United States Patent [19]

Berryman

[11] **3,797,591**

[45] **Mar. 19, 1974**

[54] **TRIGGER MECHANISM FOR DOWN-HOLE ADJUSTABLE HYDRAULIC FISHING JAR**

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[73] Assignee: **Baker Oil Tools, Inc.,** Los Angeles, Calif.

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[21] Appl. No.: **330,034**

[52] **U.S. Cl.** **175/296,** 175/303

[51] **Int. Cl.** **E21b 1/06,** E21b 1/10

[58] **Field of Search** 175/296, 297, 303, 302; 166/178

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Primary Examiner—David H. Brown

Attorney, Agent, or Firm—Bernard Kriegel

[57] **ABSTRACT**

A down-hole adjustable hydraulic fishing jar for removing stuck objects from a well bore in which hydraulic fluid within a compression chamber by-passes a compression piston through an unrestricted flow passage normally closed by a valve. The valve is instantaneously opened by a trigger mechanism adjustable down-hole to vary the tension on the running-in string required to trigger the valve to the open position. The jar is operative repetitively in any selected adjusted condition. An adjusting rig is assembled with the trigger to have limited freedom of rotation during jarring operations and to rotatively drive the trigger to enable adjustment.

23 Claims, 18 Drawing Figures

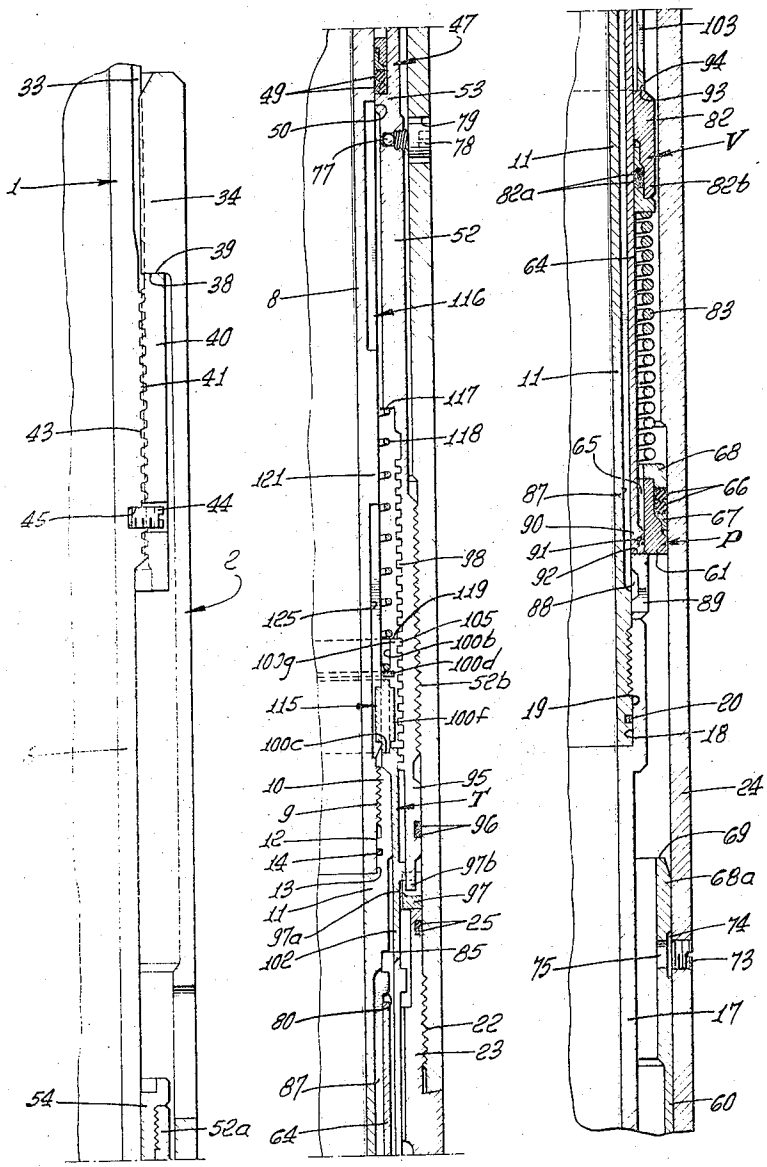


FIG. 1a.

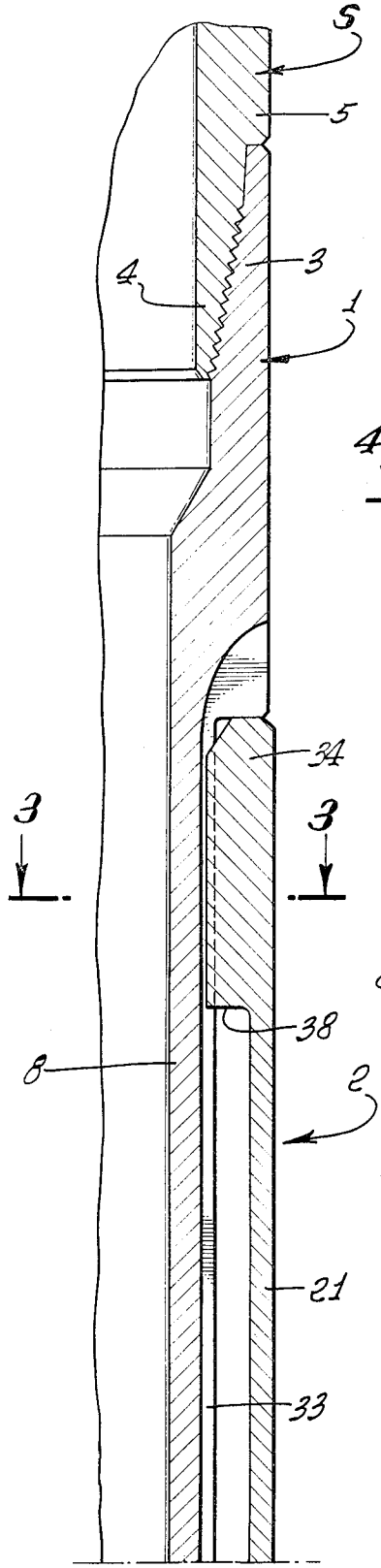


FIG. 1b.

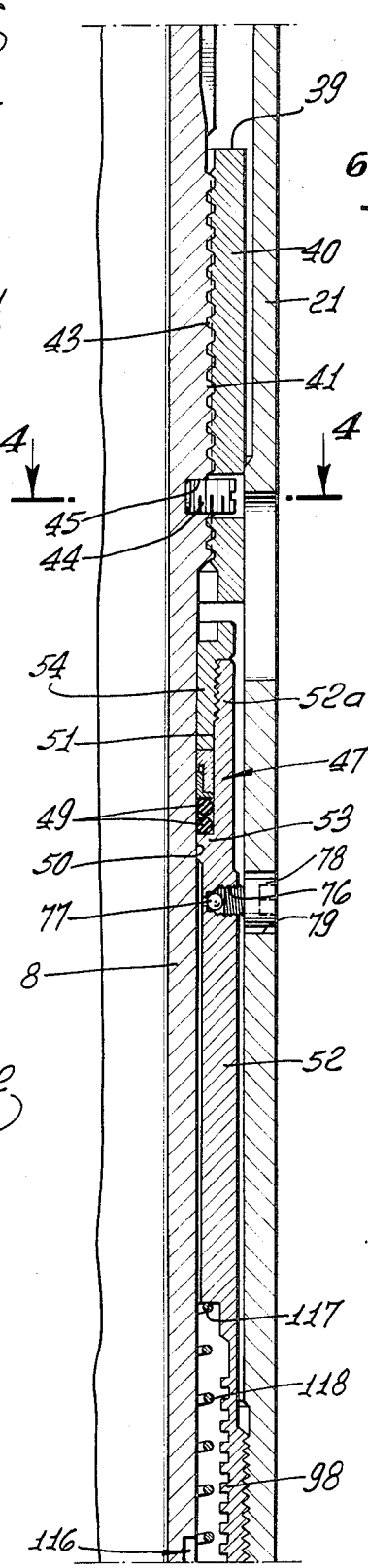


FIG. 1c.

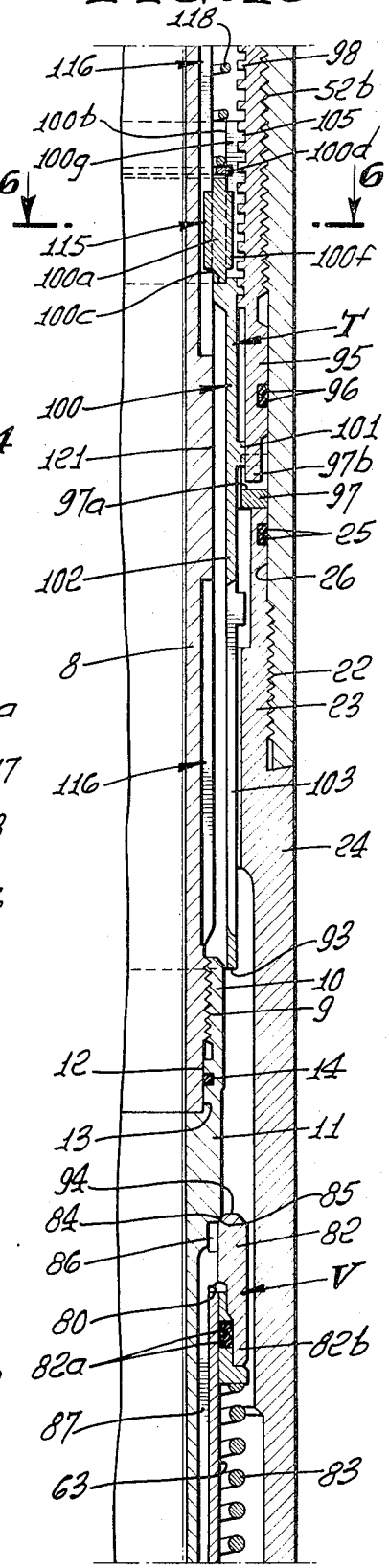


FIG. 1d.

