March 23, 1943. H. A. PHILLIPS 2,314,516

OIL SEPARATOR FOR REFRIGERATION SYSTEMS

Filed Aug. 14, 1941 2 Sheets-Sheet 1

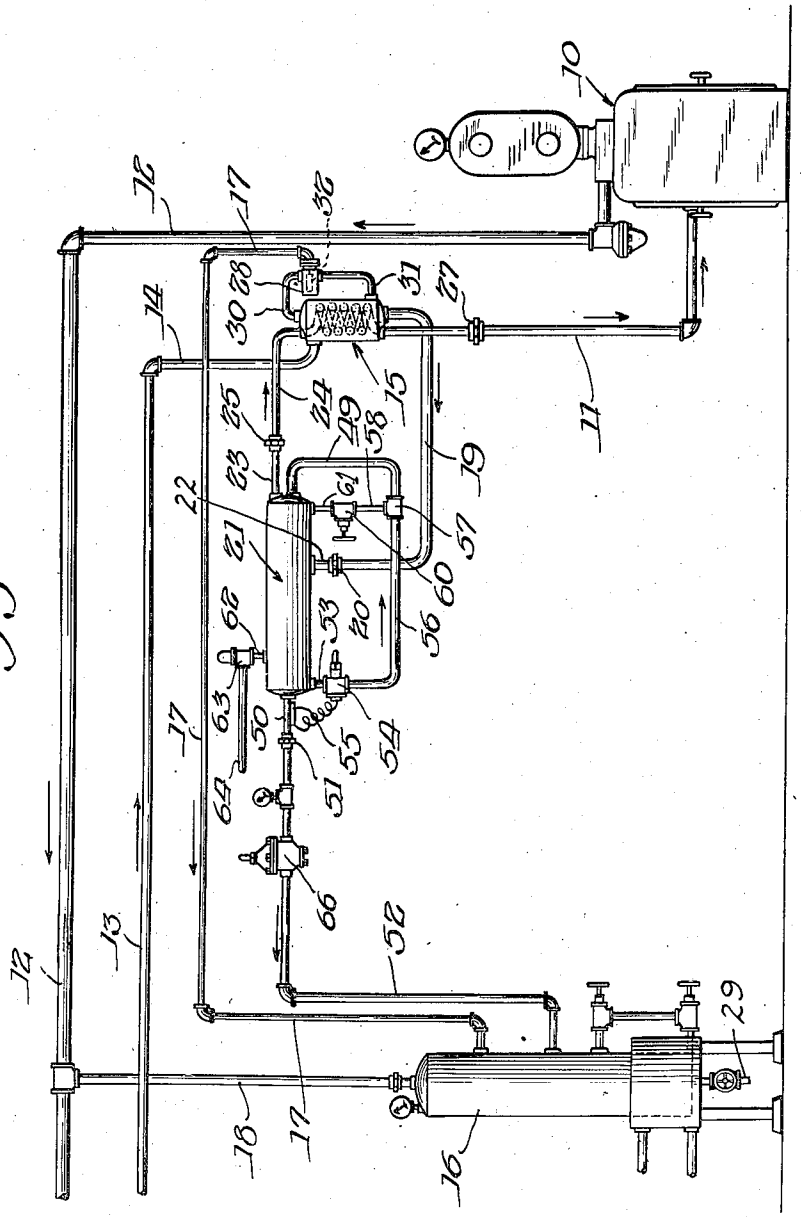


Fig. 1.

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Filed Aug. 14, 1941 2 Sheets-Sheet 2

Fig. 2.

