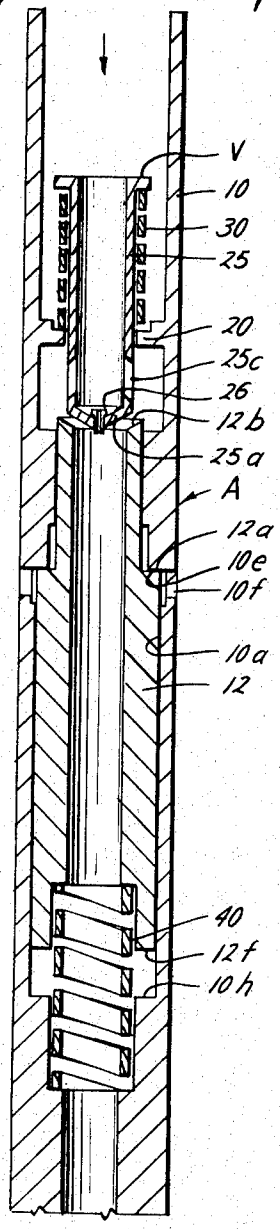
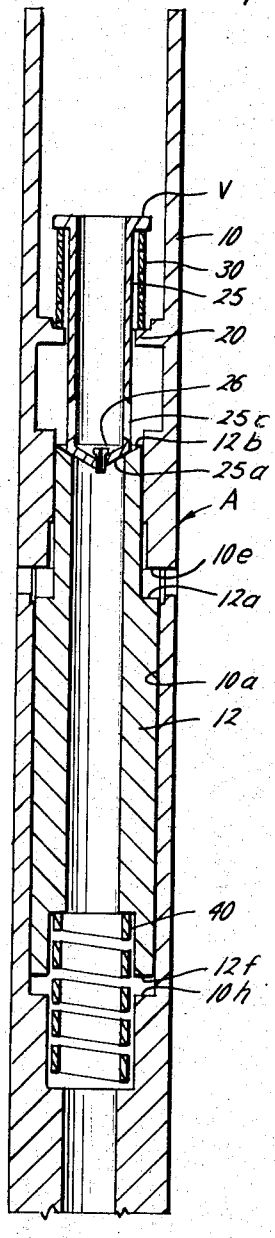
Jan. 2, 1968 R. W. BROWN 3,361,220

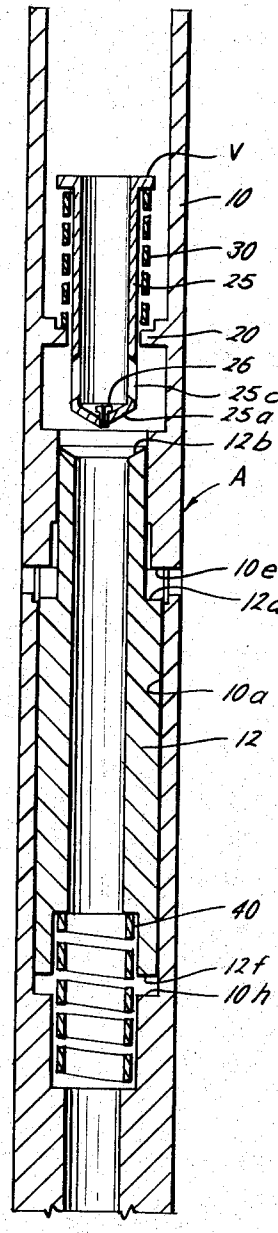
JARRING OR DRILLING MECHANISM

Filed March 17, 1965 4 Sheets-Sheet 1

Fig. 1 Fig. 2 Fig. 3







Robinson W. Brown
INVENTOR.

BY Hayden & Prawel

ATTORNEYS

Jan. 2, 1968 R. W. BROWN 3,361,220

JARRING OR DRILLING MECHANISM

Filed March 17, 1965 4 Sheets-Sheet 2

Fig. 4A

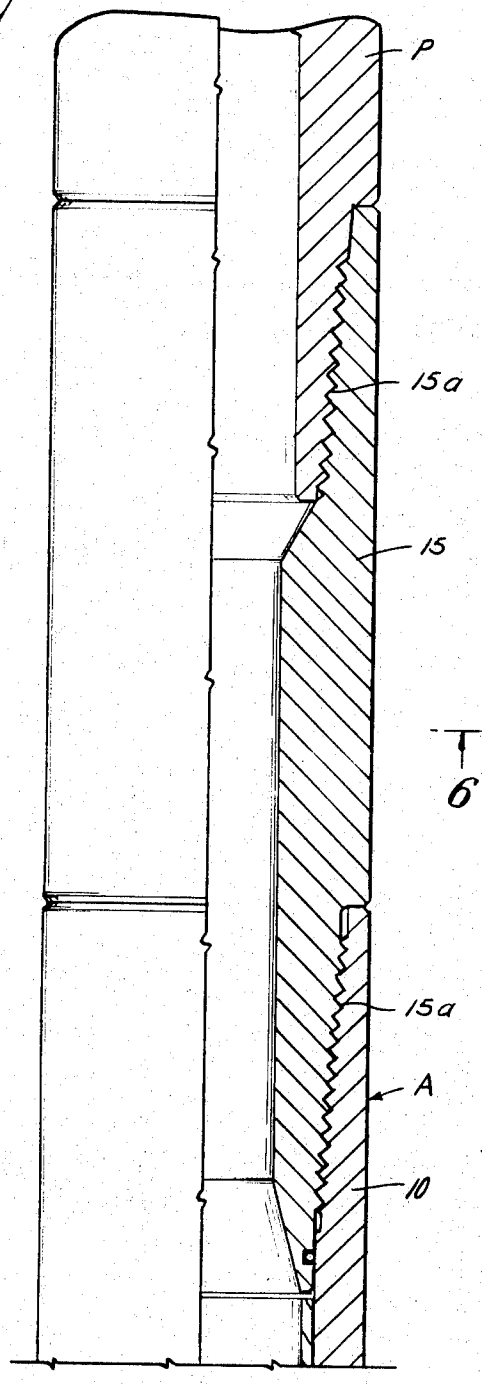
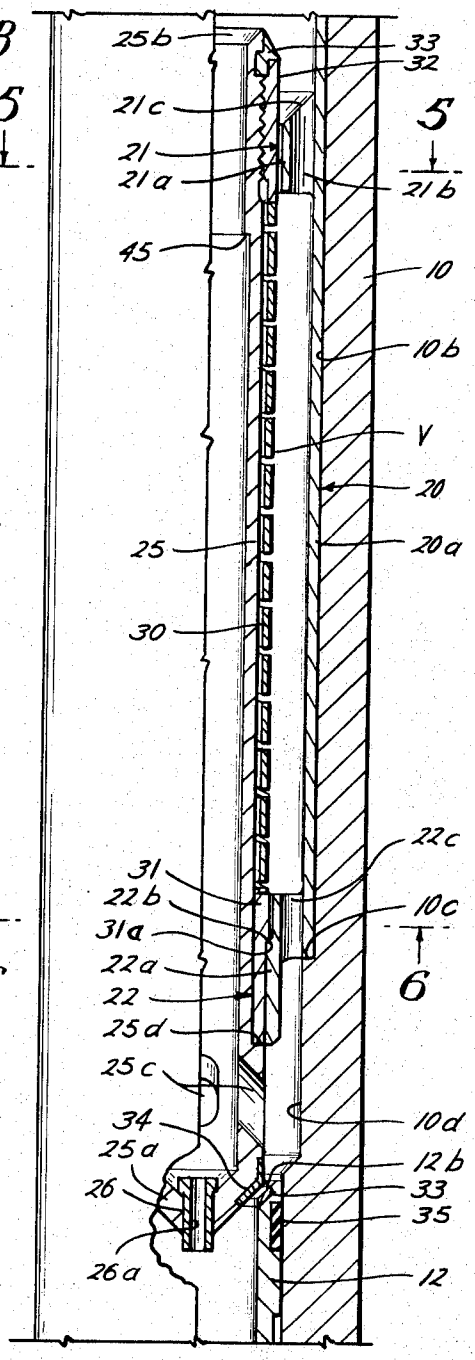


