

## Study & various components used in Automotive Air-Conditioning

**Objectives:** At the end of this lesson you shall be able to

- heat transfer in an automobile
- description of various components used in Automotive AC.

### Introduction

Due to varying conditions of heating, ventilating, cooling and dehumidification in the atmosphere at various places, the air-conditioning of automobiles is very essential. To maintain human comfort and improve internal atmosphere in an enclosed space, proper control of freshness temperature, humidity and cleanliness of the air is required.

### Heat transfer in an automobile (Fig 1)

When a car is driven or parked in the sun, heat enters the vehicle from many sources. These sources include:

- Ambient air
- Sunlight
- Engine heat
- Road heat
- Transmission
- Exhaust heat

All of these and other miscellaneous heat sources, increase the air temperature within the vehicle. In a high ambient temperature situation, (e.g. on a 37°C day), the interior of a vehicle left standing in the sun with windows closed could reach 65 - 70.

### Description of various components used in Automotive AC

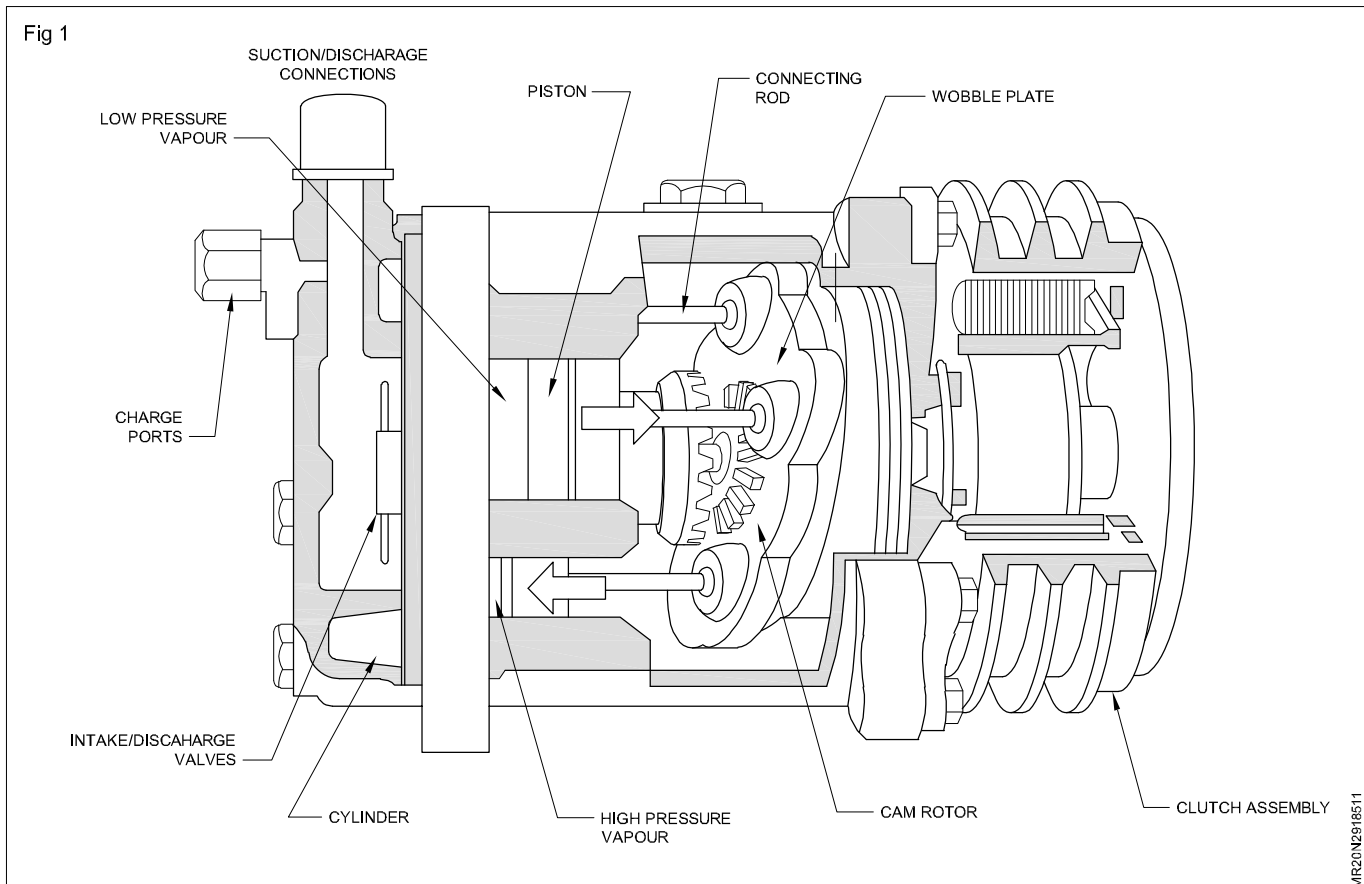
#### Compressors

##### General

There are various makes and types of compressors used in automotive air conditioning systems operating on R134a. The internal design could be Piston, Scroll, Wobble plate, Variable stroke or Vane. Regardless, all operate as the pump in the A/C system to keep the R134a and lubricating oil circulating, and to increase the refrigerant pressure and thus temperature.

##### Wobble plate

A reciprocating piston, fixed displacement compressor. The pistons are operated by a wobble plate, which moves them backwards and forwards in the cylinders. As the front shaft turns the wobble plate angle changes, causing the pistons to move in and out, pulling refrigerant vapor in through the suction side, compressing it and discharging this high pressure vapor into the condenser.

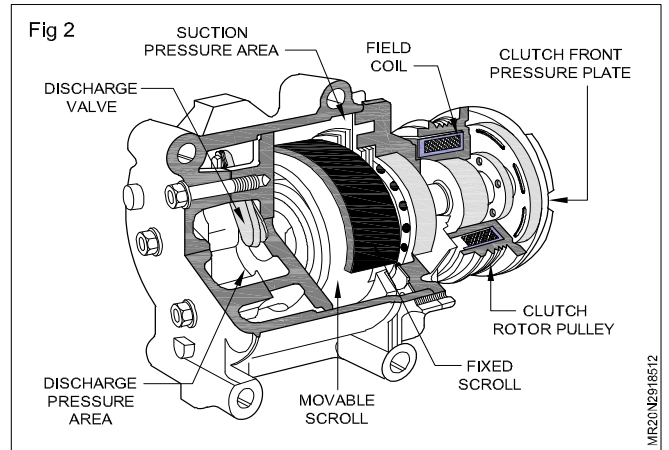


**Compressors**

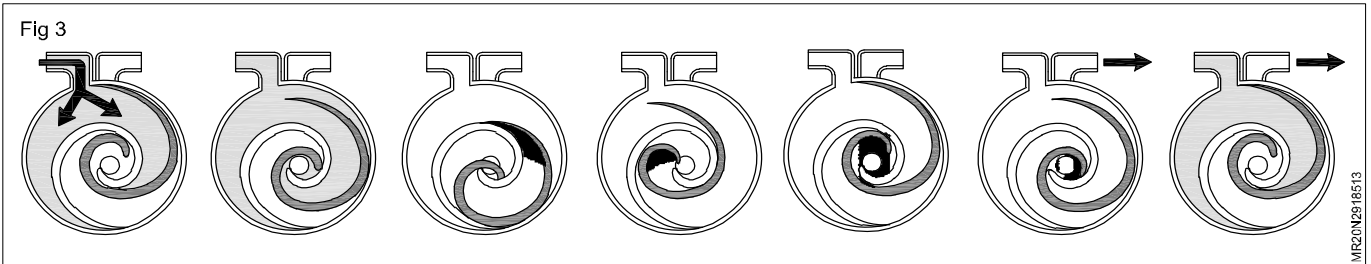
**Scroll type (Fig 2)**

This compressor uses a unique design with two scrolls, one fixed and one is movable, both are inter-leaved.

The movable spiral is able to ORBIT or oscillate without actually fully rotating. The movable scroll is connected to the input shaft via a concentric bearing. As the movable scroll oscillates within the fixed spiral, a number of pockets are formed between the spiral. As these pockets decrease in size the refrigerant is squeezed, the pressure increases and is discharged through a reed valve at the discharge port in the rear section of the compressor.



