July 29, 1969 D. L. MASSEY 3,457,999

FLUID ACTUATED DIRECTIONAL DRILLING SUB

Filed Aug. 31, 1967 4 Sheets-Sheet 1

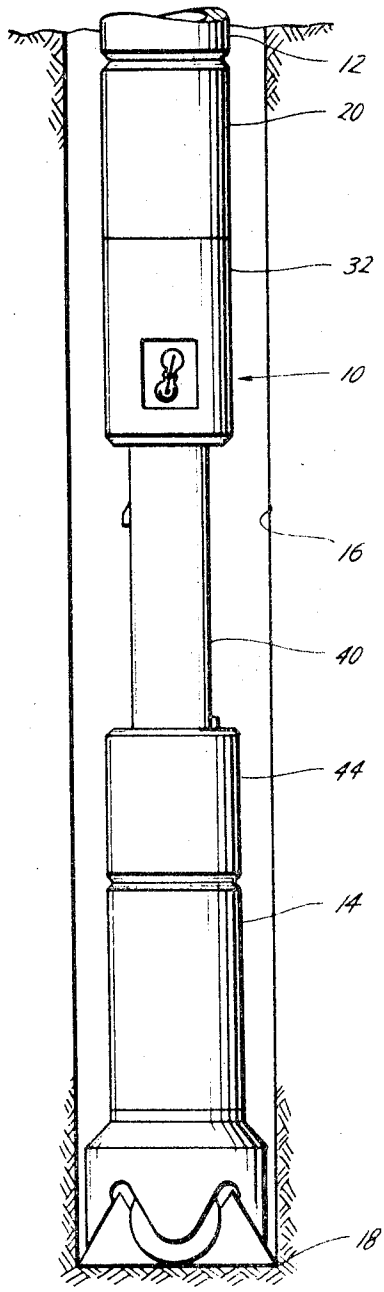
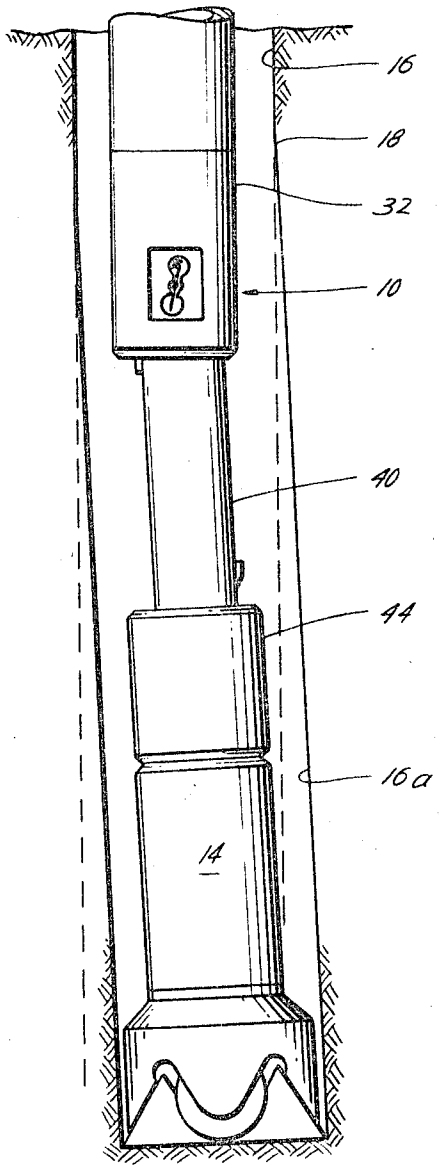


Fig. 1

Fig. 2



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FLUID ACTUATED DIRECTIONAL DRILLING SUB

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Fig. 3A

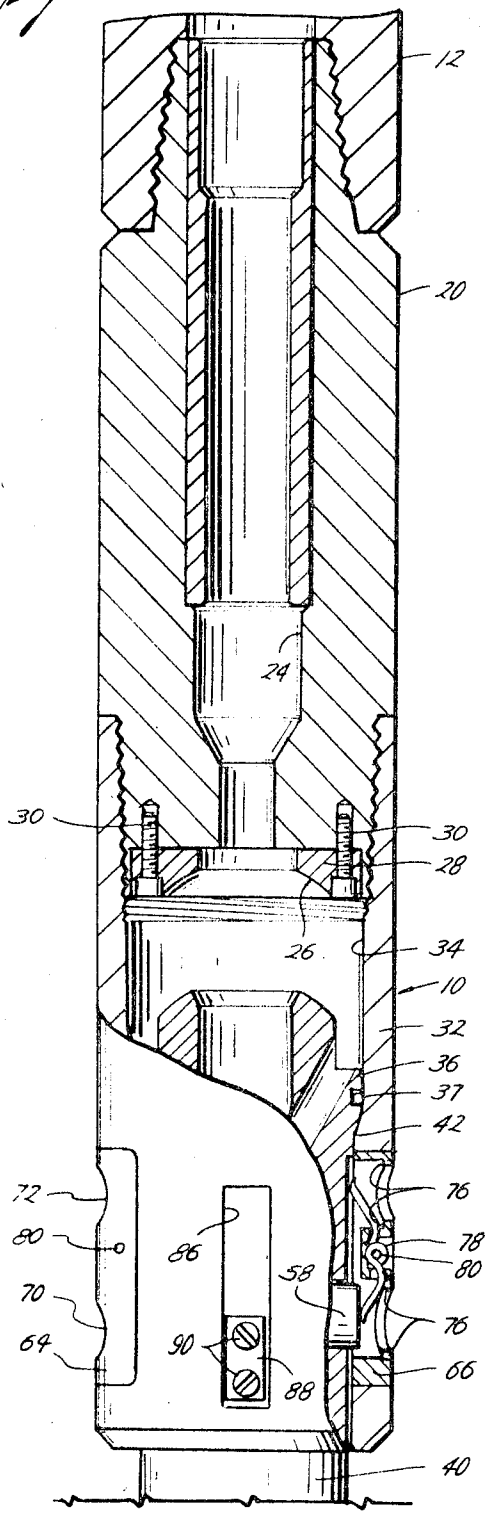
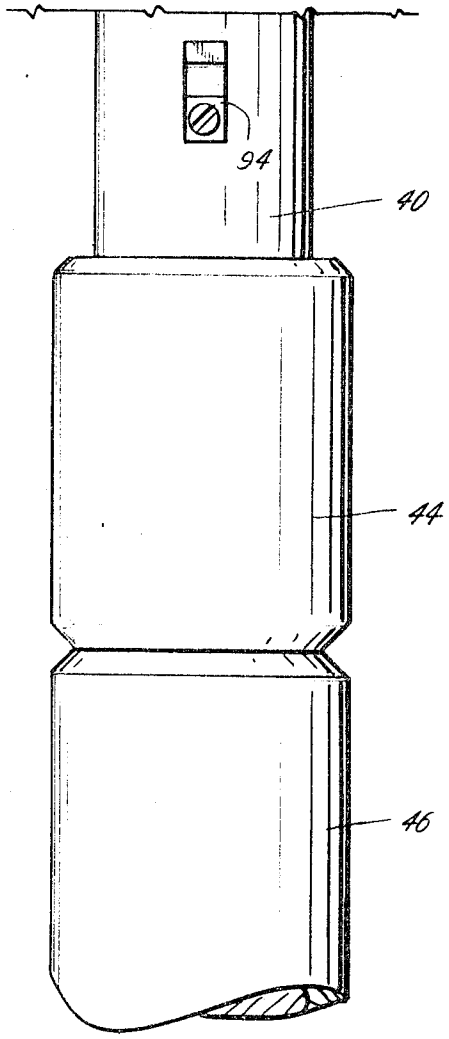


