April 29, 1952 E. M. DETERS 2,594,405

PRESSURE MAINTAINING DEVICE

Filed Jan. 24, 1946 2 SHEETS—SHEET 1

Fig. 1

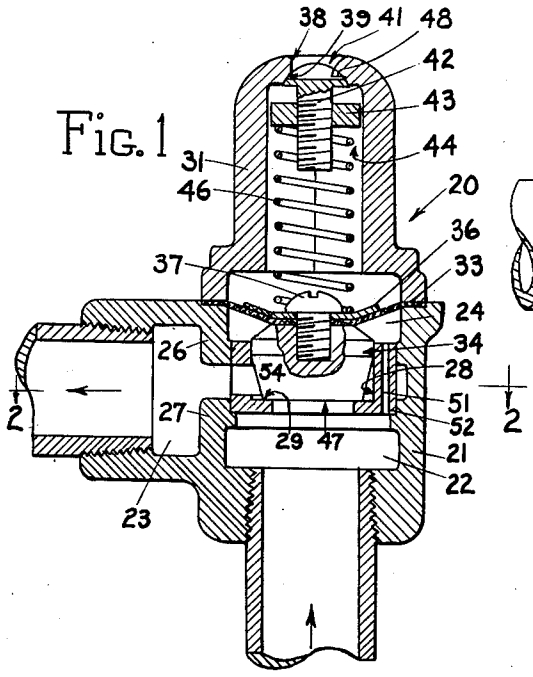
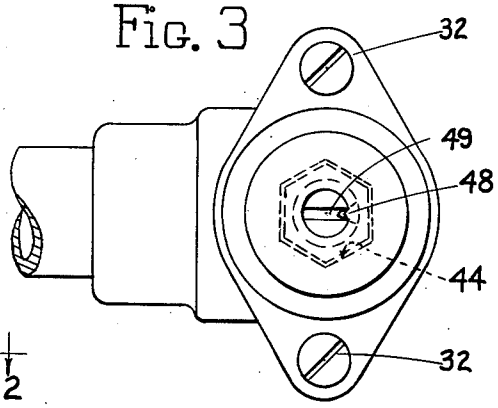


Fig. 3



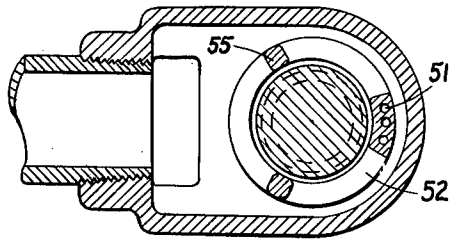


Fig. 2

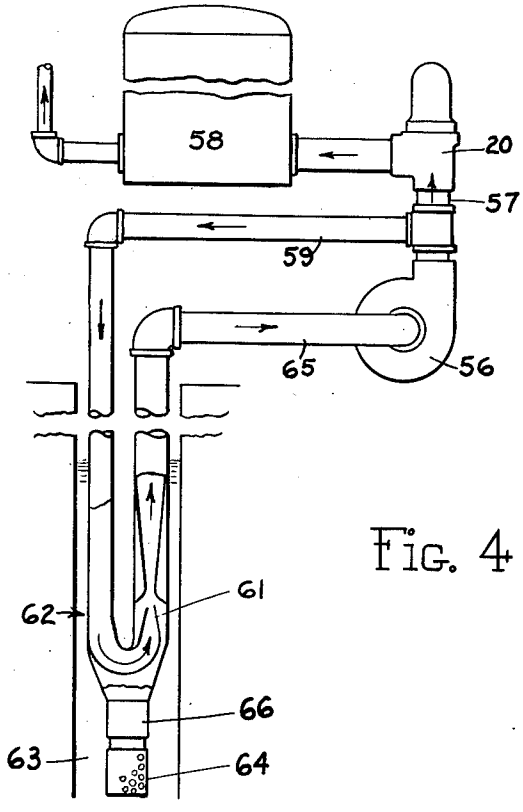


Fig. 4

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PRESSURE MAINTAINING DEVICE

Filed Jan. 24, 1946 2 SHEETS—SHEET 2

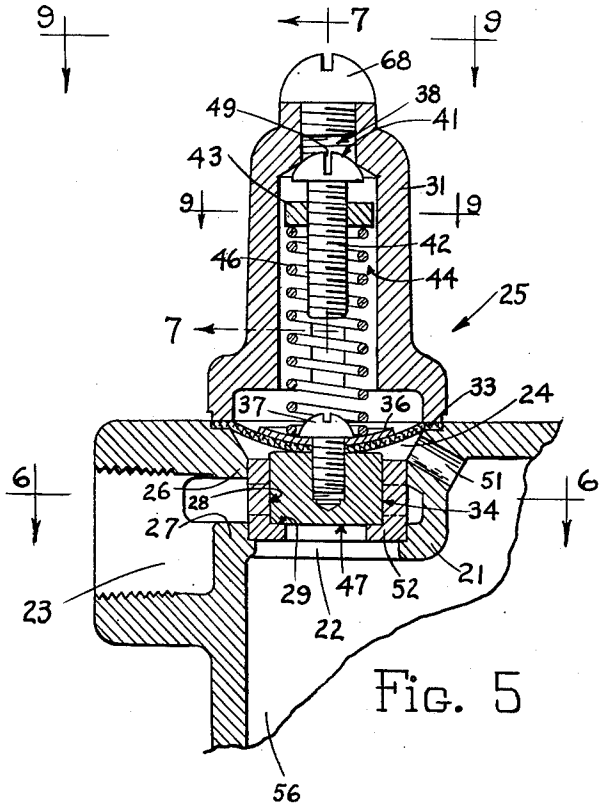


Fig. 5

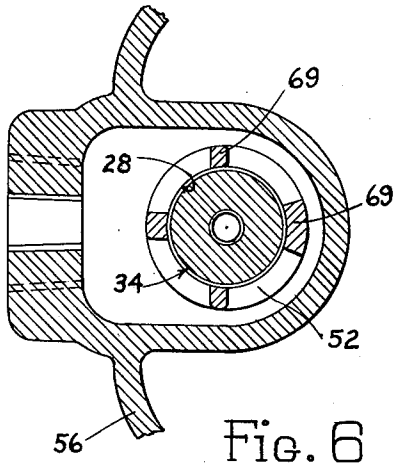


Fig. 6

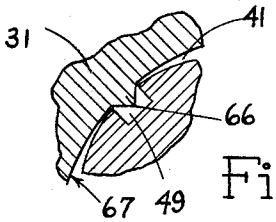


Fig. 8

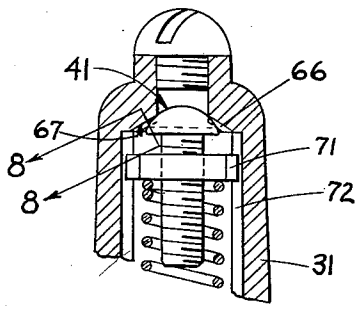


Fig. 7

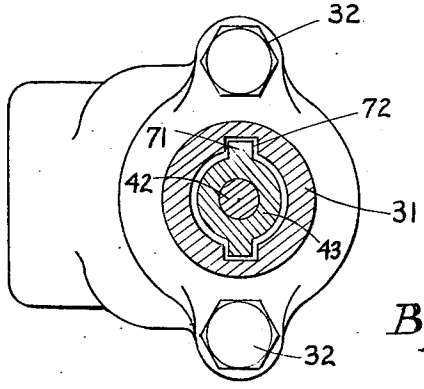


Fig. 9

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UNITED STATES PATENT OFFICE

2,594,405

PRESSURE MAINTAINING DEVICE

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Application January 24, 1946, Serial No. 643,077

7 Claims. (Cl. 137—53)

1

This invention relates generally to an improved pumping system and particularly to an improved pressure maintaining valve for use with an injector type of deep well pumping system.

In the injector type of deep well pumping system having a centrifugal pump discharging into a storage tank and also discharging a recycle stream to an injector at the bottom of a well, it is necessary to provide a resistance in the conduit leading to storage so that the pressure of the recycle stream being forced down into the well can be maintained high enough at low tank pressures to lift the well water up to the 25 feet level, 25 feet being the maximum depth from which it is practicable to pump water by suction; for example, when such a pumping system employs an injector at a depth of 100 feet, the recycle stream must be pumped into the injector at the minimum pressure necessary to lift the water the first 75 feet. Otherwise, when pressure in the storage tank is low all of the water from the pump outlet will be discharged into the storage tank and none will be recycled to the injector, resulting in the system quickly losing its prime.

A conventional method of providing this necessary resistance or back pressure has been to install a cock or plug valve in the conduit leading to storage and to close it sufficiently to maintain the desired back pressure necessary to recycle a lifting stream through the injector. This method has presented a serious disadvantage in that the partially closed cock provides a fixed restriction to flow which remains fixed at all pump discharge pressures, even at high discharge pressures where it is not needed. Some attempts have been made by others to provide a spring-loaded pressure maintaining valve which will create an automatically variable restriction in the discharge conduit, but these attempts have not produced a commercially satisfactory structure from standpoints of low cost, long life, noiseless operation, and sensitivity to pressure changes.

Accordingly, an important object of my invention is the provision of an improved spring-loaded, minimum-pressure-maintaining valve for the discharge line of an injector type pumping system which will provide an automatically variable line restriction to prevent or restrict flow in the discharge conduit at low pump discharge pressures but which will open when the discharge pressure reaches the required minimum, and will then present little resistance to flow.

Another object is the provision of such an improved back pressure maintaining device which, when set for a pre-selected resistance to a given rate of flow, will remain at that resistance until changed manually; a still further object being the provision of a simple, fool-proof and economical means for manually changing the resistance when desired.

2

Other objects and advantages will become apparent to one skilled in the art upon consideration of the accompanying drawing.

Figure 1 is a sectional side view of one form of a pressure-maintaining device which may be used to carry out the purposes of my invention;

Fig. 2 is a section taken on the line 2—2 of Figure 1;

Fig. 3 is a top outside view of the device shown in Figure 1;

Fig. 4 is a schematic view of a deep well injector type pumping system in accordance with my invention and using a pressure-maintaining device similar to that shown in Figure 1;

Fig. 5 is another modification of the invention showing how my pressure-maintaining device may be incorporated in the pump housing;

Fig. 6 is a section on the line 6—6 of Fig. 5;

Fig. 7 is a section on the line 7—7 of Fig. 5;

Fig. 8 is an enlarged section on the line 8—8 of Fig. 7, and

Fig. 9 is a section on the line 9—9 of Fig. 5.

Like reference characters refer to like parts throughout the figures.

Referring more particularly now to the pressure-regulating valve, generally designated 20, shown in Figures 1, 2, and 3, the valve is formed with a casing 21, inlet port 22, outlet port 23, bonnet opening 24, upper and lower bridgewalls 26 and 27, respectively, and having a pressed-in seat insert 52 with a cylindrical bore 28 terminating in a flat annular seat portion 29. A bell-shaped bonnet or spring housing 31 is mounted upon the casing 21 in substantial alignment with the bore 28 by means of mounting screws or bolts 32. A flexible rubber-like diaphragm 33 is interposed as a fluid sealing gasket between the bonnet and casing and defines with said casing a chamber adjacent the upper bridgewall 26. The diaphragm 33 is attached to the disk 34 by means of a pressure back-up plate 36 and the screw 37. An adjustment opening 38 is formed in the end of the bonnet 31 and at the interior edge of this adjustment opening is formed a spherical surface 39 which is adapted to fittably engage a similarly spherical head 41 of an adjustment screw 42. A spring-loading member 43 is threadedly engaged with the ad-

justing screw 42 and is engaged with the interior surface 44 of the bonnet in any suitable manner so that the loading member will be reciprocable but not rotatable therewithin; in the valve shown in Fig. 1, this is accomplished by forming the interior surface 44 hexagonally and by forming the exterior surface of the loading member hexagonally with slight clearance between the two surfaces to allow for reciprocation. A helical spring 46 is normally compressed between the pressure back up plate 36 and the loading member 43 to urge the end surface 47 of the disk into engagement with the substantially flat surface 29 in the casing and this load is manually variable by rotation of the adjusting screw 42.