Fig. 4B



Robinson W. Brown
INVENTOR.

BY Hayden & Pravel

ATTORNEYS

Jan. 2, 1968 R. W. BROWN 3,361,220

JARRING OR DRILLING MECHANISM

Filed March 17, 1965 4 Sheets-Sheet 3

Fig. 4C

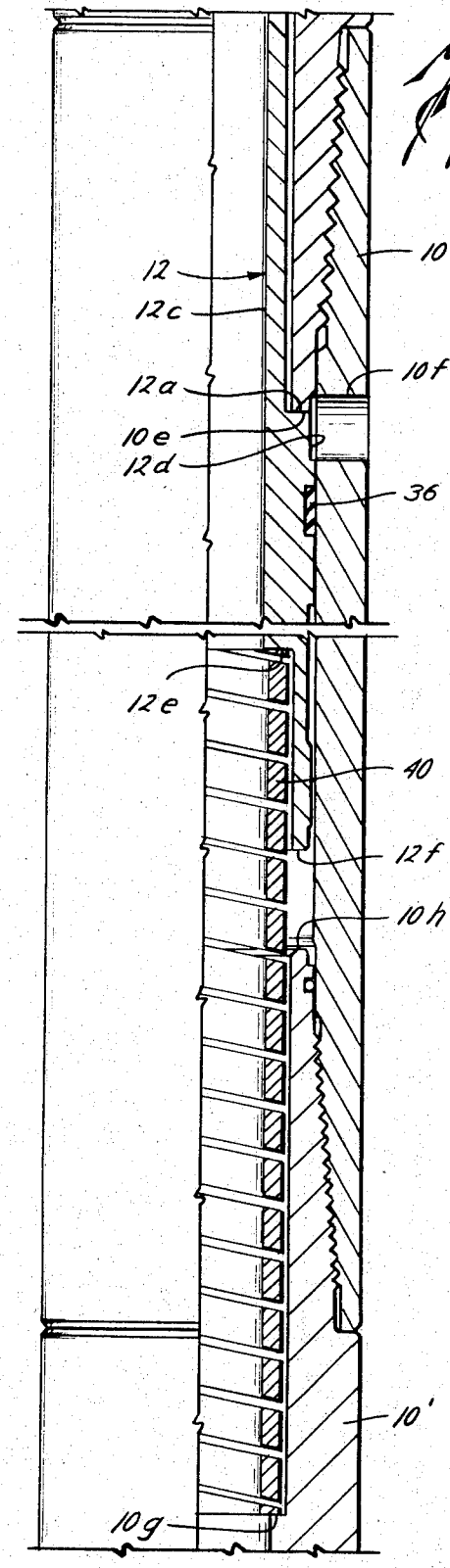


Fig. 5

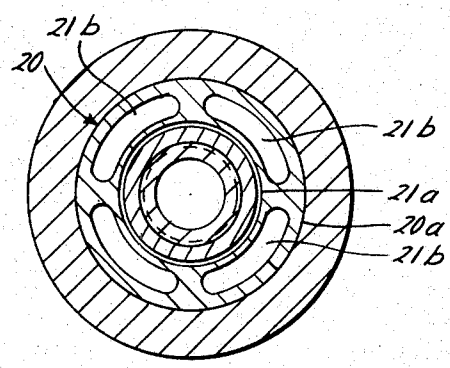
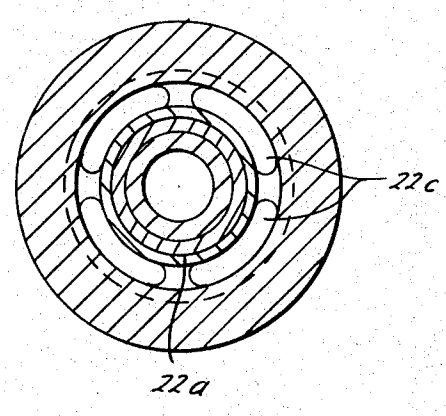


Fig. 6



Robinson W. Brown
INVENTOR.

