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TUBING SUPPORT FOR DEEP WELL PUMP

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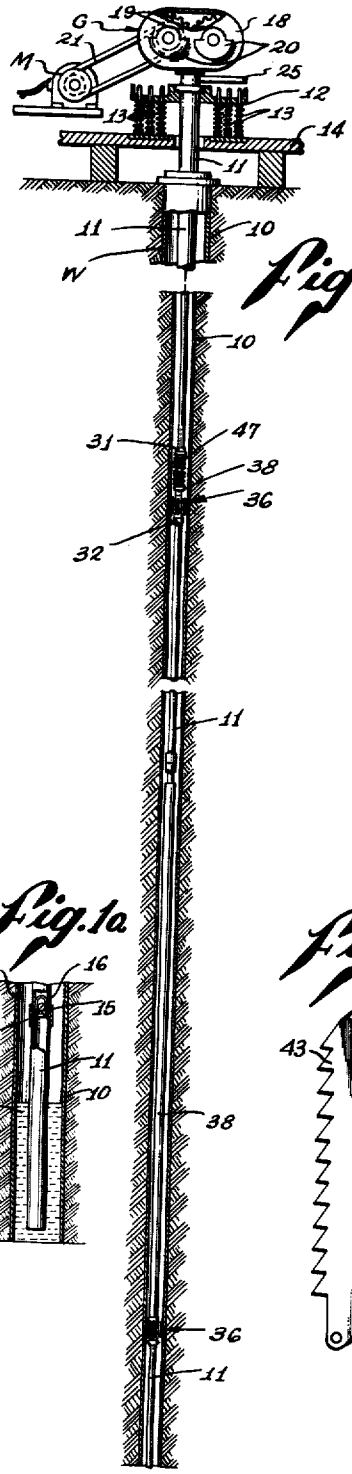


Fig. 1

Fig. 1a

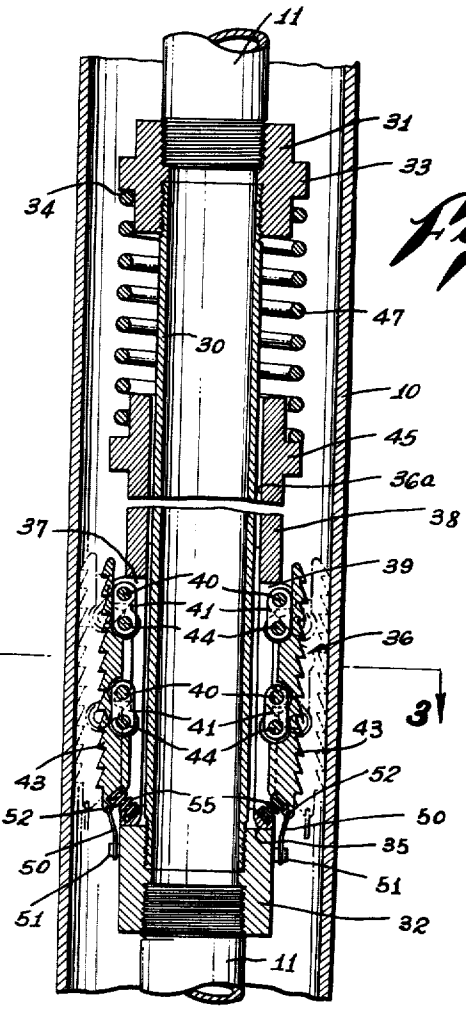


Fig. 2

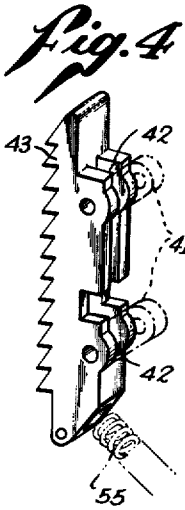


Fig. 4

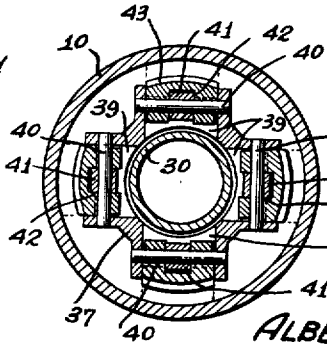


Fig. 3

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TUBING SUPPORT FOR DEEP WELL PUMP

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8 Claims. (Cl. 103—219)

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 transmitted down the pump tubing at sonic frequencies.

