

May 17, 1932.

F. T. HOLMES

1,859,089

VALVE

Filed Aug. 15, 1929

2 Sheets-Sheet 1

Fig. 2.

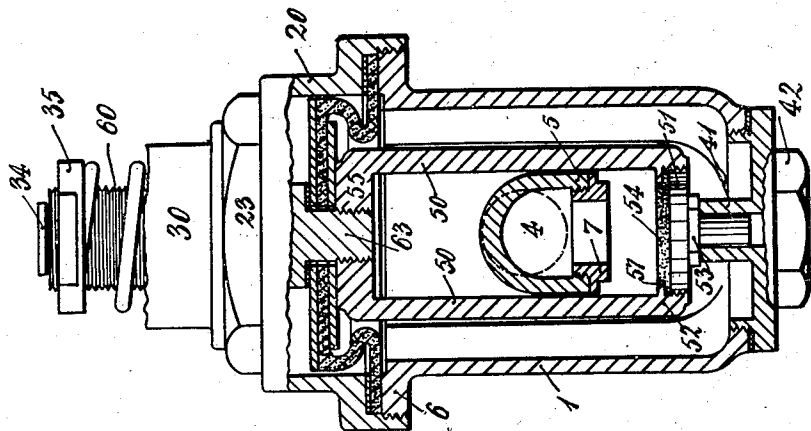
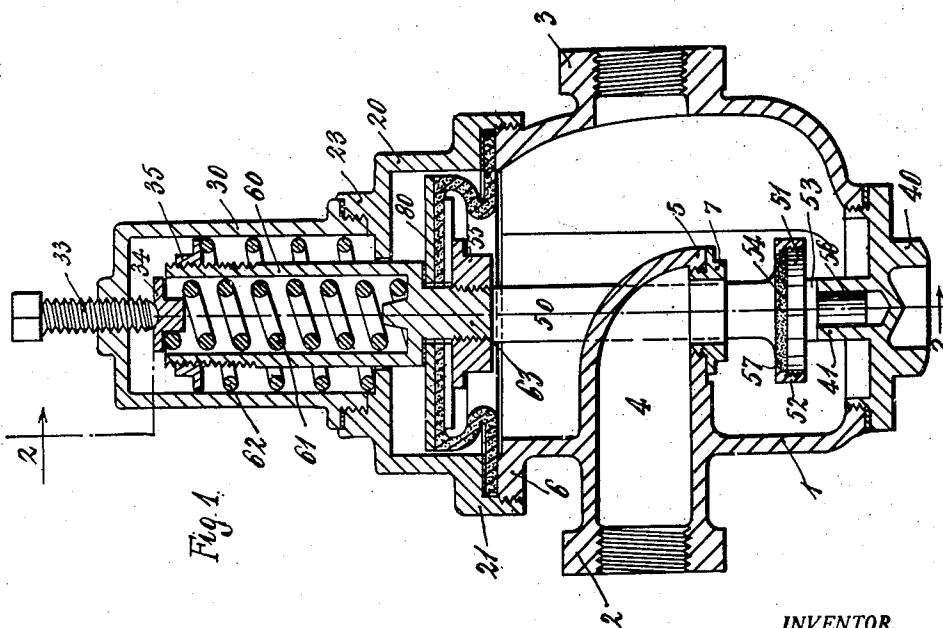


Fig. 4.



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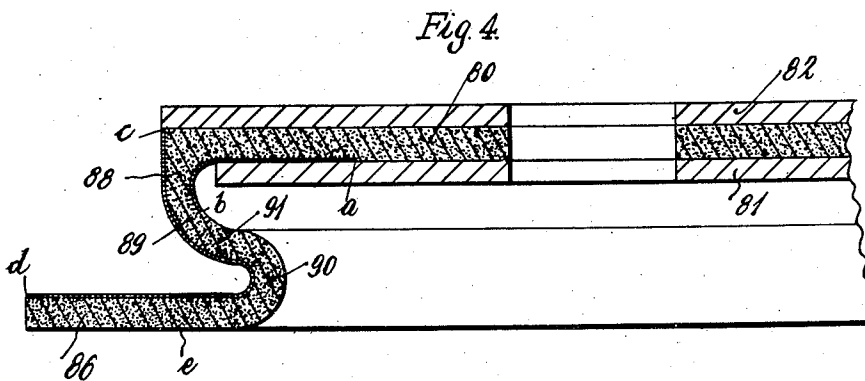
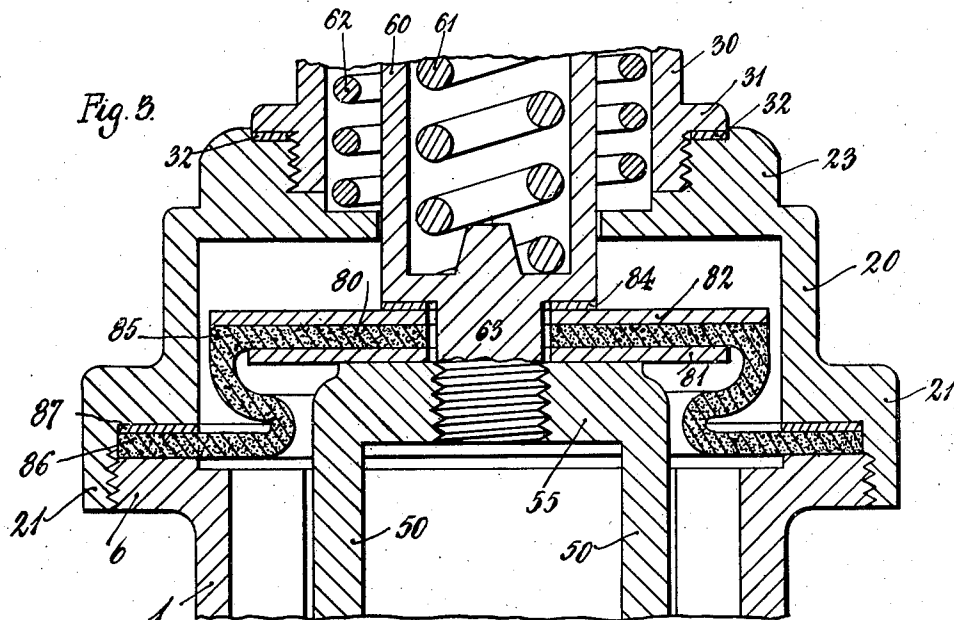
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2 Sheets-Sheet 2



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VALVE

Application filed August 15, 1929. Serial No. 386,077.

This invention relates to improvements in pressure regulating valves, such as are used for reducing the high pressure in a gas or liquid main pipe line to a lower consumption pressure.

A common principle used in these valve types and also used in my novel design is the coaction of differential pressure areas with adjustable spring means for opening and closing the valve in a predetermined manner for automatic pressure regulation. In many constructions used heretofore, there have been provided as a low pressure area either the area of a plunger or of a diaphragm. Each of these two means has its advantages and disadvantages.

According to one feature of this invention, I provide a novel means to overcome some disadvantages in each of the formerly employed elements by forming the low pressure area as a combination plunger-diaphragm, whereby at the same time further advantages not possessed by the prior construction are obtained. Still other features in my novel design will appear from the subsequent specification and claims.

In the drawings:

Fig. 1 is a vertical section on the line of symmetry of the valve and its pipe line connections;

Fig. 2 is a vertical section on the line of symmetry but at right angles to the section in Fig. 1 and with some parts shown in side elevation;

Fig. 3 is an enlarged view of the combination plunger-diaphragm and the elements directly connected to it or coacting with it; and

Fig. 4 is a detached section of the plunger-diaphragm on a larger scale and with some dimensions distorted.

I shall first give a general description of the structure and its mode of operation without particularly pointing out its novel features, in order to facilitate the understanding of the import of the modifications which form the substance of this invention and are dealt with later on.

The valve casing 1 is cast integral with the inlet and outlet flanges 2 and 3, respectively,

and with the interior downwardly discharging fluid admission channel 4 which terminates in a valve seat support 5. The comparatively short cylindrical casing 20 houses the plunger diaphragm 80 and serves as the low pressure expansion chamber. This chamber body is screwed to the top flange 6 of the valve casing with the marginal portions of the plunger-diaphragm clamped between by means of a wrench engaging flat faces provided on an upstanding flange portion 23 of the casing. The casing of the expansion chamber carries the top cap 30. The bottom of the valve casing is formed by a separate bottom cup 40 connected by threads. Supported in the middle of the diaphragm the vertically extending valve operator consisting of the two screwed together members 50 and 60 with the plunger-diaphragm clamped between, is free to perform limited vertical movements for operating the valve. The lower bifurcated or yoke member 50 carries the operable valve disk 51 by threaded engagement in a ring portion 52, and the upper hollow spindle member 60 serves as a guide for an inner depressing and an outer lifting spring, designated by 61 and 62, respectively. It is evident that a depression of the valve operator corresponds to an opening and a lifting of the operator to a closing of the valve. It will also be apparent now that this valve operates on the known principles of such valves in as far as there are provided four active forces for the valve operator: an opening force from the high pressure side on the valve disk; a closing force from the low pressure side on the plunger-diaphragm; and two oppositely directed adjustable spring forces. The amount of pressure reduction is determined by the ratios of the effective areas of the valve disk and the diaphragm of which the latter is, of course, the larger one, and by the adjustment of the spring pressure which will either accelerate or retard an opening tendency from the differential pressure areas.

