Feb. 24, 1959 M. B. CONRAD 2,874,927

SUBSURFACE TUBING TESTER

Filed Dec. 31, 1954

Fig. 1.

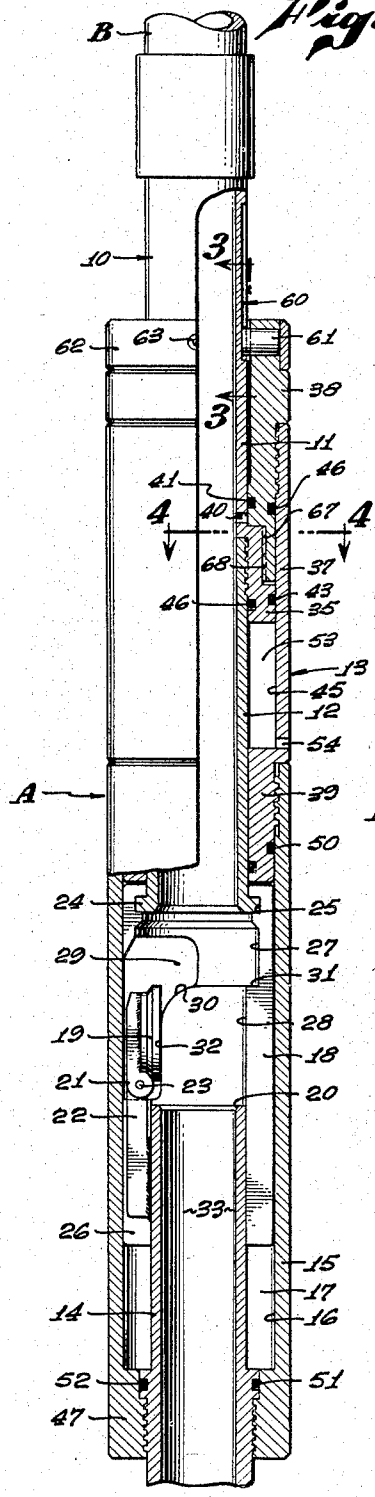


Fig. 2.

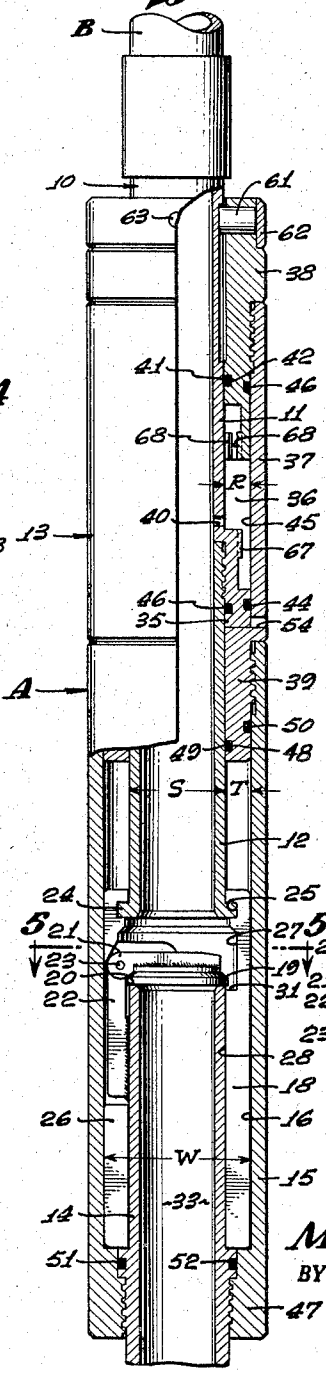


Fig. 3.

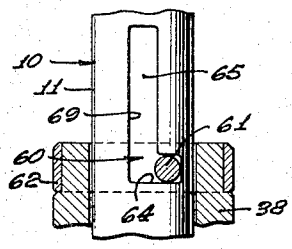


Fig. 4.

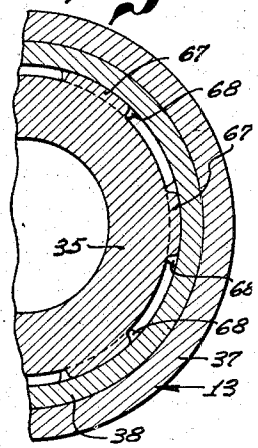
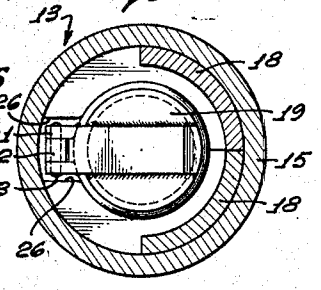


Fig. 5.



