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ART OF SEPARATING OIL IN REFRIGERATION SYSTEMS

Filed April 4, 1936

2 Sheets-Sheet 1

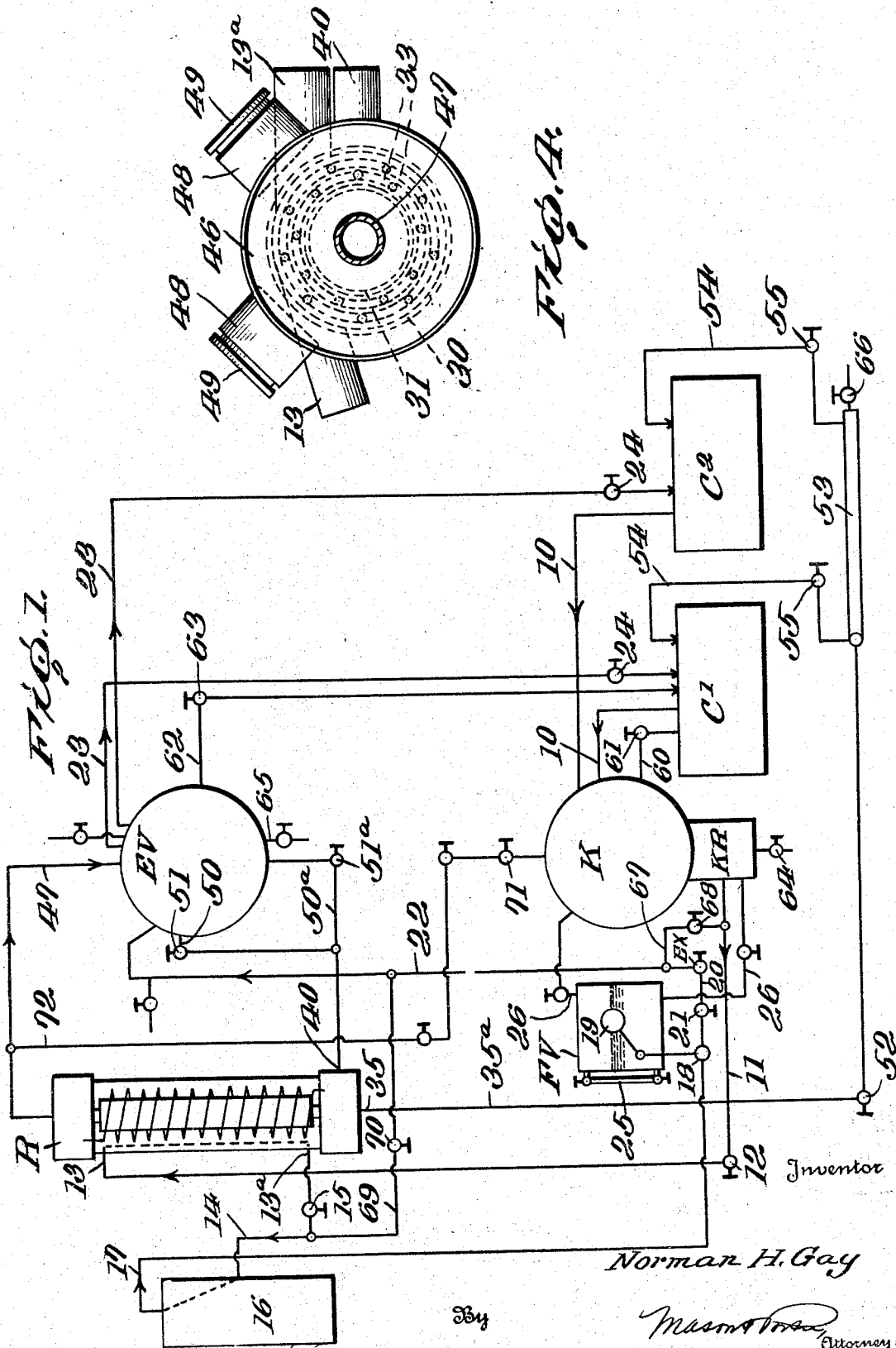


Fig. 1.

