United States Patent

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[54] **METHOD AND APPARATUS FOR DRILLING IN CASING FROM THE TOP OF A BOREHOLE**
8 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **175/260**
[51] **Int. Cl.** **F21b 9/26**
[50] **Field of Search** 175/57, 171, 260, 261, 258

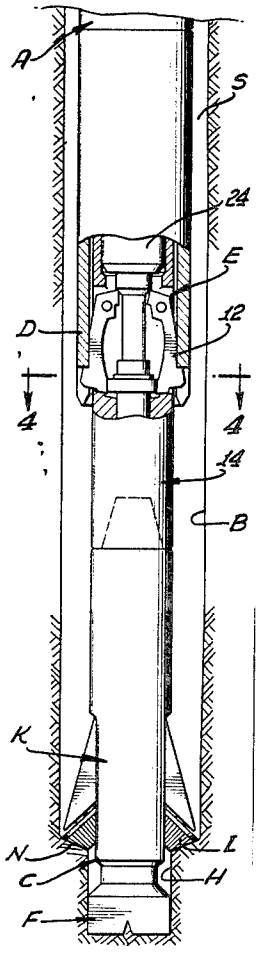
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ABSTRACT: Apparatus and method for drilling in casing at the top of a borehole, such as drilling a borehole commencing at an ocean floor, including inserting a retrievable coupling device in a casing shoe aboveground and expanding the coupling members of the device into shoe slots to secure the coupling device to the shoe, a bit being secured to the coupling device with expandable cutters to drill a borehole larger than the outside diameter of the casing or casing pile. The shoe is then secured to a casing section or sections thereabove and the casing string lowered to bring the bit against the top of the formation, or ocean floor, where drilling of the borehole is to commence. The casing string is rotated, drilling weight being applied to the casing string and through the coupling device to the bit, and drilling fluid pumped down the casing string to remove the cuttings from the bottom of the borehole being produced. When the borehole has been drilled to the required depth, the coupling members are retracted from the shoe slots, and the assemblage of coupling device and bit, with its cutters retracted, elevated through the casing string and withdrawn therefrom at the top of the finished borehole. The casing string or piling remains in the borehole and can be cemented in place therein.



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SHEET 1 OF 2

FIG. 1.

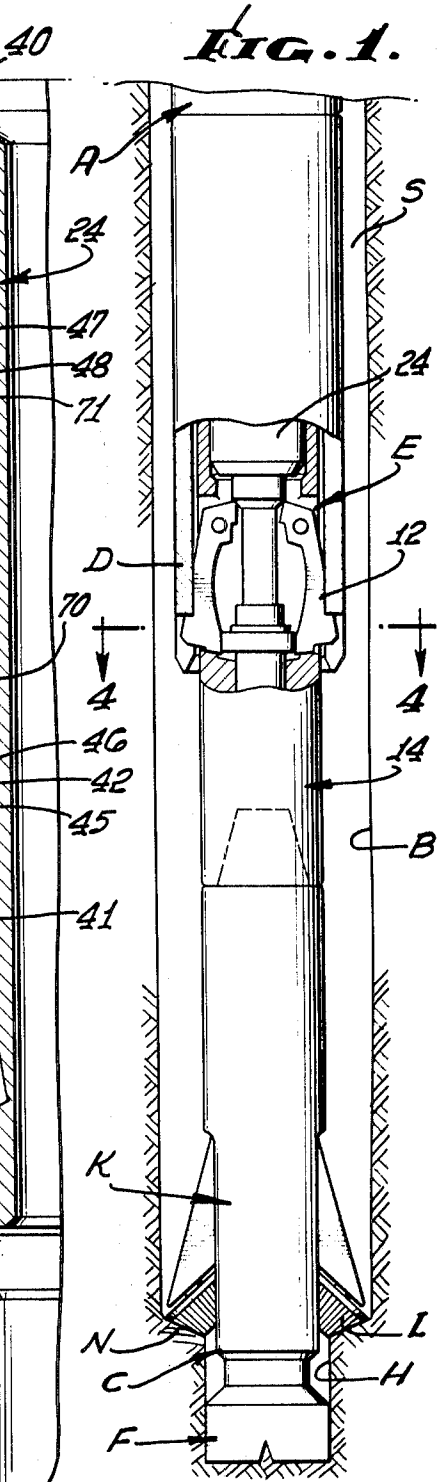


FIG. 2b.

