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EUROPEAN PATENT APPLICATION

21 Application number: 80304768.7

51 Int. Cl.³: F 26 B 21/06
 F 26 B 9/06, F 26 B 3/06
 F 26 B 21/04

22 Date of filing: 30.12.80

43 Date of publication of application:
 14.07.82 Bulletin 82/28

84 Designated Contracting States:
 AT BE CH DE FR GB IT LI LU NL SE

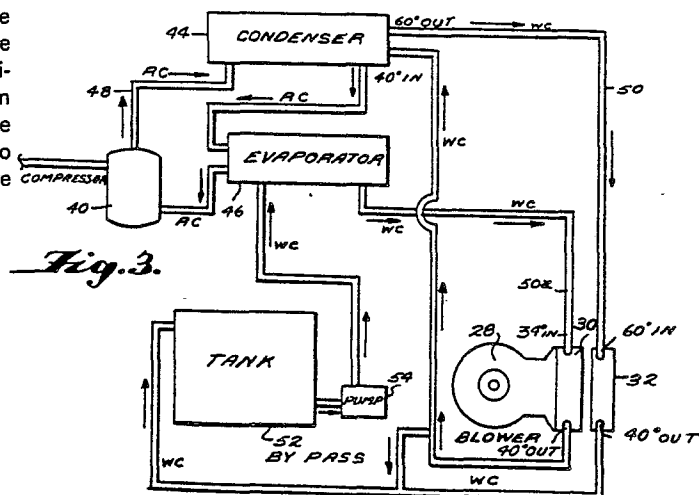
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54 Method and apparatus for adjusting the moisture content of a stored commodity.

57 Method and apparatus for adjusting the moisture content of a stored commodity stored in a storage bin, the integrity of stored commodities is maintained by creating a controlled atmosphere conducive to the removal or the addition of water by capillary action from the pores of the commodity and for controlling the moisture and temperature around the skin of the grain to achieve optimum storage conditions for the specific commodity stored. The commodity controlled atmosphere is created by withdrawing air from the storage bin, cooling the withdrawn air and adjusting the moisture content thereof, the air being reheated prior to re-entry into the storage bin, thereby adjusting the moisture content of the air contained within the storage bin.



"Method and apparatus for adjusting the moisture content of a stored commodity"

THIS INVENTION relates to a method and apparatus for drying a commodity, for example grain, stored in a storage bin, by controlling the moisture content of the air in the storage bin.

5 Various efforts have been made in the past to provide apparatus for drying a commodity to increase the storage life and quality of wheat, nuts, corn and other commodities in storage bins while maintaining the integrity of the vitamins, minerals, proteins,
10 starches and sugars in the stored commodities. A practical commodity dryer has been required in the agricultural industry for a long time, since in some years bumper crops of various commodities are produced whereas in other years, due to draught and adverse
15 growing conditions, lean crops of the same commodity are produced, resulting in large fluctuations in the price of these agricultural commodities.

As a result, there have been numerous attempts to provide various types of commodity storage bins,
20 grain elevators and the like to even out the bumper and lean crops. The known storage devices have not solved this perennial problem, since large masses of commodities have not been susceptible to prolonged periods of storage because the growth of fungus, bacteria
25 and rot has resulted in a significant waste of these commodities.

The internal conditions in the storage bin are the net result of the ambient temperature in conjunction with the condition of the commodity inside the bin
30 and the resulting transfer of heat. These three factors

combine many times to result in deleterious changes in the atmospheric conditions around the mass of the commodity, causing all or part of the commodity to spoil.

5 In U.S. Patent 2,662,603 a vault conditioner with control means is disclosed for controlling the relative humidity and temperature of merchandise storage vaults. This vault conditioner is described as being a self-contained machine constructed to meet the storage requirements of furs, foods, seeds and other products
10 sensitive to water vapour and temperature. In operation, the vault conditioner withdraws air from ceiling level in the storage room, cools it, reduces the moisture content thereof, and then discharges it at the floor level of the room. The action of the vault conditioner
15 as disclosed in U.S. Patent 2,661,603 apparently utilizes convection currents since the warmest air collects at the ceiling level from where it is withdrawn and returned to the cooling and dehumidifying unit before recirculation.

20 The prior art has not provided a commodity dryer that will extend the life of stored commodities by controlling and gradually optimizing the atmosphere surrounding the commodity to yield, after the removal of excessive moisture, the optimum atmosphere necessary to prolong
25 and preserve the vitamins, oils, minerals, proteins, starches and sugars indigenous to the condition of the particular stored commodity.

According to one aspect of the invention, there is provided a method of adjusting the moisture content
30 of a stored commodity retained in a storage bin, comprising: causing the air in the storage bin to circulate in the bin and around the commodity stored therein: withdrawing air from one end of the storage bin; using control means to adjust the moisture content of the withdrawn
35 air to an optimum value for storage of the commodity by bringing the withdrawn air into heat-exchanging relationship with successive first and second heat

exchangers operated by the control means; and returning the withdrawn air to the other end of the storage bin to control the moisture content of air circulating round the stored commodity.

5 According to another aspect of the invention, there is provided apparatus for adjusting the moisture content of a stored commodity retained in a storage bin comprising: means for withdrawing air from one end of the storage bin and returning the withdrawn
10 air to the other end of the storage bin; a first heat exchanger positioned for heat exchanging communication with the withdrawn air after removal from the one end of the storage bin; a second heat exchanger positioned for heat exchanging communication with the withdrawn
15 air prior to the returning of the withdrawn air to the other end of the storage bin; and control means for operating the first and second heat exchangers to adjust the moisture content of the withdrawn air to an optimum value for storage of the commodity,
20 thus controlling the moisture content of air circulating round the stored commodity.

