

May 15, 1962

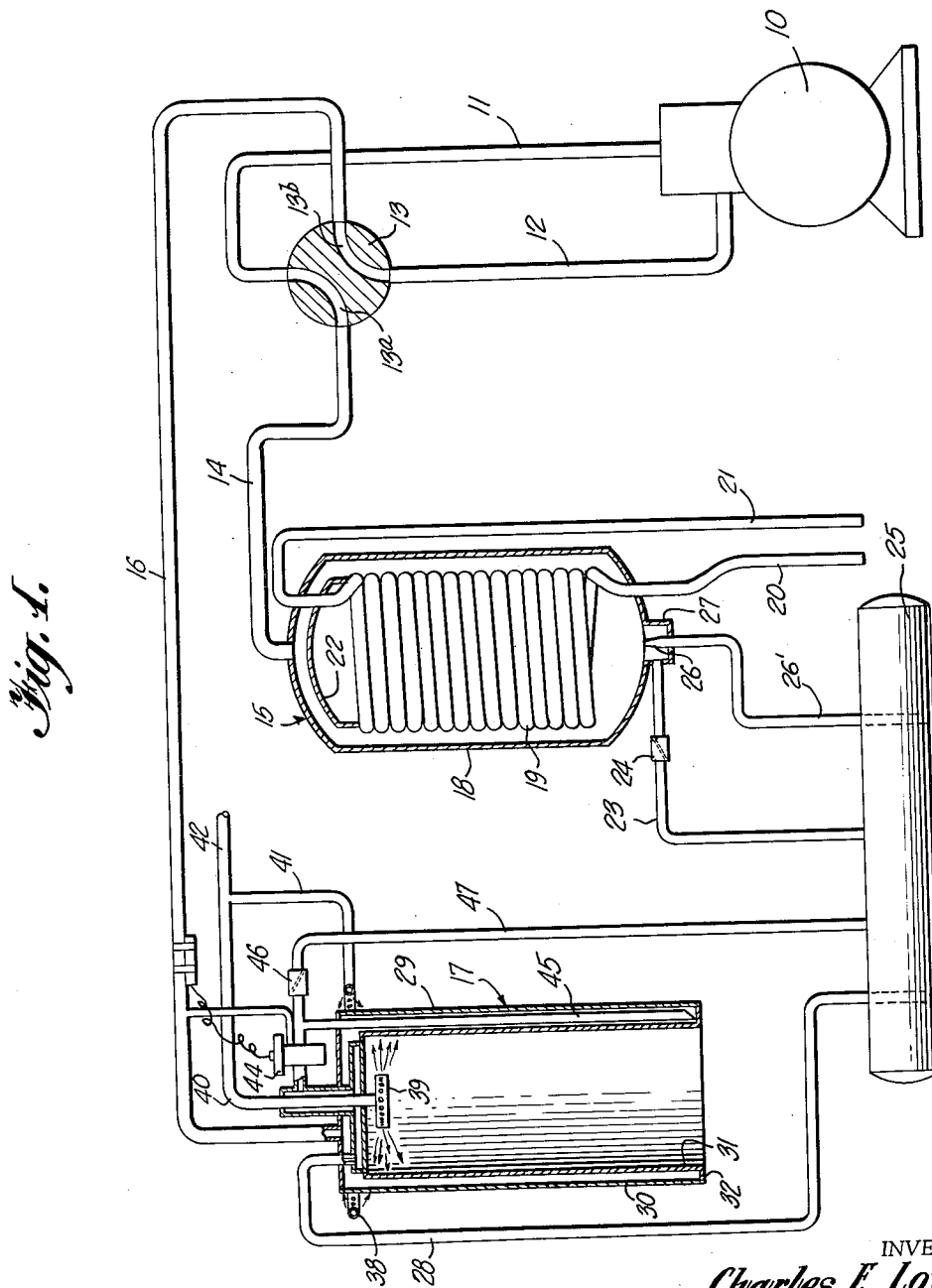
C. E. LOWE

3,034,310

HEAT PUMP TYPE ICE-MAKING MACHINE

Filed Aug. 13, 1959

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

Fig. 2.

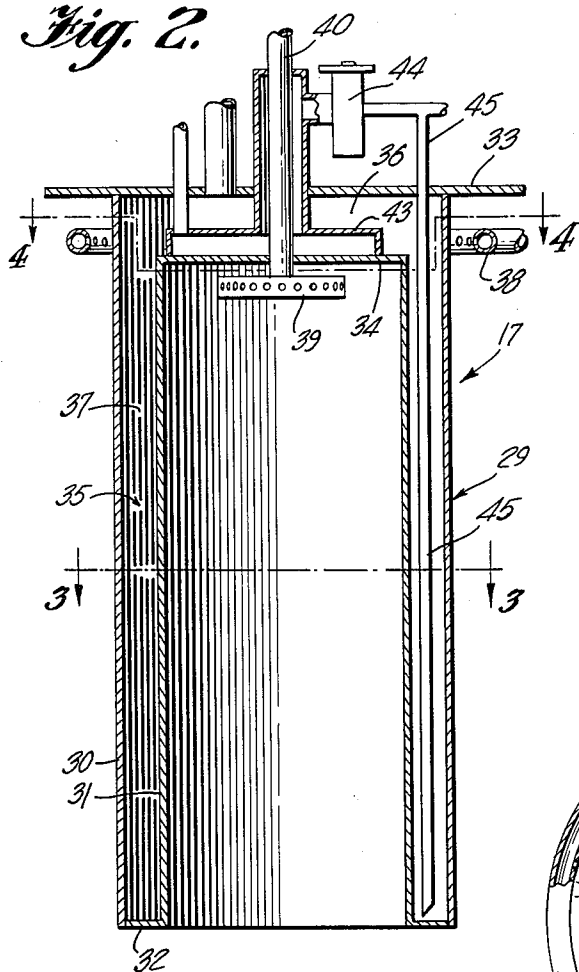


Fig. 3.