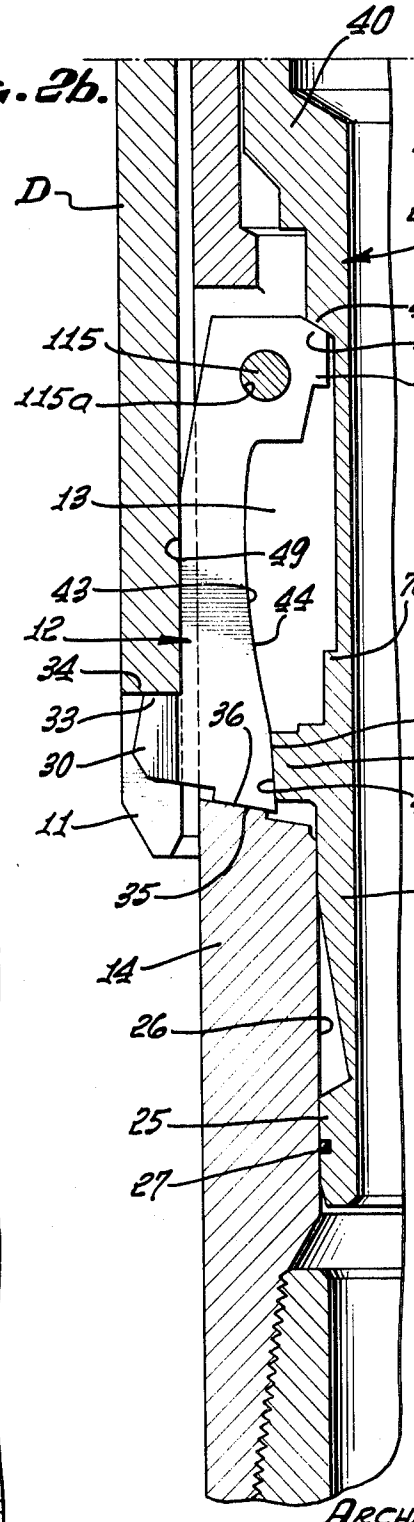
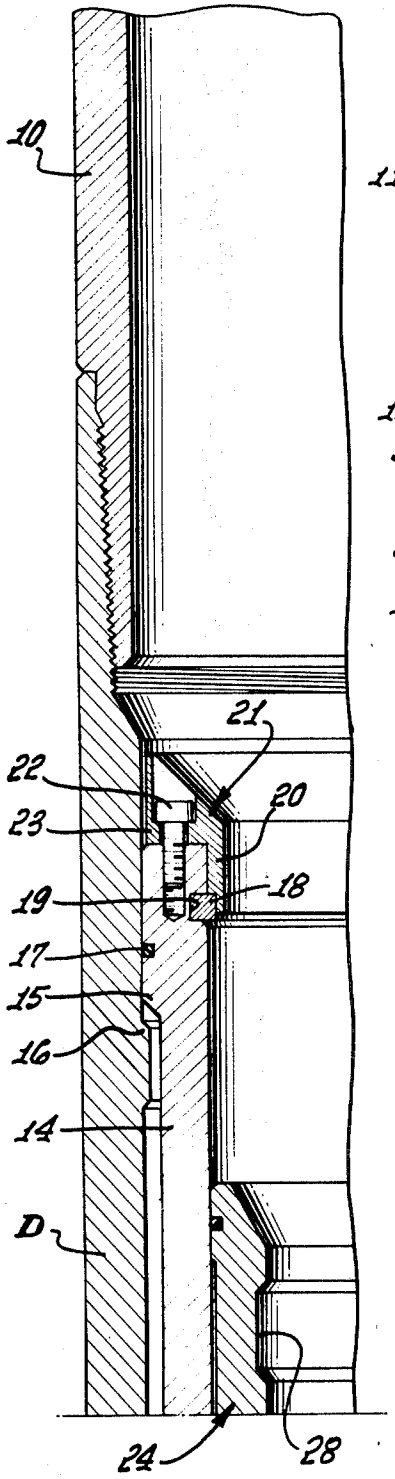


FIG. 2a.



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FIG. 3a.

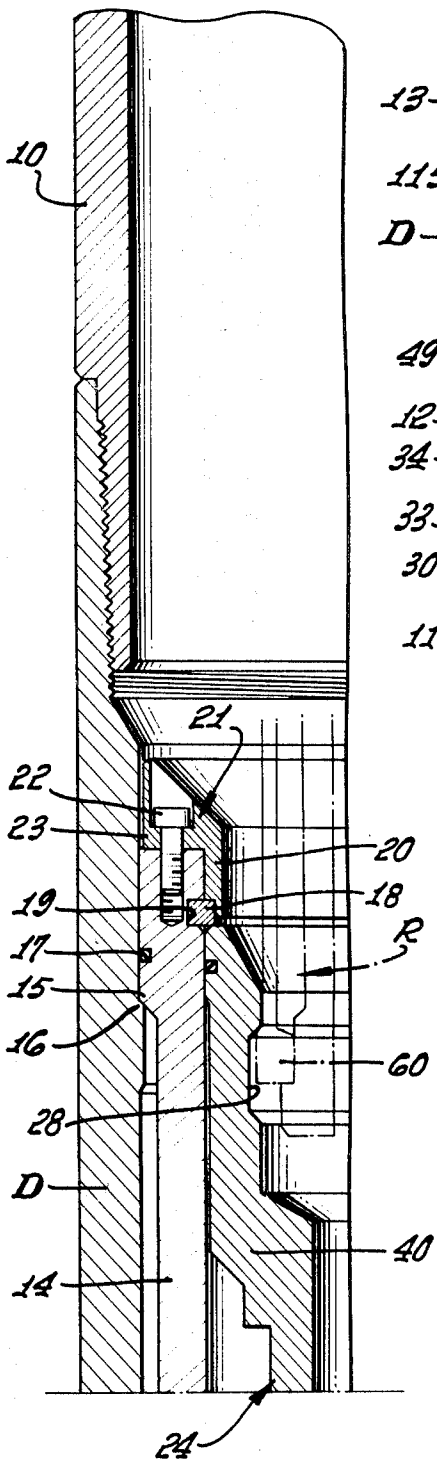


FIG. 3b.

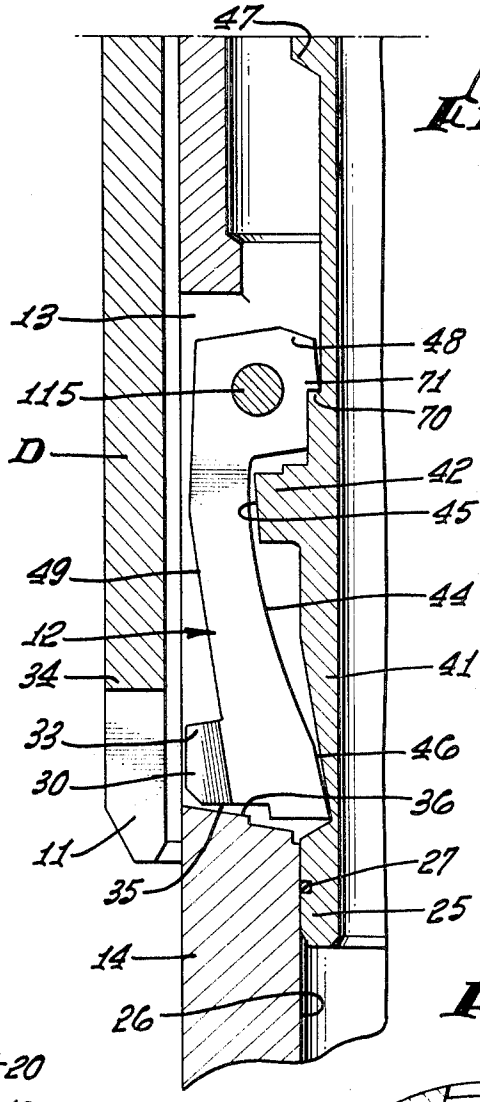
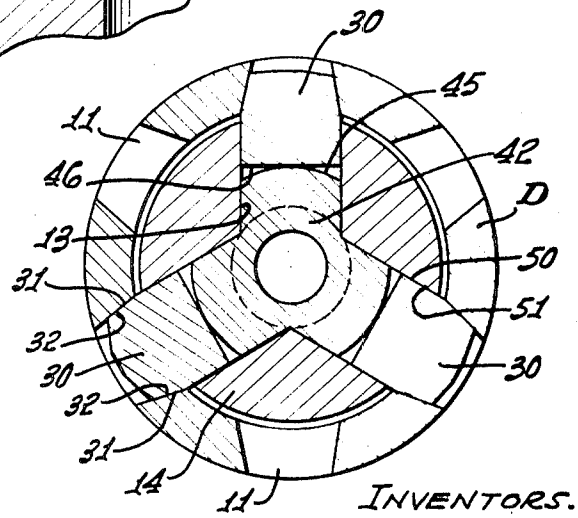


FIG. 4.



