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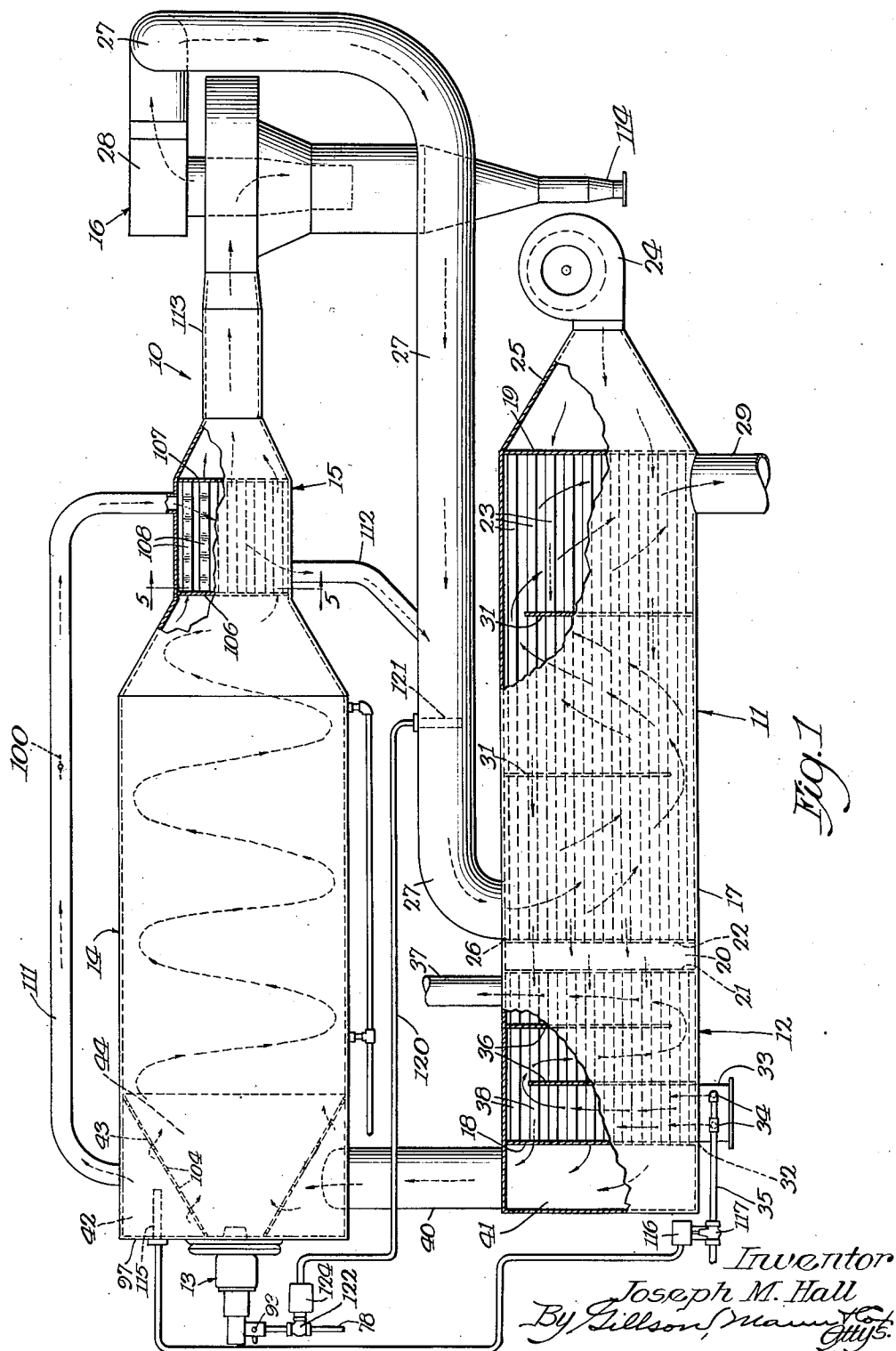
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2,188,506

