United States Patent [19]

Lanmon, II

[11] **3,724,550**

[45] **Apr. 3, 1973**

[54] **METHODS FOR RECOMPLETING WELLS**

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[22] Filed: **Sept. 28, 1971**

[21] Appl. No.: **184,419**

[52] **U.S. Cl.** **166/285,** 166/297, 166/313, 166/315

[51] **Int. Cl.** **E21b 33/00**

[58] **Field of Search**.....166/285, 297, 298, 313, 315

[56] **References Cited**

UNITED STATES PATENTS

2,935,131	5/1960	McCune	166/297
2,164,266	6/1939	Armentrout et al.	166/285
3,460,624	8/1969	Aitken et al.	166/285

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[57] **ABSTRACT**

As a preferred mode of the new and improved methods disclosed herein for recompleting a production well without removing an existing production string, an intermediate length of the production tubing is severed at spaced locations above the production packer and adjacent to a selected earth formation from which new production is to be obtained. Once the severed tubing section drops into the well bore, a perforator is lowered through the tubing string into the cleared well bore interval and actuated for gaining communication with the selected formation. A so-called "through-tubing bridge plug" having an unblocked tubular mandrel carrying an expansible sealing member is then lowered through the tubing string and operated to position the expanded sealing member in the cleared interval above the new perforations. The upper end of the mandrel is extended upwardly into and packed-off in a suitable manner within the lower end of the tubing string.

9 Claims, 4 Drawing Figures

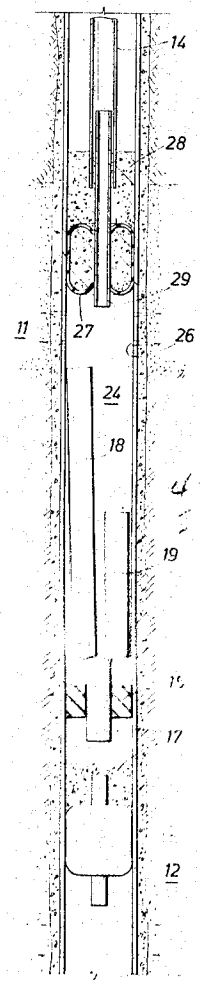


FIG. 1

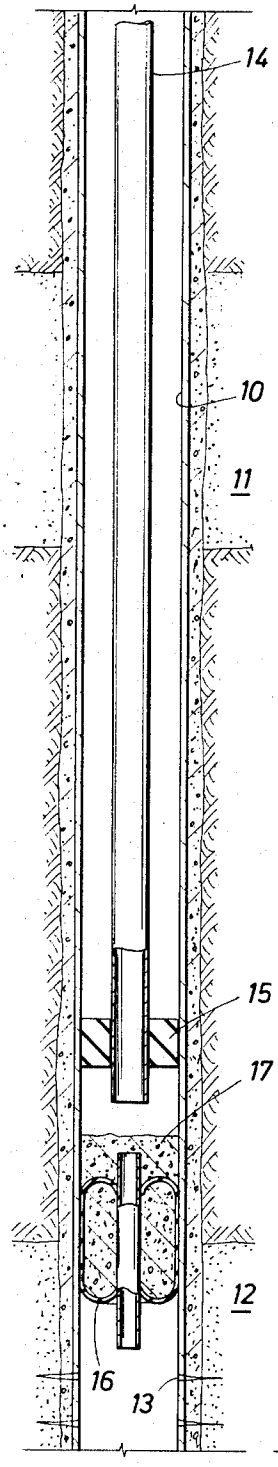


FIG. 2

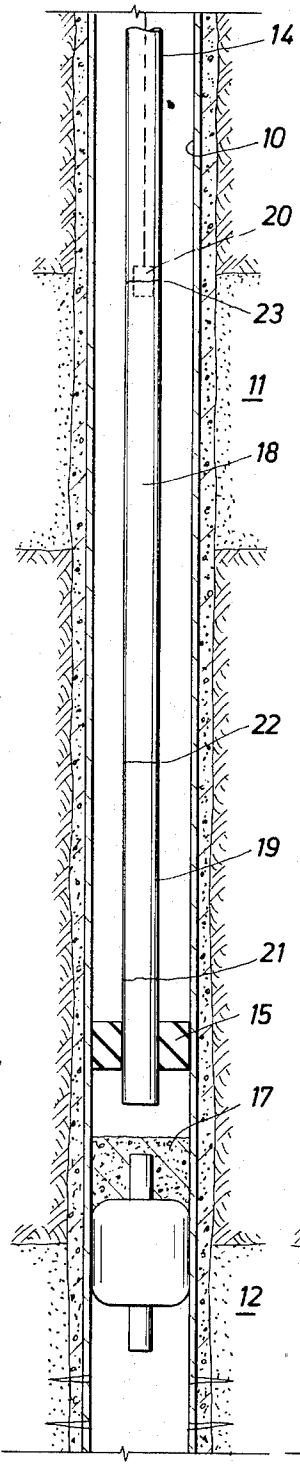


FIG. 3

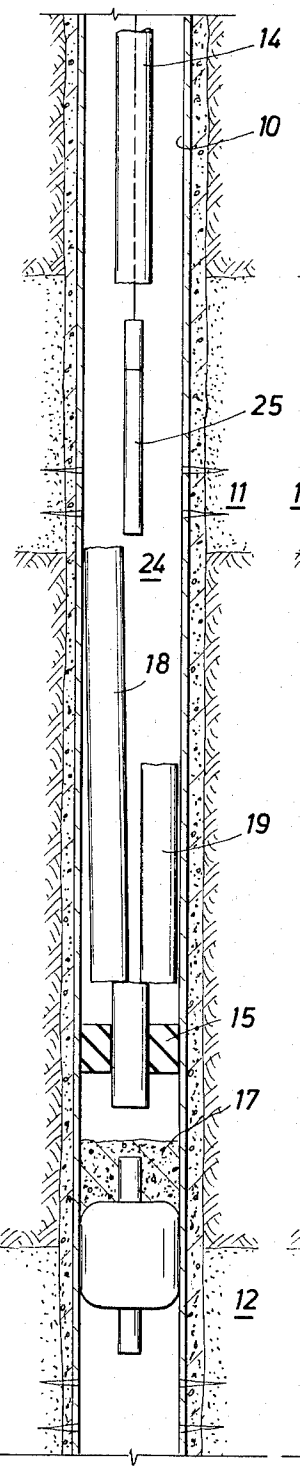
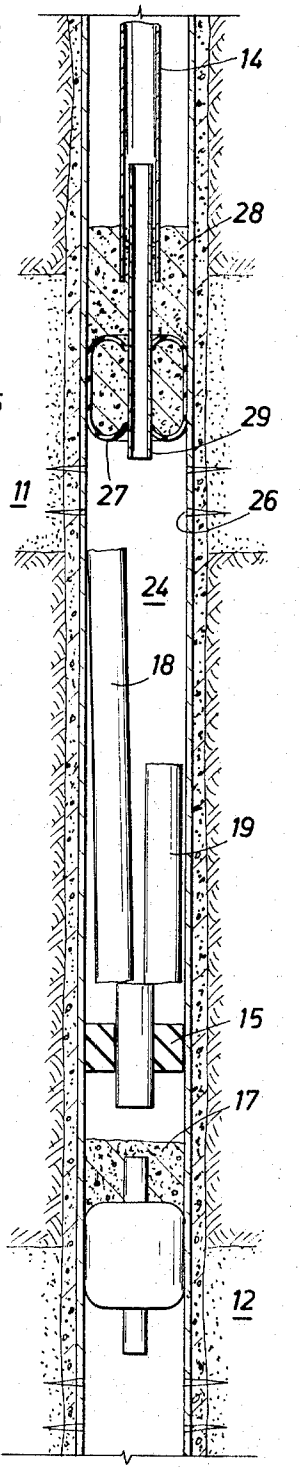


FIG. 4



METHODS FOR RECOMPLETING WELLS

It is, of course, not at all uncommon for the flow of connate fluids from an existing oil well to become so minimal that further production from the well is unprofitable. If there is only a single formation interval from which this production has been obtained, the well must either be plugged and abandoned or appropriately treated or stimulated for at least partially restoring the well to an economical production level. It will be appreciated, however, that in many instances it will be known that the well bore penetrates other unproduced formation intervals from which production could possibly be obtained. Where such unproduced formations are above the now-depleted formation, it has been the usual practice heretofore to remove the existing production string, complete one or more of these previously-untapped formations, and then reinstall a suitable production string. In many situations, however, the potential production from these formations is possibly so limited that it is presently considered uneconomical to recomplete the well to produce these untapped formations. As a result, there are many wells which remain idle today even though they penetrate untapped formation intervals of possibly marginal production capabilities.

Accordingly, it is an object of the present invention to provide new and improved methods for profitably recompleting existing production wells to obtain production from untapped formations lying above previously-completed formation intervals.