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SUBSURFACE TUBING TESTER

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20 Claims. (Cl. 251—100)

The present invention relates to valve apparatus, and more particularly to valve apparatus adapted to be incorporated in a string of tubing, or the like, for use in a well bore.

In the use of certain equipment, such as a well packer, to be lowered in a well bore on a string of tubing, or similar tubular string, it is desired to test the tubing string disposed in the well bore to determine the presence of any leaks therein. A valve device may be incorporated in the lower portion of the tubing string, this device being closed to enable the fluid in the tubing string to be subjected to a desired pressure whenever the existence of any leaks in the tubing string is to be ascertained. Following each testing operation, the valve may be reopened, to permit the well bore fluid to flow into the tubing string.

It is an object of the present invention to provide an improved valve apparatus for incorporation in a tubular string to be disposed in a well bore, which is easily shifted to a closed position whenever the tubular string is to be tested by subjecting it to internal fluid pressure, and which is also easily shifted to an open position.

Another object of the invention is to provide a valve apparatus of the character indicated which can be shifted easily to an open position despite the presence of a high fluid pressure differential within the tubing string to which the apparatus is attached.

Yet another object of the invention is to provide a hydraulically counterbalanced valve apparatus to be incorporated in a tubular string, which can be shifted easily between open and closed positions, despite the existence of a high fluid pressure differential within the tubular string.

A further object of the invention is to provide a valve apparatus especially useful when pressure testing tubular strings disposed in a well bore, which has a full, unobstructed straight through passage when in open position, to insure unimpeded flow or movement of material therethrough. The open passage may, if desired, be equal or greater in diameter than the inside diameter of the tubular string itself.

Yet a further object of the invention is to provide a valve apparatus to be incorporated in a tubular string, and embodying a downwardly closing valve member which can be elevated to open position very readily despite the existence of a very high pressure differential in the tubular string above the valve member.

Another object of the invention is to provide a valve apparatus to be incorporated in a tubular string, which can be releasably locked in a particular position to permit a relatively large force to be transmitted from the tubular string, through the valve apparatus, to another tool, such as a well packer disposed below the valve apparatus. More specifically, a large downward force can be transmitted through the valve apparatus to operate the well packer. Moreover, a large torque can also be transmitted through the valve apparatus to the well packer therebelow, to operate the latter.

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, partly in side elevation, through a valve apparatus embodying the invention, the valve being disposed in open position;

Fig. 2 is a view similar to Fig. 1 with the valve disposed in closed position;

Fig. 3 is a fragmentary longitudinal section taken along the line 3—3 on Fig. 1;

Fig. 4 is an enlarged cross-section taken along the line 4—4 on Fig. 1;

Fig. 5 is an enlarged cross-section taken along the line 5—5 on Fig. 2.

The valve apparatus A disclosed in the drawings is adapted to be incorporated in a tubular string B, such as a string of tubing or drill pipe extending to the top of a well bore, and by means of which the apparatus is lowered in the well bore to a desired location at which the equipment is to be operated, and at which the desired purposes are accomplished. The lower portion of the valve apparatus may ordinarily be attached to the upper end of a lower tool (not shown), such as a well packer that is to be anchored in packed-off condition within a well casing. The valve apparatus may permit fluid pumped down the tubular string to flow through it for continued downward movement through the well packer therebelow and for discharge from the well packer into the well bore. The fluent substances may include cement slurry, acid, formation fracturing material, and the like.

The valve apparatus is adapted to occupy an open position, such as disclosed in Fig. 1, in which the fluid can be pumped therethrough, and a closed position, such as disclosed in Fig. 2, wherein the valve apparatus is closed against downward flow of fluid, to permit the fluid in the tubular string to be subjected to an internal pressure for the purpose of testing the joints in the tubing string, and the sections of the tubing string themselves, to ascertain the existence of any leaks. During the lowering of the apparatus in the well bore, the valve will be closed at intervals for the purpose of testing the tubing thereabove, which will indicate to the operator whether any leaks exist and, if so, he will be advised of the length of the tubular string at which the leak has occurred. Such length will be near the top of the well bore, allowing the defective portion to be removed and replaced. After each pressure testing operation has occurred, the valve is preferably reshifted to an open position, to allow the well bore fluid to flow upwardly through the apparatus into the tubular string as the latter is lowered in the well bore. The open position is also secured when substances are to be pumped down through the tubular string, or in the event it is desired to have any fluid in the well bore to flow up into the tubular string.