METHOD OF DESICCATING FLUID MIXTURES

Filed Aug. 27, 1937

3 Sheets-Sheet 1



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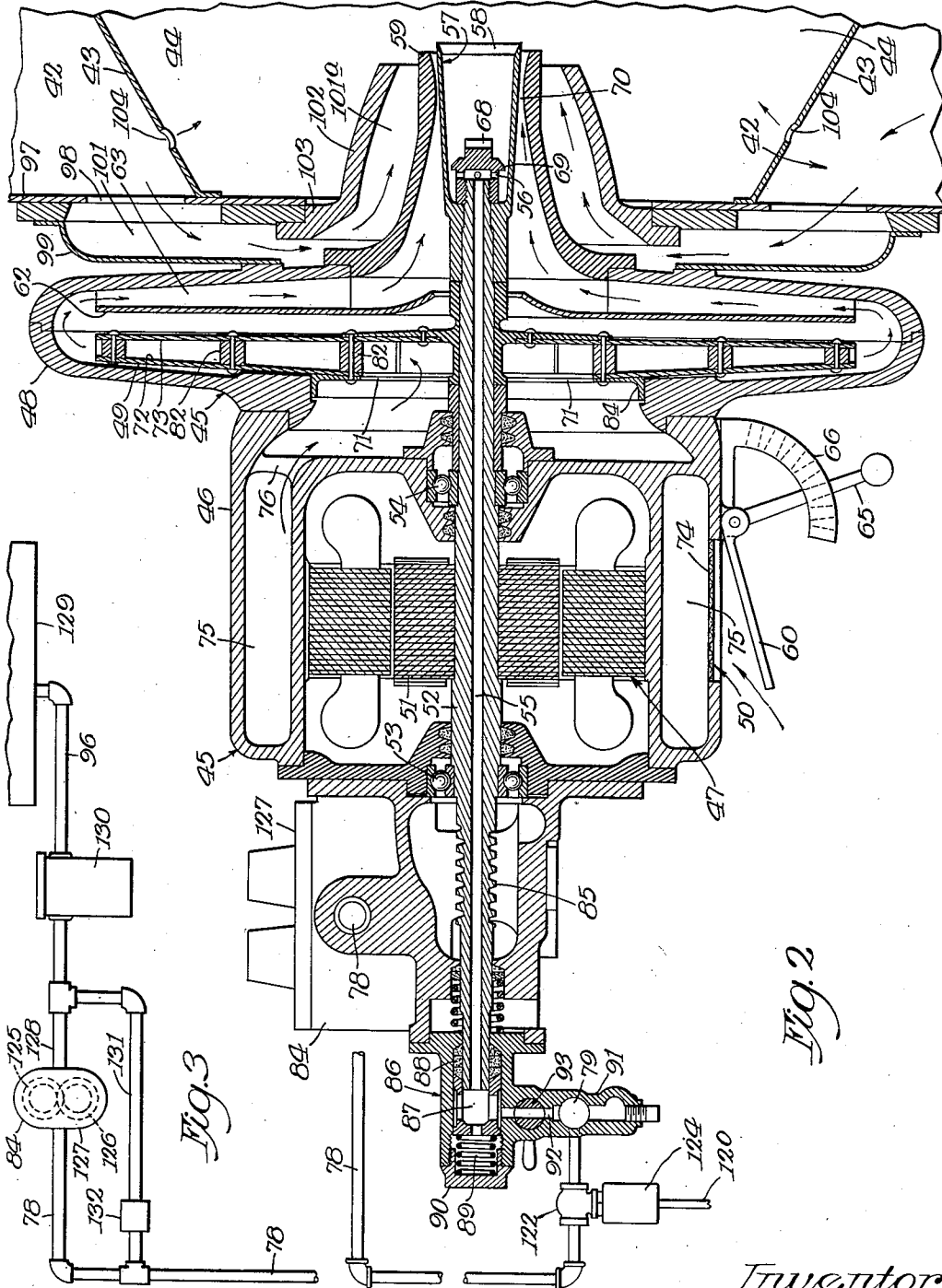
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3 Sheets-Sheet 2



