Refrigeration System

Introduction

Refrigeration is defined as the science of providing and maintaining the temperature below the surrounding atmosphere.

In this heat has to be removed from the source at a lower temperature and rejected to the atmosphere at a higher temperature. Heat is flow in reverse direction the second law of thermodynamic stipulates that external work should be supplied. Therefore a refrigerator is a heat pump using power.

Unit of Refrigeration

Ton of Refrigeration (TR) which is defined as the quantity of the heat to be removed to produce one ton of ice at 0°c within 24 hours. when initial condition of water is also 0°C.

1 TR = 210 KJ/min or 3.5 KW.

Performance of Refrigerator

when a refrigerator is removing Φ amount of heat consuming W amount of work then COP is Φ/W

Application of Refrigeration

(1) In water cooler to supply cold water for drining.
(2) To manufacture ice.
(3) for preservation of food, vegetables, milk, icecream etc
(4) for Preservation of perishable like fish, mutton, chicken etc
(5) Preservation of medicines, blood, tissues etc in hospital
(6) Preservation of dead bodies in mortuaries in hospital.
(7) Different types of industrial applications.
(8) for air conditioning in house, Hospital, office theatres Computer center etc.

Refrigerants

A Refrigerant is a working fluid in a refrigerator. It is capable of absorbing heat at a lower temperature and rejected the heat at a high temperature in the form of sensible heat or latent heat or both.

Desirable properties of Refrigerants

(1) Low boiling, low freezing point, high latent heat of evaporation.
(2) Low Specific heat and low viscosity
(3) It should be easy to liquefy.
(4) Ordourless and no hazardous effect on leakage.
(5) Chemical Slability.
(6) Non flammable
(7) Low cost

Types of Refrigerants

(1) Freon - 12

This is called dichloro difluoro methane (CCl_2F_2). This is mostly used in domestic refrigerators, water cooler and freezers. It has a boiling point of $-29°C$

(2) Freon - 22

It is monochloro difluoro methane ($CHClF_2$) and it has a boiling point of $-41°C$. It is mostly used in air conditioners

(3) Ammonia

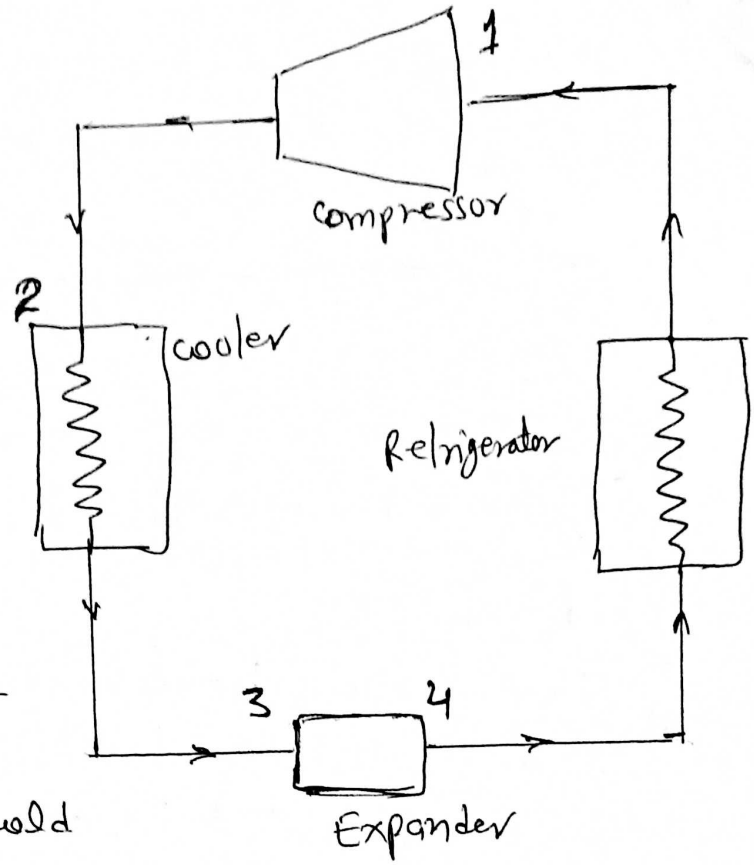
It is mostly used in absorption system. It has a boiling point of $-33.3°C$

(4) Other refrigerants include carbon dioxide (CO_2) sulphur dioxide (SO_2) and methyl chloride (CH_3Cl)
CO_2 is mainly used in marine refrigerators.

