July 3, 1951 E. J. DILLMAN ET AL 2,558,938

HEAT PUMP AND CONTROL MEANS

Filed Dec. 30, 1948 4 Sheets-Sheet 1

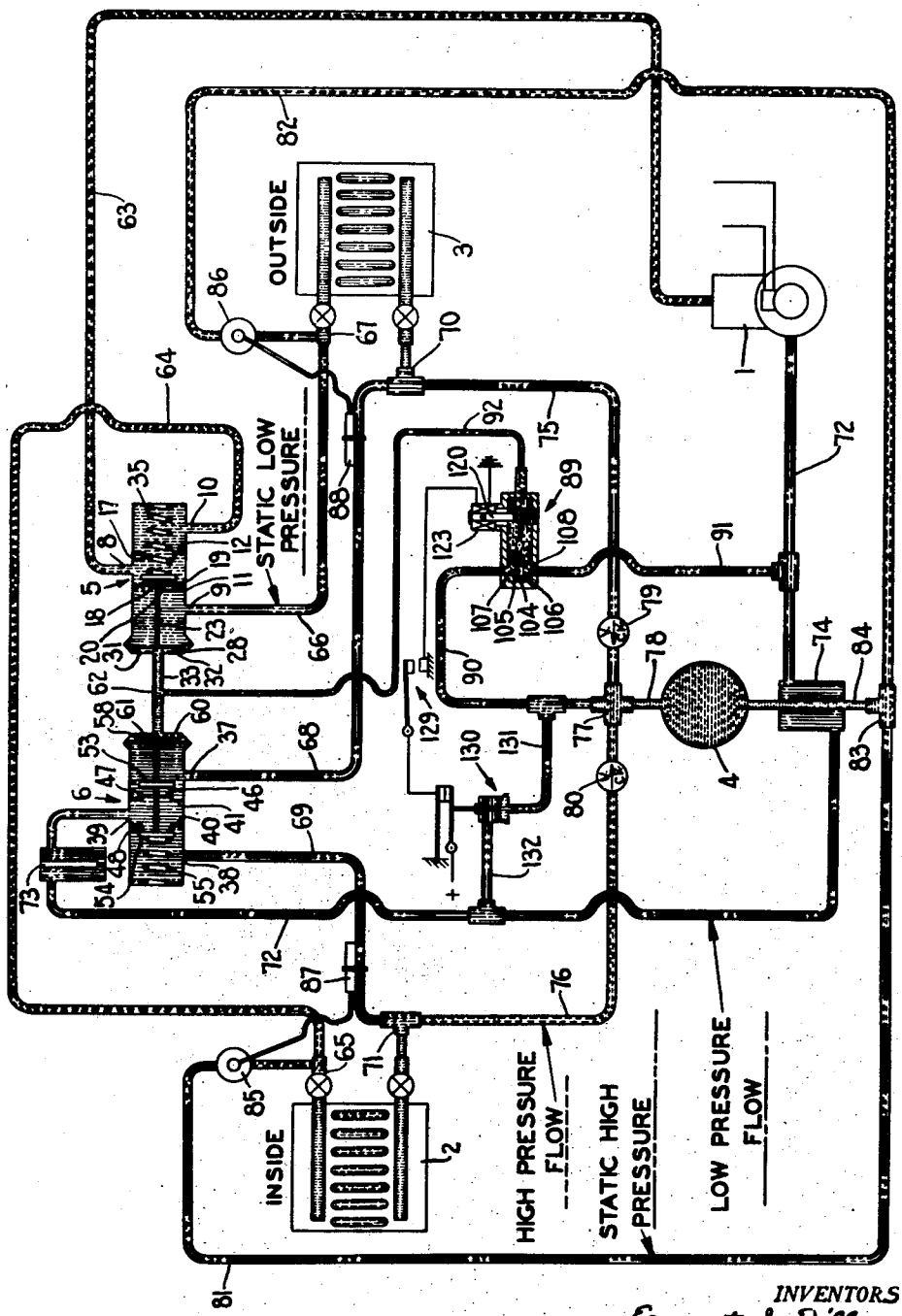


FIG. 1

INVENTORS
Earnest J. Dillman
BY Thomas E. Noakes
Andrew K. Foulds
their ATTORNEY

July 3, 1951 E. J. DILLMAN ET AL 2,558,938

HEAT PUMP AND CONTROL MEANS

Filed Dec. 30, 1948 4 Sheets-Sheet 2

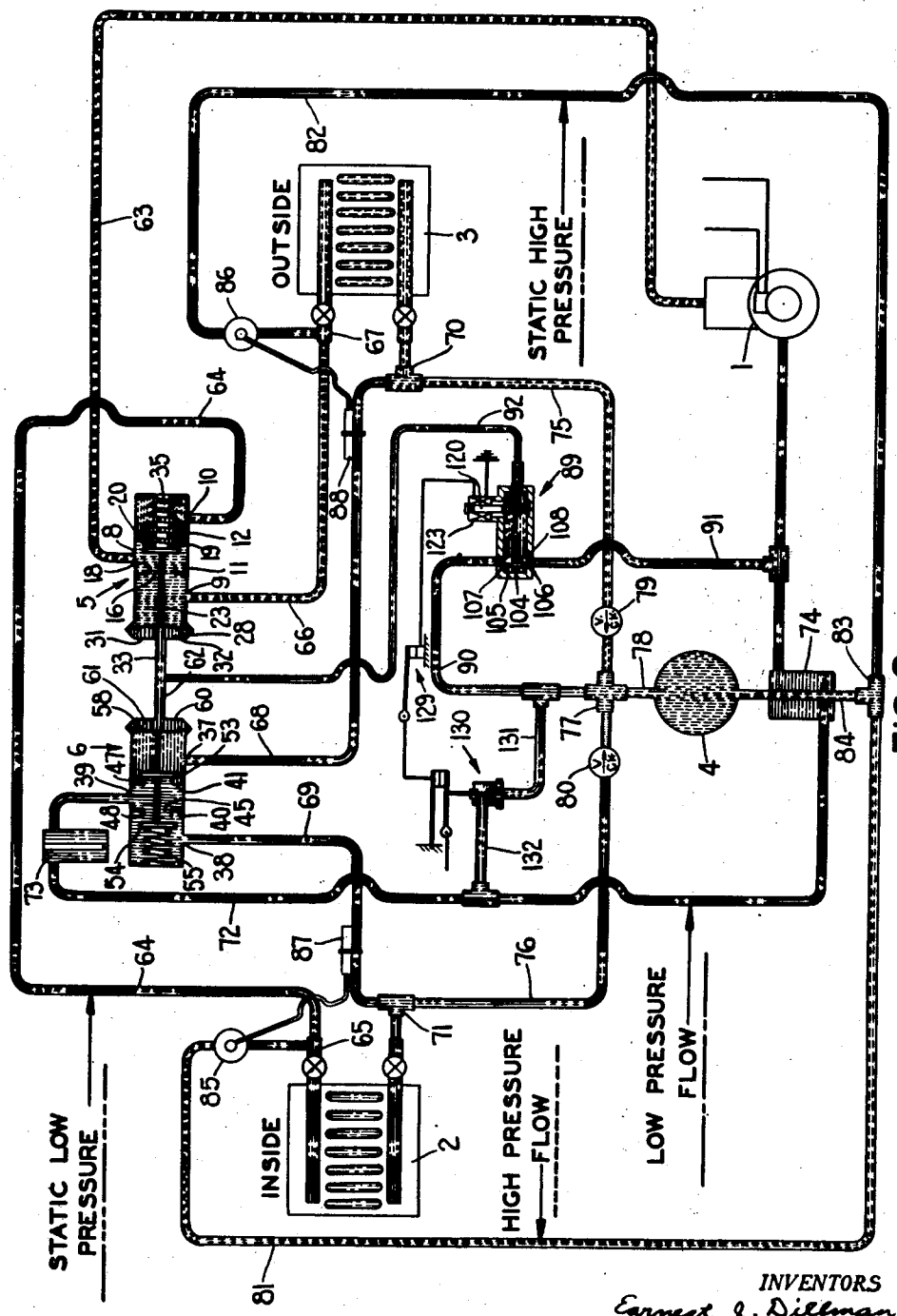


FIG. 2

INVENTORS
Earnest J. Dillman
BY Thomas E. Noakes
Andrew K. Foulds
their ATTORNEY

July 3, 1951 E. J. DILLMAN ET AL 2,558,938

HEAT PUMP AND CONTROL MEANS

Filed Dec. 30, 1948 4 Sheets-Sheet 3

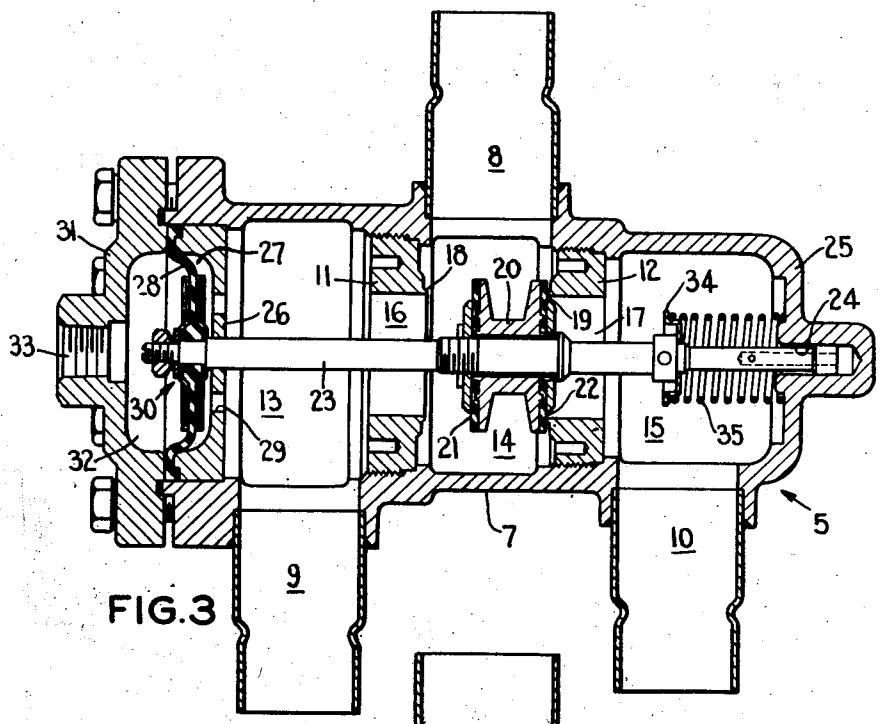


FIG. 3

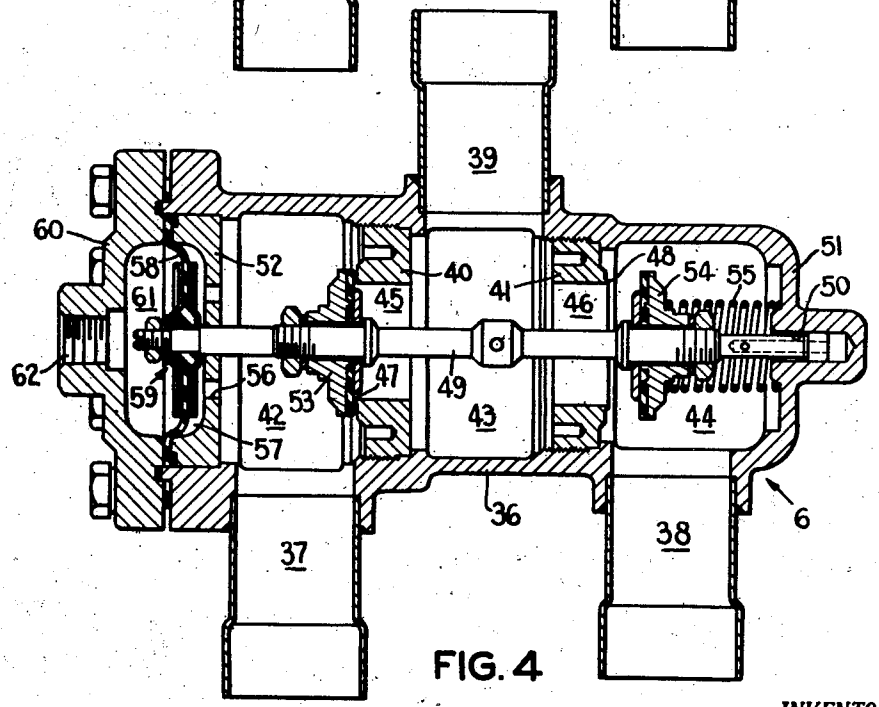


FIG. 4

INVENTORS
Ernest J. Dillman
BY Homer E. Noakes
Andrew K. Foulds
their ATTORNEY

July 3, 1951 E. J. DILLMAN ET AL 2,558,938

HEAT PUMP AND CONTROL MEANS

