As the air enters the washer with a low wet-bulb, and as adiabatic saturation will take place at a temperature close to the entering wet-bulb, considerable cooling of the air can be accomplished but with a consequent increase of the dew-point.

It is necessary to reactivate the silica gel after it has absorbed about 25 per cent of its own weight in the form of moisture. As reactivation requires a high temperature and since silica gel is only active at low temperatures, cooling of the beds must also be completed before they can be used again. This necessitates three stages in the silica gel containers and requires either three beds of silica gel or one bed divided and automatically put in position. The reactivation is usually done by means of gas or oil fires and the cooling of the beds by means of indirect water cooling or by means of small quantities of dehydrated air taken from the system beyond the interchanger.

Alumina System of Adsorption

Activated alumina contains a trifle over 91 per cent of aluminum oxide, $Al_2 O_3$ and this material will absorb nearly 100 per cent of the vapor in air up to about 8 to 10 per cent of the weight of the adsorbing material after which the adsorption falls off gradually as the saturation point is approached. The application is quite similar to that employed for silica gel, that is, the material is exposed to the air flow and after reaching about 75 per cent saturation is reactivated by removing the moisture adsorbed by means of applied heat. The actual scheme generally followed in the use of this material for continuous service varies somewhat from silica gel inasmuch as the material is placed in three units which are used consecutively for the different steps. These steps permit each unit to operate as follows:

a. In series with the preceding unit.
b. Alone.
c. In series with the following unit.

This plan allows for adsorption, reactivation and cooling the same as with silica gel.

Taking a single unit, when it is in the *a* step and operating with the preceding unit, the alumina absorbs approximately 25 per cent of the moisture in the air and takes up about 1.3 per cent of its weight of water. During the second step when it is operating alone, it takes up 100 per cent of the moisture in the air until the weight of the water absorbed is brought up to about 6.7 per cent; in the third step when the unit is operating with the following unit it extracts about 75 per cent of the moisture in the air until the water weight adsorbed comes up to about 10 per cent of the weight of the adsorber or a trifle over. The time allowable for reactivating is equal to the time occupied by the following (or second) unit adsorbing alone, plus the time when the second and third units are adsorbing in series, plus the time when the third unit is adsorbing alone, at the expiration of which time the original (or first) unit again will be required.

The temperature of air used for alumina reactivation is usually between 300 and 700 F and the air flow rate will have to be higher with the low temperature air than it will be with reactivating air of higher temperature. For example, air at 400 F for reactivating will, at 10 cu ft per hour, per

pound of alumina, require about 6 hours for reactivation. In the three unit system, after reactivation, the cooling of the activated alumina may be carried out with considerable rapidity by using dry air from the adsorption unit for circulation through the unit which has just completed reactivation and the final temperature of the unit before it goes back into service should be not over 200 F. As a basis for the amount of cooling air required each cubic foot of cooling air has been found capable of removing 2.2 Btu when heated from 85 to 200 F and still provide a sufficient margin of safety in operation.

REFRIGERATION

Air conditioning imposes requirements on refrigeration equipment not usually found in general cooling work, so that specially designed apparatus is often needed to replace that normally used for industrial cooling. Standard equipment can be adapted to meet air conditioning requirements but extreme care must be taken to determine the limits of its applicability.

In industrial or process cooling systems the load is fairly constant, noise in operation is not of paramount importance, space is available or relatively cheap, condenser water is not a source of worry, and the cooling system is to a great extent separate and independent of other mechanical equipment. By contrast air conditioning, especially as used for space cooling and comfort work in office buildings, theatres, and places of great density of population requires special consideration of all these factors. Space in public buildings is limited and condenser water is expensive. Noise interferes with the occupants and the cooling equipment must dovetail with the other air handling apparatus. Most important, the load fluctuates tremendously and is seasonal.

A complete discussion of the thermodynamic problems of refrigeration is given in the Refrigerating Data Book[2], 1932, so only a brief description of the cycle will be given here before the problems peculiar to air conditioning are considered.

The refrigeration system consists of three main parts, the evaporator, the condenser, and the compressor. Fig. 2 shows a diagram of the cycle. Heat is absorbed in the evaporator and released in the condenser. The compressor changes the level of the heat by taking it from a lower to higher plane. There are also many valves, accessories and special devices necessary for proper operation which vary somewhat with different types of cooling systems and different refrigerants.

Heat absorption is accomplished in the evaporator, or cooler, by maintaining a pressure sufficiently low to cause the refrigerant to boil at the temperature necessary to cool. The heat of ebullition is taken from the substance cooled, and the vaporized refrigerant is withdrawn by the compressor which raises the pressure to a point that permits the gas to liquify in the condenser when some readily available medium (usually water), is used to absorb the latent and super-heat. The liquid then returns to the evaporator through a pressure reducing valve and the cycle repeated. The temperature, and the corresponding pressure maintained in the evaporator is fixed by the temperature to which it is desired

[2]Published by *American Society of Refrigerating Engineers.*