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REVERSE CYCLE REFRIGERATION APPARATUS

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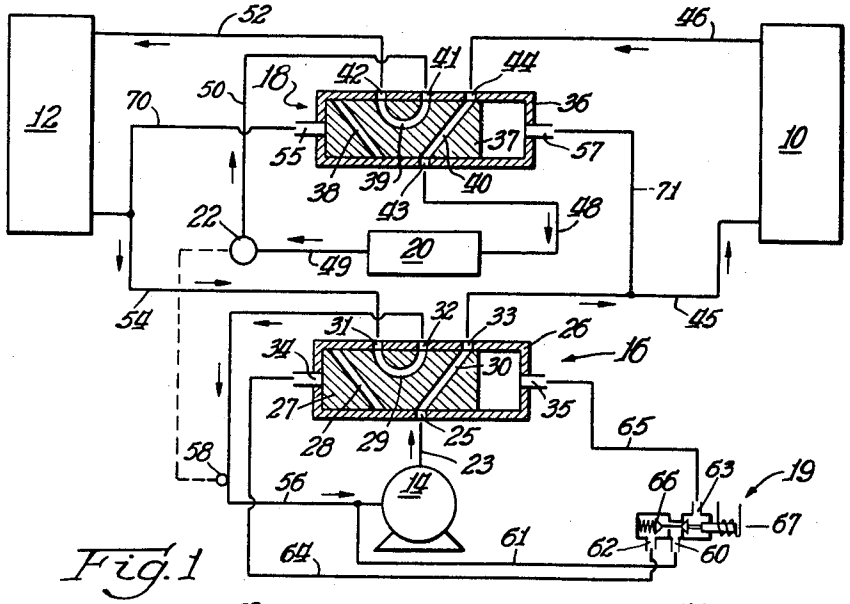


Fig. 1

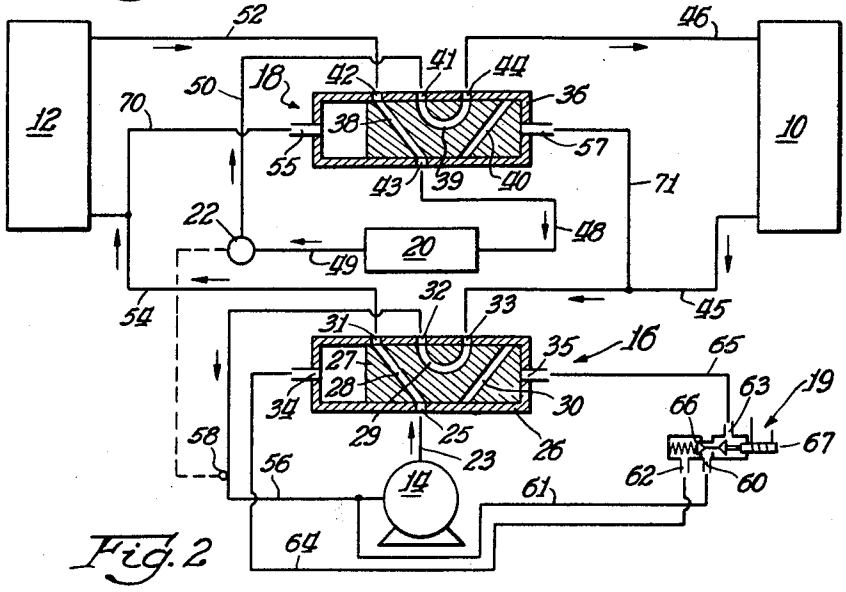


Fig. 2

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REVERSE CYCLE REFRIGERATION APPARATUS

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This invention relates to improvements in closed circuit, reverse cycle refrigeration apparatus or heat pumps of the type especially adapted for use in year-around air-conditioning systems. The invention is more particularly concerned with a unit having an outside heat exchanger and an inside heat exchanger in combination with means for reversing refrigerant flow between said heat exchangers to selectively provide cooling or heating depending on whether the inside heat exchanger is functioning as an evaporator or a condenser.

