

April 11, 1967

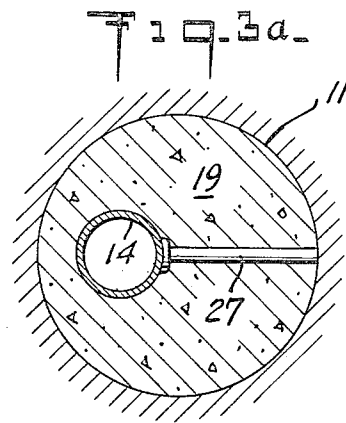
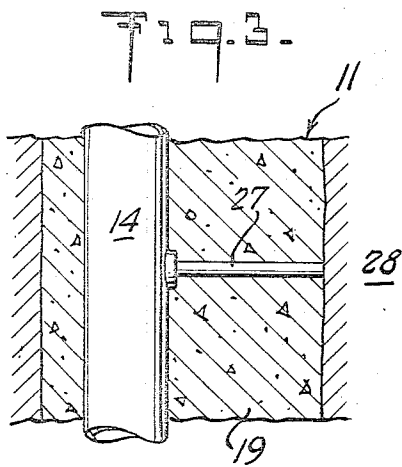
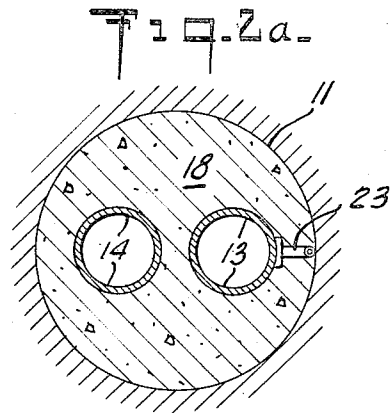
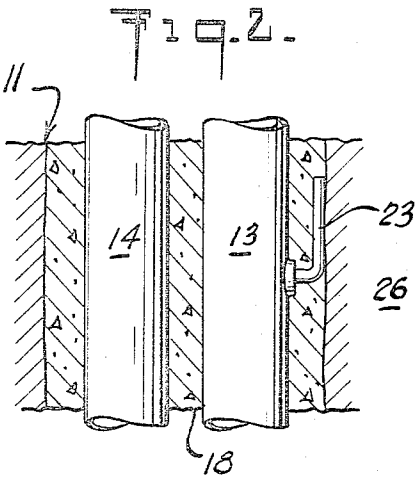
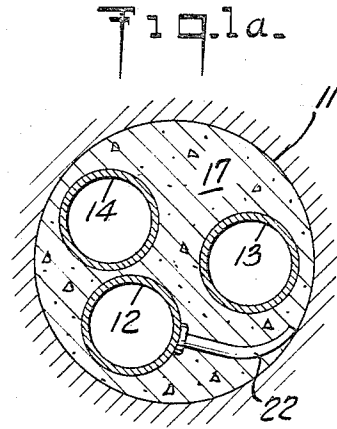
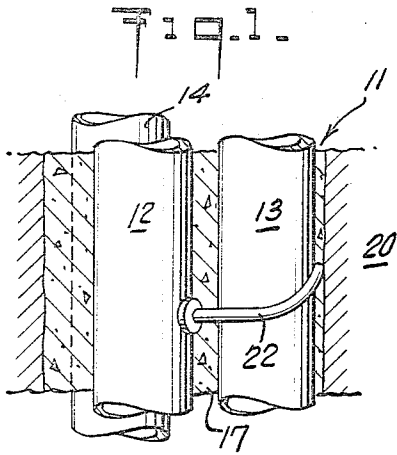
R. H. WIDMYER

