pressors of the type commonly used in power plants for various processes will produce the necessary low absolute pressure to cause evaporation of the water.

A diagrammatic representation of a typical steam ejector water cooling system is shown in Fig. 2. The figures correspond to an average representative system. The water to be cooled enters the evaporator and is cooled to a temperature corresponding to the vacuum maintained. Because of the high vacuum, a small amount of the water introduced in the evaporator is flashed into steam. As this requires heat, and the only source of heat is the rest of the water in the evaporator tank, this other water is almost instantly cooled to a temperature corresponding to the boiling point determined by the vacuum maintained. The amount of water flashed into steam is a small percentage of the total water circulated through the evaporator, amounting to approximately 11 lb per hour per ton of refrigeration developed. The remainder of the water at the desired low temperature is pumped out of the evaporator and used at the point where it is required.

The ejector compresses the vapor which has been flashed in the evaporator, plus any entrained air taken from the circulated water, to a somewhat higher absolute pressure and the vapor and air mix with the impelling steam on the discharge side of the jet. The total mixture then passes from the ejector into the condenser.

The slight amount of air which may be entrained in the cooled water is removed by a small secondary ejector which raises the pressure sufficiently so that the air can be discharged to the atmosphere. A secondary condenser is then necessary to condense the steam in the secondary jet.

While a single booster of smaller than 15 tons capacity is difficult to build, steam jet vacuum cooling units have been built for as small as 5 to 6 tons capacity. They can readily be built for steam pressures of from 5 to 200 lb per square inch and condenser water temperatures as high as 90 F. The steam consumption in pounds per hour per ton of refrigeration increases rapidly as the booster steam pressure is lowered. For example, the lowering of the booster steam pressure from 200 to 90 lb per square inch results in an increase in steam consumption of approximately 5 per cent, whereas a further decrease in booster steam pressure to 10 lb per square inch increases the steam consumption by approximately 72 per cent over that required at 200 lb per square inch.

The capacity of a steam jet system is usually controlled by controlling the number of boosters in use since the unit usually has several boosters operating on the same evaporator. Usually one booster is automatically controlled whereas the others are manually operated. The capacity is dependent, as for all compressors, upon the evaporator temperature, or in other words, the suction pressure. For example, the capacity is lowered approximately 17 per cent if the evaporator or chilled water temperature is lowered from 50 to 45 F. The capacity therefore can be controlled to some extent by regulating the evaporator temperature.

The Absorption System

The work needed for operation of a compressor is given by the equation, Work $= \int P dV$. If the working fluid which is undergoing the pressure rise does not change in volume, the required energy input to the compressor would be negligible; assuming no change in kinetic energy of material between entrance and exit of the compressor the only energy required would be that needed to increase the flow work of the fluid. Calculation will show that energy needed to raise 1 lb of ammonia from the pressure of a 0 F evaporator to that of an 85 F condenser is greater by more than 100 times when the vapor is directly compressed, as compared with energy requirements when it is first absorbed in water ($1\frac{1}{2}$ lb of water per pound of ammonia vapor) and then pumped to the higher pressure. Thus the essence of the absorption refrigeration cycle concept is the idea of raising the refrigerant pressure when the refrigerant is in liquid rather than vapor form.

The absorption and compression refrigeration cycles differ only with respect to the method of compression. Each cycle requires a condenser,

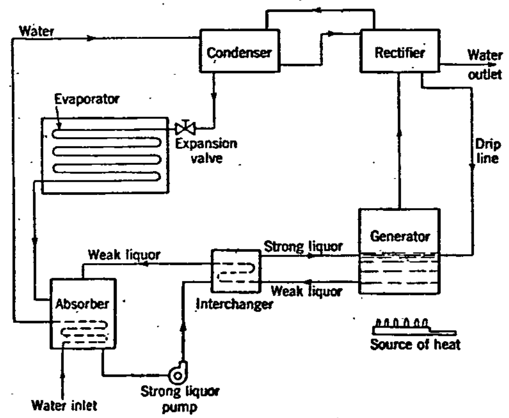

Fig. 3. Closed Absorption System

expansion valve, and evaporator, but the absorption cycle utilizes three major equipments in place of the mechanical compressor; these equipments are the *absorber*, the *pump*, and the *generator*. Vapor from the evaporator is absorbed by a low temperature absorbent fluid which is then pumped to the generator where heat is supplied to boil off the refrigerant. The absorbent is now cooled and readmitted, through a pressure-reducing valve, to the absorber.

In addition to the three primary equipments of the absorption cycle it is necessary to provide auxiliary equipment, usually an analyzer and a rectifier, to remove from the refrigerant leaving the generator, insofar as is possible, the absorbent which vaporizes and leaves the generator with the refrigerant. Removal of this material is of great importance to effective operation of the system, since even a small concentration of absorbent in the refrigerant will suffice to reduce greatly the evaporator pressure required for maintenance of a given evaporator temperature. Thermodynamic analysis of absorption cycles is relatively complex and requires the use either of tables or graphs showing the equilibrium relationships and thermodynamic properties of the refrigerant-absorbent combination. Data of this kind are available in bibliography item 1 and a discussion of various absorbents is given in bibliography item 6.