HIGH VOLUME MAIN VALVE FOR FORMATION TESTERS

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Fig. 1a.

Fig. 1b.

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HIGH VOLUME MAIN VALVE FOR FORMATION TESTERS

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ABSTRACT OF THE DISCLOSURE

A subsurface earth formation tester having a large flow passage closed by a compound valve having major and massaged valve apertures, the valve being opened by a hydraulic delayed acting mechanism which causes the preliminary closure of an unloader valve and setting of a packer below the valve mechanism, the valve being closable by positive coercion of abutting parts or by a spring and the tester having a latch mechanism for securing the assembly in conditions with the valve open or closed.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to formation testing, apparatus, and more particularly to formation testing apparatus adapted to allow the flow of large volumes of formation fluid therethrough.

In the testing of the productivity of certain subsurface earth formations traversed by a well bore, for example a gas producing formation of relatively high pressure, say 3000 p.s.i., it is the practice to set in casing extending through the productive zone a formation testing assembly which may characteristically comprise a tester valve or main valve assembly installed in a running in string of drill pipe or other tubular conduit, the pipe string having above the tester assembly a packer engageable with the casing to isolate the formation to be tested from the remainder of the well bore thereaboe, the packer including, typically, an anchor to hold it against upward movement in the well bore, and an unloader valve being usually provided in the packer or in the packer assembly to enable the balancing of pressure across the packer when it is desired to release the same. When the packer has been set, and the unloader valve is closed, then the normally closed main tester valve may be opened. However, in the case of high pressure formations, as aforementioned, the pressure is productive of extremely high forces which tend to prevent opening of the main valve if the valve passage is sufficiently large, as to allow high volume flow of the formation fluid. Moreover, if for properly set and closed, the fluid or mud in the well which has been employed to hold the formation fluid back in the formation will pass through the main valve into the running in string of pipe and prevent proper flow of the formation fluid for testing purposes.

SUMMARY OF THE INVENTION

Accordingly, among the objectives of the present invention is the provision of a formation tester main valve assembly which is adapted to be opened against relatively high formation pressure and which affords a relatively large flow passage through the main valve assembly to enable the flow of a large volume of test fluid therethrough.

Another object is to provide main valve means for a formation tester which is not only constructed to allow large volume flow when the main valve is open, but which also may be closed when the test is completed. More particularly, in accordance with this objective the valve in a specific embodiment is latched open and positively closed as the tester pipe string is moved upwardly in the well bore.

Still another object is to provide a formation testing main valve mechanism including a delayed acting assembly adapted to be latched in one condition at which the main valve is closed, and upon release of the latching means to impose a downward force on the pipe string therebelow to cause effective setting of the packer against the well wall or casing in advance of the opening of the main valve.

A further object of the invention is to provide a formation testing main valve assembly having telescopic body parts adapted to be held by latch means in a first running in condition and upon release of the latch means to be telescoped one into the other, the body parts having means therein providing an hydraulic resistance to such telescopic movement so that an axial force will be transmitted through the body parts to cause the setting of a packer below the main valve assembly.

A still further object is to provide a formation testing main valve assembly according to the next preceding object in which the telescopic body parts are adapted to be held by latch means in a second position at which the main valve is open.

Yet another object of the invention is to provide a formation testing main valve assembly which is durable, easy to use in that it may be latched and unlatched in its running and retrieving and in its testing positions by simple rotary motion of the running in string of pipe, and effective in its operation.

