Expansion Device

The following figure is the schematic diagram for vapor compression refrigeration system some notes are listed below:-

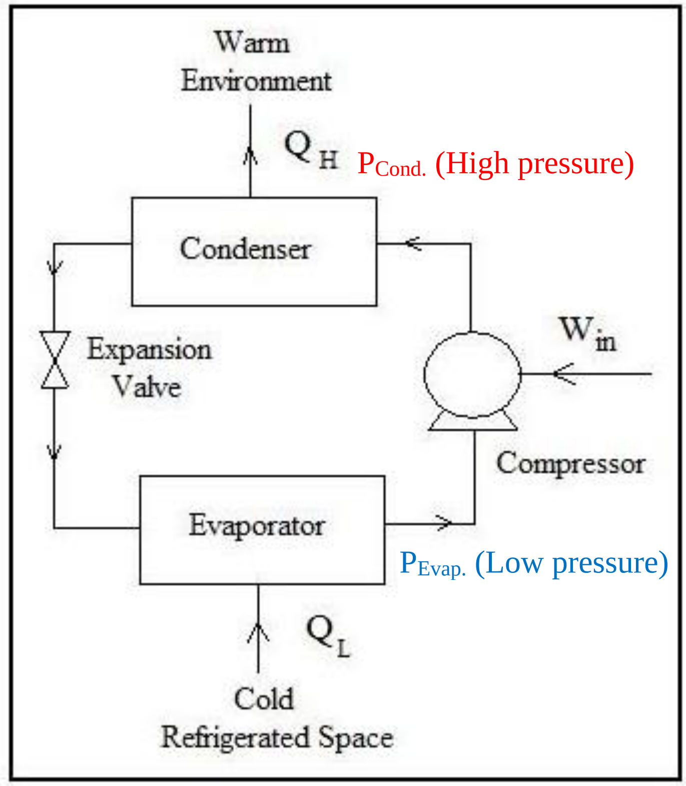
1- The system operate between two pressures condensing pressure (p_{cond}) as high pressure and evaporating pressure (p_{evap}) as low pressure.

2- The refrigerant flow rate through the system depending on the pressure difference between condenser and evaporator (p_{cond} - p_{evap}).

3- When the condenser pressure(p_{cond}) increased the pressure difference increased so that the liquid refrigerant flow rate passes through expansion device increased while the vapor flow rate pumping by compressor decreased.

4- When the evaporating pressure (p_{evap}) increased the pressure difference decreased so that the liquid refrigerant mass flow rate through expansion decreased while the vapor flow rate through compressor increased.

5- When the evaporating pressure (p_{evap}) decreased the pressure difference increased so that the liquid refrigerant mass flow rate through expansion device increased while the vapor flow rate through compressor decreased.



Vapor Compression Refrigeration Cycle

Pressure Difference (ΔP) = $P_{Cond.} - P_{Evap.}$

Q1) What is the propose of expansion device.

Ans

1- Reduce the pressure of liquid refrigerant from condensing pressure to evaporator pressure.
2- Regulate the flow of refrigerant to the evaporator.

Q2) What is the common types of expansion devices.

Ans

1-Capillary tube. 2- Superheated controlled expansion valve

3- Float valve. 4- Constant –pressure expansion valve.

Q3) Explain the specification and using of capillary tube.

Ans

The capillary tube used for small refrigeration systems limited to 10 kW refrigeration capacity, the capillary tube length 1 m to 6 m with an inside diameter 0.5 mm to 2 mm, the disadvantage of capillary tube it does not adjustable to variation of discharge pressure, suction pressure and load.

Q4) Draw and explain a diagram for balance points with a reciprocating compressor and capillary tube.

Ans

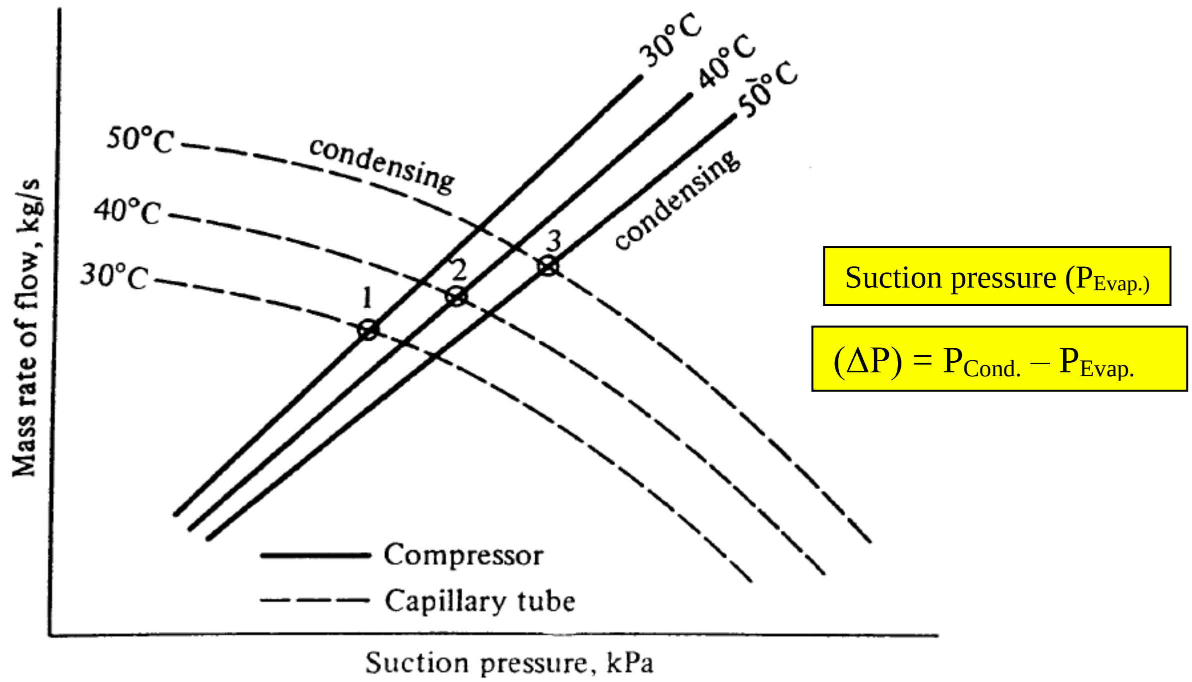
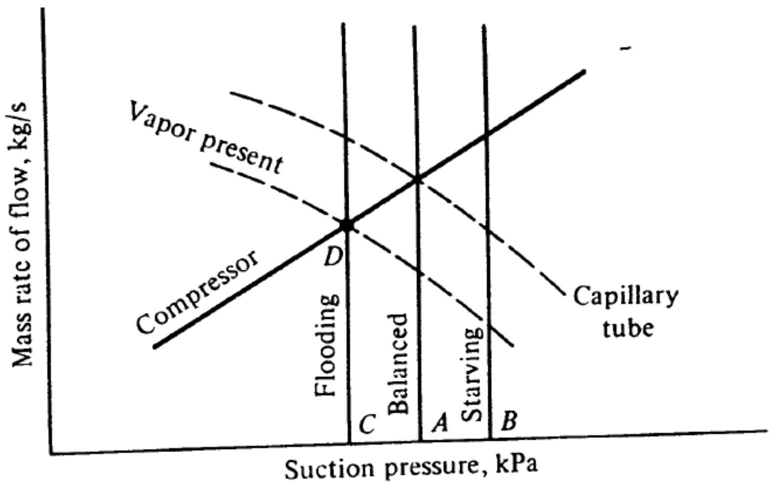


Figure 13-1 Balance points with a reciprocating compressor and capillary tube.

As condensing temperature increased ($T_{cond.}$) the condensing pressure ($P_{cond.}$) increased so the capillary tube feeds more refrigerant to the evaporator because of the increase of pressure difference ($\Delta P = P_{cond.} - P_{evap.}$) While the compressor pumped less vapor refrigerant to condenser, so that the capillary tube and compressor balanced the refrigerant flow rate shown at balance points in the fig. above.

Q5) Explain with drawing a diagram the unbalanced conditions causing starving or flooding of evaporator. The condensing pressure is constant.

Ans



Suction pressure ($P_{Evap.}$)

(ΔP) = $P_{Cond.} - P_{Evap.}$

Figure 13-2 Unbalanced conditions causing starving or flooding of the evaporator. The condensing pressure is constant.

1- Starving condition (B)

When the suction pressure (evaporator pressure) be increased as refrigeration load increased the pressure difference ($\Delta P = P_{cond.} - P_{evap.}$) decreased leads to increased the vapor pumped by compressor and the capillary tube not feed sufficient refrigerant to the evaporator causing starving condition.

