Sept. 17, 1957 D. P. GREEN ET AL 2,806,539

WELL TESTER

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FIG. 1.

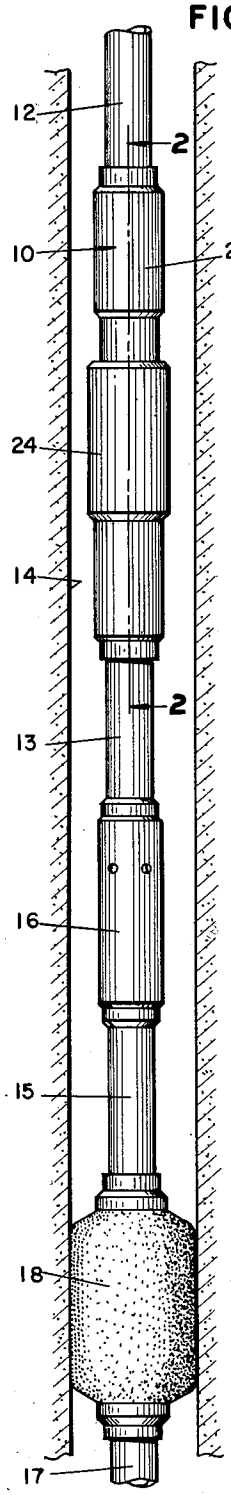
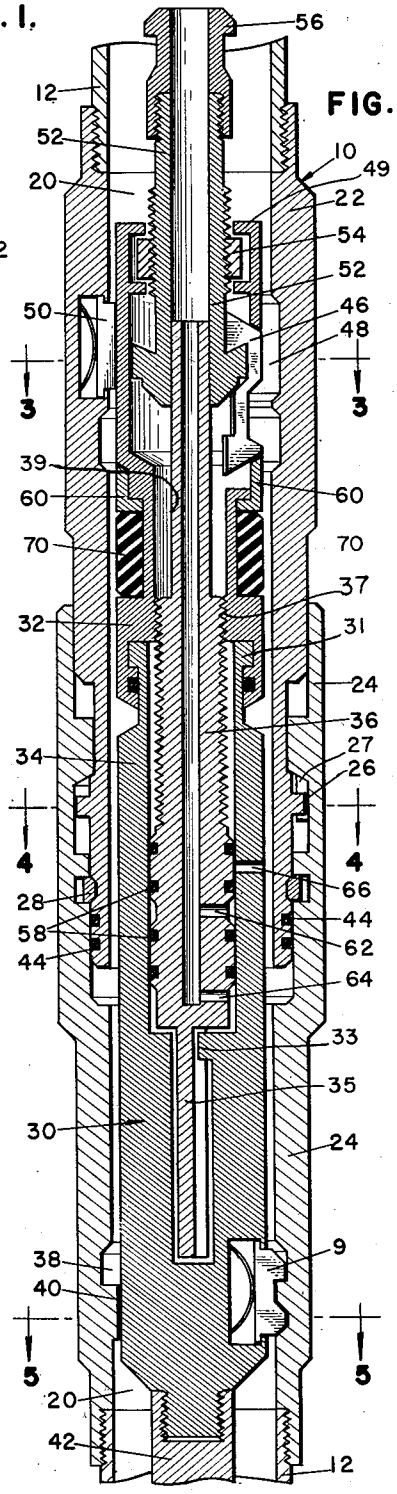


FIG. 2.



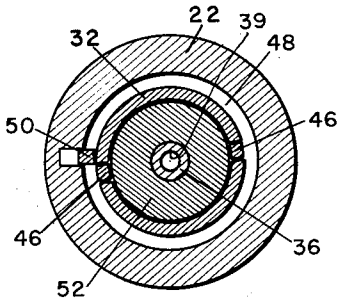
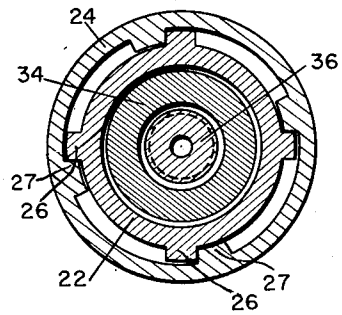


FIG. 3.