An important element of my invention is the means I utilize for locking the adjustment screw 42 when it is once set. In the Fig. 1–3 modification, this means consists of the inward extension 48 having tapering sides so that normally the resistance of the spring 46 will press the screw slot 49 into engagement with the extension 48. However, when it is desired to change the loading on the spring, it is necessary only to apply sufficient torque to the screw in the desired direction as with a screw driver, so that the wedge action between the extension 48 and the slot overcomes the spring pressure and causes the screw slot to disengage from the extension.

Another important feature of my invention lies in the means I employ for placing the diaphragm 33 in direct pressure-responsive communication with the inlet port 22. This means consists of one or more apertures 51 which may be formed in the pressed-in seat insert 52, or which may be formed directly in the housing 21.

With the inlet pressure thus in direct communication with the diaphragm, as described in the preceding paragraph, additional means must be provided to prevent the loss of fluid from the diaphragm chamber 24 to the outlet port, and in this case such additional means takes the form of the continuous cylindrical portion 54 formed on the disk closely engaging the bore 28 formed in the seat insert in a substantially fluid-tight manner.

Fig. 4 shows an injector type deep well pumping system as it would advantageously employ my improved pressure-maintaining valve 20. A centrifugal pump 56 is arranged to discharge in two directions; one direction being through the discharge conduit 57, the pressure-maintaining valve 20, and into a point of delivery or storage tank 58; the other direction being through the recycle conduit 59, the injector 62, whence it returns to the pump inlet through the return pipe 65 with additional fluid drawn from the deep well 63 through the strainer 64 and the check valve 66.

In explaining the operation of this system, assume that the pump 56 must discharge liquid at a minimum pressure of 20 lbs. into the recycle conduit 59 in order for the injector jet 61 to lift liquid from the well. To initially adjust the pressure-maintaining valve 20 to the proper value when the pumping system is first installed, the adjusting screw 42 will be screwed down to provide maximum compression on the disk 34. The pump 56 will then be started and will be unable to discharge liquid into the storage tank 58 because of the high compression on the spring 46 and the entire output of the pump will be recycled continuously through the recycle conduit, the injector, and the return pipe. Assuming further that the pump will be discharging under this recycling condition at a pressure in excess of 20 lbs. per square inch, the adjusting screw 42 will then be turned to relieve the compression on the spring 46 so that the pump outlet pressure is slightly above 20 lbs. per square inch. With this setting, the valve disk 34 will remain seated on the insert surface 29 preventing flow of liquid through the discharge conduit 57 at all pressures below that necessary to operate the injector 62. At pressures above this, the disk 34 will be lifted from its seat by the pressure acting on the diaphragm 33 to permit discharge into the storage tank 58.

For some purposes, it will be preferable to form the pressure-maintaining valve as a part of the pump housing, as shown by the modification generally designated 25 illustrated in Figs. 5–9 where the valve casing 21 is formed integral with the discharge side of the pump housing 56. In this modification, only one aperture 51, formed in the valve casing, is employed to provide direct and continuous pressure responsive communication between the diaphragm 33 and the pump discharge pressure in the housing 56. The loading member 43 is guided within the bonnet by means of the lugs 71 (Figs. 7 and 10) engaging the grooves 72. Where it is desirable, to achieve a particular flow characteristic, or for some other reason, the seat insert 52 may be provided with four vertical struts 69 instead of the three struts 55 shown in Fig. 2. And in some cases for improved guiding, the cylindrical surface 34 may extend the entire length of the disc, as shown in Fig. 5.

Figs. 5 through 8 also illustrate another modification of the means which I have devised to lock the adjustment screw 42 after it is once set in a preferred position. This means consists of a diametrically opposed pair of inward wedge-shaped extensions 66 formed on the frusto-conical surface 67 of the bonnet 31 and adapted to be engaged by the ends of the adjusting screw slot 49. When it is desired to change the loading on the spring, this may be accomplished simply by removing the outer screw 68 (which may be provided to keep out dust and prevent easy access to adjusting screw); then, by turning the screw 42 in the desired direction against the wedge action of the extensions 66 and the slot 49, as already described in connection with the modification shown in Fig. 1.

Although spring-loaded pressure-maintaining valves have previously been employed in connection with injector type pumping systems, none have been entirely satisfactory in operation. In my construction, the disk is closely guided within the seat bore, preventing chattering, whereas, in certain previous constructions, the disk has either not been guided at all or has been improperly guided, resulting in vibration, causing noisy operation and short life. Still another significant feature of my invention which previous workers in this field have overlooked is the provision of the aperture 51 placing the diaphragm in direct pressure-responsive communication with the pump outlet, thereby providing smooth and extremely sensitive response to changes in pump outlet pressure; and an important feature in combination with this is the close and continuous cylindrical fit between the upper portion 54 of the disk and the seat bore 28 whereby liquid entering the diaphragm chamber 53 escapes only very slowly past the disk into the valve outlet 23. A still further feature, representing a distinct step

forward in the art, is the extremely simple means for changing the loading on the spring 46 yet which will hold any set adjustment indefinitely under the most severe vibrating conditions; this adjusting means eliminates altogether the lock nuts and long projecting adjustment screws formerly considered necessary for satisfactory adjustment combined with ruggedness in use.

I claim:

1. A valve of the character described having in combination, a casing having an inlet port, an outlet port, a bonnet opening, a bonnet mounted across the bonnet opening, a lower bridgewall separating the inlet from the outlet ports, an upper bridgewall separating the outlet port from the bonnet opening, a seat member engaging both of said bridgewalls in a fluid tight manner, said seat member having a cylindrical bore and having an aperture surrounded by an annular seat, a valve disk having a cylindrical surface for substantially fluid tight reciprocation within said bore in said seat member and having an end surface engageable with said annular seat in a fluid tight manner, a flexible rubber-like diaphragm having the periphery thereof interposed in a fluid sealing manner between the bonnet and the housing and having a central portion thereof attached to the disk, said casing having a passageway for providing direct and continuous pressure responsive communication between said diaphragm and the inlet port, the bonnet having an opening in the end thereof and a circularly extending surface formed on the interior of the opening, an inwardly extending adjusting screw having a head adapted to abut said circularly extending surface, means associated with said circularly extending surface and said head for resisting relative rotation therebetween, a loading member threadedly engaged with the adjusting screw and mounted in the bonnet for reciprocatory movement, means acting between the bonnet and the loading member for preventing said loading member from rotating during its reciprocatory movement, a spring member compressibly interposed between the loading member and the diaphragm to resist pressure-induced movement of the diaphragm to a degree determined by the adjustment of said adjusting screw.

2. In a valve of the character described the combination of, a casing having an inlet port and an outlet port, a valve member mounted in said casing and operable to adjust the flow of pressure fluid through said ports, pressure responsive means mounted in said casing and shaped and positioned to control the movement of the valve member, means providing communication between the inlet port and the pressure responsive means, a bonnet secured to said casing and having an aperture and a projection at one end, spring means disposed in said bonnet to oppose movement of the pressure responsive means, said spring means being arranged so that the fluid pressure at the inlet port must be in excess of the spring means pressure before the pressure responsive means is operable to actuate the valve member, and an adjustable abutment means accessible through said aperture and engageable with said spring means to preselect the pressure applied to the pressure responsive means and having a recess for receiving said projection whereby to positively lock the abutment means in a predetermined position.

3. A valve of the character described having in combination, a casing having an inlet port and an outlet port, a valve element mounted in said

casing to variably control the flow of pressure fluid through said ports, pressure responsive diaphragm means for controlling the position of the valve element, means providing communication between the inlet port and the diaphragm means so that the pressure fluid acts directly against said diaphragm means, a bonnet mounted on said casing and having an aperture at the outer end, said aperture being flared on the interior of the bonnet to form a rounded surface, an abutment slidably disposed in said bonnet, a spring disposed between said abutment and said diaphragm means and arranged to oppose movement of the latter in the valve-opening direction, a screw threadably engaging said abutment and having a rounded head accessible through said aperture to adjust the position of the abutment, said rounded head shaped to interfit with said rounded surface formed in the bonnet, and interlocking means acting between said head and said surface for positively locking the screw in a desired adjusted position.

