Dec. 3, 1968 D. T. HARBISON 3,414,057

WELL PUMPING AND FORMATION TREATING APPARATUS

Filed Dec. 2, 1966 2 Sheets-Sheet 1

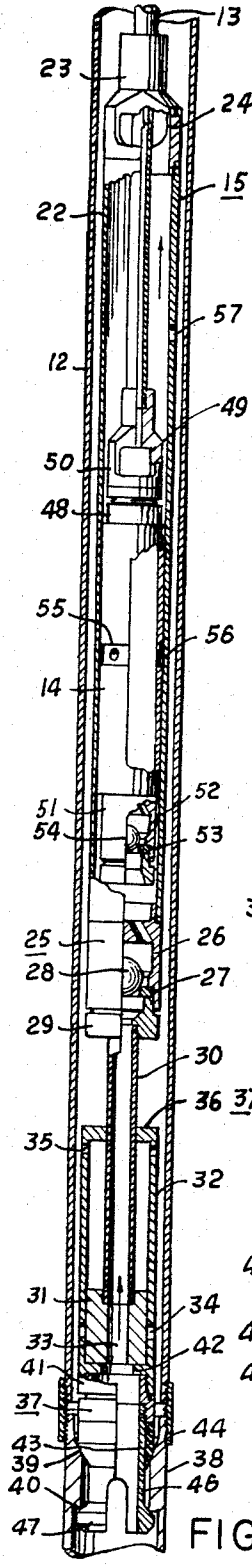


FIG. 1

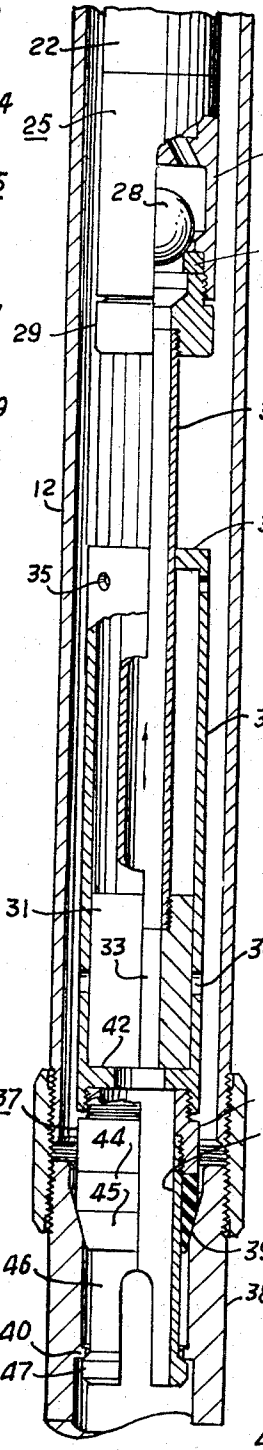


FIG. 2

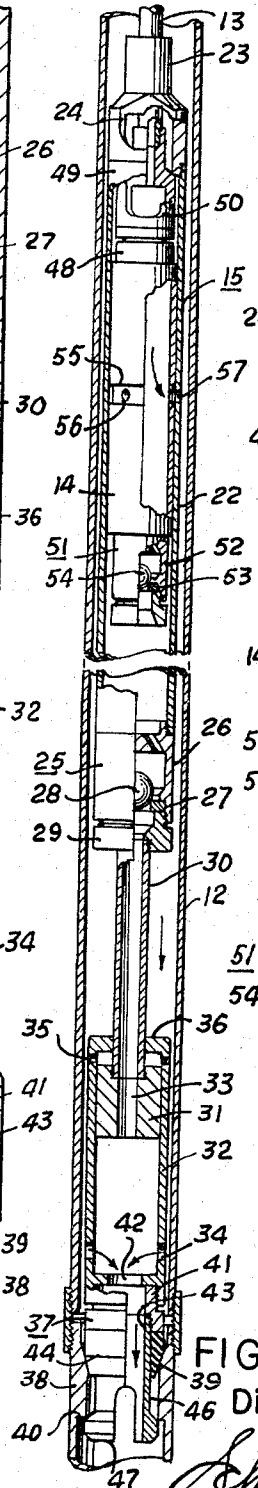


FIG. 3

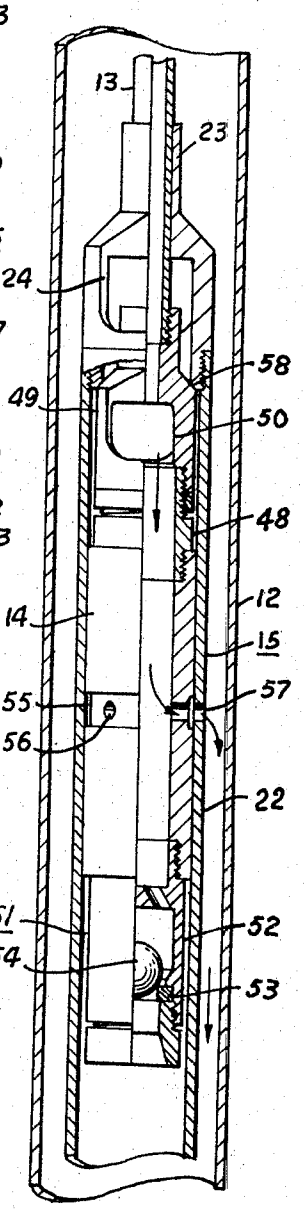


FIG. 4

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WELL PUMPING AND FORMATION TREATING APPARATUS

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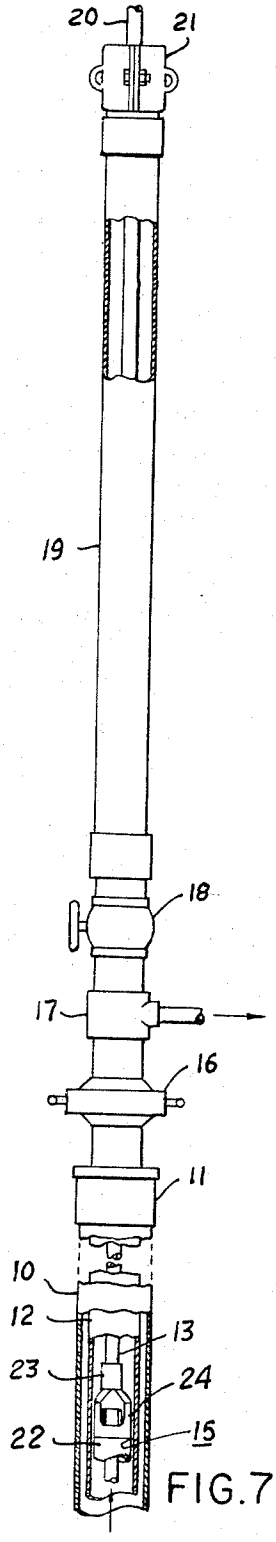


FIG. 7

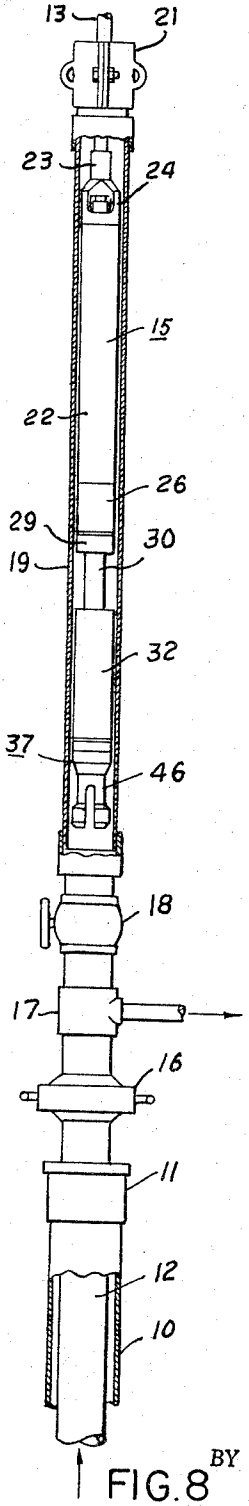


FIG. 8

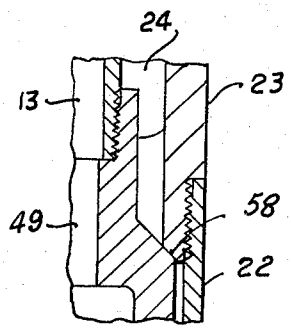


FIG. 5

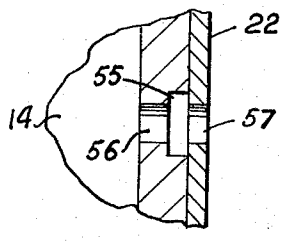


FIG. 6

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WELL PUMPING AND FORMATION TREATING APPARATUS

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3 Claims. (Cl. 166—105)

ABSTRACT OF THE DISCLOSURE

A well pumping and formation treating apparatus which permits the injection of treating fluids without the removal of the apparatus from the well whereby the pumping operation may be resumed as soon as the productivity of the formation is increased to a sufficient extent.

