Oct. 14, 1958 J. T. FOSTER 2,856,009

WELL TESTING APPARATUS

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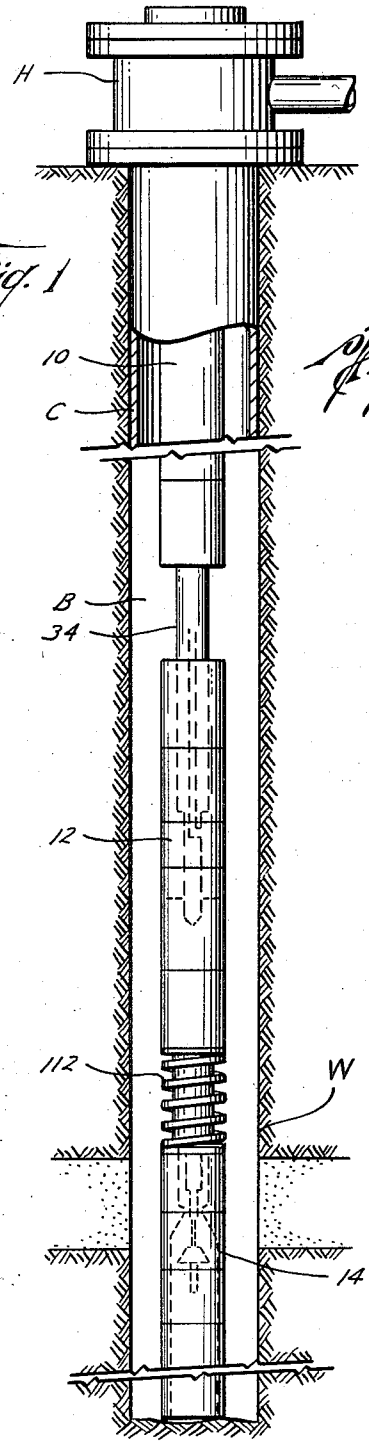



