United States Patent

Rushing et al.

[15] **3,692,126**

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[54] **RETRACTABLE DRILL BIT APPARATUS**

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[52] **U.S. Cl.** **175/259,** 175/246

[51] **Int. Cl.** **E21b 9/26**

[58] **Field of Search** 175/246, 249, 257–261

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Primary Examiner—David H. Brown

Attorney—F. H. Henson, F. P. Klipfel and D. F. Straitiff

[57] **ABSTRACT**

Apparatus including a retractable annular drill bit formed by tightly interfitting groups of bi-directionally tapered sectors normally clamped in the lower end of a drill sub by an axially movable inner clamping sleeve. The sleeve is actuable by hammer blows from a releasable cable-operated elevator and hammer tool to effect expansion and contraction of such sector groups sequentially into and sequentially out of the drill sub interior for insertion and removal via the interior of the drill string to which the drill sub is attached. Axially movable flexible translational support stem assemblies for the bit sector groups, in affiliation with a system of radially fixed stop shoulders, cooperate with axial movement of the clamping sleeve to enable it to effect such sector group expansion and contraction. A separately removable core barrel accepts the core sample made by the bit.

4 Claims, 10 Drawing Figures

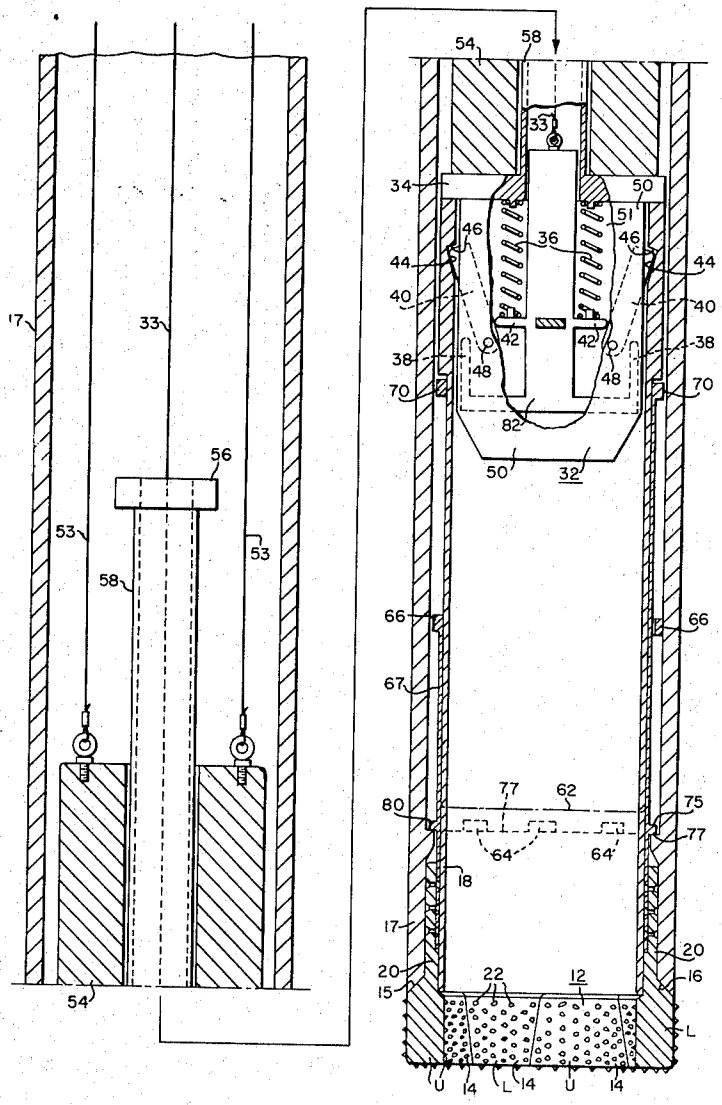
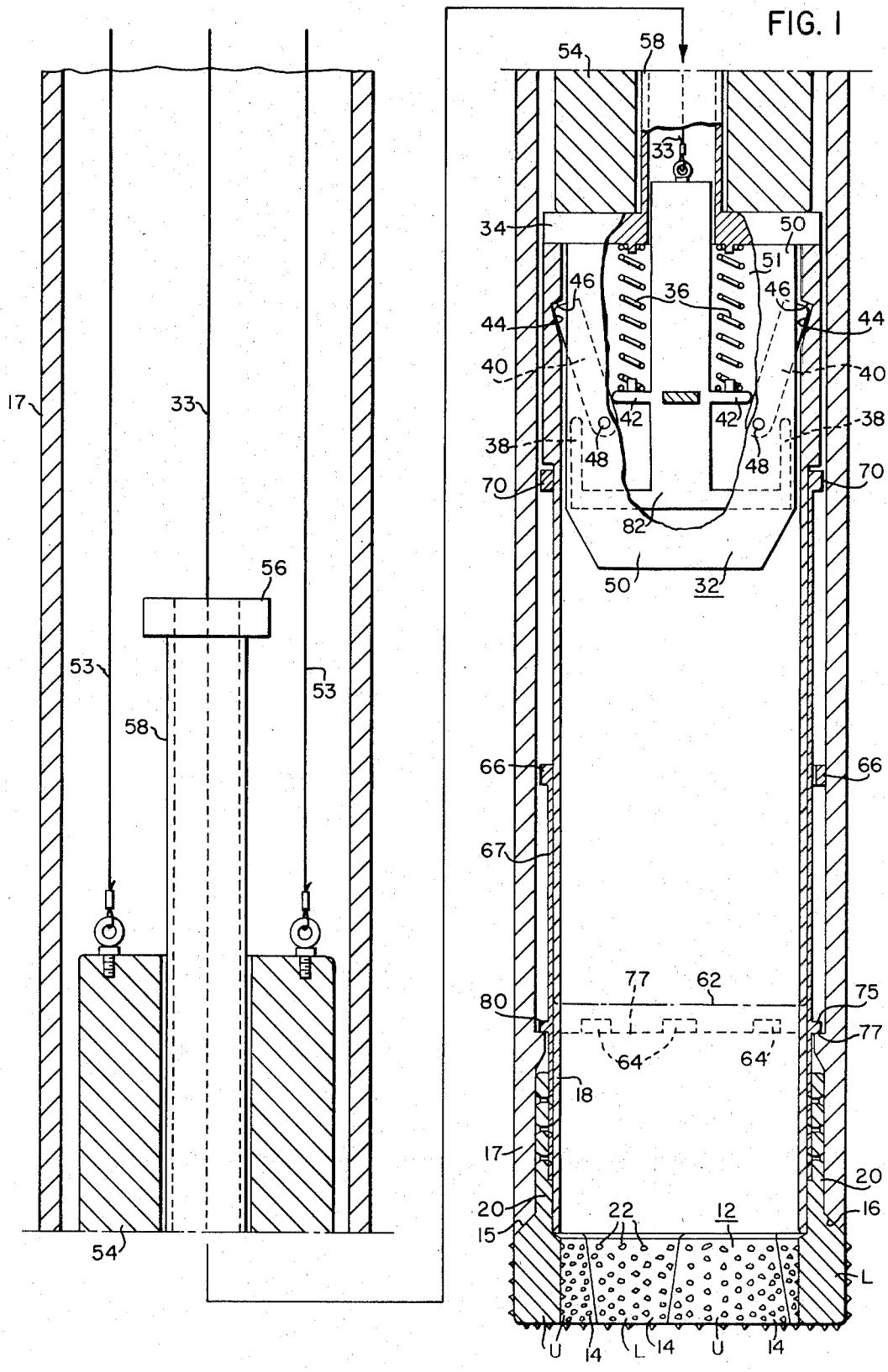


