ABSTRACT: Rotary drill bit cutters lowered on a carrier through a tubular drill string to a drive mandrel or body at the lower end of the string. A device orients or aligns the cutters with slots in the mandrel into which the cutters are expanded and then locked in expanded condition by the carrier, enabling drilling torque and weight to be transmitted from the rotating drill string and mandrel to the cutters, causing the latter to produce a cutting action in the formation. Elevation of the carrier retracts the cutters inwardly of the mandrel for withdrawal through the drill string to the drilling rig. The carrier may support a core tube for receiving a core produced by the cutters.
RETRACTABLE DRILL BITS

The present invention relates to rotary bits for drilling boreholes in formations, and more particularly to rotary bits including cutter and orienting mechanism adapted to be run through a drill string extending to the drilling rig and locked in position in a mandrel or body at the lower end of the drilling string, the cutters being retractable from their locked relation for withdrawal through the drill string to the drilling rig. An example of a retractable drill bit of the nature indicated is presented in U.S. Pat. No. 3,437,159.

The conventional mode of drilling a borehole is to secure a drill bit to the lower end of a string of drill pipe, rotate the drill pipe while imposing drilling weight on the bit, and circulating drilling fluid through the drill pipe to remove the cuttings from the bottom of the hole and flushing them upwardly around the drill pipe back to the top of the hole or the drilling rig. When the drill bit is to be removed from the borehole, because of its becoming dull or for inspection, it is necessary to withdraw the entire string of drill pipe from the hole and either replace the bit or rerun the same bit in the hole, which occupies considerable time, which increases as the depth of the hole increases, with attendant substantial cost. The prior devices for moving the cutter elements through the string of drill pipe and for withdrawing them from the string of drill pipe on a wire line, or the like, avoids the necessity for "round-tripping" the drill pipe for changing or inspecting bits, but such prior devices have not been commercially successful for a variety of reasons, among which is the comparatively small size of the cutters, difficulty in appropriately orienting the cutters with respect to the lower end of the drill pipe to which the cutters are locked, the release and withdrawal of the cutters when they are to be withdrawn through the drill string to the drilling rig, and the cost of manufacture of the tools.

By virtue of the present invention, improved rotary drill bits are provided of the type in which the cutters can be run through a string of drill pipe for latching to an appropriate drive member secured to the lower end of the drill string, as well as being released from such member for withdrawal to the drilling rig, in which the mechanism is simpler than was hitherto provided, easy to orient with respect to companion slots in the drive member into which the cutters are to be expanded, and in which such cutters are locked solidly in their outwardly expanded condition in secure torque-transmitting relation to the drive member, as well as firm driving weight-transmitting relation to the drive member. The cutters that can be run through the drill string have a relatively large cutting surface, thereby providing an increased effective cutter life. The entire mechanism is of strong and sturdy construction. The cutters are conveyed through the drill string by a carrier tube, or similar mechanism, which also serves to lock the cutters solidly against the drive member in expanded condition, and which may also carry a suitable inner core tube, in the event the cutters are to cut a core in the borehole formation, which is to be withdrawn with the borehole through the drill string to the drilling rig.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of several forms in which it may be embodied. Such forms are shown in the accompanying and forming part of the present specification. These forms 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.

Referring to the drawings:

Figs. 1a to 1d, inclusive, are views corresponding to Figs. 2a to 2d, illustrative of the portion of the apparatus locked in its drilling condition, Figs. 2b, 2c, and 2d being lower continuations of Figs. 2a, 2b and 2c, respectively;

Fig. 3 is a cross section cut along the line 3-3 on Fig. 1d;

Fig. 4 is a cross section cut along the line 4-4 on Fig. 2d;

Fig. 5 is a bottom plan view looking upwardly at Fig. 1d;

Fig. 6 is a bottom plan view looking upwardly at Fig. 2d;

Fig. 7 is a diagrammatic view in a single plane of the cam sleeve and carrier rods integral therewith;

Fig. 8 is a diagrammatic view in a single plane of the drive mandrel;

Fig. 9 is a fragmented longitudinal section, on an enlarged scale, of the running-in relationship between the pilot bit portion and a carrier rod when in the positions illustrated in Fig. 1d;

Fig. 10 is a longitudinal section through a modified form of retrievable drill bit apparatus and associated drive mandrel, with the drill bit apparatus in condition for being retrieved or elevated within the drill string;

Fig. 11 is a view similar to Fig. 10 illustrating the drill bit apparatus in locked and drilling condition with respect to the drive mandrel;

Fig. 12 is a side elevational view of the lower portion of the apparatus illustrated in Fig. 11;

Fig. 13 is a bottom view of the apparatus as seen from a position below Fig. 10;

Fig. 14 is a bottom view of the apparatus as seen from below Fig. 11;

Fig. 15 is a longitudinal section through the drive mandrel portion of the apparatus.

