

PATENT SPECIFICATION

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(54) DRILL STRING SHOCK ABSORBER

(71) We, SCHLUMBERGER TECHNOLOGY CORPORATION, a corporation organised and existing under the laws of the State of Texas, U.S.A., located at 5000 Gulf Freeway, Houston, Texas 77001, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates generally to well drilling tools, and particularly to apparatus adapted for use above a drill bit to absorb and attenuate vibration and shock loads generated by the drilling action of the bit.

In rotary drilling, it is typical to employ a multi-cone bit at the lower end of a drill collar string which is suspended from the lower end of a drill pipe extending upwardly to the surface. The entire string and the bit are rotated by a kelly and drive works at the surface to cause the bit cones to pulverize the rock and other earth formations. Drilling fluid or "mud" is pumped down the drill string and out of orifices in the bit and returns to the surface via the well annulus to cool the bit, clean the borehole bottom and to carry cuttings to the surface.

The action of a cone-type bit as it advances through rock and the like produces a substantial amount of longitudinal vibration, shock loads and other cyclical exciting forces which accelerate wear and other damage to both the bit and the drill string thereabove, as well as impeding the rate of penetration of the bit. Various attempts have been made to solve such problems by incorporating a shock absorbing device above the bit. Some prior devices utilize a rubber cushion as the absorbing or damping element. However, rubber tends to break down and extrude fairly readily and must therefore be replaced quite often to maintain an operable system. Moreover, the use of rubber or rubber-like material in a substantially confined space has resulted in an extremely high spring

rate which is considered to be undesirable. Other devices have employed a compressible gas or the like, which is difficult to maintain confined within the tool over an extended period of time, and which also provides a relatively high spring rate, particularly when used at considerable depths.

It is an object of the present invention to provide a new attenuating and shock absorbing apparatus for use in a rotary drill string above the bit.

Accordingly to the present invention, there is provided a shock absorber apparatus for use in a drill string, the apparatus comprising: telescopically disposed and slidably splined mandrel and housing members, one of said members being adapted for attachment to a drill string and the other of said members being adapted for attachment to a drill bit; an elongated, helical coil spring disposed between said members to absorb longitudinal vibrations and shock loads; and a hollow flow tube having one portion sealed with respect to said housing member and another portion sealed with respect to said mandrel member, said flow tube defining part of a chamber that encloses said coil spring and contains a lubricating oil and being arranged to transmit the pressures of a drilling fluid within said members to said oil.

The invention will now be described, by way of example only, with reference to the appended drawings, in which:

Figure 1 is a schematic illustration of a well drilling operation employing rotary drilling techniques; and

Figures 2A and 2B are longitudinal sectional views of apparatus in accordance with the present invention, Figure 2B forming a lower continuation of Figure 2A.

Referring initially to Figure 1, there is shown schematically a borehole 10 being drilled into the earth using typical rotary drilling techniques. A drill bit 11 is attached to the lower end of a drill string which includes relatively heavy drill collars 12 at

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the lower end to weight the bit, and drill pipe 13 extending upwardly to the surface where it is attached to a kelly 14 that is driven by a rotary table 15 in order to spin the entire drill string and the bit 11. A drilling fluid is pumped down the drill string and passes into the bottom of the borehole through orifices in the bit 11, and circulates back to the surface via the annulus between the drill string and the borehole wall. The drilling fluid cools the bit, scavenges the hole bottom and carries cuttings up to the surface and provides a hydrostatic head which keeps liquids and gas in the formations penetrated by the bit from coming into the borehole.

A conventional drill bit 11 employs a plurality of rotatable cutting cones having teeth that chip and eat away at the bottom of the borehole 10 as the bit is rotated. The drilling action of the bit 11 under the weight of the drill collars 12 generates a considerable amount of vibration and shock loads which are attenuated by the incorporation of an apparatus 20, the subject of the present invention, which is connected between the lower end of the drill collars 12 and the bit 11.

