March 13, 1951 A. W. KAMMERER 2,545,032

EXPANSIBLE ROTARY DRILL BIT

Filed July 29, 1946 2 Sheets-Sheet 1

Fig. 1.

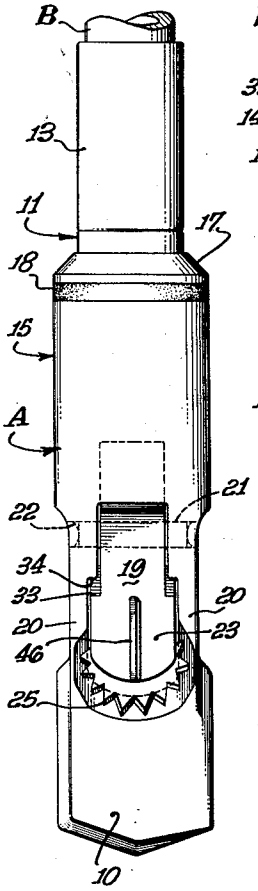


Fig. 2.

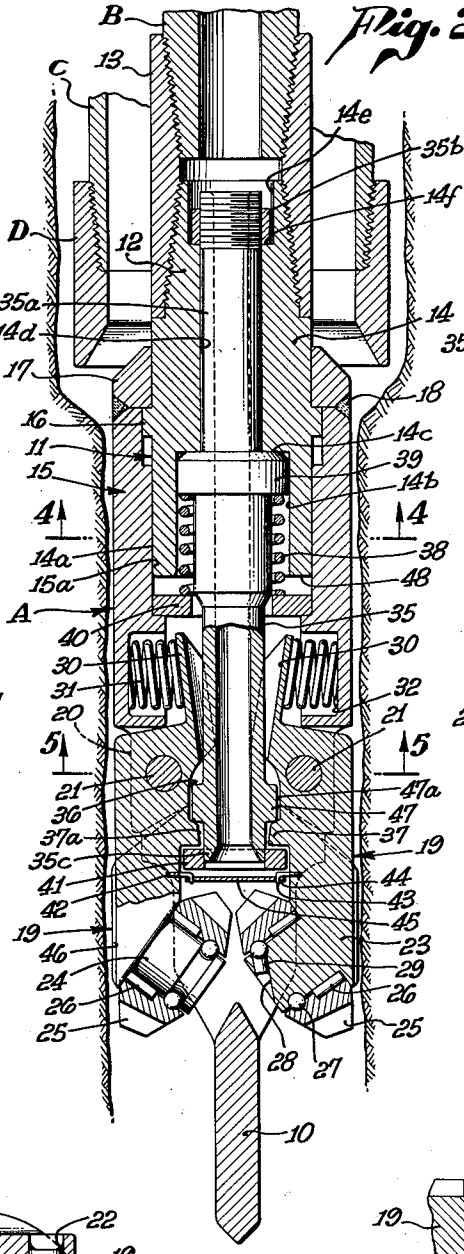


Fig. 4.

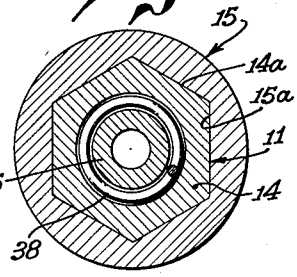


Fig. 6.

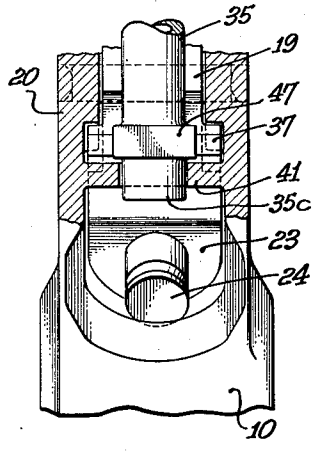


Fig. 5.

