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TUBING TESTER

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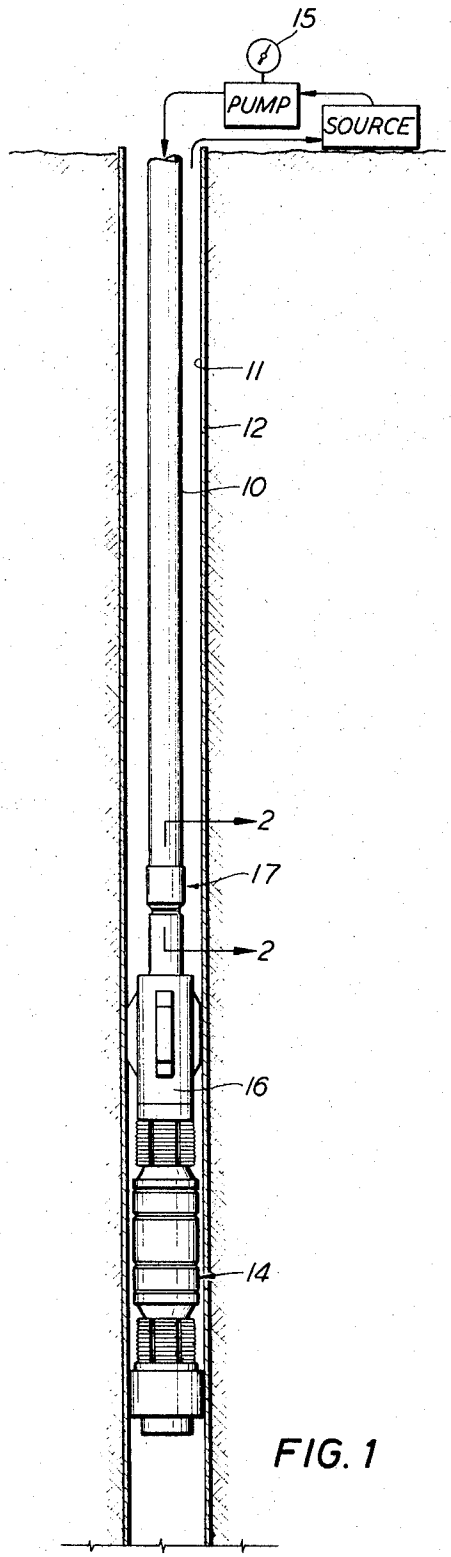


