Dec. 28, 1965 C. H. LEATHERS 3,225,566

DRILL STRING SHOCK ABSORBER

Filed Oct. 7, 1963

FIG. 1.

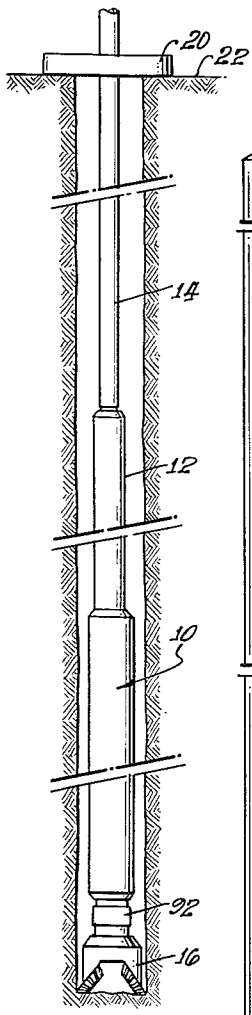


FIG. 2a.

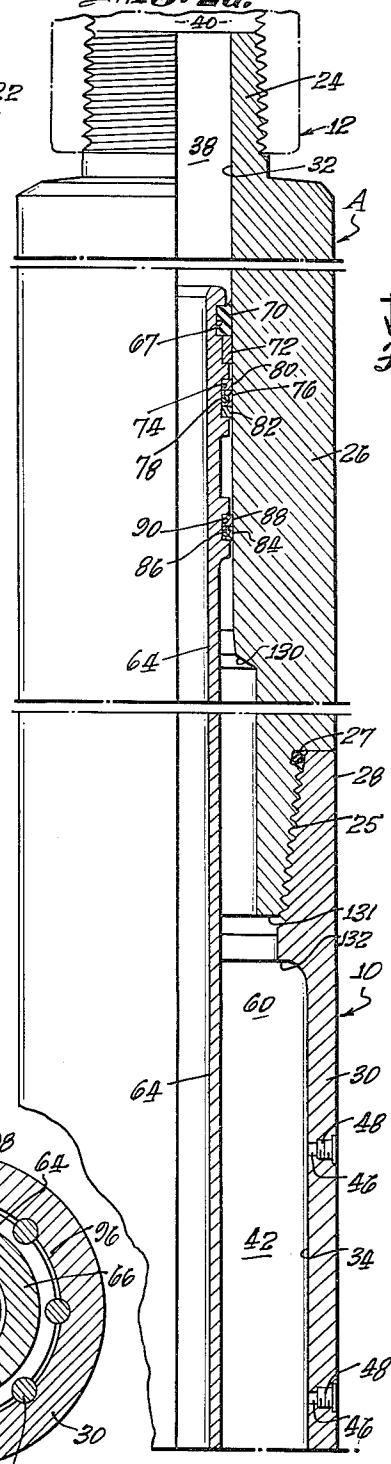


FIG. 2b.