Apparatus of the aforementioned class generally includes a compressor, a pair of expansion valves or capillary elements, a pair of check valves and a reversing valve. These elements are connected with the inside and outside heat exchangers to permit operation of the system in both the heating mode and the cooling mode. When heating is required, the inside heat exchanger functions as a condenser discharging heat to the air circulating inside the room, and the outside heat exchanger functions as an evaporator. When cooling is required, the inside heat exchanger functions as an evaporator and the outside heat exchanger functions as a condenser, rejecting heat to the outside atmosphere. One common design includes a pair of conduits connected in parallel between the two heat exchangers with a separate expansion valve in each line. In this arrangement, each conduit also includes a check valve permitting flow in one direction only so that during one mode of operation, the check valve permits flow from the condensing heat exchanger through the expansion valve to the evaporating heat exchanger while the check valve in the other conduit blocks flow through said conduit from the evaporating heat exchanger to the condensing heat exchanger thereby rendering the other expansion valve inoperative.

A number of problems are associated with this type of system. First of all, the expansion valves have control bulbs respectively associated with two different lines which alternately interconnect with the suction and discharge side of the compressor. Consequently, each of the expansion valve control bulbs is responsive to the temperature of a line which is alternately conducting hot gas from and cold gas to the compressor. This wide variation in temperatures and the corresponding pressures acting on the expansion valve diaphragms quite obviously has a detrimental effect on their operational life.

Another factor is the effective location of the filter-drier means conventionally employed to absorb moisture and filter dirt and other foreign materials from the refrigerant. Ideally, the filter-drier should be placed between the condensing heat exchanger and the expansion valve. Inasmuch as the most effective filter-drier means are unidirectional in operation, the system described above either requires the use of two separate filter-drier elements or the omission of a single filter-drier from the circuit during either the heating cycle or the cooling cycle.

Another known apparatus avoids some of these problems by using one reversing valve and another valve which may be regarded as a flow control valve, the latter being responsive to the pressure differential across the expansion valve. One disadvantage of this system is that the flow control valve must be designed to insure operation over a wide range of condensing temperatures. Moreover, there is the inherent possibility of a considerable time lag between the actuation of the reversing valve and the subsequent switchover of the flow control valve.

It is therefore a principal object of the invention to provide an improved reverse cycle refrigeration system having increased reliability and quick response to actuation of the master reversing valve.

Another object of the invention is to provide a reverse cycle refrigeration system which avoids wide variations in the pressure acting on the expansion valve diaphragm.

Additional objects and advantages will be apparent from a reading of the following detailed description taken in conjunction with the appended drawings wherein:

FIGURE 1 is a schematic diagram illustrating the refrigeration circuit in the heating mode; and

FIGURE 2 is a schematic diagram illustrating the refrigeration circuit in the cooling mode.

Referring now to FIGURE 1, a preferred embodiment of the invention includes a first heat exchanger **10**, a second heat exchanger **12**, a compressor **14**, and a refrigeration circuit including a first reversing valve **16**, a second reversing valve **18**, a pilot valve **19**, a filter-drier means **20** and an expansion valve **22**. Heat exchangers **10** and **12** are arranged so that their respective functions, i.e., evaporating and condensing, are adapted to be interchanged by reversing the direction of refrigerant flow through the system. For purposes of illustration, it will be assumed that the apparatus is employed in a typical comfort air conditioning system and that heat exchanger **10** is the inside coil and heat exchanger **12** is the outside coil.

Compressor **14**, which may be of any conventional design, has a suction side and a discharge side, the latter being fluidly interconnected to a port **25** in reversing valve **16** through conduit means **23**. Reversing valve **16**, the master valve, comprises a hollow casing **26** and a slidable spool member **27** received therein. The casing **26** is provided with control pressure ports **34**, **35** at opposite ends of the casing, said ports cooperating with the pilot valve **19** to move the spool member **27** in a manner to be described in greater detail below.

