July 14, 1959 T. B. McCULLOCH 2,894,587

PERMANENT WELL COMPLETION APPARATUS

Filed June 8, 1956

FIG. 1.

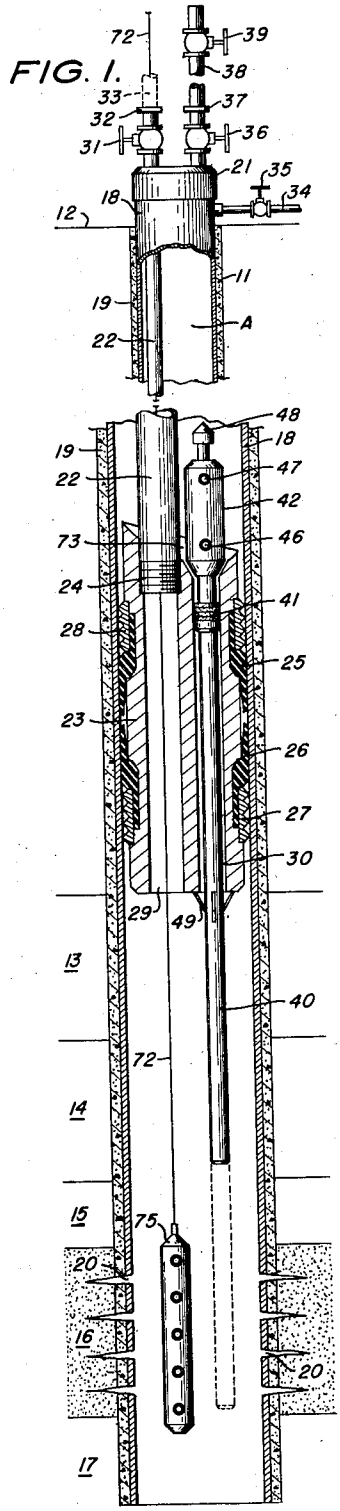


FIG. 2.

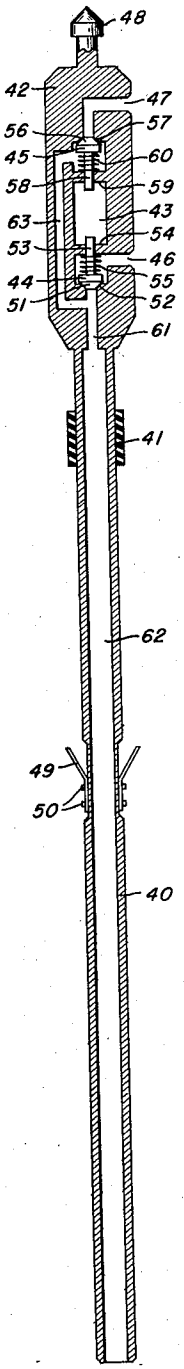


FIG. 3.

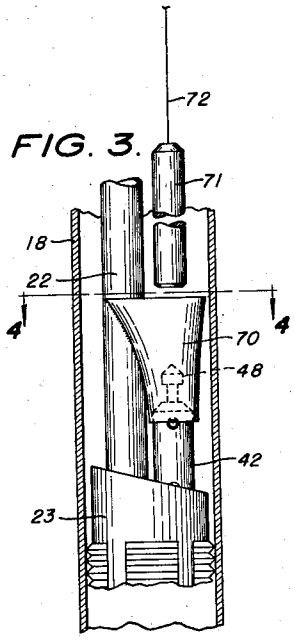


FIG. 4.

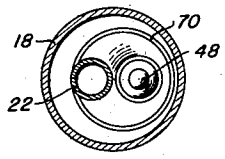
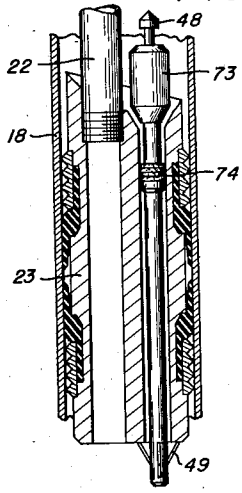


FIG. 5



INVENTOR.

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2,894,587

PERMANENT WELL COMPLETION APPARATUS

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9 Claims. (Cl. 166—183)

The present invention is directed to apparatus for completing a well. More particularly, the invention is directed to apparatus by way of which well completions and servicing operations may be conducted. In its more specific aspects, the invention is concerned with permanent well completion apparatus in which a tubing string is positioned with its lower end at a level above a plurality of productive subsurface earth strata.