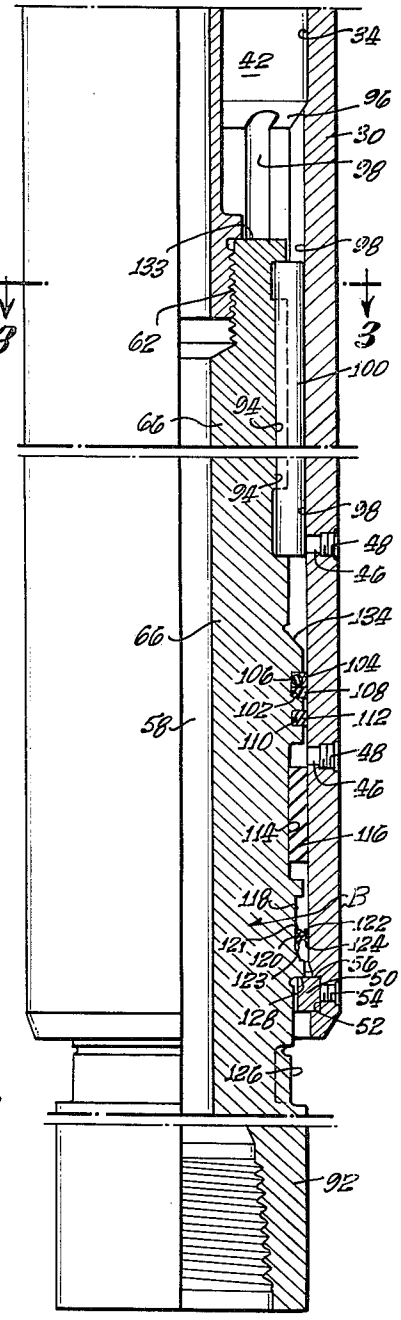
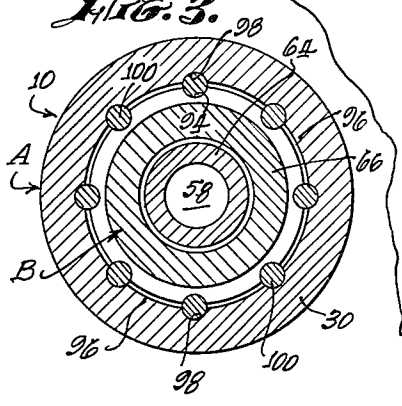


FIG. 3.



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DRILL STRING SHOCK ABSORBER

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2 Claims. (Cl. 64—23)

This invention relates to well drilling equipment, and more particularly to a drill string shock absorber for use in a rotary well drilling string.

In the rotary method of well drilling, it has become common practice to employ a drill collar section above the bit with drill pipe extending upward from the drill collar section. The drill collar section supplies as much weight as possible directly above the bit such that the compressive force necessary on the bit is exerted by the drill collar section while the drill pipe portion of the string remains in tension. However, a rotary drill bit, in meeting various earth strata, continuously subjects the drill string to shock and vibration. The drill collar removes much of the vibrational and shock forces, but a substantial amount of bouncing of the bit on the bottom of the hole can still result under various circumstances. This is especially true when resonance is induced which can cause severe vibration even above the rotary table. Accordingly, under certain circumstances severe shocks and vibrations are imparted from the drill bit to the drill string whether or not a drill collar section is employed.

The present invention provides for the absorption of vibrational and shock forces from the bit so that they will not be relayed through the drill string. This shock absorber consists of a body portion, a mandrel, and a compressible fluid in a closed chamber formed between the mandrel and the body portion. Shock and vibrational forces are transmitted from the mandrel to the compressible fluid where they are damped out and are not further transmitted upwardly through the body portion to the drill string.

An object of the present invention is the provision of an improved drill string shock absorber.

Another object of the present invention is the provision of a drill string shock absorber for damping out vibrational, shock, or intermittent forces which otherwise may have harmful effects on the drill string.

Another object of the invention is the provision of a drill string shock absorber which is efficient in operation and has a longer useful life than shock absorbers heretofore known to the art.

It is a further object of the present invention to provide a drill string shock absorber which requires no external hydraulic horsepower for its operation.

It is yet another object of the present invention to provide an improved drill string shock absorber which requires no special drilling procedure for its efficient operation

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof will be better understood from the following description considered in connection with the accompanying drawing in which a presently preferred embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawing is for the purpose of illustration and description only, and is not intended as a definition of the limits of the invention.

FIGURE 1 is a fragmentary, vertical sectional view through the earth, showing the device installed in a drilling string within a well, and showing the preferred relation of the installed device to the drill bit;

FIGURES 2*a* and 2*b* are enlarged half-sectional views in elevation; and

FIGURE 3 is a transverse sectional view taken along the line 3—3 of FIGURE 2.

It is to be understood that various changes in the form, proportion, size, weight, shape, and other details of construction within the scope of this invention may be resorted to without departing from the spirit or broad principles thereof, and without sacrificing any of the advantages thereof, and it is also to be understood that the drawings are to be interpreted as being illustrative only and not restrictive.