Fig. 3B



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FLUID ACTUATED DIRECTIONAL DRILLING SUB

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Fig. 4A

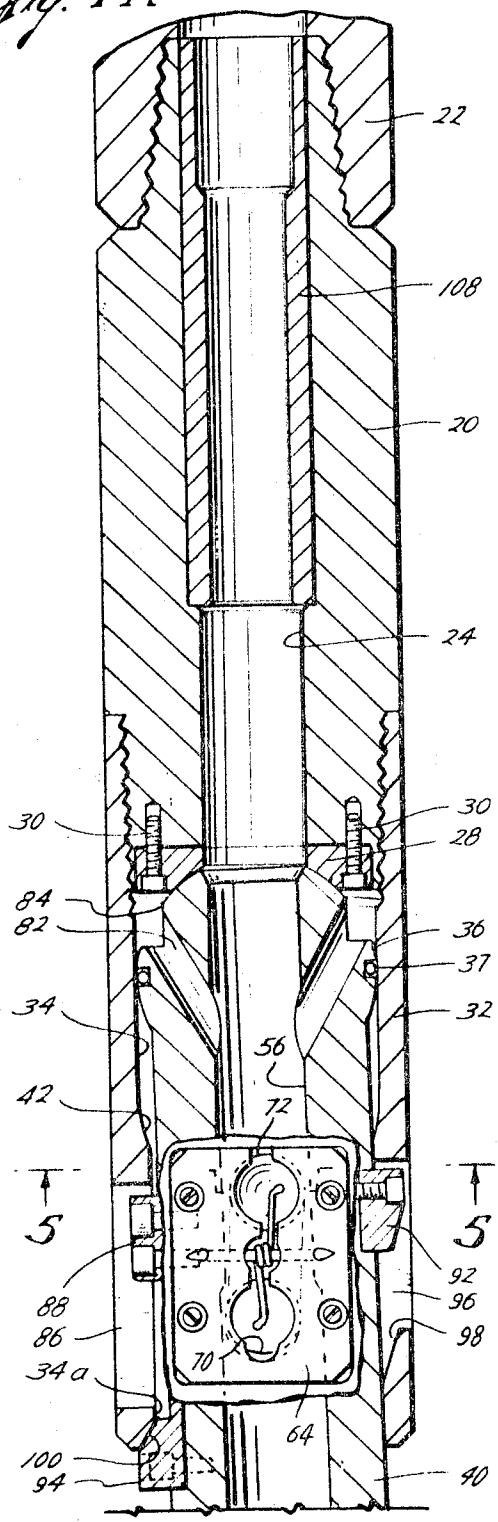


Fig. 4B

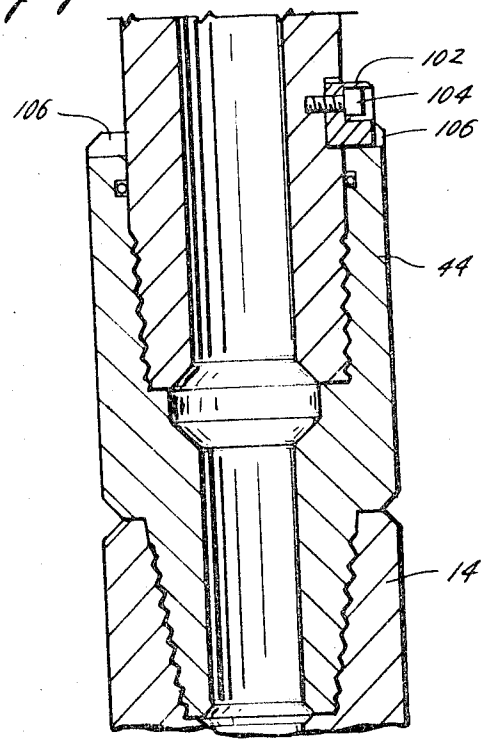
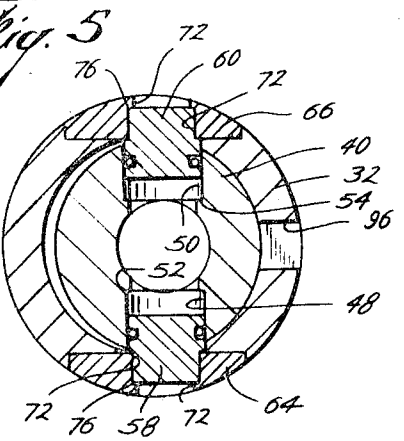


