United States Patent [19]

Anderson

[11] **3,717,208**

[45] **Feb. 20, 1973**

[54] SEAL AND EQUALIZING ARRANGEMENT FOR A DIRECTIONAL DRILLING APPARATUS

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[22] Filed: **Aug. 5, 1971**

[21] Appl. No.: **169,311**

[52] **U.S. Cl.**.....**175/74,** 175/256

[51] **Int. Cl.**.....**E21b 7/08,** F16b 27/04

[58] **Field of Search** 285/118; 175/74, 75, 256, 61

[56] **References Cited**

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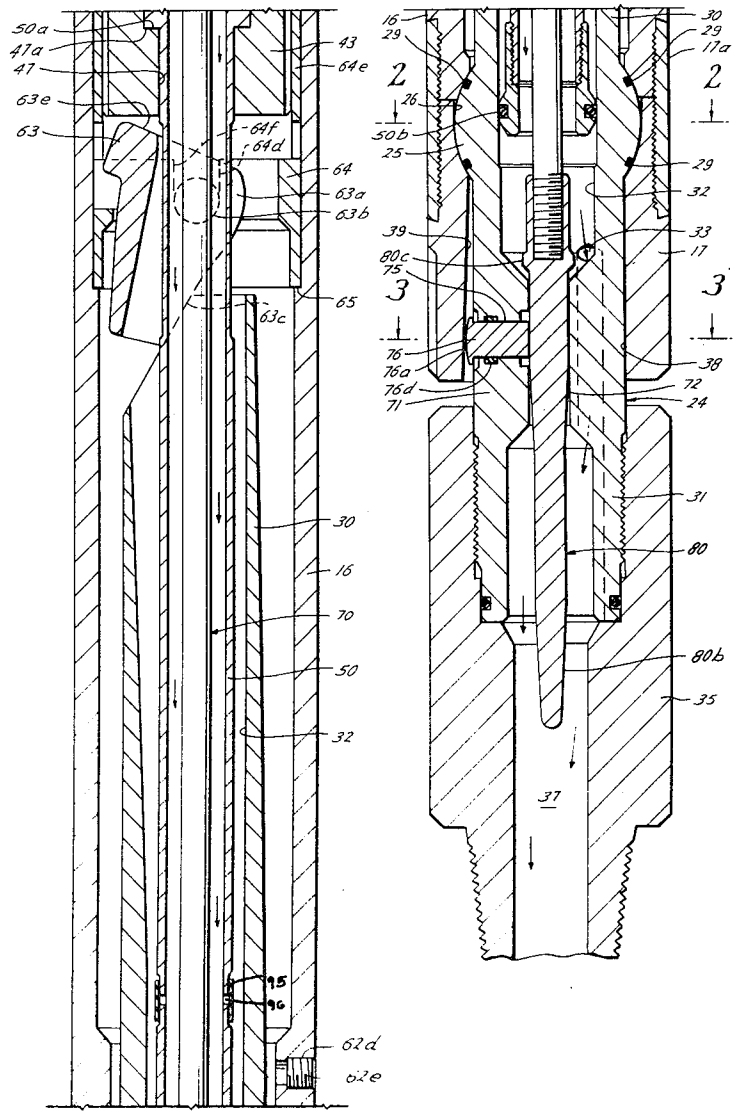
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[57] **ABSTRACT**

A deflection tool including a lower tubular assembly pivotally mounted within an upper tubular assembly, which upper assembly is provided with a piston and lever mechanism for urging the lower tubular assembly to pivot relative thereto, is provided with a seal and equalizing arrangement to inhibit fouling and to balance hydraulic pressures to better enable the lower tubular assembly to return to a nonpivoted relationship when the desired deflection in a well bore has been accomplished.

19 Claims, 6 Drawing Figures



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SHEET 1 OF 3

Fig. 1A

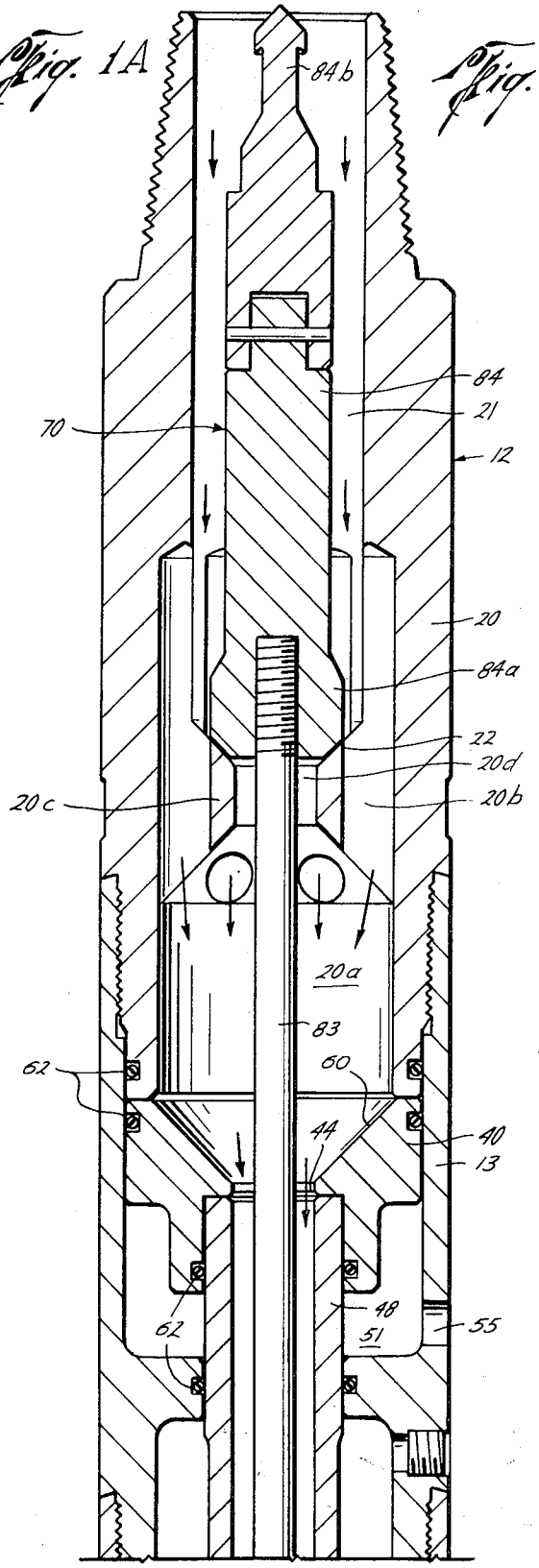
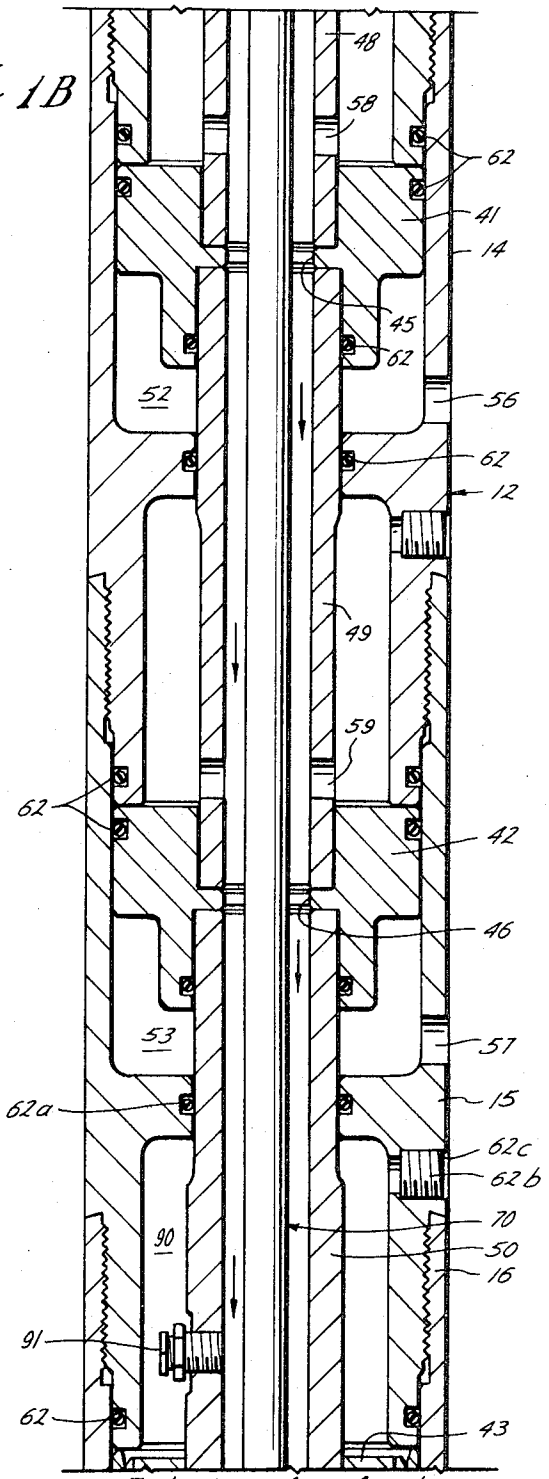


Fig. 1B



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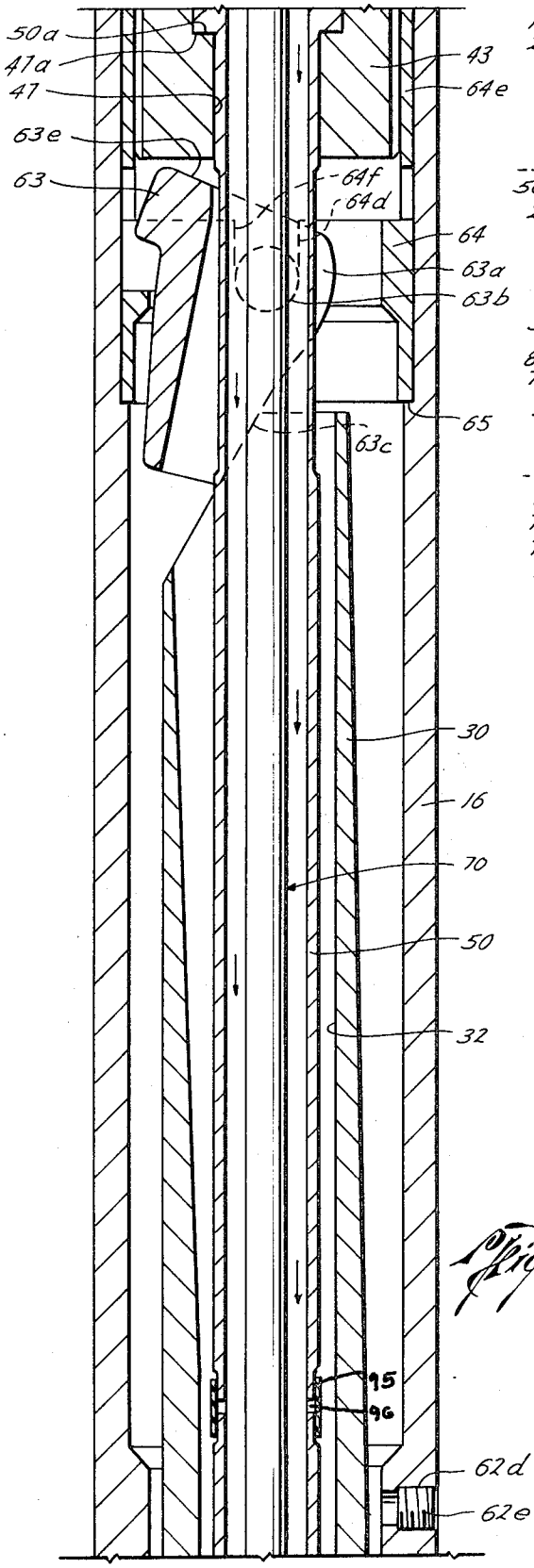


Fig. 1C

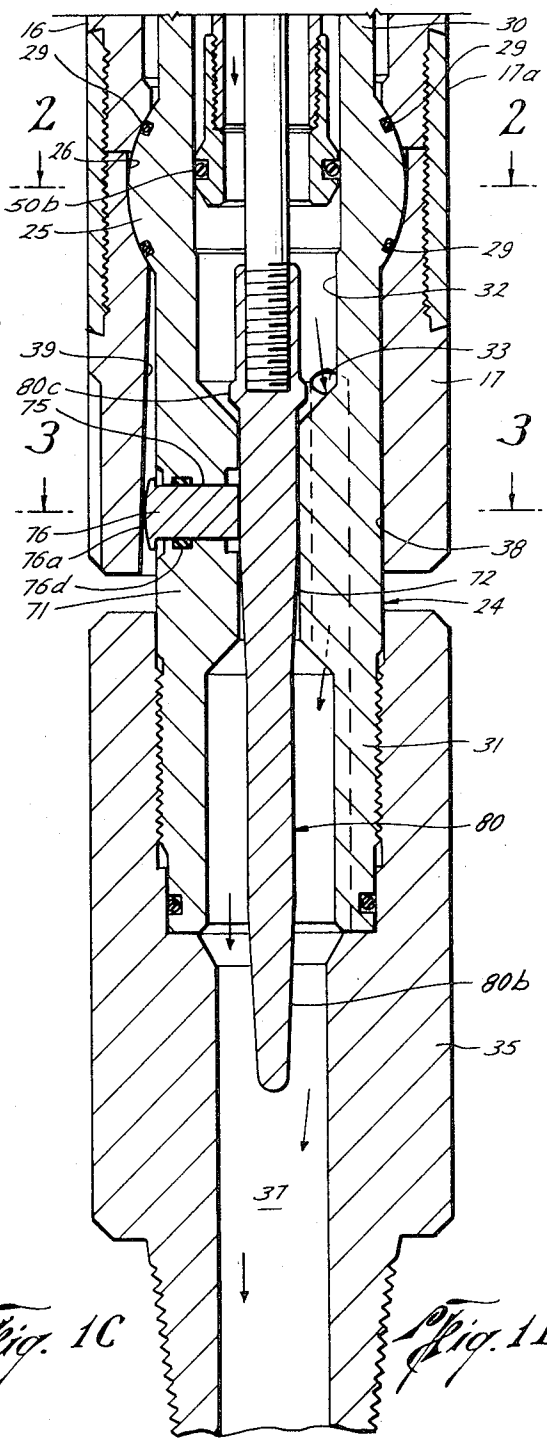


Fig. 1D

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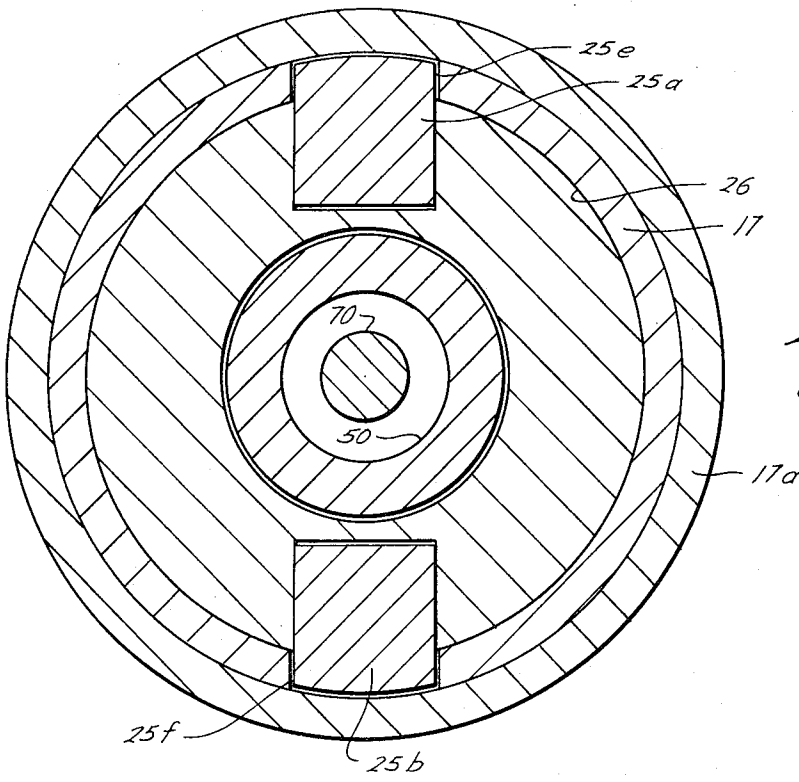


Fig. 2

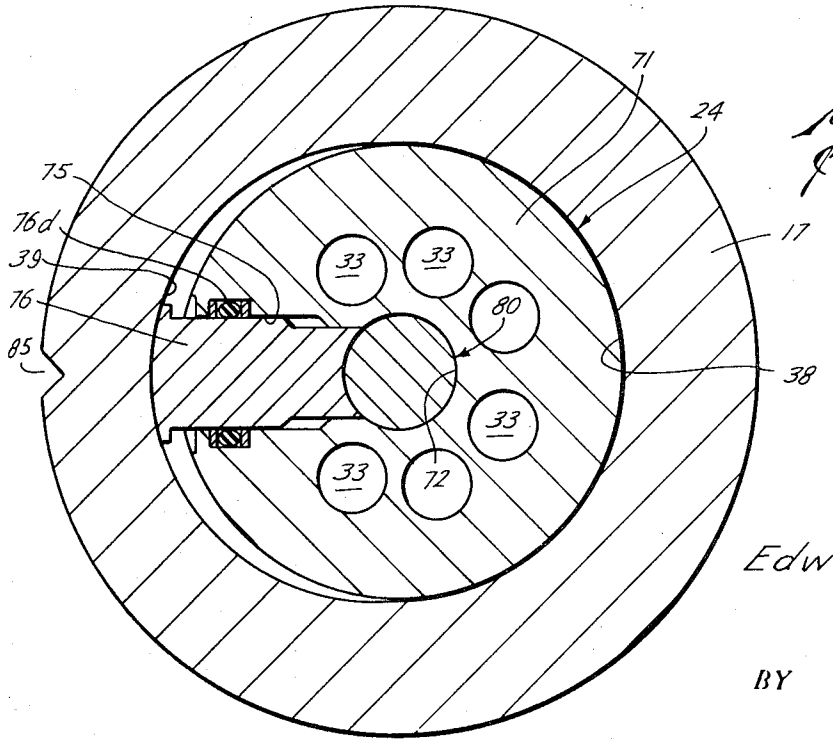


Fig. 3

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SEAL AND EQUALIZING ARRANGEMENT FOR A DIRECTIONAL DRILLING APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

The present invention is an improvement upon my copending application Ser. No. 877,978 filed on Nov. 19, 1969, now U. S. Pat. No 3,627,356.

BACKGROUND OF THE INVENTION

This invention relates to directional drilling methods and apparatus for use in drilling well bores into the earth and is particularly useful in connection with drilling apparatus wherein the drill bit is driven by a downhole fluid motor.

In the drilling of oil and gas wells, the use of downhole fluid motors for rotating the drill bit is becoming more widespread. In a goodly number of such cases, it becomes desirable at some intermediate point in the drilling process to change the direction in which the well bore is being drilled. It has been heretofore proposed to accomplish such change by pulling the drill string from the well bore, inserting a bent tool or bent sub into the drill string intermediate the drill bit motor and the lower end of the drill pipe to impart a predetermined amount of inclination to the motor drill bit assembly, such inclination being anywhere from ½° to 3°. The drill string, motor, drill bit, and permanently bent sub are thereafter run back into the well bore. Drilling is then recommenced and the angular bend in the bent sub serves to urge the drill bit in the desired new direction.

The use of a permanently bent sub has various disadvantages. Since the downhole motor unit and drill bit extend a substantial distance below the bent sub, the lateral displacement caused by the presence of the angular bend in the bent sub substantially reduces the clearance between the lower portion of the drill string and the wall of the well bore. Among other things, this means that greater care must be exercised when running in or withdrawing the drill string from the well bore. Such running in or withdrawal must be done at a slower rate of speed. Even with the exercise of care, the chances of damaging the mud cake on the wall of the well bore or of damaging the drill bit are increased. There is a much greater tendency for the drill bit to gouge and scrape the wall of the well bore. There is a much greater chance of the drill bit striking a hard shoulder or ledge protruding into the well bore. In addition, the screwing and unscrewing of the pipe joints may be more difficult because of the binding effect caused by the presence of the bent sub. For similar reasons, the orienting of the drill bit and motor unit in the desired compass direction may be rendered more difficult. Furthermore, the necessity of having to pull the drill string in order to add or remove the bent sub requires a substantial expenditure of rig time.

Another somewhat different method of changing the direction of a fluid motor driven drill bit is described in U.S. Pat. No. 3,068,946, granted to Messrs. Frisby and Cook on Dec. 18, 1962. Frisby and Cook employ a so-called "knuckle joint" which, at the appropriate moment in the drilling operation, is connected into the drill string between the drill pipe and the fluid motor unit. Their knuckle joint is flexed or bent by applying weight to the drill bit. Their knuckle joint, however, suffers from various disadvantages. For one thing it requires the withdrawal of the drill string from the well bore in order to insert or remove the knuckle joint at the appropriate points in the drilling process. More importantly, perhaps, their device does not provide any positive control over the flexing or bending of the knuckle joint. Weight can be applied to the drill bit, but there is no positive assurance that the knuckle joint has flexed in the desired manner. Depending on its orientation, it may have been limited in a straight or unflexed position. Also, since their knuckle joint is free to pivot at any time, there is increased danger of hanging up the drill string when running it into the well bore with the knuckle joint in the string.

Since the present invention may be characterized as a modified form of knuckle joint, it is pertinent to note that various forms of knuckle joints have been heretofore proposed for use in various types of subsurface well bore operations other than the actual drilling of the well bore. Representative of these is the knuckle joint described in U.S. Pat. No 2,680,483, granted to F. L. LeBus on June 8, 1954. The LeBus knuckle joint is intended for use as a fishing tool for recovering drill pipe from the well bore. As a probable consequence of this different use, it includes features which render it unsuitable for use in a drill string having a downhole fluid motor for driving the drill bit. For one thing, the LeBus device requires the running into the tool of a plug for plugging the fluid flow passage through the tool in order to operate a piston mechanism which causes the tool to bend or knuckle. Such plugging of the flow passage would not allow sufficient flow of drilling fluid to enable proper operation of a downhole fluid motor located below the knuckle joint. In addition, the LeBus tool has no means for keeping the joint in a straight position for purposes of drilling a straight section of the well bore. Thus, assuming the restriction plug were not present, the use of the LeBus device would require the pulling of the drill string from the well bore in order to insert and remove the knuckle joint before and after the drilling of a curved section of the well bore. Furthermore, since the LeBus knuckle joint is free to pivot when it is being run into the well bore, there would be an increased likelihood of hanging up the drill string when running it into the well bore.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a new and improved apparatus for directional drilling which incorporates a fluid seal and pressure equalizing arrangements to inhibit fouling by sand and debris and to balance hydraulic pressures to aid in returning the device to a normal nondeflected or nondirectional relationship when the desired deflection in the well bore has been accomplished.

It is an additional object of the invention to provide a new and improved deflection tool for use with fluid motor driven drill bits and which can be limited in a positive manner at different desired angles (including a straight angle) at different stages in the drilling operation without having to pull the drill string from the well bore.

In accordance with the invention, a deflection tool adapted to be connected in a drill string for use in the directional drilling of a well bore comprises first tubular means and second tubular means pivotally coupled

thereto. The tool also includes fluid responsive means carried within the tubular means and responsive to drilling fluid pressure in the tubular means for urging one of the tubular means to pivot relative to the other. The tool further includes locking means including a retrievable limiting device adapted for passage through the drill string and into the tubular means for limiting the extent of such pivotal movements, and a liquid seal arrangement to aid in preventing fouling of the components as well as equalizing valve means to maintain hydraulic balance in the tool.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a sectional view of part of the upper portion of the tool;

FIG. 1B is a sectional view of the portion of the tool and is connected to that portion shown in FIG. 1A with fluid pressure equalizing means therein;

FIGS. 1C and 1D are sectional views showing continuation of the tool with the lower part of FIG. 1D showing the lower assembly in sectional view;

FIG. 2 is a sectional view of the line 2—2 of FIG. 1D; and

FIG. 3 is a sectional view on the line 3—3 of FIG. 1D.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referrings to FIGS. 1A, 1B, 1C and 1D of the drawings, there is shown the upper portion of the tool which is adapted to be connected in a drill string for use in the directional drilling of a well bore into the earth. The lower part of FIG. 1D illustrates what may be referred to as the lower portion or lower assembly of the tool. FIGS. 1A through 1D show the tool in its straight or undeflected position. The deflection tool of the present invention includes, as previously mentioned, the upper tubular assembly referred to generally by the numeral 12 in FIGS. 1A through 1D of elongated cylindrical construction. The tubular assembly 12 includes a series of cylinders 13, 14, and 15 which are threaded together in an overlapping end to end manner. The upper tubular assembly 12 further includes cylindrical pivot joint seating member 17 which is connected to the lower end of the cylindrical member 16 which in turn is shown in FIG. 1B as being connected at its upper end to the cylinder 15. A connecting bushing 17*a* connects the seating member 17 and the cylindrical body member 16 together. A top sub 20 is threaded onto the upper end of cylindrical member 13 of the upper assembly 12. The upper end of the top sub is provided with a threaded pin as shown for connecting it with the lower end of a nonmagnetic survey collar which forms part of the drill pipe string. Top sub 20 includes an interior longitudinal passage 21 having the seating shoulder 22 as shown to form a seat for the retrievable probe as will be described in greater detail hereinafter.

The sub 20 includes a counterbore 20*a* formed in the lower end thereof which communicates at its upper end with a plurality of circumferentially spaced, longitudinally extending passages 20*b*. The passage 21 in the sub 20 above the shoulder 22 communicates with the passages 20*b* at their upper end as shown. The arrangement of the longitudinally extending circumferentially spaced bores 20*b* relative to the counterbore 20*a* provides a central annular ring or web 20*c* on which the shoulder 22 is formed. A passage 20*d* is formed through the central ring 20*c* for the passage of fluids through the drill string when the retrievable probe is not in position.

When the retrievable probe is in position as shown in FIG. 1A, the fluid circulation is downwardly through the passage 21, through circumferentially spaced passage means 20*b*, and then into the counterbore 20*a* to act on piston means as will be described.

The deflection tool further includes a lower tubular assembly referred to generally by the numeral 24 pivotally coupled to the upper tubular assembly 12 by the arrangement as illustrated at the upper end of FIG. 1D of the drawings. The lower assembly 24 is provided with an enlarged spherical ball joint portion 25 which is seated in a spherical socket 26 formed in the upper end of the pivot joint seating member 17 and the lower end of the cylindrical body 16 as shown at the upper end of FIG. 1D of the drawings. A pair of O-ring seals 29 is located in grooves which encircle the ball portion 25. The seals 29 leakage of fluid around the ball and socket joint. The ball joint portion 25 can be suspended on its pivot access in the manner described in U.S. Pat. No 2,680,483 to LeBus.

The lower tubular assembly 14 further includes an upper tubular portion 30 shown in FIGS. 1C and 1D located above the pivot access (an access passing through the center of the ball portion 25 at right angles to the plane of the paper in FIG. 1D) and extending upwardly within the upper tubular assembly 12. Though the length of tubular portion 30 may vary within limits, it preferably should be of suitable length to provide sufficient mechanical advantage for insuring that the lower tubular assembly 24 is pivoted in the desired manner.

The lower tubular assembly 24 further includes a lower tubular portion 31 located below the pivot access and depending downwardly and out of the lower end of the upper tubular assembly 12. The ball portion 25, the upper portion 30, and the lower portion 31 are formed from a single piece of metal. A common longitudinal passageway 32 extends from one end to the other of the lower tubular assembly 24 provided by these portions. Passage 32 includes a plurality of circumferentially spaced passages 33 of reduced diameter as shown in FIG. 3, one of which is shown in dotted line. The bottom sub 35 is threadedly connected to the end of the lower portion 31. Such bottom sub 35 includes suitable threads at the lower end thereof which is adapted to be connected to a downhole fluid motor unit for driving a rotary drill bit. The sub 35 is provided with a bore 37 that communicates with the passage 33 and passage 32 for providing fluid to the drill bit and for driving the motor.

As can be seen from FIG. 1D and the sectional view of FIG. 3, the interior of the lower portion of the upper tubular assembly 12 is shaped to allow pivoting of the lower assembly 24 in only one direction and to limit the maximum extent of such pivotal movement. As there seen, the pivot joint seating member 17 is provided with a lower center bore 38 which is cylindrical on the right hand side thereof as shown in FIG. 1D and which has formed in the opposite or left hand side thereof a tapered recess 39 having a cylindrical curvature for

enabling the lower portion 31 of the lower assembly 24 to move towards the left as viewed in FIG. 1D. The tapered recess 39 recedes from the longitudinal center axis of the pivot joint seating member 17 as it progresses in a downwardly direction. The wall of the tapered surface 39 seats the maximum limits for the extent of pivotal movement of the lower tubular assembly 24.

As described in the copending application hereinabove referred to, the deflection tool further includes fluid responsive means carried within the upper tubular assembly 12 and responsive to drilling fluid pressure in such upper assembly 12 for producing the lateral thrust on the upper portion 30 of the lower tubular assembly 24 for causing such assembly 24 to pivot about the pivot axis. Such fluid responsive means includes a series of three longitudinally spaced pistons 40, 41 and 42 slidably mounted for longitudinal movement within the upper part of the upper assembly 12. Piston 40–42 are of toridal shape and, as such, include longitudinal center bores 44–46, inclusive, which extend longitudinally therethrough. Pistons 40–42 are interconnected by tubular stems 48 and 49, the extremities of which are fitted into an enlarged portion of the centerbores 44–46 of the pistons 40–42, as shown. An elongated stem member 50 is received at one end within the lower enlarged center portion of centerbore 46 of piston 42 and extends through the upper assembly 12 and terminates adjacent the ball portion 25 of the lower tubular assembly 24, as illustrated in the drawings.

A piston shaped ram 43 is mounted on the lower stem member 50 within chamber 90 of the tool, which chamber will be described in greater detail. Ram 43 includes a longitudinal centerbore 47 having a center shoulder 47*a* which is engaged by mating shoulder 50a on the stem member 50 to provide a driving arrangement between stem member 50 and ram 43 in a downwardly direction. Grooves shown in the upper end of FIG. 1C on the circumferential edge of ram 43 accommodate the passage of fluid in chamber 90 around the ram 43 as the ram 43 moves. Seals 50b on the enlarged end of stem member 50 sealingly engage within the bore or passageway 32 adjacent the ball portion 25.

The interior of the upper portion of the upper assembly 12, and, more particularly, the interior of the cylinders 13–15 are constructed to provide individual piston chambers 51–53 for the different pistons 40–42 respectively. Chambers 51–53 are provided with fluid outlets 55, 56, and 57, respectively, at the lower extremities thereof for enabling the lower ends of these chambers to communicate with the lower pressure well bore fluid exterior of the upper assembly 12. The upper ends of the piston chambers 52 and 53 are adapted to receive the higher pressure drilling fluid within the drill string by way of inlets 58 and 59 which extend between the side walls of the stem members 48 and 49, respectively. The upper end of the upper piston 40 is exposed directly to drilling fluid leaving the counterbore 20a in the top sub 20. A concave recess 60 is provided in the top of the upper piston 40 for providing an exposed piston surface even when the piston 40 is at the upper end of its range of movement.

In addition to interconnecting the various pistons 40–42 so that they work in unison with one another and are mechanically coupled to the ram 43, the stem members, 48–50 also provide a longitudinal flow passage for conveying drilling fluid from the drill string through the upper tubular assembly 12, through chamber 90 and into the lower tubular assembly 24 where it passes through the passage 33 and into the bore 37 of sub 35. This flow passage provided by the stem members 48–50 may be consiered as being of a reduced internal diameter relative to the remainder of the longitudinal flow passages within the tubular assembles 12 and 24.

In addition to the piston mechanism just described, the fluid responsive means further includes means for converting downward movement of the pistons into a lateral thrust on the upper portion 30 of the lower tubular assembly 24. This movement or force converting means includes a control lever 63 pivotally mounted within a tubular cage 64 which is located within the upper tubular assembly 12 adjacent the upper end of the upper portion 30 of the lower tubular assembly 24. The cage 64 rests on a shoulder 65 inside the main body member 16. The control lever 63 is of a U-shaped construction having two side members one of which, 63*a*, is shown. Opposed slots 64*d*, one of which is shown in FIG. 1C, are provided in the cage 64 for receiving the projections on each of the arms of the control lever 63, such projections being designated 63*b*, one of which is shown in FIG. 1C. A control lever retainer 64*e*, is carried above the cage and in turn is provided with downwardly depending projections, one of which is illustrated in dotted line at 64*f* in FIG. 1C for engaging in the slots 64d to retain the projections 63*b* in the cage 64. The surface 63e on the upper end of the control lever 63 is adapted to be engaged by the under side of the ram 43 during its downward movement. When ram 43 bears against this surface, it causes the contact faces designated 63*c*, only one of which is shown in dotted line in FIG. 1C, to push the upper end of the tubular portion 30 of the pivotal assembly 24 toward the right. In this manner, control lever 63 converts downward movement of the pistons 40–42 and ram 43 into a lateral thrust on the upper portion 30 of the pivotal assembly 24.

The deflection tool further includes a limiting means including a retrievable limiting device referred to generally by the numeral 70, which limiting device is adapted for passage through the drill string and into the tubular assemblies 12 and 24 for limiting the extent of the pivotal movement of the lower tubular assembly 24 relative to the upper assembly 12. In addition to the limiting device 70, the limiting means or limiting mechanism also includes a guide portion 71 which is integrally formed in the lower assembly 24 as shown in FIG. 1D. The guide bushing 71 includes a central passage 72 for receiving the lower end of the retrievable limiting device 70. The bushing 71 further includes a lateral passage 75 running from the longitudinal center passage 72 to an opening 75*a* at one side of such guide bushing 71.

As indicated in FIG. 1D, the limiting mechanism further includes laterally movable positioning means movably carried by the lower portion 31 of the pivotal lower tubular assembly 24 and extending into the central passage 72 of guide portion 71 for engagement by the retrievable limiting device 70. This laterally movable positioning means is comprised of a positioning

plug or limiting plug **76** which is slidable mounted in the lateral passage **75** of the guide bushing designated **71**.

Such limiting plug **76** includes an enlarged head **76***a* at one end thereof for engaging the tapered recess **39** formed in the wall of the upper tubular assembly **12**. The opposite end of plug **76** which end is adapted to extend into the guide bushing centerbore **72** is provided with a cylindrical curvature corresponding to the curvature of the retrievable limiting device **70** as illustrated in FIG. 3. The plug **76** is constructed and arranged so that it will maintain its proper alignment relative to the limiting device **70**, that is, it is constructed and arranged so that it will not rotate in the guide bushing **71**. An O-ring seal **76***d* provides a fluid seal between the limiting plug **76** and the wall of passage **75**. As illustrated in FIG. 1D, the retrievable limiting device **70** includes an elongated cylindrical probe member referred to generally at **80** having a tapered lower end portion **80***b*. An enlargement **80***c* is formed on the probe member **80** as shown in FIG. 1D. When the probe is properly positioned, enlargement **84***a* engages and seats on seat **22**; however, when the lower and upper assemblies are not aligned, that is, when the lower assembly is pivoted at an angle relative to the upper assembly, the probe **80** will not seat as shown, but will extend only partially through bore **72**. When the probe **80** is not properly seated, enlargement **80***c* will be positioned within stem member **50** so that flow therethrough is restricted. The restricted flow serves to indicate that probe **80** is not properly seated. Threadedly connected into the probe member **80** is the rod **83**, which extends upwardly through the upper assembly **12** and tubular stem members **48–50** for connection to the lower end of a retrievable fishing sub **84**. The fishing sub **84** is provided with an annular enlargement **84***a* which is adapted to seat on the seat **22** as shown in FIG. 1A when the probe device is inserted in the tool. A fishing neck **84***b* is provided for retrieving the tool in a conventional manner with a wireline well known in the art.

As shown in FIG. 2, the ball joint **25** is supported rotatably on pins **25***a*, **25***b* which are carried in sockets **25***e* and **25***f* formed in pivot joint seating member **17**.

A scribe line **85** (see FIG. 3) as disclosed in my copending application is cut into the exterior of the upper tubular assembly **12** at the lower end thereof on the side thereof to which the lower assembly **25** is adapted to pivot. Such scribe line enables an accurate determination of the orientation of the line of deflection of the deflection tool with respect to an orienting device in a nonmagnetic directional survey collar which is connected to the drill string immediately above the deflection tool. The directional survey collar is of a well known construction and cooperates with a known type of wireline directional survey instrument which may be lowered into such collar for determining the azimuth or compass direction in which the orienting tool is facing.

The chamber **90** is defined at one end by engagement of seal **50***b* in passage **32** and by seals **29** and at the other end by seal **62***a* surrounding stem member **50**. The chamber **90** thus surrounds the stem member **50** which serves to conduct drilling fluid through the tool. Chamber **90** may be filled with oil, grease or other suitable fluid medium through opening **62***c*. Opening **62**d may function to vent air from chamber **90** as it is filled with fluid and when filled the openings may be closed by plugs **62***b* and **62***e*.

The fluid in chamber **90** prevents sand and debris from collecting on ball joint **25** and thereby inhibits fouling of the tool which might prevent its proper functioning.

It can also be appreciated that hydrostatic pressure differentials either internally or externally of the tool may cause binding or locking which inhibits proper functioning of the tool.

To eliminate this, suitable check valve means are provided in main stem member **50** for equalizing pressure within the tool under any circumstances. Such means include one-way acting check valve means **91** positioned in stem member **50** adjacent, but spaced from seal **62***a*, and the annular flexible retainer **95** covering ports **96** in stem member **50**.

Check valve means **91** accommodates flow of fluid from chamber **90** into stem member **50** while preventing flow in an opposite direction and retainer **95** permits flow from stem member **50** into chamber **90** while preventing flow in an opposite direction.

Thus when the tool is lowered into a well bore any hydrostatic pressure in the tool which exceeds the fluid pressure in chamber **90** will flow through ports **96** and equalize. Similarly, when pump pressure is increased, the fluid pressure in chamber **90** and in stem member **50** will equalize. When the tool is being withdrawn from the well, any excess pressure in chamber **90** will flow through check valve **91** until the pressure in the chamber and stem member **50** is equalized.

Therefore, excessive pressure on the ball joint which might tend to interfere with its operation, or with its return to a non-deflected position is eliminated.

It has been found that when the tool of the present invention is actuated, in some instances the hydrostatic pressure acting on the knuckle joint after a deflection has been effected will tend to retain it in cocked position in the well bore. By placing the oil seal in the manner as disclosed herein along with the pressure equalizing valve **91**, the pressure internally of the member **50** and externally thereof within the tool may be balanced or equalized at all times. Also, as noted such arrangement prevents sand or other debris from collecting on top of the socket **26** which tends to freeze or lock the cocked pivot joint in pivoted arrangement.

The operation of the present invention is otherwise the same as that disclosed in my prior copending application, and it is therefore believed unnecessary to give a detailed described of same herein.

The diameter of probe **80** adjacent limit plug **76** determines the amount of deflection of the tool, as described in my copending application.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape, and materials as well as in the details of the illustrated construction may be made without departing from the spirit of the invention.

What is claimed is:

1. A deflection tool adapted to be connected in a drill string for use in the directional drilling of a well bore comprising:

first tubular means;

second tubular means pivotally coupled to the first tubular means;

fluid responsive means carried within the tubular means and responsive to drilling fluid pressure in the tubular means for urging one of the tubular means to pivot relative to the other;

limiting means including a retrievable limiting device adapted for passage through the drill string and into the tubular means for limiting the extent of such pivotal movement while the limiting devise is in the tubular means; and

spaced seal means on said first tubular means and said second tubular means to form a closed chamber within the tool for receiving a fluid medium therein.

2. A deflection tool in accordance with claim 1 wherein the second tubular means is pivotally mounted within first tubular means and extends out one end thereof.

3. A deflection tool in accordance with claim 1 wherein the fluid responsive means includes a piston slidably located in one of the tubular means.

4. A deflection tool in accordance with claim 1 wherein the fluid responsive means includes a plurality of longitudinally spaced pistons located within one of the tubular means and interconnected by tubular stem means for enabling the pistons to work in unison with one another.

5. A deflection tool in accordance with claim 1 wherein:

the second tubular means includes an extended portion which extends into the first tubular means;

the fluid responsive means includes a longitudinally slidable piston located in the first tubular means;

the fluid responsive means includes control lever means pivotally mounted within the first tubular means adjacent the end of such extended portion for converting the longitudinal movement of the piston into the lateral thrust on the end of such extended portion;

and said first tubular means including a portion extending into said second tubular means; and relief valve means in said portion to equalize fluid pressure internally and externally of said portion within said first tubular means.

6. A deflection tool in accordance with claim 1 wherein:

the first tubular means is located above the second tubular means;

the first tubular means includes interior longitudinal passage means of reduced diameter;

the second tubular means includes receiving means for receiving the retrievable limiting device;

and the retrievable limiting device is of an elongated construction adapted for passage through the reduced diameter passage means and includes a limiting portion adapted to be seated in the receiving means and an enlarged portion located relative to such limiting portion a distance such that it remains in the reduced diameter passage means until the limiting portion has entered the receiving means, such enlarged portion being sized to substantially reduce the flow of drilling fluid through the tool as long as it is within the reduced diameter passage means.

7. A deflection tool adapted to be connected in a drill string for use in the directional drilling of a well bore comprising:

upper tubular means;

lower tubular means pivotally mounted within the upper tubular means and having an upper portion located above the pivot axis and extending upwardly within the upper tubular means and a lower portion located below the pivot axis and extending downwardly and out of the lower end of the upper tubular means;

fluid responsive means carried within the upper tubular means and responsive to drilling fluid pressure in the upper tubular means for producing a lateral thrust on the upper portion of the lower tubular means for causing the lower tubular means to pivot about the pivot axis;

laterally movable positioning means movably carried by the lower tubular means and extending into the center bore of the lower tubular means;

a retrievable limiting device adapted for passage through the drill string and into the lower tubular means for engaging the laterally movable positioning means and thereby controlling the angular relationship between the two tubular means;

and means for aiding in moving said upper and lower tubular means to a non-pivoted relationship including:

1. spaced seal means on said upper tubular member and said lower tubular member to form a closed chamber within the tool for receiving a fluid medium therein;
2. said upper tubular member including a portion extending into said lower tubular member; and
3. relief valve means in said portion to equalize fluid pressure internally and externally of said portion within said upper tubular means.

8. A deflection tool in accordance with claim 7 wherein the upper tubular means is adapted to be connected to the lower end of a string of drill pipe and the lower tubular means is adapted to be connected to a downhole fluid motor unit for driving a rotary drill bit.

9. A deflection tool in accordance with claim 7 wherein the interior of the lower portion of the upper tubular means is shaped to allow pivoting of the lower tubular means in only one direction and to limit the maximum extent of such pivoting movement.

10. A deflection tool in accordance with claim 7 wherein the fluid responsive means includes:

a plurality of toroidal pistons located for longitudinal movement within an upper portion of the upper tubular means;

tubular stem means cooperating with the center bores of the pistons for interconnecting the pistons in a spaced apart coaxial manner and for providing a central flow passage through the upper portion of the upper tubular means;

the interior of the upper portion of the upper tubular means being constructed to provide individual pistons chambers for the different pistons;

and means for converting downward force produced by the pistons into a lateral thrust on the upper portion of the lower tubular means.

11. A deflection tool in accordance with claim 7 wherein the laterally movable positioning means is car-

ried within the upper tubular means by the lower portion of the lower tubular means.

12. A deflection tool in accordance with claim 7 wherein the laterally movable positioning means comprises a positioning plug slidably mounted in a lateral passageway extending through the wall of the lower tubular member.

13. A deflection tool in accordance with claim 7 wherein the cross-sectional area of the retrievable limiting device is substantially less than the cross-sectional area of the interior of the lower tubular means for enabling a substantial flow of drilling fluid through the tubular means when the retrievable limiting device is in place in the lower tubular means.

14. A deflection tool in accordance with claim 7 wherein:

the upper tubular means includes an interior longitudinal passage means of reduced diameter located at an upper location therein;

the lower tubular means includes receiving means for receiving the retrievable limiting device;

and the retrievable limiting device is of an elongated construction adapted for passage through the reduced diameter passage means and includes a lower limiting portion adapted to be seated in the receiving means and an enlarged portion located above such limiting portion a distance such that it remains in the reduced diameter passage means until the limiting portion has entered the receiving means, such enlarged portion being sized to substantially restrict the flow of drilling fluid through the tool as long as it is within the reduced diameter passage means.

15. A deflection tool in accordance with claim 7 wherein:

the retrievable limiting device includes an elongated cylindrical probe member forming at least the lower part thereof;

the tool includes a guide bushing located within the center bore of the lower tubular means and having a longitudinal center passage for receiving the probe member, longitudinal side passages for passing drilling fluid and a lateral passage running from the center passage to an opening at one side of such guide bushing;

the lower tubular means includes a lateral passage extending through the wall thereof and in alignment with the lateral passage in the guide bushing;

and the laterally movable positioning means comprises a positioning plug slidably mounted in the lateral passages in the guide bushing and the lower tubular means, the length of such positioning plug being greater than the combined length of such lateral passages.

16. A deflection tool in accordance with claim 10 wherein the guide bushing and the cooperating lateral passage in the lower tubular means are located in a portion of the lower portion of the lower tubular means which is within the upper tubular means.

17. A deflection tool in accordance with claim 7 wherein the fluid responsive means includes:

longitudinally movable pistons means slidably located within the upper tubular means;

and means for converting downward movement of the piston means into a lateral thrust on the upper portion of the lower tubular means.

18. A deflection tool in accordance with claim 17 wherein the movement converting means comprises a control lever pivotally mounted within the upper tubular means adjacent the upper end of the upper portion of the lower tubular means and having an upper portion adapted to be engaged by the underside of the piston means during its downward movement.

19. A deflection tool in accordance with claim 18 wherein the length of the upper portion of the lower tubular means is of suitable length to provide a mechanical advantage for pivoting the lower tubular means.

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