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May 27, 1958

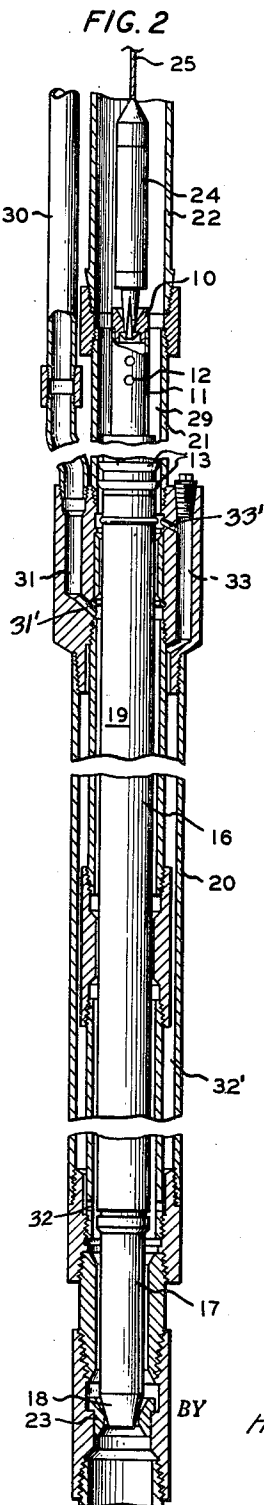
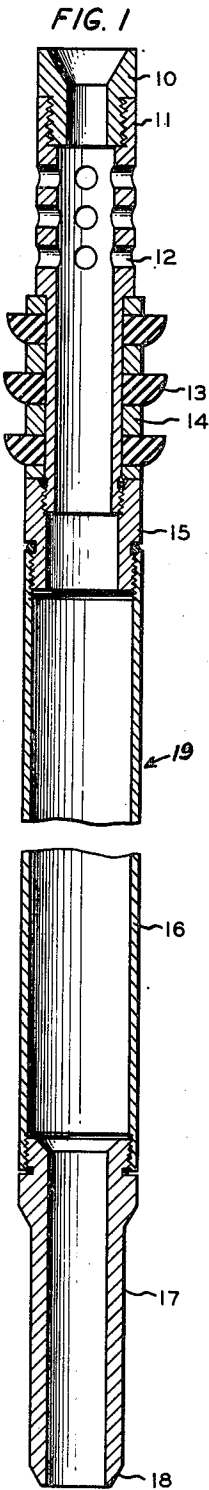
G. I. FREEZE

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APPARATUS FOR HYDRAULIC FRACTURING

