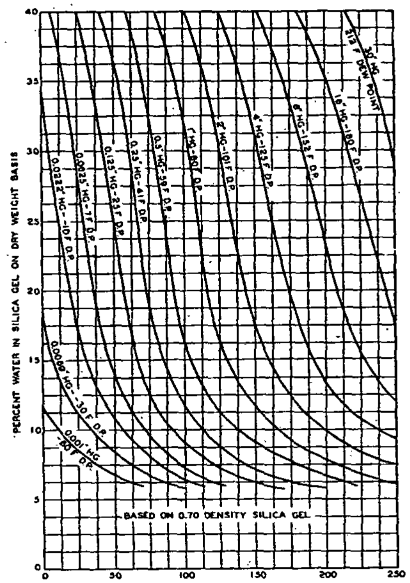

Fig. 5....Silica Gel—Water-vapor Equilibrium Curves

During the process of adsorption there is a liberation of heat which results in an elevation of the effluent air temperature. This heat is equivalent to the latent heat of vaporization of the adsorbed liquid plus an added quantity known as the *heat of wetting*, which is defined as the heat developed when a liquid and a solid surface contact one another. As the adsorbed vapor condenses, the latent heat is converted to sensible. All of the released heat, known cumulatively as the heat of adsorption, is dissipated into the desiccant, the enclosure, and the passing air stream. In comfort air conditioning it is often necessary to cool this effluent air prior to its introduction to the conditioned space, but in most other dehumidification applications this heat is not objectionable, and no provisions are made for its removal. For this reason the process is known as adiabatic adsorption, meaning that the released heat is taken up for the most part by the passing air stream, that the adsorbent chamber is insulated, and that no attempt is made to cool the effluent air. Although ordinary air-conditioning dehumidification only approaches the adiabatic process, it is called adiabatic to differentiate it from the isothermal adsorption process in which the outlet gas is cooled to inlet temperature.

It is appropriate now to discuss the factors which influence the rate and amount of water-vapor adsorption by the desiccant. Although such factors as the shape and volume of the desiccant pores and the surface tension and wetting ability of the condensed vapor are important, the foremost considerations when working with a given adsorbent and a given vapor, for example, airborne water vapor, are the temperature of the adsorbent and the dry-bulb and dew-point temperatures of the air. The latter temperature is important since it is a function of the partial pressure of the water vapor in the air. The relationships existing between these variables are best illustrated by the Silica Gel-Water-vapor equilibrium curves shown in Fig. 5. In this set of curves, silica gel and air temperature versus percent water in silica gel (dry weight basis) form the abscissa and ordinate, and air dew-point temperatures (with the corresponding vapor pressures) are the parameters. Several important characteristics of the adsorbent are brought out by these curves. For example, note that each of the curves becomes asymptotic to the X-axis somewhere between 5 and 6 percent moisture content. This is because, under normal reactivation temperatures, there is always this amount of water in the gel. Known as residual moisture, it is omnipresent and an attempt to remove it results in a physical change in the desiccant and a reduced adsorptive capacity. The term *useful concentration* is used to designate the percent moisture in the gel over and above the residual amount. The variation in this useful concentration during a test measures the magnitude of adsorption or desorption since the residual amount theoretically remains unchanged assuming no excessive activation temperatures. Note that at constant air and gel temperature the amount of moisture adsorption varies directly with the air dew-point temperature, i.e., as the air approaches saturation condition (dry-bulb temperature equal to dew-point temperature) the equilibrium moisture content of the gel increases. It can also be seen that at saturation the percent water in the gel is in the neighborhood of 40 percent of the dry weight of the gel for all temperatures.

With a fixed dew-point temperature, the moisture concentration decreases as the temperature of the air and gel is increased.

Some of the many variables that influence the results of a dynamic dehumidification operation are:

1. Type of desiccant.
2. Grain size of desiccant.
3. Shape of bed.
4. Area of bed normal to air flow.
5. Depth of bed.
6. Dry weight of desiccant.
7. Packing of the desiccant in the bed.
8. Weight of air flowing per unit of time.
9. Temperature of entering air.
10. Moisture content of entering air.
11. Contact time between air and adsorbent; a function of inlet face velocity and bed depth.
12. Barometric pressure.
13. Pressure drop through bed.
14. Duration of cycles.
15. Reactivation temperature.
16. Rate and magnitude of heat supply during reactivation.
17. Heat storage capacity of the bed.
18. Temperature gradient of the bed.
19. Air leakage from the apparatus.