Referring now to the drawing, there is shown in FIGURE 1 a typical mode of operation of the shock absorber in accordance with the present invention. The shock absorber **10** is shown disposed between a drill collar section **12** of the drill string **14** and the usual rotary bit **16** in a well **18**. The drill collar **12** is of sufficient weight to provide the necessary compressive force on the bit **16** during drilling operations. As an illustration, such a drill collar section, in drilling a 12¼ inch hole, for example, typically may weigh on the order of 100,000 pounds and it is primarily this weight that is exerted on the bit at the bottom of the hole during drilling operations. The drill string **14** is supported under tension in the usual manner by suspension from a rotary table **20** above the surface **22** of the earth.

In FIGURES 2*a* and 2*b*, there is shown a presently preferred embodiment of the shock absorber of the present invention which comprises in general a body A and a mandrel B telescopically mateable therein for axial movement of the body A and mandrel B relative one to the other. The body A is of elongate cylindrical configuration having an outside surface **28** of substantially constant diameter approximately equal to the outside diameter of the drill collar and substantially less than the diameter **18** of the well being drilled. At the upper end of the body A there is provided a male-threaded connecting end **24** of the conventional type for connection to the lower end of the adjacent drill collar or drill string component. Although the body A can be formed as an integral unit, for ease of manufacture it is constructed by division into an upper portion **26** and a lower portion **30** in the presently preferred embodiment. The upper portion **26** and the lower portion **30** are threadably engaged by mating threads **25** and appropriate sealing means **27**. The body A defines by its internal surface an upper cylinder wall **32** and a lower cylinder wall **34**. Since the body is constructed in two portions in the presently preferred embodiment an intermediate cylindrical wall **36** is necessitated to accommodate the formation of the threaded connection **25**. Essentially, however, the cylinders **32** and and **34** are those that determine the operation of the device as will become more apparent hereinafter. The upper cylinder wall **32** defines a cylindrical bore **38** extending from the upper end of the body in communication with the bore **40** through the drill collars and remainder of the drill string for circulation of drilling fluid. The length of the cylinder **38** is dependent upon the length and movement of the mandrel as discussed more fully hereinafter. The lower cylinder **42** defined by the cylinder wall **34** is of substantially greater inside diameter being limited only by the necessary wall thickness of the body at that portion defining the lower cylinder **42**. The lower cylinder **42** extends from a point proximate the upper end of the lower portion **30** of the body to the lower end **44** thereof. Thus, the lower end of the body is open with an inside wall **34** extending upwardly at constant diameter to a point just below the connection of the lower portion **30** of the body to the upper portion **26** thereof. The cylinder walls **32** and **34** then being connected by the intermediate wall **36**. Illustrative of the relative diameters,

in a typical embodiment of a shock absorber of one size the bore 38 defined by upper cylinder wall 32 is approximately three inches in diameter while the lower cylinder 42 is approximately eight inches in inside diameter.

Through the wall of the body there are provided a series of longitudinally spaced openings or ports 46 closed by removable plugs 48 for inserting fluid into the shock absorber and checking the level thereof as discussed hereinafter.

A removable retaining ring 50 is positioned in an annular groove 52 in the cylinder wall 34 proximate the lower end 44 of the body.

Removal of the retaining ring 50 allows assembly of the mandrel B into the body and the ring 50 when positioned in groove 52 prevents disassembly and furnishes a stop surface 56 to limit the downward movement of the mandrel in the body as will become apparent thereinafter.

