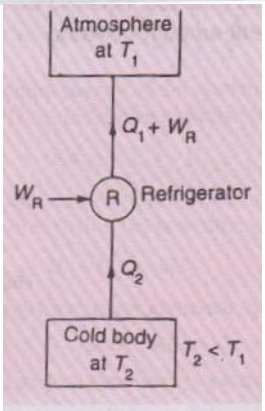
5. Car Heating, Ventilation and Air conditioning system (HVAC)

1. Fundamentals of Refrigeration and air conditioning.

A vapour compression refrigeration system* is an improved type of air refrigeration system which a suitable working substance, termed as refrigerant, is used. It condenses and evaporates at temperature and pressures close to the atmospheric conditions. The refrigerants, usually, used for this purpose are ammonia, carbon dioxide and sulphur dioxide. The refrigerant used, does not leave the system, but is circulated throughout the system alternately condensing and evaporating. In evaporating, the refrigerant absorbs its latent heat from the brine** (salt water) which is used for circulating around the cold chamber. While condensing, it gives out its latent heat to the circulating water of the cooler. The vapour compression refrigeration system is, therefore, a latent heat pump, as it pumps latent heat from the brine and delivers it to the cooler.

The vapour compression refrigeration system is now-a-days used for all purpose refrigeration. It is generally used for all industrial purposes from a small domestic refrigerator to a big air conditioning plant.

2. *Clausius Statement.* According to Clausius statement "*It is impossible for a self acting machine, working in a cyclic process, to transfer heat from a body at a lower temperature to a body at a higher temperature without the aid of an external agency.*" In other words, heat cannot flow itself from a cold body to a hot body without the help of an external agency (*i.e.* without the expenditure of mechanical work).



(*b*) Refrigerator.

The **performance of refrigerator and heat pump is measured in terms of coefficient of performance which is defined as the ratio of the maximum heat transferred (*i.e.* heat taken from the cold body) to the amount of work required to produce the desired effect. Mathematically, maximum coefficient of performance for a refrigerator,

$$(\text{C.O.P})_R = \frac{Q_2}{W_R} = \frac{Q_2}{Q_1 - Q_2} = \frac{T_2}{T_1 - T_2}$$

2. Description of vapour compression cycle with components in the circuit

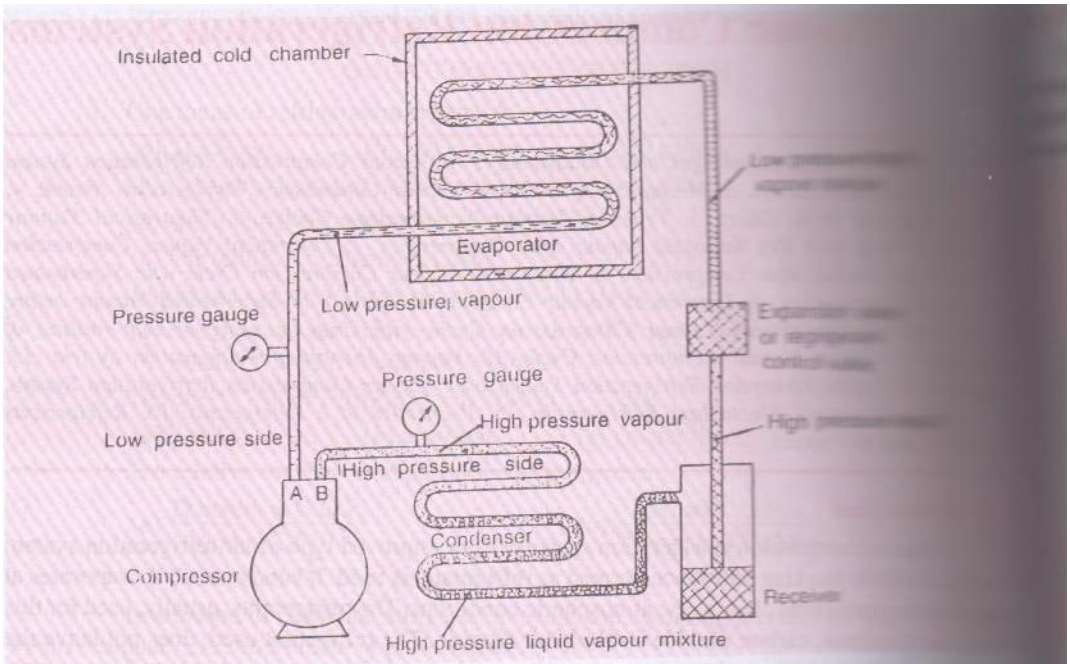


Fig. 36.1. Simple vapour compression refrigeration system.

