

July 21, 1942.

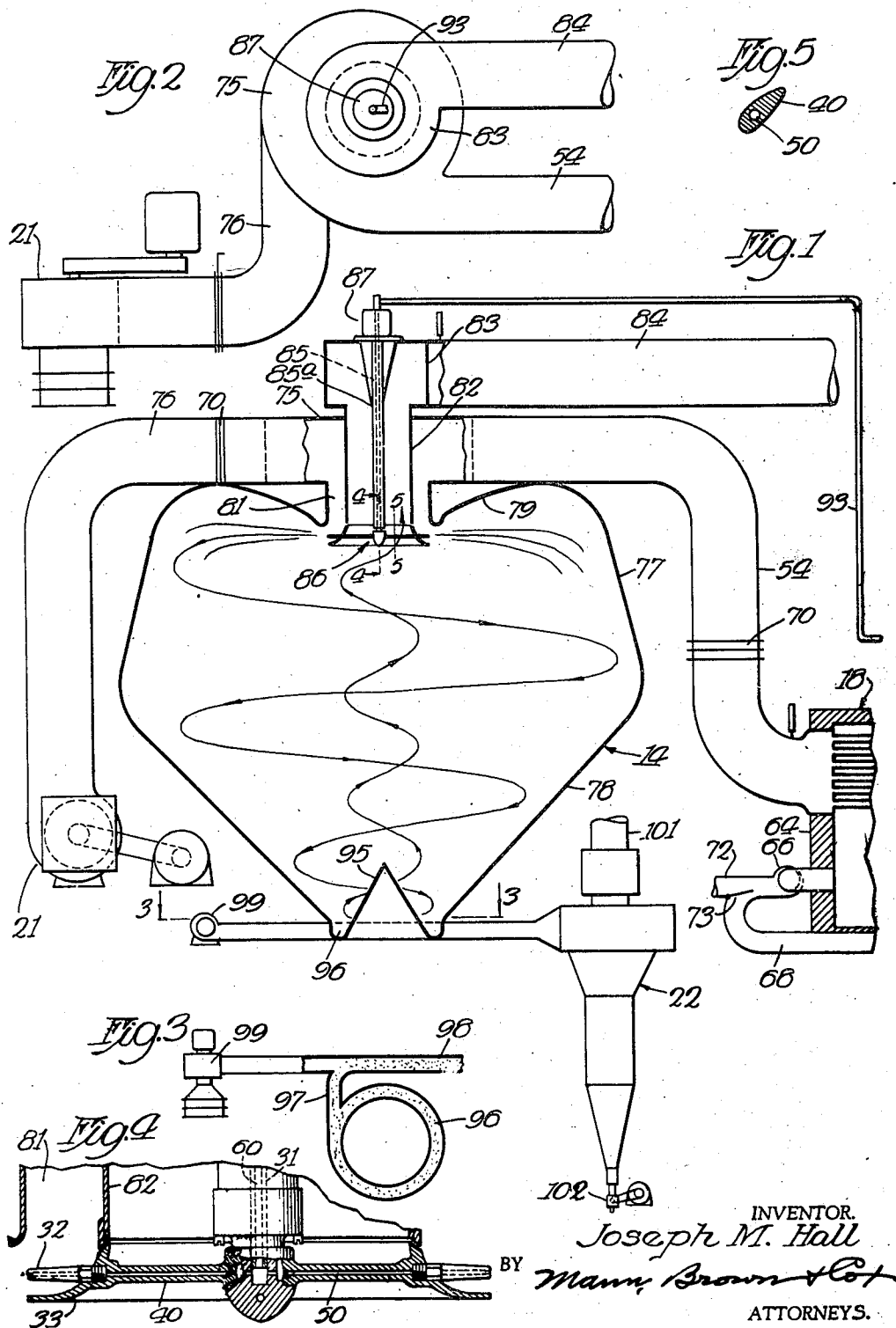
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2,290,470