I shall now give a more detailed description of the valve operation and the parts co-acting with it and, at the same time, particu-

larly point out the novel features and advantages of my design.

The bottom closure 40 is formed with a socket 41 which is inwardly machined for receiving and guiding a stem portion 56 depending from the valve disk 51 so that the valve operator is accurately guided and downwardly limited in its movements. To facilitate the attachment or removal of the bottom cup 40, its outer portion is provided with nut faces 42.

The valve disk 51 is rigidly fastened by threaded engagement to the ring portion 52 of the yoke 50 with the help of the nut faces 53. Before screwing the valve disk in its attachment ring, a flat flexible plate 54, preferably made of rubber or some composition of it, is put on top of the disk, which plate will after assemblage be clamped between the annular flange 57 of the yoke ring and the valve disk and provide a tight seal for the valve. The seat of the valve may either be directly formed on the lower portions 5 of the interior fluid channel 4 by grinding an annular portion about the channel orifice, or by providing a detachable seat member screwed in the orifice as shown in the drawings at 7.

The upper end 55 of the yoke has the shape of a plate with threaded central aperture for receiving the threaded reduced end 63 of the hollow spindle 60. This reduced end is sufficiently long to permit the accommodation between the screwed together spindle and yoke of the plunger-diaphragm assembly.

This assembly comprises, as can best be seen from Fig. 3, the plunger-diaphragm proper 80 preferably formed from rubber or some suitable rubber composition, two comparatively thin and centrally apertured metal disks 81 and 82 holding the diaphragm clamped between them, and an upper washer disk 84 which seals the whole assembly so that no fluid can pass from one side of the plunger-diaphragm to the other. The upper clamping disk 82 has the same diameter as the outer upper plunger portion 85 of the diaphragm, while the lower disk 81 is of somewhat smaller diameter to fit into the interior of the cup-shaped plunger-diaphragm structure. This inner disk is inserted in the ready shaped cup and when once inserted will remain therein and form, in connection with the rubber structure, the finished construction. Since the metal disks may be regarded as rigid with respect to the pressures employed, the upper clamped-between portion of the rubber-diaphragm will remain undeflected and, therefore, inactive in the operation of the diaphragm. The lower marginal portions 86 of the plunger-diaphragm are clamped between screwed together flange portions 6 and 21 of the valve casing and cylinder, respectively. A washer

ring 87 is added to insure a fluid tight seal between the casing and the cylinder and to prevent rumpling of the diaphragm by torsional forces while it is being screwed down on its marginal seat portions. The lower marginal and the upper inflexible portions of the plunger-diaphragm are connected by intermediate portions (see Fig. 4) which, in cross section, present an upper vertically extending plunger portion 88 and a lower pleated or corrugated portion comprising two oppositely bent sections,—an upper one 89 and a lower one 90 with a connecting portion 91 between. It is obvious that the pressures which act from the low pressure side of the valve on the disk 81 or, more generally, on the inside of the plunger-diaphragm, produce a straight axial displacement of the diaphragm which, by means of the valve operator or, more specifically, by means of the yoke 50, is transmitted to the movable valve plate.

Before stating the advantages incorporated in this combination design of a plunger-diaphragm, I shall first describe another feature of this design which is only schematically indicated in Fig. 4 by two rows of short strokes disposed along the section of the revolutionary surfaces $a-b$ of the inside and $c-d$ of the outside of the plunger-diaphragm. The strokes or dots are meant to represent a fine fabric of cotton or the like, which is superficially but inseparably impressed in the rubber material. The threads of this fabric project sufficiently from the rubber surface to prevent a close contact between the rubber material and adjacent metallic portions such as the cylinder walls. In other words, the plunger diaphragm has a fabric and not a rubber contact with the cylinder walls. The fabric is carefully joined to the rubber so that the latter does not penetrate through to the contacting wall surface. This is an important feature when there is contact with the cylinder walls. A combined surface layer is indicated in Fig. 4 between the points a and b for reinforcing the bending or critical flexing zone of the plunger-diaphragm.

The outside fabric or lining fulfills three purposes. It eliminates the sticking of the plunger-diaphragm to adjacent metal parts, especially to the cylinder walls. It is a known fact that rubber faces, when inoperative and in contact with metal parts such as brass for a long period almost amalgamate with such parts so that upon renewed operation a prompt action of the valve cannot be relied upon because of sticking between metal and rubber, and partial disintegration of the rubber. Furthermore, the friction between the cylinder walls and the operating plunger is appreciably reduced in a fabric-metal contact as compared to a rubber-metal contact.

The third purpose of this outside impressed fabric as well as the inside fabric is to reinforce certain portions of the corrugated side wall sections of the plunger-diaphragm in a manner similar to the reinforcement of tires by fabric plies at critical bending zones. These reinforced portions will withstand wear to a greater extent and also, due to their greater stiffness, divert the bending strains to the unprotected and more easily yielding portions so that by distributing the strains over a larger part of the bendable material a rupture from wear will not occur so quickly but when it does it will occur in the section between the points *b* and *c* where, according to my novel arrangement of plunger-diaphragm construction, it will do the least possible harm.

I shall presently give a short account of the advantages that accrue from the features of my design under the various possible operating conditions.

As long as the plunger-diaphragm is intact it operates on the pure diaphragm principle. Owing to the flexible and corrugated side walls of the diaphragm which actually supply the axial expansion of the diaphragm a much greater displacement is obtainable from this diaphragm than from the usual plain diaphragm of like diameter. Without increasing the dimensions of the valve, it is, therefore, possible to provide a much greater lift of the valve disk so that for the same capacity of flow smaller valves are obtained, a feature which is especially valuable in all cases where such valves have to be installed in narrow or overcrowded locations. Also, one and the same valve model can be used for a wider variety of volumetric conditions. The ordinary diaphragm permits pressure reduction only to a limited degree with a given set of springs while the plunger-diaphragm of this construction covers a comparatively wide range without requiring different springs, and this is due to its much greater stroke. The plunger-diaphragm combines, therefore, absolute tightness with the favorable operating characteristics of a plunger operated valve.

A great disadvantage of the ordinary disk diaphragms is that they easily wear near the edges of the metal parts between which they are clamped, since the strains of deflection are almost exclusively concentrated in those portions, and that, if a break occurs, it will usually, due to the strong shearing forces in such diaphragms, seize a complete circumference and thus separate the central portion from the marginal portions completely. The result is that a high pressure surge of considerable destructive energy is released upon the distribution system which may cause considerable damage in that system. At all events, following a rupture, the low pressure system will come under the full

pressure of the high pressure side. The behavior of plain diaphragm operated valves in case of diaphragm rupture resembles the behavior of electric distribution transformers without safety devices in which the high voltage insulation has broken down and given way to the high voltage so that it suddenly rushes into the distribution system.

In my plunger-diaphragm, a sudden complete rupture is much less liable to occur since the bending strains of deflection are well distributed over a larger area of the side walls which are practically free from shearing stresses. Moreover, the bending strains play a subordinate role as compared to the unfolding or rolling action of the corrugated portions, which action chiefly supplies the stroke. Even if a complete rupture should occur, no damaging results would ensue because the upper plunger portion would instantaneously assume the functions of the diaphragm so that neither a significant surge nor pressure rise would be noticeable on the low pressure side. In this connection, the desirability of having exact stops for the stroke of the valve operator becomes apparent. In former constructions the downward stroke was checked by the upper slanting wall portions of the inner fluid access channel. This, of course, represented only a rough means of limiting the stroke. In the present construction, the closing stroke is defined by the valve seat and the opening stroke by the bottom cup. Both parts are accurately machined, and the stop position of the bottom cup may furthermore be adjusted by its threads.

The only difference in the operation of the severed plunger and the intact structure is that the plunger permits a small quantity of the fluid to leak past its sealing faces. This is a property which I have found to be highly desirable and which, for this reason, I even further to a certain degree. Such valves are frequently installed in places where no attendant is present and where inspection is only rare and occasional. An indication of the defective condition of the valve long before a dangerous break-down can arise is almost imperative under such circumstances, and this indication is furnished in my structure by a slight leakage which may continue for months after the rupture without involving any real danger.

This desirable leakage is another reason why I prefer to cover the outside faces of the plunger-diaphragm with a fabric. This mesh fabric of specific, suitable kind and combined with the rubber surface layer in a specific way offers a wrinkled or non-smooth bearing surface of relatively very limited extent to the contacting cylinder walls and, consequently, does not tightly seal the expansion chamber. This is particularly so if the plunger is guided within the cylinder

without appreciable bearing pressure and, for this reason, I prefer a light contact between the plunger and the enclosing walls.

