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Young

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[54] **SPRING LOAD SYSTEM FOR DRILL STRING SHOCK ABSORBERS**

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[52] **U.S. Cl.** **64/23,** 175/321, 285/302, 403/166

[51] **Int. Cl.** **E21b 17/04**

[58] **Field of Search** ..... 64/23, 15 C, 13; 175/321; 285/302; 267/166, 174, 180, 168; 403/359, 166, 165, 164; 192/109 F

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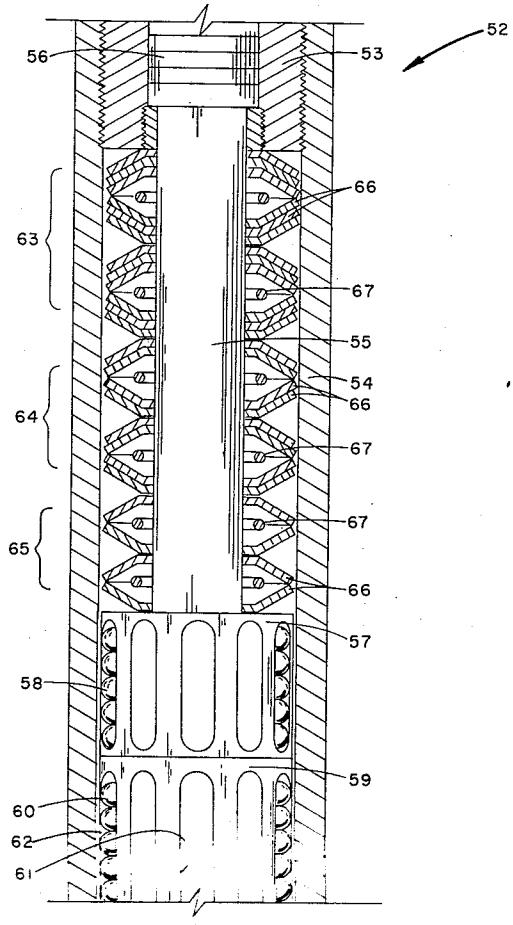
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[57] **ABSTRACT**

A shock absorbing torque transmitting well tool is disclosed that includes an outer member and an inner member telescopically arranged. A spline means between said outer member and said inner member transmits torque. A spring means is positioned between the outer member and the inner member. The spring means includes a multiplicity of spring segments arranged in discrete spring units having different spring rates. The spring means will accommodate a wide range of loads or rapidly varying load situations. The tool operates effectively in holes started from the surface with very little weight on the bit and continues to operate effectively as the weight on the bit is increased.