BY Hayden & Prewel

ATTORNEYS

Jan. 2, 1968 R. W. BROWN 3,361,220

JARRING OR DRILLING MECHANISM

Filed March 17, 1965 4 Sheets-Sheet 4

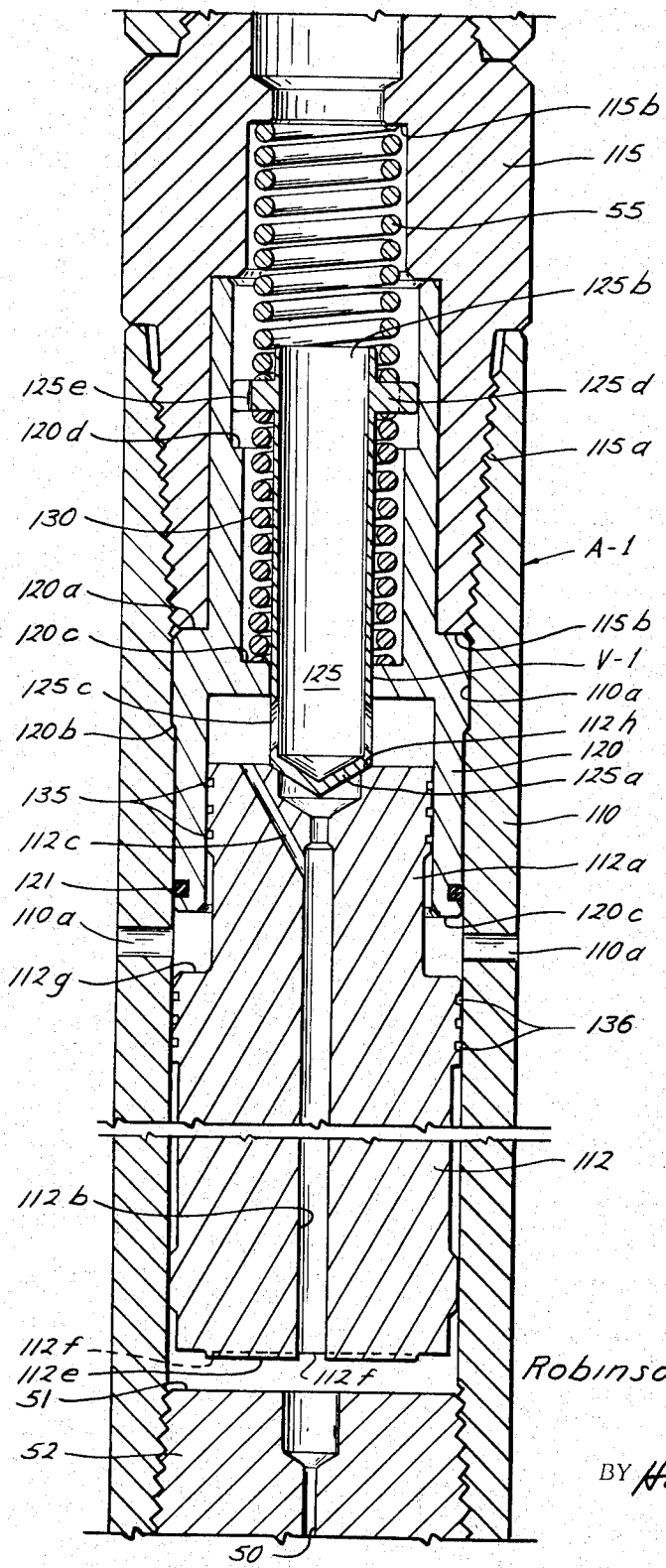


Fig. 7

Robinson W. Brown
INVENTOR.

BY Hayden & Powell

ATTORNEYS

United States Patent Office 3,361,220
Patented Jan. 2, 1968

3,361,220

JARRING OR DRILLING MECHANISM

Robinson W. Brown, San Antonio, Tex., assignor, by mesne assignments, to Bassinger Tool Company, a corporation of Texas

Filed Mar. 17, 1965, Ser. No. 444,907
10 Claims. (Cl. 175—237)

ABSTRACT OF THE DISCLOSURE

A fluid operable impact mechanism for use in a pipe string either as a jar or impact tool. The mechanism is formed of a tubular barrel connectable to a pipe string. A reciprocating hammer is located in the barrel. A single valve member upstream of the hammer is engageable with a longitudinal passage in the hammer to subject the hammer to fluid pressure. The valve member has transverse discharge passages to develop a pressure drop around the valve seat and a restricted passage to eliminate water hammer. The valve is restricted in longitudinal movement so that it does not follow the full travel of the hammer. An anvil is positioned to be contacted by the hammer. Means are provided to automatically return the hammer. These may be a restricted passage or springs. An upper anvil may be incorporated to have a two-way jar.

This invention relates to new and useful improvements in jarring or drilling mechanisms, and particularly jars for use in jarring stuck pipe in a well.

This is a continuation-in-part of my co-pending U.S. patent application Ser. No. 365,980, filed May 8, 1964, now abandoned.

In my prior U.S. Patent No. 3,038,548, a hydraulically operable jar is disclosed for applying a series of blows to a stuck pipe in a well, wherein hydraulic fluid for operation of the jarring mechanism is used and wherein longitudinal movement of the pipe string supporting the jarring mechanism is not required to obtain the jarring action on the stuck pipe.

It is an object of the present invention to provide a new and improved mechanism for performing jarring or drilling operations in a well, and having all of the advantages of the jar of said U.S. Patent No. 3,038,548, and also having certain additional features and advantages.

An important object of this invention is to provide a new and improved jarring or drilling mechanism disposed in a pipe string and having a valve means, dropable and retrievable through the inside of the pipe string, whereby the jarring mechanism may be caused to function or to cease functioning, at the will of the operator and without the necessity of pulling the pipe string from the well hole.

Another important object of this invention is to provide a new and improved mechanism suitable for jarring or drilling in a well, wherein a fluid-actuated valve is forced downwardly by fluid pressure to move a hammer downwardly, and wherein the hammer is subsequently moved upwardly by a differential fluid pressure developed across a drill bit or other orifice in the pipe string below the hammer.

Another object of this invention is to provide a new and improved jarring or drilling mechanism adapted to be operably disposed in a pipe string, wherein substantially the full open bore of the pipe string is provided through the mechanism prior to dropping the valve means therefor into the pipe string, whereby various tools such as drift indicators, string shots, bottom hole temperature indicators, and the like, may be run through the pipe string in the same manner as if such mechanism were not in the string.

A further object of this invention is to provide a jarring or drilling mechanism for use in a pipe string in a well hole, wherein the operating characteristics of the mechanism, such as valve opening or stand-off, valve spring force, and length of valve stroke may be changed at the surface without pulling the pipe string from the well hole.

A particular object of this invention is to provide a new and improved jarring or drilling mechanism for use in a pipe string, such mechanism having a new and improved valve which is adapted to be dropped downwardly from the surface to its operating position within the pipe string, and which is also adapted to be removed from the pipe string by a fishing tool or by reverse fluid circulation upwardly in the pipe string.

Still another object of this invention is to provide a new and improved mechanism which may be used for jarring or drilling, and which has a single valve disposed in the mechanism for co-action with a hammer element to obtain either upward or downward blows, or both, using air, drilling mud or other fluid as the actuating fluid for the mechanism.

Still another object of this invention is to provide a new and improved mechanism which may be used for jarring or drilling and which has a single valve disposed in the mechanism and above a hammer element for co-action with a hammer element to obtain either upward or downward blows, or both, using air, drilling mud or other fluid as the actuating fluid for the mechanism, said mechanism having a by-pass for allowing a leakage of some fluid when the valve is closed to relieve or smooth out fluid pressure shock waves which develop due to the closing of the valve.

A still further object of this invention is to provide a mechanism for jarring a stuck fish in a well, wherein an upward jar may be imparted to the stuck fish while also applying an upward strain to such fish.

A specific object of this invention is to provide a fluid-actuated jarring mechanism for jarring a stuck fish in a well, wherein jarring may be imparted to the stuck fish either upwardly or downwardly or in both directions.