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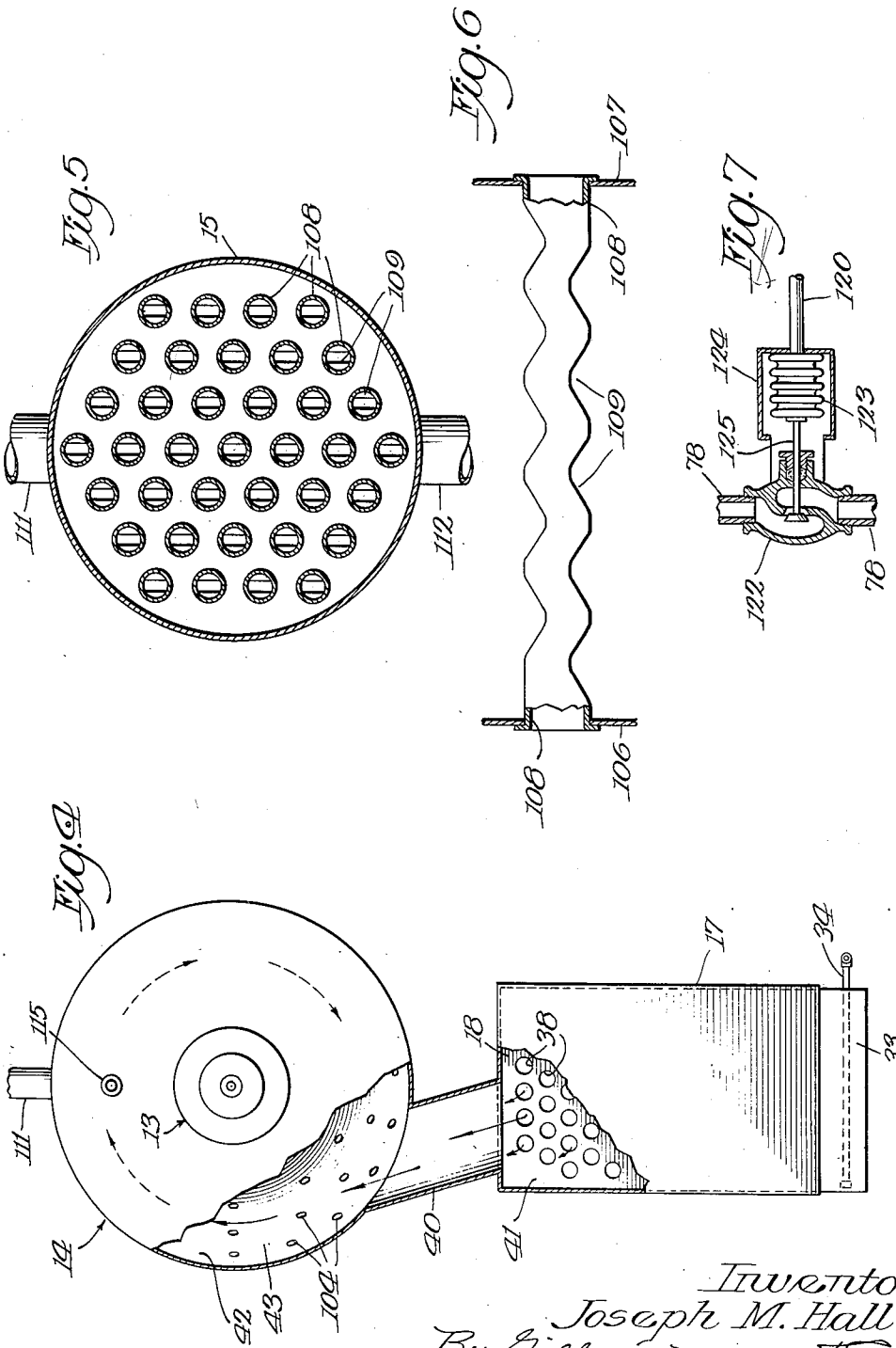
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METHOD OF DESICCATING FLUID MIXTURES

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13 Claims. (Cl. 99—203)

This invention relates to a system of evaporation or desiccation and concentration of milk and other liquid material.

One of the objects of the invention is the provision of a new and improved system for desiccating or evaporating milk and the like with a minimum of time and expense.

Another object of the invention is the provision of a new and improved apparatus for evaporating moisture from milk and other liquid material.

A further object of the invention is the provision of a new and improved method of evaporating and concentrating liquid material.

Another object of the invention is the production of a new and improved desiccated product in which the individual particles are of uniform size and shape without material loss of vitamins, enzymes or other properties which characterize the original material, each particle having a glazed or fused external surface which will preserve these properties.

A further object of the invention is the provision of a new and improved system of desiccating and evaporating or concentrating liquid material of various kinds in which the apparatus may be readily and easily installed, that is efficient and reliable in its operation and that is not likely to become broken or get out of order.

Other and further objects and advantages of the invention will appear from the following description, taken in connection with the accompanying drawings, in which:

Fig. 1 is a side elevation of the apparatus shown more or less diagrammatically;

Fig. 2 is a vertical section of the atomizing mechanism and front end portion of the superheater, with parts broken away;

Fig. 3 is a diagrammatic view of the pumping system;

Fig. 4 is an end elevation of the device, with parts broken away and parts omitted for the sake of clearness;

Fig. 5 is a cross-section of the superheater on line 5—5 of Fig. 1;

Fig. 6 is a longitudinal view of one of the conduits in the auxiliary heating device; and

Fig. 7 is a detail view of a portion of the thermostat and valve for controlling the flow of liquid to be evaporated.

