June 19, 1951 J. K. TOUBORG 2,557,621

METHOD OF DEHYDRATING REFRIGERATION UNITS

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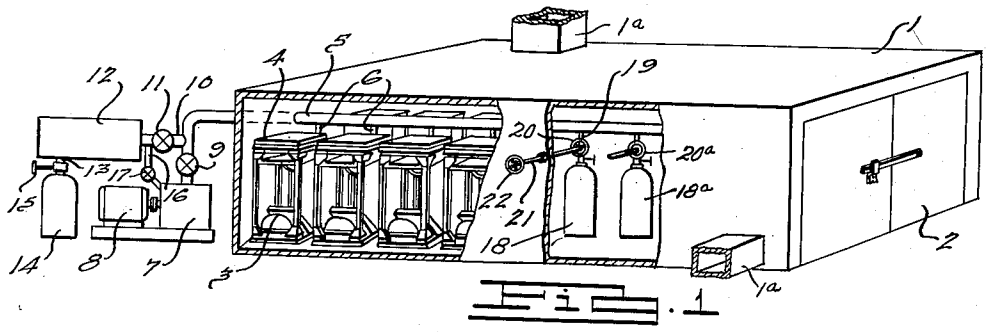

Fig. 1.

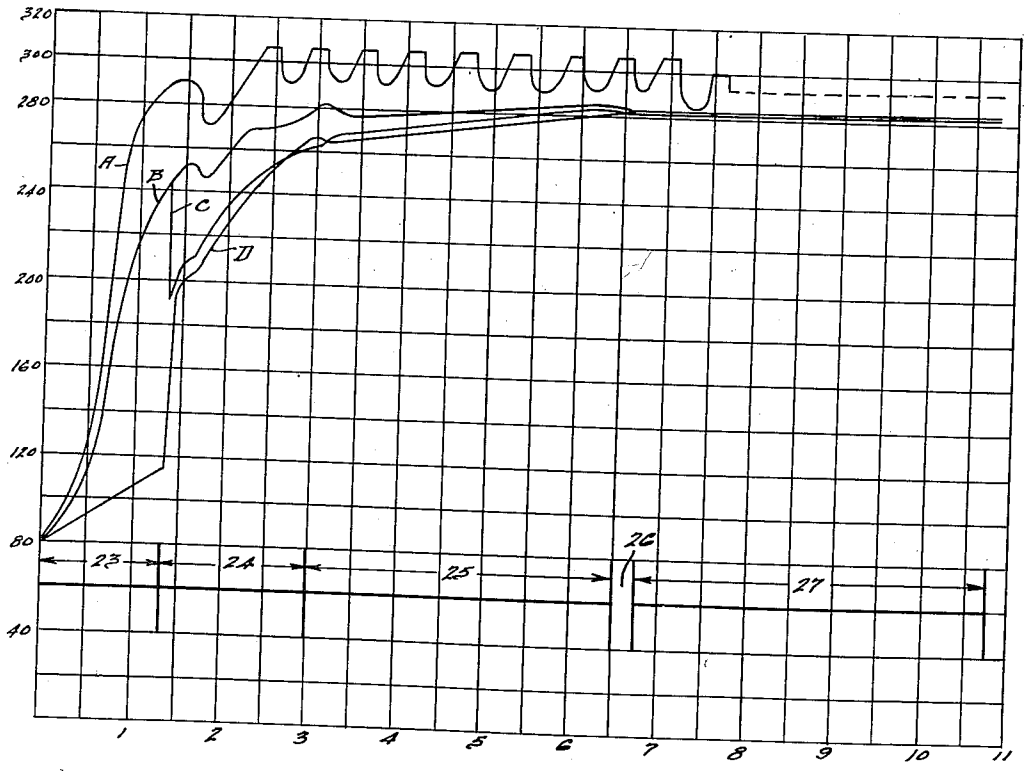

Fig. 2.

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METHOD OF DEHYDRATING REFRIGERATION UNITS

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10 Claims. (Cl. 34—15)

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This invention relates to apparatus and processes for dehydrating refrigerator units, and particularly to a device and process for drying the operating elements within the interior of a refrigeration unit having poor conducting relationship with the exterior parts thereof by the application of a heated refrigerant as a medium for transferring heat rapidly thereto from the exterior of the unit.

