June 4, 1940. E. B. HALL ET AL 2,203,595

DEVICE FOR USE IN WELLS

Filed April 21, 1936 2 Sheets-Sheet 1

Fig. 1.

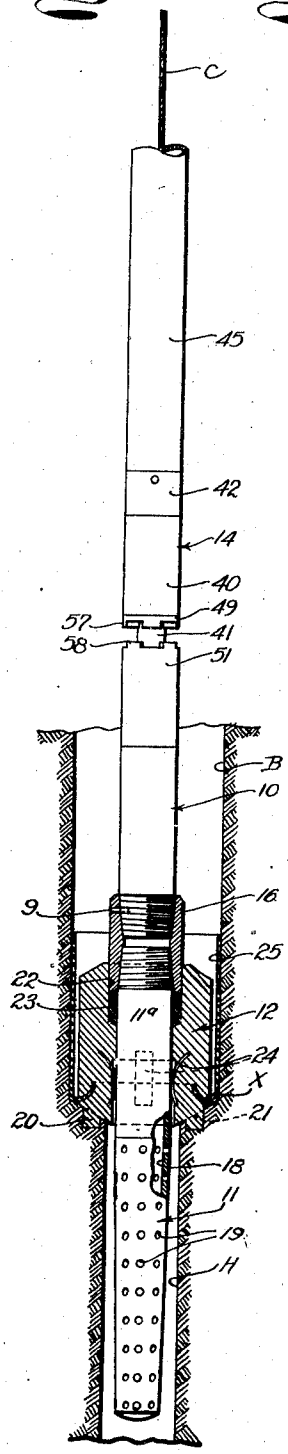


Fig. 2.

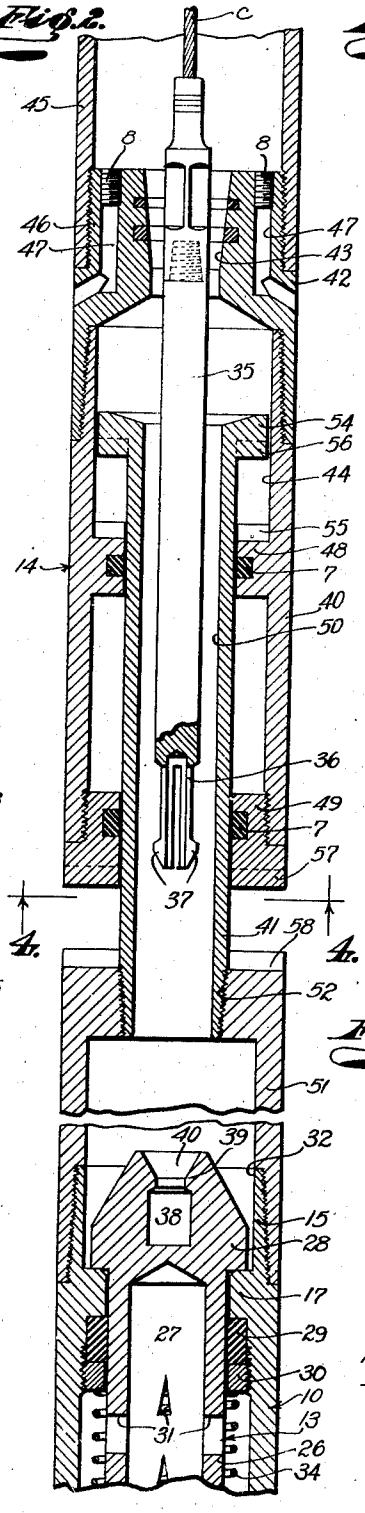


Fig. 3.

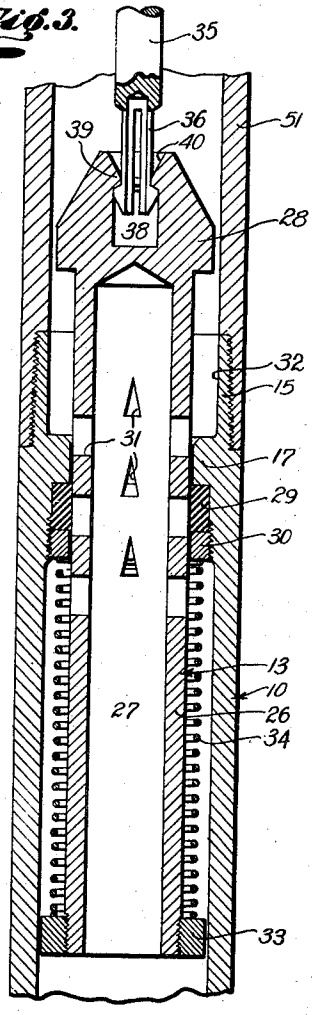
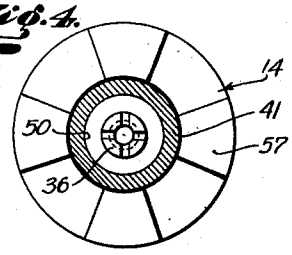


Fig. 4.



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Fig. 5.

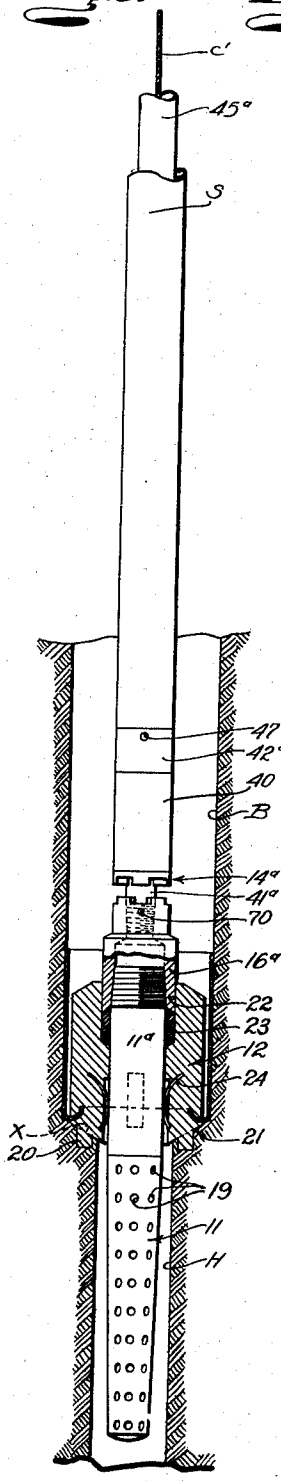


Fig. 6.