The main advantage of the present invention is the provision of a controlled atmosphere around stored commodities to provide either a drying or humidifying
25 action to retard the formation of bacteria, fungus and spoilage. The present invention provides for prolonged storage of commodities by gradually optimising the atmospheric conditions in relation to outside temperature, creating a controlled atmosphere in the
30 storage in to provide the best storage conditions for the particular commodity in regard to the geographical location of the stored commodity. The moisture content of the storage bin atmosphere is adjustable not only for the particular commodity being dried but also
35 to control the moisture content of the commodity at all stages of storage.

The method and apparatus in accordance with the

invention allow a controlled atmosphere to be created around the commodity by monitoring internal storage bin conditions and providing either moist or dry air to achieve the optimum conditions required for prolonged storage of the commodity, while preserving the nutritional value of the vitamins, minerals, proteins, starches and sugars of the stored commodity. The internal conditions of the bin and the commodity, for example grain, as heretofore described are economically controlled as a result of a correlation of the internal conditions of the storage bin with the external ambient air conditions and the resulting heat transfer. For example, when a wet commodity is first stored, dry air is added to the top of the storage bin and moist humid air is removed from the bottom of the storage bin. The quantity of dry air added and the amount of wet moist air removed per unit of time depends upon the degree of moisture required to be removed to provide optimum storage conditions for the particular ambient temperature encountered in the storage location. The method and apparatus in accordance with the invention may furthermore operate to provide both heat and dry air which is added to the storage bin to dry, for example, wheat, corn, nuts and other grains stored in the storage bin as the conditions both inside and outside the storage bin are monitored to gradually optimize the conditions required for prolonged storage of agricultural commodities. Preferably, the control means or apparatus embodying the invention employs a compressor to drive an evaporator to cool and remove moisture from air and to operate a condenser for thereafter reheating the dried air. Conveniently, apparatus in accordance with the invention further employs a hot fluid bypass for the efficient removal of ice from fins disposed on a heat exchanger coil of the evaporator where the commodity is in an especially wet condition when stored.

The control system of the commodity dryer, after

attaining the optimum atmospheric conditions in the storage bin for the stored commodity, thereafter monitor outside atmospheric conditions to achieve the optimum internal moisture in relation to ambient and commodity bin conditions to provide the optimum internal conditions
5 for prolonged storage of the commodity.

The apparatus and method in accordance with the invention achieve optimum moisture conditions by heating, adding or removing moisture from the internal
10 or core portion of the grain, or a combination thereof, and controlling the atmosphere surrounding the grain so that proper aspiration of the moisture content of the grain precludes the growth of bacteria, fungus, and the advent of decay and rot which decreases the
15 life of the commodity. The apparatus and method in accordance with the invention are advantageous in that the retained moisture of the stored commodities can be reduced, which generally, upon changes in temperature and humidity in compacted storage conditions, fosters
20 the formation of bacteria and fungus growth and spoilage which generally renders moist commodities stored in commodity bins unfit for subsequent consumption.

A further advantage of the invention is that by controlling the internal condition of the commodity
25 while monitoring the outside ambient conditions and coordinating the outside conditions with the internal condition of the commodity allows for efficient utilization of the energy required to maintain a predetermined optimum moisture content in the commodity at a given
30 temperature to prolong the life of the stored commodity. Thereafter temperature increases which increases the amount of moisture released by capillary action from the pores of the stored commodity may be utilized to efficiently and gradually withdrawn excess moisture
35 from the stored commodity to protect the oils, vitamins, salts, proteins, starches and sugars present in the commodity.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 is an enlarged view, partly in section, of a kernel of corn representing one type of grain suitable for drying in an apparatus embodying the invention;

FIGURE 2 is a side elevational view, partly in section, illustrating a storage bin associated with apparatus embodying the invention in the form of a commodity dryer;

FIGURE 3 is a schematic diagram of the commodity dryer shown in Figure 2: and

FIGURE 4 is a schematic diagram of an alternative embodiment of a commodity dryer in accordance with the invention connected to four storage bins.

Referring now to Figure 1, a commodity such as a kernel of corn 1 is depicted partly in section, illustrating the outer shell 2 having pores 4 therein communicating with the yellow proteid part 6 of the endosperm of the corn. A white starchy portion 8 is also illustrated.

After harvesting, the portions 6 and 8 contain relatively large amounts of moisture as is well-known in the agricultural art. In addition to moisture inside the corn shell 2, moisture may also be present externally on the shell 2 particularly when, under some harvesting conditions, the commodity is tightly packed in a storage bin. The removal of excess moisture from both inside the commodity and the area surrounding the outside of the commodity is important for prolonged periods of storage. More particularly the removal of such moisture helps protect the commodity from the growth of bacteria and the quality of the commodity in storage is maintained by creating a controlled atmosphere surrounding the commodity, which is conducive to the removal or addition of water by capillary action

through pores 4 of the commodity.

Figure 2 illustrates a storage bin 10 associated with apparatus in accordance with the preferred embodiment of the invention in the form of a commodity dryer in which commodities such as corn, grain, nuts and other edible substances having an internal and external moisture content may be stored, dried and maintained in an atmosphere having a controlled moisture content, thus retarding the growth of bacteria, fungus and preventing other deleterious conditions that would otherwise shorten the storage life of the commodity. The commodity bin 10 is preferably of a cylindrical cross-sectional configuration having a false bottom 12 formed with minute perforations 14 of a size sufficient to restrain the commodity from falling through onto a base 10 of the bin 10, while allowing drying air introduced into a top 18 of the commodity bin 10 via a sealable entry port to be extracted from a space 20 formed at the bottom of the commodity bin 10 via a sealable exhaust port 22 connected to an inlet port 24 of commodity dryer housing 26.

