United States Patent [19]

Sutliff et al.

[11] **3,815,693**

[45] **June 11, 1974**

[54] **VACUUM HYDRASTATIC JAR ACCELERATOR**

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[52] **U.S. Cl.** **175/232,** 175/296, 175/321

[51] **Int. Cl.** **E21b 27/00,** E21b 1/10

[58] **Field of Search** 175/293, 296, 297, 299, 175/306, 232, 321; 166/178; 267/125

[56] **References Cited**

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2,837,315 6/1958 Burns et al. 175/296

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Primary Examiner—Robert L. Wolfe

Assistant Examiner—Richard P. Tremblay

[57] **ABSTRACT**

A deep well energy storage tool for accelerating the action of a hydraulic jar providing a vertically shiftable piston on said tool and applying upwardly thereto, incidental to the tensioning and tripping of the jar, the hydrastatic pressure of a column of liquid occupying the drill string, while said piston is exposed to a vacuum thereabove.

2 Claims, 6 Drawing Figures

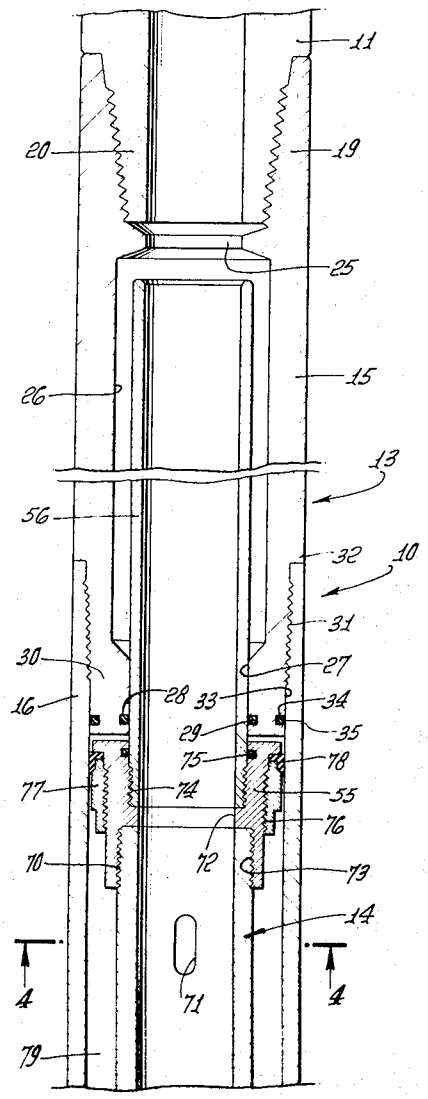


FIG. 1.

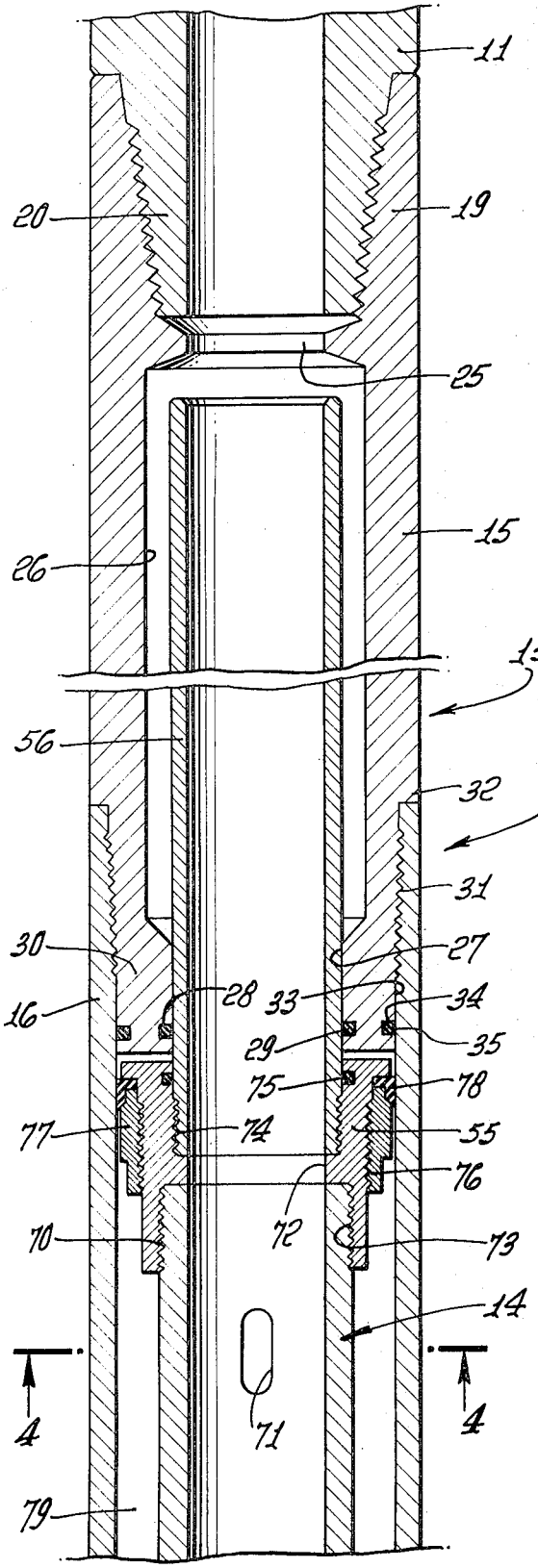

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FIG. 2.

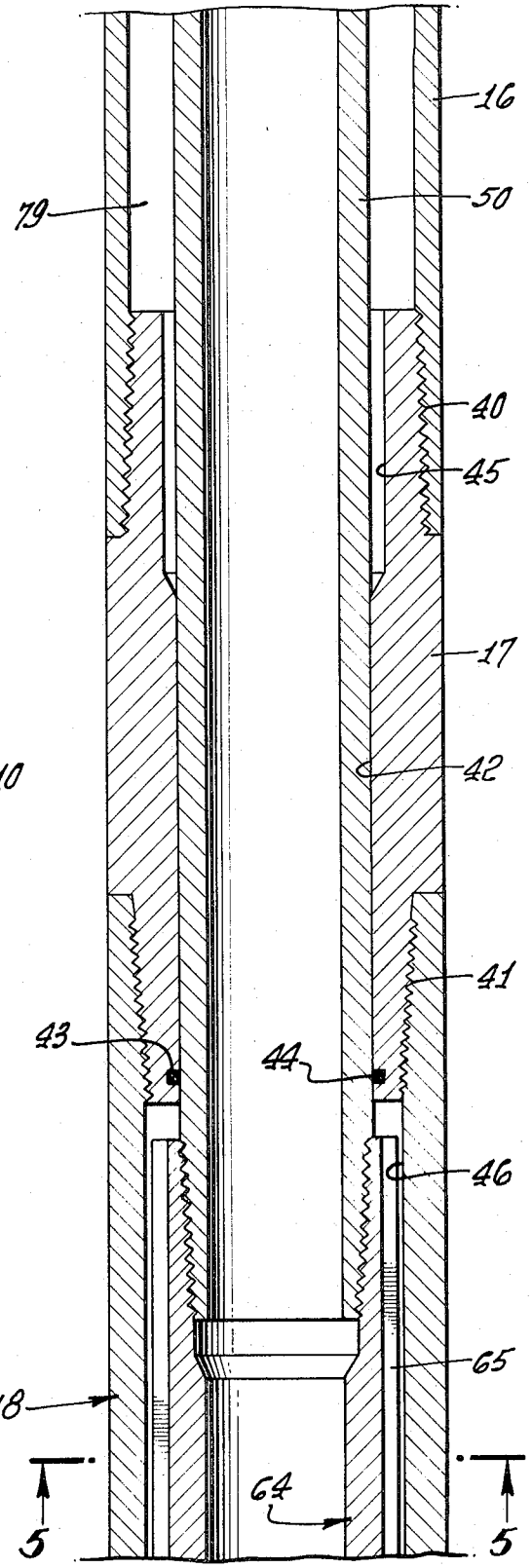

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FIG. 3.

