

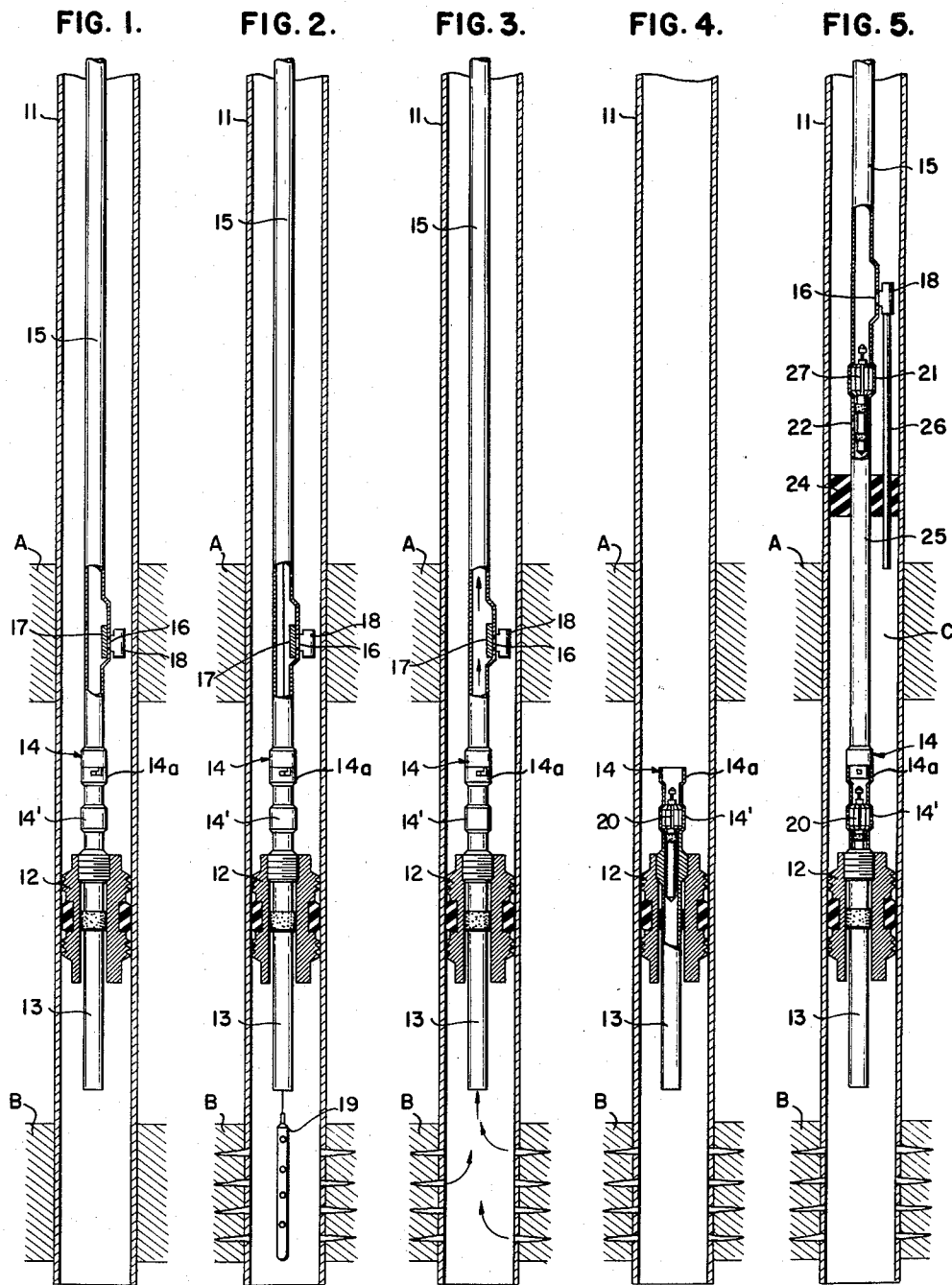
May 3, 1960

J. S. McCUNE
METHOD AND APPARATUS FOR COMPLETING
A WELL IN A PLURALITY OF ZONES

2,935,131

Filed June 5, 1957

2 Sheets-Sheet 1



INVENTOR.

JOHN S. McCune,

BY

James P. McCall
ATTORNEY.

