

Feb. 12, 1963

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3,077,086

FORCE FEED HEAT PUMP SYSTEM

Filed May 2, 1961

4 Sheets-Sheet 1

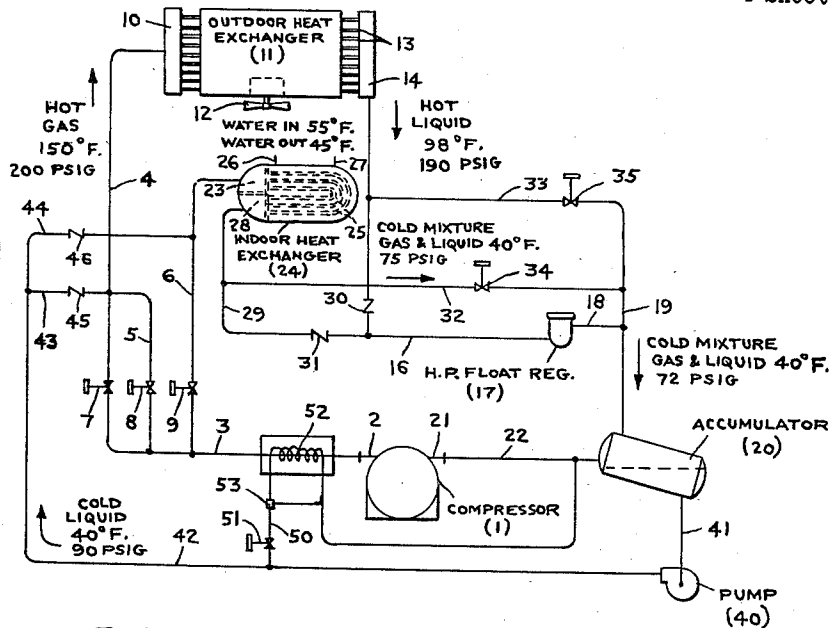


FIG. 1
COOLING CYCLE

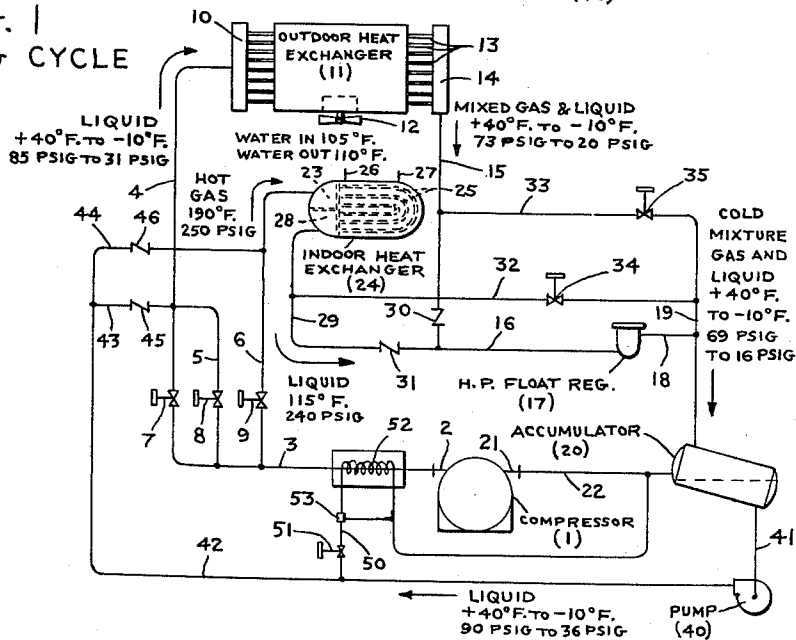


FIG. 2
HEATING CYCLE

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4 Sheets-Sheet 2

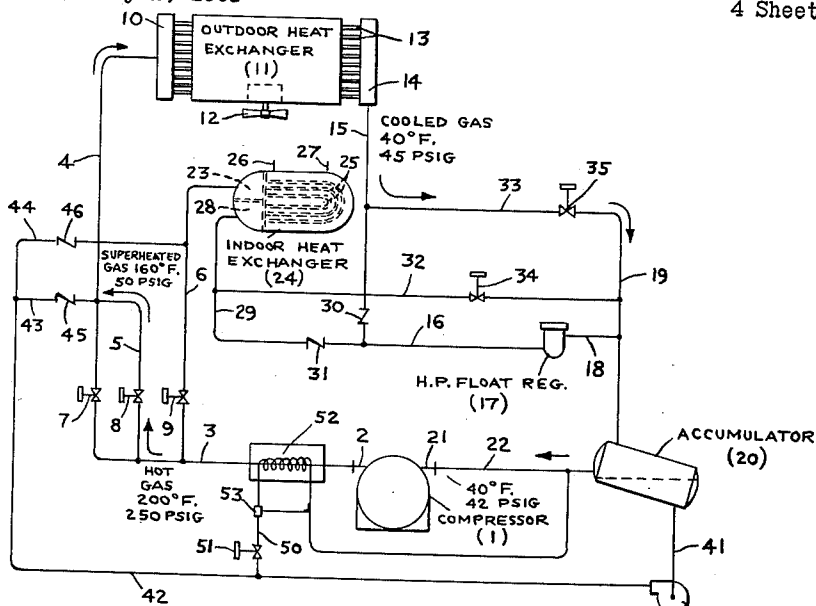


FIG. 3
DEFROST CYCLE

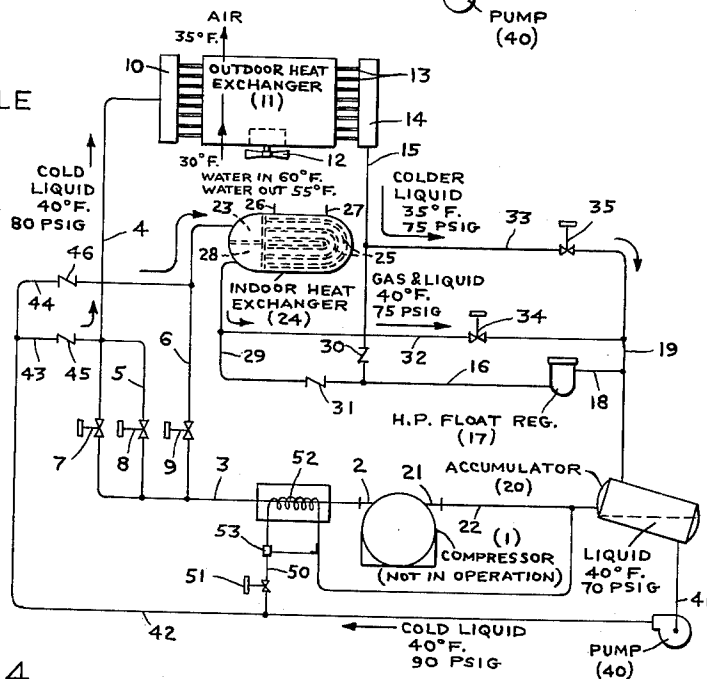


FIG. 4
INTERMEDIATE
COOLING CYCLE
PARALLEL FLOW

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4 Sheets-Sheet 3

