United States Patent

[11] 3,626,979

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[21] Appl. No. 6,621
[22] Filed Jan. 28, 1970
[45] Patented Dec. 14, 1971
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[54] **FLUID COMPRESSION SYSTEM CONTROL**
3 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **137/608,** 62/196, 62/510, 417/252, 417/308
[51] **Int. Cl.** **F17d 1/02**
[50] **Field of Search** 62/196, 510; 417/252, 308, 311; 137/608–612.1

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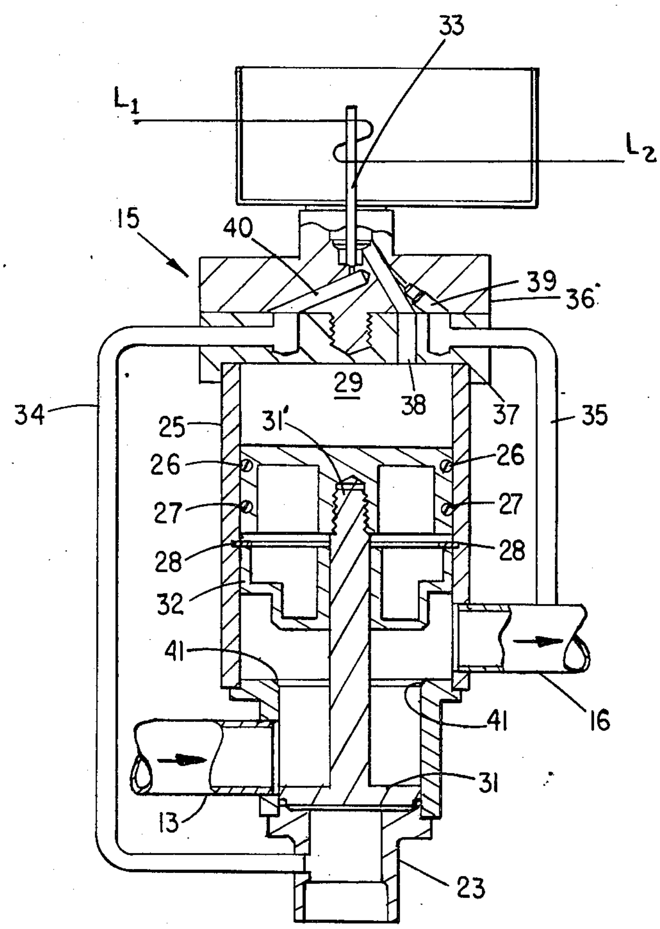
ABSTRACT: An unloading valve for controlling the capacity of a compressor comprising a housing defining a bore, an inlet to said housing connected to the discharge side of a compressor, a first outlet from said housing connected to the suction side of said compressor, and a second outlet from said housing connected to the discharge manifold of the compressor. Disposed in the bore is a piston assembly and poppet operable in response to changes of pressure in the bore. The piston and poppet move as a result of changes of pressure in the bore, created by the bore being selectively communicated with the side of the compressor and with the discharge side of the compressor. Movement of the piston assembly and poppet selectively communicates the inlet of said valve with either the suction side of the compressor when reduced capacity is required or with the discharge manifold when rated capacity is required.



