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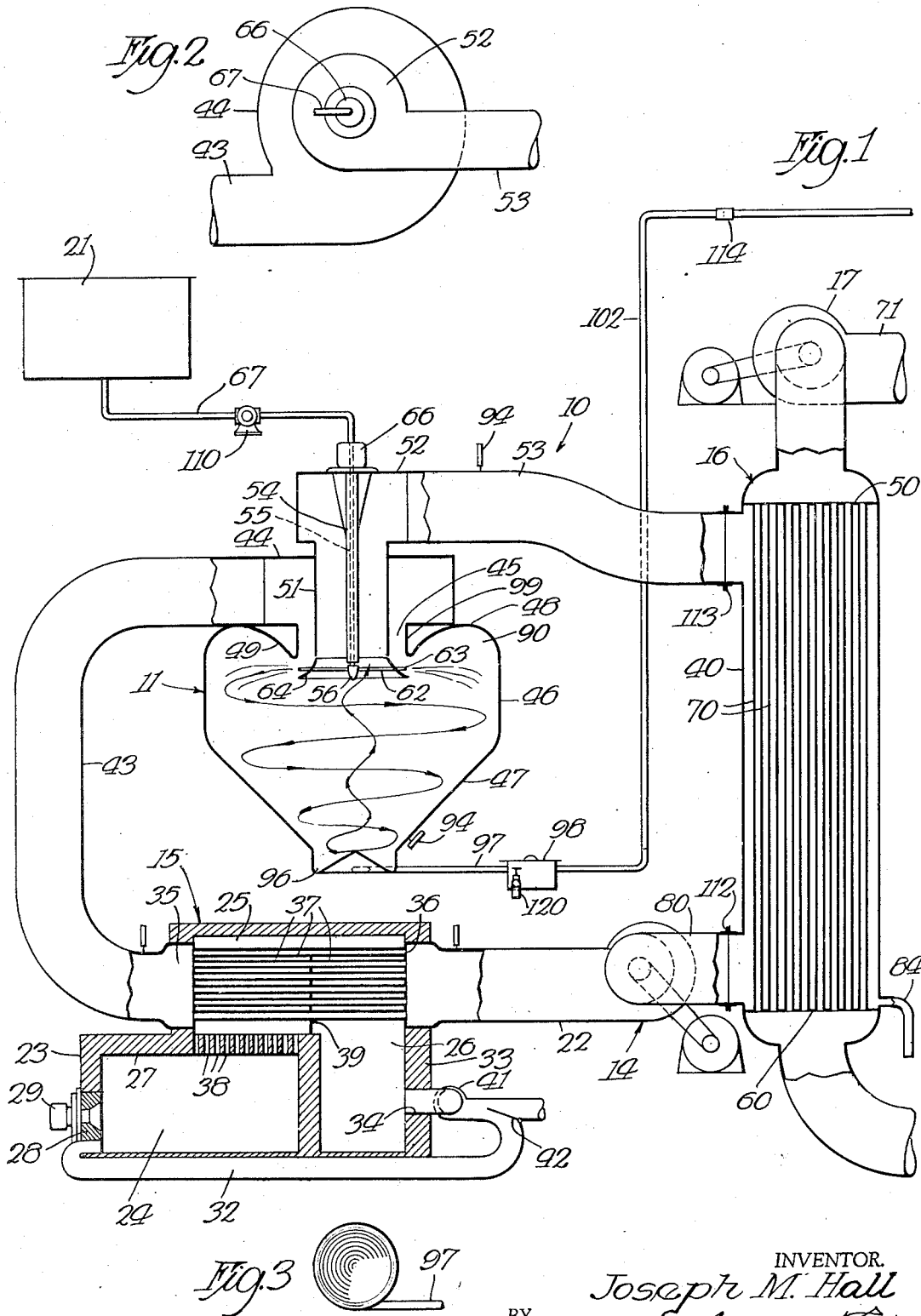
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METHOD OF AND APPARATUS FOR CONCENTRATING LIQUID PRODUCTS