Filed Dec. 30, 1948 4 Sheets-Sheet 4

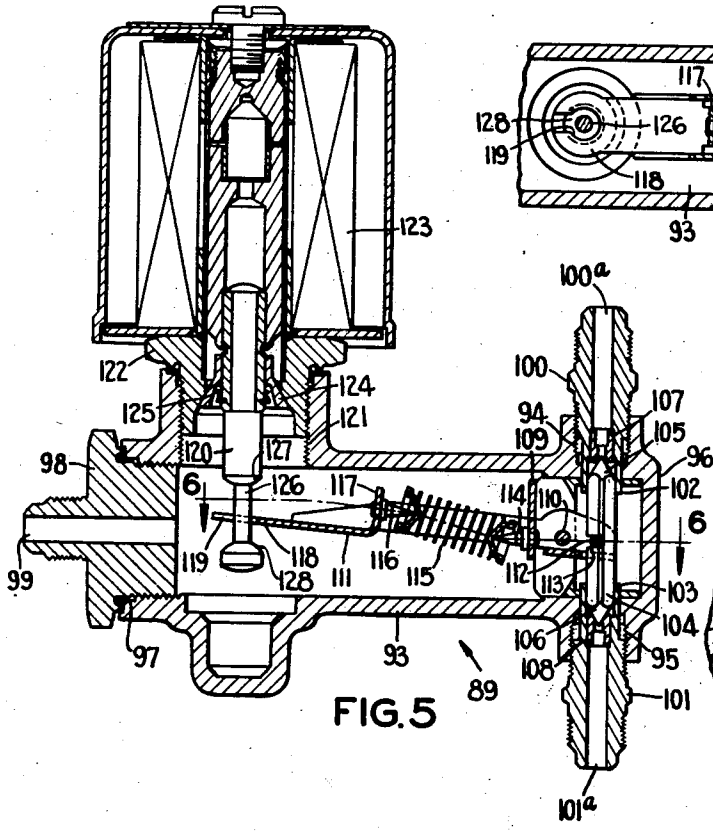


FIG. 5

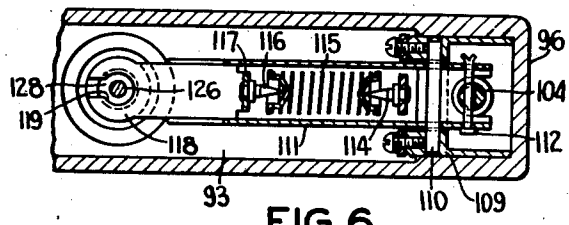


FIG. 6

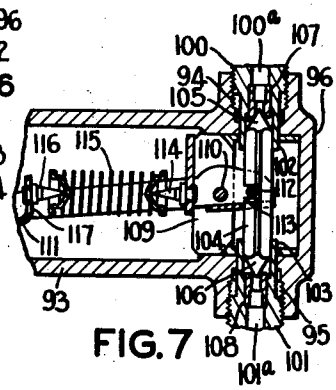


FIG. 7

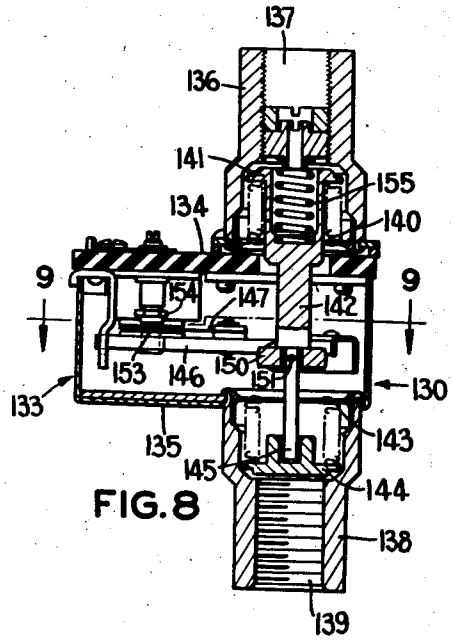


FIG. 8

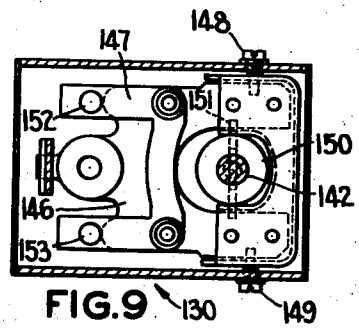


FIG. 9

INVENTORS
Earnest J. Dillman
Thomas E. Noaker
BY
Andrew K. Foulds
their ATTORNEY

Patented July 3, 1951

2,558,938

UNITED STATES PATENT OFFICE

2,558,938

HEAT PUMP AND CONTROL MEANS

Earnest J. Dillman and Thomas E. Noakes, Detroit, Mich., assignors to Detroit Lubricator Company, Detroit, Mich., a corporation of Michigan

Application December 30, 1948, Serial No. 68,246

21 Claims. (Cl. 62—3)

1

This invention relates to new and useful improvements in refrigeration systems and control means therefor and more particularly to reversible refrigeration systems commonly known as heat pumps.