Fig. 1

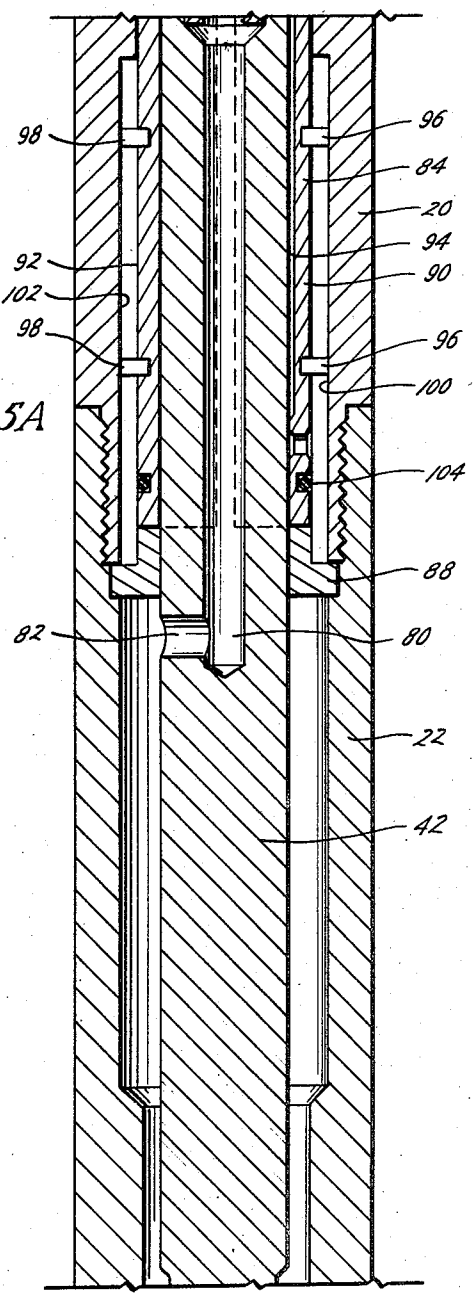



Fig. 5A

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WELL TESTING APPARATUS

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Fig. 2A

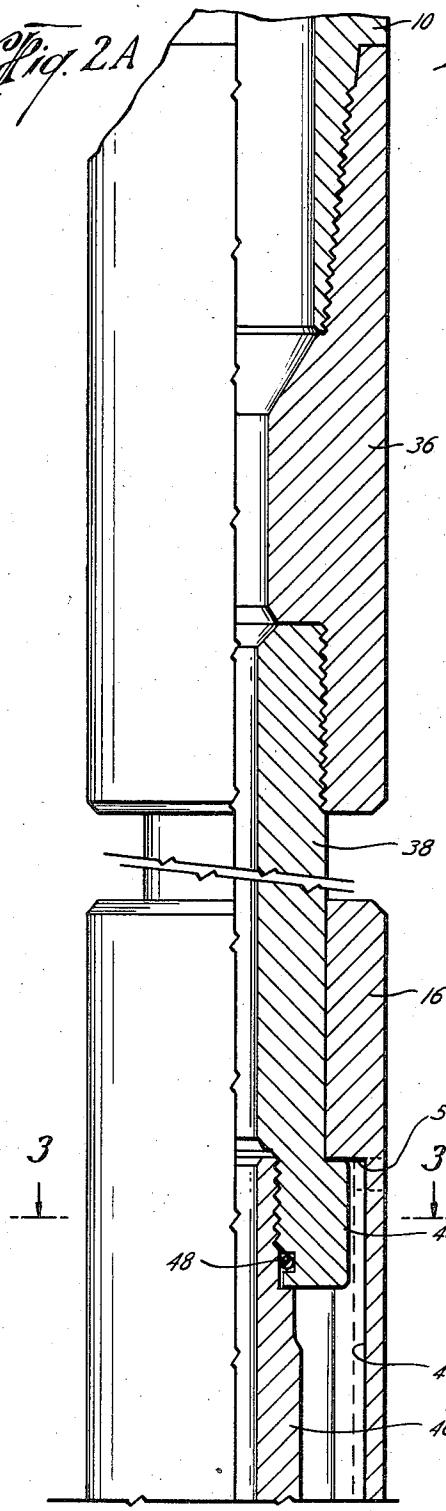
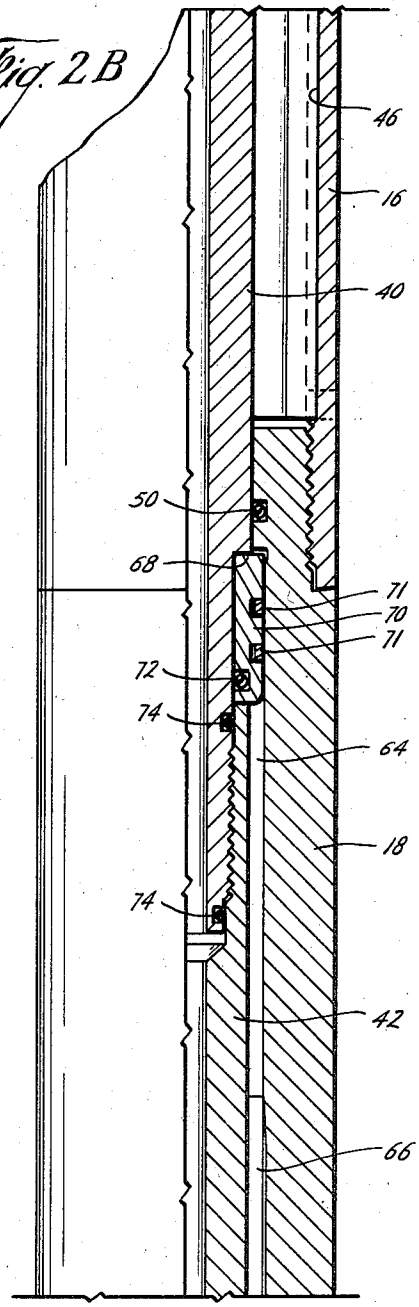



Fig. 2B




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Oct. 14, 1958 J. T. FOSTER 2,856,009

WELL TESTING APPARATUS

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Fig. 2C

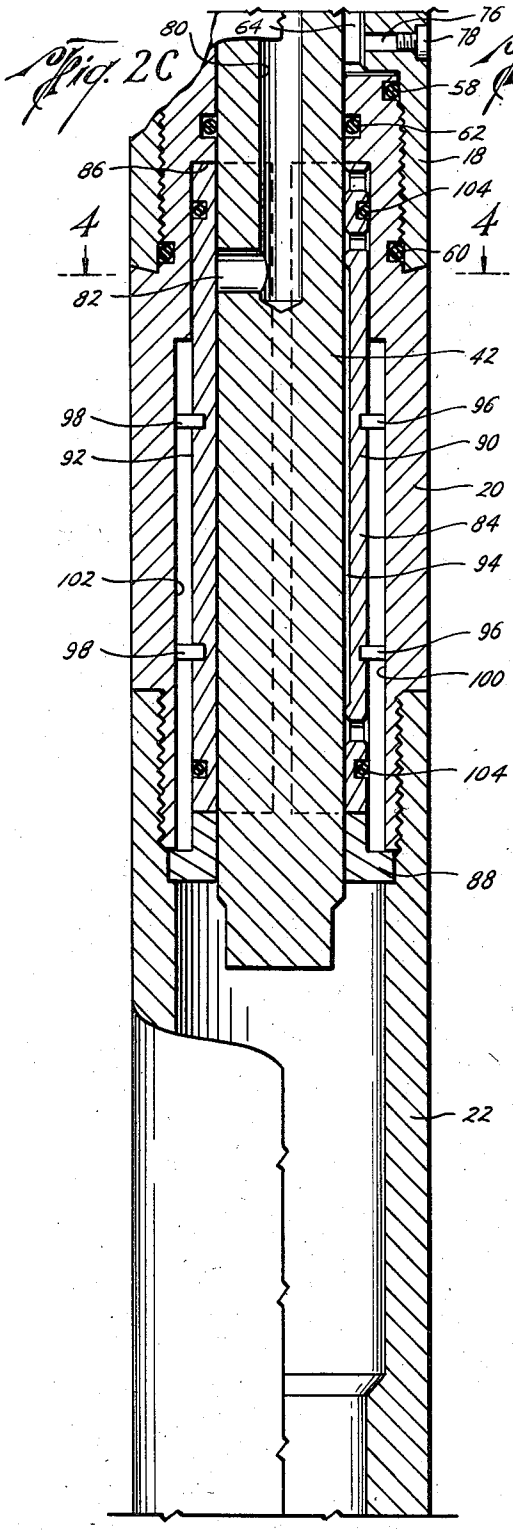
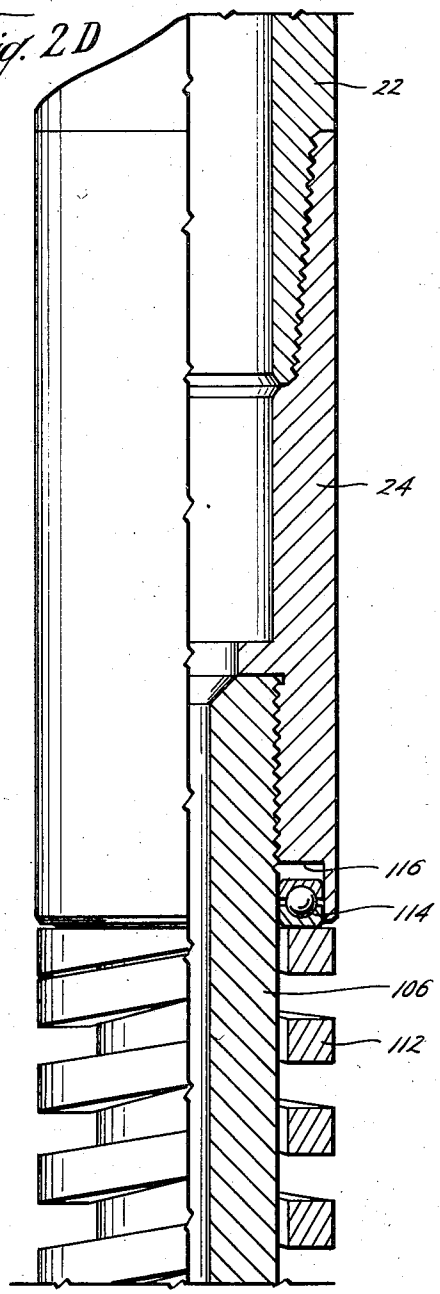



