

May 12, 1942.

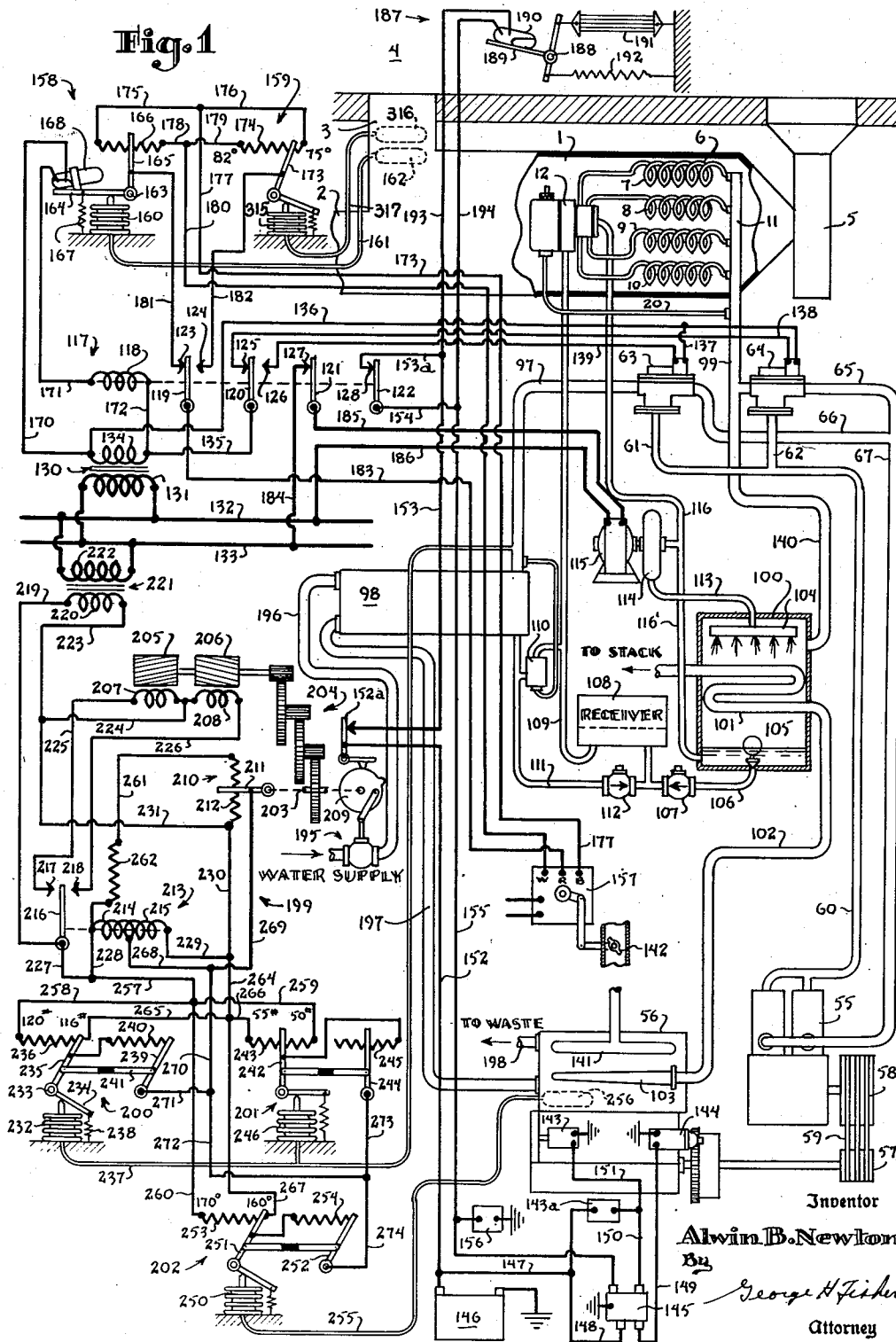
A. B. NEWTON

2,282,878

AIR CONDITIONING SYSTEM

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AIR CONDITIONING SYSTEM

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Fig. 2

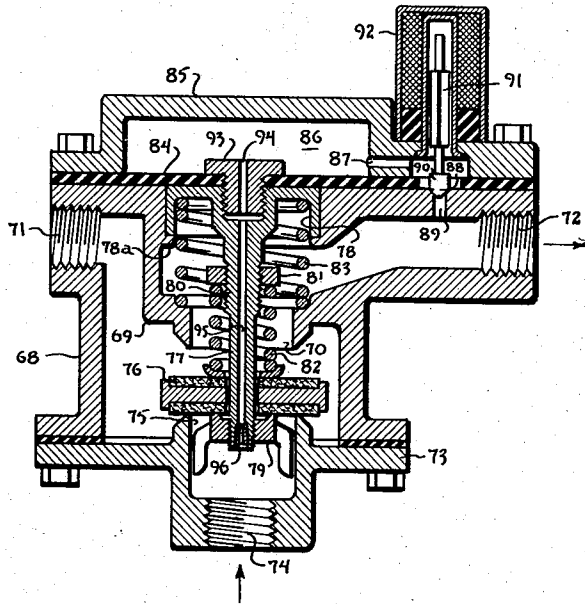
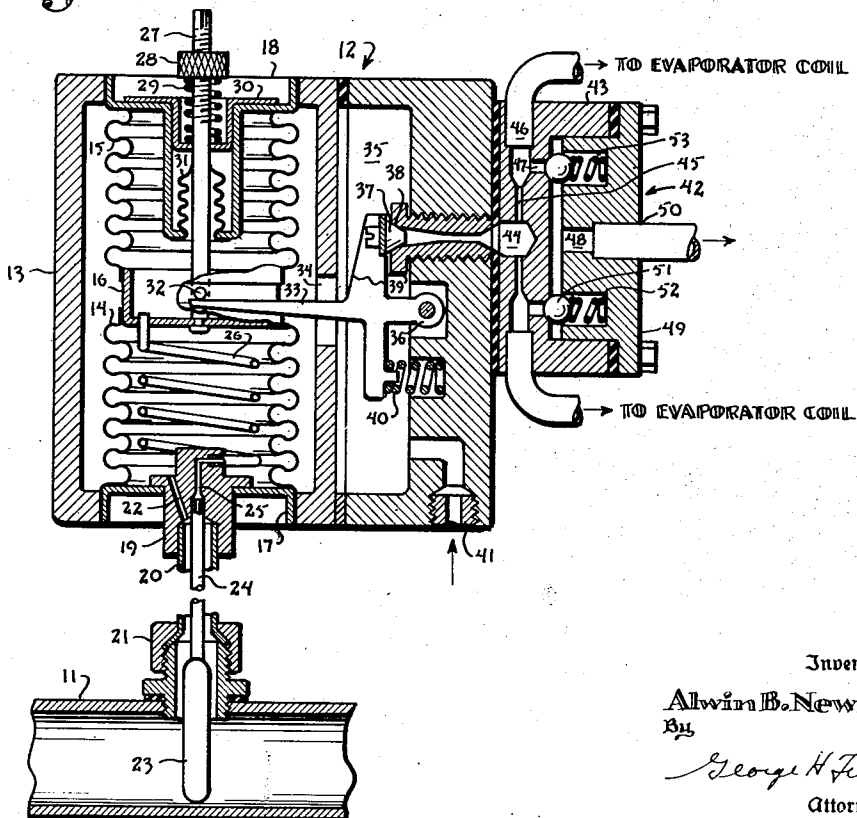


Fig. 3



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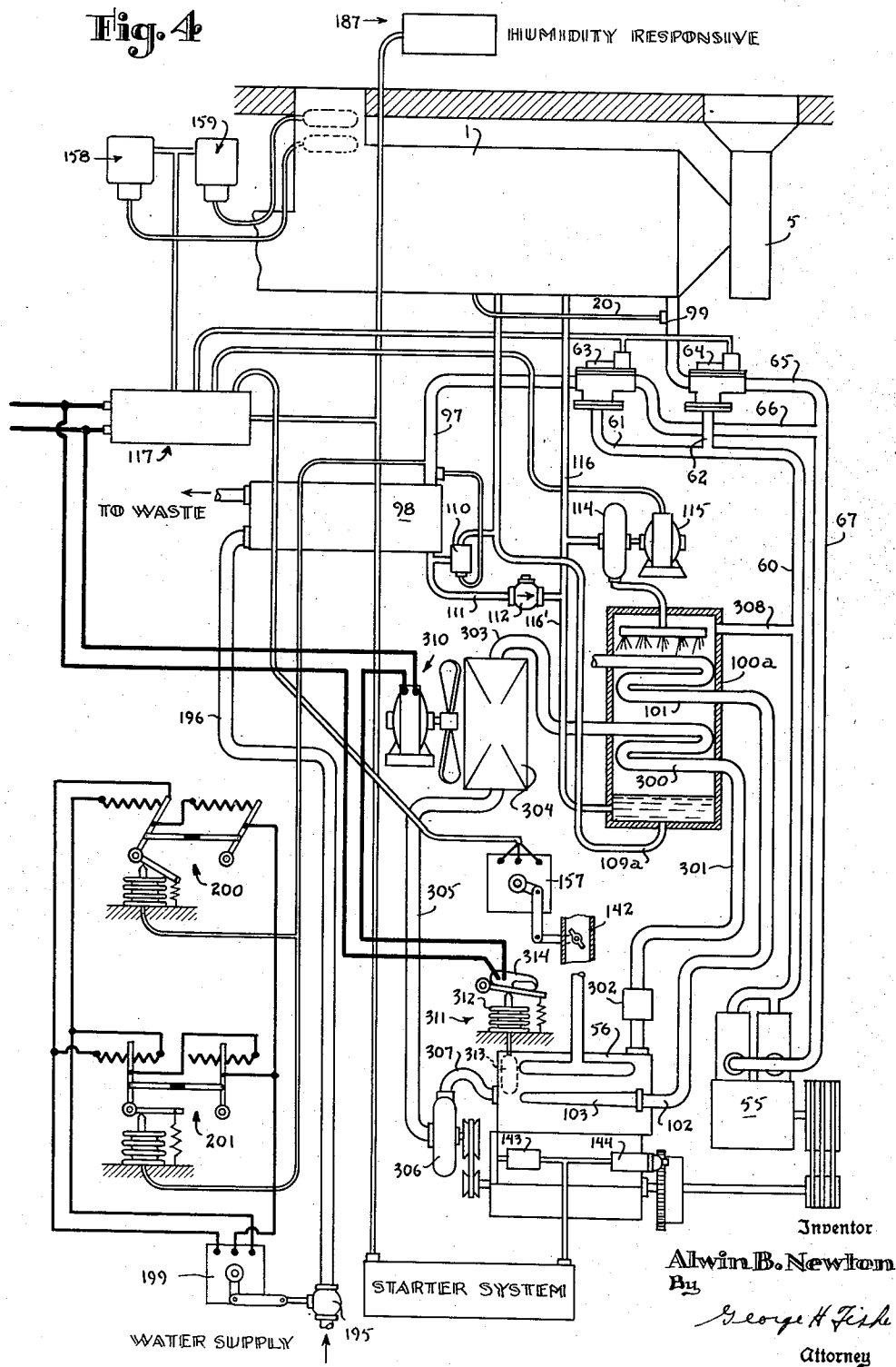
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Fig. 4



UNITED STATES PATENT OFFICE

2,282,878

AIR CONDITIONING SYSTEM

Alwin B. Newton, Minneapolis, Minn., assignor to
Minneapolis-Honeywell Regulator Company,
Minneapolis, Minn., a corporation of Delaware

Application May 6, 1938, Serial No. 206,411

30 Claims. (Cl. 257—3)

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

The primary object of this invention is to provide an air conditioning system which operates automatically to heat a conditioned space during the heating season, and to cool and dehumidify the space in a manner to maintain proper temperature and humidity conditions during the cooling season.

