

Nov. 26, 1957

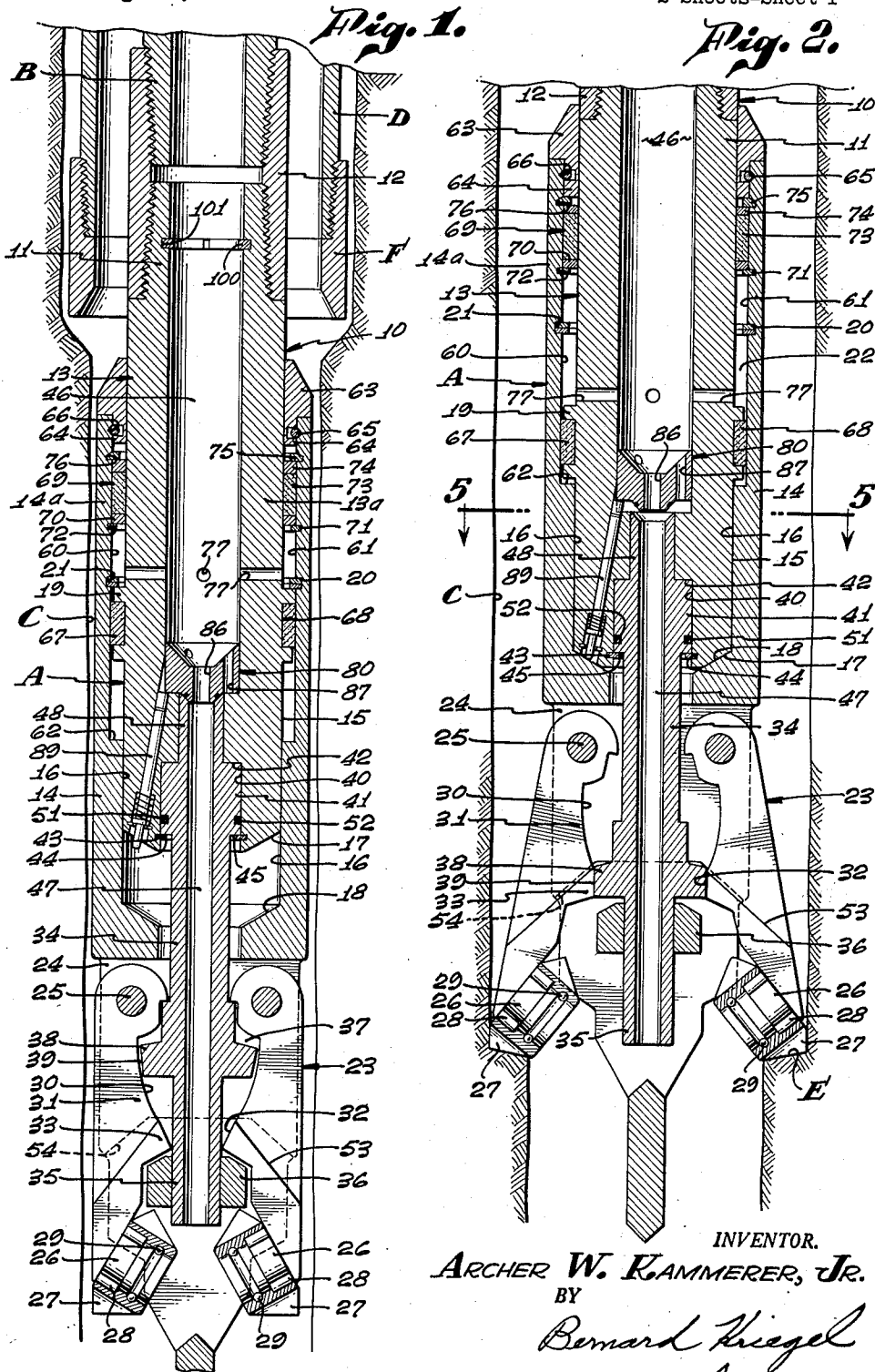
A. W. KAMMERER, JR

2,814,463

EXPANSIBLE DRILL BIT WITH INDICATOR

Filed Aug. 25, 1954

2 Sheets-Sheet 1



Nov. 26, 1957

A. W. KAMMERER, JR

2,814,463

EXPANSIBLE DRILL BIT WITH INDICATOR

Filed Aug. 25, 1954

2 Sheets-Sheet 2

Fig. 3.

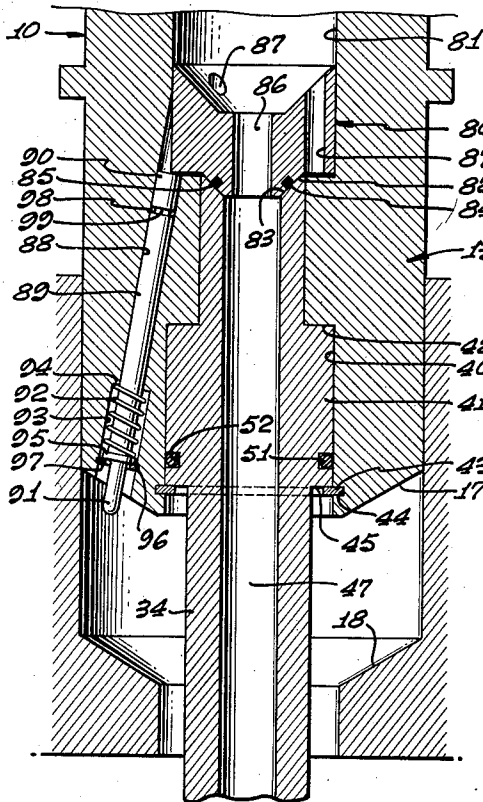


Fig. 4.

