Oct. 22, 1968 C. B. FALKNER, JR 3,406,537

SHOCK ABSORBING SUBASSEMBLY

Filed Feb. 21, 1966

FIG. 1.

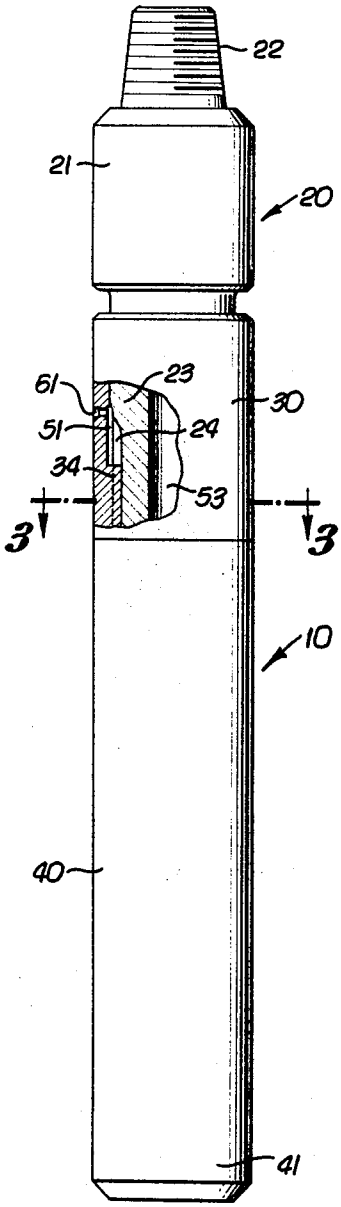


FIG. 2a

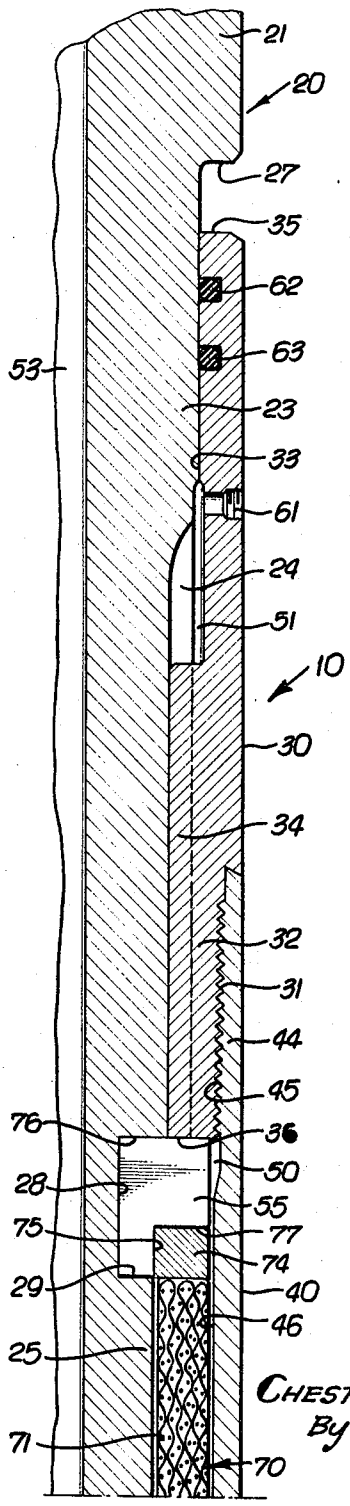


FIG. 2b.

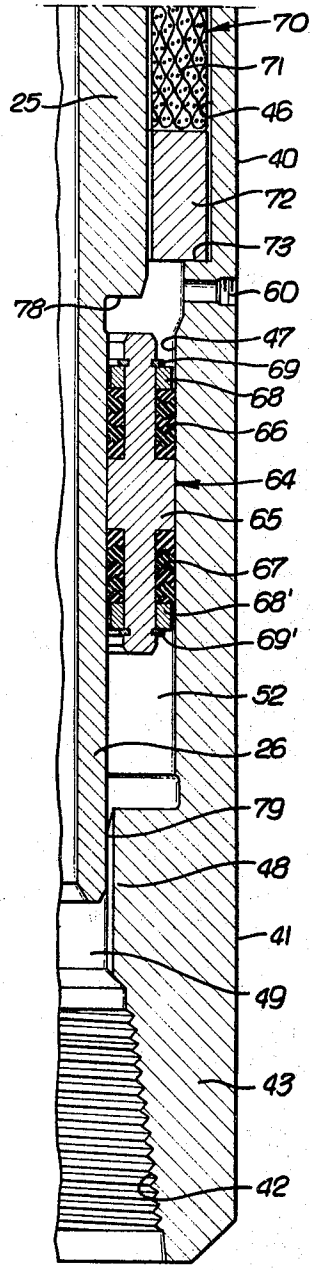
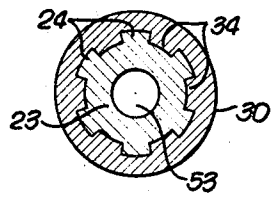


FIG. 3.



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SHOCK ABSORBING SUBASSEMBLY

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ABSTRACT OF THE DISCLOSURE

A shock absorbing subassembly for a well drilling string in which a force dampening and cushioning means of metal mesh is adapted to be compressed within an annular chamber filled with a non-compressible fluid. A floating seal at one end of the chamber retains the non-compressible fluid within the chamber and also seals the chamber from well fluids to prevent contamination of the force dampening means by such well fluids.

This invention relates in general to oil well drilling operations and in particular to subassemblies placed in the drilling string above the drilling bit to absorb vibrations, shock or impact loading otherwise imparted to the drilling string from the drilling bit during drilling operations.

In drilling oil wells on land or in sub sea environments, the drill bit generates considerable impact loads, shocks and vibrations, which, if allowed to be transmitted into the drilling string through the drill collar connecting the string and bit, causes metal fatigue and eventual cracking and failure of the collar. Also, the drilling bit life is shortened and the drilling bit can not be maintained against the hole bottom continuously.

It is therefore the primary object of the present invention to disclose and provide a shock absorbing subassembly for use in an oil well drilling string immediately above the drilling bit to cushion drill string weight against the drilling bit and to dampen and absorb bit induced vibrations, shocks and impact loads to isolate such vibrations, shocks and loads on the drill bit from the drilling string above the assembly while the drilling bit is constantly urged against the bottom of the well hole being drilled.

It is also a principal object of the present invention to disclose and provide a shock absorbing subassembly as in the foregoing object wherein the assembly includes a dampening, cushioning and shock absorbing element having operational characteristics which remain relatively constant under drilling conditions and are not affected by age, temperature, speed of loading or contact with oil or drilling fluids.

It is another object of the present invention to disclose and provide a shock absorbing subassembly as in the foregoing objects wherein the dampening element is operably interposed between a mandrel and body portion in load bearing relation within an annular chamber formed between the mandrel and body and a chamber portion is filled with an oil or hydraulic fluid to protect the internal working parts of the assembly within the chamber by an oil bath.

It is a still further object of the present invention to disclose and provide a shock absorbing subassembly as in the foregoing objects wherein an annular chamber portion is maintained full of such hydraulic fluid or oil under a slight pressure although the chamber size varies under deflection of the mandrel relative to the assembly body.

These and various other objects and advantages of the shock absorbing subassembly, of the present invention, will become apparent to those skilled in the art from a consideration of the following detailed explanation of an

exemplary embodiment thereof. Reference will be made to the appended sheet of drawings in which:

FIG. 1 is an elevation view, partly in section, of an exemplary embodiment of shock absorbing subassembly according to the present invention;

FIGS. 2*a* and 2*b* are a section view of the exemplary embodiment of subassembly of FIG. 1; and

FIG. 3 is a cross-sectional view of the exemplary embodiment of subassembly of FIG. 1 taken therein along the plane 3—3.

Referring first to FIG. 1, an exemplary embodiment of shock absorbing subassembly, in accordance with the present invention, is shown with a body portion, indicated generally at **10** and a mandrel, indicated generally at **20**, operably received into the body. The body portion includes a drive sub portion **30** and a lower or driven sub portion **40**. As seen in FIGS. 2*a* and 2*b*, the body portions **30** and **40** provide a longitudinally extending bore of varying diameter to receive the mandrel, indicated generally at **20**, which also has varying diameter portions.

The mandrel, indicated generally at **20**, includes a head portion **21** which is positioned upwardly of the body portions **30** and **40** and has an exterior diameter approximately identical to that of body portions **30** and **40**. Connecting means are provided at this upward end of the mandrel for connecting the mandrel and assembly into a drilling string. In the exemplary embodiment, such connecting means includes the provision of a threaded tool joint pin portion **22**, as seen in FIG. 1, for coupling the subassembly to the lower end of a drilling string. As seen in FIG. 2*b*, the body lower driven sub portion **40** is provided with connecting means at its lower end **41** for connecting a conventional drill bit to the assembly. The exemplary tool bit connecting means at the lower end of the body includes the provision of internal threads **42** in the tool joint box portion **43** of the body.

