Nov. 6, 1962 W. N. SUTLIFF 3,062,305

HYDRAULIC OIL WELL TOOL

Filed Dec. 22, 1959 2 Sheets-Sheet 1

FIG. 1.

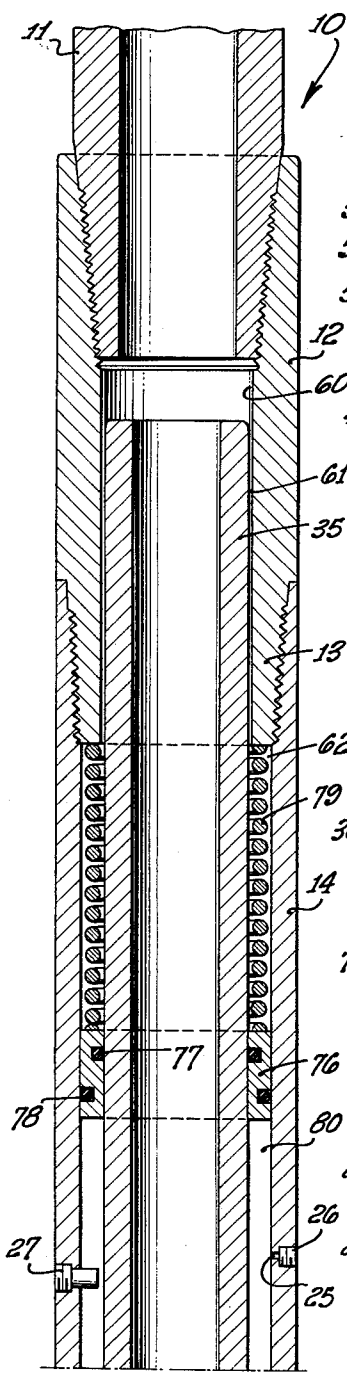


FIG. 1a.

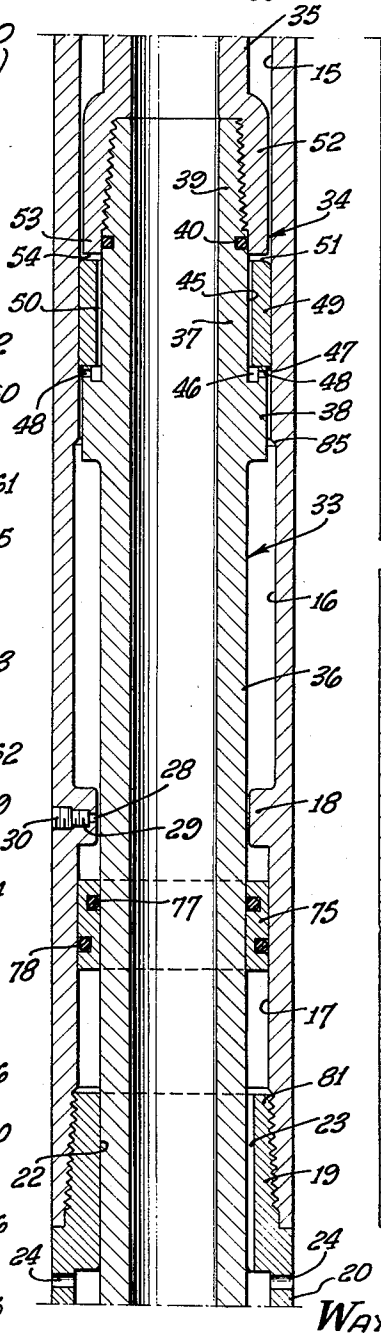
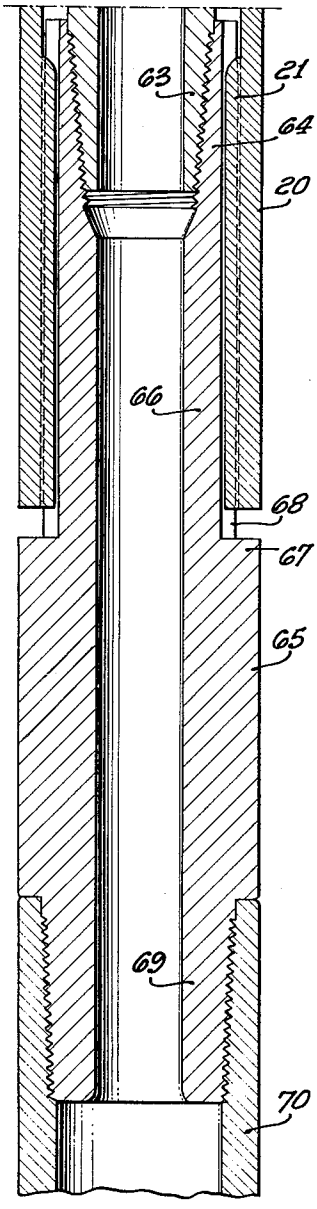


