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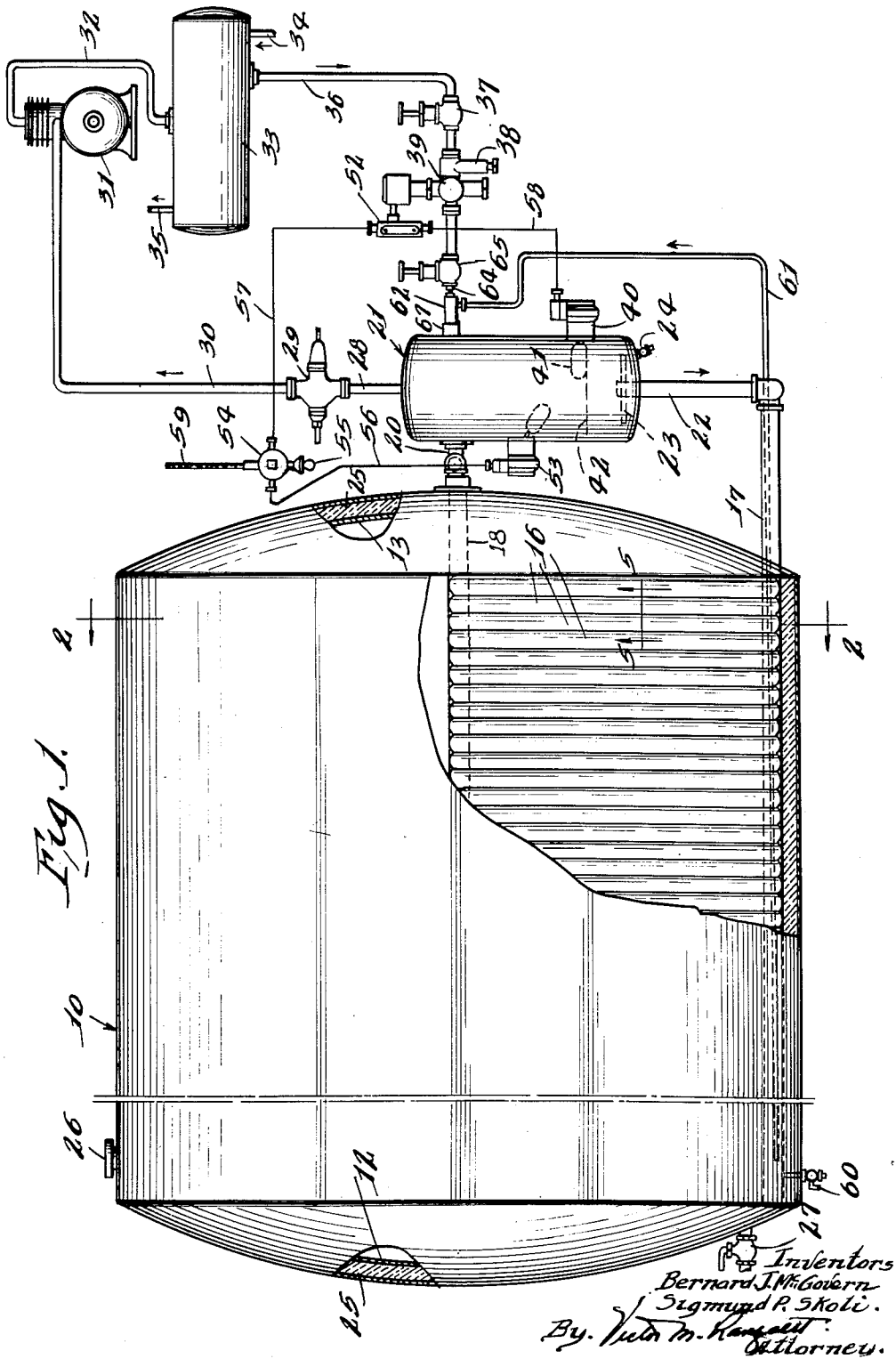
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EVAPORATOR STRUCTURE IN REFRIGERATING APPARATUS

Filed March 20, 1950

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Fig. 2.

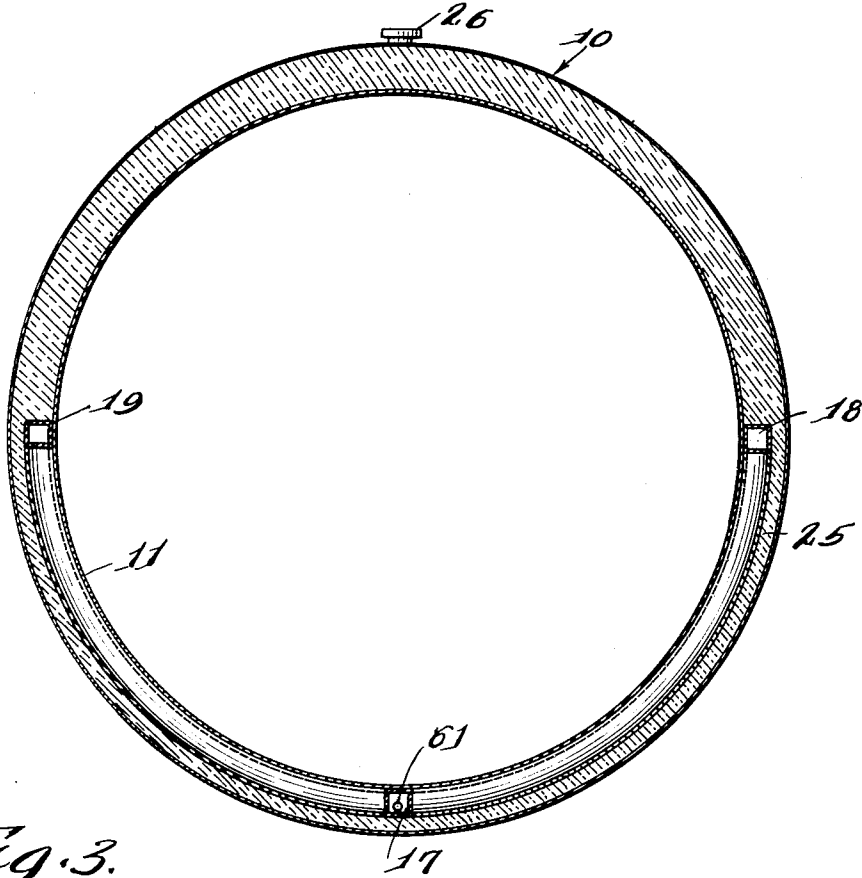
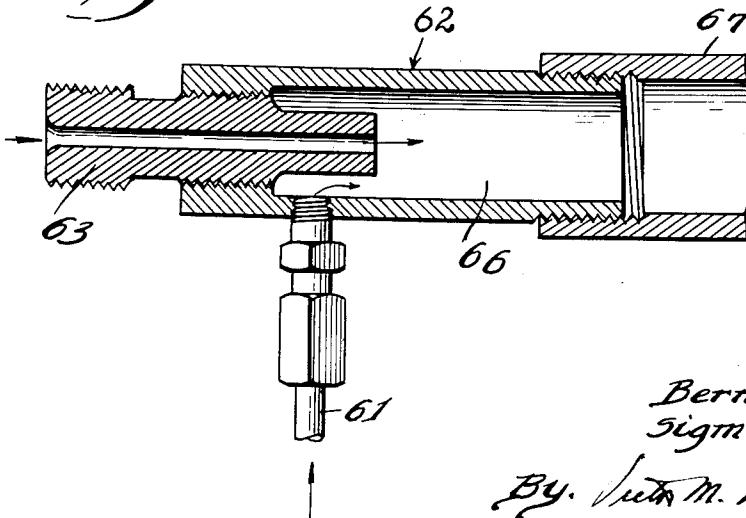


Fig. 3.