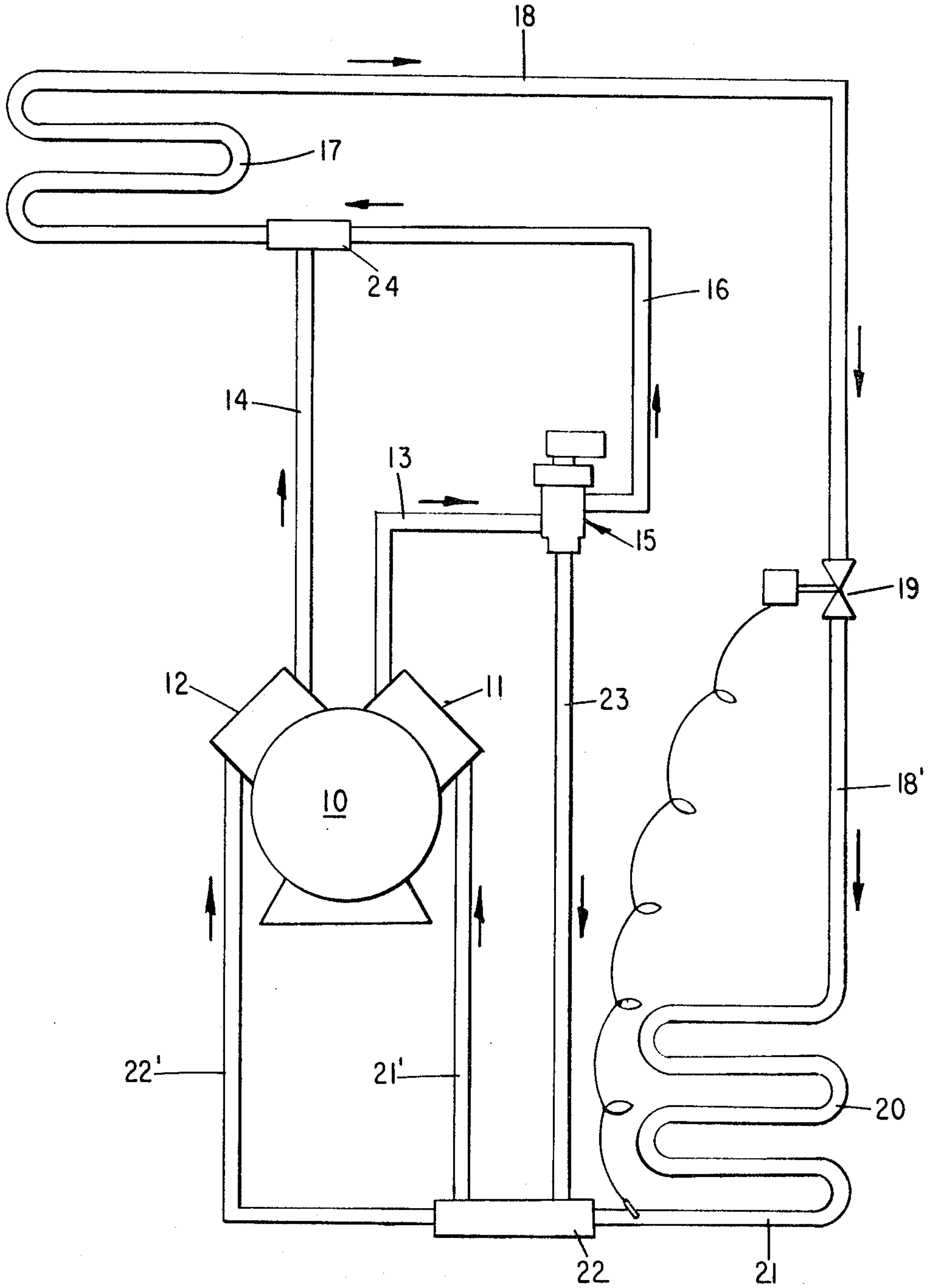


FIG. 1

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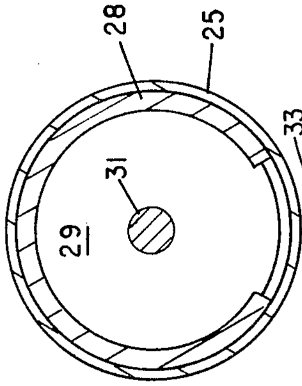

