May 12, 1964 F. I. ALEXANDER 3,132,707

METHOD AND APPARATUS FOR VIBRATING WELL PIPE

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FIG. 1.

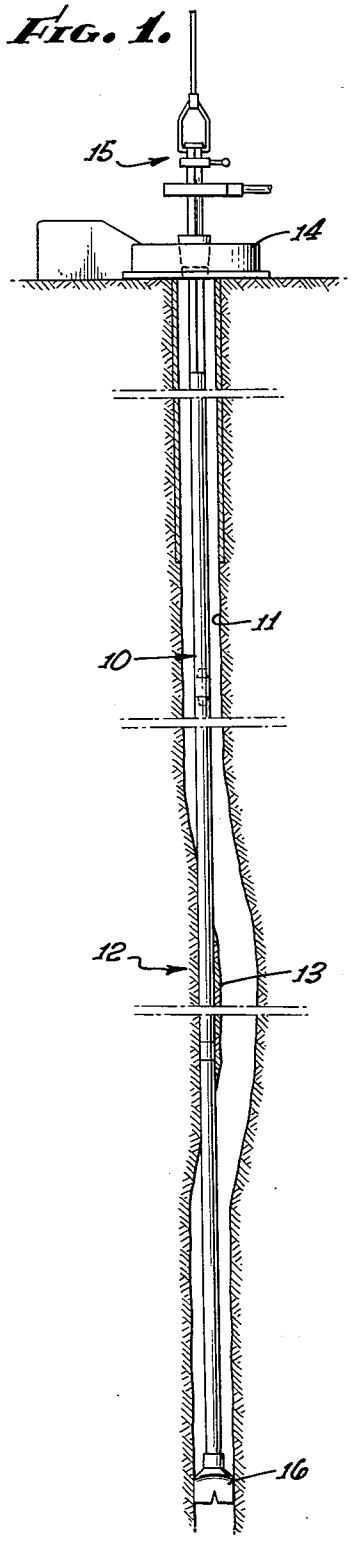


FIG. 2.

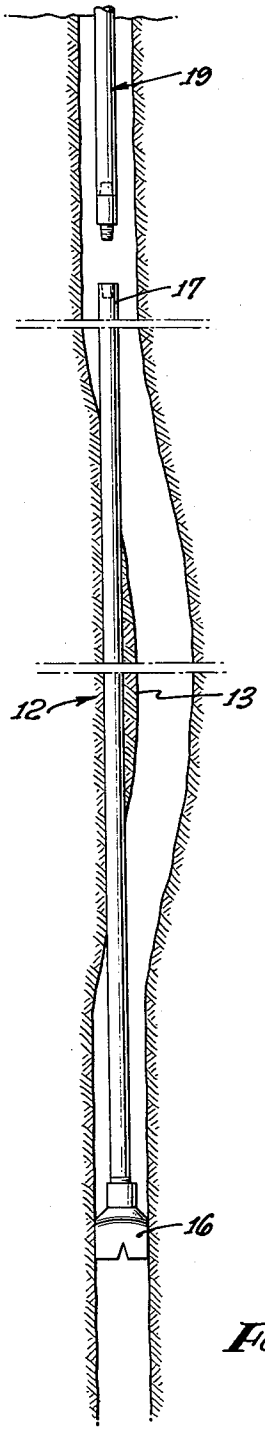
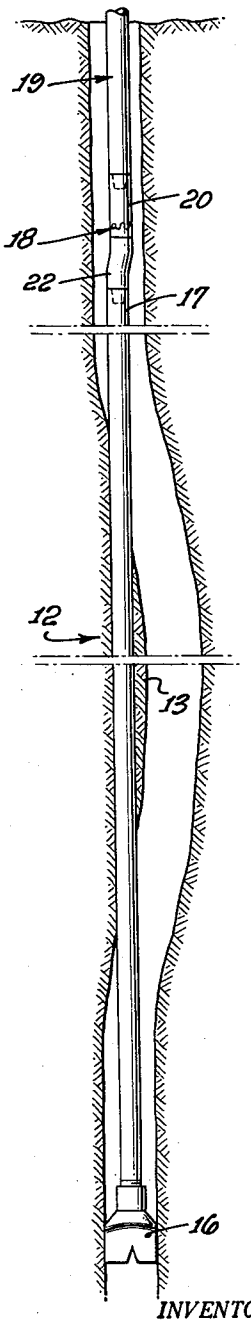


FIG. 3.



