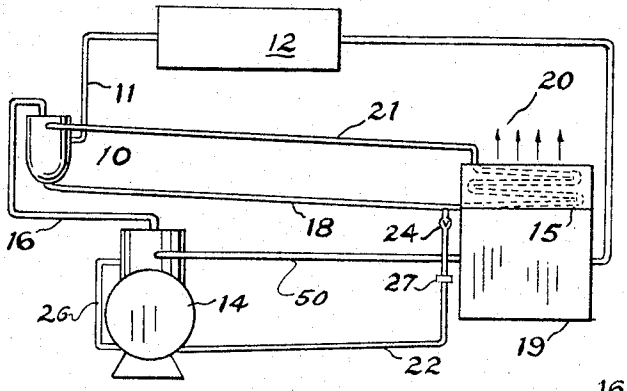
Oct. 4, 1966 P. T. McDONELL 3,276,215

LUBRICANT HANDLING METHOD AND APPARATUS FOR REFRIGERATION SYSTEMS

Filed March 26, 1964

Fig 1



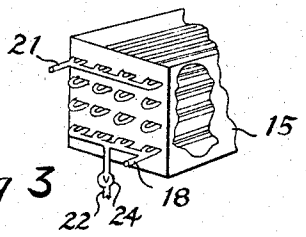




Fig 3

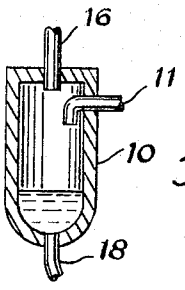



Fig 4

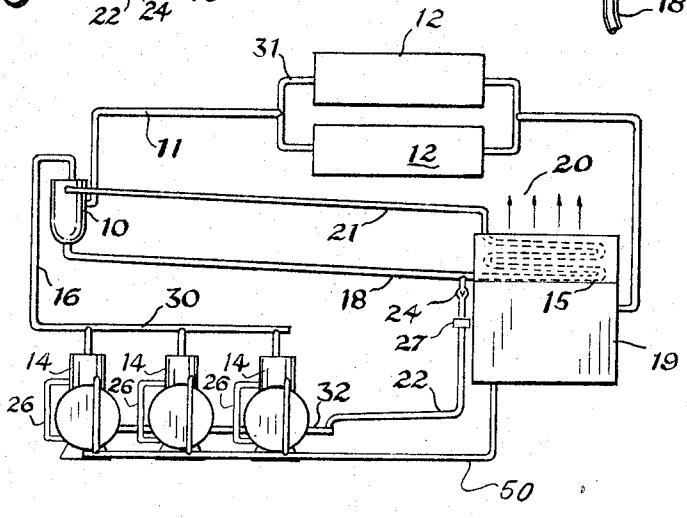



Fig 2

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United States Patent Office

3,276,215
Patented Oct. 4, 1966



3,276,215

# LUBRICANT HANDLING METHOD AND APPARATUS FOR REFRIGERATION SYSTEMS

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Filed Mar. 26, 1964, Ser. No. 354,905
2 Claims. (Cl. 62—84)

This invention relates to refrigeration systems and more particularly to apparatus for preventing damage by refrigerant in a liquid state to compressors used in refrigeration systems.

Refrigeration systems customarily return refrigerant to the compressor or compressors of the system in a gaseous state for compression by one or more of the compressors. However, portions of the refrigerant commonly used in refrigeration systems are frequently changed from a gaseous state to a liquid state when the refrigeration system is undergoing automatic or hot gas defrosting or when components of the refrigeration system are malfunctioning. If these portions of refrigerant in a liquid state enter the compressor or compressors of the refrigeration system, the compressor or compressors are seriously damaged and may even break up with sufficient force to severely injure nearby personnel.

Numerous previous efforts have been made to prevent the possible damage to equipment and personnel caused by refrigerant in a liquid state entering the compressor or compressors of a refrigeration system. Some of these previous efforts have resulted in apparatus which simply traps refrigerant in a liquid state before the refrigerant in a liquid state can enter the compressor or compressors of a refrigeration system. This apparatus makes no provision for changing the refrigerant back to its gaseous state from its liquid state and as a result there is a decrease in the amount of refrigerant available for operation of the refrigeration system.

