

June 24, 1941.

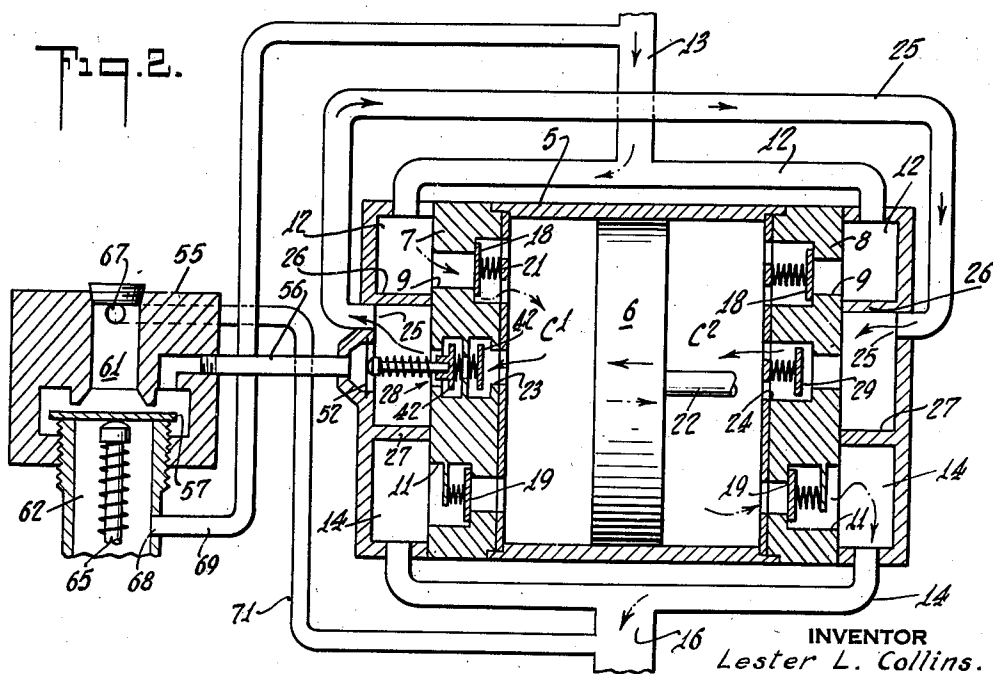
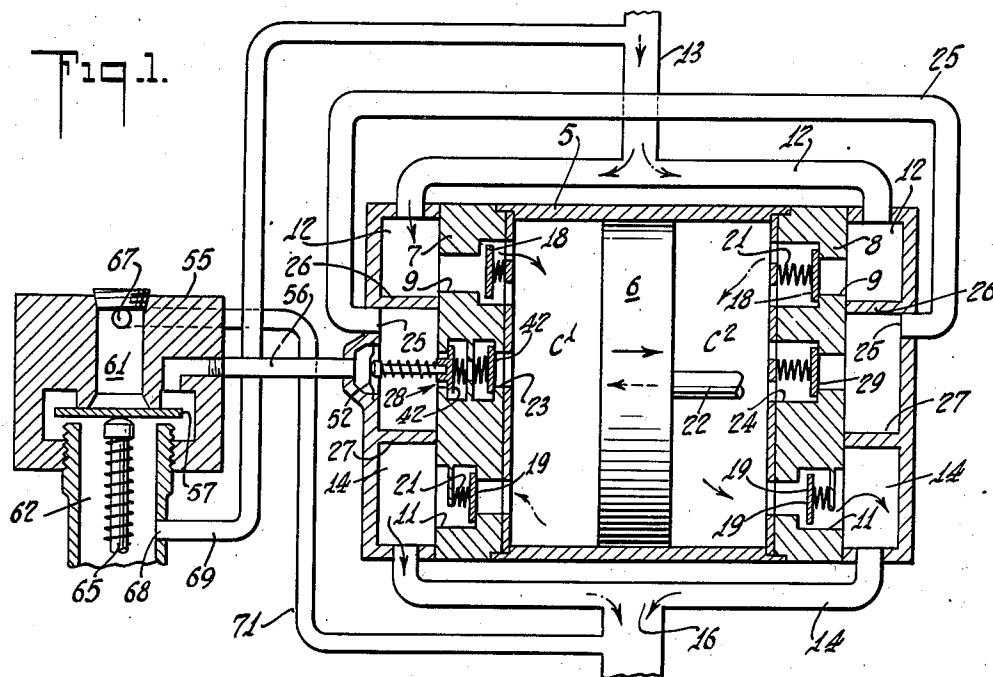
L. L. COLLINS

2,246,932

COMBINATION SINGLE AND TWO STAGE VACUUM PUMP

Filed Sept. 21, 1939

2 Sheets-Sheet 1



INVENTOR
Lester L. Collins.
BY
Raymond D. Muller
ATTORNEY

2-111

June 24, 1941.

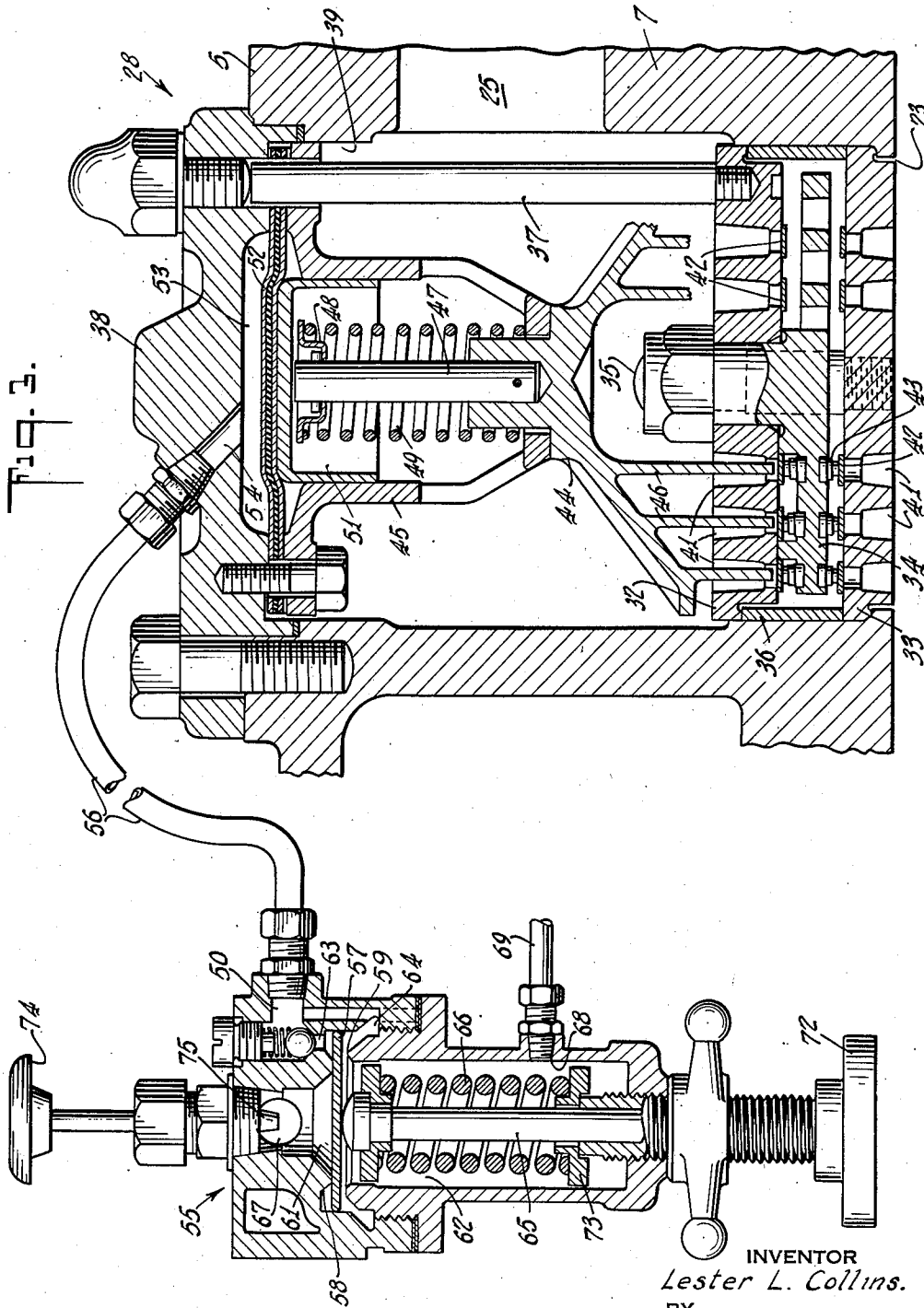
L. L. COLLINS

2,246,932

COMBINATION SINGLE AND TWO STAGE VACUUM PUMP

Filed Sept. 21, 1939

2 Sheets-Sheet 2



INVENTOR
Lester L. Collins.
BY
Raymond G. Muller
ATTORNEY

UNITED STATES PATENT OFFICE

2,246,932

COMBINATION SINGLE AND TWO STAGE
VACUUM PUMP

Lester L. Collins, Franklin, Pa., assignor to Chicago Pneumatic Tool Company, New York, N. Y., a corporation of New Jersey

Application September 21, 1939, Serial No. 295,929

16 Claims. (Cl. 230—40)

This invention relates to pumps and to valve mechanism therefor and has particular reference to a vacuum pump designed to produce a high degree of evacuation in a vessel or tank of relatively large volume.

Ordinarily, vacuum pumps are arranged to operate single stage. Unlike compressors, they are provided with few valves in order to minimize clearance and thereby to obtain high volumetric efficiency which is of especial importance at the higher vacuums. The reduction in the number of valves results, however, in relatively high air velocities which account for a large percentage of the horse power consumed. The two stage arrangement, which would increase the power consumption due to air velocities, is generally avoided.

There are occasions, however, when the pump is required to deliver a higher vacuum (that is, a high ratio between discharge and inlet pressures) than either piston chamber of the pump could deliver in one stage of operation, because the clearance space establishes a definite limit on the ratio aforementioned, at which point the volumetric efficiency approaches zero (0%) percent. On other occasions, the required vacuum is attainable with the single stage arrangement but only by permitting the volumetric efficiency to drop to an extremely low value.

Two stage operation may be effected by using one end of the cylinder for the first stage and the other end for the second stage. This reduces the piston displacement of a given size pump by approximately fifty (50%) percent. Since the actual capacity is the product of the piston displacement and the volumetric efficiency, a single stage arrangement will have a greater capacity, or will pump faster, during the time that most of the air is being withdrawn from the vessel or tank. At extremely high vacuums, say, minus 28 or minus 28.5 inches mercury, the actual capacity of the single stage pump drops below the capacity of the two stage arrangement due to the reduced efficiency and in spite of the higher displacement.

An object of this invention is to establish a high degree of evacuation with a minimum loss of time. Accordingly the invention provides a single stage system during the major part of the evacuation of the vessel and automatically converts the system to double stage when the inlet pressure drops below a predetermined amount.

Another object is to permit adjustment of the value of the pressure at which the conversion

occurs, whereby the operator may set the control element to select whichever system has been found to result in the greater capacity at any given inlet pressure.

5 A feature of the invention resides in an automatically controlled passageway between the two piston chambers which transfers the air from the low pressure to the high pressure chamber during two stage operation, but which is inoperative when the pump is arranged to operate single stage.

10 A further object is the provision of valve mechanism adapted under certain conditions to permit air to flow through a passageway in one direction and under other conditions to prevent the flow in either direction. According to this invention, the passageway is provided with a set of inlet valves and a set of discharge valves, both controlling the same passageway. As long as both valves are in operation, the passageway is blocked. Upon actuation of the inlet valve by the valve lifter, the discharge valves are conditioned for operation, and vice versa.

15 A further object is to reduce manufacturing costs by the use, wherever possible, of standard parts modified slightly in structure but adapted to function in a novel manner.

20 Other objects and structural details of the invention will be more apparent from the following description when read in conjunction with the accompanying drawings, wherein:

25 Fig. 1 is a diagrammatic view of a pump embodying the mechanism of the invention and shows the machine as it functions during single stage operation.

30 Fig. 2 is a view similar to Fig. 1, but shows the machine as it functions during two stage operation.

35 Fig. 3 is a view, chiefly in section, of the valve assembly of the invention and a differential control element therefor, shown in operative relation.

Referring to Fig. 1, there is provided in the machine of the present invention, a cylinder 5 within which a piston 6 is reciprocally mounted. The cylinder 5 is formed with inner walls 7 and 8, and the space between each of the walls 7 and 8 and a respective side of the piston 6 forms an individual compression chamber; the two chambers being identified in the drawings as C1 and C2. To permit the passage of air to and from the compression chambers C1 and C2, a plurality of ports 9 and a plurality of ports 11 are formed in each of the inner walls 7 and 8. For convenience of illustration only one port 9 and one port 11 is shown herein in each inner

wall. The ports 9 place the chambers C1 and C2 into communication with a common passageway 12 which is connected to a main air inlet 13. The ports 11 place the chambers C1 and C2 into communication with a common passageway 14 which is connected to a main air discharge or outlet 16. Positioned in each port 9 is a valve 18 arranged to function as an inlet valve, and positioned in each port 11 is a valve 19 arranged to function as a discharge valve. The several valves 18 and 19 are urged to closed position by individual springs 21. The main air inlet 13 is arranged to be connected to a vessel or tank (not shown) from which the air is taken, while the outlet 16 is arranged to discharge to atmosphere.

The several elements thus far described represent the essential elements of a vacuum pump. The piston 6 may be connected, by means of its shaft 22, to any suitable source of power and upon reciprocation of the piston the several valves 18 and 19 will function in regular sequence to admit air to the chambers C1 and C2 and permit the discharge of compressed air therefrom. With the piston 6 travelling in the direction indicated by the solid arrow in Fig. 1, inlet valve 18, in inner wall 7, has opened and air is passing from main inlet 13 through passageway 12 and port 9 into compression chamber C1. Discharge valve 19, in wall 7, is held closed by its spring 21, at this time, and prevents the escape of air from passage 14 to chamber C1. In chamber C2, on the other hand, the air previously admitted thereto is being compressed and has forced the discharge valve 19, in inner wall 8, off its seat to permit the compressed air to pass through passageway 14 and out through discharge 16. The direction of flow through the respective passageways at this time is indicated by the solid arrows in Fig. 1. Inlet valve 18, in wall 8, is held closed, at this time, by its spring 21 and by the pressure of air acting upon it from chamber C2. Still referring to Fig. 1, it will be evident that, during the return movement of piston 6, the above described operation of the valves 18 and 19 is reversed, the respective directions being indicated by the broken arrows. That is, with the piston moving leftward, as viewed in Fig. 1, inlet valve 18, in inner wall 8, and discharge valve 19, in inner wall 7, are open, whereas, inlet valve 18, in wall 7, and discharge valve 19, in wall 8, are closed.

In a pump functioning in the above manner the air introduced through inlet 13 is compressed and discharged in a single stage of operation. As long as the pressure in inlet passage 13 is moderate, the single stage arrangement results in a greater capacity or rate of evacuation. When the pressure drops beyond a certain amount, say, minus twenty-eight (28") inches mercury, the capacity under single stage condition falls below the two stage capacity. At this point, and before the inlet pressure arrives at the maximum degree of vacuum obtainable under single stage conditions, it becomes desirable to modify the operation of the machine and initiate two stage operation thereof. A control mechanism for automatically initiating such a change in operation is provided in the present machine and will now be described.