FIG. 1b.



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Filed Dec. 22, 1959 2 Sheets-Sheet 2

FIG. 2.

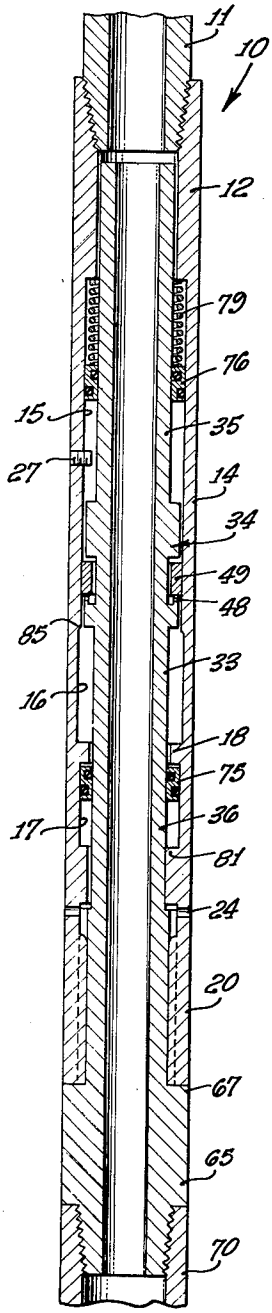


FIG. 3.

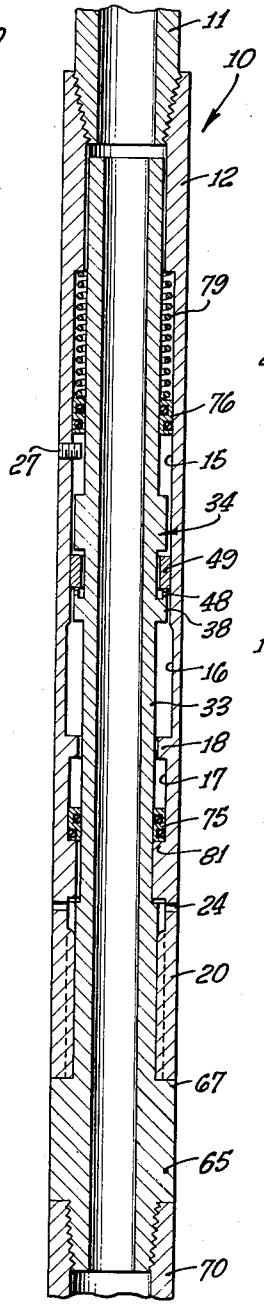


FIG. 4.

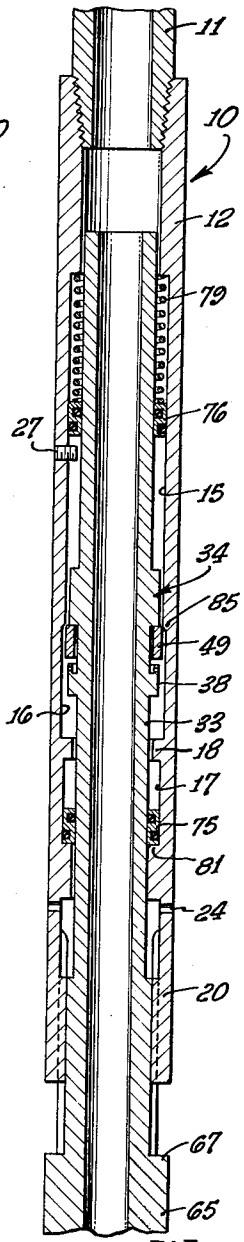
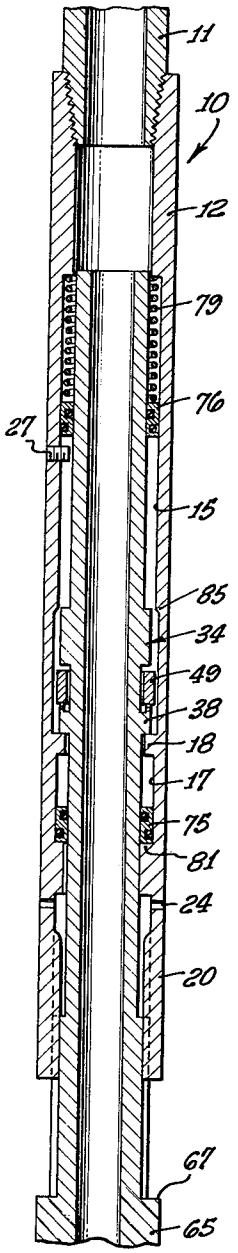