Other objects and advantages of the invention will be hereinafter described or will become apparent to those skilled in the art, and the novel features of the invention will be defined in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIGS. 1a and 1b are views schematically illustrating a formation testing string of tools disposed in a well bore traversing a formation to be tested, the packer being set against the casing, FIG. 1b being a downward extension of FIG. 1a;

FIG. 2a is a view in longitudinal section through the upper telescopic section of the main valve assembly, showing the parts latched in a running in condition; FIG. 2b is a downward extension of FIG. 2a, showing one embodiment of the compound valve in a closed position;

FIG. 2c is a downward extension of FIG. 2b, showing the unloader valve open;

FIG. 3a is a view corresponding to FIG. 2a but showing the parts telescoped one into the other to effect opening of the main valve following setting of the packer, the latch being free;

FIG. 3b is a downward extension of FIG. 3a, showing the compound valve open;

FIG. 3c is a downward extension of FIG. 3b, showing the unloader valve closed;

FIG. 4 is a transverse sectional view as taken on the line 4—4 of FIG. 2a;

FIG. 5 is a transverse sectional view as taken on the line 5—5 of FIG. 3a;

FIG. 6 is a transverse sectional view as taken on the line 6—6 of FIG. 2a;

FIG. 7 is a fragmentary view in longitudinal section showing a modified compound valve assembly in the closed position;

FIG. 8 is a fragmentary view in longitudinal section showing the valve of FIG. 7 in the open position; and
FIG. 9 is a fragmentary view in longitudinal section showing the relief assembly of FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENTS

Like reference characters in the several views of the drawings and in the following detailed description designate corresponding parts.

Referring to FIG. 1, there is shown schematically a well bore W in which casing C has been set and cemented, a protective string above the intermediate body section 12 being in communication with the well inside the casing through jet or bullet perforations I extending through the casing and cement and into the formation. Disposed in the well on a string of running in pipe S such as drill pipe are the tools illustratively employed for isolating the formation or zone Z from the well bore thereabove and for controlling the flow of fluid from the formation Z underlying test. Included in the tools in the pipe string S is a retrievable packer assembly which may be of the type more particularly shown and described in United States Letters Patent 3,094,169, issued June 18, 1963, to Martin B. Conrad. This packer includes opening of the main valve means which is normally smaller than the casing C but which is expansible outwardly into sealing contact with the casing responsive to the application of a "set-down" load on the lower anchor slips 3 which are expanded outwardly by a cone 4 into anchoring engagement with the casing when the packer body or mandrel 5 is moved downwardly relative to friction drag means 6 which hold the slips 3 against downward movement. The packer P also includes hold down slips 7 held in anchoring engagement with the casing by a cone 8. This type of packer is well known and needs no further showing or description herein, except to note that it will have a central passage for the flow of fluid from formation Z through the packer assembly.

In the tool string above the packer P is an unloader valve U which may be of the construction more particularly described in United States Letters Patent 3,094,306, issued June 18, 1963, to Martin B. Conrad. This valve has a suitable number of ports 9 adapted to be in communication with the flow passage through the packer P as the tool string is being run into the well through the fluid column in the latter, and the valve U being closed responsive to the set down load which sets the packer, but subsequently re-opened when the packer is to be recovered so as to balance internal and external pressures. In the tool string above the unloader valve U is a tester main valve assembly T made in accordance with the invention, there being above the tester T an indefinite length of pipe or weighted drill collars in which is a relief plug assembly R.

Generally, included in the tester main valve assembly is a main valve means (FIGS. 2b, 3b, 7 and 8) hereinafter to be described, which is normally closed, but which is adapted to be opened upon telescopic movement of an upper body 10 downwardly relative to the lower body 11 of the tester valve assembly T. Means (FIGS. 2a and 3a) are also included in the assembly T for causing the delayed opening of the main valve means upon such telescopic movement of bodies 10 and 11 and as the unloader valve U and the packer P are respectively being closed and set. Also included in the tester main valve assembly are latch means (FIGS. 2a, 3a, 4 and 5) for releasably holding the bodies 10 and 11 against telescopic movement thereof in both the running in and testing or valve open positions of the bodies 10 and 11.

Referring to FIGS. 2a, 3a, 4 and 5 the latch means will be seen to comprise cooperative latch means on the inner, upper tubular body 10, and on the outer, lower tubular body 11.