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FIG. 4.

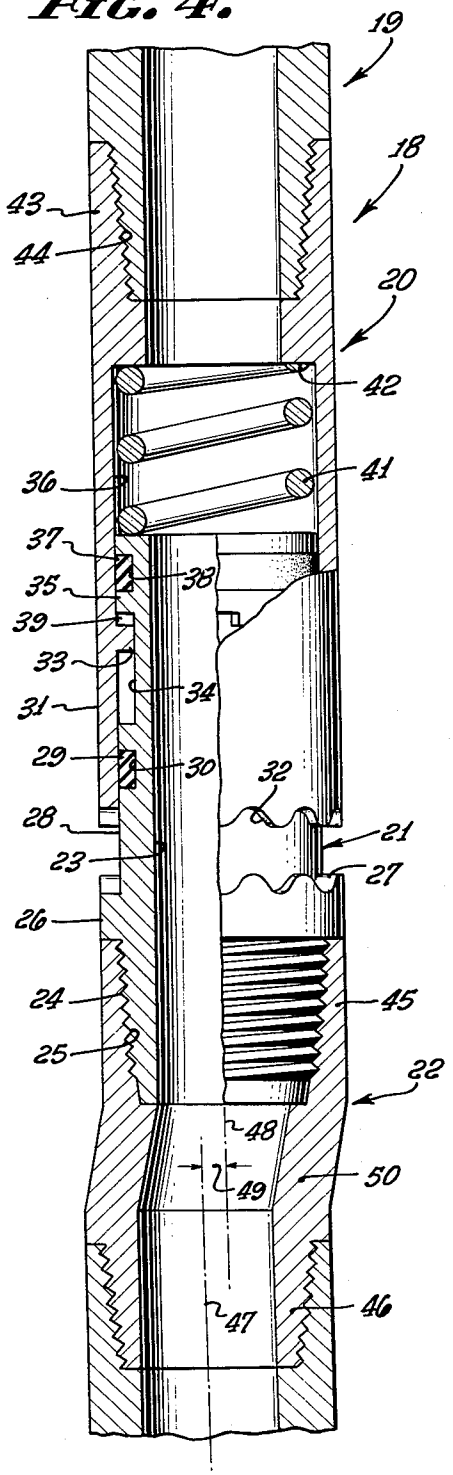
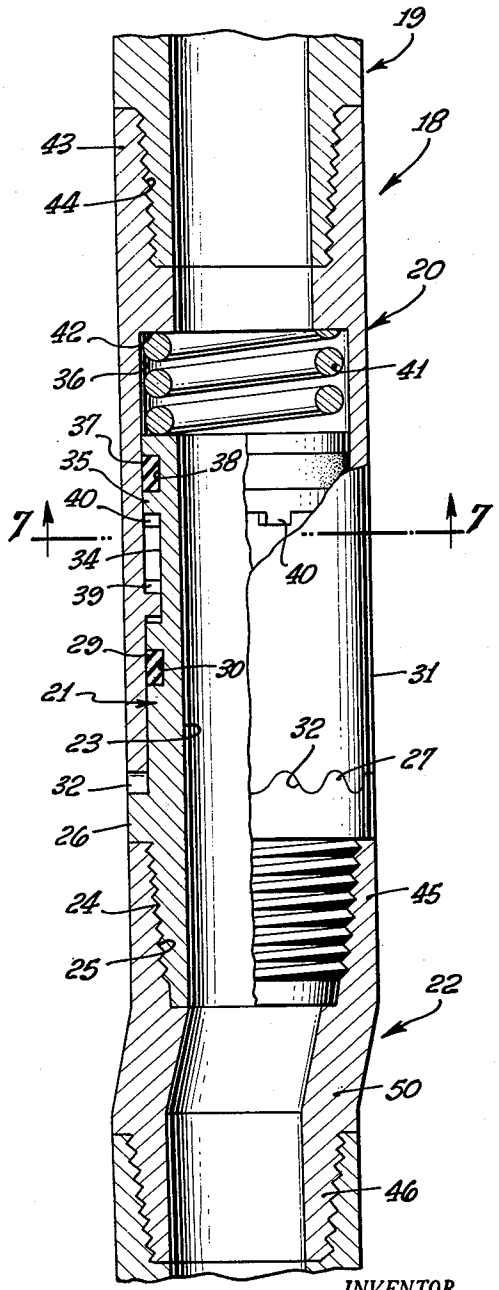


