

June 26, 1962

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CONTROL MEANS FOR REGULATING THE CAPACITY  
OF RECIPROCATING COMPRESSORS

3,040,969

Filed Sept. 1, 1959

2 Sheets-Sheet 1

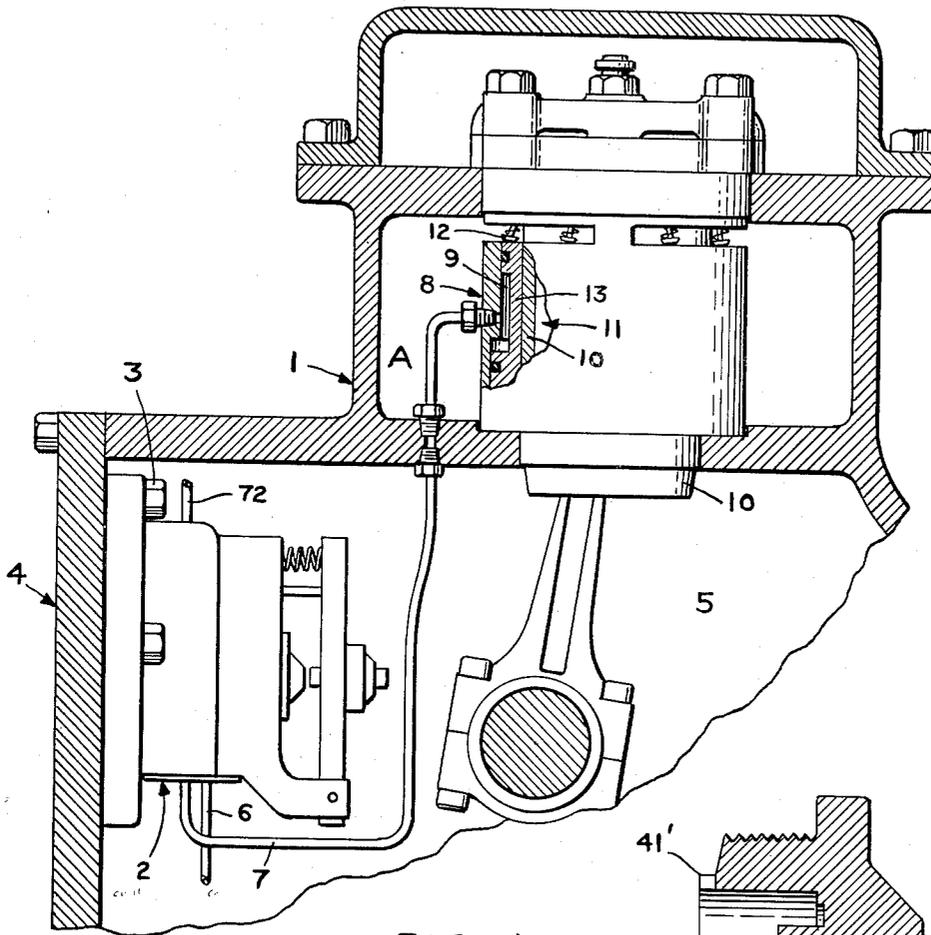


FIG. 1

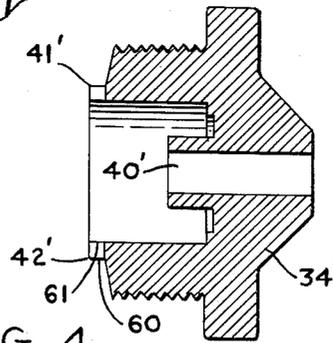


FIG. 4

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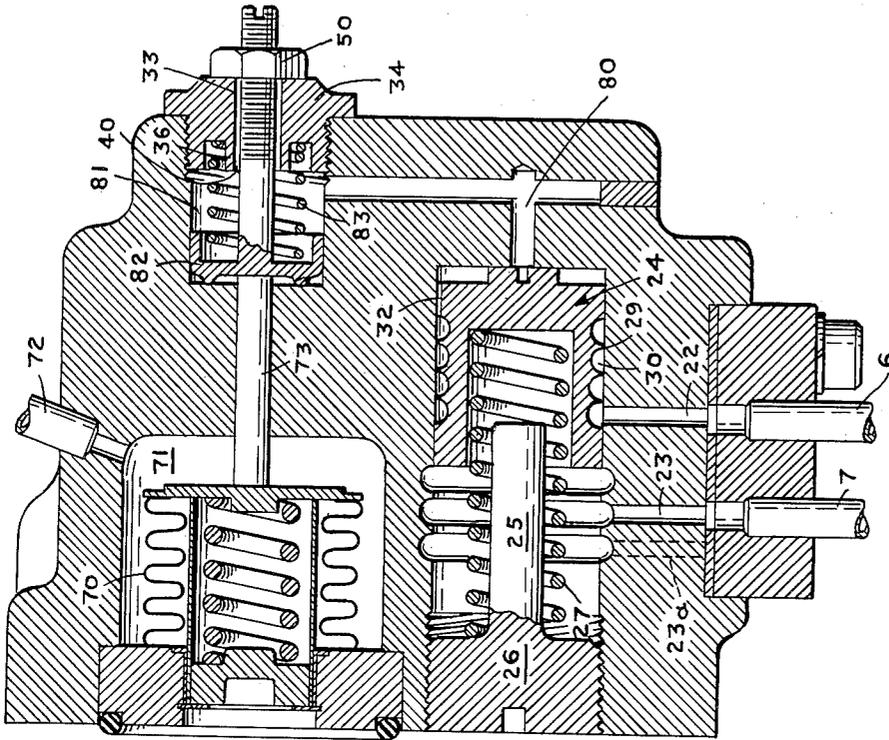


FIG. 3

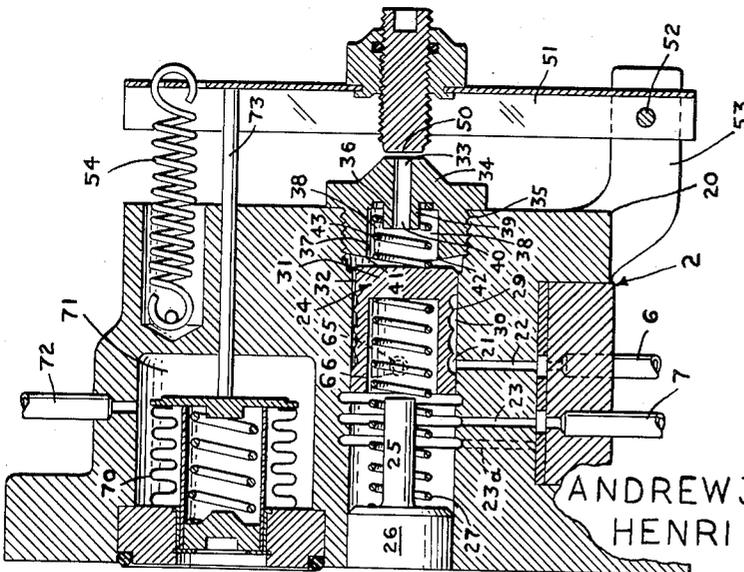


FIG. 2

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## CONTROL MEANS FOR REGULATING THE CAPACITY OF RECIPROCATING COMPRESSORS

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Filed Sept. 1, 1959, Ser. No. 837,536  
7 Claims. (Cl. 230-31)

This invention relates to reciprocating compressors and more particularly to a control for regulating the operation of the unloading means.

To adjust the capacity of a reciprocating compressor according to load conditions it has previously been proposed in United States Letters Patent 2,626,099 to provide a control, responsive to a change in suction pressure, which actuates the unloaders of the compressor in sequence to load or unload the compressor.

This construction has the disadvantage that provisions are not incorporated in the control means to preclude the actuation of the unloading means on small variations in load conditions. Accordingly, because an operating compressor tends to balance its output against the load rapid cycling results in machines embodying the above type control.