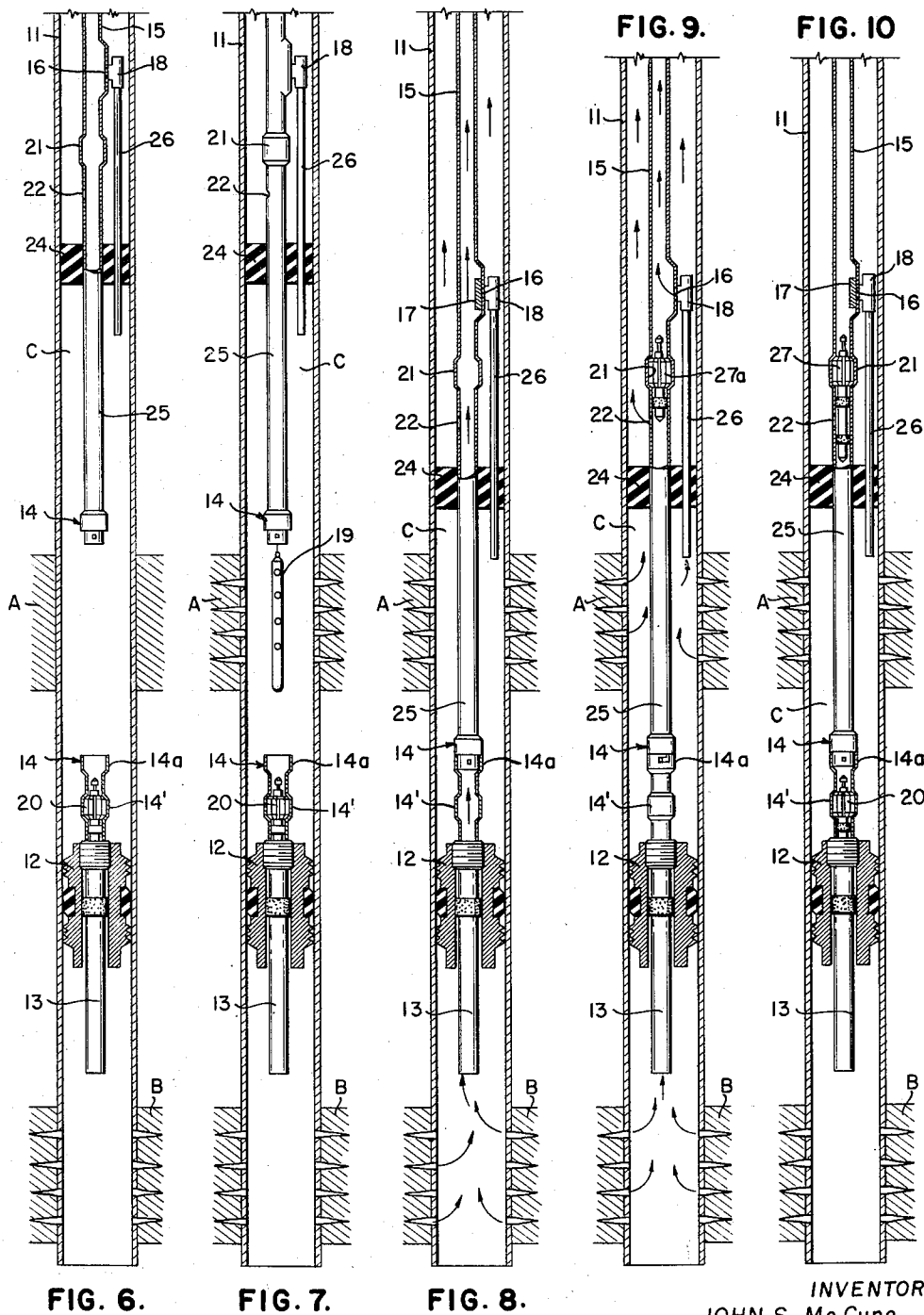
May 3, 1960

J. S. McCUNE
METHOD AND APPARATUS FOR COMPLETING
A WELL IN A PLURALITY OF ZONES

2,935,131

Filed June 5, 1957

2 Sheets-Sheet 2



INVENTOR.
JOHN S. McCune,

BY *James T. Whittaker*
ATTORNEY.