In evaporating or desiccating products that are more or less liquid, it has been found that if the liquid product be atomized or finely divided by mechanical means and immediately thereafter the liquid content of the finely divided

particles be substantially instantaneously evaporated by a gyrating current of air at a predetermined temperature and other suitable conditions, a product is obtained that, by the simple addition of the proper amount of moisture, may be restored to substantially its original condition.

Furthermore, when the liquid is treated by such a method, the desiccated solid product or the evaporated residue is so affected, or its physical condition so changed, that the material will retain its natural chemical properties, vitamins, enzymes, color, taste and odor, almost indefinitely. The reason for this remarkable preservation of the characteristic properties of the product is not thoroughly understood but the following is offered as a possible explanation.

Air under atmospheric conditions is usually, in most places, and in fair weather, well below its saturation point but varies within wide limits. Its capacity for absorbing moisture is vastly increased by the application of heat. For instance, a saturated cubic foot of air at a temperature of 10° F. and at a pressure of one atmosphere, will absorb almost twice as much moisture before reaching the saturation point, as the same amount of air at 0° F. temperature and at the same pressure. This ratio does not obtain in higher degrees but its capacity to absorb moisture continues to increase as the temperature increases. In the present invention, the air used for evaporating the moisture from the liquid is taken from the atmosphere and is heated to around 350° F. and even higher. This highly heated air is discharged into the evaporator and caused to flow in a spiral direction. The liquid to be evaporated is atomized and the particles projected into the evaporator chamber and are given a spiral movement in a direction opposite to that of the heated air whereby there is a thorough mixture of the particles and heated air and as a result the evaporation of the moisture in the particles is almost instantaneous.

The vaporizing of the moisture from the particles being almost instantaneous prevents the temperature of those particles from rising to a point that would be injurious to them.

The latent heat of vaporization causes a lowering of the temperature of the heated air. For instance, to evaporate a pound of water after it reaches the boiling point requires the addition of about 1000 B. T. U.'s. The temperature of the water will remain constant during the evaporation and this additional heat absorbed by the steam becomes latent. So in evaporating the moisture from the liquid particles, the vapor or

steam formed absorbs heat units from the air and since a considerable portion of these heat units becomes latent, the result will be an almost instantaneous lowering of the temperature of the heated air within the evaporator to a point where it will not injuriously affect the dry particles. In the meantime, these particles will be carried along by the spirally moving air current and turned over and over as they move along, thus more or less concentrating the fluffy material into individual pellet-like particles, each of which is very small, and, in the case of material like milk, or other material containing more or less sugar, the exposed surface of the sugar of each solid particle is probably slightly fused or melted by the gyrating hot air thus forming a sugar coat or glaze on the exterior, as it were, of almost infinitesimal thickness, enclosing each particle, whereby, the particle is protected against bacteria and is not so easily affected by subsequent weather conditions.

The temperature of the air, together with its rotary movement not only evaporates the moisture from each individual atomized particle but causes a glazed coat to form evenly about each particle.

Any suitable mechanism may be employed for performing this method. In the form of the construction selected to illustrate one embodiment of the invention, which is by way of example only, the reference character 10 designates the apparatus in general which comprises a preheater 11, a superheater mechanism 12, an atomizer 13, a desiccator or evaporator 14, an auxiliary heater, heat exchange device, or water eliminator 15, and a centrifugal air separator 16.

The preheater and superheater may be, and preferably are, mounted within the same casing 17, Fig. 1. The casing 17 is provided at its ends with perforated heads 18 and 19 and with the perforated partitions 21 and 22. Secured in the perforations in the heads 19 and 22 are a series of tubes 23 which constitute passages through which air is conducted from the fan or blower 24 to a chamber 20 between the two heaters. A cone-shaped casing 25 connects the discharge of the blower with the rear end of the casing 17. The preheater casing is provided with an opening 26 in which is secured one end of a conduit 27, the other end of which is connected to the discharge side of a blower or fan 28 of the separator as will presently appear.

The heated air from the separator is conducted along the conduit 27 and delivered into the preheater casing at its forward end for heating the air passing along the tubes 23, from the fan 24, and this air from the separator is discharged through an exhaust conduit at 29 at the rear end of the preheater.

