where

v_c = clearance volume.
v_d = cylinder displacement volume.

The balance of the overall volumetric efficiency is known as the superheat volumetric efficiency even though it includes some other sources of capacity loss.

The mechanical efficiency of a reciprocating and rotary compressor must be multiplied by the superheat volumetric efficiency to give the overall efficiency of the compressor.

$$\text{Eff.}_{\text{overall}} = \frac{\text{Vol Eff.}_{\text{overall}}}{\text{Vol. Eff.}_{\text{reexp.}}} \times \text{Mech. Eff.} = \text{Super. Vol. Eff.} \times \text{Mech. Eff.} \qquad (7)$$

Normally, the volumetric efficiency of a compressor varies with the

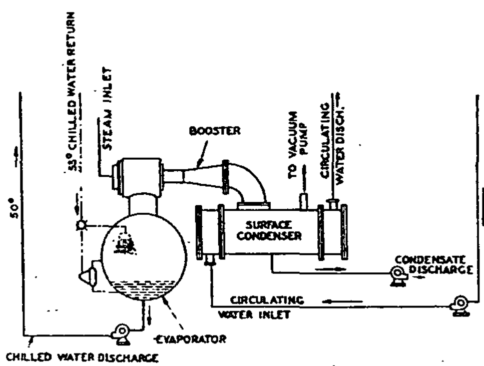

FIG. 4. STEAM EJECTOR COMPRESSION REFRIGERATION SYSTEM

ratio of compression, while the mechanical efficiency remains virtually fixed. Good standard practices for F_{12} compressors are:

	Low comp. ratio = 2.5 to 1	High comp. ratio = 5 to 1
Vol eff.$_{\text{reexp.}}$	94 to 96 per cent	88 to 92 per cent
Vol. eff.$_{\text{super.}}$	75 to 85 per cent	73 to 77 per cent
Vol. eff.$_{\text{overall}}$	70 to 81 per cent	64 to 71 per cent
Mech. eff.	75 to 85 per cent	75 to 85 per cent

These values are for one ton or larger compressors. Part of the difference expresses the change with capacity. With other refrigerants and other types of compressors there will be some further variation.

Steam Ejector Refrigeration System

Fig. 4 is a diagrammatic representation of a typical steam ejector refrigeration system. Live saturated steam is supplied to a nozzle which discharges at a high vacuum into the steam ejector. The expansion of the steam imparts a tremendous velocity to it, which entrains vapor from a flash evaporator and compresses it with a conversion from velocity to static pressure. The mixture of vapor is then delivered to a condenser. The condensate is removed by suitable means, some of it being used in some cases to supply make-up water to the evaporator circuit. The con-

denser is maintained free of air by means of a suitable purge. This may take the form of a water ejector if only a small amount of air is to be removed, as in a completely closed system. If a larger capacity is required, a two-stage purge is usually used, sometimes a combination steam and water and occasionally a two-stage steam purge. The vapor which is drawn from the evaporator is the result of spraying water which has been warmed by the cooling load into the flash evaporator. Evaporation of a part of this water occurs, which cools the remainder, which is then again returned to the cooling load to receive more heat.

The performance of the steam ejector may be studied theoretically by the use of the temperature-entropy diagram, Fig. 5. Unlike its usual application, however, the amount of working fluid is different for one portion of the cycle than for the other. Dry saturated steam under high

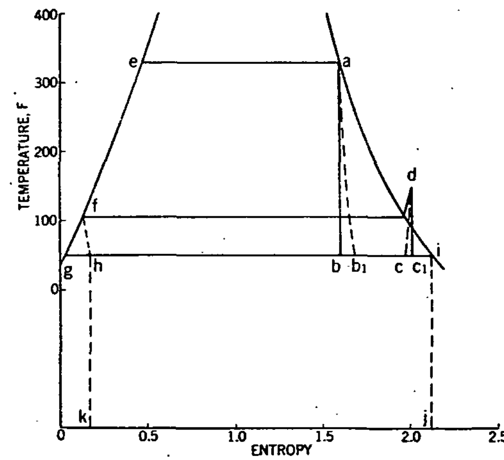

FIG. 5. STEAM EJECTOR TEMPERATURE-ENTROPY DIAGRAM

pressure, for example 100 lb per square inch gage, at *a*, is expanded through the nozzle of the steam ejector. With 100 per cent efficiency, the expansion would occur along isentropic line *ab*. Actually, however, most nozzles are only about 90 per cent efficient, the real expansion being along the line ab_1. Since the exact path of the line ab_1 is not known, the work area is normally assumed by using the isentropic giving a work area *abgea*. The velocity at the mouth of the nozzle may be determined in the usual manner using this area and the velocity coefficient of the nozzle.

At the evaporator pressure or slightly below, the vapor from the nozzle mixes with virtually dry saturated vapor from the evaporator. An impact loss also occurs at this point due to the mixture of vapors at different velocities. This results in bringing the state point of the mixture to *c*. Compression then occurs along the line *cd*, the work of compression per pound being *cdfgc*. In computing the work area, however, the point *c* is not actually known. Therefore, the work area c_1dfgc_1 is used in expressing the efficiency of the ejector, the line c_1d being an isentropic. The