Study of Mechanical Systems

Module 2

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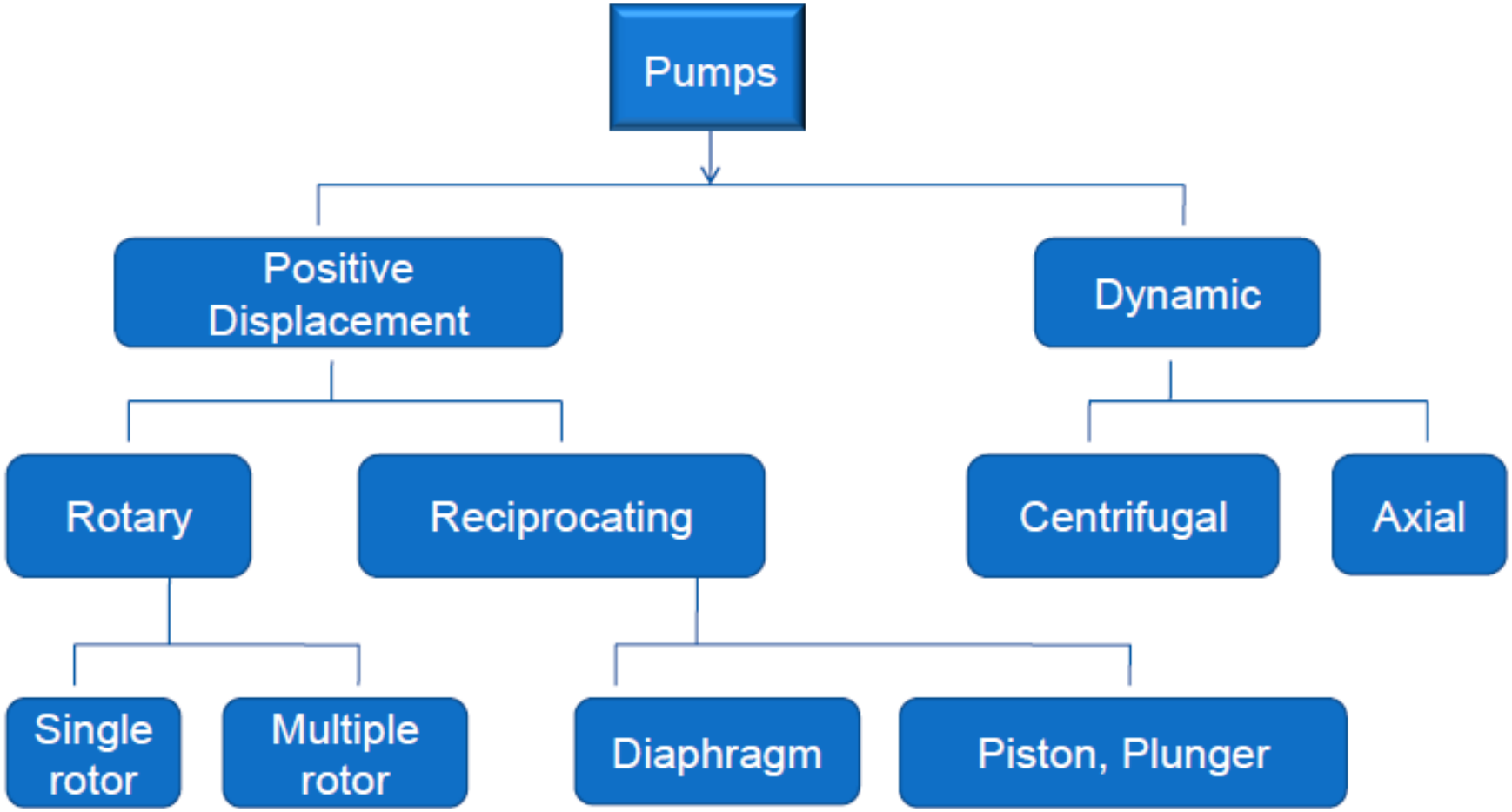
Content

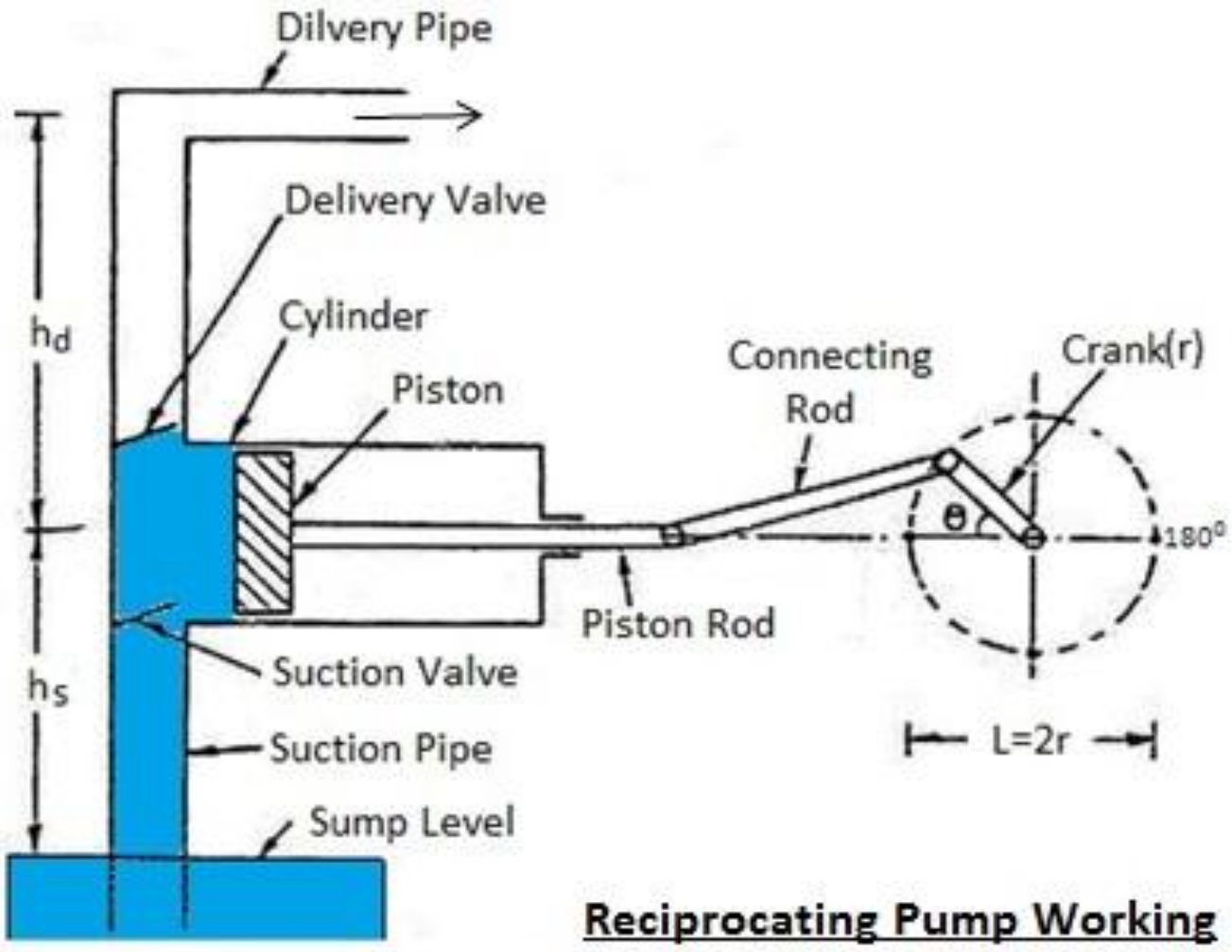
- Pumps
- Compressors
- Refrigeration
- Air conditioning system
- Hydraulic and Pneumatic systems