Fig. 2.

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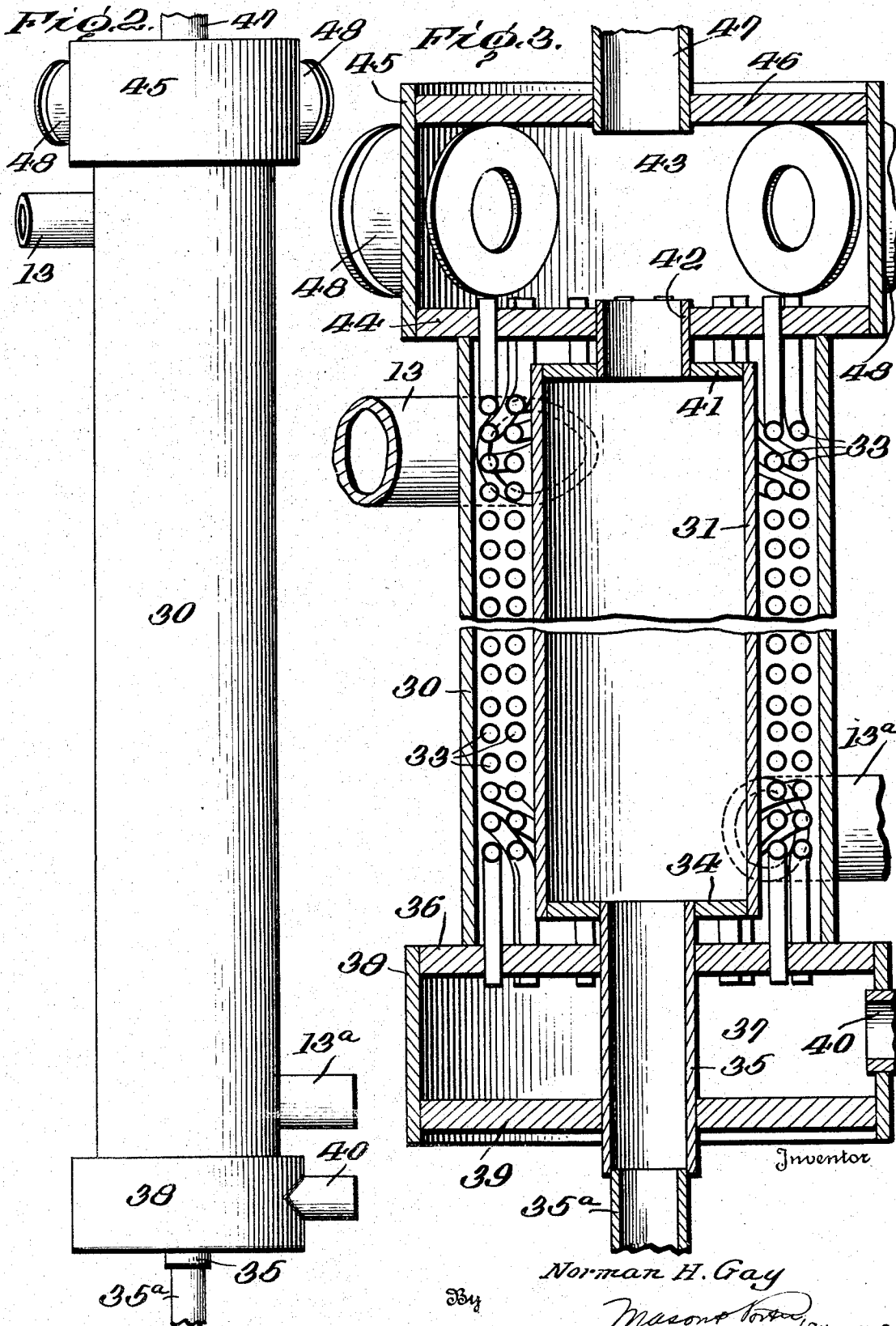
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2 Sheets-Sheet 2



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ART OF SEPARATING OIL IN REFRIGERATION SYSTEMS

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17 Claims. (Cl. 62—115)

This invention relates to the art of separating oil from refrigerant in a refrigerating apparatus of the type including a condenser and a still or evaporator, and employing oil in the course of the refrigerating cycle; and is a continuation in part of my copending application Serial No. 709,864, filed February 5, 1934.

