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OIL WELL PROCESS AND APPARATUS

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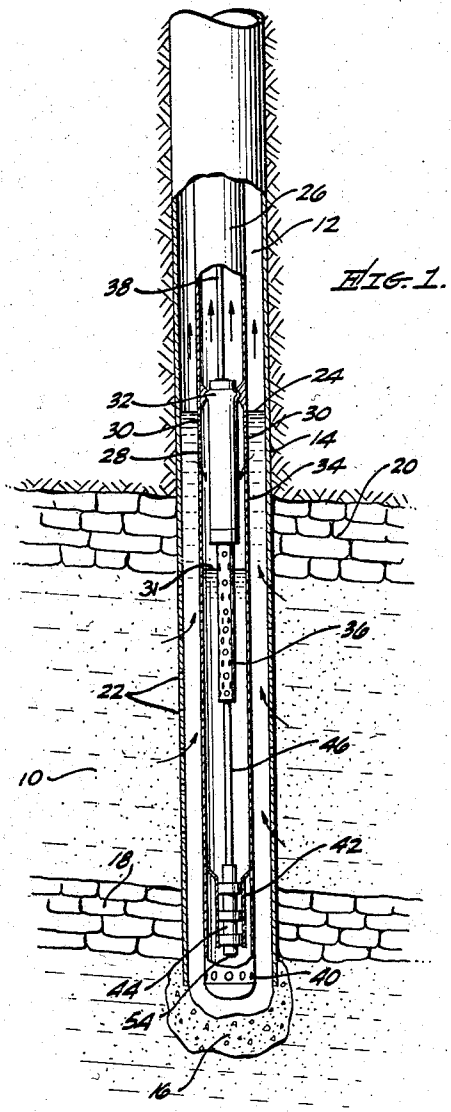


FIG. 1.

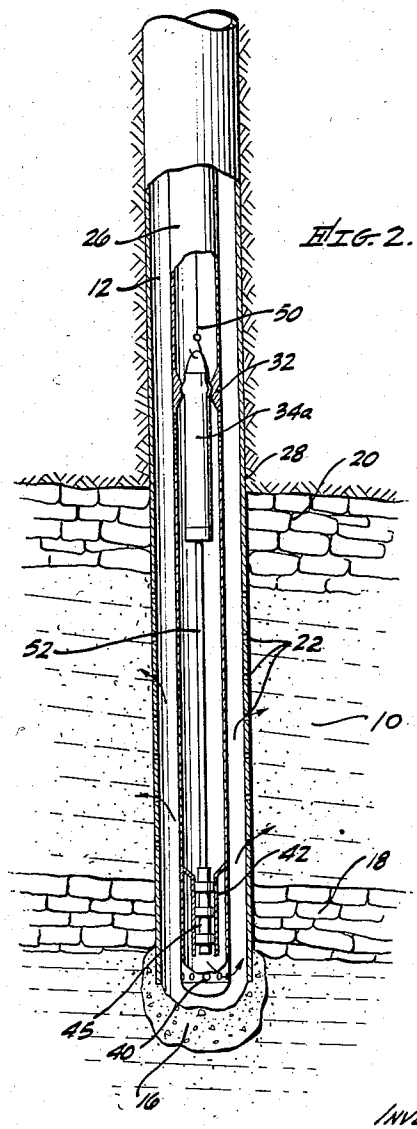


FIG. 2.

INVENTOR.
RICHARD J. GERTZEN,
By
Ivor John James Jr.
ATTORNEY.

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OIL WELL PROCESS AND APPARATUS

Richard J. Gertzen, Cut Bank, Mont., assignor to Union Oil Company of California, Los Angeles, Calif., a corporation of California

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6 Claims. (Cl. 166—105)

This invention relates to improvements in an oil well process and apparatus and particularly to an improved combination of well tubing, gas anchor, and bottom hole pump in which the process of this invention for injecting fluids into and removing fluids from an underground formation may be carried out. Particularly the present invention is applicable in the liquid treating of underground strata, such as the acidizing of limestone formations, without the removal and rerunning of the production tubing.

Although many oil and gas producing formations are essentially sandstone or similar permeable strata containing little if any limestone and are thus relatively unaffected by mineral acids, some oil and gas is found in limestone or other calcareous formations. It is common to treat such limestone formations with strong mineral acids in order to enlarge the bottom of the well bore and to dissolve part of the bore hole walls as well as internal parts of the formation in order to increase its permeability and the productivity of the well. Customarily such acid treating involves the termination of production of oil and gas from the well, the removal of sucker rods and bottom hole pump, the removal of the pump or production tubing and its perforated gas anchor at the bottom end of the tubing, disconnection of the gas anchor, and then the rerunning of the production tubing back into the hole. The acid is then run into the well bore through the production tubing and discharged at the bottom of the well bore where it contacts and reacts with the limestone formation. Such acid is inhibited against reaction with ferrous metals in any of the well known manners, such as the dissolution therein of arsenious acid, soluble arsenate and arsenite salts, organic nitrogen bases, mercaptans, etc. After treatment the production tubing is pulled from the hole, the gas anchor is reconnected, the tubing string is rerun into the hole, the sucker rods and bottom hole pump are replaced in the production tubing, excess acid is then pumped out of the hole, and finally crude petroleum is pumped from the thus treated formation.

The conventional treatment as above detailed obviously requires three round trips in the hole; that for the removal and reintroduction of the sucker rods and pump, for the production tubing, and for the acid line which usually comprises the production tubing. This extensive handling of the production tubing two times is exceedingly time consuming and therefore very expensive and may well run to over $300 to $400 per well treatment.

Other liquid treating processes for permeable formations in general also frequently involve such extensive removal and replacement of well apparatus.

It is therefore a primary object of this invention to overcome these objections and provide for a more rapid process for liquid treating of permeable underground formations without the removal of the pump or production tubing.

It is a specific object of this invention to provide a process for liquid treating permeable formations penetrated by a well bore such as acidizing a calcareous stratum, which comprises removing the bottom hole pump and sucker rods, shutting off the open perforations in the gas anchor while it remains in the bore, then opening specially provided perforations at the bottom of the gas anchor, then injecting the treating fluid or acid into the formation through the production tubing and through these lower perforations.

Another specific object is to provide an improved production tubing string and gas anchor apparatus which permits the acidizing or other liquid treating of subterranean limestone formations merely by removing and rerunning the sucker rods and the bottom hole pump.

Other objects and advantages of the present invention will become more apparent to those skilled in the art as the description and illustration thereof proceed.

Briefly the present invention comprises an improved well production apparatus in which the production or pump tubing string is provided at its lower end with an improved gas anchor structure provided with the customary perforations at its upper end and in addition to special perforations at its lower end in conjunction with a longitudinally actuated valve immediately above these perforations. In the process of this invention the specially designed pump and sucker rods are removed from the production tubing and gas anchor, an open-ended dummy pump cylinder and an imperforate tubular extension thereof provided at its lower end with a cup plunger on its exterior surface is landed in the primary pump seat by means of either the sucker rods alone or a sand line extending downwardly through the pump tubing. This closes the upper perforations of the gas anchor and permits fluid flow downwardly through the production tubing, downwardly through the dummy pump cylinder and tubular extension, through the longitudinally acting valve into the bottom perforated section of the gas anchor, and through these lower perforations into contact with the formation. The production tubing remains at all times in the borehole. Following treatment of the formation with the injected fluid, the dummy pump cylinder and its imperforate tubular extension are removed from the hole, the sucker rods and the bottom hole pump with its perforated lower pump intake portion are rerun into the hole, and the longitudinally acting valve element above the lower perforations is closed by means of a longitudinally acting valve element suspended from said pump by means of an imperforate solid extension. Pumping action is started, excess treating fluid such as acid is removed from the hole, and the production of the well begins. The double round trip in the hole of the production tubing previously required to remove and replace the gas anchor is eliminated. The improved design of the gas anchor and bottom hole pump combination according to this invention permits these advantages.

The present invention will be more readily understood by reference to the accompanying drawings in which:

Figure 1 is a vertical detailed view in partial cross section of the lower end of a borehole drilled into and through a calcareous or other formation to be treated and in which the improved gas anchor and bottom hole pump of this invention is employed, and

Figure 2 shows the same well bore with the open-ended dummy pump cylinder landed at the pump seat so that a fluid may be injected into the formation through the pump tubing.

The description of the drawings is specifically directed to the acidizing of calcareous strata for purposes of example. It should be understood that the invention may be applied to the treating of underground formations of any kind with an injected fluid.

Referring now more particularly to Figure 1, a cal-

careous subterranean stratum **10** containing oil and gas is penetrated by a well bore **12** whose walls are supported by well casing **14** and the bottom of which is provided with a cement seal **16**. The calcareous formation **10** is underlain and overlain respectively by impermeable rock strata **18** and **20**. Throughout the producing interval of the borehole penetrating permeable stratum **10**, casing **14** is provided with a plurality of perforations **22** through which the oil and gas flows into the well bore and stands up in the annulus surrounding the gas anchor **28** forming liquid level **24**. The oil and gas are separated in this annulus at level **24**, the gas flowing upwardly around pump tubing string **26** to the surface where it is removed from the casing head in the conventional way, and the oil flows into the upper end of gas anchor **28** through the upper perforations **30** forming liquid level **31**.

The gas anchor portion of the production tubing is that portion which lies below pump seat **32**. Bottom hole pump **34** is suspended in the upper portion of gas anchor **28** by means of pump seat **32** and is provided with a lower cylindrical perforated oil intake extension **36** into which the oil below level **31** flows. It is picked up by pump **34** and pumped upwardly in the annulus between sucker rods **38** and pump tubing **26**. It is removed from the top of the pump tubing and sent to production tanks in the conventional way.

The improved gas anchor according to this invention includes perforations **40** disposed at the lower extremity of the gas anchor, a seating nipple **42** concentrically disposed within the gas anchor immediately above lower perforations **40**, a cup plunger **44** whose lower end is closed at **54** is suspended by means of solid rod **46** from the bottom of the pump so that plunger **44** forms a fluid-tight seal in the seating nipple and closes off lower perforations **40** at the bottom of the gas anchor when the subterranean formation **10** is produced.

When a treating fluid is to be injected into the producing formation **10**, as in the case of acidizing a calcareous or limestone oil-producing formation, sucker rods **30** are pulled upwardly unseating bottom hole pump **34** and the dependent structure from pump seat **32** and the whole mechanism is drawn to the surface through pump tubing **26**. This opens seating nipple **42** and prepares the well for the introduction by means of the sucker rods or a sand line only of other equipment through the pump tubing preparatory to injection of treating fluid.

Referring now more particularly to Figure 2, the same elements of the same formations **10**, **18**, and **20** are shown together with the casing, pump tubing, and gas anchor elements described in connection with Figure 1. In this case a weighted dummy pump **34***a*, a hollow cylindrical element open at its upper end, is landed at pump seat **32** by means of either the sucker rods or in this case a sand line **50**. A hollow imperforate tubular extension **52** extends from the bottom of dummy pump **34** downwardly through the gas anchor **28** and is provided at its lower extremity with a second cup plunger **45** whose lower end is open. The serially connected dummy pump **34***a*, tubular extension **52**, and cup plunger **45** forms a conduit open from top to bottom for fluid flow. Cup plunger **45** seals against the internal surface of seating nipple **42** while the upper part of the gas anchor is sealed at pump seat **42**. The treating fluid, such as inhibited acid, flows downwardly through tubing string **26** around sand line **50**, flows downwardly through dummy pump **34***a* in the direction of the arrow, through tubular extension **52** and cup plunger **45**, and out through the lower perforations **40** at the bottom of gas anchor **28**. The fluids then pass by displacement upwardly through the annulus surrounding the gas anchor and into the permeable oil producing formations through perforations **22** in the directions indicated by the arrows. The acid is thus displaced back into the formation where it partially dissolves the calcareous materials so as to increase the permeability to fluid flow.

After injection of the acid and completion of the treatment, dummy pump **34***a*, the tubular extension **52**, the cup plunger **45** are pulled to the surface through the pump tubing by means of sand line **50**. The bottom hole pump **34** and its solid extension rod **46** and cup plunger **44** are replaced as shown in Figure 1 at the bottom of the production tubing within the gas anchor. The bottom of cup plunger **44** in Figure 1 is closed by means of a plug **54** or otherwise so as to prevent fluid flow through it thus shutting off lower perforations **40**. Reciprocation of sucker rod **48** actuates bottom hole pump **34** and pumps liquid from the annulus within the casing and around the gas anchor in the manner described in connection with Figure 1 from the borehole to the surface.

A complete acidizing operation has been described above and it should be noted that at no time was the pump or production tubing disturbed in the hole. By means of the modified gas anchor described above, the modified bottom hole pump with its extension rod and cup plunger operating in conjunction with the gas anchor, it is now possible to acidize or otherwise treat a subterranean formation with a fluid in the manner described without removing the production tubing, but merely by removing the bottom hole pump and replacing it with a hollow dummy pump cylinder and a hollow tubular extension which also operates in conjunction with the same gas anchor and seating nipple. The rig time required for acidization or other fluid injection for well bore treating has thus been materially reduced.