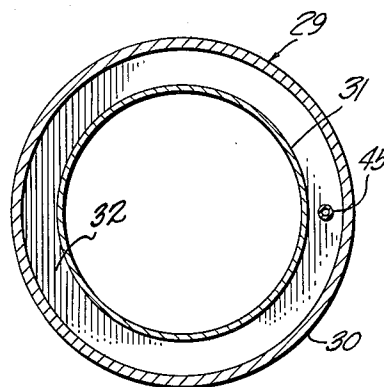


Fig. 4.

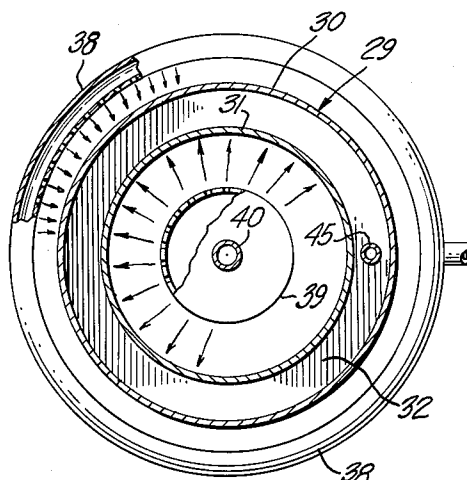
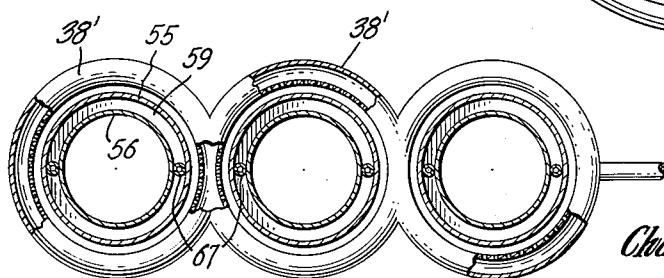


Fig. 6.



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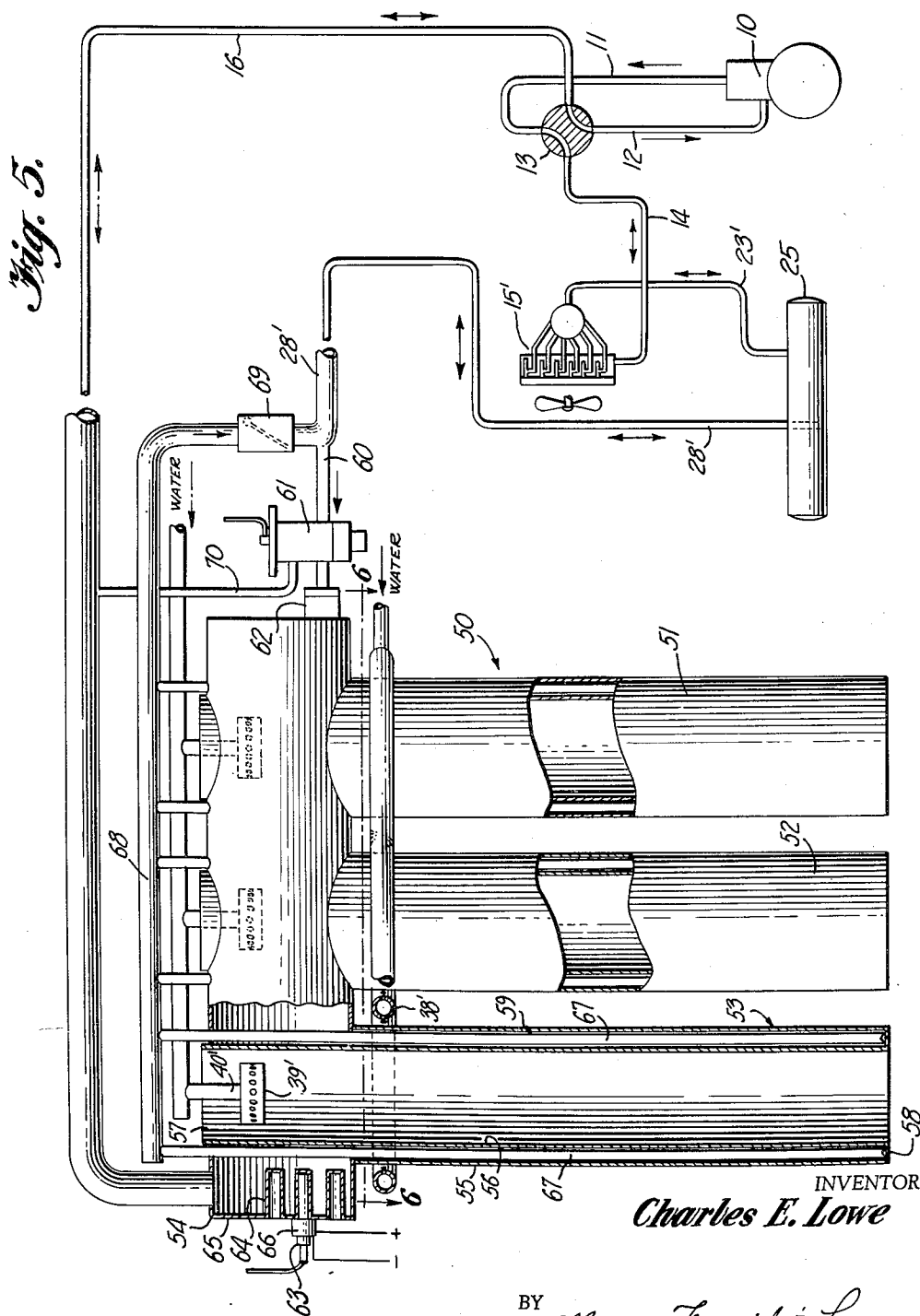
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HEAT PUMP TYPE ICE-MAKING MACHINE