METHOD OF AND APPARATUS FOR DEHYDRATING LIQUID PRODUCTS

Filed Feb. 7, 1940

2 Sheets-Sheet 1



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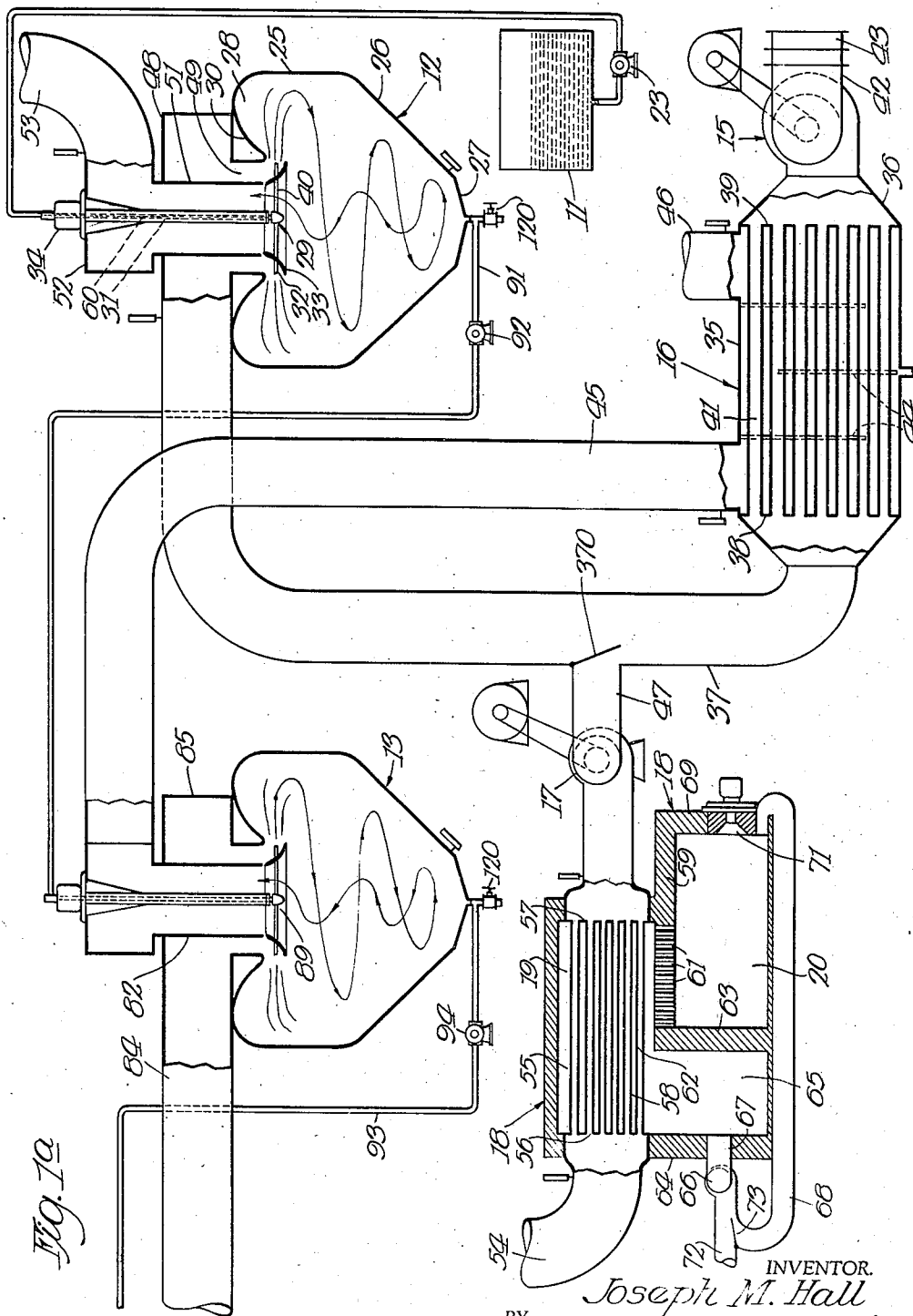
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2 Sheets-Sheet 2

