Dec. 26, 1939. C. S. CRICKMER ET AL 2,184,635

FLOW VALVE

Filed March 5, 1938

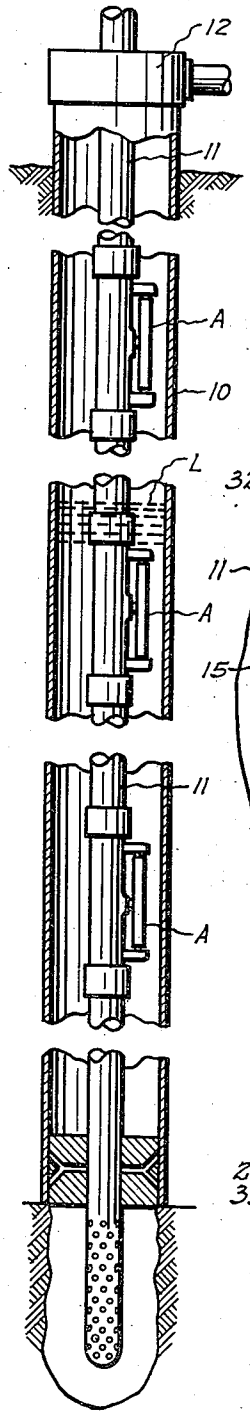

Fig. 1.

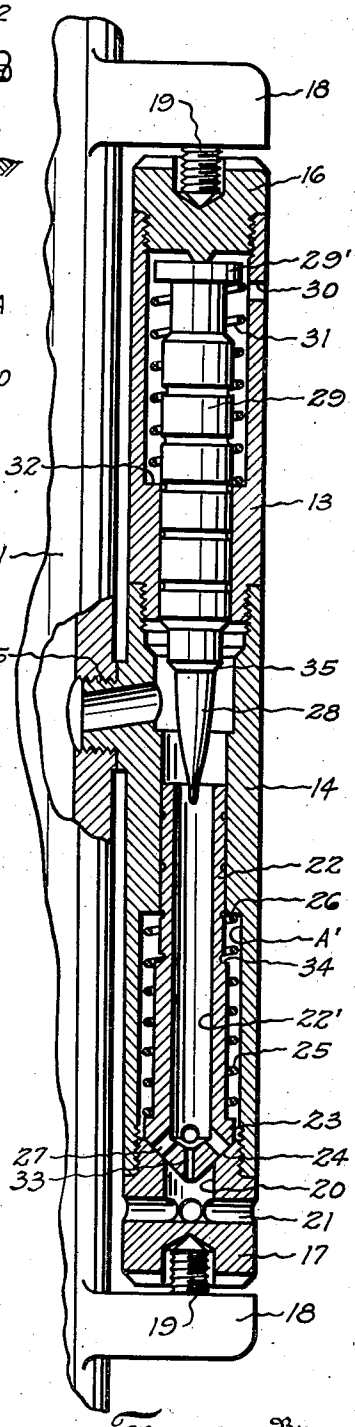

Fig. 2.

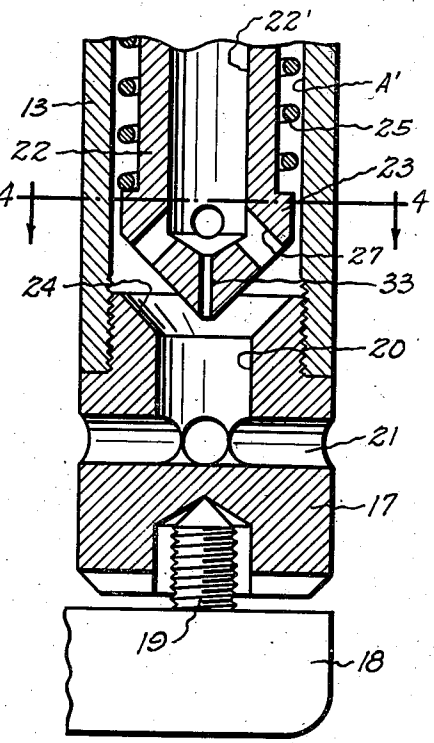

Fig. 3.

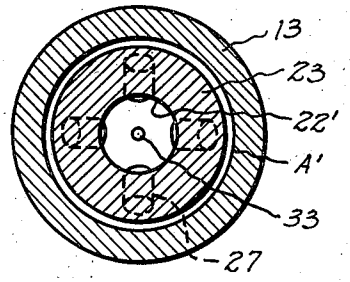

Fig. 4.

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FLOW VALVE

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6 Claims. (Cl. 103—232)

This invention relates to new and useful improvements in flow valves.

This application is filed as an improvement on the copending application of Charles S. Crickmer, Serial No. 43,648, filed October 5, 1935, patented January 17, 1939, No. 2,144,144.

One object of the invention is to provide an improved flow valve for controlling the admission of a lifting fluid, such as gas or air, from a well casing into a wall tubing, whereby the well liquid in the tubing may be raised or lifted to the surface.

An important object of the invention is to provide an improved flow valve which normally operates to control the flow of an auxiliary lifting fluid from the well casing to the tubing and which is constructed so that a reverse flow from the tubing to the casing may be had, whereby when necessary, a pressure medium may be introduced into the tubing from where it may enter the casing to lift any well liquid in said casing and thereby unload said casing of well liquid, so as to uncover those valves which may have been submerged by the standing liquid level and place said valves in condition for normal operation; the unloading of the casing in this manner being quickly and easily accomplished and eliminating the necessity of the auxiliary pressure fluid forcing the liquid downwardly in the casing and upwardly in the tubing, as has been the usual practice.

A further object of the invention is to provide an improved flow valve including a pair of coacting movable members for controlling the flow of a lifting fluid into a well tubing, one of said elements having a relatively small port therein through which a back flow from the tubing to the casing may occur when the member is in a shut-off or closed position.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawing, in which an example of the invention is shown, and wherein:

Figure 1 is a view partly in elevation and partly in section showing a plurality of the flow valves, constructed in accordance with the invention, connected in a tubing string,

Figure 2 is an enlarged view partly in elevation and partly in section of one of the valves,

Figure 3 is an enlarged sectional view of the lower end of the valve member, and

Figure 4 is a horizontal cross-sectional view taken on the line 4—4 of Figure 3.

In the drawing, the numeral 10 designates the usual well casing which has a well tubing 11 extending axially therethrough. The usual casing head 12 is connected to the upper end of the well casing. A plurality of flow valves A are connected in the tubing string 11 at spaced elevations and it is the usual practice to introduce a lifting fluid, such as gas or air into the well casing, from where said fluid flows through the valves A and into the tubing to raise the well liquid within said tubing to the surface.

Each flow valve A comprises an elongate tubular cylinder which is preferably made in an upper section 13 and a lower section 14, which sections are suitably connected together by screw threads. The bore of the cylinder communicates with the interior of the well tubing 11 through a radial nipple 15 which is preferably formed integral with the lower section 14 and is disposed near the upper end thereof. The upper end of the cylinder is closed by a cap member 16 while the lower end of said cylinder has a plug 17 screwed thereinto. The cylinder is supported exteriorly of the tubing 11 between radial bosses 18 which are preferably formed integral with the tubing. Set screws 19 are threaded through the bosses and have their inner ends engaging the cap 16 and plug 17 at the ends of the cylinder.

The plug 17 is provided with an axial bore 20, which has its upper end communicating with the bore A' of the cylinder. Radial ports 21 extend outwardly from the lower end of the bore 20 through the plug 17 and thus a communication between the interior of the well casing 10 and the interior of the well tubing 11 is established through the ports 21, bore 20 of the plug, bore A' of the cylinder and through the nipple 15.

For controlling the flow from the casing to the tubing, a tubular piston 22, having an axial bore 22', is movable vertically within the lower end of the bore A', that is within the lower section 14. This piston is formed with a valve head 23 at its lower end and said head is adapted to engage an annular seat 24 formed on the upper end of the plug 17. A coiled spring 25 surrounds the piston and normally holds said piston in a seated position, said spring being confined between the head 23 and an internal annular shoulder 26 formed within the bore of the section 14. A plurality of inclined ports 27 are provided in the head 23 and communicate with the lower end of the bore 22', and when the piston is in its lowered position with the head engaging the seat 24, the openings 27 are closed, whereby a flow from the casing is prevented.

When the piston 22 is raised, as will be explained, the valve head 23 is unseated and a flow from the casing may pass through the inclined ports 27 and upwardly through the bore 22' of the piston 22. This flow then passes through the nipple 15 and into the tubing 11. It is noted that the piston 22 acts as a velocity tube and as

the velocity of flow through said piston increases the piston is moved upwardly under tension of the spring 25.

For metering the flow as the velocity through the piston 22 increases, a metering pin 28 extends axially through the bore of the cylinder above the piston 22. The metering pin 28 is carried by a piston 29 which has its upper end exposed to the pressure within the well casing through a port 30 formed in the wall of the cylinder. A coiled spring 31 surrounds the upper end of the piston 29 and is confined between an external flange 29' on the upper end of said piston and an internal shoulder 32 formed within the bore of the section 13. The spring normally holds the piston in the position shown in Figure 1, which disposes the extreme lower end of the metering pin 28 within the upper end of the bore 22' of the lower piston 22, when said lower piston is in its seated position.