FIG. 1

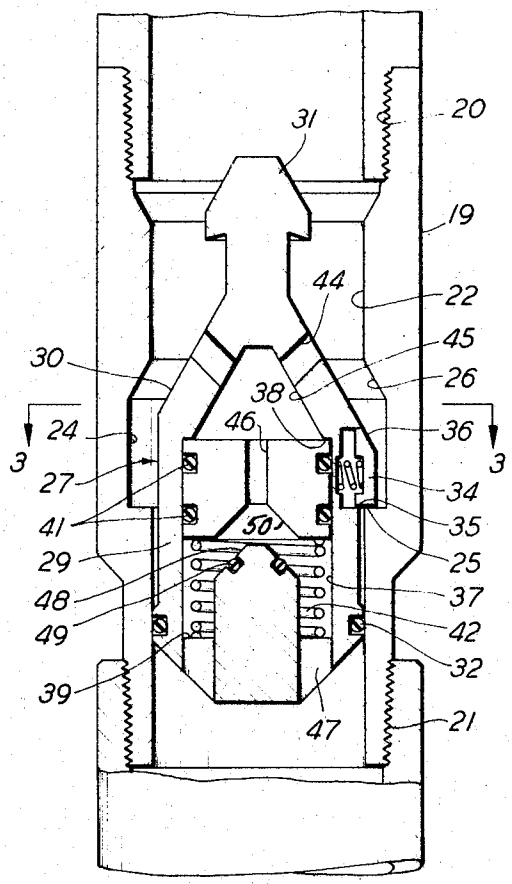


FIG. 2

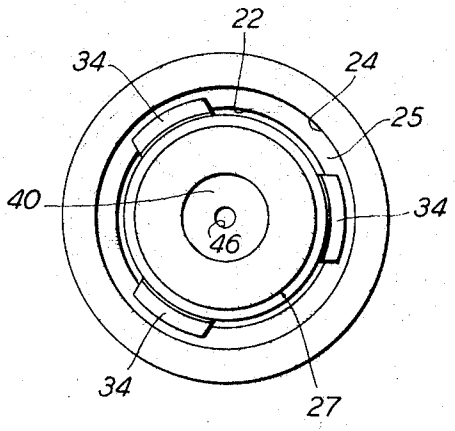


FIG. 3

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TUBING TESTER

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ABSTRACT OF THE DISCLOSURE

The particular embodiment described herein as illustrative of the invention is directed to a system for testing tubing in a well bore. To test tubing, a landing nipple is provided in the tubing string and has a bore with an enlarged landing portion. A retrievable center section is sealingly received in the enlarged portion. Spring loaded latches cooperate with the enlarged landing portion to prevent downward movement of the center section while permitting retrieval. The center section has a flow passage and a pressure responsive valve comprised of an upwardly biased piston with a longitudinal orifice and a lower valve seat. A valve member extending upward from the bottom of the center section cooperates with valve seat to seal the tubing string upon application of pressure.

This invention relates generally to well tools, and more particularly to apparatus for pressure testing of a pipe or tubing string in a well bore.

To perform pressure operations such as squeeze cementing, acidizing, or hydraulic fracturing in a well bore zone, a packer or cement retainer is set above the zone and a fluid conductor string extends from the earth's surface to the packer. The conductor string and the packer function to keep the high fluid pressures developed during such operations from acting on the casing lining the well bore to prevent damage to the casing or cement annulus. For effective operations, it is necessary that the joints of the tubing string be fluid tight and free from leaks.

It is often desirable to test the conductor string for leaks prior to the performance of a pressure operation and setting of the packer to determine whether the string will hold the required pressures. In one prior art system, a ball is dropped through the string to a seat at the lower end of the string. This technique is undesirable because the ball must be reversed out before the tubing string is pulled to prevent or eliminate pulling a fluid-filled or "wet" string. Also, the ball seat forms a restriction in the bore of the string. Another system utilizes a mechanical valve, such as a flapper valve, at the lower end of the string. This system can also cause a "wet" string to be pulled.

Accordingly, it is an object of the present invention to provide a tubing tester having a retrievable center section incorporating a valve system, which permits testing at any time, and which can be opened when the string is pulled. The valve is also removable after testing to provide a full bore, if desired.

This and other objects of the present invention are

accomplished by providing the tubing string with a landing nipple having an enlarged landing portion which is adapted to receive a center section incorporating a valve system. The center section has a plurality of spring loaded landing latches which cooperate with the enlarged landing portion for seating of the center section and preventing downward movement of the center section while at the same time permitting upward retrieval. The center section has a flow passage, including a spring loaded piston having a longitudinal orifice with a valve seat at its lower end. A valve member extends upwardly to cooperate with the valve seat. As fluid under pressure is applied through the tubing string to the valve, a pressure drop is created across the piston causing the piston to move downward and close the valve against the force of the spring. In the absence of a pressure differential across the piston, the spring opens the valve so that the tubing string can drain if pulled from the well. The center section may be retrieved by wireline at any time on reversed out and leave a full opening bore extending through the landing nipple.

The novel features of the present invention are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation together with further objects and advantages thereof, may best be understood by way of illustration and example of certain embodiments when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a cross-sectional view of a well bore having therein a tubing string in which is incorporated a tubing tester of the present invention;

FIG. 2 is an enlarged cross-sectional view of the tubing tester taken generally along line 2—2 of FIG. 1; and

FIG. 3 is a cross-sectionl view taken generally along line 3—3 of FIG. 2.