Fig. 36.1 shows the schematic diagram of a simple vapour compression refrigeration system. It consists of the following five essential parts :

1. *Compressor.* The low pressure and temperature vapour refrigerant from evaporator is drawn into the compressor through the inlet or suction valve *A*, where it is compressed to high pressure and temperature. This high pressure and temperature vapour refrigerant is discharged to the condenser through the delivery or discharge valve *B*.

2. *Condenser.* The condenser or cooler consists of coils of pipe in which the high pressure and temperature vapour refrigerant is cooled and condensed. The refrigerant, while passing through the condenser, gives up its latent heat to the surrounding condensing medium which is usually air or water.

3. *Receiver.* The condensed liquid refrigerant from the condenser is stored in a vessel known as receiver from where it is supplied to the evaporator through the expansion valve or refrigerant control valve.

4. *Expansion valve.* It is also called throttle valve or refrigerant control valve. The function of the expansion valve is to allow the liquid refrigerant under high pressure and temperature to pass at a controlled rate after reducing its pressure and temperature. Some of the liquid refrigerant evaporates as it passes through the expansion valve, but the greater portion is vaporised in the evaporator at the low pressure and temperature.

5. *Evaporator.* An evaporator consists of coils of pipe in which the liquid-vapour refrigerant at low pressure and temperature is evaporated and changed into vapour refrigerant at low pressure and temperature. In evaporating, the liquid vapour refrigerant absorbs its latent heat of vaporisation from the medium (air, water or brine) which is to be cooled.

Role of Dehydrator:

The refrigerant is stored under pressure in receiver-drier. The refrigerant is passed through dehydrator that removes any traces of moisture present in the system to avoid freezing of moisture at low temperature and thus clogging the lines.

Role of Evaporator:
The evaporator unit where the cooling effect is obtained is usually located inside the passenger compartment below the dash board. 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. It also helps in dehumidification, as warmer air travels through the evaporator coil, the moisture containing the air condenses on its surface.

3. Layout and operation of HVAC.

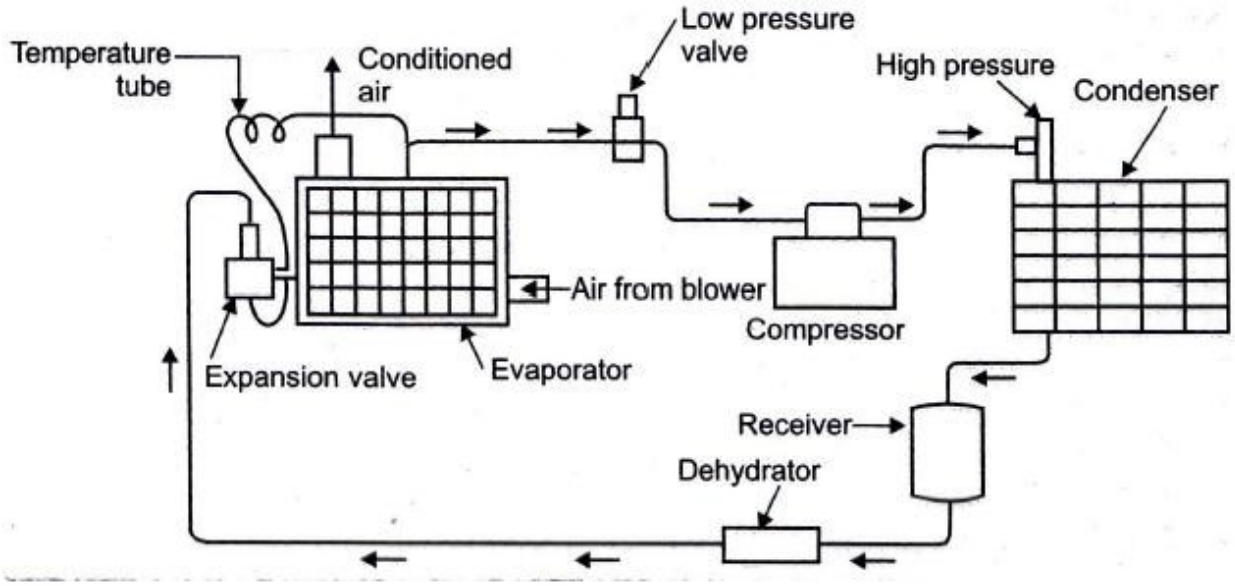


Fig. Car Air Conditioning

4. Type of refrigerants used in car air conditioning and their properties.

The recent research has called for a ban on 'R134a' refrigerant also and to replace the same with CO_2. In addition to the environmental benefits, CO_2 as a refrigerant has also the following advantages :

1. 20% less fuel consumption than today's systems, due to better average efficiency throughout the year.
2. Cooling capacity of the present air conditioning systems is limited by the compressor piston displacement, which itself is limited by the insufficient space in the engine compartment. CO_2 air conditioning systems only need about 13% of the volume flow of an R 134a system, making it possible to use smaller compressors, enabling CO_2 system to cool the passenger compartment faster.
3. As the process is also reversible, unlike today's air conditioners, it also has a heat pump function. This can be used to heat up the vehicle interior very quickly, replacing the electric supplemental heaters that the common with modern direct- injection diesel engines.

It is expected that due to the above clear advantages, CO_2 technology will start replacing present air conditioners soon. 'Luk' has specialised in the development of compressors for the new technology.

Properties of a Refrigerant

A substance which absorbs heat through expansion or vaporisation is termed as a refrigerant. A refrigerant should possess chemical, physical and thermodynamic properties which permit its efficient application in the refrigerating system. An ideal refrigerant should have the following properties:

1. Low boiling point.
2. High critical temperature.
3. High latent heat of vaporisation.
4. Low specific heat of liquid.
5. Low specific volume of vapour.
6. Non-corrosive to metal.
7. Non-flammable and non-explosive.
8. Non-toxic.
9. Easy to liquify at moderate pressure and temperature.
10. Easy of locating leaks by odour or suitable indicator.
11. Low cost.
12. Mixes well with oil.

5. Human comfort conditions.

The four important factors for comfort air conditioning are discussed as below :

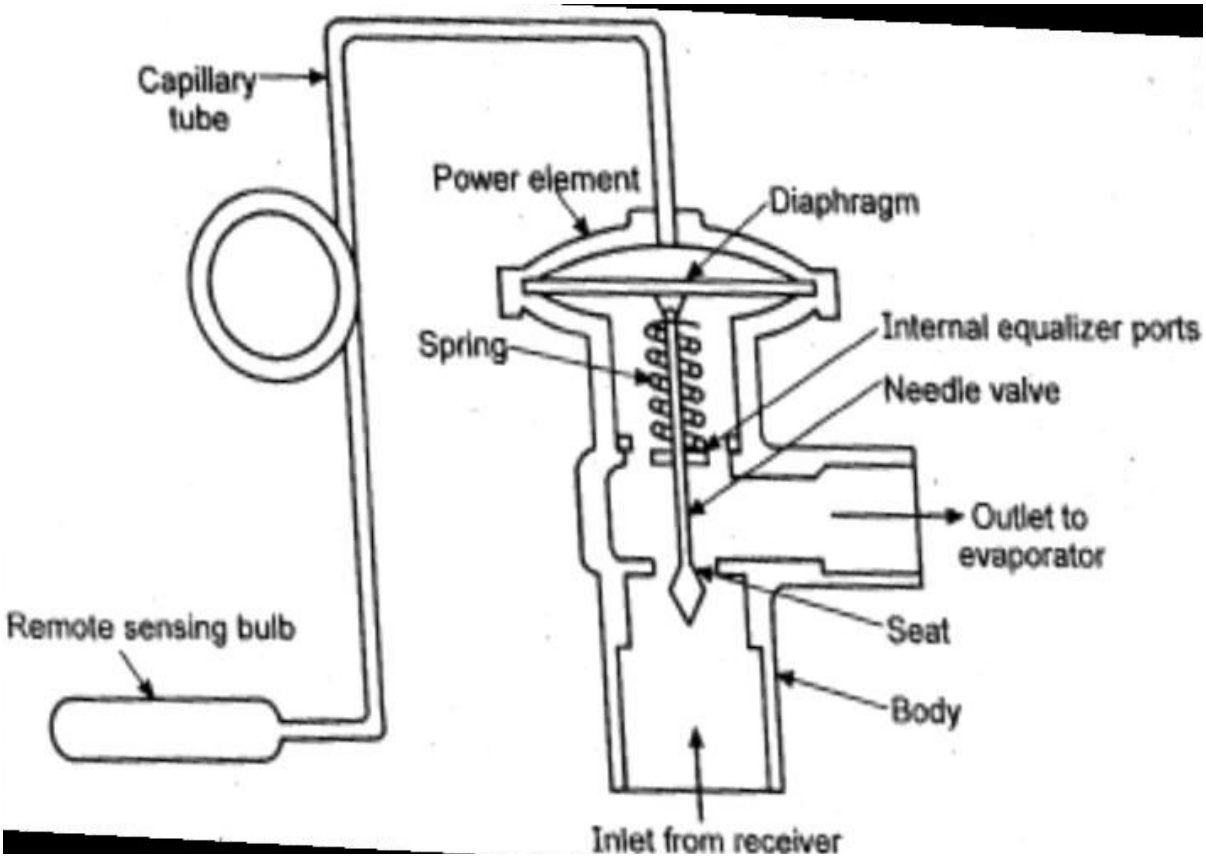
1. *Temperature of air.* In air conditioning, the control of temperature means the maintenance of any desired temperature within an enclosed space even though the temperature of the surrounding air is above or below the desired room temperature. This is accomplished either by the addition or removal of heat from the enclosed space as and when demanded. It may be noted that a human being feels comfortable when the air is at 21° C with 56% relative humidity.

