Sept. 2, 1958 C. L. HUBER 2,850,100

BY-PASS AND TESTING TOOL

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Fig. 1

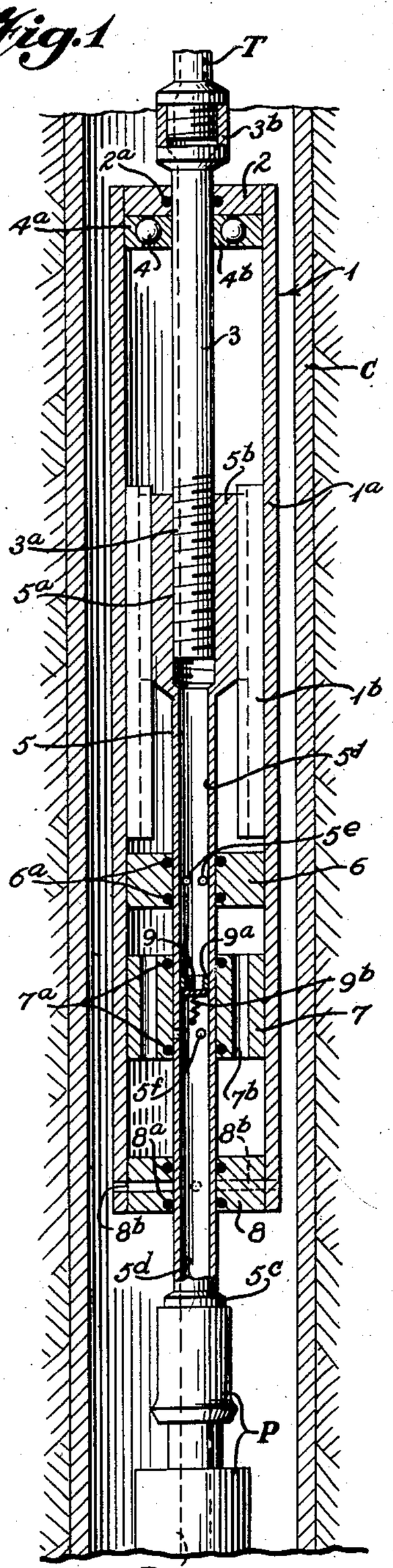

Fig. 2

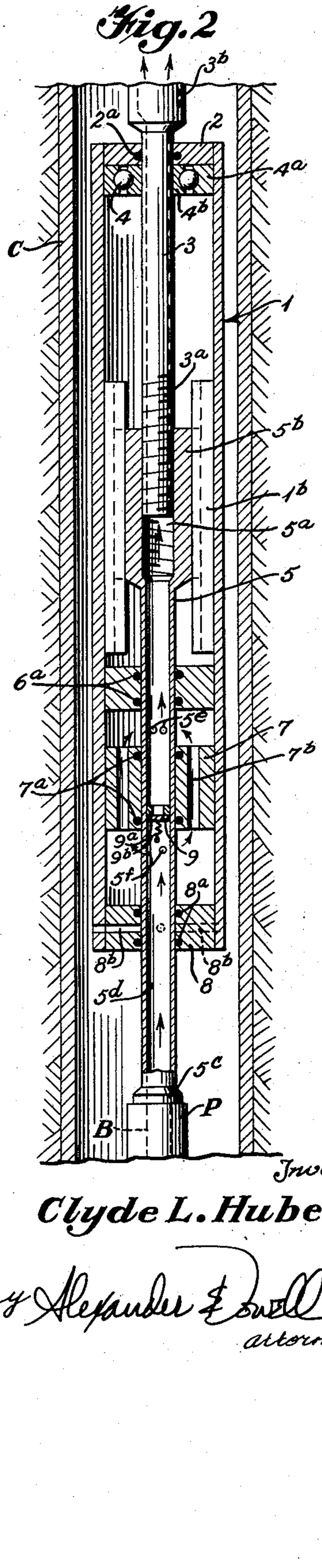

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Fig. 3

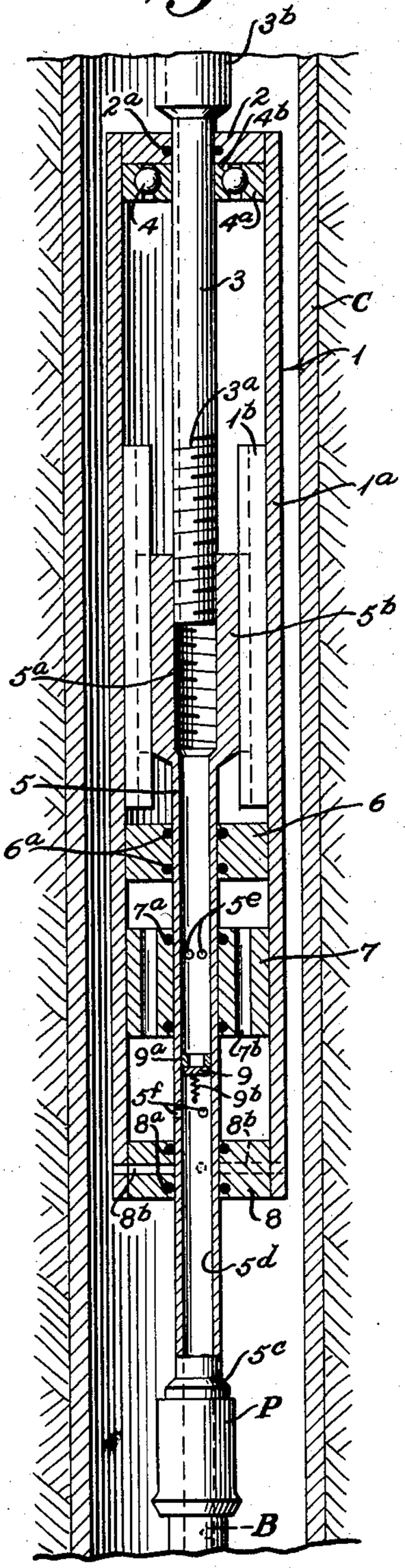
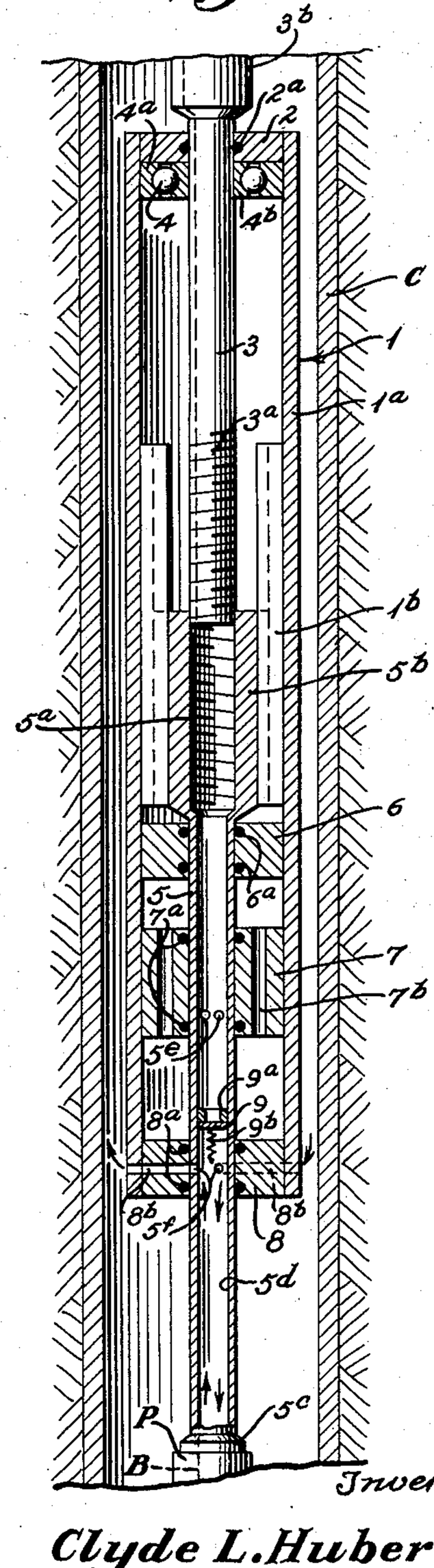


Fig. 4



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BY-PASS AND TESTING TOOL

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6 Claims. (Cl. 166—149)

This invention relates to well-testing tools to be inserted in a tubing string just above a well packer, this assembly being lowered into the well for the purpose of making a test in the manner which will be hereinafter described. More particularly, this tool is a combination tester and bypass tool capable of making a test after the packer has packed off the column of mud above the strata to be tested, and capable of bypassing the mud above the packer to the well annulus below the packer after the test has been completed for the purpose of facilitating unseating of the packer.

