

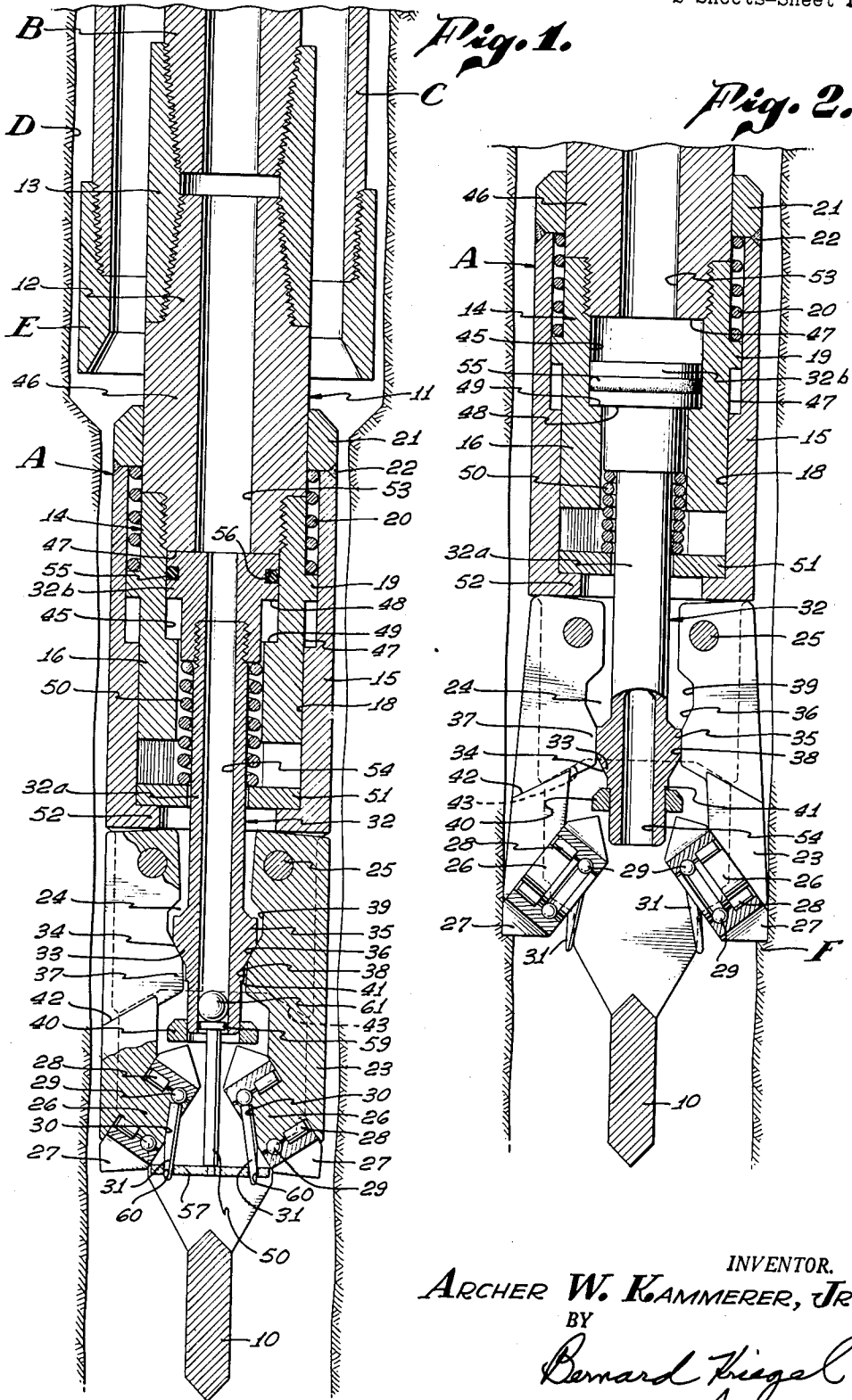
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ROTARY EXPANSIBLE DRILL BITS

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ROTARY EXPANSIBLE DRILL BITS

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13 Claims. (Cl. 255-76)

The present invention relates to rotary drill bits, and more particularly to drill bits of the expansible type adapted to enlarge the diameter of a well bore below a string of well casing disposed therein.

An object of the present invention is to provide an improved expansible rotary drill bit having cutters that are hydraulically expandible outwardly and are then locked positively in their expanded position during the time drilling weight is being imposed upon them. The locking action remains despite the removal of the hydraulic expandible force, so long as drilling weight or downweight is being imposed on the cutters.

Another object of the invention is to provide an expansible rotary drill bit having cutters that are expanded outwardly by a hydraulically operable device which is positively prevented from retracting so long as the drill bit is being subjected to drilling weight. The relieving of the drilling weight on the bit will still result in the cutters being locked in their outwardly expanded position, in the event the hydraulically operable device is still subjected to fluid pressure.

Still another object of the invention is to provide an expansible rotary drill bit in which the cutters are relatively free of any outwardly expansible forces imposed thereon during lowering of the bit in the well bore, and also during elevating of the bit in the well bore, thereby facilitating the descent of the bit and its elevation, with assurance that the cutters will not interfere with longitudinal movement of the drill bit in the well bore.

A further object of the invention is to provide a strong and sturdy expansible rotary drilling bit, which is shorter in length, simpler in construction, and more economical to manufacture.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a longitudinal section through an embodiment of the invention disposed in a well bore, with the cutters and other parts in their initial retracted position;

Fig. 2 is a longitudinal section similar to Fig. 1, disclosing the cutters locked hydraulically in their fully expanded position preparatory to the imposition of drilling weight on the cutters;

Fig. 3 is a longitudinal section similar to Fig. 1, disclosing the cutters locked in their fully expanded positions as the result of the imposition of drilling weight thereon;

Fig. 4 is a longitudinal section similar to Fig. 1, disclosing the relationship and condition of the parts when the tool is being withdrawn through the well casing disposed in the well bore.

The expansible rotary drill bit A disclosed in the drawings is attachable to a string of drill pipe B for the purpose of lowering the bit through a well casing C in a well bore D to a point below the casing shoe E at which the diameter of the bore hole is to be enlarged. The drill bit A may have a pilot bit 10 at its lower end for centering the tool in a hole that may have already been drilled, or for drilling new hole in the absence of a pre-existing hole. The main portion of the bit is capable of enlarging the bore hole by producing and operating upon a transverse formation shoulder F, as hereinafter described.

The drill bit A consists of a composite driving mandrel 11 having an upper pin 12 threadedly connected to a sub 13 forming the lower end of the drill pipe string B. This mandrel includes an upper Kelly or drill stem member 14 slidably splined to the main body 15 of the bit. As an example, a portion 16 of the Kelly may have a non-circular or hexagonal exterior 17 which is telescopically received within a companion non-circular or hexagonal internal socket 18 formed in the body. The mandrel 11 has a limited range of longitudinal movement within the body 15, its upward movement being limited by engagement of an external shoulder 19 on the Kelly portion with the lower end of a helical spring 20 encompassing the Kelly portion, the upper end of which engages a retainer ring 21 on the body suitably secured to the latter, as by use of welding material 22.

The body 15 has a plurality of expansible parts mounted on it comprising cutter supporting members 23 pivotally mounted in body slots 24 on hinge pins 25 suitably welded to the body, the cutter supporting members depending from the hinge pins. Each cutter supporting member 23 has a lower bearing supporting pin 26 inclined inwardly and downwardly, on which a roller side cutter 27 is rotatably mounted. Anti-friction roller and ball bearing elements 28, 29 are placed between each cutter 27 and bearing pin 26, the roller bearings 28 transmitting radial thrusts and the ball bearings 29 both radial and axial thrusts. The ball bearings 29 also retain each cutter 27 on a pin 26, being inserted in place through a passage 30 of the bearing support, which is then closed by a plug 31 welded to the pin 26. The plug or pin 31 extends downwardly from the passage 30, and is used to hold the cutters 27 in retracted position, as explained below.