3,313,351

PREPERFORATION APPARATUS FOR WELLS

Filed July 1, 1964

2 Sheets-Sheet 1



April 11, 1967

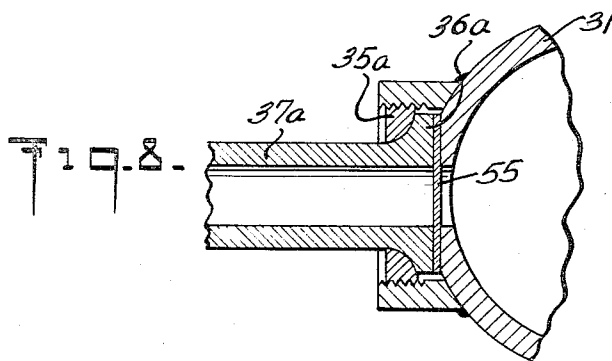
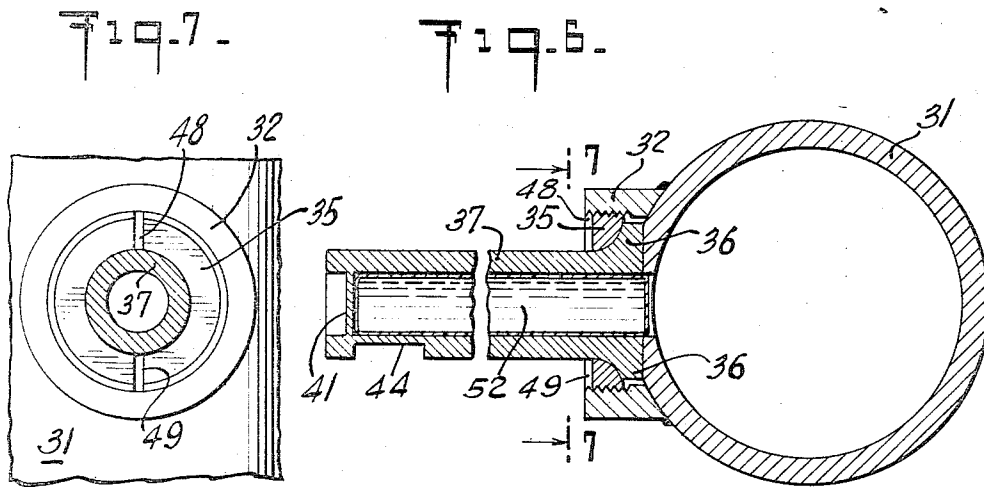
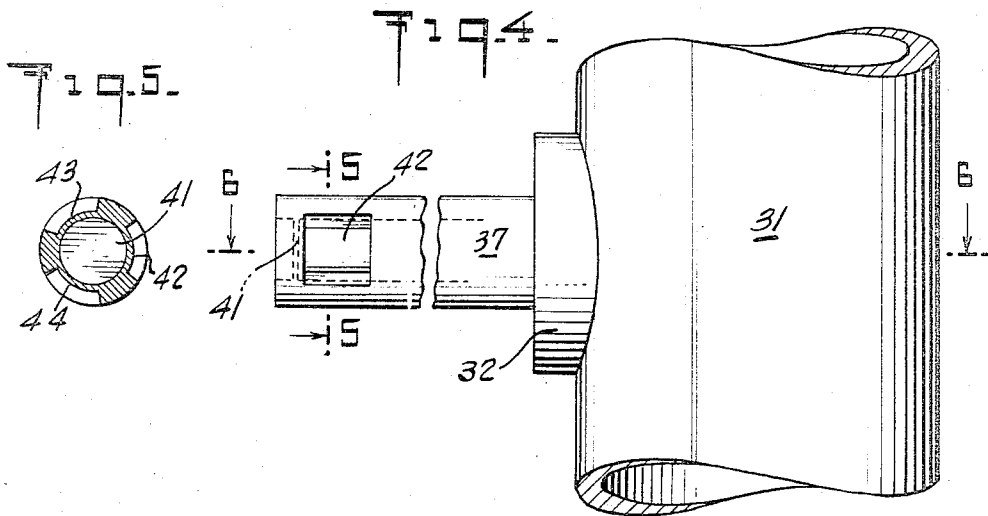
R. H. WIDMYER

3,313,351

PREPERFORATION APPARATUS FOR WELLS

Filed July 1, 1964

2 Sheets-Sheet 2



1

3,313,351

PREPERFORATION APPARATUS FOR WELLS

Richard H. Widmyer, Houston, Tex., assignor to Texaco Inc., New York, N.Y., a corporation of Delaware
 Filed July 1, 1964, Ser. No. 379,660
 4 Claims. (Cl. 166—100)

This invention is concerned with apparatus and a method for preperforation of oil and gas wells, particularly wherein multiple tubing is employed in uncased wells.

