May 22, 1951 A. G. BODINE, JR 2,553,541

DEEP WELL PUMP

Original Filed July 17, 1947 3 Sheets-Sheet 1

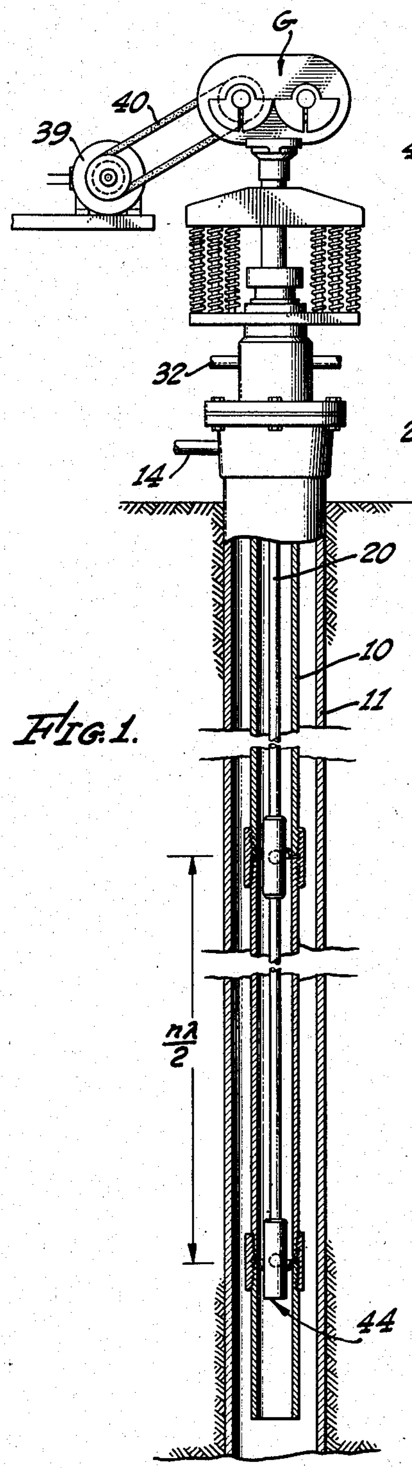

FIG. 1.

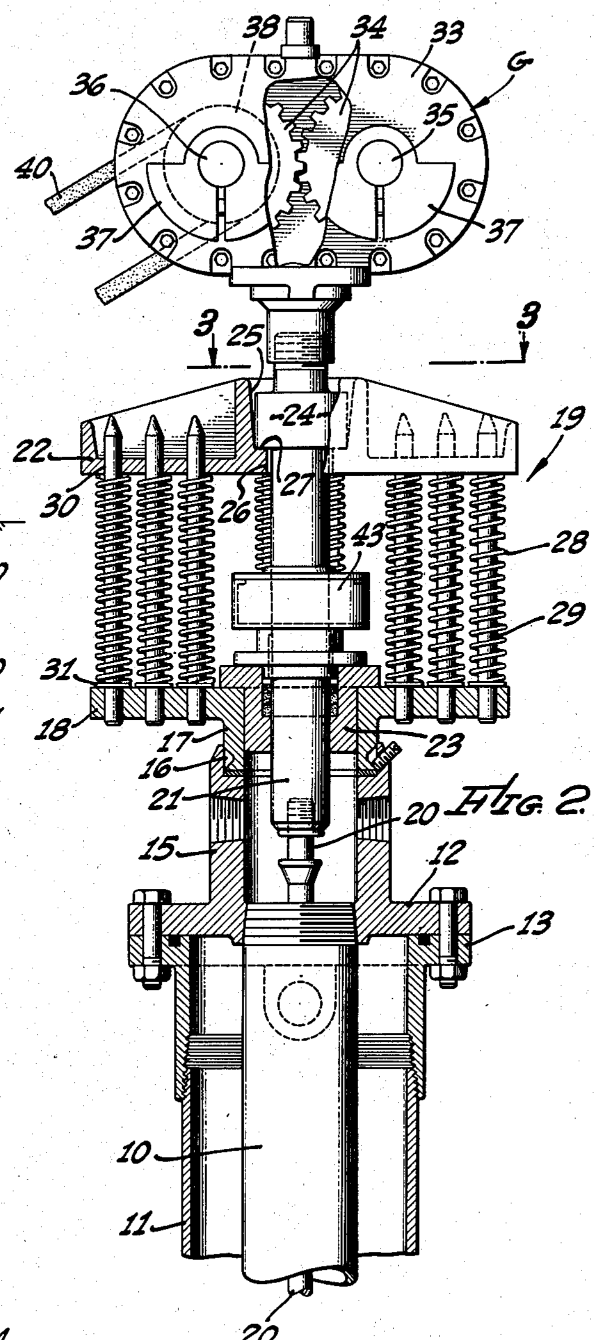

FIG. 2.