Other previous efforts to prevent injury to equipment and personnel by a refrigerant in a liquid state entering the compressor or compressors of a refrigeration system have attempted to avoid this loss of refrigerant available for the operation of a refrigeration system by trapping the refrigerant in a liquid state and returning this refrigerant to a gaseous state. These efforts have generally utilized a liquid trap in which the heat of compressed refrigerant in a gaseous state or warm liquid refrigerant is used to vaporized the refrigerant in a liquid state.

The compressed refrigerant must subsequently be used in the condenser and the difficulty with apparatus of this type is that since the compressed refrigerant must pass through the trap in a coil or similar arrangement, a leak in the coil or similar arrangement will cause some of the compressed refrigerant to simply pass from the compressor or compressors of the refrigeration system through the trap and back to the compressor or compressors of the refrigeration system. This reduces the amount of refrigerant that circulates through the entire system and causes overheating of the compressor or compressors. It also tends to equalize the pressures in the system so as to produce an efficiency loss within the system.

Thus, apparatus of this type must be carefully manufactured using components suited only for use in apparatus of this type so as to avoid leaks. This has made apparatus of this type relatively expensive to manufacture. Moreover, in an effort to insure reliability, apparatus of this type has customarily been manufactured as a single integral structure which is difficult to maintain.

A further difficulty with apparatus which vaporizes a refrigerant in a liquid state in a liquid trap is that the compressed refrigerant in a gaseous state must be circulated through the coil or similar arrangement in the liquid trap,



thus requiring expensive controls and reducing the efficiency of the refrigeration system as a whole.

Previous refrigeration systems, especially those using ammonia as a refrigerant, have not been able to defrost all of the evaporators of the system at once. Only part of the evaporators may be defrosted at a time since the heat from the other evaporators which are refrigerating is required to defrost the evaporators which are not refrigating. If all of the evaporators are located in the same enclosure, moisture from the defrosting evaporators travels to the refrigerating evaporators causing overicing on these evaporators and reducing not only the defrosting efficiency of the system but also the overall efficiency of the system.

The apparatus for preventing damage by liquid refrigerant to compressors used in refrigeration systems disclosed herein overcomes these and other problems and difficulties associated with refrigeration systems. The apparatus utilizes standard, easily obtainable, and relatively inexpensive to manufacture components to separate both lubricating oil and refrigerant in a liquid state from a refrigerant in a gaseous state and to return the refrigerant in a liquid state to a compressor of the refrigeration system in a gaseous state and the lubricating oil to a reservoir in a compressor for lubrication purposes.

The apparatus comprises a liquid trap in which refrigerant in a liquid state and lubricating oil are trapped and separated from refrigerant in a gaseous state and a vaporization member in which the refrigerant in a liquid state is changed from a liquid state to a gaseous state by exhaust heat from the condenser of the refrigeration system and in which lubricating oil accumulates to be returned to the compressor or compressors of the refrigeration system for lubrication purposes.

Gravity or a pump transfers the trapped refrigerant in a liquid state and the lubricating oil from the liquid trap to the vaporization member for vaporization and the pressure difference created between the liquid trap and the vaporization member when refrigerant in a liquid state is vaporized transfers vaporized refrigerant from the vaporization member to the liquid trap. Thus, none of the energy that the refrigeration system uses to circulate refrigerant is used as transfer means for the apparatus disclosed herein. As a result, the apparatus does not adversely affect the efficiency of the refrigeration system with which the apparatus is used.

Moreover, the possibility of the compressed refrigerant passing only through the liquid trap and a compressor of the refrigeration system is avoided since no compressed refrigerant passes through a coil in the liquid trap.

The separation of refrigerant in a liquid state and lubricating oil from refrigerant in a gaseous state and the changing of refrigerant in a liquid state to a gaseous state is accomplished by the apparatus disclosed herein in a continuous and fully automatic manner. The return of lubricating oil to the compressor or compressors of a refrigeration system for lubrication purposes is accomplished either manually or in a fully automatic manner utilizing a throttling valve or orifice in conjunction with a solenoid valve which opens to return the lubricating oil to the compressor or compressors of a refrigeration system when the compressors are operating. Thus, the apparatus disclosed herein is not only relatively inexpensive to manufacture and maintain, but it is also extremely reliable and durable so that it may be operated for extended periods of time without attention.