Air Refrigeration

Due to the availability of free air from atmosphere, air was used as a refrigerants even in commercial applications But due to low heat capacity and low COP not used in morden systems.

Closed Air Refrigeration cycle



In this cycle air is passed through pipes. Air is compressed in the compressor where the pressure and temperature are increased. The warm air from ~~atmosphere~~ compressor is cooled in a cooler with water. The cold air from cooler expands in the expander causing a big drop in pressure and temperature. Cold air from the expander is passed on to the refrigerator, where it absorbs the heat and make it cold. Then the air return to the compressor and the cycle is repeated.

Advantages of air Refrigeration

(1) Air is easily available, (free of cost)
(2) Leakage of air will not creat any problem.
(3) Air is very safe as it is non toxic and non flammable.
(4) The air system is light in weight
(5) Maintenance cost is very low.
(6) charging of the refrigerant is very easy.

Disadvantage of Refrigeration

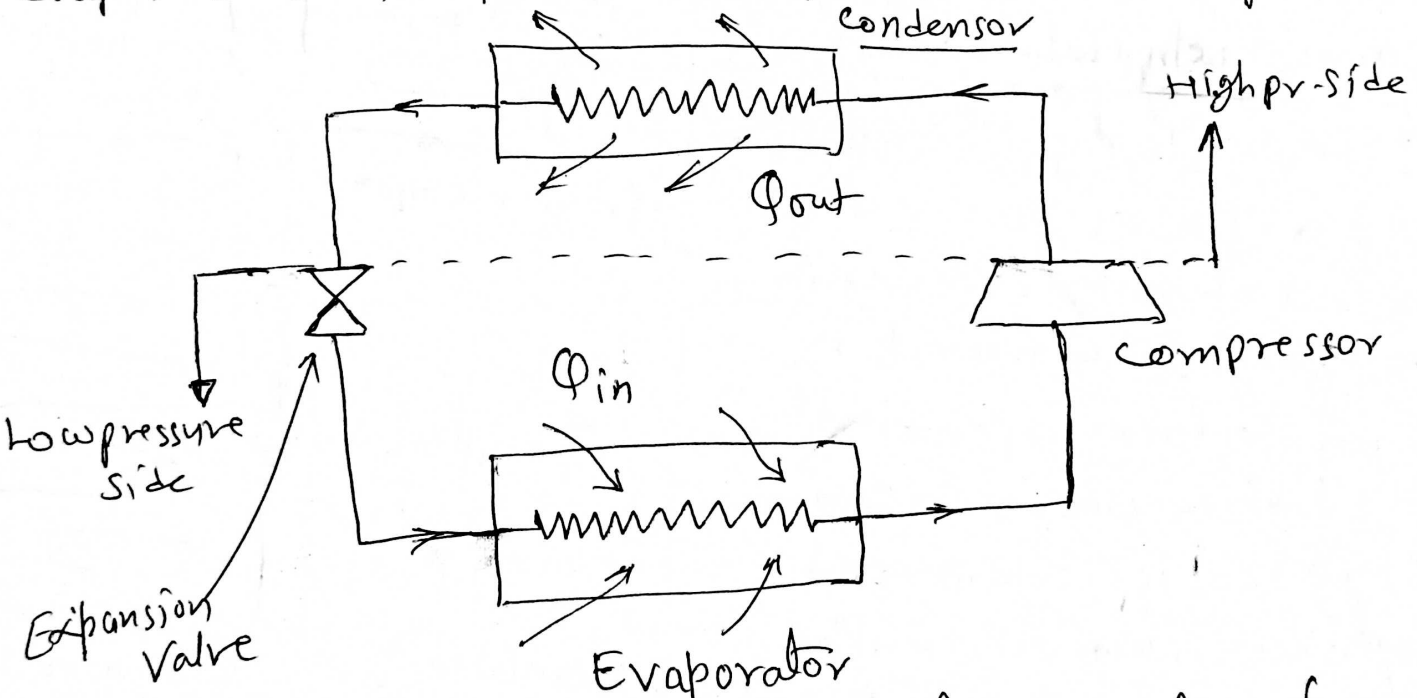
(1) COP is very low.
(2) low heat carring capacity.

Method of Refrigeration

(1) Vapour-Compression Refrigeration system
(2) Vapour Absorption Refrigeration system

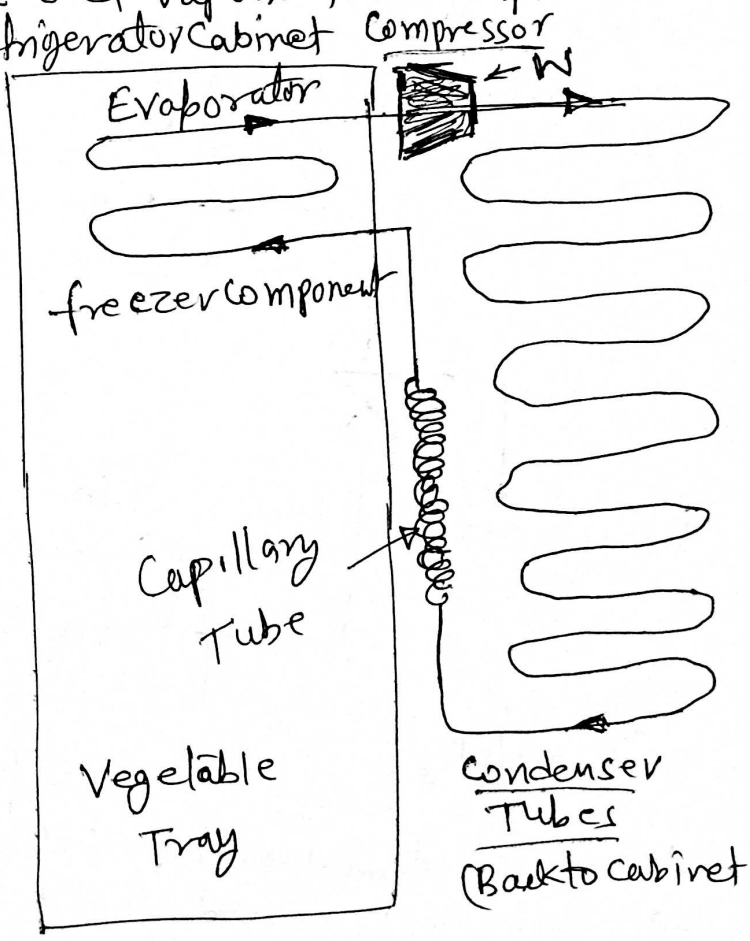
Vapour Compression Refrigeration system

It is used in refrigeration application like refrigerator, water cooler, air conditioner and cold storage. The refrigeration effect is produced at evaporator. The refrigerant enter the evaporator as wet vapour at lower pressure and low temperature.



Here it absorbed its latent heat of vaporisation from substance kept around the evaporator thus cooling them. The refrigerant usually consist of evaporator with phase changed

to dry saturated or slightly superheated state. Now it enters the compressor which is heart of the system. The refrigerant vapour is compressed to a higher pressure and high temperature as superheated vapour in the compressor. For this power is supplied to the motor connected to the compressor and it constitutes the major running cost of system. The compressed refrigerant vapour is led into the condensor. generally atmospheric air is blown over the condensor using a fan and it carries away the latent heat from refrigerant vapour. The refrigerant vapour is condensed into high pressure liquid. The liquid refrigerant enters the expansion valve which can be long spirally wound capillary tube in small refrigerators. The refrigerant is throttled to the low pressure low temperature wet vapour thus complete cycle.



