March 16, 1943. D. D. PEEBLES 2,314,159

SPRAY DRYING APPARATUS AND METHOD

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FIG_1

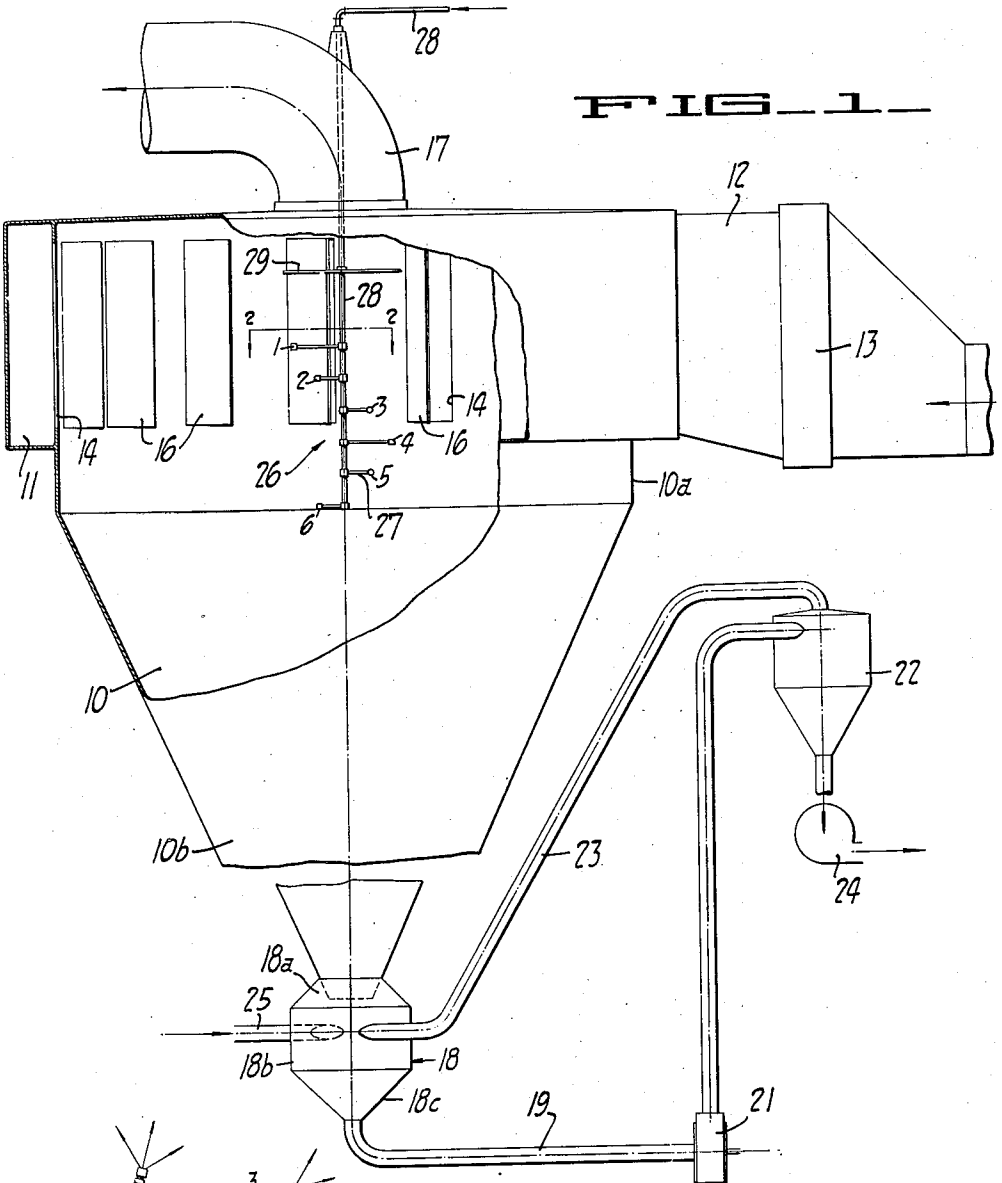
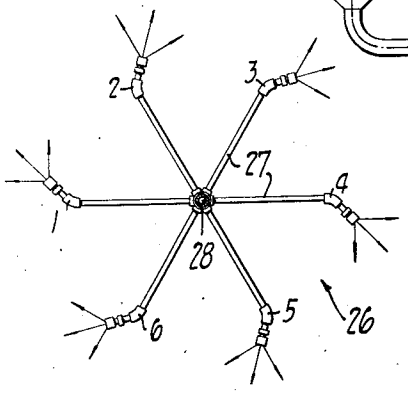


