May 26, 1936. N. H. GAY 2,042,394

ART OF PURGING AND RECTIFYING OIL IN REFRIGERATOR SYSTEMS

Filed Feb. 5, 1934. 4 Sheets-Sheet 1

Fig. 1.

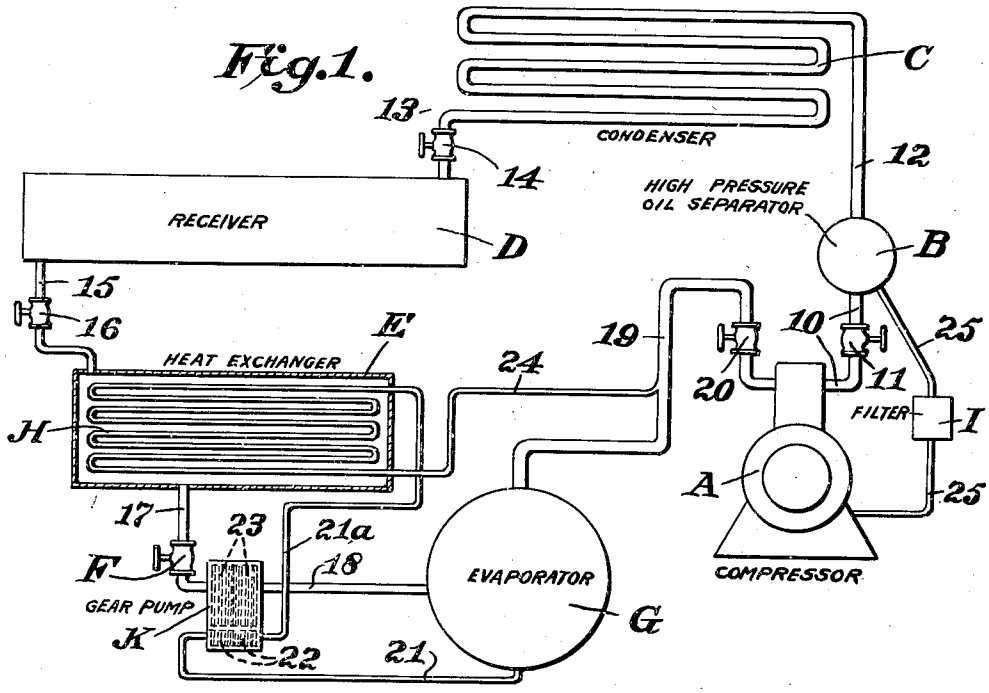
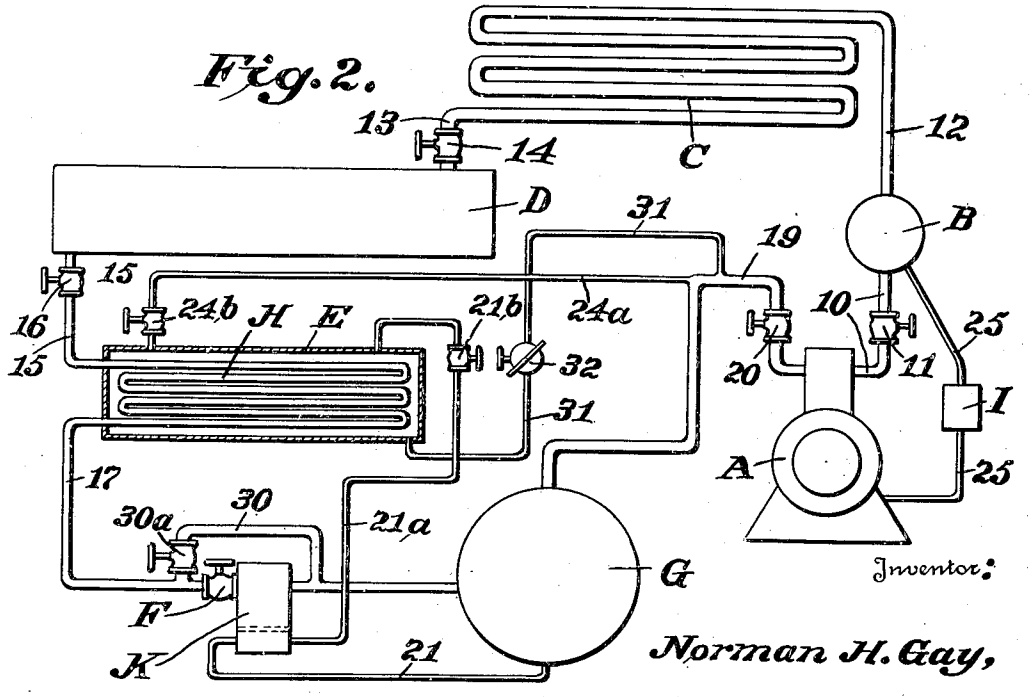


Fig. 2.



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Fig. 3.

