

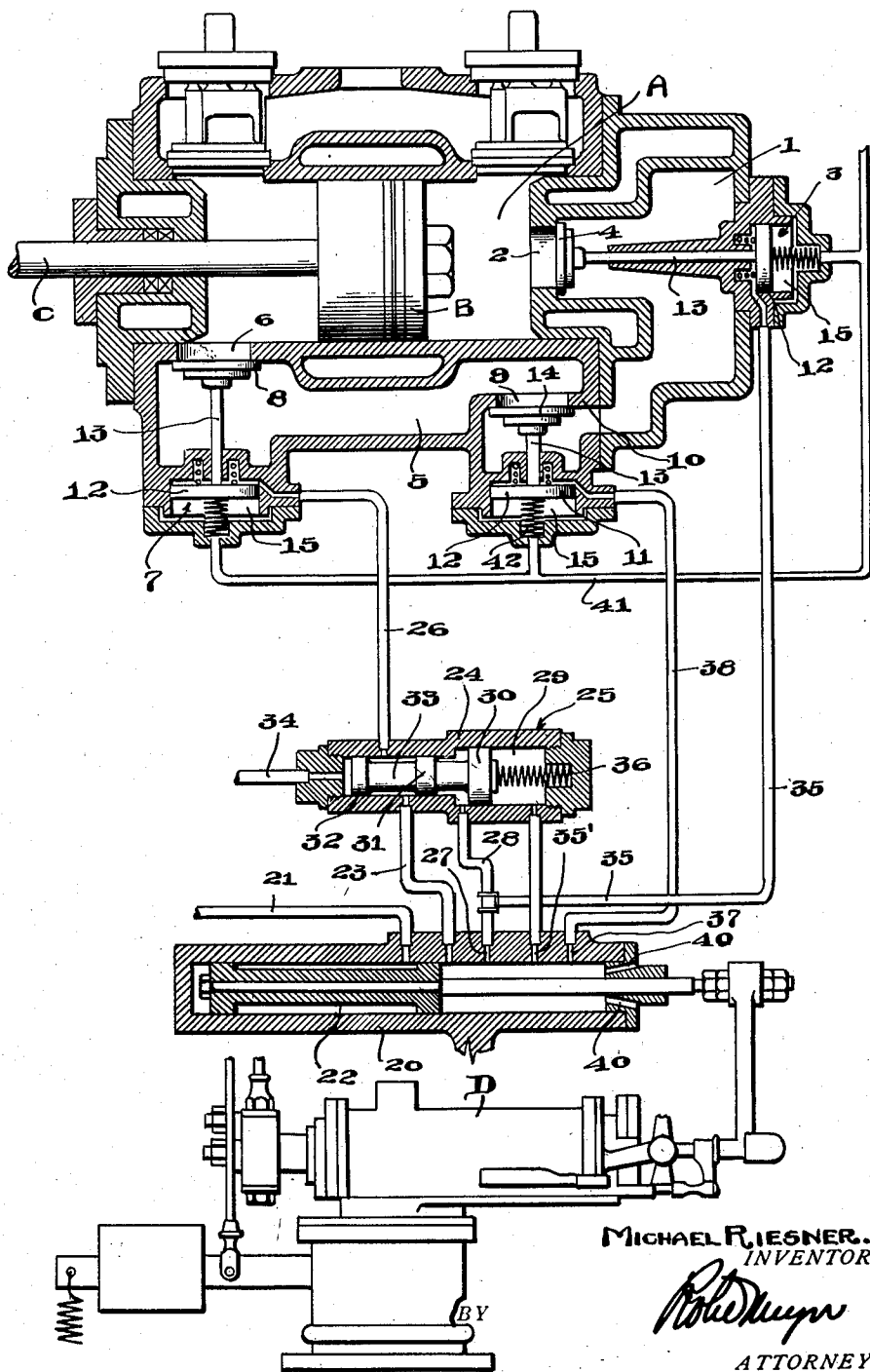
June 17, 1930.

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1,764,646

VARIABLE CAPACITY COMPRESSOR

Filed July 27, 1929



UNITED STATES PATENT OFFICE

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VARIABLE-CAPACITY COMPRESSOR

Application filed July 27, 1929. Serial No. 381,596.

This invention relates to variable capacity air or gas compressors and broadly to means for automatically unloading a compressor gradually or in fractional steps as the receiver pressure rises to predetermined points, and gradually loading the compressor as the receiver pressure falls.

The primary object of the invention is to provide an apparatus of this type which will be economical in operation, provide a relatively high compressor efficiency and one which will be relatively simple in construction.

In accordance with the present invention there is combined a plurality of unloading devices and clearance chambers, which cooperate to unload and load the cylinder of the compressor in such a way as to secure a larger number of unloading steps than the number of unloading devices used, thus reducing the number of unloading devices on the cylinder and making the compressor itself less complicated in construction.

The present invention embodies the use of a plurality of clearance chambers of unequal capacity connected to the cylinder through the unloading devices in such manner, that by the opening of one clearance chamber to the cylinder one end of the cylinder may be partly unloaded; the opening of the other clearance chamber to the cylinder will wholly unload one end of the cylinder; the opening of both clearance chambers to the cylinder will partly unload one end of the cylinder and wholly unload the other end, whereas when the clearance chambers are both open to the cylinder and to each other the compressor will be wholly unloaded or operated at zero capacity. Together with the above arrangement of clearance chambers, the present invention includes suitable pressure operated control apparatus to control operation of said unloading devices in proper sequence at proper times to permit operation of the compressor under various predetermined percentages of its full capacity in accordance with the unloading sequence just above set-out.

With these and other objects in view as may appear from the accompanying speci-

fication, the invention consists in various features of construction and combination of parts, which will be first described in connection with the accompanying drawing, which shows in section, in a semi-diagrammatic manner, a variable capacity compressor constructed in accordance with this invention, and the features forming the invention will be specifically pointed out in the claims.

Referring more particularly to the drawings A is the compressor cylinder in which the piston B reciprocates. The piston B is driven or reciprocated, through the piston rod C in any suitable manner. It is to be understood that the compressor cylinder structure is provided with suction and discharge valves, of approved type, at the crank and head ends of the cylinder A as is usual in the construction of double acting air or gas compressors of approved types.

The cylinder A has a clearance chamber 1 associated therewith which opens out through a port 2 with the head end of the cylinder and this clearance chamber 1 is of sufficient capacity to wholly unload the head end of the cylinder when the unloading device 3 is operated to unseat the valve 4 and open the clearance chamber 1 to the head end of the cylinder A. A second clearance chamber 5 is provided which opens through a port 6 into the crank end of the cylinder A and the capacity of this clearance chamber 5 is such as to only partly unload the crank end of the cylinder; preferably unload the crank end 50% of its capacity, which is 25% of the total capacity of the compressor. The communication between the clearance chamber 5 and the crank end of the cylinder A is controlled by the unloading mechanism 7 which includes the valve 8.

The clearance chambers 1 and 5 are open to communication one with the other through a port 9 formed suitably in the partition 10 which divides or separates the two clearance chambers. The port 9, like the ports 2 and 6 is controlled by a pressure operated unloading mechanism 11.

The pressure operated unloader mechanisms 3, 7 and 11 are all alike and are simi-

lar to those disclosed in my prior Patent No. 1,636,439 and they are controlled in their operation by governor mechanism such as that disclosed in my prior Patent No. 1,579,781.

More specifically, the pressure operated unloading devices include the pistons 12 which are mounted upon the stems 13. The various valves 4, 8 or 14 are connected to the valve stems 13 and are seated or unseated by movement of the respective pistons 12. The pistons 12 reciprocate in the cylinder structures 15 and are moved by fluid under pressure, the admittance of which, into the cylinders, is controlled by the governor mechanism as hereinafter more specifically described. The fluid under pressure is admitted through the governor into the cylinders 15 inwardly of the pistons 11 and forces them outwardly for unseating the valves 4.

In operation, when the pressure in the receiver (not shown) reaches a predetermined degree, the control apparatus D which is similar to that shown in my prior Patents 1,579,781 and 1,704,343 will operate and move the piston 22 of the governor or control mechanism so as to open communication between the pipe 21 which admits the pressure fluid into the cylinder 20 and the pipe 23. The fluid under pressure passes through the pipe 23, the cylinder 24 of the intermediate valve structure 25 and through the pipe 26 into the cylinder 15 of the pressure operated unloading device 7 causing the outward movement of the piston 12 and the unseating of the valve 8. This opens the crank end of the cylinder A to the clearance chamber 5 and permits a $\frac{1}{2}$ unloading of the crank end of the cylinder and a consequent operation of the compressor at 75% of its capacity.

Upon a further increase in receiver pressure, the piston 22 moves farther within the cylinder 20 and opens the pipe 21 to the port 27 and permits the pressure fluid to pass from the port 27 through the pipe 28 into the enlarged portion 29 of the cylinder 24 of the intermediate valve 25. The pressure fluid entering the enlarged portion 29 of the cylinder 24 acts on the piston 30 of the intermediate valve 25 and owing to the increased area of the piston 30 over the piston sections 31 and 32 of the plunger 33 of the valve 25, moves the plunger so as to cut off the communication between the pipes 23 and 26 and permit the fluid under pressure, which is in the cylinder 15, to bleed therefrom and exhaust through the exhaust pipe 34 of the intermediate valve 25. The port 27 also has a pipe 35 connected thereto so that at the same time that the pressure fluid is admitted into the enlarged portion 29 of the cylinder 24, in front of the piston 30, the air under pressure will be admitted

into the cylinder 15 of the unloading mechanism 3 back of piston 12 thereof to move this piston and unseat the valve 4 for opening the head end of the cylinder A to the clearance chamber 1. This wholly unloads the head end of the cylinder and permits the compressor to operate at 50% of its full capacity, since, when the pressure fluid was permitted to exhaust from the cylinder 15 of the unloading device 7 the pressure back of the piston 12 of the unloading device 7 would seat the valve 8 and cut off communication between the crank end of the cylinder and the clearance chamber 5.

Upon further increase in receiver pressure the port 35' is opened to communication with the pressure fluid entering the cylinder 20 of the controlling or regulating valve structure and the port 35 permits the pressure fluid to enter the enlarged portion 29 of the cylinder 24 in front of the piston 30. Owing to the increased area of the outer end of the piston 30, acted upon by the pressure fluid, together with the pressure applied by the spring 36, the plunger 33 will be forced to the left, in the drawings, and again open communication between the pipes 23 and 26 to permit the pressure fluid to be admitted to the cylinder 15 of the unloading device 7 in front of the piston 12 thereof to unseat the valve 8 and again open the clearance chamber 5 to the crank end of the cylinder, providing a reverse step in the unloading operation of the compressor. At this time the valve 4 will also be held unseated through admittance of the pressure fluid to the unloading mechanism 3 through the pipe 35 and thus the head end of the cylinder A of the compressor will be wholly unloaded and the crank end will be unloaded 50% which will permit the compressor to operate at 25% of its capacity.

Upon a further increase of receiver pressure the port 37 is opened to receive the fluid under pressure from the cylinder 15 of the unloading mechanism 11 for moving the piston 12 thereof to unseat the valve 14 and open the clearance chamber 1 to the clearance chamber 5 which in turn opens the head end of the cylinder A to the crank end of the cylinder A and permits the by-passing of the fluid compressed by the piston B and consequently wholly unloads both ends of the cylinder and permits the compressor to operate at zero capacity.

Decrease in receiver pressure reverses the operation above described, the compressor being loaded in a graduated manner in the same proportion of its full capacity as those in which it is unloaded; i. e., upon decrease in receiver pressure the pressure is relieved against the piston 12 of the unloading mechanism 11, through the return movement of the piston 22 by means of the governor mechanism such as disclosed in my prior Patent

1,579,781 and the pressure fluid behind the piston 12 is permitted to bleed from the cylinder 15 back into the cylinder 20 and exhaust through the exhaust openings 40 in the cylinder 20. The exhaust openings 40 are open to the atmosphere or to any suitable point and bleeding of the pressure fluid from the cylinder 20 is during the unloading operations prevented by the piston 22. When the pressure is relieved from the inner side of the piston 12, the relatively low pressure which is admitted to the cylinder through the pipe 41, together with the action of the spring 42 will move the piston 12 to seat the valve 14 and cut off the communication between the clearance chambers 1 and 5 thereby permitting the compressor to operate at 25% of its full capacity.

The relatively low pressure fluid which is admitted to the cylinder 15 of the unloading mechanism 11 and which is also admitted to the cylinders 15 of the unloading devices 3 and 7 may be supplied from an intermediate stage or inter-stage cooler.

A further decrease in receiver pressure will cut off the communication between the cylinder 15 of the unloading mechanism 7 and the cylinder 20 by the relief of the pressure from the outer or right hand end of the piston 30 of the plunger 33 and will cause the plunger to be moved by the pressure entering the cylinder 24 through the pipe 28 efficiently to permit the pressure fluid back of the piston 12 to bleed out through the cylinder 24 and its exhaust 34. This will permit the seating of the valve 8 and the cutting off of the communication between the clearance chamber 5 and the crank end of the cylinder A thereby permitting the compressor to operate at 50% of its capacity.

Upon a further decrease in receiver pressure the port 27 will be opened to the exhaust 40 which will permit the seating of the valve 4 through the bleeding of the pressure fluid from the cylinder 15 of the unloading mechanism 3. At the same time at which the pressure fluid is permitted to bleed from the unloading mechanism 3, the plunger 33 will be relieved of pressure against its piston 30 through the pipe 28 and the plunger will be urged or moved by the spring 36 and the action of the pressure fluid against the piston 32 of the plunger into position to permit the pressure fluid to again enter the cylinder 15 of the unloading mechanism 7 and open the valve 8 to allow the partial unloading of the crank end of the cylinder and the consequent operation of a compressor at 75% of its capacity.

A further decrease in receiver pressure will cause the cutting off of communication between the pipes 23 and 21 and will permit the bleeding of the pressure fluid from the cylinder 15 of the unloading device 7 back

through the pipe 23 and to the cylinder 20 and out of the exhaust 40 thereof thereby permitting the seating of the valve 8 and the operation of a compressor at its full capacity.

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

What is claimed is:

1. In a variable capacity compressor, the combination with a cylinder, of a clearance chamber for wholly unloading one end of the cylinder, a second clearance chamber for partly unloading the other end of the cylinder, a plurality of pressure operated unloading devices each acting to partially unload the cylinder, and pressure controlled governor mechanism including means for successively bringing one of said devices into action a plurality of times during each of the cylinder unloading and loading operations.

2. In a variable capacity compressor, the combination with a cylinder, of two clearance chambers one having greater capacity than the other, the dividing wall of said chambers having an opening to permit communication between the cylinders for wholly unloading the compressor, pressure operated unloading devices for controlling communication of said chambers with said cylinder and with each other, and pressure controlled governor mechanism including means for successively bringing one of said devices into action a plurality of times during each of the cylinder unloading and loading operations.

3. In a variable capacity compressor, the combination with a cylinder, of a clearance chamber for wholly unloading one end of the cylinder, a second clearance chamber for partly unloading the other end of the cylinder, the dividing wall of said chambers having an opening to permit communication between the cylinders for wholly unloading the compressor, a plurality of pressure operated unloading devices each acting to partially unload the cylinder, and for controlling communication of said chambers with each other, and pressure controlled governor mechanism including means for successively bringing one of said devices into action a plurality of times during each of the cylinder unloading and loading operations.

4. In a variable capacity compressor, the combination with a cylinder, of a clearance chamber for wholly unloading one end of the cylinder, a second clearance chamber for partly unloading the other end of the cylinder, a pressure operated unloading device for each of said chambers acting to partially unload the cylinder, and a pressure controlled governor mechanism including means

for bringing the unloading device associated with said second clearance chamber into action a plurality of times during each of the cylinder unloading and loading operations.

5 5. In a variable capacity compressor, the combination with a cylinder of a clearance chamber for wholly unloading one end of the cylinder, a second clearance chamber for partly unloading the other end of the cylinder, the dividing wall of said chambers provided with an opening to permit communication of the chambers for wholly unloading the cylinder; a pressure operated unloading device for each of said chambers acting to
10 partially unload the cylinder, a pressure operated unloading device acting to control said chamber communicating opening, and a pressure control governor mechanism including means for bringing the unloading
15 device associated with the second clearance chamber into action a plurality of times during each of the cylinder unloading and loading operations.

25 6. In a variable capacity compressor, the combination with a cylinder of a clearance chamber for wholly unloading one end of cylinder, a second clearance chamber for partly unloading the other end of the cylinder; the dividing wall of said chambers provided with an opening to permit communication of the chambers for wholly unloading the cylinder; a pressure operated unloading device for each of said chambers acting to partially unload the cylinder; a pressure operated unloading device acting to control said chamber communicating opening, and a pressure controlled governor mechanism including a pressure operated intermediate valve for bringing the unloading device associated with said second clearance chamber successively into action a plurality of times during each of the complete unloading and loading operations of the cylinder.

45 7. In a variable capacity compressor the combination with a cylinder, of means for completely unloading and loading the compressor in successive steps of predetermined percentages of the cylinder capacity, said means including a clearance chamber for
50 partially unloading one end of the cylinder, a pressure operated unloading device controlling communication between the cylinder and said clearance chamber, and a pressure controlled governor mechanism including
55 means for bringing said unloading device successively into action a plurality of times during each complete unloading and loading operation of the cylinder.

60 8. In a variable capacity compressor the combination with a cylinder, of means for completely unloading and loading the compressor in successive steps of predetermined percentages of the cylinder capacity, said means including a clearance chamber for
65 partially unloading one end of the cylinder,

a pressure operated unloading device controlling communication between the cylinder and said clearance chamber, and a pressure controlled governor mechanism including a pressure actuated intermediate valve for successively bringing said unloading device into action a plurality of times during each complete unloading and loading operation of the cylinder.

In testimony whereof I affix my signature.
MICHAEL RIESNER.

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