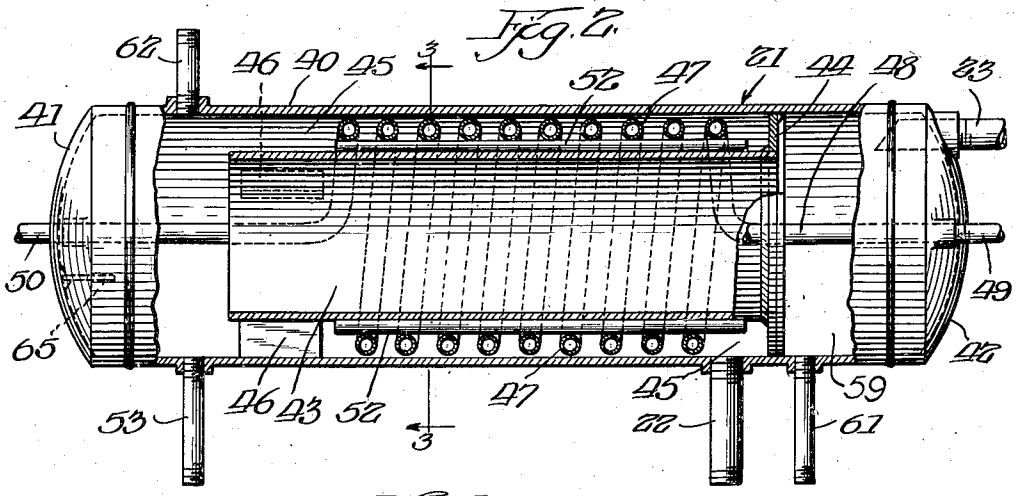


Fig. 4.

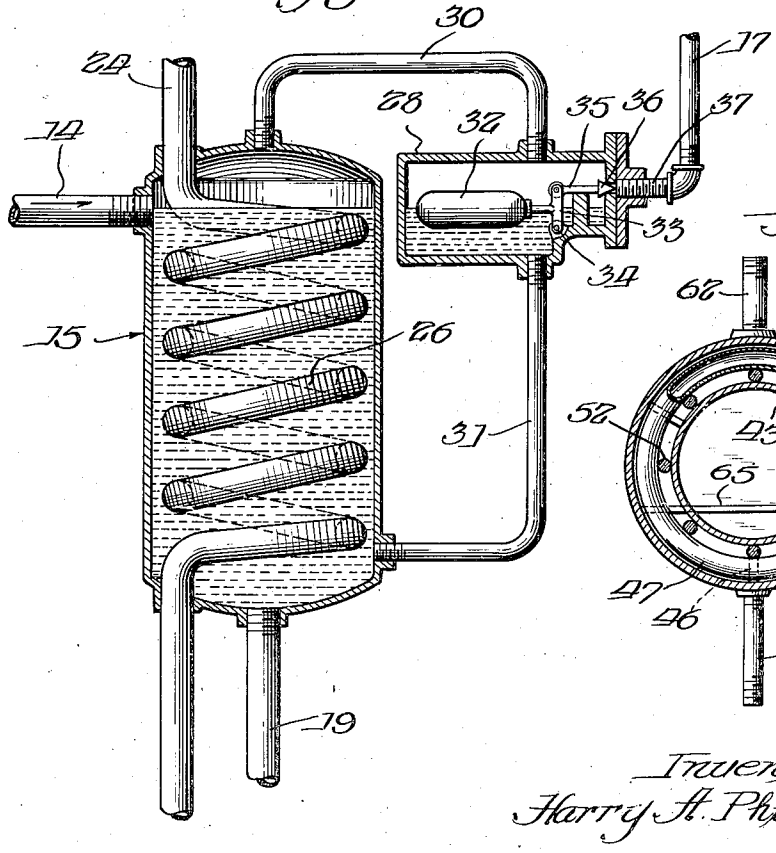


Fig. 3.

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OIL SEPARATOR FOR REFRIGERATION SYSTEMS

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7 Claims. (Cl. 62—115)

The invention relates to mechanical refrigerating systems and has more particular reference to improved apparatus in the form of an oil extractor for removing oil from the refrigerating medium of the system and for returning the oil to the suction side of the system.

