Oct. 6, 1953 J. BRABAEK 2,654,159

METHOD FOR TREATING MIXTURE CONTAINING MATERIALS AND APPARATUS THEREFOR

Filed Jan. 24, 1950 2 Sheets-Sheet 1

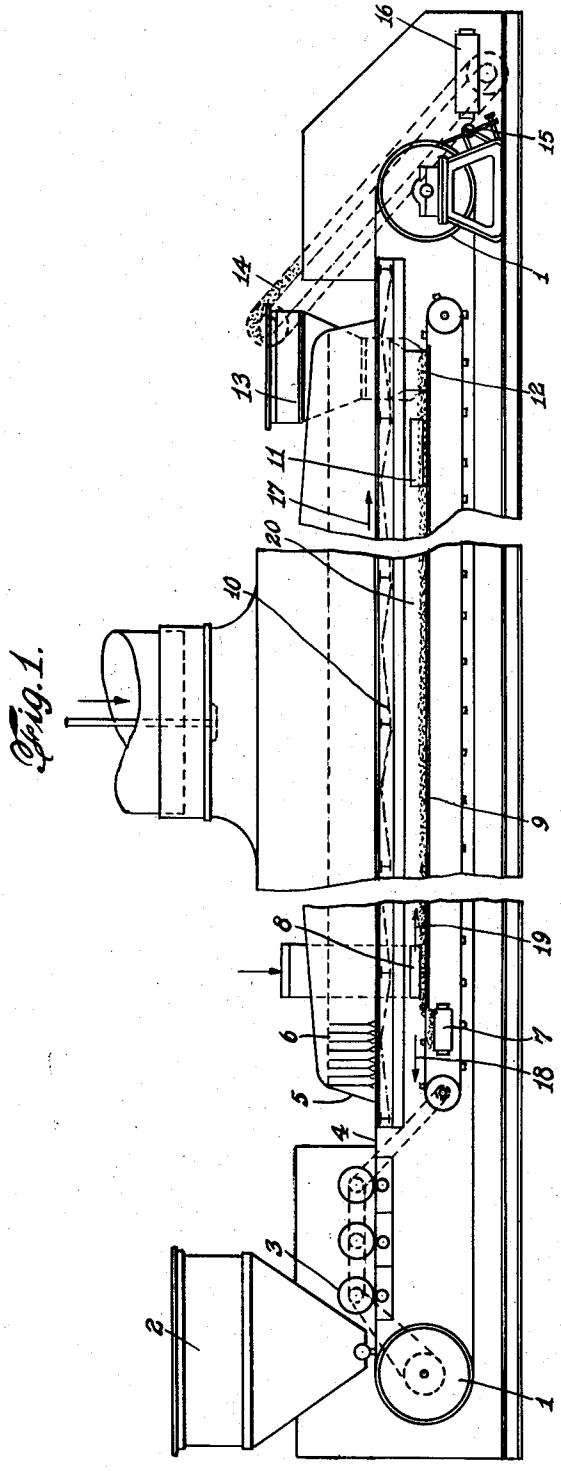


Fig. 1.

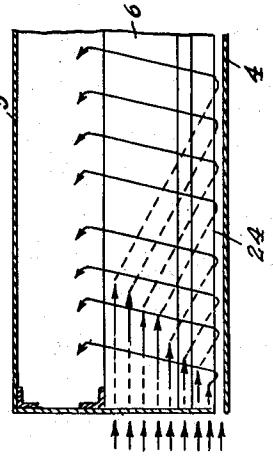


Fig. 2.

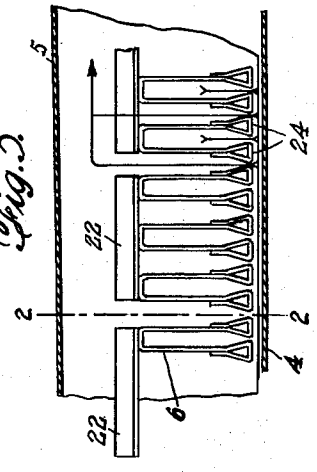


Fig. 3.

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Fig. 4.

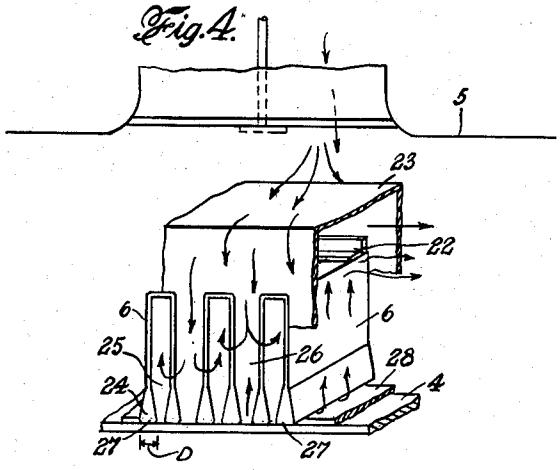


Fig. 5.

