This invention relates generally to apparatus for and a method of recovering lubricant from a solution of lubricant and working fluid in a machine employed to perform a work operation on the fluid. More particularly, this invention pertains to an apparatus for and a method of recovering lubricant from a mixture of refrigerant and lubricant in a refrigeration machine.

In a refrigeration machine of the compression type, it is necessary to provide a lubrication system for the purpose of lubricating the moving parts in the compressor and the motor employed to drive the compressor. The primary function of the compressor is to lower the temperature of the gaseous refrigerant withdrawn from the evaporator, and to force it to the condenser. It is normally inherent in the lubrication system employed in the compressor assembly that a certain amount of leakage of the lubricant into the refrigeration circuit is unavoidable. This invention is directed toward means for recovering the lubricant which finds its way into the refrigeration circuit by employing a novel mechanism for withdrawing a portion of the refrigerant-lubricant mixture present in the system, applying a source of heat to vaporize the refrigerant constituent of the mixture and providing a path of flow through which the remaining lubricant automatically passes into the lubrication system in response to any one or more of a variety of conditions.

The chief object of the invention is the provision of an improved arrangement for recovering lubricant from a mixture of working fluid and lubricant in apparatus employed for the purpose of processing the working fluid. Another object of the invention is the provision of improved apparatus for recovering lubricant from the refrigeration circuit of a refrigeration machine, and transmitting it automatically to the lubrication system for the compressor employed in the refrigeration machine.

A further object of the invention is the provision of a mechanism for recovering lubricant in a refrigeration machine which employs a novel means for utilizing the high pressure portion of the refrigeration machine for the purpose of propelling the separated lubricant from the point of recovery to the lubrication system for the motor compressor assembly.

These and other objects of the invention will be apparent upon a consideration of the ensuing specification and drawings in which:

FIGURE 1 is a diagrammatic view of a refrigeration machine equipped with a lubrication recovery mechanism forming the subject of this invention;

FIGURE 2 is a partial diagrammatic view of a portion of a refrigeration system equipped with a modification of the oil recovery mechanism illustrated in FIGURE 1;

FIGURE 3 is a partial diagrammatic view of a further modification of the invention;

FIGURE 4 is a partial diagrammatic view of another embodiment of the invention illustrated in a manner similar to that shown in FIGURE 2;

FIGURE 5 is a partial diagrammatic view of a still further embodiment of the invention; and

FIGURE 6 is a diagrammatic view of a portion of the wiring diagram employed with the modification illustrated in FIGURE 5.

Referring to FIGURE 1 for an illustration of the invention as it applies to a refrigeration machine, a motor compressor assembly 10 includes a compressor section 12 and a motor section 13. A common drive shaft is employed in the motor compressor unit. Mounted at one end of the drive shaft is a first impeller 14 for the purpose of removing vaporous refrigerant from the evaporator, compressing it and forwarding it to the second impeller 16 where it is further compressed and transmitted to the condenser 20 through discharge line 18.

In the condenser, the gaseous refrigerant is liquefied by heat transfer with a medium such as water employed for the purpose of cooling the refrigerant. Liquid refrigerant flows through line 22 into the economizer 24 which includes upper chamber 26 and lower chamber 28. The economizer chamber 28 is at a pressure lower than that in the condenser so that portions of the liquid refrigerant flowing through the valve controlled opening 27 flash off and flow via line 38 to the section of the motor compressor unit housing the motor. The remaining liquid refrigerant is cooled and flows through the valve controlled opening 29 to line 30 and into the evaporator 31. In the evaporator, the liquid refrigerant is vaporized as it flows in heat transfer relation with a cooling medium flowing inside a closed circuit which includes coil 31'. The gaseous refrigerant then flows through suction line 32 to the entrance to the impeller to complete the refrigeration circuit.

As described above the gaseous refrigerant formed in the economizer is employed to cool the motor driving the compressor. Gaseous refrigerant flowing in line 38 cools the motor and flows into line 40 for subsequent flow to a point intermediate the two stages of compression in the compressor 12. A portion of the motor housing includes a lubrication sump 36 for the purpose of storing lubricant employed in the motor compressor unit. A pump (not shown) forwards lubricant from the sump through a closed circuit including the bearings supporting the common drive shaft. During operation of the refrigeration machine, portions of the lubricant enter the refrigeration circuit described through the labyrinth type seals separating the motor section from the compressor section or are carried in the gas stream flowing in line 40.