FIG. 1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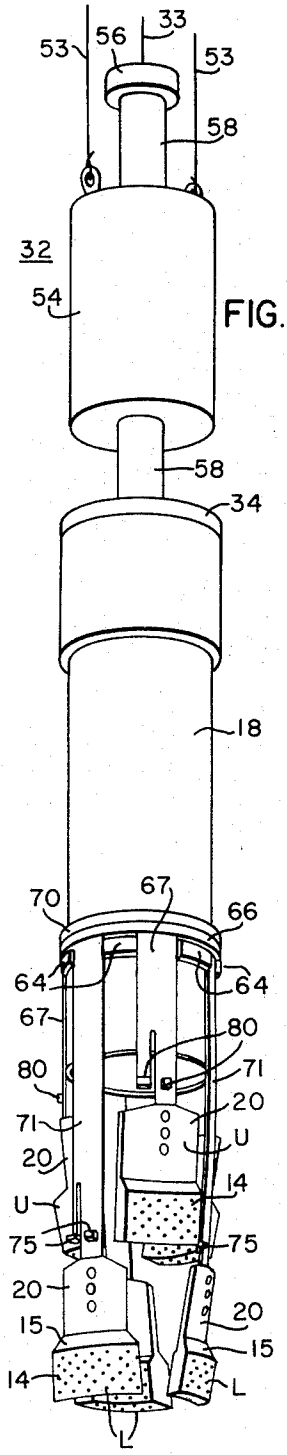