It has been the practice in the art to dehydrate the completely assembled refrigeration unit in a heated oven by applying a vacuum thereto for evacuating the interior of the units while being heated. In certain types of units, such a process proved satisfactory since a good conducting relationship existed between the various elements of the unit. In some hermetically sealed motor compressor units, for example, the motor compressor device was pressed within the upper shell of the hermetically sealed casing so that a good conducting relationship existed between the stator, rotor, compressor and the enclosing casing.

The refrigeration unit dehydrated by the apparatus and method of the present invention has the motor-compressor device spaced from the casing, mounted on springs having a minimum heat conducting relationship with the casing. Substantially no heat is directly conducted between the casing and the motor-compressor device. It is desirable, therefore, to employ a dehydrating process for rapidly heating the motor-compressor device, as well as the casing, during the process of dehydration.

To accomplish this, after the units are placed within the oven and heated while being evacuated, a suitable heated refrigerant is introduced through a manifold to the various refrigeration units. The container for the gas is mounted within the oven so that its temperature is equal to the oven temperature which is quickly raised to approximately 300°.

The hot refrigerant gas will condense upon the cool surface of the motor-compressor device and will drip into the bottom shell and form a pool in the bottom of the casing. Heat will be applied to the pool through the lower shell of the casing so as to return the liquid into gaseous form as condensation continues upon the cool surface of the device. The latent heat of vaporization must be added to the liquid refrigerant to change its state to that of a gas. This latent heat of vaporization is in turn then given up

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to the motor compressor device when the gas is condensed. A very substantial benefit is derived from this arrangement since this latent heat represents a large quantity of heat being transferred from the lower casing to the motor-compressor device.

After a predetermined time interval, the gas is then withdrawn from the manifold and units into a condenser exteriorly of the oven from which it is collected in a suitable container from which it is afterwards dried, cleaned and re-employed. When the refrigerant is being withdrawn from the system there will be some attending evaporation taking place on the lower casing, but the amount of liquid is kept small so it has no deleterious cooling effect on the motor-compressor device. While any refrigerant could be employed as the heat transfer medium, the pressure and temperature relationship of saturated F-11 (trichloromonofluoromethane) or carrene #2 (CCL_3F) make it a desirable substance for this purpose. At a temperature of 270°, approximately that to which the refrigeration units are raised, the pressure will rise only to approximately 180 pounds. A low pressure refrigerant of this type will not damage the unit.

After the gas has been withdrawn from the manifold and the units, the vacuum pump is continued in operation to reduce the pressure of the residual gases to a predetermined low point. This will leave water vapor present at too great a quantity due to the inability of the vacuum pump to remove all vapors present. Since the residual gases contain a high percentage of water vapor, nitrogen gas is then introduced into the manifold and units for the purpose of diluting the water vapor present. The nitrogen gas with the diluted water vapor is then pumped out of the manifold by the vacuum pump which continues in operation to the end of the drying cycle. At the end of the operation the unit is thoroughly dried and evacuated to approximately thirty to forty microns absolute pressure. After the unit has been dehydrated in this manner, the manifold and units are charged with a positive pressure of the operating refrigerant gas so that these units can be safety disconnected and removed from the oven. The gas is then evacuated prior to charging with a lubricant and the operating refrigerant charge in the conventional manner. Assurance is now had that the water vapor content of the refrigerant gas is such low proportion as to be incapable

of endangering in any manner the operation of the unit even under the most unfavorable conditions.

The main object of the invention is to provide a process for dehydrating refrigeration units by the use of a refrigerant by which heat is transferred to the motor-compressor device within a casing to quickly raise its temperature.

A further object of the invention is to apply a heated refrigerant to the interior of the refrigerating units after they have been evacuated and heated exteriorly to rapidly raise the temperature of the internal parts thereof which lack good conductive relation to the exterior parts of the unit.

A still further object of the invention is to provide a cycle for dehydrating the interior of the refrigerating unit which embodies the application of heat and vacuum thereto for a predetermined time, after which a heated refrigerant is applied to the unit for raising the temperature of internal parts thereof lacking good conductive relation with the heated external parts, withdrawing the refrigerant and applying a gas to the units for diluting the water vapors which are removed with the gas when the units are again evacuated.