The cutters 27 are expanded outwardly and are locked in such expanded position by a lower tubular member 32 which forms part of the composite mandrel 11. The upper end of this tubular member is telescopically arranged within the Kelly 14. It is provided with a tapered expander portion 33 including downwardly and inwardly converging expander surfaces 34 above which is located a lock portion 35. The expander surfaces 34 engage companion tapered surfaces 36 on inwardly directed lug portions 37 on the cutter supporting members 23, whereas the lock portion 35 is adapted to engage companion lock surfaces 38 on the cutter supporting members 23 which extend below its tapered expander surfaces 36.

Normally, the tubular member 32 occupies an upward position with respect to the body 15 and the cutter supporting members 23, in which its lock portion 35 is disposed in alignment with upper recesses 39 in the cutter supporting members. When the tubular member 32 is shifted downwardly, its expander surfaces 34 will engage the companion surfaces 36 on the cutter supporting members 23, to swing the latter and cutters 27 outwardly, the continued downward movement of the tubular member 32 finally locating the lock portion 35 opposite the companion lock surfaces 38 on the cutter supporting members.

The lower portion of the tubular member 32 is slid-

ble in a guide 40 extending transversely across the body 15, the downward movement of the tubular member 32 being limited by the engagement of its stop shoulder 41 with the upper surface of the guide. When such engagement occurs, the lock portions 35 of the tubular member are in full engagement with the companion lock surfaces 38 on the cutter supporting members 23. The extent of outward expansion of the cutter supporting members 23 and cutters 27 is determined by engagement of suitable stops 42 on the cutter supporting members with companion stop surfaces 43 on the body. When such engagement occurs, the tubular member 32 can still move downwardly into its locking position behind the cutter supporting member lugs 37.

The tubular member 32 extends centrally of the tool, its lower portion 32a being threaded into an upper portion 32b, which is constituted by a piston slidable in a cylinder 45 formed in the Kelly 14. As shown, the Kelly is made of two portions, one of which is an upper portion 46 threaded into the lower portion 16, in which the cylinder 45 is provided. The upper end of the piston 32b is movable with respect to the Kelly into engagement with the lower end 47 of the upper Kelly portion 46, while a lower shoulder 48 on the piston is movable downwardly with respect to the Kelly cylinder 45 into engagement with an inwardly directed release shoulder 49 formed on the lower Kelly portion 16. This shoulder 49 is spaced substantially from the lower end 47 of the upper Kelly portion 46 by an amount substantially greater than the length of the piston at its periphery where it engages the cylinder wall 45, to allow relative longitudinal movement to take place between the tubular member portion 32 of the mandrel 11 and the Kelly portion 14.

The yieldable spring 20 surrounding the Kelly and bearing upon its flange 19 causes the body 15 of the drill bit, as well as the cutters 27 and supporting members 23, to be yieldably supported by the Kelly in an upward position. A helical return spring 50 encompasses the tubular member 32, its upper end bearing upon the lower end of the piston 32b and its lower end bearing upon a thrust washer and spring seat 51 supported on an internal body shoulder 52. This return spring 50 normally urges the tubular member 32 in an upward direction, to locate its lock portion 35 in alignment with the supporting member recesses 39 and its expander portion 33 in a position that allows the cutter supporting members 23 to retract, or be maintained in retracted position. When the return spring 50 is supporting the tubular member 32 and its piston 32b in an upward position, the lower shoulder 48 of the piston is disposed a substantial distance above the release shoulder 49 on the Kelly, and the stop shoulder 41 on the tubular member 32 is disposed a substantial distance above the lower guide 40 (as disclosed in Fig. 1).

The upper portion 46 of the Kelly has a central passage 53 therethrough communicating with the cylinder 45, this passage being in alignment with a central passage 54 extending completely through the tubular member 32 and its piston 32b. The piston passage 54 is of a comparatively restricted diameter with respect to the diameter of the Kelly passage 53, to enable a back pressure to be built up in the Kelly passage above the piston 32b when fluid is being pumped through the apparatus. This pressure is sufficient to move the piston 32b in a downward direction with respect to the body 15 and against the action of the compression spring 50, to shift the tubular member 32 downwardly for the purpose of expanding the cutter supporting members 23 and cutters 27 outwardly, and then placing the lock portion 35 opposite the lugs 37 of the supporting members, to hold the cutters 27 in their outwardly expanded position. Fluid leakage between the piston 32b and cylinder 45 is prevented by providing a suitable piston ring 55, such as a rubber O ring, in a peripheral groove 56 in the piston, which sealingly and slidably engages the wall of the Kelly cylinder 45.

