May 24, 1955 W. J. BIELSTEIN 2,709,070

FLEXIBLE SHAFT AND DRAIN HOLE DRILLING APPARATUS

Filed July 8, 1953 2 Sheets-Sheet 1

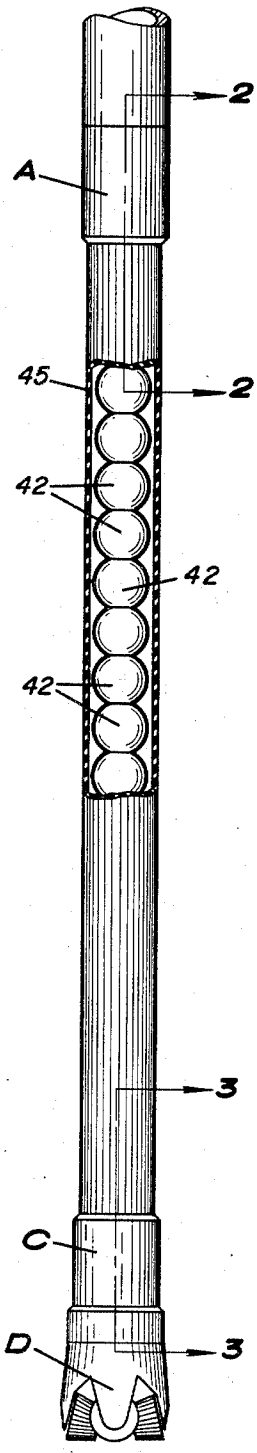


FIG. 1.

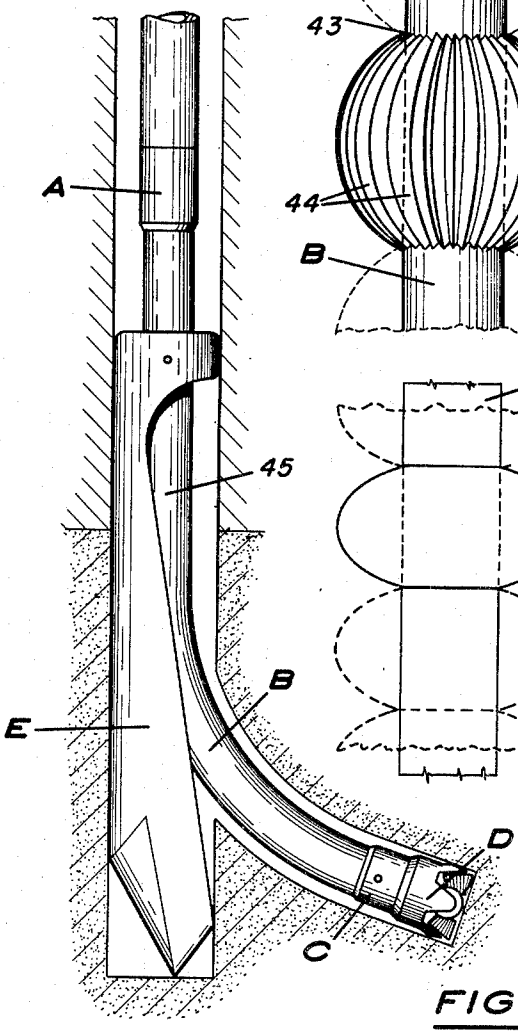


FIG. 6.

FIG. 5.

FIG. 7.

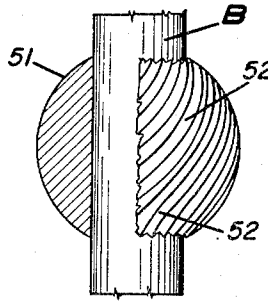


FIG. 8.

INVENTOR.
Walter J. Bielstein,
BY
J. S. McKean
ATTORNEY.

