AC component descriptions

Compressor

Function

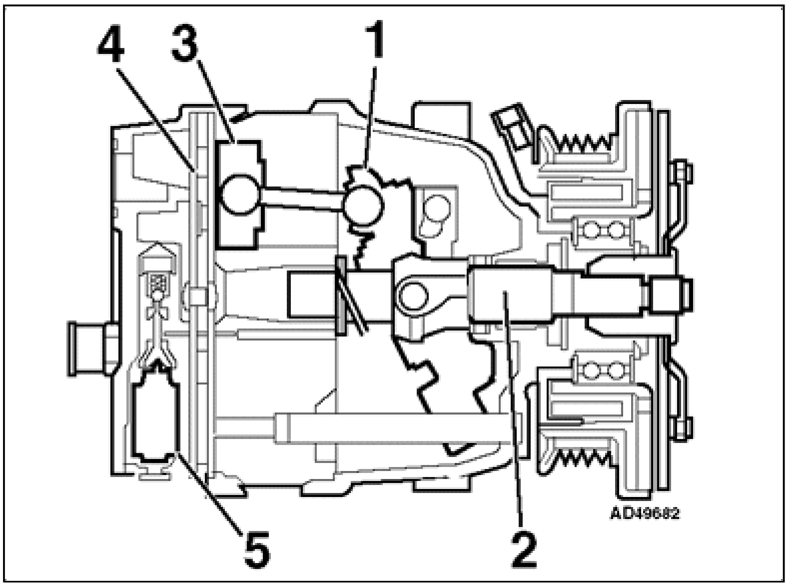
- The compressor is a mechanical pump that compresses and circulates refrigerant around the AC system.

Operation

- The compressor draws in low pressure refrigerant vapour and delivers high pressure refrigerant vapour.
- During compression the temperature of the refrigerant vapour rises considerably. The compressor can only compress vapour as liquid would destroy the compressor.
- The compressor is normally driven by a belt directly from the engine crankshaft or alternatively via the alternator or power steering pump.

Swash plate type

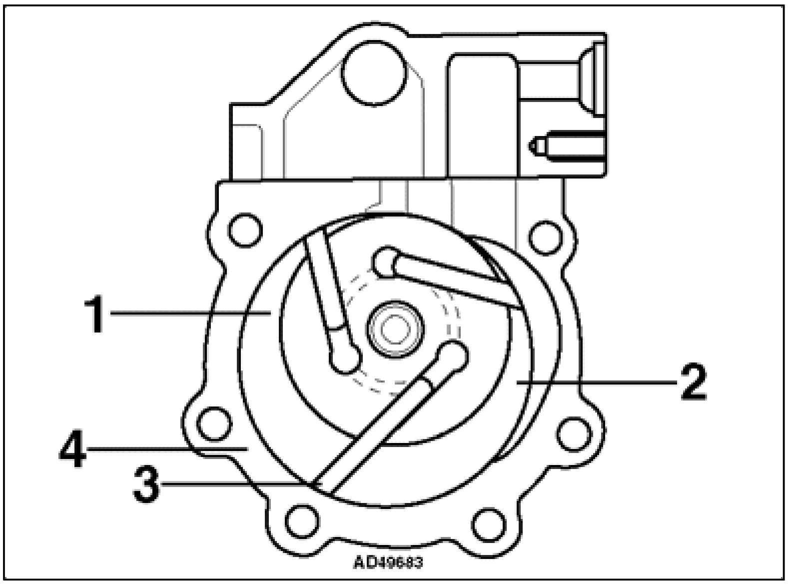
Fig 1



- The swash plate **[1]** is rigidly connected to the compressor shaft **[2]** at an oblique angle. A number of pistons **[3]** are located around the circumference of the swash plate at even intervals (the number of pistons and at which angle they are set is dependent on the capacity of the compressor).
- The swash plate converts the rotary movement of the compressor shaft into the reciprocating movement of the pistons. Reed type suction and discharge valves **[4]** are mounted in valve plates between the cylinder assembly and the cylinder head.
- Swash plate compressors can be of either fixed or variable capacity.
- Variable capacity control greatly reduces the conventional ON/OFF operation of the magnetic clutch and the mechanical shocks that this causes.
- Variable capacity compressors are fitted with a pressure control valve **[5]** that senses the pressure of the suction side, this varies the delivery capacity by allowing the swash plate to change its angle.
- Late models can be fitted with an electrically operated pressure control valve. This is controlled by the AC control module or engine control module (ECM) and reduces the power required to operate the system, improves fuel consumption and reduces exhaust emissions.

Vane type

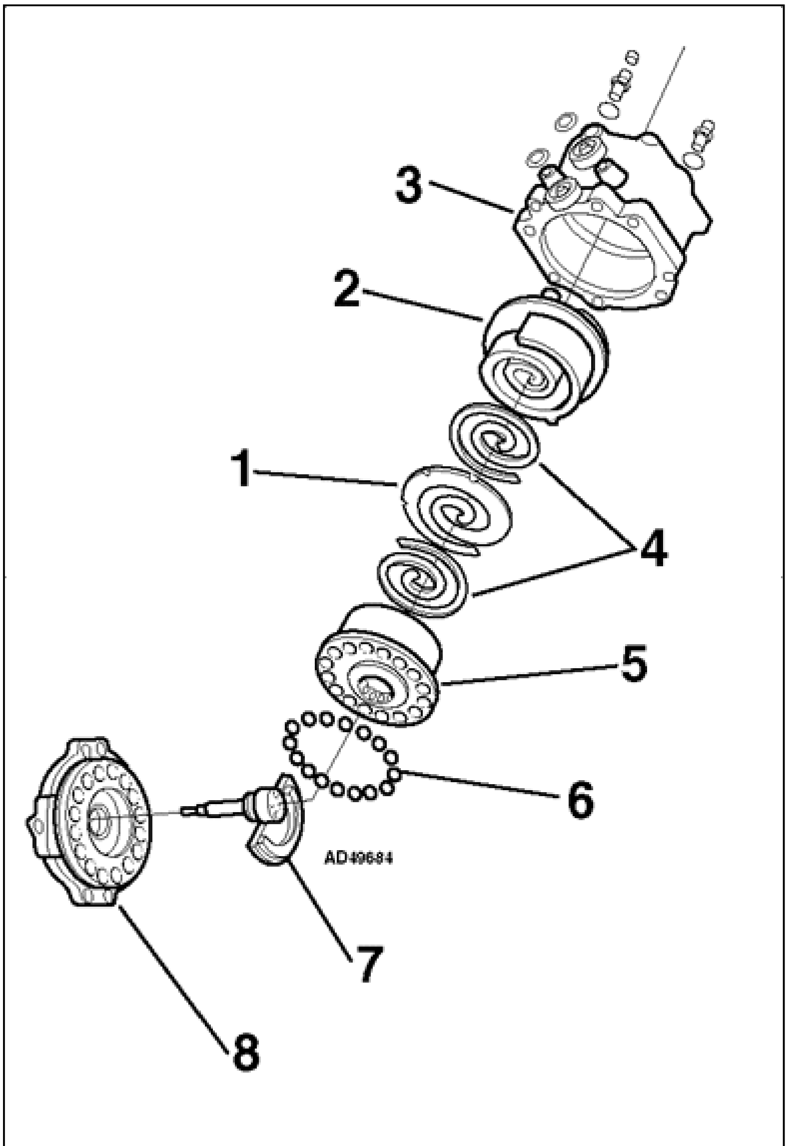
Fig 2



- The vanes **[3]** are set at even intervals within a rotor **[1]** which is mounted on the compressor shaft. When the rotor turns, centrifugal force pushes the vanes outwards against the inner wall of the compressor **[4]**. The eccentric arrangement of the rotor and the vane movements generate pressure changes in the compressor housing **[2]** which create suction for refrigerant intake, subsequently compression and finally the discharge of the refrigerant.

Scroll (Helix) type

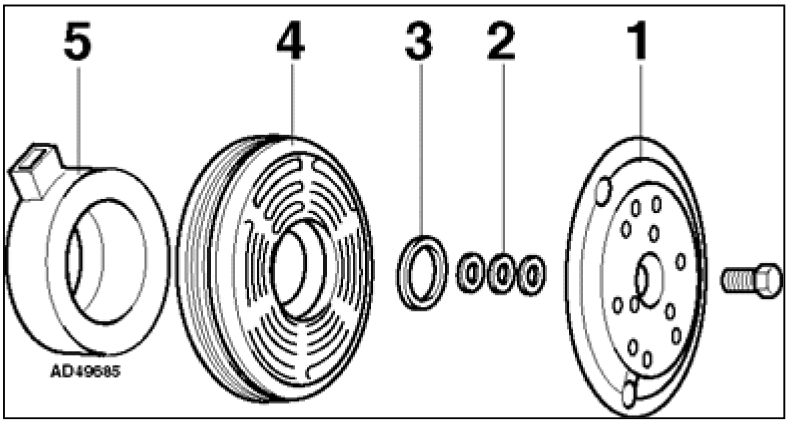
Fig 3



- The scroll compressor consists of two helices which are located in a cylindrical housing **[3]**. One helix lies within the other, one being fixed **[2]**, the other **[5]** oscillates on a drive shaft and being guided by bearing balls **[6]** and a thrust plate **[1]**. The drive shaft **[7]** incorporates a counterweight and runs in a bearing in the housing cover **[8]**. Sealing strips **[4]** provide a gas tight seal for the cavity between the helices which creates two crescent-shaped compression chambers. These expand and contract through the movement of the oscillating helix.
- Scroll compressors can be of either fixed or variable capacity.
- Variable capacity control greatly reduces the conventional ON/OFF operation of the magnetic clutch and the mechanical shocks that this causes.
- Variable capacity compressors are fitted with a control valve. To reduce delivery, the control valve passes partially compressed refrigerant vapour back into the low pressure chamber. The amount of refrigerant vapour fed back is determined by the position of the piston in relation to the bypass in the control valve.