The preferred embodiment of this invention will be described hereinafter, together with other features thereof, and additional objects will become evident from such description.

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

FIG. 1 is a schematic illustration of the apparatus of this invention in the position for the starting of a jarring stroke and the completion of the prior jarring stroke;

FIG. 2 is a view similar to FIG. 1, illustrating the jarring mechanism at an intermediate stage wherein the fluid pressure above the jarring mechanism has been developed sufficiently to move the valve and the impact element downwardly within the pipe string;

FIG. 3 is a view similar to FIG. 2, but illustrating a further step in the operation of the jarring mechanism, wherein the impact element has moved downwardly below the valve means in preparation for the return upward stroke of the impact element to the position shown in FIG. 1;

FIGS. 4A, 4B and 4C are views showing the upper, intermediate and lower portions, respectively, of the jarring mechanism of this invention in detail, such mechanism being in the position corresponding to that shown in FIG. 1;

FIG. 5 is a cross-sectional view taken on line 5—5 of FIG. 4B;

FIG. 6 is a cross-sectional view taken on line 6—6 of FIG. 4B; and

FIG. 7 is a vertical sectional view of a modified form of the present invention.

In the drawings, the letter A designates generally one embodiment of the jarring or drilling mechanism of this invention which is adapted to be connected in a pipe string, a portion of which is indicated at P in FIG. 4A. Normally, the pipe string P is a conventional drill string and the mechanism A is disposed at an intermediate position in such pipe string P, with a drill bit therebelow (not shown). Briefly, the mechanism A includes a tubular body or barrel **10** which may be formed in several sections for ease of manufacture and assembly as illustrated in the drawings. Such body **10** is provided with a suitable bore **10***a* in which a hammer element or impact element **12** is longitudinally movable. In one form of the invention (FIGS. 4A–6), a valve assembly or means V is provided which is adapted to be dropped into position through the pipe string P and which is also adapted to be retrieved therefrom. Such valve V serves to control the operation of the impact element **12** for obtaining jarring blows which are transmitted to the drill string, as will be more fully explained. Thus, should the drill string become stuck in the well hole, the valve assembly V is dropped into the drill string and assumes its operable position so that thereafter upon the application of a predetermined fluid velocity above the valve V, jarring blows are imparted to the drill string. During normal operation, the valve means V is not in the drill string and therefore substantially the full bore of the drill string is open through the mechanism A for the passage of various types of tools such as drift indicators, string shots, bottom hole temperature indicators, and the like. With this invention, only a one-way upward jar is normally desired and provided, but a one-way downward jar may be provided, or in some cases, a two-way jar for both upward and downward jarring may be provided. When using the mechanism A for drilling, only downward blows with the hammer **12** are usually provided to accomplish the drilling.

Considering the invention more in detail, the mechanism A is connected at its upper end to a top sub or adapter **15** which has the usual threaded connections **15***a* to the pipe string P. The threads **15***b* of the sub **15** are connected in any suitable manner as illustrated in FIG. 4A to the tubular body or barrel **10**.

A valve guide **20** is disposed in the upper bore **10***b* of the tubular barrel or body **10** and rests upon an inwardly extending lateral shoulder **10***c*. Such valve guide **20** includes a sleeve **20***a* which has an upper spider or guide **21** formed integrally therewith or connected thereto. Such spider **21** has an inner guide ring **21***a* with flow ports **21***b* spaced circumferentially as best seen in FIG. 5. To facilitate the guiding of the valve means or assembly V into the bore of the guide sleeve **21***a*, the upper surface **21***c* is downwardly and inwardly tapered (FIG. 4B).

The valve guide **20** also has a lower guide spider **22** which is integrally formed or otherwise connected to the sleeve **20***a*. The spider guide **22** has an inner guide sleeve **22***a* which is formed with a seating shoulder **22***b* extending laterally inwardly for a purpose to be hereinafter described. Suitable circumferentially spaced flow passages or openings **22***c* (FIG. 6) are provided for the flow of fluid, as will be more evident hereinafter.

The valve means or assembly V is formed with a tubular body **25** which is closed at its lower end by a tapered or frusto-conical end section **25***a*. Preferably, a small restricted opening is provided in the end section **25***a*, as illustrated by a wear-resistant bushing **26** having a central opening **26***a* therethrough (FIG. 4B). Such bushing **26** is of the replaceable type and is normally formed of tungsten carbide or similar hard material. The upper end **25***b* is open for the flow of hydraulic fluid or other fluid into the bore of the valve body **25**. A plurality of discharge ports **25***c* are provided at the lower end of the valve body **25**, above the closure **25***a*, for the discharge of the hydraulic fluid from the bore of the barrel **25** into the counterbore **10***d* of the barrel **10**.

The valve assembly V is also provided with a helically wound spring **30**, or any other suitable resilient means positioned externally of the valve body **25**. A slideable support or stop ring **31** is slidably mounted at the lower portion of the valve body **25** and rests upon a shoulder **25***d* on the external surface of the valve body **25**. Such stop ring **31** has an outwardly extending lateral stop shoulder **31***a* which is adapted to seat on the inwardly extending lateral shoulder **22***b* of the lower guide spider **22**. As illustrated, such shoulders **22***b* and **31***a* are suitably inclined downwardly and inwardly in the preferred form of the invention.

The spring **30** engages its lower end with the upper end of the stop ring **31** (FIG. 4B), while the upper end of the spring **30** is confined by a retaining nut **32** threaded on the upper end of the valve body **25** and secured against travel by a split lock ring **33** or any other similar means.

As illustrated in FIG. 4B, when the valve assembly V is positioned with the stop ring **31** at its lowermost position, the convolutions of the helically wound spring **30** are spaced from each other so as to permit a compression of the spring **30** as the body **25** of the valve assembly V moves downwardly with respect to the stop ring **31**, as will be more evident hereinafter. However, when the convolutions of the spring **30** engage each other so as to close the spaces between them, the downward movement of the valve body **25** is then stopped and a return force for returning the valve body **25** upwardly is provided by the compression of the spring **30**, as discussed below.

The impact element or hammer **12** is tubular in shape and is provided with a hammer surface **12***a* which extends laterally outwardly and is adapted to contact an inwardly extending lateral anvil surface **10***e* formed in the barrel or body **10**. Thus, upon an upward longitudinal movement of the impact element **12**, the hammer surface **12***a* contacts the impact or anvil surface **10***e* to impart a jarring blow to the barrel **10** and therefore to the entire drill string or other type of string P in which the mechanism A of this invention is connected.