Referring to Figs. 1 and 2, it will be seen that the inner wall 7 is formed with a port 23, in addition to the previously described ports 9 and 11, and that the inner wall 8 is formed with an additional port 24. The ports 23 and 24 establish

communication between the respective compression chambers C1 and C2 through a common passageway 25, which passageway is separated from the passageways 12 and 14 by walls 26 and 27. The flow of air through the ports 23 and 24 and the passageway 25 is controlled by a special valve assembly 28, positioned in the port 23, and by a valve 29, positioned in the port 24. The valve 29 is arranged and constructed in the same manner as the previously mentioned valves 18 and functions as an inlet valve. The valve assembly 28 is constructed as a combination inlet and discharge valve and operates normally to prevent the passage of air through the port 23, in either direction. Thus, during the normal or single stage operation of the machine no air is permitted to pass through the passageway 25 and no communication is established between the chambers C1 and C2. Under a condition and by means later to be described, however, the inlet valve of assembly 28 is unseated, or opened, thereby conditioning the assembly to function as a discharge valve. With valve assembly 28 so functioning, the air compressed in chamber C1 is forced through port 23 and passageway 25, past inlet valve 29 and into chamber C2, where it is again compressed and driven through the regular discharge ports. The machine is shown in two stage operation in Fig. 2 where the piston 6 is shown moving leftward or in a direction to compress the air in chamber C1. It will be noted that in two stage operation the regular discharge valve 19, in inner wall 7, and the regular inlet valve 18, in inner wall 8, do not function due to the change in pressures in the chambers C1 and C2.

Referring now to Fig. 3 for a consideration of the structural details of the valve assembly 28, it will be seen that the assembly represents a modification of an unloader valve such as that disclosed in the patent to W. H. Callan, No. 1,275,843, issued August 13, 1918. In the present instance, the valve assembly 28 is associated with the inner wall 7 and the outer wall of the cylinder 5. The port 23 of inner wall 7 is stepped to receive a plate assembly comprising a pair of valve seats 32 and 33 and a valve keeper 34, positioned between the seats 32 and 33. The several elements 32, 33, and 34 are held in a fixed spaced relationship by a bolt 35 and by a spacing ring 36 interposed between the two valve seats 32 and 33. The plate assembly is held within the opening 23 by a plurality of holders 37 (one shown) extending between the valve seat 32 and a closure plate 38 which closes an opening 39 in the outer wall of the cylinder 5. Each valve seat 32 and 33 is formed with several series of openings 41 and associated with each series of openings is a ring valve 42. The set of ring valves 42 associated with each valve seat is positioned adjacent the valve keeper 34, on opposite sides thereof, and the several valves are normally held against their respective seats by individual volute springs 43, supported within the valve keeper, and close the openings 41. The separate sets of ring valves 42 are thus oppositely disposed and function normally to prevent the passage of air in either direction through the assembly. It will be evident, however, that if one of the sets of valves is held open the assembly will function as a regular inlet or discharge valve, dependent upon which set is opened. Since, in the present construction, it is intended that the assembly should function as a discharge valve, during two stage operation, a valve lifter 44 is

arranged to actuate the set of ring valves associated with the upper valve seat 32. The valve lifter 44 is guided by a cylindrical bracket 45, secured to the lower face of the closure plate 38, and is formed with a plurality of fingers 46 which extend into the openings 41 in seat 32 and overlap the upper set of ring valves 42. The valve lifter 44 has secured thereto a rod 47, which extends upwardly within the bracket 45, and there is interposed between a collar 48, surrounding the rod 47, and the lower end of the bracket, a compression spring 49 which urges the valve lifter upwards into ineffective position with respect to the ring valves 42. Also positioned within the bracket 45 and supported atop the rod 47 is a lifter actuating piston 51 which is pressed upward into engagement with the lower surface of a diaphragm 52, the outer edges of which are clamped between the upper end of the bracket 45 and the closure plate 38. The lower surface of the plate 38 is recessed at its mid portion to form, above the diaphragm 52, a chamber 53 to which air may be conducted through a port 54 formed in the closure plate. It will be apparent that the introduction of air into the chamber 53, of sufficient pressure to overcome the spring 49, will force the diaphragm 52 and piston 51 downward to actuate the valve lifter 44 and thereby unseat the ring valves 42 associated with upper valve seat 32. When this occurs, the compressed air from compression chamber C1 is free to flow through lower valve seat 33, through and around valve keeper 34, past the upper set of valves 42 and through the passageway 25 to compression chamber C2.

