Aug. 11, 1942. E. D. PARKER 2,292,768

DIFFERENTIAL-PRESSURE CONTROLLED FLOW VALVE

Filed Oct. 2, 1939

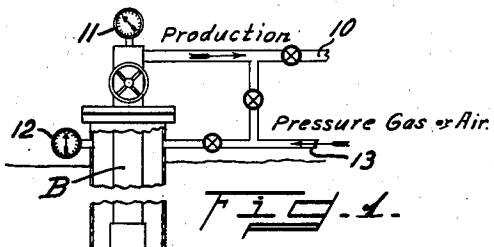


Fig. 1.

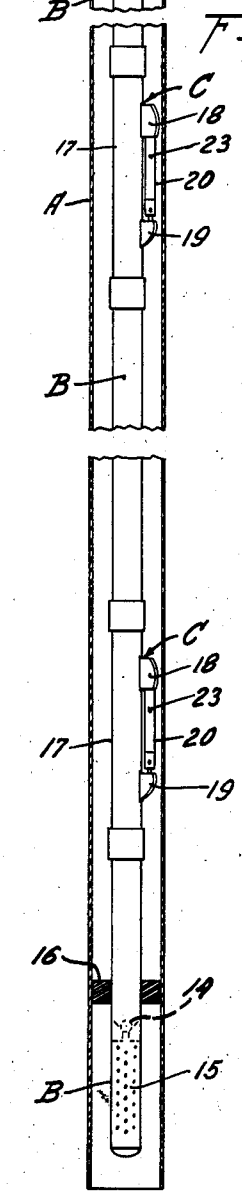


Fig. 3.

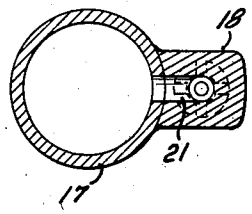


Fig. 4.

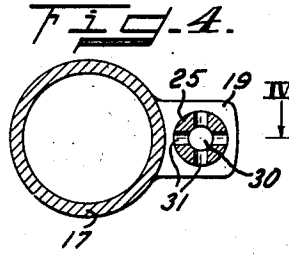
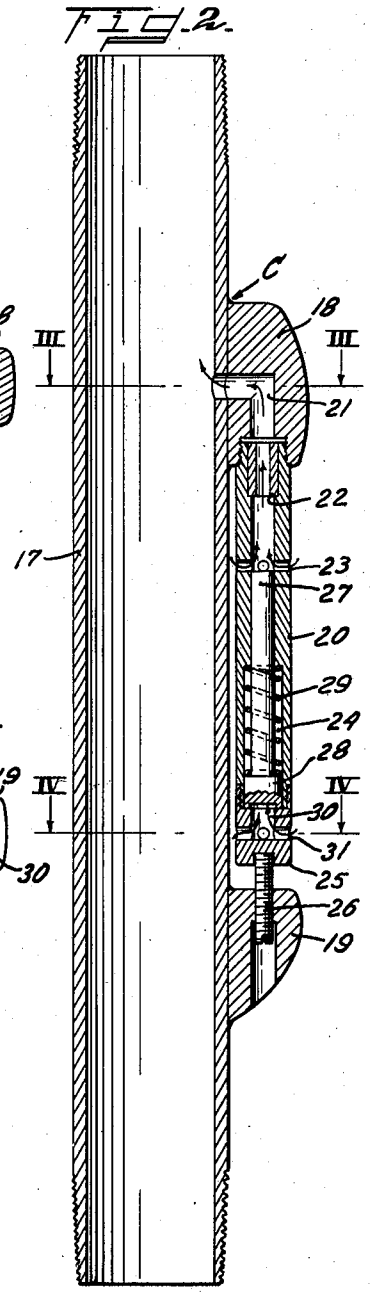


Fig. 2.



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DIFFERENTIAL PRESSURE CONTROLLED FLOW VALVE

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3 Claims. (Cl. 103—233)

This invention relates generally to gas lift apparatus employed in deep wells for production purposes and is more particularly directed to what is commonly referred to as a flow valve.

It is the principal object of the present invention to provide an improved type of flow valve for inducing pressure gas into a column of well fluid and automatically operable to closed or open positions under predetermined differential pressure conditions between said gas and said fluid column at said valve, and to provide a valve of the piston type which is subjected at opposite ends to such pressure conditions and is provided with tension means for controlling the differential under which said valve functions, said tension means being replaceable by other similar tension means of different tension value to vary said differential factor.

One form which the invention may assume is exemplified in the following description and illustrated by way of example in the accompanying drawing, in which:

Fig. 1 is a semi-diagrammatic longitudinal section through a well installation illustrating one use of my improved flow valve.

Fig. 2 is an enlarged vertical section through a valve unit constructed in accordance with the present invention.

Fig. 3 is a transverse section taken on the line III—III of Fig. 2.

Fig. 4 is a transverse section taken on the line IV—IV of Fig. 2.

In the example illustrated in Fig. 1, A designates the well casing and B designates the tubing string which, at the surface, communicates with the production line 10 and is provided with a pressure gauge 11. The upper end of the casing A is closed in the usual manner and is provided with a pressure gauge 12. Communicating with the upper end of the casing is a pressure line 13 by means of which gas or air under pressure may be pumped into the casing.

The tubing string B is, near its lower end, provided with a standing valve 14 and with a screen section 15 and, in instances where it is necessary or desirable, a packer 16 may be positioned between the tubing and the interior of the casing at a point above said screen.

C designates the flow valve units which are incorporated in the tubing string B and form detachable sections thereof, each valve unit providing a production flow passage of a uniform diameter substantially equal to the internal diameter of the standard tubing sections forming the balance of the tubing string, whereby there is provided an unobstructed tubing string affording full flow of the well fluid and permitting swabbing and such other operations as may be necessary or desirable.

Referring to Figs. 2, 3 and 4 of the drawing, it will be observed that the valve unit C comprises a main body which, primarily for economy of manufacture, is formed of a relatively short length of tubing 17 suitably screw-threaded at its opposite ends for incorporation in the tubing string B. At one side on this tubular body 17 there is disposed a head-guide 18 and a relatively spaced tail-guide 19 vertically aligned therewith, said guides being preferably formed of separate pieces welded or otherwise securely fixed to the body 17 to function as rigid parts thereof. One of the functions of these head and tail guides is to safely guide the tubing string in its installation in and withdrawal from the well casing and to protect the valve mechanism which is supported between said guides.

The valve mechanism is disposed closely adjacent and parallel to the exterior surface of the tubular body 17 and includes a tubular valve body 20 which is screw-threaded into the underside of the head-guide 18 with its bore providing a valve chamber whose upper end is in communication with a gas passage 21 formed in said head-guide and through the wall of the tubing 17 to discharge into the tubing string.

Secured in the upper end of said valve body 20, preferably by a drive fit therein, is an annular valve seat 22 and at an appreciable distance below said seat said body is provided with one or more transverse gas inlet ports 23 which communicate with the valve chamber and with the annular space between the tubing string and the interior of the well casing.

The lower portion of the valve body 20 is counterbored to provide a spring chamber 24 and is provided with a terminal cap 25 screw-threaded thereon, the lower end of said cap having a central recess formed therein for engagement by a retaining screw 26 which is screw-threaded in the tail-guide 19. This retaining screw maintains the lower end of the valve body against transverse displacement and also prevents an accidental unscrewing of the valve body from the head-guide 18, while at the same time providing a means which may be actuated to release such restraint so that the valve body 20 and its contained parts may be easily detached from the main body of the unit for repair or replacement.

Slidable within the bore of the valve body, below the valve seat 22, is a piston valve 27 whose upper end is adapted to engage said valve seat to close the gas passage 21. The lower end of the valve 27 is enlarged to provide a piston 28 which is slidable within the spring chamber 24 and provides on said valve an annular spring abutment shoulder. A coil compression spring 29 surrounds the valve 27 and is disposed within the spring chamber to engage the upper wall thereof and the piston 28 so as to mechanically exert a pressure on the valve normally tending to translate it downwardly to the open position shown in Fig. 2, in which position its upper valve end will be below the gas inlet ports 23 and its lower end will seat against the terminal cap 25.

The terminal cap 25 is centrally recessed downwardly from its upper interior surface, as at 30, and is provided with one or more transverse passages 31 intersecting said recess so as to permit entrance of exterior gas into the lower end of the valve body bore and thus subject the valve to the pressure of the gas in the well casing, with such gas pressure being exerted in a valve closing direction in opposition to reverse pressure exerted by the valve spring and by such fluid or gas pressure as may be exerted upon the opposite or valving end of said valve.

Preparatory to placing a well on production a series of the flow valve units C will be installed in the tubing string B at relatively spaced intervals of about three hundred to four hundred feet, depending upon the characteristics and production requirements of the particular well involved, with the uppermost unit submerged a predetermined distance below the normal static fluid level in the well.

With the apparatus properly installed in the well, as indicated in Fig. 1, the several flow valves are normally maintained open, as shown in Fig. 2, by their respective springs which determine the pressure differential under which they function.

To place the well on production compressed gas will be admitted into the annular space between the well casing and the string of tubing, from which space said pressure gas will be entrained into the tubing area through the respective flow valves under control of the pressure differential established by the valve springs.

Each of the flow valves will operate independently of the others and will provide an automatically functioning means for transferring pressure gas from the casing area into the tubing area when pressure conditions within the tubing at the valve level equal the difference between the casing pressure and the tension pressure of the valve spring.

If the spring 29 is so constructed as to impart a downward force of one hundred pounds on the valve stem 27, that force is effective as a differential pressure between the casing and the tubing pressures. Therefore, if the casing pressure varies, as it will under any operation, from two hundred pounds to one thousand pounds, the controlling pressure under the valve stem will keep the valve in seated position and closed against the transfer of gas from the casing to the tubing.

To open a closed valve, it is a requirement that a pressure (fluid head or otherwise) be obtained within the tubing, above the particular valve in question, equal to the casing pressure minus the spring differential pressure.

For example, let it be assumed that the uppermost flow valve C in the tubing string B is located one hundred feet below the normal static fluid level which is the same both within the tubing and within the casing A.

Assuming also that the well fluid is of that gravity which will impart a "head" pressure of .35 pound per foot of height, then the "head" pressure of the fluid standing in the tubing above said top valve will total one hundred feet multiplied by .35 pound or thirty-five pounds.

Considering further that the size of the annulus area between the casing and the tubing is five times the area of the tubing, then as pressure gas is admitted to the casing, the well fluid in the casing must be transferred into the tubing (or back into the formation when the packer 16 is not employed).

Since the valve under consideration is one hundred feet below the static fluid level, the pressure necessary to move the fluid from the annulus must be sufficient to support a fluid column in the tubing extending five hundred feet above the static fluid level or six hundred feet above said valve. This six hundred feet of fluid in the tubing will then present a "head" pressure of six hundred feet times .35 pound or two hundred ten pounds. This two hundred ten pounds "head" pressure will then represent the load requirement on the valve and the pressure within the casing will have to be increased only slightly to permit the valve to be opened.

If the "differential" built into the valve spring 29 is one hundred pounds, the valve 27 will open when the pressure load in the tubing is one hundred pounds less than the pressure in the casing.