The lower piston 22 is formed with an axial opening or port 33, which port extends from the lower end of the bore 22' of the piston to the outer surface of the head, whereby when the piston 22 is in its lowered position with the head 23 seated, a communication between the bore 22' and the interior of the casing may be had. It is noted that this port or opening 33 is relatively small, being of a much less diameter than the bore 22'.

In using the flow valves A in a well, a plurality of the valves are connected in the tubing string 11 at various elevations therein. The well liquid in the casing will be standing at a given level as indicated at L in Figure 1. As the tubing string, having the valves A connected therein, is run into the well casing, a number of the valves A will be submerged below the liquid level. In order to permit these submerged valves to be operative by pressure differential, it is necessary that the liquid level in the well casing be lowered sufficiently to uncover the submerged valves. It has been the usual practice to introduce gas, air or other lifting fluid, into the well casing and to build up a pressure of this lifting fluid in said casing. The pressure of this fluid has been depended upon to drive or force the liquid level in the well casing downwardly so as to uncover the submerged flow valves A. In order to force the liquid level in the casing downwardly in this manner, it is necessary that the level within the tubing 11 be raised or that the liquid in the casing be forced back into the formation. It has been found that in order to do this, it is necessary that an excessive or very high pressure must be built up in the casing.

Instead of introducing the lifting medium into the well casing, said lifting medium is introduced into the tubing 11 at the upper end thereof. This lifting medium which is gas or air, travels downwardly through the tubing and eventually reaches the uppermost submerged valve A. Upon reaching this valve the gas or air flows through the nipple 15 and then downwardly through the bore 22' of the tubular piston 22, from this piston the gas or air then flows through a relatively small opening or port 33 in the bottom of said piston and then escapes through the ports 21 into the interior of the casing. The gas or air flowing into the casing will aerate the liquid above the submerged valve and will lift the liquid to the surface through the well casing.

The gas or air is introduced through the tubing until the liquid level in the well casing has been lowered to uncover all of the flow valves A and it is noted that this reverse admittance or introduction of the lifting fluid is made possible by the provision of the opening 33 in the bottom of the tubular piston 22.

After the liquid level in the casing has been lowered, the gas or air is then introduced in the well casing and the required pressure is built up in said casing. When the pressure of the lifting fluid in the well casing is sufficient, the valves A are operated as will now be explained. In operation, it will be assumed that the parts are in the position shown in Figure 2 with the piston 22 in its lowered position and the piston 29 in its raised position. The liquid within the well tubing is acting downwardly on the piston 22 to hold the same in its lowered position. When the gas pressure in the well casing reaches a pre-determined point, which is sufficient to overcome the pressure of the liquid in the tubing plus the pressure of the spring 25, the tubular piston 22 is moved upwardly so as to unseat the head 23. Unseating of the head permits the lifting fluid to flow through the inclined ports 27 and through the piston 22, from where it flows through the nipple 15 into the well tubing to aerate the liquid column. As the liquid begins to move upwardly through the tubing, the load is lightened and the velocity of the gas or air entering the tubing increases. Since the gas or air is flowing through the bore 22', this increased velocity moves the piston upwardly under tension of the spring 25 and as it does so, the upper end of said piston moves upwardly with relation to the metering pin 28 which is stationary at this time. Therefore, as the velocity of gas or air admitted to the tubing is increased, the volume of gas or air entering the tubing is automatically reduced in accordance with such velocity.

The piston 22 continues its upward movement until an external shoulder 34 on said piston strikes the internal shoulder 26 within the bore of the lower section 14, at which time further upward movement of the piston is halted. In this position, the upper end of the piston has moved with relation to the metering pin 28 so that the volume of gas or air entering the tubing is very small, although the velocity is relatively high. When this velocity reaches a pre-determined point, sufficient to reduce the pressure acting against the lower end of the piston 29, the pressure above said piston moves the same downwardly under tension of the spring 31. This downward movement of the piston causes the seat 35, which is formed on the piston above the pin 28, to engage the upper end of the lower piston 22. When this seat engages the piston 22, further flow of the lifting fluid into the tubing is prevented. The parts remain in this position until the liquid in the tubing rises sufficiently to build up the pre-determined pressure necessary to move the pistons 22 and 29, after which additional lifting fluid is again introduced and the operation repeated.

It is pointed out that under normal conditions, the flow valve A operates to control the admittance of the lifting fluid from the casing to the tubing. However, when it is desired to unload the well casing, which is at the start of the flowing operation, it is only necessary to introduce the lifting fluid into the tubing so that the same can escape into the casing through the port 33 in the lower piston 22. It is noted that the size of the port 33 is such that it does not effect the normal operation of the valve, but merely provides a means whereby the communication be-

tween the tubing and casing may be established when the piston 22 is in a lowered or seated position.

What we claim and desire to secure by Letters Patent is:

1. A well flow device including, a tubular body arranged to be connected with the well tubing and lowered therewith into the well casing, said body being provided with a passage for establishing communication between the casing and tubing, a tubular piston slidable in the passage and so located that the flow of the lifting fluid from the casing to the tubing passes therethrough, a valve carried by the piston arranged to substantially close the passage and piston and actuated by the differential in pressure between the well liquid in the tubing and the lifting fluid within the casing, said valve having an opening therein which communicates with the tubing and the casing to establish communication therebetween when the valve is seated, and means for automatically metering the volume of fluid flowing through said passage according to the velocity of the well liquid passing through the tubing.

2. A well flow device including, a tubular body arranged to be connected with the well tubing and lowered therewith into the well casing, said body being provided with a passage for establishing communication between the casing and tubing, a tubular piston slidable in the passage and so located that the flow of the lifting fluid from the casing to the tubing passes therethrough, a valve carried by the piston arranged to substantially close the passage and piston and actuated by the differential in pressure between the well liquid in the tubing and the lifting fluid within the casing, said valve having an opening therein which communicates with the tubing and the casing to establish communication therebetween when the valve is seated, means for automatically metering the volume of fluid flowing through said passage according to the velocity of the well liquid passing through the tubing, and means for completely cutting off the flow of fluid through said passage when the well liquid reaches a predetermined velocity.

3. A well flow device including, a tubular body arranged to be connected with the well tubing and lowered therewith into the well casing, said body being provided with a passage for establishing communication between the casing and tubing, a tubular piston slidable in the passage and so located that the flow of the lifting fluid from the well casing to the tubing passes therethrough, a valve carried by the piston arranged to substantially close the passage and piston to prevent a free flow of fluid through the piston, said valve being actuated by the differential in pressure between the well liquid in the tubing and the lifting fluid within the casing, said valve having an axial opening therein which communicates with the tubing and the casing to establish communication therebetween when the valve is seated, and a metering pin within the passage above the piston and adapted to move into the upper end of the piston when said piston moves upwardly, the movement of the piston being controlled by the velocity of the lifting fluid which is flowing through said piston, such velocity depending on the differential in pressure between the well liquid within the tubing and the lifting fluid within the casing, whereby the volume of fluid flowing through the passage is automatically metered according to such pressure differential.

4. A well flow device including, a tubular body arranged to be connected with the well tubing and lowered therewith into the well casing, said body being provided with a passage for establishing communication between the casing and tubing, a tubular piston slidable in the passage and so located that the flow of the lifting fluid from the well casing to the tubing passes therethrough, a valve carried by the piston arranged to substantially close the passage and piston to prevent a free flow of fluid through the piston, said valve being actuated by the differential in pressure between the well liquid in the tubing and the lifting fluid within the casing, said valve having an axial opening therein which communicates with the tubing and the casing to establish communication therebetween when the valve is seated, a metering pin within the passage above the piston and adapted to move into the upper end of the piston when said piston moves upwardly, the movement of the piston being controlled by the velocity of the lifting fluid which is flowing through said piston, such velocity depending on the differential in pressure between the well liquid within the tubing and the lifting fluid within the casing, whereby the volume of fluid flowing through the passage is automatically metered according to such pressure differential, and means for completely cutting off the flow of fluid through said passage when the well liquid reaches a predetermined velocity.

5. A well flowing device including, a tubular body adapted to be connected in a well tubing and lowered therewith in a well casing, said body having a passage for establishing communication between the casing and tubing, and an elongate piston movable in the passage and actuated by the differential in pressure between the well tubing and well casing for controlling the flow of lifting fluid from the casing to the tubing, said piston having a bore through which the fluid may flow when the piston is in an unseated position, said bore having an axial port leading from its lower end for permitting a flow from the tubing to the casing when the piston is in a shut off position, the port being of sufficient size to permit a reverse flow of pressure fluid from the tubing to the casing to unload any liquid standing in the casing.

6. A well flowing device including, a tubular body adapted to be connected in a well tubing and lowered therewith in a well casing, said body having a passage for establishing communication between the casing and tubing, a valve seat within the passage, and a valve member adapted to engage said seat to control the flow of lifting fluid from the well casing to the well tubing and actuated by the pressure differential in said tubing and casing, said valve member having an axial bore extending from its upper end and terminating short of its lower end and having a coaxial port extending from the lower end of the bore and arranged so that its lower end is open to the casing when the valve member is seated, whereby a fluid pressure may be conducted from the tubing to the casing for unloading any liquid in the casing.

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