The means for controlling the flow of air to the chamber 53 comprises a differential control element 55 (Fig. 3) connected to the valve assembly 28 by a pipe line 56, one end of which extends into the port 54 in plate 38 and the other end of which extends into a port 50 formed in element 55, near its upper end. The control element 55 is broadly similar to the device disclosed in the patent to J. C. Moody and L. F. Hoffman, No. 1,682,848, issued September 4, 1928, and reference may be had to that patent for structural details not herein specifically mentioned. A plate valve 57, positioned within the control element 55 and movable between respective upper and lower valve seats 58 and 59 divides the interior of the control element into an upper chamber 61 and a lower chamber 62. The chambers 61 and 62 are connected to the port 50 by respective passages 63 and 64 and, by reason of the pipe 56, may be placed into communication with the chamber 53 of valve assembly 28. In accordance with the usual construction of devices of this sort, the plate valve 57 is adapted to close and open the passages 63 and 64 alternatively, dependent upon its position with respect to the oppositely disposed valve seats 58 and 59. A plunger 65, pressed upwardly by a compression spring 66, acts upon the lower surface of valve 57 to retain the valve normally upon upper seat 58. In this position of the valve communication between chamber 61 and passage 63 is cut off and free communication between chamber 62 and chamber 53, through passage 64 and pipe 56, is established. Movement of valve 57 downward to connect chamber 61 to chamber 53, and to close chamber 62, can thus take place only when the difference in pressure in chambers 61 and 62 is sufficient to overcome the upward pressure of spring 66.

The control element 55 is formed with an open-

ing 67, extending into the chamber 61, and a second opening 68, extending into the chamber 62. Referring now to Figs. 1 and 2, it will be seen that by means of a pipe line 69, one end of which extends into the opening 68 and the other end of which is connected to the main air inlet 13, the chamber 62 and the main air inlet are placed in constant communication. There is also shown in the drawings a pipe line 71 which extends into the opening 67 and connects the chamber 61 to the discharge outlet 16.

If it be assumed that the machine illustrated is arranged to operate as a compressor, the main air inlet 13 is opened directly to atmosphere and the air within lower chamber 62 of control element 55 is of constant atmospheric pressure. Air pressure within the chamber 61, on the other hand, will vary with the discharge or receiver pressure and when the pressure in this chamber builds up sufficiently to force the valve 57 down, against the pressure of spring 66, pressure fluid will pass into chamber 53 to cause actuation of valve lifter 44 and initiation of two stage operation. If it be assumed that the machine illustrated is a vacuum pump, the main air inlet 13 is connected to the vessel or chamber to be exhausted and, accordingly, the air pressure in chamber 62 will drop with the pressure in the vessel. Chamber 61, in this instance, may be connected directly to atmosphere or the connection to discharge 16 may be maintained since air is discharged from the pump at a substantially constant pressure. Thus, when a certain point of vacuum is reached in the chamber 62, the difference in pressure between this chamber and chamber 61 causes the valve 57 to move down and the constant pressure of chamber 61 is free to pass to chamber 53 and actuate valve lifter 44, as before described. In connection with this operation, it will be noted that the area between valve seat 32 (Fig. 3) and diaphragm 52 is a part of the connecting passageway 25 and that the air in this passageway is maintained at sub-atmospheric pressure, during single stage operation, by the regular action of special inlet valve 29 (Fig. 1). The introduction of atmospheric pressure within chamber 53, therefore, occasions a difference in pressure above and below the diaphragm 52 sufficient to overbalance the spring 49.

The control element 55 is susceptible of manual adjustment whereby the degree of vacuum required for the actuation of valve 57 may be predetermined. An adjusting knob 72 extends into the lower end of the control element and engages a collar 73 which surrounds the plunger 65 and serves as a movable base for the expansion spring 66. By turning the knob 72 in one direction or the other the pressure exerted by spring 66 may be increased or diminished and the degree of pressure variation, between chambers 61 and 62, necessary for the actuation of valve 57 may thereby be predetermined.

If it should for any reason be found desirable constantly to operate the machine two stage, regardless of pressure differences within the control element 55, a second adjusting knob 74 is provided which extends into the upper end of the control element and has its lower end 75 overlying the valve 57. By adjustment of this knob, the valve 57 may be positively held on its lower seat 59 and pressure fluid admitted constantly to the chamber 53.

What is claimed is:

1. A valve assembly including a set of ring valves arranged to prevent the passage of air

through the assembly in one direction, and a second set of ring valves arranged to prevent the passage of air therethrough in the opposite direction, whereby said sets of ring valves cooperate to prevent normally the passage of air through said assembly in either direction and whereby to permit the passage of air therethrough in one direction only upon actuation of one of said sets of valves.

2. A valve assembly comprising a set of spring pressed valves arranged to prevent the passage of pressure fluid through the assembly in one direction, a second set of spring pressed valves arranged to prevent the passage of pressure fluid through the assembly in the other direction, selectively operable mechanical means for holding one of the sets of valves open to permit the flow of fluid in one direction under control of the second set of valves, and means for disabling the mechanical holding means to prevent the flow of fluid in either direction.

3. A valve assembly comprising a pair of apertured valve seats, a set of ring valves for each valve seat and normally acting to close the apertures in a respective valve seat, a valve keeper common to both of said valve seats and having means for urging said ring valves to seated or closed position, means for securing said valve seats and said valve keeper in a fixed relationship, and a valve lifter for lifting one set of said ring valves from its valve seat to permit the other set to operate.

4. A valve assembly comprising a pair of apertured valve seats, a set of ring valves for each valve seat, said sets of valves being so positioned with respect to the apertures in their respective valve seats as to cause one set to function as an inlet valve and the other set as a discharge valve, a valve keeper common to both of said valve seats and having means for urging said ring valves to seated or closed position, means for securing said valve seats and said valve keeper in a fixed relationship, and a valve lifter for unseating one set of said ring valves from its valve seat.

5. In a pump, a plurality of piston chambers, a port formed in each of said chambers, a passageway connecting said ports, an inlet valve positioned in one of said ports, a valve assembly comprising an inlet valve and a discharge valve positioned in the other of said ports, and means for opening the inlet valve of said valve assembly whereby said assembly is conditioned to act as a discharge valve.

6. In a device of the class described, a cylinder, a piston movable within said cylinder and forming separate compression chambers within said cylinder on opposite sides of said piston, a pair of ports formed in said cylinder each communicating with a respective compression chamber, a passageway connecting said ports and thereby said chambers, an inlet valve positioned in one of the said ports, a valve assembly comprising an inlet valve and a discharge valve positioned in the other of said ports, and means for opening the inlet valve of said valve assembly whereby said assembly is conditioned to act as a discharge valve.

7. In a pump having an inlet and an outlet, the combination of a pair of piston chambers, each of which communicates under valve control with the inlet and outlet, a passageway connecting said piston chambers, a pair of oppositely disposed valves positioned in said passageway, and means for actuating one of said valves

to permit the passage of pressure fluid from one of said piston chambers to the other.

8. In a pump having an inlet and an outlet, the combination of a piston chamber, means controlled by respective inlet valves and discharge valves for placing said piston chamber in communication with the inlet and outlet, a valve assembly for venting said piston chamber, pressure fluid responsive means for actuating said valve assembly, means for controlling the flow of pressure fluid to said actuating means including a differential control element having a chamber in communication with the inlet and a chamber in communication with the outlet, and means responsive to changes in pressure within said control element chambers for placing either of said chambers into communication with said valve assembly actuating means.

