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APPARATUS AND METHOD FOR SOLIDIFYING LIQUIDS

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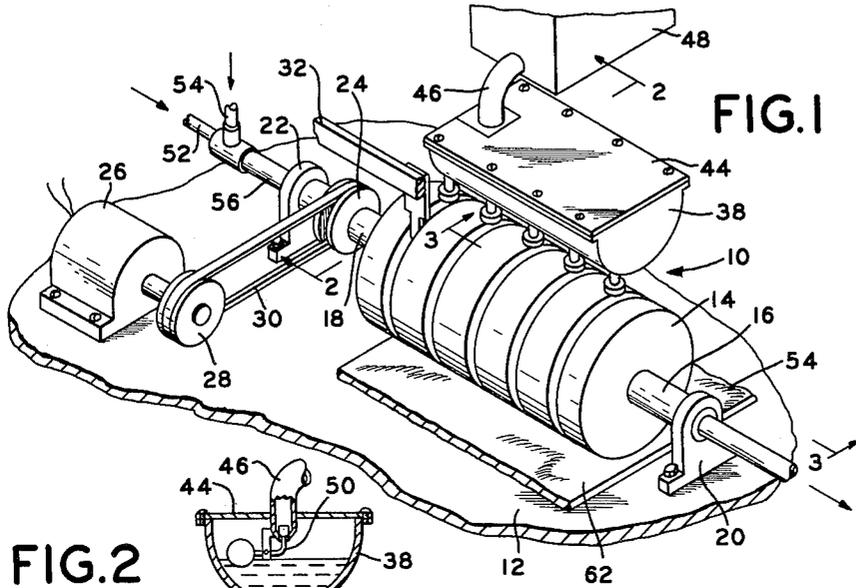


FIG. 1

FIG. 2

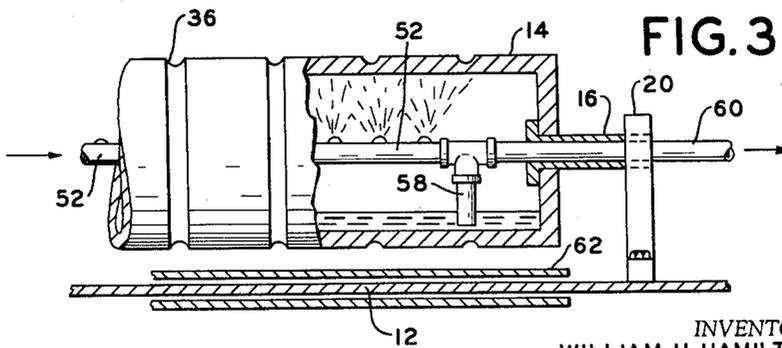
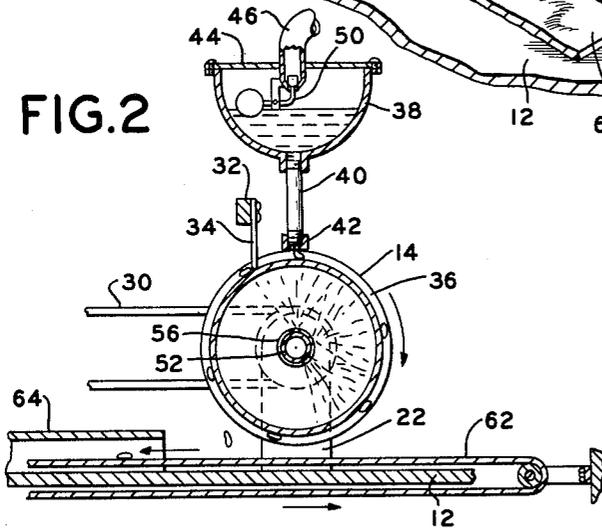


FIG. 3

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APPARATUS AND METHOD FOR  
SOLIDIFYING LIQUIDS

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mesne assignments, to Pennsalt Chemicals Corporation,  
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This invention relates to an apparatus and method for solidifying liquids, and more particularly, to an apparatus and method for solidifying liquids so as to provide a plurality of uniform discrete particles which may be freeze or vacuum dried at a uniform rate.

A plurality of rotatable drum devices have been proposed heretofore wherein liquids are solidified on the exterior of the drum and separated therefrom by a doctor blade. Such devices produce solidified liquids in flake form. Obviously, flakes produced by such devices are not uniform in size and therefore are not satisfactory for vacuum or freeze drying since it would be extremely difficult to predict the drying rate and time.

