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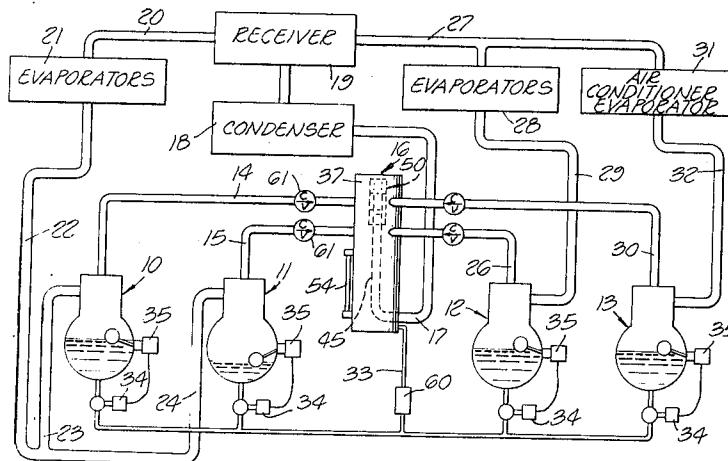
[54] **REFRIGERATION SYSTEM OIL SEPARATOR**
15 Claims, 3 Drawing Figs.

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62/468, 62/470, 62/472, 62/510, 55/459
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ABSTRACT: An oil separator for use in a refrigeration system, having a plurality of compressors and evaporators, receives the discharge of refrigerant and oil separately from each compressor to separate the oil which is returned to the compressor from the refrigerant which is passed on to a condenser.



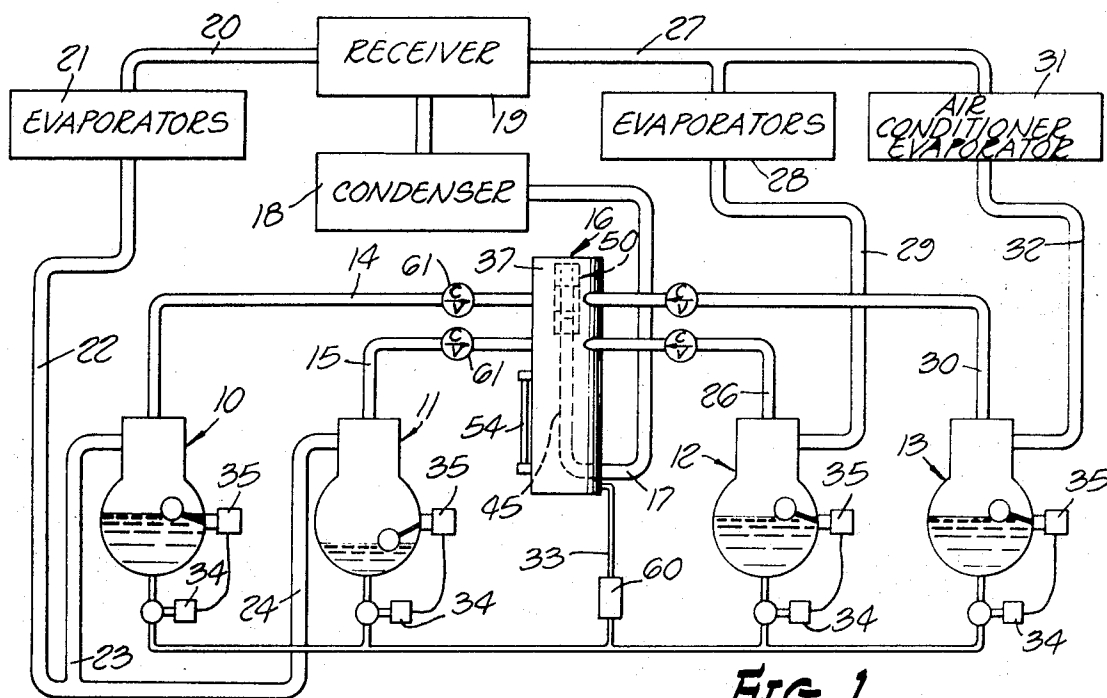


FIG. 1.