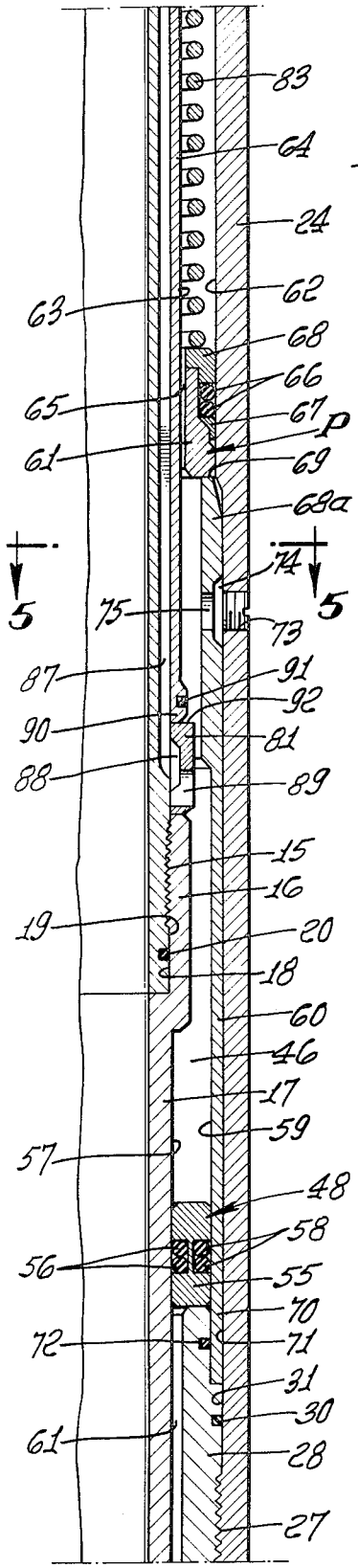


FIG. 1e.

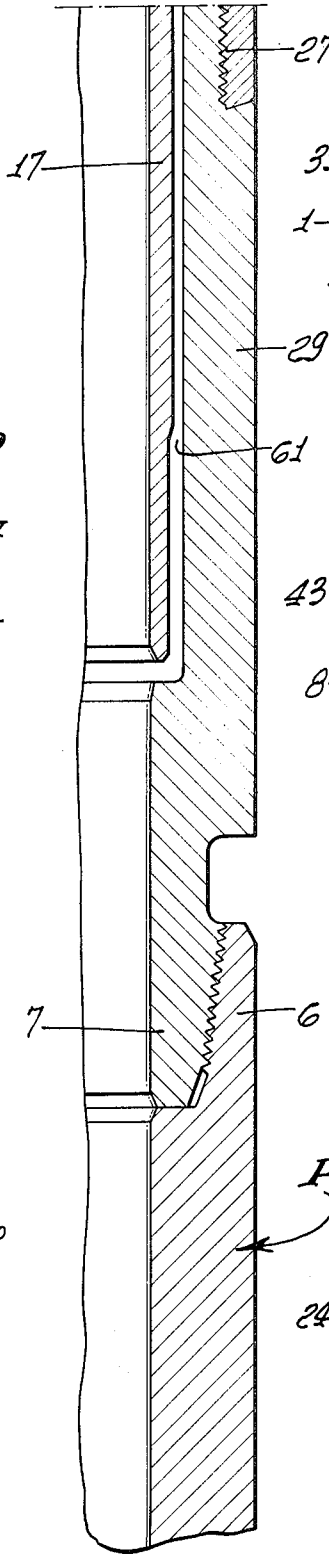


FIG. 3.

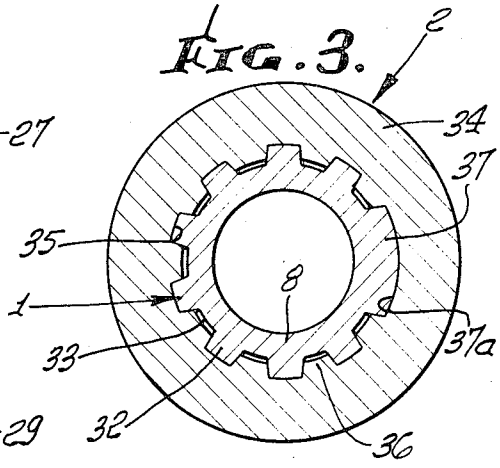


FIG. 4.

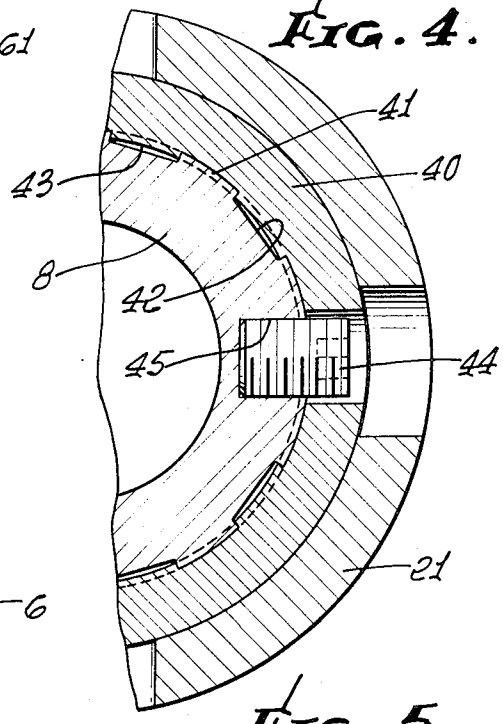


FIG. 5.

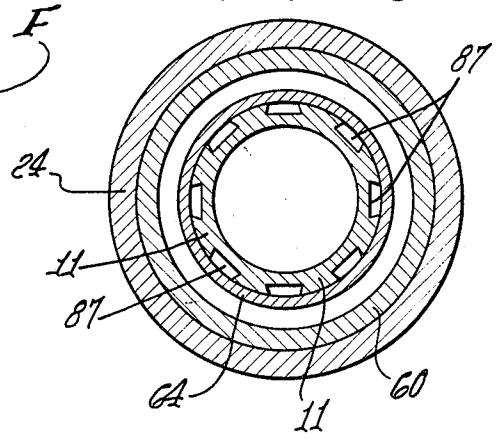


FIG. 2a.

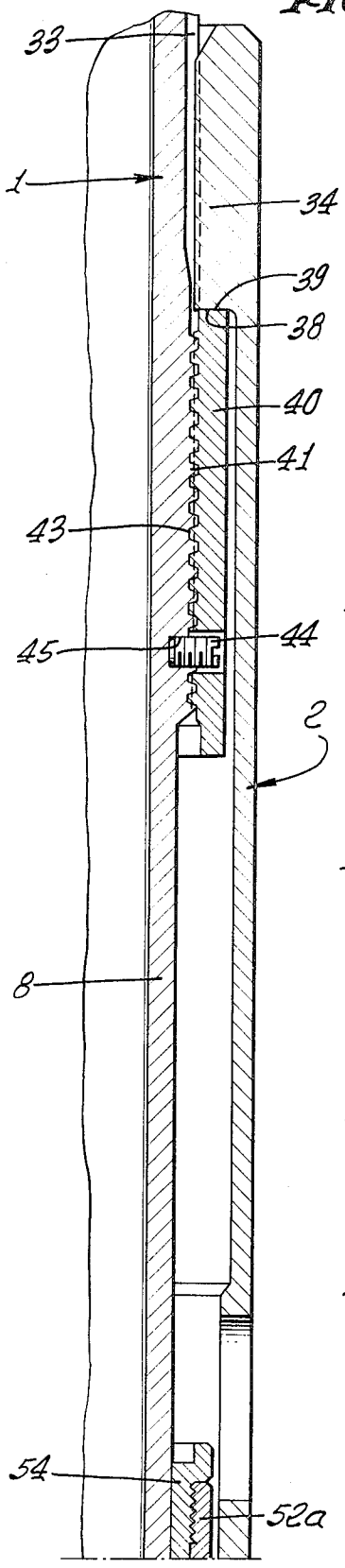


FIG. 2b.

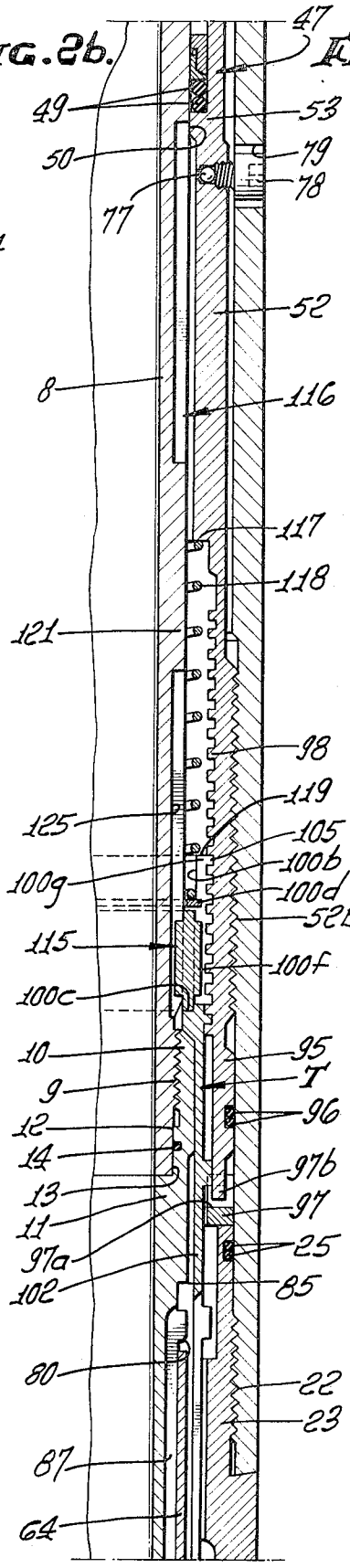


FIG. 2c.