2,935,131

METHOD AND APPARATUS FOR COMPLETING A WELL IN A PLURALITY OF ZONES

John S. McCune, Monroe City, Tex., assignor, by mesne assignments, to Jersey Production Research Company, Tulsa, Okla., a corporation of Delaware

Application June 5, 1957, Serial No. 663,716

7 Claims. (Cl. 166—45)

The present invention is directed toward a method and apparatus for isolating at all times the final completion and production of a plurality of separate productive zones one from the other.

When a cased well bore penetrates a plurality of separate productive zones, such as two or more zones, and the casing is to be perforated opposite each of the zones, the pressure differential existing between the two zones makes it imperative that the production from the two zones be isolated from each other at all times. It is an object of the present invention that the productive fluids of a plurality of separate zones be isolated one from the other at all times even at the instant of perforation.

It is also desirable and an object of the present invention that a differential be created between the casing pressure and the formation pressure of each zone so that, on the instant of perforating, the producing fluid will flow into the casing.

Another object of the present invention is that the fluid streams from each of the zones be crossed over from the tubing to the tubing casing annulus and from the tubing casing annulus to the tubing.

It will be seen that these objectives have been adequately accomplished by the following specification taken in conjunction with the drawings which schematically illustrate the various steps included in the present invention.

Figs. 1 through 9 are schematic illustrations showing the various steps and apparatus used in performing the present method.

Fig. 10 illustrates a modification of the invention of Figs. 1 through 9.

As shown in Fig. 1, a well bore having cemented therein a casing 11 has penetrated two spaced apart productive formations A and B. For reasons of clarity the conventional casing cement has been omitted from the drawings. Positioned in the casing 11 between the formations A and B is a packer assembly 12. A suitable packer which may be used is the "Baker Model D Retainer Production Packer" such as illustrated on page 561 of the 21st edition of The Composite Catalog of Oil Field and Pipe Line Equipment.

Positioned in packer 12 with its upper end extending a substantial distance above packer 12 is a production tube 13. The lower end of production tube 13 extends below packer 12 to a position above the formation B. As shown in the drawing, production tube 13 is composed of a seal nipple and a no-left-turn latching sub, both of which are conventional equipment. Connected to the upper end of production tube 13 by means of a releasable coupling assembly 14 is a tubing string 15. The lower portion 14a of releasable coupling assembly 14 defines on its inner wall a landing recess 14'. Tubing string 15 extends to a well head assembly not shown at the earth's surface. Tubing 15 has provided therein and positioned above coupling assembly 14 a closable port 16. A retrievable port closing member 17 is positioned in tubing 15 and closes off the port 16. A closure member such as 17 and the operation thereof are fully disclosed on page

995 of the twentieth edition (1954-1955) of the Composite Catalogue of Oil Field and Pipeline Equipment: Connected to the outer wall of tubing 15 and in fluid communication with port 16 is an elbow connection 18; the purpose of which will herein later be described. The apparatus of Fig. 1 affords an unobstructed bore throughout its length.

During the installation of the above-described equipment, the well casing and tubing is filled with workover fluid such as mud used during the drilling and cementing of the well to provide sufficient hydrostatic pressure to control the well. It is now desirable to create pressure in the casing lower than that of the formation to be perforated such as formation B so that when the casing is perforated the formation fluid will immediately flow into the casing. This is accomplished by lowering the fluid level in the tubing by a conventional method such as swabbing.

As shown in Fig. 2, the casing opposite the formation B is then perforated by any conventional perforator desired such as 19 which has been lowered through the tubing and because of the lower pressure created in the casing by swabbing, the productive fluid, upon perforation of the casing, immediately begins to flow into the casing and up the tubing. The perforator is then removed as shown in Fig. 3 and the producing fluids from formation B are allowed to flow until the entire system is clear of the workover fluids such as drilling mud and the like. Releasable coupling member 14 is positioned a substantial distance above packer 12 as shown.

A plug 20 is then run into the tubing by a wire line and positioned in landing recess 14' of the releasable coupling assembly 14. This completely isolates the lower formation from the casing above the packer 12. The tubing is then filled with any desirable workover fluid such as, for example, salt water. The tubing string 15 is now disconnected from the upper end of the production tube 13 along with the upper section of the releasable coupling means 14 and removed from the well bore as shown in Fig. 4.

