform slowly in cold ambient temperatures, require proper alignment, and are very delicate, they have the following big advantages:

- They consume very little current relative to their brightness.
- They can be driven by a microprocessor through an interfacing output circuit.

Vacuum Fluorescent Display (VFD)

This is the most commonly used display for automotive electronic instruments, primarily because of its durability and bright display qualities. The **vacuum fluorescent display (VFD)** generates light similar to a television picture tube, with free electrons from a heated filament striking phosphor material that emits a blue-green light (Figure 13-31).

The anode segments are coated with a fluorescent material such as phosphorous. The filament is resistance wire, heated by electrical current. The filament coating produces free electrons, which are accelerated by the electric field generated by the voltage on the accelerating grid. High voltage is applied only to the anode of those segments required to form the characters to be displayed. Since the anode is at a higher voltage than the fine wire-mesh grid, the electrons pass through the grid. The phosphors on the segment anodes impressed with high voltage glow very brightly when struck by electrons; those receiving no voltage do not glow. The instrument computer determines the segments necessary to emit light for any given message and applies the correct sequences of voltage at the anodes.

VFD displays are extremely bright, and their intensity must be controlled for night viewing. This can be done by varying the voltage on the accelerating grid: the higher the voltage, the brighter the display. Intensity can also be controlled by pulse-width dimming, or turning the display on and off very rapidly while controlling the duration of on-time. This is similar to the pulse-width modulation of a carburetor mixture control solenoid or a fuel injector. The on-off action occurs so rapidly that it cannot be detected by the human eye.

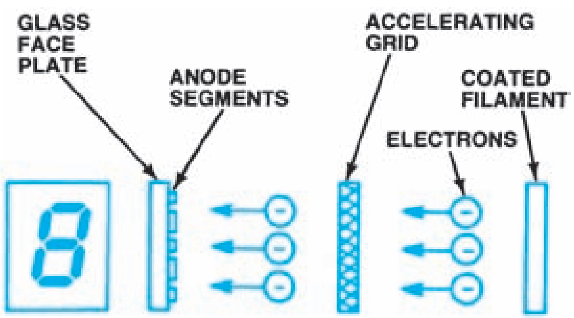

Figure 13-31. In a vacuum fluorescent display, voltage applied selectively to segment anodes makes the fluorescent material glow. (DaimlerChrysler Corporation)

Cathode Ray Tube (CRT)

Another display device used in automotive instrumentation was the *cathode-ray tube* (*CRT*), as used in the 1986–1996 Buick Riviera Buick Reatta. The CRT is essentially the same as the display used in an oscilloscope or a television set. CRTs function with an electron beam generated by an electron gun located at the rear of the tube. The CRT consists of a cathode that emits electrons and an anode that attracts them. Electrons are “shot” in a thin beam from the back of the tube. Permanent magnets around the outside neck of the tube and plates grouped around the beam on the inside of the tube shape the beam. A tube-shaped anode that surrounds the beam accelerates it as it leaves the electron gun. The beam has so much momentum that the electrons pass through the anode and strike a coating of phosphorus on the screen, causing the screen to glow at these points. The control plates are used to move the beam back and forth on the screen, causing different parts of it to illuminate. The result is a display (oscilloscope) or a picture (television).

The automotive CRT has a touch-sensitive Mylar switch panel installed over its screen. This panel contains ultra-thin wires, which are coded by row and column. Touching the screen in designated places blocks a light beam and triggers certain switches in the panel, according to the display mode desired. The switches in turn send a signal to the control circuitry, which responds by displaying the requested information on the CRT screen. In principle, this type of instrumentation combines two personal computer attributes: It has touch-screen control and is **menu driven.**

HEAD-UP DISPLAY (HUD)

The **head-up display (HUD)** is a secondary display system that projects video images onto the windshield. It is an electronic instrumentation system (Figure 13-32) that consists of a special windshield, a HUD unit containing a computer module, and a system-specific dimmer switch.