FIG. 5.



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HYDRAULIC OIL WELL TOOL

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4 Claims. (Cl. 175—297)

This invention relates to hydraulic oil well tools and is particularly useful in hydraulic jars.

In the operation of hydraulic jars, drillers find it advantageous to supplement the upward jarring blow applied through the tool to an object lodged in the well, by an immediately following downward blow against said object. The latter blow is often accomplished by dropping the drill string a short distance and then recovering a hold upon its upper end to produce a resilient downward extension of the lower end of the drill string to deliver a downward snapping impulse to the jar before the latter becomes telescopically collapsed in position for starting another upward blow. This operation is known as "spudding" the jar and when employed with hydraulic jars heretofore generally used, sometimes damages the jar by the suddenness with which the collapsing of telescopic parts of the jar is completed by the dropping of the drill string. This damage results from the operating liquid in the jar being thus caught in a pocket in the jar with no escape except through a passage which, although adequate for this purpose when resetting the jar at ordinary operating speeds, produces destructive hydraulic pressures during the abnormal speed with which the jar parts are telescoped by a spudding operation.

It is an object of the present invention to provide a hydraulic jar which will not be subject to damage such as above described from a spudding operation.

A hydraulic jar has been developed, the telescopic collapse of which in resetting the jar (whether or not this is incidental to a spudding operation) produces a vacuum in the pressure chamber of the jar and does not confine the operating liquid anywhere, under high pressure during the resetting of the jar. This jar is thus proof against damage from excessive fluid pressures during a spudding operation.

In very deep wells, vacuums thus created involve substantial net ambient fluid axial pressures against the packing and it is another object of the present invention to provide a hydraulic jar which is not only proof against damage from excessive operating fluid pressures during a spudding operation, but which also does not develop a vacuum while being reset, either normally or when spudding the jar.

It is a further object of the invention to provide a hydraulic jar which offers relatively slight axial resistance to the telescopic collapsing of the parts thereof in resetting the tool for another jarring operation, no matter how rapidly this may be accomplished.

A yet further object of the invention is to provide a hydraulic jar from which stuffing boxes and the maintenance problem of keeping these in effective operating condition are eliminated.

It is still another object of the invention to provide an oil well tool having a liquid telescopic dashpot action when vertical pressure is applied thereto from the drill string in a given direction, which tool may be very rapidly reset by an opposite telescopic action by applying vertical pressure thereto from said drill string in the opposite direction, without the development of excessive or damaging liquid pressures in or on said tool.

The manner of accomplishing the foregoing objects as well as further objects and advantages will be made manifest in the following description taken in connection with the accompanying drawings in which:

FIGS. 1, 1*a* and 1*b* provide a longitudinal vertical section of a preferred embodiment of the tool of the invention with this section divided, for convenience, into three parts. This view shows said tool in the form of a hydraulic jar, with the parts thereof positioned as just prior to the conclusion of a spudding operation.

FIG. 2 is a diagrammatic vertical sectional view of said jar at a reduced scale and showing the parts thereof as positioned at the instant said spudding operation is concluded.

FIG. 3 is a view similar to FIG. 2 but illustrates the parts of said jar as positioned a few seconds following the conclusion of said spudding operation.