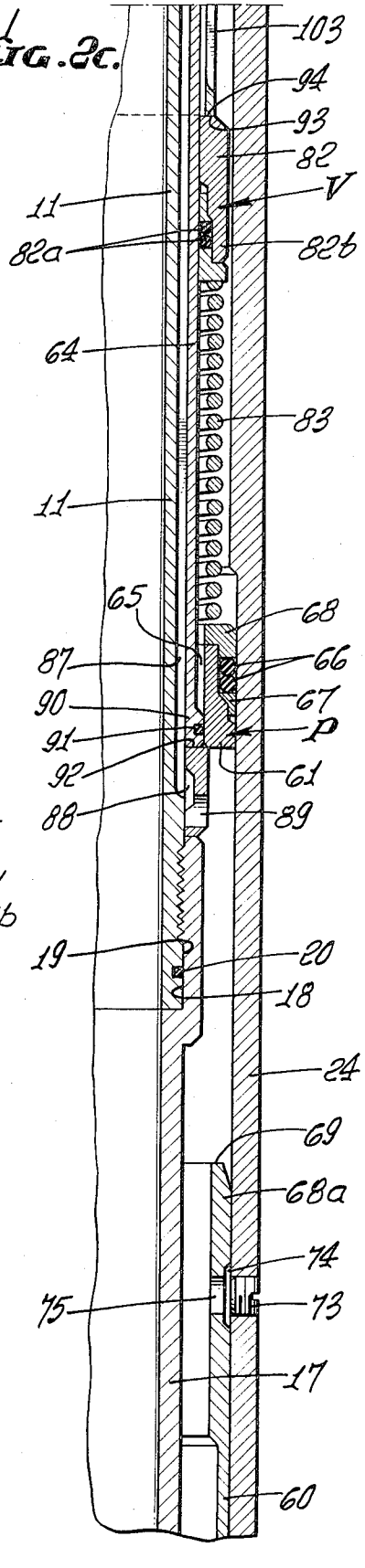


FIG. 6.

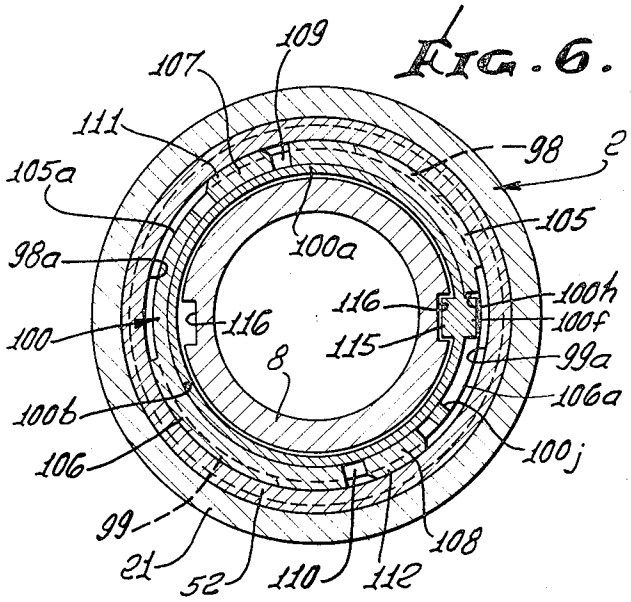


FIG. 12.

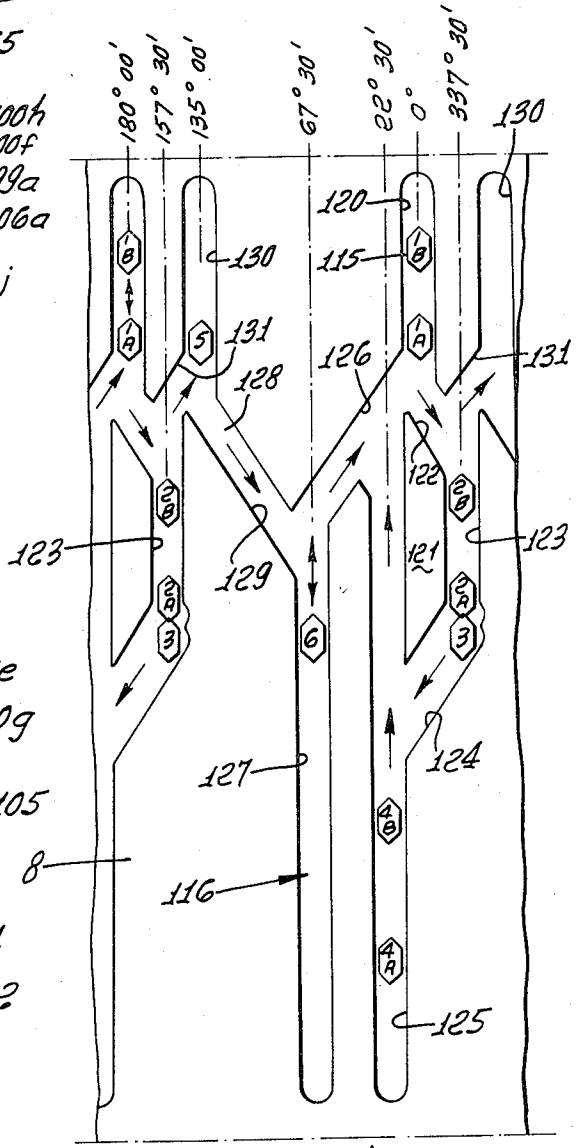


FIG. 11.

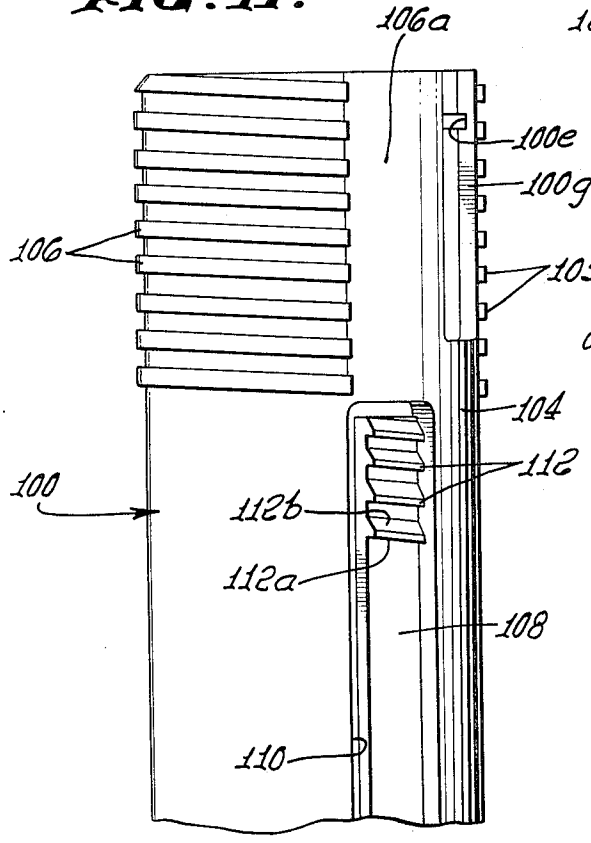


FIG. 10.

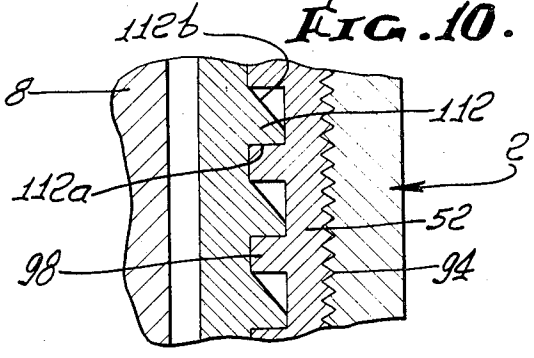


FIG. 7.

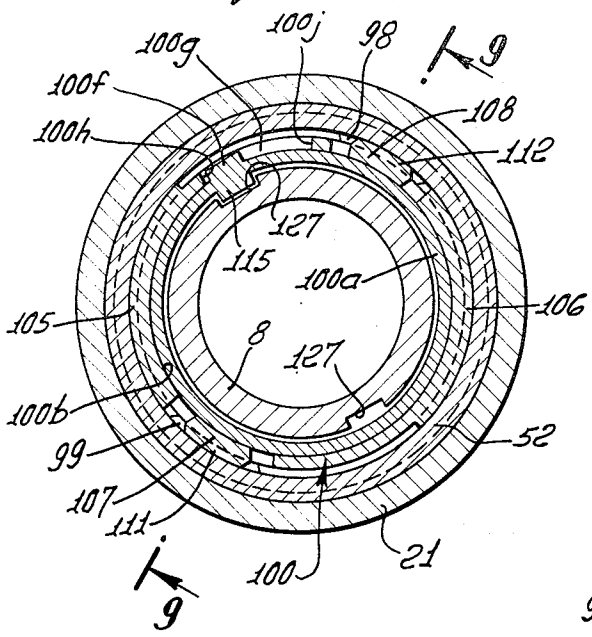


FIG. 8.