Domestic Refrigeration System

It belong to vapour compression system. The evaporator which is coldest part is located in the freezer compartment. A separate door is provided for the freezer where we can store ice, ice-cream and perishable item like mutton chicken, fish etc just below the freezer usually a chiller tray is provided. further below

and behind the main door there are several compartments with progressive high temperature. The bottom most compartment is for vegetable where a low temperature is not necessary.

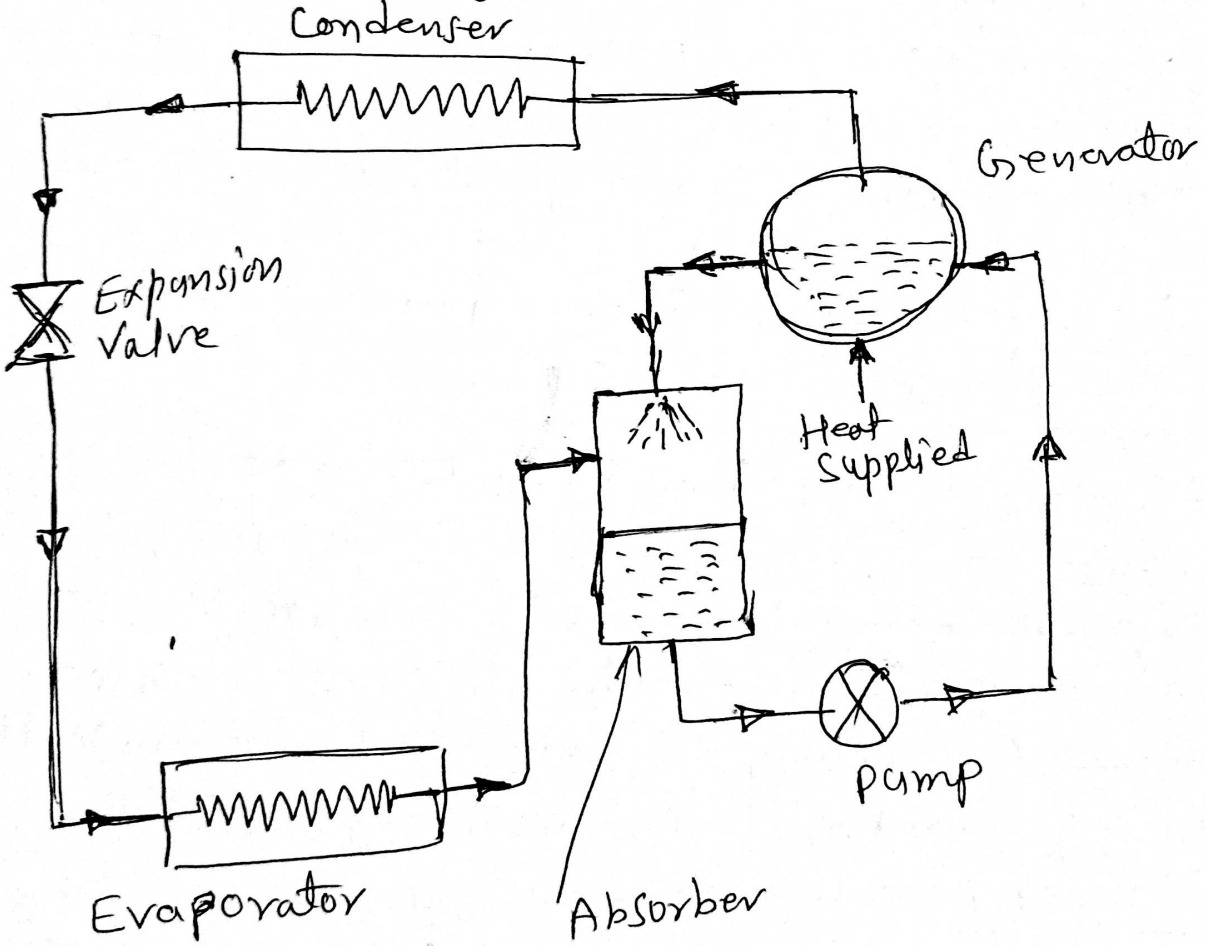
The condensor tubes are kept on the back of refrigerator cabinet. The refrigerant vapour is condensed with the help of surrounding air which rises above by natural convection. In no frost refrigerator the evaporator is located outside the freezer compartment. The cold air is made to flow into the freezer compartment by a fan

