

April 16, 1968

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3,378,079

SLEEVE VALVE APPARATUS

Filed Oct. 1, 1965

2 Sheets-Sheet 1

FIG. 1.

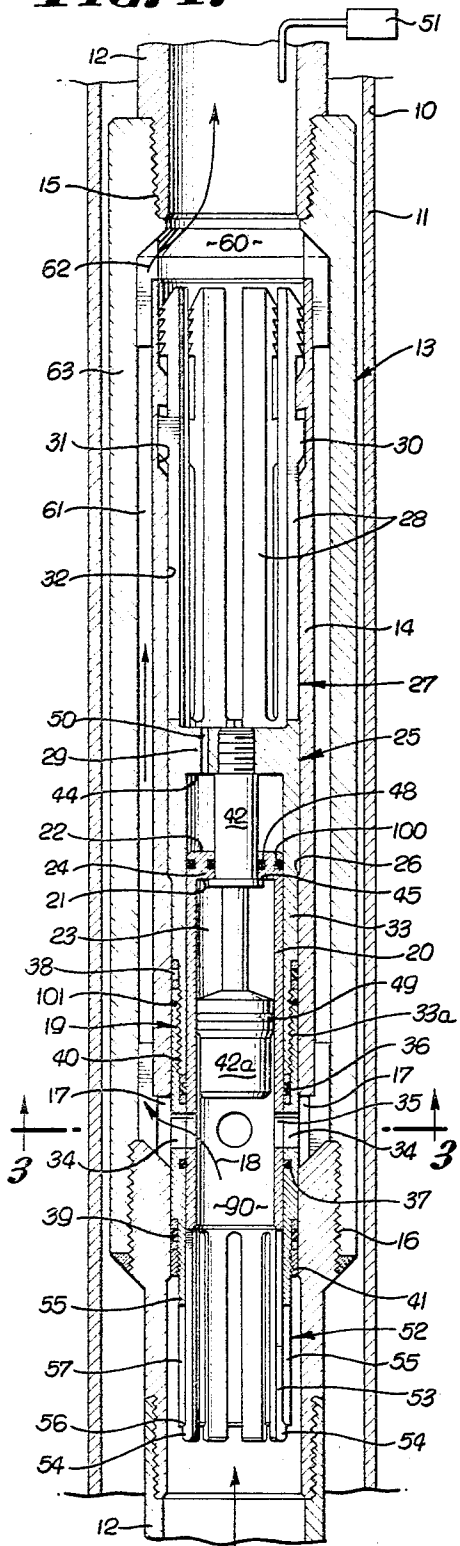
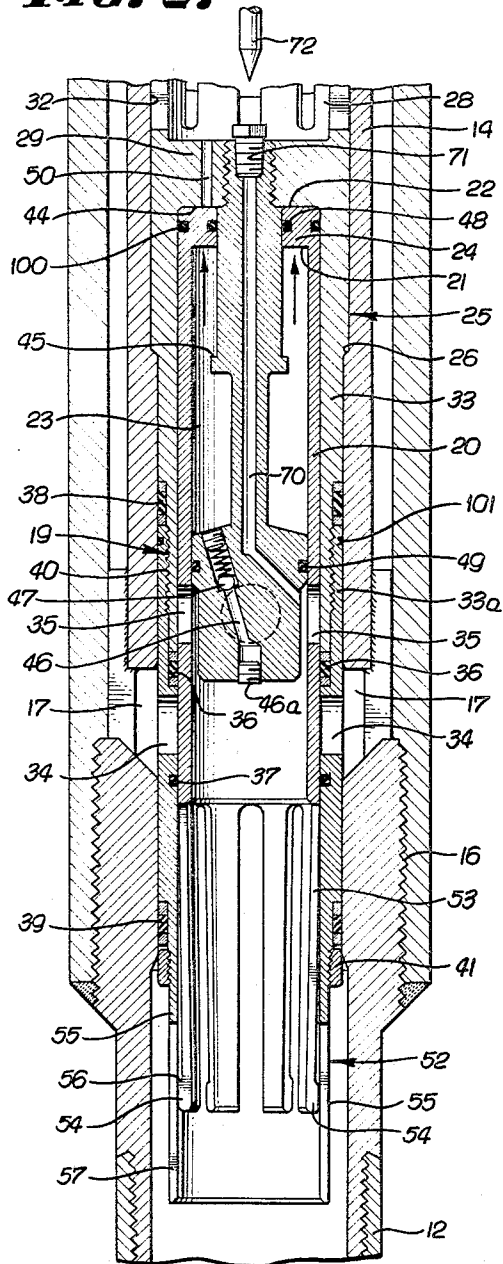


FIG. 2.



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FIG. 4.

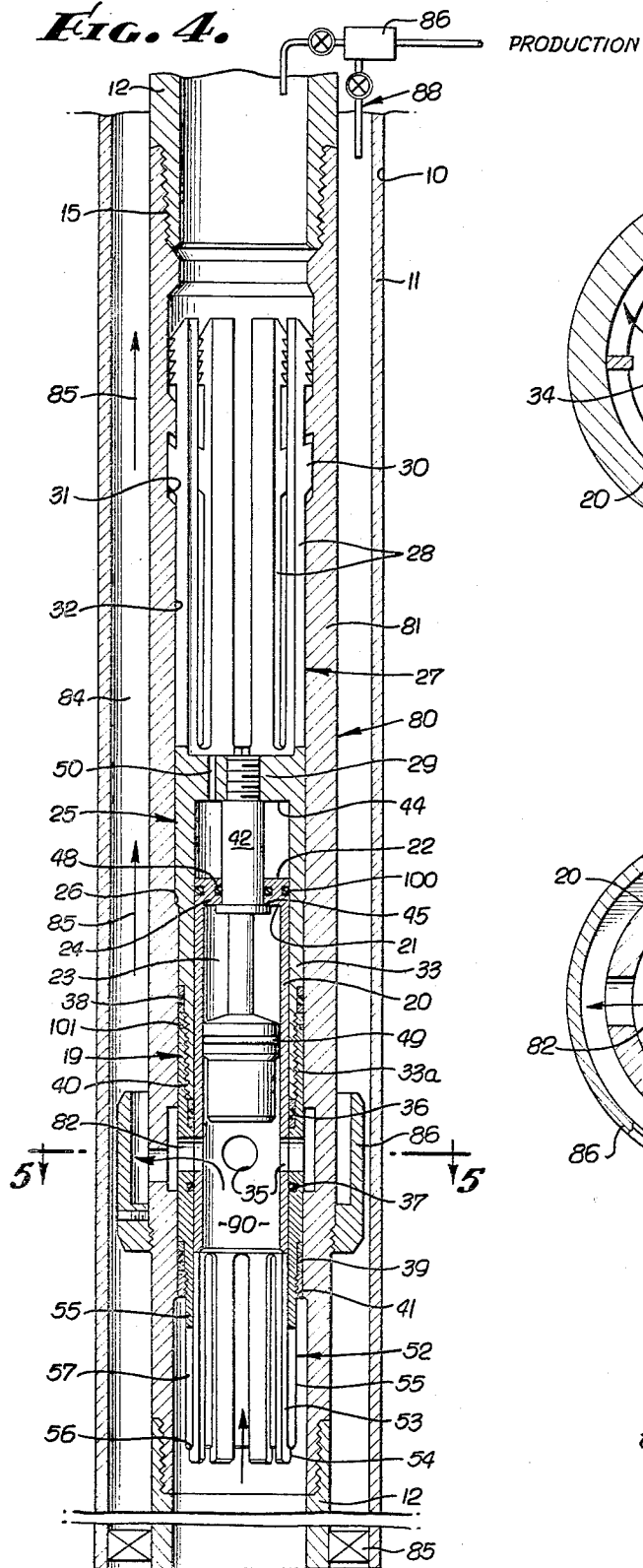


FIG. 3.

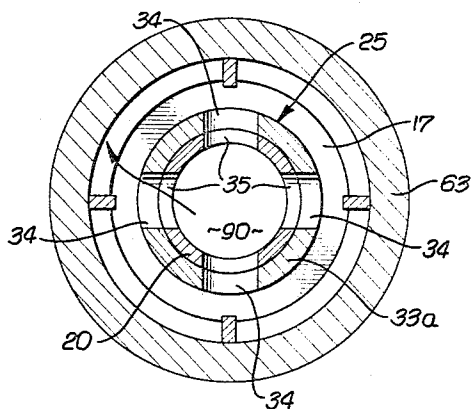
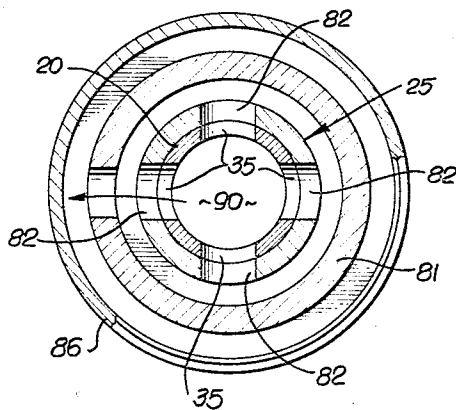


FIG. 5.



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SLEEVE VALVE APPARATUS
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ABSTRACT OF THE DISCLOSURE

The disclosed apparatus enables control of well fluid flow through a tubular body side port by means of control means including a sleeve within the body; the control means forms a sealed chamber to contain fluid under pressure, and has piston surfaces respectively exposed to pressure within the chamber and to counteracting fluid pressure outside the chamber for effecting sleeve movement lengthwise within the body; and the control means plugs the interior of the tubular body.

This invention relates generally to sub-surface well valves usable to control the flow of fluid in pipe or tubing. More particularly, the invention concerns improvements embodied in a sub-surface well valve making it controllable in response to changing the pressure of control fluid in the tubing string above the valve.

It is a major object of the invention to provide an improved sub-surface well valve of unusually advantageous construction and mode of operation, not found in prior valves of which I am aware. Basically, the valve assembly comprises tubular body means connectible in a string of tubing and having side porting through which well fluid is flowable between the interior and exterior of the tubular body means, and control means including a sleeve movable lengthwise of and within the tubular body to control the flow of well fluid through the porting, the control means forming a chamber to receive fluid under pressure, and the control means having piston surfaces respectively exposed to the pressure within the chamber and to the counteracting pressure of fluid within the tubular body but outside the chamber for effecting the lengthwise movement of the sleeve. As will appear, the fluid under pressure in the chamber may be gas pre-charged into the chamber, in which event the counteracting pressure may be controlled from the surface and applied via the tubing string interior; alternately, the invention permits the counteracting pressure to be applied from the well fluid whose flow through the side port is controlled by the sleeve. As a further variant, the invention allows the use of that well fluid to exert pressure within the chamber, in which event the counteracting pressure may be controlled from the surface and applied via the tubing string interior.

Another object of the invention is to provide a control means that includes a carrier received within the tubular body as the carrier is run in the tubing, the control sleeve being movable relative to the carrier and the piston surfaces being integral with the sleeve. Typically, the carrier has a collet with spring fingers releasably attachable to the tubular body.

Another object of the invention is to provide the carrier with an annular portion receiving the sleeve and having side porting in communication with the side porting in the tubular body, the sleeve also having side porting in flow passing communication with the side porting in the carrier and tubular body when the sleeve is in down position, but not when the sleeve is in up position. Typically, sealing rings are carried by the carrier annular portion to seal off between the sleeve and the carrier annular portion at locations above and below the side porting therein. As a result, the sealing rings are not

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moved across the side ports in the path of high pressure flow as the sleeve is displaced between its up and down positions.

Other objects and advantages of the invention include the provision of a carrier central stem projecting downwardly within the carrier annular portion, with the chamber and piston surfaces extending annularly about the stem and inwardly of the carrier annular portion; the provision of a check valve controlled inlet to the chamber, the stem containing that inlet as well as a passage to by-pass well fluid between the upper and lower sides of the carrier for pressure equalization to allow opening of the valve, such by-passing being normally blocked by a frangible element adapted to be penetrated by a tool lowered within the body to the carrier; the provision of means carried by the tubular body and communicating side porting therein to the interior of the tubular body above the control means; and the provision of guide means on the sleeve and carrier annular portion to block relative rotation therebetween while allowing vertical movement of the sleeve relative to the carrier.

These and other objects and advantages of the invention, as well as the details of an illustrative embodiment, will be more fully understood from the following detailed description of the drawings, in which:

FIG. 1 is a vertical section through one preferred form of the assembly in a well, the valve being in open condition;

FIG. 2 is an enlarged vertical section showing the valve closed;

FIG. 3 is a horizontal section taken on line 3—3 of FIG. 1;

FIG. 4 is a view like FIG. 1, but showing another form of the assembly; and

FIG. 5 is a horizontal section taken on line 5—5 of FIG. 4.

In FIG. 1, the well 10 is shown as cased at 11, and as having a tubing string 12 run downward therein. The assembly to control well fluid flow in the tubing is indicated generally at 13 and as including a tubular body means such as 14 suitably connected at 15 and 16 into the tubing string. The body has side porting, such as is seen at the lower location 17, through which well fluid is flowable at 18 between the interior and exterior of the body.

Contained within the body 14 is what may be generally referred to as control means 19 including a sleeve 20 movable lengthwise of the body to control the flow of fluid through the side ports 17. The control means forms a chamber 23 to receive fluid under pressure, and the control means also has piston surfaces, as for example are seen at 21 and 22, respectively exposed to the pressure within the chamber and to the counteracting pressure of fluid within the tubular body but outside the chamber for effecting lengthwise movement of the sleeve.

Piston surfaces 21 and 22 are typically integral with the sleeve 20, and in the example shown are formed by an interior flange 24 from which the sleeve depends. The sleeve is shown as movable vertically between the down position of FIG. 1 and the up position of FIG. 2, and relative to a carrier 25 which is downwardly received within the body 14 and against a landing shoulder 26. In this regard, the carrier includes a collet 27 having spring fingers 28 projecting vertically from the carrier flange 29. The fingers are releasably attached to the body 14, as by latch dogs 30 urged outwardly into an annular groove 31 in the body bore 32 when the carrier is landed in the body or sub 14.

In the FIGS. 1 and 2 example, the carrier 25 has an annular portion 33 receiving the sleeve 20, and it has side porting 34 in communication with the body porting 17. The sleeve also has side porting 35 in flow passing communication when the carrier and body side porting when

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the sleeve is in down position as seen in FIG. 1. In up position as seen in FIG. 2, the sleeve porting is out of flow passing communication with the carrier and body side porting, the latter then being blocked by the sleeve.

It will be noted that sealing rings 36 and 37 are carried by the carrier annular portion to seal off between the sleeve and the carrier annular portion at locations above and below the side porting therein. Accordingly, the elastomer rings remain substantially confined and are not drawn across the porting passing the high velocity flow as the valve is opened and closed, avoiding malfunction accompanying damage to these seals. Other seals are shown at 38 and 39 sealing off between the carrier 25 and the body 14. In this regard, a lower extension 33a of the carrier tubular portion 33 is threaded to the latter at 40 and retains seal 38, seal 39 being retained by nut 41.

The carrier is also shown as having a central stem 42 projecting downwardly within the carrier annular portion, and enlarged at 42a. In this regard, the piston surfaces 21 and 22 extend annularly about the stem 42 and inwardly of the carrier annular portion 33, the chamber 23 being located between the stem 42 and the carrier annular portion 33. Sleeve travel limits are established by shoulders 44 and 45 on the carrier flange 29 and carrier stem 42, the piston surfaces 22 and 21 being engageable with these shoulders as seen in FIGS. 1 and 2.

The stem enlargement 42a contains an inlet 46 which is controlled by a spring urged check valve 47, whereby pressurized gas may be pre-charged into the chamber 23 for urging the sleeves upwardly. After pre-charging, inlet 46 is sealed by plug 46a. Seals 48 and 49 between the stem and sleeve contain the gas in the chamber. Thus, when the well fluid pressure acting downward on piston surface 22 via port 50 in FIG. 2 increases above a predetermined level, the sleeve will move downward to FIG. 1 position, opening the closed valve. Such well pressure may be controlled from the surface, as indicated at 51 in FIG. 1. Additional seals are seen at 100 and 101.

Normally, the valve is in FIG. 1 position; however, when the pressure of the well fluid flowing upwardly drops sufficiently, the sleeve will move upward to close the valve. This upward stroking of the sleeve is made rapid and positive by the sudden release of means acting to yieldably resist such upward movement. One such means is seen to comprise a collet 52 having spring fingers 53 suspended from the sleeve, the fingers having latch dogs 54 whose upward movement is blocked by carrier part 55. The latter and the dogs interengage at cam interface 56 angled to allow the dogs to yieldably cam inwardly for suddenly unblocking then upward movement with the sleeve when the net upward force on the sleeve reaches a predetermined value. One of the dogs 54 moves upward in a slot 57 formed by the part 55, acting as a guide for the sleeve to block its rotation about the vertical axis of the assembly.

It will be noted that the control means 19 plugs the interior of the tubular body above the side porting 17 therein. That porting is communicated with the interior 60 of the body 14 via annular passage 61 and upper porting 62 in the body 14. Passage 61 is formed between the body 14 and the body cylinder 63. Normally the pressure of well fluid by-passed to the body interior 60 to act downward on surface 22 is sufficient that the sleeve is kept in down position. Only when the flow pressure drop sufficiently does the valve sleeve move upward to FIG. 2 position.

Finally, FIG. 2 indicates that the stem 42 contains a passage 70 to by-pass well fluid pressure between the upper and lower sides of the carrier, the passage normally being blocked by a frangible element such as plug 71. The latter may be exposed at the top center of the stem to be penetrated by a tool lowered within the string and body 14, thereby to allow fluid pressure equalization at the top and bottom of the carrier, when the sleeve is in up or closed position as seen in FIG. 2, so that the shut-in pres-

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sure of well fluid below the valve may then be applied to the top piston surface 22 for opening the valve. The lower tip of such a tool is seen at 72 in FIG. 2.

The assembly 80 illustrated in FIG. 4 includes a tubular body 81 containing a control means 19 the same as described in FIGS. 1 and 2. The body side porting 82, however, is not in communication with the upper interior of the body above the control means; rather, it communicates with the well annulus 84 between the casing and the tubular body, for example. In this case, a packer indicated at 85 may be set between the string and the casing, below the side porting 82, so that the well may be produced upwardly via the annulus 84 as shown by arrows 85. A flow deflector 86 mounted on body 81 prevents erosion of the casing outwardly of the porting 82. The sleeve may be displaced between open and closed positions solely by varying the downward pressure exerted on piston surface 22 by the column of control fluid in the string above the carrier 25, as by means of the surface control 86. The latter may be supplied at 88 with pressure of the upward production flow for return to the string as control pressure.

Finally, that form of the invention seen in FIG. 4 may be varied by removing plug 46a and ball check valve 47 (both seen in FIG. 2) to place the chamber 23 in direct communication via inlet 46 with the well fluid pressure in the string below the carrier 25. In that event, the vertical displacement of the sleeve 20 is controlled by changes in the differential pressure of control pressure acting downward on piston surface 22 and well fluid pressure acting upward on surface 21. Thus the invention affords the user a variety of modes of operation, not possible of accomplishment with prior equipment. Another advantage resides in the open and unobstructed interior 90 of the control means below the stem 42, whereby the upward flow of well fluid to the side porting is not impeded.

I claim:

1. An assembly operable to control well fluid flow in tubing, comprising tubular body means having side porting through which well fluid is flowable between the interior and exterior of said tubular body means, and control means including a sleeve movable lengthwise of and within said tubular body means to control the flow of well fluid through said porting, said control means forming a sealed chamber to contain fluid under pressure, said control means having piston surfaces respectively exposed to the pressure within said chamber and to the counteracting pressure of fluid within said tubular means but outside said chamber for effecting said lengthwise movement of said sleeve, and said control means plugging the interior of said tubular body means above the side porting therein.

2. The assembly of claim 1 in which said control means includes a carrier received within said body, said control sleeve being movable relative to the carrier and said piston surfaces being integral with said sleeve.

3. The assembly of claim 2 in which said carrier includes a collet having spring fingers releasably attachable to said tubular body.

4. The assembly of claim 1 including means to yieldably oppose and suddenly release sleeve lengthwise movement in a direction to effect closing of said porting.

5. The assembly of claim 2 in which the tubular body means extends vertically with said side porting formed therein, the carrier has an annular portion receiving the sleeve and having side porting in communication with the body side porting, said sleeve also having side porting in flow passing communication with the carrier and body side porting when the sleeve is in down position, and the sleeve has an up position in which the sleeve side porting is out of flow passing communication with the side porting in the carrier and tubular body.

6. The assembly of claim 5 including sealing rings carried by the carrier annular portion to seal off between

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the sleeve and said carrier annular portion at locations above and below the side porting therein.

7. The assembly of claim 5 including means carried by said body means and communicating said body means side porting with the interior of the tubular body means above said control means.

8. The assembly of claim 5 including a well tubing string into which said tubular body means is connected in series in a well.

9. The assembly of claim 8 including gas confined in said chamber at a pressure related to the pressure exerted downward at the control means by control fluid in the string above said control means so that the sleeve is in down position.

10. The assembly of claim 5 including guide means on the sleeve and carrier annular portion to block relative rotation therebetween while allowing vertical movement of the sleeve relative to the carrier.

11. An assembly operable to control well fluid flow in tubing, comprising tubular body means having side porting through which well fluid is flowable between the interior and exterior of said tubular body means, and control means including a sleeve movable lengthwise of and within said tubular body means to control the flow of well fluid through said porting, said control means forming a chamber to receive fluid under pressure, said control means having piston surfaces respectively exposed to the pressure within said chamber and to the counter-acting pressure of fluid within said tubular means but outside said chamber for effecting said lengthwise movement of said sleeve, said control means including a carrier received within said body, said control sleeve being movable relative to the carrier and said piston surfaces being integral with the sleeve, the tubular body means extending vertically with said side porting formed therein,

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the carrier having an annular portion receiving the sleeve and having side porting in communication with the body side porting, the sleeve also having side porting in flow passing communication with the carrier and body side porting when the sleeve is in down position, the sleeve having an up position in which the sleeve side porting is out of flow passing communication with the side porting in the carrier and tubular body, the carrier having a central stem projecting downwardly within said carrier annular portion, said piston surfaces extending annularly about said stem and inwardly of the carrier annular portion, said chamber being located between said stem and said carrier annular portion.

12. The assembly of claim 11 including a check valve controlled inlet to said chamber, the inlet being at said stem.

13. The assembly of claim 11 in which the stem has a passage to by-pass well fluid pressure between the upper and lower sides of said carrier, and including a frangible element to block said by-passing, said element located to be penetrated by a tool lowered within said body to said carrier.

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