Pumps

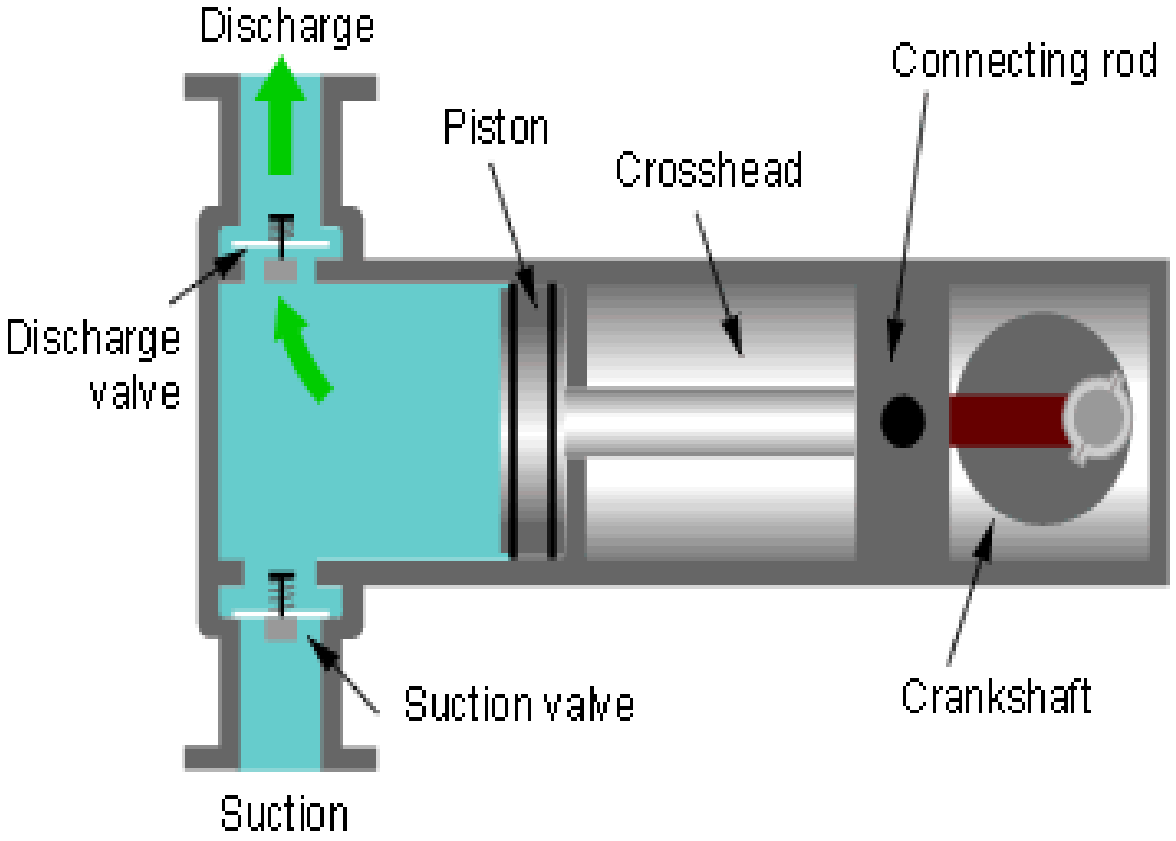
❑Pump Classification



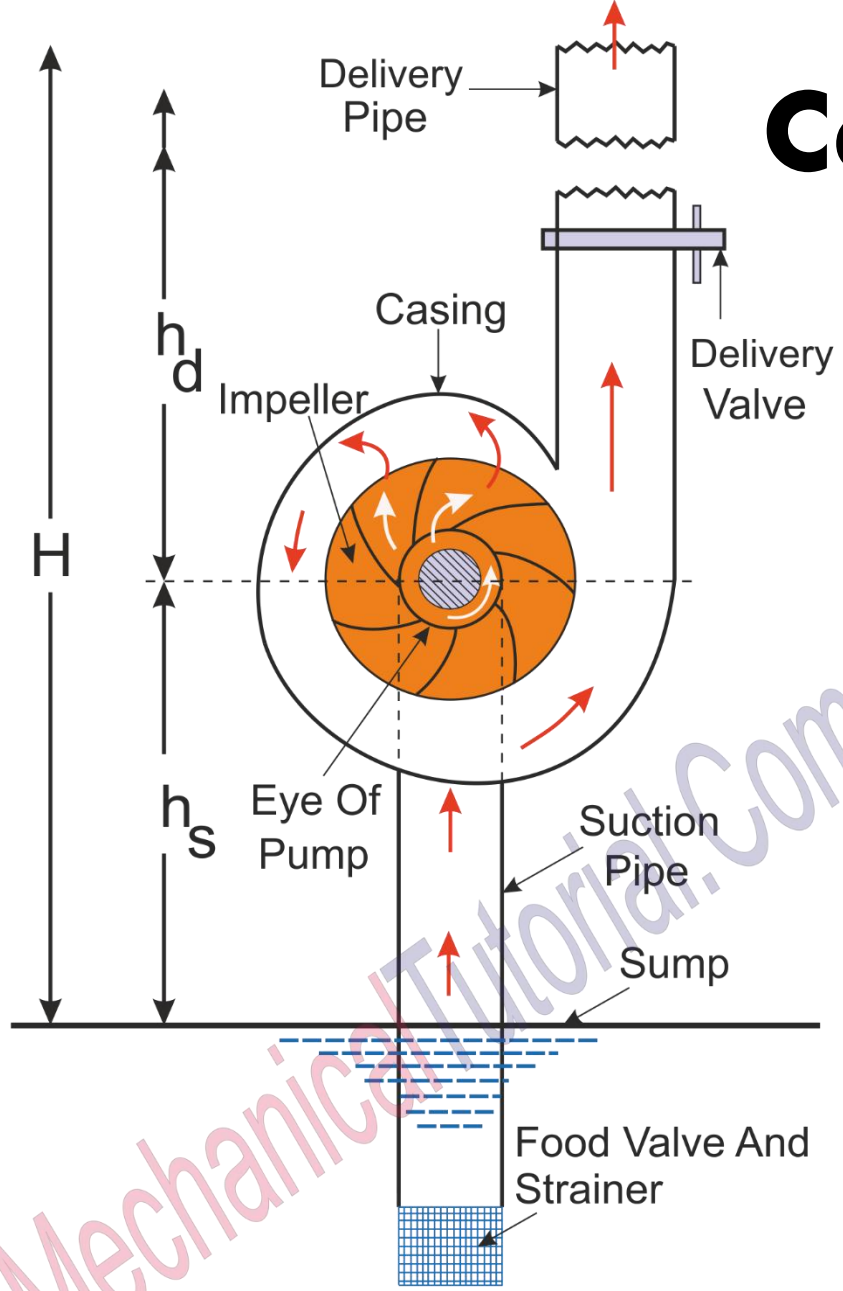
Reciprocating Pumps



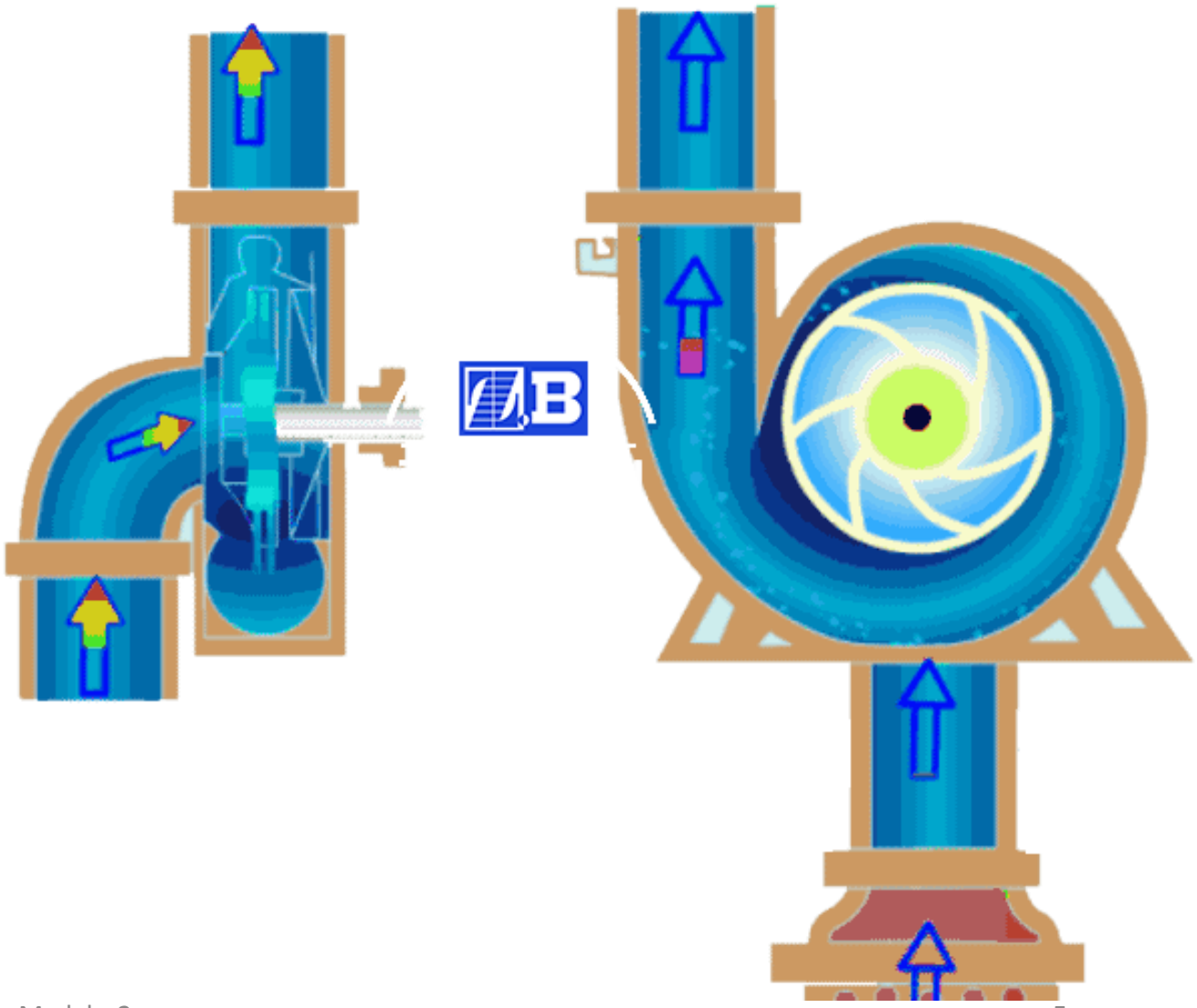
Reciprocating Pump Working



Centrifugal Pumps



Line Diagram Of Centrifugal Pump



Centrifugal Pumps

- **Casing:** A casing can be explained as a air tight passage/cover or a housing which protects and supports most of the components. In pumps, the casing is basically used to seal it to prevent leakage and sometimes retain pressure. It is also used to support some of the key parts such as shafts, bearings, etc. Spiral type casing, area of flow increases gradually. Increasing area reduces velocity and increases pressure.

- **Impellers:** An impeller is a rotating component in a centrifugal pump which is equipped with *backward curved vanes* or blades that rotate and moves the fluid in a pump. These vanes or blades are coupled to a shaft. When the impeller rotates, it converts the energy derived from a source i.e. motor to induce flow of the fluid.

Centrifugal Pumps

- **Suction Pipe with Foot Valve and Strainer:** Suction pipe is connected with the inlet of the impeller and the other end is dipped into the sump of water. At the water end, it consists of foot valve and strainer. The foot valve is a one way valve that opens in the upward direction. The strainer is used to filter the unwanted particle present in the water to prevent the centrifugal pump from blockage.

- **Delivery Pipe:** It is a pipe which is connected at its lower end to the out let of the pump and it delivers the liquid to the required height. Near the outlet of the pump on the delivery pipe, a valve is provided which controls the flow from the pump into delivery pipe.

Centrifugal Pumps

- The first step is priming. Priming is the operation in which suction pipe casing of the pump and the position of fluid with the liquid which is to be pumped so that all the air from the position of pump is driven out and no air is left.
- The necessity of priming of a centrifugal pump is due to the fact that the pressure generated at the centrifugal pump impeller is directly proportional to density of fluid that is in contact with it.
- After the pump is primed the delivery valve is still kept closed and electric motor is started to rotate the impeller.
- The liquid is made to flow in an outward radial direction there by vanes of impeller at the outer circumference with high velocity at outer circumference due to centrifugal action vacuum is created.
- This cause liquid from sump to rush through suction pipe to eye of impeller thereby replacing long discharge from center circumference of the impeller is utilized in lifting liquid to required height through delivery pipe.

Comparison of Centrifugal and Reciprocating Pumps

Centrifugal Pumps	Reciprocating Pumps
1. Steady and even flow	**1**. Intermittent and pulsating flow
2. For large discharge, small heads	**2**. For small discharge, high heads.
3. Can be used for viscous fluids e.g. oils, muddy water.	**3**. Can handle pure water or less viscous liquids only otherwise valves give frequent trouble.
4. Low initial cost	**4**. High initial cost.
5. Can run at high speed. Can be coupled directly to electric motor.	**5**. Low speed. Belt drive necessary.
6. Low maintenance cost. Periodic check up sufficient.	**6**. High maintenance cost. Frequent replacement of parts.
7. Compact less floors required.	**7**. Needs 6-7 times area than for centrifugal pumps.
8. Low head pumps have high efficiency	**8**. Efficiency of low head pumps as low as 40 per cent due to the energy losses.
9. Uniform torque	**9**. Torque not uniform.
10. Simple constructions. Less number of spare parts needed	**10**. Complicated construction. More number of spare parts needed.

Air Compressors

- Device **providing air at high pressure.**
- Takes air at atmospheric pressure, compresses it and delivers it at high pressure to storage vessel called as receiver.
- From receiver compressed air may be conveyed by the pipeline to a place where supply of compressed air is required.

Air Compressors

Applications:

1. Operate pneumatic drills, air motors, hammers, riveting and nut tightening etc.
2. Cleaning of workshops and automobiles.
3. Supercharging of I.C. Engines and gas turbines.
4. Spray painting.
5. Refrigeration and air conditioning.
6. Construction of dams and, tunnels, bridges, etc.
7. Spraying fuel in high speed diesel engines.
8. Driving mining machineries.
9. Conveying sand materials, concrete, etc.
10. Air brakes.
11. Paper industries and printing machinery.

Air Compressors

Classification:

- **According to the type of motion**

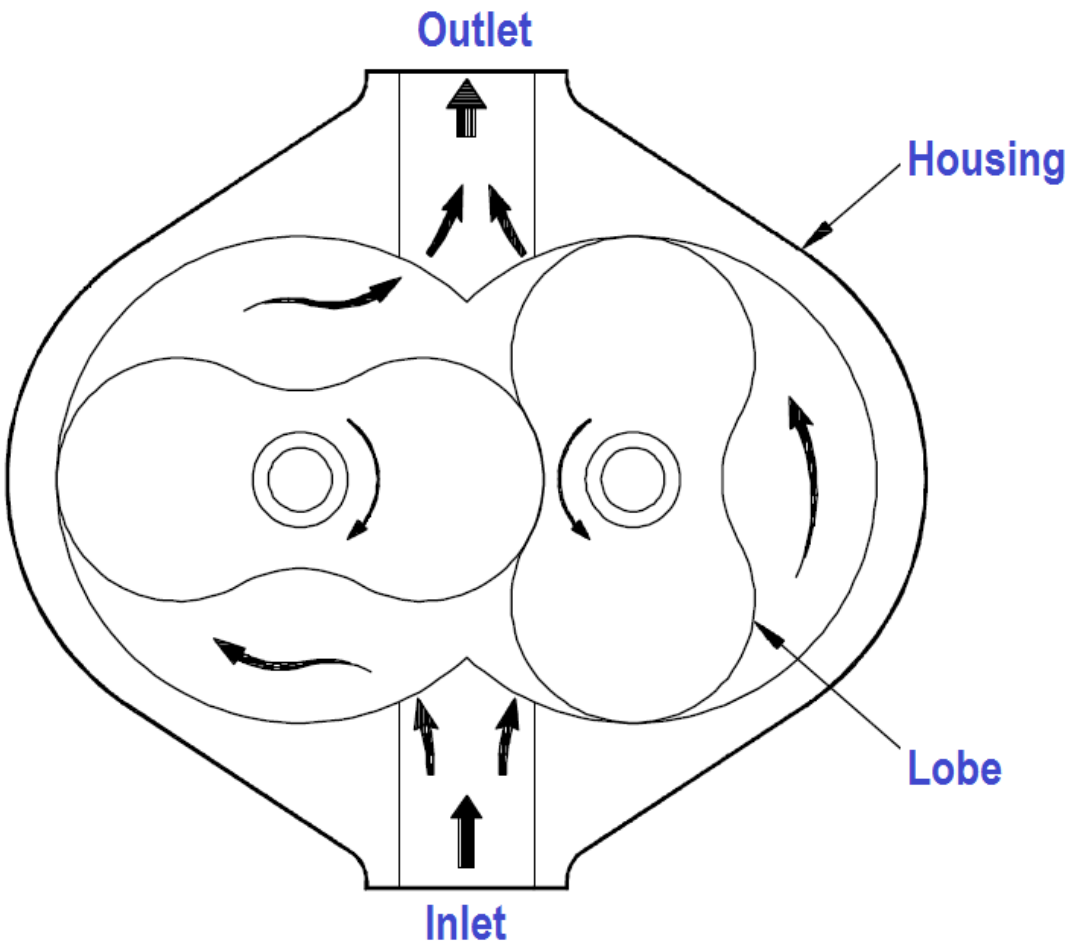
1. Reciprocating air compressors
2. Rotary air compressor

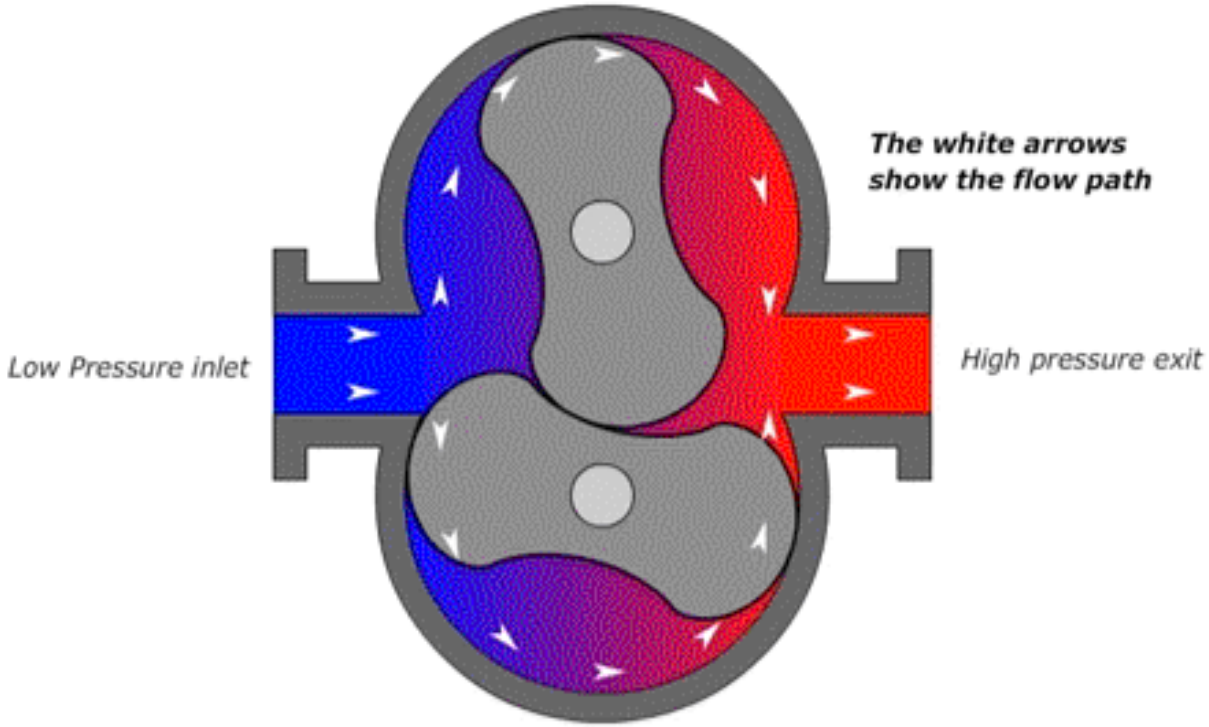
These compressors are further classified as follows:

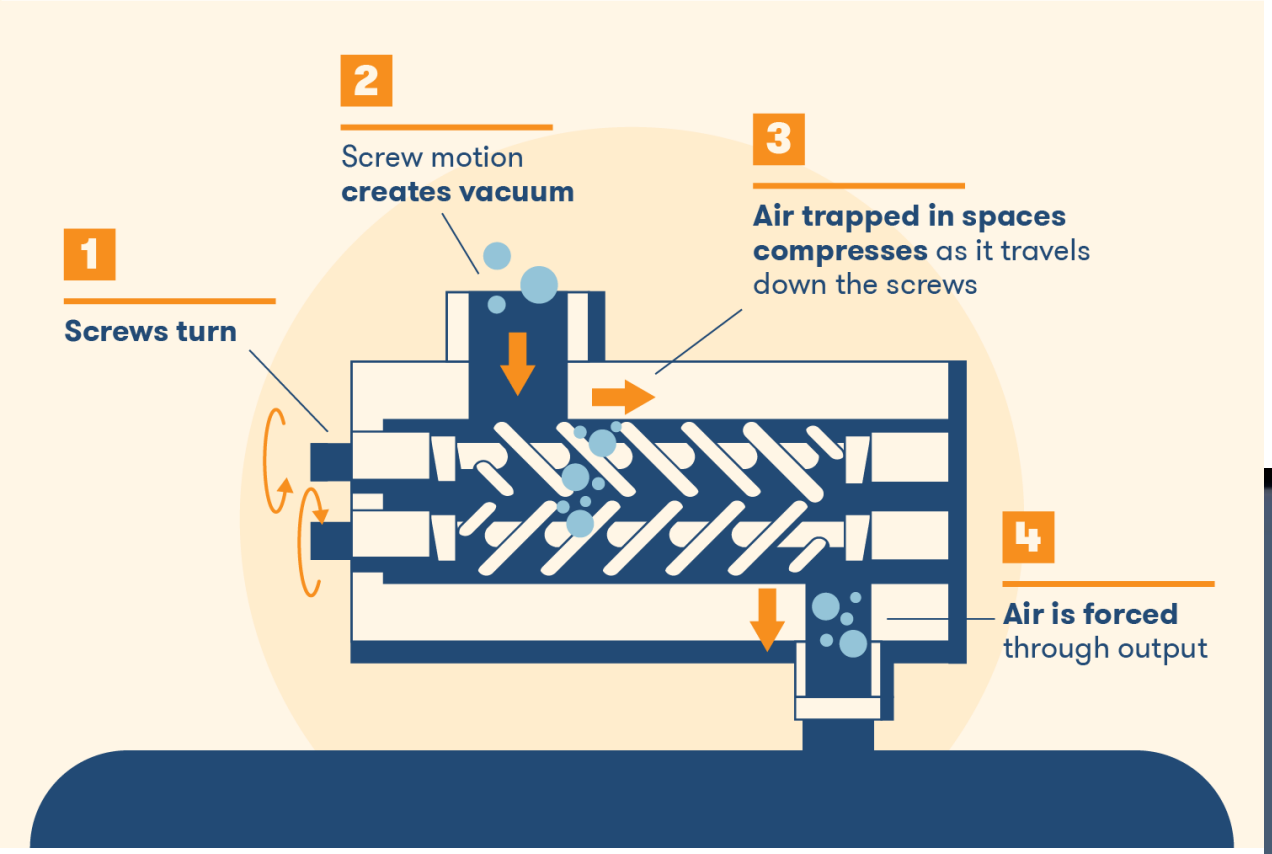
i. Positive displacement compressors:

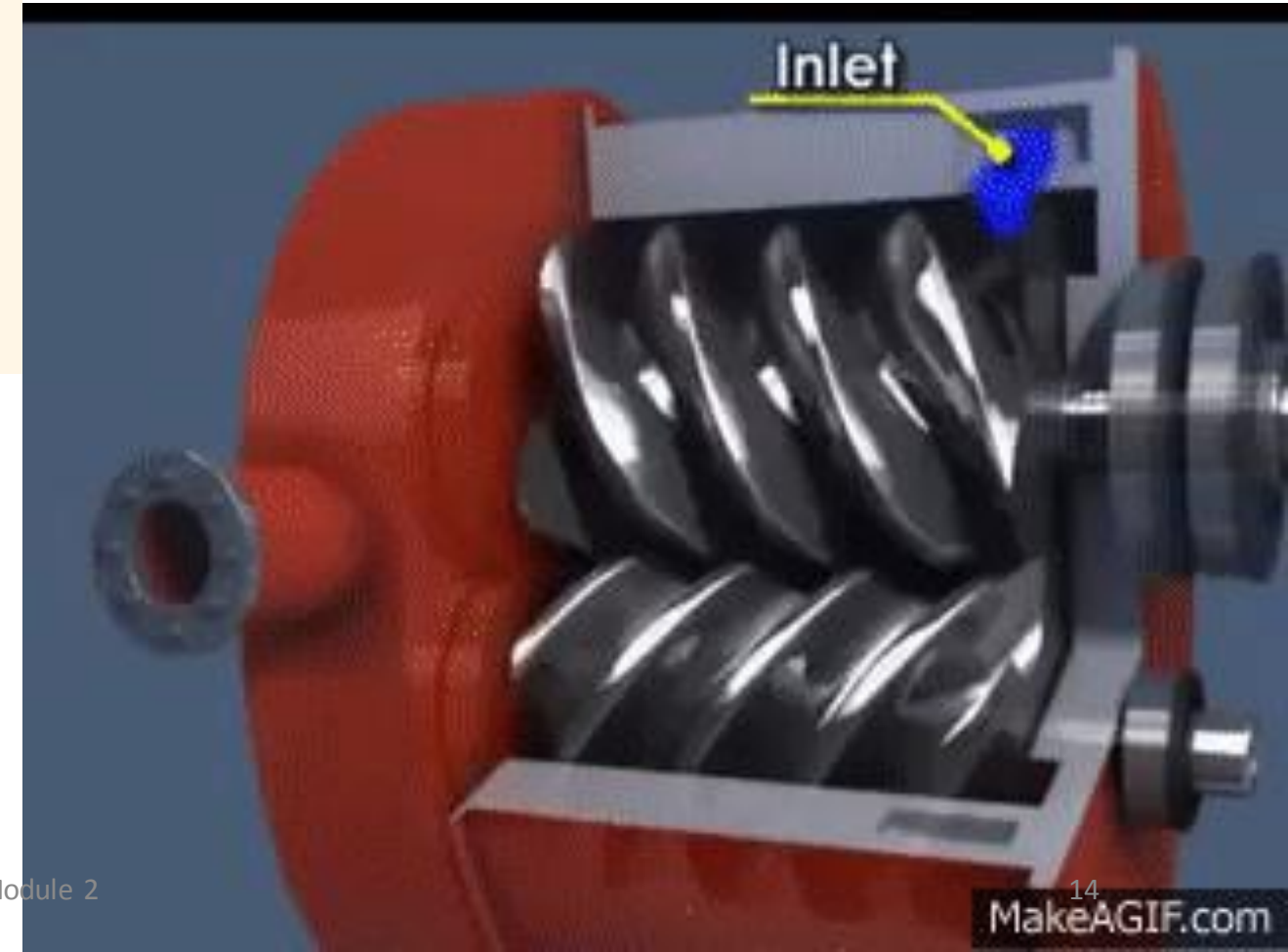
ii. Non positive displacement compressors:

Rotary Lobe Air Compressor



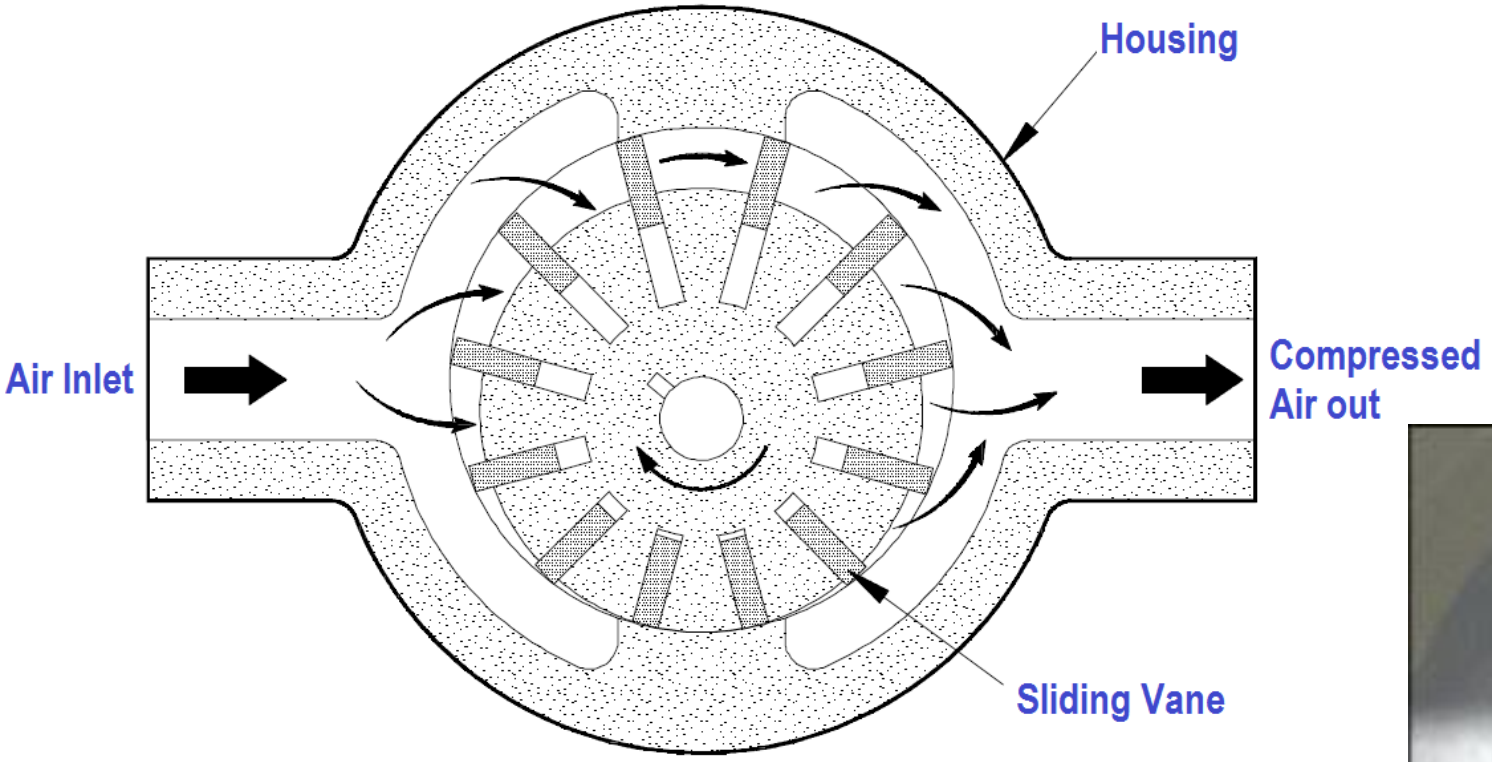


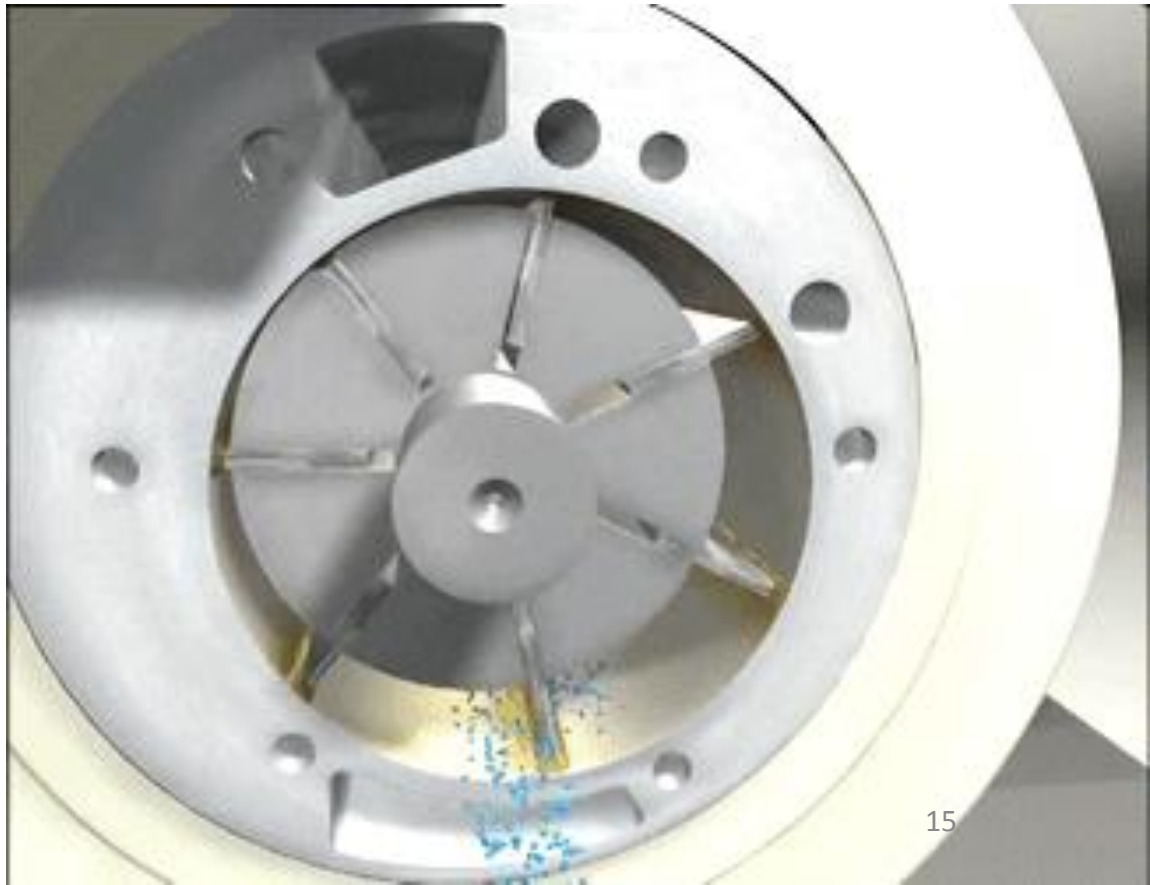




Screw Compressors

Rotary Slide Vane Air Compressor

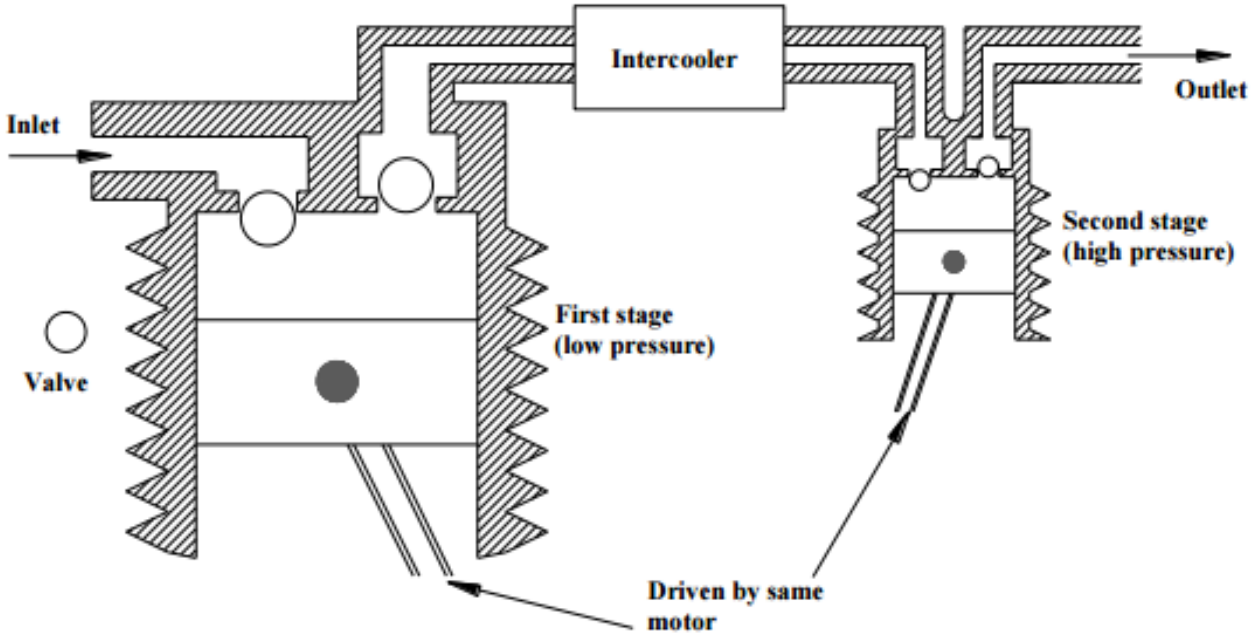




Air Compressors

- **According to number of stages:**

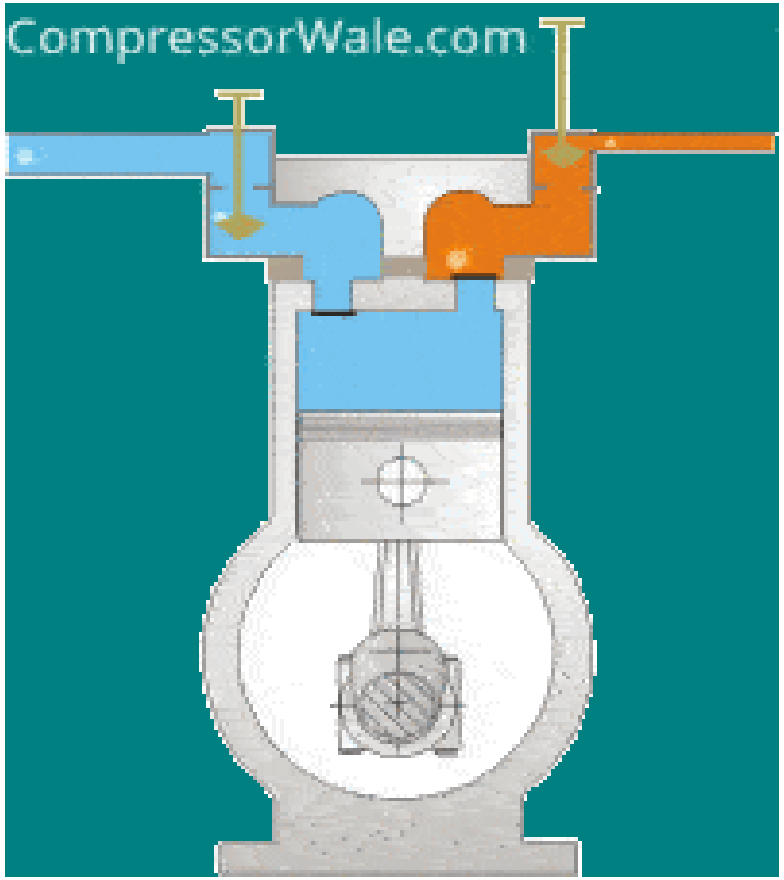
1. Single stage compressor
2. Multi-stage compressor

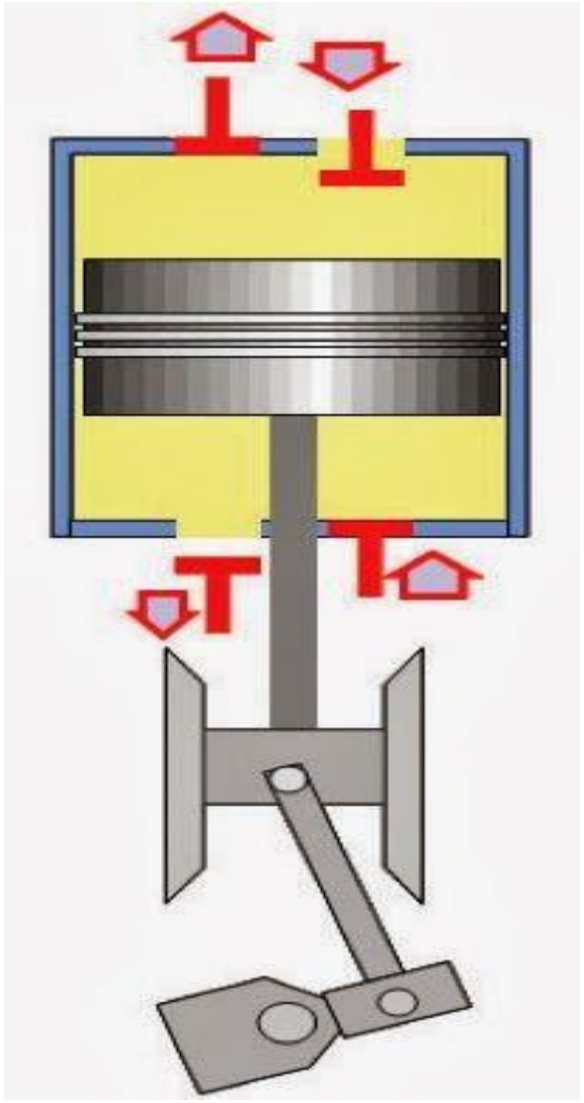


Air Compressors

- **According to working position (side) of piston**

1. Single acting compressors
2. Double acting compressors





Air Compressors

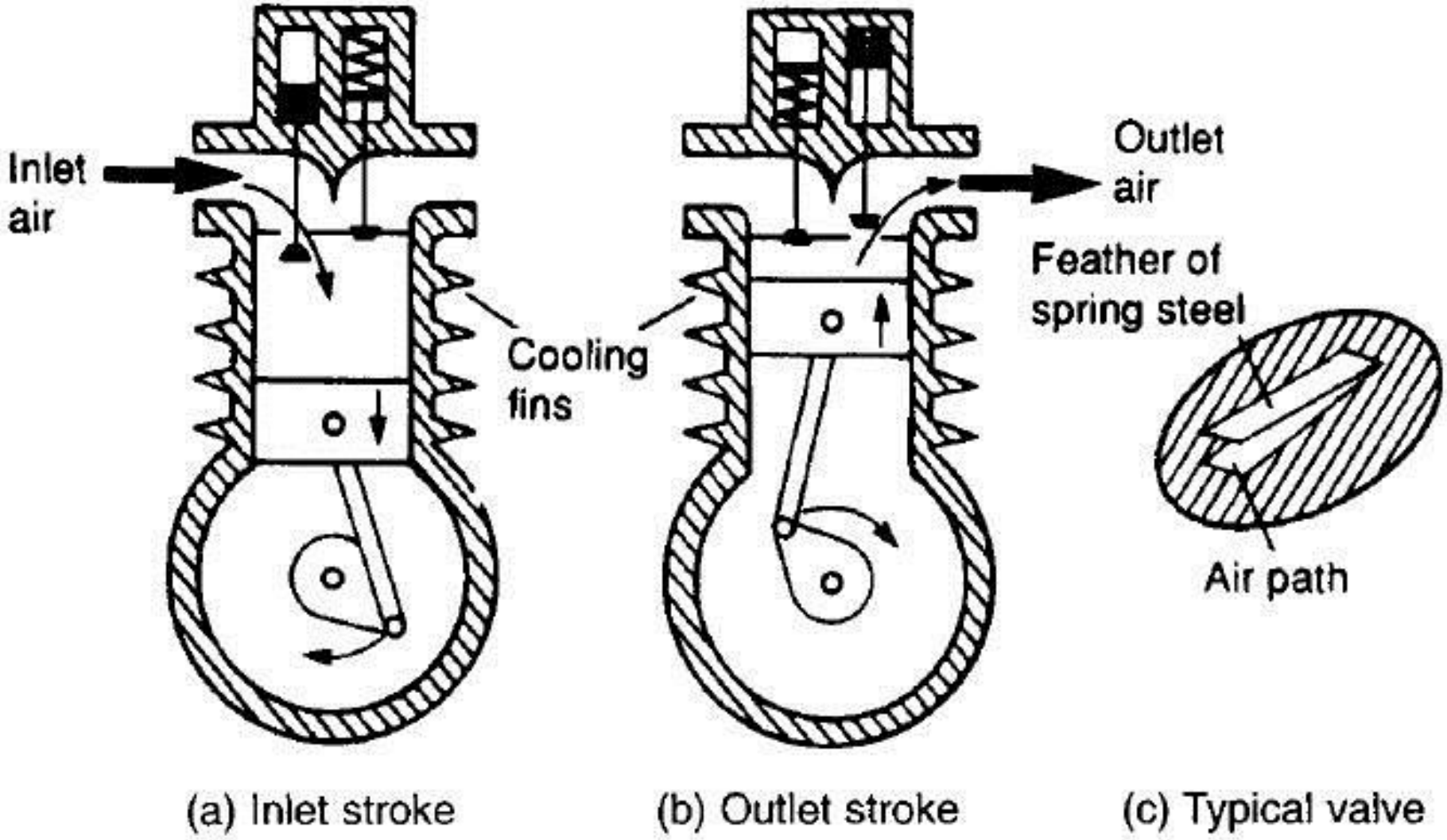
- **According to the discharge pressure**

1. Low pressure compressors: Delivery pressure less than 10 bar.
2. Medium pressure compressors: Delivery pressure in between 10 to 80 bar.
3. High pressure compressors: Delivery pressure greater than 80 bar.

- **According to capacity of compressor**

1. Low capacity compressors: Discharge capacity less than 0.15 m^3/s.
2. Medium capacity compressors: Discharge capacity in between 0.15 to 5 m^3/s.
3. High capacity compressors: Discharge capacity greater than 5 m^3/s.

Reciprocating Air Compressors



Air Compressors

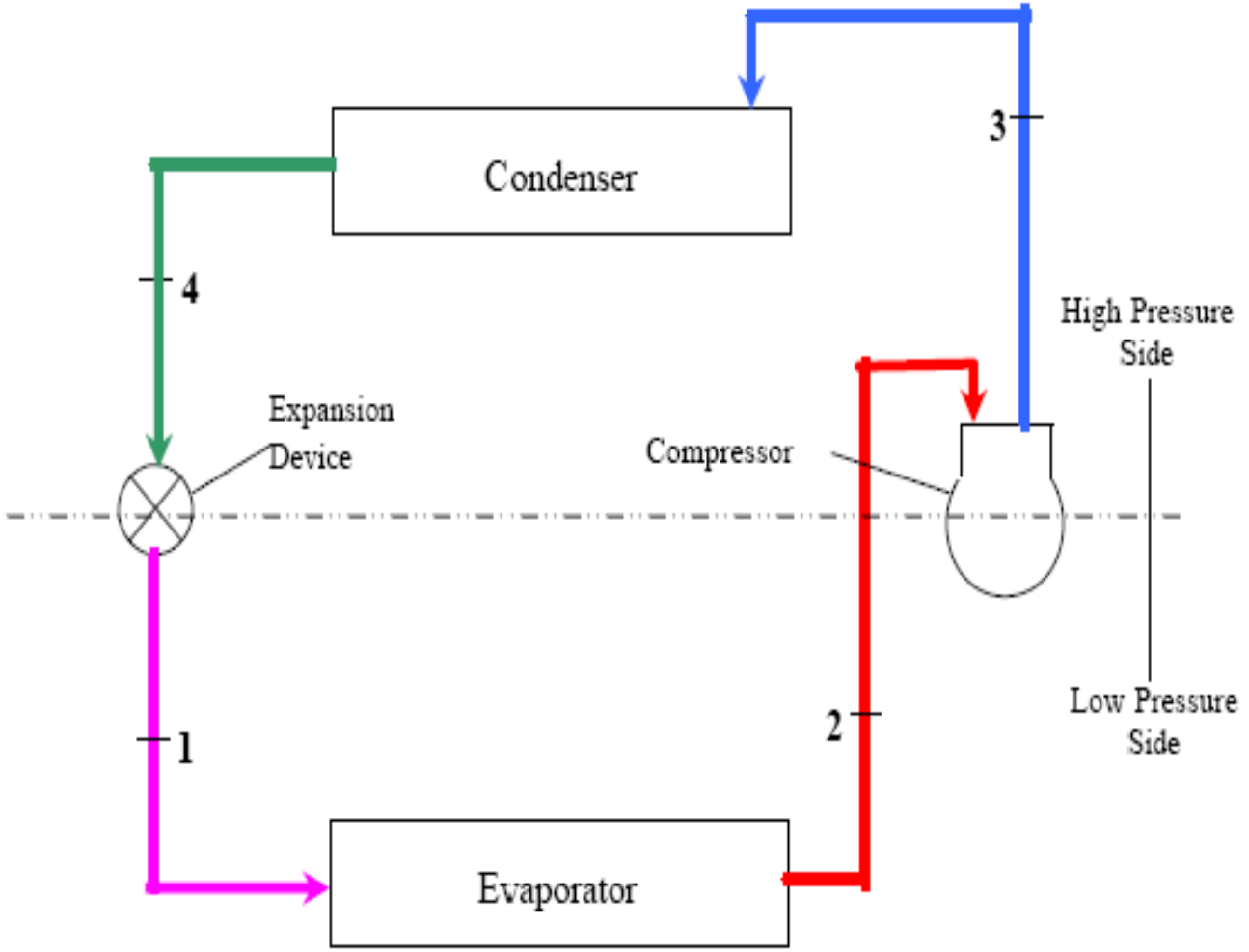
- Terminologies used:

