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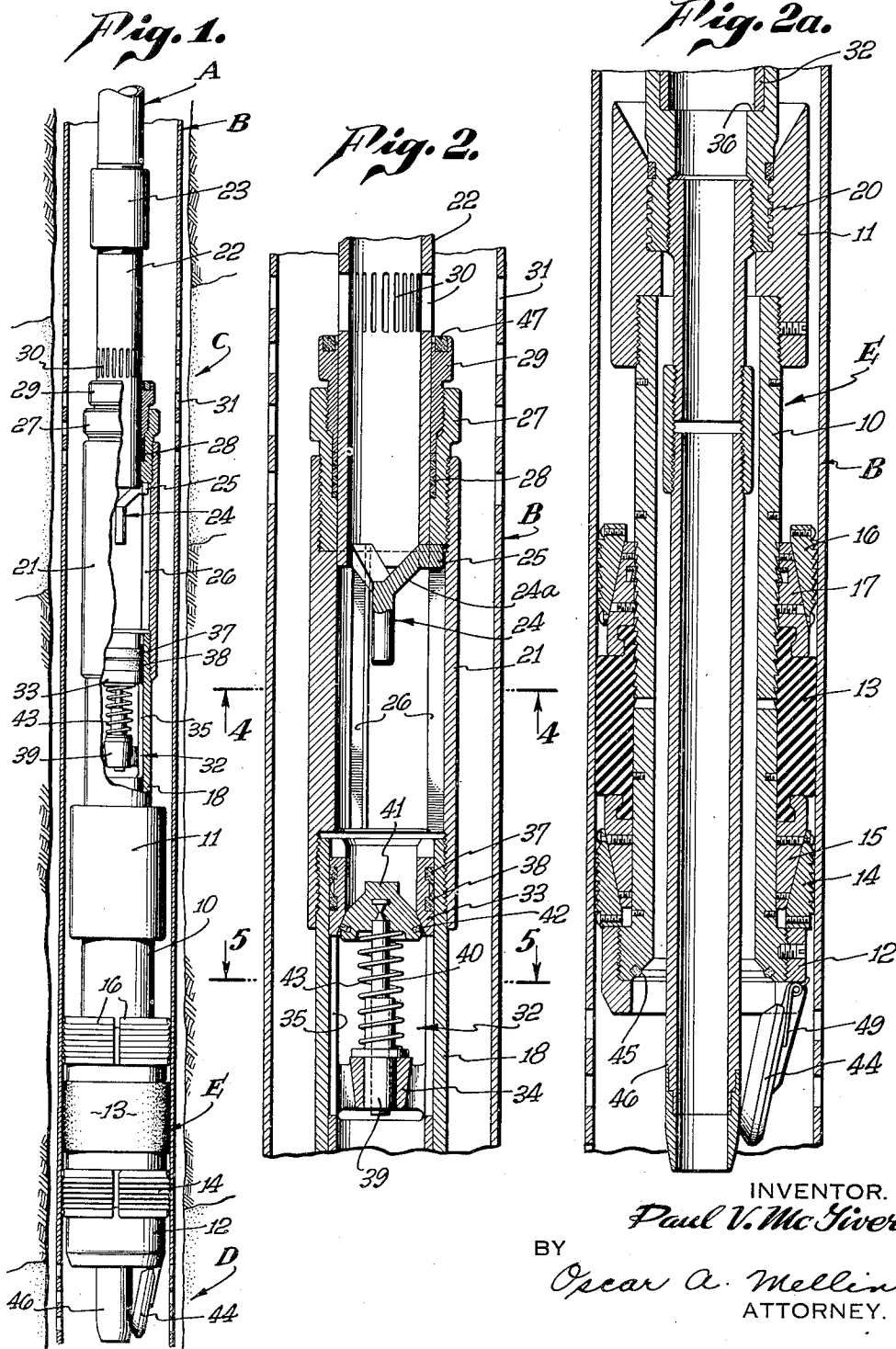
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2,507,262

