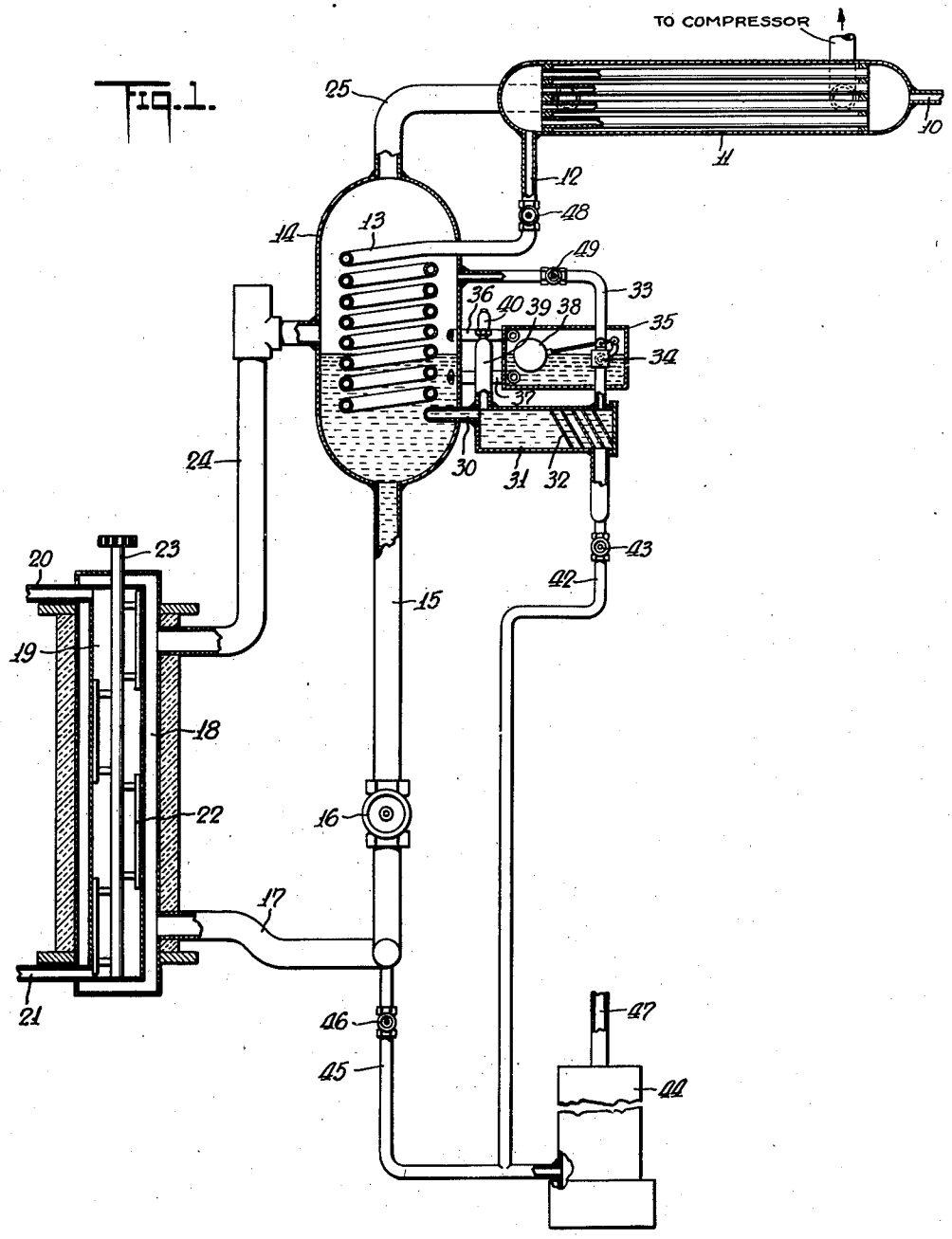
Feb. 4, 1941. B. DE H. MILLER 2,230,892

PURIFICATION OF VOLATILE REFRIGERANTS

Filed Dec. 28, 1938 2 Sheets-Sheet 1

Fig. 1.



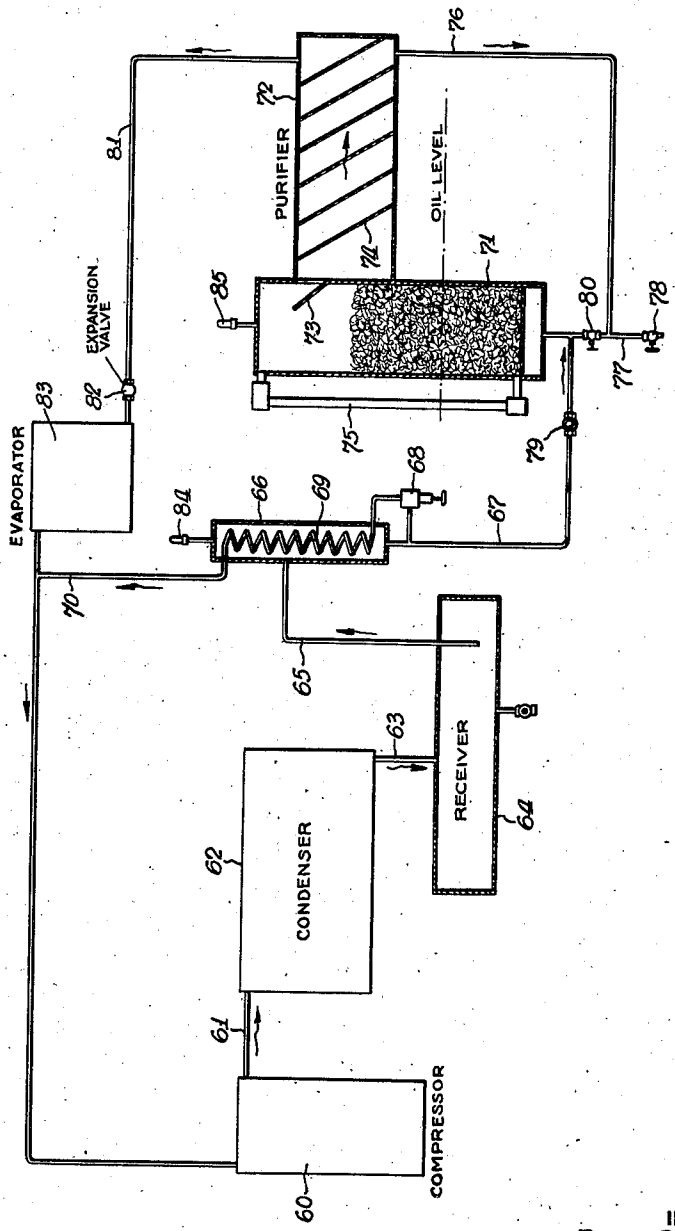
INVENTOR
Bruce De Haven Miller
BY
Dean Fairbank & Hirsch
ATTORNEYS

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Fig. 2.



INVENTOR
Bruce De Haven Miller
BY
Dean, Fairbanks & Hirsch
ATTORNEYS

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PURIFICATION OF VOLATILE REFRIGERANTS

Bruce De Haven Miller, Louisville, Ky., assignor to The Girdler Corporation, Louisville, Ky., a corporation of Delaware

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10 Claims. (Cl. 62—115)

This invention involves a method of and means for purifying the volatile refrigerant contained within a closed refrigeration system of the type in which a compressor is employed. With the ordinary compressor it is necessary to provide adequate lubrication, and in operation greater or lesser amounts of the lubricant are volatilized in the compressor or entrained by the volatile refrigerant, in leaving the compressor, and are carried along to various parts of the system. The usual refrigerant is substantially non-volatile at the temperatures and pressures employed in the condenser and receiver, and is volatilized under the reduced pressure in the evaporator. The lubricant will condense out or separate from the refrigerant at various points in the system, and will not be returned to the compressor with the refrigerant in gaseous form. As the coldest surfaces in the system are those in the evaporator, and as the refrigerant changes to gaseous form in the evaporator, the greater amount of the lubricant will usually deposit on such evaporation surfaces and form films which retard the heat transfer to the refrigerant. Such deposits of lubricant lower the efficiency of the system and are rather difficult to remove.

The main object of the present invention is to increase the efficiency of the entire system by causing the oil and other undesirable liquid constituents to be more effectively and completely deposited from the refrigerant and removed before said refrigerant reaches the evaporation section.

By means of the present invention there is effected the removal of not only the lubricant or other oil impurities, but also other extraneous material such as water which may find its way into the refrigerating system, particularly at those points where subatmospheric pressure is employed.

As an important feature of the present invention the refrigerant while in liquid form, and after leaving the condenser or receiver, is chilled to a very low temperature before the pressure is reduced to that of the evaporation section of the system. The oil and other extraneous liquids are separated from the liquid refrigerant while at this low temperature, and while under the high pressure generated by the compressor. Thus the refrigerant is substantially freed of lubricant and other extraneous liquids before passing to the evaporator, and the heat transfer surfaces of the evaporator are kept clean, and the formation of insulating films thereon is prevented.

As a further feature of the invention such non-condensible gases as may leak into or be generated in the system are likewise removed from the refrigerant while the latter is under high pressure and very low temperature.

In some refrigerating systems the lubricant employed is of greater specific gravity than the cold liquid refrigerant, and in some systems the lubricant employed is of lower specific gravity. Although the particular apparatus hereinafter described is designed primarily for those systems in which the lubricant is heavier than the liquid refrigerant, still the same apparatus may be employed for removal of lubricant along with non-condensible gases where the lubricant is lighter than the refrigerant.

Other important features and advantages of the invention will be pointed out in connection with the specific description of certain embodiments, or will be apparent from a consideration of the forms illustrated.

In the accompanying drawings:

Fig. 1 is a somewhat diagrammatic illustration of one form of apparatus embodying the present invention, certain parts being shown in section; and

Fig. 2 is a similar view of another embodiment.

In the specific construction illustrated in Fig. 1, the volatile refrigerant in liquid form is delivered through the pipe 10 from the receiver or from the condenser, and under the pressure developed by the compressor. Such liquid is ordinarily at room temperature or a little higher than that of the condenser water. As an example it may be under a pressure of 154 pounds per square inch, and at a temperature of about 86° F. The liquid refrigerant is delivered from the pipe 10 through any suitable form of heat interchanger 11 which has passages for the liquid refrigerant and separate passages for the cold refrigerant gases returning to the compressor from the evaporation system. The liquid refrigerant cooled in this interchanger is delivered through a pipe 12 to a coil 13 within the usual surge drum 14. In this coil the liquid refrigerant is cooled to a low temperature by the evaporation of the refrigerant in the drum, and by the cold refrigerant gases returning from the evaporator.

At this low temperature the lubricant and other impurities separate from the liquid refrigerant, and due to the flow of the refrigerant through the coil 13 at relatively high velocity while the evaporation system is in operation, the lubricant will be swept along with the liquid refrigerant, rather than remaining as a film within the coil.

The temperature to which the refrigerant is cooled in the coil may be about 0° F., depending upon the load carried by the evaporator, and depending upon the back pressure which may be about 15 pounds or such other pressure as will give the desired rate of evaporation of the refrigerant and desired low temperature in the evaporator.

I do not wish to be limited to any particular type of evaporation system, but show merely for purposes of illustration one in which the surge drum is mounted at a higher elevation than the evaporator, and the refrigerant is withdrawn from the bottom of the surge drum through a pipe 15 controlled by a valve 16 and delivered through a pipe 17 to the jacket 18 of the evaporator.

The particular evaporator illustrated is one in which the material to be treated may be continuously delivered through a chamber 19 encircled by the jacket 18 and continuously agitated while in the chamber and scraped from the chilled walls. The chamber is shown as having an inlet 20, an outlet 21, and scrapers or agitators 22 mounted on a central shaft 23 and serving to remove the films of solidified material as they form on the chilled periphery surfaces.

The refrigerant gas after evaporating in the jacket 18 escapes through a pipe 24 which leads to the surge drum above the normal liquid level in the latter, and from the top of the surge drum the gas passes through a pipe 25 to the heat interchanger 11, and thence back to the compressor. Any unevaporated liquid which may be carried along with the gas flowing through the pipe 24 will separate from the gas in the surge drum.

Although the specific heat of the expanded gas in the pipe 25 is substantially less than the specific heat of the liquefied refrigerant in the heat exchanger, the liquid delivered through the pipe 12 to the coil 13 may be lowered to a temperature of about 43° F. The refrigerant liquid in passing through the coil 13 in the drum 14 will be further cooled by the evaporation of liquid in the drum, as well as by the cold gases coming through the pipe 24 from the evaporator, so that the refrigerant in the coil 13 may be cooled to about 0° F., and under the compressor pressure, which may be about 154 pounds.

Obviously the lubricant or other extraneous liquids in the refrigerant will be cooled to the same temperature as the refrigerant in the coil, and as the temperature of the lubricant drops its viscosity increases. Thus it is very much easier to collect and separate the lubricant when the refrigerant liquid is at low temperature than when at a high temperature, as the greater the viscosity of the lubricating oil the greater is the tendency of the oil to adhere to or be retained by baffle surfaces in the path of flow.

In carrying out the present invention the cold liquid refrigerant containing the cold highly viscous oil in liquid form, is delivered from the coil 13 through the pipe 30 to a separator 31. This is preferably a chamber larger in cross-section than the coil, so that the rate of flow of the refrigerant will be greatly reduced. Within the separator there are provided baffles or screens 32 which may be of any suitable material, such as metal or wood, and these are preferably inclined at an angle to the direction of flow of the liquid, so that droplets of lubricant separated by adhering to these screens or baffles will not only drain to the lower side of the chamber, but the draining action will be facilitated by the flow through the chamber.

The refrigerant leaves the separator 31 through a pipe 33 having a float controlled valve 34 and thence into the surge drum, preferably at a point above the normal liquid level in the latter. The valve 34 may be located directly in the drum, or in any auxiliary chamber communicating with the drum, so that the float will control the liquid level in the drum.

Merely as an example, and to simplify the illustration, there is shown a chamber 35 communicating with the surge drum through upper and lower pipe connections 36 and 37, so that the liquid level in the chamber 35 will be the same as in the drum. The float 38 is mounted in the chamber 35, so that its operation will not in any way be interfered with by the coil 13, and this float controls the valve 34 which may also be located inside of the chamber 35 so as to avoid the necessity for separate packings or joints which might develop leaks. Obviously the chamber 35 might be entirely omitted and the float 38 and valve 34 be located inside of the drum, and in a section of pipe leading from the top of the separator 31 to the interior of the drum.

The separator 31 is also provided with a dome or conduit section 39 at the top thereof and between the inlet to the separator and the baffles. This may have a control valve 40 at the upper end. Non-condensible gases in the refrigerant will separate from the cold liquid refrigerant and rise into the dome or conduit section 39, and their escape may be permitted by opening the valve 40 as required. By removing these gases from the low temperature liquid refrigerant, there will be less escape of refrigerant vapor than is the case where the gases are drawn off from a receiver or other chamber at a temperature of condenser water or higher.

If the lubricant be of lower specific gravity than the refrigerant liquid, such lubricant will also rise into the dome or conduit section 39, and may be drawn off from time to time along with the non-condensible gases.

The separator 31 is provided with a drainage conduit 42 leading from the bottom, and beyond some or all of the baffles. This may have a control valve 43 and lead to a lubricant receiving vessel 44.

In case any oil separates from the refrigerant liquid in the drum 14 or in the conduit 15, it may be tapped off through a conduit 45 leading from the lowermost portion of the conduit 15, and also leading to the receiver 44. This conduit 45 should have a control valve 46, and the conduit 17 may lead upwardly to the evaporator from the point of connection with the pipe 45, so as to further insure the tapping off of any lubricant from the refrigerant before it goes to the evaporator. Any volatile refrigerant which may be dissolved in the lubricant and carried out through the pipes 42 or 45 to the receiver 44 will separate from the lubricant at the lower pressure in the receiver 44, and may be led back to the compressor by a pipe 47.

By providing a valve 48 in the pipe 12 and a valve 49 in the pipe 33, the supply of refrigerant may be shut off until the refrigerant in the evaporator has been evaporated, and then the valve 48 may be opened and refrigerant blown through coil 13 and chamber 31 to sweep out any oil adhering to the walls or the baffles 32 and carry it out to the receiver 44, the refrigerant gas returning to the compressor through pipe 47.

In the method and apparatus above described

the temperature of the incoming refrigerant is reduced to such a point that oil and water can be effectively separated prior to the time the refrigerant reaches the evaporator surfaces, and while the refrigerant is still under high pressure. This separation of the oil and other extraneous liquids makes it possible to maintain a highly efficient heat exchange in the evaporator, and at practically its theoretical value during the use of the apparatus.

The oil and other impurities tend to condense and collect at the first point in the system where the flow conditions are suitable and the temperature is low enough to cause such condensation and collection. In the practice of the present invention, a low temperature, along with reduction in velocity of flow of the refrigerant, is provided at a point in the system ahead of the evaporator. Thus, the oil and impurities are caused to separate out and collect before they reach the evaporator and where they do the minimum of damage, rather than in the evaporator where they would do the maximum damage. This operation is effected by utilizing the low temperature of the gas which has already passed through the evaporating stage. The apparatus requires the minimum of additional parts, expense and space.

In the construction illustrated in Fig. 2, the compressor **60** delivers the compressed volatile gas along with portions of lubricating oil, through the pipe line **61** to the condenser **62**, and the liquefied refrigerant passes through the pipe **63** to the receiver **64**. The liquid refrigerant passes through a pipe **65** to a heat exchanger **66**, and thence through a pipe **67** to a separator, hereinafter described.

A portion of the liquid refrigerant leaving the heat exchanger is tapped off and expands at an expansion valve **68** delivering to a coil **69** in the heat exchanger; and this coil delivers through a pipe **70** to the pipe line leading from the evaporator back to the intake of the compressor.

The refrigerant may be evaporated and delivered through the coil **69** at such a rate as will reduce the temperature of the liquid refrigerant in the exchanger to a temperature of about 0° F.

In the form of separator illustrated there is a vertical chamber **71**, to the bottom of which the pipe **67** delivers the liquid refrigerant and lubricant. A horizontal purifier section **72** communicates with the upper portion of the chamber **71** through a suitable port protected by a baffle **73**. Within the purifier section there are provided inclined baffles or screens **74** similar to the baffles or screens **32** shown in Fig. 1.

The cold liquid refrigerant entering the bottom of the chamber **71** comes to a substantially quiescent condition and the lubricant separates due to its greater specific gravity. The oil may be permitted to accumulate in this chamber **71** to any desired oil level which may be determined by a gauge glass **75** on the side of the chamber. The chamber **71** may be filled with mineral wool or any other suitable means which will tend to collect the oil or facilitate its separation and drainage to the lower portion of the chamber.

The liquid refrigerant passes over the baffle **73** and thence through the chamber **72** where further separation of the oil is effected. The oil separated in the chamber **72** may be withdrawn through a pipe **76** which m ; connect to a pipe **77** leading from the bottom of the chamber **71**. and the outlet may be controlled by a valve **78**. There is preferably a check valve **79** in the pipe **67** leading to the chamber **71**, and there may be a valve **80** in the pipe **77** above its connection to the pipe **76**. The oil withdrawn through the valve **78** may be delivered to a low pressure separating chamber where any dissolved gas may be drawn off and returned to the intake side of the compressor.

The chambers **71** and **72** are preferably kept substantially filled with the refrigerant liquid and oil under the high pressure, and may be insulated to maintain them at the cold temperature of the liquid coming from the exchanger **66**.

It will be understood that the chambers **71** and **72** as shown in Fig. 2, are of very much greater size in proportion to the size of the evaporator, condenser, compressor, etc. than would be employed in commercial practice, but these parts have been shown of larger size to facilitate a clearer showing of the construction, and to emphasize their importance.

The cold liquid refrigerant is drawn off from the upper side of the purifier chamber **72** through a conduit **81**, and may be delivered past an expansion valve **82** to the evaporator **83**. Non-condensible gases may be drawn off from the heat exchanger through an outlet valve **84**, and may be drawn off from the upper end of the chamber **71** through a valve **85**.

One of the most important features of the present invention is the construction and arrangement whereby the oil is separated from the refrigerant liquid while the latter is under high pressure and after it has been cooled to a temperature approximating that employed in the evaporator. The particular details whereby this is accomplished may be varied in different installations, and other types of separating apparatus may be employed.

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

1. In a refrigerating system of the type having a compressor, the method of removing lubricant from the system which includes lowering the temperature of a flowing stream of the liquid refrigerant while under pressure to a temperature at which the oil tends to separate, thereafter reducing the velocity of said stream, collecting upon contacting surfaces the oil separating from said refrigerant in said stream, and separating the cold oil from the cold liquid refrigerant flowing at said lower velocity and before lowering the pressure on the liquid refrigerant to effect evaporation of the latter.