FIG. 5.



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FIG. 6.

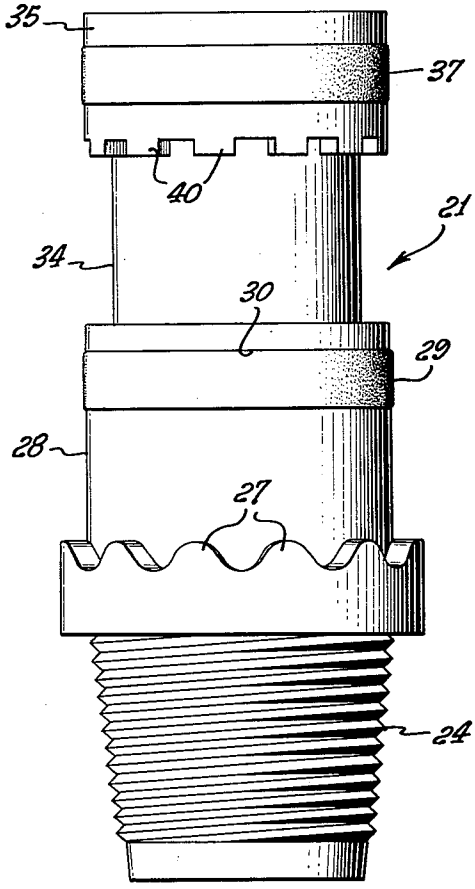
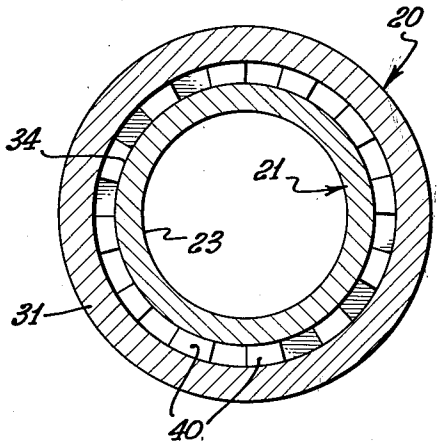


FIG. 7.



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METHOD AND APPARATUS FOR VIBRATING WELL PIPE

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6 Claims. (Cl. 175—298)

This invention relates generally to vibrating a pipe string, such as oil well drill pipe, stuck in a well in order to free the string as rapidly as possible. More particularly, the invention is directed to novel method and apparatus for pulse vibrating a pipe string which has become stuck in what is known as a key seat in a well, for the purpose of rapidly loosening the string, thereby obviating the expensive and time-consuming practices presently followed for this purpose.

In well drilling it frequently happens that the drill string becomes stuck at locations that may range from depths near the bit to intermediate depths many pipe stand lengths above the bit, depending upon conditions encountered upon a particular well being drilled and a particular reason for the pipe becoming moved. Thus, the pipe may become stuck as a result of key seating in crooked holes, or following a cave-in of the formation about the drill string.

