May 9, 1950 A. TRASK 2,506,751

COMPRESSOR SUCTION VALVE

Filed Nov. 3, 1945 2 Sheets-Sheet 1

Fig. 1.

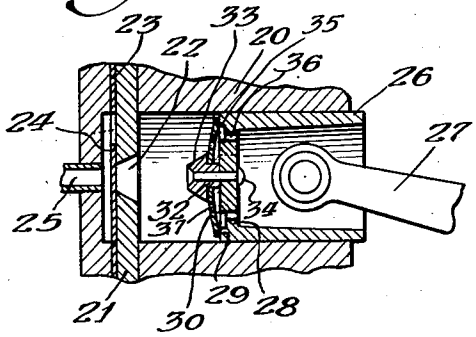


Fig. 2.

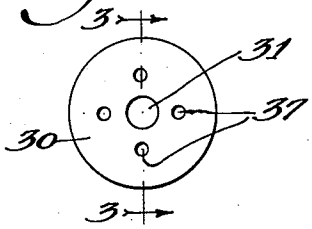


Fig. 3.

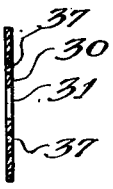


Fig. 4.

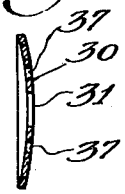


Fig. 5.

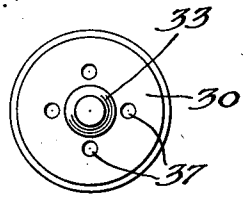


Fig. 8.

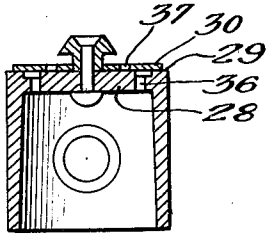


Fig. 6.

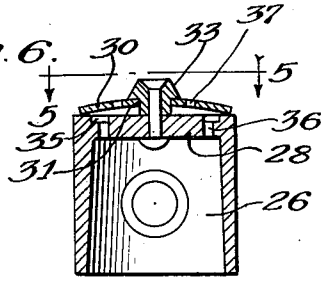


Fig. 9.

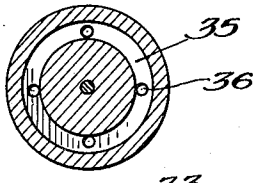


Fig. 7.

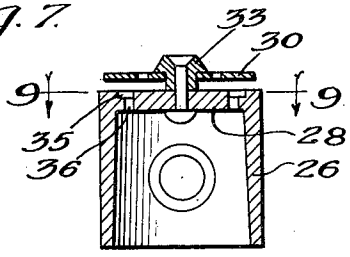
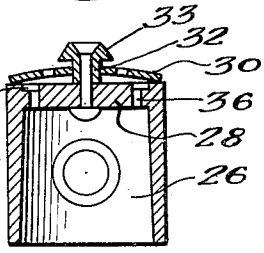


Fig. 10.



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Filed Nov. 3, 1945 2 Sheets-Sheet 2

Fig. 11.

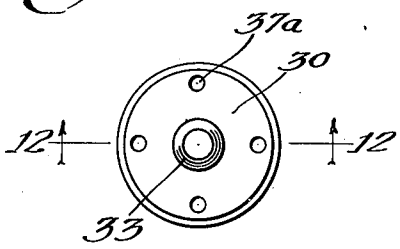


Fig. 13.

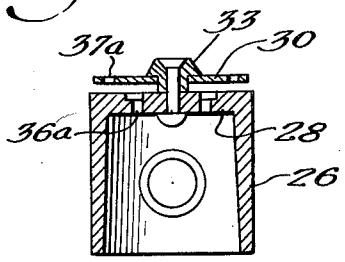


Fig. 12.