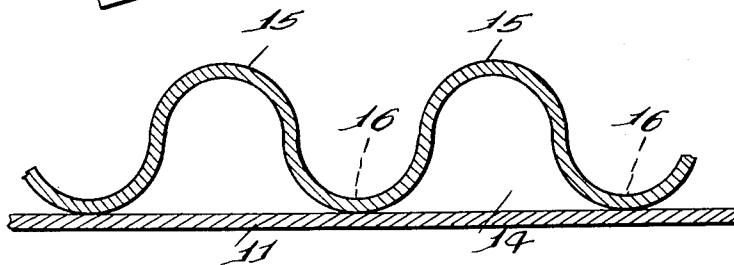


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UNITED STATES PATENT OFFICE

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EVAPORATOR STRUCTURE IN REFRIG-
ERATING APPARATUS

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11 Claims. (Cl. 62—3)

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This invention relates to refrigeration apparatus and more particularly to an apparatus including a refrigerated tank and the apparatus associated therewith for maintaining certain refrigeration operating conditions.

For the cooling of large bodies of liquid, and particularly food products or materials used in food products, it has been found advantageous to avoid the use of refrigerating coils immersed in the liquid product. It is preferred to employ tanks having smooth inner walls, which lend themselves readily to cleaning and sterilizing, and provide on the exteriors of such walls the refrigeration pipes or other ducts which are used to perform the cooling of the product contained within the tank. In order to provide efficient refrigeration and close control thereover we prefer to provide on the outside of such a tank a plurality of independent ducts or passages entered from one or more common headers and exhausting their expanded refrigerant gases into one or more common outlet headers.

We have further found that high refrigeration capacity may be attained without completely flooding such refrigerant ducts, but that substantially the equivalent refrigeration capacity of flooded ducts can be maintained by maintaining the true liquid level of the liquid refrigerant at substantially less than the total height of the upwardly extending independent ducts, and causing the foam evolving at the surface of the refrigerant in each refrigerant duct to move upwardly through the remainder of that duct to the outlet header. The foam, consisting of liquid film surrounding saturated bubbles of the refrigerant gas, will ordinarily have about the same temperature as the liquid from which such bubbles evolve and will perform in the upper portions of the refrigerant ducts a large amount of refrigerating effect. On the other hand, were the refrigerant being boiled in a relatively open space, rather than in the narrow confined passages which are afforded by the ducts such as those herein shown, the bubbles evolving at the refrigerant liquid surface would burst and return to the liquid quite readily and without performing any refrigerating effect.

In accordance with our invention apparatus is provided and controls are utilized which confine this foam in rising columns where it performs a refrigerating effect. Hence, the total amount of refrigerant required to be maintained in a system constructed in accordance with our invention may be considerably less than that which is required for an ordinary fully flooded system,

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and also a smaller surge tank for retaining the refrigerant outside of the refrigerating tank will suffice.

Another advantage arising out of the use of our invention instead of a fully flooded evaporator is that during periods of rapid boiling of the refrigerant, as does occur during initial cooling of a batch of liquid product having an initial relatively high temperature, less foam and liquid refrigerant will escape into the outlet headers and less difficulty is had in separating the liquid and gas particles of the refrigerant in the surge tank to prevent entrainment of liquid refrigerant into the compressor line flowing into the compressor.

Another advantageous feature incorporated in our invention is the isolation and automatic recovery of oil which may be carried in the refrigerant from the compressor and which generally tends to accumulate in the evaporator spaces in the refrigerant tank.

The general object of the invention is to provide in a refrigeration apparatus the foregoing features and advantages.

Particular objects and advantages of the invention will be specifically mentioned hereinafter or will become apparent from a reading of the specification in which a preferred embodiment of the invention is illustrated and described.