Vapour Absorption Refrigeration System

In this system the low pressure vapour coming out of the evaporator is compressed. The system eliminate the compressor yet produce the compressor effect by combined effects provided by an absorber, a pump and a generator. The pump consumes a lesser amount of electricity. The generator can be run by the heat energy obtained by the burning of any low cost fuel or any heat source including solar energy.

The refrigerant used is ammonia and absorber is water. Ammonia vapour coming out from the evaporator at low pressure is absorbed by water available in the absorber tank resulting strong ammonia solution. The pump pumps the solution thereby increasing its pressure and send the high pressure solution into the generator. In generator solution heated by external

heat supply. Now high pressure ammonia gas is produced which enter the condenser. The weak ammonia solution available in generator contain more amount of water. It goes back to the absorber tank, where it absorbs the incoming ammonia vapour and becomes a strong solution once again. The processes taking place in the condenser, expansion device and evaporator are similar. The absorber used in vapour absorption refrigeration system should have high affinity for the refrigerant remain in the liquid phase under the operating conditions and should posses high boiling point low specific heat and good chemical stability.



Comparision Between Vapour compression and vapour Absorption system

S.No.	Vapour Compression	Vapour Absorption
(1)	Smaller in size	(1) Very large in size for same capacity (Ammonia)
(2)	Refrigerant is Freon-12	(2) Ammonia
(3)	Electric power is used to run the compressor	(3) Heat input can be supplied by a heater or by exhaust steam or even by solar energy.
(4)	COP is higher	(4) Lower
(5)	wear and tear will be more	(5) Less
(6)	system produce noise	(6) silent in operation
(7)	maintenance cost is high	(7) Low

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Air Conditioning

Air conditioning involves the controlling and maintaining the desired temperature, humidity and direction of flow of air in closed space. Also filtering and cleaning of air is carried out by the air conditioning system.

Air conditioning doesnot always cooling the air. But during winter air conditioning means heating and humidification

Application of Air conditioning

(1) Air conditioning the houses, hotels and theatres etc
(2) Hospital, operation theatres and intensive care unit
(3) for comfort of passangers of cars, buses, trains, ships and aeroplanes.
(4) Air conditioning become very essential in many industries like textiles, food, printing machine tools etc

Terminology in Air conditioning

(1) Dry Air
Air without watervapour or moisture.

(2) Moist Air
It is mixture of air and moisture

(3) Dry Bulb temperature (DBT)

Actual temperature, measured by a standered mercury thermometer.

(4) Wet Bulb temperature (WBT)

The temperature measured by mercury thermometer when the bulb cover by wet cloth

(5) Saturated Air

A mixture of air (dry) along with maximum possible water vapour at DBT.

(6) Relative Humidity

The ratio of the mass of water vapour in a given volume of air at the given temperature to the mass of water vapour present in the same volume under the same temperature of air when it is fully saturated.