2- Balanced conditions (A)

When the compressor pumped more vapor to the condenser the condensing pressure increased and the pressure difference ($\Delta P = P_{cond.} - P_{evap.}$) increased also and the capillary tube return to feed sufficient refrigerant to the evaporator until balanced condition occurred.

3- Flooding conditions (C)

When the suction pressure (evaporator pressure) decreased by decreasing the refrigeration load the pressure difference ($\Delta P = P_{cond.} - P_{evap.}$) increased and the capillary tube feeds more refrigerant to the evaporator while the compressor pumps less vapor to condenser which leads to flooding conditions.

Q6) Explain the advantage and disadvantage of capillary tube.

Advantage :-

1- Universal acceptance in factory-sealed system.
2- Simple and no moving parts and are inexpensive.
3- They are allow the pressures in the system to equalize during the off cycle.

Disadvantage:-

1- They are not adjustable to changing load condition.
2- Clogging by foreign matter.
3- Required the mass of refrigerant charge to be held at certain limits.
4- Any change in applied heat load or condensing temperature from design condition the system operating efficiency decreased.

Q7) Explain the selection of capillary tube.

13-3 Selection of a capillary tube The designer of a new refrigeration unit employing a capillary tube must select the bore and length of the tube so that the compressor and tube fix a balance point at the desired evaporating temperature. Final adjustment of the length is most often "cut and try." A longer tube than desired is first installed in the system with the probable result that the balance point will occur at too low an evaporating temperature. The tube is shortened until the desired balance point is reached.

Q8) What is the effect of some vapor enters the capillary tube.

Ans:- As shown in the figure below that the refrigeration effect decreased when some vapor enters the capillary tube.

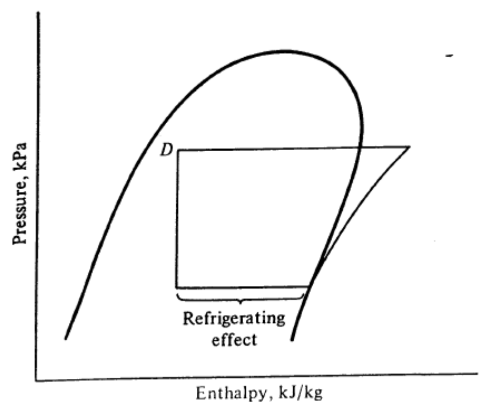


Figure 13-3 Reduction in refrigerating effect when some vapor enters the capillary tube.

Q9) Explain with drawing the chocked flow in capillary tube

Ans

When the outlet pressure of refrigerant reduced until the sonic velocity occurs at the throat. Further reductions in the suction pressure fail to increase the flow rate through the tube. The thermodynamic conditions are represented by Fanno line shown on the enthalpy-entropy diagram where the enthalpy decreases while the entropy increases as the fluid flows through the tubes.

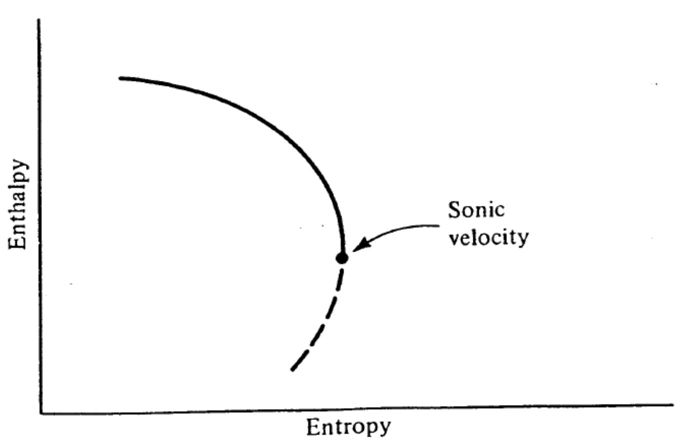


Figure 13-5 Fanno line showing choked-flow conditions.

The implication of chocked flow in a capillary tube of a refrigeration system is that at some suction pressure the flow rate curves of the capillary tube shown in the figure below where further decrease in suction pressure do not increase the rate of flow through the capillary tube.