A suitable number of baffles 31 are provided within the preheater casing for causing the air passing through the same from the conduit 27 to take a zig-zag path in order to more effectively impart its heat to the walls of the tubes 23 and from them to the fresh air that is caused by the fan or blower 24 to flow through the tubes 23 for heating this fresh air thereby utilizing the heat of the used air which would otherwise be discharged into the atmosphere. Similar tubes 18 and partitions 21 through which the fresh air discharged from the blower or fan 24 is adapted to pass from the preheater 11.

Suitable means are provided for superheating the air passing through the superheater 12. In

the form of the construction selected to illustrate one embodiment of the invention, the casing of the superheater 13 is provided with an opening 32 and secured in this opening is a casing 33 extending downward therefrom. A suitable burner 34, which is supplied with liquid or gaseous fuel through the pipe 35, is mounted within the casing 33. The casing for the superheater 12 is provided with a plurality of baffles 36 for causing the air passing over or from the burners to take a zig-zag course through the superheater for heating the fresh air passing through the tubes 38. The heated air from the burners is discharged through the discharge conduit 37. The air from the preheater passing through the tubes 38 of the superheater will have its temperature considerably increased. As an example, the air for desiccating milk is preferably heated to approximately 350° F. and may be heated still higher. Air heated to approximately 350° F. gives satisfactory results for desiccating milk. The temperature will depend on the kind of liquid mixture to be evaporated. This heated air passes through the passages 38 into a header 41 under pressure created by the blower 24 and from which it is delivered through a conduit 40 tangentially into an air or pressure chamber 42 surrounding a conical perforated member 43 which in turn forms, what may be termed, a vaporizing chamber 44 at the front end of the desiccating or evaporating chamber 14.

Suitable means are provided for atomizing or finely dividing the liquid preparatory to delivering the same into the vaporizing chamber 44 where it encounters the superheated air for evaporating the moisture as will presently appear.

The mechanism for atomizing or finely dividing the liquid comprises a casing 45, Fig. 2, having a cylindrical portion constituting a motor casing 46 within which is mounted a motor 47, and a circular enlarged portion 48 within which is mounted a blower 49. The blower 49 and the armature or rotor 51 of the motor 47 are rigidly mounted on the hollow shaft 52 which is journaled as at 53 and 54 in the casing 46. The shaft 52 is provided with an axial passage 55 for the liquid and the rear end of this passage communicates with a plurality of radial passages 56 in a cap member 68 on the rear end of the shaft. This cap member extends into a funnel-shaped member 57 which will be termed the atomizing cone. The cap member has a peripheral flange 69 rearwardly of, but adjacent to, the radial openings 56, Fig. 2. Different cap members having bores or openings 56 are provided for different types of liquids, as required.

The motor casing 46 is provided with an air passage 40 extending around the motor and through which air for the intake of the fan passes. The passage of the air around the motor serves to cool the same. The air enters the passage 40 through a port 50. A valve or closure 60 controls the amount of air entering the passage and thereby the amount of air supplied to the blower. The valve or closure 60 is operated by a handle 65 which is resilient and engages teeth in a quadrant 66 for holding the valve in adjusted position.

Mounted to extend over the radial passages 56 and into the vaporizing chamber 44 is a funnel-shaped or atomizing hood or cone 57 having the inner surface of its rear or free end beveled as at 58. Surrounding the atomizing hood or cone 57 is an air nozzle 59 which constitutes a discharge for the blower 49. This nozzle has its for-

ward end flared and rigidly secured to the fan or blower casing 48. The rear end of the air nozzle extends rearwardly about the atomizing cone 57 but is slightly spaced therefrom so as to form a narrow annular air passage 70 about said cone.

A suitable annular shield 62 is mounted in the fan casing and is rigidly connected thereto. This shield is spaced from the rear wall of the blower casing so as to form channels 63 through which air is conducted from the blower 49 into and forced through the annular channel 70 at a high velocity and under a higher pressure than the air in the atomizer chamber 14 to atomize or finely divide the liquid.

The fan or blower 49 is of the conventional type that has an axial intake as at 71 and is provided with a pair of disks 72 and 73 spaced apart by a plurality of curved or spirally arranged vanes 82 which discharge the air radially and cause the same to flow over the partition down the passage 63. A hub 83 on the blower engages the blower intake opening in the casing to form an air seal. Since the detailed construction of the fan or blower 49 is old in the art, it is not thought necessary to further illustrate or describe the same.

Means are provided for utilizing the air supplied to the intake of the blower 49 for cooling the motor. In the form of the construction shown, an air cleaner is provided at 74 through which external air is drawn and is caused to circulate around the motor through a passage 75 and from whence it is delivered through suitable openings 76 in the motor casing to the intake 71 of the blower.

