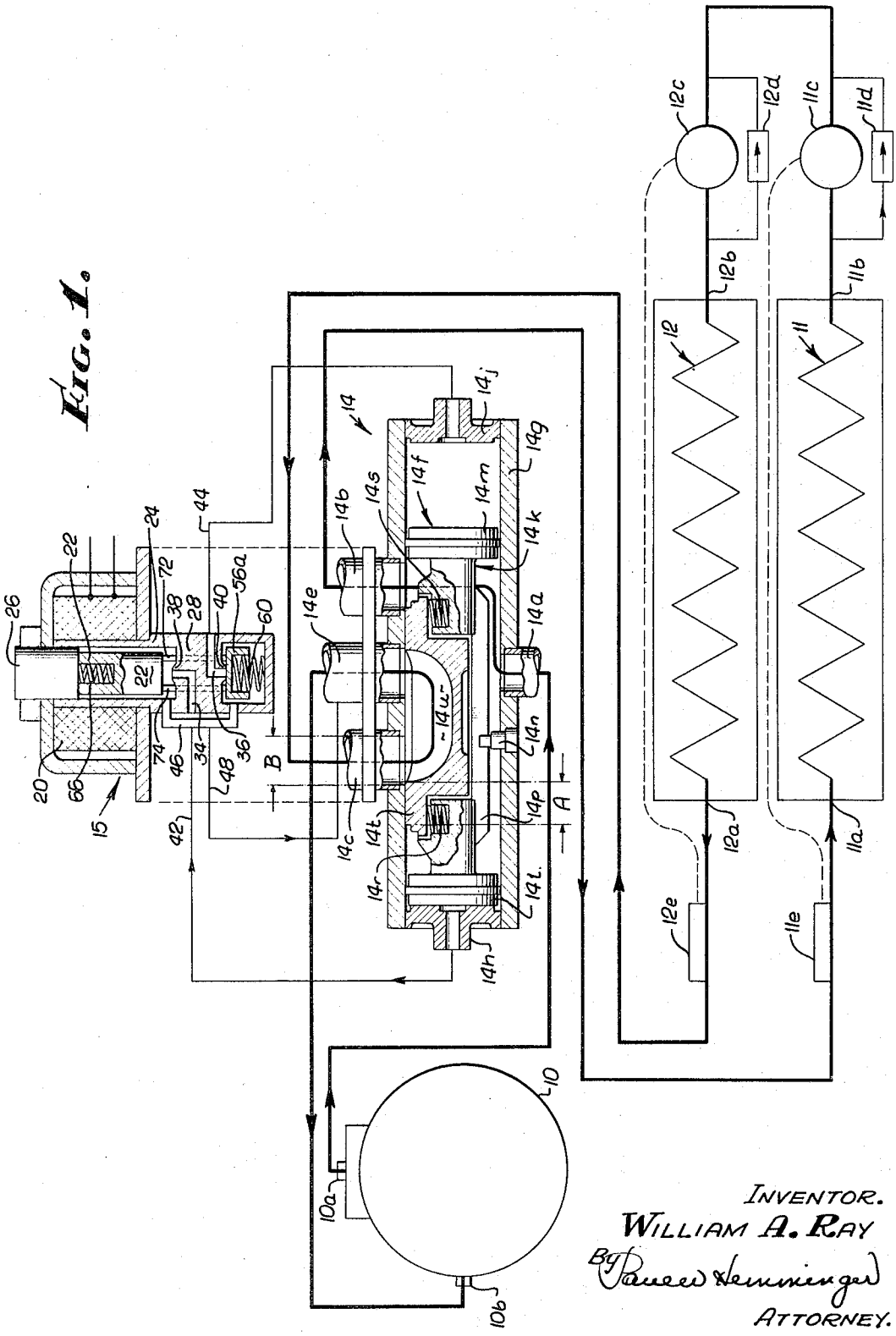
Feb. 14, 1967 W. A. RAY 3,303,665

MEANS AND TECHNIQUES USEFUL IN REFRIGERATION SYSTEMS

Filed July 22, 1965 2 Sheets-Sheet 1

FIG. 1.



INVENTOR.
WILLIAM A. RAY
By Parker & Hemminger
ATTORNEY.

Feb. 14, 1967 W. A. RAY 3,303,665

MEANS AND TECHNIQUES USEFUL IN REFRIGERATION SYSTEMS

Filed July 22, 1965 2 Sheets-Sheet 2

FIG. 2.