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May 22, 1951 A. G. BODINE, JR 2,553,541

DEEP WELL PUMP

Original Filed July 17, 1947 3 Sheets-Sheet 2

FIG. 4.

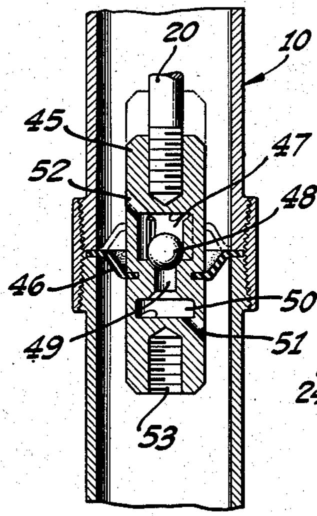
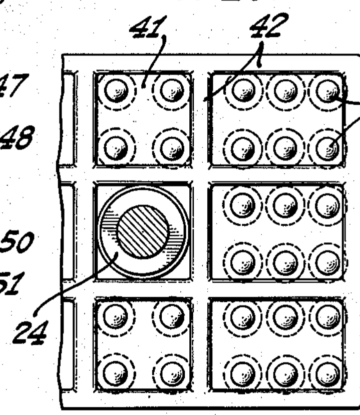


FIG. 3.



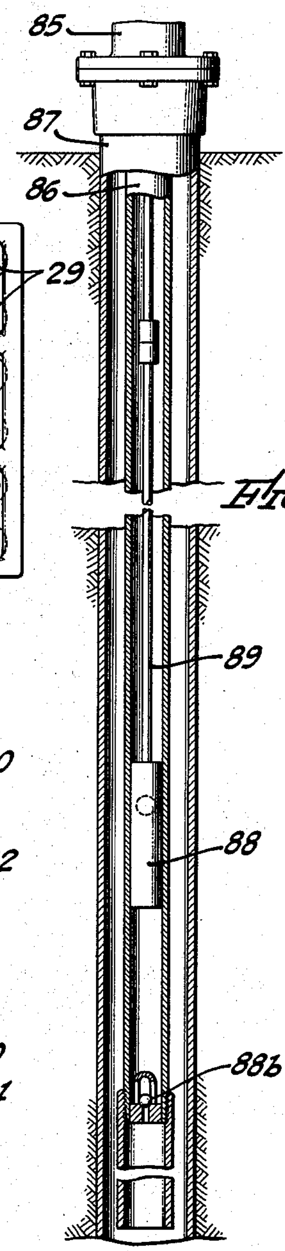


FIG. 9.

FIG. 6.

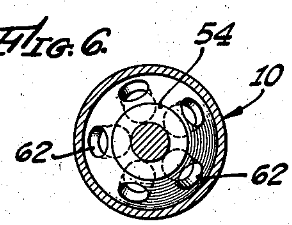
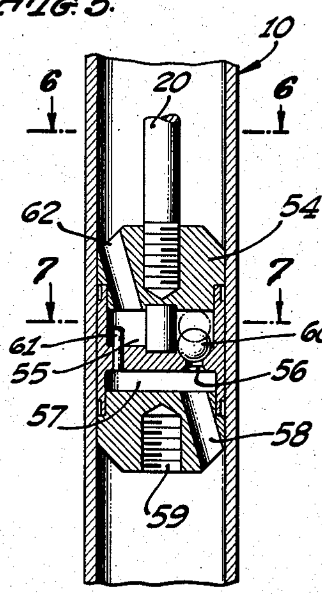


FIG. 5.



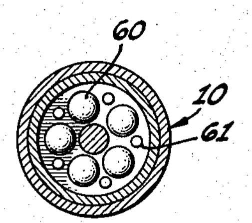


FIG. 7.

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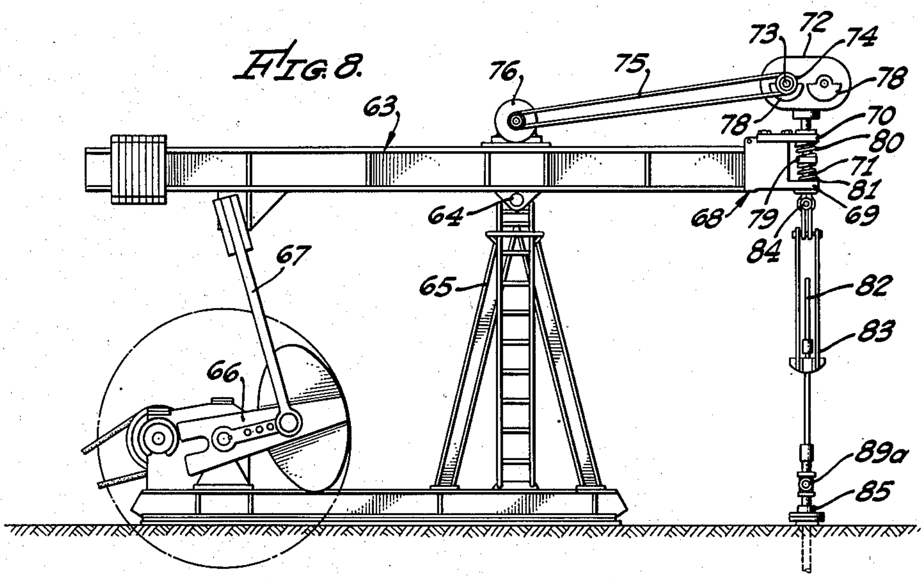
May 22, 1951 A. G. BODINE, JR 2,553,541

DEEP WELL PUMP

Original Filed July 17, 1947 3 Sheets-Sheet 3

FIG. 8.