Body sub portions **30** and **40** are coupled together by a threaded connection as best seen in FIG. 2*a*. An upper end **44** of the body sub portion **40** is provided with internal threads **45** which are engaged with the exterior threads **31** provided on the lower end **32** of the drive sub portion **30**.

Drive sub portion **30** of the body, indicated generally at **10**, includes a longitudinally extending bore **33** which is adapted to slidably receive the reduced diameter portion **23** of the mandrel, indicated generally at **20**. Interior splines **34** are provided within the drive sub portion **30** of the body to mate wtih exterior splines **24** provided in the reduced diameter portion **23** of the mandrel. The mandrel is thus adapted to be slidably and non-rotatably received into the drive sub portion **30** of the subassembly body, indicated generally at **10**.

The mandrel and body form an annular chamber **50** therebetween, as best seen in FIGS. 2*a* and 2*b*. Annular chamber **50** may communicate with an upper oil passage **51** between the splined portions of the drive sub and mandrel to oil port **61** in sub **30**. An upper portion of annular chamber **50** is provided between a still further reduced diameter portion **25** of the mandrel and an upper inner bore portion **46** of the lower driven sub portion **40** of the subassembly body. A lower chamber portion **52** may be provided, as best seen in FIG. 2*b*, between a tail further reduced or bottom end **26** of the mandrel and a lower inner bore portion **47** of the lower body **40**. Lower body or driven sub portion **40** is provided with an inwardly thickened wall portion **48** providing a bore **49** to slidably receive the mandrel tail or lower end portion **26** to axially align the mandrel within the body. An upwardly axially spaced mating alignment surface is provided on the reduced diameter portion **23** slidably received within the bore **33** of upper body or drive sub portion **30** above the splined torque transmitting portions

24 and 34 of the mandrel and body, respectively. The mandrel and body portions are thus axially aligned, are allowed relative longitudinal sliding movement and define an annular space or chamber therebetween over a portion of their common longitudinal extent.

Means are provided for limiting the relative longitudinal movement between the mandrel, indicated generally at **20**, and the body, indicated generally at **10**, to maintain the subassembly in its assembled relationship. As seen in FIG. 2*a*, the upper or drive sub portion of the body is provided with an annular end face **35**. An opposed annular seating surface **27** is formed in the mandrel between the reduced diameter portion **23** and head portion **21**. Longitudinal relative movement between the mandrel and body whereby the mandrel is moved inwardly of the body is thus limited by the head portion abutting the upper or drive sub portion of the body, the opposed surfaces **27** and **35** being thereby brought into abutting relation. In the exemplary embodiment of FIGS. 2*a* and 2*b*, the mandrel is shown in its fully protracted or extended relation to the body and the distance between surfaces **27** and **35** represents the maximum deflection of, or relative movement between, the mandrel and body. Further upward or withdrawal movement of the mandrel relative to the body is prevented by the provision of a split ring **55** on the mandrel which abuts the bottom end surface **36** of the drive sub bottom end **32** within the upper end **44** of the lower or driven body portion **40**. The split ring **55** may be assembled into a recess **28** provided in the mandrel below the spline portions **24** of the mandrel. The split ring **55** is provided with sufficient width to extend outwardly of the mandrel reduced portion **23** and its splines **24** to contact the underside of the lower end **32** of the drive sub as well as the lower end of the drive sub splines **34**. A lifting or upward movement of the mandrel will transmit lifting forces from the recess side wall **29** of the mandrel, through the split ring **55** to the undersurface **36** of the drive sub **30** and thus prevent separation of the mandrel from the body while allowing the limited deflection or relative movement between the mandrel and body allowed by the spacing of mandrel surface **27** and drive sub upper end surface **35**.

Annular dampening means are provided between the mandrel and body for absorbing and dampening vibrations and impact loads applied to the body by the drilling bit to prevent transmission thereof into the drilling string above the assembly. In the exemplary embodiment, such annular dampening means are indicated generally at **70** in the upper portion of chamber **50** between the reduced diameter portion **25** of the mandrel and the inner upper bore portion **46** of the body lower part or driven sub portion **40**. The annular dampening means preferably comprises a plurality of stainless steel spring-like wires woven into a cloth-like mesh which is gathered and compressed into an annular, resilient non-linear deflection element **71**. In making the deflection or cushion element **71**, the stainless steel spring-like wire mesh may be coiled into an annular configuration and compressed in a conventional forming die to form it into an annular resilient cushion of woven steel wires.

