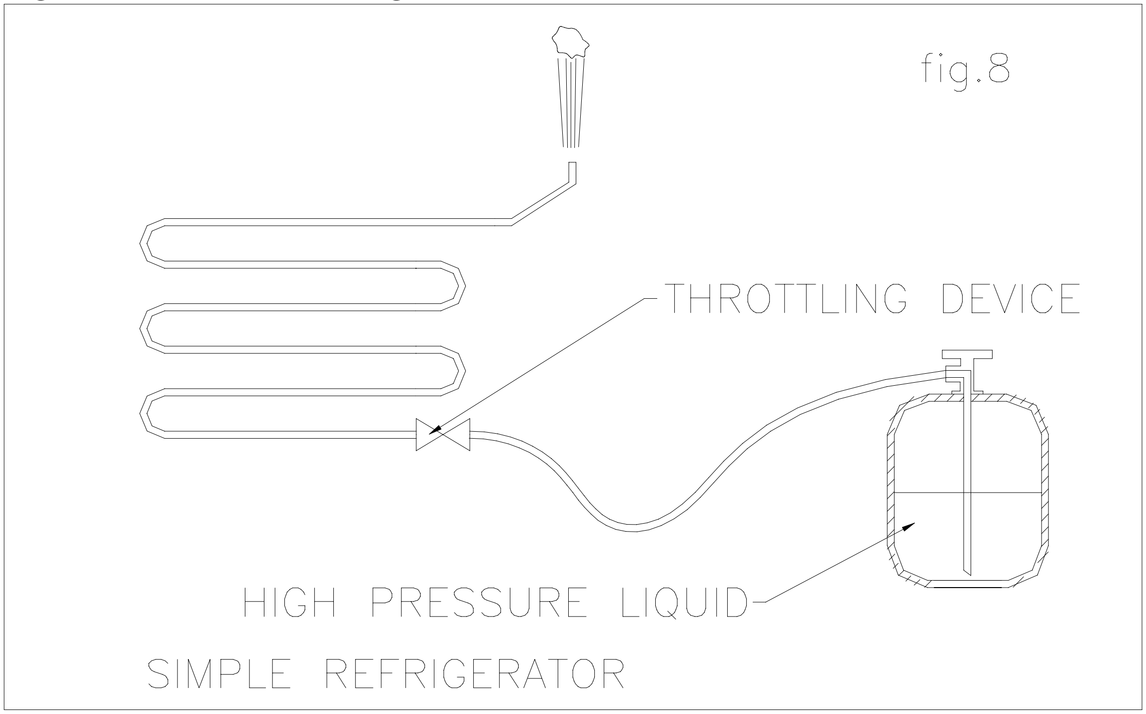
Fundamentals of Refrigeration **Part 2 Refrigeration 1**

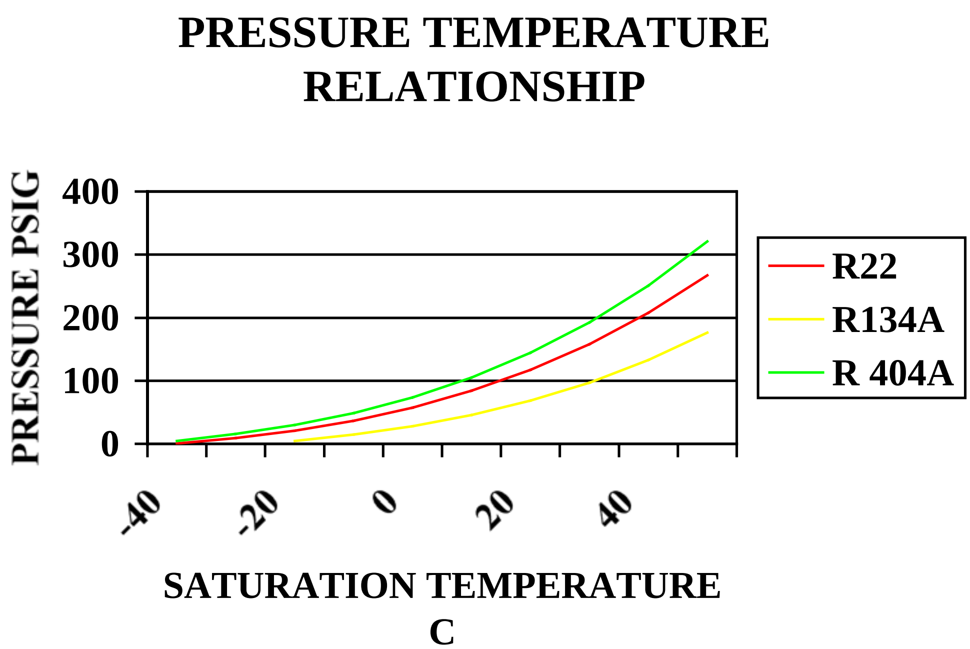
We have established in the first part of this training session that cooling in a DX coil is the result of the latent heat of vapourisation which is taking place in the coil matrix.
So let us make a refrigerator.We will need a bottle of liquid refrigerant with a boiling point that is correct for our application at atmospheric pressure, a coil matrix and a metering device.
Figure 8. shows such an arrangement.