Requirements of Comfort Air conditioning

(1) A Dry Bulb Temperature of 20°c

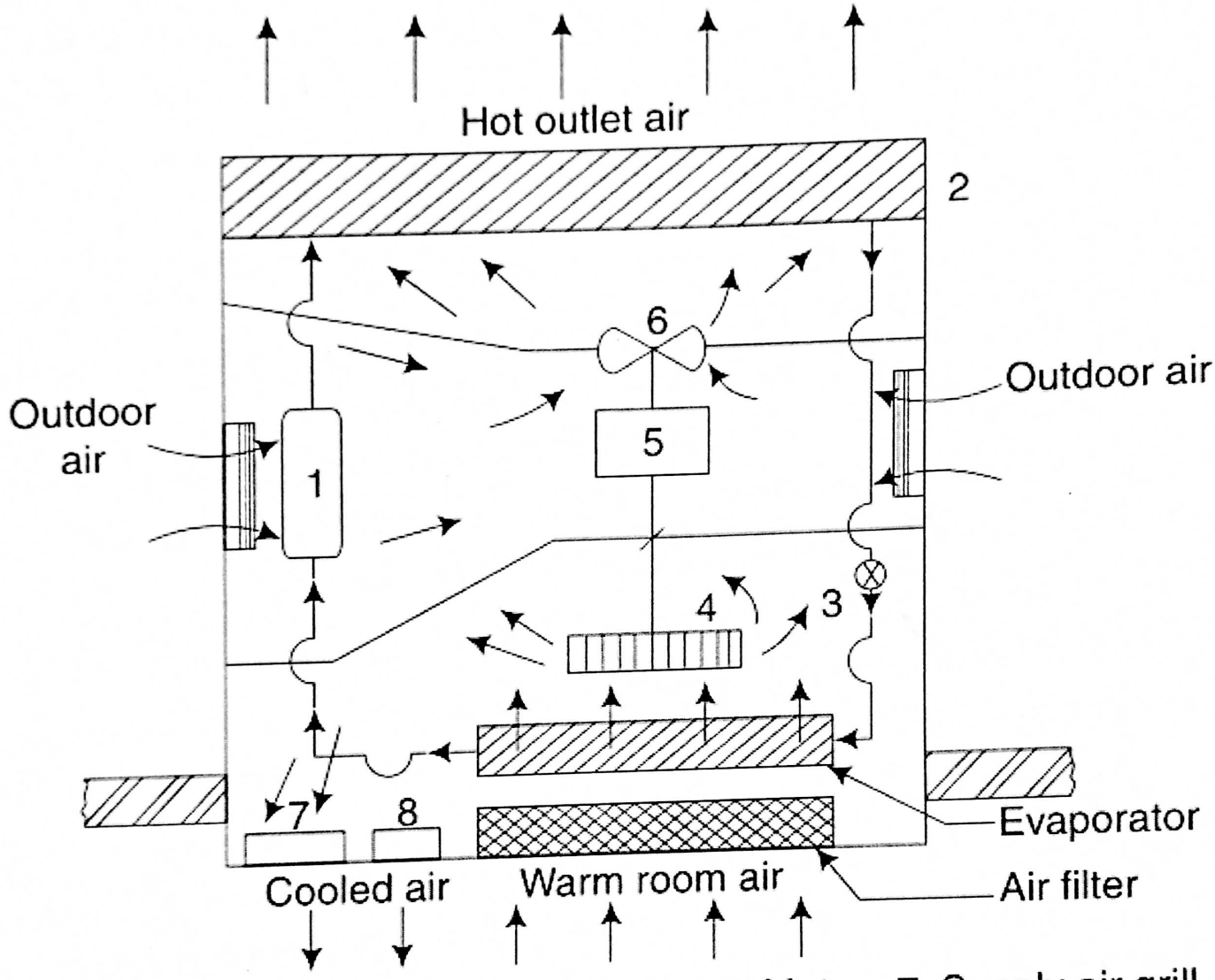
(2) Relative humidity 60% in room

(3) Under Normal condition a person inhales $0.65\ m^3$ of the oxygen and exhaust (exhales) about $0.2\ m^3$ of CO_2 in an hour.

(4) A velocity of the range of 8m/min to 14m/min.