FIG. 4

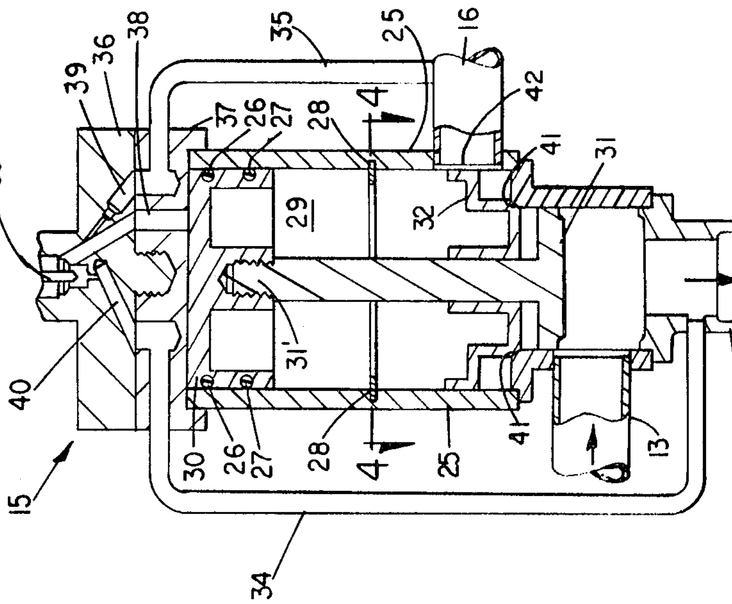

FIG. 3

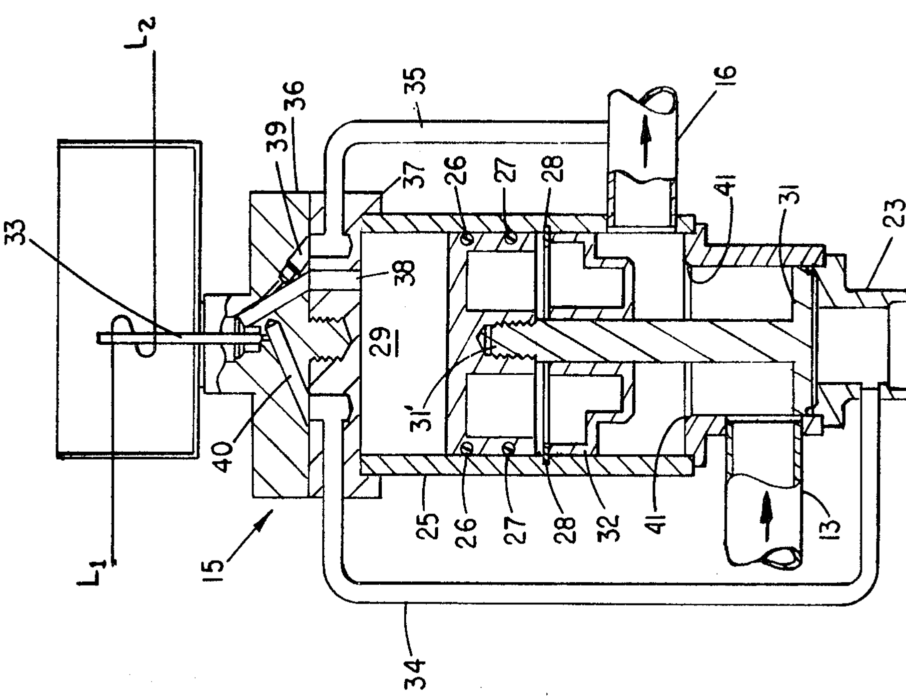

FIG. 2

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FLUID COMPRESSION SYSTEM CONTROL

BACKGROUND OF THE INVENTION

This invention relates to fluid compressors, and in particular, to an unloading valve operable to control the capacity of such compressors.

In a compressor designed to operate at relatively constant speed, the load on the system in which the compressor is employed may sometimes vary, resulting in inefficient operation of the compressor unless the capacity of the compressor may be varied to comply with the system variations. For example, constant speed compressors are generally employed in refrigeration systems wherein the load on such system may vary quite substantially.