One of the features of the present invention is the utilization of the "gas lift" effect in the separator as a means of lifting the oil during the separation.

Another feature of the present invention is the provision of an oil separating apparatus in association with the conduit line for conveying hot refrigerant liquid to the evaporator, so that a heat exchange occurs for rectifying the oil and cooling the hot high-pressure refrigerant.

Another feature of the present invention is the provision of a refrigerating apparatus employing a plurality of compressors in conjunction with a single condenser system and a single evaporator system, with a separating apparatus connected between the condenser and the evaporator, and serving for returning the separated and rectified oil to the several compressors.

One form of practicing the present invention is shown on the accompanying drawings, in which:

Figure 1 is a diagrammatic view showing the connection of the parts of the refrigerating system.

Figure 2 is a side elevation of the separating device.

Figure 3 is a vertical sectional view through the separating device, on a larger scale.

Figure 4 is an end view of the separating device.

In the drawings, a plurality of compressors C1, C2, . . . are illustrated diagrammatically as provided with individual pressure conduits 10 for delivering hot compressed gas into the condenser K which is illustrated of shell type, the gas being delivered above the normal liquid level therein. The bottom of the condenser K is provided with a receiver structure KR having a hot liquid delivery pipe 11 opening thereinto at a low level, and through which the hot condensed refrigerant liquid flows through a king valve 12 into a connection 13 at the top of the separator structure R which is illustrated as separate from the condenser and cooler.

After passing through a jacket of the separator R, as will be described hereinafter, this liquid flows from the outlet connection 13a through a conduit 14 and the shut-off valve 15 to an inter-

mediate point of the height of the scale trap 16, from which it escapes at the top by a conduit 17 and passes through the valve 18 which is controlled by a float 19 within the float valve housing FV, and then passes by conduit 20 and the shut-off valve 21 to the expansion valve EX, and thence by conduit 22 into the evaporator EV at a point thereof corresponding to the normal liquid level therein; so that this relatively warm refrigerant liquid is delivered adjacent the top surface of the liquid already contained in the evaporator EV. Evaporation occurs in the evaporator (likewise illustrated as of shell type), and the gases are withdrawn therefrom by the suction lines 23 back to the individual compressors, usually with the inclusion of a shut-off valve 24 adjacent each compressor. The float valve housing FV is provided with the gauge glass 25 and the usual shut-off cocks, and the interior of the housing is connected by conduits 26 with the bottom of the receiver structure KR and with a point of the condenser K which is well above the maximum liquid level therein.

This provides a circuit by which the refrigerant is circulated with compression at the compressor, condensation at the condenser, pressure release at the expansion valve, evaporation in the evaporator, and a return to the compressor.

The separator R is shown in Figs. 2 and 3 to comprise an outer jacket 30 and an inner jacket 31 which are spaced apart to receive a plurality of helical tubes 33 having a continuously upward course and which are of such diameter that the bubbles of refrigerant gas formed therein will operate to provide a "gas lift" for the liquids contained in these individual tubes. As the diameter of these tubes must be relatively small, owing to the small quantity of refrigerant remaining with the oil in the final stages of rectification, these tubes are referred to herein as "small tubes". The inner jacket 31 is provided with a closing bottom ring 34 which seals this jacket 31 to the discharge connection 35, through which the rectified oil is finally discharged from the separator. This tube 35 passes through the closing member 36 which seals the lower end of the outer jacket 30, and through which the lower ends of the small tubes 33 project in sealed relationship so that they open into a bottom chamber 37 formed by the closing member 36, the peripheral wall 38, and the bottom sealing wall 39 which likewise is sealed to the discharge connection 35. Communication with this lower chamber 37 is provided by a conduit 40.