Fig. 2D




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WELL TESTING APPARATUS

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Fig. 2E

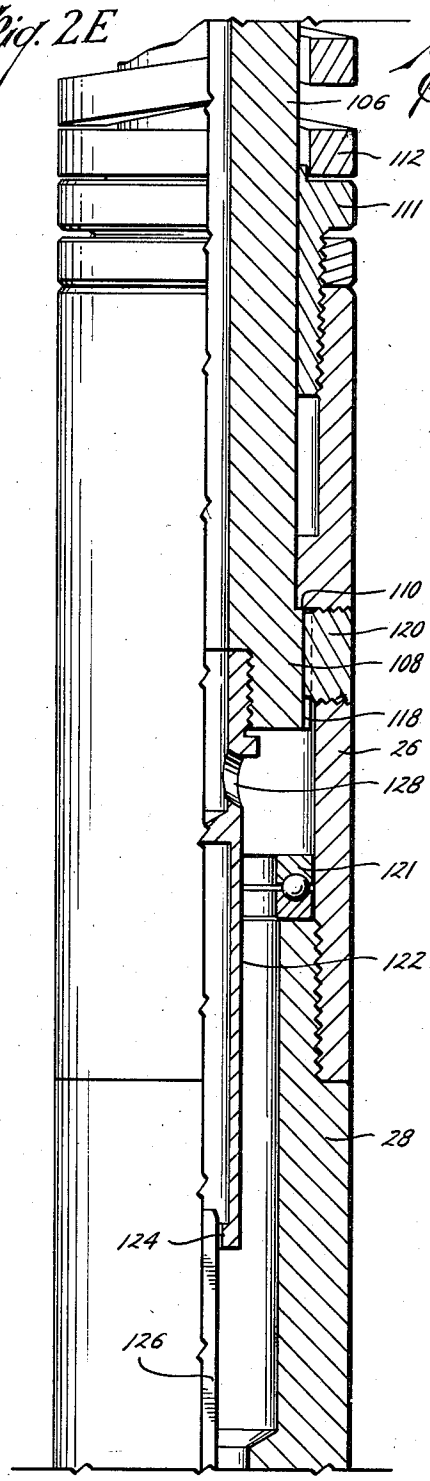
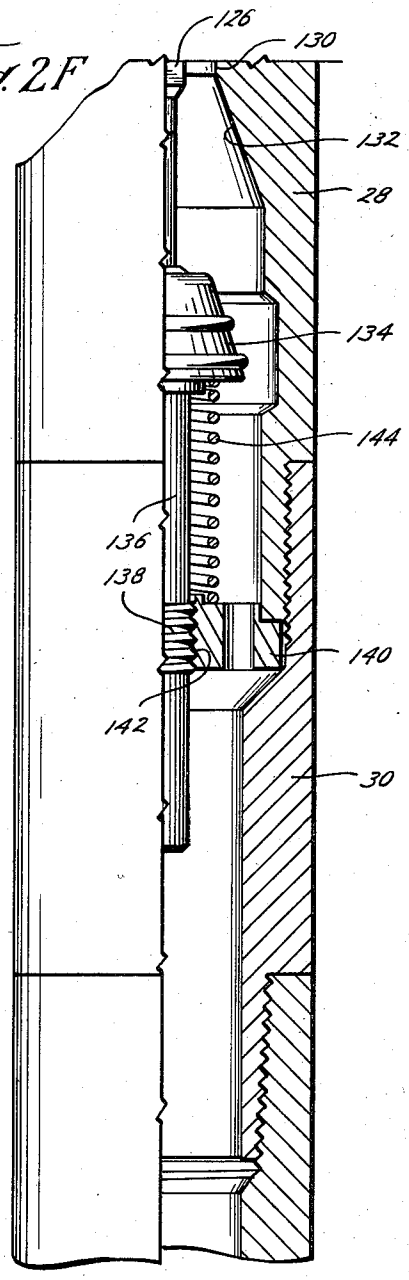