Filed Nov. 26, 1954

2 Sheets-Sheet 1



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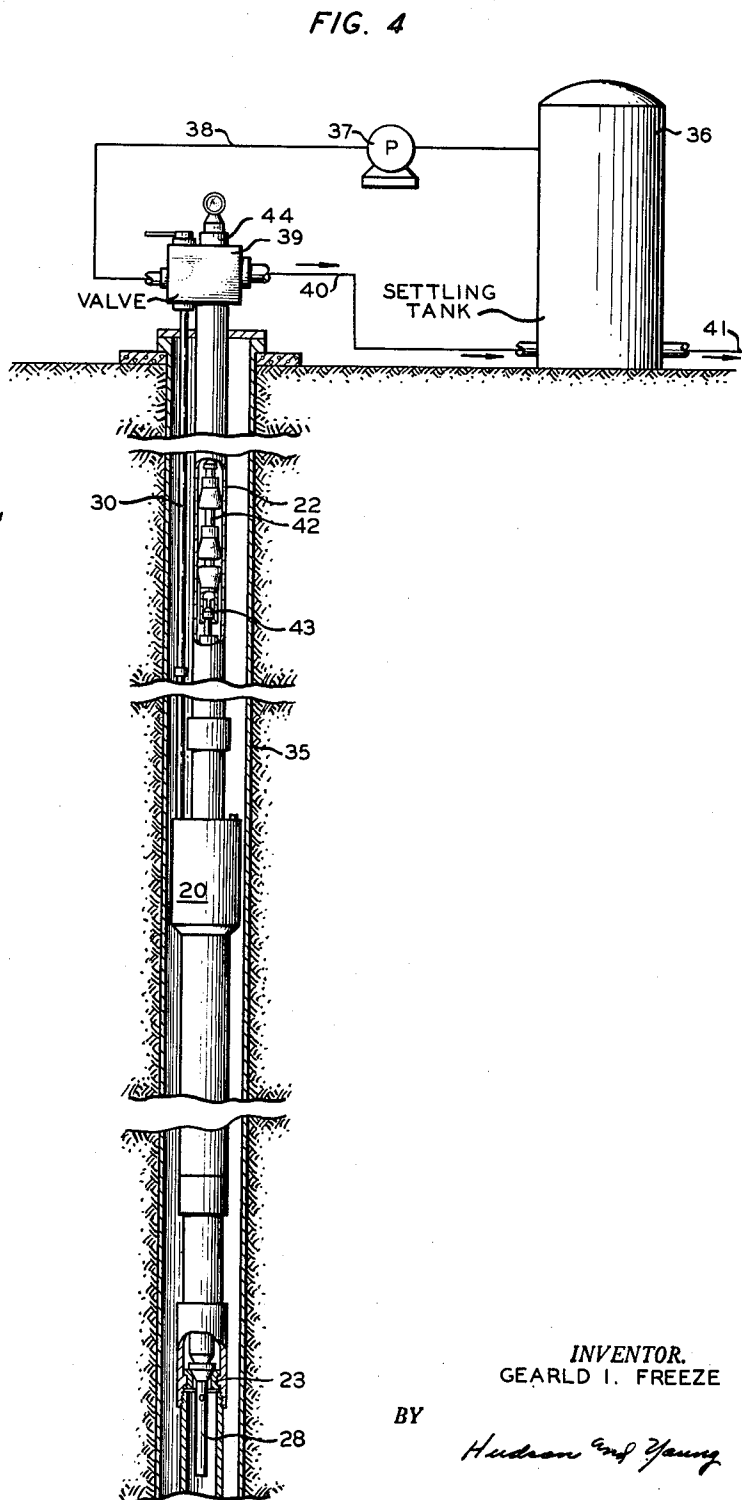
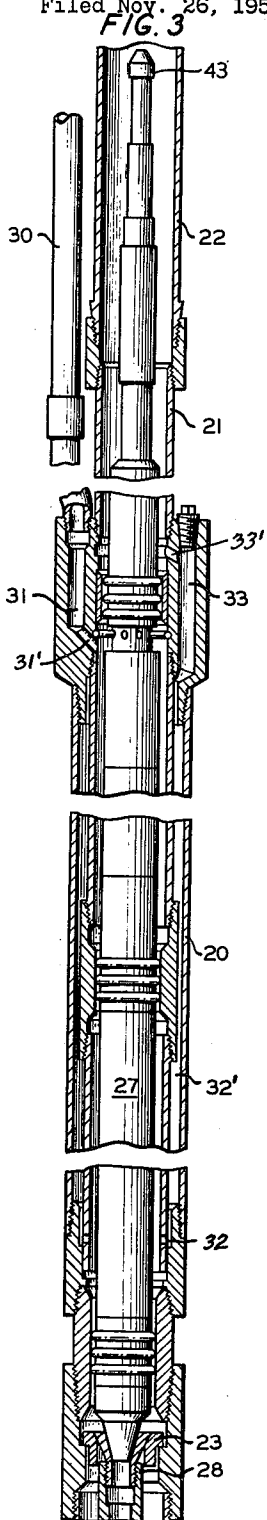
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1

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APPARATUS FOR HYDRAULIC FRACTURING

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7 Claims. (Cl. 166—115)

This invention relates to the treatment of fluid producing wells. In one aspect this invention relates to an improved method for fracturing fluid producing formations. In another aspect this invention relates to apparatus employed in hydraulic fracturing of fluid producing formations.

Various methods have been proposed in the art for increasing the productivity of oil and gas wells. For example, one method which is employed in some cases is to detonate nitroglycerine in a well to either enlarge the well diameter and/or to fracture the formations immediately adjacent the well. The use of nitroglycerine is, however, restricted in many instances because of pipe in the well, the expense, the hazards etc. Horizontal drilling is another method employed to increase the productivity of oil wells; however, the increased productivity is rarely commensurate with the cost. Acidizing is another method sometimes employed to increase productivity of a well. Acidizing is however generally limited to limestone formations. In recent years hydraulic fracturing has proved to be an efficient and effective treatment for increasing the productivity of many oil wells.

A hydraulic fracturing operation, as applied to oil and gas producing formations, generally comprises a preliminary flush of oil followed with a volume of sand-laden liquid which liquid can be lease crude oil, a refined oil, water, etc. and in some instances, a thickening material is added. Enough pressure is applied to force the sand-laden liquid outward into the formation, preferably at as high a rate as is practical. The final step comprises flushing the sand-laden liquid from the pipe and the well bore, usually with oil.

Hydraulic fracturing operations are carried out in some instances before the well is placed on the pump and in some instances after the well has been placed on the pump. When hydraulic pump equipment has been installed it has been necessary, prior to my invention, to remove the downhole equipment to prevent damage to the standing valve seating shoe and/or to prevent accumulation of sand, from the fracturing fluid, in the pump cavity. Thus, prior to my invention it has been necessary to make two complete round trips with the tubing for each fracturing job, i. e., pull the tubing to remove the pump cavity; run the tubing back into the well to carry out the fracturing operation; pull the tubing to attach the pump cavity; and then run the tubing into the well again to position the pump cavity.

When operating according to the method of my invention and employing my retrievable sealing sleeve the two above mentioned round trips of the tubing are not necessary. Thus, broadly speaking, my invention comprises a method and apparatus for forming a sealed passageway from a point in the tubing above the pump cavity and through said pump cavity by removing the pump and standing valve, and then employing a retrievable sealing sleeve adapted to form a seal with said tubing and with the standing valve seating shoe attached to the bottom of said pump cavity. The hydraulic fracturing fluid can then

2

be pumped through said tubing and said sleeve to effect fracturing of the formation without danger of damage to said standing valve seating shoe or accumulation of sand in said pump cavity.

5 An object of my invention is to provide an improved method for effecting hydraulic fracturing of fluid producing formations in a well bore.

Another object of my invention is to prevent damage to downhole equipment during hydraulic fracturing operations carried out in a well bore.

10 Another object of my invention is to provide apparatus for carrying out the aforesaid objects.

Still other objects and advantages of my invention will be apparent to those skilled in the art upon reading this disclosure, the drawings and the appended claims.

15 The attached drawings illustrate the invention diagrammatically. In the drawings like reference numerals are employed to denote like elements where possible.

Figure 1 is a longitudinal cross section of one embodiment of the sealing sleeve of the invention.

20 Figure 2 is an elevation, partly in section, of a downhole assembly showing the sealing sleeve in position in a pump cavity.

Figure 3 is an elevation, partly in section, of an assembly of down-hole hydraulic pumping equipment showing a hydraulic pump in position in a pump cavity.

Figure 4 is a schematic illustration of a hydraulic pumping system.

Referring now to the drawings the invention will be more fully explained as applied in connection with the production of oil from oil-bearing formations. The embodiment of the sealing sleeve illustrated in Figure 1 comprises a pulling and running adapter 10, a pulling neck 11 having perforations 12 therein, seating cups 13 mounted at spaced intervals on said pulling neck and held in place by cup spacers 14, a lock-nut adapter 15 for attaching said pulling neck to a tube 16, and a seating member 17 having a lower taper 18. Seating cups 13 are made of a resilient material which will not swell or deteriorate when in contact with materials encountered in wells. Synthetic rubbers of several types are available for such use and are satisfactory. Materials of construction, in general, can be selected from among those available commercially.

45 In Figure 2 the retrievable sealing sleeve is denoted generally by reference numeral 19 and is shown in position in a pump cavity denoted generally by reference numeral 20. Pulling tool 24, attached to wire line 25, is shown attached to pulling and running adapter 10 preparatory to removing sleeve 19. A tool similar to pulling tool 24 is employed to run sleeve 19 into the pump cavity 20. Seating cups 13 form a seal with tubing section 21 at a point above pump cavity 20. It is to be noted that tubing section 21 is slightly smaller in diameter than tubing 22 so as to facilitate passage of the sleeve 19 through tubing 22 and seating of seating cups 13 in tubing 21. Taper 18 is shown seated in standing valve seating shoe 23 thereby protecting said shoe during fracturing operations. Thus with seating cups 13 forming a seal with tubing section 21 at a point above pump cavity 20, and taper 18 forming a metal to metal seal with standing valve seating shoe 23, there is provided a sealed passageway through pump cavity 20, through which hydraulic fracturing fluid can be pumped, from tubing 22, without danger of damage to seating shoe 23 or accumulation of sand in pump cavity 20 or in any of the power fluid passageways 31, 31', 32, 32', 33, and 33' in the wall of said pump cavity 20. (Pulling and running tool 24 would of course not be present during fracturing operations.) Perforations 12 permit circulation to and from the annulus 29 to prevent accumulation of sand in said annulus,

3

above cups 13, which might cause sleeve 19 to become stuck.