Filed Feb. 7, 1940

2 Sheets-Sheet 1



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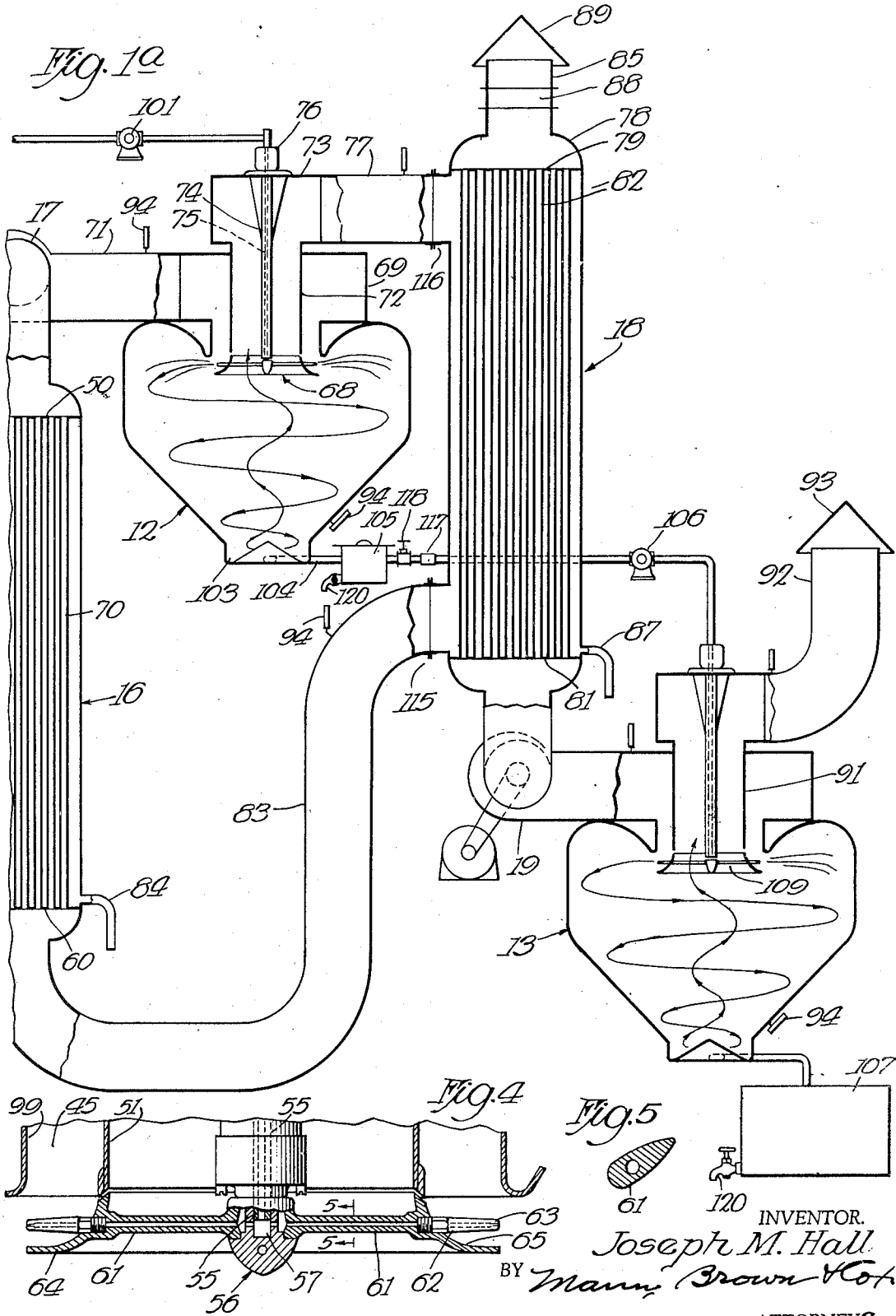
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METHOD OF AND APPARATUS FOR CONCENTRATING LIQUID PRODUCTS

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2 Sheets-Sheet 2



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METHOD OF AND APPARATUS FOR CONCENTRATING LIQUID PRODUCTS

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11 Claims. (Cl. 159—17)

This invention relates to a system for concentrating liquid products or for reducing the moisture content thereof.

One of the objects of the invention is the provision of a new and improved method of concentrating liquid products with a minimum of heat loss.

Another object of the invention is the provision of a new and improved method of concentrating a liquid product by the use of air or other gas as the heating medium arranged in a plurality of closed circuits.

A further object of the invention is the provision of a new and improved apparatus for concentrating a liquid product that is provided with a novel arrangement of mechanism for circulating the drying or evaporating medium.

Another object of the invention is the provision of a new and improved system for evaporating or condensing liquid products in a plurality of stages by the use of air or other gas as the heating medium and by employing a single heating unit for the entire system.

Another object of the invention is the provision of a new and improved method of concentrating a liquid product in such a manner that the entire process from the time the particles are introduced into any one of the evaporators of the system until these same particles are discharged therefrom requires but a few seconds of time, usually about a minute or so, whereby the treatment does not cause chemical changes in the constituent particles of the product.

A still further object of the invention is the provision of a new and improved apparatus for concentrating a liquid product that is simple in construction, easily assembled, efficient in operation, and that may be cleaned with a minimum of time and labor.

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 forward end portion of the apparatus shown more or less diagrammatically, with parts in section and parts broken away;

Fig. 1a is a side elevation of the rear portion of the apparatus shown more or less diagrammatically, with parts in section and parts broken away;

Fig. 2 is a plan view of a portion of the concentrator chamber of the first stage of evaporation;

Fig. 3 is a bottom plan view of the lower por-

tion of the first stage evaporator, shown diagrammatically;

Fig. 4 is a vertical section of the spray head and associated structure, with parts broken away; and

Fig. 5 is a section on the line 5—5 of Fig. 4.

It is common practice, in apparatuses having a plurality of stages of evaporation, to provide an evaporating chamber for each stage having means for operating one or more of the evaporators at sub-atmospheric pressure. Such a system is objectionable because of the additional power required in operating the vacuum pumps and because, in a vacuum system, leaks that develop in the system lower the efficiency of the system very materially.

The present invention seeks to avoid these difficulties by the provision of a system that operates at comparatively low temperatures and at substantially atmospheric pressure and, consequently, the equipment is very much simplified. Where the vacuum system is employed, the apparatus must be more strongly built to withstand the pressure of the atmosphere. But, in the present system, since there is but a comparatively small difference in the outside and inside pressures, the structure need not be so heavy nor so massive.

In a system employing vacuum pans or chambers where heat is applied indirectly, as in the previously named constructions, the liquid product must necessarily be present in large quantities in the evaporators or vacuum pans in order to operate with any degree of efficiency. But this prolonged exposure of the product to such temperatures as are necessary to evaporate the liquid is objectionable as adversely affecting the quality of the product.

The present invention avoids this objection by employing a system in which the product is sprayed into direct contact with the heating medium in small particles which are exposed to this medium for extremely short periods of time. Under ordinary operating conditions, the exposure in any one of the evaporators requires a comparatively few seconds of time, hence there is little time for any chemical change in the product during the concentrating period. This is considered an important feature of this invention. Milk, for instance, that has been concentrated in this manner, will retain its original taste and flavor and may be returned to its original condition simply by adding the required amount of moisture to restore its original fluidity. The heating medium employed

is a gaseous fluid and for the purpose of disclosing one form of the invention, air is used as the heat conveying medium.

Referring now to the drawings, the reference character 10 designates the concentrating system which comprises a first stage concentrator or evaporator 11, a second stage concentrator or evaporator 12, a third stage concentrator or evaporator 13, and a fan 14 for circulating the heating medium through the first closed circuit. This circuit includes the fan 14, a heater 15, the evaporator 11, a condenser or heat exchanger 16, and connecting conduits. The system also includes a second closed circuit for the drying medium comprising a fan means 17, the condenser or heat exchanger 16, for heating the heating medium in this second circuit, a condenser 18, and the connecting conduits. In the third stage concentrating mechanism, air from the outside is drawn into the system through the condenser or heat exchanger 18 for heating the same. This air is caused, by the fan 19, to pass through the third stage concentrator or evaporator 13 and is discharged into the air. The liquid product is contained in the receptacle or container 21 and is conducted to the evaporators or concentrators in series, that is, in regular order from the first, through the second, to the third concentrator and sprayed therein, respectively, as will presently appear.

Each concentrating stage has a separate circulating system for the heating medium and the condenser for the air circuit of the first stage functions as a heater for the second stage air circuit. Likewise, the condenser for the second stage air circuit functions as a heater for the third stage air circuit.

The apparatus for effecting the first stage evaporation will now be described.

Starting with the air discharged from the fan 14, the same will pass along the conduit 22 into and through the heater 15. The fan 14 is of the usual centrifugal type and need not be described in detail. The heater 15 may be of the usual or any well known type, that shown being of flue or tubular type and mounted in the upper portion of a furnace 23. The furnace 23 comprises a combustion chamber 24, a heating chamber 25 located above the combustion chamber, and a smoke chamber 26 below the rear end of the heating chamber.

The combustion chamber 24 is provided with a front wall 27 having an opening 28 therein through which the burner 29 extends and an opening 31 below the burner opening for receiving the forward end of a conduit 32 for returning a portion of the combustion gases to the combustion chamber 24, as will presently appear.

The rear wall 33 of the furnace is provided with an opening 34 into which the rear end of a conduit 41 is secured. The conduit 32 is a branch of the conduit 41, as clearly shown in Fig. 1.

