United States Patent [19]

Hill

[11] **3,850,238**

[45] **Nov. 26, 1974**

[54] **METHOD OF OPERATING A SURFACE CONTROLLED SUBSURFACE SAFETY VALVE**

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[73] Assignee: **Exxon Production Research Company**, Houston, Tex.

[22] Filed: **Oct. 25, 1973**

[21] Appl. No.: **409,536**

Related U.S. Application Data

[62] Division of Ser. No. 294,399, Oct. 2, 1972, Pat. No. 3,794,112.

[52] **U.S. Cl.** **166/314**, E21b/43/00

[58] **Field of Search** ..... 166/314, 315, 224 A, 64, 166/53

[56] **References Cited**

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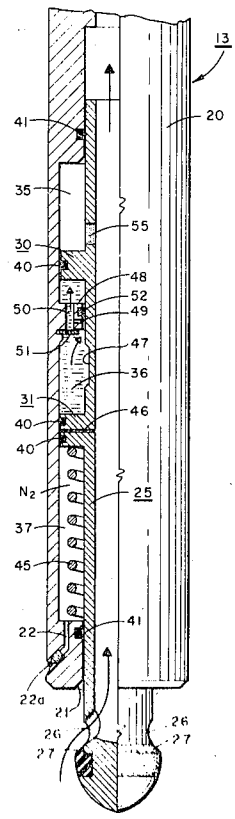
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Primary Examiner—Stephen J. Novosad
Attorney, Agent, or Firm—John S. Schneider

[57] **ABSTRACT**

A surface controlled subsurface safety valve is positioned in a well production tubing and an adjustable choke is installed in the surface production tubing. The safety valve is operated by the absolute pressure of the production fluids in the well tubing. The adjustable choke is controlled by a timer which periodically cycles the choke to reduce the flow area available for production of well fluids for a predetermined short period of time. The reduction in flow area causes a corresponding build up of pressure in the surface tubing which is transmitted down the well tubing to the subsurface valve. Biasing means urges the valve to its closed position while tubing pressure urges the valve to its open positions. During normal well flowing conditions the force of the tubing pressure is less than the force of the biasing means and the valve, while remaining fully open is moved by the biasing means towards its closed position. Such movement is retarded by a dash pot arrangement in the valve. Means are provided in the valve to bypass the dash pot and cause rapid closure of the valve when the valve has reached a predetermined point towards its closed position. Under normal operations before the valve reaches the point of rapid closure the tubing pressure force at the valve is increased substantially over the force of the biasing means and the valve is moved rapidly to its initial open position. The increase in tubing pressure at the valve results from reducing the flow area by means of the adjustable choke in the surface tubing.

2 Claims, 5 Drawing Figures



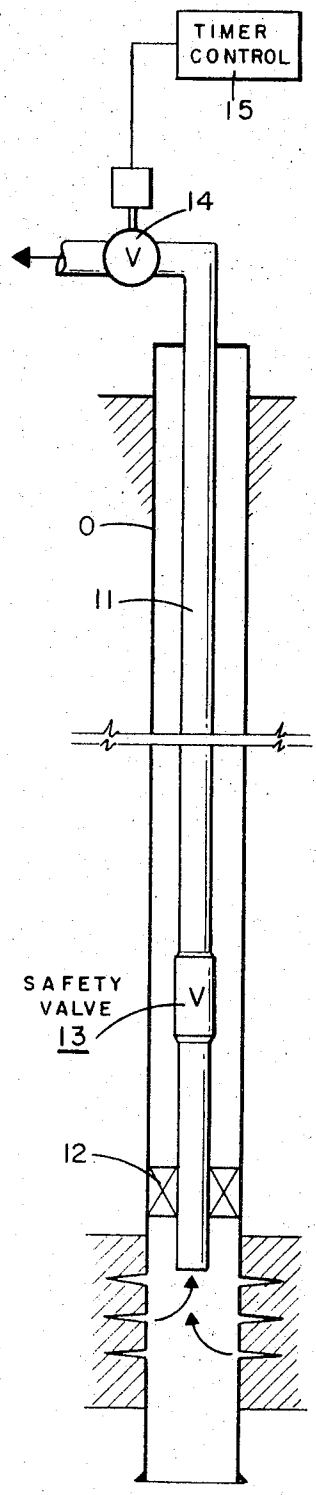


FIG. 1.