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4 Sheets-Sheet 3



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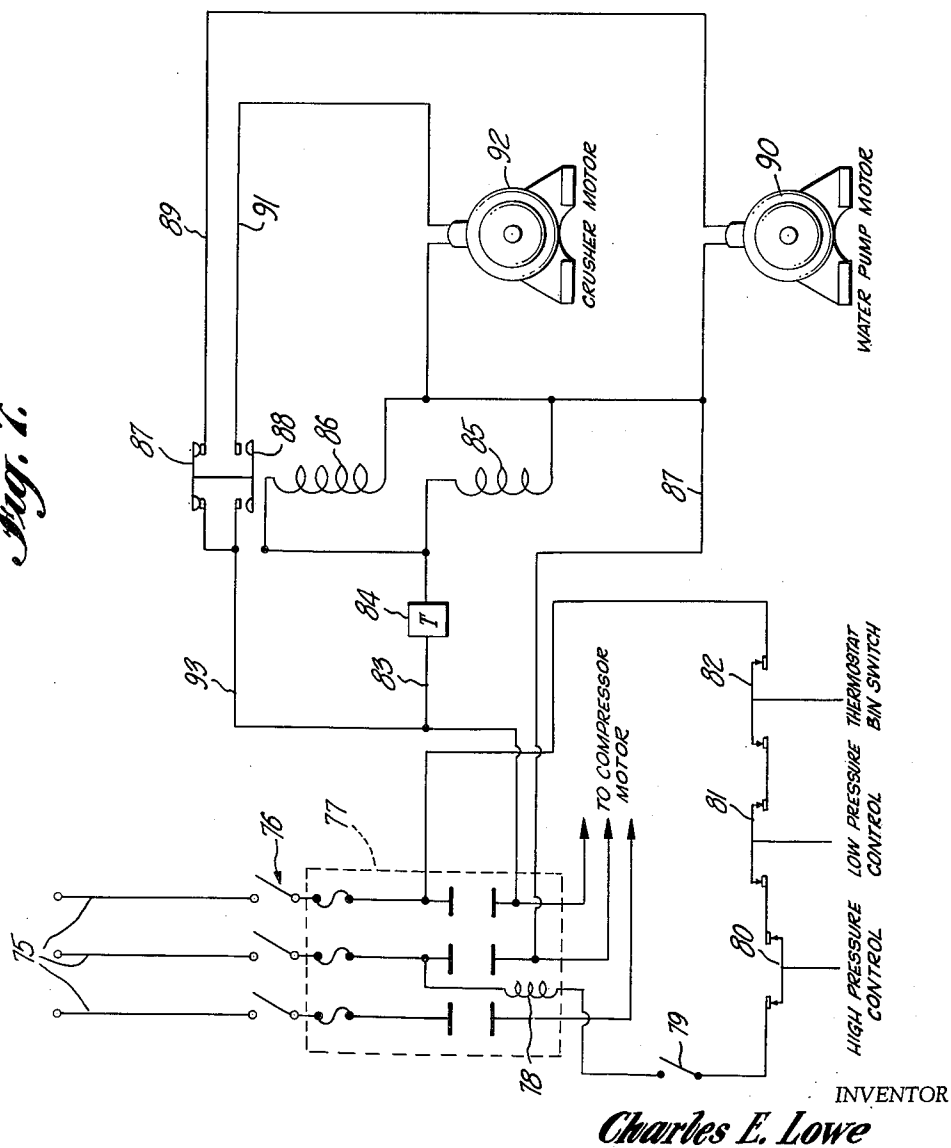
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HEAT PUMP TYPE ICE-MAKING MACHINE

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4 Sheets-Sheet 4

Fig. 2.



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3,034,310

HEAT PUMP TYPE ICE-MAKING MACHINE

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Filed Aug. 13, 1959, Ser. No. 833,411

7 Claims. (Cl. 62-197)

The present invention relates in general to heat exchange refrigeration systems, and more particularly to reversible cycle refrigeration systems for ice-making or cooling purposes involving a novel evaporator structure.

Heretofore, automatic ice-making apparatus has been devised which involves a reversible cycle refrigeration system wherein ice is produced during the normal refrigerating cycle of the apparatus when condensed liquid refrigerant is admitted to the evaporator, and the ice is discharged from the evaporator and harvested during a defrosting cycle of the apparatus when hot gaseous refrigerant is delivered directly from the compressor to the evaporator. However, improvement in the economy of construction and operation of such apparatus and particularly in the construction of the evaporator or heat exchanger components thereof and the available ice-making surface area thereof is imminently desirable.

While the present invention is applicable to liquid chilling applications as well as ice-making applications, it will be described specifically in connection with the automatic production of crushed ice. An object of the present invention is the provision of novel ice-making apparatus wherein the production of ice is accelerated in comparison with systems heretofore devised and is accomplished in a more economical manner.

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.

Another object of the present invention is the provision of automatic ice-making apparatus which is arranged to freeze flowing water into ice in the form of two concentric elongated hollow tubes and then defrost the two ice tubes to a sufficient extent to release them from the apparatus and permit them to drop endwise into a crusher or hopper.

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 two preferred embodiments of the invention.

