20 per cent. From this point its temperature rises progressively as it dries. In this range the difference in temperature between stock and air, divided by the wet-bulb depression, may be assumed proportional to the moisture content.

The moisture content of the entering stock, in the units here employed, is:

$$w_1 = \frac{40 \text{ per cent water}}{60 \text{ per cent dry stock}} = 0.6667; \; w_2 = \frac{5 \text{ per cent water}}{95 \text{ per cent dry stock}} = 0.0527.$$

$w_1 - w_2 = \Delta w = 0.614$ lb. water evaporated per pound of dry stock. Since the air leaving the dryer is 50 per cent saturated at 150 deg. from Fig. 4, $H_2 = 0.105$. Similarly, $H_1 = 0.008$, corresponding to 50 per cent humidity at 70 deg. fahr. Consequently $H_2 - H_1 = \Delta H = 0.097$ lb. water evaporated per pound dry air.

Inspection of equation (1) shows that (H) is linear in w. Hence, one can construct Fig. 5, the line marked (H) being drawn connecting the initial and final points just computed.

Since the air leaving the dryer has a temperature of 150 deg. and a humidity of 0.105, Fig. 4 shows that its wet-bulb temperature is 129 deg. fahr. This is plotted at the right-hand side of Fig. 5. Since the stock maintains a wet-bulb temperature down to 20 per cent moisture, where $w = 0.25$, the corresponding humidity can be computed by the use of equation (1) or by reading directly from the diagram, the value being 0.0392. Fig. 4 shows that the corresponding wet-bulb temperature is 105 deg. Any intermediate point on the wet-bulb temperature curve can be calculated similarly. The points for $w = 0.5$ are shown on Fig. 5.

Below the point, $w = 0.25$, the temperature of the stock begins to rise appreciably above the wet-bulb temperature. Its temperature at any given point in this range, for example at $w = 0.15$, may be computed as follows: At this point, $H = 0.0234$ [from equation (1)] and from Fig. 4, $t_w = 95$ deg. Hence the wet-bulb depression, $t - t_w = 150 - 95 = 55$ deg. The assumption made regarding the relation between stock temperature and moisture content in this range may be formulated:

$$\frac{\Delta t'}{t - t_w} = \frac{w}{0.25}$$

At the point $w = 0.15$, $\Delta t' = 33$ deg., $t' = 117$ deg. The temperature of the stock leaving the dryer, similarly computed, is 136 deg.

Fig 5 thus computed gives in graphical form the information as to the temperature humidity relationships in the dryer. The air requirements can be computed by equation (1). Thus, per 100 lb. of dry stock it is necessary to supply 633 lb. of dry air. Furthermore, since from Fig. 4 it is seen that the volume of 50 per cent saturated air at 70 deg. fahr. is 13.55 cu. ft. per pound, 8,580 cu. ft. of room air must be supplied per 100 lb. of dry stock. Similarly, since the volume of 50 per cent saturated air at 150 deg. is 18.0 cu. ft. per pound, the volume of hot-wet air discharged from the dryer is 11,400 cu. ft. per 100 lb. of dry stock. Finally, the heat necessary to supply to the dryer as a whole or to any section of it may be computed from equation (2).

Rule of Thumb Estimating

Where time does not permit detailed calculations, a method sometimes used in dryer design is to estimate a consumption of about 2½ lb. of steam furnished to the dryer for each pound of water evaporated from the material, although under favorable conditions 2 lb. of steam is sufficient. In the very slow drying of thick, bulky materials such as hardwood lumber, at low temperatures, as much as 15 lb. of low-pressure steam is sometimes required per pound of water evaporated.

The temperature will drop approximately 8½ deg. fahr. per grain of water evaporated per cubic foot of air (measured at 70 deg. fahr.) or approximately 0.62 deg. fahr. per pound of air at any temperature. Approximate calculations may be based on air volume but for exact determinations the weight of the air should be used, since the weight is a fixed quantity at any temperature, but the volume will vary with the amount of moisture absorbed and the temperature.

DRYER ARRANGEMENT AND CONSTRUCTION

Outside handling and storage space usually is an important consideration in dryer design. Continuous dryers have an advantage in this respect since they provide storage for a considerable proportion of the material in process, while for charge dryers enough outside space must be provided to handle at least one full charge awaiting the dryer and one full charge upon removal. The more rapid the drying operation, the more efficient must be the handling facilities, in order to hold operating costs to a minimum and to keep the dryer operating at maximum capacity.

An important consideration in construction is to provide tight, well-insulated doors which can easily be opened and closed, with minimum labor and loss of time. Fire resistance of doors is also important, in case of outside exposure to fire risks. Insurance rates must be considered in their relation to fire protective arrangements such as automatic sprinklers, fire doors and walls, steam jets for use in smothering fires that may start inside the dryer, etc. Ceilings of dryers should be as flat as possible and the space between the material and the walls and ceiling should be held to a minimum. A factor often overlooked is that of suitable provision for ventilation of the space around the dryer openings so that warm moist air which may escape from the dryer when the doors are opened may be carried away before it has a chance to condense on the ceiling or windows of the building in which the dryer is located or into which it opens. Convenient arrangements for the operator should also be provided where tests can be made, records kept, and clothes changed, in case it is necessary for the operator to work inside the dryer.

EXPERIMENTAL TECHNIQUE

One vitally important phase of dryer design has been ignored in the preceding discussion, namely, *the time required to dry the stock*, or, what is equivalent to the same thing, *the size of the dryer*, and the character and extent of the *contact surface* between the stock and the air. In general, this cannot be determined except on the basis of experimental data on the specific material to be dried. The source of such data may