When the mandrel 11 and its tubular member 32 are disposed in an upward position relative to the body, to place the lock portion 35 and its expander portion 33 opposite the cutter supporting member recesses 39 and above the expander surfaces 36 on the cutter supporting members, the cutters 27 and their supporting members 23 may be locked in their initially retracted position, to preclude their inadvertent outward expansion. This locking or holding device includes a holding member 57 secured to the lower end of a central rod 58 having an upper end projecting into the tubular member passage 54. A head 59 is secured to the upper end of this rod 58, having substantial clearance in the passage 54 to allow fluid to pass upwardly into the central passages 54, 53 and the drill string B. The holding member 57 has spaced holes 60 in its outer portions for receiving the lower ends of the ball retaining plugs 31.

When the holding device 57 is disposed over the plugs 31, as disclosed in Fig. 1, the cutter supporting members 23 are prevented from expanding, the cutters 27 being positively held in retracted position. Release of the holding member 57 from the plugs 31 occurs as a result of dropping a ball 61 through the tubular string B, which will gravitate through the latter and through the Kelly passage 53 and tubular member passage 54 into engagement with the head 59. The ball 61 has substantially the same diameter as the diameter of the tubular member passage 54, to allow fluid pressure to be built up thereabove. When fluid pressure is applied to the fluid in the drill pipe B and the mandrel passages 53, 54, the ball 61, rod 58 and holding member 57 are shifted downwardly, to free the latter from the plugs 31, thereby enabling the cutter supporting members 23 and the cutters 27 carried thereby to be expanded outwardly.

The drill pipe B and the drill bit A are rotated while fluid is being pumped under pressure down the drill string. In view of the throttling action of the piston passage 54, the back pressure is built up on the high pressure side of the piston 32b, urging the piston and tubular member 32 downwardly against the force of the spring 50 and causing the expander surfaces 34 on the latter to act against the supporting member surfaces 36 and forcing the latter and the cutters 27 in an outward direction. The rotation of the drill pipe B and the drill bit A continues, with the pump pressure being thus applied, the cutters 27 producing a formation shoulder F. As the formation shoulder is produced, the tubular member 32 is urged downwardly against the force of the return compression spring 50 until the supporting members 23 and cutters 27 have been expanded outwardly to their maximum position, as determined by engagement of the supporting member stop surfaces 42 with the body stop surfaces 43. When this occurs, the external surfaces locking portion 35 in the tubular member is lowered behind the companion surfaces 38 on the cutter supporting members 23. These surfaces, when the cutter supporting members 23 and cutters 27 are fully expanded, are substantially parallel to the axis of the drill bit, thereby affording a positive lock which will preclude inadvertent retraction of the cutters 27 from their maximum outwardly expanded position.

The formation shoulder F is produced in the wall of the well bore without the imposition of any downward drilling weight on the drill bit. When the cutters 27 have been expanded outwardly by the hydraulic downward movement of the tubular member 32, and locked in their maximum expanded position, the parts occupy the relative positions disclosed in Fig. 2. Thereafter, the Kelly 14 may be moved downwardly of the body 15, which will place the lower end 47 of the upper Kelly member 46 immediately adjacent the upper end of the piston 32b, and which will also place the lower end 16a of the lower Kelly member 16 in engagement with the thrust washer 51. This arrangement of parts is disclosed in Fig. 3, in which it is evident that drilling weight is being imposed

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on the cutters 27 by being transmitted from the kelly 14 directly to the body 15, and from the latter to the cutter supporting members 23 and cutters. At the same time, the location of the lower end 47 of the upper Kelly member 46 immediately adjacent the upper end of the piston 32b precludes the piston and tubular member 32 from moving upwardly, which would allow the tubular member to be elevated into a position in which its lock portion 35 is no longer disposed behind the companion lock surfaces 38 on the cutter supporting members 23.

