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 the pump tubing.

The present application is a division of my copending application entitled Deep Well Pump, Serial No. 13,422, filed March 6, 1948, now Patent No. 2,552,921 dated May 22, 1951 which application was in turn a division of my parent application entitled Method and Apparatus for Pumping, Serial No. 761,456, filed July 17, 1947, and now issued as Patent No. 2,444,912. In said parent 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. One general class of pumps disclosed in said parent application is characterized in that the oscillatory fluid displacing member is moveable relative to the pump tubing, and this class of pumps was carried over to my said copending application Serial No. 13,422. Pumps of the latter class in which the elastic waves are transmitted to the pump proper via an elastic column separate from the pump tubing are claimed in said application Serial No. 13,422, while pumps of the type in which the elastic column comprises the pump tubing are made the claimed 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 embodying elastic waves in the pump tubing to drive an oscillatory fluid displacing member which is arranged for relative oscillation within the pump tubing. The pump of the present invention will be best understood by referring now to the following detailed description of a single illustrative embodiment thereof, reference for this purpose being had to the accompanying drawing, in which:

Figure 1 is a partly elevational and partly longitudinal section of a pump embodying the invention.

Figure 2 is an enlarged detail of the lower end portion of the pump of Figure 1.

In the drawings there is shown at 10 a pump tubing suspended within well casing 11, the upper end of tubing 10 being illustratively and somewhat diagrammatically indicated as extending upward and directly supporting wave generator G.

Coupled to the lower end of pump tubing 10, so as to form a downward extension thereof, is a barrel 12 containing the operating elements of the pump proper.

The generator G may be of the same type as shown and described in connection with my earlier filed pump applications, comprising a housing 13 containing oppositely rotating meshing spur gears 14 whose shafts carry eccentric weights 15 which balance out horizontal vibrations but which cause to produce a substantial oscillatory force in a vertical direction. One of the gear shafts carries a pulley 17 driven through belt 18 from the pulley of an electric motor 20.

The pump tubing 10, understood as composed of elastic material, as, for example, rubber, is suspended in casing 11 from a spring supported platform 24, its lower end reaching downwardly to the region of the liquid to be pumped from the well bore. Platform 24 is resiliently mounted on coil springs 25 standing on stationary platform 26 which is in turn supported on the ground surface. The springs 25 are guided by rods 27 which are reciprocating in suitable apertures in the platform 24, as illustrated. Any suitable supporting provisions may be made, such as a flange or collar 28, through which the pump tubing may be suspended from this spring supported platform 24. The casing has a head 30 suitably weighted or clamped to the pump tubing, and which 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 stability 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 12 is a pump plunger 32, formed with a central fluid passage 33 extending vertically therethrough, and equipped at the upper end of said passage 33 with a check valve, here shown in the form of a valve ball 34 seating at the upper end of passageway 35, a suitable cage 36 for the ball 34 being provided on the upper end of plunger 32. Plunger 32 is mounted between a pair of opposed coil springs 37 and 38, the former of which seats upwardly against a centrally perforated flanged plate 39 formed in the upper end of barrel 12, and the latter of which seats against a flange 40 on a ring 41 screwed into the lower end of barrel 12, flange 40 being centrally perforated as indicated at 42. The port 43 in flange 39 and
employed, additional well fluid is forced upwardly through the plunger 32 on each upstroke of the barrel 12 owing to the impossibility of some fluid escaping via port 42. Pumping also results from the mud displacing action of the wall 44, in combination with the valve 45 employed, connected to the lower end of the barrel 12, will be recognized to be a pump of the character described in connection with Figures 1 and 2 of my aforesaid application Serial No. 761,486.

Substantial improvement in the pumping rate is achieved by adjusting the mass of the plunger 32 relative to the stiffness of the springs 31 and 38 in a manner to tune the system to approximately the same frequency as the wave motion in the pump tubing. Recirculation of the pump tubing and barrel 12 will then result in vertical oscillation of the plunger 32 at the same frequency and in step with the barrel 12, but at increased amplitude. In other words, plunger 32 moves up and down with barrel 12, but with an amplitude which may be a number of times that of the oscillation of the barrel 12. Operation in this mode may first be considered with valves 44 and 45 disregarded. On each downstroke of plunger 32, occurring with an acceleration greater than gravity, well fluid will be displaced thereby and forced upwardly through passage 33 and past valve 44. On each upstroke of plunger 32, valve ball 34 seats, and the column of oil is elevated. Use of valve 45 increases the fluid that will be forced upwardly through plunger passage 33 on each downstroke of the latter, since outflow by way of port 42 is prevented. Thus the pumping rate is increased. Use of the oil column above is beneficial, since the column of oil above is prevented from descending with each downstroke of plunger 32. The void is so created between valve 44 and the plunger 32 on each downstroke of the latter also helps in that the fluid flow upwardly through plunger 32 is increased because of the suction created immediately above the plunger 32; and this understanding, the resonant frequency of the plunger 32 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 12 at the frequency of the wave generator coupled to the pump tubing, while the plunger 32 will stand substantially stationary in space. On each up-stroke of the barrel 12 relative to the plunger 32, an increment of well fluid displaced by the wall or flange 46 (functioning as an oscillatory fluid displacing member) is forced upwardly through the passage 33 in plunger 32 and past the valve ball 34. On the succeeding down stroke of the barrel 12, occurring with an acceleration greater than gravity, the valve ball 34 seats, and a void is created in the space between the plunger 32 and the wall 46, causing inflow of well fluid into said space by way of the port 42. It will be seen that the result of reciprocating the pump tubing and the barrel 12 connected to its lower end is to impel successive increments of well fluid through the plunger member 32, elevating the oil column above accordingly. If the valve 45 is
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2. In a well pumping system, the combination of: a pump tubing of elastic material, a pump barrel coupled to the lower end of said tubing, a check-valved pump plunger mounted for relative reciprocation in said barrel, a pair of opposed springs mounted in said barrel above and below said plunger and engaging the top and bottom of said plunger, and a sonic wave generator operatively connected to said pump tubing and adapted to transmit alternating waves of compression and expansion longitudinally down said pump tubing to said barrel whereby said barrel reciprocates at sonic frequency, all in such a manner as to accomplish relative reciprocation between said barrel and said plunger.

3. A pumping system as defined in claim 2, in which the mass of the plunger and the stiffness of the springs are tuned to a natural resonant frequency substantially lower than the frequency of the sonic wave generator, whereby the plunger tends to remain stationary in space while the barrel reciprocates.

4. A pumping system as defined in claim 2, in which the mass of the plunger and the stiffness of the springs are tuned to a natural resonant frequency substantially equal to the frequency of the sonic wave generator, whereby the plunger reciprocates with the barrel but at augmented amplitude.

ALBERT G. BODINE, Jr.

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The following references are of record in the file of this patent:

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<thead>
<tr>
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