Jan. 2, 1951 H. F. HADLEY 2,536,995

FLUID PUMP

Filed July 26, 1945

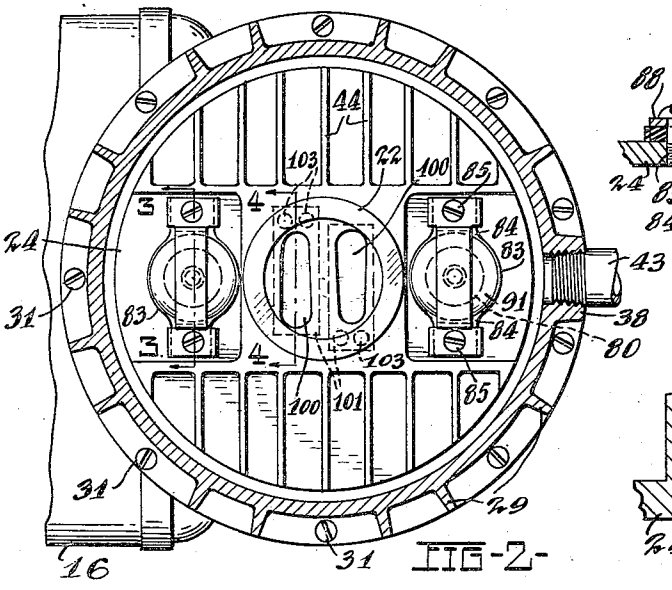


FIG-2-

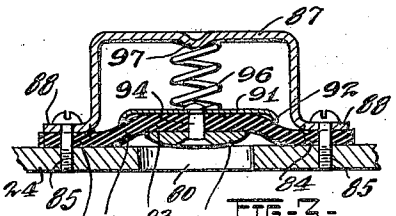


FIG-3-

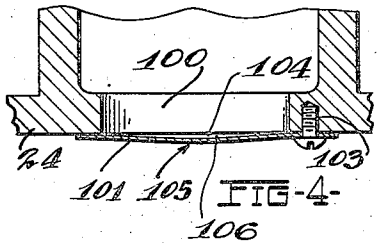


FIG-4-

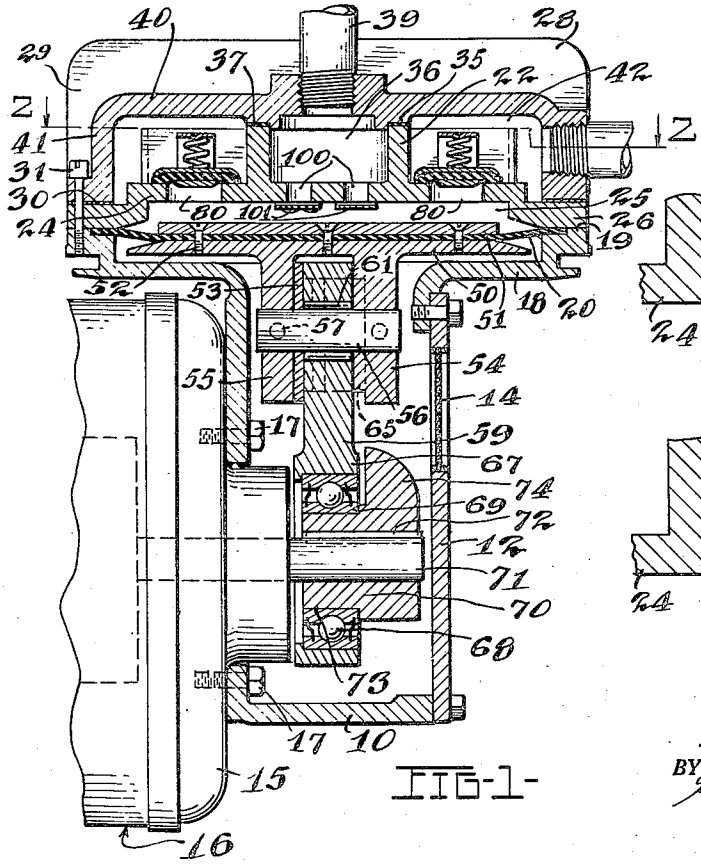


FIG-1-

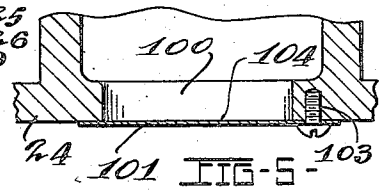


FIG-5-

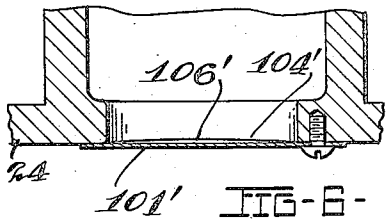


FIG-6-

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FLUID PUMP

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11 Claims. (Cl. 230—24)

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This invention relates to fluid pumps and more especially to fluid pumps or compressors of the diaphragm type.

In the use of compressors of the type or character for compressing or pumping volatile fluids, as for example air compressors, it is usual in a system wherein an air receiver is used for the storage of the compressed air, to employ in conjunction with the compressor a pressure relieving device or "unloader" mechanism to eliminate the pressure from the compression chamber when the desired compression pressure has been attained. The use of a pressure relieving device has heretofore been necessary in most installations in order that the motor or other power means for operating the compressor may be relieved of superatmospheric or compression pressure in order to facilitate subsequent starting operations of the compressor actuating motor. Such "unloader" or pressure relieving devices have been heretofore used in the form of independent instrumentalities associated with the compressor connected thereto for relieving the pressure in the compression chamber whenever the compressor operation is stopped.

One of the objects of this invention is the provision of means for eliminating superatmospheric pressure from the compression chamber when the compressor is stopped, said means forming a part of the compressor construction without the use of accessories or independent instrumentalities.

The invention comprehends an especially configurated valve arrangement which is adapted to perform the functions of an inlet valve for the compressor during operative compression cycles and to function as a pressure relieving or "unloader" device for relieving the compression pressure within the compression chamber of the compressor when the latter is brought to rest.

Another object of the invention resides in the provision of a valve construction which per se performs the function as a compressor inlet control valve and without modification or adjustment provides a means for relieving superatmospheric pressure which may exist in the compression chamber when the pumping element is stopped or comes to rest during an air compression stroke thereof.

Further objects and advantages are within the scope of this invention such as relate to the arrangement, operation and function of the related elements of the structure, to various details of construction and to combinations of parts, elements per se, and to economies of manufacture and numerous other features as will be apparent from a consideration of the specification and drawing of a form of the invention which may be preferred, in which:

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Figure 1 is a vertical sectional view illustrating a fluid pump or compressor of the diaphragm type embodying a form of my invention;

Figure 2 is a horizontal view taken substantially on the line 2—2 of Figure 1;

Figure 3 is an enlarged detailed sectional view taken substantially on the line 3—3 of Figure 2 illustrating the position of a check valve during the compression stroke of the pumping element;

Figure 4 is an enlarged detailed sectional view taken substantially on the line 4—4 of Figure 2 showing the normal position of one of the inlet valves when the fluid pump is not in operation;

Figure 5 is a view similar to Figure 4 showing the closed position of the inlet valve during a compression stroke of the pump; and

Figure 6 is a view similar to Figure 4 illlustrating a modified form of valve construction.

The fluid pump and valve construction of my invention have particular utility when utilized for the compression of gases, as for example air, but it is to be understood that I contemplate the utilization of my invention for pumping other fluids wherever the same may be found to have utility.

Referring to the drawings in detail, the arrangement is inclusive of a frame housing or casing 10 preferably formed of metal having an opening which is normally closed by means of a cover plate or closure 12. The plate or closure 12 is provided with a screened breather opening 14 in order that the air pressure within the housing 10 may be equalized with the atmosphere. The pump or compressor housing 10 in the present embodiment is particularly constructed and configurated for mounting directly upon the frame or end plate construction 15 of an electrically driven motor 16, the housing being secured to the motor frame by screws 17 or other suitable securing means. The fluid pump construction may be connected to any other source of power for operating the pumping element if desired without departing from the spirit of the invention.

The housing structure 10 is enlarged or flared outwardly as at 18, the flared portion terminates in an annular flange 19 which bounds or defines a circular recess adapted to receive the circumferential portion of a flexible diaphragm or pumping element 20. The flexible diaphragm 20 may be fabricated of rubber, synthetic rubber

or other suitable flexible material which may be reinforced with fabric, moulded integrally therewith or otherwise bonded thereto.

Positioned above the diaphragm 20 is a plate or wall 24, forming with the diaphragm a compression chamber 25, the plate 24 being formed in a peripheral flange 26 adapted to engage the periphery of the diaphragm 20 for securing the latter firmly in the recess formed by the flange 19 on portion 18 of the housing 10. Positioned above the plate 24 is a head 28 provided with cooling fins 29 and configurated with an annular surface arranged to engage a gasket 30 interposed between the head 28 and the plate 24 to provide a sealed joint. The compressor head 28, plate 24 and gasket 30 are retained in assembled relation and secured to portion 18 of the housing 10 by means of screws 31.

The plate 24 is provided with a centrally disposed upwardly projecting annular wall or flange 22 which mates with a depending annular flange 35 on the pump head 28 thus providing an air or fluid inlet passage 36 for the compression chamber 25. An annular gasket 37 of rubber or other resilient compressible material is disposed between the juxtaposed edges of the flanges 22 and 35 to provide a tight seal between the flanges. The head 28 is preferably formed with the threaded opening to accommodate an air inlet tube 39 in communication with the passage or chamber 36.

The head 28 is formed with an upper end wall 40 and an annular side wall 41 which together with the walls 22 and 35 provide an annular plenum chamber or receiver 42 surrounding the inlet chamber or passage 36. A boss portion 38 in the side wall of the head is provided with a threaded opening to accommodate a tube or pipe 43 for conveying fluid under pressure or compressed air away from the pump.

The flexible diaphragm or pumping element 20 is disposed between an circular member 50 and a disc or circular plate 51, the latter being secured to the member 50 by means of screws 52 or other suitable securing means. By this arrangement the central portion of the flexible diaphragm 20 is securedly held to the member 50. Member 50 is integrally formed with a pair of spaced depending projections 54 and 55, said projections having aligned bores to receive a journal pin 56 held in place by screws 57. A connecting rod 59 has its upper end portion extending between the projections 54 and 55 and is also bored to accommodate the journal pin 56, a needle bearing 61 being disposed between the pin and the walls of the bore in the connecting rod. A thrust bearing disc 53 preferably of the self-lubricating type is positioned between the upper portion of the connecting rod 59 and the inner wall of boss 55 while rubber blocks or resilient members 65 are disposed between the connecting rod and projection 54 whereby lateral movement between the rod and the bosses is eliminated. The rubber blocks also serve as a vibration dampening and shock absorbing means for minimizing shocks set up by rapid changes in direction of reciprocation of the diaphragm 20 and associated movable parts. The connecting rod 59 is provided with a boss 67 which is bored to accommodate a ball bearing 68. The inner race 69 of the bearing 68 snugly fits over the cylindrical portion 68 of a member 70 which is secured to the motor shaft 71 by means of a key 72. The axis of the cylindrical portion 73 of member 70 is eccentric with respect to the axis of the motor shaft 71, which eccentricity results in reciprocatory movement of the pumping diaphragm 20, connecting the rod 59 and associated parts. The member 70 is formed with a radial projection 74 which functions to substantially counterbalance the "pull" of the reciprocating parts during operation of the compressor.

The upper surface of the plate 24 is integrally provided with a plurality of spaced heat radiating fins or flanges 44 extending into the plenum chamber 42. These fins afford an extensive radiating surface area whereby a direct metallic path is provided for rapidly radiating heat of compression away from the compression chamber 25 into the compressed fluid in the plenum chamber 42. By this arrangement the compressed gases moving through and away from the chamber 42 entrains or carries away a substantial amount of the heat generated by compression or pumping operations, thus resulting in lower operating temperatures for the compressor.