In the drawings—

Fig. 1 is a somewhat diagrammatic illustration of an apparatus made in accordance with this invention, with a portion of the refrigerating tank shown in section.

Fig. 2 is a vertical sectional view on the line 2—2 of Fig. 1.

Fig. 3 is a sectional detail view of an injector for recovering oil accumulating in the refrigerating ducts of the refrigerating tank.

Fig. 4 is a sectional view of the float controlled magnetically operated switch used in connection with the surge drum.

Fig. 5 is a partial sectional view along the line 5—5 of Fig. 1.

Referring further to the drawings, the tank generally indicated as 10 is a tank provided for the cooling of large bodies of liquid, frequently liquid food products or products used in foods, and is preferably made of stainless steel, including an inner cylindrical wall 11 formed of stainless steel and stainless steel end walls 12 and 13.

As shown in Figs. 1, 2 and 5, evaporator ducts generally indicated as 14 are provided on the exterior of the tank shell by forming a sheet of corrugated metal having corrugations such as 15

and seam welding the corrugated sheet to the tank wall 11 along the lines 16, thereby forming relatively narrow confined ducts 14 between the corrugations and the tank wall.

At the bottom of the tank, extending horizontally, is a common inlet header 17 opening into all of the evaporator ducts for supplying liquid refrigerant thereto, this header comprising a pipe or tube of any appropriate configuration opening into each of the ducts 14 and having welded junctures therewith. The details of construction of this header or the outlet headers and the manner of joining them with the ducts 14 does not constitute a part of this invention and may follow any appropriate mechanical construction suitable for the purpose.

At the upper ends of the ducts 14 are outlet headers 18 and 19 connected with each of the ducts 14 for collecting refrigerant vapor rising in such ducts and for delivering such vapor into a pipe 20 and then into the surge drum 21. Since the outlet headers 18 and 19 run horizontally along opposite sides of the tank 10 they will be brought together beyond the end of the tank in the form of a yoke, joining and emptying into the pipe 20.

At the lower end of the surge drum 21 a refrigerant outlet pipe 22 is provided extending upwardly into the drum a short distance above a circular baffle plate 23, below which is left a small space for the accumulation of lubricating oil which may become mixed with the refrigerant. A drain cock 24, as indicated, is provided for the occasional discharge of such oil as accumulates in the surge drum. The refrigerant pipe 22 connects with the inlet member 17 and delivers liquid refrigerant thereinto.

It should be noted that the upper end of the surge drum is higher than the upper ends of the evaporator ducts while the lower end of the drum is positioned somewhat lower than the predetermined liquid level which, as explained hereinafter, is to be maintained in the drum, below the middle level of the evaporator ducts.

Preferably the corrugated refrigerating ducts are completely embraced on their exteriors, along with the rest of the entire tank 10, by a layer of insulation 25, such as cork or other appropriate insulating material, and the tank itself is provided with a filling opening 26, and a discharge valve 27. Such other usual equipment as manhole openings and covers for cleaning, thermometers, pressure gages, etc. which are usually supplied with such tanks, do not form a part of this invention and hence are not herein shown.

The refrigerating gas or vapor is withdrawn from the surge drum 21 through a pipe 28 through a suction regulating valve 29 thence through pipe 30 to the compressor 31 which compresses the gas and delivers it through pipe 32 into a condenser 33, which may be of standard construction, cooled by the flowing of water through the condenser entering through pipe 34 and emerging through pipe 35. The cooled condensed or liquefied refrigerant is then returned through pipe 36 through a manually operated valve 37, through the scale trap 38 and thence to the pilot operated valve generally indicated as 39 which is electrically controlled, preferably, although it may be otherwise controlled, for admitting the liquid refrigerant from the condenser into the surge tank 21.