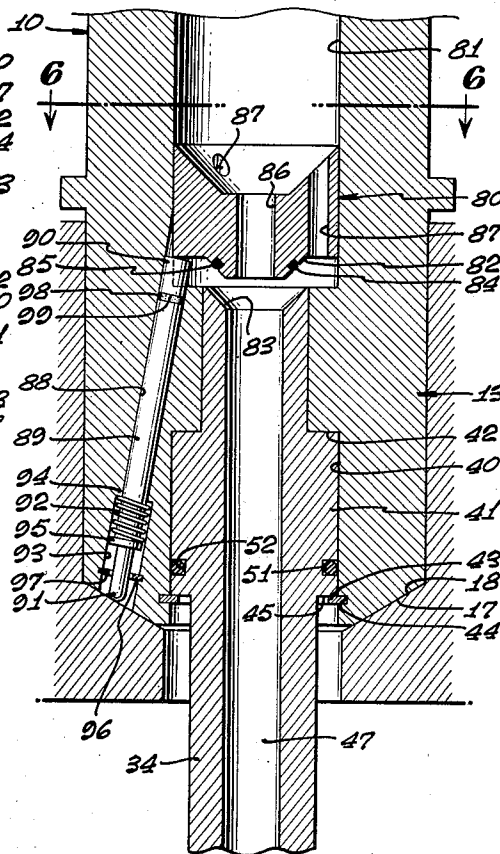


Fig. 5.

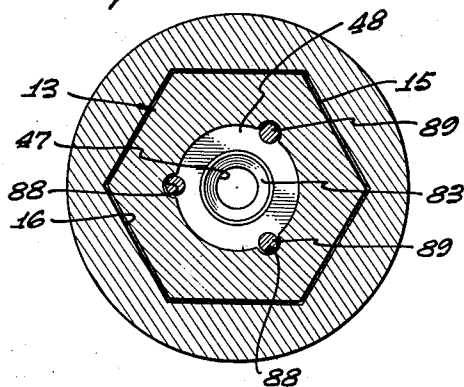
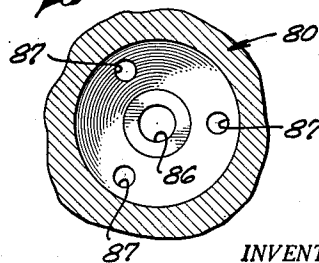


Fig. 6.



INVENTOR.
ARCHER W. KAMMERER, JR.
 BY
Bernard Krieger
 ATTORNEY.

1

2,814,463

EXPANSIBLE DRILL BIT WITH INDICATOR

Archer W. Kammerer, Jr., Fullerton, Calif., assignor, by direct and mesne assignments, to Rotary Oil Tool Company, Huntington Park, Calif., a corporation of California

Application August 25, 1954, Serial No. 452,185

18 Claims. (Cl. 255—76)

The present invention relates to rotary drill bits of the expansible type, which are capable of being run through strings of well casing, and of drilling or enlarging bore holes below the casing to a greater diameter than the inside diameter of the casing.

Rotary drill bits of the above-identified type have cutters which are initially retracted during lowering of the bit through the well casing, the cutters being expanded outwardly after the bit has been located below the casing. Usually, the drill bit is merely rotated until its cutters have been expanded outwardly, to form an annular shoulder in the wall of the bore hole, after which drilling weight is imposed on the bit and the latter progressively lowered as the drilling operation proceeds, to enlarge the hole along the required length.

Heretofore, the operator had no assurance or indication that the cutters were expanded outwardly to their maximum extent before imposing drilling weight on the rotary bit. As a result, an undersized hole would be produced in the event the cutters were not fully expanded. Moreover, in relatively soft formations, the drill bit might not drill or ream a cylindrical hole. Instead, the cutters would produce rifling grooves in the side wall of the hole.

When using expansible drill bits for enlarging bore holes drilled through relatively hard formations, a comparatively large force is required to expand the cutters outwardly to their maximum extent against the resistance offered by the hard formation. Certain types of expansible drill bits pump drilling fluid down the drill pipe and through the bit, the flow through the bit being restricted to produce a back pressure operable to expand the cutters outwardly. The restriction to fluid flow through the bit cannot be too great in view of the necessity for pumping adequate drilling fluid through the bit to flush the cuttings from the drilling zone and carry them to the top of the hole. As a result, the back pressure that can be built up is limited, correspondingly limiting the expansion force imposed on the cutters and available to penetrate the latter into hard formations.

Accordingly, it is an object of the present invention to provide an expansible drill bit which gives a sensible indication to the operator that the bit cutters have been expanded outwardly to substantially their fullest extent. By virtue of such indication, the operator is assured that a full annular shoulder has been produced in the formation on which the cutters can operate.

Another object of the invention is to provide a subsurface bore hole tool having initially retracted parts that are to be expanded outward, in which outward expansion of the parts to substantially their fullest extent provides an indication to the operator at the top of the hole of that fact.

A further object of the invention is to provide a rotary expansible drill bit, in which the cutters can be expanded hydraulically outwardly with greater hydraulic force imposed thereon, while providing for adequate circulation of drilling fluid through the drill bit during the drilling

2

operation to insure the proper flushing of formation cuttings from the region of drilling to the top of the bore hole.

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 and retracted positions;

Fig. 2 is a longitudinal section, similar to Fig. 1, disclosing the cutters locked in their fully expanded positions;

Fig. 3 is an enlarged fragmentary section disclosing a portion of the apparatus, with the parts occupying the same positions as shown in Fig. 1;

Fig. 4 is a view similar to Fig. 3, with the parts occupying the same positions as shown in Fig. 2;

Fig. 5 is a cross-section taken along the line 5—5 on Fig. 2;

Fig. 6 is a cross-section taken along the line 6—6 on Fig. 4.

The form of invention shown in the drawings includes a rotary expansible drill bit A, which can be secured to the lower end of the string of drill pipe B extending to the top of the well bore C, and by means of which the drill bit is lowered through a string of well casing D to a region below its casing shoe, where the hole enlarging operation is to commence. The general type of expansible drill bit shown in the drawings is both illustrated and described in Patent No. 2,545,036, to which attention is invited for certain structural details that are not disclosed nor described herein in detail.

The upper portion of the rotary drill bit consists of a mandrel 10 having an upper pin 11 threadedly connected to a sub 12 forming the lower end of the string of drill pipe B. This mandrel includes an upper kelly or drill stem member 13 slidably splined to the main body 14 of the drill bit. The exterior 15 of the power portion of the kelly is non-circular or hexagonal in shape, being telescopically received in a companion non-circular or hexagonal socket 16 formed in the main bit body 14. The hexagonal kelly exterior 15 and companion socket 16 form a slidable connection between these parts, enabling the kelly 13 to be moved longitudinally with respect to the body 14, while being capable of transmitting rotary movement to the body.

The mandrel 10 has a limited range of longitudinal movement within the body 14, its downward movement being determined by engagement of the lower end 17 of the kelly with an inwardly directed body shoulder 18, and its upward movement being limited by engagement of an external shoulder or piston portion 19 of the kelly, fitting within a counterbore 60 in the body of the tool above its hexagonal socket 16, with one or more stop rings 20 that may be of the split type. These stop rings are inserted within an internal groove 21 in the upper portion 14a of the main body of the bit, the stop rings extending into a confined cylindrical space 22 formed between the kelly or drill stem 13 and the body 14 of the tool.

The tool body 14 has a plurality of expansible parts mounted on it. These include cutter supporting members 23 pivotally mounted in body slots 24 on hinge pins

25 suitably secured to the body. Each cutter supporting member 23 depends from a hinge pin 25, terminating in a bearing supporting pin 26 inclined inwardly and downwardly. A side roller cutter 27 is rotably mounted on each bearing supporting pin 26, being mounted on anti-friction roller and ball bearing elements 28, 29 rollable on the bearing supporting pin. The ball bearing elements 29 lock the cutter 27 against endwise movement on the bearing supporting pin 26, as well as transmitting axial and radial thrusts between the cutter and supporting pin. The roller bearing elements 28 transmit primarily radial thrusts between these parts. The manner of mounting the ball and roller bearing elements 29, 28 between the cutter 27 and bearing supporting pin 26, and of retaining them in place, is specifically described in the above-mentioned Patent 2,545,036.

The cutter supporting members 23 and the cutters 27 mounted thereon tend to occupy a retracted position substantially and entirely within the confines of the main body 14 of the bit. These cutter supporting members and cutters are expandible outwardly, to enlarge the size of the well bore C and to operate upon a formation shoulder E that the cutters produce in the latter. To accomplish the expansion, each cutter supporting member 23 has an inclined expander surface 30 on its inner portion 31 below the hinge pin 25 which tapers in a downward and inward direction. Each expander surface 30 terminates in a lock surface 32 formed on a lock portion 33 of the cutter supporting member. The outward expansion is accomplished by producing relative longitudinal movement between the mandrel 10 and the bit body 14, which will produce corresponding relative longitudinal movement between the cutter supporting members 23 and the tubular member 34 of the mandrel. This tubular member 34 includes a lower portion 35 slidable within a guide 36 secured to the body 14 and extending across the slotted region of the body below the lock portions 33.