FIG. 4.



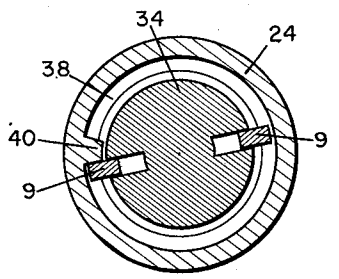


FIG. 5.

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FIG. 6.

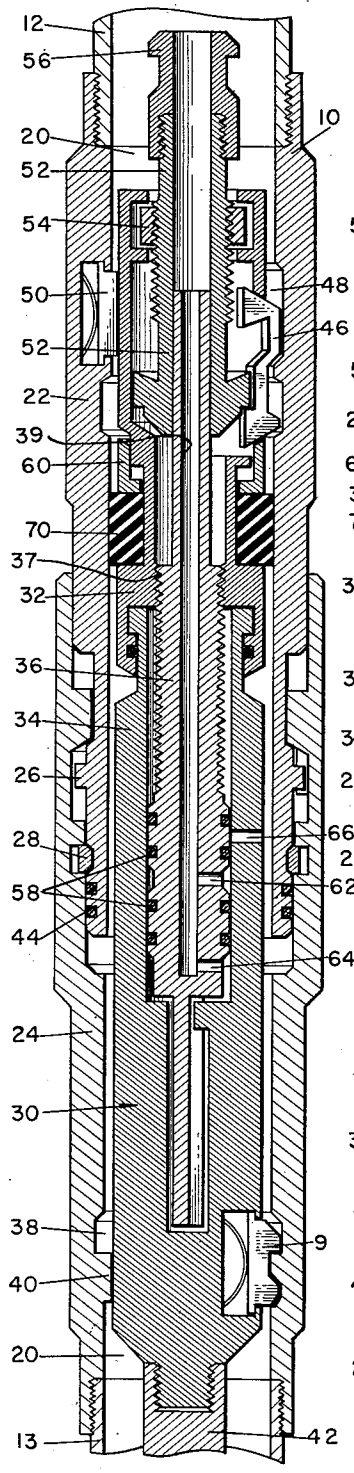


FIG. 7.

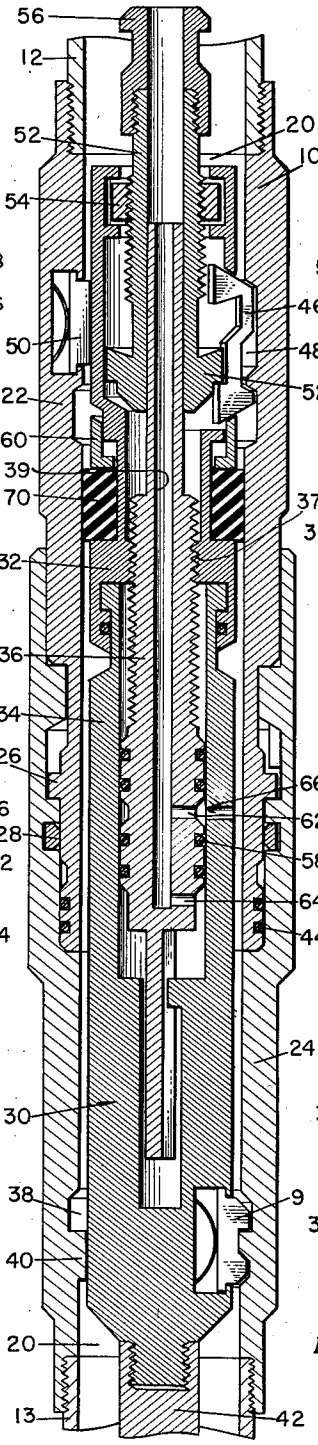
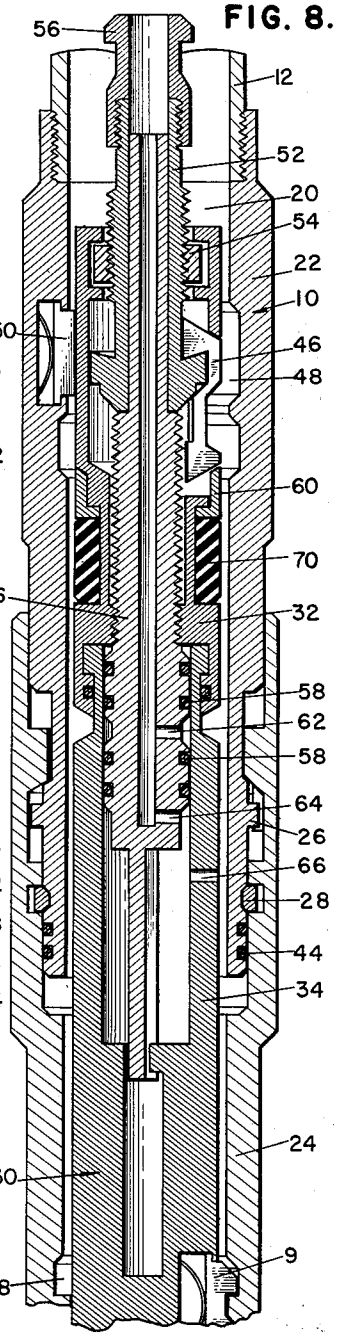


FIG. 8.



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United States Patent Office 2,806,539 Patented Sept. 17, 1957

2,806,539

WELL TESTER

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Application February 13, 1956, Serial No. 565,178

2 Claims. (Cl. 166—226)

This invention relates to a new and improved apparatus for testing wells.

In the flow testing of oil and gas wells, a well flow pipe is provided from the well surface to the formation to be tested. This pipe has a tester valve to control fluid flow therethrough and packing means to separate the formation to be tested from the fluid column that is provided to control excess formation pressures. Thus, opening the valve will permit fluid flow from the formation directly through the pipe to the well surface. After this flow has been determined the valve is usually closed, the packer unseated, and the pipe removed from the well.

However, it is frequently found that a formation believed to be productive will have little or no flow upon opening of the valve. This condition may be caused by misplaced perforations, drilling mud filter cake, or other factors peculiar to the well. If it is thought that additional treating might prove the formation productive, current practice is to remove the testing pipe, perform the treating operation, replace the testing pipe, and perform another test. Some examples of such treatments are perforating, fracturing, acidizing, or combinations of these. Certain of these treating operations, such as fracturing or acidizing, additionally require a pipe to be placed in the well bore for their performance which has to be removed before replacing the testing pipe. It is obvious that removal and replacement of such pipe as heretofore described entails time and effort which, if dispensed with, would offer considerable economy.

It is therefore the general object of this invention to provide improved apparatus for conducting one or more flow tests of a well formation, each of which may be interposed with various well treatments such as perforating or fracturing, and having the flow tests and treatments all conducted with only one placement and one removal of the testing pipe.

Briefly described, this object is attained by providing a well testing device made up of relatively rotatable upper and lower tubular housings, which form a tester, and a valve assembly adapted to be detachably connected within the tester. The valve assembly has an upper sleeve and a lower sleeve also adapted for relative rotation. A mandrel is provided within these sleeves and is actuated thereby to control fluid flow through the valve. The upper sleeve is adapted to rotate with the upper housing, and the lower sleeve is adapted to rotate with the lower housing.

