Jan. 2, 1968 C. M. LEWIS 3,360,952

CAPACITY CONTROLLED REFRIGERATION SYSTEM

Filed June 28, 1966 3 Sheets-Sheet 1

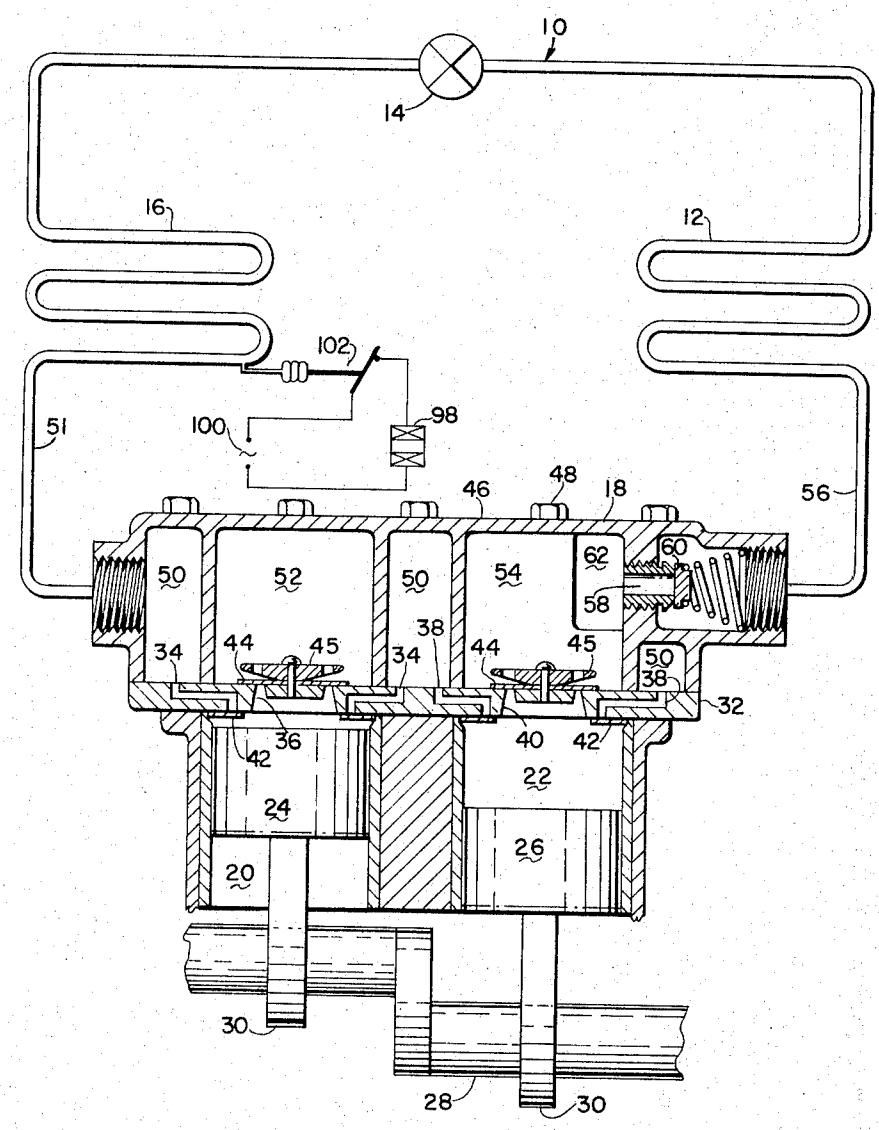


FIG. 1

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CAPACITY CONTROLLED REFRIGERATION SYSTEM

