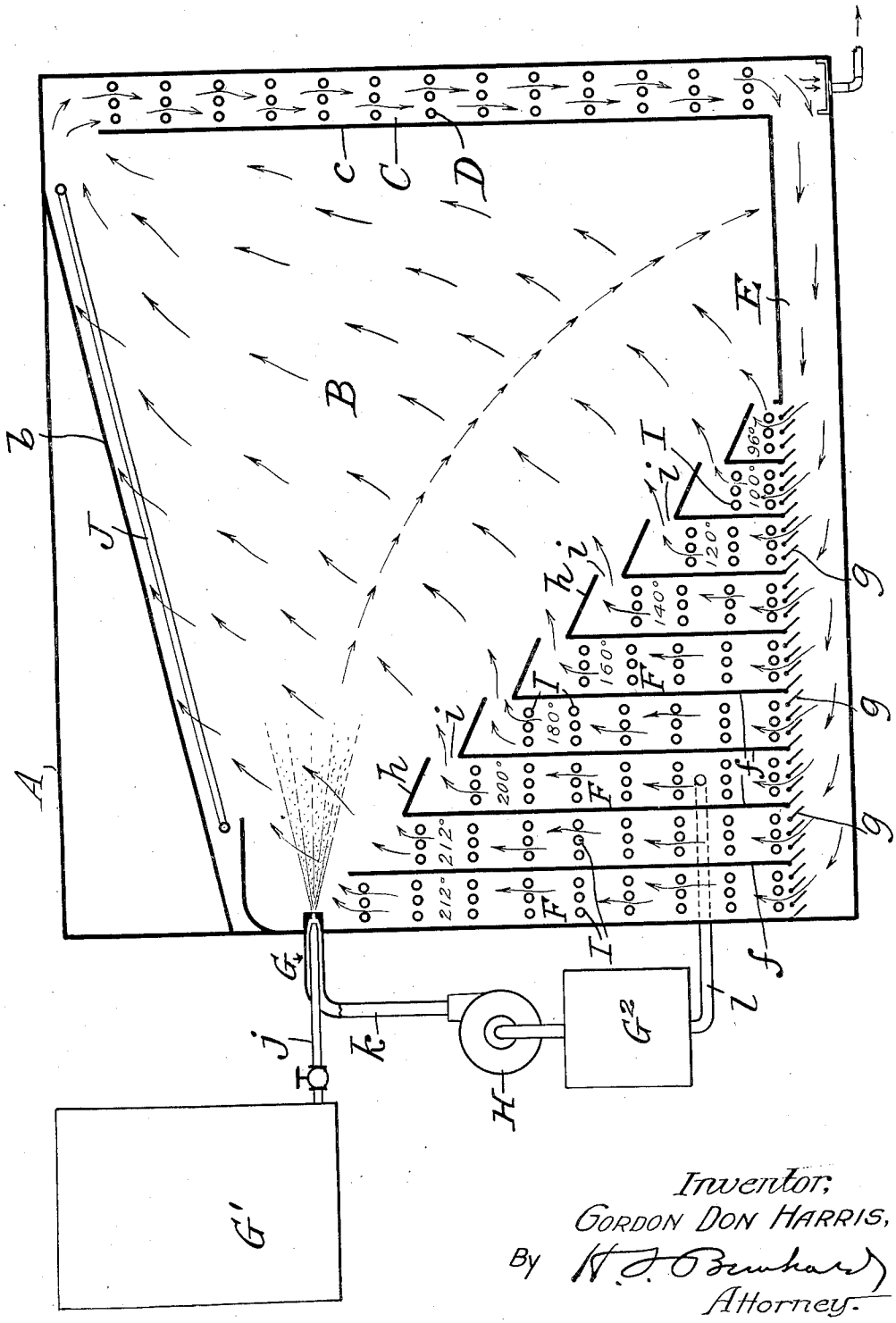
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ART OF DRYING LIQUID MATERIALS

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ART OF DRYING LIQUID MATERIALS

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This invention pertains to the art of drying liquid materials, including methods and apparatus, wherein the liquid constituent is eliminated from the solid particles under conditions which exclude bacteria from the presence of the material undergoing treatment and wherein the temperature of the product is constant, or substantially so.