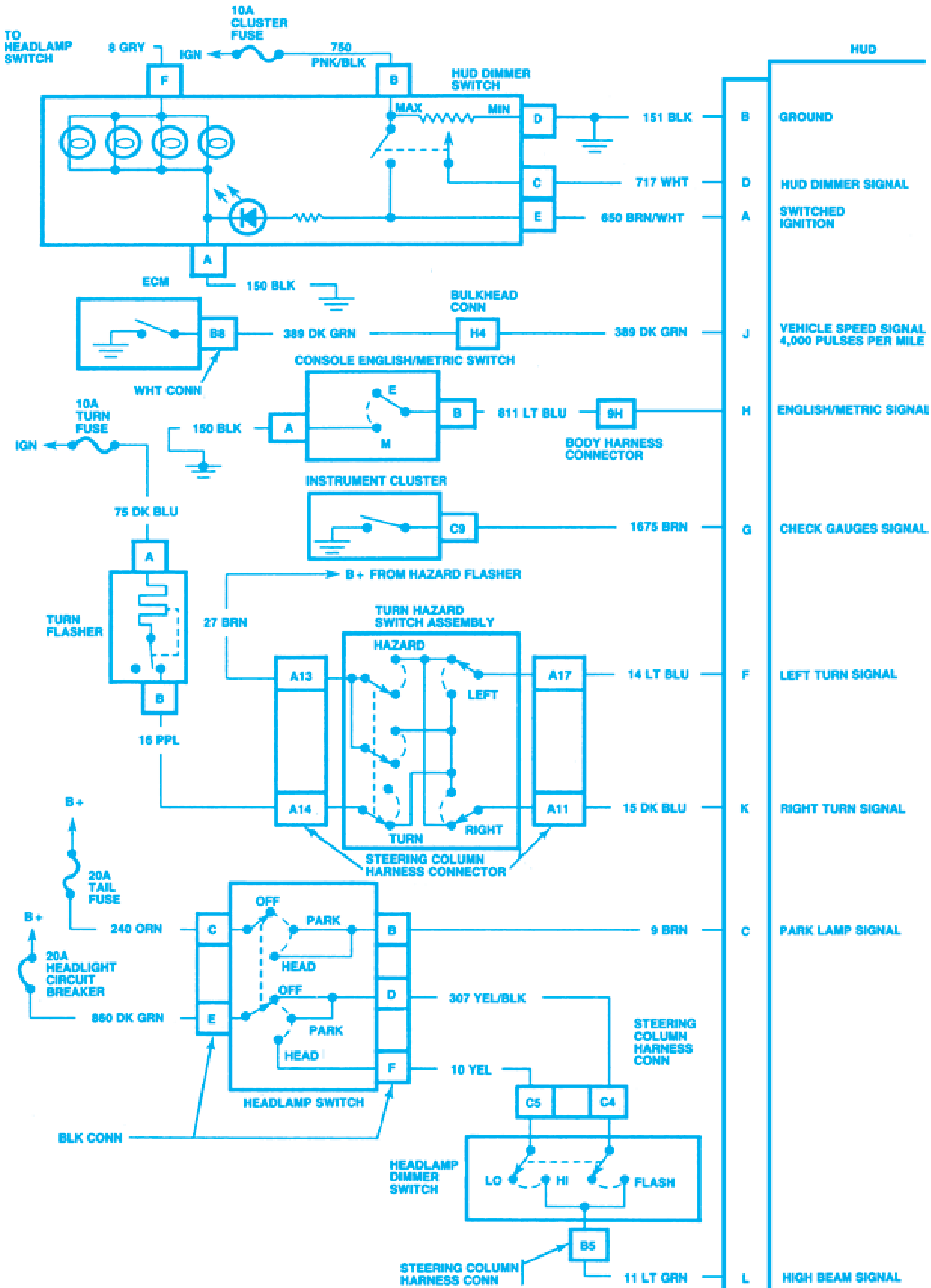

Figure 13-32. A wiring schematic of the HUD system as used by GM. (GM Service and Parts Operations)

The HUD unit processes various inputs that are part of the instrument cluster and projects frequently used driver information on the windshield area for viewing from the driver's seat. The dimmer switch provides system power for the computer module, varies the intensity of the display unit, and can change the vertical position of the display image through a mechanical cable drive system. When the ignition is turned on, the HUD unit performs a self-check routine and projects the following image (Figure 13-33) for approximately 3.5 seconds:

- Turn signal indicators
- High-beam indicator
- Check gauges indicator
- Speed (km/h or mph) indicator
- All segments of the digital speedometer

After completing the self-check, the system begins normal operation. The ECM provides vehicle speed information for HUD operation by completing a ground path to the HUD unit 4,000 times per mile. Each time the HUD unit recognizes a voltage drop at terminal J, it counts one pulse. By counting the pulses per second, the HUD unit can determine vehicle speed and project the corresponding figure on the windshield display.

Night Vision Head-Up Display (HUD)

The night vision system (Figure 13-34) used on the 2002–2003 Cadillac Deville is a monochromatic (single-color) option available to improve the vision of the driver beyond the scope of the headlamps.