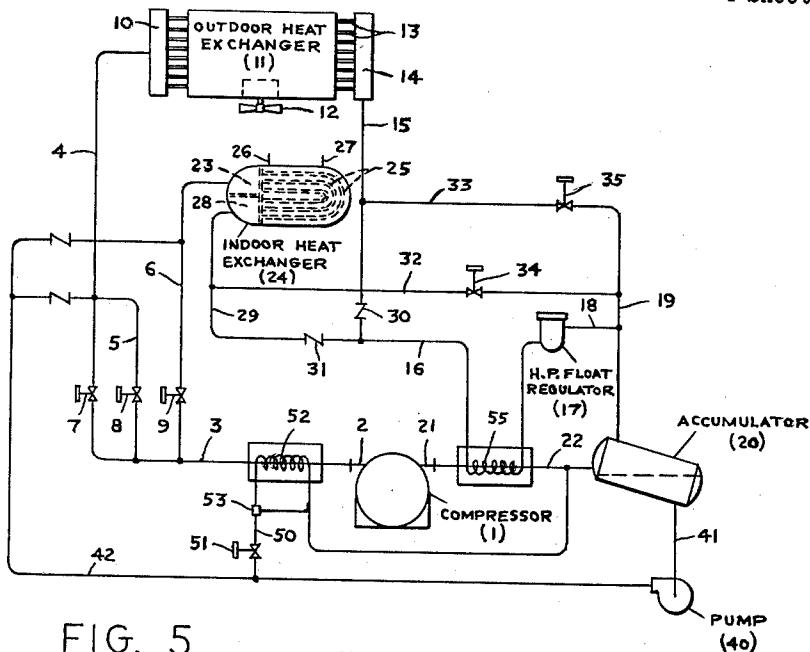


FIG. 5
WITH SUPERHEATING

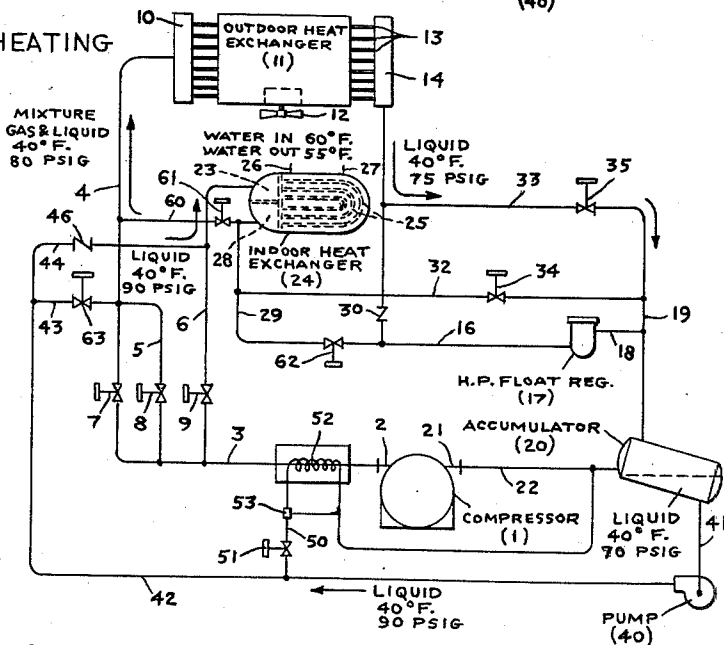


FIG. 6
INTERMEDIATE
COOLING CYCLE
SERIES FLOW

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4 Sheets-Sheet 4

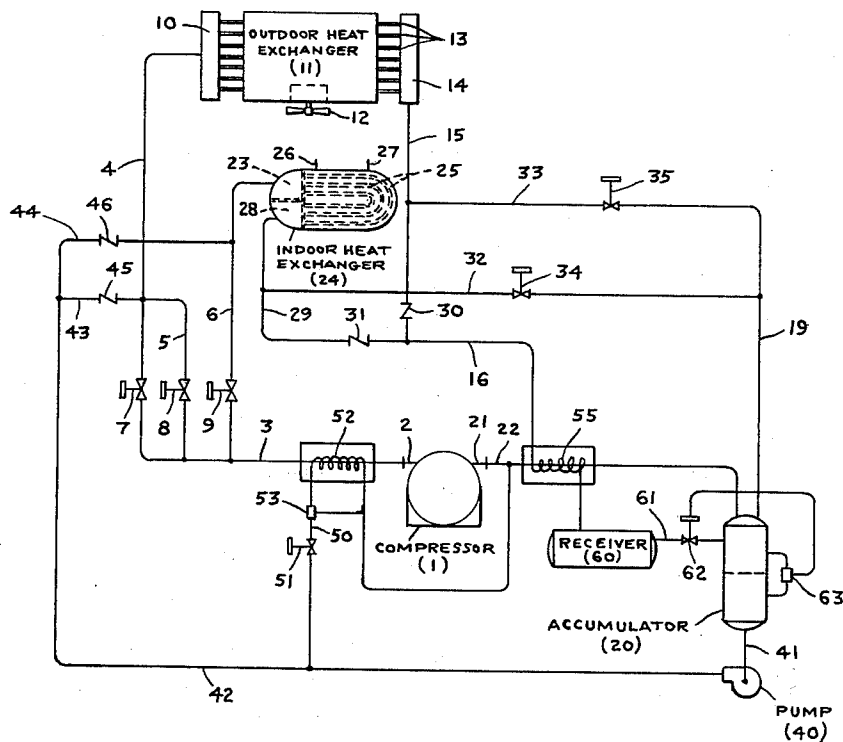


FIG. 7

WITH LOW PRESSURE SEPARATION MEANS

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FORCE FEED HEAT PUMP SYSTEM

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17 Claims. (Cl. 62-324)

The invention relates generally to heat pumps and more particularly to a heat pump embodying a force feed circulation cycle.