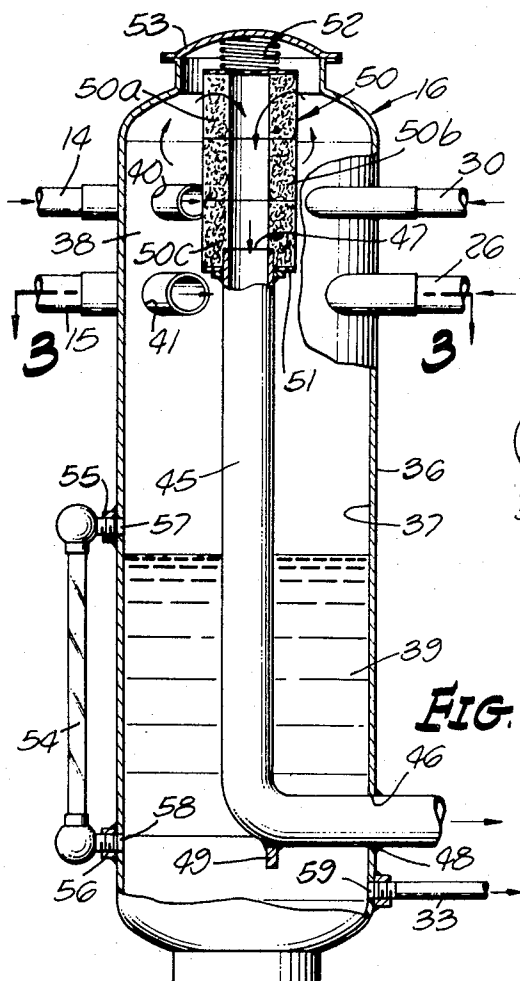


FIG. 2.

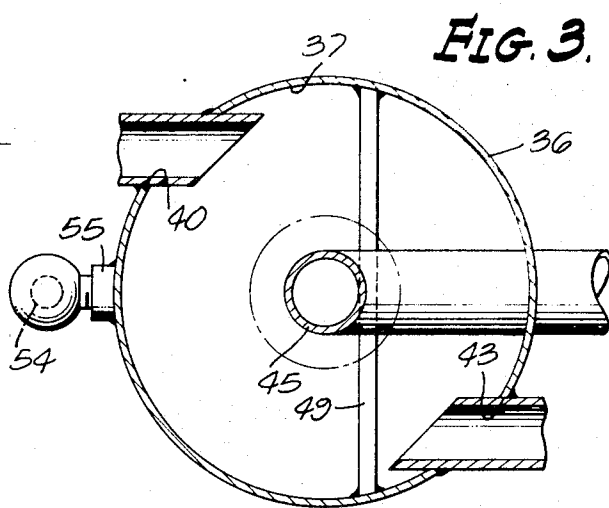


FIG. 3.

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REFRIGERATION SYSTEM OIL SEPARATOR

The invention relates generally to the refrigeration arts, and more specifically to an oil separator for use in a refrigeration system.

The refrigeration system contemplated is for a commercial installation such as a supermarket or the like wherein a plurality of large compressors work cooperatively on one receiver and one condenser to provide refrigeration for low-temperature display and storage fixtures, normal or commercial temperature display and storage fixtures and air-conditioning system.

In a typical commercial refrigeration system for a refrigeration fixture, a supply of liquid refrigerant is stored in a receiver to accommodate fluctuations in the fixture requirements for additional or less refrigerant to maintain a substantially uniform fixture temperature. The liquid is moved from the receiver by pressure through a liquid outlet line and to and through an expansion valve into an evaporator of the fixture. The refrigerant in the evaporator absorbs heat in the fixture and its contents in order to cool the fixture and contents, and the refrigerant is thus vaporized and superheated so that at the evaporator outlet it is entirely a gas. The refrigerant vapor from the evaporator outlet is drawn through a suction line into the intake low-pressure side of a refrigerant compressor where the refrigerant is compressed into a high-pressure, high-temperature vapor (heat of compression being added to superheated vapor). The hot refrigerant gas is discharged from the high-pressure side of the compressor into a condenser in which a heat exchange takes place with the cooling medium causing the gas to condense to liquefy.

In the past the practice was to provide independent and separate refrigeration systems for the low-temperature storage fixtures, the normal temperature fixtures and the air-conditioning system. Such practice required installing numerous equipment including several condensers and receivers and resulted in increased purchase, installation, power and service costs and relatively large space requirements for installation. Therefore, the more recent practice is to provide a single system for all the fixtures and the air-conditioning system. Such a single system is desirable because it avoids the duplication of equipment; for example, the entire system can function on only a single condenser and a single receiver.

