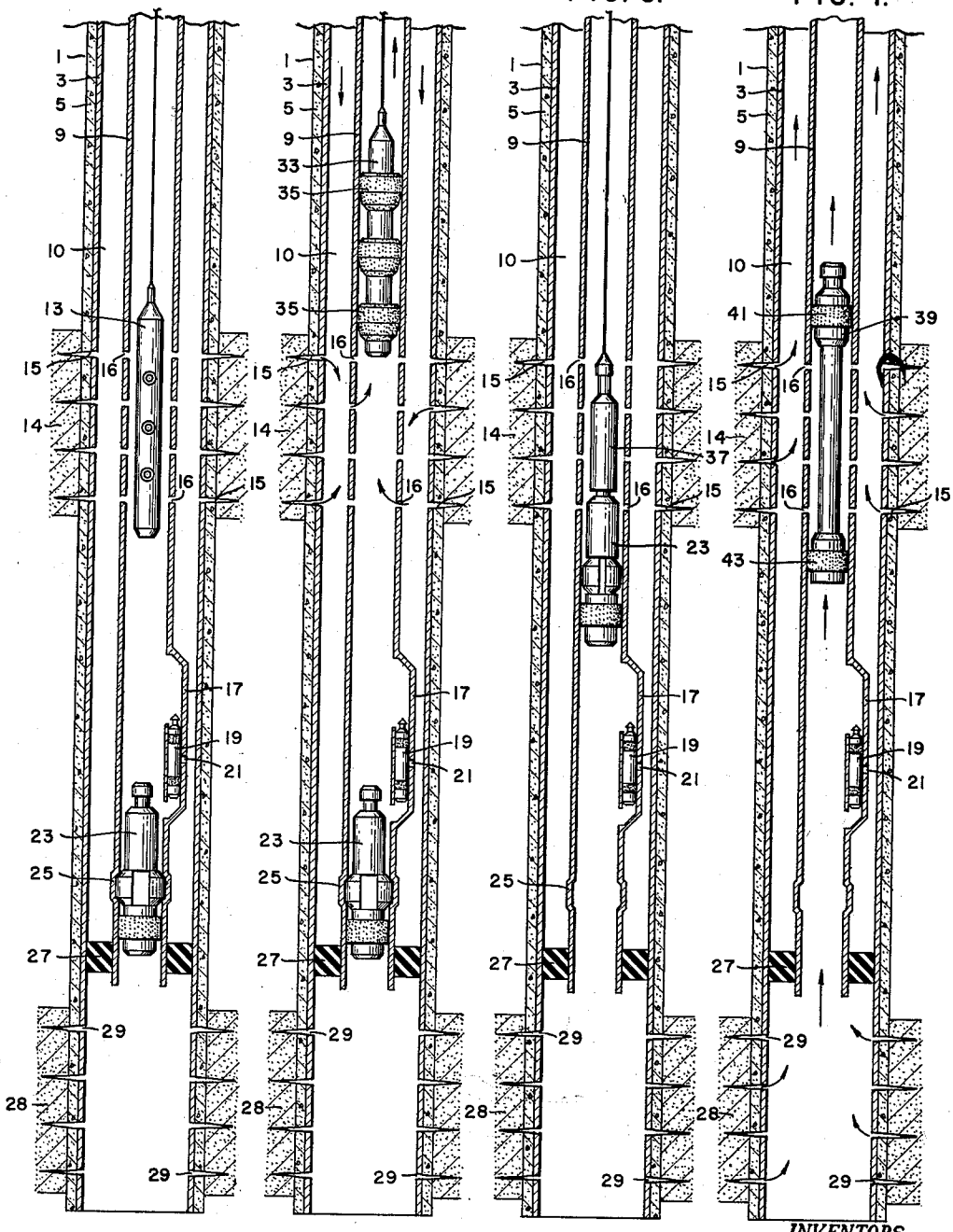
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PLURAL COMPLETION OF WELLS

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FIG. 1. FIG. 2. FIG. 3. FIG. 4.



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PLURAL COMPLETION OF WELLS

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This invention relates to the production of a plurality of productive earth formations through a single borehole, and more particularly to a method for completing a productive earth formation above the level of an existing productive earth formation that has been produced for a more or less extended period of time.

In connection with the production of oil and gas from productive earth formations, it has been the practice to cement a borehole liner, or casing, to the sides of a borehole, to perforate the casing so as to open fluid communication between the productive earth formation and the casing, and to produce the formation through a production pipe string or flow tubing. A production packer between the flow tubing and the casing seals the portion of the well bore adjacent the earth formation from the upper portion of the annulus around the flow tubing.

When it is later decided to produce a second productive earth formation that is above the level of the first productive earth formation, several techniques can be followed. A usual technique is to raise the flow tubing until the lower end thereof is above the level of the second productive earth formation, to lower a perforating gun through the flow tubing and, with the gun, to perforate the casing adjacent the second productive earth formation, and then to lower the flow tubing to its original position and reset the production packer. It is manifest that considerable expense must be entailed to carry out such an operation inasmuch as costly equipment must be brought to the well site to manipulate the flow tubing. Manifestly, a simpler, less expensive technique for carrying out the operation is desirable.

In accordance with one aspect of the present invention, a perforating gun is lowered through the flow tubing to the level of the second productive earth formation. The flow tubing, the casing, and the surrounding sheath of cement are perforated, a pack-off anchor is set in the flow tubing to blank off the perforations therein, the first productive earth formation is produced through the flow tubing and the pack-off anchor, and the second productive earth formation is produced through the annulus around the flow tubing.

Objects and features not evident from the above discussion will become apparent upon consideration of the following description when taken in connection with the accompanying drawing, wherein:

FIGS. 1 through 4 are schematic representations of an oil well installation illustrating various steps of the present invention.

With reference now to the figures generally, there is shown a borehole liner or casing pipe string **3** cemented to the wall of a borehole **1** with a cement sheath **5**. A production pipe string **9**, or flow tubing, coextends from the earth's surface with the casing **3**. The flow tubing **9** may include a gas lift mandrel **17** having a port **21**. A blank-off plug **19** is used to seal off the port **21** from the bore of the flow tubing **9**. The blank-off plug may be of the type illustrated at page 1098 of the Composite Catalog of Oil Field Equipment and Services, 24th edition (1960). A plurality of perforations **29** provide fluid communication between a first lower productive earth formation **28** and the bore of the casing **3**. A production packer **27** between the lower end of the flow

tubing **9** and the casing **3** seals off the portion of the bore adjacent perforations **29** from the annulus **10** around the tubing **9** to prevent flow of formation fluids from formation **28** up the annulus **10**.

It will be assumed that the earth formation **28** has been produced for a more or less extended period of time and that a new productive earth formation **14** has been discovered above the level of earth formation **28**. It now becomes desirable to produce earth formation **14** through the annulus **10** without vertically repositioning flow tubing **9**. As illustrated in FIG. 1, a perforating gun **13** is lowered into the flow tubing on a wire line until it is adjacent earth formation **14**, and is actuated to perforate tubing **9**, casing **3**, cement sheath **5**, and to penetrate earth formation **14**. The perforating gun may be of the type utilizing either bullets or shaped charges. If desired, other types of perforators, such as chemical or hydraulic perforators, may be used. If a shaped charge perforator is used, the strength of the explosive load in individual shaped charges and the spacing density of the charges on the perforating gun should be controlled. The shaped charges should be of sufficient strength to perforate the flow tubing **9**, the casing **3**, and the cement sheath **5**, and to penetrate the earth formation **14** to a reasonable depth. However, the strength of the charges and the density thereof should not be so great as to split the tubing. It has been found that 13 ounce shaped charges having a density of two per foot are usually satisfactory to perforate 2-inch, EUE tubing.

Either before or after the tubing and casing have been perforated, a plug **23** should be set in a landing recess **25** in flow tubing **9** to prevent fluid flow through the flow tubing between the levels of earth formations **14** and **17**. After the formation **14** has been perforated to form perforations **15**, the perforator **13** is withdrawn from the well. A swab **33** having a plurality of swab cups **35** is lowered into the flow tubing to a level above earth formation **14**. The swab **33** is reciprocated in the flow tubing in order to initiate the flow of earth formation fluid from formation **14** as shown in FIG. 2. The annulus **10** may be opened to atmosphere so that well fluids standing in the annulus **10** before formation **14** is perforated, may be withdrawn from the annulus **10** through perforations **16** in flow tubing **9** and up flow tubing **9** along with formation fluids from formation **14**. The purpose of the swabbing operation is to initiate flow of fluids from formation **14** and to reduce the hydrostatic head of fluids in annulus **10** to a level such that fluids may flow naturally from the flow tubing up the annulus. If, for some reason, it is desired to have the annulus **10** closed off from the atmosphere, the swabbing operation will take a longer time inasmuch as some of the fluids from formation **14** must migrate up the annulus to displace annulus fluids, the level of fluids in the annulus remaining the same.

The swab **33** is now withdrawn from the well. As shown in FIG. 3, a wire line retrieving tool **37** is lowered into the flow tubing until it latches on to the fishing head of plug **23**. The plug **23** is withdrawn from the well.