The present invention relates particularly to improvements in pumps of the type disclosed in my Patent No. 2,444,912. In one form of pump disclosed in said patent, an elastic pump tubing is spring supported at the ground surface, and its upper end is vibrated vertically by means of a sonic frequency elastic wave generator, causing periodic waves of tension and compression to be transmitted continuously down the pipe. These waves have too great a frequency to result in bodily reciprocation of the pump tubing as a whole, but local regions of the tubing do oscillate vertically with passage of the waves. A check valve located in the tubing at such an oscillatory region acts as a fluid impelling member to pump well fluid up the tubing. If, as is preferable, the generator is tuned to a resonant frequency of the tubing, a "standing wave" will be established, and velocity nodes (regions of minimum oscillatory movement) will appear at spaced points along the tubing (spaced by a half wave length for the frequency at which the generator is operated), while velocity anti-nodes (regions of maximum vertical oscillatory movement) will appear at points spaced half way between the velocity nodes. With resonant operation, the aforementioned check-valve should be located at a velocity anti-node. Generally speaking, a check valve is located at the lowermost velocity anti-node (which will be a half wave length from the bottom end of the tubing), and additional check valves may in some cases be located at other velocity anti-nodes located higher up.

The present invention is directed to the problem of providing suitable vertical support for the pump tubing either during operation, or as a stand-by device for supporting the lower portion of the tubing in the event of an accidental parting of the tubing. With perfect resonant operation, certain vertically spaced regions of the tubing, located at the velocity nodes, might be quite stationary, and it might seem possible simply to rigidly anchor the tubing to the casing at such points. In practice, however, there is almost always some degree of departure from theoretically perfect resonant operation, and hence some movement at the velocity nodes, not to mention the problem of accurately positioning the tubing supports at the velocity nodes so as accurately to locate the regions of zero or minimum oscillation. Further, however, the pump operates quite satisfactorily even without resonant operation, and in non-resonant operation, all portions of the tubing have substantial vertical oscillatoin with the passage of the waves.

One object of the present invention is accordingly to provide supporting means for the pump tubing, capable of sustaining the tubing throughout its oscillatory cycle, even with maximum amplitude.

Another object is the provision of a tubing supporting

device, or "catcher" adapted to catch and support the lower section of a parted pump tubing.

The invention will now be more fully disclosed, and its various objects, features and advantages will more fully appear, in connection with the following detailed description of a somewhat diagrammatically illustrated embodiment thereof, reference being had for this purpose to the accompanying drawings, in which:

Figures 1 and 1*a* taken together are a utility view, largely in longitudinal section, partly broken away, and partly to reduced scale, showing the invention incorporated in a pump positioned in a well bore, Figure 1 showing the upper portion of the pump and tubing, and Figure 1*a* showing the bottom end portion thereof;

Figure 2 is an enlarged longitudinal sectional view of the tubing support of the invention, shown anchored in position against the well casing;

Figure 3 is a transverse section on line 3—3 of Figure 2; and

Figure 4 is a perspective detail showing one of the anchoring shoes.

In the drawings an oil well bore is indicated by the letter W, and a well casing within said bore by numeral **10**, the lower end portion of the casing adjacent the productive pump being understood to be perforated in the usual manner. The stand of pump tubing **11**, understood as composed of elastic material, as steel, and also understood as being made up of a number of tubing lengths connected by ordinary coupling collars, is suspended in well bore W from movable platform **12**, its lower end reaching downwardly to the region of the liquid L to be pumped from the well bore. Platform **12** is resiliently mounted on vertical coil springs **13** standing on stationary platform **14** which may in turn be supported on the ground surface. The lower end portion of tubing **11** is controlled by a check valve **15** (Figure 1*a*), here shown as consisting of a valve ball **16** adapted to set downwardly on seat ring **17** rigidly mounted in the tubing.

Mounted on platform **12**, or on the upper end of tubing **11** extending thereabove, is a housing **18** containing a means for vertically vibrating the platform **12**, and thereby exerting a vertical oscillating force on the upper end of the tubing **11**. Since the vibrating means is employed to generate elastic waves in the pump tubing which are of the same nature as sound waves, and travel with the speed of sound in the medium of the pipe, I may properly refer to the vibrator generator means as a sound or sonic wave generator G. A sound wave generator well adapted for this purpose is described in my said Patent No. 2,444,912, and the one illustrated in Figure 1 of the present case is of that general type, having meshing oppositely rotating spur gears **19** carrying eccentric weights **20** which balance out horizontal vibrations but whose oscillations are additive in a vertical direction to produce a substantial resultant vertical oscillatory force. The driving pulley of the sound wave generator G, mounted on the shaft for one of the spur gears, is driven by electric motor M driven through belt **21**.

The oscillatory force supplied to the upper end of the elastic pump tubing **11** by generator G causes the upper end portion of the tubing to be alternately elongated and shortened. These deformations cause alternate waves of tension and compression to be launched down the tubing, traveling in the material of the tubing with the speed of sound. Thus longitudinal deformation waves of compression and tension, of wave lengths usually shorter than the length of the tubing string, travel down the tubing string, causing each transverse section thereof to oscillate vertically with each passage of a wave. Ideally, though not necessarily, the frequency of the sound wave generator and the length of the tubing are so related that the tubing stand is longitudinally resonated, which is accom-

plished by driving the sound wave generator at a resonant frequency of the tubing string. Such operation establishes a standing wave along the tubing string, with one or more velocity nodes at tubing sections a half-wave length apart. At these tubing sections, the amplitude of vertical oscillation is substantially zero, and these points accordingly are the most appropriate points at which to engage the tubing for anchoring purposes. At points halfway between these velocity nodes there will appear regions of maximum amplitude of vertical oscillation. It is best to have the check valve **15** located at such a velocity anti-node, that is, point of substantial or maximum oscillation. Preferably, therefore, the pumping system is operated at resonance, with a velocity anti-node at the location of check valve **15**. In accordance with the embodiment shown in Figure 1, the check valve **15** is positioned at a velocity anti-node located a half-wave length above the free lower end of the tubing. The upper end of the tubing, where the generator is mounted, will be understood to be the location of a velocity anti-node. The casing head may engage the tubing at the location of a velocity node.

The tubing **11** thus undergoes vertical oscillation in amounts which may differ from section to section along its length, as from substantially zero to ¼" or thereabouts. If the check valve **15** is located at a velocity anti-node the amplitude of this vertical oscillation will be maximized at the location of the check valve. It is again to be emphasized, however, that resonant operation is not essential, and that the check valve will oscillate vertically, in a manner to effect pumping as presently to be described, even though resonant operation is not established. During each oscillation of check valve **15**, with or without resonant operation, a small increment of well fluid travels upwardly in the pump tubing past the seat ring **17**, to be elevated in the pump tubing and eventually discharged via a delivery pipe indicated at **25**. For a more complete discussion, see my said Patent No. 2,444,912

All of the subject matter disclosed hereinabove is common to the aforementioned patent. The present invention is directed to an improved tubing supporting means, or catcher, and will be described first in a form or adaptation designed to support the tubing at all times and through its vibratory stroke. In this form, the tubing support of the invention is preferably, though not necessarily, arranged to engage the tubing at a velocity node, where its amplitude of oscillation is either zero, or minimized. Since it is in practice relatively difficult to locate these velocity node regions of the pump tubing, the present invention provides a tubing support capable of supporting sections of the tubing having substantial amplitude of vertical oscillation. In fact they may provide support for the tubing even though engaged with portions of the tubing having maximum vertical oscillation.