More specifically it is an object of this invention to provide a heating and cooling system for a space which consists of a refrigeration system operating on a normal cycle for cooling the space, and which operates on a reversed cycle for heating the space.

In the air conditioning art it is desirable to utilize direct expansion cooling coils in a conditioner for cooling the air being passed to the space, as these coils are very compact and efficient. In larger systems it is desirable to utilize instead of a single cooling coil, a direct expansion type heat exchanger which is formed of a plurality of parallel passes, for thereby decreasing the pressure drop. Direct expansion coils of this type present a problem of distributing the liquid refrigerant equally to the various passes, for if the refrigerant is not equally distributed, either some of the passes will become flooded, and permit the flow of liquid refrigerant to the compressor, or the expansion valve will become closed for preventing flow of refrigerant to all of the passes. In order to distribute refrigerant equally to the various passes it has become common to utilize distributor devices consisting of restricted inlet orifices for each pass. This arrangement is quite satisfactory for coils which operate only as evaporators. In reversible cycle systems it is desirable to use a single heat exchanger in the air stream as an evaporator during the cooling cycle and as a condenser during the heating cycle. When the heat exchanger is operating as a condenser, the restrictors used for distributing the liquid refrigerant when the heat exchanger operates as an evaporator are unnecessary, and in fact are undesirable as they create an additional pressure drop within the system. It is an object of this invention to provide a distributor device for a multiple pass heat exchanger which acts to distribute properly the liquid refrigerant to the various passes when the heat exchanger is operating as an evaporator, and which automatically permits by-passing of refrigerant around the distributor restrictions when the heat exchanger is operating as a condenser.

Another object is the provision of a distributor device for a multiple pass unit which utilizes the velocity of the liquid refrigerant leaving the expansion valve for aiding in the distribution of the liquid refrigerant to the various passes.

It is common to utilize valves for changing the direction of flow of refrigerant through a reversible cycle system for reversing the operation of the system. These valves must necessarily be sufficiently large to handle gaseous refrigerant and due to the high pressures involved these valves require considerable power for changing from one position to another. It is a further object of this invention to provide a reversible cycle system with change-over valves which are operated from one position to another by the pressures within the system, thereby providing for convenient control of the system operation.

A still further object of this invention is the provision of a reversible cycle system of the type which utilizes a single heat exchanger for dissipating heat during the cooling cycle, and for absorbing heat during the heating cycle, with a control arrangement for varying the supply of water or other heat exchange medium to this heat exchanger in accordance with the cooling and heating loads on the system, to thereby supply just the proper amount of heat exchange medium to meet the needs of the system, thus reducing operating costs thereof.

Another object of this invention is the provision of a system of the general type with a control arrangement for automatically controlling the supply of heat exchange medium in accordance with the demand therefor, and which places the system out of operation when the demand for heat exchange medium varies to a predetermined value.

Still another object of this invention is the provision of a control arrangement for an air conditioning system which maintains proper temperature and humidity conditions within a space by placing a cooling device into and out of operation in accordance with variations in humidity while varying the action of the cooling device in accordance with variations in temperature.

Other objects of this invention lie in various combinations and subcombinations of control apparatus and will become apparent from the following description and the appended claims.

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

Figure 1 is a diagrammatic illustration of an automatic reversible cycle air conditioning system embodying the novel features of my invention,

Figure 2 is an elevation in section of one of the refrigerant pressure operated three-way change-over valves,

Figure 3 is an elevation in section showing the expansion valve and distributor arrangement for the direct expansion cooling coils, and

Figure 4 is a view similar to Figure 1 showing a modified piping arrangement for the system.

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, or as a condenser for heating 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 3, 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 copending 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 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 downwardly, 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 connection with the coils of the heat exchange device 6. It will be understood that a restricted passage 45 and connection 46 is provided for each of the coils of the heat exchange device. 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 liquid 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.

Each of the passages or connections 46 communicate through a passage 47 with a chamber 48 formed between the member 43 and a cap member 49. This chamber 48 is connected to a discharge connection 50. Each of these passages 47 is also provided with a ball valve member 51 which is urged against its seat by means of a spring 52 located within a recess 53 located within the cover member 49. The purpose of the passages 47 and the valve members 51 is to permit the passage of refrigerant from the coils 7, 8, 9, and 10 into the outlet connection 50 when the coils 7, 8, 9, and 10 are acting as condensers. This arrangement avoids the necessity of passing the liquid refrigerant through the restricted passages 45 when the system is operating as a heating system. The operation of the distributor

device 42 will become apparent as this description proceeds.

Reference character 55 indicates a compressor which may be driven by means of an internal combustion engine 56 through any suitable drive means such as pulleys 57 and 58 over which run belts 59. The discharge of the compressor 55 is connected by means of a discharge line 60 and pipes 61 and 62 to three-way valves 63 and 64, respectively. Other ports of these three-way valves are connected by pipes 65 and 66 to a suction line 67 leading to the inlet of the compressor 55.

Referring now to Figure 2 this figure shows a preferred construction for the three-way valves 63 and 64. Each of these valves may consist of a valve casing 68 containing a transverse partition 69 having a valve port 70 therein. This valve port 70 places the passages 71 and 72 within the casing 68 into communication. The lower end of the casing 68 is provided with a cap member 73 having therein an inlet passage 74 and providing a valve port 75 which is in alignment with the port 70. Reference character 76 indicates a valve member which is adapted selectively to cover the valve port 70 or the valve port 75. This valve member is slidably mounted upon a valve stem 77 which is joined to a piston 78 which in turn is fitted into a suitable cylinder or guide formed in the casing 68 above the valve port 70. The valve stem 77 at its lower end is secured to a guide member 79 located in passage 74 below the valve port 75. The valve stem 77 is also threaded at 80 to receive the nut 81 which abuts spring 82, the lower end of this spring in turn abutting the valve member 76. The spring 82 therefore serves to urge the valve member 76 downwardly on the stem 77 and against the guide member 79 for normally causing movement of the valve member 76 with movements of the stem 77. A second spring 83 is located above the valve port 70 and serves to urge the valve stem upwardly for biasing the valve member 76 against the valve port 70.

Mounted above the valve casing 68 is a diaphragm 84 which may be formed of any suitable flexible material which is resistant to the refrigerant utilized in the system. This diaphragm is covered by means of a cap member 85 which is secured to the valve casing 68, this cap member being formed to provide a chamber 86 communicating with a port 87 leading to a valve port 88 which in turn communicates through a passage 89 with the passage 72. A valve member 90 cooperates with the port 88 and is operated by means of a plunger 91 of a solenoid 92. The diaphragm 84 is secured to the valve stem 77 by means of a nipple 93, this nipple having a passage 94 communicating with a passage 95 in the valve stem 77. A restriction 96 is located within the passage 95 so as to permit only a restricted flow of refrigerant from the inlet passage 74 through the passages 95 and 94 into the diaphragm chamber 86. If desired, this restriction may be covered with a suitable strainer.

Assuming that solenoid 92 is deenergized, the valve member 90 will cover the valve port 88 and thus prevent any escape of refrigerant through the passage 89. The passage 74 it will be noted is connected to the discharge side of the compressor and consequently the pressure at the inlet of passage 95 is relatively high. This high pressure refrigerant will pass through the restriction 96 and passages 95 and 94 into the diaphragm chamber 86 thus urging the diaphragm 84 downwardly which in turn urges the valve

stem 77 and the valve member 76 downwardly for covering the valve port 75. This will place the passages 71 and 72 into communication. Now if the solenoid 92 is energized, the valve member 90 will be withdrawn from the port 88 thus permitting flow of refrigerant from the diaphragm chamber 86 into the passage 72. This passage 72 it will be noted is connected to the inlet of the compressor and consequently the pressure within this passage is relatively low. Due to the action of the restriction 96, refrigerant will pass from the chamber 86 into the passage 72 at a faster rate than the refrigerant will pass from passage 74 into the chamber 86. Consequently the pressure above the diaphragm 84 will be reduced, thus permitting the spring 83 to move valve stem 77 and the valve member 76 upwardly for uncovering the valve port 75 and covering valve port 70. This will place the ports 71 and 74 into communication. From the description thus far, it should be apparent that the port 71 is selectively connected to ports 72 or 74 under the control of the solenoid 92. The purpose of this arrangement will become apparent as this description proceeds.

At this time it should be observed that when one of the valves 63 or 64 is in the position shown in Figure 2, wherein its port 74 is covered by the valve member 76, the port 72 is in communication with the passage 71 and the passage 74 is covered. As pointed out previously, the passage 74 is connected to the discharge side of the compressor while the passage 72 is connected to the inlet or the suction side of the compressor. If for some reason the discharge pressure of the compressor should become excessive, the valve member 76 will be urged upwardly on the valve stem 77, due to the yielding of a spring 82. This will permit flow of high pressure refrigerant around the valve member 76, through the port 70, and passage 72 to the inlet of the compressor. This arrangement therefore provides for automatic unloading of the compressor when the head pressure becomes excessive, thereby preventing damage to the compressor or other parts of the system. It should be noted that piston 78 is limited in its downward movement by shoulder 78a. This limits the amount that spring 82 may be compressed, and thus provides a definite pressure at which spring 82 will yield for unloading the compressor.

Referring again to Figure 1, the passage 71 of the three-way valve 63 is connected by a pipe 97 to an evaporator condenser 98 and the corresponding passage of three-way valve 64 is connected by a pipe 99 to the header 11 of heat exchanger 6. The three-way valves 63 and 64 therefore provide for selective communication of the heat exchangers 6 and 98 with either the inlet or outlet of the compressor 55. This arrangement provides for causing the heat exchanger 6 to operate either as a condenser or as an evaporator for thereby either cooling or heating the space.