The liquid from the bottle passes through the metering device into the coil matrix where it absorbs sufficient heat to boil off all the liquid and it then vents into the atmosphere.If we assume that we are using R22 the evaporating temperature will be -40.8°C and we will absorb 233.5 KJ/Kg of energy.Therefore if we pass 1 Kg a second through our coil we will absorb 233.5 Kw. R22 costs in the region of £4.50 a Kg so our 233.5 Kw cooler will cost us approximately £16,200.00 per hour to run.This is obviously not economic.There is also a further complication in that you would be arrested for pollution offences.
So how can we take advantage of the cooling effect which we have identified?
We need to make a system which will continually recycle the refrigerant and give us control over the point at which it evaporates.
We are all agreed that our previous refrigerator design had some fairly major drawbacks. In order to achieve a continuous cycle we need to have available a source of liquid refrigerant ,a means of safely removing evaporated refrigerant from the evaporator and a mechanism for returning it to a liquid state.
Let us reconsider the requirements for manufacturing liquid from a vapour.

1. Vapour needs to be at the saturation condition.
2. There must be a cooling device available to remove the latent heat.

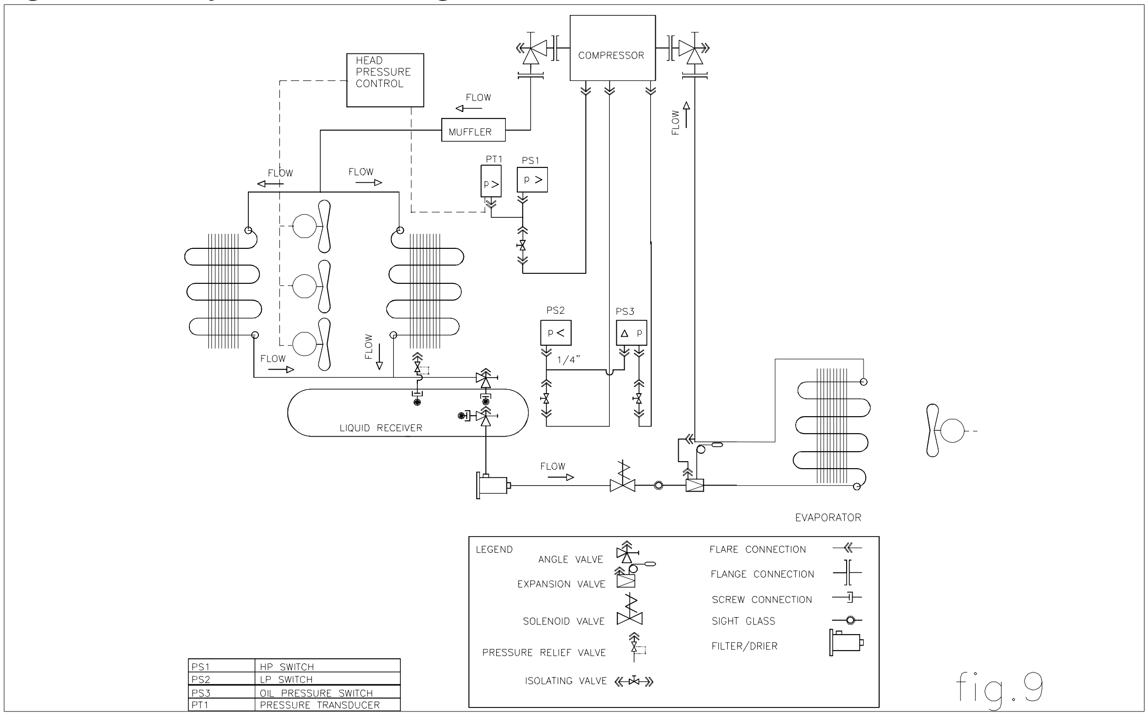
If the vapour has just left the evaporator it will be cold and therefore it will be difficult to remove any more heat. So let us reconsider the pressure/temperature relationship.



We know that the boiling point increases as the refrigerant pressure is increased. So if we can increase the pressure of the refrigerant to a level where its saturation point is higher than the ambient air we will be able to condense it by blowing air across a heat exchanger.

This is the function of the refrigeration compressor.It sucks the expanded vapour from the evaporator,compresses it and passes it into the condenser where it can be condensed into a liquid and once again expanded in the evaporator.

Figure 9. shows just such an arrangement.

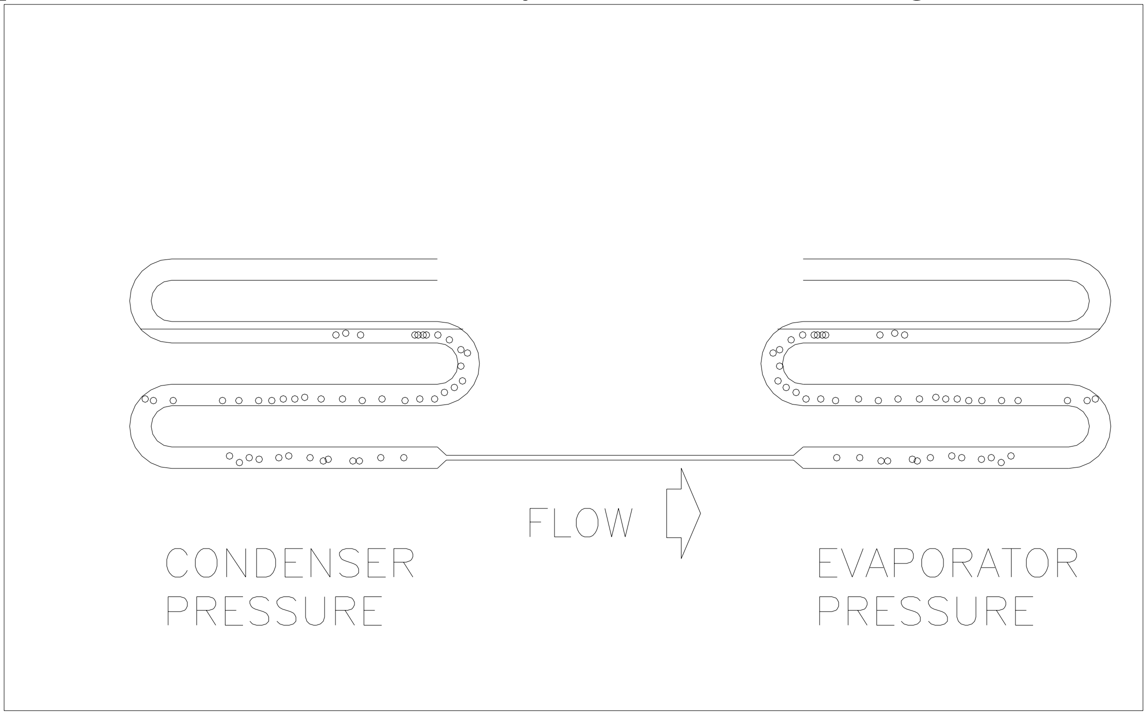


The other main advantage of this type of system is that we can control the point at which the system evaporates by regulating the flow of the liquid refrigerant into the cooling coil and changing the pressure in the evaporator.