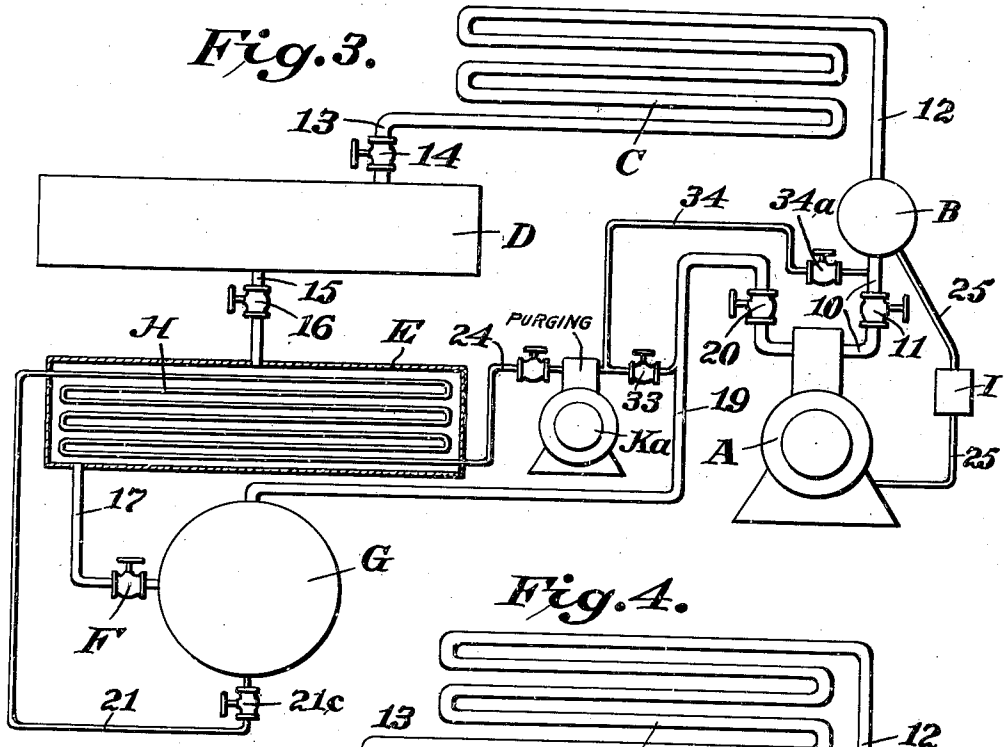
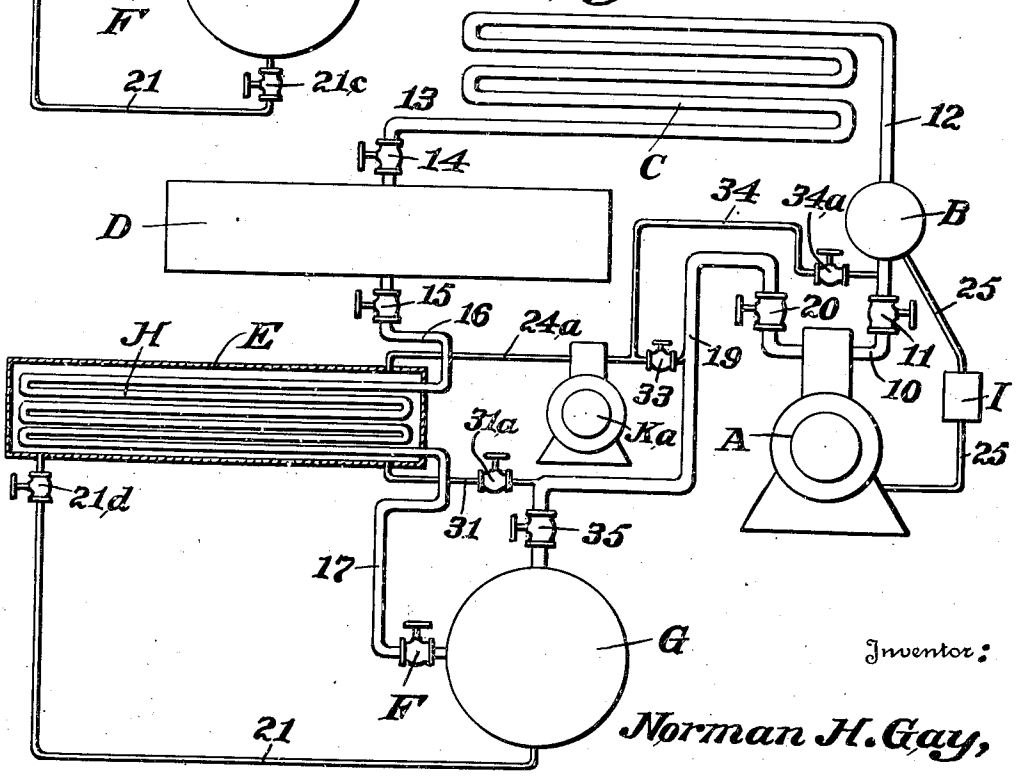


Fig. 4.



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ART OF PURGING AND RECTIFYING OIL IN REFRIGERATOR SYSTEMS

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Fig. 5.

