

Feb. 26, 1963

R. E. JAPHET

3,078,689

MULTI-CYCLE HEAT PUMP

Filed March 22, 1962

4 Sheets-Sheet 1

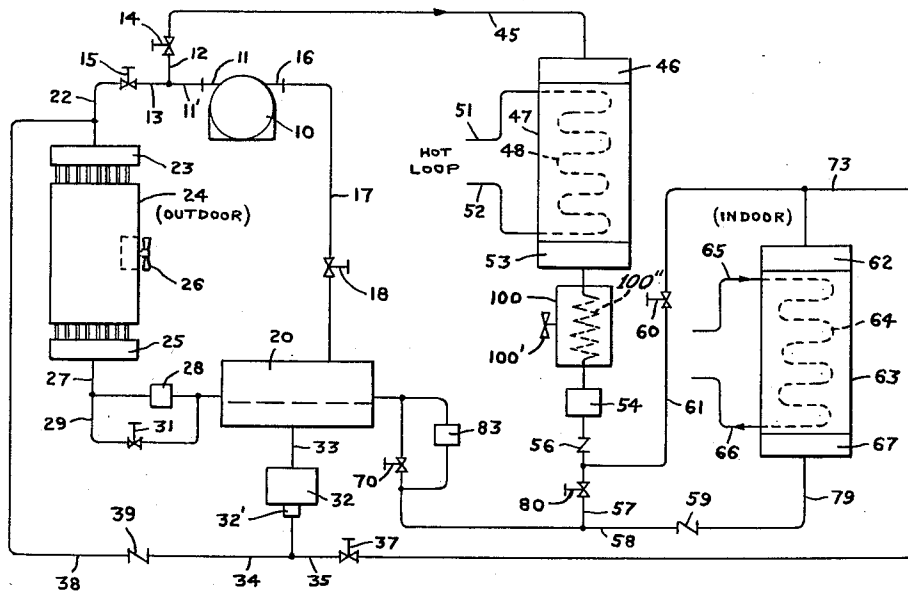


FIG. 1

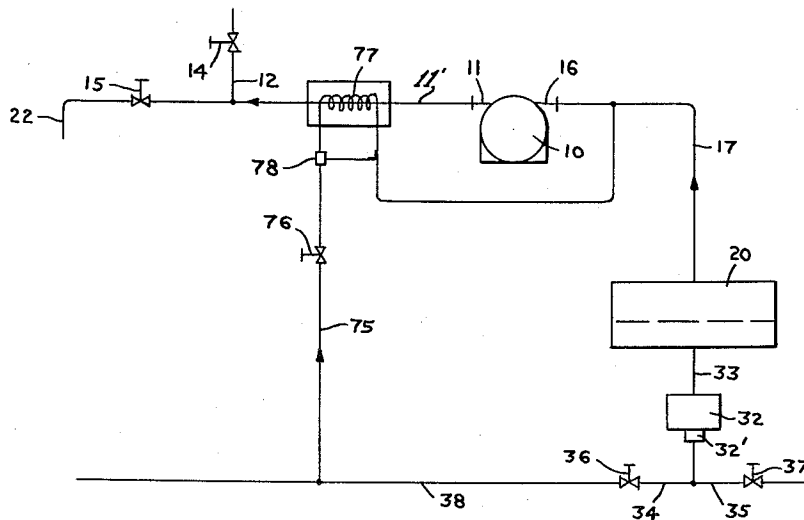


FIG. 2

RICHARD E. JAPHET
INVENTOR.

BY *Daniel A. Bobis*
att_y

Feb. 26, 1963

R. E. JAPHET

3,078,689

MULTI-CYCLE HEAT PUMP

Filed March 22, 1962

4 Sheets-Sheet 2

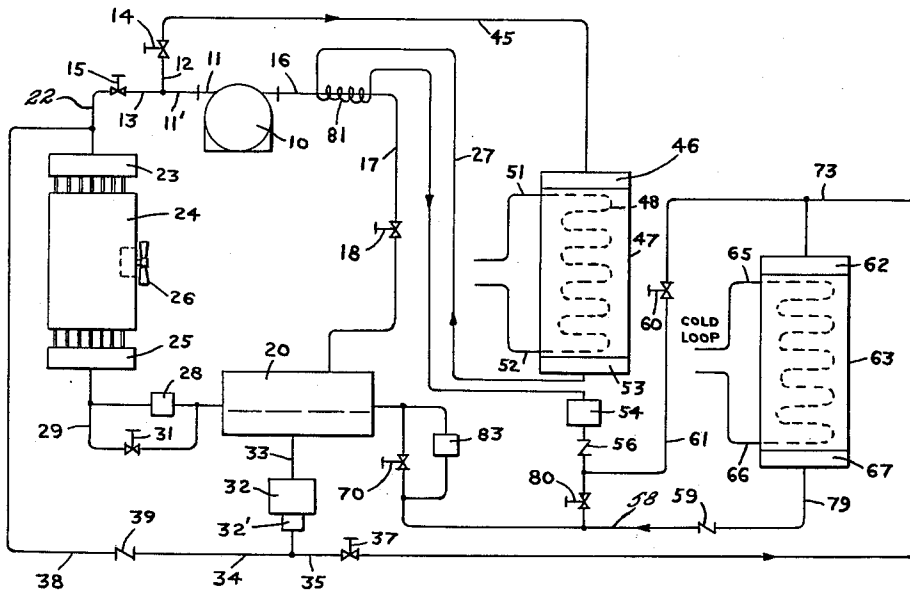


FIG. 3

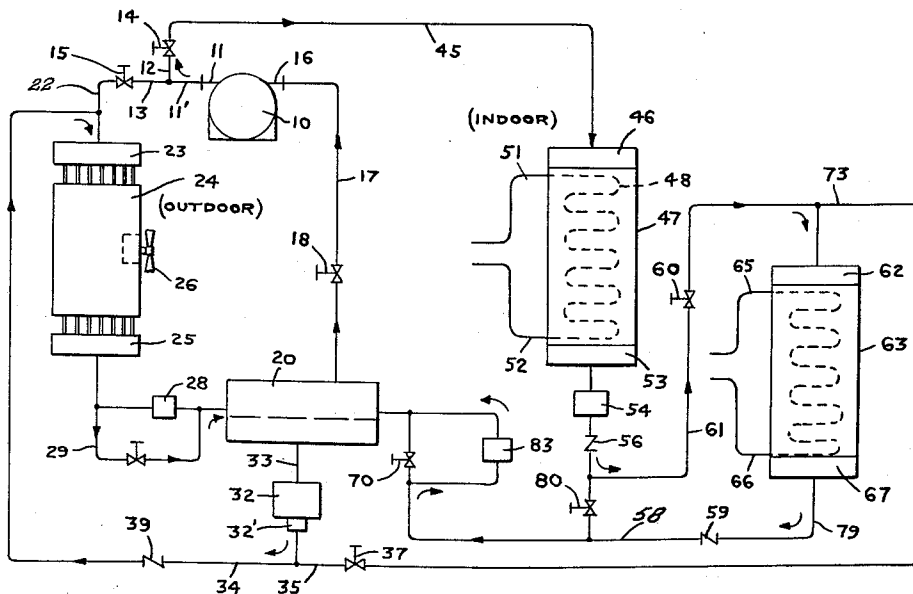


FIG. 4 WINTER OPERATION

RICHARD E. JAPHET
INVENTOR

BY *Daniel H. Bohls*
Atty

Feb. 26, 1963

R. E. JAPHET
MULTI-CYCLE HEAT PUMP

3,078,689

Filed March 22, 1962

4 Sheets-Sheet 3

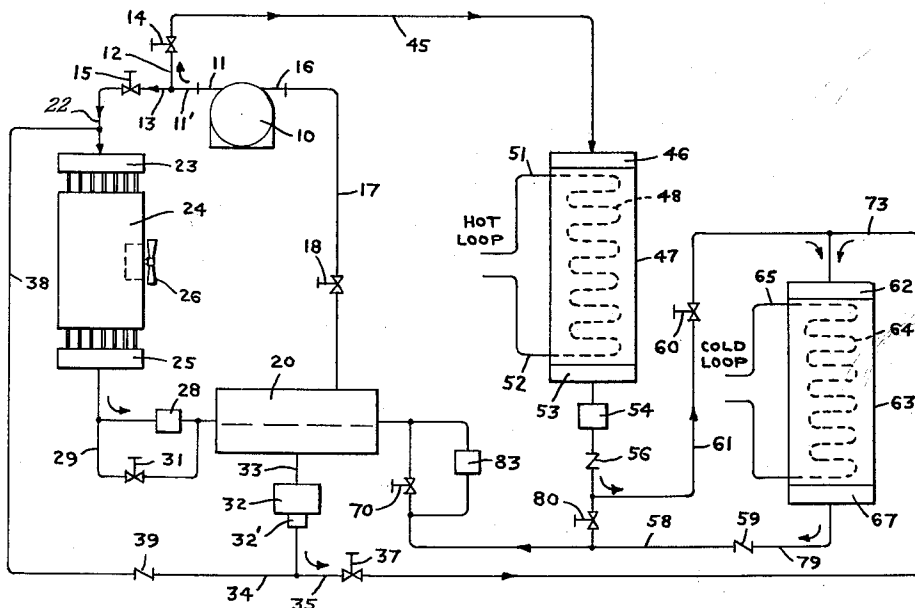


FIG. 5 SUMMER OPERATION

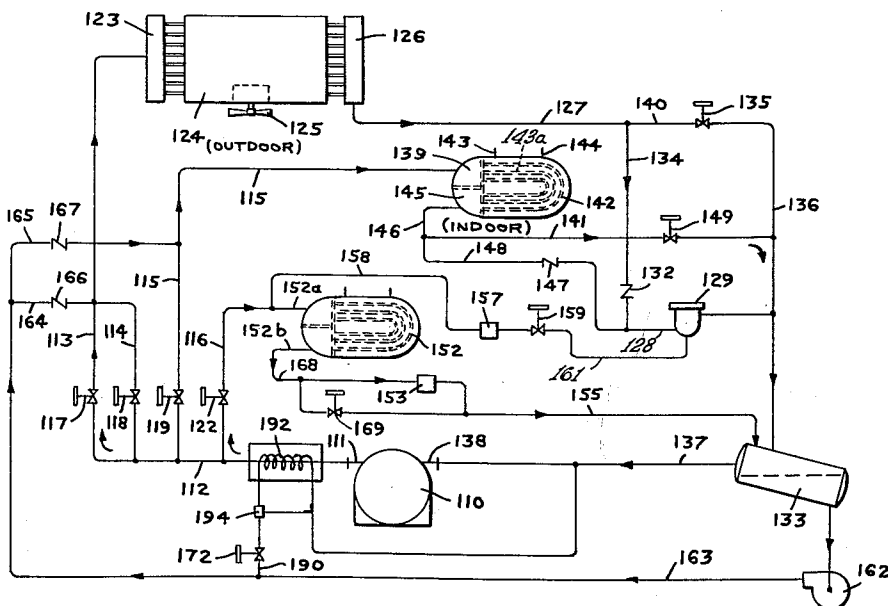


FIG. 6 COOLING WITH
AUXILIARY
HEATING

RICHARD E. JAPHET
INVENTOR.

BY *Daniel W. Bobb*
Atty

Feb. 26, 1963

R. E. JAPHET

3,078,689

MULTI-CYCLE HEAT PUMP

Filed March 22, 1962

4 Sheets-Sheet 4

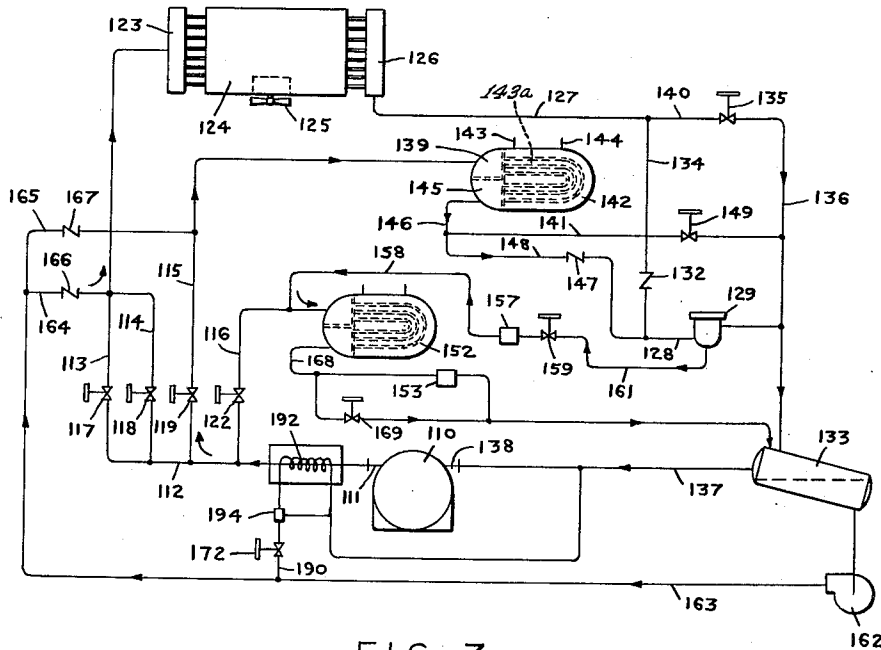


FIG. 7

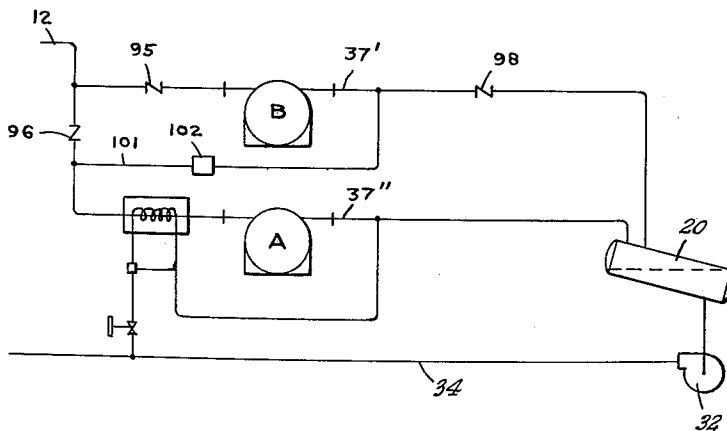


FIG. 8

RICHARD E. JAPHET
INVENTOR.

BY *Samuel A. Bobis*
Atty

1

3,078,689

MULTI-CYCLE HEAT PUMP

Richard E. Japhet, Livingston, N.J., assignor to Worth-
ington Corporation, Harrison, N.J., a corporation of
Delaware

Filed Mar. 22, 1962, Ser. No. 181,594

31 Claims. (Cl. 62—324)

This invention relates in general to an air conditioning system. It relates more particularly to a self-balancing heat pump system adapted to provide simultaneous heating and cooling to a conditioned enclosure.

Multi-unit installations such as apartment houses, laboratories, department stores, office buildings and schools are so designed as to require highly sophisticated heating and cooling systems such as the multi or dual duct systems. The primary advantage to be realized from a system of this type is that the same equipment may be used for both heating in the winter and cooling in the summer, and for providing said functions in varying degrees throughout the year.

In any versatile air conditioning system it is not sufficient to merely provide cooling in the summer and heating in the winter. To be at all practical the system must be adapted to afford complete air conditioning at various parts of a building in accordance with the diverse thermal requirements existing throughout the building. For example, during the winter period the peripheral portions of the building will normally be much colder than the center portions. Consequently, areas at the building outer walls will require considerably more heat than those centrally located. In fact, the presence of personnel and the amount of heat attributed to lighting and other facilities may require that said center portions be cooled.

The presently disclosed multi-heat pump arrangement is particularly adapted for use in high pressure dual duct systems or multi-zone installations but may also be employed in conjunction with other air conditioning systems as normally used in relatively large multi-unit enclosures. Essentially, there is provided a novel heat pump arrangement for simultaneously affording necessary heating and cooling to a building. Incorporated in the heat pump is means for maintaining the system in thermal equilibrium. A heat exchanger means disposed in a sink media or source is cooperative with other heat exchanger means positioned indoors and connected to a common accumulator into which vaporous and liquid refrigerant from both indoor and outdoor units flow. The outdoor unit functions primarily to effect thermal equilibrium to the heat pump by heat exchange with the sink media or source in accordance with the loads placed on the indoor portion.

Among the advantages accruing from the present system is that simultaneous heating and cooling may be provided to an indoor multi-duct system or any other conditioning installation by maximum use of the minimum amount of equipment, and by the most economical use of such equipment during all seasons of the year. An overall advantage is found to be continuous economical operation with very little maintenance and greatly reduced utility services such as gas and electricity.

It is therefore a primary object of the invention to provide a multi-cycle air conditioning system including a heat pump having means for simultaneously heating and cooling an enclosure.

A further object of the invention is to provide such a system which is adapted to accommodate varying conditioning loads and to readily adjust itself to said loads to provide the maximum in economy of operation.

It is a further object to provide a self-balancing heat pump system adapted to alter its operating characteristics

2

in accordance with the loads imposed thereon by conditions existing within an enclosure to be air conditioned.

Still another object of the invention is to provide a heat pump including indoor heat exchange means for providing simultaneous heating and cooling to an enclosure, an outdoor heat exchanger means for extracting or adding heat to a sink media or source in accordance with the load being imposed on the indoor portion.

The invention in brief contemplates an improved heat pump having a plurality of heat exchangers. One portion of the heat pump is usually disposed indoors for conditioning an enclosure and comprises heat exchange means connected in circuit arrangement for circulating refrigerant therethrough. This indoor arrangement is such that at least one of said heat exchange means functions in the capacity of a condenser. Thus, compressed refrigerant vapor delivered to said heat exchanger is at least partially condensed to give up heat to air or other transfer media. Second heat exchanger means in the circuit receives this and sometimes other condensed refrigerant from a high pressure regulator means whereby the said second heat exchanger functions as an evaporator. Thus, this circuit functions to provide simultaneous heating and cooling to the enclosure.

To provide a status of thermal equilibrium in the overall arrangement, the heat pump also includes heat exchanger means positioned out of doors or in heat exchange contact with a sink media or source. The latter heat exchanger is interconnected and cooperative with the indoor portion of the circuit such that said outdoor unit may either give up heat to, or extract heat from the sink media in accordance with the conditioning loads imposed on the indoor portion.

Compressor means, an accumulator and refrigerant pump means are connected through suitable valving for simultaneously delivering hot compressed vaporous refrigerant and liquid refrigerant to said respective heat exchanger means as required.

In the drawings:

FIGURE 1 is a diagrammatic sketch of the invention including the indoor and outdoor portions of the heat pump.

FIGURE 2 is a diagrammatic sketch of an alternate embodiment of the invention illustrating an arrangement for recovering oil from the refrigeration system.

FIGURE 3 is a diagrammatic sketch similar to that shown in FIGURE 1 with the addition of a superheating device which is connected into the circuit.

FIGURE 4 is a diagrammatic sketch of the arrangement shown in FIGURE 1 with the addition of arrows to indicate the refrigerant directional flow when the heat pump is functioning in winter operation.

FIGURE 5 is a diagrammatic sketch of the arrangement shown in FIGURE 1 with the addition of arrows to indicate the refrigerant directional flow when the heat pump is functioning in summer operation.

FIGURE 6 is a diagrammatic sketch of an alternate embodiment of the invention including an arrangement wherein one of the indoor heat exchangers may be selectively connected to provide either heating or cooling supplementary to the operation of the other indoor heat exchanger. Also shown by arrows is the refrigerant directional flow when the heat pump is adjusted to provide auxiliary heating during a cooling cycle.

FIGURE 7 is similar to the arrangement of FIGURE 6 wherein the arrows indicate refrigerant directional flow when the heat pump is adjusted to provide auxiliary cooling during a heating cycle.

FIGURE 8 is a diagrammatic sketch of alternate compressor means which may be used in either of the heat pump arrangements shown to provide compound compression.

To facilitate describing the invention the term thermal equilibrium is presently used to designate the desired optimum operating status of this system. Notably, the thermal units required to properly condition the building by simultaneous heating and cooling could conceivably be entirely balanced in the indoor system. Such a condition, however, as a matter of practicality is virtually impossible to attain. Consequently, the outdoor portion of the heat pump will correct any imbalance existing in the system due to the conditioning load. In referring to thermal equilibrium it is not to be inferred that the system thermally balances such heat losses as those due to friction or electrical power requirements but only those losses confined to the heat pump itself.

It is further noted that while the basic unit may be used primarily for air conditioning purposes, it is not so limited but may rather be employed in other areas. For example, the disclosed invention lends itself readily to process work in which heating and cooling is required and where a sink media is available. In the latter instance, the sink media may be process waste gas or liquid. Understandably, in process work, chemical or otherwise, the heat transfer relationship is frequently to process liquid. For this sort of work then the heat exchangers will be of the type particularly suited for air to liquid transfer.

One portion of the heat pump hereinafter described will be generally referred to as the outdoor cycle since the heat exchanger in said portion is positioned in heat exchange contact with outdoor air or the surrounding atmosphere. Alternatively, this heat exchanger may be positioned in other heat sink media such as a well, a body of water or even an underground piping system. In either event it is to be understood that the primary function of this portion of the heat pump is to provide the necessary make up to correct thermal imbalance to the system by either receiving or rejecting heat in accordance with the load requirements imposed by the indoor portion.

This stated function is accomplished by having the heat pump operate with the outdoor heat exchanger as either a condenser or an evaporator in accordance with the desired results to be achieved. The heat exchanger means positioned outdoors, for the purpose of the following description, will generally be considered as the type normally employed in which a refrigerant carrying coil circulates a fluid through a heat exchanger coil; a fan or other impelling means moves a stream of air across the coil for the purpose of exchanging heat with the refrigerant. Alternatively though, and as herein mentioned, the exchanger may transfer heat to or from a liquid such as water.

As has been previously stated, the instant heat pump is particularly adapted to simultaneously furnish heating and cooling to any of many types of air conditioning systems. These include multi-duct arrangements and multi-pipe systems which are known to the art and widely employed for air conditioning.

One such system, i.e., the multi-duct type, may generally be described as a system directing separate flows of both heated and cooled air through a building. These flows are mixed in accordance with the results to be obtained in any room or portion of the building so that the mixed air flow will provide either heating or cooling as required. The means for treating incoming streams of air is to pass said air over heat exchange coils disposed in the respective heating and cooling ducts or apparatus. An advantage residing in this type of system is that in each individual room or unit the air supply may be varied in small increments in order to provide a very fine adjustment in temperature over a wide range.

It is here noted that portions of the present novel system are disclosed in my co-pending application entitled, Forced Feed Heat Pump System, filed on May 2, 1961, and having the Serial No. 107,181.

GENERAL ARRANGEMENT OF SYSTEM (OUTDOOR PORTION)

Reference is made to FIGURE 1 of the drawings where the same parts will have the same character numerals.

The circuit, and in particular the portion which functions in conjunction with the sink media, consists of a compressor 10 having an outlet 11 which is connected through line 11' to a pair of branch lines 12 and 13 having flow control valves 14 and 15 interposed therein. The upstream side of the compressor 10 is provided with an inlet 16 which connects to conduit 17 through a cut off valve 18 and thence to the vapor section side of the accumulator 20.

The downstream side of valve 15 is communicated with a line 22 for directing compressed gaseous refrigerant from the compressor 10 to the inlet header 23 of an outdoor heat exchanger 24 having outlet header 25. This heat exchanger as previously mentioned, is in heat exchange contact with a heat sink media or source which, for the purpose of the present invention, will be described as being in the atmosphere. A fan 26 or other suitable form of inductor provides a flow of air across the heat transfer coils in said heat exchanger so that heat from the refrigerant may be transferred to the passing air stream or conversely heat from the surrounding air may be absorbed by the refrigerant.

The downstream or outlet header 25 in heat exchanger 24 is connected to line 27 and thence to the inlet side of the high pressure float regulator 28 which receives liquid refrigerant from a float chamber. The outlet side of said high pressure regulator is connected to the inlet of the accumulator 20. Bypass means consisting of line 29 and the manually or automatically operated valve 31 is connected from line 27 directly to the inlet of the accumulator 20 whereby refrigerant fluid may bypass the float regulator 28 and be delivered directly into the accumulator.

The refrigerant compressor 10, outdoor heat exchanger 24, float 28 and accumulator 20 as described, define a closed cycle which may be referred to as the high pressure side of this portion of the heat pump.

An integral part of the system is the liquid pumping circuit. This consists primarily of a pump 32 having an inlet connected to the liquid outlet of the accumulator 20 through line 33 to receive liquid refrigerant. Pump 32 may be of the type normally associated with air conditioning or refrigerant fluid pumping means.

The pump 32 is provided with a discharge outlet 32' connected to a pair of branch lines 34 and 35 having valves 39 and 37 respectively. The outlet side of valve 39 is connected to conduit 38 to permit only unidirectional liquid flow through the said line. Line 38 is connected to line 22 at a point downstream of valve 15 thus defining a low pressure or liquid circuit in the heat pump outdoor portion.

When the pressure on the downstream side of check valve 39 is insufficient to prevent flow from line 34 through the check valve, in other words when control valve 15 cuts off flow of compressed refrigerant vapor, the pressure differential across check valve 39 will permit flow of liquid refrigerant into heat exchanger 24. Normally this occurs when it is desired that the outdoor heat exchanger 24 function in the capacity of an evaporator. Thus, heat may be extracted from the atmosphere and absorbed into the cold liquid refrigerant which is then passed from the outlet 25 of heat exchanger 24 in a combined liquid and vapor flow to the accumulator 20.

The accumulator 20 is an apparatus of the type normally available on the commercial market and generally contains refrigerant in both liquid and vapor phase under pressure. Preferably it is of adequate capacity to hold the entire volume of refrigerant used in the system. This device is referred to also in the art as a

5

separator; refrigerant held therein separates into liquid and vapor phases.

As previously mentioned, the compressor 10 has a suction inlet 16 connected to one of the outlets of the separator or accumulator 20. This connection is made through line 17 and manually operated service valve 18 to the vapor portion of said accumulator. By so feeding vaporous refrigerant to the compressor, slugging of the liquid is avoided.

INDOOR PORTION OF THE SYSTEM

The indoor portion of the heat pump receives a flow of compressed vaporous refrigerant through line 12 which is connected through control valve 14 and line 11' to the compressor discharge outlet 11. Hot compressed refrigerant flows through line 45 connected to the downstream side of control valve 14 and to the upstream side or inlet header 46 of heat exchanger 47 which shall be termed for convenience as the hot loop of this portion of the circuit. A hot loop is normally found in a system adapted for air to water transfer and is here mentioned to facilitate the description.

As illustrated in FIGURE 1, heat exchanger 47 is generally of the type which includes a coil 43 connected to a source of heat transfer media such as water or other liquid. Said water or other liquid is circulated through the hot loop into inlet 51. It then passes through coil 43 in heat exchange contact with the hot compressed vaporous refrigerant entering the inlet header 46. Heat exchangers of this general type are well known in the air conditioning and refrigeration art and require no further mention of the details thereof. The heated water after passing through coil 43 egresses by way of outlet 52. This hot loop circulatory system may be directed to a hot deck, or to the air duct of a multi-duct system and thus to a coil positioned in said air duct for heat exchange contact with air flowing therethrough.

The hot loop heat exchanger 47 insofar as the refrigerant circuit functions, acts in the capacity of a condenser. That is, the vaporized compressed refrigerant in passing through the heat exchanger 47 enters the outlet header 53 transferring heat to the circulating water. Thus, at least a portion of the refrigerant will be condensed in the indoor section and pass from the said heat exchanger 47 into the high pressure float regulator 54 positioned downstream of the discharge header 53.

From the outlet side of the high pressure float regulator 54 condensed liquid refrigerant is passed through check valve 56 which communicates by way of line 57 and valve 80 to the collecting line 58. Line 57 and valve 80 provide an optional bypass for refrigerant such as may be desired.

The outlet of check valve 56 is connected through line 61 and valve 60 to the inlet header 62 of the cold heat exchanger 63. This heat exchanger means is quite similar in construction to the one previously mentioned with respect to the condenser portion of the system. In brief, heat exchanger 63 contains a heat exchange coil 64 provided with water inlet 65 and outlet 66. Coil 64 constitutes a heat exchange means or cold loop of the circuit which may be communicated to the cold duct portion of an air conditioning system for chilling air passing through the cold air duct.

Heat exchanger 63, similar to those herein mentioned, is of the type available on the open market and normally functions in this portion of the circuit as an evaporator. Liquid refrigerant, after extracting heat from the circulating water in the cold loop, passes through the outlet header 67 and thence to line 79 and valve 59 to common line 58 for conduction to accumulator 20. Conduit 58 communicates with the upstream side of valve 70 which controls flow from the indoor heat exchanger either directly or through a back pressure regulator 83 before introduction of said refrigerant into the accumulator 20.

Also connected to the inlet header 62 of heat ex-

6

changer 63 is a line 73 which communicates through valve 37 and line 35 to the discharge outlet 32' of the pump 32. This portion of the circuit as will be hereinafter explained in connection with the operation thereof, delivers a flow of pressurized liquid refrigerant to the upstream side of cold loop heat exchanger 63 primarily for the purpose of supplementing the flow to the upstream heat exchanger 47 or, alternatively, by delivering the entire flow of refrigerant to said heat exchangers 63.

OIL RECOVERY MEANS

The portion of the circuit presently shown is further characterized by the fact that oil cannot accumulate in the system in any of the heat exchangers or in any piping as occurs in heat pump arrangements now known in the prior art. In accordance with the present arrangement and referring to FIGURE 2, oil collects at only a single point in the system, namely the accumulator 20. This permits of a unique simple method of oil recovery in that oil-rich Freon, when such is the liquid, may be sampled from the downstream side of the pump 32 by a relatively small bleed line 75 having a solenoid operated valve 76 therein which can be maintained open during those cycles which include compressor operation.

The oil-rich Freon sampled through the bleed line 75 is evaporated by wrapping the bleed line as at 77 about one of the hot lines such as the discharge line 11' from the compressor 10. This evaporated refrigerant is gaseous in form containing small particles of oil and can be returned to the compressor by connecting the outlet of line 75 to the suction inlet 16 of the compressor 10.

Since there is a pressure difference between the discharge side of the pump 32 and the suction side of the compressor 10, a very effective non-clogging, easily regulated oil recovery system is incorporated into the heat pump. A control for sensing superheat in line 75 is provided as at 78 and will be utilized to regulate the flow of oil-rich Freon through line 75.

MODIFIED FORM OF THE INVENTION WITH SUPERHEATING

FIGURE 3 shows a modified form of the invention wherein means are provided for superheating gaseous refrigerant prior to compressing the same so as to insure dry gas entering the compressor 10 and, further, to increase the differential pressure across said compressor.

In FIGURE 3, identical elements have been given the same character numerals as shown in FIGURE 1. The modification is effected by the introduction to the circuit of superheating means by the addition of a coil 81. Thus line 27 is connected at one end to the outlet header 53; at the other end to the inlet of high pressure float regulator 54; at its intermediate portion coil 81 is formed in heat exchange relation to the compressor suction line 17.

In operation, compressor 10 draws relatively cool gaseous refrigerant from the accumulator 20 through line 17. Said refrigerant comes into non-contacting heat exchange relation with the hot liquid refrigerant passing through coil 81 and line 17 from condenser 47. The hot liquid then superheats the gaseous refrigerant passing through suction line 17, thus evaporating any particles of liquid refrigerant entrained in or carried by the gas being passed to the compressor, thereby insuring against any possibility of slugging that might cause damage to the compressor.

OPERATION OF THE SYSTEM

As has herein been explained the conditioning system is designed for simultaneously delivering refrigerant to coils positioned for heat exchanging air to air units of a dual duct system or to shell and tube type heat exchangers for water heating and condensing to provide both heating and cooling. This system is so adapted that it may operate under various conditions such as extremely hot or

extremely cold temperatures or during periods of the years when no temperature extremes are encountered. Essentially, the heat pump operates to provide necessary simultaneous heating and cooling; the indoor cycle by circulating a fluid through the hot and cold loop transfer heat exchangers, and then depositing the gaseous and liquefied refrigerant into the accumulator or separator 20.

Rarely, and under extraordinary loading conditions, the indoor cycle by itself may be sufficient to provide the necessary simultaneous heating and cooling. However, the outdoor portions of the system which is also attached to the common accumulator 20, furnishes necessary thermal balance to the system thus effectively providing a substantial thermal equilibrium.

OPERATION (WINTER FIG. 4)

For operating during the winter or when the outside ambient temperature is low and the demands on the indoor cycle are particularly for heating, the cycle is adjusted such that valves 14 and 60 are open and valves 15, 37 and 80 are closed.

FIGURE 4 of the drawings is identical to FIGURE 1 with the addition of arrows to illustrate refrigerant flow through the respective lines and units.

Referring to FIGURE 4, the entire output of the compressor is directed into line 45 into the indoor heat exchanger 47. This is accomplished by the closing of valve 15 and the opening of valve 14. Hot gaseous refrigerant will enter the inlet header 46 of the hot heat exchanger which now functions as a condenser in the cycle. The condensed refrigerant stream emerging from the condenser 47 through outlet header 53, will be directed to the inlet side of high pressure regulator 54 which then directs same to heat exchanger 63 in a mixture of cold liquid and vapor. This is done by closing valve 80 so that liquid refrigerant enters line 61, passes through valves 60 and thence is directed to the inlet header 62 of heat exchanger 63. From outlet header 67 of said heat exchanger, refrigerant is conducted through the line 79, check valve 59, back pressure regulator 83 and thence returned to the accumulator 20 for recirculation. It should be noted that during this operation the returning refrigerant is directed through regulator 83 by closing valve 70. Flow will then be through the back pressure regulator 83 to accumulator 20 thus preventing the suction temperature in the evaporator heat exchanger 63 from dropping below a predetermined point. This temperature will be approximately 40° to 45° F.

To provide required make up in response to the load on the indoor heat exchanger, the liquid pumping portion of the heat pump is adjusted such that valve 37 is closed and check valve 39 is open. Since there is no downstream pressure on check valve 39, the output flow from pump 32 will enter heat exchanger 24. Liquid refrigerant coming into contact with the exterior heat sink media, will thereby absorb heat from the latter, which heat is then carried back in the refrigerant stream through line 27 and high pressure regulator 28.

COOLING CYCLE (SUMMER OPERATION FIG. 5)

Referring to FIGURE 5, when the system is to be operated during warmer weather the demand on the indoor cycle will be primarily of a cooling nature, with the heat pump suitably adjusted. To furnish a minimum amount of heating to the indoor portion, only a small amount of hot compressed refrigerant is directed from the discharge 11 of compressor 10 into the line 45. The relative amount will of course depend on the degree of heating to be achieved when the primary function of the system is to cool. This may be accomplished by adjusting the control valve 14 to direct only a minor amount of the entire compressor output thereto; valve 15 is opened to receive the major portion. It is readily understood by

one knowledgeable in the art that other means such as condenser head pressure control associated with condenser 47 may be used to determine the function of said condenser. Refrigerant to the indoor portion will then pass through heat exchanger 47 and thereafter through the high pressure float regulator 54, check valve 56, valve 60 and line 61, to the inlet header 62 of the evaporator heat exchanger 63.

Since the greater part of the indoor conditioning demand will be of a cooling nature, the entire discharge of pump 32 will be directed into line 35 by opening valve 37. Upstream vapor pressure on valve 39 will maintain said valve in a closed position. Thus, the entire flow of compressed liquid refrigerant will be delivered from pump discharge 32' through valve 37, line 73 and into the inlet header 62 of heat exchanger 63. This flow is excessive in order to wet the evaporator tubes at all times thereby increasing the efficiency of the unit. From the downstream side of heat exchanger 63 refrigerant will be delivered to line 58 and 79 through check valve 59 and thence to the accumulator 20 by way of back pressure regulator 83.

Since the primary demand on the indoor portion of the cycle will be to cool, through evaporation, the function of the heat pump outdoor portion will be to remove heat from the system, and maintain the thermal balance of the unit by transferring said heat to the sink or outdoor atmosphere. To do this the major portion of the output of the compressor 10 is directed into line 13 through valve 15, line 22, and thence into inlet header 23 of outdoor heat exchanger 24. This unit will now act as a condenser so that during exchange with the outdoor air, heat will be extracted from the hot compressed refrigerant which is then returned through line 27 and high pressure regulator 28 to the accumulator 20.

While both the above mentioned examples of the operation of the system have dealt with seasonal extremes in cold and heating conditions, it should be appreciated that variable conditions during intermediate seasons of the year may be met by adjustments made within the cycle itself.

For example, minor variations to meet intermediate conditioning demands within the interior of a building may be made by regulating the degree of cooling effected by the pumping circuit, by other conventional means or through unloading of the compressor in a manner familiar to one skilled in the art. Thus, normally in the indoor cycle, refrigerant will only be delivered from the hot loop heat exchanger 47 into the cold loop heat exchanger 63. For added cooling capacity, refrigerant delivered to the latter may be supplemented by a liquid flow from the pump 32 which will be passed through line 35, valve 37 and line 13 to the inlet header 62.

ALTERNATE HEAT PUMP ARRANGEMENT

Referring to FIGURES 6 and 7 of the drawings, there is illustrated an alternate embodiment of the invention including a plurality of heat exchanger means connected and arranged in the circuit to provide auxiliary heating or cooling supplementary to the basic function of the circuit.

With reference to the drawings this embodiment of the invention comprises in brief a system including a plurality of main heat exchanger units, at least one of said units generally being positioned outdoors or in contact with a sink media while the remainder are positioned indoors. The auxiliary heat exchanger means functions independently of said main heat exchanger units but is so located and adapted to cooperate with those main heat exchangers located indoors. A common separating means including accumulator means and a high pressure float regulator, receives gaseous and liquid refrigerant from the downstream side of each of said heat exchangers. A compression means having its suction connected to the gaseous

portion of said accumulator receives a stream of said refrigerant at low pressure.

Valves means communicating the compression means discharge with the inlets of said respective heat exchangers is adapted to selectively and interchangeably deliver a flow of compressed refrigerant to certain of said units. A pump circulation cycle having its suction connected to the separating means receives a flow of liquid refrigerant. The latter is then force fed through the pump and said valve means to those heat exchangers not connected during a cycle to receive hot compressed gas.

In this system as will be hereinafter disclosed, the auxiliary heat exchanger is adapted to receive hot compressed refrigerant gas through the said valve means when the heat exchanger is connected as an auxiliary heater. Alternatively, cold refrigerant may be supplied to the auxiliary unit by directing liquid refrigerant through expansion means from the high side of the high pressure regulator and to the heat exchanger.

GENERAL ARRANGEMENT OF THE HEAT PUMP

Referring to FIGURES 6 and 7 where the same parts will have the same character numerals, a compression means is shown at 110 having a discharge outlet 111 connected to a discharge line 112 disposed to receive hot compressed gaseous refrigerant from the compressor. The discharge line 112 is connected to four conduits 113, 114, 115 and 116, each having a respective solenoid operated valve 117, 118, 119 and 122, which can be manually or automatically controlled to provide that direction of flow in the system which will produce the desired cooling, heating or defrosting function.

Of these referred to cycles, only the cooling and the heating cycles have been illustrated and will be described in the present disclosure since the defrost cycle is fully described in my previously mentioned copending application having the Serial No.107,181.

Conduit 113 communicates with the inlet header 123 of the first heat exchanger 124 which will be called for the purpose of the disclosure the outdoor heat exchanger since it is normally disposed and located such that atmospheric air can be passed thereover as by a fan 125. Heat exchangers for this purpose as has been previously mentioned are well known in the art and readily purchasable on the open market.

This heat exchanger 124 may under certain conditions also be one which is adapted for heat exchange relation with other types of heat sink or heat source media.

The outlet header 126 of the first or outdoor heat exchanger communicates through connecting lines 127 and 134, and common conduit 128, directly with the inlet of high pressure float regulator 129 through a check valve 132. The outlet of the high pressure float regulator 129 is connected to the accumulator 133 by way of conduit 136. A second line 140 communicated with the header 126 permits communication through valve 135 to the common line 136 and accumulator 133, thus bypassing the high pressure float regulator. Gaseous refrigerant separating in accumulator 133 may be drawn off through line 137 to the suction side of compressor 110 when the latter is in operation so that slugging of liquid is always avoided during the operation of the compressor.

Conduit 115 communicates with the inlet header 139 of a second heat exchanger 142 which is termed for the purpose of the present description as the indoor heat exchanger. This unit will ordinarily be positioned at an enclosed point such that either a liquid or a gas may be circulated through its coils to provide means for either transferring to or extracting heat from the conditioned area depending on the cycle in operation. This is accomplished in the present form of the invention by passing liquid into the cooling fluid inlet 143 of coil 143a, and removing by outlet 144 for conduction to the point of use.

The outlet header 145 of the second or indoor heat

exchanger is connected through lines 146, 148 and valve 147 to common line 128. As illustrated in FIGURES 6 and 7, conduits 134 and 148 are provided with check valves as at 132 and 147 respectively so that the flow of refrigerant fluid through the outdoor and indoor heat exchangers will be unidirectional at all times. This condition of operation is a specific characteristic of the present invention regardless of the particular cycle of operation.

FIGURES 6 and 7 also show lines 127 and 146 communicating through lines 140 and 141 respectively, directly to a common collecting line 136. Depending on the operating cycle which signals the automatic or manual control for setting control valves 135 and 149 for the respective lines 140 and 141, refrigerant gas and liquid from one or the other of the heat exchangers 124 or 142 can bypass the float regulator 129 and be passed directly to accumulator 133.

The operation of valves 117, 118, 119, 122, 135 and 149 may be manual or automatic in any suitable type of conventional solenoid or the like and may be pneumatically or electrically operated.

Conduit 116 communicates with the upstream or inlet of the auxiliary heat exchanger 152. The respective inlet and outlet 152a and 152b are adapted to receive both liquid and gaseous refrigerant to permit flow in one direction only. Said inlet 152a is also connected through conduit 158, expansion valve 157, and control valve 159 to the high pressure side of float regulator 129 to receive liquid therefrom.

Outlet 152b is connected through a conduit 163 to a high pressure regulator 153 or alternatively through back pressure regulator 169 to common line 155 and accumulator 133.

PUMPING CIRCUIT

Again referring to FIGURES 6 and 7, positive or force feed circulation of refrigerant liquid to the respective indoor or outdoor main heat exchangers provides the cooling phase of the system. In the heating or cooling cycles hereinafter described where a main heat exchanger is not receiving hot compressed gaseous refrigerant, the pump 162 because of the valving arrangement delivers low pressure refrigerant liquid through pump outlet line 163 connected to the conduits 164 and 165 which are in turn connected to the conduits 114 and 115 feeding liquid to the heat exchangers 124 or 142 respectively.

Conduits 164 and 165 are provided with check valves 166 and 167 which act to direct flow of refrigerant liquid depending on the setting of the control valves 117, 118, 119.

When auxiliary heat exchanger 152 is arranged as a cooling element, pressurized liquid refrigerant is conducted through conduit 161 from the high pressure float regulator 129 and directed through valve 159 and expansion valve 157 to the auxiliary heat exchanger inlet. At the downstream side of this heat exchanger, partially evaporated cold refrigerant is conducted through return conduit 168 to back pressure regulator 169 and thence into common line 155 and the accumulator 133.

It is readily apparent that the operation of the check valves 166, 167 will be similar to that of the check valves 132 and 147, the latter of which depend on the setting of the control valves 135 and 149. In the instance of the check valves 166 and 167, the pressure of hot compressed refrigerant will pressurize the downstream side of one or the other of said check valves so that the pumped refrigerant will flow through that valve which does not have pressure acting against its discharge side.

In view of the operational procedures outlined with respect to the preferred heat pump embodiment shown in FIGURE 1, a functional outline directed to the embodiment illustrated in FIGURES 6 and 7 is not deemed to be necessary. However, the following will serve to acquaint one skilled in the art with the procedure required for the

11

arrangement shown in FIGURE 7 when the heat pump is to provide auxiliary cooling during a normal heating operation.

Referring to FIGURE 7, the system there illustrated comprises a heat pump in which heat exchanger means is adjusted to provide auxiliary cooling during the cycle when the basic system is providing heating. The basic heat pump circuit shown comprises a compressor 110 having outlet 111 connected to a conduit 112 which in turn connects to conduits 113, 114 and 115 through valves 117, 118 and 119 respectively. Conduit 115, during the heating cycle, communicates with the inlet header 139 of the indoor heat exchanger 142. Hot gaseous refrigerant passes through the unit and out the downstream header 145 to conduit 146 where the same may flow through line 148 and check valve 147 and to the high pressure float regulator 129. Alternatively, the flow may be directly to the accumulator 133 through line 141, valve 149 and common line 136 thus bypassing the float regulator 129.

The low pressure cooling cycle comprises pump 162 connected at its inlet to accumulator 133 for receiving a flow of liquid refrigerant. The pump outlet communicates through lines 163 and 164 to check valve 166 and thence to conduit 113 and inlet header 123 of the heat exchanger 124. The header 123 of the outdoor heat exchanger passes liquid refrigerant into heat exchange contact with atmosphere air moved by the fan 125. Containing absorbed heat, and in a partially evaporated condition, refrigerant then flows from outlet header 126 through line 127, and control valve 135 into line 136 and to accumulator 133. Alternatively, the refrigerant flow from header 126 may be through lines 127 and 134, valve 132 and thence through the float valve 129 and hence to the accumulator 133.

Auxiliary heat exchanger 152 when functioning as a cooler, receives relatively cool liquid refrigerant. This refrigerant comes preferably from the high pressure side of the high pressure float regulator 129, through line 161 and valves 159 and 157 to the line 158 and into the heat exchanger 152. The downstream side of said heat exchanger 152 connects through line 168 and back pressure regulator 169 to the accumulator 133.

The foregoing description of the invention is made for the purpose of teaching one skilled in the art methods for employing the disclosed apparatus to achieve auxiliary heating or cooling or both in a localized area. While the latter part of the description is made with particular reference to the embodiments shown in FIGURES 6 and 7, it is not intended that such limitations be imposed on the various modes of operation available.

It is understood by those skilled in the refrigeration art that certain changes or modifications may be made in the apparatus as described for the purpose of adapting said apparatus to meet a particular set of conditions. For example, in order to achieve a greater operating range, refrigerant may be subjected to a multi-stage compression by use of a plurality of compressors.

These compressors may be connected either in series or in parallel depending on the desired result to be obtained from the compressor refrigerant. Normally for extremely lower temperatures the compressors would be connected so as to operate in series. For milder outdoor temperatures greater efficiency is obtained from the apparatus by connecting the compressors in parallel. Furthermore, it is well known in the art that refrigerant in a compound compression cycle may be subjected to desuperheating through the use of a suitable heat exchanger element interjected in the circulatory system.

COMPOUND COMPRESSION

In order to provide a wider operating range for the heat pump including higher and lower ambient temperatures, a compressor section may be adapted as noted herein to provide for the compressors being connected either in series or in parallel.

12

Referring to FIGURE 8, the compressor section illustrated includes compressors A and B which receive vaporized refrigerant from the accumulator 20, it should be mentioned that the alternate arrangement of compressors to be herein described may be used in any of the heat pump embodiments previously described.

In the description of the embodiment shown in FIGURE 8, the multi-stage compressor units A and B will be assumed to be incorporated in place of the single-stage compressor 10 shown in FIGURE 1 of the drawings. After compression, the vaporized refrigerant is pumped from the discharge of the respective compressors to the line 12. Normally, this arrangement of compressors is adaptable 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 have their respective suction inlets connected by suction lines 37' and 37'' to that portion of the accumulator 20 occupied by the gaseous refrigerant so that slugging of liquids is avoided during the operation of the compressors.

As shown in FIGURE 8, the compressor discharge lines are provided with check valves 95 and 96 respectively, which check valves direct a refrigerant liquid flow depending on the setting of the control valve 102.

In order that the compressors A and B may be selectively connected in either single-stage parallel operation or compound stage series operation, a compound staging bypass line 101 extends and communicates the discharge line of compressor A to the suction line 37' of compressor B. Interposed in this bypass is the solenoid operated valve 102. This valve may be either manually operated or may be activated to the open or closed position by automatic means.

While it is not shown in the drawings, it is to be understood that an intercooler of known type could readily be placed in the compound staging bypass line 101 to reduce the temperature of the refrigerant gas passing from the first to the second stages of the compound system. Cooling of the refrigerant at this intermediate stage of compression is found to be highly desirable. Without at least some means of cooling, the compressed gas on emerging from the second stage will ordinarily have a sufficiently high temperature to cause damage or thermal deterioration to the high stage compressor B.

To provide parallel compressor operation in the disclosed system, valves 95, 96 and 98 will assume an open position; valve 102 is closed. Compressors A and B then receive flows of vaporous refrigerant through lines 37' and 37'' which flows upon emerging from the compressors enter conduit 12.

For series operation or very high pressure operation, valve 96 will assume a closed position as will valve 98. Valves 95 and 102 are open. Vaporous liquid refrigerant then enters compressor A from conduit line 37''. Compressed gaseous refrigerant on emerging from the compressor A discharge enters conduit 101 and passes through control valve 102. As previously mentioned this portion of the system may be provided with cooling means for lowering the temperature of the compressed gaseous refrigerant prior to entering the second stage of compression.

Since valve 98 closes due to pressure difference, there will be no flow through conduit 37' but the entire input to compressor B will come from valve 102 which feeds vaporous refrigerant into the compressor at a high pressure achieved in the first stage. After the secondary compression the vaporous flow will then be directed through valve 95 and into conduit 12 for passage through the system. The pressure difference between the stages automatically closes check valve 96.

SUBCOOLING

Referring to FIGURE 1 of the drawings, the heat

pump arrangement as shown includes as optional equipment a subcooling unit 100 connected downstream of heat exchanger outlet 53 to receive a refrigerant flow therefrom. Thus said flow is directed through coil 100' over which air may be induced by a fan 100'. Normally, subcooling of a liquid refrigerant is found to be beneficial to an air conditioning circuit for several reasons. Primarily, such a unit may serve to heat incoming cold atmospheric air prior to same being introduced for circulation in a building. Secondly, subcooling of condensed refrigerant minimizes flash gas when said condensate is passed through an expansion valve.

While the invention has been described to illustrate several embodiments thereof, the general arrangement of parts may be varied structurally in accordance with the requirements of a particular installation. Also the prime mover for either or both compressor end pump units will ordinarily be an electric motor or suitable engine although alternate means for imparting rotational motion may be employed as well. This is especially pertinent in an instance where a source of otherwise wasted power is available such as hot process gas which may be utilized in conjunction with a suitable expander means.

Since the major components which make up the present heat pump are in general familiar to the art, novelty of the system is derived primarily from the relative arrangement and interconnection of said parts. This is true particularly in the valving means taught for controlling refrigerant flow throughout the system. It is understandable that the heat pump be operated and adjusted manually. Through the use of suitable controls and solenoid valves though, the entire unit might be constructed to function on an automatic cycle.

For example, refrigerant flow to the respective heat exchangers from compression and pumping means is such that said flow may be selectively and interchangeably directed, depending on the function of the particular heat exchanger. While the present description is limited basically to individual valves to achieve selective and interchangeable relationship, similar results might also be achieved through use of a suitable multi-passage composite valve means properly connected into the circuit.

It is to be understood further that the presently disclosed invention is not to be limited to the specific construction or arrangement of parts which constitute the heat pump, nor to the various modifications thereof as herein defined. These modifications together with others may readily be made by one skilled in the art without departing from the spirit and scope of the present invention.

What is claimed is:

1. In a heat pump for air conditioning an enclosure including a first cycle adapted to simultaneously furnish heating and cooling to the enclosure, and a second cycle connected to and cooperative with said first cycle, said first cycle comprising: a plurality of heat exchange means connected for circulating liquid and gaseous refrigerant to provide simultaneous heating and cooling to said enclosure, separator means connected downstream of said plurality of heat exchange means for receiving and storing refrigerant in both liquid and vapor phase, said second cycle comprising at least one other heat exchange means disposed in contact with a sink media and having the downstream side thereof connected to said separator means for discharging refrigerant thereto, compression means having its suction connected to receive vaporous refrigerant from said separator means, conduit means communicating the compression means discharge to the upstream side of the plurality of heat exchange means and to the other heat exchange means respectively, said conduit means being adapted to interchangeably and selectively discharge hot compressed refrigerant to the upstream side of at least one of the respective heat exchange means in each of said first and second cycles,

refrigerant pumping means having its suction connected to receive liquid refrigerant from said separator means, and other valve means communicating the pumping means discharge with the upstream side of the other heat exchange means in contact with the sink media to selectively and interchangeably force feed liquid refrigerant to the latter mentioned heat exchange means.

2. In a heat pump substantially as defined in claim 1 wherein said first cycle comprises a plurality of indoor heat exchange means having at least two thereof connected in series arrangement to define a condenser-evaporator cycle for circulating refrigerant to provide simultaneous heating and cooling.

3. In a heat pump substantially as defined in claim 1 wherein said first cycle comprises; at least one condenser means and at least one evaporator means connected in series for conducting refrigerant in a non-reversing cycle whereby hot compressed refrigerant is introduced to the inlet of the condenser means and circulated through the cycle.

4. In a heat pump substantially as defined in claim 3, 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.

5. In a heat pump substantially as defined in claim 4 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.

6. In a heat pump substantially as defined in claim 3 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.

7. In a heat pump substantially as defined in claim 3 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.

8. In a heat pump substantially as defined in claim 1 wherein said compression means includes a plurality of gaseous refrigerant compressors directing refrigerant to the upstream side of the respective heat exchange means in the said first and second cycles, and means for operating said compressors serially to provide multi-stage compression or for operating said compressors in parallel to provide single-stage compression.

9. A self-balancing air conditioning system for simultaneously providing heating and cooling to a conditioned enclosure including, an indoor portion of said system and a balancing portion, said indoor portion comprising; first heat exchange means and second heat exchange means, each of said heat exchange means having inlet means and outlet means, said second heat exchange means being connected downstream of said first heat exchange means to receive refrigerant therefrom and to define a refrigerating circuit for providing simultaneous heating and cooling, said balancing portion of the system comprising other heat exchange means disposed in heat exchange contact with a sink media, separator means for storing and separating gaseous and liquid refrigerant positioned downstream of said indoor and said other heat exchange means for receiving flows of said refrigerant therefrom, compression means having its suction connected to said separator to receive a gaseous refrigerant therefrom, pumping means

having its suction connected to said separator to receive liquid refrigerant therefrom, conduit means adapted to interchangeably and selectively connect the discharge side of said compression means and said pumping means respectively to the inlet of said other heat exchange means in contact with a sink media, and other conduit means connecting the outlets of said second and said other heat exchange means to said separator means when delivering refrigerant thereto.

10. In a self-balancing air conditioning system substantially as defined in claim 9 wherein the conduit means includes; a first conduit communicating the inlet of said other heat exchange means to said compressor discharge, a second conduit means communicating said heat exchange inlet to the pump discharge, and flow control means in each of said respective conduits for controlling the flow of refrigerant therethrough.

11. In a heat pump substantially as defined in claim 10 wherein said flow control means in said second conduit includes means for permitting flow in the direction of said second conduit from the pump discharge to the heat exchanger inlet.

12. In a heat pump substantially as defined in claim 11 wherein the flow control means includes a check valve means having an inlet connected downstream of said pump discharge.

13. In a self-balancing heat pump substantially as defined in claim 9 wherein said other conduit means includes means communicating the outlet of said other heat exchange means to said separator including conduit means having a high pressure receiver interposed therein, and bypass means connected in parallel flow relationship to said high pressure receiver means.

14. In a heat pump substantially as defined in claim 13 wherein the high pressure means includes a high pressure float regulator.

15. In a heat pump substantially as defined in claim 13 wherein the high pressure regulator includes a high pressure receiver having an inlet and an outlet, conduit means communicating with said respective inlet and outlet to provide a bypass around said high pressure regulator and control valve means interposed in said conduit.