May 24, 1955 W. J. BIELSTEIN 2,709,070

FLEXIBLE SHAFT AND DRAIN HOLE DRILLING APPARATUS

Filed July 8, 1953 2 Sheets-Sheet 2

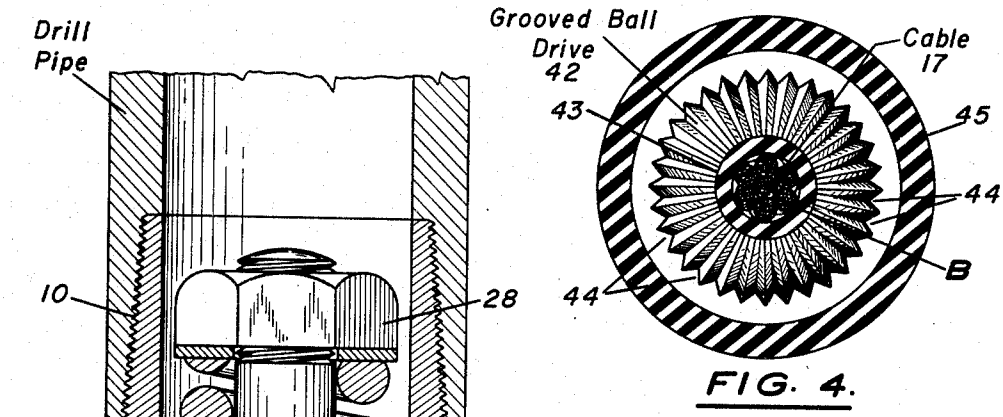


FIG. 4.

FIG. 2.

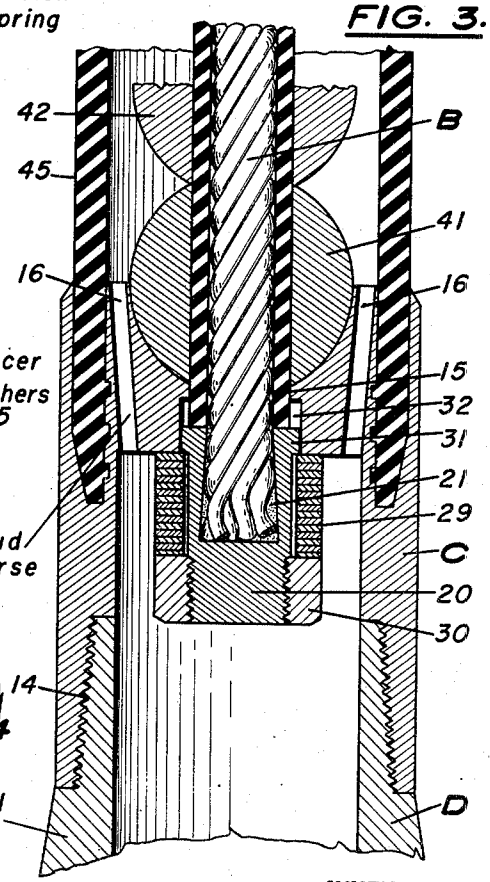


FIG. 3.

INVENTOR.
Walter J. Bielstein,
BY
J. B. McLean
ATTORNEY.

United States Patent Office 2,709,070 Patented May 24, 1955

2,709,070

FLEXIBLE SHAFT AND DRAIN HOLE DRILLING APPARATUS

Walter J. Bielstein, Corpus Christi, Tex., assignor, by mesne assignments, to Esso Research and Engineering Company, a corporation of Delaware

Application July 8, 1953, Serial No. 366,712

5 Claims. (Cl. 255—1.6)

The present invention is directed to a flexible shaft and to a drain hole drilling apparatus utilizing said flexible shaft.

The flexible shaft of the present application has the advantage that when one end is rotated about a fixed axis and the other end is free and has a lateral force exerted thereon, the maximum angle through which the free end may be deflected is limited to a predetermined value. A correlative characteristic of the device is that after the free end has been deflected said maximum amount, continued rotation with continued application of the lateral force against the free end tends to cause the free end to proceed in a straight line.

The drain hole drilling apparatus of the present application consists of a flexible shaft arranged so that one end is adapted to be secured to a drill stem and the other or free end is provided with a drilling bit. The flexible shaft has the characteristic that its total angular deflection may be controlled to a predetermined value whereby the apparatus may be deflected to drill a high-angle lateral hole but when once deflected tends to continue to drill the hole at the angle to which it was originally deflected.

