Refrigeration

- It is defined as the process of providing and maintaining a temperature well below that of surrounding atmosphere.
- In other words refrigeration is the process of cooling substance.

Terminologies of Refrigeration

Refrigerating Effect (N): It is defined as the quantity of heat extracted from a cold body or space to be cooled in a given time.

$$N = \frac{\text{Heat extracted from the cold space}}{\text{Time taken}}$$

Specific Heat of water and ice : It is the quantity of heat required to raise or lower the temperature of one kg of water (or ice), through one kelvin or (1^0 c) in one second.

Specific heat of water, C_{pw} = 4.19 kJ/kg K

Specific heat of ice, C_{pice} = 2.1 kJ/kg K.

Terminologies of Refrigeration

Capacity of a Refrigeration Unit :

- Capacity of a refrigerating machines are expressed by their cooling capacity.
- The standard unit used for expressing the capacity of refrigerating machine is ton of refrigeration.
- **One ton of refrigeration** is defined as, "the quantity of heat abstracted (refrigerating effect) to freeze one ton of water into one ton of ice in a duration of 24 hours at 0^o c".

Heat extracted from at 0^o c = latent heat of ice

Latent heat of ice = 336 kJ/kg

i.e., 336 kJ of heat should be extracted from one kg of water at 0^o C to convert it into ice.

Terminologies of Refrigeration

One ton of refrigeration = 336x1000 kJ/24 hrs.

$$= \frac{336 \times 1000 \text{ kJ/min}}{24 \times 60}$$

One ton of refrigeration = 233.333 kJ/min

= 3.8889 kJ/sec

Terminologies of Refrigeration

Co efficient of Performance: It is defined as the ratio of heat extracted in a given time (refrigerating effect) to the work input.

$$\text{Co efficient of performance} = \frac{\text{Heat extracted in evaporator}}{\text{Work Input}}$$

$$\text{Co efficient of performance} = \frac{\text{Refrigerating Effect}}{\text{Work Input}}$$

$$\text{Co efficient of performance} = \frac{N}{W}$$

The COP is always greater than 1 and known as theoretical coefficient of performance.

Refrigerants

Refrigerant: Any substance that absorbs heat through expansion and vaporisation process and loses heat due to condensation is a refrigeration process is called refrigerant.

Some examples of refrigerants are,

- *Air*
- *Ammonia (NH_3)*
- *Carbon dioxide (CO_2)*
- *Sulphur dioxide (SO_2)*
- *Freon – 12*
- *Methyl Chloride*
- *Methylene chloride.*

Classification of Refrigerants

Refrigerants are classified as,

(a) Primary Refrigerants: It is a working medium which is used for cooling the substance by absorption of latent heat.

E.G Ammonia (NH_3), Carbon dioxide (CO_2), Sulphur dioxide (SO_2), Freon 12, etc.,

(b) Secondary Refrigerants: Secondary refrigerant is a substance already cooled by primary refrigerant and then employed for cooling purposes.

E.g Ice, solid carbon dioxide.

These refrigerants cool the substance by absorption of their sensible heat.

Types of Refrigerators

- **Ice Refrigerators :** Ice is kept in the cabinet of refrigerators and this acts as the refrigerating means.
- **Air Refrigerators :** Air is used as working agent in these types of refrigerators.

  E.g., Bell Coleman Cycle.
- **Vapour Refrigerators:** The working agents employed in this type of refrigerators are ammonia, CO_2, SO_2, freons etc.,

