Sept. 1, 1970 L. B. SCOTT 3,526,278

HIGH VOLUME MAIN VALVE FOR FORMATION TESTERS

Filed April 16, 1968 5 Sheets-Sheet 1

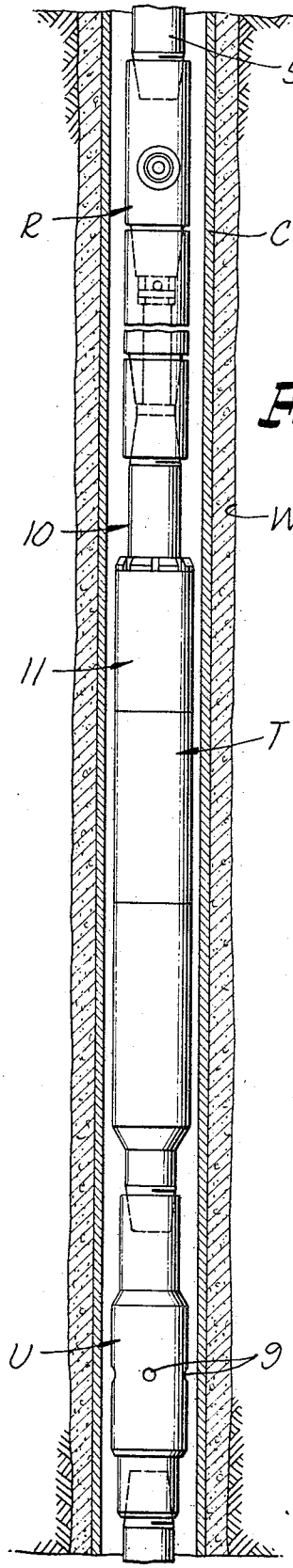


FIG. 1a.

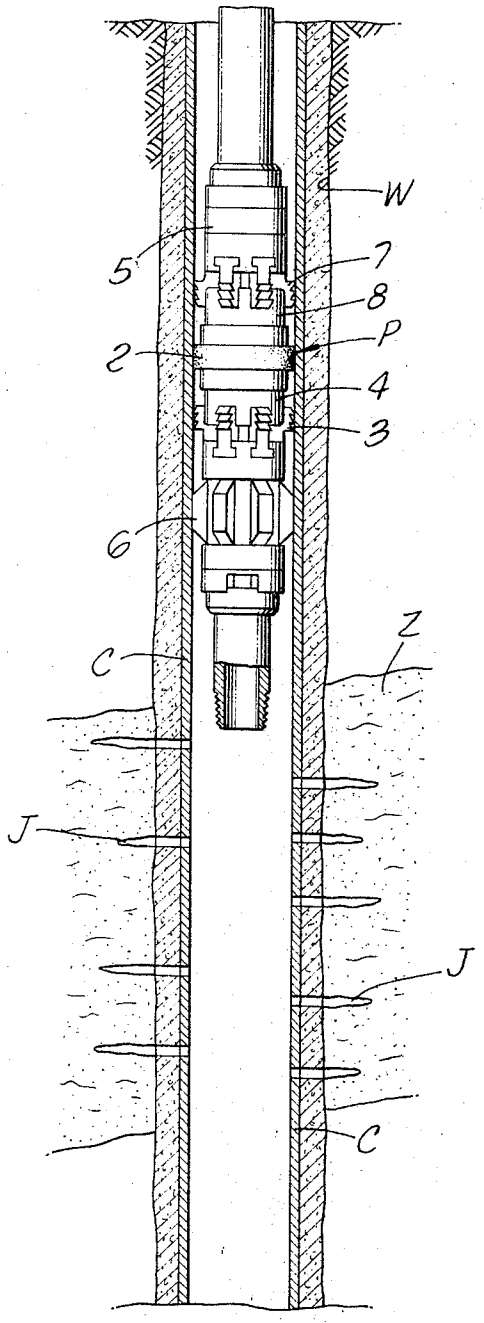


FIG. 1b.

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HIGH VOLUME MAIN VALVE FOR FORMATION TESTERS

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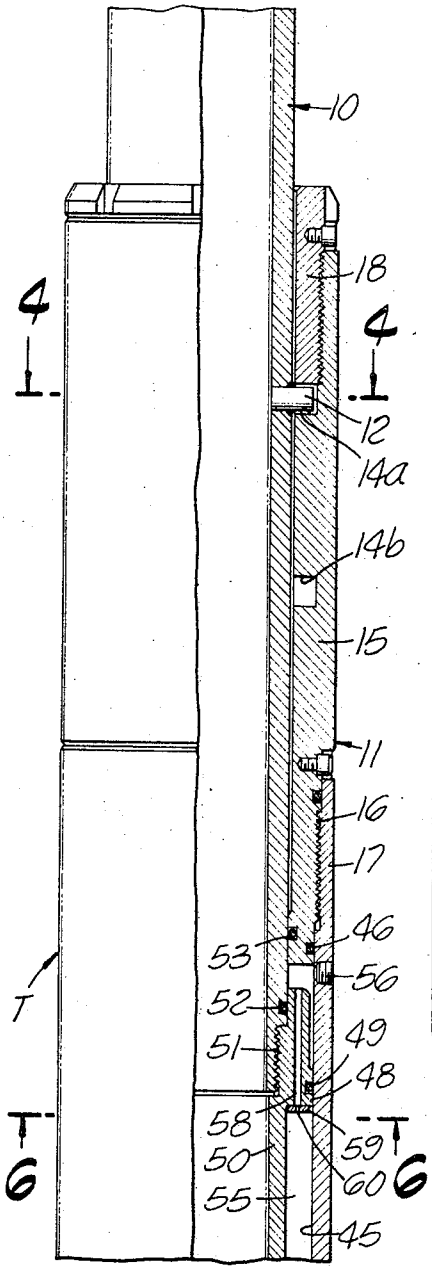


FIG. 2a.

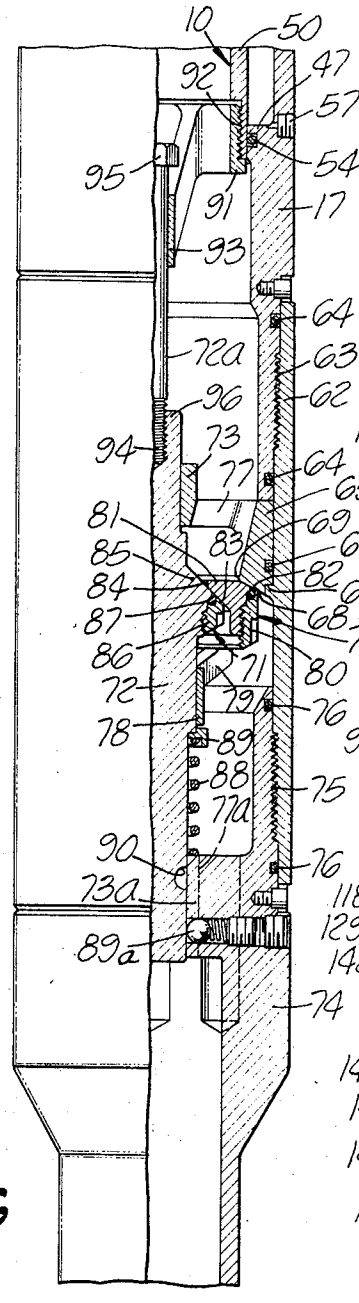


FIG. 2b.

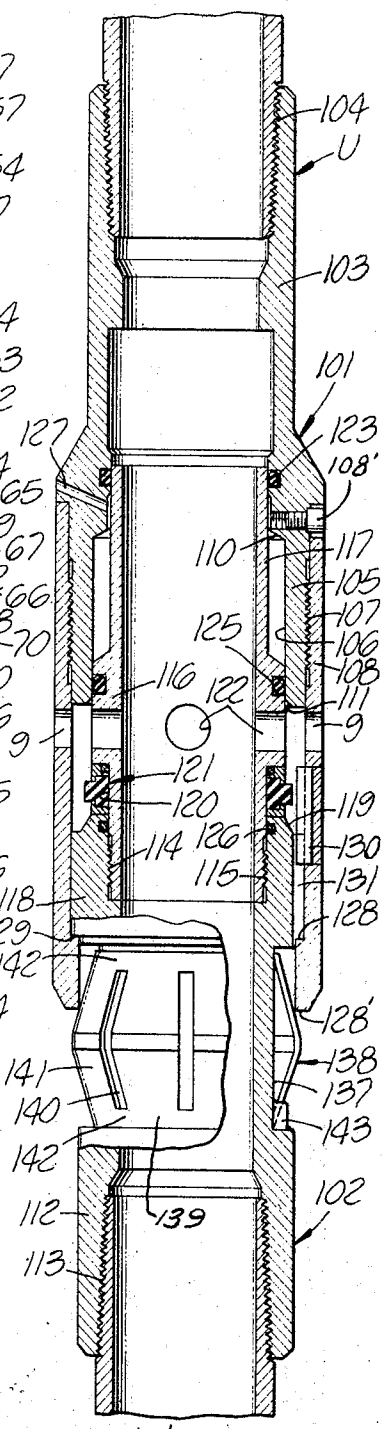


FIG. 2c.

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HIGH VOLUME MAIN VALVE FOR FORMATION TESTERS

Filed April 16, 1968 5 Sheets-Sheet 3

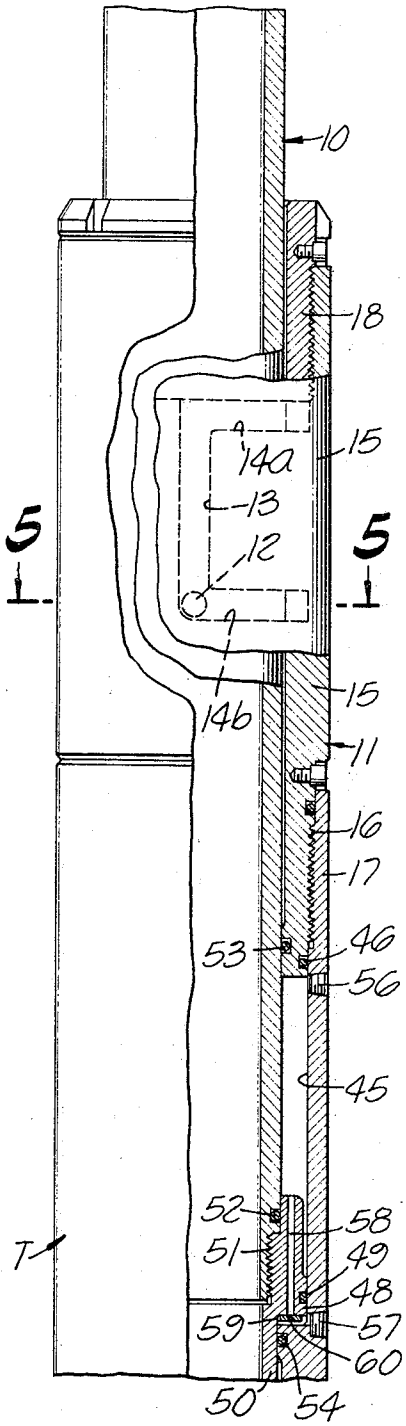


FIG. 3a.

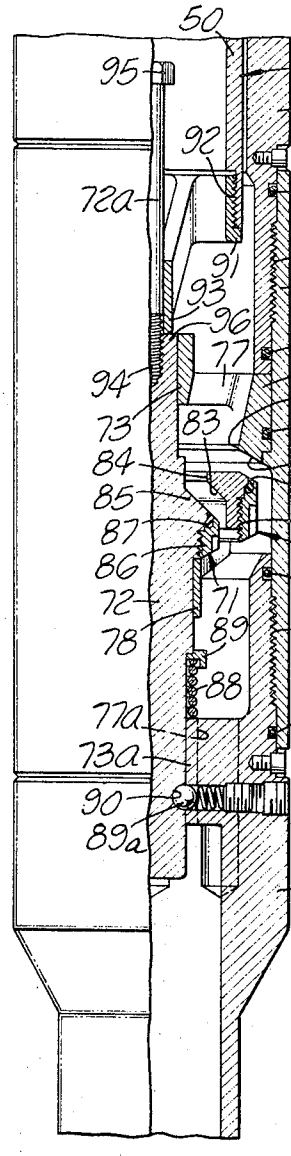


FIG. 3b.

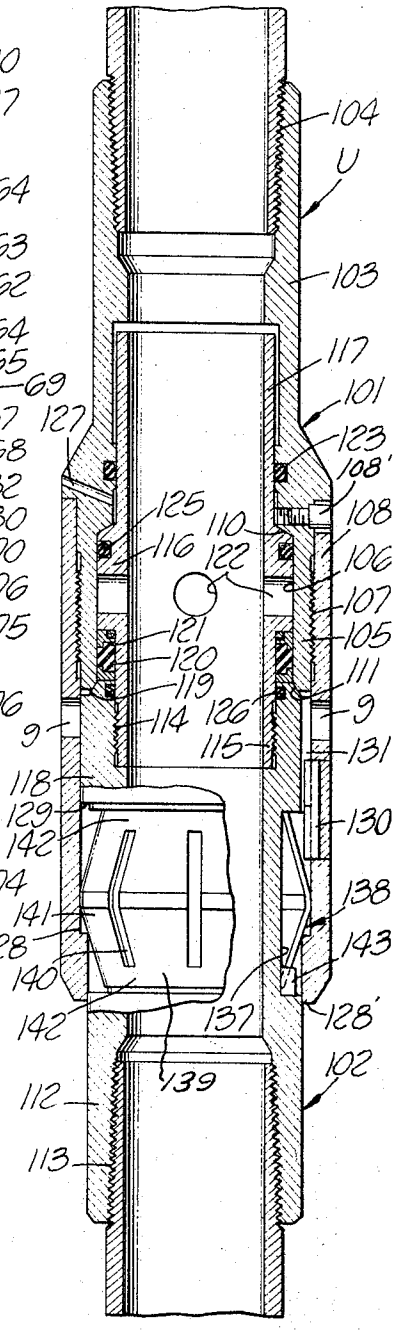


FIG. 3c.

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HIGH VOLUME MAIN VALVE FOR FORMATION TESTERS

Filed April 16, 1968 5 Sheets-Sheet 4

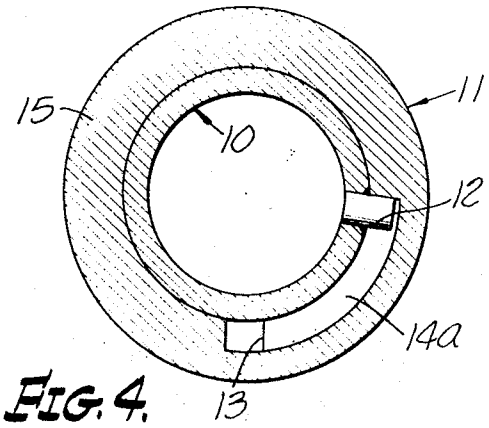


FIG. 4.

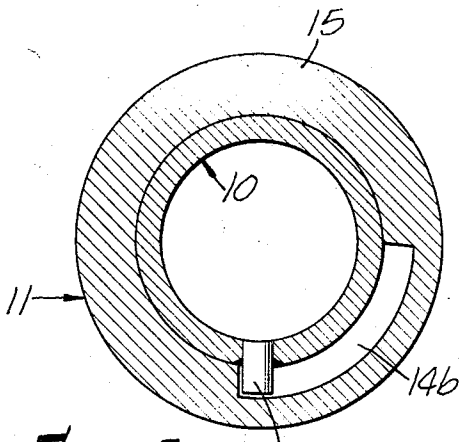


FIG. 5.

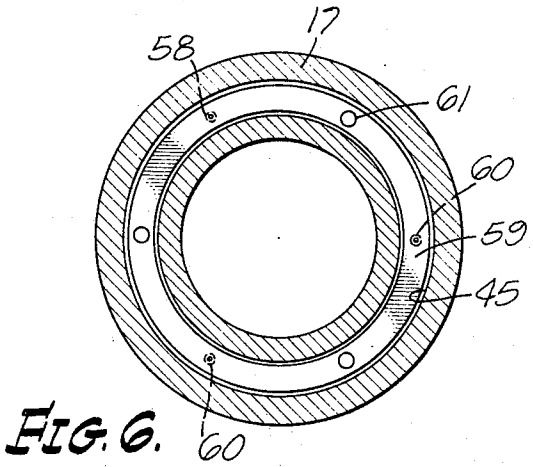


FIG. 6.

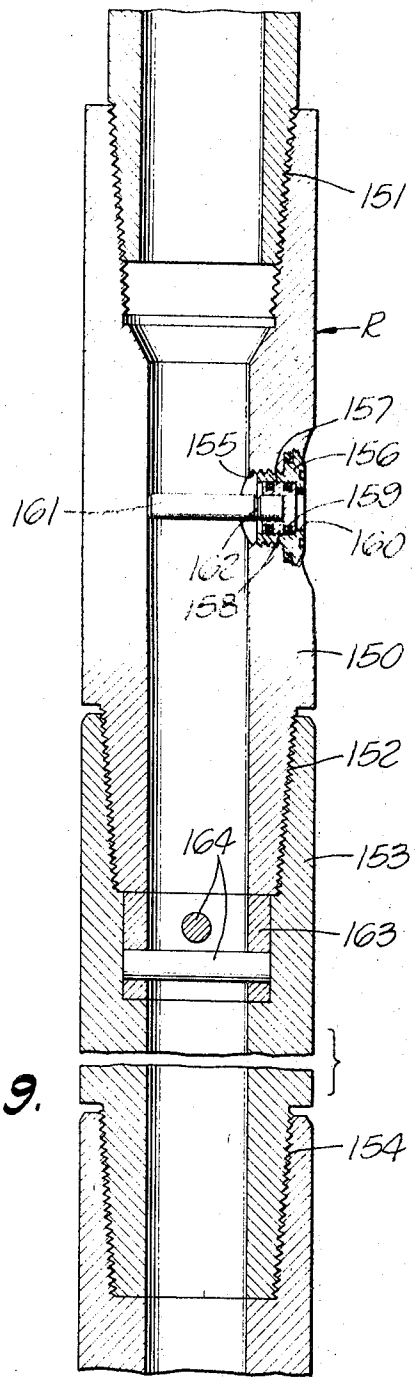


FIG. 9.

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# HIGH VOLUME MAIN VALVE FOR FORMATION TESTERS

Filed April 16, 1968 5 Sheets-Sheet 5

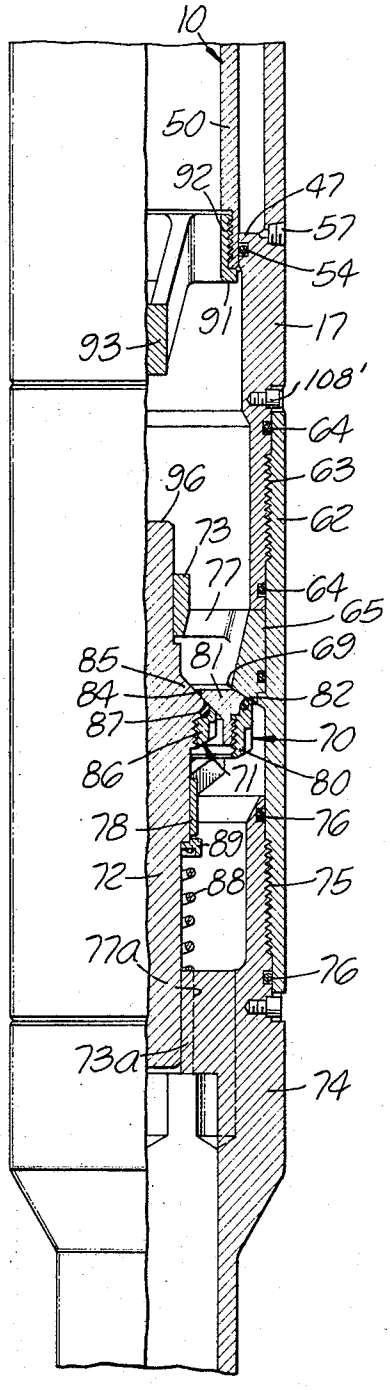


FIG. 7.