In keeping with presently prevailing practices followed in freeing the stuck pipe, such special equipment as overshot reamers and washover pipe are run into the well, generally by special service crews, for cutting away the formation about the pipe string at the stuck point location, and for washing away the formation. Such procedures are expensive and time-consuming since not only must the drilling operation be interrupted, but service crews must be notified and brought to the well location for running into the well the special equipment needed to complete successfully the freeing of the stuck pipe. Also a great deal of time is consumed in the reaming and wash-over operations in themselves. Further, if the pipe is stuck at depths associated with high temperature of the formation, the drilling fluid or mud becomes dry around the stuck pipe in a short time, and circulation of the fluid may continue at some distance from the pipe.

The present invention has for one of its major objects the provision of a novel method of rapidly freeing pipe at the stuck point, the method involving procedures which can be followed by the drilling crew as soon as it becomes evident that pipe is stuck in the well. Broadly considered, the method contemplates opening up the formation about the pipe at the key seat location by causing the pipe itself to work transversely at that location and with great force. Such transverse working of the pipe is brought about according to the novel method by relatively slowly generating torsion in the drill string, and suddenly releasing the torsion in the string at a location in the well above the stuck point to produce lashing in the string transmissible as shock torsional loading to the stuck pipe. More particularly, the method involves twisting the string to place it in torsion above the key seat, uncoupling upper and lower sections of the twisted string at a location in the well above the stuck pipe thereby to produce relative rotary directional lashing of the uncoupled string sections, and suddenly coupling the lashed sections to effect rapid transmission of shock torsional loading to the pipe at the stuck point.

As will appear, the method produces sudden release of slowly built up torsional energy in the string throughout its normally great length above the stuck point, the thus stored or potential energy being suddenly released as kinetic or lashing energy to pulse vibrate the pipe at the location at which it is stuck, producing sufficient transverse force application to work the pipe transversely for enlarging the formation. Further, as will appear, the method preferably involves repeated transmission of pulse vibrations to the stuck pipe brought about by repeating alternate uncoupling and coupling of the pipe sections as the pipe is continuously placed in torsion, so as to generate repeated violent rotary directional lashing of the pipe string in the well, the effect being to create transverse high energy surging of the pipe at the key seat. In addition, it is preferable to maintain circulation of drilling fluid or mud downwardly through the string and upwardly thereabout to the key seat location so that as the formation is opened up by the surging pipe the circulation will aid such opening up through softening of the formation and carrying loose material upwardly and away from the stuck point location.

The invention furthermore contemplates the provision of novel apparatus usable in the above described method of rapidly freeing pipe at the stuck point in a well. As broadly conceived, the apparatus includes sub means connectible into the pipe string to transmit torsional string loading, the sub means including a coupling which is suddenly releasable in the well during torsional loading transmission to produce torsional lashing in the string above the key seat and transmissible to the pipe at the stuck point. More particularly, the coupling has upper and lower interengaged cam shoulders through which string weight loading is transmissible for keeping the shoulders in interengagement to transmit torsional loading, the shoulders being vertically separable from interengagement in response to build-up of string torsion acting through the shoulders in opposition to string weight loading for producing sudden relative rotary directional slippage of the released shoulders and lashing in the string about the key seat. Further, these shoulders are vertically engageable in response to application of string weight loading thereon during their relative slippage, to produce repeated and sudden shock torsional loading in the string transmissible to the pipe at the stuck point.