In operations involving multiple tubing completions, a particular problem in connection with perforating at different levels or strata locations, has been that relating to the requirement of only perforating through one of the tubes at a given level. For this reason the prior techniques of perforating in the case of multiple completion holes were expensive, on account of the need for employing oriented type of perforation apparatus. Furthermore, the perforations thus created lacked a desirable size of passageway between the formation and the tubing that was perforated.

Consequently, it is an object of this invention to provide apparatus that is applicable to multiple tubing completion wells, and provides preperforation apparatus that eliminates the need for any "perforating gun" or similar type of perforation, following cementing of the tubing in place.

Another object of the invention is to provide preperforation apparatus that is applicable to wells for allowing simple hydraulic pressure application, following the cementing of tubing or casing into a well, to be employed for opening perforation passageways through such tubing or casing and the cementing surrounding the tubing in the well.

Another object is to provide apparatus comprising flexible radial conduits attached to well tubing for being located down hole at a location to be perforated. These conduits are connected to the interior of the tubing, and have closed ends with thin-walled sections near the ends. These conduits are long enough to at least reach the sides of the well. Then after the tubing is cemented in place at the perforation location, hydraulic pressure may be increased sufficiently to burst the thin-walled sections adjacent to the sides of the well with enough force to cause free passage for production fluids.

Briefly, the invention concerns preperforation apparatus for wells, which comprises in combination some tubing for use in uncased multiple completion operations, and radial flexible conduit means attached to said tubing at a predetermined location therealong. The said flexible conduit means is hollow and connected in open communication with the inside of said tubing. In addition there is thin-walled closure means at the extremity of the flexible tube means, for perforation under pressure following cementing of said tubing. In addition, there is means for excluding cement from the interior of said flexible tube means during cementing operation prior to said perforation.

The foregoing and other objects and benefits of the invention will be more fully set forth below in connection with the best mode contemplated by the inventor of carrying out the invention, and in connection with which there are illustrations provided in the drawings, wherein;

FIGURE 1 is a fragmentary cross sectional schematic

2

showing of a well, showing a multiple tubing completion cemented in place in the well at a producing formation;

FIGURE 1a is a transverse cross section view looking down the hole at the location of FIGURE 1;

5 FIGURE 2 is a fragmentary cross sectional schematic showing of a well, and showing a multiple tubing completion similar to FIGURE 1, but farther down hole and with only two tubes at this location therein;

10 FIGURE 2a is a transverse cross section view looking down the hole at the location of FIGURE 2;

15 FIGURE 3 is a similar fragmentary cross sectional schematic showing of a well as shown in FIGURES 1 and 2, but still farther down hole and showing one tubing completion cemented in place in the well with a single representative preperforation radial conduit attached in accordance with the invention;

FIGURE 3a is a transverse cross section view of looking down the hole at the location of FIGURE 3;

20 FIGURE 4 is an enlarged fragmentary elevation, showing a portion of tubing such as that illustrated in FIGURES 1, 2 and 3 with a flexible conduit structure attached thereto in accordance with the invention;

25 FIGURE 5 is a transverse cross section taken along the lines 5—5 of FIGURE 4, looking in the direction of the arrows;

FIGURE 6 is a cross section taken along the lines 6—6 of FIGURE 4 and looking in the direction of the arrows;

30 FIGURE 7 is a transverse cross section taken along the lines 7—7 of FIGURE 6, looking in the direction of the arrows; and,

FIGURE 8 is a fragmentary cross section similar to that of FIGURE 6 but showing a modification of that structure.

35 Heretofore in multiple completions of wells where it has been desired to provide connection between a given producing formation and only one of a plurality of tubings or casings set in the well, the technique employed was quite expensive and difficult. In addition, it had the drawbacks of any standard perforation type connection to a formation. The principal one of which involves the relatively small size passageways that are created through the cement around the tubing and into the formation.

40 By employing preperforation apparatus in accordance with this invention, large sized passageways of any feasible diameter may be provided for creating maximum flow passage between the formation surrounding the tubing and the interior passage of the tubing at that location.

45 Referring to FIGURES 1-3 and 1a-3a, it is pointed out that there is illustrated a multiple completion at three different levels of the hole, with apparatus according to this invention employed at each level to provide for large diameter perforation connections between the formation and given ones of the tubings that are set in the hole. It will be appreciated that whereas only one of the preperforation flexible conduit structures, is illustrated at each location for simplicity of the showing; there would be a plurality of these elements employed. This would create maximum cross section area connection between the producing formation and the tubing to which such formation is connected.