More specifically the outer body 11 includes, in the illustrative embodiment, an elongated upper body section 15 threaded or otherwise connected at 16 to a downwardly extended intermediate body section 17 and having a bushing 18 threaded into its upper end, the inner body 10 slidably extending through the bushing 18. The latch means may be of any desired type well known in sub-surface oil tools as J-locks including, in the illustrative embodiment, a pin 12 on the body 10 projecting radially thereinfrom into a slot in the outer body-member 15, the slot including an elongated, axially extended portion 13, an upper circumferential leg 14a, and a lower circumferential leg 14b, whereby the bodies may be latched in their relative telescopic positions for running and retrieving the string of equipment.

Relative telescopic movement of bodies 10 and 11 is limited to the extreme positions shown in FIG. 2a, in which the bodies are extended, and in FIG. 3a, in which the body 10 has moved downwardly in the body 11. In FIG. 2a, the latch member 12 engages the upper stop of latch leg 14a; while in FIG. 3a, the latch member 12 engages the lower stop of leg 14b. At either of the extreme positions body 10 may be rotated to lock the bodies against telescopic movement. Rotation of the lower body 11, if course, is resisted by the friction drag means 6 of the packer P previously described.

Time delay means in the specifically illustrated form of an hydraulic fluid transfer device are incorporated in the main valve assembly for delaying movement of bodies 10 and 11 in the contracting direction, while causing a longitudinal downward force to be applied to the lower body 11. Such time delay means includes the intermediate body section 17 in which is a cylinder 40 or bore 45, the lower end of upper body section 15 extending into the bore 45 and being sealed as at 46 to provide an upper end wall, and the body section 17 having an inwardly extending reduced diameter section 47 providing a lower wall axially spaced from the end of body section 17. The inner body 10 includes adjacent its inner end an outstanding barrier wall or piston 48 sealingly engaged as at 49 with and slideable along the cylinder or bore 45. In the specific embodiment shown the barrier wall or piston is formed on a separate lower body section 50 of body 10, this section 50 being threadedly or otherwise made a part of the body 10 as at 51. Suitable sealing means 52 are provided at the joint between the main body 10 and its section 50.

In addition sealing means are provided at 53 between the body 10 and the lower end of outer body section 15 and at 54 between inner body section 50 and reduced section 47 of the outer body section 17, so that there is effectively provided a closed hydraulic chamber 55 separated by the moveable piston 48. Fluid openings provided with removable plugs are provided at 56 and 57 so that the chamber may be filled with hydraulic fluid or oil. Passage means are provided in the piston or barrier wall 48 as by the provisions of a number of holes 58 extending axially therethrough whereby the piston will bypass fluid as the bodies 10 and 11 are telescoped in opposed axial directions. Fluid transfer retarding means are provided to impede flow of chamber fluid through passages 58 as the body 10 moves downwardly relative to body 11, such means comprising in the illustrative embodiment an orifice ring 59 having reduced diameter or restricted ports 60 aligned with passages 58, the ring being secured at spaced locations, as by screws 61, to the underside of piston or barrier wall 48. This ring 59 is composed of flexible material, or may be loosely secured by screws 61, so that upon upward movement of body 10 relative to body 11 the ring will move away from the barrier wall 48 in at least the upper region of 58, thus alleviating the restriction and allowing relatively free transfer of fluid through the passages 58. Due to the restriction of such fluid transfer by ports 60 during downward movement of body 11, it will now be understood that downward movement of body 11 will be delayed, while a downward force is hydraulically transmitted to the body 10, such force being desired and necessary to set and anchor the packer P in the use of the present inven-
tion in advance of opening of the main valve means now to be described.

One embodiment of a main valve means is illustrated in FIGS. 28 and 36 in which the valve is shown open and closed, respectively. This valve means includes a tubular valve body section 10 having an annular groove 91 and an internal annular rib 86 on the inner surface of the body 10 threaded or otherwise made part of the intermediate body section 17, as at 63, suitable sealing means being provided as at 64, 64 to render the joint fluid tight.