10 Claims, 3 Drawing Figures



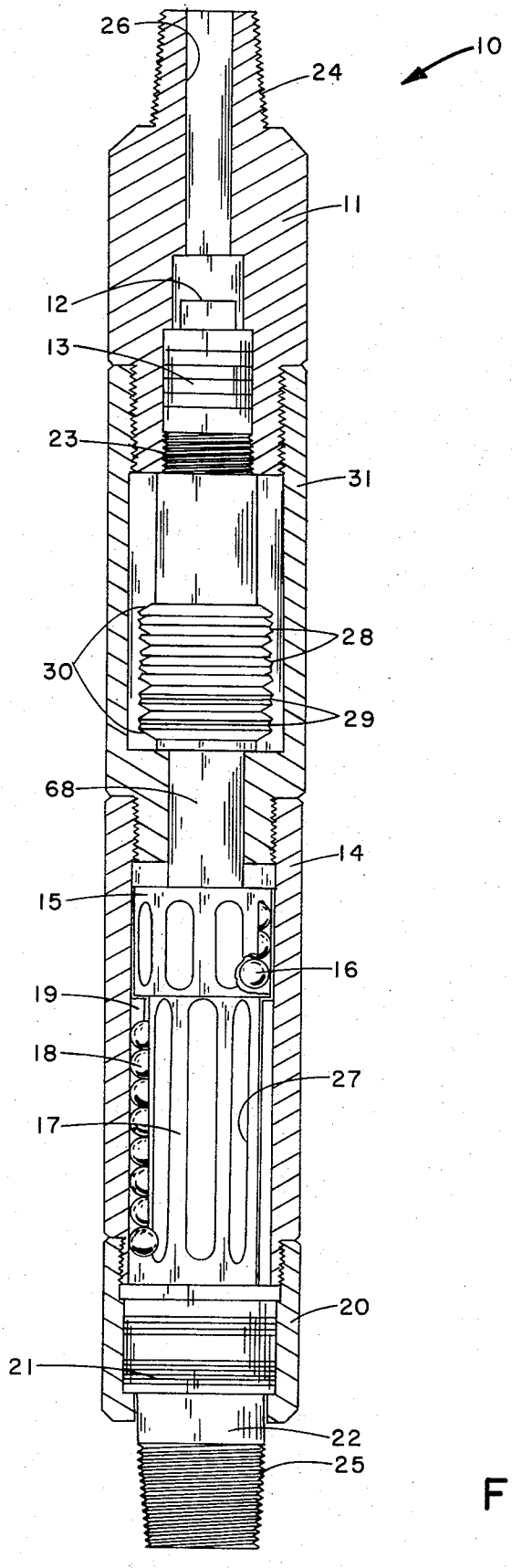


FIG. 1

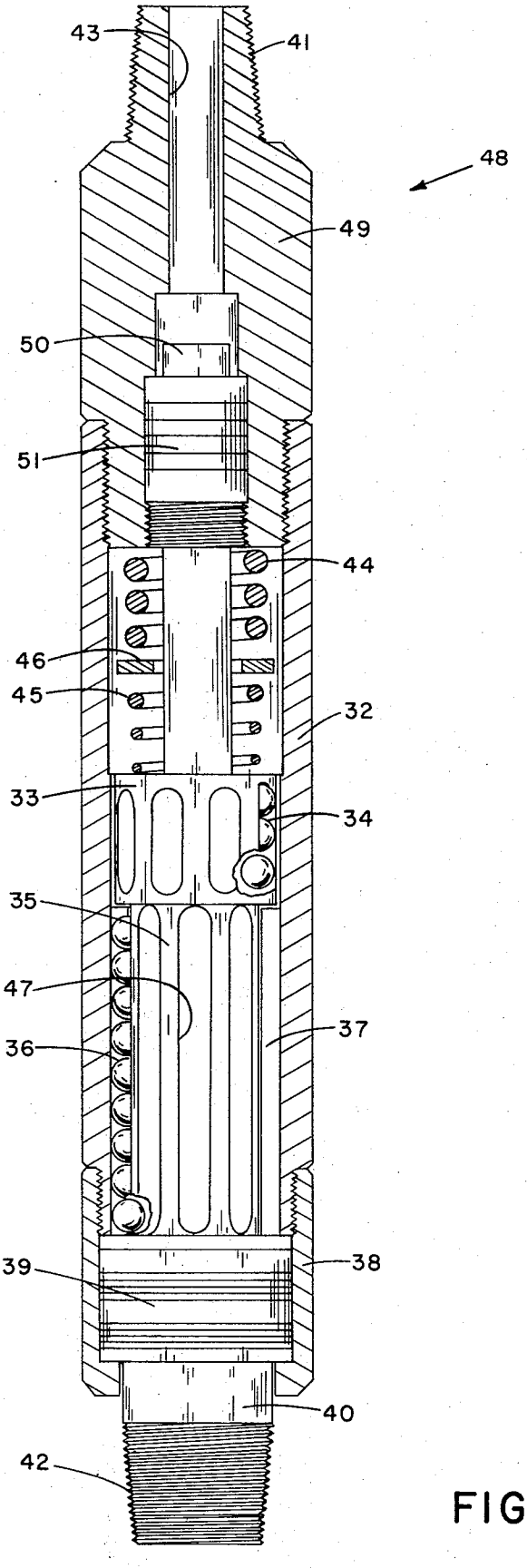


FIG. 2

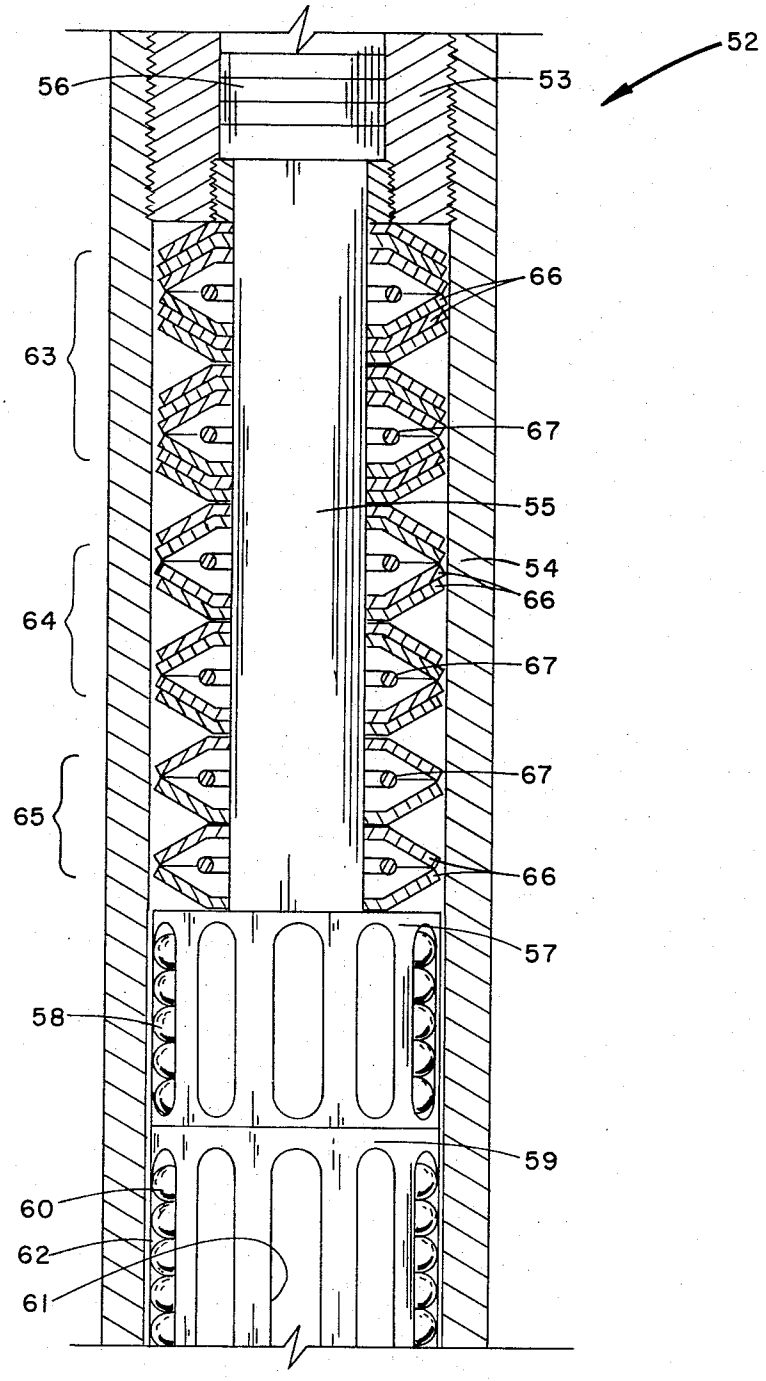


FIG. 3

SPRING LOAD SYSTEM FOR DRILL STRING SHOCK ABSORBERS

BACKGROUND OF THE INVENTION

The present invention relates to a drill string shock absorber adapted to be inserted in a drill string to absorb shock forces therein, and more particularly to a shock absorbing torque transmitting well tool with a spring means having separate spring units with different spring rates.

During the drilling of an oil well by the rotary method, it has become common practice to provide a section of drill collars above the drill bit. The section of drill collars provides the desired weight on the bit during drilling. The drill pipe above the section of the drill collars is generally in tension. This allows a relatively constant weight to be applied to the bit during drilling. When the hole is being started from the surface, the section of drill collars cannot be used because the length of the drill string is insufficient. A much smaller weight is therefore applied to the bit during drilling near the surface.