According to the invention, liquid material is atomized at relatively low pressure and by the aid of drying gases supplied in a steril, or substantially steril, condition, from a selected number of flues or chambers of the apparatus, and such atomized liquid is subjected to the action of said gases which flow by thermosiphonic action in a circulatory path within the apparatus and from which path atmospheric air is excluded. The circulation of the drying gases is obtained by the chilling effect of certain condensers and by the heating effect of boosters located respectively in different sections of the circulatory path within which such gases are directed to flow.

A salient feature of my invention consists in channeling the flow of the drying gases and in heating the resulting multiple currents of such gases to different temperatures, whereby the differently heated multiple currents are directed into contact with the atomized liquid material at different points along a theoretical line of flotation of the residual solid product, the latter floating in a definite path within a chamber the cross section of which increases or expands beyond the point of entry thereinto of the atomized liquid and of the finely divided solids and of the points of entry of the differently heated multiple currents of the drying gases, said finely divided solids deriving its initial impulse from the atomization to which the liquid material is subjected.

In my apparatus and mode of procedure, the liquid material, such as milk, is in a finely divided condition, suspended and floating in the gases of a chamber, and such divided floating material is exposed to the effects of multiple currents of the heated gases, said multiple currents being heated separately and to temperatures which vary from say 212° to 96°, more or less. The finely divided liquid at the point of entry into the chamber is exposed to the high temperature gases supplied by one of the multiple currents, and as the divided material floats within the chamber, it is exposed to the progressively decreasing temperatures of the successive multiple currents flowing upwardly across the path or line of flotation of the divided liquid material. At the point of entry into the chamber, the divided liquid material contains the largest percentage of its aqueous content, and the exposure at the entry of such material to the highest temperature of the multiple current has the effect of rapidly evaporating the aqueous content of the liquid material, and such exposure of the divided material to the progressively decreasing temperatures of the succeeding multiple currents brings about the progressive evaporation of the aqueous content present on the surfaces and within the bodies of the solid particles, whereby the floating divided material is progressively dried without an increase in the temperature of the solid particles, the temperature of the product remaining constant, or substantially constant, in the period of its flotation, or from its entry to its deposit.

Preferably, the liquid material is finely divided by atomizing such material at the point of entry into the chamber, and the gas to produce atomization is in a sterile condition, such gas being taken from or supplied by atmosphere from one of the multiple channels within the apparatus. The atomization of liquid material is under pressure, with the effect of imparting an impulse to the divided material, impelling such material across the chamber and across the paths of the upwardly flowing multiple currents of the drying gases, thus assuring the exposure of the divided material to the intimate contact therewith of the multiple currents, for the rapid evaporation of the aqueous content of such divided material, the temperature of which is constant or substantially so.

Other functions and advantages of the invention will appear from the following description taken in connection with the drawing, in which the figure is a vertical sectional

elevation of one form of apparatus wherein the direction of flow of the drying gases and of the path of movement of the residual solid product are indicated by arrows.

Within a housing A is a treating chamber B the roof *b* of which is inclined. At one end of the housing is a partition *c* forming a chamber or flue C, within which is a condenser D shown herein as a coil or coils with suitable provision for feeding thereto a cooling medium and with a valve or valves for controlling the supply of such medium to the condenser, the feeding mechanism not being shown.

At the bottom of the housing is a flue or chamber E, and erected vertically within chamber B is a series of partitions *f* which produce a series of flow channels F in communication with the chamber E. These partitions *f* extend upwardly from the bottom of the housing, it being preferred to vary the height of said partitions and thus produce flow channels F which decrease in height from one end of chamber B toward the condenser D. The gases flowing into the channels F are directed by baffles *g* which may be movable to act as valves, and at the top of some of the flow channels are other deflectors or hoods *h* which overhang the channels and are so related to the partitions *f* as to attain a series of hot air outlets *i* from the flow channels into chamber B below the path of movement of the residual solid product floating within the chamber B.

