Dec. 8, 1953 M. O. JOHNSTON 2,661,802

COMBINED SHUT-IN AND BACK CIRCULATION TOOL

Filed March 9, 1950 2 Sheets-Sheet 1

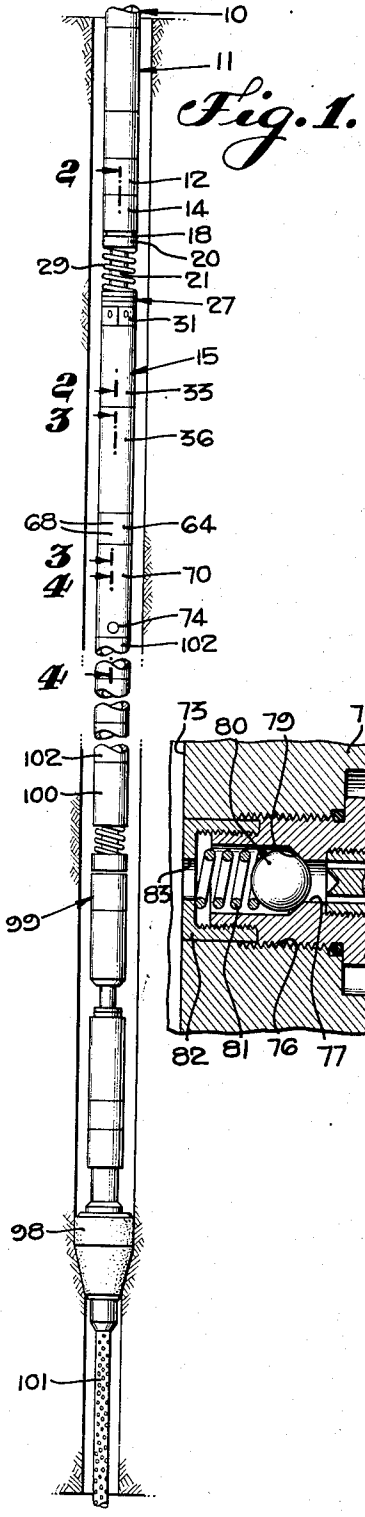


Fig. 1.

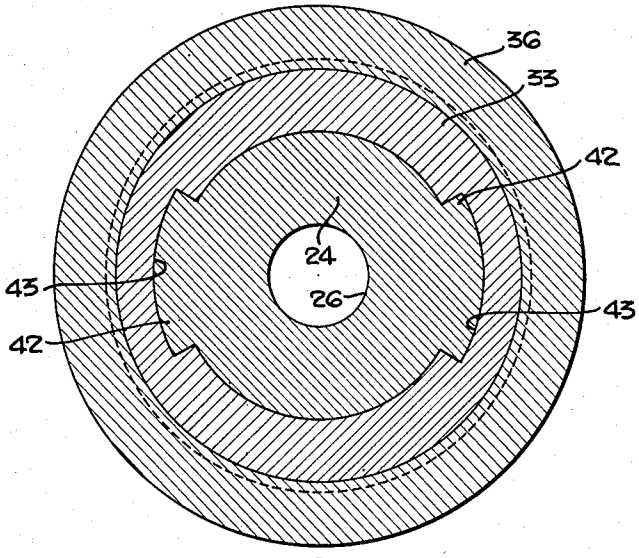


Fig. 5.