The action of the bit during drilling transmits shock forces to the drill string. The shock forces can be quite damaging to elements of the drill string and to drilling equipment at the surface. Drill string shock absorbers are commonly placed in the drill string to absorb the shock forces. A drill string shock absorber generally includes telescopically related parts that are separated by a spring means. The prior art shock absorbers have worked effectively with the full drilling weight on the bit. However, the prior art shock absorbers have not been effective during drilling near the surface because the weight on the bit is only a fraction of the weight on the bit at deeper depths. The spring means in the prior art shock absorbers has been too heavy to be effective during drilling near the surface. The present invention provides a drill string shock absorber that will operate effectively during drilling near the surface and will continue to operate effectively as the hole penetrates deeper into the earth.

DESCRIPTION OF PRIOR ART

In U.S. Pat. No. 3,383,126 to A. H. Salvatori et al., patented May 14, 1968, a drill string shock absorber is shown. The drill string shock absorber is adapted to be inserted into a rotary drill string to absorb vibrational and shock forces therein. The shock absorber includes telescopically related parts which are separated and isolated one from the other by a mass of compressible wire material.

In U.S. Pat. No. 2,585,995 to C. C. Brown, patented Feb. 19, 1952, a drilling joint is shown. The drilling joint provides an improved means for controlling the weight applied to the drill bit, localizes the neutral point in the drill stem, and prolongs the life of the drill stem by absorbing or damping out vibrations and other shocks imparted to the drill stem during operations.

In U.S. Pat. No. 2,991,635 to F. D. Warren, patented July 11, 1961, a resilient drilling tool is shown. The drilling tool comprises a pair of tubular housings or pipes telescoped together and provided with cooperating splines to transmit torque from one housing to the other. A plurality of helical springs are anchored in the annulus between the two telescoped housings to constantly urge the housings in opposite directions and effectively dampen any vibration of the drill string in which the tool is interposed.

SUMMARY OF THE INVENTION

The present invention provides a drill string shock absorber that will effectively act to reduce or eliminate shock forces transmitted from the bit upward through the drill string during drilling, especially during drilling with a wide range of loads on the bit or when rapidly varying load situations are encountered. The shock absorbing torque transmitting well tool of the present invention includes an outer member and an inner member, said outer member and said inner member being telescopically arranged. Spline means are provided between said outer member and said inner member for transmitting torque. Spring means are provided connecting said outer member and said inner member. Said spring means includes a multiplicity of spring segments arranged to provide the tool with spring units having different spring rates. The above and other objects and advantages of the present invention will become apparent from a consideration of the following detailed description of the invention when taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a longitudinal view, partly in section and partly in elevation, of one embodiment of a shock sub constructed in accordance with the present invention.

FIG. **2** is a view of a second embodiment of a shock sub constructed in accordance with the present invention.

FIG. **3** is a view of a portion of another embodiment of a shock sub constructed in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings and in particular FIG. **1**, a shock sub is shown therein and generally designated by the reference number **10**. The shock sub **10** is adapted to be positioned between a drill bit (not shown) and the section of the drill string that connects the drill bit to the drilling equipment at the surface. The shock sub **10** maintains a spring force coupled into the drill string assembly in such a manner that shock loads resulting from the action of the bit are absorbed and prevented from being transmitted up the drill string. The shock sub **10** minimizes fatigue on the drill bit, the drill string, and the surface equipment.

The shock sub **10** includes an upper packer sub **11**. The upper packer sub **11** is adapted to be connected to the portion of the drill string extending from the surface equipment. The threaded connection **24** allows the shock sub to be easily connected to and disconnected from the drill pipe. The upper packer sub **11** is threaded into a spring sub **31** and the spring sub **31** is threaded into a spline sub **14**. The spline sub **14** is threaded into a lower packer sub **20**. A drive shaft mandrel **22** fits within the lower packer sub **20**, the spline sub **14**, the spring sub **31**, and the upper packer sub **11**. The drive shaft mandrel **22** includes a threaded connection **25** for connecting the drive shaft mandrel **22** to the bit. The drive shaft mandrel **22** has limited movement within the lower packer sub **20**, the spline sub **14**, the spring sub **31**, and the upper packer sub **11**. Drilling fluid is transmitted through the shock sub **10** during drilling. Drilling fluid enters the passage **26** in the upper

packer sub **11** from the section of drill string above the shock sub **10.** The drilling fluid continues through a central passage in the wash pipe **12,** through a central passage in the drive shaft mandrel **22,** and is transmitted to the section of the drill string below the shock sub **10.**