1. **Free air delivery (F.A.D.):** volume of air delivered under the conditions of pressure and temperature existing at compressor inlet. Generally it is 1.01325 bar pressure and 15°C temperature.
2. **Power Capacity:** Quantity of free air actually delivered by the compressor in m^3/s or m^3/min.
3. **Pressure Ratio:** Ratio of outlet pressure to inlet or suction pressure.
4. **Shaft Power/ Brake Power:** Power required to drive the compressor.

Refrigeration

- Vapour Compression Refrigeration (VCR) is most commonly used method of refrigeration for refrigerators and air-conditioners etc.
- Basic Components:

1. Evaporator
2. Compressor
3. Condenser
4. Expansion Device
5. Refrigerant



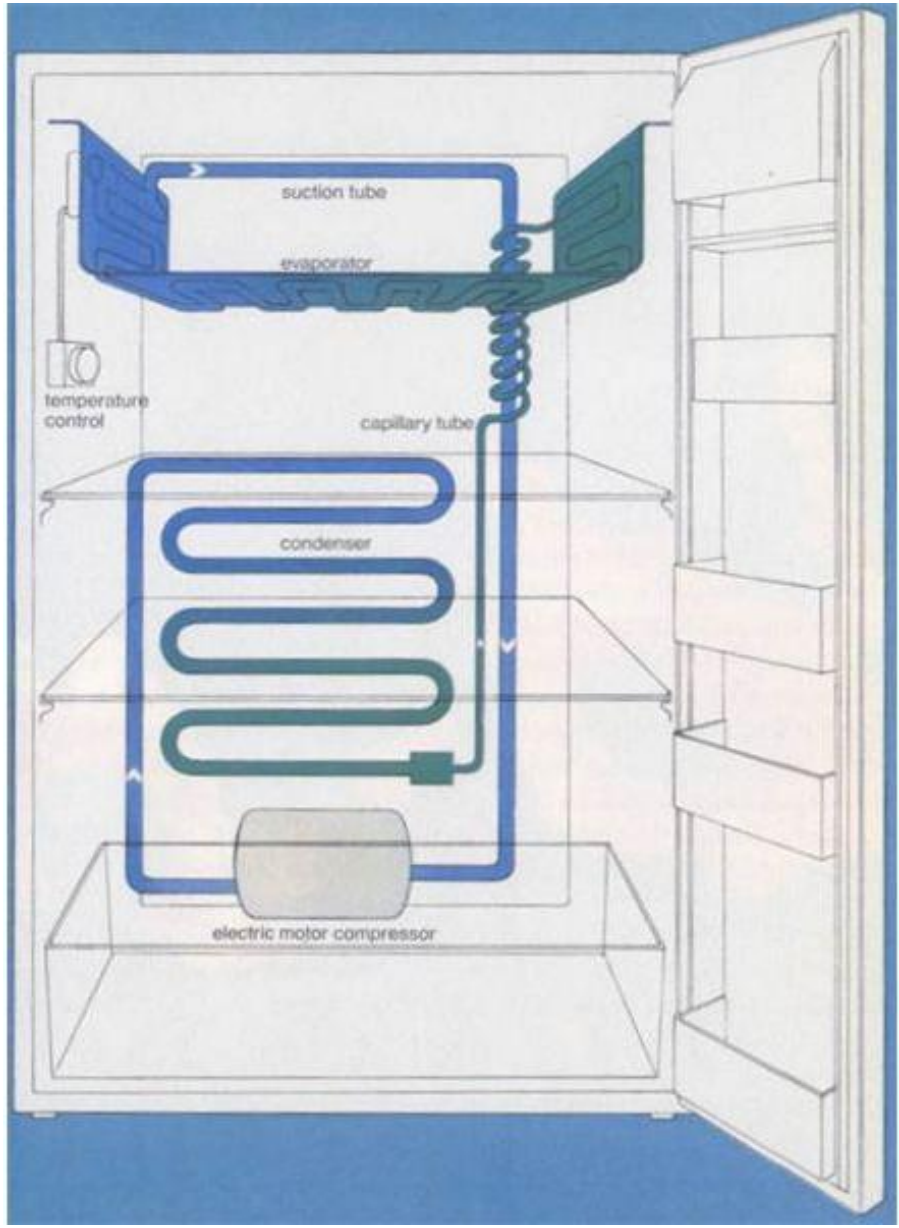
Refrigeration

1. **Evaporator:** Absorbs heat (latent heat) from the storage compartment and gives it to the refrigerant, which converts its phase from low pressure liquid to vapour. It is further supplied to the compressor.
2. **Compressor:** During suction stroke compressor draws low pressure dry vapour from evaporator. And during compression stroke temperature and pressure of the vapour increases.
3. **Condenser:** High pressure high temperature vapour refrigerant enters in condenser to reject heat to the surrounding cooler medium. While this heat (latent heat) rejection refrigerant phase changes to liquid which is at high pressure.
4. **Expansion Device:** After condensation refrigerant is stored in receiver and then passed to evaporator through expansion device (Capillary tube or throttle valve). This valve reduces pressure by keeping enthalpy constant (Isenthalpic Throttling process).
5. **Refrigerant:** NH_3, R-11, R-12, R-22. Modern refrigerants as Freon-22 and 134a.

