Dec. 6, 1960 J. W. H. SURLES 2,963,036

MEANS FOR PASSING FLUIDS THROUGH WELL TUBING WALLS

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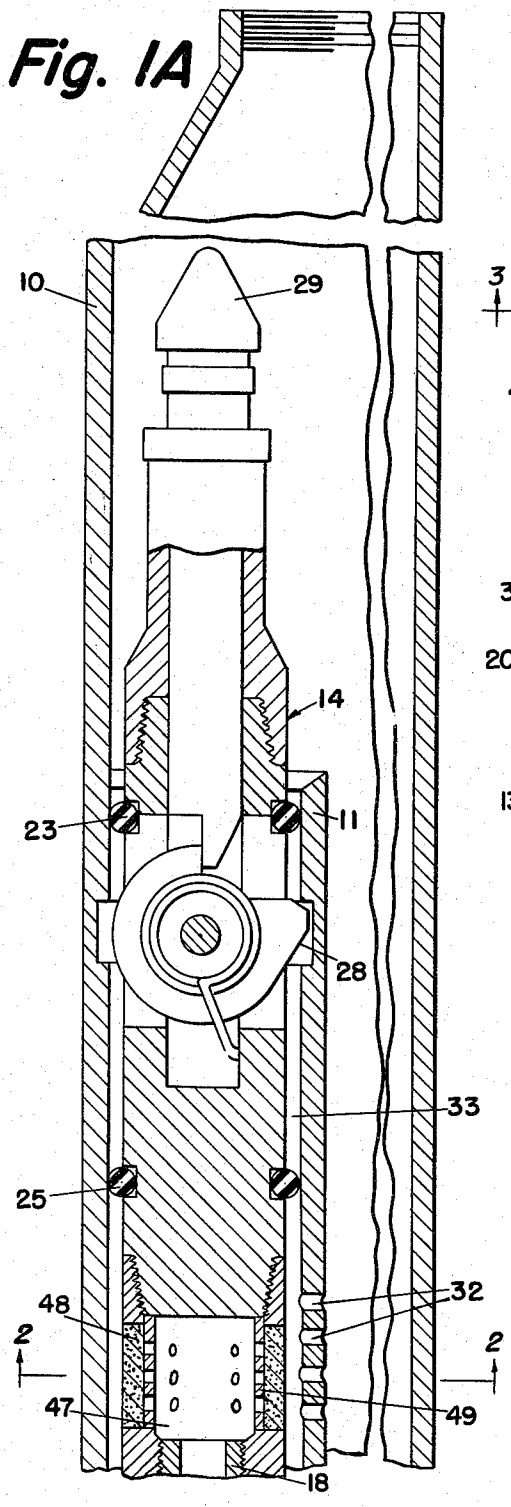
Fig. 1A



