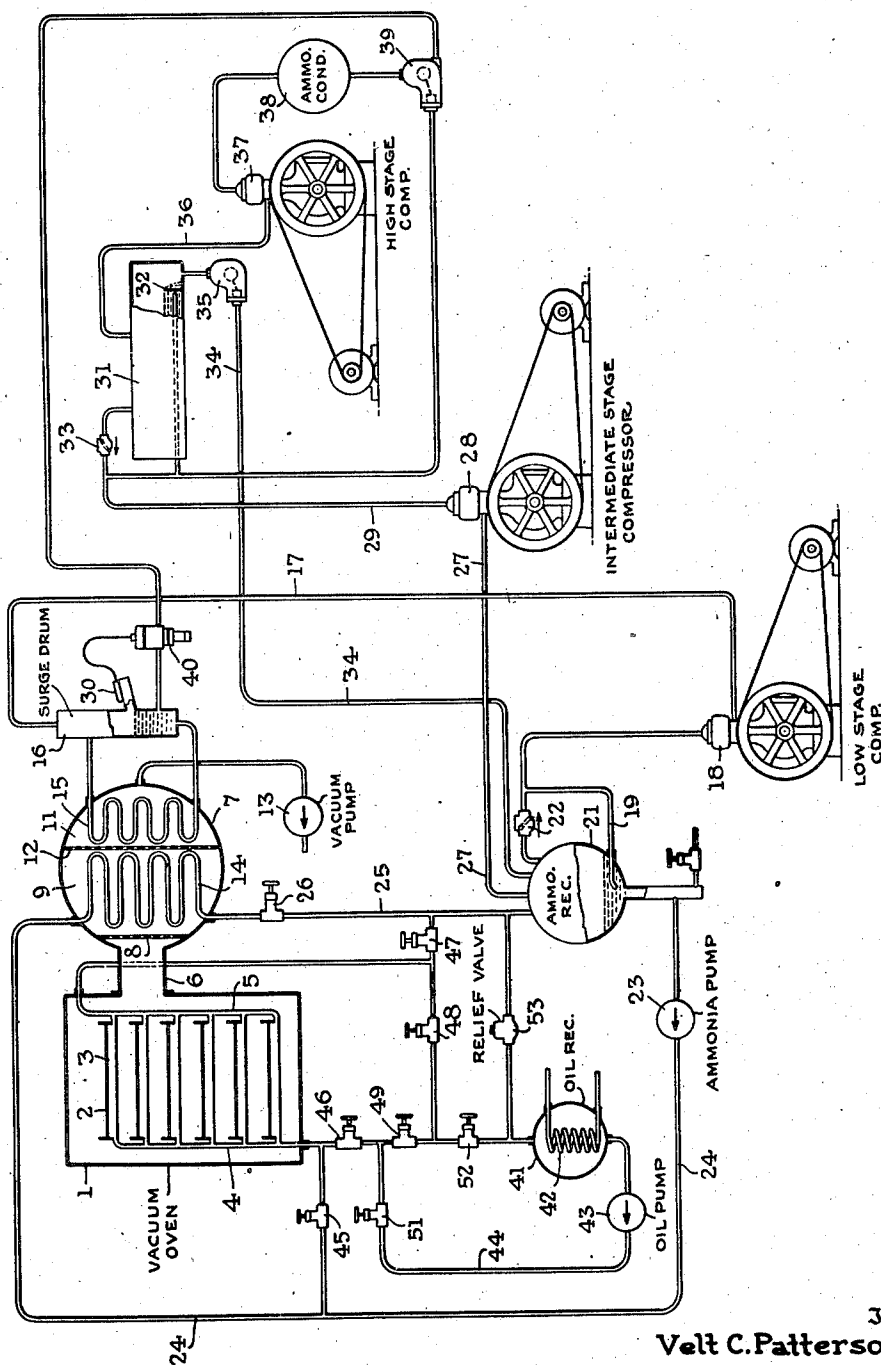


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VACUUM DRYING APPARATUS USING A REFRIGERANT
SYSTEM FOR HEATING AND COOLING
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VACUUM DRYING APPARATUS USING A REFRIGERANT SYSTEM FOR HEATING AND COOLING

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This invention relates to drying and particularly to drying from the frozen state under extremely low absolute pressures. (Say at 0.2 mm. of mercury.) Such processes are known, and have come into rather extensive use where the use of low temperatures favorably affects, or minimizes deterioration of, the materials being dried.