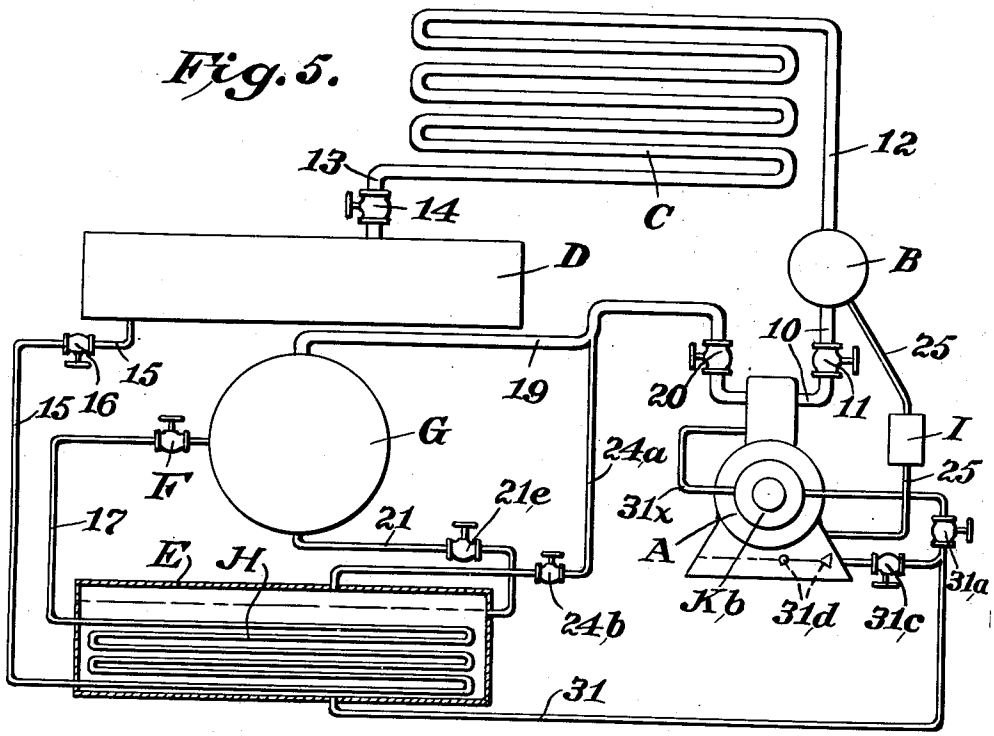
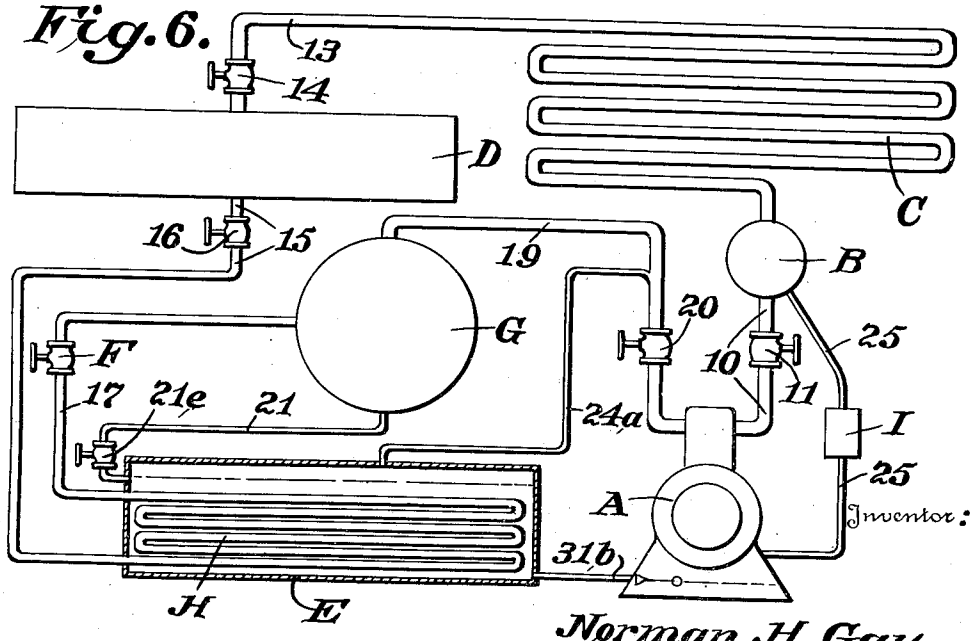


Fig. 6.



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ART OF PURGING AND RECTIFYING OIL IN REFRIGERATOR SYSTEMS

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Fig. 7.