However, several problems accompanied these large single systems. In the discharge pipe assembly between the compressors and the condenser the pulsations of the compressors fighting each other in a common pipe caused severe vibrations which necessitated anchoring the pipe in several places and in many instances resulted in pipe breakage. Since a large single system can hold up to \$3,000.00 worth of refrigerant, pipe breakage which releases this refrigerant from the system is particularly undesirable. While individual mufflers can be employed on each discharge line to reduce the vibrations, this is not particularly desirable because the mufflers add weight to the lines and are always subject to breaking unless securely anchored and because of the additional cost of each muffler. Moreover, in the discharge of all refrigeration compressors there is a combination of refrigerant gas and oil particles. It will be clearly understood to those skilled in the art that it is detrimental to the system to allow the oil to pass with the refrigerant to the condenser. Therefore, an oil separator is normally employed between the compressor and the condenser to separate the oil which is returned to the compressor from the refrigerant which is passed on to the condenser. However, it would be prohibitively expensive to use an oil separator for each compressor and a standard oil separator is less than satisfactory when employed in a single system because of the accumulative effect which occurs when several compressors discharge into a single condenser.

It has also been common for an oil separator to include a second vessel for collecting the oil separated. It is obvious that the manufacture of two vessels necessitates additional cost and therefore is undesirable.

Another disadvantage of the previous single systems is that they are essentially restricted to the use of open-type direct

drive compressors. Hermetic-type compressors might be particularly desirable in a large single refrigeration system; however, in the past if an electrical winding in a hermetic compressor grounded out and created an electrical arc in the Freon gas section of the system very large quantities of strong acids were instantly generated. These acids might migrate through the system and enter another compressor causing serious damage to the windings of that compressor.

Therefore, it is a principal object of the present invention to provide a single refrigeration system which avoids excessive vibration in the discharge pipe assembly between the compressors and the condenser. Another object of this invention is to provide a single refrigeration system employing hermetic-type compressors which reduces the effect of acids on the system created by a burnout or partial grounding of a portion of the electrical wiring in one of the compressors.

A further object of this invention is to provide an oil separator which will satisfactorily prevent oil from passing from the compressors with the refrigerant into the condensers or other parts of the refrigeration system. In accordance with this object, it is desirable that the oil separated from the refrigerant return to the compressors with a minimum of refrigerant.

Another important object of this invention is to provide an oil separator which also operates as a muffler to dampen the noise and vibration caused by pulsating discharge from the compressors.

Another feature of this invention is that the oil separator separate the oil and retain the separated oil within a single vessel or unit for return to a number of compressors, each operating at a different crankcase pressure.

Other and further objects and advantages of this invention will be made readily apparent from the accompanying drawings and following detailed description.

Briefly, the invention includes a single housing or vessel of relatively large volume which receives discharge from each compressor separately through a plurality of inlets and acts as a muffler to dampen noise and vibration. Oil in the discharge is separated from the refrigerant gas in the vessel and retained in the lower portion of the vessel where it is heated. The retained oil is subsequently returned to the compressors. An outlet conduit or member communicates the substantially oil free refrigerant gas from the upper portion of the vessel to the condenser.

IN THE DRAWINGS:

FIG. 1 is a diagrammatic representation of a single refrigeration system embodying the invention.

FIG. 2 is a side elevation, partly in section, of the oil separator.

FIG. 3 is a sectional view taken along the lines 3—3 of FIG. 2. Referring now more particularly to FIG. 1, the system includes a pair of low-temperature compressors 10 and 11 which operate a bank of low-temperature refrigeration fixtures (not shown) operating generally in the range from about minus 30° to about minus 5° F. The system also includes a standard or commercial temperature compressor 12 which serves to operate a bank of commercial or normal temperature refrigerators (not shown) operating in the range of about 25° to about 40° F., and a high temperature compressor 13 which operates and air-conditioning system.

The low-temperature compressors 10 and 11 each discharge refrigerant through separate conduits or discharge lines 14 and 15, respectively, to an oil separator, generally designated 16. The refrigerant is then passed from the oil separator 16 through a conduit 17 to a condenser 18 and then to a receiver 19, which forms a liquid refrigerant reservoir. A header 20 is provided for feeding refrigerant through expansion valves (not shown) to the individual low-temperature refrigerating evaporators which are diagrammatically illustrated by the block 21, and then through conduits 22, 23, and 24 back to the suction side of each compressor 10 and 11.

The refrigerant from the standard temperature compressor 12 is discharged through conduit 26 to the oil separator 16 and thence through the conduit 17 to the condenser 18 and receiver 19. A conduit 27 communicates the refrigerant through expansion valves (not shown) to the individual low-temperature refrigerating evaporators 28. The refrigerant passes from the evaporators 28 back to the suction side of the compressor 12 by a conduit 29.