With the downweight imposed on the apparatus, and with the string of drill pipe B and the drill bit A rotating at the proper speed, the hole is enlarged by virtue of the cutters 27 operating upon the formation shoulder F. The drilling fluid is passing out through the mandrel 11 and will commingle with the cuttings to carry them upwardly around the drill pipe string to the top of the hole. So long as drilling weight is being imposed on the tool, the cutters 27 will be held locked in their outward position. Even if the tool were to be elevated above the shoulder F, the cutters 27 can still be held locked in their outward position, so long as fluid under sufficient pressure is being pumped down through the drilling string B and through the apparatus A. It is evident that the fluid pressure will be constantly acting downwardly on the piston 32b, to hold the tubular member 32 in its locked position with respect to the cutter supporting members 23 and cutters 27.

It is, therefore, apparent that the cutters 27 may be locked in their outwardly expanded position as a result of the downward imposition of weight on the apparatus, because of the imposition of fluid pressure on the apparatus, or as a result of both the imposition of downweight and the fluid force on the apparatus. In the event it is desired to allow the cutter supporting members 23 and cutters 27 to retract, all that is necessary is to elevate the drill string B, which will elevate the kelly 14 in the body 15, and also discontinue the application of pressure to the fluid in the drill pipe, which will then allow the return spring 50 to raise the tubular member portion 32 of the mandrel 11 upwardly, to place its lock portion 35 opposite the supporting member recesses 39, and to dispose its expander surfaces 34 in their initial position with respect to the companion cutter supporting member surfaces 36. The cutters 27 may now swing inwardly under the action of gravity.

If the tool is now to be withdrawn from the well bore, the drill string B need only be elevated, which will carry the entire drill bit A upwardly. During such upward movement, it is evident that there are no elements tending to hold or urge the cutter supporting members 23 in an outward direction. The apparatus may be withdrawn readily within the casing string C and raised to the top of the well bore. If, however, the cutter supporting members 23 happen to be disposed partially or entirely in their outwardly expanded position, the outer surfaces of the cutter supporting members 23 will engage the shoe D, which will positively force them inwardly to a retracted position.

In the event the return spring 50 is incapable of shifting the piston 32b and its tubular member 32 in an upward direction to an unlocking position, after the fluid pressure within the apparatus has been relieved, the drill pipe B can still be elevated, to elevate the entire apparatus, until the cutter supporting members 23 reach a restricted diameter portion in the well bore D, to engage the shoe E. When this occurs, a further upward pull can be taken on the drill pipe B and the kelly 14, the release shoulder 49 on the latter engaging the lower shoulder 48 of the piston 32b, enabling the kelly 14 to forcibly shift the tubular member 32 upwardly within the body 15 and elevate its lock and expander portions 35, 33 above the corresponding lock and expander portions 37, 36 of the cutter supporting members 23, whereupon the cutters 27 may retract. Such upward movement of the kelly 14 in

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forcibly elevating the tubular member 32 and its piston 32b can occur since the yieldable stop spring 20 may compress and will, therefore, allow the necessary relative upward movement of the kelly and the tubular member 32 to take place with respect to the body 15 (Fig. 4).

It is, accordingly, evident that an expansible rotary drill bit has been provided which is relatively short as compared with prior art devices, inasmuch as the cutter supporting members 23 need only occupy a sufficient over-all length to extend from a point closely above the hinge pins 25 to the bearing supporting pins 26. The mechanism for expanding the cutters 27 outwardly, and for locking them in such outwardly expanded position, is combined in one unit, namely, the mandrel 11, which also simplifies the device. In addition to this arrangement, the expansion occurs hydraulically, as well as the location of the lock portion 35 of the mandrel in its proper locking position, the locking action being maintained so long as downweight is being imposed on the apparatus. The locking action also remains in the absence of drilling weight, in the event the pump pressure is still applied to the apparatus. Release of the apparatus and its withdrawal from the well bore is facilitated since the elevation of the lock and expander portions 35, 33 with respect to the cutter supporting members 23 removes all restraint tending to hold the cutter supporting members in their outward direction. Accordingly, the apparatus can be elevated in the well casing without the cutter supporting members being urged with any substantial force against the wall of the well casing.

