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FLASH DRYING APPARATUS AND METHOD UTILIZING INTERMITTENT
PULSES OF DRYING GAS

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2 Sheets-Sheet 1

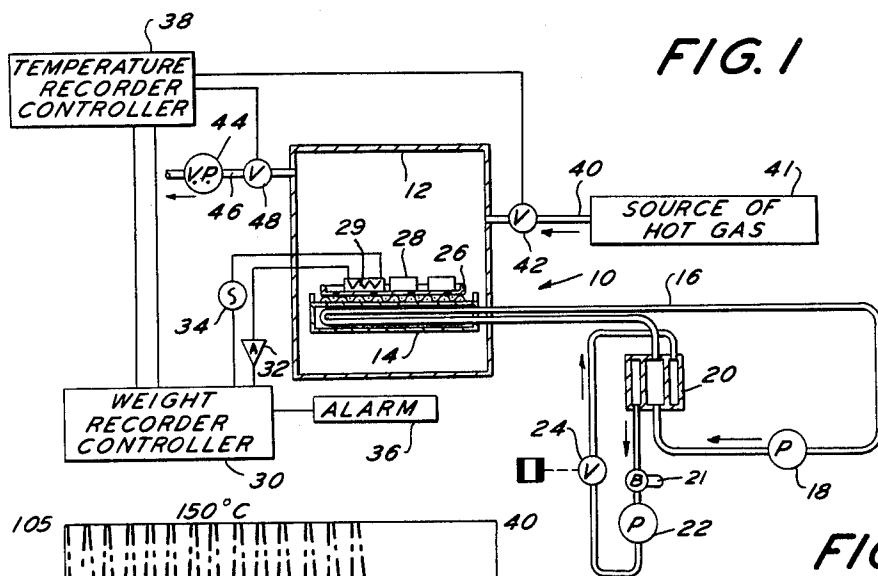


FIG. 1

