Oct. 31, 1939. M. W. KENNEY ET AL 2,178,373

REFRIGERATING SYSTEM

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FIG. 1.

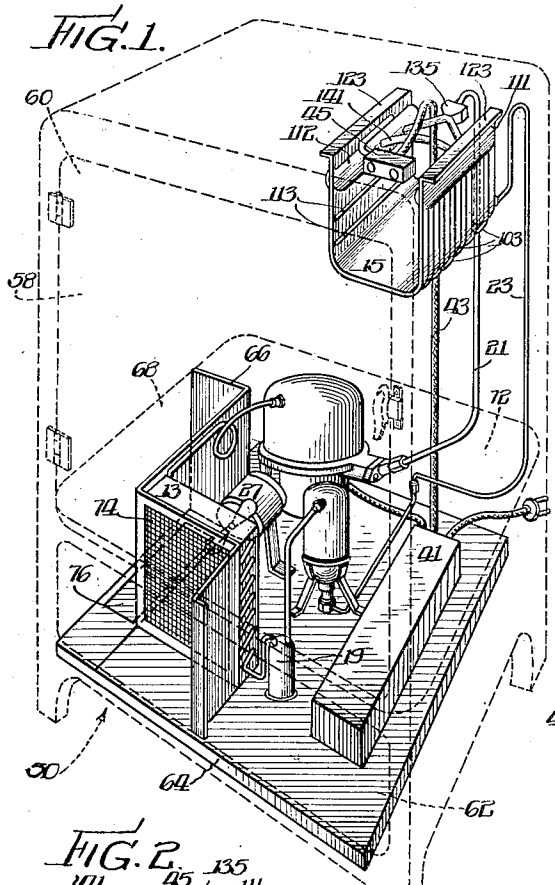


FIG. 2.

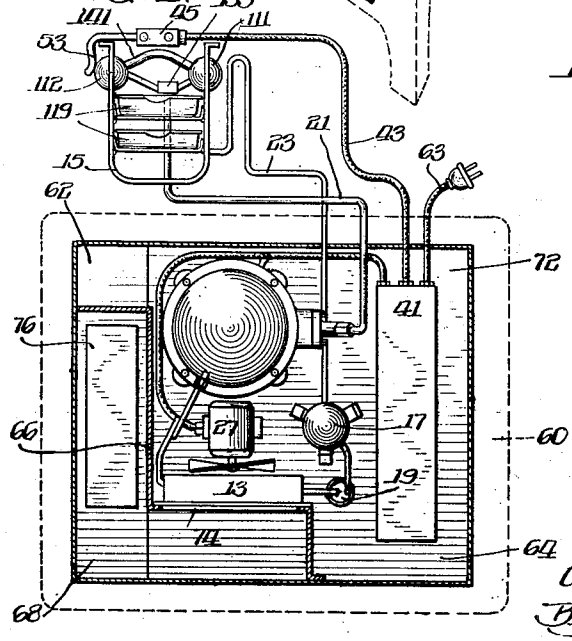


FIG. 3.

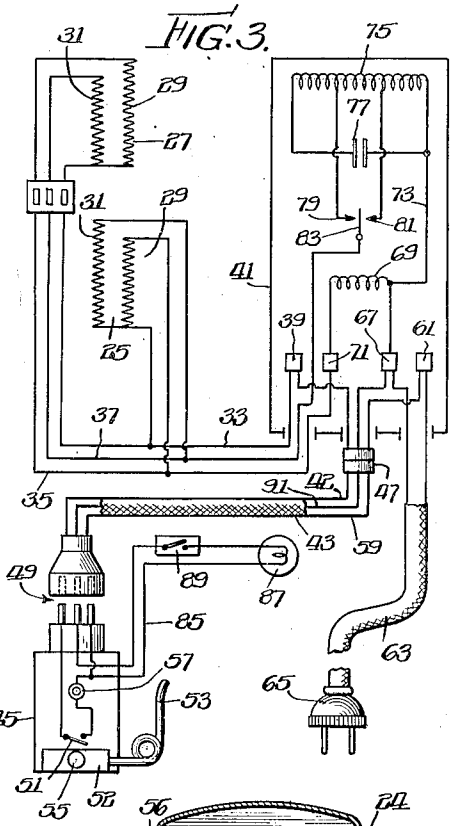
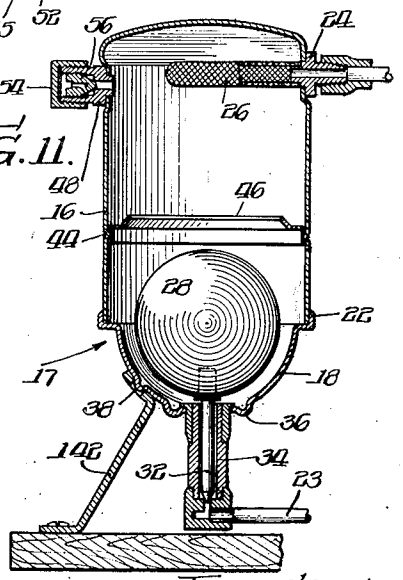


FIG. 11.



Inventors:
Mahlon W. Kenney
Arthur R. Constantine
By:- Cox & Moore Attys.

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FIG. 4.

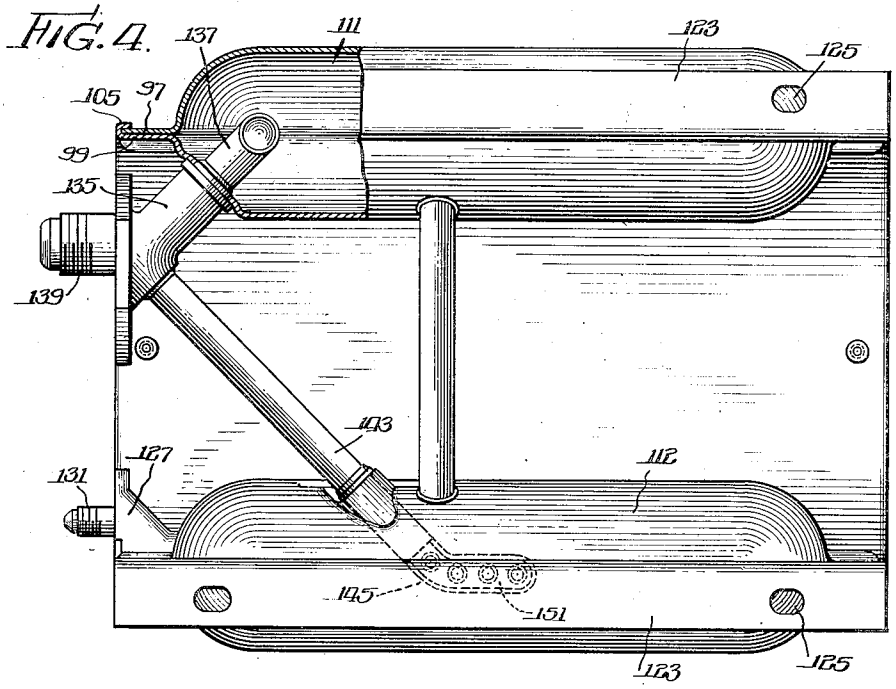


FIG. 5.

