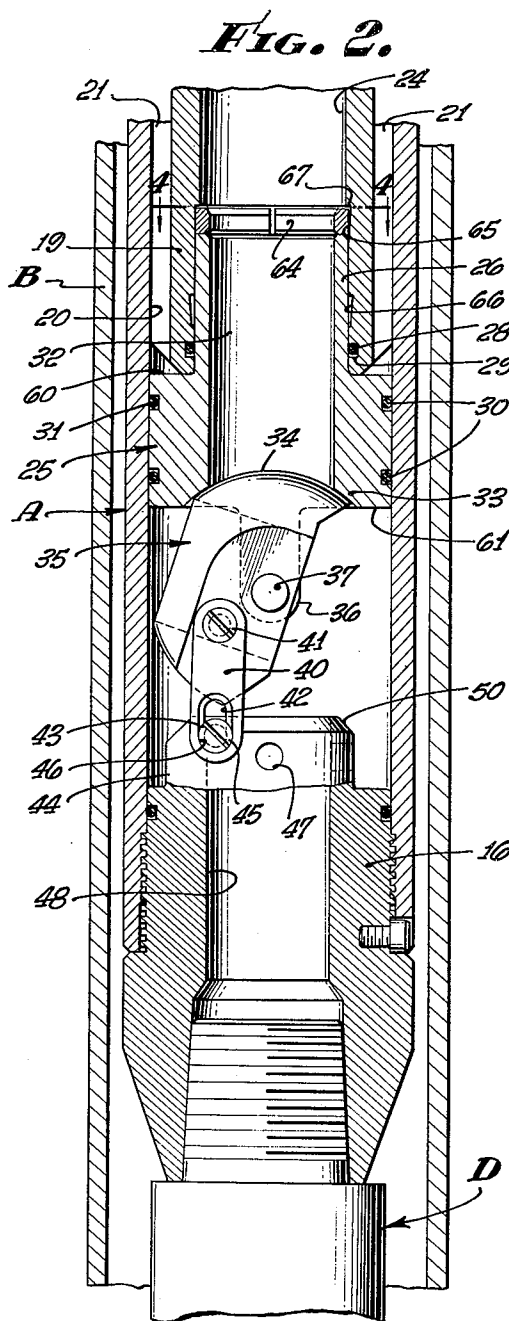


2,998,077

2 Sheets-Sheet 1



INVENTOR.
JULIAN D. KEITHAHN,
BY
Meelin and Hanscom
ATTORNEYS.

Aug. 29, 1961

J. D. KEITHAHN

2,998,077

SUBSURFACE SAFETY SHUT-OFF VALVE APPARATUS

Filed Dec. 23, 1957

2 Sheets-Sheet 2

FIG. 3.