Compressor 13 discharges refrigerant through conduit 20 to the oil separator 16. The refrigerant is then passed through the conduit 17 to the condenser 18 on the receiver 19 through the conduit 27 on the air conditioner evaporator 31 and back through conduit 32 to the suction side of compressor 13.

Oil separated from the refrigerant and collected in the oil separator 16 is returned to the individual compressors through an oil return line 33. Each compressor includes a solenoid-operated valve 34 and a float switch 35 which control the amount of oil returned to the compressor from the oil separator. Check valves 61 connected to the discharge lines of each compressor close when a compressor stops to prevent reverse flow of the refrigerant from the oil separator to the compressor.

Before describing the oil separator 16 in detail it should be noted that the oil separator performs various other important functions, each of which will be described below, besides merely separating the oil from the refrigerant. However, the unit has been designated an "oil separator" because it is the designation which is common in industry. The oil separator 16 as best seen in FIGS. 2 and 3, includes a generally cylindrical housing 36 which defines a closed vessel 37. The vessel 37 is generally described as having an upper portion or receiving chamber 38 and a lower portion 39. In the preferred embodiment, a pair of inlet openings 40 and 41 in the upper portion 38 of the vessel 37 are spaced approximately 180° apart from a pair of inlet openings 42 and 43 also in the upper portion 38 of the vessel 37. Inlet openings 40 and 41 receive the discharge lines 30 and 26, respectively. Thus, while only four openings and four discharge lines are described, it is evident that more or fewer openings and discharge lines can be used depending upon whether more or fewer than four compressors are used for the refrigeration system. Each discharge line is secured to the housing 36 preferably by welding and each discharge line extends short distance into the vessel 37 and its approximately tangent to the inner surface of the vessel 37 as shown in FIG. 3. By positioning the discharge lines in the above manner, the flow of oil and gaseous refrigerant from the compressor is oriented in one circular direction tangent to the inner surface of the upper portion 38 of the vessel 37.

The oil separator 16 also includes a cylindrical conduit or outlet member 45 which is preferably mounted symmetrically within the vessel 37. The outlet member 45 extends axially from the upper portion 38 of the vessel 37 to the lower portion 39 of the vessel 37 where it is bent approximately 90° to extend out through an outlet opening 46 in the housing 36. The end 47 of the outlet member 45 in the upper portion 38 is open. The other end of the outlet member 45 is in communication with the conduit 17. The outlet member 45 is secured to the housing 36 at 48 preferably by welding. A support member 49 extends across the vessel 37 with each end connected to the inner surface of the vessel 37 to support the outlet member 45. While not shown in the drawings, it is readily apparent that additional internal supports may be used if desired.

Extending axially about the upper section of the outlet member 45 and beyond the open end 47 is a disposable and replaceable acid filter or trap 50 also cylindrically shaped. Preferably, the acid trap 50 is comprised of three cartridges 50a, 50b, and 50c although more or fewer cartridges can be used. The lower end of the trap 50 is supported on a flange member 51 which is mounted concentrically about the outlet member 45. The other end of the trap 50 is engaged and held in place by suitable means such as a spring member 52 which extends between the trap and a removable cover or cap 53

which attaches to the upper end of the housing 36 to enclose the housing 36.

A sight gauge 54 connected by couplings 55 and 56 at each end to the housing 36 extends between the upper portion 38 and the lower portion 39 of the vessel 37. Outlet openings 57 and 58 provide for communication between the vessel 37 and the gauge 54. It should be noted that any type of gauge which will indicate the amount of oil reserve in the lower portion 39 of the vessel 37 will suffice and it need not be a sight gauge.

An outlet opening 59 in the lower portion 39 of the vessel 37 receives the oil return line 33. As seen diagrammatically in FIG. 1 within the oil return line 33 is a second acid trap or filter 60.

In operation each compressor passes high-pressure, high-temperature vapor refrigerant which includes within it oil particles through an individual discharge line and respective inlet opening in the housing 36 to the upper portion 38 of the vessel 37. Once the gas is in the vessel it flows at a relatively high velocity around the inside of the upper portion of the vessel 38. Centrifugal forces act on the oil particles to force the oil particles or droplets to separate from the primary gas stream and collect on the inner surface of the vessel 37 and become part of the oil film that is inevitably present on the inner surface of an oil separator. Gravity then acts on this oil to cause it to move downward into the lower portion 39 of the vessel where it is retained until it is returned to the compressor. The sight gauge 54 gives visual indication of the quantity of oil being retained at any one time in this portion of the vessel 37. In the meantime the substantially oil-free gaseous refrigerant passes from the upper portion 38 through the acid trap 50 into the open end 47 of the outlet member 45 and thence through the outlet member 45 and conduit 17 to the condenser 18.