The devices provided heretofore provide solidified liquids in the form of flakes. On the contrary, the present invention is designed to provide uniform discrete particles which are not in flake form. Thus, the discrete particles in accordance with the present invention may be spherical, hemispherical, rectangular, or irregular solid shapes. The uniformity of the size of the discrete particles is effected by the viscosity of the liquid, the size of the dispensing orifice, and the distance between such orifice and the drum when the liquid is highly viscous. Thus, when using a highly viscose liquid, I have found that the distance between the periphery of the drum and the dispensing orifice is critical. In accordance with the present invention, such distance is less than the length of a drop of the liquid. In this manner, the drop contacts the drum before it leaves the dispensing orifice.

The method of dragging a drop of highly viscous liquid from the dispensing orifice prevents such drop from flattening out against the periphery of the drum prior to being solidified by the temperature of the drum. In this manner, the method of the present invention provides uniform discrete particles. When the viscosity of the liquid permits, the drops are deposited within grooves on the periphery of the drum at spaced points along the longitudinal axis of the drum. In this manner, the present invention enables discrete particles to be of uniform size without being in flake form. The shape of the grooves will effect the shape of the discrete frozen particles. As a general rule, the shape of the discrete particles, whether they be spherical or hemispherical, is relatively unimportant so long as the shape and size of the particles are uniform.

The size and shape of the discrete frozen particles must be uniform since they control the drying rate of the particles. The particles formed by the apparatus and method of the present invention will be disposed within a freeze drying apparatus wherein the combination of heat and vacuum will cause the ice within the particles to sublime. If the articles to be freeze dried are of uniform size and shape, the drying time may be determined with extreme accuracy. If the articles are not uniform in size and shape, certain articles will be overdried and others will have more than the prescribed amount of moisture therein.

It is an object of the present invention to provide a novel apparatus for solidifying liquids so as to provide uniform discrete particles.

It is another object of the present invention to provide a novel method of solidifying liquids so as to provide uniform discrete particles.

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It is another object of the present invention to provide a novel method of solidifying liquids wherein a drop-forming means is disposed adjacent a cooled drum with the distance between the drum and means enabling the drop to be dragged from the drop-forming means.

It is still another object of the present invention to provide a novel apparatus for solidifying liquids capable of being utilized with any one of a plurality of liquids and capable of automatically producing a plurality of uniform discrete particles at spaced points along the length of a cooled drum.

It is still another object of the present invention to provide a novel apparatus and method for solidifying liquids wherein uniform discrete particles are produced by taking into consideration the viscosity of the liquid as well as the size and position of a drop-forming means.

Other objects will appear hereinafter.

For the purpose of illustrating the invention there is shown in the drawings forms which are presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIGURE 1 is a perspective view of the apparatus of the present invention.

FIGURE 2 is a transverse sectional view taken along the lines 2-2 in FIGURE 1.

FIGURE 3 is a longitudinal sectional view taken along the lines 3-3 in FIGURE 1.

Referring to the drawing in detail, wherein like numerals indicate like elements, there is shown in FIGURE 1 an apparatus for solidifying liquids designated generally as 10.

The apparatus 10 includes a support 12 on which a hollow cylinder 14 is rotatably mounted. The cylinder is provided with hollow axles 16 and 18 at opposite ends thereof along its longitudinal axis. The axle 16 is rotatably supported by bearing 20 mounted on the support 12. The axle 18 is rotatably supported by the bearing 22 mounted on the support 12.

A pulley 24 is fixedly secured to the axle 18. The rotary motion of the cylinder 14 is effected by a motor 26 mounted on the support 12. The motor 26 is provided with a pulley 28 on its output shaft. An endless flexible belt 30 extends around the pulleys 24 and 28.

A bracket 32 extends along the cylinder 14 substantially parallel to the longitudinal axis of the cylinder 14. The bracket 32 supports flexible doctor blades 34 at spaced points therealong. The periphery of the cylinder 14 is provided with a plurality of annular grooves 36 at spaced points therealong. A doctor blade 34 is provided for each groove 36. The cylinder 14 is mounted so as to rotate in the direction of the arrow adjacent thereto in FIGURE 2.

A manifold 38 is disposed above the cylinder 14 and supported by brackets (not shown). The manifold 38 is provided with a plurality of outlet conduits 40 corresponding to the number of grooves 36. The end of the conduits 40 adjacent the cylinder 14 are provided with readily removable orifice plates 42. The orifice plates 42 are provided with a hole therethrough which enables the liquid to be dispensed drop by drop. The orifice plates 42 are preferably removable so that different size plates may be substituted as the liquid within the manifold 38 is changed. Thus, a different size orifice plate will be utilized when the liquid is coffee extract as compared to molasses.

