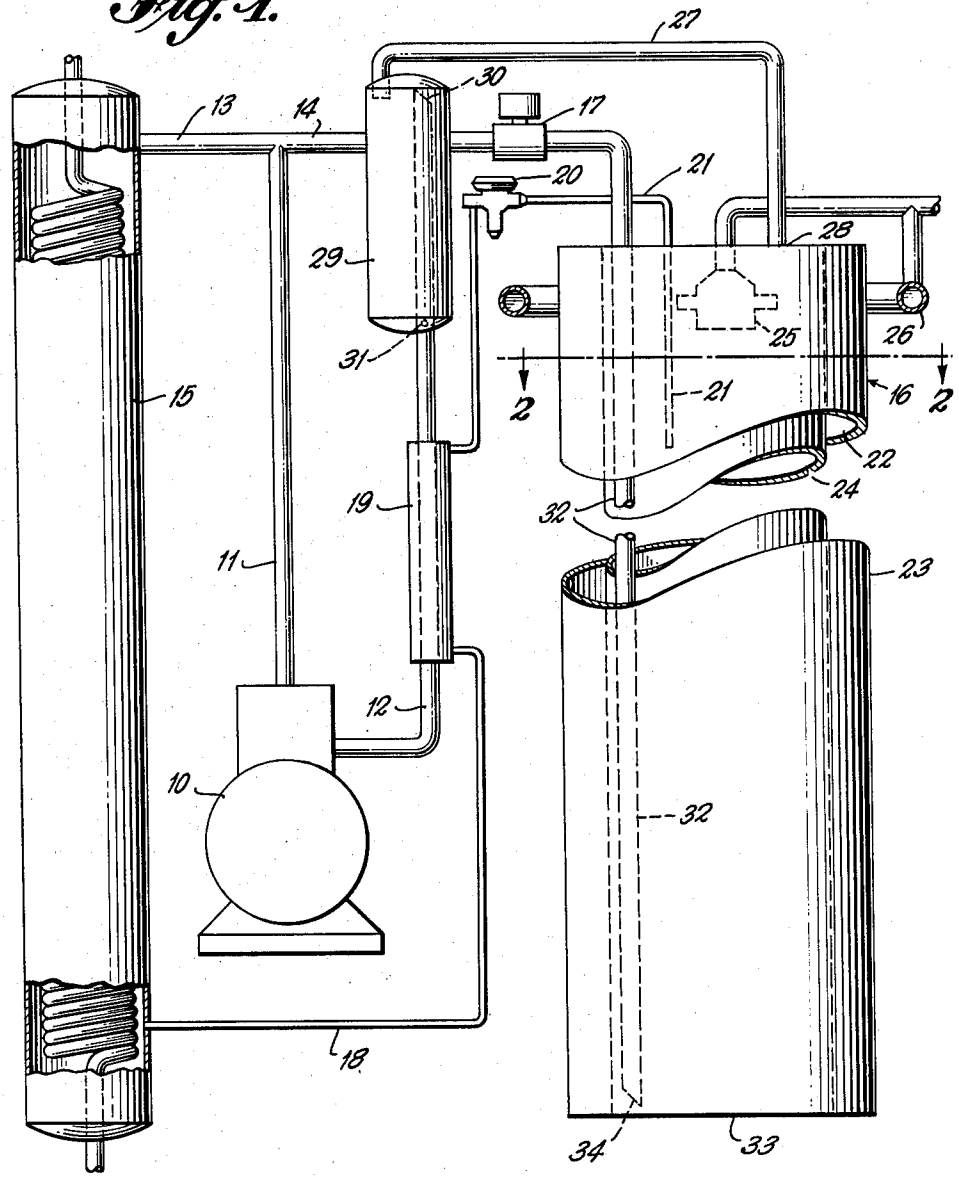
Sept. 1, 1964 C. E. LOWE 3,146,610

ICE MAKING REFRIGERATION APPARATUS AND THE LIKE

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Fig. 1.



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Fig. 2.

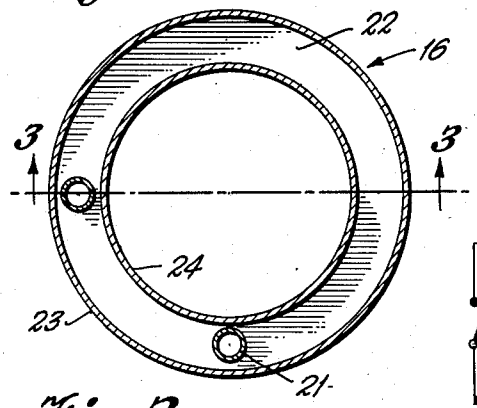


Fig. 3.

