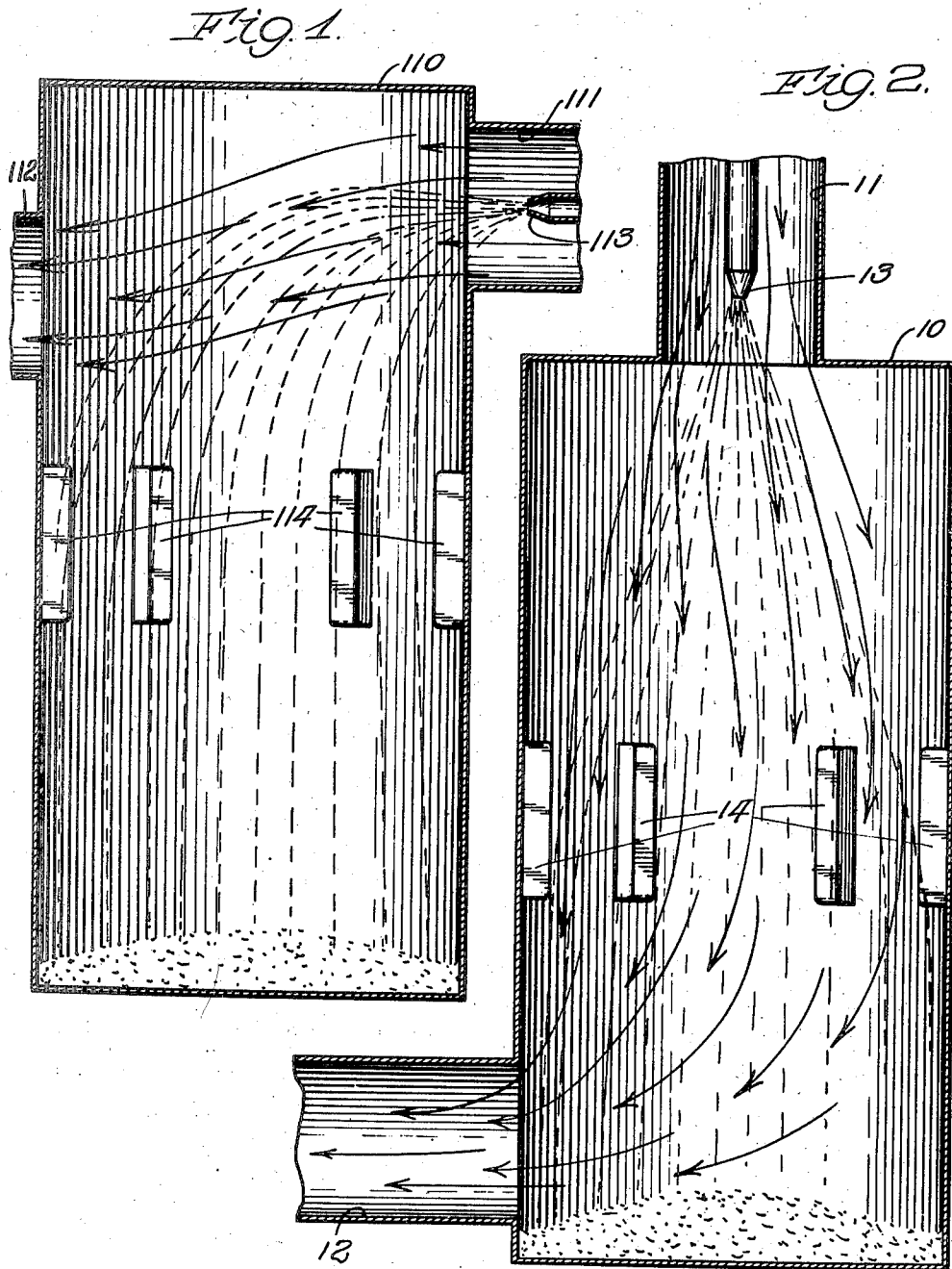


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C. J. MERRIAM
HIGH-FREQUENCY DRYING
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Inventor:
Charles J. Merriam,
By Clinton, Schroeder, Merriam, H. & Co.,
Attorneys.

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HIGH-FREQUENCY DRYING

Charles J. Merriam, Winnetka, Ill., assignor, by
mesne assignments, to Guardite Corporation,
Wilmington, Del., a corporation of Delaware

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8 Claims. (Cl. 34—1)

1 This invention relates to high frequency drying of a product which has been wet by a volatile fluid.

One of the disadvantages of ordinary drying methods is that all heat input is from the outside of the product to the inside. As a result, the outer portions of the product dry first and are at the same time subjected to the higher temperature. Thus there is always a gradient in moisture content from the inside out, and in addition it is difficult to prevent scorching of the outer portions of a product because it is hotter than the inside.

This is particularly true in spray drying operations in which an article is dried from a flowable wet condition to a fine discrete solid form in a single spraying operation during which all of the particles are unsupported except by the atmosphere in which they are operating. In ordinary spray drying operations of this type it is not practicable to do anything except to contact the falling particles with a countercurrent flow of hot gases and or with radiant heat. This accentuates the problem of preventing overdrying of the outer portions of each particle.

Two forms of apparatus for carrying out the process are shown diagrammatically in Figs. 1 and 2; Fig. 1 being a vertical section through a spray drying chamber and Fig. 2 being a vertical section through a different form of spray drying chamber.

In the present process such a spray drying operation is carried out by supplying substantially the entire heat input at the critical stage of drying by means of a high frequency current generated within the particles so that the heat gradient is from the inside out. At the same time the operation is carried out in an atmosphere within which the temperature is regulated, preferably to produce, at least at the critical times, a temperature below that of the outside of the particles being dried.

Several results may be accomplished by this regulation. In the first place it is possible to overdry the central portions of each particle beyond the finally desired moisture content. The excess amount of moisture removed from the interior of the particles may be considered as condensed on the cooler outer layers which are then overwet. After the spray drying operation the

2 particles may be normalized by mere standing so that the moisture may be equally distributed therethrough.

This particular method of procedure has great value where it is not possible, or desirable, to remove all air from the drying atmosphere. It produces the wettest and coolest part of the product where the exposure to the air occurs. The relatively hot interiors of the particles are not in contact with oxygen and, therefore, are not subject to many forms of deterioration which could occur on the outside of the particles.

Furthermore in a spray drying operation in which a cool gas is used to regulate the temperature of the outside of the particles, the gas may readily be introduced in countercurrent flow to the fall of the spray in such manner that it acts to cool the particles in the latter portion of their fall, when they require cooling, but serves as a heating and drying medium in the earlier or upper regions of the spray.

Furthermore, if the cooling gas is steam, it may in the latter stages be used to regulate evaporation, and, being cooler than the particles, will actually receive moisture therefrom even though the steam is saturated at the time it is employed. In such case, however, where saturated steam is used in this manner, it may not be desirable to use a countercurrent flow as such a flow will tend to produce condensation on the cooler particles in the initial phases of the spray because of the fact that the steam will be heated up by heat evolved from the particles themselves.

35 The invention is preferably carried out in an atmosphere substantially free from air and at low atmospheric pressure, as, for example, in the neighborhood of 2 to 4 inches of mercury absolute.

40 The process may be employed in combination with a drying current of hot gas. For example, the product may be introduced in discrete particles from an atomizer concurrently directed with a blast of superheated steam or other gas. An apparatus for carrying out this example of the process is diagrammatically illustrated in Fig 2, in which 10 is a spray drying chamber having an inlet 11 and an outlet 12. Hot gas is introduced through the inlet 11 and flows in the manner indicated by the arrows downwardly through

the chamber and then outwardly through the outlet 12. Particles to be dried are introduced to the chamber through a nozzle 13 and gravitate through the chamber to the bottom where they may be allowed to accumulate for future removal. A plurality of electrodes 14 are provided about the chamber intermediate the top and bottom thereof, and are connected by suitable means to an electromagnetic field creating device (not shown). The amount of the steam, its temperature, and its rate of flow, are correlated to the amount of product, the moisture content thereof, and to the amount of current supplied so that during the process the temperature of the exterior of the product passes that of the steam. Such a process has the advantage of using the steam as a heating and drying medium during the first part of the process and as a cooling medium in subsequent parts. It is obvious that the high frequency current does not have to be employed during the entire cycle. It may be omitted during the early stages thereof and supplied in a later portion of the cycle. The cycle may be considered as complete when the supply of high frequency current ceases, even though the steam may remain in contact with the particles for some time thereafter.

Such a process also has the advantage that the product is dried more rapidly on the exterior at first, so that the moisture content of the interior initially rises with respect to the exterior of each particle. The rate of drying then changes as the superheat of the steam is lost, and ultimately the exterior of the product becomes markedly wetter than the interior. It will be noticed that this reversal of the relative moisture content of the interior and exterior may be accomplished even though the concurrency of the steam flow is not continued to the end of the process. For example, spray may be introduced horizontally in a current of steam, and, as the particles pick up a vertical component of flow, the steam may be withdrawn to the side, and the particles permitted to fall through a quiescent atmosphere or may even be carried in a side current of gas.

An apparatus for carrying out this example of the process is illustrated diagrammatically in Fig. 1, in which 110 is a flow chamber having an inlet 111 and an outlet 112. Hot gases are introduced to the chamber through the inlet and flow more or less horizontally across the chamber and out the outlet 112. Particles to be dried are introduced to the flow through the nozzle 113. The particles after leaving the nozzle gravitate downward through the chamber and are accumulated in the bottom. A plurality of electrodes 114 are provided which are connected by suitable means to an electromagnetic field creating device.

When the concurrency of the steam or gas flow is carried out throughout the spray drying process, as particularly where the flow of the material is substantially vertically downward, a very desirable heat gradient is established from the interior of the product to the steam. That is, the interior of the product is hottest, the temperature of the exterior of the particles is intermediate, and the steam is cooler than the exterior of the particles.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom.

What I claim as new, and desire to secure by Letters Patent, is:

1. The method of drying moist particles of a substantially non-volatile material which comprises passing the material in unsupported concurrent flow by gravity in a gas substantially hotter than the particles, wherein the surface of the particles is dried, and supplying, at least during a latter portion of the flow in said gas, high frequency current to the particles, whereby they are internally heated to a temperature higher than that of the exteriors thereof.

2. The method of drying moist particles of a substantially non-volatile material which comprises passing the material in unsupported concurrent flow by gravity in a gas substantially hotter than the particles, wherein the surface of the particles is dried, and supplying, at least during a latter portion of the flow in said gas, high frequency current to the particles, whereby they are internally heated to a temperature above the then temperature of the gas.

3. The method of drying moist particles of a substantially non-volatile material which comprises passing the material in unsupported concurrent flow by gravity in a gas substantially hotter than the particles, wherein the surface of the particles is dried, supplying, at least during a latter portion of the flow, high frequency current to the particles, whereby they are heated, and correlating the rate of flow, temperature, and quantity of gas, the amount and moisture content of the particles, and the amount of high frequency current supplied thereto, so that the gas at a later stage of the flow has a lower temperature than the surface of the particles of the product to condense moisture on said surface.

4. The method as set forth in claim 3, in which the moisture is water.

5. The method of spray drying a water-wet product which comprises atomizing the product in a current of steam hotter than the particles, and heating the particles while suspended in steam by a high frequency field until they are substantially hotter than the steam.

6. The method of drying a product containing a volatile liquid which comprises producing a high-frequency field within the product to be dried whereby it is heated and the heat so produced volatilizes water in the product, characterized by supplying steam to the product during drying, the temperature of said steam being lower than the temperature of said product at the outer surface thereof, whereby the exterior of the product is maintained at a temperature markedly below the interior thereof and at a moisture content above the interior thereof.

7. The method of drying water-moist particles of a substantially non-volatile material which comprises passing the material in concurrent flow in steam which is substantially hotter than the particles, wherein the surface of the particles is dried, and supplying, at least during a latter portion of the flow in said steam, high frequency current to the particles, whereby they are internally heated to a temperature above the then temperature of the steam.

8. The method of drying water-moist particles of a substantially non-volatile material which comprises passing the material in concurrent flow in steam which is substantially hotter than the particles, wherein the surface of the particles is dried, and supplying, at least during a latter portion of the flow, high frequency current to the particles whereby they are heated, and correlat-

ing the rate of flow, temperature, and quantity of steam, the amounts and water content of the particles, and the amount of high frequency current supplied thereto, so that the steam at a later stage of the flow has a lower temperature than the surface of the particles of the product to condense water on said surface.

CHARLES J. MERRIAM.

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