

[54] MODULAR HEAT PUMP

[76] Inventor: James O. Ewing, P. O. Box 6037,
Nashville, Tenn. 37212
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[58] Field of Search 62/324, 159, 160,
62/325

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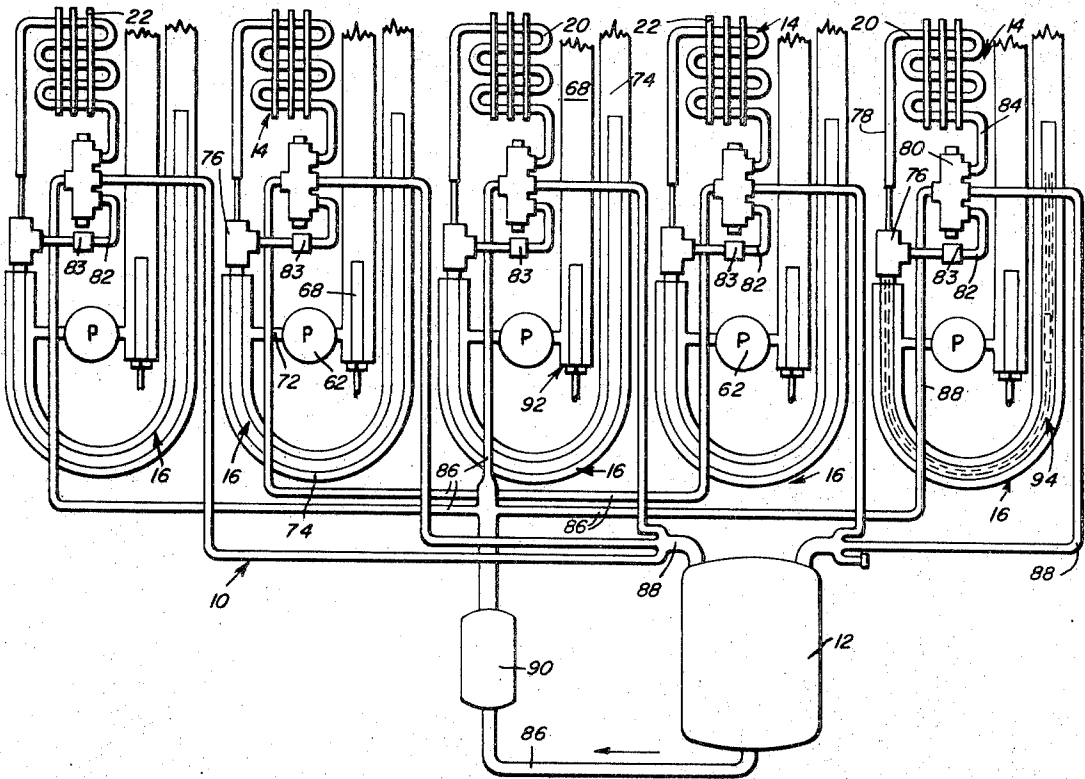
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Primary Examiner—William J. Wye
Attorney—Clarence A. O'Brien and Harvey B. Jacobson

[57] ABSTRACT

A heat pump assembly including multiple modular heat exchange units associated with a single refrigerant compressor motor unit with each heat exchange module including two heat exchange units which are alternatively and selectively employed as an evaporative heat exchange unit or a condenser heat exchange unit. One heat exchange unit in each module being associated with an ambient air circulating fan for use of the air as a heat exchange medium and the other heat exchange unit in each module associated with a liquid circulating pump system so that the liquid is used as a heat exchange medium.