Located initially substantially above the guide 36 and below the hinge pin 25 and in cutter member recesses 37 is a mandrel lock and expander 38 having outer surfaces 39 adapted to engage the expander surfaces 30 and the lock surfaces 32. The lock and expander 38 may be formed integrally with the tubular member 34, the upper end of the latter being piloted within a socket 40 in the lower portion of the kelly 13. An enlarged boss 41 on the tubular member engages a downwardly facing shoulder 42 of the kelly, the tubular member being held against this shoulder by a suitable split retainer or lock ring 43 snapped into an internal groove 44 encompassing the kelly socket 40 and engaging a downwardly directed shoulder 45 formed on the tubular member boss 41. Leakage between the boss 41 and the wall of the kelly socket is prevented by a suitable side seal 51, in the form of a rubber O ring, disposed within a groove 52 in the boss and engaging the wall of the socket 40.

The kelly 13 has a central fluid passage 46 therethrough communicating with the string of drill pipe B. Fluid pumped through this passage 46 can pass into an aligned central passage 47 in the tubular member 34, whereby drilling mud or similar drilling fluid can be pumped down through the tool for the purpose of removing the cuttings from the well bore C and flush them upwardly around the drill pipe B to the top of the hole.

Assuming that the body 14 of the tool is elevated relatively along the tubular mandrel 10, the inclined expander surfaces 30 of the cutter supporting members 23 will be shifted upwardly along the lock and expander portion 38 of the tubular member. During such upward shifting, the cutter supporting members 23, and the cutters 27 carried thereby, may be pivoted about the hinge pins 25 and urged in an outward direction. The

movement of the body 14 with respect to the tubular mandrel 10 can continue until the cutters 27 have been shifted outwardly to their fullest extent, as determined by engagement of stop shoulders 53 on the cutter supporting members with companion shoulders 54 formed in the body on opposite sides of each body slot 24. When such engagement occurs, the lower end 17 of the kelly portion of the tubular mandrel 10 will engage the body shoulder 18, and the lock and expander 38 on the tubular member 34 will be disposed behind and in engagement with the lock portions 33 on the cutter supporting members 23.

It is to be noted that the surfaces 32 of the lock portions on the cutter supporting members 23 and the companion surfaces 39 on the lock and expander portion 38 of the tubular member are substantially parallel to the axis of the drill bit, to prevent the reactive forces of the formation on the cutters 27 from moving the latter inwardly. As a practical matter, it is preferred that the coengaging lock surfaces 32, 39 be inclined slightly in a downward direction toward the axis of the tool, to insure release of the lock and expander portion 38 from the cutter supporting members 23 when the latter and the cutters 27 are to be shifted back to their retracted positions.

The relative longitudinal movement between the tubular mandrel 10 and the body 14 of the tool, for effecting outward expansion of the cutters 27, is accomplished hydraulically. The counterbore 60 receiving the piston 19 of the drill stem member 13 is formed in the upper portion 14a of the body, which actually constitutes a cylinder having a cylindrical wall 61 extending from a lower shoulder 62, defining the bottom of the counterbore 60, to an upper head and guide 63 which had a depending portion 64 inserted in the upper end of the cylinder 14a and releasably retained therein by a split snap ring 65 carried in a groove in the cylinder head portion 64 and adapted to be received within a generally V-shaped internal groove 66 in the upper portion of the cylinder wall. The head 63, with the snap ring 65 mounted in its groove, need merely be forced into the cylinder 14a, and, when located opposite the V-shaped groove 66, the snap ring will expand inherently partially into the latter, to releasably lock the cylinder head 63 to the cylinder 14a.

The confined cylinder space 22 is formed between the piston portion 19 of the kelly 13, the periphery of the kelly above the piston, and the cylinder 14a. To provide this space, a suitable packing or side seal structure 67 is disposed in a suitable piston ring groove 68 formed in the piston, which is adapted to slidably seal against the cylindrical wall 61 of the cylinder 14a. Fluid is thereby prevented from passing in a downward direction between the piston 19 and the cylinder 14a. Similarly, fluid is prevented from passing in an upward direction out of the annular cylinder space 22 by a cylindrical packing or sealing structure 69 secured to the cylinder 14a and slidably engaging the periphery of the kelly 13. This structure may take any suitable form. As shown, it consists of a lower packing supporting ring 70 resting upon a split retainer ring 71 located within an internal groove 72 in the cylinder 14a. A non-metallic packing 73 of any suitable material, rests upon the ring 70, its upper end engaging an upper packing ring 74 bearing against a split retainer ring 75 received within an internal groove 76 in the cylinder 14a. The upper and lower split rings 75, 71 prevent substantial movement of the packing structure with respect to the bit body cylinder 14a, the non-metallic packing portion 73 of the sealing structure 69 engaging the cylinder wall 61 to prevent leakage therealong and also slidably sealing against the periphery of the drill stem portion 13 of the tubular mandrel 10.

Fluid under pressure in the string of drill pipe B and

5

within the tubular mandrel 10 can be fed into the cylinder space 22 through one or more side ports 77 extending through the tubular mandrel immediately above the piston portion 19 and establishing communication between the central passage 46 through the kelly 13 and the cylinder space. Such fluid under pressure can be developed by restricting the passage 47 through the mandrel below the port 77, to enable a back pressure to be built up in the kelly portion 13 of the mandrel, which pressure will be imposed on the fluid in the cylinder space 22 acting upon the packing structure 69, to urge the body 14 of the tool in an upward direction with respect to the tubular mandrel 10, and correspondingly elevate the cutter supporting members 23 and cutters 27 with respect to the lock and expander portion 38 of the tubular member 34 and expand the cutters 27 to their fullest extent.