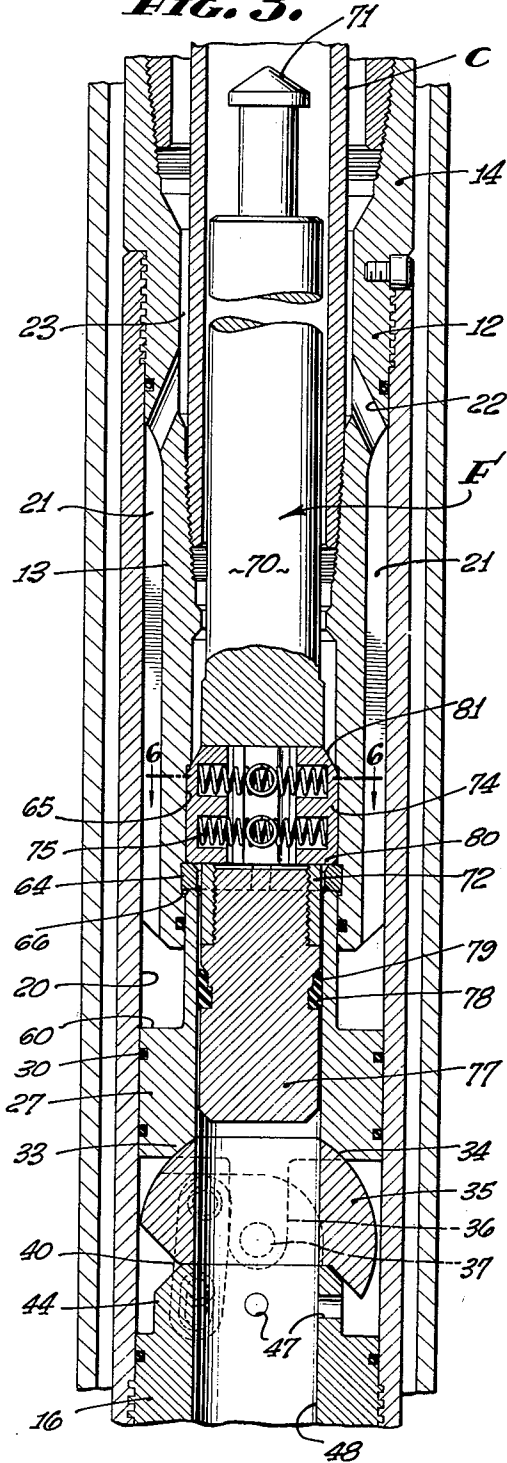


FIG. 4.

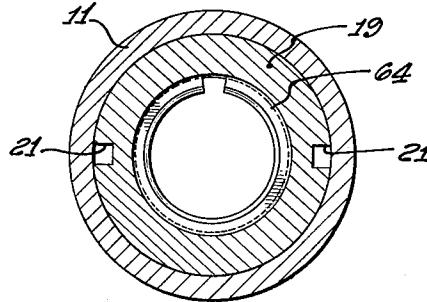


FIG. 5.

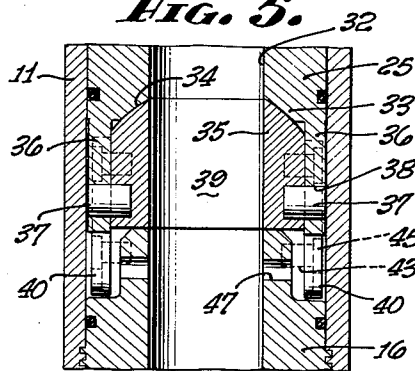
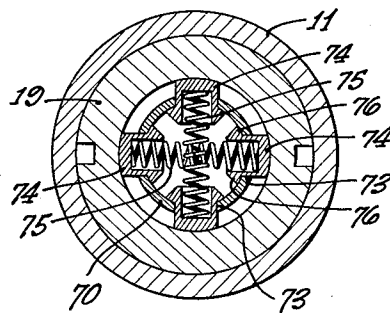


FIG. 6.



INVENTOR.
JULIAN D. KEITHAHN,
BY

Mellin and Hauscom
ATTORNEYS.

1

2,998,077

SUBSURFACE SAFETY SHUT-OFF VALVE APPARATUS

Julian D. Keithahn, Anaheim, Calif., assignor to Baker Oil Tools, Inc., Los Angeles, Calif., a corporation of California

Filed Dec. 23, 1957, Ser. No. 704,643
11 Claims. (Cl. 166—226)

The present invention relates to subsurface well bore apparatus, and more particularly to apparatus for automatically controlling the flow of well production in a well bore.

An object of the invention is to provide an improved subsurface well apparatus that automatically shuts off the well production in the well bore upon the development of a particular adverse condition or adverse conditions in or around the well, such as breaking of the surface connections due to weather conditions, enemy action, or the like.

Another object of the invention is to provide subsurface well apparatus capable of permitting or preventing the flow of well production in the well bore under the control of the operator at the top of the well bore.