Within the body section 62 is a valve seat member in the form of a ring 64 interposed between the lower end of body section 17 and body section 66 and an internal annular rib 81 as by threads, or the like, and a seal 82 being carried between the rings if desired or necessary to effect sealing engagement with the seat 68. Internally of the valve head 70 is an inner valve seat seating section 83 circumscribing a flow passage 84 through the head 70. The minor valve head 71 is engageable with the valve seat 83 and comprises an annular enlargement 85 on stem 72 on which is threaded a ring 86, a seal ring 87 being provided, if necessary or desired, to effect sealing engagement with the seat 83.

Means are provided which normally bias the major valve 70 and the minor valve 71 into closed positions during running of the tester into a well to assure that the valve means will be closed when encountering well fluids. Such biasing means includes in the illustrative embodiment a spring 88 encircling stem 72 and seating at one end on the stem supporting piston 73a, the other end of the spring 88 engaging a spring seat 89 carried by the seal 91. In addition, when the valve means are open, means are provided for releasably holding the valve stem 72 in the valve open position against the closing force of the spring 88. Such holding means, in the illustrative embodiment, includes a number of spring loaded ball boot means 89a, the balls of which are engageable in an annular groove or other seat 90 formed in the stem 72.

In order to open and positively close the main valve means when the bodies 10 and 11 are telescoped, the lower end of body section 50 of body 10 is provided with a spider-like member 91 affixed, as by a threaded joint 92, to body section 50, and having an inner ring 93 which is slideably engaged about an upward extending stem 72 of valve stem 72. This extension 72a may be threaded or otherwise connected to the stem 72 as at 94 at its lower end and the upper end has an enlarged abutment 95. The inner ring 93 of spider-like member 91 is thus moveable along stem section 72a between the upper abutment 95 and an annular groove 96 at the lower end of the body section 62. Operationally, it will now be apparent that when the body 10 is moved inwardly relative to body 11, the spider ring 93 will engage lower abutment 96, thereby moving valve stem 73 downwardly to open the minor valve, and thereafter the enlargement 85 on the stem 72 will engage the annular support 78 for the major valve causing it to move downwardly. Inasmuch as the minor valve is of much smaller effective annular area that the major valve, it will be appreciated that the minor valve can be opened against high formation pressure acting to hold the valve means closed, but when the major valve is opened, substantial flow area is provided through the assembly to accommodate large flow volumes during a formation test.

When a test has been completed, and the main valve means is to be closed, upward movement of the body 10 will cause engagement of the spider ring 93 with the upper abutment 95 on stem section 72a to then enable an upward pull to be applied, releasing the detent means 89a, further upward movement of the stem 72 then causing the minor valve head 71 to seat on minor valve head 70 and the latter to seat on the seat 68. Thereafter, the unloader valve U will be operated to equalize the pressure across the packer P to facilitate its release responsive to continued upward pull on the pipe string S.

More particularly the unloader valve U as seen in FIG. 2 and in FIG. 3c includes a pair of telescopically intersected tubular bodies generally designated 101 and 102, the tubular body 101 slideably fitting over the tubular body 102.

The tubular body 101 includes a shank 103, internally threaded as at 104 at its free exterior for connection to the packer 100 with guide pipe 105 and 106. Appropriate sealing means 123 are provided between the neck 117 of the sealing sleeve 115 and the inner periphery of the pipe 105. The shank 103 has at its inner extremity a cylindrical sealing section 105, having an internal cylindrical sealing surface 106 and having threaded connection thereto as at 107, an axially extended outer sleeve 108, the sleeve being provided with a suitable number of circumferentially spaced radial ports 9, as previously described.

Internally of the shank 103 of the body 101 is a tapered stop shoulder 110 at the outer extremity of the cylindrical sealing surface 106, and at the inner end of the sealing section 105 at the inner extremity of the seating surface 106 is a tapered surface 111, for purposes which will hereinafter more particularly appear.

The tubular body 102 is telescopically disposed within the tubular body 101 and includes a base or shank 112 internally threaded as at 113 for connection to the upper end of packer 100. At its inner end, the base 112 has threaded connection thereto as at 114, an inner sealing sleeve 115 which is provided with an enlarged central section 116, complementary to and slidable in the seating section of the tubular body 101. Extending axially from the central section 116 of the sleeve 115 is a tubular neck 117 which is slidable within the shank 103 of the tubular body 101.

Telescopic movement of the body sections in one direction is limited by engagement of the central section 116 of the sleeve 115 with the aforementioned stop shoulder 110. Adjacent the zone of attachment of the sleeve 115 to the base 112, the latter is provided with a radially projecting cylindrical enlargement 118 slidable in the outer sleeve 108 of the body 101, the enlargement 118 being provided adjacent its upper end with a tapered surface 119 which is opposed to the tapered surface 111 at the lower extremity of the seating section 105 of the outer body member 101.

Formed between the upper extremity of the annular enlargement 118 and the opposed enlarged central section 116 of the sleeve 115 there is an annular seat 120 adapted to contain a sealing element generally designated 121 which, when the valve is closed, will prevent the passage of fluid from within the valve assembly through a series of radial ports 122 in the enlarged sleeve section 116, so that the flow of fluid through the valve assembly is confined to a passage through the seat 120 into the body section 102. However, upon extension of the telescopic valve assembly, the ports 122 in the inner body member, and the ports 9 through the outer body section, will be placed in communication with one another so as to permit the flow of fluid from within the valve assembly to the exterior thereof, or vice versa.

Appropriate sealing means 123 are provided between the neck 117 of the sealing sleeve 115 and the inner periphery
of the shank 103 of the body section 101. Additional sealing means 125 is provided between the enlarged section 116 of the sleeve 115 and the seating section 105. A further seal, such as an O-ring 126 is also employed at the juncture of sleeve 115 with the base 112.

The ultrasonic means 91 extends through the body section 101 into the interval lying between the areas 123 and 125, so as to vent the space therebetween during telescopic movement of the respective body sections. In order to limit such telescopic movement of the body sections in a valve-opening direction, the outer sleeve 109 of the body section 101 is provided with a radially inwardly directed projection 128 which is engageable with a circumferentially extended stop shoulder 129 formed on the enlargement 118 of the base 112 of body section 102.

In view of the fact that the subject valve is adapted to be installed in a string of well pipe above the well packer, and in view of the fact that such well packers are normally operated by rotary movement of the pipe, means are provided for preventing relative rotation between the respective body sections 101 and 102. Preferably such means includes a key 130 carried by the outer sleeve 109 of body section 101 and slidably engaged in a key-way 131 formed in the enlarged section 118 of the base 112 of body section 102, whereby the body sections are free for relative axial movement within the limits permitted by the stop projections previously described, but rotation of the upper body section will be imparted to the lower body section by the key 130.

In this connection the base 112 of the tubular body 102 is provided with an annular seat 137 in which is disposed collet spring means generally designated 138. The collet spring means 138 preferably comprises a pair of longitudinally archcd and circumferentially extended spring elements designated 139, adapted to be assembled about the base 112 of tubular body 102 within the confines of the seat 137. Each of the spring elements 139 is longitudinally slotted, as at 140, at a plurality of circumferentially spaced points so as to effectively provide a series of circumferentially spaced leaf-like springs 141 interconnected at their upper and lower ends by webs 142.

Inasmuch as the collet spring means 138 is disposed in the space between the outer sleeve 108 of body 101 and the base 112 of body 102, it will be noted that the radially projecting portions of the leaf spring elements 141 are disposed with their free ends away from the valve. The valve is closed, as shown in FIG. 3c, the resistance of the collet spring means 138 must be overcome in order to shift the projection 128 axially therepast in a valve-opening direction. When the valve is in an open condition, as shown in FIG. 2c, it will be noted that the lower extremity of the sleeve 108 of body 101 constitutes a projection 128' opposed to the just-mentioned projection 128, and that the projection 128' is disposed for engagement with the collet spring means 138, the resistance to flexure of which must be overcome in order to close the valve.

The collet spring parts 139 are slightly less than semicircular so as to facilitate their installation about the base 112 of tubular body 102 in the seat 137, and there is preferably disposed within this seat, between a pair of opposed ends of the collet spring parts 139, a spacer block 143 which may be welded or otherwise suitably secured in place. This block 143 is in alignment with the key 130 so as to maintain a clearance between the collet spring parts 139 enabling assembly of the outer sleeve over the body 102 and onto the seating section 105 of the body 101. In order to maintain the sleeve 108 against loosening, a suitable stop such as a screw 108' may be provided, which when the outer extremity of the sleeve 108 and being secured to the body 101.

With the equipment thus far described, it will be understood that a formation may be tested by running the pipe string S into the well which will contain a column of drilling mud or fluid capable of holding a pressure on the formation to prevent the formation fluids from entering the casing. The string is run "dry" with the compound valve closed, the unloaded valve open, and the packer will be located above the formation being tested. When the lower end is in position, the latch means will be operated by rotating the string S to the right, releasing latch element 12 from groove leg 14a, such right-hand rotation also conditioning the packer P to be set in anchoring engagement with the casing C as is well known. The lowering of the pipe string will then impose a downward force on the upper body 10 which will force the lower body 11 downwardly through the action of the delayed transfer of hydraulic fluid through the barrier piston 48. Such downward movement of the body 11 will be resisted by the friction drag means 6 of the packer P, causing the setting of the downwardly holding slips 3. In addition, since the lower valve body member 102 of the unloaded valve is also held by the anchor slips against downward movement, the upper unloaded valve body 101 will move downwardly, overcoming the holding action of the collet spring means 138 to close the unloading ports 9 through the well 20. The well was allowed to flow as the assembly was being run through the well fluid. Likewise, the packer rubber 2 will be expanded and the hold down slips 7 of the packer forced into holding positions relative to the casing. Then further downward movement of the pipe string S and body 10 will be permitted as the hydraulic fluid passes through the barrier piston 48, the body 10 telescoping into the body 11 until the valve stem abutment 96 is engaged by ring 93 as it moves downwardly along the upper valve stem section 72a, thereby imposing the weight of the pipe string on the inner or minor valve 71 so as to open the same against formation pressure. Thereafter, the outer or major valve 70 will be opened as further downward movement of body 10 occurs, until the main valve means is fully open. The well will then be allowed to flow or produce for a given period of time, following which it is desired to recover the string of equipment.

This is accomplished by reversing the action, that is, by taking an upward pull on the pipe string. Recovery of the string of equipment may be accomplished with the main valve means held open, if desired, by initially effecting rotation of the body 10 relative to body 11 to cause engagement of latch member 12 with the lower groove leg 14b so that the bodies 10 and 11 are held in a telescopically contracted condition. Alternatively, the body 10 may be elevated relative to the body 11 until the latch member 12 abuts with the shoulder formed by groove leg 14a in the body 11 to cause movement of the bodies upwardly together. During the upward movement of body 10 relative to body 11, under these circumstances, the main valve means will be positively moved toward a closed position by the engagement of the spider ring 93 on body 10 with the upper abutment 95 on valve stem section 72a, the spring 88 and fluid flowing through the main valve means forcing the main valve means fully closed. In either case, such upward movement of the body 10 will be imparted to the lower body 11 resulting in opening of the unloaded valve U, as previously described, to balance the pressure across the packer P.