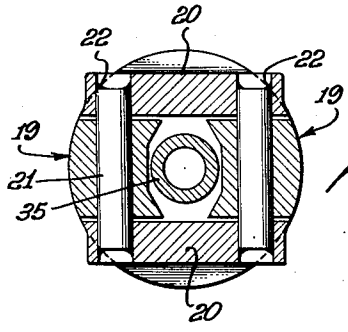
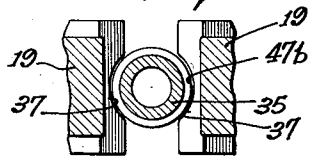


Fig. 8.



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Fig. 3.

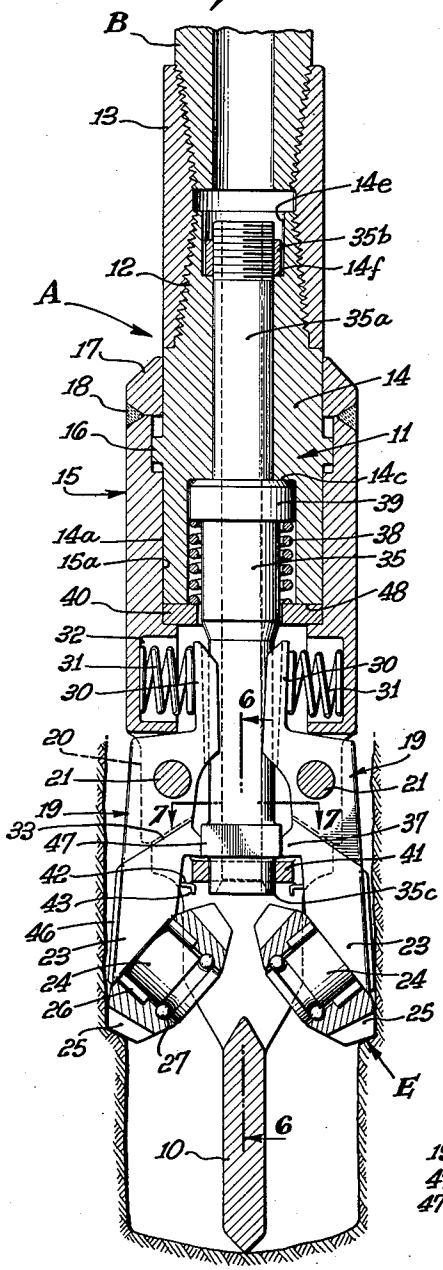


Fig. 9.

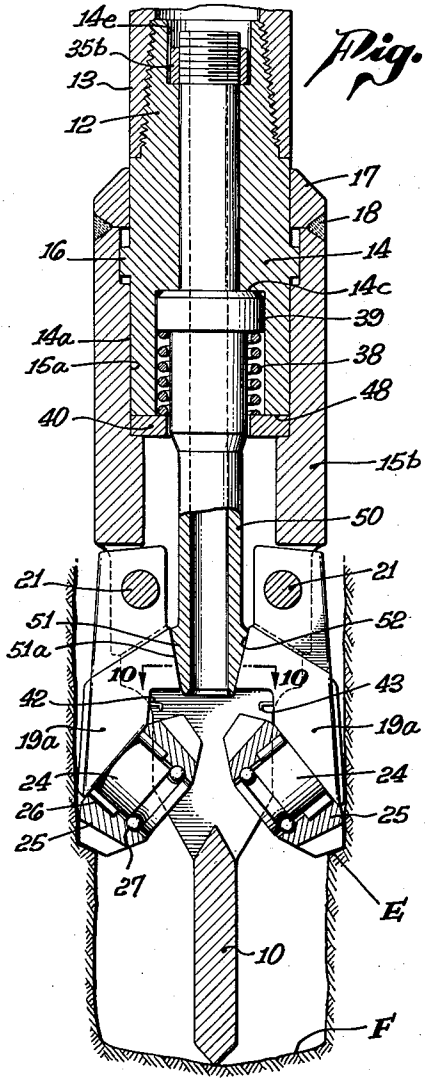


Fig. 7.

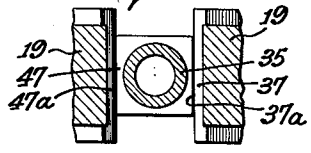
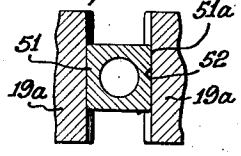


Fig. 10.