This and other objects of the present invention are attained by new and improved recompletion techniques which do not require the removal of the existing production string in order to obtain production from untapped formations lying above previously-completed formation intervals. To practice the new and improved methods of the present invention, an unrestrained intermediate portion of the existing production tubing is severed from the production string adjacent to a selected previously-isolated earth formation for dropping this severed portion into the well bore below the untapped formation to provide an accessible well bore interval adjacent to this formation. Thereafter, a perforator is lowered through the production string and positioned in the accessible well bore interval for perforating the selected formation. The lower end of the production tubing is then packed-off in the well bore above the newly-perforated formation to isolate this formation from the well bore thereabove.

The novel features of the present invention are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may be best understood by way of the following description of exemplary methods employing the principles of the invention as illustrated in the accompanying drawings, in which:

FIGS. 1–4 schematically illustrate the successive steps of a preferred mode for practicing the methods of the present invention.

Turning now to FIG. 1, there is seen a typical cased well bore 10 which penetrates an untapped potentially-producible earth formation 11 as well as a lower formation 12 which is communicated with the well bore by one or more previously-produced perforations, as at 13. As is customary, a string of small-diameter production tubing 14 is suspended in the well bore 10 and has its lower end coupled to a typical production packer 15 set above the perforations 13 for isolating the formation 12 from the well bore above the packer.

Those skilled in the art, will, of course, appreciate that when the well bore 10 was initially completed, there are many reasons why it would not have been desirable at that time to produce the upper formation 11 and production was obtained from only the lower formation 12. In any event, for purposes of explaining the present invention, let it be assumed that for some reason it is no longer desirable to obtain production from the lower formation 12; and it is now desired to complete the upper formation 11 for subsequent production. Accordingly, in the preferred mode of practicing the present invention in those situations where it is desired to permanently discontinue production from the lower earth formation 12, the lower formation is first isolated from the remainder of the well bore thereabove. Although a typical tubing plug (not shown) could be set in the production tubing 14 in the vicinity of the packer 15 for sealing the lower end of the tubing and the production packer relied upon to continue blocking communication through the annulus around the tubing above the packer, it is preferred to employ a so-called "through-tubing bridge plug" 16 (such as those shown in U.S. Pat. No. 3,460,618, U.S. Pat. No. 3,460,624 or U.S. Pat. No. 3,460,625) which is initially lowered through the production string and set in the well bore 10 above the perforations 13. Then, as described in these patents, a supply of cementitious material, as at 17, is deposited on top of the bridge plug 16 for assuring the total blockage of all fluid communication between the earth formation 12 and the remainder of the well bore 10 thereabove. It should be understood, however, that insofar as the practice of the new and improved methods of the present invention is concerned, the plugging of the well bore 10 at this lower point can be omitted if there is some reason for continuing communication with the lower formation 12.

It will be appreciated from viewing FIG. 1 that with the tubing string 14 in its depicted position, there is initially no fluid communication between the earth formation 11 and the internal bore of the tubing string. Accordingly, as best seen in FIG. 2, in the practice of the present invention, it is necessary to first remove a laterally unrestrained intermediate section of the production tubing 14 between a first location near or above the upper limit of the formation 11 and a second location at least adjacent to or preferably somewhat below the lower limit of the earth formation 11 for clearing this interval of the well bore 10 which is opposite the higher formation. Those skilled in the art will, of course, appreciate that there are various commercially-available devices which may be readily employed for cutting the production tubing 14 while it is positioned in the well bore 10. For instance, chemical or mechanical tubing cutters such as those illustrated on Pages 634 and 716 of the "1970–71 Composite Catalog of Oil Field Equipment & Services" may be utilized for the purposes of the present invention. Alternatively, explosive tubing cutters such as the one shown in U.S. Pat. No. 3,245,485 may be readily employed.

Although it is essential to sever the tubing string **14** at only two spaced locations, it is preferred in the practice of the present invention to sever the tubing at three or more selected locations for dividing the intermediate section of tubing which is to be removed from the production string into two or more separate portions, as at **18** and **19**. Thus, as illustrated in FIG. **2**, one or more tubing cutters, as at **20**, are lowered from the surface through the production string and selectively actuated for severing the tubing string **14** at three spaced locations **21–23**. If, for example, the aforementioned explosive tubing cutters are to be employed, three of these cutters **20** are either successively lowered in separate runs or they are tandemly joined and lowered as a unit into the tubing string **14** for selective actuation at their respective positions to produce the desired cuts **21–23**. In either case, to avoid the possibility of sticking the tubing cutter **20**, it is preferred to make the lowermost cut **21** first and then move the cutting tool upwardly in the tubing string **14** so that the cutting device will not have to be moved past a previously-made cut. Accordingly, as illustrated in FIG. **2**, the first two cuts **21** and **22** have already been made and the cutter **20** is now in position for producing the third cut **23**. It should also be noted that the uppermost cut **23** is preferably situated so as to place it no lower than about the upper limit of the earth formation **11**. Furthermore, the intermediate cut **22** was preferably made a short distance below the lower limit of the earth formation **11**; and the lower cut **21** is well below that. Thus, the cuts **22** and **23** are located in such a manner that the intermediate tubing section **18** which is to be removed from the immediate vicinity of the earth formation **11** will be of sufficient length that, when it falls further into the well bore **10**, its upper end will be no higher than about the lower limit of the higher earth formation **11**. The location of the lowermost cut **21** is not particularly critical so long as the lower tubing section **19** between the cuts **21** and **22** is of sufficient length to insure that the longer upper section **18** can fall free of the production tubing **14** and come to rest below the lower limit of the earth formation **11** so as to provide an accessible or cleared interval in the well bore **10**.