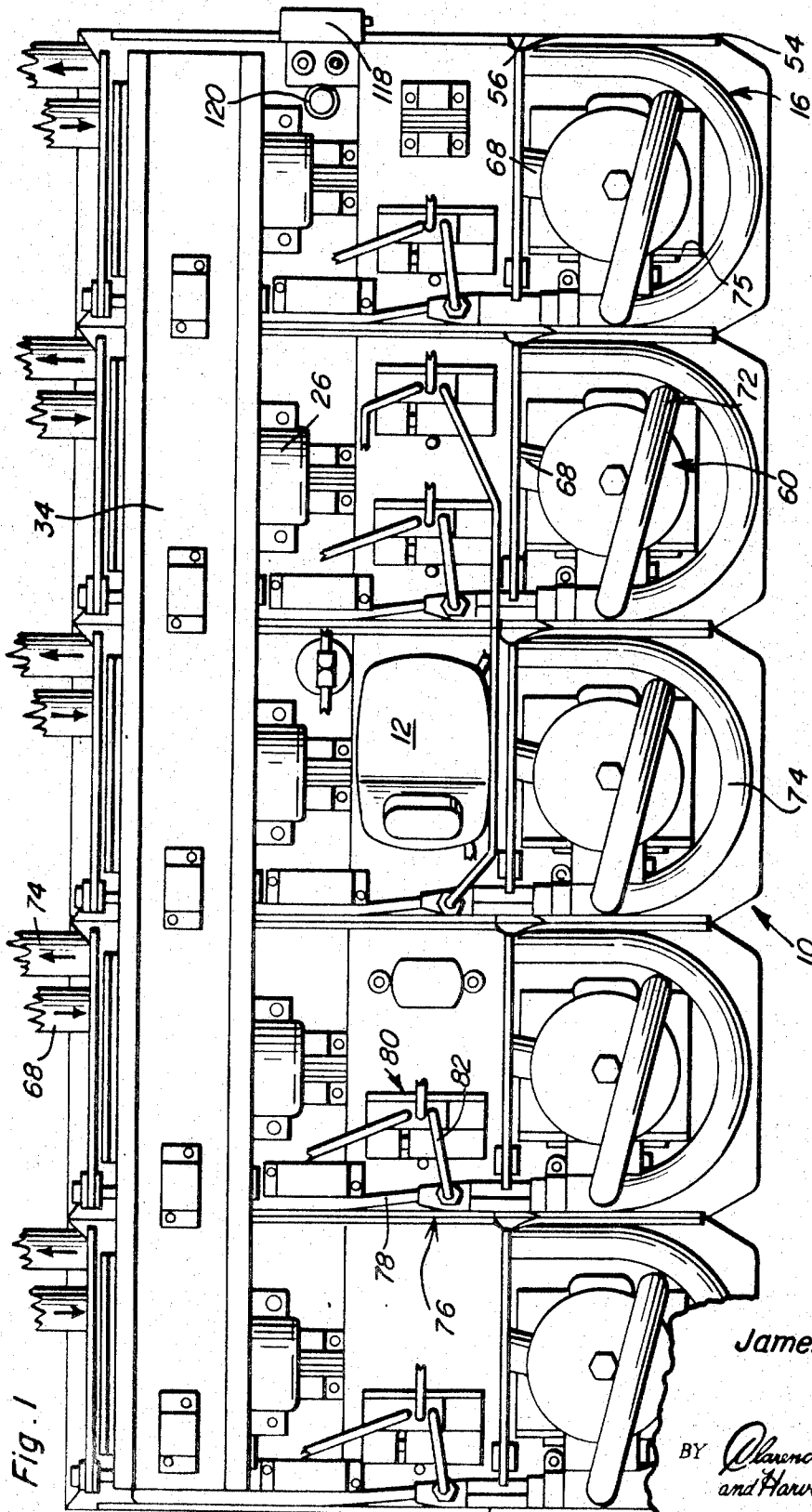
12 Claims, 6 Drawing Figures



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James O. Ewing
INVENTOR

BY *Clarence A. O'Brien*
and Harvey B. Jacobson
Attorney

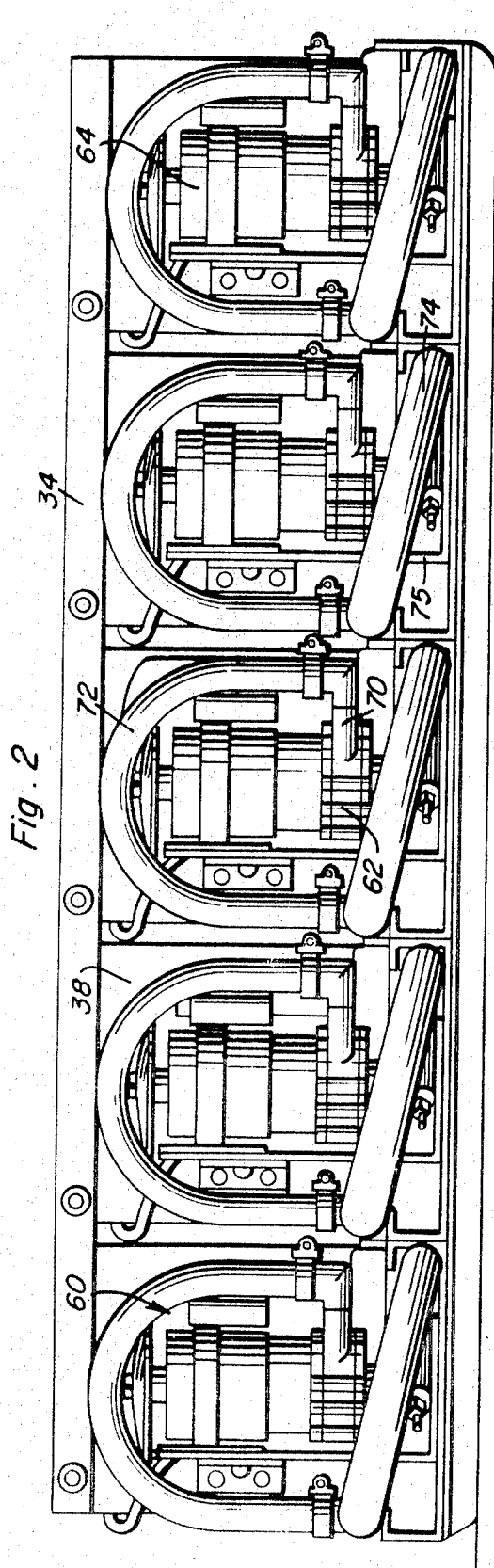