A further object of the invention is to provide valve apparatus for controlling well production, which is adapted to be disposed in the well bore, and which has a full opening therethrough when in an open condition to permit other devices, such as gun perforators or recorders, to be moved therethrough.

An additional object of the invention is to provide valve apparatus for controlling well production, which has a straight through passage when in open condition, to avoid impeding the flow of well production.

Yet another object of the invention is to provide subsurface valve apparatus for controlling well production, which can be held and locked in open condition whenever desired.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a longitudinal section through a valve apparatus disposed in a well casing, the valve being in open condition;

FIG. 2 is a view similar to FIG. 1 on an enlarged scale, disclosing the valve in closed condition;

FIG. 3 is a view on an enlarged scale similar to FIG. 1, disclosing the valve latched or locked in an open condition;

FIG. 4 is a cross section on an enlarged scale taken along the line 4—4 on FIG. 2;

FIG. 5 is an enlarged fragmentary longitudinal section taken along the line 5—5 on FIG. 1;

FIG. 6 is an enlarged cross section taken along the line 6—6 on FIG. 3.

The valve apparatus A disclosed in the drawings is adapted to be disposed within a well casing B, or similar well conduit, and to be connected to a tubular string C extending to the top of the well bore, and also to be placed in operative relation to a lower tool D, such as a well packer anchored in packed-off condition in the well casing. Only the body portion of the well packer D is illustrated in the drawings since the particular well packer itself forms no part of the present invention. Such

2

well packer may be of the specific type disclosed in Patent No. 2,695,068, and will normally be set in the well casing above casing perforations (not shown) or the like, through which production from a producing zone in the formation will flow into the well casing for upward passage through the packer D, the valve apparatus A and the tubular string C to the top of the well bore.

The valve apparatus A is designed to permit the well production to continue to flow upwardly into the tubular string C, except upon the occurrence of a particular event, whereupon the valve apparatus will automatically close and shut in the well.

As shown in the drawings, the valve apparatus A includes a housing 10 made of several parts. Thus, a central housing member 11 is threadedly attached to an upper housing head 12 having a lower threaded box 13 to which the lower end of the inner tubular string C is threadedly secured. The head 12 also has an upper threaded box 14 of a substantially greater diameter than the lower threaded box for threaded reception of the lower end of an outer tubular string E surrounding the inner tubular string C and extending to the top of the well bore. The inner and outer tubular strings C, E are spaced from one another to define an annular passage 15 therebetween.

The lower end of the central or intermediate housing member 11 is threadedly secured to a lower head 16 having a threaded box 17 for threaded attachment to the upper pin end 18 of the body of the lower packer D, which is anchored in packed-off condition in the well casing B above casing perforations (not shown).

The upper head 12 has a depending inner housing portion 19 terminating a substantial distance above the lower housing head 16. This depending housing portion 19 may have an external diameter substantially equaling the internal diameter of the outer housing wall 20, the inner housing portion having one or a plurality of longitudinal grooves 21 therein opening through the lower end of the inner housing portion 19 and communicating at the upper end with upper ports 22 in the upper head 12 which open into an annular space 23 between the upper head 12 and the inner tubular string C, this annular space 23 being in communication with the annular space 15 between the inner and outer tubular strings C, E.

The inner housing portion 19 is tubular, having a passage 24 therethrough of a minimum diameter preferably at least equal to the inside diameter of the inner tubular string C. Slidably mounted within the lower portion of the inner housing member 19 and also along the outer housing member 11 is a control sleeve 25, including an upper skirt portion 26 slidable within the lower portion of the inner housing member 19. This control sleeve has a lower annular piston head portion 27 slidable along the cylindrical wall 20 of the outer housing member 11. Leakage of fluid between the skirt 26 and inner housing member 19 is prevented by a suitable side seal 28, such as a rubber or rubber-like O ring, disposed within an internal groove 29 in the inner housing member 19 and slidably and sealingly engaging the periphery of the sleeve skirt 26. Leakage of fluid between the piston head 27 and the wall 20 of the outer housing member is prevented by one or more side seals 30, such as rubber or rubber-like O rings, mounted in ring grooves 31 in the piston and slidably and sealingly engaging the wall of the outer housing member.

