Jan. 18, 1955 J. JEHLICKA 2,699,822

APPARATUS FOR DRYING BY ATOMIZATION, PARTICULARLY OF ORGANIC SUBSTANCES

Filed Feb. 11, 1950

FIG. 1.

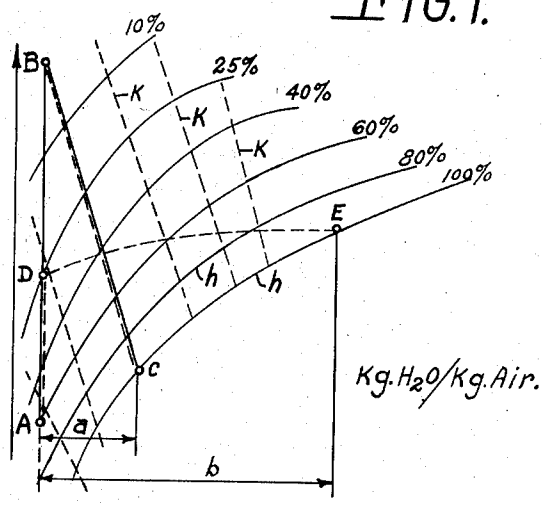
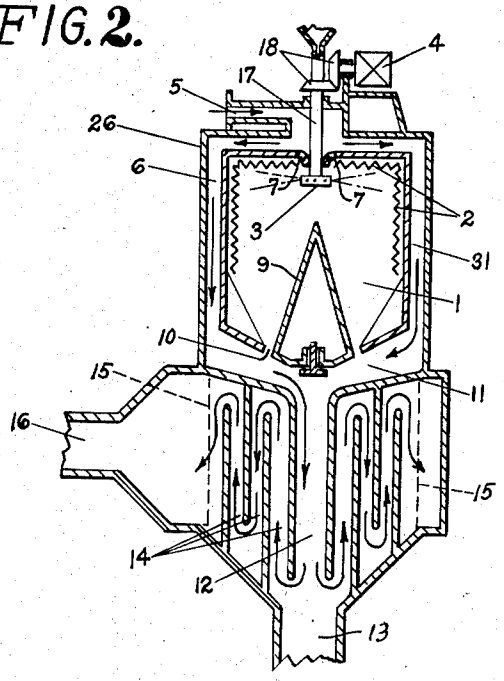


FIG. 2.



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United States Patent Office 2,699,822
Patented Jan. 18, 1955

2,699,822

APPARATUS FOR DRYING BY ATOMIZATION, PARTICULARLY OF ORGANIC SUBSTANCES

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Application February 11, 1950, Serial No. 143,625

3 Claims. (Cl. 159—4)

Dehydrated organic substances in dry powdered form, such, for instance, as powdered milk, powered fruit, powdered soap, and the like, have been produced heretofore by the process of drying by atomization. This process consists of atomizing the wet material to be dried and delivering the atomized material into an air current having a relatively high temperature for the purpose of removing from the products thus treated their inherent moisture, the drying air, during the drying operation, becoming charged with moisture up to the saturation point.

This process as heretofore carried out results in heating the organic substances to the high temperature to which the drying air is heated, and such high temperature may have a deleterious effect on the organic material being treated.

It is an object of the present invention to provide an improved process of and apparatus for drying by atomization, which while requiring a much lower temperature of drying air than that heretofore used in drying by atomization, yet makes it possible to extract a much larger quantity of moisture from the wet material to be treated, the result being a more rapid dehydration and the avoidance of any impairment of the quality of the concentrated products by being subjected to high temperature.

In the drawings:

Fig. 1 is a graph illustrating the drying or dehydrating operations as carried out under the method heretofore used, and also illustrating the corresponding drying operations as carried out by the present invention; and,

Fig. 2 is a more or less diagrammatic view illustrating a drying apparatus embodying the present invention.

Referring to the graph shown in Fig. 1, the line A—B—C indicates the phenomena of drying atomized material according to the method heretofore used. The lines *h* indicate lines of constant humidity, the lowest line indicating the limit curve corresponding to complete saturation of the air, or 100% humidity, the other lines *h* indicating an air humidity of 80%, 60%, 40%, etc. The slanting dotted lines *k* are lines of equal enthalpy and, together with the lines *h*, indicate the relation between the temperature of the heated air and the moisture absorbed thereby at various stages of the drying operation.

According to the method of drying atomized material heretofore used, the drying current of air, which initially has a temperature corresponding to the point A, is heated to a temperature indicated by the point B, while maintaining constant its absolute hygrometric condition, the relative hygrometric condition decreasing by an amount which can be readily read on the graph.

When the air comes in contact with the moist material in atomized form, the liquid, adhering to the surface of the individual particles or droplets, is evaporated. The heat required to effect such evaporation is supplied by the heated air which, as a consequence, is cooled down. This operation, if the apparatus is free of heat loss, takes place in an adiabatic manner, that is to say, along the line B—C of equal enthalpy. Upon reaching the limit curve of relative humidity at the point C the drying operation terminates inasmuch as at this point the absorptive capacity of the air is exhausted and the latter has a humidity of 100%. The total moisture absorbed by 1 kg. of pure air is indicated on the graph by the difference indicated by the line *a* of the abscissae of the points A and C, assuming, however, that the temperature of the atomized material introduced at the point B is the same as that of the hot drying air. In other words, the drying operation proper starts at a lower mixture temperature and reaches the limit curve at a point C which is still lower. It clearly appears from the graph that by the aforedescribed process which has been heretofore used, only a small quantity of moisture can be eliminated from the moist material despite the relatively high temperature employed.

In accordance with the present invention the moist atomized material to be dried is subjected simultaneously to dry, warm air and to infra-red irradiation thereby decreasing the drying period due to this simultaneous transmission of heat by convection and by radiation.

The operation of the improved drying process is shown on the graph of Fig. 1 by the dash line A—D—E. According to the improved process the drying air is heated only up to the point D. The heat necessary for the evaporation of the moisture in the wet material to be treated, which material is introduced in an atomized form into the air at the temperature corresponding to the point D, is directly obtained by infra-red radiation under a reduced pressure corresponding to the requisite quantity. Starting from the initial point D the hygrometric condition of the air increases continuously without subtracting heat from the surrounding air. The limit curve is thus reached at the point E, at which point the air has a much greater absolute humidity. The drying air, therefore, has absorbed a much greater amount of moisture without a lowering of its temperature and without any prior heating to an identical temperature as has been done in the process heretofore used. Contrary to the adiabatic drying according to the process formerly used, the drying operation in my improved process takes place in an almost isothermal manner. According to the improved process the moisture absorbed by 1 kg. of drying air corresponds to the difference, indicated by the line *b*, of the abscissae D and E, this being much greater than the amount of moisture absorbed by the drying air in accordance with the method heretofore used. In addition the improved process has the advantage that the organic material being dried is not subjected to the high temperature heretofore used and hence is not liable to the deleterious effects resulting from such high temperature.

The complete drying operation may be regarded as taking place in three phases. During the first phase all the surfaces of the individual particles or droplets of the atomized material are still wet with liquid. With progressive evaporation the drying operation enters the second phase in which the surfaces of the individual particles are partially dried, so that during this phase some portions of the surfaces of the individual particles will be dry and other portions will remain covered with moisture. However, during this phase the bodies of the particles which have partially dried surfaces still remain wet as the drying operation has been a surface operation. As the surface areas of the particles become dry the speed of the complete drying operation is slowed down considerably.

This second phase of the drying operation gradually passes into the third phase when the surface area of each particle has become dry, although the body of each particle is still impregnated more or less with moisture. The moisture in the body of each particle will reach the surface thereof where it becomes evaporated by means of capillary action, which is necessarily a slow action, and for this reason the drying operation during the third phase is the most difficult and takes the most time.

The customary method of drying by atomization accelerates only the evaporation of the moisture during the first phase of the drying operation, the drying during this phase being a surface evaporation. It has little influence during either the second or the third phase. This stems from the fact that during the surface evaporation the outer layer of the individual particle forms an enveloping crust under the action of the hot air and the albumen contained in any organic substance coagulates. Organic fats and oils which have been heated and become volatile clog the capillaries of the particles due to the coagulation of the albumen and thus prevent the passage of the mois-

ture within the body of the particle from reaching the outside surface through the capillaries unless such fats or oils completely evaporate or the capillaries burst. As a result the materals to be dried are necessarily subjected to a change of these important elements which are temperature-sensitive.

In this invention the heat is conveyed directly to the products being treated so that it is possible to overcome the harmful influences of the second and third phases of the drying referred to above. It is known that rays approximately in the infra-red range penetrate through the deepest layers of the materials to be dried and do not act merely on the outer envelope but penetrate through all the layers and dry them almost uniformly. Hence, when drying with infra-red rays, a temperature gradient such as the one which is inevitably produced during the surface drying no longer appears and the danger of irregular heating is eliminated due to the fact that small films or skins do not form on the surface. The decrease in vitamins and in essential oils of the material treated is no longer perceptible.

It is advantageous that the drying take place in an environment poor in oxygen in order in this way to avoid oxidation of the materials being treated, such oxidation in particular influencing their color, taste and odor.

For this purpose, according to this invention, the wet product is atomized in a space where the air pressure is reduced so that the solid matters released from the liquid are, so to say, in suspension in the dry gas of the liquid removed. The dry product in suspension in the gas is evacuated by suction by means of an air ejector. The quantity of air can be adjusted and measured in such a manner that the total quantity of the gases is absorbed without condensation, that is to say, the air remains unsaturated. Filters, arranged in the path of the issuing air draft may be used to retain the dry dust.

The characteristic feature of this new process consists in that the air no longer carries a substantial amount of heat but constitutes the moisture-absorbing means.

Fig. 2 shows diagrammatically an embodiment of an installation by which the drying process in accordance with the invention can be performed.

The space **1** in which the atomization takes place is constituted by the interior of a cylindrical receptacle **31**, the upper part of which and the peripheral parts of which are provided with heaters **2** which radiate infra-red rays. The materials to be dried in the form of a paste are delivered to the interior of the receptacle **31** in atomized form by means of a rotary atomizer **3** which is operated by the motor **4**. The atomizer **3** is mounted on a hollow shaft **17** and the material to be atomized is fed to the atomizer **3** through said shaft. The shaft of the motor **4** is connected to the shaft **17** by means of gearing **18**.

Surrounding the receptacle **31** is a jacket or outer envelope **26** which forms with said receptacle an air space **6** which encloses said receptacle, said jacket being provided with an air inlet **5** leading to the air space.

The receptacle **31** is provided in its bottom wall with a discharge opening **10**, and situated beneath the receptacle is a receiving conduit **12** opening into the air space and located out of line with the discharge opening.

Air which is introduced through the air inlet **5** passes into the air space **6** and downwardly therethrough, and then flows over and in contact with the outside face of the bottom wall of the receptacle **31** and into the receiving conduit **12**, as shown by the arrows in Fig. 2.

In flowing over the bottom of the receptacle **31**, said air current passes transversely across the discharge opening **10**, thereby creating suction conditions at said opening by which vapor of evaporation and solid particles suspended therein are withdrawn or ejected from the compartment **1**, and a reduced pressure is established therein, such vapor of evaporation and solid particles being delivered into the receiving conduit **12**.

The receptacle **31** has a cone-shaped member **9** rising from its bottom centrally thereof, and the discharge opening **10** is in the form of an annular opening located at the base of said cone. The receiving conduit **12** is located in the axial line of the cone and is thus offset from each and every point in the annular discharge opening **10**.

The bottom wall of the receptacle **31** is so shaped that the portion **11** of the air space beneath the receptacle has a progressively decreasing width from its outer periphery to the point where it leads into the receiving conduit, such progressively decreasing width providing a nozzle effect which tends to increase the suction produced at the discharge opening.

Situated below the receiving conduit **12** and communicating therewith is a collecting pipe **13** in which the solid particles delivered to the receiving conduit **12** accumulate.

The lower end of the conduit **12** has communication with an annular baffle separator which is provided with circuitous passages **14** that lead eventually to the delivery pipe **16**. Located in the baffle separator is a fine screen or filter **15** by which any solid particles which are carried into the passages **14** by the air current are finally screened therefrom.

The top wall of the receptacle **31** is formed with a small opening **7** through which a slight portion of the air entering the inlet **5** passes into the compartment **1**. The arrangement is such that reduced pressure or vacuum conditions prevail in the compartment **1** and it is essentially filled with vapors originating from the liquid drawn off, in which vapor there remain in suspension the solid parts from which the moisture has been removed by irradiation. At the outlet **11**, the contents of the receptacle are drawn in under the action of the air draft which acts like an ejector in the annular nozzle section **11**. The operation is carried out in such a manner that there is no condensation or droplets in the air and vapor mixture that is delivered to the passage **11**. The mixture continues its path through the conduit **12** from which the coarser particles already start to fall into the pipe **13**. The finer particles settle in the deflecting piping **14** and the residue is retained in the fine filter **15**.

Another regulation and the adaptation to the requirements of a varied manufacture may be effected by means of the conical member **9**. By using conical members having bases of different diameters, the area of the opening **10** can be varied so that by using a cone **9** of larger dimension, the said opening is narrowed and it is thus possible to modify the speed of the gases which act as a vehicle for the materials to be treated and also to modify the flow. In this manner the time of treatment of the materials in paste form in the compartment **1** may be adapted to their variable properties. Likewise by narrowing or increasing the opening **10** by using larger or smaller conical members **9**, the ejecting effect and hence the vacuum in compartment **1** is modified. Finally, by a wise selection of member **9**, as to its shape and dimensions, it is possible, through a variation of the speed of the driving gas and the adaptation of the reflecting power of its surface to the various manufacturing requirements, to cause a change in the quantity of the deposit of dried powder-like material according to the manufacturing requirements.

Among other things, the new process may be applied to the manufacture of powdered milk, powdered fruit, powdered potato, powdered soap, sundry drugs, etc., making possible the packing of the same in reduced volume and weight. Another field of application of the new process consists of concentrating solutions and emulsions to higher degrees.

I claim:

1. An apparatus for drying material comprising a compartment having a bottom wall provided with a discharge opening, means for delivering to said compartment in atomized form the material to be dried, heating means in said compartment generating infra-red rays by which moisture is evaporated from the particles of the atomized material, a receiving conduit beneath the compartment and situated out of line with the discharge opening, means directing a current of heated air over and in contact with the outside face of the bottom wall of the compartment and transversely across the discharge opening and into said receiving conduit, thereby creating a suction at said opening by which vapor of evaporation and solid particles suspended therein are withdrawn from the compartment and a reduced pressure is established therein, and whereby said vapor and suspended particles are delivered to the receiving conduit.

2. An apparatus of the class described comprising a drying compartment, means for delivering to the upper end thereof in atomized form the material to be dried, heating means in said compartment generating infra-red rays by which moisture is evaporated from the particles of atomized material, means forming with the compartment an enclosed air space which surrounds the sides of the latter and underlies the bottom thereof, said compartment having at its lower end a discharge opening lead-

ing to said air space, a receiving conduit beneath the compartment communicating with said air space at a point out of line with the discharge opening, said last named means having also an air inlet through which air is admitted to the air space at the upper end thereof whereby air entering the air inlet will flow downwardly through the air space and transversely across the discharge opening and to said receiving conduit, thereby creating suction at the discharge opening by which vapor of evaporation and solid particles suspended therein are withdrawn from the compartment and a reduced pressure is established therein.

3. Drying apparatus of the class described comprising a drying compartment, means for delivering to the upper end thereof in atomized form the material to be dried, heating means in said compartment by which moisture is evaporated from the particles of atomized material, an exterior envelope encircling the sides and bottom of said compartment and spaced slightly therefrom to form therewith an air space which surrounds the sides of the compartment and underlies the bottom wall thereof, said bottom wall having a discharge opening leading to said air space, and said envelope having an air inlet through which air enters the air space at the upper end thereof, a receiving conduit beneath the compartment communicating with the portion of the air space beneath the compartment at a point out of line with the discharge opening, said portion of the air space having a progressively decreasing dimension in the direction of the receiving conduit, whereby air entering the air inlet will flow downwardly through the air space and across and in contact with the outside face of the bottom wall of the compartment and into said receiving conduit, said discharge opening being so located that said current of air passes transversely thereacross and thereby creates a suction at the opening by which vapor of evaporation and solid particles suspended therein are withdrawn from the compartment and a reduced pressure is established therein.

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