May 28, 1968 R. A. PLUNK 3,385,384

HYDRAULIC JAR

Filed March 14, 1966

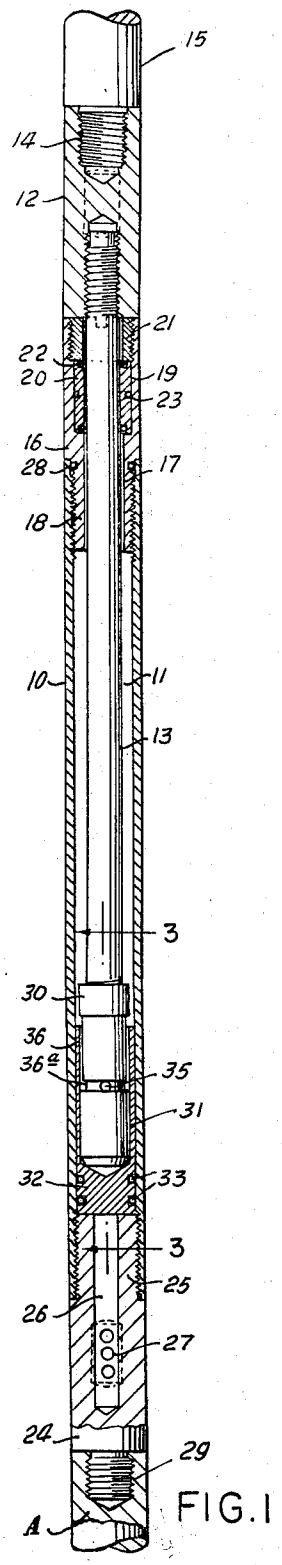


FIG. 1

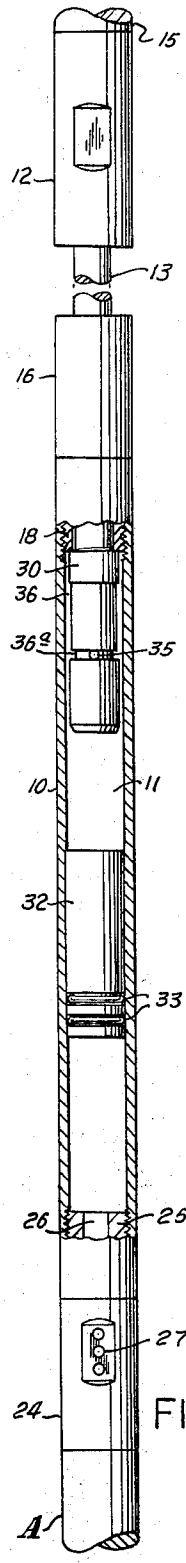


FIG. 2

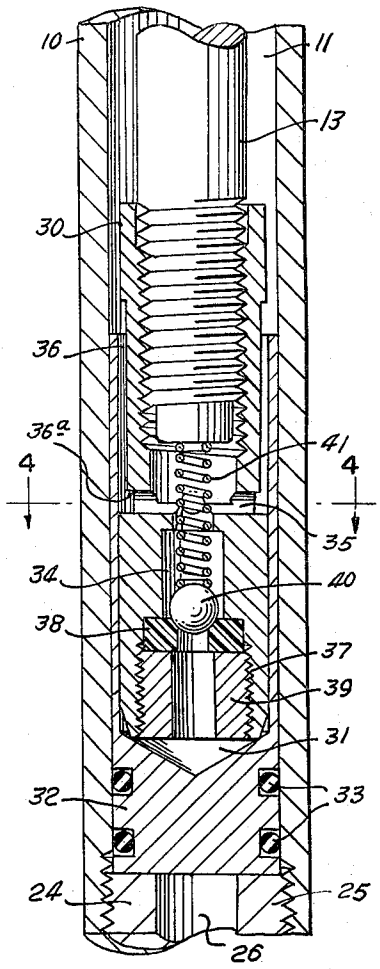


FIG. 3

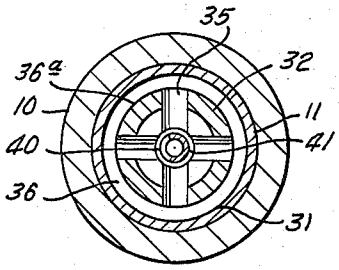


FIG. 4

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HYDRAULIC JAR

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This invention relates to new and useful improvements in well tools for jarring pipe and other devices stuck in a well.

The novel well tool of this invention is adapted to impart an upward impact to pipe or other devices stuck in a well for jarring the same to facilitate removal thereof. In addition to being of economical manufacture, the tool is of minimum length so as to be economical to use. An elongate impact element is reciprocable longitudinally of the tool within a hydraulic chamber or cylinder and has an enlarged portion which is adapted to strike an upper portion of said tool on its upstroke for imparting an upward impact or jarring blow to said tool. The impact element has a control member associated with its lower portion and slidably mounted in the lower portion of the hydraulic chamber for restraining said element against upward travel so that the blow imparted by said element is of sufficient intensity to adequately jar the tool.