As shown in Fig. 5, the tubing string 15 is modified prior to being run back into the casing. A short distance below the closable port 16 is positioned a side port landing nipple 21 provided with ports 22.

A dual string packer 24 is then positioned on the string below the side port landing nipple 21. A length of tubing 25 having attached to its lower end the upper half of the releasable coupling member 14 (the lower half of the coupling member being left in the borehole as shown in Fig. 4) is connected to the lower end of dual string packer 24. Tubing 25 is of sufficient length so as to position packer 24 above formation A and still couple the sections of the releasable coupling assembly 14 together.

As shown in Fig. 5, a length of smaller pipe 26 is connected into the elbow connection 18 with its lower end extending into and sealed about its periphery in the smaller bore of packer 24. It will be seen that the pipe 26 fluidly communicates the closable port 16 with the annulus C between the packers 12 and 24.

As shown in Fig. 5, port closing member 17 has been removed from the tubing 15 so as to allow fluid communication between the annulus C between packers 12 and 24 and the interior of the tubing string 15 above the port 22 via the pipe conduit 26. The tubing string 15 is again lowered into the hole and the two halves of the coupling member 14 are coupled together. A flow separation tool 27 which acts as a tubing plug member (as illustrated in the Composite Catalog, supra, page 4000 of the 21st ed.) is then lowered by a wire line and positioned in the recess of landing nipple 21. Separation tool 27 plugs the tubing bore and also closes off the ports 22 as shown in the side port landing nipple 21 which normally

3

communicates the interior of the tubing with the casing annulus above packer 24.

The subsurface equipment, as illustrated in Fig. 5, is then pressure checked on both the casing and the tubing sides to determine any possible leaks. It is important that no leaks occur past or through the packer 12 positioned above perforating formation B.

The separation tool or plug 27 is now removed by a conventional wire line retrieving assembly. The tubing section 25 is disconnected at 14 and the assembly as shown is raised until the lower end of tubing section 25 is positioned above the upper formation A as illustrated in Fig. 6.

The tubing string 15 is then swabbed to remove fluid so that a pressure differential is created between the pressure of casing 11 and the pressure of formation A so that upon perforation of the casing adjacent formation A the productive fluids will immediately flow into the casing and tubing. The fluids from formation B are at this time isolated by means of plug 20. A gun perforator such as 19 is lowered through the tubing to a position adjacent formation A, as shown in Fig. 7, and the casing perforated. It will be seen at this point that by means of plug 20 and packer 12 the fluids from upper zone A are completely isolated from the fluids from formation B.

The tubing string 15 is then lowered and the two sections of the releasable coupling assembly 14 are coupled together. The port closing member 17 is run in on a wire line and placed so as to close port 16 and blank off fluid flow from tubing 15 to pipe 26 or vice versa.

A wire line retrieving tool is then run in through tubing 15 and plug member 20 in landing recess 14' of releasable coupling assembly 14 is removed as shown in Fig. 8.

Lower zone B is now allowed to produce through the tubing and through the casing until the workover or drilling fluids are removed from the well bore with the fluid flow path being up through the tubing and also through the casing annulus C via side port 22 of nipple 21. After the casing and tubing has been cleared of workover fluid, a separation tool 27a, as shown in Fig. 9, is run in on a wire line and set in side port landing nipple 21. Separation tool 27a is slightly modified from that of separation tool 27 in that it is not of sufficient length to close off the side ports 22 but plugs off the bore of the tubing above the side port 22.

The port closing member 17 is now removed to open port 16. The well is now in condition to produce from the two zones A and B with the fluids from formation B flowing into the casing 11 below packer 12 through production tube 13, tubing section 25 and out through ports 22 in side port landing nipple 21 and up through the tubing casing annulus above packer 24. The production fluids from formation A flow into annulus C of casing 11 through pipe conduit 26 and then into the tubing by way of the port 16 above the separation tool 27a.

It will be seen that during all of the various steps of the present method the fluids from each of the formations A and B have been kept completely separated one from the other even at the instant of perforation of the different formations.

At times it may be desirable to perforate only the upper zone with a lower casing pressure than formation pressure. This is shown in Fig. 10 which is somewhat similar to the other Figures 1 through 9.