FIG. 2

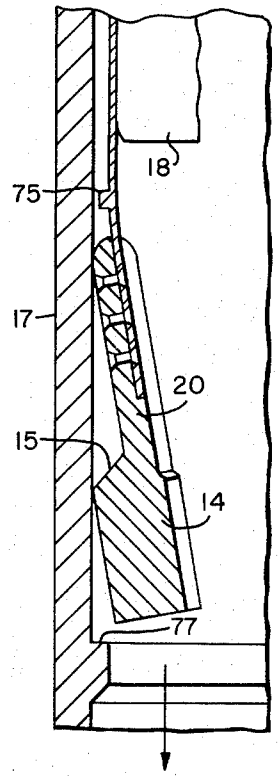


FIG. 3

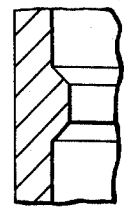


FIG. 5

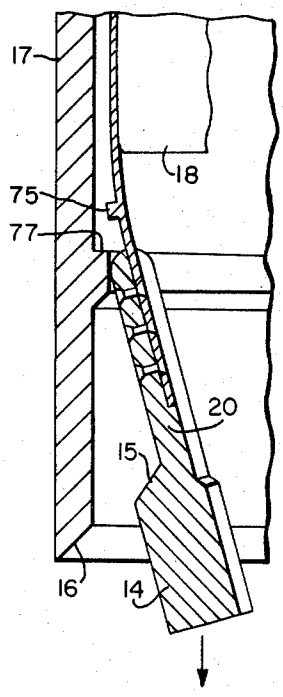
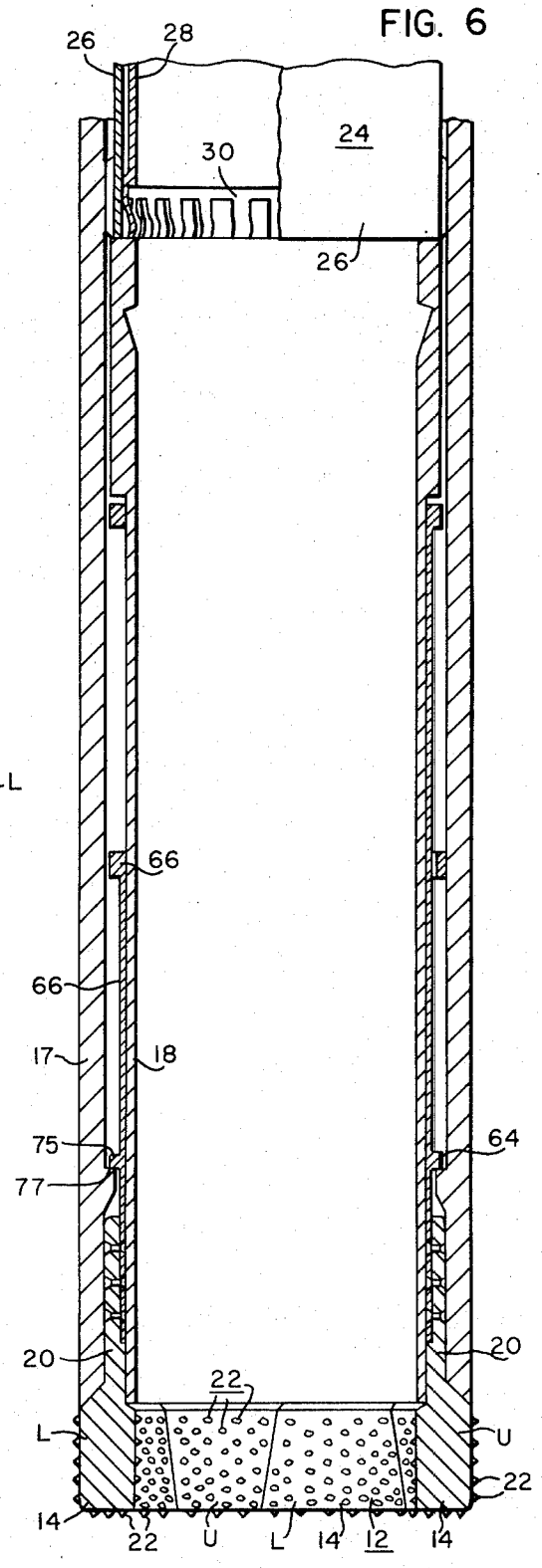


FIG. 4

FIG. 6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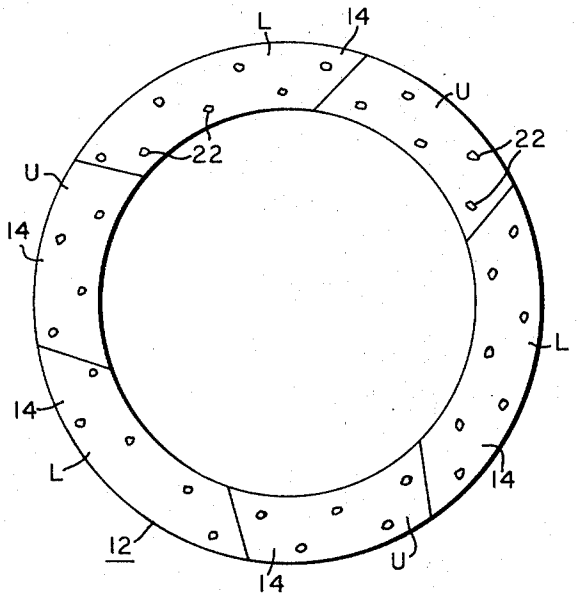
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FIG. 7