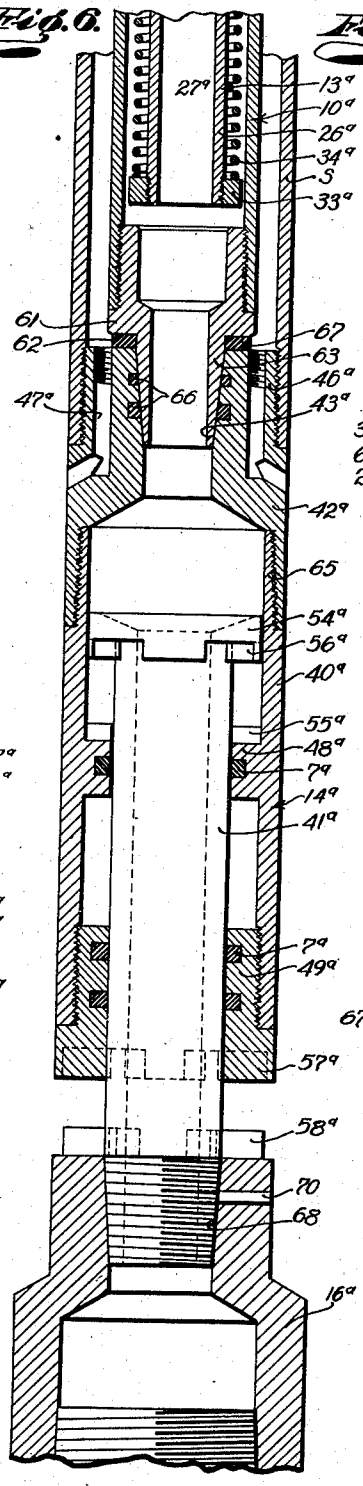
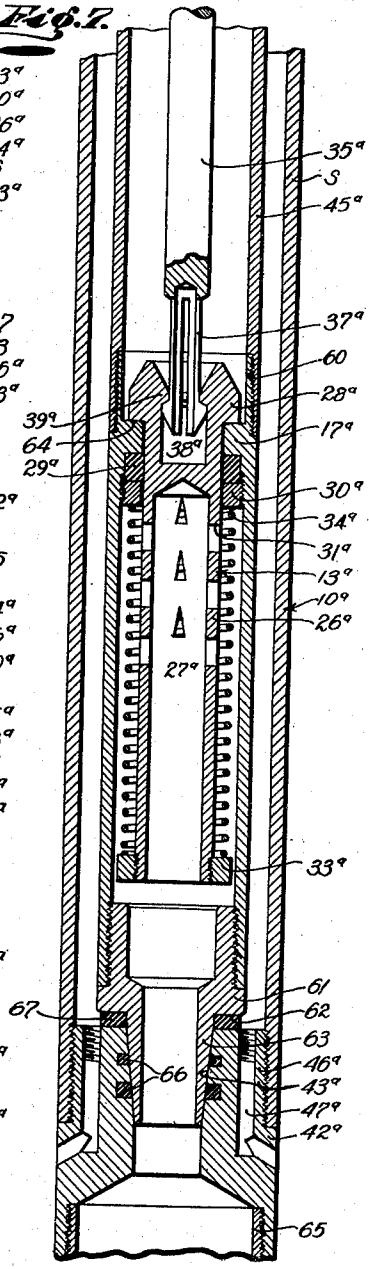


Fig. 7.



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2,203,595

DEVICE FOR USE IN WELLS

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Application April 21, 1936, Serial No. 75,564

13 Claims. (Cl. 166—1)

This invention relates to a device or appliance for use in wells and it is a general object of the invention to provide a simple, practical and improved device for facilitating the manipulation and operation of well tools.

Another object of this invention is to provide a device for connecting or associating a well tool with a string of pipe, or the like, that allows rotation and reciprocation of the string relative to the tool and that is capable of transmitting rotation and reciprocation from the string to the tool to release, actuate or otherwise control the tool.

The device or appliance provided by the present invention is adapted to be employed in connection with well tools of various characters, for example, it may be employed with drilling tools, fishing tools, testing tools, etc. We will herein disclose the device or appliance of the present invention employed or combined with a well testing apparatus, it being understood that the invention is not to be construed as restricted by this specific typical application of the invention.

Another object of this invention is to provide an apparatus to be run into the well on a tubular test string and that embodies means whereby the string may be rotated and/or reciprocated in the well and, if desired, circulation may be maintained to keep the string free for ready removal from the well. The well testers heretofore introduced usually embody a tubular test string connected with the tester and packer proper by a non-rotatable connection. The heavy hydrostatic pressures in a well force the packer or tester against the formation to positively hold the tester against movement during the test. When the test string is connected with the tester by a threaded connection or other usual means under the present practice, no circulation is maintained and it is not possible to rotate the string during the test. Often a well test is of considerable duration and the mud or solid matter in the well fluid settles about the test string and "muds" it or "freezes" it in the well, making it difficult and sometimes impossible to remove the string or the tester at the conclusion of the test. The apparatus of the present invention embodies a swivel or rotatable connection and a circulation fluid discharging means whereby the test string may be rotated and/or reciprocated as found necessary during the test, and circulation fluid may be continuously discharged into the well adjacent the tester to prevent the string from becoming "frozen" in the well so that a test of long duration may be made without danger of the apparatus becoming "frozen" in the well bore.