Referring to Fig. 10, the procedure is as follows. Prior to positioning the lower packer 12, the casing opposite the lower formation B is perforated with any type of perforator desired which is lowered through the casing.

After the lower formation B is perforated (the production from which is held in check by the drilling mud in the casing), a packer 12 such as a Baker Model D retainer production packer described supra is then set in the casing between the formations A and B. The

4

equipment used in this step is practically identical with that shown in the previous Figures 5 through 9.

After the formation B has been perforated and the packer 12 set in the casing, the tubing string is then run back in the hole. The tubing string 15 is equipped practically the same as the previous figures with production tube 13 locked in packer 12 with its upper end extending above packer 12 and connected to extension pipe 25 by means of releasable coupling 14. The upper end of extension tube 25 is connected into the lower end of a packer 24 which is positioned within the casing 11 a substantial distance above formation A. The tubing above packer 24 has contained therein a side port landing nipple 21 provided with side ports 22 and the tubing is also provided with closable port 16 which fluidly communicates with elbow connection 18. Pipe conduit 26, as in the previous figures, is connected into elbow connection 18 and extends downwardly through packer 24 into the annulus C between packers 12 and 24.

After the assembly as shown in Fig. 10 is positioned, a plug 20 is run in on a wire line and landed in landing recess 14', thus plugging off the lower formation B from the tubing above releasable coupling 14. A separation tool 27 is then lowered by means of wire line and landed in side port landing nipple 21 to plug off the side ports 22 and also the central bore of the tubing. The equipment is at this time pressure checked on both the tubing and the casing sides to be sure that the packers and plug members are functioning properly. The separation tool is then removed and the tubing is swabbed to reduce the pressure within the tubing so that the pressure within the casing and tubing is less than the pressure of the formation which is to be perforated. After this differential pressure has been created, the upper assembly is unlatched at the releasable coupling assembly 14 and the assembly is raised enough to clear the upper zone. A gun perforator is then lowered through the tubing to a position in the casing adjacent the upper formation A and the casing perforated. The tubing gun is then removed and the assembly is again lowered and coupled together at the releasable coupling assembly 14. The upper zone is now in a condition for producing and is allowed to do so until all the adjacent casing and tubing is clear of workover fluids above packer 12.

At this time a port closing member 17 is run in by wire line and set in tubing 15 to close off the passage through pipe conduit 26. After the port closing member 17 has been placed, the bottom plug 20 in landing recess 14' is removed and the lower zone is allowed to produce through the tubing until it is clear of workover fluids such as drilling mud. After it is determined that the well is clear of workover fluids, a separation tool such as 27a is run in by wire line and landed in landing nipple 21. This separation tool, as previously described, closes the bore of the tubing at this point but leaves the ports 22 open. The closure member 17 adjacent port 16 is then removed and the zones are allowed to produce separately with the flow paths from each zone being identical with those previously described with regard to Fig. 9.

It will be seen from the above disclosure that the objects as previously set out in the specification have been accomplished, that is, the fluids from each of the formations have been entirely isolated at all times from each other even on the instant of perforating the casing adjacent each of the formations. It will also be seen that a differential pressure has been created between the casing and formation pressure previous to perforating so that the production fluids from the formations A and B immediately flow into the casing upon perforating.

The present apparatus and method is quite advantageous in several respects. In creating a lower pressure in the casing compared to that of formation pressure, the producing fluids from the formation flow immediately into the casing upon perforating. This eliminates the contamination of the formation by drilling fluids and the

like which heretofore upon perforation of the formation, allowed contaminating fluids from the casing to enter the perforated formation. At times when contaminating fluids are allowed to saturate the productive formation, it takes some time to completely clear the formation before uncontaminated production is achieved.

The present invention is also advantageous in that there is sometimes a large variation between the physical make-up of the productive fluid from the different formations. With the present method these producing fluids are at all times kept isolated from each other. The invention also affords accurate and positive accounting of the production from each of the producing formations.

Although the present invention has disclosed a certain arrangement of apparatus to accomplish the present method, it will be obvious that other such arrangements may be used without diverting from the scope of the present invention.