In the drawings:

FIGURE 1 is a diagrammatic view of one form of ice-making apparatus embodying the present invention, illustrating the condenser and evaporator components in vertical section;

FIGURE 2 is an enlarged vertical section view of the evaporator heat exchanger of the apparatus shown in FIGURE 1;

FIGURE 3 is a horizontal section view taken along the line 3-3 of FIGURE 2;

FIGURE 4 is a horizontal section view taken along the line 4-4 of FIGURE 2;

FIGURE 5 is a diagrammatic view of a modified form of ice-making apparatus embodying the present invention, with parts of the evaporator shown in section;

FIGURE 6 is a section view taken along the line 6-6 of FIGURE 5; and

FIGURE 7 is a schematic diagram of one form of elec-

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trical control circuit which may be used with the present invention.

Referring to the drawings wherein like reference characters designate corresponding parts throughout the several figures, and particularly to the apparatus disclosed in FIGURES 1 to 4 of the drawings, the automatic ice-making apparatus includes the usual motor-driven compressor 10 of a reversible cycle refrigeration system having a high-pressure compressor discharge line 11 and a low-pressure compressor suction line 12 leading to a four-way valve 13. The four-way valve is provided with an adjustable rotor having a pair of conduits 13a and 13b. In the position illustrated in FIGURE 1 wherein the rotor is in a position to establish the freezing cycle of the apparatus, the conduits 13a and 13b communicate the discharge line 11 with a line 14 leading to a condenser generally indicated at 15 and the suction line 12 with a line 16 leading to the evaporator generally indicated at 17.

The condenser 15, in the form herein shown, comprises an outer shell 18 and a water coil 19 disposed within the shell and having inlet and outlet pipes 20 and 21, respectively, for communicating water from a conventional source to the coils. The hot gaseous refrigerant discharged from the compressor 10 is delivered to the interior of the condenser shell 18 at the top thereof and is distributed by a baffle 22 to progress downwardly along the coils 19 which will effect condensation of the gaseous refrigerant through heat exchange with the water flowing through the coils 19. The condensed liquid refrigerant which collects in the bottom portion of the condenser shell 18 will be delivered through the pipe 23 and check valve 24 therein to a conventional liquid refrigerant receiver 25. The check valve 24 is arranged to permit flow of refrigerant only in the direction from the condenser 15 to the receiver 25. The condenser shell is provided at its lower end with an injector nozzle 26, in the preferred embodiment, which is disposed within a well 27 at the bottom of the condenser shell 18 and is connected with the receiver 25 by a pipe 26'. The injector nozzle 26 is similar in construction, operation and purpose to the injector nozzle disclosed in my prior Patent No. 2,724,246 issued November 22, 1955, but serves no function in the freezing cycle of the apparatus. The liquid refrigerant in the receiver 25 is delivered under the high-pressure established at the discharge line 11 of the compressor through the conduit 28 to the evaporator 17.

The evaporator 17, which is more clearly illustrated in FIGURES 2 to 4 is of a special design to cause ice to be produced in the form of two concentric cylindrical tubes of ice arranged about a common vertical axis and includes a downwardly opening cup-shaped evaporator body 29 formed of an outer cylindrical wall 30 and an inner cylindrical wall 31 arranged about a common vertical axis and spaced radially from each other, and an annular bottom wall 32 connecting the lower ends of the outer and inner walls 30, 31. Upper and lower circular top plates 33 and 34 which are spaced vertically from each other, extend across the upper ends of the outer and inner walls 30 and 31 respectively, and enclose, with the outer and inner walls and the annular bottom wall 32, a refrigerant chamber 35 which has an upper portion 36 extending transversely across the evaporator body between the top plate 33, 34 and a depending annular portion 37. An outer circular water spray ring 38 extends around the outer wall 30 at the upper end thereof to spray water inwardly and downwardly upon the exposed exterior surface of the outer wall 30 and an inner, disk-like water spray head 39 is disposed immediately below the lower plate 34 to spray water outwardly upon the exposed inner surface of the inner wall 31. A conduit 40 extends from the spray head 39 vertically through the upper portion 36 of the refrigerant chamber 35 in align-

ment with the axis of the evaporator body 29 and is joined by a pipe 41 extending from the water spray ring 38 to communicate with a suitable water supply line 42.

The condensed liquid refrigerant delivered from the receiver 25 through the conduit 28 is first admitted to a jacket 43 within the upper portion 36 of the refrigerant chamber 35 and which surrounds a portion of the pipe 40 leading to the water spray head 39 to heat the water supply conduit 40 in the region of the evaporator to avoid freezing of the water therein. The liquid refrigerant is then delivered through a suitable metering device 44 such as a thermostatic expansion valve to an injection tube 45 having a leg extending downwardly through the annular portion 37 of the chamber 35 to a point adjacent the lower end of the chamber. The liquid refrigerant thus injected into the refrigerant chamber 35 is in intimate heat exchange relationship through the walls 30 and 31 with the water sprayed downwardly along these walls to freeze the water and form concentric cylindrical tubes of ice along the two walls 30 and 31. As the heat is withdrawn from the liquid refrigerant within the refrigerant chamber 35, it vaporizes and is forced to the upper portion of the chamber 35, where it is drawn off through the line 16, the four-way valve 13 and the compressor suction line 11, to be compressed and delivered again to the condenser 15. It will be appreciated that while the injector tube 45 is illustrated as extending vertically downwardly through the annular portion 37 of the refrigerant chamber 35, this tube may assume a helical or any other desired form, and to improve the heat exchange properties of the evaporator, the evaporator may be provided with a plurality of radial or helical fins (not shown) in at least the annular portion 37 thereof extending between the inner and outer walls 30 and 31.