As disclosed in the drawings, the restriction in the fluid flow through the tubular member 34, to build up the above-described back pressure, can be accomplished by providing the passage 47 through the tubular member 34 with a substantially lesser diameter than the diameter of the passage 46 through the kelly portion 13 of the mandrel thereabove. In the present instance, the back pressure that can be developed is further increased by the provision of an indicator valve or flow restricting member 80 in the tubular mandrel 10.

As disclosed, this indicator valve 80 is adapted to slide along the wall 81 of the kelly passage 46, having a lower downwardly tapering portion 82 adapted to engage and seal against a companion downwardly tapering portion 83 formed at the upper end of the tubular member 34. When such engagement occurs, leakage along the tapered surfaces is prevented by a suitable annular gasket 84 provided in a groove 85 in the tapered portion 82 of the indicator member, which sealingly engages against the tapered surface 83 of the tubular member.

The flow restricting member 80 has a central orifice or passage 86 therethrough, that is of substantially less diameter and area than the passage 47 through the tubular member 34, and, of course, much less than the area through the kelly passage 46. When the flow restricting member 80 sealingly engages the tubular member 34, a much greater back pressure can be built up in the kelly 13, this pressure being imposed on the fluid in the ports 77 and the cylinder space 22 to exert a greater relative lifting force on the body 14 of the tool and on the cutter supporting members 23 and exert a much greater outward expansion force on the cutters 27, forcing them into the wall of the formation, to insure the cutting of the proper shoulder E in the formation during rotation of the drill pipe B, the tubular mandrel 10 and the body 14 of the tool.

The relatively small size orifice or passage 86 through the flow restricting member 80 is effective in securing a great outward expansive force on the cutters 27 during their expansion to their maximum extent. Thereafter, it is desired that the flow of fluid through the tool A not be restricted to as great an extent. Accordingly, after the cutters 27 have been expanded outwardly to their maximum extent, it is desired to allow a greater flow of fluid down through the tubular member 34, for discharge through the lower end of the latter. Accordingly, provision is made for elevating the flow restricting member or valve 80 above its companion seat 83, to allow fluid to flow through the central orifice 86 and also through additional or by-pass passages 87 extending longitudinally through the flow restricting member and arcuately spaced from one another circumferentially around the latter. It is evident that the elevation of the flow restricting member 80 above its companion seat 83 will allow fluid to flow through the orifice 86 and also through the by-pass flow passages 87 as well. Such flow of fluid through a combined passage area that is much greater than the area through the central orifice 86 alone will result in a drop in the back pressure in the kelly passage 46, as well

6

as in the drill pipe B for the same volumetric rate of flow of fluid through the apparatus.

The elevation of the flow restricting member 80 is accomplished when the cutters 27 have been expanded outwardly to substantially their maximum extent. Such elevation will not only provide for the flow of a greater quantity of circulating fluid through the tool, but it will also provide an indication to the operator at the top of the hole that the cutters have been expanded outwardly to substantially their maximum extent.

The foregoing purposes are accomplished in the apparatus disclosed in the drawings by providing one or more longitudinal bores 88 through the kelly portion 13 of the mandrel and extending from its lower end 17 into the passage 46 through the kelly at the location of the flow restricting member 80. An actuating rod 89 is slidably mounted in each bore 88, this rod extending from the upper end of the bore 88 and initially projecting to a predetermined extent out of the bore below the lower end 17 of the kelly portion 13 of the tubular mandrel 10. The rod 89 is urged and retained initially in a position in which its upper end 90 is disposed at the lower end of the kelly passage 46, its lower end 91 projecting partly below the lower end 17 of the kelly, by a helical spring 92 located in a lower counterbore 93. The upper end of the spring engages a shoulder 94 at the upper end of the counterbore 93, its lower end engaging a flange 95 formed on the rod 89. The extent of downward movement of each rod 89 within the bore 88 is limited by engagement of the rod flange 95 with a stop ring 96, in the form of a split retainer ring, received within a groove 97 in the kelly surrounding the counterbore 93. Leakage of fluid along the rod 89 is prevented by a suitable seal ring 98 in a rod groove 99 slidably and sealingly engaging the wall of the bore 88.

The springs 92 normally retain the rods 89 in their downward position, which will allow the flow restricting member 80 to shift downwardly into sealing engagement with the upper tapered end 83 of the tubular member 34. When the body 14 of the tool has been elevated to its fullest extent with respect to the tubular mandrel 10, the lower end 17 of the kelly will engage the body shoulder 18. Just prior to such engagement, the lower end 91 of each rod 89 will engage the body shoulder 18 and the rod will be shifted upwardly within the kelly bore 88, to engage and shift the flow restricting member 80 in an upward direction a substantial distance above its companion seat 83. Such action will allow fluid to flow through the central orifice 86 in the flow restricting member, as well as through the by-pass passages 87 provided therein around the flow restricting orifice. The drop in pressure at the top of the well bore will advise the operator (who need merely observe the indications on a pressure gauge) that the cutters 27 have been expanded outwardly to the maximum extent, inasmuch as the flow restricting member 80 is elevated from its seat 83 only as a result of the cutters 27 having been shifted outwardly substantially to their maximum condition.