The present invention may be briefly described as apparatus for use in a well having a casing arranged therein and provided with a tubing positioned in the casing with its lower open end at a level above a plurality of productive subsurface strata, intervals, zones, formations, sands, horizons and the like. The apparatus comprises a packing means arranged adjacent the lower end of the tubing to isolate the annulus between the tubing and the casing from the casing below the lower end of the tubing. A conduit means in the packing means provides a passageway through the packing means between the annulus and the casing below the packing means. Sealingly arranged in the passageway is a retrievable elongated tubular member which projects a substantial distance below the packing means, for example, to a level adjacent a hydrocarbon productive interval to provide fluid communication between the annulus and the casing below the packing means.

The conduit means may be provided with a guide member to allow the retrievable elongated tubular member to be placed properly in the passageway. This guide member may suitably be formed within and made part of the packer.

The tubular member is suitably provided with valve means openable under pressure imposed thereon and this valve means may comprise first and second valves, one of which is openable on imposing fluid pressure on the annulus and a second of which is openable on exerting fluid pressure on the casing below the packing means. In each event, the first and second valves provide communication between the annulus and the casing below the packing member. Of course, it is understood that the valve means may comprise a single valve openable under pressure exerted either through the annulus or from the casing below the packing means.

The tubular elongated member may suitably be provided with sealing or packing means to seal between the tubular elongated member and the passageway. Also the tubular elongated member may suitably be provided with a latching member engageable with the packing means to hold the tubular elongated member in the passageway.

The tubular elongated member may also be provided with means on its upper end engageable with a fishing tool carried by a wire line and the like for lowering and raising the retrievable tubular member in the well.

The casing may have arranged therein and may be provided with a guide means above the guide member for engaging the fishing tool with the retrievable tubular member.

The present invention will be further illustrated by reference to the drawing in which:

Fig. 1, partly in section and partly enlarged, shows the apparatus of the present invention in a well;

Fig. 2 is a sectional view of the elongated tubular member;

Fig. 3 is a modified view of Fig. 1 showing a guide for the fishing tool;

Fig. 4 is a view taken along the lines 4—4 of Fig. 3; and

Fig. 5 is a partial view of Fig. 1 with the retrievable elongated member removed and the passageway therefor plugged.

Referring now to the drawing in which identical numerals will be employed to designate identical parts, a borehole **11** is drilled from the earth's surface **12** to penetrate a plurality of subsurface earth intervals **13**, **14**, **15**, **16**, and **17** of which intervals or zones **16** and **14** may be productive and intervals **13**, **15**, and **17** may be nonproductive of hydrocarbons, such as oil, gas, and the like.

Arranged in the borehole **11** is a casing **18** which is cemented in place with primary cement **19**. The casing **18** is perforated in stratum **16** to provide perforations **20** communicating the interior of the casing **18** with the stratum **16**.

Arranged in the casing **18** and extending to the wellhead **21** is a tubing string **22** which carries on its lower end a packing member **23**, the tubing **22** being threadedly connected by mating threads **24** to the packing member **23**.

The packing member **23** is provided with opposing cup packers **25** and **26** which are carried by the packing member **23** and also with slip or pipe engaging means **27** and **28** which are operable and are caused to contact the inner wall of the casing by imposition of pressure on the cup packers **25** and **26** from either below or above the packing member **23**.

The packing member **23** has a passageway **29** which communicates with the tubing **22** and has a second passageway **30** which extends through the packing member **23**.

The tubing **22** extends through the wellhead **21** and is provided with a valve or closure member **31** for control of fluid or anything introduced through the tubing **22**. A flange member **32** is also provided for connection of a lubricator, such as **33**, to the flange **32**.

The casing **18** has a conduit **34** connected thereto controlled by valve **35**. Also connected to the wellhead equipment **21** is a valve member **36** having connected thereto a flange member **37** to which is connected a lubricator **38** including a valve **39**.

Arranged in the passageway **30** is a retrievable elongated tubular member **40** provided with packing means **41** for sealing between the tubular member **40** and the wall of the passageway **30**.