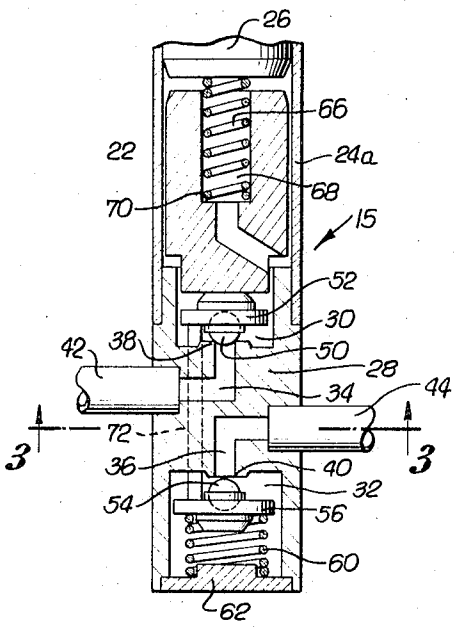


FIG. 3.

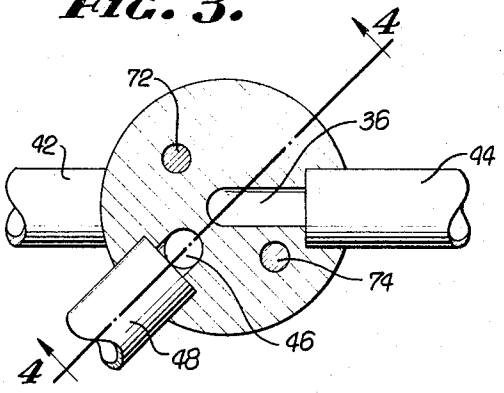


FIG. 4.

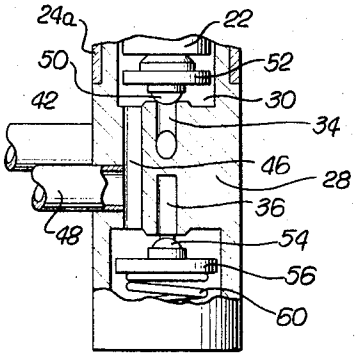
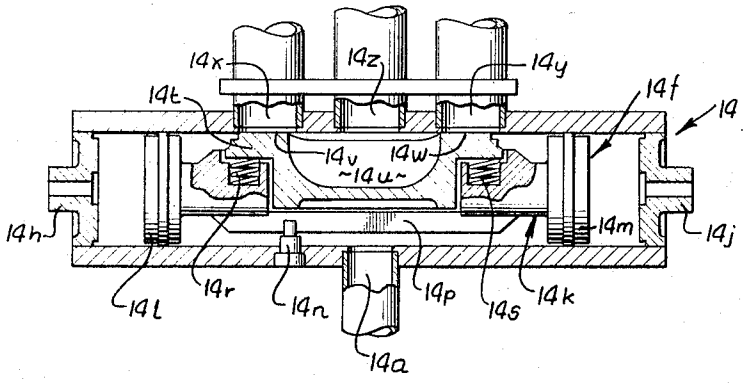


FIG. 5.



INVENTOR.
WILLIAM A. RAY
By Pennie & Hemmendinger
ATTORNEY.

United States Patent Office

3,303,665

Patented Feb. 14, 1967

3,303,665

MEANS AND TECHNIQUES USEFUL IN REFRIGERATION SYSTEMS

William Alton Ray, North Hollywood, Calif., assignor to International Telephone and Telegraph Corporation, New York, N.Y., a corporation of Maryland

Filed July 22, 1965, Ser. No. 473,939
6 Claims. (Cl. 62—324)

The present invention relates to means and techniques useful in refrigeration systems, and particularly of the type in which heat exchange elements may be interchanged to accomplish either a heating effect or a cooling effect.

Briefly, a reversible refrigeration system is disclosed herein in which a four-way transfer valve is operated and positioned in accordance with the condition of a solenoid operated pilot valve. Features of the invention involve the construction of the pilot valve, the construction of the four-way transfer valve and also the manner in which they are interconnected.