The control sleeve 25 has a passage 32 therethrough which preferably has a diameter no less than the inside diameter of the inner tubular string C. The lower end of this passage is surrounded by a valve seat 33 at the lower portion of the control sleeve 25, this valve seat preferably being a portion of a spherical surface adapted to coact with the outer surface 34 of a spherical valve

head 35 pivotally carried by the control sleeve. As specifically disclosed, diametrically opposed legs 36 are integral with, or otherwise suitably secured to, the control sleeve 25 and depend from the valve seat portion 33 thereof. The spherical valve head 35 is pivotally carried by these legs by oppositely directed trunnions 37 suitably secured to the valve head and mounted within aligned bores 38 in the legs. The head 35 has a central passage 39 therethrough having a diameter substantially equal to the diameter of the control sleeve passage 32, this head being adapted to be rocked about its trunnion axis in one direction to place its passage in alignment with the control sleeve passage, and also being adapted to be rocked about its trunnion axis in the opposite direction to place its external spherical surface 34 in engagement with the spherical seat 33 and fully across the passage 32 through the control sleeve 25.

The open and closed condition of the valve head 35 relative to its seat 33 is determined by axial movement of the control sleeve 25 within the housing 10. The valve head 35 has opposed links 40 pivotally secured thereto on its opposite sides by means of aligned pins or screws 41, each pin or screw being threadedly secured to the head and projecting outwardly therefrom through an upper hole in an associated link. The lower end of each link is provided with an elongate slot 42 adapted to receive a pin or screw 43 threaded into an upper extension 44 of the lower housing head 16. The head 45 of each pin is disposed within an enlarged recessed portion 46 of the slot 42 so that the pin or screw head 45 does not extend beyond the outer surface of the link. The lower pins 43 themselves are also in alignment with one another and are disposed on opposite sides of the head and extension 44. This extension also has one or a plurality of side ports 47 therethrough to insure fluid communication between the central passage 48 through the lower head 16 and the space between the control sleeve 25 and the lower head 16. The passage 48 through the lower head also has a diameter which is preferably the same as, or no less than, the diameter of the passages through the spherical valve head 35 and the control sleeve 25.

When the control sleeve 25 occupies a lower position within the housing 10, the spherical valve head 35 will be disposed in the open position illustrated in FIG. 1, the head being clamped in such open position between the valve seat 33 and the upper end 50 of the lower head extension 44. The valve is fully opened, there being a straight through passage through the valve apparatus that is unrestricted, and which preferably has a diameter at least equal to the inside diameter through the inner tubular string C.

The valve A is shifted to a closed position as a result of upward movement of the control sleeve 25 within the housing 10. When the control sleeve moves upwardly within the housing, it carries the head 35 upwardly with it. The links 40 move upwardly until the lower ends of the link slots engage the pins 43, whereupon the links cannot move upwardly to any further extent. As a result, the links exert a pull on the head 35 rocking it in a counter-clockwise direction (as seen in FIGS. 1 and 2) from the open position shown in FIG. 1 to the fully closed position shown in FIG. 2. At this time the sleeve 25 may have moved to its uppermost extent, as determined by engagement of its piston portion 27 with the lower end of the inner housing portion or member 19, the position being illustrated in FIG. 2.

The valve can be again placed in the open condition illustrated in FIG. 1, as a result of downward movement of the control sleeve 25 within the housing 10. Such downward movement will first move the head 35 downwardly with it until the upper ends of the link slots 42 engage the pins 43 secured to the lower head member 16. When such engagement occurs, the links cannot move downwardly any further, so that additional downward

movement of the control sleeve 25 and valve head 35 will cause the links 35 to relatively rock the valve head about its trunnion axis in a clockwise direction, as seen in FIGS. 1 and 2, back to the condition shown in FIG. 1, in which the valve head 35 again becomes clamped between the valve seat 33 and the upper end 50 of the lower housing head member 16.