G is an atomizer herein shown as a nozzle with a liquid feed pipe *j* leading from a tank or other source of supply as G′ and with an air feed pipe *k* leading from a tank G² to which sterilized air is supplied by a pipe *l* connected to one of the flow channels F or to chamber B. A pump or other circulating device H is connected to feed pipe *j* for supplying sterilized air under relatively low pressure to the nozzle G for atomizing the liquid material so as to mechanically divide such material and project the same into the chamber at a point above the outlets *i* from the flow channels. An initial impulse is thus given to the atomized liquid material with a view to projecting the same across the chamber in a substantially definite path indicated as an arc by dots and arrows.

Within the flow channels F are radiators or boosters I, the same being shown as coils to which steam is supplied, suitable provision being made as by valves for controlling the feed of steam to the coils. These radiators or boosters within the flow channels are of varying heating capacity and thus constitute a heating apparatus of differential capacity. The coils within the first and second channels F are of greater capacity than the coils in the third channel, and so on through the series, with the radiators progressively decreasing in capacity in proportion to the decreased height of the flow channels, whereby the currents of drying gases flowing upwardly within the flow channels are heated to different temperatures. Thus the gases flowing within the longer channels adjacent the atomizer are heated to higher temperatures, say 212° Fahr., whereas the gases flowing within the shorter channels are heated to lower temperatures, say 96° Fahr., the gases in the channels intermediate the longer and shorter channels being heated by the radiators to progressively decreasing temperatures between the selected maximum and minimum temperatures.

The radiators I within the flow channels are of different heating capacities so that said series of radiators collectively constitute a differential heating means or a differential radiator. In this connection it is to be observed that such differential radiator or differential heating means functions as a means for heating to different temperatures multiple currents of drying gases, and, further, that the heat units in such multiple currents are apportioned to the moisture content of the floating residual particles of material, as a result of which the product is at a substantially constant temperature and the heat units are supplied by the radiators to the multiple currents of drying gases in ratio of moisture diffusion, the temperature of the multiple air currents decreasing from the initial stage of product treatment to the final stage or stages of such product treatment.

According to my invention the circulation within the chamber is occasioned by chilling and heating the drying gases in different zones remote to the chamber into which is blown the atomized material, which successive chilling and heating of the gases sets up a flow the velocity of which is less than the speed of the atomized material at the point of entrance into the chamber. Again, the compressed air utilized for injecting the liquid material is expanded within the chamber, reducing the velocity of the inflowing air, but such air velocity imparts to the atomized material a certain velocity sufficient to carry or float the atomized material across the chamber, such floating residual product being exposed to the drying effect of the multiple currents of upwardly flowing air heated to different temperatures, as hereinbefore described.

Below the inclined roof *b* is a lifting coil J extending parallel to said roof and terminating close to the inlet to the condensing chamber C, suitable means being provided for feeding a heating medium to said coil and for controlling the feed of said heating medium to the coil.

The drying atmosphere flowing upwardly within the chamber B and downwardly within the condensing chamber C carries as a constituent thereof the aqueous content

evaporated from the finely divided liquid material. In the downflow of the atmosphere within chamber C, the aqueous content is condensed by contact with the cold surfaces of the condenser D, the atmosphere being cooled and chilled, and the water of condensation is discharged from chamber C and condenser D by a suitable pipe or a trap.

In operation, a cooling medium of a selected character is supplied to the condenser, steam is supplied to the radiators and the lifting coil, and the pump is set into operation.

The gases in the vicinity of the condenser are chilled, whereas the gases around the radiators are heated to varying temperatures, and owing to these conditions a tranquil flow of the drying gases is set up within chamber B from which outside atmospheric air is excluded except such as is admitted during the atomization of the liquid material. The gases flow downwardly within chamber C, and upwardly within the flow channels F, and thus the gases are set into motion through channel E and within the chamber B. The liquid is supplied by the atomizer in a finely divided mist or spray to the chamber within which it floats in suspension, and upon the admission of the spray it is met with an upflowing current of heated gases from the longer flues F, and is subjected to the action of the decreasingly heated gases from the remainder of the flow channels, the result of which is, mainly, to envelop the particles or globules of solid material in heated steril gases and thus effect the evaporation of moisture. The atomized material derives an impulse as a result of the atomization which carries the solid particles in a definite path across the chamber and above the outlets from the flow channels, during which movement the solid particles are progressively dried by the upflowing currents of gas from the channels, and at this period of the treatment the temperature of the channeled gas is progressively decreased in a definite ratio to the decreasing moisture content of the solid residual particles, whereby the product temperature remains practically constant during the movement within the chamber, whereas the gas temperature is conditioned to suit the product with a view to the effective elimination of moisture from the product. The ascending currents of gases from the flow channels are below the path of the product in a manner to so act upon the solid particles as to contribute to the mechanical suspension thereof within the gases of the chamber, and thus the solid particles are exposed to the gases under conditions which permit the gradual or progressive descent of such particles under the force of gravity until the particles in a thoroughly dry condition will collect or accumulate within the chamber adjacent the condenser.

It will be noted that the atomized liquid when first admitted meets a current of gases at the maximum temperature, thus effecting the rapid evaporation of moisture from the material and reducing the temperature of the residual particles, water, vapor and drying gases, by reason of such rapid evaporation. In the evaporation of the atomized material the gases become at least partly saturated with moisture and in order to lift the more or less moisture laden gases above the path of the product I provide the lifting coil below the roof of the chamber, which coil radiates heat units into such moist gases and induces or accelerates the flow of the moist air into the condensing flue C. The contact of the downflowing air with the cold surfaces of the condenser tends to condense the moisture present in the gases and to deposit the same in the condition of dew upon the condenser, whence the moisture is discharged in a suitable manner.

My invention is to be used for different liquid materials for obtaining a dry product from such liquids, but its especial utility is the treatment of whole milk, i. e. milk including the fatty contents of milk, for the reason that there is no appreciable temperature variation in the product while undergoing treatment.

Having thus fully described the invention, what I claim as new and desire to secure by Letters Patent is:

1. In the art of evaporating liquids containing solids, the process which consists in atomizing a liquid containing solids into drying gases present within a closed chamber so that the atomized particles are free to float in a determined path and to gravitate toward a common place of deposit within said chamber, circulating the drying gases through said chamber, dividing the inflowing gases into multiple currents flowing upwardly toward the path of flotation of the atomized particles, and heating such upwardly flowing multiple currents of gases to temperatures which decrease from the point of entry of the atomized liquid.

2. In the art of evaporating liquid materials containing solids, the process which consists in atomizing a liquid material into drying gases so as to project the atomized particles in a determined path within the chamber and to expose such atomized particles to the drying effect of such gases, circulating the gases through the chamber, dividing the gases into multiple currents and directing such multiple currents across the path of flotation, and heating the divided currents of drying gases to temperatures decreasing along the path of flotation of the atomized particles.

3. In the art of evaporating liquid materials containing solids, the process which consists in setting up a tranquil flow through

a closed chamber of drying gases, channeling the flow of such gases as they enter the chamber into multiple currents, injecting a liquid material containing solids into the gases in finely divided particles in a path across the multiple currents and evaporating moisture from such finely divided particles, and heating such multiple currents to temperatures which decrease progressively from the entry of the liquid and solids into the chamber.

4. In the art of evaporating liquid materials containing solids, the process which consists in setting up a tranquil flow through a closed chamber of drying gases, injecting a liquid material containing solids into the gases and projecting in a finely divided condition the particles free to float in a determined path across the chamber, dividing the gases into multiple currents flowing across the path of flotation of the divided particles, and heating such multiple currents to temperatures which decrease progressively from the entry of the particles into the chamber.

5. In an apparatus for evaporating liquid materials containing solids, the combination of a chamber having means to set up a flow of drying gases therethrough, means for injecting a liquid material containing solids into said chamber so that the particles in a finely divided condition are floatable in a determined path, a series of channels positioned within the chamber adjacent the path of flotation of the particles and operating to divide the gases into multiple currents adapted to intersect the path of flotation of the atomized particles, and means for heating the multiple currents to temperatures decreasing successively from the point of entry of the liquid material into the chamber.

6. In an apparatus for evaporating liquid materials, the combination of a closed chamber equipped with means for setting up the flow therethrough of drying gases, means for discharging in a finely divided condition into the gases a liquid material with residual solids, the cross section of said chamber increasing away from the entry of said liquid material, heating means in the upper part of said expanded chamber, channeling means in a lower part of said chamber and connected therewith for dividing the gases into multiple currents adapted to flow upwardly within the chamber, and a plurality of individual radiators of different capacities positioned within the channeling means for heating the multiple currents of the gases discharge into the chamber to temperatures progressively decreasing from the entry of the liquid material.

7. In the art of evaporating a liquid material containing solids, the process which consists in providing a chamber, projecting liquid material in a finely divided condition within said chamber, and conducting separate currents of drying gases in paths across the path of flotation of the finely divided material, said separate currents being heated to different temperatures and traversing the path of flotation successively in the order of decreasing temperatures.

8. In the art of evaporating liquid material containing solids in a body of drying air, utilizing a portion of said air to deliver in a forwardly moving direction and in an atomized state the said material into said body of air, generating at levels below that of said atomized material forwardly and upwardly moving successively placed currents of said air of progressively decreasing temperature to mingle with, and aid in the flotation of, and progressively dry, said atomized material, and providing beyond the region of flotation a downwardly flowing current of cooled air supplied from said upwardly moving air and in turn supplying the air for said upwardly moving currents.

9. In the art of evaporating liquid material containing solids in a body of drying air, moving in a forwardly directed course in an atomized state the said material into the said body of air, and generating at levels below that of said atomized material forwardly and upwardly moving successively placed currents of said air of progressively decreasing temperatures to mingle with, and aid in the flotation of, and progressively dry, said atomized material.

10. A milk evaporator comprising a chamber, means for projecting thereinto liquid milk in a finely divided condition, a plurality of means for separately channeling air and discharging the same into said chamber, and separate heating means for the air flowing within the respective channeling means, said separate heating means being of such progressively varying capacities as to heat the air to temperatures progressively decreasing from the point of entry of said liquid milk.

11. In the art of drying atomized milk traversing a chamber, the process which consists in exposing suspended milk particles to multiple currents of drying gases, the direction of flow of which multiple currents are in paths crosswise of the travel of the atomized milk particles and the temperatures of which currents so decrease from the point of entry of such atomized milk particles that the temperature of the milk particles will be substantially constant during the period of such exposure.

12. An apparatus for evaporating liquid material comprising a chamber, a plurality of partitions of varying height arranged transversely in said chamber adjacent one end thereof and forming a plurality of passageways between adjacent partitions, a conduit communicating with the upper portion of said chamber adjacent the other end thereof, and with said passageways at the lower portion of said chamber, means in said con-

duit for reducing the humidity of gases flowing therethrough, means in said passageways for heating the gases prior to introduction into the chamber and means at the end of the chamber containing the partitions for introducing a liquid into said chamber above the partitions, the heating means in the passageways from the passageway nearest the end of the chamber at which the liquid is introduced to the passageway farthest away being of progressively lesser heating capacity.

13. An apparatus for evaporating liquid material comprising a chamber, a plurality of vertical partitions of varying height arranged in said chamber adjacent one end thereof and forming a plurality of passageways between adjacent partitions, those of greatest height being nearest the end of the chamber, a conduit communicating with the upper portion of said chamber at the other end thereof, and with said passageways at the lower portion of said chamber, means in said conduit for reducing the humidity of gases flowing therethrough, means in said passageways for heating the gases prior to introduction into the chamber and means for introducing a stream of gas carrying a liquid into said chamber above said partitions, the heating means in the passageways between the partitions of greatest height having higher heating effect than the heating means in the passageways formed between the partitions of lesser height.