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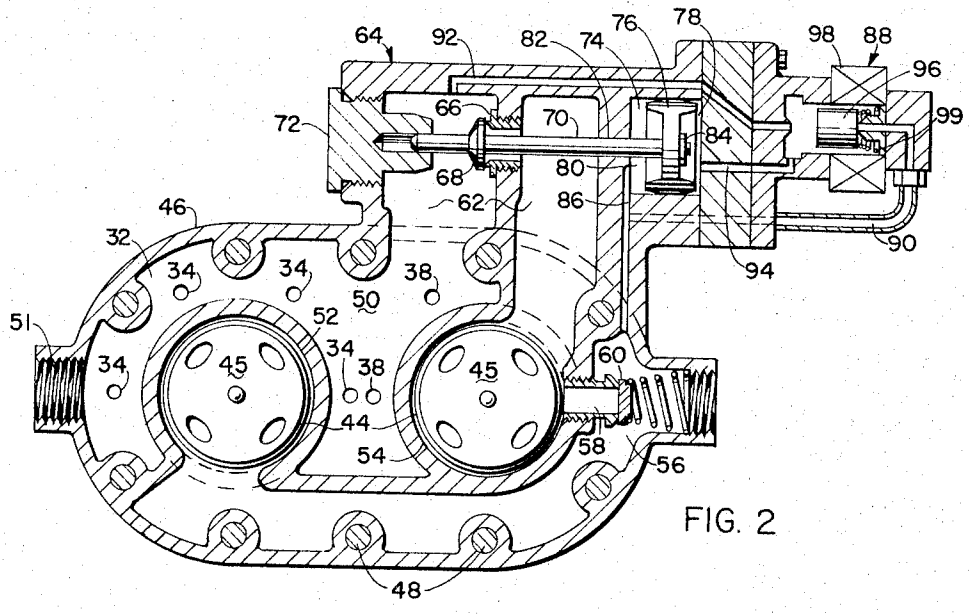


FIG. 2

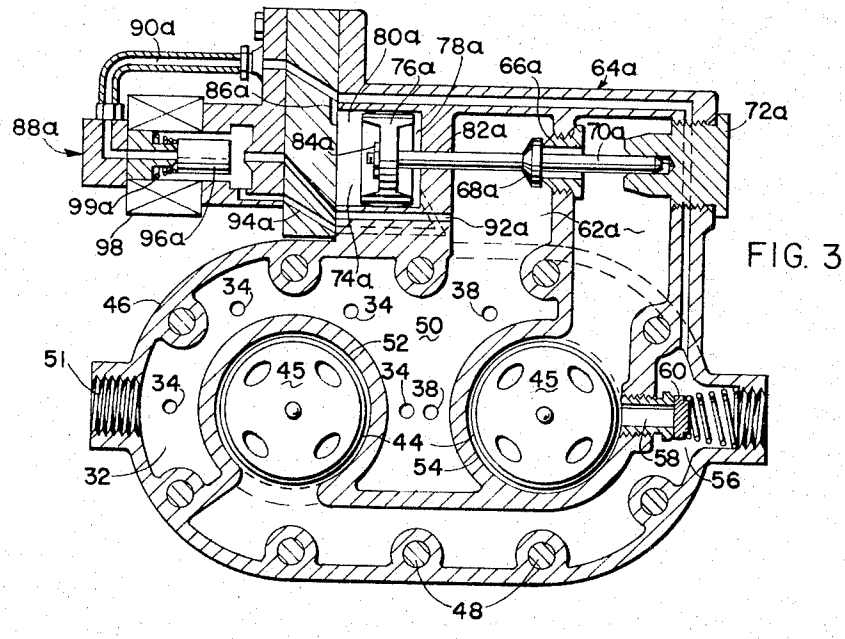


FIG. 3

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Filed June 28, 1966 3 Sheets-Sheet 3