The heating chamber 25 is provided with flue sheets or partitions 35 and 36 at the forward and rear ends of the heating chamber within which are rigidly secured a plurality of parallel flues or tubes 37 through which the air from the fan 14 travels during the operation of the apparatus. The heated gases from the combustion chamber 24 pass upwardly through the passages 38 in the top wall 27 of the combustion chamber and flow about the front ends of the tubes 37 and then downwardly on the

opposite side of a baffle 39 around the rear ends of the tubes 37 and into the smoke chamber 26 for heating the air as it passes through the tubes. Since the burner 29 is of the usual or any well known construction, it is not thought necessary to further illustrate or describe the same.

Suitable means are provided for returning a portion of the combustion gases to the combustion chamber to be recirculated through the heater 15 in order to conserve the heat contained therein. As shown, the passage 32 is employed for this purpose. The passage 32 is connected to a main passage 41 secured in the opening 34 and has its front end secured in the opening 31. In order to control the amount of combustion gases recirculated through the passage 32, a valve 42 is provided for closing either the passage 41 or the passage 32 or partially closing either, as may be desired. The heated air from the heater 15 passes through a conduit 43 into a snail 44 mounted on the concentrator chamber 11 and passes into that chamber through a passage 45 in a downwardly spiral movement.

The concentrator 11 is of the centrifugal type and comprises an upper cylindrical section 46, a lower tapered section 47 and a top wall 48 which may be depressed as at 49 and is joined to a sleeve 99 for forming the axial passage 45. The snail 44 is connected to the top wall 48 by the sleeve portion 99 which defines the opening 45. Extending downwardly through the snail 44 is a casing or sleeve 51, the lower end of which extends axially through the opening 45 and being of less diameter than said opening, an annular intake passage 100 for the concentrator is formed about the casing 51. The upper end of the casing or sleeve 51 is provided with an enlargement 52 which extends above the snail 44 and has a conduit 53 leading therefrom to the heat exchanger 16. The casing 51 constitutes a discharge passage for the air from the concentrator 11. Extending axially downwardly through the enlargement 52 and the casing 51 is a sleeve 54 within which is rotatably mounted a shaft 55 which is provided with an axial bore through which the liquid product flows into the distributor member 56, as will presently appear.

The lower end of the concentrator 11 extends downwardly as at 94 and then inwardly and upwardly to form an upwardly cone-shaped portion 95. The downwardly extending wall 94 and the cone-shaped portion 95 form a circular channel or passage 96 for collecting the liquid which will be moving spirally when it flows into the channel. An outlet passage 97 is provided which is arranged tangent to the channel 96, as shown in Fig. 3, whereby the liquid flowing in the direction of the arrow in said figure will readily flow into the passage 97. This liquid flows into a reservoir 98 from which it is drawn by the pump 101 and discharged into the second stage concentrator 12.

The distributor member 56 comprises a hollow body portion 57 in communication with the axial bore of the tubular member 55. Suitable arms 61, having bores 62 in communication with the hollow head 57, are secured in the head and extend radially outwardly therefrom. Any suitable number of these arms may be employed, four being shown. The bores 62 are reduced very materially in diameter at the outer ends of the arms to form nozzles 63 which may, in practice, be detachable so that nozzles of different bores may be employed for use in concentrating fluids of

different viscosities. When the liquid product is fed to the head, the same will be discharged through the bore 62 and nozzles 63 by centrifugal force for atomizing the product.

Suitable means are provided for deflecting the air across the nozzles. This means comprises an annular deflector member 64 in the form of the frustum of a cone having an outer concave face, as shown at 65. This deflector is supported by the arms 61 and rotates with them. The air, in being discharged from the snail 44 will be deflected outwardly across the nozzles into direct contact with the finely divided particles discharged by the nozzles 63 and being in intimate contact with those particles will evaporate a considerable portion of the moisture from them in the concentrator. The annular recess 90 formed by the central depression in the top wall of the concentrating chamber 11 is sufficiently above the sprayed liquid that none of the spray collects on this wall.

Suitable means are provided for rotating the distributor head 56 and arms and deflector rigidly connected thereto. As shown, a motor 66, mounted on the enlargement 52, is provided for this purpose. The shaft 55 may be a continuation of the motor shaft or may be rigidly attached thereto.

Appropriate means are provided for exhausting the air from the concentrator 11. As shown, the arms 61 of the distributor head 56 are flattened and turned at an angle so that they will function as an exhaust fan for removing the air from the concentrator 11. The rotation of the distributor member performs the double function of atomizing the liquid product and of exhausting the air from the dehydrating chamber.