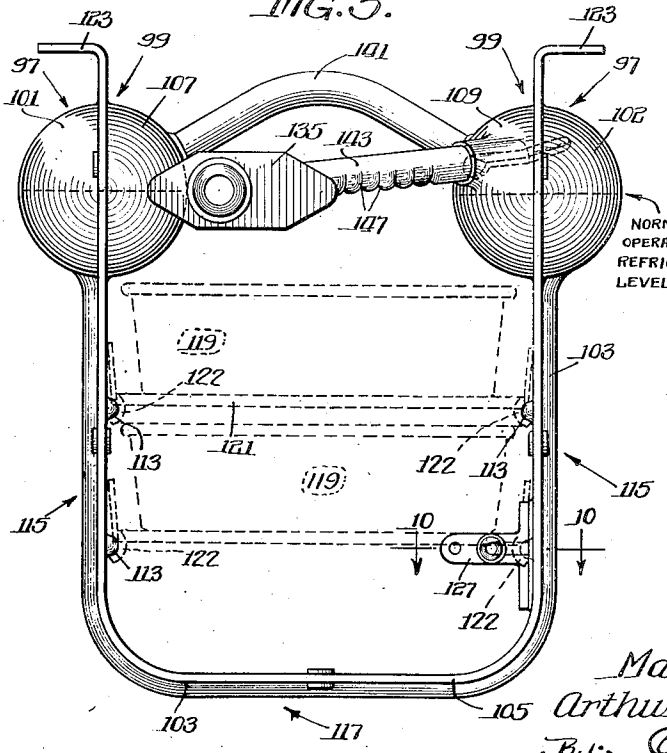
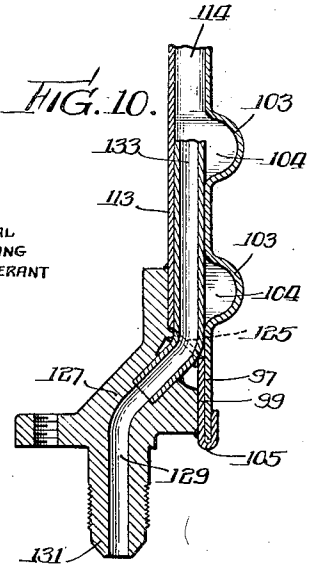


FIG. 10.



Inventors:
Marlon W. Kenney
Arthur R. Constantine
By:- Cox & Moore
attys.

Oct. 31, 1939. M. W. KENNEY ET AL 2,178,373

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FIG. 6.

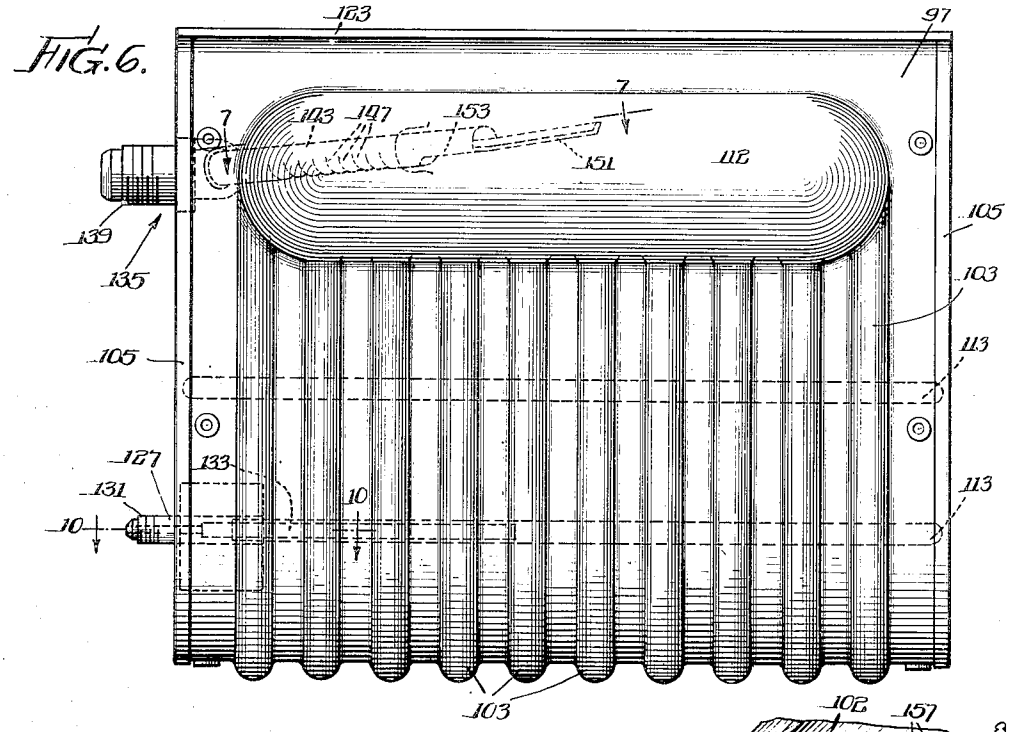


FIG. 7.

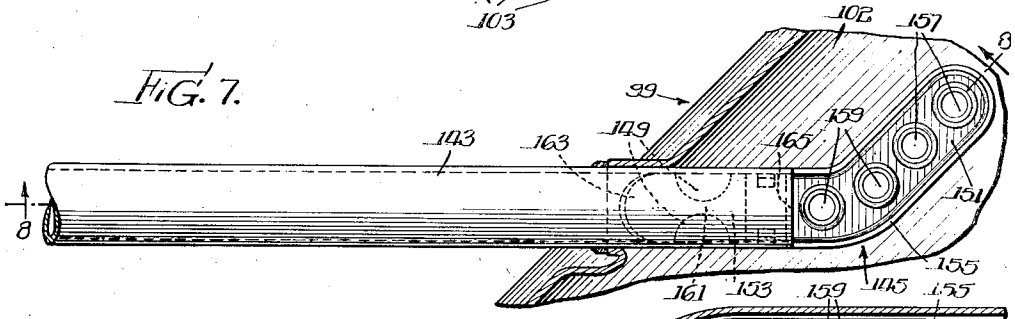


FIG. 8.

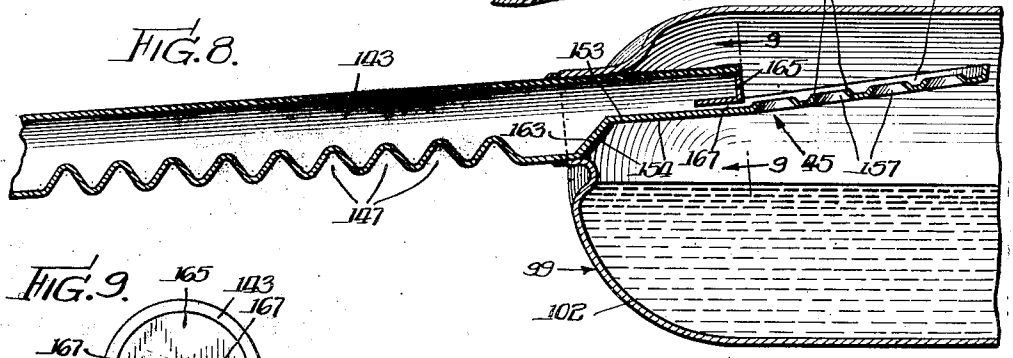
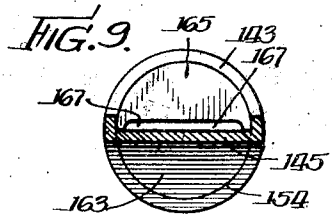


FIG. 9.



Inventors:
Mahlon W. Kenney
Arthur R. Constantine
By: Cox & Moore attys.