One of the objects of this invention is to provide a new and improved reversible refrigeration system.

Another object is to provide a reversible refrigeration system composed of simple and inexpensive parts which are easily assembled for operation.

Another object is to provide a reversible refrigeration system which includes a pair of pilot operated "three-way" valves for directing flow of refrigerant and having a means to prevent unloading the refrigerant compressor by premature operation of the flow directing valves.

Another object is to provide a reversible refrigeration system which has a pair of pilot operated "three-way" flow directing valves which are operated by a momentary pressure differential across a valve actuating diaphragm and which are held in an actuated position by a pressure differential across the closed valve members of said valves.

Another object is to provide a reversible refrigeration system having a pressure operated flow directing valve and a novel solenoid operated pilot valve.

Another object is to provide a reversible refrigeration system having a flow directing valve means which is electrically operated and having a pressure differential switch controlling said valve means which is operable to prevent unloading of the compressor by operation of said valve means at the start of operation of the refrigeration system before a suitable pressure differential is established across the system.

Another object is to provide, as a subcombination to a reversible refrigeration system, a novel solenoid operated pilot valve.

Other objects will become apparent from time to time throughout the specification and claims as hereinafter related.

This invention comprises the new and improved construction of the component parts of this system and the cooperative connection of said parts to each other to provide an improved reversible refrigeration system which will be described more fully hereinafter and the novelty of which will be particularly pointed out and distinctly claimed.

In the accompanying drawings to be taken as part of this specification there is clearly and fully illustrated one preferred embodiment of this refrigeration system and several detail views of the component parts thereof, in which drawings:

2

Figure 1 is a diagrammatic view of a reversible refrigeration system embodying this invention and showing the parts thereof in position for a heating cycle,

Fig. 2 is a diagrammatic view of the system of Fig. 1, but shows the parts of the system in position for a cooling cycle,

Fig. 3 is a longitudinal sectional view of one of the "three-way" flow directing valves used in this system and in the actuated position of Fig. 2,

Fig. 4 is a longitudinal sectional view of the other of the "three-way" flow directing valves and shown in the actuated position of Fig. 2,

Fig. 5 is a longitudinal sectional view of the solenoid operated pilot valve for this system and shown in the valve actuated position of Fig. 2,

Fig. 6 is a sectional view of the pilot valve shown in Fig. 5 taken on the section line 6—6,

Fig. 7 is a sectional view similar to that shown in Fig. 5 but showing the valve member in the position shown diagrammatically in Fig. 1,

Fig. 8 is a longitudinal sectional view of the pressure differential switch used in this system and is shown in a closed position and,

Fig. 9 is a horizontal section taken on the section line 9—9 of Fig. 8.

Referring to the drawings by characters of reference there is shown in Fig. 1 a refrigeration system of the reversible type commonly known as a heat pump which comprises essentially a compressor 1, first and second heat exchangers 2 and 3 and a refrigerant receiver 4. The heat exchangers 2 and 3 are operable to be used either as a refrigerant condenser or a refrigerant evaporator, according to the direction of operation of the refrigeration cycle. The system in the position of operation shown in Fig. 1 is arranged for a heating cycle and the heat exchanger 2 is located within the space which is to be heated and is operating as a condenser while the heat exchanger 3 is located outside of the space to be heated and is operating as a refrigerant evaporator. There are a pair of "three-way" valves 5 and 6 which are operable to determine to which of the heat exchangers 2 or 3 the refrigerant shall flow for condensation or for evaporation and hence to determine the direction of operation of the refrigeration cycle.

The term "three-way" as hereinafter used denotes a valve of the type which has three openings thereinto and which has a valve member or members which control the flow to or from one or the other of two of the openings. For exam-

ple, the valve may have a single inlet and a pair of outlets, the valve member or members determining through which of the outlets flow is to be permitted or the valve may have the reverse operation, that is, there may be two inlets and a single outlet and the valve member determining from which of the two inlets flow is to be permitted to the single outlet. If reference be had to Figs. 3 and 4 there is shown in greater detail the "three-way" valves 5 and 6 respectively.

The valve 5, as shown in Fig. 3, comprises a valve casing 7 having an inlet 8 and a pair of outlets 9 and 10. Within the casing 7 there are two plugs or wall members 11 and 12 which are screw-threadedly positioned therein and which divide the casing 7 into three chambers 13, 14 and 15. The wall members 11 and 12 each have valve ports 16 and 17 therein and have valve seats 18 and 19 facing inwardly of the middle valve chamber 14. There is a valve member 20 which is positioned in the middle valve chamber 14 and which is movable between the valve seats 18 and 19. The valve member 20 cooperates with said valve seats by engagement of resilient valve face members 21 and 22 respectively therewith. The valve member 20 is carried by a valve stem 23 which extends through the ports 16 and 17 into the chambers 13 and 15 respectively and which is guided at one end in a recess 24 in the end wall 25 of the casing 7 and at the other end through an aperture in the wall member 26. The outer surface of the wall member 26 has a recess 27 therein which is closed by a flexible diaphragm 28 of rubber or other organic elastomeric material. There are provided one or more apertures 29 in the end wall 26 for application of refrigerant pressure from the chamber 13 to the diaphragm 28. The diaphragm 28 is connected as at 30 to the valve stem 23 for actuating the valve member 20. There is a cover member 31 which closes the end of the casing 7 adjacent the diaphragm 28 and which encloses therewith a space 32 which is operable to receive a valve actuating pressure through a connection such as a conduit secured in an aperture 33 in the cover member 31. There is a flanged disc member 34 which is carried by the end of the valve stem 23 in the valve chamber 15 and which is operable to receive one end of a helical spring 35 the other end of which is positioned against the end wall 25 of the valve casing and which is operable to urge the valve member surface 21 toward engagement with the valve seat 18.

The other "three-way" valve 6 comprises a valve casing 36 having inlets 37 and 38 and an outlet 39. There are within the casing 36 a pair of plug members or internal dividing walls 40 and 41 which divide the casing 36 into three chambers 42, 43, and 44. The wall members 40 and 41 have valve ports 45 and 46 therethrough and outwardly facing valve seats 47 and 48 respectively. There is a valve stem 49 which extends through the ports 45 and 46 and which is guided at one end in a recess 50 in the end wall 51 of the casing 36 and which is guided at the other end in an aperture in an end wall member 52. Three are a pair of valve members 53 and 54 which are positioned in the chambers 42 and 44 respectively and which are spaced so that when the valve member 53 is closed against the valve seat 47, the valve member 54 is in an open position relative to its valve seat 48. There is a spring 55 which is positioned between the valve member 54 and the wall 51 of the casing and which urges the valve member 54 toward engagement with its valve seat 48. The end wall member 52 has one or more apertures 56 therein opening into a recess 57 which is closed by a valve operating diaphragm 58. The diaphragm 58 is operatively connected as at 59 to the valve stem 49 for actuating the valve members 53 and 54. There is a cover member 60 which is secured on the end of the casing 36 adjacent the diaphragm 58 and which encloses therewith a space 61 which is operable to receive a valve actuating pressure through an aperture 62 in said cover member.

