*Rotary Dryers* are suited particularly to the continuous drying of granular, crystalline, or lumpy material which does not tend to ball or stick together. They consist of a revolving cylindrical shell into which the fresh material is fed at one end and from which the dry material is removed at the other end. Lifting plates usually extend from end to end of the inside of the cylinder, parallel to its axis, projecting radially toward the center. Warm air or products of combustion are blown through the shell, either parallel or counter current to the direction of movement of the material. The rotation of the cylinder continually elevates the material and drops or throws it through the current of hot gas or air, the inclination of the shell moving the charge forward at any desired speed. To furnish additional heat to the material by contact, the cylinder is often provided with a steam jacket or with steam coils inside the cylinder. In drying material which is not injured by high temperatures, the outside of the shell may be heated by products of combustion and these gases then led through the dryer in contact with the material.

### Spray Dryers

*Spray Dryers* are used for the drying of thick liquids, including any product in solution, suspension or emulsion, such as milk, rubber latex, chemicals and soap where the desired product is a powder or fine uniform particles. The liquid is usually first concentrated to from 35 to 50 per cent solid content and is then atomized in the form of a fine spray at the top of a lofty chamber, falling through a current of heated air or furnace gases, the dried powder accumulating at the bottom of the chamber. The air can be heated to a considerably higher temperature than would be used for the same material in a contact dryer because the critical temperature in a spray dryer is the wet bulb temperature instead of the dry-bulb temperature. The drying is practically instantaneous. The spraying may be done by atomizing nozzles worked either by the pressure of the liquid or by compressed air, or the liquid may be dropped in a fine stream onto a revolving disc rotating at high speed. That portion of the powder which is carried away with the air currents may be recovered in anyone of several types of dust collectors such as cyclones, screens, dust bags or electric precipitators. The air or gas may be recirculated in part, after removing surplus moisture.

*Loft, Compartment, Cabinet or Room Dryers* consist of room-like enclosures or boxes in which the material to be dried is placed on trays, trucks, racks, or moving conveyors and is heated by warm air currents which also serve to carry away the evaporated moisture. Drying of this sort is sometimes called *air-processing*. The air is warmed, either by direct mixture with furnace gases, or by contact with surfaces heated by direct flame, flue gases, steam, hot water, or electricity. The source of heat may be *direct*—located within the dryer, usually in the form of wall coils, floor coils, or distributed coils—or *indirect*, the air being heated by radiators outside the dryer and circulated through the dryer by fans and distributing ducts. Baffles are often used to assure the passage of the heated air directly over the surface of the material and to prevent short-circuiting from inlet to outlet. Where the material is placed on trays, shelves or racks, it is advisable to use open-wire screen bottoms for small material or leave spaces between larger articles when possible, to allow





the air to travel not only over the material but also upward or downward through it.

*Tunnel Dryers* consist of a comparatively long, narrow box-like enclosure, through which the solid to be dried is moved either continuously or periodically at short intervals, being fed in at one end in a wet condition and removed from the other end in a dry condition. The material may be carried on some type of mechanical conveyor or on wheeled cars or trucks moving on a track. The drying is done by means of heated air which moves through the dryer from one end to the other, warming the material and removing the evaporated moisture. Some products dry best if the air and material are made to move in the same direction, but in most cases it is found best to have the air move in a direction opposite to the travel of the material, that is, counter-currently. Where wheeled cars are used for heavy, bulky products, the rails in the tunnel are often sloped in a ratio of 60 to 1, or 100 to 1, to obtain the benefit of gravity in moving the material.

One end of the tunnel is usually hotter than the other, to suit the varying requirements of the different stages of drying. In the natural draft tunnel, heat is provided at the hotter end by steam coils or other means, and the evaporated moisture is removed at the opposite end by means of ventilating chimneys. In the forced draft, or blower type of tunnel, the air is circulated through the tunnel by fans, being heated either by direct radiation within the tunnel, or indirect radiation in the fan duct, or a combination of both. Evaporated moisture may be removed either by ventilating chimneys or duct openings, or more rarely, by condensers in the duct system.

### Electric Induction Dryers

Some new developments are occurring in the use of electricity for drying or baking metal parts. Among these is a system whereby metal parts are passed through a high frequency field, thereby inducing currents in these parts. Heat is then generated within the parts themselves, baking *from the inside out.*

The advantage of this system is a more efficient use of electricity, since oven temperatures are lower than work temperatures, keeping radiation and ventilation losses down to a minimum. This system can be applied only to production lines turning out uniform objects. The apparatus required, in addition to the conventional oven, is a high frequency motor generator set and a system of coils within the oven to obtain the proper electric field.

## MECHANISM OF THE DRYING

### Stages of Moisture Diffusion

A thorough knowledge of the mechanism of the diffusion of moisture from the interior of a solid material to the surface and into the air is necessary to an understanding of the different types of commercial dryers, and is essential where the design of the dryer is to be based upon small scale laboratory tests. Assuming uniform velocity and distribution of air at a constant temperature and humidity, over the surface of the solid, the drying cycle will be divided ordinarily into two distinct stages. The first stage, known as the *constant rate period*, is found in the drying of any