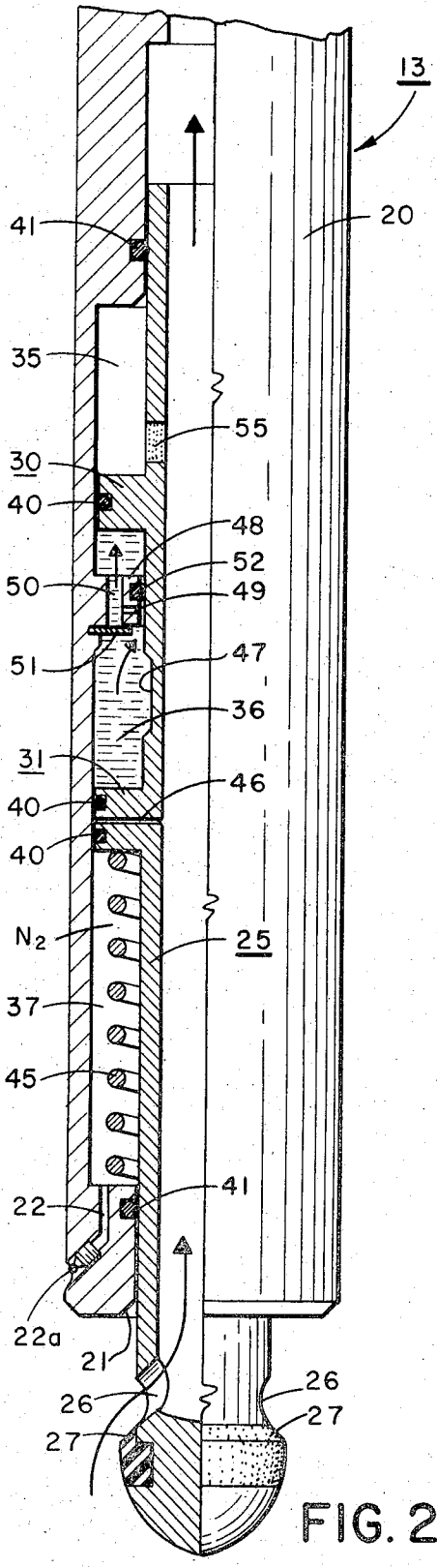


FIG. 2.

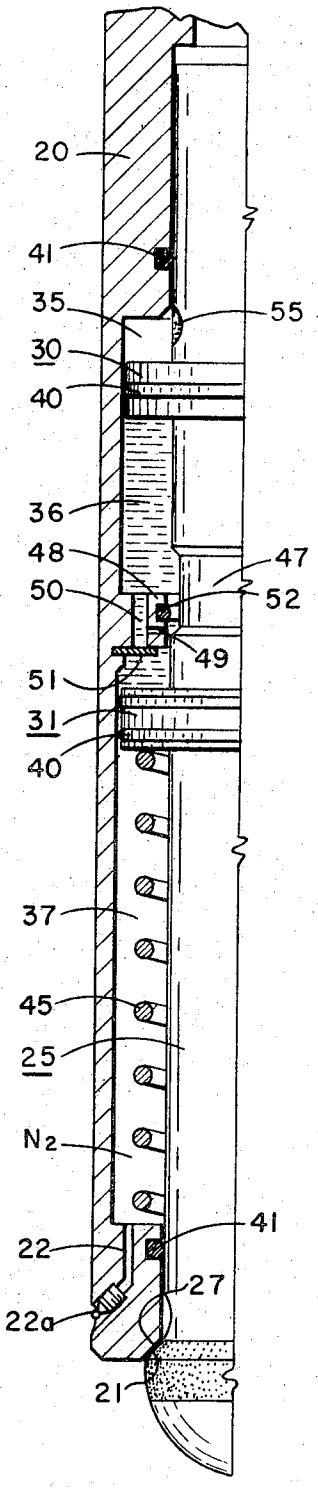


FIG. 3.

