Example 1. The total sensible heat gain in a restaurant when held at 80 F is 199,736 Btu per hour. Assuming a 12 deg F temperature differential between the entering air and the room temperatures, which is the same as assuming the dry-bulb temperature of the entering air to be 68 F, calculate the required air capacity of the system.

Solution.

$$Q = \frac{199{,}736 \times 55.2}{60 \times 12} = 15{,}313 \text{ cfm} = 1146 \text{ lb per minute.}$$

If a system similar to the one shown in Fig. 1 is used, 1146 lb per minute will be the capacity of the dehumidifier as well as of the fan equipment.

Example 2. If in addition to the 199,736 Btu per hour sensible heat load, the conditioned space has a moisture gain of 384,000 grains per hour, calculate the apparatus dew point required to give maintained conditions of 80 F dry-bulb and 65 F wet-bulb, with a corresponding 56½ F dew point.

Solution. With 384,000 grains of moisture per hour to be picked up, the entering dew-point temperature should be low enough so that the addition of this moisture will not increase the dew point above 56½ F.

Grains per pound of air saturated at 56½ F (Table 6, Chapter 1)		68.0
Less: Grains per pound to be picked up,	$\frac{384{,}000}{1146 \times 60}$,	5.6
Grains per pound allowable in entering air		62.4

This corresponds to an apparatus dew-point temperature of 54.17 F.

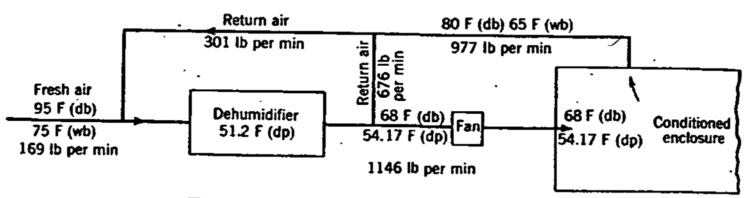

FIG. 4. DIAGRAM OF BY-PASS METHOD

Example 3. Illustration of the by-pass system. (See Fig. 4.)

Assume the same data as for Example 2. Instead of passing all of the air through the dehumidifier for cooling and dehumidifying, a portion may be passed through and the balance be mixed with the conditioned air at the leaving end of the dehumidifier, the mixture being proportioned so that the resultant conditions will be those required to give proper conditions in the area considered.

Solution. The quantity of air to be dehumidified, the quantity to be by-passed, and the apparatus dew-point temperature may be approximately calculated as follows:

Let

X = percentage of air to be by-passed.
Y = percentage of air to be passed through the dehumidifier.
t_d = apparatus dew-point temperature, degrees Fahrenheit.

The quantity X of 80 F air must mix with the quantity Y of dehumidified air to produce air with a resultant 68 F dry-bulb temperature. Also, X quantity of air at 56½ F dew point must be mixed with Y quantity of dehumidified air to give a resultant dew-point temperature of the mixture of 54.17 F. It is assumed that the air passing through the dehumidifier is saturated.

Solving simultaneous equations,

$$80.0X + Yt_d = 68.00 \qquad (3)$$
$$56.5X + Yt_d = 54.17 \qquad (4)$$
$$23.5X + 0 = 13.83$$

$$X = \frac{13.83 \times 100}{23.5} = 59 \text{ per cent, air by-passed.}$$

$$Y = 100 - X = 41 \text{ per cent, air passed through washer.}$$

The second step is to determine the apparatus dew-point temperature. Substitute X in either Equation 3 or Equation 4, and solve for t_d:

$$80 \times 0.59 + t_d \times 0.41 = 68$$

$$t_d = \frac{68 - 47}{0.41} = 51.2 \text{ F, the apparatus dew point.}$$

HEAT TO BE REMOVED BY COOLING AND DEHUMIDIFYING APPARATUS

Example 4. Assume the same data as for Example 3. If the amount of outside air, at 95 F dry-bulb and 75 F wet-bulb, required for ventilation has been found to be 169 lb per minute, determine the refrigeration capacity required.

Solution. As the total weight of the air introduced per minute is 1146 lb, and 41 per cent of it goes through the dehumidifier, the total work to be done may be computed as follows:

Air passing through dehumidifier, 1146 × 0.41	470 lb
Less: Outside air for ventilation	169 lb
Return air	301 lb

The refrigeration required for the return air is:

Total heat per pound at 65 F	29.96 Btu
Less: Total heat per pound at 51.2 F	20.92 Btu
Requirement for cooling 1 lb of return air	9.04 Btu

301 lb × 9.04 Btu = 2721 Btu per minute required to cool the return air.

The refrigeration required for the outside air is:

Total heat per pound of outside air	38.46 Btu
Less: Total heat per pound at 51.2 F	20.92 Btu
Requirement to cool 1 lb of outside air	17.54 Btu

169 lb × 17.54 Btu = 2964 Btu per minute required to cool the outside air.

Thus, the total refrigeration required is:

2721 Btu + 2964 Btu = 5685 Btu per minute, which is equivalent to a load of 28.4 tons of refrigeration.

SIZE OF REHEATERS

A properly designed air-conditioning system will have reheaters of sufficient capacity to heat the conditioned air from the apparatus dew-point temperature to the inlet delivery temperature. If winter heating is to be accomplished, consult Chapter 9.

The following general formula may be used to determine the amount of heat necessary to reheat a given quantity of air: