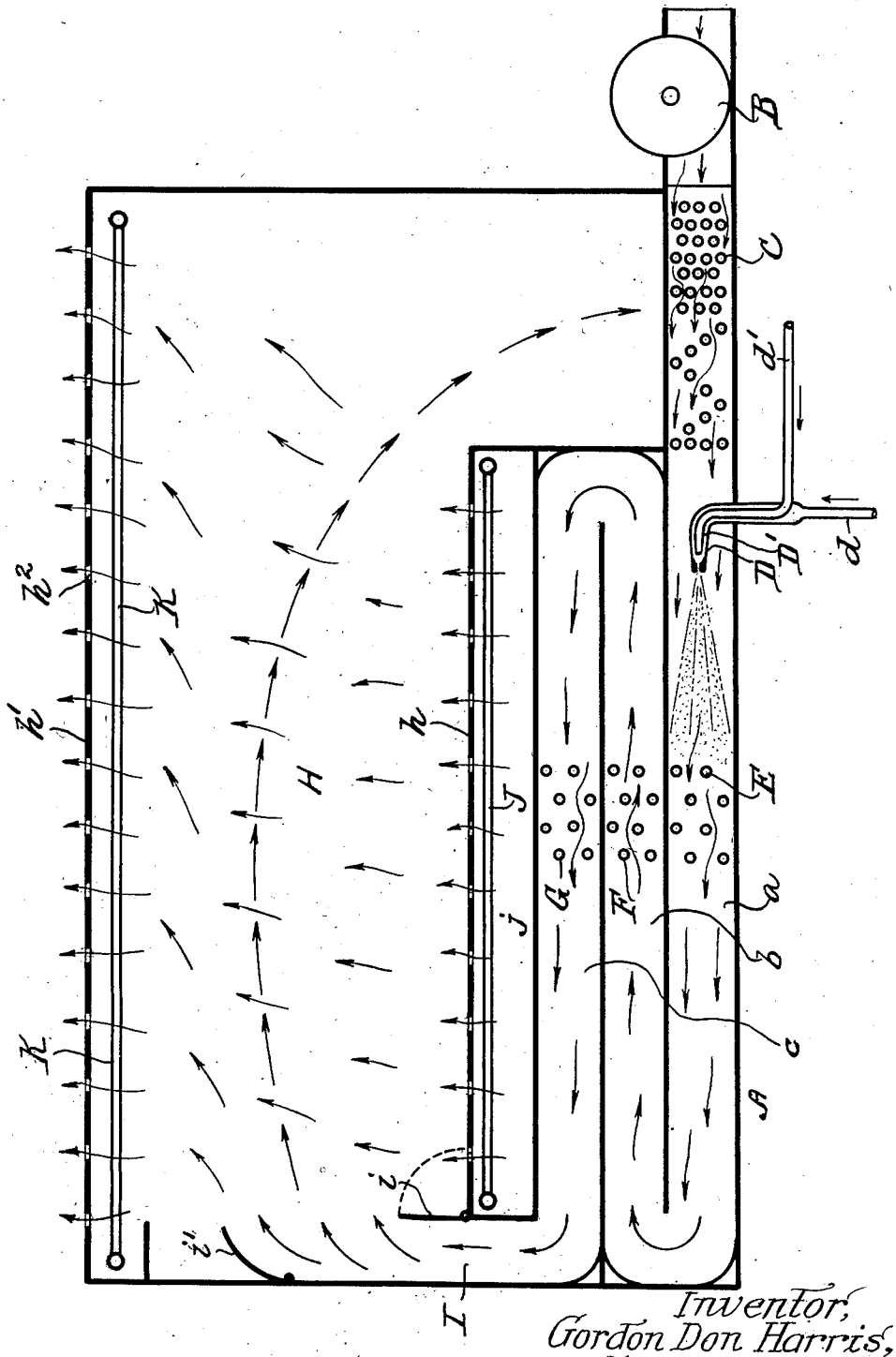
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DRYING LIQUID MATERIALS

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DRYING LIQUID MATERIALS

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This invention pertains to the art of drying liquid, or semi-liquid, materials, and it is adapted, more particularly, for the treatment of whole milk or skim milk, although it is useful in the operation of drying other materials than those specified.

The object is to conduct the drying operation under conditions which eliminate the aqueous content without injurious effect upon the residual solids and results in the production of a powder the components or particles of which are thoroughly dried both interiorly and upon the surfaces thereof.

To these ends, the improvement in the art is embodied in a process which consists in atomizing liquid or semi-liquid material into a gaseous current constituting a drying gas moving at a desired velocity and preheated to a desired temperature, conducting the current with the liquid in an atomized suspended condition within a circulatory path, boosting the temperature of the drying gas as it flows within the circulatory path by reheating said gas at intervals, thereby evaporating the aqueous content of the liquid material and partially drying the residual solid content thereof, reducing the velocity of the current by expanding the same within a chamber across which the residual solid content of the material is caused to float in an arcuate path due to the impulse given to said residual content by the initial velocity of the current, and subjecting such residual solid content to final drying as the latter floats in said arcuate path within the chamber, which final drying stage has the capacity for evaporating the relatively small percentage of moisture adherent to the surface of the solid particles.

The invention in the process includes, also, a mode of procedure for attaining the final drying of the residual solid content floating at reduced velocity within the expansion chamber. At the flotation stage, the solid particles are exposed to ascending heat from a source located below the path or trajectory of the floating particles, to the end that surface moisture adherent to the floating particles will be removed by evaporation, and, further, humidity present in the drying atmosphere is removed from the path of flotation or trajectory of the solid particles by heat radiated from a source located above the path of flotation or trajectory, the heat so radiated above said path being within the expansion chamber and tending to move the humid atmosphere upwardly and away from the path or trajectory of the solid floating particles, whereby the dried particles, or at least a substantial quantity thereof, will, by the impulse given thereto initially, be impelled across the expansion chamber and thus accumulate within a compartment whence the dried product may be removed by appropriate means or as required.

The invention pertains, also, to a novel form of apparatus embodying an elongated tunnel, preferably of the circuitous type, means for circulating air as a drying gas within said tunnel, means for initially heating said drying gas, means for atomizing liquid material into the drying gas so as to mechanically suspend atoms or particles of said material therein, and boosters or heaters positioned within the tunnel and substantially in the path of the drying gas for reheating said gas in a manner to compensate for the drop in temperature occasioned by the exchange of heat for moisture and to attain drying, at least partially, of the solid residual content of the material under treatment.

The invention with respect to the apparatus includes, also, a chamber into which is discharged the drying gas carrying the solid residual content and by which the velocity of the drying gas is reduced by expanding the same within the chamber, means for supplying heat to the chamber below the path of flotation of the solid residual particles of material within the chamber, and means for supplying heat above the path of flotation within the chamber and functioning to induce the outflow of the humidity developed within the drying gas by the evaporation of moisture from the residual content of the material during the drying thereof.

Other functions and advantages of the invention will appear from the following description taken in connection with the drawing wherein an apparatus of my invention

is diagrammatically shown in vertical sectional elevation.

An elongated tunnel A is shown as comprising flow channels *a*, *b*, *c*, positioned in superposed relation to produce a circuitous tunnel for compact construction, said tunnel constituting a closed circulatory path for a drying gas set into motion by appropriate mechanism, such as the fan or blower B, located at the entrance to the tunnel. Air circulated by the fan is initially heated to a desired temperature by appropriate means, such as heating coils C, shown as positioned within the tunnel adjacent the blower.

Means are provided for atomizing the liquid material to be treated, and for injecting the same into the drying gas. As shown, a nozzle D is provided within the flow channel *a* at a suitable distance from the initial heater, and with said nozzle is associated a feed pipe *d* and a second pipe *d'* having its delivery D' in coaxial relation to the nozzle D, whereby the two pipes *d d'* are serviceable in feeding the liquid material and in feeding air under pressure to the nozzle in a manner to atomize the liquid material and to inject said atomized material into the current of the drying gas. The atomized material flows from the nozzle in the direction of flow of the drying gas within the tunnel, and said atomized material is spread or diffused within the flowing drying gas in a manner to become suspended therein in a finely divided condition in order to expose said divided liquid material to the heated gas, the effect of which is to envelop the divided liquid by a heated gas and to exchange heat for moisture at the initial stage of the treatment. The injection of the atomized liquid material into the heated air current, results in a drop in temperature of said air, and the continued exchange of heat for moisture during the flow of said air current within the flow channels *a*, *b*, *c*, of the elongated tunnel would result in a further drop in temperature of said current were it not for the provision of radiators or boosters E, F, G, as embodied in the apparatus of this invention. Said boosters are shown as heating coils positioned within the flow channels *a*, *b*, *c*, and in the path of the current which acts as a carrier for the atomized liquid material; suitable provision being made for supplying to said coils a heating medium such as steam or hot water, or other energy.