To provide a control means of the type contemplated herein and one including means which substantially reduce the cycling tendency caused by the above control, it has been proposed in United States Patent 2,836,345 to provide a control including means which preclude any attempt to unload when fluid pressure to the unloader is insufficient to positively effect operation of the unloader.

While it appears that the proposed control shown in Patent 2,836,345 solves the cycling problem it has the disadvantage that the provisions included in the control for accomplishing this purpose take the form of a series of minute passageways associated with an intricate shut-off device which provisions undoubtedly add appreciably to the manufacturing cost of the control. Furthermore, because these controls are usually associated with the lubrication system of the compressor provision of small passageways increases the tendency of rendering the control inoperative as dirt or other matter in the oil tends to block the passage of oil in the small passageways.

Accordingly, it is an object of the present invention to provide a control of the above described type which substantially reduces the cycling tendency of prior type devices and yet accomplish this function with a control that is simple and inexpensively made and yet positive in operation.

It is another object of this invention to provide a control wherein any desired degree of sensitivity is provided by simply changing an element of the control which is easily accessible and readily removed and replaced.

Further objects and advantages of the invention will become evident from the following description with reference to the accompanying drawings in which:

FIGURE 1 is a part section showing a reciprocating compressor including the control contemplated by the present invention.

FIGURE 2 is a longitudinal section through the control shown in FIGURE 1.

FIGURE 3 is a longitudinal section through a modified control which operates in accordance with the concepts outlined herein.

FIGURE 4 is a section of a modified housing incorporating the first and second metering means.

In the construction of compressor 1 embodying the improved control means according to the present invention as shown in FIGURE 1 of the drawings the control means designated 2 is shown connected by bolt means 3

to the portion of the casing 4 of the compressor which forms the crankcase 5. The control means 2 is connected at one end through conduit means 6 to a fluid source which may be the lubrication system of the compressor (not shown) and usually housed in the crankcase portion 5. At the other end control means 2 is connected through conduit means 7 to the unloader element 8 associated with the valve means of the compressor as is well known in the art. The unloader element contemplated herein is of the type shown in United States application Serial Number 741,254, filed June 11, 1958 wherein a fluid chamber 9 is fashioned about a cylinder liner 10 housing the usual piston 11 driven by a crankshaft which is turned by a standard type prime mover (not shown).

While FIGURE 1 illustrates only one cylinder, it will be understood by those familiar with this art that the present arrangement is more advantageously used in a multi-cylinder reciprocating compressor arrangement. Furthermore, the specific cylinder arrangement and valve means associated with the compressor have not been treated in detail because they comprise elements of a conventional compressor which form no essential part of the invention but which, it will be understood, are present to form an operable machine.

As is described in detail in the above mentioned patent application, each of the cylinders of the compressor includes an unloader element 8 which permits operation of the compressor at substantially constant speed but at increments of its full capacity. When a source of fluid pressure is applied to the chamber 9 from the control means 2 the movable element 13 of the unloader functions to move the pins 12 out of engagement with the suction valve so that this valve assumes its normal position during compressor operation.

As was mentioned hereinabove, control means 2 is associated at one end with the unloader element 8 and can be arranged to actuate the unloader to load or unload the cylinder in accordance with changes in load on the compressor. Changes in load may be sensed, as is shown here by joining the sensing means of the control to the suction side of the compressor.

Referring to FIGURE 2, the illustrated control means includes a casing generally designated 20 shown in FIGURE 1 as mounted to a wall of the crankcase portion of the compressor. A fluid source (not shown) which is preferably the lubrication system of the compressor supplies fluid to a first chamber 21 formed in the control 2 through conduit means 6 which is connected to an opening 22 in the casing 20 which in turn communicates with the first chamber 21. Another opening 23 communicates the first chamber with the unloader through conduit means 7. Further openings such as 23a, as shown in FIGURE 2, may be provided in the casing depending on the number of unloaders it is desired to regulate through control means 20. Regulating device taking the form of a spool-type piston 24 is disposed in the chamber 21 and moved in the first chamber to control the flow of fluid to the respective unloaders as will be described in detail hereinafter. Stop pin 25 and plug 26 are mounted in one end of chamber 21 and act to limit the movement of the piston under the influence of fluid pressure in chamber 21.

Normally, spring 27 mounted in chamber 21 to abut plug 26 and piston 24, urges the piston 24 upwardly in the chamber 21 and in this position fluid passed to chamber 21 is prevented from passing to the unloader element 8 to move same to load or unload the piston with which it is associated.

It is evident that some means of disposing of the fluid passed to chamber 21 must be provided for. In addition, this disposition of fluid must be accomplished in such fashion so as not to adversely affect the efficiency as by

causing the machine to cycle as pointed out above.

Provisions taking the form of metering means are incorporated in the outlet end of chamber 21 to accomplish the metering of fluid from the chamber to a sump such as the crankcase 5 of the compressor.

Fluid passed to the chamber 21 flows over a series of lands 29 and grooves 30 formed on piston 24 and out the head portion 31 thereof through an orifice 32 referred to as the second metering means. The fluid escaping to the upper side of the piston is further metered by a port means designated 33 formed in the upper portion of a nozzle 34 threadably secured in the upper portion of the chamber 21 as at 35. Flow through the port 33 forming the first outlet, which is of predetermined size depending on the sensitivity desired, is regulated by a closure 50 as will be described in detail hereinafter.

To further control the rate of fluid flow out of chamber 21 to the sump a first metering means generally designated 36 is fashioned in the chamber 38 formed by the wall 37 of the nozzle 34. This metering means comprises a tube-like element 39 which extends into chamber 38 and includes a port 40 which communicates with the port 33 of the nozzle 34. For the sake of clarity the port 33 and first metering means 36 are described individually and as though they were separate structures but in actual construction the port and first metering means are formed as integral portions of the nozzle.

At times and during operation of the control it has been noted that piston 24 tends to ride during a surge of fluid pressure into abutment with the edges 41 and 42 of the wall 37 of the nozzle thusly obstructing flow from orifice 32 to metering means 36. Such obstruction interferes with the proper operation of the control. To eliminate this objection spring means 43 disposed to abut the nozzle 34 and head 31 of the piston at its ends snaps the piston out of abutment with the nozzle when the above condition occurs.

FIGURE 4 teaches a nozzle 34' constructed in accordance with the principles described above but including an extension 60 including an opening 61 for permitting flow to the port 40' even though piston 24 may be urged in abutment with edges 41' and 42'. It is evident that this construction solves the problem of obstructed flow to port 40' when piston 24 abuts edges 41' and 42' and permits elimination of spring 43 in the assembly of the control.

To further provide a construction that substantially lessens cycling or hunting of the compressor and the over-travel tendency of the piston 24 a detent ball 65 urged into abutment with grooves 30 of piston 24 by spring 66 is included in the preferred embodiment to thereby accomplish definite steps of movement and positive piston action.

As was mentioned hereinabove, flow through the port means 33, that is, flow into the crankcase, is controlled by the closure means taking the form of a nut 50 mounted on lever 51 which is pivoted at 52 to the extension 53 on the casing and limited in movement relative the nozzle by spring 54 which is connected at the other end of the lever 51.

Actuation of the closure 50 to control flow through port 33 is accomplished by sensing load conditions of the compressor. This is, of course, most easily done by connecting an actuating means, taking the form of a bellows 70, to the suction side of the compressor. More specifically, bellows member 70 is mounted in a chamber 71 formed in casing 2 which communicates with the suction manifold A of the compressor 1 through conduit means 72. When conditions in the suction side of the compressor vary the bellows member 70 senses such variation and actuates the closure 50 through rod member 73 connected to the bellows and lever to adjust fluid flow through port 33.

It is evident from the above that the amount of fluid pressure acting on piston 24 will depend on the position of adjusting closure 50 and signals from the bellows sensing changes in load conditions moves the lever 51 through

rod 73 closer or further from port 33 to move piston 24 in chamber 21 to provide communication between the fluid source and the unloader elements in any desired sequence. One or more of the unloaders may be connected to the fluid source depending on the load imposed on the compressor.

Initially, the piston will be in position shown in FIGURE 2 as fluid pressure acting on the head of the piston is nil, since the compressor is stationary. Thus the compressor starts off in the unloaded position which casts the least burden on the prime mover and reduces starting load.

However, after the initial start-up period the pressure of the operating or pressure fluid will build up and this operating fluid under pressure is delivered to conduit 6, passage 22, chamber 21, through orifice 32 to the head of piston 24. Since the bellows will signal the requirements of the system to which it is connected, the lever 51 will initially move the closure means 50 close to the port of the port means 33 thereby limiting the flow of operating fluid from the chamber 21 to therefor cause a build-up of pressure on the head 31 of piston 24 so that the spool-type piston is indexed to bring the fluid flowing from the fluid source to chamber 21 into communication with the opening 23 and conduit 7 communicating the unloader element with the chamber 21 as has been above described. When the spool-type piston is fully depressed in the chamber 21 all of the unloader elements associated with their respective cylinders are in communication with the chamber and thus in direct communication with the fluid source.

The lever arm is held in a predetermined position by the spring 54 and rod 73 until the bellows element 70 signals the unloading of one or more of the compressors by expanding. This moves the rod 73 and hence the lever arm 51 so that the adjustable closure 50 is spaced from the outlet end of the port 33 in the nozzle, thus reducing the pressure acting on the piston head 31. Spring 27 will index the position of the spool-type piston 24 and the relative position of the grooves 30 with respect to the openings connecting the chamber to the unloader from position to position, which action loads or unloads the respective cylinders in accordance with the desired operating conditions.

The operating fluid delivered, for example, from the lubrication system of the compressor through conduit means 6 opening to the first chamber 21 will flow to the pressure fluid chamber 9 of the unloader element and will act to unload the particular cylinder about which it is disposed by moving the inner element 13 downwardly and thus reduction of force against the head will allow the springs to expand the pins in a downward direction thereby allowing the annular strip valve to operate relative the ports and the suction air delivered therethrough on movement of the piston in the cylinder.

FIGURE 3 shows a modified form of control means for association with the unloader elements of the reciprocating compressor described hereinabove.

Those parts having generally the same construction and purpose as the corresponding parts in FIGURE 2 have been given the same reference characters.

Instead of associating the port and first metering means directly with the first chamber 21, the port and first metering means are shown as being disposed in association with the rod element of the sensing bellows which includes a nut thereon which is spaced from the port 33 in accordance with the load characteristics imposed on the compressor. More specifically, a passageway 80 communicates pressure fluid which flows past orifice 32 in piston 24 with nozzle-like element 34 positioned in a chamber 81 formed above chamber 71 which accommodates bellows means 70 in similar fashion as was described above for the control showing FIGURE 2. A port 33 in the nozzle functions in conjunction with closure nut 50 as a metering means and the port also accommodates the rod 73 connected to the bellows at one end and the closure nut 50 at the other end. A

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spider-like element 82 mounted on the rod 73 receives spring 83 which abuts nozzle 34 at the other end to index the movement of nut 50 relative port 33 in accordance with load conditions sensed by bellows member 70.

A first metering means fashioned in accordance with the principles and construction of that described above for the control of FIGURE 2 is provided for in the inner portion of nozzle 34. The first metering means takes the form of a downwardly extending tube 36 including a port 40 opening into port 33 of the nozzle means.

Operation of the above control resembles the operation of the control in FIGURE 2 except that a more direct adjustment of closure 33 is accomplished by providing same on the rod 73 of the bellows 70 which preferably senses load changes on the compressor by sensing changes in suction pressure.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. A controller for use with a reciprocating compressor including unloading elements each having fluid actuated means, a source of pressure fluid connected to said fluid actuated means through said controller so that said controller selectively controls the flow of fluid from said fluid source to the respective fluid actuated means as desired, said controller comprising a casing having a first chamber connected to the fluid source to receive fluid therefrom, conduit means interconnecting the first chamber to each of the fluid actuated means, a nozzle disposed in one end of said first chamber and having a port of a predetermined size on the outer portion thereof permitting return of fluid passed to the first chamber to said source of pressure fluid, said nozzle including a chamber in the interior portion thereof, tube means having a portion thereof projecting from said nozzle into said chamber, said tube means including a port on the portion thereof projecting into the chamber formed on the interior portion of the nozzle and said port connected to said port contained in the nozzle, said tube means and port included therein coacting to form a first metering element to regulate fluid flow to the port in said nozzle, a regulating means slidably disposed in the first chamber formed in the casing of said controller and adjacent the chamber in said nozzle to control flow of fluid from said first chamber to the respective fluid actuated means, a second metering means for said controller and formed in the regulating means and connecting the first chamber to the first metering means, means disposed between the regulating means and the interior of said nozzle means for normally maintaining said regulating means out of engagement with the interior portion of the nozzle means, a closure connected to the controller and disposed in spaced relation with said port on the nozzle, actuating means in the controller and connected to the closure means, and said actuating means being responsive to load changes on the compressor to adjust the location of said closure means relative to said port to regulate the location of said regulating means in said first chamber and the passage of fluid to the respective fluid actuating means in accordance with load conditions imposed on the compressor.

2. The controller claimed in claim 1 wherein the fluid source comprises the lubrication system of the compressor and the port in the nozzle being arranged to return fluid to the crankcase of the compressor.

3. A controller for use with a reciprocating compressor including unloading elements each having fluid actuated means, a source of pressure fluid connected to said fluid actuated means through said controller so that said controller selectively controls the flow of fluid from said fluid source to the respective fluid actuated means as desired, said controller comprising a casing having a first chamber connected to the fluid source, conduit means

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interconnecting the first chamber to each of the fluid actuated means, a nozzle disposed in one end of said first chamber and having a port on the outer portion thereof, said nozzle including a chamber in the interior portion thereof, tube means formed as a unitary portion of said nozzle and projecting into the chamber formed in the interior portion of said nozzle, said tube means including a port on the portion thereof projecting into the chamber in the interior portion of the nozzle and said port being connected to said port contained in the nozzle, said tube means and port included therein coacting to form a first metering element to regulate fluid flow to the port in said nozzle, a regulating means comprising a spool-type piston disposed in the first chamber formed in the casing of the controller and adjacent the chamber in said nozzle to control flow of fluid from said first chamber to the respective fluid actuated means, an orifice in said spool-type piston forming a second metering means for said controller and connecting the first chamber to the first metering means, means disposed between the regulating means and the interior of said nozzle means for normally maintaining said regulating means out of engagement with the interior portion of the nozzle means, a closure pivotably mounted on the controller and disposed in spaced relation with said port on the nozzle, actuating means in the controller and connected to the closure means, and said actuating means being responsive to load changes on the compressor to adjust the location of said closure means relative to said port to regulate the location of said spool-type piston in said first chamber and the passage of fluid to the respective fluid actuating means in accordance with load conditions on the compressor.

4. The controller claimed in claim 3 wherein the fluid source comprises the lubrication system of the compressor and the port in the nozzle being arranged to return fluid to the crankcase of the compressor.

5. A controller for use with a reciprocating compressor including unloading elements each having fluid actuated means, a source of pressure fluid connected to said fluid actuated means through said controller so that said controller selectively controls the flow of fluid from said fluid source to the respective fluid actuated means as desired, said controller comprising a casing having a first chamber connected to the fluid source, conduit means interconnecting the first chamber to each of the fluid actuated means, a nozzle disposed in one end of said first chamber and having a port on the outer portion thereof, said nozzle including a chamber in the interior portion thereof, tube means formed as a unitary portion of said nozzle and projecting into the chamber formed in the interior portion of said nozzle, said tube means including a port on the portion thereof projecting into the chamber in the interior portion of the nozzle and said port being connected to said port contained in the nozzle, said tube means and port included therein coacting to form a first metering element to regulate fluid flow to the port in said nozzle, a regulating means comprising a spool-type piston disposed in the first chamber formed in the casing of the controller and adjacent the chamber in said nozzle to control flow of fluid from said first chamber to the respective fluid actuated means, an orifice in said spool-type piston forming a second metering means for said controller and connecting the first chamber to the first metering means, spring means disposed between the piston and the interior of said nozzle means for normally maintaining said piston out of engagement with the interior portion of the nozzle means to provide for continuous communication between said first chamber and said first metering means through said orifice, spring means in the end of the first chamber remote from said nozzle and in abutment with the piston to oppose movement of the piston by the fluid from the fluid source, a closure adjustably spaced from said nozzle and comprising a nut mounted on a lever pivoted at one end to the casing and normally held in abutment with the port of said nozzle

by a spring interconnecting the lever at the other end to the casing, actuating means in the controller and connected to the lever, and said actuating means being responsive to load changes on the compressor to adjust the location of said closure relative to said port to regulate the location of said spool-type piston in said first chamber and the passage of fluid to the respective fluid actuating means in accordance with load conditions on the compressor.

6. The controller claimed in claim 5 wherein the fluid source comprises the lubrication system of the compressor and the port in the puzzle being arranged to return fluid to the crankcase of the compressor.

7. A controller for use with a reciprocating compressor including unloading elements each having fluid actuated means, a source of pressure fluid connected to said fluid actuated means through said controller so that said controller selectively controls the flow of fluid from said fluid source to the respective fluid actuated means as desired, said controller comprising a casing having a first chamber connected to the fluid source, conduit means interconnecting the first chamber to each of the fluid actuated means, a nozzle disposed in one end of said first chamber and having a port on the outer portion thereof, said nozzle including a chamber in the interior portion thereof, tube means formed as a unitary portion of said nozzle and projecting into the chamber formed in the interior portion of said nozzle, said tube means including a port on the portion thereof projecting into the chamber in the interior portion of the nozzle and said port being connected to said port contained in the nozzle, said tube means and port included therein coacting to form a first metering element to regulate fluid flow to the port in said nozzle, a regulating means comprising a spool-type piston disposed in the first chamber formed in the casing of the controller and

adjacent the chamber in said nozzle to control flow of fluid from said first chamber to the respective fluid actuated means, an orifice in said spool-type piston forming a second metering means for said controller and connecting the first chamber to the first metering means, first spring means disposed between the piston and the interior of said nozzle means for normally maintaining said piston out of engagement with the interior portion of the nozzle means to provide for continuous communication between said first chamber and said first metering means through said orifice, spring means in the end of the first chamber remote from said nozzle and in abutment with the piston to oppose movement of the piston by the fluid from the fluid source, a closure adjustably spaced from said nozzle and comprising a nut mounted on a lever pivoted at one end to the casing and normally held in abutment with the port of said nozzle by a spring interconnecting the lever at the other end to the casing, and a second chamber formed in the casing and connected to the low side of said compressor to receive pressure variations therefrom, a bellows mounted in said second chamber and being actuated by variations of pressure in said second chamber and linkage means interconnecting said bellows means and the lever of said closure whereby said closure is adjusted relative to said port on the nozzle means according to variations in pressure on the low side of the compressor.

#### References Cited in the file of this patent

#### UNITED STATES PATENTS

2,399,938	Pett	May 7, 1946
2,665,707	Stover	Jan. 12, 1954
2,673,025	Labus	Mar. 23, 1954
2,736,337	Parks	Feb. 28, 1956