50 In FIGURE 1 there is illustrated a section of well 11 having a multiple completion therein with three strings of tubing 12, 13, and 14. These tubing strings are cemented in place at each of the producing formations or

other formations of interest so that they are surrounded by cement 17 at the location of the FIGURE 1 illustration, and similarly by cement 18 at the FIGURE 2 location and likewise cement 19 at the FIGURE 3 location. The producing formation at the FIGURE 1 location may be designated by a reference number 20. The FIGURE 1 illustration shows a flexible preperforation conduit or tube 22 that is attached to the production tube 12 of the three multiple tubing strings in the well 11. It will be appreciated that while there is shown only one such preperforation tube 22 connected to the production tube 12, actually there would be in practice a plurality of such preperforation tubes located circumferentially spaced, as well as longitudinally spaced from one another. These would be all connected to the production tube 12 for providing passageways for production flow from the surrounding formation at this location, through the hole walls of well 11 to the interior of tube 12.

It will be appreciated that the preperforation conduits located at the predetermined level in the well (exemplified by preperforation tube 22) will flex but tend to maintain contact with the walls of the well as the tubing is set. This means that they can and will bend around the other tubing strings, e.g., 13 and 14, and consequently will be in a position to provide production fluid passageways around the entire circumference of the well at the desired level.

In FIGURE 2 there is illustrated a similar flexible preperforation conduit member or tube 23. This preperforation tube is connected to the production tube 13 at the location of a formation 26 and where the cement 18 is located in the hole 11. Here again, it will be appreciated that while there is illustrated only one of the flexible tubes 23 connected to production tube 13, there would be a plurality of such flexible tubes and these would be attached to production tube 13 in any feasible and convenient manner. They would be spaced both circumferentially around the tube 13 and longitudinally along same within the extent of the producing formation 26.

The same structure may be employed for connecting production tube 14 to a producing formation at another level in the hole 11, e.g., in the manner illustrated in FIGURE 3. In FIGURE 3 there is shown a flexible preperforation tube 27 that is attached to the production tube 14 and comes in contact with a surrounding formation 28. As before there would preferably be a plurality of the flexible tubes, like 27, connected to the production tube 14 and located spaced radially around the tube 14 as well as longitudinally therealong within the extent of the formation structure 28 surrounding the hole 11 at that level.

Details of the structure for a preferred embodiment of the flexible tube elements, e.g., flexible tubes 22, 23 and 27, are illustrated in FIGURES 4-7 and may be described as follows. A section of production tube or casing 31 is made up with structure for supporting each of the flexible preperforation conduits or tubes that are attached thereto. This structure preferably takes the form of a lug or short collar member 32 that is attached to the exterior of the production tube 31 in any feasible manner, e.g., by being welded thereto. This lug 32 is preferably constructed with internal threads as indicated in the FIGURE 6 showing. This will accommodate a retainer ring 35 that may be screwed down onto and create pressure contact with a flange 36 that is located on the inner end of a flexible tube or conduit member 37. The conduit 37 is of sufficient length to at least extend into contact (at the free end thereof) with the formation walls of the hole 11, e.g., as illustrated in FIGURE 3. Any feasible, sufficiently flexible, yet strong enough material may be employed in constructing the flexible tube 37. A preferred material would be plastic such as that known by the trademark Teflon.

Near the extremity of the flexible tube 37 there are a plurality of thin-walled areas or windows 41, 42, 43 and 44. These so-called windows will be constructed with a thickness sufficient to withstand the differentials of pressure involved in the cementing operations, but sufficiently thin to provide for a bursting of these sections upon application of sufficient hydraulic pressure (from within the production tube 31) to perforate and open up a passageway or passageways from the surrounding formation through the flexible tube 37 into the interior of the production tube 31.