In addition to port **25**, reversing valve **16** includes additional refrigerant ports **31**, **32**, and **33**. Depending on the position of the spool element, port **32** is adapted to be selectively interconnected to either port **31** or **33** through fluid passage means **29** in valve spool **27**. Similarly, the port **25** is adapted to be selectively interconnected to either port **31** or port **33** through fluid passage means **28** and **30**, respectively, in spool member **27**.

Reversing valve **18**, the slave valve, is of the same general design as reversing valve **16**, and comprises a casing **36** including control pressure ports **55**, **57** and refrigerant ports **41**, **42**, **43**, and **44**, and a slidable spool member **37** having fluid passage means **38**, **39**, and **40** provided therein. The pilot valve **19** may be of the solenoid actuated type and includes a port **60**, communicating at all times with compressor suction pressure through line **61**, and additional ports **62**, **63** respectively communicating with control pressure ports **34**, **35** in valve **16** through lines **64**, **65**. The position of pilot valve element **66**, which is controlled by solenoid **67**, determines the position of spool member **27** in the master reversing valve **16** by selectively interconnecting either control pressure port **34** or control pressure port **35** with compressor suction.

The circuit connecting the reversing valves, the compressor, and the heat exchangers includes conduit means **45** connecting port **33** in valve **16** to heat exchanger **10**; conduit means **46** connecting heat exchanger **10** with port **44** in valve **18**; conduit means **48** connecting port **43** with the filter-drier means **20**; conduit means **49** con-

necting filter-drier means 20 to the expansion valve 22; conduit means 50 connecting the expansion valve with port 41 in valve 18; conduit means 52 connecting port 42 in valve 18 with heat exchanger 12; conduit means 54 connecting heat exchanger 12 with port 31 in valve 16; conduit means 56 connecting port 32 in valve 16 to the suction side of the compressor; conduit means 70 connecting control pressure port 55 with conduit means 54; and conduit means 71 connecting control pressure port 57 with conduit means 45. Thermal sensing bulb 58 for expansion valve 22 is associated with conduit means 56, which constitutes the compressor suction line regardless of whether the unit is operating in the heating or cooling mode.

Operation

Referring first to FIGURE 1, to operate the unit in the heating mode, the solenoid 67 is energized to move the pilot valve element 66 against the opposition of the spring thereby positioning said element so that port 62 is in fluid communication with the suction pressure port 60. Suction is thus applied to control pressure port 34 in the master reversing valve 16 through conduit means 61 and 64. Since the other control pressure port 35 is closed, the suction applied at port 34 moves the valve spool member to the left to assume and maintain the position illustrated in FIGURE 1. The hot refrigerant gas discharged from the compressor flows to the inside heat exchanger 10 via conduit means 23, fluid passage means 30, and conduit means 45. At the same time, gas under pressure is supplied through line 71 to control pressure port 57 in the slave reversing valve 18 thereby shifting and maintaining the spool in the position shown in FIGURE 1. Refrigerant flow continues through the passage 40 in spool member 37, conduit means 48, the filter-drier means 20, expansion valve 22 and line 52 to heat exchanger 12 which is functioning as an evaporator. Thereafter, the cold, low-pressure refrigerant gas returns to the suction side of the compressor through conduit means 54, fluid passage means 29 in spool member 27 and conduit means 56. When the system is switched over to the cooling cycle, solenoid 67 is de-energized to effect fluid communication between the suction side of the compressor and control pressure port 35 in master reversing valve 16. This causes the spool member to shift to the right to assume and maintain the position shown in FIGURE 2.

Simultaneously, the hot gas discharge line is shifted from line 45 to line 54 thereby supplying hot gas through line 70 to the control pressure port 55 in the slave reversing valve 18. Refrigerant flows through heat exchanger 12, conduit means 52, fluid passage means 38, filter-drier means 20, expansion valve 22, conduit means 50, fluid passage means 39 and conduit means 46 to the inside heat exchanger 10 now functioning as an evaporator. Cold gas is returned through conduit means 45, fluid passage means 29 in the valve spool 27 through conduit means 56 to the suction side of the compressor.

It will be apparent from the foregoing description that the advantages of maintaining refrigerant flow through the filter-drier and the expansion valve element are combined with the quick response achieved by utilizing hot gas pressure from the compressor to actuate the slave reversing valve.

While this invention has been described in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not by way of limitation; and the scope of this invention is defined solely by the appended claims which should be construed as broadly as the prior art will permit.

What is claimed is:

1. In a closed circuit, reverse cycle refrigeration apparatus:

a compressor;

an inside heat exchanger;

an outside heat exchanger;

a refrigeration circuit connecting said compressor and said inside and outside heat exchangers, said circuit comprising:

a first reversing valve adapted to selectively and alternately direct refrigerant gas discharged from said compressor to said inside heat exchanger or said outside heat exchanger;

conduit means including, in series, a filter-drier means and an expansion valve;

a second reversing valve interconnecting said inside heat exchanger, said outside heat exchanger and said conduit means, said second reversing valve being arranged to reverse flow of refrigerant between said inside heat exchanger and said outside heat exchanger through said conduit means while maintaining refrigerant flow through said conduit means in the same direction regardless of the direction of the refrigerant flow between said inside and outside heat exchangers;

means for actuating said first reversing valve; and

means associated with said first reversing valve to selectively direct high pressure refrigerant gas to said second reversing valve, said gas being effective to actuate said second reversing valve whereby said second reversing valve is actuated in response to said first reversing valve.

2. An apparatus as defined in claim 1 wherein said first reversing valve includes a slidable spool member and a pair of control pressure ports, said spool member and said control pressure ports being arranged so that the position of said spool member is a function of the pressure differential between said control ports.

3. An apparatus as defined in claim 2 wherein said means for actuating said first reversing valve comprises a pilot valve adapted to selectively and alternately interconnect said control pressure ports with compressor suction pressure.

4. In a closed circuit, reverse cycle refrigeration system, the combination comprising:

a compressor having a discharge side and a suction side;

a first heat exchanger;

a second heat exchanger;

a first reversing valve having a refrigerant port connected to the discharge side of said compressor and a slidable spool member having fluid passage means adapted to selectively and alternately interconnect said port with said first heat exchanger or said second heat exchanger, said spool element having additional fluid passage means adapted to selectively and alternately interconnect said second heat exchanger or said first heat exchanger with the suction side of said compressor;

conduit means including a filter-drier means and an expansion valve means, said expansion valve means being responsive to the temperature of cold refrigerant gas on the suction side of said compressor;

a second reversing valve having a slidable spool member which is provided with fluid passage means adapted to selectively and alternately interconnect said first and second heat exchangers through said conduit means, said second reversing valve being effective to reverse the flow of refrigerant between said first heat exchanger and said second heat exchanger without changing the direction of refrigerant flow through said conduit means; and

means for conducting compressor discharge gas to said second reversing valve to move the spool member in said second reversing valve means in response to the direction of the refrigerant gas flow from said compressor, whereby a shift in the position of the spool member in said first reversing valve effects a corresponding shift in the position of the spool member in said second reversing valve.

5. In a system as defined in claim 4, means for selectively subjecting the spool member in said first re-

versing valve to compressor suction pressure, whereby said spool member is shifted by said suction pressure.

6. In a system as defined in claim 4:

means defining a pair of control pressure ports in said first reversing valve;

a pilot valve connected to the suction side of said compressor;

conduit means connecting each of said control pressure ports to said pilot valve, said valve being operative to selectively and alternately interconnect said pressure ports with the suction side of said compressor; and

means defining a pair of control pressure ports in said second reversing valve adapted to selectively supply high pressure refrigerant gas to opposite ends of the spool member in said second reversing valve.

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