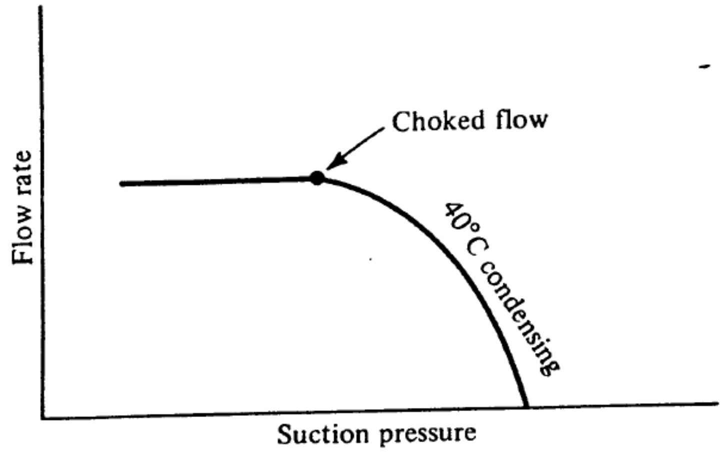


Figure 13-6 Flow through a capillary tube.

Q10) Explain with drawing the operation and performance of constant pressure expansion valve

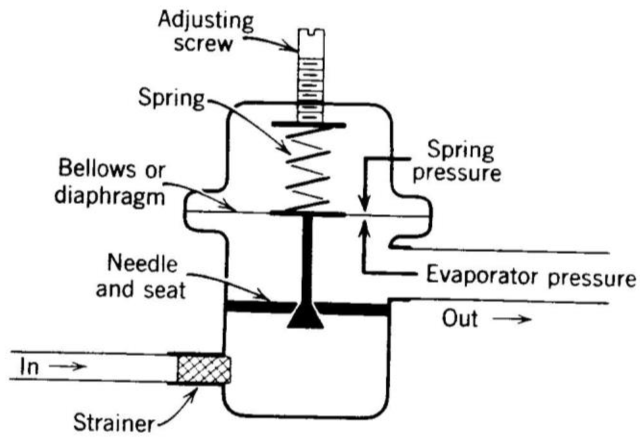


Fig. 17-2 Schematic diagram of automatic expansion valve.

Valve Operation

The constant pressure expansion valve (automatic expansion valve) maintains a constant pressure at its outlet (evaporator pressure). When the evaporator pressure drops below the control point the force of the adjusting spring open the valve wider. When the evaporator pressure rises above the adjusting spring forces the valve partially closes. The use of constant-pressure expansion valve limited to system capacity 30 kW.

Valve Performance

The effect of the valve operation on the performance of the system is charted in the fig below.

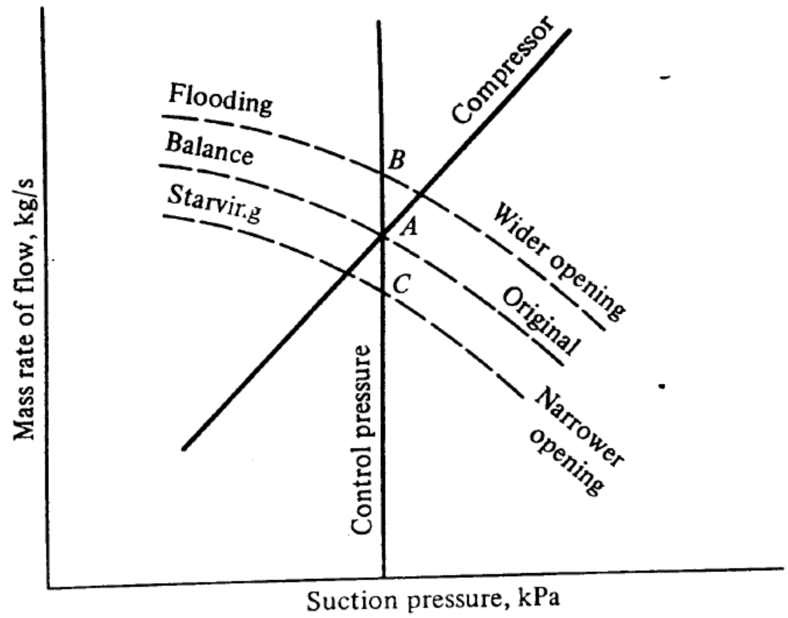


Figure 13-9 Balanced and unbalanced conditions using a constant-pressure expansion valve. The condensing pressure is constant.

At constant condensing pressure if the liquid feeding by the valve is equal to the rate of vapor pumps from the evaporator the operation point at balance (point A). if the load increased which leads to increase in suction pressure the valve closes partially and the operation point at C (starving). if the load decreased the suction pressure decreased also and the valve open wider and the operation point at B (Flooding).