A blower fan 28 provides a positive circulation of the closed atmosphere operated by the commodity dryer through the commodity in the storage bin 10 to withdraw moisture laden air from the bottom of the commodity bin and transport the air into commodity dryer housing 26. The displacement and pressure resistance to flow is dimensioned to provide a 63.3×10^6 J (60,000 BTU) differential or greater depending on the time of drying required to provide a flow through the commodity.

The capacity of the storage bin should be in the range of 36.37 m^3 to 3637 m^3 (1,000 to 100,000 bushels) and the storage bin should have a height to width ratio of greater than or equal to 1:1. The configuration of the storage bin increases the efficiency of airflow over the skin or or shell of the commodity, thereby providing greater moisture control per unit of energy expended.

The moisture-laden air is brought into contact with an evaporator heat exchanger coil 30 in which the fins are spaced such that there are from approximately 6.6 fins per metre (2 fins per foot) to 5.9 fins per cm. (15 fins per inch) depending upon climate. For example where the ambient or outside conditions generally include high temperature and high humidity the evaporator heat exchanger coils are equipped with approximately 2.4 to 3.9 fins per cm (6 to 10 fins per inch). On the other hand where ambient conditions include low humidity and high temperatures the evaporator may be of smaller size and utilise an evaporator heat exchanger coil having more than 3.9 fins per cm. (10 fins per inch). However, in environments having high humidity with temperatures near or below freezing point the evaporator heat exchanger coil preferably utilizes approximately 1 fin per 6.35 to 7.62 cm (1 fin per 2.5 to 3 inches). In climatic conditions having both a low temperature and a low humidity an evaporator heat exchanger coil having about one fin per 2.54 cm (one fin per inch) provides a system that is controllable for a variety of commodities. In climates where extremely low temperatures i.e. approximately 4.4°C to -17.8°C (40° to 0°F) are common and/or where excessive heat losses occur through the bin walls, it is preferable to introduce small amounts of auxiliary heat to the air prior to reintroducing the air to the top of the storage bin.

In the foregoing discussion the number of fins per cm (inch) is described in reference to a storage bin of approximately 2182m^3 to 3637m^3 , (60,000 to 100,000 bushel) capacity. Furthermore the number of fins per cm (inch) in the evaporator heat exchanger coil have been described with reference to an evaporator heat exchanger coil approximately 6.35 cm (2.5 inches) wide and 13.97 cm (5.5 inches) long. It will be recognized that the application of the present invention to larger storage bins having a

greater flow of air or the utilization of evaporator heat exchanger coils of varying diameter will result in variation in the size and number of fins per cm (inch) as heretofore described.

5 The dependence of the requirements of the commodity on ambient atmospheric conditions is generally a more significant consideration in controlling the atmosphere surrounding the commodity than the particular commodity being stored. The requirements of the commodity itself
10 are however a significant consideration where the commodity requires a high degree of moisture, such as dates, apricots and raisins. In the application of the present invention to such commodities the commodity dryer can be designed to remove less moisture from the air removed from
15 the bottom of the commodity bin by variation in the compressor, condenser and evaporator operation and ratings or changes in blower velocity and/or the utilization of fins further spaced-apart to allow additional moisture to remain in the system.

20 If ice forms during the cooling of the air received from the storage bin 10 the fins of the evaporator heat-exchanger coil 30 allow it to be removed by a hot fluid bypass.

 The air from the commodity bin 10 is thereby cooled
25 by being brought into contact with the evaporator heat-exchanger coil 30, so that moisture is withdrawn from the air prior to the air being brought into contact with a condenser heat exchanger coil 32 which causes the air to be reheated to a temperature approximately equal to that
30 of the air when removed from the space 20 of storage bin 10 prior to its transportation viaduct 34 back to the top 18 of commodity dryer 10. The duct 34 preferably branches into one or more secondary ducts 36 and 38 to allow the dry air to be uniformly introduced into the top 18 of the
35 storage bin 10. The evaporator heat exchanger coil 30 and the condenser heat exchanger coil 32 form part of the control means and are operatively connected to a

compressor 40 which drives the evaporator to allow removal of moisture and the condenser to reheat the air prior to the re-introduction of the dried air back into the storage bin. The commodity dryer may include an inlet 42 for the
5 introduction of ambient air for limited periods of time when the ambient air has a temperature and moisture content compatible with the moisture requirements of the commodity in a particular storage and/or drying cycle to reduce the costs of operating the commodity dryer.

10 The commodity dryer may range in capacity from 5.08 tonnes (5 tons) of refrigeration up to 508 tonnes (500 tons). The evaporator heat exchanger coil as heretofore described is designed to be of a sufficient size and have a sufficient surface area to remove moisture and gradually
15 dry the commodity in the storage bin. Furthermore, the commodity dryer is equipped to add moisture and/or heat to further increase drying and long term storage capabilities. For example, for a 3637 m^3 (100,000 bushel) storage bin, a 61 tonne (60 ton) evaporator coil and a
20 76.2 tonne (75 ton) condenser heat exchanger coil would be employed to provide a 30-day drying period. However, if a 15-day drying period is desired for a 3637 m^3 (1000,000 bushel) bin, a 122 tonne (120 ton) evaporator heat exchanger coil and 152 tonne (150 ton) condenser coil are
25 needed to provide for the drying of the commodity. Further, the heat produced by the condenser heat exchanger coil is utilized in whole or in part to reheat the air prior to its introduction back to the top of the bin for subsequent passage through the commodity and the false
30 bottom 12 of the storage bin.

