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Downen

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[54] HYDRAULIC DRILLING JAR

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[52] **U.S. Cl.** **175/297**
[51] **Int. Cl.** **E21b 1/10**
[58] **Field of Search** 175/297

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Primary Examiner—James A. Leppink

[57] **ABSTRACT**

A jar especially designed to withstand the high torques and abuse produced by deflections of the well bore from vertical encountered in deep well drilling. Both spline and hammer-anvil faces are below and outside of the zone occupied by the jar dashpot system, whereby torque and jar impact strains are not transmitted through the outer mandrel portion housing said system. Torque and jar impact strains are transmitted throughout the tool through a beefed up internal mandrel integral from end to end. Furthermore, said strains are transmitted through only a single threaded joint connecting the lower end of the outer mandrel to the bottom sub of the tool.

In addition, the jar is stabilized at four axially spaced points therein by arrangements causing the inner mandrel to smoothly journal in the outer mandrel thus uniting their strength at these points.

8 Claims, 16 Drawing Figures

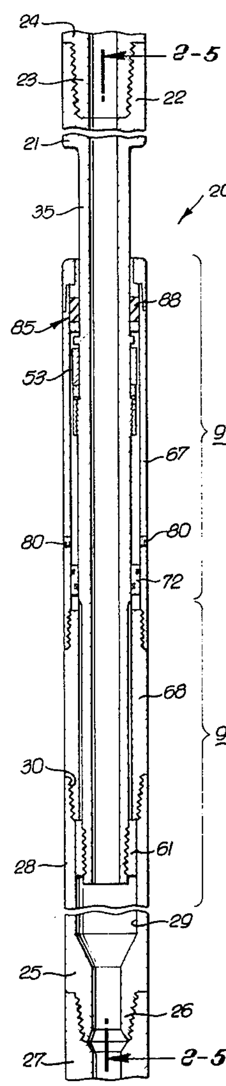


FIG. 1.

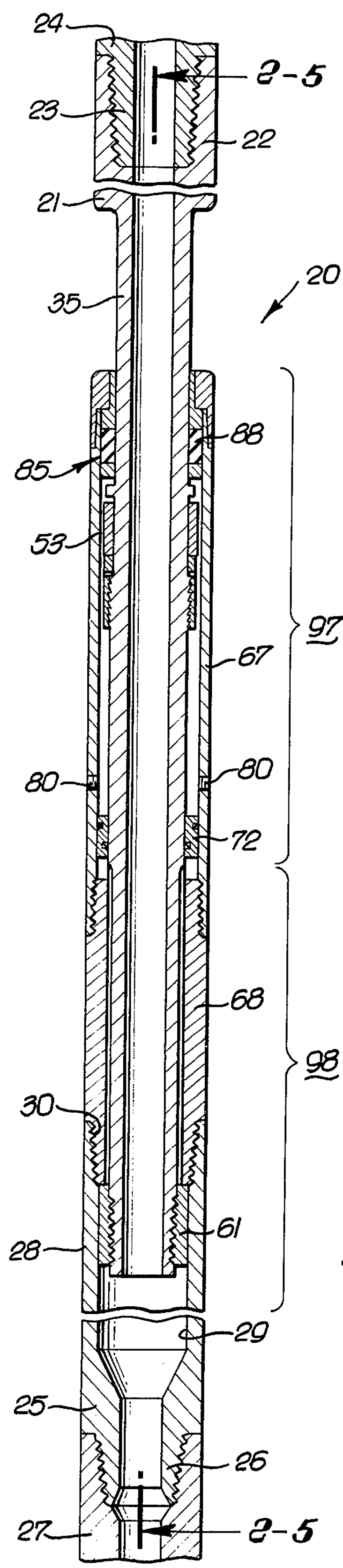


FIG. 2.

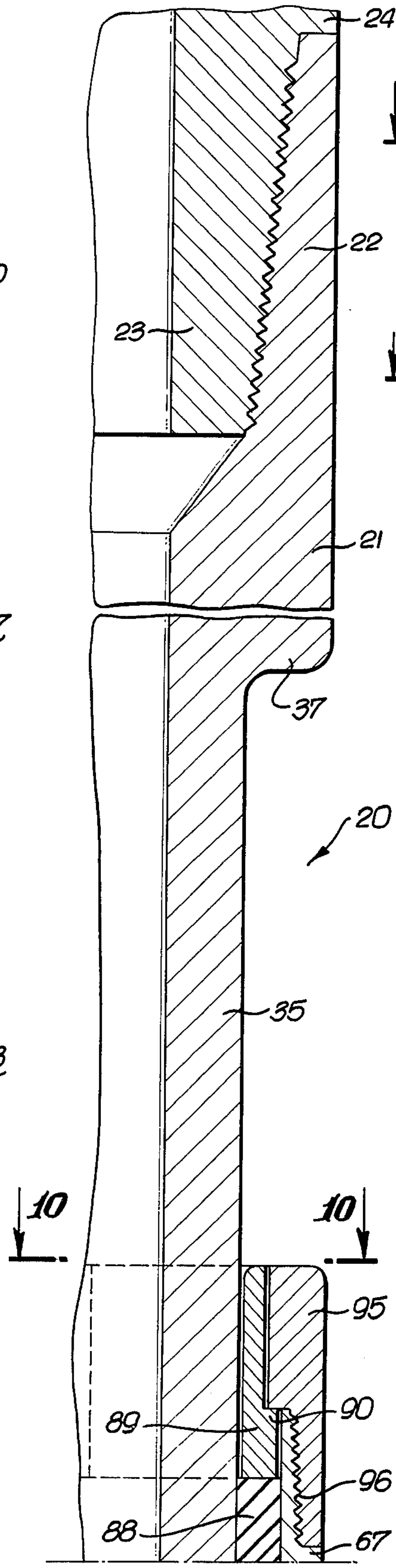
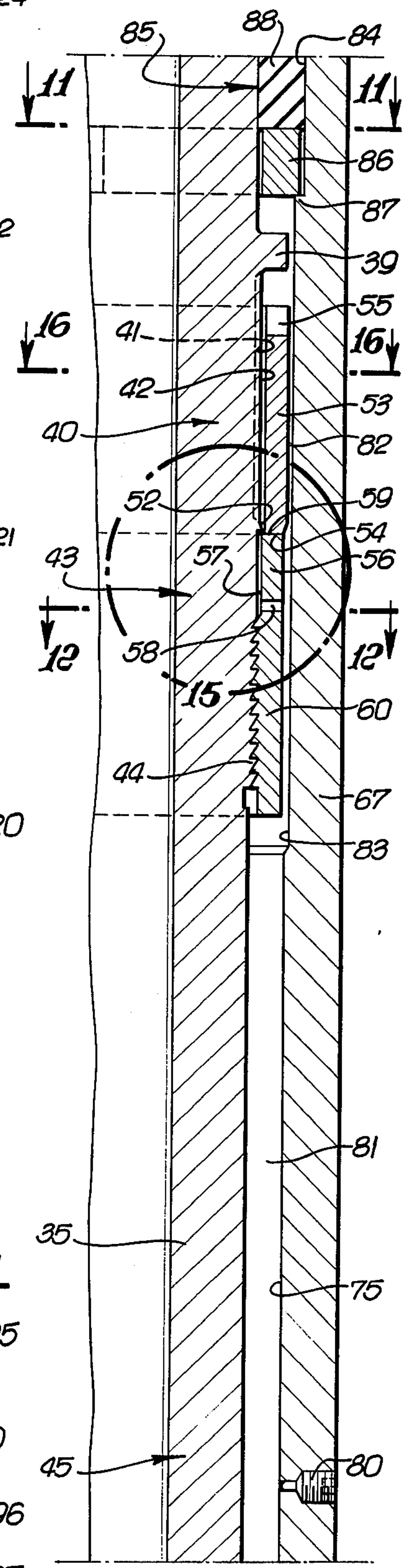


FIG. 3.



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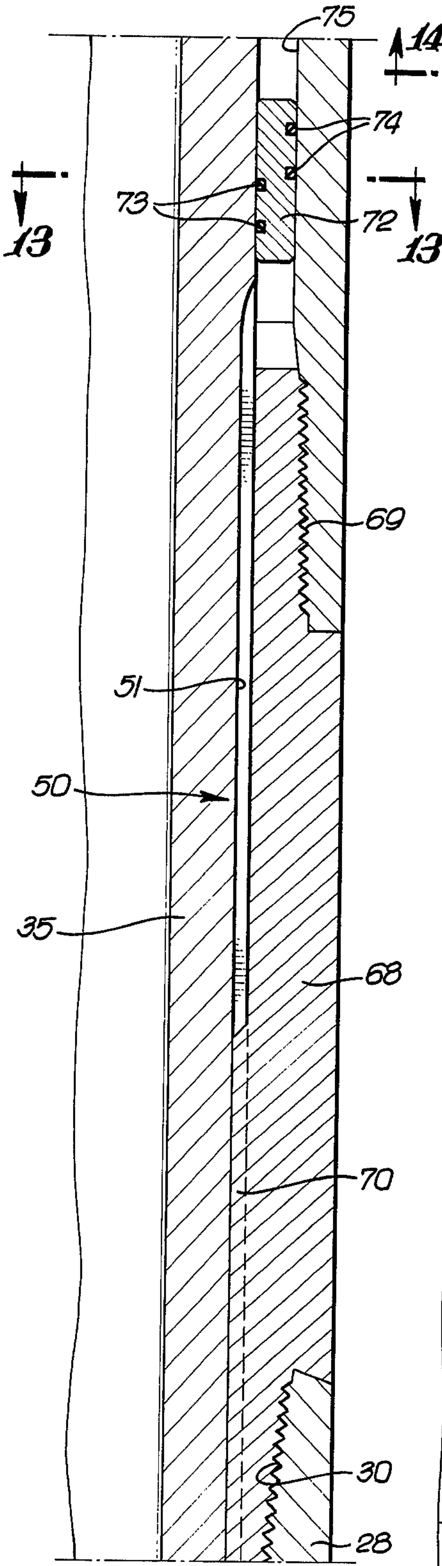

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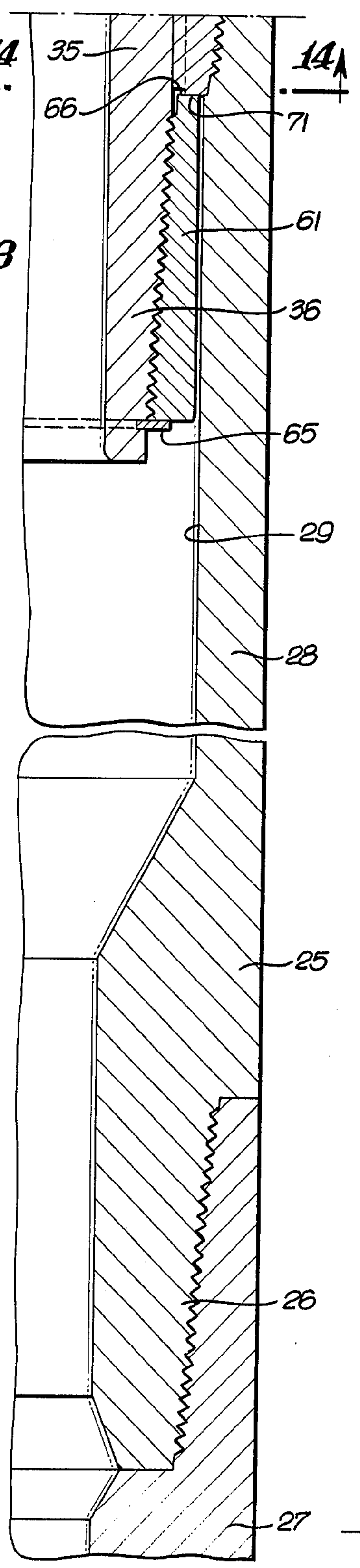
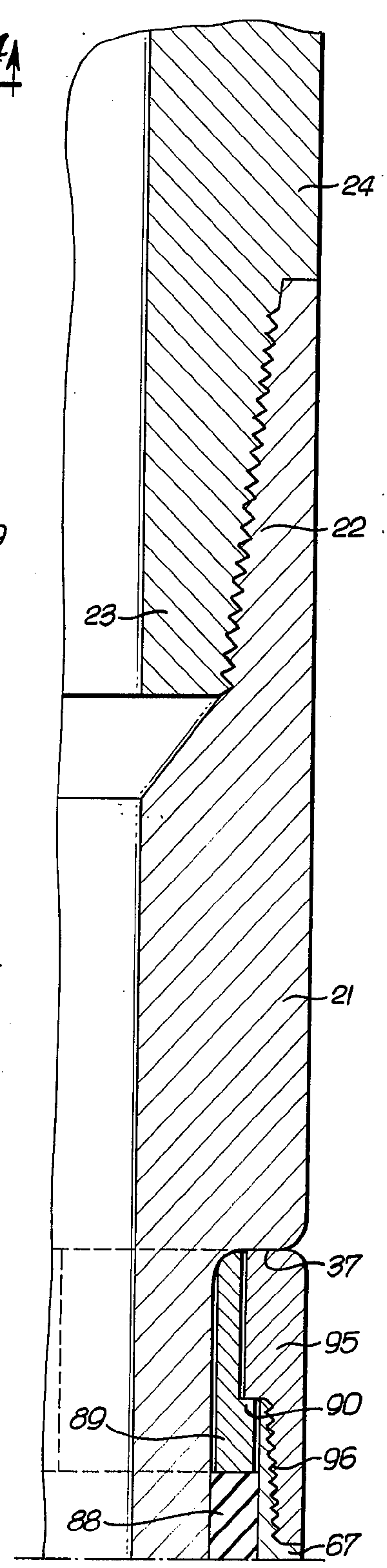


FIG. 6.



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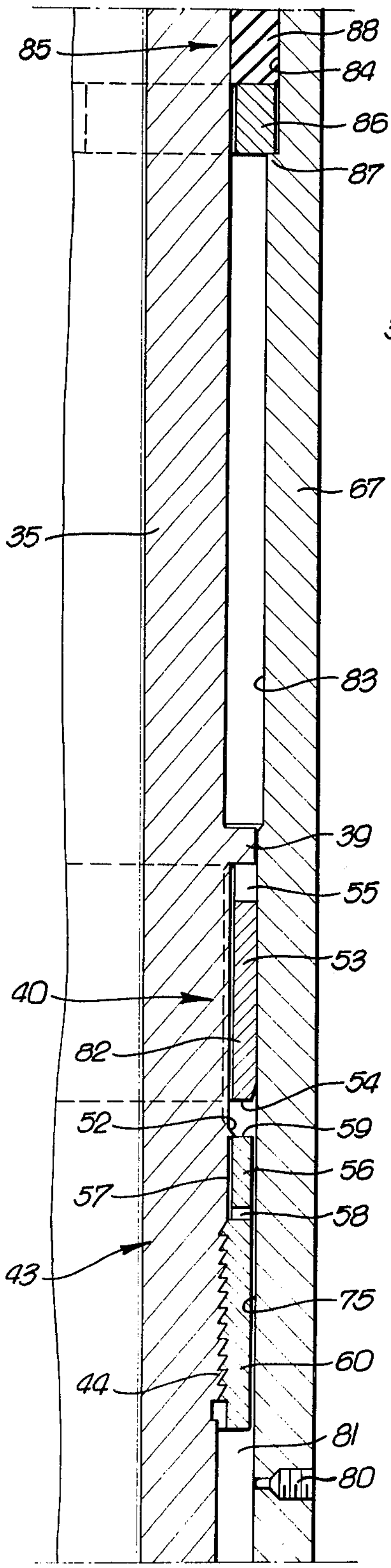

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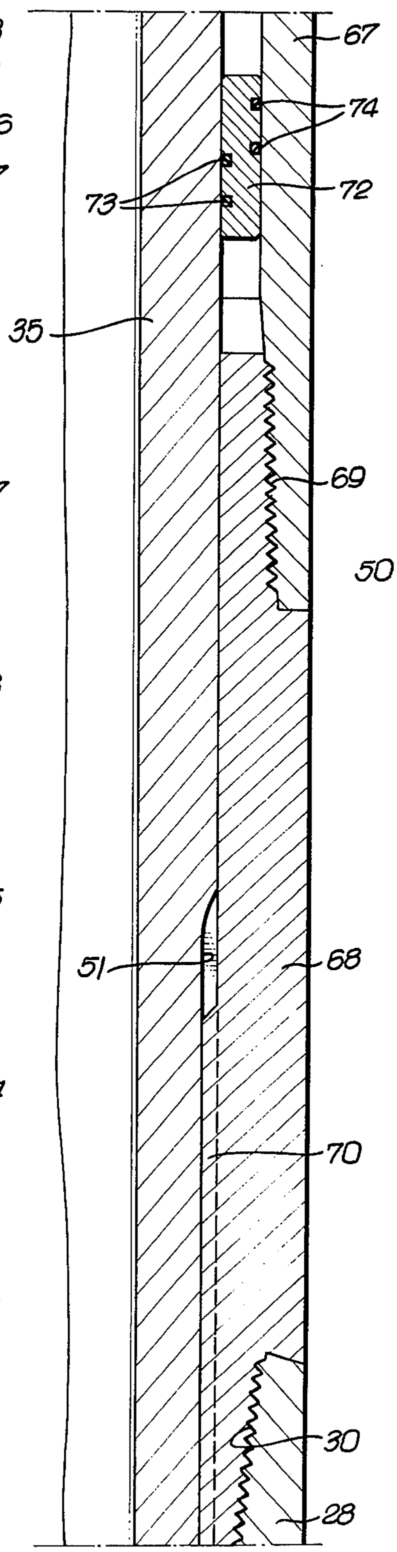

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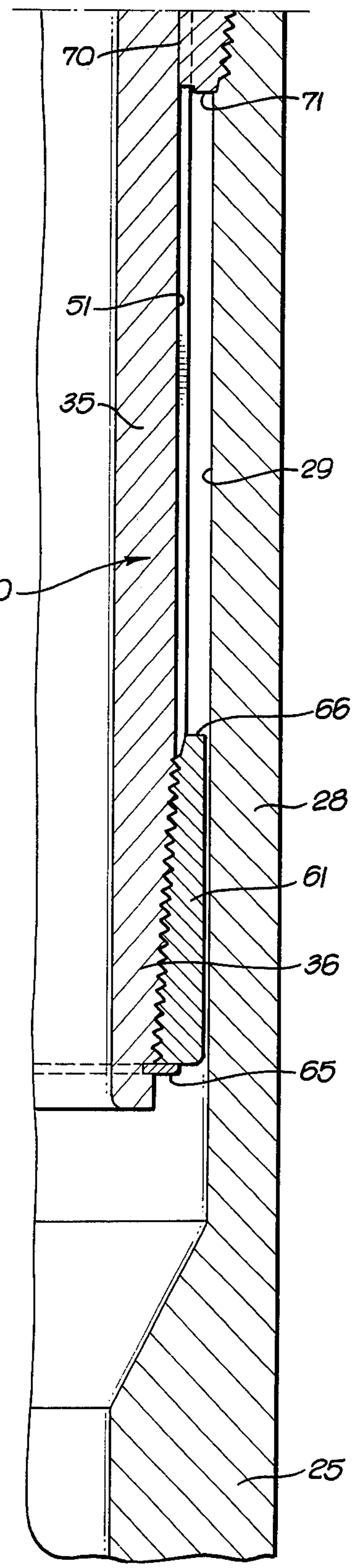

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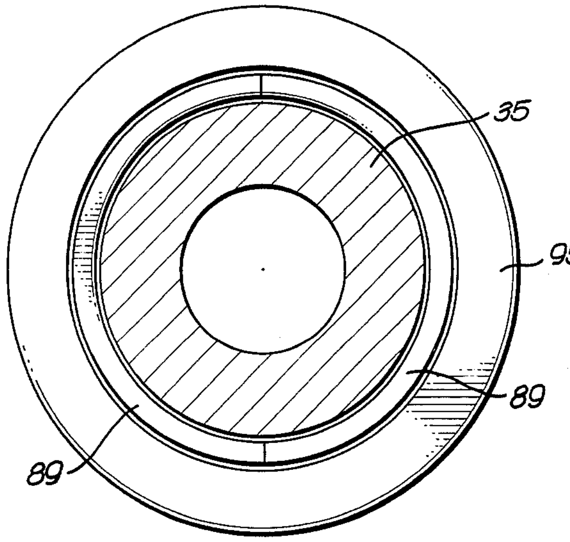
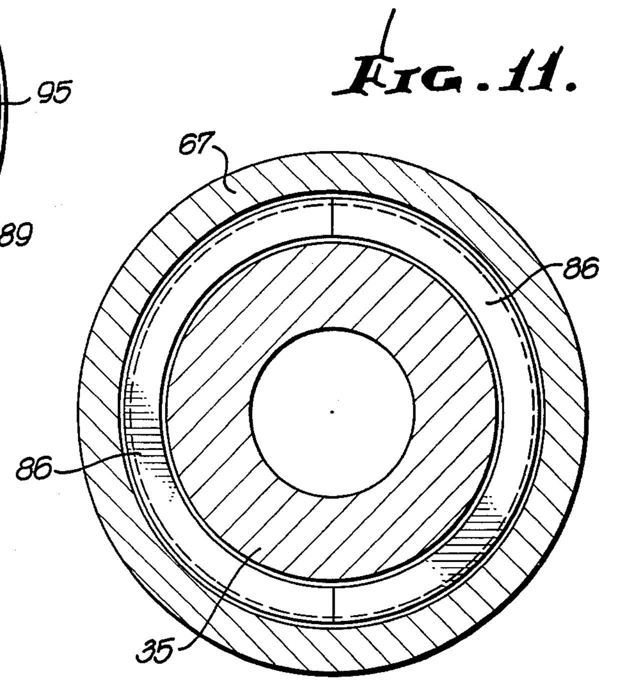


FIG. 11.



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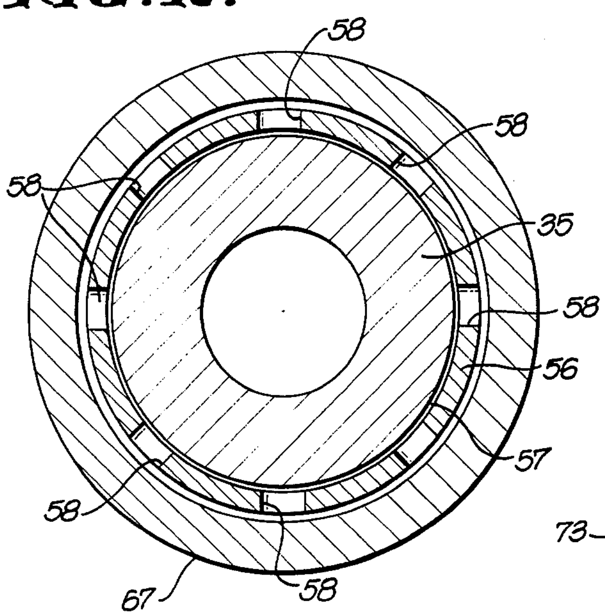

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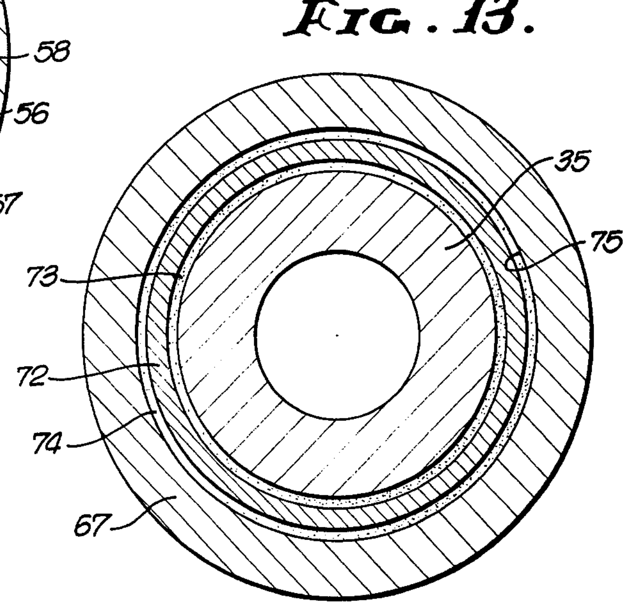

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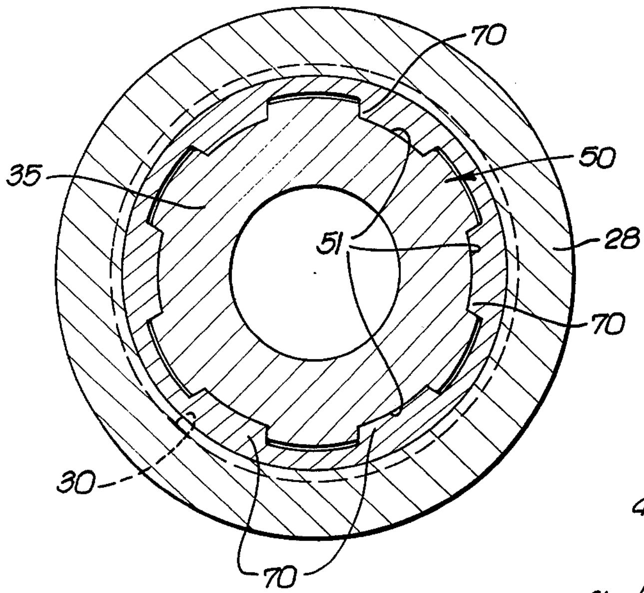

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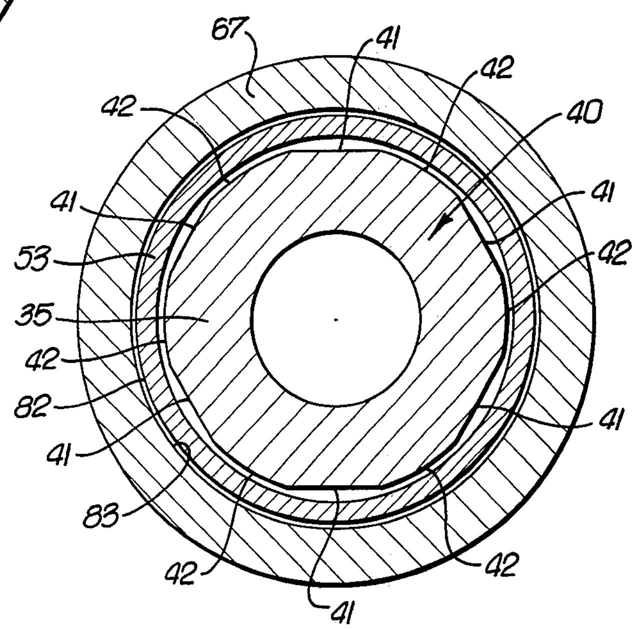

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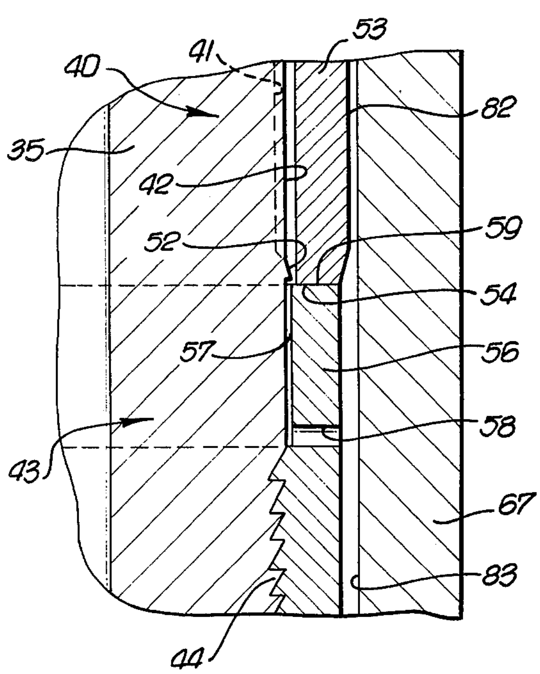

HYDRAULIC DRILLING JAR

SUMMARY OF THE INVENTION

It is a general object of the invention to provide a hydraulic jar which will excell in ruggedness jars previously available for and employed in deep well drilling.

Another object is to increase the capacity of the jar to endure jar impact and torque strains by channelling these strains preponderantly through the inner mandrel and then uniformly beefing up the inner mandrel and building this and the upper jar sub in one integral piece.

A further object is to reinforce the inner mandrel against bending strains due to direction changes in the well bore, by snuggly journalling the inner mandrel in the outer mandrel at frequent axially spaced points in the jar.

Still another object of the invention is to provide such a jar having a novel, long wearing, dashpot valve sleeve including tandem sections, one of which tightly fits the outer mandrel wall and the other of which sloppily fits a cylindrical surface provided on the inner mandrel to provide an escape orifice for the dashpot liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical sectional view partly broken away of a preferred embodiment of the invention with the parts thereof fully extended as at the moment of striking a jarring blow.

FIGS. 2 to 5 inclusive are half vertical sectional views of consecutive portions of FIG. 1 taken on line 2—5/-2—5.

FIGS. 6 to 9 inclusive are views similar respectively to FIGS. 2—5 with the parts of the invention fully retracted as when drilling with the drill resting on the bottom of the hole.

FIG. 10 is a cross sectional view taken on the line 10—10 of FIG. 2.

FIG. 11 is a cross sectional view taken on the line 11—11 of FIG. 3.

FIG. 12 is a cross sectional view taken on the line 12—12 of FIG. 3.

FIG. 13 is a cross sectional view taken on the line 13—13 of FIG. 4.

FIG. 14 is a cross sectional view taken on the line 14—14 of FIG. 5.

FIG. 15 is a double enlarged sectional view of encircled portion in FIG. 3.

FIG. 16 is a cross sectional view taken on the line 16—16 of FIG. 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring specifically to the drawings and particularly to FIGS. 1–5 inclusive, the invention is shown therein as embodied in a hydraulic jar **20** which is particularly useful in the drilling of deep oil wells. The jar **20** includes an upper sub **21** having an internally threaded box **22** with which the jar **20** may be united with the pin **23** provided at the lower end of a drill string **24**. At its lower end, the jar **20** is provided with a lower sub **25** which is provided with a threaded pin **26** from which other tool elements **27** may be suspended from jar **20**. Formed integrally with the lower sub **25** and extending upwardly therefrom is a heavy external sleeve **28** having a smooth bore **29** which is internally threaded at its upper end by heavy tapered threads **30**.

Formed integrally with upper sub **21** is a heavy tubular inner mandrel **35** which has approximately a uniform wall thickness throughout its length and extends downwardly through the jar **20** so that the lower externally threaded end portion **36** of said mandrel is disposed at all times within the bore **29** of the lower sub **25**.

In the manufacture of the upper sub **21** and mandrel **35** as a single part in the jar **20**, the mandrel has a relatively heavy wall thickness which is uniform from the upper sub **21** to the lower threaded end portion **36**, with the following exceptions: In the preferred embodiment of the jar **20** illustrated in the drawings this wall thickness is 1⅛ inches and this continues unaltered 15½ inches downardly from the shoulder **37** of the upper sub **21** formed at the juncture of said hub with said mandrel. For the next 8 inches of the mandrel **35** this is upset to provide, in the following order, an external annular stop **39**, a hex section **40** having six flat faces **41** and six arcuate faces **42**; a cylindrical section **43** and an externally threaded section **44**. For its next 13½ inches, the mandrel **35** is uniformly cylindrical with a wall thickness of 1⅛ inches, this portion being designated section **45**. The remaining 18 inches between section **45** and the lower threaded end section **36** of mandrel **35** comprises spline section **50** of said mandrel. This section has a uniform wall thickness of 1⅛ inches in which a series of parallel spline grooves **51** are milled.

The short cylindrical section **43** of mandrel **35** has a wall thickness of 1 3/16 inches which is the same wall thickness as section **40** has in the areas of the arcuate faces **42**. In the radial plane in which sections **40** and **43** meet, an annular series of circumferentially spaced lugs **52** are formed in the material of the mandrel section **40** so as to extend radially above the outer cylindrical surface of section **43** a distance of 0.0075 inches. This produces a maximum wall thickness in section **40** at the points of lugs **52** of 1.195 inches. The outside diameter of the mandrel **35** where the wall thickness of this is 1⅛ equals 4½ inches.

Slideably received by the mandrel **35** onto the hexagonal section **40** thereof is a sleeve valve **53** which is preferably formed from a Beryllium-Copper alloy, this valve having an internal diameter allowing it to just clear lugs **52**. The valve **53** is about 3 3/16 inches long and has a ground radial face **54** formed on its lower end and an annular series of radial notches **55** formed in its upper end. The sleeve valve **53** is about ½ inches shorter than the axial distance between stop **39** and lugs **52**. Also slideably received on the mandrel **35** in assembling the jar **20** is an orificing ring **56** which fits the cylindrical section **43** of said mandrel with a clearance of from 0.001 0.003 inches, the space between said ring and section **40** of the mandrel constituting a dashpot metering orifice **57** for the jar **20**. A series of holes **58** formed radially in the lower end portion of ring **56** provide an escape passage for operating oil flowing downwardly through the aforesaid metering orifice **57**. The upper surface **59** of orificing ring **56** is ground to make a close sealing fit with the ground face **54** provided on the lower end of sleeve valve **53**, the purpose of which will be made clear in the description of the operation.

The lugs **52** extend radially outwardly beyond the cylindrical surface of mandrel section **43** a distance just sufficient to overlie orificing ring **56** and confine it to its position co-extensive with section **43** when the sleeve valve **53** drifts upwardly from the ring **56** as shown in FIGS. **6** and **7**.

A retainer nut **60** is next slideably placed over the lower end of the mandrel **35** and screwed onto the threads provided by the externally threaded section **44** of the mandrel to retain orificing ring **56** and sleeve valve **53** in their assembled relations with the mandrel **35**.

As shown in FIGS. **1** and **5**, the lower threaded end portion **36** of mandrel **35** extends downwardly at all times into the heavy external sleeve **28** which is formed integrally with the lower sub **25**. Screwed upwardly onto the lower end of mandrel **35** is a hammer nut **61** which is retained in place by a snap ring **65**. The nut **61** makes a close sliding fit with the smooth bore **29** of sleeve **28** and has provided on its upper end a hardened annular hammer face **66**.

Slideably applicable upwardly over the mandrel **35** prior to the application of hammer nut **60** to said mandrel is a light-weight dashpot housing sleeve **67** and a spline sub **68** which are connected by threads **69**, said sub having external threads at its lower end which screw into the heavy tapered threads **30** provided in the upper end of lower sub **25**. The spline sub **68** has a close sliding fit with the spline section **50** of mandrel **35** and has splines **70** extending radially inwardly from the bore of said spline sub which slideably fit into the spline grooves **51** of the mandrel spline section **50**.

Provided on the lower end of spline sub **68** is a hardened annular anvil face **71**. Also slideably received on the mandrel **35** during the assembly of the jar is a metal floating packing ring **72** having internal and external O-rings **73** and **74** and making a close sliding fit with the cylindrical outer surface of mandrel section **43** and with the internal bore **75** of dashpot housing sleeve **67**. Screwed into suitable tapped holes provided in the latter sleeve are plugs **80** for use in filling an annular operating oil chamber **81** enclosed between mandrel **35** and sleeve **67** and located above floating packing ring **72**. The external cylindrical surface **82** of the sleeve valve **53** makes a close sealing fit with the bore **75** of sleeve **67** when the jar **20** is collapsed as shown in FIGS. **6–9** for purposes which will be made clear in the description of the operation.

An upper portion of the bore **75** has a counter bore **83** which is fairly shallow but affords ample clearance between said counter bore and the outer surface **82** of valve **53** for free vertical movement of said valve in said counter bore at a time and for a purpose which will also be made clear in the description of the operation.

The upper end of counter bore **83** terminates in another counter bore **84** for receiving a packing **85** for sealing off the upper end of oil chamber **81**. This packing includes a two piece junk ring **86** which fits in uper counter bore **84** against a shoulder **87** formed at the lower end thereof; packing material **88** resting on ring **86** and a two piece wear sleeve **89** which fits in the upper end of upper counterbore **84** and makes a close sliding fit both inwardly with the mandrel **35** and outwardly with the upper counter bore **84** of sleeve **67**. An upper end portion of wear sleeve **89** is turned down from the outside to provide a shoulder **90** and to receive a collar **95** shaped to fit inwardly over shoulder **90** and be screwed downwardly onto threads **96** which are recessed in the upper outer end portion of sleeve **67** so that collar **95** is flush with the outer surface of sleeve **67**.

Operation

After the jar **20** has been fully assembled as above described, the filling plugs **80**, a pair of which are provided in the sleeve **67** at diametrically opposite points therein are removed and the chamber **81** filled with a suitable operating oil after which these plugs are replaced as shown.

As previously pointed out, the jar **20** is designed primarily for use in connection with the drilling of deep wells and to replace those jars previously used in this service which have tended to develop weaknesses resulting from the abuse unavoidable in the drilling of deep wells where the lower portion of the drill string has to bend as the bore hole inclines in one direction or another from vertical. The capacity of the jar **20** to stand up under such abuse is derived from the beefed up mandrel **35** employed therein which is formed integrally with the upper sub **21** and extends without substantial diminution of wall thickness through practically the entire length of the jar so as to terminate within and in close sliding relation with the bore of the heavy external sleeve **28** which is an integral part of the lower sub **25** of the jar. Besides this unification of the structure embodied in the lower portion of the jar while the drilling is going on, this structure is further unitized by the close sliding fit of the mandrel **35** with the spline sub **68** which screws directly downwardly into the lower sub **25**.

While the mandrel **35** extends practically entirely downwardly through the other elements embodied in the jar **20**, the strength of the upper portion of the mandrel **35** is supplemented very substantially by the stabilizing effect which the floating packing ring **72** has by making a close sliding fit with both the mandrel **35** and the dashpot housing sleeve **67**. This is enhanced further by the close sliding fit made by the upper end of dashpot housing sleeve **67** with the mandrel **35** through the upper packing **85** of the jar.

A still further stabilizing action is present in the jar **20**, when the jar has collapsed as during a drilling operating, by the sleeve valve **53** making a snug sliding fit externally with the bore **75** of sleeve **67** and having only a few thousandths clearance between the inner surface of the sleeve valve **53** and the six arcuate faces **42** of the hexagonal section **40** of the mandrel **35**.

These features indicate how strength and ruggedness have been emphasized in the design of jar **20** while still providing said jar with a highly efficient tensioning dashpot section **97** which is confined to the upper half of the jar whereas the lower half of the jar provides a torque hammer-anvil and jar impact section **98** which is extremely rugged in construction.

The operation of the jar **20** in an emergency requiring the jarring loose of a tool such as a drill bit suspended therefrom will now be described. When this occurs the low **24** to lower the shoulder **37** of the upper sub **21** onto the collar **95** at the upper end of housing sleeve **67**, as shown in FIG. **6**. When, during the lowering of the mandrel **35** in this manner, the sleeve valve **53** comes to the lower end of the counter bore **83**, the friction produced by pressing sleeve valve **53** downwardly into bore **75** of sleeve **67** delays the further downward movement of sleeve valve **53** until stop **39** comes into engagement with the upper end of sleeve valve. This produces a spacing between the ground face **54** in the lower end of sleeve valve **53** and the ground face **59** on the upper end of orifice ring **56.** The lugs **52** on the mandrel **35** engage the upper ground face **59** of lower orifice ring **56** so as to cause this to remain in its normal position opposite the cylindrical section **43** of the mandrel **35** and thus continue its downward travel with mandrel **35.** When the stop **39** in its downward movement comes into contact with the sleeve valve **53** and starts it into the bore **75** of sleeve **67,** a space has been produced between the ground meeting faces of the sleeve valve **53** and the orificing ring **56** so as to allow oil to continue to flow upwardly past the sleeve valve **53,** this oil now passing inwardly between the orificing ring **56** and sleeve valve **53** and upwardly through the escape passages provided by the six flat faces **41** in hexagonal section **40** of the mandrel and outwardly from the upper end of said passages through the notches **55** formed in the upper end of sleeve valve **53.**

With the parts of the jar **20** thus disposed as shown in FIGS. **6, 7, 8** and **9,** and with the sleeve valve **53** disposed deep in the bore **75** of the sleeve **67,** the drill string **24** is now placed under an upward strain. This tends to withdraw the mandrel **35** upwardly through the tensioning dashpot section **97.** The operating oil in the chamber **81** above sleeve valve **53** is placed under an extremely high pressure because it is unable to escape downwardly between the sleeve valve **53** and the bore **75** confining said sleeve valve because of the tight fit therebetween. The only passageway permitting the compressed operating liquid to escape is the metering orifice **57** between the orificing ring **56** and the cylindrical section **43** of the mandrel **35.** This orifice is purposely made to provide an escape of compressed liquid at just that rate which will be adequate to retard the upward withdrawal of the mandrel **35** from its downwardmost position shown in FIGS. **6, 7, 8** and **9** so that the drill rig operator will be able to apply exactly the desired tension on the drill string **24** in a minimum of time for the proper operation of the jar **20** at the moment the sleeve valve **53** travels upwardly so as to be entirely within the counter bore **83** of the sleeve **67.** When this moment arrives, the mandrel **35** is no longer restrained from responding to the tremendous tension placed upwardly on the drill string **24** and jumps upwardly in response to said tension through the remaining distance necessary to apply the hammer face **66** to the anvil face **71** with a resounding impact.

To reset the jar **20,** the rig operator merely needs to lower the drill string **24** again to return the mandrel **35** to its lowermost position in the jar as shown in FIGS. **6, 7, 8** and **9.**

It is desired to point out that the orificing ring **56** does not make a close sliding fit with bore **75** of sleeve **67** so that it is not necessary to make orificing ring **56** of bearing material as is the case with the sleeve valve **53.** It is thus possible to employ a high carbon steel for the ring **56** and after the grinding operation to provide the ground face **59,** the same is hardened preferably to a rockwell hardness of 36-60. Due to the great tensil strength of the material used in making orificing ring **56,** there is no tendency of this ring to yield to the very high hydraulic pressure of the operating oil escaping downwardly through the metering orifice **58** during the tensioning of the jar **20** in a jar stroke. While notches **55** formed in the upper end of the sleeve valve **53** are a convenient way of permitting the escape of operating liquid upwardly past sleeve valve **53** during a resetting movement of the jar **20,** it is to be understood that any expedient permitting such escape of operating oil upwardly from within the sleeve valve **53** when the upper end of the latter is in contact with the stop **30** may be employed and be the mechanical equivalent of the notches **55.**

When the mandrel **35** moves downwardly through the sleeve valve **53** incidental to resetting the jar for another jarring stroke, it is highly desirable that the orificing ring **56** be held in its normal position opposite the mandrel section **43** and the lugs **52** are provided for accomplishing this purpose. This is effected by the inner diameter of the sleeve valve **53** being slightly greater than the inner diameter of the orificing ring **56** so that the sleeve valve **53** clears the lugs **52** when assembling the jar whereas the orificing ring **56** is unable to do this and is halted by said lugs when the resetting downward motion of the mandrel **35** moves the orificing ring **56** downwardly out of contact with the sleeve valve **53,** thereby providing for the operating oil (being compressed in the chamber **31** by the downward travel of sleeve valve **53**) to flow inwardly between valve **53** and ring **56** and then upwardly between valve **53** and hexagonal mandrel section **40** and out through the notches **55** in the upper end of valve **53.**

I claim:

1. A hydraulic drilling jar comprising

an upper sub provided with a threaded box for suspending the jar from the lower end of a drill string;

a lower sub provided with a threaded pin for suspending a tool assembly from said jar, said lower sub terminating integrally upwardly in a heavy external sleeve;

a spline sub, interconnected at its lower end with said lower sub to bare an annular anvil face on the lower end of said spline sub, the bore of said spline sub having splines extending radially inwardly from said bore;

a heavy tubular jar mandrel formed integrally with said upper sub and being integral, with an approximately uniform wall thickness, throughout its length, said mandrel slideably fitting within said spline sub bore and extending down through the spline sub, grooves being provided externally lengthwise where necessary in said mandrel to slideably receive said splines;

hammer means on the lower extending end portion of said mandrel, said means having an annular hardened hammer face exposed upwardly in opposition to said anvil face;

relatively light sleeve means provided on the upper end of said spline sub and extending upwardly in sheathing spaced relation with said mandrel; and

dashpot hydraulic jar tensioning and tripping means mounted in the annular space between said light sleeve means and said mandrel.

2. A jar as recited in claim **1** wherein

said lower sub sleeve is internally threaded at its upper end,

said spline sub is externally threaded at its lower end,

said spline sub screws downwardly into said lower sub sleeve, and wherein

the bore of said lower sub sleeve exceeds that of said spline sub to provide an annular space between the wall of said lower sub sleeve and said mandrel to accommodate aid hammer means in vertical opposition with said annular anvil face on the lower end of said spline sub.

3. A jar as recited in claim 1 wherein
said hammer means comprises an annulus fitting externally on the lower extending end portion of said mandrel; and
means for removably securing said annulus on said mandrel.

4. A jar as recited in claim 2 wherein the lower end portion of said mandrel is externally threaded, and wherein
said hammer means comprises an internally threaded nut which screws onto the lower end portion of said mandrel.

5. A jar as recited in claim 1 wherein
the jar mandrel is reinforced at spaced points against bending strains imposed during drilling operations by (A) a close co-axial sliding relation between said hammer means and the bore of said lower sub sleeve, (B) by a close co-axial sliding relation between said mandrel and the bore of said spline sub, (C) by a close co-axial sliding relation between a lower sliding seal ring of said dashpot mechanism, said mandrel and said dashpot enclosing sleeve, (D) by a close co-axial sliding relation between a dashpot sleeve valve, said mandrel and said dashpot enclosing sleeve, and (E) by a close co-axial sliding relation between said mandrel, on the one hand, and an upper annular seal of said dashpot mechanism and said dashpot enclosing sleeve, on the other hand.

6. A jar as recited in claim 1 wherein
said dashpot hydraulic jar tensioning and tripping means comprises:
vertically spaced upper and lower seals confining a body of operating oil in an annular chamber disposed between an upper portion of said mandrel and said light weight sleeve;
a sleeve valve;
a sleeve valve stop formed radially from said mandrel and located just below said upper seal, when said jar is in extended position;
said light weight sleeve bore having a counter bore located just below said upper seal;
an orifice ring disposed below and supporting said sleeve valve;
a retainer nut screwed onto threads provided on said mandrel, said nut supporting said ring;
lip means formed on said mandrel and cooperating with said retainer nut to limit the freedom of said ring for vertical movement relative to said mandrel;
said mandrel having lengthwise passages formed externally therein between said stop and said lip means, said mandrel presenting a smooth cylindrical surface under said orifice ring with which surface the bore of said orifice ring makes a slightly loose fit to provide a metered escape orifice during tensioning of said jar,
the abutting faces of said orifice ring and said sleeve valve being ground to prevent liquid escaping radially therebetween during said jar tensioning;
there being a free radial passage means connecting said escape orifice with the low pressure oil chamber area below said sleeve valve;
said sleeve valve having free passage means at its upper end to allow free passage of oil upwardly from within said valve during retraction of said jar to reset the same for a jarring operation;
said sleeve valve making a loose fit with said counter bore of said light sleeve but a liquid tight fit with the sleeve bore below said counter bore in which said valve functions as a dashpot during the tensioning of the jar.

7. In a hydraulic deep well tool the combination of:
telescopically related internal and external mandrels, one mandrel having means at its outer end to connect said tool to a drill string, the other mandrel having means at its outer end for suspending other tool elements from said tool;
spline means transmitting torque from one of said mandrels to the other mandrel;
stop means limiting telescopic movement between said mandrels;
vertically spaced primary and secondary annular seals for confining a body of operating oil in an annular chamber formed between said mandrels and said seals;
a sleeve valve occupying a position in said chamber close to said primary seal when said mandrels are in an extended relation;
a sleeve valve stop means formed radially outwardly from said internal mandrel between said primary seal and one end of said sleeve valve and spaced a short distance from the latter;
said external mandrel having a bore with which said sleeve valve makes a close sliding fit;
an orifice ring abutting the other end of said sleeve valve;
a retainer nut screwed onto threads provided on said internal mandrel and backing up said orifice ring;
radial lip means formed on said internal mandrel and cooperating with said nut to limit vertical movement of said orifice ring relative to said internal mandrel;
said internal mandrel having lengthwise passages formed externally therein between said stop and said lip means;
said internal mandrel presenting a smooth cylindrical surfance between said lip means and said nut, with which surface the bore of said orifice ring makes a slightly loose fit to provide a metered escape orifice during a tensioning telescopic movement in a given direction between said mandrels;
the abutting radial end faces of said orifice ring and said sleeve valve being ground to prevent liquid escaping radially therebetween during said tensioning movement;
a free radial passage being provided connecting said escape orifice with the low pressure area of said oil chamber;
passage means being provided for the escape upwardly of oil trapped between said mandrel, said stop and said sleeve valve when said stop is engaged by said valve during a relaxing telescopic movement in an opposite direction between said mandrels.

8. In a telescopic oil well tool, the functioning of which depends upon hydraulic damping of relative axial movement between the telescopic parts thereof in a given direction, the combination of:
an internal mandrel;

an external mandrel telescopically receiving said internal mandrel and spaced therefrom to provide an annular operating oil chamber therebetween;

axially spaced annular seal means sealing off upper and lower ends of said chamber;

axially spaced upper and lower valve stops extending radially externally from said inner mandrel;

an orifice ring closely spaced from said internal mandrel and resting on said lower stop, there being a cylindrical external face on said internal mandrel co-extensive axially with said ring to form a dash-pot orifice between said face and the bore of said ring;

means cooperating with said lower stop to confine said ring in axially juxtaposed relation with said face;

a sleeve valve surrounding said internal mandrel between said ring and said upper stop and having free play to shift vertically therebetween, said valve having a liquid tight sliding fit with the bore of said external mandrel, the abutting ends of said ring and valve having true radial ground faces preventing escape of oil radially between said valve and ring when said ring is lifted against said valve by pulling upwardly on said internal mandrel, there being oil escape passages formed lengthwise externally in said internal mandrel between said upper stop and said orifice ring, there also being passage means allowing oil to escape upwardly from said oil escape passages when said valve is caused to engage said upper stop when said internal mandrel is telescopically lowered in said external mandrel.

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