As seen in FIG. **3**, once the severed tubing sections **18** and **19** have been freed from the upper portion of the tubing string **14**, they will come to rest in positions such as illustrated to leave a cleared interval **24** in the well bore **10**. It will be appreciated that, in many instances, the detonation forces developed by explosive tubing cutters as at **20** will be adequate for displacing the severed sections **18** and **19** so as to drop the longer section below the accessible interval **24** of the well bore **10**. On the other hand, should the longer severed section **18** fail to fall free of the tubing string **14** when the cut **23** is made, the severed section can be dislodged from its initial position by various techniques. For example, a so-called "string shot" (not shown) which is typically comprised of a bundled detonating cord can be lowered into the tubing string **14** and actuated while it is positioned in the longer severed section **18**. The resulting explosive forces will, of course, ordinarily jar the severed sections **18** and **19** sufficiently to displace them from the tubing string **14** for clearing the accessible well bore interval **24**.

Accordingly, as illustrated in FIG. **3**, once it has been determined that the severed tubing sections **18** and **29** have been displaced, a typical perforator **25** such as shown in U.S. Pat. No. 3,048,102 is lowered through the tubing string **14** and out its freshly-severed end for positioning the perforator in the cleared well bore interval **24** immediately adjacent the earth formation **11**. Thereafter, the perforator **25** is actuated for producing one or more perforations, as at **26**, to establish fluid communication between the earth formation **11** and the cleared interval **24** of the well bore **10**.

Those skilled in the art will, of course, appreciate that typical completion practices require that the lower end of a production string be packed-off or sealed in some manner for isolating the earth formations below the string from the annulus thereabove. Accordingly, in the preferred manner of practicing the present invention, a through-tubing bridge plug **27** similar to the plug **16** is lowered through the tubing string **14** and positioned as illustrated in FIG. **4**. It will be appreciated, however, that the through-tubing plug **27** must be modified to provide permanent fluid communication between the accessible portion **24** of the well bore **10** and the tubing string **14**. For example, the bridge plug **27** may be the one illustrated in U.S. Pat. No. 3,578,083 but with its valve 87 and the associated clock-actuated valve operator 96 removed from the lower end of the tubular mandrel 70 so that its tubular bore 83 will remain open to provide fluid communication between the cleared well bore interval **24** and the lower end of the tubing string **14**. Accordingly, once the through-tubing plug **27** is positioned as illustrated in FIG. **4**, a supply of cementitious or other hardenable material is discharged from the plug's setting tool (not shown) (or, if desired, from the surface) and deposited as illustrated at **28**. It will be noted that by setting the plug **27** to leave the upper portion of its mandrel **29** extending upwardly into the lower end of the tubing string **14**, when the cementitious material **28** is deposited on top of the expanded bridge plug the lower end of the tubing string will be sealed off from the accessible portion **24** of the well bore **10** and the interior of the tubular mandrel will provide a permanent fluid passage between the earth formation **11** and the production string.

It will, of course, be appreciated that there will be some instances where elongation or contraction of the tubing string **14** will occur. Thus, if the cementitious material **28** is the sole means for sealing off the lower end of the tubing string **14**, it may be possible for severe or continuous vertical movement of the tubing string to ultimately disrupt the fluid seal between this cementitious material and the tubing string. Accordingly, as an alternative mode for practicing the present invention, the mandrel **29** of the through-tubing bridge plug **27** can be packed-off in relation to the tubing string **14** by setting a full-bore retainer production packer (not shown) such as the Model FA shown on page 491 of the aforementioned Composite Catalog in the lower end of the tubing string after the cementitious material **28** is deposited. In this situation, this full-bore packer would be set in the tubing string **14** and coaxially positioned around the upper end of the mandrel **29**. Suitable seals arranged on either the exterior of the mandrel or internal bore of the packer would provide a slidable

seal between the packer body and the mandrel. This would, of course, make it unnecessary to deposit the cementitious material **28** to a depth sufficient to cover the lower end of the tubing string **14**.