Another object of this invention is to provide a well device of the character mentioned that is such that the tester or other tool may be fully controlled, turned, jarred or otherwise manipulated in the well, as found necessary.

Another object of this invention is to provide a well tester embodying a rotatable connection between the test string and the tester proper that may be clutched or engaged at the termination of the test to allow the test string carrying the rotatable connection to be unthreaded or released from the tester proper and withdrawn from the well.

Another object of this invention is to provide a well tester of the character mentioned embodying a drillable or friable screen or liner that may be readily drilled up at the end of the test and following the disconnection of the test strings from the tester leaving the well bore free and open for other operations.

Another object of this invention is to provide a well testing apparatus comprising the combination of a drillable packer, a drillable liner, a test string for receiving the test fluid, a circulation string for maintaining circulation in the well and a rotatable connection between the tester and the said strings whereby the strings may be turned and/or reciprocated and maintained free during a long test while the tester remains stationary and may be manipuulated at the termination of the test to be disconnected from the liner and the packer and removed from the well leaving the friable liner and packer in the well to be drilled up by drilling tools.

Another object of this invention is to provide an improved well testing apparatus that is operable to make an extended test of the productivity of the well to obtain an uncontaminated sample of the well fluid without danger of obstructing the well or necessitating expensive fishing operations.

The various objects and features of our invention will be fully understood from the following detailed description of a typical preferred form and application of our invention, throughout which description reference is made to the accompanying drawings, in which:

Fig. 1 is a side elevation of the principal parts of one form of apparatus of the present invention showing it in the operative position in a well and illustrating the packer and the adjacent parts in vertical cross section. Fig. 2 is an enlarged longitudinal detailed sectional view of the ro-

tatable connection and the adjacent parts of the tester shown in Fig. 1. Fig. 3 is an enlarged longitudinal detailed sectional view of the valve and the adjacent parts of the tester. Fig. 4 is a transverse detailed sectional view taken substantially as indicated by line 4—4 on Fig. 2. Fig. 5 is a view similar to Fig. 1 illustrating another form of apparatus. Fig. 6 is an enlarged fragmentary longitudinal detailed sectional view of the rotatable and slack connection and the adjacent parts of the apparatus illustrated in Fig. 5, and Fig. 7 is an enlarged fragmentary longitudinal detailed sectional view of the valve and adjacent parts of the apparatus shown in Fig. 5.

The present invention as herein disclosed relates to the general class of well testing apparatus described and claimed in our co-pending application entitled Method and apparatus for testing wells filed December 11, 1935, Serial No. 53,922, now Patent No. 2,138,057, granted November 29, 1938.

The apparatus of the present invention illustrated in Figs. 1 to 4, inclusive, of the drawings, includes, generally, a test string 45, a tubular body 10, a screen or liner 11 detachably connected with the body 10 and adapted to extend into a rat-hole H in the lower end of a well bore B, a packer 12 associated with the liner 11 to pack off the well at the upper end of the rat-hole H, a valve 13 in the body 10 for controlling the flow of the test fluid into the string 45, and a device 14 normally forming a rotatable and slack connection between the test string 45 and the tester body 10.

The test string 45 is provided to conduct the test fluid upwardly from the tester to the surface of the ground. The string 45 may be made up of a multiplicity of lengths of pipe or tubing of suitable diameter. The tester body 10 is a simple elongate tubular member which houses the valve 13 and carries the liner 11 and packer 12. The particular body 10 illustrated in the drawings has a threaded pin 15 on its upper end and has a collar 16 threaded on its lower end. The threads connecting the collar 16 with the body 10 are preferably left hand threads or are pitched in the opposite direction to the threads in the string 45. A suitable shear pin 9 may be arranged in openings in the body 10 and collar 16. An annular inwardly projecting flange 17 is provided on the interior of the body 10 adjacent its upper end.

The liner 11 is provided to receive the test fluid or well fluid from the well and to conduct it upwardly into the body 10. The liner 11 is an elongate member proportioned to readily enter the rat-hole H. A central longitudinal opening 18 is provided in the liner 11 and spaced ports 19 in the wall of the liner admit the fluid from the rat-hole H to the opening 18. In the preferred construction the liner 11 is longitudinally tapered or of downwardly diminishing diameter to be readily pulled from the rat-hole H in the event the rat-hole caves or sands up. The upper portion 11a of the liner 11 may be cylindrical and imperforate. The upper end of the liner 11 is threaded into the coupling 16 whereby the liner is secured to the lower end of the body 10. The liner 11 is preferably formed of cast iron, rubber composition, or other material that may be readily broken up and drilled up by well drilling tools.

The packer 12 is provided to seal against the shoulder X of earth formation occurring at the upper end of the rat-hole H. The packer 12 is operable to engage the shoulder X to seal the well bore B from the rat-hole H whereby the fluid entering the liner 11 and the body 10 is uncontaminated by the rotary mud and fluid in the well bore proper. The packer 12 is preferably formed of a drillable material to be readily drilled up by drilling tools. In practice the packer 12 may be in the form of a tubular member surrounding the upper portion 11a of the liner 11. The packer 12 may be formed of cement, Bakelite, hard rubber composition, glass, marble or the like. The packer 12 is proportioned to enter and pass through the well bore B with suitable clearance. The lower end 21 of the packer 12 is adapted to seat on the shoulder X. In the particular case illustrated in the drawings the shoulder X is downwardly and inwardly tapered and the lower end 21 of the packer 12 is correspondingly tapered to properly seat on the shoulder. Fins or blades 20 project from the lower end 21 to dig or bite into the shoulder X to prevent rotation of the tester. A counterbore 22 is provided in the upper end of the packer 12 to receive the coupling 16. Packing 23 is arranged in the counterbore 22 to be compressed between the bottom wall of the counterbore and the lower end of the coupling 16. When the weight, or a portion of the weight, of the test string 45 and the associated parts is imposed on the packer 12 to force it against the seat X this force or weight is transmitted through the packing 23 so that the packing tightly seals about the liner portion 11a and tightly seals against the interior of the packer 12. The blades 20 are forced into the formation to hold the tester against rotation when the string 45 is rotated to keep it free or to disconnect it from the tester.

