

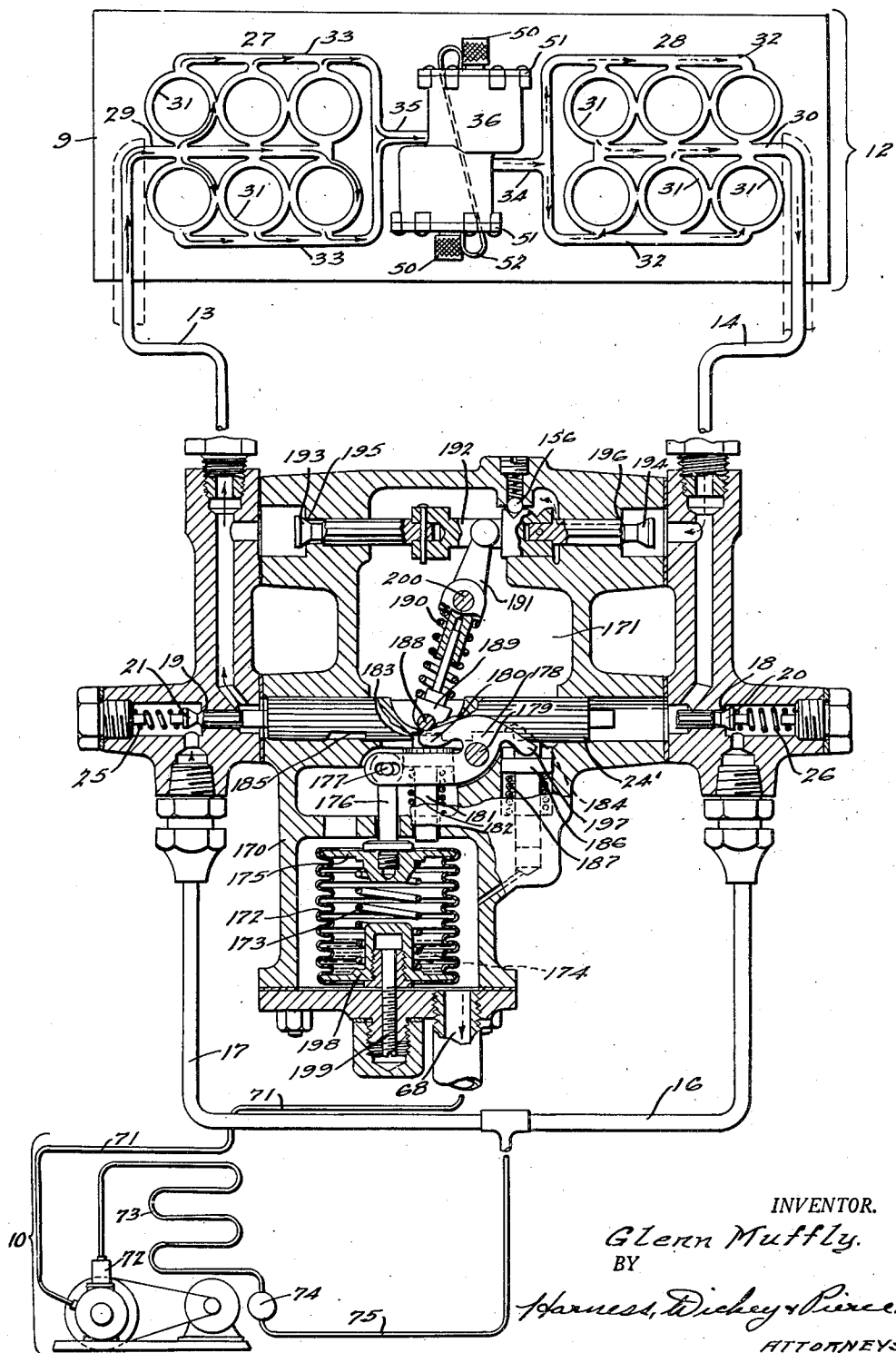
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REFRIGERATING METHODS

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REFRIGERATING METHOD

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3 Claims. (Cl. 62-172)

This is a division of application Serial No. 719,099, filed April 5, 1934, now Patent No. 2,145,774, issued January 31, 1939.

The objects of the invention are the provision of certain methods of operation and of control of apparatus for refrigerating mechanism particularly applicable to such apparatus employed in the artificial production of ice.

The above being among the objects of the present invention, the same consists in certain novel methods of control and operation, to be hereinafter described with reference to the accompanying drawing, and then claimed, having the above and other objects in view.

In the accompanying drawing which illustrates one structure capable of carrying out the methods comprising the present invention and in which like numerals refer to like parts, the figure is a more or less diagrammatic, broken, partially sectioned view of a refrigerating apparatus embodying an improved refrigerant flow controlling apparatus, the valve mechanism of which is shown in section and enlarged with respect to the remaining elements.

It will be readily understood by those skilled in the art that certain of the methods and apparatus herein disclosed are applicable for uses other than the production of ice, but, in view of the fact that the present application deals principally with the artificial production of ice, the description and explanation herein, primarily for the purpose of illustration, will be limited entirely to the application of such methods and/or apparatus to their use in the artificial production of ice.

In my previous application above identified means are disclosed for the production of ice by artificial refrigeration and it includes, in certain of the modifications there shown, a refrigerating mechanism including a compressor, condenser and receiver constituting a refrigerant high side, a water tank the bottom of which has associated therewith certain surfaces which, for the simplicity of explanation, will be referred to as cups or cones, exposed to the water within the tank, and each of which has associated with its unwetted surface an evaporating element or refrigerant low side for the purpose of refrigerating it. The evaporator sections for the ice-making areas are connected in series or in parallel, or as herein described may be connected in a combination of both with the compressor and condenser. Suitable control means are provided in the connection between the high and low sides and between certain series or groups of the cups

or cones so that one set or group of cups or cones will be refrigerated so as to cause ice to be formed in or on the same, while the other group of cups or cones will be warmed in order to cause ice previously formed in or on the cups or cones of such group to be melted loose therefrom whereby their natural buoyancy in the water within the tank will cause them to be removed from the surfaces upon which the ice was formed. The control means therein provided, particularly in certain modifications there shown, were such as to cause periodic reversal of flow of the refrigerant through the two sets or groups of evaporator sections so as to effect a constant and continuous production of ice.

The present invention deals primarily with the same type of construction as disclosed in said co-pending application above identified, now Patent No. 2,145,773, but relates to certain improvements therein. Accordingly, there is illustrated a refrigerating mechanism including a high side indicated generally at 10, a low side indicated generally at 12 and a control mechanism connecting them. The high side includes the usual motor driven compressor 72, condenser 73 and receiver 74. The low side includes two groups of evaporating units in the form of rings 31 connected in series through the dual expansion valve 36, each series being subdivided into two smaller groups, the individual rings of which are connected in parallel. Each ring 31 of the groups 27 and 28 of rings 31 is thermally associated with a corresponding ice making surface arranged in a water tank 9, the groups 27 and 28 are preferably being arranged at opposite ends of the tank 9 or otherwise spaced apart to minimize heat transfer between them. The control unit includes suitable valves for controlling the direction of flow of refrigerant from the high side 10 to the low side 12 together with thermal responsive means in the form of bellows 172, the entire control unit being such that the direction of flow of refrigerant through the low side 12 may be periodically reversed.

Any refrigerant may be employed in connection with this refrigerating system, but it is preferable to use one having a high ratio of specific heat of liquid to latent heat of vaporization, such as dichlorodifluoromethane, for instance, so that ample heat is available for melting the ice free from the refrigerated surfaces.

It will be understood that any desired and/or conventional form of control means may be employed in connection with the refrigerating system as a whole for effecting cyclic operation of

the system, where such cyclic operation of the system is desired.

A single bellows or diaphragm is employed for the multiple purpose of effecting various steps in a series of valve actions. It is possible to make one bellows perform various required functions by alternately causing it to contract with reduction of temperature and expand with reduction of surrounding pressure.

This mechanism provides means for evaporating all of the refrigerant in the ice-maker evaporator without dumping any of the liquid into suction line.

With the valve positions as shown, the refrigerant enters from tube 17 and follows the solid arrows through valve port 19, the valve 21 being lifted by piston 24' at its extreme travel to the left, and from there the liquid flows through tube 13 to the lefthand evaporator section 27. It is reduced in pressure by the dual expansion valve 36, evaporated in group 28 of the evaporator rings 31 and returns through tube 14 to the open vapor valve 194 and through chamber 171 to the outlet port 68 leading to tube 71.

The housing 170 is open to allow the vapor to flow through the entire chamber 171 and over the bellows 172 at all times. This bellows is urged to expand by the spring 173 and the vapor pressure of volatile fluid 174 with which it is charged. It will be understood that a more volatile fluid 174 would require that the spring 173 be under tension or placed outside of the bellows to assist in compressing it.

When the temperature of the vapor in chamber 171 is lowered by the reduction of heat transfer rate in the evaporator section or group 28, due to ice having been frozen to the desired thickness, the temperature of fluid 174 will be lowered and bellows 172 will contract, moving its head 175 downward, which pulls the rod 176 and pin 177 downward. The pin 177 engages the slot in rocker 178 which is pivoted to the housing 170 at 179. This causes contact point 180, which is integral with rocker 178 to depress the plunger 181 against the action of the spring 182, disengaging the plunger from the notch 183 in piston 24', which has been thereby held at its extreme leftward position.

The piston 24', upon being so released, moves to the right under the force exerted upon its left end by the high pressure liquid refrigerant. This movement of the piston allows valve 21 to close under force of spring 25 and it is thereafter held against its seat 19 by this spring plus the pressure of liquid refrigerant in tube 17. The movement of piston 24' to the right is then stopped by the righthand plunger 186, which is urged upwardly by spring 187 and engages notch 184 on its left side.

Pin 188 in the piston 24' has meantime moved member 189 to the right, compressing spring 190 between the shoulders on members 189 and 191, the latter being pivoted at 200 at a point midway of the extreme positions of movement of pin 188. This moves the upper end of member 191 to the left, so that it no longer bears against the right hand shoulder on part 192, but the movement is not enough to cause 191 to contact the lefthand shoulder of part 192, hence valves 193 and 194 are not moved. Since the pressure against 193 tending to hold it closed is greater than the pressure acting upon 194, there is nothing to move either valve, but as a safety measure I prefer to employ a snap-over device as indicated by ball 156, which engages one and then the other of

the two cooperating notches in member 192 to guard against accidental movement by vibration.

The movement of piston 24' to the right has thus far been less than enough to contact the stem of valve 20, hence both liquid valves are still closed and the vapor valves left as at the start. The result is that liquid refrigerant in section 27 of the evaporator is still supplied to the section 28 through the expansion valve as before, until such time as the pressure upon the liquid falls to a point that allows it to evaporate in section 27 before going through the expansion valve. This will stop the refrigeration of section 28 and start the refrigeration of section 27, but the pressure in section 27 will remain appreciably higher than in section 28 because of the fact that vapor cannot pass the restricted opening in the expansion valve as rapidly as liquid did (measured in weight of refrigerant). This causes a further drop of pressure in chamber 171 and allows bellows 172 to expand under the combined effect of a lower surrounding pressure and a higher internal pressure. The rise of temperature is due to stoppage of refrigeration in evaporator section 28 which allows a greater degree of superheat in the refrigerant in chamber 171 than existed before during the refrigeration of section 28.

The expansion of bellows 172 pushes upwardly on rocker 178, causing its point 197 to push downwardly on the righthand plunger 186, compressing spring 187 and releasing the piston to move farther to the right under the combined influence of pressure difference between the two ends of the piston 24' and the force of spring 190 which was compressed in the previous movement and stopped just beyond its maximum compression, in which position it is urging the piston to the right. This movement of the piston opens valve 20 by direct push and opens valve 193, simultaneously closing valve 194, by the contact of member 191 upon the left shoulder of 192.

This brings the valves into positions to make evaporator group 27 active, but there is little or no liquid refrigerant to spill into chamber 171 and thence into the suction line. Warm liquid refrigerant entering section 28 of the evaporator, which has been substantially evacuated and allowed to warm up somewhat, will rapidly melt free the ice that remains on the associated freezing surfaces in this section.

When the freezing of ice by evaporator section 27 has progressed to the point of again causing bellows 172 to contract, the left plunger 181, which is now engaged in notch 185 and holding the piston at its extreme right position, will be withdrawn from this notch and the piston will move to the left under pressure of the liquid refrigerant which now acts upon its righthand end and the righthand plunger 186 will engage the righthand side of notch 184, holding the piston from further movement until the liquid is substantially exhausted from section 28 and the bellows expands as before, to release the piston for completion of its travel, which in this case takes it back to the position shown in the drawing.

An adjustment for the lower bellows head 198 is provided by screw 199, by means of which the bellows may be positioned to give the spring 173 the required degree of compression or expansion to properly balance the contraction and expansion of the bellows so that the division of time between two adjacent portions of the cycle will be satisfactory. By changing springs 182 and 187, or by providing adjustments for changing their working lengths independently, such as by

providing adjustable stops for them at their lower extremities, it is possible to control the cycling of the system still further, prolonging or shortening the time of the piston at its two extreme positions by means of spring 182 and the time of the piston at its two intermediate positions by means of spring 187.

Assuming that the bellows 172 is charged with the same fluid used as a refrigerant in the system, containing some vapor and some liquid, and assuming that the suction chamber 171 is filled with refrigerant vapor at a constant saturated temperature condition, it will be seen that the fluid pressure acting externally upon the bellows will be exactly the same as that acting internally upon it. This, however, is a condition which, if it exists at all, is maintained only momentarily in the cycling of the system as described.