Upper packer seals **13** provide a dynamic fluid seal between the upper packer sub **11** and the drive shaft mandrel **22.** Lower packer seals **21** provide a dynamic fluid seal between the lower packer sub **20** and the drive shaft mandrel **22.** The enclosed area between the upper packer seals **13** and the lower packer seals **21** is filled with a lubricating oil. A ball spline **15** on the drive shaft mandrel **22** is located between the upper packer seals **13** and the lower packer seals **21.** The ball spline **15** includes a series of carrier balls **16** that reduce friction and facilitate relative longitudinal movement of the drive shaft mandrel **22** and the housing consisting of the upper packer sub **11,** the spring sub **31,** the spline sub **14,** and the lower packer sub **20.** A ball spline **17** is positioned between the drive shaft mandrel **22** and the spline sub **14** to transmit torque from the housing consisting of the upper packer sub **11,** the spring sub **31,** the spline sub **14,** and the lower packer sub **20.** The ball spline **17** includes a series of carrier balls **18** that transmit between spline grooves **27** connected to the drive shaft mandrel **22** and spline grooves **19** connected to the spline sub **14.**

An upper spring unit **28** and a lower spring unit **29** are positioned between the upper packer sub **11** and the drive shaft mandrel **22.** The spring units **28** and **29** absorb the shock loads resulting from the action of the bit. The upper spring unit **28** consists of six disc or "Belleville" springs **30.** The lower spring unit **29** consists of two disc or Belleville springs **30.** This arrangement allows the initial spring rate to be governed largely by the spring unit **29** until these springs have deflected to the point that they are completely bottomed out. At this time the heavier or stronger spring unit **28** will have deflected in proportion to the imposed load and will now dominate the effective spring rate. During drilling near the surface, the weight on the bit is small compared to the weight on the bit during drilling at deeper depths. During drilling near the surface, the spring unit **29** will deflect and absorb shock forces produced by the action of the bit. As the hole penetrates deeper into the earth, the spring unit **28** will dominate and the shock forces produced by the action of the bit will be absorbed. The shock forces resulting from action of the bit are also absorbed by a swabbing or damping action brought about by restricting the escape of the lubricant trapped between the springs **30.** The geometry of the spring allows them to reduce in I.D. and expand in O.D. as loads are applied. Lubricant is trapped to some degree as the springs are collapsed providing a damping effect and the shock forces are absorbed. The degree of damping action can be controlled by the oil viscosity, clearance grooves, and spring geometry.

Referring now to FIG. **2,** another embodiment of a shock sub constructed in accordance with the present invention is shown. The shock sub is generally designated by the reference number **48.** The shock sub **48** is adapted to be positioned between a drill bit (not shown) and the section of drill string that connects the drill bit to the drilling equipment at the surface. The shock sub **48** contains a spring force coupled into the drill string assembly in such a manner that shock loads resulting from the action of the bit are absorbed and prevented from being transmitted up the drill string. The shock sub **48** minimizes fatigue on the drill bit, the drill string, and the surface equipment.

The shock sub **48** includes an upper packer sub **49.** The upper packer sub **49** is adapted to be connected to the portion of the drill string extending from the surface equipment. The threaded connection **41** allows the shock sub **48** to be easily connected to and disconnected from the drill pipe. The upper packer sub **49** is threaded into a spline sub **32** and the spline sub **32** is threaded into a lower packer sub **38.** A drive shaft mandrel **40** fits within the lower packer sub **38,** the spline sub **32,** and the upper packer sub **49.** The drive shaft mandrel **40** includes a threaded connection **42** for connecting the shock sub **48** to that portion of the drill string connected to the bit. The drive shaft mandrel **40** has limited movement within the lower packer sub **38,** the spline sub **32,** and the upper packer sub **49.** Drilling fluid is transmitted through the shock sub **48** during drilling. Drilling fluid enters the passage **43** in the upper packer sub **49** from the section of the drill string above the shock sub **48.** The drilling fluid continues through a central passage in the wash pipe **50,** through a central passage in the drive shaft mandrel **40,** and is transmitted to the section of the drill string below the shock sub **48.**