The upper end of the impact element **12** is formed with a valve seating surface **12***b*, which preferably has a removable insert **33** of a hard material such as tungsten carbide mounted thereon for wear purposes. Such insert **33** may be secured by welding, screws or other attaching means of known construction so that the insert **33** may be replaced when excessive wear occurs thereon. A corresponding insert **34** is preferably provided on the lower outer edge or annular surface of the end closure **25***a* of the valve assembly V to likewise provide for a replaceable member when excessive wear occurs. Such member **34** is also preferably formed of tungsten carbide or other extremely hard material and is held in position by welding, screws or other suitable attaching means. Such inserts **33** and **34** may be preformed in single pieces or they may be formed in a plurality of sectional pieces to facilitate manufacture and assembly.

Suitable packing or seals **35** and **36** are provided above and below the hammer surface **12***a* to seal off such area from the flow of fluid normally occurring through the bore **12***c* of the impact element **12**.

Preferably, the external surface of the impact element **12** is recessed with an annular groove **12***d* which is aligned with an opening or port **10***f* in the barrel or body **10** to assure that there is no fluid lock during the hammer stroke or upward jarring action of the impact element or hammer **12**.

In the form of the invention illustrated in FIG. 4C, the impact element **12** is provided with an internal laterally extending shoulder **12***e*, which rests upon a helically wound hammer spring **40** which in turn has its lower end resting upon an inwardly extending lateral shoulder **10***g* formed in the barrel or body **10**. Such spring **40** is adapted to be compressed when the impact element or

hammer **12** moves downwardly and such compression provides for a return force on the hammer element **12** to aid in the upward movement of such element **12** for accomplishing the upward jarring blow by the engagement of the hammer surface **12***a* with the anvil surface **10***e*. On a drilling job where sufficient fluid horsepower is always available, the spring **40** is eliminated since it is subject to breakage and it decreases the force with which the hammer **12** strikes the lower anvil **10***h*.

The lower laterally extending end **12***f* normally does not contact the laterally extending surface **10***h* during jarring action, as will be more evident hereinafter, but if desired, the mechanism A of this invention may include a downward jarring blow by providing for the contact of the surface **12***f* with the lower anvil **10***h* upon the downward movement of the impact element or hammer **12**.

It should be understood that the lower portion or threaded section **10'** is a part of the tubular barrel **10** but it may also be a lower sub or adapter which is connected in the usual manner to the lower portion of the drill string or pipe extending therebelow to the drill bit, if a drill bit is used at such lower end (not shown). When the drill bit is present at the lower end of the pipe string, the mechanism A may be used for drilling operations by providing only downward blows with the hammer **12** on the surface **10***h*, as will be more fully explained.

Considering now the operation of the mechanism A of this invention, and with particular reference to the schematic illustrations of FIGS. 1–3, it will be appreciated that under normal drilling or other well conditions, the valve assembly V is not in the position shown in the drawings but instead is held at the surface until needed. Therefore, during normal operations prior to the need for the jarring action provided by the present invention, the bore of the mechanism A is open and substantially the full bore of the drill string is therefore available for the running of various types of tools therethrough, as will be understood by those skilled in the art and as pointed out above. When the valve assembly V is out of the drill string P, the portion of the mechanism A remaining therein actually creates no more of a pressure drop therethrough than would occur with a ten foot section of drill collar.

When it is desired to obtain the jarring action provided by the present invention, the valve V is dropped from the surface downwardly through the drill string and it is guided when reaching the upper guide spider **21** downwardly so that the stop ring **31** ultimately seats with its seating surface **31***a* on the support shoulder **22***b*. It is to be noted that when the valve V is seated as shown in FIG. 4B, and as illustrated in FIG. 1, the end closure **25***a* is spaced upwardly from the valve seat **12***b* provided at the upper end of the impact element **12**. Thus, as fluid is introduced into the drill string and passes downwardly therethrough, it flows through the bore of the valve body **25** and also around such valve V through the openings **21***b* and **22***c* in the upper and lower spider guides **21** and **22**, respectively.

Thus, such fluid flow is divided at the top of the tool, some passing around the outside of the valve V and some entering through the bore thereof, with both of such flows meeting in the counterbore **10***d* since the fluid from the inside of the valve body **25** flows outwardly through the port or ports **25***c* into such counterbore **10***d*. When the restricted opening **26***a* is provided by the bushing **26** or in the end closure **25***a*, a small portion of the liquid flows therethrough. With the exception of the fluid passing through the opening **26***a*, all of the fluid passes through the restricted annular space between the lower end **25***a* of the valve V and the upper valve seat **12***b* of the hammer or impact element **12**.

As the rate of circulation of the water, gas or other fluid downwardly through the drill string P is increased, the velocity of such fluid passing through the restricted space between the enclosure **25***a* and the seat **12***b* increases so that a high velocity low pressure area is established in such annular space. Thus, the restricted space below the valve V is serving as an orifice and a substantial pressure drop is established to increase the difference between the pressure of the fluid above the valve and that pressure existing therebelow. The force acting downwardly on the valve V is the product of its area exposed to the pressure above the valve multiplied by such pressure. When this force reaches a predetermined amount, it will overcome the force of the valve spring **30** and the valve body **25** will move downwardly with the stop ring **31** remaining on its seat **10***c*. The downward movement will cause the inserts **34** and **33** to contact each other and thereby close the flow of fluid therebetween so that the valve is then in the closed position. The fluid velocity or rate of circulation of the fluid which is necessary to close the valve V is determined by the strength of the valve spring **30** and the stand-off distance or space between the inserts **33** and **34** when the valve V is in the open position. The actual value of the fluid pressure above the valve V when the valve closes is the pressure which exists above the valve before closure plus the water hammer pressure caused by the valve closing. Such pressure and the force exerted on the valve V to move it downwardly at that time can of course be readily calculated mathematically, and it has been found that when using water the value of the pressure force above the valve V when the valve closes is in the neighborhood of 8000 p.s.i. When using air pressure as the actuating fluid, normal operations are conducted at 500 p.s.i With such pressure, it has been found that about 4,000 to 6,000 blows per minute may be obtained, which provides for effective drilling action if a drill bit is used, and without the necessity for drill collars to accomplish such drilling.

When the valve V closes, circulation is entirely blocked through the bore of the impact element **12** and otherwise through the drill string. Thus, the pressure existing above the valve V acts upon the hammer or impact element **12** to move it downwardly and to cause it to accelerate rapidly. Such downward force from the fluid above the valve V acting on the impact element **12** is opposed by an upward force which is equal to the pressure in the drill string below the impact element **12** and acting on its exposed lower area which is its full diameter, so that the net downward hydraulic or other fluid force is a product of the fluid pressure above the valve V multiplied by the area of the impact element **12** across the full diameter above the hammer surface **12***a*, subtracting therefrom the fluid pressure below the impact element **12** multiplied by the full exposed diameter of the impact element **12**.