Reference now being directed to Figure 2, numeral **30** designates a section of elastic tubing made up in the tubing string **11** by means of special upper and lower collars **31** and **32**. The collar **31** has annular flange **33** providing downwardly facing annular seat **34** for a purpose to appear presently. The collar **32** may resemble a conventional coupling collar, but preferably has somewhat increased wall thickness, so as to provide an upwardly facing annular shoulder **35** employed for a purpose presently to appear.

Encircling tubing section **30** between collars **31** and **32** is a tubing support member **36** comprising a lower body section **37**, and a tubular upward extension **38**, the body **37** and tubular extension **38** having a central bore **36***a* of sufficient diameter to fit tubing **30** with working clearance. Received in four 90°-spaced vertical slots **39** in body **37** and pivotally mounted on horizontal pins **40** extending thereacross are the inner, upper ends of pairs of parallel vertically swinging links **41**, the outer, lower ends of which are received in vertical slots **42** in serrated casing engaging anchor shoes **43**, being pivotally mounted on horizontal pins **44** set into the latter.

In the illustrative embodiment, there is formed on tubular member **38**, a short distance below its upper end, an outwardly extending annular flange **45** providing an upwardly facing annular shoulder, and seating downwardly on this shoulder is the lower end of a coil compression spring **47** encircling the member **38** and engaging at its upper end against the aforementioned downwardly facing annular shoulder **34**.

While the pump tubing is being lowered in the well, the links **41** and shoes **43** are in a contracted position, being collapsed downwardly and inwardly as indicated in full lines in Figure 2, and the body **37** rests at its lower end on collar **32**. Links **41** may be held temporarily in the retracted position by means of wires **50** connected between pins **51** on the body **37** and eyes **52** in the lower ends of the shoes **43**. In installing the pump, the tubing is lowered nearly but not quite to its intended operating position, and the generator G then operated. The vibratory action transmitted down the pump tubing quickly fatigues and breaks the wire **50**, whereupon the shoes are expanded under the influence of coil springs **55** placed between the body **37** and the shoes. Thus the links **41**, under the pressure of these springs, swing the shoes **43** upwardly and outwardly, causing them to become engaged tightly against the casing wall, the links having a downward and outward supporting angle in their final expanded position, as shown. With the generator G then stopped, the tubing is lowered to permit its weight to be assumed by the springs **13** under platform **12**, and by the springs **47** of the tubing supports. Each of these springs **47** transfers a portion of the total load to the corresponding body **37**, and the latter bears downwardly on the inner ends of the links **41**, causing shoes **43** to be further expanded and their serrations to bite into supporting engagement with the casing.

The pump may thereafter be operated with the pump tubing thus spring supported from the casing at selected intervals. The springs **47** are effective as load carriers throughout a substantial range of vertical oscillation amplitude of the pump tubing. In this operating position, the lower end of the tube support bodies **37** are of course spaced from the collars **32**.

To remove the pump from the well, the pump tubing is simply elevated, which causes the anchor shoes to collapse inwardly, disengaging the casing, and the body **37** to move down into engagement with collar **32**, which supports it while the tubing is being removed from the well.

In Figure 2, the tubular upward extension **38** from the body part **37** of the tubing support has been shown with a broken-out section and, in practice, for some purposes, this member **38** may be relatively short, as, for instance, only an inch or thereabout, while for other purposes and uses it may be relatively long, as for instance, approximately twenty feet. Used as described in the foregoing, the member **38** actually need not be of any particular length, the function of the member **38** being only to afford the necessary seat for the lower end of the spring **47**. This type of use is illustrated in the upper portion of Figure 1, where the member **38** is seen to be relatively short.