As is well known in the art, the bore of a well is generally filled with a heavy mud, the density of which is controlled during circulation thereof, and the mud serving to provide a back pressure on the lower strata of the well so as to control the well against blowouts. The hydrostatic pressure of the column of mud counteracts the pressure in the oil or gas bearing strata, but it also has a tendency to clog the strata and reduce the rate of flow therefrom. It is a long-established practice, therefore, to pack off the mud within the annulus above the packer to confine the mud to the well annulus above the strata to be tested, and to relieve the hydrostatic pressure of the mud thereon so as to facilitate the flow of oil or gas from the strata through the tubing string, the bore of which communicates with a passage through the packer.

It is the principal object of my invention to provide a 4-position testing and bypass tool to be inserted in the tubing string above the packer, the four positions in the testing tool including: an initial shut-in position wherein entry of the mud into the tubing string is prevented before the packer is set; a second position wherein the bore of the tubing string is connected to communicate with the passage through the packer to connect with the annulus below the packer for the purpose of taking a test sample therefrom; a third position wherein the bore of the tubing string is again shut-in so as to prevent further communication of the bore with the well annulus being tested; and a fourth position wherein the bore of the tubing string above the testing tool remains shut-in and the passage through the packer below the testing tool is connected through the testing tool with the annulus of the well above the packer so as to bypass the hydrostatic pressure of the mud from above the packer to the annulus below the packer to facilitate unseating of the packer and removal of the assembly from the well.

Another important object of this invention is to provide a testing and bypass tool wherein the mud within the annulus is not mixed with the test sample to any appreciable extent, this purpose being accomplished by the structure of the tool which permits that portion of the tubing bore which receives the test to be shut in both before and after seating of the packer.

A further very important object of my invention is to provide a testing tool of the type described wherein the tool is adjusted sequentially from one position to the next by rotation of the tubing string in a single direction. Adjustment of the position of the tool by rotation, as distinguished from lifting, of the pipe string eliminates the need for raising the string within the well while the packer is seated. This is a particularly important feature since lifting of the string while the packer is still seated as is required in many prior-art testing tools is usually very difficult and frequently results in straining and consequent elongation of the tubing.

Another important object of the present invention is to provide a dependable and relatively simple testing and bypass tool in a single self-contained unit.

Still another primary object of my invention is to provide a testing and bypass tool having check-valve means in its bore whereby circulation of the mud in the well may be restored at any time regardless of the position of the testing tool, so that the density of the mud may be altered to meet new pressure conditions within the well, or so that circulation may be restored for the purpose of reconditioning the mud.

Another important object of my invention is to provide a multiple-position testing and bypass tool, the respective positions of which may be quickly and easily controlled from the ground surface above the well and which positions may be accurately determined from the ground level by the operators.

Other objects and advantages of my invention will become apparent during the following description of the drawings, wherein:

Figure 1 is a sectional elevation view through a cased well showing the testing tool inserted in a tubing string above a packer, the testing tool being shown in cross section and being shown in its initial shut-in position.

Fig. 2 is a view similar to Fig. 1 but showing the tool adjusted to its test-sample receiving position.

Fig. 3 is a view similar to Fig. 1 but showing the tool adjusted to its second shut-in position.

Fig. 4 is a view similar to Fig. 1 but showing the tool adjusted to its final bypass position wherein the annulus above the packer is bypassed to the test strata below the packer so as to equalize the hydraulic pressures above and below the packer, the lower end of the packer not being shown in any of these figures since it may be of any conventional type.

