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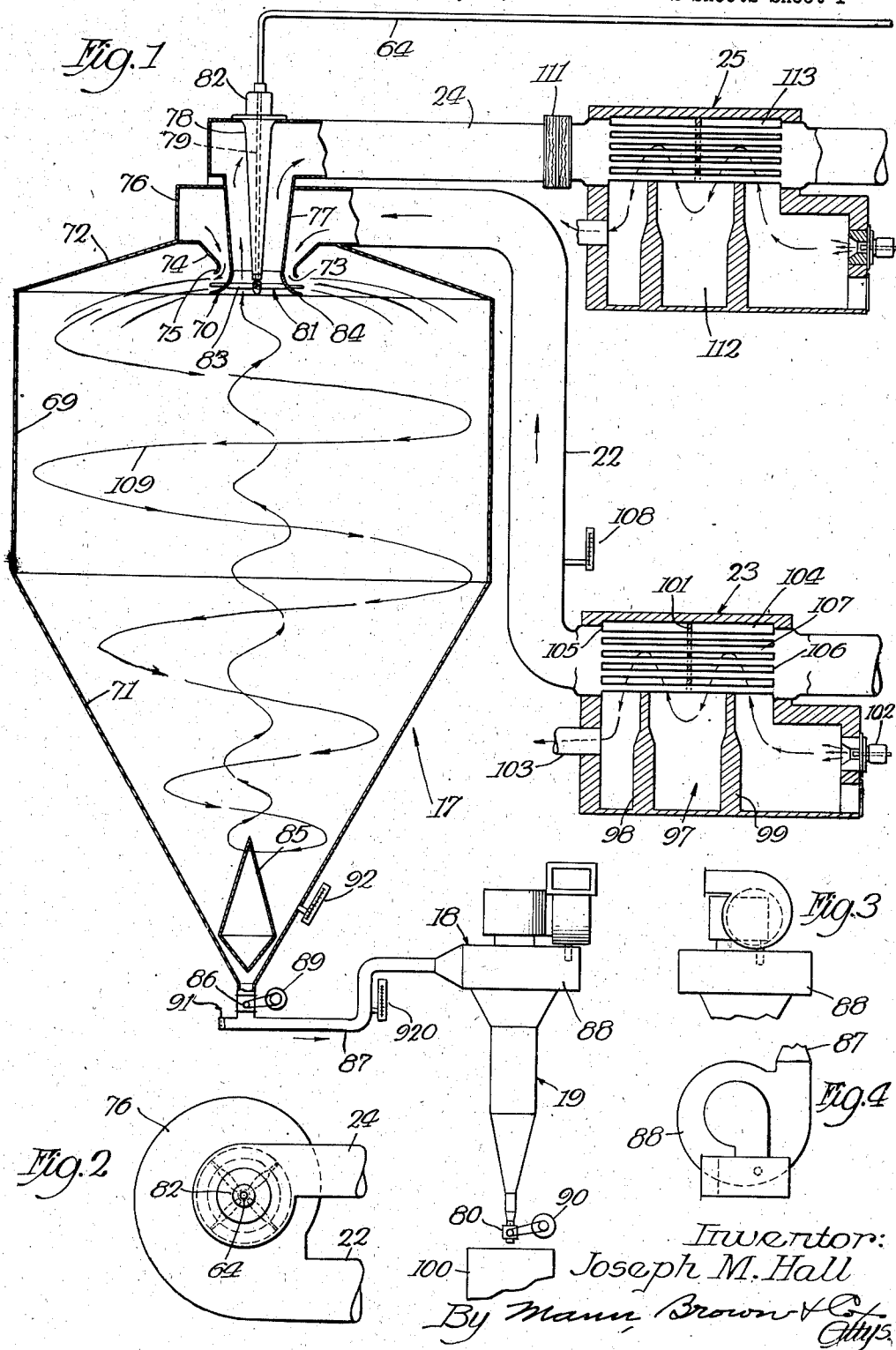
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METHOD AND APPARATUS FOR DEHYDRATING LIQUID PRODUCTS

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METHOD AND APPARATUS FOR DEHYDRATING LIQUID PRODUCTS

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6 Claims. (Cl. 159—4)

This invention relates to concentration and dehydration of liquid products.