When the ice frozen on the walls 30 and 31 of the evaporator is of suitable thickness, as determined by some conventional sensing apparatus or by a timer, the rotor of the four-way valve 13 will be shifted from the position illustrated in FIGURE 1 so that the conduits 13a and 13b will communicate the compressor discharge line 11 with the line 16 and the suction line 12 with the line 14. This establishes the defrost cycle of the apparatus, wherein the hot gaseous refrigerant discharged under the high compressor pressure is delivered directly through the line 16 to the refrigerant chamber 35 of the evaporator 17 to displace the liquid refrigerant in the annular portion 37 of the refrigerant chamber 35 and force the liquid refrigerant up the injector tube 45 and through the check valve 46 and pipe 47 to the receiver 25. The refrigerant is then forced through the pipe 26' and injector nozzle 26 into the lower end of the condenser 15 where it withdraws heat from the water in the coils 19 and vaporizes. It will be appreciated that the injector nozzle 26 will spray the liquid refrigerant upwardly against the lower wall of the baffle 22 or at least a substantial distance up into the condenser shell 18 and the nebulized refrigerant will fall downwardly upon the coils 19 to provide efficient heat exchange in the manner described in my prior Patent No. 2,724,246. When sufficient thawing occurs along the inner and outer evaporator walls 30, 31 through the heat exchange between the hot gaseous refrigerant in the refrigerant chamber 35 and the ice tubes formed on the walls 30, 31, the frost bond between the ice tubes and their adjacent evaporator walls will be broken and the ice tubes will fall by gravity to a suitable ice crusher, conveyor, hopper, or other suitable instrumentality (not shown) for subsequent processing of the ice. The four-way valve 13 will then be reversed again to assume the position illustrated in FIGURE 1 to re-establish an ice-making or freezing cycle.

It will be appreciated that due to the extremely limited volume of the refrigerant chamber 35, only a relatively small charge of refrigerant is required for effective operation of the system. The injector tube 45 in the above-described form of the invention serves the dual function

of feeding the refrigerant from the expansion valve 44 to the bottom of the refrigerant chamber 35, and also serves as the conduit through which the liquid refrigerant is removed during the defrosting or harvesting cycle of the system.

The same advantages of simplicity of construction and small volume for the refrigerant chamber within the evaporator may be achieved by closing the bottom of the body 29 over the entire area of the bottom between the lower edges of the outer shell 30 and leaving the inner shell 31 either in the form shown in FIGURE 2 or provide a bottom plate therefor which is spaced above the bottom for the outer shell 30. Such a construction, however, has a much more restricted ice-producing surface since ice will only be produced on the exterior surface of the outer shell 30.

Another form of the invention is shown in FIGURES 5 and 6 which involves a plurality of ice-producing evaporator bodies similar to that disclosed in the first embodiment, which depend from a single header, and wherein the evaporator operates as a flooded evaporator rather than relying upon the metering action of a thermostatic expansion valve which governs the rate of injection of refrigerant into the evaporator in accordance with the temperature of the gaseous refrigerant exiting from the evaporator through the compressor suction line. In the form shown in FIGURE 5, wherein the components similar to components of the first described embodiment are identified by the same reference characters as in the first embodiment, or the primes thereof, the usual compressor 10 is coupled through compressor discharge and suction lines 11, 12 with a four-way valve 13 which communicates the lines 11 and 12 selectively with a line 14 extending to a condenser 15' which is here shown to be of the air-cooled variety and with a line 16 extending to the outlet of the evaporator unit generally indicated by the reference character 50. The condensed liquid refrigerant is delivered from the condenser 15' to the receiver 25 through the conduit 23', and a conduit 28' extends from the receiver 25 to the inlet to the evaporator unit 50.

The evaporator unit 50 includes three depending, ice-forming tubular bodies 51, 52, and 53, each of identical construction and each of which is supported by and depends from a cylindrical header or manifold unit 54 arranged on a generally horizontal axis. Since the construction of the three tubular ice-forming bodies 51, 52 and 53 is identical, only one of them will be described in detail. The tubular body 53 includes an outer cylindrical wall 55 and an inner cylindrical wall 56 arranged about a common vertical axis and spaced radially from each other. The inner cylindrical wall 56 projects vertically through the height of the header 54 and projects at its upper end 57 beyond the adjacent wall of the header to which it is brazed or otherwise joined. The outer cylindrical wall 55 terminates at its upper end at the lower wall of the header 54 and is welded or otherwise joined to the wall of the header 54. The outer and inner walls 55, 56 are joined at their lower end by the annular bottom plate 58 to form an annular refrigerant chamber 59 between the walls 55 and 56 which opens upwardly into the interior of the header 54. An outer circular water spray ring 38' having a plurality of annular sections, one of which surrounds each of the tubular bodies 51, 52 and 53, is connected to a source of water and has suitable spray nozzles or openings therein for discharging a spray of water inwardly and downwardly upon the exterior surface of the outer wall 55 of each ice-forming body, and an inner, disk-like water spray head 39' is disposed below the top plate 57 of each tube-forming body to spray water outwardly upon the exposed inner surface of the inner wall 56. The spray heads 39' are connected through conduits 40' to a manifold which extends to a suitable conventional source of water.