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2,545,032

UNITED STATES PATENT OFFICE

2,545,032

EXPANSIBLE ROTARY DRILL BIT

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Application July 29, 1946, Serial No. 686,806

4 Claims. (Cl. 255—71)

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This invention relates to drill bits, and more particularly to rotary bits of the expansible type for drilling or reaming holes below well casing greater in diameter than the inside diameter of the casing through which the bit is capable of passing.

This application is a continuation-in-part of my application for "Rotary Drill Bits," Serial No. 597,744, filed June 6, 1945, now Patent No. 2,466,991.

It is an object of the present invention to provide an expansible well drilling bit, whose cutters are expanded and held outwardly by mechanisms having increased wear resistance, wear distribution, and longer life; thus offering greater assurance against the drilling of an undersized hole, increasing the footage drillable by the bit, and decreasing the extent of maintenance and repair required on the drill bit following its removal from the well bore.

A further object of the invention is to obviate the necessity for transmitting drilling torque through the device which holds outwardly the cutters of an expansible rotary well drilling bit.

Another object of the invention is to provide an expansible well drilling bit embodying a device for holding bit cutters outwardly, which device is capable of automatically adjusting itself to furnish maximum effective contact surfaces between it and the cutter supports.

The invention has other objects which will become apparent from a consideration of the several embodiments shown in the drawings accompanying and constituting part of the present specification. These forms will now be described in detail to illustrate the general principles of the invention, but it is to be understood that such detailed description is not to be taken in a limited sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a side elevation of one form of drill bit embodying the invention;

Figure 2 is a longitudinal section of the drill bit on an enlarged scale, with parts shown in retracted position for lowering through the well bore;

Figure 3 is a view similar to Figure 2 with the parts shown in expanded position;

Figure 4 is a cross-section taken along the line 4—4 of Figure 2;

Figure 5 is a cross-section taken along the line 5—5 in Figure 2;

Figure 6 is a partial longitudinal section taken along the line 6—6 in Figure 3;

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Figure 7 is a partial cross-section taken along the line 7—7 in Figure 3;

Figure 8 is a view similar to Figure 7 of a modified form of lock device;

Figure 9 is a view similar to Figure 3 of a modified form of the invention; and

Figure 10 is a cross-section taken along the line 10—10 in Figure 9.

As shown in the drawings, the rotary drill bit A is attached to a string of drill pipe B, by means of which it is lowered through a well casing C in a well bore to a point below the casing shoe D at which enlargement of the bore hole is to commence. The drill bit preferably has a pilot bit 10 at its lower end for centering the bit in a hole that may have already been drilled, or for drilling the central portion of new hole in the absence of pre-existing hole. The main portion of the bit is capable of enlarging the bore hole by producing and operating upon a formation shoulder E, as hereinafter described.

The upper end of the bit consists of a driving mandrel 11, whose upper pin 12 is 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 disclosed in the drawings, the exterior 14a of the kelly is hexagonal in shape and is telescopically received in a companion hexagonal socket 15a within the body. The mandrel has a limited range of longitudinal movement within the body, its upward movement being limited by engagement of an external shoulder 16 on the kelly with a retainer ring 17 at the upper end of the body, suitably secured thereto as by welding material 18.

The body 15 has a plurality of expansible parts mounted on it, comprising opposed cutter supporting members 19, 19 pivotally carried between bifurcated body arms 20, 20 on pivot or hinge pins 21, 21 suitably secured to the arms, as by welding material 22. Each cutter supporting member consists of a depending leg 23, having a bearing supporting pin 24 inclined inwardly and downwardly and on which is rotatably mounted a roller side cutter 25. Anti-friction roller and ball bearing elements 26, 27 are preferably placed between each cutter 25 and bearing pin 24, the roller bearing 26 transmitting radial thrusts and the ball bearings 27 both radial and axial thrusts. The ball bearings 27 also retain the cutter on the pins, being inserted in place through a passage 28 in the bearing supports, which is then closed by a plug 29 welded to the pin.

Each cutter supporting member 19 also includes an upwardly extending arm 30 against which an elastic expander 31 bears. This expander in the form of a compressed coil spring is received within a retainer pocket 32 in the body 15 and exerts its force against the arm 30, tending to swing it inwardly and thus urge the cutter 25 on the other side of the fulcrum pin 21 in an outward direction. The extent of this outward movement is limited by engagement of stop shoulders 33, 33 on opposite sides of the cutter supporting members 19 with cooperable body stop shoulders 34, 34.

After the cutters 25 have been expanded outwardly by the expander springs 31 to the maximum extent, they can be locked in this position by a tubular member 35 of the mandrel 11, which is piloted in the kelly 14 and is provided with a lock portion 47, movable from an upper position in transverse alignment with inner supporting member recesses 36, permitting retraction of the cutters, to a lower position opposite lugs 37 formed on and projecting inwardly from the supporting member legs 23, preventing retraction of the cutters.

The tubular member 35 is connected in swivel fashion to the kelly 14 to permit relative arcuate or rotary movement therebetween. However, the kelly and tubular member are movable together for longitudinal movement in both directions. This is accomplished by providing a shoulder 39 on the tubular member, received within a lower socket 14b in the kelly and abutting a companion shoulder 14c in the kelly at the upper end of the socket. The tubular member 35 has an upper portion 35a extending from the shoulder freely through the central bore 14d of the kelly, with the upper terminus of the upper member 35a received within an enlarged recess 14e in the kelly or mandrel pin 12, where a nut 35b is threaded on the terminal portion and bears against the base 14f of the upper pin recess 14e.

The arrangement between the tubular member 35 and kelly 14 is such that downward movement is transmitted from the kelly to the tubular member through the abutting shoulders 14c, 39, while upward movement is transmitted to the tubular member through engagement of the recess shoulder 14f with the nut 35b. However, the nut 35b does not serve to clamp the tubular member 35 to the kelly 14, but allows relative rotary movement therebetween.

The mandrel 11 is normally held in its upper position with respect to the main body 15 of the bit and the supporting members 19 by a helical retractor spring 38 encircling the tubular member 35, with its upper end engaging the mandrel shoulder 39 and its lower end engaging a spring seat 40 at the lower end of the hexagonal body socket 15a. This spring seat 40 also serves as an upper bearing guide for the tubular mandrel member 35, whose lower end is slidable within a lower bearing guide 41 below the lugs 37, which is integral with or secured to the depending body arms 20 of the main body of the bit. The two guides 40, 41 form a spaced two-point support for the mandrel member 35 and assist it in resisting inward movement of the cutter legs 23 to retracted position during the reaming or cutting operation.

Circulating fluid can pass downwardly through the string of drill pipe B and through the tubular mandrel 11 for ejection from its lower discharge nozzle 35c and onto the cutters 25, to cleanse them of cuttings and flush the latter from the drilling area to the top of the well bore. This circulating fluid is also availed of to unlatch the cutter supporting members 19, in the event it is desired to hold them positively in retracted position.

A positive lock may be provided by securing a hook 42 to the inner portion of each cutter supporting member below the lower mandrel guide 41, and inserting the ends 43 of these hooks in holes 44 in a strip 45 extending across the outlet 35c of the mandrel. The cutting tool A, after being lowered in retracted position to the point at which the reaming operation is to begin, may be released for operation by starting the pumps at the surface of the well bore, which will force fluid down through the drill string B and mandrel 11 and impinge upon the latch strip 45, blowing or forcing it off the hook ends 43 and permitting the spring expanders 31 to shift the supporting arms 30 inwardly and the cutters 25 outwardly against the formation.

In the operation of the device the tool A is mounted on the lower end of the drill string B with its parts held in retracted position by the latch strip 45, as shown in Figure 2. In this position of operation, the compressed retractor spring 38 holds the mandrel 11 and its kelly 14 in an upward position with respect to the body 15, as determined by engagement of the kelly shoulder 16 with the body retainer ring 17. With the mandrel in this position, its lock portion 47 is elevated above the lugs 37 on the cutter supporting members 19, being received within the inner recesses 36 in the supporting members, which permits the latter to be held inwardly against the action of the expander springs 31. The tool is lowered through the well casing C, and upon reaching the position in the well bore below the casing shoe D, at which the drilling operation is to begin, the pumps are started at the surface of the well bore and fluid impinged on the latch strip 45, forcing it hydraulically off the ends 43 of the hooks 42 and releasing the cutting supporting members 19 for outward expansion under the influence of the springs 31.