Other objects and advantages of the invention will become readily apparent from the following description considered in connection with the accompanying drawing, in which:

Figure 1 is a sectional elevation of a well bore with apparatus constructed in accordance with the present invention located therein;

Figure 2 is a longitudinal sectional view of a tester employed in the apparatus of Figure 1;

Figure 3 is a transverse section of the tester of Figure 2 taken at 3—3 thereof;

Figure 4 is a transverse section of the tester of Figure 2, taken at 4—4 thereof;

Figure 5 is a transverse section of the tester of Figure 2 taken at 5—5 thereof;

Figures 6, 7 and 8 are longitudinal sectional views of the tester of Figure 2 but showing some of the parts in different relative positions to illustrate the sequence of operation.

As illustrated in Figure 1, a tester **10** is connected in a testing pipe **12** and placed in a well bore **14**. Below the tester **10**, there is a coupling pipe **13** and an equalizing valve **16**. There is another coupling pipe **15** connecting the equalizing valve **16** to a packer **18** and beneath the packer **18** there may be a tail pipe **17**. The purpose of the packer **18** is to isolate the formation to be tested from the fluid column found in the well bore. The hydrostatic pressure of this fluid column is greater than the formation pressure and is present to prevent any blowout. The purpose of the equalizing valve **16** is to provide fluid passage from the well bore into the pipe **12** when such is desired. This valve **16**, and everything incorporated in the string below it, is conventional and forms no part of the present invention. The present invention resides in the particular construction of the tester **10**. It is pointed out that while the drawing herein illustrates the assembly as being placed in an uncased well bore, it may be used in cased well bores as well.

The details of the present invention are shown in Figures 2 to 8. Referring to Figure 2, it will be seen that the tester **10** has a passage **20** therethrough. The passage **20** is preferably of a diameter as great as that of pipe **12**. Tester **10** is made up of an upper housing **22** and a lower housing **24**, which telescope together. The lower portion of the housing **22** is provided with four outwardly extending lugs or clutch jaws **26**, and the lower housing **24** is provided with four inwardly extending lugs **27**. When the parts are in the position shown in Figure 2, this clutch arrangement prevents relative rotation between the upper housing **22** and lower housing **24**. When the housings **22** and **24** are fully telescoped together as shown in Figure 7, the lugs **26** are below the lugs **27**, so the housing **22** may then rotate freely with respect to the housing **24**. A snap ring **28** may be employed to assist in preventing telescoping until desired. Sealing means, such as O rings **44**, are provided between the housings **22** and **24** to prevent any fluid passage therebetween.

As shown in Figures 2 to 8, a removable valve assembly **30** may be located in the tester **10**. The assembly **30** includes an upper sleeve **32** and a lower sleeve **34**. The sleeves **32** and **34** are connected to each other for free relative rotation by the swivel **31**, but this connection prevents any longitudinal movement between these sleeves. A mandrel **36** is connected by threads **37** to upper sleeve **32**, and this mandrel extends down into the lower sleeve **34**. Rotation between the mandrel **36** and the sleeve **34** is prevented by the splines **33** and **35**. Thus, the arrangement is such that relative rotation between the sleeves **32** and **34** causes longitudinal movement of said mandrel within said sleeves to selectively control the position of ports **62** therein, as hereinafter described.

Referring to Figures 2 and 5, it will be seen that there is provided in lower sleeve **34** two resiliently mounted landing detents **9** adapted to register in a landing recess **38** of the lower housing **24**. Traversing a portion of landing recess **38** is an inwardly extending lug **40**. The arrangement is such that the valve assembly **30**, when moved downwardly, will be supported against further downward movement when landing detent **9** expands into landing recess **38**. As seen in Figure 5, lug **40** engages the expanded landing detent **9** and thereby limits relative rotation of lower housing **24** and lower sleeve **34**.

If desired, a pressure recording device may be attached

to the valve assembly 30 at 42 to record the various pressures encountered during a flow test.