The drain hole drilling apparatus of the present invention has the advantage that from a vertical borehole drain holes having small radii of deflection can easily be drilled. The radii of deflection of these drain holes can be fixed and positive control maintained in that when the desired angle of deflection of a drain hole being drilled has been reached no more angle will be accumulated nor will the angle obtained be lost.

Other advantages of the present invention may be seen from the following description taken in conjunction with the drawing in which:

Fig. 1 is an elevation partly in section showing a preferred embodiment of the present invention;

Fig. 2 is a sectional view partly in elevation and taken along the line 2—2 of Fig. 1;

Fig. 3 is a sectional view partly in elevation and taken along the line 3—3 of Fig. 1;

Fig. 4 is a view taken along the line 4—4 of Fig. 2;

Fig. 5 is a view in elevation of one of the grooved driving balls of the present invention;

Fig. 6 is a view in elevation showing the device of Figs. 1 through 5 having been deflected by a whipstock and drilling a lateral hole;

Fig. 7 is a schematic showing of a driving unit of a different shape from that shown in Figs. 1 through 6; and

Fig. 8 is an elevation partly in section and showing another embodiment of a driving unit of the present invention.

In the drawing principal parts are designated by letters and the remaining parts, as well as portions of the principal parts, are designated by reference numbers.

The principal parts of the device are a sub A, flexible member B, lower sub C, and drill bit D.

Upper sub A has screw threads **10** which allow it to

be attached to the lower end of a string of conventional drill pipe. The lower end of sub A has a central passage **11**, fluid courses **12** and annular groove **13**.

Lower sub C has screw threads **14** for the attachment of bit D by mating screw threads. Sub C has a central passage **15** and fluid courses **16**.

Flexible member B consists of a wire rope or cable **17** which is enclosed by a flexible sheath such as rubber or the like, an upper threaded rod **18** having a socket **19** for receiving and fastening the upper end of the wire rope, and a lower threaded rod **20** having a socket **21** for receiving and fastening the lower end of the wire rope **17**.

Threaded rod **18** fits slidingly within the central passage **11** of upper sub member A. Rod **18** defines near its lower end adjacent rope socket **19** a plurality of externally projecting keys **22**. Keys **22** are received by and make sliding contact in vertical keyways or grooves **23** which are defined by the inner wall of central passage **11**. The lower ends of grooves **23** terminate in a shoulder **24** which serves as a maximum travel stop for keys **22**.

Encircling rod **18** and resting on the shoulder defined by the lower end of sub A are a plurality of spacer washers **25**. Resting on top of spacer washers **25** and also encircling rod **18** is spring retainer plate **26**. A compression spring **27** encircling rod **18** is carried by retainer plate **26** and is held in compression by nut **28** which is threadably connected to the top of rod **18**. Spring **27** tends to bias nut **28** away from spacer washers **25**.

Encircling the lower end of rod **20** and abutting against the shoulder defined by sub C are a plurality of spacer washers **29**. A nut **30** is threadably attached to the end of rod **20** and bears against washers **29**.

Externally projecting from rod **20** are a plurality of lugs or keys **31** which are slidably engaged in grooves or keyways **32** defined by the inner wall of passageway **15** of sub C. Spring **27** in sub A tends to bias nut **30** and washers **29** upwardly against the shoulder defined by sub C.

An upper driving member is secured to upper sub A. This driving member is shown as a portion of a grooved ball **40** fastened to sub A by any suitable means such as welding or the like. Similarly, a lower drive member is secured to lower sub C, the member being shown as ball **41** secured to sub C by suitable means such as welding. The upper sub A with driving unit **40** secured thereto is in effect a torque receiving and transmitting means and similarly lower sub C with driving unit **41** secured thereto is a torque receiving and transmitting means.

Mounted on wire line flexible member B between upper driving means **40** and lower driving means **41** are spheroidal members **42**. Each member **42**, as seen in Figs. 4 and 5, is provided with an axial opening **43** through which flexible member B extends and has its exterior surface adjacent the ends of its axial passage **43** provided with driving means which, in the embodiment shown, consists of grooves **44** extending arcuately on the surface of the ball from one end of passage **43** to its other end. Thus, the series of grooved balls **42** provide a flexible driving arrangement for transmitting force from the upper driving member **40** to the lower driving member **41**.