As particularly shown in Figures 1 and 3, inclusive, the plate 24 is formed with spaced outlet ports 80 preferably arranged on diametrically opposed sides of the annular wall or flange 22. Suitable check valve mechanisms are arranged to close these outlet ports 80, one of said check valve means being illustrated in detail in Figure 3. The check valve or valve element 82 is preferably formed of flexible or yieldable material as for example rubber, synthetic rubber or the like, which if desired may be formed or moulded with a fabric reinforcement (not shown) for the purpose of enhancing the strength thereof. The ports 80 in the embodiment illustrated are of circular configuration and the valve element 82 is formed with a central circular portion 83 and diametrically opposed integral projected portions 84 as shown in Figure 2. The valve carrying plate 24 is provided with threaded openings adjacent each outlet port, and the projecting portions 84 of the valve are formed with openings in registration with the threaded openings in plate 24, said openings adapted to receive and accommodate securing means in the form of screws 85 to retain the valve in proper position with respect to the port opening. An inverted U-shaped bracket 87 is disposed above each valve and is formed with apertured ear portions 88 through which the screws 85 project whereby the bracket is held in place by the same means utilized for retaining the valve in position.

Disposed adjacent the lower surface of the valve element is a circular metallic disc 90 of a lesser diameter than that of the port 80. Positioned above or adjacent the other surface of the valve 82 is a circular disc 91 of metal or other suitable material which is of a diameter larger than that of the port 80. The disc 91 is formed with a depending peripheral flange 92 which engages the upper surface of the valve element 82 when the valve is in closed position as shown in Figure 2 and thus prevents the resilient valve element 82 from pounding the edge wall of the port opening 80 which construction minimizes wear of the valve thus prolonging the life thereof. The metallic discs 90 and 91 are secured to the valve member 82 by means of a rivet 94 or other suitable securing means to hold the discs at all times in proper relation with respect to the valve element 82. Interposed between a wall of the bracket 87 and the upper surface of the disc 91 is an expansive coil spring 96 which resiliently urges the valve element 82 to close the outlet port 80. As illustrated in Figure 3, the head of rivet 94 serves

to position one end of the coil spring, while a depending portion 97 formed on the bracket 87 serves to position the other end of the spring. Figure 3 illustrates this form of check valve in "open" position for the purposes of illustration, in which position the compressed gases may flow from the compression chamber 25 into the plenum chamber 42, the check valve being shown in "closed" position in Figure 1.

The plate 24 is formed with inlet ports 100 which establish communication between the inlet chamber 36 and the pumping or compression chamber 25. The inlet ports 100 are provided with valves or plates 101 of comparatively thin, flexible material preferably steel or the like for closing the inlet ports upon the compression cycle or stroke of the compressor or pump in a manner hereinafter described. In the form of the invention as illustrated in detail in Figure 4, one end of each valve plate is provided with a pair of juxtaposed openings to receive securing screws 103 or other suitable means for securing the valve to the valve carrying plate 24. Each of the inlet valves 101 is configurated into a slightly concave form as indicated at 105 so that the central portion is normally very slightly spaced away from the wall 104 of the plate 24 adjacent the inlet port 100. The free or movable end of the plate 101 normally rests against or contacts the flat surface of the valve plate 24.

In the operation of the pump or compressor, the free ends of the inlet valves 101 are flexed downwardly upon the suction stroke of the diaphragm 20 to admit air or other fluid into the compressor or pumping chamber 25. As the valve plates 101 are comparatively thin and flexible, they are easily distorted or flexed into full engagement or contact with the adjacent surfaces of the valve seats or surfaces surrounding the inlet ports 100. Thus, immediately upon the initiation of the compression cycle, at the beginning of the upward stroke of the diaphragm 20, pressure is set up within the compression chamber 25, and by reason of the kinetic inertia of the moving gases during compression, the valve 101 is instantly flexed by the compressed gases to close the inlet port so that the gases within the chamber 25 are compressed or forced through the outlet port 80 by reason of the pressure acting upon and elevating the check valve element 82 to open the outlet ports 80. Immediately upon the completion of the compression or positive pumping stroke of diaphragm, the pressure in the plenum chamber 42 co-acting with the pressure of the coil spring 96 serves to instantly close the check valve 82 to prevent the compressed fluid in the plenum chamber 42 from returning into the compression chamber 25. Upon the downward or suction stroke of the diaphragm 20, air or other fluid is again admitted through the inlet ports 100 past the valves 101 and the pumping or compression stroke repeated.

When the compressor is stopped by de-energizing the motor 16 the diaphragm very often comes to rest interim a compression cycle or stroke, as this is the point where greatest torque is placed upon the motor. When this condition occurs, a pressure is built up in the compression chamber 25 which makes it exceedingly difficult, if not possible, to again start the motor against the compression pressure existing in the motor. In compressor construction of usual design a separate relief or "unloader" mechanism is employed to effect a release of the pressure existing in the compression chamber prior to starting

the compressor. In the present invention, the concave configuration imparted to the valve plate 101 functions to relieve this compression pressure when the compressor is brought to rest upon or during a compression stroke. The valves 101 function to relieve the pressure upon the stopping of the compressor as the kinetic inertia of the moving gases during compression is reduced to a static or non-moving condition. Thus, when the air under some degree of compression at the stopping of the compressor ceases its internal movement, the inherent flexure of each plate 101, which has been distorted into completely "closed" position by the gas during compression, acts to attain its normal position as shown in Figure 4, thus providing a very slight elongated space 106, which is exaggerated in size in Figure 4 for purposes of illustration, and through which air in the compression chamber 25 may pass to the atmospheric chamber 36 until the pressure within the chamber 25 is lowered to atmospheric pressure or is balanced. The inlet port 80 becomes a relief port or means for eliminating the existent compression pressure in the chamber 25 immediately after the compressor operation ceases. Figure 5 illustrates the position of the valve 101 during compression stroke of the diaphragm 20, whereby the valve completely closes the inlet port 100 when the compressor is in operation.

Figure 6 illustrates a modified form of inlet port valve seat 104' and valve construction 101' wherein the valve plate 101' is of substantially flat configuration, and the valve seat 104' is provided with a slight concavity providing a space 106' through which air under pressure in the chamber 25 may seep until the pressure within the chamber 25 is equivalent to or is balanced with the outside or atmospheric pressure. During normal compressor operation, on the compression stroke of the pumping element 20, the inlet valve plate 101' will be flexed by reason of the rise in pressure and the resulting kinetic inertia of the gases or fluid being compressed to distort or flex plate 101' to coincide with or fit accurately the valve 104' to completely close in inlet port 80.

It is apparent that, within the scope of the invention, modifications and different arrangements may be made other than is herein disclosed, and the present disclosure is illustrative merely, the invention comprehending all variations thereof.

I claim:

1. In a device of the character disclosed in combination; a pump having a pumping chamber; fluid inlet and outlet ports therefor; a pumping element in said chamber; a check valve for the outlet port; a valve plate for the inlet port; means for securing one end of said valve plate to the chamber wall; the other end of said valve plate engaging the valve seat; an intermediate portion of said valve being slightly concave whereby the same is slightly spaced from the valve seat for eliminating pressure in the pumping chamber when the pump is not in operation; said inlet valve plate being flexible whereby the latter completely closes the inlet port during the pumping stroke of the pumping element.

2. In a device of the character disclosed in combination; a fluid pump having a pumping chamber; a pumping element; fluid inlet and outlet ports for said chamber; a check valve for the outlet port; a valve for the inlet port; a valve seat therefor; said inlet valve including a flex-

ible plate; means for securing one end of said valve plate to said wall; a valve seat adjacent said inlet port; said valve plate being formed with slight concavity whereby the central portion of said valve plate lies adjacent to but slightly spaced from the valve seat; said valve plate being sufficiently flexible whereby the application of increased pressure in the pumping chamber flexes the valve plate to completely close said inlet port.

3. In a device of the character disclosed in combination; a fluid pump having a pumping chamber; a pumping element cooperating with said chamber; fluid inlet and outlet ports for said chamber; a check valve for the outlet port; a valve for the inlet port; said inlet port including a substantially flat flexible plate; means for securing one end of said valve plate to said wall; a valve seat adjacent said inlet port and formed with slight concavity whereby said valve plate lies adjacent to but the central portion thereof slightly spaced from the concave valve seat; said valve plate being sufficiently flexible to completely close said inlet port upon a pumping stroke of the pumping element.

4. A pressure relieving means for a fluid pump; said fluid pump having a pumping chamber and a pumping element associated therewith; a relief port for said chamber; a valve for said relief port including a thin flexible plate; means for securing an end portion of said plate to said chamber wall; the other end portion of said plate engaging said wall; said chamber wall and valve plate being so configurated that the intermediate portion of said valve plate is slightly spaced from said wall when said fluid pump is not in operation.

5. A pressure relieving means for an air compressor; said compressor having a compression chamber and a pumping element associated therewith; a relief port in said compression chamber wall; a valve for said relief port including a relatively thin flexible plate; a valve seat for said plate; means for securing an end portion of said plate to said valve seat; the other end portion of said plate engaging said valve seat; said valve seat and valve plate being so configurated that under normal atmospheric pressure the intermediate portion of said valve plate is slightly spaced from said valve seat to render said relief port partially open.

6. A pressure relieving means for an air compressor; said compressor having a compression chamber and a diaphragm associated therewith; a relief port formed in a wall of the compression chamber; a valve for said relief port including a rectangularly shaped relatively thin flexible plate; means for securing an end portion of said plate to said chamber wall; the other end portion of said plate engaging said wall; said valve seat and chamber wall being so configurated that under normal atmospheric pressure the intermediate portion of said valve plate is slightly spaced from said wall to render said relief port partially open.

7. An inlet valve construction for a fluid pump chamber including a valve seat; a valve for said seat comprising a thin flexible plate having a portion normally in contact with the valve seat and another portion adapted to normally lie adjacent to but slightly spaced from the valve seat to establish a minute passage into said compression chamber for relieving compression pressure in said chamber; said valve being sufficiently flexible to completely close the inlet port upon an increase in fluid pressure in the pump chamber.

8. An inlet valve construction for an air compressor including a valve seat; a valve for said seat comprising a thin flexible metal plate having a portion normally in contact with the valve seat and another portion adapted to normally lie adjacent to but slightly spaced from the valve seat to establish a minute passage into said compression chamber for relieving compression pressure in said chamber; said valve being sufficiently flexible to completely close the inlet port upon an increase in air pressure in the compression chamber.

9. In a device of the character disclosed in combination; a fluid pump including a pumping chamber having a wall; fluid inlet and outlet ports in said wall; a check valve for the outlet port; a valve for the inlet port; an uniplanar valve seat surface for said inlet valve; said inlet valve including a thin flexible plate; means for securing said plate to said wall adjacent the inlet port whereby said plate may be flexed to open and close said inlet port; said plate being formed with a slight concavity whereby said inlet port is slightly open in a normal position of said valve; the concave portion of said valve being arranged to completely close the inlet port upon the application of increased fluid pressure against said valve.

10. A pressure relieving means for a fluid pump; said fluid pump having a pumping chamber and a pumping element associated therewith; a relief port for said chamber having a valve seat associated therewith; a valve for said relief port; said valve and valve seat having cooperating surfaces whereby a portion of said valve is resiliently maintained slightly spaced from the valve seat under atmospheric pressure while another portion of the valve engages the valve seat; said valve being arranged to completely close the relief port upon the setting up of increased pressure by operation of the pumping element.

11. A device of the character disclosed in combination, a fluid compressor having a diaphragm element; a wall forming with said diaphragm element a compression chamber; fluid inlet and outlet ports for said compression chamber; a check valve for the outlet port; a valve seat adjacent said inlet port; a valve for the inlet port; said inlet valve and valve seat having cooperating surfaces whereby a portion of said valve is maintained slightly spaced from the valve seat under atmospheric pressure while another portion of the valve engages the valve seat; said valve being arranged to completely close the inlet port by the setting up of increased pressure in the compression chamber during a compression stroke of the diaphragm element.

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