2. *Humidity of air.* The control of humidity of air means the increasing or decreasing of moisture contents of air during summer or winter respectively in order to produce comfortable and healthy conditions. The control of humidity is not only necessary for human comfort but it also increases the efficiency of the workers. In general, for summer air conditioning, the relative humidity should not be less than 60% whereas for winter air conditioning it should not be more than 40%.

3. *Purity of air.* It is an important factor for the comfort of a human body. It has been noticed that people do not feel comfortable when breathing contaminated air, even if it is within acceptable temperature and humidity ranges. It is thus obvious that proper filtration, cleaning and purification of air is essential to keep it free from dust and other impurities.

4. *Motion of air.* The motion or circulation of air is another important factor which should be controlled, in order to keep constant temperature throughout the conditioned space. It is, therefore, necessary that there should be equi-distribution of air throughout the space to be air conditioned.

6. Temperature control system

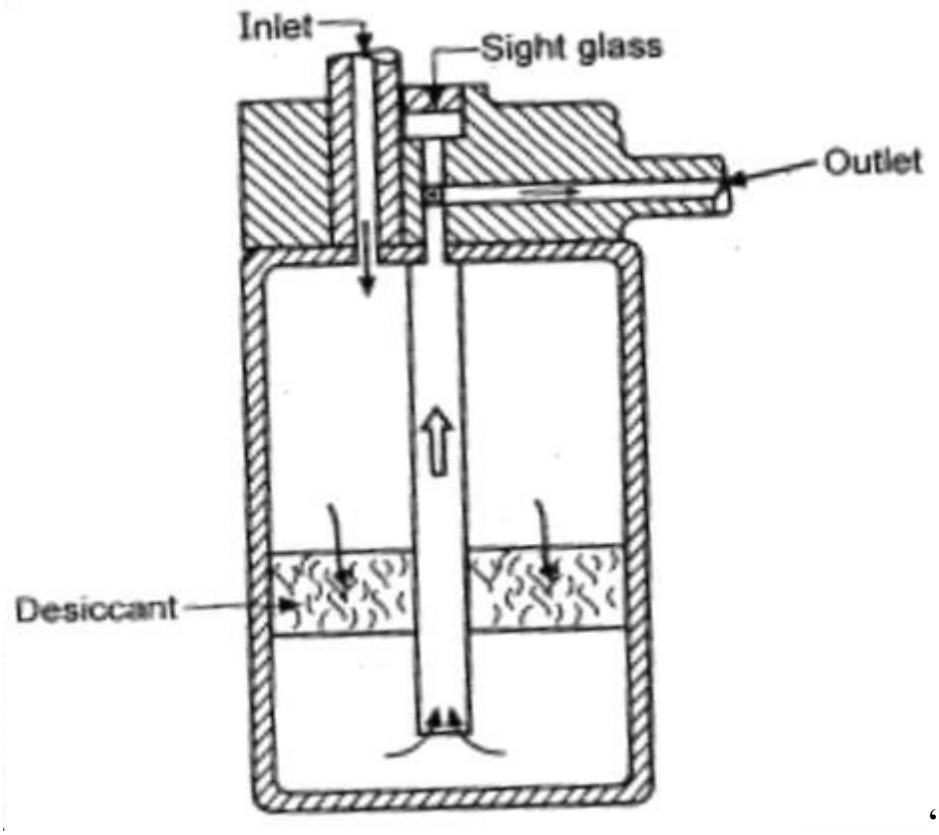


The expansion valve is placed at the evaporator inlet tube. It is used to control refrigerant flow into the evaporator. The expansion valve contains a variable orifice that is controlled by a sensing bulb placed inside the evaporator cooling fins. The sensing bulb is a sealed tube containing a small amount of refrigerant. The changes in temperature of the evaporator cause the refrigerant inside the sensing bulb to expand or contract. The action of the internal pressure of the sensing bulb controls the amount of refrigerant that flows through the expansion valve by varying the size of the orifice.

7. Humidity control

Liquid refrigerant enters through the inlet. Any dirt is filtered by the filter pads and moisture is absorbed from the refrigerant by the desiccant. Any refrigerant vapor that does not liquefy in the condenser, is trapped and held until it condenses. Finally, clean and dry liquid refrigerant leaves the receiver dehydrator and goes to expansion valve.

Evaporator also helps in dehumidification, as warmer air travels through the aluminum fins of cooler evaporator coil, the moisture content in the air condenses on its surface.


Inlet
Sight glass
Outlet
Desiccant