April 6, 1926. 1,579,782

M. RIESNER

REGULATOR FOR VARIABLE CAPACITY COMPRESSORS

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Fig. 1.

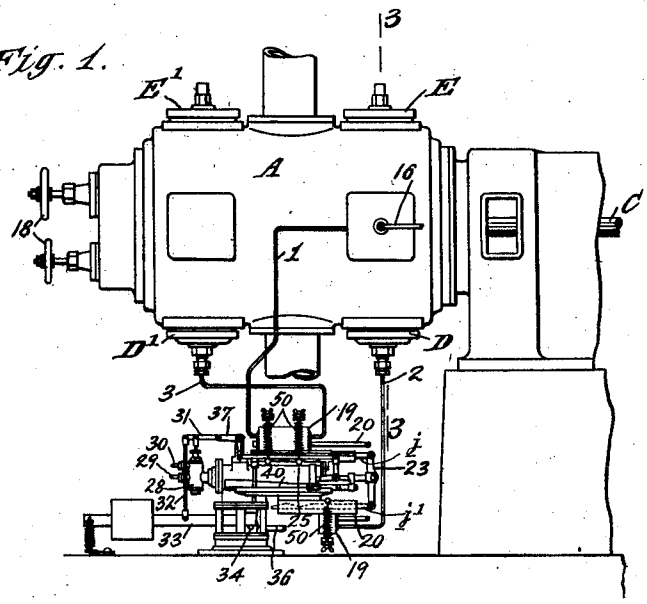
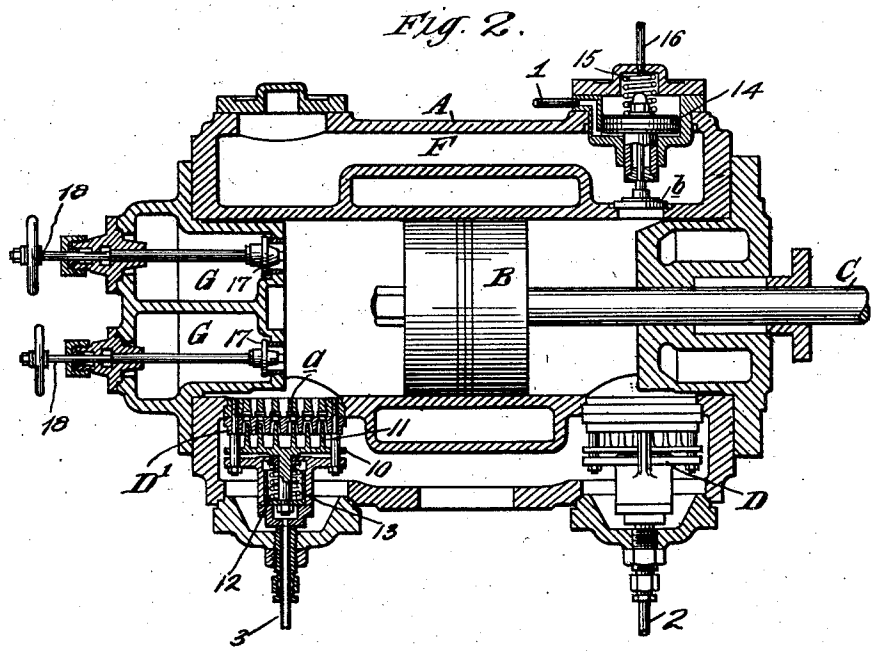


Fig. 2.



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Fig. 3.

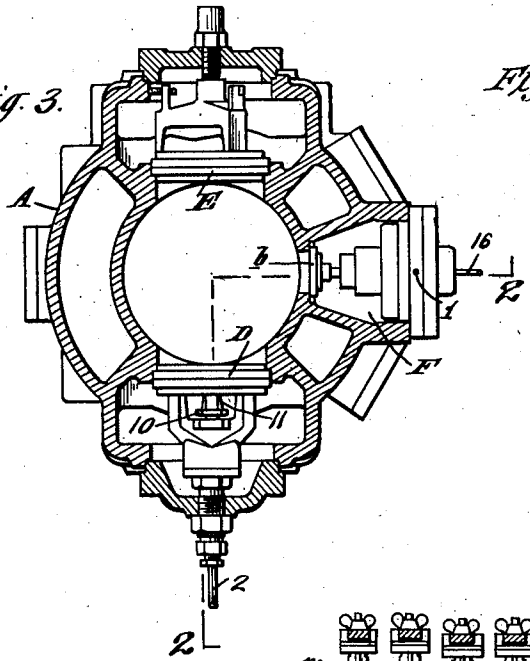


Fig. 6.

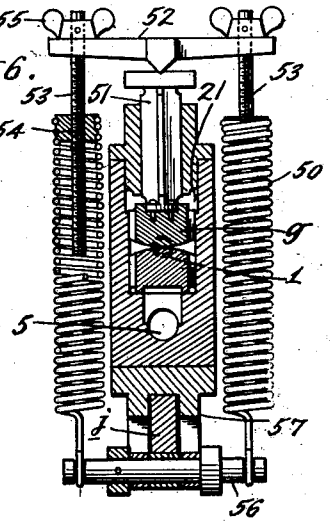


Fig. 8.

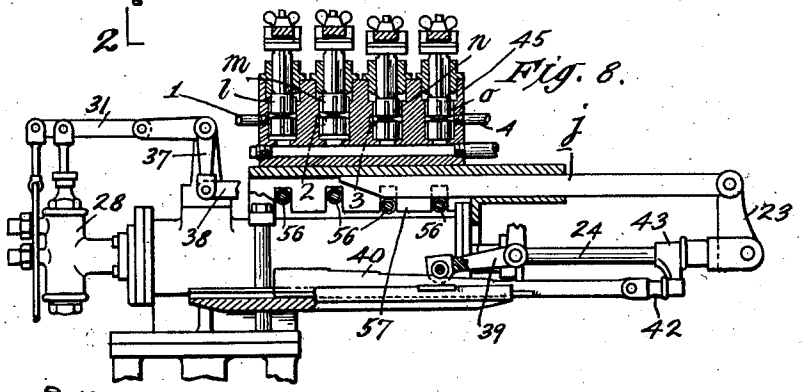
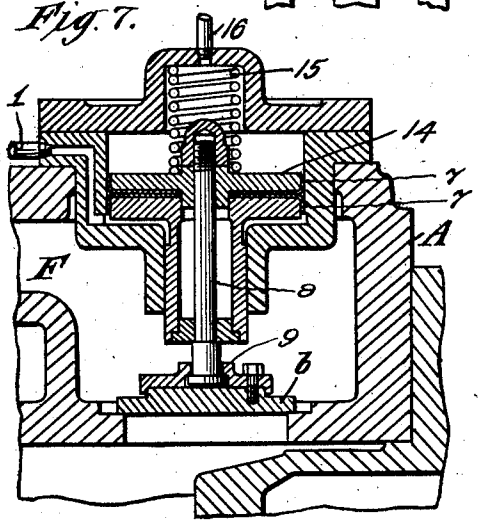


Fig. 7.



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Fig. 4.

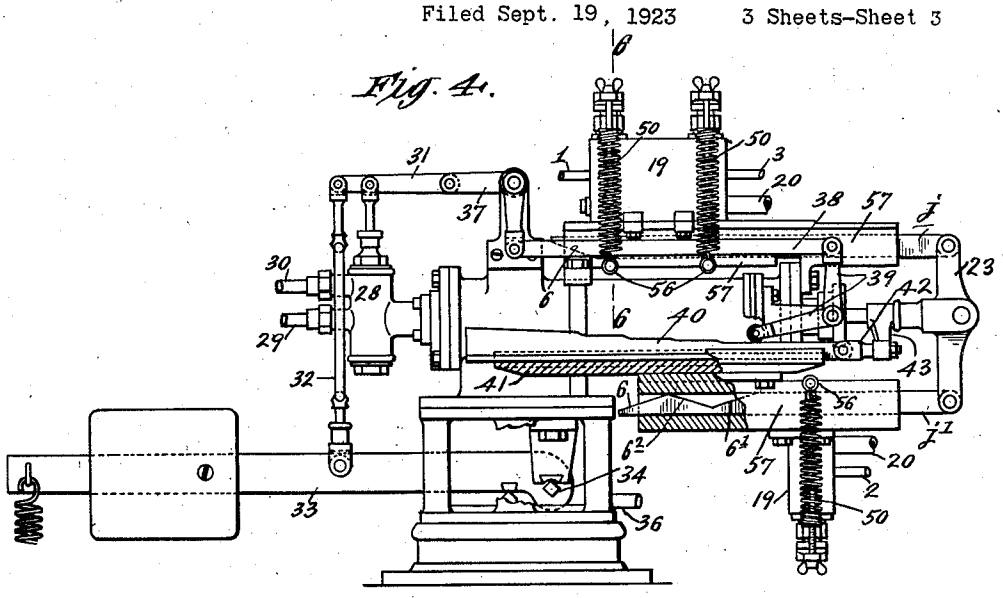
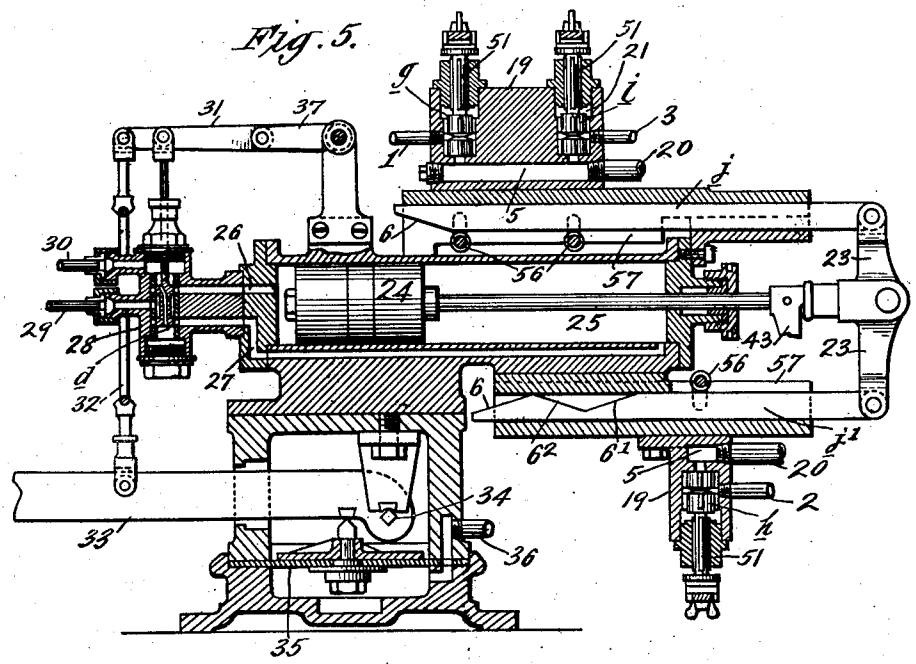


Fig. 5.



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Patented Apr. 6, 1926. 1,579,782

UNITED STATES PATENT OFFICE.

MICHAEL RIESNER, OF CINCINNATI, OHIO, ASSIGNOR TO WORTHINGTON PUMP AND MACHINERY CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF VIRGINIA.

REGULATOR FOR VARIABLE-CAPACITY COMPRESSORS.

Application filed September 19, 1923. Serial No. 663,540.

To all whom it may concern:

Be it known that I, MICHAEL RIESNER, a citizen of the United States, residing at Cincinnati, county of Hamilton, and State of Ohio, have invented certain new and useful Improvements in Regulators for Variable-Capacity Compressors, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

This invention relates to a novel regulator for variable capacity fluid compressors, the especial object of the invention being to provide an apparatus of this type which shall be more certain in action, especially under small changes of receiver pressure, and further to provide an apparatus operating with less friction and securing a higher compressor efficiency than those heretofore employed.

In constructions embodying the present invention, I employ a series of control valves, each acting to control a partial unloading of the cylinder, so as to vary the cylinder capacity in accordance with the number of control valves operated, and the required operation of these control valves is secured by a governor acting to vary the relative pressures tending to move these valves in opposite directions, for unloading or loading the cylinder. The control valves preferably are moved into unloading position by receiver pressure and into loading position by spring pressure acting against the receiver pressure, and a governor controls the valves by decreasing or increasing the spring pressure to the extent necessary to permit their movement by the receiver pressure for unloading, or to move them against the receiver pressure for loading the cylinder. The invention also includes certain features of construction and combinations of parts in a variable capacity fluid compressor apparatus, as described hereafter.

For a full understanding of the invention, a detailed description of constructions embodying the same in preferred forms will now be given in connection with the accompanying drawings forming a part of this specification, and the features forming the invention then specifically pointed out in the claims.

In the drawings—

Figure 1 is a diagrammatic side elevation of a single compressor cylinder embodying the invention, with four unloading steps secured by three unloading devices;

Figure 2 is a longitudinal section of the cylinder on the line 2 of Fig. 3;

Figure 3 is a cross section of the cylinder on the line 3 of Fig. 1;

Figure 4 is an enlarged view of the control apparatus for the unloading devices, similar to Fig. 1, but partly broken away to show the construction;

Figure 5 is a vertical section of the control apparatus;

Figure 6 is a cross section on the line 6 of Fig. 4;

Figure 7 is a detail view of my improved unloading valve;

Figure 8 is a view similar to Fig. 4, with the control valves in section, and showing a modification.

Referring now to the drawings, and especially to Figs. 1 to 7, A is the compressor cylinder, B the piston, C the piston rod driven in any suitable manner, D, D′ and E, E′ inlet and discharge valves at, respectively, the crank and head ends of the cylinder and F a clearance pocket for the crank end of the cylinder, automatically controlled by the unloading apparatus. Two hand-controlled clearance pockets G at the head end of the cylinder are shown for controlling maximum loading, but it will be understood that these may be omitted or a different number of hand-controlled devices be used. The suction and discharge valves are shown as of a type of plate valve now well known and patented by United States Letters Patent to Meyer, Reissue No. 13,991 and No. 1,341,413, so that no further description of these valves per se need be given. Each of the inlet valves D, D′ is provided with pressure-operated means for unseating and holding open the inlet valves, this means consisting of a sliding member 10 carrying fingers 11 adapted to engage the plate valves *a*, the member 10 being moved to open the valves by pressure operated piston 12 and returned to release the valves for normal operation by spring 13. The port connecting the cylinder with the clearance chamber F is controlled by a valve *b* actuated by pressure operated piston 14, which is moved by receiver pressure to open the valve for connecting the cylinder with the clearance chamber and partial unloading,

and is closed by a spring 15 which, in compound compressors, preferably is aided by intercooler pressure transmitted outside the piston through pipe 16. The valves controlling the clearance chambers G are shown as hand valves 17 of common type operated by screw stems and hand wheels 18.

Referring now to the apparatus for automatically controlling the pistons 12, 14 and valves *a*, *b*, pressure is applied to the inner side of piston 14 to open the clearance valve for the first unloading step, by receiver pressure transmitted through pipe 1. Pressure is applied to the outer side of piston 12 to open inlet valves D at the crank end of the cylinder for unloading steps 2 and 4, by pressure transmitted through pipe 2 branched to each inlet valve. Pressure is applied to piston 12 for opening inlet valves D′ at the head end of the cylinder for the third unloading step by pressure applied by pipe 3 branched to each inlet valve. Pressure in these pipes 1, 2, 3 is controlled by wing valves *g*, *h*, *i* mounted in valve casings 19 on the cylinder and acting to connect the pipes 1, 2, 3 with pressure chambers 5 supplied by pressure pipe 20 connecting with the receiver or other suitable source of pressure fluid, or to connect these pipes 1, 2, 3 with exhaust through exhaust chambers 21 exhausting by wing stems 51 according to the position of the valves. Each of these valves *g*, *h*, *i* is normally held in position to connect pipes 1, 2, 3 with exhaust chamber 21 for full loading of the compressor cylinder, by spring 50 acting upon the valve stem 51 through cross-bar 52, the spring pressure preferably being adjustable by screw rods 53 threaded in blocks 54 carrying one end of the springs and provided with thumb nuts 55 bearing against cross-bar 52 for adjusting the screws. The other ends of the springs 50 are connected to roller bars 56 sliding in guide slots in guide bar 57 and normally held depressed by a slide *j* engaging loose sleeves on the roller bars, so that the tension of the springs is decreased by the retraction of the springs or release by the wedge. A single slide *j* may be used for the control of all the valves, but in the construction shown in which the operation of one of the valves is to be reversed to provide unloading steps in excess of the number of unloading devices, it is preferable to divide the slide into two parts *j*, *j′*, the slide *j′* controlling the valve *h* as explained hereafter.

The slides *j*, *j′* are both formed with an inclined or wedge surface 6 acting to gradually release and engage the roller-bars 56 on slight movement in opposite directions, and the slide *j′*, for the purpose of producing a second operation of valve *h*, is cut-out intermediate its ends to form wedge surfaces 6′, 6².

The slides *j*, *j′* are actuated to control the spring pressure and thus the valves *g*, *h*, *i* for unloading and loading, by apparatus controlled by the receiver pressure, as usual in such unloading devices, and this receiver pressure and the operation of the valves is preferably secured through a pressure-operated member controlled directly by the receiver pressure, and the pressure fluid is controlled by a pilot valve, which pilot valve is controlled directly by the receiver pressure, and the pressure fluid controlled by the pilot valve and actuating the slides *j*, *j′* may be of any suitable character and taken from any suitable source, thus enabling the apparatus to be controlled by slight variations in receiver pressure while employing pressure as heavy as desired for actuating the slides *j*, *j′*. As illustrated and preferred, there is employed for actuating the slides *j*, *j′* a governor or regulator of the well-known Mason regulator type, and, as shown, the slides *j*, *j′* are connected by arms 23 to the rod of piston 24 moving in cylinder 25 having fluid passages 26, 27 connecting with opposite ends of the cylinder, these fluid passages being controlled by a pilot valve *d* in valve chamber 28 with which connect fluid passages 29, 30 for inlet and exhaust of pressure fluid, the pilot valve *d* having a passage through it for connecting the passage 27 with exhaust 30, when the pilot valve is raised to connect pipe 26 with inlet 29, as usual in such constructions. The pilot valve *d* is shifted by lever 31 connected by link 32 to weighted lever 33 pivoted at 34 and bearing on diaphragm 35, which diaphragm is subjected to receiver pressure through pipe 36. The pilot valve *d* is returned to position after each movement, for another unloading step on a further increase in receiver pressure, or for a loading step on decrease of receiver pressure, and for this purpose a compensating device of the usual type is used in which lever 31 is pivoted on one arm of bell-crank lever 37 instead of at a fixed point, and the other arm of the bell-crank lever 37 is connected by a link 38 to one arm of bell-crank lever 39, the other arm of which engages a wedge 40 moving on slideway 41 and connected by link 42 and arm 43 to the rod of piston 24 so as to move therewith. This regulating and compensating device is similar to the well known Mason regulator with compensator, except for the following feature:

It is important that the piston 24 should move in exact steps and thus secure an exact movement of the slides *j*, *j′* at each step, as an irregular movement of the piston 24 might not secure the desired accurate control of unloading through the pipes 1, 2, 3. For the purpose of securing this result, the wedge 40 is formed in horizontal portions of different heights, with sharp inclined steps be-

tween them. Each of these inclined steps, therefore, definitely fixes the point in the movement of the piston 24 at which the pilot valve will be shifted to return to its normal position and stop the piston 24, thus assuring the accurate positioning of the slide to control the valves g, h, i and thus the pressure in pipes 1, 2, 3 and their unloading devices.

The operation of the construction shown in Figs. 1 to 7, and above described, is as follows: Assuming that the compressor is operating at full capacity, an increase of receiver pressure above that for which the apparatus is set raises lever 33 and pilot valve d so as to admit pressure fluid from pipe 29 through the pilot valve and passage 26 to the left end of cylinder 25 and connect the other end of the cylinder through passage 27 and the central hole through pilot valve d to passage 30 for exhaust, and thus the piston 24 is moved to the right in Fig. 5 to withdraw the wedge j from contact with roller-bar 56 of valve g controlling pipe 1, thus decreasing the pressure of the springs 50 controlling this valve and permitting the receiver pressure acting on this valve through pipe 20 and chamber 5 to connect chamber 5 with pipe 1, when the pressure fluid in pipe 20 will pass through pipe 1 to the inner side of piston 14 and open valve b to connect the cylinder with clearance chamber F. This clearance chamber preferably will be made of such capacity as to unload the crank end of the cylinder A one-half, that is, a one-fourth unloading of the cylinder, so that the latter will operate at 75% capacity, assuming that the hand-controlled clearance pockets G are closed. The compensating device now returns the pilot valve d to central position, as shown in Fig. 5, preventing inlet or exhaust of motor fluid to cylinder 25 and stopping the piston 24 in this position.

On a further increase of receiver pressure, the same operation is repeated, the slides j, j' being moved another step, on which movement slide j' by wedge 6′ releases the roller-bar 56 of valve h, and this valve h is moved by the receiver pressure to admit receiver pressure from pipe 20 to pipe 2, and thus unseat the inlet valves D at the crank end of the cylinder, thus fully unloading the crank end of the cylinder so that the compressor operates at 50% capacity.

On a further increase of receiver pressure, another movement of the slides j, j' takes place and the slide j releases cross-bar 56 acting on the spring of valve i so as to secure the movement of the valve and admission of pressure fluid from pipe 20 to pipe 3, while by the same movement the slide j' by wedge 6^2, acts on roller-bar 58 controlling the springs of valve h so as to increase the spring pressure on valve h and restore it to normal position, in which pipe 2 is closed to pressure pipe 20 and open to exhaust 21. Thus the inlet valves D at the crank end of the cylinder are released and these valves reseated for normal operation, and the valves D′ at the head end of the cylinder unseated for unloading the head end, and thus the crank end of the cylinder is unloaded one-half by the clearance chamber F and the head end of the cylinder fully unloaded, the compressor thus operating at 25% capacity.

On a further increase of pressure and movement of the slides, j, j', the slide j', by wedge 6, releases the roller-bar 56 to decrease the pressure of the springs controlling valve h, and pipe 2 is again opened to pressure pipe 20, so that the inlet valves E at the crank end of the cylinder are held open for unloading, completing the unloading of the cylinder.

Decrease in receiver pressure permits the weighted lever 33 to fall and reverses the above operation in successive steps, the compressor being gradually loaded from full unloading to full capacity by movement of the slide j to the left in Fig. 5, first by connecting pipe 2 to exhaust 21, for 25% capacity; then by connecting pipe 2 to pressure pipe 20 and pipe 3 to exhaust for 50% capacity; then connecting pipe 2 to pressure pipe 20, for 75% capacity; and finally connecting pipe 1 to pressure pipe 20 for closing the clearance chamber and full capacity.

It is frequently desirable that the capacity of the cylinder shall be limited to a maximum of less than the cylinder capacity for a time, which maximum loading limit shall be maintained independently of the automatic unloading. This is provided for in the construction shown by the clearance chambers G and valves 17, the opening of either or both of which increases the cylinder clearance to the extent desired, the clearance chambers G being made of any desired capacity, according to the maximum loading limit to be provided for. The automatic unloading devices then operate on a cylinder capacity reduced by the maximum control chambers G.

The construction shown in Fig. 8 is the same, and the operation the same, as that described above in connection with Figs. 1 to 7, except that this construction is designed for use with a compressor having an unloading device for each step, so that no reversal of action of any unloading device is necessary during unloading or loading. The construction illustrated is for a compressor cylinder having four unloading devices, there being shown four valves l, m, n, o similar to valves g, h, i previously described, all of which are mounted in a single valve chamber 45, and each of which controls its corresponding pipe 1, 2, 3, 4, leading to the different unloading devices. With these

valves thus mounted, only the one part slide *j* is required, the operation of this slide and the valves being the same as previously described in connection with slide *j*. It will be understood that the unloading devices used may be of any suitable number and form, the valves controlled by the slide *j* coacting with said unloading devices in any suitable manner to secure the desired operation.

It will be seen that my improved regulator secures important advantages, especially in connection with variable capacity compressors, in that a full and quick movement of the control valves is secured, the action is certain and practically without friction, and the valves are controlled by a very narrow range of pressure, so that a very close regulation and one practically independent of maximum and minimum pressures in the receiver is provided. The construction, moreover, is very simple, durable and convenient of adjustment and repair. The receiver pressure acting on the pilot valve diaphragm is required only to remove the small balanced pilot valve, and the pressure on the operating piston actuating the control valve wedge, is required only to move the wedge against the friction of the spring roller so that this pressure also may be quite light. The spring pressure on the valves may readily be adjusted and the slide arranged to release this pressure to any extent desired, so that on such release the receiver pressure acts quickly and with certainty to secure the full movement of the valves, and admission of full receiver pressure to the unloading devices.

In such unloading apparatus it has been found difficult to provide a pressure-operated unloading valve controlling a clearance chamber, in which leakage of pressure past the piston or valve is avoided, while the certain action of the unloading device and the efficiency of the compressor, especially at full capacity, depends upon the piston and valve being non-leaking. Leakage at the piston arises especially from the fact that the piston has very little motion, and this motion in many cases is infrequent, so that piston rings have no chance to wear down, and other forms of packing are liable to leak after prolonged disuse, or to stick so as to interfere with the operation of the piston. It is important also that the piston or valve should not stick and thus interfere with the compressor control. I have provided a clearance valve and operating piston construction which secures the desired results, which construction may be applied, also, in connection with pressure-operated valves for other uses.

As shown in Fig. 7, the piston 14 acting to operate the clearance valve, is formed of two disks suitably secured together, with two cups 7 of suitable thin flexible metal between them, the flanges of these cups being turned in opposite directions along the outer side of the piston. These cups preferably are made of sheet brass, but may be made of any suitable metal. A single cup may be used with advantage, but the best results are secured with two cups arranged as shown, and it has been found in practice that such piston is absolutely tight and moves freely, notwithstanding that the piston may not be operated for a considerable time. The perfect seating of the valve, so as to make it non-leaking, is secured by attaching the valve to its stem 8 by which the piston 14 operates it, by a flexible connection as distinguished from connecting the valve rigidly to the stem. In the construction shown, the valve *b* carries a cap 9 having a recess receiving a head on the piston stem 8, which head and recess are so formed as to permit the slight tilting of the valve *b*, thus securing its perfect seating independently of the piston alinement. Any other suitable flexible joint between the piston stem 8 and valve *d* securing the same results may be used.

It will be understood that the invention is not limited to the specific form or arrangement of devices illustrated, but that the invention, as defined in the claims may be embodied in various constructions.

What I claim is:

1. In a variable capacity compressor, the combination with the cylinder, and a plurality of unloading devices, of separate control valves and fluid connections for the respective unloading devices, said control valves being subject to constant pressure tending to move them into loading position, and a member controlled by receiver pressure acting to vary said constant pressure on said control valves successively to control said unloading devices for unloading and loading the cylinder.

2. In a variable capacity compressor, the combination with the cylinder and a plurality of unloading devices, of separate control valves and fluid connections for the respective unloading devices, said control valves being subject to spring pressure tending to move them in one direction, and a member controlled by receiver pressure and acting to vary the spring pressure on said valves successively to control said unloading devices for unloading and loading the cylinder.

3. In a variable capacity compressor, the combination wth the cylinder and a plurality of unloading devices, of separate control valves and fluid connections for the respective unloading devices, said control valves being subject to spring pressure and fluid pressure tending to move the valves in opposite directions, and a member controlled

by receiver pressure and acting to vary the spring pressure to secure the movement of said valves successively to actuate said unloading devices for unloading and loading the cylinder.

4. In a variable capacity compressor, the combination with the cylinder and a plurality of unloading devices, of separate control valves and fluid connections for the respective unloading devices, said control valves being subject to spring pressure tending to close the valves and receiver pressure tending to open the valves, and a member controlled by receiver pressure and acting to vary the spring pressure to secure the movement of said valves successively to actuate said unloading devices by the receiver pressure for unloading the cylinder and against the receiver pressure for loading the cylinder.

5. In a variable capacity compressor, the combination with the cylinder and a plurality of unloading devices, of separate control valves and fluid connections for the respective unloading devices, said control valves being subject to spring pressure tending to close the valves and receiver pressure tending to open the valves, and a governor controlled by receiver pressure including a slide controlling the spring pressure on the valves and moved by the governor to vary the spring pressure to secure the movement of said valves successively to actuate said unloading devices by the receiver pressure for unloading the cylinder and against the receiver pressure for loading the cylinder.

6. In a variable capacity compressor, the combination with the cylinder and a plurality of unloading devices, of separate control valves and fluid connections for the respective unloading devices, said control valves being subject to spring pressure and fluid pressure tending to move the valves in opposite directions, and a governor including a pilot valve controlled by receiver pressure and a member actuated by fluid pressure controlled by said pilot valve and acting to vary the spring pressure to secure the movement of said valves successively to actuate said unloading devices for unloading and loading the cylinder.

7. In a variable capacity compressor, the combination with a cylinder and a plurality of unloading devices, of separate control valves and fluid connections for the respective unloading devices, and pressure controlled governor mechanism, including means for successively actuating said control valves to bring said unloading devices into action and acting to bring one of said devices into action a plurality of times during each of the cylinder unloading and loading operations.

8. In a variable capacity compressor, the combination with a cylinder and a plurality of unloading devices, of separate control valves and fluid connections for the respective unloading devices, and pressure controlled governor mechanism, including means for successively actuating said control valves and acting to unload one end of the cylinder by a plurality of steps and to load said end for an intermediate unloading step.

9. In a variable capacity compressor, the combination with a cylinder and a plurality of unloading devices for the cylinder, including a single clearance chamber, of separate control valves and fluid connections for the respective unloading devices, and pressure controlled governor mechanism for partially unloading the cylinder by said clearance chamber and then fully unloading the cylinder by unloading steps secured by discharging the fluid through the suction valve ports at one or both ends of the cylinder.

10. In a variable capacity compressor, the combination with a cylinder and a plurality of unloading devices for the cylinder, including a single clearance chamber, of separate control valves and fluid connections for the respective unloading devices, and pressure controlled governor mechanism for partially unloading said cylinder by said clearance chamber and unloading further and finally by successive steps consisting of holding the suction valves open, and including the successive opening of the suction valves at the clearance end of the cylinder for one step, releasing said valves for normal operation during another step, and again holding said valves open for a later step.

11. In a variable capacity compressor, the combination with the cylinder and a plurality of unloading devices, of separate control valves and fluid connections for the respective unloading devices, said control valves being subject to spring pressure tending to move them in one direction, and a governor controlled by receiver pressure, including a slide controlling spring pressure on the valves and moved by the governor to vary the spring pressure to secure the movement of said valves successively to control said unloading devices for unloading and loading the cylinder, said slide being formed to secure the movement of one of said valves a plurality of times during each of the cylinder unloading and loading operations to bring one of the unloading devices into action a plurality of times during each such operation.

12. In a variable capacity compressor, the combination with a cylinder and a plurality of unloading devices, each acting to partially unload the cylinder, of governor mechanism for controlling said unloading devices, including a pilot valve controlled by receiver pressure, compensating devices for returning the pilot valve to position after

each movement, and a stepped wedge actuating said compensating devices, said steps acting to definitely fix the successive movements of the member controlled by the pilot valve.

13. The combination with a fluid control valve, and a movable member controlled thereby, of compensating devices for returning the valve to position after movement, said compensating devices including a wedge provided with steps controlling the compensating action to fix the movement of the member at each action of the valve.

14. The combination with a fluid control valve, and a movable member controlled thereby, of compensating devices for returning the valve to position after movement, said compensating devices including a series of stops brought into action by the successive movements of the movable member and controlling the compensating action to fix the movement of the member at each action of the valve.

15. The combination with a valve subjected to spring pressure tending to move it in one direction, of a governor device having a movable slide holding said spring under tension and acting to vary the spring pressure by its movement to secure the movement of the valve.

16. The combination with a series of valves subjected to spring pressure tending to move them in one direction, of a governor device having a movable slide acting to hold said springs under tension and acting by its movements to vary the spring pressure on the different valves successively to secure their successive movement.

17. The combination with a valve, of a spring and connections for holding said valve under pressure, a bar attached to the spring, and a sliding wedge engaging said bar and acting to move the bar to increase or decrease the spring pressure.

18. The combination with a series of valves, of springs and connections for holding said valves under pressure, bars attached to the springs, and a sliding wedge engaging said bars and acting to move the bars to increase and decrease the spring pressure on the valves successively.

19. The combination with a series of valves subjected to spring pressure tending to move them in one direction, of a governor device having a member acting to hold said springs under tension and controlled by the governor to vary the spring pressure on the different valves successively to secure their successive movement.

In testimony whereof, I have hereunto set my hand.

MICHAEL RIESNER.