

[54] **METHOD AND APPARATUS FOR DRYING MATERIALS**

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[22] Filed: **Dec. 31, 1969**

[21] Appl. No.: **889,595**

[52] U.S. Cl. **34/15, 34/92, 62/238**

[51] Int. Cl. **F26b 3/04**

[58] Field of Search **34/15, 5, 92, 77; 165/30; 62/170, 238**

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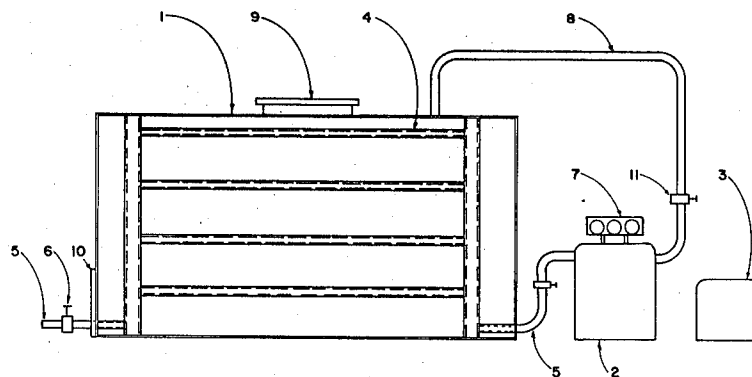
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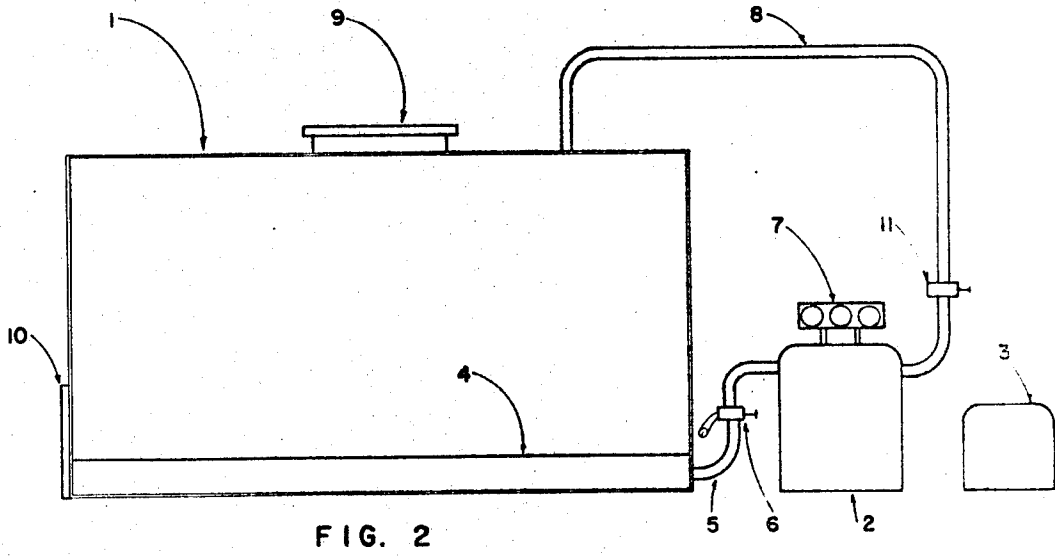
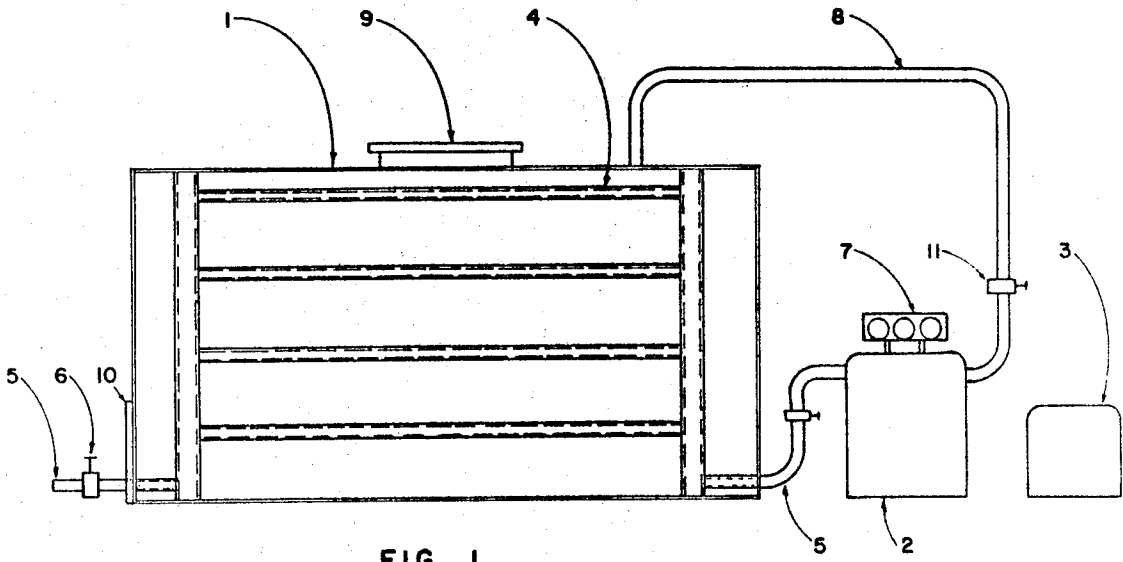
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ABSTRACT

