Dec. 14, 1943. A. C. BEARDSLEE 2,336,461

APPARATUS AND METHOD FOR PRODUCING DRY PRODUCTS

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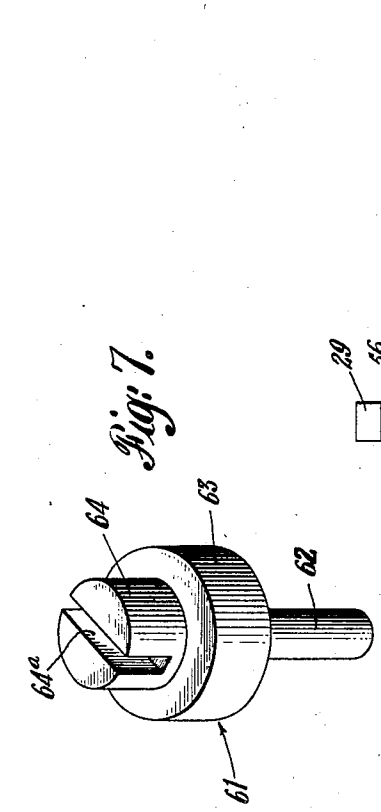


Fig. 7.

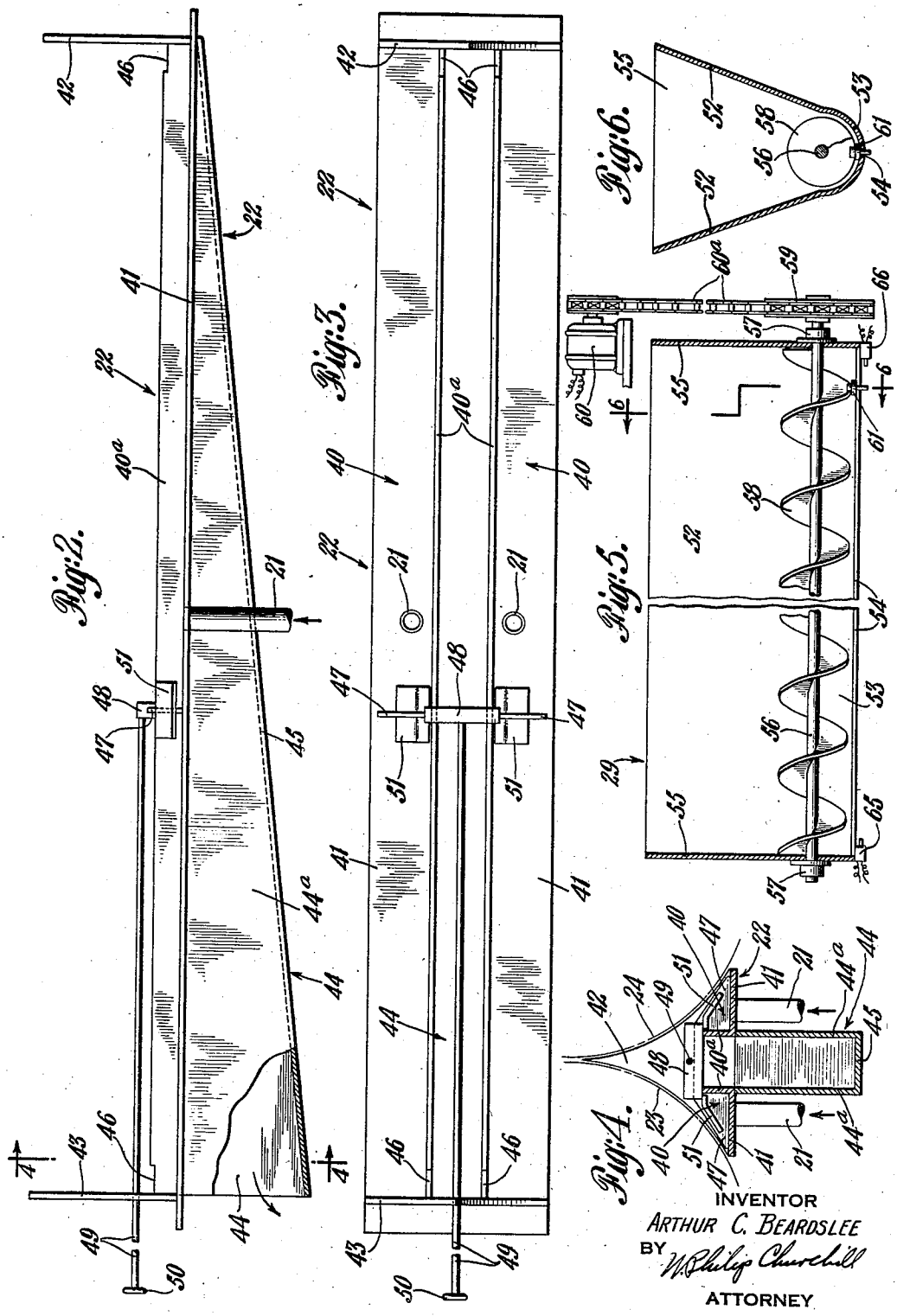
Fig. 1.

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APPARATUS AND METHOD FOR PRODUCING DRY PRODUCTS

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This invention relates to apparatus and process for drying materials, especially hygroscopic materials. The invention is particularly concerned with the drying of whey or the like in an economical manner to produce a commercially satisfactory product.

Many materials, such as those high in sugar, salts and/or proteins, become very sticky and mucilaginous when applied to a drying surface heated to a sufficiently high temperature to drive off moisture during the drying operation. Such materials may present serious problems in handling and as a practical matter are frequently extremely difficult to prepare in a non-hygroscopic powdery form. Drying methods such as spray drying applied to such materials as whey, for example, result in the production of an unsatisfactory hydroscopic product.

In the usual process of roller drying, the roll or rolls are heated so that the surface is at a temperature substantially above 212° F. The solution or suspension to be dried is spread upon these rolls in a thin film and after the moisture has been driven off by the highly heated roll, the dry film is removed by a scraper known as a "doctor blade." With products having a high sugar, salt and/or protein content however, the dry or partially dry film usually does not cleave away from the doctor blade, but instead accumulates as a plastic, soft, sticky roll or mass on the blade and becomes burned before properly drying. Even after such a mass has been dried, it is in the form of a hard lump which is very difficult to break up into a fine powder of good quality and pleasing appearance. I have discovered a simple and efficient process and apparatus which overcomes the foregoing difficulties.

One object of my invention is to facilitate drying of materials normally difficult to dry on heated rolls, by sprinkling finely divided dried material of the same or different composition, on a semi-dried film of material while it is being dried on the roll.

A further object of my invention is to make practically possible the roller drying of products presenting difficulties in drying by initiating crystallization of the crystallizable material in the semi-dried film on the drying roll, before it is scraped from the roll.

A further object of my invention is to provide a more economical, simplified process of producing dried products containing whey as a major ingredient.

A further object of this invention is to provide simplified apparatus for feeding a solution to be dried to a pair of drying rolls.

Another object of this invention is to provide apparatus for feeding powdered material continuously to a drying roll surface.

Other objects and advantages of this invention will be explained and will be apparent from a description of a preferred embodiment of the invention, described in connection with the accompanying drawings, in which

Figure 1 illustrates somewhat diagrammatically apparatus for converting ordinary whey, or other material, into a finely divided dry product.

Figure 2 is a side elevational view, partly in section and on an enlarged scale, of a feed trough for feeding material to be dried to the drying rolls shown in Figure 1.

Figure 3 is a top plan view of the feed trough illustrated in Figure 2.

Figure 4 is a vertical sectional view of this feed trough taken about on the lines 4—4 of Figure 2.

Figure 5 is a vertical sectional view through the feed hopper of Figure 1 for feeding dry material to the rolls.

Figure 6 is a vertical sectional view through this feed hopper taken on about the line 6—6 of Figure 5.

Figure 7 is a perspective on an enlarged scale of the cleaning member for the feed hopper of Figure 5.

The process of drying whey in accordance with this invention is preferably carried out by first concentrating the whey. This whey to be concentrated may be either whole or skim, and obtained from cheese, casein or other sources. If it is not already of a sufficiently high solids content, it is preferably concentrated in a vacuum pan 10 to produce a product containing about 30 to 70% solids, depending upon the nature of the original whey and of the subsequent treatment thereof. The usual type of vacuum pan may be employed and the operating conditions may be similar to those used for condensing milk and similar products. When the desired concentration of solids is reached, the concentrated whey may be withdrawn through pipe 11 to the storage tank 12. If the concentrated whey is to be kept for any substantial length of time in the storage tank, it is preferably cooled and maintained in a sufficiently cool state to preserve it against change.

If additional materials are to be mixed with the whey prior to drying, the concentrated whey may be withdrawn through the pipe 13 into a mixing tank 14, provided with an agitator 15. This agitator is preferably designed for vigorous

agitation to effect a thorough mixing of the added material with the concentrated whey. The mixture is now ready for drying and may be supplied through the pipe 16 to a feed tank 17 as needed. The level of the concentrated whey, or mixture, is preferably maintained constant in the feed tank 17 by means of a float 18 which regulates the opening and closing of the valve 19 in the pipe line 16.

The concentrated whey, or mixture thereof with other material, is withdrawn from the lower portion of the feed tank 17 by the pump 20 and delivered through the two branches of pipe 21 to the center of the feed trough 22 located immediately below the "pinch" of two drying rolls 23, 24. The drying rolls 23, 24 may be mounted upon suitable axles 25, 26 for rotation in opposite directions indicated by the arrows in Figure 1. These drying rolls 23 and 24 may also be internally heated in any suitable manner known in the drying art to a temperature well above 212° F. for example about 310–325° F. The material overflowing from feed trough 22 is collected by the overflow pipe 27 and delivered to a return conduit 28. The return conduit 28, in turn, carries this material back to the feed tank 17.

As will be hereinafter explained, a continuous stream of the concentrated whey delivered to feed trough 22 is caused to flow longitudinally along the drying rolls and a film of this material is picked up by the drying rolls and carried upwardly to the "pinch" or position where the two rolls almost touch. By suitably adjusting the rolls to vary this distance between them at the pinch, the thickness of the film on the rolls may be easily regulated. As the rolls carry this film up beyond the pinch, dry finely divided material, such as powdered whey, is dropped on the film from the powder feed hopper 29. The powdered material thus deposited may be the same as the material being dried, or it may be different material. This powdered material is preferably dropped from a single hopper in such a manner that it is sprinkled simultaneously over the semi-dry film of whey on both rolls. The film dusted with this dry powdered material is carried around the rolls until it is scraped therefrom by the doctor blades 30, 31. The addition of powdered whey to the semi-dry film of whey on the rolls is believed to initiate crystallization of the sugar and other crystallizable materials in the semi-dry film of the whey. This "seeding" of the semi-dry film may either start or accelerate crystallization. In any event, as the film reaches the doctor blades 30, 31, it has been found to be removed from the rolls and to cleave away from the doctor blades in a thin, substantially dry crinkly film which is easy to grind or reduce to a powder.

This crinkly film is dropped on the continuously moving endless belt conveyors 32, 33 which deliver the material in this condition to the conveyors 34 and 35. Conveyors 34 and 35 may be steam jacketed, or provided with some other heating device to accomplish a further drying of the product. For example, steam may be introduced through inlets 34a, 35a and the condensate or exhaust may be withdrawn through the outlets 34b, 35b. The conveyors 34 and 35 deliver the material to another conveyor 36 which is preferably artificially cooled by means of a cooling jacket or the like, to cool the dried product before grinding. A cooling medium may be introduced to the jacket through inlet 36a and withdrawn through outlet 36b. Cooling the dried product in the open air may be employed but requires a much longer time due to the heat retaining nature of the material. The material from conveyor 36 is delivered to a chute 37 which feeds the grinding apparatus 38. The ground powder may then be packaged in suitable containers 39 ready for the market.