In various types of mechanical refrigeration lubricating oil becomes mixed with the refrigerating medium used. Since the oil destroys the high operating efficiency of the evaporator it is most desirable that the oil be extracted from the refrigerating medium so that as little as possible will reach the apparatus in which the work of refrigeration is carried on. Among other detrimental effects the oil will form insulating films on the evaporator surface and excessive amounts frequently require a shut-down and blowing off of the evaporator. Also the oil interferes with the proper ebullition and vaporizing of the refrigerant and has a tendency to damp the motion of the evaporator float controls.

Accordingly an object of the invention is to provide an oil extractor of an improved type for effecting continuous separation of oil from the liquid refrigerant flowing through the extractor and which will return the extracted oil to the suction side of the system.

Another objection of the invention is to provide apparatus for separating oil from liquid ammonia or other liquid refrigerant lighter than and immiscible in oil and which will essentially comprise a trap located in the liquid line whereby the oil may be drawn off with or without some of the liquid refrigerant. The present apparatus makes it possible to use an adequate quantity of oil for lubricating the compressor since any excess which may pass along with the refrigerant is separated and short circuited directly back to the suction side of the system.

A further object resides in the provision of a heat exchanger in the liquid line so as to effect a reduction in temperature of the liquid refrigerant prior to the extraction of the oil therefrom.

A further object is to provide a gas vent in the liquid line, preferably a float controlled gas vent for venting any gaseous refrigerant in the liquid line whereby to materially decrease the turbulence of the liquid refrigerant while flowing through the oil extractor.

With these and various other objects in view, the invention may consist of certain novel features of construction and operation, as will be more fully described and particularly pointed out in the specification, drawings and claims appended hereto.

In the drawings which illustrate an embodiment of the invention and wherein like reference characters are used to designate like parts—

Fig. 1 is a diagrammatic elevational view of certain essential parts of a mechanical refrigerating system showing the improved apparatus of the invention embodied therewith;

Figure 2 is an elevational view, parts being shown in vertical section, to illustrate the internal construction of the improved oil extractor of the invention;

Figure 3 is a sectional view taken substantially along line 3—3 of Figure 2 to more clearly illustrate the construction of the spiral tubing within the oil extractor and the spacing of the same with respect to the center sleeve; and

Figure 4 is a vertical sectional view showing the heat exchanger of the invention and also illustrating the float controlled gas vent shown in associated relation therewith.

Referring to the drawings, wherein a preferred embodiment of the invention is disclosed, the numeral 10, Figure 1, indicates in its entirety an evaporator of a mechanical refrigeration system which may comprise a freezer or other conventional apparatus wherein the work of refrigeration is carried on. The liquid refrigerant after the oil has been separated therefrom is supplied to the evaporator 10 by pipe 11 and following evaporation of the same the gaseous refrigerant is conducted from the evaporator by the suction line 12, which line connects to the compressor of the system, not shown. The pipe 12 therefore comprises the suction side of the refrigerating system. A liquid receiver or reservoir, also not shown, supplies the liquid refrigerant to pipe 13, which, as shown in Figure 1, extends substantially parallel with the suction line 12 and has connection through connecting pipe 14 with the heat exchanger indicated by numeral 15. The numeral 16 represents any conventional type of still which has connection, as will be more particularly described, with the gas vent 17 from the liquid line and with the by-pass circuit of refrigeration located within the extractor 21 by means of which some gaseous refrigerant and oil is supplied thereto. In order that the gaseous refrigerant may be returned to the system the top of the still is connected by pipe 18 with the suction line 12. The pipe 14, as best shown in Figure 4, has connection with the cylindrical shell of the heat ex-

changer 15 and a continuation of this pipe, namely, 19, extends from the bottom of the shell so that the liquid refrigerant will flow through the heat exchanger, entering the same at 14 and leaving by the pipe 19, which conducts the liquid refrigerant to the oil extractor indicated by numeral 21, the same being admitted to the oil extractor through nipple 22 with which the pipe 19 connects by coupling 20.