MULTIPLE ZONE CONTROL APPARATUS

Filed March 9, 1945

2 Sheets-Sheet 1



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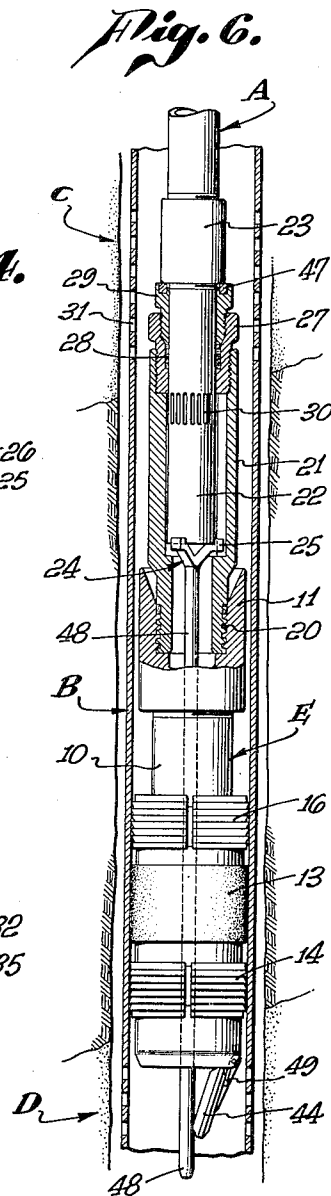
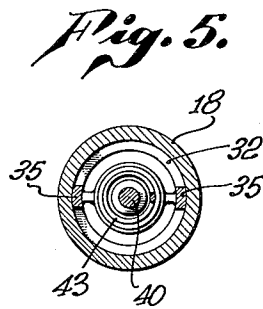
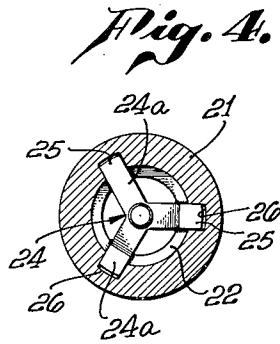
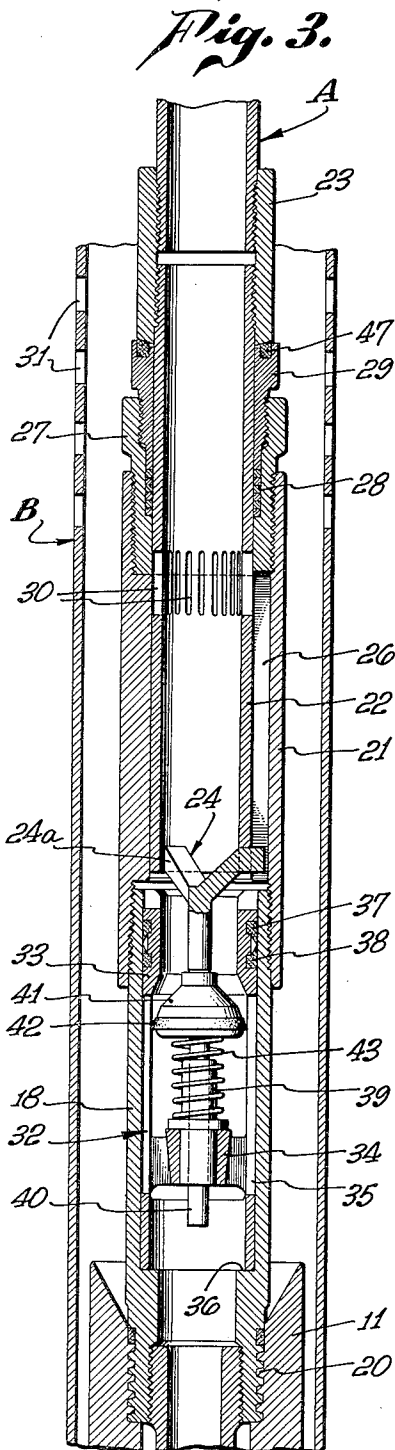
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MULTIPLE ZONE CONTROL APPARATUS

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MULTIPLE ZONE CONTROL APPARATUS

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6 Claims. (Cl. 166—2)

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This invention relates to apparatus for controlling the production from a plurality of producing zones in an oil or gas well.