The use of heat pumps particularly for air conditioning has become an accepted industrial, commercial and residential practice.

Conventional heat pump systems in use today whether of the flooded or direct expansion type have the compressors and the heat exchangers for the heat pump system connected for series flow and the heat pump systems are characterized by the fact that operation depends on reversal of the direction of flow of the refrigerant fluid in the heat exchangers and the system coupled with a change in function of the heat exchangers to obtain the desired heating and cooling.

Conventional heat pumps of the flooded type and direct expansion type have many limitations, restrictions and operational problems.

For example, in flooded type heat pumps, the surge drum height is a critical factor because the operation of the system is by gravity circulation.

Other difficulties of the flooded type heat pump system are as follows:

(1) Float controls are required on each of the heat exchangers.

(2) Oil recovery means including an oil separator are necessary from each of the heat exchangers.

(3) The heat transfer rate is relatively low so that large heat exchangers are required.

(4) Overcomplication of the controls to regulate the operation of the system results in unreliable automation which is subject to continuous mechanical failure.

(5) Because flooded systems require a large number of auxiliary traps, recovery tanks, etc. for efficient and effective operation, the commercial cost of manufacturing these units is increased.

(6) The defrost cycle of such flooded type heat pump system robs heat from the media being heated or uses external mechanical or electrical mechanisms associated with the heat pump to effect the defrosting needed.

Similarly, in direct expansion heat pump systems:

(1) The heat exchangers must be extremely large because greater heat transfer service is required due to the poor heat transfer coefficient.

(2) Larger heat exchangers are required to provide the superheat needed to obtain the desired operation in the respective heat exchangers.

(3) Each heat exchanger requires its own expansion valve arrangements which necessitates a duplication of controls for each direction of flow.

(4) There are extremely difficult expansion valve adjustment problems with outdoor weather changes.

(5) The system is subject to slugging during start-up and the defrost cycle.

(6) Due to the fact that the gas refrigerant has entrained oil, oil recovery is complicated by critical gas velocities during unloading of the compressor.

(7) Direct expansion systems normally employ a special four (4) way reversing valve.

It is also well known in the conventional type heat pump of either the flooded or direct expansion type, particularly when used for heating and cooling, that there are intermediate periods of temperature and humidity where the systems operate inefficiently.

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The present invention overcomes these and other problems by providing an improved simplified heat pump having a cooling, heating and intermediate cycle wherein a compressor functions in a condensing or high pressure side cycle and a pump functions in an evaporating or low pressure side cycle which cycles are relatively independent but coact by means of a common accumulator or the like separating means.

Thus the present invention contemplates an improved heat pump which includes, a compressor disposed to selectively pass hot compressed gaseous refrigerant from the compressor to the inlet of either a first or a second heat exchanger which heat exchangers in turn have their outlets in communication with a common separating means from which the compressor takes its suction, and a pump circulation cycle to coact with the compressor for delivering relatively cold liquid refrigerant under pressure from the separating means to the inlet of that heat exchanger not receiving hot compressed gaseous refrigerant for the heating or cooling cycle; or to operate independently and without the compressor to deliver relatively cold liquid refrigerant from the separating means and to the heat exchangers either in parallel or series during the intermediate cycle.

The present invention also contemplates a heat pump system including a compression cycle and pump circulation cycle wherein a relatively simple recovery means is provided for dissolved or entrapped lubricant in the refrigerant fluid.

The present invention also contemplates an improved heat pump system including a compression cycle, and pump circulation cycle wherein a simple defrosting cycle is established by creating an imaginary load on the compressor so that the hot gases of compression will serve to produce effective defrosting of the heat exchanger required.

Accordingly, it is an object of the present invention to provide a simple efficient force feed heat pump with better heat transfer characteristics due to its ability to provide an increased rate of circulation of refrigerant fluid whereby the heat exchange surfaces when acting as the evaporator on the low pressure side cycle are maintained wet at all times.

It is another object of the present invention to provide an improved heat pump wherein the lubricant entrained and entrapped in the refrigerant fluid is prevented from stratifying in the heat exchangers and wherein only a single point of oil recovery is necessary.

It is another object of the present invention to provide an improved heat pump wherein a single gas and liquid refrigerant separation device common to both heat exchangers is provided to obtain the required expansion from the high pressure to the low pressure condition.

It is a still further object of the present invention to provide an improved heat pump wherein during these intermediate times of the year where the operation of the system on a compression cycle is inefficient that the system can be made to work only on the pumping cycle to provide cooling as may be required.

Further objects and advantages of the invention will become evident from the following description with reference to the accompanying drawings in which:

FIGURE 1 is a diagrammatic sketch of the invention showing the cooling cycle including an outdoor heat exchanger in heat exchange communication with atmospheric air.

FIGURE 2 is a diagrammatic sketch of the invention showing the heating cycle including an outdoor heat exchanger in heat exchange relation with atmospheric air.

FIGURE 3 is a diagrammatic sketch of the invention showing the defrosting cycle for the outdoor heat exchanger illustrated in FIGURES 1, 2 and 3.

FIGURE 4 is a diagrammatic sketch of the invention showing the intermediate cooling cycle including an outdoor heat exchanger in heat exchange relation with atmospheric air.

FIGURE 5 is a diagrammatic sketch of the invention showing a modified form including a superheating means on the suction line into the compressor.

FIGURE 6 is a diagrammatic sketch of the invention showing a modified form of the intermediate cooling cycle including an outdoor heat exchanger in heat exchange relation with atmospheric air.

FIGURE 7 is a diagrammatic sketch of the invention showing a modified form including a low pressure separating means.

FIGURES 1 to 4 of the drawings illustrate diagrammatically arrangements of the same elements in the form of a heat pump in accordance with the present invention. They are distinguished in that the refrigerant temperature, pressure and flow path between the elements differ for the various cycles cooling, heating, and intermediate.

While in the heat pump system one heat exchanger is shown in heat exchange relation with atmospheric air, it will be understood that such heat exchanger could be associated with other heat sink or heat source media as will be understood by those skilled in the art and that the corresponding heat exchanger best for the medium serving as the heat sink or heat source will be utilized.

Furthermore, while the system shows a second heat exchanger in heat exchange relation with circulating water to be heated or cooled, it will be understood that heat exchange can be with other liquid media or with air or other gaseous media without departing from the scope of the present invention.