The separated oil collected in the lower portion of the vessel tends to cool and when the temperature of the oil drops below the condensing temperature of the gas refrigerant some of the refrigerant will change to a liquid state and will mix with the oil to form a solution in which the oil is greatly diluted by the refrigerant. When this solution of oil and refrigerant is returned to a compressor, the compressor will boil the refrigerant which in turn foams the oil and causes the compressor to pump most of its lubricating oil out into the refrigeration system to the detriment of the compressor and to the overall system.

To avoid this phenomenon, the superheated refrigerant gas as it passes through the outlet member 45 heats the outlet member 45 which in turn heats the oil retained in the lower portion 39 of the vessel 37 and thereby maintains the temperature of the oil above the condensing temperature of the refrigerant. Thus, an excessive amount of refrigerant will not condense to mix with the oil and dilute the oil which is returned to the compressors.

As described above, the refrigerant gas from each compressor is passed into the vessel 37 by separate and individual discharge lines. Thus, the receiving and mixing of the gaseous refrigerant from all the compressors occurs in the relatively large upper portion or chamber 38 of the vessel 37 and not in a common discharge line. This upper portion or chamber 38 acts much the same as an individual muffler attached to a discharge line, i.e., it dampens out the pulsations of the compressor. Thus, the pulsation fighting which occurred previously in the common discharge line and the resulting vibrations and noise are significantly reduced. In addition, the undesirable individual mounting of the muffler and the undesirable additional cost of a muffler are avoided.

Before the refrigerant gas can pass through the outlet member and before the oil can pass through the oil return line, they must pass through the respective acid traps or filters 50 and 60. Thus, if hermetic-type compressors are employed in the refrigeration system and a burnout occurs to create acids, the acids will be collected by the filters 50 and 60 and will not be allowed to pass through the system to contaminate the other compressors.

Although not shown, an alarm system can be provided to warn whenever a compressor has grounded out and allow a serviceman to be called to shut down the system, drain the contaminated oil out of the oil separator and install new acid traps.

This invention therefore is useful to reduce the vibrations normally present in a large single system. It also protects the equipment used in a single system against acid damage when hermetic-type compressors are employed in the system. Moreover, oil from a plurality of compressors is effectively separated from the refrigerant before the refrigerant is passed to the condenser and the separated oil is returned to the compressors without an excessive amount of refrigerant. Also, the design of the invention is such that it reduces the places where refrigerant leaks might occur and greatly simplifies the return of the separated oil to the various compressors.

I claim:

1. In a refrigeration system having a plurality of compressors operating at different suction pressures, a plurality of evaporators adapted to operate a plurality of separate and independent refrigerated fixtures, a condenser to receive vapor refrigerant from all of the compressors, and a receiver for supplying liquid refrigerant to all of the evaporators, wherein the improvement comprises: an oil separator to separate oil from the refrigerant before the refrigerant is passed to the condenser, said oil separator having a receiving chamber and an oil-retaining chamber; said oil separator further having an outlet member, said outlet member having an open end in said receiving chamber to communicate hot refrigerant gas from said oil separator to the condenser; individual discharge lines from each compressor to communicate the pulsating discharge of oil and refrigerant gas separately from each compressor whereby pulsating discharge from all of the compressors is received and mixed in said receiving chamber and the noise and vibration caused by the pulsating discharge is dampened in said receiving chamber; and oil return means operably connected to said oil-retaining chamber for returning the separated oil independently to each compressor according to the particular demands of the various compressors.

2. The system of claim 1, wherein said outlet member is heated by the hot refrigerant gas and said outlet member passes substantially through said retaining chamber to maintain the temperature of oil in said retaining chamber above the condensing temperature of the refrigerant.

3. The system of claim 1, wherein said receiving chamber is cylindrical, said discharge lines pass discharge into said receiving chamber tangent to the inner surface of said receiving chamber to generate cyclonic separation of the oil and refrigerant gas in the discharge.

4. The system of claim 1, wherein the flow of refrigerant gas from said upper portion into said outlet member is partially restricted to assist in dampening the noise and vibration.

5. The system of claim 1, wherein separated oil is retained in said retaining chamber and a return line communicates oil from said retainer.