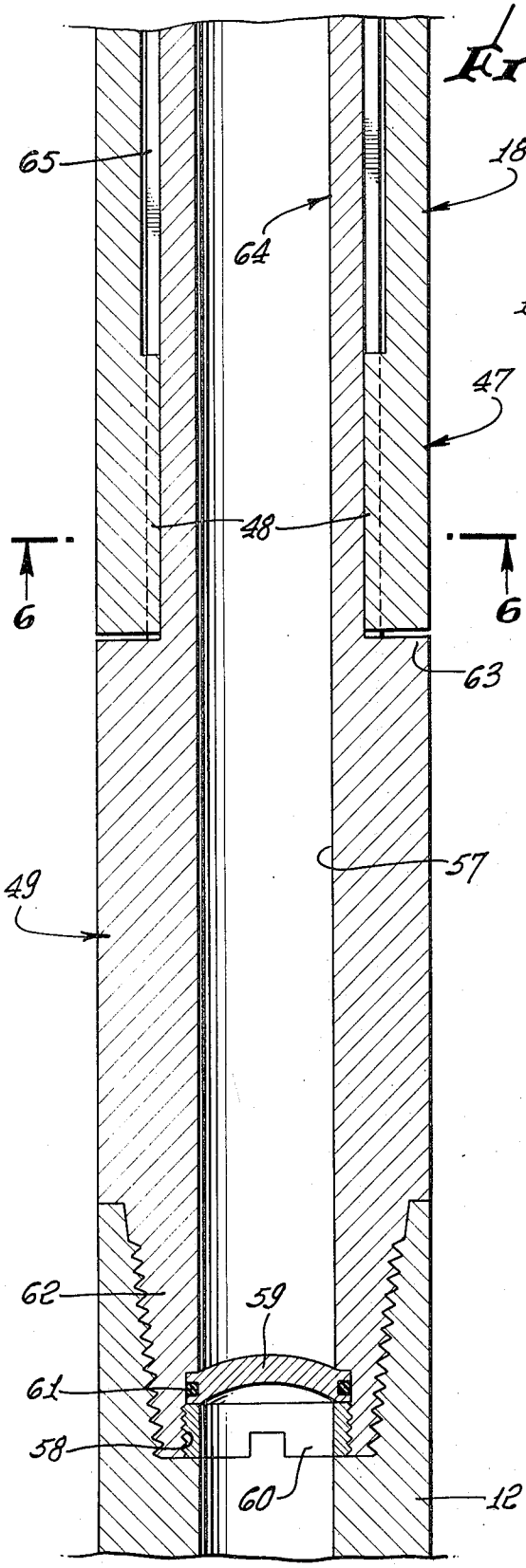


FIG. 4.

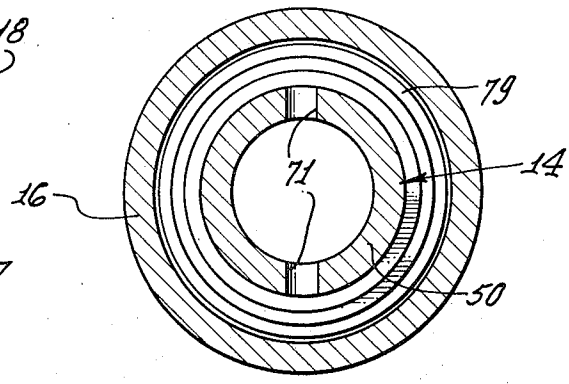


FIG. 5.

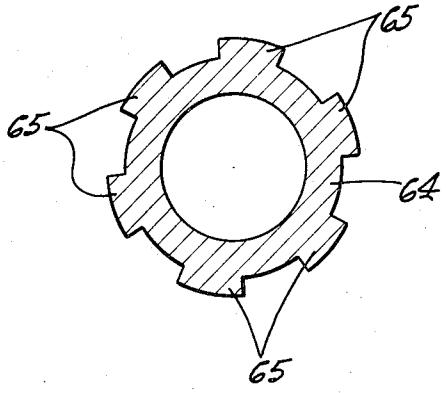
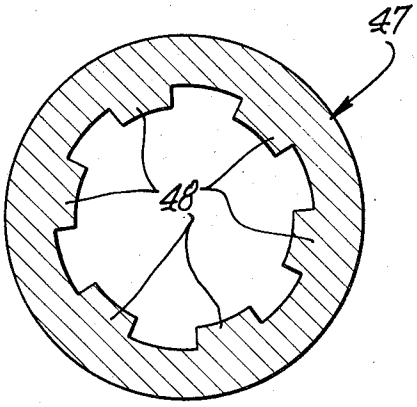


FIG. 6.