Q11) Explain with drawing the operation and performance of float expansion valve

the float valve is the type of the valve which maintains the liquid at constant level at evaporator. The valve types 1- High pressure float valve. 2- Low pressure float valve.

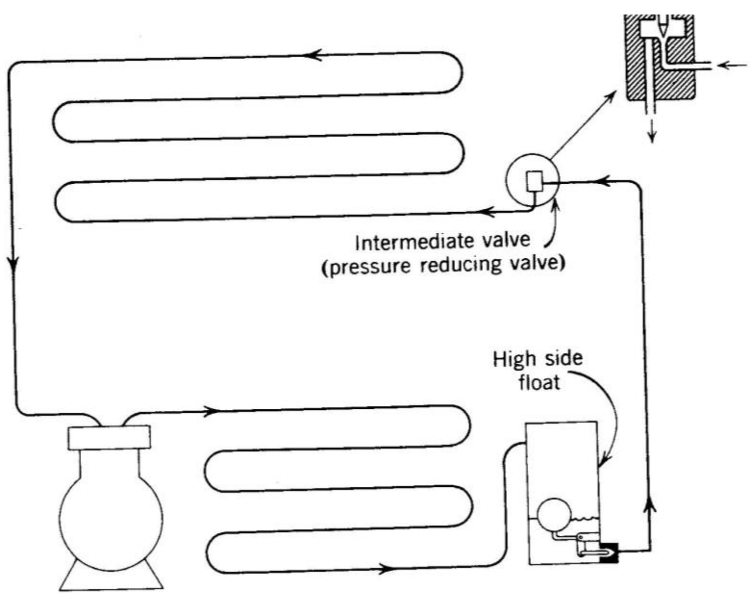


Fig. 17-31 High-pressure float valve.

A float switch which opens completely when the liquid level drops below the control point and closes completely when the level reaches the control point.

Valve Performance

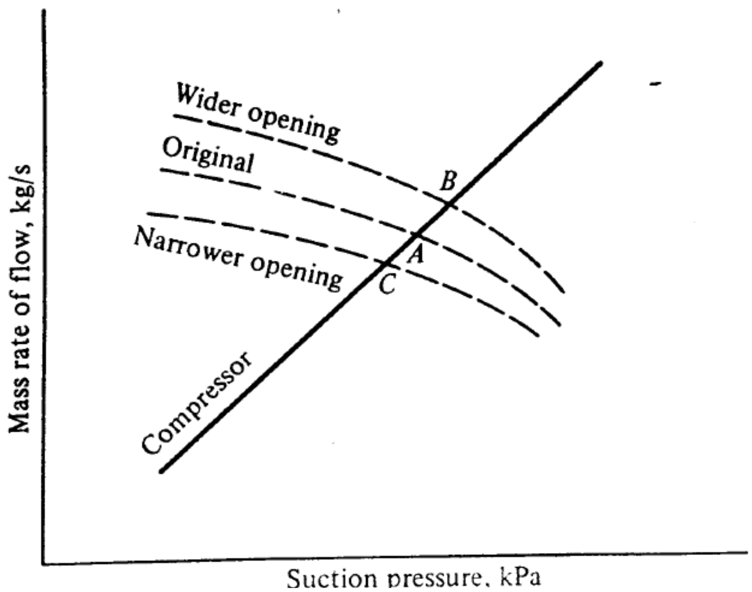


Figure 13-10 Balance points with various load conditions using a float valve. The condensing pressure is constant.

At constant load conditions the liquid level in the evaporator is maintained and the compressor pumps the same refrigerant flow rate as the valve feeds the evaporator the operation point at A (balance point). When the load increased the suction pressure increased also and the compressor pumps more vapor from the evaporator so the valve wider opening to keep the level of liquid in the evaporator the operation point at B. when the load decreased the suction pressure decreased and the liquid level in the evaporator rises so the valve closes partially and the operation point at C.

