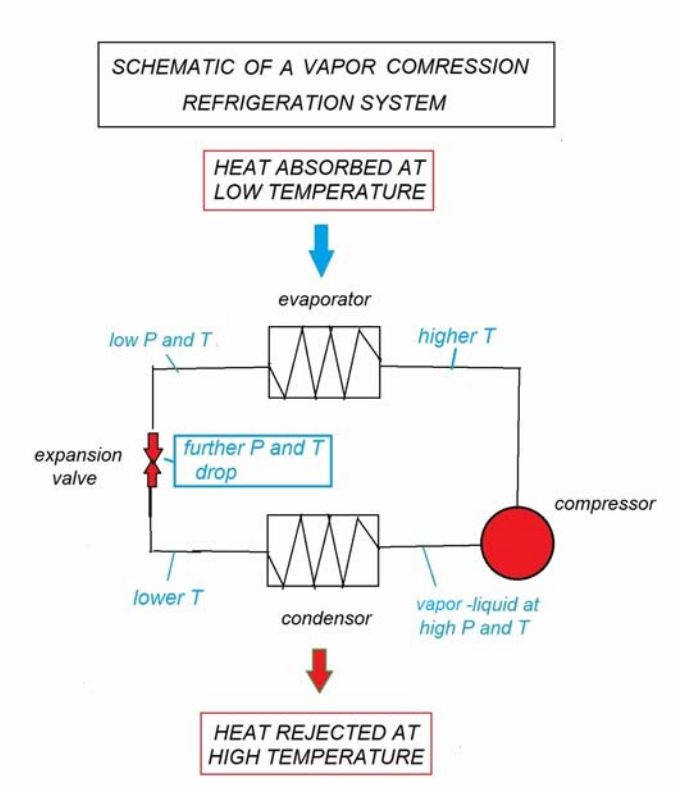
HOW DOES VAPOR COMPRESSION REFRIGERATION WORK?

Refrigeration is the process whereby heat at low temperature is moved via an expansion-compression process of a volatile gas-liquid mixture to a warmer point where the heat is rejected . It was first recognized in 1755 by the Scottish scientist William Cullen that one can cool the air above a dish of diethyl-ether when a partial vacuum is created above its surface. The process clearly makes use of the heat of vaporization. Later investigators improved on the process allowing for a continuous cooling process. Today most refrigeration processes use vapor compression of the fuid R-134 (tetraflouroethane). The other formally commonly used refrigerant was Freon, but it was banned several decades ago because of ozone layer damage. The first person to truly understand the entire mechanical refrigeration processes was the physician John Gorrie of Apalachicola, Florida back in 1842. He recognized that any cooling process must obey the basic gas law PV=nRT, where P is the pressure of the gas phase, T the temperature, and V the volume. This understanding allowed him to build the worlds first ice making machine. In his device he first compressed air, then cooled it with water and finally expanded it via an expansion valve. Although his refrigeration method did not involve the presently used, and more efficient, phase change approach, he is considered by many to be the father of refrigeration. It is interesting that his name came up in the naming of our new engineering science building here at the University of Florida several years ago. Unfortunately the name was not adopted because of the connotation of the word gory.

The majority of all present day cooling processes for home and commercial refrigerators, buildings, automobiles and trucks make use of a phase change approach using the tetrafluoromethane refrigerant R-134-a . It boils at about -26C at one atmosphere and the molecular weight is 100.03. We want here to show how the vapor compression refrigeration process works by looking at the following schematic-



The refrigerator has four basic components. They are the compressor, the condenser, the expansion valve, and the evaporator. The continuous process begins by sucking a cool gas-liquid two-phase mixture into the compressor which raises both the pressure and temperature to a high value. Next this mixture enters the condenser which removes some of the heat so that the temperature drops but the pressure is lowered by less. Next things are forced through an expansion valve which drops the pressure and also further cools the gas phase portion of the mixture. This gas-liquid mixture inters the evaporator where some of the liquid portion absorbs heat from the cooling compartment of the refrigerator. After this phase is completed the cycle repeats by again passing through the compressor. The mixture enters the evaporator near freezing temperature so that heat can be removed from the cold compartment. The overall process is very efficient, uses non-toxic fuid mixtures which can be re-used indefinitely for years. A refrigerator's Coefficient of Performance has a high value of-

$$COP = \frac{T_{cold}}{T_{hot} - T_{cold}}$$

One of my home refrigerators has run continually for forty years without requiring any maintenance.

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