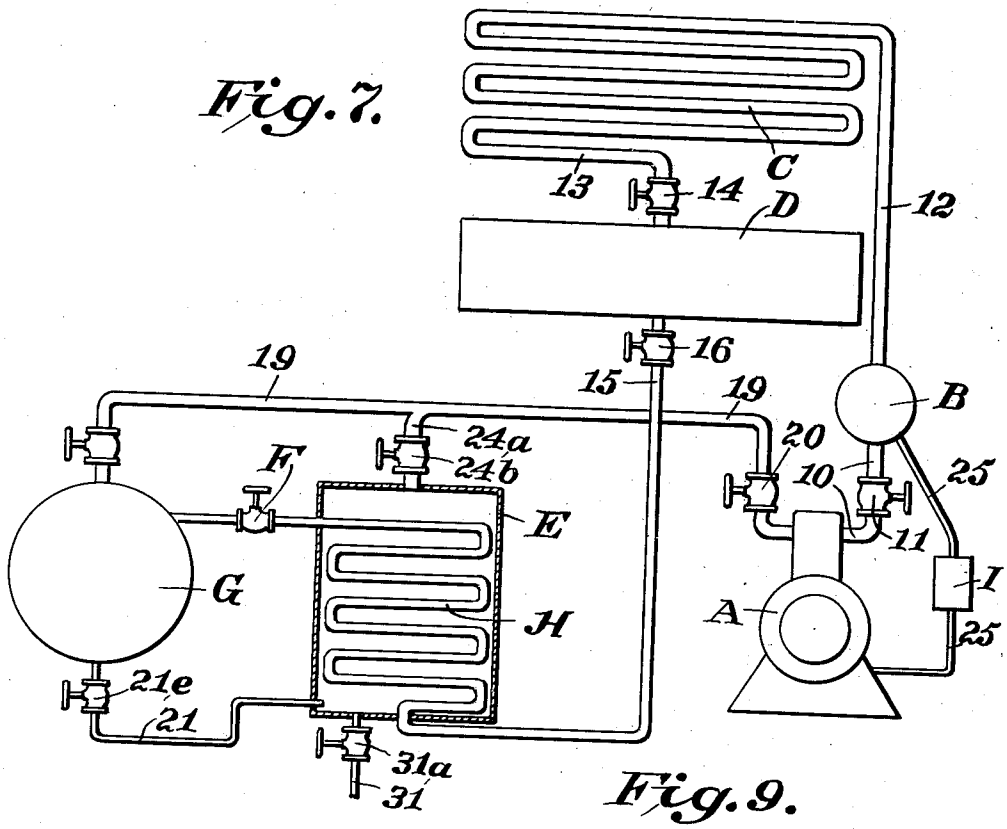


Fig. 9.

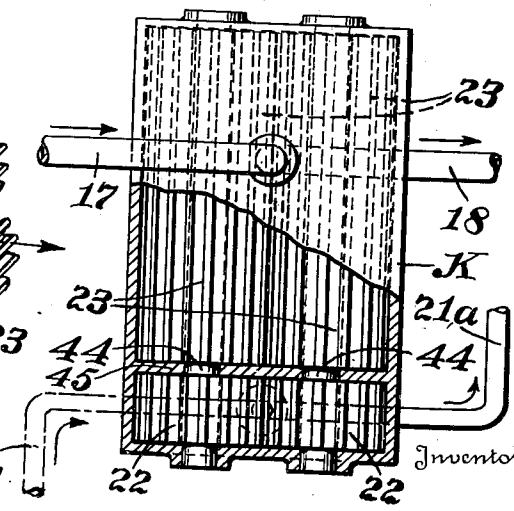
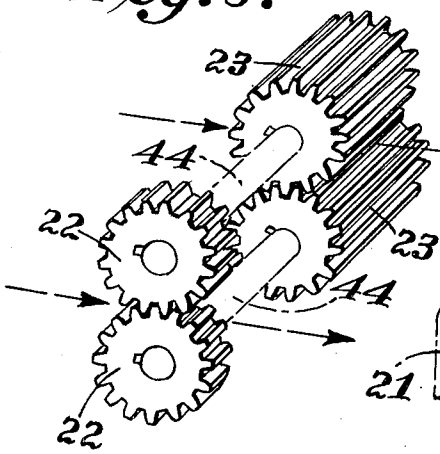


Fig. 8.



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2,042,394

UNITED STATES PATENT OFFICE

2,042,394

ART OF PURGING AND RECTIFYING OIL IN REFRIGERATOR SYSTEMS

Norman H. Gay, Los Angeles, Calif.

Application February 5, 1934, Serial No. 709,864

20 Claims. (Cl. 62—115)

The present invention relates to oil purging and rectifying operations for refrigerator systems employing evaporators, and is more particularly directed to a means of separating oil from refrigerant liquid, with employment of the "cold" in the mixture of refrigerant and oil for cooling the incoming liquid refrigerant on its way to the evaporator.

One of the features of the present apparatus is that of employing the liquid refrigerant in the evaporator, in the presence of any oil contained therein, in the usual manner of employing a liquid refrigerant, so that the concentration of the oil in the evaporator tends constantly to increase, and withdrawing the enriched mixture from the evaporator, employing the "cold" therein for cooling liquid refrigerant on its way from the condenser to the evaporator, and recovering the oil substantially freed from liquid refrigerant.

Another feature of the invention is the employment of the energy of the refrigerant in passing from the high pressure prevailing in the condenser to the lower pressure prevailing in the evaporator, for removing a mixture of liquid refrigerant enriched in oil from the evaporator and passing it through a heat interchanger in which it yields off the liquid refrigerant therein.

Another feature of the present invention is the provision of a refrigerating plant including a compressor, a condenser and an evaporator, with the heat interchanger located between the condenser and the evaporator and maintained at a lower temperature level than that prevailing in the condenser through the operation of a mixture of refrigerant liquid and oil which is delivered thereto.

With these and other objects in view, as will appear in the course of the following specification and claims, illustrative examples of practicing the present invention are set out on the accompanying drawings, in which:

Figure 1 is a diagrammatic view of a refrigerating plant of the present nature, in which the energy of the refrigerant in moving between the high pressure and low pressure portions of the system is recovered and utilized for supplying a heat exchanger with a mixture of refrigerant and oil.