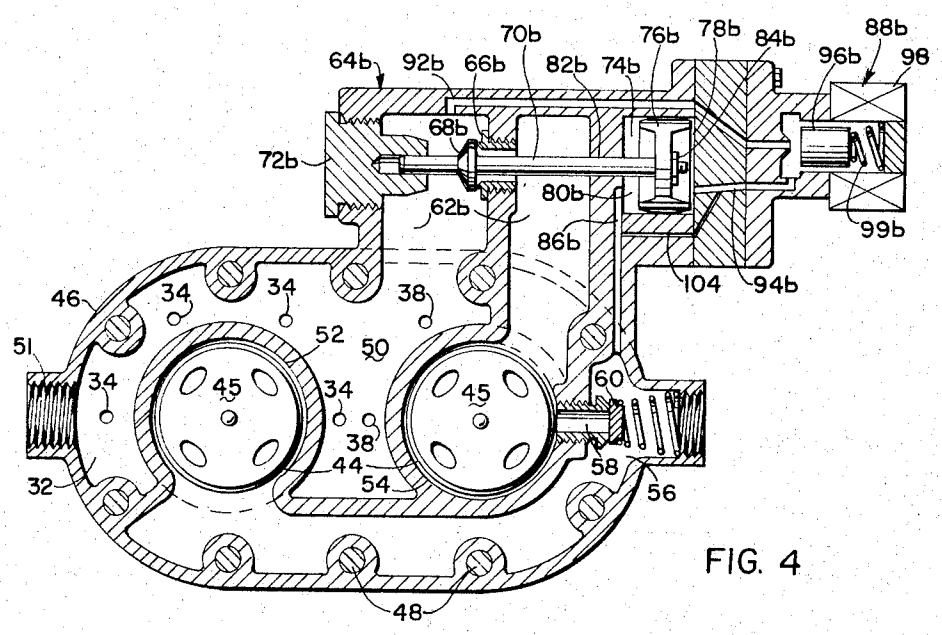


FIG. 4

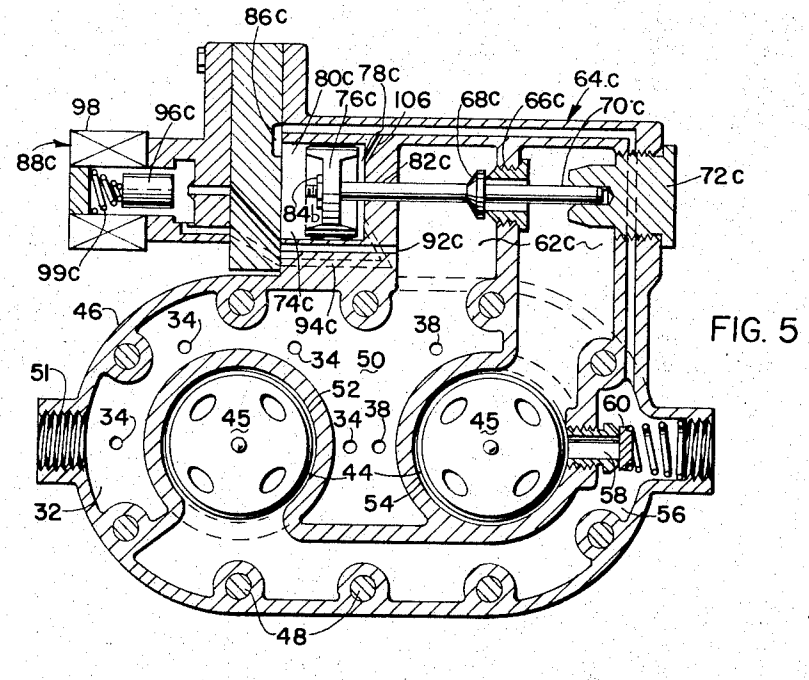


FIG. 5

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CAPACITY CONTROLLED REFRIGERATION SYSTEM

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10 Claims. (Cl. 62—196)

This invention relates to bypass capacity control for compression type refrigeration systems.

In refrigeration systems of the compression type it is often desirable to increase or decrease the capacity of the system such as to correspond to the refrigeration load as bypassing compressed refrigerant from a portion of the discharge of the compression means back to the suction side of the compression means. This may be accomplished by placement of a valve in a bypass line which extends from the discharge side of a part of the compression means to the suction side of the compression means. By opening the valve, compressed refrigerant gas from part of the compression means flows directly to the suction without passing through the condenser, expansion means and evaporator thereby reducing the refrigerating effect of the system. Many such bypass unloader systems have been developed. The instant invention affords certain advantages and is characterized by certain differences particularly in the manner in which the valve in the bypass line is actuated by gas pressures within the refrigeration system.

It is common practice to move the bypass valve to one of its extreme open or closed positions with a spring element and to move the valve to the other position by high side refrigerant pressure acting against the bias of the spring. Unfortunately the spring rate is relatively constant while the refrigerant pressure may vary, considerably particularly where an air cooled condenser is employed in cold weather conditions. Since one of the valve positions results from a balance between spring pressure and refrigerant pressure and since the refrigerant pressure varies while the spring rate is relatively constant, the bypass valve may flutter and cause excessive wear of the working parts as well as adversely affect the capacity control. It is even possible in such a system working under very cold weather conditions that insufficient refrigerant pressure will be developed to actuate the valve against the bias of the spring at a time when capacity control is particularly desirable.