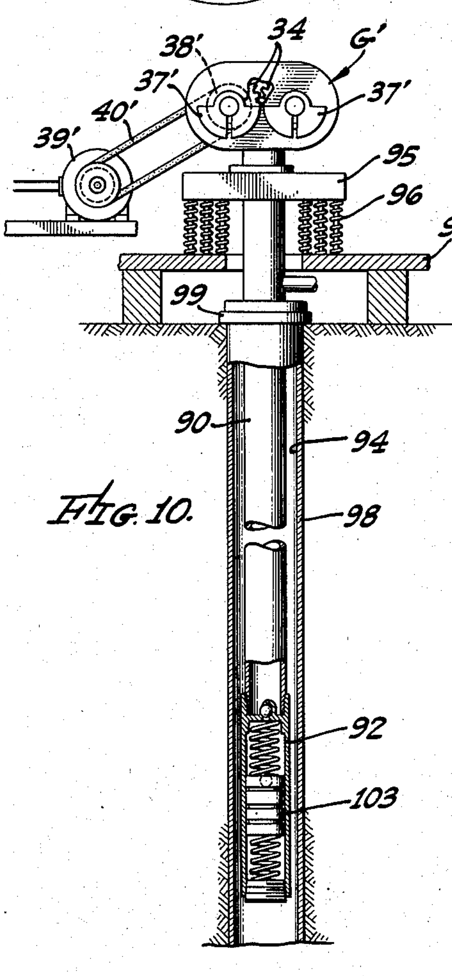


FIG. 10.

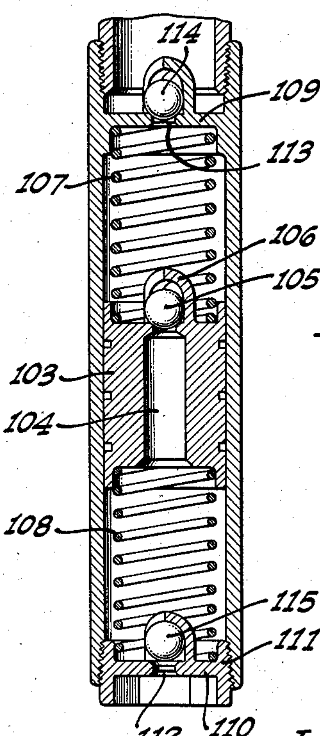


FIG. 11.

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UNITED STATES PATENT OFFICE

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DEEP WELL PUMP

Albert G. Bodine, Jr., Van Nuys, Calif.

Original application July 17, 1947, Serial No. 761,456. Divided and this application March 6, 1948, Serial No. 13,422

7 Claims. (Cl. 103—43)

1

This invention relates generally to deep well pumps, and more particularly to improvements in deep well pumps operated by periodic waves of tension and compression in an elastic column such as a rod string or the pump tubing.

The present application is a division of my co-pending parent application entitled Method and Apparatus for Pumping, Serial No. 761,456, filed July 17, 1947, and allowed October 22, 1947, now U. S. Patent No. 2,444,912 dated July 13, 1948. In said application I disclosed a type of deep well pump operated by periodic waves of tension and compression generated by means of a sonic vibration generator at the ground surface and transmitted via an elastic column to the pump unit proper at the bottom of the well, this column being in some cases the steel pump tubing, and in others a string of steel sucker rods. Several classes of pump unit were disclosed, one of which involved an oscillatory fluid displacing means rigidly connected to the pump tubing and caused to oscillate by elastic waves transmitted thereto via the elastic column. Another general class of pump disclosed in said parent application differs from the first in that the oscillatory fluid displacing member is movable relative to the pump tubing. Pumps of the latter class constitute the subject matter of the present application.

It may be regarded as a general object of the present invention to provide a deep well pump of the type employing elastic waves in an elastic column to drive an oscillatory fluid displacing member which is arranged for relative oscillation within the pump tubing.

In one general form of the present invention, the oscillatory fluid displacing member is driven by waves travelling down a string of elastic sucker rods. This form of the pump is of advantage in that it is fairly readily adaptable to existing well pumping installations. It has the further advantage that protection and support of the pump tubing, which is somewhat of a problem when the tubing is employed for the purpose of the elastic column, is no longer a factor.