The drill string B is then rotated to rotate the main bit body 15 through the splined kelly and body connection 14a, 15a, the expander springs 31 forcing the arms 30 inwardly and the cutters 25 outwardly against the formation. Rotation is continued without moving the drill string longitudinally until the side cutters 25 enlarge the diameter of the hole to the maximum extent, as determined by the eventual abutting of the supporting member stop shoulders 33 with the companion body stop shoulders 34. Thereafter, the drill string is lowered to cause the formation shoulder E, produced in the well bore by the cutters 25 under the action of the expander springs 31, to support the cutter members 25, 19 and body 15 and prevent their downward movement.

Since the body 15 cannot move downwardly, drilling weight imposed on the drilling string B shifts its connected mandrel 11 downwardly within the body 15 against the action of the retractor spring 38 until the lower end 48 of the kelly 14 engages the upper spring seat and guide 40. This downward movement also shifts the tubular member 35 downwardly, because of the abutting between the kelly and tubular member shoulders 14c, 39, to position the mandrel or tubular member lock portion 47 opposite and in alignment with the lugs 37 on the inner portions of the cutter supporting members 19, providing a posi-

tive lock by preventing inward movement of the cutters. So long as down weight is imposed on the drill string B and the cutters 25 rest on the formation shoulder E, the cutters are prevented from moving inwardly by engagement of their lugs 37 with the mandrel lock portion 47. It is also to be noted that further outward movement of the cutters beyond the predetermined maximum reaming diameter is prevented by contact between the supporting member shoulders 33 and the body shoulders 34, through which the drilling weight is transmitted to the roller cutters 25, thus relieving the hinge pins 21 of this load.

Drilling is continued by rotating the drill bit and imposing the proper drilling weight on the cutters to cause their removal of the formation material and reaming of the hole in a downward direction for the desired extent or length. When the drill bit is to be retracted and removed to the top of the well bore, all that need be done is elevate the drill string B, which moves the side cutters 25 above the formation shoulder E, and permits the retractor spring 38 to press downwardly on the body 15 and move it, together with the cutter supporting members 19, downwardly with respect to the mandrel 11. This action repositions the mandrel lock portion 47 opposite the supporting member recesses 36 and above their lugs 37, because of the engagement between the pin recess shoulder 14f and tubular member nut 35b, permitting inward swinging of the cutters 25 and their supporting members 19 when the tool passes back into the casing C upon elevation of the drill string. The cutters 25 and their supporting members 19 will ride the wall of the casing C during elevation of the string until the tool is removed from the top of the well bore.

Pads in the form of longitudinal drag reaming blades 46 can be formed at the lower outer surfaces of the cutter supporting members 19, which will ride the inner wall of the casing and prevent the cutter teeth from hanging up in the casing coupling spaces while the tool is being lowered therein. These pads 46 can be provided in addition to the hooks 42 and latch strip 45, or in place of the latter. When the latching device is used the tool can be lowered through open hole below the casing shoe D to as far a distance as desired before the reaming operation commences. If the latch is not provided downward movement of the drill string D can be stopped when the bit passes out of the shoe D and the drill pipe B and bit A rotated to allow the cutters 25 to produce the formation shoulder E under the influence of the compressed expander springs 31. Drilling in a downward direction can then proceed, as aforementioned, with the drill string B and mandrel 11 lowered against the action of the retractor spring 38 to position the lock portion 47 opposite the lugs 37 and prevent inward movement of the cutters until the drilling weight is removed from the drilling tool.