The annular space between the jackets 30 and

31 receives the hot refrigerant liquid through the connection 13 (Figs. 1 and 2) adjacent its top, and discharges this liquid, after a cooling thereof, through the bottom connection 13a into the conduit 14 as described above.

The upper end of the inner jacket 31 is sealed to a ring 41 which in turn is sealed to the drain conduit 42 leading from the upper chamber 43. This drain conduit 42 is sealed to the upper closing member 44 through which pass the upper ends of the tubes 33 in sealed relationship. The upper end of conduit 42 is preferably at a slightly lower level than the upper ends of the tubes 33. The chamber 43 is defined by the closing member 44, the peripheral wall 45, and the upper wall 46 which is connected to the separator suction conduit 47. It is preferred to provide sight glasses for the upper chamber 43 by having the bosses 48 extending therefrom and each provided with a vision window 49 in its outer end.

It will be noted that the upper and lower ends of the individual tubes 33 are preferably extended parallel to the axes of the jackets 30 and 31, so that they facilitate the assembly of parts and provide a space adjacent the upper and lower end rings 34 and 41, so that the spaces between these rings and the respective closing members 36 and 44 may operate as headers for receiving the liquid entering from the connection 13 and for the liquid to be discharged through the connection 13a. For this purpose, as shown in Fig. 4, it is preferred to have the connections 13 and 13a directed tangentially with respect to the inner jacket 31.

As shown in Fig. 1, the evaporator EV is provided with conduits 50, 50a which respectively open thereinto just at the minimum liquid level therein and at the bottom of the same, and are individually controlled by valves 51, 51a so that one or the other, or both, of these conduits may be employed according to the relative gravity of the oil compared with that of the refrigerant. Thus if the oil is lighter than the refrigerant liquid, it is withdrawn through the conduit 50; while if the oil is heavier than the refrigerant liquid, it is withdrawn through the conduit 50a. It will be understood that the liquid thus withdrawn is not pure oil but contains a considerable proportion of liquid refrigerant therein, and in many instances contains more liquid refrigerant than it does oil. This mixture is then delivered through the conduit 40 into the bottom chamber 37 of the separator, and thus passes into the individual tubes 33 and moves upward therein to fill the same to a level equivalent to the level of refrigerant in the evaporator EV. This normally is below the floor of the top chamber 43.

The incoming hot refrigerant liquid from connection 13, however, bathes these tubes and effects a heat transfer through the tube walls so that evaporation occurs of the contents within these individual tubes. It will be noted that the hottest refrigerant liquid encounters the tubes near their tops where they contain the smallest quantity of refrigerant liquid compared with the oil content; while the countercurrent flow causes the relatively cooler refrigerant liquid to encounter the cold incoming mixture from conduit 40 which contains the highest proportion of refrigerant liquid. Thus there is a continuous distillation along the length of the individual tubes without extreme pulsations occurring by a high degree of heat transfer at any particular point along the length of the individual tube. Further, by having these tubes of helical shape, the up-

ward flow is retarded and sudden pulsations in the system are avoided.

The effect of this evaporation is to create a "gas lift" in the individual tubes which causes them to discharge a mixture of gas and oil into the upper chamber 43, this oil usually containing a small further quantity of refrigerant. This upper chamber 43 permits a rapid breaking of the bubbles or foam so that the gas which passes through the conduit 47 into the top of the evaporator and thence is withdrawn by the individual suction conduits 23, is substantially free from oil. Any entrained oil carried along, however, creates no difficulty as it is held in the evaporator and sooner or later again passes through the conduit 50 or 50a back to the separator. The major quantity of the oil, however, is detained within the upper chamber 43 and flows downward through the conduit 42 into the interior space of the inner jacket 31 whose walls likewise are being heated by the hot incoming liquid refrigerant from connection 13, so that there is a slow further distillation in this chamber, with the upward escape of gas bubbles into the upper chamber 43. The oil thus is rectified in the structure R so that the substantially pure oil, free from liquid refrigerant, collects at the bottom of the inner jacket 31 and can be withdrawn therefrom through the conduit connection 35 and its extension 35a (Fig. 1) under control of the valve 52 and the oil drain header 53 which extends across the compressors and is connected thereto by the individual supply lines 54 having the control valves 55 and thus operating as oil equalizing connections between the several compressors which are in operation and have their valves 55 open.