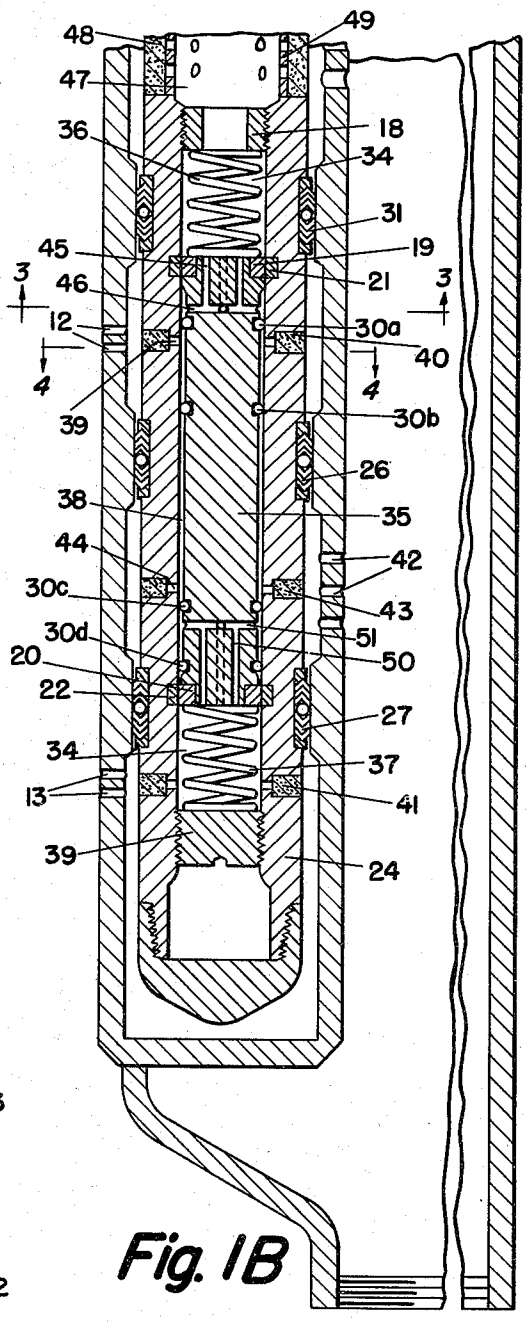


Fig. 1B

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Fig. 2

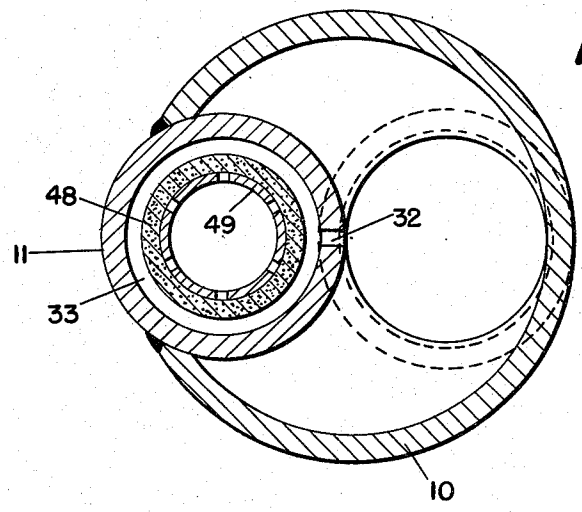


Fig. 3

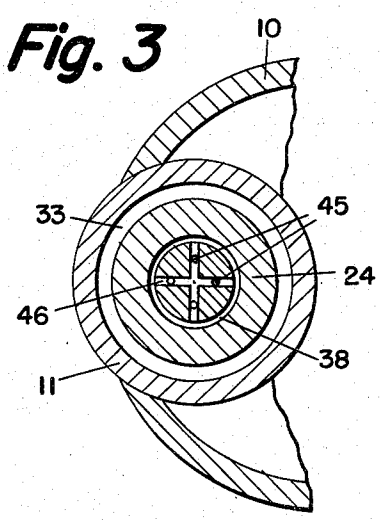
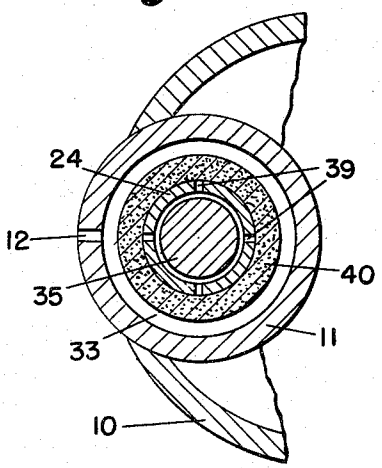


Fig. 4



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MEANS FOR PASSING FLUIDS THROUGH WELL TUBING WALLS

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4 Claims. (Cl. 137—155)

This invention relates to means for flowing fluid from or into well tubing and more particularly is directed to a well assembly which will permit fluid to be passed in either direction between the well tubing and the casing annulus.

There are various instances during the completion and production of oil or gas wells where it may be desirable to pass a fluid either from the well tubing through its wall into the annulus between the tubing and casing or from the annulus into the tubing. For example, in producing a well, it often becomes necessary to remove liquid from the tubing in order to reduce the hydrostatic head of liquid sufficiently to allow the well to flow. In many cases after a completed well has been washed and the packer has been set between the tubing and casing, the reservoir pressure will be insufficient to overcome the hydrostatic head of the water column so that it is necessary to lower the water level in the tubing before the well can be brought in. Also, during the course of producing a well, salt water may accumulate in the tubing to such height as to stop the oil flow and thus require the removal of sufficient water to permit the well to flow again.

One manner of unloading the well tubing in such cases is by gas lifting the water up the tubing. This is generally done by forcing gas down the casing annulus and through suitable means, such as a gas lift valve, into the tubing. In such instance flow of fluid in the direction from the annulus into the tubing occurs. Another manner of unloading the tubing involves forcing the liquid downwardly therein by application of gas pressure at the well head and flowing it through a suitable device into and up the casing annulus. In this case flow of fluid in the reverse direction through the tubing wall is required.