The oil extractor is shown in detail in Figure 2, it being understood that the liquid refrigerant is caused to flow through the extractor in a manner to be more particularly described, whereupon substantially pure refrigerant having the oil removed therefrom will leave the extractor by pipe 23 located at the upper right hand end thereof, and which liquid refrigerant will then flow through pipe 24 connecting with pipe 23 by means of coupling 25. Pipe 24 enters the top of the cylindrical shell of the heat exchanger 15 and is spirally coiled within the shell to form the coiled tubing indicated by numeral 26. Said tubing leaves the shell at the bottom end thereof and has connection with pipe 11 by means of coupling 27, which latter pipe, as previously explained, supplies the pure liquid refrigerant to the evaporator.

To better understand the present invention reference is made to the heat exchanger shown in Figure 4. This device brings the relatively warm liquid refrigerant from the plant reservoir into heat exchanging relation with the cool liquid refrigerant after the same has passed through the oil extractor. As a result a reduction in temperature of the refrigerant prior to oil separation is produced and better separation is obtained. The warm liquid refrigerant from the reservoir is supplied to the shell of the heat exchanger 15 by pipe 14. The flow takes place in a downward direction and at a relatively low velocity due to the large diameter of the heat exchanger drum. The liquid refrigerant from the oil separator supplied by pipe 24 is brought into heat exchanging relation therewith by the coiled tubing 26. The tubing is coiled in order to increase the heat exchange surfaces and render the same as efficient as possible. In accordance with the invention a gas vent 17 is provided for relieving any gaseous refrigerant from the liquid line and which may preferably be associated with the drum of the heat exchanger.

As shown in Figure 4, the gas venting chamber 28 has its top wall connected by pipe 30 with the upper end of the heat exchanger. The bottom wall of the chamber is connected by pipe 31 with the bottom of the heat exchanger. Chamber 28 forms a chamber for the float valve 32 having securement to link 33 pivoted at 34. The upper end of the link pivotally connects with part 35, providing a valve 36, the same having a position with respect to an opening in the chamber so that upon longitudinal movement of part 35 the valve will open or close the same. The nipple 37 forming a continuation of said valved opening connects with the gas vent line 17 above referred to and which leads to the still 16.

During operation of the refrigerating system the level of the liquid refrigerant within the heat exchanger drum 15 and within the chamber 28 will vary, due to varying gas pressures. The level in both vessels will vary uniformly and the level will tend to drop as the pressure of the gaseous refrigerant increases. It will be clearly understood that any change in the liquid level in the chamber 28 will cause movement of float 32 and in the event the liquid level should drop the float will descend correspondingly to thereby retract valve 36 and open the chamber to the gas vent 17. Any gaseous refrigerant trapped in the upper part of the heat exchanger or within the upper part of chamber 28 will thereby flow through pipe 17 to the still 16. This venting of the gaseous refrigerant at this point in the liquid line is desirable since it results in a reduction in the velocity of flow of the liquid refrigerant and also reduces turbulence in the liquid flowing through the oil extractor.

From the heat exchanger the liquid refrigerant flows through pipe 19 and into the oil extractor 21 through nipple 22. As shown in Figure 2 the extractor essentially consists of a cylindrical drum 40 having a left end member 41 and a right end member 42 and having positioned centrally of the drum and concentrically therewith a tube or sleeve 43. At the right hand end the sleeve connects with a header 44 which has a liquid tight fit with the sleeve and a similar fit with the interior of drum 40. Since the header 44 is located to the right of nipple 22 it will be understood that the nipple communicates with an inlet compartment or annular space 45 formed by the sleeve and the interior of the drum 40 and which extends from header 44 for the length of the sleeve. At the end opposite the header 44 this annular space 45 communicates with the interior of the sleeve. The sleeve is supported at this end by one or more spacing members 46. The annular space 45 is substantially occupied by coiled tubing 47, the said tubing having a straight section 48 connecting with pipe 49 at the end 42 of the extractor, which is the inlet end of the tubing. At the end 41 of the extractor the straight portion 50 passes through said end wall and has connection by coupling 51 with pipe 52 leading to the still 16. The header 44 also forms an end compartment 59 with the end member 42 which compartment has connection with the outlet 23.