The rotary expansible drill bit A shown in the drawings is lowered through the well casing D by means of the string of drill pipe B, with the cutter supporting members 23 and the cutters 27 in their initial retracted positions, and with the rods 89 in their lower positions, the lower ends 91 of the latter projecting downwardly a predetermined distance below the lower end 17 of the kelly 13 (Figs. 1 and 3). The flow restricting and indicating member 80 may shift upwardly in the kelly passage 46 during lowering of the tool through the well casing, but the extent of its shifting is limited by its engaging a split stop ring 100 provided in a groove 101 in the kelly 13 at its pin end 11. The drill pipe B can automatically fill with the fluid in the well casing D and well bore C by flowing upwardly through the tubular member passage 47 into the kelly passage 46, and through the flow re-

stricting orifice 86 and by-pass passages 87, into the drill pipe thereabove.

When the apparatus has been lowered in a well bore below the casing shoe F, the pumps at the top of the well bore are started, to pump fluid down through the drill pipe B. This fluid will shift the flow restricting member 80 down the kelly passage 46 until it engages its companion seat 83 on the tubular member. When fluid is pumped at a sufficient rate, a back pressure of a comparatively large value, if desired, depending upon the rate of fluid flow through the apparatus, is built up in the kelly passage 46, this fluid under pressure passing through the side ports 77 into the cylinder space 22, to elevate the cylinder portion 14a of the body, as well as the entire body 14 and the cutter supporting members 23 and cutters 27, with respect to the tubular mandrel 10. During such upward movement, the expander surfaces 30 of the cutter supporting members 23 are brought to bear against the lock and expander portion 38 of the mandrel, the cutters 27 being urged in an outward direction against the wall of the well bore C. The drill pipe B and rotary drill bit A are rotated at the proper speed while fluid is being pumped through the apparatus, the cutters 27 enlarging the well bore without the drill pipe being moved vertically and drilling weight being imposed on the tool.

As the cutters 27 enlarge the well bore, the hydraulic force acting upon the body 14 elevates it to a greater extent with respect to the mandrel 10 and moves the body shoulder 18 toward the lower end 17 of the kelly and the valve actuating rod 89. Immediately prior to outward expansion of the cutters 27 to their fullest extent, the body shoulder 18 will engage the rods 89 and shift them upwardly within the kelly 13 against the force of the spring 92, the upper ends 90 of the rods engaging the flow restricting member 80 and shifting it from its seat 83. When the cutters 27 are expanded to their fullest extent, the lower end 17 of the kelly will engage the body shoulder 18 and the rods 89 will have been shifted upwardly to their maximum extent, to elevate the flow restricting member 80 a substantial distance above its companion seat 83 at the upper end of the tubular member 34, and also above the lower kelly shoulder 105 at the end of the kelly fluid passage 46.

When the flow restricting member 80 has been elevated above its companion seat 83, the fluid pressure will drop and the pressure gauge at the top of the well bore will advise the operator of that fact. When the fluid pressure drops, the operator knows that the cutters 27 have been expanded outwardly to their maximum extent. Accordingly, he will then impose downweight on the drill pipe B and the mandrel 10, this downweight being transmitted directly to the body 14, and through the body shoulder 54 to the cutter supporting members 23 and cutters 27. Rotation of the drill pipe and the drill bit continues, the cutters 27 rolling around the formation shoulder E and drilling it away. During such drilling action, the lock portions 33 of the cutter supporting members bear against the companion lock surface 39 of the tubular member 34, to preclude inadvertent partial retraction of the cutters from their fully expanded position.

As drilling proceeds, fluid can be pumped readily down through the drill pipe B and through the apparatus A, since the effective passage area through the tool has been increased as a result of the elevation of the indicator valve 80 above its companion seat 83 in the mandrel 10. As a matter of fact, the combined area through the central orifice 86 and the by-pass passages 87 therearound may be made equal to or greater than the area of the passage 47 through the tubular member 34, so as to avoid any material restriction to the flow of circulating fluid through the tool. Adequate circulation fluid can be pumped through the apparatus, after the cutters 27 have been expanded outwardly to the maximum extent, to insure the proper flushing of the cuttings from the well bore to the top of the hole.

After the hole has been enlarged to the proper extent, or the cutters have become worn, it is desired to retrieve the apparatus from the well bore. The pumps are stopped and the drill pipe B raised. The initial action will be a corresponding elevation of the mandrel 10 with respect to the body 14, to remove the expander and lock portion 38 of the mandrel above the lock and expander surfaces 30, 32 on the cutter supporting members 23, allowing the latter to shift back to retracted position within the confines of the body 14. The upward movement of the mandrel 10 with respect to body 14 is limited by engagement of the piston 19 with the lower set of stop rings 20. Such upward movement also raises the lower end 17 of the kelly above the body shoulder 18 and allows the springs 92 to reshift the valve operating rods 89 back to their initial position, such as disclosed in Figs. 1 and 3, whereupon the flow restricting member or indicator valve 80 can drop back into engagement with its companion seat 83. However, it is immaterial that the flow of fluid through the apparatus is restricted to that permitted by the central orifice 86 through the indicator valve, inasmuch as such orifice is of sufficient size to permit the drill pipe B to drain during its elevation with the tool A through the well bore C and the well casing D.