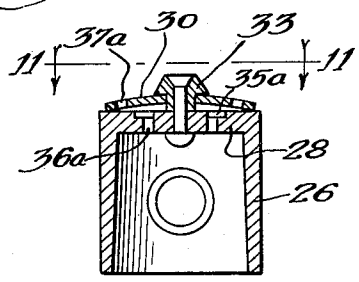
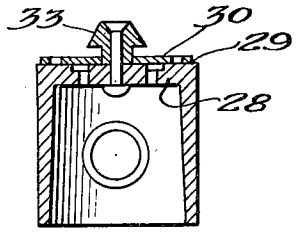


Fig. 14.



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UNITED STATES PATENT OFFICE

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COMPRESSOR SUCTION VALVE

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Application November 3, 1945, Serial No. 626,535

7 Claims. (Cl. 230—228)

1

This invention relates to valves for fluid compressors, vacuum pumps and the like, and more particularly to suction valves for high speed refrigeration compressors.

Among the principal objects and advantages of the invention, it is intended to provide an efficient, simple and inexpensive valve that is particularly well suited for use in high speed compressors or vacuum pumps. The valve is responsive to operating speed so that in starting the compressor pump will start only after a predetermined speed is reached. The valve has the property of remaining open for fluid intake for a longer portion of the compressor pumping cycle than is customary with conventional suction valves. This feature provides improved volumetric efficiency in the operation of high speed compressors. The valve forming the subject matter of the present invention also eliminates the problem of vibration or flutter that often occurs during high speed operation. The simplicity of the present valve lends it particularly well to large quantity production.

The foregoing constitute some of the principal objects and advantages of the present invention, others of which will become apparent from the description which follows and from the drawings, in which

Fig. 1 is a fragmentary, longitudinal sectional view through a portion of a cylinder showing a piston mounted therein with the valve arrangement embodying the present invention;

Fig. 2 is a plan view of the disc valve shown in Fig. 1;

Fig. 3 is a sectional view through the valve of Fig. 2; the view being taken on the line 3—3 of Fig. 2 and showing the valve in its flattened condition;

Fig. 4 is a view corresponding to Fig. 3 but showing the valve in its dished position;

Fig. 5 is an end view of the valve and piston assembly showing the view shown in Fig. 6 and illustrating a modified form of the invention, the view being taken in the direction indicated by the line 5—5 of Fig. 6;

Fig. 6 is a longitudinal sectional view through the piston and valve assembly showing this modified valve arrangement, the valve being in its normal or neutral position;

Fig. 7 is a view corresponding to Fig. 6 but showing the valve in the position which it assumes during acceleration of the piston at the first part of a high speed suction stroke;

Fig. 8 is a view of the valve and piston arrangement corresponding with Figs. 6 and 7 but shown seated against the piston head in the position assumed during acceleration of the piston during the first part of a high speed compression stroke;

Fig. 9 is a transverse sectional view taken through the piston head on the line 9—9 of Fig. 7;

2

Fig. 10 is a longitudinal sectional view through the piston showing still another embodiment of the invention wherein the normal dished valve is provided with means for an increased lift during the suction phase of a compression cycle;

Fig. 11 is an end view of a piston and valve assembly illustrating a further modification in the present invention, the view being taken on the line 11—11 of Fig. 12;

Fig. 12 is a longitudinal sectional view through a piston showing the relationship between the valve and the piston, wherein the valve is in its normal dished position corresponding to the raised condition of the piston;

Fig. 13 is a view corresponding to Fig. 12 but showing the valve in full open position assumed during acceleration during the first part of the suction stroke of the piston; and

Fig. 14 is a view corresponding to Figs. 12 and 13 but showing the valve seated against the piston head in the closed position which is assumes during the compression phase of the pumping cycle.

For purposes of illustration specific embodiments of the invention are shown and will be described, it being recognized however that many modifications may be made in the form of the device without departing from the intended scope of the invention.

Referring now to the drawings and particularly to Fig. 1, the invention is shown in conjunction with a cylinder 20 of a compressor having an end wall 21 provided with a valve port 22 that is adapted to be selectively opened or closed by a reed flap valve member 23. The reed portion of this flap valve is shown at 24 and is movable away from the port 22. A passage 25 is adapted to communicate with the valve port 22 when the reed 24 is disposed away from the port 22.