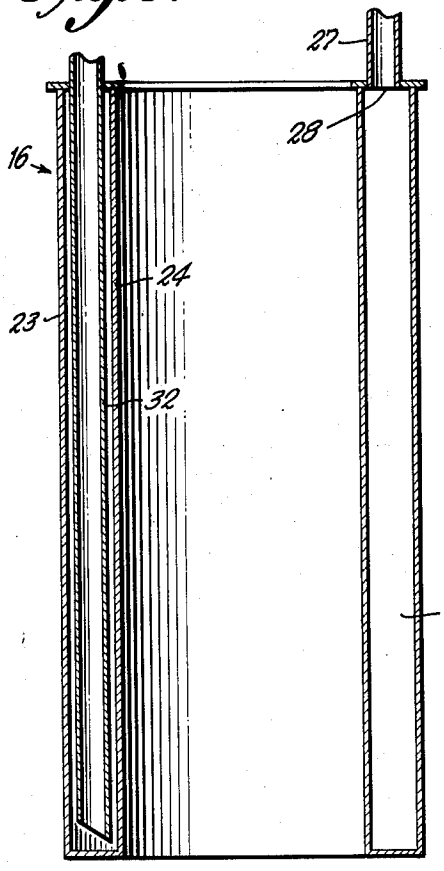
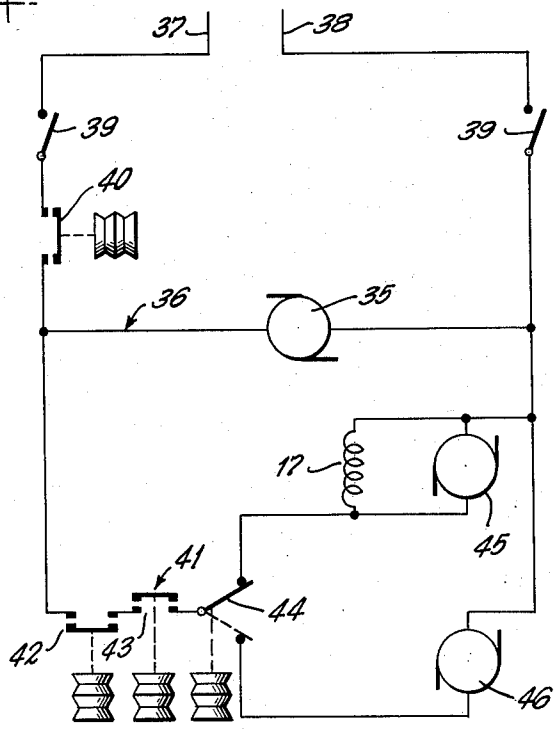


Fig. 4.



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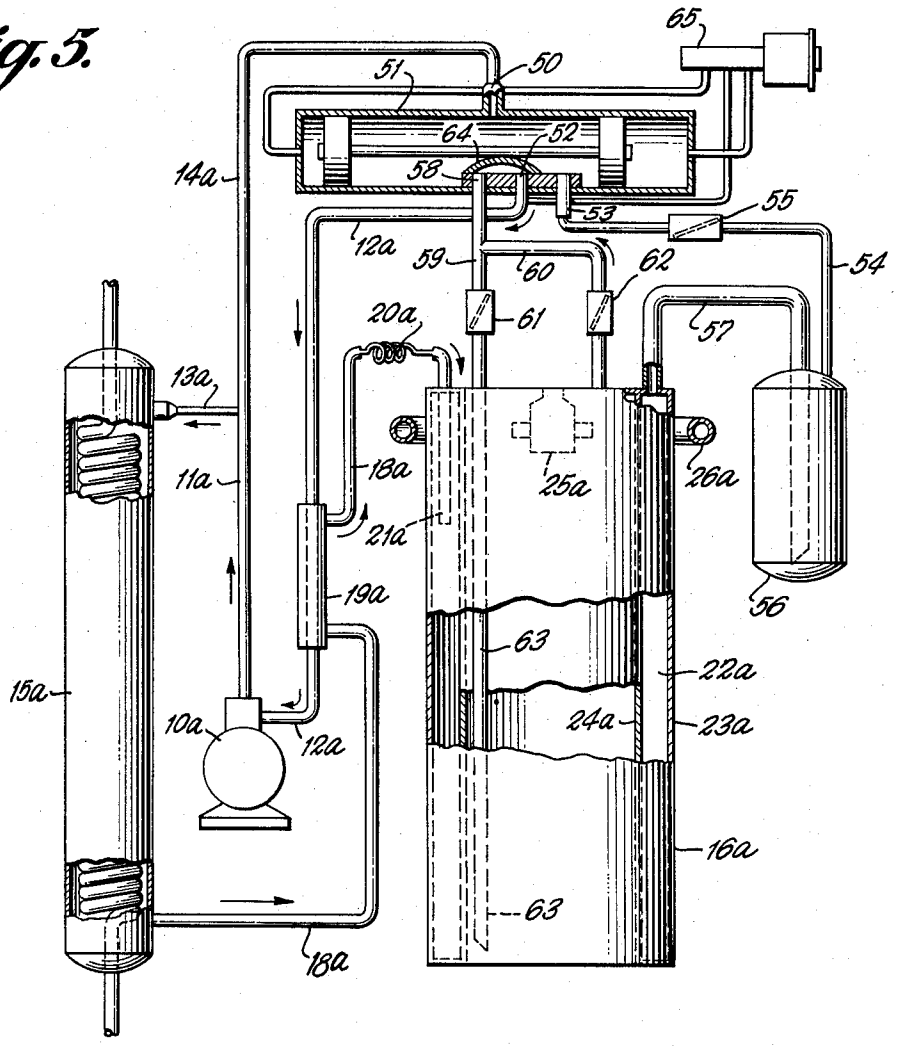
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ICE MAKING REFRIGERATION APPARATUS AND THE LIKE

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Fig. 5.



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3,146,610

ICE MAKING REFRIGERATION APPARATUS AND THE LIKE

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Filed Aug. 11, 1961, Ser. No. 130,806
6 Claims. (Cl. 62—347)

The present invention relates in general to heat exchange refrigeration systems, and more particularly to refrigeration systems for ice-making or cooling purposes which are cycled alternately through a freezing phase and a harvesting or defrosting phase in the operation of the system.

Automatic ice-making apparatus involving reversible cycle refrigeration system have gone into wide commercial use. In such systems, ice is produced during the normal refrigerating or freezing phase of the apparatus when condensed liquid refrigerant is admitted to the evaporator, and the ice is discharged from the evaporator during the defrosting or harvesting phase when hot gaseous refrigerant is delivered directly from the compressor to the evaporator. Such systems have customarily involved an evaporator having a refrigerant chamber which contains a large volume of liquid refrigerant at the conclusion of the freezing cycle. To accomplish rapid defrosting of the ice from the evaporator by hot gaseous refrigerant and avoid undesirable melting of the ice as distinguished from mere release of the frost bond between the ice and the evaporator ice-forming surfaces, it has been thought that some means must be provided to rapidly dump substantially all of the liquid refrigerant from the evaporator at the commencement of the harvesting cycle and store this refrigerant in a storage tank or another evaporator during the remainder of the harvesting cycle. Obviously the necessity of providing facilities for so handling the liquid refrigerant increases the complexity and cost of the equipment as well as requiring relatively large quantities of refrigerant.

It has been discovered that effective and rapid harvesting if ice from the evaportor by cycling hot gaseous refrigerant thereto can be achieved without requiring dumping or storing of the liquid refrigerant which remained in the evaporator at the conclusion of the freezing cycle, by introducing the hot gaseous refrigerant into the refrigerant chamber of the evaporator in such a way that the hot gaseous refrigerant is placed in effective thermal exchange relation with the liquid refrigerant throughout the entire height of the body of liquid to quickly vaporize the liquid refrigerant or warm it sufficiently to release the frost bond holding the ice to the ice-forming surfaces of the evaporator. This arrangement is especially effective in low volume evaporators of the type disclosed in my prior copending U.S. Patents No. 3,034,310 granted May 15, 1962 and No. 3,026,686 granted March 27, 1962, where the refrigerant chamber of the evaporator is a thin annular chamber between two concentric ice-forming surfaces.

While the present invention is applicable to liquid chilling applications, cooled storage room refrigeration and like applications, it will be described specifically in connection with the automatic production of ice to simplify understanding of the construction and operation of the system.

An object of the present invention is the provision of novel ice-making apparatus having a cycle of operation wherein the apparatus is cycled successively through freezing and thawing phases, which is of economical construction and has a novel mode of operation.

Another object of the present invention is the provision of novel automatic ice-making apparatus having a heat exchanger for the production of ice which is of

economical construction and which makes more efficient use of the refrigerant in effecting production of ice.

Another object of the present invention is the provision of a novel evaporator structure for automatic ice-making apparatus which is arranged to form ice on a plurality of surfaces arranged oppositely in heat-exchange relation to the refrigerant to produce ice in a manner facilitating the ready removal of the ice from the evaporator and eliminating the need of removing from the evaporator during the ice-harvesting phase the body of liquid refrigerant occupying the evaporator at the end of the freezing phase.

Other objects, advantages and capabilities of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings illustrating a plurality of embodiments of the invention.

In the drawings:

FIGURE 1 is a diagrammatic view of ice-making apparatus constructed in accordance with one preferred embodiment of the present invention;

FIGURE 2 is a horizontal section view taken along the line 2—2 of FIGURE 1;

FIGURE 3 is a vertical section view of the evaporator, taken along the line 3—3 of FIGURE 2;

FIGURE 4 is a wiring diagram of a form of electrical control circuit which may be used with the present invention; and

FIGURE 5 is a diagrammatic view of a modified form of ice-making apparatus embodying the present invention.