A flexible housing **45** is arranged outside the string of grooved balls **42** with the upper end of housing **45** secured to sub A and the lower end of housing **45** secured to sub B. By way of example, housing **45** may be a reinforced rubber hose. The lower end of housing **45** may be sealed to sub C by any suitable means, such as vulcanization. The upper end of flexible housing **45** is

secured to sub A in a rotatable fashion. The mounting means shown includes an annular groove 13 in sub A for receiving the upper end of the housing, split rings 46 and 47 and O-ring 48.

It will be understood that the device shown when used for drilling drain holes is attached to the lower end of a string of drill pipe and lowered until the drill bit D rests on the bottom of the hole after which a suitable amount of weight will be allowed to rest on the drill pipe and the bit rotated. The purpose of tension spring 27 is to allow elongation of the inner shaft or flexible member 17 and the flexible housing 45. Once the spring 27 has been compressed to its compressed height, no further deviation is possible. It will be understood that when the device is to be used the angle of deviation may be controlled by controlling the compressed height of the tension spring. A greater compressed height of the tension spring allows a greater deviation while a lesser compressed height of the tension spring allows a lesser deviation. The compression height of the spring is controlled by the use of spacer washers 25 and 29.

A preferred method for using the tool is illustrated in Fig. 6 which is an elevation of a tool such as shown in Fig. 1 provided with a whipstock E. It will be noted that while whipstocks generally are old in the art the whipstock utilized with the present invention may be shorter than usual and have a high angle of turn built in. In use, the device is run into the borehole, the whipstock set and thereafter maximum weight is applied to the tool and the drill stem rotated. As the drill pipe is rotated the sub A also rotates and likewise the sub C interconnected thereto by grooved ball drives 42 and wire rope 17. The flexible housing 45 rotates by virtue of being connected, in the manner described, to subs A and C. The connections between the sub A and the housing 45 and between the sub C and housing 45 are such that sub A may rotate or move slidably around on the upper end of the housing 45 while the lower end of housing 45 rotates with sub C. In effect the rotational connection between sub A and housing 45 takes up any play between the sub A and sub C and prevents twisting. The housing 45 provides a passageway for drilling fluid to circulate down the drill stem. These steps will cause the flexible drive to deviate until the compressed height of the tension spring 27 has been reached after which no further deviation is possible and as drilling continues the leading section of the flexible drive becomes straight and stiff. As heretofore explained, the maximum deviation is controlled by adjusting the compressed height of the tension spring before the tool is run into the hole. After a hole has been completed the whipstock may be reset and a second hole drilled without withdrawing the device to the surface.

In the embodiment of Figs. 1 to 6, inclusive, the driving units 42 have been shown as in the shape of balls. It will be obvious to a workman skilled in the art that while the driving members should be of a general spherical shape, it is not necessary that they be spherical. In Fig. 7, which is schematic, is shown grooved driving balls 50 having elliptical shapes as viewed from the side of the minor axis vertical. It will be understood that a series of driving balls 50 may be substituted for driving balls 42 in the embodiment of Figs. 1 to 5. The advantage of using driving balls of the type of 50 is that the tool will approach the maximum angle of deviation at a greater rate than will a tool in which the driving elements are spherical.

Another embodiment of driving balls is shown in Fig. 8. In Fig. 8 a driving ball 51 is shown having driving grooves 52 with a slight spiral in the direction the driving balls are to be rotated in use. It is to be understood that a series of driving balls 51 may be substituted for the series of driving balls 42 of the embodiment of Figs. 1 to 6. The advantage of the type of driving balls shown in Fig. 8 where the grooves have a slight spiral is that the tendency of the flexible shaft to become stiff and straight is somewhat relieved.