H is an expansion chamber into which leads a short flue I extending vertically from the flow channel *c* to said chamber, and adjacent this flue are the baffles or deflectors *i i'*, the latter being hinged for movement in order to provide for adjustment in a manner to direct the flow of the drying gas from the flue into said expansion chamber.

The drying medium flows at a certain velocity within the tunnel, the cross section of which tunnel is much less than the cross sectional dimensions of the expansion chamber, and when said current enters the chamber, it follows that the current is expanded and its velocity is reduced, as a result of which the solid residual particles in an approximately dry condition will traverse the chamber in an arcuate path under the impulse imparted to said solid particles by the velocity of the current, and during such flotation, the solid particles are exposed to the effect of heat supplied from a radiator J located below the floor *h* of the chamber. As shown, the floor is perforated, and it is positioned parallel to the top wall of the flow channel *c*, thus producing a chamber *j* closed on all sides except the perforated floor *h*. Within this chamber *j* is positioned the radiator J, adapted to be supplied with steam or other heating medium. Air is present at all times in the expansion chamber and in the radiator chamber, the air entering chamber *j* through some or all of the perforations in the floor *h*, and thus the heat radiated from radiator J, or air heated by said radiator, will be free to ascend above preheater *h*, the effect of which is to supply heat or heated air to the floating solid particles for the purpose of evaporating surface moisture from such particles as they traverse the expansion chamber under the energy given thereto by the velocity of the air current acquired by such current when moving in the flow channels and when expanded by flowing into the chamber H.

Means are provided for the free or unrestricted outflow of the drying atmosphere from the expansion chamber; as shown, the top wall or roof *h'* is provided with appropriate outlets h^2, and below the roof is a vapor lifting radiator K adapted to be supplied with steam or other heating medium. This radiator supplies heat to the upper part of the expansion chamber, below and adjacent to the perforated top *h'* thereof, and the heat thus supplied has the usual tendency to rise or ascend within said expansion chamber, and such ascent tends to induce a relatively gentle upward flow of the drying atmosphere, as a result of which the outflow of the drying atmosphere is accelerated and the moisture present therein is carried out of the expansion chamber by the outflowing atmosphere. It will be understood that the outflow of the drying atmosphere through the perforated top *h'* takes place above the path of flotation of the residual solid particles of dry pulverulent material floating within the expansion chamber.

Liquid or semi-liquid material supplied to the described apparatus is dried as follows:— The blower is started and steam supplied to the radiators in a manner to circulate air at the required velocity within the tunnel, the air being initially heated to a desired temperature, say 130° Fahr. Air under pressure

and liquid material are supplied to the atomizer D D′ for injecting liquid material in a finely divided condition within the current of air constituting the drying gas. The divided liquid material is diffused within the air current by spreading within the flow channel *a*, and the liquid particles are thus enveloped and surrounded by heated air within which the particles are mechanically suspended and by which said particles are carried within the circuitous tunnel. The injection of liquid material into the air current results in a drop in temperature of the drying gas, but to counteract such reduction the radiator E within the flow channel *a* reheats the gas. During the flow of the gas within channels *a*, *b*, *c*, the exchange for moisture takes place with the result that the liquid is converted into vapor, leaving solid residual particles suspended in a more or less dry condition within the flowing gas; but to maintain the drying gas in a condition for efficiently carrying on the drying operations, the gas flows into contact successively with the radiators F, G, which supply to said gas the heat units taken up by the exchange of heat for moisture, the successive radiators E, F, G, acting to boost the temperature of the gas and keep it at constant temperature, or substantially so. The evaporation begins immediately upon the injection of the finely divided liquid matter into the moving air current, and continues as said material flows with the air current within the circuitous tunnel, the effect of which is to substantially eliminate the liquid from the solid residual content by the time the latter reaches the chamber H. Experience shows, however, that a small percentage of moisture is still present in or on the surface of the residual content, and that it is a more or less difficult operation to eliminate such residual moisture, hence in this invention the residual solid particles are exposed to a final drying step, the same being performed within the chamber H. The velocity of the air current, carrying a certain moisture content and the more or less dried residual matter, is reduced by the flow of such current from the gas tunnel into the enlarged chamber, and while the humid air is free to ascend within said chamber and to make its exit therefrom through outlets provided in the roof thereof, the solid residual matter floats within the chamber due to the impetus given thereto by the velocity of the air current. The floating particles of solid matter tend by reason of the impulse given to such particles by the velocity of the air current to traverse the chamber H and to float therein over and above the perforated floor *h*, but such floating particles are exposed, more or less, to heat radiated from the underneath radiator J and from the elevated radiator K, although it may happen that some of the floating solid particles may gravitate upon the perforated floor *h*. By expanding the air current within the expansion chamber H, and by providing radiators at the top and bottom of said expansion chamber, the floating particles are exposed to the heat radiated from the radiators, but the drying atmosphere when expanded within the chamber H is free to escape unrestrainedly from such chamber, the radiator K tending, in a measure, to create a gentle upward flow of the atmosphere, and thus to accelerate the outflow of such atmosphere from the expansion chamber. The residual particles of solid matter are exposed to additional heat units supplied from a source below the trajectory of the moving particles, and within the expansion chamber, the effect of which is to evaporate the surface moisture present on such floating particles. The particles of solid matter under the impulse derived from the velocity of the air current traverse the chamber, and such particles float in a zone substantially between radiators J, K, with the result that the solid particles, or the bulk of the same, finally accumulate within a collection space of the expansion chamber.

