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FORCED FEED HEAT PUMP WITH COMPOUND COMPRESSION

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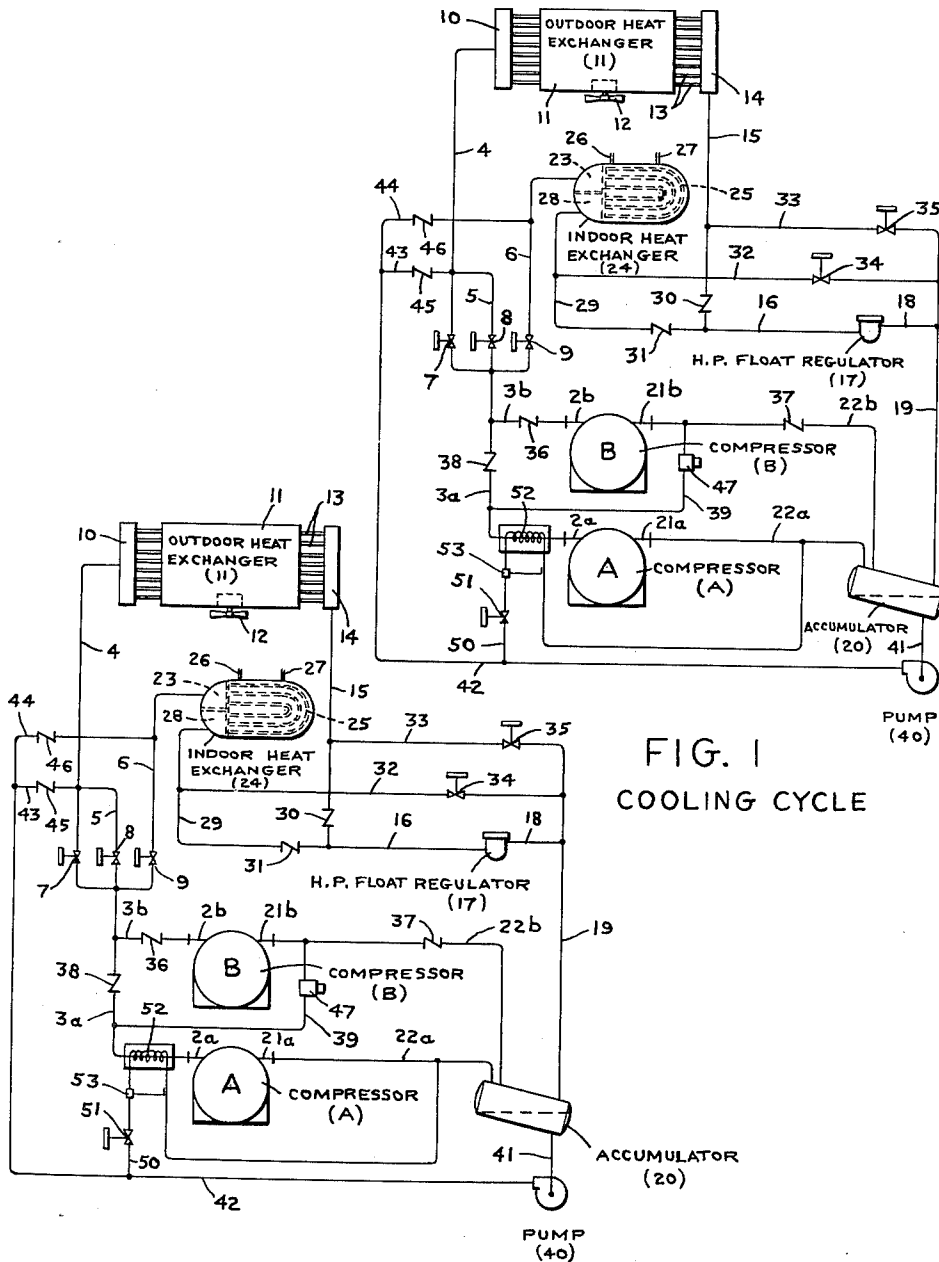


FIG. 1
COOLING CYCLE

FIG. 2
HEATING CYCLE

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FORCED FEED HEAT PUMP WITH COMPOUND COMPRESSION

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This invention relates generally to heat pumps and more particularly to a heat pump having combined compression and forced feed circulation cycles wherein the compressor means may be selectively staged for single or compound operation, as desired, dependent upon outdoor ambient temperatures.