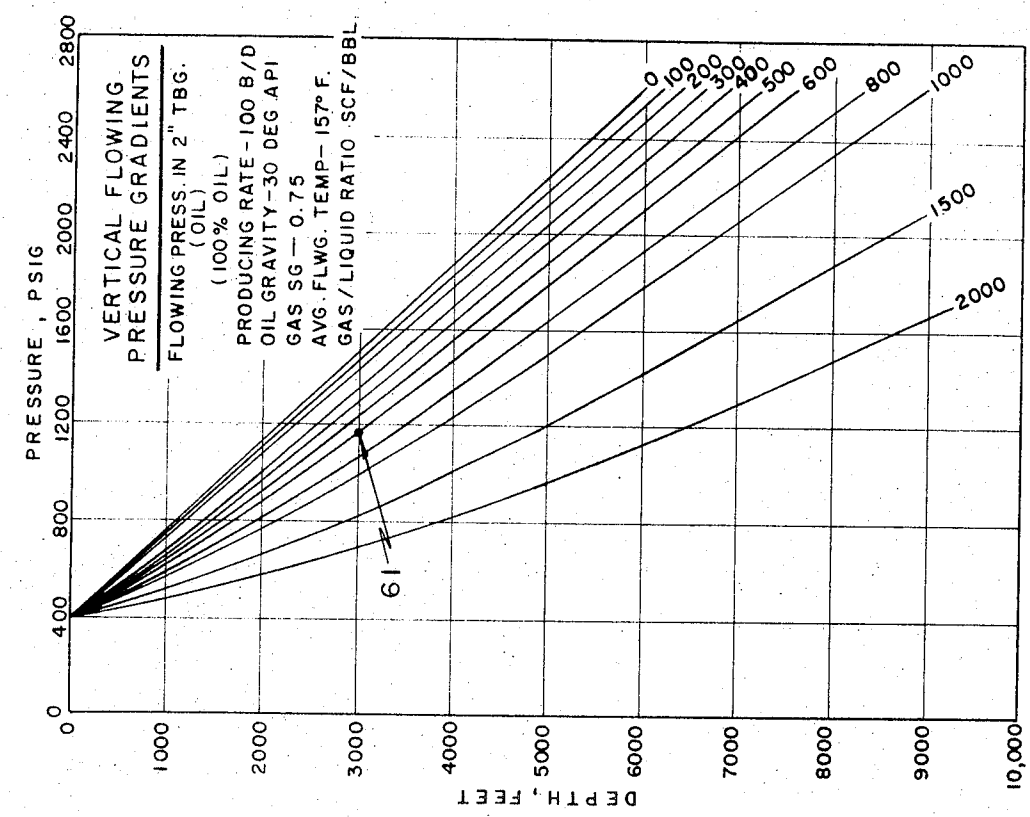

VERTICAL FLOWING
PRESSURE GRADIENTS
FLOWING PRESS. IN 2" TBG.
(OIL)
(100% OIL)
PRODUCING RATE - 100 B/D
OIL GRAVITY - 30 DEG API
GAS SG — 0.75
AVG. FLWG. TEMP — 157° F.
GAS / LIQUID RATIO SCF/BBL
0
100
200
300
400
500
600
800
1000
1500
2000
61
PRESSURE, PSIG
0
400
800
1200
1600
2000
2400
2800
DEPTH, FEET
1000
2000
3000
4000
5000
6000
7000
8000
9000
10,000

FIG. 5.