There is actually a varying amount of superheat in the vapor surrounding bellows 172 and there is a certain time lag in the temperature within the bellows as compared with the temperature surrounding it, toward which latter temperature the fluid in the bellows is always being heated or cooled.

With methyl chloride at five pounds suction pressure, under control of an expansion valve, the pressure surrounding the bellows will be practically constant during a constant operation part of the cycle. The temperature of the vapor around the bellows will gradually be reduced as the refrigerating process progresses. Assuming now that the bellows is charged with sulfur dioxide, the bellows and its charge will be cooled by the methyl chloride vapor, resulting in the vapor pressure of sulfur dioxide in the bellows dropping. The vapor pressure within the bellows will thus be caused to drop to a pressure lower than that of the methyl chloride vapor surrounding it, whereas it started well above the five pound suction pressure.

This cooling effect upon the bellows during the first stage of operation causes it to contract, actuating the mechanism as described and releasing the piston 24', thus causing valve 21 to close. Soon after this valve is closed the suction pressure will begin to drop, and at the same time the temperature of vapor surrounding bellows 172 will rise, causing an increase of the sulfur dioxide vapor pressure within the bellows. This actuates the mechanism which opens valves 20 and 193 and closes valve 194, thus initiating another cooling period, but refrigerating the other evaporator section.

The bellows is now affected in the same manner as at the beginning. The fresh supply of liquid methyl chloride brings the suction pressure back up to the five pound setting of the expansion valve, while the temperature of the vaporized methyl chloride surrounding the bellows drops, cooling the bellows so that its internal vapor pressure of sulfur dioxide drops. This causes the bellows to contract again and trip the mechanism which closes valve 20.

With valve 20 closed, the supply of liquid methyl chloride is stopped and the suction pressure drops while the suction temperature rises. This causes the bellows to expand, opening valves 21 and 194 and closing valve 193. Valve 20 remains closed, which brings us back to the start.

Should the refrigerant in the system be sulfur dioxide, the same as the charge in the bellows, it will be noted that the pressures do not cross, hence for this combination of the same gas inside and out of the bellows, it would be necessary to

place a spring or weight so that it tends to compress the bellows. By assuming the spring 173 to be under tension instead of compression this condition is met.

For convenience in assembly, it is desirable to have a rather low vapor pressure fluid in the bellows as for instance ethyl chloride (C_2H_5Cl).

Should it be desired to employ methyl chloride as the refrigerant and ethyl chloride as the charge in the bellows, it will be seen that the pressures cross to only a slight degree at the end of the evacuating portion of the cycle (when both liquid valves are closed). The use of this combination is, however, quite practicable when the spring 173 is used under compression to help the ethyl chloride expand the bellows.

Adjustments of the compression of spring 182 and of spring 187 independently, together with adjustment of spring 173 to vary its tension or compression, will accommodate the control to a wide variety of refrigerants and bellows charges. The design may be modified to use a spring external of bellows 172, tending to compress it if desired.

It is to be understood that formal changes may be made in the specific embodiment of the invention disclosed without departing from the spirit and substance of the broad invention, the scope of which is commensurate with the appended claims.

What is claimed is:

1. The method of heating and cooling a submerged surface for the purpose of alternately forming separate pieces of ice on and freeing ice from said surface comprising, operating a heat exchange means in thermal relation to said surface as an evaporator with liquid refrigerant supplied thereto and vapor removed therefrom, stopping said supply of liquid refrigerant to said means while continuing said removal of vapor therefrom, stopping said removal of vapor from said means and introducing relatively warm liquid refrigerant under relatively high pressure to said means.

2. The method of heating and cooling a submerged surface for the purpose of alternately forming separate pieces of ice on and freeing ice from said surface comprising, operating a heat exchange means in thermal relation to said surface as an evaporator with liquid refrigerant supplied thereto and vapor removed therefrom, stopping said supply of liquid refrigerant to said means while continuing said removal of vapor therefrom, stopping said removal of vapor from said means and circulating relatively warm liquid refrigerant under relatively high pressure to said means.

3. The method of heating and cooling separated areas of a submerged surface for the purpose of alternately forming ice on and freeing ice from said surface comprising, placing a heat exchange means in thermal relation to said surface, operating said means as an evaporator with liquid refrigerant supplied thereto and vapor removed therefrom, stopping said supply of liquid refrigerant to said means while continuing said removal of vapor therefrom, stopping said removal of vapor from said means and introducing relatively warm liquid refrigerant under relatively high pressure to said means, and then passing the last mentioned refrigerant through a pressure reducing device to another evaporating means.

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