In the refrigerating cycle of the apparatus, liquid refrigerant is delivered from the receiver 25 through the conduit 28' and a conduit 60 having a conventional liquid level valve 61 therein to an inlet opening 62 of the header 54. The liquid refrigerant admitted to the header 54 flows through the openings between the inner wall 56 and outer wall 55 where they join the lower portion of the header 54 to fill the refrigerant chambers 59 of the three ice-forming bodies 51-53. The level of liquid refrigerant within the refrigerant chambers 59 and header 54 are regulated by a temperature sensing bulb 63 of conventional construction seated in one of a series of sensing bulb wells 64 provided in the end wall 65 of the header 54 opposite the inlet opening 62. The wells 64 may be arranged at uniformly, vertically spaced locations on a vertical axis, or along an axis inclined to the vertical or in any desired pattern so long as they provide a series of different, vertically located positions for receiving the sensing bulb 63. The sensing bulb 63 in the preferred embodiment is also surrounded with a low voltage electrical heater 66 which is designed to increase the temperature of the sensing bulb 63 beyond the critical temperature thereof and provide energy in the form of pressure, electrical current, or other conventional energy forms to actuate the valve 61 to open the same whenever the liquid level within the header 54 is below the sensing bulb 63. When the well 64, housing the sensing bulb 63, is immersed with the liquid, the low voltage heater 66 is nullified by heat transferred to the surrounding liquid refrigerant and the sensing bulb 63 is conditioned to close the valve 61. The adjustment of these parts is such that the sensing bulb 63 and liquid level valve 61 will maintain the liquid refrigerant level within about $\frac{1}{8}$ inch of the location of the bulb 63.

A refrigerant return line is provided, which consists in the preferred embodiment of a pair of refrigerant withdrawal tubes 67 extending from the bottom of the refrigerant chamber 59 through the top of the header 54, and a common line or manifold 68 which extends from the tops of the tubes 67 through a check valve 69 to the conduit 28' communicating with the receiver 25. The check valve 29 is adjusted to open on low downstream pressure. An equalizer line 70 extends from the liquid level valve 61 to the suction line 16.

When sufficient thickness of ice has been formed on the outer and inner surfaces, respectively, of the outer and inner walls 55, 56, the four-way valve 13 is reversed from the position illustrated in FIGURE 5 to communicate the compressor discharge line 11 with the conduit 16 and the compressor suction line 12 with the conduit 14. This causes the high pressure of the gaseous refrigerant to be delivered through the line 16 directly to the header 54 to force the liquid refrigerant in the header down and out of the evaporator through the withdrawal tubes 67 and common line 68 and check valve 69 to the receiver 25. The check valve 69 automatically opens under the pressure conditions thus created. The regulation of the valve 61 by the sensing bulb 63 is neutralized and overcome by means of the equalizing line 70 whereby the high pressure produced in the suction line 16 under the defrost cycle conditions forces the liquid level valve 61 closed so that no liquid refrigerant will flow to the inlet 62 of the header 54.

FIGURE 7 illustrates one form of electrical control circuitry for the automatic ice-making apparatus described hereinabove, and will be described in conjunction with the form of ice-making apparatus illustrated in FIGURES 1 to 4 of the drawings. The electrical energy for driving the motor of the compressor 10, which in this case is assumed to be a three-phase, 220 volt, 60 cycle motor, is supplied through a three-phase line indicated by the reference character 75, having a main switch 76 and a conventional three-phase contactor 77 interposed in the three-phase line. Contactor 77 has a contactor

coil 78 which is arranged in a loop circuit extending across two of the three-phase leads 75. The loop circuit includes, in addition to the contactor coil a start-stop toggle switch 79, high pressure and low pressure safety switches 80 and 81 and a thermostatic bin switch 82, all arranged in series. The toggle switch 79 is normally open and is to be closed when it is desired to energize the ice-making apparatus, and the safety switches 80 and 81 and the thermostatic bin switch 82 are normally closed. The high pressure safety switch is of the conventional type in the refrigeration art which senses the pressure at the compressor high side or suction line 11, to open the circuit of the contactor coil 78 in response to too high a pressure in the line 11, which usually results when the water supply is defective. The low pressure safety switch 81 is designed to open the circuit through the contactor coil 78 when the pressure goes below a selected level, such as may occur if there is gas leakage or pressure loss in the refrigeration system. The thermostatic bin switch 82 is a normally closed switch which opens the circuit through the contactor coil 78 when ice in the collector bin or hopper gets up to the level of a bulb or other sensing device in the bin.

A lead 83 extends from one of the three-phase lines 75 at the outlet side of the contactor 77 through a cycling switch 84 which may be sensitive to pressure in the compressor suction line 16 or controlled by a time clock or an ice thickness switch physically sensing the thickness of ice on the evaporator surface, and is connected to one end of a solenoid coil 85 and a relay coil 86 arranged in parallel with each other, the lower ends of the coils 85 and 86 being connected to another one of the three-phase lines 75 through a common lead 87. The solenoid coil 85 regulates the position of the four-way valve 13, the valve 13 being in the condition illustrated in FIGURE 1 when the coil 85 is deenergized by virtue of the cycling switch 84 being open, whereby the refrigeration cycle is established. Upon closing of the circuit through the cycling switch 84, the solenoid coil 85 is energized, reversing the four-way valve 13 to establish the defrost cycle of the apparatus.

The relay coil 86 controls relay contacts 87 and 88, respectively, interposed in line 89 extending to a water pump motor 90 and in line 91 extending to an ice crusher motor 92. The lines 89 and 91 are each connected to the line 83 at a point between the cycling switch 84 and the contactor 77 by a lead 93. The relay contacts 88 in the line 91 are normally closed when the relay coil 86 is deenergized and the relay contacts 87 are normally open. Thus, during the refrigeration cycle of the apparatus, the water pump motor 90 is energized to provide sufficient pressure for spraying the water from the ring 38 and spray head 39 onto the evaporator surfaces. When the cycling switch 84 closes to establish the defrost cycle, energization of the relay coil 86 open-circuits the contact 87 and closes the contact 88 to energize the ice crusher motor 92 and drive the ice crusher during the period of the defrost cycle.