Other objects and features of novelty of the invention will be specifically pointed out or will become apparent when referring, for a better understanding of the invention, to the following description taken in conjunction with the accompanying drawing, wherein:

Figure 1 is a broken perspective view of an oven and apparatus associated therewith for dehydrating refrigeration units by a process embodying the present invention, and

Figure 2 is a view of a temperature-time chart illustrating the dehydrating process as applied to the refrigeration units.

In the drawing, an oven 1 is illustrated of conventional form, having heating means 1—*a* therefor controlled in the conventional manner to maintain the interior of the oven at a predetermined desirable temperature. A pair of doors 2 is employed on one end of the oven by which the refrigerating units 3, which are retained in suitable supporting frames 4, may be placed within the oven and sealed therein when the doors are closed, as illustrated. Within the oven, one or a plurality of manifolds 5 are provided to which each refrigeration unit 3 is conductively joined through suitable conductors 6.

The manifold is connected to a vacuum pump 7 which is driven by a motor 8 having in the intake conductor a valve 9 by which the manifold 5 may be connected to the vacuum pump 7 or disconnected therefrom. The manifold is also connected by a conductor 10 having a valve 11 therein to a condenser 12, the outlet 13 of which is connected to a container 14. A valve 15 is provided on the inlet neck of the container 14 for sealing the opening therethrough when the container is removed from the condenser. A branch conductor 16 is provided between the discharge conduit of the vacum pump 7 and the conductor 10 having therein a valve 17 by which the exhaust from the vacuum pump may be directed into the condenser.

Within the oven a container 18, similar to the container 14, is illustrated as being connected to the manifold 5 through the conductor 19. A valve 20 in the conductor 19 may be manipulated through a shaft 21 and operating handle 22 exteriorly of the oven 1. With this construction it is possible to bring the motor-compressor device enclosed within the hermetically sealed casing of the refrigeration unit quickly to the desired temperature.

This is accomplished by operating the vacuum pump while the oven and units are heated, to evacuate the manifold, conductors and the refrigeration units. After the system and units are thoroughly evacuated and the temperature thereof, of the oven and of the container 18 has risen a desired amount, the heated refrigerant gas in the container 18 is then introduced into the manifold and units after the valve 9 on the compressor has been closed. The gas permeates all parts of the units and in a short time raises the temperature of the motor-compressor device within the casing to a desired amount. Thereafter the valve 11 is opened to permit the refrigerant to pass within the condenser 12 and be collected in the container 14. After most of the refrigerant has been collected in this manner, the vacuum pump may be operated to extract the remainder by closing the valve 11 and opening the valves 9 and 17. The refrigerant will then be drawn by the vacuum pump from the manifold and refrigeration units into the condenser 12 from which it will pass to the container 14. The valve 15 is closed and the container 14 is disconnected from the condenser and the collected refrigerant may be cleaned and dried in the conventional manner. Thereafter the valve 17 is closed and a valve to atmosphere (not shown) is opened and the compressor is continued in operation to evacuate the system into the atmosphere as the temperature of all parts of the units approaches 270°.

All of the air by this time has been exhausted from the manifold and system and the moisture remaining within the units and system will be in the form of a water vapor which will be difficult to extract through the direct operation of the vacuum pump thereon. To remove this water vapor, nitrogen or other gas which will mix with the water vapor, is then introduced into the manifold from a similar receptacle 18*a* connected to the manifold 5 through a similar valve 20*a*. The nitrogen or other gas mixes with the water vapor in a short time and the receptacle 18*a* is then closed off from the manifold and the vacuum pump is operated to extract the nitrogen and the diluted water vapor. The vacuum pump continues to operate for a period of time with the temperature constant on all parts of the refrigeration unit. At the end of the dehydrating operation, the moisture content within the units has been lowered to a desired amount.

The temperature-time curve illustrated in Fig. 2 accurately discloses the intervals which are employed for the various steps of the process employed to thoroughly dehydrate the refrigeration units. It will be noted that after the units have been installed within the oven and connected to the manifold that the temperature is substantially 80°. The temperatures of the oven and units rise rapidly as the oven is heated thereafter.

The oven temperature curve is indicated by the letter A. The upper shell of the hermetically sealed casing is indicated by the letter B. The lower shell of the casing is illustrated by the letter C, and the temperature of the motor-compressor device contained within the casing and lacking heat conducting capacity therewith is

illustrated by the letter D. Very little contact is present between the motor-compressor device and the casing so that substantially no heat transfer occurs to the device from the casing by conduction. The heated refrigerant is depended upon to quickly bring the motor-compressor device up to the desired temperature by a transfer of heat thereto through condensation of the heated refrigerant.

It will be noted in the first hour and twenty minutes, indicated by **23** on the chart, that the casing and the oven have sharply risen in temperature while the motor-compressor device has risen in temperature only a slight amount. At the end of the period **23**, the vacuum pump is cut off from the manifold **5** and the heated refrigerant in the container **18** is then introduced into the manifold and the refrigeration units. Upon this occurrence, the temperature of the motor-compressor unit rises rapidly and the temperature of the lower shell drops. This is caused by the condensing of the refrigeration gas upon the motor-compressor unit. The condensed refrigerant drains into the bottom of the lower casing and forms a pool of liquid refrigerant. The refrigerant gas is maintained at its point of saturation. The liquid refrigerant is changed to a gas by the direct application of heat through the casing. The latent heat of vaporization added to the liquid refrigerant when changing it to a gas is given up to the motor-compressor device when the gas in contact therewith condenses thereon back to a liquid state. In this manner a large quantity of heat is transferred from the casing to the motor-compressor device when good conducting relationship is lacking therebetween.

The presence of the heated refrigerant for a period of substantially one hour and forty minutes, indicated by the numeral **24** on the chart, raises the temperature of the lower shell and the motor-compressor unit within the casing above 260°, approximately to the desired temperature. The refrigerant is withdrawn thereafter from the manifold and units in the manner above mentioned and collected in the container **14**. The liquid refrigerant in the collected pools immediately returns to a gaseous state when the pressure is lowered as the gas is withdrawn from the manifold. For the next three and one-half hours, indicated by the numeral **25** on the chart, the system and unit are evacuated as the oven temperature is maintained substantially constant, the temperature thereof varying between substantially 290° and 308° due to the "on" and "off" setting of the controls for the heating unit.

At this point the vacuum pump is cut off and nitrogen or other gas is introduced into the manifold and units and is retained therein for approximately fifteen minutes, indicated on the chart by the numeral **26**. This is sufficient time to have the nitrogen or other gas mix with most of the water vapors, after which the container for the gas is cut off from the manifold and the vacuum pump is again connected thereto for exhausting the gas and collected water vapor from the manifold and units. The vacuum pump is operated through the remainder of the dehydrating cycle, indicated on the chart by the numeral **27**, while the temperature of the oven and units remains constant. During this time all of the parts of the refrigeration unit are at a constant temperature of substantially 270° and the entire dehydrating operation has been accomplished in approximately ten and three-quarter hours. Assurance is had at the end of the operation that all of the internal area of the refrigeration unit has been completely dehydrated and that the very small quantity of moisture remaining therein will be so minute as to produce no detrimental effect upon the operation of the unit under the most adverse conditions.

While substantially any known refrigerant could be employed for bringing the motor-compressor unit rapidly to temperature, F–11 was selected because of its low pressure at a temperature of 270°. The temperature pressure relation of such refrigerants as ethyl chloride, isobutane and the like, while not so desirable as that of F–11, is such as to have the pressure sufficiently low when heated to 270° as to be employed as the heat transfer medium.

While, as pointed out above, the refrigerant, after being collected in the container **14**, is dried, cleaned and reemployed, the nitrogen or other gas used to mix with the water vapor may in a like manner be collected and dried, but in view of the small amount employed relative to its cost, this may be exhausted from the system directly into the atmosphere. It is within the purview of the invention, however, to collect the gas which dilutes the moisture so that it may be dried and re-employed.

The refrigeration unit and the frame **4** in which it is assembled have been described and claimed in the copending application of Charles B. O'Neill, Serial No. 616,816, filed September 17, 1945, now Patent No. 2,542,563, under which the assignee of the present invention has a license. Reference may be had to this application when issued to a patent for details of the frame and the refrigeration unit assembled therein. These units are entirely sealed and when dried by the present process have the interior connected to the manifold **5** through the conductors **6**.

What is claimed is:

1. The method of treating a unit having an exterior sealed casing enclosing inner parts arranged in poor heat conducting relationship with the external portion of the unit which includes the steps, of introducing a quantity of fluid into said casing, said quantity being so related to the properties of the fluid admitted that at pressures developed by said fluid in said casing said fluid will condense at temperatures below a first temperature to which said inner parts are to be heated and to evaporate at a second temperature above said first temperature, said quantity being sufficiently small so that when said interior parts are at said second temperature substantially all of said fluid will be in a vapor state, and of exteriorly heating at least a portion of said casing at which the condensed liquid collects to a temperature at least equal to said second temperature for a desired time interval whereby fluid condensed will be revaporized for recondensation on said inner parts whereby the temperature of said inner parts will be raised due to the heat of condensation, of thereafter exhausting said fluid from said casing, and of thereafter introducing into said casing a non-aqueous vapor at a pressure and a temperature at which it will not condense in said casing.

2. The method of treating a unit having an exterior sealed casing enclosing inner parts arranged in poor heat conducting relationship with the external portion of the unit which includes the steps, of introducing a quantity of fluid into said casing, said quantity being so related to the properties of the fluid admitted that at pressures developed by said fluid in said casing said fluid

will condense at temperatures below a first temperature to which said inner parts are to be heated and to evaporate at a second temperature above said first temperature, said quantity being sufficiently small so that when said interior parts are at said second temperature substantially all of said fluid will be in a vapor state, and of exteriorly heating at least a portion of said casing at which the condensed liquid collects to a temperature at least equal to said second temperature for a desired time interval whereby fluid condensed will be revaporized for recondensation on said inner parts whereby the temperature of said inner parts will be raised due to the heat of condensation, of thereafter exhausting said fluid from said casing, of thereafter introducing into said casing a nonaqueous vapor at a pressure and a temperature at which it will not condense in said casing, and of thereafter evacuating said casing whereby substantially all aqueous fluids will be removed from said casing.

3. The method of treating a unit having an exterior sealed casing enclosing inner parts arranged in poor heat conducting relationship with the external portion of the unit which includes the steps, of producing a subatmospheric pressure within said casing, of heating said casing externally, of introducing a quantity of heated gaseous form fluid at substantially a saturated pressure temperature condition into said casing to establish a predetermined fluid pressure therein, said fluid being heated to a first temperature so that it will condense at temperatures below said first temperature and to evaporate at a second temperature above said first temperature, and of exteriorly heating at least a portion of said casing at which the condensed liquid collects to a temperature at least equal to said second temperature for a desired time interval whereby fluid condensed will be revaporized for recondensation on said inner parts whereby the temperature of said inner parts will be raised due to the heat of condensation, of thereafter exhausting said fluid from said casing, and of thereafter introducing a heated nonaqeous vapor which under the admitted pressure will be noncondensible on the heated parts of said unit.

4. The method of treating a unit having an exterior sealed casing enclosing inner parts arranged in poor heat conducting relationship with the external portion of the unit which includes the steps, of producing a subatmospheric pressure within said casing, of heating said casing externally, of introducing a quantity of heated gaseous form fluid at substantially a saturated pressure temperature condition into said casing to establish a predetermined fluid pressure therein, said fluid being heated to a first temperature so that it will condense at temperatures below said first temperature and to evaporate at a second temperature above said first temperature, and of exteriorly heating at least a portion of said casing at which the condensed liquid collects to a temperature at least equal to said second temperature for a desired time interval whereby fluid condensed will be revaporized for recondensation on said inner parts whereby the temperature of said inner parts will be raised due to the heat of condensation, of thereafter exhausting said fluid from said casing, of thereafter introducing a heated nonaqueous vapor which under the admitted pressure will be noncondensible on the heated parts of said unit, and of thereafter removing at least a portion of said nonaqueous vapor.

5. The method of dehydrating a refrigeration unit having internal parts in poor conducting relationship with the external part thereof which includes the steps, of exteriorly heating the unit to a desired temperature while being evacuated, of thereafter introducing a heated nonaqueous gaseous fluid into the unit at a first temperature, said fluid having the property of condensing at temperatures below said first temperature and vaporizing at said first temperature, of raising the temperature of said internal parts by the condensation of the gaseous fluid thereon which collects into a liquid pool on the external part, and of heating the liquid pool of the condensed gaseous fluid at least to said first temperature by conduction from the exteriorly heated parts of the unit to continuously change the liquid to a gas as condensation continues on the internal parts.

