APPARATUS FOR REMOVING MOISTURE FROM LIQUID PRODUCTS

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This invention relates to a system for dehydrating liquid products.

One of the objects of the invention is the provision of a new and improved system for dehydrating liquid products by the use of a closed system for the dehydrating fluid together with novel means for shunting a portion of the heating or drying fluid through an evaporator for concentrating the liquid product preparatory to dehydrating the same.

Another object of the invention is the provision of new and improved apparatus for dehydrating liquid products by the use of superheated steam and novel mechanism for cooling and collecting the dehydrated material.

A further object of the invention is the provision of an improved method of dehydrating liquid products by the use of superheated steam and with a maximum conservation of heat.

A still further object of the invention is the provision of a new and improved apparatus for concentrating and dehydrating liquid products that is simple in construction, economical to operate, efficient in use, comparatively easy to install and that is composed of a minimum number of parts.

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 a modified form of nozzle.

In the concentrating and dehydrating of liquid products, it is necessary that a considerable amount of heat be available for evaporating the moisture contained in the product. In order that any method of evaporation or dehydration be performed economically, it is necessary that the heat applied to the heating fluid be utilized to the maximum extent. The present invention will be disclosed as utilizing super-heated steam as the heating or drying fluid and this fluid is recirculated through the dehydrating chamber. The moisture evaporated from the liquid product is converted into super-heated steam which is also recirculated. The excess steam is removed from this dehydrating system by first shunting it through a steam-jacketed evaporator and the resulting steam and condensate reintroduced into the steam under pressure, a portion or all of which is used to operate steam motors for driving pumps and other mechanism used in connection with the dehydrating system, the exhaust of this mechanism being further used as a heating medium for the feed water heater that supplies water to the primary boiler or steam generator.

Referring now to the drawings, the reference numeral 18 designates the concentrating and dehydrating system or apparatus which comprises a boiler or steam generator 11 for generating steam to be used as a drying fluid, a superheater 13 for superheating this fluid, a dehydrator or evaporator 15 into which the drying fluid for desiccating or dehydrating a liquid product is conducted, a collector 16 for collecting the dried particles, a cooler or cooling mechanism 28 for cooling the collected dehydrated material, evaporator mechanism 15 for concentrating the liquid product preparatory to dehydrating the same, a reservoir 16 for supplying the product to the evaporator, a condenser 17 for condensing the moisture evaporated from a liquid product in the evaporators, a vacuum pump 18 for reducing the pressure in the evaporators and a feed water heater 19 for pre-heating the water supplied to the boiler or steam generator 11.

The boiler or steam generator 11 may be of any suitable construction. In the form shown, it comprises a heating chamber 21 having a combustion chamber 22 in the front end thereof and a boiler 23 above the heating chamber. A baffle 24 within the heating chamber is adapted to direct the heat upwardly toward the boiler 23. An oil or gas burner 25 supplies fuel to the combustion chamber. The products of combustion pass...
through flues of the boiler 23 into the stack 28 as is usual in such constructions.

Steam from the boiler 23 is conducted by pipes 27 and 28 into the header or antechamber 30 of the super-heater 12. Steam from the boiler is maintained under pressure by adjusting the valves 31 and 32 in the pipe 28. This pressure may be maintained at any suitable amount, preferably such that it may be used to operate pumps and other motors used in the plant. By means of the valve 31, the steam from the boiler 23 may be expanded into the antechamber 28 to such an extent that the pressure is preferably, though not necessarily, maintained at substantially that of the atmosphere or slightly above. The steam is directed by a fan 33 through the super-heater 12 where it is very greatly increased as to temperature but its pressure is maintained at about atmospheric.