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

1. In the art of drying liquid material, the process which consists in atomizing liquid material and diffusing the same within a current of a drying gas moving at a desired velocity within a flow channel, expanding said current within a separating chamber and conducting the residual solid particles by flotation in a desired path within said chamber, and radiating heat upwardly from below the path of flotation and into direct contact with the solid residual particles while in suspension within said chamber.

2. In the art of drying liquid materials, the process which consists in atomizing said material within a current of a drying gas moving at a desired velocity within a flow channel, expanding said current into a separating chamber for reducing the current velocity, conducting the residual solid particles in a determined path within said chamber by the impulse imparted thereto by the velocity of the current, venting the chamber above the path of flotation of the residual particles for the exit of the humid gas from said chamber, and supplying heat upwardly from below the path of flotation of said solid particles, the ascent of which heat within the chamber contacts directly with the floating solid particles for effecting the final drying thereof.

3. In the art of drying liquid materials, the process which consists in feeding to a chamber a drying gas in which is suspended solid particles of partially dried residual content of a liquid material, venting the chamber above the path of flotation of the suspended

liquid particles for effecting the exit of the drying gas from said chamber, and effecting a flow of heated gas upwardly within said chamber and below the path of flotation of the suspended solid particles, whereby the contact of heat with the suspended particles effects the final drying of the suspended material.

4. An apparatus for drying liquid materials, embodying a tunnel, means for flowing a drying gas therein, an atomizer for feeding liquid material in a finely divided condition within said drying gas, a separating chamber into which the material-carrying gas is expanded, and a succession of heat radiators positioned at intervals within the tunnel for maintaining the drying gas at a temperature substantially constant, said radiators acting on the drying gas at a stage intermediate the atomizing means and the separating chamber.

5. An apparatus for drying liquid materials, embodying a tunnel, means for flowing a drying gas therein, atomizer means for feeding liquid material in a finely divided condition into the drying gas, a separating chamber into which the drying gas is expanded, and a succession of radiators intermediate the atomizing means and the separating chamber, said radiators being within the tunnel and in the path of the drying gas for heating the latter to a temperature substantially constant.

6. An apparatus for drying liquid materials embodying an elongated tunnel, means for flowing a drying gas therein, means for initially heating the drying gas, means for feeding liquid material in a finely divided condition within said drying gas, and a succession of radiators positioned within the tunnel and at intervals in the length thereof for supplying heat to said gas and maintaining the temperature thereof substantially constant.

7. An apparatus for drying liquid materials embodying a tunnel including a succession of flow channels, means for flowing a drying gas therein, a radiator for initially heating said gas, atomizing means for feeding liquid material in a finely divided condition to said drying gas, and a succession of radiators positioned within the flow channels and feeding heat to the drying gas for maintaining its temperature substantially constant throughout the flow within said tunnel.

8. An apparatus for drying liquid material, embodying a separating chamber, a non-foraminous tunnel connected therewith, means for flowing a drying gas at a desired velocity within the tunnel and feeding the same to said chamber, means for feeding liquid material in a finely divided condition to said drying gas, whereby the divided liquid material is evaporated and carried to said chamber by said gas, and a radiator positioned within said chamber substantially above the path of movement of the suspended product therein to move from proximity to the suspended product the vapor laden gas.

9. An apparatus for drying liquid material, embodying a separating chamber, a tunnel connected therewith, means for flowing a drying gas at a desired velocity within the tunnel and feeding the same to said chamber, means for feeding liquid material in a finely divided condition to said drying atmosphere, whereby the divided liquid material is evaporated and carried in suspension to said chamber by said gas, means in said chamber adapted to cooperate to cause an upward movement of gas past the suspended particles, said means comprising a radiator within said chamber and below the path of the suspended product for supplying heat thereto, and a radiator above the path of movement of the suspended product within said chamber.