Mounting means are provided for positioning and mounting the deflection or cushion element **71** within the body in a load bearing relation between the mandrel and body. As seen in FIG. 2*b*, a lower thrust ring **72** is positioned within the body bore **46** on a thrust ledge **73** formed within the body lower or driven sub portion **40**. The annular deflection or cushion element **71** is seated upon the thrust ring **72** within the body while the mandrel reduced diameter portion **25** is free to slide or move vertically within the element **71** and thrust ring **72**. As seen in FIG. 2*a*, a split retainer ring **74** is provided at the upper end of element **71** to retain it within the body and to transmit loading thereon, as from drill string weight for example, from the mandrel. Split ring **55** received within the mandrel recess **28** is provided with a cutout corner recess **75** to receive the generally square cross-section retainer ring **74**. Drill string weight or other loading on the mandrel is thus transmitted from the mandrel recess upper surface **76**, through split ring **55** to retainer ring **74** and into the dampening and cushion element **71**. Element **71** therefore serves as a cushion for loading on the mandrel, as by the weight of the drill string, and dampens, absorbs and cushions vibrations and any shock or impact loading applied to the body by an associated drill bit to prevent such vibrations, shocks or impact loads from being transmitted into the drill string above the assembly.

Longitudinal thrust loading of the lower body portion and associated drill bit during drilling operations is transmitted from the mandrel through the deflection or cushion element **71** to the lower body. Such thrust loading between the mandrel and body is transmitted between the mandrel surface **76** and its associated ring load transmitting surface **77** and the opposed thrust receiving ledge or surface **73** on the body. In order to maintain the drill bit on the bottom of the well hole during drilling, considerable thrust loads must be transmitted from the mandrel to the body through the deflection and cushion element **71**. The preferred form of non-linear deflection element made of compressed stainless steel spring wire allows the application of such drilling loads without deteriorating because of age, temperature, speed of loading or contact with oil or drilling fluids. As loads are applied to the drilling bit through the drill string, the dampening or cushion element **71** is longitudinally compressed and confined within the annular chamber. Relative motion between adjacent wires of the element occurs during such change in configuration, the relative movement resulting in frictional and stressing forces between adjacent wires which provide high energy absorbing characteristics of the cushioning and dampening element.

The internal working parts of the subassembly between the mandrel and body in the exemplary embodiment are protected from abrasives, cuttings or other foreign particles which may be present in the drilling fluid passing through the mandrel inner bore **53**. There may also be circulating fluids surrounding the body of the sub assembly which contain abrasives, cuttings or other contaminants which would interfere with the continued reliable operation of the sub assembly if admitted into the annular chamber formed between the mandrel and body.

In the exemplary embodiment, means are provided for introducing oil into the annular chamber formed between the mandrel and body to envelop the splines **24**, **34** and cushion element **71** in a protective oil bath. An oil introduction port **60** is provided in the lower or driven sub portion of the body, as seen in FIG. 2*b*, below the element **71**. The upper oil port **61**, as seen in FIG. 2*a*, is provided to insure complete filling of the annular chamber with oil during assembly of the apparatus as hereinafter described.

The upper portion of annular chamber **50** into which oil is introduced, is sealed off from the exterior of the body and interior of the mandrel in order to provide an enclosed annular oil bath chamber in which the oil bath is contained. As seen in FIG. 2*a*, drive sub seals **62** and **63** are provided within the upper end of the drive sub portion **30** to seal about the reduced diameter portion **23** of the mandrel. Seals **62** and **63** may comprise conventional resilient O-ring packing or sealing means. These drive sub seals **62** and **63** seal off the chamber **50**, and upper chamber portion **51**, from the exterior or surrounding environment outside of the body while allowing relative sliding movement between the mandrel and upper body, or drive sub portion **30**.

A floating seal assembly means is provided within the lower portion **52** of chamber **50** for sealing off the upper portion of the chamber from the interior of the mandrel while allowing for fluid movement in the enclosed oil bath chamber occurring during deflection or relative movement of the mandrel within the body. As best seen

in FIG. 2*b*, such floating seal means in the exemplary embodiment includes a floater ring **65** of cruciform cross-section slidably received between the mandrel portion **26** and body bore **47**. Ring **65** mounts a pair of radially spaced upper body packings **66** and a pair of radially spaced lower mandrel packings **67**. A body packing end ring **68** and a mandrel packing end ring **68'** are held in place on the floater ring, to maintain the packings **66** and **67** in operable relation to the ring **65**, by retainers **69** and **69'**. The central portion of the cruciform cross-section floater ring **65** has inner and outer circumferential surfaces slidably engaging surfaces of the mandrel and body sub respectively.