VACUUM HYDRASTATIC JAR ACCELERATOR

SUMMARY OF THE INVENTION

The present invention is an improvement on the fishing tool energizers disclosed in our U.S. Pat. Nos. 3,472,326 and 3,539,026. The energy source employed in said patented tools was comprised in a series of metal springs which were compressed during the tensioning of the hydraulic jar with which the tool was associated so that when the jar tripped the energy stored in the springs would be released to impart a rapid upward acceleration of a series of drill collars assembled in the string between the jar and said tool.

Inasmuch as the use of springs in any deep well tool introduces operational and maintenance problems, it is the prime object of the present invention to provide a well jar accelerator operating on the vacuum vs. hydrastatic pressure principle and which will utilize the energy available at the bottom of a well in a column of liquid occupying the drill string.

It is another object of the invention to provide such a deep well jar accelerator which may be employed either in wet holes or approximately dry holes.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**, **2** and **3** comprise fragmentary vertical sectional views of successive sections of the invention and show the same with the parts thereof telescopically contracted as at the start of a jarring operational.

FIG. **4** is a cross sectional view taken on the line **4—4** of FIG. **1** and shows the annular piston area of the tool against which hydrastatic pressure is applied upwardly in accelerating the action of a deep well jar associated with the tool, this view also showing the fluid ports in the internal mandrel through which operating fluid is introduced into the annular cylinder chamber of the tool.

FIG. **5** is a cross sectional view taken on the line **5—5** of FIG. **2** and illustrates the construction of the male spline sleeve of the invention.

FIG. **6** is a cross sectional view taken on the line **6—6** of FIG. **3** and illustrates the construction of the female spline sleeve of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring specifically to the drawings, the invention is there illustrated as incorporated in a well jar accelerator **10** which is secured, at its upper end to the lower end of a drill string **11**, said accelerator having suspended from the lower end thereof a fishing tool assembly **12**. The latter assembly is not illustrated in detail inasmuch as this is conventional and embraces in the order named downwardly from the accelerator **10**, one or more drill collars, a hydraulic jar and a fishing tool.

The accelerator **10** comprises an external tubular mandrel **13** and an internal tubular mandrel **14** which is slideably received within the external mandrel to allow a limited degree of extensibility of the accelerator.

The external mandrel **13** embraces an upper sub **15**, a thin tubular external cylinder forming sleeve **16**, a middle sub **17** and an external female spline sleeve **18**.

The upper sub **15** is relatively long, its length being preferably approximately five times its external diameter, this sub providing at its upper end a pin box **19** for receiving the pin **20** on the lower end of drill string **11**. The bottom of pin box **19** is provided with a short bore **25** which connects with the upper end of a counterbore **26** which extends almost to the lower end of sub **15** where it connects with a relatively short bore **27** having an internal annular groove **28** for receiving an O-ring **29**. The lower end portion **30** of upper sub **15** comprises an annular cylinder head and is externally turned down to provide threads **31**, a shoulder **32**, a smooth cylindrical surface **33** between the threads **31** and the lower end of the sub and an external annular groove **34** for receiving an O-ring **35**. The tubular external cylinder forming sleeve **16** is internally threaded at its opposite ends, the upper end of this sleeve screwing onto the threads **31** and fitting snugly against the shoulder **32** of the upper sub **15**. The O-ring **35** makes a fluid tight seal between annular cylinder head **30** and sleeve **16**.

The middle sub **17** is turned down at its opposite ends to provide external threads **40** and **41** and has a bore **42** and an annular internal O-ring groove **43** near its lower end for accommodating an O-ring **44**. The upper end portion of middle sub **17** is provided with a counterbore **45** for a purpose which will be made clear hereinafter.

The threads **40** on the upper end of middle sub **17** screw into the internal threads provided in the lower end of sleeve **16** and unite middle sub **17** with said sleeve. External female spline sleeve **18** is internally threaded at its upper end and screws on to the threads **41** of middle sub **17** to unite said sleeve with said sub. As shown in FIG. **2**, the spline sleeve **18** has a smooth bore **46** throughout the major upper portion thereof which terminates near the lower end of said sleeve (FIGS. **3** and **6**) with a radial inwardly extending series of spline teeth **48**.