As specifically disclosed, the valve apparatus A includes an inner tubular mandrel **10** whose upper portion is connected to the lower end of an adjoining section of tubing or drill pipe B, which forms part of the tubular string extending to the top of the well bore. The tubular mandrel includes an upper section **11** threadedly secured to the upper end of a lower mandrel section **12**. The mandrel is telescopically arranged within a housing **13** that includes a lower inner tubular member **14** which can be secured to the upper end of the well packer or other tool (not shown) disposed therebelow. This inner tubular member is threadedly secured to the lower end

of a lower cylinder sleeve 15 forming the lower outer portion of the housing, the inner tubular member 14 being spaced from the inner wall 16 of the lower cylinder sleeve to provide an annular space 17 in which a valve actuating sleeve 18 is disposed. This valve actuating sleeve is slidable along the lower cylinder sleeve 15 and in the annular space 17 between the latter and the inner tubular member 14, for purpose of shifting a valve member 19, such as a flapper valve head, between an open position, in which the valve head is removed from a companion valve seat 20 provided by the upper end of the inner tubular member 14, and a closed position in which the valve head 19 moves downwardly to engage such seat 20. The valve head 19 itself is pivotally carried by the inner tubular member 14, its outer end 21 being bifurcated to straddle a supporting bar or arm 22 welded to the exterior of the inner tubular member 14 and extending upwardly above the upper end of the latter. A fulcrum pin 23 pivotally supports the valve head 19 on the supporting arm 22 of the inner tubular member.

The valve actuating sleeve 18 is secured to the lower mandrel section 12, an outwardly directed flange 24 on the latter being received within an internal groove 25 in the upper portion of the sleeve. To secure the assembly of this sleeve 18 on the mandrel, the sleeve is made in two parts, which are placed laterally around the lower mandrel, with the sleeve groove 25 receiving the mandrel flange 24. The two parts or sections of the sleeve extend downwardly in the lower cylinder sleeve 15 and also almost completely around the inner tubular member 14, with the sleeve sections adjacent the valve supporting arm 22 having their confronting ends 26 spaced apart sufficiently to allow the sleeve to move freely lengthwise of the supporting arm. The sleeve 18 itself extends downwardly into the annular space 17 between the inner tubular member 14 and the lower cylindrical sleeve 15, being movable in an upward and downward direction therewithin as a result of the mandrel 10 being raised or lowered by the tubular string B.

The upper portion 27 of the control or valve actuating sleeve 18 has a greater inside diameter than the lower portion 28 of the control sleeve, the control sleeve having a cut-out section 29 in its upper portion to avoid interference with the valve head 19 when disposed in a substantially vertical position. The cutout portion may be defined by curved cam surfaces 30, which are generally convex in shape and curved in a downward direction toward the fulcrum 23 of the valve head from an upwardly facing shoulder 31 that actually defines the lower end of the enlarged internal diameter portion 27 of the control sleeve 18. Actually, the diameter of the valve head 19 is somewhat greater than the inside diameter 28 of the control sleeve 18 at its portion that slidably engages the periphery of the inner tubular member 14, but is less than the diameter of the upper portion 27 of the control sleeve. Accordingly, the cam surfaces 30 can engage the marginal portions of the valve head member 19 for the purpose of pivoting the latter about its fulcrum pin 23. The convex cam surfaces 30 merge into vertical surfaces 32 on one side of the sleeve 18, for the purpose of engaging and positively holding the valve head 19 in its fully open position.

When the tubing string B and mandrel 10 have been lowered relative to the housing 13, to shift the control sleeve 18 in the downward position shown in Fig. 2, the cam surfaces 30 are lowered to a position below the valve seat 20, which will allow the valve head 19 to drop down into engagement with the latter and close the valve apparatus against downward flow of fluid therethrough. On the other hand, elevation of the mandrel 10 with respect to the housing 13 will elevate the valve actuating sleeve 18, causing its cam surfaces 30 to engage the outer margins of the valve head 19 and pivot it upwardly about its fulcrum pin 23 to the open position disclosed in Fig. 1. When in this open position, the valve head is engaged by the vertical holding surfaces 32 and is held completely out of alignment with the passage 33 through the inner tubular member 14, which may have an inside diameter substantially equal to the inside diameter of the inner mandrel 10 and of the tubular string B thereabove. Accordingly, the flow passage is unobstructed, to allow fluids to pass unimpeded down through the valve apparatus A.