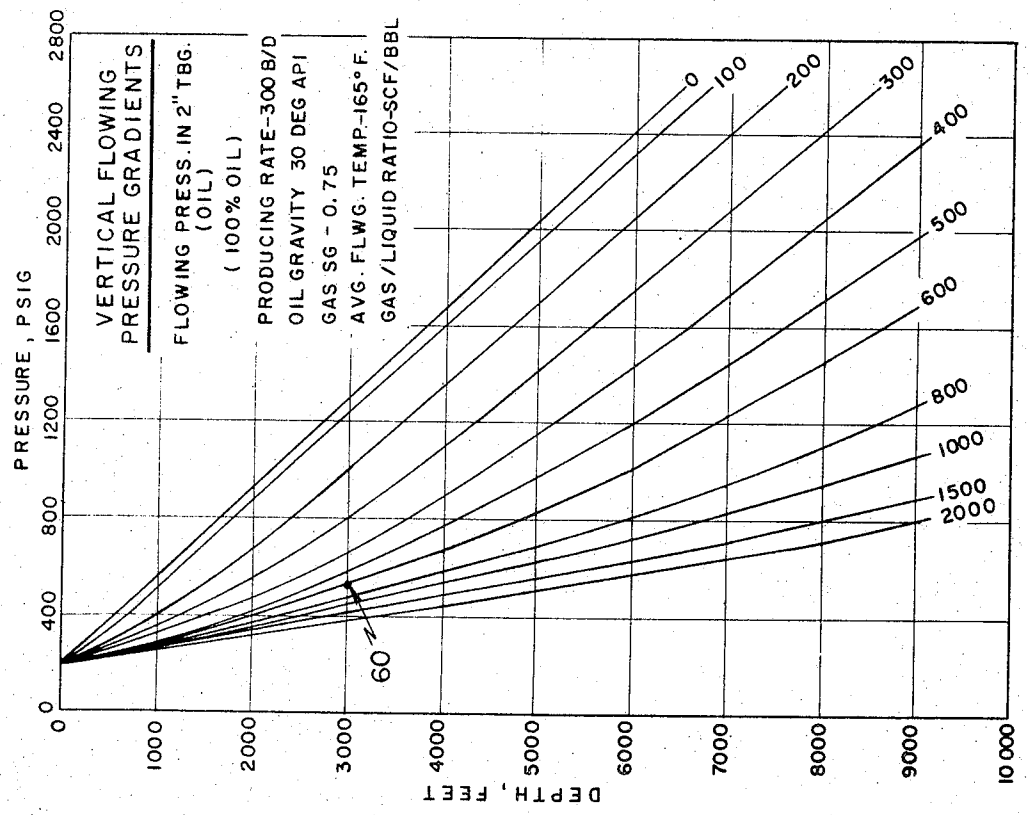

VERTICAL FLOWING
PRESSURE GRADIENTS
FLOWING PRESS. IN 2" TBG.
(OIL)
(100% OIL)
PRODUCING RATE-300 B/D
OIL GRAVITY 30 DEG API
GAS SG - 0.75
AVG. FLWG. TEMP-165° F.
GAS/LIQUID RATIO-SCF/BBL
0
100
200
300
400
500
600
800
1000
1500
2000
60
PRESSURE, PSIG
0
400
800
1200
1600
2000
2400
2800
DEPTH, FEET
1000
2000
3000
4000
5000
6000
7000
8000
9000
10 000

FIG. 4.

METHOD OF OPERATING A SURFACE CONTROLLED SUBSURFACE SAFETY VALVE

This is a division, of application Ser. No. 294,399, filed Oct. 2, 1972, and now U.S. Pat. No. 3,794,112.

BACKGROUND OF THE INVENTION

The present invention concerns a subsurface safety valve for controlling the flow of well fluids, particularly oil and/or gas produced from subsurface formations.

Surface controlled subsurface safety valves offer advantages over velocity actuated safety valves. These advantages include in-place testability, capacity production, and positive control from the surface. However, despite its advantages over velocity actuated safety valves the common hydraulic surface controlled valve, in which hydraulic operating fluid is supplied to a subsurface valve from the surface through exterior small diameter tubing or concentric larger diameter pipe, also has a disadvantage in its use in that such a valve cannot be economically installed on many existing well completions because the well tubing may be cemented in place or be otherwise unmovable except through costly and high risk means. The present valve does not require an exterior small diameter tubing or concentric larger diameter pipe or movement of the well tubing and therefore overcomes the inherent disadvantages in the hydraulic surface controlled valve.