6. The system of claim 5, wherein acid traps are located at the open end of said outlet member and in said return line to prevent acid from passing from said oil separator.

7. The refrigeration system of claim 1 wherein said oil return means includes valve means to regulate the flow of oil returning to each compressor and independent control means associated with each compressor to control said valve means.

8. In a single condenser-receiver commercial refrigeration system having a plurality of compressors, some of which operate at different suction pressures, and multiple evaporators, an oil separator having a housing defining a cylindrical vessel, said vessel having an upper receiving chamber and a lower retaining chamber; individual discharge lines to separately pass pulsating discharge from each said compressor into said receiving chamber, said receiving chamber dampening the noise and vibration resulting from the mixing of the pulsating discharge; said discharge lines passing discharge into said receiving chamber tangent to the inner surface of said

vessel to generate cyclonic separation of the oil and refrigerant gas in the discharge; said retaining chamber receiving the separated oil and having an oil outlet for the varying flow of oil returning to the compressor; a gas outlet member having an end open in said receiving chamber to pass hot refrigerant gas from said receiving chamber to the condenser, said outlet member passing substantially through said retaining chamber and transferring heat from the refrigerant gas to the oil in said retaining chamber to prevent the refrigerant from condensing and mixing with the oil; and valve means associated with each said compressor for controlling the amount of oil returned to each said compressor.

9. The refrigeration system of claim 8, wherein said oil separator includes acid trap means to prevent acid from passing from said vessel into other components of the refrigeration system, said acid trap means including a removable and replaceable cylindrical filter cartridge supported at one end about an upper section of said outlet member and extending beyond said open end; and said vessel including a removable cap assembly enclosing the other end of said cartridge whereby refrigerant flow from said receiving chamber into said open end of said outlet member passes first through said cartridge.

10. In a single refrigeration system having a plurality of compressors operating at different suction pressures, a plurality of evaporators adapted to operate separate and independent refrigerated fixtures, a condenser to receive all of the vapor refrigerant supplied by said compressors, and a receiver for supplying liquid refrigerant to all of said evaporators, an oil separator for separating oil from refrigerant received from said compressors before being passed to said condenser, said separator comprising a closed vessel having integral upper and lower portions, separate inlet lines connected to said upper portion for separate communication of the pulsating discharge of refrigerant from each compressor with the combined discharge of all the compressors being mixed in said upper portion thereby dampening the noise and vibration caused by the pulsating discharge, said lower portion adapted to receive the oil from said upper portion and maintain at least a portion of the oil received for reserve purposes, an oil return means operably connected to said lower portion including valve means to regulate the flow of oil returning to each compressor and independent control means associated with each compressor to control said valve means whereby oil returns from said lower portion to the compressors according to the particular demands of each compressor.

11. In a refrigeration system having multiple compressors and multiple evaporators, a condenser and a receiver, wherein the improvement comprises: an oil separator to separate oil from the discharge gas of the compressors before it is passed to the condenser, said oil separator having a closed vessel, said vessel including a cylindrical upper portion and a lower portion integral therewith; a plurality of inlet lines communicating with said upper portion for separate communication of the pulsating discharge from each compressor, said inlet lines having discharge ends positioned tangent to the inner surface of said cylindrical upper portion for causing cyclonic separation of the oil from the discharge gas in said upper portion; said lower portion being adapted to receive the separated oil from said upper portion and having a retaining chamber for storing at least a portion of the oil received in surplus for a varying oil return flow; an outlet member for communication of the hot gas from said housing, said outlet member having an open end in said upper portion for receiving the separated gas and extending through said retaining chamber for transferring heat from the hot gas flowing therein to the stored oil therearound; and oil return means in communication with said lower portion for returning oil according to the demand of said individual compressors.

12. The device of claim 11, wherein the discharge ends of some of said inlet lines in said vessel are positioned 180° apart from the discharge ends of the other said inlet lines in said vessel.

13. The device of claim 11, wherein the flow of refrigerant gas from said upper portion into said outlet member is partially restricted to assist in dampening noise and vibration caused by the pulsating discharge from the compressors.

14. The device of claim 11, wherein a first acid trap is positioned about the open end of said outlet member and a second acid trap prevents acid from passing from said vessel into the

refrigeration system.

15. The device of claim 14, wherein said first acid trap partially restricts the flow of refrigerant gas from said upper portion into said outlet member to assist in dampening noise and vibration caused by the pulsating discharge from the compressors.

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