In addition, when the unloaded valve opens, pressure of the weighted mud in the annular space between the string S and the casing will be admitted to the main valve body so as to equalize the pressure within the string S with annulus pressure if the main valve means are latched open. If the main valve means are closed and it is desired to equalize pressure within the pipe string S above main valve means with the unloading pressure, then it is necessary to have additional valve means in the tubing string above the main valve means. Such additional valve means is, in the illustrative embodiment, included in the relief plug assembly referred to and illustrated particularly in FIG. 9.
Relief plug assembly R comprises a tubular body 150 adapted at 151 for connection in the pipe string S thereabove and at 152 for connection to a catcher including a body 153 connectable at 154 in the pipe string S therebelow. In the body 150 is a radial port 155 in which is threaded or otherwise secured a retainer 156. This retainer has a laterally extended bore 157 receiving a plug 158 provided with suitable sealing means 159. An outer flange 160 of the retainer 156 prevents outward displacement of the plug 158. Inward displacement of the plug 158 is prevented by a frangible pin 161 engaged in the plug 158 and extending across body 150 into engagement with the opposing inner wall thereof. In a manner known in the art, a bar or other weight may be dropped through the pipe string S to cause fracture of the pin 161, the pin being preferably scored at 162 to weaken the same. The catcher previously referred to comprises, illustratively, a support 163 within body 153 having a suitable number of bars 164 therein to catch and hold the drop weight after it has broken off the pin 161. When the pin is broken, the pressure of weight fluid in the annular outer space between the string S and the casing C will displace the plug inwardly, thereby equalizing pressure. This additional valve means provided by the relief plug assembly may be located at some distance, say a number of hundred feet above the testing assembly T, and when employed with the main valve closed, the balance of annular pressure and pressure in the pipe string S and the application of annular pressure on the formation are accomplished in timed stages, namely, a first stage when the packer and unloader are released and open during which weight fluid will be applied to the formation face to contain the formation pressure, and a second stage during which when the pump out plug is released the pipe string S is filled.

In FIGS. 7 and 8 is illustrated a somewhat modified main valve assembly to which the same reference characters have been applied. This main valve assembly differs from that previously described only in that the valve stem 72 has no upward extension 72d above the end 96 thereof. In addition the spider-like member 91 of FIGS. 7 and 8 has a solid member 93 corresponding to the annular part of the first described embodiment.

The operation of the main valve means of FIGS. 7 and 8 is the same as that previously described with the exception that the spring 88 in FIGS. 7 and 8 constitutes the sole means for initiating closing movement of the valve stem 72 other than the effect of fluid flow tending to close the main valve means.

While the specific details of illustrative embodiments of the invention have been herein shown and described changes and modifications without departing from the spirit of the invention as defined in the following claims.

1. In formation testing apparatus adapted to be run into a well in a pipe string for allowing the flow of formation fluid at the top of a well, including a well packer in said string having means for setting the packer in sealed engagement with the well wall to form a seal therewith in response to longitudinal movement of the pipe string in one direction and releasable from said well wall in response to longitudinal movement of said pipe string in the other direction, said apparatus comprising testing valve means including a tubular body having a passage therethrough and main valve means in said passage normally closed during running into the well and openable in response to said longitudinal movement of said pipe string in said one direction, and means for opening said main valve means following setting of said packer during said longitudinal movement of said pipe string in said one direction, said main valve means comprising a major valve seat circumscribing said passage, a major valve engageable with said major valve seat, said major valve having an opening therethrough, a minor valve seat circumscribing said opening, a minor valve engageable with said minor valve seat, and means supporting said major and minor valves for movement into and out of engagement with the respective seats.

2. Formation testing apparatus as defined in claim 1, wherein said means for opening said main valve means includes means for first moving said minor valve off its seat and then moving said major valve off of its seat.

3. Formation testing apparatus as defined in claim 1, including means for closing said main valve means upon movement of said pipe string in said other direction, said means for closing said main valve means including a main valve stem and abutment means on said body and on said stem engageable to move said minor valve into engagement with its seat and said major valve into engagement with its seat.

4. Formation testing apparatus as defined in claim 1, including means for closing said main valve means upon movement of said pipe string in said other direction, said means for closing said main valve means including a spring normally urging said minor valve into engagement with its seat and said major valve into engagement with its seat.

5. Formation testing apparatus as defined in claim 1, wherein said body comprises telescopic body parts, and said means for opening said main valve means following setting of said packer includes an abutment on one of said body parts and an abutment on said minor valve engageable to move said minor valve off of its seat responsive to said telescopic movement, and means for retarding telescopic movement of said body parts during movement of said pipe string in said one direction.

6. Formation testing apparatus as defined in claim 5, wherein said means for retarding telescopic movement of said body parts comprises hydraulic fluid transfer means.

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