Patented Oct. 31, 1939 2,178,373

UNITED STATES PATENT OFFICE

2,178,373

REFRIGERATING SYSTEM

Mahlon W. Kenney, Chicago, and Arthur R. Constantine, River Forest, Ill., assignors, by mesne assignments, to William C. Grunow, Chicago, Ill.

Application July 7, 1934, Serial No. 734,076

7 Claims. (Cl. 62—126)

Our invention relates in general to the art of refrigeration, and more particularly to refrigeration accomplished by means of the so-called compression evaporation cycle, wherein a suitable fluid refrigerating medium is cyclically compressed in gaseous form, condensed to liquid form, and finally evaporated for the purpose of absorbing heat, the invention having particular reference to the provision of an improved evaporator for use in such a system.

An important object resides in providing apparatus of the character mentioned, comprising a refrigerant circulating system including a lubricated compressor, a condenser and an evaporator wherein the medium utilized for lubricating the compressor is substantially insoluble in the refrigerating medium when in gaseous condition, but is readily soluble therein when the refrigerant is in liquid condition, the system being arranged so that the refrigerant is maintained in gaseous condition while in the compressor, so that only a minimal quantity of the lubricant, such as may become entrained in the gaseous refrigerant, will be carried from the compressor.

A further object is to form the evaporator with means to continuously separate dissolved lubricant from the liquid refrigerant therein, and withdraw the separated lubricant from the evaporator and deliver the same to the compressor.

Another important object is to provide an evaporator wherein liquid refrigerant containing minimal quantities of dissolved lubricant, may be evaporated, said evaporator being formed with a lubricant ejector in position to receive liquid refrigerant containing dissolved lubricant, to separate the lubricant by evaporating the refrigerant and to deliver the separated lubricant from the evaporator by gravity action.

Another important object is to provide, in an evaporator for liquid refrigerant containing dissolved lubricant, means for continuously separating lubricant from the liquid refrigerant and removing the separated lubricant from the evaporator, said means comprising an ejector including a spoon-like receiver in position, above the liquid refrigerant level in the evaporator, to continuously collect, at a predetermined restricted rate, liquid refrigerant containing dissolved lubricant sprayed, above the liquid refrigerant level in the evaporator, as a result of the ebullition of the liquid refrigerant in the evaporator, the ejector being arranged to evaporate the so collected refrigerant rapidly and to drain the residual lubricant from the evaporator.

A further object is to provide a lubricant ejector comprising a separator portion extending outside of the evaporator, and connected with a refrigerant receiver located within the evaporator, so that refrigerant and dissolved lubricant collected in the receiver may drain into the separator, which being exposed to relatively high temperature outside the evaporator, causes rapid evaporation of the liquid refrigerant in the separator, and consequent separation of the refrigerant from the lubricant.

A further object is to form the separator with a plurality of pockets into which liquid, delivered from the spoon-like receiver, may successively drain in order to promote the progressive evaporation of the liquid refrigerant to the end that the lubricant, when it reaches the discharge end of the separator, may be in substantially refrigerant-free condition.

Another important object of the invention is to provide a compression-evaporation refrigerating system including a lubricated compressor and an evaporator, and employing a lubricating medium which will only form a solution with the liquid refrigerant, the evaporator having improved means for extracting and delivering, to the compressor, lubricant which may become dissolved with the liquid refrigerant and carried into and entrapped in the evaporator.

Another important object is to provide a refrigerating system including a lubricated compressor and employing a refrigerant, such as dichloromethane, which will only form a solution with the lubricant when the refrigerant is in the liquid state, and including an evaporator having means operating continuously to withdraw from the evaporator and deliver, to the compressor, lubricant which becomes entrapped in the evaporator and which, since it will not dissolve with the evaporated refrigerating medium, cannot be carried from the evaporator by the gasified refrigerant returning to the compressor.

Another important object is to provide a refrigerating system including a refrigerant compressor and an evaporator having a lubricant extractor comprising an elevated spoon positioned to receive the lubricant in the evaporator and means to drain lubricant from the spoon to the compressor; a further object being to construct the evaporator to promote violent boiling of the refrigerant in the immediate vicinity of the spoon whereby to fling the lubricant entrapped in the evaporator into the spoon by means of the forces liberated by the boiling of the refrigerant.

Another important object is to form the end of the lubricant extracting tube with a spoon con-

necting with the tube through a restricted opening or throat to control the rate at which the liquid may flow from the spoon to the extracting tube; a further object being to construct the spoon to receive a limited quantity of liquid only, said spoon having perforations through which liquid in excess of the capacity of the spoon may drop back into the refrigerant in the evaporator; a still further object being to form the extracting tube inwardly of the restricted throat with a narrow gangway defined on either side by openings communicating with the interior of the evaporator and across which gangway a limited amount of the liquid received through the throat may pass between said openings and reach the interior of the tube, the liquid passing on the gangway being retained thereon by the surface tension of the liquid and the balance of the liquid received through the throat being returned to the evaporator through the openings defining the gangway, whereby a limited portion only of the liquid received on the spoon is delivered into the extractor tube, and thence removed from the evaporator.

Another important object is to provide, in combination with an evaporator for liquid refrigerant containing dissolved lubricant, a refrigerant separator and ejector comprising a spoon-shaped receiver extending above the liquid refrigerant level within the evaporator in position to collect liquid refrigerant containing dissolved lubricant above the liquid level in the evaporator, so that refrigerant, containing dissolved lubricant, may be removed from the body of liquid in the evaporator and delivered at a predetermined rate, to a separator in which the dissolved lubricant may be segregated from the refrigerant and ejected from the evaporator.

A further object is to form the separator with a portion extending out of the evaporator and constructed to promote rapid evaporation of the refrigerant and to return the evaporated refrigerant to the evaporator while permitting the residual lubricant to drain away from the evaporator.

A further object is to form the spoon-like receiver portion of the lubricant ejector as a sheet metal stamping having upturned peripheral edges and a plurality of perforations, defined by upwardly embossed edges, within the upturned peripheral edges of the stamping whereby the receiver is adapted to collect a limited portion of the liquid refrigerant spray falling within the peripheral edges of the stamping as a result of the boiling of the liquid refrigerant in the evaporator, the remainder of the liquid spray returning to the body of refrigerant in the evaporator through said perforations.

A further object is to form the lubricant ejector with a restricted orifice or throat, between the spoon-like receiver and the portions of the ejector wherein separation of the lubricant and refrigerant occurs, so that liquid collected in the receiver is required to pass through said throat in entering the separator, a further object being to form said throat as an elongated opening of restricted width, whereby the liquid entering the separator is in substantially film-like form.

A further object is to form the separator portion of the lubricant ejector with openings immediately within the restricted throat through which the liquid enters from the spoon-like receiver, said openings affording means whereby gaseous refrigerant, evolved as a result of evaporation in the separator may re-enter the evaporator.

A further object is to form said openings on the lower side of the separator in position to define, between at least two such openings, a restricted pathway across which the liquid entering the separator is required to flow so that only that portion of the liquid maintained on said restricted pathway by surface tension may pass through the separator, the remainder of the liquid draining through said openings and falling into the liquid refrigerant body in the evaporator.

A further object is to form the lubricant ejector as a tube of heat conducting material, the lower side of which is formed with a series of corrugations, affording internal pockets, into and through which the liquid may progressively cascade in passing through the separator.