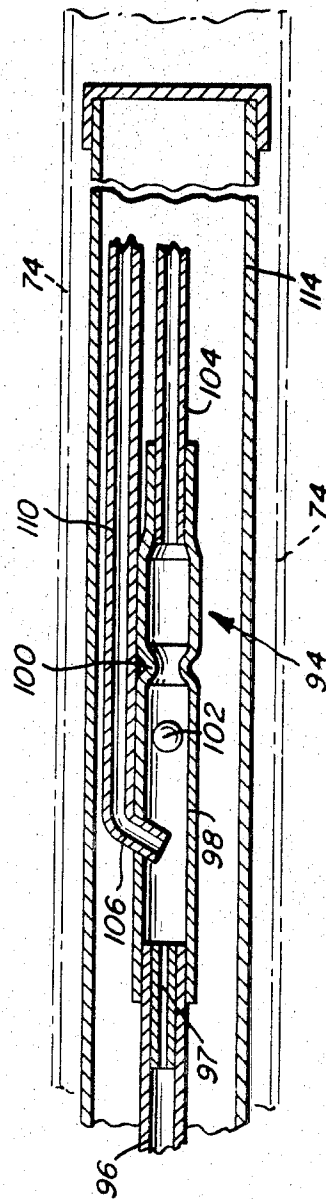


Fig. 5



James O. Ewing

INVENTOR

BY *Alvanice A. O'Brien*
and *Harvey B. Jacobson*
Attorneys

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Fig. 3

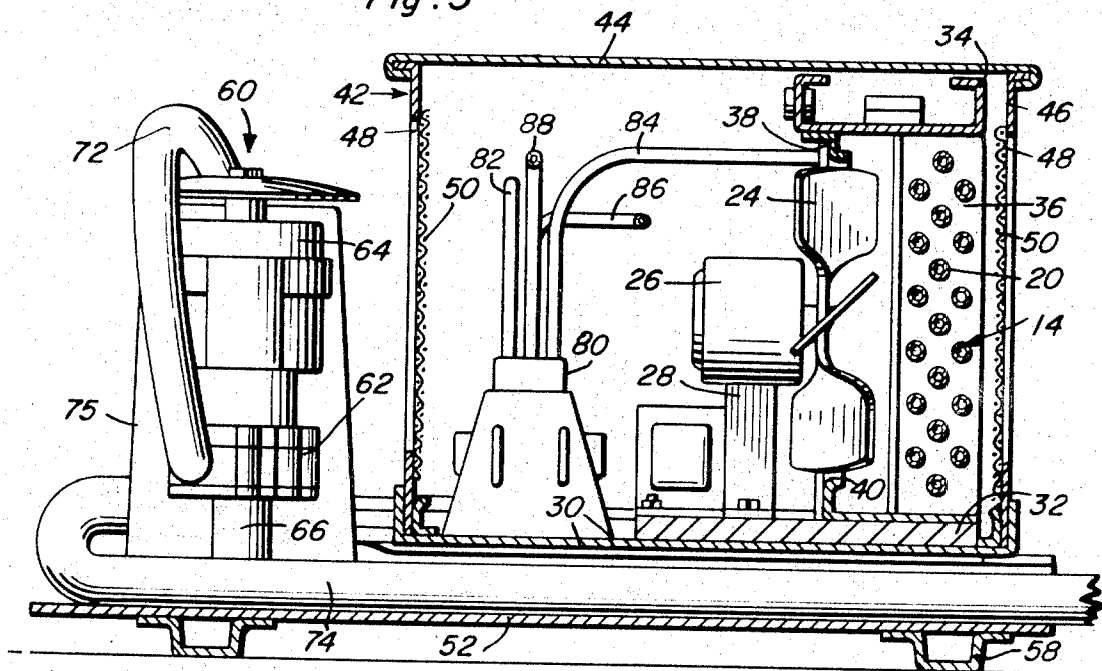
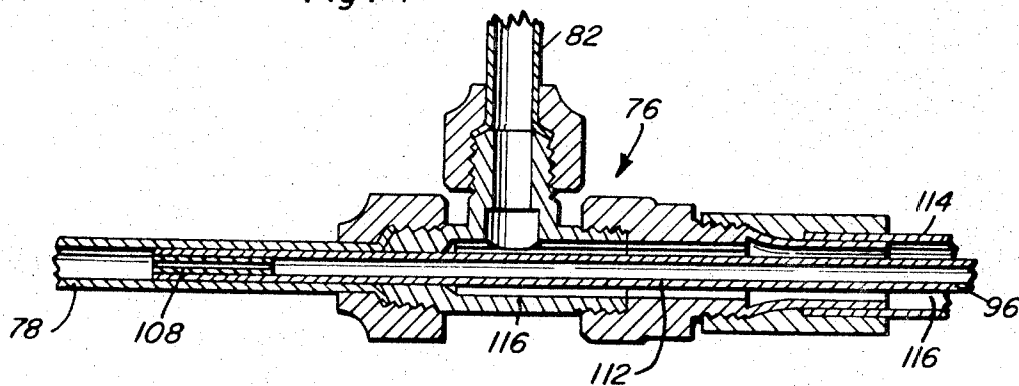


Fig. 4



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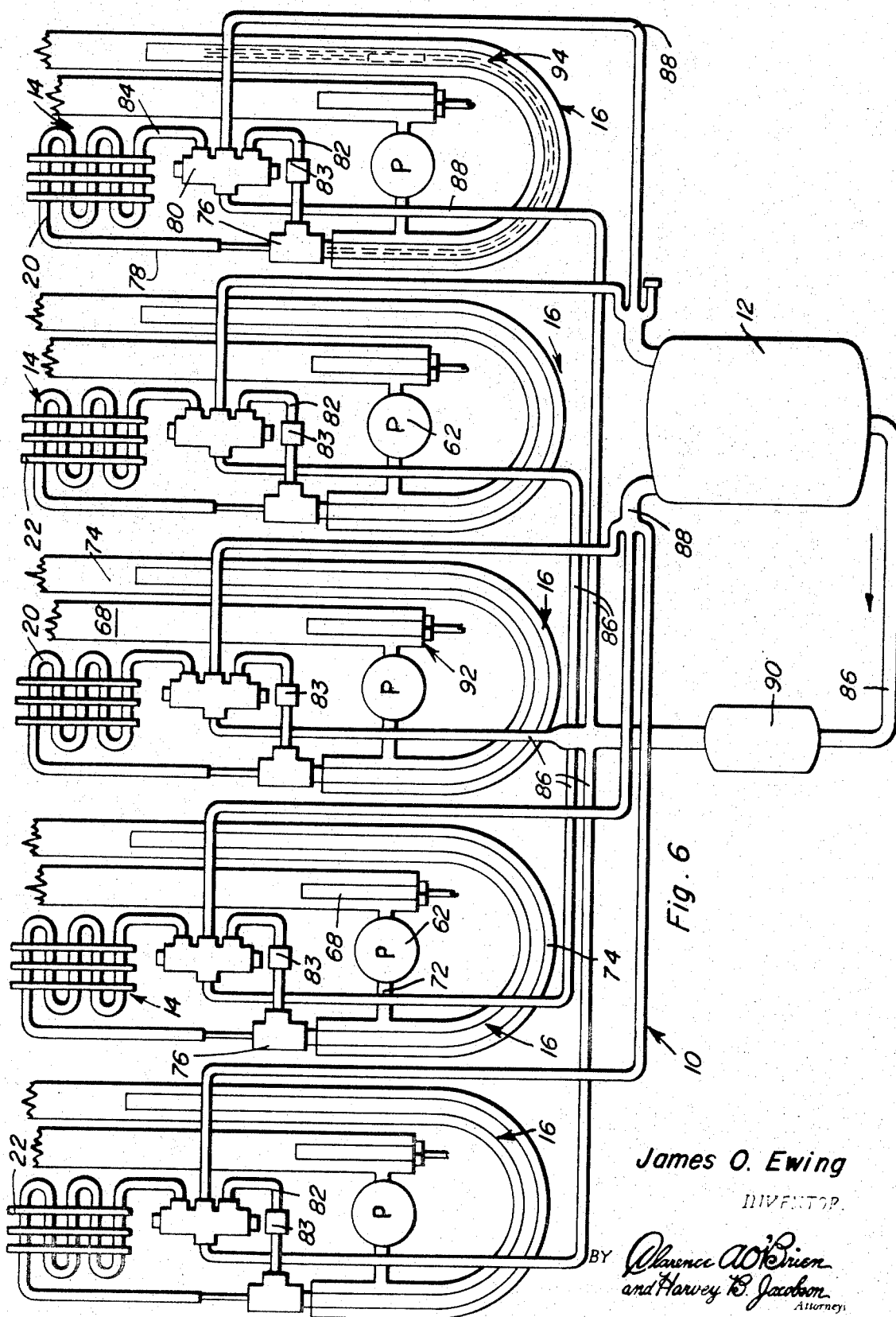
INVENTOR

BY *Clarence A. O'Brien*
and *Harvey B. Jacobson*
ATTORNEYS

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James O. Ewing
INVENTOR.

BY Clarence A. O'Brien
and Harvey E. Jacobson
Attorneys

MODULAR HEAT PUMP

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a heat pump assembly consisting of a plurality of heat pump modules associated with a single refrigerant compressor motor unit in which each module includes two heat exchange units that are alternatively and selectively employed as an evaporative heat exchange unit or a condensing heat exchange unit.

2. Description of the Prior Art

Heat pumps employing two heat exchange units which are alternatively and selectively employed as an evaporative heat exchange unit and a condensing heat exchange unit are known and have been used for various purposes. Exemplary of such heat pumps and a use thereof with which the present invention is concerned are disclosed in my prior U.S. Pat. No. 2,595,027, issued Nov. 8, 1960 for "Combination Evaporator-Condenser Assembly with Concentric Tubular Construction" and U.S. Pat. No. 3,148,513, issued Sept. 15, 1964 for "Portable Thermal Unit". While such devices are effective, in certain installations, such as where a plurality of diverse and independent liquid solutions are desired to be maintained at selected and adjustable temperatures, the use of independent heat pump assemblies sometimes introduced cost factors and size factors that were not optimum for such installations.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a modular heat pump which employs a single refrigerant compressor motor unit and a selected number of heat exchange modules associated with the single refrigerant compressor motor unit in a manner to produce a heat exchange cycle between each module and the compressor motor unit with the temperature characteristics of each module being independently adjustable and the heat exchange mode of each module being independently controlled so that the modules may maintain temperatures in heat exchange mediums either above, at or below ambient temperature.

Another object of the invention is to provide a modular heat pump which is compact in construction and capable of variation in the number of heat exchange modules associated with the single refrigerant compressor motor unit thereby providing a flexibility of installation to provide optimum satisfaction for each requirement for individual installations.

Another important object of the present invention is to provide a modular heat pump provided with automatic controls which employs substantially conventional components thus maintaining the cost at a minimum while retaining efficient operation and flexibility of installation.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top plan view of the modular heat pump of the present invention.

FIG. 2 is a rear elevational view of the modular heat pump.

FIG. 3 is a transverse sectional view of the heat pump illustrating the structural orientation of the components of one of the heat exchange modules.

FIG. 4 is a detailed longitudinal sectional view, on an enlarged scale illustrating the details of a connection employed in the heat pump.

FIG. 5 is a detailed sectional view, on an enlarged scale illustrating the details of a valve structure employed in one of the heat exchange units in each module.

FIG. 6 is a plan schematic view of the modular heat pump illustrating the association of the components thereof.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, the numeral 10 generally designates the multiple unit modular heat pump of the present invention which employs a single refrigerant compressor motor unit 12 operatively associated with multiple heat exchange units generally designated by the numeral 14 on one side of the compressor and multiple heat exchange units 16 on the opposite side of the compressor. The heat exchange units 14 are of the looped coil type with the coil loops 20 having fins 22 thereon. Each heat exchange unit 14 is provided with an axial flow fan 24 disposed inwardly thereof for forcing air through the heat exchange unit 14 and thus facilitating heat exchange between the air passing through the heat exchange unit and the fluid passing through the coil loops 20. Each fan 24 is driven by a motor 26 supported on a suitable bracket structure 28 carried by a base 30 which form a modular arrangement so that the number of units may be varied.

The heat exchange units 14 are also supported from the base 30 and the motor bracket 28 and the heat exchange unit 14 may be isolated therefrom by a cushioning device such as a board 32 of wood or other equivalent material. The top edges of the heat exchange units 14 are rigidly interconnected by a structural element such as a channel-shaped member 34 which extends from end to end of the apparatus and the individual heat exchange units are provided with end channels 36 attached to the inner edges thereof and which receive and mount a partition 38 having an enlarged aperture or opening 40 therein receiving the fan 24 to form a guide for passage of air over the heat exchange unit 14 with the fan 24 being received in the opening 40 as illustrated. The compressor motor unit 12 as well as the heat exchange units 14, fan 24 and motor 26 and other structural components associated therewith are covered by a removable casing 42 which includes a top wall 44 and depending peripheral walls 46 with the two side walls having enlarged apertures or openings 48 therein aligned with the heat exchange units 14 and directly opposed thereto with the openings 48 being provided with a screen closure 50 to provide for passage of air therethrough. The lower peripheral edge of the housing or casing 42 is telescoped into correspondingly formed channels on the base 30 and may be removably secured in place by suitable fasteners. The particular details of the manner in which the casing is connected to the base forms no particular part of the present invention.

Supported under each base is a subbase 52 which is disposed in spaced relation to the base 30 with the subbase 52 being substantially parallel thereto. Each subbase 52 is provided with upstanding edges 54 terminating in intumed flanges 56 to which the base 30 is connected. The subbases 52 are supported by longitudinal channel-shaped support members 58 which also serve to rigidly interconnect the subbases 52 and correspondingly interconnect the bases 30 and support the modular units in assembled condition.

As illustrated, the subbase 52 is longer than the base 30 and projects beyond the inner edge of the base 30. Supported on the projecting portion of each of the subbases 52 is a pump and motor assembly 60 which includes a vertically disposed pump 62 having a motor 64 disposed above the pump and directly driving the impeller of the pump. The pump has a bottom intake 66 communicated with a conduit 68 which extends forwardly under the center part of the base 30 with the conduit 68 being of a diameter to be disposed within the space between the base 30 and subbase 52 and adapted to be communicated with a container (not shown) having a liquid therein to be maintained at a constant temperature as in my prior U.S. Pat. No. 3,148,514.

The pump 62 includes a radial discharge 70 connected to a substantially U-shaped conduit 72 which extends over top of the motor 64 and extends downwardly alongside the opposite side of the motor and is communicated with a conduit 74 which forms part of the heat exchange unit 16 with the conduit 74 also extending between the base 30 and subbase 52 for communication with the container or conduit leading to the container having the liquid therein which is to be maintained at a predetermined temperature. As illustrated, the motor and pump unit 60 is supported from the subbase 52 by an L-shaped bracket 75 and the conduits are constructed preferably of plastic material and conventional coupling devices are provided for connecting the conduits and also maintaining the conduits which are of flexible character in their extended state since the flexible conduits would tend to collapse when they are bent into U-shaped configuration such as is the conduit 72 and the conduit 74.

The end of conduit 74 adjacent its communication with the conduit 72 is sealingly connected to expansion valve assembly 76 which is communicated with the loop coil 20 of the heat exchange unit 14 through a conduit 78 and communicated with a control valve assembly 80 through a conduit 82. The control valve assembly 80 is also communicated with the loop coil 20 through a conduit 84 which is communicated with the opposite side of the heat exchange unit from the conduit 78. The control valve 80 is also communicated with the discharge of the compressor motor unit 12 through a conduit 86 at one side thereof and is also communicated with the intake side of the compressor motor unit 12 through a conduit 88. Thus, the single compressor motor unit 12 which is centrally disposed on the center base 30 and supported therefrom by any suitable shock absorbing mount or the like has five discharge conduits 86 communicated therewith with each of the conduits being communicated with the control valve 80. The opposite side of each control valve 80 is in turn communicated with the intake of the com-

pressor motor unit 12 through conduits 88. A drier and filter assembly 90 is provided on the discharge side of the compressor motor unit 12. Also, each valve 80 is communicated through a conduit 84 to one side of the heat exchange unit 14 and communicated with the heat exchange unit 16 through conduit 82 so that by shifting the position of the valve 80, the heat exchange unit 14 may act as a condenser in one position and an evaporator in another position and correspondingly the heat exchange unit 16 may act as a condenser in one position of the valve and an evaporator in another position of the valve so that each individual system acts as a separately controlled heat pump with a single compressor motor unit 12 providing refrigerant compression and circulation to the heat exchange units of each module of the heat pump.

The pump 62 circulates liquid in through the conduit 68 and out through the conduit 74 with the flow being in the direction indicated by the arrows in FIG. 1. The free ends of the conduits are communicated with separate tanks, receptacles, containers or the like (not shown) in which liquids are disposed which are desired to be maintained at predetermined temperatures at, above or below ambient temperature. A temperature sensing control 92 is provided in each of the conduits 68 in order to sense the temperature of the liquid and to control the heat pump mode accordingly. Disposed within the conduit 74 is an expansion valve generally designated by numeral 94 with the details of construction thereof being illustrated in FIG. 5 and the details of construction of the expansion device 76 being illustrated in FIG. 4 which operate in substantially the same manner as the corresponding expansion devices illustrated in my prior U.S. Pat. No. 2,959,027 or prior U.S. Pat. No. 3,148,513. Specifically, a small tube 96 communicates with a slightly larger tube 98 which forms a valve chamber and includes a valve seat 100 formed therein by an inwardly extending peripheral rib which has an internal diameter smaller than a ball valve 102 which is disposed within the chamber on the side of the valve seat 100 adjacent the tube 96 which has a capillary tube restriction 97 therein. The opposite end of the tube 98 communicates with a tubular member 104 and the portion of the chamber intermediate the valve seat 100 and the tube 104 is provided with an entrance nozzle 106 for a small tube 110 which extends alongside of the tube 104 and is spirally wrapped around to its terminal end adjacent the end of tube 104. As illustrated, the nozzle 106 will prevent movement of the ball valve 102 beyond the end thereof thus capturing the ball valve for movement between the valve seat 100 in which it seals the tubular member 98 and a position adjacent to or against the nozzle 106 in which position it will not seal the nozzle 106 thus providing for one-way flow through tube 104 that is, refrigerant may flow from tube 104 into 98 but it will not flow out from tube 98 into tube 104.

The tube 96 is communicated with the expansion device 76 and extends directly through the T coupling and is in communication with the conduit 78 with a capillary tube or other restriction 108 therein so that when the heat exchange unit 16 is serving as a condenser, the restriction 108 provides expansion of refrigerant into the heat exchange unit 14 so that it serves as an evaporator.

The conduit 82 from the valve 80 also communicates with the T coupling 110 through which the tube 96 extends with the T coupling including a concentric passageway 112 in communication with and connected with the conduit 82 and also in communication with and connected with a conduit 114 which is concentric with the tube 98 and defining an annular space 116 thus providing two paths of movement for the refrigerant with one path being concentric in relation to the other with the structure being substantially the same as that illustrated in FIG. 5 of U.S. Pat. No. 3,148,513.

When the heat exchange unit 16 is in the evaporative mode condensed refrigerant passes through the tubular member 96 until it engages a ball valve 102 and forces it to closed position so that the refrigerant will then pass through the tube 110 which may be in the form of a capillary tube either straight or spiral and subsequently be discharged into the closed end of the tubular member 114 with expansion of the refrigerant causing absorption of heat from the liquid which surrounds the outer tubular member 114 within conduit 74. The evaporated refrigerant will then pass between the tube 96 and 114 through the valve and back to the intake side of the compressor motor unit. When the heat exchange unit 16 is used as a condenser, hot gas refrigerant from the compressor will pass through the valve 80, through conduit 82 and between tubes 114 and 96. The hot refrigerant gas is cooled by the liquid surrounding tube 114 as contained by the conduit 74 until it reaches the outer end of the tubular member 114 where it will enter the end of tube 104, move the valve 102 away from the valve seat 100 and pass through tube 98, tube 96 and into the conduit 78 where it expands into the heat exchange unit 14 which then acts as an evaporator with the evaporated gases then returning to the valve 80 and the compressor motor unit.

To control the unit, there is a control switch 118 having a time delay device associated therewith. The valve 80 is solenoid controlled that is normally oriented to a position to cool the liquid, that is, with the heat exchange unit 16 acting as evaporators. Each return line to the compressor motor 12 is provided with a check valve to prevent high pressure refrigerant from entering the intake conduits from the compressor motor unit. Also, high-low limit switches are provided in each conduit 82 as indicated by numeral 83 to render the transformer for the solenoid inoperative in the event high-low limits are exceeded.

The various tubes may be constructed of predetermined dimensions to provide for capillary action, expansion or restriction where required rather than employing separate restrictions.

In addition, indicator lights may be provided to indicate which modules are operating and in which mode they are in and various protective devices may be provided to prevent the motor compressor unit and the heat exchange units from being damaged in the event of malfunction of the various components. A protective shield may be provided for the upper ends of the motors which drive the pumps and plastics, metals or other materials may be employed depending upon the liquid being employed as a heat exchange medium.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

What is claimed as new is as follows:

1. A modular heat pump comprising a plurality of heat exchange modules each including two heat exchange units employed selectively and alternatively as condensers and evaporators, control means for each heat exchange module for selecting the mode of operation of each of the heat exchange units in the module, and a single refrigerant compressor motor unit communicated with each of the modules for supplying pressurized refrigerant and circulating the refrigerant through each module, each heat exchange module including a supporting structure independent of the other modules thereby enabling the number of modules in the heat pump to be varied.

