Feb. 2, 1937. M. G. EARLEY 2,069,603

MEANS OF STRAIGHTENING WELL BORES

Original Filed June 25, 1931 3 Sheets-Sheet 1

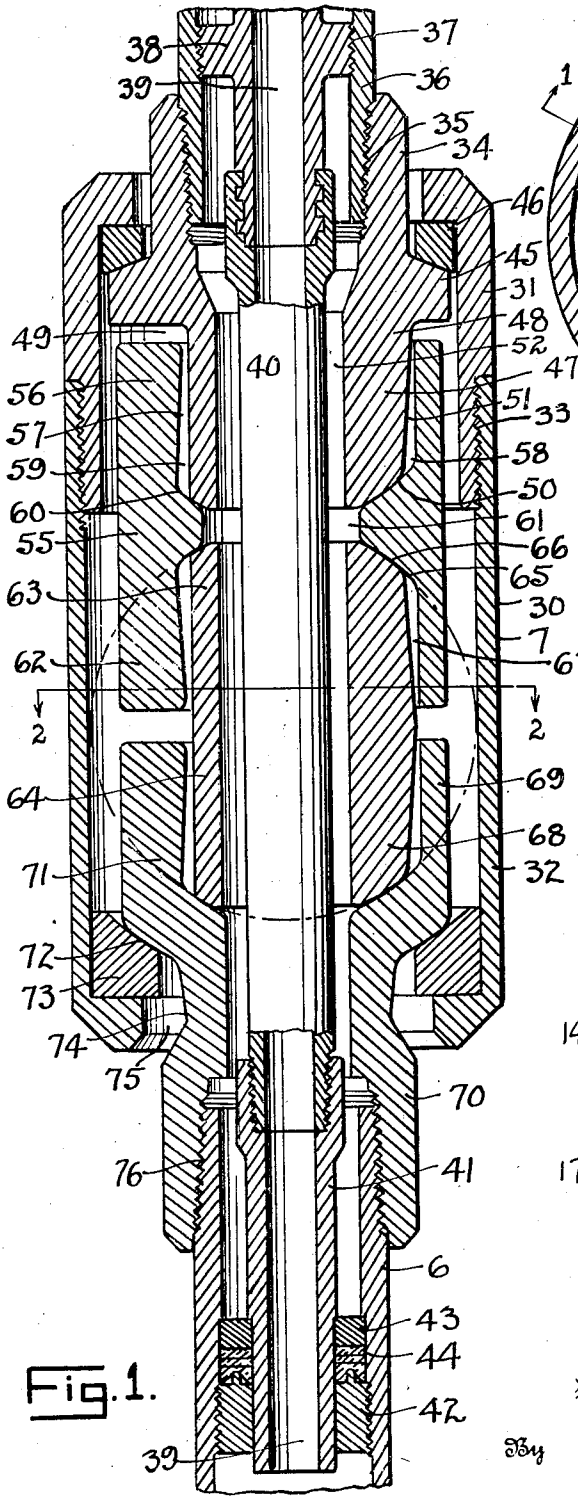


Fig. 1.

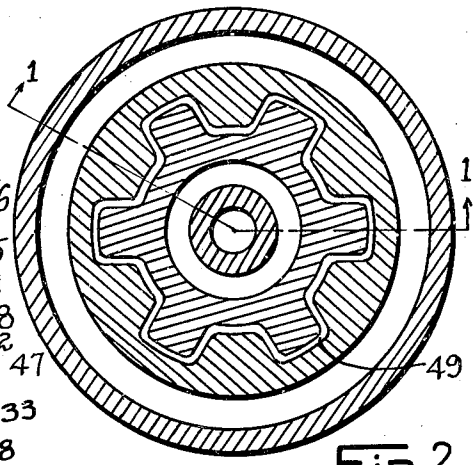


Fig. 2.

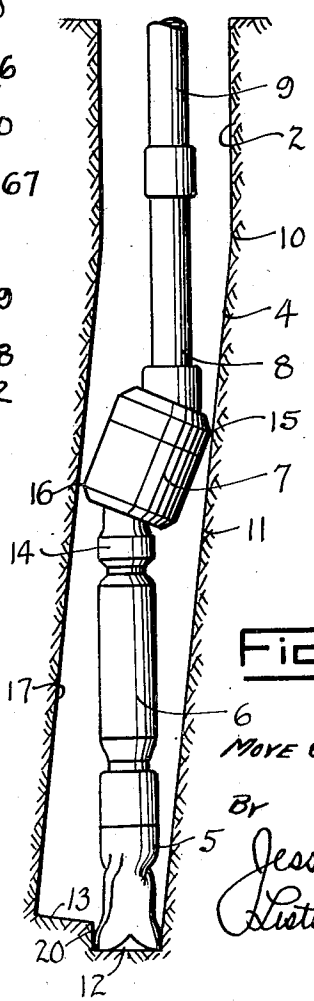


Fig. 3.