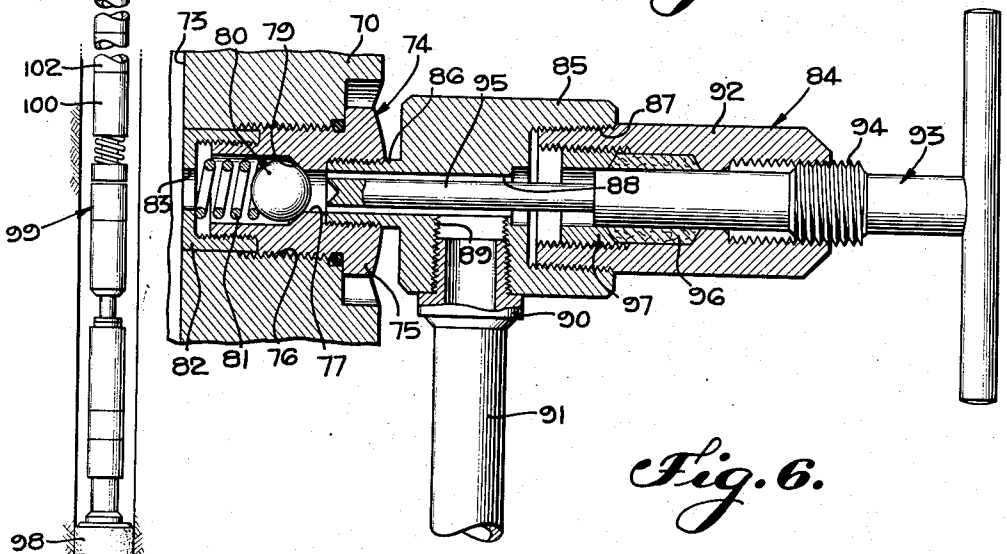


Fig. 6.

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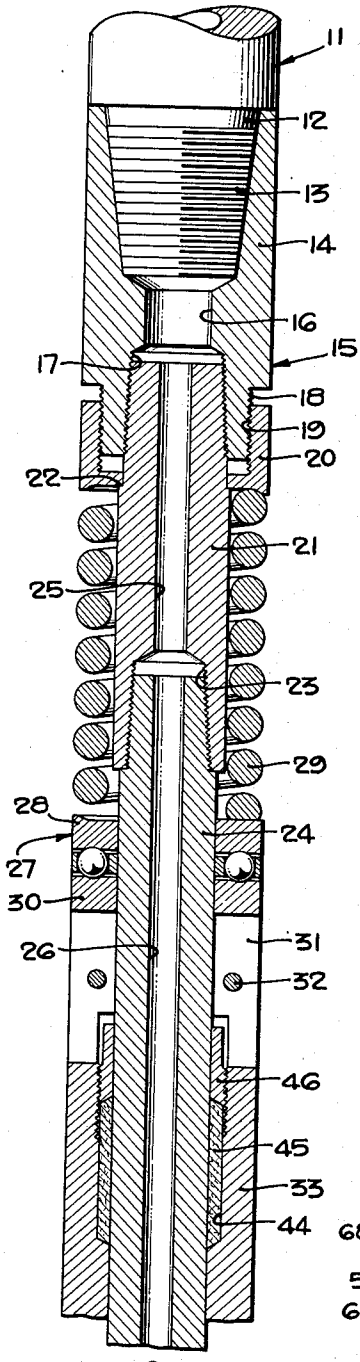


Fig. 2.

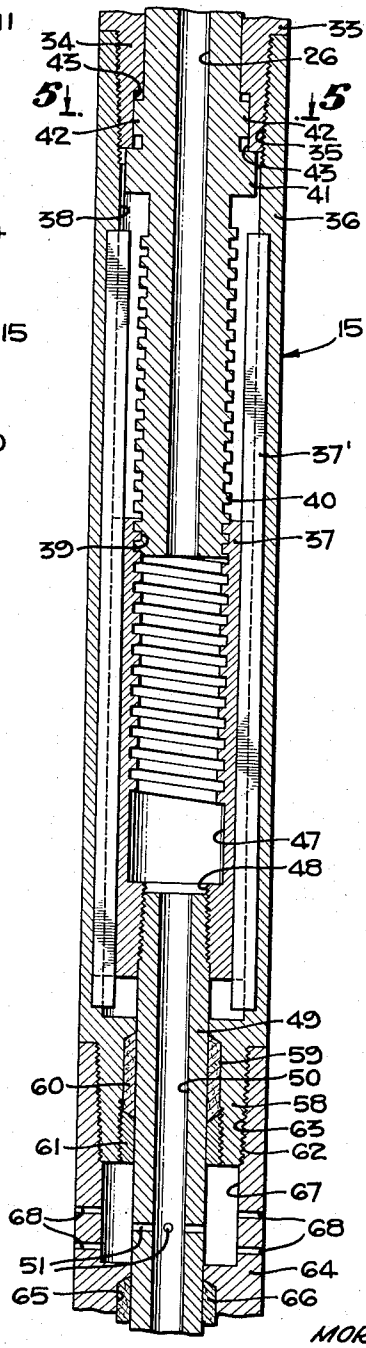


Fig. 3.