In my co-pending U.S. application, Serial No. 107,181, filed May 2, 1961, a new and improved heat pump system was described, characterized by the fact that the compressor functioned in a condensing or high pressure side cycle and a pump functioned in an evaporating or low pressure side cycle, which cycles were relatively independent but coated by means of a common accumulator or the like separating means. This system, disclosed in full detail in said co-pending application, provides a substantial improvement over conventional flooded or direct expansion type heat pump systems. It operates at much greater efficiency (when used for heating and cooling) at intermediate periods of temperature and humidity; it permits minimum size and simplicity in components, including the elimination of complex multi-way valves; it eliminates slugging during the start-up and defrost cycles; it provides a relatively simple recovery means for dissolved or entrapped lubricant in the refrigerant fluid; and it provides a simplified energy conserving defrosting cycle.

The present invention is in the nature of an improvement and modification in the basic heat pump system set forth in said above mentioned copending application. In the basic system, there was illustrated a single refrigerant compressor means, and this is sufficient for basic operation and for many purposes. However, it is possible by means of the present improvement to increase the overall efficiency of the system, to operate with more efficiency during extremes of temperature and to adapt the heat pump for efficient and economical use in climates having severe winter temperatures.

In the case of the single stage compressor system, where the ambient outdoor temperature is low, the heat required may easily exceed the heat available. In overcoming this, it has heretofore been necessary to over-design the compressor capacity or the heat exchangers or both.

It is an object of the present invention, therefore, to provide a heat pump wherein there is greater flexibility of operation under varying extreme loads of heating and cooling, and wherein the compressed refrigerant can, when desired, be selectively operated at lower operating pressures and temperatures, giving greater efficiency for given sizes of compressor and heat exchanger components.

Still another object of the invention is to combine with a heat pump having a forced feed circulation cycle a means wherein a plurality of compressors may be selectively staged in series or in parallel, depending upon the season of the year in which the system is operating.

A further object of the invention is to provide a heat pump combining compression and forced feed circulation cycles with selective single or compound staged compressors, resulting in a system having a maximum simplification and maximum efficiency under extremes of ambient temperature relative to lower first cost than prior known heat pump systems.

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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 wherein the heat pump is being operated in its cooling cycle, with the outdoor heat exchanger operating as a condenser and a pair of compressors being staged in parallel.

FIGURE 2 is a diagrammatic sketch of the invention wherein the heat pump is being operated in its heating cycle, with the outdoor heat exchanger operating as an evaporator and a pair of compressors being staged in series.

FIGURES 1 and 2 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 temperatures, pressures and flow paths between the elements differ for the respective cooling and heating cycles.

While in the heat pump system illustrated, 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. The same is true as to the second heat exchanger shown as having heat exchange relation with circulating water to be heated or cooled, and it will be understood that any liquid or gaseous media may be circulated therethrough. While a pair of compressors have been shown, it will be understood that any combination of two or more compressors or compressor units may be used without departing from the scope of the invention, providing they are suitably connected into the refrigerant circuit and suitably valved in accord with the teachings of the basic two compressor arrangement shown in the drawings.

GENERAL ARRANGEMENT OF THE HEAT PUMP

Referring now to FIGURES 1 and 2, wherein the same parts will have the same character numerals, there is shown a pair of compressors A and B. The compressor A has a discharge outlet 2a connected to a discharge line 3a disposed to receive hot compressed gaseous refrigerant from the compressor. Similarly, a compressor B has a discharge outlet 2b connected to a discharge line 3b. The discharge lines 3a and 3b intersect and are connected to the three conduits 4, 5 and 6, each of these conduits 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 and heating cycles hereinafter described. The discharge line 3b is provided with a check valve 36, and the discharge line 3a is provided with a check valve 38, the function of which will later be more fully described.

Conduit 4 communicates with the inlet header 10 of a first heat exchanger 11, which will be called for the purpose of 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. 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 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 shutdown periods.

The compressors A and B have their suction inlets 21a and 21b, respectively, connected as by suction lines 22a and 22b 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 need not be more precisely described.

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 and 2 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 unidirectional, a specific characteristic of the operation of the present invention, regardless of the particular cycle in operation.

FIGURES 1 and 2 also show that lines 15 and 29 communicate through lines 33 and 32, respectively, directly to collecting line 19 and, depending on the operating cycle which calls for the setting of the control valves 34 and 35 for the respective lines 32 and 33, 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, and many different types of programming control systems could be used.

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 accumulates. 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. It should be mentioned that the presently described system is not restricted in use to any particular refrigerant material. It will function with those gases such as Freon which are ordinarily employed for refrigerating purposes.

As shown in FIGURES 1 and 2 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 de-

frosting conduit 5 connected from the common discharge line 3 to a point downstream of the solenoid operated valve 7 and the check valve 45.

In order that the compressors A and B may be selectively connected for either single stage, parallel operation, or compound stage, series operation, a compound staging by-pass line 39 extends from the discharge line 3a to the suction line 22b. Interposed in this by-pass is a solenoid operated valve 47, and this valve may either be manually operated or may be activated to open or closed position by automatic programming means.

While it has not been shown, it is to be understood that an intercooler of known type could be placed in the compound staging by-pass line 39 to reduce the temperatures of the refrigerant gas between the first and second stages of the compound system. Cooling of the refrigerant at this intermediate stage of compression is highly desirable. Without at least some means of cooling, the compressed gas on emerging from the second stage would ordinarily have a sufficiently high temperature to cause damage or thermal deterioration to flow control elements into which it passed.

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 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 refrigerant may be sampled from the downstream side of the pump 40 by a relatively small bleed line 50, having a solenoid operated valve 51 therein which can be maintained open during the cycles which include compressor operation.

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

Since there is a pressure difference between the discharge side of the pump 40 and the suction side of the compressor A, a very effective nonclogging, 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 refrigerant through line 50.

COOLING CYCLE

(Compressors A and B Arranged in Parallel)

Specific reference is now made to FIGURE 1 of the drawings, illustrating the system of the invention as being used for a cooling cycle. This is normally for summer operation when outdoor temperatures are relatively high and it is desired to lower the temperature in any enclosure to which the system is applied.

The compressors A and B, the pump 40 and the fan 12 are placed into operation; valves 7, 34 and 51 will be opened; and all other positively operated valves will be closed. This includes the solenoid operated valve 47 in the compound staging by-pass line 39. Pressures in the system are such that check valves 37, 36 and 38 are opening in the downstream direction of flow. In the case of check valve 37, gaseous refrigerant is being admitted from the accumulator 20 to the suction side 21b of the compressor B. In the case of check valve 36, hot compressed refrigerant is being passed from the outlet 2b of the compressor B to the common line 3b. In the case of the valve 38, refrigerant from the discharge outlet 2a of the compressor A is being passed into the common line 3b. The compressors A and B are thus in parallel

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operation, both accepting gaseous refrigerant from the accumulator 20 and passing hot compressed gaseous refrigerant to the common 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 which moves 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 and 2.

Since the suction lines 22a and 22b of the compressors are connected to the upper portion of the accumulator which holds the gaseous refrigerant, only gas passes through the suction lines 22a and 22b, and the suction inlets 21a and 21b of the compressors, where it is once again compressed 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 45 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 partially evaporated 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.

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 refrigerant than is required. 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 the 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

(Compressors A and B Arranged in Parallel)

Referring again to FIGURE 1 the system may be adjusted for providing heat in a cold climate or atmosphere.

To accomplish this, compressors A and B, pump 40 and fan 12 are placed in operation. Positively operated valves 34, 7, 8 and 47 are closed. Valves 9, 35 and 51 are opened. Pressures in the system are such that check valves 37, 36 and 38 are opening in the downstream direction of flow. In the case of check valve 37, gaseous

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refrigerant is being admitted from the accumulator 20 to the suction side 21b of the compressor B. In the case of valve 36, hot compressed refrigerant is being passed from the outlet 2b of the compressor B to the common line. In the case of valve 38, refrigerant from the discharge outlet 2a of the compressor A is being passed into the common line.

The compressors A and B are thus again in parallel operation, both accepting gaseous refrigerant from the accumulator 20 and passing hot compressed gaseous refrigerant to the common conduit 6. The latter conduit directs refrigerant to the inlet header 23 of the indoor heat exchanger 24 where it gives up heat to the medium to be heated. This medium as mentioned may be water brought into the heat exchanger 24 through inlet 26 and discharged through outlet 27 to the desired point of use in heated condition.

The release of heat to the media to be heated causes the gas to condense and 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 to the high pressure float regulator 17.

In high pressure float regulator 17 the liquid flashes and during expansion cools so that relatively cool gas and liquid refrigerant is then led to the accumulator 20 through the line 19. This mixture of relatively cold gas and liquid refrigerant mixes with other relatively cold gas and liquid refrigerant which are returned from the outdoor heat exchanger 11.

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 to the latter. This is accomplished by means of the pumping circuit. Thus, pump 40 through line 41 draws cold refrigerant from the liquid layer of refrigerant in accumulator 20 and discharges it through discharge line 42. Since the hot compressed gaseous refrigerant is being discharged to conduit 6, the pumped fluid cannot pass through 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 to lines 15, 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 are recirculated through the system.

HEATING CYCLE

(Compressors Arranged in Series)

With reference to the heating cycle shown in FIGURE 2, the valves are suitably manipulated by manual or automatic means to place the cycle into operation. The pump 40 and fan 12 are placed in operation. Positively operated valves 34, 7 and 8 are closed. Valves 9, 35 and 47 are opened. Hot compressed refrigerant gas from the discharge outlet 2a of the compressor A will move through the compound staging by-pass line 39 and will enter the suction inlet 21b of the compressor B at increased temperature and pressure. The pressure in the line 22b will bias the check valve 37 into closed position, preventing dumping of the hot compressed refrigerant back into the accumulator. Check valve 36 will be biased open to permit passage of the second stage compressed refrigerant from the discharge side 2b of the compressor B into the line 6. The check valve 38, influenced by the greater pressure in the second stage downstream side of the compressor B, will be biased into a closed position. Therefore, gaseous refrigerant from the accumulator

20 will have passed in series through the compressors A and B, acting as a first and second stage. This multistaging causes the refrigerant to be more highly compressed and thus function more efficiently than was the case where the compressors were used in parallel single stage operation.

The said highly compressed gaseous refrigerant 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.

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 the line 19. This mixture of relatively cold gas and liquid refrigerant, as has been mentioned in the description of the cooling cycle, mixes with other relatively cold gas and liquid refrigerant which is returned from the outdoor heat exchanger 11 as hereinafter described. By reason of the size of the accumulator 20, the refrigerant mixture separates to provide a gaseous layer and liquid layer of the refrigerant in intimate contact with each other.

In addition to the heat of compression from the compound staged compressors, 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 to conduit 6, the pumped fluid cannot pass through 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 to lines 15, 33 and control valve 35 to collecting line 19 and thence to the accumulator 20 where it mixes with a 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 22a and 41 to the compressor A and pump, respectively, to repeat the cycle.

DEFROST CYCLE AND INTERMEDIATE COOLING CYCLE

The defrost cycles and intermediate cooling cycles, of which the disclosed invention is capable, have been more fully described as to operation in my above mentioned co-pending application Serial No. 107,181. Since the operation of these cycles is the same with plural compressors in single or compound staging, as is the case of the single compressor, the operation of these cycles will not be repeated herein, and reference is made to the complete operation as set forth in said co-pending application.

I have provided therefore a novel heat pump apparatus which is particularly characterized by a wider operating range for accomplishing either heating or cooling. It may readily be appreciated by one skilled in the art that a system as presently disclosed offers many advantages from the standpoint of both versatility and economy.

Notably, the multiple compression arrangement permits the heat pump to function at full capacity and at maximum efficiency regardless of the air conditioning load imposed thereon.

For example, to assure a high efficiency in the compressor system, the compression ratio is preferably held to a low value. As the compression ratio increases, the volumetric efficiency of the system will normally be decreased. With the instant arrangement, however, it is possible to realize a higher overall volumetric efficiency than is ordinarily obtainable.

While in the description and drawings, there has been shown and described the preferred embodiment of the invention, it is to be understood that variations may be made in the construction and arrangement of parts without departing from the spirit and scope of the invention as 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 and disposed to discharge hot compressed gaseous refrigerant interchangeably and selectively to the upstream side of at least one of said heat exchange means, and a pump circulation circuit having the 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, said compression means comprising a plurality of separate compressor units, and means for selectively connecting said compressor units in fluid circuit in parallel, single stage operation or series, compound stage operation.

2. 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 and disposed to discharge hot compressed gaseous refrigerant interchangeably and selectively to the upstream side of at least one of said heat exchange means, and a pump circulation circuit having the 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, said compression means comprising a plurality of separate compressor units, each of said compressor units having its upstream, suction side connected to the gas storage portion of said common separating means, and means for selectively connecting said compressor units in fluid circuit in parallel, single stage operation or series, compound stage operation.

3. 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 and disposed to discharge hot compressed gaseous refrigerant interchangeably and selectively to the upstream side of at least one of said heat exchange means, and a pump circulation circuit having the 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,

said compression means comprising a plurality of separate compressor units, each of said compressor units having its upstream suction side connected by a supply conduit to the gas storage portion of said common separating means and its discharge side connected to a common discharge conduit, and means for selectively connecting said compressor units in fluid circuit in parallel, single stage operation or series, compound stage operation, said last means comprising a fluid by-pass conduit connecting the discharge side of one compressor unit to the intake side of its next adjacent, upstage compressor unit, a positively operated shut-off valve in each of said by-pass conduits, a first check valve means in the supply conduits of all but the first of said compressor units, a second check valve means in the discharge side of all but the first of said compressor units, and a third check valve means in said common discharge conduit, said third means comprising separate check valves positioned between the connections of the discharge side of each of said compressor units to said common discharge conduit.

4. 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 and disposed to discharge hot, compressed, gaseous refrigerant to a common conduit, valve means in said common conduit for selectively and interchangeably delivering said hot, compressed fluid to the upstream side of at least one of said heat exchange means, and a pump circulation circuit having its suction con-

nected 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, said compression means comprising a plurality of separate compressor units, each of said compressor units having its upstream, suction side connected by a supply conduit to the gas storage portion of said common separating means and its discharge side connected to said common discharge conduit, and means for selectively connecting said compressor units in fluid circuit in parallel, single stage operation or series, compound stage operation, said last means comprising a fluid by-pass conduit connecting the discharge side of one compressor unit to the intake side of its next adjacent, upstage compressor unit, a positively operated shut-off valve in each of said by-pass conduits, a first check valve means in the supply conduits of all but the first of said compressor units, a second check valve means in the discharge side of all but the first of said compressor units, and a third check valve means in said common discharge conduit, said third means comprising separate check valves positioned between the connections of the discharge side of each of said compressor units to said common discharge conduit.

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