Magnetic clutch

Fig 4

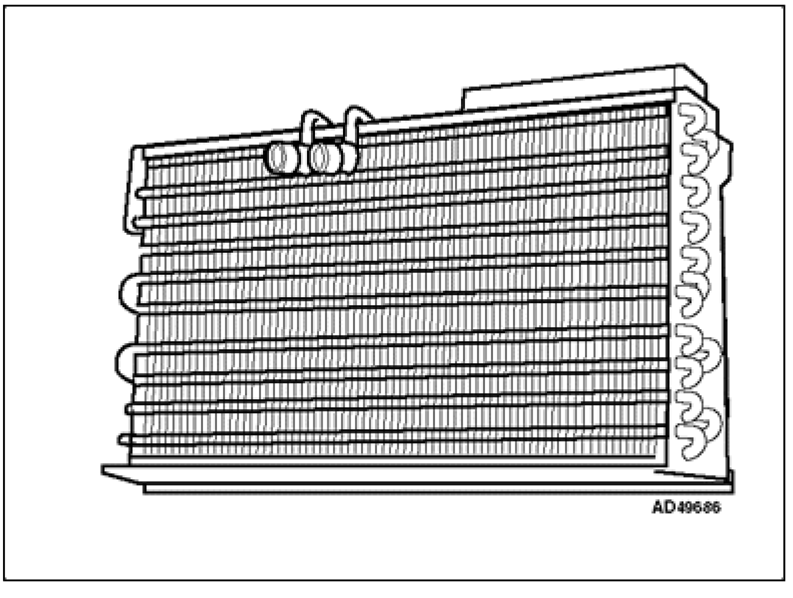


- A magnetic clutch is used to connect or disconnect the drive to the compressor.
- When voltage is applied to the clutch field coil **[5]**, the clutch plate **[1]** (which is connected to the compressor shaft) is drawn into contact with the pulley **[4]** and the compressor rotates.
- When voltage is disconnected from the clutch field coil **[5]**, the clutch plate **[1]** is released and the compressor ceases to rotate.
- The compressor clutch clearance on some models may be adjusted with shims **[2]**.
- The clutch field coil **[5]** is normally held in position with a snap ring **[3]**.
- Compressors are lubricated by oil held in the compressor and mixed with the refrigerant.

Condenser

Function

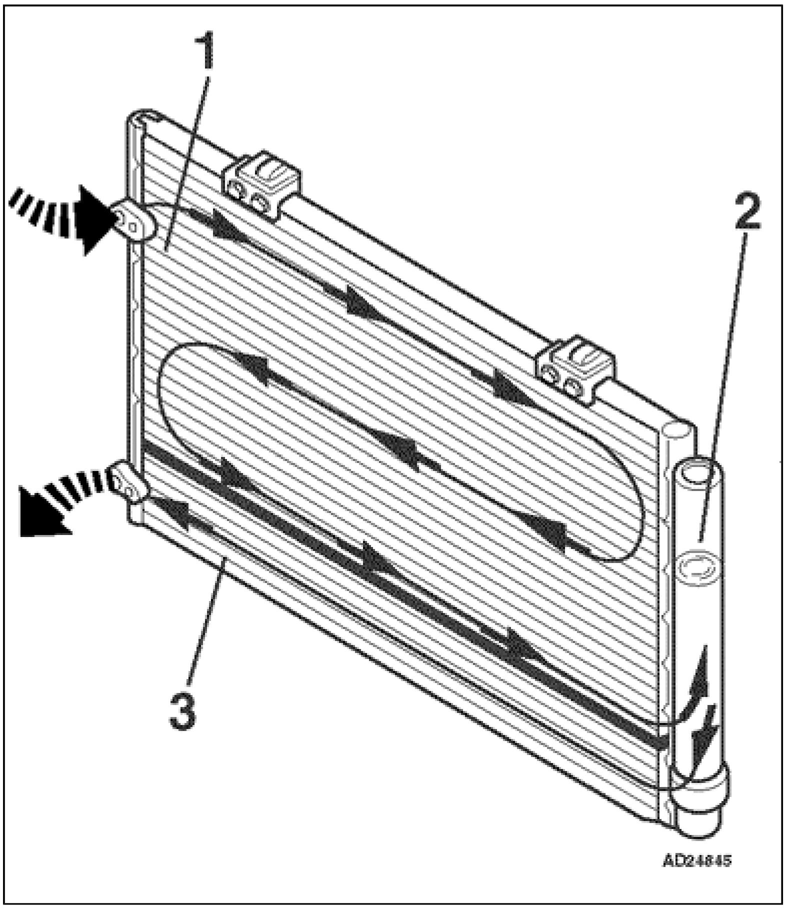
Fig 5



- As the refrigerant vapour is compressed its temperature increases and it therefore needs to be cooled before it is passed to the evaporator.
- The function of the condenser is to cool the hot refrigerant vapour ensuring it condenses into a liquid, and it is normally located in front of the engine coolant radiator.

Operation

Fig 6



- The condenser receives vapour from the compressor under high pressure.
- The vapour enters the top of the condenser and flows down through the condenser tubes.
- As cool air passes over the condenser fins the refrigerant is cooled and it condenses before leaving the bottom of the condenser as liquid.
- When the vehicle is stationary a mechanical or electrically operated fan is used to force air through the condenser fins.
- On late models the condenser is divided into three separate chambers. The top section **[1]** cools the hot vapour ensuring it condenses into liquid. It is then passed to an integral receiver/drier **[2]** (also called a modulator in this arrangement), where it is dried and separated from any remaining vapour before entering the lower section **[3]**, a sub cooler that ensures that only liquid is passed to the expansion valve.

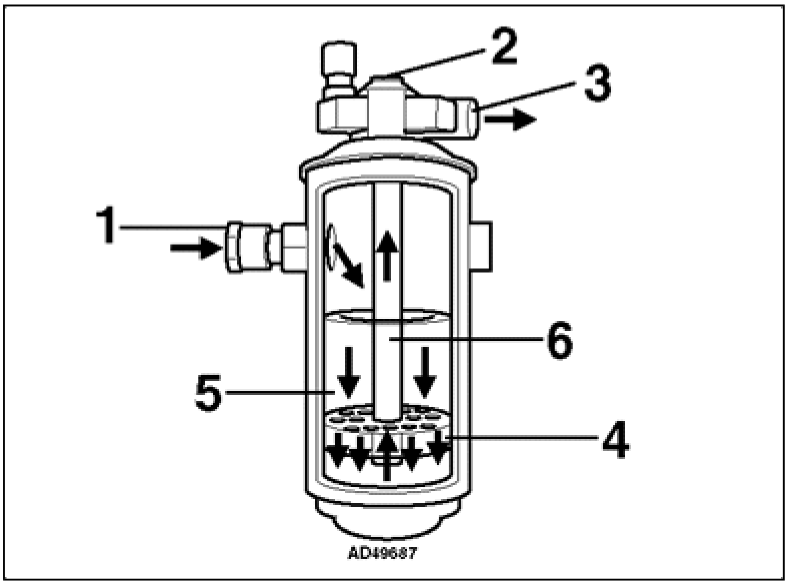
Receiver/drier

Function

- The receiver/drier is used in an expansion valve system and is located in the high pressure side of the system. On older systems it is connected by pipes and located between the condenser and the expansion valve, on late models it can be integral to the condenser.
- Its primary function is to ensure that only liquid refrigerant is passed on to the expansion valve. It also filters any impurities from the system and absorbs any moisture that may have entered the system.
- In the event of compressor damage or when the refrigerant circuit has been left open to the atmosphere, it must be serviced (integral types only), or renewed.

Operation

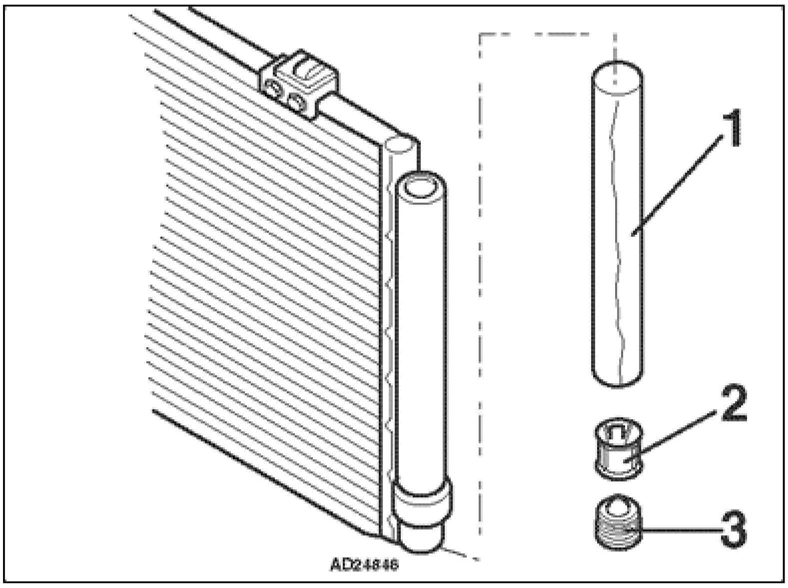
Fig 7



- The high pressure liquid passes from the condenser through the inlet line **[1]** into the receiver/drier, and a drying element **[4]** absorbs moisture from the refrigerant and filters foreign matter.
- The liquid refrigerant **[5]** then passes along a riser **[6]** to the outlet line **[3]** and on to the expansion valve.
- In some systems a sight glass **[2]** is incorporated in the outlet line.