Another important object is to provide a refrigerant evaporator comprising a pair of sheets of heat conducting material embossed to provide a pair of spaced apart headers and a plurality of refrigerant ducts interconnecting the headers, at least one of said sheets being formed with a refrigerant inlet communicating with certain of said ducts below one of said headers, and at least one of said sheets having gaseous refrigerant outlet means formed in at least one of said headers and opening above the liquid refrigerant level therein.

A further object is to form at least one of said headers with a gaseous refrigerant outlet and another header with a lubricant ejecting connection.

Another object is to interconnect the headers by means of a conduit opening at its opposite ends above the liquid refrigerant level in said headers.

Another important object is to provide a refrigerant evaporator comprising a pair of sheets of heat-conducting material, wherein at least one of which is embossed to provide spaced apart header forming depressions at the opposite ends of the sheet, and wherein at least one of said sheets is embossed to provide a plurality of spaced apart, preferably parallel, refrigerant ducts, whereby, when said sheets are secured together, said ducts will communicate at their opposite ends with said spaced headers.

Another object is to provide an evaporator comprising means forming a pair of chambers interconnected by conduits and adapted to contain a boiling liquid refrigerant and a lubricant drain comprising a tube having a spatulate end extending into one of said chambers above the liquid refrigerant level therein, and in position to receive lubricant trapped in the evaporator upon the spatulate end of the tube by spattering due to the boiling of the refrigerant.

A further object of the invention is to form the evaporator, in an inexpensive manner, by fastening together a pair of interfitting plates having depressed portions forming refrigerant headers and ducts between the plates, when fitted together, a lubricant drain tube extending through and secured in place, as by brazing, in an opening formed in one of the interfitting plates opposite one of the headers.

A further object is to emboss at least one of the evaporator forming sheets with a groove or grooves interconnecting said ducts intermediate the headers, and to form said grooves in position such that when the evaporator forming sheets are bent to form spaced apart walls containing the headers, said grooves will provide

registering inwardly extending beads on the facing surfaces of said spaced walls and adapted to provide means for supporting objects to be cooled between said spaced walls.

A further object is to provide one of the bead forming grooves with a refrigerant inlet connection.

Another object is to arrange the refrigerant inlet as a pipe extending within one of said grooves, and having one end adapted for connection with a liquid refrigerant supply, and the other end opening in one of said ducts immediately beneath the lubricant ejector, so that relatively cold liquid refrigerant entering the duct through said pipe will promote violent boiling in the duct immediately below the lubricant ejector in order to deposit liquid refrigerant containing dissolved lubricant in the spoon-shaped receiving portion of the ejector by spattering.

Another important object of the invention is to utilize the forces liberated by the boiling of the refrigerant in the evaporator to assist in the removal of dissolved lubricant held in the evaporator in solution in the liquid refrigerant therein.

Another important object of the invention resides in forming an evaporator by embossing grooves and depressions in at least one of a pair of cooperating plates of heat conducting material, securing the embossed plate together as by welding around the peripheral edges and between the grooves and depressions to provide an evaporator comprising a pair of spaced apart refrigerant headers and a plurality of refrigerant ducts communicating at their opposite ends with said headers, and finally forming said plates, after welding to provide a pair of spaced apart side walls and an interconnecting wall whereby to form a receptacle for the reception of objects to be cooled between said side walls.

A further important object of the invention is to form the outer of said evaporator forming pair of plates with the grooves which connect with the header portion while forming the inner plate with channels intersecting and communicating with said grooves, whereby at least one of said channels may comprise an inlet refrigerant header in the finished unit.

Another important object resides in providing a float controlled expansion valve in a refrigerating system of the character mentioned, said valve being positioned to receive liquid refrigerant under pressure from the condenser, and being adapted to maintain a quantity of the liquid refrigerant therein while delivering liquid refrigerant to the evaporator as needed to maintain a desirous liquid refrigerant level in the evaporator.

A further object is to form the float controlled expansion valve of formed sheet metal parts, and further to connect the valve with the condenser through a refrigerant strainer.

Another object is to form the valve with an air and fluid tight inlet through which the refrigerating medium may be introduced into the system, and through which any air entrapped in the refrigerant system may be expelled.

Another important object is to provide a mechanical refrigerating system, including a cooling device, and power operated means for delivering refrigerating energy for liberation at the cooling device, said power operated means including devices for liberating heat during the operation of the system and a fluid-circulating element for directing a stream of cooling fluid to said heat-liberating devices for the purpose of cooling the same, wherein said power operated means is mounted on a common support for insertion as a unit in a housing including walls or partitions arranged in position to cooperate with the fluid circulating element in order to direct the cooling fluid stream, created by the operation of said element, to said heat liberating devices; a further object being to form the housing as a part of a domestic refrigerator cabinet in which the cooling device is also mounted.

Another important object is to provide a mechanical refrigerating system including a cooling device, and power operated means for delivering refrigerating energy for liberation at the cooling device, said power operated means including a device liberating heat during the operation of the system, a motor driven device and air circulating means for cooling the heat liberating and motor driven devices wherein electrical means including a pair of condenser motors is provided with one motor drivingly connected with the air circulating means and the other connected for driving the motor driven device and wherein said electrical means include electrical connections for starting and operating the condenser motors from an external source of electrical power; a further object being to arrange said electrical connections for thermostatic control of said motors in response to temperatures prevailing in the vicinity of the cooling device.

These and numerous other objects and inherent advantages and functions of the invention will be apparent as the invention is more fully understood from the following description, which, taken in connection with the accompanying drawings, discloses a preferred embodiment of our invention.

Referring to the drawings:

Figure 1 is a perspective view of refrigerating apparatus embodying our present invention as assembled in a cabinet to form a domestic refrigerator;

Figure 2 is a sectional view in horizontal section taken through the device shown in Figure 1;

Figure 3 is a diagrammatic sketch showing electrical connections forming a system for powering and controlling the operation of the refrigerating apparatus shown in Figure 1;

Figure 4 is a top plan view, partially in section, of a refrigerant evaporator forming a part of the apparatus shown in Figure 1;

Figures 5 and 6 are respectively an end and a side view of the evaporator shown in Figure 4;

Figures 7, 8 and 9 are sectional views taken substantially along the lines 7—7, 8—8, and 9—9, respectively, in Figures 6, 7 and 8;

Figure 10 is a sectional view taken substantially along the line 10—10 in Figures 5 and 6; and

Figure 11 is a sectional view through a float controlled expansion valve forming a part of the apparatus shown in Figure 1.

To illustrate our invention, we have shown in the drawings a refrigerating system comprising a compressor 11, a condenser 13 and an evaporator 15 connected together by suitable conduit means, including conduits 21 and 23 respectively, to form a refrigerant circulating system with the compressor and with the condenser. The circulating system provides means in which a refrigerating medium, in gaseous condition, may be drawn from the evaporator into and compressed in the compressor, and delivered thence to the condenser in which the compressed gaseous refrigerating medium may be liquefied as by cooling. The liquid refrigerant may be delivered from the condenser to the evaporator, preferably

through an expansion device comprising, in the illustrated embodiment, a float controlled valve 17. The liquid refrigerant thus delivered in the evaporator at relatively low pressure boils and changes its state from liquid to gaseous condition with consequent absorption of heat at the evaporator. The gaseous refrigerant thus evolved in the evaporator may be returned to the compressor for a repetition of the cycle. We find that it is desirable, though by no means essential, to connect a dehydrator 19, of any suitable or preferred character, in the circulating system preferably between the condenser and the float controlled valve 17 for the purpose of removing, from the liquid refrigerant, any traces of moisture contained therein, and thus prevent the possibility of ice accumulation through freezing of the moisture in any of the conduits forming the circulating system.