When the liquid is highly viscose such as coffee extract, the orifice plate 42 will be juxtaposed to the periphery of the cylinder 14 so that the drops are deposited within the grooves 36. Deeper grooves are required for low viscosity liquids. For high viscosity liquids, the distance between the surfaces of the grooves 36 and the juxtaposed

end of the orifice plate 42 is preferably less than the transverse dimensions of a drop so that the drop is dragged from the orifice plate 42. In this manner, the drop will not flatten prior to solidification.

The manifold 38 may be provided with a removable cover 44 in any convenient manner. A delivery conduit 46 extends from a supply container 43 to the manifold 38. The supply of liquid from the container 43 to the manifold 38 is controlled by a float operated valve 50 disposed within the manifold 38.

The cooling medium for the cylinder 14 is provided by a conduit 52 which extends therethrough. As shown more clearly in FIGURE 1, the conduit 52 extends through a T-joint and a conduit 56. A pressure fluid such as air is delivered to the space between conduits 52 and 56 from conduit 54 connected to the T-joint. The cooling medium exits from the conduits 52 through a plurality of nozzles at spaced points along the length thereof within the cylinder 14 as shown more clearly in FIGURE 3. The air exits into the cylinder 14 and pressurizes the liquid collecting in the bottom of the cylinder 14 so as to force the same through the conduit 58, T-joint, and outlet conduit 60. The conduit 52 ends at the T-joint from which the conduit 58 depends. Thus, all liquid in the conduit 52 must exit through the nozzles and collect in the bottom of the cylinder 14 prior to being forced by the air upwardly into the conduit 58. It will be noted that the conduit 60 is concentrically disposed within the axle 16.

It will be noted that the nozzles on the conduit 52 are directed toward the orifice plates 42 and to that portion of the cylinder to the right of orifice plate 42 in FIGURE 2 so that the particles are frozen immediately upon contact with the cylinder 14. It will be noted that the position of the doctor blade 34 requires the particles to travel on the cylinder 14 approximately 330° prior to being separated from the cylinder 14 by the doctor blade 34.

The particles separated from the cylinder 14 are permitted to fall onto a conveyor belt 62. The conveyor belt 62 is preferably an endless belt travelling to the left in FIGURE 2 so as to correspond with the clockwise rotation of the drum 14 in FIGURE 2. The particles collected on the endless belt 62 are conveyed to a freeze drying apparatus wherein the particles will be freeze dried. In order to preserve the state of the articles, a tunnel 64 having means for cooling the same surrounds the upper half of the endless belt 62.

The operation of the apparatus 10 is as follows:

An orifice plate 42 is provided for each of the conduits 40 depending upon the liquid being disposed within the container 43. The position of the orifice plate is adjusted depending upon such liquid in the container 43. Thereafter, the motor 26 is started so as to rotate the cylinder 14, a cooling medium is circulated through the conduit 52 and air is forced through the conduit 54 into the cylinder 14. Then the conveyor belt 62 is operated by any convenient mechanism, not shown.

Then the float operated valve 50 is released by a latch mechanism (not shown) so as to permit liquid to flow from the container 43 into the manifold 38. The size of the conduit 46 is substantially greater than the summation of the holes in the orifice plates 42, whereby the liquid will collect within the manifold 38 until a predetermined level is reached. At this point, the float will close the valve 50 so as to prevent flooding of the manifold 38. If the manifold 38 becomes flooded, the pressure head will effect the ability of the orifice plate 42 to dispense the liquid drop by drop.

For highly viscose liquids, the orifice plates 42 will have been adjusted as set forth above so that drops are dragged therefrom so as to prevent such drops from flattening out. For liquids having low viscosity, the orifice plates 42 may be spaced slightly from the periphery of the cylinder 14. The drops of liquid are received within the grooves 36 wherein they are immediately solidified in the form of discrete particles of uniform size. The particles remain with-

in the grooves 36 until ejected therefrom by the doctor blade 34. The ejected particles fall onto the moving belt 62 and are conveyed through the tunnel 64 to a collection point where the articles are collected in trays and disposed within a freeze drying apparatus.

The grooves 36 are preferably V-shaped or U-shaped. I have found that grooves having square corners present problems in separation from the grooves by the doctor blade 34. For low viscosity liquids, the grooves are deeper than they are for high viscosity liquids. It is within the scope of the present invention to make discrete uniform particles without utilizing grooves on the periphery of the cylinder 14. I have run tests wherein hemispherical particles of a low viscosity liquid were made by depositing the drops of liquid on the smooth outer periphery of the cylinder 14. When the liquid was deposited on the smooth periphery of the cylinder 14, the orifice plate 42 was juxtaposed thereto so as to drag the drop from the orifice plate. Thus, the absence of grooves was only effective to provide uniform discrete particles with low viscosity liquids. When high viscosity liquids were deposited on the smooth outer periphery of the cylinder 14, the liquids flattened out and formed flakes which were not of uniform size and therefore unacceptable for freeze drying.