16. A self-balancing force feed heat pump for circulating a refrigerant and including a non-reversing cycle providing simultaneous heating and cooling to an air conditioned area, and a balancing cycle cooperative with said non-reversing cycle, said balancing cycle including heat exchanger means having an inlet and an outlet and disposed in contact with a sink media, compression means, pumping means, and a common separator means, said separator means being communicated downstream of the outlet of said heat exchanger means to receive refrigerant therefrom, conduit means communicating the inlet of said heat exchanger means in contact with a sink media to the discharge of said compression means and said pumping means respectively, said conduit means being adapted to selectively and interchangeably deliver liquid or vaporous refrigerant to the said heat exchanger means, said pump means having its suction connected to the separator means for receiving liquid refrigerant, said compressor means having its suction connected to said common separator means to receive liquid refrigerant, said non-reversing cycle of the heat pump including first heat exchanger means and second heat exchanger means connected in serial arrangement to circulate refrigerant therethrough and to deliver said refrigerant to the separator means from said second heat exchanger means, and other conduit means communicating the discharge of said compression means with the inlet of said first heat exchanger means for introducing hot compressed gaseous refrigerant to the said non-reversing cycle.

17. In a heat pump substantially as defined in claim 16 wherein the other conduit means includes a conduit communicating the compressor discharge with the inlet of said

first heat exchanger, and valve means in said conduit controlling the flow of vaporous refrigerant therethrough.

18. In a self-balancing force feed heat pump substantially as defined in claim 16 wherein the non-reversing cycle of the heat pump includes said first heat exchanger means disposed upstream of the second heat exchanger means, conduit means communicating the outlet of said first heat exchanger means to the inlet of the second heat exchanger means, and flow control means interposed in said conduit for controlling the flow of refrigerant between said first and second heat exchanger means.

19. In a heat pump substantially as defined in claim 18 wherein the flow control means in said conduit includes a flow control regulator.

20. In a heat pump substantially as defined in claim 19 wherein the flow control regulator includes a valve means.

21. In a heat pump substantially as defined in claim 19 wherein the flow control means includes a float regulator having a high pressure chamber for receiving liquid refrigerant therein and for metering said liquid to the heat exchanger disposed downstream thereof.

22. A self-balancing heat pump for providing simultaneous heating and cooling and adapted to be maintained in a condition of thermal equilibrium, said heat pump including a balancing cycle having a heat exchange means including inlet and outlet and being disposed in contact with the sink media, separator means connected to the downstream side of said heat exchange means for receiving refrigerant therefrom, compressor means having its suction connected to said separator means to receive a flow of gaseous refrigerant, the discharge of said compressor means being connected to the inlet of said heat exchange means, pumping means having its suction connected to said separator means to receive liquid refrigerant therefrom, at least one condenser having inlet and outlet, the said inlet being selectively connected to the discharge of said compressor means to receive a flow of hot compressed refrigerant, at least one evaporator having an inlet connected to the outlet of the condenser to receive a controlled refrigerant flow, said pumping means having its discharge connected to the inlet of said heat exchange means in contact with a sink media and to the inlet of said evaporator respectively to selectively deliver a flow of refrigerant liquid to one or the other of said heat exchange means or evaporator units, said heat exchange means inlet being also communicated to the discharge of said compressor means to receive a flow of hot compressed gaseous refrigerant when said inlet is not selectively connected to the pump means discharge, and means communicating the downstream side of said evaporator to the separator means for delivering refrigerant thereto.

23. A self-balancing heat pump for providing simultaneous heating and cooling and adapted to be maintained in a condition of thermal equilibrium including a balancing cycle comprising heat exchange means having inlet and outlet means and disposed in heat exchange contact with a sink media, separator means connected to the outlet means of said heat exchanger means to receive a flow of refrigerant therefrom, compressor means having its suction in communication with said separator means to receive gaseous liquid therefrom, the discharge of said compressor means being communicated to the inlet of said heat exchange means, pumping means having its suction connected to said separator means to receive liquid refrigerant, conduit means selectively communicating the inlet of said heat exchanger means with the discharge of said pumping means and said compressor means respectively, at least one condenser having an inlet communicated to the discharge of said compressor means to receive hot compressed refrigerant, at least one evaporator having an inlet and outlet, conduit means communicating the downstream side of said condenser to the inlet of said evaporator to define an indoor

circuit for providing simultaneous heating and cooling, said evaporator outlet being connected to said separator means, and means communicating the inlet of said evaporator to the discharge of said pumping means for selectively receiving a flow of compressed liquid refrigerant therefrom.

24. In a self-balancing heat pump substantially as defined in claim 23 wherein the conduit means communicating the respective condenser and evaporator includes a high pressure float regulator for controlling the flow of refrigerant therethrough.

25. In a self-balancing heat pump substantially as defined in claim 24 wherein the high pressure flow regulator includes a float regulator having a pressure chamber therein with inlet and outlet, said inlet being communicated with the downstream side of said condenser, and said flow regulator outlet being communicated with the inlet of the evaporator.

26. In a self-balancing heat pump for providing simultaneous heating and cooling substantially as defined in claim 24 wherein the high pressure flow regulator includes valve means positioned downstream thereof.

27. In a self-balancing heat pump substantially as defined in claim 23 wherein the means communicating the inlet of the evaporator to the pump discharge includes a conduit having flow control means therein for regulating the flow of liquid refrigerant through said conduit.

28. In a heat pump substantially as defined in claim 27 wherein the flow control means interposed in said conduit includes a valve means for permitting flow in one direction only from said pump to said evaporator.

29. In a self-balancing heat pump substantially as defined in claim 28 wherein the valve means includes a check valve.

30. A heat pump including a high pressure cycle and a low pressure cycle and being adapted to furnish simultaneous heating and cooling, said heat pump including; a plurality of heat exchange means, at least one of said heat exchange means being positioned in contact with a sink media, the remainder of said heat exchange means including at least two thereof connected in series and being arranged to define a refrigerant circulating portion for providing simultaneous heating and cooling to a conditioned area, a common separator means disposed downstream of each of said respective heat exchange means to receive liquid and vaporous refrigerant flows therefrom, said high pressure cycle including compressor means having a suction inlet connected to said common separator means to receive gaseous refrigerant therefrom, the discharge of said compressor means being connected

to direct hot compressed gaseous refrigerant to the upstream side of said heat exchange means defining the refrigerant circulating portion and to selectively and interchangeably deliver compressed gaseous refrigerant to the upstream side of the heat exchange means disposed in contact with the sink media, said low pressure cycle including pumping means having its suction connected to said common separating means to receive liquid refrigerant therefrom and arranged to deliver said liquid refrigerant selectively and interchangeably to the upstream side of said heat exchange means in contact with the sink media and to the upstream side of at least one of the remainder of said heat exchange means.

31. A heat pump including a high pressure cycle and a low pressure cycle and being adapted to furnish simultaneous heating and cooling, said heat pump including; a plurality of heat exchange means, at least one of said plurality of heat exchange means being disposed in contact with a sink media, the other of said heat exchange means including first and second heat exchangers being in series arrangement to define a refrigerant circulating portion for providing simultaneous heating and cooling to a conditioned area, a common separator means connected downstream of said heat exchanger means in contact with a sink media and said series arranged heat exchanger means to receive vaporous and liquid refrigerant therefrom, said high pressure cycle including compressor means having its suction connected to said common separator means to receive gaseous refrigerant therefrom, conduit means selectively and interchangeably communicating the discharge of said compressor means with the upstream side of said heat exchanger means disposed in contact with the sink media and with the upstream side of said other heat exchanger means in series arrangement, said low pressure cycle comprising pumping means having its suction connected to said common separator means to receive liquid refrigerant therefrom, and conduit means selectively and interchangeably communicating the discharge of said pumping means with the upstream side of said heat exchanger means in contact with the sink media for delivering liquid refrigerant thereto and for selectively and interchangeably delivering liquid refrigerant to the upstream side of said second heat exchanger.

References Cited in the file of this patent

UNITED STATES PATENTS

2,619,326	McLenegan	Nov. 25, 1952
2,954,680	Ruff	Oct. 4, 1960
2,998,710	Reese	Sept. 6, 1961