In the cylinder 20 is mounted a piston 26 adapted to reciprocate under the influence of power directed to the piston through a suitable connecting rod 27.

This piston 26 is provided with a piston head 28 having a flat outer surface 29 that provides a valve seat for a disc-like valve member 30. This disc-like valve member 30 is provided at its center with a perforation 31 (see Fig. 2) that receives the shank portion 32 of a valve button 33. This valve button 33 may be riveted to the valve head as shown at 34. The piston head 28 is provided on its outer surface 29 with an annular groove 35 (see Fig. 9) and a plurality of openings or valve ports 36 pass through the valve head 28 to place the interior of the piston 26 into communication with the annular groove 35. The relative locations of this groove 35 and the ports 36 in the valve head 28 may be varied as will be brought out more clearly.

Referring specifically to Figs. 2 to 4 inclusive

the valve member 30 comprises a relatively thin disc-like member that is normally dished as shown in Fig. 4 so as to be concave on one face thereof. A plurality of openings or ports 37 pass through the disc and the relative locations of these ports 37 with respect to the center of the disc likewise may be varied as will be disclosed hereinafter. The disc 30 is flexible so that it may readily assume a flat condition as shown for example in Fig. 3, but the characteristic of the material in the disc is such that the valve 30 will normally assume the dished position shown in Fig. 4.

A number of different variations or embodiments of the invention are illustrated herein, but in all of them the valve 30 when properly mounted on the piston head 28 is disposed with its concave side facing the piston head. This condition is illustrated in Figs. 6, 10 and 12 and in each instance the relationship of the various elements corresponds to the at-rest position of the piston 26. On acceleration of the piston 26 during the suction stroke thereof the valve member 30 is caused to flatten out as shown in Figs. 7 and 13, in which position the valve member 30 is held underneath the shoulder portions of the valve button 33 in spaced relationship with respect to the outer surface of the piston head 28. During this suction stroke of the piston 26 it is moving in a downwardly direction in connection with Figs. 7 and 13 or in a direction from left to right in connection with the showing of Fig. 1.

During the acceleration phase of the compression stroke the valve member 30 assumes the flat condition shown in Figs. 8 and 14 wherein the valve member is seated against the valve seat 29 formed on the outer surface of the piston head 28.

Referring particularly to Fig. 6 the valve 30 in this embodiment of the invention is shown in its normal position of rest on its valve seat on the head of the piston 26. In this form the flanged head of the button 33 holds the valve member 30 in tension between the shoulder of the button 33 and the valve seat on the end of the piston head 28. In this position the periphery of the concave face of valve member 30 is urged by spring action of the valve member against the valve seat. When the piston is placed in operation and during the initial stages of acceleration of the piston the valve member 30 remains in its at-rest position shown in Fig. 6 until the rate of reciprocation of the piston 26 is increased sufficiently to cause flexing of the valve member 30. During this reciprocating motion of the piston 26 the fluid in the cylinder 20 passes through the open ports 36 and 37 located respectively in the piston head 28 and the valve member 30. When a predetermined reciprocating speed of the piston 26 has been reached the pressure of the fluid against the concave side of the valve member 30, together with the influence of its own inertia on acceleration during the suction stroke of the piston causes the valve member 30 to assume a flattened position in spaced relationship with respect to the valve seating as shown in Fig. 7. Under these conditions the fluid in the cylinder flows into the compression chamber of the cylinder from the interior of the piston through ports 36 and 37. At the end of the suction stroke the forces applied to the valve member 30 are released so that the valve member returns to its at-rest position shown in Fig. 6. During the acceleration phase of the compression stroke of the piston the fluid taken into the compression chamber which is now located on the outside of the valve 30, causes the valve member 30 to assume its flat position shown in Fig. 8 against the valve seat. In this flattened or closed position of valve 30 the ports 36 and 37 are out of alignment and completely closed off so that the fluid in the compression chamber is forced out of the cylinder through port 22 (Fig. 1) and past the reed or flap 24.