The liquid product is forced, by a pump 110, through a passage 67 from the container 21 downwardly through the hollow motor shaft 55. This liquid passes outwardly by the action of centrifugal force through the rotating nozzles and is discharged therefrom in the form of a spray, that is, the particles are finely divided or are atomized. The air, as it enters the evaporator 11, is caused to rotate at a high velocity by the snail 44 and, moving across the nozzles 63, will evaporate a considerable portion of the moisture from the particles and the centrifugal force will throw the particles outwardly into the spirally moving air thus evaporating moisture from the solid material. The air will move downwardly in a spiral until it reaches the lower end of the evaporator 11 and then will be caused to move upwardly in a spiral of comparatively small diameter by the fan formed by the arms 61 and will be discharged into the heat exchanger 16 by the passage 53. The liquid particles will be thrown by centrifugal force outwardly against the side wall of the concentrator and will be caused to flow in a spiral path by the spirally moving air current down the side wall into the channel 96.

In the heat exchanger 16, the vapor in the air is condensed and a considerable portion of its sensible and latent heat is transferred to the air in the circuit of the second evaporator stage, as will presently appear. The heat exchanger 16 is of the usual or any well known type and comprises a casing 40 having a flue sheet or partition 50 at one end and a similar flue or partition 60 at its opposite end within which are secured the ends of tubes 70 as clearly shown in Fig. 1 of

the drawings. The air passing through the conduit or passage 53 enters the side of the casing 40 adjacent the partition 50, flows about or around the tubes 70 and is discharged through a conduit 80 at its opposite end. The conduit 80 constitutes the intake of the fan 14 thus completing the circuit for the air through the first stage evaporation.

The drying medium, which, in the present instance, is air, is also circulated in a closed circuit in the second evaporating stage. The second stage evaporating mechanism comprises an evaporator 12, and spray member or atomizing mechanism 68 which is similar to the spray member 56 described above. The evaporator 12 is similar in construction to the evaporator 11 and has mounted thereon a snail 69 similar to the snail 44 previously described. The snail 69 is in communication with the fan 17 by a conduit 71 through which air discharged from said fan passes into the evaporator 12 in a downwardly moving spiral as has already been described.

A sleeve 72, depending from the casing 73, extends axially downwardly into the evaporator 12 and has mounted axially therein a sleeve 74 within which is the rotating motor shaft 75 of the motor 76 for rotating the spray head 68. Since the construction of the evaporator 12, spray head 68 and the arrangement of the snail 69, sleeves 72 and 74 are substantially the same as in the construction described above, it is not thought necessary to repeat the description of these parts at this time.

The air withdrawn by the fan formed by the arms of the distributor member 68 is discharged through a conduit 77 into a heat exchanger 18. The heat exchanger 18 comprises a casing 78 having a flue sheet or partition 79 at one end and a flue sheet or partition 81 at the opposite end. Flues or tubes 82 are secured at their ends in the partitions as is usual in such constructions. Saturated air from the conduit 77 passes into the casing 78 and flows downwardly about the tubes 82 and is discharged into a conduit 83 which is in communication with the casing 40. From the conduit 83, the air passes upwardly through the tubes 70 of the heat exchanger 16 into the fan 17 and from the fan 17 through the conduit 71 into the evaporator chamber 12. From the chamber 12 and conduit 77, this air passes through the heat exchanger 18 thus completing the closed circuit of the heating medium for the second stage evaporator 12. The air, as it passes upwardly through the tubes or flues 70, is heated by conduction from the air of the first stage circuit as the latter flows downwardly through the heat exchanger 16. This upwardly flowing air cools the air flowing downwardly from the conduit 53 thus condensing a considerable amount of the moisture which is discharged from the casing through a pipe 84. The air in the second evaporating stage circulates in a closed circuit and consequently, the moisture evaporated from the liquid product in the evaporator 12 must be removed in order that the mechanism shall properly function.

The heat exchanger 18 is provided for this purpose. At its upper end, this exchanger is provided with a tubular extension 85 through which fresh air is caused to flow by the fan 19. This cool air functions as a condensing agent for the moisture contained in the air flowing through the closed circuit in the second stage evaporator. The moisture condensed from this air in the heat

exchanger 18 may escape through an outlet pipe 87 in the lower portion of the casing 78. Preferably, though not necessarily, a filter 88 is provided in the tubular extension 85. The tubular extension 85 may extend to the exterior of the building in which the mechanism is located and in that event, a protecting cap 89 is provided for preventing the entrance of rain, snow and the like, into said extension. The fresh air introduced into the heat exchanger 18 passes downwardly through the tubes 82 of the heat exchanger 18 where it is heated and in return, cools the air in the second stage evaporating circuit. It then passes into the fan 19 and is there discharged into the third stage evaporator 13 and from thence into the air, thereby constituting what may be termed the air circuit for the third stage evaporator.

