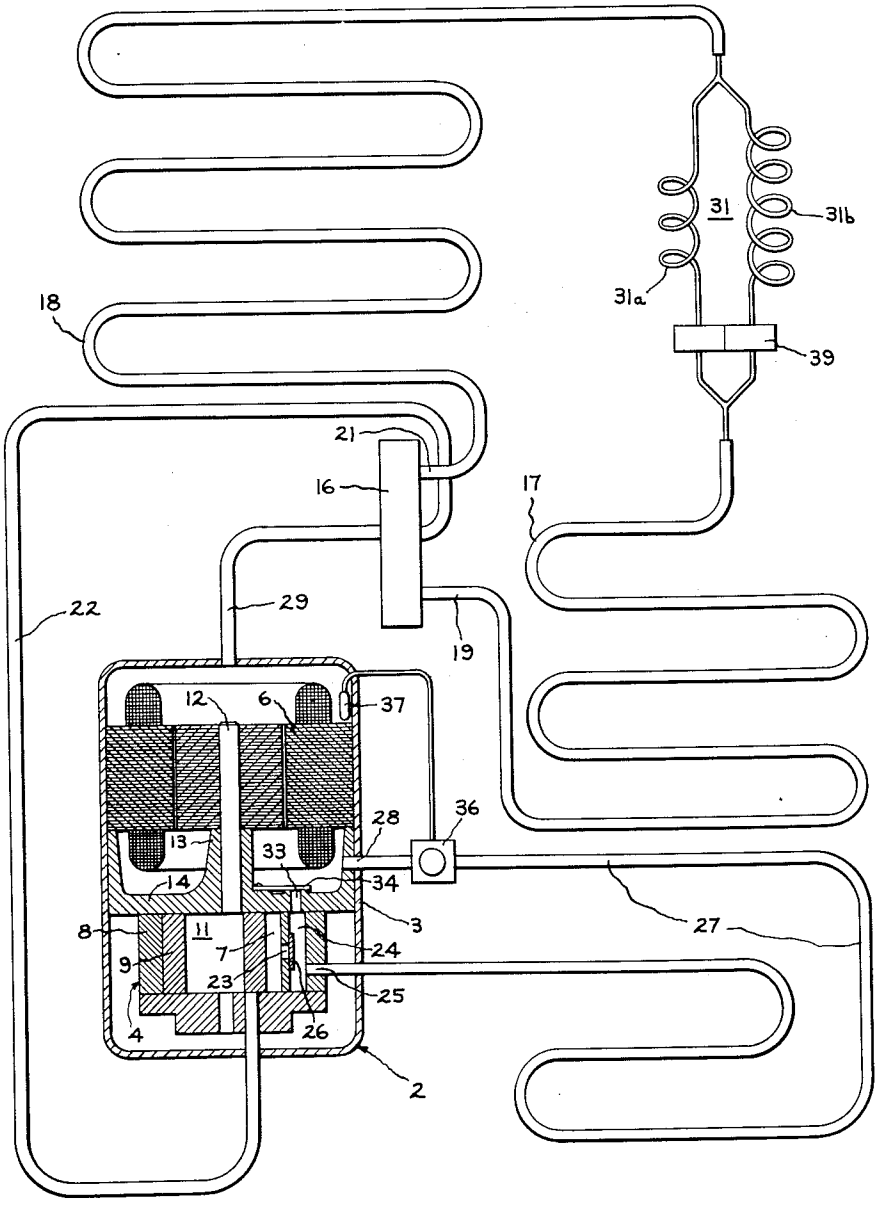
April 18, 1961 G. L. MEAGHER 2,979,917

COOLING ARRANGEMENT FOR HERMETICALLY SEALED REFRIGERANT COMPRESSOR

Filed Dec. 7, 1959



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United States Patent Office 2,979,917 Patented Apr. 18, 1961

2,979,917

COOLING ARRANGEMENT FOR HERMETICALLY SEALED REFRIGERANT COMPRESSOR

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Filed Dec. 7, 1959, Ser. No. 857,948

2 Claims. (Cl. 62—196)

The present invention relates to a refrigerant compressor and is more particularly concerned with a cooling arrangement for a refrigerant compressor of the type commonly known as a "high side case" in which the pressure within the hermetically sealed compressor case is approximately the same as the pressure on the high pressure side of the refrigerating system.

Although the present invention is useful in all types of refrigeration systems employing a compressor having a "high side case," it is particularly well adapted for use in reversible flow type refrigeration systems in which the refrigerant flowing through the system can be selectively reversed according to the desires of the operator. The latter type of refrigeration system is employed in air conditioning apparatus of the type used for both heating and cooling purposes and sometimes referred to as a "heat pump." The refrigeration system of this apparatus normally includes a pair of heat exchangers one being exposed to air from the outdoors and the other heat exchanger being exposed to air from the enclosure to be conditioned, the two heat exchangers being connected by a suitable refrigerant expansion means. A refrigerant reversing valve is used to selectively direct the high pressure refrigerant gas from the compressor into one or the other of the heat exchangers while directing the suction gas from the opposite heat exchanger into the compressor. Thus, each of the heat exchangers is operated either as an evaporator or as a condenser according to the desires of the occupant of the enclosure. During the summer or cooling season, the inside heat exchanger is generally operated as an evaporator to cool the air from the enclosure while the outdoor heat exchanger is operated as a condenser to cool and condense the refrigerant gas flowing from the compressor unit. In the winter or heating season, however, the refrigeration system is reversed so that the indoor heat exchanger operates as a condenser to warm the air passed thereover from the enclosure while the outdoor heat exchanger is operated as an evaporator to take in heat from the outdoor air being circulated through this heat exchanger.

When using a "high side" compressor in a refrigeration system, it is necessary to provide some arrangement for cooling the compressor motor during the operation of the system. One means for accomplishing this purpose is to pass the hot discharge gas from the compressor through a precooling or superheat removal coil and then to direct the precooled gas back into the hermetic case to cool the motor prior to passing the gas into the condenser of the refrigerating sytem. In those systems using a superheat removal coil, the coil is normally positioned on the condenser or outdoor side of the unit and generally forms a portion of the outdoor heat exchanger. In a reversible refrigeration system, the above-described compressor motor cooling arrangement works satisfactorily in the summer when warm air from the outdoors is passed over the outer heat exchanger that is then operating as a condenser. However, in the winter time, when the indoor heat exchanger is used as the condenser

to supply heat to the air from the enclosure, it is not practical to pass the hot discharge gas from the compressor into a superheat removal coil located adjacent the outside heat exchanger so that the heat given up by this gas is dissipated to the outside air. That is, the heat given up by the hot discharge gas could be more effectively utilized by the indoor heat exchanger to warm the room air. Also, in the winter time the compressor discharge gas is generally at a much lower temperature so that it may provide motor cooling without precooling of the gas. It has been found that, in the winter time, the superheat removal coil merely serves to condense the gas and to cause liquid refrigerant to collect in the compressor case rather than be discharged therefrom in gaseous form.

It is, therefore, an object of the present invention to provide, for a refrigeration system employing a high side case, an improved discharge gas cooling arrangement that will maintain the motor within safe operating temperatures but will not cause liquid refrigerant to collect in the hermetic case when the temperature of the compressor discharge gas is too low.

It is another object of the present invention to provide, for a reversible refrigeration system, an improved compressor motor cooling arrangement employing a superheat removal coil associated with the outdoor heat exchanger structure which will permit efficient operation of the reversible refrigeration system in both directions.

It is a more specific object of the present invention to provide for a high side case, a cooling arrangement using a superheat removal coil which provides cooling of the motor in accordance with the temperature existing in the case.

Other objects and advantages of the present invention will become apparent as the following description proceeds and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

In carrying out the present invention there is provided, in combination with a refrigeration system, a compressor and a compressor motor hermetically sealed within a casing. A discharge chamber is provided into which the compressed refrigerant gas from the compressor is discharged prior to being directed into a superheat removal coil where it is partially cooled prior to flowing into the hermetic casing. The partially cooled high pressure gas cools the compressor motor before flowing out of the case into the remaining portions of the refrigeration system. A valve controlled bypass passage leads from the discharge chamber directly into the hermetic casing and provides a means for conducting high pressure discharge gas into the casing directly from the discharge chamber without passing through the superheat removal coil whenever there is a predetermined pressure differential between the discharge chamber and the case. In the superheat removal coil there is provided a valve means which closes the superheat removal coil in response to a temperature responsive device within the case which is energized whenever the temperature within the case falls below a predetermined temperature thereby blocking the flow of gas through the superheat removal coil and forcing it to flow directly through the bypass passage into the case without precooling when the temperature within the case drops below the predetermined temperature.

For a better understanding of the invention reference may be had to the accompanying drawing, the single figure of which is a schematic view of a reversible refrigeration system incorporating the present invention and showing the compressor thereof in cross section.

Now referring to the drawing there is shown a reversible refrigeration system including a hermetically sealed com-

pressor 2 having a hermetic casing 3 in which there is disposed a refrigerant compressor unit 4 and a compressor drive motor 6. The refrigerant compressor unit 4 has an annular compression chamber 7 defined within a cylinder or housing 8. Disposed for rotation within the chamber 7 is a rotor 9 which is driven by an eccentric 11 formed as an integral part of the drive shaft 12 that extends downwardly from the compressor motor 6. A bearing 13, which, with the supporting main frame 14 defines the upper end wall of the annular compression chamber, supports the drive shaft 12 above the eccentric 11 for rotation by the drive motor 6. The main frame 14 also supports the compressor within the casing. This rotary compressor is of the type well-known in the art and contains a blade (not shown) which reciprocates within a slot formed in the compressor cylinder 8 and which wipes against the face of the rotor during its rotation within the compression chamber thereby dividing the chamber into high and low pressure sides. The cross-sectional drawing of the compressor shows that portion of the chamber 7 just ahead of the blade which is on high pressure side of the compression chamber.

As indicated in the drawing, the compressor unit 2 is in refrigerant flow relationship with a reversing means or valve 16 for reversing the direction of flow of refrigeant to a pair of heat exchangers 17 and 18. When used in an air conditioning unit, the heat exchangers are arranged so that one is exposed to outdoor air and the other is exposed to air from the enclosure to be conditioned. The reversing valve 16 may be any of the types of reversing valves well known in the art and may be electrically or mechanically operated according to the desires of the operator of the air conditioner. The reversing valve 16 operates to direct high pressure refrigerant gas into either of the conduits 19 or 21 while receiving low pressure gas from the opposite conduit. During operation of the system, low pressure suction gas flows from the reversing valve 16 through the suction line 22 which connects with the suction port of the compression chamber. The suction port delivers this low pressure gas into the compression chamber where it is compressed during rotation of the rotor 9 to a much higher pressure and is discharged through a discharge port or outlet 23 into a discharge chamber 24. Mounted within the discharge chamber 24 is a suitable valve 26 for assuring proper compression of the gases issuing from the discharge or outlet port 23 and for preventing the reverse flow of gas back into the compression chamber 7.

In order to cool the high temperature gas prior to passing this gas into the case there is provided a superheat removal coil 27 having one end 25 connecting with the discharge chamber 24 and the other end 28 leading into the case. Most of the coil 27 is arranged outside of the compressor case 3 and is normally exposed to outdoor air which removes heat from the coil. The superheat removal coil 27 is usually included as a part of the outdoor heat exchanger structure and is shown adjacent heat exchange coil 17 which will be considered the outdoor heat exchanger for purposes of explanation. The outlet 28 of the superheat removal coil communicates with the inside of the casing and discharges the partially cooled gas into the casing 3 for cooling the motor. After cooling the motor, the high pressure gas discharges from the casing through the outlet or high pressure line 29 back to the reversing valve where it is directed into the remaining portions of the refrigeration system. Gas flowing through the superheat removal coil generally remains in gaseous form, but, if a small amount of refrigerant liquifies in the coil, it is immediately carried out of the coil by the gas as it flows into the casing and, under normal operating conditions, the liquid is flashed into gaseous form when carried into contact with the warm motor surfaces.

During operation of the system, as was mentioned before, high pressure refrigerant gas is passed either first through the outdoor heat exchanger 17 or through the heat exchange 18, which for purposes of explanation will be considered the indoor heat exchanger, depending upon the particular type of operation desired for the system. When the unit is operating to cool an enclosure, it will be apparent that the outdoor heat exchanger 17 must be utilized as a condenser while the indoor heat exchanger 18 acts as an evaporator. Thus, the exhaust gas is directed from the refrigerant reversing valve 16 first into the heat exchanger 17, which is exposed to the outdoor air, where the gas gives up its heat and is condensed into liquid refrigerant. Refrigerant then flows through a restricting means, generally designated 31, into the indoor heat exchanger 18. For purposes to be explained later in the specification the restricting means is designed to provide greater restriction to the flow of refrigerant during the heating cycle than when the system is operated on the cooling cycle. The refrigerant expands to evaporator pressure as it flows through the restricting means 31 and upon entering the evaporator, or heat exchanger 18, the refrigerant absorbs heat from the indoor air being circulated over this heat exchanger. The refrigeant vaporizes in the evaporator and absorbs sufficient heat to raise its temperature very substantially. Since the indoor air flowing over the indoor heat exchanger 18, or evaporator, is usually in the 75° F. to 100° F. range, during operation of the system on the cooling cycle, the temperature of suction gas is usually raised, for example, to the 60° F. to 70° F. range prior to being drawn into the compressor. During the cooling cycle, this gas is then directed by the reversing valve 16 through the suction conduit 22 into the compressor where, in the process of compression, the temperature of the gas increases from 90° to 140° to approximately 160–210° F., depending on the original temperature and pressure of the suction gas. As was pointed out previously the high temperature discharge gas is then cooled sufficiently within the superheat removal coil 27 to provide cooling for the compressor motor 6 as it is discharged from the coil 27 into the hermetic casing.

In the winter or heating season, the reversing valve 16 is adjusted so that it directs the hot discharge gas flowing from the discharge conduit 29 into the conduit 21 and thence to the indoor heat exchanger 18. This heat exchanger then operates as a condenser and gives up heat to the room air being passed thereover. The refrigerant is condensed in heat exchanger 18 and is then passed through the restricting means 31 into the heat exchanger 17 which is then operated as an evaporator. In the evaporator, or heat exchanger 17, the refrigerant absorbs heat from the outdoor air being circulated over this heat exchanger and becomes vaporized prior to being directed by the reversing valve 16 back into the compression chamber. In the winter, or heating cycle operation of the system, the suction gas in the evaporator and the suction conduit 22 leading to the compressor is at a temperature slightly below that of the air flow over the outdoor heat exchanger 17. Thus, the suction gas in the winter time may be at a temperature anywhere from 50° on down to or below freezing and is much colder in comparison to the gas flowing through the suction line 22 in the summer time. During the compression of this suction gas its temperature is raised so that it discharges from the compressor at anyhwere from 90° F. to 130° F. depending on the original temperature and pressure of the suction gas. This is, of course, much lower than the temperature of the gas discharged during the summer operation. Obviously, a superheat removal coil of such proportions designed to promote proper cooling of the high temperature discharge gas in the summer will be so large that it condenses the winter discharge gas rather than merely cooling it sufficiently to provide motor cooling. Further, since the superheat removal coil is normally associated with the outside heat exchange structure and since outside air is always passed thereover, the gas flowing in the superheat removal coil is naturally

cooled to a greater extent by the cold winter air than it would be by the relatively warm summer air. This, of course, creates a further disparity in the amount of cooling received by the gas in the superheat removal coil during operation on the two different cycles. A further disadvantage in this arrangement is that, during the winter, it is desirable to remove all of the heat of the discharge gas at the condenser which would be the heat exchanger **18** during this type of operation. Therefore, if the gas is passed through the superheat removal coil **27**, which is exposed to outdoor air, this heat is lost as far as heating purposes are concerned.

It has been found that, under most conditions of operation on the heating cycle, the gas discharged from the compressor is of a low enough temperature to cool the motor and requires no further or at least very little precooling. In order to pass the discharge gas directly into the case without passing through the superheat removal coil whenever additional cooling is not required, the present invention provides a bypass passage **33** leading from the discharge chamber **24** to the inside of the casing. A pressure responsive valve means **34** closes the bypass passage **33** and prevents the flow of refrigerant through the passage directly into the casing unless there exists a pressure differential between the discharge chamber **24** and the inside of the casing greater than the pressure of the valve **34**. In the illustrated embodiment of the invention the valve means **34** comprises a leaf spring which is seated across the outlet side of the bypass passage **33**. In order to stop the flow of refrigerant through the superheat removal coil **27**, a shut off valve **36** is provided in the superheat removal coil **27**. In the illustrated embodiment of the invention, the shut off valve **36** is located close to the outlet end **28** of the superheat removal coil for reasons that will be explained later in the specification. The valve **36** is operated according to temperature conditions within the case by a temperature responsive means including the temperature sensitive bulb **37** located within the case **3** adjacent the motor windings. The bulb **37** contains an expansible fluid which operates a fluid motor according to temperatures prevailing within the case and energizes the fluid motor to close the valve **36** upon sensing a predetermined temperature within the case, such as the temperature 130° F. The bulb **36** and valve operating means may be any of the well known types now on the market and need not be explained in greater detail herein except insofar as to state that the valve and its sensing means must be capable of closing the superheat removal coil whenever the temperature within the case falls below a predetermined value, such as the above-mentioned 130° F.

Whenever the temperature within the case falls below this predetermined temperature set for operation of the valve **36**, for example 130°, the bulb **37** energizes the valve motor to stop the flow of refrigerant gas through the superheat removal coil **27**. When this occurs, the pressure build-up within the discharge chamber and the superheat removal coil causes the gas to flow directly through the bypass passage **33** into the case. This gas is generally at a cold enough temperature to cool the motor and to carry the heat of the motor directly from the case into the remaining portions of the system, or into the condenser of the system, which will then be the heat exchanger **18**. If, the temperature of the gas being discharged is not cold enough to maintain the motor and case temperature below the predetermined temperature, i.e., below 130° F., the valve motor **36** then opens the superheat removal coil to permit flow of sufficient refrigerant therethrough to accommodate the cooling needs of the motor. Thus, during most of the operation of the system on the heating cycle when the discharge gas requires no precooling, all of the heat of the motor and all or most of the heat carried by the gas itself is removed from the refrigerant at the indoor heat exchanger **18**. During the cooling cycle, when the suction gas is at a relatively much higher temperature, and the discharge gas accordingly needs precooling, the valve **36** remains open to pass the gas through the superheat removal coil **27** thereby cooling this gas sufficiently to supply the cooling needs of the motor.

It is desirable in the cooling season to maintain the refrigerant in the evaporator for a greater length of time so that it will absorb as much heat from the outdoor air as possible before flowing into the compressor. A system which is optimized for operation only on the cooling cycle generally has too little restriction in the refrigerant expansion means **31** to provide optimum performance when operated to supply heat. That is, in a system optimized for cooling, the compressor normally circulates refrigerant through the evaporator faster than the surface can evaporate the refrigerant when the system is operated on the heating cycle. The compressor then pumps unevaporated refrigerant and the system efficiency is low. In order to overcome this problem, the system of the present invention incorporates a variable restriction for the gas expansion means. Thus, during the summer or cooling operation, a valve **39** is actuated to permit refrigerant flow only through the relatively short capillary **31***a*. However, during the winter or heating season, the valve **39** is actuated to permit refrigerant flow only through the relatively long capillary **31***b* to increase the restriction between the heat exchangers during the heating season. The increased restriction causes subcooled liquid refrigerant to build up in the indoor heat exchanger **18** to a much greater extent than during operation with the relatively short capillary **31***a*. This, in turn, increases the condensing temperature and pressure of the indoor heat exchanger **18** and thereby reduces the pumping rate of the compressor to a level required to circulate only enough refrigerant through the outdoor heat exchanger **17** that can be fully evaporated by the outdoor air flowing over this heat exchanger. This creates a more efficient refrigeration system because it effectively prevents the pumping of unevaporated refrigerant from the evaporator, or heat exchanger **17**, through the compressor. The valve **39** may be operated in any well known manner, however, it is contemplated that it be actuated to its cooling or heating positions at the same time as the reversing valve **16** is moved to change the direction of refrigerant flow through the heat exchangers.

Operation of the system with the greater restriction **31***b* between the heat exchangers would normally create an overcharged condition in the system as well as an unreasonably high head pressure. However, in the arrangement of the present invention, with the valve **36** preventing refrigerant from flowing through the desuperheater coil into the case, there is provided a convenient means for removing some of the refrigerant from the system during the heating season. That is, since the inlet end **25** of the superheat removal coil **27** is exposed to the high pressure gas, the coil **27** operates as a trap and causes some of the refrigerant of the system to condense out and collect within the coil thereby effectively removing it from the system. This reduces the head pressure as well as adjusting the effective refrigerant charge within the system for optimum performance during the heating cycle. It has been found that a 10-foot coil of ⅜ inch tubing having an .017 inch wall thickness will hold approximately ½ pound of condensed Freon 22 at 40° F. Thus, in the illustrated refrigeration system, when the restriction is increased as the unit is changed from the cooling to the heating operation, the refrigerant is permitted to condense out of the system and to collect in the superheat removal coil so that the head pressure is not quite so great and the flow through the system is much slower thereby permitting complete evaporation of the refrigerant in the evaporator. This feature adapts the refrigeration system to provide a more efficient type of refrigerant flow for the temperature conditions that usually prevail during the heating season.

By the present invention there is provided a very simple arrangement whereby a high side compressor may be cooled under all suction gas temperature conditions by using a superheat removal coil that is controlled by the temperature within the case. Moreover the present invention makes it possible to utilize a compressor motor cooling arrangement, including a superheat removal coil associated with the outdoor heat exchanger structure, in a reversible refrigeration system while obtaining reasonably efficient operation of the refrigeration system for both cooling and heating purposes.

While in accordance with the patent statutes there has been described what at present is considered to be the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention and it is, therefore, the intent of the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a reversible refrigeration system, the combination comprising a hermetically sealed casing for containing a high pressure refrigerant gas, a compressor and a compressor motor mounted in said casing, a reversing valve, a suction line for delivering low pressure refrigerant gas from said reversing valve to said compressor, a high pressure line for delivering high pressure refrigerant gas from said casing to said reversing valve, a discharge chamber directly connected to the outlet of said compressor, a superheat removal coil having its inlet communicating with said discharge chamber and its outlet connecting with said casing thereby to cool the high pressure refrigerant gas from said compressor and to discharge said partially cooled gas into said casing to cool said compressor motor, a bypass passage connecting said discharge chamber directly with said case, valve means in said bypass passage for admitting refrigerant from said discharge chamber into said case upon a predetermined pressure differential between said discharge chamber and said case, valve means in said superheat removal coil for closing said superheat removal coil, and means in said case responsive to the temperature within said case for actuating said valve means to close said superheat removal coil when said temperature within said case falls below a predetermined temperature thereby to cause discharge gas to flow directly through said bypass passage into said case without precooling when said temperature within said case drops below said predetermined temperature.

2. In a reversible refrigerating system, the combination comprising a hermetically sealed casing for containing a high pressure refrigerant gas, a compressor and a compressor motor mounted in said casing, a reversing valve, a suction line for delivering low pressure refrigerant gas from said reversing valve to said compressor, a high pressure line for delivering high pressure refrigerant gas from said casing to said reversing valve, a pair of heat exchangers connected in refrigerant flow relationship with said reversing valve and having connected therebetween a flow restricting means, means in said system for interjecting greater flow restriction between said heat exchangers when flow of refrigerant is in one direction than when the flow of refrigerant is in the other direction, a discharge chamber directly connected to the outlet of said compressor, a superheat removal coil having its inlet communicating with said discharge chamber and said outlet connecting with said casing thereby to cool the high pressure refrigerant gas from said compressor and to discharge said partially cooled gas into said casing to cool said compressor motor, a bypass passage connecting said discharge chamber directly with said case, valve means in said bypass passage for admitting refrigerant from said discharge chamber into said casing upon a predetermined pressure differential between said discharge chamber and said case, valve means in said superheat removal coil adjacent the outlet end of said superheat removal coil for closing said superheat removal coil, and means in said case responsive to the temperature within the case for actuating said valve means to close said superheat removal coil when the temperature within said case falls below a predetermined temperature so that discharge gas is forced to flow directly through said bypass passage into said case without precooling and whereby some refrigerant is condensed into liquid form in said superheat removal coil and stored therein when said temperature of said case drops below said predetermined temperature.

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