**Compression Cycle (Fig 3)**

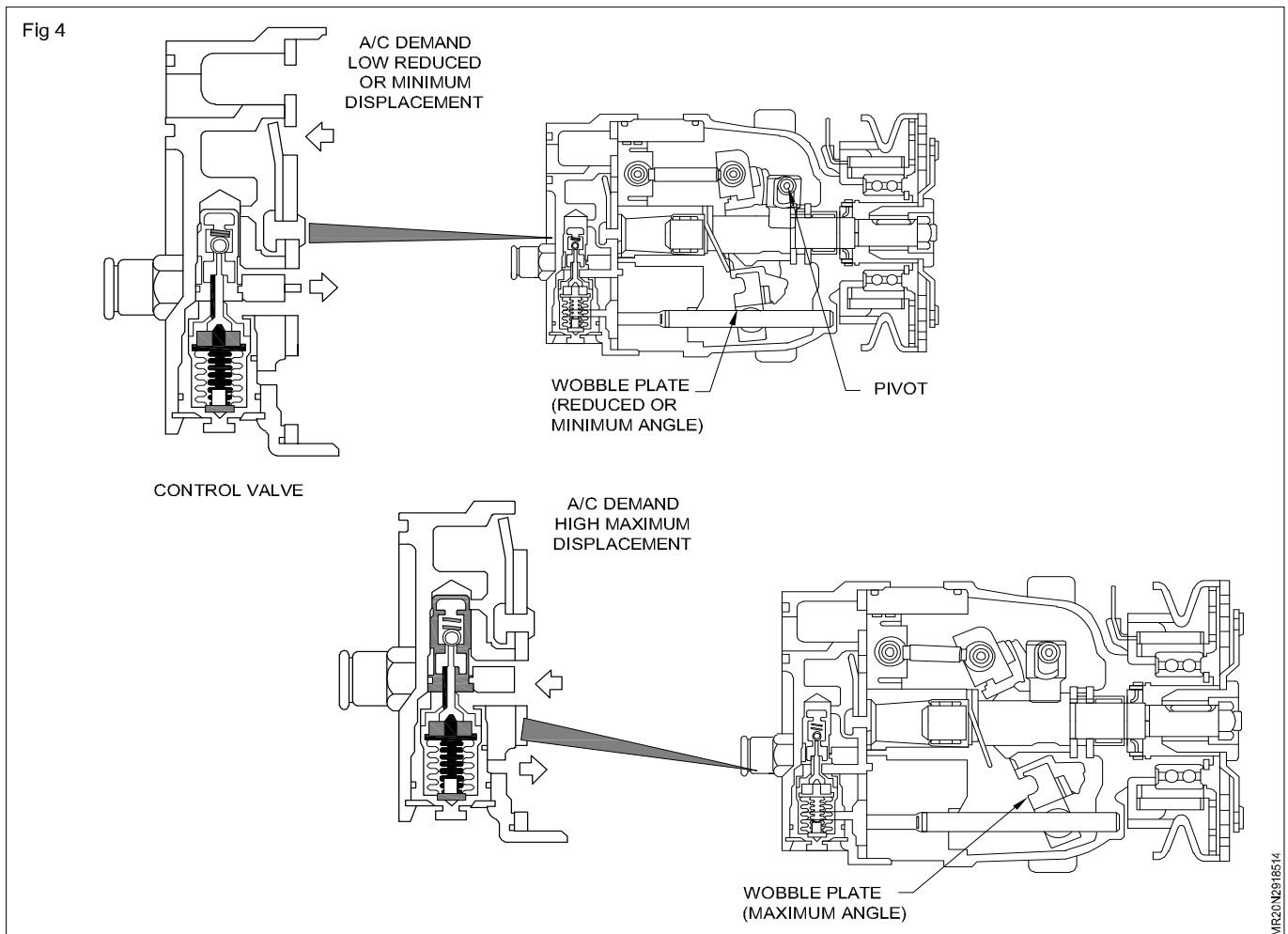


**Compressors**

**Variable stroke - V5 Compressor (Fig 4&5)**

The V5 compressor is a non-cycling variable displacement compressor. The compressor varies displacement to

control capacity to meet A/C system demand at all operating conditions. The compressor features a variable angle wobble plate in five (V5) cylinder axial piston design.



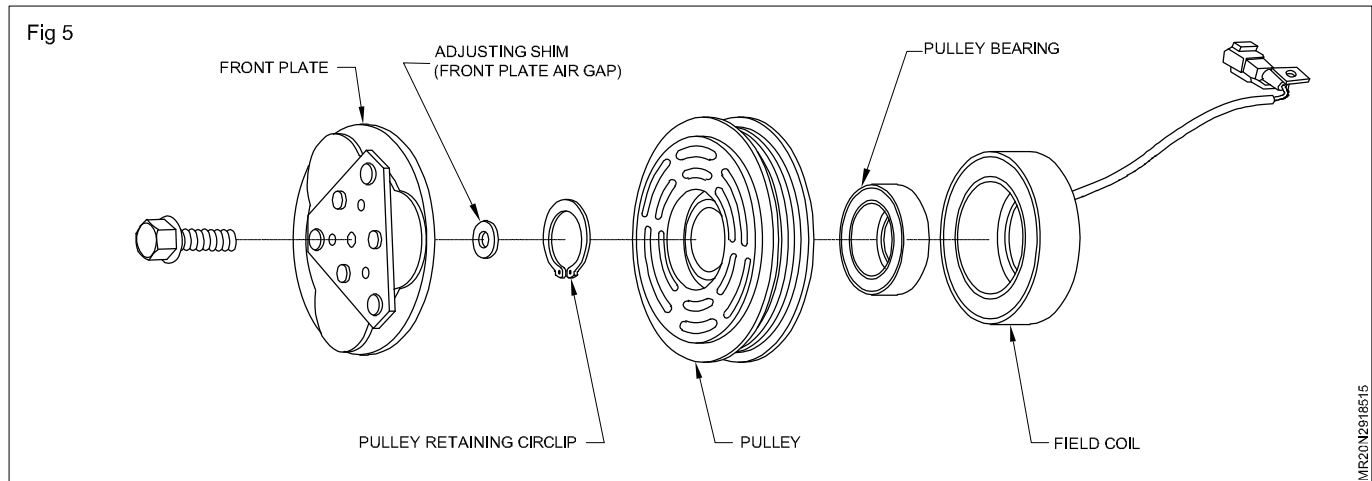
Displacement is controlled by a bellows actuated control valve located in the rear cylinder head. This control valve senses and responds to the system suction pressure or A/C system demand. Through regulation of compressor crankcase pressure, the wobble plate angle, and therefore compressor displacement is variable.

In general, the compressor discharge pressure is much greater than the compressor crankcase. Which is greater than or equal to the compressor suction pressure. At maximum displacement, compressor crankcase pressure

is equal to the compressor suction pressure. At reduced or minimum displacement, the compressor crankcase pressure is greater than the suction pressure.

### Compressor Clutch

The clutch is designed to connect the rotor pulley to the compressor input shaft when the field coil is energized. The clutch is used to transmit the power from the engine crankshaft to the compressor by means of a drive belt.



### Condensers (Fig 6&7)

The Condenser function is to act as a heat exchanger and allow heat to flow from the hot refrigerant to the cooler outside air.

R134a entering the condenser will be a high-pressure high temperature vapor. As the R134a vapor travels through the tubes of the condenser heat is given off to the cooler ambient air; the refrigerant vapor condenses and changes to a liquid state.

At this point a large amount of heat is given off by the R134a. The refrigerant will now be a hot, high pressure liquid.