Integral receiver/drier

Fig 8



- Integral types have a desiccant cartridge **[1]** and filter **[2]** that can be accessed after refrigerant discharging by removing the plug **[3]**.

  NOTE: nbsp;The filter is integral to the plug on some models.

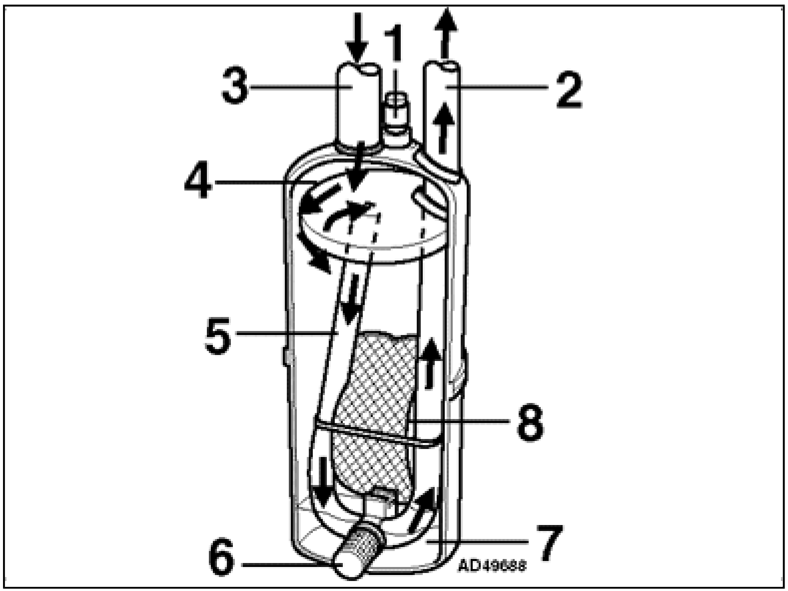
Accumulator/drier

Function

- The accumulator/drier is used in a fixed orifice tube system and is located in the refrigerant circuit between the evaporator and the compressor.
- Its primary function is to prevent liquid refrigerant from entering and damaging the compressor.
- To achieve this it acts as a reservoir for liquid refrigerant which failed to vaporise while passing through the evaporator, and allows only refrigerant vapour to be drawn off by the compressor.
- The accumulator/drier also acts as a filter ensuring that the refrigerant circuit is clean, and absorbs moisture that may have entered the refrigerant.
- In the event of compressor damage or when the refrigerant circuit has been left open to the atmosphere, it must be renewed.

Operation

Fig 9

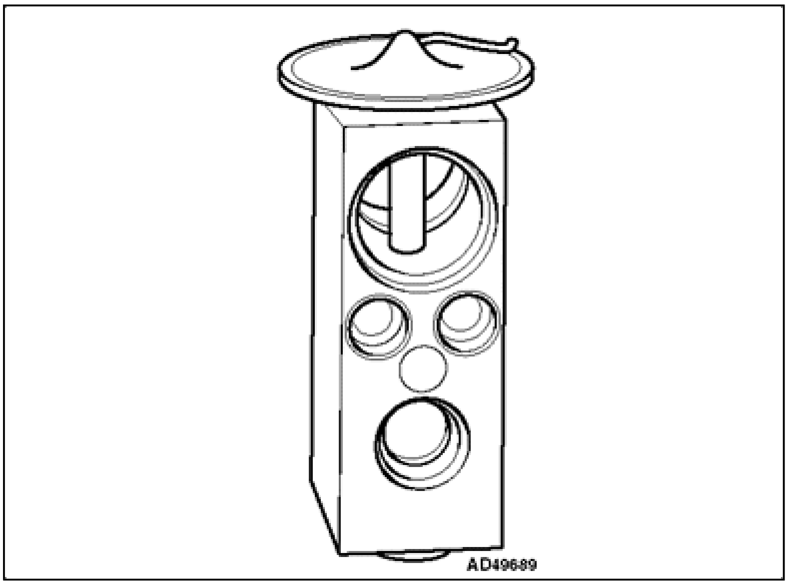


- Refrigerant vapour passes from the evaporator through the inlet line **[3]** into the accumulator/drier and flows around the cap **[4]** creating a vortex. The drying element **[8]** collects any moisture absorbed by the refrigerant.
- Refrigerant vapour collects under the cap where it is extracted through the opening of the U-shaped tube into the outlet line **[2]**.
- The heavier liquid tends to flow towards the bottom of the accumulator/drier, where it has a second opportunity to vaporise.
- Behind the filter screen **[6]** there is a small hole in the U-shaped tube **[5]**. Oil collected in the accumulator/drier **[7]** is extracted through this opening and mixed with the outgoing refrigerant vapour.
- A connection at the top of the accumulator/drier **[1]** accommodates the low pressure switch.

Expansion valve

Function

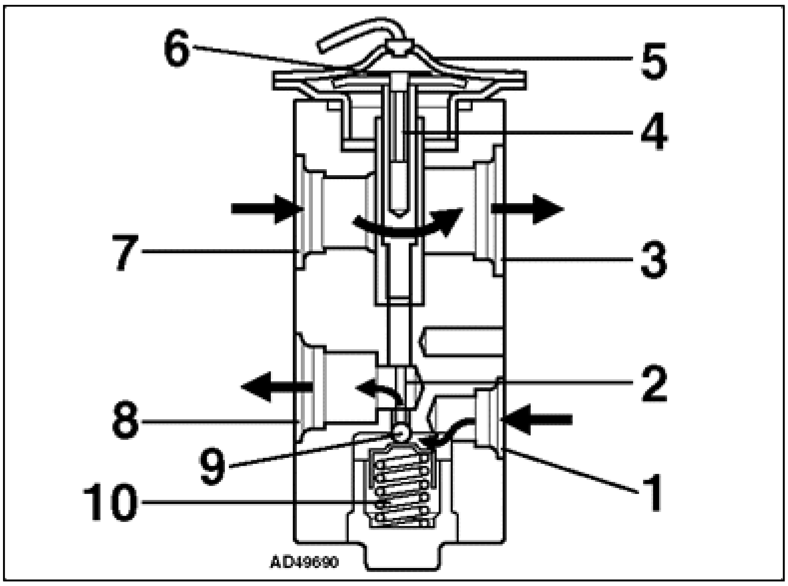
Fig 10



- Located in the high pressure line between the receiver/drier and the evaporator the expansion valve separates the refrigerant circuit high and low pressure sides.
- By controlling the flow of refrigerant into the evaporator, it ensures complete evaporation of the liquid refrigerant so that only refrigerant vapour can return to the compressor.
- Expansion valves are not adjustable and are changed as a complete service unit.

Operation - block valve type

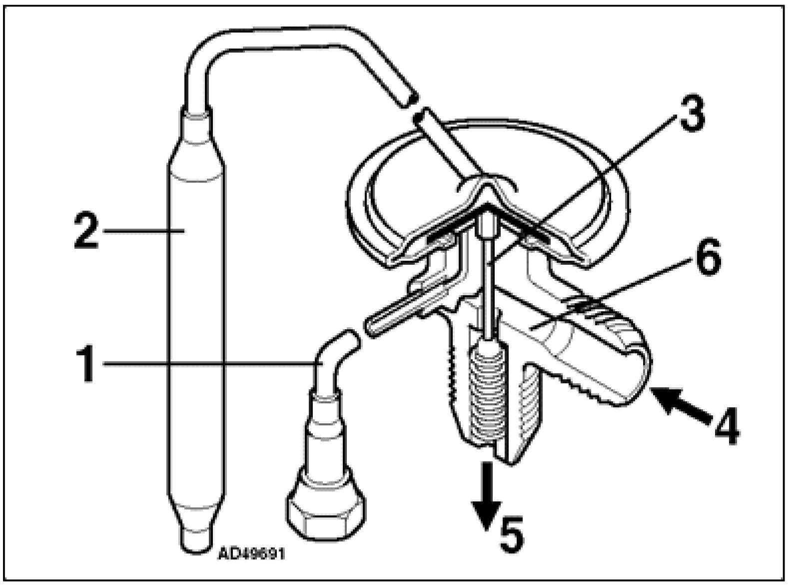
Fig 11



- This type of expansion valve consists of the diaphragm head **[5]** and the valve body. The refrigerant from the receiver/drier **[1]** flows through the lower bore and is injected in precisely metered quantities. The metering is carried out by a sensor **[4]** and diaphragm chamber **[6]** filled with a small amount of refrigerant.
- The sensor **[4]** monitors the temperature of the refrigerant vapour returning from the evaporator **[7]**. When the temperature rises, the sensor heats the liquid refrigerant enclosed by the diaphragm. The refrigerant expands and the diaphragm pushes on a valve slide **[2]** that forces the ball **[9]** downwards away from the valve seat against spring pressure **[10]**. This increases the flow of the refrigerant to the evaporator **[8]**. The ball valve closes again as soon as the temperature in the evaporator falls and the refrigerant in the diaphragm head cools. Refrigerant vapour returns to the compressor via the connection **[3]**.