10. A process of drying solids suspended in liquids comprising spraying material in a finely divided state into a moving body of drying gas, and so treating the drying gas as to keep the temperature of the material substantially constant.

11. In the art of drying liquid materials the steps of floating finely divided material in a path in a drying gas, supplying an upwardly directed current of heated gas to said material from below, and heating the gas above the material to aid in the flow of gas through the materials.

12. A process of removing a constituent from atomized material comprising subjecting material to the action of a gas into which the desired constituent tends to vaporize and the suspended particles are carried along in the flow stream of the gas, and adding regulated amounts of heat at successive stages of the flow stream to keep the temperature of the atomized material substantially constant.

13. In the art of drying liquid materials the steps of floating a finely divided material in a path in a drying gas and supplying heat from below the path and above the path to cause a change of gas in contact with the material.

14. A process of removing a constituent from atomized material comprising subjecting the material to the action of a gas into which the desired constituent vaporizes and keeping the temperature of the material substantially constant by adding heat in a quantity sufficient to compensate for the latent heat of vaporization of the vaporized constituent.

15. In the art of drying liquid material, the process which consists in flowing a dry-gas through a flow channel of substantial length, injecting atomized liquid material into the current of said drying gas moving within said flow channel, heating the drying gas after the introduction of said liquid ma-

terial without the addition of further gas to said flow channel, and expanding the drying gas into a separating chamber.

16. In the art of drying liquid material, the process which consists in blowing a drying gas within a flow channel of substantially uniform cross-sectional area and of substantial length, initially heating said gas to a desired temperature, injecting the liquid material in a finely divided condition within the heated gas flowing within said channel, further heating said gas at a plurality of points in said channel to maintain the temperature thereof substantially constant, and expanding the drying gas into a separating chamber.

17. An apparatus for drying liquid material comprising a chamber, means for expanding into said chamber a current of drying gas in which is suspended particles of a partially dried material, and means for moving the vapor laden gas away from the particles of material, said means comprising a radiator positioned within the chamber substantially above the path of flotation of the suspended particles of material.

18. An apparatus for drying liquid material comprising a chamber, means for expanding into said chamber a current of drying gas in which is suspended particles of a partially dried material, and means for moving the vapor laden gas away from the particles of material, said means comprising a radiator positioned within the chamber and spaced from the upper wall thereof substantially above the path of flotation of the suspended particles of material.

19. An apparatus for drying liquid material comprising a separating chamber, means for expanding therein a current of a previously heated material-carrying drying gas, means in said chamber for effecting an upward movement of gas past the suspended particles, said means comprising a radiator positioned below the path of flotation of the suspended material particles.

20. An apparatus for drying liquid material comprising a chamber, means for moving a current of material-carrying drying gas therein and means in said chamber to effect a change of gas in contact with said particles, said means comprising a radiator positioned in the chamber substantially above the path of the suspended material particles.

21. An apparatus for drying liquid materials comprising a chamber, means for moving a current of a drying gas containing suspended particles of liquid therein, a plurality of cooperating means in said chamber for effecting an upward movement of gas past the suspended particles, said means comprising radiators positioned in said chamber above and below the path of flotation of the suspended particles.

22. An apparatus for drying liquid material comprising a chamber, means for projecting a current of material carrying gas across said chamber, means in said chamber beneath the current of drying gas for effecting an upward movement of the gas to facilitate drying of the material, said means comprising a heat radiator positioned in the lower portion of the chamber.

23. An apparatus for drying liquid material comprising a chamber, means for projecting a current of gas across said chamber, means in said chamber beneath the current of drying gas for effecting an upward movement of the gas to facilitate drying of the material, said means comprising a heat radiator positioned in the lower portion of the chamber and a heat radiator in the upper portion of the chamber above the current of drying gas.

24. A process of drying liquid material comprising introducing finely divided liquid into a heated drying gas, conveying the gas and material suspended therein through an elongated conduit, heating the gas at intervals in said conduit to maintain the temperature thereof substantially constant, and then expanding the gas to permit the material to precipitate therefrom.

25. A process of drying liquid material comprising introducing finely divided liquid into a heated drying gas, conveying the gas and material suspended therein through an elongated conduit, heating the gas at intervals in said conduit to maintain the temperature thereof substantially constant, introducing the treated gas into an expansion chamber and setting up a current of heated air transverse to the flow of the material to facilitate the drying thereof.

In testimony whereof I have hereto signed my name this 26th day of January, 1923.

GORDON D. HARRIS.