General Arrangement of the Heat Pump

Thus, referring to FIGURES 1 to 4 where the same parts will have the same character numerals, a compressor is shown at 1 having a discharge outlet 2 connected to a discharge line 3 disposed to receive hot compressed gaseous refrigerant from the compressor. The discharge line 3 is connected to three conduits 4, 5 and 6, each having their respective solenoid operated valves 7, 8 and 9 which can be manually or automatically controlled to provide that direction of flow in the system which will produce the desired cooling, heating or defrost cycles hereinafter described:

Conduit 4 communicates with the inlet header 10 of a first heat exchanger 11 which will be called for the purpose of the present disclosure the outdoor heat exchanger because it is disposed and located so that atmospheric air can be passed thereover as by a fan 12 to permit good heat exchange relation to occur between the coils 13 of the heat exchanger and the air. Heat exchangers for this purpose are well known and are easily purchasable on the open market.

As indicated above, this heat exchanger may for all purposes also be one which is adapted for heat exchange relation with other types of heat sink and heat source media.

The outlet header 14 of the first or outdoor heat exchanger communicates through connecting line 15 and common conduit 16 with a high pressure float regulator 17 in turn connected by connecting conduit 18 to collecting line 19 leading to accumulator 20. High pressure float regulators and accumulators are elements which are also well known in the refrigeration art and require no further description.

The accumulator shall be sized sufficiently large to permit a proper separation of the gaseous and liquid refrigerant which is delivered to the accumulator and shall be constructed to act as a high pressure receiver for storing the entire charge of the refrigerant as may be necessary during shut down periods.

The compressor has its suction inlet 21 connected as by a suction line 22 to that portion of the accumulator

20 occupied by the gaseous refrigerant so that slugging of liquid is avoided during the operation of the compressor.

Conduit 6 communicates with the inlet chamber 23 of the second heat exchanger 24 which is termed for the purposes of the present description as the indoor heat exchanger because it will be disposed at an enclosed point such that either a liquid or gas may be circulated over the coils 25 to provide means for transferring heat or abstracting heat depending on the cycle in operation at the time. This is accomplished in the present form of the invention by passing liquid through inlet 26 and removing it by outlet 27. Heat exchangers for this purpose are well known in the air conditioning and refrigeration art and are easily purchasable on the open market.

The outlet chamber 28 for the second or indoor heat exchanger 24 is also connected through return line 29 to the common line 16 which communicates with the high pressure float regulator 17.

FIGURES 1 to 4 show that the conduits 15 and 29 are provided with check valves as at 30 and 31 respectively so that the flow of refrigerant fluid through the outdoor and indoor heat exchangers will be uni-directional, a specific characteristic of the operation of the present invention regardless of the particular cycle in operation.

FIGURES 1 to 4 also show that lines 15 and 29 communicate through lines 32 and 33 respectively directly to collecting line 19 and depending on the operating cycle which calls for the setting for the control valves 34 and 35 for the respective lines 33 and 32 refrigerant gas and liquid from one or the other of the heat exchangers 11 or 24 can by-pass the high pressure float regulator 17 and be passed directly to the accumulator 20.

The operation of the control valves 7, 8, 9, 34 and 35 may be manual or automatic.

Pumping System

In order to provide the positive or force feeding circulation of refrigerant liquid to the respective indoor and outdoor heat exchangers in the various cycles hereinafter described where the heat exchanger is not receiving hot compressed gaseous refrigerant a pump 40 is provided having its suction connected by line 41 to the portion of the accumulator 20 in which the liquid refrigerant settles. The pump discharges through common discharge line 42 to the connecting conduits 43 and 44 which are in turn connected to the conduits 4 and 6 leading to the outdoor and indoor heat exchangers 11 and 24.

As shown in FIGURES 1 to 4 connecting conduits 43 and 44 are provided with check valves 45 and 46 respectively, which check valves will direct the flow of refrigerant liquid depending on the settings of control valves 7 and 9.

Check valves 30 and 31 also operate similarly depending on the settings of control valves 34 and 35.

In both the case of check valves 30 and 31 and check valves 45 and 46 the pressure of the refrigerant will pressurize one or the other of the check valves so that flow will occur through that check valve which does not have the pressure acting against its discharge side.

The valves 34 and 35 also permit the inclusion of a defrosting cycle which is accomplished through the defrosting conduit 5 connected through valve 8 to the common discharge line 3 and to a point downstream of the solenoid operated valve 7 and the check valve 45 which defrosting cycle is more fully described hereinafter.

Oil Recovery Means

The heat pump with a force feed pumping arrangement as above described is particularly characterized by the fact that no oil can accumulate in the system in any of the heat exchangers or in any piping traps as occurs

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in heat pump arrangements now known in the prior art. Oil collects at only a single point in the system, namely the accumulator 20 and this permits a unique simple method of oil recovery in that oil-rich Freon may be sampled from the downstream side of pump 40 by a relatively small bleed line 50 having a solenoid operated valve 51 therein which can be maintained open during these cycles which include compressor operation.

The oil-rich Freon sampled through the bleed line 40 is evaporated by wrapping the bleed line as at 52 about one of the hot lines such as the discharge line 3 from the compressor. This evaporated refrigerant in gaseous form containing small particles of oil can be returned to the compressor by connecting the outlet of line 50 to the suction inlet line 22 leading to the suction of the compressor

Since there is a pressure difference between the discharge side of the pump 40 and the suction side of the compressor 1, a very effective non-clogging, easily regulated oil recovery system will be incorporated in the heat pump. A control for sensing superheat in line 50 is provided as at 53 and will be utilized to regulate the flow of oil-rich Freon through line 50.

Figure 5—Modified Form of the Invention With Superheating

FIGURE 5 shows a modified form of the invention wherein means is provided for superheating the gaseous refrigerant before it is passed into the compressor suction so as to insure against moist gas entering the compressor and further to increase the differential of temperature across the compressor.

In FIGURE 5 identical elements have been given the same character numerals and as shown the modification to produce the above results consists in merely changing the line leading to the high pressure float regulator 17.

Thus line 16 connected at one end to the respective lines 15 and 29 and at the other end to the high pressure float regulator 17 has its intermediate portion coiled as at 55 about the suction line 22.

In operation as the compressor 1 draws gaseous refrigerant from the accumulator 20 through line 22 the gaseous refrigerant comes into non-contacting heat exchange relation with the hot liquid refrigerant passing through coil 55 of line 16. The hot liquid refrigerant superheats the gaseous refrigerant passing through suction line 22, thereby evaporating any particles of liquid refrigerant entrained in or carried by the gas being passed to the compressor, thus insuring against any possibility of slugging that might cause damage to the compressor.

The operating cycles of this modified form of the invention is otherwise identical with those hereinafter described for the form of the invention shown in FIGURES 1 to 4.

Figure 7—Modified Form of Invention With Low Pressure Separation Means

In the above described heat pump only a preferred form of the invention is illustrated and this shows the use of a high pressure actuated separating means to separate the hot compressed gaseous refrigerant from the cold low pressure refrigerant liquid.

This separation of gas and liquid can also be accomplished by means of a low pressure actuated arrangement such as is shown in FIGURE 7 of the drawings. Thus, in FIGURE 7 identical elements have been given the same character numerals, and as shown the modification line 16 now leads to a high pressure type receiver 60 which in turn is connected to the accumulator through a feed line 61. Flow of refrigerant liquid through the line 61 is regulated by control valve 62 which is actuated in response to signals from the level controller 63. Level controllers with means to deliver electrical or pneumatic signals to the control valve 62 are well known in the control art and their opera-

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tion for the purpose shown in the drawing is also understood and therefore will not be described more fully.

The above described heat pumps as shown in FIGURES 1, 5 and 7 can be operated so to include a compression cycle or without a compression cycle. When the system is operated with compression the equivalent cooling and heating cycles of conventional heat pumps can be obtained. When the system is operated without compression the valves are so positioned that the pump can force or positively feed refrigerant liquid to the respective heat exchangers in parallel or in series and the heat exchangers will return the liquid to a mixing source so that cooling can be obtained.

These various operating cycles of the heat pump system will now be more fully described, and reference is provided on the figure described for approximate temperature, pressure conditions and for the physical state of the refrigerant at given points in the cycle.

The valves other than check valves will be regulated to their open, closed or modulated positions either manually or automatically.

Cooling Cycle

Cooling of a liquid or gaseous media in heat exchange relation with the indoor heat exchanger 24 can be obtained by operating the heat pump in the following manner:

First, the compressor 1, the pump 40 and the fan 12 are placed into operation. Valves 7, 34 and 51 will be open and all other valves will be closed. Hot compressed gaseous refrigerant from compressor 1 will pass through the discharge outlet 2 and common discharge line 3 to the conduit 4 connected to the inlet header 10 of outdoor heat exchanger 11. In the outdoor heat exchanger 11 the hot compressed gaseous refrigerant will be condensed to provide a hot liquid refrigerant which will collect in the outlet header 14 of the outdoor heat exchanger 11.

The hot liquid refrigerant passes from the outlet header 14 through lines 15 and 16 to the high pressure float regulator 17 which serves to pass or meter liquid of which a portion flashes into gas through lines 18 and 19 to the accumulator 20. This mixture of relatively cold gas and liquid refrigerant mixes with other relatively cold gas and liquid refrigerant which is returned from the indoor heat exchanger as hereinafter described.

In the accumulator 20 which is properly sized, the gaseous and liquid refrigerant separate so that a gas layer occupies the upper portion of the accumulator and the liquid layer occupies the lower portion of the accumulator, as is indicated by the dotted line in FIGURES 1 to 4.

Since the suction line 22 of the compressor is connected to the upper portion of the accumulator which holds the gaseous refrigerant only gas passes through the suction line 22 and the suction inlet 21 of the compressor where it is once again recompressed to repeat the condensing cycle.

The relatively cold liquid refrigerant in the accumulator 20 is also pumped with positive pressure to the indoor heat exchanger 24 by means of the pumping system above described. Thus pump 40 receives liquid through the line 41 and discharges the refrigerant liquid through line 42. Due to the fact that hot compressed gaseous refrigerant is passing through conduit 4 the check valve 43 is prevented from opening and this discharged liquid refrigerant under pressure must be delivered through conduit 44 and check valve 46 to the conduit 6 connected to the inlet header 23 of the indoor heat exchanger 24.

At the indoor heat exchanger the liquid refrigerant is passed therethrough into heat exchange relation with fluid which is delivered through line 26 and removed by line 27 so that the cold liquid refrigerant is heated as it cools the fluid being passed through the indoor heat exchanger. This cooled fluid media as it leaves line 27 may be passed to any suitable point of use.

It is believed clear to those skilled in the air condition-

ing and refrigeration art that air or other gaseous media could also be cooled by passing in heat exchange relation with a suitable type indoor heat exchanger without departing from the scope of this invention.

The refrigerant collected in the outlet header 28 of heat exchanger 24 will be part gas and part liquid because the pump supplies a greater quantity of liquid than is required for the capacity of the heat exchanger. This is advantageous because the inner surface of the tubes of the heat exchanger will under these conditions be continually wetted thereby increasing the efficiency of the heat exchanger.

This mixture of gaseous and liquid refrigerant will be passed from the outlet header 28 through lines 29, 32 and control valve 34 to the collecting line 19 where it joins with a like mixture of gas and liquid from the high pressure float regulator 17 as it flows through line 19 to the accumulator 20 connected thereto.

This pumping circulation cycle will operate continuously to provide the desired cooling as long as the compressor continues to operate with the valves set for the cooling cycle as above described.

Heating Cycle

In the heating cycle shown in FIGURE 2 the compressor 1, the pump 40 and the fan 12 are first placed into operation. All valves are closed except control valves 9, 35 and 51.

Hot compressed gaseous refrigerant will be discharged from the compressor through discharge outlet 2 and discharge line 3 to conduit 6 and will be passed by conduit 6 to the inlet header 23 of the indoor heat exchanger 24 where it gives up heat to the medium to be heated, as for example, water brought into the heat exchanger 24 through inlet 26 and discharged to the desired point of use through outlet 27 in the heated condition. It is understood that heat exchange could be made with other liquid media or air or other gaseous media without departing from the scope of this invention, and that where air or a gas media is used that the type heat exchanger required for this media will also be used as is well known in the heat pump art.

The release of heat to the media to be heated causes the gas to condense to provide liquid refrigerant, which liquid refrigerant passes through the outlet header 28 of the heat exchanger 24 through line 29 and check valve 31 to the common line 16 leading into the high pressure float regulator 17.

In high pressure float regulator 17 the liquid flashes and during the expansion cools so that relatively cool gas and liquid refrigerant is then led to the accumulator 20 through line 19. This mixture of relatively cold gas and liquid refrigerant similar to the cooling cycle mixes with other relatively cold gas and liquid refrigerant which is returned from the indoor heat exchanger as hereinafter described. By reason of the size of the accumulator 20 the refrigerant mixture separates to provide a gaseous layer and a liquid layer of the refrigerant in intimate contact with each other.

Since the suction line 22 communicates with the gaseous portion of the refrigerant in the accumulator the compressor will draw gaseous refrigerant through the suction inlet line 22 and suction inlet 21 into the compressor where it will be recompressed to pass through the cycle above described.

In addition to the heat of compression heat is also drawn from the heat source in contact with the outdoor heat exchanger 11 by force feeding refrigerant liquid to the outdoor heat exchanger. This is accomplished by means of the pumping assembly. Thus pump 40 through line 41 draws cold liquid refrigerant from the liquid layer of the refrigerant in the accumulator 20 and discharges it through discharge line 42. Since hot compressed gaseous refrigerant is being discharged through conduit 6 the

pumped fluid cannot pass through the check valve 46 and instead passes through check valve 45 in conduit 43 into conduit 4 connected thereto where it is forced to the inlet header 10 of the outdoor heat exchanger 11. As it passes through coils 13 of the outdoor heat exchanger 11 the liquid refrigerant which will always be colder than the heat source will pick up heat from the heat source and then from the outlet header 14 it will be passed through lines 15, line 33, and control valve 35 to collecting line 19 and thence to the accumulator 20 where it mixes with the mixture of gas and liquid refrigerant returning from the high pressure float regulator 17 to the accumulator 20. The mixtures passed to the accumulator separate and as above described recirculate through lines 22 and 41 to the compressor and pump respectively, to repeat the cycle.

Defrost Cycle

When the heating cycle is in operation and an outside heat exchanger is used in non-contacting heat exchange relation with air as has been above described, it is known that ice or frost will collect on the outside surface of the coils of the outdoor heat exchanger. As this coating of ice or frost increases, the efficiency of the outdoor heat exchanger will reduce and accordingly it is necessary to provide a mechanism for removing this ice or frost. This is accomplished in the present invention by means of a simple defrost cycle.

The defrost cycle is characterized by the fact that the compressor is artificially loaded, and operates to flow hot gas as the heat carrying medium through the system in a non-condensing cycle. This is accomplished by inserting the equivalent of an orifice in the flow path across which the compressor moves the defrosting fluid. In actual operation this orifice is effective by constricting the control valve 8 to accomplish this result.

Thus as shown in FIGURE 3 compressor 1 is placed in operation. Fan 12 and pump 40 are not put in operation. All valves will be closed except control valves 8 and 35. As the compressor operates hot compressed gaseous refrigerant is discharged through the discharge outlet 2 and discharge line 3 to the defrost conduit 5 which has the control valve 8 therein. As indicated in FIGURE 3 the hot compressed gaseous refrigerant will as it passes through the control valve 8 reduce the pressure from 250 p.s.i.g. to 50 p.s.i.g. so that the gas on the downstream side of the control valve 8 is superheated gas at the temperature and pressure indicated. This hot superheated gas is passed to conduit 4 and thence to the inlet header 10 of the heat exchanger 11.

Since the fan 12 is not in operation the hot compressed gaseous refrigerant will deliver the bulk of its heat to the walls of the coils thereby melting the encrusted ice and frost on the outer surface of the coils and the cooled gaseous refrigerant collected in the outlet header 14 will then be returned by differential pressure through lines 15, 33, control valve 35 and line 19 to the accumulator 20 which circuit merely serves to return the cooled gaseous refrigerant back to the compressor through suction line 22 and suction inlet 21. The cycle will be repeated until the heat exchanger is completely free of ice or frost and this should be accomplished in approximately 15 to 20 minutes so as to permit the heating cycle to be continued without an excessive length of interruption.

The effect of the restriction in the defrost flow cycle is to impose the artificial load on the compressor. If the compressor did not operate with such a load very little heat would be generated. However, with this heat load imposed the compressor must do work in lifting the gas from 50 to 250 pounds which work is transmitted into heat carried by the gas and this heat is utilized to defrost the outdoor coil of the heat exchanger 11 very rapidly. Thus capacity is not robbed from the media previously heated nor is heat drawn from the very space of system which the heat pump is required to supply heat to. Fur-

thermore, no additional equipment or other means such as hot water sprays, electric resistance heaters or blankets are required.

The heat utilized for the defrost cycle in the present invention is obtained by direct conversion of the electrical input into the compressor motor into heat which is carried by the gaseous refrigerant circulated through the system.

Intermediate Cooling Cycle

In the intermediate cooling cycle cooling is effected by a mixing process where the heat content of two portions of the refrigerant is changed by circulating it through the respective heat exchangers.

One portion can discharge heat to the heat sink, the other can absorb heat from the media to be cooled and the respective portions can then be remixed together for recirculation through the system once again.

This operating cycle is designed for limited conditions where some but not a large quantity of cooling is required. Furthermore the circulation can be either in parallel as shown in FIGURE 4 or in series as shown in FIGURE 6 and these respective operating cycles will not be described.

Thus by reference to FIGURE 4 we find in this cycle that only the pump 40 and fan 12 will be in operation. The compressor will not be in operation. In addition, valves 7, 8, 9 and 51 will be closed and valves 34 and 35 will be open.

In operation pump 40 draws refrigerant liquid from the accumulator 20 and discharges the liquid under pressure through line 42 and through connecting conduits 43 and 44 simultaneously into conduits 4 and 6 respectively, which in turn direct the liquid refrigerant to the inlet header 10 for the heat exchanger 11 and inlet header 23 for the heat exchanger 24.

Refrigerant liquid in heat exchanger 11 will pass through the coils 13 in non-contacting heat relation with air passed thereacross by the fan 12 and will be cooled. The cooled refrigerant collects in the outlet header 14 and is passed via lines 15, 33 and collecting line 19 to the accumulator 18.

Similarly, liquid refrigerant in heat exchanger 24 will pass through its coils in non-contacting heat exchange relation with the media, be it liquid or gas or other fluid to be cooled, as for example, water which is introduced through inlet 26 and discharged through outlet 27 of the heat exchanger 24 which cooled liquid can be utilized for cooling at any suitable point.

The heat exchange relation passes a mixture of gas and liquid refrigerant to the outlet header 28 of the heat exchanger 24, which mixture flows via lines 32, control valve 34 and collecting line 19 to the accumulator 20 where it mixes with the cooled liquid refrigerant returning from the heat exchanger 11. Mixture of the two provides a liquid refrigerant having an ambient temperature which will once again permit it to absorb heat from the media to be cooled by repetition of the flow cycle above described.

Where the intermediate cooling cycle is accomplished by series flow, the system must be modified as shown in FIGURE 6.

This is done by providing a connecting line at 60 to connect the outlet header 23 of heat exchanger 24 to conduit 4, and inserting a solenoid operated control 61, valves in line 60 and replacing the check valves in lines 29 and 43 with solenoid valves as at 62 and 63.

During operation of this modified system only the pump 40 and fan 12 will be in operation. Once again, the compressor will not be in operation. Valves 7, 8, 9, 34, 51, 62, 63 will be closed and valves 61 and 35 will be open.

Pump 40 will draw cold liquid refrigerant from the accumulator 20 and discharge this liquid through lines 42 and 44 and conduit 6 into the inlet header 23 of the heat exchanger 24. The liquid refrigerant will give up

heat to the water circulated through the heat exchanger through inlet 26 and outlet 27 and will as a result of the heat exchange relation be converted into a mixture of gas and liquid refrigerant which collects in the outlet header 28 of the heat exchanger 24. The mixture of gas and liquid refrigerant is passed from the outlet header 28 via connecting line 60 and conduit 4 to the inlet header 10 of the outdoor heat exchanger 11 where the refrigerant is cooled by heat exchange relation with air passed over the coils 13 of the heat exchanger 11, thereby condensing the gaseous portion of the refrigerant. The now liquid refrigerant collects in the outlet header 14 and is passed by lines 15, 33 and 19 to the accumulator 20 connected by line 41 to the pump 40 which permits this cycle to repeat itself as long as the pump 40 and fan 12 continue to operate.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. In a heat pump, a plurality of heat exchange means, a common separating means for storing and separating gaseous and liquid refrigerant, means connecting the downstream side of each of said heat exchange means to said separating means, a compression means, said compression means having its suction connected to said common separating means, conduit means communicating the discharge of said compression means to the upstream side of said heat exchange means, said conduit means being adapted to deliver hot compressed gaseous refrigerant interchangeably and selectively to the upstream side of at least one of said heat exchange means, and a pump circulation cycle having its suction connected to said separating means to receive liquid refrigerant therefrom and to force feed an excess of liquid refrigerant to the upstream side of at least one other of said heat exchange means not receiving hot compressed gaseous refrigerant from said compression means.

2. In a heat pump, a first heat exchange means and a second heat exchange means each having inlet means and outlet means, at least one compressing means, at least one pumping means, means to interchangeably and selectively connect the compressing means and the pumping means to the respective inlet means for the first and second heat exchange means, a common separating means for storing and separating gaseous and liquid refrigerant, means connecting the respective outlet means for said first and said second heat exchange means to the common separating means, said compression means having its suction connected to said common separating means to receive gaseous refrigerant therefrom and to pass hot compressed gaseous refrigerant to that heat exchange means selectively connected to the discharge of the compression means, and said pumping means having its suction connected to said common separating means to receive liquid refrigerant therefrom and to pass an excess of liquid refrigerant under pressure to that heat exchanger means selectively connected to the discharge of the pumping means.

3. In the heat pump as claimed in claim 2, an oil recovery means including, line means connected between the discharge side of said pumping means and the suction side of the compression means for bypassing a predetermined quantity of mixed oil and liquid refrigerant, and means in said line means for superheating the mixed oil and liquid refrigerant whereby a vaporized mixture of oil and gas refrigerant is passed to said suction side of the compressor.

4. In the heat pump as claimed in claim 3 wherein said superheating means comprises, a cooling coil formed in said line means, said cooling coil mounted at any suitable point in the heat pump for non-contacting heat exchange relation with means carrying said hot gaseous refrigerant.

5. In the heat pump as claimed in claim 2 wherein means connected between the separating means and the

suction of the compression means acts to superheat gaseous refrigerant passing from the separating means to the suction of the compressor.

6. In the heat pump as claimed in claim 2 wherein a return line provides means for connecting the suction of the compressor to the separation means for passing the gaseous refrigerant from the separation means to the suction inlet of the compressor, and means connecting the downstream side of the heat exchange means to the separation means operatively connected to said return line for superheating the gaseous refrigerant passing to said compression means.

7. In a heat pump, a first heat exchange means and a second heat exchange means each having inlet means and outlet means, at least one compressing means, at least one pumping means, means to interchangeably and selectively connect the compressing means and the pumping means to the respective inlet means for the first and second heat exchange means, a common separating means for storing and separating gaseous and liquid refrigerant including, a flow regulating means to meter the high pressure mixture of gaseous and liquid refrigerant therethrough, an accumulator means operatively associated with said flow regulating means, means connecting the outlet means of the heat exchange means selectively connected to receive hot compressed gaseous refrigerant to the flow regulating means, means connecting the outlet means of that heat exchange means selectively connected to the pumping means to the accumulator means, said compression means having its suction connected to said common separating means to receive gaseous refrigerant therefrom and to pass hot compressed gaseous refrigerant to that heat exchange means selectively connected to the discharge of the compression means, and said pumping means having its suction connected to said common separating means to receive liquid refrigerant therefrom and to pass an excess of liquid refrigerant under pressure to that heat exchanger means selectively connected to the discharge of the pumping means.

8. In the heat pump as claimed in claim 7 wherein said regulating means comprises, a high pressure float regulator having an inlet and an outlet, said inlet connected to the outlet of that heat exchanger selectively connected to receive hot compressed gaseous refrigerant, and said outlet for the float regulator connected to the accumulator to pass the flashed mixture of gaseous and liquid refrigerant thereto.

9. In the heat pump as claimed in claim 7 wherein said regulator means comprises, a high pressure receiver, said receiver having an inlet and an outlet the inlet of said receiver connected to the outlet means of the heat exchange means selectively connected to receive hot compressed gaseous refrigerant, conduit means connecting the outlet of said high pressure receiver to the accumulator, a control valve means in said conduit for regulating flow of refrigerant from said receiver to said accumulator, a liquid level control means on said accumulator, and means connecting said liquid level control means to said control valve means to automatically regulate operation of the control valve in accordance with variations of the level of liquid refrigerant in said accumulator from the desired predetermined level.