Operation - thermostatic valve type

Fig 12



- The thermostatic expansion valve (TXV) with thermal bulb **[2]** is located directly in the evaporator inlet. High pressure liquid refrigerant from the receiver/drier enters the valve at **[4]** and acts against the spring loaded valve **[6]** to be injected into the evaporator **[5]**.
- A thermal sensing bulb **[2]** is placed on the low pressure line. When the temperature rises, the sensor heats the liquid refrigerant enclosed by the diaphragm. The refrigerant expands and the diaphragm pushes the valve downwards away from its seat. This increases the flow of the refrigerant to the evaporator **[5]**. The valve closes again as soon as the temperature in the evaporator falls and the refrigerant in the diaphragm cools.
- A pressure equalisation line **[1]** is used to compensate for varying outlet pressures. Some are fitted externally to the suction line as shown, while others types use an internal drilling.

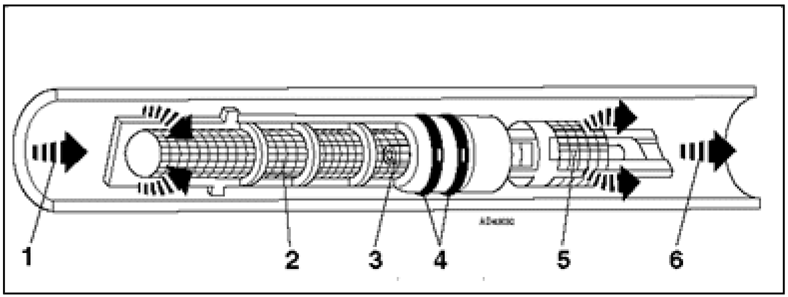
Fixed orifice tube

Function

- The orifice tube is located in the high pressure line between the condenser and the evaporator.
- The exact location may be visible from the outside by a shoulder in the refrigerant line. This is a restriction which stops the orifice tube from being pushed into the evaporator.
- The orifice tube separates the refrigerant circuit high pressure side from the low pressure side and meters the flow of refrigerant into the evaporator.
- The orifice tube cannot ensure complete evaporation of the liquid refrigerant within the evaporator so an accumulator is used to ensure that only refrigerant vapour can return to the compressor.

Operation

Fig 13



- The liquid refrigerant **[1]** flows from the condenser at high pressure to the inlet side of the orifice tube **[3]**. Two O rings **[4]** prevent refrigerant from bypassing the orifice tube. A screen filter at the inlet **[2]** ensures that the orifice does not become blocked. The screen on the outlet side **[5]** finely atomises the refrigerant before it is delivered to the evaporator **[6]**.
- The inside diameter of the fixed orifice tube varies between vehicle types. Each fixed orifice tube is colour coded to show the calibration of the tube. It is important to install the correctly calibrated fixed orifice tube as cooling performance can otherwise be significantly affected.
- If the compressor has suffered internal damage, the fixed orifice tube and/or filter can become blocked with metal particles and should be renewed.

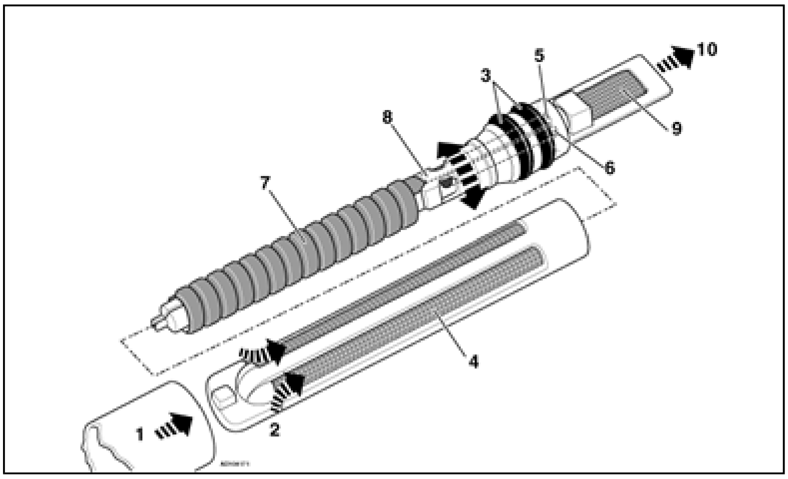
Variable orifice tube

Function

- The variable orifice tube is located in the high pressure line between the condenser and the evaporator.
- The exact location may be visible from the outside by a shoulder in the refrigerant line. This is a restriction which stops the orifice tube from being pushed into the evaporator.
- The orifice tube separates the refrigerant circuit high pressure side from the low pressure side and meters the flow of refrigerant into the evaporator via two orifices, one fixed and one variable.
- The variable orifice tube cannot ensure complete evaporation of the liquid refrigerant within the evaporator so an accumulator is used to ensure that only refrigerant vapour can return to the compressor.

Operation

Fig 14



- The liquid refrigerant **[1]** flows from the condenser at high pressure to the inlet side of the variable orifice tube **[2]**. Two O rings **[3]** prevent refrigerant from bypassing the variable orifice tube. A screen filter at the inlet **[4]** ensures that the orifices do not become blocked. Refrigerant flow is metered via the fixed orifice **[5]** and the variable orifice **[6]**. The quantity of refrigerant is metered depending on the refrigerant temperature. As the temperature rises the bi-metal spring **[7]** rotates operating a restrictor **[8]** to meter the flow of refrigerant through the variable orifice **[6]**. The screen on the outlet side **[9]** finely atomises the refrigerant before it is delivered to the evaporator **[10]**.

- The inside diameter of each orifice may vary between vehicle types. Each orifice tube is colour coded to show the calibration of the tube. It is important to install the correctly calibrated orifice tube as cooling performance can otherwise be significantly affected.
- If the compressor has suffered internal damage, the orifice tube and/or filter can become blocked with metal particles and should be renewed.

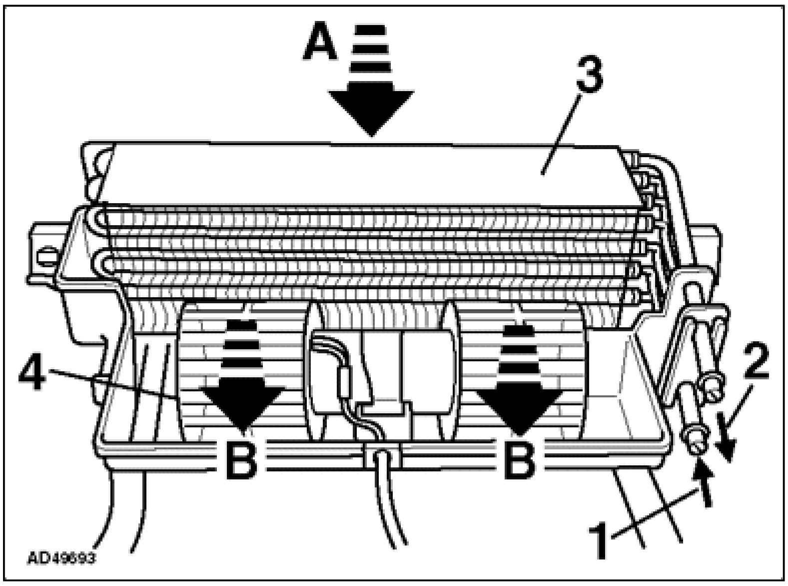
Evaporator

Function

- The evaporator is normally located in the heater air intake.
- The evaporator receives cold refrigerant vapour and cools the air in the passenger compartment, it also de-humidifies (removes moisture from) the passenger compartment air.
- Some vehicles are fitted with more than one evaporator, for example, one in the front of the vehicle and one in the rear passenger compartment.

Operation

Fig 15



- The evaporator receives a mixture of cold refrigerant liquid and vapour from the expansion valve or orifice tube (depending on system type) **[1]**.
- Air (normally re-circulated) [A], is drawn over the evaporator fins **[3]** by an electric fan **[4]**.
- As the air passes over the evaporator fins, it is cooled and blown into the passenger compartment **[B]**, before being recirculated through the evaporator.
- The heat from the intake air ensures that the refrigerant liquid is vapourised before it leaves the evaporator **[2]**, and is drawn back into the compressor for recirculation.
- Water vapour in the air that passes through the evaporator condenses on the fins, with the result that the air is de-humidified, the water that is collected in the process runs away through drainage channels.

Service connectors

Function

- The service connectors are normally located in the engine bay. The low pressure service connector may be on the AC compressor, or on the low pressure refrigerant line. The high pressure service connector may be on the AC compressor, the high pressure refrigerant line, or the receiver/drier. Some vehicles may be fitted with only a high pressure service connector.
- Service connectors allow the connection of a manifold gauge set to the refrigerant circuit for service and testing.

NOTE: Compressors may have service connectors identified by SUC (suction) for the low pressure connection and DIS (discharge) for the high pressure connection.