Referring to the drawings, wherein like reference characters designate corresponding parts throughout the several figures and particularly to the embodiment of the apparatus disclosed in FIGURES 1 to 4 thereof, the automatic ice-making apparatus of this embodiment includes the usual motor-driven compressor **10** having a high pressure compressor discharge line **11** and a low pressure compressor suction line **12**. The high pressure discharge line **11** divides into two branch lines **13** and **14**, the branch line **13** leading to the condenser **15** and the branch **14** to the evaporator **16** through the solenoid controlled valve **17**. The condenser **15** in the embodiment herein shown is of the type formed of an outer tank or shell into which the hot gaseous refrigerant is admitted from the inlet branch **13**, having an internal water coil in communication with an exterior source of cool water to withdraw heat from the hot gaseous refrigerant admitted to the condenser throughout heat exchange with the water in the water coils and condense the refrigerant to the liquid state. It will be appreciated, however, that any other form of condenser of the many different types now known in the trade may be used instead of the particular type of condenser herein shown. A condenser outlet line **18** leads from the point near the lower end of the condenser **15** through the heat exchanger **19** in thermal communication with the compressor suction line **12**, and thence through a suitable metering device such as a thermostatic expansion valve **20** to a liquid feed tube **21** entering the top of the refrigerant chamber **22** of the evaporator **16** and projecting downwarly to a selected level in the upper regions of the chamber **22**, the feed tube **21** having an outlet opening at its lower end. In one example, the feed tube extends about 11½ inches downwardly from the top of the evaporator where the evaporator has a total height of about 40 inches.

The evaporator **16** may be of the type disclosed in my copending U.S. Patent No. 3,034,310 granted May 15, 1962, in that it is in the general form of a downwardly opening tubular cylinder having radially outwardly and inwardly facing concentric surfaces **23** and **24** on which ice is to be formed, between which the annular

cylindrical refrigerant chamber 22 is disposed to which refrigerant is metered by the expansion valve 20. Inner and outer spray rings 25 and 26 are disposed adjacent the upper ends of the inner and outer concentric evaporator surfaces and are supplied with water from an external source to spray water downwardly upon the evaporator surfaces to form ice which is frost-bonded to these surfaces until the harvesting phase begins.

A refrigerant vapor return conduit 27 communicating with an inlet opening 28 at the top of the refrigerant chamber 22 in the evaporator forms a part of the refrigerant return section of the refrigeration system. The return conduit 27 opens into the top of a surge tank 29, to which the compressor suction line 12 is connected. The end of the suction line 12 in the surge tank 29 extends upwardly from the bottom of the surge tank to an inlet opening 30 near the top of the surge tank located above the level of any liquid refrigerant which accumulates therein to admit only vapor phase refrigerant through the inlet opening 30 of the suction line 12. A small orifice 31 may also be provided in the wall of the suction line 12 immediately above the bottom of the surge tank 29 for restricted return of oil and liquid refrigerant to the suction line, the amount of such liquids admitted through the orifice 31 being limited to that which would be vaporized in the heat exchanger 19.

The branch line 14 of the high pressure compressor discharge line 11, which is regulated by the solenoid valve 17, terminates in a vertical, elongated injector tube 32 which enters the refrigerant chamber 22 at the top of the evaporator 16 and extends to a level immediately adjacent to the bottom 33 of the refrigerant chamber. The hot gaseous refrigerant injector tube 32 has an outlet opening 34 at the lower end thereof and is provided to discharge the hot gaseous refrigerant into the liquid refrigerant in the refrigerant chamber at the commencement of a harvesting cycle at the bottom of the body of liquid refrigerant so that the hot gaseous refrigerant will pass upwardly through the entire height of liquid refrigerant in heat exchange relation with the liquid refrigerant at all levels. With this arrangement, the liquid refrigerant is either quickly vaporized or is heated sufficiently at all levels to thaw the frost bond holding the concentric bodies of ice on the evaporator surfaces 23, 24 and cause the ice bodies to be gravitationally discharged to fall into an ice crusher or other conventional handling apparatus. Since this apparatus effects harvesting of the ice by heating or vaporizing the liquid phase refrigerant in the evaporator rather than by displacement of liquid phase refrigerant from the evaporator, there is no need to provide any liquid refrigerant outlet from the refrigerant chamber 22 or any special means for getting all of the liquid phase refrigerant out of the chamber or any means for storing liquid refrigerant withdrawn from the refrigerant chamber.

One form of electrical control circuit which may be used to effect automatic cycling of this apparatus through successive freezing and harvesting phases is illustrated in FIGURE 4, wherein the compressor motor, indicated at 35, is in one parallel branch circuit 36 disposed across the 110 volt supply lines 37, 38 with a two-pole main power switch 39 interposed in the two leads connecting the branch circuit 36 with the 110 volt supply lines and a bin switch 40 responsive to the level of ice in the usual ice-collecting bin interposed in one of the leads to the branch circuit 36. An additional branch circuit 41 is coupled across the supply lines 37, 38 in parallel circuit relation with the branch circuit 36 and includes low pressure and high pressure safety switches 42 and 43 and a cycling or harvesting switch 44 arranged in series relation in the branch 41. The cycling switch 44 may be a temperature switch responsive to the temperature in the zone of the evaporator 16 or a pressure switch, a time-clock switch, or any other well known type of cycling switch, and includes a movable contact, which, in the freezing phase, engages a stationary contact as illustrated

in broken lines in FIGURE 4, closing the circuit through circulating pump motor 46, which supplies pressure for the water supply to the spray rings 25 and 26. In the harvesting phase position of the movable contact of cycling switch 44 illustrated by solid lines in FIGURE 4, the movable contact engages a stationary contact closing the circuit through the coil of solenoid controlled valve 17 and through an ice crusher motor 45.