10. In a heat pump, a first heat exchange means and a second heat exchange means each having inlet means and outlet means, at least one compressing means, at least one pumping means, means to interchangeably and selectively connect the compressing means and the pumping means to the respective inlet means for the first and second heat exchange means, a common separating means for storing and separating gaseous and liquid refrigerant, means connecting the respective outlet means for said first and said second heat exchange means to the common separating means, said compression means having its suction connected to said separating means to receive gaseous refrigerant therefrom and to pass hot compressed gaseous

refrigerant to that heat exchange means selectively connected to the discharge of the compression means, and said pumping means having its suction connected to said common separating means to receive liquid refrigerant therefrom and to pass an excess of liquid refrigerant to that heat exchanger means selectively connected to the discharge of the pumping means and not receiving hot compressed gaseous refrigerant from said compressor whereby the pumping means will coact with said compressing means during the cooling and heating cycles; and said pumping means adapted to operate independently of the compressing means to deliver an excess of relatively cold refrigerant from the common separating means to the inlet of each of said first and second heat exchange means in parallel and in series during the intermediate cooling cycles.

11. In a heat pump having cooling, heating and intermediate cooling cycles, a high pressure side cycle including, compression means and at least one heat exchange means, a low pressure side cycle including, pump means, and at least one other heat exchange means, means to interchangeably and selectively deliver hot compressed gaseous refrigerant from said compression means to the upstream side of said first mentioned heat exchange means and to the upstream side of said second heat exchange means to permit said heat exchange means to function interchangeably, means to interchangeably and selectively feed cold liquid refrigerant from said pump means to the upstream side of said first mentioned heat exchange means and to the upstream side of said second heat exchange means when the respective heat exchange means is not connected to receive hot gaseous refrigerant from said compression means, a common separating means for storing and separating gaseous and liquid refrigerant, means connecting the downstream side of said first heat exchange means and said second heat exchange means to said common separating means, said compression means having its suction inlet connected to said common separating means and its discharge outlet connected to said means for interchangeably and selectively delivering hot compressed gaseous refrigerant to the upstream side of the respective first and second heat exchange means, and said pump means having its suction connected to said common separating means and its discharge connected to said means for delivering cold liquid refrigerant to said first and said second heat exchange means and at all times to deliver an excess of liquid refrigerant to the respective heat exchange means connected thereto for the particular cycle of operation.

12. In a heat pump having cooling, heating and intermediate cooling cycles, a high pressure side condensing cycle including, a first heat exchanger having an inlet and an outlet, a second heat exchanger having an inlet and an outlet, a compressor, means to interchangeably and selectively connect the discharge of said compressor to the inlet side of the respective first and second heat exchangers to permit said first heat exchanger and said second heat exchanger to function interchangeably, a common separating means for storing and separating gaseous and liquid refrigerant, means connecting the respective outlet side of said first and second heat exchanger to said separating means, and said compressor having its suction connected to said separating means to receive gaseous refrigerant therefrom and to deliver hot compressed gaseous refrigerant through said means to the selected heat exchanger, and a circulation cycle having a pump therein connected to receive liquid refrigerant from said separating means and during the heating and cooling cycle to coact with the compressor for delivering relatively cold refrigerant under pressure from the separating means to the inlet of that heat exchanger not receiving hot compressed gaseous refrigerant, and said circulation cycle disposed to operate independently of the compressor to selectively deliver relatively cold liquid refrigerant from the separating means to the respective heat exchangers for

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selective parallel and series operation on the intermediate cycle.

13. In a heat pump having cooling, heating and intermediate cooling cycles, a high pressure side cycle including, compression means and at least one heat exchange means, a low pressure side cycle including, pump means, and at least one other heat exchange means, means to interchangeably and selectively deliver hot compressed gaseous refrigerant from said compression means to the upstream side of said first mentioned heat exchange means and to the upstream side of said second heat exchange means to permit said heat exchange means to function interchangeably, means to interchangeably and selectively feed cold liquid refrigerant from said pump means to the upstream side of said first mentioned heat exchange means and to the upstream side of said second heat exchange means when the respective heat exchange means is not connected to receive hot gaseous refrigerant from said compression means, a common separating means for storing and separating gaseous and liquid refrigerant, means connecting the downstream side of said first heat exchange means and said second heat exchange means to said common separating means, said compression means having its suction inlet connected to said common separating means and its outlet connected to said means for interchangeably and selectively delivering hot compressed gaseous refrigerant to the upstream side of the respective first and second heat exchange means, and said pump means having its suction connected to said common separating means to receive liquid refrigerant from said separating means and during the heating and cooling cycle to coact with the compressor for delivering relatively cold refrigerant under pressure from the separating means to the inlet of that heat exchanger not receiving hot compressed gaseous refrigerant; and said pump means disposed to operate independently and without the compressor to selectively deliver relatively cold liquid refrigerant from the separating means to the respective heat exchangers during the intermediate cycle.

14. In the heat pump as claimed in claim 11, an oil recovery means including, line means connected between the discharge side of said pumping means and the suction side of the compression means for bypassing a predetermined quantity of mixed oil and liquid refrigerant, and means in said line means for superheating the mixed oil and liquid refrigerant whereby a vaporized mixture of oil and gas refrigerant is passed to said suction side of the compressor.

15. In the heat pump as claimed in claim 11 wherein means connected between the separating means and the

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suction of the compression means acts to superheat gaseous refrigerant passing from the separating means to the suction of the compressor.

16. In the heat pump as claimed in claim 2, a defrost means comprising, a defrost line connecting the discharge of said compression means to the inlet for that heat exchanger means to be defrosted, restriction means in said defrost line, said defrost line and means for interchangeably and selectively connecting the compression means and the pump means to the respective heat exchanger adapted to permit free flow of gaseous refrigerant to and from the heat exchange means to be defrosted whereby the compression means is loaded due to the work of forcing the gaseous refrigerant through said restriction means.

17. In a heat pump having at least one heat exchange means in communication with a heat sink and heat source media, compression means, conduit means connecting the discharge outlet of said compressor to the upstream side of said heat exchange means, valve means in said conduit to be closed during defrosting of the heat exchange means, separating means for storing and separating gaseous and liquid refrigerant, means connecting the downstream side of said heat exchanger to the separating means, and means connecting the suction of said compression means to the separating means to draw gaseous refrigerant therefrom, the combination therewith of a defrost cycle including, a conduit connected to the discharge of said compression means and to said conduit means downstream of the valve means to permit hot compressed refrigerant to be directed from the compressor to the inlet of said heat exchange means, valve means to selectively control flow through said defrost conduit, and means forming a restriction in said defrost conduit to force said compressor to perform work when the defrost conduit valve is open for defrosting.

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