It is desirable to space the coiled tubing 47 with respect to the sleeve 43 and therefore a plurality of rods 52 are located at spaced points around the periphery of sleeve 43. The rods have the effect of locating each convolution of the tubing relatively close to the inner wall of drum 40 and in so doing each convolution is thus spaced a distance from the sleeve 43.

In the operation of the refrigerating system described the liquid refrigerant having oil in admixture therewith enters the oil extractor through nipple 22 and the same is caused to flow toward the left whereby the liquid is brought into intimate contact with the tubing 47, each convolution thereof acting as a baffle with respect to the flow of the liquid refrigerant. Pipe 23 provides the outlet for the liquid refrigerant and thus to leave the oil extractor it is necessary for the refrigerant to flow in a direction toward the right through sleeve 43. The oil extractor will become substantially full of liquid refrigerant before the same reaches pipe 23 and flows out through said pipe on its way to the heat exchanger as described. The refrigerant having oil in admixture therewith is cooled during flow through the annular space 45 since tubing 47 comprises an auxiliary cooling coil, as will be better understood as the description proceeds. This cooling of the liquid refrigerant also cools the oil which settles to the bottom of the extractor, whereas, the liquid refrigerant rises and eventually leaves the extractor by pipe 23. The nipple 53 leading from the base of the extractor at the left end thereof

conducts this oil and some liquid refrigerant from the extractor. Said nipple 53 has connection with an expansion valve 54 having a thermostatic control bulb 55 which regulates the expansion valve in accordance with the temperature of the expanded refrigerant gas flowing through pipe 50. From the expansion valve pipe 56 conducts the refrigerant along with the oil to a T 57, which T has connection with a by-pass pipe 58 and with pipe 49, which, as above explained, provides the inlet connection for the expansion coil 47. The by-pass 58 has a manual control valve 60 associated therewith and this valve joins with nipple 61, connecting with the bottom of the oil extractor on the right side of header 44. In the event any oil collects in the extractor on this side of the header it is possible to conduct the same together with some liquid refrigerant to pipe 49 which leads to the expansion coil 47. Said coil 47 may also be described as a by-pass circuit of refrigeration since as a result of the same the oil by-passes the evaporator and is returned to the suction line.

While return of the oil to the compressor is desirable in small installations, it is considered best for the present invention to remove the oil from the gaseous refrigerant and therefore an ammonia regenerator or still 16 is employed. For conducting the gaseous refrigerant from the still to the suction line 12 of the system the pipe 18 is provided and the extracted oil may be drawn off either intermittently or continuously by the oil outlet 29.

The refrigerant is expanded in coil 47 and as a result the same produces a cooling effect. Due to the heat exchanging relationship which the expansion coil 47 has with the liquid refrigerant within the oil extractor said refrigerant is materially cooled and likewise the oil is congealed to an extent sufficient to facilitate its separation. The cool liquid refrigerant leaves the extractor at 23 and flows through pipe 24 into tubing 26 where a heat exchange is effected to produce a temperature drop on the relatively warm liquid refrigerant flowing through the drum of the heat exchanger 15.

Since each convolution of the tubing 47 is spaced from the sleeve 43 the liquid refrigerant in flowing toward the left end of the extractor is caused to flow over each convolution and in so doing a substantial cooling of the same results and any gas still remaining in the liquid refrigerant is separated therefrom, which gas may leave the oil extractor through nipple 62 connecting with the relief valve 63 and pipe 64 leading to the still 16 or directly to the suction line. The oil extractor is also designed so as to require a maximum length of flow of the liquid refrigerant which gives the necessary time element for properly separating the oil therefrom. The velocity of flow is substantially reduced and the fact that the liquid refrigerant is required to flow over each convolution also further reduces its velocity. A baffle 65 is located on the inside of header 41 adjacent the nipple 53 to minimize turbulence of the liquid at this end of the header.