In the operation of the embodiment shown in FIGURES 1 to 4, assuming that the unit is charged, bin switch 40 and safety switches 42 and 43 are all closed, and the main power switch 39 has just been closed, the compressor motor 35 is energized. The cycling switch 44 will be in the broken line position due to a higher range temperature at the evaporator, causing the circulating pump motor 46 to be energized so that water will be sprayed from the spray rings 25, 26 onto the ice-forming surfaces 23, 24. The coil of the valve 17 will be deenergized, leaving this valve in a closed position and therefore closing off the branch line 14. Thus, hot gaseous refrigerant discharged through the high pressure line 11 from the compressor 10 will be led through the condenser inlet branch 13 to the condenser 15 where the hot gaseous refrigerant will condense and reject heat to the water flowing through the interior water coils of the condenser. The condensed liquid refrigerant will then be conducted through the line 18, heat exchanger 19 and thermostatic expansion valve 20, to the feed tube 21 to feed the cooled liquid refrigerant into the refrigerant chamber 22 of the evaporator 16. The evaporation of the liquid refrigerant in the evaporator 16, which is under low pressure, withdraws heat from the water sprayed on the concentric inner and outer surfaces 23, 24 of the evaporator 16, forming two concentric tubes of ice which are adhered to the evaporator surfaces by frost bonds. The evaporated refrigerant is withdrawn through the return conduit 27, surge tank 29, and compressor suction line 12 to the compressor 10 to be compressed and recycled through the system.

When the control for the cycling switch 44 senses a selected condition at the evaporator, for example, a low temperature condition produced upon the formation of a selected amount of ice on the evaporator surfaces 23, 24, the cycling switch 44 is tripped to assume the solid line position illustrated in FIGURE 4, wherein the coil of solenoid valve 17 is energized to open this valve, the ice crusher motor 45 is energized, and the circulating pump motor 46 is deenergized. The high pressure discharge line 11 of the compressor 10 is then placed in direct communication with the refrigerant chamber 22, the hot gaseous refrigerant body delivered through the branch conduit 14, valve 17, and injector tube 32 to the bottom of the refrigerant chamber 22 to heat the body of liquid refrigerant in the refrigerant chamber. The hot gaseous refrigerant rising from the outlet opening 34 of the injector tube 32 heats the liquid refrigerant or vaporizes it at such a rate that the frost bond adhering the ice tubes to the evaporator surfaces 23, 24 is rapidly destroyed so that the ice may be gravitationally discharged without significant melting of the ice.

Another ice-making refrigeration system employing an evaporator of the construction described in connection with the preceding embodiment, but wherein the system is of different construction in some respects, is illustrated in FIGURE 5. Referring to the exemplary construction diagrammatically illustrated in FIGURE 5, the automatic ice-making appliance of this embodiment includes a motor-driven compressor 10*a* having a high pressure discharge line 11*a* which divides into two branches 13*a* and 14*a*. The branch line 13*a* leads to the condenser 15*a* and the branch line 14*a* leads to the inlet 59 of a four-way valve 51. A condenser outlet conduit 18*a* extends through a heat exchanger 19*a* in heat exchange relationship with the low pressure compressor suction line 12*a* and thence through a capillary tube 20*a*, or thermostatic expansion valve, to a feed tube 21*a* extending into and opening in-

wardly of the refrigerant chamber 22*a* in the evaporator 16*a*. The evaporator 16*a* is of the same construction as the evaporator 16 described in connection with the preceding embodiment, and includes inner and outer spray rings 25*a* and 26*a* to spray water downwardly upon the ice-forming surfaces 23*a*, 24*a* of the evaporator 16*a*. One outlet 52 of the four-way valve 51 communicates with the compressor suction line 12*a*, and another outlet 53 of the four-way valve communicates with line 54 having a check valve 55 therein and extending to the top of an accumulator tank 56. The accumulator tank 56 is designed to accommodate only a very small amount of refrigerant. The accumulator tank 56 communicates with the refrigerant chamber 22*a* by means of a transfer tube 57 which just enters the top of the refrigerant chamber 22*a*. The third outlet 58 has two branches 59 and 60 each having a check valve 61, 62 respectively therein, the branch 59 having an elongated terminal portion 63 forming an injector tube extending downwardly through substantially the entire height of the refrigerant chamber 22*a* and terminating adjacent the bottom thereof. The check valve 61 opens in response to high pressure at the four-way valve outlet 58 and closes in response to low pressure at said outlet, while the check valve 62 opens in response to low pressure at the outlet 58 and closes in response to high pressure.