The present invention also allows all of the evaporators of a refrigeration system to be defrosted at once. By recirculating the refrigerant vaporized by the present invention through the evaporators of the system, the additional heat needed from refrigerating evaporators to defrost the evaporators of the system is avoided.

These and other features and advantages of the present invention will be more clearly understood from the following detailed description and the accompanying drawings in which like characters of reference designate corresponding parts in all figures and in which:

FIG. 1 is a schematic presentation of the embodiment of the invention disclosed herein used in a refrigeration system having a single compressor.

FIG. 2 is a schematic presentation of the embodiment of the invention disclosed herein used in a refrigeration system having a plurality of compressors and evaporators.

FIG. 3 is a partial perspective view of the vaporization coil used in the embodiment of the present invention shown in FIGS. 1 and 2.

FIG. 4 is a cross-sectional view of the liquid trap used in the embodiment of the present invention shown in FIGS. 1 and 2.

These figures and the following detailed description disclose a specific embodiment of the present invention but the invention is not limited to the details disclosed since it may be embodied in other equivalent forms.

The embodiment of the present invention comprises generally a liquid trap **10** and a vaporization coil **15** connected in a conventional refrigeration system having a compressor **14**, an evaporator **12**, and a condenser **19**. The liquid trap **10** is connected in the refrigeration system between the evaporator **12** and the compressor **14** and communicates with the vaporization coil **15** so that refrigerant in a liquid state that is trapped by the liquid trap **10** is transferred to the vaporization coil **15** where it is vaporized and then transferred back to the liquid trap **10**.

The liquid trap **10** is of a known type that separates a liquid from a gas. As a mixture of the refrigerant in a liquid state, refrigerant in a gaseous state, and lubricating oil flows into the liquid trap **10** through a refrigerant return pipe **11** connecting the evaporator **12** and the liquid trap **10**, the refrigerant in a gaseous state moves to the upper portion of the liquid trap **10**, and the refrigerant in a liquid state and the lubricating oil settle to the lower portion of the liquid trap **10**.

The upper portion of the liquid trap **10** communicates with the suction inlet of the compressor **14** through a gas return pipe **16**, thus allowing the refrigerant in a gaseous state to flow to the compressor **14** to be compressed by the compressor **14** from which the refrigerant flows through the tubing **50** for recycling through the refrigeration system. The lower portion of the liquid trap **10** communicates with the lowermost coils of the vaporization coil **15** through a liquid transfer pipe **18** which is inclined so that the force of gravity causes the refrigerant in a liquid state and the lubricating oil collected in the lower portion of the liquid trap **10** to flow from the liquid trap **10** to the vaporization coil **15** substantially as fast as the mixture entering the liquid trap **10** is separated.

The vaporization coil **15** is of known type such as that used for evaporative condensers and is positioned in the refrigeration system so that the liquid transfer pipe **18** is inclined as described above. The condenser **19** is also positioned so that the hot air exhaust **20** from the condenser **19** flows through the vaporization coil **15**. Thus, as refrigerant in the liquid state and the lubricating oil enter the lowermost coils of the vaporization coil **15**, heat from the hot air exhaust **20** vaporizes the refrigerant in a liquid state. The vaporized refrigerant creates a higher pressure in the vaporization coil **15** than is present in the liquid trap **10**. This pressure forces the vaporized refrigerant through the vaporization coil **15** and back to the liquid trap **10** through a gas transfer pipe **21** connecting the uppermost coils of the vaporization coil **15** and the upper portion of the liquid trap **10**. The gas transfer pipe **21** is inclined so that the vaporized refrigerant will rise to the liquid trap **10** whereas any refrigerant in a liquid state will drain back into the vaporization coil **15** to be vaporized. It will be understood that any vaporized refrigerant that condenses while on the way from the vaporization coil **15** to the liquid trap **10** merely drains back into the vaporization coil **15** under the force of gravity to be vaporized again. Thus, principally refrigerant in a gaseous form reaches the liquid trap **10** from the vaporization coil **15**. However, if some refrigerant in a liquid state is carried along the gas transfer pipe **21** between bubbles of vaporized refrigerant and forced into the liquid trap **10**, the liquid trap **10** separates the refrigerant in a liquid state from the refrigerant in a gaseous state and returns the refrigerant in a liquid state to the vaporization coil **15** for vaporization.



The lubricating oil that enters the lowermost coils of the vaporization coil **15** with the refrigerant in a liquid state is not vaporized by the heat from the hot air exhaust **20** as is the refrigerant since the vaporization temperature of the lubricating oil is above the temperature of the hot air exhaust **20**. Therefore, as the refrigerant in a liquid state is vaporized, the lubricating oil accumulates in the lowermost coils of the vaporization coil **15**.

An oil return pipe **22** connects the lowermost coils of the vaporization coil **15** with the oil reservoir in the compressor **14**, and a normally closed solenoid **24** and an orifice **27** are imposed in the oil return pipe **22**. The solenoid valve **24** is connected to an activating source of known type so that it closes the oil return pipe **22** when the compressor **14** is not operating and opens the oil return pipe **22** when the compressor **14** is operating. Since most of the heavier liquid entering the vaporization coil **15** is lubricating oil, that portion of the liquid passing into the oil return pipe **22** when the compressor **14** is operating is principally lubricating oil. The orifice **27** serves to prevent high flow rates of liquid through the oil return pipe **22** thereby permitting only a small portion of the total quantity of liquid entering the vaporization coil **15** to return to the oil reservoir in the compressor **14**.

When the compressor **14** is operating, the lubricating oil accumulates in the lowermost coils of the vaporization coil **15** and is returned to the oil reservoir in the compressor **14** by the oil return pipe **22** and the orifice **27** along with small amounts of refrigerant in a liquid state. A vent pipe **26** connects the oil reservoir of the compressor **14** with the suction inlet of the compressor **14**. Thus, any refrigerant in a liquid state returning to the oil reservoir in the compressor **14** is vaporized due to the heat of the compressor **14** and is transferred to the compression cylinder of the compressor **14** to be circulated through the refrigeration system by the suction of the compressor **14**.

When the compressor **14** is not operating, the solenoid valve **24** closes the oil return pipe **22** and prevents any liquid from flowing into the oil reservoir of the compressor **14**. Since the vaporization coil **15** is customarily located so that refrigerant in a liquid state is not vaporized when the refrigeration system is not operating, the refrigerant in the liquid trap **10** and the vaporization coil **15** accumulated when the system is not operating is prevented from flooding the oil reservoir in the compressor **14** by the solenoid valve **24** closing the oil return pipe **22**. Each time the compressor **14** is started and stopped the solenoid valve **24** opens and closes the oil return pipe **22**, thus the above procedure is repeated each time the system starts and stops operation.

The use of the present invention in a multiple refrigeration system having a plurality of compressors **14**, a condenser **19**, and a plurality of evaporators **12** is shown in FIG. 2. The refrigerant return pipe **11** connects the evaporators **12** and the liquid trap **10** through an evaporator manifold **31** connecting the evaporators **12**. Refrigerant in a liquid state and lubricating oil are trapped by the liquid trap **10**, and transferred to the vaporization coil **15** in the same manner as heretofore described. The vaporization coil **15** vaporizes the refrigerant in a

liquid state and transfers the vaporized refrigerant back to the liquid trap **10** while accumulating the lubrication oil as heretofore described.

The gas return pipe **16** connects the liquid trap **10** with a compressor manifold **30** which distributes the refrigerant in a gaseous state equally between the suction inlets of the compressors **14**. The oil return pipe **22** connects the lowermost coils of the vaporization coil **15** with an oil reservoir manifold **32** which distributes the lubricating oil returned by the oil return pipe **22** equally between the compressors **14**.

*Operation*

It will now be understood that as a mixture of refrigerant in a gaseous state, refrigerant in a liquid state, and lubricating oil exit the evaporator **12** of the refrigeration system shown in FIG. 1 during a hot gas defrosting cycle or some malfunction of a component of the refrigeration system it is separated by the liquid trap **10** so that the refrigerant in a gaseous state rises to the upper portion of the liquid trap **10** and the refrigerant in a liquid state along with the lubricating oil settles to the lower portion of the liquid trap **10**.

The refrigerant in a gaseous state is forced from the liquid trap **10** through the gas return pipe **16** to the compressor **14** by the suction pressure created by the compressor **14**, and the refrigerant in a liquid state along with the lubricating oil trapped by the liquid trap **10** is transferred by gravity through the liquid transfer pipe **18** to the lowermost coils of the vaporization coil **15**.

Heat from the hot air exhaust **20** vaporizes the refrigerant in a liquid state in the lowermost coils of the vaporization coil **15**; thus raising the pressure in the vaporization coil **15** above that in the liquid trap **10**. The pressure difference between the vaporization coil **15** and the liquid trap **10** causes the vaporized refrigerant to rise through the vaporization coil **15** and return to the liquid trap **10** where the suction from the compressor **14** causes the vaporized refrigerant to be forced into the compressor **14**.

The lubricating oil is accumulated in the lowermost coils of the vaporization coil **15** as the refrigerant in a liquid state is vaporized by the heat from the condenser **19**, and since the refrigerant in a liquid state is vaporized substantially as fast as it enters the vaporization coil **15**, principally lubricating oil is returned to the oil reservoir in the compressor **14** via the oil return pipe **22** and the orifice **27** when the compressor **14** is operating.

When the compressor **14** stops operation the solenoid valve **24** is closed preventing any of the lubricating oil and refrigerant in a liquid state that enters the vaporization coil **15** from the liquid trap **10** or any of the vaporized refrigerant condensed in the vaporization coil **15** from returning to the oil reservoir in the compressor **14** when the compressor **14** is not operating.

In a multiple refrigeration system, the mixture of refrigerant in a liquid state, refrigerant in a gaseous state, and lubricating oil is collected by the evaporator manifold **31** from the evaporators **12** and transferred to the liquid trap **10** through the refrigerant return pipe **11**.

The refrigerant in a liquid state is vaporized in the vaporization coil **15** as explained above, and transferred



to the liquid trap **10**. The refrigerant in a gaseous state is transferred to the compressor manifold **30** through the gas return pipe **16** which distributes the refrigerant to the compressors **14** equally.

The accumulated lubricating oil is transferred as explained above through the oil return pipe **22** to the oil reservoir manifold **32** which distributes the lubricating oil to the oil reservoirs of the compressors **14** equally.

It will be obvious to those skilled in the art that many variations may be made in the embodiments here chosen for the purpose of illustrating the present invention without departing from the scope thereof as defined by the appended claims.

What is claimed as invention is:

**1.** A refrigeration system comprising a compressor; a condenser; an evaporator; a refrigerant; trapping means operatively positioned between the compressor and the evaporator for separating refrigerant in a gaseous state from the refrigerant in a liquid state and lubricating oil; a coil operatively connected to said trapping means so as to receive refrigerant in a liquid state and lubricating oil from said trapping means, said coil being positioned in the hot air exhaust from the condenser; means for conducting refrigerant in a gaseous state from the coil to the trapping means; means for selectively draining lubricating oil at a controlled rate of flow from the coil to an oil reservoir in the compressor; and means for allowing refrigerant in a gaseous state to pass from the oil reservoir to a compression cylinder of the compressor.

**2.** A method providing only refrigerant in a gaseous state to the compressor in a refrigeration system having a compressor, a condenser, and an evaporator, said method comprising the steps of separating refrigerant in a liquid state and lubricating oil from refrigerant in a gaseous state between the evaporator and the compressor, moving the refrigerant in a liquid state obtained by said separation into the hot air exhaust from the condenser by gravity, heating the refrigerant in a liquid state with the heat of the hot air exhaust from the condenser until said refrigerant changes from liquid state to gaseous state, moving refrigerant in a gaseous state from the hot air exhaust of the condenser to the evaporator, moving the lubricating oil and refrigerant in a liquid state trapped therein to the oil reservoir of the compressor by gravity, vaporizing refrigerant in a liquid state in the oil reservoir of the compressor by the heat of the compressor, and allowing refrigerant in a gaseous state to escape from the oil reservoir of the compressor to a compression cylinder of the compressor.

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