Referring now to Figures 2A and 2B for an illustration of a preferred embodiment of the present invention, the drill string shock absorber apparatus 20 includes a mandrel 21 extending upwardly within the lower end of a tubular housing assembly 22. The housing assembly 22 may include several threadedly interconnected sections such as an upper sub 23 having internal threads 24 for connecting to the lower end of the drill collars 12, upper and lower intermediate sections 25 and 26, and a lower spline and seal sub 27. The mandrel 21 has a lower box 28 with internal threads 29 adapted for connection to the drill bit 11, and is telescopically disposed for limited longitudinal movement relative to the housing assembly 22. Longitudinally extending spline ribs 30 extending inwardly of the sub 27 are in mesh with companion spline grooves 31 on the mandrel 21 in order to prevent relative rotation. A seal packing assembly 32 of suitable construction is carried by the sub 27 and is sealingly slidable on the outer periphery 33 of the mandrel 21 above the threaded box 28 to prevent leakage of fluid.

An elongated hollow tube 36 having a through bore 37 for the passage of drilling fluids is positioned within the housing assembly 22 and has an enlarged diameter upper end section 38 that carries a packing assembly 39 which is sealingly slidable against the inner wall surface 40 of the housing section 25. In addition, another packing assembly 41 which may be located

at the upper end of the mandrel 21 seals against the outer wall surface 42 of the tube 36 to provide an elongated annular cavity 43 between the upper section 38 of the tube and the upper end portion 44 of the mandrel.

A resilient structure indicated generally at 48 is disposed within the cavity 43 to afford a yieldable resistance to relative longitudinal movement of the mandrel 21 and the housing assembly 22. The structure 48 in a preferred form comprises a cylindrical helical coil spring 50 of rectangular cross-section, the spring having its lower end portion 51 fixed to the upper end of the mandrel 21 by threads 52, and its upper end portion 53 fixed with respect to the housing sections 25 and 26 by lock nuts 54 which engage above an inwardly directed shoulder 55 on the housing. The spring 50 may be manufactured from a length of thick-walled pipe stock by milling at least one helical groove 56 through the wall from a point 57 near the lower end to a point 58 near the upper end, providing a resultant resilient member with a relatively low spring rate. The interior spaces in the cavity 43 and those between the spline sub 27 and the mandrel 21 are filled with a suitable lubricant such as silicone oil which is confined within a volume whose boundaries are defined in part by the packing assemblies 39, 41 and 32. The pressure of the oil will be substantially the same as that of the drilling fluids inside the tool because the tube 36 is free floating. Moreover it will be appreciated that the oil moves through the space between the splines 30, 31 during relative longitudinal movement to provide a dashpot effect as will be discussed more fully herebelow.

In operation, the apparatus 20 is assembled as shown in the drawings and the interior spaces between the mandrel 21, the housing 22 and the tube 36 are filled with lubricating oil through a suitable port (not shown). The apparatus then is connected in the drill string between the lower end of the drill collars 12 and the bit 11 and lowered with the drill string into the borehole. When the bit 11 lands on the bottom, the mandrel 21 will move upwardly somewhat within the housing as the weight of the drill collar is applied thereto, and as mud circulation is initiated by the surface pumps a fluid pressure equal to the pressure drop across the bit orifices is transmitted to the lubricating oil in the cavity 43 by the piston section 38 at the upper end of the tube 36. This pressure acts downwardly on the mandrel 21 over a transverse cross-sectional area defined by the difference in seal diameters for the packing assemblies 32 and 41 to cause telescoping extension of the mandrel in opposition to the drill

string weight, with the result that the mandrel 21 will occupy a position midway between the limits of its longitudinal travel relative to the housing 22. Then as the drill string and the bit 11 are turned by the rotary 15, shock loads, vibration and other exciting forces generated by the bit 11 are absorbed by the resilient action of the helical coil spring 50. Peak loads are damped out by the dashpot effect of restricted oil flow past the splines 30 and 31 during relative longitudinal movement.

It now will be recognized that a new drill string shock absorbing apparatus has been provided. The mechanical coil spring 48 provides a resilient structure with a low spring rate which is effective and reliable in attenuating the exciting forces generated by the bit. The fluid pressure drop across the drill bit is effectively used in opposition to the drilling weight to enable the mandrel and housing to telescope readily as shock loads and vibrations are absorbed.