Reference character 100 indicates an auxiliary evaporator which contains a heat exchange coil 101 connected by a pipe 102 to the exhaust manifold 103 of internal combustion engines 56. The coil 101 is therefore heated by exhaust gases from engine 56. Located above the coil 101 is a spray pipe 104, and located below the coil 101 is a sump for collecting refrigerant which has been sprayed over the coil 101. This sump is provided with a float valve 105 for maintaining at least a predetermined amount of liquid refrigerant therein. This float valve controls the flow of refrigerant into pipe 106 which leads through a check valve

107 into receiver 108. This receiver in turn is connected by pipe 109 to the expansion valve 12 for heat exchanger 6 and to the expansion valve 110 for the evaporator-condenser 98. This evaporator-condenser is also connected by pipe 111 through check valve 112 with the receiver 108. The spray pipe 100 is connected by pipe 113 to the outlet of a pump 114 which is driven by a motor 115. The inlet of this pump 114 is connected by pipes 116 and 116' to the sump of the auxiliary evaporator 100 and to the outlet connection 50 of the distributor device associated with heat exchanger 6.

The solenoids of the three-way valves 63 and 64 are controlled by means of a relay 117 which includes a relay coil 118 which operates through a suitable armature a series of switch arms 119, 120, 121, and 122. The switch arm 119 cooperates with an "in" contact 123 and with an "out" contact 124, which the switch arm 120 cooperates with an "in" contact 125 and an "out" contact 126. The switch arm 121 cooperates with an "in" contact 127, and switch arm 122 cooperates with an "in" contact 128. When the relay coil 118 is energized in a manner which will be described hereinafter, the switch arms 119, 120, 121, and 122 will be brought into engagement with their respective "in" contacts. However, when relay coil 118 is deenergized, the switch arms will disengage their respective "in" contacts and the switch arms 119 and 120 will engage the "out" contacts 124 and 126, respectively.

Reference character 130 indicates a step-down transformer having a primary 131 connected across line wires 132 and 133. The secondary 134 of the transformer 130 has one terminal connected to the switch arm 120 by a wire 135, and its other terminal is connected by wires 136 and 137 to the solenoids of three-way valves 63 and 64. The "in" contact 125 of the relay 117 is connected by wire 138 to the solenoid of three-way valve 64, and the "out" contact 126 is connected by wire 139 to the solenoid of three-way valve 63. By this arrangement it will be apparent that when relay coil 118 is energized, the switch arm 120 will engage contact 125 and energize the solenoid of three-way valve 64 as follows: transformer secondary 134, wire 135, switch arm 120, contact 125, wire 138, solenoid of valve 64, and wire 136 to the other side of transformer secondary 134. At this time therefore the solenoid of valve 64 will be energized while the solenoid of valve 63 will be deenergized. Similarly when the relay coil 117 is deenergized, the switch arm 120 will engage contact 127 for energizing the solenoid of three-way valve 63 while deenergizing the solenoid of three-way valve 64. It will therefore be seen that whenever the solenoid of valve 63 is energized, the solenoid of valve 64 is deenergized and vice versa.

During the cooling season the relay coil 118 of the relay 117 will be deenergized, this causing engagement of switch arm 120 with contact 127 for energizing the solenoid of three-way valve 63 while deenergizing the solenoid of valve 64. This will cause the valve member 76 of the three-way valve 63 to cover its port 70 thus placing its passages 71 and 74 into communication. The three-way valve 64 however will assume the position shown in Figure 2 wherein the passages 71 and 72 are placed into communication. For these positions of the three-way valves 63 and 64, refrigerant will flow from the compressor 55 through discharge line 60 and pipe 61 into three-way valve 63, passing from this valve through pipe 97 into the evaporator-condenser 98. At this time this

heat exchanger will operate as a condenser for condensing the compressed refrigerant. The liquified refrigerant will then flow from heat exchanger 98 through pipe 111 and check valve 112 into receiver 108. From this receiver the refrigerant will flow through liquid line 109 to the combined expansion valve and distributor 12. Referring to Figure 3, the refrigerant will flow through the expansion valve port 38 into the chamber 44 and the restrictions 45 into the coils 7, 8, 9, and 10 wherein it evaporates for cooling the air passing through chamber 1. From the header 11, the evaporated refrigerant will flow through pipe 99 and through the three-way valve 64 to pipe 65 and through suction line 67 back to the compressor 55. At this time it will be apparent that the heat exchanger 98 will operate as a condenser and the heat exchanger 6 in the conditioning chamber 1 will act as an evaporator for cooling and dehumidifying the air passing to the space 4.

During the heating season the relay coil 118 of relay 117 will be energized for causing engagement of the switch arm 120 with contact 125, thus energizing the solenoid of three-way valve 64 and deenergizing the solenoid of three-way valve 63. This will cause the solenoid valve 63 to assume the position shown in Figure 2 wherein the passages 71 and 72 are in communication, and will cause the three-way valve 64 to assume a position in which the passages 71 and 74 are in communication. With the valves 63 and 64 in these positions, refrigerant will flow from the compressor through discharge line 60 and pipe 62 into the three-way valve 64 and then through pipe 99 and header 11 to the coils 7, 8, 9, and 10. These coils will now act as condensers for condensing the refrigerant and delivering up its latent heat of evaporation to the air being heated. The liquified refrigerant will flow from each of these coils into the respective passages 46 of the distributor device 42, and will pass through passages 47 and check valves 51 into the chamber 48 from which it passes through pipe 116 to the inlet of pump 114.

This refrigerant is then forced into the spray pipe 104 by the pump 114 and is sprayed over the pipe 101 which is heated by exhaust gases from the engine 56. This will re-evaporate a portion of the sprayed refrigerant and this re-evaporated portion will pass from the auxiliary evaporator through pipe 140 and to the pipe 99 and back through the coils 7, 8, 9, and 10 for transferring the heat of the exhaust gases to the air passing through the conditioning chamber 1. The un-evaporated portion of the sprayed refrigerant in the auxiliary evaporator 100 collects in the sump of this device and is recirculated through pipe 115 and pump 114 for being again sprayed over the coil 101. This arrangement provides for very efficient heat transfer between exhaust gases of the engine and the high pressure refrigerant in the system.

Liquid refrigerant will also pass from the auxiliary evaporator 100 through pipe 106 and check valve 107 into the receiver 108 and will pass from this receiver through pipe 109 to the expansion valve 110 connected to the evaporator-condenser 98. This liquid refrigerant will then evaporate within this device and absorb heat from the water or other medium being passed through this device, the evaporated refrigerant passing through pipe 97 to three-way valve 93 and through pipe 66 and suction line 67 back to the compressor 55.

From the description thus far it should be apparent that I have provided an arrangement for

reversing the operation of a refrigeration system under the control of the relay 117. When this relay 117 is energized the heat exchanger 6 in the conditioning chamber will operate as a condenser for heating the air and the heat exchanger 98 will operate as an evaporator for absorbing heat from an outside source. Also at this time the exhaust heat from the engine will be transferred to the exchanger 6 due to the action of the auxiliary evaporator 100. When the relay 117 is deenergized however, the heat exchanger 6 will operate as an evaporator for cooling the air passing through chamber 1 and the heat exchanger 98 will operate as a condenser for dissipating the heat absorbed by the heat exchanger 6.

Referring now to the internal combustion engine 56 this engine may be of any desired type and is shown as including an intake manifold 141, a throttle valve 142, a generator 143, and a starting motor 144. Reference character 145 indicates a relay for controlling the starting motor 144 in a manner to cause operation of the starting motor for starting the engine when the ignition circuit is closed, and for deenergizing the starting motor after the engine has started. This relay 145 may be of any desired type and if desired may be of the type shown and described in Patent No. 1,773,913 issued to L. K. Loehr et al. on August 26, 1930. This starting relay is so arranged that upon the closing of a control circuit, a magnetic device is energized which causes closing of a switch in the starter circuit. For this purpose the relay 145 is connected to a storage battery 146 by means of wires 147 and 148, and by a wire 149 to the starting motor 144. This relay 145 is also provided with a lockout circuit for preventing energization of the starting motor 143 when the engine is in operation as evidenced by operation of the generator 143. For this purpose the relay 145 is connected by wires 150 and 151 to the generator 143. The wire 151 is additionally connected to the storage battery 146 through a reverse current relay 143a for charging said storage battery. The storage battery 146 is additionally connected by wire 152, switch arm 152a, wire 153, and wire 153a to the contact 128 of relay 117, and the cooperating switch arm 122 is connected by wires 154 and 155 to the control terminal of the relay 143. This wire 155 is also connected to the spark coil 156. By this arrangement, when the relay 117 is energized the spark coil 156 will be energized and also the starting relay 145 will be energized for causing operation of the starting motor. This in turn will cause starting of the engine 56 and the relay 145 in response to this starting of the engine will deenergize the starting motor 144 and maintain this motor deenergized so long as the engine is in operation. When the relay 145 and spark coil 156 are deenergized however, as by deenergization of relay 117, the engine will stop.

The throttle valve 142 of the engine 56 may be positioned by means of a proportioning motor 157. This motor may be of any desired type and preferably is of the type shown and described in Patent No. 2,028,110 issued to D. G. Taylor on January 14, 1936. This type of motor is adapted to be controlled by means of one or more potentiometer controllers and will assume intermediate positions corresponding to the position of the slider of a potentiometer controller upon its resistance.

Proportioning motor 157 is arranged to be controlled by means of a winter thermostat 158 and a summer thermostat 159. Referring to the winter thermostat 158, this may be of any desired type and is shown as comprising a bellows 160

which is connected by a capillary tube 161 to a control bulb 162 located within the return air inlet 3. The bellows 60 may actuate a bell crank lever 163 having an actuating arm 164 and a control arm or slider 165 which cooperates with a resistance 166 to form a control potentiometer for motor 157. The bulb 162, tube 161, and bellows 160 are charged with a suitable volatile fill for causing the pressure within bellows 160 to increase upon increase in return air or space temperature. Thus as the space temperature increases, the pressure within bellows 160 will increase for causing movement of slider 165 to the right across resistance 166. Upon decrease in temperature however the bellows 160 will contract under the biasing action of a spring 167 thus moving slider 165 to the left across resistance 166. This instrument may be so designed and adjusted as to cause the slider 165 to engage the extreme right-hand end of resistance 166 when the space temperature is at 72° F. while engaging the left-hand end of resistance 166 when the space temperature falls to 70° F. The winter thermostat 158 is also provided with an auxiliary switching means for energizing the relay 117 when the space temperature falls below 72° F. This switching means is diagrammatically illustrated as comprising a mercury switch 168 mounted upon the actuating arm 164 in such a manner that its electrodes are unbridged when the slider 165 engages the right-hand end of resistance 166 while causing these contacts to be bridged whenever the slider 165 moves away from this extreme right-hand position. The mercury switch 168 is connected in series with the transformer secondary 134 and relay coil 118 by wires 170, 171, and 172. It will be apparent that when the space temperature is above 72° F., the electrodes of mercury switch 168 will be unbridged thus deenergizing relay coil 118, while when the space temperature is at 72° or below, the relay coil 118 will be energized.

Referring to the summer thermostat 159, this instrument may be formed similarly to the thermostat 158. It comprises a bellows 315, bulb 316 located in return air duct 3, and connecting tubing 317. It further includes a slider 173 operated by bellows 315 and which cooperates with a resistance 174 to form a control potentiometer. This instrument may be so designed and adjusted as to cause the slider 173 to engage the right-hand end of resistance 174 when the space temperature is at 75° or below while engaging the left-hand end of resistance 174 when the space temperature rises to 82° F.

Referring now to the connections between the thermostats 158 and 159 and the motor 157, it will be noted that the left-hand end of resistance 166 and the right-hand end of resistance 174 are connected by wires 175, 176, and 177 to terminal B of the proportioning motor 157, while the right-hand end of resistance 166 and the left-hand end of resistance 174 are connected by wires 178, 179, and 180 to terminal W of motor 157. The slider 165 of thermostat 158 is connected by wire 181 to the contact 123 of relay 117, and the slider 173 of thermostat 159 is connected by wire 182 to the contact 124. The switch arm 119 of this relay is connected to terminal R of motor 157 by wire 183.

Referring again to the motor 157, this motor will operate in a direction for opening the throttle valve 142 as the resistance between terminals R and B is decreased, and will operate to close the throttle valve 142 as the resistance between

terminals R and W is decreased. With the thermostats 158 and 159 in the positions shown the space temperature is at 71° F., which causes the slider 165 of thermostat 158 to engage the center of resistance 166. For this value of temperature, the switch 168 is tilted so that its electrodes are bridged, this energizing the relay 117 thus causing the switch arm 119 to engage the contact 123. This, it will be noted, disconnects terminal R of motor 157 from the thermostat 159 and connects this terminal of the motor to the slider 165 of thermostat 158. Due to the slider 165 engaging the center of resistance 166, the resistance connected between terminals R and W and between terminals R and B of the motor are equal. Accordingly the motor 157 has assumed mid-position in which the throttle valve 142 is half open. If the space temperature decreases, the slider 165 will move to the left across resistance 166 thus decreasing the resistance connected between terminals R and B of the motor, while increasing the resistance connected between terminals R and W. This will cause the motor 157 to rotate in a direction for opening the throttling valve 142 wider thereby increasing the speed of the engine. Upon an increase in space temperature the slider 165 will move to the right across resistance 166 for causing motor 157 to move the throttle valve 142 to a further closed position.

When the space temperature rises above 72° F. the electrodes of mercury switch 168 will become unbridged thus deenergizing the relay 117. The resulting engagement of switch arm 119 with contact 124 will completely disconnect the slider 165 of thermostat 158 from the proportioning motor 157, and will connect the potentiometer slider 173 of thermostat 159 to this motor. If the space temperature is below 75° F., the slider 173 of thermostat 159 will engage the right-hand end of resistance 174 and this will complete a substantial short circuit from terminal R of the motor through wire 183, switch arm 119, contact 124, wire 182, slider 173, wire 176, and wire 177 to terminal B of the motor thus causing this motor to run to a position in which the throttle valve is wide open. As the space temperature increases above 75° F., the slider 173 will move to the left across resistance 174 and the motor 157 will follow up this movement for moving throttle valve 142 towards closed position.

It should be noted that contact 127 of relay 117 is connected by a wire 184 to the line wire 133 and the switch arm 121 is connected by wire 185 to the pump motor 115. This pump motor 115 in turn is connected by a wire 186 to the line wire 132. Thus when the switch arm 121 engages contact 127 the pump motor 115 will be energized.

From the foregoing description it should be apparent that when the space temperature is above 72° F. the mercury switch 168 of thermostat 158 will be in open position, this causing deenergization of the relay 117. This will cause the switch arm 119 to engage the contact 124 for placing the summer thermostat 159 in control of the engine throttle valve. Also due to switch arm 120 engaging contact 126, the solenoid of three-way valve 63 will be energized and the solenoid of three-way valve 64 will be deenergized. This will position these valves in a manner to cause the system to operate on the cooling cycle. Due to the switch arm 121 being disengaged from contact 127 the pump 115 will not operate at this time. Also due to switch arm 122 being dis-

engaged from contact 128, the energizing circuit for the starting relay 145 and the engine ignition will not be closed through this relay 117. Consequently the engine 56 will not operate at this time unless placed into operation by the space relative humidity controller 187.

Referring to this humidity controller 187 this controller may be of any desired type and is shown diagrammatically as comprising a bell crank lever 188 having an arm 189 carrying a mercury switch 190. Attached to the lever 188 is a humidity responsive device which may consist of a plurality of strands 191 of hair or other moisture responsive material. A spring 192 is also provided for biasing the lever 188 in a direction to maintain the strands 191 taut. Upon an increase in relative humidity, these strands will increase in length this permitting rotation of lever 188 in a direction for tilting the mercury switch 190 to closed position. Upon a decrease in relative humidity, the strands 191 will shrink thus rotating lever 188 for tilting mercury switch 190 to open position. The mercury switch 190 is connected by wires 193 and 194 to the wires 153 and 154 thus placing the switch 190 in parallel relationship with the switch arm 122 and contact 121 of the relay 117. The humidity controller 187 may be adjusted in a manner to cause closure of mercury switch 90 only when the relative humidity rises to a predetermined value such as 60%. Thus when the system is operating on the cooling cycle, the engine 56 will remain at rest so long as the relative humidity is below 60%. When this relative humidity rises above this value, closure of the mercury switch 190 will cause closure of the engine starting circuit thereby placing engine 56 into operation. At this time the engine speed will be dependent upon the space temperature. Thus if the space temperature is at 75° F. or below the engine will be run at high speed for operating the heat exchanger 6 at a low temperature for providing maximum dehumidification. This will reduce the space relative humidity relatively quickly thus causing the humidity controller 187 to stop the engine in a relatively short time. Due to this relatively short period of operation only a slight amount of cooling will be done. As the space temperature increases, the engine will be operated at slower and slower speeds, this causing the heat exchanger 6 to operate at higher and higher temperatures for performing a smaller amount of dehumidification. Due to this action, the engine must operate for longer periods when the space temperature is high before the humidity controller 187 will stop the engine. This will provide for doing a larger amount of cooling thus preventing the space temperature from becoming excessive. If desired, instead of utilizing a plain type humidity controller as shown, a compensated humidity controller such as shown in my co-pending application Serial No. 199,217, filed March 31, 1938, may be utilized. This type of humidity controller is automatically adjusted in accordance with space temperature for lowering the control point of the humidity controller upon increase in space temperature. Thus with a controller of this type, if the space temperature becomes excessive, the humidity controller will place the compressor into operation even though the space relative humidity has not increased.

If the space temperature should now fall below 72° F. the mercury switch 168 of thermostat 158 will close, this energizing the relay 117. Due to

the resulting engagement of switch arm 119 with contact 123, the thermostat 158 will be placed in control of the throttle valve motor 157 while the thermostat 159 will be disconnected from this motor. Also due to the switch arm 120 engaging contact 125 the solenoid of three-way valve 64 will be energized and the solenoid of three-way valve 63 will be deenergized. This will cause the valves 63 and 64 to assume positions for causing operation of the system on the heating cycle for heating the space. In addition, engagement of switch arm 121 with contact 127 will start the refrigerant circulating pump 115, and engagement of switch arm 122 with contact 128 will complete the engine starting circuit thus placing the engine 56 into operation. Thus when the space temperature is above 72° F. the three-way valves 63 and 64 will be in position for operating the system on the cooling cycle, the summer thermostat 159 will be placed in control of the engine throttle valve, and the starting and stopping of the engine will be placed under the control of the humidity controller 187. When the space temperature falls below 72° F. the three-way valves 63 and 64 will be positioned for operating the system on the heating cycle, the engine will be placed into operation, the circulating pump 115 will be placed into operation, and the throttle valve motor 157 will be placed under the control of the winter thermostat 158.

The heat exchanger 98 it will be understood operates as an evaporator during the cooling cycle for absorbing heat from the water passing therethrough, and acts as a condenser during the cooling cycle for dissipating the heat absorbed from the conditioned space. An additional feature of the present invention lies in a control arrangement for automatically varying the supply of water or other heating and cooling medium to the heat exchanger 98 in accordance with the demand for either heating or cooling. Referring now to the control arrangement, reference character 195 indicates a water supply control valve, this valve being connected to the water inlet of the heat exchanger 98 by pipe 196. The water outlet for the heat exchanger 98 is connected by a pipe 197 to the water jacket of engine 56, and outlet of this water jacket is connected by a pipe 198 to waste. This pipe 198 it will be understood may return the water to its source if the source of water supply is from a well or pond. If city water is utilized, this pipe 198 may be connected to a sewer.

The valve 195 is actuated by means of a suitable proportioning motor generally indicated as 199, this motor being under the conjoint control of a winter controller 200, a summer controller 201, and an engine temperature responsive thermostat 202. Referring to the motor 199, this motor may be of the type shown and described in the Taylor patent and is diagrammatically indicated as comprising a main operating shaft 203 which is driven through a gear train 204 by means of a reversible electric motor indicated as comprising rotors 205 and 206 cooperating with field coils 207 and 208. The rotor 206 and coil 208 form a motor for driving the shaft 203 in one direction, and the rotor 205 and coil 207 form a motor for driving the shaft 203 in the opposite direction. The shaft 203 carries a crank 209 which is connected to the valve stem of valve 195. This shaft also operates a balancing potentiometer 210 comprising a slider 211 and a balancing resistance 212.

Energization of the field coils 207 and 208 is

controlled by means of a balancing relay 213 which comprises a pair of serially connected relay coils 214 and 215 which actuate through a suitable armature, a switch arm 216 cooperating with contacts 217 and 218. The switch arm 216 is connected by wire 219 to the secondary 220 of step-down transformer 221, the primary 222 of which is connected across the line wire 132 and 133. The other terminal of secondary 220 is connected by wires 223 and 224 to the connected ends of field coils 207 and 208. The contact 217 is connected by wire 225 to the field coil 207, and the contact 218 is connected by wire 226 to the field coil 208. In addition the relay coils 214 and 215 are connected in series across the transformer secondary 220 by means of wires 219, 227, 228, 229, 230, 231, and 223. When the relay coils 214 and 215 are equally energized, the switch arm 216 will assume mid-position in which it is disengaged from contact 217 and contact 218. If the relay coil 215 should become energized more highly than coil 214 the switch arm 216 will engage contact 218 and this will energize the motor field 208 for driving the operating shaft 203 in a direction for opening the valve 195. If relay coil 214 becomes energized more highly than coil 215, the switch arm 216 will engage contact 217 for energizing motor field 207 this driving the shaft 203 in a direction for closing valve 195.

Referring to the controller 200, this controller includes a bellows 232 which operates a bell crank lever 233 having an actuating arm 234 and a slider 235 which cooperates with resistance 236 to form a control potentiometer. The bellows 232 is connected by a tube 237 to the pipe 97 adjacent the heat exchanger 98. The actuating arm 234 may be biased against the bellows 232 by means of a spring 238. This spring may be so adjusted as to cause the slider 235 to engage the right-hand end of resistance 236 when the pressure within bellows 232 is below a predetermined value. If Freon is used as the refrigerant in the system, this value may be approximately 116 lbs. per sq. inch. When the pressure within bellows 232 rises to 120 lbs. per sq. inch the bellows will expand against the action of spring 238 for causing the slider 235 to engage the left-hand end of resistance 236. The bellows 232 may also actuate a second slider 239 cooperating with a resistance 240. This slider 239 is indicated as being actuated with slider 235 by means of an insulated connection 241.

The winter pressure controller 201 may be formed similarly to the pressure controller 200 and comprises a first slider 242 cooperating with a resistance 243 to form a control potentiometer, and a second slider 244 cooperating with a resistance 245 for forming a rheostat. This instrument also includes a bellows 246 which is connected by the tube 237 to pipe 97 along with the bellows 232 of the controller 200. This winter pressure controller 201 may be so designed and adjusted as to cause the slider 242 to engage the right-hand end of resistance 243 when the pressure within heat exchanger 98 is 50 lbs. per sq. inch or below, while engaging the left-hand end of this resistance when the pressure rises to 55 lbs. per sq. inch.

Referring to the thermostat 202 this thermostat may be formed similarly to the controllers 200 and 201 and consists of a bellows 250 for operating sliders 251 and 252 which cooperate with resistances 253 and 254, respectively. The bellows 250 is connected by a capillary tube 255

to a control bulb 256 located in the engine water jacket. This instrument may be so designed and adjusted as to cause the switch arm 251 to engage the right-hand end of resistance 253 when the engine temperature is below 160° F. while engaging the left-hand end of resistance 253 when the engine temperature rises to 170° F.

Referring now to the connections between the relay 213 and the various controllers it will be noted that the left-hand end of resistance 236, the right-hand end of resistance 243, and the left-hand end of resistance 253 are connected to the relay coil 214 by wires 228, 257, 258, 259, and 260. Also the relay coil 214 is connected to the upper end of the balancing resistance 212 by wire 261 and resistance 262. The lower end of balancing resistance 211, the right-hand end of resistance 236, the left-hand end of resistance 243, and the right-hand end of resistance 253 are connected to the relay coil 215 by wires 229, 230, 264, 265, 266, and 267. The resistances 212, 236, 243, and 253 are therefore connected in parallel with the serially connected relay coils across the transformer secondary 220. The junctions of relay coils 214 and 215 are connected by wires 268, 269, 270, 271, 272, 273, and 274 to the sliders 211, 239, 244, and 252. The resistances 240, 245, and 254 it will be noted are connected to the sliders 235, 242, and 251, respectively. The sliders 211, 235, 242, and 251 therefore are each connected to the junction of relay coils 214 and 215. It will be apparent that this arrangement will cause each of these sliders to divide their respective resistances into one portion which is connected in parallel with relay coil 214, and a second portion which is connected in parallel with the relay coil 215. Thus movement of any of the sliders on their resistances will vary the relative energization of the relay coils 214 and 215.

With the parts in the positions shown, the system is operating on the heating cycle. Consequently the heat exchanger 98 is now acting as an evaporator and the refrigerant pressure therein is therefore relatively low, this pressure at this time being 52.5 lbs. per sq. inch as indicated by the slider 242 of controller 201 engaging the center of resistance 243. Due to this low pressure the slider 235 of controller 200 is engaging the right-hand end of resistance 236. Also at this time the engine temperature is below 160° F. as indicated by the slider 251 engaging the right-hand end of resistance 253. With the slider 235 in the position shown, the slider 239 is engaging the right-hand end of resistance 240 and therefore the entire resistance 240 is connected in series with the slider 235. Due to this resistance being connected in series with slider 235, a very small amount of current will flow through this slider and consequently the position of this slider will have substantially no effect upon the position assumed by motor 199. Also with the slider 251 of thermostat 202 in the position shown, the entire resistance 254 is connected in series with slider 251, causing this extreme position of slider 251 to have but a slight effect upon the motor position.

With slider 242 in the mid-position shown, only one-half of the resistance 245 is in circuit with this slider, and consequently movement of slider 242 will have a substantial effect upon the motor position. As previously mentioned, with the parts in the position shown, the heat exchanger 98 is operating as an evaporator for absorbing heat from the water passing through

this exchanger. If the demand for heat increases, the engine speed will be increased this tending to reduce the pressure within heat exchanger 98. This decrease in pressure within heat exchanger 98 will cause movement of the slider 242 to the right across resistance 243. This will have the effect of decreasing the portion of resistance 243 which is connected in parallel with relay coil 214, and will increase the portion of this resistance which is connected in parallel with relay coil 215. This will cause the switch arm 216 to engage contact 217 for energizing motor field 207, which rotates shaft 203 in a direction for opening the valve 195 and increasing the supply of water to the heat exchanger 98. This action has the effect of increasing the amount of heat supplied to the reversed cycle of the refrigeration system. As the shaft 203 rotates for opening valve 195, the slider 211 of the balancing potentiometer will move downwardly on resistance 212 thereby decreasing the portion of this resistance which is connected in parallel with relay coil 215, while increasing the portion of this resistance which is connected in parallel with relay coil 214, this action thus tending to balance out the initial unbalancing action of the controller 201. It will be apparent that when shaft 203 rotates an amount proportionate to the movement of slider 242 on resistance 243, the relay coils 214 and 215 will again become balanced for causing switch arm 216 to disengage contact 217 for stopping the motor at this point. Upon an increase in pressure within heat exchanger 98, the slider 242 will move to the left across resistance 243 and this will cause movement of the motor 199 in a direction for closing the valve 195 an amount proportionate to the pressure increase. It should therefore be apparent that the controller 201 will act to cause opening of the valve 195 as the refrigerant pressure in heat exchanger 98 falls below 55 lbs. per sq. inch and will cause the valve 195 to be wide open when the refrigerant pressure falls to 50 lbs. per sq. inch. This action tends to maintain the refrigerant pressure substantially constant and thus supplies just enough heating water to the heat exchanger 98 to meet the demands of the system.

When the system is operating on the cooling cycle, the heat exchanger 98 will operate as a condenser and therefore the refrigerant pressure therein at this time will be relatively high. This will cause the slider 242 of controller 201 to engage the left-hand end of resistance 243 and at this time the slider 244 will insert the entire resistance 243 into circuit with slider 242, thus causing this extreme position of slider 242 to have substantially no effect upon the motor position. In other words the slider 242 in engaging the left-hand end of resistance 243 will by itself be incapable of maintaining the valve 195 in closed position. During the cooling cycle the controller 200 will control the valve 195 in a manner to maintain the refrigerant pressure within heat exchanger 98 between 116 and 120 lbs. per sq. inch. Thus if the refrigerant pressure rises to 120 lbs. per sq. inch, the slider 235 will engage the left-hand end of resistance 236 and at this time the resistance 240 will be entirely out of circuit with slider 235. Due to engagement of slider 235 with the left-hand end of resistance 236, the relay coil 214 will be substantially short-circuited while the entire resistances 236 will be connected in parallel with relay coil 215. This will cause switch arm 216 to engage

contact 217 for energizing field coil 207. This will run valve 195 towards open position and the slider 211 of the balancing potentiometer will move downwardly across resistance 212 for tending to rebalance the energization of relay coils 214 and 215. This action however will be incapable of rebalancing the energization of coils 214 and 215 until the slider 211 engages the lower end of resistance 212, at which time the valve 195 will be wide open. Therefore when the refrigerant pressure is at 120 lbs. per sq. inch, the valve 195 will be wide open. As the cooling load on the system decreases, less water will be required for condensing the refrigerant and consequently the refrigerant pressure will decrease. This decrease in pressure will cause slider 235 to move to the right across resistance 236 thus inserting a portion of this resistance in parallel with relay coil 214 and decreasing the portion of this resistance which is in parallel with relay coil 215. This will cause relay coil 215 to become more highly energized than coil 214 thus causing switch arm 216 to engage contact 218 for energizing motor field 208. Energization of motor field 208 will cause rotation of shaft 203 for closing valve 195 and this rotation of shaft 203 will cause movement of slider 211 upwardly across resistance 212, thus tending to rebalance energization of relay coils 214 and 215. Therefore as the refrigerant pressure decreases, the valve 195 will be closed an amount proportionate to the decrease in pressure and will tend to become completely closed when the refrigerant pressure falls to 116 lbs. per sq. inch. This action will proportion the water supply to heat exchanger 98 during the summer cycle in accordance with the demand for cooling water.

In the event that either the controller 200 or 201 fails to supply enough water to heat exchanger 98 for preventing overheating of the engine 56, the slider 251 of the engine thermostat 202 will move from the extreme position shown towards the left across resistance 253. This will remove a portion of the resistance 254 from circuit with slider 251 thereby increasing the effect of slider 251 on the motor 199. Also the movement of slider 251 to the left across resistance 260 will decrease the portion of this resistance which is in parallel with relay coil 214 and increase the portion of this resistance which is in parallel with relay coil 215 thus causing switch arm 216 to engage contact 217 for thereby opening the valve 195. In response to this opening movement of the valve 195, the balancing potentiometer 110 will rebalance the relay coils 214 and 215 when the valve 195 has been opened an amount proportionate to the movement of slider 251 on resistance 253.

The controllers 200, 201, and 202 therefore conjointly control the valve motor 199 in a manner to increase the supply of water to heat exchanger 98 as the pressure increases when the system is operating on the summer cycle; to increase the supply of water when the refrigerant pressure decreases below a predetermined value when the system is operating on the cooling cycle; and to increase the supply of water at any time in the event that the engine becomes overheated. Due to the action of the auxiliary rheostats associated with each of these controllers, these controllers automatically reduce their effect upon the valve motor as they become satisfied, thereby transferring the control of the valve motor to any controller which is not satisfied.

It should be noted that switch arm 152a is connected into the engine starting and ignition circuit, and is actuated by the crank 209 in a manner to stop the engine whenever valve 195 is wide open. As valve 195 is opened wide when the compressor head pressure becomes excessive on the cooling cycle, when the suction pressure becomes excessive on the heating cycle, or when the engine overheats, this arrangement provides a safety control for stopping the engine if any one of these conditions occurs. This will prevent damage to the engine from overheating, prevent freezing of water in heat exchanger 98 during the heating cycle, and will stop the engine upon failure of cooling water during the cooling cycle.

Referring to the resistance 262 which is interposed between the upper end of the balancing resistance 212 and the relay coil 214, the purpose of this resistance is to balance out the effect upon the relay coils of the auxiliary rheostats. This resistance 262 should be one-half the value of the balancing resistance 212.

Operation of Figure 1

With the parts in the positions shown, the space temperature is approximately 71° F. as indicated by the slider 165 of thermostat 158 engaging the center of its resistance 166. Due to the space temperature being below 72° F. the mercury switch 168 is closed and relay 117 is energized. In the manner previously described, energization of this relay has placed the potentiometer of thermostat 158 in control of the throttle valve motor 157, has positioned three-way valves 63 and 64 for causing operation of the system on the heating cycle, has caused energization of the pump 114, and has placed the engine 56 into operation. Due to the system operating on the heating cycle, the heat exchanger 98 is operated as an evaporator and consequently the refrigerant pressure therein is relatively low as indicated by the slider 242 of controller 201 engaging the center of its resistance. This has caused the valve 195 to be half open. Due to the slider 165 of winter thermostat 158 engaging the center of resistance 166, the throttle valve motor 157 has assumed a position in which the throttle valve 142 is half open. The engine 56 is therefore operating at an intermediate speed.

If the heating load upon the system increases, the space temperature will fall which will cause movement of slider 165 to the left across resistance 166 thereby causing the motor 157 to open the throttle valve 142 wider. This will increase the speed of the engine thereby causing more heat to be absorbed by the heat exchanger 98 from the water supplied thereto. This will result in the refrigerant pressure within the heat exchanger 98 becoming lower and in response to this fall in refrigerant pressure, the winter pressure controller 201 will operate to open valve 195 wider for supplying a larger amount of water to the heat exchanger thus tending to maintain a substantially constant pressure within heat exchanger 98 and balancing the water supply against the heating load. This arrangement provides for supplying just the proper amount of water to meet the requirements of this system, thereby conserving on operating expenses of the system.

As the heating load on the system decreases, the space temperature will increase and in response to this increase in space temperature, the winter thermostat 158 will cause shifting of the throttle valve 142 towards closed position for

reducing the engine speed. This action will maintain the space temperature within the range of the thermostat 158. As the engine speed is decreased, it will be apparent that if the supply of cooling water is higher than necessary, the pressure on heat exchanger 98 will tend to rise and in response to this rise in pressure, the pressure controller 201 will reduce the supply of water to heat exchanger 98.

When the space temperature rises above 72° F. the mercury switch 168 of thermostat 158 will deenergize relay 117 and this will transfer the control of the throttle valve motor 157 from the thermostat 158 to the thermostat 159. Deenergization of relay 117 additionally will position three-way valves 63 and 64 for operating the system on the cooling cycle. Additionally this deenergization of relay 117 will stop the pump 114 and will place the engine starting circuit under the control of the space relative humidity controller 187. At this time the engine will be stopped and started in accordance with the relative humidity in the space and its speed when in operation will be determined by the thermostat 159.

As pointed out previously, when the relative humidity within the space rises to a predetermined value, the engine will be started by the controller 187. If the space temperature is relatively low, such as 75° F., the thermostat 159 will cause the throttle valve 142 to be wide open thus causing operation of the engine at full speed. This will result in reducing the temperature of the heat exchanger 6 to a minimum value whereby this heat exchanger will perform a relatively large amount of dehumidification as compared to sensible heat cooling. This will result in reducing the relative humidity in a very short time to a value at which the controller 187 stops the engine. Due to this short period of operation, only a small amount of cooling will be performed. As the space temperature increases, the engine will be operated at slower and slower speeds during its periods of operation as determined by the humidity controller 187. Thus when the space temperature is at 82° F. the engine will be operated at low speed which will cause the temperature of the heat exchanger to be relatively high at which time only a slight amount of dehumidification is performed as compared to the sensible heat cooling performed. This will require the engine 56 to operate for a substantial period of time before the relative humidity controller stops the engine, and consequently a large amount of cooling will be performed for maintaining the space temperature at a proper value.

It should be noted that this control system will provide for intermittent reheat in the event that reheat is necessary in order to obtain proper humidity conditions within a space. For instance during cool damp weather the humidity within the space may be excessive while the temperature is fairly low. At this time the humidity controller will cause operation of the engine for dehumidifying the space. If this engine operation results in the space temperature falling below 72° F., the thermostat 158 will reverse the operation of the system thus causing the heat exchanger to now heat the space instead of cooling it. This heating action will continue until the space temperature rises above 72° F. at which time the system will again be placed on the cooling cycle thus permitting the dehumidifying action to continue.

During the cooling cycle the pressure controller 200 will operate to increase and to decrease the supply of cooling water to the heat exchanger 98 in a manner to maintain substantially a constant refrigerant pressure within this heat exchanger. Also during both the heating and the cooling cycles the engine temperature responsive thermostat 202 will operate to increase the supply of cooling water to the heat exchanger 98 and the engine in the event that the engine should commence overheating. In addition, whenever valve 195 becomes wide open, switch arm 152a will stop the engine for preventing damage to the system due to failure of water supply, or to other improper operating conditions.

Figure 4

Referring to Figure 4 this figure shows a slightly modified system from that shown in Figure 1. In this figure the details of the various controllers and relays have not been illustrated and the portions of this figure which are identical to the system of Figure 1 are indicated by the same reference characters.

In Figure 4 the refrigeration system is substantially the same as for Fig. 1. However, the auxiliary evaporator 100a of Figure 4 differs from the auxiliary evaporator of Figure 1 in that it is provided with a second heat exchange coil 300, the inlet of which is connected by a pipe 301 to the outlet of the engine water jacket, a thermostat 302 being provided for maintaining the engine temperature at a proper value. The outlet of heat exchange coil 300 is connected by a pipe 303 to a radiator 304 and this radiator is connected by pipe 305 to a pump 306 which in turn is connected by pipe 307 to the inlet of the engine water jacket. The pump 306 may be driven by the engine 56, and this pump causes the engine cooling water to circulate through heat exchange coil 300, radiator 304 and back to the engine. Due to the spray of liquid refrigerant over the heat exchange coil 300, the engine cooling water will give up its heat to this sprayed refrigerant, thereby providing for cooling of the engine and transfer of the jacket heat of the engine to the air being heated.

It should be noted that the auxiliary evaporator 100a of Figure 4 is connected into the refrigeration system in a slightly different manner from that shown in Figure 1. In Figure 4 the auxiliary evaporator 100a is also utilized as a receiver for the refrigerant thereby eliminating use of the separate receiver 108 of Figure 1. In Figure 4 when the system is operating on the heating cycle, refrigerant will pass from the compressor 55 through pipes 60 and 62 into three-way valve 64 and from three-way valve 64 through pipe 99 into the header 11 of heat exchanger 6, and the condensed refrigerant will pass from the heat exchanger 6 through the pipe 116 (as in Figure 1) to the pump 114 which sprays it into the auxiliary evaporator 100a. The evaporated portion of the refrigerant will pass from auxiliary evaporator 100a through pipe 308 to the pipe 60, and this refrigerant will pass back into the heat exchanger 6 along with the refrigerant being delivered by the compressor 55. Also liquid refrigerant at the bottom of auxiliary evaporator 100a will be drawn through pipe 116' by the pump 114 and resprayed over the heating surface as occurs in Figure 1. The unevaporated portion of the liquid refrigerant leaves the receiver formed in the bottom of auxiliary evaporator 100a, and passes through pipe 109a through the expansion

valve 110 and thence into the heat exchanger 98. This refrigerant is evaporated in exchanger 98 and passes through pipe 97 to the three-way valve 63 and from there through pipes 66 and 67 to the compressor.

When the system is operating on the cooling cycle, refrigerant will pass from the compressor through pipes 60 and 61 to the three-way valve 63 and then through pipe 97 into the heat exchanger 98 wherein it is condensed. This condensed refrigerant then passes through pipe 111, check valve 112, and pipe 116 into the receiver formed in the bottom of auxiliary evaporator 100a, and from there passes through pipe 109a to the expansion valve device 12 of the heat exchanger 6. The refrigerant then flows from this heat exchanger through pipe 99, three-way valve 64, and pipes 65 and 67 to the compressor. When the system is operating on the cooling cycle the pump 114 is out of operation and consequently no liquid refrigerant is sprayed over the coils 101 and 300 in the auxiliary evaporator. The chamber within this auxiliary evaporator will remain in communication with the discharge line 60 of the compressor and the refrigerant pressure will therefore become equal to the compressor head pressure. This refrigerant is already in the gaseous state and consequently will merely fill the auxiliary evaporator 100a without absorbing heat from the heat exchange coils 101 and 300.

Reference character 310 indicates a motor driven fan for blowing air across the radiator 304. This fan may be controlled by means of a thermostat 311 responsive to the engine temperature. The thermostat 311 may be of usual form and is shown as including a bellows 312 connected to a control bulb 313 in the engine water jacket, the bellows 312 actuating a mercury switch 314. This mercury switch 314 is connected in series with the fan 310 as shown. The thermostat 311 may be designed in a manner to place the fan 310 in operation whenever the engine temperature exceeds a predetermined value such as 170° F. During the heating cycle of this system the auxiliary evaporator 100a should cool the engine cooling water sufficiently to maintain the engine temperature below 170° F. and consequently the fan 310 will remain out of operation. However, when the system is operating on the cooling cycle, the auxiliary evaporator 100a is out of operation and this will cause the engine temperature to rise to a value at which the fan 310 is placed into operation. At this time the fan 310 will be placed into and out of operation by the thermostat 311 in a manner to maintain a substantially constant engine temperature.

It should be noted that in Figure 4, the heat exchanger 98 and the engine water jacket are not connected in series as in Figure 1. For this reason the water supply valve 195 for the heat exchanger 98 is controlled only by the two refrigerant pressure controllers 200 and 201.

It should now be apparent that this invention provides a completely automatic summer-winter air conditioning system which utilizes a refrigeration system operating on a normal cycle for cooling the space and which operates on a reversed cycle for heating the space. It should further be apparent that this invention utilizes an internal combustion engine for driving the compressor, provides for utilizing the waste heat from this engine when the system is operating on the heating cycle, and provides for properly cooling the engine when the system is operating

either on the cooling or heating cycle. Also it should be seen that this invention provides a reversible cycle refrigeration system for use in air conditioning installations which utilizes a multiple pass type of heat exchanger in the air stream, and which provides for proper distribution of the liquid refrigerant to the various passes while the system is operating on the cooling cycle and which provides for eliminating the pressure drop of the distributing device when the system is operating on the heating cycle. It will further be seen that my invention provides for maintaining proper space conditions during both summer and winter and automatically changes from heating to cooling operation depending upon space conditions.

While throughout this description I have mentioned specific values of temperature and pressure at which the various instruments may be set, it will be understood that these values are illustrative only and may be varied as desired for different installations and applications of my invention. While I have shown and described preferred forms of my invention, I do not limit myself to the specific embodiments shown, as many modifications and adaptations of various features and subcombinations of my invention will occur to those skilled in the art. I therefore desire to be limited only by the scope of the appended claims.

I claim as my invention:

1. A conditioning system comprising, in combination, a refrigeration system including actuating means and heat exchange devices in heat exchange relationship with a space to be conditioned and with a medium outside of said space to be conditioned, means including valve means for connecting said devices to each other and to said actuating means in different manners to selectively cool or heat said space, pressure actuated means including a chamber having a movable wall for shifting at least a portion of said valve means from one position to another upon change in pressure applied to said movable wall, and means including pilot valve means for utilizing pressure differences within said system for changing the pressure applied to said movable wall sufficiently to cause shifting of said valve means.

2. A conditioning system comprising, in combination, a refrigeration system including actuating means and heat exchange devices in heat exchange relationship with a space to be conditioned and with a medium outside of said space to be conditioned, means including valve means for connecting said devices to each other and to said actuating means in a manner to selectively cool or heat said space, pressure actuated means for shifting said valve means from one position to another, means including pilot valve means for utilizing pressure differences within said systems for actuating said pressure actuated means, and yieldable means associated with said valve means and actuating means therefor for permitting movement of said valve means independently of said actuating means when the pressures within a portion of said refrigeration system become undesirable.

3. A conditioning system comprising, in combination, actuating means, a first device in heat exchange relationship with a space for cooling or heating said space, a second device in heat exchange relationship with a medium exterior of said space, means including valve means for

connecting said devices to each other and to said actuating means in a manner to selectively cause said first device to operate as an evaporator while causing said second device to act as a condenser, or for causing said first device to act as a condenser while said second device acts as an evaporator, pressure actuated means including a chamber having a movable wall for shifting at least a portion of said valve means from one position to another upon change in pressure applied to said movable wall, and means including pilot valve means for utilizing pressure differences within said system for changing the pressure applied to said movable wall sufficiently to cause shifting of said valve means.

4. A conditioning system comprising, in combination, a compressor, a first heat exchange device in heat exchange relationship with said space, a second heat exchange device in heat exchange relation with medium external of said space, means including a three-way valve for selectively connecting said first and second devices to said compressor in a manner for causing said first device to operate as a condenser while said second device acts as an evaporator, or for causing said first device to act as an evaporator while said second device acts as a condenser, said three-way valve having a first port connected to the outlet of said compressor, a second port connected to the inlet of said compressor, and a valve member for selectively placing either of said ports in communication with a third port, actuating means for said valve member, and yieldable means for permitting movement of said valve member to a position placing said first and second ports in communication when the pressure at the outlet of the compressor becomes excessive.

5. In a conditioning system, in combination, a refrigeration system including actuating means, a first heat exchange device in heat exchange relationship with a space to be conditioned, a second heat exchange device in heat exchange relationship with a medium external to said space, said first heat exchange device being formed to provide a plurality of parallel passes for the flow of refrigerant therethrough, a first expansion valve for said first heat exchange device, a second expansion valve for said second heat exchange device, a distributor connected to the outlet of said first expansion valve, said distributor including a chamber receiving the jet of liquid refrigerant from said first expansion valve, and a plurality of restricted connections leading from said chamber to each of said first heat exchange device passes, means including valve means for connecting said heat exchange devices to each other and to said actuating means in a manner to selectively cause said first heat exchange device to operate as an evaporator while said second heat exchange device acts as a condenser, or to cause said first heat exchange device to operate as a condenser while said second heat exchange device acts as an evaporator, pressure actuated means for shifting said valve means from one position to another, means including pilot valve means for utilizing pressure differences within said system for actuating said pressure actuated means, and pressure actuated means for permitting flow of refrigerant around said restricted connections when said valve means is positioned for causing said first heat exchange device to act as a condenser.

6. In a conditioning system, in combination, a refrigeration system including actuating means

and heat exchange devices, one of said devices including a plurality of parallel passes, a distributor for distributing liquid refrigerant to said passes, said distributor including a plurality of restricted passages interposed between a source of liquid refrigerant supply and said passes, means including valve means for selectively causing said one heat exchange device to operate as an evaporator or as a condenser, a plurality of by-pass passages for by-passing said restricted connections, and check valve means interposed in said by-pass passages.

7. In a conditioning system, in combination, a refrigeration system including actuating means and heat exchange devices, one of said heat exchange devices including a plurality of passes, means including valve means for causing said one heat exchange device to operate either as an evaporator or as a condenser, a distributor device for distributing liquid refrigerant to said one heat exchange device when it operates as an evaporator and for collecting liquid refrigerant from said one heat exchange device when it acts as a condenser, said distributor device comprising an inlet for liquid refrigerant, a plurality of restricted passages connecting said inlet to said passes, an outlet for liquid refrigerant, a plurality of passages connecting said passes to said outlet, and check valve means associated with said last mentioned passages.

8. In a conditioning system, in combination, a refrigeration system including actuating means, a first heat exchange device in heat exchange relationship with a space to be conditioned and comprising a plurality of parallel passes for refrigerant flow, a second heat exchange device, expansion valve means for said first and second heat exchange devices, means including change-over valve means for selectively causing said first heat exchange device to operate as an evaporator while said second heat exchange device operates as a condenser, or for causing said first heat exchange device to operate as a condenser while said second heat exchange device operates as an evaporator, a distributor device connected to said first heat exchange device for distributing liquid refrigerant to said passes when said first device is operating as an evaporator and for collecting liquid refrigerant from said passes when said device acts as a condenser, said distributor device including a plurality of restricted passages, by-pass passages around said restricted passages, check valve means associated with said by-pass passages for causing refrigerant to be forced through said restricted passages when said first heat exchange device operates as an evaporator, while allowing flow of refrigerant through said by-pass passages when said first heat exchange device acts as a condenser, pressure actuated means for actuating said change-over valve means, means including pilot valve means for utilizing pressure differences within the refrigeration system for actuating said pressure actuated means, means for supplying medium to said second heat exchange device to heat said second heat exchange device when acting as an evaporator and for cooling said second heat exchange device when acting as a condenser, and means responsive to the pressure of the refrigerant in said second heat exchange device for controlling said supplying means.

9. In a conditioning system, in combination, a refrigeration system including a compressor and heat exchange devices, one of said heat exchange

devices being arranged to operate either as an evaporator or as a condenser, means for supplying medium to said one heat exchange device for supplying heat to said one heat exchange device while it is operating as an evaporator and to cool said one heat exchange device while it is operating as a condenser, means responsive to conditions which are measures of the demand for cooling or heating medium for controlling said supplying means, and means actuated by said controlling means for stopping said compressor upon a predetermined demand for said medium.

10. In a conditioning system, in combination, a refrigeration system including a compressor and heat exchange devices, one of said heat exchange devices being arranged to operate either as an evaporator or as a condenser, an internal combustion engine for driving said compressor, means for supplying medium to said one heat exchange device and to said internal combustion engine in series, said medium acting to supply heat for said one heat exchange device while it is operating as an evaporator, to cool said one heat exchange device while it is operating as a condenser, and to cool said internal combustion engine, and means responsive to the refrigerant pressure within said one heat exchange device and to the temperature of said internal combustion engine for controlling said supplying means in a manner to increase the supply of medium upon rise or fall in said pressure above or below predetermined values, and upon rise in temperature of said engine above a predetermined value.

11. In a summer-winter air conditioning system, in combination, a refrigeration system including a compressor, and heat exchange devices, change-over valve means for causing one of said heat exchange devices to operate as an evaporator or as a condenser, an internal combustion engine for driving said compressor, means for supplying medium to said one heat exchange device and to said internal combustion engine in series, said medium acting to supply heat for said one heat exchange device while it is operating as an evaporator, to cool said one heat exchange device while it is operating as a condenser, and to cool said internal combustion engine, means responsive to the temperature of said space for starting said internal combustion engine and positioning said change-over valve means in a manner to operate said one heat exchange device as an evaporator when space temperature falls below a predetermined value while positioning said change-over valve means in a manner to operate said one heat exchange device as a condenser when the space temperature is above such value, means for starting said engine when the space relative humidity rises to a value requiring dehumidification, means responsive to space temperature for varying the output of said engine when in operation while said one heat exchange device is operating as a condenser, and means responsive to the demand for cooling or heating medium for said one heat exchange device and to the demand for cooling of said engine for controlling said medium supplying means.

12. In a summer-winter air conditioning system, in combination, a refrigeration system including a compressor, and heat exchange devices, change-over valve means for causing one of said heat exchange devices to operate as an evaporator or as a condenser, an internal combustion engine for driving said compressor, means responsive to the temperature of said space for starting said internal combustion engine and

positioning said change-over valve means in a manner to operate said one heat exchange device as an evaporator when space temperature falls below a predetermined value while positioning said change-over valve means in a manner to operate said one heat exchange device as a condenser when the space temperature is above such value, means for starting said engine when the space relative humidity rises to a value requiring dehumidification, and means responsive to space temperature for varying the output of said engine when in operation while said one heat exchange device is operating as a condenser.

13. In a summer-winter air conditioning system, in combination, a refrigeration system including actuating means and heat exchange devices, change-over valve means for causing one of said heat exchange devices to operate as an evaporator or as a condenser, means responsive to space temperature for starting said actuating means and positioning said change-over valve means in a manner to operate said one heat exchange device as an evaporator when space temperature falls below a predetermined value, while positioning said change-over valve means to operate said one heat exchange device as a condenser when space temperature rises above said value, means for placing said actuating means in operation when space relative humidity rises to a value requiring dehumidification, and means responsive to space temperature for varying the output of said actuating means at this time.

14. In an air conditioning system, in combination, a cooling and dehumidifying means for cooling and dehumidifying the air passed to a space being conditioned, humidity influenced means for placing said cooling and dehumidifying means into operation when the humidity within the space rises to a predetermined value, and temperature responsive means for increasing the capacity of said cooling and dehumidifying means upon decrease in space temperature, and for decreasing the capacity of said cooling and dehumidifying means upon increase in space temperature.

15. In a conditioning system, in combination, a reversible cycle refrigeration system including a compressor and a heat exchanger in heat exchange relationship with a space to be conditioned, change-over valve means for selectively causing said refrigeration system to cool or heat said space, an auxiliary evaporator associated with said change-over valve means and said heat exchanger in a manner to receive condensed refrigerant from said heat exchanger when said change-over valve means is positioned for operating said heat exchanger as a condenser, means for causing refrigerant evaporated in said auxiliary evaporator to be returned to said heat exchanger, an internal combustion engine for driving said compressor, means for supplying waste heat from said engine to said auxiliary evaporator, and space condition responsive means for controlling said engine and said change-over valve means.

16. In a conditioning system, in combination, a reversible cycle refrigeration system including a compressor and heat exchangers in heat exchange relationship with a space to be conditioned and with medium outside of said space, change-over valve means for changing the flow of refrigerant through said refrigeration system in a manner to cause said system to cool said space when said change-over valve means is in one position, and to heat said space when said

change-over valve means is in another position, an auxiliary evaporator associated with one of said heat exchangers for receiving liquid refrigerant therefrom and for returning evaporated refrigerant thereto, an internal combustion engine for driving said compressor, means for supplying waste heat from said engine to said auxiliary evaporator, and means including said change-over valve means for placing said auxiliary evaporator out of operation when the system is operating for cooling the space.

17. In a conditioning system, in combination, a reversible cycle refrigeration system including a compressor and heat exchangers in heat exchange relationship with a space to be conditioned and with medium outside of said space, change-over valve means for changing the flow of refrigerant through said refrigeration system in a manner to cause said system to cool said space when said change-over valve means is in one position, and to heat said space when said change-over valve means is in another position, an auxiliary evaporator associated with one of said heat exchangers for receiving liquid refrigerant therefrom and for returning evaporated refrigerant thereto, an internal combustion engine for driving said compressor, means for supplying waste heat from said engine to said auxiliary evaporator, a pump associated with said last mentioned heat exchanger and said auxiliary evaporator for aiding circulation of refrigerant therebetween, and means for placing said pump out of operation when said system is operating to cool the space.

18. In a conditioning system, in combination, a reversible cycle refrigeration system including a compressor and heat exchangers in heat exchange relationship with a space to be conditioned and with medium outside of said space, change-over valve means for changing the flow of refrigerant through said refrigeration system in a manner to cause said system to cool said space when said change-over valve means is in one position, and to heat said space when said change-over valve means is in another position, an auxiliary evaporator associated with one of said heat exchangers for receiving liquid refrigerant therefrom and for returning evaporated refrigerant thereto, an internal combustion engine for driving said compressor, means for supplying waste heat from said engine to said auxiliary evaporator, a pump associated with said last mentioned heat exchanger and said auxiliary evaporator for aiding circulation of refrigerant therebetween, and temperature responsive means for controlling said internal combustion engine and said pump in a manner to place said engine and pump in operation when the temperature to which said temperature responsive means responds falls to a predetermined value.

19. In a heating system, in combination, a condenser in heat exchange relationship with a zone to be heated, an evaporator for absorbing heat from outside of said zone, a compressor connected to said condenser and evaporator, an internal combustion engine for driving said compressor, an auxiliary evaporator receiving heat from said internal combustion engine, means including a pump for passing liquid refrigerant from said condenser to said auxiliary evaporator and temperature responsive means for placing said pump into and out of operation.

20. In a heating system, in combination, a condenser in heat exchange relationship with a zone

to be heated, an evaporator for absorbing heat from outside of said zone, a compressor connected to said condenser and evaporator, an auxiliary evaporator receiving heat from an outside source, said auxiliary evaporator including heat exchange surface, and means for passing condensed refrigerant from said condenser over said heat exchange surface, for returning evaporated refrigerant from said auxiliary evaporator to said condenser, and for collecting unevaporated refrigerant which has passed over said heat exchange surface and recirculating it over said surface.

21. In a heating system, in combination, a condenser in heat exchange relationship with a zone to be heated, an evaporator for absorbing heat from outside of said zone, a compressor connected to said condenser and evaporator, an internal combustion engine for driving said compressor, an auxiliary evaporator, means for passing liquid refrigerant from said condenser to said auxiliary evaporator and for passing evaporated refrigerant from said auxiliary evaporator to said condenser, a heat exchange device in said auxiliary evaporator, means for passing cooling water from said engine through said heat exchange device, supplemental cooling means for said cooling water, and means for placing said supplemental cooling means into and out of operation.

22. A conditioning system comprising, in combination, a compressor, a first heat exchange device in heat exchange relationship with said space, a second heat exchange device in heat exchange relation with medium external of said space, means including a three-way valve for selectively connecting said first and second devices to said compressor in a manner for causing said first device to operate as a condenser while said second device acts as an evaporator, or for causing said first device to act as an evaporator while said second device acts as a condenser, said three-way valve having a first port connected to the outlet of said compressor, a second port connected to the inlet of said compressor, and a valve member for selectively placing either of said ports in communication with a third port, pressure actuated means including a chamber having a movable wall for shifting said valve member from one position to another upon change in pressure applied to said movable wall, means including pilot valve means for utilizing pressure differences within the refrigeration system for changing the pressure applied to said movable wall for thereby changing the position of said valve member, and yieldable means for permitting movement of said valve member to a position placing said first and second ports in communication when the pressure at the outlet of the compressor becomes excessive.

23. In a reversible refrigeration system, in combination, a compressor, heat exchange devices, one being in heat exchange relationship with a space and another being in heat exchange relationship with a medium external to said space, valve means for selectively causing said system to heat or cool said space, said valve means communicating with the inlet and outlet of said compressor and normally placing said inlet and outlet out of direct communication, and means for positioning at least a portion of said valve means in a manner to place said inlet and outlet in direct communication when the pressure at the outlet of the compressor becomes excessive for thereby relieving such excessive pressure.

24. In a reversible refrigeration system, in

combination, a first heat exchanger, a second heat exchanger, a compressor having an inlet and an outlet, selective valve means communicating with the inlet and outlet of the compressor for selectively connecting the outlet of the compressor to the first heat exchanger and the inlet to the second heat exchanger or connecting the inlet to the first heat exchanger and the outlet to the second heat exchanger, piping means including expansion valve means between said heat exchangers, means for supplying medium for cooling said first heat exchanger when it acts as a condenser and for supplying heat thereto when it acts as an evaporator, a valve for controlling the flow of said medium, a motor for positioning said valve, and control means responsive to the pressure of the refrigerant in said first heat exchanger for controlling said motor in a manner to open said valve upon rise in pressure above a predetermined high value or upon fall in pressure below a predetermined low value.

25. A refrigeration system including actuating means and heat exchange devices, one of said heat exchange devices being arranged to operate either as an evaporator or as a condenser, means for supplying medium to said one heat exchange device for providing a source of heat when said one heat exchange device is acting as an evaporator and for cooling said one heat exchange device when it acts as a condenser, a valve for controlling the flow of said medium at all times, a motor for positioning said valve, and control means responsive to conditions which are measures of the demand for heating or cooling of the refrigerant in said one heat exchanger for controlling said motor in a manner to open said valve upon demand for heating or cooling.

26. In a reversible refrigeration system, in combination, compressing means and heat exchange devices, said compressing means comprising a compressor mechanism and a driving mechanism therefor, reversing means for causing one of said heat exchange devices to operate either as an evaporator or as a condenser, means for passing medium into heat exchange relationship with one of said mechanisms and through said one heat exchange device for thereby cooling said one mechanism and either cooling or heating said heat exchange device, a valve for controlling the flow of said medium, a motor for positioning said valve, means responsive to the temperature of said one mechanism for controlling said motor in a manner to open said valve upon rise in temperature of said one mechanism, and means responsive to conditions which are a measure of the demand for heating or cooling of said one heat exchange device for controlling said motor in a manner to open said valve independently of said temperature responsive means upon demand for either heating or cooling of said one heat exchange device.

27. In a reversible refrigeration system, in combination, compressing means and heat exchange devices, said compressing means comprising a compressor mechanism and a driving mechanism therefor, reversing means for causing one of said heat exchange devices to operate either as an evaporator or as a condenser, means for passing medium into heat exchange relationship with one of said mechanisms and through said one heat exchange device for thereby cooling said one mechanism and either cooling or heating said

heat exchange device, valve means for controlling the flow of said medium through said one heat exchange device and into heat exchange relationship with said one mechanism, means responsive to the temperature of said one mechanism for controlling said valve means in a manner to increase the flow of said medium upon increase in said temperature, means responsive to demand for cooling of said one heat exchange device for controlling said valve means in a manner to increase the flow of medium independently of said temperature responsive means upon increase in demand for cooling of said one heat exchange device, and means responsive to the demand for heating of said one heat exchange device for controlling said valve means in a manner to increase the flow of medium independently of said temperature responsive means upon increase in demand for heating of said one heat exchange device.

28. In a reversible refrigeration system, in combination, compressing means and heat exchange devices, said compressing means comprising a compressor mechanism and a driving mechanism therefor, reversing means for changing the system from heating to cooling and vice versa, means for supplying medium to at least one of said heat exchange devices when the system is cooling and for furnishing heat to at least one of said heat exchange devices when the system is heating, means for also passing said medium in heat exchange relationship with one of said mechanisms for cooling the same, a valve for controlling the flow of said medium, a motor for positioning said valve, thermostatic means responsive to the temperature of said one mechanism for controlling said motor in a manner to open said valve upon rise in temperature of said one mechanism, and means responsive to the demand for said medium by said heat exchange devices for opening said valve independently of said thermostatic means.

29. In an air conditioning system, in combination, a direct expansion cooling coil for cooling and dehumidifying the air in a space, a variable capacity compressing means connected to said cooling coil, a first controller for placing said compressing means into and out of operation, a second controller for varying the capacity of said compressing means, a device responding to the relative humidity of the air in said space for controlling said first controller to start the compressor when relative humidity rises to a predetermined value, and a thermostat responding to space temperature for controlling said second controller in a manner to reduce the capacity of the compressing means upon rise in temperature.

30. In a system of the class described, in combination, a heat exchange device, a compressing means connected to said heat exchange device, said compressing means including a compressing mechanism and a driving mechanism therefor, controlling means for varying the supply of heat exchange medium to said heat exchange device in accordance with the demand for heat exchange medium by said heat exchange device and in accordance with the temperature of one of said mechanisms, and means actuated by said controlling means for stopping said compressing means when the demand for heat exchange medium reaches a predetermined value.

ALWIN B. NEWTON.