FIG. 4 is a view similar to FIG. 3 and shows the parts of said jar as disposed during a jarring operation, this view illustrating the instant that the piston of the jar comes opposite the enlarged portion of the cylinder of the jar whereby the outer tubular element, secured to the lower end of the drill string, is freed from restraint whereby the tension under which the drill string has been placed operates to rapidly pull the outer tubular element upwardly to consummate the jarring operation.

FIG. 5 illustrates the parts of the jar at the conclusion of said jarring operation.

Referring specifically to the drawings, the invention is there shown as embodied in a hydraulic jar **10** which is suspended on the lower end of a drill string **11** and which includes an upper sub **12** which screws onto said drill string and has a lower pin end **13** which screws into the threaded upper end of outer tubular element **14** of the jar. The element **14** forms a cylinder for the jar **10** including a bore **15**, a counterbore **16**, and a bore **17** which is separated from said counterbore by an internal shoulder **18** which performs the function of a hammer for the jar.

The lower end of tubular element **14** is internally threaded and is screwed onto the threaded pin end **19** of a spline sleeve **20**. This sleeve is provided with internal splines **21** for a purpose which will be explained later. A bore **22** is provided in the pin end **19**, there being one or more vertical fluid passages **23** formed in said bore. Lateral fluid passages **24** are also provided in the sleeve **20**.

Provided in the outer tubular element **14** is an air escape port **25** closed by a plug **26**, a secondary packing ring stop plug **27** and a liquid inlet hole **28**, having a check valve **29** and closed by a plug **30**.

The tool **10** also includes an inner tubular element **33** which is composite in character to provide a piston section **34** which is located in between an upper end section **35** and a lower end section **36**. The piston section **34** has a tubular mandrel **37** which is formed integral with the lower end section **36** to provide an external annular anvil shoulder **38**.

The piston section mandrel **37** has a threaded upper pin end **39** and has an annular groove just below said threads to receive an O-ring **40**. The mandrel **37** has a cylindrical outer surface **45** which terminates at its lower end in an undercut annular channel **46** forming a wall **47** having a series of radial holes **48** communicating with said channel. Vertically slidably mounted on the mandrel **37** is an annular valve sleeve **49** which makes a sliding fit with bore **15** when it is disposed therein. The sleeve **49** is fluted internally to provide vertical passages **50** which are coextensive in length with the sleeve. This sleeve is also provided at its upper end with a ground radial sealing face **51**.

The upper end section **35** of the inner tubular element **33** is a separate part and is provided with an internally threaded box end **52** at its lower end which screws onto pin end **39** of mandrel **37** and has an annular extension **53** at its lower end which makes a sealing engagement

with the O-ring 40 and provides a ground radial face 54 which forms a substantially fluid-tight seal with ground face 51 when the sleeve 49 is moved axially into engagement with extension 53. Upper section 35 of inner tubular element 33 makes a loose sliding fit in the central passage 60 in the sub 12 to provide an annular fluid passage 61 allowing ambient fluid to freely pass between the passage 60 and the space 62 confined by the outer tubular element 14 just below the pin end 13 of sub 12.

At its lower end, the lower end section 36 of inner tubular element 33 is provided with a threaded pin end 63 which screws into an internally threaded box end 64 of a spline sub 65. An upper portion 66 of this sub is turned down to provide an annular shoulder 67 and external splines 68 which slidably mesh with internal splines 21 on spline sleeve 20. At its lower end the sub 65 has a threaded pin end 69 which screws into an upper sub 70 of a fishing tool (not shown) which is adapted to be rotated to engage this with a piece of equipment lost in the well. It is now to be noted that the outer surfaces respectively of upper and lower end portions 35 and 36 of inner tubular element 33 are shown as of the same diameter. This however is not an essential characteristic of the present invention, for a reason which will be pointed out hereinafter.

For convenience in manufacture and for replacement of worn parts in the tool 10, it is preferable to make the upper and lower tubular sections 35 and 36 with the same external diameter and also make the bores 15 and 17 of the same internal diameter. This is because the tool 10 includes a primary annular packing ring 75 which is axially slidable between the tubular element 14 and the lower section 36 of the inner tubular element 33, and a secondary packing ring 76 which is axially slidable between the outer tubular element 14 and the upper section 35 of the inner tubular element 33. Each of the packing rings 75 and 76 is both internally and externally channeled to receive O-rings 77 and 78 which make fluid-tight sealing engagement with the external and internal cylindrical surfaces of the parts between which said rings are axially slidable.