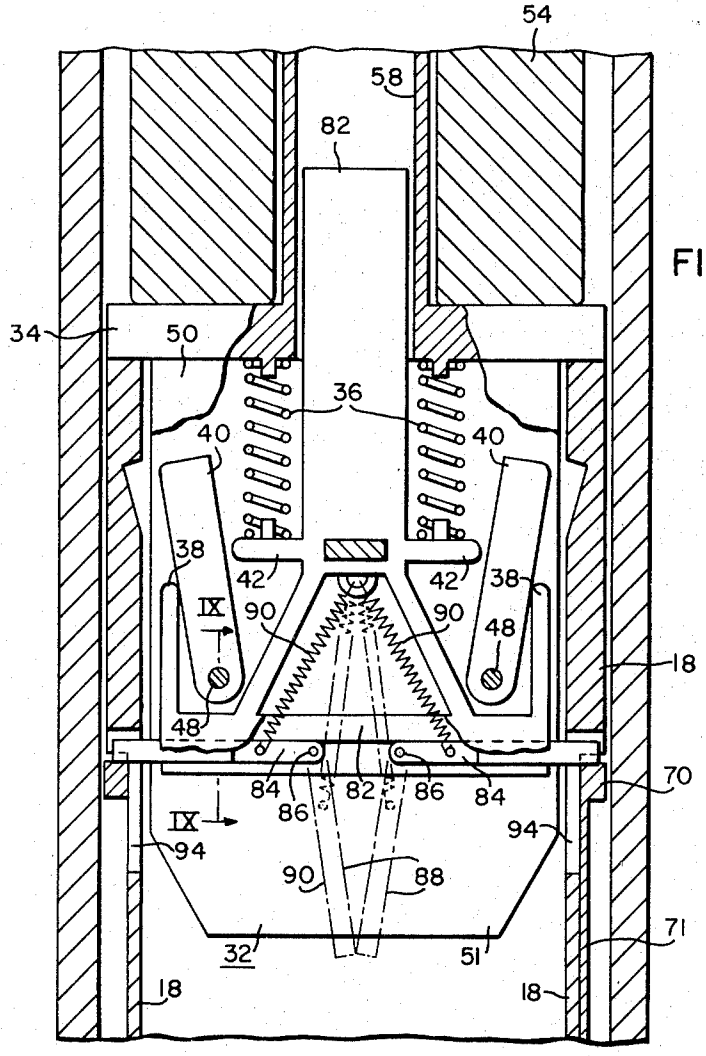

FIG. 8

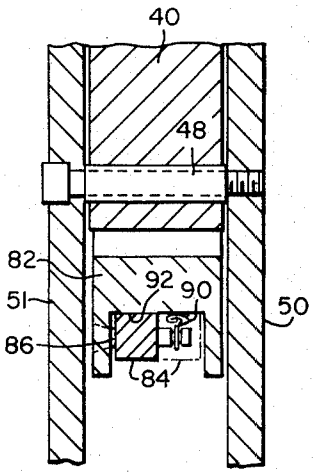

FIG. 9

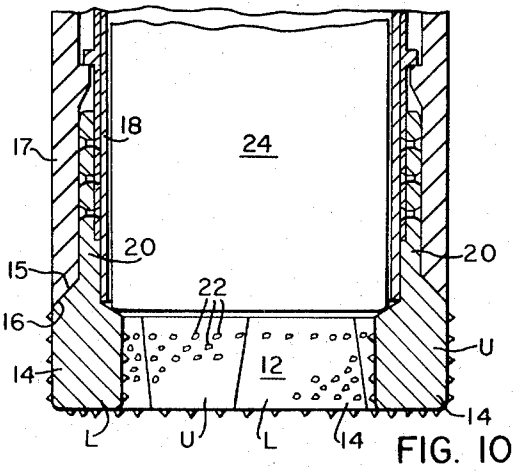

FIG. 10

RETRACTABLE DRILL BIT APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to core drilling apparatus, and more particularly to such apparatus as includes a retractable core bit capable of being removed and inserted via the interior of a drill string to avoid withdrawal of such string from the drilled hole for replacement of drilled bits.

2. Description of the Prior Art

The following U.S. patents were received as a result of a preliminary search: U.S. Pat. Nos. 3,437,159; 2,982,366; 2,979,144; 2,842,343; 2,764,388; 2,345,699; and 2,068,704.

Each of the above prior art patents discloses some form of retractable bit assembly having a circular array of cutter elements at the ends of flexible arms that permit their being displaced radially inward for transport via the interior of a drill string, and radially outward to a working position on a drill sub or collar at the bottom of such drill string. In all of these assemblies, the cutter elements are expanded radially outward toward their working positions on the drill sub or collar by the spreading action of an end tapered member actuated downwardly by gravity under control of a lowering cable and tool which may include an auxiliary weight to assist such gravity actuation.

A number of the assemblies in their collapsed state, store the several retractable cutter elements at an equal number of different vertical locations to and from which the elements are moved sequentially during contracting and expanding the bit. In the remaining assemblies, all of the cutter elements are expanded and contracted simultaneously. The foregoing sequential-actuation arrangements are characterized by a high degree of complexity involving a system of spring biased dogs, slots, longitudinal guide grooves, annular dog-accommodating grooves, conns, etc.; and the foregoing simultaneous-actuation arrangements sacrifice cutter surface area in order to enable sufficient contraction of the total cutter element array to pass simultaneously into the drill sub.

SUMMARY OF THE INVENTION

The present invention:

In providing a core bit formed as a complete annulus of interfitting sectors, enables mutual support of the bit sectors circumferentially, rather than relying on special grooved configurations in the drill sub as heretofore, and affords opportunity for a greater cutting area of the bit;

In providing an arrangement whereby the sectors making up such complete interfitting annular bit are raised and lowered in two or more groups, the vertical space occupied by the bit apparatus when in its fully retracted state is minimized;

In providing an arrangement wherein the bit sectors are tapered both lengthwise as well as widthwise to enable those of a first group to slide between those of a second group while moving longitudinally, enables the two groups to be actuated positively with percussive blows to and from their expanded interfitting working positions in the bit annulus;