The relative movement between the mandrel 10 and its control sleeve 18, on the one hand, and the valve housing 13 and the valve head 19, on the other hand, is secured, inasmuch as the tool (not shown) secured to the lower end of the mandrel may have friction drag springs or drag blocks, or the like, incorporated therein that frictionally engage the wall of the well casing in which the apparatus is being run, to resist vertical movement of the tool therewithin, and also of the housing 13 and valve head 19. Accordingly, the tubular string B may be manipulated to lower or elevate the mandrel 10 and valve actuating sleeve 18 with respect to the valve housing 13 and the valve head 19. When the mandrel 10 occupies its upper position with respect to the housing 13, the cam surfaces 32 hold the valve head in open position. Whenever the tubular string B is to be subjected to an internal fluid pressure differential, the mandrel 10 is merely lowered within the housing 13, to allow the valve head 19 to move downwardly into engagement with the valve seat 20, which will permit pressure to be imposed on the fluid in the tubular string, for the purpose of testing the latter for leaks.

To insure that the hydraulic pressure within the apparatus A will not tend to shift it inadvertently to open position, a hydraulically counterbalancing device is incorporated therein. The tubular mandrel 10 has an annular piston 35 secured thereto, as by forming it integrally with the lower portion of the upper mandrel section 11. This piston 35 extends within an annular space 36 formed in the housing 13 between an upper cylinder sleeve 37 and the mandrel 10 itself, the piston being located below an upper cylinder head 38 threadedly secured to the upper sleeve 37 and extending inwardly to the periphery of the upper mandrel section 11. The upper cylinder sleeve 37 terminates in an intermediate cylinder head 39 that extends inwardly to the periphery of the lower mandrel section 12, and which is threadedly secured to the upper end of the lower cylinder sleeve 15.

The fluid under pressure in the interior of the tubular string B and mandrel 10 may be imposed on the piston 35 and the cylinder, being allowed to pass into the annular cylinder space 36 between the piston and the upper cylinder head 38 through one or more side ports 40 extending through the upper mandrel section 11 immediately above the piston. Leakage of fluid from this cylinder space 36 in an upward direction is prevented by a suitable side seal 41 mounted in a groove 42 in the upper cylinder head and slidably and sealingly engaging the periphery of the upper mandrel section 11. Leakage of fluid in a downward direction from the cylinder space 36 along the piston is prevented by a suitable side seal or piston ring 43 disposed in a piston groove 44 and adapted to slidably and sealingly engage the inner wall 45 of the upper cylinder sleeve 37. If desired, thread seals 46 may be provided on the upper cylinder head 38 and on the piston 35 to prevent leakage of fluid through the threaded joints between the upper cylinder head 38 and upper cylinder sleeve 37 and the piston 35 and the lower mandrel section 12.

The fluid within the mandrel 10 is also effective to act in an upward direction upon the intermediate cylinder head 39 and on the lower cylinder head 47 formed integrally with the lower cylinder sleeve 15 and threadedly secured to the inner tubular portion 14. Leakage of fluid in an upward direction between the intermediate cylinder head 39 and the lower mandrel section 12 is prevented by a suitable side seal 48 mounted in an in-

ternal groove 49 in the intermediate head and slidably and sealingly engaging the lower mandrel section 12. If desired, a thread seal 50 may also be provided between the intermediate cylinder head 39 and the lower cylinder sleeve 15 to prevent leakage of fluid through their threaded connection. Similarly, a thread seal 51 may be provided in a groove 52 in the inner tubular member 14 for engagement with the lower head 47 to prevent fluid from leaking in a downward direction through the threaded connection between these members.

Fluid in the annular cylinder space 53 between the piston 35 and the intermediate cylinder head 39 is allowed to pass freely into the surrounding well bore through one or more bleeder holes 54 extending through the upper cylinder sleeve 37 immediately above the intermediate cylinder head 39. As the piston 35 moves downward toward the intermediate cylinder head 39, the fluid may be expelled from this cylinder space 53 through the bleeder hole 54, and, conversely, when the piston is elevated from the intermediate cylinder head, fluid can pass back into the cylinder space 53 through the bleeder hole 54.

When the mandrel 10 and valve actuating sleeve 18 have been lowered within the housing 13 to the position disclosed in Fig. 2, to allow the valve head 19 to engage its seat 20, any fluid under pressure within the tubular string B and mandrel 10 will also pass outwardly through the side port 40 into the cylinder space 36, acting downwardly on the mandrel piston 35 over its cross-sectional area, which is the area R between the periphery of the upper mandrel section 11 and the inner wall 45 of the housing 13. The fluid under pressure is also acting on the mandrel 10 in an upward direction over the cross-sectional area S of the mandrel itself extending to the periphery of the lower mandrel section 12, due to the fact that the upper end of the tubing string B has a transverse plate or head thereacross at the top of the well bore. If the annular piston area R is made equal to the cross-sectional mandrel area S, then the fluid under pressure acting on the mandrel 10 is counterbalanced, since it is acting thereon over equal and opposite areas. Accordingly, regardless of the fluid pressure within the mandrel 10, there will be no tendency for the mandrel to shift in an upward direction with respect to the housing 13, which would tend to cause its cam surfaces 30 to shift the valve head 19 from its seat 20 and to an open position. If desired, the areas R and S can be made somewhat dissimilar. For example, the area R may be made slightly greater than the area S so that the fluid pressure is actually tending to hold the mandrel 10 in a downward direction, thereby offering assurance against its inadvertent elevation to open the valve.

Because of the arrangement disclosed, the hydraulic forces tending to shift the housing 13 and its inner tubular member 14 in a downward direction relative to the mandrel 10 can also be counterbalanced, to prevent such relative lowering movement, which would cause the valve to be shifted to open position. With the valve in the closed position shown in Fig. 2, the fluid under pressure within the tubular string B is also being exerted within the annular cylinder space 36 above the piston 35 in an upward direction on the upper cylinder head 38 over the annular area R. By the same token, it is acting in a downward direction over the entire internal cross-sectional area of the lower cylinder sleeve 15 over the area W, which area is greater than the annular area R. However, the same fluid under pressure is acting in an upward direction on the housing 13 over the annular area T extending from the inner wall 16 of the lower cylinder sleeve 15 to the periphery of the lower mandrel section 12. By making the sum of the areas R and T equal to the area W, the housing 13 is also in a hydraulically balanced condition, so that the fluid pressure differential within the apparatus does not tend to shift the housing in either direction. Here again, the areas R, T and W can be varied, if desired, to provide a somewhat unbalanced hydraulic condition. The making of the sum of the areas R and T slightly greater than the area W will cause the fluid pressure to tend to hold the valve in its closed position.

It is, accordingly, seen that the hydraulic forces acting on the mandrel 10 can be balanced, so that the fluid pressure has no tendency to shift the mandrel to effect opening of the valve, and the hydraulic forces on the housing 13 can also be balanced, to prevent any tendency for such forces to shift the housing with respect to the mandrel. Accordingly, the valve will remain in its closed position until purposely opened by the mechanical elevation of the mandrel 10 with respect to the housing 13, to cause the cam surfaces 30 to pivot the valve head 19 in an upward direction to its fully open position. Such opening action can occur despite the presence of a high pressure differential within the mandrel 10 and the housing 13.

It may be desired to lock the valve in its open position during lowering of the apparatus in the well casing and between the times that the valve is to be closed, to permit the tubing B to be tested. A J or L type of lock and pin arrangement may be incorporated in the apparatus. Thus, the mandrel 10 may have an external generally L shaped groove 60 formed in its upper portion for the reception of a pin 61 extending through the upper part of the cylinder head 38 and retained therein by an encompassing sleeve 62 extending across its outer end, this sleeve being attached to the upper cylinder head 38 by one or more screws 63. When the mandrel 10 is in an upper position relative to the housing 13, it may be turned to locate the pin 61 in the horizontal or foot portion 64 of the L slot. With the pin in this position, the mandrel cannot be lowered with respect to the housing, insuring that the valve head 19 will be held in its open position. However, upon rotating the tubular string B and mandrel 10 to the left, or in a counter-clockwise direction, as seen from the top of the well bore, the mandrel will be shifted so that the vertical portion 65 of the slot is aligned with the pin 61, which will allow the mandrel 10 to be lowered relative to the housing 10 to place the valve head 19 in a closed position, the pin merely riding relatively upward within the vertical portion 65 of the slot or groove 60.

Not only will the pin 61 prevent the mandrel 10 from moving downwardly within the housing 13 when the valve is to remain in its open position, but it also will transmit any downward movement from the mandrel 10 to the housing 13, this movement being, in turn, transmitted from the inner tubular member 14 of the housing to the well tool (not shown) connected therebelow. Such downward movement may be necessary to set a lower well packer, such as a set down packer. Moreover, any turning motion of the mandrel 10 will be transmitted through the pin 61 to the housing 13, and from the housing to the well tool disposed therebelow, for the purpose of operating the latter.

It may be desired to impose substantial downward forces on the well tool connected to the lower portion of the valve apparatus A, and the pin may not have sufficient strength to transmit such forces safely. Accordingly, a large number of longitudinal external splines 67 may be provided on the upper portion of the piston 35 for engagement with internal splines 68 provided on the lower portion of the upper cylinder head 38 and which can be disposed below the piston splines. When the splines 67, 68 are in alignment with one another, a large downward force can be transmitted from the mandrel 10 to the upper cylinder head 38, and from the latter through the cylinder sleeve 37, 15 to the inner tubular member 14 and to the well tool disposed therebelow.

The splines 67, 68 are disposed in such position of alignment when the mandrel 10 has been turned to the right, to place the pin 61 in the foot portion 64 of the L slot 60. When the end of the foot portion engages the

pin, the splines will be in alignment with each other. Accordingly, the pin and slot insure the appropriate location of the splines in vertical alignment. When it is desired to lower the mandrel **10** with respect to the housing **13**, to permit the valve to close, then the tubular string B and mandrel **10** are turned to the left, which action can proceed to the extent determined by engagement of the pin **61** with the left wall **69** of the vertical slot portion **65**. When the pin engages this wall, the splines **67**, **68** on the members are disaligned from each other, one set of splines being aligned with the vertical grooves on the other member. Since the pin **61** is now in alignment with the vertical portion **65** in the L slot, the mandrel **10** can be lowered for the purpose of allowing the flapper valve head **19** to swing downwardly into engagement with its companion seat **20**.

From the foregoing specific description of the apparatus, it is evident that a valve mechanism has been provided which can be shifted very easily between open and closed positions, to allow the tubing string to be subjected to very high pressures, or to provide a full opening through the apparatus. The valve apparatus is shiftable easily despite the presence of high pressures in the apparatus and, during the existence of such pressures, there is no tendency for the tool parts to be shifted hydraulically and inadvertently with respect to each other. Despite the fact that the valve head **19** is moved in a downward direction to engage its companion seat **20**, and thereby close the valve apparatus, it can still be shifted in an upward direction to a valve opening position, even when high pressures are present in the apparatus thereabove. The valve apparatus is capable of transmitting large vertical forces between the tubular string B and the well tool that might be connected to the lower portion of the apparatus, as well as comparatively large torques. The releasable locking slot and pin arrangement **60**, **61** will insure the proper location of the splines **67**, **68** in an operative or inoperative position.

The inventor claims:

1. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore; inner and outer tubular members telescopically arranged with respect to each other; a valve seat on one of said members; a valve element movable laterally with respect to said members into engagement with said seat to prevent downward flow of fluid through said members and laterally out of engagement with said seat completely to one side of said seat to permit such flow of fluid; and means engageable with said valve element in response to relative extending telescopic movement between said members to shift said valve element laterally of said tubular member from engagement with said seat.

2. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore; inner and outer tubular members telescopically arranged with respect to each other; a valve seat on one of said members; a valve element carried by said one member and movable laterally into engagement with said seat to prevent downward flow of fluid through said members and out of engagement with said seat to permit such flow of fluid; and means on the other of said members engageable with said valve element in response to relative extending telescopic movement between said members to shift said valve element from engagement with said seat.

3. In valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: inner and outer tubular members telescopically arranged with respect to each other and having a fluid passage therethrough; a valve seat on one of said members surrounding said passage; a valve element movable laterally of said members into engagement with said seat and out of engagement from said seat to a position completely to one side of said passage; and means disposed to one side of and out of said passage and engageable with said valve element in response to relative extending telescopic movement between said members to shift said valve element to such position.

4. In valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore; inner and outer tubular members telescopically arranged with respect to each other and having a fluid passage therethrough; a valve seat on one of said members surrounding said passage; a valve element carried by said one of said members and movable laterally of said members into engagement with said seat and out of engagement from said seat to a position substantially completely to one side of said passage; and means on the other of said members disposed to one side of said passage and engageable with said valve element in response to relative extending telescopic movement between said members to shift said valve element to such position.

5. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: inner and outer tubular members telescopically arranged with respect to each other; a valve seat on one of said members; a valve element pivotally carried by said one member and swingable into engagement with said seat to prevent downward flow of fluid through said members and out of engagement with said seat to permit such flow of fluid; and cam means on the other of said members disposed out of the path of fluid flow through said seat and engageable with said valve element in response to relative extending telescopic movement between said members to shift said valve element from engagement with said seat.

6. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: inner and outer tubular members telescopically arranged with respect to each other and having a fluid passage therethrough; a valve seat on one of said members surrounding said passage; a valve element pivotally carried by said one of said members and swingable laterally of said members into engagement with said seat to prevent downward flow of fluid through said passage and out of engagement from said seat to a position substantially completely to one side of said passage to permit such flow of fluid; and cam means on the other of said members disposed out of the path of fluid flow through said seat and engageable with said valve element in response to relative extending telescopic movement between said members to shift said valve element to such position.

7. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: inner and outer tubular members telescopically arranged with respect to each other and having a fluid passage therethrough, said outer member extending longitudinally from said inner member when said members are in contracted telescopic relation; a valve seat on said outer member; a valve element pivotally carried by said outer member and movable into engagement with said seat to prevent downward flow of fluid through said members and out of engagement with said seat to permit such flow of fluid; slidable seal means between said members to prevent leakage therebetween, whereby fluid flowing through one member is directed into said other member; and cam means on said inner member disposed out of the path of fluid flow through said seat and engageable with said valve element in response to relative telescopic movement between said members to shift said valve element with respect to said seat.

8. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: inner and outer tubular members telescopically arranged with respect to each other and having a fluid passage therethrough, said outer member extending longitudinally from said inner member when said members are in contracted telescopic relation; a valve seat on said outer member surrounding said passage; a valve element pivotally carried by said outer member and swingable into engagement with said seat to prevent downward flow of fluid through said passage and out of engagement from said seat to a

position substantially completely to one side of said passage to permit such flow of fluid; slidable seal means between said members to prevent leakage therebetween, whereby fluid flowing through one member is directed into said other member; and cam means carried by said inner member and disposed out of the path of fluid flow through said seat and engageable with said valve element in response to relative telescopic movement between said members to shift said valve element to such position.

9. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: an upper, inner member adapted to be connected to the tubular string; a lower, outer member telescopically arranged in leakproof relation with respect to said inner member; a valve seat on one of said members; a valve element movable with respect to said members into engagement with said seat to prevent downward flow of fluid through said members and out of engagement with said seat to permit such flow of fluid; means engageable with said valve element in response to relative telescopic movement between said members to shift said valve element with respect to said seat; said inner member having a fluid pressure actuatable surface subject to the pressure of fluid in said inner member and tending to elevate said inner member with respect to said outer member; and fluid actuated means on said inner member subject to the pressure of fluid in said inner member and tending to lower said inner member with respect to said outer member.

10. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: inner and outer tubular members telescopically arranged with respect to each other; a valve seat on one of said members; a valve element movable with respect to said members into engagement with said seat to prevent downward flow of fluid through said members and out of engagement with said seat to permit such flow of fluid; and means engageable with said valve element in response to relative telescopic movement between said members to shift said valve element with respect to said seat; one of said members having a surface subject to the pressure of fluid in said one member, whereby said fluid tends to shift said one member longitudinally in one direction with respect to said other member to remove said valve element from said seat; said one member having another surface subject to the pressure of fluid in said one member, whereby said fluid tends to shift said one member in the opposite longitudinal direction.

11. In a valve apparatus as defined in claim 10; wherein the areas of said surfaces are substantially equal.

12. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: an upper, inner member adapted to be connected to the tubular string; a lower, outer member telescopically arranged in leakproof relation with respect to said inner member; a valve seat on one of said members; a valve element carried by said one member and movable into engagement with said seat to prevent downward flow of fluid through said members and out of engagement with said seat to permit such flow of fluid; means on the other of said members engageable with said valve element in response to relative telescopic movement between said members to shift said valve element with respect to said seat; said inner member having a fluid pressure actuatable surface subject to the pressure of fluid in said inner member and tending to elevate said inner member with respect to said outer member; and fluid actuated means on said inner member subject to the pressure of fluid in said inner member and tending to lower said inner member with respect to said outer member.

13. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: an upper, inner member adapted to be connected to the tubular string; a lower, outer member telescopically arranged in leakproof relation with respect to said inner member; said members having a fluid passage therethorugh; a valve seat on said outer member surrounding said passage; a valve element pivotally carried by said outer member movable laterally of said outer member into engagement with said seat and out of engagement from said seat to a position substantially completely to one side of said passage; cam means on said inner member disposed to one side of said passage engageable with said valve element in response to relative telescopic movement between said members to shift said valve element to such position; said inner member having a fluid pressure actuatable surface subject to the pressure of fluid in said inner member and tending to elevate said inner member with respect to said outer member; and fluid actuated means on said inner member subject to the pressure of fluid in said inner member and tending to lower said inner member with respect to said outer member.

14. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: inner and outer tubular members telescopically arranged with respect to each other; a valve seat on one of said members; a valve element movable with respect to said members into engagement with said seat to prevent downward flow of fluid through said members and out of engagement with said seat to permit such flow of fluid; means engageable with said valve element in response to relative extending telescopic movement between said members to shift said valve element from engagement with said seat; and releasable lock means engaging said members to prevent their inward telescopic movement with respect to each other to hold said valve element from said seat.

15. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: inner and outer tubular members telescopically arranged with respect to each other; a valve seat on one of said members; a valve element movable with respect to said members into and out of engagement with said seat; means engageable with said valve element in response to relative extending telescopic movement between said members to shift said valve element from engagement with said seat; and releasable lock means engaging said members to prevent longitudinal movement between said members with said valve element held off said seat.

16. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: inner and outer tubular members telescopically arranged with respect to each other; a valve seat on one of said members; a valve element pivotally carried by said one member and swingable into engagement with said seat to prevent downward flow of fluid through said members and out of engagement with said seat to permit such flow of fluid; cam means on the other of said members engageable with said valve element in response to relative extending telescopic movement between said members to shift said valve element from engagement with said seat; and releasable lock means engaging said members to prevent relative longitudinal movement between said members to hold said members in a position in which said cam means holds said valve means off said seat.

17. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: an upper, inner tubular member adapted to be connected to the tubular string; a lower, outer tubular member telescopically arranged in leakproof relation to said inner member; a valve seat carried by said outer member; a valve head pivotally carried by said outer member and swingable into and out of engagement with said seat; a cam secured to said inner member and engageable with said valve head upon upward movement of said inner member in said outer member to swing said valve head away from said seat; a piston secured to said inner member above said seat; said outer member including a cylinder slidable along said piston and along said inner member above said piston; and said inner tubular member having a port above said piston for directing fluid from the interior of

said inner member to the space between said piston and cylinder.

18. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: an upper, inner tubular member adapted to be connected to the tubular string; a lower, outer tubular member telescopically arranged in leakproof relation to said inner member; a valve seat carried by said outer member; a valve head pivotally carried by said outer member and swingable into and out of engagement with said seat; a cam secured to said inner member and engageable with said valve head upon upward movement of said inner member in said outer member to swing said valve head away from said seat; a piston secured to said inner member above said seat; said outer member including a cylinder slidable along said piston and along said inner member above said piston; said inner tubular member having a port above said piston for directing fluid from the interior of said inner member to the space between said piston and cylinder; and releasable lock means operable by manipulation of the tubular string engaging said members to prevent their longitudinal movement with respect to each other with said cam holding said valve head off said seat.

19. In a valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: an upper, inner tubular member adapted to be connected to the tubular string; a lower, outer tubular member telescopically arranged in leakproof relation to said inner member; a valve seat carried by said outer member; a valve head pivotally carried by said outer member and swingable into and out of engagement with said seat; a cam secured to said inner member and engageable with said valve head upon upward movement of said inner member in said outer member to swing said valve head away from said seat; a piston secured to said inner member above said seat; said outer member including a cylinder slidable along said piston and along said inner member above said piston; said inner tubular member having a port above said piston for directing fluid from the interior of said inner member to the space between said piston and cylinder;

said outer member having circumferentially spaced inner splines; said inner member having circumferentially spaced outer splines thereon adapted to be disposed above said inner splines; and means on said members to selectively locate said splines in alignment with each other to prevent downward movement of said inner member in said outer member or completely out of alignment with each other to permit such downward movement.

20. In valve apparatus adapted to be incorporated in a tubular string to be disposed in a well bore: inner and outer tubular members telescopically arranged with respect to each other and having a fluid passage therethrough; a valve seat on one of said members surrounding said passage; a valve element movable laterally of said members into engagement with said seat and out of engagement from said seat to a position completely to one side of said passage; and means engageable with said valve element in response to relative extending telescopic movement between said members to positively shift said valve element to such position.

References Cited in the file of this patent

UNITED STATES PATENTS

223,886	Conklin	Jan. 27, 1880
362,166	Lieb	May 3, 1887
414,509	Fisher	Nov. 5, 1889
586,079	Sullivan	July 6, 1897
1,241,352	Doering	Sept. 25, 1917
1,299,480	Kirby	Apr. 8, 1919
1,314,650	Holt	Sept. 2, 1919
1,842,869	Hale	Jan. 26, 1932
2,215,491	Ziegler	Sept. 24, 1940
2,503,031	Davidson	Apr. 4, 1950
2,507,262	McGwern	May 9, 1950
2,509,470	Baker	May 30, 1950
2,664,266	Johnson	Dec. 29, 1953

FOREIGN PATENTS

503,054	France	Mar. 8, 1920