Confined in the space 62 between the pin end 13 and secondary packing ring 76 is an expansive coil spring 79.

Operation

While the invention is illustrated herein as a hydraulic jar, and its operation as such will now be described, it is to be borne in mind that the invention is applicable to any telescopic oil well tool operating through an annular body of confined operating liquid and providing a means for applying an excessive retarding action on axial movement between the tubular elements thereof in one direction while providing the opportunity for resetting the tool by a reverse relative movement and doing this very rapidly without the parts of the tool suffering damage, and without the necessity of creating a vacuum in the liquid compression chamber.

Before lowering the tool 10 into a well for use in a jarring operation, or even before attaching this to the lower end of a drill string 11, the annular chamber 80 formed between inner and outer tubular elements 14 and 33 and closed at its upper and lower ends by packing rings 75 and 76, is filled with an operating liquid, preferably a light lubricating oil, in the following manner. When the secondary packing ring 76 is not subjected to an upward pressure of oil in the chamber 80, the tension with which the expansive coil spring 79 is assembled in the tool 10 forces ring 76 downward against the secondary packing ring stop pin 27. It is to be noted that with the ring 76 so positioned, the air escape port 25 is disposed above the lower edge of the ring 76 and is thus closed by this ring. The plug 26 is now removed, uncovering the outer end of air escape port 25.

The plug 30 is also removed and a fitting screwed into its place for delivering operating liquid through the check valve 29 into the chamber 80. The free axial movement of the primary packing ring 75 is limited to the space between the internal hammer shoulder 18 and the upper end of pin 19 which serves as a stop 81.

The operating liquid is delivered into the chamber 80 under pressure so that if the primary packing ring 75 is not at its lowermost position resting against the stop 81, the incoming operating liquid forces it into this position and as the level of liquid rises in the chamber 80 the air in this chamber is forced out through the air outlet port 25 thus completely filling the space between the packing rings 75 and 76 with operating liquid. When liquid flows out through the air outlet port 25 the plug 26 is inserted to close this port and a certain amount of additional operating liquid is delivered into the chamber 80 to lift the secondary packing ring 76 approximately to the position in which this is shown in FIGS. 3, 4 and 5 so that the liquid trapped in chamber 80 will always be under a superambient pressure and the secondary packing ring 76 will be held upwardly by this liquid out of contact with the stop pin 27 at all times. When the chamber 80 has thus been charged with operating liquid the fitting through which this was delivered to the check valve 29 is removed and replaced by the stop plug 30 as shown in FIG. 1*a*.

It is to be noted that while the sleeve 49 has been described as having a sliding fit with the cylinder bore 15 when disposed within this bore, this fit is loose enough so that during the stretching of the drill string 11 in preparation for a jarring stroke, the fit between the sleeve 49 and bore 15 is such as to permit the escape of a certain amount of operating liquid through the space between said sleeve and said bore to allow a retarded upward movement of the outer tubular element 14 under the strain imposed by the drill string 11 so that the driller will be able to have applied the proper degree of tension on the drill string 11 just as the jarring action takes place. Assuming therefore, that the parts of the tool 10 are relatively disposed as illustrated in FIG. 5 when the tool is lowered in the well, this is the situation when the fishing tool 70 engages the fish in the well and downward movement of the fishing tool 70 is thus halted. It will then be assumed that the drill string 11 is rotated to rotate the fishing tool 70 and engage this with the fish. The drill string 11 may be lowered incidental to making this engagement and this lowering of the drill string may be done suddenly or at a moderate speed. Regardless of the rate at which the drill string is lowered to telescopically collapse the tubular elements of tool 10, in their extended relation shown in FIG. 5, to their completely collapsed relation shown in FIG. 2, no internal pressures or vacuums will be set up within the pressure chamber of the tool which would tend to damage the tool in any way.

