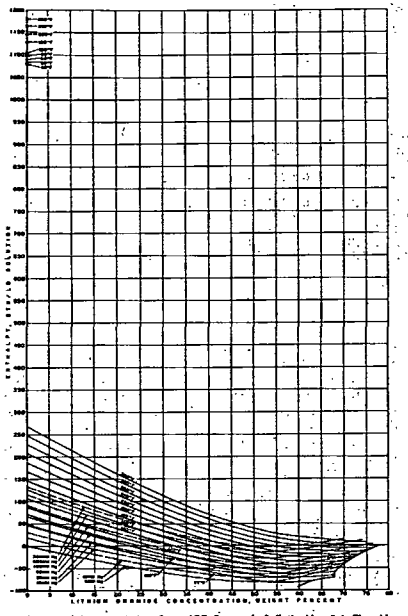

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Fig. 21 .... Enthalpy-Concentration Diagram for Lithium Bromide-Water Combination*

A relatively recent innovation[25] is the incorporation of the *multiple-effect principle in the generator of the absorption* system. Since the boiling point of the solution in the generator depends upon the pressure above it, it is possible, by the judicious selection of pressures, to arrange two or more generators in series so that the vapor expelled from the first or highest pressure generator can supply its heat of condensation to cause the solution in the second generator to boil, and the process is repeated through the series. External heat has to be applied only to the first generator. It is obvious that such a system can do much to improve the CP. Because of the highly concentrated solutions involved, the boiling temperatures of any two adjacent generators, or effects, are far apart, and it is therefore necessary to use liquid heat exchangers between the effects to realize the gain in CP.

Some form of concentration control is generally desirable. In an absorption system, the evaporator pressure, and its temperature, is a function of the concentration and temperature of the absorbent solution. In general, the designer will not have control of the temperature of the absorbent solution because its temperature will depend upon the temperature of the heat sink. Therefore, to have any control over the evaporator pressure, the designer must work with the other variable, concentration. For systems using water as the refrigerant, it is particularly essential to control the evaporator pressure, to prevent freezing of the refrigerant.

Control of concentration is generally accomplished by storing some of the pure liquid refrigerant out of the system when a more concentrated absorbent is required, and releasing it to the system when a more dilute absorbent is required. The storage volume may be a receiver between the condenser and evaporator, a receiver to store unevaporated refrigerant passing through the evaporator, or it may be the evaporator itself. Control of the storage is usually attained by means of some form of valve, actuated by either evaporator temperature or pressure, or, in some cases, by the temperature of the heat sink. The control of concentration may improve the coefficient of performance slightly, as it avoids operation with excessively low evaporator temperatures, but its primary purpose is to keep the evaporator operating in the desired and safe temperature range.

Other auxiliary equipment mainly consists of operating and safety controls.

Cycle Analysis

Although the analysis of the ideal cycle by means of the Carnot relation is useful for determining the limiting conditions, a more detailed analysis of a real cycle is necessary for design purposes. Such an analysis generally consists of heat balances and material balances around the various components as well as around the system as a whole.

In a system having a nonvolatile absorbent (Fig. 28) heat and material balances can be set up to enable the designer to calculate both the quantities of heat and quantities of fluid flowing in each of the various components. The various fluid streams are numbered 1 through 12 for convenience. The equations are set up on the basis of one pound of refrigerant

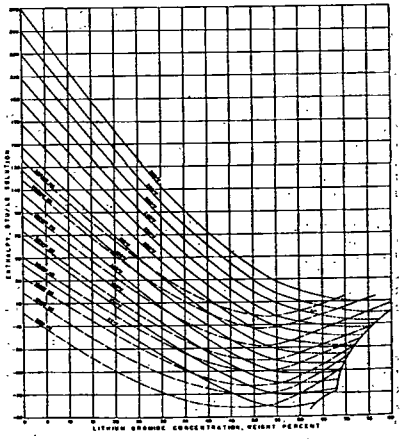

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Fig. 22 .... Enlarged Enthalpy-Concentration Diagram for Lithium Bromide-Water Combination*

flowing through the evaporator per unit of time. For the generalized analysis, it is assumed that heat gains and heat losses of the system are zero, except for those occurring at designated heat exchange surfaces.