Referring now to the drawings, like reference characters are used to designate similar parts in the various views, wherein are shown a well casing C into which extends a conventional-type tubing string T attached at its lower end to the upper end of the testing and bypass tool 1. The lower end of the testing and bypass tool is coupled to the upper end of a packer P which has a passage B extending therethrough and open at its bottom to the well annulus. Only the top portion of the packer tool is shown in the figures in view of the fact that any conventional-type packer may be used with the present testing and bypass tool, provided the packer has a bore extending through its length and open at its bottom to the well annulus.

The testing and bypass tool 1 which comprises the present invention includes an outer body 1*a*, which body is preferably cylindrical in form, the upper end of the body being sealed by a stuffing box 2 through which a hollow spindle 3 passes, the stuffing box 2 being sealed to the body 1*a* along its outer periphery and being provided with packing 2*a* adapted to seal the inner periphery of the stuffing box 2 to the spindle 3 so as to prevent entry of fluids into the body 1*a*.

Below the stuffing box 2 is a set of ball bearings 4, the outer race 4*a* of which is fixed to the body 1*a* and the inner race 4*b* of which is fixed to the spindle 3. The spindle 3 is thus rotatably mounted in the upper end of the body 1*a*, and the spindle is threaded at its lower end 3*a* to engage threads 5*a* in the upper end of a sliding hollow mandrel 5. The upper end of the mandrel 5

in the vicinity of the threads 5*a* is enlarged and is splined as at 5*b* to an internally splined sleeve 1*b* fixed within the body 1*a*, this spline arrangement preventing the mandrel 5 from rotating with respect to the body 1*a* while at the same time permitting the mandrel 5 to move up and down within the body as the spindle 3 is rotated, the threads 3*a*—5*a* causing the vertical motion of the mandrel 5.

Within the body 1*a* and below the sleeve 1*b* is fixed a stuffing box 6 having upper and lower spaced packing members 6*a*, and below the stuffing box 6 is another stuffing box 7 which likewise has spaced upper and lower packing 7*a* and which, in addition, has a plurality of openings 7*b* axially disposed with respect to the body 1*a* so as to permit the flow of fluid within the body 1*a* past the stuffing box 7. The lower end of the body 1*a* is enclosed by still another stuffing box 8 which has upper and lower spaced packing members 8*a* and which, in addition, has a plurality of radially disposed ducts 8*b* which not only pass radially through the stuffing box 8 but also through the walls of the body 1*a* and communicate with the well annulus outside of the body. The mandrel 5 passes downwardly through the respective stuffing boxes 6, 7 and 8 and the packing 6*a*, 7*a*, 8*a* prevents the flow of fluids between the inner diameters of the stuffing boxes 6, 7 and 8 and the outer surface of the mandrel 5. The lower end of the mandrel 5*c* is provided with a tool joint which connects to the upper end of the packer P, and the bore 5*d* of the mandrel 5 connects with the annulus of the well below the packer P through the passage B of the packer.

Within the bore 5*d* of the mandrel 5 is located a one-way check valve 9 which engages a valve seat 9*a* fixed in the bore 5*d* and which check valve 9 is pressed by a spring 9*b* against the valve seat 9*a* so as to seal the bore 5*d* of the mandrel 5 against upward passage of well fluids, but so as to be unseated by pressure above the check valve so as to permit downward flow of fluid through the bore of the mandrel 5 for the purpose hereinafter discussed. The mandrel 5 is also provided with an upper series of apertures 5*e* through the wall of the mandrel, and is further provided with a plurality of lower annularly disposed apertures 5*f* for the purpose hereinafter described.

Operation

As stated in the objects of this invention, the testing and bypass tool is connected into the tubing string between the tubing T and the packer P, the upper end of the spindle 3 having a tool joint 3*b* which connects to the lower end of the tubing T. It is to be understood that the packer P may be of any conventional design, such as a "hook-wall" packer, and should include well gripping dogs to assist in the setting of the packer. The assembly is then lowered into the well with the mandrel 5 in the position shown in Fig. 1.