In providing a releasable cable-operated tool for effecting the hammer-blow assembly and disassembly of the retractable bit, the positive actuation is afforded by cable manipulation from the top of the bore hole;

By provision of an inner clamping sleeve on which the bit sector groups are slidably mounted during transport while retracted, and which tightly clamps them in position when expanded in working position, a core barrel for receipt of the core sample bored by the bit is enabled to be raised and lowered through the drill stem without disturbing the bit, in contrast to certain of the prior art arrangements where the core barrel serves such functions and the bit is retracted and expanded each time the core barrel is raised and lowered; and

By provision of a relatively simple arrangement of flexible support stem assemblies for the bit sector groups, in affiliation with a system of radially fixed stop shoulders, cooperation with the clamping sleeve is afforded whereby the sequential expansion and contraction of such sector groups into and out of the drill sub by the hammer blow actuation is afforded in a positive manner, rather than in a negative manner of certain of the prior art arrangements where reliance is placed on spring-biased dogs dropping into openings, which may be subject to plugging with drill cuttings, to accomplish sequential bit sector positioning.

Other features and advantages of the present invention will become apparent from the following detailed description when taken in connection with accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevation view, partly in outline and partly in section, showing an exemplified embodiment of the retractable core drill bit apparatus of the present invention, including a cable-operated elevator-and-hammer tool, in place in a drill pipe sub;

FIG. **2** is a perspective view in outline, showing the retractable core drill bit and elevator-and-hammer tool of FIG. **1** as they appear when the bit is contracted and removed from the interior of the drill pipe;

FIGS. **3** and **4** are segmental section views of a portion of the retractable core drill bit of FIG. **1**, showing relationships between a bit sector and a stop shoulder in the drill sub during different stages of assembly of the bit;

FIG. **5** is a segmental view of an alternate configuration of the drill sub shoulder shown in FIGS. **3** and **4**;

FIG. **6** is an elevation view, in cross section, showing the retractable core drill bit apparatus of FIG. **1** as assembled on the drill pipe sub, but with the elevator-and-hammer tool of FIG. **1** withdrawn, and showing one suitable arrangement for location of a core barrel atop the clamping sleeve of such apparatus;

FIG. **7** is a bottom view in outline, showing an exemplification of the annular core drill bit of the present invention as composed of two interfitting groups of bit sectors;

FIG. **8** is a vertical elevation view, partly in outline and partly in section, showing an alternate construction of the elevator-and-hammer tool of the present invention, which enables automatic release of such tool upon completion of bit assembly;

FIG. **9** is a section view taken along the line IX—IX in FIG. **8**; and,

FIG. **10** is an elevation view, partly in outline and partly in section, showing an alternate arrangement and

construction of the core drill bit for accommodating the core barrel within the clamping sleeve of the bit apparatus, rather than atop such sleeve as in FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring particularly to FIGS. 1, 6 and 7 in the drawings, in its assembled state, the exemplified core drill bit 12 of the present invention is in the form of a ring composed of two interleaved groups U and L of tightly interfitting bi-directionally tapered bit sectors 14 having mutually aligned upwardly contracting segmented annular shoulders 15 at their upper and outer portions which are tightly squeezed by the lower end of a central clamping sleeve 18 against a correspondingly tapered downwardly flaring annular shoulder 16 of a cylindrical drill sub 17. Upwardly extending bi-directionally tapered shank portions 20 of each of the bit sectors 14 collectively form a continuous segmented tightly fitting hollow cylindrical integral portion of the annular ring array 12 of bit sectors 14, which portion is also tightly clamped radially between the outer surface of the central clamping sleeve 18 and the inner cylindrical surface of the drill sub 17.

The inner and outer cylindrical surfaces, as well as the bottom annular surface of the drill bit 12 is studded with the usual cutting elements 22, such as diamonds, so that as such bit is rotated by the drill sub 17 via the drill pipe (not shown), a cylindrical core (not shown) is bored in the subsurface formation and travels upwardly through the center of such bit into the interior of the clamping sleeve 18 to be received and retained by a core barrel 24, either located with its receiving end atop such clamping sleeve 18 as shown in FIG. 6, or disposed within such sleeve 18 with its receiving end immediately atop the annular bit 12. The inner diameter of the annular bit 12, will be, as shown, of such size as to assure that the core diameter is accommodated by the interior of the clamping sleeve 18 and/or the core barrel 24, in the two cases.

The core barrel may take the usual form as including, FIG. 6, an outer shell 26 rotatable in unison with the drill sub 17 and an inner shell 28 suitably mounted by bearing means (not shown) to remain non-rotationally disposed within such outer shell, with a fingered core-catcher 30 disposed at its lower core-accepting end. By use of the usual cable-operated core elevator (not shown) the core barrel 24 may be raised and lowered into and out of the drill pipe or casing string (not shown) for recovering the core, without disturbing the drill bit 12 at the bottom of drill sub 17.

The usual chip release grooves (not shown) may be provided the bit sectors 14 to permit the cuttings to pass radially outward to the bit exterior for removal, as by liquid or pneumatic flushing, and the usual liquid circulation passages (not shown) also may be provided such bit sectors for communication to the inner regions of such chip release grooves.