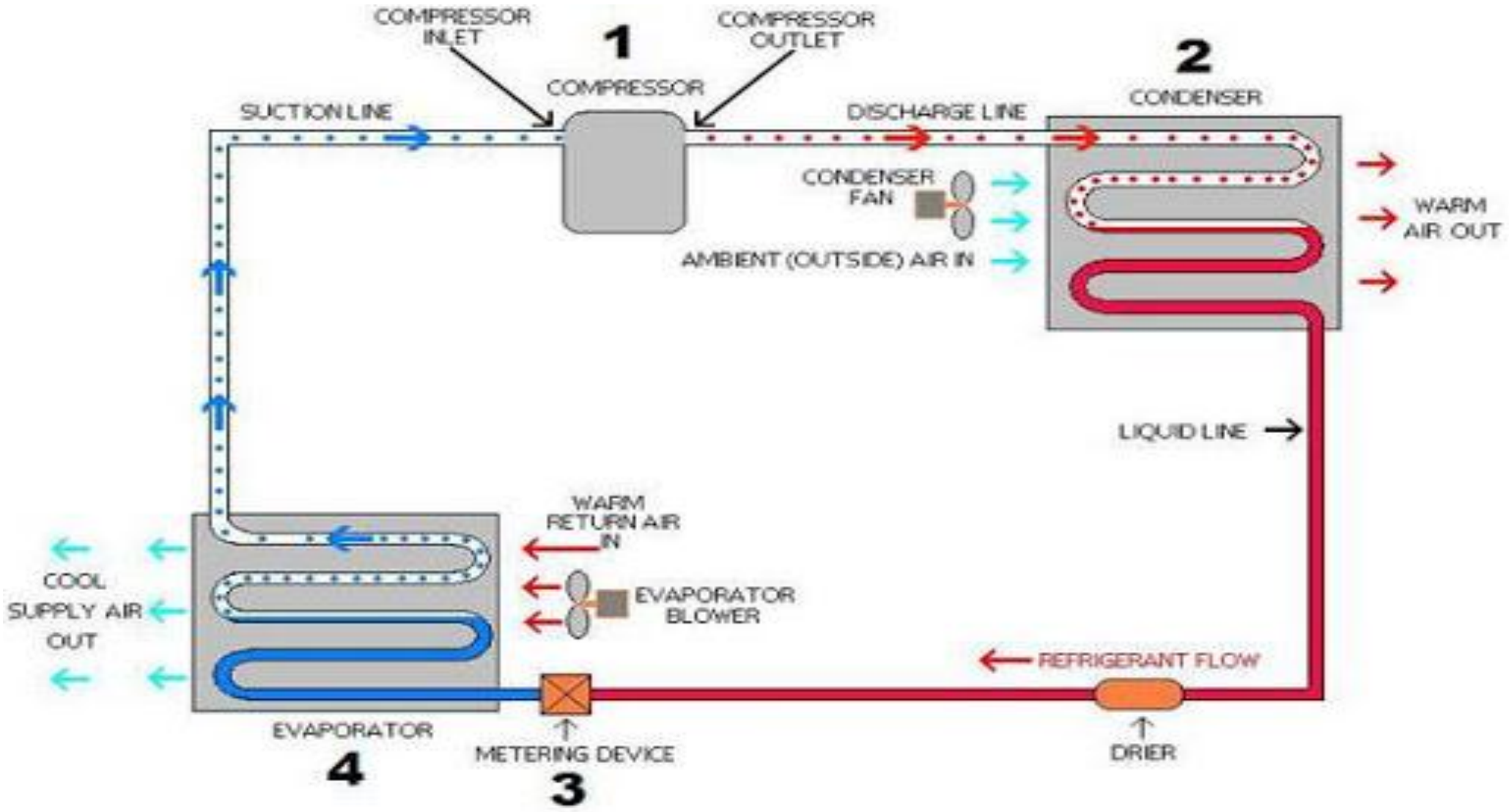
Refrigeration

- Household refrigerators is application of vapour compression refrigeration and consists following main elements:

1. Evaporator (coils of Aluminum, stainless steel)
2. Hermetically sealed compressor (type of reciprocating compressor)
3. Condenser (coils of copper)
4. Receiver
5. Expansion valve (capillary tube)



Air Conditioning

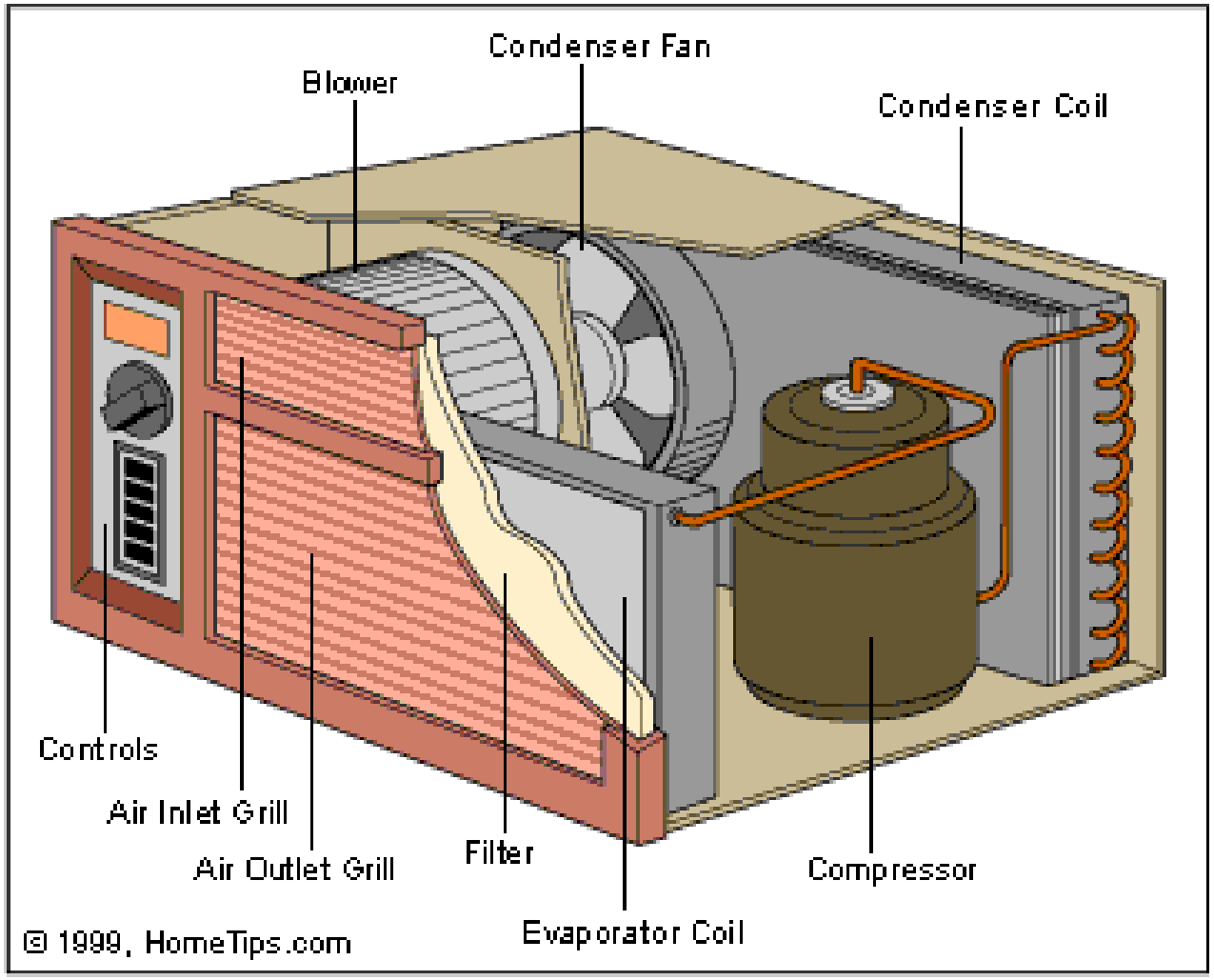


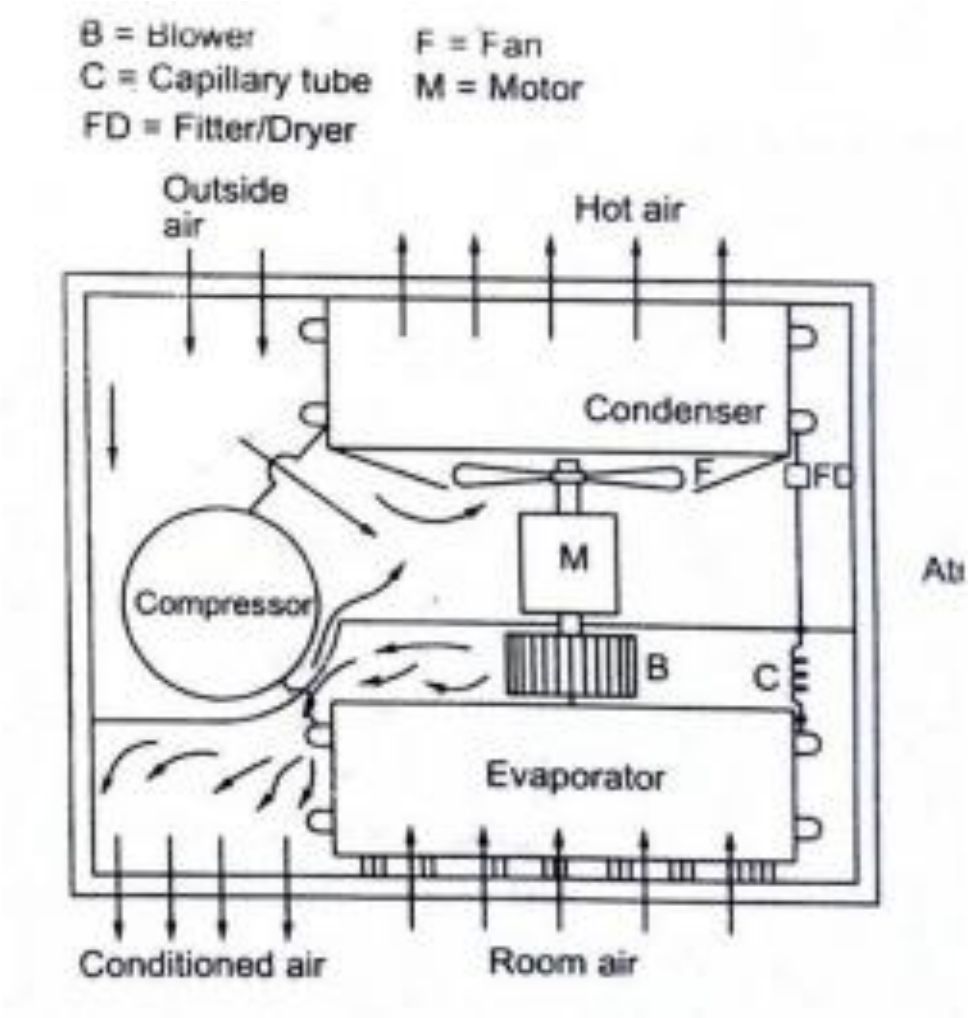
Air Conditioning

- **Air Conditioning:** It is a simultaneous control of temperature, humidity (moisture content on air), motion (circulation and movement) and purity (air filtering and cleaning) of air within an enclosed space.
- For human comfort in industries, offices, houses, hospitals, commercials etc.
- Same components as refrigerators, only addition is blower and fans.
- Blowers are placed behind the evaporator, which pulls the air through cooling coil and through filter provided on the coil face. This air is discharged back to room.
- Whereas, fans are placed behind the condenser to cool down the condenser by forced convection. It pulls the air from sides and throws air over the condenser coil.

Air Conditioning

Window AC





Air Conditioning

Split AC