The commodity dryer achieves its advantages by monitoring, controlling and re-using the same air by providing a closed atmosphere in which the moisture content of the commodity bin is gradually reduced or increased in
35 relation to the moisture requirements of the commodity at various stages of storage and the ambient atmospheric conditions at the storage location. In general, for a given

temperature and commodity, as the humidity of the location of the commodity dryer increases the number of fins is decreased as described earlier in order to allow the removal of moisture from the evaporator heat exchanger coil. It will be recognized that the size and configuration of the fins of the evaporator coil may be modified in accordance with the invention as long as the unit is constructed to create a moisture controlled atmosphere surrounding the commodity to control by capillary action the water content of the stored commodity. To assist in the control of moisture in the stored commodity, the air within the commodity bin 10 is moved at a low velocity, generally approximately 14.2m^3 per minute (500 cubic feet per minute) with an operational range of approximately 5.68 to 28.4m^3 per minute (200 to 1,000 cubic feet per minute). The unit is designed to float from approximately 29.5 kg. (65 lbs) to 4.5 kg. (10 lbs) suction pressure which of course depends upon differences in the amount of chaff or small particulate matter associated with the commodity.

It will be recognised that the velocity of the air over the evaporator coil fins in conjunction with the fin size determines to a large degree the moisture maintenance capacity of the commodity dryer for the type of climatic conditions encountered as heretofore described. Furthermore the capacity of the commodity dryer for a given volume of storage is given a fixed velocity of air related to coil length or area.

Figure 3 is a schematic diagram of the commodity dryer shown in Figure 2 and illustrates in further detail the internal components of the dryer.

The compressor 40 is connected in a series loop with a condenser 44 and in evaporator 46 by a conduit 48 carrying a refrigerant to form a heat pump circuit. A conventional variable control unit (not shown) for controlling the power input to compressor 40 controls the operation of the compressor which may be coupled to the speed of blower fan 28 in effecting the drying of the commodity in the

commodity bin. The control system of the commodity dryer is similar to industrial refrigeration devices and the compressor 40 and refrigerant conduit 48 may contain a standard refrigerant such as freon or any one of a number of other available refrigerants known to those skilled in the art.

A second conduit 50 containing a heat transferring fluid which may be water, or preferably a water and glycol or glycol solution, is connected from the condenser 44 via the condenser heat exchanger coil 32, a tank 52 and pump 51 to the evaporator 46 from where the conduit 50 joins a further conduit 50a which carries the heat transferring fluid through the evaporator heat exchanger coils 30 and back to the condenser 44 where the further conduit 50a connects with the second conduit 50 to form a closed system.

A bypass line allows the heat transferring fluid output from the evaporator heat exchanger coil 30 to join with the fluid output from the condenser heat exchanger coil 32 prior to the output from the condenser heat exchanger coil 32 entering the tank 52.

In use of the commodity dryer, heat transferring fluid leaving the evaporator 46 and having a temperature of approximately 1.1°C (34°F) is pumped through the evaporator heat exchanger coil 30 over which air withdrawn from the storage bin is blown by the blower fan 28. Thus, heat is transferred to the heat transferring fluid and the withdrawn air is cooled.

The heat transferring fluid is then pumped to the condenser 44 at a temperature of approximately 4.4°C (40°F) and is further heated to a temperature of approximately 15.6°C (60°F) before passing out of the condenser through the second conduit 50 to the condenser heat exchanger coil 32 where the heat transferring fluid gives up heat to the cool dried withdrawn air blown over the coil 32 by the blower 28 prior to re-entering the storage bin. The now cooled heat transferring fluid having a

temperature of approximately 4.4°C (40°F) is then passed through the tank 52 and pump 54 and input to the evaporator where the fluid is further cooled to 1.1°C (34°F) to allow cooling of further air withdrawn from the storage
5 bin.

The bypass line allows heat transferring fluid at a temperature of 4.4°C (40°F) to pass from the further conduit 50a into the second conduit 50 to mix with the heat transferring fluid output from the condenser heat
10 exchanger coil 32 at 4.4°C (40°F) the heat from which may be used in removing ice from the fins of the evaporator heat exchanger coil.

The apparatus and method in accordance with the invention achieve removal of moisture from and around the
15 commodity stored in the commodity dryer by inducing capillary action of the water content in the pores of the commodity, for example grain, stored in the storage bin. In a commodity such as grain, the moisture and temperature differences between the internal or embryo portion of the
20 shell or skin of the kernel and the atmosphere surrounding the commodity are together vitally important in increasing the storage life of the commodity. Each commodity has its particular requirements of internal and external moisture content which, advantageously, may be accommodated by
25 adjustments made in the control means of the apparatus in accordance with the invention. It will be recognized that commodities such as dates require a greater moisture content than walnuts.

A commodity, such as grain, may be stored in a bin
30 which is attached to apparatus in accordance with the invention for adjusting the moisture content of the commodity and the temperature of the internal atmosphere of the storage bin may be altered by gradually reducing the volume of heated dry air introduced into the one end of
35 the bin. The gradual reduction of temperature creates a skin temperature of the grain below that of the embryo resulting in a migration of moisture from the embryo

toward the shield or shell part of the kernel. The gradual reduction in shell temperature of the grain below that of the embryo results in the migration of moisture to the skin of the embryo where the atmosphere surrounding the skin of the embryo is cooler and lower in humidity resulting in the evaporation of moisture to the atmosphere which is subsequently removed by the first heat exchanger.

The gradual reduction in temperature results in a superior drying technique in that the oils, vitamins, salts, proteins, starches, sugars and trace nutrients of the commodity are not removed with the water. It will be recognized that nutrients remaining in the water are increasingly resistant to evaporation through the shell or skin of the commodity so that additional lowering of the temperature results in this moisture being increasingly retainable by the commodity. As a result, further drops in temperature after the additional drying period result in the commodity maintaining the vitamins, proteins, starches and sugars indigenous to the particular commodity stored in the commodity dryer.

Advantageously, the nutrients in the commodity are retained since the moisture is generally removed without raising the temperature of the commodity it being sufficient to suppress the dew point of the withdrawn air unless the temperature of the storage bin air is at or near the freezing point of water. In addition, the energy required to remove the moisture is reduced because the residual heat of the commodity is utilized to evaporate the moisture contained therein. Furthermore, the gradual optimization of the atmosphere surrounding the commodity reduces bacteria, fungus and spoilage. These advantages are achieved while saving energy since a proportion of the external energy used to operate the first heat exchanger is recovered in the second heat exchanger.

Referring now to Figure 4 a further embodiment of a commodity dryer in accordance with the invention is illustrated in which four separate pairs of evaporator and

condenser heat exchanger coils are employed to control the atmospheric conditions in four separate commodity bins. In this embodiment the storage bins, such as corn bins 70, 72, 74 and 76, each have an air outlet port 78 to transport air from the bottom of the bin to an evaporator heat exchanger coil 80 from whence the air is transported to a condenser heat exchanger coil 82 and then back to the top of the storage bin via an air inlet port 84. Preferably a variable speed blower and control for the evaporator and condenser heat exchanger coils are provided to assist in the control of the conditions in each of the commodity bins.

Commodity dryer 86 drives each of the evaporator heat exchanger coils 80 and condenser heat exchanger coils 82 by control means formed by a compressor 40, condenser 44 and evaporator 46 connected by a refrigerant conduit 48 in a manner similar to that shown in Figure 3. Similarly, evaporator 46 provides via a heat transfer fluid conduit 88 a cool glycol solution to each of the evaporator heat exchanger coils 80 where heat is removed from the withdrawn air passing over the evaporator exchanger coils 80. A return conduit 90 transports the warmed glycol solution from the evaporator heat exchanger coils 80 to the condenser 44 where the glycol solution is further heated. The glycol solution is then transported via conduit 92 to condenser heat exchanger coils 82 to reheat the withdrawn storage bin air prior to the reintroduction of the air into the top of the respective commodity bins 70, 72, 74 and 76. The now cool glycol solution is returned via conduit 94, tank 52 and pump 54 to evaporator 46 to thereafter again be transported to evaporator heat exchanger coil 80 via conduit 88 to continue the cooling and heating cycle of the storage bin air. A separate variable speed blower (not shown) is associated with each of the corn bins 70, 72, 74 and 76 to assist in the separate control of each of the bins by varying the velocity of air flow through the commodity as hereinbefore des-

cribed. It will be recognized that the utilization of glycol filled lines 88, 90, 92 and 94 allow one control means including a compressor, condenser and evaporator to drive each pair of heat exchanger coils without the need
5 for individual control means or a number of individual commodity dryers thus further reducing the cost of acquisition and operation of apparatus in accordance with the invention.

Preferably, the or each corn bin is of cylindrical
10 configuration having a height to width ratio of greater than or equal to 1:1. It will be recognized that other configurations and other methods of utilizing the commodity dryer to various arrays of corn bins or other type of commodity bins may be accomplished by those
15 skilled in the art. Furthermore, apparatus, in the form of a commodity dryer, in accordance with the invention may be further modified in applications involving the arrangement of multiple storage bins by having separate control systems utilized for heating and cooling of air for each
20 individual commodity in an arrangement of bins in which each bin may contain a different commodity.

It will of course be recognized that, where different commodities are placed in each storage bin, different conditions are placed in each storage bin, different
25 conditions are required so that the commodity dryer should be set up to accommodate the optimum conditions for each of the commodities stored.

Individual control of each of the commodity bins may be accomplished utilizing a central control unit for all
30 the bins or by individually analyzing and treating air withdrawn from the bottom of the storage bins through the evaporator and condenser heat exchanger coils. Further, individual conditions for each storage bin may be further optimized by having a heater located just prior to the
35 introduction of the air from the commodity dryer air return line into the particular bin to provide heat, where it is necessary to heat the air introduced to the top of

the storage bin to optimize the conditions for the commodity stored in a particular storage bin.

Generally it will be recognized that the control means of a commodity dryer embodying the invention may be
5 achieved by utilizing any cooling device that is capable of producing temperatures below that of the saturation temperature of the atmosphere being removed from the storage bin. The saturation temperature may be below the
10 saturation temperature of the water due to dew point suppressants that may still be soluble in the moisture being removed from the stored commodity.

In a similar manner it will be recognized that the condenser heat exchanger coil or afterheat source may comprise any device that has a controllable heat source
15 which will raise the deliquescence level of the air being returned to the commodity dryer. Commonly, this is a condenser heat exchanger coil through which a refrigerant fluid which produces a proportional dew point differential of about 3.6 kJ per watt of power used (2545 BTUs per
20 horse-power used) to produce the refrigeration necessary to cool the condensing coil. Since the refrigerants have generally lower watts per Joule (horsepower per BTU) requirements for compression at lower temperatures, the drier the commodity becomes the less power is required to
25 control the atmosphere inside the storage bin.

CLAIMS:

1. A method of adjusting the moisture content of a stored commodity retained in a storage bin, comprising:
5 causing the air in the storage bin to circulate in the bin and around the commodity stored therein; withdrawing air from one end of the storage bin; using control means to adjust the moisture content of the withdrawn air to an optimum value for storage of the commodity by bringing the
10 withdrawn air into heat-exchanging relationship with successive first and second heat exchangers operated by the control means; and returning the withdrawn air to the other end of the storage bin to control the moisture content of air circulating round the stored commodity.
- 15 2. A method according to Claim 1, wherein the moisture content of the withdrawn air is adjusted by reducing the temperature of the withdrawn air as the air is withdrawn from the storage bin and reheating the withdrawn air to
20 approximately the temperature of said air when withdrawn from the storage bin prior to returning the withdrawn air to the other end of the storage bin.
3. A method according to Claim 2, and further comprising
25 heating the withdrawn air to a temperature higher than that of the withdrawn air when removed from the storage bin prior to returning the withdrawn air to the storage bin.
- 30 4. A method according to Claim 1, 2 or 3 and further comprising adding ambient air to the air of the storage bin when the ambient air has a temperature and a moisture content compatible with the optimum moisture content for the storage of the commodity.

5. A method according to Claim 1, wherein the moisture content of the withdrawn air is adjusted by moistening the withdrawn air prior to return to said air to the other end of the storage bin.

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6. A method according to any one of claims 1 to 5, and further comprising adding airborne treating agents to the withdrawn air prior to returning said air to the storage bin.

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7. Apparatus for adjusting the moisture content of a stored commodity retained in a storage bin comprising: means for withdrawing air from one end of the storage bin and returning the withdrawn air to the other end of the storage bin; a first heat exchanger positioned for heat exchanging communication with the withdrawn air after removal from the one end of the storage bin; a second heat exchanger positioned for heat exchanging communication with the withdrawn air to the other end of the storage bin; and control means for operating the first and second heat exchangers to adjust the moisture content of the withdrawn air to an optimum value for storage of the commodity thus controlling the moisture content of air circulating round the stored commodity.

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8. Apparatus according to Claim 7, wherein the first and second heat exchangers are provided in a heat pump circuit comprising a compressor, evaporator, condenser and containing heat transferring fluid, the first heat exchanger being operatively connected to the evaporator and the second heat exchanger being operatively connected to the condenser.

9. Apparatus according to Claim 7 or 8, wherein the means for withdrawing air from one end of the storage bin and returning the withdrawn air to the other end of the storage bin comprises a variable speed blower capable of

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displacing from approximately 5.7 to 28.3 cubic metres of air per minute.

10. Apparatus according to claim 8 or 9, wherein the
5 evaporator of the heat pump circuit is connected to a
plurality of first heat exchangers and the condenser of
the heat pump circuit is connected to a plurality of first
heat exchangers and the condenser of the heat pump circuit
is connected to a plurality of second heat exchangers,
10 each pair of first and second heat exchangers being associated with a storage bin.

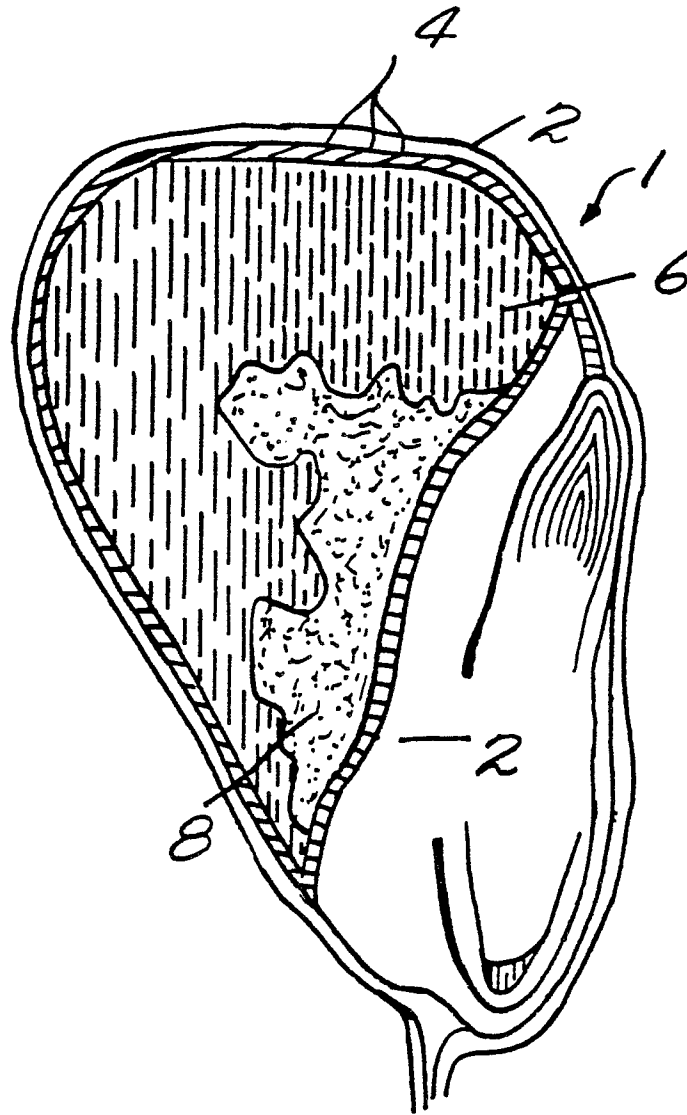
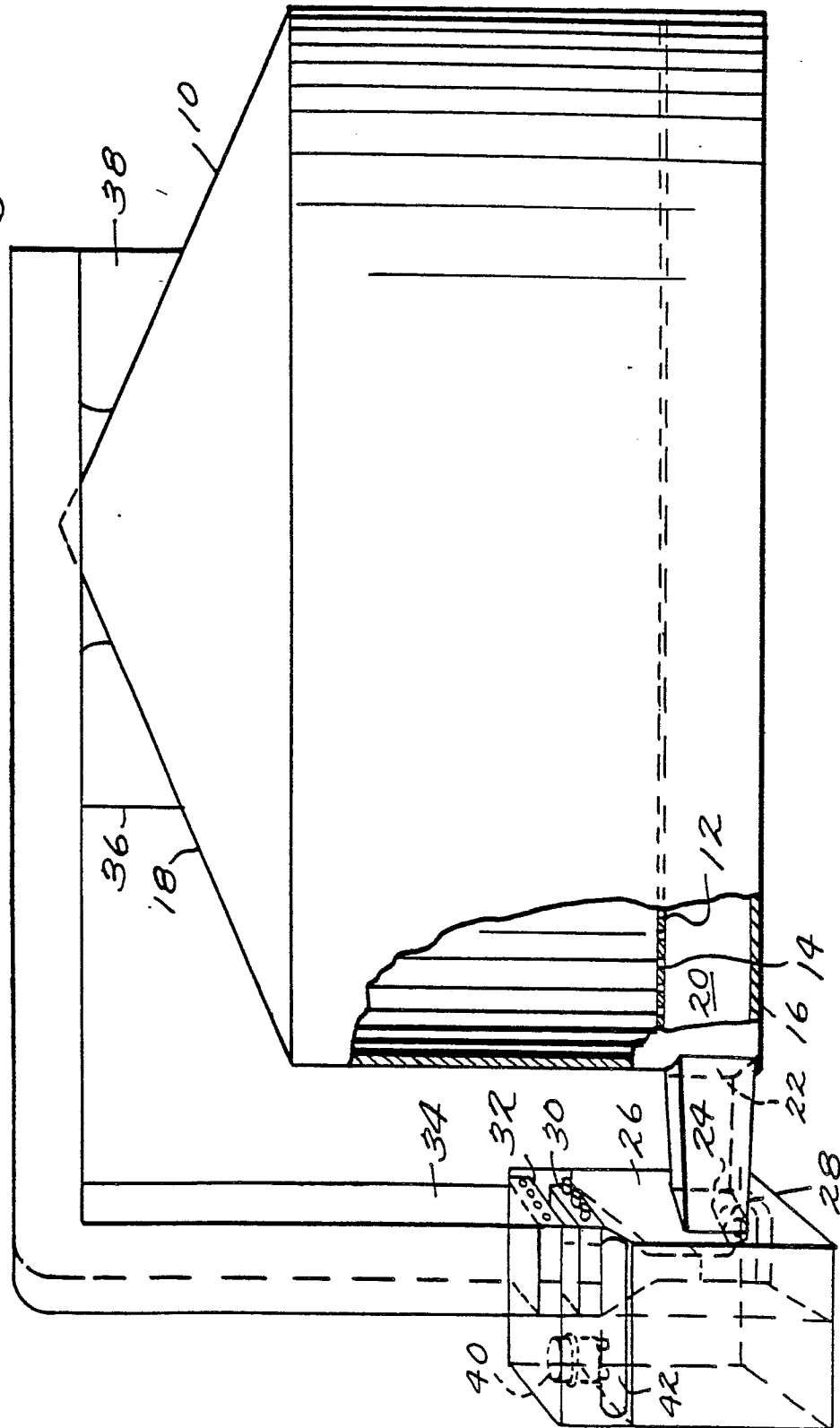
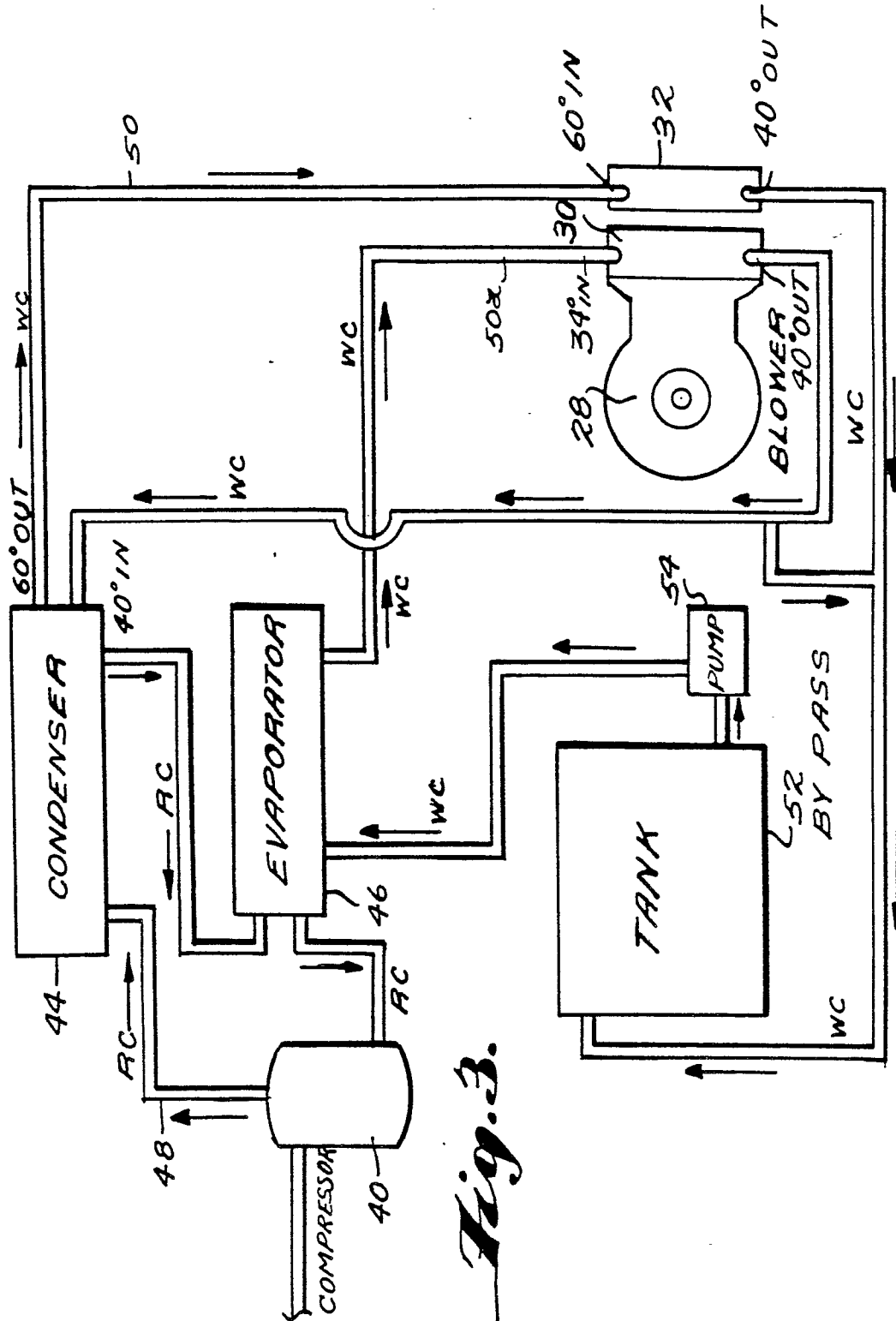
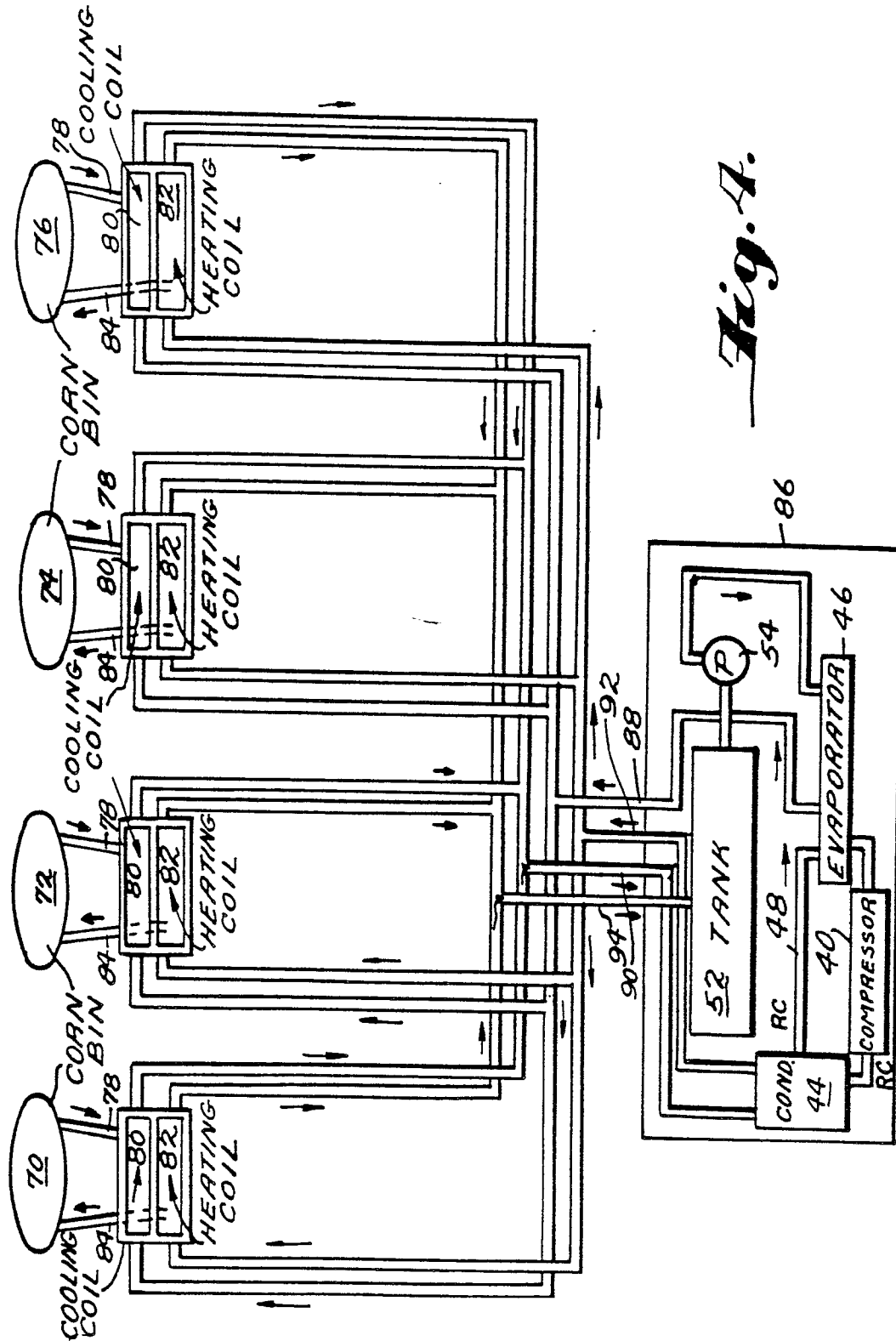
Fig. 1.

Fig. 2.

*Fig. 3.*





0055787

Application number

EP 80 30 4768

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	<u>CH - A - 182 139 (ESCHER WYSS)</u> * the whole document * --	1,2,7 8,10	F 26 B 21/06 9/06 3/06 21/04
	<u>US - A - 4 134 216 (STEVENS)</u> * the whole document * --	1,2,7	
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			CATEGORY OF CITED DOCUMENTS
			X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
			&: member of the same patent family, corresponding document
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
The Hague	04-09-1981	DE RIJCK	