The operation being described assumes that the inner tubular element 33 is supported by the fish in the well against any further downward movement and the outer tubular element 14 is fastened directly to the lower end of the drill string and the weight of the latter is being imposed on the outer tubular element with either a moderate downward speed or a very rapid downward speed. In either case, the bore 15 of the tool will move downwardly over the piston section 34 thereof, and if the downward speed of the outer element be moderate the spaces available permit operating liquid trapped between the piston section 34 and the secondary packing ring 76 to flow downwardly around the piston section and into the counterbore 16 of the tool without further compressing the expansive coil spring 79. These liquid passages include the annular space between the box end 52 of the upper section 35 of the inner tubular element and the bore 15 (FIG. 1*a*), the vertical space between the ground faces 51 and 54, the fluted vertical passages 50 formed internally in the sleeve 49, the annular recess 46, the circumferentially disposed radial holes 48 formed in annular

wall 47, and the annular space between anvil shoulder 38 and the wall 15.

If the drill string drives the outer tubular element of the tool 10 downwardly at a rate that is too rapid for the passages above described to so accommodate a flow of operating liquid downwardly around the piston section 34 as not to further compress the spring 79, the operating liquid trapped in the chamber 80 above the piston section 34 will not be able to escape with sufficient rapidity to prevent the spring 79 being partially collapsed by the downward movement of the outer tubular element 14, and there will likewise be a tendency to create a vacuum in the portion of the liquid chamber 80 disposed below the piston section 34 of the inner tubular element 33.

In the tool 10, however, the latter tendency is overcome by giving primary packing ring 75 a degree of freedom for vertical movement which compensates for the increase in the space within the chamber 80 below the piston section 34 by this packing ring simply rising upwardly from its position resting against the stop 81 towards its upper position in which it would closely approach the internal shoulder 18. The tool 10 is so designed however that the distance between the stops 18 and 81 is such that no matter how rapidly the two tubular elements of the tool 10 are vertically telescoped in resetting the tool, the packing ring 75 is never quite lifted into contact with the shoulder 18. The pressure of the operating liquid in the portion of liquid chamber 80 below the piston section 34, therefore, is never lowered substantially below that of the ambient fluid which has access to the lower face of primary packing ring 75 through passages 23 and 24 (FIG. 1*a*).

As mentioned in the brief description of the figures, FIGS. 1, 1*a* and 1*b* illustrate the mechanism of the tool 10 with the parts thereof positioned as they will be just prior to the conclusion of a spudding operation which is the most severe test which could be given a hydraulic tool in resetting the tool from its maximum extended condition to its maximum collapsed condition. These three views show how the primary packing ring 75 has risen to maintain the operating liquid in the portion of the chamber 80 below piston section 34 at ambient pressure as this ring is still some distance from its upper limiting shoulder 18. FIG. 2 illustrates the tool 10 at the instant this spudding operation is concluded by impact of the spline sleeve 20 with the shoulder 67 on the lower sub 65 of the tool. This view shows that a space still separates the primary packing ring 75 and the internal hammer shoulder 18 at the conclusion of the spudding operation, thus illustrating the complete lack of any opportunity of forming a vacuum in the chamber 80 incidental to even the most violent spudding operation. The only pressure imposed on the operating liquid above the piston section 34 is that necessary to slightly increase the compression under which the expansive coil spring 79 is subjected thereby slightly increasing the degree to which this spring is collapsed as shown in FIG. 2.

To complete the resetting of the tool 10 for starting a jarring operation, it is only necessary to allow it to remain in its maximum collapsed position shown in FIG. 2 for a few moments which will result in the expansive action of spring 79 forcing the secondary packing ring 76 downwardly from the position in which it is shown in FIG. 2 to the position in which it is shown in FIG. 3, this action forcing the excess operating oil out of the portion of the chamber 80 above the piston section 34 and into the portion of the chamber 80 below that piston section so as to force the primary packing ring 75 downwardly to rest upon the stop shoulder 81 formed on the pin end 19 of the spline sleeve 20.

FIG. 3 thus illustrates the tool 10 with its parts related as at the conclusion of the resetting of the tool for starting another jarring operation. To effect such a jarring operation, the driller operates the rigging supporting the drill string 11 to place a substantial upward strain on this. Such a strain is made possible by the retarding action applied to upward movement of the outer tubular element 14 by the valve sleeve 49, friction on which lifts this sleeve to bring the upper radial ground face 51 thereof into contact with the lower ground radial face 54 of the piston section 34 so as to compel the liquid in the portion of chamber 80 disposed below said piston section to pass between the sleeve 49 and the bore 15 in order for the outer tubular element 14 to have any upward movement in response to the tremendous upward strain placed thereon by the tensioning of the drill string 11.