An object of the invention is to provide an improved apparatus for selectively controlling fluid flow from a plurality of producing zones in a well bore through a tubular string to the top of the well bore.

A further object of the invention is to selectively and individually establish communication between a tubular conduit and either an upper or lower zone in a well bore, the selection being determined by movement of the tubular conduit from the top of the well bore.

Still another object of the invention is to effect selective control of fluid flow into a tubular conduit from high and low pressure producing zones in a well bore by utilizing the pressure in the high pressure zone to prevent flow of its fluid into the conduit when the low pressure zone is flowing into the conduit, and to nullify such effect of pressure to permit the high pressure zone to flow into the tubular conduit when flow from the low pressure zone is prevented.

Another object of the invention is to provide an apparatus cooperable with a well packer to selectively and individually control the flow of fluid into a tubular conduit from a plurality of producing zones in a well bore separated by the packer, in which the apparatus is adapted to be run into and removed from the well bore with the tubular conduit without disturbing the setting of the packer in the well bore.

In its general aspects, the invention contemplates a packer anchored in a casing or liner between upper and lower producing zones in a well bore, to prevent comingling of the fluids from the zones. A tubular production string or conduit is positioned in the casing for cooperation with the well packer, and is provided with a lateral passage or side ports positioned above the well packer in order that fluid can flow from the upper zone into the tubular string. The tubular string is also provided with a device for engagement with a back pressure or other valve controlling flow of fluid into the tubular string from the lower zone, to open the valve and permit flow from the lower zone into the tubular string when the latter is manipulated to close the side ports and prevent flow of fluid from the upper zone into the conduit.

The conduit is telescopically arranged to permit its longitudinal manipulation in controlling its side ports and the aforementioned valve. The telescopic arrangement is, moreover, preferably such as to furnish a splined driving connection in

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order that the tubular string may be rotated to connect or disconnect it from the well packer. This arrangement enables the tubular string or conduit to be lowered through the well bore and coupled to a packer already positioned therein, or removed from the well bore without disturbing the position of the packer.

This invention has other objects which will become apparent from a consideration of the various forms of apparatus shown in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, but it is to be understood that such detailed description is not to be taken in a limited sense, since the scope of the invention is best defined by the claims appended hereto.

Referring to the drawings:

Figure 1 is a longitudinal view, partly in section and partly in elevation, of one form of the apparatus installed in a cased well bore;

Figures 2 and 2a constitute a combined longitudinal section, on an enlarged scale, of part of the apparatus shown in Figure 1;

Figure 3 is a view similar to Figure 2 of the apparatus in another operative position;

Figure 4 is a cross-section taken along the line 4—4 in Figure 2;

Figure 5 is a cross-section taken along the line 5—5 in Figure 2; and

Figure 6 is a view similar to Figure 1 of a modified form of the invention.

In the specific embodiment shown in Figures 1 to 5, inclusive, the control apparatus is designed to form part of a tubular string A by means of which it is lowered or otherwise movable through a casing or liner B positioned in a well bore having a plurality of longitudinally spaced producing zones C, D. A packer E is anchored in the casing or liner between these producing zones to segregate the production therefrom in conjunction with the control apparatus.

The packer E may be of any suitable construction, being shown for illustrative purposes as a production apparatus specifically described in United States Patent No. 2,189,703. It includes a tubular body 10 to which is secured an upper head 11 and a lower guide 12, and on which is mounted a packing member 13 to seal off against the casing B and prevent flow of fluid between the body and casing. The packer is anchored to the casing against both downward and upward movement therein by a set of lower slips 14 cooperable with a lower conical expander 15, and by a set of upper slips 16 cooperable with an upper conical expander 17.