In order to minimize the length of the tool, the lower end of the impact element is slidably confined in the control member whereby said member undergoes a limited upward movement with said element so as to resist initial upward travel of said element and whereby the separation of said element from said member is abrupt or sudden and necessitates the application of an upward strain of appreciable magnitude to the element. The control member has sealing engagement with the wall of the chamber whereby upward movement of said member is permitted only by the displacement of the element, and said member has its lower end exposed to the pressure externally of the tool whereby the movement of said member during upward travel of said element is in response to the environment of said tool and the resulting pressure differential across said member. The intensity of the jarring blow or impact is dependent on but not solely determined by the clearance between the element and member and is variable by increasing and decreasing said clearance.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawing, wherein an example of the invention is shown, and wherein:

FIG. 1 is a longitudinal, sectional view of a well tool for jarring pipe and other devices stuck in a well,

FIG. 2 is a broken, side elevational view, partly in section, of the well tool showing its piston withdrawn from its cylinder,

FIG. 3 is a transverse, vertical, sectional view, taken on the line 3—3 of FIG. 1 and on an enlarged scale, showing the piston and a portion of the mandrel of the tool, and

FIG. 4 is a horizontal, cross-sectional view taken on the line 4—4 of FIG. 3.

In the drawing, the numeral **10** designates the elongate, cylindrical, tubular casing or housing of a well tool for jarring pipe and other devices stuck in a well and having a cylindrical, coextensive bore **11** of relatively large diameter. An upper connecting member or coupling **12**, of the same external diameter as the housing **10**, is screwthreaded on the upper end of an elongate, cylindrical element or mandrel **13** which extends coaxially throughout the major portion of the bore **11** of said housing. The

coupling **12** overlies the body and has a screwthreaded socket **14** in its upper end for connection with the lower male coupling or fitting **15** of a measuring line or wire rope (not shown). An anvil body or member **16**, of same external diameter as the housing and having a coaxial bore **17**, is interposed between the coupling and housing and is formed with a depending reduced lower end portion or pin **18** for screwthreaded engagement in the upper end of the bore of said housing. The upper end portion of the bore **17** of the anvil body **16** is enlarged to provide a counterbore **19** for receiving an annular seal carrier or sleeve **20** and an overlying, annular nut or retainer **21**, which is screwthreaded in the upper end of the counterbore, in surrounding relation to the mandrel **13**.

Internal O-rings or other packing rings **22** are recessed in the upper and lower ends of the seal carrier **20** for sealing off around the mandrel, while the intermediate portion of said carrier has an external O-ring or other packing ring **23** for sealing off therearound. A male connecting member or coupling **24**, similar to the coupling **12** and of the same external diameter as the housing **10**, has its upstanding reduced end portion or pin **25** screwthreaded in the lower end of the bore **11** of said housing and an axial bore or passage **26** extending from its upper end to a point adjacent its lower end for establishing communication between said housing bore and exteriorly opening, lateral ports **27** formed in the coupling. For sealing off between the housing bore **11** and the pin **18** of the anvil body, the inner portion of said pin carries an external packing ring **28** which is similar to the packing rings **22** and **23**. An axial screwthreaded pin **29** depends from the lower end of the lower coupling for connection with the upper end of a pulling tool or other mechanism A, a portion of which is shown at A. It is noted that the anvil body **16** and lower coupling **24**, as well as the upper coupling **12** to a lesser extent, form parts or continuations of the housing **10** of the well tool and coact with said housing to form the body of said tool, whereby said housing may be described as an elongate sleeve or tube extending between and connecting said anvil body and lower coupling.

An elongate, tubular head or piston element **30**, of enlarged diameter but of less diameter than the bore **11** of the housing **10**, is screwthreaded on the lower extremity of the mandrel **13** so as to depend therefrom into the upwardly opening, relatively deep socket or cylinder **31** of an elongate, cup-shaped piston or control member **32** reciprocable and having a close sliding fit in said housing bore (FIG. 3). The mandrel head **30** has a snug sliding fit in the cylinder **31**, which is of relatively large diameter, while the housing bore functions as a hydraulic chamber or cylinder for the cup-shaped piston **32** which has a pair of O-rings or other packing rings **33** recessed in its lower end portion for positive sealing engagement with the cylinder wall to prevent said housing bore from communicating with the passage **26** and ports **27** whereby only the lower end of said piston is exposed to the exterior of said tool. As will be apparent, the enlarged mandrel head is adapted to strike the lower end **18** of the anvil body **16** upon upward movement of the mandrel relative to the housing so as to impart an upward impact or jarring blow to said housing and the force or intensity of the jarring stroke is controlled by the separation of said mandrel head from the cup-shaped piston (FIG. 2).

An axial bore **34**, of reduced diameter, extends throughout the lower portion of the mandrel head **30** for establishing communication between the lower end of the socket or cylinder **31** of the piston **32** and a plurality of lateral or radial ports **35** (FIGS. 3 and 4) formed in said head a short distance below its connection with the mandrel **13**. The intermediate portion of the mandrel head, at and

above the ports 35, is reduced in diameter to provide an annular flow space or passage 36 between said head and the cylinder of the cup-shaped piston for communication with said ports. If desired, the lower end of the reduced portion of the mandrel head 30 may be recessed as shown at 36*a* to facilitate flow from the ports to the passage or space 36. A coaxial counterbore 37 is formed by enlarging the lower portion of the bore 34 for receiving a valve seat 38, of plastic or other suitable resilient material, and the counterbore is screwthreaded for engagement by an annular retainer 39 which forms a continuation of said bore. Downward flow through the bore of the mandrel head is prevented by a spherical valve element or valve ball 40 which overlies the seat 38 and which is held in engagement therewith by a helical spring 41 confined between the ball and the lower end of the mandrel.

Manifestly, the valve ball 40 and its seat 38 function as a simple form of check valve, which opens or unseats to permit upward flow through the bore 34 and its communicating ports 35 and passage 36 during downward movement of the head 30 with the mandrel 13 so as to facilitate such downward movement and full engagement of said mandrel head within the cylinder 31 of the cup-shaped piston 32, and which closes or seats to prevent downward flow through said bore and its ports and passage upon upward movement of said mandrel head so as to resist withdrawal thereof from said cylinder of said piston. Separation of the mandrel head and piston is restrained also by the tight sliding fit of said head in the cylinder of the piston whereby the separation of said mandrel head from said piston is rather abrupt or sudden and requires the application of an upward pull or strain of considerable force and duration to the mandrel. Consequently, after withdrawal or separation from the piston 32, the upward movement of the mandrel head 30 is rapid and said head strikes the lower end of the anvil body 16 (FIG. 2) with an intense force for imparting a jarring blow to the tool through its housing 10 which is secured to said anvil body. The intensity of this blow may be varied by altering the clearance between the mandrel head and the cylinder 31 of the cup-shaped piston, and, obviously, the closer the fit therebetween, the greater the resistance to separation or withdrawal of said mandrel head.

In use of the tool, the bore 11 of the housing 10 above the cup-shaped piston 32 is filled with oil or other suitable noncompressible fluid and, preferably, with a liquid that has a stable viscosity at the relatively high temperatures encountered in deep wells. Although the cup-shaped piston has a close fit within the cylinder, which is formed by the housing bore, said piston is adapted to undergo downward movement and limited upward movement with the mandrel 13. The enlarged head or piston 30 of the mandrel has a looser fit within the cylinder or socket 31 of the piston 32; however, the clearance between said mandrel head and cylinder is slight whereby flow around said head is restricted so as to resist withdrawal thereof from said cylinder and permit limited drawing of said piston 32 upwardly with said mandrel head. The mandrel 13 is adapted to be inserted in the housing bore 11 after the filling of the latter and downward movement of said mandrel through said bore is permitted by the ample clearance provided between said bore and the head of said mandrel. Due to the recess 36*a* and flow space or passage 36, upward flow around the mandrel head 30 is permitted by the upward opening of the valve 40 after said head enters the cylinder of the cup-shaped piston whereby the liquid or noncompressible fluid may bypass said mandrel head by flowing upwardly through the annular retainer 39, bore 34 and ports 35 to said recess and said head may fully engage and seat within said cylinder as shown in FIGS. 1 and 3.

When an upward strain of a strength sufficient to overcome the resistance of the liquid to upward movement is applied to the mandrel 13 by the measuring line or wire rope and the pulling tool A is connected to pipe or other device stuck in a well, said mandrel moves upwardly relative to the housing 10. Due to the tight fit of the enlarged mandrel head 30 within the cylinder or socket 31 of the cup-shaped piston 32, the latter is drawn or moves upwardly as permitted by the displacement of the upwardly moving mandrel whereby upward travel of said mandrel is impeded or resisted until said mandrel head is withdrawn from said cylinder or socket. Since the lower end of the cup-shaped piston is exposed through the passage 26 and ports 27 to the exterior of the well tool, said piston is responsive to the fluid pressure of the environment of said tool and is moved by the pressure differential thereacross except for the frictional resistance provided by the positive sealing engagement of the O-rings 33 with the cylinder wall 11. The well tool is operative in a vacuum as well as under high fluid pressures. In a vacuum, the piston 32 remains positioned adjacent the lower end of the housing 10 upon upward travel of the mandrel 13; at atmospheric pressure, said piston travels upwardly only if the pressure differential is great enough to overcome the frictional resistance of the sealing rings; and at the relatively high pressures normally present in wells, said piston follows but lags behind the upward travel of said mandrel.

Due to the absence of positive sealing means between the mandrel head 30 and piston cylinder or socket 31, the liquid or non-compressible fluid bypasses said head so as to gradually fill said cylinder or socket and the piston 32 follows the upward travel of the mandrel 13 at a substantially constant rate of lag when the pressure externally of the well tool is relatively high. Upon upward travel of the mandrel when the external pressure is substantially atmospheric, a partial vacuum is created within the cylinder or socket of the piston by the increased pressure of the liquid above said piston which forces said piston downwardly away from the mandrel head. Since the lower end of the cup-shaped piston is several times greater in area than the upper end of the wall forming its cylinder or socket 31, said piston follows the upward travel of the mandrel at a substantially constant rate of lag even when the external fluid pressure is several times less than the pressure of the liquid contained in the tool and created by said mandrel travel. The rate of lag is dependent upon the ratio of the mandrel area to the piston area and the interval of time required to withdraw or separate the head of said mandrel from said piston is controlled by intensity of the upward strain placed on said mandrel as well as by the clearance between said mandrel head and the piston cylinder or socket.

Once the mandrel head 30 leaves the piston cylinder or socket 31, the upward travel of the mandrel 13 is rapid whereby said head strikes the anvil body 16 with an intense force and said intensity increases with the strength or intensity of the upward strain placed on the mandrel. Since the cylinder formed by the bore 11 of the housing 10 is of constant diameter, said housing may be formed of stock tubing so as to materially reduce the cost of manufacture. Also, the upward travel of the cup-shaped piston 32 with the mandrel for resisting upward movement of said mandrel makes it possible for the tool to be of less length and less expensive to make and use than conventional impact tools or jars. Manifestly, the tool may be inverted to provide a downward jarring action.

The foregoing description of the invention is explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made, within the scope of the appended claims, without departing from the spirit of the invention.

What I claim and desire to secure by Letters Patent is:

1. A well tool for jarring pipe and other devices stuck in a well including a body adapted to be connected to a support for lowering into a well and attachment to a device stuck therein, the body having a hydraulic chamber extending longitudinally thereof, an impact element reciprocable in the chamber and having a portion projecting upwardly therefrom for connection with the support,

an upwardly facing impact surface on the element, a downwardly facing anvil surface at the upper portion of said chamber for striking by the upwardly facing impact surface upon upward travel of said element, and a control member slidably mounted in the lower portion of said chamber, the control member having a closed lower end and an upwardly opening socket formed therein, said element having at least a lower portion complementary to the socket for slidable confinement therein and detachable connection to the control member whereby said member undergoes limited upward movement with said element so as to resist initial upward travel of the latter.

2. A well tool as set forth in claim 1 wherein the control member has a downwardly facing surface exposed to the pressure externally of the tool, and means on said member for sealing off between the hydraulic chamber and member to prevent said chamber from communicating with the exterior of said tool whereby the movement of said member is in response to the pressure differential thereacross.

3. A well tool as set forth in claim 1 wherein the upwardly facing impact surface of the element is at the lower portion thereof above and adjacent its confinement in the socket of the control member.

4. A well tool as set forth in claim 1 including means for sealing off around the control member to prevent the bypassing of fluid therearound whereby upward movement of said member is limited by the displacement of the upwardly moving impact element.

5. A well tool as set forth in claim 1 wherein the impact element has an enlarged portion on its lower end for slidable confinement within the socket of the control member and forming the upwardly facing impact surface of said element.

6. A well tool for jarring pipe and other devices stuck in a well including a body adapted to be connected to a support for lowering into a well and attachment to a device stuck therein, the body having a hydraulic chamber extending longitudinally thereof, an impact element reciprocable in the chamber and having a portion projecting upwardly therefrom for connection with the support, an upwardly facing impact surface on the element, a downwardly facing anvil surface at the upper portion of said chamber for striking by the upwardly facing impact surface upon upward travel of said element, and a control member slidably mounted in the lower portion of said chamber and having an upwardly opening socket formed therein, said element having at least a lower portion complementary to the socket for slidable confinement therein and detachable connection to the control member whereby said member undergoes limited upward movement with said element so as to resist initial upward travel of the latter, the lower portion of said element which is slidably confined in said socket having a passage for establishing communication between said socket and chamber above said control member, and downwardly facing valve means for permitting upward flow and preventing downward flow through the passage.

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