FIG_2



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SPRAY DRYING APPARATUS AND METHOD

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9 Claims. (Cl. 159—4)

This invention relates generally to the art of spray drying various materials and to apparatus for carrying out such methods.

In the past various types of spray drying equipment have been employed for the manufacture of dry powdered products from various fluid materials, as for example from milk, vegetable and fruit juices, sugar syrups, and the like.

One type of equipment makes use of a centrifugal atomizer for atomizing the fluid feed within a desiccating chamber (see Peebles 1,914,895 and 1,984,381). In one type of such equipment the fluid feed is supplied under high pressure to a stationary atomizing nozzle, from which the material is sprayed in finely atomized form into the desiccating chamber. Also in such equipment it is common to introduce drying gas into the periphery of the drying space, and to provide an outlet for gas centrally of the top of the drying chamber (see Gray and Jensen Patent 1,078,848). Such equipment is limited with respect to capacity, and for a given installation it is not practical to operate beyond a given capacity by varying certain factors, as for example by increasing the rate of flow of material to the atomizing nozzle together with an increase in the supply of drying gas. The primary drying zone in such equipment is limited to a shallow plane or core extending outwardly from the atomizing nozzle.

It is an object of the present invention to provide an improved spray drying apparatus and method of the above character capable of having relatively high capacity for the size of desiccating chamber employed.

A further object of the invention is to provide an improved spray drier which will effectively atomize and distribute the atomized material in the drying gas, without using excessively high fluid pressures upon the atomizing means.

Additional objects of the invention will appear from the following description in which the preferred embodiment of the invention has been set forth in detail in conjunction with the accompanying drawing.

Referring to the drawing:

Figure 1 is a side elevational view illustrating apparatus incorporating the present invention; and

Figure 2 is an enlarged cross sectional detail taken along the line 2—2 of Figure 1 and serving to illustrate the manner in which the several nozzles are distributed about the central axis of the desiccating chamber.

The equipment illustrated in the drawing consists of a desiccating chamber 10 which is preferably formed symmetrically about a central vertical axis. Although the invention is susceptible of variation with respect to the shape of the chamber, and with respect to the location and arrangement of the inflow and outflow ducts, in this instance I have shown a chamber which has an upper cylindrically shaped portion 10*a*, and a lower conical shaped portion 10*b*. For the inflow of hot desiccating gas, an annular conduit 11 surrounds the upper portion of the chamber and is connected by conduit 12 to a heater 13, and thence to a suitable air blower. Circumferentially spaced slots 14 connect between conduit 11 and the interior of the chamber, and louvers 16 adjacent these slots direct the incoming gas tangentially, thus causing cyclonic movement of gas within the desiccating chamber about the central vertical axis. An exhaust conduit 17 communicates centrally through the top of the chamber and serves to exhaust a part of the gas, together with a minor part of the dried material.

The lower end of conical portion 10*b* communicates with the top of a secondary chamber 18, which in turn has its lower portion connected to the discharge conduit 19. Chamber 18 is circular in contour, and preferably is formed with a conical shaped upper portion 18*a*, a cylindrical shaped middle portion 18*b*, and a conical shaped lower portion 18*c*. Conduit 19 connects with a blower 21 which discharges to separating means such as the cyclonic separator 22. Conduit 23 returns gas exhausted from separator 22 tangentially into chamber 18. Separated material together with some gas is shown being removed from separator 22 by blower 24. An additional conduit 25 connects tangentially with chamber 18 and serves to introduce additional drying gas. Cyclonic movement of gas in chamber 10 is in the same direction as in the chamber 18.

With prior types of spray drying equipment, it has been customary to locate the single atomizing nozzle near the center of the desiccating chamber to discharge an atomized spray downwardly. The optimum point of location of such an atomizing nozzle along the axis of the chamber is somewhat critical. Location too high or too low within the chamber impairs capacity and may cause impairment of the quality of the product. Also it may cause sticking of material on the side walls of the chamber and inadequate drying.

With the present invention I secure increased capacity by providing a cluster 26 of atomizing

nozzles in place of a single centrally located nozzle. With the arrangement as illustrated, six atomizing nozzles are employed, numbered 1 to 6, inclusive, although the number may vary in practice. Each nozzle is shown mounted upon the outer end of a radially extending pipe 27, and the inner ends of these pipes connect to a common fluid supply pipe 28. Thus the nozzles are spaced about and outwardly from the axis of the chamber, and they are also spaced along the length of the axis. The pipe 28 is shown extending upwardly to the exterior of the apparatus, and is connected to suitable pumping means for supplying the fluid feed material at a desired pressure.

The individual nozzles are preferably of a type capable of delivering a hollow conical spray of finely atomized material, such as a cone having an included angle of the order of 90°. Such nozzles are well known to those skilled in the art, and may be purchased upon the open market. For example, reference can be made to nozzles sold under the trade name of "Monarch," Type 621 MP.

For proper functioning of the apparatus, the individual nozzles are preferably directed substantially as illustrated in Figure 2. Instead of being faced in a direction radial with respect to the axis of the chamber, or in a direction perpendicular to such radius, they are each directed at an intermediate angle such as an angle of the order of 45° with respect to the radial connecting pipes 27. The direction in which the nozzles are faced corresponds generally to the direction of cyclonic movement of drying gas. Positioning the nozzles in this fashion serves to minimize contact and resulting sticking of incompletely desiccated material with the side walls of the chamber immediately surrounding the nozzle cluster, and in general it promotes optimum distribution of the atomized material in entrainment with the drying gas.

As previously stated, the individual nozzles are spaced apart circumferentially as viewed in plan, they are spaced outwardly from the central axis, and they are also spaced in a vertical direction as viewed in Figure 1. Thus it can be said that the nozzles lie within the surface of a cylinder, the cylinder being of substantial diameter and vertical extent and concentric with the central axis of the chamber. For example, with a desiccating chamber having a total height of about 28 feet, the distance between the uppermost and lowermost nozzles 1 and 6 can be of the order of 5 feet. Preferably in connection with the vertical spacing a baffle wall 29 is mounted below the top wall of the chamber and between the top wall and the uppermost nozzle 1. This baffle can be circular in contour, with a diameter corresponding generally to the diameter of the inlet end of conduit 17. It can be conveniently mounted upon pipe 28, concentric with the axis of the chamber.

Operation of the apparatus described above can be reviewed as follows: Hot drying gas, such as hot air, is supplied to the desiccating chamber through conduits 11 and 12. Gas is continuously exhausted from the chamber through the conduit 17, together with a minor part of the dried material. Some gas is continuously removed from the bottom of the chamber through secondary chamber 18 and conduit 19; and a part of this gas is reintroduced into the secondary chamber through conduit 23. The material to be desiccated, such as skim milk, is supplied through pipe 28 at a suitable pressure, as for example a pressure of the order of 2500 pounds per square inch. In discharging from the nozzles of the cluster 26, the milk is in finely atomized condition, and is entrained by the cyclonic drying gas. Evolution of moisture to form dry particles occurs substantially instantaneously, and the dried material progresses downwardly through the secondary chamber 18 to be finally removed through the conduit 19. The milk as supplied through pipe 28 may be raw milk or may be a concentrate obtained by evaporation.

Because of the positioning and distribution of the nozzles, the droplets of liquid are introduced into the desiccating chamber in such a way as to form a substantially cylindrical shaped zone of droplets concentric with the axis of the chamber. A large part of the drying occurs within this primary drying zone, and drying continues as the particles progress outwardly. Most of the dried material progresses downwardly to be finally discharged through conduit 19, while a minor part passes out with gas exhausted through conduit 17. In the secondary chamber 18, the solid particles are subjected to further drying. The amount of gas introduced through conduit 25 is relatively small compared to the flow through the conduit 12, and should not be sufficient to interfere with downward flow of gas through conical portion 10b. Such introduction of gas blends with the gas withdrawn from chamber portion 10b to reduce the relative humidity of gas in secondary chamber 18 and conduit 19.

The temperature and flow rates employed can be varied depending upon the materials being dried. By way of example, the drying of milk products, gas can be introduced through conduit 12 at a temperature of 260° F. and removed through conduit 17 at about 155° F. Gas leaving the lower end of conical portion 10b can be about 195° F., and gas introduced through conduit 25 at a somewhat higher temperature, such as from 220 to 260° F. It should be understood that secondary chamber 15 can be omitted and conduit 19 connected directly to the lower end of conical portion 10b, although use of the secondary chamber is desirable to effect a final finishing drying after discharge of material from the main desiccating chamber.

It will be evident that my invention is of such character that it can be applied in the rebuilding of existing spray drying equipment to afford a greater capacity without changing the size of the desiccating chamber. In actual tests, the capacity of prior spray driers has been increased about four times, by use of the present invention, together with suitable changes in the air handling and heating equipment to compensate for the increased capacity.

In addition to affording greater capacity, the invention makes possible use of pressures much less than pressures employed in the past on single atomizing nozzles. For example in prior equipment, it has been customary to supply the milk to a single atomizing nozzle at pressures as high as 5,000 to 6,000 pounds per square inch. Such extremely high pressures call for special and expensive pumping equipment, together with special high pressure fittings. It will be evident that the greatly reduced pressures made possible by the present invention (such as pressures of the order of 2,500 pounds per square inch when desiccating milk) simplify the type of pumping equipment required and the type of fittings em-

ployed for connecting the pumping equipment with the nozzle cluster.

When employed for the manufacture of milk powder, my apparatus is capable of producing a high quality product, relatively free of objectionable discoloration.

I claim:

1. In a spray drying apparatus, a desiccating chamber, means for maintaining cyclonic currents of drying gas within the chamber, the cyclonic movement being about a central axis of the chamber, a conduit serving to exhaust gas from one end of the chamber from a region concentric with said axis, a plurality of fluid atomizing nozzles disposed within the chamber, the nozzles being distributed about said axis and in a direction longitudinally of the axis, and a baffle interposed between the space occupied by said nozzles and the region of communication between said chamber and said exhaust conduit, said baffle being of substantial extent in a direction at right angles to said axis, thereby serving to intercept direct flow of gas from said space to the inlet end of the exhaust conduit.

2. In a spray drying apparatus, a desiccating chamber, means for introducing hot desiccating gas into the upper portion of the chamber in a direction to cause gas within the chamber to swirl cyclonically about a central axis of the chamber, the chamber having a lower conical shaped portion, a conduit communicating with the lower end of said chamber and serving to remove desiccating material, an exhaust conduit communicating with the upper end of said chamber at a region concentric with said axis, a plurality of fluid atomizing nozzles disposed within the chamber and distributed about said axis and spaced apart in a direction longitudinally of the axis, and a baffle interposed between the space occupied by said nozzles and the point of communication between said chamber and the exhaust conduit, said baffle being of substantial extent in a direction at right angles to said axis, thereby serving to intercept direct flow of gas from said space to the inlet end of the exhaust conduit.

3. In spray drying apparatus, a desiccating chamber having a lower conical shaped portion and having a vertical central axis, means for introducing hot drying gas into the upper portion of the chamber, the direction of introduction of the drying gas serving to cause cyclonic movement of drying gas within the chamber about said axis, a conduit connecting to the lower end of the chamber for removal of desiccated material, an exhaust conduit connected to the upper end of the chamber at a point concentric with said axis, a plurality of atomizing nozzles disposed within the chamber, the nozzles being distributed about said axis and being spaced apart in a vertical direction, each of said nozzles being faced in a direction intermediate the direction of a radius drawn from the axis through the nozzle and a direction at right angles to such radius, and a baffle disposed between the space occupied by said nozzles and the region of communication between the chamber and the exhaust conduit.

4. In a drying apparatus for producing substantially dry divided solids from liquid material, a desiccating chamber, means for maintaining cyclonic currents of drying gas within the chamber, the cyclonic movement being about a central axis of the chamber with progression of the drying gas inwardly toward said axis, means for withdrawing desiccated material in substantially dry powdered form from said chamber, and a plurality of atomizing nozzles disposed within the chamber, said nozzles each being positioned outwardly from the axis of the chamber a substantial portion of the distance between said axis and the peripheral wall of the chamber and being spaced from each other axially of the chamber.

5. In a drying apparatus for producing substantially dry divided solids from liquid material, a desiccating chamber, means for maintaining cyclonic currents of drying gas within the chamber, the cyclonic movement being about a central axis of the chamber with progression of the drying gas inwardly toward said axis, means for withdrawing desiccated material in substantially dry powdered form from said chamber, and a plurality of atomizing nozzles disposed within said chamber, said nozzles each being positioned outwardly from the axis of the chamber a substantial portion of the distance between said axis and the peripheral wall of the chamber and being spaced from each other axially of the chamber, said nozzles also being disposed at circumferentially spaced points about said axis and being positioned to direct atomized material in directions generally outwardly from said axis and predominantly in the general direction of said cyclonic currents.

6. In a drying apparatus for producing substantially dry divided solids from liquid material, a vertically extending desiccating chamber having a cylindrical upper portion and a conical lower portion, means providing a plurality of gas inlets spaced about the periphery of said cylindrical portion for introducing drying gas and maintaining cyclonic currents of drying gas within the chamber, the cyclonic movement being about the central vertical axis of the chamber with progression of the drying gas inwardly toward said axis, means for withdrawing desiccated material in substantially dry powdered form from the lower end of said chamber, means for withdrawing drying gas from the central portion of the upper end of said chamber, and a plurality of atomizing nozzles disposed within the cylindrical portion of said chamber, said nozzles each being positioned outwardly from the axis of the chamber a substantial portion of the distance between said axis and the peripheral wall of the chamber and being spaced from each other axially of the chamber, said nozzles being positioned to direct atomized material in directions generally outwardly from said axis.

7. In a drying method the steps of continuously supplying drying gas to the outer periphery of a drying space, causing the gas in said space to have cyclonic movement about the central axis of the space with progression of gas inwardly toward said axis, introducing atomized particles of material to be dried into said space at a plurality of axially spaced regions also spaced a substantial distance from said axis, causing the particles to be dried to solid form in said space, exhausting gas from said space and removing substantially dried divided material from said space.

8. In a drying method the steps of continuously supplying drying gas to the outer periphery of a drying space, causing the gas in said space to have cyclonic movement about the central axis of the space with progression of gas inwardly toward said axis, introducing atomized particles of material to be dried in directions

generally outwardly from said axis into said space at a plurality of axially spaced regions also spaced a substantial distance from said axis and disposed at spaced points around said axis, causing the particles to be dried to solid form in said space, exhausting gas from said space and removing substantially dried divided material from said space.

9. In a drying method the steps of continuously supplying drying gas to the outer periphery of the upper portion of a vertically extending drying space, causing the gas in said space to have cyclonic movement about the central vertical axis of the space with progression of gas inwardly toward said axis, introducing atomized particles of material to be dried in directions generally outwardly from said axis and predominantly in the same general direction as said cyclonic movement into said space at a plurality of axially spaced regions also spaced a substantial distance from said axis, causing the particles to be dried to solid form in said space, exhausting gas from the central upper portion of said space and removing substantially dried divided material from the lower portion of said space.

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