Accordingly, it will be appreciated that the present invention has provided new and improved methods for recompleting previously-completed well bores penetrating one or more potentially-producible untapped formations. By practicing the present invention, it is no longer necessary to remove an existing production string for gaining access to a previously-isolated formation and then isolating this formation interval from the remainder of the well bore thereabove. Where lower formations are to be abandoned, the new and improved methods disclosed herein further provide for isolating these formations before the previously-isolated formations are completed.

While only a particular mode of practicing the invention has been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects; and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. A method for completing a well bore without removing a string of production tubing arranged therein and having a lower portion thereof isolated from fluid communication with an untapped earth formation penetrated by said well bore, said method comprising the steps of: severing said lower tubing portion from said string of production tubing in said well bore for separating said lower tubing portion from the upper portion of said string of production tubing to provide an accessible interval in said well bore adjacent to said earth formation; perforating said earth formation for establishing fluid communication between said upper tubing portion and said earth formation; and packing-off said upper tubing portion in relation to said well bore above said earth formation for isolating said accessible well bore interval from the remainder of said well bore thereabove.

2. The method of claim **1** wherein said well bore further penetrates a lower earth formation below said untapped formation and including the further step of: packing-off said well bore below said untapped formation for isolating said lower formation from said untapped formation.

3. The method of claim **1** wherein said well bore further penetrates a lower earth formation below said untapped formation and including the further step of: before said lower tubing portion is severed from said string of production tubing, packing-off said well bore below said untapped formation for isolating said lower formation from said untapped formation.

4. A method for completing a well bore without removing therefrom a string of production tubing having a lower portion coupled to a packer and an intermediate portion situated above said packer and isolated from fluid communication with a previously-untapped earth formation penetrated by said well bore, said method comprising the steps of: severing said intermediate portion of said tubing string from said lower portion of said tubing string and the upper portion of said tubing string for providing an accessible interval in said well bore above said packer and adjacent to said earth formation; lowering a perforator through said upper portion of said tubing string and into said accessible well bore interval for establishing fluid communication between said earth formation and said upper portion of said tubing string; and packing-off said upper portion of said tubing string above said accessible well bore interval for isolating said earth formation from the remainder of said well bore thereabove.

5. The method of claim **4** wherein the last step thereof is performed by lowering an expansible sealing member coaxially mounted around an upright tubular body through said upper portion of said tubing string; and expanding said sealing member in said accessible well bore interval with said tubular body extending upwardly into the lower end of said upper portion of said tubing string for providing fluid communication between said earth formation and said upper portion of said tubing string.

6. The method of claim **4** including the further step of: before said intermediate portion of said tubing string is severed from upper and lower portions of said tubing string, packing-off said well bore below said earth formation for isolating said earth formation from the remainder of said well bore therebelow.

7. The method of claim **4** wherein the first step thereof is performed by cutting said intermediate portion of said tubing string from said lower portion of said tubing string; and cutting said intermediate portion of said tubing string from said upper portion of said tubing string for freeing said intermediate portion of said tubing string to fall into said well bore below said accessible well bore interval.

8. A method for completing a well bore without removing therefrom a string of production tubing having a lower portion coupled to a packer and an intermediate portion situated above said packer and isolated from fluid communication with a previously-untapped earth formation penetrated by said well bore, said method comprising the steps of: lowering at least one cutting device into said tubing string and successively actuating said cutting device at spaced locations therein for severing said intermediate portion of said tubing string from said upper and lower portions thereof to drop said severed intermediate portion into said well bore onto said packer and provide an accessible interval in said well bore adjacent to said earth formation; lowering at least one perforator through said upper portion of said tubing string and actuating said perforator in said accessible well bore interval for establishing fluid communication with said earth formation; lowering a through-tubing bridge plug having an expansible sealing member mounted around an upright tubular body through said upper portion of said tubing string and expanding said sealing member in said accessible well bore interval with said tubular body extending upwardly into the lower end of said upper portion of said tubing string for isolating said accessible well bore interval from the remainder of the well bore thereabove; and sealing-off said tubular body within said lower end of said upper portion of said tubing string for blocking fluid communication between said upper portion of said tubing string and the remainder of said well bore above said sealing member.

9. The method of claim 8 including the further step of: before said intermediate portion of said tubing string is severed from upper and lower portions of said tubing string, packing-off said well bore below said earth formation for isolating said earth formation from the remainder of said well bore therebelow.

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