Operation - R12 service connectors

Fig 16

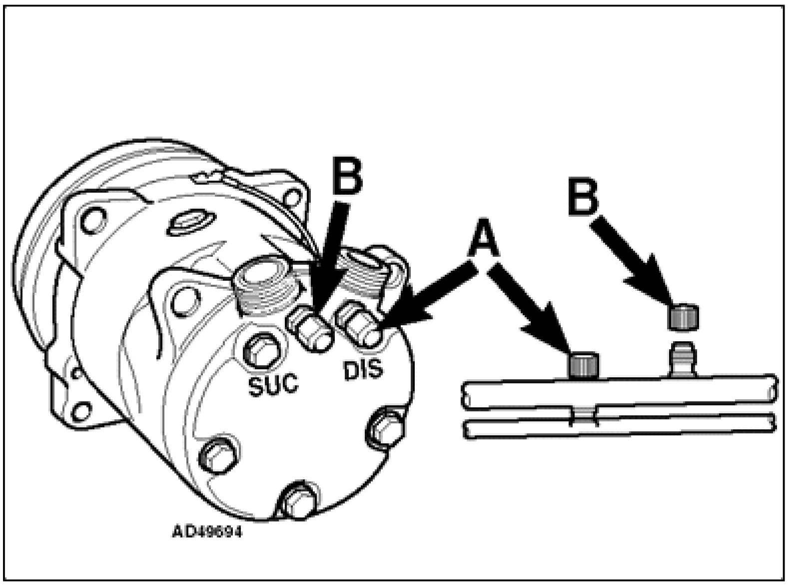
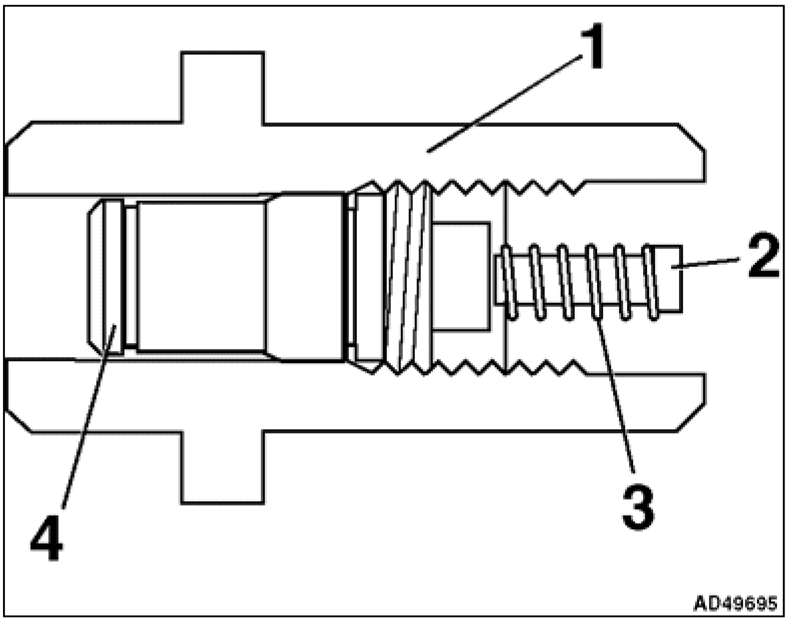


Fig 17



- The protective caps prevent the valves becoming contaminated with dirt and provide an additional seal when the system is in operation. They must be reinstalled after servicing or repairs.
- The service connectors are internally and externally threaded couplings and they both use screw-on connectors. The high pressure **Fig 16 [A]** and low pressure **Fig 16 [B]** service connectors normally have 3/8 inch external threads.
- The high and low pressure service connectors are not identified except where they are fitted to the compressor.
- Some vehicles use one 3/8 inch (high pressure) and one 7/16 inch (low pressure) externally threaded coupling.
- The service connectors contain Schrader type valves. An integral valve core **Fig 17 [4]** is screwed into the connector body **Fig 17 [1]**.
- The valves work like a tyre valve, depressing pin [2] against the seating spring **Fig 17 [3]** opens the valve.

Operation - R134a service connectors

Fig 17

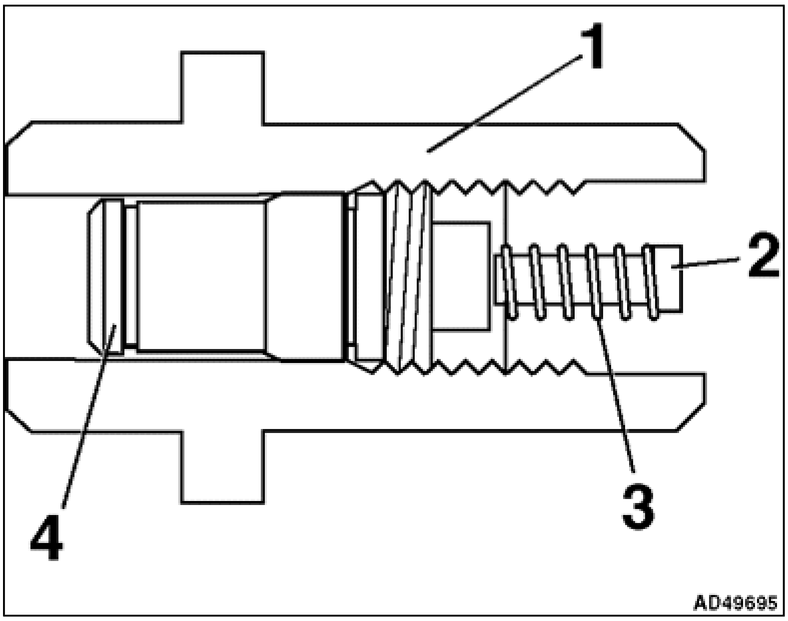
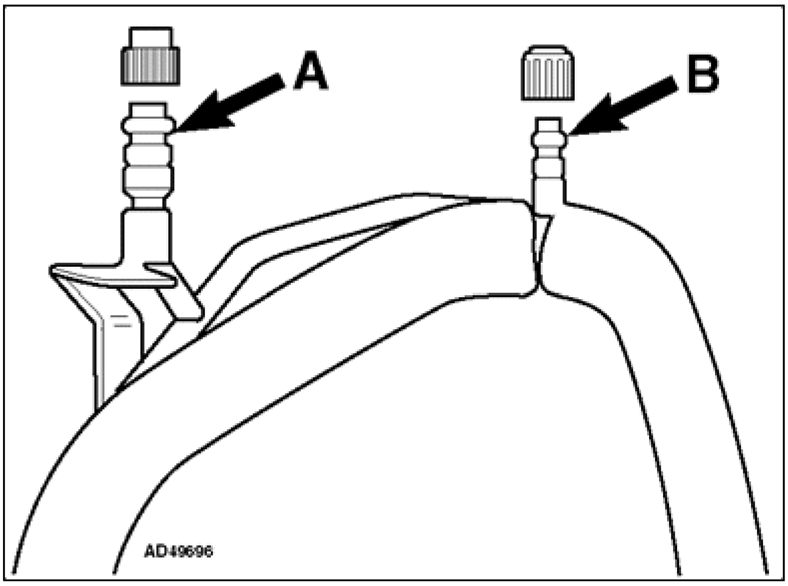


Fig 18



- The service connectors are internally threaded couplings and both use push-on connectors. The high pressure **Fig 18 [A]** and low pressure **Fig 18 [B]** service connectors have different size couplings.
- The high pressure service connector has a large diameter while the low pressure service connector is of a smaller diameter. The service connectors contain Schrader type valves as in R12 connectors .

NOTE: Do not use ordinary tyre valves for servicing an air conditioning system. Tyre valve seal material deteriorates rapidly when it comes in contact with refrigerant.

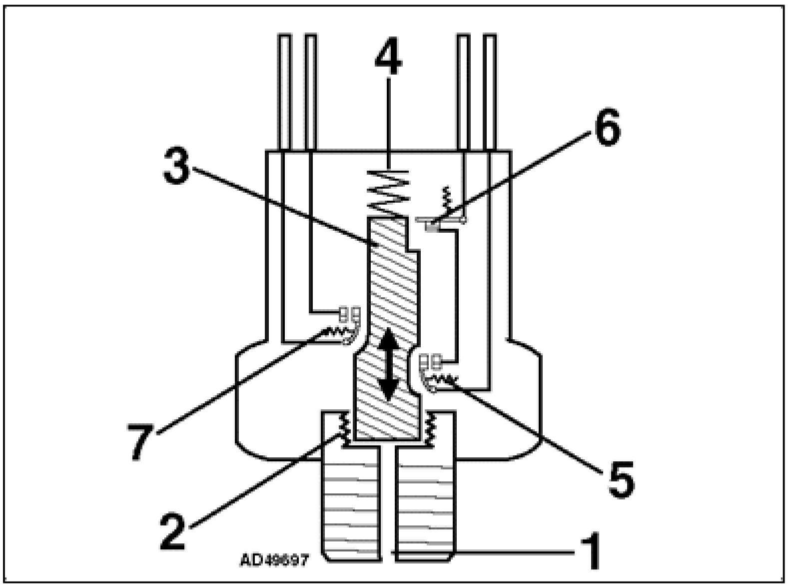
Refrigerant pressure switches

Function

- Refrigerant pressure switches may be located in the low pressure and/or high pressure lines of the refrigerant circuit depending upon the type of system.
- The contacts of the switch are opened or closed according to the circuit pressure and switches that have more than one set of contacts are called dual, triple or quadruple pressure switches.
- The operating pressures of the switches and their function will vary according to the type of system, for example:
- A low or triple pressure switch is used to ensure that the compressor will not operate if the refrigerant pressure is too low.
- A high or triple pressure switch is used to ensure that the compressor will not operate if the refrigerant pressure is too high.
- A low pressure switch is used to control (cycle) the compressor operation on orifice tube systems.
- A high pressure switch may be used to operate the condenser or engine coolant blower motors.