A second form of the present invention employs the pump tubing as the elastic column, and secures a magnified pumping stroke of the oscillatory fluid displacing member by certain special provisions which can be discussed to better advantage hereinafter.

The invention will be more fully understood by now referring to the following detailed description of several illustrative embodiments thereof, reference for this purpose being had to the accompanying drawings, in which:

Figure 1 is a utility view, partly in section, showing one embodiment of the invention;

2

Figure 2 is a vertical longitudinal sectional view through the upper end portion of the pumping system of Figure 1;

Figure 3 is a detail taken in accordance with arrows 3—3 in Figure 2;

Figure 4 is a vertical sectional view showing a fluid displacing and check valve unit which may be used in the pumping system of Figure 1;

Figure 5 is a view similar to Figure 4 but showing a modification;

Figure 6 is a section taken on line 6—6 in Figure 5;

Figure 7 is a section taken on line 7—7 of Figure 5;

Figure 8 is an elevational view showing the surface equipment of a modification of the invention;

Figure 9 is a vertical sectional view of the underground portion of the pumping system of Figure 8;

Figure 10 is a partly elevational and partly longitudinal sectional view of another embodiment of the invention; and

Figure 11 is an enlarged detail of the lower end portion of the pump of Figure 10.

Referring first to the embodiment of Figures 1 through 4, I show at 10 a pump tubing suspended within well casing 11, the upper end of tubing 10 being screwed into a central opening through tubing head 12, to which is secured casing head 13 carrying casing 11, the latter being provided with gas outlet pipe 14. Upstanding from tubing head 12 is a tubular extension or cup 15, the upper end of which is counterbored at 16 to receive the tubular lower end portion 17 of the base plate 18 of spring supporting means 19 for the sucker rod string 20 that extends downwardly through pump tubing 10. The sucker rod string will be understood to be of elastic material, ordinarily steel of good fatigue properties. The upper end of string 20 is screwed into a suspension rod 21 which projects up through base plate 18 and top plate 22 of spring supporting means 19, being slidably fitted in stuffing box 23 carried by base plate 18. Rod 21 has near its upper end an enlarged head 24 received within a recess 25 formed in the top of top plate 22, the bottom defining wall of recess 25 being bored through, as at 26, on a diameter just sufficient to pass the rod 21, so as to afford an upwardly facing shoulder 27 which is engaged by head 24. Between the base member 18 and top member 22 are a plurality of coil springs 28, which are positioned on vertical pins 29 set tightly into base 18 and projecting with working clearance through bores 30 in top member 22. Preferably, the pins 29 are provided near their lower ends with washers 31, which are welded both to the pins and to the plate 18.

The weight of the sucker rod string 20 is thus transferred by rod 21 to top member 22 of spring supporting means 19, and thus to the springs 19 which are in turn supported through base member 18 from tubing head 12. The casing head 13 which carries tubing head 12 will be understood to be suitably supported to carry the load thus placed upon it by any appropriate supporting means, not shown. Tubing head member 12 will be seen to receive the flow from pump tubing 10, and is provided with flow pipes 32.

Mounted on the top end of rod 21 above spring supporting means 19 is a wave generator G which may be of various types but is here shown as comprising a housing 33 journalling a pair of meshing oppositely rotating spur gears 34, these gears being on shafts 35 and 36 carrying eccentric weights 37 which balance out horizontal vibrations but are additive to produce a substantial resultant oscillatory force in a vertical direction. The driving pulley 38 of the sound wave generator, mounted on the shaft for one of the spur gears, is driven by electric motor 39 through belt 40. It will be understood that the function of this wave generator thus connected to the elastic sucker rod string 20 is to transmit alternating longitudinal waves of compression and tension down said string to the pumping means below.

The top member 22 of spring supporting means 19 consists preferably of a plate 41 and webs 42 forming pockets within which oil-soaked waste may be lodged in order to maintain lubrication of the portions of the pins 29 that reciprocate in the bores 30 in plate 41 during the operation of the pump. For the purpose of lubricating rod 21 where it passes through stuffing box 23, an oil cup 43 may be supported on and above the stuffing box, and when filled with oil, will maintain proper lubrication of the parts for an extended period.

The lower end of rod string 20 is screwed into a pump plunger consisting of an oscillatory fluid impelling and check valve unit 44 (Figure 1) which may be, for instance, of the type shown in either of Figures 4 or 5–7. Referring first to the form of Figure 4, rod 20 is screwed into cylindrical plunger body 45, to which is fitted a flexible diaphragm 46 peripherally clamped by or to the surrounding pump tubing 10. Within body 45 is a valve chamber 47 containing valve ball 48 adapted to seat at the upper end of bore 49 leading upwardly from annular recess 50, the latter receiving fluid by way of a plurality of upwardly inclined passageways 51 opening through the side of body 45. Leading upwardly and outwardly from valve chamber 47 are a plurality of fluid passageways 52 opening through the side of body 45. The body 45 is shown formed in its lower end with a screw threaded socket 53 adapted to receive a lower sucker rod section. For the check valve unit at the lower end of the rod string, the socket 53 is not needed and might have been omitted. Just as in the embodiments of Figures 2 and 13 of my parent application Serial No. 761,456, however, for multi-stage pumping a plurality of the check valve units 44 may be employed in the sucker rod string, spaced apart preferably a half-wave length of the wave generated by the generator G, as has been indicated in Figure 1. For the one or more additional valves above the lowermost one, the socket 53 must thus be provided.

In operation, the generator G is driven and functions to transmit alternating longitudinal elastic deformation waves of compression and expansion down the length of the spring-supported elastic sucker rod string 20, the springs 28 oscillating in step with the vibration frequency of the generator, and the waves of compression and expansion being continuously transmitted down the sucker rod string to the one or more check valve and fluid impelling units 44 incorporated therein. It is to be understood that the vibration frequency of the generator is characteristically high enough relative to the length of the sucker rod string to produce a longitudinal wave in the string having a quarter-wave length which is no longer than substantially the length of the string. In most cases, the generator speed is sufficient to produce a plurality of quarter-wave lengths along the string. And preferably, the speed of the generator is so adjusted relative to the length of the string as to resonate the latter and thus set up a standing wave therein, with a velocity anti-node (region of maximum velocity) located adjacent each check valve. It will thus be understood that the sucker rod portion immediately adjacent each plunger unit 44 will be set into vertical oscillation, and that the flexible diaphram 46 functions with or as a part of the plunger by oscillating accordingly. On each downward movement of the body 45 and diaphragm 46 occurring with an acceleration greater than gravity, fluid within the pump tubing below the diaphragm is caused to flow inwardly through passageway 51 and upwardly past the valve ball 48; and on each up stroke of the body 45 and diaphragm 46, the valve ball 48 seats, and liquid is propelled in an upward direction by the diaphragm 46 and the vertically projected area of the body 45 and ball 48 operating against the fluid column.

The reciprocable plunger unit shown in Figures 5 to 7 incorporates within its own structure the entirety of the fluid impelling and check valve functions. In this instance, the sucker rod string 20 is screwed into cylinder plunger body 54, which is of a diameter to fit slidably within the pump tubing. Within a central region of the plunger body is a valve chamber 55, and extending downwardly from the lower surface of this chamber are a plurality of passageways 56 leading to annular chamber 57, there being a plurality of fluid entrance passageways 58 extending upwardly into chamber 57 around the outside of the screw threaded sucker rod socket 59 formed in the bottom of the plunger body. Valve balls 60 in chamber 55 seat at the upper ends of passages 56, and spacer pins 61 maintain them in proper position. A plurality of passageways 62 extend upwardly from valve chamber 55 around the upper sucker rod socket, and open through the upper end of the body as shown.

Assuming again vertical reciprocation of the end portion of rod 20 screwed into plunger 54 as a result of longitudinal deformation waves of compression and expansion transmitted down the sucker rod string from wave generator G, the body 54 will be rapidly reciprocated at the frequency of operation of the wave generator, to pump fluid in an upward direction therethrough. On each down stroke fluid is displaced by the lower end area of the valve body 54 and caused to flow upwardly through passageways 58 and 56 to enter the valve chamber 55, past the unseated balls 60, and on each up stroke of the body 54, the increment of fluid thus pumped into chamber 55 is elevated by the vertically projected area of the body and balls 60 which are effective against the column of oil above, the valve balls **60**, of course, seating at such time.

It will be evident that the check-valved plunger body **54**, oscillated vertically by the longitudinal elastic deformation waves transmitted down the rod string, becomes both fluid impelling and check valve means. As in the case of Figure 4, the valve assembly of Figures 5–7 may be used either at the lower end of the sucker rod string, in which case the bottom socket **53** is not used, or a plurality of such units may be used in the rod string, preferably at spacings of one-half wave length, in which case the lower sucker rod sockets in all units but the lowermost are used.

A form of the invention has now been disclosed wherein the pump plunger is rapidly reciprocated through a small amplitude stroke by means of alternating longitudinal elastic deformation waves of compression and expansion transmitted down a string of sucker rods as the elastic column. In a further modification, the sucker rod string may not only have longitudinal deformation waves thus transmitted down its length, but may also be slowly bodily reciprocated through a relatively long pump stroke. Such an embodiment is disclosed in Figures 8 and 9, to which reference is now directed. In said figures, numeral **63** designates generally a more or less conventional counter-weighted walking beam, which is pivotally mounted at **64** on a suitable supporting structure **65**, the walking beam being oscillated in a vertical plane by means of the usual crank **66** and connecting rod **67**, driven in any conventional manner. At the forward end of walking beam **63** is a head **68** having at its bottom a projecting ledge **69**, and having demountably secured to its top a projecting plate **70**, the ledge **69** and plate **70** being vertically perforated to receive a rod **71** that carries at its top end a sonic vibrator **72** serving as a longitudinal wave generator. This generator may be of the general type disclosed in Figure 2, being understood to have within its housing a pair of spur gears, the shaft **73** of one of said gears being provided with pulley **74** driven by belt **75** from electric motor **76** mounted on walking beam **63**, preferably immediately over supporting structure **65**. Shaft **73**, and the shaft **77** carrying the other spur gear of generator **72**, are provided with unbalanced weights **78**, like those described in connection with the generator of Figure 2.

Rod **71**, which is vertically reciprocable in members **69** and **70**, has midway between said members a head or flange **79**, and a pair of coil compression springs **80** and **81** encircle rod **71** between said head **79** and the members **69** and **70**, respectively.

The lower end of rod **71** is connected to the upper end of the polished rod **82** of the well through any conventional means such as indicated at **83**, said means including a horizontal pivot joint at **84** to permit the rocking action of the walking beam.

Polished rod **82** extends downwardly through stuffing box **85** into pump tubing **86** suspended inside casing **87**, a pump plunger **88** of any suitable character being connected to the lower end of the elastic sucker rod string **89** suspended from polished rod **82**. The column of oil in the tubing is delivered by way of flow pipe **89a**. The plunger **88** might be of the usual ball check-valve character known in conventional well pumps employing sucker rods, or it might be of the type disclosed in Figures 5 to 7, or any other suited to

the purpose. A standing valve **88b** is shown in the bottom of the pump tubing.

The pump of Figures 8 and 9 might be operated with the walking beam stationary, in which case its operation is similar to that described in connection with Figures 1 to 7, the standing valve **88b** being in this instance unnecessary. The vibration generator **72**, operated at suitable speed, transmits longitudinal deformation waves of compression and expansion down the sucker rod string to the check-valved pump plunger **88**, causing the latter to oscillate rapidly through a small amplitude, e. g., a fraction of an inch, such action being permitted by the springs **80** and **81** which support the sucker rod string and wave generator for vertical reciprocation relative to the walking beam. The oscillating plunger functions as fluid impelling and check valve means, in accordance with principles already disclosed, and the fluid column is elevated accordingly. In addition to this action, the walking beam **63** may be slowly reciprocated so as to give the sucker rod string not only a rapid wave motion causing portions thereof to reciprocate rapidly in a vertical direction through an amplitude of the order of a fraction of an inch, but also to have a slow vertical pumping stroke of the order of several feet. This long stroke action of the rod string and connected plunger, in conjunction with the standing valve **88b**, will result in pumping in the manner of the conventional deep well plunger pump. When both types of movement of the sucker rod are used in combination, the result is additive. It should also be noted that pumping in accordance with the principles of the present invention can be accomplished by a sufficiently rapid, low amplitude oscillation of the walking beam **63**. This would only require a shortening of the crank arm **66** so as to give a small amplitude reciprocation to the upper end of the sucker rod string. In order to give the necessary wave pattern in the rod string by which the invention is characterized, the walking beam will of course have to be oscillated or vibrated at a sonic frequency comparable to that at which the wave generator **72** is otherwise driven. In other words, the walking beam in this case becomes the sonic wave generator. It should also be noted that in such a version of the invention, the springs **80** and **81** are no longer necessary, it being sufficient that the sucker rod string is suspended from the walking beam in the ordinary way.

In Figures 10 and 11 are shown a further modification of the invention wherein the alternating longitudinal waves of compression and tension are transmitted down an elastic pump tubing **90**, which in this instance has the dual functions of production tubing and elastic wave transmitting column. Mounted on the upper end of tubing **90** is a sonic wave generator G′, and coupled to its lower end so as to form a downward extension thereof is a barrel **92** containing the pump proper. The generator G′ may be of the same type as shown in connection with the previously described embodiments, but in this instance is mounted directly onto the upper end of the pump tubing. Thus, it has oppositely rotating spur gears **34′** carrying eccentric weights **37′** which balance out horizontal vibrations but which produce a substantial oscillatory force in a vertical direction, one of the gear shafts carrying a pulley **38′** driven through belt **40′** from electric motor **39′**. The pump tubing **90**, understood as composed of elastic material, as steel, is suspended in well bore **94** from platform **95**, its lower end reaching downwardly to the region of the liquid to be pumped from the well bore. Platform 95 is resiliently mounted on vertical coil springs 96 standing on platform 97 which is in turn supported on the ground surface. The well bore is lined with casing 98 having the usual perforations (not shown) opposite the oil bearing strata. This casing has a head 99 suitably fitted or clamped to the pump tubing, and may be arranged to permit a slight vertical oscillation of the pump tubing, or the pump tubing and the speed of the generator may be adjusted to establish a velocity node at the juncture of the pump tubing with the casing head, in which case there will be no relative movement of these parts. This would mean, of course, that the casing head would be located a quarter-wave length below the upper end of the tubing.

Mounted for sliding reciprocation within barrel 92 is a pump plunger 103, formed with a central fluid passage 104 extending vertically therethrough, and equipped at the upper end of said passage 104 with a check valve, here shown in the form of a valve ball 105 seating at the upper end of passageway 104, a suitable cage 106 for the ball 104 being provided on the upper end of plunger 103. Plunger 103 is mounted between a pair of opposed coil springs 107 and 108, the former of which seats upwardly against a centrally perforated flange 109 formed in the upper end of barrel 92, and the latter of which seats against a flange 110 on a ring 111 screwed into the lower end of barrel 92, flange 110 being centrally perforated as indicated at 112. The port 113 in flange 109 and the port 112 in flange 110 may preferably be controlled by check valves 114 and 115, respectively, though such valves are not essential to operation of the pump.

Opperation of the pump will first be considered without the valves 114 and 115, the ports 112 and 113 being assumed to be open. First assume that the mass of the plunger or piston 103 and the stiffness of springs 107 and 108 are tuned to a much lower frequency than the frequency of the longitudinal waves transmitted down the pump tubing to the barrel 92. That is to say, the natural resonant frequency of the plunger 103 mounted between the springs 107 and 108, is to be assumed as much lower than that of the waves in the pump tubing. It will of course be understood that the greater the mass of the plunger 103, and the less the stiffness of the springs 107 and 108, the lower will be the resonant oscillation frequency of the plunger 103; and with this understanding, the resonant frequency of the plunger 103 may readily be made less than that of the waves transmitted down the pump tubing. In this situation, the longitudinal waves transmitted down the pump tubing will result in vertical oscillation of the barrel 92 at the frequency of the wave generator coupled to the pump tubing, while the plunger 103 will stand substantially stationary in space. On each upstroke of the barrel 92 relative to the plunger 103, an increment of well fluid displaced by the wall or flange 110 (functioning as an oscillatory fluid displacing member) is forced upwardly through the passage 104 in plunger 103 and past the valve ball 105. On the succeeding down stroke of the barrel 102, occurring with an acceleration greater than gravity, the valve ball 105 seats, and a void is created in the space between the plunger 103 and the wall 110, causing inflow of well fluid into said space by way of the port 112. It will be seen that the result of reciprocating the pump tubing and the barrel 92 connected to its lower end and is to impel successive increments of well fluid through the plunger member 103, elevating the oil column above accordingly. If the valve 115 is employed, additional well fluid is forced upwardly through the plunger 103 on each upstroke of the barrel 92 owing to the impossibility of some fluid escaping via port 112. Pumping also results from the fluid displacing action of the wall 110, in combination with the valve 115 since this combination, connected to the lower end of the barrel 92, will be recognized to be a pump of the character described in connection with Figures 1 and 2 of my aforesaid application Serial No. 761,456.

Substantial improvement in the pumping rate is achieved by adjusting the mass of the plunger 103 relative to the stiffness of the springs 107 and 108 in a manner to tune the system to approximately the same frequency as the wave motion in the pump tubing. Reciprocation of the pump tubing and barrel 92 will then result in vertical oscillation of plunger 103 at the same frequency and in step with the barrel 92, but at increased amplitude. In other words, plunger 103 moves up and down with barrel 92, but with an amplitude which may be a number of times that of the oscillation of the barrel 92. Operation in this mode may first be considered with valves 114 and 115 disregarded. On each downstroke of plunger 103, occurring with an acceleration greater than gravity, well fluid will be displaced thereby and forced upwardly through passage 104 and past valve 105. On each upstroke of plunger 103, valve ball 105 seats, and the column of oil is elevated. Use of valve 115 increases the fluid that will be forced upwardly through plunger passage 104 on each downstroke of the latter, since outflow by way of port 112 is prevented. Thus the pumping rate is increased. Use of the valve 114 is beneficial, since the column of oil above is prevented from descending with each downstroke of plunger 103. The void so created between valve 114 and the plunger 103 on each downstroke of the latter also helps in that the fluid flow upwardly through plunger 103 is increased because of the suction created immediately above it.

Several embodiments of the invention have now been disclosed all of which, however, are characterized by the fact that relative movement occurs between the oscillatory plunger member and the pump barrel. My aforesaid parent application Serial No. 761,456 contains generic claims broadly covering the subject matter of the present application, while specific claims to the forms of my pump characterized by relative movement between the pump plunger and the pump barrel are confined to the present case.

It will be understood that the embodiments selected for illustration herein are merely illustrative of and not restrictive on the invention, and that various changes in design, structure, and arrangement may be made without departing from the spirit and scope of the present invention or of the appended claims.

I claim:

1. In a well pumping system, the combination of: a production tubing having a fluid inlet and an outlet for pumped fluid, said tubing being adapted for placement in the well with said fluid inlet in communication with well fluid therein, a check-valved fluid displacing plunger mounted within said tubing between the fluid inlet and fluid outlet thereof for relative reciprocation with respect to said tubing, an elastic column of

solid material extending from the ground surface to the region of said plunger, said column being adapted to transmit elastic deformation waves of tension and compression longitudinally through the structure thereof, a sonic wave generator at the ground surface operatively connected to said elastic column and adapted to continuously transmit alternating waves of compression and tension longitudinally down said elastic column and thereby cause sonic frequency reciprocation of the lower end of said column, said sonic wave generator being operable at a speed sufficient to generate longitudinal waves in the structure of the column having a quarter-wave length which is no longer than substantially the length of the column, whereby the lower end of the column reciprocates longitudinally relative to other portions of said column, and means connected to the lower end portions of said column for effecting relative longitudinal reciprocation of said plunger and said tubing in response to said longitudinal reciprocation of said lower end portion of said column.

2. In a well pumping system, the combination of: a production tubing having a fluid inlet and an outlet for pumped fluid, said tubing being adapted for placement in the well with said fluid inlet in communication with well fluid therein, a check-valved fluid displacing plunger mounted within said tubing between the fluid inlet and fluid outlet thereof for relative reciprocation with respect to said tubing, an elastic column of solid material inside said tubing adapted to transmit elastic deformation waves of tension and compression longitudinally through the structure thereof, said column having an operative connection at its lower end with said plunger, a sonic wave generator operatively connected to the upper end of said elastic column and adapted to continuously transmit alternating waves of compression and tension down said elastic column in a manner to effect sonic frequency reciprocation of the lower end of said column and of said plunger within said tubing, said sonic wave generator being operable at a speed sufficient to generate longitudinal waves in the structure of the column having a quarter-wave length which is no longer than substantially the length of the column, whereby the lower end portion of said column and the plunger reciprocate longitudinally relatively to other portions of said column and to said tubing.

3. In a well pumping system, the combination of: a production tubing having a fluid inlet and an outlet for pumped fluid, said tubing being adapted for placement in the well with said fluid inlet in communication with the well fluid therein, a check-valved fluid displacing plunger mounted within said tubing between the fluid inlet and fluid outlet thereof for relative reciprocation with respect to said tubing, a string of elastic sucker rods inside said tubing connected to said plunger and extending to the ground surface, said string of elastic sucker rods being adapted to transmit elastic deformation waves of tension and compression longitudinally through the structure thereof, and a sonic wave generator connected to the upper end of said sucker rod string and adapted to continuously transmit alternating waves of compression and expansion longitudinally down said elastic rod string, said sonic wave generator being operable at a speed sufficient to generate longitudinal waves of compression and tension in the structure of the sucker rod string having a quarter-wave length which is no longer than substantially the length of said string, thereby causing sonic frequency reciprocation of the lower end of said rod string relative to other portions thereof, and consequent reciprocation of the said plunger relative to said pump tubing.

4. A pumping system as defined in claim 3, including also resilient mounting means supporting the upper end portion of said rod string for vertical sonic frequency reciprocation.

5. A pumping system as defined in claim 3, including also means for reciprocating the rod string together with said sonic generator through a pumping stroke which is relatively long and relatively slow compared with the sonic frequency reciprocation of the said lower end portion of the rod string.

6. In a well pumping system, the combination of: a pump tubing, a check-valved fluid displacing plunger mounted for relative reciprocation within and with respect to said pump tubing, a string of elastic sucker rods connected to said plunger and extending to the ground surface, means for reciprocating said rod string through a normal pumping stroke at normal pumping frequency, and a sonic wave generator operatively connected to the upper end of said sucker rod string and adapted to continuously transmit longitudinally down the normally reciprocating rod string alternating waves of compression and expansion whereby to cause relatively small amplitude sonic frequency reciprocation to be superimposed on the normal reciprocation of the lower end of the rod string and plunger.

7. In a well pumping system, the combination of: a production tubing having a fluid inlet and an outlet for pumped fluid, said tubing being adapted for placement in the well with said inlet in communication with well fluid therein, a check-valved fluid displacing plunger mounted within said tubing between the fluid inlet and fluid outlet thereof for relative reciprocation with respect to said tubing, an elastic column of solid material extending from the ground surface to the region of said plunger, said column being adapted to transmit elastic deformation waves of tension and compression longitudinally through the structure thereof, and a sonic wave generator at the ground surface operatively connected to said elastic column and adapted to continuously transmit alternating waves of compression and tension longitudinally down said elastic column and thereby cause sonic frequency reciprocation of the lower end of said column, said sonic wave generator being operable at a speed sufficient to generate longitudinal waves in the structure of the column having a quarter-wave length which is no longer than substantially the length of the column, whereby the lower end of the column reciprocates longitudinally relative to other portions of said column and to said plunger.

ALBERT G. BODINE, Jr.

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FOREIGN PATENTS

Number	Country	Date
146,436	Great Britain	Nov. 25, 1920