After having described the preferred construction of my combination plunger-diaphragm and its various advantages, I wish it to be understood that my invention need not be carried out in exactly the same manner as exemplified before. Any mechanical combination of a plunger and a diaphragm so arranged that the plunger will readily take over the function of the diaphragm after its partial or complete rupture and thus prevent the disturbance or interruption of the low pressure service, will lie within the scope of my invention. I might, for instance, choose a greater number of bends in the corrugated side walls instead of only two, or go to the other extreme and combine a plain disk diaphragm with a plunger as second member.

The top cap 30 is attached to an upstanding flange 23 of the expansion chamber in a fluid-tight manner by threaded engagement and further by a lateral flange 31 on the cap with washer ring seal 32. The combined volume of the expansion chamber and the top cap is ample to provide the necessary breathing air for the diaphragm. This top cap represents, therefore, an additional or, better, a secondary protection if a timely replacement of the defective plunger-diaphragm should have been overlooked and also the severed plunger should have become worn to a considerable measure. There is, however, sufficient crawling passage left along the threads of the adjusting screw 33 for small amounts of leakage water to appear on top of the cap and disclose the defective valve condition. Such crawling passage may, of course, also be provided in any other suitable manner. The adjusting screw 33 presses on the head plate 34 of the interior spring and thus permits the adjustment of the tension in that spring. The tension of the outer spring 62 is adjusted by the nut 35 which travels up and down on outer spindle threads.

The yoke and the carrier for the valve disk are made integral and, after the rubber disk has been attached in the manner described above, the whole structure is then assembled in the place shown by swinging over the inlet passage. Space for this is provided in the casing extension in line with the inlet passage. Except for this extension, the valve casing is symmetrical and, as shown in the figure, makes a neat outside form appearance with small bulk and with all parts of the valve very easily assembled.

What I claim is:

1. The combination with a pressure regulating valve comprising a valve, a valve operator, a low pressure expansion cylinder and means for limiting the stroke of the valve operator, of a plunger-diaphragm connected

in marginal portions to the cylinder for tightly sealing the same and in central portions to the valve operator for actuating the valve, and having expansible corrugated intermediate portions for axial expansion in partial contact with the cylinder walls, said intermediate portions also containing circumferential sections of lesser resistance to wear for said plunger-diaphragm to act in said cylinder as a diaphragm of relatively great stroke in non-worn condition and as a plunger of like stroke if partly or completely ruptured in said lesser resistance sections.

2. A valve with pressure expansion chamber and a plunger-diaphragm operable therein, the latter consisting of a diaphragm, a plunger with leaking seal, and of connecting means between the two with lesser resistance to wear, for said plunger-diaphragm to act in said chamber as a diaphragm in non-worn condition and as a leaking plunger when partly or completely ruptured in said lesser resistance connecting means.

3. The combination with a metallic pressure expansion chamber and a plunger-diaphragm therein made from rubber or rubber composition and comprising, plunger portions and diaphragm portions separated by flexible intermediate portions, of a fabric inseparably connected with surface sections of said various plunger-diaphragm portions for reinforcing the same, preventing amalgamation between the contacting parts of said chamber and plunger-diaphragm, reducing friction and providing a leaking plunger seal, said fabric covering being interrupted in circumferential sections of said intermediate plunger-diaphragm portions for making such unprotected portions sections of lesser resistance to wear.

4. In a pressure regulator structure, a combined plunger head and diaphragm member comprising a horizontally arranged disk to act as a plunger head having a circumferential extension depending downwardly, then axially and then downwardly again and then outwardly into final horizontal annular form to serve as a diaphragm anchor, said member being formed of an elastic body material including vulcanized rubber, rigid plate members above and below the upper horizontal disk portion as an unbendable piston head, fabric fastened smoothly over the outer surface of said extension through its curved portions, and a fabric covering fastened along the lower inside surface and extending from under one of said rigid plate members as far as the extent of the first bend from the horizontal to the vertical portion so as to bridge with a stiffening layer that portion of the body material as it may bend between the rigid plate members and the lower part of the extended body portion, whereby the region of greatest bending strain is distributed over a larger area, the outer wall of said

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disk being arranged parallel to the axis for at least the thickness of the disk, whereby the disk may fit a pressure cylinder as a plunger and its extension may act as a diaphragm along with the plunger portion.

In testimony whereof I have affixed my signature.

FRANKLIN T. HOLMES.