It will be observed that by having structure, such as that illustrated in FIGURES 4-7, with four of the so-called windows at the extremity of the flexible tube 37; it is insured that at least one of the window sections 41-44 will be substantially in contact with the formation or walls of the hole 11, in order that upon application of breaking or perforation action from within the tube there will be an opening or free passageway created from the producing formation through the flexible conduit into the production tube or casing. This is exemplified by the showings in FIGURES 1, 2 and 3, where three different attitudes that the flexible tube may take are shown. In each case, at least one of the thin-walled areas will be directly in contact with the formation or wall of the hole 11 to which cement is applied.

The retainer ring 35 is constructed with a pair of radial grooves 48 and 49 which are provided so that the retainer ring may be tightened with the use of a spanner wrench.

It will be appreciated that it is standard practice for production tubing to be placed in a well with cementing at the particular formations of interest, i.e., where production has been found to exist. This is done so that unwanted fluids from the well bore may be excluded. It is this procedure which necessitates the perforation of a desired production tubing at such producing formation, in order to create passages for the flow of production fluid from the formation through the cement seal into the production tubing within the hole. In multiple completion wells, as explained above, the perforation becomes more difficult and costly where there is a multiple completion, since care must be taken to perforate only from a given production tube to the walls of the well. In other words, the perforation must be into the formation without also perforating any other of the multiple production tubes in the well. This invention provides for overcoming these difficulties by applying structure to the invention, to a given one of the production tubes located at a given producing formation of interest.

It is pointed out that this invention contemplates a novel method of completing wells with independent production from a plurality of production zones that are spaced vertically along the well bore. Among the steps that are involved in this method are the following.

Flexible conduit means are attached to individual ones of a plurality of casing or tubing strings with such conduit means located at the production zones of interest. These conduit means are closed at the free extremities thereof with an arrangement such that cementing pressure differentials will not have any effect but application of sufficient hydraulic pressure from within the conduit means will burst open a passageway to the bore hole wall. Also these conduit means extend far enough radially from the tubing string to ensure contact with the walls of the bore hole all the way around the tubing string.

The tubing strings are cemented into place at each of the production zones. This may be accomplished in a conventional manner by pumping cement slurry down through special tubing or directly through the string of tubing itself so as to flow out into the annular space surrounding the tubing strings within the bore hole.

During the foregoing cementing step, the cement will be excluded from the interior of the indicated conduit means.

5

After the cementing step has been completed and the cement has set in place in the bore hole so that extraneous fluids are kept away from the producing formations, the hydraulic pressure within the tubing string that has the flexible conduit means attached thereto will be increased to the point where the free end arrangement is burst. This then provides the desired free passages for flow of production fluid into the tubing string.

The foregoing step of excluding the cement from the interior of the conduit means, may take various specific forms. For example, the exclusion may be accomplished by filling the interior of the conduit means with an appropriate semi-solid substance, e.g., something including an acid that would resist contamination by the cement yet would be displaced out of the opening in the free end when it had burst.

Another specific procedure for carrying out the cement exclusion step is that of providing a cementing pressure resistant sealing disc across the opening which connects the interior of the conduit means with the inside of the tubing string.

APPARATUS OPERATION

To be sure that the manner in which the apparatus according to the invention operates is clearly set forth, its operation during a typical well completion will be described.

Also, two elements of apparatus not previously described will be mentioned here. First there is a fluid, semi-fluid or semi-solid material 52 (FIGURE 6) which fills the flexible tube member 37 in order to exclude the cement flowing through the production tube 31. Second, there is illustrated in FIGURE 8 an alternative provision for excluding such flowing cement. This takes the form of a seal disc 55 that is placed at the inner end of flexible tube member 37a so as to be held in place tightly by pressure from the flange 36a when the retainer ring 35a is tightened.

The cement 17, 18 and 19 will be applied around the preperforation flexible tube structure in order to create the desired formation seal within the hole. Thereafter, simply by a hydraulic pressure increase the desired perforation openings will be created for flow of production fluid therethrough. Such openings will be created when the one or more of the so-called windows 41-44 bursts under the hydraulic pressure and the action thus created penetrates the formation.

A preferred procedure for the application of the cement 17, 18 and 19 to the annulus of the hole 11 is for it to be applied by pumping down through that one of the production tubes which terminates just below the corresponding formation. Consequently, with structure according to this invention, some provision must be made for excluding the cement from entering the inner open end of the flexible tube members, e.g., 22, 23 and 27. One manner of excluding this cement is that illustrated in FIGURE 6 where there is shown the fluid or semi-fluid material 52 that fills the interior of the flexible tube 37 from one end to the other.

After the cementing has been completed and it is desired to open the passageways, i.e., to perforate by breaking the thin-walled or so-called window sections at the end of the flexible tubes, e.g., the tube 37; it is merely necessary to supply sufficient hydraulic pressure to the fluid within production tube 31 so that the window adjacent to the walls of the hole will be broken through (preferably by bursting action) and allow the material 52 to be forced out through the opening and dispersed into the formation. The foregoing is accomplished in such manner as to provide the desired passageway or opening for flow of production fluid thereafter, from the

6

formation through the flexible tube 37 and into the production tube 31.

It will be appreciated that the substance 52, if it is a fluid, must be contained by being encased in a thin capsule or the like (not shown). However, if the substance is semi-solid in nature it may be self-supporting and would act to provide the desired cement exclusion function by reason of its physical form. In any event it is preferred that the substance be one, such as an acid, that will act to resist contamination by the cement during cementing operation. Then thereafter during the perforation operation, it should act to clear undesired matter from the passageway created and thus aid in providing superior opening for flow of production fluid.

It is pointed out that in the case where a plurality of the flexible tubes such as the tube 37 are employed at a given location on the production tubing string, it will probably be necessary to employ some technique for plugging the first of the flexible tubes to burst the windows thereof, so that sufficient pressure will be maintained to accomplish bursting the windows of the remainder of the flexible tubes. One such technique could be that of using proper sized balls of a suitable material which would be introduced into the hydraulic fluid used to apply the bursting pressure. These would tend to plug the production tube end of each flexible tube as its window burst, and after reduction of the bursting pressure these balls would fall down in the production tube out of the way.

It will be appreciated from the foregoing description that this invention provides a superior structure and method that is relatively inexpensive to employ and that provides the added benefits of large diameter passageways for carrying production fluid from a producing zone into a production tubing. In addition, there is the provision of such passageways only into a given one of a multiple completion set of production tubes in a hole, while the effective distribution of these passageways is substantially around the entire circumference of the bore hole. The latter is without any "shadow" areas created by the other tubing strings of the multiple completion.

While preferred embodiments of the invention have been described above in considerable detail in accordance with the applicable statutes, this is not to be taken as in any way limiting the invention, but merely as being descriptive thereof.

I claim:

1. Preperforation apparatus for wells, comprising in combination tubing for use in uncased multiple completion operations, radial flexible conduit means attached to said tubing at a predetermined location therealong, said flexible conduit means being hollow and connected in open communication with the inside of said tubing, and thin-walled closure means at the extremity of said flexible tube means, said thin-walled closure means comprising a plurality of windows for causing at least one of said windows to be in contact with the walls of said well.

2. Preperforation apparatus according to claim 1 wherein said plurality of windows are four in number, one being on the end and the other three being spaced circumferentially around said conduit means adjacent to the end.

3. Preperforation apparatus for wells, comprising in combination tubing for use in uncased multiple completion operations, a plurality of radially attached flexible tubes having the interiors thereof connected to the interior of said tubing and being spaced both circumferentially and longitudinally on the tubing at a predetermined location therealong, four thin-walled windows on each of said flexible tubes located at the free extremity thereof, said flexible tubes being long enough to at least reach the walls of the well, and a substance having fluid characteristics filling each of said flexible tubes in order to exclude cement while it is pumped through said tubing.

4. In multiple completion well structure, a plurality of tubing strings each having preperforation apparatus according to claim 3.

References Cited by the Examiner

UNITED STATES PATENTS

2,018,285	10/1935	Schweitzer et al. ----	166—223
2,855,049	10/1958	Zandmer -----	166—100
2,886,109	5/1959	Yancey et al. -----	166—100
3,120,268	2/1964	Caldwell -----	166—100

OTHER REFERENCES

The Permeator: Pipeline to Greater Oil Recovery, The Oil and Gas Journal, October 26, 1959, vol. 57, No. 44, pp. 100-102, 104 and 105.

References Cited by the Applicant

UNITED STATES PATENTS

3,057,405	10/1962	Mallinger.
10 CHARLES E. O'CONNELL, <i>Primary Examiner.</i>		
JAMES A. LEPPINK, <i>Examiner.</i>		