During the normal ice-making or freezing phase, the valve member 64 of the four-way valve 51 is positioned responsive to the pilot valve 65 to communicate the four-way valve outlet 58 with the outlet 52 connected to the suction side of the compressor 10*a*. While the high pressure discharge from the compressor 10*a* communicates through the branch 14*a* and the four-way valve inlet 50 to the interior of the four-way valve casing and the outlet 53, the check valve 55 responsive to the high pressure at the outlet 53 prevents passage of the hot gaseous refrigerant through the line 54 to the accumulator tank 56. Hot gaseous refrigerant is, however, communicated through the branch 13*a* to the condenser 15*a*, where it liquifies and is conducted through the conduit 18*a*, heat exchanger 19*a* and capillary tube 20*a* to the feed tube 21*a* where it is introduced into the refrigerant chamber 22*a*. The vaporized refrigerant in the refrigerant chamber 22*a* is withdrawn through the check valve 62, branch 60 and four-way valve outlet 58, to the suction conduit 12*a* and compressor 10*a*. When the sensing tube, control bulb or other condition sensing facility at the evaporator responds to the accumulation of the desired quantity of ice, the pilot valve 65 is activated to reverse the position of the valve member 64 of four-way valve 51 and communicates the outlet 52 with outlet 53. Thereupon, hot gaseous refrigerant under high pressure discharged from the compressor 10*a* through the conduit 11*a* and branch 14*a* is discharged through the inlet 50 into the interior of the four-way valve 51 and thence through outlet 58, branch 59, check valve 61 and terminal portion 63 to the bottom portion of the refrigerant chamber 22*a*, which warms the liquid refrigerant in the refrigerant chamber 22*a* enough to produce gravitational discharge of the ice from the ice-forming surfaces of the evaporator 16*a* and then activate the sensing bulb to shift the system back to the freezing phase. The branch 60 is closed during this harvesting phase by reason of the closing of the check valve 62 responsive to the high pressure at the outlet 58 and the accumulator tank 56 is placed in communication with the suction line 12*a* to compressor 10*a* by the connecting of the four-way valve outlets 52 and 53. It will be noted that the hot gaseous refrigerant is introduced into the refrigerant chamber at the bottom of the evaporator and that the inlet of the transfer tube 57 is adjacent the top of the refrigerant chamber 22*a* so that only a very small amount of refrigerant, if any, will pass to the accumulator tank 56, perhaps a few ounces more or less. By this construction, slugging of any liquid refrigerant from the refrigerant chamber 22*a* through the suction line 12*a* to the compressor 10*a* is avoided, and effective cycling of the apparatus through the freezing phase and harvesting phase is achieved. The automatic electrical control circuit for this embodiment may be similar in principle to that illustrated in FIGURE 4 used in conjunction with the embodiment of FIGURES 1 to 4.

While but two preferred examples of the present invention have been particularly shown and described, it is apparent that various modifications may be made therein within the spirit and scope of the invention. For example, where greater evaporation capacity is desired than can be conveniently obtained with one evaporator, two or more evaporators of the same construction as described herein interconnected in parallel relation in the refrigeration circuit between the condenser and the surge tank or accumulator may be employed. It is desired, therefore, that only such limitations be placed on the invention as are imposed by the prior art and set forth in the appended claims.

What is claimed is:

1. In ice-making apparatus, a refrigeration system including an evaporator in the form of a vertically elongated body of tubular configuration arranged along a vertical axis having a central bore open at the bottom of the body extending substantially throughout the height thereof and a refrigerant chamber surrounding said bore, said body having a cylindrical inner wall bounding said bore and an outer cylindrical wall spaced outwardly therefrom, said inner and outer cylindrical walls forming a pair of concentric ice-forming surfaces in intimate thermal communication with said refrigerant chamber extending substantially the height of said evaporator body, inner and outer water spray means adjacent the upper ends of said walls for discharging water on said cylindrical walls, said refrigeration system having control means for alternately cycling the same through a freezing phase and an ice harvesting phase, means for injecting liquid refrigerant into said refrigerant chamber adjacent the top thereof to travel downwardly over the major axial length of the chamber in heat exchange relation with said cylindrical walls during the freezing phase for freezing the water sprayed on said inner and outer cylindrical surfaces into a pair of concentric annular bodies of ice, a hot gaseous refrigerant injector tube extending from externally of said evaporator body downwardly through substantially the height of said refrigerant chamber having an outlet opening at the bottom of said injector tube disposed immediately adjacent the bottom of said refrigerant chamber, and means for delivering hot gaseous refrigerant under pressure to said injector tube during said ice harvesting phase to inject the hot gaseous refrigerant into said refrigerant chamber adjacent the bottom thereof whereby the hot gaseous refrigerant progresses upwardly throughout the height of the refrigerant chamber to thaw any frost bond between said ice bodies and said walls without substantial transfer of liquid phase refrigerant from said refrigerant chamber and release the ice bodies for gravitational discharge therefrom.