Fig. 2F




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WELL TESTING APPARATUS

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Fig. 5B

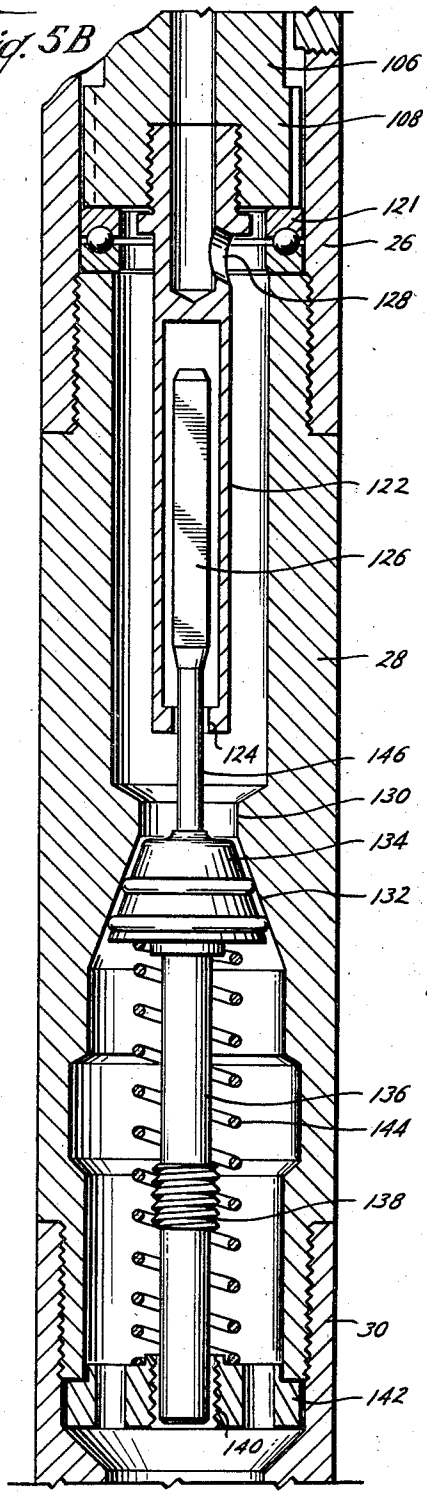



Fig. 3

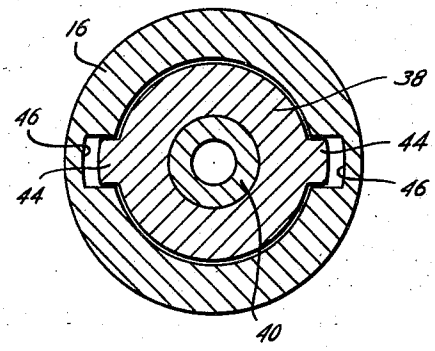
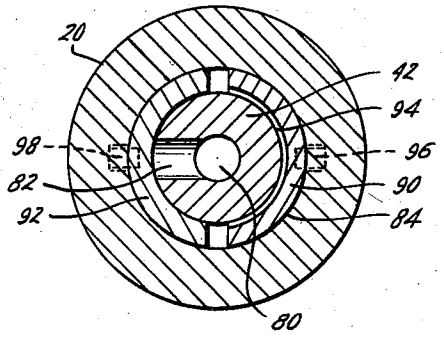



Fig. 4




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United States Patent Office 2,856,009 Patented Oct. 14, 1958



2,856,009

# WELL TESTING APPARATUS

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Application March 1, 1956, Serial No. 568,811

3 Claims. (Cl. 166—226)

This invention relates to well testing apparatus, and more particularly to a device adapted to be connected into a string of well pipe for lowering into a well bore, and which may be used in the determination of the fluid pressure conditions in the well and also for the purpose of removing a sample of the well fluid at any desired point in the well.

The invention finds particular application in connection with the production of oil wells wherein drilling mud is circulated in the well bore during the drilling operation, such mud being often weighted with heavy materials, such as barite, or the like, whereby the pressure in the well may be kept under control.

Upon completion of the drilling operation the drilling mud is frequently allowed to remain in the well, and in order to produce the well it is often desirable to determine the pressure at a predetermined depth in the well, for which purpose a formation tester is introduced into the well bore, through which fluid is allowed to flow from the desired level. Formation testing equipment for this purpose, as heretofore commonly employed usually comprises a tubular string of pipe having a valve adjacent its lower end, which is closed during the lowering of the string in the bore, and which may be opened to permit the flow of fluid therethrough. Means are also commonly provided for packing off the annulus surrounding the string at a desired location in the well to permit well fluid to be withdrawn from a particular formation which it is desired to test.

The present invention has for an important object the provision of well testing apparatus designed to be connected into a tubular string of pipe for lowering into a well bore, and having means for closing the string during the lowering of the same in the well, but which is operable by manipulation of the string to open the string when the equipment has been positioned at the desired point in the well.

Another object of the invention is to provide well testing apparatus having inner and outer telescopingly arranged tubular parts which may be connected into a tubing string, and which are assembled and constructed in a manner to close the string when the parts are in extended condition during the lowering of the string in the well, but which are readily movable to a retracted condition by manipulation of the string to open the string when the apparatus has reached the desired level in the well.

A further object of the invention is the provision of well testing apparatus of the kind referred to having means whereby the parts are restrained against relative longitudinal movement to maintain the string in closed condition during the lowering of the string in the well, and whereby relative longitudinal movement may be imparted to the parts to open the string, by the exertion of a predetermined force on the string when the apparatus is at the desired location.

Another object of the invention is to provide well testing apparatus of the kind mentioned having valve mechanism including inner and outer telescopingly arranged tubular parts movable longitudinally relative to each other, and embodying means for yieldably resisting relative movement of the parts in a direction to open the valve.



Another object of the invention is to provide well testing apparatus having inner and outer telescopingly arranged tubular parts which are movable longitudinally relative to each other, and including valve means positioned to be opened upon relative longitudinal movement of the parts in one direction and hydraulic means for retarding such movement but which is operable to cause sudden relative movement of the parts to open the valve.

A further object of the invention is the provision of well testing apparatus of the kind referred to having valve mechanism including inner and outer telescopingly arranged tubular parts movable longitudinally relative to each other, an annular fluid chamber formed between the parts, a piston in the chamber on one of the parts the chamber having a restriction therein mediate its ends into and out of which the piston is movable upon relative longitudinal movement of the parts, the restriction and piston coacting to permit fluid to flow from one side of the piston to the other side thereof as the piston moves in the restriction, and the piston being freely movable in the chamber when the piston has moved out of the restriction to cause sudden movement of the valve to a fully open position.

The invention also contemplates the provision of well testing apparatus of the kind referred to embodying auxiliary valve means, which is held in open position to permit the flow of fluid in the tubing during the testing operation, which may be operated by manipulation of the tubing string to permit the auxiliary valve to close to entrap a sample of the well fluid, and also to assure fluid tight closing of the string at the conclusion of the testing operation.

The above and other important objects and advantages of the invention may best be understood from the following detailed description constituting a specification of the same when considered in conjunction with the annexed drawings, wherein—

Figure 1 is a fragmentary side elevational view, on a reduced scale, illustrating the invention, and showing the well testing apparatus in position in the bore of a well, preparatory to operation of the apparatus to make a test;

Figures 2A, 2B, 2C, 2D, 2E and 2F are successive, fragmentary views, partly in cross-section, illustrating the invention, and showing the parts in the running-in position, preliminary to the opening of the tubing string to conduct a test;

Figure 3 is a cross-sectional view taken along the line 3—3 of Figure 2A, looking in the direction of the arrows;

Figure 4 is a cross-sectional view taken along the line 4—4 of Figure 2C looking in the direction of the arrows;

Figure 5A is a view similar to that of Figure 2C showing the parts in position to admit well pressure to the tubing string for the purpose of conducting a test; and,

Figure 5B is a view similar to that of Figure 2F showing the auxiliary valve of the invention in closed position.

Referring now to the drawings in greater detail, the well testing apparatus of the invention is illustrated in connection with its use in a conventional tubing string **10** in a well W, such as an oil well having a bore B, which may be provided with the usual casing C. Well head equipment H of usual construction is also provided, by which communication may be established with the tubing string **10** at the ground level, and whereby the bore of the well may be closed.

The well testing apparatus comprises upper and lower outer tubular parts or housings, **12** and **14**, respectively,

the upper housing or outer part 12 enclosing mechanism by which the tubing may be closed during the insertion of the apparatus in the well, and thereafter opened to conduct the test, while the lower housing or outer part 14 contains auxiliary valve means, which is operable to close the string to entrap a sample of well fluid therein at the conclusion of a test, and also to assure a fluid tight closing of the string.

The upper outer part 12 is made up of a number of tubular sections 16, 18, 20, 22, and 24, threadably connected together, and the lower outer part 14 is made up of a number of tubular sections 26, 28, 30, and 32, likewise threadably connected together.

Within the upper outer part 12 an inner tubular part 34 is telescopingly fitted, to permit relative longitudinal movement between the inner and outer upper parts, and this inner part is connected at its upper end in communication with the tubing string 10 by suitable means, such as the coupling element 36. The inner tubular part 34 is conveniently made up of a number of sections 38, 40 and 42, threadably connected together, the sections 40 and 42 being of somewhat smaller external diameter than the section 38.

At its lower end the section 38 is provided with external lugs 44, which extend into internal longitudinal grooves 46 in the upper outer section 16, whereby the upper inner and outer parts are caused to rotate together, while at the same time they may move longitudinally relative to each other. Suitable packing means, such as an O-ring 48 is disposed in an internal groove in the section 38, provided for that purpose, to form a fluid tight seal between the sections 38 and 40. Packing, such as the O-ring 50 is also disposed in an internal groove in the upper end of the outer tubular section 18, to form a fluid tight seal between the inner and outer parts. The lugs 44 are also engageable at their upper ends with a downwardly facing internal shoulder 56 within the outer section 16, to limit upward movement of the inner part relative to the upper outer part.

Suitable sealing means, such as the O-rings 58 and 60, disposed in external grooves in the outer section 20, provided for that purpose, form fluid tight seals between the upper end of the section 20 and the lower end of the section 18, and an O-ring 62 is also disposed in an internal groove within the upper end of the outer section 20 to form a fluid tight seal between the inner section 42 and the outer section 20. Between the O-ring seals 50 and 62 a fluid containing chamber 64 is formed within the outer section 18, above the upper end of the outer section 20, and the lower portion of the outer section 18 is provided with internal longitudinal grooves, such as that indicated at 66.

The lower end portion of the inner section 40 is somewhat reduced, to provide a downwardly facing external shoulder 68, against which an annular element 70 located in the chamber 64, is seated, to form a piston movable with the inner part in the chamber, this annular element being engaged by the upper end of the inner section 42 to clamp the element between the inner sections 40 and 42. The element 70 may be provided with piston rings, such as those indicated at 71, located in external grooves provided to receive the same, and which engage the inner wall of the outer section 18 in the chamber 64 to restrict the flow of fluid past the piston upon relative longitudinal movement of the inner and outer parts. Suitable sealing means, such as the O-ring 72, located in an internal groove in the element 70, forms a fluid tight seal between the element and the inner section 40. Seal forming elements, such as O-rings 74 are also provided in external grooves in the inner section 40, to form a fluid tight seal between the sections 40 and 42 beneath the piston 70.

It will be apparent that the portion of the outer section 18 above the longitudinal grooves 66 forms a restriction in the chamber 64, into and out of which the piston 70 may move, upon relative longitudinal movement between the upper inner and outer parts. An opening 76 may be provided in the outer section 18, in communication with the chamber 64, and leading to the exterior, and through which the chamber may be filled with liquid. The opening 76 is closed by a suitable screw plug 78.

By filling the chamber 64 with liquid, it will be apparent that relative movement of the upper inner and outer parts, in a direction to move the parts toward retracted position will be resisted by the liquid in the chamber, which must leak past the piston 70, and that when the piston has moved out of the upper restricted portion of the chamber and into the portion of the chamber in which the grooves 66 are located, liquid may then flow freely past the piston, to permit the parts to move suddenly to fully retracted position.

The section 42 of the upper inner part has a bore 80, which communicates at its upper end with the interior of the section 40, and which is closed at its lower end, and also has a side opening 82 in communication with the bore 80 and opening exteriorly of the section 42.

Within the outer section 20, an internal longitudinally split sleeve 84 is positioned in surrounding relation to the inner section 42, the interior of the sleeve and the exterior of the section 42 being closely fitted together for longitudinal sliding movement relative to each other to effectively close the opening 82 when the opening is within the sleeve, without the use of packing. The sleeve 84 is seated at its upper end on a downwardly facing internal shoulder 86 formed within the outer section 20 and is held in position by a ring 88 clamped between the outer sections 20 and 22 and upon which the lower end of the sleeve is seated. The sleeve is made in two semi-cylindrical sections 90 and 92, the section 90 being relieved interiorly, as indicated at 94, and the halves of the sleeve being keyed to the outer section 20, as by means of keys 96 and 98 which fit into internal longitudinal grooves 100 and 102 in the outer section 20 to hold the sleeve against rotation therein. The sleeve halves 90 and 92 may be held in assembled relation for the purpose of inserting the sleeve into the section 20, by means of snap rings 104 received in external grooves provided therefor.

By the above arrangement it will be readily seen that when the apparatus is in extended condition the opening 82 will be inside of the sleeve 84 and the tubing string will be closed, as best seen in Figure 2C, but when the parts are moved to retracted condition, the opening 82 will be moved downwardly beyond the lower end of the sleeve to the position illustrated in Figure 5A to open the tubing string.

Within the lower outer part 14 a lower inner tubular part 106 is telescopingly extended, whose upper end is threadably connected to the lower end of the section 24 of the upper outer part 12 for longitudinal movement therewith. The inner part 106 has an externally enlarged portion 108 at its lower end which is engageable with an internal shoulder 110 on the outer section 26 to limit upward movement of the inner part relative to the lower outer part. A coil spring 112 surrounds the inner part 106, one end of the spring being seated on a tubular bearing element 111, threadably attached to the upper end of the outer section 26, while the other end of the spring is seated on suitable bearing means, such as the roller bearing device indicated at 114, carried within a counterbore 116 in the lower end of the outer section 24. The spring 112 is positioned to coact with the upper and lower outer parts 12 and 14 to yieldingly hold the lower inner part in extended position relative to the lower outer part.

