(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 942 309 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
09.07.2008 Bulletin 2008/28

(51) Int Cl.:
F25D 17/02 *(2006.01)*

(21) Application number: **07254641.9**

(22) Date of filing: **30.11.2007**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

(30) Priority: **28.12.2006 US 646972**

(71) Applicant: **WHIRLPOOL CORPORATION**
Benton Harbor
Michigan 49022 (US)

(72) Inventors:
- **Cur, Nihat O**
  Saint Joseph, Michigan 49085 (US)
- **Vonderhaar, John Joseph**
  Michigan 49085 (US)
- **Kuehl, Steven John**
  Michigan 49127 (US)

(74) Representative: **Nicholls, Michael John**
J.A. Kemp & Co.
14, South Square
Gray's Inn
London WC1R 5JJ (GB)

(54) **Distributed refrigeration system for kitchens**

(57) A refrigeration appliance system for a residential kitchen having multiple separate refrigerating modules (20,22) and a single, continuously operating variable capacity central cooling unit (10) with a variable speed compressor (12) for chilling a cooling medium. A cooling medium circuit supplies cooling medium to the plurality of refrigerating modules (20,22) from the central cooling unit (10). Flow control devices (46) control flow of cooling medium to the refrigerating modules (20,22). A control circuit (56) controls the central cooling unit (10) and the temperature in the refrigerating modules (20,22). The refrigerating modules (20,22) can be refrigerator, freezer or refrigerator freezer modules. The cooling medium can be air, cooling liquid or refrigerant. A below freezing freezer module having an insulated freezer cabinet (24), a freezer compressor (12), a freezer condenser (14) and a freezer evaporator (40) can be combined with the refrigeration appliance system for providing 0°F freezer storage without requiring the central cooling unit to provide 0°F cooling medium.

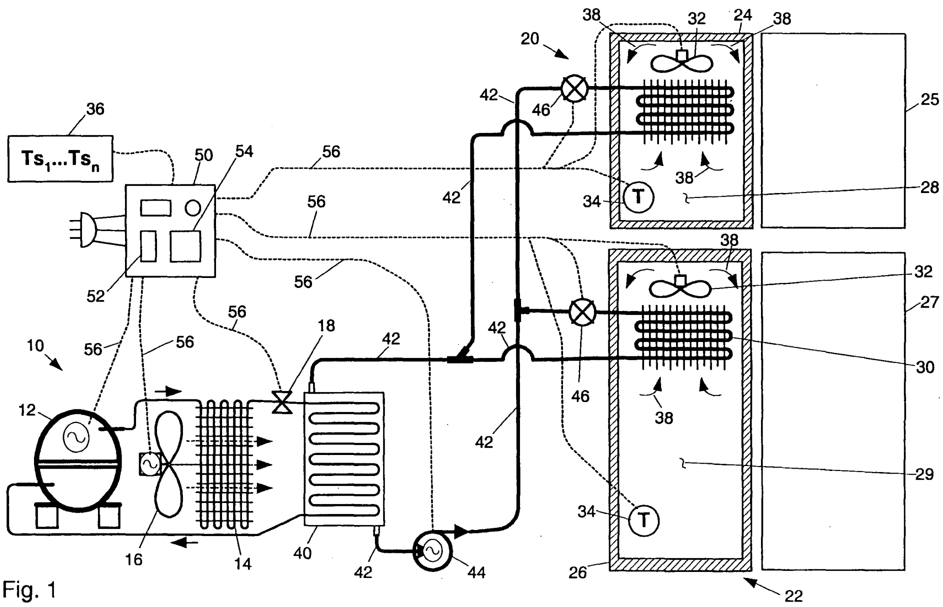

Fig. 1

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Description

[0001] The invention relates to refrigeration appliances for use in residential kitchens and other adjoining rooms in a dwelling.

[0002] Refrigeration appliances for use in residential kitchens and other rooms in a dwelling unit are known. Modular refrigeration devices such as refrigerator, freezer, ice maker and wine cooler modules for use in residential dwellings are known.

[0003] The invention relates to a refrigeration appliance system for use in a residential kitchen and other rooms in a dwelling having a plurality of separate refrigerating modules each having an insulated cabinet, an apparatus for receiving a cooling medium to cool the interior of the refrigerating module, a temperature sensor for sensing the temperature in the module and a temperature selector for selecting an operating temperature for the insulated refrigerating module.

[0004] The refrigeration appliance system includes a single, continuously operating variable capacity central cooling unit for chilling a cooling medium comprising a variable speed compressor, a condenser, a variable speed condenser fan and a controller, a cooling medium circuit connecting the central cooling unit and the plurality of refrigerating modules to supply cooling medium from the central cooling unit to the plurality of refrigerating modules, and to return cooling medium to the central cooling unit from the refrigerating modules and a plurality of cooling medium flow control devices connected in the cooling medium circuit for controlling flow of cooling medium to each of the refrigerating modules.

[0005] The refrigeration appliance system can have a control circuit connecting the temperature sensors, the temperature selectors and the cooling medium flow control devices for the plurality of refrigerating modules with the controller. The controller can have a first portion to adjust the capacity of the central cooling unit in response to the aggregate cooling load of the plurality of refrigerating modules in order to supply sufficient cooling medium to cool the plurality of refrigerating modules to the respective selected operating temperatures, and a second portion to adjust the volume of cooling medium directed to respective ones of the refrigerating modules to maintain the selected operating temperature in the respective refrigerating modules.

[0006] The refrigeration appliance system can also have at least one below freezing freezer module having an insulated freezer cabinet, a freezer cooling unit comprising a freezer compressor and a freezer condenser, a freezer evaporator for cooling the freezer compartment, a freezer expansion device connected in a refrigerant circuit with the freezer cooling unit and freezer evaporator, a freezer temperature sensor for sensing the temperature in the freezer compartment and a freezer temperature selector for selecting an operating temperature for the freezer compartment.

[0007] The refrigeration appliance system can have a freezer control circuit connecting the freezer temperature sensor, the freezer temperature selector, the freezer cooling unit to control operation of the freezer cooling unit to maintain the selected freezer compartment temperature.

[0008] The refrigeration appliance system cooling medium can be air and the cooling medium circuit can be insulated ducts connecting the central cooling unit and the plurality of refrigerating modules for supplying chilled air to the plurality of refrigerating modules and returning air from the refrigerating modules to the central cooling unit. The apparatus for receiving a cooling medium can be air inlets from the insulated ducts leading to the respective refrigerating modules and air outlets leading from the respective refrigerating modules to the insulated ducts. The cooling medium flow control devices can be a baffle for each refrigerating module for controlling the flow of chilled air flowing into the refrigerating module through the air inlet.

[0009] The central cooling unit can include an evaporator and an expansion device with feedback based on the refrigerating system load connected in a refrigerant circuit with the variable speed compressor and condenser and arranged to chill the cooling medium air to a temperature below the lowest selected refrigerating module operating temperature and at least one evaporator fan to circulate the chilled cooling medium air through the insulated ducts to respective refrigerating modules. The second portion of the controller can be arranged to operate the baffles of the respective refrigerating modules to control the flow of chilled air flowing into the respective refrigerating modules to maintain the respective selected operating temperatures.

[0010] In another aspect of the invention the cooling medium can be a liquid coolant and the cooling medium circuit can include insulated conduits leading from the central cooling unit to each of the refrigerating modules for supplying liquid coolant to each of the refrigerating modules and for returning liquid coolant to the central cooling unit. The apparatus for receiving cooling medium for the respective refrigerating modules can be a heat exchanger in communication with the interior of the insulated cabinet, and the cooling medium flow control devices comprise a valve for controlling the flow of liquid coolant to the heat exchanger.

[0011] The central cooling unit can be a chilled liquid evaporator and an expansion device with feedback based on the refrigerating system load connected in a refrigerant circuit with the variable speed compressor and condenser and arranged to chill the liquid coolant to a temperature below the lowest selected refrigerating module operating temperature, and a pump arranged to circulate the liquid coolant to the respective refrigerating modules. The second portion of the controller can be arranged to operate the valves to control the flow of chilled liquid coolant through the respective refrigerating module heat exchangers to maintain the respective selected operating temperatures.

[0012] In another aspect of the invention the cooling medium can be a refrigerant and the cooling medium circuit can include insulated conduits leading from the central cooling unit to each of the refrigerating modules for supplying refrigerant to each of the refrigerating modules and for returning refrigerant to the central cooling unit. The apparatus for receiving cooling medium can be a refrigerating module evaporator in communication with the interior of the insulated cabinet and a refrigerating module evaporator fan can be arranged to circulate air chilled by the refrigerating module evaporator in the insulated cabinet.

[0013] The cooling medium flow control devices can be expansion devices with feedback based on load for adjusting flow of refrigerant to the refrigerating module evaporators of the respective refrigerating modules, and the second portion of the controller can be arranged to control the expansion valves for the respective refrigerating modules to maintain the respective selected operating temperatures.

[0014] The refrigerating modules can be above freezing refrigerator modules arranged for storing foods at above freezing temperatures.

[0015] The invention will be further described by way of example with reference to the accompanying drawings, in which:-

[0016] Fig. 1 is a schematic drawing illustrating a modular refrigeration appliance system according to the invention.

[0017] Fig. 2 is a schematic drawing illustrating another embodiment of a modular refrigeration appliance system according to the invention.

[0018] Fig. 3 is a schematic drawing illustrating another embodiment of a modular refrigeration appliance system according to the invention.

[0019] Fig. 4 is a schematic drawing illustrating another embodiment of a modular refrigeration appliance system according to the invention.

[0020] Fig. 5 is a schematic drawing illustrating a refrigeration appliance module that can be used in combination with a modular refrigeration appliance system according to the invention.

[0021] In a modular kitchen with multiple refrigeration modules the refrigeration system to cool the modules is a challenging problem. The simplest approach would be to have individual complete refrigeration systems for each module. In early phases of modularity for residential kitchens this might be the approach taken, especially when modular refrigeration product choices are few and economies of scale are not available. However, as modularity becomes more mainstream and kitchen designs begin to incorporate modular refrigeration products with appropriate infrastructure it will become desirable to have a single central cooling system from cost, manufacturing and energy efficiency perspectives. Consumers will be primarily interested in energy efficiency, cost, flexibility and expandability offered by a modular refrigeration appliance system with less concern about the central cooling technology to support the modular system.

[0022] According to the invention, a modular refrigeration appliance system can be provided for a residential kitchen and adjoining rooms in a dwelling that can include a central cooling unit for some or all the refrigerating modules that a consumer may desire to include in their kitchen, either at the time of construction, or to expand or change refrigerating modules over time as needs or desires change. A modular kitchen could allow consumers to select multiple refrigeration modules fitting their lifestyles the best with ultimate flexibility in their kitchens and totally customizable kitchens with modular appliances not only for refrigeration but also for food preparation and kitchen clean-up. According to the invention a single, variable capacity central cooling unit can be provided that is capable of matching the cooling need to the aggregate heat load of the refrigerating modules. The central cooling unit can be arranged to run continuously by controlling the volume of cooling medium directed to each refrigerating module so that each module will be cooled to a user selected temperature and maintained at the desired temperature accurately. The cooling medium can be cold air, refrigerant or a liquid coolant such as an ethylene glycol and water solution. The central cooling unit can be a vapor compression system, but is not limited to that. If a central cooling unit is a vapor compression cooling system the central cooling unit can have a variable capacity compressor capable of handling the cooling load from multiple refrigerating module products. Refrigerating module products can include above freezing refrigerator modules, below freezing freezer modules, refrigerator freezer modules having above freezing and below freezing compartments in various configurations that can include, but are not limited to, built in, stackable, under counter or drawer configurations. Also, refrigerating module products could include specific purpose modules such as ice maker, wine cooler and bar refrigerator units. In addition, conventional refrigeration products having a complete refrigeration system can be combined with a modular refrigeration appliance system according to the invention. For example, one or more below freezing freezer units can be combined with a modular refrigeration system appliance arranged for a plurality of fresh food above freezing refrigerator modules. As will be described in more detail below, a hybrid approach can be an energy efficient approach to providing cooling for modular products since the central cooling unit can run under more favorable cooling cycle conditions since a very cold, i.e. below 0°F, cooling medium would not be required.

[0023] Turning to Fig. 1, in one embodiment of the invention, illustrated in schematic form, refrigerating modules 20 and 22 can be connected in a refrigeration appliance system that can include a central cooling unit 10. In the embodiment illustrated in Fig. 1 two refrigerating modules 20, 22 are illustrated. According to the invention more than two refrigerating modules can be provided in the refrigeration appliance system as desired and although two or three refrigerating modules are included in the disclosed embodiments, they should be understood to include the possibility of one or more than two or three refrigerating modules within the scope of the invention. In addition, the refrigeration appliance system can be arranged to permit expansion of the refrigeration appliance system subsequent to initial installation by adding additional refrigerating modules as a user's needs change over time requiring new or additional refrigerating modules. In practice refrigerating modules 20, 22 can be installed in a residential kitchen and/or in adjoining or nearby rooms such as a great room, bar, recreation room and the like. Central cooling unit 10 can be installed in a nearby location such as a basement, utility room, garage, or, if desired, in the kitchen in the proximity of some or all of the refrigeration appliance modules depending on the style of dwelling and whether a basement or crawl space is available or desired for installation of the central cooling unit 10. Refrigerating modules 20, 22 can be free standing or built in modules and can be general purpose refrigerator or freezer modules, or can be special purpose modules such as an ice maker or a wine cooler. Refrigerating modules 20, 22 can take of the form of a conventional refrigerator or freezer cabinet having a hinged door, or can take the form of a refrigerator drawer appliance such as disclosed in co-pending non-provisional application S.N. 11/102,321 filed April 8, 2005 fully incorporated herein by reference.

[0024] Refrigerating module 20 can have an insulated cabinet 24 and an insulated door 25 that can be hinged to insulated cabinet 24 to selectively open and close an opening 28 in insulated cabinet 24. Refrigerating module 22 can have an insulating cabinet 26 and an insulated door 27 that can be hinged to insulated cabinet 26 to selectively open and close an opening 29 in insulated cabinet 26. Those skilled in the art will understand that insulated doors 25 and 27 can be provided with a suitable handle, not shown, to facilitate opening and closing insulated doors 25 and 27. Refrigerating modules 20 and 22 can each have a heat exchanger 30 positioned in the insulated cabinets 24 and 26 respectively. Similarly, refrigerating modules 20 and 22 can have a variable speed heat exchanger fan 32 positioned to circulate air (illustrated by air flow arrows 38) over the respective heat exchangers 30 and through the respective refrigerating modules 20, 22. Those skilled in the art will appreciate that a single speed fan can be used instead of a variable speed fan 32. Refrigerating modules 20, 22 can also have a temperature sensor 34 arranged to sense the temperature of the interior of refrigerating modules 20, 22. Temperature sensor 34 can be a thermister or other well known electronic or mechanical temperature sensing mechanism or device. Temperature selectors 36 can be provided for each of the refrigerating modules 20, 22 to allow the user to select the operating temperature for the respective refrigerating modules 20, 22. While temperature selectors 36 are illustrated schematically spaced from refrigerating modules 20, 22, those skilled in the art will understand that temperature selectors 36 can be located in each of the refrigerating modules 20, 22 as is well known in the art, or could be centrally located if desired. Temperature selectors 36 can comprise a well known mechanical or electronic selector mechanism to allow a user to select an operating temperature for the respective refrigerating modules 20, 22.

[0025] The refrigeration appliance system illustrated in schematic form in Fig. 1 also includes a central cooling unit 10. Central cooling unit 10 can include a variable speed compressor 12, a condenser 14, and an expansion device 18 connected in a refrigerating circuit with a chilled liquid evaporator 40. A variable speed condenser fan 16 can be provided to circulate air over condenser 14. Chilled liquid evaporator 40 can be a shell and tube evaporator also known as a secondary loop evaporator. Expansion device 18 can be an expansion device with feedback arranged to control refrigerant flow through expansion device 18 based on the heat load in the refrigeration appliance system. Central cooling unit 10 can be connected to the refrigerating modules 20, 22 with insulated conduits 42 forming a cooling medium circuit for conveying liquid coolant from chilled liquid evaporator 40 to heat exchangers 30 and from heat exchangers 30 to chilled liquid evaporator 40. Liquid coolant, not shown, contained in chilled liquid evaporator 40, insulated conduits 42 and heat exchangers 30 can be circulated by a pump 44 that can be a variable speed pump. Further, each refrigerating module can have a valve 46 to control flow of liquid coolant into the heat exchanger 30. Valves 46 can be on-off valves to allow or prevent flow of liquid coolant through the heat exchanger 30 for a refrigerating module. Those skilled in the art will appreciate that if a single speed heat exchanger fan 32 is used in a refrigerating module 20, 22 an adjustable valve 46 can be used to control the amount of liquid coolant flowing into a heat exchanger 30, although it can be more energy efficient to use a variable speed heat exchanger fan 32, a variable speed pump 44 and an on-off valve 46 to control the temperature in the respective refrigerating modules 20, 22. Central cooling unit 10 can also have a microprocessor based controller 50 having a first portion 52 that can be arranged to control the operation of central cooling unit 10 and a second portion 54 arranged to control the volume of liquid coolant directed to the respective refrigerating modules 20, 22. A control circuit 56 can be provided to connect the temperature sensors 34, the temperature selectors 36, the variable speed compressor 12, the variable speed condenser fan 16, the expansion device 18, pump 44, valves 46 and heat exchanger fans 32 with controller 50. Thus, a refrigeration appliance system according to the invention is illustrated in Fig. 1 as a distributed refrigeration system that can have a variable capacity vapor compression condensing unit and secondary loop utilizing a chilled liquid evaporator network. One example of a liquid coolant that can be used is DYNALENE HC heat transfer fluid, a water-based organic salt that is non-toxic, non-flammable with low viscosity, although those skilled in the art will understand that other liquid coolant solutions such as an ethylene glycol and water solution can be used as desired.

[0026] According to the invention, central cooling unit 10 can be continuously operating so that chilled liquid at an adequate temperature to achieve the lowest selected temperature in the refrigeration appliance system is continuously circulated in insulated conduits 42 forming a cooling medium circuit from chilled liquid evaporator 40 to refrigerating modules 20, 22. Controller 50 can be arranged to adjust the capacity of the central cooling unit 10 in response to the aggregate cooling load of the plurality of refrigerating modules 20, 22. As noted above, while two refrigerating modules 20, 22 are illustrated in Fig. 1, according to the invention one or more than two refrigerating modules can be connected in the refrigerating appliance system. The aggregate cooling load can be determined by the first portion 52 of controller 50 as a function of temperatures sensed by temperature sensors 34, operating temperatures selected by temperature selectors 36, and feedback from expansion device 18. Controller 50 can also be arranged to control the operating temperature in each of the refrigerating modules 20, 22. Second portion 54 of controller 50 can be arranged to control valves 46 and heat exchanger fans 32 to maintain the selected operating temperatures in the respective refrigerating modules based on the settings of temperature selectors 36 and temperature sensors 34. Thus, according to the invention, a single continuously operating variable capacity central cooling unit 10 can be provided for a plurality of refrigerating modules 20, 22 that can be set to operate at different operating temperatures. The variable capacity central cooling unit 10 can be arranged for chilling a cooling medium. A cooling medium circuit, insulated conduits 42, can be provided connecting the central cooling unit 10 to supply a cooling medium from the central cooling unit 10 to the plurality of refrigerating modules 20, 22. A plurality of cooling medium flow control devices, valves 46, can be connected in the cooling medium circuit, insulated conduits 42, for controlling flow of cooling medium to each of the refrigerating modules 20, 22. A controller 50 and control circuit 56 can be provided to adjust the capacity of the variable capacity central cooling unit 10 in order to supply sufficient cooling medium to cool the plurality of refrigerating modules 20,22 to the respective selected operating temperatures, and the controller 50 and control circuit 56 can be arranged to adjust the volume of cooling medium directed to respective ones of the refrigerating modules 20, 22 by controlling the cooling medium flow control devices, valves 46, to maintain the selected operating temperature in the respective refrigerating modules 20, 22. Controller 50 can control the speed of variable speed pump 44 to vary the volume of liquid cooling in the cooling medium circuit, insulated conduits 42, and controller 50 can control the speed of variable speed heat exchanger fans 32 to further control the operating temperature in the respective refrigerating modules 20, 22.

[0027] Turning to Fig. 2, in another embodiment of the invention, illustrated in schematic form, refrigerating modules 70 and 72 can be connected in a refrigeration appliance system that can include a central cooling unit 60. Similar to the embodiment illustrated in Fig. 1, two refrigerating modules 70, 72 are illustrated. According to the invention more than two refrigerating modules can be provided in the refrigeration appliance system as desired. Refrigerating modules 70, 72 can be free standing or built in modules and can be general purpose refrigerator, or can be special purpose modules. Refrigerating module 70 can have an insulated cabinet 74 and an insulated door 75 that can be hinged to insulated cabinet 74 to selectively open and close opening 78 in insulated cabinet 74. Refrigerating module 72 can have an insulating cabinet 76 and an insulated door 77 that can be hinged to insulated cabinet 76 to selectively open and close opening 79 in insulated cabinet 76. Those skilled in the art will understand that insulated doors 75 and 77 can be provided with a suitable handle, not shown, to facilitate opening and closing insulated doors 75 and 77. Refrigerating modules 70, 72 can have a temperature sensor 84 arranged to sense the temperature of the interior of refrigerating modules 70, 72. Temperature sensor 84 can be a thermister or other well known electronic or mechanical temperature sensing mechanism or device. Temperature selectors 86 can be provided for each of the refrigerating modules 70, 72 to allow the user to select the operating temperature for the respective refrigerating modules 70, 72. While temperature selectors 86 are illustrated schematically spaced from refrigerating modules 70, 72, a temperature selector 86 can be located in each of the refrigerating modules 70, 72 as is well known in the art, or can be centrally located if desired. Temperature selectors 86 can comprise a well known mechanical or electronic selector mechanism to allow a user to select an operating temperature for the respective refrigerating modules 70, 72.

[0028] The refrigeration appliance system illustrated in schematic form in Fig. 2 also includes a central cooling unit 60. Central cooling unit 60 can include a variable speed compressor 62, a condenser 64 and an expansion device 68 connected in a refrigerating circuit with an evaporator 90. A variable speed condenser fan 66 can be provided to circulate air over condenser 64. Evaporator 90 can be a tube and fin evaporator for cooling air that can be used as the cooling medium in the embodiment of Fig. 2. Expansion device 68 can be an expansion device with feedback arranged to control flow through the expansion device 68 based on the heat load in the refrigeration appliance system including the refrigerating modules 70, 72. Central cooling unit 60 can be connected to the refrigerating modules 70, 72 with insulated ducts 92 forming a cooling medium circuit for conveying chilled air from evaporator 90 to refrigerating modules 70, 72. Chilled air can be circulated by an evaporator fan 94 that can be a variable speed fan. Air inlets 93 can lead from the insulated ducts 92 to the respective refrigerating modules 70, 72, and air outlets 95 can lead from the respective refrigerating modules 70, 72 to the air ducts 92. Air inlets 93 and air outlets 95 form the apparatus for receiving the cooling medium, chilled air, in the refrigerating modules 70, 72. Air inlets 93 and air outlets 95 can be positioned with respect to insulated cabinets 74, 76 to provide a desired chilled air flow pattern in the respective refrigerating modules 70, 72. Air flow arrows 80 schematically illustrate the air flow in the insulated cabinets 74, 76. Further, each refrigerating module 70, 72 can have a baffle 96 to control flow of chilled air through air inlets 93 into the respective refrigerating modules 70, 72. Baffles

96 can be on-off or variable to control flow of chilled air through a refrigerating module. Baffles 96 can be adjustable between open and closed positions to permit or block flow of chilled air into the respective refrigerating modules 70, 72 and variable speed evaporator fan 94 can vary the flow of chilled air into the respective refrigerating modules 70, 72. Baffles 96 can also be variably movable between open and closed positions to permit, block and vary the flow of chilled air into the respective refrigerating modules 70, 72. Central cooling unit 60 can have a microprocessor based controller 100 having a first portion 102 that can be arranged to control the operation of central cooling unit 60 and a second portion 104 to control the volume of chilled air directed to the respective refrigerating modules 70, 72 similar to controller 50 in the embodiment of Fig. 1. A control circuit 106 can be provided to connect the temperature sensors 84, the temperature selectors 86, the variable speed compressor 62, the variable speed condenser fan 66, the expansion device 68, evaporator fan 94, and baffles 96 to controller 100. Thus, a refrigeration appliance system according to the invention is illustrated in Fig. 2 as a distributed refrigeration system having a variable capacity vapor compression condensing unit and a chilled forced air cooling delivery network.

[0029] According to the invention, central cooling unit 60 can be continuously operating so that chilled air is continuously circulated in insulated ducts 92 forming a cooling medium circuit from evaporator 90 to refrigerating modules 70, 72 and back to evaporator 90. Controller 100 can be arranged to adjust the capacity of the central cooling unit 60 in response to the aggregate cooling load of the plurality of refrigerating modules 70, 72. As noted above, while two refrigerating modules 70, 72 are illustrated in Fig. 2, according to the invention one or more than two refrigerating modules can be connected in the refrigerating appliance system. The aggregate cooling load can be determined by the first portion 102 of controller 100 as a function of temperatures sensed by temperature sensors 84, operating temperatures selected with temperature selectors 86, and feedback from expansion device 68. Controller 100 can also be arranged to control the operating temperature in each of the refrigerating modules 70, 72. Second portion 104 of controller 100 can be arranged to control baffles 96 and evaporator fan 94 to maintain the selected operating temperatures based on the settings of temperature selectors 86 and temperature sensors 84. Thus, according to the invention, a single continuously operating variable capacity central cooling unit 60 can be provided for a plurality of refrigerating modules 70, 72 that can be set to operate at different operating temperatures. The variable capacity central cooling unit 60 can be arranged for chilling a cooling medium. A cooling medium circuit, insulated ducts 92, can be provided connecting the central cooling unit 60 to supply the cooling medium from the central cooling unit 60 to the plurality of refrigerating modules 70, 72. A plurality of cooling medium flow control devices, baffles 96, can be provided for controlling flow of cooling medium, chilled air, to each of the refrigerating modules 70, 72, through air inlets 93 and air outlets 95. A controller 100 and control circuit 106 can be provided to adjust the capacity of the variable capacity central cooling unit 60 in order to supply sufficient cooling medium to cool the plurality of refrigerating modules 70, 72 to the respective selected operating temperatures, and the controller 100 and control circuit 106 can be arranged to adjust the volume of cooling medium directed to respective ones of the refrigerating modules 70, 72 by controlling the cooling medium flow control devices, evaporator fan 94 and baffles 96, to maintain the selected operating temperature in the respective refrigerating modules 70, 72. Controller 100 can control the speed of variable speed fan 94 to vary the volume of cooling medium, chilled air, in the cooling medium circuit, insulated ducts 92, to further control the operating temperature in the respective refrigerating modules 70, 72. The embodiment of Fig. 2 is preferably used for above freezing refrigerator modules to avoid the need to circulate chilled air in the cooling medium circuit to achieve temperatures approximating 0°F for freezer modules, although freezer modules can be included in the Fig. 2 embodiment if desired.

[0030] Turning to Fig. 3, in another embodiment of the invention, illustrated in schematic form, refrigerating modules 120, 122 and 124 can be connected in a refrigeration appliance system that can include a central cooling unit 110. According to the invention one or two refrigerating modules or more than three refrigerating modules can be provided in the refrigeration appliance system as desired. Refrigerating modules 120, 122 and 124 can be free standing or built in modules and can be general purpose refrigerator or freezer modules or can be special purpose modules. Refrigerating module 120 can have an insulated cabinet 126 and an insulated door 127 that can be hinged to insulated cabinet 126 to selectively open and close an opening 135 in insulated cabinet 126. Refrigerating module 122 can have an insulated cabinet 128 and an insulated door 129 that can be hinged to insulated cabinet 128 to selectively open and close an opening 137 in insulated cabinet 128. Refrigerating module 124 can have an insulated cabinet 140 and an insulated door 141 to selectively open and close an opening 139 in insulated cabinet 140. Those skilled in the art will understand that insulated doors 127, 129 and 141 can be provided with a suitable handle, not shown, to facilitate opening and closing insulated doors 127, 129 and 141. Refrigerating modules 120, 122, and 124 can include a refrigerating module evaporator 130 and a refrigerating module variable speed evaporator fan 132 arranged to circulate chilled air in the respective refrigerating modules. Air flow arrows 148 schematically illustrate the chilled air flow in the respective refrigerating modules. Refrigerating modules 120, 122 and 124 can have a temperature sensor 134 arranged to sense the temperature of the interior of refrigerating modules 120, 122 and 124. Temperature sensor 134 can be a thermister or other well known electronic or mechanical temperature sensing mechanism or device. Temperature selectors 136 can be provided for each of the refrigerating modules 120, 122 and 124 to allow the user to select the operating temperature for the respective refrigerating modules 120, 122 and 124. While temperature selectors 136 are illustrated schematically spaced from refrigerating modules 120, 122 and 124 a temperature selector 136 can be located in each of the refrigerating modules 120, 122 and 124 as is well known in the art, or can be centrally located if desired. Temperature selectors 136 can comprise a well known mechanical or electronic selector mechanism to allow a user to select an operating temperature for the respective refrigerating modules 120, 122 and 124.

[0031] The refrigeration appliance system illustrated in schematic form in Fig. 3 also includes a central cooling unit 110. Central cooling unit 110 can include a variable speed compressor 112, a condenser 114 and a variable speed condenser fan 116. Central cooling unit 110 can also include a manifold 117 and an accumulator 118. Central cooling unit 110 can be connected to the refrigerating modules 120, 122 and 124 with insulated supply conduits 142 and insulated return conduits 144 forming a cooling medium circuit for conveying refrigerant from central cooling unit 110 through manifold 117 to refrigerating modules 120, 122, and 124 and returning refrigerant from refrigerating modules 120, 122, and 124 to accumulator 118 through insulated return conduits 144 for delivery to variable speed compressor 112. Refrigerating module evaporators 130 form the apparatus for receiving the cooling medium, refrigerant, in the refrigerating modules 120, 122 and 124. Further, each refrigerating module 120, 122 and 124 can have an expansion device 138 to control flow of refrigerant into the respective refrigerating module evaporators 130. Expansion devices 138 can be an expansion device with feedback arranged to control refrigerant flow through expansion device 138 based on the heat load in the respective refrigerating module 120, 122, and 124 and the operating temperature selected by the respective temperature selector 136. Central cooling unit 110 can also have a microprocessor based controller 150 having a first portion 152 that can be arranged to control the operation of central cooling unit 110 and a second portion 154 to control the volume of refrigerant directed to the respective refrigerating modules 120, 122 and 124 similar to controller 50 in the embodiment of Fig. 1. A control circuit 156 can be provided to connect the temperature sensors 134, the temperature selectors 136, the variable speed compressor 112, the variable speed condenser fan 116, expansion devices 138 and evaporator fans 132 to controller 150. Thus, a refrigeration appliance system according to the invention is illustrated in Fig. 3 as a distributed refrigeration system having a variable capacity vapor compression condensing unit and an evaporator network. Depending on the refrigerating modules selected, the evaporators can all be above freezing, all below freezing, or a mixture of above freezer and below freezing refrigerating modules.

[0032] According to the invention, central cooling unit 110 can be continuously operating so that refrigerant is continuously circulated in insulated supply conduits 142 and insulated return conduits 144 forming a cooling medium circuit from condenser 114 through manifold 117 to refrigerating modules 120, 122 and 124 and back to compressor 112 through accumulator 118. Controller 150 can be arranged to adjust the capacity of the central cooling unit 110 in response to the aggregate cooling load of the plurality of refrigerating modules 120, 122 and 124. As noted above, while three refrigerating modules 120, 122 and 124 are illustrated in Fig. 3, according to the invention one or more than three refrigerating modules can be connected in the refrigerating appliance system. The aggregate cooling load can be determined by the first portion 152 of controller 150 as a function of temperatures sensed by temperature sensors 134, operating temperatures selected with temperature selectors 136 and feedback from expansion devices 138. Controller 150 can also be arranged to control the operating temperature in each of the refrigerating modules 120, 122 and 124. Second portion 154 of controller 150 can be arranged to control expansion devices 138 and refrigerating module evaporator fans 132 to maintain the selected operating temperatures based on the settings of temperature selectors 136 and temperature sensors 134. Controller 150 can be arranged to maintain approximately the same evaporator pressure in the refrigerating module evaporators 130 and control the temperature in the respective refrigerating modules by varying the flow of refrigerant into the refrigerating module evaporators 130 and controlling the speed of the respective refrigerating module evaporator fans 132. Thus, according to the invention, a single, continuously operating variable capacity central cooling unit 110 can be provided for a plurality of refrigerating modules 120, 122 and 124 that can be set to operate at different operating temperatures. The variable capacity central cooling unit 110 can be arranged for chilling a cooling medium, a refrigerant. A cooling medium circuit, insulated supply conduits and insulated return conduits 142, 144, can be provided connecting the central cooling unit 110 to supply the cooling medium from the central cooling unit 110 to the plurality of refrigerating modules 120, 122 and 124. A plurality of cooling medium flow control devices, expansion devices 138, can be provided for controlling flow of cooling medium, refrigerant, to each of the refrigerating modules 120, 122 and 124. A controller 150 and control circuit 156 can be provided to adjust the capacity of the variable capacity central cooling unit 110 in order to supply sufficient cooling medium to cool the plurality of refrigerating modules 120, 122 and 124 to the respective selected operating temperatures, and the controller 150 and control circuit 156 can be arranged to adjust the volume of cooling medium, refrigerant, directed to respective ones of the refrigerating modules 120, 122 and 124 by controlling the cooling medium flow control devices, expansion devices 138 and refrigerating module evaporator fans 132, to maintain the selected operating temperature in the respective refrigerating modules 120, 122 and 124. Controller 150 can control the speed of variable speed compressor 112, variable speed condenser fan 116 and expansion devices 138 to control the vapor pressure of the cooling medium, refrigerant, in the cooling medium circuit, insulated supply and return conduits 142, 144, to further control the operating temperature in the respective refrigerating modules 120, 122 and 124.

[0033] Turning to Fig. 4, in another embodiment of the invention, illustrated in schematic form, refrigerating modules

120, 124 and 160 can be connected in a refrigeration appliance system that can include a central cooling unit 110. According to the invention one or two refrigerating modules or more than three refrigerating modules can be provided in the refrigeration appliance system as desired. As described in the embodiment disclosed in Fig. 3, refrigerating modules 120 and 124 can be free standing or built in modules and can be general purpose refrigerator, freezer or can be special purpose modules. Refrigerating module 160 can be a refrigerator freezer having a refrigerator compartment 168 and a freezer compartment 166. Refrigerator compartment 168 can have an insulated refrigerator compartment door 174 hinged to insulated cabinet 162 and freezer compartment 166 can have an insulated freezer compartment door 172 hinged to insulated cabinet 162. Those skilled in the art will understand that insulated doors 127, 141, 172 and 174 can be provided with a suitable handle, not shown, to facilitate opening and closing insulated doors 127, 141, 172 and 174. Refrigerating modules 120, 124 and 160 can include a refrigerating module evaporator 130 and a variable speed refrigerating module evaporator fan 132 arranged to circulate chilled air in the respective refrigerating modules, see air flow arrows 148. Refrigerating modules 120 and 124 can have a temperature sensor 134 arranged to sense the temperature of the interior of refrigerating modules 120, 124. Refrigerator freezer module 160 can have a temperature sensor 134 for refrigerator compartment 168 and a temperature sensor 134 for freezer compartment 166. Temperature sensors 134 can be a thermister or other well known electronic or mechanical temperature sensing mechanism or device. Temperature selectors 136 can be provided for each of the refrigerating modules 120 and 124 to allow the user to select the operating temperature for the respective refrigerating modules 120 and 124. Refrigerator freezer 160 can have two temperature selectors 136, one for the refrigerator compartment 168 and one for the freezer compartment 166. While temperature selectors 136 are illustrated schematically spaced from refrigerating modules 120, 124 and 160 a temperature selector (s) 136 can be located in each of the refrigerating modules 120, 124 and 160 as is well known in the art, or alternately can be centrally located if desired. Temperature selectors 136 can comprise a well known mechanical or electronic selector mechanism to allow a user to select an operating temperature for the respective refrigerating modules 120, 124 and 160.

[0034] The refrigeration appliance system illustrated in schematic form in Fig. 4, similar to the embodiment illustrated in Fig. 3, can include a central cooling unit 110. Central cooling unit 110 can include a variable speed compressor 112, a condenser 114 and a variable speed condenser fan 116. Central cooling unit 110 can also include a manifold 117 and an accumulator 118. Central cooling unit 110 can be connected to the refrigerating modules 120, 124 and 160 with insulated supply conduits 142 and insulated return conduits 144 forming a cooling medium circuit for conveying refrigerant from central cooling unit 110 through manifold 117 to refrigerating modules 120, 124 and 160 and returning refrigerant from refrigerating modules 120, 124 and 160 to accumulator 118 through insulated return conduits 144 for delivery to variable speed compressor 112. Refrigerating module evaporators 130 form the apparatus for receiving the cooling medium, refrigerant, in the refrigerating modules 120, 124 and 160. Further, each refrigerating module 120, 124 and 160 can have an expansion device 138 to control flow of refrigerant into the respective refrigerating module evaporators 130. Expansion devices 138 can be an expansion device with feedback arranged to control refrigerant flow through expansion device 138 based on the heat load in the respective refrigerating modules 120, 124 and 160 and the operating temperature(s) selected with the temperature selectors 136. Central cooling unit 110 can also have a microprocessor based controller 150 having a first portion 152 that can be arranged to control the operation of central cooling unit 110 and a second portion 154 to control the volume of refrigerant directed to the respective refrigerating modules 120, 124 and 160 similar to microprocessor based controller 50 in the embodiment of Fig. 1. A control circuit 156 can be provided to connect the temperature sensors 134, the temperature selectors 136, the variable speed compressor 112, the variable speed condenser fan 116, expansion devices 138 and evaporator fans 132 to controller 150. Thus, a refrigeration appliance system according to the invention is illustrated in Fig. 4 as a distributed refrigeration system having a variable capacity vapor compression condensing unit and an evaporator network. Depending on the refrigerating modules selected, the evaporators can all be above freezing, all below freezing, or a mixture of above freezer and below freezing refrigerating modules and/or in addition to refrigerator freezer module 160.

[0035] Refrigerating module 160 can be a two temperature refrigerator freezer module that can be arranged to have an above freezing refrigerator compartment 168 and a below freezing freezer compartment 166 as noted above. An insulated compartment separator 164 can be provided to divide insulated cabinet 162 into a refrigerator compartment 168 and a freezer compartment 166. Freezer compartment 166 can have an evaporator compartment that can be formed by an evaporator compartment wall 170 that can be arranged to separate the refrigerating module evaporator 130 from the freezer compartment 166. Evaporator compartment wall 170 is illustrated schematically as a dashed line below refrigerating module evaporator 130 to indicate that air flows (air flow arrows 148) into freezer compartment 166 from the refrigerating module evaporator 130, and similarly, air returns to the evaporator compartment under the influence of refrigerating module evaporator fan 132. Insulated compartment separator 164 can have chilled air passages 176 positioned on compartment separator 164 that can allow chilled air (air flow arrows 158) from the freezer compartment 166 or evaporator compartment to flow into refrigerator compartment 168 as is well known in the art. Compartment separator 164 can have a refrigerator compartment damper 178 to control the flow of air from the refrigerator compartment 168 back to freezer compartment 166 and refrigerating module evaporator 130 drawn by refrigerating module evaporator fan 132. In the embodiment of the invention illustrated in Fig. 4, refrigerator compartment damper 178 is shown in the return air path from refrigerator compartment 168. Those skilled in the art will understand that chilled air passages 176 could be arranged in the return air path from refrigerator compartment 168 and refrigerant compartment damper 178 arranged in the flow of chilled air into refrigerator compartment 168 if desired. Refrigerator compartment damper 178 can be an automatic damper operated by controller 150 as illustrated in Fig. 4, or, if desired, refrigerator compartment damper 178 can be a manually adjustable damper manually adjusted by the user and temperature sensor 134 and temperature selector 136 eliminated from freezer compartment 166.

[0036] Similar to the embodiment of Fig. 3, according to the invention, central cooling unit 110 can be continuously operating so that refrigerant is continuously circulated in insulated supply conduits 142 and return conduits 144 forming a cooling medium circuit from condenser 114 through manifold 117 to refrigerating modules 120, 124 and 160 and back to compressor 112 through accumulator 118. Controller 150 can be arranged to adjust the capacity of the central cooling unit 110 in response to the aggregate cooling load of the plurality of refrigerating modules 120, 124 and 160. As noted above, while three refrigerating modules 120, 124 and 160 are illustrated in Fig. 4, according to the invention one or two or more than three refrigerating modules can be connected in the refrigerating appliance system. The aggregate cooling load can be determined by the first portion 152 of controller 150 as a function of temperatures sensed by temperature sensors 134, operating temperatures selected with temperature selectors 136, and feedback from expansion devices 138. Controller 150 can also be arranged to control the operating temperature in each of the refrigerating modules 120, 124 and 160. Second portion 154 of controller 150 can be arranged to control expansion devices 138 and refrigerating module evaporator fans 132 to maintain the selected operating temperatures based on the settings of temperature selectors 136 and temperature sensors 134. In addition, second portion 154 of controller 150 can be arranged to control refrigerator compartment damper 178 to control the amount of chilled air flowing from freezer compartment 166 and refrigerating module evaporator 132 through compartment separator 164 into refrigerator compartment 168 in conjunction with refrigerating module evaporator fan 132 to maintain the user selected temperature in refrigerator compartment 168 as well as in freezer compartment 166. Controller 150 can be arranged to maintain approximately the same evaporator pressure in the refrigerating module evaporators 130 and control the temperature in the respective refrigerating modules 120, 124 and 160 by varying the flow of refrigerant into the refrigerating module evaporators 130 and controlling the speed of the respective refrigerating module evaporator fans 132. Thus, according to the invention, a single, continuously operating variable capacity central cooling unit 110 can be provided for a plurality of refrigerating modules 120, 124 and 160 that can be set to operate at different operating temperatures, and refrigerating module 160 can be set to have a refrigerator compartment and a freezer compartment. The variable capacity central cooling unit 110 can be arranged for chilling a cooling medium, a refrigerant. A cooling medium circuit, insulated supply conduits and insulated return conduits 142, 144, can be provided connecting the central cooling unit 110 to supply the cooling medium from the central cooling unit 110 to the plurality of refrigerating modules 120, 124 and 160. A plurality of cooling medium flow control devices, expansion devices 138, can be provided for controlling flow of cooling medium, refrigerant, to each of the refrigerating modules 120, 124 and 160. A controller 150 and control circuit 156 can be provided to adjust the capacity of the variable capacity central cooling unit 110 in order to supply sufficient cooling medium to cool the plurality of refrigerating modules 120, 124 and 160 to the respective selected operating temperatures, and the controller 150 and control circuit 156 can be arranged adjust the volume of cooling medium, refrigerant, directed to respective ones of the refrigerating modules 120, 124 and 160 by controlling the cooling medium flow control devices, expansion devices 138 and refrigerating module evaporator fans 132, to maintain the selected operating temperature in the respective refrigerating modules 120, 124 and 160. Controller 150 can control the speed of variable speed compressor 112, variable speed condenser fan 116 and expansion devices 138 to control the vapor pressure of the cooling medium, refrigerant, in the cooling medium circuit, insulated supply and return conduits 142, 144, to further control the operating temperature in the respective refrigerating modules 120, 124 and 160.

[0037] Turning to Fig. 5, a freezer module 180 is illustrated that can be used in combination with a refrigeration appliance system according to the invention. Freezer module 180 can be a conventional freezer capable of operating without connection to the refrigeration appliance system according to the invention. Particularly when a freezer module arranged for 0°F storage temperatures is desired for use in combination with the embodiments illustrated in Fig. 1 (employing liquid coolant as the cooling medium), Fig. 2 (employing chilled air as the cooling medium), or Fig. 3 (particularly when above freezing refrigerator modules will be connected in the refrigeration appliance system) it can be advantageous to incorporate a freezer module 180 as illustrated in Fig. 5. However, a freezer module 180 can be combined with any of the embodiments according to the invention. Freezer module 180 can have a insulated freezer cabinet 182 defining an opening 184 for access to the freezer compartment and can have an insulated freezer door 185 hinged to the insulated freezer cabinet 182 to selectively open and close the freezer compartment. Freezer door 185 can have a handle, not shown, to facilitate opening and closing freezer door 185 for access to freezer module 180. Freezer module 180 can include a freezer cooling unit 189 in a machinery compartment 186 outside the refrigerated portion of the freezer cabinet 182 that can include a freezer compressor 190, a freezer condenser 192 and a freezer condenser fan 194. Freezer module 180 can include a freezer evaporator 196 that can be positioned in insulated freezer cabinet 182 and can have a freezer evaporator fan 198 and a freezer expansion device 204. Freezer module 180 can have a freezer temperature sensor 200 that can be similar to the temperature sensors described above. Freezer module 180 can also have a freezer temperature selector 202 to allow user to select the operating temperature for the freezer module. Freezer module 180 can have a controller 208 and a control circuit 206 connecting the freezer temperature sensor 200, freezer temperature selector 202, freezer compressor 190, freezer condenser fan 194 and freezer evaporator fan 198 to controller 208. Controller 208 can operate freezer module 180 in a manner similar to conventional freezer products as is well known in the art. Those skilled in the art will understand that freezer compressor 190, freezer condenser fan 194 and freezer evaporator fan 198 can be provided with variable speed motors as desired for optimum operation. Freezer expansion device 204 can be an expansion device with feedback as used in the embodiments of Figs. 1-4 or can be a capillary tube expansion device, again as well known in the art. Freezer compressor 190 can be a variable speed compressor if desired as is well known in the art. Alternately, those skilled in the art will understand that freezer condenser 192 and/or freezer evaporator 196 can be static heat exchangers and that if a static heat exchanger is used the respective freezer condenser fan 194 and/or freezer evaporator fan 198 could be eliminated. For example freezer module 180 could be a chest freezer having freezer evaporator 196 positioned in contact with the inner liner 210 defining the freezer compartment in the insulation between the inner liner 210 and cabinet 182 as is well known in the art. Similarly, freezer condenser 192 could be positioned in contact with cabinet 182 positioned in the insulation between inner liner 210 and cabinet 182 as is well known in the art.

[0038] While the invention has been specifically described in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not of limitation, and the scope of the invention is defined by the appended claims.

Parts List

[0039]

10	Central cooling unit	56	Control circuit
11		57	
12	Variable speed compressor	58	
13		59	
14	Condenser	60	Central cooling unit
15		61	
16	Variable speed condenser fan	62	Variable speed compressor
17		63	
18	Expansion device	64	Condenser
19		65	
20	Refrigerating module	66	Variable speed condenser fan
21		67	
22	Refrigerating module	68	Expansion device
23		69	
24	Insulated cabinet	70	Refrigerating module
25	Insulated door	71	
26	Insulated cabinet	72	Refrigerating module
27	Insulated door	73	
28	Opening	74	Insulated cabinet
29	Opening	75	Insulated door
30	Heat exchanger	76	Insulated cabinet
31		77	Insulated door

(continued)

32	Adjustable speed heat exchanger fan	78	Opening
33		79	Opening
34	Temperature sensor	80	Air flow arrows
35		82	
36	Temperature selector	83	
37		84	Temperature sensor
38	Air flow arrows	85	
39		86	Temperature selector
40	Chilled liquid evaporator	87	
41		88	
42	Insulated conduits	89	
43		90	Evaporator
44	Variable speed pump	91	
45		92	Insulated ducts
46	On-off valve	93	Air inlet
47		94	Variable speed evaporator fan
48		95	Air outlet
49		96	Baffle
50	Controller	97	
51		98	
52	1st portion of the controller	99	
53		100	Controller
54	2nd portion of the controller	101	
55		102	1st portion of the controller
103		149	
104	2nd portion of the controller	150	Controller
105		151	
106		152	1st portion of the controller
107		153	
108		154	2nd portion of the controller
109		155	
110	Central cooling unit	156	
111		157	
112	Variable speed compressor	158	Air flow arrows
113		159	
114	Condenser	160	Refrigerator freezer module
115		161	
116	Variable speed condenser fan	162	Insulated cabinet
117	Manifold	163	

(continued)

118	Accumulator	164	Compartment separator
119		165	
120	Refrigerating module	166	Freezer compartment
121		167	
122	Refrigerating module	168	Refrigerator compartment
123		169	
124	Refrigerating module	170	Evaporator compartment wall
125		171	
126	Insulated cabinet	172	Freezer compartment door
127	Insulated door	173	
128	Insulated cabinet	174	Refrigerator compartment door
129	Insulated door	175	
130	Refrigerating module evaporator	176	Chilled air passage
131		177	
132	Variable speed refrigerating module evaporator fan	178	Refrigerator compartment damper
133		179	
134	Temperature sensor	180	Freezer module
135	Opening	181	
136	Temperature selector	182	Insulated freezer cabinet
137	Opening	183	
138	Expansion device	184	Opening
139	Opening	185	Insulated freezer door
140	Insulated cabinet	186	Machinery compartment
141	Insulated door	187	
142	Insulated supply conduits	188	Air flow arrows
143		189	Freezer cooling unit
144	Insulated return conduits	190	Freezer compressor
145		191	
146		192	Freezer condenser
147		193	
148	Air flow arrows	194	Freezer condenser fan
195			
196	Freezer evaporator		
197			
198	Freezer evaporator fan		
199			
200	Freezer temperature sensor		
201			

(continued)

202	Freezer temperature selector		
203			
204	Freezer expansion device		
205			
206	Freezer control circuit		
207			
208	Freezer controller		
209			
210	Inner liner		

Claims

1. A refrigeration appliance system constructed and arranged for use in a residential kitchen and other rooms in a dwelling comprising:

a plurality of separate refrigerating modules each having:

an insulated cabinet having an opening for access to the interior of the cabinet;
at least one insulated door for covering and uncovering an opening in the insulated cabinet;
an apparatus for receiving a cooling medium to cool the interior of the refrigerating module;
at least one temperature sensor for sensing the temperature in the module; and
at least one temperature selector for selecting an operating temperature for the insulated refrigerating module;

a single, continuously operating variable capacity central cooling unit for chilling a cooling medium comprising a variable speed compressor, a condenser, a variable speed condenser fan and a controller;
a cooling medium circuit connecting the central cooling unit and the plurality of refrigerating modules to supply cooling medium from the central cooling unit to the plurality of refrigerating modules, and to return cooling medium to the central cooling unit from the refrigerating modules;
a plurality of cooling medium flow control devices connected in the cooling medium circuit for controlling flow of cooling medium to each of the refrigerating modules;
a control circuit connecting the temperature sensors, the temperature selectors and the cooling medium flow control devices for the plurality of refrigerating modules with the controller, said controller including:

a first portion to adjust the capacity of the central cooling unit in response to the aggregate cooling load of the plurality of refrigerating modules in order to supply sufficient cooling medium to cool the plurality of refrigerating modules to the respective selected operating temperatures, and
a second portion to adjust the volume of cooling medium directed to respective ones of the refrigerating modules to maintain the selected operating temperature in the respective refrigerating modules; and

at least one below freezing freezer module comprising:

an insulated freezer cabinet defining a freezer compartment having an opening for access to the freezer compartment and an insulated freezer door for selectively closing the opening;
a freezer cooling unit comprising a freezer compressor and a freezer condenser;
a freezer evaporator for cooling the freezer compartment;
a freezer expansion device connected in a refrigerant circuit with the freezer cooling unit and freezer evaporator;

a freezer temperature sensor for sensing the temperature in the freezer compartment;
a freezer temperature selector for selecting an operating temperature for the freezer compartment; and
a freezer control circuit connecting the freezer temperature sensor, the freezer temperature selector, the freezer cooling unit to control operation of the freezer cooling unit to maintain the selected freezer compartment temperature.

2. The refrigeration appliance system of claim 1, wherein the freezer module includes a freezer evaporator fan connected in the freezer control circuit and arranged to circulate air chilled by the freezer evaporator in the freezer compartment.

3. The refrigeration appliance system of claim 2, wherein the freezer cooling unit includes a freezer condenser fan connected in the freezer control circuit.

4. The refrigeration appliance system of claim 3, wherein the freezer evaporator fan and the freezer condenser fan are variable speed fans.

5. The refrigeration appliance system of claim 4, wherein the freezer compressor is a variable speed compressor and the freezer expansion device is an expansion device with feedback based on load for adjusting flow of refrigerant to the freezer evaporator, and wherein the freezer control circuit is arranged to control the variable speed compressor, variable speed freezer condenser fan, variable speed evaporator fan and freezer expansion device to maintain the selected operating temperature in the freezer compartment.

6. The refrigeration appliance system of claim 1, wherein the cooling medium is air; the cooling medium circuit comprises insulated ducts connecting the central cooling unit and the plurality of refrigerating modules for supplying chilled air to the plurality of refrigerating modules and returning air from the refrigerating modules to the central cooling unit; the apparatus for receiving a cooling medium comprises air inlets from the insulated ducts leading to the respective refrigerating modules and air outlets leading from the respective refrigerating modules to the insulated ducts; and the cooling medium flow control devices comprise a baffle for each refrigerating module for controlling the flow of chilled air flowing into the refrigerating module through the air inlet; the central cooling unit further comprises an evaporator and an expansion device with feedback based on the refrigerating system load connected in a refrigerant circuit with the variable speed compressor and condenser and arranged to chill the cooling medium air to a temperature below the lowest selected refrigerating module operating temperature and at least one evaporator fan to circulate the chilled cooling medium air through the insulated ducts to respective refrigerating modules; and the second portion of the controller is arranged to operate the baffles of the respective refrigerating modules to control the flow of chilled air flowing into the respective refrigerating modules to maintain the respective selected operating temperatures.

7. The refrigeration appliance system of claim 1, wherein the cooling medium is a liquid coolant; the cooling medium circuit includes insulated conduits leading from the central cooling unit to each of the refrigerating modules for supplying liquid coolant to each of the refrigerating modules and for returning liquid coolant to the central cooling unit; the apparatus for receiving cooling medium for the respective refrigerating modules comprises a heat exchanger in communication with the interior of the insulated cabinet; and the cooling medium flow control devices comprise a valve for controlling the flow of liquid coolant to the heat exchanger; the central cooling unit further comprises a chilled liquid evaporator and an expansion device with feedback based on the refrigerating system load connected in a refrigerant circuit with the variable speed compressor and condenser and arranged to chill the liquid coolant to a temperature below the lowest selected refrigerating module operating temperature, and a pump arranged to circulate the liquid coolant to the respective refrigerating modules; and the second portion of the controller is arranged to operate the valves to control the flow of chilled liquid coolant through the respective refrigerating module heat exchangers to maintain the respective selected operating temperatures.

8. The refrigeration appliance system of claim 7, wherein the valves are on-off valves to control flow of liquid coolant to the respective refrigerating modules, and the pump is a variable speed pump and the first portion of the controller adjusts the flow rate of liquid coolant in the cooling medium circuit by controlling the speed of the variable speed pump.

9. The refrigeration appliance system of claim 7, wherein each of the refrigerating modules further includes a variable speed heat exchanger fan arranged for circulating air over the heat exchanger in the insulated cabinet.

10. The refrigeration appliance system of claim 1, wherein the cooling medium is a refrigerant; the cooling medium circuit includes insulated conduits leading from the central cooling unit to each of the refrigerating modules for

supplying refrigerant to each of the refrigerating modules and for returning refrigerant to the central cooling unit; the apparatus for receiving cooling medium comprises a refrigerating module evaporator in communication with the interior of the insulated cabinet and a refrigerating module evaporator fan arranged to circulate air chilled by the refrigerating module evaporator in the insulated cabinet; the cooling medium flow control devices comprise expansion devices with feedback based on load for adjusting flow of refrigerant to the refrigerating module evaporators of the respective refrigerating modules; and the second portion of the controller is arranged to control the expansion valves for the respective refrigerating modules to maintain the respective selected operating temperatures.

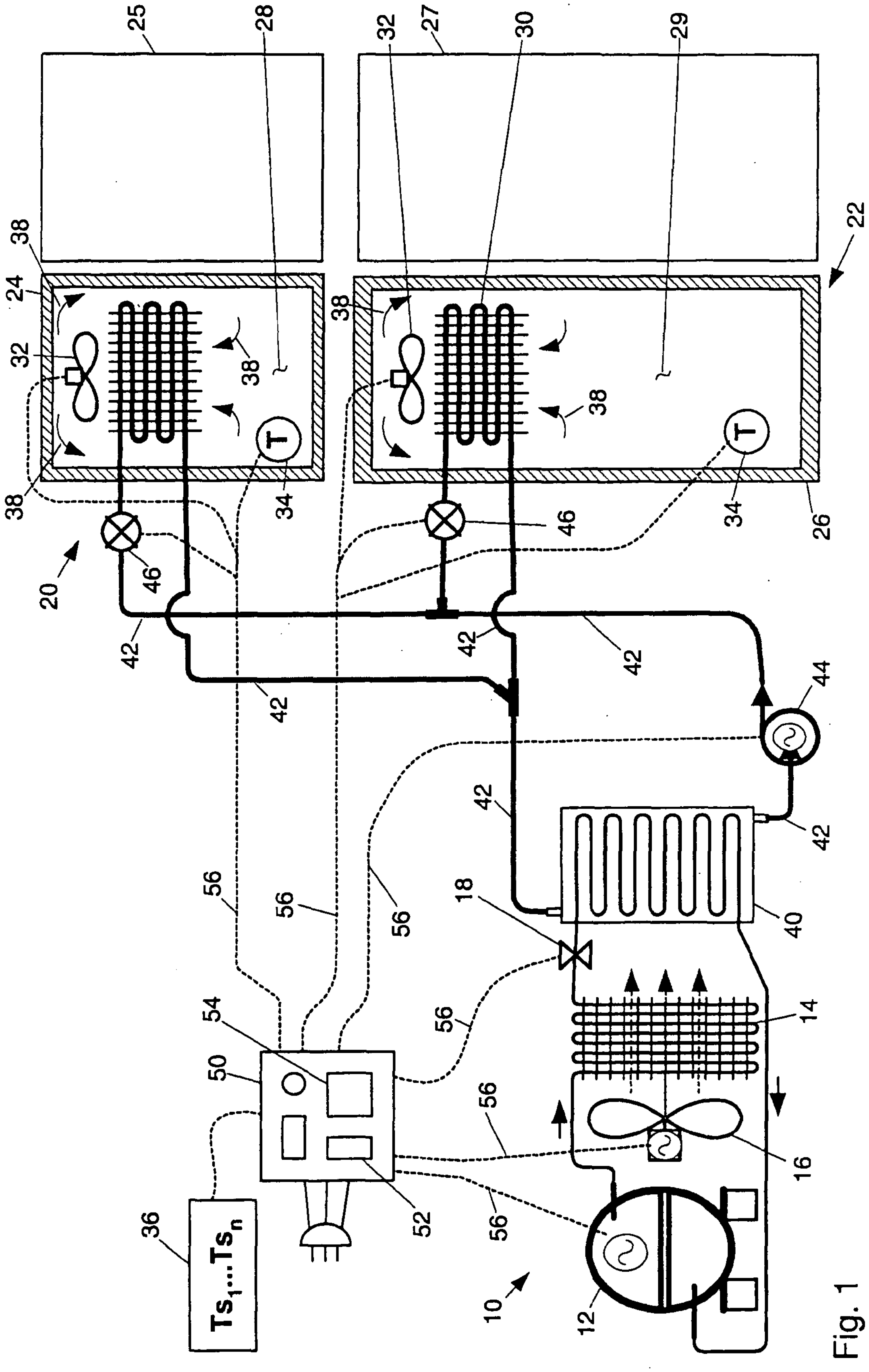
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Fig. 1

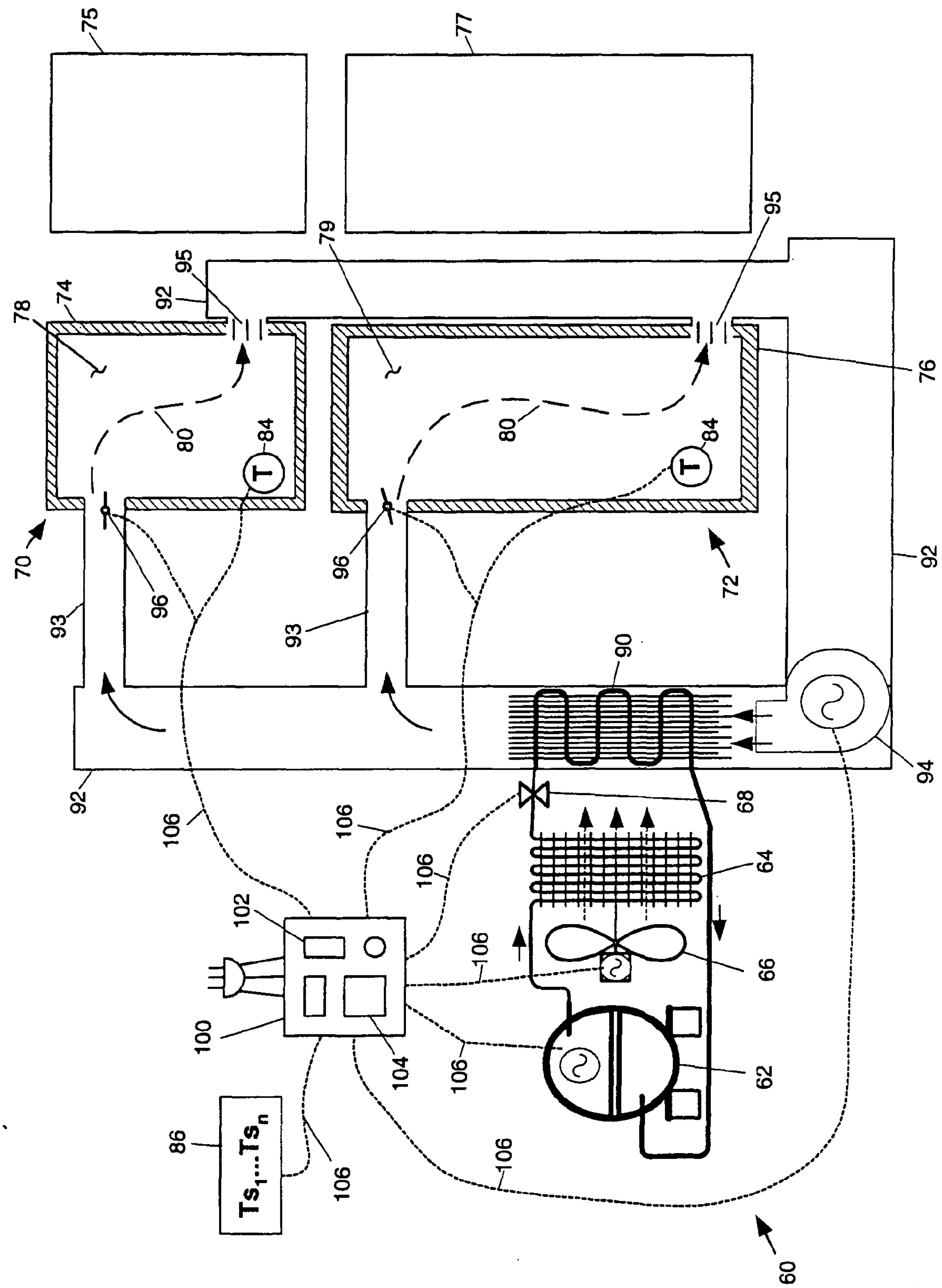
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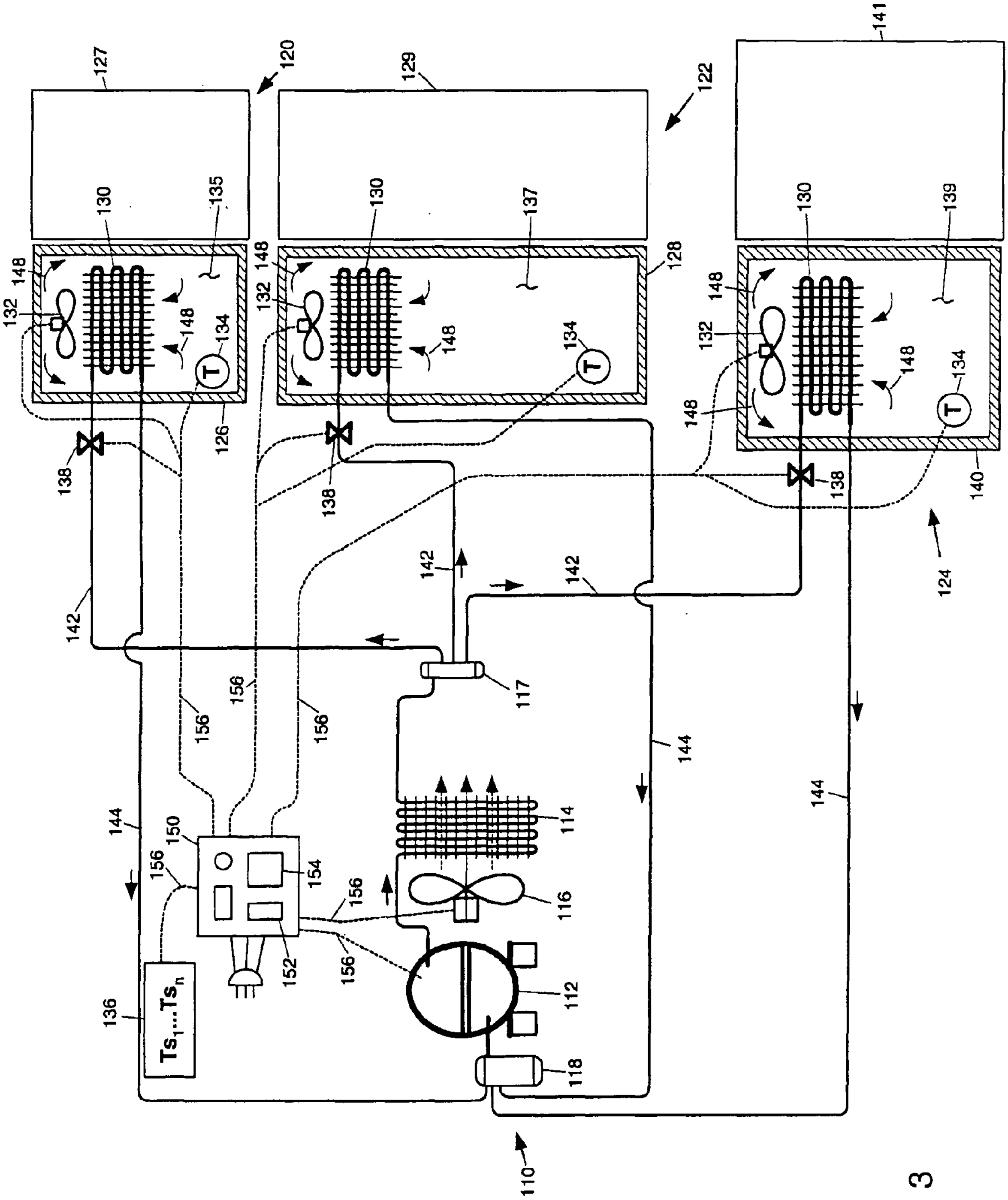
Fig. 2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136
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110
124

Fig. 3

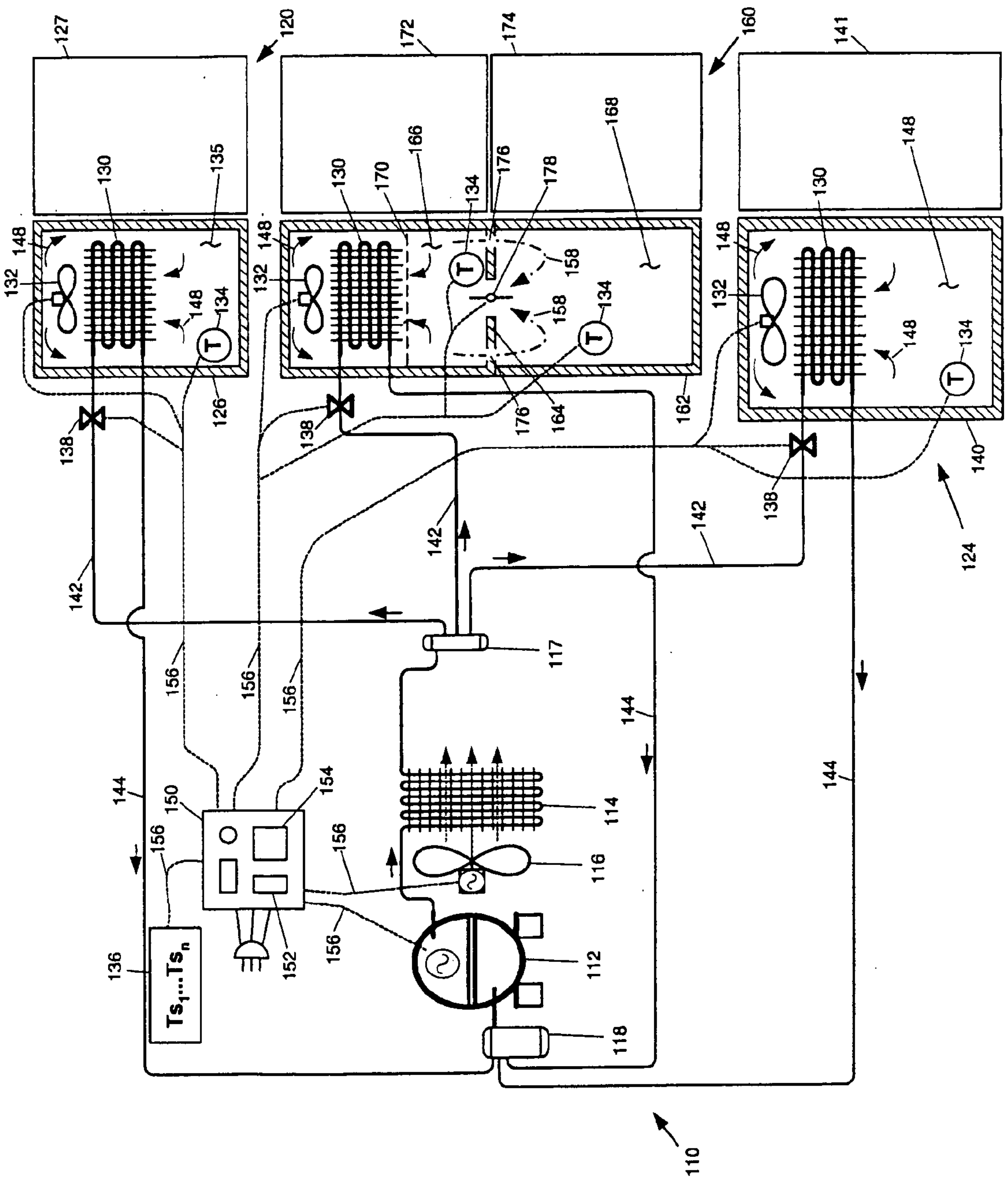
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Fig. 4

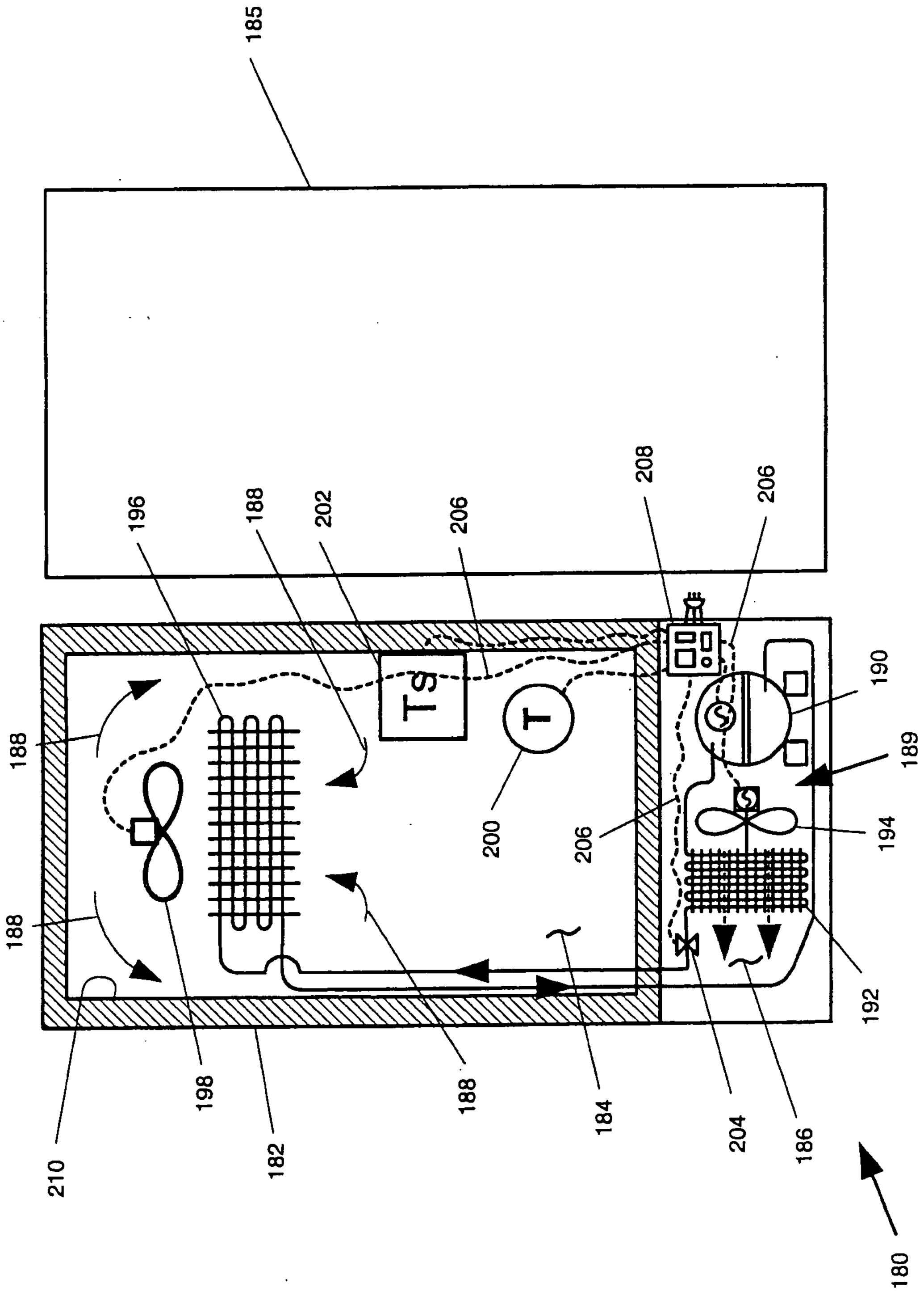
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Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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