Floater seal means, indicated generally at **64**, may tend to move longitudinally of the body with the deflection or relative movement of the mandrel within a body. The floater also compensates for thermal expansion of the hydraulic fluid, such as oil, within the annular chamber defined between the seals **63** and **64**. The packing or seal element **66** and **67** of the floater seal means are pressure-energized by the end rings holding them on the floater ring **65** and are preferably molded from an oil-resistant elastomer compound.

To assemble the exemplary subassembly, the mandrel, indicated generally at **20**, may be held by clamping in a vise positioned about the mandrel head **21**. The drive sub or upper body portion **30** is then installed onto the mandrel with the drive sub seals **62** and **63** already assembled therein. The drive sub seal **62** and **63** are preferably lubricated with a non-detergent lube oil prior to such assembly to the mandrel.

After the drive sub body portion **30** has been placed upon the mandrel, the split ring **55** and split retainer ring **74** are positioned on the mandrel, ring **55** limiting sliding movement of the drive sub body portion **30** relative to the mandrel. The dampening or shock absorbing element **71** may then be placed on the mandrel below ring **74** with the thrust ring **72** assembled about the mandrel to the underside of the element **71**.

The exemplary floater seal means, indicated generally at **64**, is then assembled onto the mandrel with the floater ring **65** upper end against the lower shoulder **78** of the mandrel reduced diameter portion **25**. The lower or driven sub body portion **40** may then be assembled about the mandrel and connected by threads **45** to the drive sub threads **31**. The drive sub threads should be coated with high pressure thread lubricant prior to such assembly.

The shock subassembly is then preferably placed in a horizontal position with the oil port **60** in the drive sub facing upwardly. A conventional oil fill hose may then be connected to the oil fill port **60** in order to fill the annulus between the mandrel and body with hydraulic fluid, such as oil. The annulus will be full when oil overflows port **60**.

In order to properly place the floater seal means, indicated generally at **64**, in operative position, a conventional floater locator may be introduced through the slot **79** in the bore **49** of the lower body and against the floater ring. By plugging port **60** after the overflow of oil therefrom has been detected, a slight oil pressure may be produced within the annulus by an oil fill pump operating through port **60**. When sufficient oil under pressure has been introduced into the annulus to move the floater seal, indicated generally at **64**, approximately one inch, the oil bath and floater seal means are in operable condition. The floater locating means may then be removed from the slot **79** and the port **60** closed by a conventional oil plug.

The subassembly is thereby placed in operable condition ready to be inserted into a drilling string immediately above a conventional drilling bit. It can be seen from the foregoing detailed explanation of an exemplary embodiment of shock subassembly, according to the present invention, that the foregoing objects have been attained.

The shock absorbing subassembly, according to the present invention, allows transmission of drilling loads to the drill bit while cushioning the drill string weight upon the drill bit during relative movement therebetween. The stainless steel wire mesh dampening element **71** maintains relatively constant operating characteristics in absorbing bit induced vibrations, shocks or impact loads without being affected by age, temperature, speed of loading or contact with oil or other fluids. The bit vibrations, etc. are not transmitted to the drill string or collar connecting the string and assembly and the bit is urged against the bottom of the well hole constantly.

The internal working parts of the assembly including the splined torque transmitting portions **24** and **34** of the mandrel and body drive sub, and the dampening element, may be enveloped in a protective oil bath within the annular chamber defined by the spaced seal means in the annulus formed between the mandrel and body. Oil pressure in the annular chamber is virtually the same pressure as that within the mandrel bore and is maintained by the provision of the floating seal means.

Drilling torque is transmitted to the bit through a preferably heavy splined engagement between the mandrel and body while the mandrel is free to deflect relative to the body through a limited extent. The subassembly then operates to transmit drilling torque and thrust to the drilling bit but absorbs or isolates the bit vibrations, shocks or impact loads experienced during normal drilling operations.

Having thus described an exemplary embodiment of the shock absorbing subassembly according to the present invention, it should be understood that the herein disclosed embodiment is exemplary only and that various alterations, modifications and adaptations may be made thereon within the scope of the present invention which is defined and limited only by the following claims.