The inner part is provided with one or more external grooves 118 in its lower end portion 108, and the outer section 26 has one or more clutch elements, such as that shown at 120 positioned for intermeshing engagement

with the grooves 118 when the inner part 106 is in extended position, as shown in Figure 2E, whereby the section 26 is connected to the part 106 for rotation therewith. Upon downward movement of part 106 relative to section 26 the clutch mechanism 118, 120 will be released to permit the part 106 to rotate independently of the lower outer part 14. Suitable bearing means such as the roller bearing device 121 is positioned on the upper end of the outer section 28, within the outer section 26, in position for engagement with the lower end of the inner part 106 when the same is in its lowermost position to reduce friction when the inner part 106 is rotated.

A tubular extension 122 is attached to the lower end of part 106, extending downwardly therefrom and whose lower end has an end opening 124 of polygonal shape to receive a valve stem 126 of corresponding shape slidably extended therethrough. The extension 122 is of substantially smaller diameter than the internal diameter of the outer section 28 and is provided with a side opening 128 which communicates with the interior of outer section 28 and with the interior of the inner part 106.

Beneath the extension 122 the outer section 28 has an internally thickened portion 130 which forms an upwardly tapering valve seat 132, upon which an auxiliary valve 134 mounted for longitudinal movement in the section 28 is adapted to seat. The valve 134 has the upper valve stem 126, and is also provided with a lower valve stem 136 which is externally threaded, as indicated at 138, mediate its ends. The valve stem 136 extends through an internally threaded opening 140 in a guide element or spider 142 clamped between the outer sections 28 and 30, the threads 138 of the stem being engageable with the internal threads of the opening 140 to hold the valve in open position, as seen in Figure 2F. A coil spring 144 surrounds the stem 136 and bears at one end upon the lower face of the valve 134 and at its other end upon the spider 142 to yieldingly urge the valve toward closing position.

The upper stem 126 has a portion 146 of reduced diameter below the polygonally shaped upper portion thereof which is freely rotatable in the opening 124 of the extension 122 to permit the inner part 106 to rotate independently of the valve 134 when the part 106 is in its lowered position in the outer part 14.

By this valve mechanism, and the actuating means therefor, the valve will be held in open position by the threads 138, in engagement with the internal threads of the spider 140, and by rotation of the stem 10 with the tubular extension 122 in contact with the polygonal upper end portion of the stem 126, the valve stem 136 may be released from the spider, whereupon the valve will be closed by the action of the spring 144, to entrap and hold a sample of well fluid in the string, in the event that there should be some leakage between the upper inner and outer parts.

In making use of the invention, constructed and arranged as described above, the testing apparatus is lowered into the well bore connected to the tubing string 10, with the parts in extended condition, and the valve 134 open, as illustrated in Figures 2A to 2F, inclusive. The tubing string 10 may be extended downwardly from the lower end of the testing apparatus by attaching further sections of tubing to the section 30, and when the lower end of the tubing reaches the bottom of the hole, the upper inner part may be moved downwardly, relative to the upper outer part by the downward force asserted by the string against the resistance of the liquid in the chamber 64, until the piston 70 moves out of the restricted portion of the chamber into the portion in which the grooves 66 are located, whereupon the inner part 42 will be moved suddenly downwardly to move the opening 82 to open position below the sleeve 84, to permit the well fluid to flow upwardly through the string, whereby the pressure in the well may be determined.

At the conclusion of the test the string 10 may be moved upwardly to move the upper inner part upwardly in the upper outer part, to move the opening 82 upwardly to a position within the sleeve 84, to close the stem. Should it be desired to entrap a sample of well fluid in the stem, and to assure that the sample will not be lost by leakage between the inner and outer parts, the string may be lowered to engage the coupling 36 of the section 16 with the upper outer part, whereupon upon further downward movement of the string the upper outer part will move downwardly to move the lower inner part 106 downwardly in the lower outer part to release the clutch 118, 120, and the string may then be rotated to the left to rotate the valve stem 136, through the extension 122 and valve stem 126 to unscrew the lefthand threads 138 from the spider 149. The valve 134 will then be moved to closed position under the influence of the spring 144.

The lower outer part 14, together with the valve 134 and its actuating mechanism, constitute a valve assembly, which may be operated to entrap a sample of well fluid in the tubing string. The lower outer part 14 forms a tubular valve casing, while the inner part 106, together with its extension 122 and the valve stem 126 constitute the actuating mechanism for the valve.

It will thus be seen, that the invention provides well testing apparatus, which may be easily connected into a tubing string for lowering into a well, and which may be operated solely by manipulation of the string to open and close the string, and also to entrap a sample of well fluid therein.

The invention has been disclosed herein in connection with a certain specific embodiment of the same, but it will be understood that this is intended by way of illustration only, and that numerous changes can be made in the construction and arrangement of the various parts, without departing from the spirit of the invention or the scope of the appended claims.