Operation - refrigerant dual pressure switch

Fig 19

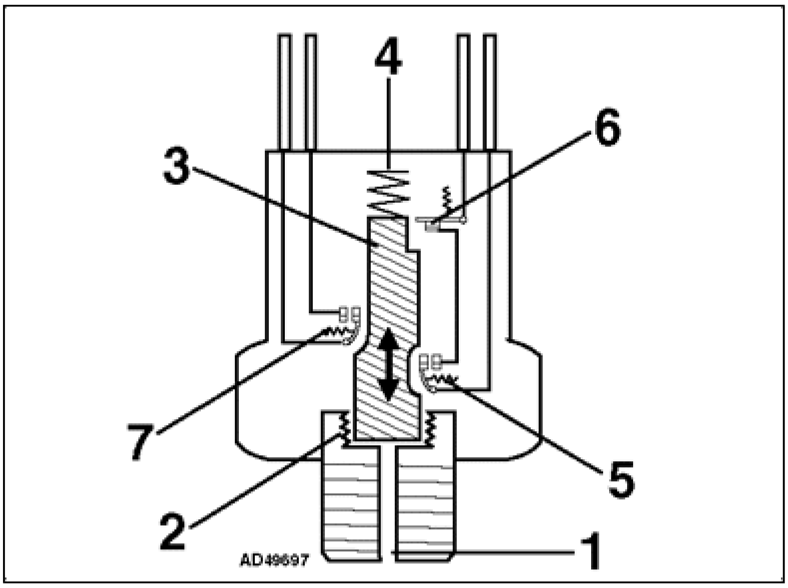


- Refrigerant enters the dual pressure switch (sometimes referred to as a binary switch) through the drilling **[1]** and pressure is sensed by the membrane **[2]** to operate the actuator **[3]** against the spring **[4]**.
- If the refrigerant pressure falls below approximately 2 bar the low pressure switch contacts **[5]** open and the compressor clutch circuit is broken.
- When the refrigerant pressure rises above approximately 3 bar the low pressure switch contacts close and the compressor clutch circuit is closed.

- If the refrigerant pressure rises above approximately 27 bar the high pressure switch contacts **[6]** open and the compressor clutch circuit is broken.
- When the refrigerant pressure returns to approximately 23 bar the high pressure switch contacts close and the compressor clutch circuit is closed.

Operation - refrigerant triple/quadruple pressure switch

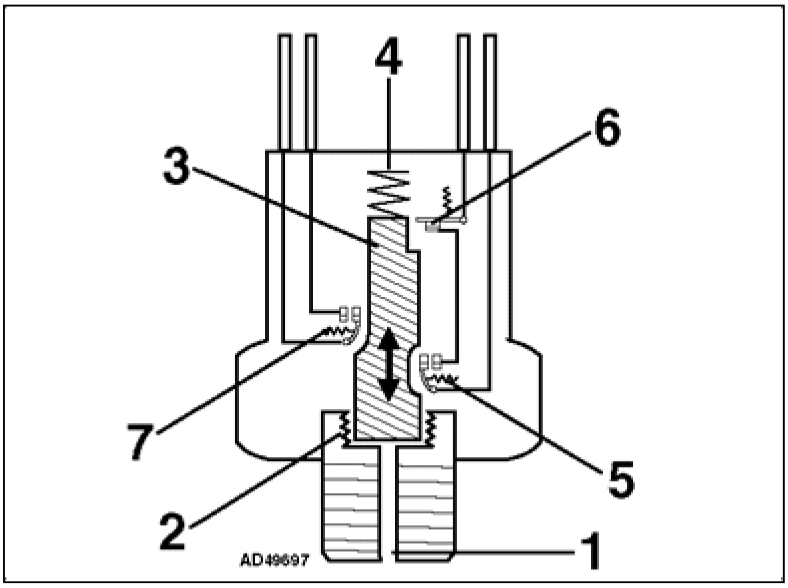
Fig 19



- The refrigerant triple pressure switch (sometimes referred to as a trinary switch or pressostat) operates in the same way as the dual pressure switch to control the compressor operation.
- It has additional contacts to control the condenser or engine coolant blower motors.
- If the refrigerant rises above approximately 15-19 bar the switch contacts **[7]** close and the condenser or engine coolant blower motor circuit is operated.
- The quadruple pressure switch has an additional set of contacts to enable the condenser or engine coolant blower motor(s) to be operated in stages dependent on the refrigerant pressure.

Operation - refrigerant high pressure switch

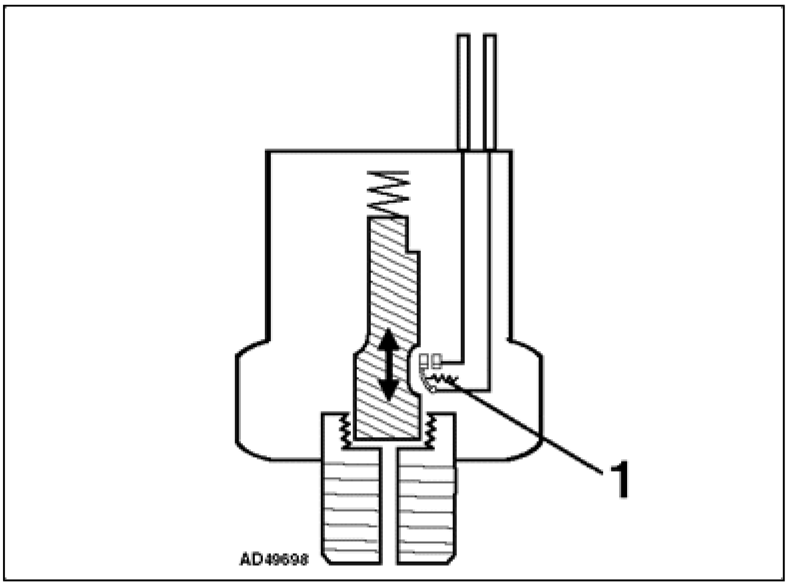
Fig 19



- The refrigerant high pressure switch operates in a similar way to the dual pressure switch, but has only high pressure contacts **[6]** to control the operation of the compressor.

Operation - refrigerant low pressure switch

Fig 20



- The refrigerant low pressure switch (sometimes referred to as a cycling switch in fixed orifice tube systems) operates in a similar way to the dual pressure switch, but has only low pressure contacts **[1]** to control the operation of the compressor.

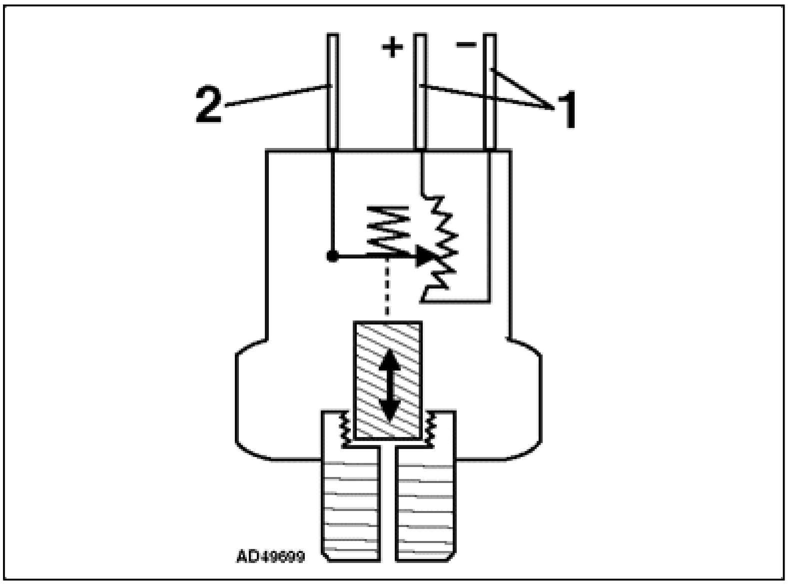
Refrigerant pressure sensor

Function

- A refrigerant pressure sensor may be used to control the operation of both the compressor and condenser or engine coolant blower motors via either the AC control module or engine control module (ECM).

Operation - analogue type

Fig 21



- Analogue pressure sensors operate in a similar way to the dual pressure switch but the contacts are replaced by a variable resistance or pressure sensitive crystal.
- The pressure sensor is supplied with a reference voltage to its connections **[1]** from the AC control module or engine control module (ECM).
- The control voltage emitted from its connection **[2]** varies in proportion to the refrigerant pressure.

Operation - digital type

Fig 22

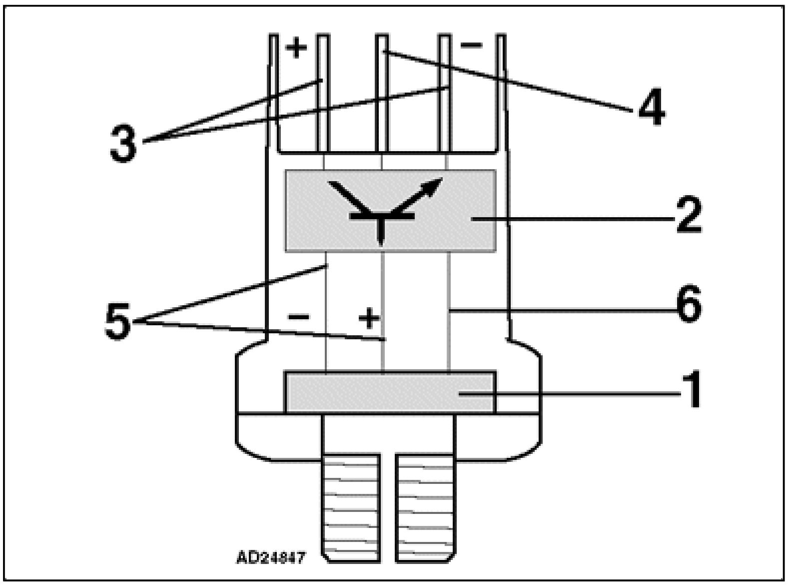
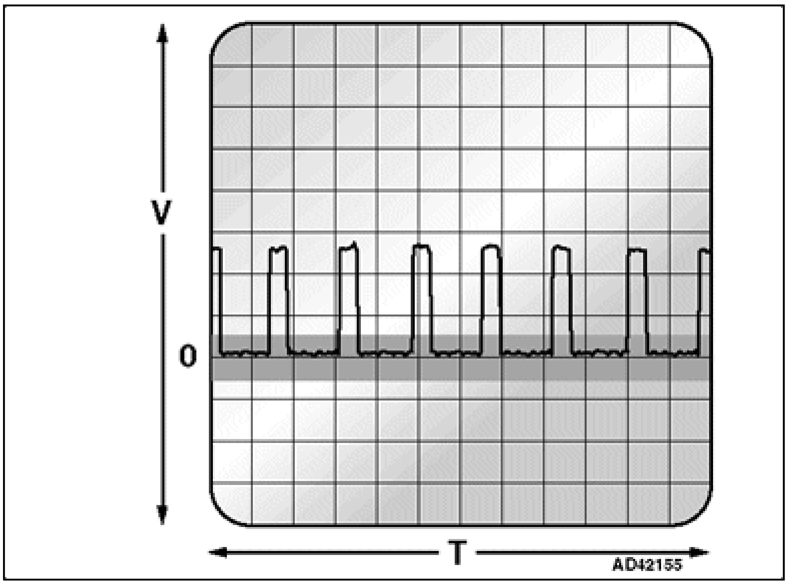