Referring to Figures 2 and 3, it will be seen that there is provided on the upper sleeve 32, a pair of detents 46 which are adapted to register in a latching recess 48 of the upper housing 22. Traversing a portion of latching recess 48 is a resiliently mounted key 50. Also provided in a socket 49 at the top of the upper sleeve 32 is an externally threaded latching sleeve 52, restrained against longitudinal movement within upper sleeve 32 by an internally threaded split spring ring 54. A portion of sleeve 52 is cone shaped and adapted to force the latching detents 46 outwardly when moved in longitudinal relation with respect thereto.

As shown in Figure 6, the latching sleeve 52 may be forced downwardly through the split ring 54. This forces latching detents 46 into latching recess 48, and thereby prevents relative longitudinal movement of upper sleeve 32 and upper housing 22. As seen in Figure 3, key 50 is adapted to engage one or the other of the latching detents 46 and thereby limits relative rotation of upper sleeve 32 and upper housing 22. In the event latching detents 46 are expanded while radially aligned with key 50, the resilient mounting of key 50 allows such expansion but returns the key to engaging position upon rotation of housing 22.

A projecting coupling 56 of conventional design, for accommodating a grapple, such as an overshot or spear, is connected to the upper portion of latching sleeve 52, for the purpose of placing and retrieving the valve assembly 30. A wire line jar (not shown) may be used to apply forces to latching sleeve 52. It is pointed out that other means could be so connected and perform the same function. As an example, pump cups in combination with an upwardly opening check valve would permit the valve assembly 30 to be lowered and latched by pump pressure and later raised by the same means, the check valve serving to provide the relatively high latching force.

A packer 70, such as a hollow cylinder of rubber, is provided intermediate upper sleeve 32 and upper housing 22. When compressed longitudinally by moving the packer shoe 60 downwardly, the packer 70 seals the valve assembly 30 to the upper housing 22 as shown in Figures 6 and 7. The detents 46, provided with a wedge shaped configuration, abut against the shoe 60 and produce the downward movement after expanding into latching recess 48 as previously described.

It will be seen that the valve assembly 30, upon being placed in the housing 22 and latched as described, temporarily becomes part of the housing 22 and prevents flow of fluid through the passage 20. With the parts in the position shown in Figure 6, when the housing 22 is rotated with respect to the housing 24, the sleeve 32 rotates with respect to the sleeve 34.

When the sleeve 32 is rotated with respect to the sleeve 34, the threads 37 act as a screw-jack so that the mandrel 36 moves longitudinally.

When making a test in a well bore the packer 18 is set, as shown in Figure 1, and the equalizing valve 16 is closed. The purpose of the tester 10 is to control the flow of well fluid from the tail pipe 17 up through the lower part of the string into the pipe 12. Until the valve assembly 30 is placed in the housings 22 and 24 and the packer 70 set, fluid can flow freely through the passage 20. After the assembly is so located, and the packer 70 set, as shown in Figure 6, the position of the mandrel 36 controls the flow through the passage 20.

To cause the mandrel 36 to serve this purpose, it is provided with a fluid passage 39 which terminates at its lower end in a radial upper port 62 and lower radial port 64, one or the other of which ports being adapted to register with a port 66 in lower sleeve 34. With the parts in the position shown in Figure 6, both ports 62 and 64 are below port 66 so no fluid can flow through passage 39.

As illustrated in Figure 7, when longitudinal upward movement of mandrel 36 within sleeves 32 and 34 is effected, the upper port 62 comes into registry with sleeve port 66. Fluid may then flow from the formation being tested through the tail pipe 17 and on up through the couplings 15 and 13, the equalizing valve 16 and the tester 10 into the pipe 12. The flow through the tester 10 is through the annular space between the sleeve 34 and the housing 24 up to the port 62 and then through the ports 62 and 66 and the passage 39. Although not illustrated in the drawing, it will be clear that additional movement will place sleeve port 66 between upper port 62 and lower port 64, and in between the two lower O rings 58 on the mandrel thereby preventing flow through the tester 10. Still further longitudinal movement (not illustrated) will register lower port 64 with sleeve port 66 and again permit flow therethrough. With the ports 66 and 64 in matched position, by reverse circulation, fluid in pipe 12 may be pumped to the surface. Sealing means, such as O rings 58, prevent fluid leakage intermediate mandrel 36 and sleeve 34 and thus insure control of fluid flow as previously described, but, of course, other means may be employed to control the flow.

