$1105.5 \times 0.75 = 830$ lb of wet material or $\frac{830}{98} = 8.45$ cu ft of material.

Assuming a 48 in. wide belt with an effective 42 in. width for the product each foot of belt length carries 0.146 cu ft or 14.3 lb of wet material. Hence, the linear feet of belt must be $\frac{830}{14.3} = 58$ ft and the total area of exposed product is 232 sq ft. Based on 50 fpm velocity directed at a right angle to the belt the total air circulation will be $232 \times 50 = 11600$ cfm.

For space economy and in order to expose periodically fresh layers of powder to air, a multiple vertical belt arrangement (Fig. 17) with belts traveling in opposite directions is selected. Three belts each 19.4 ft long will be required. Fig. 17 illustrates the physical arrangement of the dryer.[6] The housing will be about 25 ft long, 8 ft wide and 7 ft high.

Step 3: At the drying conditions of 160 F dry-bulb and 100 F wet-bulb the air moisture content (from Fig. 3) is 0.028 lb per pound of air. Make-up air will be assumed at 80 F dry-bulb and 72 F dew-point (summer weather) or a humidity of 0.0168 lb per pound of air. The *pick-up* is therefore 0.0280 − 0.0168 or 0.0112 lb per

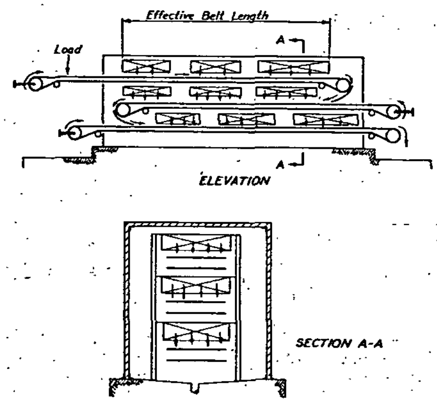

FIG. 17. CONTINUOUS BELT DRYER FOR CERAMIC POWDER[6]

pound of air. Then $\frac{205.5}{0.0112} = 18400$ lb of air per hour or 307 lb per min.

At the elevated temperature the total air quantity of 11,600 cfm represents 675 lb of air per min. Hence,

Per cent make-up air = 46 per cent

Per cent recirculated = 54 per cent

Step 4: Although the drying condition and drying rate should preferably be determined from experience or test results such as are illustrated in Figs. 4 to 8, the drying conditions can sometimes be estimated if the regain characteristics of the product or a similar product are known. In this case the regain characteristics of clay could be used as a guide. Inspection of regain data for typical clays indicates that at about one half of one per cent the vapor pressure of the moisture in the product is about 0.7 in. Hg less than the vapor pressure of free moisture at the product temperature. A safe assumption is that the product temperature approximates the air wet-bulb temperature. If an assumption is made regarding the per cent recirculated air the desired vapor pressure in the dryer can be estimated. For example assume a use of 46 per cent outside air or 307 lb per min. Then the moisture *pick-up* = $\frac{205.5}{60 \times 307}$ = 0.0112 lb per pound of air, with a consequent total of 0.0168 + 0.0112 = 0.0280 lb of moisture per pound of air in the leaving outside air which has about 1.25 in. Hg vapor pressure. This will therefore be the vapor pressure of the moisture in the product and thus the vapor pressure of free water at product temperature can be 1.25 + 0.7 = 1.95 in. Hg. The temperature corresponding to 1.95 in. Hg is 100 F and thus the air wet-bulb can be estimated to be 100 F. At 100 F wet-bulb temperature and 0.028 lb moisture per pound of air the dry-bulb temperature is 160 F. Obviously, the assumed percentage of recirculated air affects the results and therefore it is important that it be based on experience. About 50 per cent recirculation is reasonable for the type dryer considered in this example.

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 6 by substitution of the following values: $G = 307 \times 60 = 18420$ lb of air per hr; $s = 24 + 0.45 \left(\frac{0.028 + 0.0229}{2}\right) = 0.251$; $S = 900$ lb; $t_i = 80$ F; $t_2 = 160$ F; $t_2' = 100$ F; $r = 1100$ (approx.); $w = 0.005$ lb; $s' = 0.22$.

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

The heat input requirement is therefore 609,000 Btu per hr plus radiation and convection losses (B) 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.

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