Fig 23



- Digital pressure sensors operate in a similar way to the analogue type but use a pressure sensitive crystal **Fig 22 [1]** and a microprocessor **Fig 22 [2]** to produce a digital signal.
- The pressure sensor is supplied with a voltage to its connections **Fig 22 [3]** from the AC control module or engine control module (ECM) and returns a signal through connection **Fig 22 [4]**.
- The crystal is supplied with a reference voltage from the microprocessor **Fig 22 [5]**.
- The crystal distorts as the refrigerant pressure varies resulting in a change to its electrical resistance. This change varies the voltage emitted to the microprocessor **Fig 22 [6]** where a digital signal is generated.
- The digital signal reflects the refrigerant pressure by a varying pulse width (duty cycle).

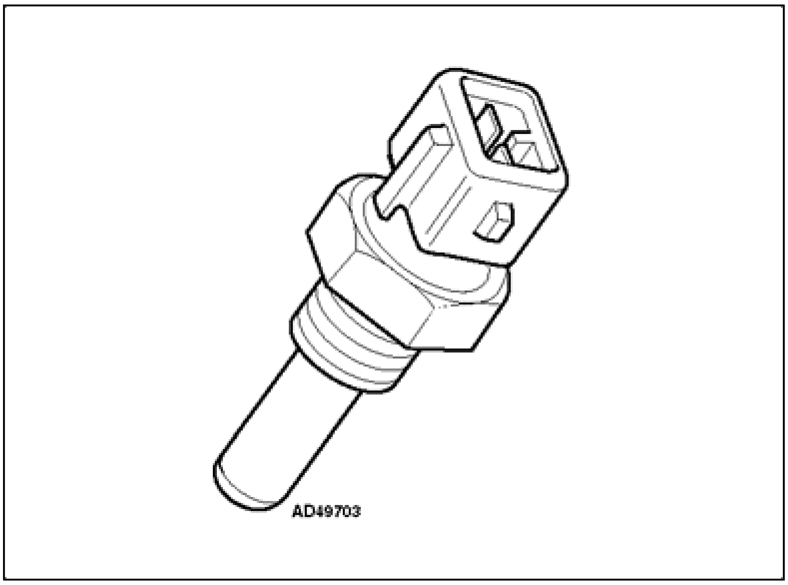
Temperature switches and temperature sensors

Function

- Both temperature switches and sensors may be used to control the operation of the AC system for example:
- the engine coolant temperature may be monitored to ensure that the engine does not overheat due to the additional heat generated when the AC system is operating.
- the temperature of the evaporator may be monitored to ensure that if its temperature falls to a point that may allow freezing, the compressor operation is interrupted.
- both in-car and ambient air temperature may be monitored to control the operation of the AC system.

Operation - engine coolant temperature (ECT) sensor

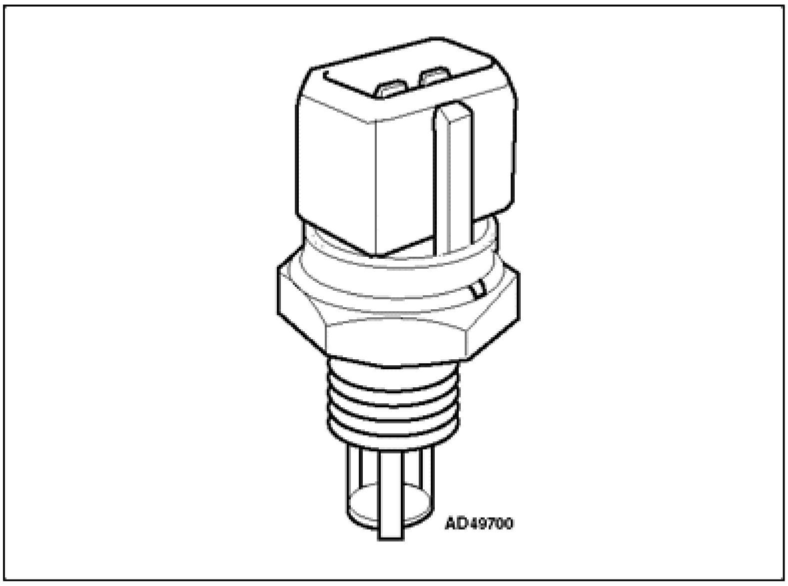
Fig 24



- The engine coolant temperature (ECT) sensor is located in the cooling system either in the radiator or on the engine and is connected to the AC control module or cooling fan control module.
- In most cases the sensor incorporates a negative temperature coefficient (NTC) resistor, which decreases in resistance as the coolant temperature rises.

Operation - air temperature sensor

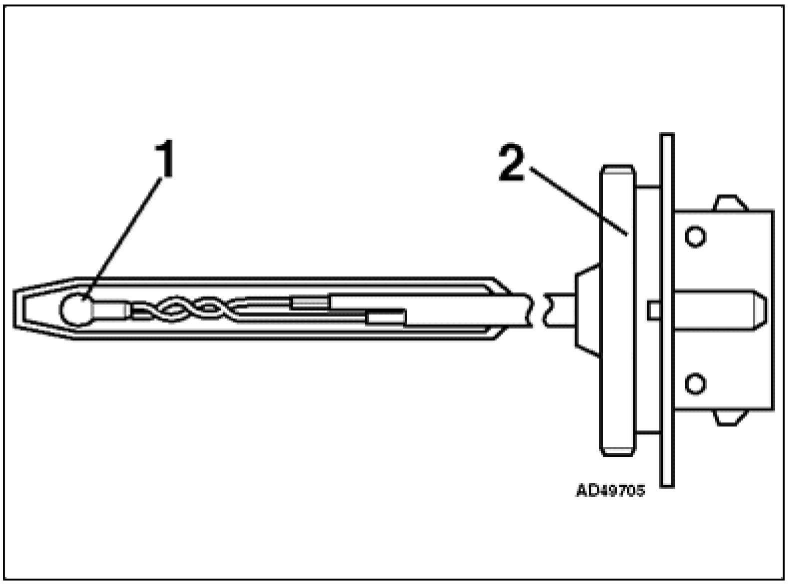
Fig 25



- Air temperature sensors may be fitted at various locations both inside and outside the vehicle and are connected to the AC control module.
- In most cases the sensor incorporates a negative temperature coefficient (NTC) resistor, which decreases in resistance as the air temperature rises.

Operation - evaporator temperature sensor

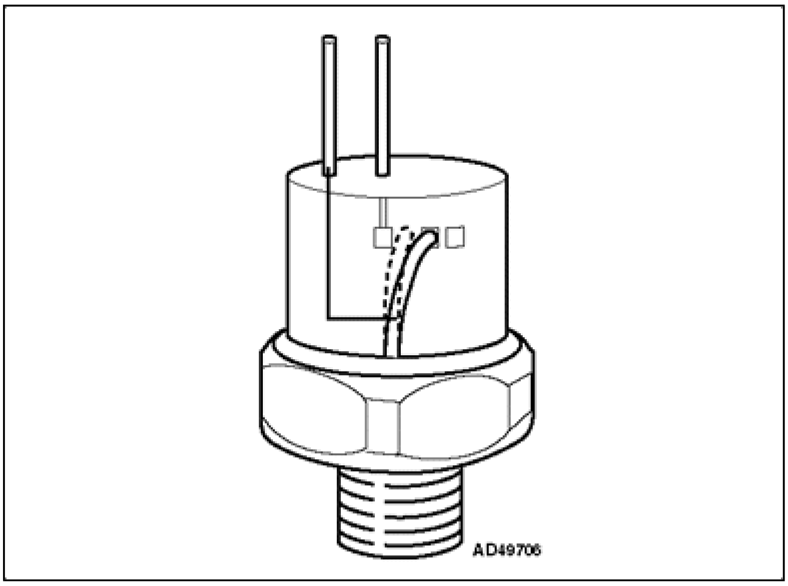
Fig 26



- The evaporator temperature sensor is located in the evaporator housing and is connected to an electronic control module.
- The temperature sensor probe **[1]** is placed into the evaporator cooling fins and changes its resistance in proportion to temperature changes. If the temperature falls to a point where freezing may occur, the sensor signal is used to switch the compressor off until the temperature rises again.
- In most cases the sensor incorporates a negative temperature coefficient (NTC) resistor, which decreases in resistance as the evaporator temperature rises.
- The sensor may incorporate a transistor within the assembly **[2]** to act as a switch.