Expansion

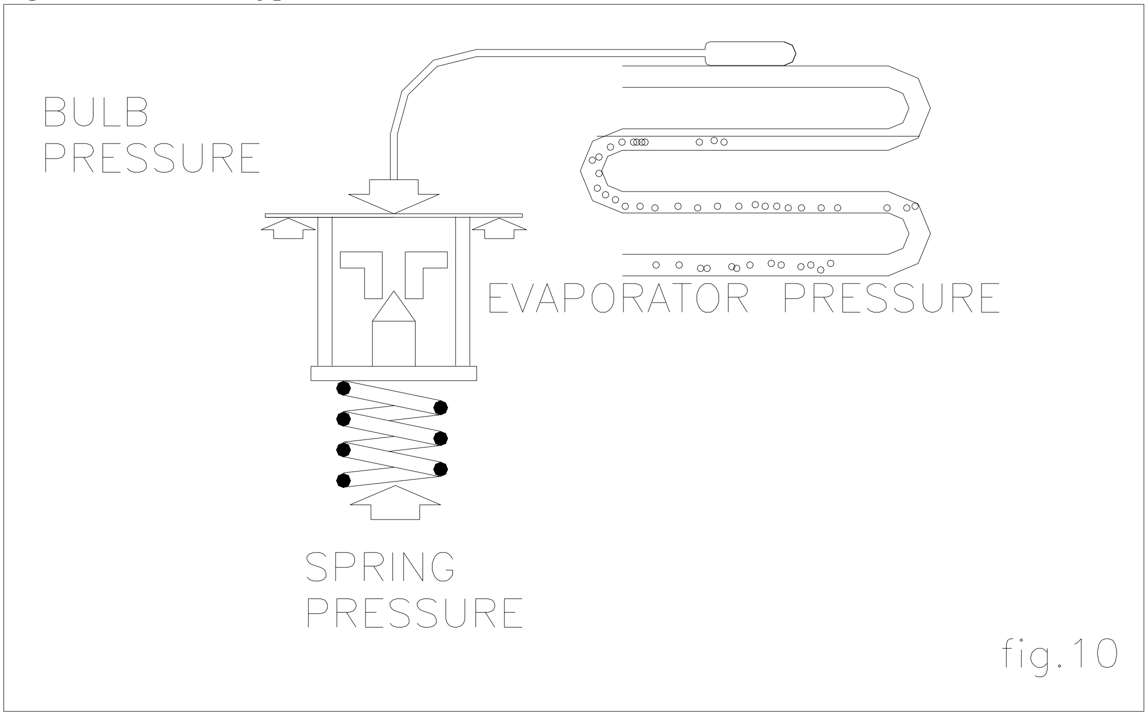
It is now appropriate for us to consider the ways in which refrigerant can be metered into the evaporator coil to give us the control which we require.

The simplest method is to restrict the size of the tube which joins the condenser to the evaporator. The flow through this tube will be determined by the difference in pressure between the condenser and the evaporator. As the pressure increases more flow is possible. This method of control is widely used on small domestic refrigerators.



In a refrigeration system which is subject to a variation in the load ,a more sophisticated control is required to give satisfactory control. The most common type of control that is used is the thermostatic expansion valve. To understand the operation of the thermostatic expansion valve we need to go back to the phenomenon of superheat. The purpose of the thermostatic expansion valve is to ensure that all the liquid entering the heat exchanger coil is satisfactorily vapourised. To ensure that this has occurred it follows that the refrigerant leaving the evaporator will be superheated to some extent. The thermostatic expansion valve is, therefore, a device for controlling the level of superheat of the vapour leaving the evaporator.

How does this device work?
Figure 10. shows a typical valve.



The valve has a diaphragm which is used to open and close the valve. Above the diaphragm is pressure from a thermostatic element which increases as the temperature of the pipe ,to which the bulb is attached, increases. This pressure tends to open the valve. Acting against this pressure is the evaporator pressure and the spring pressure. The spring pressure is usually adjustable and gives an adjustment to the superheat, which will be achieved on the coil. It should be remembered that it is not possible to have a spring, which exerts no pressure. The minimum superheat on expansion valves is 3°C and is generally 5°C. We should also now consider where the superheat is coming from. The superheat on the evaporator can only come from the air entering the coil. We also know that the amount of heat that can be exchanged ,when the difference between the two streams is less than 3°C, is practically non existant. This means in reality that temperature difference between the entering air and the evaporating temperature will always be greater than 6°C.

If the coils boils off all the refrigerant at an early stage in the coil a large amount of coil surface is available to superheat the vapourised refrigerant. This causes the temperature of the suction line to rise and increases the temperature of the sensing bulb. As the suction pressure has not increased, the sensing bulb will exert more pressure on the top of the diaphragm which will cause the valve to open.

As the valve opens more liquid refrigerant enters the coil. The refrigerant will then require more of the coil surface to evaporate and the temperature of the bulb will not be as great as it was before. This means that the tendancy is for the valve to close. The valve will balance at a point where the liquid entering the coil is completely vapourised and the level of superheat is relatively stable.

Major components

The functions of various components used in a typical refrigeration system are described below. We will refer to fig.9 once again.