With reference to Figures 2 to 4, the material to be dried is supplied to the feed trough 22 through the two branch feed pipes 21 which are located substantially centrally of the two drying rolls 23, 24. The feed trough itself comprises two separate feeding compartments 40, 40, with an inclined overflow trough 44 located therebetween. The feeding compartments 40, 40 are defined by two central vertical partitions 40a, 40a, cooperating with the horizontal base plates 41, 41 extending the length of the rolls. These compartments are each open on their outer side adjacent the surfaces of the rolls. End walls 42 and 43 of generally triangular shape may be provided to close the ends of the entire feed trough 22. Feed pipes 21 extend up through the plates 41 and are preferably made flush with the upper surfaces thereof.

The central overflow trough 44 below the feeding compartments 40, 40 includes the side walls 44a, 44a which may be downward extensions of the partitions 40a, 40a, and the base 45 which is inclined from one end of the overflow trough to the other. At each end, the vertical partitions 40a, 40a are provided with notches 46 in the nature of weirs.

Two cleaning blades 47 rigidly connected by a cross bar 48 are preferably mounted for reciprocation in the feed troughs 40, 40 in order to scrape any coagulated or other accumulated material from the walls of the feeding compartments from time to time. These cleaning blades 47 and the cross bar 48 may be reciprocated manually as a unit means of a suitable rod 49 having a handle 50. During normal operation of the feed trough 22, the cleaning blades 47 are preferably positioned over the center of the feed pipes 21 serving to divide the flow of material from these feed pipes so that one-half flows toward one end of each feeding compartment and the other half flows toward the other end of each compartment. To assist this dividing action, and ensure a uniform feed of material to the rolls, deflector blades 51 may be employed rigidly connected to the cleaning blades 47.

In the operation of this feeding device, the cleaning blades 47 are positioned over the centers of the feed pipes 21 and the material to be dried is flowed continuously up into the feed compartments 40, 40 through the pipes 21. The cleaning blades 47 and deflector blades 51 cooperate to divide the flow of material in each of these compartments so that it is distributed equally towards the ends thereof. As the material flows toward the ends of the feed compartment, it is picked up by the surfaces of the drying rolls 23 and 24 which moves upwardly, and the thickness of the film on the drying rolls is adjusted at the pinch thereof, which is immediately above the inclined overflow trough 44. Any excess from the drying rolls is dropped into the overflow trough. The rate of feed of material to be dried through the feed pipes 21 is preferably adjusted to provide substantially more material than will be picked up by the drying rolls 23, 24, and consequently this excess overflows through the notches 46 in the partitions 40a, 40a into the overflow

trough 44, whence it is returned by gravity to the feed tank 17 via the conduits 27, 28.

The notches 46 in the nature of weirs serve to maintain a substantially constant level of the concentrated solution or suspension in the feed compartments at all times. If desired, these overflow notches 46 could be made adjustable so that the height of material in the compartment 40 could be readily varied. By reason of the proximity of the feed trough 22 to the heated surfaces of the drying rolls, some of the material in the feed troughs, such as the albumen in whey, is apt to become coagulated or partially solidified. Such material may stick to the walls of the compartments 40 obstructing a uniform flow of the material to be dried therethrough. It is advisable, therefore, to move the cleaning blades 47 periodically back and forth throughout the length of the feed compartments to scrape any accumulated material from the partitions 40*a*, 40*a* and from the base plates 41, 41.

As the film of material to be dried is picked up by the drying rolls 23, 24 is moved to a position above the pinch of the drying rolls, a supply of powdered material is deposited thereon from the feed hopper 29 located directly above the pinch. Feed hopper 29 may be conveniently constructed with suitably inclined side walls 52 connected near their lower portions by an arcuate section 53 provided with a longitudinally extending slot 54 in its lowermost portion. The ends of this hopper may be closed by suitable end walls 55. This hopper, which is open at its top, is provided with a shaft 56 rotatably mounted in suitable bearings 57 attached to the end walls 55. Shaft 56 is provided with a helical conveyor screw 58 which is generally concentric with the lower arcuate portion 53 of the hopper walls. One end of the shaft may be provided with a sprocket 59 which is driven through a suitable chain 60*a* from an electric motor 60.