Referring back to Fig. 1 we find that the inlet 8 to the "three-way" valve 5 is connected by a conduit 63 to the outlet or compression side of the compressor 1. The outlet 10 of the valve 5 is connected by a conduit 64 to one end 65 of the heat exchanger 2. The valve outlet 9 is connected by a conduit 66 to one end 67 of the heat exchanger 3. The inlets 37 and 38 to the "three-way" valve 6 are connected by conduits 68 and 69 respectively to the other ends 70 and 71 respectively of the heat exchangers 3 and 2. The outlet 39 of the "three-way" valve 6 is connected by a conduit 72 to the inlet or suction side of the compressor 1. The conduit 72 has a liquid trap 73 therein and also has a portion 74 which is arranged for heat exchange with the outlet 84 from the refrigerant receiver 4. The end portions 70 and 71 of the heat exchangers 3 and 2 respectively are connected by conduits 75 and 76 to the arms of a "cross" 77 which is connected to the inlet 78 of the receiver 4. The conduits 75 and 76 each have check valves 79 and 80 therein which open on a pressure differential and flow toward the receiver inlet 78. The ends 65 and 67 of the heat exchangers 2 and 3 are connected by conduits 81 and 82 to the legs of a T connection 83 which is connected to the outlet 84 from the receiver 4. The conduits 81 and 82 each have positioned therein and adjacent the heat exchangers 2 and 3 refrigeration expansion valves 85 and 86 respectively. The expansion valves 85 and 86 are of the thermostatic type and include a pressure responsive means for establishing a definite maximum operating pressure for these valves. Such a means for limiting the pressure of operation of thermostatic expansion valves is inherent in expansion valves of the "gas-charged" type and they may also be provided by an auxiliary pressure responsive diaphragm in an expansion valve of the "liquid-charged" type which has a lost motion arrangement to permit closing of the valve independently of the temperature of the thermostatic bulb element. The former or "gas-charged" valve is clearly and fully illustrated in Patent No. 1,971,695 to Ploeger and one form of the latter type or "liquid-charged" valve having a maximum pressure limiting feature is illustrated in Patent No. 2,192,117 to D. D. Wile. The valves 85 and 86 have thermostatic bulb elements 87 and 88 which are responsive to temperature of refrigerant in the conduits 69 and 68 respectively to throttle the operation of these valves for maintaining a constant superheat setting, subject, however, to the aforementioned pressure limiting feature. There is a solenoid operated pilot valve 89 which has inlets connected by conduits 90 and 91 respectively to the high pressure side of the system at the refrigerant receiver 4 and to the low pressure side of the system at the suction line conduit 72, the valve 89 also having an outlet which is operable to be connected by conduit 92 to the apertures 33 and 62 on the "three-way" valves 5 and 6 for

supplying pressure to the diaphragm chambers 32 and 61.

The pilot valve 89 is shown in detail in Figs. 5, 6, and 7, reference being made thereto for a more detailed description as follows: The valve 89 comprises a hollow casing 93 which has alined upper and lower apertures 94 and 95 in the upper and lower walls thereof adjacent the end wall 96. There is an end opening 97 opposite the end wall 96 in which there is screw-threadedly positioned a plug or wall member 98 having an outlet aperture 99 therethrough. There are inlet fitting members 100 and 101 which are screw-threadedly held in the apertures 94 and 95 respectively and which have tubular projections 102 and 103 which extend into the end of the casing 93 and provide a guide means for a valve member 104. The inlet fitting members 100 and 101 are each hollow and provide inlet passages 100a and 101a respectively. The valve member 104 has valve ends 105 and 106 which cooperate with valve seat members 107 and 108 respectively in the inlet fittings 100 and 101. The valve member 104 is of a length such that when the valve end 106 is closed against the valve seat 108 the valve end 105 is open relative to its valve seat 107. There is a bracket member 109 positioned within the casing 93 adjacent the valve member 104 and which carries a fulcrum or pivot pin 110 for a valve operating lever 111. The valve lever 111 carries at one end a pin 112 which fits a slot 113 in the valve member 104 and which is operable upon movement of the lever 111 to move the valve member 104. The bracket 109 has a projecting pin portion 114 which supports a supporting member for an overtravel spring 115 which has its other end supported by a similar projecting member 116 carried by an upturned projection 117 on the lever 111. The free end portion 118 of the lever 111 extends toward the end wall 98 and has a slot 119 therein for receiving the end of a solenoid plunger 120. Adjacent the end wall 98 of the casing 93 and in the upper wall thereof there is an aperture 121 which has screw-threadedly secured therein a plug member 122 which supports and has sealed thereon a solenoid coil 123 for operating this valve. The solenoid coil 123 encloses the plunger 120 which is shown in Fig. 5 in an energized or up position. The plunger 120 carries thereon a sleeve member 124 which is operable to engage the inner wall surface of the plug 122 and compress a spring 125 to provide a starting or "kick-off" force for moving the plunger downward upon de-energization of the coil 123. The lower end of the plunger 120 has an annular groove therein providing a reduced portion 126 which has upper and lower shoulders 127 and 128 respectively. When the solenoid coil 123 is de-energized and the plunger 120 is resting on the end portion 119 of the lever 111, the lever 111 has assumed a downwardly extending position as shown in Fig. 7 and holds the valve member 104 in an up position closing the outlet passage 100a. In this position the overtravel spring 115 is substantially on center relative to the fulcrum 110 for the lever 111 and the plunger 120 is being supported by the lever end portion 118, the valve member 104 thus being held closed by the weight of the plunger 120. When in the down position of the lever the upper shoulder 127 on the plunger 120 rests on the lever end portion 118, the plunger reduced portion 126 having free movement through the lever slot 119. Upon energization of the solenoid coil 123 the plunger 120 is moved upward quickly so that the lower plunger shoulder 128 strikes the lever end portion 118 with an impact blow and moves it and the spring 115 to an overcenter position wherefrom the force of the spring 115 continues movement of the lever 111 to an up position. When the plunger 120 is in its up position and the solenoid coil 123 is energized the end portion 118 of the lever 111 comes to rest intermediate the plunger shoulders 127 and 128 so that the solenoid coil 123 is not required to supply the force required for holding the valve member 104 in its down position. In this upward position of the lever 111 the spring 115 exerts an upward force on the lever substantially equal to the weight of the plunger 120 for holding the valve member end portion 106 closed against the valve seat 108. Upon deenergization of the solenoid coil 123 the solenoid plunger 120 is released and strikes the lever end portion 118 with an impact force which together with the weight of the plunger 120 is operable to overcome the force of the spring 115 to move the lever 111 and the valve member 104 to the position from which it started as is indicated in Fig. 7.

Returning to Fig. 1 it is seen that the solenoid coil 123 of the valve 89 is connected to an open switch 129 which upon closing is operable to energize the aforementioned solenoid coil. The switch 129 is connected in series with the closed contacts of a pressure differential switch 130 which is connected by a conduit 131 to the inlet side of the refrigerant receiver 4 and by a conduit 132 to the suction or return line 72 to the compressor 1. The pressure differential switch 130 is responsive to a differential pressure between the high pressure side and the low pressure side of the system and is operable to prevent energization of the solenoid coil 123 upon closing the switch 129 unless there is a predetermined differential of pressure established across the system.

The pressure differential switch 130 is shown in detail in Figs. 8 and 9, reference being had thereto for a more complete description which follows: The pressure differential switch 130 comprises a switch casing 133 having an upper wall 134 and a lower wall 135. There is a low pressure inlet fitting 136 having an inlet passage 137 therethrough and which is carried by the upper wall 134 of the casing 133. There is a high pressure inlet fitting 138 which has an inlet passage 139 and which is carried by the lower wall 135 of the casing 133. There is a pressure responsive bellows 140 which is positioned within the end of the low pressure fitting 136 and which is secured and sealed to the walls thereof and which has one end secured and sealed to the end portion 141 of a thrust rod 142. There is a similar bellows 143 which is secured to the walls of the high pressure fitting 138 and which has a thrust head 144 secured thereto and which abuts the other end 145 of the thrust rod 142. Within the casing 133 there is pivotally supported a lever member 146 which carries on its free operating end a U-shaped contact carrying arm 147. The lever 146 is fulcrumed to the walls of the casing 133 by pivot pins or screws 148 and 149. The lever 146 has a bifurcated end portion the legs of which receive the pivot pins 148 and 149 and between which legs is pivotally supported a rockable member 150. The member 150 has an aperture through its central portion and through which extends the end portion 145 of the thrust

member 142, the member 142 being secured to the abutment member 150 for movement therewith by its pivot pin 151. There are a pair of contacts 152 and 153 which cooperate with a pair of fixed contacts 154 (only one of which is visible in Fig. 8). Only a general description of the construction of this switch is given herein as this switch structure does not in itself form a part of the present invention since any suitable pressure differential switch would serve the needs of the system. This switch substantially as shown herein is shown and described more fully in the patent application of E. J. Dillman, Serial No. 756,265, now Patent No. 2,548,877, granted April 17, 1951. The thrust rod 142 is urged downward by a spring 155 within the low pressure inlet fitting 136. In operation this switch responds to the differential of pressure supplied to the inlet passages 137 and 139. Pressure from the low side of the refrigeration system is supplied to the inlet passage 137 and pressure from the high side of the system is supplied to the inlet passage 139. During periods when the system is shut down the pressure is equalized throughout the system and since the pressure in the passages 137 and 139 acting upon the bellows 140 and 143 respectively is equal the force of the spring 155 will move the thrust member 142 downward to rotate the lever 146 and open the contacts 152 and 153 from engagement with the fixed contacts 154. However, when the system is started a pressure differential is established so that there is a low pressure in the passage 137 and a high pressure in the passage 139. This differential of pressure acts upon the bellows 143 and 140 respectively and upon reaching a predetermined differential will cause the bellows head 144 to move upward and move the thrust rod 142 to rotate the lever 146 and close the contacts 152 and 153 against the fixed contacts 154.