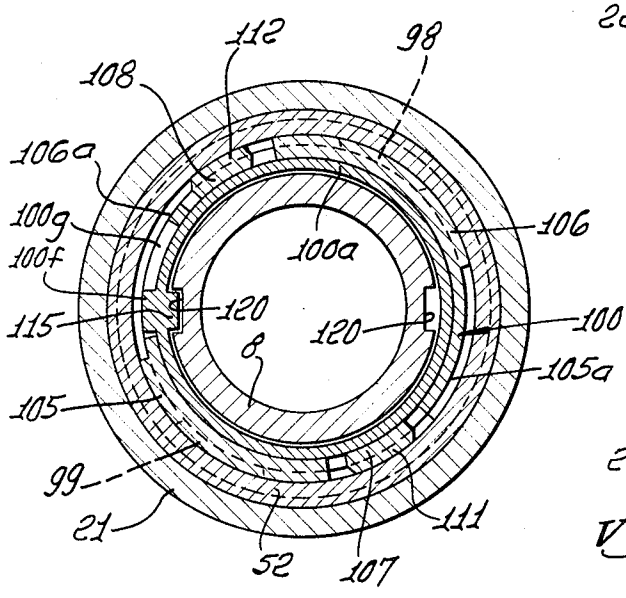
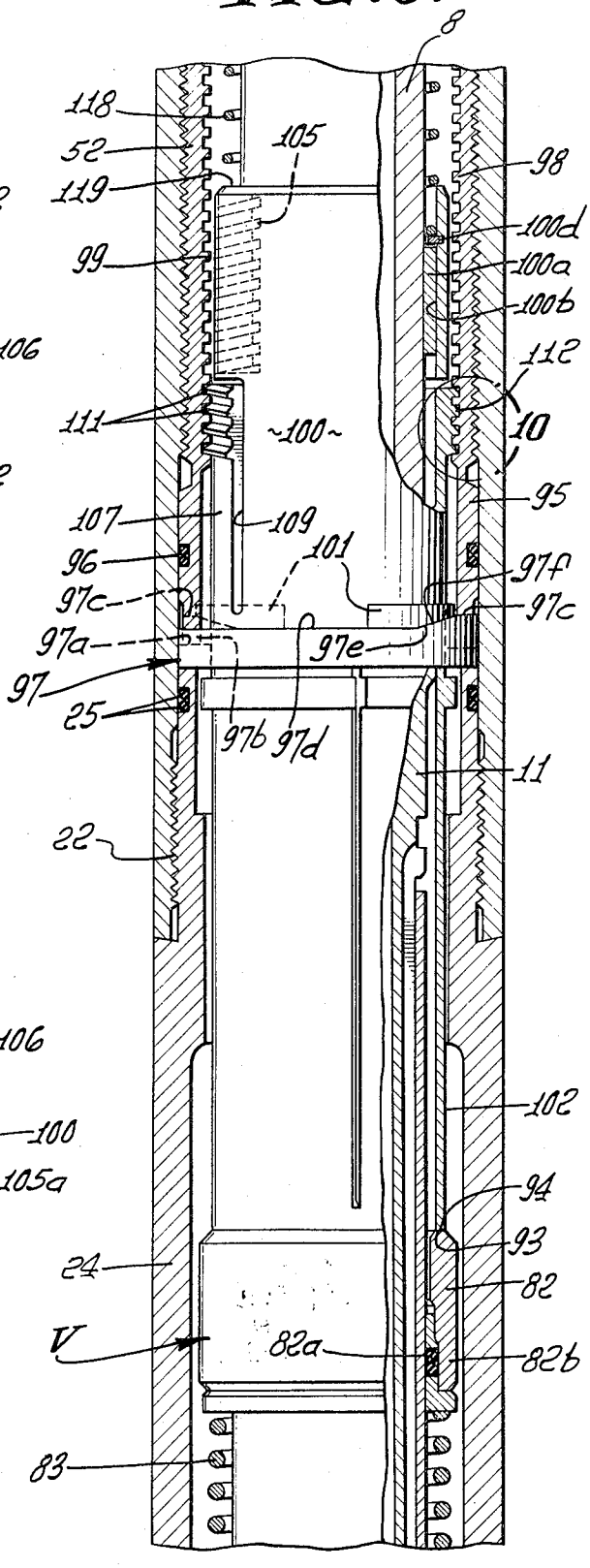


FIG. 9.



TRIGGER MECHANISM FOR DOWN-HOLE ADJUSTABLE HYDRAULIC FISHING JAR

Fishing jars are employed when it becomes necessary to remove from a well bore extending into the earth, such as oil or gas well, various "fish," such as a length of drill pipe or a subsurface tool which may be stuck in the well bore. Typically, fishing jars are run at the lower end of a string of drill pipe, commonly referred to as the fishing or running string, in a position above the fishing tool, which may be a spear or overshot adapted to engage and grip the fish so that the fish may be pulled from the well bore upon pulling the fishing string. The jar is employed for the purpose of applying hammer blows tending to release the stuck fish while the fishing string is under tension. Jars of the hydraulic type, in general, comprise a pressure chamber containing a quantity of hydraulic fluid which is compressed when an upward strain or tension is applied to the running string, the compressed hydraulic fluid bleeding through a restricted flow passage to enable the pulling rig at the surface of the earth to apply the necessary strain or tension to the running string before the compressed hydraulic fluid is allowed to rapidly by-pass the restricted passage so that the jarring hammer impacts against an anvil to apply an upward hammer blow.

Adjustment of the conventional hydraulic jars to vary the metering time before the jar applies the hammer blow requires that the fishing string and jar be pulled from the well bore for adjustment of the so-called time-regulated devices at the earth's surface, and then the fishing string and jar must be run back into the well bore and again connected to the fish, a time consuming and, therefore, costly operation.

The operation of such jars is time consuming when multiple hammer blows are to be successively applied to the fish since the bleeding of the hydraulic fluid through the restricted passage causes a time delay depending upon the magnitude of the tension which is applied to the fishing string. In other words, if the tension is low, a comparatively long period of time is required for the flow of hydraulic fluid through the restricted passage. If the delay is as much as 2 to 4 minutes per jarring action and the action is repeated 500 times, a common occurrence, then the substantial cost of delivering 500 blows is obvious. On the other hand, where high jarring forces are desired, the oil flows more rapidly through the restricted passage as the higher tension is applied to the fishing string, and under such circumstances, the magnitude of the jarring blow may be limited by the ability of the pulling rig at the earth's surface to sufficiently tension the fishing string before the jar operates to apply the jarring blow.

In essence, such prior hydraulic jars may be characterized as motion sensitive or motion triggered jars, the time required for the motion to occur being a function of the applied tension and the metered flow of the hydraulic fluid through the restricted passage, so that in any event, even with the use of time regulating adjustments of the relatively moving parts, there is an inherent time delay with consequential loss of useful working time. Further time is lost with conventional jars, when it becomes necessary to adjust the metering time, either up or down, due to the necessity of pulling the fishing string and jar from the well bore to effect the adjustment. Not only does the metering of the hydraulic fluid through a restricted passage cause a time delay

problem, but, in addition, tremendous heat is generated, prospectively causing seal failure which would also require pulling the fishing string and jar from the well bore, as well as reduction in fluid viscosity with resultant premature tripping. Such heating of the fluid is a problem that is aggravated when the jar is operated in a hole containing no liquid to assist in heat dissipation, rendering certain of the prior art hydraulic jars inoperative in a dry hole.

In my pending application for U.S. Pat., filed Mar. 15, 1972, Ser. No. 234,737, now Pat. No. 3,735,827, there is disclosed an improved down-hole adjustable jar which eliminates the substantial time delays characteristic of the prior art jars, in that it provides a load responsive jar which is released to provide the jarring action responsive to the tension applied to the fishing string. When the fishing string tension reaches a desired magnitude, the jarring action is applied. My prior invention obviates the problem of waiting for the hydraulic fluid to flow through a restricted passage and also obviates the problem of releasing or jarring before the desired fishing string tension is reached.

The hydraulic jarring tool of the present invention, like that of the above-identified application, is one in which the hydraulic fluid is placed under compression in a compression chamber, responsive to tension applied to the running or fishing string, and when the desired tension is reached a normally closed valve is shifted to its full open position to allow the instantaneous bleeding off of the compressed hydraulic fluid through a large bypass flow passage. The valve is opened by a trigger mechanism which is adjustable with respect to the valve, so that the valve is triggered open when a predetermined tension has been applied to the fishing string. Following the operation of the jar, the mere lowering of the fishing string enables the jar to be reconditioned for another jarring action.

In order to avoid the necessity of removing the fishing string and jar from the well bore to adjust or vary the magnitude of the jarring action, the present invention further provides means whereby simple manipulation of the fishing string effects adjustment of the valve trigger mechanism, the jar being capable of adjustment throughout its entire operable range of jarring force while in the well, but, as distinguished from my prior jar referred to above, the present jar has an improved trigger mechanism which enables the trigger to remain stationary in a selected adjusted position during jarring operations and to be actuated from its selected position only when it is to be adjusted.

In accomplishing the foregoing, the invention contemplates interposing an adjusting ring between the trigger and the cam slot which effects release of the trigger from one position of adjustment and its engagement in another adjusted position, the trigger adjusting ring carrying the cam lug which engages in the cam slot and having limited freedom of rotation relative to the trigger to the angular extent necessary to allow the adjusting ring to follow the cam track during jarring operations without rotating the trigger on its threaded support while under load. However, when the trigger is to be adjusted the adjusting ring rotatively drives the trigger in response to movement of the cam follower lug on the adjusting ring through the adjusting portion of the cam slot. As a result of this novel trigger adjusting mechanism the cam follower lug and the cam slot walls

are not subjected to severe loading and possible damage during the jarring operations.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but is is to be understood that such detailed description is not to be taken in a limiting sense.

Referring to the drawings:

FIGS. 1*a* through 1*e* together constitute a longitudinal quarter section of a jarring tool made in accordance with the invention and installed in a fishing string, FIGS. 1*b* through 1*e* respectively being successive downward extensions of FIG. 1*a*, the jarring tool being shown in a neutral condition;

FIGS. 2*a* through 2*c* together constitute a fragmentary, longitudinal quarter section through portions of the jarring tool, FIGS. 2*b* and 2*c* respectively being successive downward extensions of FIG. 2*a*, showing the jarring tool in the jarring condition;

FIG. 3 is a horizontal section through the jarring tool, taken on the line 3—3 of FIG. 1*a*, showing the splined connection between the telescopic bodies;

FIG. 4 is a fragmentary horizontal section through the jarring tool, taken on the line 4—4 of FIG. 1*b*, showing the connection of the hammer to the mandrel;

FIG. 5 is a horizontal section through the jarring tool, taken on the line 5—5 of FIG. 1*d*, showing the large flow area bypass of the valve means;

FIG. 6 is a horizontal section through the jarring tool, taken on the line 6—6 of FIG. 1*c*, showing the threaded connection between the trigger and the ratchet sub of the adjustable trigger mechanism; and showing the connection between the trigger and the adjusting sleeve for enabling limited free rotation of the adjusting key.

FIG. 7 is a view corresponding to FIG. 6, but showing the trigger angularly shifted in the ratchet sub and adjustably connected to the latter by the ratchet means;

FIG. 8 is a view also corresponding to FIG. 6, but showing the trigger further angularly shifted from the position of FIG. 7, 180° from the position of FIG. 6, and threadedly connected to the ratchet sub in another position.