Heat balance around whole system:

$$q_e + q_g + q_p - q_a - q_c = 0 \quad (20)$$

Heat balance around evaporator:

$$q_e + h_3 - h_4 = 0 \quad (21)$$

Heat balance around absorber:

$$-q_a + h_1 + Mh_{12} - (M+1)h_4 = 0 \quad (22)$$

Heat balance around generator:

$$q_g + (M+1)h_5 - Mh_{10} - h_9 = 0 \quad (23)$$

Heat balance around condenser:

$$-q_c - h_1 + h_9 = 0 \quad (24)$$

Heat balance around liquid heat exchanger:

$$q_{(LHe)} = M(h_{10} - h_{11}) = (M+1)(h_5 - h_7) \quad (25)$$

Heat balance around refrigerant precooler:

$$q_{pc} = h_1 - h_2 = h_4 - h_3 \quad (26)$$

where

q_e = heat flow to evaporator, Btu per unit time.
q_g = heat flow to generator, Btu per unit time.
q_p = heat flow to pump, Btu per unit time.
q_a = heat flow from absorber, Btu per unit time.
q_c = heat flow from condenser, Btu per unit time.
h_i = enthalpy of ith stream, Btu per pound.

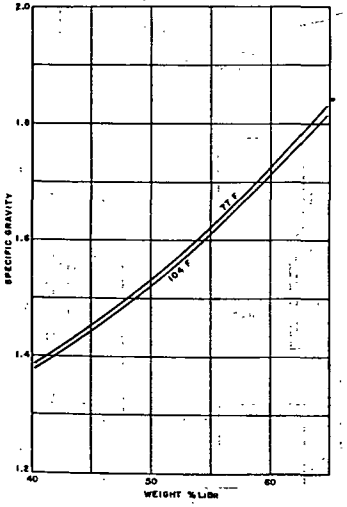

Fig. 23 .... Specific Gravity of Aqueous Solutions of Lithium Bromide

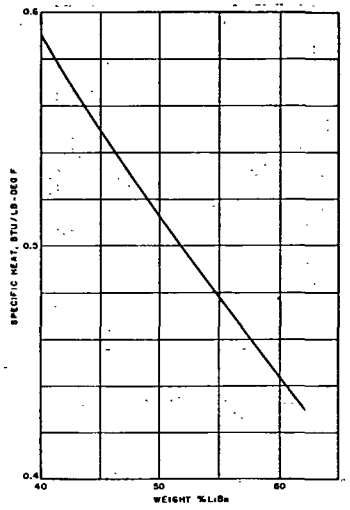

Fig. 24 .... Specific Heat of Aqueous Solutions of Lithium Bromide

M = weight of absorbent solution entering absorber, pounds per pound of refrigerant.
$q_{(LHe)}$ = heat exchange in liquid heat exchanger, Btu per unit time.
q_{pc} = heat exchange in refrigerant precooler, Btu per unit time.

The heat equivalent of the energy supplied to the pump may be evaluated by considering that the pump is lifting $(M+1)$ pounds of solution from the absorber pressure to the generator pressure. If P_g is the generator pressure, and P_a the

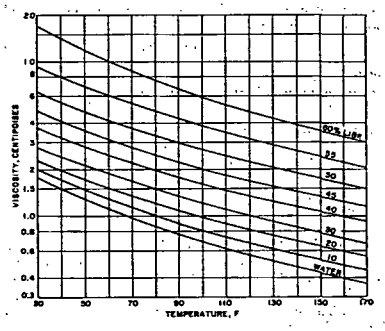

Fig. 25 .... Viscosities of Aqueous Solutions of Lithium Bromide