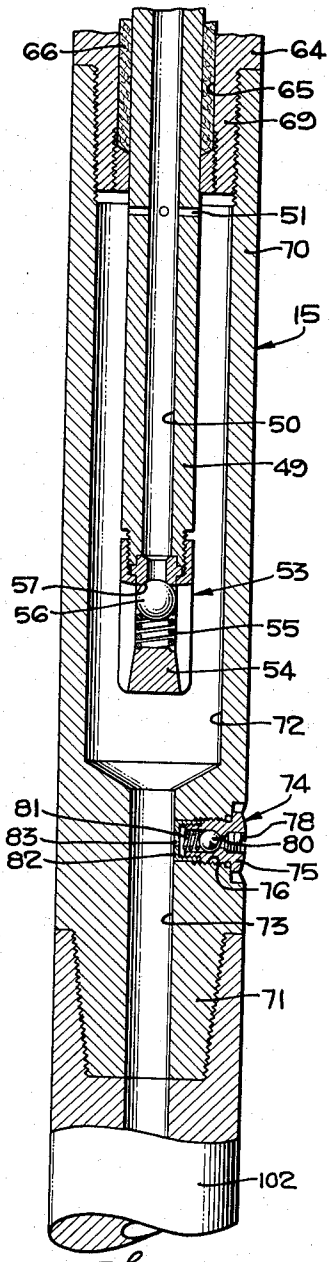


Fig. 4.

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Patented Dec. 8, 1953

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UNITED STATES PATENT OFFICE

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COMBINED SHUT-IN AND BACK CIRCULATION TOOL

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4 Claims. (Cl. 166—1)

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This invention relates to an oil well tool and particularly pertains to a combined shut-in and back circulation tool.

In oil well drilling operations it is common practice to pack off the well bore at a desired level and obtain an entrapped sample of the formation fluid yield by the use of a formation tester. In this operation it is desirable to make a test to ascertain the fluid pressure exerted by the connate fluid in the formation and it is also desirable to produce a back circulation of the drilling fluid within which the testing tool is submerged. A tool for these purposes should be associated with the tester and disposed between the retaining valve structure of the tester and the trip valve which occurs at the lower end of a supporting string of pipe. It is the principal object of the present invention therefore to provide a valve structure which may be manipulated from the surface of the well through the supporting string of pipe and by which the connate fluid passing through the tester may be shut in to obtain a desired fluid pressure reading after the test is made or which structure may be manipulated to perform a back scuttling action in the well for emergency purposes and to allow the drilling fluid to enter the tool above the connate fluid therein.

The present invention contemplates the provision of a tubular housing interposed between the retaining valve and trip valve of a formation tester and which tubular housing may be manipulated to permit connate fluid to flow through the tester and above the retaining valve where it is restrained and to thereafter flow upwardly into the drill pipe when the trip valve is opened, said structure embodying the use of a back scuttling valve carried within the tubular housing and capable of manipulation to establish communication between the interior of the shut-in valve structure and the well bore whereby drilling fluid may enter the valve structure when desired.

The invention is illustrated by way of example in the accompanying drawings in which:

Figure 1 is a view in elevation showing the application of the present invention to the usual formation tester assembly.

Fig. 2 is an enlarged fragmentary view in longitudinal section as seen on the line 2—2 of Fig. 1 and shows the construction of the upper section of the present invention.

Fig. 3 is an enlarged fragmentary view in longitudinal section as seen on the line 3—3 of Fig. 1 and shows the lower section of the present invention indicating the shut-in valve in its open position.

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Fig. 4 is a fragmentary view in longitudinal section as seen on the line 4—4 of Fig. 1 showing the details of the trap valve structure.