Q12) Explain with drawing the operation and performance of superheat- controlled (thermostatic) expansion valve

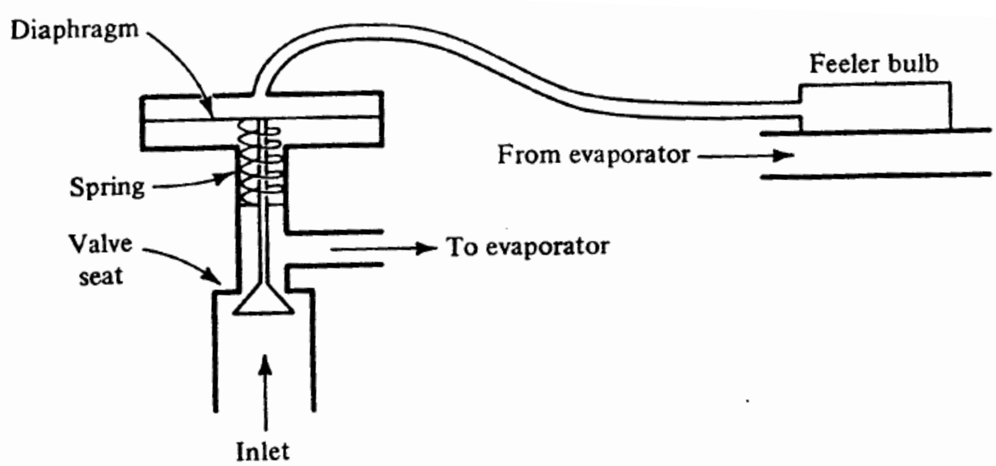


Figure 13-12 A schematic diagram of the basic superheat-controlled expansion valve.

The valve controlling the magnitude of superheat of the suction gas leaving the evaporator. The superheat expansion valve regulates the rate of flow of liquid refrigerant according to the rate of evaporation in the evaporator. A feeler bulb is partially filled with liquid of the same refrigerant as in the system. The fluid in the bulb called (power fluid).
The feeler bulb is clamped to the outlet of the evaporator so that the power fluid temperature is the temperature of the suction line. When the pressure of power fluid (over the diaphragm is greater than the pressure of the evaporator and the spring force the valve is partially opened and when the pressure of the evaporator and the spring forces greater than power fluid force the valve is partially closed.

-The types of superheat expansion valve is
1- Internal equalizer.
2- External equalizer. (The pressure at outlet of evaporator instead of evaporator pressure)

Q13) Explain with drawing the operation of electric expansion valve.

13-12 Electric expansion valves The electric expansion valve, shown schematically in Fig. 13-17, uses a thermistor to sense the presence of liquid in the outlet stream of the evaporator. When no liquid is present, the temperature of the thermistor increases, which drops its resistance and permits a greater current flow through the heater at the valve. The valve is thereby opened, allowing an increased refrigerant flow rate. One of the applications of the electric expansion valve is for heat pumps (Chap. 18), where

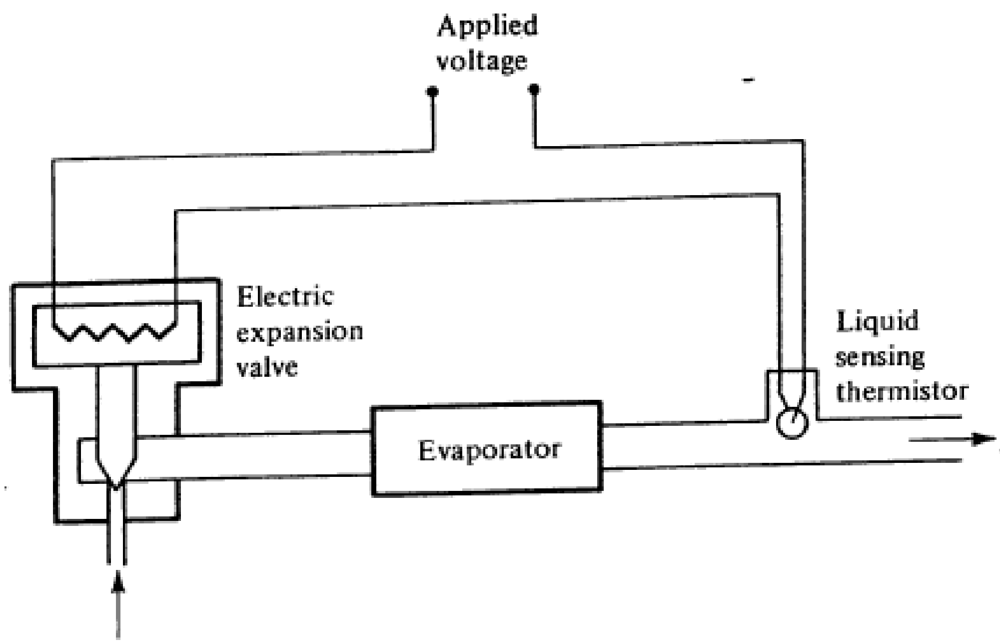


Figure 13-17 An electric expansion valve.