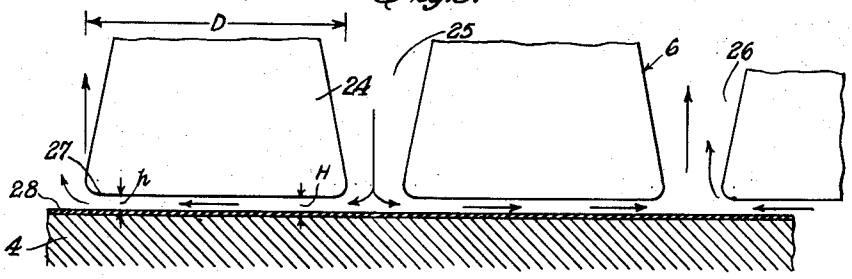
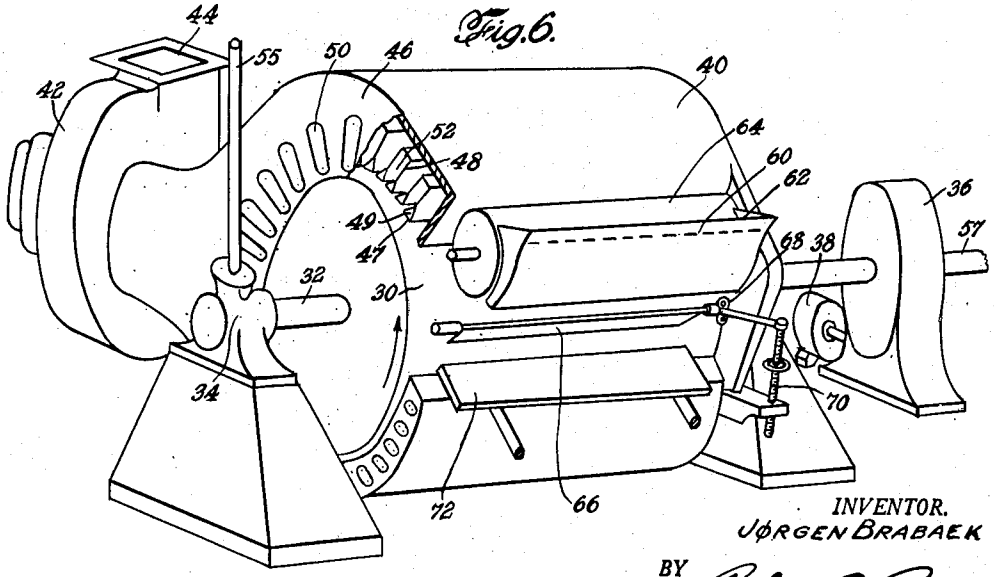


Fig. 6.



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METHOD FOR TREATING MIXTURE CONTAINING MATERIALS AND APPARATUS THEREFOR

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Application January 24, 1950, Serial No. 140,340
In Denmark June 1, 1944

1 Claim. (Cl. 34—25)

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This invention relates to the drying of materials and is particularly concerned with a process and apparatus for continuously and efficiently drying a moving layer of material.

For the cooling, evaporation, desiccation or like treatment of liquid or moisture-containing materials which may be converted into paste form, it is a known practice to place the materials as a thin layer on a supporting surface consisting, for example, of a conveyor belt or a drum on which surface the materials are subjected in one or more drying zones to rapidly flowing, separate currents of air or other gas. The gases pass to and from the drying zone through slit-shaped inlet and outlet passages formed between partitions extending vertically across the supporting surface at right angles to the direction of movement of the surface.

For this purpose, heated air, or at any rate, air of a temperature higher than that of the material being treated is used in order to increase the power of the air to absorb the moisture from the material, inasmuch as the high temperature of the air will give a relatively smaller saturation in the air than in the material treated, even if the vapor pressure were equal in the two media.

It has, however, been found that the efficiency of this process is materially less than previously presumed, primarily due to the fact that the air remains in the drying zone for such a short period of time that its humidity is not appreciably increased, with the result that the exhaust of the hot air will entail a considerable loss of thermal energy.

It is the principal object of the invention to provide an improved method of drying which avoids the above noted disadvantages.