When the valve is opened under these pressure conditions, the load of two hundred ten pounds is engaged by a force of three hundred ten pounds and must move upwards, that being the line or direction of least resistance in the tubing. As soon as the inertia of this load has been overcome, it will require less pressure to keep it moving, and as the pressure cannot be reduced, there will be an increase in velocity. This increase in velocity of the upwardly moving fluid column in the tubing will be a uniform accelerated velocity and a pressure drop will occur across the valve seat. When the pressure drop at that point is equal to the "differential" force of the valve spring 29, the gas pressure exerted upon the lower piston end 28 of the valve 27 will force the valve to its upper position, closing the gas inlet ports 23 and engaging the valve seat 22 and arresting the injection of gas through the gas passage 21 and into the tubing string.

With the valve thus closed, the operating cycle thereof is completed, and as the fluid continues to rise in the tubing, this top valve will be in operation as frequently as pressure conditions within the tubing are equal to the requirements of that valve.

The valves below the top or uppermost valve become effective as the fluid level in the well casing is lowered, each valve operating independently of all others. In this manner it is possible to flow a well at any predetermined rate of production by controlling the casing pressures applied.

Attention is directed to the fact that the gas inlet ports 23 are spaced a considerable distance from the valve seat 22. This provides an early cut-off of the gas inlet ports 23 and thus promotes a relatively quick closing action of the valve, and also prevents certain eroding effects of the

pressure gas which might otherwise cause trouble through leakage.

From the foregoing it will be understood by those skilled in the art that my improved valve, being automatically operable by differential pressure conditions of the lifting gas and the production column at the valve, will provide a flow means fully capable of meeting various flow requirements incident to the gas lift method of production, and that, by reason of the fact that the controlling differential factor, as predetermined by the valve spring tension, may be varied, said valve may easily and quickly be conditioned to meet definite requirements depending not only on the characteristics of a particular well, but also upon the producer's requirements as to the allowable production rate as determined by operating conditions or prorated allowables.

While the device herein illustrated and described is a preferred form of embodiment of the invention, it is to be understood that various changes of structure may be made by those skilled in the art without departing from the spirit of the invention as defined in the appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. In combination with a well tubing and casing with a compressed air chamber therebetween, a flow valve, a housing therefor having relatively large and small cylindrical portions and having a shoulder between said portions, ports extending from the compressed air chamber to the small cylindrical portion, and a port leading from one end of the small cylindrical portion into the tubing, a piston having a close fit with the small cylindrical portion and slidable therein so as to cover or uncover said ports leading to the compressed air chamber, a head on the piston, said head having a close fit with the large cylindrical portion, means whereby the outer end of said head is exposed to the pressures in the compressed air chamber, and a spring interposed between the head and the said shoulder.

2. In combination with a well tubing and casing, with a compressed air chamber therebetween, a housing, a small piston chamber in one end of said housing and a communicating large chamber in the other end thereof, a shoulder at the end of the large chamber adjacent the small piston chamber, a piston slidable in the small piston chamber and having a snug fit therewith and exiting into the large chamber, a head in said large chamber and on said piston, said head making a snug fit with the large chamber, a spring interposed in said large chamber between the shoulder and said head, means whereby the outer portion of said head is exposed to the pressures in the compressed air chamber, ports extending from the compressed air chamber into the small piston chamber immediately above the end of said piston when it is in extreme open position, and adapted to be closed by said piston when the piston is in closed position and a passageway leading from the small piston chamber into the tubing.

3. In combination with a well tubing and casing with a compressed air chamber therebetween, a flow valve having a spring chamber and a piston chamber, a piston slidable in said piston chamber and extending into said spring chamber, a head on one end of said piston and making a snug fit with said spring chamber, so as to prevent fluid from passing into said spring chamber, ports leading from said compressed air chamber into said piston chamber, a spring in said spring chamber and acting on said head to move said piston, so as to open said ports, a passageway leading from the piston chamber into the well tubing so that pressures in the tubing will be exerted on the piston, said spring yielding to allow the piston to close said ports when the casing pressure exceeds the tubing pressure plus the tension of the spring and the weight of the piston.

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