FIG. 9 is a fragmentary longitudinal section, taken on the line 9—9 of FIG. 9, with portions of the trigger mechanism shown in elevation and in condition for adjustment;

FIG. 10 is a fragmentary detail in section embraced by the circle 10 in FIG. 9 and on an enlarged scale, showing the trigger ratchet engaged with the ratchet sub;

FIG. 11 is a fragmentary side elevation of the trigger; and

FIG. 12 is a planar developement of the key slot for effecting the down-hole adjustment of the jar and showing various operating positions of the companion key.

As seen in the drawings, the down-hole adjustable hydraulic fishing jar comprises an elongated and telescopic assembly of an inner elongated tubular mandrel or body 1 and an outer elongated tubular body or housing 2. At its upper end, the mandrel 1 is provided with an internally threaded box 3 adapted to receive the externally threaded pin 4 at the lower end of an upwardly extended section of drill pipe or drill collar 5, which constitutes a portion of the running or fishing string S on which the jar is run into a well bore, and by which the jarring tool is operated to provide a jarring action for a fishing tool F connected to the lower end of the body or housing 2. The upper box end 6 of the fishing tool F is threadedly connected to an externally threaded pin 7 provided at the lower end of the jar housing 2.

The body 1 comprises an upper tubular body section 8 externally threaded at 9 to receive the upper internally threaded end 10 of an intermediate mandrel section 11. The end 10 of the mandrel section 11, below the threads therein, has an internal cylindrical wall 12 adapted to receive an external cylindrical wall 13 at the lower extremity of the mandrel section 8, and a suitable seal 14 is interposed between these cylindrical walls 12 and 13. The lower end of the intermediate mandrel section 11 is threaded at 15 into the internally threaded end 16 of a lower mandrel section 17, the end 16 of the mandrel section 17 having a cylindrical bore 18 adapted to receive the lower cylindrical end 19 of the mandrel section 11, with a suitable seal ring 20 interposed therebetween.

The outer body or housing 2 is shown as comprising an upper tubular housing section 21 having at its lower end a threaded connection 22 with an externally threaded upper end 23 of an intermediate housing section 24. The upper end portion 23 of the housing section 24 carries a suitable sealing ring 25 engageable with the inner cylindrical surface 26 of the housing section 21. At its lower end, the intermediate housing section 24 is threaded at 27 for connection with the externally threaded upper end 28 of a lower housing section and connector sub 29. The upper end 28 of the lower housing section 29 has a suitable seal ring 30 engaging the cylindrical inner wall 31 of the intermediate housing 24.

The mandrel 1 and housing 2 are interconnected for relative longitudinal or telescopic movement, as seen in FIGS. 1*a* and 3. More particularly, the upper mandrel section 8 is provided with external, circumferentially spaced longitudinally extended ribs 32 and grooves 33, and the upper end portion 34 of the housing section 21 is provided with complemental grooves 35 and ribs 36 engaging with the mandrel section 8 to provide a splined connection. In order to assure assembly of the housing section 21 on the mandrel section 8 in a predetermined orientation, the mandrel section 8 has one rib 37 of greater angular extent than the ribs 32 and the housing portion 34 has a groove 37*a* of correspondingly greater angular extent than the grooves 35 for receiving the rib 37. Such orientation of the mandrel 1 and housing 2 establishes the relationship of adjustable trigger means T and the means for adjusting this trigger, as will be later described.

The end portion 34 of the housing section 21 is relatively massive and has a lower radial shoulder 38 which constitutes an abutment or anvil opposed to and adapted to be struck by the opposing radial shoulder 39 provided by a hammer 40 carried by the mandrel section 8, upon telescopic extension of the bodies 1 and 2. Preferably, the hammer 40 is detachably applied to the mandrel section 8, as best seen in FIGS. 1*a* and 4, by means of a number of threaded, longitudinally ex-

tended and circumferentially spaced ribs 41 on the mandrel section 8 separated by grooves 42, the threads on the ribs 41 engaging a thread 43 within the hammer 40. The hammer 40 is fixed in place on the mandrel section 8, by suitable means such as a set screw 44 threaded into a socket 45 in the mandrel section 8.

Within the space between the body 1 and the housing 2 is a hydraulic fluid chamber 46 defined between an upper sealing means 47 (FIG. 1*b*) and a lower sealing means 48 (FIG. 1*d*). More specifically, the upper sealing means 47 is provided by a pair of seal rings 49 confined between the opposing cylindrical walls 50 on the mandrel section 8 and 51 on the upper end of a trigger supporting sleeve or ratchet sub 52, hereinafter to be described. The end portion 52*a* of the trigger supporting sleeve or ratchet sub 52 has a radially inwardly projecting shoulder 53 against which the seal rings 49 are held by a gland 54 threaded into the end 52*a* of the sleeve 52, so as to effectively seal against very high pressure when the hydraulic fluid is being compressed in the chamber 46. The lower sealing means 48 is in the form of an annular, floating piston 55 reciprocable in the chamber 46 and having inner seal rings 56 which engage an outer cylindrical wall 57 of the mandrel section 17 and outer seal rings 58 which engage an inner cylindrical wall 59 of a sleeve 60, later to be described, which is disposed in the lower portion of the intermediate housing section 24. This floating piston 55 not only constitutes the lower seal 48 but, also, the piston 55 is a pressure compensating piston which serves to equalize the pressure in the chamber 46 with the pressure in the fishing string, since the underside of the piston 55 is exposed to the pressure present in the running or fishing string S through the open annular space 61 between the lower mandrel section 17 and the lower body section 29.

Provided within the hydraulic fluid chamber 46 between the upper seal means 47 and the lower seal means 48 are valved compression piston means P (FIG. 1*d*), as well as normally closed by-pass valve means V (FIG. 1*c*), and adjustable valve trigger means T (FIGS. 1*b* and 1*c*) which cooperate, as will be later described, in such a manner that when the fishing tool F is anchored in engagement with a fish and the mandrel 1 is moved upwardly relative to the housing 2, the transfer of hydraulic fluid within the chamber 46, through the compression piston means P to the chamber 46 below the piston means P is shut off and, thereafter, further upward movement of the mandrel 1 will move the compression piston P upwardly within the hydraulic fluid chamber 46 to apply compressive force to the hydraulic fluid between the compression piston means P and the upper seal means 47, until the hydraulic fluid is compressed to the extent determined by the tension applied to the running or fishing string S and by the setting of the trigger means T, which opens the by-pass valve means V. Opening of the by-pass valve means V enables the stored energy or tension in the running string S to accellerate the mandrel 1 upwardly at high velocity to cause the application of a hammer blow or jarring action of the hammer surface 49 against the anvil 38. Thereupon, the mandrel 1 may be lowered to its initial position with respect to the housing 2 and the jarring action repeated. The time required to effect each jarring action is determined solely by the time required to tension the fishing string S to a selected value. Therefore, the tool of the present invention is capable of effecting a large number of hammer blows or actions within a relatively short period of time, as compared with prior jarring tools in which the metering of compressed hydraulic fluid through a restricted passage is relied upon to sufficiently deter the jarring action until the desired running string tension can be accomplished by the pulling rig at the top of the well. Moreover, the elimination of such conventinal high pressure metering of compressed hydraulic fluid eliminates the generation of substantial heat in the fluid, so that the seal life in the present jar is enhanced. The jar is operable in a dry well bore, as well as in a well bore containing fluid which assists in the dissipation of heat.

Referring more particularly to FIG. 1*d*, the compression piston means P is shown as comprising an annular piston body 61 slidably engageable within the cylindrical wall 62 within the intermediate housing section 24 and having an inside diameter larger than the outer cylindrical wall 63 of a sleeve 64 on the intermediate mandrel section 11, so as to provide an annular flow passage 65 betwen the piston 61 and the sleeve 64. About its outer periphery, the piston 61 has a pair of seal rings 66 disposed between a seat 67 and a ring 68, to be deformed into sealing engagement with the cylinder wall 62. The sleeve 60, previously referred to, which provides the cylinder wall 59, has an upper end section 68*a* providing a stop shoulder 69 limiting downward movement of the compression piston 61, the lower end 70 of the sleeve 60 extending into an annular space 71 defined by the upper end 28 of the lower housing section 29 and the lower end of the intermediate housing section 24, a suitable seal ring 72 being interposed between the end 70 of the sleeve 60 and the end 28 of the housing section 29 to prevent loss of hydraulic fluid from the chamber 46. The hydraulic chamber 46 is adapted to be filled with suitable hydraulic fluid through a filler opening 73 which communicates with an annular space 74 and radial ports 75 in the upper end 68*a* of the sleeve 60. The bleeding of substantially all air from the piston chamber 46 is enabled by the provision of an outlet port 76, in the aforementioned trigger support or ratchet sub 52, just below the upper seal means 47, the port having therein suitable ball plug means 77 adapted to be forcibly closed by a plug 78, access to the head of which is provided by a radial slot 79 in the upper housing section 21, enabling the plug to be manipulated by an appropriate tool (not shown), but relative angular motion of the ratchet sub 52 and the housing 3 is prevented.

The sleeve 64, which forms the inner cylinder wall 63 for the compression piston means P, is adapted to be assembled endwise on the intermediate mandrel section 11 over the threaded lower end of the latter and retained in place between an upper, downwardly facing shoulder 80 on the mandrel section 11 and a lower ring 81 which abuts with the upper end of the lower mandrel section 11.

The sleeve 64 slidably supports adjacent its upper end an annular valve member 82 included in the by-pass valve means V. A coiled compression spring 83 is interposed between the valve member 82 and the compression piston 61, to normally bias the valve member 82 upwardly to effect engagement of an annular seating surface 84 on the valve member 82 with an opposing, complemental annular seating surface 85 on the intermediate mandrel section 11, which limits upward movement of the valve member 82. Seal rings 82*a* are

provided within the lower skirt 82*b* of the valve member 82 to slidably and sealingly engage the inner chamber wall 63. The spring 83 also normally biases the piston 61 downwardly into abutting contact with the shoulder 69. The intermediate mandrel section just below the valve seat 85 is provided with an annular groove 86 which communicates with a number of longitudinally extended grooves 87 (FIG. 5) in the mandrel section 11, these grooves 87 extending downwardly below the piston 61 when it is in its lowermost position, and communicating with an inner annular groove 88 in the ring 81, which has a suitable number of lateral ports 89 spaced circumferentially thereabout for communication with the chamber 46 above the lower seal means 48. Thus, the annular groove 86 and longitudinally extending groove 87 in the mandrel section 11, together with the annular groove 88 and radial ports 89 in the ring 81, provide by-pass flow passsages of substantial flow area through which hydraulic fluid may transfer from the hydraulic fluid chamber 46 above the compression piston 61, when the valve 82 is off its seat 85, to the chamber 46 below the compression piston 61.