It is therefore an object of this invention to provide a refrigerant system which eliminates the above indicated failings and disadvantages of the prior art systems.

It is a further object to provide a refrigeration system with a bypass capacity control valve which does not flutter and which will not be adversely affected by variations in refrigerant gas pressure.

Another object of this invention is to provide a refrigerant system bypass capacity control valve which does not require a spring as a prime motivating means.

A further object of the invention is to provide a bypass capacity control valve in a refrigeration system wherein the differential in pressure on the bypass valve opens the valve and the differential in pressure upon a piston closes the valve.

Another object of this invention is to provide a bypass valve actuator piston wherein one side of the piston is continuously under high side pressure while the pressure on the other side is controlled between high side pressure and suction pressure.

Still another object of this invention is to provide a refrigeration system bypass unloader valve wherein the bypass valve is arranged on the downstream side of its

seat and opening of the valve results from the differential in pressure across the valve.

Other objects and advantages will become apparent as this specification proceeds to describe the invention with reference to the accompanying drawing wherein like elements have been identified by like reference numerals in which:

FIGURE 1 is a diagrammatic view of a refrigeration system in corporating the invention including a portion of the compression means therefor;

FIGURE 2 illustrates a first form of unloader mechanism of the invention utilizing a three-way solenoid valve actuator;

FIGURE 3 illustrates a second form of unloader mechanism of the invention utilizing a three-way solenoid valve actuator;

FIGURE 4 illustrates a third form of unloader mechanism of the invention utilizing a two-way solenoid valve actuator; and

FIGURE 5 illustrates a fourth form of unloader mechanism of the invention utilizing a two-way solenoid valve actuator.

Referring now to FIGURE 1, there is shown a refrigeration system **10** having a refrigerant condenser **12**, a refrigerant expansion means **14**, a refrigerant evaporator **16** and a refrigerant compression means **18** respectively serially connected in a closed refrigerant circuit.

Compression means **18** has a first compression cylinder **20** and a second compression cylinder **22** having pistons **24** and **26** respectively mounted therein and arranged to be reciprocated by crankshaft **28** through connecting rods **30**. Compressor **18** has a valve plate **32** mounted at the end of compression cylinders **20** and **22** for admitting and discharging refrigerant to and from cylinders **20** and **22**. Suction ports **34** and discharge ports **36** are disposed in plate **32** and communicate with first cylinder **20**. Suction ports **38** and discharge ports **40** are disposed in plate **32** and communicate with second cylinder **22**. Suction ports **34** and **38** are each provided with an annular spring suction valve **42** and discharge ports **36** and **40** are each provided with an annular spring discharge valve **44**. Valves **44** are provided with a stop member **45** to limit their open position.

Now with reference to FIGURES 1 and 2 it will be seen that disposed on the side of valve plate **32** opposite cylinders **20** and **22** is a cylinder head **46** which may be bolted to the cylinders as by bolts **48**. Cylinder head **46** includes a suction chamber **50** which forms part of a suction passageway **51** extending from the outlet of evaporator **16** to the suction ports **34** and **38**. Cylinder head **46** has a first cylinder discharge chamber **52** and a second cylinder discharge chamber **54** communicating respectively with discharge ports **36** and **40** for receiving refrigerant compressed in cylinders **20** and **22**. Chamber **52** forms part of a first discharge passageway **56** extending from discharge port **36** to the inlet of condenser **12**. Chamber **54** forms part of a second discharge passageway **58** extending from discharge port **40** to discharge passageway **56**. Passageway **58** has disposed therein a check valve **60** arranged to permit flow in passage **58** only in a direction away from chamber **54** toward passage **56**.

Chamber **54** also communicates with bypass passageway **62** defined by cylinder head **46** which extends to suction passageway **51** for bypassing refrigerant gas from discharge chamber **54** to suction chamber **50**. A bypass unloader valve means **64** is provided for passageway **62** for controlling the flow of refrigerant gas therethrough.

Unloader valve means **64** includes an annular valve seat **66** through which passageway **62** extends and a valve **68** arranged on the downstream side of seat **66** in cooperative relationship therewith. Seat **66** may have external threads

for sealingly securing it in passageway 62. Valve 68 is mounted on valve stem 70 for guiding of valve 68 to and from the face of seat 66. At one end of valve stem 70 is a valve stem guide 72 which may be secured to cylinder head 46 by appropriate threads.