For safety purposes and for facility in handling the plant, one compressor C1 is provided with a pump-out connection 60 having a control valve 61 for clearing the condenser K, and a similar pump-out connection 62 with a valve 63 for clearing the evaporator. The condenser K has a drain connection 64 at the bottom of its receiver KR, and the cooler has a drain connection 65 at its bottom. The oil header 53 has a connection 66 by which the oil may be charged or drained and suction applied.

An emergency by-pass connection 67 extends from the conduit 11 at a point closely adjacent the reservoir KR and through a control valve 68, and is connected to the conduit 22 and thus with the evaporator EV at the low pressure side of the expansion valve EX. This permits a quick release of the liquid refrigerant in the receiver KR, if so desired. Similarly, the conduit 14 is provided with a branch 69 having a valve 70 therein, and leading to the conduit 22, so that the liquid may be passed from the separator outlet directly to the evaporator without passing through the scale trap 16 or the float valve 18 and expansion valve EX.

A relief connection through valve 71 and conduit 72 connects the top of the condenser K with the suction conduit 47 from the separator to permit relieving gases which are present at the top of the condenser.

It is obvious that the invention is not limited solely to the form of construction shown, but that it may be modified in many ways within the scope of the appended claims.

I claim:

1. A separating apparatus for refrigerating plants, comprising inner and outer jackets and walls sealing the space between the jackets and

providing chambers at the upper and lower ends of said jackets, a plurality of small tubes communicating with said chambers and being located in the space between the jackets, an inlet connection for hot refrigerant liquid at the upper end of the jacket space, an outlet connection for refrigerant liquid at the lower end of the jacket space, a connection for delivering a mixture of oil and liquid refrigerant into the lower chamber, a suction connection from the upper chamber, and an oil withdrawal connection at the lower end of the space inside the inner jacket, the upper end of the space within said inner jacket being in communication with the upper chamber at a low level thereof.

2. A separating apparatus for refrigerating plants, comprising inner and outer jackets and walls sealing the space between the jackets and providing chambers at the upper and lower ends of said jackets, a plurality of small tubes communicating with said chambers and being located in the space between the inner and outer jackets, at least major portions of said tubes being helical, an inlet connection for hot refrigerant liquid at the upper end of the jacket space, an outlet connection for refrigerant liquid at the lower end of the jacket space, a connection for delivering a mixture of oil and liquid refrigerant into the lower chamber, a suction connection from the upper chamber, and an oil withdrawal connection at the lower end of the space inside the inner jacket, the upper end of the space within said inner jacket being in communication with the upper chamber at a low level thereof.

3. A separating apparatus for refrigerating plants, comprising concentric inner and outer jackets and walls sealing the space between the jackets and providing chambers at the upper and lower ends of said jackets, a plurality of small tubes communicating with said chambers and being located in the space between the inner and outer jackets, the upper and lower ends of each tube being directed substantially parallel to the axis of the jackets and the intermediate portions of each tube being helical and nesting with the other tubes within the jacket space, an inlet connection for hot refrigerant liquid at the upper end of the jacket space, an outlet connection for refrigerant liquid at the lower end of the jacket space, a connection for delivering a mixture of oil and liquid refrigerant into the lower chamber, a suction connection from the upper chamber, and an oil withdrawal connection at the lower end of the space inside the inner jacket, the upper end of the space within said inner jacket being in communication with the upper chamber at a low level thereof.