One phase of the present invention is addressed to the solution or obviation of problems arising as a result of pressure conditions that may result in difficulties in operating the pilot valve. It has been observed that refrigeration systems may at various times, due to high ambient temperatures or other abnormal conditions, develop high head pressures, and these head pressures make it extremely difficult to build small pilot valves for controlling the main transfer valve in a reversible system, and indeed such excessive pressures may actually prevent operation of the pilot valve as intended. This latter condition is a particularly serious condition as refrigeration systems are hermetically sealed, are evacuated and recharged with refrigeration fluid, all of which is time consuming and expensive. One aspect of the present invention therefore involves a unique construction of a pilot valve and its connections in the system whereby pressures, particularly excessive pressures, are ineffective to stall or to prevent operation of the pilot valve, and this in general is accomplished by pressuring the underside of a three-way pilot valve.

It is therefore a general object of the present invention to provide an improved refrigeration system, and particularly one of the reversible type.

Another object of the present invention is to provide an improved three-way pilot valve useful particularly in refrigeration systems.

Another object of the present invention is to provide a four-way transfer valve which is particularly useful in a refrigeration system.

Another object of the present invention is to provide a reversible refrigeration system involving a four-way transfer valve and a three-way pilot valve with the valves being interconnected with respect to each other and to other elements in the system such that pressure conditions in the system are advantageously used to assure operation of the pilot valve under all conditions, and particularly under excessive pressure conditions which may be developed in the system and with assurance that a main slide valve substantially or entirely covers the main ports so that no more than two ports are open to each other at any one time so as to assure no differential head pressure loss in the system which otherwise might result in non-operation of the main valve.

Another specific object of the present invention is to provide an improved refrigeration system in which should excessive pressures be developed, a three-way pilot valve serves to relieve the same with at all times the pilot valve being operable and in control regardless of the pressure.

Another object of the present invention is to provide a system of this character in which the pilot valve relieves excessive pressures.

Another object of the present invention is to provide a system of this character in which pressures in the system actually tend to aid the pilot valve in its operation.

Another object of the present invention is to provide a system of this character in which the pilot valve is connected such that while one of the sides of the pilot valve may be relieving pressure, the four-way transfer valve responds to such pressures developed across the pilot valve even though leaking.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. This invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof, may be best understood by reference to the following description taken in connection with the accompanying drawings in which:

FIG. 1 illustrates a reversible refrigeration system embodying features of the present invention.

FIG. 2 is generally a transverse sectional view through a pilot valve embodying features of the present invention, the same being intended to be connected in the system of FIG. 1 and being a solenoid operated valve, but for purposes of simplicity the complete solenoid coil is omitted from FIG. 2.

FIG. 3 is a sectional view taken along the line of 3—3 of FIG. 2.

FIG. 4 is a sectional view taken generally as indicated by lines 4—4 in FIG. 3.

FIG. 5 illustrates the movable valve element in an intermediate position.

Referring to FIG. 1, the reversible refrigeration system includes a conventional motor operated compressor **10**, a pair of heat exchange elements **11** and **12** illustrated in the form of coils, a four-way transfer valve **14** for selectively connecting the pressure outlet connection **10***a* of compressor **10** to either the coil ends **11***a* or **12***a* while simultaneously connecting the suction side or inlet connection **10***b* of compressor **10** to the other coil end **11***b* or **12***b*. For this purpose, the four-way transfer valve which is actually a flow reversing valve is moved and positioned in accordance with the operation of a three-way solenoid operated pilot valve **15**. In conventional manner, the other coil ends **11***b* and **12***b* are interconnected by expansion valves **11***c*, **12***c* and check valves **11***d* and **12***d*, and each of the expansion valves **11***c* and **12***c* are operated in accordance with thermal conditions at the coil ends **11***a* and **12***a*, respectively. For this latter purpose, conventional temperature responsive bulbs **11***e*, **12***e*, in the form of so-called capillary bulbs, are in heat exchange relationship to the refrigerant leaving the coil ends **11***a* and **12***a*, respectively, for operating such expansion valves **11***c* and **12***c* in conventional manner.