#### Design types

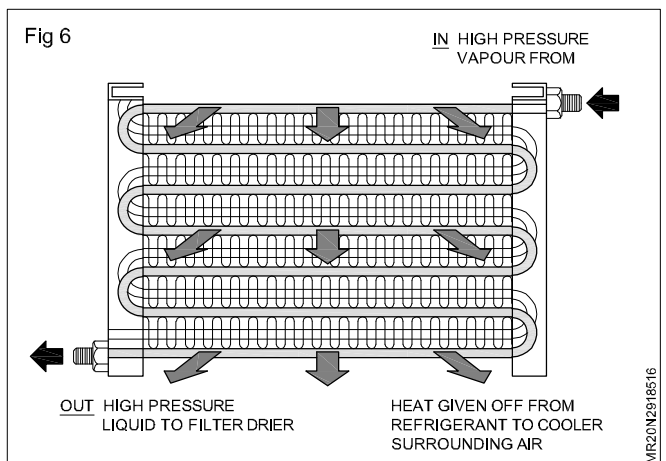
##### Serpentine

This type of condenser consists of one long tube which is coiled over and back on itself with cooling fins in between the tubes.

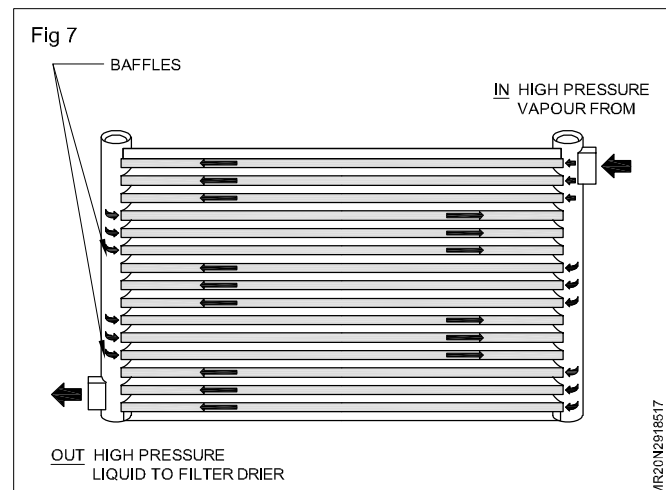
Parallel flow design (Recommended for R134a)

This design is very similar to a cross flow radiator. Instead of refrigerant travelling through one passage (like serpentine type), it can now travel across numerous passages. This will give larger surface area for the cooler ambient air to contact.

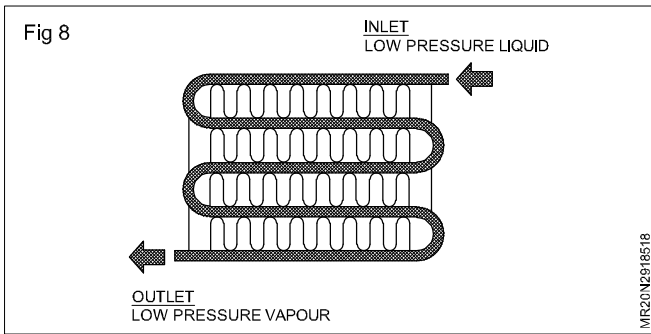
### Serpentine flow



### Parallel flow



## Evaporator (Fig 8)



The evaporator unit where the cooling effect is obtained is usually located inside the passenger compartment below the dashboard. A high capacity blower circulates the air in the car interior across the evaporator coils, and this drops the temperature of the air inside the passenger compartment. The heat picked up by the refrigerant goes back to the compressor in the vapour form, where the refrigerant is again compressed and the cycle goes on.

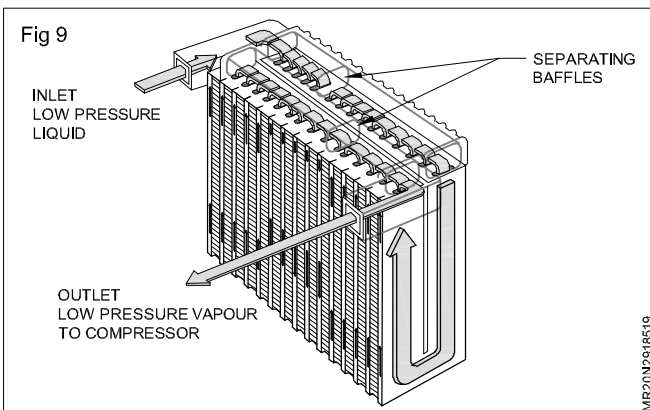
### Design types

#### Serpentine

This type of evaporator consists of one long tube which is coiled over and back on itself with cooling fins in between the tubes. Same design as the serpentine condenser but approximately five times deeper.

#### Plate & Fin Laminated Evaporators (Fig 9)

Similar operation to the parallel flow condenser where the refrigerant has a multi flow pass creating a large surface area.



Most manufacturers prefer to use the plate and fin design for R134a because of 20% performance increase over the serpentine design.

### Thermal Expansion Valves (Fig 10)

Refrigerant flow to the evaporator must be controlled to obtain maximum cooling, while ensuring that complete evaporation of the liquid refrigerant takes place. This is accomplished by the thermal expansion valve (TXV).

- 1 From Filter Drier
- 2 To Evaporator Inlet
- 3 Capillary tube
- 4 Metering Orifice

- 5 Ball Valve
- 6 Spring
- 7 Diaphragm
- 8 Refrigerant
- 9 Pressure Compensating Tube

### Pressures in control (Fig 11 to 12)

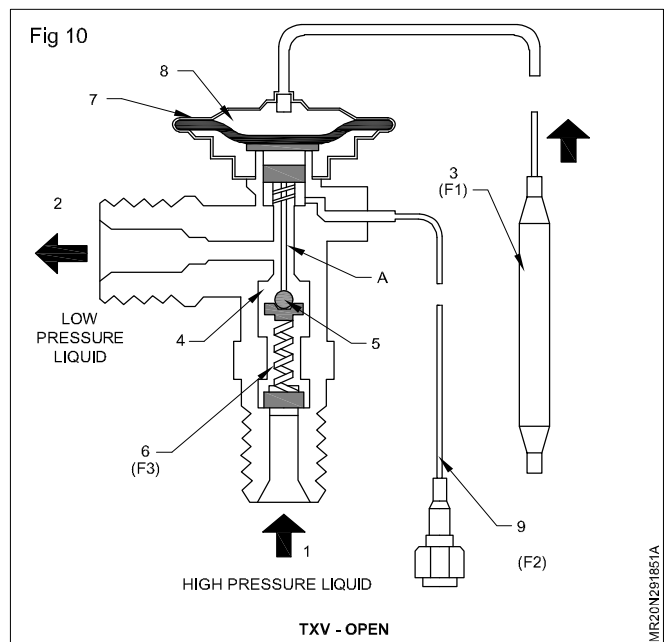
As shown in the illustration, the TXV controls the refrigerant flow by using a system of opposing pressures which will call:

F1 - Temperature sensing capillary tube Sealed tube filled with refrigerant. This refrigerant is also filled above the diaphragm (7). The capillary tube sensing bulb (3) is attached to the evaporator outlet tube surface.

F2 - Pressure compensation tube This is a hollow tube connected to the evaporator outlet tube and senses the pressure of the R134a refrigerant leaving the evaporator coil. (Other TX valves may not use this tube as pressure is provided internally within the valve).

F3 - Pressure spring

This spring (6) is located under the ball valve (5).