Operation - engine coolant temperature (ECT) switch

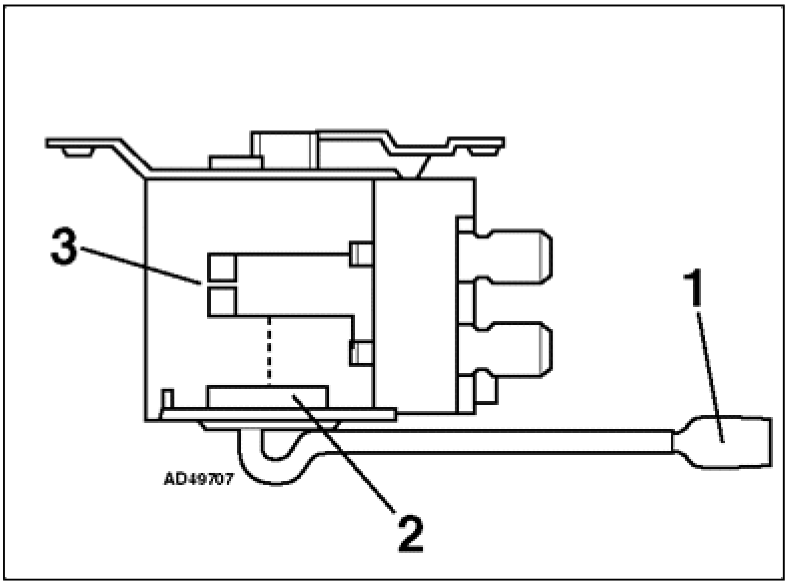
Fig 27



- The engine coolant temperature (ECT) switch is located in the cooling system either in the radiator or on the engine. It incorporates a bimetallic switch that either opens or closes as the coolant temperature rises.
- The engine coolant temperature (ECT) switch may be used to operate cooling fans or interrupt the compressor operation.

Operation - evaporator temperature switch

Fig 28



- The evaporator temperature switch is located in or near the evaporator housing while the sensor capillary tube **[1]** is positioned in the evaporator cooling fins.
- Temperature changes within the evaporator cause proportional pressure changes in the capillary tube, the pressure in the sensor capillary tube decreases as the temperature decreases.
- This pressure decrease acts on a membrane **[2]** which is connected to the switch contacts **[3]**. When the contacts open the compressor clutch circuit is interrupted.
- Typically the switch contacts open at approximately 1℃ and close at approximately 4℃.

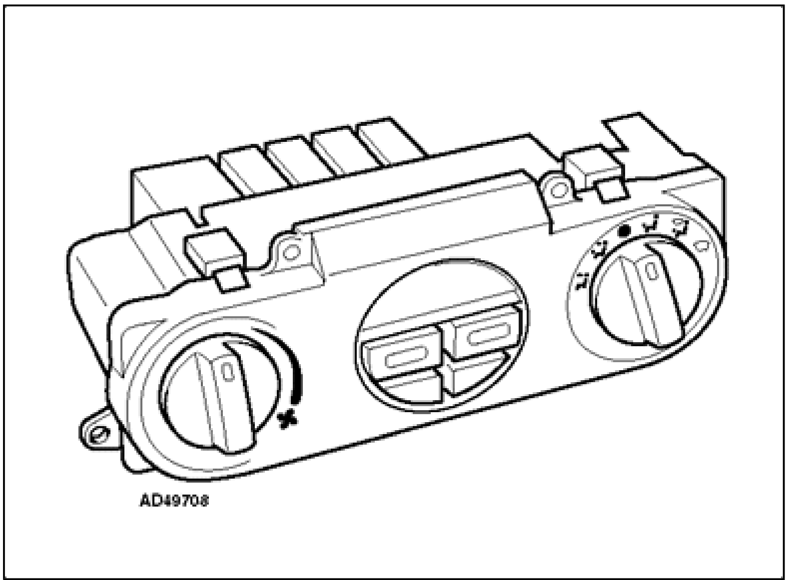
Electronic control modules

Function

- Automatic and semi-automatic systems may be controlled by an AC control module.
- The AC control module is commonly integrated into the AC/heater control panel but in some systems may be a separate unit installed either under the bonnet or inside the vehicle. The engine control module (ECM) may also control certain AC components.
- The AC and engine control modules are normally linked and may have a common data link connector (DLC) for access to fault diagnosis data.

Operation - AC control module

Fig 29



- Electrical signals from the heating and AC system controls and sensors are received and processed by the electronic circuits in the AC control module.
- The AC control module automatically maintains the in-car temperature selected at the control panel.
- The AC control module receives inputs from:
  - AC evaporator temperature sensor.
  - AC refrigerant pressure sensor.
  - AC/heater controls.
  - Automatic transmission.
  - Engine speed (RPM) sensor.
  - Heater output temperature sensor.
  - In-car temperature sensor.
  - Outside air temperature sensor.
  - Vehicle speed sensor (VSS).
- Outputs from the AC control module control the following:
  - AC compressor clutch.
  - AC/heater blower motor
  - AC/heater flap solenoid or motors.
  - Condenser blower motor(s).
  - Engine coolant blower motor(s).
  - Engine coolant heater regulator valve.

NOTE: The AC control module may be equipped with a self-diagnosis system.

- Faults recorded by the AC control module need to be rectified before any further diagnosis of the AC system.

Operation - engine control module (ECM)

Fig 30

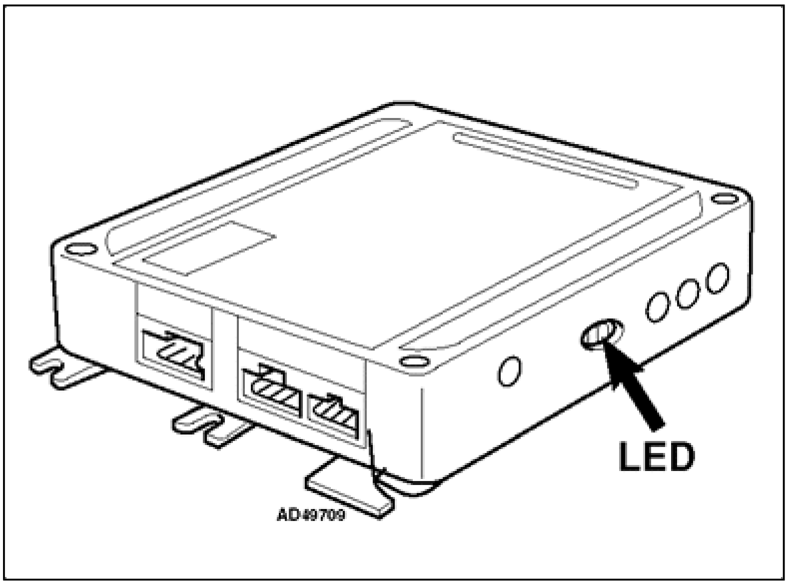
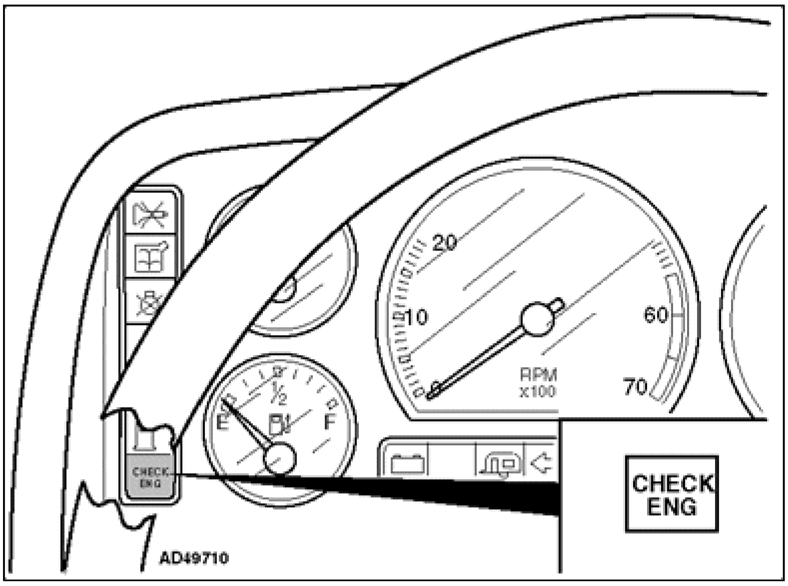


Fig 31



- Electrical signals from the fuel and ignition system sensors are received and processed by the electronic circuits in the ECM.
- The ECM controls the fuel, ignition and exhaust emission systems.
- Additionally it may be used to control certain functions of the AC system.
- ECM inputs that may affect the AC function:
  - AC ON signal.
  - Automatic transmission.
  - Engine coolant temperature.
  - Engine load.
  - Engine speed (RPM).
  - Throttle position.
  - Vehicle speed.
- Outputs from the ECM that control the AC function:
  - AC compressor clutch operation.
  - Engine coolant blower motor(s).
  - Condenser blower motor(s).

NOTE: The ECM may be equipped with a self-diagnosis system.

- Faults may be indicated by an LED on the ECM or a malfunction indicator lamp (MIL) or check engine warning light on the instrument panel .
- Faults recorded by the ECM may affect the operation of the AC system and need to be rectified before the diagnosis of AC faults.
- For details of ECM fault diagnosis - refer to the relevant Autodata Engine Management Manual.