This position may be referred to as the first shut-in position, and it should be apparent that the bore of the tubing or spindle and the upper portion of the mandrel is closed against entry of fluid from below by the fact that the upper apertures 5*e* through the mandrel 5 are shut in between the packing members 6*a* of the stuffing box 6, and by the further fact that the lower apertures 5*f* of the mandrel 5 are shut in between the packing members 7*a* of the stuffing box 7.

When the assembly has been lowered to the required depth within the well casing C the packer P is then set in the conventional manner so as to seal off the well strata to be tested which is located below the packer P from the annulus of the well above the packer P. By this means the packer supports the weight of the mud within the annulus thereabove, and thereby prevents the mud from pressurizing and perhaps clogging the strata to be tested.

When the packer has been set, the operator then rotates the tubing string T through a predetermined number of turns and thereby rotates the spindle 3 which is connected thereto through the same number of revolutions. When the tubing T and the string 3 have been thus rotated, the mandrel 5 then assumes the position shown in Fig. 2 which is the testing position. In this position the fluids from below the packer P flow upwardly through the passage B of the packer and continue to flow upwardly through the bore 5*d* of the mandrel 5. When the fluids reach a point just below the check valve 9 they pass outwardly of the bore 5*d* of the mandrel through the lower apertures 5*f* and continue to travel upwardly through the openings 7*b* in the stuffing box 7, and finally return into the bore 5*d* of the mandrel 5 through the upper apertures 5*e*. Once within the bore 5*d* and above the check valve 9, the fluids may then pass upwardly to the ground surface through the hollow spindle 3 and the tubing T.

When sufficient fluid has been withdrawn from the strata below the packer P, and an adequate test sample has been obtained, the tubing string may then be rotated through another predetermined number of revolutions in the same direction, so as to cause the mandrel 5 to travel downwardly to the position shown in Fig. 3. In this position the testing tool is again shut in so that no fluid can flow upwardly from the bore B through the bore 5*d* of the mandrel and beyond the check valve 9. In this position the fluid could flow upwardly through the passage B and through the lower portion of the bore 5*d* and outwardly through the apertures 5*f*, but since the upper apertures 5*e* are shut in which the stuffing box 7 no further upward flow of the fluids may be had, at least not upwardly beyond the stuffing box 7.

In this second shut-in position the test has been completed and the next step in the sequence of operation of the tool would be to prepare to withdraw the assembly from the well. In order to accomplish such withdrawal, it is highly desirable to bypass the hydrostatic pressure of the mud in the annulus above the packer P to the test annulus below the packer P, and in order to perform this function it is only necessary to again rotate the tubing T through a further predetermined number of revolutions so as to cause the mandrel 5 to travel downwardly to its final bypass position as shown in Fig. 4.

In this position the upper apertures 5*e* are still shut in within the stuffing box 7, and the lower apertures 5*f* have traveled downwardly to register with the ducts 8*b* in the stuffing box 8, which lower apertures 5*f* when registered with the ducts 3*b* permit the well fluids outside of the testing tool 1 to travel inwardly into the bore 5*d* of the mandrel 5 and thereby travel downwardly through the passage B of the packer P and thence into the annulus below the packer in the vicinity of the test strata. Of course it is not necessarily true that in the bypass position the well fluids will travel downwardly since, in the event that the pressure within the strata below the packer exceeds the hydrostatic pressure of the mud in the annulus above the packer, the flow of fluid would be upwardly instead of downwardly through the path just described.

As is well known to those skilled in the art, once the fluid pressures have been equalized above and below the packer it is a relatively simple matter to raise the tubing string and unseat the packer so as to permit the entire assembly, including the tubing T, the testing and bypass tool 1 and the packer P to be retrieved by withdrawing the assembly to the surface.

Once retrieved, the testing and bypass tool need only be rotated in the opposite direction so as to again raise the mandrel 5 to the position shown in Fig. 1 with respect to the body 1*a* of the tool. In this position the testing and bypass tool is again ready to be lowered in the well.

If means is used to lock the tool joint between the individual tubing members of the tubing string and between the lower end of the tubing string and the testing

and bypass tool, it then becomes possible for multiple tests to be run at different elevations within the well without the necessity of removing the assembly therefrom. In other words, with the tool joints so secured to prevent them from unscrewing when rotation of the tubing is reversed, the tubing may then be rotated in the reverse direction so as to reverse the sequence of positioning the mandrel 5 with respect to the various stuffing boxes. In this case it would be unnecessary to remove the assembly from the well before running another test.