As stated heretofore, it is an object of this invention to provide the advantages of flooded

refrigeration without the necessity of completely flooding the evaporating tubes or ducts 14. In accordance therewith, float controlled switch 40 is positioned on the surge tank 21 as shown with the float element 41 positioned at such a level as to maintain in the surge tank a liquid level at the dotted line 42 and thereby a correspondingly substantially equal level in the ducts 14. The rest of the space in the ducts above this liquid level, when the apparatus is operating, ordinarily will be occupied by foam or froth rising from the refrigerant boiling in the evaporator tubes, these bubbles usually breaking as or before they encounter the header outlets 18 and 19.

The switch 40 is shown in greater detail in Fig. 4 and includes the float element 41 mounted on the rod 43 pivoted on a horizontal pivot pin 44 secured in the valve casing, the outer end of the rod 43 being pivotally connected at 45 to a link 46 pivotally connected to a steel disk 47 mounted for vertical reciprocation in vertically extending recess 48 in the non-magnetic housing 49. Mounted above and outside of the housing 49 is a permanent magnet 50 which is mounted for vertical movement in a switch structure, not herein shown in detail, but permitting the magnet 50 to be drawn downwardly against the top of the housing member 49 whenever the disk 47 rises to the top of the passage in which it moves. When the magnet 50 drops down by being attracted by the disk 47 it causes a switch mechanism mounted within the casing 51 to be actuated to close a circuit which is connected with a solenoid contained within the housing 52, thus causing the solenoid operated valve 39 to be opened.

When the float 41 rises to a predetermined control level the steel disk 47 is retracted from the magnet 50, breaking the magnetic attraction between the two and a light spring in the switch causes the magnet to rise, and the circuit which held the solenoid of valve 39 energized will be opened and that valve will close. Switch mechanisms operating in accordance with the above described functions are well known in the art, hence require no further description herein.

The details of construction of the solenoid operated valve 39 do not constitute a part of this invention, hence are not shown, but it may be stated that preferably this valve is normally closed by gravity or spring action and opened by the energizing of the solenoid, which latter action occurs whenever the float 41 has been lowered by the falling of the liquid level in the surge tank below the line 42, or under extraordinary circumstances even when the float 41 is raised to normal switch operating position but the switch for some reason fails to open the circuit to the solenoid. The valve 39, when opened by the solenoid, opens to an adjusted wide open position, the size of the orifice in nozzle shown in Fig. 3 being relied upon for throttling the flow of liquid refrigerant to the surge drum.

Briefly, when the liquid level reaches the dotted line 42, the raising of the float element 41 acting through the magnetic switch 40 will close the pilot or solenoid operated valve 39, stopping the flow of liquid refrigerant into the surge drum. When the liquid level drops below the line 42 the reverse operation will occur and more liquid refrigerant will be supplied to the surge drum. As a precautionary measure another float operated switch 53 is provided, as shown at a higher

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level on the surge drum. Should the magnetic switch 51 have failed to cut off the admission of liquid refrigerant to the surge drum when it should have operated, the float controlled magnetically operated switch 53 will serve to close the valve 39, and at the same time operate a warning signal 54. The float controlled magnetic switch 53 may be of the same type as that shown in Fig. 4, while the details of construction of the warning signal do not form a part of this invention and may consist of any suitable electrically operated sound making device, and may even include, if desired, a signal light such as a light bulb 55.

The lines 56, 57 and 58 represent schematically the electrical cables employed in the operation of the switches, warning signal and solenoid, and the cable 59 leads to the power supply. The solenoid valve itself will be recognized by those skilled in the art as standard equipment readily available on the market.

In commercial practice, a small amount of lubricating oil will be absorbed by the refrigerant in its passage through the compressor and will be carried along in the liquid refrigerant into the pipe 22, thence into the bottom inlet header 17. This oil will tend to separate out from the liquid refrigerant carried in the header and in the upwardly extending evaporation ducts 14 and accumulate in the bottom of the header 17. The processing tank 10, which is a generally cylindrical tank, usually is mounted in a slightly inclined position so that the liquid product chilled therein may all effectively be drained through the outlet valve 27.