Fig. 1a



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METHOD OF AND APPARATUS FOR DEHYDRATING LIQUID PRODUCTS

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7 Claims. (Cl. 159—4)

This invention relates to a system of desiccating or dehydrating liquid products and one of the principal objects of the invention is the provision of a new and improved arrangement of the various structures of the system whereby a large amount of air at atmospheric temperature may be mixed with a quantity of heated air for forming the dehydrating medium.

Another object of the invention is the provision of a new and improved dehydrating system having novel means for dehydrating liquid products and novel means for circulating and recirculating all, or portions only of the drying medium.

A further object of the invention is the provision of a new and improved means for insuring delivery of the dehydrated product from the dehydrator in a continuous process.

Another object of the invention is the utilization of a large portion of fresh air in the drying medium without first passing it through a heater.

Another object of the invention is the provision of a new and improved system for dehydrating liquid products employing an apparatus that is simple in construction, efficient and economical in operation, requires a minimum of artificial heat, is composed of few parts, and that is not likely to become deranged 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 diagrammatic view in elevation of a portion of an apparatus for dehydrating liquid products;

Fig. 1a is a similar view of the remaining portion of the apparatus;

Fig. 2 is a top plan view of a portion of the construction shown in Fig. 1;

Fig. 3 is a section on the line 3—3 of Fig. 1;

Fig. 4 is a cross-section on the line 4—4 of Fig. 1; and

Fig. 5 is a section on the line 5—5 of Fig. 1.

In dehydrating liquid products, it is common practice to remove the moisture from the product by a heating gaseous medium such as air, dry steam or the like. The present invention employs heated air for this purpose. Air under atmospheric conditions is usually much below its saturation point and consequently it possesses considerable capacity for absorbing moisture.

The present invention seeks to take advantage of this fact in the provision of means for heat-

ing only a portion of the air supplied to the dehydrator and to mix this heated portion with a copious supply of air under atmospheric conditions immediately prior to the dehydrating operation. By means of this arrangement, an economy in heat units is obtained due to utilizing such a large number of heat units contained in air under atmospheric conditions. A high rate of evaporation may be obtained at moderately elevated temperatures of the heating medium if the liquid product be atomized and projected into direct contact with the heating medium while it is moving at high velocity.

In the present invention, the concentration and dehydration are accomplished by projecting the atomized liquid product into spirally moving currents of moderately heated air. The outward and downward movement of the liquid particles through the air, together with their centrifugal movement radially outward in the spirally moving heated current of air insures a constantly changing contact of those particles and air and such everchanging contact is conducive to a high rate of evaporation. With this system, excellent results may be obtained by the use of air heated but a few degrees above the boiling point of water, say from 220° to 225° F. although much higher temperatures may be employed, if desired. The evaporation of the moisture from around the particles prevents the particles from becoming overheated while they contain moisture. But the evaporation of the moisture quickly lowers the temperature of the air so that the dried particles do not come in contact with air at temperatures sufficiently high to injuriously affect the product. Furthermore, the process is of such short duration that the particles are not subjected to heat at even at moderately high temperatures for but a few moments.

Referring now to the drawings, the reference character 10 designates the apparatus which comprises a tank 11 for containing the liquid product to be dehydrated; an evaporating chamber or cabinet 12 which, for convenience, may be termed the first-stage evaporator; a second evaporator chamber or cabinet 13 which may be termed the second-stage evaporator; and a dehydrator chamber or cabinet 14, which may be termed the third-stage evaporator, in which the liquid product is dehydrated. The apparatus also comprises a fan 15 which introduces air into the system and causes it to flow through the heat exchanger 16, a second fan 17, a furnace 18 having the heater 19, and a blower 21 for introducing fresh air into the system at the

intake of the dehydrator 14, as will presently appear. A collector 22 is also provided for collecting the dehydrated material discharged from the dehydrator 14. The liquid product and the drying medium pass through the second evaporator and the dehydrator in opposite directions.

Referring now to Fig. 1a, the liquid product contained in the reservoir or container 11 is forced by the pump 23 through the conduit 24 into the first-stage evaporator 12 in the usual manner. The first-stage evaporator 12 is of the centrifugal separator type and comprises an upper cylindrical section 25 and a lower tapered section 26. The lower end 27 of the tapered portion 26 has its walls at a more obtuse angle to the axis of the chamber than the remaining part of the tapered portion for shortening the height of the evaporator, as clearly shown in said figure. The upper part of the cylindrical portion 25 is closed by the top wall 30 which may have its central part depressed to form an annular upwardly extending portion 28 of the main chamber which extends above the distributor or spray member 29, as will presently appear.

The distributor member 29 is in the form shown in my copending application, Serial No. 275,934, filed May 26, 1939, and comprises a rotating hollow shaft 31, Fig. 3, extending axially downwardly through the upper portion of the chamber 25 and has attached, at its lower end, a plurality of arms 40 having nozzles 32 attached thereto. Attached to the arms 40 is an annular deflector member 33 concave on its upper surface. The distributor member 29 is attached to the hollow shaft 31 and is rotated by a motor 34. The arms 40, to which the nozzles 32 are attached, are each provided with a passage 50 in communication with the passage 60, formed in the hollow shaft 31, and are shaped to form fan blades, as shown at 40 in Fig. 4, for exhausting air from the chamber 12. The liquid product passes downwardly from the conduit 24 through the hollow rotating shaft 31, through the passages in the arms 40 and, by the action of centrifugal force, it is discharged from the nozzles 32 into the evaporator 12 in the form of a spray of finely divided particles.

Suitable means are provided for evaporating a portion of the moisture sprayed into the cabinet or chamber. In the form of the construction shown, air is employed as the heating and evaporating medium. This air is heated and circulated through the system, including the heat exchanger 16, in a manner that will shortly be described.

The heat exchanger 16 comprises an outer casing 35 having a tapered end 36 in communication with the discharge of the fan 15. The casing is tapered at its opposite end and is in communication with a conduit 37. The casing is provided at each end with partitions or flue sheets 38 and 39 which are perforated and have tubes or flues 41 secured in the perforations, the tubes forming passages for the air through the heat exchanger. The intake 42 of the fan 15 is provided with suitable filters 43 so as to clean the fresh air introduced into the system and forced by the fan 15 through the heat exchanger 16. The air introduced by the fan 15 is heated in the exchanger by the air exhausted from the second evaporator, as will presently appear.

Mounted within the casing 16 are a plurality of baffles 44 extending from opposite sides of the heat exchanger so as to cause the heated air exhausted from the second evaporator 13 and

introduced through the conduit 45 into the casing 35 at one end thereof to take a zig-zag course through the heat exchanger as it flows around the tubes 41 and out through the discharge conduit 46 at the opposite end of the casing 35 thereby imparting a maximum amount of heat to the air introduced into the conduit 37 by the fan 15. The air passing through the heat exchanger 16 from the conduit 45 is discharged through a pipe 46 into the atmosphere after it has imparted heat to the air introduced into the heat exchanger by the fan 15 or it may be used for other heating purposes about the plant.

A portion of the air flowing through the heat exchanger 16 from the fan 15 may be diverted by an adjustable valve 370 into the conduit 47 and the remainder is delivered to a snail 48 which discharges the air in a spiral form through the opening 49 into the chamber 12 onto the deflector 33 across the spray of the liquid product. This heated air, moving spirally around the walls of the chamber is exhausted by the fan formed by the distributor 29 through a sleeve or conduit 51 extending axially upwardly through the snail 48 into the casing 52 from which it is finally discharged through the conduit 53. The intimate contact between the heated air and atomized particles of the liquid product within the first stage evaporator 12 evaporates a considerable portion of the moisture and the concentrate falls or flows by gravity to the bottom of said evaporator.

A portion of the air deflected into the conduit 47 by the valve 370 is caused to flow through the heater 19 of the furnace 18 into the conduit 54 by the fan 17. The furnace 18 comprises the heater or heating chamber 19 and the combustion chamber 20. The heater 19, which is in the upper portion of the furnace 18, comprises a casing 55 provided with the flue sheets or partitions 56 and 57 which are perforated and have tubes or flues 58 secured therein through which air from the fan 17 passes to the conduit 54. The top wall 59 of the combustion chamber is provided, at its front end, with passages 61 through which the heated gases pass into the heater 19 about the forward end portions of the tubes 58 for heating the air as it passes through said tubes.

The heater chamber is provided with one or more baffles 62, one being shown, which causes the heated combustion gases to take a zig-zag path therethrough. The rear wall 63 of the combustion chamber is spaced forwardly of the rear wall 64 of the furnace to form a discharge chamber 65 for the exhaust gases. In order to conserve heat, a portion of these gases may be recirculated by a fan 66. This fan exhausts from the chamber 65 through a conduit 67 connected with the intake of the fan and discharges into a conduit 68. This conduit returns the heated gases to the combustion chamber through the front wall 69 of the furnace. The remainder of the gases in the chamber 65 is discharged into the stack through a conduit 72. A valve 73 is provided for directing all, or a portion, of the gas into the conduit 68, as may be desired.

The air, in passing through the heater 19, is heated to a high temperature and is delivered, in this heated condition, through the conduit 54 to a snail 75 having an outlet into the dehydrator 14. The conduit 54 may be provided with an air filter 70, if desired. A large volume of fresh air, at atmospheric temperature, is adapted to be mixed with the highly heated air from the fur-

nace 18. In the form of the construction selected to illustrate one embodiment of the invention, the blower 21 is employed for this purpose.

The blower 21 draws in fresh air and discharges it through the conduit 76 and through the filter 70 in said conduit, into the snail 75 of conventional design, where it is thoroughly mixed with the heated air by the gyratory motion given the two streams of air by said snail.

The dehydrator 14 is similar to the first stage evaporator and comprises an upper portion 77, a lower tapered portion 78, and a depressed top portion 79. The top portion 79 is provided with an enlarged opening 81, the walls of which are integral with the snail 75 and constitute an outlet for said snail. Extending axially downwardly through the opening 81 and axially of the dehydrator is a sleeve or cylindrical casing 82 of less diameter than the opening 81 and which is connected at its upper end to, and supported by, an enlarged casing 83 which in turn is in communication with a conduit 84 leading to the second evaporator chamber 13. Extending axially downwardly through the casing 83 and sleeve or cylindrical casing 82 is a hollow shaft 85 through which the concentrated liquid product is delivered to the rotating distributor head or member 86 beneath the sleeve or casing 82. The shaft 85 is protected by a sleeve 85a surrounding the same. This shaft is adapted to be rotated in any suitable manner as by means of the motor 87. Since the distributor member or distributor 86 is similar to the distributor 29 already described, it is not thought necessary to further illustrate or describe the same further than to say that the distributor or distributor member, as in the one previously described, functions as an atomizer and as an exhaust fan for removing the air or evaporating medium from the chamber 14.

The drying medium passes from the snail 75 into the dehydrator and is directed across the spray for dehydrating the sprayed particles, as in the previous construction. This air passes downwardly in a spiral path to the lower portion of the dehydrator and then passes upwardly in a spiral path of smaller diameter and is exhausted through the casing 82 by the spray head 86, the arms of which are constructed to constitute an exhaust fan. These arms are flattened and turned at an angle to form the fan blades, as shown in Figs. 4 and 5. The dry particles of the product are thrown by centrifugal force against the walls of the cabinet and fall by gravity to the bottom of the cabinet.