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MEANS OF STRAIGHTENING WELL BORES

Original Filed June 25, 1931 3 Sheets-Sheet 2

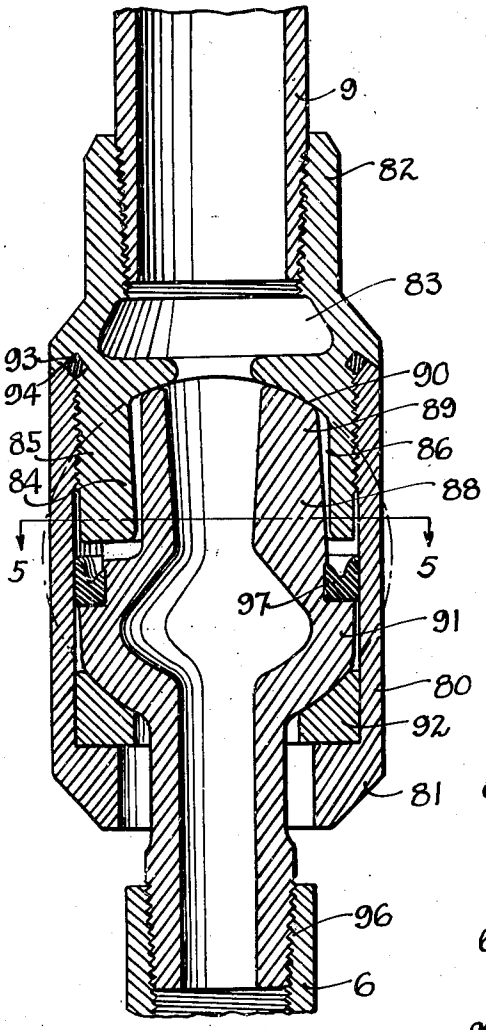


Fig. 4

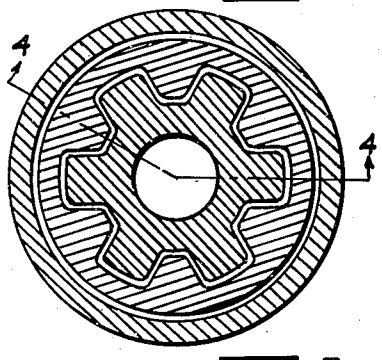


Fig. 5

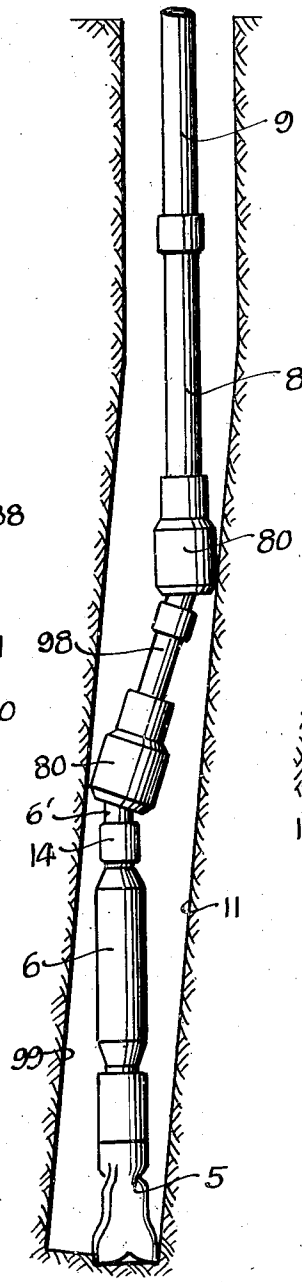


Fig. 6.

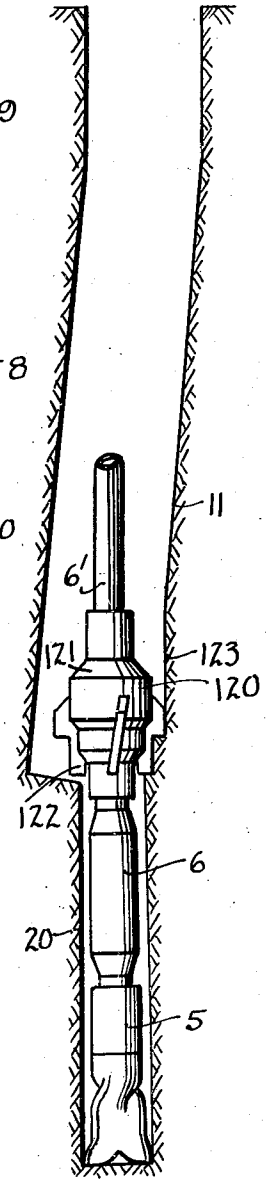


Fig. 9.