The lock portion 47 of the tubular member preferably has flat faces 47a engaging corresponding flat faces 37a on the lugs 37 extending inwardly from the cutter supporting members. These flat faces are preferred to present a surface contact between the members, and thus increase the load carrying capacity of the lock device, enabling it to resist to a greater extent the ractive force of the formation tending to press the cutters 25 inwardly from their expanded positions. The remaining portions of the tubular

member 35, namely, the shoulder 39, the upper section 35a above the shoulder, and the portions which ride in the upper and lower bearing guides 40, 41 are all circular in cross-section to permit relative rotation, even to a slight extent, between the tubular member 35 and the kelly 14 within which it is received.

The relative rotation of the tubular member 35 and its locking portion 47 with respect to the driving kelly 14 is important, since it permits the lock portion 47 to adjust itself with respect to the lugs 37 on the cutter supports 19 and thus insures a surface contact therebetween. There is a slight play of the supporting members 19 on their hinge pins 21, permitting a slight angular adjustment of the supporting member about a longitudinal axis with respect to the expander portion 47. In the event that an error has been made in the mounting of the pin 21 in the body 15, the supporting member 19 may pivot slightly above the longitudinal axis, and this pivoting action, coupled with the swivel arrangement of the tubular member 35 and lock portion 47 with respect to the kelly 14 (which permits the tubular member 35 to rock or move about the body axis), offers assurance that the contact between the lock portion 47, 47a and the lugs 37, 37a will be a surface contact.

The inability of the tubular member 35 to swivel or move about the bit axis might merely result in a line contact between the cutter lugs 37 and the lock portion 47 of the tubular member, thus producing concentrated wear along both of these parts during their resistance to the formation reactive forces tending to press the cutters 25 inwardly from their retracted positions. Such wear would permit the cutters to shift inwardly, and would result in the production of a reamed hole of lesser diameter than the diameter desired.

There is still a further advantage to the swivel or relatively oscillatable connection between the tubular lock member 35 and the driving kelly 14. Although the kelly is telescopically splined to the body 15, a slight amount of relative arcuate movement between them is permitted, because of the working clearances that must be maintained between the hexagonal kelly 14a and hexagonal socket 15a in the body. The rigid attachment of the tubular lock member 35 to the kelly 14 would result in angularly moving the lock portion 47 with respect to the cutter supports 19 during the drilling operation and would result in line contact between the lock portion 47 and lugs 37, rather than the desirable surface contact. The swivel connection prevents the transmission of such relative angular movement of the kelly 14 with respect to the body 15 to the tubular member 35, since the latter is free and is unaffected by the turning movement of the kelly. The drilling torque transmitted through the driving kelly 14 to the body 15 need not pass through the tubular member 35 and its locking portion 47 onto the supporting members 19.

While it is preferred to employ a surface contact 47a, 37a between the lock portion 47 and the cutter supporting member lugs 37, because of their greater load transmitting capacity, the swivel or oscillatable arrangement between the tubular lock member 35 and driving kelly 14 also offers an advantage in connection with a lock ring of circular cross-section, such as disclosed in my above-referred to patent application. The swivel connection enables the lock ring 47b to rotate during use of the device, and distributes the wear

uniformly around the ring. This arrangement is disclosed in the modification shown in Figure 8. A surface contact may be provided between the circular cross-section ring 47*b*, since the lugs 37 may also be provided with an arcuate shape of substantially the same radius as the lock ring. Rotation of the ring 47*b* within the body would enhance the life of the lock portion of the tubular mandrel 35 materially, by distributing the wear around the entire ring circumference.

Another embodiment of the invention is disclosed in Figure 9, in which the same type of swivel connection between the driving kelly 14 and tubular member 50 is disclosed. However, in this modification, elastic or spring means are not employed for initially expanding the cutters 25 outwardly, with the tubular mandrel only being used as a locking device to prevent inward movement of the cutters after they have been expanded outwardly. As shown in Figure 9, the cutters 25 are arranged on their supporting members 19*a* in substantially the same manner as in the other form of the invention. A downwardly and inwardly tapered expander 51 is provided on the bottom end of the tubular member 50 for cooperation with correspondingly tapered surfaces 52 on the inner portions of the supporting members 19*a*.