I do not limit my invention to the exact form shown in the drawings for obviously changes may be made therein within the scope of the following claims.

I claim:

1. A well testing and bypass tool to be inserted in a tubing string above a packer having a passage therethrough, comprising a hollow body; a spindle journaled in the body and connected to the tubing; a mandrel slidably splined in the body to permit axial motion thereof with respect to the body, the mandrel and the spindle being connected by threaded engagement so that rotation of the latter causes axial motion of the former, the lower end of the mandrel being connected to the packer and said mandrel and said spindle having bores communicating with the bore of the tubing and with the passage through the packer, said mandrel having spaced upper and lower series of apertures through its wall; an obstruction in the bore of the mandrel between the upper and lower series of apertures and preventing upward flow of fluids therepast, and said mandrel being adjustable to four selected positions; a first stuffing box in the body for closing said upper series of apertures in the first mandrel position; a second stuffing box in the body and longitudinally spaced from the first for closing the upper series of apertures in the third and fourth mandrel positions, said second stuffing box having longitudinal openings therethrough to circumvent the obstruction when the upper and lower series of apertures are located in the spaces on respectively opposite sides of the second stuffing box in the second mandrel position; and a third stuffing box longitudinally spaced from the other stuffing boxes and sealing the lower end of the body to the mandrel and having radial ducts extending outwardly through the body, and said lower series of apertures registering with said ducts in the fourth mandrel position to bypass well fluids around the packer.

2. In a tool as set forth in claim 1, said obstruction comprising a valve seat in the mandrel bore; a valve below said seat; and a spring yieldably urging said valve upwardly against said seat.

3. A well testing and bypass tool to be inserted in a tubing string above a packer having a passage therethrough, comprising a hollow body; a spindle journaled in the body and connected to the tubing; a mandrel slidably splined in the body to permit axial motion thereof with respect to the body, the mandrel and the spindle being connected by threaded engagement so that rotation

of the latter causes axial motion of the former, the lower end of the mandrel being connected to the packer and said mandrel and said spindle having bores communicating with the bore of the tubing and with the passage through the packer, said mandrel having spaced upper and lower apertures through its wall; an obstruction in the bore of the mandrel between the upper and lower apertures and preventing upward flow of fluids therepast, and said mandrel being longitudinally adjustable in said body to any one of four positions; stuffing box means in the body including a group of longitudinally spaced stuffing boxes surrounding the mandrel, one or another of said boxes closing the upper apertures when the mandrel is in any one of the first, third or fourth positions, and one of said boxes having longitudinal openings connecting together for fluid-flow the spaces within the body longitudinally separated by said last-mentioned box to bypass said obstruction when the mandrel is in the second position, and still another of said stuffing boxes having radial ducts extending outwardly through the body, said lower apertures registering with the ducts in the fourth mandrel position.

4. In a tool as set forth in claim 3, said obstruction comprising a valve seat in the mandrel bore; a valve below said seat; and a spring yieldably urging said valve upwardly against said seat.

5. In a well testing and bypass tool for insertion in a pipe string above a packer, said tool having a hollow body and having a hollow mandrel axially movable to four positions within the body, flow control means comprising longitudinally spaced stuffing boxes within said body and surrounding said mandrel, the mandrel having longitudinally spaced apertures through its wall and having an obstruction within its bore between the apertures, one or another of said stuffing boxes closing the upper apertures when the mandrel is in any one of the first, third or fourth positions, and one of said boxes having longitudinal openings connecting together for fluid-flow the spaces within the body longitudinally separated by said last mentioned box to bypass said obstruction when the mandrel is in the second position, and still another of said stuffing boxes having radial ducts extending outwardly through the body, said lower apertures registering with the ducts in the fourth mandrel position.

6. In a tool as set forth in claim 5, said obstruction comprising a valve seat in the mandrel bore; a valve below said seat; and a spring yieldably urging said valve upwardly against said seat.

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