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MEANS OF STRAIGHTENING WELL BORES

Original Filed June 25, 1931 3 Sheets-Sheet 3

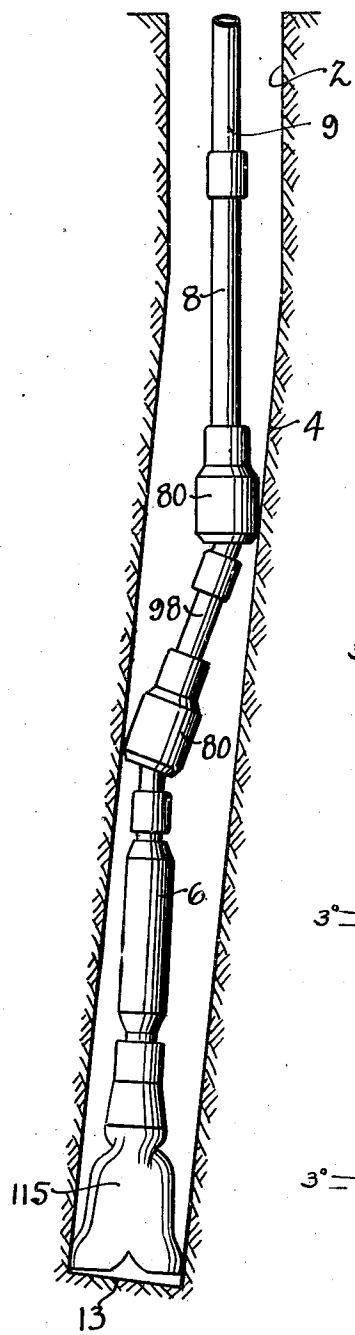


Fig. 7.

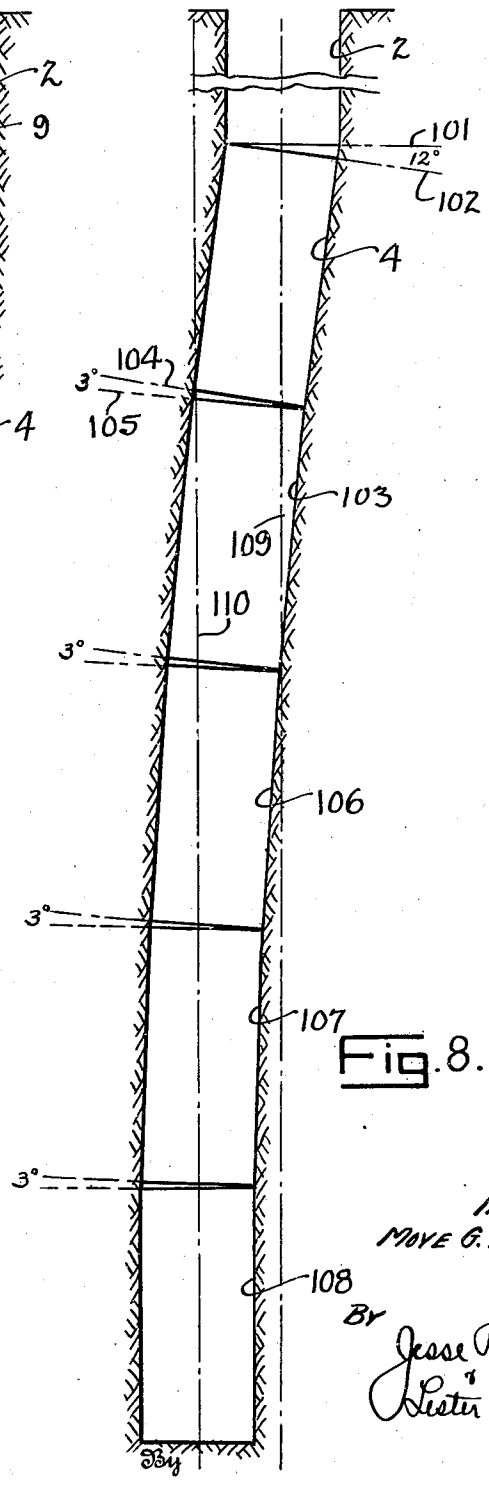


Fig. 8.

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Patented Feb. 2, 1937 2,069,603

UNITED STATES PATENT OFFICE

2,069,603

MEANS OF STRAIGHTENING WELL BORES

Moye G. Earley, Houston, Tex., assignor to J. S. Abercrombie Company, a corporation

Original application June 25, 1931, Serial No. 546,766. Divided and this application June 1, 1934, Serial No. 728,543

2 Claims. (Cl. 255—28)

The invention relates to an improvement in means of straightening or correcting the direction of well bores.