An improvement in the method and apparatus used in vacuum drying materials such as grain, cotton, pulps, papers and peats in chambers, wherein the internal pressures are below atmospheric pressure. The previous methods and apparatus are simplified with respect to heating by distributing the heat generated by the operating vacuum pump throughout a heat exchanger manifold located inside the chamber.

2 Claims, 2 Drawing Figures





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METHOD AND APPARATUS FOR DRYING MATERIALS

SUMMARY OF THE INVENTION

The method and apparatus set forth in the instant application provides for a method and apparatus of lowering the temperature, preventing condensation, removing the water moisture from the inside of the sealed container having an absolute pressure of near-vacuum condition thereby expelling water moisture from the surrounding atmosphere inside the said container.

Prior art methods and apparatuses for drying materials have been cumbersome, difficult to operate and generally have produced uneconomical methods and apparatuses for drying materials. The method and apparatus set forth herein describes and claims a method and apparatus for drying materials such as grain, cotton, pulps, papers, peats and other related materials which are in a condition for which a drying operation is needed or required. Prior art devices have used various methods of agitation and temperature control so as to reduce the hazard of killing the germ with respect to grains and succeeding in drying materials or grains without detrimental effect to the end product or the dried materials. The material generally has been raised in temperature thereby driving the water moisture or withdrawing water moisture from the container which surrounds or stores the material therein. The apparatus for drying materials have been ineffective in that water moisture returns and is condensed on the material during the time it is cooled.

The instant invention provides a method and an apparatus for enclosing wet material by means of a vacuum container by which the material is placed and is subsequently dried having the pressure reduced so that the vacuum effect or a near-vacuum effect is undertaken in the container. This operation reduces the temperature by which the air or the water moisture in the wet material may be withdrawn from the container without raising the temperature above 180°. In the case of grains it should be noted that the maximum temperature should not exceed 160° Fahrenheit. The reduction in pressure thereby lowers the temperature of the material by which the water moisture may escape and thus produces a dried material without agitation and without raising it to the temperature of the surrounding area or the material above 180° Fahrenheit (160° Fahrenheit in the case of grains). It thereby reduces the possibility of killing the germ in wheat grains or other similar grains and reduces the possibility of detrimental effect with respect to other materials heretofore set forth.

The method set forth comprises of the following steps: placing the materials in a container having a sealed inlet and outlet, reducing the pressure within the said container below atmospheric pressure, raising the temperature of the said material in the said container, and withdrawing the said moisture from the said material within the said container.

The apparatus set forth in the disclosure comprises: a hollow container having a sealable inlet and outlet, a pumping means adapted to withdraw air from the said container and provide a partial vacuum, pumping lines to the said pumping means and to the said container and interconnected therebetween, and a heat producing means to provide for an increase in temperature of the said container and of the said material which will increase the temperature of the material to a predetermined level.

Other objects, features and advantages of the invention will be apparent from the following description when read with reference to the accompanying drawings. In the drawings, wherein like reference numerals denote corresponding parts throughout the several views:

FIG. 1 represents a diagrammatical view of the apparatus defined in this disclosure;

FIG. 2 is another diagrammatical view showing the apparatus which is similar to the apparatus shown in FIG. 1.