This invention relates to new and useful improvements in apparatuses for pumping wells and treating oil bearing formations.

As is well known, the productivity of substantially all oil bearing formations gradually decreases until it becomes uneconomical to continue the extraction of oil therefrom and this is particularly true when the formations are being produced through pumping wells. This decrease in productivity is due to a number of factors, usually clogging of the interstices or pores of the formations, and occurs before depletion of the oil. It is standard procedure to treat oil bearing formations for increasing the productivity thereof by injecting various fluids into the formations and these fluids include acids, other chemicals, detergents, gaseous compositions, steam, liquids, hot water or water containing soluble oil or a microemulsion. Also, it is common practice to utilize one or more of a group of wells as injection wells for driving the oil in a common formation toward other wells of the group. In addition to this type of secondary recovery method which is known as "waterflooding," tertiary production has been made possible by the injection of water containing soluble oil or a microemulsion.

Heretofore, when fluids have been injected into a pumping well for treating the oil bearing formation adjacent thereto increase the productivity of said formation and/or for driving the oil in said formation toward other wells, it has been necessary to remove the pumping apparatus from the well in order to permit the passage of the injected fluids. The necessity for this relatively expensive and time consuming operation, which requires special equipment and personnel, is eliminated by the novel structure of this invention which permits the injection of treating fluids without removal of the pumping apparatus. In carrying out the invention, a conventional pump assembly of the type having a seating nipple for sealing engagement with a holddown shoe is utilized whereby the pump plunger and working barrel of the assembly may be lowered and positioned within a well tubing or other conductor on the lower end of a pump rod. The pump assembly may have a stationary or a reciprocable working barrel and has its normally stationary member, either its barrel or its plunger, slidably connected to its seating nipple whereby said assembly may undergo limited movement relative to said nipple. The slidable connection includes valve means for controlling communication between the portions of the well conductor above and below the seating nipple and allowing the injected fluids to bypass said the stationary member of the pump assembly and is opened nipple. The valve means is held closed by the weight of upon a predetermined upward movement of said member with said assembly whereby treating fluids injected into the well conductor may flow around the pump assembly

and through the valve means into the portion of the conductor below the seating nipple. Upon completion of the treatment, it is only necessary to lower the pump assembly so as to close the valve means in order to resume the pumping operation.

Summary of the invention

A pump assembly having a plunger member and a coacting working barrel member adapted to undergo relative reciprocation by means of a pump rod which is connected to one of the members and which is utilized for lowering the assembly into a well conductor having means for supporting said assembly. Seating means depends from and is slidably connected to the assembly for sealing engagement with the supporting means whereby said assembly may undergo limited upward movement relative to the seating means when the latter is engaged with said supporting means. The slidable connection includes valve means for controlling communication between the portions of the well conductor above and below the seating means and for allowing the injection of treating fluids past said seating means. The valve means is held closed by the weight of the assembly and is opened by upward movement of said assembly relative to the seating means whereby the treating fluids may flow around said assembly and through said valve means into the conductor below said seating means. In order to resume the pumping operation, it is only necessary to lower the pump assembly so as to close the valve means.

If desired, the pump rod as well as the pump plunger may be tubular whereby said rod may be employed to conduct the injected fluids to the pump assembly. Lateral openings may be provided in the tubular plunger and working barrel for communication with each other when the pump assembly undergoes upward movement relative to the seating means whereby the injected fluids may flow from said assembly into the well conductor and through the valve means past and seating means.

