

Aug. 4, 1942.

A. L. GIBBONS ET AL
WELL STRAIGHTENING DEVICE

2,292,268

Filed March 6, 1939

2 Sheets-Sheet 1

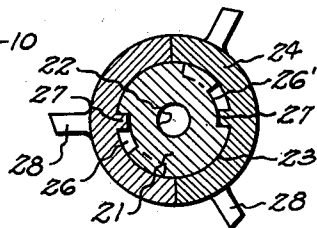
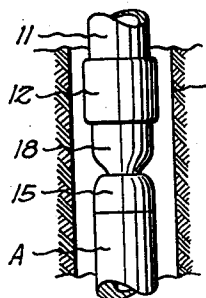


Fig. 7.

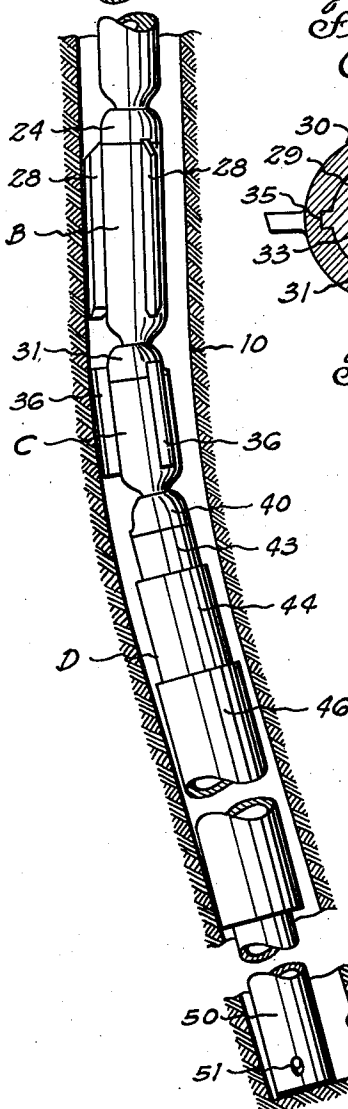


Fig. 1.

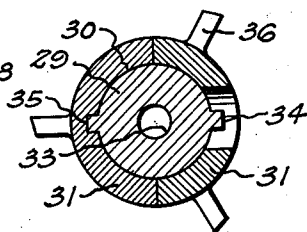


Fig. 8.

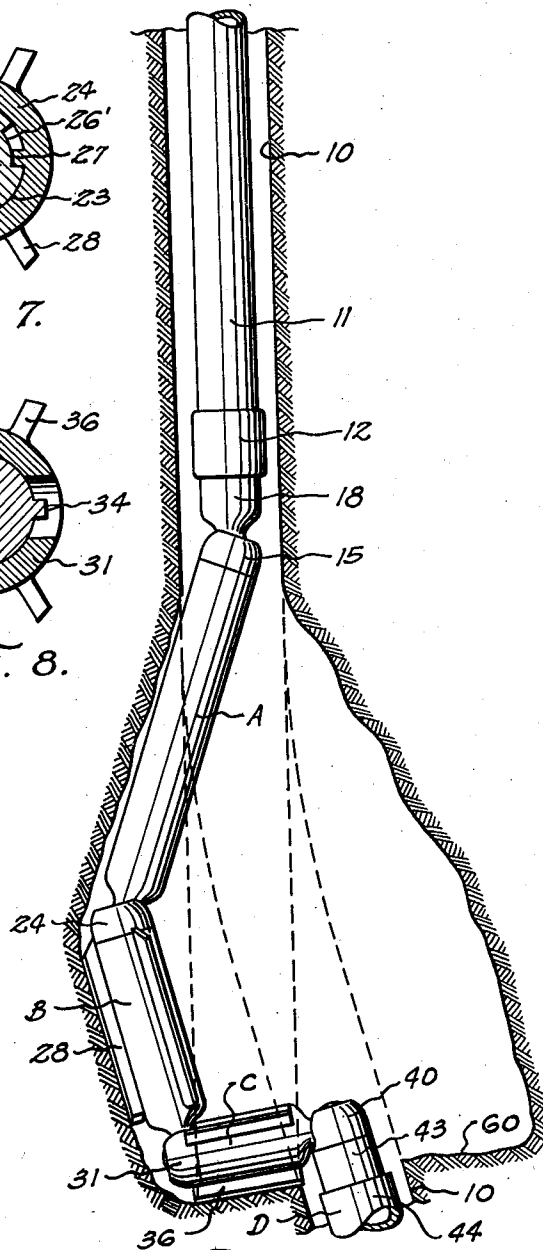


Fig. 2.

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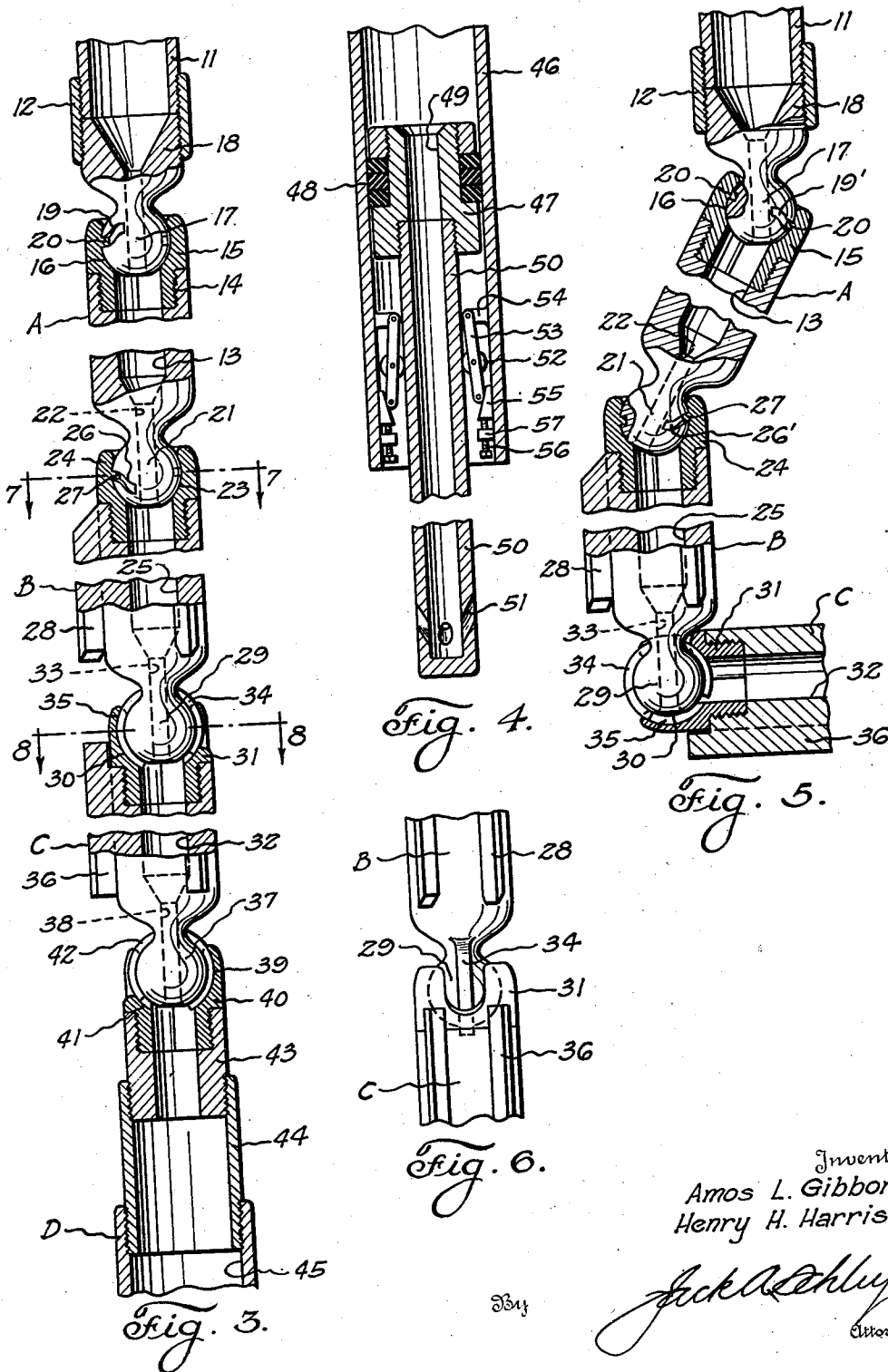
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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WELL STRAIGHTENING DEVICE

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6 Claims. (Cl. 255—74)

This invention relates to new and useful improvements in well straightening devices.

It is well known in the oil industry that in drilling well bores to deeper depths, difficulty is experienced in maintaining a true vertical line during the drilling operation. Inclined subterranean structures, as well as other causes, result in the offsetting of the drill as it rotates and thus instead of producing a straight bore, said bore curves or inclines from the vertical. Whenever the bore curves or inclines from the vertical, additional strain is placed on the drilling equipment and, in many instances, twisting off of the drill pipe occurs. Further, once the bore is curved, it is manifest that continued drilling results in an increased curvature or inclination from the vertical, which is most undesirable.

One object of this invention is to provide an improved means for straightening a well bore which has been drilled at an inclination from the vertical.

An important object of the invention is to provide an improved device adapted to be lowered into a crooked or inclined well bore and which is arranged to be operated by the ordinary drill stem to drill out the formation at the point where the bore begins its incline from the vertical, whereby when the regular drilling is subsequently continued, it may follow a true vertical line rather than the inclined path described by the crooked bore.

Another object of the invention is to provide an improved well bore straightening device which is constructed in sections which are connected to each other by pivotal joints, whereby said sections may hang in vertical alinement with each other to permit ready lowering of the device through the well bore to the desired location; said sections being arranged to be offset with relation to each other and being provided with cutting members, whereby when offset and rotated, an enlarged chamber considerably larger than the well bore may be drilled out of the formation around said bore, so that subsequent true vertical drilling may be accomplished.

A particular object of the invention is to provide an improved well straightening device, of the character described, wherein the sections are connected to each other by ball and socket joints, which joints include means for controlling the direction in which the sections are deflected or offset, whereby it is assured that the formation immediately below the vertical portion of the bore is removed, so as to permit subsequent

straight or vertical drilling to straighten the bore.

Another object of the invention is to provide an improved well straightening device wherein certain of the sections are formed with external elongate cutting members and also wherein means is provided for circulating a drilling fluid through and around said device, whereby the cuttings removed by the cutting members are carried to the surface.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings, in which an example of the invention is shown, and wherein:

Figure 1 is an elevation of a well straightening device, constructed in accordance with the invention, and showing the same inserted within the well bore,

Figure 2 is a similar view, with the sections of the device in a deflected or operating position,

Figure 3 is an enlarged view, partly in elevation and partly in section, and illustrating the sections, together with the connections therebetween,

Figure 4 is a transverse, vertical, sectional view of the lower end of the device,

Figure 5 is an enlarged view, partly in elevation and partly in section, with the sections of the device in a deflected or operating position,

Figure 6 is a partial elevation of the connection between the cutting sections of the device, said view being taken at a right angle to the parts shown in Figure 3,

Figure 7 is a horizontal, cross-sectional view, taken on the line 7—7 of Figure 3, and

Figure 8 is a horizontal, cross-sectional view, taken on the line 8—8 of Figure 3.

In the drawings, the numeral 10 designates a well bore which has been drilled in any desired manner. As illustrated in Figure 1, the bore has been drilled at an incline from the vertical, whereby a crooked hole has been formed. There are numerous causes which produce a crooked or inclined well bore and it is not deemed necessary to enumerate said causes. However, it is manifest that when the well bore inclines from the vertical, an undue strain is placed on the drilling equipment and particularly on the drill stem or pipe and it is, therefore, desirable that said bore be straightened so that it will extend substantially vertical from the surface of the

ground. When a bore is started at an incline from the vertical, continued drilling will not remedy such inclination and will not bring said bore back to the true vertical, but rather such continued drilling will only result in increasing the incline or curvature of the hole.

In carrying out the invention, the improved well straightening device is arranged to be attached to the lower end of the usual drill stem or pipe 11, said device being coupled to the pipe by an ordinary coupling collar 12. The device includes a plurality of sections A, B, C and D, which sections are connected together by means of pivotal connections, as will be hereinafter explained, whereby said sections are capable of deflection or offsetting with relation to each other.

The uppermost section A is elongate and is cylindrical in cross-section, being provided with an axial bore 13 which extends entirely there-through. The extreme upper end of the bore is enlarged and internally screw-threaded at 14, whereby a split collar 15 may be threaded thereinto. The upper portion of the bore of the collar 15 is rounded to form a socket 16, within which a ball 17 is adapted to seat. The ball is formed integral with a head 18, which is provided with external screw threads and which is adapted to be threaded into the coupling collar 12, whereby the ball 17 is secured to the lower end of the drill stem 11. Obviously, by making the collar 15 in two sections, it is possible to engage the socket 16 around the ball 17, after which the upper end of the section A may be threaded onto the collar 15.

The connection between the ball 17 and its socket 16 is an important feature of the invention and is clearly shown in Figures 3 and 5. The exterior surface of the ball 17 is provided with a pair of curved grooves or recesses 19 and said recesses are located diametrically opposite each other. Each recess is arranged to receive a radially extending lug 20 which is formed on the inner surface of the wall of the socket 16. Each lug 20 is preferably angular in cross-section. Each groove has one end thereof disposed substantially in alinement with the horizontal axis of the ball 17. One of said grooves inclines or curves upwardly from the horizontal axis, while the opposite groove, indicated as 19', is inclined or curved downwardly from said horizontal axis. With the parts in the position shown in Figure 1, the lug 20, which is engaged in the groove 19, is at the lower end of said groove, while the opposite lug 20 is located at the upper end of its groove 19'.

Assuming that the section A is substantially stationary, while the drill stem 11 and ball 17 secured thereto are rotated in a clockwise direction, it will be manifest that the lugs 20 will ride in the grooves 19 and 19'. Due to the inclination or curvature of said grooves, a cam action between said grooves and the lugs 20 engaging therein will occur, with the result that the lug 20 will be moved upwardly on the ball. At the same time, the opposite lug 20 will ride downwardly through the groove 19' and such movement of the lugs will result in a tilting action which is imparted to the socket 16 secured to the upper end of the section A. Therefore, with the parts in the position shown in Figure 3, a rotation of the drill stem 11, while the section A remains stationary, will result in a tilting of said section, whereby the same is inclined or offset from the vertical. A reverse rotation of the drill stem and ball 17 will cause the lugs 20 to move

in an opposite direction in their respective groove, whereby said lugs are again alined with the horizontal axis of the ball and the section A is returned to a vertical position. From the above, it will be seen that the construction of the ball and socket provides a means whereby a rotation of the drill stem will result in a deflection or inclination of the section A.

A ball 21, similar to the ball 17, is preferably formed integral with the lower end of the section A and an axial port 22 extends through the ball and communicates with the bore 13 of the section. The ball 21 is adapted to be mounted within a socket 23 formed within a collar 24, which collar is similar in construction to the collar 15. The collar 24 is threaded into the upper end of the bore 25 of the section B. This section is constructed in substantially the same manner as the section A, being cylindrical but having a shorter length.

The ball 21 is connected to its socket 23 by substantially the same means as the connection between the ball 17 and its socket 16. A pair of diametrically opposed grooves 26 and 26' are formed in the outer surface of the ball 21 and lugs 27 extend radially from the wall of the socket 23 and are engageable within the grooves. As is clearly shown in Figure 3, the groove 26, which is immediately below the groove 19 in the ball 17, has one end terminating in the same plane as the horizontal axis of the ball 21. However, instead of this groove curving upwardly on the surface of the ball, as does the groove 19 in the ball 17, said groove curves downwardly on the ball 21. The opposite groove 26' of the ball 21 has one end disposed in the same plane as the horizontal axis and this groove curves upwardly on the surface of the ball 21. With the section B alined vertically with the section A, the lug 27 is in the upper end of the groove 26, while the opposite lug is at the lower end of the other groove 26'. Therefore, if a relative rotation between the sections A and B occurs, the lug in the groove 26 will ride downwardly in said groove, while the opposite lug will ride upwardly in the groove 26', which results in a tilting or deflection of the section B with relation to the section A. The direction of such deflection will be to the right in Figure 3, whereby the section B will assume the position shown in Figure 5 with relation to the section A. It is pointed out that the direction of movement of the section B with relation to the section A is directly opposite to the movement of the section A with relation to the drill stem and this is brought about by the disposition or inclination of the grooves 26 and 26' on the ball 21, which inclination is directly opposite to the inclination of the grooves 19 and 19' in the ball 17. Thus, assuming the parts to be in a vertical position, as shown in Figure 3, a rotation of the drill stem 11 will impart rotation to the ball 17, and assuming that the sections A and B are stationary the section A will be deflected to the left in Figure 3 with relation to the drill stem. As soon as the lugs 20 reach the ends of the grooves 19 and 19', the rotation of the drill stem will be imparted to the section A. Such rotation of the section A will cause the grooves 26 and 26' on the ball 21 to rotate relative to the lugs 27, whereby the section B will be deflected or tilted with relation to the section A, as has been explained.

The section B will be hereinafter referred to as the upper cutting section and is provided

with a plurality of elongate cutting blades or members 28 on its exterior surface. These blades extend substantially throughout the vertical length of the section. A ball 29 is formed integral with the lower end of the section B and is adapted to engage within the socket 30 of a collar 31. This collar is split and is adapted to be threaded into the upper end of the bore 32 of the next section C of the device. The ball 29 is provided with an axial passage 33 which communicates with the lower end of the bore 25 of the upper cutting section B.

The ball 29 is provided with a pair of radially directed ribs 34, which are preferably made integral with the exterior surface of said ball. The ribs are located diametrically opposite each other and are adapted to engage within grooves 35 which are formed in the wall of the socket 30. With this arrangement, the ball 29 cannot rotate with relation to its socket 30, yet may undergo a swinging movement with relation thereto. The swinging movement is, however, limited to a given vertical plane. Therefore, the section C can move in only one plane with relation to the section B.

The section C is shorter in length than is the section B and is formed with vertical, radially extending cutting elements or blades 36, which extend substantially throughout the vertical length of the section. The lower end of the section C is provided with a ball 37, which is preferably made integral therewith and this ball is formed with a vertical, axial passage 38 which communicates with the lower end of the bore 32 of the section C. The ball 37 is adapted to engage within a socket 39 formed within a collar 40. The collar 40 is split so as to be readily engageable around the ball 37 and has its socket 39 formed with grooves 41, similar to the grooves 35 in the socket 30. The ball 37 has external ribs 42, similar to the ribs 34 on the ball 29, and said ribs are engageable within the grooves 41 within the socket 39. With this arrangement, the socket 40 may undergo a swinging or tilting movement with relation to the ball, such movement being limited to a single vertical plane since rotation of the parts with relation to each other is prevented by the ribs 42 engaging within the grooves 41.

The socket collar 40 is threaded into the upper end of a nipple 43, which nipple has its lower end threaded into the bore of a coupling 44. The lower end of the coupling is, in turn, threaded into the upper end of the bore 45 of the lower section D of the device. As is clearly shown in Figure 4, the lower section D includes an elongate tubular body or sleeve 46 which has its lower end open. A piston 47 is movable vertically in the bore 45 of the sleeve 46 and this piston is provided with suitable packing rings 48 which engage the wall of the bore. The piston is provided with an axial bore 49 which has its lower end enlarged and internally screw-threaded to receive the upper end of an elongate pipe section 50. The lower end of the pipe 50 is closed and is formed with upwardly and outwardly inclined radial ports 51 which are located just above the closed lower end.

Manifestly, the pipe 50 extends axially of the sleeve 46 of the lowermost section D and, for frictionally holding said pipe in a predetermined position with relation to the sleeve, a pair of knurled rollers 52 (Figure 4) are provided. The rollers are carried by arms 53, each of which has its upper end pivoted to a bracket 54 which

is secured to the wall of the sleeve. The lower end of each arm 53 is arranged to be engaged by a wedge block 55 which is carried by an elongate screw 56. The screw is threaded through a suitable collar 57 secured to the inner wall of the sleeve 46 at the lower end thereof and, obviously, when the screw 56 is tightened, the wedge block 55 is moved upwardly to force the arm 53 which carries the roller 52 outwardly away from the wall of the sleeve. When this occurs, the knurled roller 52, carried by said arm, is forced into frictional engagement with the pipe 50 and such frictional engagement of the rollers with said pipe is sufficient to sustain the weight of the pipe and the piston carried thereby. In this manner, said pipe and piston may be frictionally held in any position with relation to the sleeve 46. When this frictional engagement is overcome, it will be manifest that the sleeve may move downwardly with relation to the pipe 50 due to the telescoping action between these parts.

In operation, the device is coupled to the lower end of the drill stem 11 by means of the coupling 12 and is lowered into the well bore 10, which has been erroneously drilled at an incline from the vertical. The pipe section 50 at the lower end of the device is of a proper length and is so adjusted with relation to the sleeve 46 of the lowermost section D that, when the device is lowered into the bore, downward movement of the device is stopped by the pipe 50 striking the lower end of the bore so as to position the cutting sections B and C substantially opposite the point where the inclination of the bore commences. This position of the device is shown in Figure 1 and due to the inclination of the bore the sections B and C will tend to lean to the low side of the inclined bore.

With the parts in this position, a rotation is imparted to the drill stem by any suitable means (not shown) and, as said drill pipe rotates, it will be manifest that a rotation will be imparted to the sections of the device. Due to the engagement of the inclined grooves 19 and 19' with the lugs 20 of the socket 16 at the upper end of the section A, it will be manifest that a rotation of the drill stem will tend to urge the section A to its tilted position. However, since the cutting blades 28 of the upper cutting section B are in engagement with the wall, such tilting movement is defeated at this time. As the drill stem continues to rotate, the cutting blades 28 of the section B, as well as the cutting blades of the section C, will bore out the side walls of the hole 10 and, as they cut out this formation, it will be manifest that a deflection of the section A will be permitted. Such deflection will gradually increase as the wall of the bore is enlarged in diameter until the maximum deflection of the uppermost section A is accomplished. Of course, as the upper section is being deflected to the left with relation to the drill stem in Figure 1, the section B, due to its ball and socket connection, will be deflected in an opposite direction, that is, to the right in Figure 1 with relation to section A. At the same time, the lower cutting section C will also tend to be deflected or swung with relation to the section D. It will naturally swing to the left in Figure 1 because it was originally inclined that way due to the inclination of the bore hole. As the drilling continues, the various sections will continue to deflect because the wall of the bore is gradually increasing due to the cutting action

of the sections B and C. During the cutting action or drilling out of the wall of the bore 10, a suitable drilling fluid may be circulated downwardly through the drill stem 11. This drilling fluid will pass through the section A, then through the sections B, C and D and finally downwardly through the pipe 50 to escape from the lower end of said pipe through the outlet port 51. The drilling fluid will then flow upwardly outside of the drill stem to the surface and will therefore wash the cuttings to the surface, as well as lubricate the cutting blades 28 and 36.

Obviously, as the sections A, B and C of the tool are deflected from the vertical, as has been described, the drill stem moves downwardly in the bore. Deflection of the sections will continue until the position shown in Figure 2 is reached, which position shows the maximum deflection possible. In such position, it will be obvious that the upper cutting section B is following the vertical wall of the bore formed by the tool, while the section C has been deflected to a substantially horizontal position. When such position is reached, continued rotation of the drill stem 11 and a resultant rotation of the sections A, B and C will continue the drilling operation. Since the blades 36 of the section C are substantially in a horizontal plane, it will be obvious that a horizontal shoulder 60 will be formed around the original bore 10, as shown in Figure 2. When the maximum deflection of the sections has occurred and drilling is continued, it is obvious that all of the sections must move downwardly and it is at this time that the telescoping action of the pipe 50 with relation to the sleeve 46 of the lower section D comes into action. After maximum deflection of the sections has been attained, continued drilling forces the sections downwardly as a unit and, in order to permit such downward movement, in order to form the shoulder 60, the section D must move downwardly through the lower end of the original bore 10. Such downward movement is permitted because the weight imposed downwardly on the sleeve 46 is sufficient to overcome the frictional grip of the knurled rollers 52 with the pipe 50, whereby a telescoping action of the sleeve 46 on the piston 47 occurs. Thus, drilling may continue for any desired period after maximum deflection of the sections has been obtained.

The horizontal shoulder 60 which is formed by the lower cutting section C has a portion thereof substantially in alignment with the vertical portion of the bore 10. Such alignment is brought about by the deflection of the section C to a substantially horizontal plane and at substantially a right angle to the lowermost section D. By forming the shoulder 60 within the formation and locating a portion thereof substantially in alignment with the vertical portion of the well bore 10, it will be seen that the tool may be removed from the bore, after which the usual drill bit may be lowered through the bore. Such bit will strike the shoulder 60 and drilling may continue in vertical alignment with the well bore. Therefore, the drill bit need not follow the original curved bore but may start drilling anew in the shoulder 60 formed by the tool herein described.

In order to remove the tool, it is only necessary to reverse the rotation of the drill stem 11 and such reverse rotation acting through the grooves 19 and lugs 20 will return the section A to a vertical position with relation to the drill stem.

Similarly, such reverse rotation will cause the section B to also become vertically aligned with the section A, such alignment being accomplished by the coating grooves 26 and 26' and the lugs 27. As soon as the sections A and B are aligned with each other, the weight of the sections C and D will automatically align these sections vertically with the uppermost section. Thus, the drill stem may be pulled upwardly to remove the device after the shoulder 60 has been formed.

The device is relatively simple in construction and includes the plurality of sections which may be deflected from the vertical so that when rotated they will enlarge the original bore or hole 10. The connection between the various sections is such that the deflection or inclination of said sections may be controlled so that the formation may be properly drilled out and a new surface for the ordinary drill bit provided. In this manner, a well bore which is erroneously inclined from the vertical may be readily straightened in a minimum time and with minimum effort.

The foregoing description of the invention is explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made, within the scope of the appended claims, without departing from the spirit of the invention.

What we claim and desire to secure by Letters Patent is:

1. A well straightening device adapted to be lowered into an inclined well bore including, a plurality of sections arranged to be deflected from the vertical and along a longitudinal axis, means on the sections for drilling out the formation to enlarge the well bore when the sections are rotated, means for automatically deflecting said sections to gradually enlarge the diameter of the hole being drilled by said sections as said drilling continues, and adjustable means on the lowermost section adapted to engage the bottom of the inclined well bore for positioning the cutters of sections opposite the point where the well bore begins its incline from the vertical, said means being arranged to telescope the lowermost section when maximum deflection of the members has occurred to permit the sections to move downwardly through the formation.

2. A well straightening device adapted to be lowered into an inclined well bore including, a plurality of sections arranged to be deflected from the vertical and along a longitudinal axis, means on the sections for drilling out the formation to enlarge the well bore when the sections are rotated, means for automatically deflecting said sections to gradually enlarge the diameter of the hole being drilled by said sections as said drilling continues, means for controlling the direction of deflection of said sections, means for limiting the deflection of the sections to control the diameter of the opening drilled by said sections, and adjustable means on the lowermost section adapted to engage the bottom of the inclined well bore for positioning the cutters of sections opposite the point where the well bore begins its incline from the vertical, said means being arranged to telescope the lowermost section when maximum deflection of the members has occurred to permit the sections to move downwardly through the formation.

3. A well straightening device adapted to be connected to a drill stem and arranged to be lowered into an inclined well bore including, an upper section, a ball and socket connection be-

tween said section and the drill stem, coacting means on said ball and socket for tilting the section to deflect the same from the vertical when the drill stem is rotated, an upper cutting section below the upper section, a ball and socket connection between the sections, coacting means on said ball and socket for controlling the direction of tilting relative to each other, a lower cutting section connected to the upper cutting section and arranged to swing with relation thereto, a guide section connected to the lower cutting section and capable of swinging relative thereto, and means for limiting the deflection of the sections with relation to each other and to the drill stem, whereby the size of the opening drilled by the cutting sections when the same are rotated may be controlled.

4. A well straightening device adapted to be connected to a drill stem and arranged to be lowered into an inclined well bore including, an upper section, a ball and socket connection between said section and the drill stem, coacting means on said ball and socket for tilting the section to deflect the same from the vertical when the drill stem is rotated, an upper cutting section below the upper section, a ball and socket connection between the sections, coacting means on said ball and socket for controlling the direction of tilting relative to each other, a lower cutting section connected to the upper cutting section and arranged to swing with relation thereto, a guide section connected to the lower cutting section and capable of swinging relative thereto, and means for limiting the deflection of the sections with relation to each other and to the drill stem, whereby the size of the opening drilled by the cutting sections when the same are rotated may be controlled, all of the sections have communicating axial passages which communicate with the bore of the drill stem, whereby a drilling fluid may be circulated through the stem and sections and upwardly therearound during the drilling operation.

5. A well straightening device adapted to be lowered into an inclined well bore including, an upper section connected to a drill stem and arranged to undergo a tilting movement relative thereto, a pair of cutting sections having cutting members thereon connected to each other so as to be capable of deflection with relation to each other, said cutting sections having connection with the upper section and being adapted to tilt with relation thereto, and a lower section secured to the cutting sections so as to swing relative thereto, all of the sections being capable of deflection from the axis of the drill stem and also from the axis of adjacent sections, whereby the cutting sections may be deflected outwardly so as to enlarge the bore when the drill stem is rotated, all of the sections have communicating axial passages which communicate with the bore of the drill stem, whereby a drilling fluid may be circulated through the stem and sections and upwardly therearound during the drilling operation.

6. A well straightening device adapted to be connected to a drill stem and arranged to be lowered into an inclined well bore including, an upper section, a ball and socket connection between said section and the drill stem, coacting means on said ball and socket for tilting the section to deflect the same from the vertical when the drill stem is rotated, an upper cutting section below the upper section, a ball and socket connection between the sections, coacting means on said latter ball and socket for controlling the direction of tilting relative to each other, a lower cutting section connected to the upper cutting section and arranged to swing with relation thereto, and means for limiting the deflection of the sections with relation to each other and to the drill stem, whereby the size of the opening drilled by the cutting sections when the same are rotated may be controlled.

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