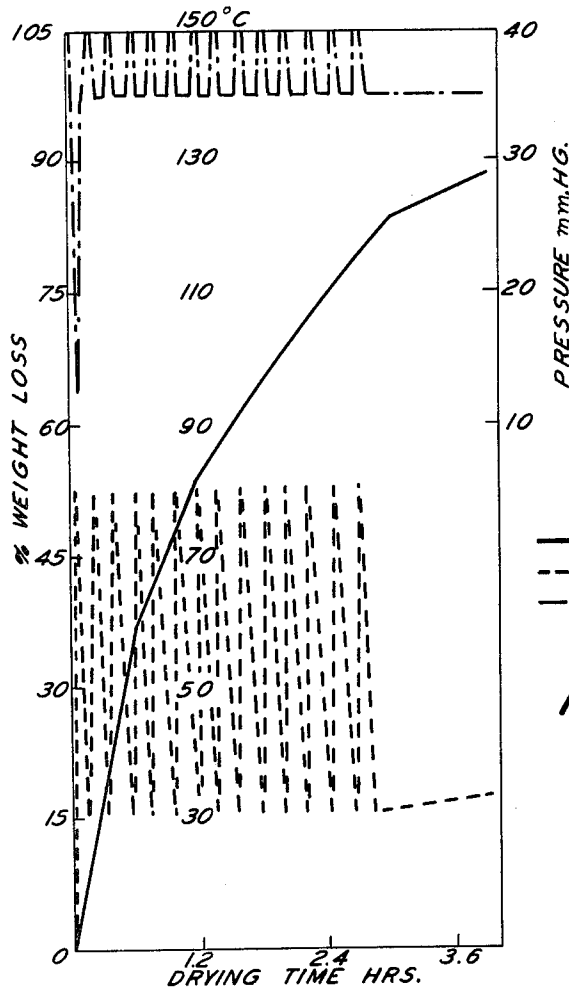


FIG. 2

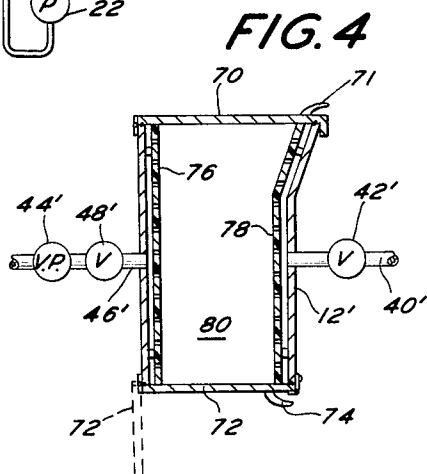


FIG. 4

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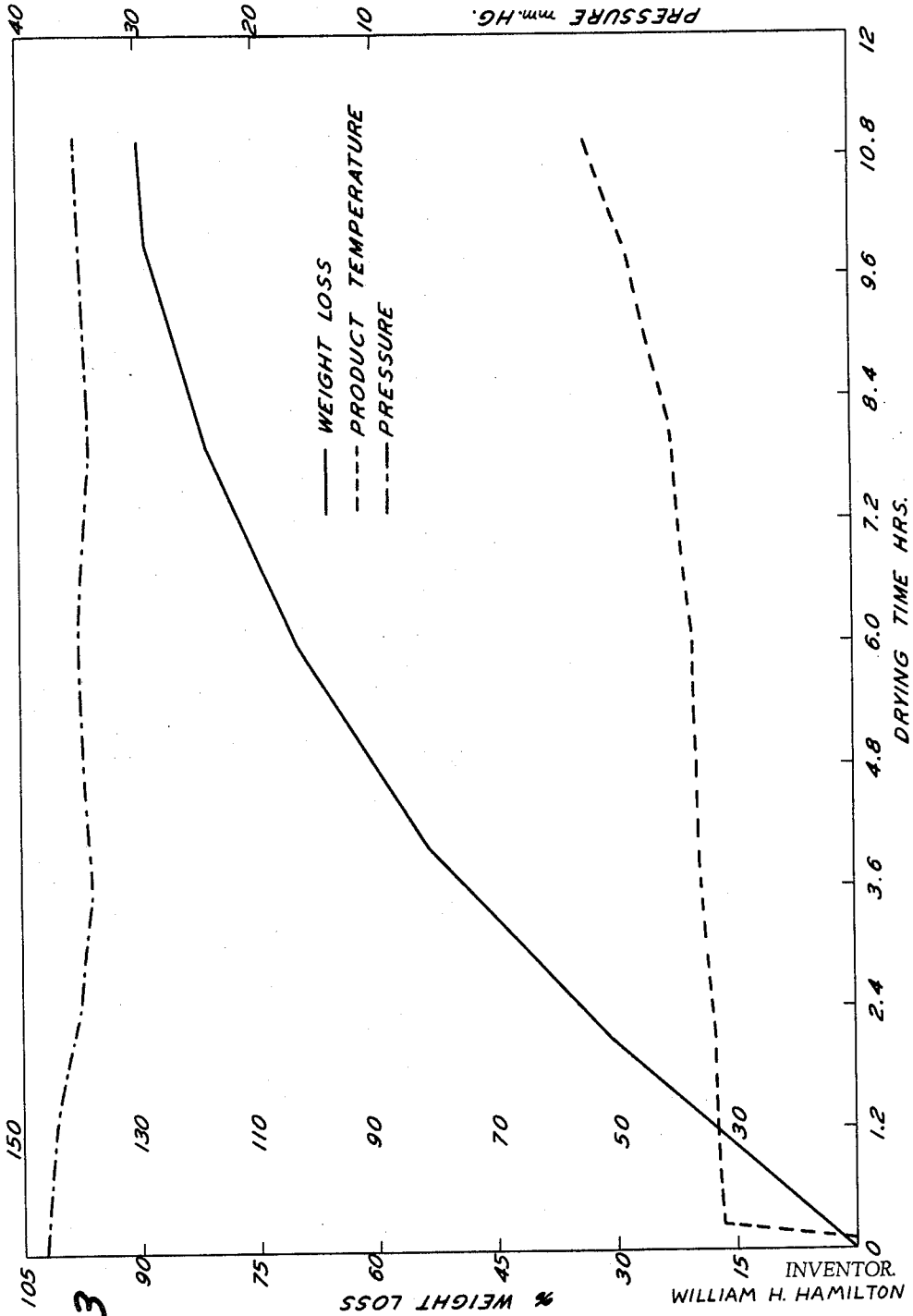
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1

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FLASH DRYING APPARATUS AND METHOD UTILIZING INTERMITTENT PULSES OF DRYING GAS

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Filed Sept. 28, 1962, Ser. No. 226,961
10 Claims. (Cl. 34-15)

This application is a continuation-in-part of my co-pending application Serial No. 148,126 filed on October 27, 1961 and entitled "Drying Apparatus and Method."

This invention relates to an apparatus and method for flash drying products.

The most common methods of removing moisture from products are freeze drying and vacuum drying. The present invention is a substantial improvement over the apparatus and methods used heretofore for vacuum drying. Vacuum drying apparatus and methods include the provision of a means to evacuate a chamber within which the product is to be disposed and means to apply heat to the product while the product is subjected to the reduced pressure. Depending upon the nature of the product and the amount of residual moisture desired, the time required to vacuum dry a product generally ranges between eight and sixteen hours.

The flash drying apparatus and method of the present invention is a novel departure from the apparatus and methods proposed heretofore for vacuum drying. In accordance with the present invention, the product to be dried is periodically and sequentially subjected to hot gases at atmospheric pressure and an evacuated atmosphere wherein the moisture is flashed off. Actual comparison tests have indicated that the present invention reduces the time cycle by more than fifty percent (50%).

The reasons why the present invention reduces the time cycle to such an unexpected amount has not been definitely ascertained. However, it is believed that the substantial decrease in the time cycle results from the fact that the product is periodically subjected to hot gases at atmospheric pressure thereby enabling heat of the gases to impregnate the voids in the product, such voids being created by prior steps wherein the moisture was flashed off. The hot gases are preferably superheated steam which by its very nature does have some moisture. Other gases which may be utilized include hot inert gases such as nitrogen or the like. The alternating sequence of the steps wherein the product is subjected to hot gases at atmospheric pressure and then an evacuated atmosphere is preferably responsive to the temperature of the product.

The products which may be flash dried in accordance with the present invention include foods such as meats and vegetables, bones, blood, pharmaceuticals, etc. If color and flavor are an important factor such as where the product is food, the product may be subjected to a tumbling action or otherwise moved during the flash drying process when the trays for the product are made of thermally conductive material. Otherwise, the product will not have uniform color. Products which have been flash dried in accordance with the present invention have been found to shrink only about ten percent as compared to conventional vacuum drying methods wherein the shrinkage of the product is fifty percent (50%) or greater. As a result of this substantially smaller amount of shrinkage, the products which have been flashed in accordance with the present invention will rehydrate sub- of shrinkage, the products which have been flash dried in accordance with conventional methods, for example, a product which has been dried in accordance with a conventional vacuum drying process may require ten minutes

2

for rehydration whereas the identical product dried in accordance with the present invention may require only two to three minutes for rehydration.

It is an object of the present invention to provide a novel vacuum drying apparatus and method.

It is another object of the present invention to provide a novel apparatus and method for flash drying products.

It is another object of the present invention to provide a novel apparatus and method which reduces the amount of shrinkage of the product during the drying process.

It is another object of the present invention to provide a novel apparatus and method for drying products so that the products may be rehydrated quicker than those products which have been dried in accordance with conventional methods.

It is another object of the present invention to provide a novel apparatus and method which substantially reduces the time cycle for effecting the drying of a product.

It is another object of the present invention to provide a novel apparatus and method for drying products faster with less shrinkage without sacrificing color or flavor.

Other objects will appear hereinafter.

For the purpose of illustrating the invention there is shown in the drawings forms which are presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIGURE 1 is a schematic illustration of the apparatus of the present invention.

FIGURE 2 is a graph illustrating moisture removed, pressure and temperature of the product versus drying time in accordance with the present invention.

FIGURE 3 is a graph similar to FIGURE 2 but illustrating the same characteristics as associated with conventional apparatus and methods.

FIGURE 4 is a cross sectional view of another embodiment of the present invention.

Referring to the drawing in detail, wherein like numerals indicate like elements, there is shown in FIGURE 1 a drying apparatus designated generally as 10.

The apparatus 10 includes a housing 12 within which the product 28 is to be flash dried. The housing 12 may have one or more shelves 14 adapted to be heated in any conventional manner. As illustrated, the shelf 14 is hollow and will be heated by means of a flowable medium in conduit 16. Conduit 16 is provided with a pump 18 and a portion of the conduit passes through a heat exchanger 20.

The temperature of the heat exchanger 20 is regulated by a controlling fluid such as steam which is circulated therethrough by means of a conduit containing a steam generator 21, a pump 22, and a solenoid operated control valve 24. Suitable automatic temperature responsive controls may be provided to operate the pump 22 and valve 24. As will be made clear hereinafter, use of the shelf 14 as a source of heat is optional and may be used only during a portion of the cycle since the temperature of the product will be primarily increased by introducing a hot gas into the housing.

The products to be dried are preferably supported within the housing 12 by means of a tray 26. Tray 26 is preferably made from a thermally non-conductive material such as a high temperature lightweight plastic. For example, tray 26 may be made of polypropylene. In this manner, discoloration and overheating of the product are avoided. The tray 26 is spaced from the shelf 14 by means of a wire spacer or the like.

In order that the operating cycle for the apparatus and method of the present invention to be responsive to the temperature of the product, at least one of the products 28 will have a temperature responsive coil 29 or the

like embedded therein and in series with an amplifier 32 and a weight recorder and controller 30 across the source of potential 34. The controller 30 may be provided with an alarm 36 which may be audible and/or visible. The alarm 36 is primarily designed to give a signal indicative of the fact that the product is being overheated thereby indicating that the apparatus is not functioning properly.

Since the weight of the product is a function of the amount of moisture therein, and the amount of moisture therein is indicative of the strength of the signal received by the controller 30, a permanent record may be ascertained of the change in weight of the product 28. The controller 30 is preferably electrically coupled to a temperature recorder and controller 38. Controller 38 will maintain a permanent record of the temperature of the product as a function of the strength of the signal received and will alternatively operate the valves 42 and 48 as a function of the strength of the signal indicative of the predetermined high and low temperature limits for the product 28.

Valve 42 is in a conduit 40. One end of conduit 40 communicates with the interior of housing 12. The other end of conduit 40 is connected to a source of hot gas 41. Valve 48 is disposed in a conduit 46. One end of conduit 46 is in communication with the interior of housing 12. The other end of conduit 46 is coupled to a vacuum pump 44 which is adapted to evacuate the housing 12.

The operation of the apparatus and method of the present invention is as follows:

The product to be dried is placed on the tray 26 which is disposed within the housing 12. Preferably, the product 28 is comprised of a plurality of small articles of uniform size. The graphs in FIGURES 2 and 3 are based on three-eighths of an inch diced turnip cubes. A temperature sensing coil or the like will be embedded in one or more of the products 28. While the products 28 are at atmospheric pressure, a hot gas such as superheated steam will be introduced into the chamber to increase the temperature of the products 28. As indicated in FIGURE 2, the temperature of the product was raised up to approximately 80° C. When the products 28 reach this temperature, valve 42 was closed and valve 48 opened in response to a signal from controller 38.