In the position of the four-way valve **14** shown in FIG. 1, the flow path of the refrigerant is as follows: from the pressure outlet **10***a* to the valve inlet opening **14***a*, through the valve connection **14***b*, to the coil end **11***a*, through the coil **11** which at this time serves as a condenser element, through the check valve **11***d*, through the expansion valve **12***c* which is controlled by the temperature responsive element **12***e*, through the coil **12**, through the valve connection **14***c* to the valve connection **14***e*, and to the compressor inlet connection **10***b*. It is noted that the compressor outlet and inlet connections **10***a*, **10***b* are connected directly to the valve connections **14***a* and **14***e*, respectively, at all times and that the movable valve element **14***f* serves to selectively communicate, in one position of valve element **14***f*, the connections **14***a* and **14***b* and the connections **14***c* and **14***e*, and in the other position of valve element **14***f* the connection **14***a* is placed in communication with connection **14***c* and **14***e* is placed in communication with connection **14***b* so that in this other position of valve element **14***f* the coil **12** functions

as a condenser element, and the other element 11 functions as an evaporator element. In the first condition described above, the coil 11 functions as a condenser and the coil 12 functions as an evaporator element. In the second condition where the coil 11 functions as an evaporator element, the refrigerant flow is through the check valve 12*d* and through the expansion valve 11*c* which is controlled by the thermal responsive element 11*e*.

The valve 14 has a generally cylindrical stationary valve body 14*g* having apertured disc shaped end members 14*h*, 14*j* for applying suitable pressures to a "floating" movable piston assembly 14*k* formed with piston elements 14*l*, 14*m* on opposite ends thereof, the assembly 14*k* being guided in its movement by a stationary pin 14*n* on the valve body 14*g* engaging an elongated slotted portion in a rib portion 14*p* that interconnects the piston portions 14*l*, 14*m*. These piston portions 14*l*, 14*m*, as shown, have inwardly extending rod portions each of which are recessed to receive a corresponding coil compression spring 14*r*, 14*s* acting against a dished valve element 14*t* to at all times urge it towards the three valve ports in body 14*g* and at the ends of conduits or connections 14*b*, 14*c*, 14*e*, respectively. For this purpose, the valve element 14*t* which has a dished portion 14*u* that forms a conduit for intercommunicating the suction connection or line 14*e* to either connections or lines 14*c* or 14*b* depending upon the position of the assembly 14*k* is guided for slidable movement on the piston rod portions so that such valve element 14*t* is spring urged into conformity with the stationary valve ports for providing a seal between valve ports.

In FIGS. 1 and 5, the valve element 14*t* has sealing surfaces or lands 14*v*, 14*w* which are preferably substantially equal to the area of their corresponding ports 14*x* and 14*y*, and are such that the center port 14*z* is never in communication with both ports 14*x* and 14*y* with, for example, the port dimension B being substantially equal to the dimension A. Also, as shown in FIG. 5, when the assembly 14*k* is in a position to establish communication between either port 14*x* or 14*y*, the other port 14*x*, 14*y* is in communication with the pressure inlet 14*a*. When the left-hand edge of land 14*v* is in alignment with the edge of port 14*x* as shown in FIG. 5, the valve 14*x*, 14*v* is open slightly to place port 14*x* in communication with suction outlet 14*z*, and at this time the left-hand edge of land 14*w* is displaced to the left with respect to the inner edge of port 14*y*; and also the valve 14*w*, 14*y* is open to establish communication between pressure line 14*a* and line 14*b*. For these purposes, under the conditions mentioned above, the distance between the right-hand edge of land 14*w* and the outer edge of port 14*y* may be, for example, 0.187 inch to provide what may be termed a negative overlap.

The pilot valve 15 is shown in more or less diagrammatic form in FIG. 1, and an actual construction may be as shown in FIGS. 2–4. For purposes of comparison like elements have identical reference numerals.

The pilot valve 15 is operated by a solenoid having an energizing coil 20 surrounding a magnetizable plunger 22 which is slidable in a hermetically sealed casing 24. The casing 24, as shown in FIG. 2, may include a brass sleeve member 24*a* about which the winding 20 is disposed and which is closed by a plug or cap 26.

The casing 24 is provided with an intermediate wall portion 28 which separates generally the casing into an upper chamber 30 and a lower chamber 32, and L-shaped fluid passages 34 and 36 are in such wall portion 28 with passages 34 and 36 terminating in valve seats 38 and 40, respectively, these valve seats 38 and 40 being in communication via corresponding fluid lines 42 and 44 with ends of the four-way valve housing 14*g*. As seen in FIG. 4, the chambers 30 and 32 intercommunicate through a bore 46 which is in communication with one end of a fluid line 48, the other end of line 48 communicating with the compressor suction line 14*e*. This bore 46 shown in FIG. 2 is illustrated diagrammatically in FIG. 1 as an interconnecting fluid line 46 for simplicity and ease of comparison.