While but two specific embodiments of the invention have been particularly shown and described, it will be apparent that various modifications may be made therein within the spirit and scope of the invention, and 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 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 surrounding said bore 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, an outer spray ring adjacent the upper end of said outer cylindrical wall having inwardly directed spray openings, a water spray head disposed within said central bore adjacent the upper end thereof having outwardly directed spray openings for discharging water on said inner cylindrical wall, means for supplying water to said spray ring and said spray head under pressure, a vertically arranged liquid transfer tube extending from a point above and externally of said evaporator body downwardly through said annular refrigerant chamber and terminating in an open lower end immediately adjacent the bottom of said refrigerant chamber, said refrigeration system having control means for alternately cycling the same through a freezing phase and ice-harvesting phase, means for delivering liquid refrigerant to said transfer tube during said freezing phase to transfer the liquid refrigerant downwardly through said transfer tube and inject the same through the open lower end thereof 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, valve conduit means in open communication with said transfer tube during said ice-harvesting phase, and means for delivering hot gaseous refrigerant under pressure to said refrigerant chamber adjacent the top thereof during said ice-harvesting phase to force substantially all of the liquid refrigerant in said refrigerant chamber upwardly through said transfer tube into said valved conduit means communicating therewith and heat said inner and outer cylindrical walls through heat exchange between said walls and the hot gaseous refrigerant throughout the height of the walls for thawing any frost bond between said ice bodies and said walls and discharging the ice bodies gravitationally therefrom.

2. In ice-making apparatus, a refrigeration system including control means for alternately cycling the system through a freezing phase and an ice-harvesting phase, an evaporator in the form of a vertically elongated tubular body concentric with 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 surrounding said bore 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, a stationary outer spray ring adjacent the upper end of said outer cylindrical wall having inwardly directed spray openings, a stationary outer spray head disposed within said central bore adjacent the upper end thereof having outwardly directed spray openings for discharging water on said inner cylindrical wall, means for supplying water to said spray ring and said spray head under pressure, a vertically arranged liquid transfer tube extending from a point above and externally of said evaporator body downwardly through said annular refrigerant chamber and terminating in an open lower end immediately adjacent the bottom of said refrigerant chamber, a heat exchanger serving as a condenser during said freezing phase and having an injector nozzle for discharging liquid refrigerant in spray form into heat exchange relation with surfaces of the heat exchanger during the harvesting phase to vaporize the liquid refrigerant, means for delivering liquid refrigerant during said freezing phase to said transfer tube and downwardly through the latter to inject the liquid refrigerant through the open lower end thereof into said refrigerant chamber in heat exchange relation with

said cylindrical walls substantially throughout the height thereof for freezing the water sprayed on said cylindrical surfaces into a pair of concentric annular bodies of ice, conduit means communicating said transfer tube at a point exterior of said evaporator body with said injector nozzle of said heat exchanger, said conduit means having check valve means closing said conduit means during said freezing phase and opening said conduit means to communicate said transfer tube with said injector nozzle during the harvesting phase, and means for delivering hot gaseous refrigerant under pressure to said refrigerant chamber adjacent the top thereof during said harvesting phase to force substantially all of the liquid refrigerant in said refrigerant chamber upwardly through said transfer tube and said conduit means to discharge the same through said injector nozzle into said heat exchanger, said hot gaseous refrigerant heating said inner and outer cylindrical walls through heat exchange between said walls and the hot gaseous refrigerant throughout the height of the walls for thawing any frost bond between said ice bodies and said walls and discharging the ice bodies gravitationally therefrom.

3. In ice-making apparatus, a refrigeration system including an evaporator in the form of a downwardly opening, cup shaped, vertically elongated body arranged along a vertical axis having a shallow cylindrical refrigerant chamber at the top thereof a downwardly opening central bore depending below the cylindrical refrigerant chamber and extending substantially through the height of the evaporator surrounded by an annular rim portion, said annular rim portion having a cylindrical outer ice-forming surface and a cylindrical inner ice-forming surface arranged concentrically with the vertical axis of the body and extending substantially the entire height thereof and an annular refrigerant chamber in communication with said cylindrical refrigerant chamber and located between said outer and inner ice-forming surfaces in intimate thermal communication therewith being substantially co-extensive vertically with said ice-forming surfaces, a water spray ring positioned adjacent the upper end of said outer ice-forming surface in concentric surrounding relation therewith having inwardly directed openings, a cylindrical water spray head disposed within the central downwardly opening bore of said evaporator body adjacent the upper end of said inner ice-forming surface and centered on the axis thereof having outwardly directed openings, means for supplying water to said spray ring and said spray head under pressure to be sprayed on said outer and inner ice-forming surfaces including a water supply conduit for said spray head extending through said cylindrical refrigerant chamber, means for delivering liquid refrigerant to said annular refrigerant chamber adjacent the bottom thereof for a selected freezing period to freeze the water sprayed onto said ice-forming surfaces to form a pair of concentric annular cylindrical bodies of ice about said surfaces, said means for delivering liquid refrigerant having a low pressure section located within the annular refrigerant chamber having an outlet at the bottom thereof and a high pressure section including a jacket surrounding the portion of the spray head water supply conduit within said cylindrical refrigerant chamber in intimate heat exchange relation therewith to transfer heat to the water supply conduit from high pressure liquid refrigerant in said jacket and a means for delivering hot gaseous refrigerant under pressure to said annular refrigerant chamber for a selected defrost period to force the liquid refrigerant therefrom for thawing the ice bodies from said ice-forming surfaces and discharging the ice bodies gravitationally therefrom.