WHAT WE CLAIM IS:—

1. A shock absorber apparatus for use in a drill string, the apparatus comprising telescopically disposed and slidably splined mandrel and housing members, one of said members being adapted for attachment to a drill string and the other of said members being adapted for attachment to a drill bit; an elongated, helical coil spring disposed between said members to absorb longitudinal vibrations and shock loads; and a hollow flow tube having one portion sealed with respect to said housing member and another portion sealed with respect to said mandrel member, said flow tube defining part of a chamber that encloses said coil spring and contains a lubricating oil and being arranged to transmit the pressures of a drilling fluid within said members to said oil.

2. The apparatus of claim 1, wherein said

mandrel member has a transverse cross-sectional area that is subject to the pressure of said lubricating oil.

3. The apparatus of claim 1 or claim 2, wherein said members are slidably splined by spline means which prevent relative rotation of said housing and mandrel members, and comprising fluid passage means extending past said spline means for conveying said oil during telescoping movement of the members in a manner to provide a dashpot effect to damp out peak load changes.

4. The apparatus of claim 3, further including coengageable seal means on said mandrel and housing members adjacent said spline means for preventing leakage of said oil to the exterior of said members.

5. The apparatus of any one of the previous claims, wherein said coil spring has a rectangular section and provides a relatively low spring rate.

6. The apparatus of any one of the previous claims, wherein said one portion of the flow tube is at or adjacent one end thereof and includes an outwardly directed shoulder sealingly slidable with respect to said housing member to transmit the pressure of drilling fluids within said apparatus to said lubricating oil, and said other portion of the flow tube is at or adjacent the other end thereof and is sealingly slidable with respect to said mandrel member, said flow tube having an intermediate portion spaced inwardly of said housing member to define a wall of said chamber.

7. A shock absorber apparatus for use in a drill string, the apparatus being substantially as herein described with reference to Figures 2A and 2B of the accompanying drawings.

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string weight, with the result that the mandrel 21 will occupy a position midway between the limits of its longitudinal travel relative to the housing 22. Then as the drill string and the bit 11 are turned by the rotary 15, shock loads, vibration and other exciting forces generated by the bit 11 are absorbed by the resilient action of the helical coil spring 50. Peak loads are damped out by the dashpot effect of restricted oil flow past the splines 30 and 31 during relative longitudinal movement.

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1. A shock absorber apparatus for use in a drill string, the apparatus comprising telescopically disposed and slidably splined mandrel and housing members, one of said members being adapted for attachment to a drill string and the other of said members being adapted for attachment to a drill bit; an elongated, helical coil spring disposed between said members to absorb longitudinal vibrations and shock loads; and a hollow flow tube having one portion sealed with respect to said housing member and another portion sealed with respect to said mandrel member, said flow tube defining part of a chamber that encloses said coil spring and contains a lubricating oil and being arranged to transmit the pressures of a drilling fluid within said members to said oil.

2. The apparatus of claim 1, wherein said

mandrel member has a transverse cross-sectional area that is subject to the pressure of said lubricating oil.

3. The apparatus of claim 1 or claim 2, wherein said members are slidably splined by spline means which prevent relative rotation of said housing and mandrel members, and comprising fluid passage means extending past said spline means for conveying said oil during telescoping movement of the members in a manner to provide a dashpot effect to damp out peak load changes.

4. The apparatus of claim 3, further including coengageable seal means on said mandrel and housing members adjacent said spline means for preventing leakage of said oil to the exterior of said members.

5. The apparatus of any one of the previous claims, wherein said coil spring has a rectangular section and provides a relatively low spring rate.

6. The apparatus of any one of the previous claims, wherein said one portion of the flow tube is at or adjacent one end thereof and includes an outwardly directed shoulder sealingly slidable with respect to said housing member to transmit the pressure of drilling fluids within said apparatus to said lubricating oil, and said other portion of the flow tube is at or adjacent the other end thereof and is sealingly slidable with respect to said mandrel member, said flow tube having an intermediate portion spaced inwardly of said housing member to define a wall of said chamber.

7. A shock absorber apparatus for use in a drill string, the apparatus being substantially as herein described with reference to Figures 2A and 2B of the accompanying drawings.

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