A correction curve to correct the air velocity in any given problem is incorporated in Fig. 14. This curve is based on the variation of drying rate with the 0.8 power of the velocity.

The use of Fig. 14 in practical drying problems is as follows: Since the drying conditions of temperature and relative humidity are fixed, the corresponding absolute drying rate is read from Fig. 14. This value is then multiplied by the correction factor corresponding to the air velocity employed. The rate so obtained, however, does not include any effects of radiation or of conduction through unwetted surfaces. These effects tend to increase the rate of evaporation so that the chart is conservative.[5]

While it has been demonstrated empirically that the rate of drying during the falling-rate period is approximately proportional to the free water content of the material, actual calculations of drying during the falling-rate period are not satisfactory because of the number of variables involved. There are always present too many unknowns or experimentally determined coefficients, constants and limits. Consequently, whenever unbound moisture is to be removed, it is best to determine drying time by means of pilot tests as indicated by Fig. 4.

Although Fig. 14 is applicable only to the constant-rate period of drying, it has been found that some materials exhibiting a distinct falling-rate period are influenced by velocity, humidity and temperature in approximately the same degree as is the case for the constant-rate period (see Figs. 4 to 7). For these materials a knowledge of the drying time under any set of conditions can be used to predict the drying time under other conditions by analogy to the constant rate period.

The following nomenclature will be used in the discussion of design calculations:

H = humidity ratio of air, pounds of water vapor per pound of dry air
G = pounds of dry air supplied to the dryer per unit of time.
S = pounds of stock dried per unit of time in a continuous dryer.
S' = pounds of stock charged per batch to a discontinuous dryer.
θ = time.
Q = total heat supplied to the dryer.
t = air temperature.
t' = stock temperature.
t'' = average stock temperature over short time interval, in a batch dryer.
t_w = wet-bulb temperature.
s' = specific heat of the stock.
B = total radiation and conduction losses per unit time.
w = pounds of water per pound of dry stock.
r = heat of evaporation of water.
s = humid heat of air, *i.e.*, heat necessary to raise 1 lb of dry air + H lb of steam 1 F deg.

Subscript (1) designates conditions at the point where the material in question (air or stock) enters, and (2) where it leaves the dryer.

Air dryers may be divided into two classes, those in which *all moisture* evaporated from the stock *leaves the dryer as vapor* in the effluent air, and those in which *part or all* of the moisture *is condensed* from the air *in the drying equipment itself*. In any continuously operating dryer of the first type the relation between moisture content of the stock and quantity of air required for the drying operation is given by the equation:

$$G\,(H_2 - H_1) = S(w_1 - w_2) \tag{4}$$

In discontinuous dryers, *e.g.*, compartment dryers, the drying operation is given by the equation:

$$G(H_2 - H_1) = S'\frac{dw}{d\theta} \tag{5}$$

In the continuous dryer, the heat consumption per unit time is:

$$\frac{Q}{\theta} = Gs_1(t_2 - t_1) + G(r_2 + t_2 - t'_2)(H_2 - H_1) + S(t'_2 - t'_1)(s' + w_1) + B \tag{6}$$

Equation 6 assumes continuity of operation. For charge or batch operations, the total time of the drying cycle may be broken up into a number of periods, sufficiently short so that over each period average values of t, t' and H may be employed provided the third term of the right hand member of the equation is modified to read:

$$S'(t''_2 - t''_1)\,(s' - w_1)$$

and in the second term t'_2 be replaced by

$$\frac{t'_1 + t''_2}{2}$$

Theoretically these periods should be very short and the equation integrated. Practically, the error introduced by using a small number of long periods and employing average values of the variables over each is not serious. The evaluation of Equation 5 may be approximated in a similar manner.

The first term of the right hand member of Equation 6 represents heat lost as sensible heat in the effluent air. In many drying operations this becomes excessive. Each pound of air supplied should remove the maximum amount of moisture. This is best accomplished by bringing the air into contact with the stock with sufficient intimacy so that the air leaving the dryer is saturated, or nearly so. Counter-current as against parallel flow of air and stock gives rise to optimum operating conditions, resulting in a minimum quantity of air required (G), and a corresponding minimum loss, as sensible heat, in the exit air. Similarly, continuous operation is superior to intermittent operation.

Despite the fact that the sensible heat loss increases with the rise in temperature of the air, the percentage of heat lost from this source decreases, provided the increase in moisture carrying capacity of the air, due to high temperature, is actually utilized. To secure maximum thermal efficiency in drying, a high drying temperature and high saturation of the outlet air are imperative.

The second term of the right member of Equation 6 represents the latent heat of evaporation of the water plus the heat to raise this water to the temperature of evaporation. The third term of the equation represents heat to raise the temperature of the stock plus the water which remains unevaporated in the stock.

The changes taking place in the air during the drying process can be