A reciprocating cleaning member 61, having a pin portion 62, may be provided for preventing clogging of the slot 54. The pin portion 62 extends through the slot 54 and a collar portion 63 of the member 61 is adapted to slide along the upper surface of the walls of the slot 54. Collar portion 63 has associated therewith a lug 64 provided with a suitable diagonal groove 64*a* adapted to receive the edge of the helical conveyor 58 in sliding contact therewith. The cleaning member 61 is thus mechanically moved upon rotation of the conveyor screw 58 from one end of the slot 54 to the other. Suitable reversing switches 65 and 66 are located at each end of the hopper 29 and adapted to be contacted by the pin 62 of the cleaning member 61 as it reaches the end of its travel in a given direction. These reversing switches may be connected by wires in a known manner to the electric motor 60, so that as the cleaning member 61 reaches one end of the hopper the reversing switch is actuated, changing the direction of drive of the electric motor and the direction of rotation of the conveyor screw 58. The cleaning member 61 thus moves to the other end of the hopper when its direction is again changed. It will thus be seen that the conveyor screw 58 agitates the dried powder in the hopper 29 providing sufficient quantities adjacent the slot 54 at all times. The cleaning member 61 which reciprocates back and forth through the slot keeps it free, preventing any clogging because of heat and moist air rising from the drying rolls. In this manner a uniform supply of powdered material may be deposited upon the partially dry film on the drying rolls. If desired, the hopper 29 may be tightly closed except for the slot 54 and warm air may be introduced into the hopper under slight pressure to prevent the dry material in the hopper from absorbing moisture which runs from the drying rolls.

After the film to be dried carrying the powdered material reaches the doctor blades 30, 31 it is scraped from the roll surface by these blades in a thin, crinkly, substantially dry film which is deposited on the endless belt conveyors 32, 33. This film is then deposited continuously by the belt conveyors in the conveyors 34, 35 which are heated. On these conveyors, the film may be broken up somewhat and is further dried under the influence of the heat. From the heated conveyors, the dried material is delivered to the conveyor 36, where it is rapidly cooled to prevent any burning and to render the material immediately available for grinding. The grinding mill 38 may be any suitable mill of the hammer mill type. Some of the dried ground material obtained in this manner may be readily transferred after grinding to the feed hopper 29 for deposit on drying rolls. The balance of the material may be packaged directly for shipment.

The foregoing invention has been described in connection with whey, a product containing in the dry form about 65 to 70% lactose. The process is particularly suited for producing dry finely divided non-hygroscopic whey either alone or admixed with other materials compatible therewith, such as food ingredients commonly mixed with whey in making cattle feeds or other food products. My inventon makes it possible to dry in an economical manner high sugar normally hygroscopic materials, such as those containing substantially more than 55% sugar on a dry basis with the production of non-hygroscopic products. Products containing a considerable proportion of colloidal material such as proteins, and which normally are hygroscopic may also be conveniently dried according to my invention. The material known as "fishstick" would be an example of such a normally hygroscopic proteinaceous material. My process may also be employed for "seeding" films of other materials containing crystallizable salts, while the film is on the drying roll.

The material being dried may, if desired, be mixed with other ingredients before application to the drying roll. Or the ingredient to be added to material being dried may instead be added in whole, or in part, as the powdered material dropped on the drying rolls. When a high sugar material is being dried, the deposited powder is preferably at least partially of a crystalline nature, although it need not be of the same composition as the material being dried.

The addition of the powdered material to the partially dry film on the drying surface may have some cooling as well as a drying effect on the film. When crystalline materials such as high sugar products are being treated, the powdered material is thought to produce "seeding" or initiating of crystallization in the film. In any event, this procedure enables the production of non-hygroscopic dried products on an open drying roll, which have been either very difficult or impossible to achieve heretofore.