In Figure 3 a hydraulic pump denoted generally by reference numeral 27 is shown positioned in pump cavity 20. Pump 27 seats in standing valve assembly 28. Power fluid is supplied to said pump through tubing 30 and pas- 5 sageways 31 and 31' into the engine end of pump 27 and pump discharge fluid, and power fluid, discharge from pump cavity 20 through passageways 32, 32', 33, and 33' 10 into production tubing 22 and returned to the surface. When it is desired to remove the pump from the pump cavity, circulation of the power fluid is reversed, i. e., it is pumped down production tubing 22 and a recovery swab 42, which attaches itself to fishing neck 43 on the 15 top of pump 27, and provides a seal with tubing 22, is pumped to bottom. When circulation of the power fluid is returned to normal, i. e. through tubing 30, the pump is removed from the well. When it is desired to return the pump to the well it is "pumped in" through tubing 22. Such operations are well known and will be readily under- 20 stood by those skilled in the art. It is also well known that there are other types of hydraulic pumps with which the operation is somewhat different. That is, the power fluid is pumped down the central tubing and the power fluid and produced fluid returned to the surface through the smaller parallel tubing. These pumps can be removed simply by reversing the circulation of power fluid.

Figure 4 is a schematic representation of a hydraulic pump cavity 20 and a standing valve 34 in a well bore 35, together with associated surface equipment. Power fluid is pumped from settling tank 36 by pump 37 through line 38, valve assembly 39 into tubing 30 as described above. Pump discharge fluid and power fluid is returned to the surface through production tubing 22 and passes through valve assembly 39 into line 40 and settling tank 36. Net produced fluid is removed through line 41. When pump 27 is being removed, and rises to valve 39, the recovery swab 42 engages a catching mechanism in lifting means 44 and is then lifted mechanically from tubing 22.

In operation, when it becomes necessary or desirable to perform the fracturing operation pump 27 is removed as described above. Pump standing valve 28 is removed with a wire line fishing tool. My retrievable sealing sleeve 19 is then run by means of a wire line running tool similar to pulling tool 24. Seating caps 13 on sealing sleeve 19 form a seal with tubing section 21 at a point above pump cavity 20 and taper 18 forms a metal to metal seal with standing valve seating shoe 23 to form a sealed passageway from tubing 22 through pump cavity 20. Fracturing fluid can then be pumped through said passageway to fracture the formation without danger of damage to said seating shoe 23 or accumulation of sand in pump cavity 20 or in any of the power fluid passageways 31, 31', 32, 32', 33, and 33' in the wall of said pump cavity 20. After the fracturing operation is completed, sleeve 19 is removed with wire line pulling tool 24, standing valve 28 is run with a wire line running tool, or is dropped into place, pump 27 is "pumped in" and production is resumed. During the entire operation according to the method of my invention and employing the apparatus of my invention it has not been necessary to remove the tubing; and seating shoe 23 and pump cavity 20 have been protected. These advantages of my invention will be readily understood by those skilled in the art.

Also, as will be evident to those skilled in the art, various modifications of the invention can be made, or followed, in the light of the above disclosure and the attached drawings, without departing from the spirit or scope of said disclosure, said drawings or the appended claims.

I claim:

1. A sealing sleeve adapted to form a sealed passageway from a tubing in a well bore and through a pump

4

cavity attached to said tubing, said pump cavity being adapted to receive a pump and having power fluid supply ports in the wall thereof, which comprises: a tube adapted to be inserted through said tubing and into said pump cavity; a first sealing means comprising a resilient pack- 5 ing material attached to the upper portion of said tube and adapted to form a seal with said tubing at a point above said pump cavity; and a second sealing means comprising a tapered end on the lower extremity of said tube adapted to seat in a standing valve seating shoe at- 10 tached to the bottom of said pump cavity.