The gaseous refrigerant from the expansion coil 47 flows through pipe 50 into pipe 52 and thus to still 16 from which the refrigerant is eventually conducted to the suction line 12 of the refrigerating system. A back pressure valve 66 is located in the return line 52 of this auxiliary expansion circuit so that some control may be had of the pressure existing within the extractor. By a proper setting of the back pressure valve 66 it is possible to maintain a pressure in the oil extractor which will cool the refrigerant and oil to the desired temperature but not to a temperature low enough to freeze the oil. In the event the suction pressure should become extremely low, such as sometimes exists in a booster system, then the oil might freeze within the extractor, which, of course, would practically prevent its separation and return to the suction line.

The oil separator of the invention has a high operating efficiency since the liquid refrigerant is maintained at a low temperature and also because the liquid moves at a low velocity through the separator and in a substantially horizontal direction. The separated oil may be withdrawn at two points, namely, through 53 or through 61. The preferred construction and arrangement of the coil 47 is shown in Figure 2. At first it was thought that the liquid should be passed in a spiral motion around the coil but it was found better to make the annular space generous and let the liquid pass horizontally across the coils, giving the oil a chance to separate between each turn of the group. This action has been further facilitated by spacing the coil 47 from sleeve 43 so that any gas coming into the separator along with the liquid refrigerant will collect in the upper portion of the cylindrical member and possibly condense rather than travel to the end of the member and then back again through the sleeve.

The invention is not to be limited to or by details of construction of the particular embodiment thereof illustrated by the drawings, as various other forms of the device will of course be apparent to those skilled in the art without departing from the spirit of the invention or the scope of the claims.

What is claimed is:

1. A refrigerating system including a liquid refrigerant supply line and a return line for the expanded gaseous refrigerant, a cylindrical member interposed in the liquid refrigerant supply line, said member having end walls to thereby form a container which is adapted to receive and deliver liquid refrigerant, means within the cylindrical member providing a trap for separating any oil from the said liquid refrigerant, a refrigerating coil located within the cylindrical member, the inlet end of said refrigerating coil having connection with the member so as to receive the oil separated by the trap and also any liquid refrigerant admixed therewith, the opposite end of the refrigerating coil having connection with the return line for the expanded gaseous refrigerant, and a back pressure valve interposed in the said connections joining the refrigerating coil with the return line, whereby a predetermined pressure can be maintained in the refrigerating coil.

2. A refrigerating system including a liquid refrigerant supply line and a return line for the expanded gaseous refrigerant, a cylindrical member interposed in the liquid refrigerant supply line and positioned with its longitudinal axis horizontal, said member having end walls to thereby form a container and which receives liquid from the supply line connecting with the member in the vicinity of the bottom thereof and which delivers liquid refrigerant through an outlet connecting with the cylindrical member in the upper portion thereof, means within the cylindrical member providing a trap for separating any oil from the said liquid refrigerant, a refrigerating coil located within the cylindrical member, the inlet end of said refrigerating coil having connection with the member so as to receive the oil

separated by the trap and also any liquid refrigerant admixed therewith, the opposite end of the refrigerating coil having connection with the return line for the expanded gaseous refrigerant, and a back pressure valve interposed in the said connections joining the refrigerating coil with the return line, whereby a predetermined pressure can be maintained in the refrigerating coil to produce the desired temperature.

3. A refrigerating system including a liquid refrigerant supply line and a return line for the expanded gaseous refrigerant, a cylindrical member interposed in the liquid refrigerant supply line, said member having end walls to thereby form a container which is adapted to receive and deliver liquid refrigerant, means within the cylindrical member providing a trap for separating any oil from the said liquid refrigerant, a refrigerating coil located within the cylindrical member, the inlet end of said refrigerating coil having connection with the member so as to receive the oil separated by the trap and also any liquid refrigerant admixed therewith, the opposite end of the refrigerating coil having connection with the return line for the expanded gaseous refrigerant, a back pressure valve interposed in the said connections joining the refrigerating coil with the return line, whereby a predetermined pressure can be maintained in the refrigerating coil, and a relief valve having connection with the cylindrical member in the upper portion thereof to vent any gaseous refrigerant to the return line in the event of an excessive gas pressure within the cylindrical member.