The invention contemplates herein apparatus for recovering the lubricant which inadvertently finds its way into the refrigeration circuit in the manner described. A separation chamber 42 is connected to the evaporator through line 44. Line 44 includes at its end a mechanism for communicating with the chamber a check valve 46 which is provided with an aperture 47 for a purpose to be later explained. Line 48 connects the separation chamber with the lubrication sump 36 for the purpose of providing a path of flow for the recovered lubricant back to the sump of the motor housing.

Line 44 is arranged so as to permit a portion of the refrigerant-lubricant mixture which collects in this section of the system to flow into the separation chamber where it is subjected to heat through the action of high resistance element 56 connected to a suitable source of electric energy. The line 44 is arranged so that vapor which is formed as a result of the heat applied in the chamber 42 may flow through line 44 in a direction opposite the direction the liquid mixture is flowing. It will thus be obvious that the mixture present in chamber 42 eventually becomes rich in lubricant. To assist in the transmission of the lubricant present in chamber 42 through line 48 there is provided a line 50 connecting the high pressure portion of the condenser with the chamber 42. Flow through line 50 is controlled by solenoid valve 52 which in turn is governed by a timer controlled switch mechanism 54 arranged so as to periodically complete, for a short period of time, a circuit through the coil controlling solenoid valve 52, opening the valve and permitting
3,004,396

high pressure refrigerant to pass directly into the separation chamber. This has the effect of pressurizing the separation chamber with a source of gaseous refrigerant having a pressure in excess of the pressure in the motor housing so that flow through line 44 ensues. Valve plate 46 rises and substantially blocks passage through line 44 so as to preserve the necessary pressure differential between the condenser and the evaporator. Aperture 47 in valve plate 46 permits the high pressure gas in chamber 42 to escape through line 44 into the evaporator and condenser period of time which valve 52 is opened. A check valve 49 and a filter 49' are employed in line 48 to assure the desired direction of flow and the removal of solid contaminants from the oil.

Considering the operation of the embodiment of the invention described above, a mixture of refrigerant and lubricant is continuously withdrawn from the evaporator through the line 44 into the chamber 42. Heater 56 supplies heat sufficient to vaporize the liquid refrigerant which flows back through line 44 to the evaporator. Periodically, on a predetermined time cycle, the timer mechanism associated with switch 55 resets the switch and completes a circuit through the coil controlling solenoid valve 52. High pressure refrigerant flows into the chamber 42 creating a pressure differential between chamber 42 and sump 36 sufficient to cause the flow of the mixture now rich in lubricant to sump 36.

In the embodiment illustrated in FIGURE 2, a float controlled switch 53 operates in response to the position of float 54*. The switch 53 is in series with the coil controlling solenoid valve 52 so that energization of the coil occurs upon actuation of the switch. This mechanism replaces the timer, described in connection with the embodiment described in FIGURE 1, and provides a control based upon the level of liquid in the chamber 42. It will be obvious that the control of flow from the separation chamber 42 to the compressor sump 36 is responsive to a level of fluid rather than a predetermined time interval as is the case in the first embodiment described.

FIGURE 3 illustrates a third embodiment of the invention wherein an improved valve mechanism for controlling flow in line 59 is provided. The valve 55 in the embodiment illustrated in FIGURE 3 is controlled through the action of a coil 55' adapted to effect by magnetic attraction upward movement of an armature member upon energization thereof. A linkage 56a connects the armature with a cover plate 57 so that when the armature is at its uppermost position, the cover plate 57 is in its lowermost position permitting communication between the evaporator and the separation chamber. Upon deenergization of coil 55' armature 56 drops by gravity causing cover plate 57 to move upwardly through the operation of linkage 56a to close off the end of line 44 disposed within the separation chamber 42. Operation of this embodiment is similar to that described in connection with the explanation of the first embodiment.

Control of the flow of lubricant from separation chamber 42 to the sump 36 in response to the need or demand for additional lubricant in the sump 36 is the subject of the embodiment illustrated in FIGURE 4. It will be noted that a second switch 57 located in the compressor sump 36, operates under the control of float 58 and is provided in series with the switch 53 so as to assure energization of the coil 55' under those circumstances when the level of lubricant within the compressor sump indicates a need for replacement.

In the embodiment of the invention illustrated in FIGURE 5, the arrangement shown in FIGURE 3 is provided with a pilot switch 59 under the influence of a weighted float 60. Material 61 is added to the float ball for the purpose of providing the extra weight. The float 54 operates in response to the level of fluid within the separation chamber 42. Float 60, however, is operative in response to the specific density of the fluid in the chamber, an indication of the relative amount of lubricant in the mixture. Thus, the embodiment of the invention illustrated in FIGURE 5 operates to assure movement of the lubricant to the compression chamber under those circumstances where the mixture in the chamber is sufficiently rich in lubricant and is sufficiently great in volume to assure effective transfer of the fluid.

The circuit diagram illustrated in FIGURE 6 is employed in conjunction with the arrangement illustrated in FIGURE 5 to assure proper operation of the valve controlling flow in the line connecting the chamber and the condenser. It will be noted that switch 53 and switch 59 are connected in parallel across coil 55' so that a circuit through the coil 55' may be completed through either of the switches. Switch 53 is arranged so as to be closed when the float 54 reaches a predetermined minimum level of liquid in the chamber 42. Switch 59 is arranged to open as the float 60 drops as it senses a specific density of the mixture indicating relatively pure lubricant. When the liquid mixture in chamber 42 attains a predetermined lubricant purity the level of the liquid has exceeded the predetermined minimum so that both circuits through coil 55' are open and the armature drops to permit communication between line 59 and the chamber 42.

During passage of liquid from the chamber 42, the minimum liquid level is eventually reached and switch 53 closed to energize the coil 55' and prevent further communication between the line 59 and the chamber 42 while establishing communication between the evaporator and the chamber. Even though the switch 53 eventually opens as the liquid level rises during the filling cycle, the float 60 has risen and closed switch 59 to maintain coil 55' energized. Switch 59 will subsequently open as float 60 drops in response to the attainment of the predetermined specific density through the action of the heating means 53.

It will be apparent that the recovery of lubricant from a working fluid in equipment where mixing of the two components is practically unavoidable in each embodiment is accomplished through the use of a chamber periodically subject to the working fluid under pressure greater than that existing in the chamber or in the sump.

It is also apparent that the system outlined above can be used to recover from the refrigerant system any other contaminants which may be in the system by either resulting from corrosion or admission of air or water from the atmosphere or water circulating systems in the heat exchangers. These contaminants, along with any lubricant can be discharged directly to atmosphere for complete removal, or through a filtering and/or drying mechanism directly into the evaporator or other low pressure area of the refrigerant system.

While we have described a preferred embodiment of the invention, it will be understood the invention is not limited thereto since it may be otherwise embodied within the scope of the following claims.

We claim:

1. Apparatus for recovering lubricant from a mixture of refrigerant and lubricant in a refrigeration machine comprising means forming a chamber in communication with the evaporator of the refrigeration machine for receiving from the evaporator a mixture of refrigerant and lubricant, means for heating the mixture in said chamber to vaporize portions of the refrigerant and elevate the concentration of lubricant within the mixture, means providing a restricted path of flow from the chamber to the sump of the compressor of said refrigeration machine, and means automatically operable to elevate the pressure within said chamber to force the concentrated mixture through said restricted flow path to the compressor.

2. The invention set forth in claim 1 wherein means are provided for substantially isolating the evaporator from the relatively high pressure in the chamber during evacuation of the fluid therefrom.

3. The invention set forth in claim 2 wherein said last
8,004,396

mentioned means includes a check valve having an opening therein to afford passage between the evaporator and chamber for substantial equalization of pressure there-whereafter the mixture has passed to the compressor.

4. The method of recovering lubricant from a mixture of lubricant and refrigerant circulating in a refrigeration machine which consists in the steps of withdrawing a portion of the mixture from the evaporator, subjecting the mixture to a source of heat sufficient to vaporize the refrigerant and periodically subjecting the mixture to pressure within the machine in excess of the pressure within the portion of the machine to which it is desired to transmit the mixture for the purpose of creating a pressure difference sufficient to provide flow of the mixture to the desired locale in the machine.

5. In a refrigeration machine including a compressor, a condenser and an evaporator connected to form a closed circuit for the flow of refrigerant wherein a lubrication system is provided to satisfy the lubrication requirement of the compressor, apparatus for recovering lubricant that may enter the refrigerant flow circuit comprising means in communication with a portion of the machine having a normal operating pressure below the pressure within the compressor wherein said lubricant is normally stored for receiving a portion of the mixture of refrigerant and lubricant, means for supplying heat to the portion of the mixture to vaporize the refrigerant and increase the proportion of lubricant in said mixture, and means for periodically subjecting the concentrated mixture to pressure within the system in excess of the pressure wherein said lubricant is normally stored to transmit the mixture thereto.

6. The invention set forth in claim 5 wherein said last mentioned means includes a line connecting the means for receiving the mixture with the high pressure side of the machine, a valve controlling flow in said line and control mechanism for regulating operation of said valve.

7. The invention set forth in claim 6 wherein said control mechanism includes a circuit and a time controlled switch for closing said circuit to energize said valve.

8. The invention set forth in claim 6 wherein said control mechanism includes a circuit and a float controlled switch for closing said circuit to energize said valve.

9. The invention set forth in claim 6 wherein said control mechanism includes a switch located in the normal lubrication storage locale and a second float controlled switch in said mixture receiving means connected in series with said first switch for energizing said circuit.

10. The invention set forth in claim 6 wherein said control mechanism includes a valve regulating circuit, a first float controlled switch operable in response to the amount of concentrated mixture and a second float controlled switch responsive to a characteristic of the mixture determinative of the relation of lubricant to refrigerant in the mixture connected in parallel with said first float controlled switch.

11. In a machine having a working fluid subject to pressure variations and a lubrication system for satisfying the machine lubrication requirement wherein there is an intentional mixture of the working fluid and lubricant, mechanism for recovering the lubricant for transmittal to the lubrication system comprising means forming a chamber in communication with a portion of the machine having a relatively low pressure for receiving a portion of the mixture, means for separating the working fluid from said mixture, and means for periodically subjecting the reconstituted mixture to a portion of the machine having a pressure in excess of the pressure wherein said lubricant is stored for supply to said system to create a pressure difference sufficient to transmit said reconstituted mixture thereto.

12. In a refrigeration machine including a compressor, a motor assembly and the economizer for supplying refrigerant gas formed in the economizer as a coolant for said motor, and a lubrication system for said compressor including a sump within said motor assembly for storing lubricant, a system for recovering lubricant that may become mixed with said refrigerant during normal operation of said machine comprising a receptacle for accommodating a mixture of refrigerant and lubricant, a line connecting the receptacle and the evaporator, means for separating the refrigerant from the mixture within the receptacle and means for subjecting said receptacle to refrigerant pressure in excess of the pressure in said sump for transferring the reconstituted mixture to the sump.

13. The invention described in claim 12 wherein said last mentioned means includes control mechanism operable in response to a predetermined time interval.

14. The invention described in claim 12 wherein said last mentioned means includes control mechanism operable in response to the level of mixture within said receptacle.

15. The invention described in claim 12 wherein said last mentioned means includes control mechanism operable in response to a requirement for additional lubricant in the sump.

16. The invention described in claim 12 wherein said last mentioned means includes control mechanism operable in response to the concentration of lubricant in said mixture.

17. In a machine having a working fluid subject to pressure variations and a lubrication system for accommodating a mixture containing the working fluid, mechanism for recovering the material from the mixture comprising means forming a chamber in communication with a section of the machine having a relatively low pressure for accommodating a portion of the mixture, means for separating the working fluid from said mixture and means for periodically subjecting the reconstituted mixture to a section of the machine having a pressure in excess of the pressure wherein said material may be normally stored to create a pressure difference sufficient to transmit said reconstituted mixture thereto.

References Cited in the file of this patent

UNITED STATES PATENTS

320,308 Suckert ------------ June 16, 1885
2,128,388 Williams et al. ---------- Aug. 30, 1938
2,411,347 Trumpler ************ Nov. 19, 1946
2,778,195 Christensen ********** Jan. 22, 1957