2. In a refrigerating system of the type using a volatile refrigerant and having a compressor, the method which includes condensing the refrigerant gases and oil vapors delivered by the compressor, cooling a stream of the liquid refrigerant to a low temperature to increase the viscosity of the oil therein, thereafter reducing the velocity of said stream, separating the condensed oil from the cold liquid refrigerant while moving at the lower velocity, delivering the cold liquid refrigerant freed from the oil to an evaporator, and effecting the cooling of the condensed gas and oil vapor by the action of the cold gases returning from the evaporator to the compressor.

3. The process of refrigeration which includes compressing a volatile refrigerant by means of an oil-lubricated compressor, condensing the compressed refrigerant and the oil vapors to liquid form, passing the mixed liquid in heat exchange relationship with the expanded refrigerant vapors to thereby lower the temperature of said liquid to a point where the oil will

adhere to contacting surfaces, separating said oil from the cold refrigerant liquid, delivering the purified refrigerant liquid through an evaporating stage at a lower pressure, and passing the resulting gas in heat exchange relationship with the incoming mixed liquid under higher pressure.

4. In a refrigerating system of the type in which the vapors of a volatile refrigerant are compressed by an oil-lubricated compressor, the combination of a condenser adapted to lower the temperature of the mixed refrigerant vapors and oil vapors below their condensing points, a heat exchanger to lower the temperature of the liquid mixture to a point where the oil constituent tends to deposit upon contacting surfaces, a separator to receive the cold mixture and to retain the cold oil while permitting the free passage of the cold refrigerant therethrough, means for delivering the cold liquid refrigerant to an evaporating system at lower pressure, and means for returning the gases from the evaporating system to said heat exchanger.

5. A refrigerating system including an evaporator, a surge drum at higher elevation, means for delivering liquid refrigerant from the lower portion of the drum to said evaporator, means for returning refrigerant gas from the evaporator to the surge drum, a coil within said surge drum for receiving the liquid refrigerant under higher pressure, a separator for removing oil from the cold liquid refrigerant delivered from said coil, means for removing the oil from said separator, and means for delivering liquid refrigerant from said separator at lower pressure to said surge drum.

6. A refrigerating system including a separating chamber, means for delivering a stream of cold liquid refrigerant containing oil and under high pressure, to said separating chamber and through which the refrigerant flows at lower velocity to permit separation of the oil, means for delivering the cold liquid refrigerant from said separating chamber to an evaporator at lower pressure, and means for cooling the liquid refrigerant before delivering to said separating chamber, by the evaporation of liquid refrigerant at low pressure.

7. A refrigerating system including a separating chamber having perforated baffles, means for cooling the liquid refrigerant while under high pressure by refrigerant gases under low pressure, means for withdrawing cold liquid oil from the lower portion of said separator beyond said baffles, and a conduit leading from the upper portion of said separator beyond said baffles and having an expansion valve for delivering the cold purified liquid refrigerant to lower pressure for refrigerating purposes.

8. A refrigerating system including a separating chamber having perforated baffles, means for cooling the liquid refrigerant while under high pressure by refrigerant gases under low pressure, means for withdrawing cold liquid oil from the lower portion of said separator beyond said baffles, a conduit leading from the upper portion of said separator beyond said baffles and having an expansion valve for delivering the cold purified liquid refrigerant to lower pressure for refrigerating purposes, and means for withdrawing the non-condensible gases from said separating chamber.

9. A refrigerating system including a separating chamber extending in a substantially horizontal direction and having an inlet at one end for cold liquid refrigerant under high pressure and containing oil, a conduit leading from the lower portion of the other end for withdrawing cold oil under high pressure, a conduit leading from the upper portion of the last mentioned end for withdrawing cold liquid refrigerant under high pressure, a series of baffles in said chamber between the inlet and the outlet ends, and means for cooling the liquid refrigerant and oil before delivering to said separator by cold refrigerant gases under low pressure.

10. A refrigerating system including a separating chamber extending in a substantially horizontal direction and having an inlet at one end for cold liquid refrigerant under high pressure and containing oil, a conduit leading from the lower portion of the other end for withdrawing cold oil under high pressure, a conduit leading from the upper portion of the last mentioned end for withdrawing cold liquid refrigerant under high pressure, and means for cooling the liquid refrigerant and oil before delivery to said separator, by cold refrigerant gases under low pressure.

BRUCE DE HAVEN MILLER.