Still another instance where fluid flow through the wall of the tubing is required occurs in squeeze cementing operations carried out after a packer has been set between the tubing and casing, for example, in a permanent type completion well. In cases of this kind it is necessary to have provided a flow device near to but above the packer which will permit fluid to pass in either direction between the tubing and annulus. An extension hanger is placed above such device in the well tubing and an extension tube of smaller diameter than the well tubing is seated in the hanger. Cement grout is then pumped down the tubing and fluid beneath the grout flows out of the extension tube and through the flow device into and up the casing annulus. After the cement has been squeezed into place, it is then necessary to wash out the excess cement grout by pumping water into the casing annulus and reversing the direction of circulation in the well.

The present invention provides a device which is useful in carrying out the foregoing types of well operations. The device is located in a side pocket mandrel positioned at a suitable depth as a part of the tubing string. The device can readily be set in position in

the mandrel side pocket or removed from the tubing by means of a wire line. The device serves as a two-way valve which is actuated by application of hydraulic pressure either to the tubing or to the casing annulus to effect fluid flow in either direction desired.

The invention is described more specifically with reference to the accompanying drawings, in which:

Figs. 1A and 1B, which taken together constitute Fig. 1, are elevational views mainly in section of a well tubing assembly according to the invention including the flow control device.

Figs. 2, 3 and 4 are cross-sectional views taken, respectively, on the lines 2—2, 3—3 and 4—4 of Fig. 1.

With reference to the drawings, 10 represents a side pocket mandrel of conventional type adapted for insertion in a string of well tubing. The mandrel contains a cylindrical side pocket 11 having a wall portion integral with the mandrel wall with two sets of ports 12 and 13 for permitting fluid flow therethrough. A flow control device 14 is positioned in the side pocket 11 and comprises a housing 24 to which are attached conventional latching means 28 and a pulling head 29. Packing rings 26 and 27 between ports 12 and 13 and an additional packing ring 31 above ports 12 prevent fluid flow along the lower part of the annulus 33 between the tool and the side pocket wall. Above the upper packing ring 31 the side pocket contains ports 32 which provide for fluid communication between the device and the well tubing. An O-ring 23 located in annulus 33 near the top of side pocket 11 prevents silt from entering the top of the annulus from the tubing and together with O-ring 25 aids in centering the device in the side pocket.

Housing 24 has a cylindrical longitudinal chamber 34 containing a piston valve member 35 and compression springs 36 and 37 at the upper and lower ends thereof, respectively. The upper spring abuts against a collar 18 and the lower spring against a plug 39 which are screwed into the housing at the ends of the longitudinal chamber 34. The springs 36 and 37 are designed to exert predetermined opposing forces against the ends of piston 35 such that, during normal operation of the well, the piston will be positioned in chamber 34 in the manner illustrated in Fig. 1 but will be forced downwardly or upwardly whenever predetermined pressures are applied to the well tubing or casing annulus respectively. Also, to assist in properly positioning piston 35 during normal well operation, it is preferred to install ring magnets 19 and 20 at the ends of the piston and cooperating rings 21 and 22 of ferromagnetic material in the wall of housing 24. Piston 35 carriers four O-rings 30*a*, 30*b*, 30*c* and 30*d* positioned in annulus 38 of the chamber around the piston, which O-rings normally prevent fluid flow in the annulus.

Between packing rings 26 and 31 means are provided for fluid communication with mandrel ports 12 through the wall of housing 24. For this purpose it is preferred to provide several flow ports 39 which are surrounded by a sintered metal band 40. Beneath packing ring 27 similar fluid communication means, including ports surrounded by a sintered metal band 41, are provided. Also, between packing rings 26 and 27 and adjacent ports 42 in the side pocket 11, the device contains another sintered metal ring 43 surrounding ports 44 communicating with annulus 38.

The upper end of piston valve member 35 contains a set of longitudinal channels 45 connecting with one or more cross-channels 46 leading to the annulus 38. This provides for fluid flow from the well tubing when piston 35 has been forced downwardly by hydraulic pressure applied within the well tubing. Above the valve a chamber 47 provides for fluid communication with the

well tubing through ports **32**. The housing wall adjacent ports **32** preferably is constructed of a sintered metal band **48** and a perforated stainless steel ring **49**. This construction allows fluid to flow into the device while preventing any solid matter from entering it.

The lower part of piston valve member **35** is constructed similarly to its top and contains longitudinal channels **50** that connect with cross-channels **51** which terminate at annulus **38** between O-rings **30***c* and **30***d*. This provides for fluid flow from outside of the well tubing through the device when the piston has been forced upwardly by hydraulic pressure applied in the annulus between the well casing and tubing.