Fig. 5 is a view in transverse section through the locking mechanism as seen on the line 5—5 of Fig. 3.

Fig. 6 is a fragmentary view showing the auxiliary valve structure provided for releasing internal pressure within the tubular valve housing and the operating tool therefor.

Referring more particularly to the drawings, 10 indicates a supporting string of pipe which has a threaded connection with the housing of a trip valve structure 11. The trip valve structure is formed at its lower end with a pin 12 which extends into a box 13 of a sub 14 which forms a part of the combined shut-in valve and back scuttling valve with which the present invention is particularly concerned and which valve is generally indicated in Fig. 1 at 15. The sub 14 has a central passageway 16 through it which terminates in a threaded counterbore 17. The lower end of the sub is reduced in diameter as indicated at 18 and is externally threaded at 19 to receive an adjusting cap 20. Threaded into the bore 17 and extending downwardly from the sub is the upper tubular mandrel section 21. Near the upper end of the mandrel section 21 and below its threaded portion is a shoulder 22 against which the lower end of the adjusting cap 20 abuts. The lower end of the mandrel 21 is formed with an internally threaded counterbore 23 to receive the upper threaded end of the main section 24 of the tubular mandrel. The upper section 21 of the tubular mandrel has a central bore 25 and the lower section has a central bore 26 longitudinally aligned therewith and extending entirely therethrough. Mounted upon the main section 24 is a ball thrust bearing 27, the upper race 28 of which provides a seat for a collar compression spring 29, the upper end of the compression spring 29 resting against the lower face of the adjustable cap 20. The thrust bearing has a lower race 30 which rests against the upper face of a split collar 31. The parts of this collar are held together by clamping bolts 32. The collar rests against the end face of the upper section 33 of a tubular housing which is formed at its lower end with a threaded pin 34 to extend within a threaded box 35 of an intermediate housing section 36 carrying a sliding nut 37. The nut 37 is cylindrical and fits within a central bore 38 of the intermediate housing

section 36. This nut is formed with an internally threaded bore 39 comprising acme or other type coarse threads and receives threads 40 formed upon a length of the main tubular mandrel section 24. The main tubular mandrel section is formed with a collar 41 which in its upper position abuts against the lower end face of the pin 34 of the upper tubular section 33. Directly above the collar and extending radially from the mandrel are lugs 42 which in their uppermost position register with keyways 43 cut into the inner wall of the upper housing section 33. The upper end of the housing section 33 is formed with a counterbore 44 to receive packing 45 which circumscribes the mandrel 24 and is held in position by a stuffing gland 46 threaded into the upper end of the counterbore 44 and through which the mandrel 24 extends with a substantially tight fit. The threaded section 39 of the nut is relieved at its lower end so that a clearance opening 47 will occur within the nut 37 and below the lower end of the threaded section 39. Communicating with the cylindrical bore 47 within the nut 37 is a threaded bore 48 which receives a perforated mandrel section 49. This valve section has a central longitudinally extending passageway 50 through which fluid may flow. The walls of the tubular valve section of the perforated mandrel section 49 are formed with radial ports 51 for a purpose to be hereinafter described. The lower end of the mandrel section 49 is fitted with a check valve structure 53 comprising a frame 54 which supports a spring 55. The spring 55 presses yieldably against a valve ball 56. The valve ball 56 is held against a valve seat 57 which is mounted directly at the lower end of the perforated mandrel section 49 so that the valve 56 will act to obstruct the flow of fluid into the passageway 50 of the mandrel section 49. The perforated mandrel section 49 extends downwardly beyond the end of the intermediate housing section 36. The lower end of the housing section is fitted with a tubular extension 58 of reduced diameter. A counterbore 59 is formed in the tubular extension 58 to receive packing 60. A nut 61 is threaded into the outer end of the counterbore 59 to hold the packing. The extension 58 is externally threaded at 62 to engage threads 63 formed at the end of a coupling sub 64. The mandrel 49 extends downwardly through the coupling sub 64 and therebeyond. A counterbore 65 is formed within this sub to receive a packing 66. This packing is of relatively long length and serves not only to pack the mandrel so that it may have longitudinal movement and still remain fluid-tight but also to pack off the ports 51 when the mandrel section 49 is drawn upwardly to a position where the ports 51 will be closed. At the upper end of the extension sub 64 is an enlarged bore 67 which provides a fluid passageway to establish communication between back circulation ports 68 and the ports 51 of the mandrel under certain circumstances. The back circulation ports 68 are formed through the wall of the sub 64 and permit well fluid under hydrostatic pressure to flow into the tool as hereinafter described. The lower end of the connecting sub 64 is formed with a threaded extension 69 which is threaded into the upper end of a lower housing section 70. The lower housing section 70 terminates with a pin section 71 which may be threaded into the box portion of the upper end of a desired number of stands of pipe above the usual retaining valve structure. The lower housing section 70 is formed with a relatively large bore 72 which terminates in a smaller longitudinally aligned fluid passageway 73 extending through the pin section 71.