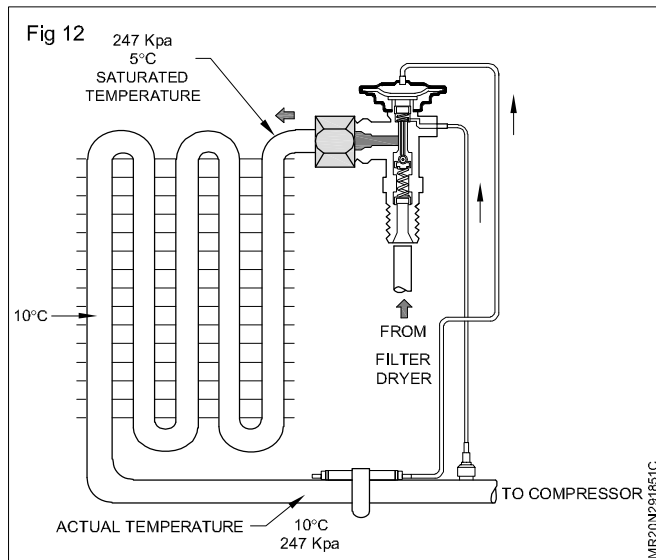
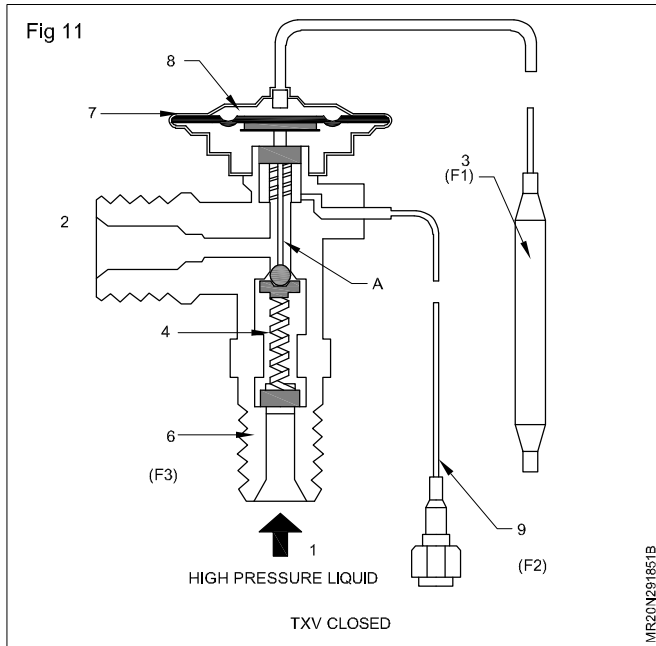


**Operation Open:** When the evaporator outlet tube temperature increases, the refrigerant (3) in the capillary tube expands, forcing the diaphragm (7) downwards and thus pushing pin (A) also downwards causing the ball valve (5) to move away from the metering orifice (4), allowing more R134a to enter the evaporator inlet side.

#### Closed

As the evaporator outlet tube becomes cooler, the refrigerant in the capillary tube

(3) contracts. Forces F2 and F3 cause the diaphragm (7) and pin (A) to move upward allowing the ball valve to move towards the metering orifice (4), restricting the R134a flow. The outlet tube gets warmer and the process starts over.



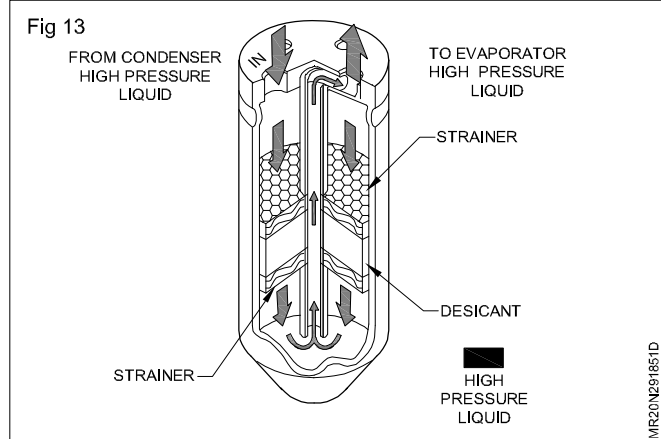
### Filter Drier Receiver (Fig 13)

The filter drier acts as a particle filter, refrigerant storage container and most importantly moisture absorber.

Moisture, temperature and R134a causes hydrofluoric and hydrochloric acid. The silica gel beads (desiccant) located in the FDR absorb small quantities of moisture thus preventing acid establishment.

Most R134a filter dryers have NO sight glass. This is because at approximately 70°C refrigerant temperature the PAG oil will foam giving a false impression of low gas charge. If the FDR does utilize a sight glass ensure correct diagnosis when viewing.

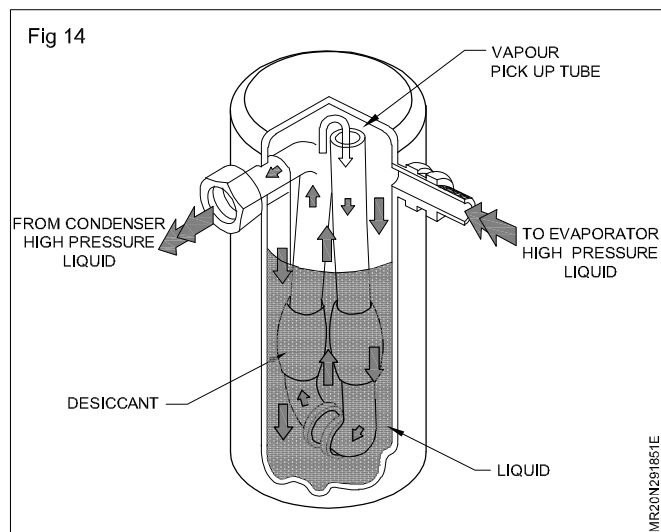
**Note: Ensure the connection indicated with the word "IN" is connected to the condenser outlet.**



### Accumulator (Orifice Tube System) (Fig 14)

The function of the accumulator is to store refrigerant, filter particles, absorb moisture and separate vaporous R134a from liquid R134a.

The normal process of the Orifice Tube system works when R134a leaves the evaporator coil as a mixture of vapor and liquid. This liquid enters the accumulator and falls to the bottom. The vapor rises to the top and continues onto compressor. The liquid R134a in the bottom of the accumulator gradually vaporizes off. This vapor rises, then pulls into the compressor.



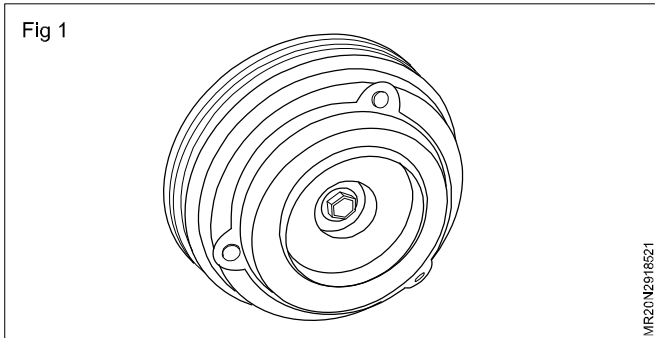


# Compressor clutch

**Objectives:** At the end of this lesson you shall be able to

- details of compressor clutch
- magnetic clutch operation, freewheeling (de engaging clutch)
- servicing and testing magnetic clutch operation.

**Compressor Clutch and its operation:** A compressor clutch provides the means of torque transfer from the engine Front End Accessory Drive to the compressor rotating assembly. **Electromagnetic clutches** operate electrically but transmit torque mechanically. (Fig 1)



The ability of the clutch to engage and disengage is critical on several levels.

Firstly, to stop compressor operation when the cooling demand in the cabin is satisfied. If not disengaged when this occurs a phenomena known as "evaporator freeze" happens. Airflow becomes obstructed under these conditions.

Secondly there are conditions that occur in an AC system of which the compressor operation needs to cease, such as