A releasable connection is provided between the packer 12 and the liner 11 to permit the upward withdrawal of the liner through the packer in the event that the packer becomes immovably lodged in the well. The releasable connection between the liner 11 and the packer 12 includes a plurality of bowed leaf springs 24 whose ends are cast or otherwise secured in the drillable packer 12. The springs 24 are bowed or curved to bear inwardly against the portion 11a of the liner. The springs 24 exert a sufficient inward force on the liner portion 11a to dependably hold the packer 12 on the liner when the apparatus is run into the well and are adapted to yield when the packer 12 is immovably caught and the liner 11 is moved upwardly. A basket 25 may be provided on the packer 12 to seal with the side wall of the well bore B. The basket 25 may be formed of rubber or the like and is tubular. The sealing basket 25 surrounds the packer 12 and is of sufficient length to project upwardly beyond the upper end of the packer. The lower edge portion of the basket 25 is cast or embedded in the packer 12. Thus the lower end of the basket 25 is closed. The upper end of the basket 25 is open to the well bore B so that the hydrostatic pressure in the well bore forces the basket 25 outwardly into effective sealing engagement with the wall of the bore.

The valve 13 is provided to govern the admission of the test fluid from the body 10 to the test string 45. The valve 13 includes a longitudinally shiftable tube 26 arranged longitudinally within the body 10. The valve tube 26 passes through the flange 17 with suitable clearance. The longitudinal opening 27 of the valve tube 26 is open at its lower end to communicate with the interior of the liner 11. An integral cap 28 closes the upper end of the opening 27. Packing

29 is arranged against the lower surface of the flange 17 to seal about the tube 26. A nut 30 may be threaded in the body 10 to compress the packing 29. Circumferentially and longitudinally spaced ports 31 are provided in the wall of the tube 26. The ports are adapted to be brought into communication with the opening 32 of the body 10 above the flange 17 when the tube 26 is moved upwardly relative to the body. The ports 31 are preferably of upwardly diminishing capacity having upwardly convergent side walls and are preferably staggered or offset vertically. When the valve tube 26 is in its normal or closed position the cap 28 engages the upper side of the flange 17 and the ports 31 are all out of communication with the body opening 32 above the flange 17. Means is provided for yieldingly holding the valve tube 26 in its down or closed position. A nut 33 is threaded on the lower portion of the valve tube 26. A spring 34 surrounds the valve tube 26 and is arranged under compression between the nut 33 and the gland 30 to urge the tube 26 downwardly to the position where the ports 31 are out of communication with the body opening 32 above the flange 17.

Means is provided for controlling or operating the valve 13. In accordance with the broader aspects of the invention the means for operating the valve 13 may be varied considerably. The particular valve operating means illustrated in the drawings includes a line or cable C adapted to be run through the test string 45 and a mandrel or rod 35 on the lower end of the cable C. A series of spring fingers 36 is provided on the lower end of the rod 35. The spring fingers 36 have lugs 37 adjacent their lower ends. The lugs 37 have inclined upper and lower faces. A socket 38 is provided in the upper end of the cap 28 and is adapted to receive the fingers 36. An inwardly projecting annular flange 39 is provided on the wall of the socket 38 adjacent its upper end. The flange 39 has a downwardly and inwardly inclined upper surface 40. When the cable C is lowered through the test string 45 the rod 35 moves downwardly so that the lugs 37 of the spring fingers 36 engage the surface 40. The weight of the rod 35 is such that the lugs 37 of the spring fingers 36 suddenly snap past the flange 39 to engage under the flange. The cooperation of the lugs 37 with the flange 39 dependably connects the line C with the valve tube 26 so that a sufficiently heavy upward strain may be placed on the cable C to overcome the spring 34 and move the valve tube 26 upwardly. The spring fingers 36 may be disengaged or released from the socket 38 by suddenly jerking or moving the cable C upwardly with a comparatively heavy force. This disengagement of the fingers 36 from the socket 38 frees the cable C from the valve tube 26.

The liner 11, the packer 12 and the valve means described above are specifically described and claimed in our co-pending application, referred to above.

The rotatable connecting device 14 between the test string 45 and the tester body 10 includes a tubular member 40 on the string 45 and a tubular member 41 on the body 10. The members 40 and 41 are telescopically assembled and are related for relative rotation and longitudinal movement so that either member can be moved a limited distance lengthwise or rotated independently of the other member. An adapter or coupler 42 is threaded on the upper end of the member 40. The coupler 42 has a central longitudinal opening 43 which is preferably tapered downwardly and inwardly. In the particular form of the invention being described the member 40 is the outer part of the connecting device 14 and is tubular having a central longitudinal opening 44. The lower end of the test string 45 is threaded on a pin 46 on the upper end of the coupler 42. Ports 47 are provided in the pin 46 and the coupler 42. In the form of the invention being described the ports 47 are closed by suitable plugs 8. The outer member 40 of the device 14 is provided between its ends with an annular internal flange 48. A nut or guide 49 is threaded in the lower end of the member 40.

The inner member 41 of the device 14 is an elongate tubular part having a central longitudinal opening 50. The member 41 is connected with the upper end of the body 10. In the construction illustrated in the drawings a cap 51 is threaded on the pin 15 on the upper end of the body 10. The cap 51 has a reduced threaded opening 52 in its upper portion and the lower end of the member 41 is threaded into the opening 52. The cap 51 may have the same internal diameter as the body 10 and may be considered as an extension of the body. The cap 51 is of sufficient length to receive the valve tube 26 when the valve tube is moved upwardly to its open position. The member 41 projects upwardly from the cap 51 to extend through the guide 49 and the flange 48. The member 41 is suitably guided in the guide 49 and the flange 48. Rings 7 of packing are provided in the openings of the guide 49 and flange 48 to seal about the member 41. The passage or opening 50 of the member 41 maintains the lower end of the string 45 in communication with the opening 32 of the body 10 above the flange 17. A collar or flange 54 is provided on the upper end of the member 41. The flange 48 and the flange 54 are adapted to cooperate to limit the relative longitudinal movement between the members 40 and 41 in one direction. The guide 49 and the cap 51 are adapted to cooperate to limit the relative longitudinal movement between the members 40 and 41 in the other direction.

Clutch means are provided to connect the members 40 and 41 for the transmission of rotation when in the extended position and when in the contracted position. Clutch parts 55 are provided on the upper side of the flange 48 and complementary clutch parts 56 are provided on the under side of the flange 54. When the string 45 is moved upwardly the clutch parts 55 may be brought into cooperation with the clutch parts 56 to connect the members 40 and 41 for the transmission of rotation. When the clutch parts 55 and 56 are in cooperation the string 45 may be turned to turn the body 10 and the parts connected therewith. Suitable clutch parts 57 are provided on the lower side of the guide 49. Complementary clutch parts 58 may be provided on the upper end of the cap 51. When the string 45 is lowered the clutch parts 57 may be brought into cooperation with the clutch parts 58 to clutch the connecting device 14 for the transmission of rotation.

When the well is to be tested the body 10 carrying the liner 11, the packer 12 and the valve 13 is connected with the lower end of the string 45 by the rotatable connecting device 14. The string 45 is run into the well bore B until the lower end 21 of the packer 12 engages the shoulder X of earth formation. When the packer 12 is in this position the liner 11 extends

into the rat-hole H. The weight, or a portion of the weight, of the string 45 is allowed to rest on the packer 12 so that its lower end 21 tightly seals against the shoulder X. The weight of the string 45 imposed on the packer 12 is transmitted through the packing 23 and the packing tightly seals between the packer 12 and the imperforate portion 11a of the liner 11. Following the setting of the packer 12 the string 45 may be reciprocated or rotated, or both, to prevent it from becoming sanded or mudded in the well. The device 14 allows this manipulation without disturbing the tester proper. The basket 25 of the packer 12 is expanded against the wall of the well bore B by the hydrostatic pressure in the well and effects a tight seal between the well bore B and the rat-hole H.

Following the setting of the packer 12 the valve 13 is opened to place the rat-hole H in communication with the test string 45. To open the valve 13 the line or cable C is run into the string 45 to have the rod 35 pass downwardly through the openings 43 and 50 and to enter the spring fingers 36 in the socket 38. The line or cable C is raised and the lugs 37 cooperate with the flange 39 to transmit the upward movement to the valve tube 26. In this manner the valve tube 26 may be raised against the action of the spring 34. It is preferred to raise the valve tube 26 slowly so that the ports 31 are slowly brought into communication with the opening 32 above the flange 17. Opening of the ports 31 to the opening 32 above the flange 17 allows the well fluid under pressure from the rat-hole H to flow upwardly through the member 41 into the string 45. The valve 13 may be opened slowly to provide for the gradual reduction in pressure on the fluid in the rat-hole H to reduce the possibility of caving or sanding up the rat-hole H. The gradual opening of the valve 13 also may assist in preventing the packer 12 from being crushed or excessively wedged against the shoulder X.

The fluid in the stratum penetrated by the rat-hole H may flow in sufficient quantities and under sufficient pressure to pass upwardly through the string 45 to the upper end of the well. In some cases it may be necessary to pump the test fluid from the string 45. The test string 45 is adapted to receive the test fluid produced from the formation penetrated by the rat-hole H, which test fluid is uncontaminated by the mud or fluid in the well bore B. Subsequent to the opening of the valve 13 or if desired subsequent to the setting of the packer 12, the string 45 may be raised or brought to a position where the clutch parts 57 and 58 and the clutch parts 55 and 56 are spaced apart. When the string 45 is in this position it may be rotated or reciprocated freely without turning or disturbing the body 10 or the other parts of the tester. This movement of the string 45 may be continuous throughout the test or the string 45 may be rotated or reciprocated from time to time to prevent the string from becoming frozen in the well. As is well understood by those skilled in the art, the rotation and/or reciprocation of the string 45 will prevent the cuttings and sand from settling out of the mud and accumulating about the string 45 and the string is thus maintained free. As the test string 45 may be maintained free so long as the rotation or reciprocation of the string 45 is continued, a test of a long duration may be made.

When a sufficient sample or test has been obtained the cable C is suddenly raised to release the spring fingers 36 from the socket 38. Upon the disengagement of the spring fingers 36 from the socket 38 the spring 34 automatically returns the valve tube 26 to the closed position where the lower end of the head 28 seals against the flange 17. The string 45 may then be raised to remove the testing apparatus from the well.

When the packer 12 and the liner 11 are not sanded or caught in the well the string 45 may be readily pulled upwardly to remove the entire testing apparatus from the well. The liner 11 is tapered so that it may be easily pulled from the rat-hole H even though the rat-hole may be caved or sanded up. In the event that the packer 12 is immovably caught in the well the string 45 may be pulled upwardly to withdraw the liner 11 through the packer 12. The springs 24 yield to permit this withdrawal of the liner 11 through the packer 12. If desired or believed necessary the string 45 may be suddenly raised to bring the clutch parts 55 into jarring engagement with the clutch parts 56 to provide an upward jarring action or the string 45 may be suddenly dropped to bring the clutch parts 57 into jarring engagement with the clutch parts 58. This jarring of the testing apparatus may free the caught liner or packer from the well. If the packer 12 is fixed or caught in the well and the liner is withdrawn through the packer, as above described, the testing apparatus may be removed from the well leaving the packer seated on the shoulder X. As the packer 12 is formed of a drillable material it may be readily drilled up by suitable drilling tools to leave the well unobstructed for further operations.