The inventor claims:

1. In a rotary well drilling bit: a main body; cutter means mounted on said body for expansion laterally outward of said body; a mandrel connectible directly to a drill string and slidably splined to said body, whereby torque is transmittable from the drill string to said mandrel and from said mandrel to said body, said mandrel including a hydraulically operable portion engageable with said cutter means and movable downward of the body by the pressure of the fluid in the drill string to expand said cutter means laterally outward, said mandrel including another portion movable downwardly of said body into a position adapted to engage said hydraulically operable portion to prevent retraction of said hydraulically operable portion from its cutter means expanding position.

2. In a rotary well drilling bit: a main body; cutter means mounted on said body for expansion laterally outward of said body; a mandrel connectible directly to a drill string and slidably splined to said body, whereby torque is transmittable from the drill string to said mandrel and from said mandrel to said body, said mandrel including a longitudinally movable portion engageable with said cutter means and movable downward of said body to expand said cutter means laterally outward, said mandrel including another portion movable downwardly of said body into a position adapted to engage said longitudinally movable portion to prevent retraction of said longitudinally movable portion from its cutter means expanding position.

3. In a rotary well drilling bit: a main body; cutter means mounted on said body for expansion laterally outward of said body; means for expanding and holding said cutter means laterally outward, said expanding and holding means comprising a mandrel connectible directly to a drill string and slidably splined to said body, whereby torque is transmittable from the drill string to said mandrel and from said mandrel to said body, said mandrel including a hydraulically operable portion movable downward of the body by the pressure of the fluid in the drill string into a position expanding and holding said cutter means laterally outward.

4. In a rotary well drilling bit: a main body; cutter means mounted on said body for expansion laterally outward of said body; means for expanding and holding

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said cutter means laterally outward, said expanding and holding means comprising a mandrel connectible directly to a drill string and slidably splined to said body, whereby torque is transmittable from the drill string to said mandrel and from said mandrel to said body, said mandrel including a hydraulically operable portion movable downward of the body by the pressure of the fluid in the drill string; and expander means on said hydraulically operable portion engaging said cutter means to expand said cutter means laterally outward upon movement of said hydraulically operable portion downwardly of said body.

5. In a rotary well drilling bit: a main body; cutter means mounted on said body for expansion laterally outward of said body; means for expanding and holding said cutter means laterally outward, said expanding and holding means comprising a mandrel connectible directly to a drill string and slidably splined to said body, whereby torque is transmittable from the drill string to said mandrel and from said mandrel to said body, said mandrel including a hydraulically operable portion movable downward of the body by the pressure of the fluid in the drill string; and expander means on said hydraulically operable portion engaging said cutter means to expand said cutter means laterally outward upon movement of said hydraulically operable portion downwardly of said body; said mandrel including another portion movable downwardly of said body into a position adjacent and engageable with said hydraulically operable portion to prevent upward movement of said hydraulically operable portion from its cutter means expanding position.

6. In a rotary well drilling bit: a main body; cutter means mounted on said body for expansion laterally outward of said body; means for expanding and holding said cutter means laterally outward, said expanding and holding means comprising a mandrel connectible directly to a drill string and slidably splined to said body, whereby torque is transmittable from the drill string to said mandrel and from said mandrel to said body, said mandrel including a hydraulically operable portion movable downward of the body by the pressure of the fluid in the drill string; expander means on said hydraulically operable portion engaging said cutter means to expand said cutter means laterally outward upon movement of said hydraulically operable portion downwardly of said body; and holding means on said hydraulically operable portion above said expander means and engageable with said cutter means to prevent its retraction from its outwardly expanded position.

7. In a rotary well drilling bit: a main body; cutter means mounted on said body for expansion laterally outward of said body; means for expanding and holding said cutter means laterally outward, said expanding and holding means comprising a mandrel connectible directly to a drill string and slidably splined to said body, whereby torque is transmittable from the drill string to said mandrel and from said mandrel to said body, said mandrel including a hydraulically operable portion movable downward of the body by the pressure of the fluid in the drill string; expander means on said hydraulically operable portion engaging said cutter means to expand said cutter means laterally outward upon movement of said hydraulically operable portion downwardly of said body; and holding means on said hydraulically operable portion above said expander means and engageable with said cutter means to prevent its retraction from its outwardly expanded position; said mandrel including another portion movable downwardly of said body into a position adjacent and engageable with said hydraulically operable portion to prevent upward movement of said holding means from its position preventing retraction of said cutter means.

8. In a rotary well drilling bit: a main body; cutter means mounted on said body for expansion laterally outward of said body; a first member connectible to a drill string and slidably splined to said body; a second member

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telescoped with respect to said first member and having expander means thereon engageable with said cutter means; means on said second member responsive to fluid pressure in the drill string to move said second member and expander means downwardly relative to said body to cause said expander means to move said cutter means laterally outward; said first member being movable downwardly relative to said body into a position adapted to engage said second member to prevent elevation of said second member within said body from its downward position therewithin.

9. In a rotary well drilling bit: a main body; cutter means mounted on said body for expansion laterally outward of said body; a first member connectible to a drill string and slidably splined to said body; a second member telescoped with respect to said first member and having expander means thereon engageable with said cutter means; means on said second member responsive to fluid pressure in the drill string to move said second member and expander means downwardly relative to said body to cause said expander means to move said cutter means laterally outward; holding means on said second member above said expander means engageable with said cutter means to hold said cutter means in its expanded position; said first member being movable downwardly relative to said body into a position adapted to engage said second member to prevent elevation of said second member within said body from its downward position.

10. In a rotary well drilling bit: a main body; cutter means mounted on said body for expansion laterally outward of said body; a first member connectible to a drill string and slidably splined to said body; a second member telescoped with respect to said first member and having expander means thereon engageable with said cutter means; means on said second member responsive to fluid pressure in the drill string to move said second member and expander means downwardly relative to said body to cause said expander means to move said cutter means laterally outward; said first member being movable downwardly relative to said body into a position adapted to engage said second member to prevent elevation of said second member within said body from its downward position therewithin; and spring means engaging said second member to elevate said second member within said body to a position permitting retraction of said cutter means.

11. In a rotary well drilling bit: a main body; cutter means mounted on said body for expansion laterally outward of said body; a first member connectible to a drill string and slidably splined to said body; a second member telescoped with respect to said first member and having expander means thereon engageable with said cutter means; means on said second member responsive to fluid pressure in the drill string to move said second member and expander means downwardly relative to said body to cause said expander means to move said cutter means laterally outward; said first member being movable downwardly relative to said body into a position adapted to engage said second member to prevent elevation of said second member within said body from its downward position therewithin; and means on said first member engageable with said second member to elevate said second member within said body to a position permitting retraction of said cutter means.

12. In a rotary well drilling bit: a main body; cutter means mounted on said body for expansion laterally outward of said body; a first member connectible to a drill string and slidably splined to said body; a second member telescoped with respect to said first member and having expander means thereon engageable with said cutter means; means on said second member responsive to fluid pressure in the drill string to move said second member and expander means downwardly relative to said body to cause said expander means to move said cutter means laterally outward; said first member being movable downwardly relative to said body into a position adapted to

engage said second member to prevent elevation of said second member within said body from its downward position therewithin; spring means engaging said second member to elevate said second member within said body to a position permitting retraction of said cutter means; and means on said first member engageable with said second member to elevate said second member within said body to a position permitting retraction of said cutter means.

13. In a rotary well drilling bit: a main body; cutter means mounted on said body for expansion laterally outward of said body; a first member connectible to a drill string and slidably splined to said body; a second member telescoped with respect to said first member and having expander means thereon engageable with said cutter means; means on said second member responsive to fluid pressure in the drill string to move said second member and expander means downwardly relative to said body to cause said expander means to move said cutter means laterally outward; holding means on said second member

above said expander means engageable with said cutter means to hold said cutter means in its expanded position; said first member being movable downwardly relative to said body into a position adapted to engage said second member to prevent elevation of said second member within said body from its downward position; spring means engaging said second member to elevate said second member within said body to a position permitting retraction of said cutter means; and means on said first member engageable with said second member to elevate said second member within said body to a position permitting retraction of said cutter means.

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