sideration is the method of introducing the air to the dryer. This is often called the distribution system. If there are dead areas, the air in that section will cool down rapidly, saturation will be reached and drying will be much slower in that section. If drying is to be uniform, then the circulation in every section of the dryer must be uniform. In addition, care must be taken not to have the air travel too far, causing a temperature drop too great and causing just as unequal drying conditions as if there were not enough circulation. The velocities must also be uniform over the goods at all parts or the drying will again become uneven.

Many of the older types of dryers were, and still are, of the type known as gravity or natural draft dryers. In these dryers, the natural laws of gravity are utilized to create a circulation. By regulating dampers and using chimneys or stacks, the moisture laden air is permitted to escape and an equal amount of fresh air admitted. The system is simple, and in some cases, may be adequate. The circulation cannot be increased beyond the amount of fresh air used, and hence, the circulation is inadequate to carry the proper heat uniformly through the dryer. This usually means that the drying is slow and often varies as the weather fluctuates. In a gravity dryer the circulation is usually slow, and such dryers are practically limited to materials which require baking or similar heat treatment rather than removal of much moisture. Even in a baking process, however, a rapid circulation results in much more even application of the heat so that most modern dryers have mechanical circulation by fans.

Many materials, such as gelatines, photographic films, etc., require drying at temperatures lower than the outside temperature. In such cases, the air must be cooled and dehumidified by refrigeration. It is then most economical not to use any fresh air in summer, but to recirculate all the air and remove the excess moisture by means of cold sprays of water or cooling coils. In high temperature dryers, on the other hand, the required temperature may be higher than steam temperatures and these may be secured either by entirely heating the air by oil or gas fired heaters, or such heaters may be utilized as a booster to the steam heated air. As such dryers need only a very small amount of fresh air, it may be best to recirculate a large volume and introduce only a very small quantity of fresh air heated to a high temperature by oil or gas heaters. These make possible temperatures up to 1000 F.

It is obvious that the air circulating through a dryer cannot be at the saturation point or drying would stop. The amount of saturation that can be carried in a dryer varies with the design of the dryer, rarely being over 50 per cent in a batch type dryer while in a tunnel dryer it may be 75 per cent or even higher.

Heat and Humidity Control

Regardless of whether the source of heat is steam or oil or gas fired heaters, there should be absolute control over the temperature and humidity. There is very little excuse today for hand operated valve control. If results do not have to be very accurate, a periodic setting of a thermostat and hand controlled dampers may be sufficient, but, in any case, there should be a recording instrument on every modern dryer. Only in this way can there be a check of the vigilance of the operator. The controls may be made more elaborate controlling automatically the

heat source, the humidity source, the amount of air recirculated and the amount of air exhausted. Although these are usually set to produce the desired temperature and humidity, in some cases controls have been developed which mechanically change their settings in accordance with a predetermined schedule. In some cases samples of the material are suspended on sensitized scales in the dryer opposite peep holes and the dryer is operated until the samples have reached the proper weight.

Operating the Dryer

No matter how well the dryer may be designed, a considerable part of the success of a drying operation depends upon the operator. He must watch the material and study the results in a constant effort toward improvement. Good dryer operation includes regular sampling and testing of material, watching the conditions within the dryer, and keeping systematic and complete records of all essential data, such as the movement of material, the length of the drying period, the temperatures and humidities at critical points in the dryer, and the extent to which the equipment is kept fully occupied. Standard schedules of drying time and drying conditions for material of different kinds are also useful in estimating production and regulating the operation of the dryer.

Moisture Content Calculations

Moisture content is usually expressed as a percentage of the original combined weight of the material and its contained water. Thus, if the moisture content were 20 per cent, the dry material would weigh 80 per cent of the total weight. In drying some types of material, notably lumber, it is customary to use the *bone dry* or water free weight of the material as the divisor, the weight of the water being calculated as a percentage of this dry weight. Regain, or absorption of hygroscopic moisture after drying, is almost always expressed by the latter method, as a percentage of the water free weight of the material.

The usual procedure, in determining the moisture content of a representative sample of the material, is to weigh this sample before it has had a chance to lose weight by evaporation, then dry it to a water free basis in an oven heated to a temperature slightly above the boiling point (about 215 F) until it has reached constant weight, then take a second weight record, and subtract the second weight from the first to determine the weight of the water. This figure can then be multiplied by 100 and divided by either the first weight or the second weight to obtain the percentage based on the original or final weight of the sample. Ovens used for this purpose are usually heated by steam or electricity and thermostatically controlled to prevent overheating.

Time of Drying

In Table 1, the average temperature range and drying time for a number of representative materials is given. The figures do not represent the maximum speeds attainable, nor necessarily the optimum temperature conditions, but are fairly typical of general commercial practice. In materials in which no capillary movement of free water can take place, the speed is limited by the rate of transfusion through the material, which is again determined by the critical temperatures and maximum gradients