(5) The conditioned air should be free from dust bacteria, odour and toxic gases.

Window Air Conditioner



Window Air Conditioner

A simple air conditioning system without ducts assembled inside a casing suitable for installation on window or wall opening is called the window air conditioner. The unit consists of vapour compression system a double shaft motor, a blower, a fan, air filter, supply air grill. Return air grill, fresh air damper, drain tray and control panel. The blower sucks the warm air from the room through air filter and evaporator or cooling coil of the system Then it deliver cooled and dehumidified air back into the room through the supply air grill. The moisture condensing out the air is passed over the evaporated coil is drained out. The supply air grill adjusted louvers and to change the direction of air flow to ensure uniform distribution of conditioned air inside the room. The controlled conditioned air send into the room. mixes with room air and decreases the temperature and humidity level in room and thereby maintain human comfort. fresh air is admitted through adjustable damper for the purpose of ventilation.

It is available for 0.5 to 3 TR. will operate with 230 Volt and single phase Ac supply.

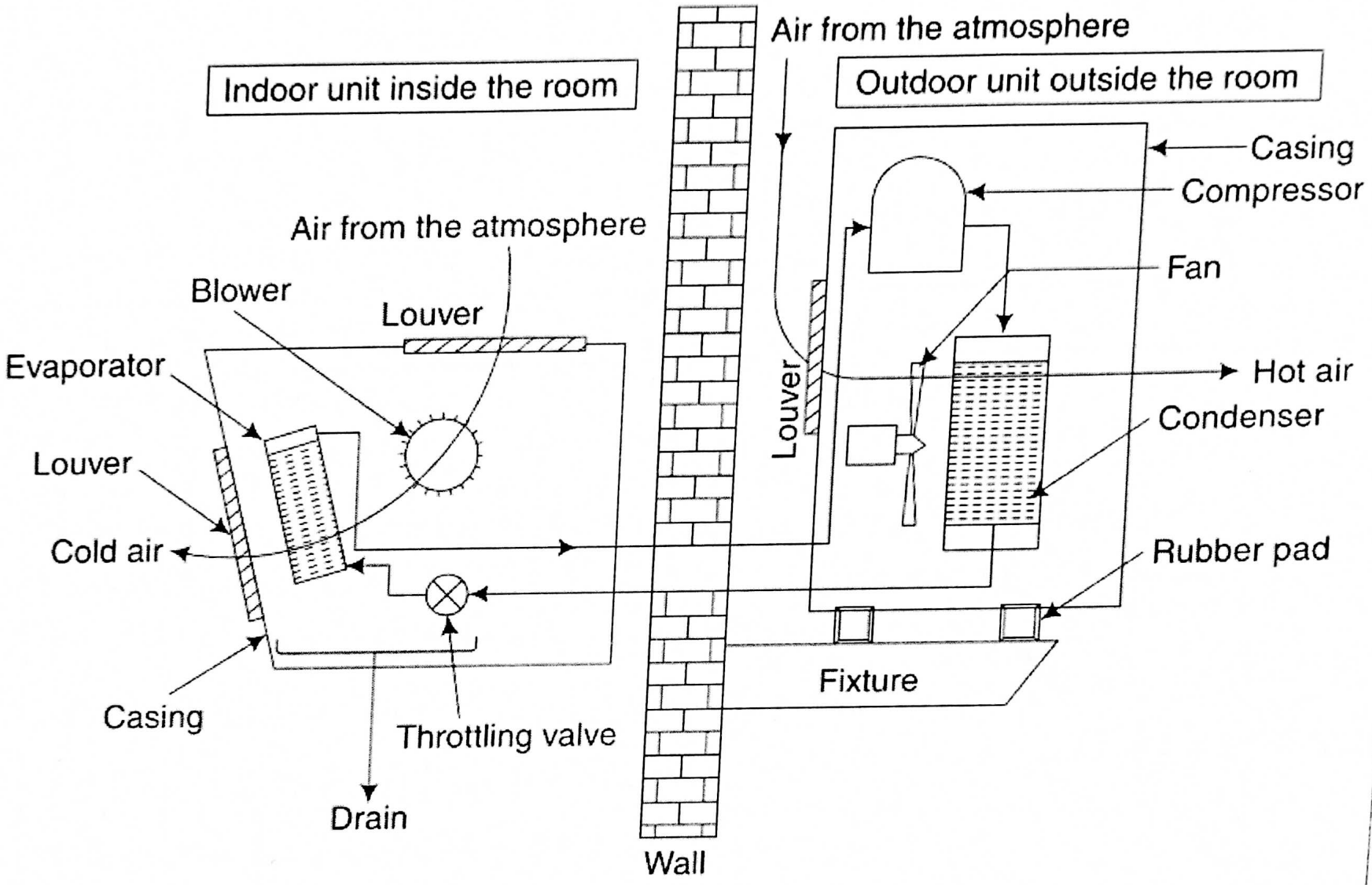
Split Air Conditioner

In split air conditioner the components are placed in two cabinet Indore cabinet unit and outdoor unit. The Indore unit placed inside the conditioned room while outside unit placed outside the room. They both are connected with the help of tubes in high pressure liquid and low pressure (liquid) vapour would passes through a hole in the wall.

The main components of Indoor unit are blower (B), evaporator (E) throttling valve (Th.V) and drainage (D) system. The high pressure liquid refrigerant from the outdoor unit is allowed to flow from the throttling valve to obtain low pressure vapour refrigerant. The pressure wet vapour refrigerant is then allowed to pass through evaporator. As the blower blow air over the evaporator, low pressure refrigerant obtained from throttling valve is evaporated to produce chillness in surrounding of the evaporator. The Inlet and outlet louvers are placed at suitable location to enable free cold air flow.