Solid adsorption dehumidifiers are mostly of the stationary dual-bed type in which one desiccant bed is adsorbing while the other is being reactivated by electricity, gas, or steam.

Fig. 6 shows a schematic flow diagram for a typical dual-bed dehumidification unit. There are two types of units: (*a*) Shallow-bed; (*b*) Deep-bed.

Shallow-bed machines have comparatively thin desiccant beds and moisture removal is not complete in one pass through the bed. Low dew points may be maintained by progressive lowering of the room dew point as increasingly drier air enters the machine. The machine capacity must be in excess of internal moisture load and infiltration of moisture from external sources. Increased dryness can be obtained by reducing outlet air flow and recirculation of excess air from the dry air outlet to the humid air inlet on

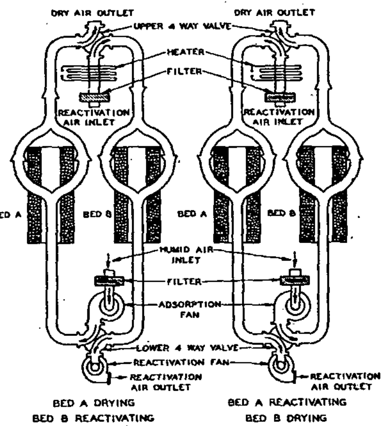

Fig. 6....Typical Dual-Bed Dehumidification Unit Air-Flow Diagram

the machine. Fig. 7 shows a typical cycle diagram for a shallow-bed machine.

Deep bed machines have desiccant beds 10 in. and more in depth. Deep bed units are used when extreme dryness is required in one pass through the dehumidifier and the air cannot be recirculated. Fig. 8 shows a typical cycle diagram for a deep-bed dehumidifier.

Most fixed-bed machines work on a predetermined time cycle. Smaller machines usually have a nonadjustable cycle. Larger units have adjustable time cycles that can be changed for various operating conditions.

The average hourly moisture removal capacity of a dehumidifier can be determined as follows:

$$W = \frac{60Q(G_i - G_o)}{7000v} \qquad (1)$$

where

W = moisture removed, pounds per hour.
Q = air volume, cfm.
60 = conversion of cubic feet per minute to cubic feet per hour.
G_i = moisture content of air entering dehumidifier, grains of moisture per pound of dry air.

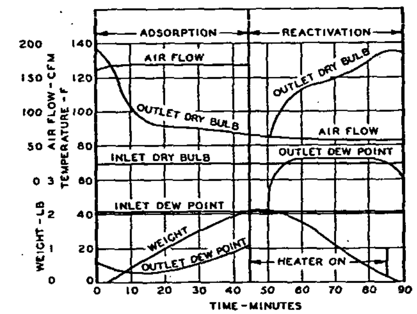

Fig. 7....Typical Cycle Diagram for Shallow-Bed Dehumidifier

G_o = moisture content of air leaving dehumidifier, grains of moisture per pound of dry air.
v = specific volume of the air, cubic feet per pound.
7000 = conversion from grains to pounds.

Moisture removal capacity may be increased by (1) higher inlet dew point; (2) for a constant entering dew point, lower temperature and greater saturation; (3) larger air quantity, which causes a decrease in the dryness of the effluent air.

If the air to be dehumidified is very warm, and especially where a very low dew point is required, it is advantageous to install a precooler to reduce the temperature of the inlet air. In this way the working temperature in the adsorber is lowered, and the overall performance appreciably increased. Some equipment manufacturers install cooling coils in the adsorbent beds for the same purpose, while others divide the adsorbent bed and install coolers between the sections.

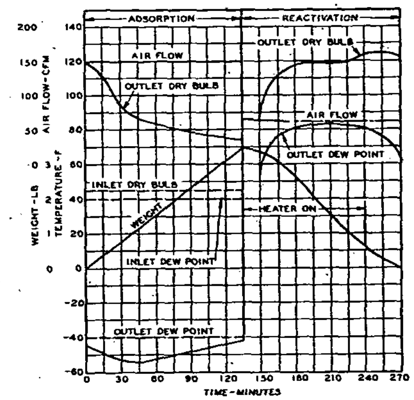

Fig. 8....Typical Cycle Diagram for Deep-Bed Dehumidifier