The superheater comprises a heating chamber 34 having the baffles 35 and 36 extending upwardly from its bottom wall and the heat exchanger 38 comprising the heating elements or tubes 37 in its upper portion. Attached from the upper wall 38 of the superheater is a baffle 39 extending downwardly between the baffles 35 and 36. The firebox or combustion chamber 41 is provided with a suitable burner 42 and the highly heated products of combustion of this burner are directed in a zig-zag path among the tubes 37 of the superheater by the baffles 35, 39 and 36. These gases are discharged through a pipe 43 into the stack. The superheated steam is conducted through a conduit 44 to the dehydrator 13 and withdrawn from the dehydrator 13 and conducted back through the conduit 44 to the fan 33 thus forming what will be termed a closed circuit for the dehydrating fluid, as will presently appear.

Suitable means are provided for concentrating the liquid product before it is discharged into the dehydrator 13. In the form of the construction shown, the primary evaporator 46 and a secondary evaporator 47 are employed for this purpose. The evaporator 46 comprises a casing 48 having partitions or tube sheets 49 and 51 spaced from each other and in which a plurality of tubes 52, extending longitudinally of the casing 48, are secured. The tube sheets 49 and 51 divide the evaporator into an upper header 53 and a lower header 54. The space within the casing 48 between the tube sheets 49 and 51 and among the tubes 52 constitutes what may be termed a heating or steam jacket 50 and steam conducted from the dehydrating system is conducted to this jacket to heat the liquid product which is supplied to the header 54 from the reservoir 16 by the pipe 55. As shown on the drawings, a conduit 56 is employed for conducting steam from the separator 14 to the steam jacket 50 for evaporating moisture from the liquid product contained in the evaporator 46, as will presently appear. This steam, on being condensed, or partially condensed, is withdrawn from the jacket 50 through a pipe 57 and delivered to the feed water heater 19 for preheating the same preparatory to delivering it to the boiler 11.

The form of steam generated in the evaporator 46 passes over into a liquid collector 58 through a pipe 59. Due to the agitation of the material in the boiling operation in the evaporator 46, particles of the liquid are carried over by the steam into the collector 58 and are directed by a deflector 60 into the bottom of the evaporator. The steam separated from these particles is conducted over to the steam jacket 50a of the secondary evaporator 47 through a pipe 60 for further evaporating moisture from the liquid product in this evaporator.

The lower header 54a of the secondary evaporator 47 is in communication with the header 54 through a tube 61 having a thermostatic valve therein for controlling the flow of condensate through this tube to the header 54a. The collector 58 is in communication with the pipe 61 through a pipe 62 so that the liquid collected in the lower portion of the collector 58 is fed into the header 54a of the evaporator 47 along with the condensate from the header 54. Since the construction of the secondary evaporator 47 is substantially the same as that of the primary evaporator 46, it is not thought necessary to repeat the description.

The steam introduced to the jacket 50a through the pipe 60 is adapted to evaporate further moisture from the liquid product contained in the evaporator 47. This may be done by reducing the pressure in the evaporator, as will presently appear. Due to the violent boiling of the liquid, particles of the same will pass over with the evaporated steam through the passage 71 leading from the header 53a into a collector 63 which is similar to the collector 58. A deflector 64 directs the liquid into the bottom part of the collector and permits the steam to escape through a pipe 65 which leads to the condenser 17. The condenser 17 is in communication with the vacuum pump 16 through a tube or pipe 66.

The bottom header 54a is in communication with an atomizing mechanism 67 of the dehydrator 13 through the pipes or tubes 68 and 69, as shown in Fig. 1 of the drawings. The amount of concentrated liquid material supplied to the dehydrator through the tube 65 is controlled by a valve 68, Fig. 1. A pump 71 in the pipe 66 is adapted to deliver the concentrate to the spray mechanism under pressure. The lower end of the collector 63 is in communication with the tubes 68 and 69 through a pipe 72 which conducts the collected liquid product to the pump 71.