Fig. 5



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FLUID ACTUATED DIRECTIONAL DRILLING SUB

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Fig. 6

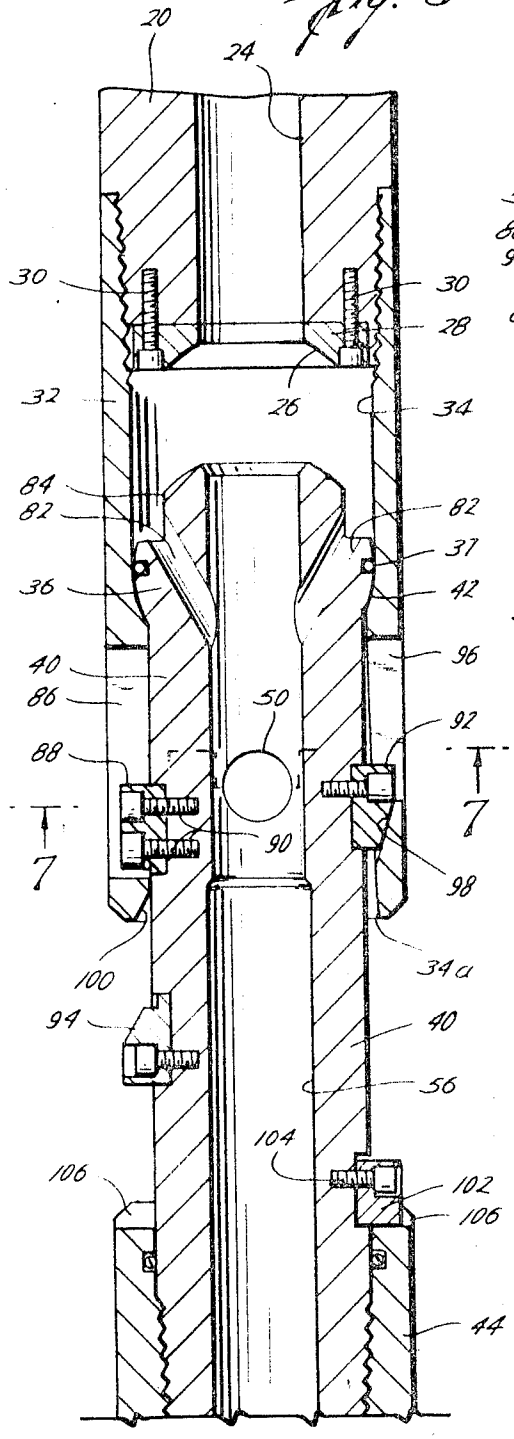


Fig. 7

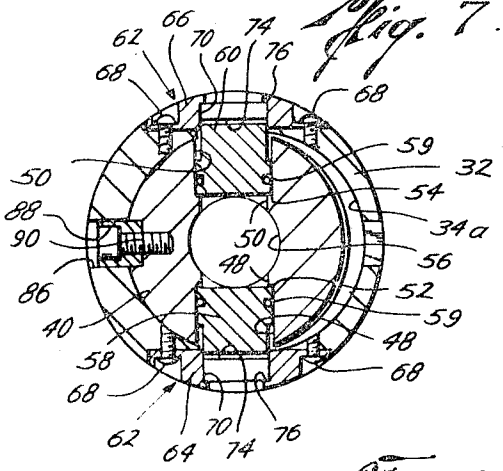
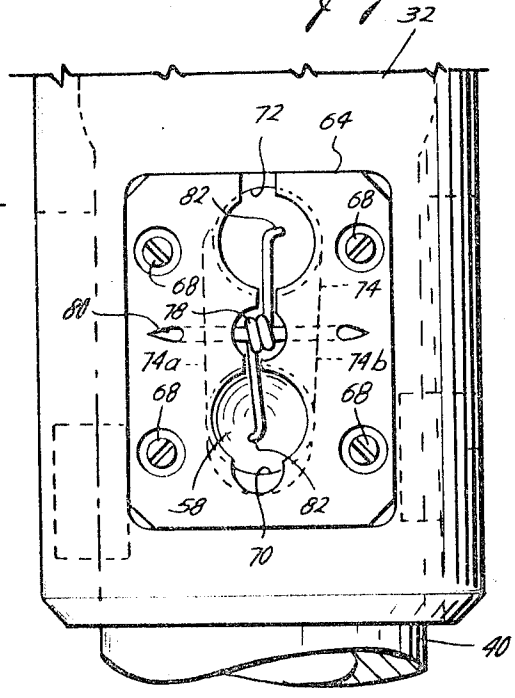


Fig. 8



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FLUID ACTUATED DIRECTIONAL DRILLING SUB

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U.S. Cl. 175—61 14 Claims

ABSTRACT OF THE DISCLOSURE

A bendable sub for use with a bottomhole fluid-driven bit in a well string. The sub may be locked or unlocked in either straight or angled positions through variation of pressure of fluid within the well string and sub and by adjusting load of the drill string on the sub and drill bit. An orienting sub member for attachment to the well string is provided with a socket which receives a ball member formed on a mandrel slidable within a body member secured to the orienting sub, the mandrel being in turn attached to the drill bit. The ball of the mandrel which is slidable within the body member engages with the socket for directional drilling. Pistons within the mandrel engage apertures within the body member, such pistons being actuated by pressure of fluid within the device.

Background of the invention

The use of bottomhole fluid-driven bits suspended on a well string, e.g. turbodrill systems, have come into wide use due to their high speed capability resulting in faster drilling, better mud circulation and faster cleaning of the bottom of the well bore. Another advantage of the turbodrill system is the elimination of whipstocks in directional drilling since the well string does not rotate as in conventional rotary drilling but merely moves through the vertical plane by means of a draw works.

Present practice in deviating well bores when using turbo type or other drills having self-containing power units involve the use of rigid bent subs attached to the well string and from which the turbodrill is suspended. Once the drill bit on the conventional bent sub reaches the bottom of the hole, directional drilling is commenced by orienting the bent sub and forcing the drill bit into the earth in the desired direction. Serious drawbacks in use of such rigid bent subs are apparent for, if the bent sub is very large or if it is bent at a very great angle, it will tend to stick or drag on the wall of the well bore while it is being lowered into position to commence the directional drilling. Not only is time consumed when the well string must be pulled from the hole to add the bent sub when deviation of the hole is desired, but the dragging action of the bent sub arrangement on the well bore tends to cause cave-ins that seriously hamper drilling operations.

Furthermore, quite frequently while lowering the well string into the bore, a "bridged-over" or caved-in section of the bore will be encountered before operational depth is reached which would necessitate withdrawing the well string equipped with a conventional rigid bent sub and going back into the bore with a straight hook-up to drill out such bridged-over section. Naturally this operation is very expensive and time consuming. In contrast, when the drill string is equipped with the adjustable bent sub of the present invention, the sub can be locked in a straight drilling position at the point of contact with the bridged-over section which allows the operator to drill and clean out all obstructions and bridged-over sections as they are encountered.

Thus the present invention provides a sub arrangement which is adjustable downhole for either straight or directional drilling by mere actuation of pressure of fluid within the drill string and sub and by adjusting load of the drill string on the drill bit. Thus a straight hole may be drilled and then angled and vice versa without having to remove the well string and bit from the hole. Not only is the well bore maintained intack without cave-in but time consuming removal of the well string to add conventional rigid subs or other such angling devices is eliminated.

Summary of the invention

The present invention is directed to the provision of an apparatus and a method for deflecting a well bore by means of a fluid actuated adjustable sub which suspends a bottomhole fluid-driven bit from a well string. The adjustable sub generally comprises an orienting sub member for connection to the drill string and having a socket at its lower end, a mandrel having a ball member at its upper end for engagement with the socket, a body member slidably receiving the mandrel and connected to the orienting sub member, and angle block means including a piston-spring arrangement which is actuated by pressure of fluid within the drill pipe to axially and radially position the mandrel within the body member for either straight or angled drilling. Fluid pressure within the drill string is manipulated to lock or unlock the adjustable bendable sub device whereupon load of the drill string on the sub and bit coacting with pressure of fluid in the drill pipe adjusts the device of the present invention for either straight or angled sub positions.

The present invention thus provides an apparatus and a method for drilling a straight well bore into the earth by means of a bottomhole fluid-driven bit suspended from a well string by the device of the present invention. When directional or angled drilling becomes necessary, fluid pressure within the drill string may be manipulated to unlock the adjustable sub followed by adjustment of weight of the drill string on the sub and drill bit to shift position of the mandrel within the sub. The entire operation may be effected while the drill string, sub and bit remain downhole thus greatly reducing time required otherwise by conventional systems. Once the appropriate direction has been assumed by the well bore, the device of the present invention may be readjusted to resume straight drilling. Again the entire operation occurs while the drill string, sub and bit are downhole.

It is, therefore, an object of the present invention to provide a fluid actuated, bendable sub to suspend a bottomhole fluid-driven bit from a well string wherein such sub is locked and unlocked by manipulation of pressure of fluid within the drill string and adjusted by varying load of the drill string on the drill bit for either straight or angled positioning of the sub. The sub may be actuated without the use of conventional cumbersome accessory equipment such as ball drop means, wire line actuated restrictive pistons and the like.

A further object of the present invention is the provision of a directional drilling device for deflecting a well bore wherein the device includes an orienting sub member for connection into a well string at one end and having a socket at the other end, a mandrel having a ball member at one end for engagement with the socket of the orienting sub, a body member slidably receiving the ball end of the mandrel and connected to the orienting sub, and angle block means secured to the body member and actuated by pressure of fluid within the drilling string as well as loading of the drill string on the drill bit to axially and radially position the mandrel within the body member for either angled or straight drilling.

Yet a further object of the present invention is to provide a directional drilling device for deflecting a well bore having an orienting sub member with an axial passageway and adapted at one end to be connected to the drill pipe with a thrust plate secured to the other end for receiving a ball member, a body member also having an axial passageway and secured to the orienting sub member to slidably receive therein a mandrel having a ball formed at one end to contact the thrust plate, and a pair of angle blocks within the body member coacting with pistons slidable transversely through the mandrel upon manipulation of fluid pressure within the device.

Still another object of the present invention is to provide a method of deflecting a well bore being drilled by a bottomhole fluid-driven bit suspended from a well string by means of a fluid actuated bendable sub which is adjustable by varying load of the drill string for either straight or angled positioning.

Another object of the present invention is the provision of a method of deflecting a well bore being drilled by a bottomhole fluid-driven bit suspended from a well string by means of a fluid actuated locking sub adjustable wherein the sub is bendable by varying fluid pressure within the well string and loading of the drill string on the sub and drill bit to effect either angled or straight drilling.

Other and further objects, features and advantages will be apparent from the following description of presently preferred embodiments of the invention, given for the purpose of disclosure, and taken in conjunction with the accompanying drawings.

Brief description of the drawings

In the drawings forming a part of the disclosure herein, like character references designate like parts throughout the several views wherein,

FIGURE 1 is an elevational view showing the device of the present invention in a straight drilling position downhole of the well bore,

FIGURE 2 is a similar elevational view showing the device of the present invention in an angled position for directional drilling,

FIGURE 3A is a partial elevational view, partly in cross-section, of the device of the present invention,

FIGURE 3B is a partial elevational view of the mandrel shown connected to a bottomhole fluid-driven bit device,

FIGURE 4 is a partial elevational view, predominately in cross-section, of the device of the present invention and more particularly the angle block means thereof,

FIGURE 4B is a partial elevational view in cross-section showing the lower end of the mandrel of the present invention,

FIGURE 5 is a cross-sectional view taken along the line 5—5 of FIGURE 4A showing the piston means coacting with the mandrel and angle block means of the present invention,

FIGURE 6 is a cross-sectional elevational view of the present invention showing coacting of wedge and angle block means,

FIGURE 7 is a cross-sectional view taken along line 7—7 of FIGURE 6 showing the pistons within the mandrel and wedge block means wherein the device is positioned for straight drilling, and

FIGURE 8 is a partial elevational view showing the angle block means secured to the body member of the present invention.

Description of the preferred embodiment

The present invention generally comprises a method of and apparatus for deflecting a well bore wherein the well is drilled by a bottomhole fluid-driven bit commonly known, for example, as a turbodrill. Such drill bit means is suspended from a well string by a sub device of the present invention which is capable of orienting the drill bit in either straight or angled positions for either straight or directional upon manipulation of pressure of fluid within the drill string and sub and loading of the drill string on the drill bit. The device of the present invention is best characterized as a fluid actuated locking sub which is adjustable by sliding movement of a mandrel within a body member wherein the mandrel has a ball member at its upper end which is engageable with a corresponding socket member of an orienting sub secured to the top of the body member. The orienting sub, mandrel and body members each have axial passageways therethrough for communication of drilling fluid from the well string to the drill bit, such fluid also acting on pistons within the mandrel for selective engagement with angle blocks within the body member.

Referring now to the drawings and particularly to FIGURES 1 and 2, the reference numeral **10** generally designates the device of the present invention shown secured at its upper end to a conventional well string **12** and at its lower end to a conventional turbo type drill **14**. The device **10** is illustrated in FIGURE 1 in a straight position downhole of a well bore **16** wherein drilling has proceeded in a straight direction to a depth point **18**.

FIGURE 2 is illustrative of the device **10** of the present invention in an angled position wherein the well bore **16** has been drilled from the depth point **18** in an angled direction resulting in a deviated well bore **16***a*. Although the representation in FIGURE 2 may exaggerate sharpness of the angle of the well bore **16**, the illustration will facilitate description of the method involved in the present invention as described hereafter.

The adjustable sub of the present invention is more clearly shown in FIGURE 3A as having an orienting sub member **20** adapted at its upper end to be connected to a drill pipe of well string **12** such as by a conventional threaded connection. The orienting sub member **20** is provided with an axial passageway **24** for flow of drilling fluid therethrough and at its lower end in a concave surface **26** forming a socket for receiving a ball member. Preferably the socket is formed of a concave thrust plate **28** as shown which is secured to the orienting sub member **20** such as by bolts **30**.

A body member **32** securely engages the lower end of the orienting sub member **20** such as by a threaded connection as shown and is provided with an axial passageway **34** for passage of drilling fluid therethrough and also for slidably receiving the ball end **36** of a mandrel **40**. The body member is formed such that there is an inwardly directed annular shoulder **42** formed on the interior body wall within the axial passageway **34** and intermediate the ends of the body member **32** to limit sliding movement of the mandrel therein. As is more clearly shown in FIGURES 6 and 7, the axial passageway **34** at the lower end of the body member **32** tapers on one side to flare radially outwardly in a semi-circular, semi-elliptical cross-sectional configuration **34***a*.

With further reference to FIGURES 6 and 7, the mandrel **40** terminates at its lower end for connection (such as by threads) to a lower sub **44** and the lower sub **44** is in turn connected to a bottomhole fluid-driven type bit represented generally by numeral **46** as shown in FIGURE 3B. The mandrel **40** is provided with opposed apertures **48** and **50** (best shown in FIGURE 7) transversely of its longitudinal axis, each aperture having annular seating shoulders **52** and **54** respectively adjacent the axial passageway **56** of the mandrel. Such apertures slidably receive respective pistons **58** and **60**.

As shown in FIGURE 7 and as further shown in FIGURES 3A, 4A and 8, angle block means represented generally by the reference character **62** are secured in diametric relation within the walls of the body member intermediate the ends thereof. The angle block means include a pair of angle blocks **64** and **66** secured to the body member **32** such as by bolts **68**, both angle blocks preferably being rounded at their respective outer surfaces to conform with the cylindrical configuration of the body member. Both angle blocks have first and second aper-

tures 70 and 72 therein, the axis between centers of said apertures being at an angle relative to the longitudinal axis of the semi-circular, semi-elliptical bore of the body member. A channel 74 on the interior surface of each block is provided to guide the pistons (the piston 58 as shown in FIGURES 3A and 8) from one aperture to the other as will be explained hereafter. Each said aperture is further provided with an annular seating shoulder 76 adjacent the exterior of the block to limit outward travel of the piston therethrough. Secured within each angle block are torsion springs 78 retained by spring pins 80, each torsion spring having elongated arms 82 for contact with the outer ends of each piston in order to yieldingly maintain each piston normally within the mandrel. It will be recognized, of course, that other spring means may be used as a helical spring wound around each piston acting against each angle plate to perform the same function.

Referring once again to FIGURES 4A and 6, the ball member 36 integrally formed of the mandrel 40 is provided with a plurality of ducts 82 extending from the terminal periphery of the ball to the axial passageway 56 of the mandrel in order to permit communication of drilling fluid from the periphery of the ball to the interior of the mandrel upon seating of the ball member with the socket or thrust plate 28 of the orienting sub as shown in FIGURE 4A. The ducts 82 thus permit drainage of drilling fluid contained within the axial passageway 34 of the body member when the ball member is seated against the thrust plate to eliminate fluid backpressure and facilitate the seating operation. Preferably, the ball member 36 is also provided with an annular undercut or relief 84 to further assist drainage of drilling fluid into the interior of the mandrel during seating of the ball member with the thrust plate.

In order to properly align the mandrel 40 for sliding engagement with the body member 32, a longitudinal slot 86 is provided in the body member in which slides a torque block 88 secured to the mandrel such as by bolts 90. Close tolerance of the wedge block 88 with the sides of the longitudinal slot 86 thus causes the torque block 88 to prevent rotative movement of the mandrel 40 relative to the body member 32 when a twisting or rotative torque is applied to the mandrel upon actuation of the drill bit below it. Thus the torque block 88 effectively reduces wear on the pistons 58 and 60 since otherwise the pistons would absorb the torque.

Further secured to the mandrel 40 are wedge blocks 92 and 94 which are engageable with the body member in order to laterally stabilize the mandrel 40 upon longitudinal sliding thereof within the body member. As shown in FIGURE 6, when the mandrel 40 slides to its lowermost position within the body member 32, i.e. the device of the present invention is in a straight position for straight drilling, the wedge block 92 which is slidable within the longitudinal slot 96 in the body member is wedged (by weight of the drill bit means and pressure of drilling fluid acting on the ball member of the mandrel) into and rests against an angled face 98 within the body member to steady and maintain the mandrel in such a straightened position. However, as shown in FIGURE 4A, when the mandrel 40 slides (by means of load of the drill string 12 bearing down on the drill bit means) to its uppermost position for engagement of the ball member 36 with the thrust plate 28, the wedge block 94 engages an angled face 100 in the body member to force and maintain the mandrel 40 in an angled position for angled drilling so that when the fluid pumps are turned on the pistons 58 and 60 will be thrust into the apertures 72 for angled drilling.

Further provided toward the lower end of the mandrel 40 is a locking key 102 secured to the mandrel preferably by a bolt 104 for locking engagement with one of a plurality of keyways 106 provided in the top periphery of the lower sub 44 as shown in FIGURES 4B and 6. Thus the mandrel 40 which is connected to the lower sub 44 such as by threadable engagement is locked against screwable disengagement therefrom by means of the key 102. It is preferred that a plurality of keyways 106 be provided in the lower sub 44 so that the key 102 may be screwed into the mandrel 40 to engage a keyway 106 at any radial point where the mandrel lower sub joint is made up tight. As further shown in FIGURE 4B, the lower sub 44 in turn may be connected such as by threadable engagement of the self-powered drill bit means 14.

An understanding of operation of the device of the present invention is best facilitated by a discussion of assembly of the tool. First, of course, a suitable O ring seal 37 is inserted in an appropriate groove about the outside of the ball member 36 and the mandrel 40 is then inserted into the body member 32 by passing the mandrel down through the axial passageway 34 of the body member until the ball member 36 is seated against the annular shoulder 42 as shown in FIGURE 6. Then the torque block 88 is secured to the mandrel 40 and the pistons 58 and 60 are inserted into the apertures 48 and 50 of the mandrel as shown in FIGURE 7. It will be recognized that the pistons 58 and 60 are preferably provided with appropriate sealing means such as O rings 59 so that the pistons are slidable within the apertures of the mandrel yet are sealed against passage of fluid between each piston and the aperture walls in the mandrel.

Once the pistons have been inserted, the angle blocks 64 and 66 each having springs 78 retained therein by spring pins 80 are secured to the body members 32 by means of appropriate bolts 68. Although it should now be apparent, both angle blocks should be installed so that the apertures 70 of each angle block are diametrically opposed and the apertures 72 of each angle block are likewise diametrically opposed. Thus, when the mandrel 40 is in its most extended position as shown in FIGURE 6, the dual pistons 58 and 60 should engage the lower apertures 70 of each angle block. When, as shown in FIGURES 4A and 5, the mandrel 40 slides upwardly within the body member 32, the pistons 58 and 60 slide along the channels 74 formed interiorly of both angle blocks whereupon the pistons engage with the upper apertures 72 of each angle block. Since the axis between centers of the apertures 70 and 72 of each angle block are at an angle relative to the longitudinal axis of the body member, the mandrel 40 is likewise disposed at an angle within the body member 32 as shown in FIGURE 4A and is steadied in such position by means of the wedge block 94 (which is then secured along with the wedge block 92 to the mandrel) resting against the angled face 100 at the lower end of the body member.

As better shown in dotted outline in FIGURE 8, the channels 74 of each angle block have a straight side 74*a* and an angled side 74*b*, the angled side being parallel to the axis between centers of the apertures 70 and 72. Thus when the apparatus of the present invention is to be placed in an angled position, the pistons 58 and 60 travel upwardly along the straight sides 74*a* of the channels 74 until the wedge block 94 contacts the angled face 100 of the body member. When the apparatus is to be placed in a position for straight drilling, the pistons 58 and 60 travel downwardly along the angled sides 74*b* of the channels 74 until the wedge block 92 contacts the angled surface 98 of the body member. Such loci of travel by the pistons coacting with the respective wedge blocks effectively reduces piston wear and facilitates adjustment of the present invention between straight and angled positions.

Finally, the orienting sub 20 is secured to the body member 32 such as by threadable engagement therewith. It is the purpose of the provision of a thrust plate 28 secured to the lower end of the orienting sub 20 to receive the load of the ball member 36 when the mandrel 40 is in its uppermost position as shown in FIGURE 4A. Thus, wear of the pistons 58 and 60 is significantly reduced when such pistons engage the upper apertures 72 of each angle block 64 and 66. In order for the pistons to be prop-

erly aligned so as to freely slide within the apertures **72** of each angle block, shims (not shown in the drawings) may be installed between the thrust plate **28** and the orienting sub **20** and held therebetween by force of the bolts **30** which engage the thrust plate **28** with the orienting sub. Then a conventional orienting sleeve **108** may be inserted within the axial passageway of the orienting sub for coacting with an orienting mandrel (not shown) for use in properly orienting the drill bit in the desired direction as is well known in the art.

In operation, the bendable directional drilling sub of the present invention as shown in FIGURE 1 is secured to a conventional well string such as by threadable engagement of the orienting sub **20** with the lower end of the drill pipe **12**. Then the device **10**, assembled as just described and having the lower sub **44** secured to the mandrel **40**, is connected into a conventional bottomhole fluid-driven bit means **14**.

It is to be understood, of course, that conventional drilling fluid passes downwardly through the drill string **12** through the axial passageways of the orienting sub **20**, body member **32**, mandrel **40**, lower sub **44** and then into the drill bit means **14**. Assuming then that straight drilling is to be commenced, pressure of the fluid is reduced such as by shutting off the fluid pump (not shown) at the well surface. Weight of the drill string **12** is taken off of the drill bit means **14** by suspending the drill string (such as with the usual draw works, not shown) so that the bit means **14** does not contact the bottom of the hole or object to be drilled. Under these circumstances, the arms **82** of the torsion spring **78** force the pistons **58** and **60** inwardly within the mandrel **40** to seat against the shoulders **52** and **54** within the apertures **48** and **50** of the mandrel. As a result, the weight of the drill bit suspended from the lower sub **44** pulls the mandrel **40** downwardly through the body member **32** so that the ball member **36** of the mandrel rests against the annular shoulder **42** within the axial passageway **34** of the body member. The wedge block **92** then engages the angled surface **98** within the body member **32** to stabilize the mandrel **40** in a straight position as shown in FIGURE 6. Pressure of the drilling fluid within the axial passageways of the body member **32** and the mandrel **40** is then increased to overcome force of the torsion spring **78** and act against the pistons **58** and **60** which are forced outwardly through the apertures **48** and **50** respectively in the mandrel and into the lower apertures **70** with each angle block **64** and **66**. Maintaining or increasing pressure of the fluid causes the pistons to remain engaged with the apertures **70** of the angle block. Straight drilling may then be commenced by lowering the drill string **12** so that the bit means **14** contacts the bottom of the hole or the object to be drilled, and further increases of fluid pressure causes the drill bit means **14** to function and drill out the well bore **16** as shown in FIGURE 1.

Assuming now that the well bore **16** of FIGURE 1 has been drilled to the depth point **18** and it is desired to deflect angle of the well bore, again pressure of the drilling fluid and weight of the drill string on the drill bit are manipulated to operate the device of the present invention. Accordingly, pressure of the drilling fluid within the body member **32** and mandrel **40** is reduced such as by turning off the fluid pumps at the well surface. Then load of the drill string **12** is permitted to bear down on the drill bit means **14** with such drill bit means resting on the bottom of the hole. By first reducing pressure of the fluid within the body member **32** and mandrel **40**, the arms **82** of the torsion spring **78** force the pistons **58** and **60** back into the apertures **48** and **50** respectively of the mandrel **40** whereupon weight of the drill string **12** acting on the body member **32** causes the body member **32** to slide downwardly, or stated conversely, the ball member **36** of the mandrel **40** slides upwardly within the body member **32** so that the upper end of the ball member engages and is seated against the thrust end of the ball member engages and is seated against the thrust plate **28** within the orienting sub **20** simultaneously with the wedge block **94** contacting the angled face **100**. Drilling fluid within the axial passageway **34** of the body member **32** caught between the outer periphery of the ball member **36** and the interior wall of the body member **32** forming the axial passageway **34** is vented through the ducts **82** into the axial passageway **56** of the mandrel **40** so that the ball member **36** freely seats against the thrust plate **28**.

Upon seating of the ball member **36** with the thrust plate **28**, pressure of the drillng fluid within the axial apertues **34** and **56** of the body member **32** and mandrel **40** respectively, is increased once again to overcome tension of the torsion spring **78** so that the pistons **58** and **60** are pushed outwardly by force of the drilling fluid through the apertures **48** and **50** respectively in the mandrel **40** and into the dual aperture **72** of the angle blocks **64** and **66** as shown in FIGURES 4A and 5. As before, maintaining or increasing fluid pressure causes the pistons **58** and **60** to remain in such outward positions to lock the mandrel **40** at an angle within the body member **32** as shown in FIGURE 4A. Further increasing pressure of the drilling fluid actuates the drill bit means **14** and angled drilling may proceed as shown in FIGURE 2.

Of course, when angled drilling as shown in FIGURE 2 has proceeded to the desired point, straight drilling may be resumed by manipulating drilling fluid pressure and weight of the drill string **12** on the drill bit means **14** as discussed previously with regard to straight drilling operations. Straight or angled drilling may be employed intermittently at will merely by manipulating fluid pressure and drill string loading as described resulting in vast labor savings since the drill pipe **12** and device **10** of the present invention need not be removed from the hole each time the well bore **16** is deviated. The time and expense of "making trips" by removing stands of the drill pipe **12** is obviated which those skilled in the art will recognize as being of extreme significance.

It should now be aparent that the device **10** of the present invention may be altered for use by varying angles merely by varying the degree of the angle of the axis between centers of the first and second apertures **70** and **72** within the angle blocks **64** and **66** of the body member **32** relative to the longitudinal axis of the body member with consequent varying of the angle of taper of the bore within the body member which terminates with the configuration **34***a*. Of course, angles of contact of the wedge block **94** with the angled face **100** must be varied accordingly. Additionally, it is to be understood that the embodiment of the present invention described herein as having the angle blocks **64** and **66** separate from but secured to the body member **32** may be slightly modified by those skilled in the art whereby such angle blocks are integral with the body member.

The present invention, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned as well as those inherent therein. While presently preferred embodiments of the invention are given for the purpose of disclosure, numerous changes in the details of construction and arrangement of parts can be made which will readily suggest themselves to those skilled in the art and which are encompassed within the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. A directional drilling device for deflecting a well bore, comprising,

an orienting sub member adapted at one end to be connected to a drill pipe and having a concave surface at its opposite end forming a socket for receiving a ball member, said orienting sub member having an axial passageway therethrough,

a mandrel having an axial passageway therethrough and terminating at one end with an integral ball member of greater diameter than that of the mandrel,

a body member having first and second ends, the first end securely engaging about the socket end of the orienting sub member, said body member having an axial passageway therethrough for slidably receiving the ball end of the mandrel and having an inwardly directed annular shoulder formed on the interior body wall within the axial passageway and intermediate the ends of the body member for limiting sliding of the mandrel therein, said axial passageway flaring radially outwardly at the second end of the body member, and

angle block means secured to the body member and piston means within the mandrel coacting with the angle block means for axially and radially positioning said mandrel within said body member.

2. The invention of claim **1** wherein the mandrel is provided with opposed apertures transversely of its longitudinal axis, each said aperture having an annular seating shoulder adjacent the axial passageway of the mandrel, and wherein the angle block and piston means includes,

a pair of angle blocks secured in diametric relation within the walls of the body member intermediate the ends thereof, each said angle block having first and second apertures adjacent either end of the block with a channel therebetween on the interior surface of said block, the axis between centers of the first and second apertures being at an angle relative to the longitudinal axis of the body member, and each aperture having an annular seating shoulder adjacent the exterior of the block,

first and second pistons each slidably positioned within an aperture of the mandrel for engagement with the holes and channel of an angle block, and

spring means for yieldingly maintaining each piston normally within the mandrel.

3. The invention of claim **1** wherein the ball member of the mandrel includes duct means therethrough for fluid communication between the terminus periphery of the ball and the axial passageway of the mandrel upon seating of the ball member within the socket of the orienting sub.

4. The invention of claim **1** including,

a longitudinal slot provided in the body member, and

torque block means secured to the mandrel for longitudinal sliding engagement with the slot in the body member thereby preventing rotative movement of the mandrel relative to the body member.

5. The invention of claim **1** including wedge block means secured to the mandrel for engagement with the body member and for laterally stabilizing said mandrel upon longitudinal sliding thereof within the body member.

6. The invention of claim **1** wherein the outward radial flare of the axial passageway of the second end of the body member assumes a semi-circular, semi-elliptical cross-sectional configuration.

7. A directional drilling device for deflecting a well bore, comprising,

an orienting sub member having an axial passageway therethrough and adapted at one end to be connected to a drill pipe,

a thrust plate secured to the other end of the orienting sub member, said thrust plate having a concave outer surface forming a socket for receiving a ball member,

a mandrel having an axial passageway therethrough and terminating at one end with an integral ball member of greater diameter than that of the mandrel, said mandrel also having opposed apertures transversely of its longitudinal axis, each said aperture having an annular seating shoulder adjacent the axial passageway of the mandrel,

a body member having first and second ends, the first end securely engaging the end of the orienting sub member about the thrust plate, said body member having an axial passageway therethrough for slidably receiving the ball end of the mandrel and having an inwardly directed annular shoulder formed on the interior body wall within the axial passageway and intermediate the ends of the body member for limiting sliding of the mandrel therein, said axial passageway flaring radially outward at the second end of the body member,

a pair of angle blocks secured in diametric relation within the walls of the body member intermediate the ends thereof, each said angle block having first and second apertures adjacent either end of the block with a channel therebetween on the interior surface of said block, the axis between centers of the first and second apertures being at an angle relative to the longitudinal axis of the body member, and each aperture having an annular seating shoulder adjacent the exterior of the block,

first and second pistons each slidably positioned within one of the mandrel apertures for engagement with the holes and channel of one of the angle blocks, and

spring means for yieldingly maintaining each piston normally within the mandrel.

8. The invention of claim **7** wherein the ball member of the mandrel includes duct means therethrough for fluid communication between the terminous periphery of the ball and the axial passageway of the mandrel upon seating of the ball member within the socket of the thrust plate.

9. The invention of claim **7** including:

a longitudinal slot provided in the body member, and

torque block means secured to the mandrel for longitudinal sliding engagement with the slot in the body member thereby preventing rotative movement of the mandrel relative to the body member.

10. The invention of claim **7** including wedge block means secured to the mandrel for engagement with the body member and for laterally stabilizing said mandrel upon longitudinal sliding thereof into the body member.

11. The invention of claim **7** wherein the outward radial flare of the axial passageway at the second end of the body member assumes a semi-circular, semi-elliptical cross-sectional configuration, the long axis of said ellipse being at a right angle with the longitudinal axis of the pistons.

12. The invention of claim **7** including additionally,

duct means through the ball member of the mandrel for fluid communication between the terminous periphery of the ball and the axial passageway of the mandrel upon seating of the ball member within the socket of the orienting sub,

a longitudinal slot provided in the body member,

torque block means secured to the mandrel for longitudinal sliding engagement with the slot in the body member thereby preventing rotative movement of the mandrel relative to the body member,

wedge block means secured to the mandrel for engagement with the body member and for laterally stabilizing said mandrel upon longitudinal sliding thereof into the body member, and

semi-circular, semi-elliptical cross-sectional configuration assumed by the outward radial flare of the axial pasageway at the second end of the body member, the long axis of said ellipse being at right angles with the longitudinal axis of the pistons.

13. A method of deflecting a well bore being drilled by a bottomhole fluid-driven bit suspended from a well string by means of a fluid actuated locking sub adjustable by load of the drill string for straight and angle positioning, said method comprising the steps of,

reducing the fluid pressure within the well string and locking sub and taking load of the drill string off of the sub to unlock said sub from a straight position,

increasing load of the drill string on the sub to shift the sub to an angled position,

increasing fluid pressure to lock said sub in the angled position, and

further increasing fluid pressure to drive the bit.

14. The method of claim **13** including additionally,

reducing the fluid pressure within the well string and locking sub and taking load of the drill string off of the sub to unlock said sub from an angled position,

decreasing load of the drill string on the sub to shift the sub to a straight position,

increasing fluid pressure to lock said sub in the straight position, and

further increasing fluid pressure to drive the bit.

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