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AIR CONDITIONING SYSTEM

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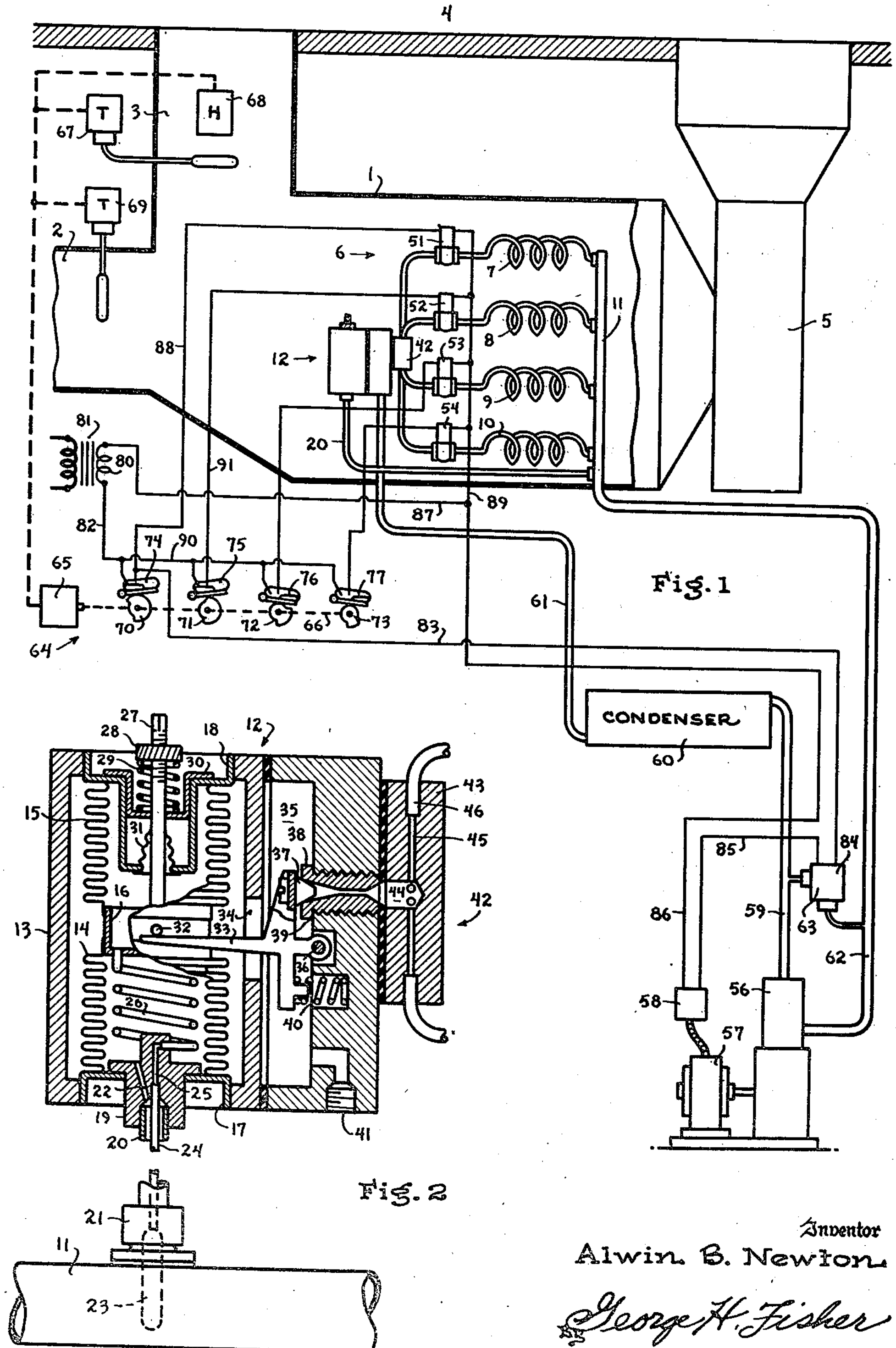

Fig. 1

Fig. 2

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AIR CONDITIONING SYSTEM

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4 Claims. (Cl. 62—6)

This invention relates in general to air conditioning and more particularly to automatic controls therefor.