6. The method of dehydrating a refrigeration unit having internal parts in poor conducting relationship with the external part thereof which includes the steps, of exteriorly heating the unit to a desired temperature while being evacuated, of thereafter introducing a heated nonaqueous gaseous fluid into the uiit at a first temperature, said fluid having the property of condensing at temperatures below said first temperatures and vaporizing at said first temperature, of raising the temperature of said internal parts by the condensation of the gaseous fluid thereon which collects into a liquid pool on the external part, of heating the liquid pool of the condensed gaseous fluid by conduction from the exteriorly heated parts of the unit to continuously change the liquid to a gas as condensation continues on the internal parts, and of maintaining the temperature surrounding said unit at a temperature at least equal to said first temperature whereby said gaseous fluid is maintained in a saturated condition as the temperature of the internal parts is raised.

7. The method of dehydrating a refrigeration unit having internal parts in poor conducting relationship with the external part thereof which includes the steps, of exteriorly heating the unit to a desired temperature while being evacuated, of thereafter introducing a heated nonaqueous gaseous fluid into the unit at a first temperature, said fluid having the property of condensing at temperatures below said first temperature and vaporizing at said first temperature, of raising the temperature of said internal parts by the condensation of the gaseous fluid thereon which collects into a liquid pool on the external part, of heating the liquid pool of the condensed gaseous fluid at least to said first temperature by conduction from the exteriorly heated parts of the unit to continuously change the liquid to a gas as condensation continues on the internal parts, of withdrawing the gaseous fluid from the refrigeration unit, and of condensing and collecting the gaseous fluid in a container.

8. The method of dehydrating a refrigeration unit having internal parts in poor conducting relationship with the external part thereof which includes the steps, of exteriorly heating the unit to a desired temperature while being evacuated, of thereafter introducing a heated nonaqueous gaseous fluid into the unit at a first temperature, said fluid having the property of condensing at temperatures below said first temperature, of raising the temperature of said internal parts by the condensation of the gaseous fluid thereon

which collects into a liquid pool on the external part, of heating the liquid pool of the condensed gaseous fluid at least to said first temperature by conduction from the exteriorly heated parts of the unit to continuously change the liquid to a gas as condensation continues on the internal parts, of withdrawing the gaseous fluid from the refrigeration unit, of condensing and collecting the gaseous fluid in a container, and of thereafter further evacuating the unit as its temperature is maintained substantially constant.

9. The method of dehydrating a refrigeration unit having internal parts in poor conducting relationship with the external part thereof which includes the steps, of exteriorly heating the unit to a desired temperature while being evacuated, of thereafter introducing a heated nonaqueous gaseous fluid into the unit at a first temperature, said fluid having the property of condensing at temperatures below said first temperature and vaporizing at said first temperature, of raising the temperature of said internal parts by the condensation of the gaseous fluid thereon which collects into a liquid pool on the external part, of heating the liquid pool of condensed gaseous fluid at least to said first temperature by conduction from the exteriorly heated parts of the unit to continuously change the liquid to a gas as condensation continues on the internal parts, of withdrawing the gaseous liquid from the refrigeration unit, of condensing and collecting the gaseous liquid in a container, of thereafter further evacuating the unit as its temperature is maintained substantially constant, of introducing a heated dry inert gas which will dilute the water vapors remaining in the unit, and of thereafter withdrawing the last said gas and diluted water vapors.

10. The method of dehydrating a refrigeration unit having internal parts in poor conducting relationship with the external part thereof which includes the steps, of exteriorly heating the unit to a desired temperature while being evacuated, of thereafter introducing a heated nonaqueous gaseous fluid into the unit at a first temperature, said fluid having the property of condensing at a temperature below said first temperature and vaporizing at said first temperature, of raising the temperature of said internal parts by the condensation of the gaseous fluid thereon which collects into a liquid pool on the external part, of heating the liquid pool of the condensed gaseous fluid at least to said first temperature by conduction from the exteriorly heated parts of the unit to continuously change the liquid to a gas as condensation continues on the internal parts, of withdrawing the gaseous fluid from the refrigeration unit, of condensing and collecting the gaseous fluid in a container, of thereafter further evacuating the unit as its temperature is maintained substantially constant, of introducing a heated dry inert gas which will dilute the water vapors remaining in the unit, of thereafter withdrawing the last said gas and diluted water vapors, and of continuing to evacuate the unit while being maintained at a desired temperature.

JENS K. TOUBORG.

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