As an example of the utilization of the present invention, in well bores drilled in Montana for the production of oil and gas from the Madison lime from a depth of 4000 feet the gas anchor and pump tubing assembly in the particular well was about 40 feet long. The distance between the pump seat and the seating nipple was slightly over 23 feet. The seating nipple was 12 inches long fabricated from 1.50 inch diameter extra heavy pipe welded at its upper end by means of a funnel-shaped fitting to the inner wall of the gas anchor about 17 feet from the bottom. A plurality of 0.5 inch holes were drilled below the seating nipple and uniformly spaced around the bottom of the gas anchor. A 1.50 inch cup plunger plugged at its lower end was connected by means of a 0.75 inch steel rod at the bottom of the pump body. The perforated tubular extension comprising the pump intake consisted of a 1 inch schedule 80 tube closed at its lower end at the point of attachment of the 0.75 inch rod and provided with a plurality of perforations through which the oil flowed to the pump intake. The dummy pump cylinder was provided with a hollow 1.50 inch cup plunger with its lower plug removed connected to the bottom of the dummy pump by means of a 1 inch schedule 80 tube about 16 feet in length. The dummy pump cylinder comprises a 2 inch schedule 80 pipe open at its upper end and provided with exterior means for engagement in the pump seat in the same fitting at which the pump is landed. This equipment was employed in the acidizing of a well in the Cut Bank field in Montana in which 500 to 4000 gallons of inhibited acid were introduced into and the excess removed from an oil well drilled into the Madison lime. The entire acid treating operation required only four hours, whereas previous acidizing treatments in this same area and using conventional practice required as much as 16 hours in which the production or pump tubing was removed and rerun twice.

It is apparent therefore that the present invention has effected a substantial improvement in the acid treating of wells drilled into calcareous oil-producing formation. It is obvious also that the present invention may as well be applied to treating other formations with other fluids in the same manner as herein described and that the same advantages in time and expense are realized.

A particular embodiment of the present invention has been hereinabove described in considerable detail by way of illustration. It should be understood that various other modifications and adaptations thereof may be made by those skilled in this particular art without departing from the spirit and scope of this invention as set forth in the appended claims.

I claim:

1. A well pump assembly comprising a tubular body member adapted to be inserted into a well bore on a well tubing string, said body member having at least one upper aperture extending laterally through the walls and adjacent the upper end thereof and at least one lower aperture extending laterally through the walls and adjacent the lower end thereof; a pump seat disposed within said body member above said upper aperture; a well pump supported within said body member on said pump seat; a perforate tubular member extending downwardly within said body member from the intake port of said pump; a valve seat disposed within said body member above said lower aperture and below said tubular member; a valve element in register with said valve seat and sealing the lower end of said body member above said lower aperture; and an imperforate connecting rod having its upper end affixed to said pump and its lower end affixed to said valve element, whereby when said pump is seated communication between the well fluid producing portion of the well bore and the interior of said body member is only via said upper aperture but when said pump is raised said communication is also via said lower aperture.

2. An apparatus according to claim 1 wherein said valve seat comprises a cylindrical seating nipple welded by means of a funnel shaped element at its upper end to the inner wall of said body member, and wherein said valve element comprises a cup plunger disposed within said seating nipple.

3. An apparatus according to claim 1 in combination with a sucker rod extending through said tubing string and connected to said pump whereby said pump is actuated and whereby said pump, said tubular member, said connecting rod and said valve element may be pulled from said body member, thereby opening said lower aperture into flow communication with said tubing string.

4. An apparatus according to claim 1 in combination with a cylindrical dummy pump open at its upper end and

adapted to be seated in said pump seat, a hollow imperforate tubular extension open at its lower end depending from said dummy pump forming an open ended conduit extending from above said pump seat to below said valve seat, and a valve element at the lower end of said tubular extension adapted to register with said valve seat, whereby said dummy pump and tubular extension may be disposed in said body member thereby closing said upper aperture and opening said lower aperture to communication with said tubing string and permitting fluid introduction through said string and said body member into the surrounding permeable strata.

5. An improved gas anchor and fluid pump for producing valuable fluids from underground permeable strata penetrated by a borehole which comprises an elongated tubular body member attached at the bottom end of a tubing string extending through said borehole and provided at its upper end with at least one upper perforation and at least one lower perforation adjacent its lower end, a pump seat disposed on the inner surface of said body member above said upper perforation, a valve seat disposed on the inner surface of said body member above said lower perforation, a reciprocating bottom hole pump within said anchor attached to said pump seat with its fluid intake below and its outlet above said pump seat and reciprocated by means of a sucker rod string extending through said tubing string, and a longitudinally acting valve element suspended from the lower end of said pump by means of an imperforate connecting rod and in register with said valve seat to close said valve when said pump is seated in said pump seat.

6. An apparatus according to claim 5 wherein said longitudinally acting valve element comprises a cup plunger at the lower end of said connecting rod and said valve seat comprises a seating nipple open at each end and connected at its upper end to the inner wall of said body member above said lower perforation by means of a funnel-shaped element.

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