In operation this system functions generally as follows: Referring to Fig. 1 we find the various component parts of this system in position for a heating cycle, that is, the heat exchanger 2 which is positioned inside the room or other space which is to be heated or cooled is arranged for operation as a refrigerant condenser and the outside heat exchanger 3 is arranged for operation as a refrigerant evaporator. For most efficient operation the electrical connections from the compressor 1 would normally be connected in a circuit having a thermostatic control so that the system would be started and stopped according to the heat requirements of the space being heated or cooled, this feature, however, forming no part of this invention. Similarly the switch 129 which is operable to energize the solenoid valve 89 for changing the operation of the system from heating to cooling and vice versa would probably be a thermostatic switch so that upon a sufficient rise of temperature the system would automatically switch over to cooling operation. When operating as a heating cycle the compressor 1 is compressing a refrigerant gas of any suitable type and discharging the compressed gas through the conduit 63 to the inlet 8 of the "three-way" valve 5. At this point of operation low pressure refrigerant gas is being supplied to the pressure receiving spaces 32 and 61 back of the valve actuating diaphragms 28 and 58 so that these valves are held in the positions indicated by the force of the springs 35 and 55 and the pressure differential across the valve members. The compressed refrigerant gas is discharged from the valve 5 through the open valve port 17 and the outlet 10 to the conduit 64 which leads to one end 65 of the heat exchanger or condenser 2. When the compressed refrigerant reaches the heat exchanger 2 at the end 65 it is forced to go through this heat exchanger rather than through the conduit 81 since the expansion valve 85 is closed by the high pressure of refrigerant in the conduit 81. The compressed and heated refrigerant gives up its heat in passing through the condenser 2 and is discharged therefrom into a conduit 76 as a refrigerant liquid. There can be no flow through the branch conduit 69 to and through the "three-way" valve 6 since the valve member 54 therein is in a closed position, there being only a static high pressure in this conduit. The high pressure refrigerant, now liquified, passes through the conduit 76 and the check valve 80 to the receiver 4. From the receiver 4 the liquified refrigerant passes out through the outlet 84 and conduit 82 to the expansion valve 86 at the inlet end 67 of the heat exchanger or evaporator 3. Upon passing through the expansion valve 86 the refrigerant flows into the evaporator 3 and is evaporated and receives heat from the outside air or other medium with which evaporator is in contact. It should be noted that from the inlet end 67 of the evaporator 3 the conduit 66 which runs to one end of the "three-way" valve 5 transmits only a static low pressure since the valve 20 is closed against its valve seat 18. From the outlet 70 of the evaporator 3 flow through the conduit 75 is prevented even though the check valve 79 is arranged to open upon flow toward the receiver 4 since the refrigerant in the conduit 75 is at a low pressure and the refrigerant on the other side of the check valve 79 is at a high pressure. The refrigerant flowing from the outlet end 70 of the evaporator 3 passes through the conduit 68 to the inlet 37 of the "three-way" valve 6. Refrigerant entering the "three-way" valve 6 through the inlet 37 passes through the open valve port 46 and out through the outlet 39 to the suction line or return conduit 72 leading back to the inlet side of the compressor 1. There is a portion 74 of the suction line conduit 72 which is in heat exchange relation with the outlet 84 of the receiver 4 and is operable to cool the liquid refrigerant passing from the receiver 4 and thereby increase the efficiency of the heat transfer to the refrigerant upon evaporation. The expansion valve 86 which controls flow of refrigerant into the evaporator 3 is thermostatically modulated by its thermostatic power element which has a bulb element 88 responsive to the temperature of refrigerant at the outlet from the evaporator 3, and is operable to maintain a constant and predetermined superheat for refrigerant passing through the evaporator, this construction and operation being well known in the art. It should be noted that the expansion valve 86 opens because there is a differential of pressure between that in the inlet 67 to the evaporator 3 and the pressure in the bulb element 88 and that the expansion valve 85 remains closed and is operable to prevent flow through the conduit 81 because there is a high refrigerant pressure in the line 65. The high pressure in the line 65 is operable to hold the valve 85 closed independently of the temperature of the bulb element 87 because of the pressure limiting feature previously mentioned.

The pilot valve 89 is a solenoid operated valve and has its outlet connected by conduit 92 for supplying pressure to the diaphragm chambers

of the "three-way" valves 5 and 6 and has a pair of inlets, one connected to the high pressure side of the system and the other connected to the low pressure side of the system. At this point of operation the valve member end 105 is closed against its valve seat 107 closing the high pressure inlet so that only low pressure is supplied to the valve diaphragm chambers. The pressure differential switch 130 is responsive to a differential pressure between the high pressure side of the system and the low pressure side and when such a differential is established maintains its switch contacts closed and permits operation of the solenoid coil 123 which is in series with it.

When it is desired to change the operation of this system to a cooling cycle, the switch 129 is closed either thermostatically or manually or by any suitable means as may be desired and the valve 89 is then energized and the solenoid plunger 120 moved to an up position and the valve member 104 to a down position so that the low pressure inlet to the valve is closed and the high pressure inlet is open. High pressure refrigerant passes through the pilot valve 89 and the conduit 92 to the diaphragm chambers of the "three-way" valves 5 and 6 and produces a high pressure therein. As is seen by reference to Fig. 1, when the system is operated on a heating cycle there is low pressure adjacent each of the valve operating diaphragms and so when high pressure is supplied to the diaphragm chambers there is established a momentary pressure differential across the diaphragms 28 and 58 which is operable to move the respective valve members of the valves 5 and 6 to the positions indicated in Fig. 2. When the valve members of the valves 5 and 6 are moved to the positions indicated in Fig. 2 the system is arranged for cooling operation and high pressure is being supplied to the chambers adjacent the diaphragms 28 and 58 so that there is an equalization of the pressure thereacross. However, there is a differential of pressure established across the closed valve members of these valves and this pressure differential is sufficient to maintain these valve members in their actuated position against the force of the springs 35 and 55. When operating on a cooling cycle the compressed refrigerant gas is discharged from the compressor 1 through the conduit 63 to the inlet 8 of the "three-way" valve 5 and then through the open valve port 16 and outlet 9 to the conduit 66 which leads to the inlet end 67 of the heat exchanger 3 (which is now operating as a refrigerant condenser). The refrigerant at the inlet to the condenser is prevented from bypassing the condenser through the conduit 82 by the expansion valve 86 which has a high pressure within it and is inoperative to permit flow therethrough as was the expansion valve 85 on the heating cycle. The hot refrigerant passes through the condenser 3 and gives up its heat to the outside air and is discharged through the condenser outlet 70 into the conduit 75 which leads to the receiver 4. Flow from the outlet 70 of the condenser 3 through the conduit 68 is prevented since the valve member 53 of the "three-way" valve 6 is in a closed position and only a static pressure exists in this line. The refrigerant which flows through the conduit 75 from the condenser 3 is operable to open the check valve 79 and permit flow to the receiver 4. From the receiver 4 refrigerant flows through conduit 81 and the expansion valve 85 to the inlet end 65 of the heat exchanger 2 (which is now operating as a refrigerant evaporator). Flow through the conduit 82 from the receiver 4 is prevented by the closed expansion valve 86. Refrigerant from the conduit 81 passes through the expansion valve 85 and into the evaporator 2 wherein it is evaporated and absorbs heat from the room or other space which is being cooled and passes out through the conduit 69 to the "three-way" valve 6. The flow of refrigerant through the expansion valve 85 is modulated to maintain a constant superheat as was valve 86 on the heating cycle. At the inlet to the evaporator 2 flow through the conduit 64 is prevented since the valve member 20 in the "three-way" valve 5 is closed against the valve seat 19 preventing flow through that line. At the outlet 71 of the evaporator 2 flow through the conduit 76 is prevented even though the check valve 80 opens on flow toward the receiver 4 because the pressure in the conduit 76 is low pressure and the pressure on the other side of the check valve 80 is high pressure. From the conduit 69 the refrigerant vapor passes through the open valve port 45 and through the outlet 39 of the "three-way" valve 6 and is returned to the compressor 1 through the suction line conduit 72. From the foregoing it is seen that there is herein provided a simple refrigeration system which has an inside and an outside heat exchanger either of which may operate as a condenser or an evaporator and which has flow controlling valves which are operable to direct refrigerant flow for condensation to one or the other of the heat exchangers so that the system may be reversed for heating or cooling as desired. It should be noted that although the expansion valves 85 and 86 are preferably thermostatic valves it would be possible to use pressure actuated or "automatic" valves for conditions where the outside air temperature does not fall below the evaporator temperature on the heating cycle. It should be also noted that by the arrangement used in this system the "three-way" valves 5 and 6 are actuated only by a momentary pressure differential across the diaphragms 28 and 58 and the valve members are held in their actuated positions by the differential of pressures thereacross (although in the position of Fig. 1 the springs 35 and 55 are assisting the pressure differential in holding the valve members closed). In each of the positions of the valves 5 and 6 as indicated in Figs. 1 and 2 after the valve member has been moved to the position shown the pressure admitted to the valve chambers adjacent the diaphragms is the same as in the diaphragm actuating chambers. By this arrangement the forces exerted on the valve operating diaphragms are reduced and their operating lives materially extended.