It is, therefore, apparent that a rotary expandable drill bit has been provided, in which a positive indication is given to the operator of the full outward expansion of the cutters. As a result, he is assured of the production of a full formation shoulder E before imposing downweight on the tool, which will also insure the drilling of a truly cylindrical enlarged hole of the required diameter. When drilling in soft formations, the fact of outward expansion of the cutters to their maximum extent, before downweight or drilling weight is imposed on the apparatus A, will insure the provision of a maximum shoulder to support the cutters 27, and thereby minimize the tendency of the cutters to produce a rifling action in the well bore C during rotation of the tool and its lowering in the hole. In the event that the apparatus is being used in relatively hard formations, the valve indicating mechanism 80 incorporated in the apparatus will insure the provision of a greater hydraulic expansion force for insuring the full outward expansion of the cutters, than would be present in the absence of the indicating device.

The inventor claims:

1. In a rotary well drilling bit for operation in a well bore: a main body; cutter means mounted on said body for expansion from a retracted position laterally outward of said body; means movable downwardly relative to said body and said cutter means for expanding said cutter means laterally outward of said body; and means movable relative to said expanding means in response to downward movement of said expanding means to a position substantially fully expanding said cutter means outwardly for providing an indication of substantially full cutter expansion that can be sensed at the top of the well bore.

2. In a rotary well drilling bit for operation in a well bore; a main body; cutter means mounted on said body for expansion from a retracted position laterally outward of said body; means for expanding said cutter means laterally outward of said body; and means on and movable with respect to said expanding means and engageable with means fixed with respect to said body upon substantially full outward expansion of said cutter means for providing an indication of such substantially full outward cutter expansion capable of being sensed at the top of the well bore.

3. In a rotary well drilling bit for operation in a well bore: a main body; cutter means mounted on said body for expansion from a retracted position laterally outward of said body; said body having a central fluid passage provided with a fluid outlet within said body from which drilling fluid is adapted to discharge into the body and the well bore adjacent said cutter means; means for ex-

panding said cutter means laterally outward of said body; means for determining the pressure of fluid in said passage; and means operable upon outward expansion of said cutter means to shift said determining means to change the fluid pressure in said passage.

4. In a rotary well drilling bit for operation in a well bore: a main body; cutter means mounted on said body for expansion from a retracted position laterally outward of said body; means providing a central fluid passage in said body extending along said cutter means; means for expanding said cutter means laterally outward of said body; a device in said passage to restrict flow of fluid in that portion of said passage extending along said cutter means; and means operable upon outward expansion of said cutter means for shifting said device to a position allowing greater flow of fluid in said passage portion.

5. In a rotary well drilling bit for operation in a well bore: a main body having a central fluid passage; cutter means mounted on said body for expansion from a retracted position laterally outward of said body; means for expanding said cutter means laterally outward of said body; a device in said passage having a central flow restricting passage for reducing flow of fluid in said central fluid passage below said device; and means operable upon outward expansion of said cutter means for shifting said device to a position allowing fluid to by-pass around said central flow restricting passage and flow at a greater rate into said central fluid passage below said device.

6. In a rotary well drilling bit for operation in a well bore: a main body having a central fluid passage; cutter means mounted on said body for expansion from a retracted position laterally outward of said body; means for expanding said cutter means laterally outward of said body; a device in said passage having a plurality of flow passages communicable with said body passage below said device, said device being adapted to occupy a position in said body passage in which at least one of said flow passages is closed; and means operable upon outward expansion of said cutter means for shifting said device to a position opening said closed flow passage.

7. In a rotary well drilling bit for operation in a well bore: a main body having a fluid passage; cutter means mounted on said body for expansion from a retracted position laterally outward of said body; means above said cutter means and responsive to the pressure of fluid in said passage for expanding said cutter means laterally outward of said body; means for determining the pressure of fluid in said passage; and means operable upon outward expansion of said cutter means to shift said determining means relative to said expanding means to a position decreasing the fluid pressure in said passage.

8. In a rotary well drilling bit for operation in a well bore: a main body having a fluid passage; cutter means mounted on said body for expansion from a retracted position laterally outward of said body; means above said cutter means and responsive to the pressure of fluid in said passage for expanding said cutter means laterally outward of said body; a device in said passage to restrict flow of fluid therein and cause pressure to be built up in said passage above said device to operate said expanding means; and means operable upon outward expansion of said cutter means for shifting said device to a position allowing greater flow of fluid in said passage.

9. In a rotary well drilling bit for operation in a well bore: a main body having a fluid passage; cutter means mounted on said body for expansion from a retracted position laterally outward of said body; means above said cutter means and responsive to the pressure of fluid in said passage for expanding said cutter means laterally outward of said body; a device in said passage having a flow restricting passage to cause pressure to be built up in said passage above said device to operate said expanding means; and means operable upon outward expansion of

said cutter means for shifting said device to a position allowing fluid to by-pass around said flow restricting passage.