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METHOD AND APPARATUS FOR DRILLING IN CASING FROM THE TOP OF A BOREHOLE

The resent invention relates to apparatus and methods for drilling in casing at the top of a borehole, using the casing as the rotary drilling string.

Apparatus has been proposed for drilling a borehole, such as a well bore, using a casing string that is to remain in the well bore as the drilling string. By way of example, such apparatus is illustrated and described in U.S. Pat. No. 3,123,160. Although the various forms of apparatus disclosed therein are desirable, they are relatively costly to produce since their manner of use requires many parts for effecting running of the apparatus into the casing string, coupling it thereto, and then retrieving it through the casing string after the drilling operation in the well bore has been completed, or the cutters of the drill bit portion of the apparatus have become dull, requiring their replacement before drilling can proceed.

The present invention provides apparatus for drilling a borehole, as downwardly from an ocean floor, that is much simpler and less costly than the prior art devices, where a string of surface casing or a casing pile is to be placed in a borehole of relatively short extent, which, for example, may be of the order of 100 to 500 feet extending downwardly from the top of the borehole. In general, a coupling apparatus with a bit connected thereto is releasably secured or coupled to the lower end of a casing string, and the casing string with the apparatus and bit connected thereto then lowered to engage the bit cutters with the top of the formation or subsea floor, where the casing string is rotated to rotate the cutters and commence the drilling of the borehole, which continues downwardly until the desired depth of hole is reached. Thereafter, the coupling device is released from the casing string to enable it, together with the drilling bit attached thereto, to be withdrawn through the casing string to the top of the borehole. With apparatus embodying the present invention, it is not necessary to provide any mechanism for orienting the coupling mechanism with associated parts of the casing string in order to lock the coupling mechanism thereto. As a practical matter, a coupling mechanism and a drilling bit of the expansible type cannot be lowered through the casing string and latched or locked in position within a casing shoe, as in U.S. Pat. No. 3,123,160. The only provision made is for retrieving the coupling device and drill bit, or other apparatus connected thereto, through the casing string to the top of the borehole. Accordingly, the apparatus is much simpler than prior devices, and is correspondingly less costly to manufacture.

In addition to the foregoing advantages of the invention, the apparatus need not make any provision for effecting its coupling to the casing shoe while the casing string and its shoe are in a borehole, which enables the apparatus to have a comparatively large diameter, straight-through fluid passage for the flow of drilling fluid. This is to be compared with restrictions in the passage of the apparatus illustrated in U.S. Pat. No. 3,123,160. In addition, there is no need for effecting any orienting of the coupling members of the coupling device with companion slots, or the like, in the shoe of the casing string, further enabling simplification of the apparatus, its manufacturing cost, and maintenance cost.

The invention further contemplates a method of drilling in casing or casing piles from the top of the well bore by securing the retrievable coupling and bit attached thereto to the shoe of the casing above ground, as on the drilling rig, after which the casing string, with the coupling and bit attached thereto, is lowered and the drilling of the borehole commenced at the ground surface, the coupling mechanism and drill bit being retrieved only after the borehole has been drilled to the required depth, which, for example, may be from about 100 to about 500 feet, the casing string remaining in the borehole.

This invention possesses many other advantages and has other purposes which may be made more clearly apparent from a consideration of a form and method embodying the invention. This form and method are shown and described in the present specification and in the drawings accompanying and constituting a part thereof. They 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:

FIG. 1 is a side elevational view of the apparatus disposed in a well bore, parts being disclosed in longitudinal section;

FIGS. 2*a* and 2*b* together constitute an enlarged quarter sectional view of the coupling portion of the apparatus latched to the above of the casing string, FIG. 2*b* being a lower continuation of Fig. 2*a*;

FIGS. 3*a* and 3*b* are views corresponding to Figs. 2*a* and 2*b*, with the coupling portion of the apparatus released from the casing shoe; and

FIG. 4 is enlarged cross section taken on the line 4—4 of Fig. 1.