Figure 2 is a similar diagrammatic view of a modified form of the invention, in which a change in temperature effect in the exchanger is employed to eject separated oil therefrom.

Figure 3 is a similar view of another modification, in which a separately driven purging pump is employed for introducing the cold mixture of refrigerant liquid and oil into the heat exchanger.

Figure 4 is a similar view of a further modification, in which a separate purging pump is used in conjunction with an oil trap.

Figure 5 is a similar diagrammatic view of a further modification, in which a gravitational flow from the evaporator is employed to deliver the mixture of refrigerant liquid and oil to the heat exchanger.

Figure 6 is a similar diagrammatic view employing the gravitational feed to the heat exchanger, with a gravitational return to the crank case of the main compressor.

Figure 7 is a similar diagrammatic view in which the evaporator and heat exchanger are located substantially on the same level.

Figure 8 is a perspective view showing in detail the motor and pump arrangement employable in Figures 1 and 2.

Figure 9 is a top elevation of this pump, with its casing partly broken away to show the arrangement of parts.

In all figures, a main compressor A delivers hot compressed refrigerant gas through a conduit 10 and past a shut-off valve 11 to a high pressure oil separator B, and thence through a conduit 12 to a condenser C, in which the temperature of the refrigerant gas is reduced below the critical point so that refrigerant liquid may flow through conduit 13 past a shut-off valve 14 into a receiver D, in which it is collected and passes in accordance with its consumption through a discharge conduit 15 past a shut-off valve 16 into a heat exchanger E, from which it passes through conduit 17, past an expansion valve F, and through a conduit 18 to an evaporator G, moving from the high pressure portion to the low pressure portion at its passage from valve F. The liquid refrigerant in the evaporator G is volatilized in the usual way and passes through a conduit 19 and shut-off valve 20 back to the compressor A.

In the operation of such devices, a part of the lubricating oil employed in the compressor A is carried along with the hot compressed gas moving through the oil separator B, and usually is trapped in part in the separator, although a portion of it usually continues into the condenser C and is picked up by the condensing refrigerant liquid and carried forward through the receiver D and past the expansion valve F, so that it accumulates in the evaporator G. A mixture of refrigerant liquid and oil thus enters the evaporator

G, but only the liquid refrigerant escapes therefrom by volatilization, so that the contents of the evaporator are continually being enriched in oil, especially at the heat transfer surfaces. This oil is not a valuable cooling medium for employment in the evaporator, and it is desirable to recover it therefrom, usually for further employment in the compressor. The aforesaid difficulty is especially true in a plant operating with a refrigerant medium which when in the liquid condition operates to dissolve the oil, as distinguished from holding the oil in suspension therein. Such is the case in the employment of refrigerant media of the hydrocarbon and organic halide types.

As shown in Figure 1, the heat exchanger E has an external casing into which the mixture of refrigerant liquid and oil from receiver D enters, and is provided internally with a cooling coil H. A conduit 21 leads from the bottom of the evaporator G (or point of greatest quiescence) to a motor-pump housing K which is illustrated in Figures 1, 8 and 9 as having pairs of gears mounted on shafts for simultaneous movement, the pair 22 being of lesser length than the pair 23. The pair 22 operates to aspire the mixture of refrigerant liquid and oil from conduit 21 and deliver it through a pipe 21*a* into the cooling coil H, while the pair 23 is operated as a fluid motor by the energy of the refrigerant passing from expansion valve F to evaporator G. The gears are suitably of lesser length axially than the gears 23, in proper proportion to withdraw the mixture of refrigerant liquid and oil from the evaporator G on the basis of proportion of oil contained in the refrigerant moving through conduit 18 to that moving in the pipe 21. For example, the length of the gears 23 may be five times that of gears 22. The mixture of refrigerant liquid and oil in coil H is warmed by the warm refrigerant liquid coming from the receiver D, so that the refrigerant liquid within the coil H is caused to evaporate, this latter difficulty of itself operating as a trickle-type evaporator, with a return of the refrigerant as a gas through conduit 24 to the main return conduit 19, and thus back to the compressor A. The suction of the compressor A likewise draws the oil through conduits 24 and 19 back to the compressor, where it serves to lubricate the cylinder and piston, and is ejected to the high pressure oil separator B from which it may flow through a filter I back to the crank case of compressor A through conduit 25.

It will be noted that the structure may operate as a self-balancing system. As the demands of refrigeration upon the evaporator G increase, a greater quantity of refrigerant liquid is volatilized therein and withdrawn through conduit 19, while the corresponding oil of the entering mixture remains in the evaporator G. The usual regulation of the passage of refrigerant from the receiver D to the evaporator G now causes a correspondingly greater quantity of liquid to move in this direction and to pass through the motor gears 23 of the motor-pump assembly K, producing a greater speed of these gears and a greater pumping effect at the pump gears 22 thereof, so that a greater quantity of relatively enriched refrigerant-oil mixture is pumped through pipes 21 and 21*a* to the cooling coil H, thus increasing the cooling effect in the heat exchanger E so that this cooling effect may be maintained proportionate to the greater quantity of liquid flowing from the receiver D. On the other hand, when the demand upon the evaporator G falls, a less quantity of refrigerant liquid is volatilized therein, and a lesser replacement quantity flows through the motor-pump K, and a lesser quantity of oil-refrigerant mixture is pumped through the coil H.