It is noted that the predetermined upward movement of the pump assembly relative to its seating nipple required to open the valve means is insufficient to unseat said nipple and that neither said valve means nor the slidable connection interferes with the normal movement of the reciprocable member of said assembly relative to its stationary member. In the event that the pump rod as well as the pump plunger is tubular, said rod may be employed to conduct the injected fluids to the pump assembly. Lateral openings are provided in the tubular plunger and working barrel and are adapted to communicate when the pump assembly undergoes the predetermined upward movement relative to its seating nipple whereby the injected fluids may flow from said assembly into the well conductor and then through the valve means past said nipple. If desired, the well conductor may be provided with an upstanding portion above its surface connections for housing the pump assembly including its seating nipple in the event that the well commences to flow due to the injection of the treating fluids. Pumping of the well may be resumed upon repositioning of the pump assembly within the well conductor.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings, wherein examples of the invention are shown, and wherein:

FIG. 1 is a transverse, vertical, sectional view, partly broken away, of a well pumping and treating apparatus constructed in accordance with the invention and mounted in a well conductor with the valve means being closed,

FIG. 2 is an enlarged, transverse, vertical sectional view, partly broken away, of the lower portion of the apparatus and conductor with the valve means closed,

FIG. 3 is a view, similar to FIG. 1, with the pump assembly raised and the valve means opened,

FIG. 4 is a view, similar to FIG. 2, of the upper portion of the apparatus with the pump assembly raised and the valve means opened,

FIG. 5 is an enlarged, sectional view showing the engagement of the pump plunger with a stop shoulder of the working barrel,

FIG. 6 is an enlarged, sectional view showing the lateral openings of the pump plunger and working barrel in communication,

FIG. 7 is a side elevational view, partly in section, of the upper portion of the apparatus and an upstanding extension of the conductor for housing said apparatus, and

FIG. 8 is a view, similar to FIG. 7, showing the apparatus housing within the upstanding extension of the conductor.

In the drawings, the numeral **10** designates a conventional well casing adapted to be cemented in a well bore (not shown) in the usual manner and having a tubing head **11** (FIG. 7) at its upper end for suspending a well tubing **12** in the casing. If desired, the tubing may be cemented in the well bore and utilized as the casing for communicating directly with the formation. A pump or sucker rod **13**, which may be tubular as shown, depends through the tubing **12** for supporting the tubular plunger **14** of a pump assembly **15** (FIGS. 1–4). The tubing projects above the tubing head **11** for supporting a blowout preventer **16** and pumping T **17** and, in accordance with the invention, has a shutoff valve **18** mounted therein above the pumping T. An upstanding joint or section of tubing **19** may be connected to the upper end of the valve **18** and is of sufficient length to house the pump assembly **15** (FIG. 8) and permit closing of the valve when the use of said pump assembly is not required. Usually, the upper end portion of the pump rod **13** is in the form of a polished rod **20**, which may be tubular, for coacting with an oil saver or stripper **21** mounted on the upper end of the upstanding tubing section **19**.

The pump assembly is shown most clearly in FIGS. 1–4 and includes an elongate, cylindrical working barrel **22** for coacting with the plunger **14** and having at its upper end a guide bonnet **23** through which the pump rod is slidable. As shown by the numeral **24**, the lower portion of the guide bonnet **23** is enlarged for screwthreaded connection with the barrel **22** and, when the pump rod is solid, is laterally ported so as to communicate with the tubing **12** as well as said barrel. Communication of the upper end of the working barrel with the tubing is unnecessary when the pump rod is tubular. A standing valve **25** is mounted on the lower end of the barrel **22** and includes a blind cage **26** screwthreaded into said barrel and having an annular, upwardly-facing valve seat **27** for coacting with a valve ball **28** to permit the flow of well fluids into said barrel upon the upstroke of the plunger and to prevent such flow upon the downstroke of said plunger.

For retaining the valve seat **27** in the valve cage **26**, a collar **29** is screwthreaded in the lower end of said cage and has a cylindrical tube **30** depending therefrom for suspending a cylindrical slide valve **31** within a coacting, complementary valve sleeve **32** (FIGS. 1–3). The slide valve **31** has an axial bore **33** communicating with the tube **30** for permitting the upward flow of well fluids from the lower portion of the tubing through said tube to the working barrel **22** and is adapted to control flow through radial ports **34** formed in the lower portion of the valve sleeve **32**. Radial, pressure-equalizing ports **35** are provided in the upper portion of the valve sleeve immediately below a circular plate **36** which closes the upper end of said sleeve and through which the tube is slidable. Upon upward movement of the slide valve relative to the valve sleeve **32**, which movement is limited by the plate **36**, the ports **34** are opened to permit flow from the tubing **12** into said sleeve as shown by the arrows in FIG. 3.