As disclosed in the drawings, an apparatus is provided for the purpose of drilling in casing or casing piling A in the formation through use of the string of casing A as a rotary drill string, the casing remaining in the hole B produced by the apparatus and cemented therein after the hole has been drilled to the desired depth. Drilling apparatus C is releasably locked to a casing shoe D by a coupling apparatus E, the drilling apparatus extending downwardly therefrom, and including a pilot bit F for drilling the central portion H of the borehole, and an expandable type of drill bit K connected to the pilot bit, or integral therewith, and having expandable cutters L thereon which will enlarge the size of the hole B to the desired final diameter. The casing A, with the coupling E, expandable bit K and pilot bit F secured thereto, is assembled above ground, the assemblage being lowered to the formation to commence drilling of the borehole therein, in which the casing string A is to remain. After the hole has been drilled to its final depth, the coupling apparatus E, expandable bit K and pilot bit F are withdrawn through the interior of the casing to the top of the hole.

The expandable bit K may be of any suitable type, capable of being moved through the interior of the casing string A and to have its normally retracted cutters L expanded outwardly outwardly to the effective cutting diameter required to enlarge the hole H produced by the pilot bit F, the cutters disclosed being capable of drilling upon a formation shoulder N extending between the wall of the pilot hole H and the wall of the final diameter hole B. By way of example, the expandable drill bit may be of the specific form illustrated in U.S. Pat. No. 2,758,819.

The lower end of the casing string A is constituted by the tubular shoe D, the upper end of which is threadedly secured to the lower end of an adjacent casing section 10 forming part of the casing string extending to a rotary drilling rig (not shown) at the top of the borehole, or disposed on a drilling vessel (not shown) thereabove floating in an ocean or other body of water. The lower portion of the shoe is provided with a plurality of circumferentially spaced slots 11 opening downwardly through its lower end, in which expandable and retractable coupling members 12 of the coupling apparatus are adapted to be received. These coupling members are disposed in circumferentially spaced, elongate slots 13 in the body portion 14 of the coupling apparatus, being pivotally mounted on hinge pins 115 extending across the slots and suitably secured to the body. The maximum external diameter of the body 14 is less than the minimum inside diameter through the casing string A, so that the body 14 and the entire coupling apparatus E itself, together with the expandable drill bit K and pilot bit F, can be raised through the casing string in connection with removal of the apparatus to the drilling rig at the top of the bore hole, or on the drilling vessel.

The upper portion of the body has an external flange 15 engageable with an upwardly facing shoulder 16 in the shoe to limit downward movement of the body 14 in the shoe, the coupling members 12 then being in a position for alignment

with the slots 11. Leakage of fluid between the body and shoe is prevented by a suitable elastomer side seal 17 on the body sealingly engaging the inner wall of the shoe D. The body carries a two-piece abutment ring 18 held in an internal circumferential groove 19 in the body by the depending skirt 20 of a retainer member 21 secured to the body 14 by a plurality of capscrews 22 extending through a retainer flange 23 and threaded into the upper end of the body 14.

The stop ring 18 determines the upper limit of movement of a longitudinally shiftable tubular plunger or mandrel 24 within the main body 14, the mandrel extending downwardly from the stop ring to a position across the body slots 13 and terminating in a lower head 25 slidable in a central cylindrical bore 26 of the body, leakage of fluid between the head and the cylindrical bore being prevented by a suitable side seal ring 27 on the head engaging the body wall. The mandrel has a circumferential internal groove 28 in its upper portion adapted to receive a suitable retrieving tool apparatus R (FIG. 3*a*) used for releasing the coupling apparatus E from the casing shoe D and for elevating it, together with the expandable bit K and pilot bit F secured to its lower portion, through the casing string A to the top of the well bore B. By way of example, the retrieving tool apparatus that can be used is illustrated and described in U.S. Pat. application Ser. No. 788,162, filed Dec. 31, 1968, now U.S. Pat. No. 3,545,553.