Since the circulation of fluid through the hammer or impact element **12** and the bit is stopped, or substantially stopped, when the valve closes, and as the hammer or impact element **12** obtains a downward velocity, fluid is displaced through the bit nozzles or other restrictions below the tool A, causing the pressure below the impact element **12** and within the drill string P to increase, but not enough to stop the downward movement of the impact element **12** itself.

When the hammer spring **40** is used, it opposes such downward motion of the impact element **12**, but its force is small compared to the hydraulic or other fluid forces.

The valve body **25** and the impact element **12** move downwardly together due to the hydraulic or other fluid force acting thereabove, until the downward movement of the valve body **25** is stopped by the spring **30** becoming solid (FIG. 2) or by any other suitable stop means. Thus, when the convolutions of the spring **30** have contacted each other and the spaces therebetween have thus been closed, the spring is actually a solid sleeve and prevents further downward movement of the valve body **25** since the stop ring **31** is seated against downward movement.

When the downward movement of the valve body **25** is stopped, the impact element or hammer **12** still con-

tinues to move since it has attained a high momentum and therefore moves away from and below the valve V to again open the restricted opening between the valve end closure 25*a* and the upper valve seat 12*b*. As soon as the circulation through the tool is reestablished by the separation of the impact element 12 from the valve V, the downward movement of the hammer is decelerated, stopped and finally accelerated upwardly by the fluid forces acting on it. Also, immediately after circulation is started, the spring 30 is free to return the valve body 25 upwardly to its original position (FIGS. 1, 3 and 4B).

The net force acting upwardly on the hammer while the circulation therethrough is occurring is the pressure below the hammer multiplied by the area exposed thereto plus the force of the spring 40 minus the pressure above the hammer multiplied by its upper area exposed thereto. After the valve has been released by the downward movement of the hammer or impact element 12, the pressures above and below the impact element are substantially the same but the area of the impact element 12 exposed to the lower pressure is considerably larger, generally about twice that of the upper area exposed to the upper pressure and therefore a strong upward force is exerted to return the hammer element 12 upwardly, even without the hammer spring 40. In the usual case, the fluid pressure acting upwardly on the hammer element 12 is provided by reason of a pressure drop through the conventional fluid discharge openings in a drill bit mounted at the lower end of the pipe string P, but if a drill bit is not being used, a suitable orifice 50 (FIG. 7), as will be explained, may be provided in the pipe string P below the hammer element 12 to develop such fluid pressure differential. Such upward acceleration of the hammer or impact element 12 results in a jarring impact blow by the hammer surface or face 12*a* with the impact or anvil surface 10*e*, such jarring blow being transmitted through the barrel of the mechanism A to the entire drill string to effect a jarring thereof for freeing a stuck portion in the well hole.

If the lower end of the pipe string has a grapple or other fishing tool (not shown) thereon which is connected to a stuck fish, such as a section of stuck pipe in the well, an upward strain may be taken on the stuck fish by pulling upwardly on the upper end of the pipe string P at the surface of the well simultaneously with the upward jarring action to obtain a still greater upward force on the stuck fish.

Immediately after the anvil surface 10*e* is struck by the hammer surface 12*a*, the fluid pressure acting on the valve V will again return it downwardly to close the valve and thus stop fluid circulation through the jarring mechanism A to repeat the cycle. It is therefore believed evident that an automatic repetitive jarring action is obtained by simply maintaining a predetermined fluid velocity in the drill string from the surface.

If it is desired to provide for the two-way jarring action so as to include also a downward jarring blow, the rate of circulation of the water or other fluid in the drill string may be increased so that the final velocity of the hammer or impact element 12, when the valve V opens, is great enough so that the downward movement of such hammer or impact element 12 is not stopped or arrested until the lower hammer surface 12*f* strikes the lower anvil 10*h*. Then, upon the return of the impact element 12 upwardly, the upward jar is again obtained by the contact of the impact or hammer surface 12*a* with the anvil surface 10*e*. By maintaining such relatively high circulation rate with the water or other fluid, the two-way jar can also be maintained automatically in repetitive succession and without any movement of the drill string itself.

In some instances, particularly when drilling with a drill bit on the lower end of the pipe string, it may be desirable to provide a one-way jar in a downward direction only and without any upward jarring blow. Such one-way downward jarring blow may be obtained with the same apparatus disclosed in FIGS. 4A–4C by providing a negative stand-off, that is, by providing a spring 30 of a shorter length than illustrated so that upon the upstroke of the impact element 12, the surfaces 12*b* and 25*a* engage to decelerate and stop the upward travel of the impact element 12 to prevent contact of the impact surface 12*a* with the anvil surface 10*e*. Thus, at the start of the downstroke for the downward jar, the wear rings 33 and 34 are engaged and when the spring 30 becomes compressed to a solid sleeve, the valve V stops its downward movement while the element 12 continues downwardly until the jar is obtained by the contact of the lower hammer surface 12*f* with the lower impact surface 10*h*.

In addition to the metal-to-metal impacts of the hammers and anvils, whether the device is operated as a one-way or a two-way jar high water hammer pressures are built up when the valve closes to cause a high hydraulic force to be exerted downwardly on the entire drill string. Such water hammer pressure acting on the drill string further assists in the loosening or releasing of a stuck portion of such drill string. Although the opening 26*a* may be omitted or closed to obtain the full water hammer effect, it is generally desirable to have such opening 26*a* so that the intensity of the water hammer is sufficiently decreased to obtain a smoother and less violent jarring action.

After the jarring action has been completed with the jarring mechanism A, the valve assembly V may be fished out of the drill string with a suitable fishing tool adapted to engage the inner shoulder 45 (FIG. 4B), or in some cases, the fluid may be circulated in reverse so that it passes upwardly through the drill string to pump the valve assembly V to the surface.

It is important to note that the valve assembly itself is thus available at the surface when needed for replacing various parts and for changing the operating conditions of the mechanism A, without requiring a round trip of the drill string itself. Thus, the valve spring 30 may be changed at the surface to change its force when it is desired to provide a faster or slower closing action at the valve V. The length of the valve stroke on the valve assembly V may also be adjusted at the surface by providing a valve spring 30 which has more space between each of the convolutions, or in some cases less space between such convolutions. The stand-off distance or the restriction space between the end closure 25*a* and the seat 12*b* at the upper end of the hammer 12 may be readily changed in the field or at any other time by replacing the stop ring 31 with another having the location of the shoulder 31*a* displaced longitudinally from the position illustrated. Thus, the operating characteristics of the mechanism A may be changed without making a round trip or otherwise pulling the pipe string, thereby reducing the costs of operations and rendering the apparatus extremely versatile. It should also be noted that the operation of the mechanism A may be stopped or started at the surface in accordance with the will or desires of the operator, without making a round trip of the pipe string P.

In FIG. 7, a modified form of the present invention is illustrated, wherein the valve V–1 is permanently mounted in the mechanism A–1 rather than being dropped therein. Such mechanism A–1 has a body 110 with lateral ports 110*a* therein. An adapter 115 is connected to the body 110, preferably by threads 115*a*, as shown in FIG. 7. A bit or bit sub 110′ is usually connected to the lower end of the body 110, although a grapple or other fishing tool may be connected thereto instead of the bit or bit sub 110′.

A fixed sleeve 120 is disposed in the bore of the body 110 and it extends upwardly into the bore of the sub 115. An upper shoulder 120*a* engages the lower end 115*b* of the adapter 115 while a lower shoulder 120*b* seats in an annular groove 110*b* to fix the sleeve 120 against movement relative to the body 110. An O-ring 121 provides a fluid-tight seal between the body 110 and the sleeve 120.

The valve V–1 is formed with a tubular body 125 which preferably has a closed lower end 125*a*, although a bush-

ing 26 with an opening therethrough as shown in FIG. 4B may be employed. The upper end 125*b* is open for fluid flow to one or more discharge ports 125*c*. The body 125 has an external shoulder 125*d* having longitudinal passages 125*e* therethrough, and such shoulder 125*d* engages the upper end of a coil spring 130 which has its lower end seated on an inwardly extending flange 120*c*. The downward movement of the valve V–1 is stopped when the shoulder 125*d* engages stop surface 120*d* on the sleeve 120.

An upper spring 55 is preferably confined between the shoulder 125*d* and an inner abutment 115*b* to dampen the movements of the valve V–1 when it returns upwardly so as to cause the valve V–1 to settle down for the next stroke more quickly than if such spring 55 were omitted.

A longitudinally movable hammer 112 is disposed in the bore of the body 110, with a reduced diameter upper portion 112*a* thereof extending into the bore of the sleeve 120. Annular seal grooves 135 and 136 are provided on the hammer 112 for providing a fluid-tight seal with the bore of the sleeve 120 and the body 110 when the actuating fluid is air or other gas. Conventional O-ring seals of rubber are inserted in such grooves 135 and 136 if the actuating fluid is mud or other liquid.

A longitudinal central passage 112*b* extends through the hammer 112, and it connects with a leak or by-pass 112*c*. When using air or gas pressure, it is also desirable to provide an orifice 112*d* in the passage 112*b* to create a positive pressure drop through the passage 112*b*. However, if the length of the passage is enough to create an adequate pressure drop through the passage 112*b* so as to avoid buffering of the hammer action, the orifice 112*d* may be omitted. In any event, when such orifice 112*d* is used, it must be larger in diameter than the orifice 50 or the air holes in a drill bit therebelow so that an adequate upward pressure is provided for the return of the hammer 112 upwardly, as previously mentioned in connection with FIGS. 1–6.

The lower end of the hammer 112 has projections 112*e* formed by channels 112*f* crossing at ninety degrees with respect to each other to assure the passage of air or other fluid to the full lower end of the hammer 112, particularly during the initial starting up of the mechanism.

The hammer 112 is adapted to hit downward blows on the upper surface 51 of the bit or bit sub 52. The restriction 50 may be omitted when the element 52 is a drill bit since the drill bit itself has fluid discharges passages therethrough which serve the same purpose, namely, the inducing of a pressure drop in order to provide the proper pressure for the upward movement of the hammer 112. It should be noted that if blows are desired in an upward direction, the shoulder 112*g* may contact the lower end 120*c* of the sleeve 120. As heretofore explained in connection with FIGS. 1–6, the length of the spring 130 will determine whether the upward blows are obtained. Thus, if the valve V–1 seats on the seating surface 112*h* of the hammer 112 before the surfaces 112*g* and 120*c* contact each other, the upward blows can be avoided.

The use of the apparatus A–1 of FIG. 7 is essentially the same as that described in connection with FIGS. 1–6. The presence of the permanently mounted valve V–1 renders the mechanism A–1 especially suitable for percussion drilling. It has been found that blows may be imparted directly to the upper end of the drill bit by the hammer 112 with such frequency and effectiveness that the drill collars usually required for drilling a well are unnecessary. It should also be noted that both of the mechanisms A and A–1 operate with a single fluid-actuated valve in conjunction with a small leak or by-pass for providing smooth hammer action.

The foregoing disclosure and description of the invention is illustrative and 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 is claimed is:

1. A fluid operable jarring mechanism for use in a pipe string, comprising:
   (a) a tubular body adapted to be connected in a pipe string,
   (b) a tubular impact element mounted in said body for longitudinal movement relative thereto,
   (c) single valve means in the body above the impact element,
   (d) said impact element having a longitudinal passage therethrough and a valve seat formed at the upper end of the passage,
   (e) said valve means having its lower end closed with a seating surface thereon for engagement with said annular valve seat to close fluid flow through the impact element and transmit a downward fluid force to the valve means and the impact element,
   (f) means for limiting such downward movement of the valve means prior to stopping the downward movement of the impact element to separate the seating surface of said valve means and the valve seat on said impact element for opening the bore of said impact element to the flow of fluid therethrough, and
   (g) an upper anvil means adapted to be contacted by said impact element with a jarring force upon a return upward movement of said impact element.

2. a fluid operable jarring mechanism for use in a pipe string, comprising:
   (a) a tubular barrel adapted to be connected in a pipe string,
   (b) a tubular impact element mounted in said barrel for longitudinal movement relative thereto,
   (c) single valve means in the pipe string,
   (d) said impact element having a valve seat formed at its upper end,
   (e) said valve means having its lower end closed with a seating surface thereon for engagement with said annular valve seat to close fluid flow through the impact element and transmit a downward fluid force to the valve means and the impact element,
   (f) means for limiting such downward movement of the valve means prior to stopping the downward movement of the impact element to separate the seating surface of said valve means and the valve seat on said impact element for opening the bore of said impact element to the flow of fluid therethrough,
   (g) a lower anvil means adapted to be contacted by said impact element with a jarring force to stop the downward movement of the impact element, and
   (h) an upper anvil means adapted to be contacted by said impact element with a jarring force upon a return upward movement of said impact element.

3. A fluid operable jarring mechanism for use in a pipe string, comprising:
   (a) a tubular barrel adapted to be connected in a pipe string,
   (b) a tubular impact element mounted in said barrel for longitudinal movement relative thereto,
   (c) a single valve means in the pipe string,
   (d) said impact element having a valve seat formed at its upper end,
   (e) said valve means having its lower end closed with a seating surface thereon for engagement with said annular valve seat to close fluid flow through the impact element and transmit a downward fluid force to the valve means and the impact element,
   (f) means for limiting such downward movement of the valve means prior to stopping the downward movement of the impact element to separate the seating surface of said valve means and the valve seat on said impact element for opening the bore of said impact element to the flow of fluid therethrough,
   (g) resilient means in said tubular barrel supporting

said impact element and adapted to be compressed upon a downward movement of the impact element to aid in stopping such downward movement and in returning the impact element upwardly, and

(h) an upper anvil means adapted to be contacted by said impact element with a jarring force upon a return upward movement of said impact element.