For simplicity in construction the header 17 will be parallel to this slightly inclined inner wall of the tank, hence oil accumulating in the header will tend to be drained toward that end of the tank which is adjacent the valve 27.

While a pet cock 60 is provided as shown connected to the lower end of the header for manual draining of the oil from that header and may be used upon occasion when the apparatus is being emptied, it is preferred that the oil be constantly automatically returned to the surge drum and for this purpose we insert a pipe 61 into the header 17, and position the open end of the pipe at the lowest point in the header. The pipe 61, at its other end, is connected to the ejector generally designated as 62 having an ejector nozzle 63 connected by a union 64 to the normally open hand operated valve 65 through which the liquid refrigerant is flowing toward the surge tank when the valve 39 is open. The aspirating chamber 66 is then connected by a short pipe 67 to empty into the surge drum as shown. Hence, whenever the valve 39 is open and liquid refrigerant is being forced by pressure in the high pressure side of the refrigerating system through the ejector nozzle 63, oil whether mixed or not with liquid refrigerant will be aspirated through the pipe 61 and discharged into the surge drum 21. Thus excessive accumulations of oil in the evaporation tubes is prevented.

The baffle plate 23, shown in the surge drum, is provided to permit oil during quiescent periods to drop down to the bottom of the surge drum and accumulate below the baffle plate from which space such oil may be evacuated whenever necessary through valve 24.

While we have shown in the drawings and described in considerable detail the preferred embodiment of our invention, it should be understood that the invention is susceptible of some

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changes and variations without departing from the novel concept defined in the claims.

We claim as our invention:

1. In a refrigeration apparatus, a cooling tank, a refrigerant inlet header positioned on the exterior of the bottom surface of said tank, evaporator ducts communicating with said header and rising therefrom on the exterior of said tank, an outlet header on the exterior of said tank in communication with the top end of each duct, a refrigerant surge tank positioned adjoining the cooling tank and having the lower end of its refrigerant holding space located at a level well below the top level of said ducts and the top of said space higher than the top level of said ducts, conduits unrestrictedly connecting each header with the surge tank, a compressor connected with the upper end of the surge tank for withdrawing refrigerant vapor therefrom and compressing it, a refrigerant condenser connected with the compressor, conduit means connecting the condenser and surge tank, a solenoid operated valve interposed in said conduit means, a float controlled switch mechanism electrically connected with the solenoid of said valve and connected with the surge tank having a float element within said surge tank operatively controlled by the liquid level in the surge tank and positioned at such a level as to actuate the switch mechanism to effect closing of said valve when the liquid level in the surge tank lies intermediate the top and bottom level of said evaporator ducts.

2. In a refrigeration apparatus, a cooling tank having in heat exchange relation with the interior of the tank, a plurality of upwardly extending refrigerant evaporator conduits, each conduit having walls defining a duct of such restricted cross-sectional area that refrigerant foam arising in each of said conduits during boiling of a body of liquid refrigerant in the lower ends of said conduits, rises in foam condition throughout substantially the remaining height of said conduits; means for supplying liquid refrigerant by gravity flow into the lower ends of said conduits; means for evacuating refrigerant vapor from the upper ends of said conduits; and float controlled means for regulating and maintaining the level of the liquid refrigerant in the conduits at a level substantially below the top ends of said conduits.

3. In a refrigeration apparatus, a cooling tank having in heat exchange relation with the interior of the tank, a plurality of upwardly extending refrigerant evaporator conduits, each conduit having walls defining a duct of such restricted cross-sectional area that refrigerant foam arising in each of said conduits during boiling of a body of liquid refrigerant in the lower ends of said conduits, rises in foam condition throughout substantially the remaining height of said conduits; means for supplying liquid refrigerant by gravity flow into the lower ends of said conduits; means for evacuating refrigerant vapor and liquid from the upper ends of said conduits; and float controlled means for regulating and maintaining the level of the liquid refrigerant in the conduits at a level substantially about midway between the top and bottom levels of the ends of said conduits.