At the low absolute pressures used in such processes, evaporation of water produces sub-freezing temperatures, so that materials to be dried can be frozen simply by subjecting them to the pressure to be used during drying. However, this procedure is objectionable in many cases, and the preferred practice is to freeze material to be dried completely before subjecting it to the low absolute pressure.

The preferred way of creating the low pressures required for such drying is to collapse vapors against low temperature heat-exchange surfaces, using a vacuum pump of moderate capacity simply to receive air and any other non-condensable gases which may be present. This requires a low temperature refrigerating system but is more economical than it would be to use vacuum pumps large enough to handle the tremendous volumes of water vapor evolved at such low pressure.

During drying it is necessary to supply to the frozen substance being dried the latent heat demanded for sublimation of ice into water vapor. This heat must be supplied at such a temperature and at such a rate that the material being dried is always at a sub-freezing temperature.

The invention provides a double purpose heat-exchanger associated with the pans or other supports for material being dried, with connections by which this exchanger may be operated to freeze the product, as a preliminary to drying, and alternatively to supply heat to the product at controlled temperature and rate during drying.

In most mechanical refrigerating systems of the type used to collapse the vapor removed by drying, some lubricating oil circulates with the refrigerant, which usually is ammonia. The oil and refrigerant are thus compatible. According to the invention lubricating oil at a controlled temperature is circulated through the exchanger at a controlled rate to supply heat during drying. During preliminary freezing of material which is to be dried, the same exchanger is temporarily connected in the main refrigerative circuit as a portion of the low side thereof so as to function as a refrigerative evaporator, at a sub-freezing temperature.

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The invention will now be explained by reference to the accompanying drawing which is a diagram part in section and part in elevation.

In the drawing the drying chamber 1 is an air tight enclosure with an access door (not illustrated). The chamber must be constructed to withstand atmospheric pressure when the chamber is substantially completely evacuated. In the chamber 1 are mounted trays 2, each with a jacket space 3 connected at one end to an inlet manifold 4 and at the other to a discharge manifold 5.

Chamber 1 communicates through a large connection 6 with the interior of a vapor-condensing drum 7. Gases and vapors flowing through connection 6 enter drum 7 through a distributing grid 8. The space within drum 7 is divided into two communicating chambers 9 and 11 by a grid 12, the grid serving to distribute the flowing gases and vapor. From chamber 11 a connection leads to the vacuum pump 13.

In chamber 9 is a refrigerating evaporator 14 which is operated at low temperature (say minus 40° C.) and is so designed as to collapse and freeze about 90% of the off-flowing vapor. In chamber 11 is a refrigerating evaporator 15 which is operated at a still lower temperature (say minus 50° C.) and is designed to collapse and freeze substantially the remainder of the vapor. Thus the vacuum pump 13 withdraws air with the minimum practicable vapor content. The chamber 1 is maintained at an absolute pressure of the order of 0.2 millimeters of mercury.

The high side of the refrigerating circuit is of the three stage type and resembles that shown in applicant's Patent 2,351,700, June 20, 1944.

Evaporator 15 is connected top and bottom with a surge drum 16 from which a suction line 17 leads to the intake of low stage compressor 18. This discharges through line 19 beneath liquid refrigerant in receiver 21. A vapor by-pass controlled by check valve 22 ensures that liquid refrigerant cannot be forced back to compressor 18 through connection 19. A pump 23 circulates liquid refrigerant from receiver 21 through line 24 to and through evaporator 14. Evaporated refrigerant and any liquid not evaporated return to receiver 21 through line 25 in which there is a normally open valve 26.

From the vapor space in receiver 21 a suction line 27 leads to the intake of the intermediate compressor 28. This discharges through line 29 into intermediate receiver 31. Discharge is beneath a bath of liquid refrigerant retained by a weir 32. A vapor by-pass controlled by a check

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valve 33 protects against back-flow of liquid to compressor 28. Liquid refrigerant overflowing weir 32 flows through line 34 to receiver 21 under the control of high side float valve 35.

From the vapor space in receiver 31 a suction line 36 leads to the intake of high-stage compressor 37 which discharges into condenser 38. The condenser 38 discharges liquid refrigerant into the bath of liquid refrigerant retained by weir 32 in receiver 31, such discharge being controlled by high side float valve 39.

The refrigerant required by evaporator 15 is fed to its surge drum by a thermal expansion valve 40, fed from the float chamber of valve 39. The thermal bulb 30 of the expansion valve is subject to the temperature at the surge drum as indicated in the diagram.

A receiver 41 may receive oil from any suitable source. This source may be the lubricating system for the compressors, but since these connections are not a part of the invention, and may take various forms, they are not shown.

A heating coil 42 is located in receiver 41 and may be operated to hold the oil at any suitable temperature. The use of automatic temperature control is an obvious expedient, but is not claimed as a patentable feature and hence need not be illustrated. A pump 43 withdraws oil from receiver 41 and discharges it through line 44.

Valves 45 and 46 are provided to connect inlet manifold 4 selectively with refrigerant line 24 or oil supply line 44. Valves 47 and 48 are provided to connect discharge manifold 5 selectively with receiver 21 or oil receiver 41.

A normally closed valve 49 is provided to drain manifolds 4 and 5 and spaces 3 at the end of a heating cycle. Normally open valves 51 and 52, are provided, but for present purposes may be assumed to be continuously open. The relief valve 53 permits escape of vaporized refrigerant (if present) from oil receiver 41 to receiver 21.

Assume that the compressors are in operation and that the trays 2 have just been charged with material to be dried. Oil pump 43, vacuum pump 13 and ammonia pump 23 would be shut down at such time. The spaces 3 in the heat exchanger, associated with the trays, would have been drained free of oil by opening the valves 46, 48, 49 and 52 while the valves 45, 47 and 51 were closed. After this operation the valves 46, 48 and 52 are closed, and 45, 47 and 51 remain closed, while valve 49 remains open. By opening the valves 45 and 47 and starting the ammonia pump 23 the material on the pans 2 can be quickly frozen. At this time the valve 26 may or may not be open.

After the material in the pans is hard frozen the procedure is to close the chamber 1 from the atmosphere and drain the spaces 3 free of all refrigerant. This can be done by closing the valve 45 and opening the valves 46, 47 and 48 so that the refrigerant will drain back to the receiver 21. After this has been done the valves 47 and 49 are again closed.

The next step is to open the valve 26, if closed, and to start the vacuum pump 13. As soon as the desired low absolute pressure has been established in the chamber 1 the circulation of oil can be started. With the coil 42 being operated at the proper temperature the valves 51, 46, 48 and 52 are opened and the oil pump 43 is started. The effect is to circulate oil at the proper temperature through the spaces 3 and back to the oil receiver 41.

At the conclusion of the drying operation the apparatus is shut down and the valves are ma-

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nipulated to drain all oil back to the receiver 41. Probably a little oil will remain in the spaces 3 and manifolds 4 and 5, but since it is lubricating oil normally present in the refrigerant circuit it does no harm. Similarly, if some refrigerant should return from the spaces 3 to the oil receiver 41 it would do no harm. It would simply be driven off in the vapor phase through the relief valve 53 to the receiver 21.

By the above means the material is frozen before it is subjected to vacuum drying. The main refrigerating system is availed of to perform this freezing step, and the freezing operation is carried out in the dryer itself. The same exchanger which is used for this freezing step is also used to deliver latent heat to the material being dried.

It is important that the heat conveying liquid, above described as oil, be compatible with the refrigerant used in the refrigerating system. It is desirable to use lubricating oil because such oil is compatible with the refrigerant and is normally present in the circuit.

The vacuum maintained by the pump 13 is of the order of 0.2 millimeters of mercury absolute, and this pressure corresponds at least approximately with the temperature of the evaporator 15 on the basis of the thermodynamic properties of water. This condition is imposed by the fact that water is the volatile liquid removed in drying.

What is claimed is:

1. A plant for drying from the frozen state, comprising a closed drying chamber; a mechanical refrigerative circuit containing a volatile refrigerant and having a high side, and a low side, the latter of which includes low temperature refrigerative evaporator means having heat exchange surface exposed to vapors evolved in said chamber; evacuating means for withdrawing non-condensable gases from said chamber; a heat exchanger affording within said chamber at least one heat exchange surface for sustaining material to be dried; means for circulating a heat conveying liquid, said liquid being compatible with the refrigerant used in said refrigerating circuit; and valve means operable to connect the last named heat exchanger selectively in circuit with said circulating means, or in said refrigerative circuit as a portion of the low side thereof, and alternatively to interrupt said connections and drain said heat exchanger.

2. A plant for drying from the frozen state, comprising a closed drying chamber; a mechanical refrigerating circuit containing a volatile refrigerant and a lubricating oil, said circuit having a high side and a low side, the latter of which includes low temperature refrigerative evaporator means having heat exchange surface exposed to vapors evolved in said chamber; evacuating means for withdrawing noncondensable gases from said chamber; a heat exchanger affording within said chamber at least one heat exchange surface for sustaining material to be dried; means for circulating a lubricating oil essentially identical with that in the refrigerating circuit; means for controlling the temperature of the circulated oil; and valve means operable to connect the last named heat exchanger selectively in circuit with said circulating means, or in the low side of said refrigerating circuit as an evaporator.

3. A plant for drying from the frozen state, comprising a closed drying chamber; a mechanical refrigerating circuit containing a volatile refrigerant and a lubricating oil, said circuit having a high side and a low side, the latter of which includes low temperature refrigerative

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evaporator means having heat exchange surface exposed to vapors evolved in said chamber; evacuating means for withdrawing noncondensable gases from said chamber; a heat exchanger affording within said chamber at least one heat exchange surface for sustaining material to be dried; means for circulating a lubricating oil essentially identical with that in the refrigerating circuit; means for controlling the temperature of the circulated oil; and valve means operable to connect the last named heat exchanger selectively in circuit with said circulating means, or in the low side of said refrigerating circuit as an evaporator, and alternatively to interrupt said connections and drain said exchanger.

4. A plant for drying from the frozen state, comprising a closed drying chamber; a mechanical refrigerating circuit containing a volatile refrigerant and a lubricating oil, said circuit having a high side and a low side, the latter of which includes low temperature refrigerative evaporator means having heat exchange surface exposed to vapors evolved in said chamber; evacuating means for withdrawing noncondensable gases from said chamber; a heat exchanger affording within said chamber at least one heat exchange surface for sustaining material to be dried; means for circulating a lubricating oil essentially identical with that in the refrigerating circuit; means for controlling the temperature of the circulated oil; and valve means operable to connect the last named heat exchanger selectively in circuit with said circulating means, or in the low side of said refrigerating circuit as an evaporator, and alternatively to interrupt said connections and establish at the will of the operator either of two drain connections, one of which drains the exchanger to said circulating means and the other of which drains the exchanger to the refrigerative circuit.

5. A plant for drying from the frozen state, comprising a closed drying chamber; a mechanical refrigerative circuit containing a volatile refrigerant and having a high side and a low side, the latter of which includes low temperature refrigerative evaporator means having heat exchange surface exposed to vapors evolved in said chamber; evacuating means for withdrawing noncondensable gases from said chamber; a heat exchanger affording within said chamber at least one heat exchange surface for sustaining material to be dried; means for circulating a low temperature heat supplying medium compatible with said volatile refrigerant; and valve means for operating the last named exchanger in two phases, in one of which it is disconnected from

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said circulating means and connected in the low side of said refrigerative circuit to function as a low temperature refrigerative evaporator, and in the other of which it is disconnected from said refrigerative circuit and connected in circuit with said circulating means to function as a low temperature heat source.

6. A plant for drying from the frozen state, comprising a closed drying chamber; a mechanical refrigerative circuit containing a volatile refrigerant and having a high side and a low side, the latter of which includes at least two refrigerative evaporators, one of which is operated at a lower temperature than the other, both said evaporators having heat exchange surface exposed to vapors evolved in the chamber; evacuating means for withdrawing noncondensable gases from said chamber, the evacuating means and evaporators being relatively so located that flow from the chamber toward the evacuating means encounters first the evaporator of higher and then the evaporator of lower temperature; a heat exchanger affording within said chamber at least one surface for sustaining material to be dried; means for circulating a low temperature heat conveying liquid compatible with said refrigerant; and valve means for operating the last named exchanger in two phases in one of which it is disconnected from said circulating means and connected in the low side of said refrigerative circuit to function as a low temperature refrigerative evaporator, and in the other of which it is disconnected from said refrigerative circuit and connected in circuit with said circulating means to function as a low temperature heat source.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,315,766	Feldman	Sept. 9, 1919
1,479,551	Labolle	Jan. 1, 1924
1,608,982	Hatch	Nov. 30, 1926
2,215,265	Flosdorf	Sept. 17, 1940
2,292,447	Irwin, Jr.	Aug. 11, 1942
2,302,253	Reichel et al.	Nov. 17, 1942
2,345,548	Flosdorf et al.	Mar. 28, 1944
2,374,232	Pfeiffer et al.	Apr. 24, 1945
2,434,003	Morrison	Jan. 6, 1948

FOREIGN PATENTS

Number	Country	Date
840,092	France	Jan. 11, 1939