2. In ice-making apparatus, a refrigeration system including an evaporator in the form of a vertically elongated tubular body arranged along a vertical axis having a central bore open at the bottom of the body extending substantially throughout the height thereof and a closed annular refrigerant chamber including a cylindrical inner wall bounding said bore and an outer cylindrical wall spaced outwardly therefrom, an annular bottom wall extending between the lower ends of said cylindrical walls and defining the bottom wall of said refrigerant chamber, said inner and outer cylindrical walls forming a pair of concentric ice-forming surfaces in intimate thermal communication with said refrigerant chamber extending substantially the height of said evaporator body, said inner cylindrical wall being spaced from said outer cylindrical wall a small fraction of the radius of said outer cylindrical wall, inner and outer water spray means adjacent the

upper ends of said walls for discharging water on said cylindrical walls, a liquid refrigerant feed tube extending from above of the evaporator body a short distance downwardly into said refrigerant chamber having a discharge opening located at a height to discharge liquid refrigerant downwardly over the major axial length of the chamber, said refrigeration system having control means for alternately cycling the same through a freezing phase and an ice harvesting phase, means for delivering liquid refrigerant to said feed tube during the freezing phase to inject liquid refrigerant into said refrigerant chamber for freezing the water sprayed on said inner and outer cylindrical surfaces into a pair of concentric annular bodies of ice, a hot gaseous refrigerant injector tube extending from externally of said evaporator body downwardly through substantially the height of said refrigerant chamber having an outlet opening at the bottom of said injector tube disposed immediately adjacent the bottom of said refrigerant chamber, means for delivering hot gaseous refrigerant under pressure to said injector tube during said ice harvesting phase to inject the hot gaseous refrigerant into any body of liquid refrigerant in said refrigerant chamber adjacent the bottom of the body of liquid refrigerant whereby the hot gaesous refrigerant progresses upwardly throughout the height of the body of liquid refrigerant to thaw any frost bond between said ice bodies and said walls without substantial transfer of liquid phase refrigerant from said refrigerant chamber and release the ice bodies for gravitational discharge therefrom, and conduit means coupled between said refrigerant chamber and a suction limb of the refrigeration system during said harvesting phase including tank means for separating liquid phase refrigerant out of any refrigerant drawn through said last-mentioned conduit means to the suction limb.

3. In ice-making apparatus and the like, a refrigeration system adapted to be cycled alternately through a freezing phase and a harvesting phase including an evaporator in the form of a vertically elongated tubular cylindrical body having a pair of radially spaced cylindrical surfaces concentric with a vertical axis through said evaporator body extending substantially throughout the height thereof and defining inner and outer ice-forming surfaces and a closed bottom annular refrigerant chamber therebetween, water spray means adjacent the upper ends of said inner and outer ice-forming surfaces for spraying water thereon during the freezing phase, a compressor having discharge and suction sides, a condenser, an accumulator tank having a transfer tube connection with said refrigerant chamber and a suction conduit connection with the suction side of said compressor, valve means for connecting said refrigerant chamber with said suction side and disconnecting the same from said discharge side of the compressor during the freezing phase, conduit means continuously connecting said discharge side of the compressor with said condenser, conduit means for the flow of condensed liquid refrigerant from said condenser to said refrigerant chamber including a liquid refrigerant feed tube extending downwardly through the top of the refrigerant chamber having a discharge opening located at a height to discharge liquid refrigerant downwardly over the major axial length of the refrigerant chamber, valved conduit means extending to the bottom of said refrigerant chamber for directly applying hot gaseous refrigerant under pressure from the discharge side of said compressor to the bottom of said refrigerant chamber at the beginning of the harvesting phase to heat said ice-forming surfaces sufficiently to release any ice thereon for gravitational discharge, means disconnecting said refrigerant chamber from said suction side during the harvesting phase, and valve means controlling said suction conduit connection of the accumulator for opening the same during the harvesting phase to lower the pressure in said accumulator to admit refrigerant from said refrigerant chamber to said accumulator.

4. In ice-making apparatus and the like, a refrigeration system adapted to be cycled alternately through a freezing phase and a harvesting phase including an evaporator in the form of a vertically elongated tubular cylindrical body having a pair of radially spaced cylindrical surfaces concentric with a vertical axis through said evaporator body extending substantially throughout the height thereof and defining inner and outer ice-forming surfaces and a closed bottom annular refrigerant chamber therebetween, water spray means adjacent the upper ends of said inner and outer ice-forming surfaces for spraying water thereon during the freezing phase, a compressor having discharge and suction sides, a condenser, a heat exchanger, a four-way valve means having connections with the suction side of said compressor and with said refrigerant chamber, an accumulator tank having a transfer tube connection with said refrigerant chamber and a valved suction conduit connection with said four-way valve, a branched conduit connected to the discharge side of said compressor having a first branch connected with said condenser and a second branch connected with said four-way valve means, said four-way valve means including means for connecting said refrigerant chamber with said suction side of the compressor through said heat exchanger during the freezing phase and concurrently disconnecting said refrigerant chamber from said second branch of the branched conduit connected to the discharge side of the compressor, conduit means for the flow of condensed liquid refrigerant from said condenser through said heat exchanger to said refrigerant chamber including a liquid refrigerant feed tube extending downwardly through the top of the refrigerant chamber having a discharge opening located at a height to discharge liquid refrigerant downwardly over the major axial length of the refrigerant chamber, an injector tube extending through the height of said refrigerant chamber and opening at the bottom thereof, said four-way valve means further including means for connecting said injector tube with the second branch of said branched conduit connected to the discharge side of the compressor for directly discharging hot gaseous refrigerant under pressure from the compressor into the bottom of said refrigerant chamber at the beginning of the harvesting phase to heat said ice-forming surfaces and thaw any frost bond connecting ice to said ice-forming surfaces, said four-way valve means including means disconnecting said refrigerant chamber from said suction side of the compressor during the harvesting phase and connecting said suction conduit connection of said accumulator tank with said suction side for withdrawing only gaseous refrigerant from said accumulator tank to said compressor, said accumulator tank being in open communication through said transfer tube with said refrigerant chamber during the harvesting cycle to receive refrigerant from said refrigerant chamber responsive to pressures produced in said refrigerant chamber, and means closing said suction conduit connection of said accumulator tank at the beginning of the freezing phase to cause the liquid refrigerant in the accumulrator tank to be forced back through the transfer tube into said refrigerant chamber.