4. In a refrigeration apparatus, a cooling tank having in heat exchange relation with the interior of the tank, a plurality of upwardly extending refrigerant evaporator conduits, each conduit having walls defining a duct of such restricted cross-sectional area that refrigerant

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foam arising in each of said conduits during boiling of a body of liquid refrigerant in the lower ends of said conduits, rises in foam condition throughout substantially the remaining height of said conduits; a surge tank so positioned relatively to said cooling tank that the upper end of said surge tank is at a level above the upper ends of said conduits and the lower end of said surge tank is below the upper ends of said conduits; a refrigerant inlet header connected for supplying liquid refrigerant by gravity flow from the surge tank into the lower ends of said conduits; a vapor and refrigerant outlet header connecting the upper ends of said conduits and said surge tank; and means for supplying liquid refrigerant to said surge tank including means for regulating and limiting the liquid level in said surge tank at a level substantially below the top ends of said conduits.

5. In a refrigeration apparatus, a cooling tank having in heat exchange relation with the interior of the tank, a plurality of upwardly extending refrigerant evaporator conduits, each conduit having walls defining a duct of such restricted cross-sectional area that refrigerant foam arising in each of said conduits during boiling of a body of liquid refrigerant in the lower ends of said conduits, rises in foam condition throughout substantially the remaining height of said conduits; a surge tank so positioned relatively to said cooling tank that the upper end of said surge tank is at a level above the upper ends of said conduits and the lower end of said surge tank is below the upper ends of said conduits; a refrigerant inlet header connected for supplying liquid refrigerant by gravity flow from the surge tank to the lower ends of said conduits; a vapor and refrigerant outlet header connecting the upper ends of said conduits and said surge tank; and means for supplying liquid refrigerant to said surge tank including means for regulating and limiting the liquid level in said surge tank at a level substantially about midway between the top and bottom ends of said conduits.

6. In a refrigeration apparatus, a cooling tank having in heat exchange relation with the interior of the tank, a plurality of upwardly extending refrigerant evaporator conduits, each conduit having walls defining ducts of such restricted cross-sectional area that refrigerant foam arising in each of said conduits during boiling of a body of liquid refrigerant in the lower ends of said conduits, rises in foam condition throughout substantially the remaining height of said conduits; a surge tank so positioned relatively to said cooling tank that the upper end of said surge tank is at a level above the upper ends of said conduits and the lower end of said surge tank is below the upper ends of said conduits; means, including an outlet header, connecting said upper ends of said conduits and said surge tank; a refrigerant inlet header connected for supplying liquid refrigerant by gravity flow from the surge tank to the lower ends of said conduits; a tube extending from within the lowermost portion of said inlet header and beyond the exterior of said header; an ejector connected with the exterior portion of said tube; and means for supplying and discharging liquid refrigerant through the ejector to the surge tank and simultaneously aspirating lubricating oil through said tube from the bottom of the inlet header and delivering it into said surge tank along with the refrigerant.

7. In a refrigeration apparatus, a cooling tank having in heat exchange relation with the in-

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terior of the tank, a plurality of upwardly extending refrigerant evaporator conduits; a surge tank having its upper end disposed relatively to the cooling tank above the level of the upper ends of said conduits; means, including an outlet header, connecting said upper ends of said conduits and said surge tank; an inlet header connecting the surge tank and the lower ends of said conduits for delivering liquid refrigerant thereto by gravity flow, said inlet header being inclined from the horizontal to provide a lower end in which lubricating oil may collect; a tube extending into said inlet header having an apertured end portion wholly within the lower end portion of and extending beyond the exterior of said header; means including a conduit for supplying liquid refrigerant under pressure into said surge tank; and an injector disposed in said last mentioned conduit connected with the exterior portion of said tube and conducting said refrigerant supply through said injector, simultaneously aspirating lubricating oil from said tube and injecting it along with liquid refrigerant into the surge tank.