The float valve 17 is of simple construction comprising a cylindrical sheet metal shell 16 forming side walls and an integral top, and a sheet metal cover portion 18 of generally semi-spherical configuration sealed to the lower opening of the cylindrical member 16 in order to form a sealed housing providing a float chamber, the cup-shaped member 18 having peripheral flanges 22 sealed to the edges of the open ends of the shell 16. At its upper end, the shell carries an inlet fitting comprising a nipple 24 sealed in an opening formed in the shell, the inner end of the nipple opening into the shell and carrying a filter element 26 preferably in the form of a wire screen. The outer end of the nipple 24 is threaded for connection with the conduit leading from the condenser, so that condensed liquid refrigerants may be delivered through the nipple and screen into the float chamber. The cup-shaped portion 18 is shaped to receive a preferably spherical float member 28 carrying a valve stem 32 in position to enter a channeled sleeve 34 which is sealed at one end in an opening located centrally in the bottom of the cup-shaped element 18, said element 18 having a strengthening ridge embossed therein around said opening. The channelled sleeve 34 provides a valve seat with which the valve stem 32 cooperates to provide a control for the liquid refrigerant delivered from the float chamber through the channelled sleeve 34. The outer end of the sleeve 34 is provided for connecting with the conduit leading to the evaporator inlet. The cup-shaped portion 18 is also embossed outwardly as at 38 to facilitate the connection of supporting legs 42 by which the casing forming the float chamber may be supported in operative position. As the level of liquid rises in the float chamber, the float 28 will be raised and will lift the valve stem in the sleeve 34 to permit liquid refrigerant to escape from the float chamber to the evaporator. The walls of the casing 16 are provided with an annular inwardly extending groove to interfittingly receive and support a corresponding groove annular element 46 located within the float chamber in position to engage and limit the upward movement of the float 28 therein, and thus prevent the possibility of the float rising to a height in the chamber permitting the valve stem 32 to escape from the sleeve 34. We also find it convenient to provide the valve chamber with means permitting the introduction of the refrigerating medium into the system at this point. To this end the upper portions of the casing 16 are formed with a channeled fitting 48 sealed in an opening in the casing with its channel opening at one end into the float chamber. The fitting 48 outwardly of the float chamber is externally threaded to receive a cap 54 for sealing the outer end of the channel. The outer end of the channel is internally threaded to receive a valve 56, and the channel is formed with a valve seat inwardly of the threaded portion adapted to be hermetically closed by screwing the valve 56 firmly against the seat. The valve 56 is provided with a channel which, when the valve 56 is raised from its seat, provides communication between the outer and inner ends of the fitting, but which is so arranged that communication between the outer and inner ends of the fitting is cut off when the valve is firmly seated. The system may be loaded with the refrigerating medium by removing the cap 54 and valve element 56 entirely from the fitting 48. A refrigerant delivery line is then connected to the fitting 48 as by threading it upon the threads which ultimately carry the closure cap 54. A desired amount of refrigerant is then pumped into the system under pressure, the compressor being operated during the loading process in order to distribute the refrigerant properly in the system. After loading is completed, the refrigerant delivery connection is broken, the valve element 56 is inserted, but is not immediately seated. A vacuum connection is then applied as by threading the same upon the threads normally carrying the cover cap 54. This vacuum connection preferably has means manually operable without removing the connection in order to seat the valve. The vacuum connection is maintained for a sufficient interval to withdraw from the system all air and moisture which has entered during the loading operation, the compressor during this air and moisture evacuation process, being preferably blanketed so that the system operates at a higher temperature than would otherwise be the case, thus driving off any air and moisture which may be dissolved or occluded in the lubricant and refrigerant. Since the lubricant is in liquid condition when it reaches the float chamber, air and moisture will be drawn off through the fitting 48 and the vacuum connection without abstracting any material quantity of the refrigerant.

Although the present invention is not necessarily restricted to a system embodied in domestic refrigeration, we have shown a refrigerating system arranged in a cabinet 50 of any suitable or preferred construction affording a refrigerating compartment 58, in which the evaporator or heat absorber 15 is located. The compartment 58 preferably has heat insulating walls, and includes a frontal opening giving access to the compartment, a door or other closure member 60 being provided for said opening. The motor compressor unit, the condenser, and condenser cooling means, and auxiliary apparatus for operating and controlling the same, need not necessarily be housed in the cabinet at all, but may be separately enclosed or located remotely from the cabinet, if desired. We prefer, however, to provide the cabinet with a mechanism compartment 62 adjacent and preferably immediately beneath the refrigerating compartment, and to house therein the compressor, condenser, and associated operating and control mechanism. The compressor, condenser, and associated operating and control mechanism which is enclosed in the mechanism housing, are preferably all mounted on a common panel 64 adapted for removable insertion in the cabinet so that the devices mounted on the panel may be assembled as a unit in the mechanism compartment. The mechanism compart-

ment also is preferably formed with a partition 66 defining chambers 68 and 72 on opposite sides of the partition, and within the walls of the mechanism compartment. The apparatus carried by the support 64 when the same is assembled in the mechanism compartment, is located within the chamber 72 with the condenser 13 disposed in an opening 74 formed in the partition. The chamber 68 has an opening 76 through which air, blown into the chamber through the condenser and the opening 74 by the blower 27, may escape from the cabinet. The opening 76 is preferably in the bottom wall of the chamber 68, and the mechanism compartment has an opening, preferably in the rear wall of the cabinet through which air may be drawn into the chamber 72, and around the compressor and expelled thence through the condenser and the opening 74. The apparatus carried on the panel 64 may be introduced in the mechanism compartment through said rear wall opening.

The compressor 11 may be of any suitable or convenient form, although we prefer to utilize a compressor powered by means of an electric motor 25, the motor and compressor parts being enclosed in an hermetic casing to form a sealed unit having a refrigerant inlet connected by means of the conduit 21 with the evaporator and a compressed refrigerant outlet connected with the condenser, a suitable medium for lubricating the operating parts of the motor compressor unit being contained within the sealed casing of the unit.

The condenser 13 also may be of any suitable or preferred construction, preferably comprising a series of pipe coils formed with heat dissipating fins and arranged in a casing through which a cooling medium may be circulated past the pipe coils and fins for the purpose of absorbing heat from the condenser and the refrigerating medium passing therethrough. We prefer also to provide a suitable blower, preferably a fan, powered by an electric motor 27 by means of which air or other cooling fluid may be forced through the condenser for the purpose of cooling the same.