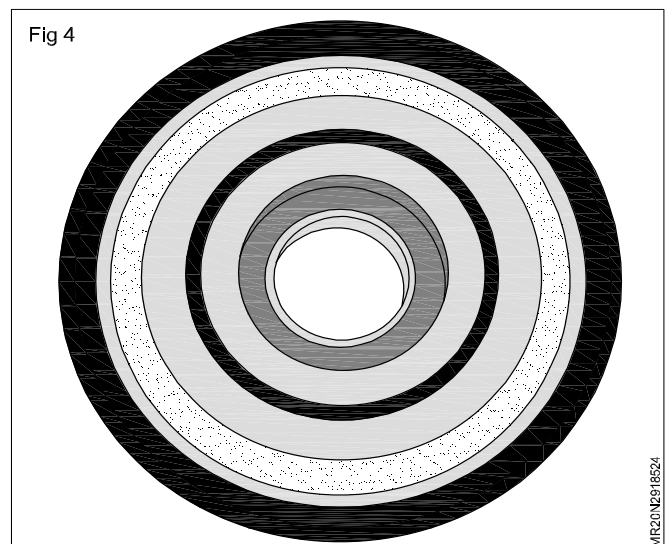
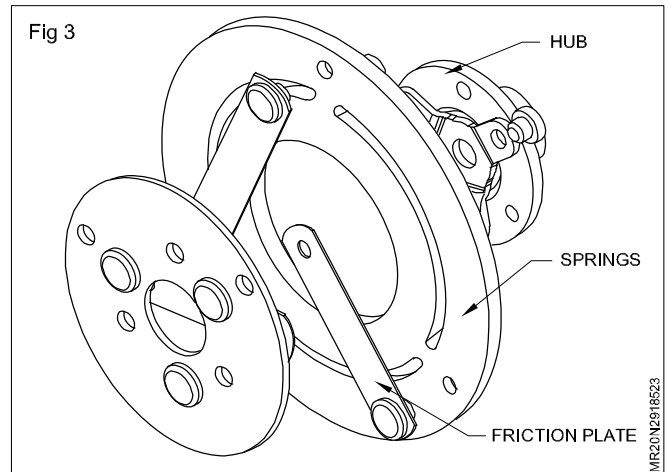
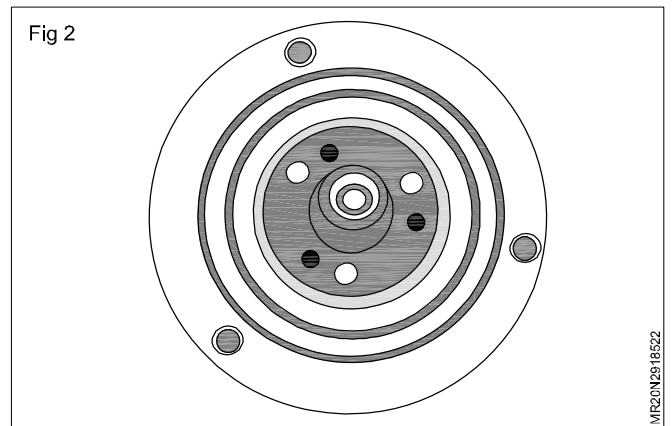
- 1 Excessive Discharge Pressure & temperature
- 2 Low Refrigerant Charge
- 3 Low suction pressure & temperature.

**A AC compressor clutch has three key components; they are (Figs 2 to 5)**

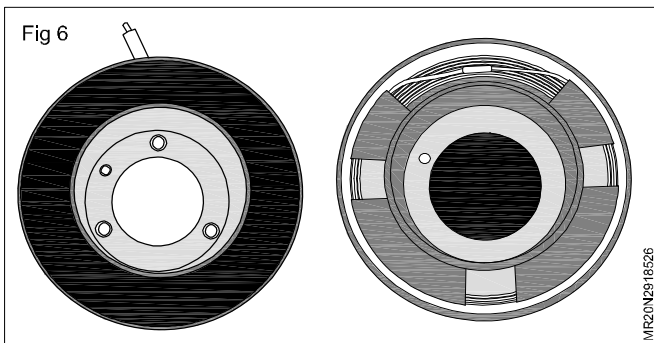
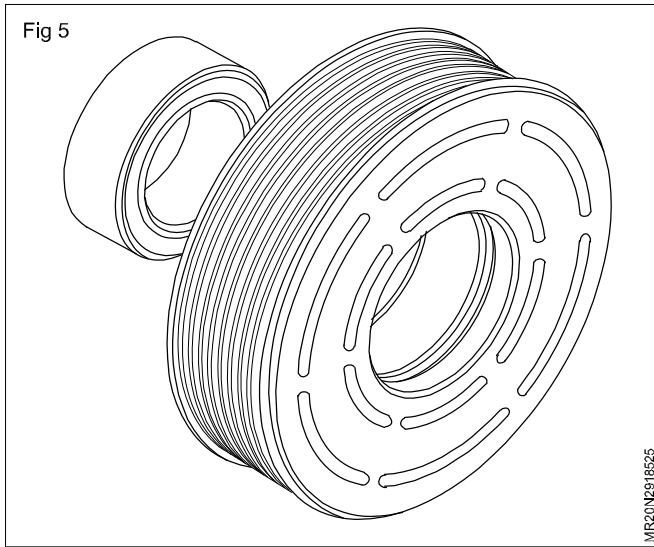
- 1 Armature - coupled directly to the compressor shaft to transfer the rotational torque from the pulley to the compressor
- 2 Rotor or Pulley - Belt driven and coupled to the engine drive train
- 3 Coil - Electrically connected to the AC relay and produces an electromagnetic field when energized.

**Armature:** Coupled to the compressor shaft using either a key or a spine. It's comprised of several parts, first the hub which connects to the compressor. Second the springs which connect the hub to the friction plate, these "springs" can be steel or rubber. Lastly the friction plate which mates directly to the pulley friction surface.

**Rotor:** Normally mounted on the compressor nose, the rotor is connected to the accessory drive using the drive belt. It has two basic parts, the rotor and the rotor bearing which is a sealed two-row bearing.



**Coil:** Normally mounted on the compressor body the clutch coil provides the electromagnetic field which attracts the armature when energized. As shown on the bottom picture it is simply a continuous wrap of copper wire which produces a strong magnetic field. The copper wire is wound on a plastic "bobbin" and then inserted into a steel can. Epoxy is then deposited resulting in a water resistant component.

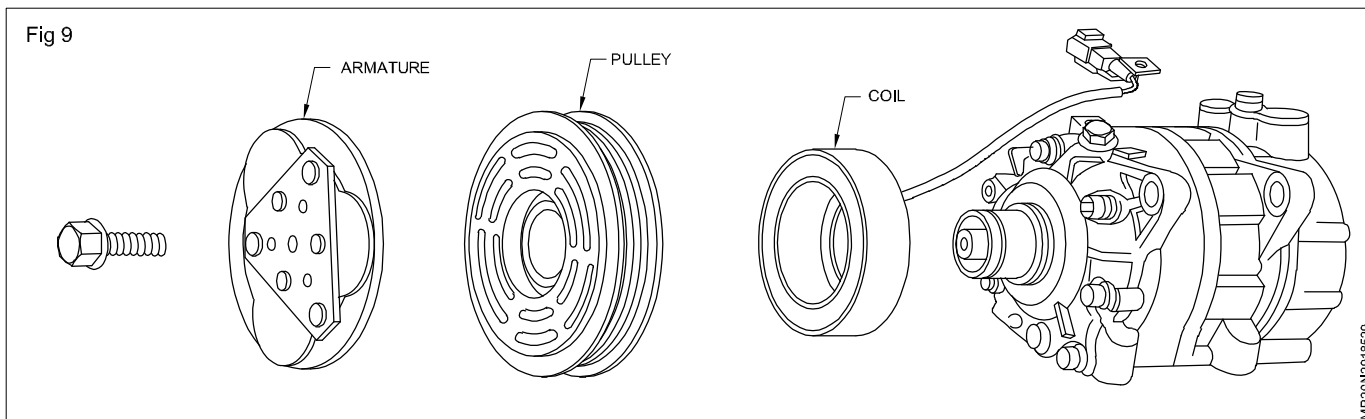
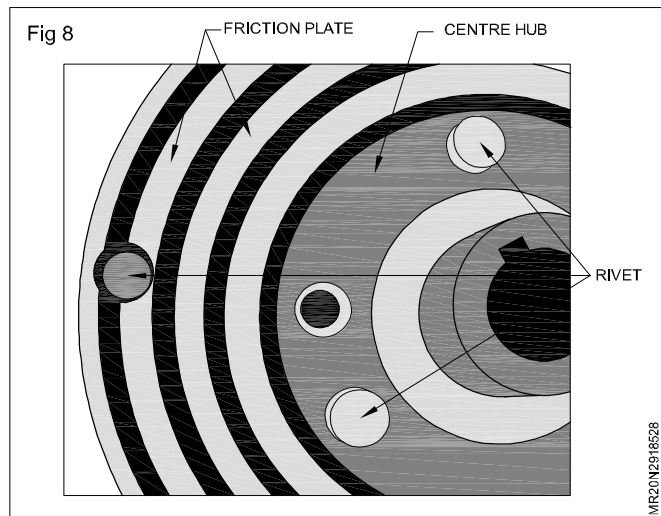
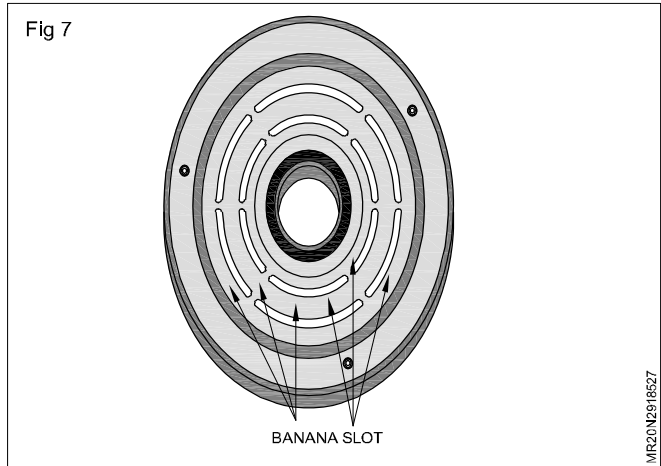