Adjacent the other end of valve stem 70 is a cylindrical chamber 74 defined by cylinder head 46. Chamber 74 has a movable partition 76 therein dividing chamber 74 into a first portion 78 and a second portion 80. Partition 76 preferably is a piston slidably mounted for reciprocal movement along the axis of cylindrical chamber 74. Valve stem 70 slidably extends through a bore 82 in a wall defining the second portion 80 of chamber 74. Valve stem 70 is co-axially arranged with piston 76 and fastened thereto as by a nut 84. Thus it will be seen that movement of piston 76 toward portion 78 of chamber 74 affects closure of valve 68 and movement of valve 68 away from seat 66 affects movement of piston 76 toward second portion 80 of chamber 74.

The movement of valve 68 and piston 76 is controlled by the fluid pressures on these parts. Thus there is provided a passageway 86 communicating with first discharge passageway 56 with the second portion 80 of chamber 74. Passageway 86 communicates with passage 56 on the downstream side of check valve 58 thereby at all times placing second portion 80 of chamber 74 in fluid communication with the discharge chamber 52 of first cylinder 20.

The pressure in first portion 78 of chamber 74 is controlled between a high pressure equal to about the pressure in second portion 80 and a low pressure equal to about the pressure in suction chamber 50. In the form of the invention shown in FIGURE 2, this is accomplished with a three-way solenoid selector valve 88 having a first port communicating with passageway 56 via passageway 90, a second port communicating with suction passageway 51 via passageway 92, and a common port communicating with the first portion 78 of chamber 74 via passageway 94. Solenoid valve 88 also has a port operator 96 and a solenoid coil 98 for actuating operator 96.

When solenoid coil 98 is energized to move operator 96 to the right, first portion 78 of chamber 74 is communicated with and placed at the pressure of suction passageway 51 via passageways 92 and 94 whereby the differential pressure on piston 76 forces valve 68 to the closed position via stem 70 thereby loading the compressor, i.e. cylinder 22. It will be understood that second portion 80 is in continuous communication with passageway 56 via passageway 86 and the effective area of piston 76 is sufficiently greater than the face area of valve seat 66 so that valve 68 will close in spite of the differential pressure acting on valve 68.

When coil 98 is de-energized and operator 96 is moved to the left position by action of the bias spring 99, portion 78 of chamber 74 is communicated with and placed at the pressure of passageway 56 via passageways 90 and 94 equalizing the pressure on both sides of piston 76 whereupon the differential pressure on valve 68 forces valve 68 to the open position thereby unloading the compressor.

Solenoid coil 98 may be selectively energized by an electric circuit shown in FIGURE 1 including in series with coil 98 an electric power source 100 and a pressure switch 102. Switch 102 is constructed to open when the pressure at the evaporator 16 falls below a predetermined value which is indicative of a low load on the refrigeration system. Thus as the load on the refrigeration system decreases to a predetermined value, switch 102 opens de-energizing coil 98 and unloading the compressor. When the load on the refrigeration system increases above a predetermined value, switch 102 closes, energizing coil 98 and loading the compressor.

The form of the invention shown in FIGURE 3 is similar to that shown in FIGURE 2 and elements having similar functions have been identified by similar reference numerals followed by the suffix "*a*." The form of the invention shown in FIGURE 3 differs from that of FIGURE 2 mainly in that the position of the valve stem guide 72 and the cylindrical chamber 74 are interchanged.

It will however be noted that the portion 78*a* of chamber 74*a* which is selectively placed under high and low pressures is disposed on the side of piston 76*a* adjacent the wall incorporating bore 82*a*.