As shown in FIG. 4, a pack-off anchor **39** is set in the flow tubing **9** adjacent the earth formation **14** so that the annular sealing element **41** thereof is above the uppermost of perforations **16**, and the annular sealing element **43** is below the lowermost of perforations **16**. The term "pack-off anchor" is used to designate an apparatus having an open bore, two or more annular sealing elements, and a setting apparatus adapted to seal off holes or perforations in a well pipe string at a predetermined level in the pipe string. The term is well known to the art, and apparatus of this nature is described at page 4339 of the "Composite Catalog of Oil Field Equipment and Services," 24th edition (1960).

The apparatus is only schematically illustrated in FIG. 4.

The lower earth formation **28** may now be produced through the flow tubing **9** and the bore of the pack-off anchor **39**. Earth formation **14** is produced through perforations **15** and through the annulus **10**.

When it is desired to work over or stimulate the earth formation **14**, certain jobs may be accomplished by working in the annulus without affecting the well hookup, whereas in other jobs, the pack-off anchor **39** is withdrawn from the well by a conventional wire line retracting apparatus to permit circulation. In this latter type workover, the plug **23** is reset in the well, and acid, fracturing fluid, cement, or other liquid is injected into the earth formation through perforations **16** and **15** and the portion of annulus **10** therebetween. When the operation is completed, blank-off plug **19** is removed and the injected liquid is circulated up the annulus **10** and out of the well. Blank-off plug **19** is replaced in mandrel **17**, plug **23** is removed, and pack-off anchor **39** is replaced in the position illustrated in FIG. 4.

It has been found that it is possible to reduce the cost of initiating production from a second productive earth formation by as much as 75% utilizing the technique described above.

The invention is not to be restricted to the specific structural details or arrangement of parts herein set forth, as various modifications thereof may be effected without departing from the spirit and scope of this invention.

The objects and features of the invention having been completely described, what it is desired to claim is:

1. In a well comprising a cased borehole and a flow tubing string extending to a first productive earth formation for producing the formation, and packer means between the flow tubing and casing for preventing fluid flow up the annulus between the flow tubing and casing, a method of initiating production of a formation at a level above the packer comprising: perforating the flow tubing and casing at the level of a second productive earth formation above the packer and first productive earth formation; blanking off the perforations in the flow tubing with a pack-off anchor; producing the second earth formation through the annulus between the flow tubing and the casing; and producing the first productive earth formation through the flow tubing and the pack-off anchor.

2. In a well comprising a cased borehole and a flow tubing string extending to a first productive earth formation for producing the formation, and packer means between the flow tubing and casing for preventing fluid flow up the annulus between the flow tubing and casing, a method of initiating production of a formation at a level above the packer comprising: perforating the flow tubing and casing at the level of a second productive earth formation above the packer and first productive earth formation; blocking fluid flow through the flow tubing bore at a level between the first and second earth formations; swabbing the flow tubing above the second earth formation to flow earth formation fluids from the second earth formation and to reduce the hydrostatic head of fluids in the annulus between the flow tubing and the casing of the borehole until the hydrostatic head is sufficiently low to permit production of earth formation fluids through the annulus from the second earth formation; reopening the bore of the flow tubing between the first and second earth formation; and blanking off the perforations in the flow tubing with a pack-off anchor.

3. In a well comprising a cased borehole and a flow tubing string extending to a first productive earth formation for producing the formation, and packer means between the flow tubing and casing for preventing fluid flow up the annulus between the flow tubing and casing, a method of initiating production of a formation at a level above the packer comprising: perforating the flow tubing and casing at the level of a second productive earth formation above the packer and first productive earth formation; lowering a tubular member in said flow tubing and sealingly positioning it in said flow tubing with its upper end sealed above and its lower end sealed below the perforations in said flow tubing to isolate the second earth formation from the first earth formation; producing the second earth formations through the annulus between the flow tubing and the casing; and producing the first productive earth formation through the flow tubing and the tubular member.

4. In a well comprising a cased borehole and a flow tubing string extending to a first productive earth formation for producing the formation, and packer means between the flow tubing and casing for preventing fluid flow up the annulus between the flow tubing and casing, a method of initiating production of a formation at a level above the packer comprising: perforating the flow tubing and casing at the level of a second productive earth formation above the packer and first productive earth formation; blocking fluid flow through the flow tubing bore at a level between the first and second earth formations, swabbing the flow tubing above the second earth formation to flow earth formation fluids from the second earth formation and to reduce the hydrostatic head of fluids in the annulus between the flow tubing and casing of the borehole until the hydrostatic head is sufficiently low to permit production of earth formation fluids through the annulus from the second earth formation; reopening the bore of the flow tubing between the first and second earth formations; and lowering a tubular member in said flow tubing and sealingly positioning it in said flow tubing with its upper end sealed above and its lower end sealed below the perforations in said flow tubing to isolate the second earth formation from the first earth formation.

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