In the event that the packer 12 and the liner 11, or either one of them, is immovably caught in the well, it may be desired to unthread the body 10 from the liner to allow the body 10, the valve 13 and the rotatable connection 14 to be withdrawn from the well on the string 45. To unthread the body 10 from the liner 11 the string 45 may be raised to bring the clutch parts 55 into clutching engagement with the parts 56, or may be lowered to bring the clutch parts 57 into engagement with the clutch parts 58. Following this raising or lowering of the string 45 the string is rotated to break the shear pin 9 and unthread the lower end of the body 10 from the coupling 16. Following the disconnection of the body 10 from the liner 11 the string 45 together with the body 10 and device 14 may be removed from the well leaving the drillable liner 11 and packer 12 in the well bore. The liner and packer may be readily drilled up by suitable drilling tools to leave the well bore free and unobstructed. The string 45 may be rotated or reciprocated when possible or practical to assist in maintaining the string 45 free.

Figs. 5, 6 and 7 of the drawings illustrate a form of the invention wherein circulation may be maintained in the well throughout the use or operation of the device or tester. The apparatus illustrated in Figs. 5, 6 and 7 includes, generally, a tubular circulation string S, a test string 45a, a tubular body 10a, a liner 11, a packer 12 associated with the liner 11, a valve 13a in the body 10a for controlling the flow of the test fluid into the string 45a and a device 14a normally forming a slack, rotatable connection between the string S and the liner 11. The liner 11 and the packer 12 may be identical with the liner 11 and packer 12 of the form of the invention illustrated in Figs. 1 to 4, inclusive, of the drawings, and corresponding reference numerals are applied to corresponding parts of these elements.

The circulation string S is provided to carry or suspend the testing apparatus and to conduct the circulation fluid downwardly into the well bore B. The string S may be made up of several lengths of pipe of suitable diameter in the usual or conventional manner. The test string 45a is provided to receive the test fluid from the formation being tested and to conduct this fluid to the surface of the ground or to retain the test fluid as the case may be. The test string 45a extends longitudinally through the string S with suitable clearance to leave a passage for the free flow of the circulation fluid.

The body 10a is connected with the lower end of the test string 45a and is provided to house the valve 13a. The body 10a is an elongate tubular structure arranged longitudinally within the string S. In the construction illustrated in the drawings a pin 60 is provided on the upper end of the body 10a and is threaded into the lower end of the test string 45a whereby the body 10a forms a continuation of the test string. An annular internal flange 17a is provided on the body 10a adjacent its upper end. A nipple 61 is provided on the lower end of the body 10a and presents a downwardly facing annular shoulder 62. The nipple 61 has a downwardly and inwardly tapered part 63 projecting from its lower end.

The valve 13a is provided to govern the admission of the test fluid to the lower end of the test string 45a. The valve 13a is housed in the body 10a and is similar to the valve 13 described above. The valve 13a includes a tube 26a having a longitudinal opening 27a closed at its upper end by a cap 28a. The tube 26a shiftably or slidably passes through the flange 17a. Longitudinally and circumferentially spaced ports 31a of upwardly diminishing capacity are provided in the wall of the tube 26a. The ports 31a have upwardly convergent side walls and normally communicate with the interior of the body 10a below its flange 17a. The head 28a has a downwardly facing valve surface 64 adapted to seat against the flange 17a to close off communication between the lower end of the test string 45a and the interior of the body 10a below the flange. Means is provided for yieldingly urging the valve tube 26a to its down position where the surface 64 cooperates with the flange 17a. A nut 33a is threaded on the lower end of the valve tube 26a. A nut 30a is threaded in the body 10a below the flange 17a. A spring 34a surrounds the valve tube 26a and is arranged under compression between the nuts 33a and 30a. Packing 29a is compressed between the nut 30a and the flange 17a to seal about the valve tube 26a.

Means is provided for facilitating the raising of the valve tube 26a to bring the ports 31a into communication with the test string 45a and thus admit the test fluid to the test string. A cable C1 carrying a rod 35a is adapted to be run into the test string 45a. A plurality of spring fingers 37a is provided on the lower end of the rod 35a. The spring fingers 37a are adapted to be received in a socket 38a in the head 28a. A flange 39a is provided on the wall of the socket 38a adjacent its upper end. When the line or cable C1 is run downwardly through the string 45a the fingers 37a enter the flaring upper end of the socket 38a. The fingers 37a flex inwardly past the flange 39a under the weight of the rod 35a. The spring fingers 37a are adapted to cooperate with the under side of the flange 39a to connect the cable C1 with the valve tube 26a whereby the cable may be raised to bring the ports 31a into communication with the test string 45a.

The connecting device 14a forms a connection between the strings 45a and S and the liner 11 and is such that the strings may be rotated and reciprocated during the testing operation without shifting or disturbing the liner 11 or the packer 12. In accordance with the form of the invention being described the device 14a is such that circulation may be maintained in the well throughout the test. The connecting device 14a includes a tubular member 40a secured to the lower end of the string S and a tubular member 41a secured to the liner 11.