10. In a rotary well drilling bit for operation in a well bore: a main body having a fluid passage; cutter means mounted on said body for expansion from a retracted position laterally outward of said body; means above said cutter means and responsive to the pressure of fluid in said passage for expanding said cutter means laterally outward of said body; means for determining the pressure of fluid in said passage; and means on said expanding means engageable with means on said body upon substantially full outward expansion of said cutter means for shifting said determining means to a position allowing greater flow of fluid in said passage.

11. In a rotary well drilling bit for operation in a well bore: a main body; cutter means mounted on and carried by said body for expansion laterally outward of said body; means for expanding and holding said cutter means outwardly of said body, including a mandrel connectible to a drill string and slidably splined to said body, whereby drilling torque is transmitted from said mandrel to said body; and means operable by said mandrel upon longitudinal shifting of said mandrel with respect to said body for providing an indication capable of being sensed at the top of the well bore that the cutter means has been expanded laterally outward.

12. In a rotary well drilling bit for operation in a well bore: a main body; cutter means mounted on and carried by said body for expansion laterally outward of said body; means for expanding and holding said cutter means outwardly of said body, including a mandrel connectible to a drill string and slidably splined to said body, whereby drilling torque is transmitted from said mandrel to said body, said mandrel having a fluid passage; means for determining the pressure of fluid in said passage; and means operated by said mandrel upon downward shifting of said mandrel with respect to said body to shift said determining means to a position changing the fluid pressure in said passage.

13. In a rotary well drilling bit for operation in a well bore: a main body; cutter means mounted on and carried by said body for expansion laterally outward of said body; means for expanding and holding said cutter means outwardly of said body, including a mandrel connectible to a drill string and slidably splined to said body, whereby drilling torque is transmitted from said mandrel to said body; and means carried by said mandrel and engageable with said body, upon longitudinal movement of said mandrel with respect to said body, to be shifted by said body relative to said mandrel to provide an indication capable of being sensed at the top of the well bore that the cutter means has been expanded.

14. In a rotary well drilling bit for operation in a well bore: a main body; cutter means mounted on and carried by said body for expansion laterally outward of said body; means for expanding and holding said cutter means outwardly of said body, including a mandrel connectible to a drill string and slidably splined to said body, whereby drilling torque is transmitted from said mandrel to said body, said mandrel having a fluid passage; means for determining the pressure of fluid in said passage; and means carried by said mandrel and engageable with said body, upon downward movement of said mandrel with respect to said body, to be shifted by said body to shift said determining means to a position changing the fluid pressure in said passage.

15. In a rotary well drilling bit for operation in a well bore: a main body; cutter means mounted on said body for expansion laterally outward of said body; a mandrel connectible to a drill string and slidably splined to said body, said mandrel having a fluid passage communicat- ing with the drill string; coengageable expander means on said mandrel and cutter means; hydraulically oper- able means on said body subject to the pressure of fluid

11

in said passage to elevate said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; means in said passage for determining the pressure of fluid in said passage; and means responsive to elevation of said body with respect to said mandrel for shifting said determining means to a position changing the fluid pressure in said passage.

16. In a rotary well drilling bit for operation in a well bore: a main body; cutter means mounted on said body for expansion laterally outward of said body; a mandrel connectible to a drill string and slidably splined to said body, said mandrel having a fluid passage communicating with the drill string; coengageable expander means on said mandrel and cutter means; hydraulically operable means on said body subject to the pressure of fluid in said passage to elevate said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; a device in said passage to restrict flow of fluid therein to enable fluid pressure to be built up in said passage; and means responsive to elevation of said body with respect to said mandrel for shifting said device in said passage to a position allowing greater flow of fluid in said passage.

17. In a rotary well drilling bit for operation in a well bore: a main body; cutter means mounted on said body for expansion laterally outward of said body; a mandrel connectible to a drill string and slidably splined to said body, said mandrel having a fluid passage communicating with the drill string; coengageable expander means on said mandrel and cutter means; hydraulically oper-

12

able means on said body subject to the pressure of fluid in said passage to elevate said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; a device in said mandrel passage having a plurality of flow passages, said device being adapted to occupy a position in said mandrel passage in which at least one of said flow passages is closed; and means responsive to elevation of said body with respect to said mandrel for shifting said device in said mandrel passage to a position opening said closed flow passage.

18. In a rotary well drilling bit for operation in a well bore: a main body; cutter means mounted on said body for expansion from a retracted position laterally outward of said body; means for expanding said cutter means laterally outward of said body, said expanding means having a fluid passage; means in said passage for determining the pressure of fluid in said passage; and means operable upon outward expansion of said cutter means to shift said determining means to change the fluid pressure in said passage.

References Cited in the file of this patent

UNITED STATES PATENTS

1,611,282	Samuelson	Dec. 21, 1926
1,900,226	Conant	Mar. 7, 1933
2,699,921	Garrison	Jan. 18, 1955

FOREIGN PATENTS

378,227	France	Aug. 3, 1907
---------	--------	--------------