In order to close off the annular space 65 between the piston 61 and the cylinder wall 63, upon initial upward movement of the mandrel 1, the sleeve 64 has an enlarged lower end section 90 constituting a valve member having a suitable external seal ring 91 engageable within the compression piston 61, as seen in FIG. 2*c*. When the valve portion 90 of the sleeve 64 is within the piston 61, the ring 81 provides an annular upwardly facing shoulder 92 engageable beneath the piston 61, so that further upward movement of the mandrel 1 will correspondingly move the piston 61 upwardly, compressing the hydraulic fluid in the chamber 46 above the piston 61. The greater the compression of the hydraulic fluid, the greater the force acting on the valve 82 to hold it seated, due to the net effective differential area of the valve 82 subjected to the pressurized fluid, the differential area being determined by the radial extent between the outer end of the seating surface 84 and surface 63 engaged by the seals 82*a*.

The extent to which the hydraulic fluid in the chamber 46 between the compression piston means P and the upper seal means 47 can be compressed, and, therefore, the tension applicable to the running or fishing string S, is determined by the space between a lower abutment surface 93 provided by the trigger means T and the upper end surface 94 of the valve member 82. The trigger means T is constructed to position its abutment surface 93 to contact the valve 82 and unseat the latter, enabling the by-pass of fluid through the passages 87, the mandrel 1 then rapidly accelerating upwardly due to stored energy in the running string S. If desired, a separate accelerating tool (not shown) may be employed to more rapidly accelerate the mandrel upwardly.

Referring to FIGS. 1*b*, 1*c* and 6–11, the adjustable trigger means T for unseating the valve 82 will now be described. The trigger supporting sleeve or ratchet sub 52, previously referred to, is externally threaded into the upper housing section at 52*b* and a downwardly extending cylindrical skirt 95 carrying suitable seal rings 96 engaged with the inner cylindrical wall 26 of the housing section 21. At the lower extremity of the skirt 95 is a stop ring 97 which seats on the upper end of the intermediate housing section 24, and which will be later described. About the skirt 95, the ratchet sub 52 is provided with internal ribs, conveniently formed as an internal thread, such as a square thread 98, of limited angular extent, say slightly less than 45°, as seen in FIG. 6, and in diametrically opposed relation to the thread 98, the ratchet sub 52 has a similar thread 99 of corresponding limited angular extent, the thread or rib ends being ramped for a purpose which will later be described. Between the threads 98 and 99 are diametrically opposed smooth walled slots 98*a* and 99*a* where the threads 98 and 99 are interrupted. These ribbed or threaded sections 98 and 99 support the trigger means T which includes a trigger sleeve 100 adjustable between a lower position with respect to the ratchet sub 52, as shown in FIG. 1*c*, at which a pair of diametrically opposed circumferentially extended stop lugs 101 (only one of which is seen) on the trigger sleeve 100 is engageable with the stop ring 97 at the lower end of the ratchet sub 52, and successive positions of adjustment upwardly with respect to rhe ratchet sub 52. The trigger sleeve 100 consists of an elongated skirt 102 having circumferentially spaced longitudinally spaced slots 103 to permit the free flow of hydraulic fluid. At the upper end of the skirt 102 is a supporting section 104 having circumferentially spaced external ribbed or threaded sections 105 and 106 and intervening unthreaded sections 105*a* and 106*a*, the ribs or threads of threaded sections 105 and 106 being complemental to the internal ribs or threads 98 and 99 of the ratchet sub 52 to connect the trigger sleeve 100 to the ratchet sub 52.

The trigger sleeve 100 also comprises ratchet means engageable with the thread sections 98 and 99, when the thread sections 105 and 106 are disengaged from the thread sections 98 and 99, to hold the trigger sleeve 100 in an adjusted axial position with respect to the ratchet sub 52 until the thread sections 98, 99 and 105, 106 are reengaged. More specifically, the trigger sleeve 100 has resilient ratchet arms 107 and 108 formed by milling inverted U-shaped grooves 109 and 110, respectively, in the trigger sleeve 100, at diametrically opposite locations, adjacent to the solid thread sections 105 and 106. At the upper ends of the resilient arms 107 and 108 are segments of external ratchet ribs or threads 111 and 112, these ratchet threads being best seen in FIG. 10, in which the ribs or threads 112 are exemplary. The ratchet threads 112 have a radial, lower surface 112*a* adapted to engage the upper surface of the thread 98 and hold against downward movement of the trigger sleeve 100 with respect to the ratchet sub 52 and housing 2, but upward ratcheting of the trigger sleeve with respect to the ratchet sub 52 is allowed, due to the downwardly and outwardly sloped upper surface 112*b* on the ratchet teeth 112, which cause the resilient ratchet arms 107 and 108 to be cammed inwardly so that the ratchet teeth 112 can clear the thread segments 98 and 99.

As previously described, the mandrel 1 and the housing 2 are fixed in a predetermined orientation by the splined connection provided by the rib 37 on the upper mandrel section 8 and the longitudinally extended groove 37*a* in the upper housing section 21. In order that the thread segments 98 and 99 in the ratchet sub 52 can be orientated in a known relationship to the housing 2, these segments are formed in a predetermined relationship to the cap screw 78 which is disposed in the housing slot 79, as previously described. Thus, the relative orientation of the thread sections 98

and 99 and the mandrel 1 is established to enable the angular actuation of the trigger sleeve 10 by companion key and slot means, herein shown as including a cam lug or key 115 projecting radially inward from a trigger adjusting means including a ring 100*a* carried by the trigger sleeve 100 and a compound slot 116 formed in the outer periphery of the upper mandrel section 8, a planar development of the slot 116 being shown in FIG. 12.

In the illustrative embodiment, as best seen in FIGS. 1*c*, 2*b* and 6 through 8, the upper portion 104 of the trigger sleeve 100 has an internal bore 100*b* in which the adjusting ring 100*a* is disposed. The ring 100*a* seats on a shoulder 100*c*, at the base of the bore 100*b* and is axially confined by a snap ring 100*d* inserted in a groove 100*e* in the trigger sleeve 100. The cam lug or key 115 is provided on the internal periphery of the ring 100*a*, and the ring 100*a* also has an external lug or key 100*f* which extends outwardly and into an elongated, axially extended slot 100*g* in the trigger sleeve 100. This slot 100*g* has an angular extent between side walls 100*h* and 100*j* which allows limited freedom of relative rotation of the trigger sleeve 100 and the adjusting means or ring 100*a* during jarring operation of the tool, as will be later described, to relieve the key 115, and the walls of the slot 116 from loading.

The slot 116 is so formed that relative longitudinal movement between the mandrel 1 and the housing 2, under the desired circumstances, will effect angular motion of the trigger sleeve 100 to engage and disengage the thread segments 98 and 99 on the ratchet sub 52 with the solid or rigid thread segments 105, 106 on the trigger sleeve 100, or to effect engagement and disengagement of the ratchet threads 111 and 112 with the thread segments 98 and 99. The slot 116 will also position the sleeve 100 for longitudinal ratcheting movement of the trigger sleeve 100 upwardly with respect to the ratchet sub 52, as well as free downward movement of the trigger sleeve 100 with respect to the ratchet sub 52 when none of the thread segments 105, 111 or 106, 112 of the trigger sleeve is engaged with the respective ratchet sub thread segments 98 and 99.

In the latter connection, the ratchet sub 52 includes an internal radial shoulder 117 against which seats the upper end of a compression spring 118, the lower end of the spring 118 seating on the upper end surface 119 of the trigger sleeve 100 to provide a normal downward bias tending to normally cause the lugs 101 on the trigger sleeve 100 to engage the stop 97 at the lower end of the ratchet sub 52.

Referring to FIGS. 6 and 12, it will be seen that the compound slot 116 has a vertically extended upper section 120, the open lower end of which is opposed by a land 121 having a downwardly inclined upper end surface 122 leading to an intermediate slot section 123 which also extends vertically. At the base of the slot section 123 is a downwardly inclined surface 124 extending to the left and leading into a lower vertical slot section 125, the open upper end of which is opposed by an inclined cam surface 126 which leads back to the upper vertical slot 120. Extending downwardly in parallel relation to slot section 125, and opposed at its open upper end by a cam surface 126, is another vertically extended slot section 127 communicating at its upper end with a downwardly and laterally extended slot section 128 having a downwardly inclined wall 129. This wall 129 opposes another upwardly extending slot section 130. A cam surface 131 leads downwardly and to the left from the slot section 130 and opposes the open upper end of the slot section 123.

In the embodiment depicted in FIG. 12, it will be understood that the slot pattern is repetitive at diametrically opposite locations, so that, as will later be described, the key or pin 115 in one phase of operation may be at a starting point in the slot 120 at the 0° marking and in another phase of operation may be at a starting point in the corresponding slot at the 180° mark. If desired, diametrically opposite pins or lugs 115 may be employed on the adjusting ring 100*a* to engage in the diametrically opposing and corresponding slot sections.

In the use of a jarring tool with the trigger sleeve 100 in a starting position, as shown in FIGS. 1*a*–1*e* and in FIG. 6, the running or fishing string S will be elevated thereby causing upward movement of the mandrel 1 with respect to the housing 2. Therefore, as seen in FIG. 12, the slot 116 in the mandrel 1 is correspondingly moved longitudinally with respect to the pin or key 115 to locate the latter in the various operating positions shown at the locations 1A through 6. However, the angular extent of the slot 100*g* in the trigger sleeve 100 is such that movement of the key 115 from position 1A through slot section 123, into slot section 125 and back into slot section 120, during jarring operations, will not cause engagement of the outer key 100*f* with either of the side walls 100*h* and 100*j* to cause rotative movement of the trigger sleeve 100.