It is a further object of the invention to provide improved apparatus for drying a moving layer of moist material.

It is a still further object of the invention to provide apparatus of the character indicated which insure more efficient contact between the material being treated and the drying medium.

It has been found that an increase in the rate of evaporation may be effected more efficaciously and with far less loss of energy by a more intense contact between the air and the material in the drying zone. According to the present invention non-saturated air of a temperature considerably lower than that of the surface supporting the material to be treated is passed in a laminar stream over relatively long stretches of the material. The surface of the material is thereby cooled while at the same time it receives heat

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from the supporting surface and thus will give off its moisture to the air which, however, will remain unsaturated. Thus, the invention represents a basic departure from traditional methods which have involved leading the air at high speed against the layer of material rather than letting it pass over the material for any length of time. Heretofore, care has even been taken to carry the air away from the material as quickly as possible, with the result that the time of contact has been relatively short.

According to one embodiment of the invention, the drying zone through which the material to be treated is passed comprises a long, narrow slit, sufficiently long that the required absorption of moisture may take place but sufficiently narrow that turbulent air currents are avoided and a substantially laminar flow of air is obtained. According to the invention the length of the passageway provided for the flow of air in the drying zone, in which the air flows parallel to the layer of the material being treated, is substantially greater than the distance from the supporting surface to the surface of the members forming the upper wall of the passageway.

It is advantageous to provide a uniform distribution of drying air across the entire width of the drying zone, so that a uniform drying of the material will be obtained. According to the invention this effect is attained by sucking in the drying air directly from the atmosphere and leading it to the drying zone without previous heating or other treatment, the air entering through an inlet passage directly connected with the drying zone and open at either or both ends, whereby a direct flow of air to the drying zone and a uniform distribution of the air across the entire width of the drying zone are ensured.

The cooling effect which, in contrast to heretofore known methods the drying air exerts on the material, makes it possible to subject the base to much higher temperatures than has formerly been possible, and in many cases it is possible to heat the base to a temperature that would injure the material if the air current did not exert its cooling effect.

Other objects and features of the invention will be apparent from the following detailed description and from the drawings, in which:

Fig. 1 is a side view partly in section and partly in elevation of one form of the apparatus of the invention;

Fig. 2 is a vertical section taken along the line III—III in Fig. 3;

Fig. 3 is an enlarged view of a portion of Fig. 1;

Fig. 4 is a perspective view of a section of the drying zone showing details of construction;

Fig. 5 is an enlarged diagrammatic view showing the relationship of the elements forming the drying zone; and

Fig. 6 is a perspective view, partly-broken away, of another embodiment of the invention.

Referring to the drawings, and particularly to Fig. 1, the material to be treated is discharged from a hopper 2 onto a moving support, which in the embodiment illustrated is a conveyor belt 4, passing over a pair of drums 1. Press rollers 3 riding on belt 4 spread the material in a thin layer on belt 4 which moves continuously in the direction indicated by the arrow 17. Positioned over the belt is a casing 5, which is provided with a top air inlet, and is also provided with a series of air-guiding members 6 which form inlet and outlet passages for the air supplied to the drying zone, as will be described more in detail hereinafter. The conveyor belt 4 is suitably heated by a number of gas burners 10 placed below the belt.

The material, having passed through the drying zone, is scraped off the belt, as by a scraper 15, and transferred to a conveyor 16, and the material is then carried by means of an elevator 14 to a hopper 13. Below the gas burners 10 is an after-drying passage or zone 20 through which passes a conveyor belt 9 moving in the direction indicated by the arrow 18. On this conveyor belt 9 the material received from the lower end 12 of hopper 13 is submitted to an after-drying treatment with air which is supplied through an inlet passage 8 and flows in the direction indicated by the arrow 19 into an outlet 11. The material is removed from conveyor 9 by a scraper or rotating brush or other convenient device (not shown) to a crosswise conveyor 7, which carries the dry material out of the plant. Each of the various conveyors may be run at a speed selected in accordance with the particular operating conditions encountered.

Referring particularly to Figs. 2, 3 and 4, the air-guiding members 6 are secured, as by angle irons 22, to the sides of an air channel 23 mounted in casing 5 and extending to the bottom of and enclosing the spaces between each air-guiding member 6. The members 6 are, in the embodiment illustrated, substantially U-shaped in cross-section and the walls thereof terminate in triangular end sections 24, the bases of which are parallel to the conveyor belt 4. The air is drawn into casing 5 and around the members 6 by any convenient suction device as indicated by the arrows in Fig. 5, the air entering through the top of casing 5 flows downwardly over air channel 23 and is drawn from each side of channel 23 into the spaces 25 formed by the walls of each member 6. The air is then drawn downwardly and through the relatively thin space formed between the bases of the triangular sections 24 and the belt 4. The air then flows upwardly in the spaces 26 between members 6 and is drawn away through the interior of air channel 23.