The internal tubular mandrel **14** comprises a lower sub **49**, a tubular internal cylinder forming sleeve **50**, an annular piston **55** and a tubular internal vacuum cylinder forming sleeve **56**.

The lower sub **49** has an internal bore **57** extending throughout its length, this having a threaded counterbore **58** in its lower end for receiving a seal disc **59** and a nut **60** for holding this in place. The seal disc **59** is provided externally with an O-ring **61** for forming a seal between said disc and bore **58**. Formed externally on the lower end of sub **49** is a threaded pin **62** for connecting sub **49** for fishing tool assembly **12**. Sub **49** is turned down to form a shoulder **63** from which a male spline sleeve **64** extends upwardly to form the balance of the sub **49**. The sleeve **64** is provided with a circumferentially spaced series of external splines **65** which intermesh with the splines **48** of the female spline section **47** of the female spline sleeve **18**. The upper end of sleeve **64** is internally counterbored and threaded to screw onto the externally threaded lower end of tubular internal cylinder forming sleeve **50**. The latter sleeve has a smooth cylindrical outer surface which makes a slideable sealing engagement with O-ring **44** and the upper end of said sleeve is provided with external threads **70** and, just below said threads has formed therein a pair of diametrically opposed slots **71** for a purpose to be made clear hereinafter.

The annular piston **55** has a short bore **72** which connects downwardly with an internally threaded counter-

bore 73 which screws onto external threads 70 of sleeve 50 and connects upwardly with an internally threaded counterbore 74 which screws onto the externally threaded lower end of sleeve 56. The upper portion of counterbore 74 is smooth and has formed therein an internal annular groove for accommodating an O-ring 75, the latter forming a liquid tight seal between piston 55 and sleeve 56. The piston 55 makes a close sliding fit with the smooth cylindrical inner surface of sleeve 16 and the lower portion of the piston is turned down to provide external threads 76 onto which an internally threaded packer compression nut 77 screws, said nut extending into and compressing a cup shaped packer 78 against said piston and expanding said packer so that it pressurally engages the smooth internal cylindrical surface of the external cylinder forming sleeve 16.

OPERATION

As already noted, the drawings illustrate the parts of the accelerator 10 in contracted relation to each other as at the moment of starting a jarring operation. Such an operation of the accelerator 10 requires the presence of a body of liquid in the drill string 11. If the well hole itself is occupied with such a liquid the seal disc 59 may be omitted in assemblying the tool as the well liquid inside and outside the drill string 11 will seek a common level so that this fluid within the drill string will be equal in depth to the fluid in the hole. This fluid flows through the slots 71 into the annular piston chamber 79 so as to fill this chamber.

The jarring operation starts with lifting the drill string 11 a sufficient distance to bring the middle sub 17 into engagement with the piston 55. This upward movement of the external mandrel 13 produces a vacuum in that portion of the annular piston chamber 79 disposed above the piston 55. The full hydrastatic pressure of the liquid column confined in the drill string 11 is at this time being applied through the slots 71 to that portion of the piston chamber 79 located below piston 55 and is thus imposed upwardly against said piston. This pressure may vary from one to five or more tons, depending upon the diameter of the tool 10 and the height of the column of liquid in the drill string. The lifting on the drill string 11 continues after the middle sub 17 engages the piston 55 so as to transmit a direct pull through the inner mandrel 14 to the fishing tool assembly 12. The jar in this assembly gradually yields to this pressure for a predetermined period of time, at the end of which the jar trips, allowing free movement for a short distance upwardly of the drill string 11 terminating in a resumption of the direct connection between the drill string and the fishing tool assembly and imparting a sharp upward blow on the fish tending to release this from its stuck position which of course is the object of the jarring operation.

The accelerator 10 of the invention responds to the pressure of the confined well fluid against the bottom end of piston 55 at the instant the jar trips to apply a sufficient upward fluid pressure on the inner mandrel 14 to cause a rapid upward movement of the drill collars embodied in the fishing tool assembly 12 and located between the tool 10 and the jar of said assembly so that when the free movement allowed by the jar is concluded and direct connection with the fish is reestablished, considerable momentum has been stored up in the substantial weight embodied in said drill collars so that these apply a hammer blow of substantial force to the fish which has been greatly augmented by the action of the accelerator 10.