The valves 42 and 48 remain in this position until the pressure in the housing 12 is reduced down to a pressure between the range of approximately 5 to 50 mm. of mercury. As illustrated in FIGURE 2, the pressure was reduced to approximately 30 to 40 mm. of mercury. While the pressure within the housing 12 is being reduced, moisture in the products 28 is being flashed off. As soon as the predetermined low level for the pressure within the housing 12 is reached, the temperature of the products 28 will have decreased to the predetermined low temperature cut off point. At this point, valve 48 is closed and valve 42 opened in response to a signal from controller 38.

As soon as valve 42 is opened, hot gases such as superheated steam will be introduced into the housing 12 to reheat the products 28 and raise the pressure therein to atmospheric pressure. The introduced hot gases impregnate the voids in the products 28 created by the removal of moisture. As soon as the temperature of the product again reaches the predetermined high temperature of approximately 80°, the valve 42 is closed and valve 48 is opened in response to a signal from controller 38. The above process is repeated until the amount of predetermined residual moisture in the product is attained. As indicated in FIGURE 2, the products 28 reached dryness in a time cycle of four hours. During this time cycle, the product temperature varied between approximately 80° C. and 32° C. while the pressure in the chamber varied between atmospheric pressure and 35 mm. of mercury. As will be evident from FIGURE 2, the above process was repeated approximately fourteen times during the three hour drying cycle.

The identical product was vacuum dried in accordance with conventional methods as shown in FIGURE 3 where-in the pressure of the chamber was maintained uniform at approximately 35 mm. of mercury and the product temperature varied between about 32° C. and 55° C. It will be noted that the time cycle required approximately eleven hours to obtain the residual moisture of eleven percent. Hence, the time cycle to effect a predetermined amount of residual moisture is three times as long when using conventional equipment when compared with the present invention.

Notwithstanding the substantial decrease in the length of the time cycle, the present invention substantially reduced the shrinkage of the product. In conventional methods, the product normally shrinks more than fifty percent. In accordance with the present invention, the product generally has a shrinkage of less than ten percent. Accordingly, the product which has been dried in accordance with the present invention may be rehydrated at a much faster rate. While a conventionally dried product may require between eight and twelve minutes to be rehydrated, the present invention enables the identical product to be rehydrated within three minutes. Notwithstanding the decrease in the period for rehydration and the time cycle for effecting a drying of the product, color and flavor of the product has not been sacrificed. Uniform color and flavor may be obtained by tumbling or otherwise agitating the products during the drying cycle when thermally conductive trays are used. Drying chambers having apparatus for tumbling the product during the drying cycle is commercially available. Such tumbling apparatus is not necessary if the color of the product is not important. Generally, the color of the product is only important with those products which are intended to be consumed by humans immediately upon rehydration.

In FIGURE 4, there is illustrated another embodiment of the present invention which is identical with apparatus 10 except as will be made clear hereinafter. Hence, like elements of apparatus 10' and 10 are provided with primed numerals in FIGURE 4. Also, it is not deemed necessary to illustrate the circuitry of FIGURE 1 in FIGURE 4 since the identical circuitry is used.

Apparatus 10' includes a housing 12' which is open at its top and bottom. A lid 70 having a handle 71 is hingedly connected to housing 12' to selectively permit access into the interior of housing 12'. A bottom outlet door 72 having a handle 74 is hingedly connected to housing 12' to selectively permit discharge from housing 12'. Perforated plates 76 and 78 of a thermally non-conductive material are each juxtaposed to and spaced from one of the upright side walls of housing 12' to define a chamber 80 therebetween for receiving the products to be dried. It will be noted that door 72 constitutes the bottom of chamber 80 and therefore is made from a thermally non-conductive material. If desired, only the inner face of door 72 may be provided with a layer of thermally non-conductive material.