Referring now to FIG. 1, a string of tubing **10** extends into a well bore **11** having a casing **12**. Attached to the end of the tubing string is a typical cement retainer packer **14** and setting tool **16** which can be operated to pack-off the casing and place the tubing string in fluid communication with a zone below the packer for subsequent pressure operations. Inasmuch as the tubing string will be subjected to high pressure during the operations, it is advisable to check the tubing string to determine that there are no leaks in the tubing. Accordingly, at the bottom of the string of tubing above the packer **14** is the tubing testing apparatus **17** of the present invention. It is so constructed that the testing may be performed either going into or out of the well bore with the tubing string.

As shown in FIG. 2, the tubing testing apparatus includes a sub **19** having female pipe threads **20** at the top end and male pipe threads **21** at the bottom end to permit interconnection into the tubing string. The sub **19** has a full opening bore **22** with a centrally located, enlarged cylindrically shaped recessed portion **24** defined between a bottom wall **25** arranged perpendicular to the axis of bore **22** and a tapered top wall **25** which connects to bore **22**. A retrievable center section **27** is adapted for reception into recess **24**. Section **27** has a valve system which closes in response to application of fluid pressure in the tubing string and opens or is open in the absence of applied pressure in fluid string.

Center section 27 is formed of a generally cylindrically shaped body 29 having a tapered top portion 30 connected to a fishing head 31. Head 31 provides for easy attachment or coupling with a fishing tool for wireline retrieval of the center section 27. The body portion 29 has an enlarged sealing portion including a circumferential groove in which a sealing member 32 is positioned. Sealing member 32 forms a seal between center section 27 and the wall of bore 22. To retain the center section 29 positioned in the recess, the center section 27 is provided around its circumference with a plurality of recesses each containing radially extending, spring loaded latches 34. The latches have flat bottom surfaces 35 which cooperate with bottom wall 25 of recess 24 to prohibit downward movement of center section 27. The latches have tapering upper surfaces 36 which cooperate with tapering top wall 26 to permit upward withdrawal. Latches 34 may be retained in the body recesses in any convenient, well known manner. The latch system permits positioning of the center section in the recess while making up the tubing string. If desired, the latch system could be revised in a well known manner to permit insertion by pumping or forcing it through a tubing string in position in a well bore.

Center section 27 has an internal, cylindrically formed chamber 37 extending between upper and lower annular shoulders 38 ad 39. A piston 40 having a plurality of circumferential grooves containing seal members 41 is slidably and sealingly received in chamber 37 between the shoulders 38, 39. A spring 42 disposed between the lower shoulder 39 and piston 40 normally urges the piston in an upward direction to engage upper shoulder 38.

A flow passageway through the body 27 is provided in the following manner. Ports 44 in top portion 30 open to a chamber extension 45 of chamber 37. Piston 40 has a metering flow orifice 46 terminating at a lower, conically-shaped valve seat 50. Ports 47 at the lower part of body 27 open to chamber 37. To form the valve, a valve member 48 is disposed in the lower part of chamber 37 and has a conically-shaped upper end carrying a sealing element 49 for sealing against the valve seat 50 in a closed position for the valve.

Relative to the operation of the device, the central section 27 is inserted in the sub 19 and located in a tubing string above packer 14. While the unit is being lowered into the well, the liquid in the well enters the tubing string by passing through the flow passage formed by ports 47, chambers 37, orifice 46 and ports 44. Spring 42 additionally acts on piston 40 to prevent the closing of valve seat 50 on valve member 48.

When it is desired to test the tubing for leaks, a liquid is supplied by a pump connected to a source to the tubing string and can flow through the string, the flow passage and passed out the lower end of the packer to return in the annulus between the casing and tubing.