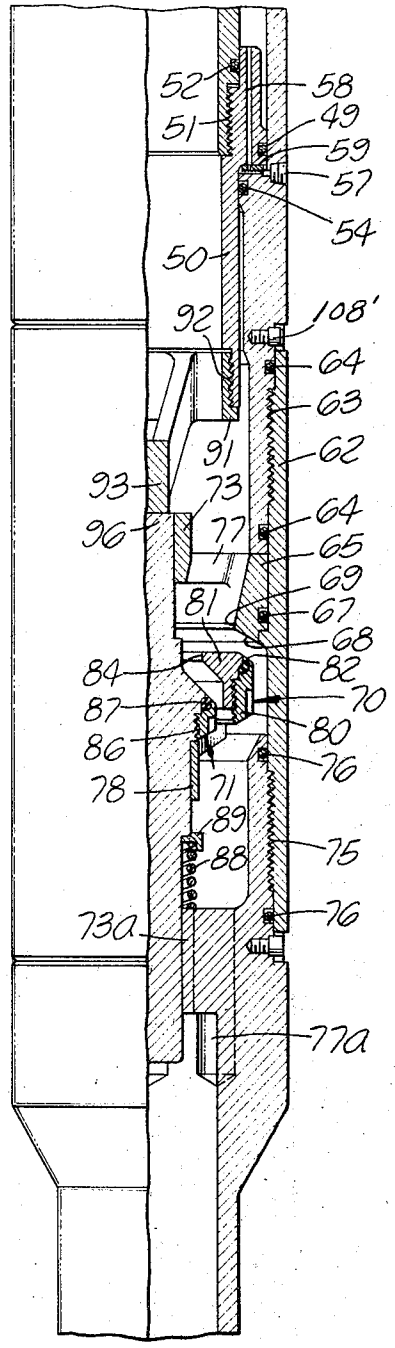


FIG. 8.

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United States Patent Office 3,526,278 Patented Sept. 1, 1970



3,526,278

# HIGH VOLUME MAIN VALVE FOR FORMATION TESTERS

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Filed Apr. 16, 1968, Ser. No. 721,649
Int. Cl. E21b 33/00
U.S. Cl. 166—152 6 Claims

## ABSTRACT OF THE DISCLOSURE

A subsurface earth formation tester having a large flow passage closed by a compound valve having major and minor valve seating areas, 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 coengagement 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 5000 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 below the tester assembly a packer engageable with the casing to isolate the formation to be tested from the remainder of the well bore thereabove, 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 some reason the packer and unloader valve below the tester have not been 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. 1*a* and 1*b* 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. 1*b* being a downward extension of FIG. 1*a*;

FIG. 2*a* 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. 2*b* is a downward extension of FIG. 2*a*, showing one embodiment of the compound valve in a closed position;

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

FIG. 3*a* is a view corresponding to FIG. 2*a* 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. 3*b* is a downward extension of FIG. 3*a*, showing the compound valve open;

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

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

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

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

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 productive subsurface zone Z being in communication with the well inside the casing through jet or bullet perforations J 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 undergoing 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 a packing rubber **2** 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 upwardly 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 retrieved 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 main valve means (FIGS. 2*b*, 3*b*, 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. 2*a* and 3*a*) are also included in the assembly T for causing the delayed opening of the main valve means during 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. 2*a*, 3*a*, 4 and 5) for releasably holding the bodies **10** and **11** against telescopic movement in both the running in and testing or valve open positions of the bodies **10** and **11**.

Referring to FIGS. 2*a*, 3*a*, 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** threadedly 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 subsurface oil tools as J-locks including, in the illustrative embodiment, a pin **12** on the body **10** projecting radially therefrom into a slot in the outer body member **15**, the slot including an elongated, axially extended portion **13**, an upper circumferential leg **14***a*, and a lower circumferential leg **14***b*, 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. 2*a*, in which the bodies are extended, and in FIG. 3*a*, in which the body **10** has moved downwardly in the body **11**. In FIG. 2*a*, the latch member **12** engages the upper stop of latch leg **14***a*; while in FIG. 3*a*, the latch member **12** engages the lower stop of leg **14***b*. 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 the telescopic 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 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 movable piston or wall **48**. Filler and vent 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 opposite 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 region of passages **58**, thereby 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 or impeded, 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. 2*b* and 3*b* in which the valve is shown open and closed, respectively. This valve means includes a tubular valve body or housing consisting of a lower section **62** of body **11** 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** of body **11** and an internal shoulder **66** within body section **62**, a seal **67** being provided to prevent bypass of fluid externally of the seal member **65**. A valve seating surface **68** is provided on member **65** and circumscribes the flow passage **69** through the seat. Cooperative with the seat **68** is valve means including a major valve head **70** and a minor valve head **71** carried by an elongated valve stem **72**. This stem **72** is shiftably carried by means allowing reciprocation thereof, and more particularly comprising a spider-like support **73** formed as part of ring **65** and another spider-like support **73***a* within a lower body section **64** of body **11**, this lower body section being joined to body section **62** as at **75** and the joint having suitable sealing means **76**. The spiders **73** and **73***a* afford flow passages **77** and **77***a* for the flow of fluid during the testing of a formation.

The valve head **70** previously referred to includes an annular support **78** slideably mounted on stem **72** and having angularly spaced arms **79** on which an outer ring **80** is fixed, this outer ring supporting an inner ring **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 seating surface **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 both 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 spider **73***a*, the other end of the spring **88** engaging a spring seat **89** carried by the stem **62**. 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 detent means **89***a*, 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 extension **72***a* of valve stem **72**. This extension **72***a* 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 **72***a* between the upper abutment **95** and a lower abutment **96** at the upper end of stem **72**. 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 **72** 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 **72***a* to then enable an upward pull to be applied, releasing the detent means **89***a*, further upward movement of the stem **72** then causing minor valve head **71** to seat on major 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. 3*c* includes a pair of telescopically interengaged 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 extremity for connection to a complementally threaded pipe coupling in the string of pipe. The shank **103** has at its inner extremity a cylindrical sealing section **105**, having an internal cylindrical sealing surface **106** and having threadedly connected 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 seating 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 P. At its inner end, the base **112** has threadedly connected thereto as at **114**, an inner sealing sleeve **115** which is provided with an enlarged central section **116**, complemental 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 eleeve **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 path passing from the body section **101** 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.

Appropiate 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.

A vent passage 127 extends through the body section 101 into the interval lying between the seals 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 108 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 rotative 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 108 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 arched 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 arched 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 in the path of the projection 128 so that when the valve is closed, as shown in FIG. 3*c*, 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. 2*c*, 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 disposed 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, this screw extending through the upper 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 to be tested. Thereupon, the latch means will be operated by rotating the string S to the right, releasing latch element 12 from groove leg 14*a*, 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 unloader valve is also held by the anchor slips against downward movement, the upper unloader valve body 101 will move downwardly, overcoming the holding action of the collet spring means 138 to close the unloader ports 9 through which fluid in 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 72*a*, 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 14*b* 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 14*a* 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 72*a*, 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 unloader valve U, as previously described, to balance the pressure across the packer P.

In addition, when the unloader valve opens, pressure of the weighted fluid 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 annulus 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 some distance, say a number of hundred feet above the tester assembly T, and when employed with the main valve closed, the balancing of annulus pressure and pressure in the pipe string S and the application of annulus pressure on the formation are accomplished in timed stages, namely, a first stage when the packer and unloader are released and open during which weighted 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 **72***a* 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 alterations may be made without departing from the spirit of the invention as defined in the following claims.

I claim:

**1.** In formation testing apparatus adapted to be run into a well in a pipe string for allowing the flow of formation fluid ot the top of a well, including a well packer in said string having means for setting the packer in sealed engageemnt 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 denfied 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 coengageable 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 coengageable 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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