As heretofore mentioned, the refrigeration system of our present invention is particularly well adapted for use in domestic refrigerators, for which reason we prefer to provide means for operating the compressor driving and condenser cooling motor from a single phase alternating current electrical power source, since power of this character is most usually available for the operation of domestic refrigerators. It is obvious, however, that the compressor driving and condenser cooling means may be of any suitable or preferred construction, but we prefer to utilize electric motors which may be operated and controlled simultaneously from a common power source through a common control system, in order thus to avoid duplication of motor control elements. To accomplish the foregoing, we have shown on the drawings in Figure 3 a control system for operating electric motors 25 and 27 in parallel from a common power source. Each motor comprises a plurality of like windings 29 and 31 connected in parallel, the windings 29 being connected to receive alternating current electrical power from the power source without substantial change in phase while the windings 31 receive power from the source through a phase changer whereby each motor may operate as a polyphase machine. The windings of each motor are connected together at one end and to a common conductor 33. The opposite ends of the windings 19 of each motor are also connected together and to a common conductor 35, and the free ends of the windings 31 are connected together and to a common conductor 37. The common conductor 33 is connected to a terminal 39 located within a casing 41 which houses a part of the electrical supply and control system. The terminal 39 is connected by means of a conductor 42, preferably forming a part of a cable 43 which extends from the casing 41 to a thermostat control casing 45 located adjacent the evaporator. The opposite ends of the cable 43 may be provided with detachable plug connectors 47 and 49 to facilitate the electrical connections necessary between the electrical elements in the casings 41 and 45. The conductor 42 when the system is assembled for operation, forms a connection with one side of a switch 51, preferably located in a casing 45, which switch is opened and closed by thermostatic means 52 including the thermostat element 53, which extends in heat exchange relationship with the atmosphere adjacent the evaporator 15, so that the switch 51 may be operated in response to temperature conditions prevailing in the vicinity of the evaporator. The thermostatic means 52 also includes mechanism manually adjustable as by means of the control knob 55 which is preferably mounted on the casing 45 in order to determine the temperature prevailing in the vicinity of the evaporator at which the switch 51 will open or close. The switch 51 is in series with a manually operable switch 57, which also is or may be mounted on the casing 45, and which is connected by means of a conductor 59, preferably forming a part of the cable 43 to a terminal 61 in the casing 41. The terminal 61 is connected by means of a conductor, preferably forming a part of the cable 63, with means 65, preferably in the form of an electric plug of ordinary construction, adapted for removable insertion in a power outlet socket such as is usually provided in commercial or domestic power systems. The cable 63 has another conductor adapted for detachable connection in the external power delivery circuit which conductor connects with a terminal 67 within the casing 41. This terminal 67 is in turn electrically connected with one end of a solenoid 69, also located within the casing 41, the other end of which solenoid is connected with a terminal 71 within the casing 41. The terminal 71 is also connected with the common conductor 35. When the device 65 is connected in an external circuit, power will be delivered between the terminals 61 and 67 to energize a circuit extending between said terminals and including in series the solenoid 69, the conductor 35, the windings 29 of the motors 27 and 25, the common conductor 33, the conductor 42, the switches 51 and 57 and the conductor 59. This circuit, the switches 51 and 57 being closed, will deliver electrical power to the windings 29 of both motors, which power will be substantially in phase with the power source.

The terminal 67 is also connected by means of a conductor 73 with one end of an induction coil 75, the other end of which is also connected through a condenser 77 with the conductor 73, the conductor induction coil and condenser being all housed within the casing 41. The induction coil 75 has taps connected to stationary contacts 79 and 81 between which a shiftable blade 83 is movable in response to the current flowing through the solenoid 69. The blade 83 is electrically connected with the common con-

ductor 37, and is adapted to selectively connect the contacts 79 and 81 with said common conductor, and thence to the windings 31 of the motors in response to varying current flow in the solenoid 69. It will thus be seen that the motor windings 31 are included in a circuit extending from the terminal 67 through the conductor 73, the condenser-induction coil system 75—77, one or other of the contacts 79, 81, the conductor 37, the windings 31, and thence through the conductors 33 and 41, the switches 51 and 57, and the conductor 59 to the terminal 61. The reactive system comprising the induction coil 75 and condenser 77 is adapted to shift the phase of the power applied to the windings 31, so that these windings when so energized form with the windings 29, polyphase motor driving means.

The blade 83 is adapted to vary the reactive effect of the network comprising the induction coil 75 and the condenser 77. The motors preferably employed are of the so-called capacitor induction motors, the windings comprising split-phase windings adapted to be energized so that the motors may be started in operation from standstill position when energized with single phase alternating current applied between the terminals 61 and 67. It will be noted that both of the parallel circuits including the windings 29 and 31 are controlled by the switches 51 and 57, so that when the plug 65 is connected to a power outlet, the motors will remain inactive until both of the switches 51 and 57 have been closed. The switch 57 being manually operable, affords manual control for the motor while the switch 51 provides for automatic control, so that the motors and hence the refrigerating system, may be placed in operation automatically whenever the temperature in the vicinity of the evaporator rises above a predetermined value, which value may be determined by means of the knob 55. When the plug 65 is connected with an external power source, alternating current will be delivered through the parallel circuits heretofore mentioned, which includes the several windings of the motors. The current delivered to the windings 29, however, will have a different phase relationship with respect to that delivered to the windings 31 because of the reactive effect provided by the induction coil 75 and the condenser 77. In this way a rotating field may be created in the motors for the purpose of starting the same. At the instant of starting, the switch 83 will engage one or other of the contacts 79, 81 in order that the proper phase relationship to start the motors will prevail in the current delivered to the windings. As the motors reach normal operating speed, the current flowing in the coils 69 will decrease, and the switch 83 will be moved under the influence of the solenoid, and will engage the other of said contacts 79, 81, in order to alter the reactive effect produced upon the current flowing to the motor windings 31, and thus to provide a desired phase relationship of current flowing in the windings for maximum operating efficiency after the motors have reached normal operating speed.

The electrical system also includes a circuit 85 containing a lamp 87, and a switch 89, said circuit being connected between the conductor 59 of the cable 43, and another conductor 91 forming a part of said cable, and connected to the terminal 67, so that whenever the plug 65 is connected to the external power source, the lamp 87 will be energized providing the switch 85 is closed. The lamp 87 is or may be arranged in any suitable or convenient position within the refrigerator compartment, while the switch 89 is arranged to cooperate with the door giving access to the compartment. The door, when closed, is arranged to hold the switch 89 in open position, the switch closing to energize the lamp and illuminating the interior of the refrigerator compartment whenever the door is opened.

As heretofore mentioned, the motor-compressor unit, the condenser, condenser cooling motor, the float valve, the dehydrator, and the mechanism contained in the housing 41, are mounted on the panel 64 for assembly as a unit in the mechanism compartment, while the evaporator and the control mechanism, supported in and by the casing 45, which is mounted on the evaporator, may be assembled as a unit in the refrigerating compartment 58. The cable 43 and the refrigerant conduit 21 and 23 are preferably built into the insulated walls of the cabinet in position to facilitate the necessary connections with the evaporator and the apparatus within the mechanism compartment after the same have been assembled in the cabinet. This arrangement greatly simplifies the assembly of the refrigerating system in the cabinet, and thus reduces manufacturing costs.