The apparatus illustrated in Figs. 1a to 9 of the drawings includes a retractable drill bit A adapted to be raised and lowered through a tubular drill string B extending to a drilling rig (not shown), and by means of which torque is transmitted through the apparatus while drilling weight is applied thereto. The lower pin 10 of the tubular drill string is threadedly secured to a latch coupling sub 11, which is, in turn, threadedly attached to an outer tube or barrel 12 of a required length, the lower end of which is threadedly secured to a sub 13 threadted onto the upper portion of a drive mandrel or body 14 having a plurality of circumferentially spaced slots 15 opening downwardly through the lower end 16 of the body. Each slot 15 is defined by laterally outwardly tapering or converging sidewalls 15' (Fig. 6) and by an upper surface 17 inclined in a downward and outward direction (Figs. 1a, 2d).

The drilling apparatus A is raised and lowered through the drill string and into latched or coupled relation to the drive mandrel 14 on a tubular carrier member 18 consisting of a required number of sections threadedly attached to one another, the lower end of the carrier tube being threadedly attached to a terminal portion or bit 19 having circumferentially spaced laterally extending drive keys 20, each key being slidable within a longitudinal slot 21 in a flat carrier rod 22 depending from and integral with an upper orienting cam sleeve 23 which has downwardly converging V-shaped cams 24 providing tapered cam surfaces 25 adapted to coact with companion upwardly extending axial cam teeth 26 having corresponding cam surfaces 27, which are on the upper end of the drive mandrel 14.

The lower end 28 of each carrier rod fits within an inner groove 29 in a bit pad or cutter member 30, being suitably secured thereto as by welding or brazing. This bit pad or segment has diamond cutting elements 31 embedded in its outer receiving surface 32, as well as in its downwardly and inwardly tapering surface 33, and also in its end face 34, for the purpose of cutting the borehole. The upper end 35 of each bit pad is inclined in a downward and outward direction, being adapted to conform to the inclination of the upper end 17 of the slot into which it is moveable and with which it is engageable. It has an inwardly extending foot portion 36 adapted to be engaged
by the lower end 37 of the carrier shoe or pilot bit 19. Its sides 38 are tapered to engage with and conform to the tapered sides 16 of the bit slot 15 when expanded fully outwardly thereto into.

The drive keys 20 are slidable respectively upwardly along the carrier rod slots 21 to the upper portion of the orienting cam sleeve 24. The carrier rods, as described above, are integral with the orienting cam sleeve, being laterally deflectable with respect thereto by providing slots 39 at each side of the upper portion of each rod that separate the rod from the main portion of the sleeve itself (FIG. 7). Each rod has an outer cam tooth 40 suitably attached thereto that has cam surfaces 41 forming continuations of the orienting cam sleeve surfaces 25. Each carrier rod also has a laterally inwardly directed stop shoulder 42 which is engaged by a companion downwardly facing shoulder 43 on the pilot bit or backup member 19 during lowering of the apparatus through the drill string 8 and into the outer barrel 11, 12, 13 of the drilling apparatus, as described hereinbelow (FIGS. 1d, 2d, 7, 9).

The upper end of the carrier tube 18 is threadedly attached to an outer housing 45 of a swivel 46 of any suitable form. As disclosed, the swivel includes an inwardly directed housing flange 47 against which upper and lower bearings 48, 49 engage, the lower bearing engaging an upwardly facing shoulder 50 on a bearing stem 51, the upper bearing being engaged by a nut 52 threadedly attached to the upper end of the bearing stem. An inner core tube or barrel 53 has its upper end threadedly attached to the stem 51, this barrel being of the desired length for receiving a core produced by the cutters 30, its lower end being threadedly attached to a shoe 54 having an inner tapered surface 55 coacting with a suitable core lifter or catcher 56 for trapping the core in the inner barrel or tube. As the core is formed in the tube, any liquid therein can pass upwardly through a valve seat 57 secured within the bearing stem 51 by a lower split snapping retainer 58 fitting within a groove 59 in the stem. A ball check valve member 60 is disposed in a passage 61 in the stem above the seat, being movable by fluid upwardly from the latter to allow the fluid to flow through the seat and outwardly through a bleed port 62 in the stem, the ball moving downwardly into engagement with the seat 57 in the event that reverse fluid flow tends to occur.