As heretofore explained, changes may be made in the sizes and proportions of parts entering into the apparatus of the present invention. Changes in the results which may be obtained by changing the design of certain parts and by changing the method of use may be noted as follows: By changing the diameter of the driving balls the radius of inclination of the drain hole is altered. The smaller the diameter of the driving ball, the other things being equal, the smaller the radius of inclination of the drain hole. By changing the tension of the inner drive, the radius of inclination of the drain hole is changed. The greater the tension applied to the flexible member or wire rope 17, the greater the tendency of the apparatus to drill straight. Changing the weight applied to the bit changes the rate of deviation; the maximum rate of deviation is acquired by applying maximum weight. Changing the compressed height of the tension spring changes the deviation limits as previously explained.

Having fully described and illustrated preferred embodiments of the present invention, what is desired to be claimed is:

1. A flexible shaft comprising, in combination, a plurality of substanitally identical spheroidal bodies, each body having an axial passage and gripping means on its exterior surfaces adjacent the ends of said passage, said bodies being arranged in a row with corresponding gripping surfaces in contact, a first torque receiving and transmitting means having an axial passage with gripping means on its exterior surface adjacent one end thereof arranged at one end of said row of spheroidal bodies with said gripping means in contact with a corresponding gripping means of the end spheroidal body, a second torque receiving and transmitting means having an axial passage and a gripping means on its exterior surface adjacent an end of said passage arranged at the other end of said row with said gripping means in contact with a corresponding gripping means of the end spheroidal body, an elongated tensioning member of substantially the same diameter of the axial passages of said spheroidal bodies and said first and second torque receiving and transmitting means threaded through the axial passages of said first and second torque transmitting and receiving means and of said spheroidal members, and retaining means mounted on said elongated tensioning member exerting a bias on said two torque receiving and transmitting means to force them toward one another, said retaining means positively limiting the maximum distance said first and second torque receiving and transmitting means may be spaced apart to a predetermined value.

2. A device in accordance with claim 1 in which a flexible housing encases said row of spheroidal bodies with one end in sealing fixed contact with one of said torque receiving and transmitting means and the other end in sealing rotatable contact with the other torque receiving and transmitting means.

3. A device in accordance with claim 2 in which the first torque receiving and transmitting means is provided with screw threads adapted to connect it with a lower end of string pipe and in which the second torque receiving and transmitting means has a drill bit mounted thereon.

4. A flexible shaft comprising, in combination, a plurality of substantially identical spheroidal bodies, each body having an axial passage and gripping means on its exterior surfaces adjacent the ends of said passage, said bodies being arranged in a row with corresponding gripping surfaces in contact, a first torque receiving and transmitting unit having an axial passage of substantially the same diameter as the axial passages of said spheroidal bodies with gripping means on its exterior surface adjacent a first end thereof, an annular groove of substantially greater diameter than said axial passage surrounding said gripping means and having fluid passages between said axial passage and said groove, said first torque re-

ceiving and transmitting unit arranged at a first end of said row of spheroidal bodies with said gripping means in contact with a corresponding gripping means of the end spheroidal body, a second torque receiving and transmitting unit having an axial passage and gripping means on its exterior surface adjacent a first end of said passage, an annular groove in said first end of substantially greater diameter and surrounding said axial passage and fluid passages between said axial passage and said groove, said second torque receiving and transmitting unit being arranged at the second end of said row of spheroidal bodies with its gripping means in contact with a corresponding gripping means with the end spheroidal body, a wire rope of substantially the same diameter as the axial passages of said spheroidal bodies and of said first and second torque receiving and transmitting units threaded through the axial passages of said first and second torque transmitting and receiving units and of said spheroidal members, a first retaining means mounted on the first end of said wire rope, a spring encircling said wire rope between said first retaining member and said first torque receiving

and transmitting unit and a second retaining means fixed to the second end of said wire rope in contact with said second torque receiving and transmitting unit and a flexible housing encasing said row of spheroidal bodies with its first end in sealing rotatable contact with the annular groove of said first torque receiving and transmitting unit and its second end in the annular groove of and in fixed contact with said second torque receiving and transmitting unit.

5. A device in accordance with claim 4 in which the first torque receiving and transmitting unit is provided with screw threads adapted for attaching it to the lower end of string of drill pipe and in which a drill bit is secured to said second torque receiving and transmitting unit.

References Cited in the file of this patent

UNITED STATES PATENTS

2,441,719	Potter	May 18, 1948
2,669,429	Zublin	Feb. 16, 1954