2. The structure as defined in claim 1 wherein one heat exchange unit in each module is provided with ambient air circulating means to enable the ambient air and the refrigerant passing through the heat exchange unit to be in heat exchange relation to each other, the other heat exchange unit in each module including pump means pumping liquid in heat exchange relation to the refrigerant in the heat exchange unit for enabling the liquid being pumped to be maintained at a selected temperature at, above or below ambient air temperature.

3. A modular heat pump comprising a plurality of heat exchange modules each including two heat exchange units employed selectively and alternatively as condensers and evaporators, control means for each heat exchange module for selecting the mode of operation of each of the heat exchange units in the module, and a single refrigerant compressor motor unit communicated with each of the modules for supplying pressurized refrigerant and circulating the refrigerant through each module, one heat exchange unit in each module being provided with ambient air circulating means to enable the ambient air and the refrigerant passing through the heat exchange unit to be in heat exchange relation to each other, the other heat exchange unit in each module including pump means pumping liquid in heat exchange relation to the refrigerant in the heat exchange unit for enabling the liquid being pumped to be maintained at a selected temperature at, above or below ambient air temperature.

4. The structure as defined in claim 3 wherein said control means includes a reversing valve to selectively direct the flow of refrigerant from the compressor motor unit to a selected heat exchange unit in each module and selectively return refrigerant from one of the heat exchange units of each module whereby the heat exchange units in each module are selectively and alternatively employed as evaporators and condensers.

5. The structure as defined in claim 1 wherein said supporting structure includes an independent supporting base for each module, and a connecting structural member interconnecting said bases for maintaining

them in assembled relation, each of said bases including a subbase spaced below the base and providing space therebetween for passage of circulating conduits for liquid, one of the heat exchange units of each module being disposed in a circulating conduit disposed in the space between the subbase and base.

6. The structure as defined in claim 5 wherein the other of said conduits in which the liquid circulates includes a temperature sensing means to control the heat exchange unit in said one conduit to enable liquid passing through the conduits to be maintained at a predetermined temperature.

7. The structure as defined in claim 6 wherein each heat exchange module includes a separate electrically driven pump for circulating liquid in relation to the heat exchange unit in said one conduit.

8. The structure as defined in claim 7 wherein one heat exchange unit in each module is provided with ambient air circulating means to enable the ambient air and the refrigerant passing through the heat exchange unit to be in heat exchange relation to each other, the other heat exchange unit in each module including pump means pumping liquid in heat exchange relation to the refrigerant in the heat exchange unit for enabling the liquid being pumped to be maintained at a selected temperature at, above or below ambient air temperature, said control means including a reversing valve to selectively direct the flow of refrigerant from the compressor motor unit to a selected heat exchange unit in each module and selectively return refrigerant from one of the heat exchange units of each module whereby the heat exchange units in each module are selectively and alternatively employed as evaporators and condensers.

9. A modular heat pump comprising a compressor motor unit, a plurality of heat exchange modules connected with said compressor motor unit for circulating refrigerant, and means supporting said modules in predetermined relation to each other and the compressor motor unit to enable variation in the number of modules in the heat pump, each heat exchange module including a heat exchange unit using ambient air as a

heat exchange medium and a heat exchange unit using liquid as a heat exchange medium, reversing valve means selectively communicating the compressor motor unit with the heat exchange units whereby the heat exchange units are selectively used as evaporative or condensing heat exchange unit, said heat exchange unit using liquid heat exchange medium including a circulating pump, an intake conduit and a discharge conduit communicating with the liquid heat exchange medium, and a heat exchange means disposed in the discharge conduit.

10. The structure as defined in claim 9 wherein said intake conduit includes temperature sensing probe controlling operation of the reversing valve means to maintain the liquid temperature at, above or below ambient temperature.

11. The structure as defined in claim 10 wherein said heat exchange unit using ambient air heat exchange medium includes a coil and fin type heat exchanger, a fan and motor assembly orientated for inducing air flow past the heat exchanger, said heat exchanger, fan and motor assembly and circulating pump being mounted in alignment on a supporting base with the supporting bases of the plurality of modules being disposed in side by side relation.

12. A modular heat pump comprising a plurality of heat exchange modules with each module including two heat exchange units employed selectively and alternatively as condensers and evaporators, a single refrigerant compressor motor unit communicated with each of the modules for supplying pressurized gaseous refrigerant and circulating the refrigerant through each module, control means for each heat exchange module for controlling the mode of operation of each heat exchange unit in the module, the number of heat exchange modules being variable with each heat exchange module being independent of the other modules, and different heat exchange mediums associated with the heat exchange units in each module whereby one heat exchange medium may be maintained at a predetermined temperature.

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