The outer housing 45 of the swivel 46 is threadedly attached to an adapter coupling 63, which is, in turn, threaded into a latch body 64, these parts being firmly secured to each other by a locknut 65 threaded on the coupling 63 and bearing against the lower end of the latch body. This body has circumferentially spaced centering wings 66 secured thereto for centering the latch body within the coupling sub 11 of the outer barrel portion of the apparatus, this coupling sub having a circumferential internal latch groove 67 therein adapted to receive laterally shiftable latches 68 slidable in a transverse slot 69 in the latch body. The latches are urged outwardly by helical compression springs 70 acting between the oppositely facing latches, to snap the latches 68 into the lock groove 67 when aligned therewith.

The latches 68 are retractable from the groove 67 by the upward movement of a retracting rod 71 slidable longitudinally in the latch body 64 and having retracting pins 72 thereon disposed in slots 73 in the latches and adapted to engage tapered cam faces 74 forming one side of each slot 73. The retracting rod 71 is moved upwardly to effect retraction of the latches 68 by the groove 67 of the latch body having a suitable overshot (not shown) with a retracting head 75 attached to the retracting rod by a threaded connection 76, or the like.

The latch mechanism, per se, forms no part of the present invention. A similar retracting mechanism is illustrated and described in U.S. Pat. No. 3,437,159, referred to above.

The drive mandrel or body has longitudinal indentations of a suitably spaced 77 opening through the upper end thereof and downwardly into its slots 15, each groove having the same centerline as the V-shaped space formed by the mandrel cam teeth 26 and by the slots 15 (FIG. 8). On the other hand, the carrier rods 22 have their centerline in alignment with the centerline of the V-shaped cam teeth 40, 24 secured thereto and integral with the orienting cam sleeve 23, and are also centered with respect to the bit pads 30 (FIGS. 1d, 7). Thus, assuming the orienting cam sleeve 23, with the bit pads 30 secured to the rods 22, has its teeth 40, 24 fully meshed with the drive mandrel teeth 26, the rods 22 will be in alignment with the longitudinal grooves 77 and the pads 30 will be in alignment with the body slots 15, permitting outward expansion of the carrier rods 22 in the body grooves 77 and of the pads 30 into the slots 15.

In the operation of the apparatus illustrated in FIGS. 1 to 9, it is assumed that the drill string B, with the outer barrel 11, 12, 13 and drive mandrel 14 attached thereto, is disposed in a borehole with the lower end of the drive mandrel elevated a short distance above the bottom of the borehole. The mechanism A, with the bit pads or cutters 30 in retracted position and in the relationship disclosed in FIGS. 1a to 9, is then lowered through the drill string by means of a suitable overshot attached head 75, the bit pads 30 being disposed inwardly, as permitted by the inward deflection of the carrier rods 22, which maintain the cam teeth 40 attached thereto in a lateral inward position. During such lowering action, the lateral inward position of the carrier rods 22 locates their shoulders 42 under the companion downwardly facing shoulder 43 on the pilot bit or backup member 19, with the keys 20 disposed in the upper portion of the slots 21, as illustrated in FIG. 1d. Thus, the weight of the apparatus above the pilot bit 19 is transmitted through the pilot bit shoulder 43 to the carrier rods 22 to force such rods and the bit pads 30 downwardly through the drill string.

When the drive mandrel 14 is reached, the bit pads 30 will move into it and the cam teeth 40 on the carrier rods and the cam teeth 24 on the orienting cam sleeve 23 will then engage a companion cam teeth 26 on the mandrel, so as to turn the sleeve 23, carrier rods 22 and bit pads 30, as well as the carrier tube 18, rotationally secured thereto through the keys 20, into a position in which the carrier rods 22 are disposed opposite the longitudinal body grooves 77 and the bit pads 30 opposite the slots 15, at which time the cam teeth 40 secured to the outer surfaces of the carrier rods 22 are disposed opposite a downwardly and outwardly inclined inner wall 80 of the orienting tube sub 13, providing a recess into which the cam teeth 40 can expand, permitting the carrier rods 22 to expand fully into the longitudinal grooves 77 and the bit pads 30 to expand fully outwardly into the mandrel slots 15. The outward expansion of the cam teeth 40 into the recessed slot 15 of the outer barrel 11 removes the carrier rod shoulders 42 from under the pilot bit shoulder 43, which then allows the carrier tube 18, core barrel 53 therewithin, and locking mechanism 63-75, disposed thereabove to move downwardly with the keys 20 sliding along the slots 21 until the pilot bit 19 is disposed in its lowestmost position, with its end 37 engaging the tapered inner surfaces 81 of the bit pads and the tapered stop shoulder 82 on the drive mandrel 14. At this time, the outer longitudinal surface 83 of the pilot bit is disposed behind the inner longitudinal surfaces 84 of the rods 22, retaining the bit pads 30 in snug engagement with the drive mandrel 14, with the upper drilling weight surfaces 35 of the bit pads engaging the tapered surfaces 17 of the drive mandrel, and with the tapered sides 38 of the bit pads snugly engaging the companion tapered sides 16 of the mandrel slots 15. At this time, the outer reaming faces 32 of the bit pads are disposed laterally outwardly of the inner reaming faces 26 of the drive mandrel, and of the bit pads being disposed below the lower end 16 of the drive mandrel and also laterally outwardly of the tapered lower surface 316 of the drive mandrel (FIG. 2d, 6).

The drive mandrel 14 and the bit pads 30 form an entry throat 85 into which a core formed by the bit cutters 30 can move upwardly into the internal core barrel 33. However, the backup member 19 is formed as a bit to reduce the diameter of the core formed by the bit pads for entry into the core barrel. Thus, the pilot bit has diamond cutting elements 31a on its inner reaming face 86, as well as on its end face 87, to perform a cutting action on the formation.
When the carrier tube 18 has reached its lowermost position within the outer barrel, as disclosed in FIGS. 2a to 2d, the latches 68 are aligned with the groove 67 in the coupling sub 11, the springs 70 expanding such latches outwardly, and thereby retaining the parts in their relative relation illustrated in FIGS. 2a to 2d.

The drill string B is rotated at the desired speed and appropriate drilling weight is applied to the bit portion of the apparatus secured to the drill string, so as to penetrate the bit pads or cutters 30, as well as the pilot bit 19, into the formation. During this action, drilling fluid is circulated down the drill string, passing around the exterior of the latch body 64 and through the annular space 88 between the carrier tube 18 and outer barrel 11, 12 to the lower portion of the carrier tube, where the fluid can flow inwardly through one or more fluid bypass holes or ports 89 into the annular space 90 between the carrier tube and the inner core barrel 53, the fluid flowing downwardly through such space and through the passageway 91 provided between the pilot bit 19 and the shoe 54 (FIGS. 1d, 3, 4), and then into the throat of the pilot bit, the fluid removing the cuttings from the bottom of the hole, as well as cleaning the pilot bit 19 and the bit pads 30, and flushing the cuttings laterally outwardly for upward passage along the upper portion of the outer tube 14, 13, 12, 11 and the drill string B back to the drilling rig.

During the drilling action, the drilling weight is imposed directly from the drive mandrel 14 through the shoulders 17 onto the bit pads 30, the drilling torque being transmitted directly from the sides 16 of the mandrel slots 15 to the bit pads 30. All parts rotate, with the exception of the inner core barrel 53 and its associated parts, because of the presence of the swivel 46, the core passing relatively upwardly into the core barrel 53 as cutting of the annular portion of the borehole proceeds.

When the core is to be removed, a suitable overhot is lowered on a wire line through the drill string B into coupling relation to the head 75. An upper pulld is then taken on the wire line, which will elevate the retracting head 71, causing the retracting pins 72 to engage the inclined latched surfaces 74 and retract the latches 68 laterally inwardly from the groove 67, whereupon the upper pulld on the wire line is continued. Such upper pulld and movement elevates the carrier tube 18 and inner barrel 53, causing the core catcher 56 to engage and break off the core from the hole bottom. Elevation of the carrier tube 18 moves the pilot bit 19 upwardly from its position behind the bit pads or cutters 30, the keys 20 sliding upwardly in the grooves until they reach the upper portion of the slots 21, whereupon they will elevate the orienting cam sleeve 23 and the carrier rods 22, the upward pull of the latter being transmitted to the bit pads 30 which are shifted inwardly by the tapered shoulders 17, 35, as permitted by the flexibility of the carrier rods 22, the parts then being in condition for complete withdrawal of the drive mandrel 14, outer barrel 11, 12, 13 and drill string B to the top of the borehole. During such upward movement, the core lifter or trap ring 56 has moved relatively downwardly against the tapered surface 55 of the shoe 54, wedging the lifter inwardly into firm engagement with the core to prevent it from dropping out of the barrel 53.

At the drilling rig, the core can be removed and the parts of the apparatus inspected. The same apparatus, including the bit pads 30 and bit 19, if not worn, can then be reinserted through the drill string B and the foregoing cycle of operation repeated. If the pads 30 or bit 19 are worn excessively, they can be replaced.

The specific embodiment of the invention illustrated in FIGS. 10 to 15 is generally the same as that described above. However, modifications have been made in the orienting mandrel cam 26a, and in the bit pads or cutters 30a, which are of much larger circumferential and lateral extent, to provide a much greater surface area for action on the formation, and also to eliminate the need for a pilot bit to cut the inner portion of the formation inwardly of the bit pads, as in the other embodiment of the invention. Moreover, in place of a pilot bit, a drive and backup foot 19a is provided having the drive keys 20a which ride in the longitudinal slots 21 in the carrier rod 22 and in the orienting cam sleeve 23. The slots 15a of the mandrel 14a are wider than in the other form of the invention having a lower portion 15b with sides 16a, 16b that taper laterally outwardly toward each other, the intervening legs 100 defining the mandrel slots 15a. Each leg has a driving leading face 16a engageable with a companion side 38a of a bit pad to transmit torque therewith, and also has a lower trailing portion 15b spaced from the upper tapered end 17 of the slot which is engageable with the lower leading side 38b of the bit pad, the bit pad having an upper leading portion 30c overlapping the trailing portion 100a of the leg and fitting within an upper extension 15c of the slot. Each bit pad 30a is shaped to conform to the slot 15a, the pad having an end face 105 which merges into an upwardly inclined face 106, which, in turn, merges into a reaming face 107 of the pad, the reaming bit face extending from the drive side 16b of the body slot 15a to the opposite end of the offset slot portion 15c. When the cutters 30a are disposed in the mandrel slots 15a circumferentially spaced depending lugs 108 on the carrier tube 18, foot 19a extend between the lower portions of the bit pads 30a, the lower ends of the legs being disposed to above the end faces 105 of the bit pads 30a in sides. The bit pads also have inner reaming faces 110 which extend radially inwardly beyond the inner surfaces of the lugs 108 and of the throat 111 of the drive foot so as to determine the outside diameter of the core being produced. The faces 105, 106, 107, 110 of each bit pad have diamond cutting elements 31 embedded therein.

The lower ends 28 of the carrier rods 22 are secured to the inner portions of the bit pads 30a, in the same manner as the other form of the invention, the orienting cam sleeve 23 and the cam teeth 40 on the carrier rods 22 being the same as in the other form of the invention and being adapted to engage with the mandrel cam surfaces 27 in the same manner, to orient the carrier rods 22 and bit pads 30a with the mandrel grooves 77 and the mandrel slots 15a. When the cam teeth 26a, 40, 24 are fully engaged, the carrier tube 18 and its drive foot 19a, together with the inner core barrel 53, are lowered with the mechanism theretobrave, to bring the carrier tube and its drive foot to its lowermost position (FIG. 11) in which the drive rod 19a is disposed behind the bit pads or cutters 30a with its lugs 108 located between the lower portions of the bit pads or cutters, the drive foot having an end shoulder 115 between its lugs engaging upwardly directed transverse faces 116 on the cutters, thereby firmly locking the bit pads 30a in their outwardly expanded position, and the upper ends 21a of the slots engaging the upper tapered end 17 of the mandrel slots 15a and with the trailing side of each bit pad engaging the side 16b of its companion slot, the offset portions 30c of the bit pads being located within the offset portions 15c of the slots. The lower leading side 38b of each bit pad is disposed in engagement with the opposite edge 15a of its slot, and is also located closely adjacent to a drive lug 108 (FIGS. 13, 14). At this time, the lower drilling faces 105 of the bit pads are disposed below the lower end of the mandrel 14a and the drive lugs 108, with the tapered faces 106 of the bit pads and their reaming faces 107 being disposed outwardly of the corresponding surfaces of the drive mandrel 14a.

When it is desired to retrieve the apparatus from the drive mandrel 14a and outer barrel 11, 12, 13, the head 75 is elevated, as in the other form of the invention, by an overhot connected to a wire line, to retract the latches 68 from their lock groove 67 and elevate the core barrel 53 and carrier tube 18, until the drive keys 20a engage the oriented sleeve 23 at the top of the slots 21, the drive foot 19a also having been elevated from the bit pads 30. The upward motion of the carrier tube foot 19a then elevates the cam sleeve 23 and its arms or rods 22 to urge the bit pads 30a upwardly, which will be shifted inwardly by the engagement of the bit pads 30a with the tapered surfaces 25 with the tapered surfaces 17 of the mandrel 14a. Because of the substantial arcuate extent of the bit pads 30a and their overlapping relation when in a retracted
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7 position, as disclosed in Fig. 12, it is necessary to turn them so that the portions riding along the inner wall of the drive mandrel 14a will be appropriately aligned with the mandrel grooves. Accordingly, the mandrel has a second set of inclined or cam surfaces 120, disclosed most clearly in Fig. 15, extending in an upward direction from the side of one groove 77 to the side of an adjacent groove 77. The bit pads 35a will engage the surfaces 120, which will turn the bit pads sufficiently to bring their outermost portions into alignment with the mandrel grooves 77, through which they will pass and thereby become fully released from the mandrel 14a. Elevation of the apparatus can continue to withdraw the apparatus through the drill string to the drilling rig.

The bit pads in the form of invention illustrated in Figs. 10 to 15 are of a greater arcuate extent than in the other form of the invention, and have a much larger surface presented for cutting action on the formation. In fact, as disclosed in Fig. 14, the inner portion of the drilling faces of the bit pads together cover almost 360°, which obviates the necessity for providing an additional inner bit for cutting the inner portion of the formation, which is true of the other embodiment of the invention. In addition, the remaining drilling surfaces 105, 106, 107 of the bit pads, as well as their reaming surfaces 107, have greatly increased as compared to the other form of the invention.

We claim:

1. Retrieval drill bit apparatus adapted to be moved longitudinally through a tubular drilling string disposed in a borehole: an outer structure adapted to be secured to the drilling string and including a drive mandrel; cutter means comprising a plurality of expandable and retractable cutters; a carrier supporting said cutter means and in telescopic relation thereto, said carrier supporting said cutter means with said cutters in full retracted position for movement within the drilling string and mandrel; coengageable orienting means on said mandrel and cutters for securing said cutters to said mandrel with said cutters in expanded position; and coengageable coupling means on said mandrel and cutters for securing said cutters to said mandrel with said cutters in expanded position; and coengageable orienting means on said cutter means and outer structure to orient said cutters for simultaneous lateral outerward expansion from fully retracted position into coupled relation to said mandrel; said carrier being movable downwardly of said cutter means to a position retaining said cutters expanded outwardly and coupled to said mandrel.

2. Retrieval drill bit apparatus adapted to be moved longitudinally through a tubular drilling string disposed in a borehole: an outer structure adapted to be secured to the drilling string and including a drive mandrel; cutter means comprising a plurality of expandable and retractable cutters; a carrier supporting said cutter means and in telescopic relation thereto, coengageable orienting means on said mandrel and cutters for securing said cutters to said mandrel with said cutters in expanded position; and coengageable orienting means on said cutter means and outer structure to orient said cutters for simultaneous lateral outerward expansion from coupled relation to said mandrel; said carrier being movable downwardly of said cutter means to a position retaining said cutters expanded outwardly and coupled to said mandrel; said coengageable orienting means also limiting downward movement of said cutter means in said outer structure.

3. Retrieval drill bit apparatus adapted to be moved longitudinally through a tubular drilling string disposed in a borehole: an outer structure adapted to be secured to the drilling string and including a drive mandrel; cutter means comprising a plurality of expandable and retractable cutters; a carrier supporting said cutter means and in telescopic relation thereto; coengageable coupling means on said mandrel and cutters for securing said cutters to said mandrel with said cutters in expanded position; and coengageable orienting means on said cutter means and outer structure to orient said cutters for simultaneous lateral outerward expansion from coupled relation to said mandrel; said carrier being movable downwardly of said cutter means to a position retaining said cutters expanded outwardly and coupled to said mandrel; said cutter means including an upper cam sleeve having said orienting means thereon, circumferentially spaced laterally shiftable arms secured to and depending from said sleeve, the lower portions of said arms being secured to said cutter.

4. Retrieval drill bit apparatus as defined in claim 3; said coengageable orienting means limiting downward movement of said cutters and locating said cutters for lateral expansion into coupling engagement with said mandrel.

5. Retrieval drill bit apparatus as defined in claim 3; said coengageable orienting means limiting downward movement of said cutters and locating said cutters for lateral expansion into coupling engagement with said mandrel, said mandrel having longitudinal grooves into which said arms move upon lateral outward expansion of said arms and cutters.

6. Retrieval drill bit apparatus as defined in claim 3; said arms having longitudinal slots; said carrier having keys slidable in said slots and engageable with said cam sleeve at the upper ends of said slots to elevate said cutter means in said outer structure and upwardly through the drilling string.

7. Retrieval drill bit apparatus as defined in claim 3; said coengageable orienting means limiting downward movement of said cutters and locating said cutters for lateral expansion into coupling engagement with said mandrel, said arms having longitudinal slots; said carrier having keys slidable in said slots and engageable with said cam sleeve at the upper ends of said slots to elevate said cutter means in said outer structure and upwardly through the drilling string.

8. Retrieval drill bit apparatus as defined in claim 3; said coengageable orienting means limiting downward movement of said cutters and locating said cutters for lateral expansion into coupling engagement with said mandrel, said arms having longitudinal slots; said carrier having keys slidable in said slots and engageable with said cam sleeve at the upper ends of said slots to elevate said cutter means in said outer structure and upwardly through the drilling string; said mandrel having longitudinal grooves into which said arms move upon lateral outward expansion of said arms and cutters.

9. Retrieval drill bit apparatus as defined in claim 3; said arms having longitudinal slots; said carrier having keys slidable in said slots and engageable with said cam sleeve at the upper ends of said slots to elevate said cutter means in said outer structure and upwardly through the drilling string; said carrier projecting laterally inwardly of said cutters to drill an inner portion of the borehole when disposed in its position retaining said cutters laterally outwardly.

10. Retrieval drill bit apparatus as defined in claim 1; said cutters being in circumferential overlapping relation when retracted within said mandrel.

11. Retrieval drill bit apparatus as defined in claim 3; said coengageable orienting means limiting downward movement of said cutters and locating said cutters for lateral expansion into coupling engagement with said mandrel; said cutters being in circumferential overlapping relation when retracted within said mandrel.

12. Retrieval drill bit apparatus as defined in claim 3; said arms having longitudinal slots; said carrier having keys slidable in said slots and engageable with said cam sleeve at the upper ends of said slots to elevate said cutter means in said outer structure and upwardly through the drilling string; said cutters being in circumferential overlapping relation when retracted within said mandrel.

13. Retrieval drill bit apparatus adapted to be moved longitudinally through a tubular drilling string disposed in a borehole: an outer structure adapted to be secured to the drilling string and including a drive mandrel; cutter means comprising a plurality of expandable and retractable cutters; a carrier supporting said cutter means and in telescopic relation thereto; said mandrel having circumferentially spaced slots opening to the exterior of said mandrel and into which said cutters are expandable; and coengageable orienting means on said cutter means and outer structure to orient said cutters in alignment with said slots for outward expansion thereof and in coupling relation to said mandrel; said carrier being movable...
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ble downwardly of said cutter means to a position behind said cutters to retain said cutters outwardly in said slots and coupled to said mandrel, said coengageable orienting means also limiting downward movement of said cutter means in said slots.

15. Retrievable drill bit apparatus adapted to be moved longitudinally through a tubular drilling string disposed in a borehole: an outer structure adapted to be secured to the drilling string and including a drive mandrel, cutter means comprising a plurality of expandable and retractable cutters; a carrier supporting said cutter means and in telescopic relation thereto; said mandrel having circumferentially spaced slots into which said cutters are expandable, and coengageable orienting means on said cutter means and outer structure to orient said cutters in alignment with said slots for outward expansion thereinto and in coupling relation to said mandrel; said carrier being movable downwardly of said cutter means to a position behind said cutters to retain said cutters outwardly in said slots and coupled to said mandrel; said coengageable orienting means also limiting downward movement of said cutter means in said slots.

16. Retrievable drill bit apparatus as defined in claim 15, said coengageable orienting means limiting downward movement of said cutters and locating said cutters for lateral expansion into said mandrel slots.

17. Retrievable drill bit apparatus as defined in claim 15, said coengageable orienting means limiting downward movement of said cutters and locating said cutters for lateral expansion into said mandrel slots; said mandrel having longitudinal grooves into which said arms are expandable, and coengageable orienting means on said cutter means and outer structure to orient said cutters in alignment with said slots for outward expansion thereinto and in coupling relation to said mandrel; said carrier being movable downwardly of said cutter means to a position behind said cutters to retain said cutters outwardly in said slots and coupled to said mandrel; said carrier having keys slidable in said arm slots and engageable with said cam sleeve at the upper ends of said arm slots to engage said cutter means in said outer structure and upwardly through the drilling string.

18. Retrievable drill bit apparatus as defined in claim 15; said arms having longitudinal slots; said carrier having keys slidable in said arm slots and engageable with said cam sleeve at the upper ends of said arm slots to elevate said cutter means in said outer structure and upwardly through the drilling string.

19. Retrievable drill bit apparatus as defined in claim 15, said coengageable orienting means limiting downward movement of said cutters and locating said cutters for lateral expansion into said mandrel slots; said arms having longitudinal slots; said carrier having keys slidable in said arm slots and engageable with said cam sleeve at the upper ends of said arm slots to elevate said cutter means in said outer structure and upwardly through the drilling string.

20. Retrievable drill bit apparatus as defined in claim 15, said coengageable orienting means limiting downward movement of said cutters and locating said cutters for lateral expansion into said mandrel slots; said arms having longitudinal slots; said carrier having keys slidable in said arm slots and engageable with said cam sleeve at the upper ends of said arm slots to elevate said cutter means in said outer structure and upwardly through the drilling string; said mandrel having longitudinal grooves into which said arms move upon lateral outward expansion of said arms and cutters.

21. Retrievable drill bit apparatus as defined in claim 13; said cutters being in circumferential overlapping relation when retracted within said mandrel.

22. Retrievable drill bit apparatus as defined in claim 15; said cutters being in circumferential overlapping relation when retracted within said mandrel.

23. Retrievable drill bit apparatus as defined in claim 3; said coengageable orienting means limiting downward movement of said cutters and locating said cutters for lateral expansion into said mandrel slots; said mandrel having longitudinal grooves into which said arms move upon lateral outward expansion of said arms and cutters; said cutters being in circumferential overlapping relation when retracted within said mandrel; said outer structure having cam means engaged by said cutters upon elevation of said cutter means in said outer structure to orient said overlapping cutters with said longitudinal grooves to permit passage of a portion of said cutters through said grooves.

24. Retrievable drill bit apparatus as defined in claim 15, said coengageable orienting means limiting downward movement of said cutters and locating said cutters for lateral expansion into said mandrel slots; said mandrel having longitudinal grooves into which said arms move upon lateral outward expansion of said arms and cutters; said cutters being in circumferential overlapping relation when retracted within said mandrel; said outer structure having cam means engaged by said cutters upon elevation of said cutter means in said outer structure to orient said overlapping cutters with said longitudinal grooves to permit passage of a portion of said cutters through said grooves.

25. Retrievable drill bit apparatus as defined in claim 3; said cutter means including an upper cam sleeve having said orienting means thereon, circumferentially spaced laterally shiftable arms secured to and depending from said sleeve, the lower portions of said arms being secured to said cutter means when retracted within said mandrel, said position behind said cutters to retain said cutters outwardly in said slots and coupled to said mandrel, said coengageable orienting means also limiting downward movement of said cutter means when retracted within said mandrel.

26. Retrievable drill bit apparatus adapted to be moved longitudinally through a tubular drilling string disposed in a borehole: an outer structure adapted to be secured to the drilling string and including a drive mandrel; cutter means comprising a plurality of expandable and retractable cutters; a carrier supporting said cutter means and in telescopic relation thereto; said mandrel having circumferentially spaced slots into which said cutters are expandable, and coengageable orienting means on said cutter means and outer structure to orient said cutters in alignment with said slots for outward expansion thereinto and in coupling relation to said mandrel; said carrier being movable downwardly of said cutter means to a position behind said cutters to retain said cutters outwardly in said slots and coupled to said mandrel; said mandrel having longitudinal grooves into which said arms move upon lateral outward expansion of said arms and cutters; said cutters being in circumferential overlapping relation when retracted within said mandrel; said outer structure having cam means engaged by said cutters upon elevation of said cutter means in said outer structure to orient said overlapping cutters with said longitudinal grooves to permit passage of a portion of said cutters through said grooves.

27. Retrievable drill bit apparatus adapted to be moved longitudinally through a tubular drilling string disposed in a borehole: an outer structure adapted to be secured to the drilling string and including a drive mandrel; cutter means comprising a plurality of expandable and retractable cutters; a carrier supporting said cutter means and in telescopic relation thereto; said mandrel having circumferentially spaced slots into which said cutters are expandable, and coengageable orienting means on said cutter means and outer structure to orient said cutters in alignment with said slots for outward expansion thereinto and in coupling relation to said mandrel; said carrier being movable downwardly of said cutter means to a position behind said cutters to retain said cutters outwardly in said slots and coupled to said mandrel; said mandrel having upper circumferentially offset portions; said cutters having offset portions fitting snugly within said offset portions of said slots.