One of the objects of the invention is the provision of a new and improved concentrating and dehydrating apparatus having novel means for desiccating liquid products of various types.

Another object of the invention is the provision of a new and improved system for concentrating and dehydrating liquid products that employs a minimum number of vacuum pans or chambers.

A further object of the invention is the provision of a new and improved method and apparatus for concentrating and dehydrating liquid products on a large production scale in a continuous process.

A still further object of the invention is the provision of a new and improved apparatus for concentrating and desiccating liquid products having a minimum number of parts and those parts so constructed that they may be washed or cleansed with a minimum of labor and expense.

Another object of the invention is the provision of a new and improved apparatus for concentrating and desiccating liquid products that is inexpensive to manufacture, simple in construction, easily assembled, that may be operated at a minimum of expense, and one that employs air as the dehydrating medium.

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

Figs. 1 and 1a, taken together, show a side elevation of the apparatus shown diagrammatically and with parts in section and parts broken away;

Fig. 2 is a top plan view of the upper portion of the dehydrator or desiccator;

Fig. 3 is a side elevation of the dryer and air separator taken 90° from that shown in Fig. 1;

Fig. 4 is a top plan view of Fig. 3;

Fig. 5 is a top plan view of the upper portion of the evaporator; and

Fig. 6 is a perspective view of a portion of the fan and associated parts, with parts broken away.

In order to disclose one embodiment of the invention, the structure will be described as an apparatus for, and system of, evaporating and desiccating milk and like products. It is understood, however, that this is by way of example only and that the system or apparatus may be

used for concentrating other liquid products that may be subjected to a similar treatment.

In the treatment of milk and other food products, it is necessary, and is the custom at the present time with most of the larger producers, to thoroughly clean and sterilize each portion of the apparatus that contacts the milk at least once each 24 hours in order to insure against contamination and the growth of injurious bacteria. One of the principal objects of the present invention is the construction of an apparatus that may be easily, quickly and inexpensively cleaned. By employing large evaporating chambers of the centrifugal separator type instead of the tubular vacuum chambers usually employed, the cleaning operation is immensely simplified and the parts readily and easily cleansed.

In the apparatus herein disclosed, the liquid product to be treated is moved in one direction through the apparatus and the evaporating or dehydrating fluid is moved through the apparatus in a closed circuit in the opposite direction.

Referring now to the drawings, Figs. 1 and 1a, taken together show, more or less diagrammatically, one embodiment of the invention. The entire evaporating and desiccating apparatus is designated by the reference character 10 and the apparatus for handling the liquid product comprises a reservoir 11 for containing the liquid product to be dehydrated, a vacuum pan or chamber 12, a separator 13, a vacuum pump 14 and a condenser 15 for partially evaporating the moisture from the liquid. This apparatus also comprises an evaporator chamber 16 for concentrating the product, a desiccator chamber 17 for dehydrating or desiccating the product and a cooler 18 and air separator 19 for cooling and collecting the powder.

The heating medium or fluid is air and the mechanism for handling the air comprises an air conduit 20, a fan or blower 21 and an air conduit 22 within which is located the furnace or heater 23. The conduit 22 delivers heated air into the dehydrating or desiccating chamber 17. The mechanism also comprises a return conduit 24 and a furnace or heater 25 for heating the air in the conduit 24. The conduit 24 delivers the heated air into the evaporating chamber 16. An air passage 27 conducts the air from the evaporating chamber 16 to the vacuum chamber or pan 12 for concentrating the liquid milk discharged therein, as will presently appear.

The vacuum pan or chamber 12 comprises an upright elongated chamber or casing 27 having a partition 28 in its upper end and a partition 29

in its lower end forming the headers 31 and 32, respectively. Suitable tubes 33 have their upper and lower ends rigidly secured in the partitions 28 and 29. These tubular members are in communication with the headers 31 and 32 and milk or other liquid product from the reservoir 11 is adapted to fill the lower header 32 and partially fill the tubes 33. A pipe 30 between the reservoir and the vacuum chamber conducts the liquid product to the vacuum pan or chamber 12 and a valve 30a controls the flow of the liquid product. The level of the liquid products in the tubes may be above that in the reservoir 11 because of the partial vacuum in the header 31 and tubes 33. The liquid will be caused to rise therein by atmospheric pressure. The header 31 is in communication with the separator 13 through a conduit 34 and a deflector 35 is provided on the inner end of the conduit 34 for directing the liquid product carried over from the vacuum chamber by the vapor generated therein downwardly into the lower portion of the separator 13. A suitable gauge 36 may be mounted on the conduit 34 for indicating the pressure in the conduit, header and separator. The outer casing 27 of the vacuum chamber 12 forms a jacket about the tubes 33 and this casing is in communication with an air passage or conduit 37 which conducts heated air from the evaporator 16, as will presently appear.

The separator 13 comprises an upper enlarged section 38 and a lower reduced section 39, the lower portion of which contains more or less of the liquid product. The upper section 38 has an extension to which a tube 41 is attached and this tube is in communication with the jacket of the steam condenser 15 which in turn is in communication with the vacuum pump 14 through a passage 42. The condenser 15 has a coil 43 therein for conducting cool water to and from the condenser for condensing the vapor that is withdrawn from the liquid product while in the vacuum pan or chamber 12 and separator 13. The water condensed may be discharged from the vacuum pumps into the waste or it may be utilized in other portions of the plant.

The header 32 is provided with an outlet passage 44 which is also in communication with the lower section 39 of the separator by a conduit 45. The heated air entering the jacket of the vacuum chamber 12 through the passage 37 will impart its heat to the milk contained in the tubes 33 and since the milk in the tubes is under a partial vacuum, the milk will be boiled and the moisture, in the form of vapor, withdrawn by the vacuum pump 14. The evaporation of the moisture in the milk will in turn reduce the temperature of the air in the jacket 27 below its saturation point. As a consequence, a certain amount of the moisture in the air will be precipitated and the liquid may pass outward through the tube 46 either as a waste or it may be utilized for other purposes about the plant.

The milk or liquid product in the passage 44 is transferred by the pump 47 to a spray head 48 in the evaporator 16 through the pipe 40. The spray head 48, Figs. 1a and 6, is suspended by a spindle 49 axially of the evaporator chamber 16. The spindle 49 is provided with suitable journals and is adapted to be rotated in any conventional manner as by means of the motor 51. The armature shaft of the motor constitutes a spindle which is surrounded by a tapered cone-shaped shield 52 that positions the same. The spindle 49 is hollow and is adapted to convey the liquid

product to the spray head 48 from the pipe 40. The spray head 48 comprises a plurality of arms 53 which extend radially outwardly in a substantially horizontal plane. These arms are hollow and have nozzle openings 54 which discharge the liquid product outwardly in a spray as the arms rotate. These arms extend through a deflector 55 which is located directly beneath a tapered air conduit 56 which is in communication with the air passage 37, as will presently appear.

The deflector 55 is flared at its lower end and has its side curved in cross-section so as to deflect the air entering through the air conduit 24 downwardly and outwardly, as will presently appear.

The evaporator 16 is in the form of a cyclone separator having an enlarged cylindrical body portion 57, a lower conical portion 58 and a top or upper, somewhat conical, portion 59. The upper portion 59 has a depending downwardly tapered portion or extension 61 extending about the spindle 49 which is in the axis of the evaporator. The lower ends of the tapered portion 61 is curved downwardly and outwardly as at 62 to form with the curved portion of the member 55 a passage for directing the air downwardly and outwardly within the evaporator across the nozzles 54.

The conduit 24 extends from the dehydrator 17 through the heater 25 to a point above the evaporator 16 and terminates in a snail 63 above the downwardly extending portion 61 in order that air passing through the conduit 24 and through the snail 63 will be given a rotary movement so that it will enter the evaporator in a rotating spiral form. A thermometer 66 is provided for indicating the temperature of the air in the lower portion of the evaporator.

Suitable means are provided for withdrawing the air axially from the evaporator. In the form of the construction shown, the spray head 48 is so constructed that it forms an exhaust fan for this purpose. As shown in Fig. 6, the arms 53 are made in the form of fan blades so that they will exhaust the air from the evaporator and discharge the same into the passage 37.

It will thus be seen that the liquid product, after it has had part of its moisture removed in the vacuum pan or chamber 12, is supplied through the passages 44 and 40 to the spray head 48 which discharges the same in a spray into the rotating column of air supplied through the conduit 24 and since this air has been heated by the heater 25, a considerable portion of the moisture will be evaporated and the air removed from the evaporator will be conducted over to the vacuum chamber 12 for heating the liquid product contained therein, as described above. The concentrate collected in the bottom of the evaporator 16 is withdrawn through a conduit 64 by means of the pump 65 and is delivered to the dessicator 17.

The dehydrator or desiccator 17 is similar in construction to the evaporator 16 and comprises an upper cylindrical section 69, a lower tapered section 71 and an upper or dome-like section 72 which has an axial opening 73 therein. The dome section 72 has a depending conical member 74 which tapers downwardly and is flared outwardly at its lower end as at 75. The conduit 22 for conducting heated air to the dehydrator is provided with a snail 76 which is attached to the upper section 72 and extends about the opening 73 so that air passing along the conduit 22

will be caused to rotate and move downwardly through the opening 73.

Suitable means are provided for conducting the air delivered by the conduit 22 from the dehydrating chamber 17 axially thereof. The conduit 24 through which the air is exhausted is provided at its outer end with a downwardly extending tapered section 77 which extends through the snail 76 and terminates adjacent to the curved portion 75 of the air deflector 74. Secured to, and depending downwardly from, the upper wall of the conduit 24, axially of the opening 73, is a tapered shield 78 and the spindle 79 of a spray head 81 extends axially through the shield 78. This spindle is adapted to be rotated by a motor 82 mounted above the spindle. The spray head 81 is similar to the spray head 48 and is provided with a plurality of arms 83 that are attached to the spindle 79 and have longitudinal passages therethrough in communication with an axial passage in the spindle 79 so that the liquid product passing along the pipe 64 from the evaporator 16 will pass downwardly through the spindle 79 and be discharged in a spray through the arms 83. The arms 83 pass outwardly through a deflector 70 which has its outer surface curved downwardly and outwardly as shown at 84 for directing air entering from the conduit 22 outwardly across the nozzles for dehydrating the liquid product discharged by said nozzles. In order to exhaust the air from the dehydrator, the arms 83 are in the form of fan blades as shown at 53 in Fig. 6.

Since the spray head arrangement is substantially the same as that shown in Fig. 1a, it is not thought necessary to further illustrate or describe the same.

The fan blades or arms 83 exhaust the air from the dehydrator 17 and discharge the same upwardly through the tapered member 77 into the conduit 24. The air entering through the conduit 22 is of such temperature that the particles of the liquid product are dehydrated and due to the centrifugal action of the mass within the dehydrator chamber, the air is separated from the dehydrated particles and is withdrawn by the fan 83 as described above.

In order to reduce turbulence in the lower portion of the dehydrator 17, a double cone-shaped member 85 is mounted therein so that the rotating air, as it descends, will rotate about the upper portion of the double cone thereby throwing the solid particles out against the walls of the dehydrator which will slide down the inclination of these walls. These particles will slide downwardly and be discharged by a power operated valve 86 into a passage 87 leading to a snail 88 of a combined cooler and centrifugal air separator 18, 19. The valve 86 is of the usual power operated type and is adapted to be operated by a suitable motor 89. The outer end of the passage 87 is closed by a valve 91 which is adapted to be opened or partially opened to introduce fresh air for cooling the product down to storage temperature, which in the case of milk powder may be around 100° F. The powder may be removed through power operated valve 88 operated by motor 90 which permits the powder to fall by gravity into the container 100. This air is utilized for conveying the mixture of air and dehydrated material to the separator 19 and for cooling the material. A thermometer 92 attached to the dehydrator 17 is employed for indicating the temperature of the air therein and a ther-

mometer 920 indicates the temperature of the air in the passage 87.

Air is used as the heating medium and it is circulated in a closed system. The mechanism for circulating the air and its path of movement will now be described.

Starting with the fan 21, the air is drawn into the fan 21 through the air conduit 20 which is in communication with the jacket of the vacuum chamber or pan 12. An air intake valve 93 is provided in the air conduit 20 for admitting fresh air as occasion may be required. A barometer 94 is provided for determining the pressure of the air in the conduit 20 and a thermometer 95 indicates the temperature of the air passing along said conduit. The fan 21 is of the usual type and is operated by a motor 96. The fan discharges the air into the conduit 22 and causes the same to flow along the conduit into the heater 23.

The heater 23 is of the usual or any well known construction and comprises a combustion chamber 97 which is provided with baffles 98 and 99 extending upwardly from the bottom wall of the heater and a baffle 101 which extends down from the top wall thereof in a plane substantially midway between the baffles 98 and 99. The chamber 97 is provided at one end with a fuel feeding device 102 which supplies fuel such as oil or gas to the combustion chamber and the products of combustion are discharged from the chamber through a pipe 103 at opposite ends of the chamber.

A heating chamber 104 is mounted above the combustion chamber and this heating chamber comprises the perforated heads 105 and 106 in the perforations of which are secured flues or tubes 107 heated by the gases of combustion. The air from the fan 21 passes through these tubes and is heated as it passes through the same.

The air passing through the superheater is discharged into the outer end of the pipe 22 and into the snail 76. A thermometer 108 is provided in the conduit section 22 for indicating the temperature of the air passing from the furnace or heater 23. The air passing around the snail 76 is given a rotary movement and passes downwardly through the opening 73 across the nozzles of the arms 83 for dehydrating the spray of the liquid product discharged by those nozzles.

The concave surface of the shield or deflector 78 directs the air outwardly toward the periphery of the dehydrator and the centrifugal movement of this column of air throws the dehydrated particles of the product outwardly against the interior wall of the dehydrator and these particles slide downwardly into the lower portion of the dehydrator and are removed through the valve 86 as previously described.

The incoming air rotates in a wide spiral as indicated by the arrows 109 about the vertical axis of the dehydrator and this spiral gradually narrows toward the lower portion of the dehydrator and rotating about the upper section of the cone 85 in a small spiral moves upwardly in a spiral of small diameter and is exhausted by the fan formed by the header 81 and is discharged through the shield section 77 into the return conduit 24 through a filter 111 which is adapted to remove any of the solid particles carried along with the air.

The air, in dehydrating the liquid products, has its temperature greatly reduced and before this air is introduced into the evaporator 16 for

concentrating the liquid product, it is passed through the heater 25 for increasing its temperature. The heater 25 is similar in construction to the heater 23 and comprises the combustion chamber 112 above which is located the heating chamber 113 as in the previous constructions. Since the construction of the heater is substantially the same as that of the heater 23, it is not thought necessary to further describe the same.

The air from the heater passes into the forward section of the conduit 24 into the evaporator 16. A thermometer 114, secured in the wall of the conduit 24, indicates the temperature of the air as it passes from the heater 25. The air passes into a snail 63 which causes the air to rotate and as it rotates, it passes downwardly across the nozzles 54 in the spray head 48. As the heated air passes downwardly and outwardly into the evaporator chamber 16, in a wide spiral, it comes in contact with the finely divided particles of the liquid product discharged by the nozzles 54 and evaporates a considerable portion of the moisture contained in these particles. The concentrated liquid will flow down to the bottom of the evaporator and be removed by the pump 65 as described above. The temperature of the air will be greatly reduced in the evaporator 16 due to its imparting heat to the liquid particles in concentrating the liquid.

The air will be withdrawn by the header 48 which functions as a fan and is discharged into the air passage 37 at greatly reduced temperature. This air passes along the passage 37 into the jacket of the vacuum chamber or pan 12 and passes among the tubes 33 heating the same for evaporating the fresh liquid product supplied to the evaporator from the container or reservoir 11. The air, after passing through the vacuum chamber has its temperature still further reduced and moisture removed therefrom by condensation. It is discharged into the air conduit 20 which completes the circuit.

In order that the system shall operate economically, it is desirable that the air be recirculated and the temperatures maintained in the different parts of the system be substantially constant. It is also necessary, in order to operate efficiently, that there be a substantially constant relation between the amount of liquid treated and the temperature of the air in the various parts of the system in treating any particular product. It has been found that the following, which is given by way of example only, gives satisfactory results for dehydrating or desiccating skim milk.

In a plant having a capacity of fifteen pounds of milk powder per minute and in which the evaporator chamber is probably fifteen feet in greatest diameter and ten feet high and the dehydrator chamber is probably seventeen feet in greatest diameter and probably eighteen feet high, the following operating conditions were observed:

The air enters the fan 21 at substantially 125° F. and 8500 cubic feet of air per minute is passed through the fan. The air passes from the superheater at a temperature of 400° F. and after it passes through the dehydrator 17 into the conduit 24, its temperature is around 200° F. While in the dehydrator, it has evaporated about thirty pounds of water in producing fifteen pounds of powder. With that additional amount of moisture in such a volume of air, the saturation point of the air would be around 140° so that the air that is being discharged at 200° is above the saturation point. In passing through the super-

heater 25, the temperature of the air is raised to 540° F. and is discharged into the evaporating chamber 16 at that temperature. In the evaporating chamber, somewhere about 62.5 lbs. of water is evaporated per minute. The air leaving the evaporator chamber is around 160° F. and is saturated at that temperature. This saturated air passes into the vacuum pan or chamber 12 for boiling the liquid product introduced therein from the supply reservoir. A partial vacuum of around 27.5 inches is maintained in this vacuum chamber which results in a boiling of the liquid at around 115° F. with a consequent condensation of the moisture from the air. This absorption of heat by the liquid reduces the temperature of the air passing through the vacuum pan to around 130° F. with a consequent condensation of the moisture therein and the fresh air introduced through the valve 93 will further reduce the temperature to around 125° F. The amount of liquid supplied to the vacuum chamber or pan is around 170 lbs. skimmed milk per minute and the amount of moisture evaporated from this milk in the vacuum chamber is around 62.5 lbs. per minute. In evaporating this amount of water from the milk, about 92.5 lbs. of moisture is condensed and removed from this air thus reducing its temperature to around 130° F.

While the above data is given in more or less detail, it is understood that the same is by way of example only and that the invention may vary within wide limits and that the scope of the invention is not to be limited beyond the terms of the claims appended hereto.

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 that changes in size, shape, proportion and details may be made without departing from the spirit and scope of the appended claims.

I claim as my invention:

1. An apparatus for dehydrating milk and other liquid products comprising a desiccating chamber, an evaporating chamber, a vacuum pan having heat exchange surfaces, a conduit for conducting air from the vacuum pan to said desiccating chamber, a second conduit for conducting air from said desiccator to said evaporating chamber, a passage for conducting air from said evaporating chamber to said vacuum pan and across said heat exchange surfaces, heating means heating the air flowing in said conduits, through said chambers and across said heat exchange surfaces, means for discharging said air into said chambers in a rotary movement, means for causing said product to pass through said pan and chambers in a direction counter to the movement of the air through the same, means for spraying the product into said air within said chamber, and means for cooling the desiccated product.

2. In an apparatus for desiccating liquid products, a plurality of centrifugal air separators, means for circulating a stream of air through said separators in a predetermined order in series, means for conducting a liquid product to said separators and for spraying said product into said separators in series in the reverse order, means for heating the air to a predetermined high temperature just prior to its introduction into one of said separators for desiccating the product, means for heating the air discharged from said one separator to a temperature far

above that in said one separator just prior to its introduction into another of said separators for removing moisture from said sprayed product for concentrating the product, and means for preheating said product and removing moisture from said air preparatory to reusing the air in the apparatus, said last-named means comprising a vacuum chamber through which the air discharged from said last-named separator is conducted, a reservoir for the fresh liquid product, and means for conducting said fresh liquid product to said vacuum chamber from said reservoir and for conducting the same from said reservoir to said second-named means.

3. In a system of dehydrating a liquid product, a vacuum chamber in the form of a heat exchanger, an enlarged evaporating chamber, a dehydrating chamber, means for conveying a liquid product first to said vacuum chamber, then to said evaporating chamber and then to said dehydrating chamber, a rotary spray for said evaporator and said dehydrator, respectively, for spraying said liquid product in said evaporator and dehydrator, means for circulating the same air in a closed circuit through said chambers without replenishing the air supply, first to said vacuum chamber and then to said dehydrating chamber and then to said evaporating chamber, means for heating the air during its passage between the evaporating and dehydrating chambers to a predetermined temperature, means for heating the air in its passage from the dehydrating chamber to the evaporating chamber to a temperature above said predetermined temperature, means for discharging said air across said sprays for evaporating moisture from the sprayed particles, and means for conducting said air through said vacuum chamber in heat exchange relation to the fresh liquid product in said vacuum chamber.

4. A method of concentrating and desiccating a liquid product in a gaseous drying medium moving in a closed circuit which comprises passing all of said medium through a heater, then causing the same to move spirally downwardly into and upwardly out of a dehydrating chamber, again heating said medium but to a high temperature above that of the first heating and causing the same to flow spirally downwardly into and upwardly out of an evaporating chamber, then conducting all of said medium discharged from said evaporating chamber through a preconcentrator and back to the point of beginning in a closed circuit, simultaneously conducting a fresh liquid product through said preconcentrator in heat exchange relation with said medium for preconcentration of said product, then spraying the concentrate from said preconcentrator into said

downwardly moving spiral only of said medium in said evaporating chamber for still further concentrating said product and then conducting the liquid concentrate from said evaporating chamber to said dehydrating chamber and spraying the same into the downwardly moving spiral only of said drying medium in said dehydrating chamber, and finally removing the desiccated material from said dehydrating chamber.

5. A method of desiccating a liquid product in a continuous operation which comprises circulating the same stream of air continuously in a closed circuit through a third, a second and a first space in series in the order named, concentrating a liquid product by first bringing the same into heat exchange relation with said stream of air in said first space while said product is under subatmospheric pressure, then spraying the concentrate into said stream of air within said second space, then spraying the concentrate from the second space into the stream of air in said third space, causing said stream of air to move spirally within said third and then said second space at high velocity, and heating said stream of air just prior to each spraying process, the heating of said air being much greater immediately prior to the spraying operation in the second space than prior to the spraying operation in the third space.

6. A method of evaporating and dehydrating a liquid product which comprises heating a current of air to a temperature around 400° F., causing the same to flow in a spiral form in a closed dehydrating chamber, conducting the air from said chamber, heating the same to around 540° F. and discharging the heated air into an evaporating chamber, causing the air to rotate in said evaporating chamber, conducting said air from the evaporating chamber through a heat exchanger chamber for reducing the temperature and moisture content thereof, recycling the air through said dehydrating chamber, said evaporating chamber and through said heat exchanger chamber, in series, in the order named, causing a liquid product to flow through said heat exchanger chamber in heat exchange relation with said air passing therethrough for concentration, conducting the concentrate of said product from said last-named chamber to said evaporating chamber and spraying the same into the spirally moving air therein, conducting the concentrate to said dehydrating chamber and spraying the same into the spirally moving air therein, and finally collecting the dehydrated material.

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