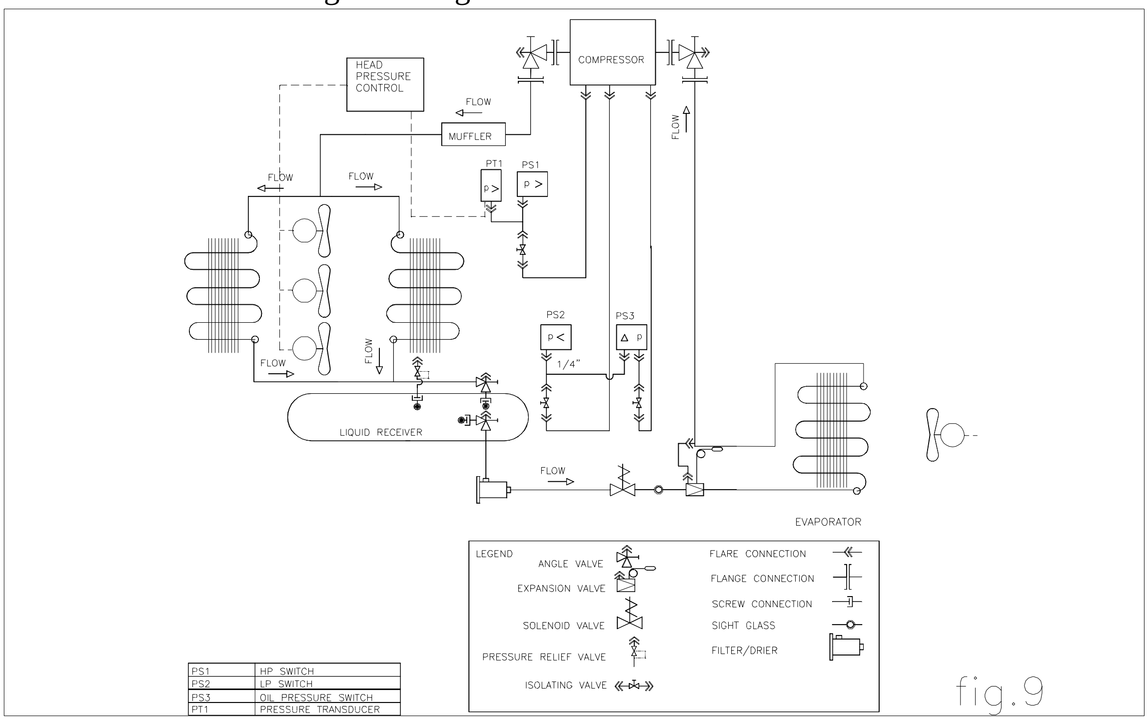


fig.9

Sight glass

This device enables the engineer to see the refrigerant as it approaches the expansion valve..It gives an indication as to the quality(proportion of liquid to vapour) which is approaching the expansion valve.It has a coloured ring around the central glass which changes colour in the presence of moisture.When the ring is green it indicates that the system is operating with dry refrigerant.As the moisture content increases it changes its shade to a yellow colour which will warn of a contamination problem.

Liquid line solenoid valve

This valve closes whenever the compressor stops.Its function is to prevent the migration of refrigerant from the system into the compressor crankcase.

Filter drier

All the liquid refrigerant supplying the expansion valve passes through the filter drier. Its function is to remove any unwanted moisture or contaminants which may be present in the system before they have an opportunity to cause damage to the more sensitive components in the system.

Liquid receiver

This is a vessel which holds a quantity of the unit refrigerant charge in a liquid form to pass directly into the liquid line.It also acts as a vapour separation device whereby any liquid refrigerant which vaporises after passing through the condenser can return to the condenser by flowing back up the inlet pipes.

Discharge muffler

This component is used to damp any gas pulsations caused by the reciprocating action of the compressor.It is similar in construction to a silencer fitted on the exhaust pipe of a car.

High pressure switch

The high pressure switch turns off the compressor when it detects pressures which would be damaging to the refrigeration plant.Typical causes of high pressures are as follows:-

1.) Inadequate performance from the condenser.

2.) Valves closed in the discharge line.

3.) Excessive load on the evaporator side of the system.

Pressure relief valve

The pressure relief valve is a final protection against high pressures.It will come into operation in the event of a failure of the high pressure switch to detect the excess pressure or in the case of a fire.The pressure relief valve discharges the refrigerant to the atmosphere in order to prevent an explosion.

Low pressure switch

The low pressure switch is fitted to prevent the compressor operating in conditions which could lead to damage or contamination.In very low temperature cooling systems they are set to prevent the system operating in a vacuum.If the compressor was operating in a vacuum any leaks would cause air and contaminants to be drawn into the system.In water chillers the low pressure switch is also used to prevent operation of the compressor at evaporating temperatures below the freezing point of the fluid being cooled.