These and other objects and advantages of the present invention, as well as the details of an illustrative embodiment, will be more fully understood from the following detailed description of the drawings in which:

FIG. 1 is a general view showing the pipe string in the well and stuck therein at a key seat location;

FIG. 2 is an enlarged elevation showing the drill string after removal of the pipe above key seat location;

FIG. 3 is a view similar to FIG. 2 showing the manner in which the fishing tool of the present invention is connected to the fish pipe above the key seat location;

FIG. 4 is an enlarged elevation partly in section taken through the tool operable to produce lashing in the pipe string, the tool being shown in extended position;

FIG. 5 is a view similar to FIG. 4 showing the tool in contracted condition;

FIG. 6 is a view showing the lower coupler body portion of the tool shown in FIGS. 4 and 5; and

FIG. 7 is a view taken on line 7—7 of FIG. 5.

Referring first to FIGS. 1 through 3, the drill pipe string is shown generally at **10** run down into the well upon hole **11** and stuck at a key seat location **12**. Such key seating of the pipe frequently occurs where rotary drilling is continued in a crooked hole, the rotating pipe tending to form a tight groove **13** in the formation against which it bears, as shown. The surface equipment is shown to include a rotary table **14** which is used in rotating and torsionally twisting the drill string as and for the purpose described. Above the table there is shown hoisting or elevating mechanism **15** of the conventional type, used in elevating and lowering the string in the hole. At the lower end of the string is shown a bit **16**.

In accordance with the general method of loosening the stuck pipe as disclosed by the present invention, when the driller ascertains that the pipe is stuck in the well, he proceeds through known methods to remove from the well a portion of the string above the stuck point location, thereby leaving in the hole what will be referred to as the fish, the upper end portion of which is shown at 17. He then runs into the well the sub or tool shown generally at 18 in FIG. 3, the tool being lowered and rotated until it becomes attached to the fish. Such attachment is completed by rotating the string 19 and the tool 18 in a rotary direction so as to threadedly connect the tool 18 to the fish.

The tool 18 is better shown in detail in FIG. 4 to include upper and lower tubular bodies 20 and 21, the latter being illustrated by itself in FIG. 6. The upper and lower tubular bodies together comprise a tubular coupling, and the complete sub means includes in addition to the coupling an attachment 22 suspended from the lower tubular body 21.

Referring to FIGS. 4 and 6, body 21 contains a through bore 23 of a size to pass conventional tools axially therethrough, such as darts. The lower end of the body 21 is threaded at 24 for connection to the internal threads 25 of the attachment 22. Above the thread location body 21 has an annular flange 26, the top edge of which forms circularly undulating upwardly projecting lugs 27 as shown, about an intermediate reduced diameter skirt portion 28. The latter mounts a ring packing or seal 29 in a groove 30 for packing off against the cylindrical skirt 31 of the upper tubular body 18, as seen in FIG. 4.

The lower edge portion of skirt 31 forms circularly undulating downwardly projecting lugs 32 which are adapted to mesh with the lugs 27 as best seen in FIG. 5, when the upper tubular body 18 is collapsed on the lower tubular body. It will be understood that the lugs 27 and 32 may be axially separated to the extent indicated in FIG. 4, in response to axial extension of the upper and lower tubular bodies 20 and 21.

Integral with the skirt portion 31 of the upper tubular body 20 is an internal annular flange 33 received within an annular groove 34 formed in the lower tubular body 21, the groove 34 having sufficient length axially so as to allow the flange 33 to move between the positions shown in FIGS. 4 and 5. Likewise, the uppermost portion of the lower tubular body 21 is in the form of an annular flange 35 having a sliding fit against the bore 36 of the skirt portion 31 above the flange 33. A packer 37 in groove 38 in flange 35 seals off between the flange 35 and the skirt 31.

Formed on the flanges 33 and 35 are complementary rotary driving teeth 39 and 40, these being adapted to interengage when the upper tubular body 20 is drawn upwardly to fullest extent relative to the lower tubular body 21. It will be understood that under these conditions string weight loading is not fully applied downwardly upon the upper tubular body 20 since it would collapse together the bodies 20 and 21 and engage the lugs 32 and 27. A heavy compression spring 41 is shown in FIG. 4 between the upper end of body 21 and a shoulder 42 on the upper body 20 for holding the two bodies axially separated. Of course, the spring is readily compressed when string weight loading is lowered upon the upper body 20, collapsing it toward the lower body 21.

Referring to FIGS. 3 and 4, the upper end of the sub means 18, and specifically the tubular body 20 is in the form of a box 43 having internal threads 44 for reception of the threaded pin end of drill pipe. As previously described, the lower end of the tubular body 21 is in the form of a threaded pin received in the internally threaded box 45 of the attachment 22, the lower end of which comprises an externally threaded pin member 46. As will be seen from FIG. 4, the axis 47 of the pin end 46

of the attachment 22 is laterally offset from the axis 48 of the tubular body 21, by an amount indicated at 49. Thus, the pin end 46 of the attachment, which is adapted to be screwed into the box member 17 of the fish pipe, is eccentric with respect to the coupling members 20 and 21 and the pipe string thereabove. The attachment 22 has a tubular body portion 50 intermediate the box and pin portions 45 and 46 of the attachment, and downwardly and laterally angled as shown in FIG. 4. The purpose of the attachment 22 is to effect transverse working or surging to the pipe at the key seat in response to downward transmission of shock torsional loading through the sub means, as will be described.

Referring now to the method of operating the equipment illustrated, and to the method of pulse vibrating a pipe string stuck in a well, it will be understood that, as previously described, the attachment 22 is connected into the box member 17 of the fish pipe as illustrated in FIG. 3, by lowering the sub means 18 suspended at the lower end of the upper drill string, while rotating the sub means. Under these conditions the tubular bodies 20 and 21 may be extended as shown in FIG. 4 so that the driving teeth 39 and 40 are engaged for transmitting makeup torque to the attachment 22. During such makeup to the fish pipe, insufficient string weight is lowered onto the sub means to effect disengagement of the driving teeth 39 and 40.

Thereafter, the string weight is lowered to collapse axially the tubular bodies 20 and 21 to the position shown in FIG. 5, at which time the cam lugs 27 and 32 interengage as illustrated. The pipe is then rotated at the well head as by operating the rotary table in either rotary direction, to twist the string and place the string in torsion above the key seat location. During such twisting the cam lugs 27 and 32 remain sufficiently engaged to transmit torsional loading downwardly through the sub means. Generally speaking, a great deal of potential energy is stored in the string during twisting thereof, as may be realized from the fact that the rotary table will undergo about one revolution for each 1000 feet of free pipe string length, so that if, for example, the stuck point is at 5000 feet, the upper end of the pipe string will be rotated about five times, strong potential energy throughout the string above the stuck point.

The torsion built up in the string during such twisting is applied across the cam lugs 27 and 32 so that in the absence of downward string weight loading, these cam lugs would separate. Generally speaking, the amount of string weight loading applied downward determines the amount of torsion build-up required to cause complete axial separation and disengagement of the cam lugs 27 and 32. When such separation occurs, the coupler bodies 20 and 21 are immediately effectively uncoupled so that the twisted pipe string lengths above and below the sub means will suddenly be freed to rotate oppositely, thereby producing rotary directional lashing of the uncoupled upper and lower string sections. Such lashing of the lower string section is transmitted downwardly through the eccentric attachment 22, the stored potential energy in the lower string section being released as a pulse of kinetic energy operating to surge or bodily pulse transversely the pipe at the key seat formation. As previously described, such a high order energy release in a transverse direction is sufficient to enlarge the key seat formation for the purpose of freeing the pipe at the key seat.

Furthermore, it will be understood that the cam lugs 27 and 32 will normally suddenly engage to couple the upper and lower tubular bodies 20 and 21 at some point before complete torsional unwinding of the upper and lower string sections, due to the constant downward application of string weight. Such sudden engagement and effective coupling of the lashing string sections produces shock torsional loading of the string at the location of the sub means, which shock loading is transmitted down-

wardly through the eccentric attachment 22 and operates to pulse vibrate the pipe at the key seat and in a transverse direction as previously described. Finally, since the string is continuously twisted at its upper end by operation of the rotary table, the cam lugs 27 and 32 will repeatedly disengage and engage to effect repeated transmission of shock torsional loading to the string at the key seat location, acting to oscillate or work the stuck pipe transversely back and forth and around in the key seat formation, enlarging the formation to free the pipe.

As previously mentioned, circulation may be continued through the string during such mechanical working of the pipe in the key seat formation, the drilling fluid rising up and gaining entrance to the key seat as the pipe works back and forth therein, the fluid acting to soften the formation to promote enlargement thereof. After the pipe is freed, the sub 18 may be freed from the fish 17 and run out of the hole and the drill string run back in to permit continued drilling, all of this being carried out by the drilling crew in a minimum amount of time.

I claim:

1. Apparatus usable in the method of pulse vibrating a pipe string stuck in a well, comprising axially elongated sub means connectible vertically in a pipe string to transmit torsional string loading in the well, said means including inner and outer relatively axially and telescopically movable tubular coupling bodies for transmitting fluid circulation through the string and said coupling, interengaged upper and lower cam lugs on said bodies through which string weight loading is transmitted for keeping the lugs in interengagement to transmit said torsional loading, said upper and lower lugs being connectible by said sub bodies to upper and lower portions respectively of the string to be integral therewith, said lugs being adapted to slip relatively and separate from interengagement in response to build-up of string torsion acting through the lugs in opposition to said string weight loading to produce sudden relative rotary directional slippage of the separated lugs and lashing in the string above the stuck point, said lugs being vertically engageable in response to application of string weight loading on said bodies during said lug slippage to produce sudden shock torsional loading in the string transmissible to the pipe at the stuck point, said lugs being spaced about the coupling axis and being in the form of undulations whereby the upper and lower lugs will repeatedly separate and engage in response to transmission of torsion in either rotary direction about the coupling axis.

2. The invention as defined in claim 1 in which the upper lugs project downwardly at the lower end of the outer tubular body.

3. The invention as defined in claim 1 including vertically separated and disengaged drive shoulders on said coupling bodies above the level of said lugs, said drive shoulders being interengageable in response to relative vertical body movement of said bodies acting to separate vertically said lugs whereby said drive shoulders may transmit rotary driving torque through the coupling bodies.

4. The invention as defined in claim 3 in which said drive shoulders are at the outside of said inner tubular body and at the inside of said outer tubular body, said drive shoulders being sufficiently vertically separated so as to be engageable only after complete vertical separation of said cam lugs on said bodies.

5. Apparatus usable in the method of pulse vibrating a pipe string stuck in a well, comprising axially elongated sub means connectible vertically in a pipe string to transmit torsional string loading in the well, said means including inner and outer relatively axially and telescopically movable tubular coupling bodies for transmitting fluid circulation through the string and said coupling, interengaged upper and lower cam lugs on said bodies through which string weight loading is transmitted for keeping the lugs in interengagement to transmit said torsional loading, said upper and lower lugs being connectible by said sub bodies to upper and lower portions respectively of the string to be integral therewith, said lugs being adapted to slip relatively and separate from interengagement in response to build-up of string torsion acting through the lugs in opposition to said string weight loading to produce sudden relative rotary directional slippage of the separated lugs and lashing in the string above the stuck point, said lugs being vertically engageable in response to application of string weight loading on said bodies during said lug slippage to produce sudden shock torsional loading in the string transmissible to the pipe at the stuck point, the lowermost portion of said sub means including a threaded connector below the coupling bodies and transversely offset with respect to the coupling axis whereby upon downward transmission of said shock torsional loading said offset portion of the sub means is caused to move eccentrically with respect to the coupling axis.

6. The invention as defined in claim 5 in which said lowermost portion of the sub means is tubular and extends downwardly and transversely with respect to the coupling axis.

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