14. An apparatus for evaporating liquid material comprising a chamber, a plurality of vertical partitions extending upwardly and arranged transversely in said chamber adjacent one end thereof and forming a plurality of passageways between adjacent partitions, a conduit communicating with the upper portion of said chamber adjacent the other end thereof, and with said passageways at the lower portion of said chamber, means in said conduit for reducing the humidity of gases flowing therethrough, means in said passageways for heating the gases prior to introduction into the chamber and means for withdrawing heated gas from one of said passageways and injecting it into the chamber together with the liquid to be evaporated above the partitions at the end of the chamber containing the partitions, the heating means in the passageways from the passageway nearest the end of the chamber at which the liquid is introduced to the passageway farthest away being of progressively lesser heating capacity.

15. An apparatus for evaporating liquids comprising a horizontally arranged chamber of gradually increasing cross section, means for introducing atomized liquid into the chamber at the point of smallest cross section, means for introducing a plurality of streams of drying gas into said chamber at a plurality of points lengthwise thereof and means for separately heating each of said streams so as to maintain the temperature of the material substantially constant.

16. An apparatus for evaporating liquids comprising a substantially horizontally arranged chamber of gradually increasing cross section, means for introducing atomized liquid into the chamber at the point of smallest cross section, means for introducing a plurality of streams of drying gas into said chamber at a plurality of points lengthwise thereof and means for separately heating each of said streams, the means for heating the streams introduced into the chamber adjacent the portion of the chamber of smallest cross section having a greater heating effect than the means for heating the other streams so as to maintain the temperature of the material substantially constant.

17. A method of drying liquid material containing solids comprising floating the material in finely divided form in a substantially horizontally flowing stream of drying gas, supplying upwardly flowing heated gas to said material from a plurality of points below and spaced along the path of said stream, and graduating the temperature of the upwardly flowing gas to maintain the temperature of the material substantially constant.

18. An apparatus for evaporating liquid material comprising a chamber, a plurality of partitions arranged transversely in said chamber adjacent one end thereof and extending upwardly from the floor of said chamber and terminating at varying distances from the roof of said chamber, said partitions serving to form a plurality of passageways, means for introducing a gas containing the material to be evaporated into said chamber above the partitions, a conduit communicating with the upper portion of said chamber at the other end thereof and communicating with the passageways adjacent the floor of said chamber, means in said conduit for reducing the humidity of gases passing therethrough, means in said passageways for heating gases prior to introducing them into the chamber, and valve means arranged at the lower portion of each of said passageways to regulate the amount of gas passing through said passageways, the heating means in the passageways from the passageway nearest the end of the chamber at which the liquid is introduced to the passageway farthest away being of progressively lesser heating capacity.

19. A method of drying liquid materials comprising floating finely divided material in a horizontal path in a drying gas, supplying in an upward direction, heated gas to said material from below, and heating progressive portions of said upwardly directed gas in the direction of flow of the horizontal gas to progressively decreasing temperatures so

that the temperature of the material will remain substantially constant.

20. In the art of drying atomized milk traversing a chamber, the process which consists in atomizing milk with a gas, exposing suspended milk particles to multiple currents of drying gases, the direction of flow of which multiple currents are in paths crosswise of the travel of the atomized milk particles and the temperatures of which currents so decrease from the point of entry of such atomized milk particles that the temperature of the milk particles will be substantially constant during the period of such exposure, separating the dried milk from the gas and recycling the gas for atomizing the milk and to the multiple currents of drying gas.

21. A method of drying liquid materials comprising floating finely divided material in a horizontal path in a drying gas, supplying in an upward direction, heated gas to said material from below, and heating progressive portions of said upwardly directed gas in the direction of flow of the horizontal gas to progressively decreasing temperatures so that the temperature of the material will remain substantially constant, separating the dried milk from the gas, and recycling the gas as the drying gas moving in the horizontal path and as the gas supplied in the upward direction.

In testimony whereof I have hereto signed my name this 19th day of June, 1923.

GORDON D. HARRIS.