The evaporator also is of simple and inexpensive construction, being preferably formed of sheets 97 and 99 of heat conducting material. These sheets are formed in such a way, that when fitted and secured together, passages in which the refrigerant may be evaporated are formed between the sheets. To this end the sheet 97 is formed with spaced header forming depressions 101 and 102 near the opposite end edges of the sheet, and one of the sheets is provided with a series of parallel duct forming grooves 103 so that when the sheets are fastened together, the depressions and grooves form spaced header chambers 111 and 112 interconnected by a plurality of parallel ducts 104. The depressions 101 and 102 and the grooves 103 are preferably formed in the sheet 97 and the other sheet 99 is assembled in position to overlie the depressions 101 and grooves 103, the sheets being secured together as by curling the edge of one sheet about the edge of the other, as shown at 105, and by welding around the peripheral edges of the sheets and between the grooves 103 to form a closed refrigerant space defined, between the plates, by the header forming depressions and interconnecting grooves. The sheet 99, also, is preferably formed with depressions 107 and 109 in position respectively opposite the depressions 101 and 102, so that the depressions 101 and 102 cooperate, in the evaporator unit, respectively, with the depressions 107 and 109 to form the elongated cylindrical header chambers 111 and 112. One of the sheets, preferably the sheet 99, is also formed at intervals with depressions or grooves 113, forming ducts 114 intersecting and communicating with the ducts 104. After the formed sheets 97 and 99 have been secured together in substantially flat condition, they may be bent to provide a channel-shaped evaporator element having a cross-sectional configuration substantially as shown in Figure 5 of the drawings, and comprising spaced apart side walls 115 and a bottom wall 117, the side walls containing the header chambers, with the refrigerant ducts 104 extending beneath the header spaces in the side walls 115 and in the bottom wall 117. The ridges 113 project inwardly of the facing surfaces of the walls 115, and form pairs of registering ridges on and between which objects to be cooled may

be supported. In Figure 5 of the drawings we have indicated in dotted lines an object comprising a tray 119, adapted to contain liquid to be refrigerated, mounted between the walls 115 and supported on a shelf 121, the opposite edges of which rest upon and are supported by a pair of the ridges 113. The shelves 121 may have downwardly extending lugs 122 struck from the material thereof and curved to fit the ridges 113 whereby the shelves may have slidable interfitting engagement with the ridges 113. The opposite ends of the sheets 97 and 99 form the upper edges of the spaced walls 115 of the evaporator unit and may be bent to form flanges 123, which may be perforated as at 125 to receive supports by which the evaporator is hung or otherwise mounted within the refrigerating chamber 58.

The evaporator also is provided with an inlet connection for liquid refrigerant which is preferably positioned to deliver the refrigerant to the evaporator at a point below the header chambers. To this end we utilize one of the shelf-supporting ridges 113 to form an inlet header. The ridge, so employed as an inlet header, is provided with an opening 125 at one end, and a fitting 127 having a channel 129 is secured to the evaporator with one end of the channel in communication with the header duct 114 defined by said ridge. The fitting is provided with preferably threaded means 131 whereby the channel 129 may be connected with the conduit 23 through which liquid refrigerant is delivered from the compressor, condenser and float valve. The fitting 127 is, of course, firmly sealed on the evaporator to prevent the escape of the refrigerating medium from the system at the point of entry, and we prefer to provide a pipe 133 extending within the inlet header duct 114 with one end of the pipe in communication with the channel 129 of the inlet fitting. The other end of the pipe 133 opens in the duct 114 opposite one of the refrigerant ducts 104 located substantially midway of the opposite ends of the evaporator, so that the refrigerant will enter the evaporator at said centrally located duct. We prefer to position the inlet fitting at the end of the evaporator opposite the end at which the containers 119 are introduced into and removed from the shelves 121, it being understood that the evaporator is mounted in the refrigerating compartment with one end facing the door to facilitate insertion and removal of objects through said door facing end. The inlet fitting also is preferably located entirely within the lateral confines of the evaporator walls in order to eliminate lateral projections.

The evaporator is also provided with an outlet for evaporated refrigerant which outlet is also located within the lateral confines of the evaporator walls and which preferably comprises a fitting 135 secured in an opening formed preferably in the sheet 99 at the header space 111. The fitting 135 has an extension comprising a pipe or conduit 137 extending within the chamber 111 and having an end opening above the normal liquid refrigerant level therein. The pipe 137 communicates with a channel in the fitting 135, and the fitting is formed with a preferably threaded portion 139 by means of which the channel may be connected with the refrigerant conduit 21 leading to the suction side of the compressor. The outlet fitting 135 may, of course, be connected in either or both of the headers, but we prefer to connect it in the header forming portion 107, and to interconnect the header chambers by means of a conduit 141 fastened to and between the header forming portions 107 and 109, whereby gasified refrigerant collecting in the header chamber 112 may escape through the conduit 141 into the header 111 and thence, through the outlet fitting, to the compressor. The connecting conduit 141 in addition to its gasified refrigerant conducting function, increases the strength and rigidity of the evaporator by assisting in holding the spaced walls 115 rigidly in spaced relationship. The conduit 141 also provides a convenient handle for carrying the evaporator unit and holding the same in position while it is being assembled in the cabinet.

When the evaporator is in operation in a refrigerating system, the level of the liquid refrigerant in the evaporator is normally maintained at an elevation in the headers as shown in Figure 5 of the drawings, the outlet pipe 137 opening above said level. The refrigerating medium which we prefer to use in the system, comprises dichloromethane, and we prefer to operate the system under pressure conditions such that the liquid refrigerant entering the evaporator will boil at the temperature prevailing in the vicinity of the evaporator, that is to say, within the refrigerating compartment. We prefer also to use a mineral oil for lubricating the compressor. This oil is insoluble in gaseous dichloromethane, but is soluble in the refrigerant when liquid. Even though lubricant is not soluble in dichloromethane when in gaseous condition, slight traces of the lubricant may escape from the compressor by entrainment with the compressed gaseous refrigerant discharged to the condenser. The gaseous refrigerant liquefies in passing through the condenser, and the entrained lubricant will then dissolve in the refrigerant, and we have found in operation that the liquid refrigerant delivered from the condenser contains appreciable traces of dissolved lubricant which is carried in solution with the refrigerant into the evaporator. The lubricant does not, of course, evaporate at temperatures prevailing at the evaporator, and since dichloromethane and other refrigerants, which may be utilized in systems embodying our invention, have the capacity of dissolving lubricant in any proportion, it will be apparent that, if no means is provided for extracting the dissolved lubricant from the evaporator, the lubricant in the system will eventually become concentrated in the evaporator and thus not only impair the lubrication of the compressor but also impair the efficiency of the evaporator. We consequently provide a lubricant separator and extractor which, in the illustrated embodiment, is formed as an integral part of the evaporator.

The lubricant separator and extractor comprises a tubular element 143 communicating at one end with the outlet fitting 135 and fastened at its other end, at a slightly higher elevation, in a wall defining one of the header chambers. The element 143 is preferably connected with the header forming wall 109, so that the lubricant extractor communicates with the header chamber 112 above the liquid refrigerant level therein, while the gasified refrigerant outlet pipe 137 communicates with the other header chamber 111. The end of the pipe 143 which is connected to the header is provided with a refrigerant collector 145, which is supported in the header immediately above the duct 103, in which the refrigerant inlet pipe 133 opens. The relatively cold liquid refrigerant entering the duct, at the open end of the inlet pipe 133, sets up a vigorous