The mechanism for the third stage evaporating circuit comprises the evaporator 13 and associated parts and since it is similar to that already described, it is not thought necessary to further illustrate or describe the same.

The air discharged from the third stage evaporator 13 by the fan 19 or distributor member 109 is forced upwardly through the sleeve or tubular member 91 and is discharged into the atmosphere through a pipe or passage 92 which may extend to the exterior of the building and be provided with a protective cap 93.

Thermometers 94 may be placed anterior and posterior to the heater 15 and to each of the evaporators and heat exchangers for indicating the temperature of the air flowing through the different systems. Thermometers 94 may also be mounted on the evaporator chambers to indicate the temperature within those chambers.

The distribution of the liquid product and associated mechanism will now be described. The product is contained in the receptacle 21 and is delivered by a pump 110 to the distributor member 56. The liquid product is atomized and the particles are thrown by centrifugal force, as described above, against the walls of the first evaporator chamber and flow downwardly therein into the circular channel 96 in a circular movement and are discharged through the tangential passage 97 into the reservoir 98 and from there pumped through the conduit 102 by the pump 101 to the distributor member 68. The liquid is further concentrated in the concentrator 12 and is collected in the channel 103 which is similar to the channel 96 in the first stage evaporator. The concentrate that collects in the channel 103 is moving clockwise in the channel and escapes from the channel through a conduit 104 arranged tangentially to the channel 103 in a manner similar to that already described. The concentrate is collected in a reservoir 105 from which it is pumped by the pump 106 into the third stage evaporator 13 where it is still further concentrated and is discharged into the reservoir 107 in its final concentrated form.

Certain liquid products are impaired and their chief characteristics very much affected by high temperatures employed in the evaporating stages. In the present invention, this is avoided by atomizing the product and discharging it in currents of air at moderately high temperatures for only an extremely brief interval of time. It has been found that treated under such conditions, the products, such as milk, for instance, will retain all the original flavor and other characteristics.

Suitable valves 120 are provided for the reser-

voirs 98, 105 and 107 for removing the concentrate therefrom, if desired.

While in the construction shown, mechanism for a three stage evaporating system only is disclosed, it is evident that any suitable number of additional closed evaporating stages or circuits similar to the second stage circuit mechanism may be added between the second and third stage evaporating mechanism. It is also understood that the second stage may be omitted, if desired, for reducing the number of evaporating stages.

The system, as shown, may be regarded as composed of a front, a rear, and an intermediate section. The front section comprises the heater 15, fan 14 and first stage evaporator 11; the intermediate section comprises the second stage evaporator mechanism including the heat exchanger 16, the fan 17 and evaporator 12; and, the rear section includes the heat exchanger 18, the fan 19 and the third stage evaporator 13. The system may be contracted by removing the intermediate section which may be done by disconnecting the conduits 22, 53 and 102 at the points 112, 113 and 114 between the front and intermediate sections and at the points 115, 116 and 117 in the conduits 83, 77 and 104 between the rear and intermediate sections, closing the valve 118 in the liquid conduit 104, and then connecting the conduits 83 and 77 of the rear section to the corresponding conduits 22 and 53 of the front section. Additional intermediate units may be added between the forward and intermediate units or between the intermediate units or between two intermediate units. In other words, the intermediate units are interchangeable. This is considered an important feature of the invention because it permits the system to be enlarged or contracted to meet different operating conditions.

If a larger number of stages of evaporation be employed, in the interests of economy, the initial temperatures used should be increased to the point where the air and product discharged from the system are but slightly above atmospheric temperature.

In all constructions, the heat exchangers in the system function as a condenser for the preceding closed circuit and also as a heater for the succeeding circuit. The system is flexible—it can be extended or contracted, as desired, and be operated at various temperatures as best adapted for the particular product to be treated.

With the use of the centrifugal type of evaporator chamber for each stage of evaporation, the highest temperature for the drying medium may be relatively low, as for concentrating milk, for instance, and may be in the neighborhood of boiling water. This is extremely important in the evaporation or concentration of certain products, especially those products that are affected by chemical reactions caused or accelerated by high temperatures.