In order that the liquid product shall flow from the evaporator 46 to the evaporator 47 and that the steam evaporated from the liquid in the evaporator 46 shall be carried over into the evaporator 47 and shall evaporate moisture from the liquid product contained in the evaporator 47, it is necessary that the pressure in the jacket 50a and on the liquid contained in the header 54a be maintained less than that in the evaporator 46. For reducing the pressure on the liquid product contained in the evaporator 46, the heating jacket 50a of the evaporator 47 is in communication with the exhaust pump 16 by means of a pipe 73 secured at one end in the jacket 50a and in communication with the pipe 66 at its other end. A valve 74 in the pipe 13 is adapted to control the pressure within the evaporator 46, which is accomplished through the pipe 60, collector 58 and passage 30 leading from the header 53 to the liquid collector 58. By properly adjusting the parts, the pressure in the jacket 50a of the evaporator 47 is maintained slightly below that in the evaporator 46 so that the vapor evaporated in the evaporator 46 in will flow into the heating jacket 50a of the evaporator 47. The pressure in the evaporator 47 is considerably reduced owing to its connection through the collector 58 and conduit 60 with the condenser 17 and vacuum pump 16 whereby the liquid in the evaporator 47 will boil at greatly reduced temperature.

The liquid product is delivered by a suitable pump 71, or the like, through the pipe 69 to the
spray or atomizing mechanism 67. The spray mechanism comprises a spray head 76, Figs. 6 and 7, rigidly mounted on a rotating hollow spindle 16, see Fig. 6, which extends upwardly through the conduit 44 and 45, Fig. 2, and is surrounded by a housing 77 which is rigidly secured to a plate 76, Fig. 6, which in turn is mounted on the upper wall of the conduit 45. The spindle is adapted to be rotated by a suitable motor 78 mounted on a plate 81 secured to the plate 78. The spindle 16 is hollow, as shown at 80, for conducting the liquid product to the spray head and may be attached to, or constitute a prolongation of, the armature shaft 82 of the motor, see Fig. 6. The housing 77 is provided with a cap preventing the dehydration fluid from overheating the liquid product during its flow through the spindle.

Surrounding the housing 77 is a casing 84 having its upper end rigidly connected to the plate 78 as by being welded thereto and having its lower end tapered for engaging the housing 77 to which it is rigidly connected as by welding or the like. The casing 84 constitutes a brace for holding the housing 77 rigid relative to the plate 78. Slidably splined on the lower end of the spindle 16, see Fig. 7, is a hub 83 of the spray head 78. This hub is held in position on the spindle 16 by a bullet nosed cap member 85 having its tapered portion extending downwardly and having an axial projection 87 thereon extending upwardly into a recess 88 in the hub 83 and having integral threads for engaging screw-threads on the lower end of the spindle 16. The cap 85 is provided with an annular shoulder 89 which is adapted to engage a corresponding annular projection 91 on the hub 83 for holding the parts rigidly connected together. The cap member 85 is secured at its central portion with a cavity 92 which is in communication with the bore 90 of the spindle 76 and constitutes a small reservoir for liquid delivered thereto through caused bore. Radial passages 93 extend to the recess 88.

Suitable bearings are provided for the lower end of the spindle 16. In the form of the construction shown, two sets of ball bearings 93 are employed for this purpose. These bearings are slidably mounted on the reduced lower end of the spindle 76 whereby the spindle may be removed when necessary or desired. The bearings are mounted in a sleeve 94 which is provided on its upper end with a rabbet 95 for receiving the lower end of the casing 77 to which it is rigidly secured as by being welded thereto. The lower end of the sleeve is provided with a cap 96 having an axial opening for receiving an upwardly extending projection 97 of the hub 83. The projection 97 is adapted to engage the inner race of the lower roller bearing for holding the roller bearings in position against a shoulder 98 on the spindle 76, as clearly shown in Fig. 7 of the drawings. The cap 96 is secured to the lower end of the sleeve 94 by means of the tapped screws 99. The cap 96 is provided with a recess in which a liquid seal 101 is mounted.

The spindle 76 is rotated at high speed and in order to prevent heating of the bearings, these bearings are water-cooled. As shown, the sleeve 94 is provided with an annular recess 102 and water is adapted to be circulated around this recess. The water enters through a pipe 103 and is discharged through a pipe 104.

Means are provided also for lubricating the bearings. As shown, a passage 105 leading to a cavity 106 above the bearings is provided with a grease nipple 108 through which the lubricant may be introduced.

The hub 83 is provided with a plurality of radially extending arms or nozzle members 106 each having an axial bore 109 in communication with the recess 88 and the recess 92 in the spindle 76 through the passages 93. The outer ends of the arms 106, 22 are rigidly connected to an annular deflector member 111 which is concave on its outer surface, as clearly shown in Fig. 7. The arms 106 are so constructed that they constitute the vanes of a fan for exhausting the dehydration drying medium from the dehydrator, as will presently appear. The arms are so constructed that the flow of the exhaust will be uniform from the inner to the outer ends of these arms. In order that this may be accomplished, the flat portion 112 of the inner end of the arm, Fig. 9, is turned at a greater angle to the horizontal than the flat portion 113 of the outer end of said arms, Fig. 10.

The outer ends of the arms 106 are each provided with threaded sockets 114 for receiving the inner threaded ends of the spray nozzles 115 which extend outwardly beyond the deflector member 111. These nozzles is provided with a bore 116 which is adapted to align with the bore 109 of the corresponding arm when it is attached to its supporting arm and the outer end of the bore 116 is greatly reduced to form a nozzle or atomizer opening as at 117. The high velocity of the rotation of these nozzles tends to atomize the liquid or discharges the same in the form of a spray in the dehydrator.

Liquid products vary so much in their fluidity and other characteristics that in order to properly atomize the same it is desirable to have nozzles of different lengths and atomizer openings of different diameters. For instance, where the liquid product is thicker or more or less viscous, a nozzle of shorter length and larger atomizer opening is provided; such, for instance, as the construction shown at 119 in Fig. 11. When thicker products, or products of less fluidity, are to be atomized, the nozzle 115 is unscrewed and nozzle 118 attached in its place.

The cap 85 is provided with a transverse opening 119 for receiving a tool for attaching or removing the cap. By means of this arrangement, the head may be readily removed by first removing the cap 85 and then sliding the head downwardly from the spindle 76. After the head has been removed, the spindle 76 may be readily removed by disconnecting the pipe 93 from the motor, releasing the motor base from the plate 78 and moving the same upwardly. This is considered an important feature of the invention because the head and other parts of the mechanism must be cleaned at frequent intervals, usually at least once every twenty-four hours when used for dehydrating food products.

Suitable means are provided for directing the superheated steam entering through the passage 44 downwardly across the liquid spray discharged by the nozzles. In the construction shown, the top wall 121 of the dehydrator chamber 13 has an axial opening in which is rigidly secured a guide member 122, Fig. 2. This guide member is in the form of a frustum of a cone having its side wall converging downwardly with its lower end curved outwardly as shown at 123, see Figs. 6 and 7. Opposite the guide member 122 is the deflector 111. A downwardly tapered casing 124, see Fig. 2, extending through the upper wall of the passage 44 is rigidly attached to the bottom
wall of the passage 48 as shown in said figure. It is also rigidly secured to the upper wall of the passage 44 and forms a gas or steam-tight joint therewith. The lower end of the casing 124 has rigidly attached thereto an annular reinforcing or strengthening ring 125 which has its lower end provided with an inclined surface 126 which diverges downwardly. The deflector 111 is provided on its upper edge with a corresponding inclined surface 127 which converges upwardly. These inclined surfaces overlap each other and are in close proximity as clearly shown in Fig. 7 and by means of this arrangement, the dehydrated medium which flows downwardly through the intake passage 128 formed by the casing 124 and deflector 111, will not tend to bypass into the exhaust passage 130 formed by the casing 124.

The steam, or other drying gaseous medium, in passing down the passage 120 between the directing member 122 and the casing 124, will be directed outwardly and downwardly across the outer end of the nozzle 116 by the deflector 111 thereby atomizing the liquid product as it escapes through the atomizer-opening 117.

The dehydrator is so constructed that it functions somewhat like a cyclone separator and in order that a greater portion of the steam, or drying medium, shall be separated from the dehydrated material after it is desiccated, suitable means are provided for causing the steam, when it is introduced into the dehydrator, to rotate about the axis of the dehydrator so as to centrifugally separate the solid material from the dehydrating fluid employed. As shown, the steam passing through the conduit 44 is conducted through a snail 129, that is, is caused to take a spiral path about the axis of the collector and it continues in a spiral path as it passes through the intake passage 128 across the nozzles 116 into the dehydrator where it encounters the finely divided liquid particles that are being discharged by the spray head as it rotates at high speed, thereby dehydrating or reducing the moisture content of those particles. The high speed at which the nozzles rotate through the entering stream of drying medium and the friction between the incoming drying medium and the nozzles or deflector 111 will cause an increase in the rotating velocity of the entering steam or drying medium. This spiral motion of the steam will cause the dried particles of the liquid product to be thrown outwardly by centrifugal force toward the walls of the dehydrator and will be directed by the conical wall 131 downwardly by gravity into a circular passage 132 at the bottom of the dehydrator, Fig. 2.

The intake of the fan 33 is connected to the passage 45 and this, together with the fan blades 108 of the spray head, will exhaust a greater portion of this steam axially upwardly through the casing 124 from the dehydrator. As a result of this construction, the drying medium entering the chamber from the conduit through a deflector 111, moves downwardly in an outer spiral to the lower portion of the chamber, reverses and flows upwardly in an inner spiral in contact with the outer spiral and is discharged through the passage 130 into the discharge conduit 46.

The dehydrator 13 is provided with a channel 133 around its lower end for receiving the dehydrated material flowing down the inclined walls 131 thereof. The conical walls 131 extend slightly over this passage as shown at 133. An inverted conical deflector member 134 has its lower edge extending slightly over the passage 133 as at 135 and its apex extends axially upwardly within the lower portion of the dehydrator for directing the particles falling thereon into the circular channel or passage 132. The overhanging portions 132 and 136 of the walls 111 and 134 tend to prevent the particles falling into the passage 132 from escaping back into the dehydrator, as will presently appear.

Where dehydrator is completed within the chamber 14, the dried particles falling into the passage 132 are at such temperature that they must be cooled before storage in order to avoid agglomeration. The cooling mechanism 26 is located at any convenient position, either directly below the dehydrator or spaced laterally therefrom. If directly below, the dehydrated particles may fall by gravity into the cooling mechanism, but if located laterally thereof, as shown in the drawings, suitable means must be provided for conveying those particles to the cooling mechanism. Any suitable conveyor may be used for this purpose.

In the construction shown, which is by way of example only, a fluid conveyor is employed for this purpose. The use of a fluid conveyor necessitates the use of a collector for separating the dehydrated material from the conveying fluid. The centrifugal collector 14, which is of conventional design, is employed for this purpose. The fan of the collector 14 has its intake in communication with the passage 132 through a conduit 137 for conveying the dried particles mixed with a limited amount of steam, or other drying medium, from the dehydrator over to the collector. In order that this steam, or other medium, shall remain dry or superheated, a suitable shunt is provided in the form of a passage or conduit 136 for shunting a portion of the heated drying medium from the conduit 44 into the passage 132 for raising the temperature of the steam therein and also for boosting the velocity of the steam around the channel 132 and through the pipe 137. The amount of steam, or other drying medium, directed through the passage 132 is adapted to be controlled by a valve 140. Just sufficient heated drying gaseous medium or superheated steam is employed to insure the dehydrated particles remaining rotational velocity being conveyed to the cooling mechanism. The conduit 136 directs steam, or other heated drying medium to the passage 137 as at a point adjacent to, but not in communication with, a discharge passage 137 which conducts the steam to the collector 14. The passages 136 and 137 being adjacent to each other, the steam is caused to move around the passage, as will appear from an inspection of Fig. 4. This movement of the steam will insure against the dried particles collecting in the passage 132 and obstructing free flow of those particles. The mixture of steam and dried particles will be separated in the collector 14. The dry particles are discharged through the passage 136 and the steam discharged through the passage 50 which is tangential to the collector 14. The steam is conducted to the jacket 17 of the primary evaporator, as described above.

It will thus be seen that the steam circulated through the dehydrator for desiccating the liquid product operates in what may be termed a closed circuit and for convenience of description will be called the dehydrating circuit. In this circuit the steam forced through superheater 12 passes along the conduit 44 into the dehydrator 13 and back through the casing 124, conduit 45 and fan.
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33 to the superheater. There is also what may be considered a closed circuit for the heating fluid utilized by the evaporator 46 for heating the liquid products therein. In this circuit, which may be termed the evaporator circuit, steam from the boiler 23 passes through the pipes 27 and 28 into the antechamber 29, thence through the superheater or heat exchanger tubes 37, down the pipe 38, around the passage 133, thence through the passage 133, through the collector 14, into the passage 56, then into the heating jacket 50 of the evaporator 46, from thence the steam and condensate are conducted through the pipe 57 to the preheater 19, and from thence back to the boiler 11, thus completing the circuit.

Under certain conditions it is necessary, or at least desirable, that a considerable portion of the steam be taken from the primary heater 11 and introduced into the dehydrating system, and at the same time additional water be introduced through the valve 148, as, for instance, when milk is being dehydrated and it is tainted with objectionable odors, as wild onions, and the like. In such cases, more of the steam generated in the boiler is continuously introduced into the system in order that the drying fluid be mixed with fresh steam for maintaining the drying fluid in a more or less uncontaminated condition.

In order to cool the material conveyed from the dehydrator, or evaporator chamber, it is discharged from the conveyor and separator 14 into the cooler 20. The cooler 20 comprises a support 155 on the top of which is mounted the separator 14 and which also supports a cyclone collector 155. The dried material separated from the steam is discharged through the passage 155 into the collector 150 across the discharge passage 139 of a fan 141 which discharges air tangentially into said collector. This air cools the product and finally escapes upwardly through an axial passage 155. The collector 150 operates as a cyclone collector for separating the cooled solid particles from the air discharged from the fan 141. This fan may be operated by an independent motor 142 and the air may be taken from the atmosphere or from a suitable source of conditioned air. The centrifugal separator 14 is adapted to be operated by a suitable motor 143, see Fig. 5. Since the separator 14 employed may be of any commercial type and since the details of this separator constitute no part of the present invention, it is not thought necessary to specifically describe the same any further than to say it is of the horizontal centrifugal type.

The cooled particles gravitate to the lower conical portion of the collector 150 from which they may be removed through a rotary valve 151 operated by a motor 152.

Since moisture is being continuously added to the system from the liquid product, it is necessary to continuously remove the same amount from the system. In the construction shown, this is accomplished by using steam through the pipe 145 from the boiler for operating pumps such as the vacuum pump 18 where the steam from the pipe 148 enters the pump 18 through the passage 149 and the pipe 146 discharges the exhausted steam. Where the steam necessary to operate the pumps and other motors is in excess of that evaporated from the liquid products, which it is usually is, it is necessary to add fresh water to the system and this may be done through the pipe 141, the amount being controlled by a valve 148.

The preheater 19 is of the usual or any well known construction and in the form shown, the pipe 57 delivers the steam and the condensed moisture into the preheater and is pumped therefrom by the pump 148 into the boiler. The preheater is adapted to be heated by exhaust steam entering through the pipe 151 and is discharged through the pipe 152. The exhaust steam may be taken from the pumps as from the discharge of the vacuum pump 18 through the pipe 146 or from other engines and pumps employed in the plant.

If it is desired to remove a portion of the concentrate, it may be removed through a branch pipe 157, the flow of the liquid being controlled by a valve 158.

When necessary or desirable, steam may be shunted from the boiler 11 into the jacket 50 or passage 56 for raising the temperature of the steam contained therein, this is done by manipulating the valve 32. In order not to exert too much back pressure in the pipe 56, the valve 32 is operated so as to cause the steam to expand in the pipe 144 so as to maintain the pressure therein below that in the passage 56.

In the operation of the system described above for dehydrating milk, the following results were obtained to give satisfactory results. The pressure of the steam in the boiler 11 was whatever was necessary to operate the various pumps and other apparatus in the plant and was around 50 to 70 pounds. The steam or vapor introduced into the dehydrator was around 400° to 450° F. and at very low pressure, about that of the atmosphere or slightly above. The cubical capacity of the dehydrator was about 5,000 cubic feet and the velocity of the steam was such that about 15,000 cubic feet was introduced into the dehydrator per minute. The powder was discharged at around 225° F. and was cooled to 100° F. The above is given by way of example only and it is not here intended that the words used shall be construed as words of limitation but merely as words of description of one form of the device that has proven practical.

While the dehydrator 13 and associated mechanism is disclosed as completely drying the sprayed particles, it is understood that by increasing the feed of the liquid product or by spraying a fresh product into the chamber in sufficient volume, the mechanism will function as a concentrator for concentrating the liquid product.

This is a division of my application, Serial No. 244,042.

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, proportions and details of construction may be made without departing from the spirit and scope of the appended claims.

I claim:

1. In an apparatus for concentrating and dehydrating liquid products, a steam generator, a dehydrator, a superheater for superheating steam from said generator, means for discharging a spray of liquid products into said dehydrator, means for discharging a steam of superheated steam from said superheater into the upper portion of said dehydrator in a downwardly moving spiral across said spray for dehydrating the particle of said spray, an evaporator for containing a liquid product, and means for conveying a portion of the steam from said superheater to said evaporator for concentrating said liquid product.
In a system for dehydrating liquid products, a superheater, means for discharging a liquid product in the form of a spray, a superheater, means for discharging a liquid product, means for recirculating steam through said superheater and dehydrator, an evaporator for concentrating said liquid product, and means for reproducing an aqueous fluid through said generator, a plurality of evaporators arranged in a predetermined order for concentrating said liquid product prior to its delivery to said dehydrator, a source of supply of said liquid product, means for conducting the said vaporizers to the one next in order of said vaporizers for further concentrating said liquid product, and means for reducing the pressure on said product in at least one of said evaporators.

In a system for dehydrating liquid products, a dehydrator, means for discharging a liquid product in the form of a spray, means for discharging a superheated fluid across said spray for dehydrating the particles of said spray, means for withdrawing the major portion of said fluid through the upper portion of said dehydrator, a channel extending about the lower portion of said dehydrator, a cooler, and means for conducting superheated fluid through said channel for heating said dehydrated material and for conducting the same from said channel to said cooler.

In an apparatus for dehydrating a liquid product comprising a dehydrating chamber, means for introducing a superheated steam drying medium at substantially atmospheric pressure into said chamber, means for spraying a liquid product into said drying medium, a superheater, a boiler, means for circulating steam in a closed circuit through said superheater and dehydrator, an evaporator, means for supplying a liquid product to said evaporator, means for conveying steam from said superheater to said evaporator for evaporating moisture from said product, means for conducting said steam in condensed form to said boiler, means for conducting steam from said boiler to said superheater, and a conduit for conducting steam from said system for use in other apparatus for compensating for the increase in steam derived from the moisture evaporated from said product.

In an apparatus for concentrating and dehydrating liquid products, a boiler for vaporizing a drying medium, a superheater for superheating the vapor of said medium, a dehydrator, means for discharging a spray of liquid products into the upper portion of said dehydrator, a channel extending around the lower end of said dehydrator, a cooler, a conduit between said channel and cooler, and means for introducing superheated steam into said superheater for assisting in conveying the dehydrated product to said cooler.

In a system for dehydrating liquid products, a steam generator, a dryer, a dehydrator, means for spraying a liquid product into said dehydrator, a channel extending around the lower end of said dehydrator, a cooler, a conduit between said channel and cooler, and means for introducing superheated steam into said superheater for assisting in conveying the dehydrated product to said cooler.
12. In a system for dehydrating liquid products, a steam generator, a steam superheater, a dehydrator, means for spraying a liquid product into said dehydrator, means for conducting steam from said generator through said superheater into said dehydrator, means for discharging said steam into the upper portion of said dehydrator for reducing said liquid product to powder form, cooling mechanism, means including steam for conducting hot dehydrated products in powder form from said dehydrator and delivering the same to said cooler, and means for discharging air onto said product for cooling the same.

13. In a system for dehydrating liquid products, a steam generator, a dehydrator, means for spraying a liquid product in finely divided particles into the upper portion of said dehydrator, a superheater, means including a conduit for conducting superheated steam from said superheater to said dehydrator and for discharging the same in a downwardly moving spiral across said particles for dehydrating the same, a second conduit for conducting the steam back to said superheater for reheating the same, a cooler for discharging fresh air across the dehydrated product for cooling the same, means for circulating an aqueous fluid through said generator and converting the same into steam and for conducting the steam through said superheater and dehydrator and for conducting the dehydrated material to said cooler, and means for cooling the dehydrated material delivered to said cooler.

14. In a system for dehydrating liquid products, a dehydrator, means for delivering a liquid product to said dehydrator in the form of finely divided particles, means for dehydrating said particles by the aid of steam, a cooler, means for heating said particles with steam and for conducting the same to said cooler, means for cooling said particles with a current of cool air, and means for separating the dehydrated particles from said air.

15. A method for dehydrating a liquid product which comprises concentrating the product, atomizing the concentrated product into a stream of superheated steam for dehydrating the particles, heating the dried particles and conducting the same to a distance by a current of steam, separating the dried particles from the steam, cooling the dried particles with a cooling medium, and finally separating those particles from the cooling medium.

JOSEPH M. HALL.

CERTIFICATE OF CORRECTION.


JOSEPH M. HALL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 6, second column, line 73, claim 11, after the word and comma "dehydrator," insert --and means for--; and that the said letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 15th day of May, A. D. 1945.

Leslie Frazer
Acting Commissioner of Patents.
12. In a system for dehydrating liquid products, a steam generator, a steam superheater, a dehydrator, means for spraying a liquid product into said dehydrator, means for conducting steam from said generator through said superheater into said dehydrator, means for discharging said steam into the upper portion of said dehydrator for reducing said liquid product to powder form, cooling mechanism, means including steam for conducting hot dehydrated products in powder form from said dehydrator and delivering the same to said cooler, and means for discharging air onto said product for cooling the same.

13. In a system for dehydrating liquid products, a steam generator, a dehydrator, means for spraying a liquid product in finely divided particles into the upper portion of said dehydrator, a superheater, means including a conduit for conducting superheated steam from said superheater to said dehydrator and for discharging the same in a downwardly moving spiral across said particles for dehydrating the same, a second conduit for conducting the steam back to said superheater for reheating the same, a cooler for discharging fresh air across the dehydrated product for cooling the same, means for circulating an aqueous fluid through said generator and converting the same into steam and for conducting the steam through said superheater and dehydrator and for conducting the dehydrated material to said cooler, and means for cooling the dehydrated material delivered to said cooler.

14. In a system for dehydrating liquid products, a dehydrator, means for delivering a liquid product to said dehydrator in the form of finely divided particles, means for dehydrating said particles by the aid of steam, a cooler, means for heating said particles with steam and for conducting the same to said cooler, means for cooling said particles with a current of cool air, and means for separating the dehydrated particles from said air.

15. A method for dehydrating a liquid product which comprises concentrating the product, atomizing the concentrated product into a stream of superheated steam for dehydrating the particles, heating the dried particles and conducting the same to a distance by a current of steam, separating the dried particles from the steam, cooling the dried particles with a cooling medium, and finally separating those particles from the cooling medium.

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January 23, 1945.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 6, second column, line 73, claim 11, after the word and comma "dehydrator," insert --and means for--; and that the said letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 15th day of May, A. D. 1945.

Leslie Frazer
Acting Commissioner of Patents.

(Seal)