The mandrel B as shown in FIGURE 2 is an elongate member having a bore 58 of substantially constant inside diameter extending throughout the length of the mandrel, which bore is co-extensive with the bore 40 through the drill string when the mandrel is assembled within the body as shown in FIGURE 2. The mandrel is adapted to be longitudinally slidably movable within the body portion of the shock absorber and to define an annular chamber 60 between the exterior surface of the mandrel and the internal wall of the body. For ease of manufacture the mandrel is again constructed in two parts which are threadably engaged by threads 62, that part of the mandrel above the threads being referred to herein as the upper portion or tubular portion 64 of the mandrel and that beneath the threads being referred to as the lower portion 66 of the mandrel. The tubular portion 64 of the mandrel has an outside diameter substantially less than the inside diameter of the bore 38 in the upper portion of the body A and is adapted to be slidably movable with respect thereto. As shown particularly in FIGURE 2*a* sealing means are provided between the outer surface of the tubular portion and the cylinder wall 32 of the body to provide fluid sealing therebetween. Specifically the wall thickness of the tubular portion is increased over longitudinal sections thereof to allow for formation of annular grooves in the wall proximate the upper end thereof. In an annular groove 67 formed proximate the upper end 68 of the tubular portion there is inserted a piston ring 70 and a back up ring 72 adjacent thereto. The piston ring 70 and back up ring 72 are formed of suitable elastomeric material and are of sufficient outside diameter as to be in firm sealing engagement with the cylinder wall 32. Spaced beneath the piston rings in a second annular groove 74 is an upper sealing assembly comprising in this embodiment a sealing ring 76 formed of Teflon or like material with an O-ring 78 positioned between the inner wall of the groove 74 and the inner surface of the sealing ring 76. Wiper rings 80 and 82 are positioned in the annular groove 74 at opposite sides of the sealing ring 76. A second sealing assembly comprising a sealing ring 84, an O-ring 86, and a wiper ring 88 is positioned in an annular groove 90 spaced from the first sealing assembly which includes the sealing ring 76.

The lower mandrel portion 66 has a maximum outside diameter substantially equal to but less than the diameter of the cylinder wall 34 such that it is slidably mateable therewith. At the lower end of the lower mandrel portion 66 there is provided a threaded joint 92 for connection of the bit 16 or other element in the drill string. As shown in FIGURES 2*b* and 3 proximate the upper end of the lower portion 66 of the mandrel there are provided a series of circumferentially spaced longitudinally extending grooves 94 in the outer surface thereof. At a corresponding longitudinal position along the cylinder wall 34 of the body B there is provided an inwardly extending annular protrusion 96 in which circumferentially spaced longitudinally extending grooves 98 are formed. The grooves 98 in the internal wall of the body are spaced in mateable relationship with the grooves 94 in the mandrel such that splines 100 can be inserted therein as shown in FIGURE 3, to allow longitudinal movement of the mandrel and body while preventing rotational movement therebetween. These splines are thus drive splines which cause the mandrel to be rotated when the body is rotated.

As shown in FIGURE 2*b* the mandrel increases to its maximum diameter beneath the spline portion and in this region of maximum diameter there are provided a series of annular grooves for sealing and stabilization purposes. Thus, in the annular groove 102 there is provided a sealing assembly similar to that previously discussed comprising a sealing ring 104 with an O-ring 106 positioned between the sealing ring and the wall of the groove and a back up ring 108. In the annular groove 110 is an elastomeric wiper ring 112. Spaced therebelow in an annular groove 114 is a stabilizing ring 116 which is of considerable longitudinal extent, its purpose being to prevent radial movement between the mandrel and body. Beneath the stabilizing ring 116 in annular groove 118 is a final sealing assembly which makes use of a floating sealing ring 120. Drilling fluid from within the well produces an upward pressure against the ring 120 and pressure from fluid leakage around the other seals exerts a downward force against the ring. As this fluid leakage pressure builds up, it forces sealing ring 120 downwardly against the drilling fluid pressure to increase the volume and thus reduce the pressure above the seal. This seal 120 thus effectively prevents any intermixing of the drill fluid with the compressible shock absorber fluid while floating to relieve pressure on the seal.

Beneath the floating seal assembly an annular depression 126 is provided to define a lower stop surface 128, the extent of the annular depression 126 being from the stop surface 128 to the proximity of the connecting joint 92 at the lower end of the mandrel.

From the foregoing it will be seen that the mandrel and body define therebetween a cavity which is annular in configuration and extends from the upper sealing ring 84 to the lower sealing ring 104.