One of the methods for varying the capacity of a compressor operating at constant speed is to provide means for bypassing some or all of the compressor's output back to the suction side of the compressor from some point in the discharge manifold. One of the methods for obtaining the above-described reduction of capacity is to employ a valve that selectively communicates internal passages in the compressor cylinder that connects the discharge side of the compressor with the suction side thereof, to provide the desired control of the compressor capacity. Although such a method is efficient, the increased manufacturing costs are undesirable. Secondly, if maintenance is required, increased costs result due to the unloading device being located internally of the compressor cylinder. Another method of reducing capacity is to employ three-way valves externally of the compressor, in the discharge manifold. However, such valves are relatively expensive to manufacture and often require maintenance due to utilization springs which wear, due to their constant use in such applications.

Additionally, such valves generally create relatively large pressure drops therethrough and thus do not provide maximum capacity when the compressor is fully loaded.

The object of this invention is the provision of a three-way valve that is relatively inexpensive to manufacture, substantially maintenance free, and one that does not create the excessive undesirable pressure drops so as to preclude delivery of rated capacity when such is required.

SUMMARY OF THE INVENTION

This invention relates to fluid compressors, and in particular, to a method and apparatus for controlling the capacity of the compressor. More particularly, this invention relates to such a compressor employed in fluid compression systems including a refrigeration system.

The novel valve herein disclosed provides means to obtain the desired capacity control for such compressors. The valve includes a housing having an inlet in communication with the discharge side of the compressor. The valve includes first and second discharge lines extending therefrom, the first line being connected to the suction side of the compressor, and the second line being connected to the discharge manifold of the compressor. The valve functions to selectively communicate the discharge side of the compressor with either the suction side thereof or with the discharge manifold.

The housing of the valve defines a bore. Disposed in the bore is pressure-responsive means including a piston assembly and a poppet. Means associated with the valve selectively communicate the bore with either the suction side of the compressor when it is desired to operate the compressor at reduced capacity, or with the discharge side of the compressor when it is desired to operate the compressor at maximum capacity. When the bore is in communication with the suction side of the compressor, the piston and poppet move within the bore so as to communicate the inlet of the housing with the suction side of the compressor and to prevent communication between said inlet and the discharge manifold. The short circuiting of the refrigerant flow thus obtained effectively reduces the capacity of the compressor when maximum capacity is not needed, due to a decrease in the load on the system.

When maximum or rated capacity is desired, the bore of the valve is placed in communication with the discharge side of the compressor. The piston assembly and the poppet are thereby moved so as to communicate the inlet of the valve with the discharge manifold. When compressors of the type under discussion are employed in a refrigeration system, the discharge manifold is connected to the inlet of the condenser of such system.

Although the invention has been discussed as being employed with a reciprocating-type compressor, it should be understood that the invention can be also utilized with other types of fluid compressors, such as centrifugal types, employed in other applications besides refrigeration systems.

For example, in applications where a centrifugal compressor is employed to provide pressurized gas, it may be desirable to operate the machine even though no output therefrom is required, due to there being no load on the system. During such operation, the invention may be actuated so that gas discharged from the compressor is vented to the atmosphere or other relatively low-pressure area. Thus, it is apparent that the invention may readily be utilized with any type of compressor in any pressurized system where it is desirable to vary the output of the compressor, either totally, as with the centrifugal compressor, or partially, as with the reciprocating compressor.

The attached drawings illustrate a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically shows a refrigeration system illustrating the invention herein disclosed;

FIG. 2 is a cross-sectional view of the novel unloading valve utilized in the invention illustrating one operating position;

FIG. 3 is a cross-sectional view of the valve in its second operating position; and

FIG. 4 is a fragmentary sectional view taken along the line IV—IV of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings there is shown the present invention employed in a refrigeration system. As noted above, the invention may be employed with compressors utilized in other applications wherein the load on the system may vary. In referring to the drawings, like numerals shall refer to like parts.