This self-balancing feature of operation is further facilitated by the fact that if the cooling of liquid from condenser D by the operation of the heat exchanger E is not sufficient, the transfer of the mixture of refrigerant liquid and oil through the expansion valve F results in the immediate formation of a greater quantity of "flash" gas, so that the volume of mingled liquid and gas passing through the motor gears 23 is increased, and the pump action correspondingly is augmented to deliver a greater volume into the cooling coil H; while an excessive cooling effect by the coil H results in a reduction of the amount of "flash" gas formed, and thus a reduction in the speed of movement of the motor gears 23 and a lesser delivery to the cooling coil H. This cooling coil H therefore operates as a trickle-type evaporator in exact consonance with the demands of the system.

In the form shown in Figure 2, essentially the same principle is employed, but the heat exchanger E has its casing supplied with the mixture of refrigerant liquid and oil through the pipe 21*a*, past a regulating valve 21*b*, while the cooling coil H is connected between conduits 15 and 17. The motor pump K operates as before, but a regulating by-pass including a conduit 30 and an auxiliary expansion valve 30*a* operating as a control is employed in shunt of the main flow through the gear motor. The refrigerant liquid volatilized within the shell of the heat exchanger E is withdrawn through conduit 24*a* past the regulating valve 24*b* into the main return conduit 19 back to the compressor A. The oil tends to collect in the bottom of the heat exchanger casing, but may be drawn off through the conduit 31 past a stop and check valve 32 into the main return conduit 19 during periods of operation of the compressor A with the valve 24*b* closed. This system operates in the same manner as that described above, with the further feasibility of shutting off the flow of the liquid moving in conduit 21 by closing the valve F, while the flow to the evaporator is continued through the auxiliary expansion valve 30*a*. Thus the refrigerant may be drawn from the exchanger E for further concentrating the oil. In this system, also, it is possible to accumulate the oil within the heat exchanger E, and then eject it therefrom by closing the main expansion valve F and the valves 21*b* and 24*b* and opening the auxiliary expansion valve 30*a*. The volatilization of liquid refrigerant within the heat exchanger E now operates to increase the pressure existing therein and to force the liquid in exchanger E through conduit 31 back to the main return conduit 19.

In the form of construction shown in Figure 3, the motor-pump operated by the energy of the refrigerant medium in passing through the high portion to the low portion side of the system is omitted, and a separate purging pump K*a* is employed. The normal main circuit of refrigerant from compressor A through the trap B, condenser C, receiver D, the casing of exchanger E, through expansion valve F to evaporator G, and by the main return conduit 19 back to the compressor A is as before. The conduit 21 is controlled by a valve 21*c* and delivers the mixture of refrigerant liquid and oil to the cooling

coil H in heat exchanger E and thence by conduit 24 to the purging compressor Ka. The purging compressor Ka is illustrated as connected through a valve 33 to the main return conduit 19, and by a conduit 34 with the control valve 34a to the high pressure outlet conduit 10 from the compressor A.

In this arrangement, the auxiliary or purging pump Ka may be a separately driven compressor, a compressor driven with the main compressor A, or even one cylinder of a multi-cylinder main compressor. This plant may be operated in several ways with respect to the removal of refrigerant and oil from the coil H. If the valve 34a is kept closed the valve 33 is opened, it operates substantially in the same manner as the plant illustrated in Figure 1, by a direct return of refrigerant gas and oil to the main return conduit 19; the power required of the purging pump Ka then being merely that for moving the refrigerant as a mixture of liquid with the lubricating oil, and as gas with the oil, from the evaporator G to the return conduit 19. It will be noted that the valve 21c, if partly closed, will operate as an expansion valve for this auxiliary refrigeration system, in which the heat exchanger E has its cooling coil H operating as the evaporator. If the valve 33 is closed and valve 34a is opened, the plant may be operated as before, and the purging pump becomes an auxiliary compressor operating in shunt to the main compressor A, and delivering the purged oil to the oil trap B independently of any passage through the main compressor A. In this latter case, a greater amount of power is demanded at the purging pump Ka, but the capacity of the plant is increased.

In the form of construction shown in Figure 4, the circuit from compressor A through condenser C, heat exchanger E, and evaporator G is the same as before, and the purging pump Ka is employed. In this case, as in Figure 2, the conduit 16 from receiver D is connected to the cooling coil H and thence by conduit 17 and expansion valve F with the evaporator G. Conduit 21 is connected through valve 21d with the shell of the exchanger E, refrigerant gas being drawn off from this shell through conduit 24a to the purging pump Ka, and then delivered through valve 33 to the main return conduit 19 or through pipe 34 and valve 34a to the high pressure conduit 10. In this case, the oil may be accumulated in the exchanger E to a desired degree, and then valve 31a of conduit 31 opened and the oil discharged back into the main return conduit 19 again. A control valve 35 may be located on the return conduit 19 in such case.