4. A fluid operable jarring mechanism for use in a pipe string, comprising:

(a) a tubular body adapted to be connected in a pipe string,

(b) a tubular hammer having a longitudinal passage therethrough and mounted in said body for longitudinal movement relative thereto,

(c) a single valve means in the body and adapted to seat on the hammer to close said passage, and

(d) fluid by-pass means providing a restricted opening for the flow of fluid therethrough when the valve means is seated on the hammer for developing a predetermined pressure above said valve means to move same longitudinally for transmitting the fluid pressure to the hammer to develop a relatively smooth reciprocating longitudinal movement of the hammer in the body.

5. A fluid operable jarring mechanism for use in a pipe string, comprising:

(a) a tubular body adapted to be connected in a pipe string,

(b) a tubular hammer mounted in said body for longitudinal movement relative thereto,

(c) single valve means disposed for longitudinal movement in the body,

(d) resilient means supporting said valve means in said body for the longitudinal movement from a position above the hammer to a position in seating engagement with the hammer, and

(e) fluid by-pass means providing a restricted opening for the flow of fluid therethrough when the valve means is seated on the hammer for developing a predetermined pressure above said valve means to move same longitudinally for transmitting the fluid pressure to the hammer to develop a relatively smooth reciprocating longitudinal movement of the hammer in the body.

6. A fluid impact tool which comprises, in combination: a housing adapted to be connected at its upper end to the lower end of a well drill string; an anvil at the lower end of the housing; a hammer reciprocally disposed in said housing for beating on said anvil and having a fluid pressure actuatable area disposed for fluid pressure to act thereagainst to urge the hammer away from the anvil; a fluid passageway through the hammer communicating with the upper end of the housing, said area and the exterior of the tool; valve means disposed above the hammer to alternately restrict and release flow of fluid through the hammer to respectively decrease and increase pressure of fluid acting on such area to move the hammer away from striking engagement with the anvil and to cause it to move toward striking engagement with the anvil; said passageway having a restriction therein downstream of said area of a flow capacity less than that of said hammer passageway with the valve means releasing flow of fluid so that fluid pressure on said area increases to drive the hammer away from the anvil and yet of a capacity great enough that with the valve means restricting flow through the hammer passageway, the fluid pressure on said area decreases to permit the hammer to be moved toward the anvil; and means mechanically and fixedly connecting the anvil to the lower end of the housing and preventing any relative longitudinal movement therebetween whereby large fluid pressures can be employed to drive said hammer without tending to affect the relative longitudinal positions of the anvil and housing.

7. The tool of claim 6 wherein the last mentioned means is a threaded joint.

8. A fluid impact tool which comprises, in combination: a housing; an anvil closing a lower end of the housing and screwed thereto so that pressure in the housing cannot tend to cause relative movement between the housing and anvil; a hammer reciprocally disposed in the housing to beat on the anvil and having an area against which fluid pressure can act to move the hammer in a return stroke; a flow passageway through the hammer communicating the upper portion of the housing with said area; valve means carried by the housing above the hammer and having a valve member restricting flow through the hammer passageway during at least an initial portion of the hammer's power stroke and permitting flow through the hammer passageway during at least an initial portion of the hammer's return stroke so that fluid pressure can act on said area to move the hammer in its return stroke; a flow passageway through the anvil communicating said area with the exterior of the tool; and a restriction in the last mentioned passageway limiting flow of fluid from the tool to be less than that flowing through the hammer passageway when the valve means is permitting flow therethrough so that fluid pressure on said area increases to drive the hammer in its return stroke and yet permitting great enough flow, when the valve means is restricting fluid flowing through the hammer passageway, that fluid pressure acting on said area is reduced so that the hammer can move in its power stroke.

9. A fluid operable jarring mechanism for use in a pipe string, comprising:

(a) a tubular barrel adapted to be connected in a pipe string,

(b) a tubular impact element mounted in said barrel for longitudinal movement relative thereto,

(c) single tubular valve means in the pipe string,

(d) said impact element having a valve seat formed at its upper end,

(e) said valve means having its lower end closed with a seating surface thereon for engagement with said annular valve seat to substantially close fluid flow through the impact element and transmit a downward fluid force to the valve means and the impact element,

(f) said tubular valve means having a series of discharge ports upstream of its lower end whereby fluid introduced into the barrel will flow through the discharge ports and assist in creating a pressure drop between the valve and its seat,

(g) means for limiting such downward movement of the valve means prior to stopping the downward movement of the impact element to separate the seating surface of said valve means and the valve seat on said impact element for opening the bore of said impact element to the flow of fluid therethrough, and

(h) said impact element having a sufficient area thereof exposed to the fluid pressure in the pipe string therebelow to develop a return force on the impact element to stop the downward movement and return the impact element upwardly.

10. A fluid operable jarring mechanism for use in a pipe string, comprising:

(a) a tubular barrel adapted to be connected in a pipe string,

(b) a tubular impact element mounted in said barrel for longitudinal movement relative thereto,

(c) single tubular valve means in the pipe string,

(d) said impact element having a valve seat formed at its upper end,

(e) said valve means having its lower end closed with a seating surface thereon for engagement with said annular valve seat to substantially close fluid flow through the impact element and transmit a downward fluid force to the valve means and the impact element,

(f) said tubular valve means having a restricted opening at its lower end permitting restricted flow therethrough and decreasing water hammer,

(g) means for limiting such downward movement of the valve means prior to stopping the downward movement of the impact element to separate the seating surface of said valve means and the valve seat on said impact element for opening the bore of said impact element to the flow of fluid therethrough, and

(h) said impact element having a sufficient area thereof exposed to the fluid pressure in the pipe string therebelow to develop a return force on the impact element to stop the downward movement and return the impact element upwardly.

References Cited

UNITED STATES PATENTS

1,861,042	4/1932	Zublin	175—296
2,321,597	6/1943	Hobbs	251—267
2,837,315	6/1958	Burns et al.	175—296
2,873,093	2/1959	Hidebrandt et al.	175—296
2,942,851	6/1960	Beck	175—296
2,951,467	9/1960	Morrison	175—296
2,996,075	8/1961	Deimer et al.	251—267
3,185,227	5/1965	Nelson	175—296

JAMES A. LEPPINK, *Primary Examiner.*