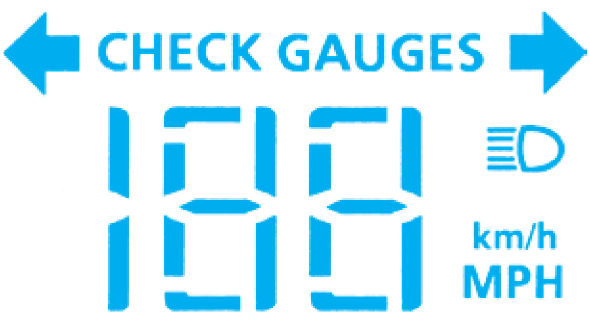

Figure 13-33. The HUD system display image. (GM Service and Parts Operations)

The night vision operates only under the following conditions:

- The ignition is on.
- The front fog lamps or the headlamps are on during low light conditions. The night vision system uses the signal from the ambient light sensor to determine when low-light conditions exist.
- The night vision system is on.

The night vision system contains the following components:

- The head-up display (HUD)
- The head-up display (HUD) switches
- The night vision camera

Head-Up Display (HUD)

Night vision uses a HUD to project the night vision video images onto the windshield. The HUD projects the detected object images onto the windshield based on the video signals from the night vision camera.

Head-Up Display Switches

- **On/Off and Dimming Switch:** This turns the HUD display and the night vision system on or off. When the HUD is turned on, the system warm-up logo is displayed for a period of approximately 45 seconds. The on/off and dimming switch is also used to adjust the brightness of the video image. Moving the switch up will increase the HUD video image brightness. Moving the switch down will decrease the HUD video image brightness.
- **Up/Down Switch:** The HUD in the night vision system has an electric tilt adjust motor that adjusts the video image to the preferred windshield location of the driver. Pressing the Up/Down switch directs the tilt motor to adjust the night vision video image up or down, within a certain range.

Night Vision Camera

The night vision camera senses the heat given off by objects that are in the field of view of the camera. Warmer objects, such as pedestrians, animals, and other moving vehicles, appear whiter on the displayed image. Colder objects, such as the sky, signs and parked vehicles, appear darker on the displayed image. The night vision camera sends the detected object image information to the HUD via the high video signal circuit and the low video signal circuit.

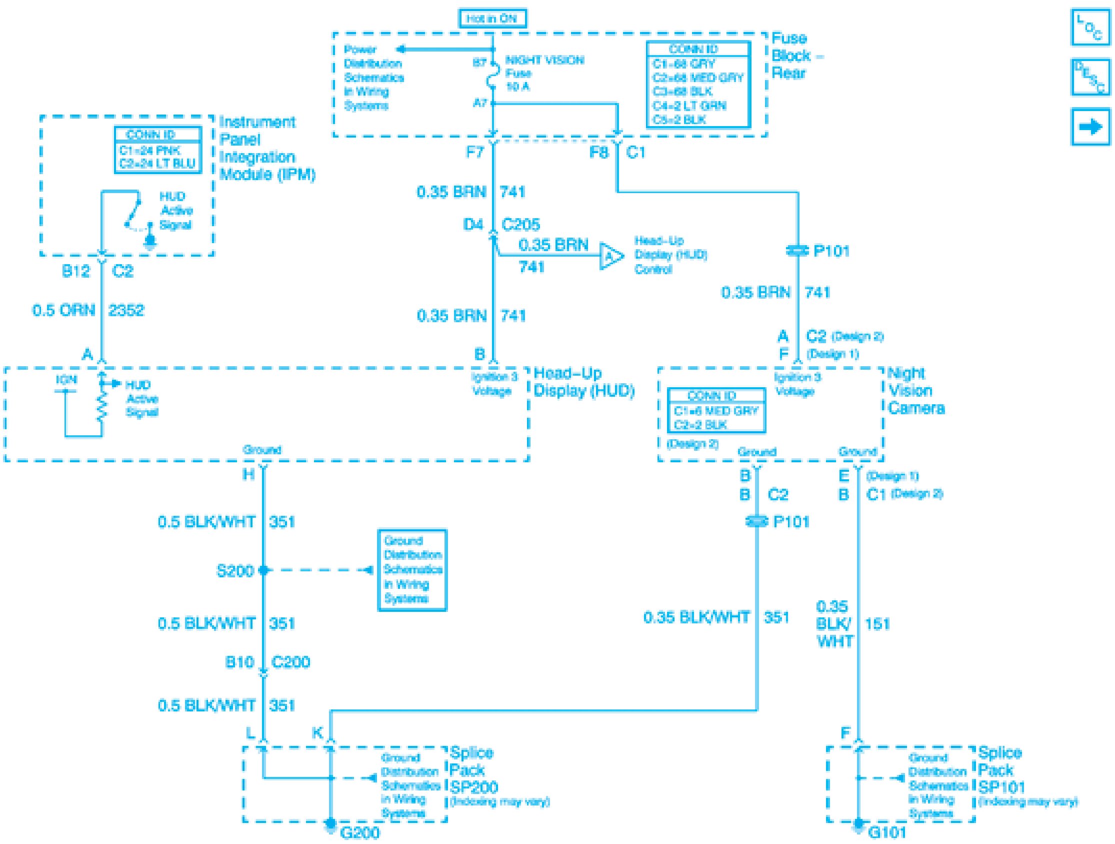

Figure 13-34. GM night vision HUD system schematic. (GM Service and Parts Operations)

SUMMARY

Instruments include gauges and warning lamps. There are various types of gauges, including mechanical, bimetallic, electromagnetic, and electronic. A voltage drop, a grounding switch, a ground sensor, or fiber optics can light warning lamps. Late-model vehicles may have a digital display instead of traditional analog gauges. Digital displays can be individual or they can be part of a more elaborate vehicle electronic system, such as a trip computer or message center. Electronic instruments or driver information systems (DISs) have the same purpose as the traditional analog instruments: The DIS displays vehicle-operating information to the driver and includes all gauge and speedometer information. The primary difference between the electronic (DIS) and traditional systems is the way in which the information is displayed. The DIS is also called a driver information center (DIC). Body control module (BCM) computers act as managers of other computers in a comprehensive vehicle system.

Electronic displays may use a light-emitting diode (LED), a liquid-crystal display (LCD), a vacuum fluorescent display (VFD), or a cathode-ray tube (CRT) to transmit information. Some instrumentation is menu-driven, giving the user an opportunity to select the information to be displayed. Touch-sensitive screens similar to those on personal computers are used instead of keyboards or pushbuttons on some late-model systems. A head-up display (HUD) is a secondary display system that projects video images onto the windshield. The GM night vision system is a head-up display (HUD) system that projects useful vehicle information in front of the driver near the windshield.

Review Questions

1. Which of the following is *not* a reason why warning lamps have replaced gauges in automobiles?
   a. Cheaper to manufacture
   b. Cheaper to install
   c. More accurate
   d. Easier to understand
2. Temperature compensation in bimetallic gauges is accomplished by:
   a. Current flow through the heater coil
   b. The shape of the bimetallic strip
   c. An external resistor in the circuit
   d. Hermetically sealing the unit
3. Gauges with three-coil movements are most often used by:
   a. General Motors
   b. Ford
   c. DaimlerChrysler
   d. Toyota
4. An oil pressure warning lamp is usually controlled by:
   a. Voltage drop
   b. Ground switch
   c. Ground sensor
   d. Manual switch
5. The sending unit in the fuel gauge uses a:
   a. Fixed resistor
   b. Zener diode
   c. Float
   d. Diaphragm
6. Buzzers are a special type of warning device that are activated by:
   a. Voltage drop
   b. Ground switches
   c. Diaphragms
   d. Optical fibers
7. Two technicians are discussing driver information systems. Technician A says the head-up display (HUD) is a secondary display system that projects video images onto the windshield. Technician B says that a liquid-crystal display (LCD) is an indicator in which electrons from a heated filament strike a phosphor material that emits light. Who is right?
   a. A only
   b. B only
   c. Both A and B
   d. Neither A nor B
8. In GM BCM computer-controlled electric fan circuits:
   a. The BCM switches the control line voltage on/off with pulse-width modulation.
   b. The fan control module switches the ground on/off.
   c. Both A and B
   d. Neither A nor B
9. Electromagnetic gauges do *not* use a:
   a. Mechanical movement
   b. D'Arsonval movement
   c. Air core movement
   d. Two- or three-coil movement
10. Which type of gauge does *not* use an instrument voltage regulator (IVR)?
    a. D'Arsonval movement
    b. Air core movement
    c. Two-coil movement
    d. Three-coil movement
11. Technician A says GM's electronic speedometer interprets vehicle speed by using a buffer to switch the voltage on/off. Technician B says GM's electronic speedometer uses a buffer to translate the analog input of the PM generator into digital signals. Who is right?
    a. A only
    b. B only
    c. Both A and B
    d. Neither A nor B
12. Technician A says an electronic speedometer cannot use a stepper motor to provide the display. Technician B says the use of nonvolatile RAM prevents the odometer from being turned back. Who is right?
    a. A only
    b. B only
    c. Both A and B
    d. Neither A nor B
13. An electronic display device using electrodes and polarized fluid to create numbers and characters is called:
    a. LCD
    b. LED

c. VFD
d. CRT

14. Which electronic display device is most frequently used because it is very bright, consumes relatively little power, and can provide a wide variety of colors through the use of filters?
 a. LCD
 b. LED
 c. VFD
 d. CRT

15. Which electronic display device is difficult to read in daylight and consumes considerable power relative to its brightness?
 a. LCD
 b. LED
 c. VFD
 d. CRT