In the form shown in Figure 5, the main compressor A has an extended shaft provided with a liquid pump Kb. The main circuit from compressor A through condenser C, heat exchanger E, and evaporator G back to the compressor through the main return conduit 19 is as before. In this form, a gravitational delivery of the mixed refrigerant liquid and oil is accomplished from the evaporator G to the shell of the heat exchanger E. The hot refrigerant liquid is passed into the cooling coil H of the exchanger E and then moves through the pipe 17 and expansion valve F into the evaporator G. No difficulty is encountered in this, as the receiver D maintains a gravity head, to the valve F, of liquid subject to the high pressure in this portion of the system. Upon leaving the expansion valve F, the refrigerant enters the evaporator G as before, and a portion of the mixture in the evaporator G is permitted to pass downward through discharge pipe 21 past control valve 21e. The refrigerant liquid volatilized in the heat exchanger E moves through the conduit 24a back to the main return conduit 19. The oil may be accumulated in the bottom of the heat exchanger for a desired period, and then permitted to escape through conduit 31 past the valve 31a thereof to the oil pump Kb, and then to the cylinder-piston space of the compressor A through a conduit 31x. This system may also be operated in the manner described for that of Figure 2, as for example when the compressor A is not running. The valves 24b and 21e are closed, and the refrigerant gas permitted to build up in the exchanger E so that upon opening valves 31a and 31c, the liquid moves to the crank case at which it may be controlled by the float-operated valve structure 31d.

In the form shown in Figure 6 is shown a system much resembling that of Figure 5, but employing a simple gravitational feed of oil from the shell of evaporator E through pipe 31 and float valve 31d into the crank case of the compressor A.

In the form shown in Figure 7, the heat exchanger E is represented as being of vertical rather than horizontal type, and located at substantially the same level as the evaporator G. The main circuit from the compressor A through condenser C and evaporator G is the same as before, the hot liquid refrigerant from receiver D moving through the cooling coil H and expansion valve F on its way to the evaporator G. The valve 21e in the conduit 21 providing a passage for the mixture of refrigerant liquid and oil from evaporator G to the shell of exchanger E may be employed as a secondary expansion valve, and valve 24b regulated to control the evaporation effect in the heat exchanger E. In this apparatus, the oil may be permitted to accumulate to a desired point and then is relieved through an escape conduit 31 past a valve 31a.

Figures 8 and 9 show a construction of a motor-pump of the gear type as described in conjunction with Figures 1 and 2. The pump gears 22 are of short axial extent compared to the motor gears 23, being joined thereto by shaft portions 44 which are shown in Figure 9, but extend through intermediate web wall 45 which is sealed with respect to the two sets of gears 22 and 23 to prevent a short circuit from conduit 17 leading from expansion valve F to conduit 21a leading to the heat exchanger E.

This type of purging system is especially valuable with refrigerants which are themselves soluble in the lubricating oil and operate in the liquid condition to dissolve lubricating oil; such as dichlorodifluoro methane, methyl chloride, methylene chloride, dichlorethylene, butane, isobutane, propane, etc. With such refrigerants, also, it is essential that moisture be excluded from the system, in some cases, to prevent chemical action or hydrolysis caused by, induced by or catalyzed by the presence of water, and in other cases to prevent moisture from freezing out of the mixture at the expansion valve in the evaporator or in the conduits between the expansion valve or evaporator, thereby causing a stoppage of the flow of the refrigerant through the system. A particular virtue of the present arrangement, therefore, is that the oil remains sealed within the system and no dehydration is necessary before it is returned to the compressor. Further, such refrigerants require the expendi-

ture of a considerable portion of the refrigerating effect in cooling the warm liquid refrigerant from condenser temperature to evaporator temperature; and hence a withdrawal of the mixed liquid from the evaporator would normally be attended by a considerable heat loss, especially in view of the fact that this liquid must be taken as it is, because the oil will not separate therefrom as it does from refrigerants of the ammonia type, for example. Hence, by recovering the "cold" from the separated portion and employing it in reducing the temperature of the warm condensed liquid, the two important purposes are accomplished at the same time, of purging oil from the evaporator and of reducing the temperature of liquid passing to the evaporator.

It is obvious that the invention may be practiced in many other ways without departing from the scope of the appended claims.

Having thus described the invention, what I claim as new and desire to secure by Letters Patent, is:

1. 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 means for withdrawing a mixture of oil and refrigerant liquid from the evaporator to the heat exchanger and volatilizing the refrigerant liquid therein to produce the said cooling effect thereof.

2. 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, continuously operating means for withdrawing a mixture of oil and refrigerant liquid from the evaporator and the heat exchanger, said withdrawing means including devices for proportioning the quantity of said mixture with relation to the quantity of refrigerant liquid moving toward the evaporator, and an exhaust conduit for the removal of refrigerant gas from the mixture in said heat exchanger whereby the volatilization of refrigerant liquid therein will produce the said cooling effect thereof.

3. 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, continuously operating means for withdrawing a mixture of oil and refrigerant liquid from the evaporator and the heat exchanger, said withdrawing means including devices for proportioning the quantity of said mixture with relation to the quantity of refrigerant liquid moving toward the evaporator and operating in accordance with the temperature of the liquid entering the evaporator, and an exhaust conduit for the removal of refrigerant gas from the mixture in said heat exchanger whereby the volatilization of refrigerant liquid therein will produce the said cooling effect thereof.

4. 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 means operated by the energy of refrigerant in passing to the evaporator for withdrawing a mixture of oil and refrigerant liquid from the evaporator to the heat exchanger for producing the said cooling effect therein.