9. In a pump having an inlet and outlet, the combination of a pair of piston chambers, each of which communicates under valve control with the inlet and outlet, a passageway connecting said piston chambers, a pair of oppositely disposed valves positioned in said passageway, pressure fluid responsive means for actuating one of said valves to permit the passage of air from one of said piston chambers to the other, means for controlling the flow of pressure fluid to said actuating means including a differential control element having a chamber in communication with the inlet and a chamber in communication with the outlet, and means responsive to changes in pressure within said control element chambers for placing either of said chambers into communication with said valve actuating means.

10. In a pump having an inlet and an outlet, the combination of a pair of piston chambers each of which communicates under valve control with the inlet and outlet, a passageway connecting said chambers, a pair of oppositely disposed valves positioned in said passageway, pressure fluid responsive means for actuating one of said valves to permit the passage of air from one of said piston chambers to the other, means for controlling the flow of pressure fluid to said actuating means including a differential control element having a first chamber in communication with the inlet and a second chamber in communication with the outlet, and means responsive to a predetermined difference in pressure between said control element chambers for placing the second said chamber into communication with said valve actuating means.

11. In a pump having an inlet and an outlet, the combination of a pair of piston chambers each of which communicates under valve control with the inlet and outlet, a passageway connecting said chambers, a pair of oppositely disposed valves positioned in said passageway, pressure fluid responsive means for actuating one of said valves to permit the passage of air from one of said piston chambers to the other, means for controlling the flow of pressure fluid to said actuating means including a differential control element having a first chamber in communication with the inlet and a second chamber in communication with the outlet, means responsive to a predetermined difference in pressure between said control element chambers for placing the second said chamber into communication with said valve actuating means, and an adjustable resilient means acting upon said last mentioned means for holding said means against operation until said predetermined extent of pressure variation is reached.

12. In a pump or compressor having an inlet and an outlet, a first and a second piston chamber each having a discharge valve connecting the chamber to the outlet and an admission valve connecting the chamber to the inlet, a passageway connecting the chambers with each other, a supplementary discharge valve between the first chamber and the passageway, a supplementary inlet valve between the passageway and the second chamber, means for preventing the flow of pressure fluid through said passageway from the first to the second piston chamber to cause both chambers to operate single stage, and automatic means for releasing the flow preventing means to cause the chambers to operate double stage.

13. A pump or compressor according to claim 12, in which the automatic means operates in response to a predetermined difference in pressure between the inlet and outlet.

14. A pump or compressor according to claim 12, in which the flow preventing means comprises a releasable inlet valve adjacent the supplementary discharge valve.

15. A valve assembly, comprising a first valve settable to effective and ineffective positions and adapted when in effective position to prevent the passage of air through the assembly in one direction, a second valve settable to effective and ineffective positions and adapted when in effective position to prevent the passage of air through the assembly in the opposite direction, whereby said valves cooperate to prevent normally the passage of air through the assembly in either direction and whereby to permit the

passage of air through the assembly in one direction only upon movement of one of said valves to ineffective position, means urging said first and second valves to effective position, actuating means for moving one of said valves to ineffective position, and a yielding means resisting operation of said actuating means.

16. In a pump or compressor having an inlet and an outlet, a pair of piston chambers each having a discharge valve connecting the chamber to the outlet and an admission valve connecting the chamber to the inlet, a passageway connecting the chambers with each other, a valve assembly positioned in said passageway for controlling the flow of air therethrough and comprising, a first valve settable to effective and ineffective positions and adapted when in effective position to prevent the flow of air through the passageway in one direction, a second valve settable to effective and ineffective positions and adapted when in effective position to prevent the flow of air through the passageway in the opposite direction, whereby said valves cooperate to prevent normally the flow of air through the passageway in either direction and whereby to permit the flow of air through the passageway in one direction only upon movement of one of said valves to ineffective position, means urging said first and second valves to effective position, actuating means for moving one of said valves to ineffective position, and means responsive to a predetermined difference in pressure between the inlet and the outlet for initiating operation of said actuating means.

LESTER L. COLLINS.