The lower end of the dehydrator 14 is provided with an upstanding conical member 95. The conical member 95 may be integral with the walls of the dehydrator and forms with said walls an annular channel or passage 96. The passage 96 is connected with an outlet passage 97, Fig. 3, which is tangential to the passage 96.

The air discharged from the dehydrator 78, while its temperature has been lowered, is still far above its saturation point and for that reason is employed in concentrating the liquid product after it leaves the first-stage evaporator. The air passing along the conduit 84 from the dehydrator 14 enters a snail 88 which delivers the air into the second-stage evaporator 13 in a spiral form across the nozzles of the spray head 89 for evaporating moisture from the concentrated liquid product. Since the construction of the evaporator 13 is similar to the evaporator 12 and the parts are similarly arranged and function in a

like manner, it is not thought necessary to repeat the description of the same at this point.

The air exhausted from the evaporator 13 by the distributor 89 is discharged into the conduit 45 and from thence the air passes through the heat exchanger 16 for heating fresh air forced through the heat exchanger by the fan 15 as has already been described.

It will thus be seen that the liquid product has a portion of its moisture evaporated in the first-stage evaporator 12 by fresh air which is heated from the air discharged from the second-stage evaporator and that the concentrate which is discharged from the bottom of the evaporator 12 into a conduit 91 is forced by the pump 92 into the second-stage evaporator 13 where it is further concentrated in said evaporator by air discharged from the dehydrator 14. The concentrate from the evaporator chamber 13 is caused to flow through a conduit 93 by a pump 94 into the dehydrator 14 where it is sprayed into heated air moving spirally in the dehydrator and dehydrated or reduced to a powder which is collected in the lower portion of the dehydrator 14 and the powder removed therefrom to the separator 18. In other words, the liquid advances from the second-stage evaporator 12 to the first-stage evaporator 13 and thence to the dehydrator 14 whereas the air advances in the opposite direction through first the dehydrator 14 and then the second evaporator 13. Fresh air is employed in the first-stage evaporator but this air is heated by the air discharged from the second-stage evaporator.

In the operation of centrifugal separators, there is usually a partial vacuum formed along the axis of the separator due to the centrifugal action of the rotating mass of air. As a result of this phenomenon, some of the dried particles may be carried upwardly by the rotating inner column of air and are in turn thrown outwardly by the centrifugal force of the inner column into the outer rotating column thus starting the cycle all over again.

Suitable means are provided for preventing this recirculation by causing the particles to be discharged from the cabinet as soon as they are deposited in the lower part thereof. As shown, this is accomplished by causing a blast of air to be discharged across the outer end of the conduit 97 so as to partially exhaust the air from said conduit by induction. As shown, this is accomplished by a conduit 98 through which a current of fresh air is caused to flow by a fan 99. The outer end of the conduit 97, where it is connected to the conduit 98, is so constructed that it discharges into the conduit and in the direction of the flow of air therein, and, as a result, a partial vacuum is created by induction in the conduits 97 and 96. The air and dehydrated material is delivered by the conduit 98 into a centrifugal air separator 22 of a conventional type. The air is discharged axially from the separator through the conduit 101 and the material is discharged through a power control valve 102 in the lower portion of the separator 22, as is usual in such constructions. Since the separator 22 is of the usual or any well known construction, it is not necessary to describe the details of the same.

It will thus be seen that in this system, only a portion of the gaseous drying medium is heated and that the remaining portion of the drying medium is introduced directly from the atmosphere.

The product may, if desired, be removed from

either the first or second stage evaporators through the valves 120 in a more or less concentrated form, as desired.

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 detail may be made without departing from the spirit and scope of the appended claims.

I claim as my invention:

1. In a system for dehydrating liquid products, a dehydrator, means for discharging the liquid product in the form of a spray into said dehydrator, means for introducing dry air into said dehydrator and for causing the same to travel downward in a spiral path to the lower portion of said dehydrator and then spirally upwardly in a spiral of small diameter for dehydrating the sprayed particles and for separating the same from the air by gravity and centrifugal action, a conduit in tangential communication with the lower portion of said dehydrator, and means for creating a partial vacuum in the conduit whereby the dried particles in said dehydrator will, while continuing to rotate about the axis of the dehydrator, fall by gravity into the lowermost portion of said dehydrator and be withdrawn tangentially therefrom and through said conduit.

2. In a dehydrating system, a dehydrator of the centrifugal type having an upper section circular in cross-section and a lower tapered section, said lower tapered section having a circular channel in its lower portion for receiving dehydrated particles of said product and a conduit tangent to said channel and in communication therewith, and means for causing a stream of air to flow along said conduit for creating a partial vacuum therein for assisting in removing the dried particles of said product from said dehydrator.

3. In a system for dehydrating a liquid product, a dehydrator chamber, an air heater for heating a small stream of fresh air to high temperature, means for discharging the heated air into said chamber, means for mixing a large stream of cool fresh air with said heated air and for discharging the mixture into said dehydrator in a downward spiral, means for discharging a liquid product in finely divided particles into said mixture of air within said dehydrator chamber for dehydrating said particles, and means for preheating said first named stream of air, said means comprising a heat exchanger through which all the air discharged from said dehydrator is conducted for preheating said small stream of air.

4. In a system for dehydrating liquid products comprising a dehydrator having a dehydrating chamber and a snail chamber above said dehydrating chamber, means for discharging a liquid product in the form of finely divided particles into said dehydrating chamber in an annular spray about the axis of said dehydrator adjacent to the top thereof, means for heating air, means for introducing the same at high temperature through the circular periphery of said snail

chamber, and means for separately introducing fresh air at atmospheric temperature through said periphery for rotation concurrently with said heated air and for mixing therewith in said chamber before the latter contacts said product, and means including said snail for causing the mixed air to travel downwardly in a spiral across the sprayed particles and then spirally upwardly in the same direction and discharging the same from said dehydrator, for dehydrating said particles.

5. A method of dehydrating a liquid product within a chamber and for removing the same therefrom which comprises discharging the product in said chamber in the form of an annular spray, heating a quantity of fresh air to a high temperature, causing the same to move in a spiral current, introducing a quantity of fresh air at atmospheric temperature to said spiral current to assist its rotation and mix with it, discharging the mixed air through the top of the chamber across the sprayed material, and causing the mixed air to travel first downwardly in said chamber in an outer spiral path and then upwardly in an inner spiral path through said annular spray without contacting said spray, for removing the dehydrated particles from the air by centrifugal force.

6. In a dehydrating system, a dehydrator chamber, means for discharging a copious supply of fresh air at atmospheric temperature into said chamber, means for heating a small stream of air and for discharging the same into said copious supply for heating the same just prior to its discharge into said dehydrator chamber, means for causing the mixed air to move spirally downwardly in an outer spiral within said chamber and then spirally upwardly in an inner spiral within the first-named spiral and in contact therewith and in the same rotational direction thereas, means for spraying a liquid product into said outer spiral only for dehydrating said product, an annular passage extending about the lower portion of said chamber to receive the dehydrated product therefrom, and means for directing a stream of air into tangential communication with the annular passage to assist the dehydrated product to move in the annular passage in the same rotational direction as the spiral currents and to induce the dehydrated product from the annular passage.

7. A method of evaporating a liquid product within an enlarged chamber by a rotating mass of air, which comprises heating only a portion of said mass of air, mixing the heated air with an unheated mass of fresh air preparatory to its entry into said chamber, causing said mass of mixed air to rotate spirally within an enlarged chamber, rotatably spraying a liquid product into the spirally moving mass of air, and separating said air from said product within said chamber by centrifugal action, causing the last-named air to be discharged from said chamber and utilizing heat therein for preheating the portion of said air that is heated just prior to its entry into said chamber.

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