The pressure differential switch 130 which is provided to control the operation of the solenoid pilot valve 89 is operable as a safety means to prevent unloading of the refrigerant compressor by premature actuation of the "three-way" flow controlling valves 5 and 6. To explain this feature of the system reference is made again to Fig. 1. In Fig. 1 the system is shown for operation of the heating cycle and is then in an operating position. Let us assume for a moment that the system has been shut down and the pressures of the refrigerant gas equalized throughout the entire system. At this point the pressures on the valve actuating diaphragms of the "three-way" valves 5 and 6 will be equalized as would the pressures across the valve members themselves and the valve members would be held in the positions

shown by the springs 35 and 55 respectively. The pilot valve 89 would be in the position indicated. Assume now that the pressure differential switch 130 has been eliminated from the system and that the system has just been started in operation. As the compressor 1 begins its operation it begins to increase the pressure on the high side of the system by discharging compressed refrigerant through the conduit 63 and to decrease the pressure on the low side of the system by drawing in refrigerant gas from the suction line conduit 72. At this point the "three-way" valves 5 and 6 are set for discharge of refrigerant to the heat exchanger 2 for condensation and to the heat exchanger 3 for evaporation. Now, before the compressor 1 has had time to build up to the normal operating pressure differential between the high and low sides of the system suppose that the pilot valve 89 is energized and switches from supplying low pressure to supplying high pressure to the diaphragm chambers of the "three-way" valves 5 and 6.

At this point in operation the high pressure supplied through the pilot valve 89 is not yet up to its maximum operating value and the low pressure on the other side of the diaphragms is not yet reduced to its proper value with the result that a lower pressure differential is established across the valve operating diaphragms 28 and 58. This lower valve actuating pressure differential will cause the valves 5 and 6 to be actuated very slowly with the result that the flow from the "three-way" valve 5 will be divided between the outlet conduits 64 and 66 to the heat exchangers 2 and 3 respectively. Similarly, the slow actuation of the "three-way" valve 6 will cause both of the valve ports therein to be opened and thus to permit flow from both heat exchangers 2 and 3 through conduits 69 and 68 respectively for return through the suction line conduit 72 to the compressor 1. It is thus seen that by this premature actuation of the "three-way" valves 5 and 6 the refrigerant passes through the receiver 4 and is permitted to short circuit directly back to the compressor 1 and will unload the compressor with the result that the system would be inoperative until shut down and restarted. The pressure differential switch 130 is responsive to the differential of pressure between the high and low pressure sides of the system and is operable to close at a pressure differential which is sufficiently high to cause the "three-way" valves 5 and 6 to have their normal quick operation. By the use of this pressure differential switch in the system the pilot valve 89 cannot be operated until the suitable pressure differential is established between the high and the low sides of the system. The result of this arrangement is that even if the switch 129 is closed calling for a cooling cycle and the system is started after a shut down period the system will begin its operation on a heating cycle until the required pressure differential is established at which point the system will then change to cooling operation.

Having thus described the invention what is claimed and desired to be secured by Letters Patent of the United States is:

1. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, valve means determining which of said heat exchangers functions as a condenser, actuating means for said valve means, and safety means operable to render said actuating means ineffective, said last-named means including means operable upon occurrence of a predetermined pressure differential across the system to render said actuating means effective.

2. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, valve means operable to direct the flow of refrigerant to one or the other of said heat exchangers for refrigeration condensation, actuating means for said valve means, and means operable to render said actuating means ineffective, said last-named means including pressure responsive means responsive to the establishment of a predetermined pressure differential across the system to render said actuating means effective.

3. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, valve means operable to direct the flow of refrigerant to one or the other of said heat exchangers for refrigerant condensation, means cooperable with and operable to actuate said valve means to change the flow of refrigerant for condensation from one of said heat exchangers to the other, and means responsive to the differential of pressure between the high and low pressure sides of the system and controlling the operation of said valve means, said last-named means dominating the operation of said valve actuating means.

4. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, valve means operable to direct the flow of refrigerant to one or the other of said heat exchangers for refrigerant condensation, electrically operable means for actuating said valve means to change the flow of refrigerant for condensation from one of said heat exchangers to the other, and a pressure actuated switch responsive to the differential of pressure between the high and low pressure sides of the system and controlling the energization of said valve actuating means.

5. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, valve means operable to direct the flow of refrigerant to one or the other of said heat exchangers for refrigerant condensation, means for actuating said valve means to change the flow of refrigerant for condensation from one of said heat exchangers to the other, and means controlling the operation of said valve actuating means and operable to prevent operation of the same at the start of the refrigeration cycle until a pressure differential is established between the high and low pressure sides of the system.

6. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat

exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, valve means having a normal initial position directing refrigerant flow to said first heat exchanger for condensation and being operable upon actuation to change the direction of refrigerant flow to said second heat exchanger for condensation, means for actuating said valve means, and means to prevent operation of said actuating means at the start of the refrigeration cycle until a pressure differential is established between the high and low pressure sides of the system.

7. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, valve means having a normal initial position directing refrigerant flow to said first heat exchanger for condensation and being operable upon actuation to change the direction of refrigerant flow to said second heat exchanger for condensation, electrically operable means for actuating said valve means, and a pressure operated switch operable to prevent energization of said actuating means at the start of the refrigeration cycle until a pressure differential is established between the high and low pressure sides of the system.

8. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, pressure operated valve means having a normal initial position directing refrigerant flow to said first heat exchanger for condensation and being operable upon actuation to change the direction of refrigerant flow to said second heat exchanger for condensation, an electrically operated pilot valve controlling the supply of pressure for actuating said valve means, and means to prevent operation of said pilot valve at the start of the refrigeration cycle until a pressure differential is established between the high and low pressure sides of the system.

9. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, a pair of "three-way" flow directing valves, one of said valves having an inlet connected to the outlet from said compressor and having a pair of outlets connected one to each of said heat exchangers, the other of said valves having a pair of inlets connected one to each of said heat exchangers and an outlet connected to the inlet to said compressor, said valves having valve members having a normal initial position directing refrigerant flow to said first heat exchanger for condensation and being operable upon actuation to change the direction of refrigerant flow to said second heat exchanger for condensation, means for actuating said valves, and means responsive to a pressure differential between the high and the low pressure sides of the system and controlling said valve actuating means.

10. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, a pair of "three-way" flow directing valves, one of said valves having an inlet connected to the outlet from said compressor and having a pair of outlets connected one to each of said heat exchangers, the other of said valves having a pair of inlets connected one to each of said heat exchangers and an outlet connected to the inlet to said compressor, said valves having valve members having a normal initial position directing refrigerant flow to said first heat exchanger for condensation and being operable upon actuation to change the direction of refrigerant flow to said second heat exchanger for condensation, pressure responsive diaphragms for actuating said valves, a "three-way" valve controlling the supply of pressure from the high or the low pressure sides of the system to said diaphragms for actuating said valves, and means responsive to a pressure differential between the high and the low pressure sides of the system and controlling the operation of said "three-way" pressure controlling valve.

11. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, a pair of "three-way" flow directing valves, one of said valves having an inlet connected to the outlet from said compressor and having a pair of outlets connected one to each of said heat exchangers, the other of said valves having a pair of inlets connected one to each of said heat exchangers and an outlet connected to the inlet to said compressor, said valves having valve members having a normal initial position directing refrigerant flow to said first heat exchanger for condensation and being operable upon actuation to change the direction of refrigerant flow to said second heat exchanger for condensation, pressure responsive diaphragms on said valves and operable upon application of pressure from the high pressure side of the system to move said valve members to effect said change in direction of refrigerant flow, an electric solenoid operated "three-way" valve having inlets connected to the high and the low pressure sides of the system and an outlet connected for supply of pressure to said diaphragms, said solenoid valve having a normal initial position for establishing connection from the low pressure side of the system to said diaphragms, and being operable upon energization to close off said low pressure connection and to establish a high pressure connection, and a pressure responsive switch connected for response to the differential between the high and the low pressure sides of the system and having initially open switch contacts preventing energization of said solenoid valve at the start of a refrigeration cycle until a predetermined pressure differential is established across the system.

12. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, a pair of "three-way" flow directing valves; one of said valves having a casing having two internal

walls dividing the same into three chambers, an inlet opening into the middle chamber of said valve and connected to the outlet from said compressor, said internal walls having valve ports therein with valve seats facing inwardly of said middle chamber, a valve member movable between said valve seats and operable to close one or the other of said ports so as to direct refrigerant flow through the open port, outlets from the outer valve chambers connected one to each of said heat exchangers; the other of said valves having a casing having two internal walls dividing the same into three chambers, said last-named internal walls having valve ports therein with valve seats facing outward into the valve outer chambers, a pair of valve members one cooperable with each of said outward facing valve seats and so spaced and interconnected for movement that when one valve member is closing its port the other port is open, inlets to the valve outer chambers connected one to each of said heat exchangers, an outlet from the valve middle chamber connected to the inlet of said compressor; the valve members of said valves having an initial position directing flow of refrigerant to said first heat exchanger for condensation and being actuable substantially simultaneously to move to an actuated position for changing the direction of refrigerant flow to said second heat exchanger for condensation, and said valve connections being such that in both initial and actuated positions refrigerant high side pressure is supplied to the valve inlet adjacent a closed valve member and refrigerant low side pressure is supplied to the valve outlet adjacent a closed valve member thereby establishing a pressure differential across each closed valve member for holding the same in valve closed position.

13. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, a pair of "three-way" flow directing valves; one of said valves having a casing having two internal walls dividing the same into three chambers, an inlet opening into the middle chamber of said valve and connected to the outlet from said compressor, said internal walls having valve ports therein with valve seats facing inwardly of said middle chamber, a valve member movable between said valve seats and operable to close one or the other of said ports so as to direct refrigerant flow through the open port, outlets from the outer valve chambers connected one to each of said heat exchangers; the other of said valves having a casing having two internal walls dividing the same into three chambers, said last-named internal walls having valve ports therein with valve seats facing outward into the valve outer chambers, a pair of valve members one cooperable with each of said outward facing valve seats and so spaced and interconnected for movement that when one valve member is closing its port the other port is open, inlets to the valve outer chambers connected one to each of said heat exchangers, an outlet from the valve middle chamber connected to the inlet of said compressor; the valve members of said valves having an initial position directing flow of refrigerant to said first heat exchanger for condensation and being actuable substantially simultaneously to move to an actuated position for changing the direction of refrigerant flow to said second heat exchanger for condensation, said valve connections being such that in both initial and actuated positions refrigerant high side pressure is supplied to the valve inlet adjacent a closed valve member and refrigerant low side pressure is supplied to the valve outlet adjacent a closed valve member thereby establishing a pressure differential across each closed valve member for holding the same in valve closed position, means for actuating said valve, and means responsive to a pressure differential between the high and the low pressure sides of the system and controlling said valve actuating means.

14. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, a pair of "three-way" flow directing valves; one of said valves having a casing having two internal walls dividing the same into three chambers, an inlet opening into the middle chamber of said valve and connected to the outlet from said compressor, said internal walls having valve ports therein with valve seats facing inwardly of said middle chamber, a valve member movable between said valve seats and operable to close one or the other of said ports so as to direct refrigerant flow through the open port, outlets from the outer valve chambers connected one to each of said heat exchangers; the other of said valves having a casing having two internal walls dividing the same into three chambers, said last-named internal walls having valve ports therein with valve seats facing outward into the valve outer chambers, a pair of valve members one cooperable with each of said outward facing valve seats and so spaced and interconnected for movement that when one valve member is closing its port the other port is open, inlets to the valve outer chambers connected one to each of said heat exchangers, an outlet from the valve middle chamber connected to the inlet of said compressor; the valve members of said valves having an initial position directing flow of refrigerant to said first heat exchanger for condensation and being actuable substantially simultaneously to move to an actuated position for changing the direction of refrigerant flow to said second heat exchanger for condensation, said valve connections being such that in both initial and actuated positions refrigerant high side pressure is supplied to the valve inlet adjacent a closed valve member and refrigerant low side pressure is supplied to the valve outlet adjacent a closed valve member thereby establishing a pressure differential across each closed valve member for holding the same in valve closed position, pressure responsive diaphragms on said valves and operable upon application of pressure from the high pressure side of the system to move said valve members to effect said change in direction of refrigerant flow, an electric solenoid operated "three-way" valve having inlets connected to the high and the low pressure sides of the system and an outlet connected for supply of pressure to said diaphragms, said solenoid valve having a normal initial position for establishing connection from the low pressure side of the system to said diaphragms and being operable upon energization to close off said low pressure connection and to establish a high pressure connection, and a pressure responsive switch connected for response to the differential between the high and the low pressure sides of the system and having

initially open switch contacts preventing energization of said solenoid valve at the start of a refrigeration cycle until a predetermined pressure differential is established across the system.

15. The combination with a reversible refrigeration system having a compressor, two heat exchangers either of which may function as a condenser or an evaporator, and two pressure operated "three-way" valves for determining to which heat exchanger refrigerant may flow for condensation; of an electric solenoid operated pilot valve comprising a valve casing enclosing a chamber, alined inlet ports in the top and bottom walls of said casing each having a valve seat, a valve member movable vertically between said valve seats and having valve end portions cooperable one with each of said valve seats and operable to close off flow through one inlet and to permit flow through the other inlet, a lever fulcrumed in said casing and engaging said valve member for moving the same, the free end of said lever having a normal initial position slanting downward and holding said valve member closing said upper inlet port, an outlet port through the end wall of said casing adjacent the free end of said lever, said casing having an aperture in its upper wall adjacent the free end of said lever, a solenoid coil having a plunger and secured at one end in said last-named aperture, said solenoid plunger having an end portion engageable with said lever, said plunger end portion having a groove providing upper and lower spaced shoulders, said plunger upper shoulder resting on the free end of said lever when in a down position so that said valve member is held closed by the weight of the plunger, a bracket member in said casing adjacent the pivot point of said lever, an overtravel spring compressively positioned between said bracket and said lever and substantially on center when said lever is in a down position, said plunger being operable upon energization of said solenoid coil to move upward and to cause said lower shoulder to strike said lever end with an impact to move said spring overcenter for actuating said lever, said spring being operable upon movement overcenter to move said lever to an up position and said valve member to a down position, said spring holding said lever up with a force substantially equal to the weight of said plunger, said lever and said plunger coming to rest in up positions such that the free end of said lever is intermediate said shoulders, said plunger being operable upon deenergization of said coil to strike said lever end with an impact which together with the plunger's weight is sufficient to overcome the force of said spring and return the lever to a down position, said inlet ports being connected to the high and the low pressure sides of the system, and said outlet port being connected to said "three-way" valves for supplying an actuating pressure thereto.

16. The combination with a reversible refrigeration system having a compressor, two heat exchangers either of which may function as a condenser or an evaporator, and two pressure operated "three-way" valves for determining to which heat exchanger refrigerant may flow for condensation; of an electric solenoid operated pilot valve comprising a valve casing enclosing a chamber, alined inlet ports in the top and bottom walls of said casing each having a valve seat, a valve member movable vertically between said valve seats and having valve end portions cooperable one with each of said valve seats and operable to close off flow through one inlet and to permit flow through the other inlet, a lever fulcrumed in said casing and engaging said valve member for moving the same, the free end of said lever having a normal initial position slanting downward and holding said valve member closing said upper inlet port, an outlet port through the end wall of said casing adjacent the free end of said lever, said casing having an aperture in its upper wall adjacent the free end of said lever, a solenoid coil having a plunger and secured at one end in said last-named aperture, said solenoid plunger having an end portion engageable with said lever, said plunger end portion having a groove providing upper and lower spaced shoulders, said plunger upper shoulder resting on the free end of said lever when in a down position so that said valve member is held closed by the weight of the plunger, a bracket member in said casing adjacent the pivot point of said lever, an overtravel spring compressively positioned between said bracket and said lever and substantially on center when said lever is in a down position, said plunger being operable upon energization of said solenoid coil to move upward and to cause said lower shoulder to strike said lever end with an impact to move said spring overcenter for actuating said lever, said spring being operable upon movement overcenter to move said lever to an up position and said valve member to a down position, said spring holding said lever up with a force substantially equal to the weight of said plunger, said lever and said plunger coming to rest in up positions such that the free end of said lever is intermediate said shoulders, said plunger being operable upon deenergization of said coil to strike said lever with an impact which together with the plunger's weight is sufficient to overcome the force of said spring and return the lever to a down position, said inlet ports being connected to the high and the low pressure sides of the system, said outlet port being connected to said "three-way" valves for supplying an actuating pressure thereto, and a pressure repsonsive switch responsive to the establishment of a pressure differential across the system and controlling the energization of said solenoid coil.