Following a jarring action as above described, the drill string 11 may be lowered to again contract the elements of the accelerator 10 as shown in the drawings so that the jarring action may be repeated as many times as necessary to secure the desired end. If operations are carried on in a wet hole, that is a well substantially filled with a liquid, such as rotary mud, the seal disc 59 is omitted from the accelerator. If such a disc is used, as when the hole outside the drill string is relatively dry, a go-devil can be dropped down the drill string after completion of the fish removing operation so as to penetrate the seal disc 59 and permit the escape downwardly of the liquid from the drill string 11 into the well hole.

It is to be noted that the packer 78 is a cup packing which functions merely in a downward direction and freely allows any liquid accumulating between the piston 55 and the cylinder head 30 to escape downwardly past this packing each time the piston 55 is returned to its upward position in the annular chamber 79 as shown in the drawing.

The splined relation between the external and internal mandrels 13 and 14 provide constant torque transmitting relation between these mandrels throughout the various longitudinal relationships which these mandrels have to each other during the operation of the tool 10.

The counterbore 45 is provided in the upper end of the sub 17 to downwardly prolong annular chamber 79 and thus maintain communication between said chamber and passages 71 throughout the extension of the tool 10.

1. A well jar accelerator comprising:

a tubular internal mandrel terminating in a sub at it lower end and having an annular piston near its upper end;

a tubular external mandrel slideably enclosing said piston and internal mandrel and terminating in a sub at its lower end, said upper sub being provided for connecting the tool to a drill string, and said lower sub for connecting said tool to a fishing tool assembly including a jar, whereby said accelerator may be extended by lifting on said drill string and returned to normal contracted condition by lowering said drill string;

means forming an annular vacuum cylinder chamber in said external mandrel which is closed at its upper end and in which said piston makes a sealed sliding fit to produce an approximate vacuum therein, above said piston, when said accelerator is so extended;

means limiting the maximum extensibility of said accelerator, there being passage means accessible to the liquid confined within said drill string and said accelerator and communicating with said cylinder chamber beneath said annular piston whereby the hydrastatic pressure existing in said liquid may impinge upon the bottom of said piston to impart an upward thrust on said internal mandrel which is transmitted to said jar coincident with the extension of said accelerator and during the tensioning and tripping of said jar; and

a seal disc means provided in said lower sub for temporarily blocking the escape of fluid downwardly from said accelerator.

2. A well jar accelerator comprising:

a tubular internal mandrel terminating in a sub at its lower end and having an annular piston near its upper end;

a tubular external mandrel slideably enclosing said piston and internal mandrel and terminating in a sub at its upper end, said upper sub being provided for connecting the tool to a drill string, and said lower sub for connecting said tool to a fishing tool assembly including a jar, whereby said accelerator may be extended by lifting on said drill string and returned to normal contracted condition by lowering said drill string;

means forming an annular vacuum cylinder chamber in said external mandrel which is closed at its upper end and in which said piston makes a sealed sliding fit to produce an approximate vacuum therein, above said piston, when said accelerator is so extended;

means limiting the maximum extensibility of said accelerator, there being passage means accessible to the liquid confined within said drill string and said accelerator and communicating with said cylinder chamber beneath said annular piston whereby the hydrastatic pressure existing in said liquid may impinge upon the bottom of said piston to impart an upward thrust on said internal mandrel which is transmitted to said jar coincident with the extension of said accelerator and during the tensioning and tripping of said jar;

said cylinder chamber being closed at its upper end by a cylinder head formed by said upper sub and having a central bore provided with O-ring seal means; and

a tubular sleeve provided on said piston and slideably axially extending upwardly through said cylinder head to form an expansible vacuum chamber between said head, said piston, said sleeve and said external mandrel,

said internal mandrel including a smooth middle sleeve which connects said piston to said bottom sub, and wherein

said bottom sub embodies a male spline sleeve to which said middle sleeve connects;

said external mandrel embodying a smooth bore middle sub having O-ring seal means which slideably receives said middle sleeve, and a female spline sleeve which slideably receives and meshes with said male spline sleeve to transmit torque between said mandrels;

said passage means being provided in said smooth middle sleeve near its upper end.

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