Step 5: The *pick-up* of moisture per pound for the total air circulated is $\frac{205.5}{60 \times 675}$ = 0.0051 lb. 0.0280 − 0.0051 = 0.0229 lb moisture per lb of air for the supply air.

Assuming an existing wet-bulb of 100 F, the supply air dry-bulb will be 182 F. The mixture of recirculated air at 160 F dry-bulb and 100 F wet-bulb, with outside air at 80 F dry-bulb and 72 F dew-point, will be at approximately 120 F dry-bulb and 89 F wet-bulb.

Step 6: The heat required may be determined from Equation 26 by substitution of the following values: N_a = 307 × 60 = 18420 lb of air per hr; S = 900 lb; c_s = $24 + 0.45\left(\frac{0.028 + 0.0229}{2}\right) = 0.251$; t_1 = 80 F; t_2 = 160 F; t_2' = 100 F; λ = 1100 (approx.); W = 0.005 lb; s_1 = 0.22.

$$Q = 18420\ (0.251)\ (160-80) + 18420\ (1100 + 160 - 100)\ (0.028 - 0.0168) + 900\ (100 - 80)\ (0.22 + 0.005) + Q_{rc}$$
$$= 609{,}000 \text{ Btu per hr} + Q_{rc}$$

The heat input requirement is therefore 609,000 Btu per hr plus radiation and convection losses (Q_{rc}) which may be computed from the known construction of the dryer surfaces and the heat transfer coefficients.

Summer conditions were used in *Example 1* in order to obtain the maximum heat requirement which would be the case, except under the unusual condition where radiation and conduction losses are a large percentage of the total. In winter it is usually possible to take advantage of drier makeup air, and either speed up the process or operate at a lower dry-bulb temperature.

Controls for the system selected for Example 1 would consist of a thermostat in the main return air duct controlling the heat input to maintain constant dry-bulb temperature. A wet-bulb controller in the return circulating duct would maintain constant desired wet-bulb temperature by simultaneous positioning of three sets of dampers in the makeup air, the exhaust air and the recirculated air ducts.

LETTER SYMBOLS USED IN CHAPTER 46

A = area of heat transfer and evaporation, square feet.
a = drying area, square feet per cubic foot of bed volume.
B = a constant (for use in Equation 22).
B' = a constant (for use in Equation 23).
c_s = humid heat, Btu per (pound of dry air) (Fahrenheit degree).
d = diffusivity of the liquid or vapor, square feet per hour.
D_p = average diameter of particle, feet.
D_{p1} = drop diameter at start of evaporation, feet.
D_{p2} = drop diameter of dry particle, feet.
e = Naperian base of logarithms = 2.718.
G = mass velocity of dry air, pounds per (hour) (square foot).
ΔH_m = logarithmic mean of inlet and outlet humidity driving force across the air film adjacent to the particle through which the water vapor diffuses, pound per pound. (The surface humidity is taken as the humidity corresponding to the wet-bulb temperature of the drying air).
H_1 = humidity ratio of entering air, pounds of water vapor per pound of dry air.
H_2 = humidity ratio of leaving air, pounds of water vapor per pound of dry air.
h = film heat transfer coefficient, Btu per (hour) (square foot) (Fahrenheit degree).
h_c = coefficient of heat transfer by convection, Btu per (hour) (square foot) (Fahrenheit degree).
h_r = coefficient of heat transfer by radiation, Btu per (hour) (square foot) (Fahrenheit degree).
h_t = total gas film heat transfer coefficient, Btu per (hour) (square foot) (Fahrenheit degree).
K = a constant (a function of the constant drying rate).

k_f = gas film thermal conductivity, Btu per (hour) (square foot) (Fahrenheit degree per foot).
k_g = mass transfer coefficient, pounds per (hour) (square foot) (atmosphere).
L = material thickness, feet.
M = molecular weight of the diffusing vapor.
N_a = dry air supplied to the dryer, pounds per hour.
Δp = $p_s - p_a$ = vapor pressure difference, atmospheres.
p_s = vapor pressure of water at t_s, atmospheres.
p_1 = partial pressure of water vapor in air, atmospheres.
p_s = vapor pressure at the particle surface corresponding to the liquid temperature, atmospheres.
p_a = vapor pressure of liquid in the drying medium, atmospheres.
Q_{rc} = radiation and conduction loss, Btu per hour.
Q = total heat supplied to dryer, Btu.
q = rate of heat transfer, Btu per hour.
R = gas constant (cubic feet) (atmospheres) per (Fahrenheit degree).
S = weight of stock dried in a continuous dryer, pounds per hour.
S' = weight of stock charged in a discontinuous dryer, pounds per batch.
s = specific heat of stock, Btu per pound.
T = absolute temperature of the gas, Fahrenheit degrees.
t_a = air or gas temperature, Fahrenheit degrees.
t_h = temperature of the heating medium, Fahrenheit degrees.
t_s = temperature of particle, solid or surface of evaporation, Fahrenheit degrees.
t_w = wet-bulb temperature of drying air, Fahrenheit degrees.
t_1 = entering air temperature, Fahrenheit degrees.
t_2 = leaving air temperature, Fahrenheit degrees.
t_1' = entering stock temperature, Fahrenheit degrees.
t_2' = leaving stock temperature, Fahrenheit degrees.
t'' = average stock temperature over short interval of time, in batch dryer (t_1'' = entering, t_2'' = leaving) Fahrenheit degrees.
Δt = $(t_a - t_s)$ = temperature difference between air and surface of evaporation, Fahrenheit degrees.
Δt_m = logarithmic mean between temperature entering and leaving the bed, and the wet-bulb temperature, Fahrenheit degrees.
U = overall heat transfer coefficient, Btu per (hour) (square foot) (Fahrenheit degrees temperature difference between heating medium and product).
W = moisture content on dry basis at any time θ, pounds of water per pound.
W_c = critical moisture content, pounds water per pound dry material.
W_d = water content, dry basis, of the drop as it enters the drying chamber, pounds per pound of dry solid.
W_e = moisture content at equilibrium with external conditions, pounds per pound dry material.
W_o = initial moisture or moisture content at start of diffusional period, pounds per pound.
w = pounds of water.
$\frac{dW}{d\theta}$ = drying rate, pounds of water per (hour) (pound dry material).
$\left(\frac{dW}{d\theta}\right)_c$ = constant drying rate, pounds per (hour) (pound dry material).
$\left(\frac{dW}{d\theta}\right)_f$ = falling rate, pounds water per (hour) (pound of dry stock).
$\frac{dw}{d\theta}$ = drying rate or rate of evaporation, pounds of water per hour (Eq. 1).
θ = time, hours.
θ_c = drying time for constant rate period, hours.
θ_f = drying time during falling rate period, hours.
θ_t = total drying time, hours.
λ = latent heat of evaporation at t_s, Btu per pound.
μ = viscosity of the air stream, pounds per (hour) (square foot).
ρ_L = density of evaporating liquid, pounds per cubic foot.
ρ_s = bulk density of dry granular bed, density of dry particle, pounds per cubic foot.