The following is one example of how the system may be operated in concentrating milk. Air enters the first stage evaporator 11 at around 219° F. and leaves the same at around 175° F. approximately saturated. A number of heat units are removed in the condenser from this saturated air thus condensing the moisture therefrom. These heat units are transferred to the air circuit of the second stage evaporator for heating the air in that circuit. The number of heat units removed by the heat exchanger 16 from the air in the first stage evaporator circuit are replaced by the heater 15. Likewise, the number of heat

units removed in the second stage evaporator circuit by the heat exchanger 18 and transferred to the air entering the third stage evaporator are replaced by the heat units transferred to it by the heat exchanger 16. The number of heat units transferred from the first evaporator circuit to the second, in the example given, and from the second to the third in the operation of the system may be the same in all stages. In each circuit, the air leaves the evaporator chamber substantially saturated. The temperature of the air entering each evaporator chamber is in decreasing order. For instance, air enters the second evaporator 12 at around 166° F. and leaves at around 125° F. saturated and the air enters the third chamber at around 115° F. and leaves at 73° F. saturated. The liquid product enters the first chamber at around 80° F., the second at around 175° F. and the third around 125° F. and leaves the third around 73° F. The system may be operated differently for different products and under different conditions and the above is given as one example of how the system may be operated in the interests of economy.

The construction herein disclosed has a high degree of efficiency because of the intimate contact between the air and the fine particles of the sprayed product at each stage of evaporation. Because of this efficiency in evaporation of the product in each stage, the air in the first stage need not necessarily be above about 220° F. when it enters the first stage evaporator. This temperature will not adversely affect the evaporation of milk. The system may be operated at higher temperatures, if desired, for evaporating other products or even milk if a greater degree of concentration is desired. But, if materially higher temperatures are employed, for instance, an additional unit may be necessary in the interest of economy, in this respect, the saturated air discharged from the system should be about, or possibly above, the temperature of the outside air.

It will thus be seen that there are three circuits for the drying medium; that the first two are closed circuit, and the third an open circuit; that there is a circuit for each evaporating stage; that the drying medium for the first stage only is heated; that the drying mediums for the remaining stages are heated by a heat exchanger from the preceding stage; and, that the drying mediums operate at moderate temperature.

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. A method of concentrating a liquid product which comprises discharging the product in the form of a spray into a spirally moving current of heated air for evaporating a portion of the moisture of said product to form a concentrate, transferring a portion of the heat of said heated air to another volume of air, causing the last-named air to move spirally into a second stage evaporator chamber, spraying said concentrate into said last-named spirally moving air, and removing the concentrate from said second-stage evaporator.

2. A system for concentrating liquid products comprising a plurality of concentrating stages, a centrifugal evaporator in each stage, means for spraying a liquid product in each evaporator, a

gaseous drying medium for each stage, means for causing said medium to circulate through said evaporators for evaporating moisture from the sprayed particles, means for heating the drying medium in the first stage evaporator, and means for transferring heat from the first stage medium in succession to the mediums of the remaining stages for evaporating moisture from the sprayed concentrate from the preceding evaporating stage.

3. In a system for dehydrating a liquid product, a first stage section, a final stage section and one or more intermediate stage sections, each stage section comprising a cyclone separator type of concentrator, and having a separate circuit for a heating medium for each section and a common heat exchanger between adjacent sections, means for adding thermal units to the heating medium of the first stage section, means, including said heat exchangers, for transferring a portion of those units to the remaining stage sections successively, means for causing the heating medium in the chambers to move spirally, and means for spraying the product into the spirally moving air in each chamber, in series, from the first to the final stage sections.

4. In a system for dehydrating a liquid product, a first stage section, a final stage section and one or more intermediate stage sections, each stage section comprising a cyclone separator type of concentrator and having a separate gaseous drying medium circuit for each stage section, means for adding thermal units to the drying medium of the front stage section, heat exchangers common to adjacent sections for transferring heat from the drying medium of the first stage section to the drying medium of the other stage sections in succession, means for discharging the liquid product into said air within said chambers, means for conducting the air from the top portions of the chambers, and means for conducting the concentrate from the lower portions of said chambers.

5. An apparatus for concentrating liquid products comprising first, second and third stage evaporators, a first stage heat exchanger and a second stage heat exchanger, means for circulating a drying medium through said first stage evaporator and first stage heat exchanger in a closed circuit, means for heating the drying medium just prior to its entry into the first stage evaporator, means for circulating a drying medium through said second stage evaporator and through said first and second stage heat exchangers in a closed circuit, means for circulating fresh air through the third stage evaporator and said second stage heat exchanger, means for spraying a liquid product into the first stage evaporator for concentrating the product, means for spraying the concentrate from the first stage evaporator into the second stage evaporator for further concentrating said product, and means for spraying the further concentrated product from said second stage evaporator into said third stage evaporator for dehydrating the same.