In the arrangement shown in Fig. 6 the ports 37 in the dished valve member 30 are disposed adjacent to the center of the valve member 30, whereas the ports 36 in the valve head 28 are disposed at remote positions with respect to the center of the valve head. Under these conditions the spherical curvature or dished shaped condition of the valve member 30 creates an arched passage for communication between ports 36 and 37 during all the time that valve member 30 retains its dished shaped condition. When the valve member 30 is in its flat open position shown in Fig. 7, additional openings are provided around the edges of the valve to provide freer flow of the fluid from inside the piston 26 to the compression side of the cylinder. The annular groove 35 in the valve seat 29 increases the cross sectional area of communication from ports 36 to the annular opening provided under the periphery of the valve member 30 while the valve is in its open position shown in Fig. 7. Thus valve member 30 provides a proportionately large suction opening and thereby high volumetric efficiency is obtained at high speeds of compression operation. This is one important feature of the present invention.

The preloading of spring tensioning under valve button 33, tending to maintain its spherical curvature in opposition to its force of inertia and to the fluid resistance, gains three important functional results. In the first place, by means of this tension, the beginning of valve functioning when the compressor is first started may be delayed to any one of a wide range of speeds. The specific speed of operation will depend upon the amount of spring tension in the valve 30, and the greater this tension, the higher the speed at which the compression will begin. In the second place, the beginning of compression is definite and critical to the speed of reciprocation. The valve will remain completely inoperative up to a predetermined speed and will then begin to function fully when a small increase of compressor speed is added.

In a compressor having a normal speed of 1725 R. P. M. for example, valve 30 may be designed to remain inoperative and thereby to keep the compressor unloaded during the period when the compressor is started from rest and is accelerated up to a speed of 300 R. P. M. At 325 R. P. M. the compressor will function to cause compression.

The third important functional result gained by preloading the valve 30 with spring tension is the preventing of suction valve flutter during all parts of the pumping cycle.

At the end of the suction stroke, valve 30 regains its normal position of rest as shown in Fig. 6 and remains unseated in this dished condition during the first part of the compression stroke. The seating of valve 30 takes place when acceleration of the piston 26 is sufficient to cause the inertia of the valve to equal its spring tendency to retain the spherical curvature which holds the valve off its seat. The forces that overcome this spring tendency result from the combined influence of the inertia of the valve 30

and the pressure of the fluid being compressed.

When a valve is designed to meet the selected loading speed, a ratio of valve thickness to spherical curvature is selected to produce an inertia-tension balance in the valve at the speed it is desired to have compression started. For example: In a compressor operated at 1750 R. P. M. and having a piston diameter of 1⅜" it is desired to start compression at 300 R. P. M. A valve 1½" in diameter is made from flat spring valve steel .016" in thickness and dished to a spherical curvature having the seating surface of the valve next to its central hole .012" higher than the plane of its periphery. Under valve button 33 the valve is compressed .002" so that its normal lift from its seat adjacent to the valve button is .010".

Valves constructed in accordance with this invention will deliver improved volumetric efficiency at high speeds because such valves allow a greater volume of fluid to enter the compression chamber during the suction portion of the pumping cycle than is allowed by the conventional suction valves, which are given an inherent tendency to remain seated in opposition to the fluid flow forcing the valve open by means of fluid pressure. The unseated valve construction of this invention permits an increased fluid volume to be admitted to compression because the valve is constructed so that it will open sooner and close later than the conventional valves that are retained flat on their seats in their normal at-rest position.

At the end of a compression stroke, which is of course the beginning of a suction stroke of the piston 26, the valve 30 will be opened by the spring tension which normally holds the valve 30 in its dished condition before a fluid pressure and flow is induced that would otherwise open the valve at a later point during the pumping cycle. This earlier opening of the valve will allow a larger volume of fluid to reach the compression chamber to be pumped thereby resulting in an improved volumetric efficiency.