The operation of the bypass unloader shown in FIGURE 3 is similar to that of FIGURE 2. Thus when coil 98 is energized to move operator 96a to the left, first portion 78*a* of chamber 74*a* is communicated with and placed at the pressure of suction passageway 51 via passageways 92*a* and 94*a* whereby the differential pressure on piston 76*a* forces valve 68*a* to the closed position via stem 70*a* thereby loading the compressor. It will be understood that second portion 80*a* of chamber 74*a* is in continuous communication with passageway 56 via passageway 86*a* and that the effective area of piston 76*a* is sufficiently greater than the face area of valve seat 66*a* so that valve 68*a* will close in spite of the differential pressure acting on valve 68*a*. When coil 98 is de-energized and operator 96*a* is moved to the right position by action of bias sping 99*a*, portion 78*a* of chamber 74*a* is communicated with and placed at the pressure of passageway 56 via passageways 90*a* and 94*a* equalizing the pressure on both sides of piston 76*a* whereupon the differential pressure on valve 68*a* forces valve 68*a* to the open position thereby unloading the compressor.

The form of the invention shown in FIGURE 4 is similar to that shown in FIGURE 2 and elements having similar functions have been identified by similar reference numerals followed by the suffix "*b*." The form of the invention shown in FIGURE 4 differs from that of FIGURE 2 mainly in that a selector valve 88*b* of the two-way type is employed rather than a three-way valve as in the form shown in FIGURE 2. Two-way solenoid valve 88*b* has an inlet port which communicates with passageway 94*b* similar to passageway 94. Valve 88*b* also has an outlet port which communicates with passageway 92*b* similar to passageway 92. In addition the form of the invention shown in FIGURE 4 has a restrictor passageway 104 communicating passageway 56 with first portion 78*b* of chamber 74*b*. It should be understood that the term "restrictor passageway" as used hereinafter may be a passageway relatively large in cross-section having a restrictive portion or restrictor orifice therein. Passageways 104, 94*b* and 92*b* define together a control passageway for controlling the pressure in first portion 78*b* of chamber 74*b*. Port operator 96*b* controls the flow from passageway 94*b* to passageway 92*b*.

Thus when coil 98 is energized to move operator 96*b* to the right, first portion 78*b* of chamber 74*b* is communicated with passageway 51 via passageway 92*b* and 94*b*. Passageways 92*b* and 94*b* are sufficiently large so as to bleed off the flow of fluid passing in restrictor passageway 104 without materially raising the pressure in the first portion 78*b* of chamber 74*b* whereby the differential pressure on piston 76*b* forces valve 68*b* to the closed position via stem 70*b* thereby loading the compressor. When coil 98 is de-energized and operator 96*b* is moved to the left position by action of bias spring 99*b* terminating flow from passageway 94*b* to passageway 92*b*, pressure in portion 78*b* of chamber 74*b* is increased to that of passageway 56 via the fluid passing in restrictor passageway 104 equalizing the pressures on both sides of piston 76*b* whereupon the differential pressure on valve 68*b* forces valve 68*b* to the open position thereby unloading the compressor.

The form of the invention shown in FIGURE 5 is similar to that shown in FIGURE 3 and elements having similar functions have been identified by similar reference numerals followed by the suffix "*c*." The form of the invention shown in FIGURE 4 differs from that of FIGURE 3

mainly in that a selector valve 88c of the two-way type is employed rather than a three-way valve as in the form shown in FIGURE 3. Two-way solenoid valve 88c has an inlet port which communicates with passage 94c similar to passageway 94. Valve 88c also has an outlet port which communicates with passageway 92c similar to passageway 92. In addition the form of the invention shown in FIGURE 5 has a restrictor passageway 106 communicating passageway 56 with portion 78c of chamber 74c. Passageways 106, 94c and 92c together define a control passageway for controlling the pressure in first portion 78c of chamber 74c. Port operator 96c controls the flow from passageway 94c to passageway 92c.

Thus when coil 98 is energized to move operator 96c to the left, first portion 78c of chamber 74c is communicated with passageway 51 via passageways 94c and 92c. Passageways 92c and 94c are sufficiently large so as to bleed off the flow of fluid passing in restrictor passageway 106 without materially raising the pressure in first portion 78c of chamber 74c whereby the differential pressure on piston 76c forces valve 68c to the closed position via stem 70c thereby loading the compressor. When coil 98 is de-energized and operator 96c is moved to the right position by action of bias spring 99c terminating flow from passage 94c to passageway 92c, pressure in portion 78c of chamber 74c is increased to that of passageway 56 via the fluid passing in restrictor passageway 106 equalizing the pressure on both sides of piston 76b whereupon the differential pressure on valve 68c forces valve 68c to the open position thereby unloading the compressor.

