the line C-D is a measure of the ratio of latent to total heat removed, and that any line parallel to C-D gives the same heat ratio.

To enhance the practical usefulness of the psychrometric chart illustrated in Fig. 13, a set of marked master slope lines is included. The value of this arrangement is easily illustrated by the graphical example shown.

Example 1. To determine the required average effective external coil surface temperature. *Given:* (1) Air entering cooling coil at temperature of 83 F dry-bulb and 69 F wet-bulb. (2) Ratio of latent to total heat that must be removed from air is 35 per cent. *Required:* To find the average external coil surface temperature.

Solution. (1) Draw through point N, at the origin of the heat load ratio lines, a line N-O with a slope of 35 per cent in accordance with scale S. (2) Mark in the body of the

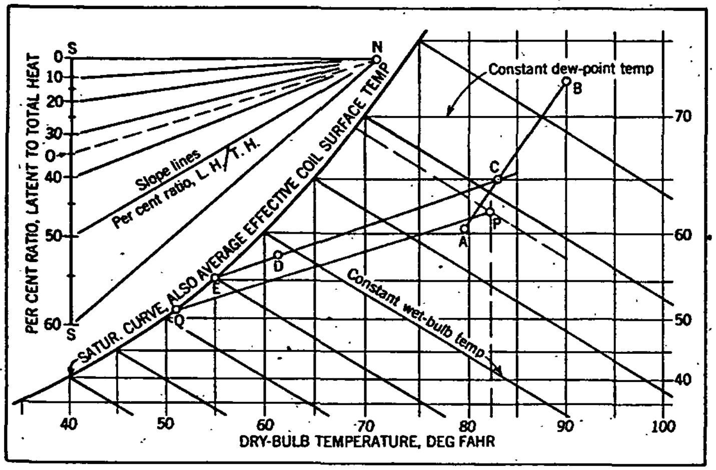

FIG. 13. PSYCHROMETRIC CHART SHOWING STRAIGHT-LINE-METHOD FOR REPRESENTING COIL PERFORMANCE

chart, point P representing the condition of air entering the cooling coil at 83 F dry-bulb and 69 F wet-bulb. (3) Through point P draw a line P-Q parallel to line N-O. (4) The line P-Q intersects the saturation curve at 51 F, which means that the effective external coil surface temperature must be maintained at 51 F in order to obtain the desired 35 per cent latent to total ratio of heat removal from the air passing over the given cooling coil.

Inspection of Equation 12 reveals that the total capacity of a coil is dependent on the entering and leaving wet-bulb temperatures. The entering dry-bulb temperature is unimportant.

The amount of latent heat of condensation of a coil can be calculated from:

$$Q_l = 1060\, Ew\, (W_1 - W_s) \tag{14}$$

where

Q_l = latent heat removed, Btu per hour per square foot of coil face area.
W_1 = pounds of moisture per pound of dry air entering the coil.
W_s = pounds of moisture per pound of dry air saturated at the average surface temperature.
1060 = average value of latent heat of water vapor, Btu per pound of vapor.

The amount of sensible heat removed can be obtained by subtracting the value of Q_l from the value of Q in Equation 12.

Equation 12 gives accurate results when it is used for coils having a small change of temperature of the fluid in the tubes, as for example with evaporating refrigerants and with water having a small temperature rise. In cases where water in the tubes has a large temperature rise, the effective surface temperature changes throughout the depth of the coil, and in extreme cases moisture may be condensed on only a portion of the coil. In such cases it is possible to estimate the wet and dry portions of the coil separately, using cut-and-try methods.[6]

Internal Film Coefficient

The internal film coefficient, f_r, which appears in Equation 3, is evaluated in various ways, depending upon the nature of the fluid, and whether the fluid is changing state.

When evaporating refrigerants are being used in tubes, the temperature of the fluid is fairly constant, being affected principally by pressure drop through the tubes, by superheat of the evaporated refrigerant, and by the presence of oil in solution. To obtain maximum coil capacity it is necessary to keep the pressure drop through the tubes at a minimum (¼ lb per square inch), to keep the superheat as low as possible without carrying liquid back to the compressor, and to arrange for good separation and return of oil to the compressor. An additional important factor is the removal of gas so that the tube surface may be flooded with liquid as much as possible. The internal film coefficient is markedly increased by heavy heat loads, because the increased turbulence and gas velocity cause good contact of the liquid with the tubes. Values of f_r usually lie between 150 and 450. For accurate rating of dehumidifying coils, good results are obtainable by first determining the average external surface temperature as previously described, and then using the difference between the external film temperature and the refrigerant for evaluating f_r in Equation 15.

$$f_r = \frac{Q}{\frac{a}{R}\,(t_s - t_r)} \tag{15}$$

The term $(t_s - t_r)$ is commonly written Δt. The usefulness of the foregoing equation is impaired by the fact that both f_r and Δt must be evaluated experimentally. More direct results can be obtained by ignoring f_r and determining the relation between Δt and total coil capacity:

$$\Delta t = t_s - t_r = mQ^n \tag{16}$$

where

m and n = constants determined by tests.

When water is used as a cooling medium in tubes, the rate of heat transfer is a function of water velocity, because this results in an increase in the number of contacts of the water molecules with the tube surface, per unit of time. Thus increased water velocity and reduced tube diameter cause increased heat transfer. Heat transfer is also greater at

[6]Calculation of Coil Surface Areas for Air Cooling and Dehumidification, by John McElgin and D. C. Wiley (A.S.H.V.E. TRANSACTIONS, Vol. 46, 1940, p. 139).