4. A valve of the character described having in combination, a casing having an inlet port and an outlet port, a valve element mounted in said casing to variably control the flow of pressure fluid through said ports, a pressure responsive diaphragm for controlling the position of the valve element, means providing communication between the inlet port and the diaphragm so that the pressure fluid acts directly against said diaphragm, a bonnet secured to said casing and having an elongated chamber formed therein, said bonnet having an aperture and a projection projecting inwardly of said aperture, an abutment shaped and positioned to interfit slidably in said chamber for reciprocation only, guide means acting between said bonnet and said abutment holding the abutment against rotational movement, a spring disposed between said abutment and said diaphragm for opposing the movement of the latter, said spring being arranged so that for any predetermined setting the pressure at the inlet port must be in excess of the pressure applied by the spring before the diaphragm is operable to actuate the valve element, and threadable means accessible through said aperture in the bonnet and engageable with the abutment to adjust the position thereof, said means having a recess for the reception of said projection whereby to positively lock the abutment in a desired adjusted position.

5. In a valve of character described, the combination of a casing having an inlet port, an outlet port and an aperture, a valve member mounted in said casing and operable to adjust the flow of pressure fluid through said ports, pressure responsive means mounted in said casing and shaped and positioned to control the movement of the valve member, means providing communication between the inlet port and the pressure responsive means so that the latter means is responsive to the pressure at the inlet port, a movable abutment mounted in said casing in spaced relation to said pressure responsive means, means disposed in the casing and accessible through said aperture for adjusting the relative position of the abutment with respect to the pressure responsive means, spring means disposed between said abutment and said pressure responsive means to oppose movement of the pressure responsive means, and means acting directly between the means for adjusting the abutment and the casing for positively locking the abutment in a predetermined adjusted position.

6. A valve of the character described having in combination, a housing with a bonnet, said housing having an inlet port, an outlet port, a bonnet opening, a first bridgewall separating the inlet from the outlet port, a second bridgewall separating the outlet port from the bonnet opening, a seat insert comprising spaced members, the first of which engages the first bridgewall and the second which engages the second bridgewall in fluid tight relation, said first member having an aperture formed therein with a smooth surface surrounding said aperture forming a seat, and said second member having an aperture formed therein, a flexible diaphragm mounted in said housing spanning the bonnet opening and providing a diaphragm pressure chamber between the diaphragm and the first member, said seat member having a plurality of passageways providing communication between said diaphragm chamber and said inlet port to render the diaphragm responsive to the inlet port pressure, said passageways being small in diameter for restricted communication between the inlet port and the diaphragm chamber to prevent rapid movement of the diaphragm in response to pressure surges at the inlet port, the spring member mounted in said bonnet and engageable with said diaphragm to oppose the movement of the latter under the pressure in said chamber, and a valve element fixed to said diaphragm and movable therewith, said valve element having a first portion of substantial axial length and shaped to slidably fit in said aperture in the second member to prevent the passage of liquid out of the outlet port through the aperture in the second member and having a second portion of smaller diameter than the aperture in the second member and having an end surface engageable with said seat formed on the first member whereby to control the flow of pressure fluid between the inlet and outlet ports.

7. In a valve of the character described, the combination of a housing, a bonnet attached thereto, said housing having an inlet port, an outlet port, and a diaphragm chamber, a lower bridgewall separating the inlet from the outlet port, an upper bridgewall spaced from said lower

bridgewall and separating the outlet port from the diaphragm chamber, the upper bridgewall having a cylindrical imperforate bore extending between the outlet chamber and the diaphragm chamber, the lower bridgewall having an aperture extending between the inlet and outlet ports surrounded by an annular seat facing the upper bridgewall, a flexible diaphragm on the housing defining one wall of the diaphragm chamber, said housing having relatively small aperture means formed therein to place said chamber in direct and continuous pressure responsive communication with the inlet port, the cross-sectonal area of the aperture means being small as compared with the area of the diaphragm exposed to the chamber, a valve disc connected directly to the diaphragm and movable therewith, the disc having a cylindrical surface shaped to slidably fit in said bore to prevent flow of liquid from the inlet port through the bore and having an annular surface of smaller diameter adapted to abut against said annular seat in a liquid tight manner to prevent the flow of liquid between the inlet and outlet ports, and manually adjustable spring means mounted in the bonnet arranged to act against the diaphragm to maintain the disc against the annular seat until the pressure at the inlet port exceeds that of the spring means.

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