In retraction of the bit 12 from its working position at the bottom of the drill sub 17 as shown in FIGS. 1, 6, 7, and 10, after cable removal of the core barrel 24, FIGS. 6 and 10, an elevator-and-hammer tool 32, FIG. 1, is lowered by a cable 33 downwardly through the drill pipe or casing (not shown) and into the drill sub 17, while they remain stationary in the formation hole made by the core bit 12. A lower latching end of the tool 32 enters the upper end of the clamping sleeve 18 until its downward movement is arrested by engagement of a stop flange 34 atop such latching end with the top of the clamping sleeve, whereupon, continued lowering of the cable 33 permits a pair of vertical compression springs 36 reacting against the bottom of flange 34 to lower a pair of latch-retraction arms 38 away from the under side of a pair of pivotally mounted latching fingers 40 while simultaneously lowering a pair of latch-effectuation arms 42 into actuating contact with the upper side of such fingers 40 to cause same to flare outwardly into nested disposition at their upper ends in a tapered annular groove 44 in the inner wall of the clamping sleeve 18 near its upper end. The upper end of the groove 44 forms an annular shoulder 46 for abutting engagement by the upper ends of latching fingers 40. Relatively strong pins 48 pivotally connect the lower ends of latching fingers 40 to the flange 34 via parallel plates 50 and 51 attached to and depending therefrom. In an actual construction, duplicate latching fingers 40, retraction arms 38, effectuation arms 42, springs 36, and plates 50 and 51 are arranged in extension at right angles to those shown in FIG. 1.

Once having thus introduced the lower latching end of the elevator-and-hammer tool 32 to the upper end of the clamping sleeve 18, the cable 33 is allowed to remain relaxed, while a pair of hammer-blow-actuation cables 53 are periodically lifted from atop the drill or casing string (not shown) to intermittently raise an annular weight member 54, weighing about 5 pounds in one particular actual construction, a considerable distance, about 2 feet in such construction, to cause such member 54 to repeatedly strike the under-side of an annular flange 56 at the upper end of a hollow rod 58 attached to and extending centrally upward from the flange 34; cable 33 extending downwardly through such hollow rod 58, and weight member 54 encircling it for slidable guidance.

It should be understood that between each successive raising of the weight member 54 into striking engagement with the stop flange 56, there will be a corresponding lowering, but at a slower rate aimed at preventing any significant downward blows of such member 54 against the top of the flange 34 at this time.

The foregoing upward blows dealt repeatedly against the under surface of the stop flange 56, are transmitted to the clamping sleeve 18 via the hollow rod 58, flange 34, depending plates 50 and 51, pins 48, the latching fingers 40, and the annular shoulder 46 which becomes repeatedly engaged by the upper ends of such fingers.

Such repeated upward blows thus transmitted to the clamping sleeve 18, forces such sleeve upwardly from its clamping position within the bit sectors 14 and their shanks 20 to a raised position where its lower end is disposed at the dot-and-dash line 62 in FIG. 1, whereupon a plurality of circumferentially spaced-apart outwardly projecting rectangular stop tabs 64, FIGS. 1 and 2, comes into abutment with the under side of a lift ring 66 encircling such sleeve 18, from which depend a plurality of circumferentially spaced-apart flexible stems 67 extending downwardly into attachment with inner recessed regions of the shanks 20 of bit sectors 14 forming the upper group U of the assembled bit 12.

Continued delivery of upwardly delivered percussive forces to the clamping sleeve **18**, will be experienced by its stop tabs **64**, the lifting ring **66**, stems **67**, shanks **20** and bit sectors **14** of group U. Due to the bi-directional taper of the bit sectors **14**, and the slope of tapered shoulder **16** at the bottom of drill sub **17**, such forces will cause progressive inward and upward dislodgement of such sectors of group U from their tight-fitting positions between those of group L, as such dislodgement permits of continued progressive upward movement of the clamping sleeve **17** while tabs **14** carry the contracted array of bit sectors **14** of group U along with it via ring **66** and the stems **67**. Once such bit sectors of group U are thus percussively broken free of the annular assembled formation between the group L bit sectors, continued percussion blows may not be necessary and a steady pull on the cables **53** while the weight member **54** is held against stop flange **56** may suffice.

As the lifting ring **66** is carried upwardly by the stop tabs **64** on the clamping sleeve, which results in raising of the radially contracted array of group U bit sectors, such ring **66** comes into contact with a lift ring **70** for the bit sector group L which is relatively easily radially contracted and carried upwardly through the interior of the drill sub **17** in disposition beneath contracted bit sector group U, via respective support stems **71** extending downwardly from such ring **70**, through accommodating openings in the lift ring **66**, to the shanks **20** of the bit sectors of such upper group. In the case of both groups, their radially inward contracted positions can be maintained by an inward flexural bias imparted to the stems **67** and **71**, although, even if outwardly biased, or without any significant bending bias, they will remain compacted by the inner cylindrical surface of the drill sub **17** and the interior of the drill or casing string (not shown) enroute to the surface for removal of the collapsed bit for inspection and/or replacement of the dulled bit.

During run-in of a replacement bit, a collapsed bit assemblage as shown in FIG. **2**, with the upper group of bit sectors U contracted inwardly between the support stems **71** for the lower group of bit sectors L which are also contracted inwardly and disposed beneath sectors U, is introduced into the top of the drill or casing string (not shown) and lowered via the cables **53** and the elevator-and-hammer tool **32**, which is held suspended via the weight member **54** in supporting engagement with the stop flange **56** (FIGS. **1** and **2**) and which in turn supports the collapsed bit assemblage by way of the hollow rod **58**, the flange **34**, plates **50** and **51**, the pins **48**, the latching fingers **40**, and the tapered annular shoulder **46** in the clamping sleeve **18** of such collapsed bit assemblage.

During such lowering of the tool **32** and depending collapsed bit assemblage, the rings **66** and **70** will be maintained adjacent to the stop tabs **64** on the clamping sleeve, as shown in FIG. **2**, by virtue of a friction fit between such rings and sleeve, while the width of such tabs **64** maintains circumferentially spaced-apart alignment between the stems **67** and the stems **71**, hence between the upper bit sectors U and the lower bit sectors L. Simultaneously, cable **33** is played out, but maintained slack.

Continued lowering in suspension by cables **53** ultimately results in outwardly projecting stop tabs **75** near the lower ends of the stems **71** and/or non-bending divided portions thereof, FIGS. **1** and **2**, come into abutting engagement with an annular stop shoulder **77** projecting inwardly from the inner wall of the drill sub **17** near its bottom open end; the lower bit sectors U, including their upper shank portions **20**, having first moved down past such shoulder in their inwardly cocked attitude, as indicated in FIGS. **3** and **4**.

Following such abutment of stop tabs **75** of stems **71** with the drill sub shoulder **77**, the lower bit sectors L, their stems **71**, and their ring **70** are thereby arrested against further downward movement, and continued lowering of the clamping sleeve **18** (which at this and subsequent stages can be assured by alternate gentle raises and rapid drops of the cables **53** to cause the weight member **54** to deliver downward hammer blows to the flange **34** and thereby the top of sleeve **18**) results in sliding movement of such sleeve through the ring **70** while the upper bit sectors U, accommodated by longitudinal tapers of both bit sector groups, are carried by friction drag of the ring **70** on sleeve **18**, past the drill sub shoulder **77** and between the lower bit sectors L which thereby become displaced radially outward toward their ultimated desired seated position against the tapered shoulder **16** on the drill sub bottom. During the final stages of such wedging movement of the upper bit sectors U between the lower bit sectors L, as such wedging action becomes tighter, stop tabs **80** on or near the lower ends of stems **67** and/or non-bending divided portions thereof will have come into abutment with the drill sub shoulder **77**, and continued downwardly hammered movement of the clamping sleeve **18** forces such sleeve downwardly through both rings **70** and **66**, (now spaced apart vertically as shown in FIG. **1**) and through the edge-abutting shank portions **20** of the bit sectors **14** until the stop tabs **64** on such sleeve also reaches the drill sub shoulder **77**, whereupon the assembly of the bit **12** is thus completed.

At this time, manipulation of the cables **53** are terminated, and a pull is exerted on the cable **33**, FIGS. **1** and **2**, to raise the latch-effectuation arms **42** and the latch-retraction arms **38**, via a common support member **82** to which such cable is anchored, against the bias force of the springs **36** to cause the latching fingers **40** to swing inwardly about pins **48**, free of the groove **44** and support shoulder **46** in the clamping sleeve **18**. By sustaining such pull on the cable **33** the latching fingers are maintained inwardly retracted and the elevator-and-hammer tool **32** is lifted out of the clamping sleeve **18** and raised to the surface via the interior of the drill sub **17** and the drill pipe or casing (not shown) from which such sub depends, thereby enabling introduction of the core barrel **24** and rotation of the assembled core bit **12** in a manner previously described.

In behalf of assuring that the elevator-and-hammer tool assembly **32** is not withdrawn prior to complete assembly of the drill bit **12** onto the drill sub **17**, such tool may take an alternate form, as shown in FIGS. **8** and **9**, for example, constructed, in conjunction with slight modification of the clamping sleeve **18**, to enable the tool to be raised only after such complete assembly.

In accord with such exemplification as shown in FIGS. **8** and **9**, parts which correspond functionally to

those in tool **32** in FIG. **1**, are given the same reference numerals. The automatic release function is provided by a pair of retractable release arms **84** pivotally connected by pins **86** to the bottom of the common support member **82** for the latch-retraction arms **38** and latch-effectuation arms **42**. During run-in of the tools for pick-up of the bit assembly, the arms **84** are ineffectuated by contracting same downwardly to end-abutting positions indicated by dot-dash outlines **88** in FIG. **9** in which they are held by over-center tension springs **90**, to enable such tool to function as previously described in connection with bit assembly pick-up. When used during lowering of the retracted bit assembly down through the drill string, however, the arms **84** are aligned horizontally and held therein against a horizontal shoulder **92** near the bottom of support member **82** by the same springs **90**, the ends of such release arms **84** projecting into longitudinal slots **94** in the clamping sleeve **18**. The release arms **84** are so arranged that when in their horizontal positions, their projecting ends extending through the grooves **94** lie in the path of relative vertical travel between the ring **70** for stems **71** of the lower bit sectors L and the clamping sleeve **18**, and function to lift the support member **82**, during the final stages of bit assembly, sufficiently to cause its latch-retraction arms **38** to disengage the latching fingers **40** from the clamping sleeve **18** to free the tool **32**, which only then can be raised via the cables **53** (FIG. **1**) the weight member **54**, the flange atop hollow rod member **58**, flange **34**, and plates **50** and **51**. Sufficient vertical clearance is provided at the top of grooves **94** to permit raising of the tool **32** clear of the support shoulder **46** in clamping sleeve **18**, before the automatic release arms **84** strike the upper ends of such grooves and become deflected downwardly and tend to permit re-expansion of the latching fingers **40**, which may be rounded at their outer projecting edge to permit sliding travel along the inner wall of the drill pipe, or arranged to have such travel limited. Otherwise, the cable **33** of FIGS. **1** and **2**, could be provided, if necessary, to suspend the tool **32** and hold fingers **40** retracted as previously described in connection with FIG. **1**, once such automatic release has been realized during an initial stage of raising of the tool by the cables **53** as described above.

We claim:

1. A retractable bit assembly comprising,

a tubular drill sub for mounting on the lower end of a drill string,

an annular drill bit assembly at the bottom of said drill sub formed by tightly interfitting groups of bi-directionally tapered sectors having upper shank portions forming a divided mounting boss extending upwardly into the lower end of said drill sub,

a clamping sleeve disposed in said drill sub in extension into said mounting boss in tight slidable fit therewith,

flexible translational support stem assemblies attached to the bit sector groups and extending upward therefrom around said clamping sleeve, and

radially fixed stop shoulder means affiliated with said drill sub, said clamping sleeve, and said support stem assemblies, cooperable with axial movement of said clamping sleeve to effect sequential contraction and expansion of said bit sector groups to and from said annular bit assembly.

2. The retractable bit assembly of claim **1**, including in combination therewith, a core barrel removably affiliated therewith to receive a formation core bored by said annular drill bit assembly.

3. A retractable drill bit assembly comprising,

a tubular drill sub for mounting on the lower end of a drill string,

said drill sub having a downwardly flaring tapered annular shoulder at its lowermost end and an inwardly projecting annular stop shoulder disposed above such lowermost end;

plural tightly interfitting groups of drill bit sectors forming a continuous divided annular array in assembled position on the lowermost end of said drill sub,

each of said drill bit sectors having an outer segmented annular shoulder in engagement with respective portions of said downwardly flaring tapered annular stop shoulder at the lowermost end of said drill sub,

the bit sectors of the several groups being tapered lengthwise and widthwise to permit sequential expansion and contraction of such groups to and from said annular array by simultaneous axialwise and radialwise movement thereof, and

each of said bit sectors having corresponding bi-directionally tapered shank portions extending vertically upward which form a continuous divided mounting boss configuration coaxial with said annular array;

a clamping sleeve disposed in said drill sub in tight-fitting disposition within said divided mounting boss thereby forced outwardly against an inner cylindrical wall of said drill sub disposed beneath its aforesaid inwardly projecting annular stop shoulder,

said clamping sleeve having a thick-walled upper end that affords an elongated annular clearance space therebelow between its outer cylindrical surface and the inner cylindrical surface of said drill sub,

said thick-walled upper end of said clamping sleeve being adapted to receive a cable-operated releasable elevator-and-hammer tool for imparting suspension forces and bi-directional vertical percussive blows to such upper end, and

said clamping sleeve having a plurality of combined longitudinal stop and circumferential spacer tabs extending radially outward therefrom near the bottom of said sleeve in abutting engagement with the aforesaid annular stop shoulder within said drill sub;

a plurality of vertically extending translational supports stems disposed in the aforesaid annular clearance space in circumferentially spaced-apart array between the aforesaid longitudinal stop and circumferential spacer tabs on said clamping sleeve,

said translational support stems being connected at their lower ends to respective shank portions of said bit sectors and being relatively rigid longitudinally for delivery of longitudinal thrust and pull forced to such bit sectors during their assembly and disassembly to and from the aforesaid annular array, while also being flexural to permit radial movement of such bit sectors during such assembly and disassembly,

said translational support stems consisting of stem groups, equal in number to the number of bit sector groups,

the stems of each group being equal and interconnected at their upper ends by a respective lift ring in close sliding fit with the outer surface of said clamping sleeve,

the stems of the several stem groups being of sufficiently different length to permit sequential radial contraction of the bit sector groups from the aforesaid annular array to different vertical positions by progressive upward movement of said longitudinal stop and circumferential spacer tabs sequentially into displacing abutment with the several lift rings;

and a plurality of vertically extending longitudinally rigid stop means attached at their upper ends to the several lift rings, respectively, and in abutment at their lower ends with the aforesaid annular stop shoulder in said drill sub.

4. The retractable drill bit assembly of claim 1, wherein,

said clamping sleeve is adapted for releasable connection with said elevator-and-hammer tool by inclusion of an upwardly flaring annular groove in its inner surface near its upper end, and

said elevator-and-hammer tool comprises pivotal latching fingers for end engagement with said annular groove,

a lower abutment member for engagement with the upper end of said clamping sleeve,

a vertical guide member attached to said flange and having an upper abutment member disposed above said lower abutment member,

a weight member vertically movable on said guide member to strike hammer blows on such upper and lower abutment members selectively, and

cable means for effecting raising and lowering of said tool and vertical actuation of said weight member.

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