Shifting of the control sleeve 35 within the housing 10, to place the valve head 35 in the open or closed position, depends upon the pressure of the fluid in the annulus 15 between the inner and outer tubular strings C, E as compared to the pressure of the well formation, and more particularly the pressure within the valve apparatus A. If the pressure within the annulus 15 between the inner and outer tubular strings exceeds the pressure of the well production, the control sleeve 25 will be shifted and held in the lower position within the housing 10 illustrated in FIG. 1. The pressure in the annulus 15 will be exerted through the ports 22 and the longitudinal grooves 21 on the upper side 60 of the piston head 27, urging the control sleeve 25 downwardly. The well production pressure will be exerted through the fluid in the lower head 16, the ports 47 and the space between the lower head and the piston 27, acting upwardly on the lower side 61 of the piston and tending to urge the control sleeve 25 in an upward direction. So long as the pressure in the annulus 15 exceeds the well production pressure, the control sleeve 25 will be shifted downwardly and held in this downward position, in order to locate and maintain the valve in the open position shown in FIG. 1. However, should the well production pressure exceed the pressure in the annulus 15, then the well production pressure will shift the control sleeve 25 upwardly to the position shown in FIG. 2, in which the valve head 35 will be disposed in closed position across the control sleeve, the well production pressure acting on the head 35 and tending to hold it in closed engagement against its companion seat 33.

Normally, a predominating fluid pressure is maintained in the annulus 15 between the inner and outer tubular strings C, E, so that the control sleeve 25 is held in its lower position, such as shown in FIG. 1. If, however, the pressure in the annulus 15 is lowered or relieved for any reason, as, for example, as the result of disruption of the connections at the top of the well bore, the well production pressure then predominates and will act on the lower end 61 of the control sleeve to shift it upwardly to the position shown in FIG. 2, thereby automatically closing the valve. At any subsequent time that it is desired to reopen the valve, it is merely necessary to re-establish a predominant pressure in the annulus 15 between the inner and outer tubular strings, to effect a downward shifting of the control sleeve 25 and a rocking of the valve head 35 once again about its trunnion axis to the fully opened condition shown in FIGS. 1 and 5.

Because of the fully open and straight through passage through the valve apparatus A, there are no restrictions whatsoever, nor changes in direction, to the flow of the well production through the valve apparatus. It continues into the inner tubular string C, to be conducted thereby to the top of the well bore. If it becomes necessary to perform any operation in the well bore below the valve apparatus A through the use of other equipment, such other equipment can be lowered through the inner tubular string C and through the open valve apparatus A into the well bore therebelow, as below the production packer D. As an example, if it is desired to record the temperature or pressure below the production packer, a suitable recording instrumentality can be lowered through inner tubular string C, valve apparatus A and production packer D, and then withdrawn through the apparatus to the top of the well bore. If the casing B is to be perforated below the well packer D, then the perforating apparatus, such as a gun perforator or a shaped charge perforator, can be lowered through the inner tubu-

5

far string C, valve apparatus A and packer D to a position below the latter, the perforator being used to perform its function and then withdrawn through the packer, valve apparatus and tubing string C to the top of the well bore. When other operations are to be performed in the well bore, it is unnecessary to remove the various tubular strings C, E and the valve apparatus A.