The members 40a and 41a are telescopically related for relative rotation and longitudinal movement. A pin 65 is provided on the upper end of the member 40a and an adapter or coupler 42a is threaded on the pin 65. A pin 46a on the upper end of the coupler 42a is threaded into the lower end of the circulation string S. The coupler 42a may be identical with the above described coupler 42. The socket 43a in the upper end of the coupler 42a is adapted to receive the tapered part 63 of the nipple 61. The socket 43a is tapered downwardly and inwardly and packing rings 66 are provided in the socket to seal with the nipple part 63. A packing washer 67 is arranged between the shoulder 62 and the upper end of the coupler 42a to insure a tight seal between the coupler and the nipple 61. Ports 47a are provided in the coupler 42a and the pin 46a to conduct the circulation fluid from the string S to the well bore. It is to be noted that the ports 47a discharge the circulation fluid into the well bore B a short distance above the packer 12 to maintain circulation in substantially the entire well bore. The outer member 40a has an internal flange 48a between its ends. A guide 49a is threaded in the lower end of the member 40a.

The inner member 41a of the device 14a is connected with the upper end of the liner 11. In the preferred construction illustrated, a coupling 16a is threaded on the upper end of the liner 11 and has a reduced opening 68 in its upper end. The lower end of the member 41a is threaded into the opening 68. The threads of the member 41a and the opening 68 are preferably left-hand threads whereby the member 41a may be unthreaded from the coupling 16a without disturbing the threaded connections in the string S and the other parts of the apparatus. In practice a suitable shear pin 70 may be arranged in openings in the coupling 16a and the member 41a. The member 41a extends upwardly from the coupling 16a to shiftably pass through the guide 49a and the flange 48a. Packing rings 7a are provided in the openings of the guide 49a and the flange 48a to seal about the member 41a.

Clutch means are provided on the members 40a and 41a for the transmission of rotation when it is desired to unthread the member 41a from the coupling 16a or when for any reason it is desirable to rotate the tester. A flange 54a is provided on the upper end of the member 41a and carries clutch parts 56a. Complementary clutch parts 55a are provided on the upper side of the flange 48a. The clutch parts 56a and 55a may be engaged by raising the string S whereupon the string S may be rotated to transmit rotation to the member 41a. Clutch parts 57a are provided on the lower side of the guide 49a and complementary clutch parts 58a are provided on the upper end of the coupling 16a. The

clutch parts 57ª may be engaged with the clutch parts 58ª by moving the string S downwardly.

In employing the apparatus illustrated in Figs. 5 to 7 of the drawings the device 14ª may be connected with the lower end of the string S to secure the liner and packer assembly to the string. The string S carrying the device 14ª, the liner 11, and the packer 12 may be run into the well. The lower end of the packer 12 is adapted to seat on the shoulder X of earth formation. The weight or a portion of the weight of the string S may be imposed on the packer 12 to force the blades 20 into the earth formation. Following this seating of the packer 12 the test string 45ª carrying the body 10 may be run into the string S. The tapered part 63 is adapted to enter and seat in the socket 43ª to support the body 10ª and the string 45ª. The part 63 seated in the socket 43ª is effectively sealed about by the packing rings 66 and the washer 67. When it is desired to open the valve 13ª to admit the test fluid to the string 45ª, the cable C^1 carrying the rod 35ª is run into the string 45ª. As above described the spring fingers 37ª are adapted to enter the socket 38ª and cooperate with the flange 39ª for the transmission of upward force to the tube 26ª. The cable C^1 may be raised to move the tube 26ª upwardly. The upward movement of the tube 26ª uncovers the ports 31ª above the flange 17ª placing the interior of the tube in communication with the test string 45ª. This allows the test fluid to flow upwardly from the rat-hole H into the test string 45ª.

Immediately upon the setting of the string 45ª, and thereafter, circulation fluid may be pumped downwardly through the string S to discharge from the ports 47ª. This circulation fluid flowing through the well bore B prevents the string S from becoming sanded or frozen in the well bore. If desired or found necessary the string S may be rotated continuously during the test or, if desired, the string S may be reciprocated. The device 14ª is such that the string S, carrying the string 45ª, may be rotated and/or reciprocated at will throughout the test operation without moving or disturbing the liner 11 or the packer 12. In this manner the string S is provented from becoming stuck or frozen in the well bore B.

When a sufficient test has been obtained the cable C^1 may be suddenly raised to free the spring fingers 37ª from the socket 38ª whereupon the cable C^1 may be withdrawn from the well. The spring 34ª automatically moves the valve tube 26ª downwardly to bring the surface 64 against the flange 17ª. This closes the lower end of the test string 45ª. Following the closing of the valve 13ª the test string 45ª containing the test fluid may be withdrawn from the well bore. Following the removal of the string 45ª, the string S may be withdrawn from the well. In most instances the string S may be merely pulled upwardly to carry with it the liner 11 and the packer 12. In some cases it may be found necessary to turn or jar the liner 11 and the packer 12 to free them for removal. The string S may be moved longitudinally to engage the clutch parts 57ª and 58ª, or the clutch parts 55ª and 56ª, whereupon the string S may be rotated. The clutch parts transmit the rotation of the liner 11 which in turn may transmit the rotation to the packer 12. The rotation of the liner and packer may free them for removal. To impart a jarring action to the test equipment the string S may be reciprocated to bring the clutch parts 56ª and 55ª and the clutch parts 57ª and 58ª into jarring engagement. This jarring action may free the liner 11 and the packer 12. If the liner and packer are freed by the actions just described the string S may be pulled upwardly to remove the entire apparatus from the well. In the event, however, that the liner 11 and the packer 12 remain fast in the well bore it may become necessary to disconnect the string S from the liner 11. To disconnect the string S from the liner 11 the string S is moved either up or down to engage the clutch parts. The string S is then rotated in a direction to unthread the member 41ª from the opening 68. The rotation of the string breaks the shear pin 70. Upon the unthreading of the member 41ª from the opening 68 the string S carrying the device 14ª may be removed from the well. This leaves the liner 11 and the packer 12 in the well bore. The liner and packer are formed of drillable materials and may be easily drilled up by suitable drilling tools to leave the well bore unobstructed for further operations.

Having described only typical preferred forms and applications of our invention we do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to ourselves any variations or modifications that may appear to those skilled in the art or fall within the scope of the following claims.