Having fully disclosed and illustrated the apparatus and method of the present invention, what I claim is:

1. A method for completing a cased well filled with a workover fluid and containing a tubing string positioned therein and traversing a plurality of hydrocarbon productive formations comprising the steps of reducing the pressure in the casing below the pressure of a first formation by lowering the level of said workover fluid, perforating said first formation, producing from said first formation, isolating said first formation from a second of said formations, filling the tubing with workover fluid, reducing the pressure in the casing below the pressure of said second formation by lowering the level of workover fluid in the tubing, perforating said second formation, and simultaneously producing from said second formation and said first formation through separate paths of flow to the earth's surface whereby fluids from said formation are isolated and contamination of said formations is eliminated.

2. A method for completing a cased well filled with a workover fluid and traversing a plurality of productive formations with a tubing string arranged in the casing with its lower end positioned immediately above the lower formation, comprising the steps of isolating the lower formation from an upper formation, removing sufficient workover fluid from the well to reduce the hydrostatic pressure in the well to less than lower formation pressure, perforating said lower formation, producing fluids from said lower formation, isolating said lower formation and the producing fluids therefrom from an upper formation, filling the tubing with workover fluid, moving the tubing and positioning its lower end immediately above the upper formation, removing sufficient workover fluid from the tubing to reduce the hydrostatic pressure in the well to less than upper formation pressure, perforating said upper formation, producing fluids simultaneously from said upper and lower formations through separate paths of flow and maintaining isolation of said fluids one from the other whereby contamination of said formations is eliminated.

3. A method for completing a cased well filled with a workover fluid and traversing a plurality of productive formations comprising the steps of perforating a first selected formation, positioning a tubing string in said casing with its lower end just above said first selected formation, isolating said first selected formation from a second selected formation, moving the tubing and positioning its lower end immediately above the second selected formation, removing sufficient workover fluid from the tubing to reduce the hydrostatic pressure in the well

to less than the pressure of said second selected formation, perforating said second selected formation, separately and simultaneously producing fluids from said first and second selected formations while maintaining at all times isolation of the fluids of each of said formations one from the other.

4. A method for completing a cased well filled with a workover fluid and traversing a plurality of productive formations and having a tubing positioned therein with its lower end just above a first selected formation comprising the steps of removing sufficient workover fluid from the well to reduce the hydrostatic pressure in the well to less than the pressure of said first selected formation, perforating said first selected formation, completely isolating said first selected formation and the fluids therefrom, filling the tubing with workover fluid, moving the tubing and positioning its lower end immediately above a second selected formation, removing sufficient workover fluid from the tubing to reduce the hydrostatic pressure in the well to less than the pressure of said selected second formation, perforating said second selected formation, producing fluids from said second selected formation while maintaining isolation of said first formation and its fluids and simultaneously producing isolated fluids from each of said selected formations whereby contamination of said formations is eliminated.

5. Apparatus for completing a cased well penetrating a plurality of productive formations comprising, in combination, a tubing arranged in said cased well with its lower end positioned above a lower formation, first and second spaced apart packing means arranged on said tubing for closing off the tubing-casing annulus, said first packing means being positioned between said lower formation and an upper formation, said second packing means being positioned above said upper formation, a first closable port in said tubing positioned above said second packing means, a fluid conduit connected to the exterior of said tubing above and extending through said second packing means whereby fluid communication is provided between the tubing and the casing annulus below said second packing means, at least one second closable port in said tubing between said first closable port and said second packing means, and a retrievable tubing bore closure member arranged in said tubing between said first and second closable ports, whereby isolated communication is provided to each of said formations, said tubing having a full opening bore on removal of said bore closure means.

6. An apparatus in accordance with claim 5 in which said tubing is provided with a releasable coupling member positioned between said first and second packing means whereby said tubing can be disjointed and the portion thereof above the coupling member is movable vertically.

7. An apparatus in accordance with claim 6 in which the lower end of said tubing below said releasable coupling means is provided with means for receiving a tubing plug whereby said lower formation is isolated upon placement of said plug member.

References Cited in the file of this patent

UNITED STATES PATENTS

1,834,946	Halliburton	Dec. 8, 1931
2,368,428	Saurenman	Jan. 30, 1945
2,649,916	Brown	Aug. 25, 1953
2,745,497	Dale et al.	May 15, 1956
2,760,578	Tausch	Aug. 28, 1956
2,776,013	Tausch	Jan. 1, 1957
2,785,754	True	Mar. 19, 1957