SUMMARY OF THE INVENTION

Briefly, the apparatus of the invention comprises a subsurface safety valve for use in controlling flow of well fluids through well tubing or pipe and includes a valve housing and a flow tube arranged in the valve housing. The flow tube is movable between a first position in which well fluids are prevented from flowing through the flow tube and well tubing and a second position in which the well fluids are permitted to flow through the flow tube and well tubing. The valve also includes biasing means for urging the flow tube to its first position as well as means for retarding movement of the flow tube in its movement toward the first position thereof. The absolute pressure of the well fluids in the well tubing acts on the flow tube to move the flow tube, the flow tube being moved towards its second position against the bias of the biasing means when the absolute pressure of the well fluids exceeds a predetermined amount. Periodically, the flow of well fluids is choked momentarily at the surface by means of a time adjustable choke which causes a pressure pulse to travel down the well tubing to the valve. The pressure pulse is at least equal to the predetermined absolute pressure necessary to move the flow tube to its second position. The adjustable choke is timed to permit the flow tube to move slowly from its second position towards its first position for a selected period of time. Then, before the flow tube reaches its first position the flow tube is returned to its second position under normal operations. The valve will close if the pressure pulse is not sent from the adjustable choke to the valve. After the valve is closed it can be reopened by increasing the well tubing pressure in amounts sufficient to overcome the bias of the biasing means and move the flow tube from its first position to its second position. The pulsing cycles are then repeated and the flow of fluids through the well tubing is unimpeded during normal operations.

In the operation of the subsurface valve of the present invention the flow of fluids from the well tubing is periodically reduced momentarily at the surface to cause a pressure pulse to travel down the well tubing from the surface to the subsurface valve. The increased absolute pressure at the valve resulting from the pressure pulse forces the valve to a fully open position. Under normal flow conditions the force of the absolute pressure at the valve is less than the force of biasing means tending to close the valve. Thus the valve moves towards closure under normal flow conditions while remaining fully open for a selected time period. Prior to closure of the valve the increased absolute pressure at the valve caused by reducing the flow of fluids at the surface causes the valve to reset it its initial open position.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a subsurface safety valve in accordance with the invention arranged in a well tubing suspended in a well casing;

FIG. 2 shows the safety valve of FIG. 1 in open position;

FIG. 3 shows the safety valve of FIG. 1 in fully closed position; and

FIGS. 4 and 5 illustrate typical flowing pressure gradient curves.

DETAILED DESCRIPTION OF THE INVENTION

There is shown in FIG. 1 a well casing 10 in which a well pipe or tubing string 11 is suspended. A packer 12 closes the annulus between the casing and tubing string. The directional flow of well fluids from a subsurface producing formation is indicated by the arrowed lines. A safety valve 13 is arranged in tubing 11. An adjustable choke 14 is connected to tubing 11 at the surface and a suitable timer control 15 controls the operation of choke 14.

In FIG. 2 details of valve 13 are shown. a valve housing 20 contains a valve seat 21 and an opening 22 in which is positioned a valve 22*a*. The lower end of flow tube 25 contains openings 26 and a valve seating surface 27. In the valve's closed position as seen in FIG. 3 surface 27 has engaged valve seat 21 and openings 26 in the flow tube are positioned within housing 20. Flow tube 25 is provided with an outwardly extending upper shoulder piston 30 and an outwardly extending lower shoulder piston 31. These shoulders together with inner wall of housing 20 form three chambers, 35, 36 and 37, isolated from each other by seals 40 which engage the inner wall of housing 20. Upper seal 41 on the inner wall of housing 20 above chamber 35 and lower seal 41 on the inner wall of housing 20 below chamber 37 are balanced seals. They engage the outer wall of flow tube 25 and prevent fluids from flowing between flow tube 25 and the inner wall of housing 20 at those points. Lower chamber 37 contains a spring 45 which acts against shoulder 31 to urge or bias flow tube 25 upwardly towards the closed position of the valve. Shoulder 31 may be provided with a passage 46 which extends from the inner wall of flow tube 25 to the outer wall thereof between seals 40 located on shoulder 31. The valve 22*a*, arranged in the opening 22, is used to charge chamber 30 with and retain in chamber 30 nitrogen or other gas. Chamber 36 is completely filled with a suitable hydraulic fluid as indicated. The outer wall of flow tube 25 is formed to provide an annular re-

cess 47 a predetermined distance below shoulder piston 30. An annular shoulder 48 is provided on the inner wall of housing 20. Shoulder 48 contains a small sized orifice 49 and a large fluid return bypass 50 on one end of which is positioned a flexible check valve flapper 51. A seal 52 is positioned on the inner wall of shoulder 48 and engages the unrecessed portion of the outer wall of flow tube 25. An opening 55 in flow tube 25 is covered with sintered metal or other filter and fluidly communicates chamber 35 and the interior of flow tube 25.

