

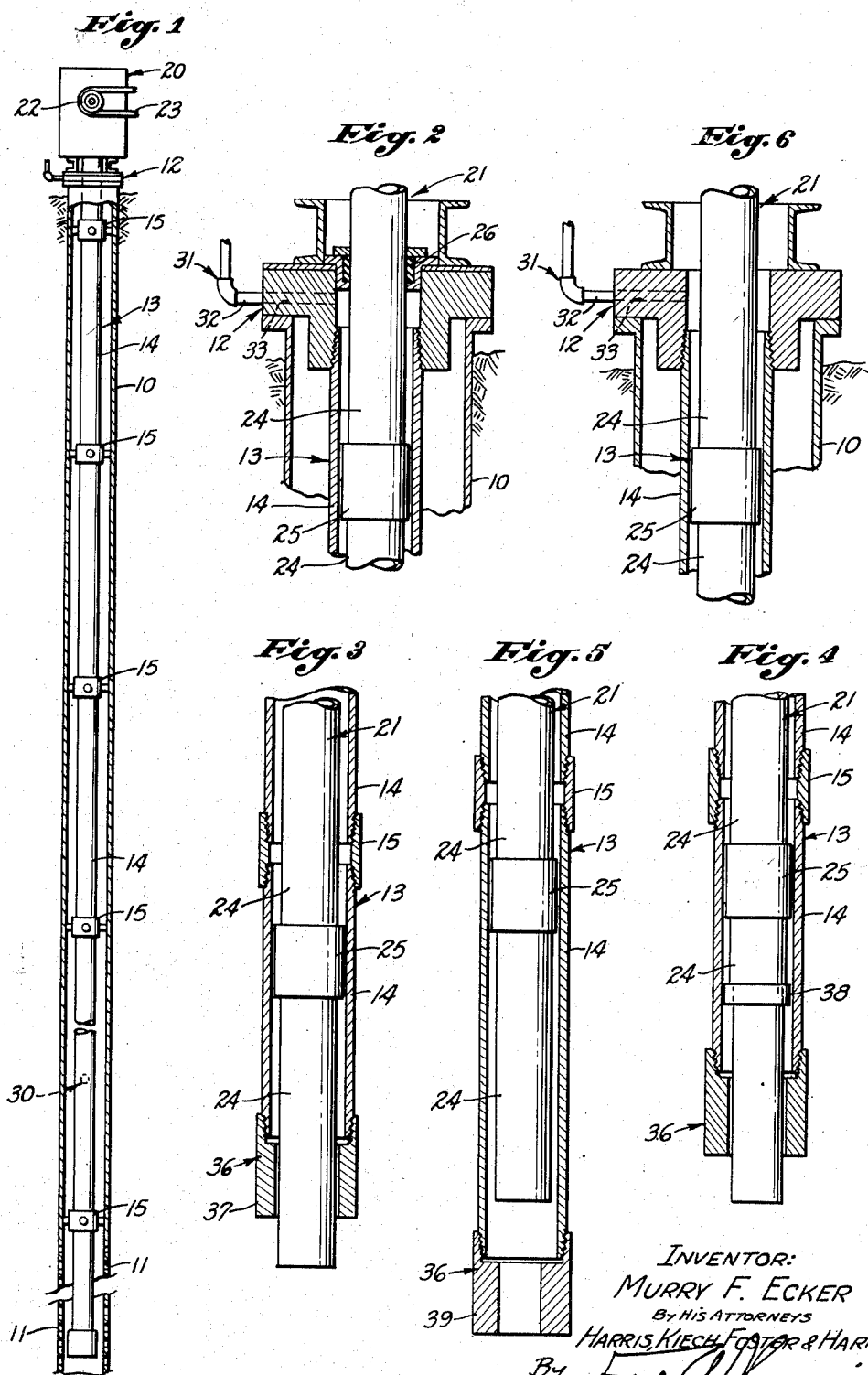
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SONIC WELL-PUMPING APPARATUS

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SONIC WELL-PUMPING APPARATUS

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In general, the present invention relates to a well pumping apparatus of the type disclosed in Patent No. 2,444,912, granted July 13, 1948 to Albert G. Bodine, Jr., an object of this invention being to provide a well pumping apparatus which is an improvement over that disclosed in the Bodine patent mentioned.