In the air conditioning art, it has become common to provide for varying the capacity of an air conditioning unit by using a plurality of direct expansion cooling coils, each coil having a separate expansion valve and also having a solenoid valve, the solenoid valves being sequentially controlled in accordance with the cooling load for thereby varying the number of coils in operation in accordance with the cooling load. This type of arrangement while being very flexible and efficient has the disadvantage of being relatively expensive, due to its requiring a separate expansion valve for each coil.

It is an object of this invention to provide a system of this general type which is not only both effective and flexible but which also does not require a separate expansion valve for each coil. This result is achieved by employing a single large expansion valve for the entire group of coils, and by providing a distributor which equally distributes the refrigerant from the expansion valve to the coils, the cut-off valves being located in the connections between the distributor and coils.

Other objects will appear from the following description and the appended claims.

For a full disclosure of this invention reference is made to the following detailed description and to the accompanying drawing, in which:

Figure 1 is a diagrammatic illustration of an air conditioning system embodying the features of the invention, and

Figure 2 is an elevation in section showing the expansion valve and distributor arrangement for the direct expansion coils.

Referring to Figure 1, reference character 1 indicates an air conditioning chamber having a fresh air inlet 2, and a return air inlet 3 which communicates with a space to be conditioned 4. The discharge end of the chamber 1 is connected to a fan 5 which acts to draw air through the chamber 1 and discharge it through suitable duct means into the space 4. Located within the chamber 1 is a heat exchange device generally indicated as 6, this heat exchange device being adapted to operate as an evaporator for cooling the space. The heat exchange device 6 preferably is formed of a plurality of separate cooling coils or refrigerant passes 7, 8, 9, and 10. The right-hand ends of these coils are connected to a suitable header 11 while the left-hand ends of these coils are connected to a combined expansion valve and distributor device indicated as 12.

Referring now to Figure 2, this figure indicates the construction of the combined expansion valve and distributor device 12. Referring to the expansion valve portion of this device, this valve may be of the same type shown in my co-pending application Serial No. 192,818, filed February 26, 1938. This expansion valve may comprise a diaphragm casing 13 which houses a diaphragm structure formed of diaphragms 14 and 15 and a connecting member 16. The diaphragm or bellows 14 is sealed to the lower surface of the diaphragm casing 13 and the lower end thereof is closed by means of a cup member 17. The bellows 15 is similarly sealed to the upper end of casing 13, and its open end is closed by means of a cup member 18. Both the bellows 14 and the bellows 15 are sealed as by soldering to the member 16 so as to provide a unitary fluid tight device. The cup member 17 is provided with a fitting 19 which is connected by a pipe 20 to a fitting 21 located on the header 11. A passage 22 is provided within the fitting 19 for placing the interior of the bellows 14 into communication with the interior of the header 11. The pressure within bellows 14 is therefore equal to the pressure within this header. Also located within the fitting 21 is a thermostatic bulb 23 which is connected to a capillary tube 24 located within the pipe 20, this tube 24 being attached to the fitting 19 in a manner to communicate with a passage 25 in this fitting. This passage 25 is connected by means of a coiled tube 26 located within the bellows 14 to the interior of the bellows 15. The bulb 23 contains a suitable volatile fill which preferably is the same as the refrigerant used in the system. The arrangement just described therefore will cause a pressure to exist within the bellows 15 which is indicative of the temperature in the header 11, while the pressure within the bellows 14 is equal to the pressure within said header.

Connected to the member 16 is a rod 27 which extends upwardly through the cup member 18, this rod being threaded at its upper end as shown and carrying a nut 28 engaging a spring 29 which is supported by means of a spring retainer 30. A sealing bellows 31 is provided for preventing the escape of vapor from the bellows 15. With the arrangement just described it will be apparent that upon an increase in pressure within the header 11 the bellows 14 will expand and the bellows 15 will contract, while upon an increase in temperature at bulb 23 the pressure within bellows 15 will increase thereby causing expansion of this bellows and contraction of the bellows 14. The bellows 14 and 15 therefore act in opposition and the vertical position assumed by the connecting member 16 is an indication of the degree of superheat of the refrigerant at the fitting 21.