The valve port 38 and the captivated ball 50 in the floatingly mounted ball carrier assembly 52 defines one valve, and likewise the other valve port 40 and captivated ball 54 in the other floatingly mounted ball carrier assembly 56 defines a second valve. These ball carrier assemblies 52, 56 are of identical construction and involve generally a disc shaped element having means loosely mounting a ball thereon. The lower assembly is contacted and urged upwardly by a coil compression spring 60 having its lower end seated on plug 62. The other or upper ball carrier assembly 52 is contacted and downwardly by the lower end of plunger 22, the plunger being urged downwardly by coil compression spring 66 having its upper end seated on plug 26 and its lower end extending into a fluid channel 68 and engaging the plunger shouldered portion 70. For purposes of illustration in FIG. 1, the seat 38 cooperates with the lower end of plunger 22 to define the previously mentioned valve and similarly the other valve seat 40 cooperates with a spring seat 56*a* for spring 60 in defining the other previously mentioned valve. As illustrated in FIGS. 1 and 3, a pair of pins 72 and 74 are floatingly mounted in the wall portion 28 to extend between the movable valve elements which in FIG. 2 are the ball carrier assemblies 52 and 56 and in FIG. 1 the plunger 22 and spring seat 56*a*.

The spring 66 is stronger than the spring 60 so that in the deenergized condition of solenoid winding 20 shown in FIG. 2, the port 38 is closed and the port 40 is open; and when such winding 20 is energized, the port 38 is open and port 40 is closed corresponding to the condition shown in FIG. 1. Energization of winding 20 may thus correspond either to a cooling condition or a heating condition depending upon where the heat exchange coils 11 and 12 are located with respect to the environment under consideration.

In the energized condition of solenoid 20 as in FIG. 1, the movable valve assembly 14*k* is positioned to the left being maintained therein due to a pressure differential resulting from the fact that at this time the line 42 is connected via port 38, conduit 46 and line 48 to the compressor suction or return line 14*e*, the other port 40 being closed. To move the valve assembly 14*k* to the right to its other extreme position, the winding 20 is deenergized to achieve the condition shown in FIG. 2 where now the compressor return or suction line 14*e* is communicated to the bore in the housing end 14*j* via line 44, port 40, conduit 46 and line 48, to produce the desired movement as a result of the pressure on the left hand side of piston 14*m* being smaller than the pressure on its right hand side. Consequently, flow of refrigerant is reversed through the coils 11 and 12. During the above mentioned movement, there may be sufficient leakage past piston 14*c* into line 42 to destroy any otherwise adverse cavitation resulting from the piston 14*l* moving away from housing end 14*h*; and with such assumed leakage should the pressure in line 42 rise above a predetermined amount, it may be relieved by its causing the port 38 to open in which case such pressure overcomes the force of spring 66.

Subsequently, when it is desired to return the valve assembly 14*k* to its position shown in FIG. 1, the winding 20 is energized in which case valve port 38 is open and port 40 is closed, and the action is as indicated above with at this time movement being accomplished as a result of a difference in pressure on the outer and inner surface of piston 14*l* with the port in this instance being opened slightly to relieve any excessive pressure conditions in line 44 resulting from any leakage past the piston 14*m*. When the port 40 is thus opened, the pressure overcomes the force of spring 60.

It will also be seen that excessive pressures, when and as they are developed in the system, act on elements of the pilot valve such that they do not tend to stall or

prevent movement of the solenoid plunger. Thus, under the static condition shown in FIG. 1, the chambers **30** and **32** intercommunicated by passageway **46** (FIG. 4) are at the pressure of the suction line **14***e* (FIG. 1), and pressure in line **42** aids the winding **20** when energized to move the plunger **22** to its upper attracted position in FIG. 1. Also, in the static condition shown in FIG. 1, excessive pressure in line **44** applied to spring **60** overcomes the action of spring **60** on plunger **22** to render spring **66** more effective to move the plunger **22** downwardly when winding **20** is deenergized. This arrangement results in permissive use of a smaller, more reliable pilot valve.

It should be noted in particular that the main slide valve element **14***f* substantially or entirely covers the main ports **14***b*, **14***c*, **14***e* such that no more than two of such ports are open to each other at any one time. If this is not done, the differential head pressure in the system required to operate the valve element **14***f* may be lost, hence resulting in stalling the movement of the main valve element **14***f*.

While the particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. In a reversible refrigeration system of the character described the combination comprising: a compressor having a pressure outlet and an exhaust inlet; a first coil; a second coil; a four-way transfer valve including a casing and a valve element slidably mounted in said casing; an electromagnetically operated pilot valve; said casing having a pressure inlet in communication with the pressure outlet of said compressor; said casing having an exhaust outlet in communication with said compressor exhaust inlet; means intercommunicating one end of said first coil with one end of said second coil; said casing having a first valve port in communication with the other end of said first coil; said casing having a second port in communication with the other end of said second coil; said valve element being effective in a first position thereof to intercommunicate said casing pressure inlet with said first port and simultaneously intercommunicate said casing exhaust outlet with said second port; said valve element being effective in a second position thereof to intercommunicate said casing pressure inlet with said second port and to simultaneously intercommunicate said first port with said casing pressure exhaust outlet; said valve element having a first piston and a second piston respectively on opposite ends thereof which define with said casing a corresponding first casing chamber and a second casing chamber; said pilot valve including a housing defining two chambers; means intercommunicating said casing exhaust outlet with each of the two last mentioned chambers; said last two mentioned pilot valve chambers being separated by a wall portion; two fluid channels extending through said wall portion and terminating respectively at a corresponding valve seat, one of said fluid channels being in communication with said first casing chamber and the other of said fluid channels being in communication with said second casing chamber; a valve element in one of said pilot valve chambers; resilient means normally urging the last mentioned valve element into engagement with one of said pilot valve ports; a solenoid plunger movably mounted in the other of said pilot valve chambers and including valve means cooperating with the other of said pilot valve ports; means normally urging said plunger to normally close the last mentioned port; and means interconnecting said plunger and the valve element in said one pilot valve chamber.

2. In an arrangement as set forth in claim **1** in which the last mentioned means is a one-way connection between the plunger and the valve element in said one pilot valve chamber.

3. In an arrangement as set forth in claim **1** in which the first mentioned valve element includes a valve member slidably mounted on said piston portions with spring means acting between said piston portions and said member to urge said valve member toward said first and second casing ports.

4. In a reversible refrigeration system of the character described, wherein a four-way transfer valve is effective to reverse the direction of flow of refrigerant through a first and a second coil in accordance with refrigerant pressure acting on a slide valve element movable in a casing which defines with said slidable valve element a first chamber and a second chamber, and wherein said casing has a refrigerant pressure inlet, an exhaust outlet, and a pair of ports cooperating with said valve element, and wherein said pair of ports are respectively in communication with a corresponding one end of said first and second coils with means being provided to intercommunicate the other ends of said coils, and wherein said valve element, in one position thereof, is effective to selectively communicate said pressure inlet to said one end of said first coil and to simultaneously intercommunicate said exhaust outlet with said one end of said second coil, and wherein, in a second position of said valve element, said valve element is effective to selectively communicate said pressure inlet with said one end of said second coil and to simultaneously intercommunicate said exhaust outlet with said one end of said first coil, the improvement which resides in providing first valve means for communicating said first chamber to said exhaust outlet, second valve means for communicating said second chamber with said exhaust outlet, electromagnetically operated means including a plunger movable in a closed chamber in a housing, said closed chamber being in communication at all times with said exhaust outlet, said plunger in its energized condition being effective to open said first valve and close said second valve and being effective in its deenergized condition to close said first valve and open said second valve, the said first valve and second valve means including parts in different closed spaces, said first valve having a movable element, and a one-way connection between said plunger and said movable valve element.

5. A reversible refrigeration system as set forth in claim **4**, including first means urging said plunger to normally close said second valve and to normally open said first valve, and second means, weaker than said first means, tending to move said movable valve element to its valve closing position.

6. A system as set forth in claim **1** in which said valve element is movable to substantially cover said ports such that at no time are said ports open to each other.

References Cited by the Examiner

UNITED STATES PATENTS

2,976,701	3/1961	Greenawalt	62—324
2,991,631	7/1961	Ray	62—324
3,056,574	10/1962	Greenawalt	62—324

WILLIAM J. WYE, *Primary Examiner.*