4. An oil separator of the character described, a container having end walls and positioned with its longitudinal axis horizontally disposed, a refrigerating coil within said container, said coil having an inlet extending through one end wall of the container and having an outlet extending through the opposite end wall, an open ended sleeve within the container and within said refrigerating coil, a partition joining the sleeve at one end thereof to the container to form a compartment with the end wall at said end of the container and an annular space between the sleeve and the longitudinal wall of the container communicating with the compartment only through the sleeve, an inlet for liquid refrigerant located adjacent one side of the partition and in communication with said annular space, an outlet for liquid refrigerant at the end of the container provided with the end compartment and which requires that the liquid refrigerant flow the length of the annular space and then back through the sleeve to reach said outlet, and a drain for withdrawing the separated oil from the container and any liquid refrigerant admixed therewith, said drain having connection with the container at the end opposite the outlet for the liquid refrigerant.

5. An oil separator of the character described, a cylindrical member having end walls and positioned with its longitudinal axis horizontally disposed, an open ended sleeve located within the member substantially concentric with the cylindrical wall thereof, a partition extending between the periphery of the sleeve at one end thereof and the cylindrical wall of the member and which thereby forms said member into two compartments having communication only through said sleeve, one of said compartments including the annular space between the sleeve and the cylindrical wall of the member and located on one side of the partition, the other compartment comprising the chamber on the opposite side of the partition formed by the same and the adjacent end wall of the member, an inlet for liquid refrigerant connecting with the member so as to deliver the liquid to the annular space adjacent the partition, an outlet for the liquid refrigerant in communication with said end compartment, and a refrigerant expansion coil located within the annular space and having its inlet connecting with the lower portion of the member at the end opposite said end compartment, whereby any oil separated from the liquid refrigerant during its flow through the member and any refrigerant admixed therewith is delivered to said expansion coil.

6. An oil separator of the character described, a container provided with an inlet for liquid refrigerant having oil admixed therewith and provided with an outlet for substantially pure liquid refrigerant, a refrigerant expansion coil within the container, said coil having a plurality of convolutions of approximately the same diameter as the interior of the container, an open ended tube within the expansion coil concentrically disposed with respect to the convolutions thereof but spaced therefrom, a partition supporting the tube at one end and dividing the container into an inlet compartment and an outlet compartment having communication with each other only through the tube, the inlet compartment connecting with said inlet and including the annular space between the tube and the container and which is substantially occupied by the refrigerant expansion coil, the outlet compartment connecting with said outlet comprising the space between the partition and the adjacent end wall of the container, and a drain for separated oil and any liquid refrigerant admixed therewith, said drain extending from the container adjacent the end opposite the end compartment and connecting with the inlet for the expansion coil.

7. An oil separator of the character described, a container having an inlet for liquid refrigerant containing oil and having an outlet for substantially pure liquid refrigerant and which is spaced with respect to the inlet, means within the container dividing the interior thereof into an inlet compartment having connection with said inlet and into an outlet compartment having connection with said outlet, said compartments communicating with each other in a manner requiring the maximum length of flow for the liquid to travel from the inlet to the outlet, a refrigerant expansion coil located within the container and within the inlet compartment thereof, said expansion coil having a cooling effect upon the liquid refrigerant within the inlet compartment to thereby facilitate the separation of the oil from said liquid refrigerant, a drain for withdrawing the separated oil and any liquid refrigerant admixed therewith from the said inlet compartment, and means located exteriorly of said container for connecting the drain with the inlet end of said refrigerant expansion coil.

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