The member 16 is provided with a pin 32 which cooperates with a lever arm 33 extending through an opening 34 into the valve chamber 35. This lever is pivoted to the valve chamber casing at 36 and carries a valve member 37 cooperating with a valve port 38 located in a nipple 39. A spring 40 is provided for urging the lever 33 in a direction tending to maintain the valve member 37 against the valve port 38. In operation, liquid refrigerant enters at 41 and passes through port 38 to the distributor device 42. If the amount of superheat of the refrigerant leaving the coils 7, 8, 9, and 10 should increase, the pressure within bellows 15 will increase this causing downward movement of the member 16, and due to engagement of pin 32 with lever 33 the valve member 37 will be moved away from port 38 to increase the supply of liquid refrigerant to the coils. Conversely, upon decrease in the amount of superheat, the member 16 will move upwardly, thereby permitting valve member 37 to approach port 38 under the action of spring 40. By adjusting the nut 28 any desired degree of superheat may be maintained.

Referring now to the distributor device 42, this device consists of a member 43 having a chamber 44, this device being secured to the valve casing in a manner to cause the chamber 44 to register with the opening in nipple 39. The member 43 is also provided with a plurality of restricted radial passages 45 which lead from the chamber 44 to openings 46 which are adapted for individual connection with the coils of the evaporator 6. It will be understood that a restricted passage 45 and connection 46 is provided for each of the coils. It will be noted that the nipple 39 is formed to provide a venturi and that the chamber 44 is in direct alignment with the valve port 38, so that the stream of liquid passing through the valve is discharged into the chamber 44 at high velocity. This high velocity discharge of refrigerant into the chamber 44 causes the refrigerant to become a homogeneous mixture of liquid and gas within this chamber and to pass through the restricted passages 45 into the coils 7, 8, 9, and 10. Due to this action of refrigerant within the chamber 44, both the gaseous and liquid refrigerant will be divided equally between the various coils. This arrangement therefore provides for the passing of the proper amount of liquid refrigerant to each coil and thereby prevents the flooding of one coil and the starving of another.

Interposed in the connections between the distributor 42 and the coils 7, 8, 9, and 10 are solenoid valves 51, 52, 53, and 54. These valves are of the type which open when energized and which close when deenergized. These valves are provided for the purpose of controlling the number of cooling coils which are in operation.

Referring to the remainder of the refrigeration system this system includes a compressor 56 which is driven by means of an electric motor 57 having a starting box 58. The compressor 56 is connected by a discharge line 59 to a condenser 60 which is in turn connected by a liquid line 61 to the inlet of the expansion valve 12. This compressor is also connected by a suction line 62 to the header 11. This compressor is provided with a combination high and low pressure cut-out 63 which may be of any suitable type. This device includes a switch (not shown) which is opened upon either an excessive head pressure or a predetermined low suction pressure occurring.

The solenoid refrigerant valves and the compressor are controlled by means of a step controller generally indicated as 64. This step controller includes an electric proportioning motor 65 which may be of the type shown in the Taylor Patent 2,028,110. This motor is provided with an operating shaft 66 and assumes intermediate positions depending upon the combined effect of a return air thermostat 67, humidity controller 68 and an outside thermostat 69. The control circuit between the thermostat 67, humidity controller 68 and thermostat 69 may be of the effective temperature type disclosed in the Haines Patent 2,173,331 dated Sept. 19, 1939, or preferably may be of the type disclosed in my copending application Serial No. 182,817 filed December 31, 1937. This arrangement causes the shaft 66 to be rotated to positions corresponding to the effective temperature of the air in the space 4 and this effective temperature is in turn varied by outside temperature in order to maintain comfortable conditions in the space.

The shaft 66 carries cams 70, 71, 72, and 73 which actuate mercury switches 74, 75, 76, and 77. These cams are designed and positioned on the shaft 66 so that when this shaft reaches its clockwise limit of rotation, the mercury switches are all tilted so as to unbridge their electrodes. As the shaft 66 rotates counter-clockwise due to an increase in effective temperature, that is, due to either an increase in temperature or humidity in the space, the cam 70 will first tilt the mercury switch 74 to closed position. Upon a further increase in effective temperature the shaft 66 will rotate further in the counter-clockwise direction for causing cam 71 to tilt switch 75 to closed position. Switches 76 and 77 are similarly tilted to closed position in sequence upon continued counter-clockwise rotation of shaft 66. Upon decrease in effective temperature the shaft 66 is rotated clockwise for opening the mercury switches in inverse order.

Assuming first that the effective temperature within the space is such that no cooling is necessary, the controls for the motor 65 will cause this motor to position its shaft at its clockwise limit of rotation at which all of the mercury switches are open. Upon rise in effective temperature due to either rise in relative humidity or temperature, the shaft 66 will be rotated counter-clockwise for tilting mercury switch 74 to closed position. This will complete a circuit from the transformer secondary 80 of transformer 81 to the compressor starting box 58 as follows: wire 82, mercury switch 74, wire 83, high and low pressure cut-out 84, wire 85, starting box 58, wire 86 and wire 87 to secondary 80. This will place the compressor in operation under the control of the controller 84. Closure of mercury switch 74 will also energize solenoid valve 51 as follows: transformer secondary 80, wire 82, mercury switch 74, wire 88, solenoid valve 51, wire 89, and wire 87 to secondary 80. Therefore upon an initial call for cooling the compressor is placed into operation and one evaporator coil is placed into operation. At this time as the load upon the compressor imposed by coil 7 is quite small the pressure of the evaporating refrigerant in this coil will be low and thus this coil will operate at relatively low temperature. This will cause the coil 7 to have a substantial dehumidifying effect and the air which is cooled by coil 7 will be mixed with the uncooled air passing over coils 8, 9, and 10, this mixture being completed in the fan 5 so that air at relatively high temperature is discharged into the space 4. This arrangement thus provides for securing a substantial amount of dehumidification without performing a large amount of cooling and without the necessity of discharging cold air into the conditioned space.

If operation of coil 7 is insufficient to carry the existing cooling load, the effective temperature in the space will continue to rise thus causing further rotation of shaft 63 for closing the mercury switch 75. This will energize solenoid valve 52 as follows: transformer secondary 80, wire 82, wire 90, mercury switch 75, wire 91, solenoid valve 52, wire 89, and wire 87 to secondary 80. The placing of coil 8 in operation will increase the effective cooling area thereby providing a larger amount of cooling. Similarly upon continued increase in cooling load the mercury switch 76 will be closed for energizing solenoid valve 53 which places coil 9 into operation, and if still further cooling is required the mercury switch 77 is closed for opening solenoid valve 54 and placing 10 in operation. Thus at such time the entire cooling coil is employed for obtaining maximum cooling.

It should be noted that when only valve 51 is open, the expansion valve will supply just enough refrigerant to maintain the superheat of the refrigerant leaving coil 7 at the desired value, the supply of refrigerant to coil 7 being varied in accordance with the rate of evaporation in said coil. When valve 52 is opened for placing coil 8 in operation, refrigerant will now be supplied to both coils 7 and 8. Due to the additional heat exchange surface, the superheat of the refrigerant in header 11 will increase, which will cause the expansion valve to open wider for supplying enough refrigerant to maintain both coils 7 and 8 fully effective. In the same manner, the expansion valve will readjust itself when coils 9 and 10 are placed in operation so as to always supply the proper amount of refrigerant to the evaporator 6 as determined by the number of coils in operation. As the coils are placed out of operation, the expansion valve will reduce the total supply of refrigerant correspondingly. Due to the action of the distributor, the refrigerant will be equally divided among the operating evaporator coils irrespective of the number of coils which are operating.

From the foregoing description it will be apparent that this invention provides for automatically varying the amount of coil surface placed in operation in accordance with temperature or humidity or both, this control of coil surface being secured positively by placing coil sections into and out of operation, the arrangement requiring only a single expansion valve for all of the coils even though the number of coils placed into and out of operation is varied.

As various modifications of the invention may be made without departing from its scope it is desired to be limited only by the appended claims.

I claim as my invention:

1. In an air conditioning system, in combination, a conditioning chamber through which a stream of air is passed to a conditioned space, a direct expansion cooling device located in said chamber, said cooling device comprising a plurality of separate heat exchange conduits adapted to contain refrigerant and in heat exchange relationship with said air stream, said conduits having inlets and outlets, a source of liquid refrigerant, a single expansion valve connected to receive refrigerant from said source, a distributor receiving low pressure refrigerant from said expansion valve, said distributor comprising a chamber communicating with said expansion valve and with a plurality of restricted passages, individual connections between the outlets of said restricted passages and said heat exchange conduits whereby each restricted passage meters the supply of refrigerant from the expansion valve to corresponding heat exchange conduit, a separate valve in each of said individual connections, operating means for opening and closing the valves in sequence, and means responsive to the humidity in said space for controlling said operating means for opening said valves in sequence upon rise in humidity and for closing the valves in sequence upon fall in humidity.

2. In an air conditioning system, in combination, a conditioning chamber through which a stream of air is passed to a conditioned space, a direct expansion cooling device located in said chamber, said cooling device comprising a plurality of separate heat exchange conduits adapted to contain refrigerant and in heat exchange relationship with said air stream, said conduits having inlets and outlets, a source of liquid refrigerant, a single expansion valve connected to receive refrigerant from said source, a distributor receiving low pressure refrigerant from said expansion valve, said distributor comprising a chamber communicating with said expansion valve and with a plurality of restricted passages, individual connections between the outlets of said restricted passages and said heat exchange conduits whereby each restricted passage meters the supply of refrigerant from the expansion valve to a corresponding heat exchange conduit, a separate valve in each of said individual connections, a separate motor for each of said valves, a separate controller for each of said motors, each motor and associated controller being arranged to cause complete opening of the valve when the controller is in one position and for causing complete closing of the valve when the controller is in another position, a movable member arranged to cause movement of said controllers between their first and second positions in sequence upon movement of said member through a predetermined operating range, and means responsive to the humidity in said space for graduatingly positioning said movable member in accordance with variations in humidity.

3. In an air conditioning system, in combination, a conditioning chamber through which a stream of air is passed to a conditioned space, a direct expansion cooling device located in said chamber, said cooling device compriisng a plurality of separate heat exchange conduits adapted to contain refrigerant and in heat exchange relationship with said air stream, said conduits having inlets and outlets, a source of liquid refrigerant, a single expansion valve connected to receive refrigerant from said source, a distributor receiving low pressure refrigerant from said expansion valve, said distributor comprising a chamber communicating with said expansion valve and with a plurality of restricted passages, individual connections between the outlets of said restricted passages and said heat exchange

conduits whereby each restricted passage meters the supply of refrigerant from the expansion valve to a corresponding heat exchange conduit, a separate valve in each of said individual connections, an electromagnet for each of said valves, a separate switch for each of said electromagnets for energizing and deenergizing the same, a movable member for actuating the switches in sequence, a reversible electric motor for positioning said movable member, and means responsive to the cooling load for graduatingly controlling said reversible electric motor.

4. In an air conditioning system, in combination, a conditioning chamber through which a stream of air is passed to a conditioned space, a direct expansion cooling device located in said chamber, said cooling device comprising a plurality of separate heat exchange conduits adapted to contain refrigerant and in heat exchange relationship with said air stream, said conduits having inlets and outlets, and being located side by side in said conditioning chamber whereby the air stream in said chamber flows across said heat exchange devices in parallel relationship, a source of liquid refrigerant, a single expansion valve connected to receive refrigerant from said source, a distributor receiving low pressure refrigerant from said expansion valve, said distributor comprising a chamber communicating with said expansion valve and with a plurality of restricted passages, individual connections between the outlets of said restricted passages and said heat exchange conduits whereby each restricted passage meters the supply of refrigerant from the expansion valve to a corresponding heat exchange conduit, a separate valve in each of said individual connections, an electromagnet for each of said valves, a separate switch for each of said electromagnets for energizing and deenergizing the same, a movable member for actuating the switches in sequence, a reversible electric motor for positioning said movable member, and means responsive to the cooling load for graduatingly controlling said reversible electric motor.

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