

Jan. 5, 1943.

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2,307,016

DIFFERENTIAL STAGE LIFT FLOW DEVICE, DIAPHRAGM TYPE

Filed Dec. 8, 1939

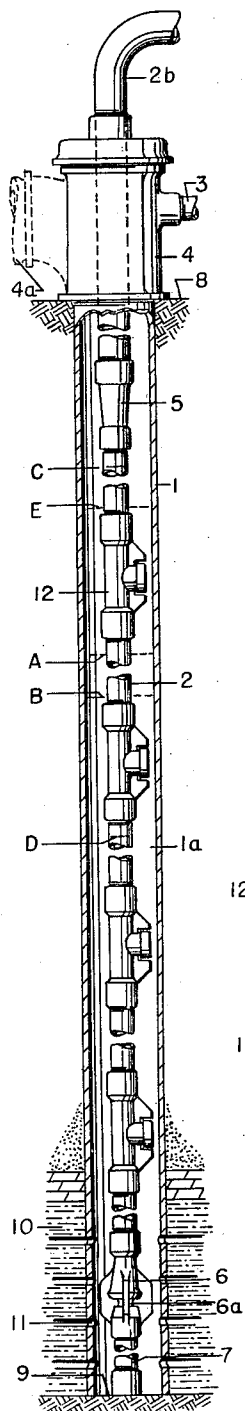


Fig. 1.

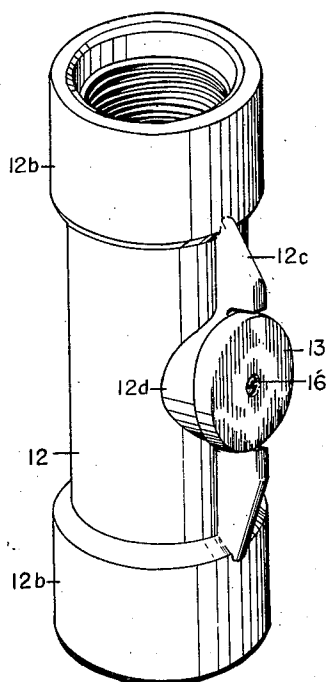


Fig. 2.

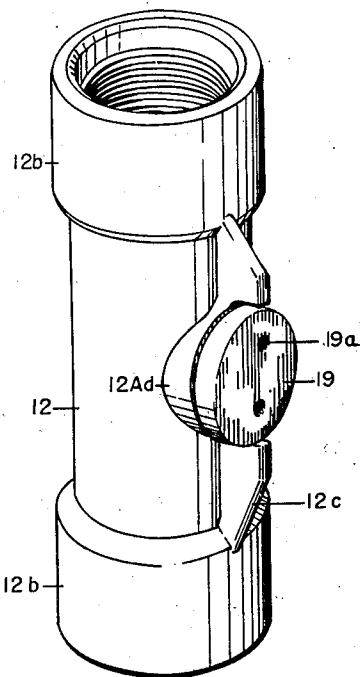


Fig. 4.

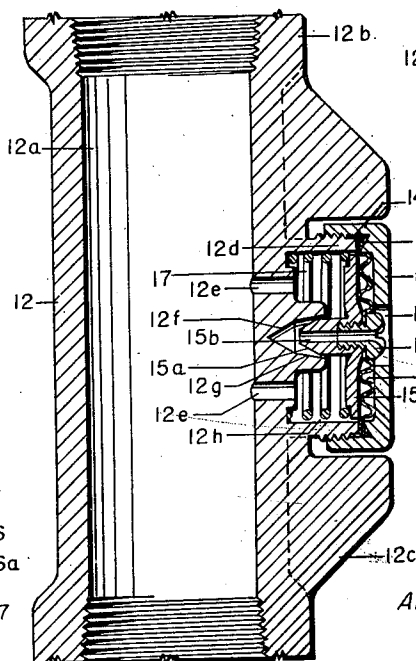


Fig. 3.

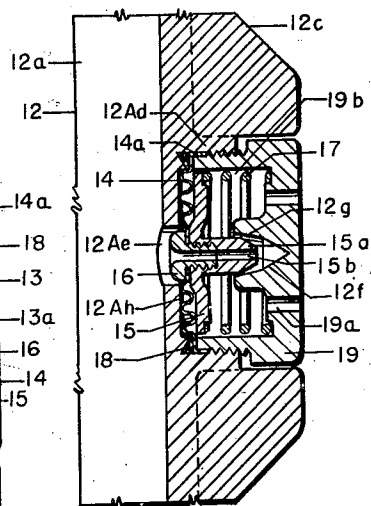


Fig. 5.

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2,307,016

DIFFERENTIAL STAGE LIFT FLOW DEVICE,
DIAPHRAGM TYPE

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Application December 8, 1939, Serial No. 308,312

6 Claims. (Cl. 137—111)

My invention relates to flowing devices for cased wells.

The principal object is to start wells at comparatively low pressures and to cause them to flow through either the tubing or the casing at low gas-oil ratios by employing similar means for flowing either way.

Other objects are: (1) to cause the valve to seat with comparatively great force; (2) to automatically control the admission of pressure fluid to the load in proportion to the work required; (3) to avoid the use of all sliding contacts; and (4) to employ mechanism of extremely few parts, simple in design and inexpensive to manufacture.

These objects are attained by interposing a diaphragm with a valve attached to it, between the pressure fluid and the upstanding liquid column in the eduction tube. The valve has an opening extending through it and the diaphragm and is adapted to allow passage of pressure fluid into the well liquid in the eduction tube at low differentials and to cut off such flow at higher differentials.

The foregoing will clearly appear from mechanism illustrated in the accompanying drawing, in which:

Fig. 1 is an installation plan of the devices in a well.

Fig. 2 is a perspective view of the preferred embodiment of the invention for tubing flow.

Fig. 3 is a longitudinal section of the device shown in Fig. 2.

Fig. 4 is a perspective view of a modified form of the invention illustrated in Figs. 2 and 3.

Fig. 5 is a partial vertical section of the device shown in Fig. 4.

Similar reference characters are employed to designate similar parts throughout the several views.

In Figs. 2 and 3, the tubular body 12, having the opening 12a aligned with and of the same size as the tubing passage and having its ends formed into the half couplings 12b, also has guide fins 12c and the tubular boss 12d, preferably all cast or otherwise fabricated in one piece.

The difference between the value of the pressure fluid in the induction tube and the force of the well liquid in the eduction tube at any level will be referred to as the differential.

The column of well liquid caused to stand up in the eduction tube above the liquid level in the induction tube will be referred to as the upstanding column.

The induction tube will be considered as the one having its inner surface in contact with the

pressure fluid, and the eduction tube will be considered to be the one having its inner surface in contact with the well liquid.

The annularly corrugated diaphragm 14, having the circular flange 14a fitting closely over the tubular boss 12d, is hermetically secured between this boss and the packing 18 by the cap 13, having threaded engagement over the boss 12d which boss is centrally disposed between the guide fins 12c. The diameter of this diaphragm may be such as two inches. The circular plate 15, having slight clearance within the chamber 12h, is secured to the flat central portion of the diaphragm by means of the threaded engagement between this plate and the screw 16. The diaphragm and the plate 15 are urged against the cap 13 by the force of the spring 17 installed under some compression between the plate 15 and the floor of the bore 12h within which bore the spring has slight clearance. The opening 13a, central of the cap 13, is aligned with the extension having the valve 15a formed upon its end, and is adapted to receive the head of the screw 16, as appears in Fig. 3. The purpose of the plate 15 is to restrain the diaphragm and thus prevent it from rupture during high differentials.

The tubular valve 15a, which may have a diameter such as $\frac{3}{8}$ to $\frac{1}{2}$ inch, is adapted to close upon the seat 12f, and is positioned central of the tapered bore 12g. The extension formed into the valve 15a, in the open position of the valve as shown in Fig. 3, has impaired clearance within the bore 12g as the valve approaches its seat 12f. In this manner, the valve will permit the passage of less pressure fluid into the upstanding column as the differential increases, and vice versa.

The diameter of the opening 15b through the valve member and the screw 16 ordinarily may be such as $\frac{1}{8}$ to $\frac{1}{4}$ inch, and, of course, may be varied to meet different well conditions. The greatest clearance between the valve member and the tapered bore 12g is when the valve is widest open as appears. This clearance at such time may be, for example, such as the equivalent of a circular opening having a diameter of $\frac{1}{8}$ to $\frac{1}{4}$ inch. When the valve is seated, the side clearance between it and the tapered bore 12g may be such as two to five thousandths inch.

The only valve seating force for tubing flow is exerted upon the exterior of the diaphragm by the pressure fluid acting through the opening 13a. This force is predetermined and constant at any given value of the pressure fluid.

The seating of the valve is resisted by the force

required to flex the diaphragm, the force of the spring, and the pressure of the upstanding column. These are the only valve unseating forces. The force required to flex the diaphragm and spring is predetermined and constant; whereas, the upstanding column exerts the only variable force, the value of which depends upon the position in the upstanding column where it is exercised.

In both forms of the invention, the valves are normally supported resiliently open until closed by the differential force.

The valves in both forms may be adjusted to close at progressively more or less differential from the uppermost to the lowermost and to admit in the same order or in reverse order, progressively more or less pressure fluid as different well conditions may require.

In flowing the well through the tubing, the path of the pressure fluid out of the annular space 1a and into the tubing 2 is via the opening 13a, the passage 15b, the annular space between the extension formed into the valve 15a and the wall of the bore 12g, the chamber 12h, and the openings 12e, in the order named.

The valve 15a should be adjusted to close at a pressure per square inch somewhat greater than the force per square inch exerted by the well liquid between adjacent devices, which may be spaced 150 to 300 feet apart. In both forms of the invention, the valve should be so adjusted in order to provide for continuous even flow of well liquid through the eduction tube, which will result from two or more valves being open at once.

The valve of the pressure fluid employed to flow the well should be at least two to three times the differential force required to close the valves, and may be much greater. Manifestly, increasing the value of the pressure fluid will increase the rate of liquid expulsion.

The diameter of the diaphragm, being many times greater than the diameter of the valve, it is evident that comparatively great force will be imparted to the valve, enabling it to be leak-proof upon its seat.

It will be understood that expulsion of well liquid will be accomplished by the expansion of pressure fluid injected into the upstanding column through the devices herein shown.

During tubing flow, in Fig. 1 the discharge opening 4a in the casing head will be considered as closed. The devices 12 are shown connected into the tubing 2 central of the well casing 1, the casing head 4 being employed to effect a hermetic seal between the tubing and the casing proximately above the ground surface 8. Within the upper portion of the well, the tubing may be enlarged for tubing flow, the two sizes being joined together by the swaged nipple 5. For casing flow, the tubing, which then becomes the induction tube, may be smaller and preferably all of one size. The flow line 2b, being an extension of the eduction tube 2, will be considered as open and connected to a production tank.

The anchor string 7, connected to the eduction tube 2 by means of the nipple 6, having lateral openings 6a, may extend to the bottom of the well bore 9. The contents of the producing formation 10 enters the well through gun perforations 11.

The well liquid is assumed to be standing in both tubing and casing at B.

Now, to flow the well through the tubing, turn pressure fluid of proper value out of the pipe

line 3 into the annular space 1a. The valves in all devices will be quickly closed by the excess pressure exterior of the diaphragm. The liquid in the casing will be depressed to a level shown at B, while the balancing upstanding column will rise to C.

The valve in the device next above the base of the upstanding column will open, while the next valve above will be closed by either slight pressure or will be partially open, according to the differential obtaining there.

If the rate of liquid flow from the well exceeds the rate of in-flow, the level B will be gradually lowered, uncovering the lower valves; while the upper valves will close, in turn, as the liquid level is lowered within the annular space 1a.

The construction shown in Figs. 4 and 5 is an adaptation to casing flow of the device shown in Figs. 2 and 3 for tubing flow.

The diaphragm and valve are reversed in position from that shown in Fig. 3. The cap 19 intermediate of the guide fins 12c and having the openings 19a, is threadedly engaged within the boss 12Ad, and hermetically clamps the diaphragm upon the packing 18, thereby positioning the diaphragm in close proximity to the flat surface 12Ah with the head of the screw 16 registering with the opening 12Ae, central of this flat surface.

Where not otherwise stated, the construction and operation in Figs. 4 and 5 will be understood as being the same as in Figs. 2 and 3.

For casing flow, the pressure fluid valve seating force is exerted upon the diaphragm through the opening 12Ae; while the unseating force of the well liquid in the upstanding column acts through the openings 19a and the chamber 19b upon the other side of the diaphragm by contacting the plate 15. This unseating force is aided by the spring 17 and the force required to flex the diaphragm, as was stated for the tubing flow method.

In Fig. 5 the casing flow path of the pressure fluid is out of the induction tube 2 via the opening 12Ae, the opening 15b, the annular clearance between the tubular extension of the member 15 having its end formed into the valve 15a and the wall of the tapered bore 12g, the chamber 19b, and the openings 19a, in the order named.

The installation plan in Fig. 1 will be modified for flowing through the casing by replacing the larger size tubing and swaged nipple 5 with tubing of the smaller size shown below. The input pressure fluid line 3 of the tubing flow method will be replaced by a plug. The eduction tube discharge opening 4a will be open, and the pressure fluid will be supplied into the induction tube 2 through the line 2b. The liquid level in both induction and eduction tubes will be assumed to be at A, Fig. 1.

Now, to flow the well through the annular space 1a, employing the casing as the eduction tube, turn pressure fluid from the line 2b into the tubing 2 which pressure fluid will soon build up enough pressure to close the valves 15a, Fig. 5, in all of the devices. The liquid in the induction tube will be depressed to D, while the upstanding column in the eduction tube will rise and upstand from D to E.

The device next above the base of the upstanding column at D will then be open, due to the slight differential obtaining there; while the device next above it will remain closed by slight

force or be partially open, as was explained for the tubing flow, to which this operation of flowing through the casing is so similar as to be readily understood without further explanation.

Manifestly, the size of the openings through which the pressure fluid passes in its travel through the devices should vary according to the volumetric flow and physical properties of the liquid, the depth of the well, and the value of the pressure fluid.

The comparatively low starting pressures resulting from stage lifting and the metered flow of the power medium to the load, affords unusually low gas-liquid ratios and, at the same time, enables the well to produce more than the employment of higher pressures would permit. It is obvious that many mechanical changes, substitutions, and adaptations may be made in the construction, and that equivalents may be substituted for the parts shown; and I reserve the right to make such mechanical changes, substitutions, and adaptations within the scope of the invention as comprehended by the stated objects and appended claims.

What is claimed is:

1. A tubing coupling having a cylindrical chamber in the wall thereof, ports opening inwardly and outwardly from within said chamber to the interior and exterior of the valve body, a tapered bore in the wall of the chamber opposite one of said ports, a diaphragm adjacent said last mentioned port and having its periphery hermetically secured to the walls of the chamber, a tubular valve passing through said diaphragm and terminating within said tapered bore to control the flow of fluid as the valve moves within the bore and to close the passage through the chamber when the valve seats within the bore, and means resiliently urging the valve outwardly from within said bore.

2. A tubular valve body having a chamber in the wall thereof with ports opening to the interior and exterior of the body, one of said ports opening centrally of the chamber, a tapered bore in the wall of the chamber opposite said last mentioned port and in alinement therewith, a tubular valve extending into said bore, the walls of said bore cooperating with the surface of the valve to control the flow of fluid through the valve, there being a valve seat at the inner end of the bore for engagement by the valve to close the passage therethrough and means resiliently urging the valve away from said bore.

3. A valve body having a chamber in the wall thereof with ports inwardly and outwardly therefrom to the interior and exterior of the body, one of said ports opening centrally of the chamber, a tapered bore in the wall opposite said last men-

tioned port and in alinement therewith, a valve moveable in the chamber and having a portion extending into said bore, a passage in said valve terminating within said bore, the walls of said bore cooperating with the surface of the valve to control the flow of fluid through the valve, there being a valve seat at the inner end of the bore for engagement by the valve to close the passage therethrough, and means within said chamber resiliently urging the valve from within said bore.

4. A valve body having a tubular boss thereon, a diaphragm, means securing the periphery of said diaphragm to said boss and forming a chamber therein, ports opening from said chamber to the interior of the valve body, a tubular valve member secured to the diaphragm and extending into said chamber, a tapered bore in the wall of the chamber receiving the inner end of the valve member and forming a closure seat when the diaphragm is flexed by a differential pressure between the outside and inside of the body, and means normally urging the valve member resiliently outwardly.

5. A valve body having a tubular boss thereon, a shoulder within said boss, a diaphragm, a cap member secured within the boss to clamp the periphery of the diaphragm to the shoulder and form a chamber, a port opening from the interior of the body to the inner surface of said diaphragm, an inwardly opening tapered bore within the cap member, and a tubular valve secured to the diaphragm and extending into said bore, there being openings through the cap member from within the chamber, whereby passage of pressure fluid from the interior to the exterior of the body is controlled in accordance with the differential pressure therebetween.

6. A flow device for wells including a tubular valve body having a radial counterbore in the wall thereof, means closing said counterbore to form a chamber in the wall of the body, a diaphragm sealably engaging the wall of the counterbore proximate one end of the chamber, a tubular valve member secured centrally of the diaphragm and providing a passage axially of the chamber, a tapered bore in the wall of the chamber into which said valve member extends, and means normally urging the valve outwardly from within said bore, there being passages from the interior of said chamber to the interior and exterior of the valve body, whereby pressure fluid is admitted through said chamber and valve member by a predetermined differential pressure between the interior and exterior of the valve body.

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