As illustrated in Figure 8, the mandrel 36, upon further upward movement within the sleeves 32 and 34, is adapted to abut with and return the latching sleeve 52 to its initial position, thus reversing the latching procedure previously described and making the valve assembly 30 ready for withdrawal. It is also pointed out that a straight vertical pull on retrieving coupling 56 will provide the same unlatching action. The valve assembly 30 may therefore be unlatched in this manner if desired. The valve assembly 30 may now be withdrawn.

The valve assembly 30 may be initially latched in the tester 10, at the surface, in the position shown in Figure 6. The testing pipe 12 is placed in the well bore and the packer 18 expanded as illustrated in Figure 1. The valve assembly 30 is then used as a conventional tester to keep fluid out of the testing pipe until the selected formation is to be tested. After the packer 18 is set, it serves as a support for the lower housing 24. The pipe 12 and upper housing 22 may then be lowered slightly to move the clutch jaws 26 out of engagement with the lugs 27, so that the housing 22 may then be rotated by the pipe 12 to cause the mandrel 36 to bring the valve ports 62 and 66 into alignment to permit flow into the pipe 12, as described above. After the test is completed, additional rotation will close the valve as described and will permit a record to be made of the actual formation pressure. Continued rotation will match ports 64 and 66 so reverse circulation may be accomplished when the valve 16 is opened or packer 18 is unseated. Still further rotation will unlatch the valve as previously described. If additional treatment such as perforating is desired, the valve assembly 30 may be removed by pumping it out or by retrieving it on a wire line.

Although a preferred embodiment of this invention has been illustrated and described herein, various changes may be made by those skilled in this art without departing from the spirit of the invention as defined in the appended claims.

That which is being claimed is:

1. A well tester adapted to be connected to a well pipe comprising an upper fluid conducting housing and a lower fluid conducting housing telescoped together, clutch means connecting said housings to prevent relative rotation therebetween at times but permit relative rotation when desired, a valve assembly for controlling the flow of fluid through said housings, said valve assembly having two sleeves having a flow path therethrough and a swivel connecting them together and being adapted to be placed in said housings or removed therefrom, means for detachably connecting one of said sleeves to said upper housing to rotate therewith, means for detachably connecting the other of said sleeves to said lower housing to rotate there-

with, and means in the valve assembly for opening and closing the flow path through said sleeves and conduct fluid through said valve assembly, said last mentioned means being actuated by relative rotation of said housings.

2. A well tester adapted to be connected to a well pipe comprising an upper fluid conducting housing and a lower fluid conducting housing telescoped together, clutch means connecting said housings to prevent relative rotation therebetween at times but permit relative rotation when desired, a valve assembly for controlling the flow of fluid through said housings, said valve assembly being adapted to be mounted in said housing and retrieved therefrom by a wire line, said assembly including two sleeves with a swivel connecting them, and a mandrel having a fluid passage therein screw threaded to one of them and splined

to the other, the lower of said sleeves having a port therein, a packer for effecting a seal between the upper of said sleeves and the upper housing, means for detachably connecting one of said sleeves to the upper housing to rotate therewith, means for detachably connecting the other of said sleeves to the lower housing to rotate therewith, and means in the valve assembly actuated by relative rotation of said housings for bringing the fluid passage in the mandrel into registration with the port in the lower sleeve to control flow of fluid through said valve assembly.

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