Let it be a coil of a horseshoe magnet with a north and south pole. Lines of magnetic flux extend perpendicular to the circular pulley. When energized the flux field overcomes the air gap between the armature and pulley which pulls the armature into contact with the pulley friction surface. Once contacted the magnetic force and friction between the surfaces results in the armature turning until fully moving at the same speed as the pulley. The lines of flux actually pass into the rotor and in turn attract and pull the armature into contact to complete the clutch engagement. The "banana" slots in the pulley allow the passage of these north / south magnetic flux to the armature. (Fig 6)

**freewheeling (de engaging clutch) (Figs 7 to 9)**

The clutch is designed to connect the rotor pulley to the compressor input shaft when the field coil is energized. The clutch is used to transmit the power from the engine crankshaft to the compressor by means of a drive belt.

When the clutch is not engaged the compressor shaft does not rotate and refrigerant does not circulate the rotor pulley free wheels. The field coil is actually an electromagnet, once energized it draws the pressure plate towards it, locking the rotor pulley and the pressure plate together causing the compressor internals to turn, creating pressure and circulating refrigerant.



# Check and replace magnetic clutch and electrical wiring of automobile A.C

**Objectives :** At the end of this lesson you shall be able to

- explain the function of magnetic clutch
- explain the operation of magnetic clutch
- explain purpose of using bearing in the clutch mechanism
- when to replace the bearing
- explain the purpose of battery
- explain the purpose of blower switch
- explain the purpose of HP-LP switch
- explain the electrical components how they connected in the circuit.

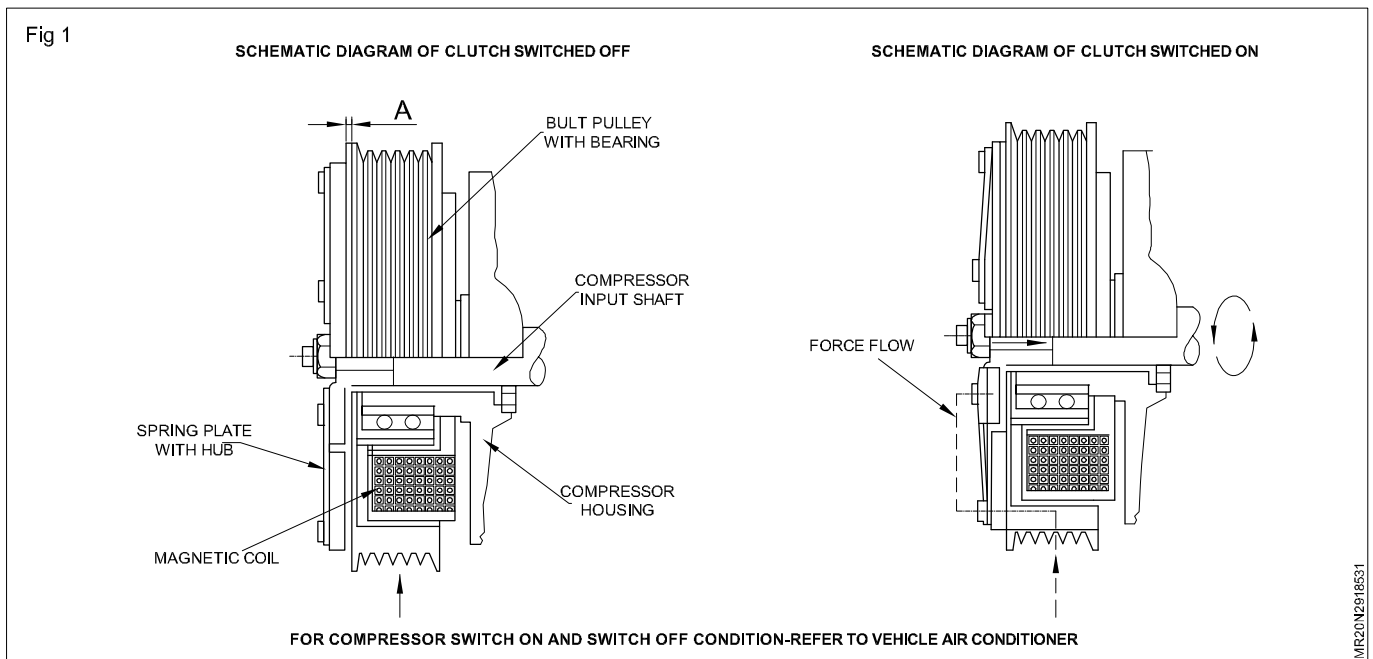
## Function of magnetic clutch (Fig 1)

The vehicle engine drives the belt pulley (arrow) by means of the ribbed V-belt. The belt pulley rotates freely when the compressor is switched off.

When the compressor is turned on, voltage is supplied to at the magnetic coil. A magnetic force field is created. This force field draws the spring plate towards the rotating belt pulley (the open space "A" is bridged) and makes a connection between the belt pulley and the shaft of the compressor.

The compressor runs on until the electrical supply to the magnetic coil is present. When it is open the spring plate is then retracted by the belt pulley by means of springs. the belt pulley again runs without driving the compressor shaft.

**Operation:** When the voltage is applied to the clutch field coil, the clutch plate (which is connected to the compressor shaft) is drawn into contact with the pulley and the compressor rotates. When voltage is disconnected from the clutch field coil the clutch plate is released and the compressor ceases to rotate.



## Purpose of bearing in the clutch mechanism

When clutch engage with compressor pulley heavy friction is occurring, to reduce the friction of the pulley rotation. Provided "bearing clutch mechanism".

## Replacing of bearing

When bearing damage or noise will heard it must change the bearing.

## Magnetic clutch

The drive train is connected between the compressor and vehicle engine while the engine is running by means of the magnetic clutch.

## Design

The clutch comprises

- Belt pulley with bearing
- Spring plate with hub
- Magnetic coil

The hub of the spring plate is permanently mounted the compressor input shaft. The belt pulley is mounted in a pivot bearing on the housing of the compressor at the shaft output. The magnetic coil is permanently connected to the compressor housing. There is an open space "A" between the spring plate and the belt pulley.



## Battery

Electrical energy to operate the blower motor, compressor etc.

## Blower switch

To adjust blower speeds.

## HP switch

If refrigerant pressure gets too high it can cause air conditioning system damage, some vehicles have a high pressure cut off switch designated to shut the system off if pressures get too high.

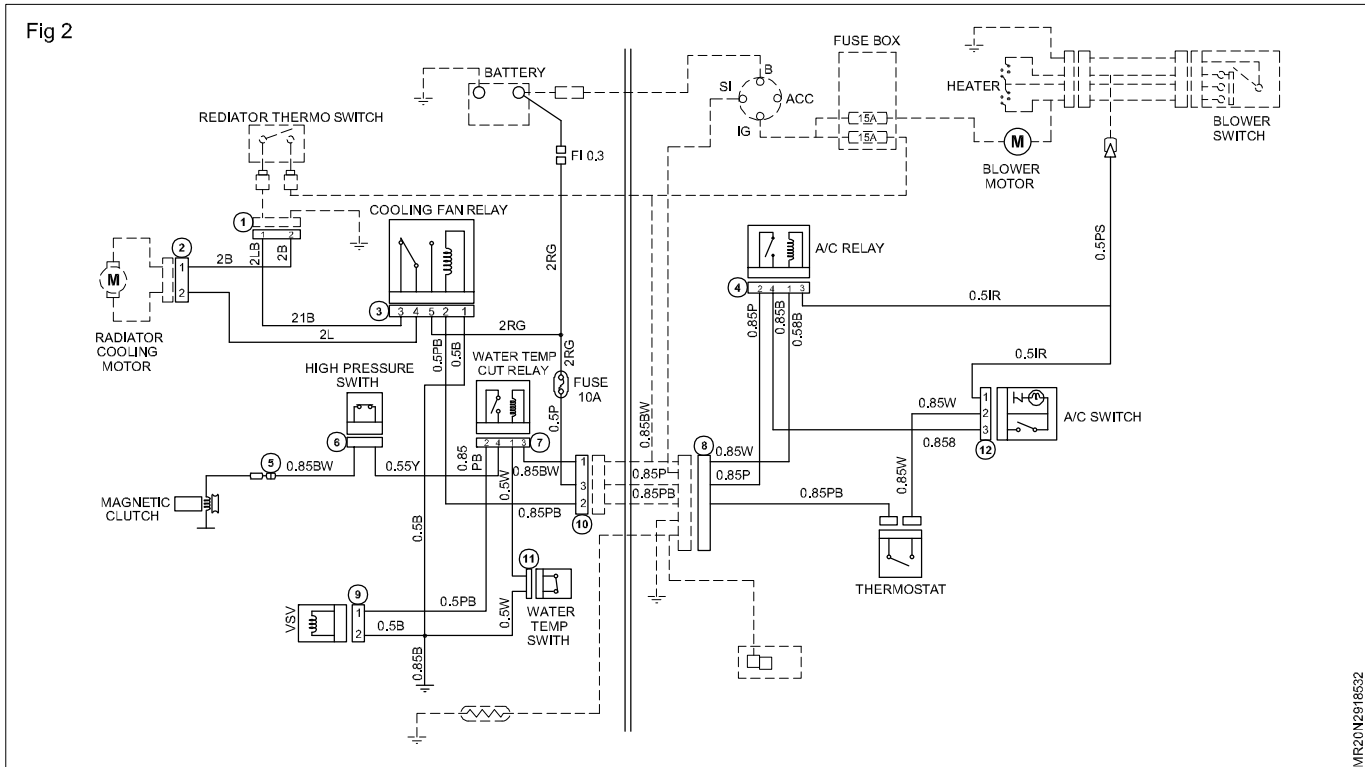
Once pressures drop back to normal, the compressor kicks back in.

## LP-switch

These switches shut the compressor down when refrigerant levels drop too low. Since the air conditioning systems use their refrigerant to carry lubrication, running the system without an adequate charge can cause compressor damage.

## Wiring circuit

The above electrical components are connected in the circuit which is shown in Fig 2.



## Wiring of Automobile AC

**Objectives:** At the end of this lesson you shall be able to

- wiring of Automobile A/C
- resistance Circuit of Blower Motor
- compressor Cycling Controls.

### Wiring A/C System

**Control/Wiring layout (Series Connection) (Figs 1 to 5):** Pressure switches are connected in series with the compressor clutch. If an "under" or "over" system pressure occurs the pressure switch will "open circuit" breaking the circuit to the compressor clutch.

With electronic fuel injected vehicles the ELECTRONIC CONTROL MODULE (ECM) is usually interconnected into the A/C wiring circuit. When the A/C switch is engaged a request signal is sent to the ECM, if the A/C circuit is intact, i.e. the pressure switches are at closed circuit, the ECM activates a relay by creating an earth and power is supplied to the compressor clutch. Also an RPM increase generally takes place to avoid engine stall whilst at idle.

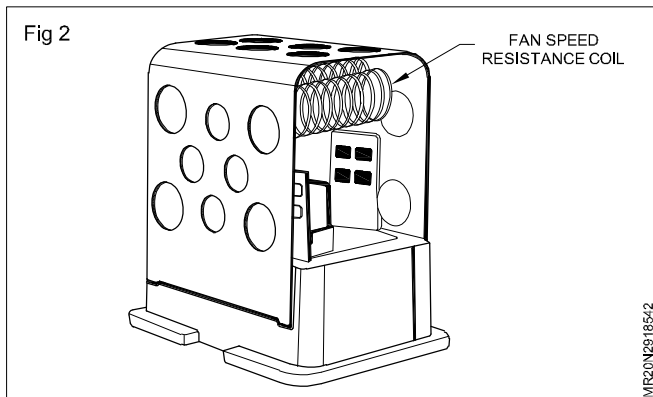
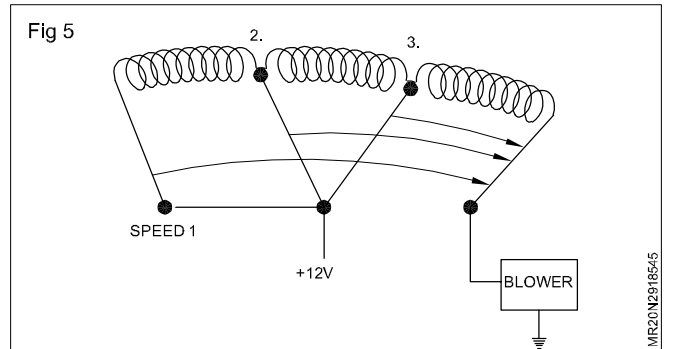
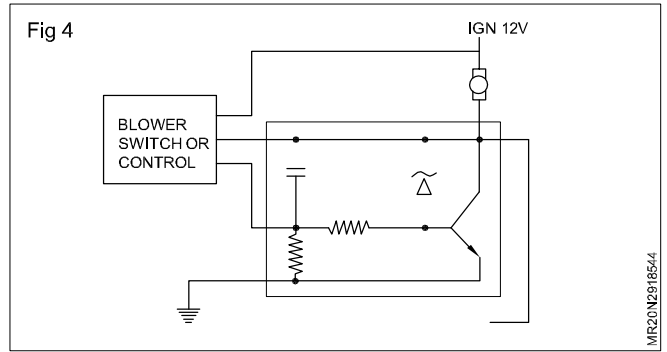
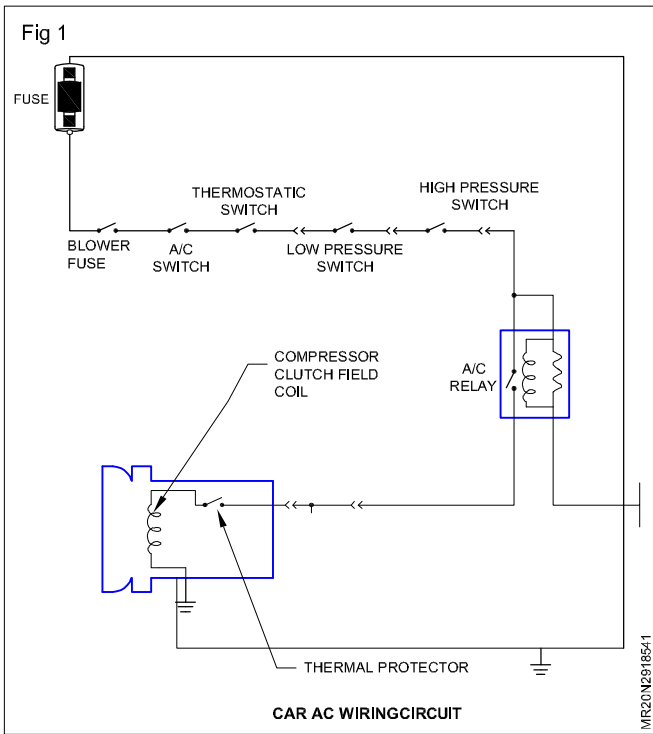
### Blower Speed Controls

#### Coil type

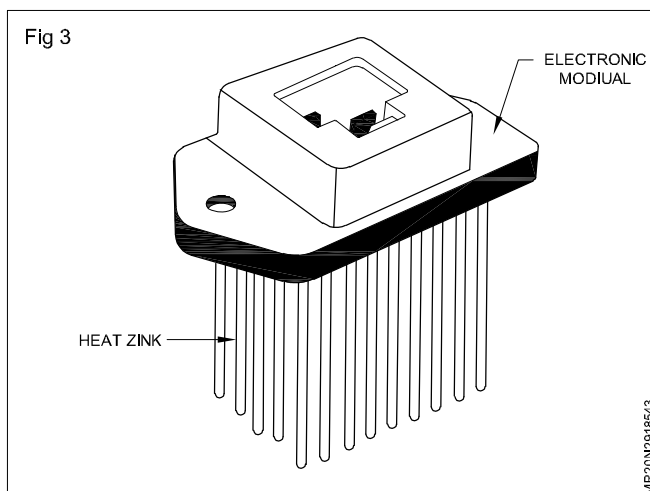
This blower speed regulator simply consists of coiled wires connected in series. These coiled wires are of varied thickness. The current flows through either one or a combination of all the coils. The resistance of the coil(s) alter the blower speeds.