The upper end of the tubular elongated member **40** may be enlarged as at **42** and may enclose valve means **43** comprised of valves **44** and **45** which communicate with the annulus A between the tubing and casing by means of ports **46** and **47**.

As shown in the drawing, the tubular member **40**, when seated in passageway **30**, extends into the annulus A but does not extend to the wellhead **21** and is not co-extensive with tubing **22**. Figs. 1 and 5 show the tubular member **40** extending above the packing member **23** a sufficient distance to be retrieved from passageway **30** when desired.

The enlarged upper end **42** of the tubular member **40** is provided with a fishing neck and spear designated by the numeral **48** for engaging with a wire line fishing tool as will be described.

The tubular elongated member **40** is also provided with

latching means, such as spring latches 49, which are secured to the tubular elongated member 40 by frangible connecting means 50. Latches 49 prevent upward movement of tubular member 40 due to pressure but can be sheared loose by upward pull by a wire line retrieving tool.

The valve 44 is comprised of a valve seating member 51 which is designed to seat on seat 52 and a valve stem 53 arranged in a spider or plate 54 for centering same. A spring member 55 biases the valve member 51 into seating engagement with the seat 52.

The valve member 45 also comprises a valve seating member 56 which seats on the seat 57. A valve stem 58 is arranged in a spider or plate 59 and a biasing means 60 biases the seating member 56 against the seat 57.

The valve stems 53 and 58 are suitably sealed in the spider or plates 54 and 59.

The port 56 communicates with the interior of the valve 44 and by means of vertical passageway 61 with the passageway 62 in the elongated tubular member 40. The passageway 61 communicates by means of lateral and vertical passageways 63 with the valve 45 which, in turn, communicates with the port 47. As shown in dotted lines in Fig. 1, tubular member 40 may be of any desirable length.

Referring now to Figs. 3 and 4, the tubing 22 has attached thereto above the packing member 23 a guide member such as 70 for properly positioning a retrieving or fishing tool 71 attached to a wire line or cable 72 run into the well from the earth's surface 12 to engage with the spear and fishing neck 48 of the tubular extension member 40.

The packing member 23 is also provided with a guide surface generally indicated by the numeral 73 for guiding the tubular extension member 40 into the passageway 30.

Referring now to Fig. 5, it will be seen that the tubular extension member 40 has been retrieved from the packing member 23 leaving the passageway 30 to be plugged by a wire line plug 73 which may be suitably lowered and arranged within the passageway 30. The plug 73 is provided with packing means 74 for sealing between the walls of the plug and the passageway 30. Plug 73 is also provided with latch springs 49 as is tubular member 40.

The present invention may be employed in permanent well completion operations as described in World Oil, March 1954, and is designed to be used in gun perforating, cementing, washing such as to remove sand and debris, acidizing, well stimulating, fracturing of formations, strata, sands, and the like, and in the injection in or removal of any type of fluid, and the like from the well.

For example, the present invention may be used suitably in cementing operations. Referring to Fig. 1 assuming that the gun perforator, such as 75, which may be either a shaped charge or a bullet gun perforator or which may be a mechanically or chemically operated perforator, is lowered on the wire line 72 to perforate the zone 16 and to form perforations 20 in the casing 18, cement 19, and the zone 16. Production may then be had up through the passageway 29 and the tubing 22, the passageway 30 being closed either with the tubular extension member 40 or the plug 73 as has been described. After the hydrocarbons have been produced and further production is uneconomical for any reason such as salt water or gas invasion, and the like, it may be desirable to cement the perforations 20 and then to reperforate in the same zone or in a vertically displaced zone such as in the sand, stratum, or interval 14. Under these conditions, a retrievable tubular extension member, such as 40, of a length as indicated in the dotted lines in Fig. 1 is lowered in the annulus A and seated and sealed in passageway 30 as shown.

Cement may then be flowed down the tubing 22 to deposit in the region of and in the perforations 20 to cause the formation of plugs or filter cakes in the perforations. A slurry of a low fluid loss cement, such as described in U.S. Patent 2,582,459 to Salathiel may be employed, although other low fluid loss cements may be used.