boiling of the refrigerant in said duct. The vigorous boiling so initiated causes a certain amount of refrigerant, containing dissolved oil, to spatter above the refrigerant level in the header, and some of this spattered refrigerant drops into collector 145, from whence it drains into the tube 143. The lower surface of the tube 143 is provided with a plurality of corrugations 147, and since the tube is inclined downwardly toward the outlet fitting 135, the liquid refrigerant and dissolved lubricant will cascade progressively into the pockets provided in the tube by the corrugations 147. Since the corrugated portion of the tube extends outwardly of the evaporator, it is subjected to the relatively higher temperature of the surrounding atmosphere, and consequently, the refrigerant is rapidly evaporated in the tube and returns into the header through openings 149 formed in the tube, while the residual lubricant drains into the outlet fitting and is returned to the compressor through the conduit 21. The separated lubricant during its travel through the conduit 21 does go into solution with the gaseous refrigerant which is also returned to the compressor through said conduit, but the lubricant maintains its separate identity as such. The element 145 is preferably formed as a separate sheet metal stamping having a spatulate fluid receiving portion 151, and a fluid delivery portion 153 which is connected to the tube 143 and by which fluid, received in the receiving portion, is delivered into the tube. The lower portion of the inner end of the tube 143 is cut away as shown at 154 to receive the element 145. The spatulate portion of the element 145 has edges formed with an upstanding peripheral flange 155, and is also formed with perforations 157, the edges of which are embossed upwardly as at 159. The delivery portion 153 of the element 145 comprises an extension formed at one end of the spatulate portion 151, said extension having lateral notches defining the openings 149 and a restricted neck 161 between the lateral notches, the side edges of the extension 153 being fastened to the opposite sides of the tube 143 at the cut-out edges of the same. The end of the extension 153 opposite from the spatulate portion 151 is bent downwardly to form a lip 163 having a circular edge conforming with and secured to the tube at the end of the cut-out portion. The inner end of the tube 143, above the element 145, is closed by means of a semi-circular disk 165. The upper curved edge of the disk fits within and is secured to the upper end edge of the tube 143. The lower edge of the disk is cut to form a restricted opening or throat 167 through which the liquid delivered from the portion 151 passes into the tube 143. The perforations 157 in the spatulate portion 151 permit a portion of the refrigerant spray falling within the flanges 155 to return to the refrigerant body within the evaporator, so that only a part of the liquid sprayed into the spatulate receiver will drain through the throat 167. The liquid passing through the throat 167, in order to enter the corrugated portion of the tube 143 must also pass across the neck 161, so that only so much of the liquid as is retained by surface tension on the neck is delivered into the corrugated portion of the tube 143. The liquid not so retained upon the restricted neck 161 returns to the main body to lubricant in the headers through the openings 149.

It will be seen that the openings 157 and the restricted neck 161 both serve to limit the amount of liquid passing into the separator tube 143 from the evaporator, and that the throat 167, by causing the liquid to flow onto the delivery portion 153 as a film of uniform thickness and width, assists the neck 161 to perform its flow restricting function. It is desirable to thus restrict the quantity of liquid delivered to the tube 143 in order not to sacrifice the refrigerating energy. By properly proportioning the size of the apertures 157 and the width of the neck 161, we permit only enough liquid to be delivered in the separator tube 143 as is necessary to eject lubricant from the evaporator as fast as it is introduced at the inlet.

It is thought that the invention and its numerous attendant functions and advantages will be understood from the foregoing description; and it is obvious that numerous changes may be made in the form, construction and arrangement of the several parts of the illustrated apparatus without departing from the spirit and scope of the invention, and without sacrificing any of its attendant advantages, the embodiment herein shown being merely a preferred arrangement for the purpose of illustrating our inventive concept.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. An evaporator or boiler comprising means forming an evaporator space adapted to contain an evaporable liquid at a predetermined level therein, means to exhaust, from the evaporator, gases evolved as a result of the evaporation of liquid in the evaporator, means for extracting a non-evaporable constituent of the liquid in the evaporator comprising a receiver element within the evaporator in position above the liquid level therein, to receive liquid containing the unevaporable constituent by spattering as a result of the ebullition of the evaporable constituent of the liquid in the evaporator, and means forming a drain for removing liquid in the receiver from the evaporator, said receiver being formed with a narrowed portion across which the liquid therein drains from the evaporator so that only so much of the liquid as may be retained on the narrowed portion by surface tension escapes from the evaporator.

2. An evaporator or boiler comprising means forming an evaporator space adapted to contain an evaporable liquid at a predetermined level therein, means to exhaust, from the evaporator, gases evolved as a result of the evaporation of liquid in the evaporator, means for extracting a non-evaporable constituent of the liquid in the evaporator comprising a receiver element within the evaporator in position above the liquid level therein, to receive liquid containing the unevaporable constituent by spattering as a result of the ebullition of the evaporable constituent of the liquid in the evaporator, and means forming a drain for removing liquid in the receiver from the evaporator, said drain comprising a conduit comprising a series of pockets into which the liquid delivered therein may successively flow, said conduit extending out of the evaporator and communicating with the interior of the evaporator in position to receive liquid from the receiver, whereby the evaporable constituent of liquid received in the pockets of the conduit may be rapidly evaporated due to the relatively higher temperature of the conduit means outside of the evaporator and returned to the evaporator above the liquid level therein, while the non-evaporable constituent is removed from the evaporator through said drain.

3. An evaporator or boiler comprising means forming an evaporator space adapted to contain an evaporable liquid at a predetermined level

therein, means to exhaust, from the evaporator, gases evolved as a result of the evaporation of liquid in the evaporator, means for extracting a non-evaporable constituent of the liquid in the evaporator comprising a receiver element within the evaporator in position above the liquid level therein, to receive liquid containing the unevaporable constituent by spattering as a result of the ebullition of the evaporable constituent of the liquid in the evaporator, and means forming a drain for removing liquid in the receiver from the evaporator, said drain means comprising a conduit having a series of pockets into which the liquid delivered by the receiver may successively flow to permit the evaporable constituent to be rapidly separated from the unevaporable constituent by evaporation and the unevaporable constituent to be removed from the evaporator.

4. An evaporator or boiler comprising sheet metal means forming an evaporator space comprising a header and a duct opening into the header, said evaporator being adapted to receive an evaporable liquid therein to a desired level in the header, extractor means comprising a receiver element disposed in said header above the liquid level therein and opposite said duct, and means for delivering an evaporable liquid into said duct at a point removed from said header whereby to produce vigorous ebullition of the liquid immediately beneath the receiver element, a suction connection on said evaporator above the liquid level in said header, and means forming a conduit for draining liquid from the receiver element to said suction connection, said conduit means forming a plurality of pockets through which liquid, drained from the receiver element, successively cascades whereby to permit evaporation of the evaporable constituent of said liquid.

5. An evaporator or boiler comprising sheet metal means forming an evaporator space comprising spaced headers and a plurality of ducts opening at their opposite ends in the headers, said evaporator being adapted to receive an evaporable liquid therein to a predetermined level in said headers, extractor means in at least one of said headers comprising a receiver element disposed above the liquid level therein substantially opposite at least one of said ducts, means for delivering liquid into the duct opening in said header opposite said receiver element whereby to produce vigorous ebullition of the liquid beneath said receiver element, means interconnecting said headers above the liquid level therein, a suction connection in the other of said headers than that containing the receiver element, and means comprising a pipe connecting with said suction connection outwardly of said evaporator and extending through the wall of the header containing the receiver element, said receiver element being arranged to drain into said pipe to deliver liquid from the receiver into said conduit and thence into the suction connection.

6. An evaporator as set forth in claim 5, wherein the pipe, outwardly of the evaporator, forms a series of pockets through which the liquid, drained from the receiver element, successively cascades whereby to permit evaporation of the evaporable constituent of said liquid to the end that the non-evaporable constituent of the liquid may be delivered to the suction connection in liquid condition.

7. A flooded evaporator for a refrigerating machine, said evaporator including a header for separating liquid and gaseous refrigerant, a refrigerating circulating conduit communicating with said header, means for admitting refrigerant to said evaporator, and means for withdrawing a mixture of refrigerant and lubricant entrained therein from said header, said means including a series of pockets arranged to permit the evaporation of liquid refrigerant from the mixture passing through the pockets and to cause the residual liquid to flow progressively from one end of the series of pockets to the other toward the outlet end of the withdrawing means.

MAHLON W. KENNEY.
ARTHUR R. CONSTANTINE.