I claim:

1. A shock absorbing subassembly for use in an oil well drilling string above the drilling bit to isolate bit induced vibration and impact loads from the drill string above the assembly, said subassembly comprising:

a body having a longitudinally extending bore and connecting means at one end for connecting to a drill bit;

a mandrel non-rotatably received in said body and forming an annular chamber having upper and lower portions therewith, said mandrel having connecting means at an end outwardly of said body for connecting to a drill string;

means for providing limited relative longitudinal movement between said mandrel and body;

seal means between said mandrel and body for sealing off said annular chamber from the interior of said mandrel and the exterior of said body;

opposed load transmitting surfaces on said mandrel and body within said chamber for transmitting longitudinal thrust loading between said mandrel and body; and

annular damping means comprising spring-like stainless steel wire woven into a cloth-like mesh and compressed to a desired annular shape to provide non-linear deflection characteristics to the mandrel and body assembly,

said annular damping means positioned within said upper chamber portion in thrust transmitting relation between said opposed surfaces for dampening and absorbing vibrations and impact loads applied to the annular ends thereof by said mandrel and body opposed load transmitting surfaces.

2. A subassembly for use in a well drilling string including a body, a mandrel slidably and non-rotatably received in the body and means for providing limited relative longitudinal movement therebetween, the combination therewith of:

an annular dampening means between said mandrel and body for absorbing and dampening vibrations and impact loads applied to said body, said dampening

means including a woven mesh of steel spring-like wire compressed into an annular, resilient non-linear deflection element;

and means on said body and means on said mandrel in engagement with opposite ends of said dampening means for compressing said dampening means; and

seal means spaced from each of the ends of said dampening means and confining an oil bath means for said dampening means in a closed variable volume defined by the limited relative longitudinal movement of the body and mandrel.

3. The provision of claim 2 wherein:

said seal means includes at least one floating seal means between said mandrel and body movable longitudinally within said body, while sealing between said body and mandrel, under influence of hydraulic fluid pressures exerted thereon by said oil bath means.

4. A shock absorbing sub assembly for use in an oil well drilling string above the drilling bit to isolate bit induced vibrations and impact loads from the drill string, said sub assembly comprising:

a body having a longitudinally extending bore and means at one end for connecting to a drill bit;

a mandrel longitudinally slidably and non-rotatably received in said bore, said mandrel and body bore defining an annular chamber therebetween over a portion of the common longitudinal extent;

means for limiting relative longitudinal movement between said mandrel and body;

vibration dampening and shock cushioning means within said annular chamber for dampening and cushioning vibrations and impact loads transmitted thereto,

said dampening and cushioning means including spring-like wire woven into a mesh and compressed into a resilient non-linear deflection element of generally annular shape to fit within said body bore;

means for mounting said cushioning means within said body bore;

means for seating said mandrel on said dampening and cushioning means; and

seal means provided between said body and mandrel spaced from each end of said dampening and cushioning means to provide an enclosed annular chamber about said dampening and cushioning means,

said chamber being filled with oil to envelop said dampening and cushioning means within an oil bath to isolate it from fluid within said mandrel or outside of said body,

one of said seal means being responsive to well fluids passing through said mandrel and responsive to displacement of oil within said annular chamber.

5. A sub assembly as stated in claim 4 wherein said one of said seal means includes a seal body member of cruciform cross-section having sliding engagement with said sub body and mandrel.

6. In a shock absorbing subassembly for a drilling string the combination of:

a sub body means having a through bore;

a mandrel receivable within said bore and having an external shoulder cooperable with one end of said body means for limiting relative movement in one direction;

said body means and said mandrel defining an annular chamber having an upper chamber portion and a lower chamber portion;

means carried by said mandrel at the upper end of said upper chamber portion cooperable with said body means for limiting relative movement between said mandrel and body means in a direction opposite to the first above-mentioned direction;

an annular body of compressed spring-like wire mesh having resilient non-linear deflection characteristics retained within said upper chamber portion,

the upper end portion of said annular resilient body being seated against said means limiting movement carried by said mandrel,

the lower end of said resilient annular body being provided a seat on said body means;

a floating seal means positioned within said lower chamber portion and having sliding sealing engagement with said mandrel and said body means;

said upper chamber portion being substantially filled with a non-compressible fluid, said fluid being in contact with the upper end of said floating seal means;

means on said body means for aligning and receiving the lower end of said mandrel and providing communication of well fluids passing through said mandrel with the portion of the lower chamber portion below said floating seal means;

and means for transmitting rotation of said mandrel to said body means.

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