At the end of the suction stroke of the piston 26 the valve 30 will be held open by the spring tension until forces resulting from fluid flow and valve inertia induced by the compression stroke cause the valve to close. Thus valve 30 closes only sometime after the beginning of the compression stroke. Since the valve must be forced closed against its spring tension, it will remain open longer than in the case of the conventional suction valves that are retained on their seats by induced tension. The lag in the seating of valve 30 takes advantage of the inertia of the fluid inrush to the compression chamber by providing time to include the last of the inlet flow induced by the inertia of the fluid itself.

In high speed gasoline engines it is common practice to open the intake valves before the piston has reached the position corresponding to upper dead center and to close the valves many degrees of angular rotation after the end of the intake stroke. This timing permits faster engine speeds than could be attained with the use of a shorter timed intake stroke, because the increased time admits an increased charge that obviously contains more latent energy. Likewise the efficiency of a compressor employing a valve of this invention, is increased because the normally open suction valve increases the time and length in angular degrees of the suction portion of the pumping cycle. More fluid enters the compression chamber during each suction stroke, more fluid is compressed, and an improved volumetric efficiency is gained.

The weight tension ratio of valve 30 may be such that the valve will flex in opening and in assuming a flat position on the valve seat 29 under the influence of its own inertia. Valves of the type described will function independently of fluid flow and will pump a high vacuum when called upon to do so. When a high density fluid, such as Freon is pumped at pressures above atmospheric pressures, then valve 30 may be constructed to have a stronger tension adapted to resist both the forces of inertia and fluid flow which forces flatten out the valve on its seat 29 during the compression stroke. Though the valve is simple, it effects a complicated and exact coordination of many factors that become resolved into a definite ratio of thickness to diameter and amount of spherical curvature for each combination of loading speed, normal running speed and fluid density in a high speed pump.

A different embodiment of the invention is shown in Fig. 10 wherein all the various elements are the same as those shown in Figs. 1 to 9 inclusive, except that the height of the shank 32 on the button 33 is greater than in the previous embodiment. In other words, when the valve 30 is in its at-rest position as shown in Fig. 10 there is a space between the shoulder on the head of the button 33 and the valve 30. This extra space permits the valve 30 to move freely above its seat in a direction away from the valve seat without the valve 30 being flexed to a flat condition.

Valve 30 in this embodiment of the invention functions substantially in the same manner as previously described with respect to the first embodiment. The functional difference is in the realization of a higher lift of the valve from the seat of the suction stroke resulting in advantages in vacuum pumps and compressors supplied with fluids at low absolute pressures. Valves arranged in accordance with the embodiment shown in Fig. 10 will pump and control fluids at very low density and pressure with very good volumetric efficiency and will create higher vacuum than can be obtained by conventional compressor suction valves.

The third embodiment of the invention is shown in Figs. 11 to 14 inclusive. In this embodiment the elements making up the entire assembly are similar to the first embodiment of the invention except for the relative location of the fluid intake ports 36 and 37 respectively in the head 28 of the piston 26 and in the valve 30. In this instance the ports in the valve 30 are shown at 37*a* in Fig. 11 and are disposed adjacent to the outer periphery of the valve. The piston head 28 as shown in Fig. 12 is provided with its ports shown at 36*a* disposed adjacent to the center of the head and the annular groove indicated at 35*a* has a diameter less than that of the groove 35 shown in Fig. 1. In this third embodiment of the invention, the valve button 33 holds the valve 30 under a slight tension on its seat as is the case in connection with the first embodiment of the invention. If desired, of course, the valve button 33 may allow limited vertical clearance as in the case of the embodiment shown in Fig. 10.

Suction valves of the type shown in Figs. 11 to 14 inclusive are adapted for starting compression at lower reciprocating speeds than are the valves in the first two embodiments. As

previously mentioned, the valves of all three embodiments are influenced by their own inertia and by their own fluid. The valve shown in the third embodiment, however, is influenced to a greater degree by the flow of fluid that is being pumped. At the start of compressor operation during the inertia acceleration phase, fluid flows from the cylinder through ports 37*a* in the valve 30, through the arched passage between the valve 30 and its seat (Fig. 12) and finally through the piston ports 36*a* during the compression stroke when the reciprocating speed of the piston 26 is insufficient to cause the valve to flatten out against its valve seat. Because the ports 37*a* are located close to the periphery of the valve 30 and the clearance beneath the ports is limited the flow of fluid is restricted, thus providing a quicker valve seating at which full compression begins. The position of ports 37*a* affects the compressor R. P. M. at which a valve of this type will start compression. The closer the ports 37*a* are located to the periphery of the valve, the slower will be the required reciprocating speed of the piston at which compression starts. The closer the ports are to the center of the valve 30, the greater the speed required to start compression. When the reciprocating speed of the piston 26 increases to that required to operate the valve 30, the cycle of operation as shown in Figs. 12 to 14 inclusive corresponds precisely with that previously explained with respect to Figs. 6 to 8 inclusive.

Having thus described my invention, I claim:

1. In a suction valve assembly a piston, a substantially flat valve seat on the head of said piston, a resilient suction valve with a spherical curvature adapted to substantially flatten out so as to conform to and engage the valve seat, the concave face of the valve being disposed toward the piston head, means for retaining the valve normally in unseated condition with the center of the valve spaced from the valve seat, and a fluid port in said valve adapted to be closed by said valve seat.

2. In a suction valve assembly a piston, a substantially flat valve seat on the head of said piston, a resilient suction valve with a spherical curvature adapted to substantially flatten out so as to conform to and engage the valve seat, the concave face of the valve being disposed toward the piston head, and means for retaining the valve normally in unseated condition with the center of the valve spaced from the valve seat, the piston having a port extending through the valve seat thereon, and the valve having a port therethrough disposed in staggered relationship with the first mentioned port.

3. In a suction valve assembly a piston, a substantially flat valve seat on the head of said piston, a resilient suction valve with a spherical curvature adapted to substantially flatten out so as to conform to and engage the valve seat, the concave face of the valve being disposed toward the piston head, and means for retaining the valve normally in unseated condition with the center of the valve spaced from the valve seat, the piston having a port extending through the valve seat thereon adjacent to the center of the seat, and the valve having a port therethrough disposed adjacent to the periphery thereof.

4. In a suction valve assembly a piston, a substantially flat valve seat on the head of said piston, a resilient suction valve with a spherical curvature adapted to substantially flatten out so as to conform to and engage the valve seat, the concave face of the valve being disposed toward the piston head, and means for retaining the valve normally in unseated condition with the center of the valve spaced from the valve seat, the piston having a port extending through the valve seat thereon adjacent to its periphery, and the valve having a port therethrough disposed adjacent to the center thereof.

5. In a suction valve assembly a piston, a substantially flat valve seat on the head of said piston, a resilient suction valve with a spherical curvature adapted to substantially flatten out so as to conform to and engage the valve seat, the concave face of the valve being disposed toward the piston head, means for retaining the valve normally in unseated condition with the center of the valve spaced from the valve seat and retaining the periphery of the concave side of said valve in contact with said valve seat while said valve retains its normal spherical curvature, and a fluid port in said valve adapted to be closed by said valve seat.

6. In a suction valve assembly a piston, a substantially flat valve seat on the head of said piston, a resilient suction valve with a spherical curvature adapted to substantially flatten out so as to conform to and engage the valve seat, the concave face of the valve being disposed toward the piston head, means for retaining the valve normally in unseated relationship to its seat and for restraining its movement relative to its seat to allow a limited movement of the concave periphery of the valve away from the seat while said valve retains its normal spherical curvature, and a fluid port in said valve adapted to be closed by said valve seat.

7. In a suction valve assembly a piston, a substantially flat valve seat on the head of said piston, a resilient suction valve with a spherical curvature adapted to substantially flatten out so as to conform to and engage the valve seat, the concave face of the valve being disposed toward the piston head, means for retaining the valve normally in unseated condition with the center of the valve spaced from the valve seat, said retaining means including means for guiding the valve so as to maintain the concave side of said valve in proper relationship with the seat for intermittent seating on said flat valve seat, and a fluid port in said valve adapted to be closed by said valve seat.

ALLEN TRASK.

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