In an alternative use, the tubing support is employed primarily, or exclusively, in "stand--by service as tubing "catcher," to catch and thereafter support the lower section of tubing in event of an accidental parting of the tubing string. For this purpose, the spring **47** may be entirely omitted. The member **38** is in this case made long, as beforementioned, and as indicated in the lower portion of Figure 1. It is also made very heavy, for instance, of the order of 1,000 pounds. In this case, the shoes **43** are initially expanded in the manner previously described, that is, by running the generator to cause tie wires **50** to fatigue and break, permitting the shoes to be expanded by action of the spring **55**. Once

this nas been accomplished, the pump tubing can be lowered a little, whereupon the substantial weight of the tubular member **38** acting against the upper ends of the links **41** causes the shoes **43** to be further spread apart and their teeth to be set tightly into the walls of the casing. The great weight of the member **38** continuously bearing downward on the inner ends of the links **41** assures that the shoes **43** will remain tightly set against the casing during operation.

As stated, with the last described form of the invention, the springs **47** can be either used or omitted. If used, they supply a spring support for the tubing during the operation of the pump. If not used, the entire weight of the pump tubing hangs from the spring supported platform **12** at the ground surface. In such case, the upper end of the tubular member **38** faces and is spaced a short distance from the shoulder at the lower end of collar **31**. In the event of an accidental parting of the tubing string above, the tubing will fall, but the lower end of the coupling **31** will shortly engage the upper end of the tubular member **38**, and the parted section of the tubing string will thus be supported from the casing through the expanded shoes **43**.

The invention is thus capable of use as a means for spring supporting the tubing string at selected intervals therealong throughout the operation of the pump, and it will of course be evident that the supporting devices are available also for the support of the parted section of the tubing string in the event of failure above. This use of the invention is indicated in the upper portion of Figure 1. Alternatively, for situations in which it is not desired that the pump tubing be supported during operation, the form of the invention with the long, heavy tube **38** is employed. The device is shown with the elongated tubular section **38**, but without the spring **47**, in the lower portion of Figure 1. Here, the device acts merely in stand-by service, to catch the parted section of the tubing in the event of a failure above the catcher. But the form with the long heavy tube **38** can also be used with the spring **38** to obtain spring support for the tubing string during operation.

It will be understood that the drawings and description are for illustrative purposes only, and that various changes in design, structure and arrangement may be made without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. A pump tubing support for a deep well pump of the class employing a string of elastic pump tubing suspended in a well casing and operated by longitudinal waves of tension and compression transmitted downwardly in the medium of the elastic tubing string whereby to establish longitudinal vibrations in said tubing, said tubing string having a collar, comprising: a body adapted to encircle said pump tubing below said collar with working clearance to accommodate the vibratory movement of the tubing, means for supporting said body on said tubing below said collar during lowering of the tubing into the well casing, said body having an upwardly facing shoulder opposed to and spaced below said tubing collar, casing engaging anchor shoes, links pivotally connected at their upper ends to said body and at their lower ends to said shoes, so as to mount said shoes for movement between a lower collapsed contracted position and an upper expanded casing engaging position, means for expanding said shoes after the tubing has been lowered in the casing, and means for exerting a downward force on said body to cause the casing engaging shoes to be moved into forcible engagement with said casing said body being adapted to catch the lower segment of said tubing string by said collar in the event of parting of said string above said collar.

2. The subject matter of claim 1, wherein the means for exerting the downward force on said body comprises a spring acting between said collar and said body.

3. The subject matter of claim 1, wherein the means for exerting the downward force on said body is heavily weighted and exerts said force owing to its weight.

4. A pump tubing support for a deep well pump of the class employing a string of elastic pump tubing suspended in a well casing and operated by longitudinal waves of tension and compression transmitted downwardly in the medium of the elastic tubing string whereby to establish longitudinal vibrations in said tubing, said tubing string having a pair of longitudinally spaced collars, comprising: a body adapted to encircle said pump tubing between said collars and to seat on the lowermost collar during lowering and elevation of the tubing into and from the well casing, casing engaging anchor shoes mounted on said body for movement between a collapsed contracted position and an expanded casing engaging position, means for supporting said shoes in contracted position while the tubing is being lowered, means for expanding said shoes after the tubing has been lowered in the well casing, and a coil spring surrounding said tubing between said body and the uppermost of said collars, the lower end of said spring being supported by said body, and the upper end of said spring being disposed in supporting relation to the last-mentioned collar.

5. A pump tubing support for a deep well pump of the class employing a string of elastic pump tubing suspended in a well casing and operated by longitudinal waves of tension and compression transmitted downwardly in the medium of the elastic tubing string whereby to establish longitudinal vibrations in the tubing, said tubing string having a pair of longitudinally spaced collars, comprising: a heavily weighted body adapted to encircle said vibratory pump tubing between said collars with working clearance for the tubing and to seat on the lowermost collar during lowering and elevation of the tubing into and from the well casing, casing engaging anchor shoes mounted on said body for movement between a collapsed contracted position and an expanded casing engaging position, means for supporting said shoes in contracted position while the tubing is being lowered, and means for expanding said shoes after the tubing has been lowered to position, said shoes being set tightly against said casing by virtue of the weight of said body when the lowermost tubing collar is lowered from supporting engagement with said body, or said weighted body being adapted to catch the lower segment of said tubing string by said upper collar in the event of parting of the string at a point above said collar.

6. In a sonic deep well pump of the character described operable in a well casing, the combination of: a sonic pump tubing suspended in the well casing, said pump being operative by elastic vibration of said tubing through predetermined stroke limits in its longitudinal direction owing to passage of elastic deformation waves transmitted therealong, a collar on said vibratory tubing having a downwardly facing engaging shoulder, a supporting body located in the annular space between said well casing and said longitudinally vibratory tubing with working clearance relative to said tubing and anchoring means for rigidly supporting said body against the well casing at a position below said collar during operation of the pump, the upper portion of said body having an upwardly facing engaging shoulder opposed to and vertically alined with said downwardly facing shoulder on said tubing collar and spaced below the lowermost limiting position of said downwardly facing shoulder during vibration of said tubing between said stroke limits, said body being adapted to catch the lower segment of said tubing string by said collar in the event of parting of the string at a point above said collar.

7. A pump tubing support for a deep well pump of the class employing a string of elastic pump tubing suspended in a well casing and operated by longitudinal waves of tension and compression transmitted down-

wardly in the medium of the elastic tubing string whereby to establish longitudinal vibrations in the tubing, said tubing string having a collar providing a downwardly facing shoulder, comprising: a body adapted to encircle said vibratory pump tubing below said collar, with working clearance for the tubing, means for supporting said body on said tubing below said collar during lowering of the tubing into the well casing, said body having an upwardly facing shoulder opposed to and adapted to be normally spaced below said downwardly facing shoulder on said tubing collar when said body is set in the casing, casing engaging anchor shoes mounted on said body for movement between a collapsed contracted position and an expanded casing engaging position, means for supporting said shoes in contracted position while the tubing is being lowered, and means for expanding said shoes after the tubing has been lowered to position, said body being adapted to catch the lower segment of said tubing string by said upper collar in the event of parting of the string at a point above said collar.

8. A pump tubing support for a deep well pump of the class employing a string of elastic pump tubing suspended in a well casing and operated by longitudinal waves of tension and compression transmitted downwardly in the medium of the elastic tubing string whereby to establish longitudinal vibrations in the tubing, said tubing string having a collar providing a downwardly facing shoulder, comprising: a heavily weighted body

adapted to encircle said vibratory pump tubing below said collar, with working clearance for the tubing, means for supporting said body on said tubing below said collar during lowering of the tubing into the well casing, said body having an upwardly facing shoulder opposed to and adapted to be normally spaced below said downwardly facing shoulder on said tubing collar when said body is set in the casing, casing engaging anchor shoes mounted on said body for movement between a collapsed contracted position and an expanded casing engaging position, means for supporting said shoes in contracted position while the tubing is being lowered, and means for expanding said shoes after the tubing has been lowered to position, said shoes being set tightly against said casing by virtue of the weight of said body when the lowermost tubing collar is lowered from supporting engagement with said body, and said weighted body being adapted to catch the lower segment of said tubing string by said upper collar in the event of parting of the string at a point above said collar.

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