As the mandrel 1 moves upwardly, the by-pass passages 87 are closed by the valve member 82 of the valve means V, but fluid is free to by-pass the compression piston means P through the annular clearance 65 until the seal 91 above the stop shoulder 92 sealingly engages within the compression piston 61 and the shoulder 92 engages the piston 61 and moves it upwardly, as upward movement of the mandrel continues. As upward movement of the compression piston 61 commences, the upper surface 94 of the valve 82 is spaced below the abutment surface 93 of the trigger sleeve 100 a distance determined by the relative axial position of the trigger sleeve 100 in the ratchet sub 52, which can be adjusted, as will later be described, so that more or less compressive force will be applied to the hydraulic fluid between the compression piston 61 and the upper seal means 47, allowing more or less energy to be stored in the fishing string S to create the ultimate jarring blow when the valve means V is opened. The jarring action can be repeated as often as desired merely by lowering the fishing string and mandrel 1 to the starting position and then pulling upwardly on the fishing string, the adjusting ring 100*a* merely idling or freely moving in the trigger sleeve 100.

As seen in FIG. 12 when the mandrel 1 is in the lower position, the indexing lug or key 115 would be in slot section 120 at position 1A. As the mandrel 1 is moved upwardly, the lug 115 will progressively engage the cam surface 122 and be cammed into slot section 123. At position 2A, the compression of hydraulic fluid will commence and, at point 3, the by-pass valve means V will be opened and the mandrel will then be accelerated upwardly to effect the jarring action, the indexing lug 115 being cammed by the slot wall 124 into the slot section 125, and being at position 4A when the hammer strikes the mandrel to effect the jarring action.

Thereafter, the mandrel 1 may be lowered and the indexing lug 115 will contact the angular wall 126 and thereby be cammed back into the slot 120 to the point of beginning.

During this relative telescoping of the mandrel and the trigger during each jarring action, it will be noted that from the starting point 1A in the slot section 120 until the key 115 is returned to that point the thread segments 98 and 99 in the ratchet sub 52 will remain engaged by the solid thread segments 105 and 106 on the trigger sleeve 100, since the adjusting ring 100*a* does not transmit angular motion to the trigger sleeve 100 so that the respective solid threads remain in continuous full engagement.

When it is desired to adjust the jar apparatus, the position of the trigger sleeve 100 axially with respect to the ratchet sub 52 is adjusted in the following manner. The running string S and the mandrel 1 are elevated, again, until the lug 115 is at the position 2A and the compression piston means P compresses the fluid in the chamber 46, but the tension applied is less than that required to unseat the valve 82. The mandrel 1 is then lowered so that the lug 115 will contact the cam surface 131 at the top of the slot section 123 and be cammed to position 5 in the slot 130, and the adjusting ring lug 100*f* will engage the slot wall 100*h* of the trigger sleeve 100 causing angular movement of the latter to a position at which the trigger sleeve 100 will be released from the ratchet sub 52. In this connection, it will be noted that the angular distance between the slot section 120 and the slot section 130 is 45° in the illustrative embodiment. In the same direction that the trigger sleeve 100 rotates, that is, in a left-hand rotational direction as viewed in FIG. 6, the threaded sections 105 and 106 of the trigger sleeve 100 will shift angularly clear of the thread sections 98 and 99 within the ratchet sub 52, and the trigger sleeve 100 is then free to move downwardly under the positive bias of the spring 118, until the stop lug 101 on the trigger sleeve 100 abuts with the stop means 97. The running string is then again tensioned, moving the mandrel 1 upwardly, so that the indexing lug 115 will engage the angular surface 129 at the bottom of slot section 130 and be moved through slot 128 into slot 127, as indicated at position 6, thereby causing corresponding angular movement of the trigger sleeve 100. The angular travel of the trigger sleeve 100 from the starting position with the lug at 1A to the position 6 is sufficient to move the trigger sleeve 100 from the position of FIG. 6 to the position of FIG. 8, at which the resilient ratchet arms 107 and 108 are now in longitudinal alignment with the holding thread sections 98 and 99, respectively, within the ratchet sub 52. With the ratchet means so aligned, the fishing string is tensioned to compress the hydraulic fluid in the chamber 46 until the desired tension has been reached, during the course of which, as seen in FIG. 9, the valve member 82 will abut with the lower end of the trigger sleeve 100 and lift the latter progressively, as the ratchet teeth surfaces 112*b* cause the ratchet arms 107 and 108 to be flexed inwardly. When the desired tension is reached to produce a subsequent jar of the desired magnitude, the fishing string is again lowered to lower the mandrel 1, the indexing lug 115 moving from position 6 and being caused to be cammed back to slot 120 by the cam surface 126, and the adjusting ring causing corresponding angular movement of the trigger sleeve 100. At this time, the trigger sleeve 100 will have been rotated a full 180° to the position relative to the ratchet sub shown in FIG. 8, at which the holding teeth 98 and 99 within the ratchet sub are engaged by the solid teeth 106 and 105, respectively, on the trigger sleeve 100. The trigger sleeve is, therefore, as described above, elevated to a new position of adjustment which is determined by the magnitude of the tension applied to the fishing string during the process of the adjustment.

Each change in the adjustment of the trigger sleeve requires the same procedure. When the tension is initially applied to the running string, the trigger sleeve will be located at its lowermost position with the stop lugs 101 engaged with the stop ring 97. However, the mandrel need not be moved upwardly to such an extent that the valve 82 contacts the lower end of the trigger sleeve 100 when the minimum jarring force is desired, the axial position of the trigger sleeve 100 within the ratchet sub 52 being determined by engagement of the trigger sleeve stop 101 with the opposing stop 97, at which position the ratchet threads 111 and 112 and the sub threads 98 and 99 may be out of axial alignment. Proper engagement of the respective ratchet teeth 111 with a thread section 98 or 99 in the ratchet sub is assured by enabling an increment of free downward motion of the trigger sleeve after it has been rotated to align the ratchet teeth with the ratchet sub teeth, so that even if the ratchet teeth and ratchet sub teeth are confronting one another and, therefore, are unable to become properly engaged when the teeth are angularly moved into longitudinal alignment, the trigger sleeve is permitted to move downwardly under the influence of the spring 118 until the ratchet threads are fully engaged, as seen in FIG. 10.

Accordingly, as best seen in FIG. 9, the stop member 97 at the lower end of the ratchet sub 52, which, as previously indicated, is in the form of a split ring, has, in the plane of the split, upwardly opening notches 97*a* adapted to receive orienting lugs 97*b* which depend from the lower end of the ratchet sub 52. The stop ring 97 has raised portions 97*c* separated by angularly extended depressions or recesses 97*d* adapted to receive the companion stop part of lug 101 on the sleeve 100. Transition from the recess 97*d* to the raised portion 97*c* is made by means of an inclined cam surface 97*f*, which mates with a corresponding cam surface 97*e* on the lower wall of lugs 101. The height of the raised portion with respect to the recess is at least equal to the pitch of the ratchet threads 111.

When this apparatus is being adjusted and the pin or cam lug 115 is in position 5, the trigger sleeve will have moved downward until lugs 101 contact the bottom of recess 97*d*. When the mandrel is now moved upward, the trigger sleeve 100 is rotated as the cam lug 115 moves from position 5 to position 6. This rotation engages the ratchet teeth 111 with a thread section 98 or 99, and during the first portion of this movement lifts the trigger sleeve as the lugs 101 are cammed up from the recess surface of the stop ring 97*d* to its raised portion 97*c*. At this time, the ratchet teeth 111 may not be in perfect axial alignment with threads in section 98 or 99. However, before rotation ceases, when position 6 is reached, the lug 101 will pass the end of the raised portion 97*c* and the trigger sleeve will be urged downward by spring 118 until the ratchet teeth are fully engaged, as shown in FIG. 9. The holding thread segments will also be in correct axial alignment and will mesh

without conflict when the mandrel is lowered and the trigger sleeve rotates as cam lug 115 progresses from position 6 to position 1.

I claim:

1. In a hydraulic fishing jar adapted to be run into a well on a fishing string and connected to a fish in the well bore, inner and outer elongated bodies telescopically interengaged, means defining between said bodies a hydraulic fluid chamber, compression piston means in said chamber operable upon telescopic movement of said bodies in one direction to compress the hydraulic fluid in said chamber, valve means in said chamber including means providing a by-pass flow passage, a valve member for normally closing said flow passage and shiftable to an open position at which said compressed hydraulic fluid is released to said flow passage, trigger means responsive to tensioning of said fishing string to compress the hydraulic fluid in said chamber for moving said valve member to said open position, hammer and anvil means on said bodies movable into engagement by the tension in said fishing string when said valve member is moved to said open position, and adjusting means for adjustably positioning said trigger means with respect to said valve member for adjusting the maximum tension applicable to said fishing string, said adjusting means idling during jarring operations.

2. In a hydraulic fishing jar as defined in claim 1, said means for adjustably positioning said trigger means being responsive to manipulation of said fishing string.

3. In a hydraulic fishing jar as defined in claim 1, said means for adjustably positioning said trigger means including holding means engageable for connecting said trigger means to one of said bodies and releasable upon rotation of said trigger means relative to said one of said bodies, and the other of said bodies and said adjusting means having means for rotating said trigger means responsive to relative telescopic movement of said bodies.

4. In a hydraulic fishing jar as defined in claim 1, said means for adjustably positioning said trigger means including holding means engageable for connecting said trigger means to one of said bodies and releasable upon rotation of said trigger means relative to said one of said bodies, and the other of said bodies and said adjusting means having means for rotating said trigger means responsive to relative telescopic movement of said bodies, and means for moving said trigger means to adjusted positions with respect to said one of said bodies and said valve member when said trigger means is released from said one of said bodies.

5. In a hydraulic fishing jar as defined in claim 1, said trigger means and one of said bodies having coengageable holding means releasable to permit adjustment of said trigger means with respect to said one of said bodies and said valve member, and means for moving said trigger means to adjusted positions determined by tension applied to the fishing string.

6. In a hydraulic fishing jar as defined in claim 1, said trigger means comprising a tubular member rotatable relative to said bodies, said member and one of said bodies having opposed angularly spaced ribbed and unribbed portions, said ribbed portions being engageable and releasable upon rotation of said member, the other of said bodies and said adjusting means having means responsive to relative telescoping of said bodies for rotating said member.

7. In a hydraulic fishing jar as defined in claim 1, said trigger means comprising a tubular member rotatable relative to said bodies, said member and one of said bodies having opposed angularly spaced ribbed and unribbed portions, said ribbed portions being engageable and releasable upon rotation of said member, the other of said bodies and said adjusting means having means responsive to relative telescoping of said bodies for rotating said member, and means for moving said member longitudinally of said one of said bodies when said ribbed portions are released for re-engagement of said ribbed portions at a location spaced longitudinally of said one of said bodies.

8. In a hydraulic fishing jar as defined in claim 1, said trigger means comprising a tubular member rotatable relative to said bodies, said member and one of said bodies having opposed angularly spaced ribbed and unribbed portions, said ribbed portions being engageable and releasable upon rotation of said member, the other of said bodies and said adjusting means having means responsive to relative telescoping of said bodies for rotating said member, and means for moving said member longitudinally of said one of said bodies when said ribbed portions are released for re-engagement of said ribbed portions at a location spaced longitudinally of said one of said bodies in responsive to telescopic movement of said bodies.

9. In a hydraulic fishing jar as defined in claim 1, said trigger means comprising a tubular member rotatable relative to said bodies, said member and one of said bodies having opposed angularly spaced ribbed and unribbed portions, said ribbed portions being engageable and releasable upon rotation of said member, the other of said bodies and said adjusting means having means responsive to relative telescoping of said bodies for rotating said member, and means for moving said member longitudinally of said one of said bodies when said ribbed portions are released for re-engagement of said ribbed portions at a location spaced longitudinally of said one of said bodies in response to telescopic movement of said bodies and depending upon the magnitude of compression of said hydraulic fluid.

10. In a hydraulic fishing jar as defined in claim 1, said trigger means comprising a tubular member rotatable relative to said bodies, said member and one of said bodies having opposed angularly spaced ribbed and unribbed portions, said ribbed portions being engageable and releasable upon rotation of said member, the other of said bodies and said adjusting means having means responsive to relative telescoping of said bodies for rotating said member, and means for moving said member longitudinally of said one of said bodies when said ribbed portions are released for re-engagement of said ribbed portions at a location spaced longitudinally of said one of said bodies, said ribbed portions comprising threaded segments.

11. In a hydraulic fishing jar as defined in claim 1, said trigger means comprising a tubular member rotatable relative to said bodies, said member and one of said bodies having opposed angularly spaced ribbed and unribbed portions, said ribbed portions being engageable and releasable upon rotation of said member, the other of said bodies and said adjusting means having means responsive to relative telescoping of said bodies for rotating said member, and including ratchet means for holding said member in position for re-

engagement of said ribbed portions at adjusted longitudinally spaced locations.

12. In a hydraulic fishing jar as defined in claim 1, said trigger means comprising a tubular member rotatable relative to said bodies, said member and one of said bodies having opposed angularly spaced ribbed and unribbed portions, said ribbed portions being engageable and releasable upon rotation of said member, the other of said bodies and said adjusting means having means responsive to relative telescoping of said bodies for rotating said member, and including ratchet means for holding said member in position for re-engagement of said ribbed portions at adjusted longitudinally spaced locations, said ratchet means including resilient ratchet arms complemental to said ribbed portions.

13. In a hydraulic fishing jar as defined in claim 1, said trigger means comprising a tubular member rotatable relative to said bodies, said member and one of said bodies having opposed angularly spaced ribbed and unribbed portions, said ribbed portions being engageable and releasable upon rotation of said member, the other of said bodies and said adjusting means having means responsive to relative telescoping of said bodies for rotating said member, and means for moving said member longitudinally of said one of said bodies when said ribbed portions are released for re-engagement of said ribbed portions at a location spaced longitudinally of said one of said bodies, including a spring normally biasing said member in one direction, and means movable with one of said bodies into engagement with said member to move the latter in the other direction.

14. In a hydraulic fishing jar as defined in claim 1, said trigger means comprising a tubular member rotatable relative to said bodies, said member and one of said bodies having opposed angularly spaced ribbed and unribbed portions, said ribbed portions being engageable and releasable upon rotation of said member, the other of said bodies and said adjusting means having means responsive to relative telescoping of said bodies for rotating said member, means for moving said member longitudinally of said one of said bodies when said ribbed portions are released for re-engagement of said ribbed portions at a location spaced longitudinally of said one of said bodies, including a spring normally biasing said member in one direction, and means including said valve member movable with one of said bodies into engagement with said trigger member to move the latter in the other direction in response to telescopic movement of said bodies.

15. In a hydraulic fishing jar as defined in claim 1, said means defining said hydraulic fluid chamber comprising upper and lower seal means between said bodies, one of said seal means being a floating piston for compensating for the pressure of fluid in the well.

16. In a hydraulic fishing jar as defined in claim 1, said compression piston means comprising an annular piston between said bodies and having a peripheral wall spaced from one of said bodies to provide a fluid passage, and including valve means carried by said one of said bodies to close said passage upon telescopic movement of said bodies.

17. In a hydraulic fishing jar as defined in claim 1, said trigger means comprising a tubular member rotatable relative to said bodies, said member and one of said bodies having opposed angularly spaced ribbed and unribbed portions, said ribbed portions and unribbed portions being engageable and releasable upon rotation of said member, said adjusting means and the other of said bodies having pin and slot means responsive to relative telescoping of said bodies for rotating said adjusting means, and said adjusting means and said member having means for rotating said member to engage and release said ribbed portions.

18. In a hydraulic jar as defined in claim 17, said means for rotating said member including a slot in one of said member and said adjusting means extending angularly between opposed sides walls and a lug on the other of said member and said adjusting means disposed in said slot and engageable with said side walls for rotating said member.

19. In a hydraulic jar adapted to be run into a well on a fishing string and connected to a fish in the well bore, inner and outer telescopic bodies, means including longitudinally spaced seals defining between said bodies a hydraulic fluid chamber, compression piston means including an annular piston carried by one of said bodies and shiftable longitudinally in said chamber by the other of said bodies upon telescopic movement of said bodies in one direction to compress hydraulic fluid in said chamber, valve means in said chamber including means providing by-pass flow passage communicating with said chamber at opposite ends of said piston, a valve member normally closing said flow passage and shiftable to an open position to allow hydraulic fluid to by-pass said piston, trigger means carried by one of said bodies and opposing said valve member to move said valve member to said open position upon predetermined movement of said bodies in said direction, hammer and anvil means on said bodies movable into engagement by the tension in said fishing string in response to further telescopic movement of said bodies in said one direction when said valve member is moved to said open position, and means for adjustably positioning said trigger means with respect to said valve member for adjusting the maximum tension applicable to said fishing string, said adjusting means idling during jarring operations.

20. In a hydraulic fishing jar as defined in claim 19, means responsive to manipulation of said fishing string for adjusting the position of said trigger means, including holding means engageable for connecting said trigger means to one of said bodies and releasable upon rotation of said trigger means relative to said one of said bodies, and the other of said bodies and said adjusting means having means for rotating said trigger means responsive to relative telescopic movement of said bodies.

21. In a hydraulic fishing jar as defined in claim 19, said trigger means and one of said bodies having coengageable holding means for holding said trigger means in longitudinally adjusted positions on said one of said bodies, said holding means being releasable and engageable upon rotation of said trigger means with respect to said one of said bodies, means for enabling longitudinal movement of said trigger means with respect to said one of said bodies when said holding means are released, and companion pin and slot means on said adjusting means and one of said bodies for rotating said trigger means responsive to telescopic movement of said bodies, said pin and slot means comprising a compound slot having longitudinally extended, circumferentially spaced sections and connecting sections de-

fined by inclined walls for camming said pin between said longitudinally extended sections to release said holding means and engage said holding means, said adjusting means and said trigger means having means allowing freedom of rotation of said adjusting means relative to said trigger means during jarring operations.

22. In a hydraulic fishing jar as defined in claim **19**, said trigger means and one of said bodies having coengageable means for holding said trigger means in longitudinally adjusted positions on said one of said bodies, said holding means being releasable and engageable upon rotation of said trigger means with respect to said one of said bodies, means for enabling longitudinal movement of said trigger means with respect to said one of said bodies when said holding means are released, and companion pin and slot means on said adjusting means and one of said bodies for rotating said trigger means responsive to telescopic movement of said bodies, said pin and slot means comprising a compound slot having longitudinally extended, circumferentially spaced sections and connecting sections defined by inclined walls for camming said pin between said longitudinally extended sections to release said holding means and engage said holding means, said adjusting means and said trigger means having means allowing freedom of rotation of said adjusting means relative to said trigger means during jarring operations, and means for moving said trigger means longitudinally when said pin is in one of said longitudinally extended sections and said holding means are released.

23. In a hydraulic fishing jar as defined in claim **19**, said trigger means and one of said bodies having coengageable holding means for holding said trigger means in longitudinally adjusted positions on said one of said bodies, said holding means being releasable and engageable upon rotation of said trigger means with respect to said one of said bodies, means for enabling longitudinal movement of said trigger means with respect to said one of said bodies when said holding means are released, and companion pin and slot means on said adjusting means and one of said bodies for rotating said trigger means responsive to telescopic movement of said bodies, said pin and slot means comprising a compound slot having longitudinally extended, circumferentially spaced sections and connecting sections defined by inclined walls for camming said pin between said longitudinally extended sections to release said holding means and engage said holding means, means for moving said trigger means longitudinally when said pin is in one of said longitudinally extended sections and said holding means are released, including spring means biasing said trigger means to a lowermost position, and means responsive to telescopic movement of said bodies in said one direction to move said trigger means to an upwardly adjusted position depending upon the tension of said fishing string, said adjusting means including a ring rotatably mounted with respect to said trigger means, said ring and said trigger means having pin and slot means for allowing freedom of rotation therebetween during rotation of said trigger means by the first-mentioned pin and slot means during jarring operations.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,797,591 Dated March 19, 1974

Inventor(s) William O. Berryman

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 9, line 2: "10" should read --100--.

Signed and sealed this 5th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents