May 29, 1962 G. TRÉPAUD 3,036,443

FREEZING APPARATUS

Filed Feb. 11, 1958 2 Sheets-Sheet 1

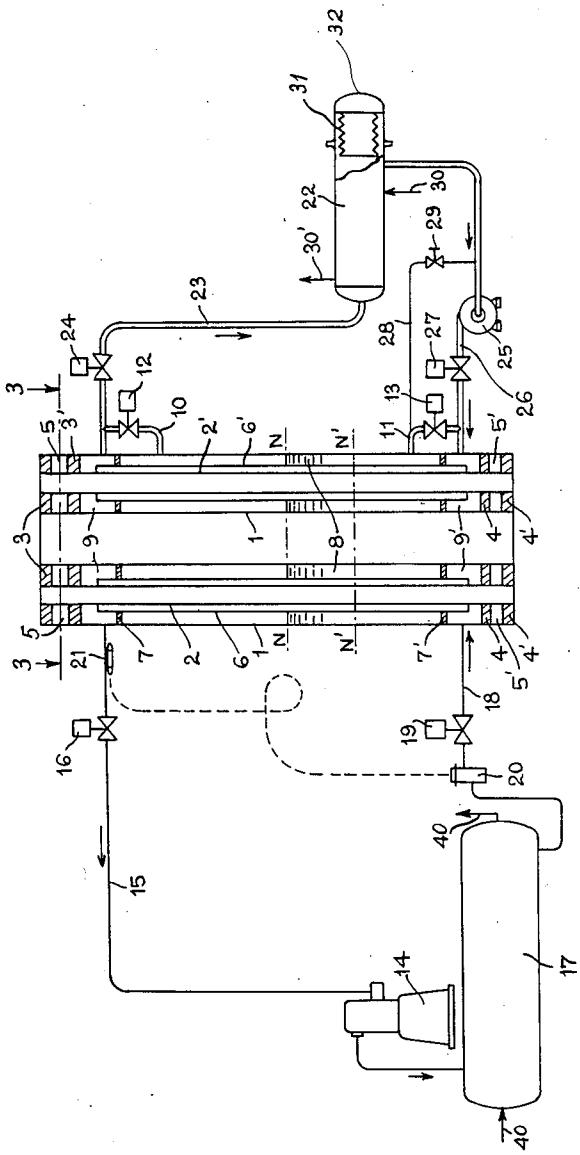


FIG. 1

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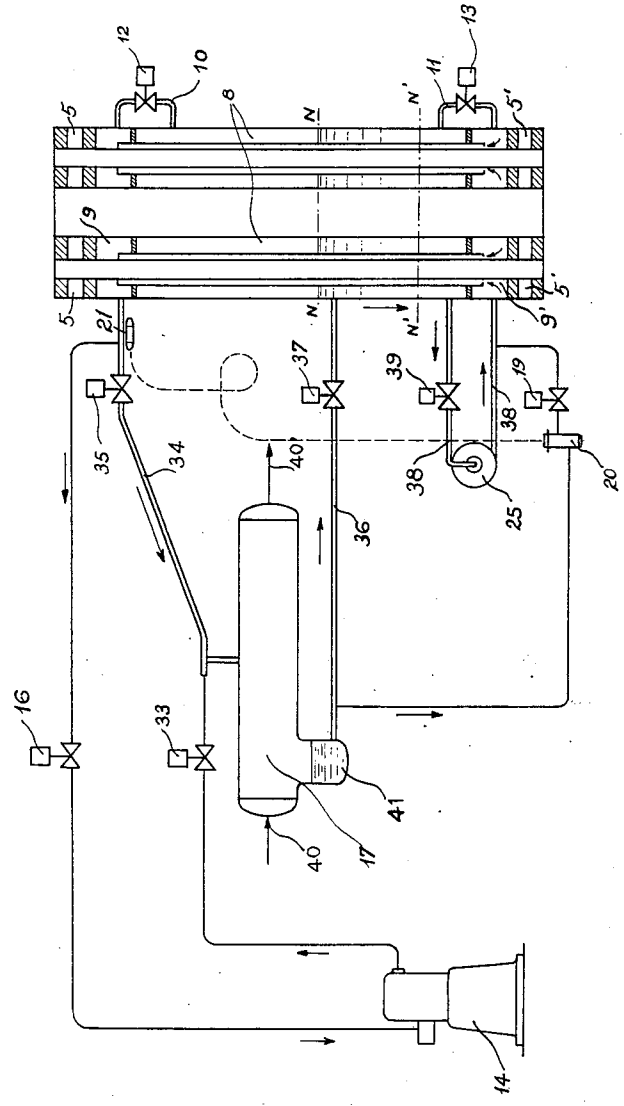


FIG. 2

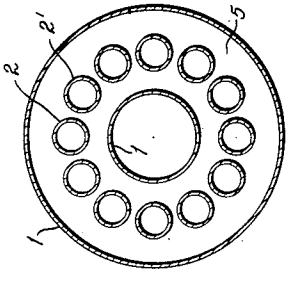


FIG. 3

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FREEZING APPARATUS

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The present invention relates to the tubular freezing apparatus in which the ice is produced, in the shape of cylindrical tubes or bars, in pipes vertically disposed in an enclosed space in which these pipes bathe in a cold-producing fluid: for the withdrawing, the bars of ice are separated from the walls of the freezing pipes by the action of a warm fluid sent in the enclosed space and fall in a collecting container which is usually equipped with a device to cut them into lengths. The tubular freezing apparatus of this type are divided into two classes: in the first class, the freezing is produced by means of a brine cooled in a separate cold generator, whereas in the apparatus of the second class, referred to as "direct expansion apparatus"—and to which belong the apparatus according to the present invention—to obtain the freezing a cold producing liquid such as ammonia or Freon, is evaporated directly in the enclosed space containing the freezing pipes by means of a compressor and a condenser connected in series with this enclosed space. These apparatus work, either in a "flooded state" and, in this case, the cold producing liquid fills up, to a given height, the enclosed space containing the freezing pipes, or by injection of the cold producing liquid in the enclosed space where it evaporates. In freezing apparatus working in the flooded state, the withdrawing of the bars of ice out the freezing pipes is carried out by forcing, by means of hot gases coming from the compressor, the cold producing liquid, out of the enclosed space which contains the freezing pipes, in a special container. The hot gases coming into direct contact with the outer wall of the freezing pipes bring about the superficial melting of the tubes of ice which is necessary for the withdrawing. The cold producing liquid placed in reserve, after this withdrawing, is brought anew in the refrigerator. This travelling of the cold producing liquid requires complicated hand operated as well as self acting devices. In addition, the heating of the freezing pipes, necessary for the withdrawing, is not carried out in a homogeneous way, as the transmission of the heat is hindered and delayed by the remaining liquid and by a condensation taking place at the surface of the cold pipes between the wall and the steam. To end, with this process for the withdrawing, it is necessary to keep the compressor running also during the phase of the withdrawing, thus resulting in an important consumption of energy.

An object of the invention is to provide a process for the withdrawing of the ice, said process being particularly suitable for the tubular refrigerators working in the flooded state. A further object of the invention is the provision of a process for the withdrawing of the ice, which consists in circulating, through the enclosed space containing the freezing pipes, the cold producing medium in the liquid state which has been previously heated in an exchanger after the stopping of the compressor.

When compared with the withdrawing by means of hot gases from the compressor, the advantages of this new process are as follows:

(1) The cold producing machine proper (compressor) works only during the freezing phase and is stopped during the withdrawing of the ice.

(2) The transmission of heat between the heated cold producing liquid and the wall of the freezing pipes is carried out under very good conditions and allows to speed up the withdrawing operation.

(3) The calories required for the withdrawing are brought from the outside by a circulation of water, using

for instance the water which, in the preceding freezing phase, was used to cool the hot gases in the condenser of the refrigerator. Besides, on account of the very small specific heat of the liquid Freon used as a cold producing fluid (0.225), the amount of heat brought into action, for instance to bring the cold producing from −8° or −10° to 5° or 7°, is comparatively small and forms but a small part of the total amount of calories required. In addition, it is possible to recover the cold contained in the water used to heat the liquid Freon, for instance by using anew this water in the condenser or by filling up the refrigerator in the following cycle.

(4) The equipment requires only a heat exchanger and a circulating pump for the liquid Freon: besides the exchanger can, in important plants, be constituted by the proper condenser of the refrigerator. The flow of the pump must be rather important to secure a fast heating of the Freon, in two or three minutes for instance, with a fall of the temperature of about 2° between the inlet and the outlet of the refrigerator, but, on account of the reduced loss of head, the consumption of energy necessary to drive the pump is much smaller than the consumption required in the known plants, for the working of the compressor during the phase of the withdrawing.

By way of example, two forms of embodiment of a plant for the working up of the process according to the invention are described hereafter and schematically illustrated in the annexed drawing.

FIGURE 1 illustrates a plant including a separate exchanger to heat the cold producing liquid.

FIGURE 2 illustrates a plant in which the cold producing medium is heated in the condenser of the freezing machine during the withdrawing; and

FIGURE 3 is a large scale fragmentary sectional view taken on the line 3—3 of FIGURE 1.

The proper tubular refrigerator, schematically illustrated in FIGURE 1, is constituted by an enclosed space **1**, having for instance an annular section and in which are mounted pipes **2**, **2'** . . . in which the water to be frozen circulates during the freezing phase: these pipes are fixed at their ends in watertight plates **3**, **3'** and **4**, **4'** forming, in a known way, two compartments **5**, **5'** in which the cold producing fluid as no access, to avoid the formation of ice in the ends of pipes **2**, **2'** which would hinder the withdrawing of the ice from said pipes. The pipes **2**, **2'** . . . are, in a known way, surrounded with metallic sleeves **6**, **6'** . . . opened at both ends, the working of which shall be described hereafter. The sleeves **6**, **6'** . . . are fixed at their ends in transverse plates **7**, **7'**. The inner chamber **8** of the enclosed space **1** is connected with two end chambers **9**, **9'** through pipings **10**, **11**, provided with hand valves **12**, **13**, which will be designated hereafter as "cocks." The circuit for the feeding of the machine with water to be congealed and the devices collecting the ice are not illustrated as these devices are known and do not form a part of the invention.

The plant includes a cold producing machine constituted by a compressor **14** which sucks the expanded vapours of the cold producing medium in the upper chamber **9** of the refrigerator through a piping **15** provided with a cock **16** and forces back these vapours in a condenser **17** connected with the lower chamber **9'** of the refrigerator through a piping **18** provided with a cock **19** and a thermostatic valve **20**, governed by the pressure of the gases in the bulb **21**, at the outlet of the refrigerator.

According to the invention, the plant includes a heat exchanger **22** connected, on the one hand, with the upper chamber **9** of the refrigerator by the piping **23** provided with a cock **24** and, on the other hand, with a pump **25** connected with the lower chamber **9'** of the refrigerator by a pipe **26** provided with a cock **27**: a level balancing

pipe 28, provided with a cock 29, connects directly the central chamber 8 of the refrigerator with the inlet of the pump 25. The exchanger 22 is provided with a circulation of water 30, 30' and this water can possibly, as above indicated, be the same as the water used in the condenser 17 to cool the gases discharged by the compressor 14.

The machine works as follows: during the freezing, the cocks 12, 13, 16, 19, are open, the cocks 24, 27, 29 are shut off.

The feeding of the refrigerator with liquid Freon from the condenser 17 is carried out through the thermostatic valve 20: its level reaches for instance N in the enclosed space 1. On account of the suction of the compressor, the liquid goes up in the tubular sleeves 6, 6' . . . round the pipes 2, 2' . . . , said sleeves securing thereby a less tumultuous boiling of the liquid and a better transmission of the cold to the pipes 2.

During the withdrawing phase, the cocks 12, 13, 16, 19 are shut off and the cocks 24, 27, 29 are open. The compressor 14 is stopped, the pump 25 is started and circulates the liquid Freon through the exchanger 22 which is filled up with liquid Freon. The heated Freon is forced by the pump 25 into the chamber 9', flows through the tubular sleeves 6 round the pipes 2, and heats them up to the upper chamber 9 and flows from there through the piping 23 to the exchanger. Thanks to the tubular sleeves 6, the liquid Freon forced under pressure from the pump in the lower chamber 9' is uniformly allotted at the inlet of the pipes 2 so that all these freezing tubes are simultaneously heated.

During the heating phase, the cock 29 connects up the inlet of the pump with the central chamber 8 of the refrigerator in which the level of the liquid Freon comes in N', below N, because a part of the liquid is at each moment of this phase in the upper chamber 9.

After the withdrawing, when the bars of ice have moved down out of the refrigerator, the level of the liquid Freon must be brought back to the value N necessary for the freezing phase for the reasons given hereafter: it is sufficient for that to open the cocks 12 and 13 and to stop the pump 25: as all the conduit pipes are then open, the liquid falls back in a few seconds in the lower part of the circuit so that it becomes possible to open anew the cocks 16, 19, to close the cocks 24, 27, 29 and to start anew the compressor for the next withdrawing. The immediate restoration of a suitable level is of great importance: it avoids, on the one hand, the damages which could result in the compressor from a stroke of the liquid owing to a too high level and, on the other hand, it avoids, for the cold producing machine, to have to work in poor conditions if the level remains too low during the rather long time necessary for the restoration of the level by the action of the thermostatic regulator.

As the exchanger 22 is still full of liquid Freon, it is possible, to have the disposal of some hot Freon for the next withdrawing, which is thereby accelerated, to circulate the heating water through the exchanger during all the freezing phase or during a part of this phase. The expansion of the liquid Freon is in that case permitted by the compression of the part of the gas contained in the piping 23, but it is possible, in case of need, to add an expansion compenser constituted by tight elastic bellows 31 arranged in one of the ends 32 of the exchanger 22.

In the form of embodiment illustrated in FIGURE 2, there is no exchanger, and the heating of the Freon for the withdrawing is carried out in the condenser 17 of the cold producing machine, arranged in this case above the level N of the liquid Freon during the freezing phase in the inclosed space 1 of the refrigerator and provided with a cock 33, allowing to isolate it from the compressor 14. The condenser 17 is connected, on the one hand, through the piping 34 provided with a cock 35, with the upper chamber 9 of the refrigerator, and on the other hand, at its lower part 41 in which the condensed Freon accumulates, it is connected with the central chamber 8

through a pipe 36 provided with a cock 37. A piping 38 in which are mounted the pump 25 and a cock 39, connects the bottom of the central chamber 8 with the lower chamber 9' of the refrigerator.

During the freezing phase, the water circulation 40, 40' of the condenser cools down and condenses the vapours forced back by the compressor whereas, during the withdrawing phase, this water circulation heats the cold liquid Freon which is circulated by the pump 25, through the refrigerator as in the former example.

The apparatus works as follows:

During the freezing phase, the cocks 12, 13, 16, 19 and 33 are open, the cocks 35, 37, 39 are closed.

During the withdrawing phase, the compression is stopped, the cocks 12, 13, 16, 19, 33 are closed, the cocks 35, 37 and 39 are open and the pump 25 is started. The pump sucks the liquid Freon from the central chamber 8 of the refrigerator and forces it into the lower chamber 9', from where the liquid rises through the sleeves 6 around the pipes 2 up to the upper chamber 9, passes through the piping 34 in the condenser 17 where it is heated and flows back, through the duct 36, in the chamber 8 of the refrigerator. The level of the liquid in this chamber 8 decreases from N to N' during this phase of the working as this liquid is partly in the upper chamber 9 and partly in the condenser 17. After the withdrawing of the ice, the stopping of the pump and the opening of the cocks 12, 13, causes instantly the fall of the liquid in the lower part of the circuit and thereby the restoration of the level N, which is suitable for the working in the freezing phase. The starting of the next freezing operation is obtained very simply by shutting off the cocks 35, 37, 39, opening the cocks 16, 33, 19 and starting anew the compressor.

The automatic working of the plants illustrated in FIGURES 1 and 2 can be obtained very simply.

What I claim is:

1. In a tubular freezing apparatus operated on alternate freezing and thawing phases, including an evaporating chamber partially filled with a liquid cold producing medium and provided with freezing tubes containing the water to be frozen and arranged vertically therein to be refrigerated in a flooded condition by the evaporation of said liquid medium during the freezing phase, the provision of a compressor connected to the upper part of said evaporating chamber to draw the vapors of the cold producing medium therefrom, of a condenser provided with cold water circulating means and connected to said compressor to condense the compressed vapors discharged by the compressor and to return the condensed cold producing medium to the lower part of the evaporating chamber, of means to heat said cold producing liquid during the thawing phase, said means comprising a heat exchanger, of means to circulate heating water through said heat exchanger, and of means to circulate said heated liquid medium through said evaporating chamber to thaw the ice loose from the inner walls of the freezing tubes, said means comprising a pump connected in series with said heat exchanger and said evaporating chamber to suck the heated cold producing liquid medium from the upper part of said chamber and to discharge same in the lower part thereof, of valve means to isolate the compressor and the condenser from the evaporating chamber during the thawing phase and of valve means to isolate the pump and the exchanger from said chamber during the freezing phase, of means to circulate the heating water in the heat exchanger during the freezing phase during which said exchanger is isolated from the evaporating chamber to obtain a reserve of hot cold producing medium for the next thawing phase, said exchanger being provided with means for compensating the expansion of said liquid and formed by metallic bellows arranged at one end of the exchanger.

2. In a tubular freezing apparatus operated on alternate freezing and thawing phases, including an evaporating

chamber partially filled with a liquid cold producing medium and provided with freezing tubes containing the water to be frozen and arranged vertically therein to be refrigerated in a flooded condition by the evaporation of said liquid medium during the freezing phase, the provision of a compressor connected to the upper part of said evaporating chamber to draw the vapors of the cold producing medium therefrom, of a condenser provided with cold water circulating means and connected to said compressor to condense the compressed vapors discharged by the compressor and to return the condensed cold producing medium to the lower part of the evaporating chamber, of valve means to isolate the compressor from the evaporating chamber during the thawing phase, of means to heat the liquid cold producing medium in said condenser, of a pump, and of means for connecting said pump in series with the condenser to said evaporating chamber to circulate the heated liquid cold producing medium through said chamber, the condenser being located above the level at which the liquid cold producing medium is maintained in the evaporating chamber during the freezing phase.

3. A tubular freezing apparatus of the direct expansion type operated in a flooded condition comprising a vertical cylindrical evaporator, perforated transverse partitions arranged near the upper and lower ends of said evaporator, freezing tubes tightly fixed in the perforations of said transverse partitions, means to circulate the water to be frozen through said tubes, a second perforated transverse partition arranged near each end of the evaporating chamber below the first upper partition and above the first lower partition, thin tubular metallic sleeves arranged coaxially around the said freezing tubes, tightly fitting in the perforations of said second partition and having their ends freely opening in the chambers formed between said first and second partitions, a cold producing machine comprising a compressor and a condenser connected in series between said upper and lower chambers of the evaporator, two pipings provided with valve means and arranged between the central chamber of the evaporator and its upper and lower chambers respectively, a heat exchanger and a pump connected in series between said upper and lower chambers of the evaporator, valve means to isolate during the thawing phase the cold producing machine from the evaporator and to isolate therefrom the pump and the exchanger during the freezing phase, whereby the liquid cold producing medium is circulated through the evaporator during the thawing phase, and means to heat in the exchanger said circulating liquid medium.

4. In a tubular freezing apparatus operated on alternate freezing and thawing phases, including an evaporating chamber partially filled with a liquid cold producing

medium, and provided with freezing tubes containing the water to be frozen and arranged vertically therein to be refrigerated in a flooded condition by the evaporation of said liquid medium during the freezing phases, the provision of a heat exchanger, of a supply of heat, and of a pump, means being further provided to supply the heat to said exchanger, and to circulate during the thawing phases the liquid cold producing medium contained in the evaporating chamber through a closed circuit comprising said heat exchanger, said pump and said evaporating chamber, whereby the ice bars formed in said freezing tubes during the freezing phases are superficially melted and thereby separated from the inner walls of said freezing tubes.

5. A tubular freezing apparatus operated on alternate freezing and thawing phases, including an evaporating chamber partially filled with a liquid cold producing medium and provided with freezing tubes containing the water to be frozen and arranged vertically therein to be refrigerated in a flooded condition by the evaporation of said liquid medium during the freezing phases, a compressor, a conduit connecting said compressor to the upper part of said evaporating chamber to draw the vapors of the cold producing medium therefrom, a condenser provided with cold water circulating means, said condenser being connected to said compressor to condense the compressed vapors discharged by the compressor and to return the condensed cold producing medium to the lower part of the evaporating chamber, means to heat said cold producing liquid during the thawing phases, said means comprising a heat exchanger, means to circulate water through said heat exchanger, and means to circulate said heated liquid medium through said evaporating chamber to thaw the ice loose from the inner walls of the freezing tubes, said last named means comprising a pump connected in series with said heat exchanger and said evaporating chamber to draw the heated cold producing liquid medium from the upper part of said chamber and to discharge same in the lower part thereof, valve means to isolate the compressor and the condenser from the evaporating chamber during the thawing phases and valve means to isolate the pump and the exchanger from said chamber during the freezing phases.

References Cited in the file of this patent

UNITED STATES PATENTS

2,387,899	Gruner	Oct. 30, 1945
2,397,347	Gruner	Mar. 26, 1946
2,628,479	Powers et al.	Feb. 17, 1953
2,700,280	Heuser	Jan. 25, 1955
2,775,098	MacLeod	Dec. 25, 1956