Having described our invention, we claim:

1. Well testing apparatus including a tubular test string, a tubular body, a liner for receiving fluid from the well, a connection between the body and liner releasable by rotation, a packer associated with the liner to pack off the well, a valve in the body for controlling the flow of fluid from the liner to the string, and a swivel connection between the body and string allowing rotation of the string relative to the body, the swivel connection including parts engageable by manipulation of the string to transmit rotation to the body to release the first mentioned connection.

2. Well testing apparatus including a tubular test string, a tubular body, a liner for receiving fluid from the well, a connection between the body and liner releasable by rotation, a packer associated with the liner to pack off the well, a valve in the body for controlling the flow of fluid from the liner to the string, and a swivel connection between the body and string comprising two tubular fluid conducting members telescopically related for free relative rotative and limited longitudinal movement, and parts on the members engageable by relative longitudinal movement between the members to transmit rotation to release the first mentioned connection.

3. Well testing apparatus including a tubular test string, a tubular body, a liner for receiving fluid from the well, a connection between the body and liner releasable by rotation, a packer associated with the liner to pack off the well, a valve in the body for controlling the flow of fluid from the liner to the string, a swivel connection between the body and string allowing rotation of the string relative to the body, the swivel connection including parts engageable by manipulation of the string to transmit rotation to the body to release the first mentioned connection, and an element passed through the string and the swivel connection to control the valve.

4. Well testing apparatus including a liner for receiving fluid from the well, a packer associated with the liner and operable to pack off the

well, a test string for receiving the test fluid, a tubular circulation string for carrying circulation fluid, said strings being one within the other and both extending downward to adjacent the liner and a connection rotatably connecting the lower ends of said strings with the liner and discharging the circulation fluid into the well.

5. Well testing apparatus including a liner for reciving fluid from the well, a packer associated with the liner and operable to pack off the well, a test string for receiving the test fluid, a tubular circulation string for carrying circulation fluid, and a connection rotatably connecting said strings with the liner and discharging the circulation fluid into the well, said connection comprising, two telescopically associated members related for relative rotation, one of said members being connected with the said strings and having a port for discharging the circulation fluid, the other member being tubular and connected with the liner to conduct the test fluid therefrom to the test string.

6. Well testing apparatus including a liner for receiving fluid from the well, a packer associated with the liner and operable to pack off the well, a test string for receiving the test fluid, a tubular circulation string extending downwardly around the test string to a point adjacent the liner for carrying circulation fluid, a valve in the test string, and a rotatable fluid conducting connection between the liner and the lower ends of the circulation string and the said test string.

7. Well testing apparatus including a liner for receiving fluid from the well, a packer associated with the liner and operable to pack off the well, a test string for receiving the test fluid, a tubular circulation string for carrying circulation fluid, a valve in the test string, and a rotatable fluid conducting connection between the body and said strings, said connection comprising, a member connected with said strings and having a port for discharging the circulation fluid into the well, a member related to the first mentioned member for relative rotation and longitudinal movement and operable to conduct the test fluid from the liner to the test string, and a releasable connection between the second mentioned member and the liner.

8. Well testing apparatus including a liner for receiving fluid from the well, a packer associated with the liner and operable to pack off the well, a test string for receiving the test fluid, a tubular circulation string for carrying circulation fluid, a valve in the test string, and a rotatable fluid conducting connection between the liner and said strings, said connection comprising, a member connected with said strings and having a port for discharging the circulation fluid into the well, a member related to the first mentioned member for relative rotation and longitudinal movement and operable to conduct the test fluid from the liner to the test string, a connection between the second mentioned member and the liner releasable by rotation, and parts on the members engageable by relative longitudinal movement to transmit rotation for releasing the last named connection from the liner.

9. In combination, an operating string, a well tool, and means rotatably connecting the string and the tool, said means including, two members related for relative rotation and longitudinal movement, one member being connected with the string, and having a port in communication with the string and opening to the exteriors of said members for discharging fluid into the well, the other member being connected with the tool, and clutch parts on the members engageable for the transmission of rotation from the string to the tool.

10. Apparatus of the character described including a well tester, a circulation string, a test string in the circulation string and means connecting the strings with the tester comprising, two members related for relative rotation and longitudinal movement, one member connected with the strings, the other member connected with the tester, the first mentioned member having a port for discharging the circulation fluid in the well, and parts on the members engageable for the transmission of rotation.

11. An apparatus for making formation tests in wells comprising a tubular test string of pipe, packing means on the test string for isolating the lower portion of the well to be tested from the upper portion, valve means adjacent the packing means for keeping the test string dry while the apparatus is being lowered into the well, and means adapted to be introduced through the test string and connected to the valve means for opening the valve means after the packing means has been seated.

12. An apparatus for making formation tests in wells comprising a tubular test string of pipe, packing means on the test string for isolating the lower portion of the well to be tested from the upper portion, valve means adjacent the packing means for keeping the test string dry while the apparatus is being lowered into the well, and means adapted to be introduced through the test string and connected to the valve means for opening the valve means after the packing means has been seated, the connection between the test string and the packing means being such as to permit rotation of the test string while the packing means remains seated so as to prevent sticking of the test string.

13. Well testing apparatus including a liner for receiving fluid from the well, a packer associated with the liner to pack off the well, a tubular test string, and means releasably and rotatably connecting the test string with the liner whereby the string may be rotated freely and continuously relative to the liner and packer and may be released from the liner when the same is in the well, said means including, two telescopically associated tubular members related for relative longitudinal movement and for relative rotative movement when in a predetermined relative longitudinal position, one member being secured to the test string, readily releasable threads connecting the other member with the liner, a shear pin normally connecting the said other member and the liner against relative rotation, and clutch parts on the members cooperable to transmit rotation to break the shear pin and unthread the threads and thus detach the said other member from the liner.

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