In the operation of the present tool, fluid under pressure may be entrapped between the bore 72 of the lower housing section 70 and the retaining valve under certain conditions and it will be necessary to relieve this pressure when the tool is withdrawn from the well in order to disassemble the structure. In order to accomplish this a releasing check valve is provided as generally indicated at 74. This check valve comprises a housing portion 75 threaded into a bore 76 extending radially from the fluid passageway 73 and through the wall of the pin section 71. The housing 75 is formed with a central bore 77. The outer end of this bore is threaded to receive a temporary plug 78. The inner end of the bore terminates in a valve seat 79 (Fig. 6) to receive a valve ball 80. The ball 80 is yieldingly held on the seat by a spring 81 which is positioned by a retaining cap 82. The retaining cap 82 is threaded onto the inner end of the housing 75 and has a central fluid opening 83.

In order to bleed the entrapped fluid from the bore 72 in the lower housing section 70 a tool 84 is provided as generally indicated in Fig. 6 of the drawings. This comprises a housing 85 formed with a threaded stem 86 at one end and a threaded counterbore 87 at its opposite end. The threaded stem 86 is designed to be screwed into the opening in the valve housing 74 normally receiving the temporary plug 78. A bore 88 extends through the housing 85 from the counterbore 87 and through the stem 86. At a point intermediate the ends of this bore a lateral threaded passageway 89 is provided to receive a threaded coupling 90. This coupling is carried by a bleed tube 91. The threaded counterbore 87 of the housing 85 carries a tubular packing sleeve 92. This extends in longitudinal alignment with the bore 88 and receives an operating pin 93. The outer end of the pin 93 is threaded at 94 and fits into a threaded bore of the sleeve 92. The opposite end of the pin 93 has an extension portion 95 which passes into and through the bore 88 of the housing 85. The pin is made fluid tight by a packing 96. This packing is held in position by a packing nut 97.

In operation of the present invention the combined shut-in and back circulation tool is constructed as shown in the drawings and is assembled with other instrumentalities as particularly shown in Fig. 1 of the drawings. As previously stated this is preferably used in connection with the formation or casing testing structures of the Patent No. 2,073,107 issued to Mordica O. Johnston on March 9, 1937, entitled Well Testing Method and Apparatus Therefor. In this structure a packer 98 is carried at the lower end of a tester 99 which includes a retaining valve 100. At the lower end of the packer there is a perforated anchor 101 through which connate fluid may flow upwardly through the packer and the tester structure 99. When the packer 98 is set and the weight of the drill string 10 is imposed upon the retaining valve 100 of the tester 99 fluid may flow upwardly through the pin section 71 (Fig. 4) of the combined shut-in and back circulation tool 15. It travels through passageway 73 into the enlarged bore 72 of the lower housing 70 and then through the radial ports 51 and the lower mandrel section 49 after which it travels upwardly through the center passageway 50 in the lower mandrel section and