4. A separating apparatus for refrigerating plants, comprising concentric inner and outer jackets and walls sealing the space between the jackets and providing chambers at the upper and lower ends of said jackets, a plurality of small tubes communicating with said chambers and being located in the space between the inner and outer jackets, the upper and lower ends of each tube being directed substantially parallel to the axis of the jackets and the intermediate portions of each tube being helical and nesting with the other tubes within the jacket space, said walls and the axial portions of the tubes providing headers at the upper and lower ends of the jacket space, an inlet connection for hot refrigerant liquid at the upper end of the jacket space, an outlet connection for refrigerant liquid at the lower end of the jacket space, a connection for delivering a mixture of oil and liquid refrigerant into the lower chamber, a suction connection from the upper chamber, and an oil withdrawal connection at the lower end of the space inside the inner jacket, the upper end of the space within said inner jacket being in communication with the upper chamber at a low level thereof.

erant liquid at the lower end of the jacket space, said inlet and outlet connections being arranged tangentially to direct the flow into and out of the headers and along the outsides of the helical portions of the tubes, a connection for delivering a mixture of oil and liquid refrigerant into the lower chamber, a suction connection from the upper chamber, and an oil withdrawal connection at the lower end of the space inside the inner jacket, the upper end of the space within said inner jacket being in communication with the upper chamber at a low level thereof.

5. A refrigerating apparatus having a high level evaporator, a low level condenser, a compressor, conduit means connecting the same in circuit, a float valve in said conduit means between the condenser and evaporator and responsive to the liquid level in the condenser, and a separator comprising a jacket and a plurality of small tubes therein, the space within the jacket being arranged in the conduit means between the condenser and the evaporator so that hot liquid refrigerant flows over the outsides of said tubes, the upper ends of the tubes being located above the level of liquid in the evaporator and the lower end of the separator being below the lowest point of the evaporator, an inlet connection to the lower ends of said tubes for delivering a mixture of oil and liquid refrigerant from said evaporator into the tubes, said tubes operating by gas-lift induced by the vaporization of refrigerant therein by the heat of said hot refrigerant liquid, an outlet connection from the upper ends of the tubes to the evaporator for returning gaseous refrigerant to the evaporator, and an oil collection means for receiving oil from the upper ends of said tubes.

6. In a refrigerating plant including a compressor, a condenser, and an evaporator connected in circuit, a separator comprising a plurality of small tubes enclosed by jacket means having its space connected in the circuit between the condenser and the evaporator, means for introducing a mixture of oil and refrigerant liquid from the evaporator at the lower ends of the tubes, a suction connection from the upper ends of the tubes for returning gaseous refrigerant toward the compressor, and means for collecting oil issuing from the upper ends of said tubes and returning it to the compressor.

7. In a refrigerating plant including a compressor, a condenser, and an evaporator connected in circuit, a separator comprising a plurality of small tubes enclosed by jacket means having its space connected in the circuit between the condenser and the evaporator, means for introducing a mixture of oil and refrigerant liquid from the evaporator at the lower ends of the tubes, a suction connection from the upper ends of the tubes for returning gaseous refrigerant toward the compressor, means for collecting oil issuing from the upper ends of said tubes, and a valved pressure relief connection from the bottom of the condenser for passing liquid refrigerant directly to the evaporator.

8. In a refrigerating plant including a compressor, a condenser and an evaporator connected in circuit, a heat exchanger disposed between the condenser and evaporator to cool the liquid refrigerant, and extending above and below the level of the liquid in the evaporator, means for withdrawing a mixture of oil and refrigerant liquid by gravity from the evaporator to the heat exchanger and volatilizing the refrigerant liquid therein to produce the cooling

effect in said heat exchanger, the refrigerant gas operating by gas-lift effect to move the mixture in said exchanger, means for returning gaseous refrigerant to the evaporator, and means for

collecting the oil from the evaporated mixture.

9. In a refrigerating plant including a compressor, a condenser and an evaporator connected in circuit, a heat exchanger disposed between the condenser and evaporator to cool the liquid refrigerant and having a first conduit means for the liquid refrigerant to be cooled and a second conduit means for receiving a mixture of oil and refrigerant liquid from the evaporator for producing the said cooling effect therein and to return gaseous refrigerant to the evaporator, the inlet of said second conduit means to the exchanger being below the normal oil level in the evaporator, the vaporization of refrigerant in said second conduit operating to provoke circulation therethrough by the gas-lift effect, and means for withdrawing oil from the gaseous refrigerant at a high level in said second conduit.

10. In a refrigerating plant including a compressor, a condenser, and an evaporator connected in circuit, a heat exchanger including a first chamber through which liquid refrigerant is passed from the condenser to the evaporator and a second chamber for a cooling fluid, said second chamber extending above and below the liquid level in the evaporator, conduit means connecting said second chamber to the evaporator at a high level thereof and also at the oil level therein for delivering by gravity a mixture of oil and refrigerant liquid to said second chamber and returning gaseous refrigerant to said evaporator, and an oil trap connected at the upper end of said second chamber, the gas-lift effect of evaporated refrigerant in said second chamber being effective to move the mixture of oil and liquid refrigerant toward and to move at least the oil into said trap.

11. In a refrigerating plant including a compressor, a condenser and an evaporator connected in circuit, a heat exchanger disposed between the condenser and evaporator and including a collection chamber and first conduit means in heat exchange relation with a second conduit means for the refrigerant liquid on its way to the evaporator, said first conduit means extending above and below the liquid level in the evaporator and being in free communication with said collection chamber at the top of the latter, a gas exhaust connection from the upper ends of the first conduit means and said collection chamber, and further conduit means for passing a mixture of oil and liquid refrigerant by gravity from the evaporator into the lower end of said first conduit means.

12. A separating apparatus for refrigerating plants comprising an enclosing casing, a plurality of small tubes located within said casing and each having a continuously upward course, header means at the top and bottom of the casing in communication with the corresponding ends of each of said tubes, means for introducing a warm circulating medium into the casing space sur-

rounding said tubes near the upper end thereof, an outlet connection for said medium adjacent the lower end of the said casing space, and drainage means for receiving oil from the upper header.

13. A separating apparatus as in claim 12, in which each of the individual tubes extends into the upper header means to a point above the oil drainage means.

14. In a refrigerating plant including a compressor, a condenser, and an evaporator connected to the circuit, a separator comprising jacket means comprising inner and outer walls and having the annular space between said walls connected in the circuit between the condenser and the evaporator, a plurality of small tubes extending upwardly in said annular space, means for introducing a mixture of oil and refrigerant liquid from the evaporator at the lower ends of the tubes, a suction connection from the upper ends of the tubes for returning gaseous refrigerant toward the compressor, the space within said inner wall having communication with the upper ends of the tubes and constituting a collection chamber for oil, said collection chamber being warmed by heat transferred through said inner wall.

15. A separating apparatus for a refrigerating plant comprising inner and outer walls providing an inner space and an annular space, a plurality of tubes having a continuously upward course in the said annular space, upper and lower header means in communication with the ends of said tubes, means for introducing a warming medium at the upper end of the annular space and for exhausting said medium at the lower end of said annular space, and an oil drainage connection from the upper header into said inner space.

16. A separating apparatus for refrigerating plants, comprising inner and outer walls spaced horizontally apart to provide an inner space and an annular space, separate end closure means for said walls, a plurality of tubes having a continuously upward course within said annular space, upper and lower header means in communication with the ends of said tubes, said header means including the closing means for the outer wall, inlet and exhaust connections for a warming medium in communication with said annular space, and an oil drainage connection from the upper header into said space.

17. A separating apparatus for refrigerating plants, comprising horizontally spaced inner and outer walls providing an inner space and an annular space, a plurality of tubes having a continuously upward course within the annular space, inlet and outlet connections for a warming medium in communication with said annular space, header means at the upper and lower ends of the outer wall for closing the same and providing header spaces in communication with the ends of said tubes, the inner space providing a collection chamber for oil, and an oil drainage means from the upper header into said inner space.