Referring to FIG. 1 there is shown a refrigeration system including multicylinder compressor **10** comprising cylinders **11** and **12**. Cylinders **11** and **12** have extending therefrom discharge lines **13** and **14** respectively; discharge line **14** extends to discharge manifold **24** and line **13** communicates cylinder **11** with unloading valve **15**. Valve **15** has extending therefrom a first discharge conduit **16** and a second discharge conduit **23**. As will be apparent hereinafter, valve **15** functions to selectively communicate line **13** with either conduit **16** or conduit **23**.

Conduit **16** communicates valve **15** with discharge manifold **24**. Connected to the discharge manifold is condenser **17**. Line **18** connects the outlet of the condenser to the inlet of thermal expansion valve **19**, which functions as the refrigerant expansion device. It should be understood that other expansion devices, such as capillary tubes may be employed in lieu of expansion valve **19**. The outlet of expansion valve **19** is connected to the inlet of evaporator coil **20** via conduit **18'**.

The outlet from evaporator coil **20** is connected to suction manifold **22** via conduit **21**. Additionally, conduit **23** communicates valve **15** with suction manifold **22**. Suction lines **21'** and **22'** extend from the suction manifold to cylinders **11** and **12**, respectively.

In operation, gaseous refrigerant is discharged from compressor cylinders **11** and **12** via lines **13** and **14**. The high-pressure refrigerant gas flowing through line **14** passes to the condenser **17** via discharge manifold **24**.

The gaseous refrigerant flowing through line **13** is either passed to suction manifold **22** or to discharge manifold **24**, depending upon the operation of valve **15**, as will be apparent hereinafter. If rated or maximum capacity is desired, valve **15** will function to pass the refrigerant gas to discharge manifold **24** and thence to condenser **17**. However, if less than maximum capacity is desired, valve **15** will operate to communicate line **13** with discharge conduit **23** and thence to suction manifold **22**.

The gaseous refrigerant flowing through condenser **17** is passed in heat transfer relation with a relatively cold medium by means not shown whereby the cold medium extracts heat from the gaseous refrigerant to condense same.

The liquid refrigerant thus formed in condenser **17** flows via line **18** to expansion valve **19** and thence to evaporator **20**. The refrigerant flowing through evaporator coil **20** passes in heat transfer relation with the medium to be cooled, such as room air, passed thereover by means not shown, whereby the refrigerant extracts heat from the medium to be cooled and is vaporized thereby.

The vaporous refrigerant formed in evaporator coil **20** flows to suction manifold **22** via conduit **21** and thence to the suction side of cylinders **11** and **12** of compressor **10**.

In referring now to FIGS. **2** and **3**, there is shown a cross-sectional view of the novel valve **15** shown in a loaded position and an unloaded position, respectively. The novel valve **15** includes a housing **25**, which defines a cylindrical bore **29**. Disposed in bore **29** is piston assembly **30**, the piston assembly being operable to reciprocally move in the bore. The piston assembly includes stem section **31**, which threadably engages the upper portion of the piston assembly at **31'**.

Additionally disposed in bore **29** is poppet **32**, which also moves in a reciprocal manner in the bore. C-ring **28** limits the upward movement of the poppet in the bore. Piston assembly **30** includes seal rings **26** and **27**, such as O-rings or piston rings, mounted thereon for sealing purposes.

As noted hereinbefore, discharge line **13** communicates the inlet of the valve with the discharge side of cylinder **11**. The gaseous refrigerant thus introduced into bore **29** will be directed by the operation of piston assembly **30** and poppet **32**, as will be apparent hereinafter, to either discharge conduit **16** or discharge conduit **23**.

A relatively small bleed line **35** extends from discharge conduit **16** to orifice **39** provided in cap **36**. Threadably engaging the lower portion of cap **36** is end piece **37**, which functions to close off the upper portion of bore **29**. Orifice **38** in end piece **37** is selectively communicated with orifice **39** in cap **36** and with orifice **40** in cap **36**. Orifice **40** is in communication with discharge conduit **23** via bleed line **34**.

Acting to control the communication of orifice **38** with orifices **39** and **40** is solenoid-actuated valve **33**. As shown in FIG. **2**, when full capacity is desired, valve **33** will operate to communicate orifice **39** with orifice **38**.

As shown in FIG. **3** wherein valve **15** is shown in its unloaded position, solenoid **33** functions to communicate orifice **38** with orifice **40**. FIG. **2** illustrates solenoid valve **33** in its deenergized position, whereas FIG. **3** illustrates solenoid valve **33** in its energized position. A source of power represented by lines L_1 and L_2 controls the energization of solenoid valve **33**. A switch, not shown, controls the supply of power to solenoid valve **33**. It should be understood that other means may be employed to selectively communicate the orifices in lieu of solenoid valve **33**.

Referring now to FIG. **3** wherein the novel valve is shown in its unloaded position, the manner in which the valve operates will hereinafter be described. As noted hereinabove, in the position illustrated by FIG. **3**, orifice **38** is in communication with orifice **40**. The piston assembly **30** is at the highest position within bore **29**. Poppet **32** is seated on seat **41**, thereby preventing flow from line **13** to conduit **16** and communicating line **13** with conduit **23**. Conduit **23**, as noted before, communicates with suction manifold **22** and is, therefore, at suction pressure. Similarly, line **13** is at suction pressure when in communication with conduit **23**. Cylinder **11** is thereby prevented from reaching discharge pressure and the compressor is operated at reduced capacity as desired. The cost of operating the compressor at reduced capacity is substantially decreased since less power is required by the machine.

When it is desired to deliver rated capacity due to an increase in the load on the refrigeration system, solenoid valve **33** is deenergized so that communication between orifices **38** and **40** is prevented and orifice **38** is placed in communication with orifice **39**.

Refrigerant gas at discharge pressure flows from conduit **16** having communication with manifold **24**, through line **35** to orifice **39** and thence to orifice **38** in communication therewith. The lower surface of the stem **31** of piston assembly **30** has suction pressure acting thereon. The refrigerant gas at discharge pressure acting on the top surface of piston assembly **30** thus causes the piston assembly to move downwardly in bore **29** so as to prevent communication between line **13** and conduit **23**, the poppet **32** and the stem **31** having a sliding fit enabling such action to obtain.

The refrigerant gas flowing from line **13** through valve **15** fills the space defined by the upper surface of the stem portion and the lower surface of the poppet. The pressure therein increases rapidly and very quickly reaches a magnitude to supply a force to move the poppet in an upward direction in bore **29**. The upward movement of poppet **32** is limited by C-ring **28**. When poppet **32** has reached its upper limit of movement, line **13** and discharge conduit **16** are in communication, thus placing line **13** at discharge pressure, the parts assuming the position indicated in FIG. **2**. Cylinder **11** thereby operates in its loaded position and discharges refrigerant gas therefrom at rated discharge pressure.

Assume now that the compressor is operating at rated capacity with the piston assembly and poppet positioned as shown in FIG. **2**. If the load on the system decreases, it becomes desirable to reduce the capacity of the compressor to reduce the operating cost thereof and to prevent compressor flooding. To obtain the desired reduced capacity, solenoid valve **33** is energized so as to communicate orifice **38** with orifice **40**. Communication of these orifices causes the refrigerant gas acting on the top surface of piston **30** to flow from orifice **38** through orifice **40** and bleed line **34** to conduit **23**, which is at suction pressure as noted hereinbefore. The refrigerant gas trapped between piston **30** and poppet **32**, which is substantially at discharge pressure, causes the piston assembly to begin moving in an upward direction in the bore as the pressure on the upper surface thereof is reduced. It should be noted that refrigerant gas at discharge pressure is able to pass into the space between the lower surface of the piston assembly and the upper surface of the poppet when the valve is in its loaded position as shown in FIG. **2** by leakage around the poppet and through the space of the C-ring, as clearly shown in FIG. **4** This space is thus maintained at substantially discharge pressure as is desired. The upward movement of piston assembly **30** in bore **29** starts to communicate line **13** with conduit **23** thereby diverting a portion of the flow of refrigerant gas through conduit **23** to the suction manifold and, additionally, reducing the pressure acting on the lower surface of poppet **32**.

The reduced pressure lessens the force acting on the lower surface of poppet **32**, and thereby creates a force acting on the poppet, which causes the poppet to move downwardly in the bore and to thus sit on seat **41**. Poppet **32**, when seated, prevents any flow of refrigerant gas from line **13** to conduit **16** and diverts all of the flow of refrigerant gas to conduit **23**. Additionally, discharge pressure is maintained in bore **29**, via the small passageway **42** shown in FIG. **3**, provided between the top portion of the poppet and the housing. The passageway permits leakage of refrigerant gas from discharge conduit **16** back into the bore. The discharge pressure acts on the lower portion of the piston assembly and causes the piston assembly to move upward in bore **29** to its maximum position as shown in FIG. 3.

It is, therefore, readily apparent that the novel valve herein disclosed readily permits rapid and efficient reduction in compressor capacity when desired, and in addition, obviates the repair and manufacturing cost problems of the prior art. Additionally, the relatively large diameter conduits extending from valve **15** and the absence of restrictions in the bore thereof, reduce the pressure drops therethrough as is desired to obtain rated capacity when required.

While I have described and illustrated a preferred embodiment of my invention, it will be understood that the invention is not limited thereto but may be otherwise embodied within the scope of the following claims.

I claim:

1. An unloading valve for controlling the capacity of a fluid compressor comprising:

A. a housing;

B. inlet means to said housing;

C. first discharge means from said housing;

D. second discharge means from said housing;

E. pressure-responsive means disposed in said housing having a first operating position when the fluid compressor is functioning at rated capacity and having a second operating position when said fluid compressor is functioning at reduced capacity, said pressure-responsive means communicating said inlet means and said first discharge means when in its first operating position, and communicating said inlet means with said second discharge means when in its second operating position, said pressure-responsive means including:

  1. piston means reciprocally disposed in said valve housing; and

  2. poppet means reciprocally disposed in said valve housing, the movement thereof being in an opposite direction to the movement of said piston; and

F. means operable to vary the pressure acting on said pressure-responsive means, said pressure being of a first magnitude when it is desired to have said pressure-responsive means in its first operating position, and being of a second magnitude when it is desired to have said pressure-responsive means in its second operating position.

2. The unloading valve in accordance with claim **1** wherein said piston assembly includes a piston portion and a stem portion and wherein said poppet means is mounted about said stem portion to move relative thereto.

3. A method of operating an unloading valve for controlling the capacity of a compression mechanism comprising the steps of:

A. selectively communicating the bore of said unloading valve with the discharge side of said compression mechanism when it is desired to operate at rated capacity, and with the suction side of said compression mechanism when it is desired to operate below rated capacity;

B. moving a piston reciprocally disposed in the bore of said valve in an upward direction in said bore when said bore is in communication with the suction side of said compression mechanism and moving said piston in a downward direction in said bore when said bore is in communication with the discharge side of said compression mechanism; and

C. moving a poppet disposed in said bore in an opposite direction to the movement of said piston, said poppet and piston acting in conjunction with each other to communicate the inlet of said valve with the inlet of said compression mechanism when said bore is in communication with the suction side of said compression mechanism, and communicating the inlet of said valve to the discharge side of said compression mechanism when said bore is in communication with the discharge side of said compression mechanism.

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