The description of the various parts of the apparatus is herein set forth. Container 1 in FIG. 1, is a hollow container into which the material is placed and by which a drying

process may be provided. Container 1, has a top closure 9 which provides an entrance for the material into container 1. A bottom closure 10 is provided as an exit or a means of withdrawal for the materials from the container. A pumping means 2 is operated to create the vacuum. Control valves 6 and 11 provide for the closure valves with respect to the suction discharge lines, exhaust line 5, and suction line 8 and are provided as pipes which must withstand pressures of at least 50 pounds per square inch. Control panel 7, provides for an indicator of the various pressures throughout the lines and within container 1. Pipes or manifolds 4, are within the container 1 and act as a heat transferring manifold and provide for a means through which the exhaust from the pump may transfer heat to the inside of the container and the material placed herein. Power source 3, provides for an outside power source for the pumping means and other control mechanisms used in the apparatus. FIG. 2, is of the similar configuration as shown in FIG. 1; the various lines, valves, control panels and control mechanisms are of a similar system as shown in FIG. 1.

The operation of the apparatus is herein set forth. In FIG. 1, an apparatus is shown having the material entered into container 1 through closure 9. Closure 9 is closed and sealed by means of a pressure sealing mechanism which is well known in the art. Valve 11, is a two way valve and is opened to the atmosphere and to suction line 8. Thence valve 6 is opened and power source 3 provides for a pumping means to vacuum pump 2 which starts to withdraw air from container 1. When a predetermined temperature is reached as shown by control panel 7, valve 11 is opened only to suction line 8; at that predetermined time moisture is withdrawn from the material. The moisture will be drawn through vacuum pump 2, and exhausted through manifold 4 and discharged into the atmosphere. Thus the material is dry as shown by control panel 7; at that time valve 11 will be opened to the atmosphere allowing container 1 to regain a pressure of atmospheric. At this time the material within the container is dried and subsequently door 10 may be opened and the material unloaded or withdrawn from container 1.

In the case of FIG. 2, the wet material is loaded through closure 9; closure 9 is closed and sealed and valve 6 is then opened. Power source 3 is applied to pumping means 2, and thus the water moisture is withdrawn by means of a vacuuming system. When a predetermined temperature is reached as shown by control panel 7 valve 6 is slowly closed to suction line 5 and opened to the atmosphere. At that predetermined time the water moisture would be withdrawn from the material and a similar procedure will be followed as in the case with the apparatus shown in FIG. 1. The operation of the invention is best described by the thermodynamic theory which is derived from the equation $PV=RT$. In this equation P designates pressure, V designates volume, R designates universal gas constant and T represents the absolute temperature (460° plus the Fahrenheit temperature above zero). In this equation it may be shown that if the pressure (p) is decreased then the temperature (T) is also decreased to maintain an equality between the sides of the equation. It is well known in the art that this thermodynamic equation represents a theory that when the pressure is decreased then the temperature is also decreased if the other remaining quantities of the equation are the same; that is if the volume and the gas constant remain equal then a decrease in pressure must result in a decrease in temperature. If the pressure is lowered to a near-vacuum (absolute pressure) it will be seen that the boiling point of water is considerably lower due to that pressure decrease. It is therefore apparent that if the pressure is decreased sufficiently the temperature of the container in the apparatus will reach a point where the moisture contained in any material placed herein would be evaporated at a lesser temperature than would ordinarily be the case than having an atmospheric pressure surrounding the material within the container.

The operation of the apparatus herein disclosed provides for a method to remove moisture from material using a tem-

perature from 33° Fahrenheit to 180° Fahrenheit together with a pressure of atmospheric down to a pressure of 0.20 inches of mercury absolute pressure. By this means the moisture would be vaporized and be removed from the material at a low temperature. The air may be exhausted through a manifold or a coil pipe through the grain to increase the temperature within the container and then that air is exhausted into the atmosphere. The transfer of heat from the air exhausted from the pumping means is provided by the manifold or coil pipe. Thus the grain is heated as the pressure within the container is lowered by using the heated air pumped from that container by means of a heat transferring system through a manifold. The drying may be performed in a container having a variation in size and configuration which may be dependent upon the amount of material or volume of material that requires drying.

Material such as grain having a volume of 250 bushels may be dried between 10 and 15 minutes in time from a moisture content of 14 to 30 percent down to a moisture content of 12 to 13 percent; generally, the water moisture in grains or like materials would necessarily have to be reduced to at least 13 percent in order to prevent the grains from becoming "musty" or "tough" condition. Other various materials may take from 11 to 60 minutes depending upon the requirements of the remaining moisture after being dried; those moisture requirements may vary from one geographical location to another or from one location to another.