then through the central passageways 25 and 26 to the sub 14. In view of the fact that the trip valve 11 above the sub 14 is normally closed circulation through the tool 15 will be interrupted by the trip valve 11. When the trip valve is opened by dropping a go-devil thereon or through some other instrumentality a sample of the connate fluid may pass upwardly through the tester 99 and the tool 15. It is preferable to interpose a plurality of stands of pipe between the retaining valve 100 and the combined shut-in and back circulation tool 15, so that an entrapped sample may be obtained when the shut-in tool is closed as will be hereinafter explained. It is also to be understood that in common practice a pressure recording device is disposed within the perforated anchor so that the pressure of the connate fluid may be recorded. Normally the tool generally indicated at 15 is set as indicated in Figs. 2 and 3 of the drawings. At this time the ports 51 will be open below the connecting sub 64. In the event that it is desirable to entrap a shut-in sample weight is applied to force the lugs 42 downwardly out of engagement with keyways 43 and against the action of the spring 29. The drill string and the mandrel section 24 may then be rotated so that the threaded section 40 of the mandrel will act to move the sleeve upwardly. The pitch of the threads 39 and 40 are such as to require that the mandrel shall be rotated approximately seven times in order to draw the ports 51 into a closed position within the packing 66. When the ports 51 have been closed the connate fluid which has risen through the open tester and the extra stands of pipe as indicated at 102 in Fig. 1 of the drawings will be entrapped by the closing of the ports 51 and by the closing of the retaining valve 100 in the tester 99 as the string of pipe is lifted preparatory to being withdrawn from the well. It will be obvious that the entrapped fluid will be under the pressure of the connate fluid, which pressure will be recorded by the pressure recording mechanism placed within the perforated anchor. The entrapped sample of fluid cannot at this time pass upwardly through the drill string or outwardly through the valve structure 74, thus the shut-in pressure may be obtained.

In the event that it is desired to complete the test and withdraw the string of pipe and the testing tool from the well, pressure on the string of pipe is relieved on the testing tool so that the combined shut-in and back circulation tool and the tester 99 with its packer 98 may be withdrawn from the well. After the tool 15 has been withdrawn the recovered sample entrapped within the section of drill pipe 102 and the bore 72 at the lower end of the section 70 may be removed by use of the tool 84. This is accomplished by first unscrewing the plug 78 in the valve structure 74 and thereafter screwing the extension 86 of the tool 84 in the threaded bore from the threaded plug 78. When the extension 86 has been screwed into position the pin 95 may be advanced by its rotation and by the action of the threads 94 on the pin. This will force the pin 95 inwardly to encounter the valve ball 80 which will be moved from its seat against the expansive action of spring 81. When this takes place the entrapped fluid within the bore 72 and the length of pipe 102 will be expelled by the pressure which has been imposed upon the fluid. The entrapped fluid which is the retained sample will then bleed out through the pipe 91 into a suitable receptacle.

In case of emergency when the packer 98 is set it may be desirable to impose a counter fluid pressure upon the connate fluid in the well. This may be normally accomplished by creating a back circulation of fluid downwardly through the string of pipe and the tester. The back circulation flows downwardly through the tubular mandrel to move the valve ball 56 off of its seat 57. In the event however that it is desired to impose the pressure of the hydrostatic fluid head of the well upon the connate fluid the supporting string 10 is rotated in the same direction as previously described for the rotation of the threaded mandrel 24 to draw the radial ports 51 of the perforated mandrel 49 upwardly through the packing 66. Further rotation of the threaded mandrel will draw the ports 51 upwardly into the bore 67 of the connecting sub 64. The fluid within the well bore may then pass inwardly through the back circulation ports 68 and into the space 67. This fluid is under the pressure exerted by the hydrostatic head of fluid within the well and this fluid will then be forced through the ports 51 and downwardly through the passageway 58 to the ball valve 56. This valve is then opened so that the fluid under hydrostatic pressure may be imposed upon the connate fluid which is attempting to rise from beneath the packer 98 and through the tester 99.

It will thus be seen that the combined shut-in and back circulation tool here shown is compact in construction, and that it may be operated easily to insure that a shut-in pressure may be recorded, that a sample of the shut-in fluid may be obtained, and that under emergency conditions it is possible to impose a superior pressure upon that of the connate fluid either by pump pressure through the drill string or hydrostatic pressure exerted by the column of fluid standing above the tool in the well bore.