Having thus clearly shown and described the invention, what is claimed as new and desired to secure by Letters Patent is:

1. In well testing apparatus the combination with a tubing string adapted to be inserted in a well bore of means for controlling the flow of fluid in said string comprising upper and lower outer tubular parts, an upper inner tubular part telescopingly positioned in said upper outer part, means for connecting said upper inner part to a tubing string for movement therewith, means on said upper inner and outer parts positioned for coaction to hold the upper inner and outer parts against relative rotation in all longitudinal positions of the upper inner and outer parts relative to each other, said upper inner part having a passageway in communication with the interior of the string and with the interior of the upper outer part, means in the upper outer part positioned to close the passageway in one position of the upper inner part in the upper outer part and to open the passageway in another position of the upper inner part in the upper outer part, a lower inner tubular part telescopingly positioned in said lower outer part connected in communication with the interior of said upper outer part and said lower outer part and rotationally and longitudinally movable with said upper outer part, means on said lower inner and outer parts positioned for coacting in one longitudinal position of the lower inner part in the lower outer part to hold the lower inner and outer parts against relative rotation and in another longitudinal position of the lower inner part in the lower outer part to permit such relative rotation, said lower outer part being in communication at its lower end with the interior of the well bore, a valve formed in said lower outer part and through which fluid may flow through said lower outer part, a valve movably positioned in the lower outer part for movement into and out of closing contact with said seat, means releasably connecting the valve to the lower outer part to releasably hold the valve in open position and releas-

able upon rotation of the valve, interengageable means on the lower inner part and said valve positioned for coaction in one longitudinal position of the lower inner and outer parts relative to each other to cause the valve to rotate with said lower inner part and in another longitudinal position of the lower inner and outer parts relative to each other to permit the lower inner part to rotate independently of said valve and means for moving the valve to closing position upon release of said releasable means.

2. In well testing apparatus the combination with a tubing string adapted to be inserted in a well bore of means for controlling the flow of fluid in said string comprising upper and lower outer tubular parts, an upper inner tubular part telescopingly positioned in said upper outer part, means on said upper inner and outer parts positioned for coaction to hold the upper inner and outer parts against relative rotation in all longitudinal positions of the upper inner and outer parts relative to each other, means for connecting said upper inner part to a tubing string for movement therewith, said upper inner part having a passageway in communication with the interior of the string and with the interior of said upper outer part, means in the upper outer part positioned to close the passageway when the upper inner and outer parts are in one position of longitudinal movement relative to each other and to open the passageway when the upper inner and outer parts are in another position of longitudinal movement relative to each other, a lower inner tubular part telescopingly positioned in said lower outer part and connected to said upper outer part for rotational and longitudinal movement therewith and in communication with the interior of said upper outer part and with the interior of said lower outer part, means on said lower inner and outer parts positioned for coaction in one longitudinal position of the lower inner part in the lower outer part to hold the lower inner and outer parts against relative to hold the lower inner and outer parts against relative rotation and in another longitudinal position of the lower inner part in the lower outer part to permit such relative rotation, said lower outer part being in communication at its lower end with the interior of the well bore, a valve seat formed in said lower outer part and through which fluid from said bore may flow upwardly through said lower outer part, a valve movably positioned in the lower outer part for longitudinal movement into and out of closing contact with said seat, means releasably connecting the valve to the lower outer part to releasably hold the valve in open position and releasable upon rotation of the valve in said lower outer part, interengageable means on said lower inner part and valve position for coaction in one longitudinal position of the lower inner part in the lower outer part to cause the valve to rotate with the lower inner part and in another longitudinal position of the lower inner part in the lower outer part to permit the lower inner part to rotate independently of said valve, and yieldable means positioned for coaction with said lower outer part and said valve to yieldingly urge the valve toward closing position.

3. In well testing apparatus the combination with a tubing string adapted to be inserted in a well bore of



means for controlling the flow of fluid in said string comprising upper and lower outer tubular parts, an upper inner tubular part telescopingly positioned in said upper outer part, means for connecting said upper inner part to a tubing string for movement therewith, means on said upper inner and outer parts positioned for coaction to hold the upper inner and outer parts against relative rotation in all longitudinal positions of the upper inner and outer parts relative to each other, said upper inner part having a passageway in communication with the interior of the string and with the interior of the upper outer part, means in the upper outer part positioned to close the passageway in one position of the upper inner part in the upper outer part and to open the passageway in another position of the upper inner part in the upper outer part, a lower inner tubular part telescopingly positioned in said lower outer part and connected to said upper outer part for rotational and longitudinal movement therewith and in communication with the interior of said upper outer part and with the interior of said lower outer part, means on said lower inner and outer parts positioned for coaction in one longitudinal position of the lower inner part in the lower outer part to hold the lower inner and outer parts against relative rotation and in another longitudinal position of the lower inner part in the lower outer part to permit such relative rotation, yieldable means positioned for coaction with said upper and lower outer parts to urge said upper and lower outer parts in a direction to yieldingly said lower outer part in position to rotate with said lower inner part, said lower outer part being in communication at its lower end with the interior of the well bore, a valve seat formed in said lower outer part and through which fluid from said bore may flow upwardly through said lower outer part, a valve movably positioned in the lower outer part for longitudinal movement into and out of closing contact with said seat, means releasably connecting the valve to the lower outer part to releasably hold the valve in open position and releasable upon rotation of the valve in the lower outer part, interengageable means on said lower inner part and valve positioned for coaction when said lower inner part is in position to rotate in said lower outer part and said valve is open to cause the valve to rotate with the lower inner part and when said valve is closed to permit rotation of said lower inner part independently of said valve, and yieldable means positioned for coaction with said lower outer part and said valve to yieldingly urge the valve toward closing position.

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