The vacuum within the container shown in FIGS. 1 and 2 is obtained by withdrawing the moistened air from the tank without moving the material in any way. The heating is obtained by using the same air through an exhaust manifold of the vacuum pump at a controlled rate by use of valves shown in FIGS. 1 and 2. Additional heating may be required; the additional heat may be obtained from the exhaust heat from an internal combustion engine if that type of engine is used, or the additional heat may be used from an external source as required in any particular case under varying conditions. The control of the temperature may be confined through the use of valves in combination with an internal temperature gauge which may be thermostatically controlled so as to open and close valves and provide the means of a temperature or heat producing mechanism. It may be seen in FIG. 1 that the manifold 4 may surround the tank or in the case of FIG. 2 may consist of a perforated plate which will allow the moisturized air exhausted from the vacuum pump into the chamber; and the air withdrawn from the top of the grain material is stored within chamber 1 or container 1. This method enables the exhausted heat to penetrate through the grain material. Thus by controlling the degree of temperature within the container the ideal temperature is maintained. The exhaust is then returned to the atmosphere. The low absolute pressure within the tank provides for the creation of a moisture raising condition and the near-vacuum subsequent pressure will decrease to a point where the moisture is driven from the material in the form of a vapor. At a set time the gauges and instruments on the control panel will indicate a particular predetermined condition of the grain, the temperature or any other condition within or outside of the container 1. The dry material or grain may be unloaded as provided in a prior description heretofore set forth. The process for the method may be obtained by placing the material within the container having a sealable inlet and outlet. The pressure within the container is reduced below atmospheric pressure; the temperature is thereby raised within

the container and the material is dried by drawing the moisture away from the container and reducing the pressure therein. In a storage facility, elevator, transportation vehicle or other similar means of grain or material storage, a similar apparatus may be constructed having a sealed container such as described herein that could provide a method whereby the material could be dried by a pressure reducing method and thus provide for a dry material or grain without any chemical process and would reduce and retard the germination in the case of grains and would prevent detrimental effects on various other materials with which temperature control is necessary.

While there has been disclosed in this specification forms in which the invention may be embodied, it is to be understood that these forms are shown for the purpose of illustration only, and that the invention is not limited to the specific disclosure, but may be modified and embodied in various equivalent forms without departing from the spirit of the invention. In short, the invention includes all the modifications and embodiments coming within the scope of the claims appended to herein.

I claim:

1. A method of reducing moisture in materials such as grain, cotton, pulps, papers, and peats, comprising the steps of:
 - a. placing the moisture laden materials in a chamber and sealing the chamber;
 - b. reducing the pressure within the sealed chamber below atmospheric pressure in a range optionally selected down to 0.20 inches of mercury by operating a vacuum pump;
 - c. heating the material in the chamber by utilizing the heat generated upon operating the vacuum pump as this heat is passed through heat exchanging manifolds located in the sealed chamber during the pressure reducing step, and being limited to a maximum temperature of 180° Fahrenheit; and
 - d. withdrawing the moisture from the materials and from the chamber, during and following the heating of the materials when the chamber is under vacuum.
2. A dryer for extracting laden moisture from grain, cotton, pulp, and peat, materials, comprising:
 - a. a fully enclosed horizontal cylindrical chamber having sealable access means for the entry above and withdrawal below of these materials;
 - b. a heat transfer manifold of multiple longitudinal pipes with end headers distributed throughout the interior of the fully enclosed cylindrical chamber to receive and to guide heated air;
 - c. a vacuum pump and pipe subassembly connected to the chamber to remove air from the chamber around the heat transfer manifold where the materials are located;
 - d. a heat exchange means about the vacuum pump to receive the air pumped out of the chamber and through the pump to utilize the heat generated about the pump to heat this air and thereafter to guide the heated air through the heat transfer manifold positioned within the fully enclosed chamber in which the materials are being dried;
 - e. a valve means in the vacuum pipe conducting moisture laden air from the horizontal cylindrical chamber to the vacuum pump, to be opened following the drying of the material to bring the drying chamber pressure back to atmospheric pressure to enable the opening of the sealable access means to unload and load the dryer, and
 - f. an energy means to drive the vacuum pump.

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