The main component of the outdoor unit are the fan (F) condensor (Condi) and compressor (Comp.). The low pressure vapour refrigerant from the evaporator of indoor unit is allowed to flow through the compressor to obtain high pressure & high temperature refrigerant. The high pressure and temperature vapour is then allowed to pass through condensor. As the fan blows air over condenser high pressure vapour condenser to form high pressure liquid refrigerant Air Inlet and outlet louvers are placed at suitable placed to enable free air flow. Rubber pad are used to mount the out door unit, the working of compressor will produce Vibration.

Split Air Conditioner



Central Air Conditioning

This system is used only for heavy loads of about 20 tons or more for large building, star hotels, hospital; cinema etc. In factory all air conditioner components are assembled at site in a control room and ducts are used to distribute the conditioned air. The duct work should be designed fabricated and erected carefully.

Differentiate Unitary and Central Air conditioning system

S.No	Unitary Type	Central
(1)	The capital cost is high	(1) Cost is low
(2)	factory assembled	(2) Assembled at site.
(3)	located in the space to be conditioned	(3) located away from the conditioned space.
(4)	Smaller capacity units	(4) Larger capacity unit 20 Tons
(5)	No Need for duct	(5) Extensive duct work is essential
(6)	failure in the system will affect the one room only	(6) will affect all the rooms
(7)	Installation charge is less	(7) Much Higher

Thermoelectric Cooling

It works on peltier Effect. Two dissimilar conductors replace both vapour and liquid phase. The D.C power source

used to pumps electrons from one semiconductor to other. In a pair of semiconductor with different characterstics forma thermoelectric cooling module They are connected electrically in series and thermally in parallel so that two functions are created. Semiconductor material are of N & P type. They have either more electron than necessary to complete a perfect molecular lattice structure (N type) or donot have enough electron to complete a lattice structure (P type) The extra electron in the N type material and holes left in the P type material are called carries and they are agaret that move the heat energy from the cold to hot function leading to refrigerent effect. These coolers operate in the range of +60°c to -40°c. Good thermoelectric semiconductor material such as bismuth telluride are widely used in these cooling devices