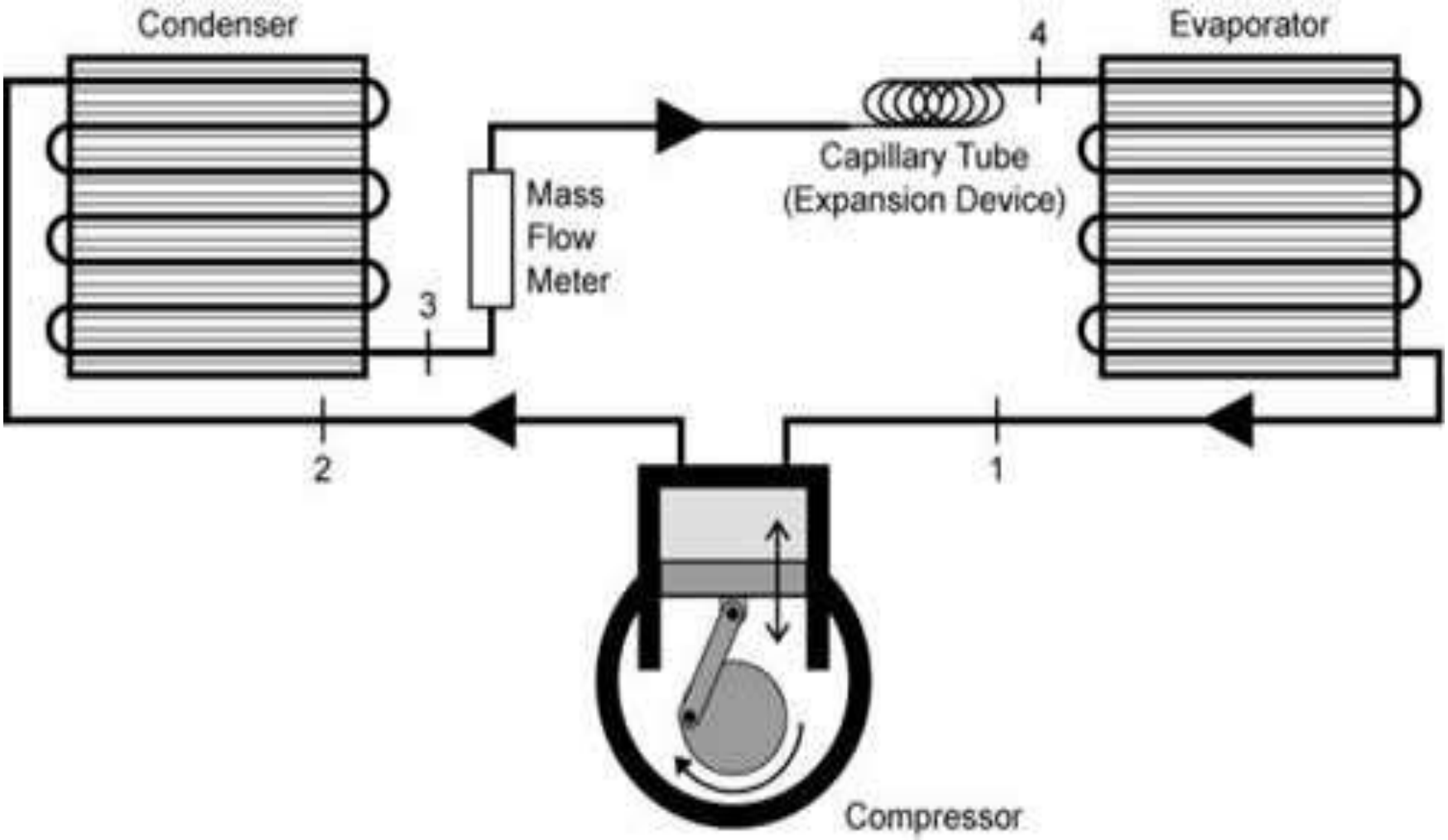
Applications of Refrigeration

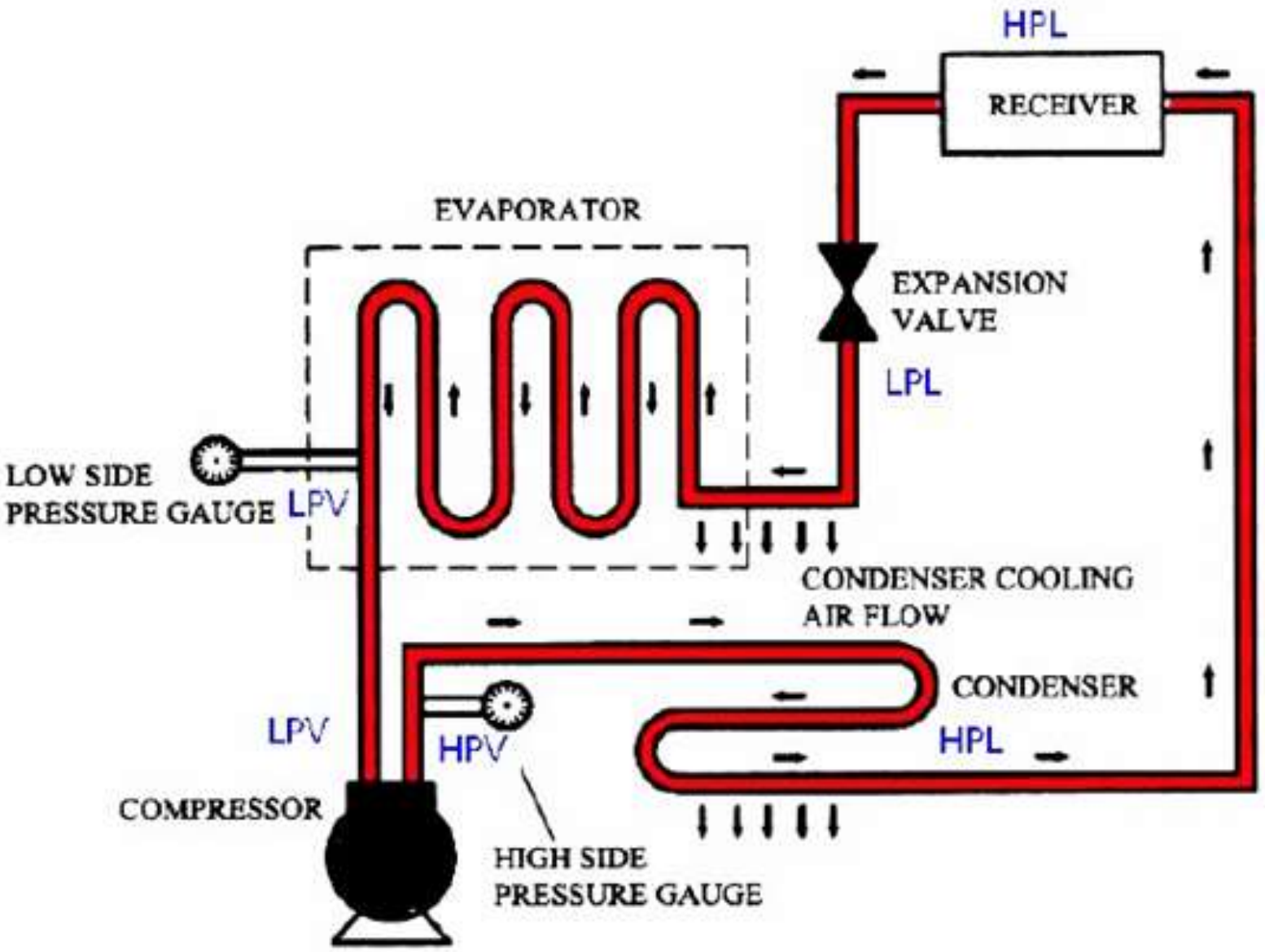
- In chemical industries, for separating and liquefying the gases.
- In manufacturing and storing ice.
- For the preservation of perishable food items in cold storages.
- For cooling water.
- For controlling humidity of air manufacture and heat treatment of steels.
- For chilling the oil to remove wax in oil refineries.
- For the preservation of tablets and medicines in pharmaceutical industries.
- For the preservation of blood tissues etc.,
- For comfort air conditioning the hospitals, theatres, etc.,

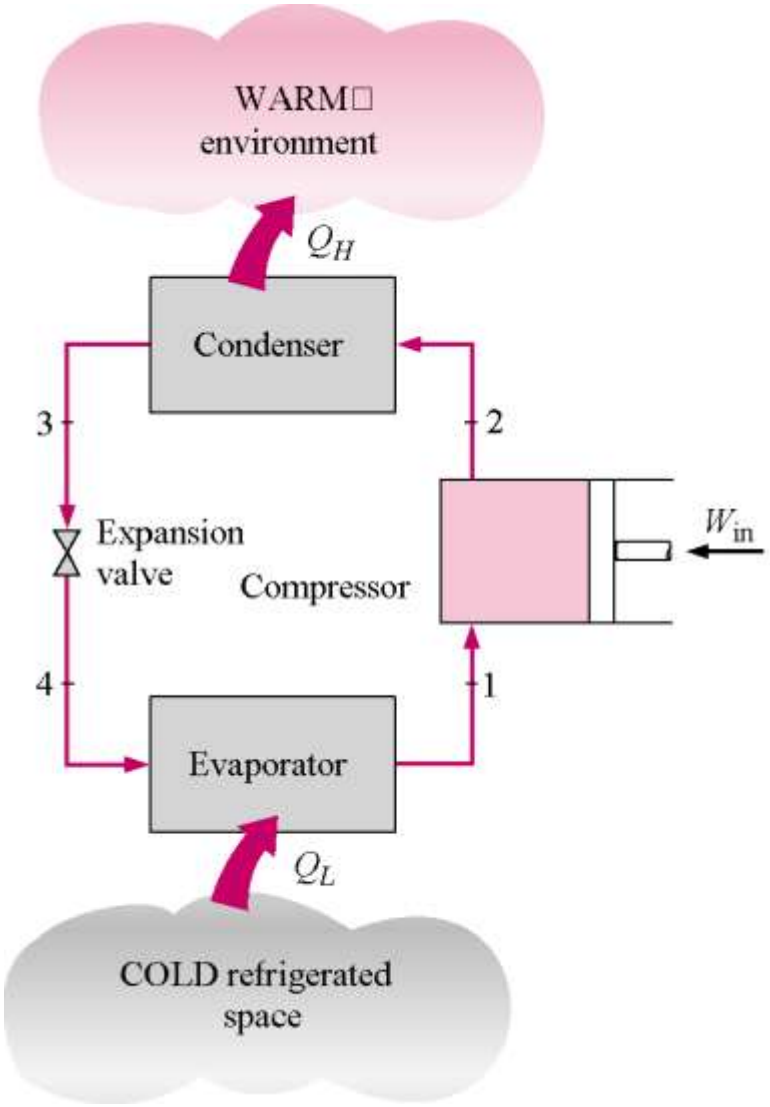
Properties of Refrigeration

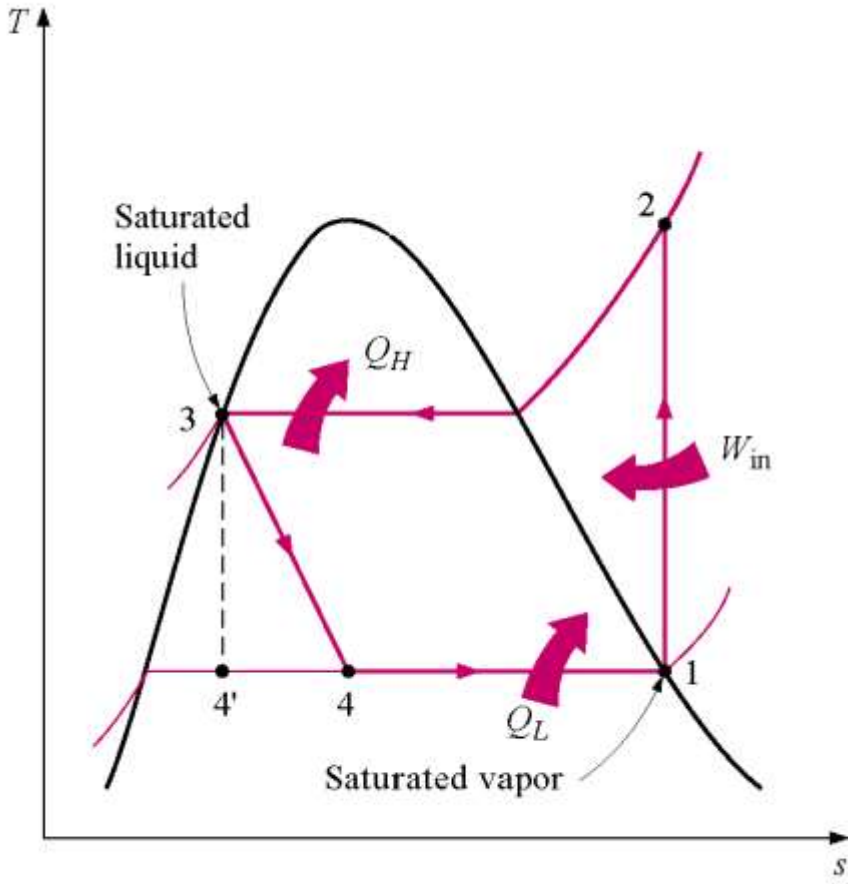
- A good refrigerant should have high latent heat of vapourisation.
- It should have low boiling and low freezing point.
- It should be non toxic and should non corrosiveness
- It should be non flammable and non explosive.
- It should have high thermal conductivity
- It should be easy to handle
- It should have low specific volume of vapour.
- It should have high co efficient of performance

Vapour Compression Refrigeration System




HPL
RECEIVER
EVAPORATOR
EXPANSION
VALVE
LPL
LOW SIDE
PRESSURE GAUGE
LPV
CONDENSER COOLING
AIR FLOW
CONDENSER
LPV
HPV
HPL
COMPRESSOR
HIGH SIDE
PRESSURE GAUGE



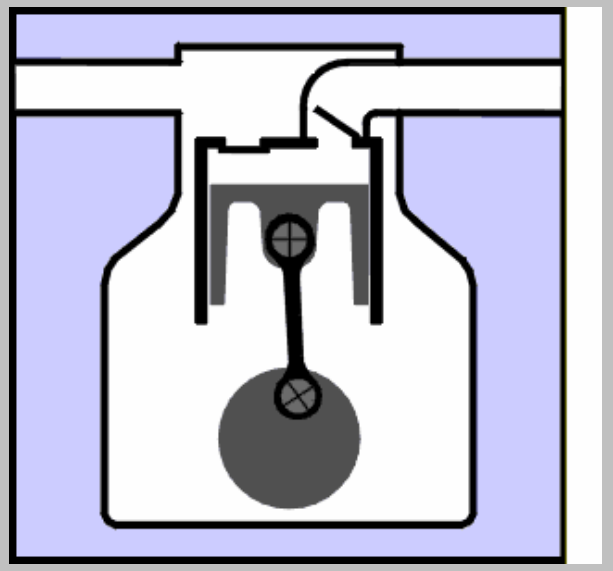


S – entropy means transformation, increases with increase in temperature and decreases with decrease in temperature

ƍ Q = T ds

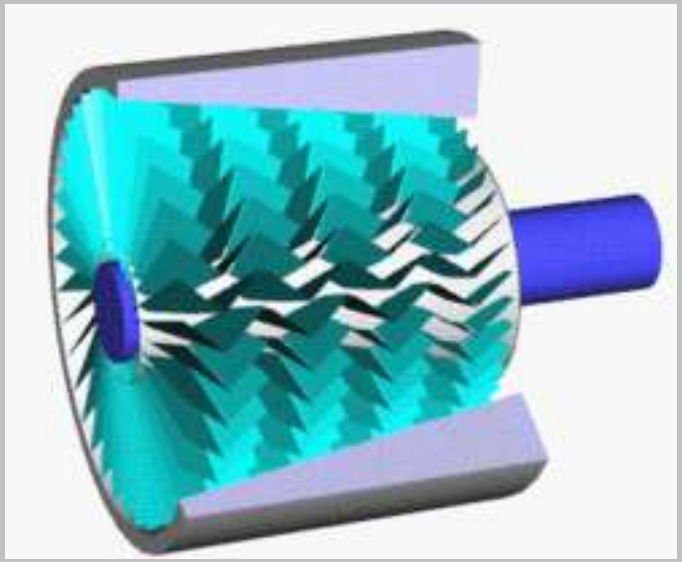
Vapour Compression Refrigeration System - Construction

- This system consists of a compressor, condenser, a receiver tank, an expansion valve and an evaporator.
- **Compressor :** Reciprocating compressors generally used. For very big plants centrifugal compressors directly coupled with high speed rotating engines (gas turbine) are used.



Vapour Compression Refrigeration System - Construction

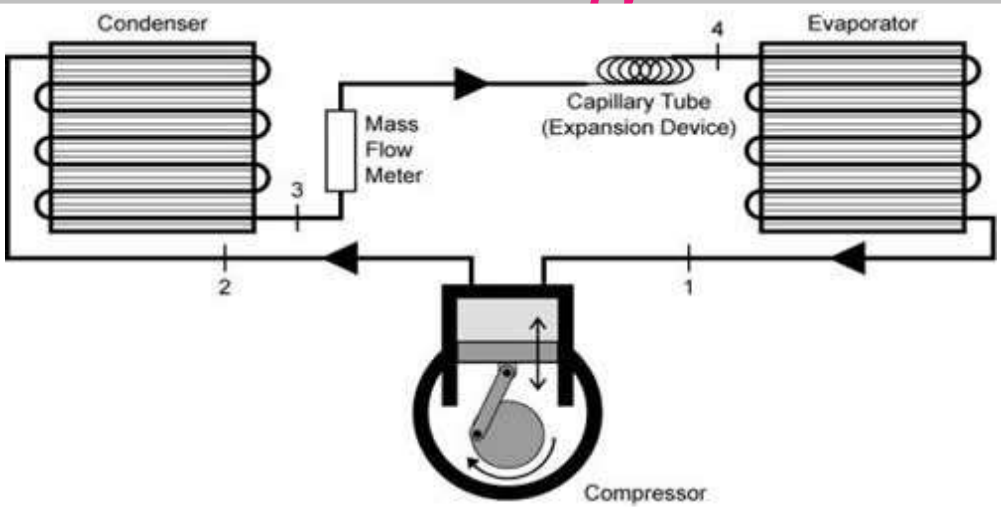
Compressor: For very big plants Centrifugal compressors directly coupled with high speed rotating engines (gas turbine) are used



Vapour Compression Refrigeration System - Construction

- **Condenser :** It is a coil of tubes made of copper.
- **Receiver tank:** It is the reservoir of liquid refrigerant.
- **Expansion Valve:** This is a throttle valve. High pressure refrigerant is made to flow at a controlled rate through this valve.
- **Evaporator :** It is the actual cooler and kept in the space to be cooled. The evaporator is a coil of tubes made of copper

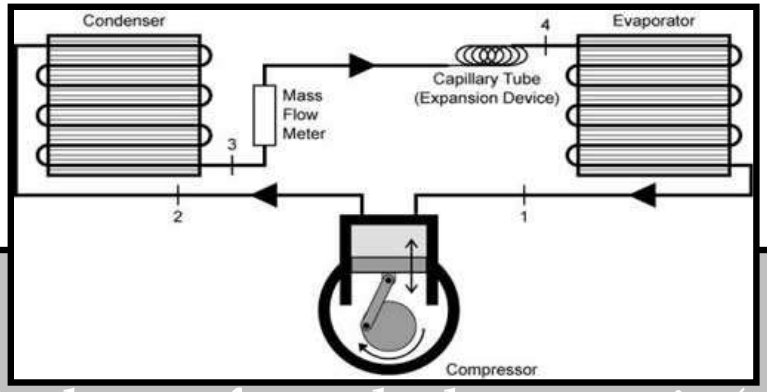
Vapour Compression Refrigeration System - Working



Working :

1. The low pressure refrigerant vapour coming out of the evaporator flows into the compressor.
2. The compressor is driven by a prime mover.
3. In the compressor the refrigerant vapour is compressed.
4. The high pressure refrigerant vapour from the compressor is then passed through the condenser.
5. The refrigerant gives out the heat it had taken in the evaporator (N)

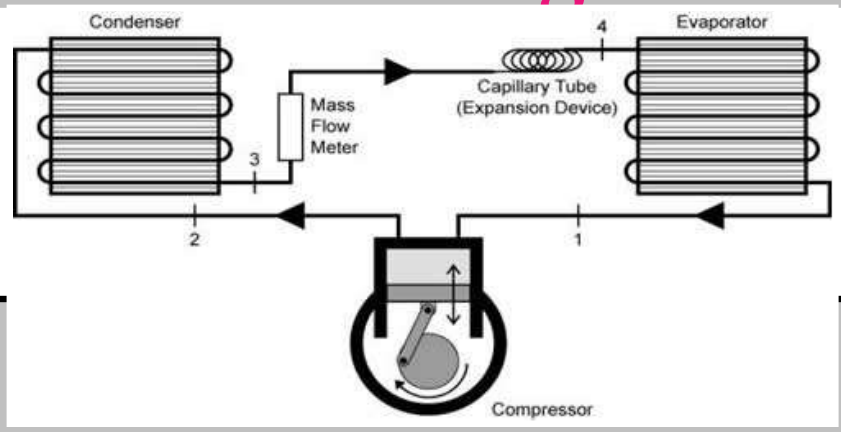
Vapour Compression Refrigeration System - Working



Working :

6. The heat equivalent of work done on it (w) on the compressor.
7. This heat is carried by condenser medium which may be air or water.
8. The high pressure liquid refrigerant then enters the expansion valve.
9. This valve allows the high pressure liquid refrigerant to flow at a controlled rate into the evaporator.
10. While passing though this valve the liquid partially evaporates.

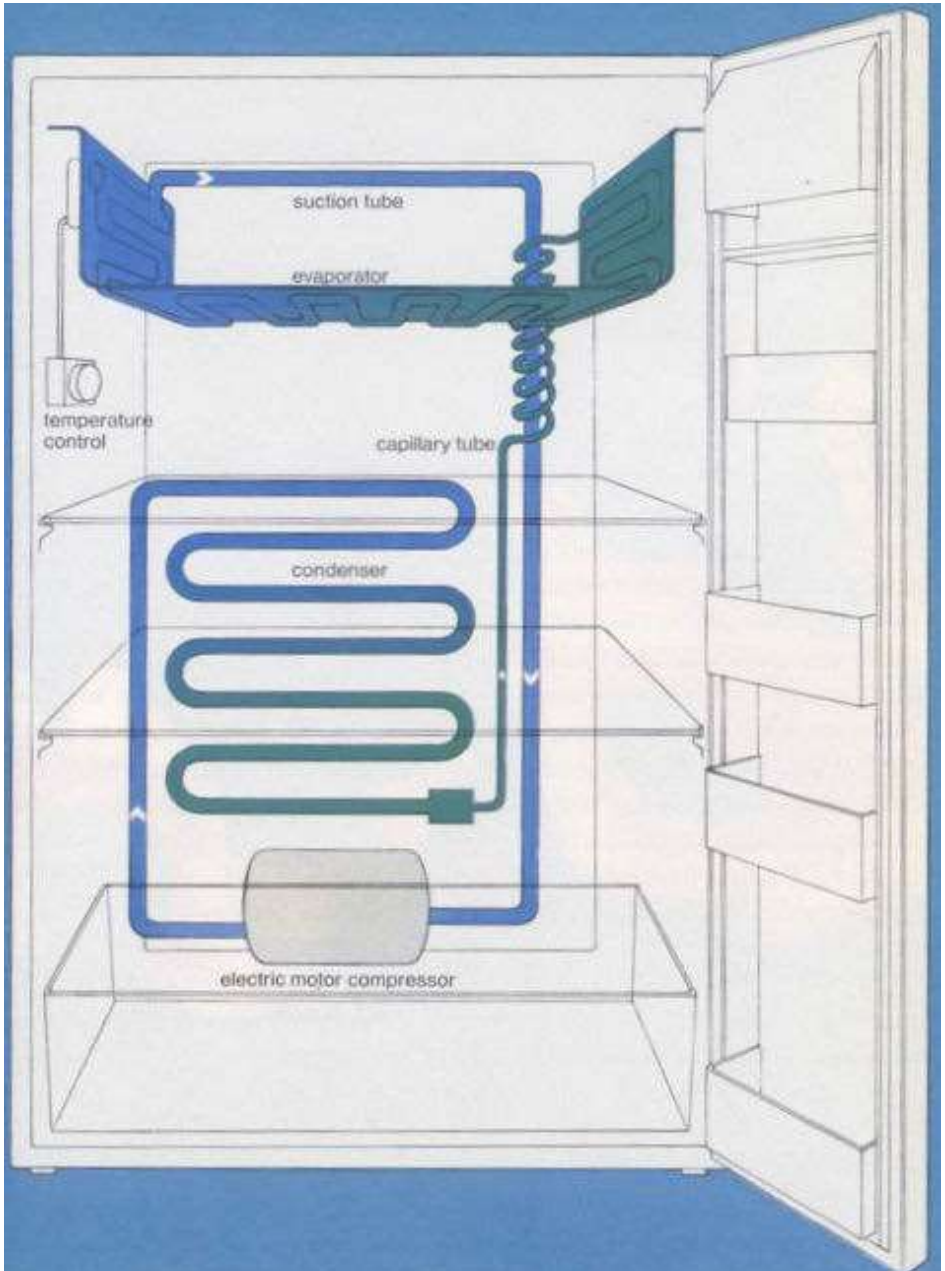
Vapour Compression Refrigeration System - Working



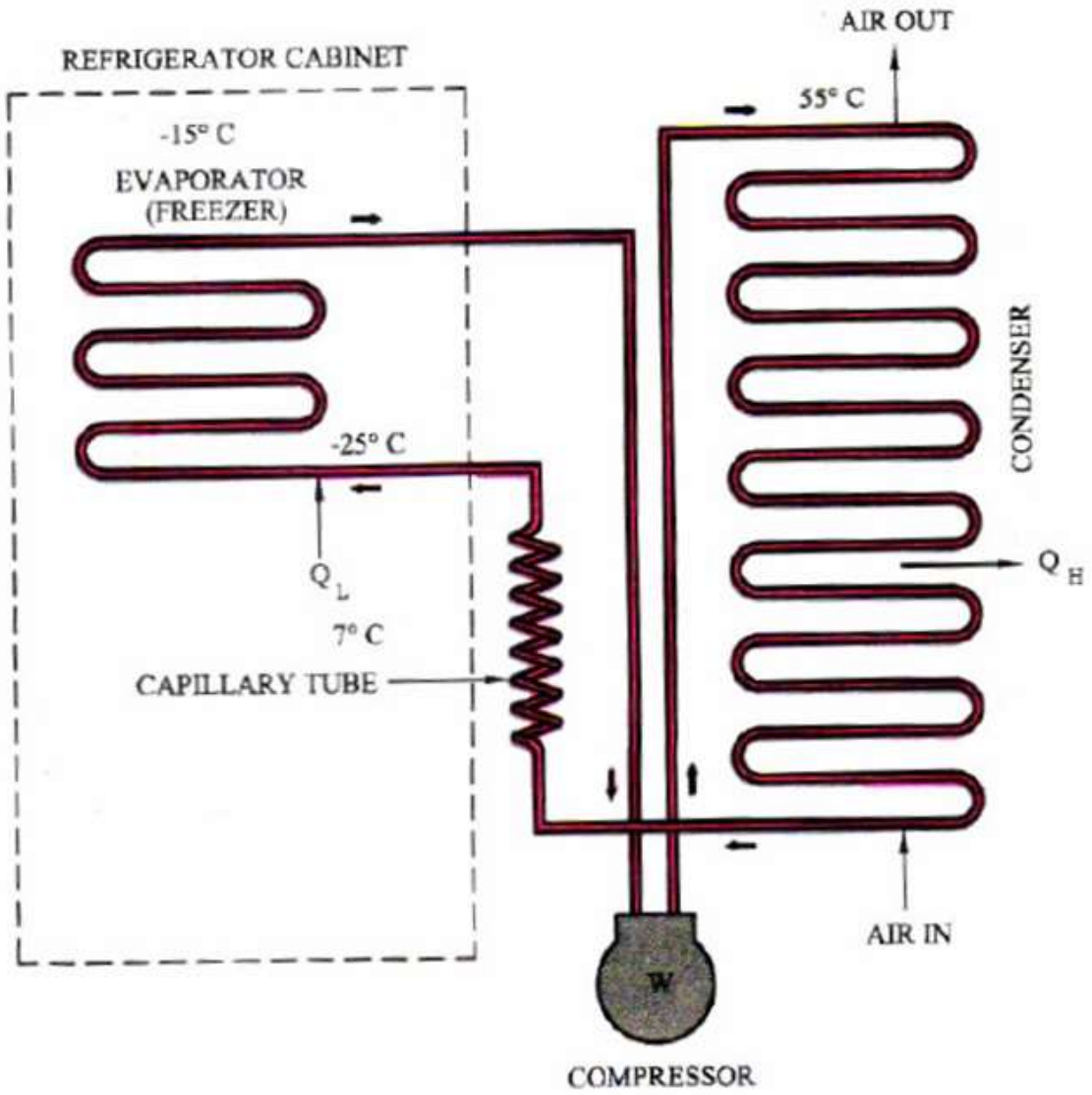
Working :

11. Most of the refrigerant is vapourised only in the evaporator, at a low pressure.
12. In the evaporator the liquid refrigerant absorbs its latent heat of vapourisation from the material which is to be cooled.
13. Thus the refrigerating effect (N) is obtained.
14. Then the low pressure refrigerant enters the compressor and the cycle is repeated.

Layout of Domestic Refrigerator



Layout of Domestic refrigerator



Domestic refrigerator……

- House hold refrigerators use vapor compression cycle
- Less energy: (90 W to 600 W)
  - Due to small and high efficiency motors and compressors,
  - better insulation materials,
  - large coil surface area,
  - better door seals
- Designed to maintain:
  - Freezer section -18 °C
  - Refrigeration section at 3 °C

Domestic refrigerator……

- Insulation materials:
  - Fiber glass, k= 0.032 W/m °C
  - Urethane foam, k= 0.019 W/m °C
    - Wall thickness for foam
      - For freezer section reduced from 90 to 48 mm
      - For refrigeration section reduced from 70 to 40 mm
- Works better up to the environment of 43°C
- Ice maker (2 to 3 kg/day)
- Vapor absorption is more expensive and less efficient

Domestic refrigerator……

- Energy consumption can be minimized for practicing good measures
  - Open the refrigeration doors fewest times possible
  - Cool the hot foods to room temperature
  - Clean the condenser coil behind the refrigerator
  - Check the door gaskets for air leaks
  - Avoid unnecessary low temperature settings
  - Avoid excessive ice build up
  - Use the power saver switch
  - Do not block the air flow passages to and from the condenser coil.

AIR CONDITIONING

AIR CONDITIONING:

Air Conditioning is the process of conditioning the air according to the human comfort, irrespective of external conditions.

AIR CONDITIONING

Applications of Air Conditioning

- Used in offices, hotels, buses, cars.,etc
- Used in industries having tool room machines.
- Used in textile industries to control moisture.
- Used in printing press.
- Used in Food industries, Chemical plants.

CLASSIFICATION OF AIR CONDITIONING

Air conditioning systems are classified as

1) According to the purpose
   a) Comfort Air conditioning.
   b) Industrial Air conditioning.
2) According to Season of the year
   a) Summer Air conditioning.
   b) Winter Air conditioning.
   c) Year round Air conditioning.

AIR CONDITIONING

Types of Air conditioners

a) Room Air conditioners

b) Winter Air conditioners

c) Central Air conditioners

Functions of Air conditioners

a) Cleaning air.

b) Controlling the temp of air.

c) Controlling the moisture content.

d) Circulating the air.

TERMINOLOGIES

1) Dry air: The atmospheric air which no water vapour is called dry air.
2) Psychrometry: Psychrometry is the study of the properties of atmospheric air.
3) Temperature: The degree of hotness (or) Coldness is called the temperature.
4) Moisture: Moisture is the water vapour present in the air.

Window Type Air Conditioner

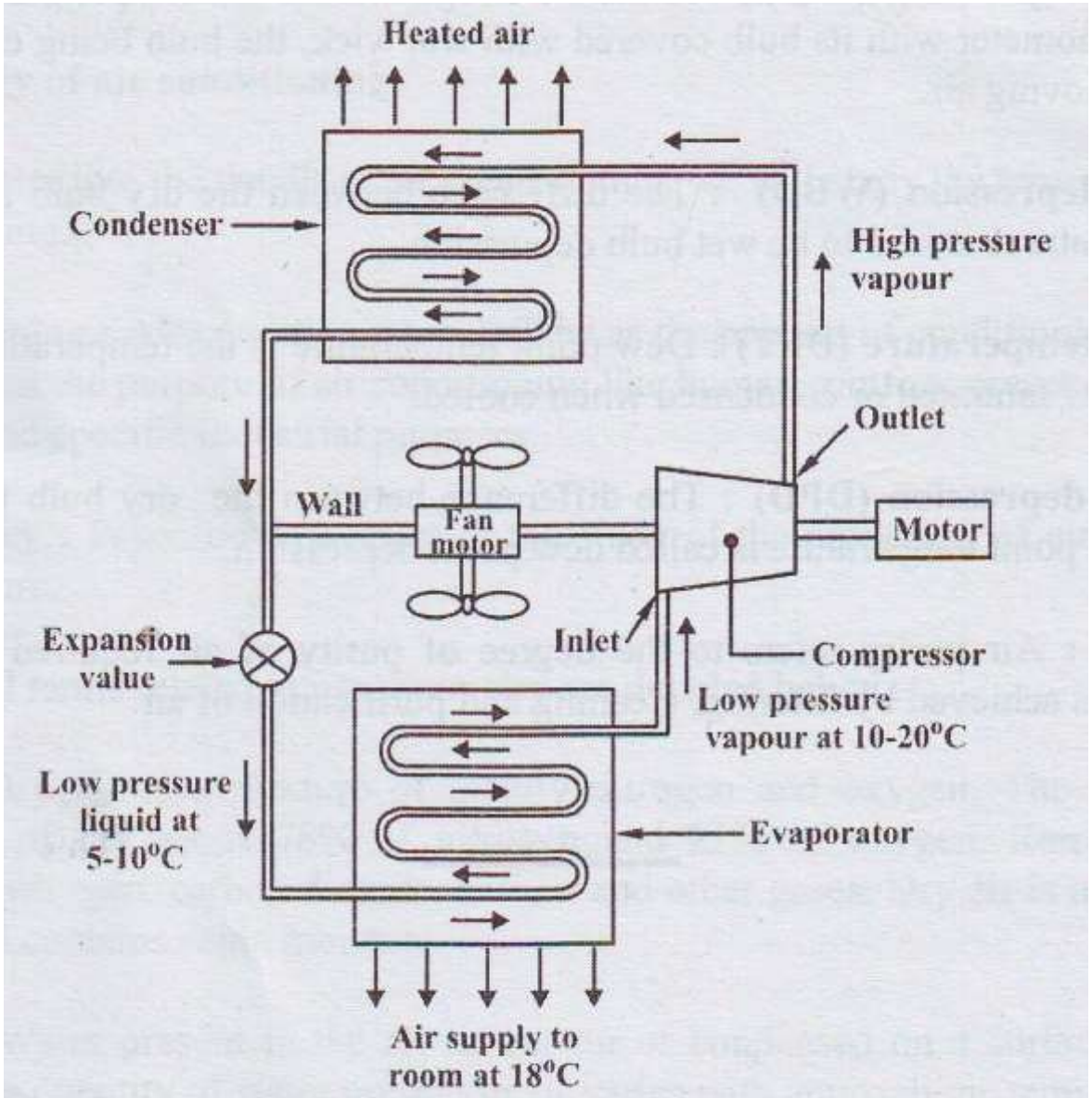
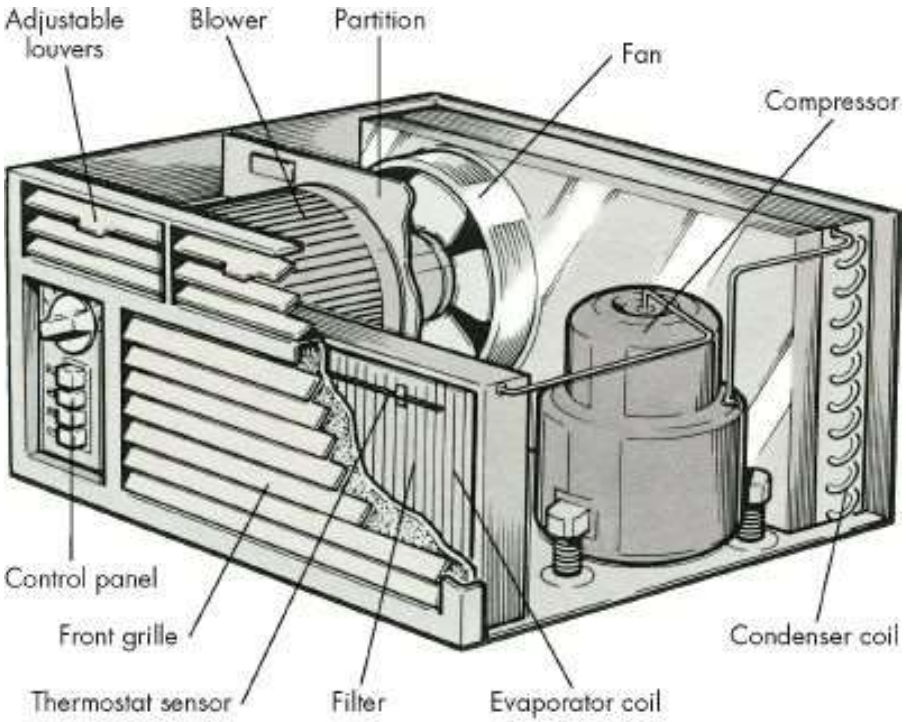
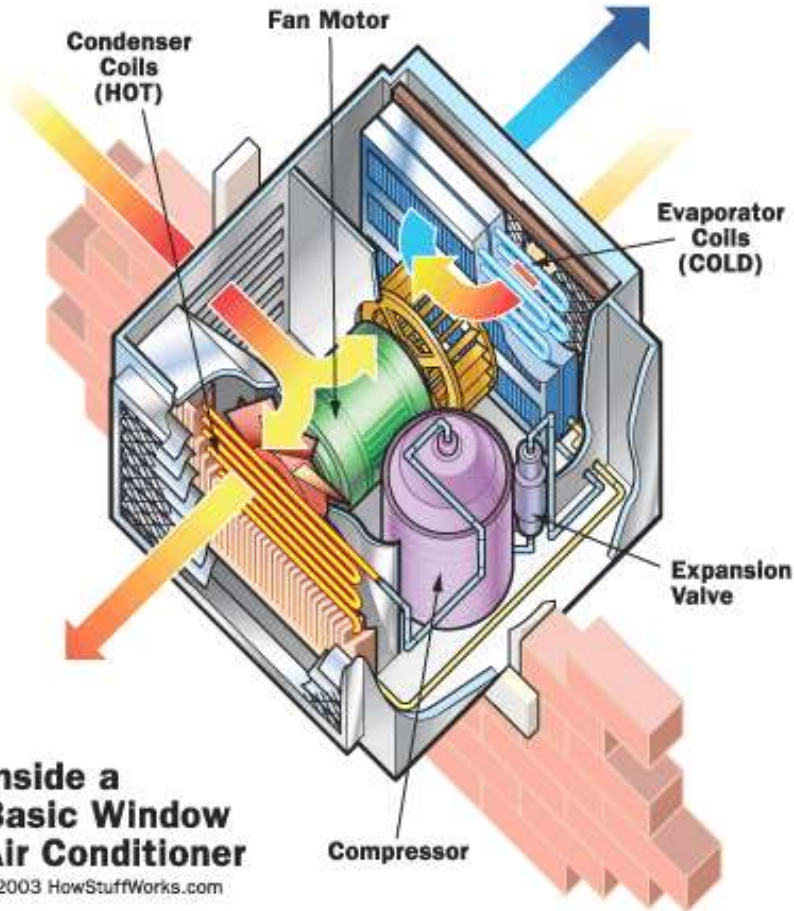


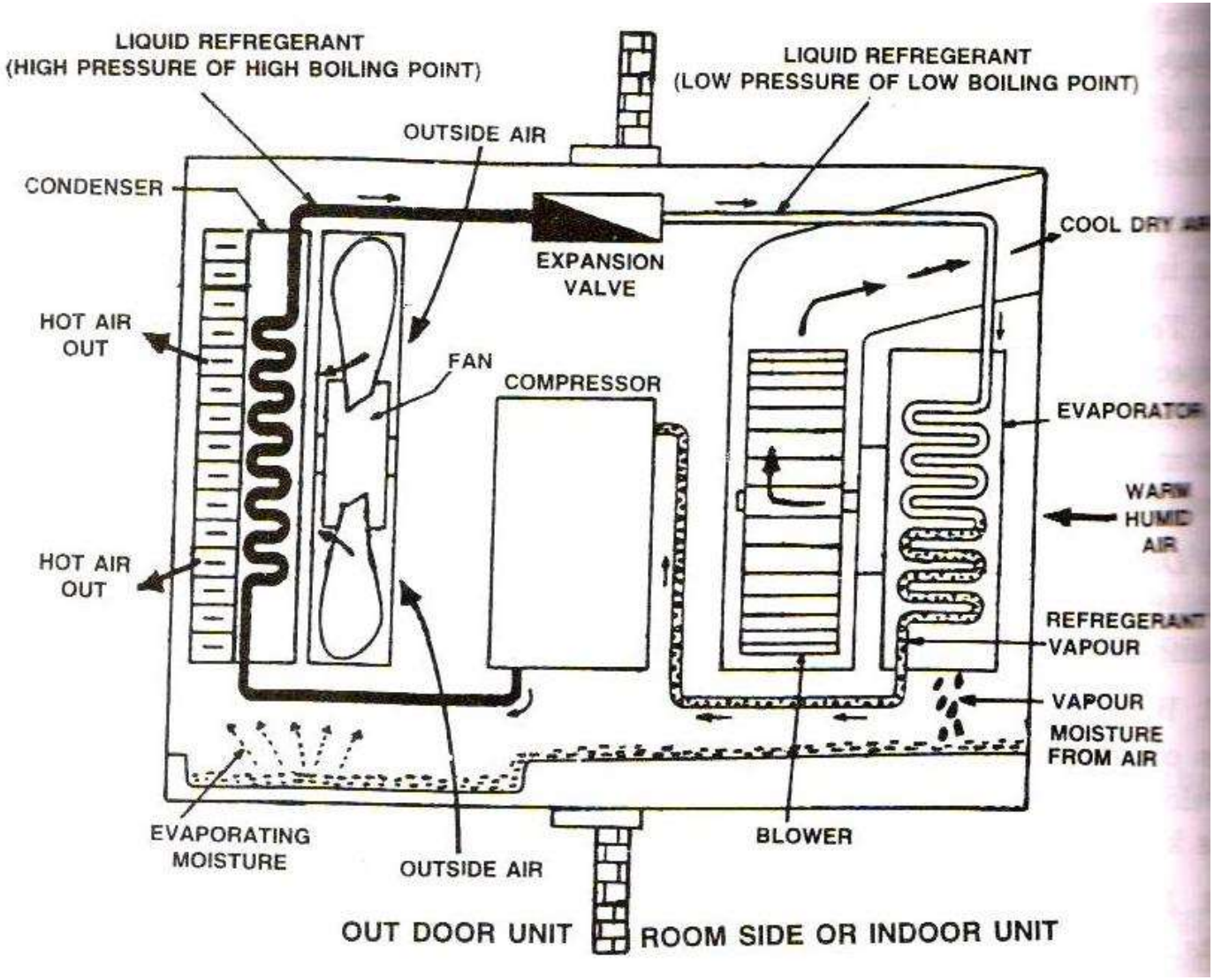
Fig.1 Window room air conditioner

Window Type Air Conditioner





Window Type Air Conditioner



Window Type Air Conditioner - Working

- The low pressure vapour refigerant from the evaporator is sucked by compressor through the open inlet valve.
- The compressor compresses the vapour refrigerant.
- The high pressure and high temperature vapour refrigerant then flows to the condenser through the open outlet valve.
- In the condenser, the outside atmospheric temperature in summer being around 42° C, air is circulated by fan.
- After condensation, the high pressure liquid refrigerant formed passes through an expansion valve which reduces its pressure

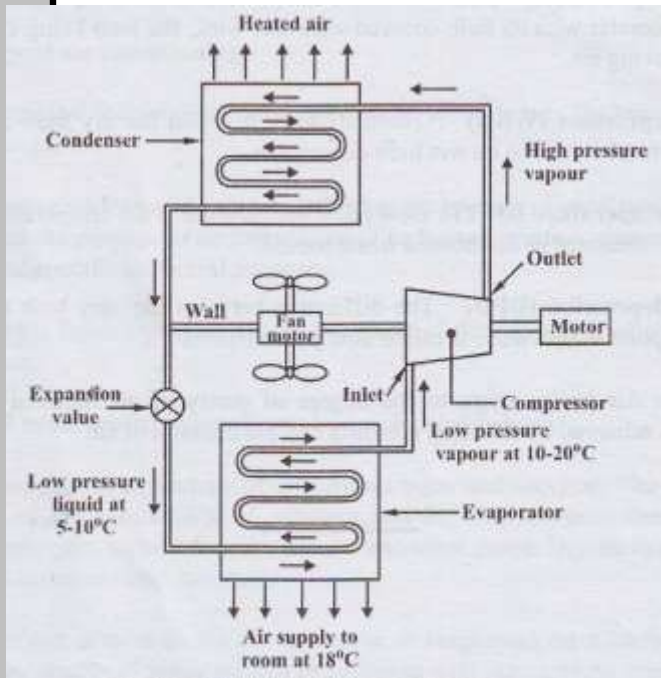


Fig.1 Window room air conditioner

Window Type Air Conditioner - Working

- The low pressure refrigerant then enters the evaporator and evaporates, thus absorbing latent heat of vapourisation from the room air.
- The equipment which is used for evaporating the refrigerant is called evaporator.
- After evaporation, the refrigerant becomes vapour.
- The low pressure vapour is again passed to the compressor. Thus the cycle is repeated.
- A partition separates high temperature side of condenser, compressor and low temperature side of evaporator

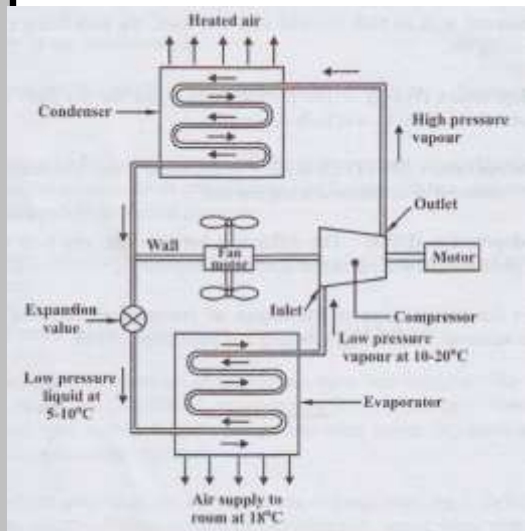


Fig.1 Window room air conditioner

Window Type Air Conditioner - Working

- The quantity of air circulated can be controlled by the dampers.
- The moisture in the air passing over the evaporator coil is dehumidified and drip into the trays.
- The unit automatically stops when the required temperature is reached in the room. This is accomplished by the thermostat and control panel.
- Generally, the refrigerant monochloro difluro methane ($CHCLF_2$) is used in air conditioner. It is called Freon 22.

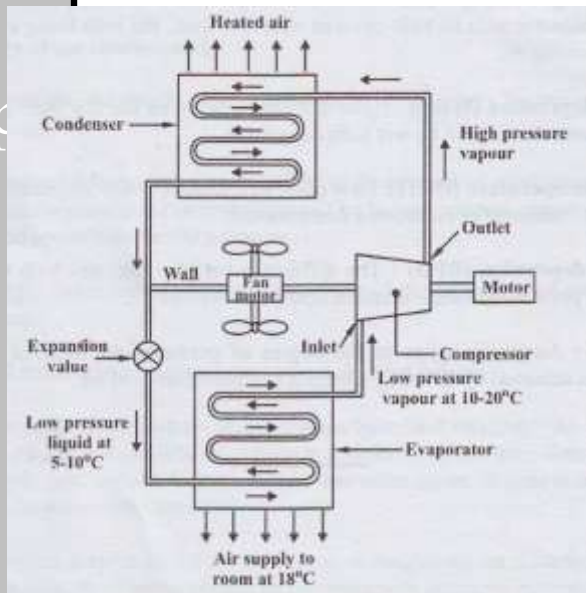


Fig.1 Window room air conditioner

Merits and Demerits of Window type air conditioner

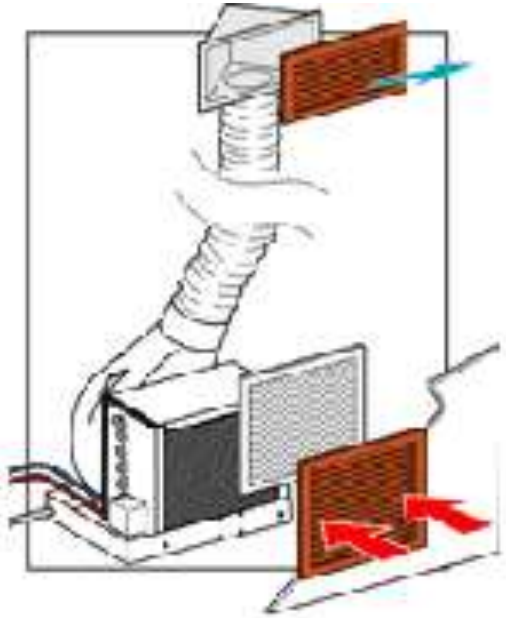
Merits :

- A separate temperature control is provided in each room.
- Ducts are not required for distribution.
- Cost is less.
- Skilled technician is required for installation.

Demerits:

- It makes noise.
- Large hole is made in the external wall or a large opening to be created in the window panel. This leads to insecurity to inmates.
- Air quantity cannot be varied.

Split Type Air Conditioner - Construction



Split Type Air Conditioner - Layout

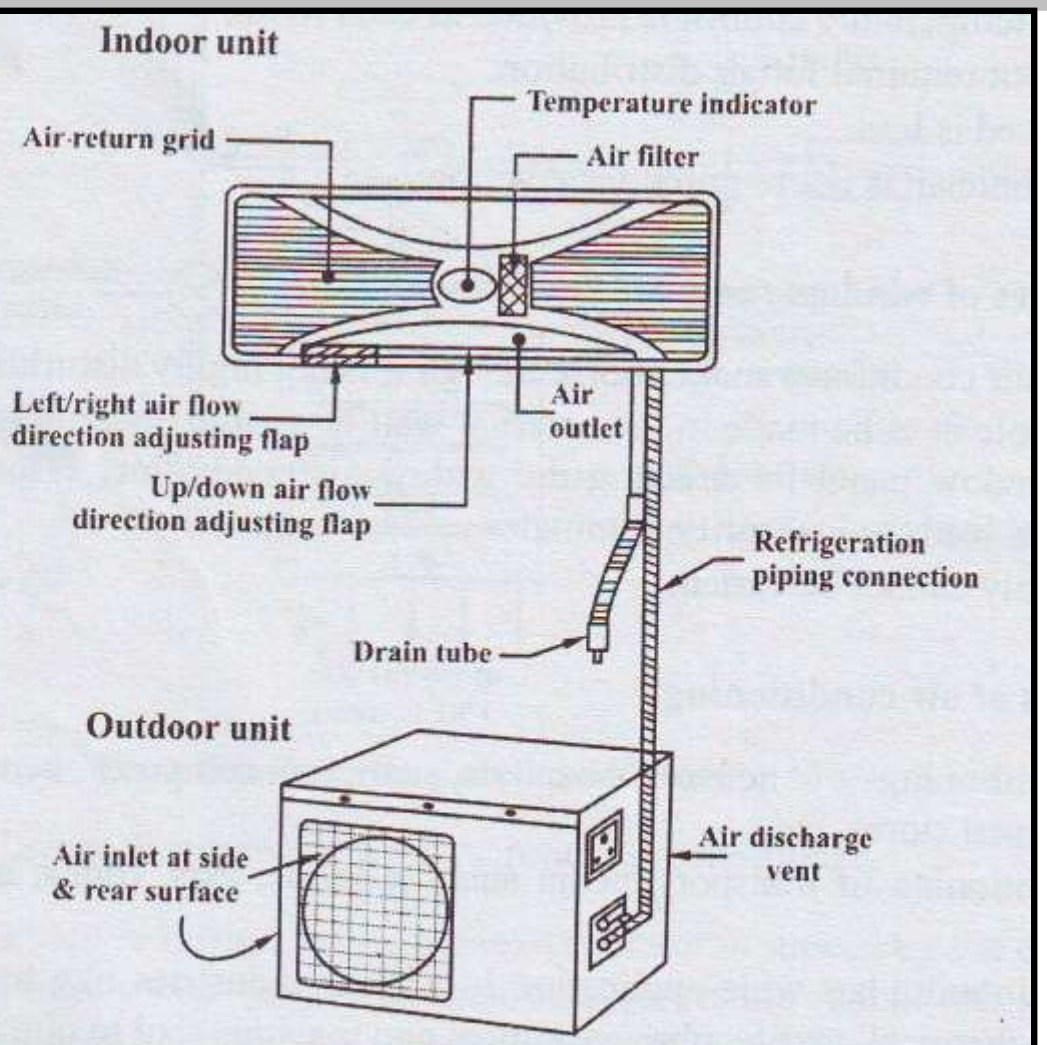
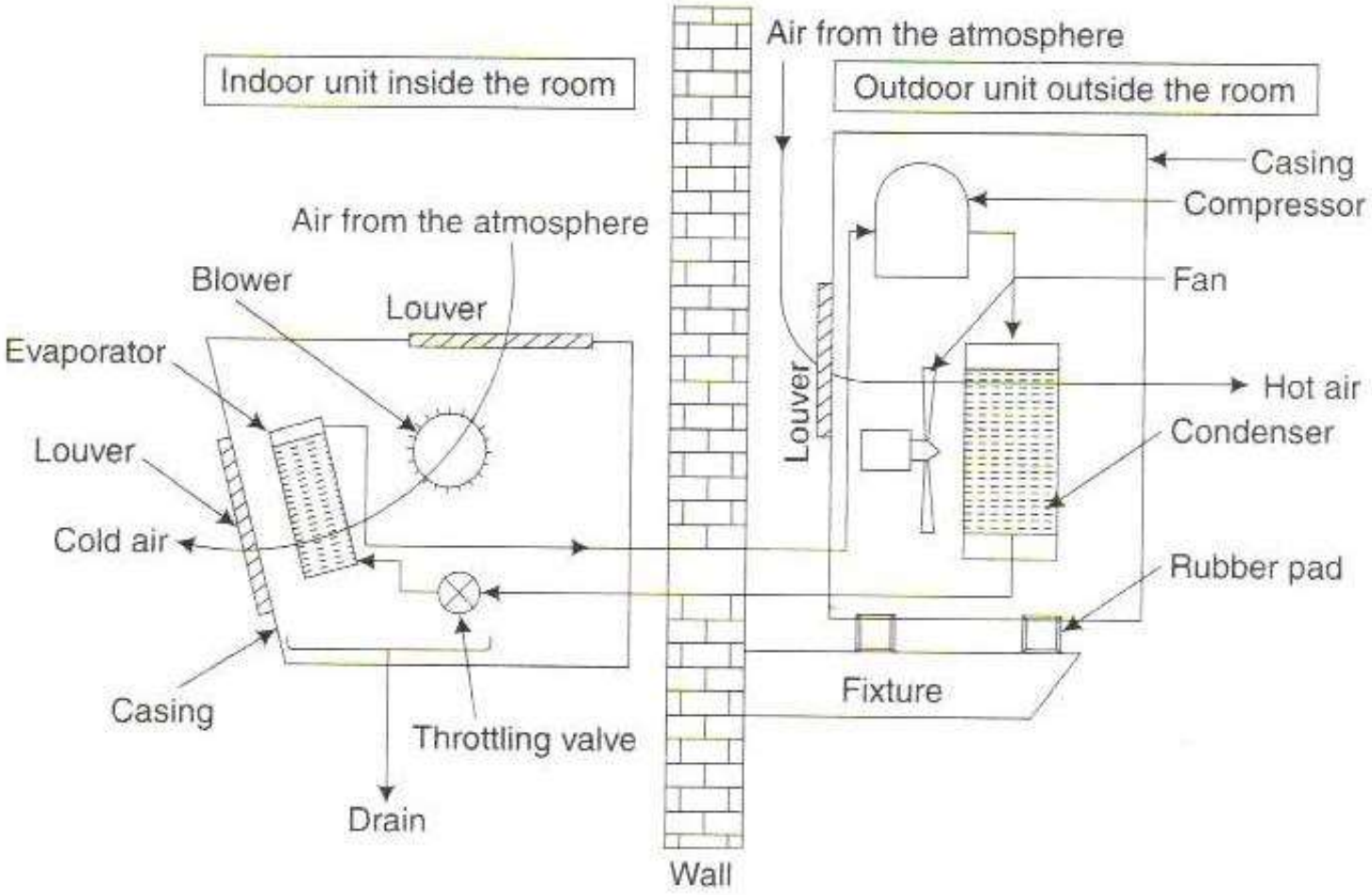


Fig.1 Split type room air conditioner

Fig.1 shows the layout diagram of a split type room air conditioner.

Split Type Air Conditioner - Layout



Split Type Air Conditioner - Layout

- In split air type air conditioner noise making components like compressor and condenser are mounted outside or away from room.
- Split type air conditioning system has two main components.

  (i) Outdoor Unit (ii) Indoor unit.

- The outdoor unit consists of compressor and condenser.
- The indoor unit consists of power cables, refrigerant tube and an evaporator mounted inside the room.

Split Type Air Conditioner - Working

- Compressor is used to compress the refrigerant.
- The refrigerant moves between the evaporator and condenser through the circuit of tubing and fins in the coils.
- The evaporator and condenser are usually made of coil of copper tubes and surrounded by aluminium fins.
- The liquid refrigerant coming from the condenser evaporates in the indoor evaporator coil.
- During this process the heat is removed from the indoor unit air and thus, the room is cooled.
- Air return grid takes in the indoor air.
- Water is dehumidified out of air is drained through the drain pipe.

Split Type Air Conditioner - Working

- The hot refrigerant vapour is passed to the compressor and then to the condenser where it becomes liquid.
- Thus the cycle is repeated.
- A thermostat is used to keep the room at a constant, comfortable temperature avoiding the frequent turning on off.

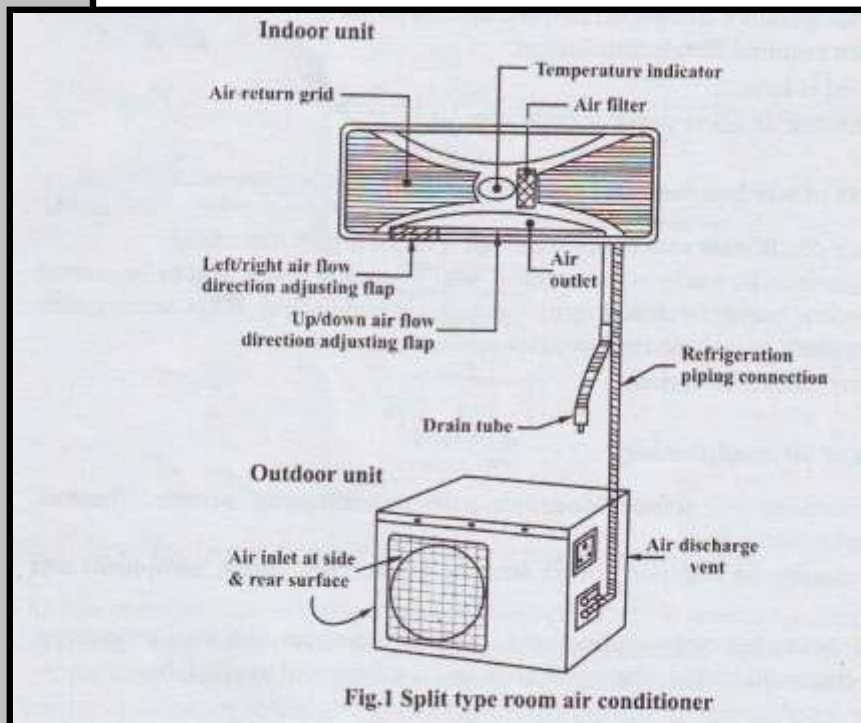


Fig.1 Split type room air conditioner

Fig.1 shows the layout diagram of a split type room air conditioner.

Merits and Demerits of Split type air conditioner

Merits :

- It is compact
- It is energy and money saving.
- Duct is not used.
- Easier to install.
- It is noiseless, because rotary air compressor used is, kept outside.
- It is more efficient and powerful.
- It has the flexibility for zoning.

Merits and Demerits of Split type air conditioner

DeMerits :

- Initial cost is higher than window air conditioner
- Skilled technician is required for installation.
- Each zone or room requires thermostat to control the air cooling.

Applications of air conditioning

- Used in houses, hospitals, offices, computer centres, theatres, departmental stores etc.,
- Air-conditioning of transport media such as buses, cars trains, aeroplanes and ships.
- Wide application in food processing, printing, chemical, pharmaceutical and machine tool, etc.,