Referring particularly to Fig. 5, it will be observed that the bases 27 of the triangular portions 24 lie parallel to the surface of belt 4 on which is supported a thin layer of material 28 and that the length D of the bases 27 is of a substantially greater order of magnitude than the distance H between the upper surface of belt 4 and the lower surface of the bases 27. It is a feature of the invention that a substantially laminar, as distinguished from a turbulent, flow of air across the surface of the material 28 is obtained. It has been found that such laminar flow can be obtained and a substantial increase in efficiency realized by making the ratio of H to D at least 1:8, and the ratio is advantageously set within the range of 1:8 to 1:20. In practice, of course, the thin layer of material 28 reduces the distance H to a slightly smaller value, e. g. h. However, since the thickness of layer 28 is relatively insignificant as compared with H, H and h can, in practice, be considered as having substantially the same value. The thickness of the material on the carrying surface is in most cases, for example, between about 0.05 mm. and 0.5 mm. In the drawings the thickness of layer 28 is, for purposes of illustration, necessarily exaggerated. It is desirable to provide some convenient mechanism to permit the casing 5 to be raised or lowered with respect to belt 4 whereby H (or h) may be adjusted to any desired value.

While the invention has been described above in connection with an embodiment involving a continuous horizontal belt as the supporting surface for the layer of material being treated, the supporting surface may also be provided by the surface of a rotating drum.

Referring particularly to Fig. 6, a drum 30 is rotatably mounted on hollow stub shafts 32 and 33, shaft 32 being supported in bearing 34 and shaft 33 passing through a gear box 36 in which suitable gearing provides a driving connection between the shaft and a motor 38. Arranged over a substantial portion of the surface of drum 30 is an air case 40 connected to an exhaust blower 42 having an outlet 44. Extending between the side walls 46 of air case 40 are a series of air-guiding members 48 similar in construction to the air-guiding members 6, except that the former are arranged along a circular path so as to conform to the curvature of drum 30. As in the embodiment shown in Fig. 1, the bases 47 of the triangular end portions 49 of members 48 are spaced from the surface of drum 40 in such manner that the ratio H:D is at least 1:8 as described hereinabove. Each of the side walls 46 is provided with apertures 50 which communicate with the channels 52 between the walls of each air-guiding member 48. Apertures 50 thus permit air to be drawn by the action of blower 42 into both ends of channels 52.

The drum 30 is conveniently heated by steam which is introduced into shaft 32 through inlet 55. The steam condensate is withdrawn through shaft 33 and an outlet 57 connected to any convenient suction device (not shown). Interiorly of drum 30 a flexible tube (not shown) may be connected to shaft 33 to permit the condensate to be withdrawn from the lower portion of drum 30.

The material to be treated 60 is maintained in a trough 62 mounted across the surface of drum 30 between the ends of air case 40 and is applied to drum 30 by means of a feed roll 64 rotatably mounted in trough 62. The dehydrated material which has passed through the drying zone is removed by a knife mounted in bearings 68 below feed roll 62 and connected with an adjusting device 70, by means of which the angle of contact of the knife 66 with drum 30 can be varied. A catch plate 72 below knife 66 deflects the material scraped off the drum into a convenient container.

In operation the material 60 is spread in a thin layer on the surface of drum 30 by the action of feed roll 64. By reason of the rotation of

drum 30 the film of material is carried into the drying zone formed between the surface of drum 30 and air case 40 where it is subjected to laminar streams of air. The air, under the action of blower 42 is drawn through apertures 50 into each end of channels 52 between the walls of each air guiding member 48. The air passes downwardly in channels 52, across the surface of the material 60 on drum 30 in the narrow drying zone below the lower surface of bases 47, then upwardly between members 48 and through the upper portion of casing 40 to outlet 44.

In accordance with my process, I can rapidly and efficiently dehydrate or desiccate all types of materials by exposing a thin layer of the materials on a heated moving surface to an extended laminar flow of air. The process may be carried out with a wide range of temperature conditions, the temperature of the air being substantially lower than the temperature of the supporting surface. The air is conveniently at room temperature e. g. 15–30° C. although it may be heated somewhat if desired. The temperature of the supporting surface, preferably at least 60° C., is advantageously between 100° and 140° C. The velocity of the air drawn across the surface of the material may vary depending upon operating conditions. Generally speaking, the velocity of the air is between 25 and 100 feet per second.

The efficiency attainable by my improved apparatus may be illustrated by practical experiments wherein it has been shown that the base on which the drying material rests might be heated to 110–140° C. without the material being heated to more than 50–60°, i. e., a temperature difference of 60–80° is obtainable, whereas in known apparatus temperature differences of only 30–50° could be obtained, other factors being equal.

Since my process is intended to remove only the moisture and not the solid or viscous material, it is sometimes advantageous to subject material to a pre-drying step or, in the case of solutions, a pre-evaporation step until the viscosity and cohesion to the material is sufficient to prevent particles of the material from being carried away by the air current.

It will further be understood that one or more special treatments may in whole or in part be given the material in the drying zone. Thus, the raw material may during its passage through the drying zone be chemically or physically treated e. g. by oxidation, by irradiation with ultra-violet light, or by the addition of other substances, e. g. vitamins. If, for instance, the raw material consists of glands or blood, this material may be sterilized by exposure to ultra-violet rays during the passage through the drying zone, whereby a perfect sterilization will be possible when the material is lying in a very thin, filmy layer.

In the treatment of starch it may be especially advantageous to place immediately before the drying zone or in the first part of the latter a heating zone in which the raw material may be made to dextrinate before it enters the drying zone. In continuous operation the raw material may be caramelized or the starch converted into dextrine after the preliminary heating step.

Further, a cooling zone may be placed immediately beyond the drying zone which will be advantageous when it is a question of drying gelatine and certain kinds of glue which are kept semi-fluid by the drying heat and which prior

to being scraped off should be coagulated by cooling.

My process is of special importance in the desiccation of all kinds of finely-cut green fodder and garden produce, such as lucerene, clover, green grass and beet leaves. The plants may be harvested very early, e. g. before they have attained ripeness, for it will then be possible to retain all their nutrient values in their most digestive form during the drying. The material is placed on the conveyor in a sufficiently pasty consistency to make it form a filmy layer so dense that a sterilizing or vitaminizing irradiation may be effectively applied. All heretofore known desiccation methods for such products have had the drawback that the desiccation has not been uniform because of the thick and thin parts of the plant have been unequally affected or because the desiccation economy has required too high temperatures, too long a period of treatment or the use of unsuitable material, e. g. a product harvested too late, exposed to weather or otherwise depreciated in value.

Finally, the method according to the invention may be used in the treatment of products which after drying are to be exposed to especially high temperature, such as raw cement slurry. In that case the raw material is first applied to the external surface of the moving of a drum of the type shown in Fig. 6, and after drying, the material is scraped off and placed in the interior of the drum which by suitable means is heated to a temperature suitable for the burning of cement, and the hot air or gases resulting are used for the drying of the material on the surface of the drum. These gases may also be used for an after-drying of the material scraped off the outside of the drum and taken through the drum in a relatively thick or porous layer, the said air or gases being, if necessary, first passed through a drying or purifying cyclone. Before these gases are taken to the after-drying zone they may be further heated, as by passing them through a heater or by adding to them hot exhaust gases, e. g. the waste gases from the engine operating the plant. Thereby part of the waste heat of the engine may be utilized. Obviously, the temperatures employed in treating cement are much higher than those mentioned above in connection with the treatment of heat-sensitive materials such as food stuffs.

In the production of cement according to this method a particular heat economy is effected, inasmuch as both the inside and outside of the moving base are utilized and at the same time the same heat supply may be used both internally and externally, first assisting in the burning of the cement and then in the drying of the slurry.

This application is a continuation-in-part of my co-pending application Serial No. 700,364, filed October 1, 1946, now abandoned.

What I claim and desire to secure by Letters Patent:

A method of treating moisture-containing fluid materials to remove at least a portion of the moisture therefrom which comprises spreading the material to be treated in a thin layer having a thickness 0.05 mm. to 0.5 mm., moving said layer unidirectionally through a drying zone, heating the underside of said layer to a temperature substantially above the ambient temperature, passing a plurality of streams of non-saturated air at the ambient temperature across the top surface of the layer of material and parallel thereto in said drying zone at a velocity of 25

to 100 feet per second, each of said plurality of streams being caused to undergo laminar flow across said surface for a predetermined distance substantially less than the distance transversed by said layer in said drying zone, each stream being confined in flowing across said surface for said predetermined distance and having a height above said surface which bears the ratio to said predetermined distance of 1:8 to 1:20, and removing each of said air streams from contact with said surface after having transversed said predetermined distance.

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