The highest blower speed when selected is normally from direct battery voltage via a relay.

**Electronic:** The function of the electronic controller is to convert low current signals from the ECM to a higher current, varying the voltage to the blower motor. Blower speeds may be infinity variable and usually can use up to 13 speeds.



This type of speed controller is normally used with the electronic climate control (ECC) system. The highest blower speed when selected is normally from direct battery voltage via a relay.



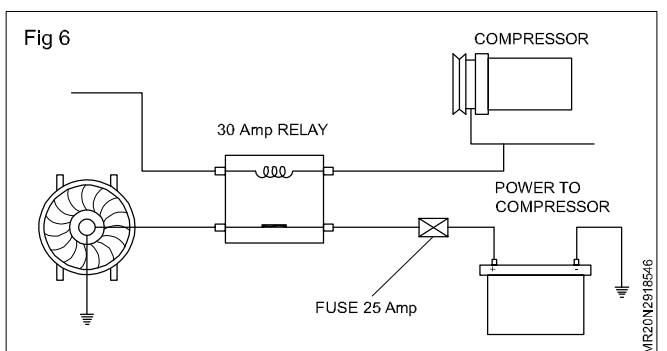
**Condenser electric fan:** Most vehicles with air conditioning require an electric fan to assist air flow, either pushing or pulling the air through the condenser, depending on which side of the condenser the fan is placed.

The majority of vehicles using R134a require this additional condenser cooling due to the higher operating pressures of R134a. Also most modern vehicles now have smaller grilles or bumper bar openings. This causes poor air flow conditions especially by the amount of air flow over the condenser.

The condenser fan is operated with A/C engaged in various ways:

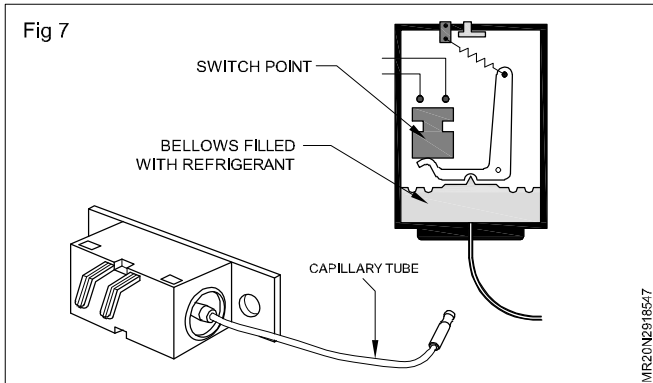
- Medium pressure switch;
- Indirect connection to the compressor clutch
- Via the Electronic Control Module (ECM);
- Signal from the A/C switch activation.

### Compressor Cycling Controls (Figs 6 to 8)

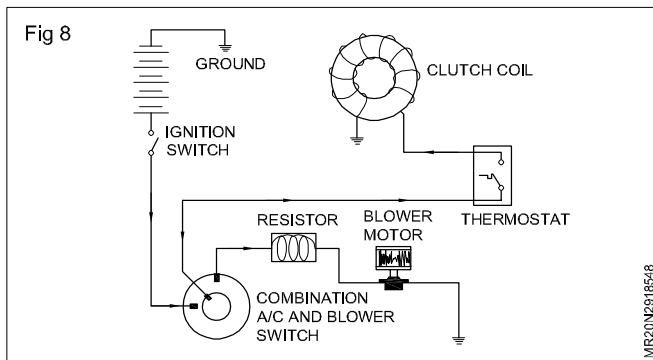


**Thermostatic switch (Anti ice-up device):** The thermostat is connected in series to the compressor clutch. When the temperature of the evaporator coil approaches freezing this temperature is sensed by the thermostat capillary tube which is in contact with the evaporator fins. The capillary tube contains refrigerant which expands or contracts depending on the temperature on this tube. The points inside the thermostatic switch open up when the refrigerant in the capillary tube contracts (sensing a cold evaporator coil) and interrupt the A/C

electrical circuit turning the compressor off. When the evaporator temperature rises again to a preset point (4 - 5?) the thermostat points then close. The refrigerant in the capillary tube has expanded (sensing a warmer evaporator coil and the electrical circuit is re-established to the compressor clutch.



**Electrical circuit**



**Thermistor and Amplifier:** This has the same function as the thermostatic switch except rather than mechanical action with contact points and capillary tube, the thermistor and amplifier is electronically activated. The thermistor is a sensing probe but unlike the thermostat capillary tube it senses the air temperature coming off the evaporator coil.

**Thermistor**

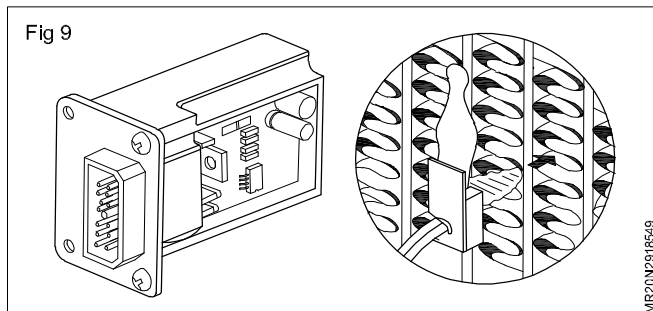
Electrical wiring containing a sensor which is a NTC resistor.

(Negative Temperature Co-efficient).

**Amplifier (Fig 9)**

A small electronic device containing a circuit board and electrical components.

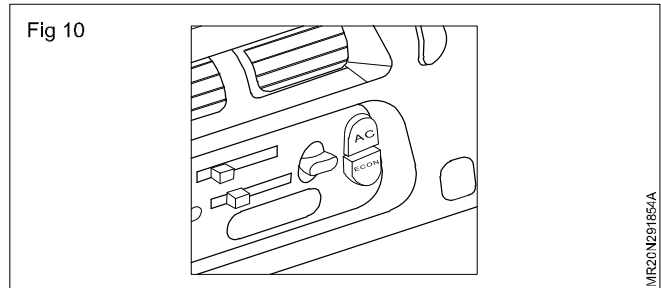
Thermistor resistance is amplified and used to control or switch the A/C clutch on or off.



**Economy mode (Fig 10)**

This function is normally associated with the use of a thermistor amplifier. In economy mode the compressor cut out temperature is set higher than a normal A/C mode. This means the compressor stays on for a lesser time, decreasing engine load and improving fuel economy and engine performance.

Center vent temperatures will also be slightly higher due to the compressor cycling off at a higher evaporator temperature.



**Pressure cycling switch - Electrical (Fig 11)**

Some vehicles using the Cycling Clutch Orifice Tube (CCOT) system utilize a pressure switch located in the low side of the A/C system between the evaporator and compressor for compressor control.

This pressure switch is electrically connected in series with the compressor clutch.

Once the low side pressure reaches approximately 200 kPa, the compressor clutch is deactivated by the pressure switch opening. A low side pressure of approximately 200 kPa corresponds to an evaporator coil temperature of approximately + 0.40C (above freezing point).

Once the compressor is deactivated the low pressure rises followed by the evaporator coil temperature rising. At a pre-determined low pressure point, the pressure switch reactivates the compressor clutch. The evaporator temperature lowers again and the compressor re-engages.

**Note: Normally a low pressure cut off switch is not used with a pressure cycling switch as the pressure cycling switch is located on the low side. It serves as a low pressure cut off also.**