In the drilling of wells it is the rule rather than the exception that the well bore is quite crooked, in the majority of cases and deviates from the vertical a considerable distance. In fact, it is not uncommmon for a well to be deflected from one to five or six degrees which will cause considerable lateral deviation from the vertical when the depth of the well is considered. In many instances wells have been drilled wherein the bottom of the well bore was offset a distance of several hundred feet from the top and its general contour quite crooked. When the operator realizes that his well is crooked it is then necessary to plug up the well bore to an elevation where the bore is straight and to then recommence drilling in the hope that the second start will result in a straight hole. In many instances where the bit passes from one formation to another it strikes the second formation along a plane of cleavage or strikes a boulder or other obstruction and the bit will be deflected from its normal vertical position. The plugging back of the well and re-drilling, gives no assurance that a straight hole will be obtained on the second attempt and in fact it often occurs that the bore will have to be plugged as many as three or four times before a comparatively straight hole is obtained. The present invention contemplates the provision of a means for straightening or correcting the bore as soon as any deviation is observed and elimirates the inconvenience and cost of plugging the well and re-drilling the same.

The present invention is a division of my prior copending application which resulted in my Patent 1,971,480, granted August 28, 1934, wherein the method of drilling is claimed, while the present invention is restricted to the apparatus for such drilling.

It is one of the objects of the invention to provide a drill stem coupling of special construction which will permit an offset in the drill stem which will cause the drill bit to be positioned at an inclination with respect to the drill pipe.

Another object of the invention is to provide a coupling in the drill pipe which will buckle when weight is placed thereon so that the drill bit will be moved to a position which is inclined with respect to the bore in which it is located.

Another object of the invention is to provide a drill stem coupling which will allow the drill bit to follow the contour of the well bore when being lowered into or removed from the well but which will permit an offset relationship of the bit with respect to the remainder of the drill pipe when weight is placed upon the coupling.

A still further object of the invention is to continue the drilling of a crooked well bore in a more nearly vertical direction by utilizing a special type of drill stem coupling.

Another object of the invention is to provide a means of straightening well bores by positioning the drill in the crooked bore at an inclination toward the vertical and continuing the drilling of the well bore.

It is also an object of the invention to correct the inclination of the well bore by tilting the bit to a position between the vertical and the inclination of the well bore with respect to the vertical and continuing the drilling of the bore with the bit thus positioned until the direction of the bore returns to vertical.

Other and further objects of the invention will be readily apparent when the following description is considered in connection with the accompanying drawings wherein

Fig. 1 is a central vertical section of one type of coupling which may be used in practicing the invention, the section having been taken on the line 1—1 of Fig. 2.

Fig. 2 is a central vertical section taken on the line 2—2 of Fig. 1.

Fig. 3 is a diagrammatic view of the mechanism used in practicing the invention and illustrating the positioning of the same in a crooked well bore.

Fig. 4 is a sectional view of another form of coupling which may be used and is a view taken on the line 4—4 of Fig. 5.

Fig. 5 is a central horizontal section taken on the line 5—5 of Fig. 4.

Fig. 6 is a diagrammatic view of the inventon.

Fig. 7 is another diagrammatic showing of the invention using a full bore bit.

Fig. 8 is a schematic showing of the successive corrections of the well bore.

Fig. 9 is a section of a modification of the invention showing a reamer on the drill bit.

In the rotary method of drilling wells the drill bit is connected to a string of drill pipe and rotation of the bit accomplished by rotation of the string of pipe. When the drill bit strikes an obstruction it is often deflected. Sometimes the deflection is caused by permitting too great a weight on the string of pipe so that the drill pipe is flexed and in this manner deflects the bit. Regardless of the cause of the deflection the crooked well bore which results is objectionable

as it not only offsets the location of the bottom of the well but also makes it inconvenient for continued drilling due to flexure necessary in the drill pipe and also increases the cost of operation of the well if it is to be pumped at a later date.

In order that the invention may be understood reference may be had to Fig. 3 where the straight or vertical portion of the bore is indicated at 2. This well bore may be any length but a deflection in the bore is indicated as occuring at 4 and beyond that point the bore is inclined with respect to the vertical. This inclination may have been determined by conditions observed by the driller; it may have been ascertained by a survey of the well, or by the simple process of an acid bottle test.

When it has been determined that the hole is crooked and it is desired to straighten the same and restore the drilling operation to a vertical hole, the drill bit indicated generally at 5, will be connected to a section of pipe or drill collar 6 whose length may be varied in accordance with conditions which will be later described. Above this section of pipe will be the improved coupling 7, which constitutes one of the elements of this invention. This coupling will be of such construction that it will flex when weight is placed on the drill stem and cause the coupling to assume the inclined position shown in Fig. 3. Above this coupling will be a section 8 of drill pipe which will preferably be stiff and rigid. Above this section 8 will be the standard sections of drill pipe 9 which continue to the surface.