Typical flowing pressure gradient curves are shown in FIGS. 4 and 5. In FIG. 4 the flowing pressure at an assumed valve depth of 3,000 feet for a gas-oil ratio(-GOR) of 600 is 540 psig as indicated at 60. In FIG. 5 at 3,000 feet and a GOR of 600 the flowing pressure is 1,190 psig as indicated at 61. Thus, when the producing rate is reduced from 300 barrels per day to 400 barrels per day the surface tubing pressure increases to 400 psig and the pressure 3,000 feet depth increases to 1,190 psig. A 200 psig pressure change at the surface results in a 650 psi pressure change at 3,000 feet. These flowing pressure gradient curves are for stabilized conditions and do not reflect the time required to achieve the pressure changes.

In operation, referring in particular to FIG. 2 and using the pressure curve examples given above flow tube 25 is biased upwardly by spring 45 and, if used, nitrogen pressure, acting with an upward force on shoulder 31 to bias the valve toward its closed position. The valve is operable by spring force alone however addition of the nitrogen charge increases flexibility. Flow tube 25 is biased downwardly by the force of tubing fluid pressure acting with a downward force on piston shoulder 30 in chamber 35 to bias the valve open. Chamber 35 is in fluid communication with tubing pressure within flow tube 25 through the sintered metal or other filter covered opening 55. The valve closes when seating surface 27 engages valve seat 21 as shown in FIG. 3.

During normal flowing conditions the force exerted by for example 540 psig tubing pressure is less than the force acting upwardly on shoulder piston 31 caused by spring 45 alone or together with a gas charge in chamber 37 and the valve is consequently attempting to close by movement of flow tube 25 upwardly as indicated in FIG. 2. Closure of the valve is slowed or retarded however by the hydraulic fluid in chamber 36 which is forced to pass through the small sized orifice 49 in shoulder 48 while seal 52 engages the outer wall of flow tube 25. After the flow tube has moved a perdetermined distance towards closure, the recess 47 on tje outer wall of flow tube 25 moves into position adjacent seal 52 permitting the hydraulic fluid to bypass the small sized orifice 49 and cause rapid upward movement of flow tube 25 and thereby rapid closure of the valve. However, before recess 47 reaches seal 52 to permit fluid to bypass the small sized orifice 49 the pressure at the safety has increased to 1,190 psig tubing pressure through prior operation of the timer 15 and decreasing the size of adjustable choke 14. The pressure pulse passes through opening 55 into chamber 35 and acts on shoulder piston 30 to force flow tube 25 downwardly to its initial position. In moving the flow tube downwardly hydraulic fluid in chamber 36 bypasses small sized orifice 49 and flows through large fluid return bypass 50 and flapper valve 51 which results in rapid resetting of flow tube 25 and the safety valve. The tubing pressure is cycled continuously to allow continuous production of fluids through flow tube 25 without interruption under normal operations. When it is necessary or desirable to close the safety valve the timer does not operate the adjustable choke to reduce the size thereof and flow tube 25 moves upwardly to engage the valve seating surfaces as shown in FIG. 3.

Timer 15, choke 14 and the control apparatus for controlling choke 14 are commercially available components. For example, the choke might suitably be a diaphragm-type valve which is spring-opened and fluid pressure closable. The timer may suitably be an electric or mechanical clock mechanism which energized a solenoid valve at preselected times. The solenoid valve opens at such times to permit a gas pressure to operate the choke to reduce choke size a preselected amount momentarily.

Changes and modifications may be made in the illustrative embodiments of the invention shown and described herein without departing from the scope of the invention as defined in the appended claims.

Having fully described the nature, objects, apparatus, method and advantages of my invention I claim:

I claim:

1. A method for operating a subsurface safety valve used in closing off flow of well fluids through a well tubing comprising the steps of:

periodically reducing momentarily at the surface the flow of fluids from a well tubing to cause a pressure pulse to travel down the well tubing from the surface to the subsurface valve;

said pressure pulse causing a flow tube component of said valve to move from a third position in which said valve is fully open to an initial second position in which said valve is also fully open;

said flow tube moving under normal operating well fluid pressures from its initial second position towards said third position thereof; and

said flow tube moving to its first position in which said valve is closed from its third position thereof under normal operating well pressures.

2. A method as recited in claim 1 in which said flow tube moves slowly from its second position to its third position and rapidly from its third position to its first position and rapidly from its third position to its second position.

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