Upper packer seals **51** provide a dynamic fluid seal between the upper packer sub **48** and the drive shaft mandrel **40.** Lower packer seals **39** provide a dynamic fluid seal between the lower packer sub **38** and the drive shaft mandrel **40.** The enclosed area between the upper packer seals **51** and the lower packer seals **39** is filled with a lubricating oil. A ball spline **33** on the drive shaft mandrel **40** is located between the upper packer seals **51** and the lower packer seals **39.** The ball spline **51** includes a series of carrier balls **34** that reduce friction and facilitate relative longitudinal movement of the drive shaft mandrel **40** and the housing consisting of the upper packer sub **49,** the spline sub **32,** and the lower packer sub **38.** A ball spline **35** is positioned between the drive shaft mandrel **40** and the spline sub **32** to transmit torque from the housing consisting of the upper packer sub **49,** the spline sub **32,** and the lower packer sub **38.** The ball spline **35** includes a series of carrier balls **36** that transmit torque between spline grooves **47** connected to the drive shaft mandrel **40** and spline grooves **37** connected to the spline sub **32.**

Springs **44** and **45** are positioned between the upper packer sub **49** and the drive shaft mandrel **40.** A divider **46** connects springs **44** and **45.** The springs **44** and **45** absorb the shock load resulting from the action of the bit. The cross-sectional area of spring **45** is less than the cross-sectional area of spring **44.** The combination of springs **44** and **45** provides a progressive increase in spring rate. This arrangement allows for the initial spring rate to be governed largely by the weaker spring **45** until spring **45** has deflected to the point that it is completely bottomed out on divider **46.** At that time the heavier spring **44** has been deflected in proportion to the imposed load and will now dominate the effective spring rate. This insures that the shock sub **28** will operate effectively during drilling near the surface and continue to operate effectively as the hole penetrates deeper into the earth.

Referring now to FIG. 3, a portion of another embodiment of a shock sub constructed in accordance with the present invention is shown. The shock sub is generally designated by the reference number 52. The shock sub 52 is adapted to be positioned between a drill bit (not shown) and the section of drill string that connects the drill bit to the drilling equipment at the surface. The shock sub 52 contains a spring force coupled into the drill string assembly in such a manner that shock loads resulting from the action of the bit are absorbed and prevented from being transmitted up the drill string. The shock sub 52 minimizes fatigue on the drill bit, the drill string, and the surface equipment.

The shock sub 52 includes an upper packer sub 53. The upper packer sub 53 is adapted to be connected to the portion of the drill string extending from the surface equipment. The upper packer sub 53 is threaded into a spline sub 54. A drive shaft mandrel 55 fits within the spline sub 54 and the upper packer sub 53. The drive shaft mandrel 55 includes a threaded connection (not shown) for connecting the shock sub 52 to that portion of the drill string connected to the bit. The drive shaft mandrel 55 has limited movement within the spline sub 54, and the upper packer sub 53. Drilling fluid is transmitted through the shock sub 52 during drilling. Drilling fluid enters a passage in the upper packer sub 53 from the section of the drill string above the shock sub 52. The drilling fluid continues through a central passage in the drive shaft mandrel 55 and is transmitted to the section of the drill string below the shock sub 52.

Upper packer seals 56 provide a dynamic fluid seal between the upper packer sub 53 and the drive shaft mandrel 55. Lower packer seals (not shown) provide a dynamic fluid seal between a lower packer sub (not shown) connected to spline sub 54 and the drive shaft mandrel 55. The enclosed area between the upper packer seals 56 and the lower packer seals is filled with a lubricating oil. A ball spline 57 on the drive shaft mandrel 55 is located between the upper packer seals 56 and the lower packer seals. The ball spline 57 includes a series of carrier balls 58 that reduce friction and facilitate relative longitudinal movement of the drive shaft mandrel 55 and the housing consisting of the upper packer sub 53, the spline sub 54, and the lower packer sub. A ball spline 59 is positioned between the drive shaft mandrel 55 and the spline sub 54 to transmit torque from the housing consisting of the upper packer sub 53, the spline sub 54, and the lower packer sub. The ball spline 59 includes a series of carrier balls 60 that transmit torque between spline grooves 61 connected to the drive shaft mandrel 55 and the spline grooves 62 connected to the spline sub 54.