When this device is lowered into the well bore the bit, of course, penetrates the bore first and will hang in a vertical position from the drill pipe 9, while the bit is being lowered through the vertical position 2 of the well bore. As the drill bit, however, is lowered into the inclined portion of the well and passes the point of deflection 10, the drill will come in contact with the lowermost wall 11 of the inclined bore, due to the provision of the coupling or connection 7 as the bit is lowered it will assume a position substantially parallel to the inclined lower surface 11 of the inclined portion of the bore.

The lowering of the bit is then continued until the bit 5 comes into engagement with the bottom 13 of the well bore. When this positioning occurs the parts will be in the same position as shown in Fig. 3, except that the top 14 of the section 6 will be reclining against the wall 11 of the bore. At this point, however, the weight of at least part of the drill pipe 9 is lowered onto the drill bit and when this weight is received by the coupling 7, this coupling is of such construction that it will assume the inclined position shown in Fig. 3 and the top of the coupling, due to the stiffness of the section 8 and the drill pipe 9, will remain against the side 11 of the inclined bore. The bottom of the coupling, however, will flex under the weight which is applied thereto and inasmuch as it is offset from the longitudnial axis of the drill pipe 9, and the section 8, due to its reclining position on the wall 11, it will obviously move to an offset position as far as possible. The amount of this offset movement will be limited either by the internal construction of the coupling or by the diameter of the well bore and in the illustration shown in Fig. 3 the inclination or offset relationship has been limited by the well bore where the top of the coupling contacts at 15 and the base of the coupling contacts on the opposite side of the bore at 16. It should be noted that the side of the bore 17 is what will be termed the high side, or upper side of the well bore, whereas the side 11 will be designated as the lower side.

With the parts shown in the position of Fig. 3, the drill stem 9 is rotated from the surface. The coupling is of such construction that it will also rotate and impart rotation to the drill bit which is connected below the coupling. In this manner drilling of the well is continued with the bit in the postion shown in Fig. 3 so that the continuation of the well bore indicated at 20 will be at an inclination more nearly toward the vertical than is the inclination of the well bore 4. It is to be understood that the bit 5, as seen in Fig. 3, may or may not be in a substantially vertical postion. Its position at this time depends upon the degree of inclination of the bore with respect to the vertical, upon the diameter of the bore, the diameter of the bit, and upon the limiting movement of the coupling 7. As an example, however, suppose that the inclination of the bore below the point 10 were 6° from vertical, and the construction of the coupling 7 were such that it would permit an inclination of 3° of the drill bit with respect to the longitudinal axis of the drill pipe 9. It is then apparent that when the parts are positioned as shown in Fig. 3, the drill bit would still be positioned 3° from vertical, and that a correction of 3° would have have been made. The gradual correction of the bore is desirable in order that a sharp bend or change in direction of the well bore will not occur. The bore 20 continuing from the point 13 would therefore have to be drilled at an angle of but 3° with respect to the vertical portion 4 of the bore.

In order that a complete understanding of the operation of the device may be had, reference is made to Fig. 8 where a diagrammatic showing of the well bore after the inclination thereof has been corrected is shown. The first deflection of the bore is indicated by the portion at 4, the same as in Fig. 3. For purposes of illustration this angle of inclination with respect to the vertical is indicated by the lines 101 and 102, which show that the inclination is at an angle of 12° from the vertical. It is now the problem of the operator to make a correction of 12° in order to restore the direction of the well bore to vertical. It is desirable to make this correction gradually rather than to make it abruptly in a short distance. With this in mind, therefore, a correction of 3° will first be made by drilling the section indicated at 103 and as shown by the lines 104 and 105 the correction is 3°. This correction is accomplished in a manner such as previously described in connection with Fig. 3. However, if a pilot bit or bit of less diameter than the well bore is used the hole 20 shown in Fig. 3 will be drilled a distance substantially equal to the distance from the lower edge 12 of the drill bit up to the coupling 7 of the lowermost coupling 80, such as seen in Fig. 6. When this pilot hole 20 has been drilled at a corrected angle of 3° the bit will then be removed from the well and a bit of standard gauge lowered into the well. This bit lowered at this time is preferably what is known as a diamond point bit or a bit having a pilot point thereon so that the operator will be sure that this standard gauge bit will follow the pilot hole 20 along the corrected inclination. This standard gauge bit is used to ream out the hole to bring it up to standard gauge the same as the straight hole 2 or the

incline hole 4. As seen in Fig. 8, that portion 103 of the hole has been reamed out at the corrected inclination due to the use of the method and apparatus of this invention.

In the use of the both the pilot bit and the standard gauge bit while practicing this invention it is desirable that the operator observe the distance which the bits pass into the well bore. Thus, if the operator insists that the length of the bit 5, the pipe 6 and the member 14 up to the coupling is, for example 30 feet, he will then place the bit 5 on the bottom 13 and begin drilling. He will, however, observe the distance that the drill bit passes into the hole so that he will know when the coupling approaches the shoulder 13 and in this manner know that he has drilled the desired distance in making the correction. When the standard bit is then inserted, he will again observe the distance which is being reamed out and limit that distance to the same as the depth of the pilot hole which has been drilled. In this manner the section 103, as seen in Fig. 8, is formed.

It is now desired to make a second correction of 3° and the pilot bit is again lowered into the hole and the section 106 is drilled with the pilot bit, thus making a second correction of 3°. The pilot bit is then removed and the standard gauge bit used to ream out the hole. This operation is repeated to form the section of hole 107 and again repeated to create the last portion 108 of the well bore. In this manner there have been four corrections of 3° each, so that the section 108 is vertical, the same as the section 2, but is offset therefrom a distance equal to the distance between the center lines 109 and 110. The center line 109 represents that of the original vertical bore 2, whereas the line 110 represents that of the corrected bore 108. It is to be understood that the inclination of the portion 4 and the portion 108 may be determined by acid bottle measurements or by any other means.

When the section 108 has been completed the well bore is again vertical and the usual type of tool being employed in that formation may then be lowered into the well and the drilling continued.

The example given above is merely hypothetical and has been exaggerated intentionally in order that a complete understanding of the invention may be had. Under usual conditions the inclination would probably be very slight and the correction would be accordingly slight, but in event the deviation is considerable, as shown in the illustration, it is possible to restore the bore to a vertical position by practicing the invention as herein described.

In Fig. 7 a view of the invention is shown wherein the double couplings of Fig. 6 have been illustrated in combination with a full gauge bit 115. This illustration is given in order to indicate that the invention may be practiced by using a full gauge bit but when this is used the correction which can be made will be less than if a pilot or smaller gauge bit is used. In the illustration of Fig. 7 the correction will be less due to the fact that the bit occupies the full diameter of the well bore and due to the fact the inclination of the bit with respect to the crooked hole will be less than if a pilot bit were used. Where the inclination or deviation of the well bore is slight it is quite possible that a full gauge bit may be used in making the correction as seen in Fig. 7, using either the coupling 7 or the coupling 80 as desired.

The theory of the invention is based upon the forces which will be applied to the couplings 7 or 80 and the buckling or flexing of the coupling is accomplished due to the fact that the lines of force are applied in the coupling in a manner such that the resultant of the horizontal and vertical components will give a resultant at an inclination to the vertical component, and when the weight of the drill stem, or part of such weight, is applied to the coupling. When the drill bit rests on the bottom of the well bore, the coupling will be buckled or flexed due to the fact that the contact of the bit with the well bore occurs at a position which is offset from the vertical center line of the drill stem 8. It is to be understood that if the operations as described in connection with Fig. 8 were continued beyond the section 108 the well bore would again be inclined away from the vertical but in a direction opposite to that of the inclination of the section 4. It is, therefore, apparent that when the driller is advised that he has made a sufficient number of corrections to have balanced the inclination of the section 4 that he will then cease operation with the couplings and replace his standard drill bit coupling directly on the drill stem.

While the invention has been shown and described as primarily directed to the restoring of the well bore to vertical, it is to be understood that it may be applied for other purposes such as in side tracking the well bore around junk in the hole. It often occurs that tools are lost in the hole and cannot be removed and a whip stock or other device is used to side track the bore away from the junk so that the drilling may proceed. If this is desired, this invention may be practiced without using the whip stock by merely plugging the well to a point above the junk and then attaching couplings in the drill pipe and the bit will be directed at an incline with respect to the vertical bore. After suitable inclination has been obtained a full gauge bit may be used to continue the inclination a sufficient distance so that the bore will be deflected to one side of the junk. In this manner the well can be drilled at any desired inclination away from the vertical. After this distance has been accomplished the couplings will again be used to straighten up the bore to a vertical position so that the well bore will continue in a vertical direction but slightly offset from the original position. Applying this idea to Fig. 8 the junk would be located at about the elevation of the section 106 and the coupling could have been used throughout the side tracking operation, or, if desired, a straight bit could be used in drilling the section 103 so that it would have continued in the direction of the section 4 and after the proper deviation was accomplished the couplings would then again have been used to restore the vertical direction of the bore.

One form of the coupling 7 has been illustrated in Figs. 1 and 2 and comprises the housing 30, which is preferably made up of a cap 31 and a base 32, which are threaded into engagement with each other at 33. Inside of the cap 31 is a connecting member 34, which is threaded at 35 to a section of pipe 36. This section may be the section 8 illustrated in Fig. 3, or it may be a usual type of drill pipe. As shown in Fig. 1, however, this pipe 36 is threaded at 37 to receive the plug connection 38, which serves as a passage for a flow of flushing fluid and is provided with the central opening 39. Connected to this plug 38 is a conduit 40, which extends substantially the

length of the coupling 7 and receives a nipple 41 on the lower end thereof. This nipple 41 is connected to the member 6, which may be the same as the section 6 shown in Fig. 3. Inside of this section is a positioning ring 42, which receives the nipple 41 and a seal is maintained about this nipple by means of the stop ring 43 and the packing 44. By adjustment of the ring 42 the sealing around the nipple 41 may be adjusted. It is intended that the conduit 40 may be of more or less flexible material so as to allow for the flexure or buckling of the coupling when the top of the drill bit is offset. With this arrangement a flow of fluid may be obtained through the coupling in order to maintain the usual circulation necessary in drilling by the rotary method.

In order that the coupling will transmit rotation from the pipe 8 to the pipe 6, it is necessary that drive members be provided, and the connecting member 34 is the uppermost element of this drive connection. This connecting member is formed with the shoulder 45 which abuts against the contact ring 46 carried inside of the cap 31. This contact ring serves as a seal and transmits the thrust from the connecting member 34 to the cap 31, when the weight of the drill bit and portions below the connecting member are suspended. Below the shoulder 45 the connecting member 34 is formed with a ribbed construction 47 and on the righthand side of Fig. 1, one of the ribs 48 is shown in section. On the lefthand side of Fig. 1 the section has been so illustrated that a channel 49 has been shown. This channel is disposed between two of the ribs 48. The lower end of the portion 47 is rounded or beveled at 50 on the arc of a circle, and the ribs 48 are preferably tapered as shown at 51. The center part of this portion 47 is hollow, as at 52, and the conduit 40 passes axially through the same.

A sleeve 55 is provided inside of the housing 30 and is internally ribbed as at 56 in order to receive the ribbed portion of the connecting member. These two parts are interfitting with the ribs in co-engagement, as best seen in Fig. 2. Thus, if the connecting member 34 is rotated it will also impart rotation to the sleeve 55. However, the ribs 57 are tapered downwardly and outwardly so that the space between the ribs 57 and the channels 49, and the ribs 48 and the channel 58 in the sleeve 55 gradually increases in width and is of greater width at 59. The ribs 56 terminate in an annular shoulder 60, which is formed on an arc of a circle substantially the same as the circular arc on which the end 50 of the coupling 34 is formed. Thus a portion of a ball and socket connection is formed at this point which will allow the sleeve 55 to tilt angularly in any direction, a number of degrees at least equal to the taper between the co-operating ribs on the parts. For purposes of illustration this coupling may be made up to permit an angular inclination of 3°.

The center of the sleeve 55 is provided with a passage 61 so that the conduit 40 may extend therethrough. The lower portion 62 of the sleeve 55 is identical with the upper portion previously described and is arranged to receive the upper end 63 of the drive bushing 64, which is formed with a ball seat at 65 to engage the lower shoulder 66 on the sleeve 55, which shoulder is the same as the shoulder 60. This drive bushing 64 is tapered at 67 in a manner similar to the taper of the ribs 48, so that a 3° tilting will be available at this point also. This drive bushing 64 is symmetrical in its construction and the lower portion 68 is of the same arrangement as the upper portion and is adapted to be received in the upper end 69 of the lower connecting member 70. This upper end 69 of the connecting member 70 is formed identically the same as either end of the sleeve 55 and further description thereof is not believed to be necessary. The arc of the circle on which the shoulder 65 is formed has been indicated by the line 71.

The lower connecting member 70 is formed with a shoulder 72 similar to the shoulder 45 on the upper connecting member and this member abuts on the lower contact ring 73 so that a thrust will be transmitted from the connecting member to the housing 7 when the drill bit is suspended. This connecting member is reduced in size at 74 to pass through the opening 75 in the base 32 of the housing 7 and is threaded at 76 to receive the pipe 6.

From the foregoing construction it seems readily apparent that there are three 3° angular displacements provided in the coupling so that the final resultant angular position of the pipe 6 with respect to the pipe 36 will be an inclination of 3°. The connecting members inside of the housing are required, however, in order to carry the thrust which will be applied to the coupling when the bit is to be rotated in the drilling operation. This trust will be transmitted from the connecting member 34 to the sleeve 55 to the drive bushing 64 and to the lower connecting member 70. All of these parts intermesh with each other due to the rib and channel construction so that a positive drive will be assured even though angular displacement is possible.

Figs. 4 and 5 show a modified form of coupling which is indicated at 80. This coupling contains the base 81 and the cap 82. This cap 82, however, is connected directly to the pipe 9 and is provided with a hollow area 83 to allow for circulation of fluid through the coupling. This cap 82 is provided with a rib construction 84, which, as seen in Fig. 5, constitutes alternate ribs 85 and channel 86. These ribs and channels are tapered outwardly and upwardly so that the drive bushing 88 disposed therein will be rotated but, due to the tapered form of the ribs 89 on this drive bushing, limited angular displacement will be permitted between the two members and the thrust from the cap 82 to the drive bushing 88 will occur at the point 90, which is a portion of a ball and socket seat as described in connection with the Fig. 1 coupling.

With this arrangement rotation will occur but tilting movement will be possible. The drive bushing 88 is disposed in the base 81 of the coupling and the shoulder 91 abuts against a contact ring 92 to carry the thrust when the bit is suspended on the coupling. A packing 97 is provided above the shoulder 91 and is preferably of the type which will expand when subjected to fluid pressure so that it will form a seal between the drive bushing 88 and the base 81 of the coupling. Thus the slight tilting movement of the drive bushing 88 with respect to the base of the coupling will not destroy the seal. If desired a packing 93 may be provided between the base and the cap and the base is tapered at 94 to seat in the groove in the cap. The lower end of the drive bushing 88 is threaded at 96 to connect with the pipe 6 or other section, which is below the coupling.

As seen in Fig. 3, the operation of the bit and the method is the same as disclosed in connection

with Fig. 3, except that two of the couplings **80** are necessary as each allows a deflection of the bit with respect to the drill pipe **9**. However, the arrangement shown in Fig. 6 is of particular advantage where the inclination of the well bore is slight and has continued for a considerable distance before it was discovered. Thus, the coupling **80** will be positioned above the section **8** of the drill pipe and directly below this coupling **80** will be a second coupling, which is positioned away from the first coupling, however, a considerable distance. This connection is by means of the section of pipe **98** and this length of pipe may be varied as the amount of angular displacement of the bit depends to some extent upon the length of this pipe **98** and the length of the pipe **6** connected to the bit **5**.

It will be readily apparent that if the lower coupling **80** were positioned, we will say, at a point **99** in the inclined bore the top of the bit **5** would then be inclined with respect to the bore at a greater degree than it would be if the parts were in the position shown in Fig. 6. The operation of this form of the invention is the same as in the Fig. 3 embodiment.

Fig. 9 of the drawings shows an arrangement wherein the bit **5** has entered the pilot hole or corrected hole **20** and has drilled this hole for a considerable distance. This is the manner in which the pilot bit **5** of Figs. 3 and 6 will penetrate the formation. In Fig. 9, however, a slightly modified form of the apparatus is used in which the drill collar **6** is positioned as in the previous modification but the short section of pipe **6'**, as seen in Fig. 6, and the coupling **14** have been repositioned and connected directly to the drill collar **6**, a reamer coupling **120**. This coupling is preferably connected directly to the drill collar **6** in any suitable manner and embodies a body portion **121**, which is fitted with laterally directed reamer blades **122**. These blades are integral with the body **121** or they may be removable and are preferably removable in order that they may be replaced when worn. The blades here shown are of the two stage type so that the reaming operation is performed in two steps. As noted in Fig. 9 the lower wall **11** of the inclined bore has been reamed away as at **123** and as this reamer **120** proceeds into the pilot hole the pilot hole will be reamed out to standard gauge. With a structure of this type it would be possible to modify somewhat the method as practiced in connection with Fig. 8 by merely making the drilling operation continuous until such time as the driller had reason to believe that the inclination of the well bore had been corrected to the desired direction. The driller could then remove the entire device including the reaming collar, the drill bit and the swivel coupling and run in an acid bottle or other device to determine the amount of correction which had been made.

As seen in Fig. 9, the section of pipe **6'** of Fig. 6 has been elongated somewhat and would have attached to its upper end either one of the couplings **80** of Fig. 6 or a coupling such as **7** in Fig. 3, so that the top of the drill bit and the reamer coupling would be offset with respect to the longitudinal axis of the drill pipe. It is believed that the modification of Fig. 9 will be readily understood from the foregoing description and it will be unnecessary to give any further illustration thereof in connection with the coupling embodied in this invention.

While specific forms of the coupling have been shown and described it is to be understood that the invention broadly contemplates a means of correcting the inclination of the well bore or changing its direction, and that the invention may be practiced by devices other than those here illustrated so long as the means of tilting the top of tne drill bit so that the bit assumes a position at an inclination with respect to the well bore is utilized.

What is claimed is:

1. A coupling for drill stems including a plurality of relatively tiltable interfitting members adapted to transmit rotation to each other, a housing for said members, means to connect a pipe to said members to project from opposite ends of said housing, and means to conduct liquid through said members including a flexible tube extending therethrough.

2. A well bore straightening tool including a hollow drill stem, a reamer means having a circulating fluid passage formed therethrough, a drilling bit having a circulating fluid passage formed therethrough, a universal joint operatively connecting said reamer and stem, and a flexible duct means interconnecting said stem reamer and bit circulating fluid passages.

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