During normal operation of the well the valve member **35** is in the position as shown in Fig. 1. However, whenever it is desired to remove water from the well tubing, the valve can be caused to open by applying gas or air pressure to the tubing at the well head. In such case it is preferable that the well tubing contain a check valve (not shown) installed beneath the side pocket mandrel so as to prevent fluid from being forced into the oil or gas formation from which the well produces. The pressure applied in the tubing increases the force acting on the top face of piston **35** and causes it, along with O-rings **30**, to slide downwardly in chamber **34** against the upward thrust of spring **37**. As the piston moves downwardly fluid in the lower part of chamber **34** is forced through sintered metal ring **41** and mandrel ports **13**. The valve reaches its open position when O-ring **30***a* passes beneath port **39** adjacent sintered metal ring **40**, and fluid then can pass through the device and flow through mandrel ports **12** into the casing annulus and out of the well at the well head. When the water level is lowered to the desired depth, admission of gas at the well head is stopped and gas in the tubing is vented. The valve in the flow control device closes and normal operation of the well is then continued.

In cases where it becomes desirable to pass fluid from the casing annulus into the well tubing, the valve can be caused to open in the opposite direction by applying pressure to the casing annulus. For example, in gas lifting the well, gas under pressure is applied to the annulus at the well head. This forces liquid in the annulus through mandrel ports **13** and sintered metal band **41** and into chamber **34** beneath piston **35**. The resulting increase in pressure causes the piston to move upwardly until O-ring **30***c* has passed port **44** in the housing wall. This permits the liquid to flow through channels **50** and **51**, sintered metal band **43** and ports **42** and thence up the well tubing from which it is withdrawn at the well head. When the casing annulus has been emptied of liquid, gas will then pass in the same manner into the tubing to effect gas lifting of the well.

Modifications of the device as shown in the drawing can be made without departing from the scope of the invention. For example, the piston valve member need not contain channels at its ends but can be solid throughout. In such case the application of hydraulic pressure would force an end of the piston past the corresponding outlet port in the housing wall to open the valve and allow flow through the device. Also, the sintered metal bands need not be used and openings in the housing wall can be employed instead to provide fluid communication through the device. Likewise, the structure of the device beneath the pulling head and latching means could be reversed so that pressure applied in the tubing would cause the piston valve to move upwardly while pressure applied in the casing annulus would cause it to move downwardly.

I claim:

1. In combination, a side pocket mandrel positioned in a string of well tubing, said mandrel providing separate first and second passageways for fluid flow through said mandrel between the outside and inside of the tubing, a housing positioned inside the mandrel side pocket and having a longitudinal chamber and separate fluid flow passages leading through said chamber and cooperating respectively with said first and second passageways; piston means slidably positioned inside said chamber, said piston means in one position blocking fluid flow through each of said first and second passageways, the fluid flow passage which cooperates with said first passageway including a portion of said chamber above the upper end of said piston means and the fluid flow passage which cooperates with said second passageway including a portion of said chamber below the lower end of said piston means; and opposed spring means at each end of the piston means for yieldably maintaining the same in such blocking position, whereby application of pressure inside the tubing, and through a portion of said first passageway and the fluid flow passage cooperating therewith, to the upper end of said piston means, moves the latter means from blocking position in said first passageway, and whereby application of pressure outside the tubing, and through a portion of said second passageway and the fluid flow passage cooperating therewith, to the lower end of said piston means, moves the latter means from blocking position in said second passageway.

2. A device adapted to be positioned in a well tubing side pocket mandrel for regulating fluid flow through ports in the mandrel, comprising a housing having a longitudinal chamber with upper, intermediate, and lower wall passageways along said chamber; a piston slidably positioned in said chamber, said housing having a fluid passage which communicates with said chamber above the upper end of said piston, the lower wall passageway communicating with said chamber below the lower end of said piston; and opposed spring means above and below said piston for yieldably maintaining the same in position adjacent said upper and intermediate wall passageways to block fluid flow therethrough, whereby application of pressure through the housing passage and said chamber to the upper end of said piston moves the piston downwardly to unblock said upper wall passageway, and whereby application of pressure through said lower wall passageway and said chamber to the lower end of said piston moves the piston upwardly to unblock said intermediate wall passageway.

3. A device according to claim 2, including also permanent magnets at each end of said piston and cooperating ferromagnetic inserts in the housing wall, for rather firmly maintaining the piston in position for blocking fluid flow through said upper and intermediate wall passageways.

4. A device according to claim 2, wherein said piston is provided near each end with a flow channel leading from its adjacent end to its side, the application of pressure effecting unblocking by positioning a flow channel in fluid communication with the corresponding wall passageway.

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