6. In an apparatus for evaporating moisture from a liquid product, a plurality of evaporating chambers of the centrifugal type arranged in series for the passage of the product therethrough, a reservoir for containing the liquid product to be evaporated, liquid spraying means in each chamber, means for conducting said product from said reservoir to the spraying means in the first of the chambers of said series and for conducting the concentrated product from each

chamber, except the last, to the spraying means of the succeeding chamber, a heater anterior to the first evaporating chamber, a heat exchanger anterior to each of the remaining evaporating chambers and posterior to each, except the last, conduits for conducting a gaseous drying medium to and from the first chamber in a closed circuit through said heater and the first of said heat exchangers, conduits for forming a closed circuit for a drying medium through each of the succeeding chambers and corresponding heat exchangers in a closed circuit, except for the last evaporator chamber, the drying medium for which is discharged directly into the air, and means in each chamber for causing the drying medium to descend in an outer spiral and to ascend to the discharge opening in an inner spiral.

7. In an apparatus for concentrating a liquid product, first, second and third stage evaporators, means for spraying a liquid product into said evaporators in series in the order named, a heater, a first and a second stage heat exchanger, means for continuously circulating a drying medium through said heater, first stage evaporator and through said first stage heat exchanger in a closed circuit for removing moisture from said product, means for circulating a drying medium through said first stage heat exchanger, said second stage evaporator and through said second stage heat exchanger in a closed circuit for removing further moisture from said product, and means for circulating a drying medium through said second stage heat exchanger and said third stage evaporator for removing still further moisture from said product, said heat exchangers functioning as condensers for the one circuit and as a heater for the following circuit.

8. A method of concentrating a liquid product which comprises evaporating moisture from the product in a plurality of stages in series by first spraying the product into a current of spirally moving air confined in a chamber in each stage in succession, causing the air in the first stage chamber to flow in a closed circuit through a heater, then through said last-named chamber for removing moisture from said product and then through a heat exchanger for removing moisture from said air, causing air for the second stage chamber to flow through said heat exchanger for heating said air, then through said second stage chamber for removing further moisture from said product, then through a second heat exchanger, and finally causing fresh air to flow through said last-named heat exchanger through the last-stage chamber and into the atmosphere.

9. In a system for concentrating a liquid product, a first stage evaporating mechanism, a final stage evaporating mechanism and a removable intermediate stage evaporating mechanism arranged in series, means for spraying a liquid product into said evaporators in series, each mechanism comprising a cyclone type of evaporator, a heater for the first stage evaporator, a heat exchanger between the first and intermediate stage mechanisms, a second heat exchang-

er between the intermediate and final stage evaporators, means for circulating a drying medium through said heater, first stage evaporator and the first mentioned heat exchanger, means for circulating a separate body of drying medium through said first-named heat exchanger, said intermediate stage evaporator and said second heat exchanger, means for circulating a body of air through said second heat exchanger and said final stage evaporator, and means for detachably connecting said sections together, said means being so constructed and arranged that said intermediate mechanism may be removed and said first and final stage mechanisms may be operatively connected together.

10. In a system for concentrating liquid products, an apparatus comprising a first stage section, a final stage section and at least one intermediate stage section, each section comprising a cyclone separator type of evaporator chamber and each section having a separate air circuit, a heat exchanger common to adjacent sections, means for forcing air through each of said circuits and through the corresponding heat exchanger, said heat exchangers constituting condensers for the preceding circuit and a heater for the next succeeding circuit, means for spraying a liquid product in succession into said sections into the air moving through said evaporators, and means for detachably connecting said sections together whereby the number of sections may be readily expanded or contracted.

11. In an apparatus for evaporating moisture from a liquid product, a plurality of evaporating chambers of the centrifugal type arranged in series for the passage of the product there-through, a reservoir for containing the liquid product to be evaporated, liquid spraying means in each chamber for spraying said product into a rotating body of gaseous medium in said chamber, means for conducting said product from said reservoir to the spraying means in the first chamber of said series and for conducting the concentrated product from said first chamber to the spraying means of the succeeding chamber, a heater anterior to the first evaporating chamber and a heat exchanger posterior thereof, conduits for conducting a gaseous drying medium to and from the first chamber, means including said conduits and a fan for circulating all of said drying medium through said heater in a spiral path through the first chamber of said series and then through said heat exchanger in a closed circuit, in the order named, conduits for conducting a gaseous evaporating medium through said heat exchanger for heating said evaporating medium and for causing the removal of moisture by condensation from the gaseous drying medium flowing through said heat exchanger, and means including said last-named conduits and a fan for causing all of said evaporating medium to flow through said heat exchanger and the next adjacent evaporator chamber of said series in the order named for further reducing the moisture content of said liquid product.

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