5. 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, the connection for the delivery of liquid to the evaporator including branch conduits, means operated by the flow of refrigerant entering the evaporator through one of said conduits for withdrawing a mixture of oil and refrigerant liquid from the evaporator to the heat exchanger to produce the cooling effect therein, and means for regulating the flow through the other branch conduit.

6. 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, a conduit from the evaporator for delivering cooling liquid refrigerant to said second chamber, and an exhaust connection from said second chamber for the gas produced in said second chamber.

7. 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, a conduit from the evaporator for delivering cooling liquid refrigerant to said second chamber, a valve on said conduit operating as an expansion valve for the operation of said second chamber as an auxiliary evaporator space for cooling the liquid refrigerant passing through said first chamber, and an exhaust connection from said second chamber.

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, means for withdrawing a mixture of oil and refrigerant liquid from the evaporator to the heat exchanger to produce the cooling effect therein, an exhaust connection from said heat exchanger, and an oil withdrawal conduit from the bottom of said heat exchanger for returning the oil to the compressor.

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 moving toward the evaporator, a conduit from the evaporator to the heat exchanger for delivering a mixture of oil and refrigerant liquid thereto to produce the cooling effect therein, and power operated means to move the refrigerant liquid through said conduit and to withdraw refrigerant gas from said heat exchanger.

10. A refrigerating plant as in claim 9, in which said power operated means is connected to deliver the refrigerant gas to said compressor.

11. A refrigerating plant as in claim 9, in which the power operated means is connected to deliver the refrigerant gas under pressure to the condenser.

12. In a refrigerating plant including a compressor, an oil trap, a condenser, an expansion valve and an evaporator connected in circuit, a heat exchanger disposed between the condenser and expansion valve for cooling the liquid refrigerant moving toward said expansion valve, a conduit from the evaporator to the heat exchanger for delivering a mixture of oil and refrigerant liquid thereto to produce the cooling effect therein, and pump means for withdrawing

refrigerant gas and oil from said heat exchanger and delivering the same to said oil trap.

13. In a refrigerating plant including a compressor, a condenser and an evaporator connected in circuit, said compressor having a lubricating oil sump, a heat exchanger disposed between the condenser and evaporator to cool the liquid refrigerant moving toward the evaporator, a continuously open conduit for delivering a mixture of oil and refrigerant liquid from the evaporator to the heat exchanger to produce the cooling effect therein, an exhaust connection to said heat exchanger, and an oil conduit from the heat exchanger to said sump.

14. In a refrigerating plant including a compressor having an oil supply chamber, a condenser, an expansion valve and an evaporator connected in circuit, a heat exchanger disposed between the condenser and expansion valve to cool the liquid moving to said expansion valve, said heat exchanger being located at a lower level than said evaporator, a continuously open gravity supply conduit from said evaporator to the heat exchanger, an exhaust connection from the heat exchanger to the compressor, and an oil conduit from said heat exchanger to the compressor oil chamber.

15. In a refrigerating plant including a compressor, a condenser, an evaporator, and conduit means for connecting the same in circuit, a heat exchanger having two separated chambers, one said chamber being connected in said conduit means between said condenser and evaporator, continuously open conduit means establishing communication of the other said chamber with the liquid space of said evaporator and with the compressor for the movement of liquid refrigerant into said other chamber, and means located in the conduit means between the evaporator and said other chamber for controlling the rate of movement of liquid refrigerant therethrough.

16. A refrigerating plant as in claim 15, in which said controlling means includes a valve operative to maintain a pressure differential between said evaporator and second chamber.

17. A refrigerating plant as in claim 15, including an auxiliary compressor for evacuating refrigerant gas from said second chamber.

18. The method of purging, rectifying and reclaiming oil from refrigerant in a refrigerating system whose operation includes the steps of compressing the gaseous refrigerant in the presence of the oil, condensing the compressed gas with oil therein to a liquid mixture, and effecting an evaporation of the refrigerant from the liquid mixture, which comprises withdrawing from the evaporation step a part of said mixture and bringing the same into heat-exchange relationship with the condensed mixture, and effecting a further evaporation of refrigerant from said part whereby to cool said condensed mixture prior to evaporation thereof.

19. In a refrigerating plant including a compressor, a condenser, an evaporator, and conduit means for connecting the same in circuit, a heat exchanger having two separated chambers, one said chamber being connected in said conduit means between said condenser and evaporator, continuously open conduit means establishing communication of the other said chamber with the liquid space of said evaporator and with the compressor, means located in the conduit means between the evaporator and said other chamber for controlling the rate of movement of liquid therethrough, said controlling means including a pump for moving the liquid, and means employing the energy of refrigerant entering said evaporator for driving said pump.

20. In a refrigerating plant including a compressor, a condenser, an evaporator, and conduit means for connecting the same in circuit, a heat exchanger having two separated chambers, one said chamber being connected in said conduit means between said condenser and evaporator, continuously open conduit means establishing communication of the other said chamber with the liquid space of said evaporator and with the compressor, means located in the conduit means between the evaporator and said other chamber for controlling the rate of movement of liquid therethrough, said controlling means including a valve for stopping the flow of liquid, a valve between said second chamber and condenser, and a withdrawal duct from a low level of said second chamber for the discharge of oil by the pressure developed in said second chamber when said two valves are closed.

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