12

Automotive Lighting Systems

LEARNING OBJECTIVES

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

- Identify and explain the operation of most automotive headlight systems.
- Identify the common bulbs used in automotive lighting systems.
- Define the taillamp, license plate lamp, and parking lamp circuits.
- Identify the components and define the stop lamp and turn signal circuits.
- Define the hazard warning lamp (emergency flasher) circuit.
- Identify the components and explain the operation of the backup light, side marker, and clearance lamp circuits.
- Identify the components and explain the operation of the instrument panel lighting.

KEY TERMS

Asymmetrical
Backup Lamps
Clearance Markers
Daytime Running Lights (DRL)
Dimmer Switch
Flasher Units
Halogen Sealed-Beam Headlamps
Hazard Warning Lamp
Headlamp Circuit
High-Intensity Discharge (HID) Lamp
Potentiometers
Rheostats
Sealed-Beam Headlamps
Side Marker Lamps
Stop Lamps
Symmetrical
Turn Signal Switch

INTRODUCTION

Automotive lighting circuits include important safety features, so they must be properly understood and serviced. Lighting circuits follow general patterns, according to the devices they serve, although slight variations appear from manufacturer to manufacturer.

HEADLAMP CIRCUITS

The **headlamp circuit** is one of the most standardized automotive circuits, because headlamp use is regulated by laws that until recently had seen little change since the 1940s. There are two basic types of headlamp circuits, as follows:

- Two-lamp circuit
- Four-lamp circuit

Manufacturers select the type of circuit on the basis of automotive body styling. Each circuit must provide a high-beam and a low-beam light, a switch or switches to control the beams, and a high-beam indicator.

Circuit Diagrams

Most often, the headlamps are grounded and switches are installed between the lamps and the power source, as shown in Figure 12-1. Some circuits have insulated bulbs and a grounded switch, as shown in Figure 12-2. In both cases, all lamp filaments are connected in parallel. The failure of one filament will not affect current flow through the others.

A two-lamp circuit (Figure 12-3) uses lamps that contain both a high-beam and a low-beam filament. A four-lamp circuit (Figure 12-4) has two double-filament lamps and two lamps with single, high-beam filaments. Lamp types are explained in more detail later in this chapter.

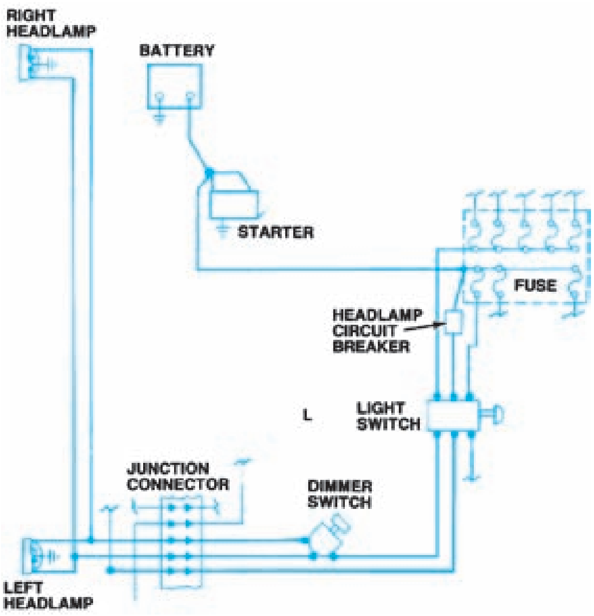

Figure 12-1. Most headlamp circuits have insulated switches and grounded bulbs.

Switches and Circuit Breakers

The three operating conditions of a headlamp circuit are as follows:

- **Off**—No current
- **Low-beam**—Current through low-beam filaments
- **High-beam**—Current through both the low-beam and the high-beam filaments

One or two switches control these current paths; the switches may control other lighting circuits as well. Most domestic cars have a main headlamp switch with three positions, as shown in Figure 12-5.

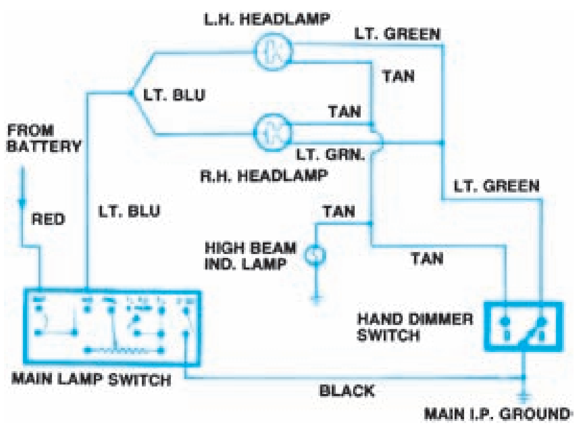

Figure 12-2. Some headlamp circuits use grounded switches and insulated bulbs. (GM Service and Parts Operations)

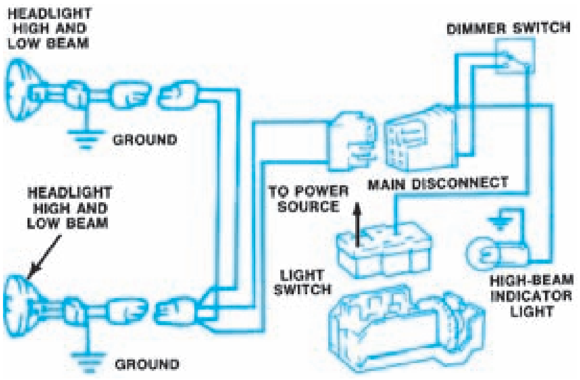

Figure 12-3. A two-lamp headlamp circuit uses two double-filament bulbs.

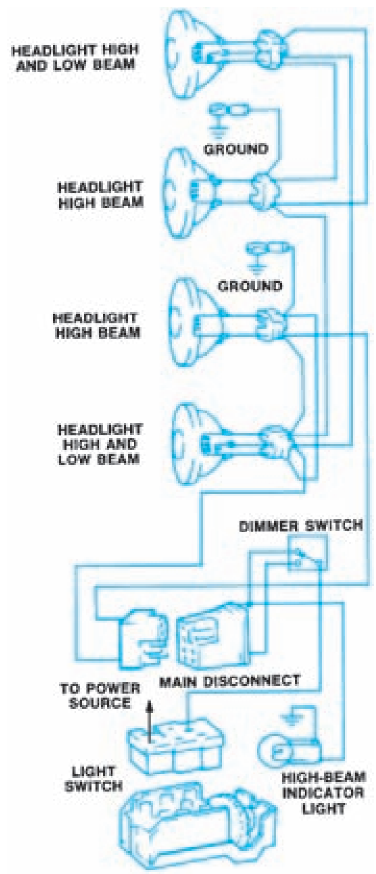

Figure 12-4. A four-lamp headlamp circuit uses two double-filament bulbs and two single-filament bulbs.

- **First position**—Off, no current.
- **Second position**—Current flows to parking lamps, taillamps, and other circuits.
- **Third position**—Current flows to both the second-position circuits and to the headlamp circuit.

The headlamp switch is connected to the battery whether the ignition switch is on or off. A two-position **dimmer switch** is connected in series with the headlamp switch. The dimmer switch controls the high- and low-beam current paths. If the headlamps are grounded at the bulb, as shown in Figure 12-6, the dimmer switch is installed between the main headlamp switch and the bulbs. If the headlamps are remotely grounded, as shown in Figure 12-2, the dimmer switch is installed between the bulbs and ground.

The dimmer switch on older cars and most light-duty trucks is foot operated and mounted near the pedals. On late-model cars, it generally is mounted on the steering column and operated by a multi-function stalk or lever, as shown in Figure 12-7. Some imported and late-model domestic cars use a

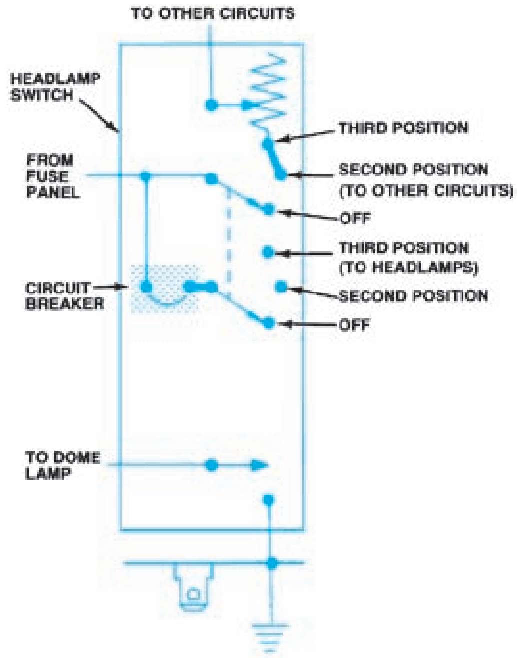

Figure 12-5. The main headlamp switch controls both the headlamp circuit and various other lighting circuits. (DaimlerChrysler Corporation)

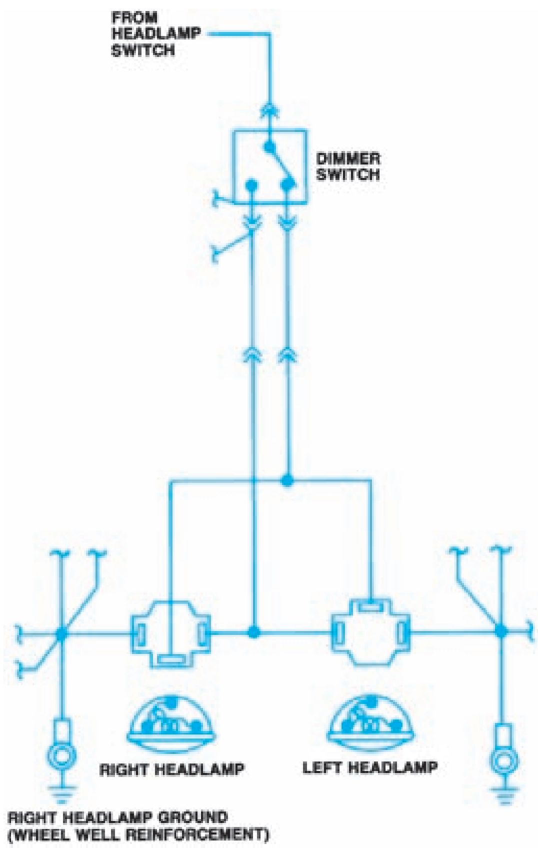

Figure 12-6. Most dimmer switches are insulated and control current flow to grounded bulbs. (DaimlerChrysler Corporation)

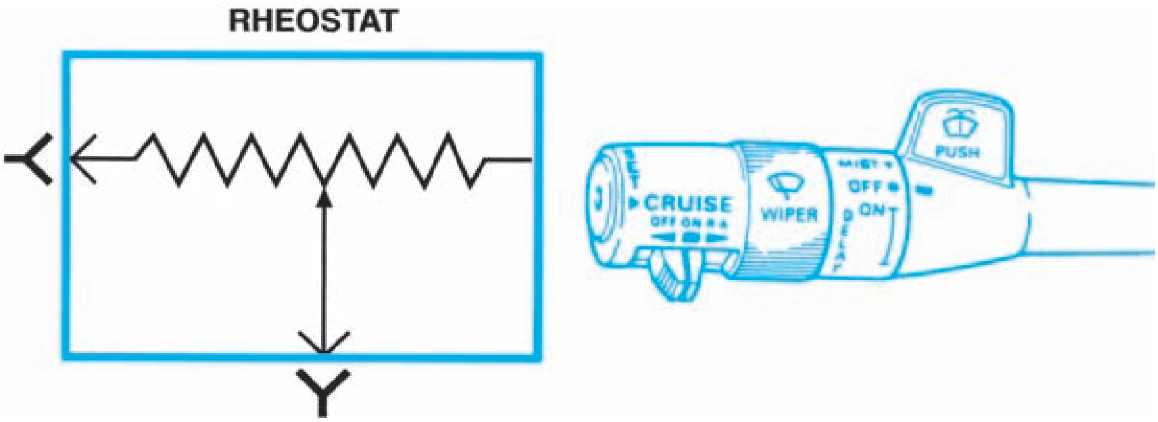

Figure 12-7. Late-model dimmer switches are operated by a steering column-mounted multifunction stalk or lever and control other lamp circuits. (GM Service and Parts Operations)

Figure 12-8. Headlamp switches may be mounted on the steering column and operated by a stalk or lever.

single switch to control all of the headlamp circuit operations. The following basic types of headlamp switches are used:

- Mounted on the steering column and operated by a lever (Figure 12-8)
- A push-pull switch mounted on the instrument panel (Figure 12-9)
- A rocker-type switch mounted on the instrument panel (Figure 12-10)

All systems must have an indicator lamp for high-beam operation. The indicator lamp is mounted on the instrument panel. It forms a parallel path to ground for a small amount of high-beam current and lights when the high-beam filaments light.