Spring units 63, 64, and 65 are positioned between the upper packer sub 53 and the drive shaft mandrel 55. The spring units 63, 64, and 65 absorb the shock loads resulting from the action of the bit. The spring units 63, 64, and 65 consist of a multiplicity of disc or Belleville springs 66 arranged in various combinations of series and parallel stacking. Spring unit 63 consists of two sets of six disc or Belleville springs 66. Spring unit 64 consists of two sets of four disc or Belleville spring 66 and spring unit 65 consists of two sets of two disc or Belleville springs 66. This arrangement allows for the initial spring rate to be governed largely by the lesser spring unit 65 until these springs have deflected to the point that they are completely bottomed out on the stops 67. At that time the adjacent and heavier spring unit 64 will have deflected in proportion to the imposed load and will now dominate the effective spring rate. This will continue until the springs 66 making up spring unit 64 have deflected to the point where they are completely bottomed out on the stops 67. At that time the adjacent and heavier spring unit 63 will have been deflected in proportion to the imposed load and will now dominate the effective spring rate. The spring units 63, 64, and 65 will therefore accommodate a great variety of effective loads and degrees of deflection.

A swabbing or damping action is provided by restricting the escape of lubricant trapped between the Belleville springs 66. The geometry of the springs allows them to reduce in I.D. and expand in O.D. as loads are applied. Lubricant is trapped to some degree as the springs are collapsed and the shock loads are absorbed. The oil viscosity, clearance grooves, and spring geometry can be used to control the damping action. The shock sub 52 will operate effectively during drilling near the surface and continue to operate effectively as the hole penetrates deeper into the earth and greater weight is applied to the bit.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A shock absorbing torque transmitting well tool, comprising:
   - an outer member;
   - an inner member, said outer member and said inner member being telescopically arranged;
   - spline means between said outer member and said inner member for transmitting torque; and
   - spring means connected to said outer member and connected to said inner member, said spring means including a first spring unit with a first spring constant and a second spring unit with a second and different spring constant said first spring unit and said second spring unit including a multiplicity of disc springs positioned between said inner and outer members.

2. The shock absorbing torque transmitting well tool of claim 1 including stop elements connected to said disc springs.

3. The shock absorbing torque transmitting well tool of claim 2 wherein the stop elements are annular elements positioned between matching disc elements.

4. The shock absorbing torque transmitting well tool of claim 3 including oil positioned between said inner and outer member wherein the clearance between said disc springs and said inner and outer members restricts the passage of said oil.

5. A shock absorbing torque transmitting well tool, comprising:
   - an outer member;
   - an inner member, said outer member and said inner member being telescopically arranged;
   - spline means between said outer member and said inner member for transmitting torque; and
   - spring means connected with said outer member and connected with said inner member, said spring means including a first spring unit with a multiplicity of disc spring elements and a second spring unit with a second and different multiplicity of disc spring elements.

6. The shock absorbing torque transmitting well tool of claim 5 including a fluid between said inner member and said outer member with the disc spring elements positioned between said inner member and said outer member to restrict passage of said fluid.

7. The shock absorbing torque transmitting well tool of claim 6 including stop elements positioned within said disc spring elements.

8. A shock absorbing torque transmitting well tool, comprising:

an outer member;

an inner member, said outer member and said inner member being telescopically arranged;

an upper seal between said outer member and said inner member;

a lower seal between said outer member and said inner member;

a fluid between said upper seal and said lower seal;

spline means between said outer member and said inner member for transmitting torque; and

spring means connected with said outer member and connected with said inner member with said spring means including a first multiplicity of disc spring units and a second multiplicity of disc spring units, said first multiplicity of disc spring units being a different number of disc spring units than said second multiplicity of disc spring units.

9. The shock absorbing torque transmitting well tool of claim 8 wherein said first and second multiplicity of disc spring units are positioned between said outer member and said inner member to restrict passage of said fluid.

10. The shock absorbing torque transmitting well tool of claim 9 including stop elements within said disc spring units.

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