Thus, it will be seen that it is possible to practice the method of the present invention without using grooves when particular liquids are being solidified. When grooves are provided on the cylinder 14, the grooves will be uniform in size and shape. If different liquids are being solidified, different sized grooves may be utilized. Thus, different liquids can be solidified by providing a partition wall in the manifold 38 and separate inlets to each chamber of the manifold 38.

If desired, the manifold 38 may be provided with a cooling or heating jacket so as to maintain the liquids in a predetermined state. The cylinder 14 is preferably made from a high heat transfer material such as aluminum. If desired, a valve may be provided for each conduit 40 in place of the orifice plates. However, the provision of a separate valve for each conduit 40 is not preferred since control of the valves presents a problem and materially increases the cost of the apparatus 10 of the present invention.

Substantially all liquids may be solidified by use of the apparatus 10 of the present invention. Tests have been run wherein the liquids were coffee extract, fruit extracts, juices, milk, soups, etc. Excellent results have been attained with the apparatus 10 of the present invention as pertains to providing an automatic apparatus capable of consistently producing discrete particles of uniform size in a frozen state for use in a freeze drying apparatus. In this regard, it will be noted that the apparatus 10 is completely automatic and requires no attention whatsoever until the container 43 is empty. Means (not shown) may be provided within the container 43 to render a visible and ascertainable signal that the same is empty.

The present invention may be embodied with other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. Apparatus comprising a hollow cylinder, means for rotating said cylinder, conduits operatively associated with said cylinder for supplying a cooling medium to said cylinder for cooling the same, conduits for removing said cooling medium from said cylinder, a manifold having a plurality of outlet conduits, means connected to said outlet conduits for causing liquids to exit therefrom drop by drop, said outlet conduits being disposed with respect to said cylinder so that said drops are received on the exterior surface of said cylinder so as to form a plurality of discrete frozen particles of uniform size and shape, scraper means for separating the frozen particles from

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said cylinder, and the surface of said cylinder being juxtaposed to the means connected to the outlet conduits and spaced therefrom by a distance less than the transverse dimension of a drop so that the drops contact the exterior surface of said cylinder prior to losing contact with said means connected in said outlet conduits.

2. In apparatus for solidifying liquids comprising a movable surface, means for moving said surface, means for cooling said surface, adjustable means for delivering liquid drop by drop on a portion of said surface so as to form a plurality of discrete frozen particles of uniform size and shape, means for separating the frozen particles from said surface, the improvement comprising said delivering means having its discharge portion juxtaposed to said surface and spaced therefrom by a distance less than the transverse dimension of a drop but approximating said transverse dimension wherein each drop contacts the surface before losing contact with said discharge portion.

3. Apparatus comprising a hollow cylinder, means for rotating said cylinder, conduits operatively associated with said cylinder for supplying a cooling medium into the interior of said cylinder for cooling the same, a conduit for removing said cooling medium from the interior of said cylinder, a manifold above said cylinder and having a plurality of outlet conduits, a float responsive valve controlling the introduction of liquid into said manifold, means connected to said outlet conduits for causing liquids to exit therefrom drop by drop, said cylinder having semi-circular peripheral grooves on its exterior surface, each outlet conduit being aligned with one of said grooves so that drops are discharged into the grooves wherein they solidify to form discrete frozen particles of uniform size and shape, and scraper means for separating the

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frozen particles from said cylinder, said scraper means being positioned at a point more than 180 arcuate degrees in the direction of rotation of said cylinder with respect to the drop causing means, with the scraper means having a portion disposed in each groove.

4. Apparatus in accordance with claim 3 wherein the means on each outlet conduit for causing the liquids to be deposited drop by drop includes an adjustable nozzle having a removably mounted orifice plate having a hole therethrough calibrated with respect to the liquid so that the liquid may pass therethrough drop by drop.

5. A method of solidifying liquids comprising the steps of moving a support surface, cooling said surface, feeding liquid drop by drop on said surface, causing each drop to contact both its feeding means and said surface before separating from its feeding means, freezing said drops into discrete particles of uniform size and shape while said particles are supported by said surface, and separating said particles from said surface.

6. A method in accordance with claim 5 wherein said surface is the outer peripheral surface of a cylinder and said step of moving said surface includes rotating said cylinder about its longitudinal axis, and said feeding step including discharging the drops into semi-circular grooves on the surface.

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