An annular seating nipple **37** is mounted on the lower end of the valve sleeve for engagement with a cylindrical holddown shoe **38** connected in the lower portion of the tubing and having formed therein an annular, upwardly-facing, inclined seat **39** spaced above an annular, downwardly facing shoulder **40** (FIGS. 1–3). The seating nipple **37** includes a top collar **41** having its upper end screwthreaded in the valve sleeve **32** so as to bear against an annular, internal shoulder **42**, a cylindrical body **43** screwthreaded into the lower end of the collar for depending through the annular seat **39** of the shoe **38**, and an elastic packing member **44** secured on the upper portion of the body below said collar. As best shown in FIG. 2, the packing member **44** has an external, tapered lower end surface **45** for complementary engagement with the seat of the shoe to seal off therebetween and the lower portion of the body **43** is bifurcated to provide a pair of depending, resilient elements **46** having external enlargements **47** on their extremities for detachable locking engagement with the shoulder **40** of said shoe. In addition to resting on the annular shoulder **42** at the lower end of the valve sleeve **32** so as to support the working barrel **22** of the pump assembly **15**, the slide valve **31** has a snug fit within said valve sleeve for coacting with its weight and the weight of said working barrel to resist upward movement of said barrel upon upward reciprocation of the plunger **14** of said pump assembly.

The tubular pump plunger is in the form of a cylindrical tube having a snug sliding fit in the working barrel, the exterior of said plunger and the interior of said barrel being polished to facilitate reciprocation of said plunger. As shown most clearly in FIG. 4, a coupling **48** is screwthreaded in the upper end of the plunger **14** and has its upper end screwthreaded in the lower end of an adapter **49** which has the lower end of the pump rod **13** screwthreaded into its reduced upper end. When the pump rod is solid, the adapter **49** has large lateral openings **50** in its enlarged lower portion for establishing communication between the barrel **22** and the interior of the plunger in the usual manner, the diameter of said adapter being less than the internal diameter of the barrel. Manifestly, the lateral openings **50** would interfere with the lifting of the well fluids through a tubular pump rod. A travelling valve **51** is carried by the lower end of the plunger **14** and includes a blind cage **52** screwthreaded into said plunger and having an annular, upwardly-facing valve seat **53** retained therein for coacting with a valve ball **54** to permit upward flow into and prevent downward flow out of said plunger. When the pump rod is tubular, the plunger has an external, annular groove or recess **55** intermediate its end communicating with radial ports **56** in said plunger and adapted to communicate with radial ports **57** in the upper portion of the working barrel when said plunger is disposed in said barrel portion (FIGS. 3, 4 and 6). This communication is not required when the pump rod is solid.

In operation, the pump plunger **14** is reciprocated within the working barrel **22** by the pump rod **13** to draw well fluids through the standing valve **25** into said barrel upon the upstroke and to force said fluids through the travelling valve **51** and into and through said plunger upon its downstroke for lifting upon its next downstroke. The lifted well fluids pass through the openings **50** of the plunger adapter **49** into the working barrel and through the ports of the guide bonnet **23** into the tubing **12** in the usual manner. When the pump rod is tubular, the plunger adapter has no lateral openings so as to permit lifting of the well fluids through said rod.

Due to the construction of the pump assembly **15** including its slide valve **31** and valve sleeve **32**, said assembly facilitates the treating of the oil bearing formation of a well to increase the productivity thereof. This

treatment involves the injection of suitable fluids, such as acids, other chemicals, detergents, gaseous compositions, steam, liquids, hot water or water containing soluble oil or a microemulsion, into the formation adjacent the well for acting upon said formation and/or for deriving well fluids toward other wells in secondary or tertiary recovery methods. When it is desired to inject a fluid or fluids, the pump rod **13** is raised until the plunger adapter **49** strikes an annular, internal, downwardly-facing shoulder **58** on the lower end of the guide bonnet **23** (FIGS. 4 and 5) whereby the working barrel **22** is lifted upon continued upward movement of said pump rod. As shown in FIG. 3, the slide valve **31** moves upwardly with the working barrel so as to uncover the ports **34** in the lower portion of the valve sleeve **32** and establish communication between the interior of said sleeve and the tubing **12** above the seating nipple **37** and the coacting holddown shoe **38**. When the pump plunger **14** has the external, annular groove **55** and ports **56** and the barrel **22** has the ports **57**, the interior of said plunger communicates directly with the tubing in the uppermost position of said plunger.