It is to be understood that the nut 37 and the intermediate housing section 36 are suitably splined together by splines 37' so that the nut may move longitudinally of the housing section 36 as the threaded section 40 on the main tubular mandrel section 24 is rotated.

While I have shown the preferred form of my invention as now known to me, it will be understood that various changes may be made in combination, construction and arrangement of parts by those skilled in the art, without departing from the spirit of the invention as claimed.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. An oil well tool for creating a shut-in pressure or back circulation within a string of pipe suspended in a well which comprises; an outer tubular housing adapted to carry an element formed with a well packer at its lower end and adapted to be connected to a supporting string of pipe at its upper end, said tool including: a tubular housing, a threaded tubular mandrel extending upwardly therethrough and connecting with the supporting string of pipe, a traveling nut within the tubular housing and through which the threaded tubular mandrel section extends, a perforated mandrel section secured at the lower end of said nut and extending downwardly through the lower portion of said tubular housing, a check valve at the lower end of said perforate mandrel section to permit the outflow of fluid from said mandrel section, packing means within the lower portion of the housing and through which the perforate mandrel section extends, and ports through the side wall of the

lower portion of the housing establishing communication between the interior thereof and the fluid within which the tool is submerged, the mandrel section being formed with radial ports which may be positioned by the rotation of the threaded mandrel section as the threaded nut is moved to dispose the ports in the mandrel section in an uncovered position below the packing and an uncovered position above the packing and a closed position within the packing and intermediate the ends thereof.

2. An oil well tool of the class described, comprising a tubular housing, a traveling nut slidably but non-rotatably received by the housing, a tubular mandrel telescopically received within the tubular housing and having means at its upper end for connection to a supporting string of pipe and having its lower end threadedly engaging said nut, a tubular section carried by the nut, extending downwardly therefrom, and having its lower end closed to the upward flow of fluid thereinto, packing means within the housing below the nut and through which the tubular section extends, said housing having ports in the side wall thereof disposed above the packing means, said tubular section having ports formed in the side wall thereof initially disposed above the packing means in communication with the ports in the housing and adapted to be placed, upon rotation of the mandrel, within the confines of the packing means, or below the packing means in communication with the interior of the housing.

3. An oil well tool of the class described, comprising a tubular housing, a traveling nut slidably but non-rotatably received by the housing, a tubular mandrel telescopically received within the tubular housing and having means at its upper end for connection to a supporting string of pipe and having its lower end threadedly engaging said nut, a tubular section carried by the nut, extending downwardly therefrom, and having its lower end closed to the upward flow of fluid thereinto, packing means within the housing below the nut and through which the tubular section extends, said housing having ports in the side wall thereof disposed above the packing means, said tubular section having ports formed in the side wall thereof initially disposed above the packing means in communication with the ports in the housing and adapted to be placed,

upon rotation of the mandrel, within the confines of the packing means, or below the packing means in communication with the interior of the housing, other packing means below the nut, disposed above the housing ports and through which the tubular section extends.

4. An oil well tool of the class described, comprising a tubular housing, a traveling nut slidably but non-rotatably received by the housing, a tubular mandrel telescopically received within the tubular housing and having means at its upper end for connection to a supporting string of pipe and having its lower end threadedly engaging said nut, a tubular section carried by the nut, extending downwardly therefrom, and having its lower end closed to the upward flow of fluid thereinto, packing means within the housing below the nut and through which the tubular section extends, said housing having ports in the side wall thereof disposed above the packing means, said tubular section having ports formed in the side wall thereof initially disposed above the packing means in communication with the ports in the housing and adapted to be placed, upon rotation of the mandrel, within the confines of the packing means, or below the packing means in communication with the interior of the housing, other packing means below the nut, disposed above the housing ports and through which the tubular section extends, spring means urging the tubular mandrel upwardly relative to the housing, and means preventing rotation of the tubular mandrel relative to the housing, responsive to downward movement of the mandrel relative to the housing to release the mandrel for rotary movement.

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