Briefly, the well pumping apparatus disclosed by the Bodine patent comprises a production tubing which is adapted to convey pumped fluid upwardly to the surface of the ground and the lower end of which extends downwardly into a body of fluid in the well. The submerged lower end of the production tubing contains an upwardly opening check valve means and is adapted to be oscillated vertically in such a manner as to pump well fluid past the check valve means and upwardly through the production tubing. More specifically, the submerged lower end of the production tubing is adapted to be oscillated vertically with downward accelerations exceeding the acceleration of gravity so that the check valve means descends faster than the production column in the tubing, whereby well fluid flows upwardly through the check valve means into the tubing thereabove. Thus, an increment of well fluid is introduced into the production tubing above the check valve means during each downward stroke of the submerged lower end of the tubing and the production column is elevated by a like increment during the upward stroke thereof. In accordance with the Bodine patent, the submerged lower end of the production tubing is oscillated sonically by means of an oscillator operatively connected thereto, power from the oscillator being transmitted to the submerged lower end of the production tubing through the production tubing itself by making use of longitudinal deformation waves of compression and expansion set up in the structure of the production tubing. By establishing a condition of standing wave resonance in the production tubing, a velocity antinode can be produced in the production tubing at the check valve means, which acts as a fluid displacing member during the upstroke, so that the maximum possible amplitude of oscillation for the fluid displacing member is obtained.

As disclosed in the aforementioned Bodine patent, there are a number of such velocity antinodes, i. e., points of maximum amplitude of oscillation, which are spaced apart along the production tubing distances equal to one-half of the standing wave length. Located midway between the velocity antinodes are points of minimum amplitude of oscillation, the Bodine patent disclosing an apparatus wherein the production tubing is suspended in a well casing and is resiliently anchored thereto at such points of minimum amplitude of oscillation. With this arrangement, the production tubing and the well casing may be maintained in spaced relation at least in the vicinity of the points of minimum amplitude of oscillation. However, since such points of minimum oscillation amplitude may be spaced apart several hundred feet, it is virtually impossible to maintain the production tubing and the well casing in spaced relation throughout the entire length of the production tubing, particularly where the well bore is not absolutely vertical and straight. Consequently, rubbing contact between the production tubing and the well casing frequently occurs at or in the vicinity of the points of maximum oscillation amplitude with the result that considerable wear of both the production tubing and the well casing may occur. Such wear of the well casing in particular is extremely

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undesirable since, in most instances, the well casing is cemented in and cannot be removed for replacement.

In view of the foregoing difficulty, it has been proposed to connect the sections of the production tubing with couplings or collars having rollers or the like thereon which are adapted to engage the well casing, the purpose of this arrangement being to center the production tubing in the well casing and to minimize wear of the casing. However, such arrangements have not proven satisfactory because of the fact that the rollers or other antifriction devices ultimately become detached from the production tubing and fall to the bottom of the well. Another disadvantage of the arrangement disclosed in the Bodine patent wherein the production tubing is suspended in the well casing is that fatigue failures of the production tubing, which are not uncommon, permit that portion of the production tubing which is located below the point of failure to drop to the bottom of the well. Recovery of such a portion of the production tubing involves a fishing job, which is frequently difficult and expensive.

A primary object of the present invention is to provide a well pump apparatus of the sonic type which obviates the foregoing disadvantages of the apparatus disclosed in the Bodine patent and similar apparatuses.

An important object of the invention is to provide a well pumping apparatus which eliminates any possibility of casing wear by disposing the oscillatory production tubing in a guide tubing which is suspended in the well casing and which is preferably spaced inwardly therefrom. With this construction, wear is confined to the guide and production tubings, which is an important feature.

Another object is to provide a well pumping apparatus wherein the production tubing makes a relatively close sliding fit with the guide tubing, thereby eliminating any necessity for attaching antifriction devices to the production tubing and minimizing lateral vibrations of the production tubing.

Another important object of the invention is to provide a well pumping apparatus of the foregoing character which includes means for supplying a lubricant to the clearance between the guide and production tubings so as to lubricate the tubings, thereby minimizing wear thereof.

An extremely important object of the present invention is to provide a well pumping apparatus of the foregoing nature which includes means for catching the lower end of the production tubing in the event of failure thereof, thereby avoiding any necessity for fishing jobs. A related object is to provide such a catching means which includes interengageable elements on the guide and production tubings.

Another object is to provide a well pumping apparatus wherein the catching means includes a collar at the lower end of the guide tubing which is of smaller diameter than a collar on the production tubing so that the two collars engage to catch the lower end of the production tubing in the event of failure.

Still another object is to provide an apparatus wherein the catching means comprises a collar at the lower end of the guide tubing which is smaller than the production tubing so that it supports the lower end of the production tubing in the event of failure.

The foregoing objects and advantages of the present invention together with other objects and advantages thereof which will become evident, may be attained through the utilization of the exemplary embodiments of the invention which are illustrated in the accompanying drawing and which are described in detail hereinafter. Referring to the drawing:

Fig. 1 is a utility view of a well pumping apparatus which embodies the invention as installed in a well;

Fig. 2 is a fragmentary vertical sectional view of one embodiment of the upper end of the invention;

Fig. 3 is a fragmentary vertical sectional view of one embodiment of the lower end of the invention;

Fig. 4 is a fragmentary vertical sectional view of another embodiment of the lower end of the invention;

Fig. 5 is a fragmentary vertical sectional view of still

another embodiment of the lower end of the invention; and,

Fig. 6 is a fragmentary vertical sectional view of another embodiment of the upper end of the invention.

Referring particularly to Figs. 1 and 2 of the drawing, the numeral 10 designates a casing which is set in an oil well, for example, and which is open at its lower end to an oil producing formation adjacent the well, as by being provided with perforations 11 therein. The casing 10 is provided at its upper end with a casing head, designated generally by the numeral 12, into which a guide tubing 13 is threaded, the guide tubing extending downwardly into the well and being suspended from the casing head. The guide tubing 13 consists of a plurality of guide tubing sections 14 which are interconnected by guide tubing couplings or collars 15, the uppermost guide tubing section 14 being threaded into the casing head 12. In order to center the guide tubing 13 in the casing 10, the guide tubing collars 15 are of the spider type and are adapted to engage the casing.

Mounted on the casing head 12 is a suspension means 20 for a production tubing 21 which is disposed within the guide tubing 13, the suspension means 20 incorporating an oscillator means 22 which is operatively connected to the production tubing 21 and which may be driven by a belt 23, for example. The suspension means 20 and oscillator means 22 per se form no part of the present invention and are not illustrated in detail, reference being made to the aforementioned Bodine patent for the details of a suitable suspension means and oscillator means. The production tubing 21 consists of a plurality of production tubing sections 24 which are interconnected by production tubing collars or couplings 25, the uppermost production tubing section 24 being operatively connected to the suspension means 20 and the oscillator means 22. In Fig. 2, the uppermost production tubing section 24 is illustrated as sealed relative to the casing head 12 by packing 26 for use in wells where it is desired to maintain pressure in the casing. Otherwise, the packing 26 may be omitted, as shown in Fig. 6.

As indicated in Fig. 1, the production tubing 21 carries a check valve means 30 which is located at a velocity antinode in the production tubing where the amplitude of vertical oscillation is a maximum when the production tubing is oscillated by the oscillator means 22. As more fully discussed in the aforementioned Bodine patent, this results in pumping of fluid from the well to the surface.

The effective external diameter of the production tubing 21 is substantially equal to but slightly less than the effective internal diameter of the guide tubing 13 so as to provide a relatively close sliding fit between the guide and production tubings while providing a slight annular clearance therebetween. This is accomplished by making the external diameter of the production tubing collars 25 substantially equal to but slightly less than the internal diameter of the guide tubing sections 14. Preferably, the production tubing collars 25 are staggered relative to the guide tubing collars 15 to prevent aligning the production tubing collars with any gaps between the ends of the guide tubing sections 14.

As will be apparent, the present invention, by providing a pumping apparatus wherein the oscillatory production tubing 21 operates in the guide tubing 13, eliminates any possibility of wear of the casing, any wear being confined to the guide and production tubings, which is an important feature of the invention. Also, because of the relatively close fit between the guide and production tubings 13 and 21, lateral vibration of the production tubing is minimized to minimize wear of both the guide and production tubings without the use of any rollers or other antifriction devices, which is another feature of the invention. In this connection, it will be noted that lateral vibrations are further minimized by the spider-type guide tubing collars 15.

Wear of the guide and production tubings 13 and 21 is further minimized in accordance with the present invention by providing the apparatus with means 31 for supplying a lubricant to the clearance between the guide and production tubings. The lubricating means 31 is shown as comprising a lubricant supply pipe 32 which may be connected to any suitable lubricant source, not shown, and which is connected to a passage 33 in the casing head 12, the passage 33 communicating at its inner end with the upper end of the clearance between the guide and produc-

tion tubings. In the case of an oil well pumping apparatus, the supply pipe 32 may be connected to the production fluid discharge from the production tubing 21 so that a part of the production fluid drains back into the well through the clearance between the guide and production tubings to lubricate the bearing surfaces therebetween. Lubricating the bearing surfaces of the guide and production tubings 13 and 21 in this manner materially reduces wear, which is another important feature of the invention.

Referring particularly to Fig. 3, the invention comprises means 36, including interengageable elements on the guide and production tubings 13 and 21, for catching and supporting the production tubing in the event that the production tubing fails so that the lower portion thereof becomes detached. In the embodiment illustrated in Fig. 3, one of the elements of the catching means 36 is the lowermost production tubing collar 25 and the other element thereof is a collar 37 threaded onto the lowermost guide tubing section 14. The internal diameter of the catching collar 37 is greater than the external diameter of the lowermost production tubing section 24 so that the lowermost production tubing section may oscillate freely therein, but is less than the external diameter of the production tubing collars 25 so that, in the event of failure of the production tubing 21, the lowermost production tubing collar engages the catching collar 37. With this construction, any portion of the production tubing 21 which becomes detached as a result of failure of the production tubing may be removed from the well readily by removing the guide tubing 13 so that any necessity for a fishing job in the event of failure of the production tubing is eliminated, which is an important feature.

The embodiment of the invention illustrated in Fig. 4 is similar to that illustrated in Fig. 3, the only difference being that a special collar 38 is carried by the production tubing 21 for engagement with the catching collar 37, the special collar 38 replacing the lowermost production tubing collar 25 as an element of the catching means 36.

In the embodiment illustrated in Fig. 5, the catching means 36 includes a collar 39 which is connected to the lower end of the guide tubing 13 and the internal diameter of which is less than the external diameter of the lowermost production tubing section 24, the lower end of the production tubing 21 being disposed entirely within the guide tubing 13. In this embodiment, the lower end of the lowermost production tubing section 24 constitutes an element of the catching means 36, being adapted to engage the collar 39 to support any portion of the production tubing which becomes detached as a result of failure.

It will thus be apparent that the present invention eliminates wear of the casing 10 and confines any wear to the guide and production tubings 13 and 21, minimizing wear of the guide and production tubings by minimizing lateral vibrations thereof and by lubrication thereof, eliminates any necessity for a fishing job in the event of failure of the production tubing, and avoids the use of parts which may wear or break off and fall into the well. Although I have disclosed several exemplary embodiments of the invention for purposes of illustration, it will be understood that various changes, modifications and substitutions may be incorporated in such embodiments without departing from the spirit of the invention.

I claim as my invention:

1. In a sonic well pumping apparatus of the character described, the combination of: a first tubing set in a well; a second tubing set in the well within said first tubing, the external diameter of said second tubing being slightly less than the internal diameter of said first tubing to provide a relatively close fit between said tubings while providing a slight clearance therebetween; means including interengageable elements on said first and second tubings for catching said second tubing in the event of failure thereof; check valve means carried by said second tubing; and sonic oscillator means operatively connected to said second tubing for producing a condition of standing wave resonance in said second tubing, said check valve means being located at a point of maximum amplitude of oscillation of said second tubing.

2. In a sonic well pumping apparatus of the character described, the combination of: a first tubing set in a well; a second tubing set in the well within said first tubing, the external diameter of said second tubing being

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slightly less than the internal diameter of said first tubing to provide a relatively close fit between said tubings while providing a slight clearance therebetween; means communicating with said clearance between said tubings for delivering a lubricant thereto to lubricate said tubings; check valve means carried by said second tubing; and sonic oscillator means operatively connected to said second tubing for producing periodic waves of tension and compression at sonic frequencies in said second tubing, said check valve means being located at a point of maximum amplitude of oscillation of said second tubing.

3. In a sonic well pumping apparatus of the character described, the combination of: a first tubing set in a well; a second tubing set in the well within said first tubing, the external diameter of said second tubing being slightly less than the internal diameter of said first tubing to provide a relatively close fit between said tubings while providing a slight clearance therebetween; means including interengageable elements on said first and second tubings for catching said second tubing in the event of failure thereof; means communicating with said clearance between said tubings for delivering a lubricant thereto to lubricate said tubings; check valve means carried by said second tubing; and sonic oscillator means operatively connected to said second tubing for producing a condition of standing wave resonance in said second tubing, said check valve means being located at a point of maximum amplitude of oscillation of said second tubing.

4. In a sonic well pumping apparatus of the character described, the combination of: a guide tubing set in a well; a production tubing suspended in the well within said guide tubing and including tubing sections interconnected by couplings, the external diameter of said couplings being slightly less than the internal diameter of said guide tubing to provide a relatively close sliding fit between said couplings and said guide tubing while providing slight clearances therebetween; means comprising interengageable elements on said guide and production tubings for catching said production tubing in the event of failure thereof; means communicating with said clearances for delivering a lubricant thereto to lubricate said couplings and said guide tubing; and sonic oscillator means operatively connected to said production tubing for producing a condition of standing wave resonance in said production tubing.

5. An apparatus as set forth in claim 4 wherein said catching means comprises a collar on said guide tubing which is engageable by a collar on said production tubing.

6. An apparatus as set forth in claim 4 wherein said catching means comprises a collar on said guide tubing which is engageable by the lower end of said production tubing.

7. In a sonic well pumping apparatus of the character described, the combination of: a casing set in a well; a

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guide tubing set in the well within and spaced inwardly from said casing; means carried by said guide tubing and engageable with said casing for spacing said guide tubing inwardly from said casing; a production tubing suspended in the well within said guide tubing and making a close fit with said guide tubing; upwardly-opening check valve means in said production tubing; and sonic oscillator means operatively connected to said production tubing for producing periodic waves of tension and compression at sonic frequencies in said production tubing.

8. In a sonic well pumping apparatus of the character described, the combination of: a first tubing set in a well; a second tubing set in the well within said first tubing; means including interengageable elements on said first and second tubings for catching said second tubing in the event of failure thereof; upwardly opening check valve means in said second tubing; and sonic oscillator means operatively connected to said second tubing for producing a condition of standing wave resonance in said second tubing, said check valve means being located at a point of maximum amplitude of oscillation of said second tubing.

9. In a sonic well pumping apparatus, the combination of: a tubing member set in a well; an inner member set in the well within said tubing member and extending downwardly therein to a point adjacent the lower end thereof, said inner member having a generally longitudinal passage therethrough; means including interengageable elements on said members for catching said inner member in the event of failure thereof; upwardly-opening check valve means carried by said inner member in said passage; and sonic oscillator means operatively connected to said inner member for producing a condition of standing wave resonance in said inner member, said check valve means being located at a point of maximum amplitude of oscillation of said inner member.

10. An apparatus as defined in claim 9 wherein said catching means includes a collar on said tubing member which is engageable by a collar on said inner member.

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