A/C System Controls

Temperature Control

The heating, ventilation and air-conditioning system depends on the engine as a source of heat and energy to drive the system that removes the heat. The combustion process supplies the heat needed to warm the vehicle interior. The engine's output powers the A/C compressor to cool the vehicle interior.

At normal operating temperatures, the engine coolant is about 220° F (105° C) due to the cooling system pressure cap, thermostat and the engine cooling fan. When the system is ON, the A/C evaporator operates at a constant temperature of 32° F (0° C) based on the characteristics of the refrigerant. Beyond this, there are driver controls to regulate the amount of heat added to or from the interior in order to achieve a comfortable interior temperature.

Temperature Control System

Main controls in system.

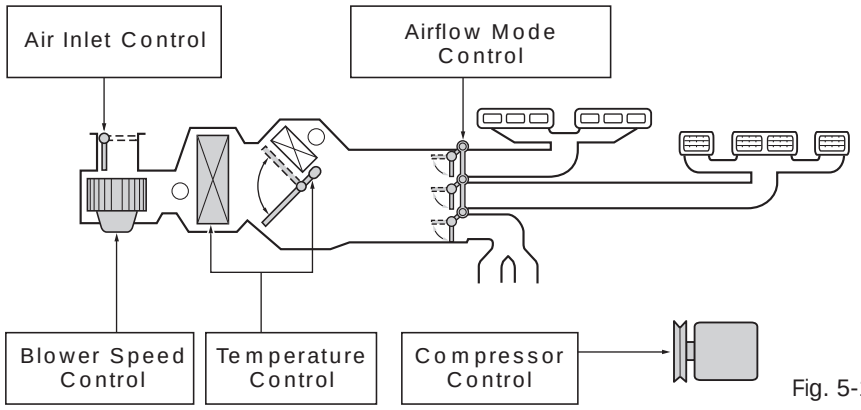


Fig. 5-1
752f501

Heater Control Valve

In simple systems, the heater control valve may be the only adjustable temperature control. It controls the flow of hot coolant through the heater core (heat exchanger) to increase the air temperature going to the interior.

Function of Heater Control Valve

- *Allows hot coolant into heater core.*
- *Normally only closed at maximum cold setting.*

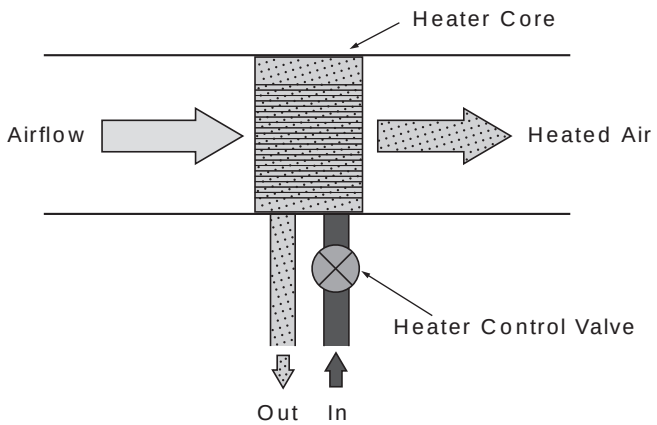


Fig. 5-2
752f502

A cable-operated lever on the heater control valve controls the flow of hot coolant through the heater core. On current Toyota vehicles, the valve is completely closed when the system requires maximum cool air. At all other times, the heater valve is fully open. Only some Toyota models use a heater control valve. Heat to the interior is controlled by controlling air flow.

Cable-Operated Heater Control Valve

- *Operated by temperature control knob or lever.*
- *Cable adjustment is important.*