8. In a refrigeration apparatus, a cooling tank having in heat exchange relation with the interior of the tank, a plurality of upwardly extending refrigerant evaporator conduits; a surge tank having its upper end disposed, relatively to the cooling tank, above the level of the upper ends of said conduits; means, including an outlet header, connecting said upper ends of said conduits and said surge tank; a refrigerant inlet header connected with the surge tank and consecutively with the lower ends of said conduits, said inlet header being inclined downwardly toward its terminal end; a relatively small tube extending into said inlet header and having an apertured end portion disposed in the bottom space of said terminal end of said header where oil may gravitationally accumulate; means, including a conduit, for supplying liquid refrigerant under pressure into said surge tank; and an injector disposed in the last mentioned conduit connected with said tube aspirating lubricating oil from said tube and injecting it along with liquid refrigerant into the surge tank.

9. In a refrigeration apparatus, a cooling tank having in heat exchange relation with the interior of the tank, a plurality of upwardly extending refrigerant evaporator conduits; a surge tank having its upper end disposed relatively to the cooling tank above the level of the upper ends of said conduits; means, including an outlet header, connecting said upper ends of said conduits and said surge tank; a refrigerant outlet pipe disposed for withdrawing liquid refrigerant from the surge tank at a level substantially above the bottom of said tank; a refrigerant inlet header connected with said pipe and consecutively with the lower ends of said conduits, said inlet header being inclined downwardly toward its terminal end; a relatively small tube extending into said inlet header and having an apertured end portion disposed in the bottom space of the terminal end of said header where oil may gravitationally accumulate; means, including a conduit, for supplying liquid refrigerant under pressure into said surge tank; and an injector disposed in the last mentioned conduit connected with said tube for aspirating lubricating oil from said tube and injecting it along with liquid refrigerant into the surge tank.

10. In a refrigeration apparatus, a cooling tank having an inlet header on the bottom of the tank

and evaporator conduits connected with and rising therefrom, the bottom wall surface of said header being inclined to a low point to facilitate gravity accumulation of oil thereat; an outlet header connected with the upper ends of said conduits; a surge drum unrestrictedly connected with each header and positioned to extend from above the level of the top ends of said conduits to a level about midway of the vertical extent of said conduits; means for withdrawing from the upper end of the drum, refrigerant vapor for compression and condensing; means for delivering liquid refrigerant under pressure to said drum; means for regulating said delivering means to maintain a liquid level in the surge drum, and thereby hydrostatically a liquid level in said conduits, at a level substantially below the upper ends of said conduits; a relatively small oil recovery tube having an open end positioned within said inlet header at said low point; and an injector positioned in said delivering means connected with said tube, the liquid refrigerant delivered through said injector under pressure to said drum, aspirating oil from said tube and delivering it into said drum.

11. In a refrigeration apparatus, a cooling tank having in heat exchange relation with the interior of the tank, a plurality of upwardly extending evaporator conduits; a surge tank having its upper end disposed, relatively to the cooling tank, above the level of the upper ends of said conduits; an outlet header connecting said upper ends of said conduits and said surge tank; an inlet header connecting the surge tank and the lower ends of

said conduits for delivering liquid refrigerant thereto, said inlet header being inclined from the horizontal to provide a lower end in which lubricating oil may collect; a tube extending into said inlet header having an apertured end portion in the lower end portion of said header; means including a conduit for supplying liquid refrigerant under pressure into said surge tank; an injector disposed in said last mentioned conduit connected with said tube for aspirating lubricating oil from said tube and injecting it along with liquid refrigerant into the surge tank; and means for withdrawing said oil gravitationally collecting in the bottom of said surge tank.

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