Each coupling or lock member 12 has a lower projecting lug portion 30 whose sides 31 (Fig. 4) converge toward each other in a lateral outward direction, being adapted for engagement with companion tapered sides 32 in one of the casing slots 11 when the coupling or lock member lug 30 is expanded outwardly into such slot. When expanded outwardly, the upper end 33 of the lug engages a companion shoulder 34 defining the upper end of the shoe slot 11, and, at this time, a lower thrust surface 35 on the inner portion of the coupling member 12 engages a companion stop or thrust surface 36 defining the outer lower portion of the body slot 13 in which the lock member 12 is located.

The coupling members 12 are expanded outwardly prior to connection of the casing shoe D to the casing string A thereabove, by aligning the coupling member lugs 30 with respect to the shoe slots 11 and then moving the tubular plunger or mandrel 24 downwardly within the body 14 of the tool. Such alignment takes place upon engagement of the body flange 15 with the shoe shoulder 16 (Fig. 3*a*), and by then turning the body 14 within the shoe until the coupling members are substantially aligned with the shoe slots 11, permitting their lug portions 30 to be projected outwardly thereinto. The mandrel 24 includes an upper portion 40 of relatively large external diameter slidable within the upper portion of the body 14, and a smaller diameter portion 41 extending within the coupling members and terminating in the lower head 25. Above the lower head, the mandrel is provided with an expander 42 disposed initially within recesses 43 in the coupling members below the hinge pins 115, the expander being engageable with inclined inner surfaces 44 on the coupling members for the purpose of expanding the latter outwardly upon downward movement of the mandrel 24 and its expander 42 along the expander surfaces 44. When the coupling members are expanded outwardly to their full position, external longitudinal holding surfaces 45 on the expander engage companion inner holding surfaces 46 at the lower portion of the coupling members for the purpose of retaining the coupling members in their outward expanded condition. At this time, the upper thrust surface 33 of each coupling lug 30 engages the shoulder 34 at the upper end of each shoe slot 11, the lower thrust surface 35 of the coupling member engaging the companion stop or thrust surface 36 on the body, with an upper abutment 47 on the mandrel above the hinge pin engaging a companion abutment portion 48 at the upper end of each coupling member. The parts are then in the condition disclosed in Figs. 2*a*, 2*b*, an outer longitudinal surface 49 on each coupling member 12 above its thrust surface 33 engaging the inner wall of the shoe D, each coupling member 12 then being solidly held between the shoe D, mandrel 24 and the body 14 of the coupling apparatus E. Each hinge pin 115 makes a relatively loose fit in the companion hole 115*a* passing through the upper portion of the coupling member, the sides 50 of each coupling member slidably engaging the sides 51 of the body slots 13 (Fig. 4). Accordingly, drilling weight will be transmitted directly from the casing shoe D through the lower portion of each coupling member 12 to the body 14 of the coupling apparatus, drilling torque being transmitted directly from the casing shoe D, through a side 34 of each slot 11 to the coupling member 12 therein, and to a side 51 of the body 14, none of the drilling weight and torque being imposed upon the hinge pin 115 itself.

When the coupling apparatus E is to be released from the casing shoe D, the retrieving tool R of any suitable type is employed, being lowered through the casing string A, on a suitable wire line or tubing, (not shown), into the mandrel 24 and having latches 60 that move into the mandrel groove 28, being held therein. An upward pull on the wire line and retrieving tool R then elevates the mandrel 24 within the body 14, elevating the expander 42 along the coupling members 12 and bringing an upwardly facing retracting shoulder 70 on the mandrel into engagement with inwardly extending retracting finers 71 at the upper ends of the coupling members 12, swinging such inner fingers 71 upwardly and the lug portions 30 inwardly of the body 14 of the coupling apparatus.

In the use of the equipment, it is assembled at the drilling rig by inserting the coupling apparatus E downwardly through the casing shoe D, with the mandrel 24 in its upper position within the body 14 and with the coupling members 12 in their retracted position substantially entirely within the confines of the body periphery (Figs. 3*a*, 3*b*). When the coupling device has been inserted in the shoe to the extent at which its flange 15 engages the shoe shoulder 16, the coupling device E is turned until the operator observes that the lugs 30 are substantially aligned with the circumferentially spaced shoe slots 11. A downward force is then exerted on the mandrel 24 to shift it downwardly within the body, its expander 42 engaging the expander surfaces 44 of the initially retracted coupling or lock members 12, expanding their lugs 30 outwardly into the shoe slots 11 with which they have been aligned, downward movement of the mandrel continuing until full expansion of the coupling lugs has been effected into the slots, with the tapered sides 31 of The lugs snugly engaging the companion sides 32 of the slots, the upper thrust surfaces 33 engaging the thrust shoulders 34 at the upper ends of the slots 11, the lower thrust surfaces 35 engaging the stop or thrust surfaces 36 at the lower ends of the body slots, the expander 42 being disposed behind the holding surfaces 46 on the lower portions of the coupling members, and with the upper abutments 48 engaging the companion abutment surfaces 47 on the mandrel, the parts then being in the position illustrated in FIGS. 1, 2*a*, 2*b* and 4.

The expandable bit K can now be threadedly secured to the lower end of the body 14 of the coupling device E, and the pilot bit F secured to the lower end of the expandable bit. The casing string A is then threadedly secured to the upper end of the casing shoe D. The assembled combination is then lowered from the drilling rig toward the top of the formation or ocean floor if the borehole B is to be drilled in a formation underlying a body of water. Drilling of the borehole can now commence, circulating fluid being pumped down through the casing string A and through the assemblage of apparatus, the fluid pressure expanding the cutters of the expandable tool K outwardly, as described in U.S. Pat. No. 2,758,819. Appropriate drilling weight is setdown on the pilot bit F and the expanded cutters L, the drilling weight being transmitted from the shoe D through the coupling members 12 to the body 14 of the coupling apparatus, and thence downwardly through the expandable bit K and the pilot bit F. The casing string A is rotated to rotate the apparatus connected thereto and depending therefrom, the circulating fluid circulating the cuttings out of the borehole H, B, in a known manner.

Since the equipment is primarily designed for drilling only a relatively short length of borehole B, of the order of about 100 to 500 feet, the cutters of the drill bits F, K, will remain in an adequately sharp condition until the required hole length has been produced. The coupling device E and drill bits F, K can then be released from the casing string A and pulled upwardly therethrough to the top of the well bore the casing string, with its casing shoe D attached thereto, remaining in position in the borehole. A suitable retrieving tool, R, such as the tool illustrated in the above-identified U.S. Pat. application, can be used which will have latch elements **60** received within the mandrel groove **28**, so as to couple the retrieving tool to the mandrel, the retrieving tool having been lowered through the well casing on a wire line (not shown) or string of tubing (not shown). After the retrieving tool R is coupled to the mandrel **24**, an upward pull is taken on the wire line or tubing which will pull the mandrel upwardly in the body **14**, removing the expander **42** from the holding surfaces **46** of the coupling members **12** and back toward its initial position, the retracting shoulder **70** on the mandrel engaging the inwardly directed portions **71** of the coupling members, swinging the latter laterally inwardly completely out of the body slots **11** and with the outer ends of the lugs **30** disposed within the peripheral confines of the body **14**. At this time, the upper end of the mandrel engages the stop ring **18** so that upward force or movement of the mandrel is transmitted through the stop ring to the body **14**. Upward movement of the wire line or tubing string and running-in tool R now elevates the body **14** and the entire coupling apparatus E within the casing shoe D and casing string A, the coupling apparatus passing upwardly through the shoe, followed by the expandable drill bit K, whose cutters L have been retracted in the manner described in U.S. Pat. No. 2,758,819, and the pilot bit F. All of the apparatus is then raised by the wire line or tubing through the casing string to the drilling rig.

The casing string A can now be cemented in the borehole, as by pumping a suitable quantity of cement slurry downwardly through the casing for upward passage through the annulus S between the casing string and the wall of the bore hole B.

It is to be noted that there is a straight-through passage through the mandrel **24** to facilitate flow of the drilling fluid therethrough, and also through the expandable drill bit K and pilot bit F into the borehole. Prior apparatus, such as disclosed in U.S. Pat. No. 3,123,160, embody baffle elements or restricting members disposed across the mandrel passage, the circulating fluid being required to pursue a circuitous path therethrough. In the present case, a comparatively simple apparatus is provided, in which the coupling device E and companion casing shoe D need not have any orienting mechanism, since the coupling apparatus is secured to the casing shoe at the drilling rig, rather than to a casing shoe forming part of a casing string already disposed in a borehole or well bore. Although the mechanism has been greatly simplified when compared with prior devices, yet the release of the coupling device in the casing shoe and the withdrawal of the coupling device and other tools secured thereto through the casing string is effected in a simple manner merely by taking an upward pull on the mandrel **24** of the coupling device.

The borehole B is drilled from the surface of the ground or floor of the ocean to the desired depth through use of the casing A as the drill string, the coupling E, and associated apparatus K, F, then being released and withdrawn through the casing string to the drilling rig, after which the casing string is cemented in place. The entire operation is performed with relatively economical equipment. The result of positioning a casing pile or surface casing A in a borehole B extending downwardly from the ocean floor or the like, is accomplished in a simple and expeditious manner.

We claim:

1. In apparatus for drilling a borehole in a formation: a string of pipe to be lowered toward the formation and thereinto, said pipe including a shoe at its lower end and having a slot; a coupling device movable longitudinally through the pipe and into its shoe and having an initially expanded coupling member in said slot for coupling said device to said shoe; said shoe having stop means therein; said coupling device having stop means above said coupling member engageable with said other stop means to prevent downward movement of said coupling member from said slot; a well tool secured to said coupling device depending therefrom below said shoe, said well tool being movable longitudinally through said pipe; a tubular member movable in said coupling device and having a straight-through unobstructed central passage extending throughout its length, said tubular member engaging said coupling member to retain said coupling member in said slot; said tubular member having releasable means thereon for moving said tubular member in said coupling device to a position released from said coupling member to permit retraction of said coupling member from said slot and upward withdrawal through said pipe of said coupling member and well tool secured thereto.

2. In apparatus as defined in claim 1; said releasable means comprising an internal circumferential groove in said tubular member surrounding said passage.

3. In apparatus as defined in claim 1; said slot having opposed sidewalls simultaneously engaging said coupling member when said coupling member is fully expanded into said slot; said coupling device being rotatable freely within said shoe through more than one revolution when its stop means engages said shoe stop means to align said coupling member with said slot.

4. In apparatus as defined in claim 1; said well tool having expandable and retractable cutter means thereon for drilling the borehole in the formation, said cutter means having an expanded hole cutting diameter greater than the outside diameter of said string of pipe; said cutter means being retractable to allow said well tool to be moved upwardly through the string of pipe.

5. In apparatus as defined in claim 1; said well tool having expandable and retractable cutter means thereon for drilling the borehole in the formation, said cutter means having an expanded hole cutting diameter greater than the outside diameter of said string of pipe; said cutter means being retractable to allow said well tool to be moved upwardly through the string of pipe; said slot having opposed sidewalls simultaneously engaging said coupling member when said coupling member is fully expanded into said slot; said coupling device being rotatable freely within said shoe through more than one revolution when its stop means engages said shoe stop means to align said coupling member with said slot.

6. In apparatus as defined in claim 1; said well tool having expandable and retractable cutter means thereon for drilling the borehole in the formation, said cutter means having an expanded hole cutting diameter greater than the outside diameter of said string of pipe; said cutter means being retractable to allow said well tool to be moved upwardly through the string of pipe; said slot having opposed sidewalls simultaneously engaging said coupling member when said coupling member is fully expanded into said slot; said coupling device being rotatable freely within said shoe through more than one revolution when its stop means engages said shoe stop means to align said coupling member with said slot; said releasable means comprising an internal circumferential groove in said tubular member surrounding said passage.

7. In apparatus as defined in claim 1; said tubular member having means thereon engaging said coupling member upon upward movement of said tubular member in said coupling device to retract said coupling member from said slot.

8. In a method of drilling a borehole in a formation beginning at the top thereof, providing a string of pipe having a coupling device releasably secured to its lower end portion and a drill bit secured to the coupling device and having expandable and retractable cutter means thereon below the lower end of the string of pipe, expanding said cutter means to an effective bore hole drilling diameter greater than the out-

side diameter of said pipe, then lowering said pipe into engagement with the top of the formation, rotating said pipe with said cutter means expanded while progressively lowering said said pipe to apply drilling weight from said pipe to said coupling device and to said drill bit and its cutter means to cut the borehole to a desired depth and to a diameter greater than the outside diameter of the pipe, releasing said coupling device from the lower end portion of said pipe, retracting said cutter means from their expanded condition, and elevating said coupling device and drill bit through the pipe to the top of the borehole while said pipe remains in the borehole.