to cool the air. The temperature and pressure in the condenser are determined by the temperature and quantity of the condensing medium. The two pressures govern the size of the compressor and the amount of power required to drive it.

The heat released in the condenser is equal to the sum of the heat absorbed in the evaporator and the heat equivalent of the power required to drive the compressor, with small corrections for direct losses or gains from the surfaces exposed to the atmosphere.

When designing air conditioning systems, the capacity of equipment is fixed by selecting apparatus of sufficient size to maintain predetermined temperatures and humidities in treated spaces when arbitrarily established maximum atmospheric temperatures occur coincident with given population, lighting, power consumption, etc. These factors determine the maximum duty of the cooling system. The duty does not necessarily

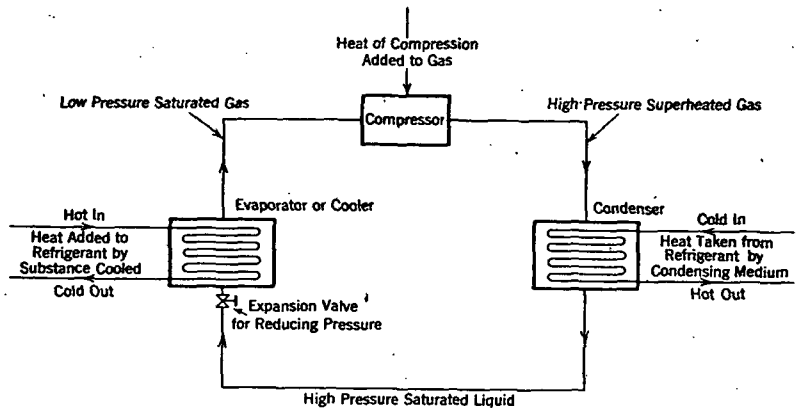


FIG. 2. TYPICAL REFRIGERATION DIAGRAM

determine the size or capacity of the refrigeration apparatus. The capacity is expressed in "tons ice melting effect" or in units equal to the absorption of the heat given up by one ton of ice at 32 F melting to water at 32 F in 24 hours. This is equivalent to heat absorption at a rate of approximately 200 Btu/minute.

After the maximum duty is determined, the other factors surrounding the installation must be investigated. The total heat to be removed by the cooling system has many sources, some substantially constant and others extremely variable. These sources can be roughly classified as follows, the first column indicating the order in size and second the order of variability:

1. Outside air supplied.
2. Population.
3. Transmission through walls.
4. Light and power consumed.

1. Fresh air supplied.
2. Transmission through walls.
3. Light and power consumed.
4. Population

By combining these two columns, a third grouping is obtained as follows:

1. Fresh air supplied.
3. Population.

2. Transmission through walls.
4. Light and power consumed.

In this last arrangement, the first two items are governed by atmospheric temperatures and therefore subject to tremendous fluctuations in size. As they generally form 40 per cent to 60 per cent of the entire maximum load, it is obvious that the duty of the cooling system will be much less than maximum most of the time.

A survey of Weather Bureau records indicates that maximum temperatures occur less than 5 per cent of the cooling period and also that the duration of peak conditions is never more than three or four hours.

Design of System

As previously mentioned, two factors control the size of the refrigeration system, the evaporator or suction, and the condenser or head, temperatures. With the knowledge that the system will operate most of the time with a load of not over 60 per cent of maximum, and that maximum demands will occur infrequently and only for short periods, some provision must be made to insure economical operation under average conditions. This can be done by overloading the machine under extreme demands and basing the design on normal or average loads. Flexibility in arrangement can be provided in several ways.

Variations in load change the efficiency of any machine and a refrigerating system can be costly and inefficient if improperly designed or operated. Fortunately, the trouble can be concentrated in the compressor and the problem relieved of many complications. It is comparatively easy to furnish condensers and evaporators to carry maximum load and so arranged that they will function properly at small demands. They affect the compressor performance to some extent but most of the compressor problems are in the machine itself.

Variations in load are usually effected by lowering the suction temperature and pumping a larger volume of gas per ton through a greater pressure range. This is possible because the latent heat of the refrigerant remains nearly constant throughout the small range used and the specific volume varies rapidly with change in pressure. As the compressor must remove the gas evaporated, the evaporator temperature fixes the displacement required. The objection to such a method is that the total power consumed remains nearly constant and the power per unit of cooling increases rapidly. Such operation is satisfactory as long as the load is kept within 10 per cent of the rating of the compressor but this condition does not commonly occur in air conditioning applications.

Operating Methods

It is possible to divide the entire refrigeration system into a number of small units, which will allow cutting in and out of compressors, condensers, etc., as the load fluctuates. This, however, is an expensive method as a number of small units are more expensive than one large unit. There is a certain amount of duplication of equipment necessary, which tends to increase the initial cost of the system and makes the fixed charges applicable to the operation of the air conditioning and cooling system, greater than necessary.