The milk or other liquid that is being desiccated is supplied to the atomizer by the rotary pump 84 which is operated from the shaft 52 by suitable gearing driven by a worm 85 on said shaft. The pump is of the usual construction and need not be described in detail. It is built into the case 45 as a matter of convenience. The pump arrangement is shown diagrammatically in Fig. 3 and comprises the rotors 125 and 126 within the case 127 having an intake 128 and the discharge 78. The milk is stored in a tank 129 from which it is drawn through a strainer 130 into the intake 128.

Suitable means are provided for bypassing a surplus back to the intake 128 when the pressure within the discharge 78 rises above a predetermined amount. As shown, a return passage 131 is provided around the pump. A relief valve 132 is provided in this passage so that when the pressure in the discharge passage 78 rises above a predetermined amount, this valve will open and permit the liquid to return to the pump intake passage 128.

In practice, the pump and bypass are built in the pump casing 127 but are shown diagrammatically in Fig. 3 as being separate for purposes of illustration.

Appropriate means are provided for controlling the amount of liquid supplied to the atomizer by the pump. In the form of the device shown, both manually operated and thermally controlled means are provided for this purpose. As illustrated, a casing 86 is secured at the front of the casing 45 which is provided with a cavity 87 extending axially of the shaft 52 and surrounds the forward end thereof. This cavity is provided with a packing gland 88 extending about the shaft to form a liquid-tight joint. A spring 89 operating against the cap 90 holds this gland compressed.

The casing 86 is provided with a projection 91 having a passage 92 therein. The passage 92 is provided with a manually operated valve 93 provided with a transverse aperture which may be turned in alinement with the passage 92, transversely thereof, or at an angle thereto for controlling the amount of liquid flowing through said passage.

In desiccating liquids having various amounts of solid matter the amount of heat required to evaporate a given amount of liquid will vary considerably depending on the moisture content to be evaporated. For instance, a liquid with a low solid content, or rather with a high moisture content, requires more heat than that containing a lower percentage of moisture because of the very much larger amount of latent heat that will be contained in the evaporated moisture. The greater the moisture content in the liquid, the lower will be the temperature of the air passing from the separator. But the temperature of the air within the separator must not fall below the capacity of the air to retain the moisture as otherwise the powder or desiccated product will be affected by the moisture.

In order to control the temperature of the air passing through the separator and insure against its falling below its saturation point, suitable thermostatically controlled means are provided for automatically regulating the amount of liquid supplied to the system. In the form of the construction shown, this is accomplished by a thermostat 121 located in the return passage 27 which is adapted to control the operation of a valve 122, Fig. 7, in the liquid supply or pump discharge passage 78. When the temperature of the air in the passage 27 rises above a predetermined amount, the heat will volatilize more of the volatile liquid in the thermostat 121 and the pressure of this fluid will expand the metal bellows 124 which in turn will open the valve 122 attached thereto and will close the valve when the temperature is lowered. The thermostat 121 may be of any approved construction. That shown is the fluid type but other types may be used, if desired.

The end wall 97 of the desiccator 14 is provided with a plurality of openings 98, Fig. 2, radially outwardly beyond the conical perforated member 43 and suitable shields 99 are extended over these openings to form the upper portion of an air channel 101. The inner portion of this channel is formed by a conical casing auxiliary nozzle 102 having a radially extending base 103 rigidly secured to the end wall 97 of the desiccator. The rear portion of the conical member or auxiliary nozzle extends about, and is spaced from, the air nozzle 59 to form the lower portion of the air channel 101. As a combined result of the aspirating effect of the air passing through the channel 70 and the pressure of the air within the air chamber 42, heated air directly from the passage 40 will pass from the air chamber 42 through the opening 98 and passage 101 causing the same to impinge on the finely divided liquid for instantaneously evaporating the moisture from the finely divided particles, as will presently appear.

In the operation of the device, the milk or other liquid contained in the supply tank 129 is supplied through a conduit 96, Fig. 3, and the liquid passes through the strainer 130 into the pump 84. From the pump the liquid is pumped through the valves 124 and 93 into the chamber 87 from whence it is forced along the axial passage 55 and through the openings 56. Due to the

fact that the shaft is rotating at a high speed, the milk or other liquids, being delivered radially through the openings 56 will be directed by the disk 69 onto the hood or atomizing cone 57. Since this atomizing cone is flared outwardly, extends rearwardly beyond the nozzles 59 and 102, and is rotating at high speed, the liquid will flow outwardly along the interior of the cup in a thin film and be discharged radially therefrom due to centrifugal action. Due to inertia, they will continue to move in the direction of rotation of the shaft 52. It will be broken into spray by the high velocity air emerging from the passage 70 at right angles to the radial movement of these particles to assume a more or less cone shape. A current of heated air from the auxiliary nozzle 118, caused by the pressure in the chamber 42 and by the aspirating effect of the high velocity air flowing through the nozzle 59, will flow across the rotating mass of liquid particles and air thus thoroughly mixing the air and particles and projecting the same into the stream of spirally moving hot air where the moisture is almost instantaneously evaporated.