The flow of liquid through orifice 46 of the flow passage develops a pressure differential acting across an effective area of piston 40 to move the piston in a downward direction when the developed force on the piston exceeds the restraining force of spring 42. Movement of piston 40 in response to the pressure differential created by the fluid flow closes the valve by bringing valve seat 50 into sealing relationship with valve member 48. When the valve closes, flow of fluid is stopped and a pressure indication is immediately apparent at the surface indicator 15 as the pressure in the tubing string increases. As long as the pressure is maintained on the valve it will stay closed. The pressure in the tubing string is increased to a selected testing pressure. At this point or possibly sooner, if the string has a leak, a noted decrease in pressure gives an indication of the occurrence of the event. If a leak is present, the pumping is stopped, and upon removal of the differential pressure across the piston, the spring 42 will move piston 40 to disengage valve member 48 from valve seat 50 thereby opening the valve orifice 46. Accordingly, the flow passageway is open and, as the tubing is withdrawn from the well, fluid in the tubing string can pass through the passageway during pulling of the string. At any time during the operation of pulling tubing, testing can be repeated until the leak is definitely found.

After testing, and while in the well bore, center section 27 may be removed from the tubing tester by pumping fluid through the casing and tubing annulus or it can be removed by lowering a fishing tool into engagement with fishing neck 31. To reverse the center section out by fluid pressure, of course, the seal 31 is conventionally designed to hold pressure across couplings and the like. Also, latches 34 are elongated and arranged in a well known manner to prevent accidental locking. During retrieval, the tapered upper surface of the spring loaded latches 36 will be curved inwardly to permit the center section to move upwardly without locking. Accordingly, although the center section will not move downward due to the square shoulder forming the bottom wall of the recess and the flat bottom wall of the spring loaded latches, the tapering top wall and the tapering top surface of the latches permit withdrawal. After withdrawal, there is a full bore through the sub 19 for any subsequent well operations.

As may be appreciated from the foregoing description, a tubing testing apparatus has been provided which may be installed upon assembly of the tubing string and which permits testing either going in or out of the well bore with a tubing string without trapping liquid in the tubing string.

While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects; and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. Pipe testing apparatus for use in a well bore comprising: a valve body movable longitudinally in a pipe string disposed in a well bore, said body having an upwardly facing valve seat, means for limiting movement of said valve body in a downward direction in the pipe string, a downwardly closing valve element on said valve body for controlling communication of fluid through the pipe string, said valve elements having surface areas responsive to a pressure differential developed by a fluid flow past said valve element in a downward direction for moving said valve element to closed position against said valve seat, and means providing an upwardly directed force in the absence of a fluid flow for moving said valve element to open position.

2. A retrievable, flow control valve for use in a well bore in controlling flow of fluid through a string of pipe comprising, a body member sized for passage through a string of pipe and having means for latching with respect to a string of pipe in at least one direction, a flow passageway through said body, valve members in said passageway arranged for relative movement between opened and closed fluid communication positions, a movable one of said members having a flow orifice therethrough for producing a pressure differential thereacross in the presence of fluid flow and having an effective area responsive to a differential pressure for moving said one member to a closed position, and means for relatively moving said members to an open position in the absence of a pressure differential.

3. A retrievable, flow control valve for use in a well bore in controlling flow of fluid through a string of pipe comprising, a body member sized for passage through a string of pipe and having means for latching with respect to a string of pipe in at least one direction, means for sealing said body member relative to the wall of a string of

pipe, a chamber in said body member, piston means movably received in said chamber and having a flow orifice and a valve seat, a valve member disposed in said body and cooperable with said valve seat for closing or opening said flow orifice, means for normally retaining said piston means in a position opening said flow orifice in the absence of a pressure differential across said piston means, and means opening said chamber to the exterior of the body member at locations above and below said sealing means whereby a fluid flow through the orifice will create a pressure differential across the piston to close the flow orifice.

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