5. In ice-making apparatus and the like, a refrigeration system adapted to be cycled alternately through a freezing phase and a harvesting phase including an evaporator in the form of a vertically elongated tubular cylindrical body having a downwardly opening central bore, said body including a pair of radially spaced cylindrical surfaces concentric with a vertical axis through said evaporator body extending substantially throughout the height thereof and defining inner and outer ice-forming surfaces and a closed bottom annular refrigerant chamber therebetween, water spray means adjacent the upper ends of said inner and outer ice-forming surfaces for spraying water thereon during the freezing phase, a compressor having discharge and suction sides, a condenser, a

four-way valve means having connections with the discharge and suction sides of said compressor and said refrigerant chamber, an accumulator tank having a transfer tube connection with the top of said refrigerant chamber and a suction conduit connection through a check valve with said four-way valve means, conduit means continuously connecting said discharge side of the compressor with said condenser, conduit means for the flow of condensed liquid refrigerant from said condenser to said refrigerant chamber including a liquid refrigerant feed tube extending downwardly through the top of the refrigerant chamber having a discharge opening located at a height to discharge liquid refrigerant downwardly over the major axial length of the refrigerant chamber, a branched conduit connected to said four-way valve means having a first leg including an injector tube extending substantially through the height of the refrigerant chamber to an open end near the bottom thereof and a second leg connected to the top of the refrigerant chamber, said four-way valve means including means for directly applying hot gaseous refrigerant under pressure from the discharge side of said compressor to said branched conduit at the beginning of the harvesting phase and connecting said suction conduit of the accumulator with said suction side of the compressor, said legs of said branched conduit each having valve means responsive to the application of hot gaseous refrigerant to said branched conduit to communicate the same through said injector tube into said refrigerant chamber at the bottom thereof to heat liquid refrigerant therein and said ice-forming surfaces and responsive to the hot gaseous refrigerant to close said second leg of the branched conduit, said four-way valve means including means for connecting said branched conduit with said suction side of the compressor during the freezing phase, and said valve means of said branched conduit legs being responsive to connection of said branched conduit to said suction side to close said first leg and open said second leg to connect the refrigerant chamber with said suction side, and means controlling said suction conduit connection of said accumulator tank for closing the same at the beginning of the freezing phase.

6. In ice-making apparatus and the like, a refrigeration system adapted to be cycled alternately through a freezing phase and a harvesting phase including an evaporator in the form of a vertically elongated tubular cylindrical body having a pair of radially spaced cylindrical surfaces concentric with a vertical axis through said evaporator body extending substantially throughout the height thereof and defining inner and outer ice-forming surfaces and a closed bottom annular refrigerant chamber therebetween, water spray means adjacent the upper end of said inner and outer ice-forming surfaces for spraying water thereon during the freezing phase, a compressor having discharge and suction sides, a condenser, a surge tank having a conduit connection with the top of said refrigerant chamber and a suction conduit connection with the suction side of the compressor for separating out liquid phase refrigerant entrained in refrigerant returned from said refrigerant chamber to the suction side of the compressor, conduit means continuously connecting said discharge side of the compressor with said condenser, conduit means for the flow of condensed liquid refrigerant from said condenser to said refrigerant chamber including a liquid refrigerant feed tube extending downwardly through the top of the refrigerant chamber having a discharge opening adjacent the top of the refrigerant chamber for discharging liquid refrigerant downwardly over the major length of the chamber, and valved conduit means including an elongated gaseous refrigerant injector tube extending vertically through the height of the refrigerant chamber having a discharge opening adjacent the bottom of the refrigerant chamber for directly applying hot gaseous refrigerant under pressure from the discharge side of the compressor to the bottom of the refrigerant chamber at the beginning of the harvesting phase to heat said ice-forming surfaces sufficiently to release any ice thereon for gravitational discharge.

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