4. In ice-making apparatus, a refrigeration system including an evaporator in the form of a downwardly opening, cup shaped, vertically elongated body arranged along a vertical axis having a downwardly opening central bore extending substantially through the height thereof surrounded by an annular rim portion, said annular rim

portion including an annular wall having a cylindrical outer ice-forming surface and an annular inner wall spaced therefrom having a cylindrical inner ice-forming surface arranged concentrically with the vertical axis of the body and extending substantially the entire height thereof and an annular refrigerant chamber located between said outer and inner walls in intimate thermal communication therewith being substantially coextensive vertically with said ice-forming surfaces, a water spray ring positioned adjacent the upper end of said outer ice-forming surface in concentric surrounding relation therewith having inwardly directed openings, a cylindrical water spray head disposed within the central downwardly opening bore of said evaporator body adjacent the upper end of said inner ice-forming surface and centered on the axle thereof having outer directed openings, means for supplying water to said spray ring and said spray head under pressure to be sprayed on said outer and inner ice-forming surfaces, an injector tube extending from the top of said evaporator body through said refrigerant chamber to a point near the bottom thereof, means for delivering liquid refrigerant to the bottom of said refrigerant chamber through said injector tube for a selected freezing period to freeze the water sprayed onto said ice-forming surfaces to form a pair of concentric annular cylindrical bodies of ice about said surfaces, means for delivering hot gaseous refrigerant under pressure to the top of said refrigerant chamber for a selected defrost period to force the liquid refrigerant therefrom through said injector tube and for thawing the ice bodies from said ice-forming surfaces and discharging the ice bodies gravitationally therefrom, thermostatic expansion valve means for regulating the admission of liquid refrigerant to said injector tube and refrigerant chamber during the freezing period, and a conduit and check valve means for returning liquid refrigerant from said refrigerant chamber through said injector tube to the refrigeration system in by-passing relation to the expansion valve during the defrost period.

5. In ice-making apparatus, a refrigeration system including an evaporator assembly comprising a plurality of vertically elongated tubular bodies arranged along parallel vertical axes each having a central bore open at the bottom of the body extending substantially throughout the height thereof providing a cylindrical outer ice-forming surface and a cylindrical inner ice-forming surface arranged concentrically with the vertical axis of each body and extending substantially throughout the entire height thereof providing a closed-bottom annular refrigerant chamber located between said outer and inner ice-forming surfaces in intimate thermal communication therewith and extending substantially coextensively vertically with said ice-forming surfaces, a water spray ring positioned adjacent the upper end of each of said ice-forming surfaces in concentric surrounding relation therewith having inwardly directed openings, a water spray head disposed within the central bore of each of said bodies adjacent the upper end of the inner ice-forming surface having outwardly directed openings, means for supplying water to each of said spray rings and said spray ring heads under pressure to be sprayed on said outer and inner ice-forming surfaces, a common header tank at the upper end of said evaporator bodies in communication with the refrigerant chamber of each of said evaporator bodies to deliver refrigerant thereto, conduit means for delivering liquid refrigerant to said header tank

and refrigerant chambers communicating therewith during a freezing period including a liquid valve for regulating refrigerant flow therethrough, and sensing means positionable at selected vertical levels in said header tank and responsive to the liquid refrigerant level therein for regulating said liquid valve to maintain a selected liquid refrigerant level within said header tank and throughout the refrigerant chambers of said evaporator bodies during the freezing period.

6. The combination recited in claim 5, wherein control means are provided for regulating said conduit means to deliver liquid refrigerant to said header tank and refrigerant chambers communicating therewith for a selected freezing period to freeze water sprayed onto said ice-forming surfaces to form a pair of concentric annular cylindrical bodies of ice about the ice-forming surfaces of each of said evaporator bodies and including means for delivering hot gaseous refrigerant under pressure to the refrigerant chamber of each of said bodies for a selected defrost period to force the liquid refrigerant therefrom for thawing the ice bodies from said ice-forming surfaces and discharging the ice bodies gravitationally therefrom.

7. In ice-making apparatus, a refrigeration system including an evaporator assembly comprising a plurality of vertically elongated tubular bodies arranged along parallel vertical axes each having a central bore open at the bottom of the body extending substantially throughout the height thereof providing a cylindrical outer ice-forming surface and a cylindrical inner ice-forming surface arranged concentrically with the vertical axis of each body and extending substantially throughout the entire height thereof providing a closed-bottom annular refrigerant chamber located between said outer and inner ice-forming surfaces in intimate thermal communication therewith and extending substantially coextensively vertically with said ice-forming surfaces, a water spray ring positioned adjacent the upper end of each of said ice-forming surfaces in concentric surrounding relation therewith having inwardly directed openings, a water spray head disposed within the central bore of each of said bodies adjacent the upper end of the inner ice-forming surface having outwardly directed openings, means for supplying water to each of said spray rings and said spray ring heads under pressure to be sprayed on said outer and inner ice-forming surfaces, a common header tank at the upper end of said evaporator bodies in communication with the refrigerant chamber of each of said evaporator bodies to deliver refrigerant thereto, conduit means for delivering liquid refrigerant to said header tank and refrigerant chambers communicating therewith including a liquid valve for regulating refrigerant flow therethrough, and means responsive to the liquid refrigerant level in said header tank for regulating said liquid valve to selectively maintain a selected liquid refrigerant level within said header tank and throughout the refrigerant chambers of said evaporator bodies.

References Cited in the file of this patent

UNITED STATES PATENTS

1,020,759	Holden	Mar. 19, 1912
1,960,802	Backstrom	May 29, 1934
2,595,588	Lee	May 6, 1952
2,739,457	Chapman	Mar. 27, 1956