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The control apparatus comprises a valve housing 18 coupled to the head portion 11 of the production packer through a left-handed threaded connection or the like 20. An outer barrel 21 is threaded in the top end of the valve housing and receives a tubular mandrel 22 whose upper head 23 is threadedly attached to the tubular string extending to the top of the well bore. The lower end of the mandrel 22 is in the form of a crow foot 24, welded or otherwise suitably attached to the remaining tubular part of the mandrel, having a plurality of outwardly extending keys 25 received in keyways or longitudinal grooves 26 formed in the outer barrel. The key and keyway arrangement forms a rotary coupling or slideable spline connection between the mandrel 22 and outer barrel 21, to transmit rotary movement of the tubular string to the valve housing 18 in screwing or unscrewing the latter into or from the production packer E.

A packing box 27 threaded in the upper end of the outer barrel 21 contains a mandrel packing 28 urged into leakproof, slideable, sealing engagement with the outer surface of the mandrel by a packing nut 29 threaded into the packing box 27. The mandrel has one or more passages in the form of side ports or lateral outlets 30 adapted to be positioned above the mandrel packing 28 and packing nut 29 to permit flow of fluid from the upper producing zone C through the casing or liner perforations 31 into the tubular string A for passage to the top of the well bore. Upon lowering of the tubing string and its mandrel 22 to a sufficient extent, the side ports or lateral outlets 30 will be positioned within or below the mandrel packing 28 to close the ports or passages 30 against entry of fluid into the tubular string A from the upper producing zone C.

The valve housing 18 contains a valve cage 32 consisting essentially of an upper valve seat 33 and a spider 34 separated by longitudinal ribs 35. The valve cage 32 preferably rests upon a shoulder 36 at the lower portion of the valve housing 18, and is provided with opposed side seals 37, 38 at its upper end engaging the valve housing to prevent leakage of fluid past the exterior of the valve cage in both directions. The spider 34 serves as a support for a spring seat and guide 39 in which a valve stem 40 is longitudinally slideable. The upper end of the stem carries a valve head 41 engageable with the valve seat 33, and a side seal 42 may be secured in the head for contact with the seat to prevent undesired leakage in an upward direction between the head and seat when the valve is closed. A helical spring 43 extends between the spring seat 39 and the valve head 41 to urge the latter into engagement with its cooperable seat 33 and hold the valve in closed position.

The valve arrangement disclosed constitutes a back pressure device tending to prevent upward passage of fluid from the lower zone D through the packer E into the tubing string A. However, upon lowering of the tubular string and its connected mandrel 22 to a sufficient extent, the lower end 24 of the latter engages the valve head 41 and moves it downwardly from its seat 33 to open and ineffective position, thus permitting flow of fluid upwardly from the lower producing horizon D, through the production packer E, through the spider 34, between the ribs 35 and around the valve head 41, between the outward diverging extensions 24a of the crow foot 24, into the mandrel 22 and production tubing thereabove.

The parts are preferably so arranged that

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when the tubular mandrel 22 is in an upper position, the side ports or passages 30 are open to the flow of fluid from the upper zone C, with the valve head 41 engaging its seat to prevent upward passage of fluid into the tubular string A from the lower zone D (as in Figure 2). Upon lowering of the tubing string A and its mandrel 22 to a sufficient extent, the side ports 30 will be positioned within or below the mandrel packing 28, with the mandrel crow foot 24 pressing the valve head 41 downwardly from its seat 33 against the action of the spring 43, thus closing the side ports 30 to the flow of fluid from the upper zone C, but permitting passage of fluid in an upward direction from the lower zone D through the open valve into the mandrel and tubular string (as in Figure 3).

The parts are also preferably arranged and proportioned in such manner that production from the upper zone C is shut off by passage of the side ports 30 completely into or below the mandrel packing 28 before the mandrel 22 opens the valve by displacing its head 41 from the seat 33. Similarly, the valve head 41 will be permitted to engage its seat under the influence of the helical spring 43, upon elevation of the tubular string A and connected mandrel 22, before the side ports 30 move above the mandrel packing 28 into communication with the upper zone C.

In the event that the packer E includes a back pressure valve member 44 and cooperable seat 45 on the packer guide 12, a tubular extension 46 depending from the valve housing 18 is provided to hold this lower back pressure valve 44, 45 in open position and allow the production to enter the extension or stinger 46 for passage into the valve housing 18. The provision of such a lower back pressure valve and tubular extension depending from the valve housing will have no effect upon the operation of the control mechanism in the manner described above.

As further assurance against leakage of fluid from the upper zone C into the tubular string A when the tubing string and its mandrel are lowered, a mandrel head seal 47 can be located at the upper end of the packing nut 29 for engagement by the lower end of the mandrel head 23. This arrangement provides two seals against leakage of fluid from the upper zone C, one furnished by the mandrel packing 28 itself, and the other by the upper mandrel head seal 47.

The tubular string A, including the mandrel 22, outer barrel 21 and valve housing 18, may be lowered as a unit into the well to the position at which the production packer E has previously been set. If a left-hand threaded connection 20 is provided at the upper end of the packer, the tubing string is rotated to the left to thread the valve housing 18 into the packer, the splined connection 25, 26 between mandrel 22 and the outer barrel 21 transmitting the required rotary movement of the mandrel to the valve housing. Such coupling of the valve housing and the outer barrel to the production packer permits the telescopic longitudinal movement of the valve mandrel 22 within the outer barrel 21 to selectively expose the ports 30 to the flow of fluid from the upper zone C or to place the ports below the mandrel packing 28 with the mandrel crow foot 24 holding the back pressure valve 41 open, in order to permit flow from the lower zone D into the tubular string. If it is desired to remove the tubular string and its control apparatus from the well bore, the entire tubing string can be rotated to the right to unscrew the valve housing 18 from

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the packer E and permit elevation of the entire device to the top of the well bore.

Another modification of the invention is shown in Figure 6, in which the valve 44 at the lower end of the production packer is utilized alone for preventing upward passage of fluid from the lower zone D into the tubular string A. Instead of having the valve housing 18, the outer barrel 21 is threaded directly or indirectly into the upper end 11 of the production packer. The extension 48 depending from the valve mandrel 22 is long enough to move the flapper valve 44, or other valve, at the lower end of the production packer E to open position upon lowering of the tubing string A and mandrel 22 sufficiently to place the side ports 30 below the mandrel packing 23, or in closed position.

In the modification just described, the general operation of the device is substantially the same as in the first modification, with the exception that a fixed tubular or other extension 46 depending from the valve housing 18 is not required to keep the flapper valve 44 at the lower end of the packing open at all times. In both modifications, removal of the tubing string A and its control apparatus from connection with the well packer E and its withdrawal to the top of the well bore will permit the spring 49 at the lower end of the production packer to close the flapper valve 44 and prevent the production from the lower zone D from passing upwardly into and through the well packer E.

It is, therefore, apparent that a control apparatus has been provided for determining the flow of fluid between a tubing string and upper and lower zones in a well bore. The production into the tubing string is individual and selective from either the upper zone or the lower zone, and production from the upper zone through proper manipulation of the tubing string automatically effects closing of the production from the lower zone. Usually, the apparatus is employed in a relation in which the formation pressure in the lower zone is higher than that in the upper zone, so that such formation pressure assists the helical spring 43 or valve spring 49 at the lower end of the production packer in closing the valve and holding it closed.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. An apparatus for controlling the flow of fluids in a well bore having upper and lower zones, including a packer in said well bore positioned between said zones, a tubular conduit whose lower portion comprises upper and lower members telescopically arranged one within the other, said lower member being coupled to said packer and said upper member to an upper portion of said tubular conduit extending to the top of the well bore, one of said members having passage means for conducting fluid between said upper zone and interior of said conduit, cooperating means on said members for selectively opening and closing said passage means upon longitudinal movement of said upper member by said conduit string relative to said lower member, a valve for controlling flow of fluid through said packer between said lower zone and the interior of said conduit, means securing said valve in fixed position with respect to said packer, and means on said upper member engageable with said valve to effect its opening upon longitudinal movement of said upper member by said conduit string relative to said lower member in a direction to close said passage means and to effect its closing

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upon longitudinal movement of said upper member by said conduit string relative to said lower member in another direction to open said passage means.

2. An apparatus for controlling the flow of fluids in a well bore having upper and lower zones, including a packer in said well bore positioned between said zones, a tubular conduit whose lower portion comprises upper and lower members telescopically arranged one within the other, said lower member being coupled to said packer and said upper member to an upper portion of said tubular conduit, one of said members having passage means for conducting fluid between said upper zone and interior of said conduit, cooperating means on said members for closing said passage means upon downward movement of said upper member relative to said lower member and for opening said passage means upon upward movement of said upper member relative to said lower member, a downwardly opening valve for controlling flow of fluid through said packer between said lower zone and interior of said conduit, and means on said upper member engageable with said valve to move it downwardly to open position upon downward movement of said upper member relative to said lower member to close said passage means.

3. An apparatus for controlling the flow of fluid in a well bore having upper and lower zones, including a packer in said well bore positioned between said zones, a tubular conduit whose lower portion comprises inner and outer members telescopically arranged with respect to one another, said outer member being coupled to said packer and said inner member to an upper portion of said tubular conduit, said inner member having a port above said packer for conducting fluid between said upper zone and interior of said conduit, cooperating means on said members for closing said port upon downward movement of said inner member relative to said outer member and for opening said port upon upward movement of said inner member relative to said outer member, a downwardly opening valve in said apparatus for controlling flow of fluid through said packer between said lower zone and interior of said conduit, and means on said inner member engageable with said valve to shift it downwardly to open position upon downward movement of said inner member.

4. An apparatus for controlling the flow of fluid in a well bore having upper and lower zones, including a packer in said well bore positioned between said zones, a tubular conduit whose lower portion comprises upper and lower members telescopically splined to one another, said lower member being threadedly attached to said packer and said upper member being secured to an upper portion of said tubular conduit, one of said members having passage means for conducting fluid between said upper zone and interior of said conduit, cooperating means on said members for closing said passage means upon downward movement of said upper member relative to said lower member and for opening said passage means upon upward movement of said upper member relative to said lower member, a downwardly opening valve in said apparatus for controlling flow of fluid through said packer between said lower zone and interior of said conduit, and means on said upper member engageable with said valve to shift it to open position upon downward movement of said upper member to a position closing said passage means, movement of said upper member in

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an upward direction allowing said valve to close.

5. Flow control apparatus adapted to be positioned in a well bore, including a tubular conduit having upper and lower members telescopically arranged one within the other, said upper member having passage means for conducting fluid between the exterior of said conduit and the interior of said upper member, cooperable means on said members for selectively opening or closing said passage means upon movement of said upper member by said conduit string relative to said lower member, a valve for controlling flow of fluid interiorly of said conduit, means securing said valve in fixed position with respect to said lower member, and means on said upper member engageable with said valve to shift said valve to open position upon longitudinal movement of said upper member in one direction relative to said lower member to open said passage means, said means on said upper member allowing said valve to close upon longitudinal movement of said upper member in another direction relative to said lower member to a position opening said passage means.

6. Flow control apparatus adapted to be positioned in a well bore, including a tubular conduit having upper and lower members telescopically arranged one within the other, one of said members providing a passage for conducting fluid between the exterior of said conduit and the interior of said upper member, cooperable means on said

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members for closing said passage means upon downward movement of said upper member by said tubular conduit relative to said lower member and for opening said passage means upon upward movement of said upper member relative to said lower member, a downwardly opening valve in said lower member for controlling upward flow of fluid through said conduit, and means on said upper member engageable with said valve to hold said valve in open position upon downward movement of said upper member relative to said lower member, movement of said upper member in an upward direction relative to said lower member allowing said valve to close.

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