2. A retrievable sleeve adapted to be employed during hydraulic fracturing operations in well bores, wherein hydraulic pumping equipment including a pump cavity adapted to receive a pump and having power fluid supply ports in the wall thereof attached to a tubing and a standing valve seating shoe is attached to the bottom of said pump cavity, and adapted to protect said seating shoe and prevent accumulation of sand in said pump cavity during said fracturing operations, which com- 15 prises: an elongated tube having a tapered lower extremity adapted to coast with and seat in said seating shoe, thereby protecting said seating shoe; and seating cups on the upper portion of said tube, said seating cups being adapted to form a seal with said tubing at a point above said pump cavity so as to provide a passageway for fracturing fluid from said tubing through said pump cavity and thereby prevent accumulation of sand in said pump cavity.

3. A retrievable sealing sleeve adapted to form a sealed passageway from a tubing in a well bore and through a pump cavity attached to said tubing, which comprises: a pulling neck having perforations in the upper portion thereof; a plurality of seating cups mounted at spaced intervals on said pulling neck and adapted to form a seal with said tubing above said pump cavity; cup spacers mounted on said pulling neck between said seating cups; a lock-nut adapter attached to the bottom of said pulling neck; a tube attached to the bottom of said lock-nut adapter; and a seating member attached to the bottom of said tube, said seating member having a tapered lower extremity adapted to seat in a standing valve seating shoe attached to the bottom of said pump cavity.

4. Apparatus for carrying out hydraulic fracturing operations in well bores wherein hydraulic pumping equipment has been installed, which comprises, in combination: a tubing; a pump cavity, having power fluid supply ports in the wall thereof, attached to said tubing; a standing valve seating shoe attached to the lower portion of said pump cavity; a pulling neck attached to the upper end of an elongated sealing sleeve adapted to be inserted through said tubing and into said pump cavity; a seating cup on the lower portion of said pulling neck adapted to form a seal between said pulling neck and said tubing at a point above said pump cavity; and a tapered end on the lower extremity of said sleeve adapted to cooperate with and seat in said seating shoe so as to form a sealed passageway from said tubing through said pump cavity.

5. Apparatus for carrying out hydraulic fracturing operations in well bores wherein hydraulic pumping equipment has been installed, which comprises, in combination: a tubing positioned in said well bore; a pump cavity attached to said tubing; a standing valve seating shoe attached to the lower portion of said pump cavity; an elongated sleeve comprising a pulling neck having perforations therein, a tube attached to the bottom of said pulling neck, and a seating member attached to the bottom end of said tube; said sleeve being adapted to be inserted through said tubing and into said pump cavity; said pulling neck having a plurality of seating cups on the lower portion thereof below said perforations and adapted to form a seal between said sleeve and said tubing at points above said pump cavity; and said seating member having a tapered end on the lower extremity

5

thereof adapted to cooperate with and seat in said seating shoe so as to form a sealed passage way from said tubing through said pump cavity.

6. Apparatus for carrying out hydraulic fracturing operations in well bores wherein hydraulic pumping equipment has been installed, which comprises, in combination: a tubing positioned in said well bore; a pump cavity attached to said tubing, said pump cavity being adapted to receive a pump and having side ports in the wall thereof communicating with power fluid passageways in said wall for supplying power fluid to said pump; a standing valve seating shoe attached to the bottom of said pump cavity; and an elongated sealing sleeve having sealing means on the upper portion thereof adapted to form a seal with said tubing at a point above said pump cavity, and having a seating member on its lower extremity adapted to seat in said seating member.

7. Apparatus for carrying out hydraulic fracturing operations in well bores wherein hydraulic pumping equipment has been installed, which comprises, in combination: a tubing positioned in said well bore; a pump cavity, adapted to receive a pump, attached to the bot-

6

tom of said tubing and having power fluid passageways in the wall thereof for supplying power fluid to said pump; a standing valve seating shoe attached to the bottom of said pump cavity; and an elongated sealing sleeve having seating cups on the upper portion thereof adapted to form a seal with said tubing at points above said pump cavity, and having a tapered lower extremity adapted to seat in said seating shoe so as to provide a sealed pathway for fracturing fluid from said tubing through said pump cavity, said pathway thus being out of communication with said pump cavity and said power fluid passageways so as to prevent accumulation of sand in said pump cavity and said power fluid passageways.

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