The valve apparatus A can be latched or locked in its open condition whenever desired. As shown, a split expansible lock ring 64 is disposed in an enlarged diameter portion 65 of the inner housing member 19, this large diameter portion opening at its lower end into an internal groove 66 in the inner housing portion. The split expansible lock ring 64 initially occupies an upper position in engagement with a downwardly facing shoulder 67 in the inner housing member 19. The ring 64 extends inwardly into the inner housing portion, but its internal diameter is still substantially greater than the inside diameter of the inner tubular string C. When the control sleeve 25 is in its lowermost position, the upper end of its skirt 26 is disposed at the lower end of or immediately below the internal groove 66. Shifting of the lock or latch ring 64 downwardly within the inner housing member 19 into alignment with the groove 66 permits it to expand thereinto, extending at least partly across the upper end of the control sleeve 25 and thereby preventing the control sleeve from moving upwardly in the valve housing 10. The valve apparatus is thus locked in the open condition shown in FIG. 1, and also FIG. 3.

A tool F for shifting the lock ring 64 from its upper position shown in FIG. 1 to its lower position within the groove 66 is illustrated in FIGS. 3 and 6. Such tool includes a mandrel 70 that may have an upper spear head 71 for engagement by a suitable overshot. The lower portion 72 of the mandrel is hollow or sleeve-like and has a plurality of slots 73 through its wall through which latch dogs 74 project. These latch dogs are urged radially outwardly by helical compression springs 75, the outermost movement of the latch dogs being limited by engagement of their oppositely directed side wings 76 with the inner wall of the sleeve portion 72 of the mandrel. The sleeve portion of the mandrel is closed by a mandrel head 77, the upper portion of which is threadedly secured to the sleeve. This mandrel head 77 has an external diameter corresponding to the internal diameter of the control sleeve 25, and it also carries a suitable seal ring 78 in a peripheral groove 79 in slidably sealing engagement with the inner wall of the control sleeve. The lower ends 80 of the dogs 74 are substantially normal to the axis of the mandrel 70, whereas the upper, outer portions 81 of the dogs are tapered in an upward and inward direction.

When the valve apparatus A is to be locked in the open condition disclosed in FIG. 1, the tool F may be inserted within the inner tubular string C and pumped downwardly therethrough into the valve apparatus. The latch dogs 74 slide along the wall of the inner tubular string C and will allow the mandrel 70 to move downwardly until the lower ends 80 of the dogs engage the upper side of the split, expansible lock ring 64. At this time, the mandrel head 77 is disposed within the control sleeve 25, enabling pressure to be applied through the fluid in the inner tubular string on the mandrel, which will force the mandrel 70 downwardly, carrying the lock ring 64 downwardly with it, by virtue of engagement of the dogs 74 therewith, until the lock ring is disposed in alignment with the internal groove 66. The ring 64 will expand outwardly into the internal groove for the purpose of locking the control sleeve 25 in the position shown in FIG. 3, wherein the valve apparatus is in its open condition.

A suitable overshot (not shown) can be lowered through the inner tubular string C on a suitable sand line, or other wire line, this overshot becoming connected to the spear head 71 in a known manner, allowing the sand

6

line to be elevated to carry the mandrel upwardly with it. The tapered upper ends 81 of the dogs 74 will cause such dogs to be shifted inwardly whenever restrictions are encountered, the dogs moving back into the inner tubular string C and sliding along the wall of the latter while the tool is being elevated to the top of the hole. The latch ring 64 will remain in the groove 66 and will hold the control sleeve 25 in a position securing the valve apparatus open.

The tool F is operative to shift the valve apparatus to the open condition or to hold it in the open condition. If the valve is in the closed condition, the dogs 74 will engage the latch or lock ring 64, the downward force of the tool being transmitted through the lock ring to the control sleeve 25, with which it is in engagement, as shown in FIG. 2, shifting the control sleeve downwardly, until the lock ring snaps into the lock groove 66, secure the valve apparatus in the open condition. If the control sleeve is already in the valve opening condition, such as shown in FIG. 1, then the dogs 74 of the tool will still engage the latch ring 64 to shift it downwardly in the housing until it snaps into the groove 66 immediately above the control sleeve 25, preventing upward movement of the latter within the housing 10 to a valve closing position.

The inventor claims:

1. In valve apparatus: a housing having a fluid passage; a control member slidable in said housing and having a passage communicating with said housing passage, said member passage being surrounded by a valve seat; a valve head; means pivotally mounting said valve head on said member for sliding movement along said seat; means connecting said valve head to said housing, whereby relative longitudinal movement between said control member and housing pivots said valve head on said member; and means for moving said member longitudinally within said housing to slide said head along said seat between open and closed relations to said seat.

2. In valve apparatus adapted to be disposed in a well bore; a housing having upper and lower aligned fluid passages; a control member slidable in said housing between said passages and having a passage aligned with said passages, said member passage being surrounded by a valve seat; a valve head; means pivotally mounting said valve head on said member; means connecting said valve head to said housing, whereby relative longitudinal movement between said control member and housing pivots said valve head on said member, said head having a passage; and means for moving said member longitudinally within said housing to swing said head about its pivot axis between a position in which said head passage is communicable with said housing passages and member passage and a position in which said head is in closed relation against said seat.

3. In valve apparatus adapted to be disposed in a well bore; a housing having upper and lower aligned fluid passages; a control member slidable in said housing between said passages and having a passage aligned with said passages, said member passage being surrounded by a valve seat; a valve head; means pivotally mounting said valve head on said member; means connecting said valve head to said housing, whereby relative longitudinal movement between said control member and housing pivots said valve head on said member, said head having a passage; said control member including fluid operated means for moving said member longitudinally within said housing to swing said head about its pivot axis between a position in which said head passage is communicable with said housing passages and member passage and a position in which said head is in closed relation against said seat.

4. In apparatus for controlling flow of fluid in a well bore: a housing adapted to be secured to a tubular string and having a fluid passage; a control member slidable in said housing and having a passage communicat-

ing with said housing passage, said member passage being surrounded by a valve seat; a valve head; means pivotally mounting said valve head on said member for sliding movement along said seat; means connecting said valve head to said housing, whereby relative longitudinal movement between said control member and housing pivots said valve head on said member; and fluid operated means responsive to the pressure of fluid externally of the tubular string for moving said member longitudinally within said housing to slide said head along said seat from closed relation against said seat to open relation to said seat.

5. An apparatus for controlling flow of fluid in a well bore: a housing adapted to be secured to a tubular string and having upper and lower aligned fluid passages; a control member slidable in said housing between said passages and having a passage aligned with said passages, said member passage being surrounded by a valve seat; a valve head; means pivotally mounting said valve head on said member; means connecting said valve head to said housing, whereby relative longitudinal movement between said control member and housing pivots said valve head on said member, said head having a passage; and fluid operated means responsive to the pressure of fluid externally of the tubular string for moving said member longitudinally within said housing to swing said head about its pivot axis from closed relation against said seat, in which said head passage is out of communication with said member passage and one of said housing passages, to a position in which said head passage is communicable with said housing passages and member passage.

6. In apparatus for controlling flow of fluid in a well bore: a housing having a fluid passage; an inner tubular string secured to said housing and communicating with said passage; an outer tubular string surrounding said inner string and secured to said housing; a control member slidable in said housing and having a passage communicating with said housing passage, said member passage being surrounded by a valve seat; a valve head; means pivotally mounting said valve head on said member; means connecting said valve head to said housing, whereby relative longitudinal movement between said control member and housing pivots said valve head on said member; and fluid operated means responsive to the pressure of fluid in the annulus between said tubular strings for moving said member longitudinally within said housing to shift said head from closed relation against said seat to open relation to said seat.