After the cement has been deposited and forced into the perforations 20 and zone 16 as desired, excess fluid cement may be removed by circulating fluid, such as oil or water, drilling mud, and the like, down the tubing 22 through passageway 29 and up the tubular extension member 40. By imposing pressure on the washing fluid, the valve 44 is caused to open and the fluid and fluid cement pass outwardly into the annulus A through the passageway 46. Likewise, fluid of the nature described may be introduced from annulus A by imposing pressure through port 47 on the valve 45 causing it to unseat and allowing fluid to pass through the vertical and lateral passageway 63 and 62 down into the desired region in the well below the packing member 23. In other words, the present invention is applicable either to flow down the tubing or up through the tubular member into the annulus or through the annulus down through the tubular member and up the tubing.

The present invention is of considerable advantage and utility in that the tubing is full opening at all times. The tubing extension may be left in place and used as a production tubing if desirable or for injection of fluids and wells may be worked over and recompleted without removing the tubing extension provided a tubing extension of a proper length is employed such that it will not be perforated by a perforator.

It is intended that tubular extension members of the nature described of varying lengths may be employed and that a plurality of productive zones may be worked over or serviced either proceeding downwardly in the well from below the packer or upwardly in the well below the packer. As illustrative only the tubular extension member 40 may have a length ranging from 50 to 2000 feet although it is not intended to restrict this invention to any particular length.

Any illustrations given are by way of a better understanding of the invention and not by way of limitation.

The nature and objects of the present invention having been completely described and illustrated, what I wish to claim as new and useful and to secure by Letters Patent is:

1. Permanent well completion apparatus for use in a well having a casing arranged therein and provided with a tubing permanently positioned in the casing with its lower open end at a level above a plurality of productive subsurface intervals which comprises packing means arranged adjacent the lower end of the tubing to isolate the annulus between the tubing and the casing from the casing below the lower end of the tubing, a conduit means in said packing means providing a passageway free of obstructions through said packing means between the annulus and the casing below the packing means, and a retrievable elongated tubular member having an open lower end and having its wall free of openings, said retrievable tubular member being lowerable through the annulus and being retrievably and sealingly arranged in said passageway and projecting a substantial distance below said packing means and the lower open end of the tubing to provide fluid communication between the annulus and the casing below the packing means, the retrievable tubular member extending into the annulus a distance substantially less than the length of the tubing.

2. Apparatus in accordance with claim 1 in which the packing means is formed to provide a guide surface for guiding the retrievable elongated tubular member into said passageway.

3. Apparatus in accordance with claim 1 in which the upper end of the tubular member is provided with valve means openable under pressure imposed thereon.

4. Apparatus in accordance with claim 1 in which the

upper end of the tubular member is provided with valve means openable under fluid pressure imposed on the annulus.

5. Apparatus in accordance with claim 1 in which the upper end of the tubular member is provided with valve means openable under fluid pressure imposed on the casing below the packing means.

6. Apparatus in accordance with claim 1 in which the upper end of the tubular member is provided with a first spring biased valve normally closed and openable on imposing an increase in fluid pressure on the annulus above the packing means and a second spring biased valve normally closed and openable on imposing an increase in fluid pressure on the casing below the packing means, said valve communicating separately with the annulus by means of separate spaced-apart ports and said valves being positioned in separate passageways in the tubular member communicating with said ports.

7. Apparatus in accordance with claim 1 in which the tubular member is provided with a latch member engageable with the packing means to hold said tubular member in said passageway.

8. Apparatus in accordance with claim 1 in which a guide means is provided in said casing spaced above and adjacent said packing means for engaging a fishing tool with said retrievable tubular member.

9. Permanent well completion apparatus for use in a well having a casing arranged therein and provided with a tubing permanently positioned in the casing with its lower open end at a level above a plurality of productive subsurface intervals which comprises packing means arranged adjacent the lower end of the tubing to isolate the annulus between the tubing and the casing from the casing below the lower end of the tubing, a conduit means in said packing means providing a passageway free of

obstructions through said packing means between the annulus and the casing below the packing means, and a retrievable elongated tubular member having an open lower end and having its wall free of openings, said retrievable tubular member being lowerable through the annulus and being retrievably and sealingly arranged in said passageway and projecting a substantial distance below said packing means and the lower open end of the tubing to provide fluid communication between the annulus and the casing below the packing means, said retrievable tubular member being provided with means on its upper end engageable with a fishing tool for lowering and raising said retrievable tubular member in said well and said retrievable tubular member having a valve arranged in its upper end openable under pressure imposed on said valve, said retrievable tubular member extending into the annulus a distance substantially less than the length of the tubing.

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