### *Radiant Heat*

Radiant heat can at best supply only a portion of the total heat of vaporization. About one-third to one-half of the heat given off by a radiating surface passes through the air to the object which is to be dried without materially raising the temperature of the intervening air. The remaining portion of the heat from the radiator warms the air by convection and produces warm air currents which in turn transfer their heat to the material. A given amount of heat can be supplied to the material by means of heated air currents with only one-tenth to one-fifteenth as much radiating surface as would be required if this same quantity of heat were to be transferred by direct radiation. Direct radiation is, therefore, only an incidental source of heat in most dryers, except in the drying of certain kinds of material where the advantages of radiant heat will offset the higher first cost of the equipment. In vacuum dryers radiant heat is particularly useful in the drying of some bulky solids, owing to the difficulty of transferring heat to the material by means of rarified air currents at extremely low pressures.

### *Continuous and Intermittent Operation*

Dryers may be operated continuously or intermittently. In the continuous type, the material is fed in at one end of the dryer and discharged at the other end when dry. The movement may be either a steady flow, or may consist of the periodic or progressive removal of a minor portion of the charge at one end of the dryer and the admission of a like portion at the other end, at more or less regular intervals. Dryers of the intermittent type, often called charge dryers, are filled at the start with the material to be dried and are emptied again when the drying is completed, after which the process is repeated. The material in charge dryers is usually stationary but is sometimes shifted in position periodically or kept in continuous motion within the dryer for greater uniformity and speed of drying.

With constant rates of flow of air and material, continuous dryers are usually simple to control and can be fitted advantageously into the train of manufacturing operations with minimum loss of time and requirements for storage and handling. Charge dryers, on the other hand, permit the use of complicated schedules of temperature and humidity which would be difficult to attain with continuous operation, and they have the important advantages of simplicity and low first cost, making them particularly adapted to small installations and experimental work.

Temperature and humidity conditions in a charge dryer should be substantially uniform throughout the dryer, in order to produce uniform drying throughout the charge and prevent injury to the material. These conditions may remain uniform throughout the drying cycle or may be changed periodically as the drying progresses. In continuous or progressive dryers, the drying conditions usually vary from one end of the dryer to the other, either to suit the varying requirements of the different stages of drying or because of different rates of evaporation at different positions in the dryer. With some materials the highest temperatures and lowest humidities are used at the charging end of the dryer and with others, particularly bulky, plastic materials like lumber and clay, the





most severe conditions are called for at the discharge end with gradually lower temperatures and higher humidities toward the end where the fresh material enters. Some continuous dryers maintain an approximately uniform drying condition from one end to the other, where the path of travel is short and the water can be quickly and easily evaporated.

A higher heat efficiency is usually obtained with a continuous dryer than with a charge dryer, particularly where a counter current flow of air and material is possible. The air in a charge dryer must be changed frequently in order to maintain uniform conditions and to prevent the accumulation of evaporated moisture. This means that only a small part of the heat in this air can be utilized for drying. To conserve as much heat as possible, the air in charge dryers is often recirculated through the material after reheating and removal of surplus moisture by condensation or mixture with fresh outside air. On the other hand, in continuous dryers of the counter-current type, a large part of the heat of the air passing through the dryer can be utilized in evaporation, since the air can enter at the discharge end in a hot-dry condition and emerge at the charging end in a condition approaching saturation.

### *Low and High Temperature Drying*

The division line between what is known as low-temperature drying and high-temperature drying is, roughly speaking, the boiling point of water under ordinary atmospheric conditions. In high-temperature drying, the temperatures range from 212 to 1,000 deg. fahr. or more. Under these conditions, all of the water in the material will vaporize quickly and the humidity of the air becomes of minor importance. High-temperature drying is usually faster and more economical of heat than low-temperature drying, but often cannot be used because many materials, particularly foods and other organic substances, are injured or destroyed by temperatures above the boiling point. For such materials low-temperature drying is required, the drying being produced by supplying enough heat to the material, and surrounding it with a sufficiently low humidity, so as to produce a higher vapor pressure within the material at its surface than is present in the air surrounding it. As long as this difference in vapor pressure is maintained, the drying will proceed until completed.

In drying with temperatures above the boiling point, the vehicle used may be gas, such as products of combustion, air, or the vapor of the water being evaporated, *i.e.*, superheated steam. It is important, in high temperature drying, to remove products of oxidation as well as explosive and inflammable gases as quickly as possible, by means of ample circulation. Agitator fans within the dryer are often used in high-temperature work to create the necessary velocity for close contact with the material without moving an excessive volume of air or gas through the dryer. Static electricity, which sometimes accumulates in high-temperature drying because of the low humidities, making powders and fabrics difficult to handle, may often be controlled by a small steam spray. Many materials dried at high temperatures are soft when removed from the dryer and must be hardened in air that is warm enough and dry enough to prevent sweating and moulding. Within the critical limits,