Because headlamps are an important safety feature, a Type 1, self-setting circuit breaker protects the circuitry. The circuit breaker can be built into the headlamp switch, as shown in Figure 12-5, or it can be a separate unit, as shown in Figure 12-1.

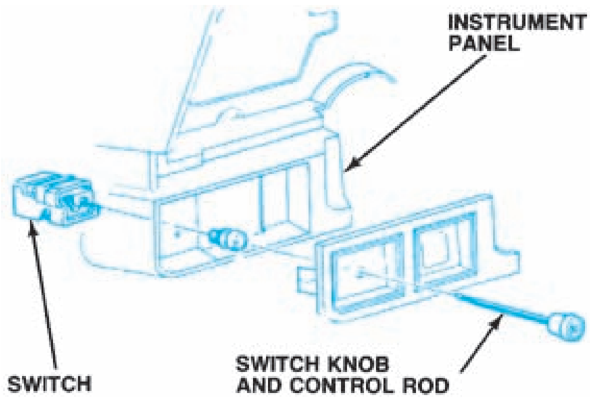

Figure 12-9. Push-pull headlamp switches are mounted on the instrument panel.

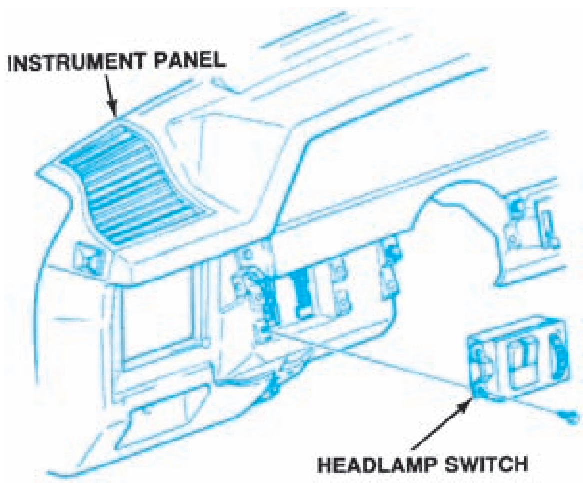

Figure 12-10. Rocker-type headlamp switches usually have a separate rotary rheostat control. (GM Service and Parts Operations)

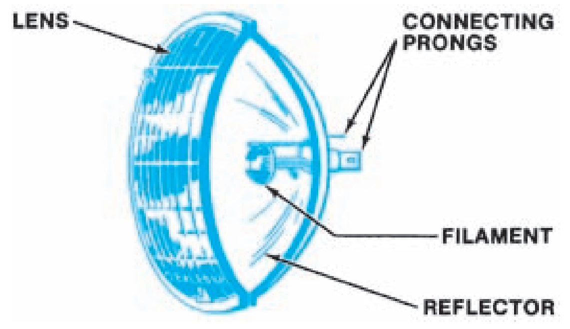

Figure 12-11. A cutaway view of a conventional sealed-beam headlamp.

Headlamps

Until 1940, a small replaceable bulb mounted behind a glass lens was used to provide light for night driving. Safety standards established in the United States in 1940 made round, sealed-beam units mandatory on domestic cars. Repeated attempts to modify the standards after World War II were only partially successful, beginning with the introduction of rectangular sealed-beam units in the mid-1970s. The first major change in headlight design came with the rectangular halogen headlamp, which appeared on some 1980 models. Since that time, considerable progress has been made in establishing other types, such as composite headlamps that use replaceable halogen bulbs.

Conventional Sealed-Beam Headlamps

A **sealed-beam headlamp** is a one-piece, replaceable unit containing a tungsten filament, a reflector, a lens, and connecting terminals, as shown in Figure 12-12. The position of the filament in front of the reflector determines whether the filament will cast a high or a low beam. The glass lens is designed to spread this beam in a specific way. Headlamps have **symmetrical** or **asymmetrical** beams, as shown in Figure 12-12. All high beams are spread symmetrically; all low beams are spread asymmetrically.

Halogen Sealed-Beam Headlamps

Halogen sealed-beam headlamps (Figure 12-13) first appeared as options on some 1980 domestic cars. Their illumination comes from passing current

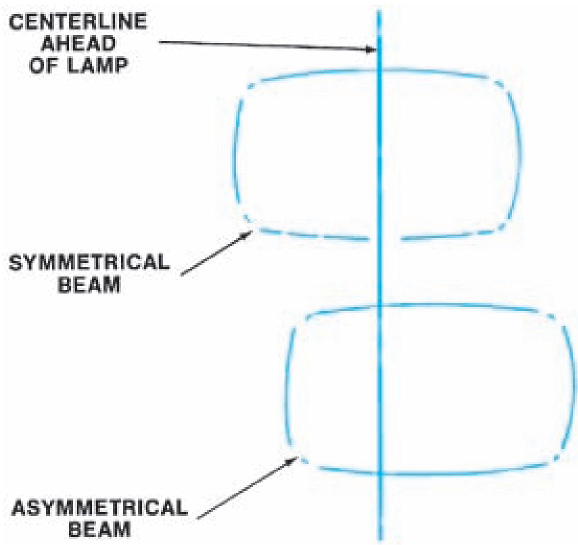

Figure 12-12. The glass lens design determines whether the beam is symmetrical or asymmetrical.

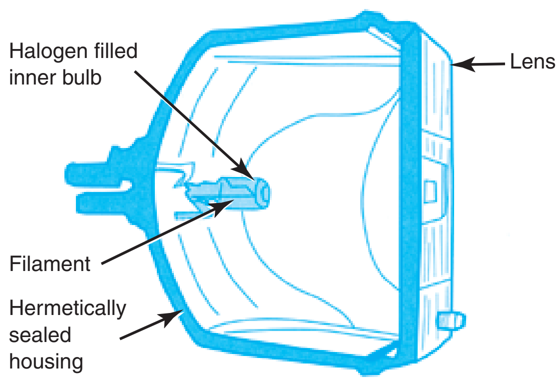

Figure 12-13. Halogen sealed-beam headlamps. (DaimlerChrysler Corporation)

through a filament in a pressure-filled halogen capsule, instead of through a filament in a conventional evacuated sealed-beam bulb. Halogen lamps provide brighter, whiter light than conventional headlamps.

Service and adjustment procedures are the same for halogen sealed-beam lamps as they are for conventional sealed-beams. Early bulb-type halogen lamps were not interchangeable with conventional sealed-beam headlamps, but today halogen sealed-beam lamps can often be used as direct replacements for their conventional counterpart. Halogen lamps are manufactured of glass or plastic. Glass lamps carry an "H" prefix; plastic lamps have an "HP" prefix. Plastic lamps are less susceptible to stone damage and also weigh considerably less than glass lamps.

Historical Headlamp Control Levers

Late-model cars are not the first to have a column-mounted lever controlling the headlamp circuit. The headlamps on the 1929 REO Wolverine Model B were turned on and off by a lever mounted to the left of the horn button on the steering wheel. This lever also controlled the high-low beam switching. The REO instruction book pointed out that, because each headlamp filament produced twenty-one candlepower, the headlamps should not be used when the car was standing still, to avoid draining the battery.

Halogen sealed-beam lamps are manufactured in the same sizes and types as conventional sealed-beams, with one additional type, as follows:

- Type 2E lamps contain both a high-beam and a low-beam inside a rectangular, 4 × 6 1/2-inch (102 × 165-mm) housing.

Like conventional sealed-beams, the type code and aiming pads are molded into the lens of the bulb.

Composite Headlamps

Composite headlamps first appeared on some 1984 models as a part of the aerodynamic styling concept that has characterized car design since the mid-1980s. Composite headlamp design uses a replaceable halogen headlamp bulb that fits into a socket at the rear of the reflector, as shown in Figure 12-14. Since the headlamp housing does not require replacement unless damaged, it can be incorporated as a permanent feature of automotive styling. The housing can be designed to accept a single bulb or dual bulbs.

Composite headlamps can be manufactured by two different methods. In one, polycarbonate plastic is used to form the lens portion of the headlamp housing, as shown Figure 12-15, and the inside of the housing is completely sealed. In the other, a glass lens cover is permanently bonded with a reflector housing to form a single unit. Because this type of composite headlamp is vented to the atmosphere, water droplets may form on the inside of the glass lens cover when the headlamps are off. Such condensation disappears rapidly when the lights are turned on and does not affect headlamp performance.

Replacement halogen bulbs may contain both high- and low-beam filaments for use in two-headlamp systems, and individual high- or low-beam filaments for use in four-headlamp systems. The halogen bulbs have a quartz surface that can be easily stained when handled. For this reason, the bulbs are furnished in protective plastic covers that should not be removed until the bulb has been installed. If the quartz surface is accidentally touched with bare hands, it should be cleaned immediately with a soft cloth moistened with alcohol.

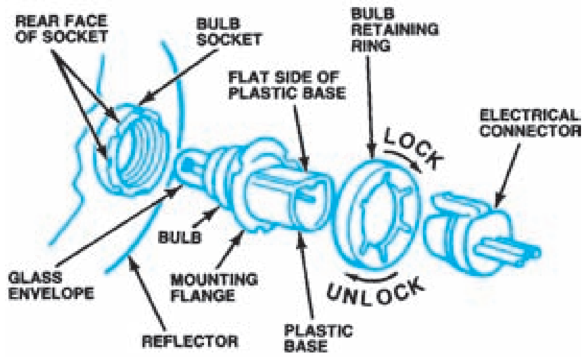

Figure 12-14. A replaceable halogen bulb is installed through the rear of the reflector and held in place with a retaining ring. (GM Service and Parts Operations)

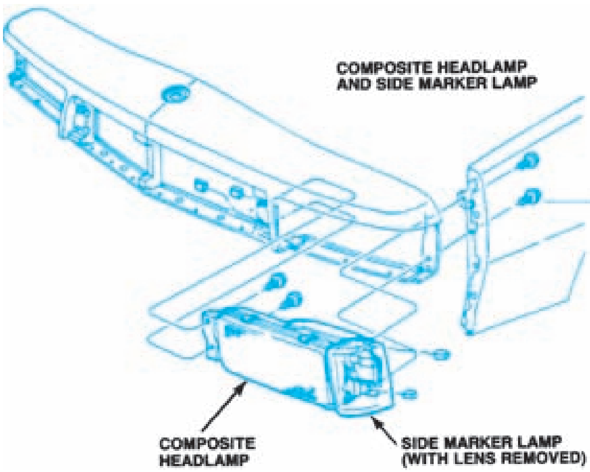

Figure 12-15. Composite headlights use a polycarbonate lens and form a permanent part of the car's styling. (GM Service and Parts Operations)

AUTOMOTIVE HEADLAMPS

HEADLAMP TYPE AND SIZE	ID CODE①	TRADE NO.②	DESIGN WATTS @ 12.8 VOLTS HIGH BEAM	LOW BEAM
5-3/4 INCH CIRCULAR SEALED-BEAM	2C1	4000	37.5	60
	2C1	4040③	37.5	60
	2C1	H5006	35	35
	1C1	4001	37.5	
	1C1	H4001	37.5	
	1C1	5001	50	
	1C1	H5001	50	
7 INCH CIRCULAR SEALED-BEAM	2D1	6014	50	50
	2D1	H6014	60	50
	2D1	6015③	60	50
	2D1	6016④	60	50
	2D1	H6017	60	35
4 X 6-12 INCH RECTANGULAR SEALED-BEAM	1A1	4651	50	
	1A1	H4651	50	
	2A1	4652	40	60
	2A1	H4656	35	35
	2A1	H4662	40	45
	2A1	H4739	40	50
	2E1	H4666	65	45
5-1/2 X 8 INCH RECTANGULAR SEALED-BEAM	2B1	6052	65	
	2B1	H6052	65	
	2B1	H6054	65	55
3 X 5 INCH RECTANGULAR	H1	H4701	65	
	H3	H4703	65	
	H4	H4704	60	55④
REPLACEMENT HALOGEN BULB		9094	65	45

NOTES:
① THE FIRST CHARACTER INDICATES THE NUMBER OF BEAMS IN THE BULB, THE SECOND INDICATES THE SIZE AND NUMBER OF BULBS USED ON THE CAR, AND THE THIRD IS AN SAE PHOTOMETRIC SPECIFICATION. ② H INDICATES A HALOGEN SEALED-BEAM. ③ HEAVY DUTY. ④ AT 13.2 VOLTS.

Figure 12-16. Common sealed-beam headlamps and replaceable halogen bulbs. (GM Service and Parts Operations)

Replacing the halogen bulb in a composite headlamp does not normally disturb the alignment of the headlamp assembly. There should be no need for headlamp alignment unless the composite headlamp assembly is removed or replaced. If alignment is required, however, special adapters must be used with the alignment devices. Figure 12-16 describes the automotive headlamps currently in use.

High-Intensity Discharge (HID) Lamps

The latest headlight development is the **high-intensity discharge (HID) lamp** (Figure 12-17). These headlamps put out three times more light and twice the light spread on the road than conventional halogen headlamps. They also use about two-thirds less power to operate and will last two to three times as long. HID lamps produce light in both ultraviolet and visible wave-lengths, causing highway signs and other reflective materials to glow.

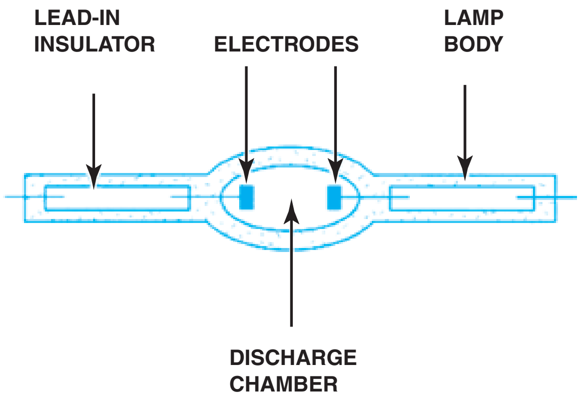

Figure 12-17. High-intensity discharge (HID) lamps.

These lamps do not rely on a glowing element for light. Instead the HID lamp contains a pair of electrodes, similar to spark plug electrodes, surrounded by gas. The electrode is the end of an electrical conductor that produces a spark. Light is produced by an arc that jumps from one electrode to another, like a welder's arc. The presence of an inert gas amplifies the light given off by the arcing. More than 15,000 volts are needed to jump the gap in the electrodes. To provide this voltage, a voltage booster and controller are required. Once the gap is bridged, only 80 volts is needed to keep the current flow across the gap. The large light output of the HID allows them to be smaller in size. HIDs will usually show signs of failure before they burn out.

Headlamp Location and Mounting

State and federal laws control the installation of headlamps. Automotive designers must place headlamps within certain height and width ranges. In addition, two- or four-lamp systems must follow one of the patterns shown in Figure 12-18.

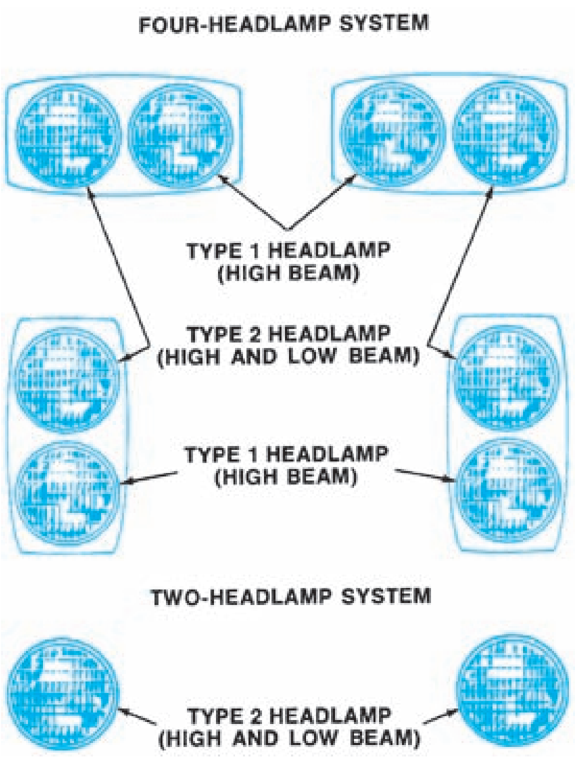

Figure 12-18. The law requires that headlamps be arranged in one of these patterns. The same requirements apply to rectangular lamps.

Headlamps are mounted so that their aim can be adjusted. Most circular and rectangular lamps have three adjustment points, as shown in Figure 12-19. The sealed-beam unit is placed in an adjustable mounting, which is retained by a stationary mounting. Many cars have a decorative bezel that hides this hardware while still allowing lamp adjustment, as shown in Figure 12-20. Composite headlamps use a similar two-point adjustment system, as in Figure 12-21, but require the use of special adapters with the alignment devices.

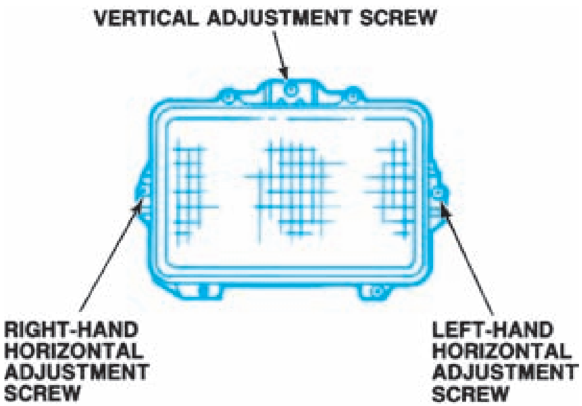

Figure 12-19. Most sealed-beam headlamps have vertical and horizontal adjusting screws. (GM Service and Parts Operations)

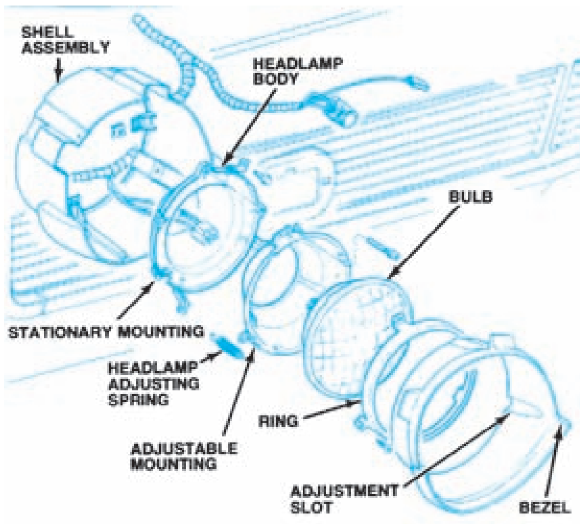

Figure 12-20. Headlamps are held in an adjustable mounting which is generally concealed by a decorative bezel.

Concealed Headlamps

Another automotive styling feature is concealed headlamps, either stationary lamps behind movable doors, as in Figure 12-22, or lamps that move in and out of the car's bodywork as in, Figure 12-23. The doors can be metal or clear plastic.

Electric motors or vacuum actuators operate headlamp-concealing mechanisms. Electrically operated systems usually have a relay controlling current flow to the motor. Vacuum-actuated systems work with engine vacuum stored in a reservoir.

Federal law requires that the main headlamp switch control the concealing mechanisms on late-model cars and that "pop-up" headlamps that rise out of the hood must not come on until they have completed 75 percent of their travel. Switches used with electrically operated headlamp doors have additional contacts to activate the relay (Figure 12-24). Vacuum-actuated systems usually have a vacuum switch attached to the headlamp switch. Some older cars may have a separate switch to control the door. All concealed headlamp systems also must have a manual opening method, such as a crank or a lever, as a backup system.

Some 1967 and earlier cars have a clear plastic lens cover, or fairing, over the sealed-beam unit. These are not legal on later-model cars.

Automatic Headlamp Systems

Photocells and solid-state circuitry are used to control headlamp operation in many vehicles today. A system can turn the lamps on and off; on past models they controlled the high- and low-beam switching. Some parts can be adjusted, but defective parts cannot be repaired. All automatic

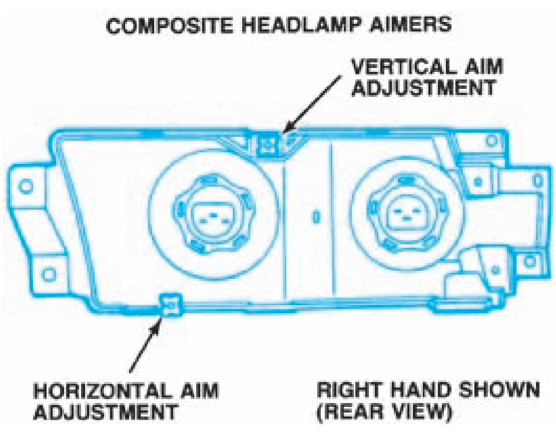

Figure 12-21. Composite headlamps also have vertical and horizontal adjustments. (GM Service and Parts Operations)

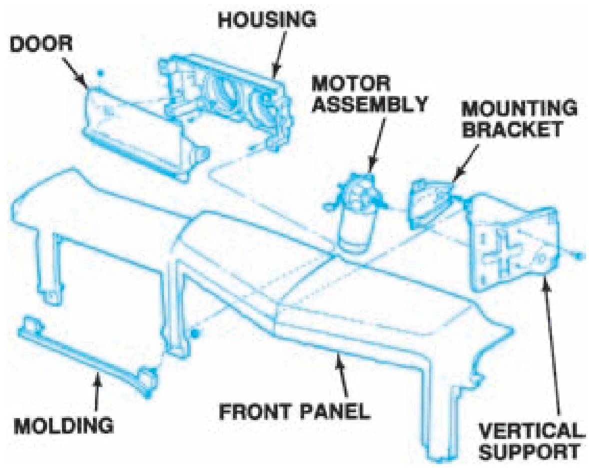

Figure 12-22. Headlamps can be concealed by a movable door. (DaimlerChrysler Corporation)

Figure 12-23. Headlamps can be concealed by moving them into and out of the car's bodywork.

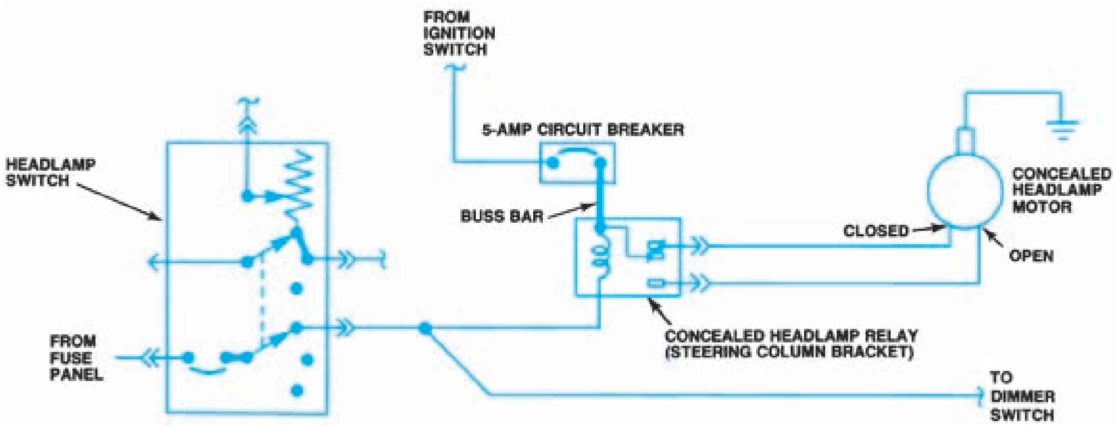

Figure 12-24. The main headlamp switch must operate the concealing mechanism. (DaimlerChrysler Corporation)

systems have manual switches to override the automatic functions.

On-Off Control

The photocell or ambient light sensor used in this system may be mounted on top of the instrument panel (Figure 12-25) facing upward so that it is exposed to natural outside light. In some older applications it may be mounted to the rearview mirror assembly facing outward for exposure to outside light. The photocell voltage is amplified and applied to a solid-state control module. Photocell voltage decreases as outside light decreases. Most photocells are adjustable for earlier or later turn-on. At a predetermined low light and voltage level, the module turns the headlamps on. The module often contains time-delay circuitry, so that:

- When the vehicle is momentarily in dark or light, such as when passing under a bridge or a streetlamp, the headlights do not flash on or off.
- When the automobile's ignition is turned off, the headlights remain on for a specified length of time and then are turned off.

