depression is the driving force, whereas with mass transfer coefficients the driving force is expressed in terms of humidity or vapor pressure differential.

Fig. 3 permits a ready estimate of the constant drying rate for various air temperatures and humidities. The chart is based on the difference between the dry-bulb and wet-bulb temperatures of the entering stream of air, and on an air velocity of 300 fpm. It may be assumed satisfactory for tray drying of any material in the constant-rate drying period. It does not apply to rotary or through-circulation drying. A curve for correcting

TABLE 1. CONVECTION HEAT TRANSFER (h_c) AND RATES OF DRYING $\left(\frac{dw}{d\theta}\right)$ COEFFICIENTS FOR CONSTANT RATE PERIOD.

DIRECTION OF AIR FLOW	h_c	$\frac{dw}{d\theta}$
Parallel to plane surfaces[3]	$0.0128G^{0.8}$	$\frac{0.0128G^{0.8}A}{H}(t_a - t_w)$
Perpendicular to plane surfaces[1]	$0.37G^{0.37}$	$\frac{0.37G^{0.37}A}{H}(t_a - t_w)$
Through circulation[4] (for Reynolds number > 300)	$\frac{0.37G^{0.59}c_s}{D_p^{0.41}}$	$\frac{0.37c_s a G^{0.59}\Delta t_m}{\rho_s H D_p^{0.41}}$

LETTERS SYMBOLS FOR TABLE 1

(*not previously defined*)

h_c = convection heat transfer coefficient, Btu per (hour) (square foot) (Fahrenheit degree).

G = mass velocity of dry air, pounds per (hour) (square foot).

t_w = wet-bulb temperature of drying air, Fahrenheit.

a = drying area, square feet per cubic foot of bed volume.

ρ_s = bulk density of dry granular bed, pounds per cubic foot.

D_p = average diameter of particle, feet.

Δt_m = logarithmic mean difference between air temperature entering and leaving the bed and the wet-bulb temperature, Fahrenheit.

c_s = humid heat, Btu per (pound of dry air) (Fahrenheit degree).

the air velocity is incorporated in Fig. 3. This curve is based on the variation of drying rate with the 0.8 power of the velocity.

Evaporation from Liquid Drops. For the important problem of spray drying, evaporation rates of liquid drops must be estimated. Below a value of Reynolds number (D_pG/μ) of 10 for spherical particles, the heat transfer coefficient across the gas film surrounding the drop is given by

$$h = \frac{2k_f}{D_p} \quad (2)$$

where

h = film heat transfer coefficient, Btu per (hour) (square foot) (Fahrenheit degree).

k_f = thermal conductivity of gas film, Btu per (hour) (square foot) (Fahrenheit degree per foot).

Equation 2 is applicable when the Reynolds number for liquid drops

is less than 10. Drop diameters are almost always less than 500 microns, and usually in the range of 20 to 150 microns.

The rate of evaporation of drops may be expressed in terms of heat transfer or mass transfer. In terms of heat transfer, the evaporation rate is given by the equation:

$$\frac{dw}{d\theta} = \frac{2\pi k_f D_p}{H}(t_a - t_s) \quad (3)$$

where

$\frac{dw}{d\theta}$ = evaporation rate, pounds per hour.

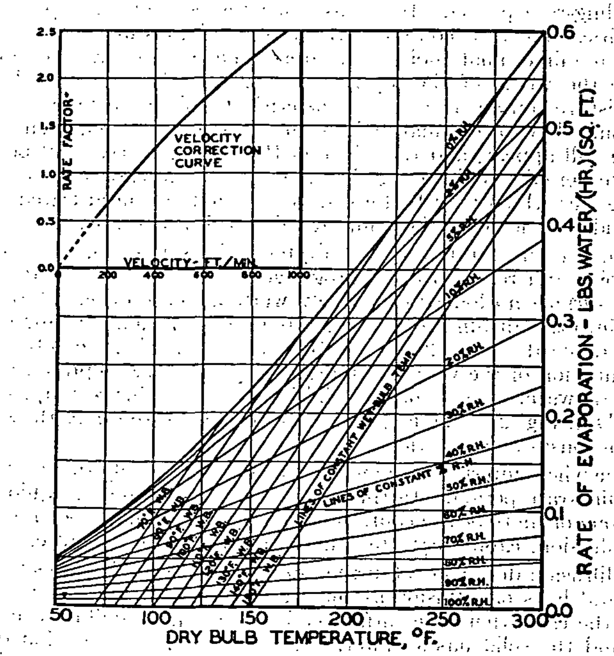

FIG. 3. RATE OF EVAPORATION CHART[3]

Drying at Air Temperatures above the Boiling Point of the Liquid. When the temperature of the drying air is maintained above the boiling point of the liquid being evaporated, or when superheated vapors are used for drying, the usual equations for mass transfer, expressing rate of evaporation as a function of the vapor pressure difference, lose significance, since large errors are introduced in the expression for vapor pressure driving force due to its apparently small value. Such cases can be treated conveniently on a basis of heat transfer, since a temperature difference must always exist in order that drying may proceed.

Constant-Rate Period When Heat Transfer Depends on Conduction and Radiation. In indirect drying, where heat transfer and drying do not depend on the flow of heated gases, the drying rate depends either on heat