Pipe 40' communicates with the space between plate 78 and the juxtaposed upright wall of housing 12'. Pipe 46' communicates with the space between plate 76 and the juxtaposed upright wall of housing 12'. The upper end of housing 12' may be flared outwardly to facilitate introduction of the product into chamber 80 such as by pouring. At the end of the cycle, door 72 is opened and the product is discharged into a hopper, container, or the like. Apparatus 10' eliminates the necessity for separate discrete trays for each batch of products, eliminates the heaters such as heated shelf 14, and materially reduces handling of the product. Otherwise, apparatus 10' operates as described above.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. A method of drying a frozen product comprising introducing a product into a chamber, heating the product by introducing a heated gas into said chamber closed to exit of a gas until the product reaches a predetermined high temperature, flashing off moisture from the product by reducing the pressure in the chamber to about 5-50 millimeters of mercury and until the temperature of the product reaches a predetermined low temperature, then repeating said steps of heating and flashing in that order until the product contains a predetermined amount of residual moisture.

2. A method in accordance with claim 1 wherein said gas is at atmospheric pressure when it is introduced into the chamber.

3. A method of drying products comprising placing a plurality of frozen products of substantially uniform size in a chamber, alternatively and sequentially heating the products and subliming moisture from the products, said heating step including heating the products and simultaneously increasing the pressure in said chamber by introducing a heated gas into the chamber until the products reach a predetermined high temperature, said subliming step including subliming moisture from the products by reducing pressure in the chamber until the temperature of the products reaches a predetermined low temperature, removing sublimed moisture from said chamber simultaneously with the step of reducing pressure in the chamber, then repeating said steps in that order until the product contains a predetermined amount of residual moisture.

4. A method in accordance with claim 3 including the step of detecting the temperature of the products and controlling the sequence of said steps of heating and subliming in response to the desired minimum and maximum temperature of the products so that heating is initiated when the product temperature reaches a set minimum and the subliming step is initiated when the product temperature reaches a given maximum.

5. A drying apparatus comprising a housing, means in said housing for supporting a product to be dried within the housing, means in said housing for heating products to be dried in the housing, first means coupled to said housing for selectively evacuating the housing to decrease the temperature and pressure within said housing, second means coupled to said housing for heating a gas and introducing said heated gas into the housing to heat the products to be dried and increase the pressure within said housing, said second means being without said housing, and control means for alternatively and repetitively placing the housing, in communication with the first and second means, whereby products to be dried will alternatively and repetitively be subjected to an atmosphere of increased pressure and temperature and then decreased temperature and pressure.

6. Apparatus in accordance with claim 5 including means for detecting the temperature of the product, and

said control means being coupled to and responsive to the temperature detecting means so that heating is initiated when the product temperature reaches a set minimum and the subliming step is initiated when the product temperature reaches a given maximum.

7. Apparatus in accordance with claim 5 wherein said second means includes a source of heated inert gas.

8. Apparatus in accordance with claim 5 wherein said housing is constructed and arranged in a manner so as to have a selectively movable lid means at the top for enabling a product to be introduced into the chamber, and selectively movable door means at the bottom of said housing for enabling a product to be removed from said chamber.

9. Apparatus in accordance with claim 5 including first and second upright spaced plates disposed in said housing and having apertures therethrough, the products to be dried being disposable on said supporting means between said plates, said first plate being constructed and arranged with respect to said first means in a manner so that the first means communicates with that portion of the chamber between said plates by way of the apertures in said first plate, and said second plate being constructed and arranged with respect to said second means so that said second means communicates with that portion of the chamber between said plates by way of the apertures in said second plate.

10. A drying apparatus comprising a housing, means for supporting a product to be dried within the housing, means for radiantly heating products on said supporting means, means for detecting the temperature of products being dried, a first means including a valved conduit coupled to said housing for selectively reducing the pressure in said housing, a second means including a valved conduit for introducing a hot gas into the housing to heat said product, circuitry coupling said detecting means to said valves for alternatively and repetitively placing said housing in communication with said first and second means in response to the temperature of the product, whereby products to be dried will be alternatively and repetitively subjected to increasing and decreasing temperature.

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