The cutters 25 may be held in an inward position initially by a latch strip 45, in the same manner as the other arrangements, and upon the drilling tool being lowered on the string of drill pipe B to the bottom F of the well bore, and with the pilot bit 10 resting on the hole bottom, the pumps may be started at the surface of the well bore to cause the fluid exhausting from the tubular member 50 to blow the latch strip off the hook ends 43 of the latch device. Then the tool is rotated and drilling weight imposed downwardly on the drill pipe B and kelly 14 to rotate the body 15*b* and cutters 25 around the axis of the bore. During such rotation the kelly 14 is gradually fed downwardly and the tubular member 50 with its tapered expander 51 is also forced downwardly, because of the abutting shoulders 14*c*, 39, to drive the tapered expander or wedge 51 down along the tapered surfaces 52 of the supporting members 19*a*, urging them gradually outwardly until the lower end 48 of the kelly engages the guide washer 40, which limits the extent of downward movement of the tubular member and expander. Rotary movement may be continued and the proper drilling weight imposed in order to enlarge the hole being drilled by the pilot bit 10 to the required diameter.

The tapered expander 51 may have flat faces 51*a* to cooperate with corresponding flat or tapered faces 52 on the supporting members 19*a*, offering a large bearing surface resisting inward movement of the cutters 25, or, if desired, the cross-section of the expander 51 may be circular. In any event, the swivel arrangement between the expander and lock device 50 and the driving kelly 14 enables an automatic adjustment to take place, insuring most effective bearing contact between the expander 51 and its cooperable supporting members 19*a*. The necessity for transmitting any drilling torque through the tapered expander 51 and through the supporting members 19*a* for the cutters is also obviated, which, as mentioned above, would disrupt the bearing arrangement between the parts indicated.

In the modification disclosed in Figure 9, elevation of the drill string B to remove the drilling

weight immediately allows the retractor spring 38 to shift the body 15*b* of the tool downwardly with respect to the expander 51, elevating the expander 51 with respect to the supporting members 19*a*, and permitting inward retraction of the cutters 25 during upward movement of the well tool through the well casing.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A rotary well drilling bit, including a body, cutter means mounted on said body for lateral expansion with respect to said body, elastic means engaging said cutter means for expanding said cutter means laterally outward, a lock device movable in one longitudinal direction along said body to a position preventing inward movement of said cutter means from its outwardly expanded position, said lock device comprising a first member splined to said body and a second member rotatable within said first member and engageable with said cutter means, and relatively rotatable abutments carried by said members mounting said second member with respect to said first member.

2. A rotary well drilling bit, including a body, cutter means mounted on said body for lateral expansion with respect to said body, elastic means engaging said cutter means for expanding said cutter means laterally outward, a lock device movable in one longitudinal direction along said body to a position preventing inward movement of said cutter means from its outwardly expanded position, said lock device comprising a one-piece first member splined to said body and a second member rotatably supported within said first member and engageable with said cutter means, said members having opposed engaging surfaces defining supporting means within said first member.

3. A rotary well drilling bit, including a body, cutter means mounted on said body, means engageable with said cutter means for expanding and holding said cutter means laterally outward, comprising a first member connectable to a drill string and slidably splined to said body, a second member rotatable within said first member and engageable with said cutter means for holding said cutter means laterally outward, said second member extending through said first member from its point of connection with the drill string, means on said second member at said point of connection with said drill string in abutting contact with said first member for preventing substantial relative longitudinal movement between said members in one direction while permitting relative rotation therebetween, and means on one of said members coengaging with means on the other of said members preventing substantial relative longitudinal movement between said members in the opposite direction whole permitting relative rotation therebetween.

4. A rotary well drilling bit, including a body, cutter means mounted on said body for lateral expansion with respect to said body, means for expanding and holding said cutter means laterally outward, comprising a one-piece first member connectible to a drill string and slidably splined to said body, a second member piloted within said first member and engageable with said cutter means along a substantial surface of contact for holding said cutter means laterally outward, said members having laterally disposed relatively movable portions in contacting relationship swivelly connecting said members together, and spring means between said body and

the second of said members for shifting said second member to a position permitting retraction of said cutter means with respect to said body.

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