This cavity designated generally as 60 is filled with a compressible fluid. The compressible fluid is such that it will not be compressed under the normal loads imposed on its volume to an extent sufficient to prevent isolation of the body from the mandrel. Conversely, the fluid must be sufficiently compressible as to provide a damping action under the loads imposed. In this embodiment silicone oil is utilized. As will become more apparent hereinafter the effective diameters of the annular volume of fluid is the diameter of bore 38 as an inside diameter and the diameter of cylinder wall 34 as an outside diameter. The compressibility of the liquid and function thereof will be more apparent in connection with the operation of an illustrative embodiment of the invention. Accordingly, after assembly of the mandrel B into the body A, the cavity 60 is filled with compressible liquid, such as silicone oil, through one of the filler ports 46. With the bit 16 connected to the lower end of the mandrel at the joint 92 and the upper end of the shock absorber connected to the drill collar section 12 at the upper end 24 of the body the shock absorber with no upward force on the bit will remain in the fully expanded condition as shown in FIGURE 2 with the stop surface 128 of the mandrel in bearing contact with the retaining ring 50 of the body. The shock absorber will remain in this condition during lowering into the well and until the bit rests on the bottom of the hole. As the weight of the drill collar is lowered onto the bit the mandrel is urged upwardly into the body. At this point it can be seen that as the stop surface 128 is moved upwardly from the retaining ring 50 there is no longitudinal connection between the bit and the drill string except through the liquid filling the cavity 60. That is, the bit is connected longitudinally only to the mandrel, while the drill string is connected longitudinally only to the body and the mandrel and body

are connected longitudinally only through the liquid in the cavity **60**. Accordingly, as the weight of the drill collars is lowered onto the bit all of the downward force is exerted against the liquid volume by the effective area of the downwardly facing transverse surfaces extending from the bore diameter **32** to the cylinder diameter at **34** of the body such as at **130**, **131** and **132**. These forces are transmitted to the mandrel by the force of the fluid acting against the upward facing effective transverse surfaces of the mandrel extending from the diameter of bore **32** to that of cylinder wall **34**. Accordingly, the transverse mandrel surfaces such as **133** and **134** act as piston faces of the mandrel movable within the cylinder. Thus, as the weight of the drill collar comes to rest on the bit the liquid within the cavity **60** is compressed by that amount of force. For example, under a drill collar load of 100,000 pounds the liquid is compressed sufficiently to allow the mandrel to move upwardly by approximately 1¾" in the illustrative embodiment described.

From this balanced position under load, the mandrel is then free to move upwardly or downwardly relative to the body against the compressible liquid when shock forces, vibrations, or other intermittent forces are exerted on the bit. The compressibility of the liquid prevents such intermittent forces from being transmitted to the body A and thus to the drill string by absorbing such forces due to its compressibility. In effect the liquid acts in a manner similar to a constant rate spring in absorbing and damping out shocks and vibrations transmitted to it.

The present invention thus provides an improved drill string shock absorber which is simple and efficient in operation, does not require hydraulic horsepower for its operation, is self-contained and capable of long periods of operation.

What is claimed is:

1. A drill string shock absorber comprising:

an elongated cylindrical tubular body having an open lower end;

a mandrel telescopically engageable with said body extending from said lower end thereof and adapted for longitudinal movement within said cylindrical body;

means on said body and on said mandrel for attachment and connection to other drill string apparatus above and below said shock absorber respectively;

said body and mandrel having a central passageway for transmission of drilling fluid therethrough;

said body and said mandrel defining a longitudinally extending annular chamber therebetween;

first and second transverse surface means defining closed ends of said chamber, said first transverse surface means being affixed to said body, said second transverse surface means being affixed to said mandrel, said transverse surface means defining closed opposite ends of said chamber; and

said chamber being filled with a compressible liquid whereby intermittent, shock, and vibrational forces on said mandrel cause movement of said second transverse surface means against the compressible liquid within said chamber to thereby damp said forces against the upper portion of said drill string.

2. A drill string shock absorber as in claim **1** wherein the inner surface of said cylinder body and the outer surface of said mandrel are rotatably interconnected, whereby rotational movement of said cylinder body imparts rotational movement to said mandrel.

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