In each of the aforedescribed forms of the invention it will be apparent that the bypass valve is disposed on the downstream side of its seat so gas pressure differential across the valve opens the valve. Also there is a piston connected to the valve for closing the valve. One side of the piston is continuously under high side or discharge pressure for closing the valve. In each form opening of the valve is accomplished by applying high side pressure to the other side of the piston thereby substantially balancing the forces on the piston and permitting the bypass valve to open by the differential pressures on the valve. Conversely, closure of the valve is effected by relief of the pressure on said other side of the piston. In each form the effective area of the piston must be greater than that of the bypass valve face so that the piston can effect closure of the bypass valve in spite of differential pressure on the bypass valve. While the arrangement described does not require the use of a spring to motivate the valve to either the closed or open position it is contemplated that a weak spring might be used to bias the valve in one direction or the other to merely effect trimming or adjustment of the valve.

Although I have described in detail the preferred embodiment of my invention, I contemplate that many changes may be made without departing from the scope or spirit of my invention and I desire to be limited only by the claims.

I claim:

1. A refrigeration system comprising a refrigerant compressor means, a refrigerant condenser, a refrigerant throttling means and a refrigerant evaporator connected respectively in series, said compressor means including first and second compression cylinders each including a movable piston therein, each of said cylinders having associated therewith a suction port and a discharge port provided respectively with a suction valve and a discharge valve, a suction passageway extending to said suction ports from said evaporator, a first discharge passageway extending from the discharge port of said first cylinder to said condenser, a second discharge passageway extending from the discharge port of said second cylinder and communicating with said first discharge passageway, a check valve means disposed in said second discharge passageway substantially limiting flow therethrough to a flow direction away from said discharge port of said second cylinder, a bypass passageway communicating with said discharge port of said second cylinder upstream of said check valve means and extending to said suction passageway, a bypass unloader valve means disposed in said bypass passageway for controlling the flow of fluid from said discharge port of said second cylinder through said bypass passageway to said suction passageway, said valve mean including a valve seat, a valve disposed on the downstream side of said seat in cooperative relationship with said seat, means forming a chamber, a movable partition dividing said chamber into first and second portions, connecting means operatively connecting said partition to said valve whereby movement of said partition toward said first portion of said chamber moves said valve toward said seat and movement of said valve away from said seat moves said partition toward said second portion of said chamber, means communicating said second portion of said chamber with said first discharge passageway on the downstream side of said check valve means, and selector means for selectively applying first cylinder discharge pressure and suction pressure to said first portion of said chamber whereby said bypass valve is respectively opened and closed.

2. The apparatus as defined by claim 1 wherein said connecting means extends through a wall of said chamber.

3. The apparatus defined by claim 2 wherein said selector means includes means for selectively communicating said first portion of said chamber with said suction passageway and with said first discharge passageway on the downstream side of said check valve means.

4. The apparatus as defined by claim 3 wherein said chamber is cylindrical and said partition is a piston slidably mounted therein.

5. The apparatus as defined by claim 3 wherein said connecting means extends through a wall of said first portion of said chamber and the area of the side of said partition facing said second portion of said chamber is greater than the face area of said valve seat.

6. The apparatus as defined by claim 3 wherein said connecting means extends through a wall of said second portion of said chamber and the area of the side of said partition facing said first portion of said chamber is greater than the face area of said valve seat.

7. The apparatus as defined by claim 2 wherein said selector means includes a control passageway extending from said first discharge passageway on the downstream side of said check valve means to said suction passageway, a two way valve disposed in said control passageway for selectively terminating the flow therethrough a restrictor disposed in said control passageway upstream of said two way valve for restricting the flow through said control passageway and means providing fluid communication between said first portion of said chamber and a point in said control passageway upstream of said two way valve and downstream of said restrictor.

8. The apparatus as defined by claim 7 wherein said chamber is cylindrical and said partition is a piston slidably mounted therein.

9. The apparatus as defined by claim 7 wherein said connecting means extends through a wall of said first portion of said chamber and the area of the side of said partition facing said second portion of said chamber is greater than the face area of said valve seat.

10. The apparatus as defined by claim 7 wherein said connecting means extends through a wall of said second portion of said chamber and the area of the side of said partition facing said first portion of said chamber is greater than the face area of said valve seat.

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MEYER PERLIN, *Primary Examiner.*