7. In apparatus for controlling flow of fluid in a well bore: a housing having upper and lower aligned fluid passages; an inner tubular member secured to said housing and communicating with said upper passage; an outer tubular string surrounding said inner string and secured to said housing; a control member slidable in said housing between said passages and having a passage aligned with said passages, said member passage being surrounded by a valve seat; a valve head; means pivotally mounting said valve head on said member; means connecting said valve head to said housing, whereby relative longitudinal movement between said control member and housing pivots said valve head on said member, said head having a passage; and fluid operated means responsive to the pressure of fluid in the annulus between said tubular strings for moving said member longitudinally within said housing to swing said head about its pivot axis from closed relation against said seat to a position in which said head passage is communicable with said housing passages and member passage.

8. In well apparatus for controlling flow of well production in a well bore having a packer set therein above a formation producing zone: a housing adapted to be operatively associated with said packer and having a passage through which well production from the zone

can flow; an inner tubular string secured to said housing and communicating with said passage; an outer tubular string surrounding said inner string and secured to said housing; a control member slidable in said housing and having a passage communicating with said housing passage, said member passage being surrounded by a valve seat; a valve head; means pivotally mounting said valve head on said member; means connecting said valve head to said housing, whereby relative longitudinal movement between said control member and housing pivots said valve head on said member; said control member including fluid operated means subject to the pressure of the well production to shift said control member upwardly within said housing to pivot said head to closed relation against said seat, said fluid operated means being subject to the pressure of fluid in the annulus between said tubular strings to shift said member downwardly within said housing to pivot said head to open relation with respect to said seat.

9. In apparatus for controlling flow of well production in a well bore having a packer set therein above a formation producing zone; a housing adapted to be operatively associated with said packer and having upper and lower aligned fluid passages; an inner tubular string secured to said housing communicating with said upper passage; an outer tubular string surrounding said inner string and secured to said housing; a control member slidable in said housing between said passages and having a passage aligned with said passages, said member passage being surrounded by a valve seat; a valve head; means pivotally mounting said valve head on said member; means connecting said valve head to said housing, whereby relative longitudinal movement between said control member and housing pivots said valve head on said member, said head having a passage; said control member including fluid operated means subject to the pressure of the well production to be shifted upwardly within said housing to pivot said head to closed relation against said seat, said fluid operated means being subject to the pressure of the fluid in the annulus between said tubular strings to pivot said head to open relation with respect to said seat, whereby well production can flow through said lower passage, head passage, member passage and upper passage into said inner tubular string.

10. In valve apparatus: a housing having a fluid passage; a control member slidable in said housing and having a passage communicating with said housing passage, said member passage being surrounded by a valve seat; a valve head; means pivotally mounting said valve head on said member; means connecting said valve head to said housing, whereby relative longitudinal movement between said control member and housing pivots said valve head on said member; means for moving said member longitudinally within said housing to shift said head between open and closed relations to said seat; and means for locking said control member in said housing in a position in which said head is in open relation to said seat.

11. In apparatus for controlling flow of fluid in a well bore: a housing having a fluid passage; an inner tubular string secured to said housing and communicating with said passage; an outer tubular string surrounding said inner string and secured to said housing; a control member slidable in said housing and having a passage communicating with said housing passage, said member passage being surrounded by a valve seat; a valve head; means pivotally mounting said valve head on said member; means connecting said valve head to said housing, whereby relative longitudinal movement between said control member and housing pivots said valve head on said member; and fluid operated means responsive to the pressure of the fluid in the annulus between said tubular strings for moving said member longitudinally within

2,998,077

9

said housing to shift said head from closed relation
against said seat to open relation to said seat.

References Cited in the file of this patent

UNITED STATES PATENTS

2,033,563 Wells ----- Mar. 10, 1936

5

2,389,985
2,785,755
2,786,535
2,798,561
2,812,821
2,848,053
2,894,715

10

Justice et al. ----- Nov. 27, 1945
En Dean ----- Mar. 19, 1957
Boer et al. ----- Mar. 26, 1957
True ----- July 9, 1957
Nelson ----- Nov. 12, 1957
Curry ----- Aug. 19, 1958
Bostock ----- July 14, 1959