Twilight Sentinel

GM luxury vehicles use a system called Twilight Sentinel. The twilight delay switch in the headlamp switch assembly is supplied a 5 volt reference from the instrument panel integration module (IPM) as shown in Figure 12-26. The

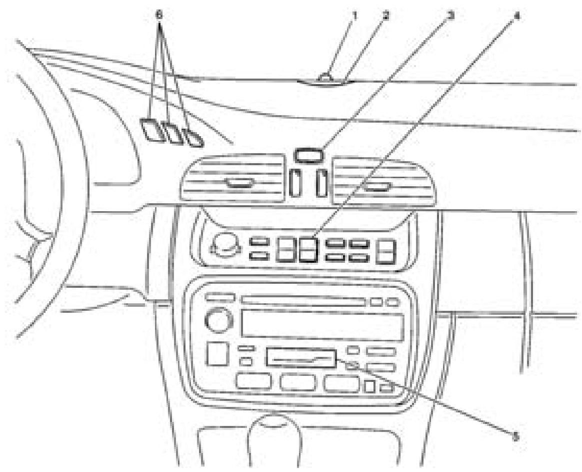

Figure 12-25. This photocell or ambient light sensor is mounted near the center of the dash panel and reacts to outside light to control the headlight on-off operation. The instrument panel integration module (IPM), which is the system amplifier is also shown. (GM Service and Parts Operations)

IPM also provides ground to the twilight delay switch. The switch is a potentiometer in which the resistance varies as the switch is moved. The IPM receives an input voltage proportional to the resistance of the potentiometer through the twilight delay signal circuit. The IPM sends a class 2 message to the dash integration module (DIM) indicating the on/off status and delay length for the twilight sentinel. With the twilight sentinel switch in any position other than OFF, the DIM will turn the headlamps on or off according to the daytime/nighttime status sent by the IPM. The DIM uses the twilight delay signal in order to keep the headlamps and park lamps on after the

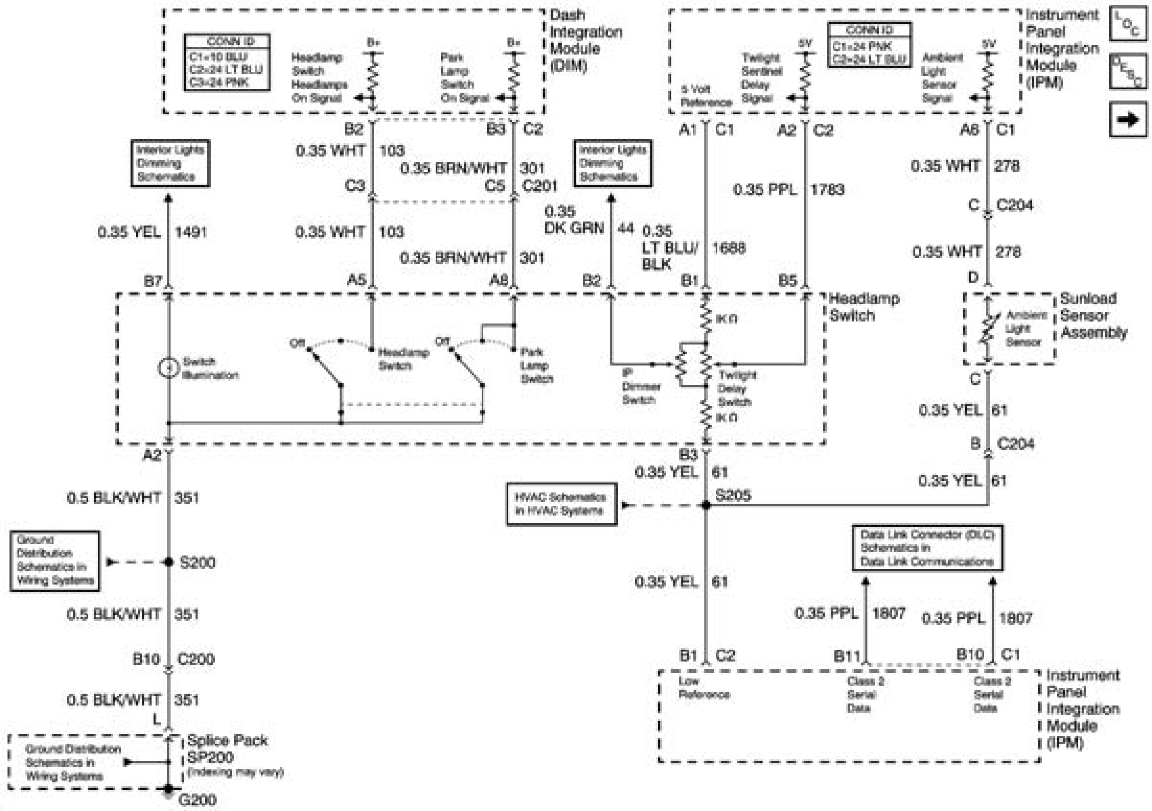

Figure 12-26. GM twilight sentinel.

ignition switch transitions from ON to OFF during nighttime conditions.

Daytime Running Lights

Daytime running lights (DRL) have been mandated for use in Canada and several other countries since 1990 and are included as standard equipment on General Motors vehicles since 1996 (Figure 12-27). The basic idea behind these lights is that dimly lit headlights during the day make the vehicle more visible to other drivers, especially when the sun is behind the vehicle during sunset or after dawn. Generally, when the ignition is on and it is not dusk or dark, the daytime running lights will be on. When it is dusk, the system operates like an automatic headlamp system.

The DRL systems use an ambient light sensor, a light-sensitive transistor that varies its voltage signal to the body control module (BCM) in response to changes to the outside (ambient) light level. When the BCM receives this signal it will either turn on the DRL or the headlight relay for auto headlamp operation. Any function or condition that turns on the headlights will cancel the daytime running lamps operation. The DRL are separate lamps independent of the headlamps. With the headlight switch in the OFF position, the DRL will either be turned on or off after an approximately 8-second delay, depending on whether daylight or low light conditions are sensed. The DRL 10-amp fuse in the engine wiring harness junction block supplies battery positive voltage to the DRL relay switch contacts. The ignition 10-amp fuse in the engine wiring harness junction block supplies ignition positive voltage to the DRL relay coil. When the BCM energizes the DRL relay in daylight conditions, the current flows to both DRL lamps and to ground. The DRL will operate when the ignition switch is in the RUN position, the gear selector is not in the PARK position, and the parking brake is released. When these conditions have been met and the ambient light sensor indicates daytime conditions, the DRL will illuminate.

Some systems channel the headlamp current through a resistor and reduce the current and power to the lights to reduce their daytime intensity. Others use pulse-width modulation (PWM) through a separate control module that modulates

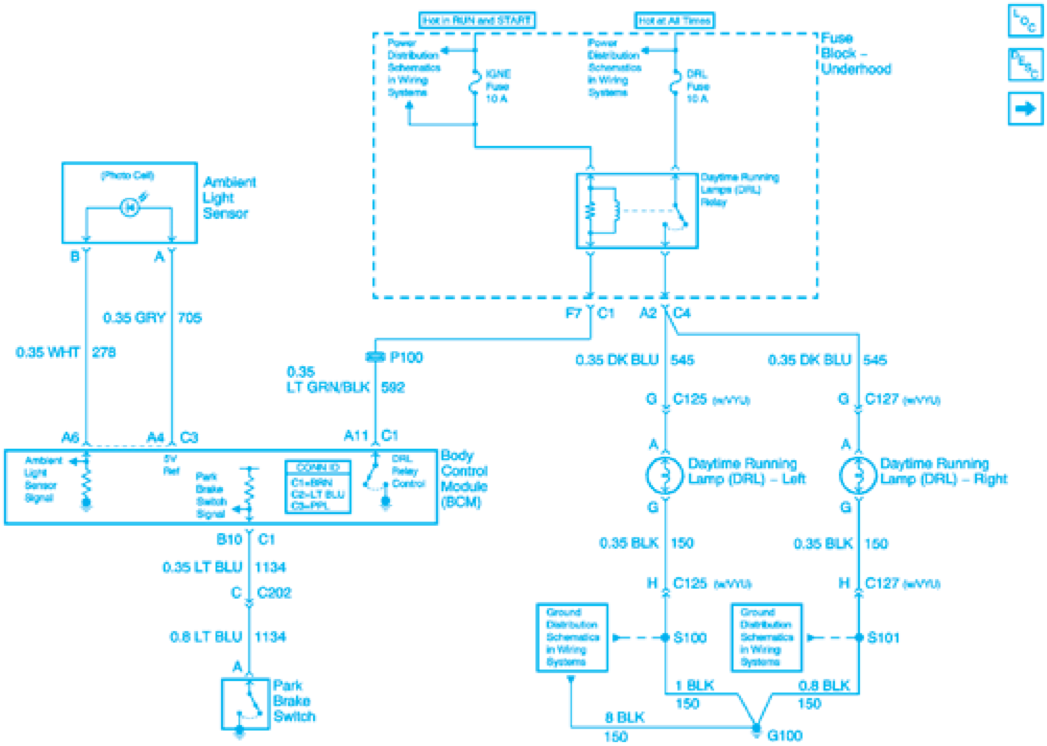

Figure 12-27. Daytime running lights. (GM Service and Parts Operations)

the voltage to the headlights and reduces the daytime intensity.

COMMON AUTOMOTIVE BULBS

Sealed-beam and composite headlamps are very specialized types of lamp bulbs. The other bulbs used in automotive lighting circuits are much smaller and less standardized. Each specific bulb has a unique trade number that is used consistently by all manufacturers.

Most small automotive bulbs are clear and are mounted behind colored lenses. Some applications, however, may call for a red (R) or an amber (NA) bulb.

Small automotive bulbs use either a brass or a glass wedge base. Bulbs with a brass base fit into a matching socket. The single or double contacts on the base of the bulb are the insulated contacts for the bulb's filaments. A matching contact in the socket supplies current to the bulb filament (Figure 12-28). A single-contact bulb contains one filament; a double-contact bulb has two filaments. The ground end of the bulb filament is connected directly to the base of the bulb, which is grounded through contact with the socket. In many cases, a separate ground wire leads from the socket to a ground connection. All double-contact bulbs are indexed so that they will fit into the socket in only one way. This is called an indexed base.

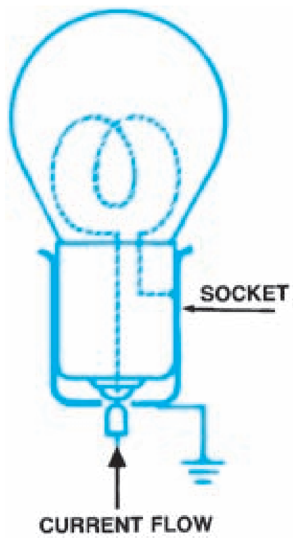

Figure 12-28. Automotive bulbs and sockets must be matched.

Figure 12-29. Wedge-base bulbs are increasingly used for interior lighting applications.

Historical Fact: Gas Lighting

Headlamps that burned acetylene gas were used on early cars, trucks, and motorcycles. The acetylene gas came from a prefilled pressurized container or from a "gas generator."

One type of acetylene gas generator used a drip method. A tank filled with water was mounted above another tank containing calcium carbide. A valve controlled the dripping of water onto the calcium carbide. When water was allowed to drip onto the calcium carbide, acetylene gas formed. The gas was routed through a small pipe to the headlamps. The headlamps were lit with a match or by an electric spark across a special lighting attachment.

Wedge-base bulbs generally have been used for instrument cluster and other interior lighting applications. The base and optical part of the bulb are a one-piece, formed-glass shell with four filament wires extending through the base and crimped around it to form the external contacts (Figure 12-29). The design locates the contacts accurately, permitting direct electrical contact with the socket, which contains shoulders to hold the bulb in place. The bulb is installed by pushing it straight into its socket, with no indexing required.

Wedge-base 2358 bulbs with a new socket design were introduced in 1987 as replacements for the brass-base 1157 and 2057 bulbs for exterior lighting applications. The wires of the low-profile plastic socket exit from the side instead of the rear (Figure 12-30). This reduces the possibility of wire damage and permits the socket to be used in more confined areas. Since the introduction of this base-socket design, a series of these bulbs has been made available in both clear and amber versions.

Figure 12-30. Wedge-base bulbs with plastic sockets are used for some external lighting applications. (DaimlerChrysler Corporation)

TAILLAMP, LICENSE PLATE LAMP, AND PARKING LAMP CIRCUITS

The taillamps, license plate lamps, and parking lamps illuminate the car for other drivers to see.

Circuit Diagram

These lamps usually share a single circuit because the laws of some states require that they be lit at the same time. Figure 12-31 shows a typical circuit diagram. Since the main headlamp switch controls the lamps, they can be lit whether the ignition switch is on or off.

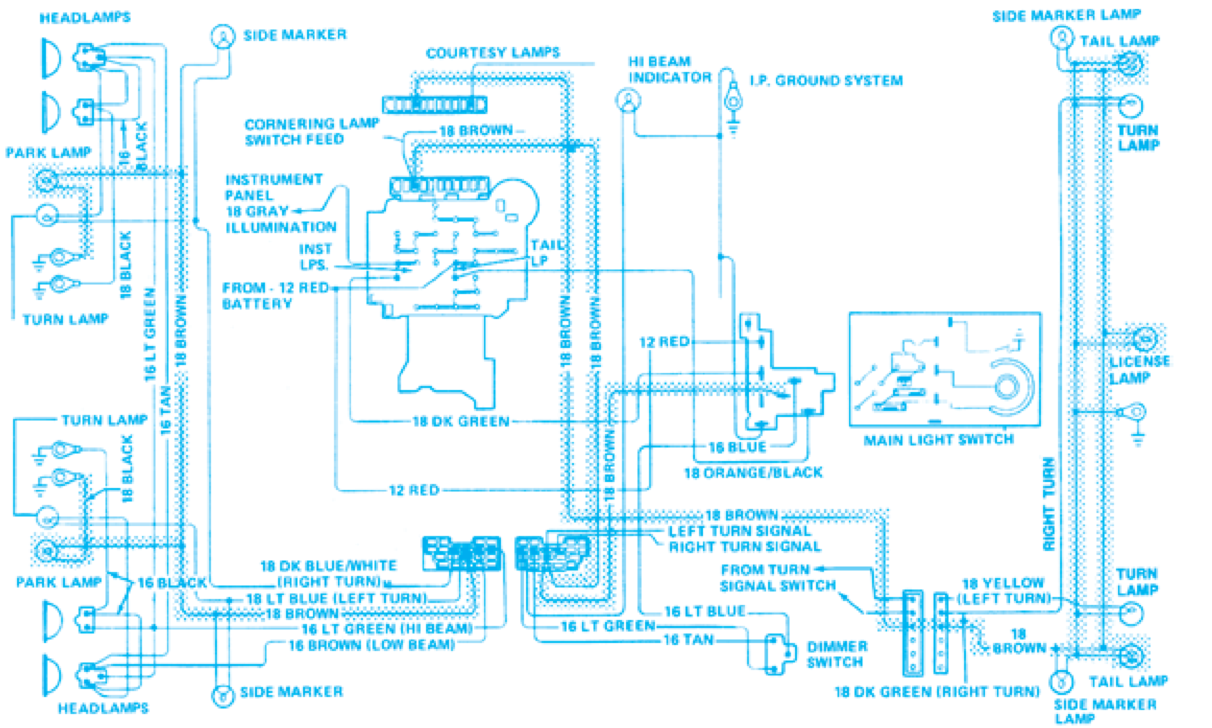

Figure 12-31. A taillamp, license plate lamp, and parking lamp circuit diagram. (GM Service and Parts Operations)

Switches and Fuses

These lamps are controlled by contacts within the main headlamp switch. They can be lit when the headlamps are off (Figure 12-32). A fuse (usually 20 amperes) protects the circuit.

Bulbs

The bulb designs most commonly used as taillamps and parking lamps are the G-6 single-contact bayonet and the S-8 double-contact bayonet. The tail and parking lamps may each be one filament of a double-filament bulb. License plate lamps are usually G-6 single-contact bayonet or T-3 1/4-wedge bulbs.

STOP LAMP AND TURN SIGNAL CIRCUITS

Stop lamps, also called brake lamps, are always red. Federal law requires a red center high-mounted stop lamp (CHMSL), on 1986 and later

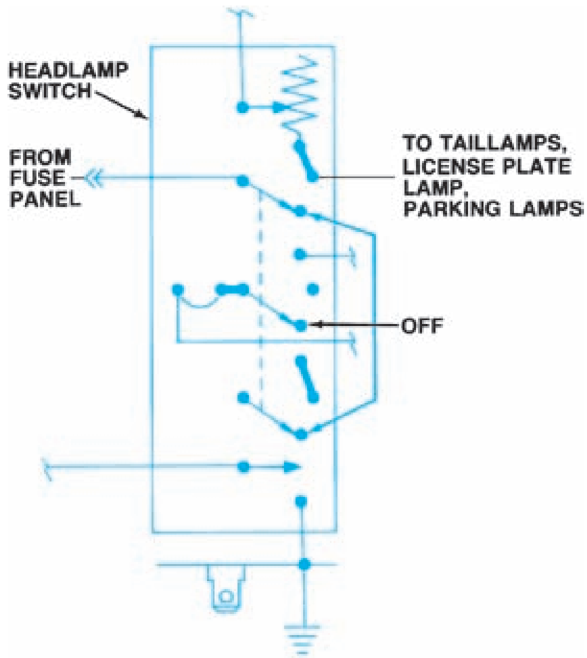

Figure 12-32. Contacts in the main headlamp switch provide current to the taillamps, license plate lamps, and parking lamps. (DaimlerChrysler Corporation)

models. Turn signals, or directionals, are either amber or white on the front of the car and either red or amber on the rear.

Circuit Diagram

A typical circuit diagram with stop and turn lamps as separate bulbs is shown in figure 12-38A. When the brakes are applied, the brake switch is closed and the stop lamps light. The brake switch receives current from the fuse panel and is not affected by the ignition switch.

When the turn signal switch is moved in either direction, the corresponding turn signal lamps receive current through the flasher unit. The flasher unit causes the current to start and stop very rapidly, as we will see later. The turn signal lamp flashes on and off with the interrupted current. The turn signal switch receives current through the ignition switch, so that the signals will light only if the ignition switch is on.

In many cars, the stop and turn signals are both provided by one filament, as shown in Figure 12-33B and Figure 12-34. When the turn signal switch is closed, the filament receives interrupted current through the flasher unit. When the brakes are applied, the filament receives a steady flow of current through the brake switch and special contacts in the turn signal switch. If both switches are closed at once, brake switch current is not allowed through the turn signal switch to the filament on the signaling side. The signaling filament receives interrupted current through the flasher unit, so it flashes on and off. The filament on the opposite side of the car receives a steady flow of current through the brake switch and the turn signal switch, so it is continuously lit. Figure 12-34 shows the integration of the single-filament CHMSL in a typical stop-and-turn signal circuit.

Switches, Fuses, and Flashers

Several units affect current flow through the stop lamp and turn signal circuits. The ignition switch is located between the battery and the turn signal switch (Figure 12-35), so the current cannot flow through the turn signal switch if the ignition switch is off. The ignition switch does not control the brake switch; it is connected directly to battery voltage through the fuse panel (Figure 12-35).

Before the mid-1960s, the brake switch was often located within the brake hydraulic system and operated by hydraulic pressure. Because of changes in braking system design, this type of switch is no longer commonly used. On late-model cars, the brake switch is usually mounted

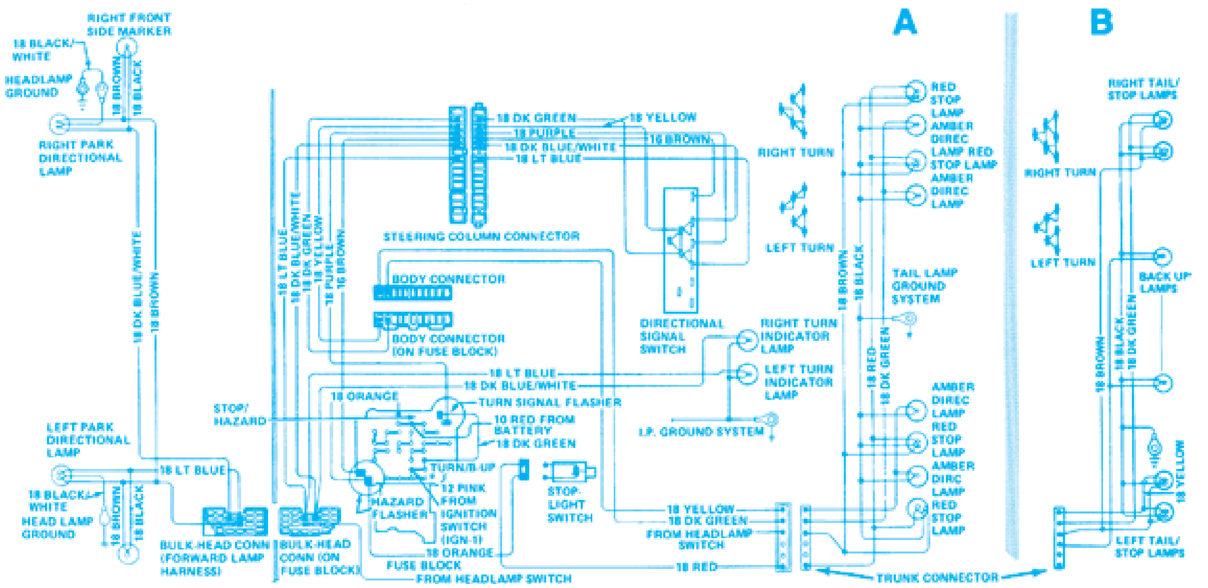

Figure 12-33. Stop lamp and turn signal circuits. The basic drawing (A) has separate bulbs for each function. The alternate view of the rear lamps (B) has single bulbs with double filaments. One filament of each bulb works for stop lamps and for turn signals. (GM Service and Parts Operations)

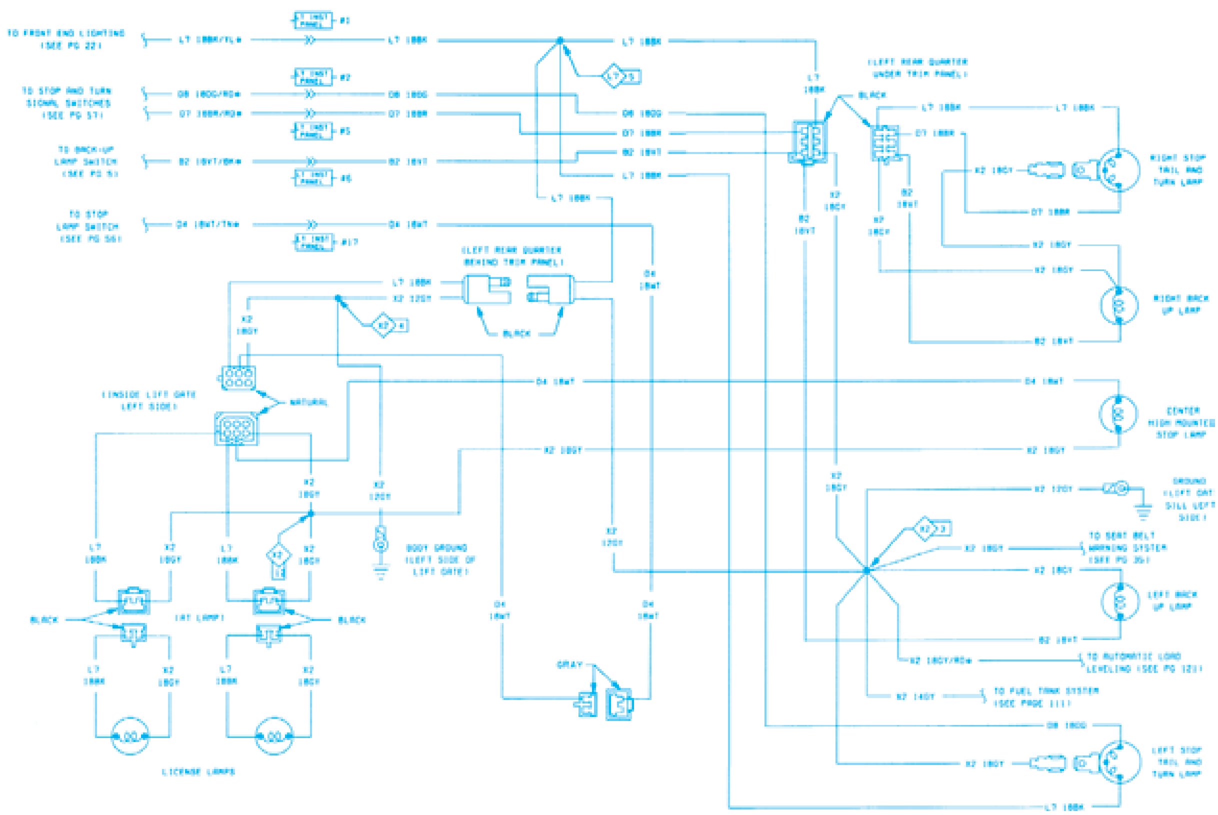

Figure 12-34. A typical rear lighting circuit diagram showing the inclusion of the center high-mounted stop lamp (CHMSL) mandated by law on 1986 and later models. (DaimlerChrysler Corporation)

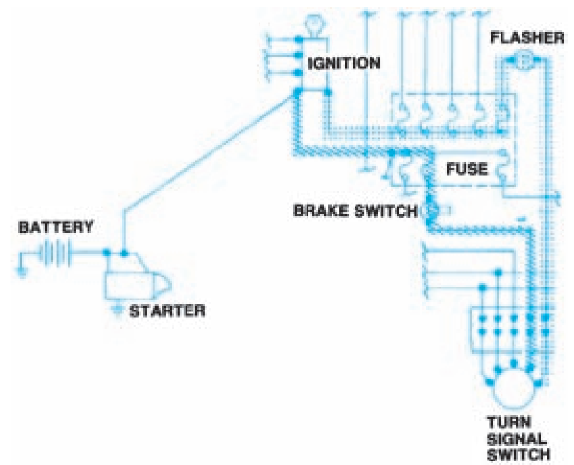

Figure 12-35. The ignition switch controls current to the turn signal switch, but does not affect current to the brake switch.

on the bracket that holds the brake pedal. When the pedal is pressed, the switch is closed.

The **turn signal switch** is mounted within the steering column and operated by a lever (Figure 12-36). Moving the lever up or down

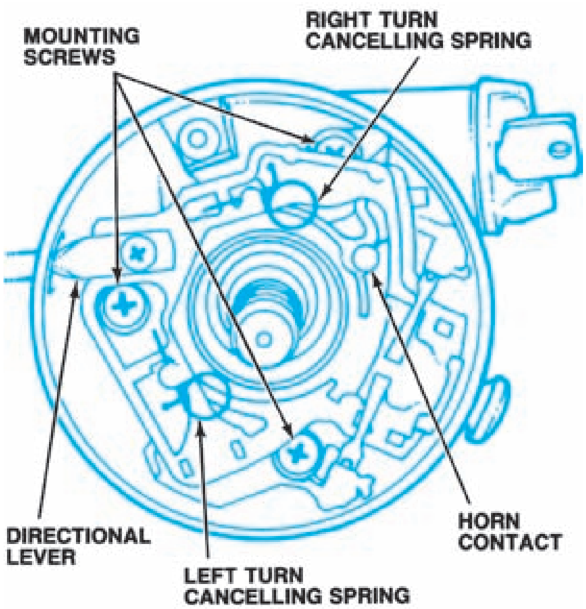

Figure 12-36. The turn signal switch includes various springs and cams to control the contact points.

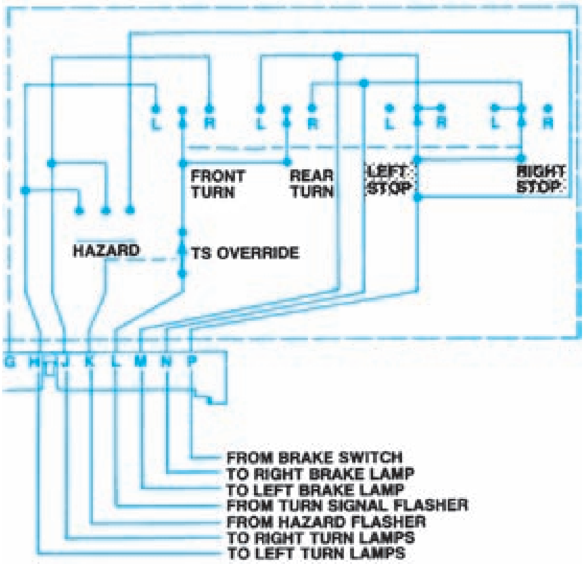

Figure 12-37. When the stop lamps and turn signals share a common filament, stop lamp current flows through the turn signal switch.

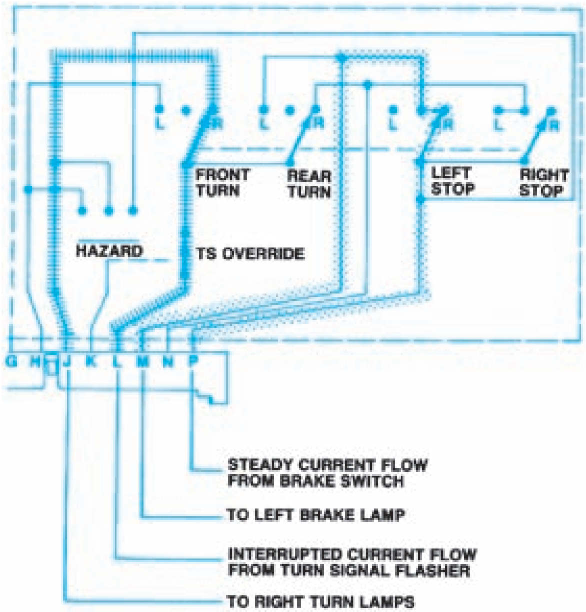

Figure 12-38. When a right turn is signaled, the turn signal switch contacts send flasher current to the right-hand filament and brake switch current to the left-hand filament.

closes contacts to supply current to the flasher unit and to the appropriate turn signal lamp. A turn signal switch includes cams and springs that cancel the signal after the turn has been completed. That is, as the steering wheel is turned in the signaled direction and then returns to its normal position, the cams and springs separate the turn signal switch contacts.

In systems using separate filaments for the stop and turn lamps, the brake and turn signal switches are not connected. If the car uses the same filament for both purposes, there must be a way for the turn signal switch to interrupt the brake switch current and allow only flasher unit current to the filament on the side being signaled. To do this, brake switch current is routed through contacts within the turn signal switch (Figure 12-37). By linking certain contacts, the bulbs can receive either brake switch current or flasher current, depending upon which direction is being signaled.

For example, Figure 12-38 shows current flow through the switch when the brake switch is closed and a right turn is signaled. Steady current through the brake switch is sent to the left brake lamp. Interrupted current from the turn signal is sent to the right turn lamps.

Flasher units supply a rapid on-off-on current to the turn signal lamps. To do this, they act very much like Type 1 self-setting circuit breakers. Current flows through a bimetallic arm (Figure 12-39), heating the arm until it bends and opens a set of

Figure 12-39. The internal components of a turn signal flasher.

contact points. When the current stops, the arm cools and the contact points close again. This cycle occurs rapidly so that the turn signal lamps flash on and off about once every second. Flasher units usually are installed in the wiring harness beneath the instrument panel or in the fuse panel.

Some manufacturers use two flashers, one for the turn signals and one for the hazard warning lamps. Other manufacturers use a single flasher that controls both the turn signals and the hazard warning lamps. This type of flasher is called a *combination flasher*.

Switch the Bulbs, Not the Switch

Have you ever been stumped by a turn signal problem where the lamps on one side flashed properly, but those on the other side lit and burned steadily without flashing? The flasher checks out okay, and the panel indicator lights but doesn't flash. Both bulbs, front and rear, light; power is getting to the sockets. Sounds like trouble with the switch? Maybe it is. However, before you tear into the steering column, try swapping the front and rear bulbs from one side to the other. Sometimes, a little corrosion on a socket and the resistance of an individual bulb can add up to cumulative resistance that unbalances the circuit and prevents flashing. Swapping the bulbs or cleaning the contacts can reduce the resistance to within limits, restore equilibrium, and get the system working correctly again.

The turn signal circuit must include one or more indicators to show the driver that the turn signals are operating. These indicators are small bulbs in the instrument panel that provide a parallel path to ground for some of the flasher unit current. Most systems have separate indicators for the right and left sides, although some cars use only one indicator bulb for both sides. On some models, additional indicators are mounted on the front fenders facing the driver. Two separate fuses, rated at about 20 amperes, usually protect the stop lamp and turn signal lamp circuits.

Bulbs

The bulb types traditionally used as stop or turn signal lamps are the S-8 single- and double-contact bayonet base, although the 2358 wedge-base bulbs are being used more frequently. The stop and turn filaments may be part of a double-filament bulb.

HAZARD WARNING LAMP (EMERGENCY FLASHER) CIRCUITS

All motor vehicles sold in the United States since 1967 have a **hazard warning lamp** circuit. It is designed to warn other drivers of possible danger in emergencies.

Circuit Diagram

The hazard warning lamp circuit uses the turn signal lamp circuitry, a special switch, and a heavy-duty flasher unit. The switch receives battery current through the fuse panel. When the switch is closed, all of the car's turn signal lamps receive current through the hazard flasher unit. An indicator bulb in the instrument panel provides a parallel path to ground for some of the flasher current.

Switches, Fuses, and Flashers

The hazard warning switch can be a separate unit or it can be part of the turn signal switch (Figure 12-40). In both cases, the switch contacts route battery current from the fuse panel through the hazard flasher unit to all of the turn signal lamps at once. In most systems, the hazard warning switch overrides the operation of the turn signal switch. A 15- to 20-ampere fuse protects the hazard warning circuit.

The hazard warning flasher looks like a turn signal flasher when assembled, but it is constructed differently and operates differently, in order to control the large amount of current required to flash all of the turn signal lamps at once.

The flasher consists of a stationary contact, a movable contact mounted on a bimetallic arm, and a high-resistance coil (Figure 12-41). The coil is connected in parallel with the contact points, which are normally open. When the hazard warning switch

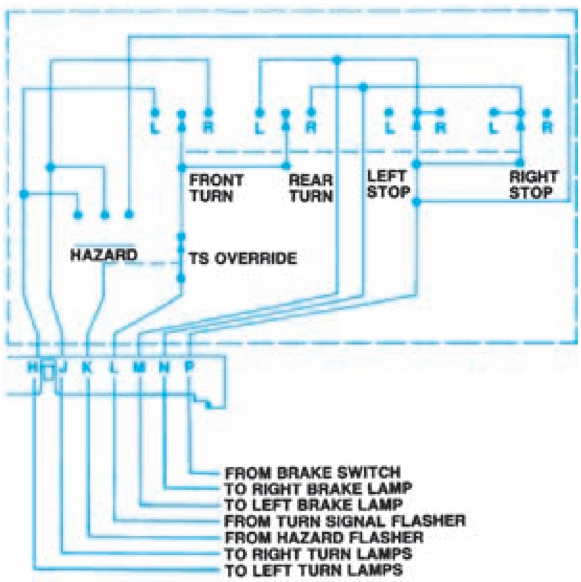

Figure 12-40. The hazard warning switch is often a part of the turn signal switch. (DaimlerChrysler Corporation)

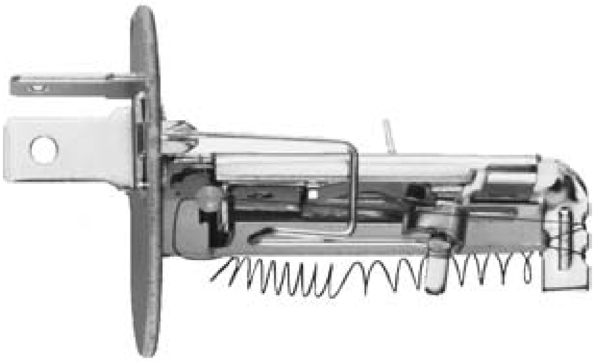

Figure 12-41. The hazard flasher is constructed to control a large amount of current.

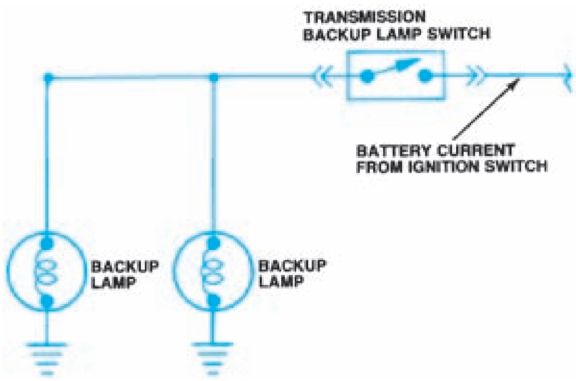

Figure 12-42. A typical backup lamp circuit. (DaimlerChrysler Corporation)

is closed and current flows to the flasher, the high resistance of the coil does not allow enough current to light the lamps. However, the coil heats up and causes the bimetallic strip to close the contacts. The contacts form a parallel circuit branch and conduct current to the lamps. Decreased current flow through the coil allows it to cool and the bimetallic strip opens the contacts again. This cycle repeats about 30 times per minute.

BACKUP LAMP CIRCUITS

The white **backup lamps** light when the car's transmission or transaxle is in reverse. The lamps have been used for decades, but have been required by law since 1971. Backup lamps and license plate lamps are the only white lamps allowed on the rear of a car.

Circuit Diagram

A typical backup lamp circuit diagram is shown in Figure 12-42. Figure 12-43 shows integration of the backup lamp with the stop, taillamp, and turn signals in a typical rear lighting diagram. When the transmission switch is closed, the backup lamps receive current through the ignition switch. The lamps will not light when the ignition switch is off.

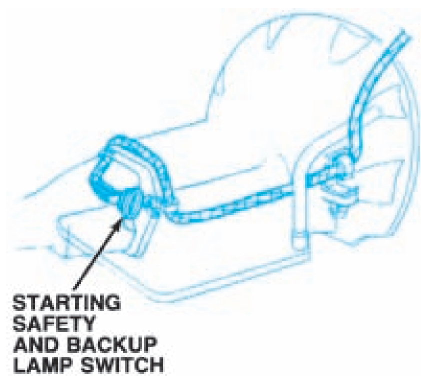

Figure 12-43. The backup lamp switch can be mounted on the transmission housing. (DaimlerChrysler Corporation)

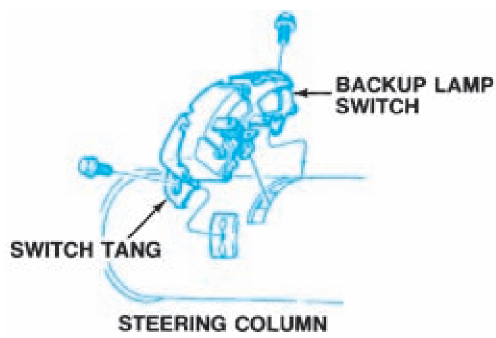

Figure 12-44. The backup lamp switch can be mounted near the gearshift lever. (GM Service and Parts Operations)

Switches and Fuses

The backup lamp switch generally is installed on the transmission or transaxle housing (Figure 12-43), but it may be mounted near the gear selector lever (Figure 12-42) on some vehicles. The backup switch may be combined with the neutral safety switch. A 15- to 20-ampere fuse, which often is shared with other circuits, protects the circuit.

Bulbs

The bulb designs most commonly used for backup lamps are S-8 single-contact bayonet and double-contact indexed.

SIDE MARKER AND CLEARANCE LAMP CIRCUITS

Side marker lamps are mounted on the right and left sides toward the front and rear of the vehicle to indicate its length. Side marker lamps are required on all cars built since 1969 and are found on many earlier models as well. Front side markers are amber; rear side markers are red. On some vehicles, the parking lamp or taillamp bulbs are used to provide the side marker function.

Clearance markers are required on some vehicles, according to their height and width. Clearance lamps, if used, are included in the side marker lamp circuitry. Clearance lamps face forward or rearward. Like side markers, front clearance lamps are amber; rear lamps are red.

Circuit Diagrams

Side marker lamps can be either grounded or insulated. Figures 12-45 shows a GM Cadillac Seville circuit with independently grounded side markers. Figure 12-46 shows a circuit that has the ground path for current through the turn signal bulb filaments. When the headlamp switch is off and the turn signal switch is on, both the turn signal and the side marker on the side being signaled will flash. When the headlamp switch is on, only enough current flows to light the side marker. The turn signal lamp does not light until the turn signal switch and flasher are closed; then the turn signal lamp will light. The side marker lamp will not light, because 12 volts are applied to each end of the filament. There is no voltage drop and no current flow. When the turn signal flasher opens, the turn signal lamp goes out.

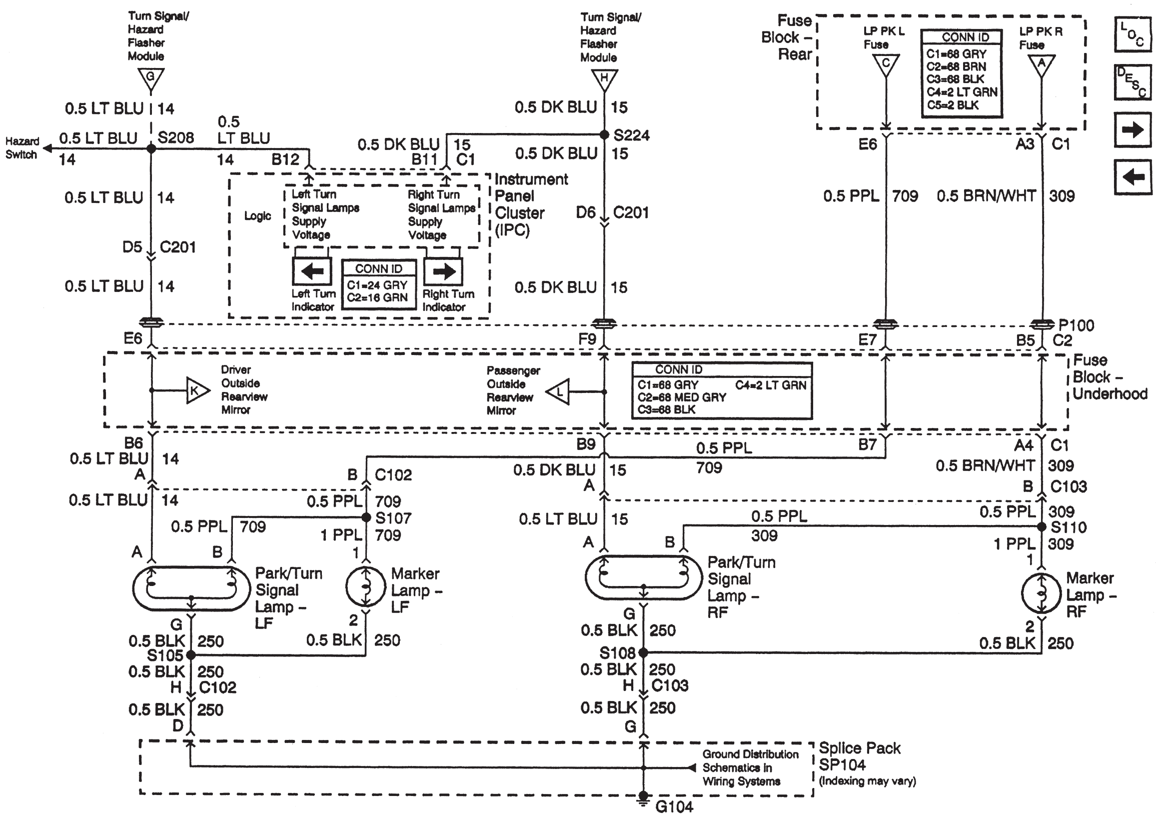

Figure 12-45. Side marker lamps can be independently grounded. (GM Service and Parts Operations)

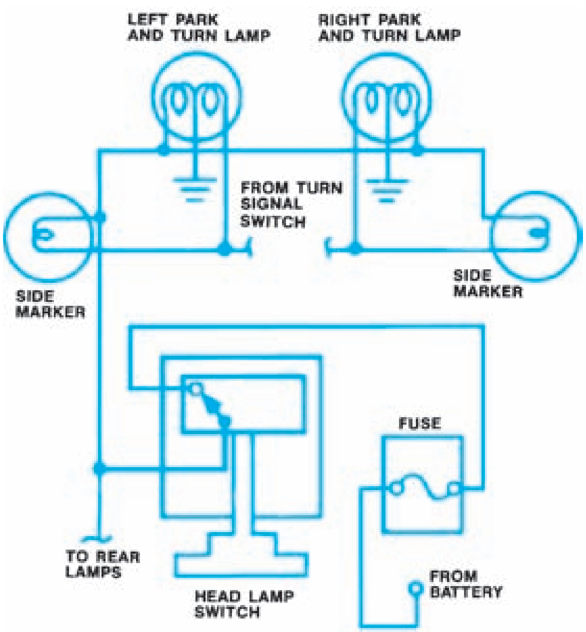

Figure 12-46. Side marker lamps can be grounded through the turn signal filaments.

Normal headlamp circuit current lights the side marker lamp. This sequence makes the two lamps flash alternately—one is lit while the other is not.

Switches and Fuses

Side marker lamps are controlled by contacts within the main headlamp switch. Their circuit is protected by a 20-ampere fuse, which usually is shared with other circuits.

Bulbs

The G-6 and S-8 single- and double-contact bayonet base bulbs commonly are used for side marker lamps.

■ Installing New Bulbs

If you replace a bulb in a parking light, turn signal, stop lamp, or taillamp, you may find that the bulb will not light unless you hold it against the socket. This may be due to weakened springs or flattened contacts. To solve the problem, apply a drop of solder to the contact points at the base of the bulb. Add more solder if necessary or file off the excess. The result will be a good solid connection. Also, for a weak spring, if the wires going to the socket are given slack, you may be able to gently stretch the spring.

INSTRUMENT PANEL AND INTERIOR LAMP CIRCUITS

Instrument Panel

The lamps within the instrument panel can be divided into three categories: indicator lamps, warning lamps, and illumination lamps. We have seen that some circuits, such as high-beam headlamps and turn signal lamps, include an indicator mounted on the instrument panel. Warning lamps, which alert the driver to vehicle operating conditions, are discussed in Chapter 13. Lamps that simply illuminate the instrument panel are explained in the following section.

Circuit Diagram

All late-model automobiles use a printed circuit behind the instrument panel to simplify connections and conserve space. The connections can also be made with conventional wiring (Figure 12-47).

Switches and Rheostats

The rheostat may be a separate unit in the panel lamp circuit. Current to the panel lamps is controlled by contacts within the main headlamp switch (Figure 12-48). The instrument panel lamps receive current when the parking and taillamps are lit and when the headlamps are lit.

Rheostats and **potentiometers** are variable resistors that allow the driver to control the brightness of the panel lamps. The rheostat or the potentiometer for the panel lamps can be a separate unit (Figure 12-46) or it can be a part of the main headlamp switch.

Bulbs

The T-3 1/4 bulb with a wedge or miniature bayonet base is a design commonly used in instrument panel illumination.

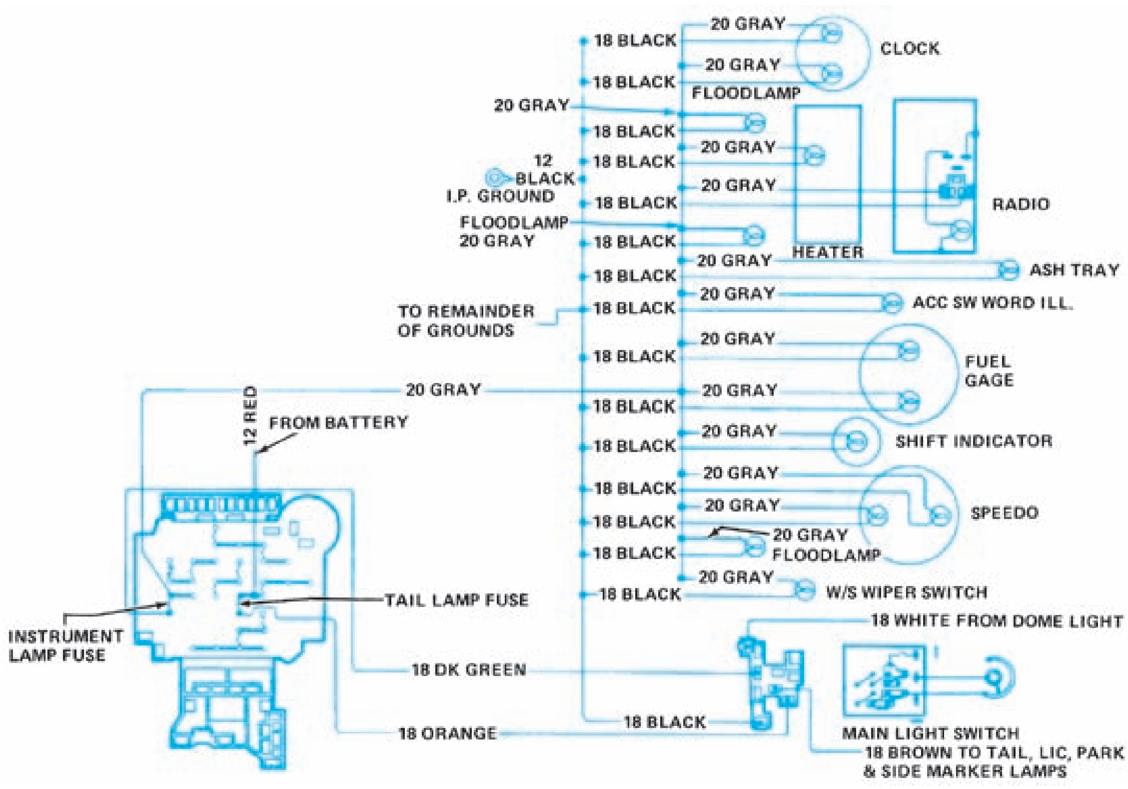

Figure 12-47. Multistrand wiring can be used behind the instrument panel. (GM Service and Parts Operations)

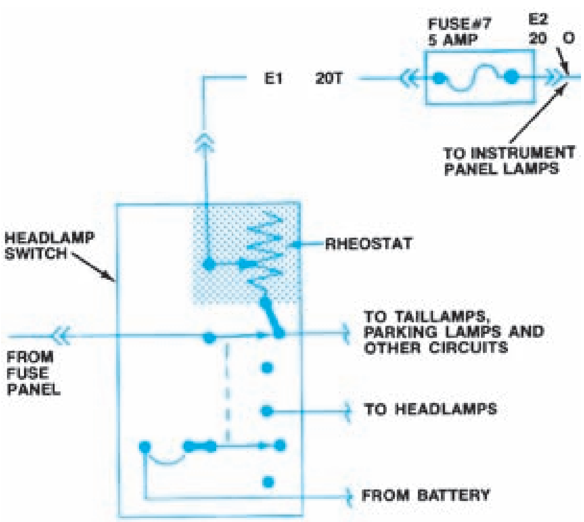

Figure 12-48. The panel lamps receive current through the main headlamp switch, which may also contain a rheostat to control the current. (DaimlerChrysler Corporation)

Interior Lamps

Interior (courtesy) lamps light the interior of the car for the convenience of the driver and passengers.

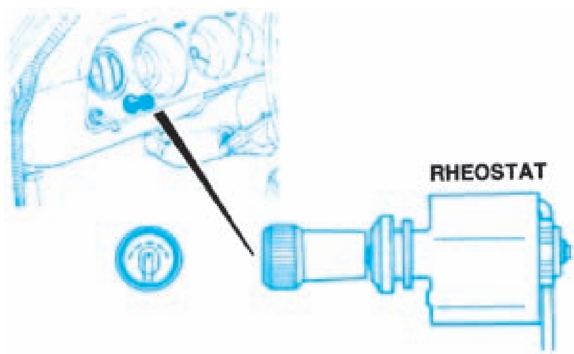

Figure 12-49. The rheostat may be a separate unit in the panel lamp circuit. (DaimlerChrysler Corporation)

Circuit diagram

Interior lamps receive current from the battery through the fuse panel. Switches at the doors control this current and light the lamps when one of the doors is opened. Many manufacturers install the bulbs between the power source and the grounded switch (Figure 12-50). Others, including Ford and Chrysler, install the switches between the power source and the grounded bulb (Figure 12-51).

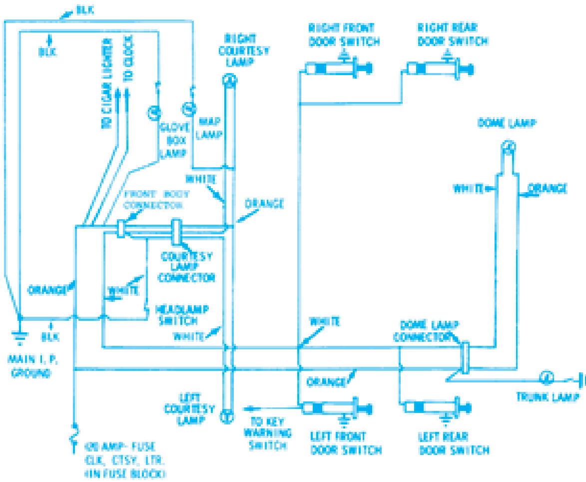

Figure 12-50. The interior (courtesy) lamp circuit may have insulated bulbs and grounded switches. (GM Service and Parts Operations)

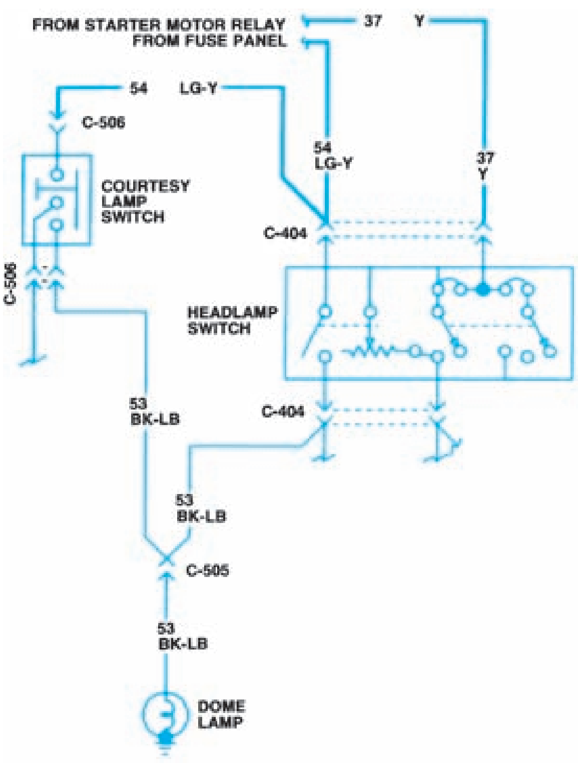

Figure 12-51. The interior lamps may be grounded and also have insulated switches.

Courtesy lamp circuits also may contain lamps to illuminate the glove box, trunk, and engine compartment. Additional switches that react to glove box door, trunk lid, or hood opening control current through these bulbs.

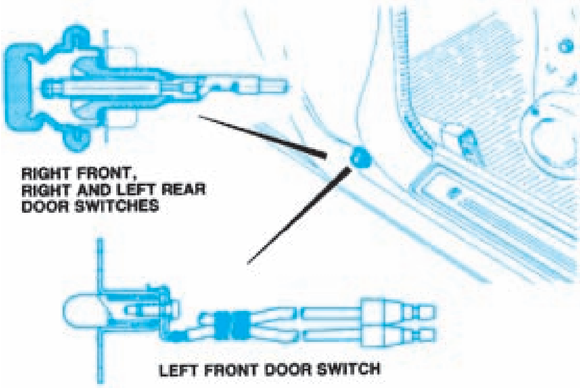

Figure 12-52. Interior lamps are controlled by switches at the door jambs. (DaimlerChrysler Corporation)

Switches

The switches used in courtesy lamp circuits are push-pull types (Figure 12-52). Spring tension closes the contacts when a door is opened. When a door is closed, it pushes the contacts apart to stop current flow. When any one switch is closed, the circuit is complete and all lamps are lit.

Accessory Lighting

Every car manufacturer offers unique accessory lighting circuits. These range from hand-controlled spotlights to driving and fog lamps. Each additional accessory circuit requires more bulbs, more wiring, and possibly an additional switch.

For example, cornering lamps can be mounted on the front sides of the car to provide more light in the direction of a turn. When the turn signal switch is operated while the headlamps are on, special contacts in the turn signal switch conduct a steady flow of current to the cornering lamp on the side being signaled.

One or more of the interior lamps may have a manually controlled switch to complete the circuit, (Figure 12-53). This switch allows the driver or passengers to light the bulb even when all the doors are closed.

Bulbs

The S-8 bulbs are used for trunk and engine compartment lamps, with T-3 1/4 wedge and T-3 3/4 double-end-cap bulbs used as courtesy lamps.

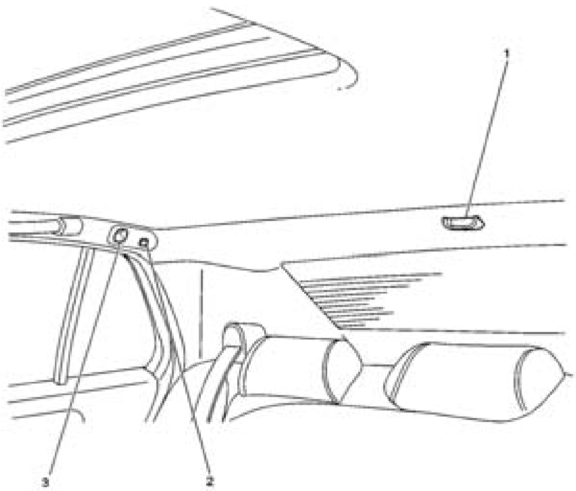

Figure 12-53. Interior lamps often have a manual switch to override the automatic operation. (GM Service and Parts Operations)

SUMMARY

Headlamp circuits must provide low- and high-beam lights for driving, and a high-beam indicator lamp for driver use. Two or four lamps may be used. Most often, the lamps are grounded, but some circuits have insulated lamps and grounded switches. The main headlamp switch also controls other lamp circuits. The main switch sometimes controls high-low beam switching, but a separate dimmer switch usually controls this. A circuit breaker protects the headlamp circuit.

Conventional sealed-beam headlamps use a tungsten filament; halogen sealed-beam lamps pass current through a pressure-filled halogen capsule. Halogen headlamps provide a brighter light with less current. Sealed-beam headlamps have either a high-beam filament (Type 1) or both a high- and low-beam filament (Type 2). Headlamps are always connected with multiple-plug connectors.

Changes in federal lighting standards have permitted sealed-beam headlamps made of plastic instead of glass. Plastic headlamps weigh considerably less and are more damage-resistant than glass. The changes also have resulted in the use of a composite headlamp in place of sealed-beams. The composite headlamp consists of a polycarbonate lens housing and a replaceable halogen bulb that contains a dual filament. Since the lens housing is not replaced, it has been integrated into vehicle styling.

Headlights are mounted so that their aim can be adjusted vertically and horizontally. Some cars have concealed headlamps with doors or mountings that are operated by vacuum or by electric motors. The main headlamp switch controls these mechanisms, and there also is a manual control provided to open and close the mechanisms if necessary.

Photocells and solid-state modules are used to control headlamp on-off switching, beam switching operation, and daytime running lights (DRL) on many late-model vehicles. Bulbs used in other lighting circuits are smaller than sealed-beam units and must be installed in matching sockets. These other lighting circuits include the following:

- Taillamp, license plate lamp, and parking lamp circuits
- Stop lamp and turn signal circuits
- Hazard warning (emergency flasher) circuit
- Backup lamp circuit
- Side marker and clearance lamp circuit
- Instrument panel and interior lamp circuits

Review Questions

Choose the single most correct answer.

1. Which of the following is true concerning headlamp circuits?
   a. The circuits can have totally insulated bulbs and grounded switches.
   b. The lamp filaments are connected in series.
   c. All circuits use lamps that contain both a high beam and a low beam.
   d. The headlamps receive power through the ignition switch.
2. Because headlamps are an important safety feature, they are protected by:
   a. Heavy fuses
   b. Fusible links
   c. Type-I circuit breakers
   d. Type-II circuit breakers
3. All high beams are spread:
   a. Symmetrically
   b. Asymmetrically
   c. Either A or B
   d. Neither A nor B
4. All types of headlamps have _____ that are used when adjusting the beam.
   a. Connecting prongs
   b. Aiming pads
   c. Filaments
   d. Reflectors
5. Concealed headlamps can be operated by all of the following methods, *except*:
   a. Electric motor
   b. Vacuum actuator
   c. Manually
   d. Accessory belt
6. Which of the following is not true of automatic headlamp systems?
   a. Can turn headlamps on or off
   b. Can control high- and low-beam switching
   c. Are easily repaired when defective
   d. Can be adjusted to fit various conditions
7. On small automobile bulbs that have only one contact, the contact is:
   a. Insulated
   b. Indexed
   c. Grounded
   d. Festooned
8. Double-contact bulbs that are designed to fit into the socket only one way are called:
   a. Miniature bayonet base
   b. Single-contact bayonet
   c. Double-contact indexed
   d. Double-contact bayonet
9. The taillamps, license plate lamps, and parking lamps are generally protected by:
   a. A Type-I circuit breaker
   b. A Type-II circuit breaker
   c. A 20-amp fuse
   d. Three fusible links
10. Turn signal flasher units supply a rapid on-off-on current flow to the turn signal lamps by acting very much like:
    a. Circuit breakers
    b. Fuses
    c. Zener diodes
    d. Transistorized regulators
11. Which of the following is *not* part of the hazard warning lamp circuit?
    a. Turn signal lamps
    b. Brake lamps
    c. Flasher unit
    d. Instrument panel
12. The only white lamps allowed on the rear of a car are:
    a. Backup lamps and turn signal lamps
    b. Backup lamps and license plate lamps
    c. License plate lamps and turn signal lamps
    d. Turn signal lamps and backup lamps
13. Brightness of the instrument panel lamps is *not* controlled by:
    a. Diodes
    b. Rheostats
    c. Potentiometers
    d. Variable resistors
14. The switches used in courtesy lamp circuits are:
    a. Compound switches
    b. Push-pull switches
    c. Three-way switches
    d. Rheostats

15. Which of the following is *not* true of composite headlamps?
    a. Use replaceable bulbs
    b. Are part of the car's styling
    c. Have a polycarbonate lens
    d. May be red or amber

16. Halogen sealed-beam lamps:
    a. Are not as damage-resistant as glass
    b. Produce 30 percent less light
    c. May be made of plastic
    d. Have been used since the 1940s