17. An electric solenoid operated pilot valve comprising a valve casing enclosing a chamber, alined inlet ports in the top and bottom walls of said casing each having a valve seat, a valve member movable vertically between said valve seats and having valve end portions cooperable one with each of said valve seats and operable to close off flow through one inlet and to permit flow through the other inlet, a lever fulcrumed in said casing and engaging said valve member for moving the same, the free end of said lever having a normal initial position slanting downward and holding said valve member closing said upper inlet port, an outlet port through the end wall of said casing adjacent the free end of said lever, said casing having an aperture in its upper wall adjacent the free end of said lever, a solenoid coil having a plunger and secured at one end in said last-named aperture, said solenoid plunger having an end portion engageable with said lever, said plunger end portion having a groove providing upper and lower spaced shoulders, said plunger upper shoulder resting on the free end of said lever when in a down position so that said valve member is held closed by the weight of the plunger, a bracket member in said casing adjacent the pivot point of said lever,

an overtravel spring compressively positioned between said bracket and said lever and substantially on center when said lever is in a down position, said plunger being operable upon energization of said solenoid coil to move upward and to cause said lower shoulder to strike said lever end with an impact to move said spring overcenter for actuating said lever, said spring being operable upon movement overcenter to move said lever to an up position and said valve member to a down position, said spring holding said lever up with a force substantially equal to the weight of said plunger, said lever and said plunger coming to rest in up positions such that the free end of said lever is intermediate said shoulders, and said plunger being operable upon deenergization of said coil to strike said lever end with an impact which together with the plunger's weight is sufficient to overcome the force of said spring and return the lever to a down position.

18. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, first and second "three-way" flow directing valves controlling the direction of operation of the refrigeration cycle, said first valve having one inlet and two outlets, said second valve having two inlets and one outlet, a refrigerant receiver having an inlet and an outlet, pressure responsive means controlling the operation of said "three-way" valves, a "three-way" electric solenoid pilot valve having two inlets and one outlet, a pressure responsive switch controlling said solenoid valve and having high and low pressure inlets, a conduit connecting the outlet of said compressor to the inlet of said first-"three-way" valve, a conduit connecting one of the outlets of said first valve to one end of said first heat exchanger, a conduit connecting the other outlet of said first valve to one end of said second heat exchanger, a conduit connecting the other end of said first heat exchanger to one of the inlets to said second valve, a conduit connecting the other end of said second heat exchanger to the other inlet to said second valve, a return conduit connecting the outlet of said second valve to the inlet to said compressor, two conduits connecting said one ends of said first and second heat exchangers respectively to the outlet from said receiver, each of said last-named conduits having positioned therein adjacent its respective heat exchanger an expansion valve of the type which requires a reduction of pressure at its outlet to a predetermined low value to open, two conduits connecting said other ends of said first and second heat exchangers respectively to the inlet to said receiver, each of said last-named conduits having a check valve therein which opens upon flow toward said receiver, conduits connecting the inlet side of said receiver and the compressor return conduit respectively to the inlets of said pilot valve, a conduit connecting the outlet of said pilot valve to said pressure responsive means, and conduits connecting the inlet side of said receiver and said compressor return conduit to the high and the low pressure inlets respectively of said pressure responsive switch.

19. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, first and second "three-way" flow directing valves controlling the direction of operation of the refrigeration cycle; said first valve having a casing having one central inlet and two end outlets, said casing having two internal walls separating said inlet and said outlets and dividing the casing into three chambers, said walls having valve ports therethrough with valve seats facing inwardly of the middle valve chamber, a valve member movable between said valve seats to control the direction of outflow from said valve and carried by a valve stem which projects through one of said ports into one of the end valve chambers, a pressure responsive diaphragm closing one end of said one chamber and operatively connected to said stem for moving said valve member, a cover member closing said one end of said one valve chamber and enclosing with said diaphragm a space for receiving a valve actuating pressure, a spring operatively engaging said valve member and urging the same to close said one valve port, a conduit connecting the outlet from said compressor to said valve inlet, a conduit connecting the outlet from said one valve chamber to one end of said second heat exchanger, a conduit connecting the outlet from the other of said valve chambers to one end of said first heat exchanger; said second valve having a casing having two internal walls dividing it into three chambers, two inlets one to each of the end chambers and an outlet from the middle of said chambers, said internal walls having valve ports therethrough with outwardly facing valve seats, a pair of valve members one in each end chamber interconnected for movement and spaced so that when one is closed the other is open, a valve stem supporting said valve members and extending through both of said ports and into one of said end chambers, a pressure responsive diaphragm closing one end of said one chamber and operatively connected to said stem for moving said valve members, a cover member closing said one end of said one chamber and enclosing with said diaphragm a space for receiving a valve actuating pressure, a spring operatively engaging one of said valve members and urging the valve member in the other end chamber toward closed position, a conduit connecting the inlet to said one chamber to the other end of said second heat exchanger, a conduit connecting the inlet to said other end chamber to the other end of said first heat exchanger, a conduit connecting the outlet from said middle chamber to the inlet to said compressor; a refrigerant receiver having an inlet and an outlet, two conduits connecting the other ends of said heat exchangers to the inlet of said receiver, check valves one in each of said last-named conduits and opening in the direction of flow toward said receiver, two conduits connecting said one ends of said heat exchangers to the outlet from said receiver, expansion valves one in each of said last-named conduits and controlling refrigerant flow therethrough, said expansion valves being of the thermostatic type and having pressure responsive means determining a predetermined maximum operating pressure, a "three-way" solenoid pivot valve controlling the application of pressure to said valve actuating diaphragms and having two inlets and one outlet, a conduit connecting said pilot valve outlet to the space enclosed adjacent said valve actuating diaphragms, conduits connecting said pilot valve inlets to the inlet of said receiver

and to the suction side of said compressor, a pressure differential switch controlling energization of said pilot valve and having high and low pressure inlets, and conduits connecting said high pressure inlet to the inlet of said receiver and said low pressure inlet to the suction side of said compressor.

20. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, a pair of "three-way" flow directing valves, one of said valves having an inlet connected to the outlet from said compressor and having a pair of outlets connected one to each of said heat exchangers, the other of said valves having a pair of inlets connected one to each of said heat exchangers and an outlet connected to the inlet to said compressor, said valves having valve members having a normal initial position directing refrigerant flow to said first heat exchanger for condensation and being operable upon actuation to change the direction of refrigerant flow to said second heat exchanger for condensation, pressure responsive diaphragms for actuating said valves, and a "three-way" valve controlling the supply of pressure from the high or the low pressure sides of the system to said diaphragms for actuating said valves.

21. In a reversible refrigeration system, a compressor, a first heat exchanger, a second heat exchanger, one of said heat exchangers being operable as a refrigerant condenser and the other as a refrigerant evaporator according to the direction of operation of the refrigeration cycle, a pair of "three-way" flow directing valves, one of said valves having an inlet connected to the outlet from said compressor and having a pair of outlets connected one to each of said heat exchangers, the other of said valves having a pair of inlets connected one to each of said heat exchangers and an outlet connected to the inlet to said compressor, said valves having valve members having a normal initial position directing refrigerant flow to said first heat exchanger for condensation and being operable upon actuation to change the direction of refrigerant flow to said second heat exchanger for condensation, pressure responsive diaphragms on said valves and operable upon application of pressure from the high pressure side of the system to move said valve members to effect said change in direction of refrigerant flow, an electric solenoid operated "three-way" valve having inlets connected to the high and the low pressure sides of the system and an outlet connected for supply of pressure to said diaphragms, said solenoid valve having a normal initial position for establishing connection from the low pressure side of the system to said diaphragms, and being operable upon energization to close off said low pressure connection and to establish a high pressure connection.

EARNEST J. DILLMAN.
THOMAS E. NOAKES.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,135,285	Gibson	Nov. 1, 1938
2,148,415	Labberton	Feb. 21, 1939