In the event that the pump rod **13** is tubular as shown, the fluid to be injected may be introduced through said rod and/or the tubing **12** and conducted through the ports **56** and **57** into said tubing. From the latter, the injected fluid flows through the ports **34** into the valve sleeve **32** for passage through the seating nipple **37** into the lower portion of the tubing below the holddown shoe **38**. Injection through the tubular pump rod is desirable when the treating fluid is relatively expensive and necessitates the minimum use thereof. When the pump rod is solid or nontubular, the groove **55** and ports **56** and **57** are not required since the injected fluid is introduced only through the tubing and bypasses the seating nipple and holddown shoe by means of the valve sleeve ports in the manner described; however, it is readily apparent that the provision of said groove **55** and ports **56** and **57** does not interfere with the use of a solid or nontubular rod. Accordingly, either type of pump rod may be employed with the pump assembly **15** in carrying out the invention.

Since the upstanding joint or section of tubing **19** is of sufficient length to house the entire pump assembly **15** including its seating nipple **37**, said assembly may be raised until said seating nipple is disposed above the shutoff valve **18** as shown in FIG. 8. Only a predetermined force is required to disengage the enlargement **47** of the resilient elements **46** from the shoulder **40** of the holddown shoe **38** and permit this positioning of the pump assembly, which positioning is desirable when the injected fluid causes the producing formation to flow of its own accord due to the cleansing or loosening of said formation whereby the gas pressure is sufficient to lift the well fluids. Whenever desirable or necessary, the pump assembly **15** may be readily lowered to the position shown in FIGS. 1 and 2 and pumping of the well resumed. Of course, the pump assembly may be readily removed in the event that the well continues to flow since it is only necessary to position said assembly within the tubing section **19**, close the shutoff valve and disconnect said tubing section from said valve. It is noted that the invention is not limited to well pumps having stationary working barrels since it is well known to reciprocate working barrels relative to stationary pump plungers. In applying this invention to a pump of the latter type, the plunger rather than the barrel is slidably connected to the seating nipple of the pump.

The foregoing description of the invention is explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made, within the scope of the appended claims, without departing from the spirit of the invention.

What I claim and desire to secure by Letters Patent is:

1. A well pumping and formation treating apparatus including a pump assembly having a plunger member and a coacting working barrel member adapted to undergo relative reciprocation, a pump rod connected to one of the members for reciprocating the same relative to the other member of said pump assembly and for lowering said assembly into a well conductor having means for supporting said assembly, seating means depending from said assembly for sealing engagement with the supporting means, means slidably connecting the seating means and assembly for permitting limited upward movement of said assembly relative to said seating means when the latter is engaged with said supporting means, the slidable connecting means including means for conducting well fluids from below said seating means to the interior of said assembly, said connecting means including valve means for controlling communication between the portions of the well conductor above and below said seating means, the valve means being held closed by the weight of said assembly and being opened by upward movement of said assembly relative to said seating means whereby treating fluids injected into the well conductor above said assembly may flow around said assembly and through said valve means into the portion of the conductor below said seating means, the pump rod being tubular and communicating with the interior of said assembly, said assembly having valve means for controlling communication between its interior and the well conductor, the valve means of said assembly being cloed during normal reciprocation of one of the members relative to the other member of said assembly and being opened upon said upward movement of said reciprocable member relative to said other member of said assembly whereby treating fluids may be injected into the well conductor through said pump rod and assembly.

2. A well pumping and formation treating apparatus as set forth in claim **1** wherein the means for conducting well fluids from below the seating means to the interior of the pump assembly includes a tubular member connected to said assembly for movement therewith relative to said seating means, the valve means including a stationary member connected to said means, the valve means including a stationary member connected to said seating means and a movable member connected to the tubular member for movement therewith relative to the stationary member.

3. A well pumping and formation treating apparatus as set forth in claim **1** wherein the plunger member is reciprocable relative to the working barrel member of the pump assembly, said plunger member being tubular and in communication with the pump rod, the valve means of said assembly including lateral ports in said plunger and working barrel members which are out of communication during normal reciprocation of said plunger member and in communication upon upward movement of said plunger member relative to said working barrel member.

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