When, due to the slow upward movement of the outer tubular element 14 the point of juncture 85 between the bore 15 and counterbore 16 arrives opposite the upper end of valve sleeve 49 as shown in FIG. 4, the restraint imposed upon the upward movement of the outer tubular element is relaxed by an ample passage being opened for a flow of operating liquid from the portion of chamber 80 below piston section 34 to the portion of said chamber above said section with the result that the outer tubular element 14 is snapped upwardly causing the hammer shoulder 18 to strike a tremendous blow against the anvil shoulder 38 which of course is transmitted through the inner tubular element 33 to the fishing tool 70.

While the embodiment of the invention disclosed herein has been described as providing for a restricted flow of operating liquid past the piston section 34 during the tensioning of the drill string 11 by allowing adequate space between the sleeve 49 and the bore 15 to permit this passage of operating liquid past the piston section, it is to be understood that the present invention would operate equally well with other alternative passage means provided in the piston section 34 for this restricted flow of operating liquid. Examples of such alternative passage means may be found in my copending applications for U.S. Letters Patent Serial No. 648,137 filed March 25, 1957, on Hydraulic Jar, now U.S. Patent No. 2,922,626, and Serial No. 809,153 filed April 27, 1959, on Sleeve Valve and Oil Well Tool Embodying the Same.

While a preferred embodiment of the invention disclosed herein is of an oil well jar, this is for illustrative purposes only and many modifications and changes can be made in the invention as disclosed without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. In a telescopic oil well tool, which employs, in its operation, a quantity of operating liquid trapped between the telescopic parts thereof, the combination of: an outer tubular element a portion of which comprises a cylinder; an inner tubular element telescopically related with said outer tubular element and comprising opposite end sections separated by a piston section, the latter functioning as a piston in said cylinder; a primary floating packing ring disposed within said outer tubular element and slidably engaging the latter and one end section of said inner tubular element for providing a seal between said tubular elements; a stop shoulder on said outer tubular element limiting axial movement of said primary ring relative to said outer element in a direction away from said piston to define a high pressure area between said piston and said primary floating packing ring when the latter is in engagement with said stop shoulder; a secondary floating packing ring disposed within said cylinder and slidably engaging said cylinder and the other end section of said inner tubular element for sealing off the space between said cylinder and said other end section, to define a low pressure area between said piston and said secondary floating packing ring, said packing rings thus cooperating with the other parts recited to provide a closed tubular chamber for confining operating liquid; and closure means optionally removable for introducing liquid into said chamber, there being passage means provided in said tool allowing liquid in said chamber to by-pass said piston to escape from said high pressure area of said chamber into said low pressure area thereof at a severely restricted

rate to substantially retard a given relative axial movement between said tubular elements compressing a body of said liquid between said piston and said primary packing ring with the latter resting against said stop shoulder, a reverse relative movement between said tubular elements to reset said tool being facilitated by a relatively free axial movement of said primary packing ring away from said stop shoulder.

2. A combination as in claim 1 in which said piston section provides an anvil and an annular internal shoulder on said outer tubular element provides a hammer and a portion of said cylinder adjacent said hammer has an enlarged diameter into which said piston passes at the conclusion of said given relative movement whereby said retarding action ceases and said tool functions as a hydraulic jar by the speed of said relative movement being suddenly increased until said hammer and anvil come into collision.

3. A combination as in claim 2 in which an expansive coiled spring is provided between said tubular elements and which bears at one end against said outer tubular element and at the other against said secondary floating packing ring, said operating liquid being introduced under pressure so as to compress said spring whereby the latter maintains said liquid, in the low pressure area of said chamber, under constant superambient pressure, said liquid thus quickly returning said primary packing ring against said stop shoulder following a reverse relative resetting movement as aforesaid.

4. A combination as in claim 1 in which an expansive coiled spring is provided between said tubular elements and which bears at one end against said outer tubular element and at the other against said secondary floating packing ring, said operating liquid being introduced under pressure so as to compress said spring whereby the latter maintains said liquid, in the low pressure area of said chamber, under constant superambient pressure, said liquid thus quickly returning said primary packing ring against said stop shoulder following a reverse relative resetting movement as aforesaid.

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