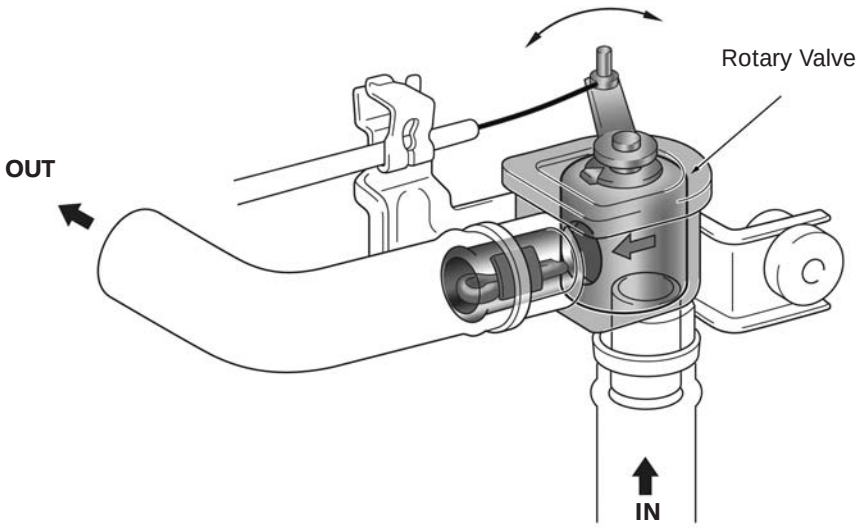


Fig. 5-3
752f50

The heater control valve controls the flow of hot coolant into the heater core and opens in steps when the set temperature knob or slider moves from the MAX COLD setting to a warmer setting. A misadjusted heater control valve can result in reduced heating if it doesn't open fully or will cool poorly if it's not fully closed.

Heater control valves respond slowly to changes due to the thermal inertia of liquids, that is, the resistance of the coolant in the heater core to temperature changes. The Heater control valve is usually open during A/C operation except at coldest temperature settings (67° F or below).

Air Mix Temperature Control

Air is more responsive to temperature changes than a liquid. To take advantage of this, some current air-distribution systems continuously circulate hot coolant through the heater core. In this type of system, when heat is needed, a controlled amount of air is allowed to pass through the heater core. The heated air mixes with unheated air that bypasses the heater core to achieve a comfortable mix. Since air has much less thermal inertia than liquid, this system provides a very responsive, yet stable adjustment of the air temperature.

Air Mix Temperature Control

Damper is moved by cable or electric servo-motor.

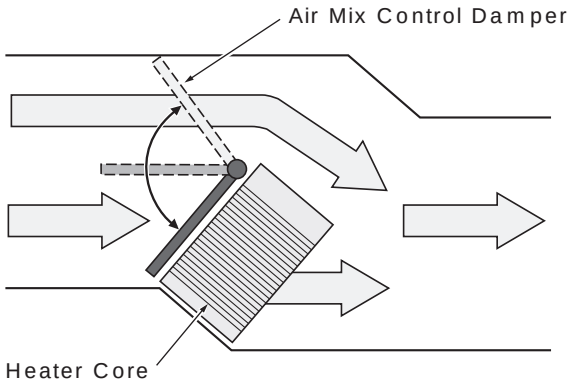


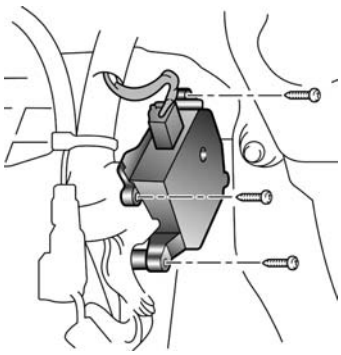
Fig. 5-4
752f504

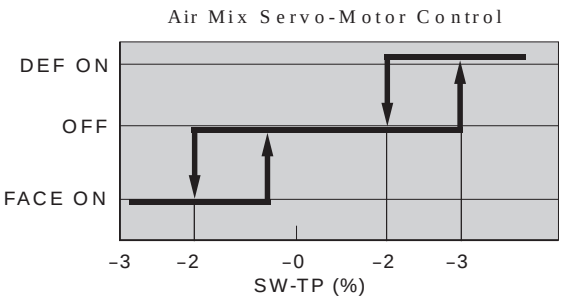
A movable door or damper called the **blend door** inside the blower housing controls the air through and around the heater core and/or A/C evaporator. The amount of air mix is controlled by either a cable or a variable vacuum signal from a control panel.

Toyota vehicles use an electric motor to control the blend door. The **air mix servo-motor** thus regulates the temperature depending on a variable signal from an electric control (variable resistor) or by a signal generated by another device. Additional information on servo-motors is in Section 6.

Air Mix Servo-Motor

- *Moves air mix damper or blend door.*
- *Also used for air inlet damper.*





SW: Target Damper Opening Angle
TP: Actual Damper Opening

Fig. 5-5
752f505

The servo-motor may have an integral (built-in) variable resistor that provides a signal to confirm the current position of the blend door. Later, we will discuss why this function is important in automatic A/C systems.

Air mix temperature control systems still use a heater control valve, but it is usually open under all conditions except maximum cooling. In other words, the heater is at maximum hot unless the temperature control is set to the coldest range.

Blend Door

- *Shown in heat position.*
- *Dotted line is cool position.*
- *Can be in between or blended.*

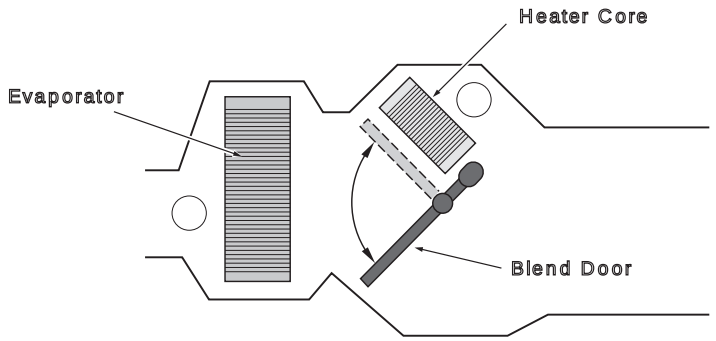


Fig. 5-6
752f506

Blower Speed Control

The fan that circulates interior air is controlled by the driver to regulate temperature and airflow. Fan speed is usually variable in steps by controlling the source voltage to the fan motor through a series resistor.

Note: When several resistors are connected in series, each resistor will drop some portion of the total source voltage, and the total of all voltage drops equals the source voltage.

Terminal 1 of the blower motor is supplied source voltage by the heater relay whenever the blower switch is ON, but the motor connection to ground passes through a string of resistors (typically three) called a series resistor. The multiple position fan switch provides a connection to ground from the various points in the series portion of the circuit. Increasing resistance in the ground leg of the circuit limits current flow to reduce fan speed while less resistance raises fan speed.

At low fan speeds, the blower switch does not provide a ground path. All of the series resistors are used to reduce the source voltage to the motor. At the HI speed position, the blower switch bypasses all of the resistors to provide full source voltage to the motor.

Some vehicles have push buttons for fan speed selection instead of a conventional rotary switch. The large size of a rotary switch means it can handle the relatively high current of the blower fan circuit directly. With smaller push buttons, a relay isolates the switches from the high current fan circuit.

Blower Fan Speed Circuit

- *Blower resistor controls fan speed.*
- *Blower motor current controlled by fan switches, blower control relay and resistor.*

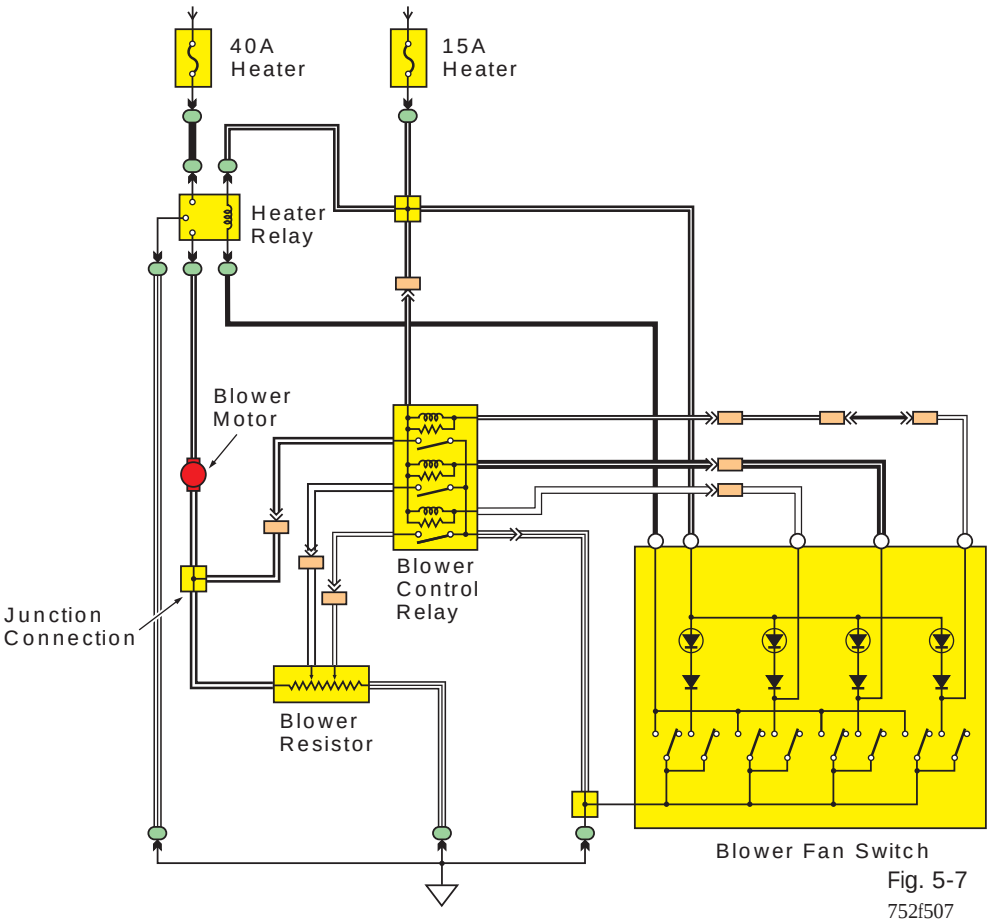


Fig. 5-7
752f507

Typically, three or four speeds are available for blower fan operation (depending on the number of elements in the series resistor). A specific blower speed is provided for each switch position while the highest speed bypasses the resistor.

Some late model vehicles use a large-diameter, small-width blower fan and a compact, brushless blower motor. A built-in solid state control circuit controls the blower motor speeds.

Old vs. New Style Blower Motors

New type is brushless with no blower resistor.

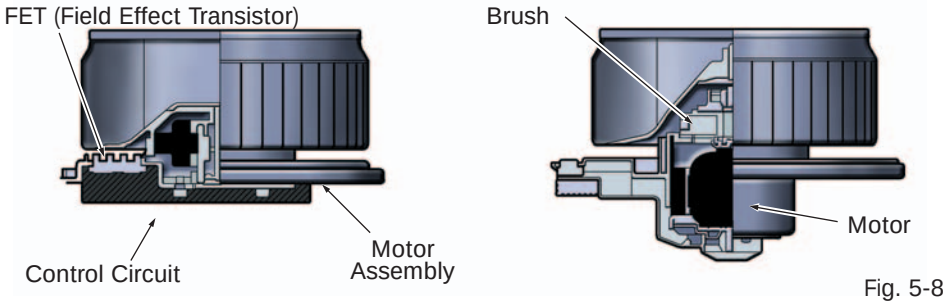


Fig. 5-8
752f508

Air Filters

Many vehicles have a **clean air filter** located after the air inlet control to deodorize and remove dust from the outside air. This filter must be changed at specified intervals according to operating conditions.

Clean Air Filter

- *Behind glove box.*
- *Replacement interval in* Vehicle Owner's Manual.

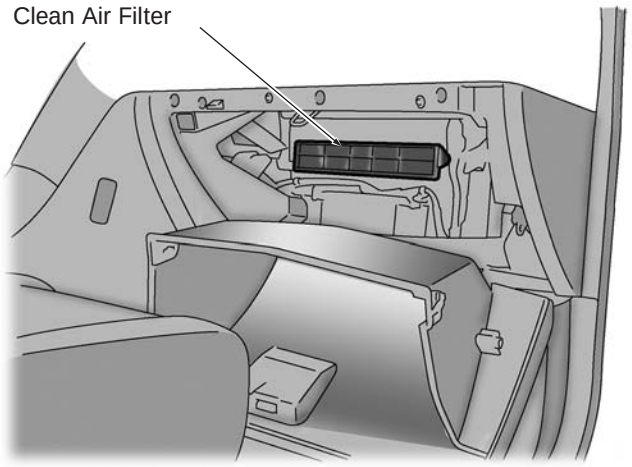


Fig. 5-9
752f509

A Plasmacluster™ generator provides an additional method of filtering the air. The unit takes water and oxygen molecules from the air and produces positive and negative ions which circulate and help reduce airborne germs.

The generator is installed in the air distribution system. It is controlled by the A/C ECU and operates in conjunction with the blower motor.

Caution: This device uses high voltage which may be hazardous when servicing the system.

Plasmacluster™ Generator

- *Produces positive and negative ions*
- *Reduces airborne germs*

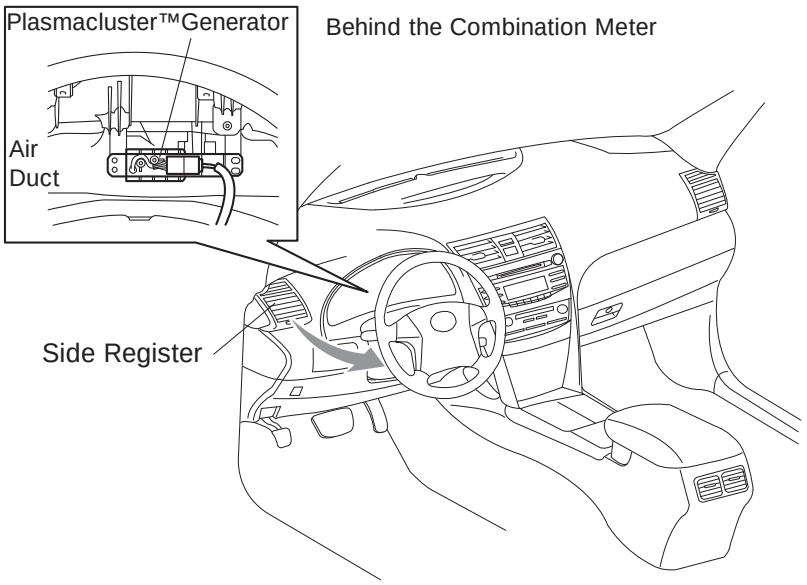


Fig. 5-10
752f510

Air Distribution Control

Manual A/C systems use servo-motors or cables to control the air distribution and air flow. Many Toyota models have push-button, air distribution selector switches. When pressed, the various switches send signals to an amplifier (ECU) that controls the movement of the damper doors with a servo-motor. Some Toyota vehicles may have touch-sensitive air distribution controls on a screen display.

A/C Control Panel

Shown with all segments illuminated.

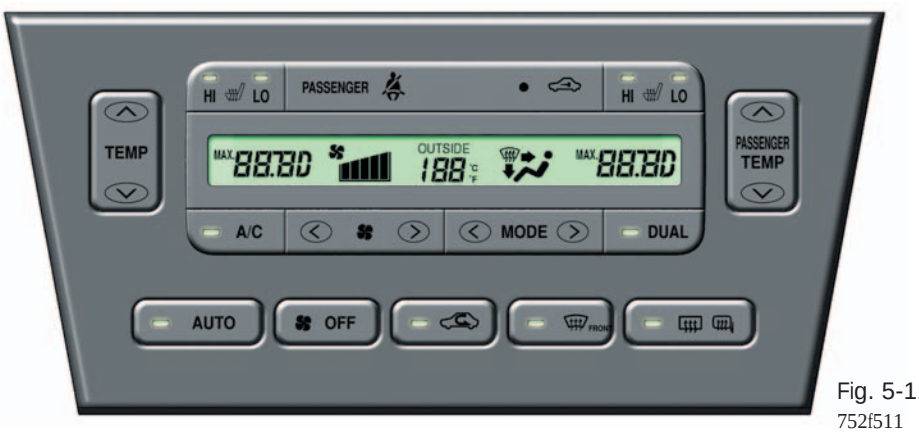


Fig. 5-11
752f511

The air distribution system delivers air from the HVAC system to the various parts of the interior. Fresh air first enters the vehicle at an air inlet, usually at the base of the front windshield.

Control of Air Distribution Schematic

Blend or mix doors controlled by servo-motors.

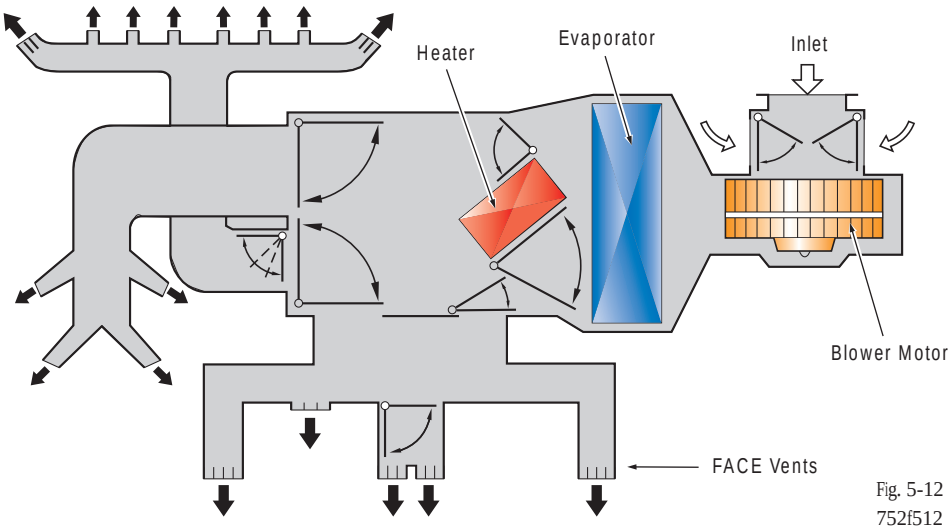


Fig. 5-12
752f512

Air Inlet Control

The air inlet control is a damper that is driver-controlled to allow fresh air to enter (open) or to recirculate air in the interior (closed). The driver has a choice of air inlet modes: **FRESH** or **RECIRC** (recirculated air). One or two dampers positioned before the blower motor controls this mode.

FRESH The fresh air intake mode allows maximum airflow through the vents since the blower fan is assisted by vehicle speed. This mode is useful for defogging windows in cold weather when outside humidity is lower than that produced by vehicle occupants.

RECIRC This mode allows the blower motor fan to recirculate the air from inside the vehicle and provides maximum A/C performance since the air is already "conditioned" (low temperature and humidity). This mode also prevents foul outside odors from entering the vehicle. However, total airflow is limited because the body air inlets are closed.

Newer vehicles may provide a blend of both modes for greater comfort and windshield defrosting under most conditions. These vehicles may typically switch to full recirculation when the system is set to the lowest temperature (**MAX COOL**).

At higher road speeds, airflow through the air inlet increases due to aerodynamic forces. At lower vehicle speeds, the blower fan assists normal airflow. From the blower fan, air passes through the evaporator, then through or around the heater core before going to the **plenum**, the central chamber inside the blower housing, then to the various ducts and air outlets.

Air Distribution Control and Air Outlet Mode Chart

Note: Amount of airflow from outlets in various modes shown in chart below and in Vehicle Repair Manual.

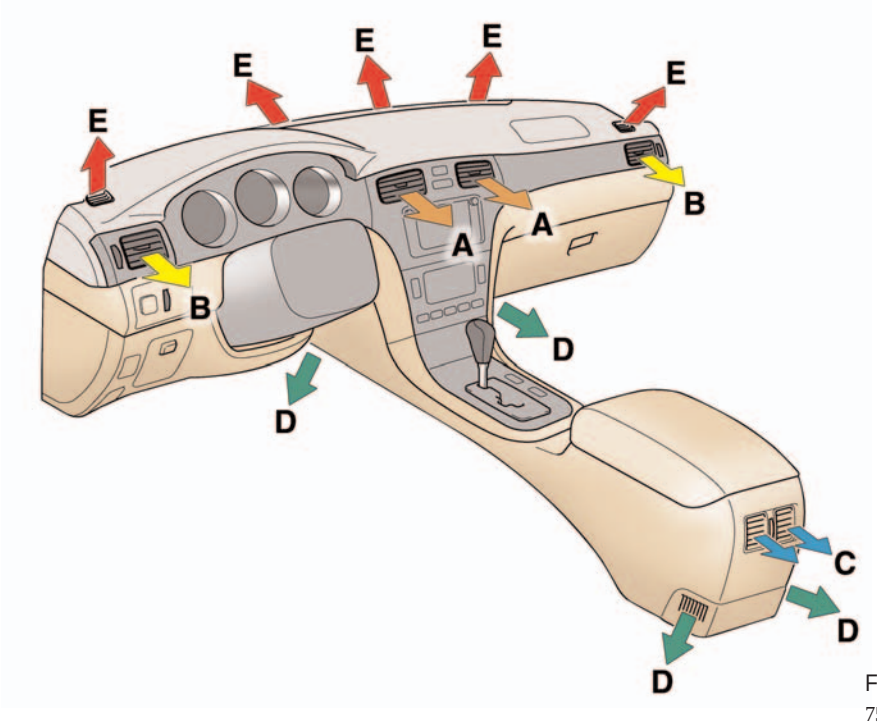


Fig. 5-13
752f513

Air Outlet Mode	A Center Face	B Side Face	C Rear Face	D Foot	E Defroster
FACE 	◯	◯	◯	–	–
BI-LEVEL 	○	○	○	○	–
FOOT 	–	○	–	◯	○
FOOT/DEF 	–	○	–	○	○
DEF 	–	○	–	–	◯

Typical Mode Position Charts

Mode Position

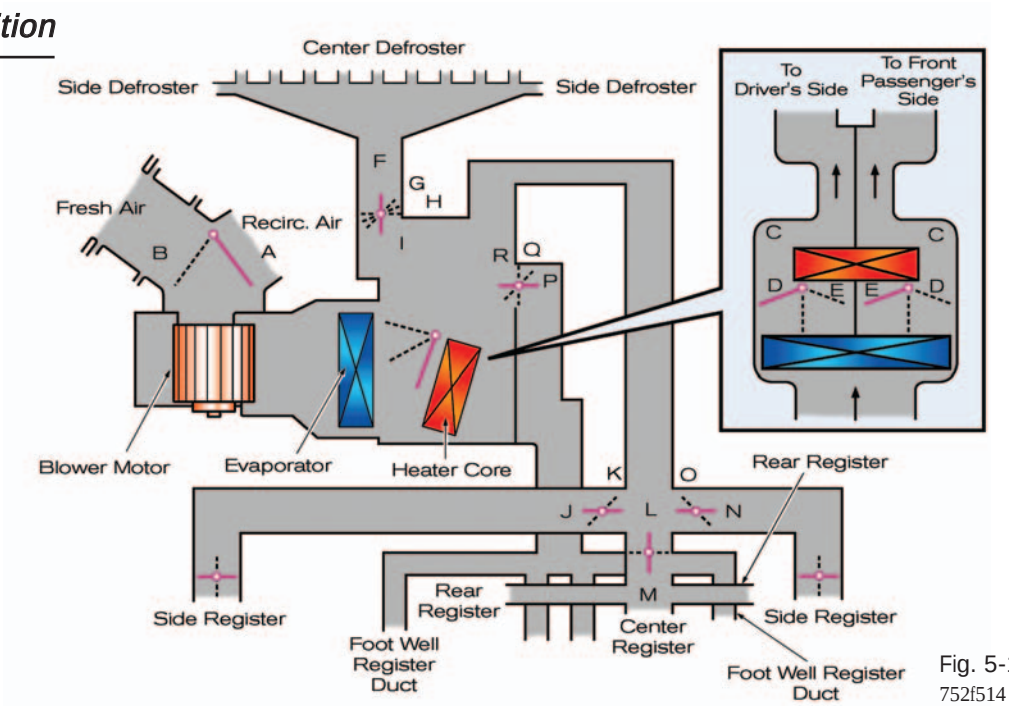


Fig. 5-14
752f514

Damper Operation Chart (typical)

Control Damper	Control Position	Damper Position	Operation
Air Inlet Control Damper	FRESH	A	Brings in fresh air
	RECIRC	B	Recirculates inside air
Air Mix Damper L/R Independent Control	MAX COLD – MAX HOT TEMP SETTING 65° F (18° C) – 85° F (32° C)	E ~ D ~ C E' ~ D' ~ C'	Varies the mixture ratio between fresh and recirculated air to regulate temperature
Mode Control Damper	DEF	F, K, L, O, R	Defrosts the windshield through the center defroster, side defroster and side register
	FOOT/DEF	G, K, L, O, Q	Defrosts the windshield through the center defroster, side defroster and side register while air also blows from the front and rear foot well register ducts
	FOOT	H, K, L, O, P	Air blows out of the front and rear foot well register duct and side register. In addition, air blows out slightly from the center defroster and side defroster
	BI-LEVEL	I, J, M, N, P	Air blows out of the center registers, side registers and foot well register ducts
	FACE	I, J, M, N, R	Air blows out of the center registers and side register

Dual-Plane Air Distribution

The size of the circle ○ indicates the proportion of airflow volume.

Dual-Plane HVAC Housing

Twin-bladed blower motor provides different air volume.

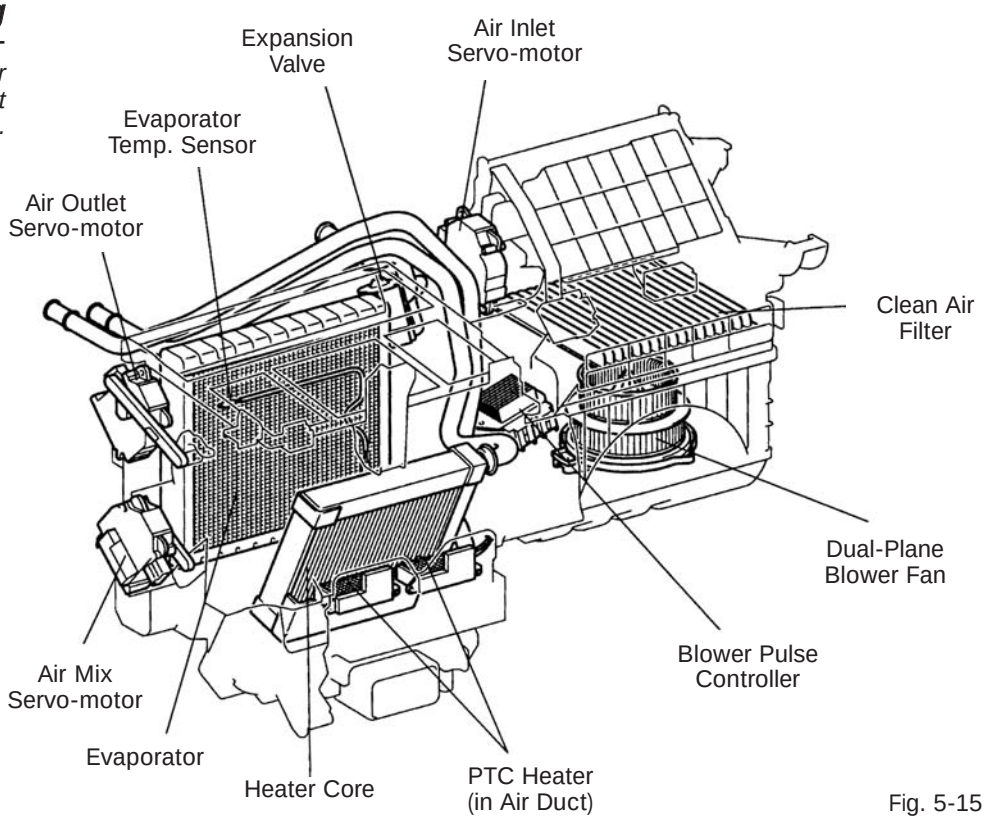


Fig. 5-15
752f515

This system also provides 2-way airflow in the vehicle. Under 2-way flow operation, the system can introduce outside air and circulate internal air at the same time. This allows warm RECIRC air to flow to the foot area while dry, FRESH air flows to the upper area. The 2-way flow system provides good heating and de-misting performance.

2-Way Airflow

FRESH and RECIRC combined airflow

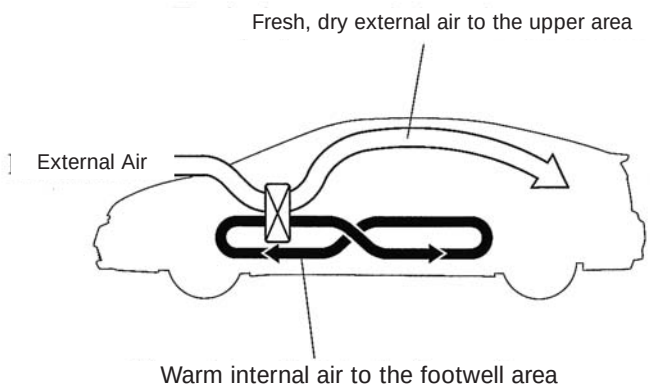


Fig. 5-16
752f516

A partition plate inside the A/C blower unit divides the airflow path (external and internal passages). Thus, by controlling the external and internal air doors separately, the vehicle has the following FRESH and RECIRC airflow modes:

- FRESH air
- RECIRC air
- BI-LEVEL, FRESH AIR/RECIRC air (2-way flow)

Notes

If the A/C is ON, the evaporator cools the air inside the plenum. The air is then brought to the desired temperature by the position of the blend door, the hot heater core and the air mix servo-motor. There are additional damper doors (mode control dampers) that determine the distribution of the treated air from the plenum into the passenger compartment. There are usually three or more air outlets to the vehicle's interior:

Distribution Mode	Air Direction, primary	Air Direction, secondary
DEF (Defrost)	Air flows to vents at base of windshield	Foot level vents
HEAT	Air flows to foot vents	Defrost vents
BI-LEVEL	Air flows to both foot and dash vents	–
FACE or VENT	Air flows to dash level vents	–

Typical mode settings. See *Vehicle Repair Manual* for specific settings.

Vehicle Repair Manuals describe specific air distribution patterns using a chart (see sample charts). Notice that the larger circles indicate more airflow than the smaller circles.

Air distribution to the desired air outlet duct is controlled by a switch on the instrument panel. Some vehicles use a slide lever connected by a cable to a variable-position damper. The damper doors can also be operated by vacuum, supplied by a rotary vacuum switch on the instrument panel.

Current vehicles may use an air-distribution system featuring a dual-plane blower motor. This produces different airflow volume from a single fan speed. The small and large fan blades circulate air through different air distribution paths in the blower housing. This results in more airflow to the FOOT vents than to the FACE vents.