It will be apparent that this invention may be practiced using a single drying roll or a different arrangement of multiple drying rolls than illustrated in the drawings. Other arrangements for feeding the liquid and powdered materials to the roll or rolls may also be employed or substituted

for those shown. The powdered material may, for example, also be deposited as a coating on the conveyor belts 32, 33 to prevent any sticking of the hot dried film thereto. The apparatus illustrated is preferred, however, because of its efficiency and ease of operation.

The terms and expressions which I have employed are used as terms of description and not of limitation, and I have no intention, in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but recognize that various modifications are possible within the scope of the invention claimed.

I claim:

1. A process of drying liquid materials comprising applying a film of said liquid material to a heated drying surface, adding finely divided dry solids to said film, and subsequently removing said film and solids from said surface.

2. A process of drying whey to produce a non-hygroscopic product comprising applying a film of a solution of whey having a substantially greater solids content than normal to a heated drying surface, thereafter depositing on said film finely divided crystalline seeding material, and removing said film with the finely divided material thereon.

3. A process of roller drying normally hygroscopic liquid material to produce a dry non-hygroscopic product comprising concentrating the material to be dried to a liquid having a solids content of at least about 30%, continuously feeding a film of said concentrated liquid to the surface of a rotating drying roll, depositing finely divided material compatible with the material being dried upon said film, and thereafter scraping said film and deposited material from the surface of said roll.

4. A continuous process of drying a solution of material having a high sugar content comprising applying a continuous film of said solution to the surface of a rotating drying roll, depositing powdered crystalline material on said film, removing the dried film from said surface, grinding said dried film to a powder and utilizing a portion of said ground dried film for deposit on the film of material on said roll.

5. A process of drying whey comprising feeding a solution of whey concentrated to a solids content up to about 70% to the heated surface of a drying roll, depositing dry finely divided whey upon the whey being dried on said surface, allowing the whey to dry with said deposit thereon, and scraping the dried whey off said surface.

6. A process of drying whey comprising feeding a solution of whey concentrated to a solids content of about 40 to 70% to the surface of a drying roll, depositing dry finely divided whey upon the whey being dried on said surface, allowing the whey to dry with said deposit thereon, removing the whey being dried from said surface in the form of a film, heating said film to further dry the same, and cooling and grinding the dried whey.

7. A process of roller drying comprising rotating a pair of drying rolls so that adjacent surfaces thereof move upwardly at approximately the same speed toward the pinch thereof, feeding a solution of material to be dried to said surfaces below said pinch, dropping a stream of finely divided material compatible with the material being dried upon the material on said surfaces immediately above said pinch, and removing the dried material from said surfaces.

8. Drying apparatus comprising a rotatable heated drying roll, means for supplying a film of liquid material to be dried to the surface of said roll, and means for depositing dry finely divided material upon a partially dried portion of the film on said roll.

9. Drying apparatus comprising a rotatable drying roll, means for feeding a continuous film of material to be dried to an underneath portion of said roll, and means for continuously dropping and uniformly distributing finely divided solid material to an upper portion of said roll coated with said film in a partially dried condition.

10. Apparatus for drying comprising a pair of rotatable drying rolls arranged in side by side relationship so that adjacent surfaces thereof move upwardly toward the pinch thereof, means for feeding liquid material to be dried to the surfaces of said rolls below said pinch, means located above said pinch for dropping a stream of finely divided solids on the material on said surfaces, and means for removing dried material from said surfaces.

11. Drying apparatus comprising a rotatable heated drying roll, and means for feeding a film of liquid to be dried to a surface of said roll, said means comprising a trough adjacent a lower portion of said surface, means for flowing said liquid into a central portion of said trough, weir means near each end of the trough for allowing excess liquid to overflow and maintain a constant liquid level in the trough, and a blade disposed in the trough for dividing the flow of liquid therein, said blade being movable to clean the walls of said trough.

12. A process of roller drying a normally hygroscopic liquid material to produce a dry non-hygroscopic product comprising continuously feeding a film of said liquid onto the heated surface of a rotating drying roll, depositing on said film finely divided seeding material compatible with the material being dried, and removing the dried film and deposited material from the surface of said roll.

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