As the air from the superheater and conduit 40 revolves about the cone member 43, the pressure will cause the air to pass through the openings 104 in said conical member and this air will continue to gyrate as it advances through the evaporator. This air, being at a high temperature and rotating in a direction contra to that of the liquid particles, insures thorough mixing of those particles with the hot air with a consequent extremely rapid evaporation of the moisture from the particles, leaving the solid content in the form of finely divided dry material which is carried along in the gyrating current of air. The latent heat of the moisture absorbed by the air in the evaporator will very greatly lower the temperature of the air and some of the particles may not have all moisture removed therefrom in the main portion of the evaporator.

It is difficult to get perfect evaporation, and none of the particles may pass through the evaporator without having all their moisture removed, as for instance, where a particle has been partially insulated by an envelope of steam surrounding the same. In order to insure complete evaporation or desiccation of the particles, the mixture of particles and air is caused to flow through the water eliminator 15. In flowing through the eliminator 15, the direction of the air flow is abruptly changed one or more times, thus causing the relatively heavy particles to impinge on or strike the heated walls of the eliminator thereby vaporizing the moisture remaining in the particles. The eliminator also raises the temperature of the mixture stream somewhat and insures that all the particles entering the separator are bone dry.

The auxiliary heater or water eliminator 15 may comprise an integral portion of the rear end of the desiccator. It comprises a cylindrical casing 105 having the end walls 106 and 107 which are perforated and have a plurality of tubes 108 secured in the perforations through which the mixture of air and particles passes on its path to the separator. The surfaces of the tubes may be corrugated as shown at 109 in Fig. 6. The corrugations cause the particles to take a zig-zag course through the tubes and consequently the particles will be caused to come into contact with the heated walls of the tubes which will vaporize the moisture that may be associated with the particles. The tubes are heated by a shunt passage

111, which conducts heated air from the pressure chamber 42 to the rear end of the auxiliary heater 15 and is discharged through a conduit 112 from the forward end of the auxiliary heater into the discharge air passage 27 from the air separator. A valve 100 in the conduit 112 controls the amount of heated air delivered to the auxiliary heater.

The milk powder laden air passes from the auxiliary heater into the air separator 16 through the conduit 113 where the milk powder is deposited and gravitates downwardly to the discharge opening 114 of the separator. Since the air separator is of the usual or any well known construction of centrifugal separators, it is not thought necessary to describe the same in detail any further than to state that the passage or conduit 113 delivers the air tangentially into the air separator as is usual in such constructions. The air passes tangentially from the separator through the conduit 27 into the preheater as described above. The entrance and discharge openings of the separator are tangential and so arranged as to cause the air to flow in one direction in the separator, which, in the construction shown, is right-handed when viewed from above.

Suitable means are provided for controlling the temperature of the superheated air. As shown, a thermostat 115 is mounted in the pressure chamber 42 and this thermostat is adapted to operate a control 116 which in turn controls the opening of a valve 117 in the pipe 118 which supplies fuel to the burners 34. Since the control 116 and valve 117 are similar to that shown in Fig. 7, the description need not be repeated.

While the thermostats disclosed are of the volatile liquid-metal bellows type, it is understood that any suitable type may be employed as those illustrated are by way of example only.

While the apparatus shown is for desiccating milk, it is understood that the apparatus may be used, with slight modification, for concentrating a liquid by evaporation. When used as a liquid condenser, the air separator 16 is replaced by a liquid separator for separating the concentrated liquid particles from the air. By varying the ranges of the various controls, any degree of evaporation or concentration of the liquid may be obtained.

The temperature of the air as well as the proportionate amount of air and liquid employed in either concentration of the liquid mixture or in its desiccation will vary considerably depending on the liquid treated and the amount of concentration desired.

The term "evaporation" is used in this application as a generic term for removing a part or all the moisture from the finely divided particles.

It is thought from the foregoing taken in connection with the accompanying drawings that the construction and operation of my device will be apparent to those skilled in the art, and that changes in size, shape, proportion and details of construction may be made without departing from the spirit and scope of the appended claims.

I claim as my invention:

1. A system of desiccating milk which comprises reducing the milk in fine particles, evaporating moisture from the individual particles, and finally subjecting the desiccated particles to a fresh current of heated air for partially fusing the exterior surface of each particle to provide a protective coat or case for the same.

2. A method of milk preparation which comprises breaking the milk up into fine particles, 75

treating the particles with a gyrating current of air heated to such a temperature as to evaporate the moisture from the particles and adding additional heat units to the mixture of air and said particles for forming a coat about each particle, and then separating the particles from the air.

3. A continuous method of separating the solid content of a liquid product from the moisture content by atomizing a stream of liquid product and simultaneously subjecting the atomized liquid product to a blast of air of such temperature as to substantially instantaneously vaporize the major liquid content of the product and then additionally heating the mixture of air and solid content and promptly thereafter separating the solid content from the air by centrifugal action.

4. A method of desiccating a liquid product in a continuous operation which comprises reducing the liquid product to finely divided particles, projecting those particles into a current of air at a temperature materially above the boiling point of water for dehydrating said product, maintaining the mixture of said air and dehydrated particles above the condensation point of the moisture in said air, then elevating the temperature of the mixture, and promptly thereafter separating the solid particles from said heated air by centrifugal action.

5. A method of desiccating milk in a continuous operation which comprises reducing the milk to finely divided particles, projecting said particles into a current of air rotating about a horizontal axis at a temperature of from 350° F. to 400° F. for evaporating moisture from said particles and forming pellets of said particles and immediately thereafter treating the mixture of air and particles with heated air, and promptly thereafter separating the air from said pellets.

6. A method of evaporating a liquid mixture in a continuous operation which comprises dividing the mixture into finely divided particles, discharging the particles into a heated gyrating air current for evaporating moisture from said particles, reheating the particles by the aid of air at substantially the same temperature as that originally of the gyrating current, and immediately thereafter separating said particles from the air current.

7. A method of evaporating a liquid product in a continuous operation which comprises reducing said product to finely divided particles, discharging said particles spirally into a current of heated air flowing spirally in the opposite direction about a horizontal axis for evaporating the moisture from said product, causing the mixture of air and particles to pass through a heat exchange device for heating the mixture of air and dehydrated particles well above the saturation point of said air, and then separating the particles from the moving air by causing the material laden air to rotate about a vertical axis in a closed space and finally exhausting the air axially of the whirling mass.

8. A method of dehydrating and collecting liquid products in a continuous operation which comprises atomizing the product, discharging the atomized product into a stream of heated air, promptly thereafter causing the mixture of air and atomized particles to pass spirally through a chamber having a multiplicity of passages of a higher temperature than said mixture, and immediately thereafter separating the dehydrated particles from said air by centrifugal action.

9. A method of dehydrating a liquid product in a continuous operation which comprises reducing the product to finely divided particles and projecting the particles into a rotating body of heated air for dehydrating particles of said product, reheating the mixture of air and particles for elevating the temperature thereof, then separating the air from the particles, and finally using said last-named air for heating fresh air for repeating the dehydrating process.

10. A method of dehydrating liquid products in a continuous operation which comprises reducing the product to fine particles and discharging the same in a spray, heating air and discharging a portion of said air across said spray for dehydrating said particles, further heating the mixture of air and dehydrated particles by heat from the remaining portion of said air, and utilizing the last-named portion of air for preheating fresh air used in the dehydration of other of said particles.

11. A method of dehydrating liquid products in a continuous operation which comprises reducing the product to fine particles and discharging the same in a spray, heating air and discharging a portion of said air across said spray for dehydrating said particles, heating the mixture of air and dehydrated particles by heat from the remaining portion of said air, separating the dehydrated particles from the first-named portion of air, and utilizing both portions of air for heating fresh air used in dehydrating additional particles.

12. A method of dehydrating liquid products in a continuous operation which comprises atomizing the products and projecting the same into a stream of heated air, then additionally heating the mixture of air and atomized particles, separating the dehydrated products from the air, and controlling the amount of liquid product atomized by the temperature of the air after it has been separated from the dehydrated particles.

13. A method of dehydrating liquid products in a continuous operation which comprises reducing liquid milk products to finely divided particles, discharging a current of heated air across the finely divided particles, maintaining said air during its discharge at a predetermined temperature, promptly thereafter heating the mixture of air and finely divided products, separating the dehydrated particles from the air, and automatically controlling the amount of liquid being treated.

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