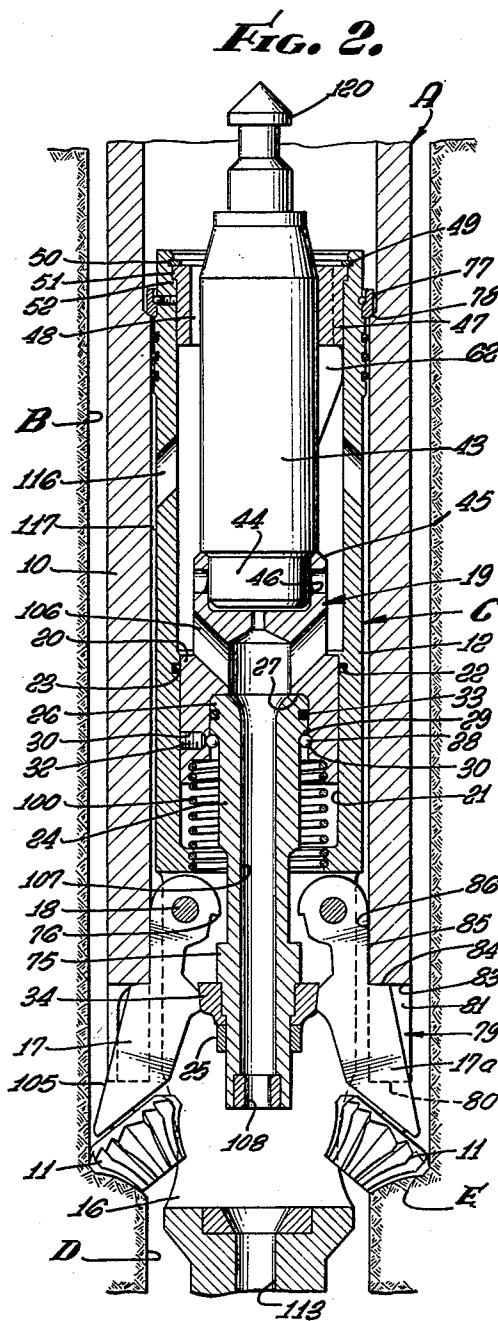


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RETRIEVABLE DRILLING APPARATUS FOR BORE HOLES

Filed Aug. 24, 1959

3 Sheets-Sheet 1



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3,074,494

RETRIEVABLE DRILLING APPARATUS FOR BORE HOLES

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FIG. 3.

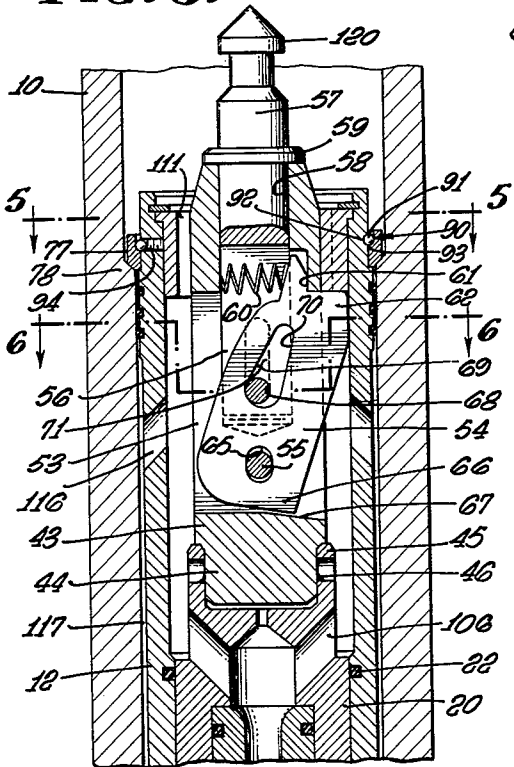


FIG. 5.

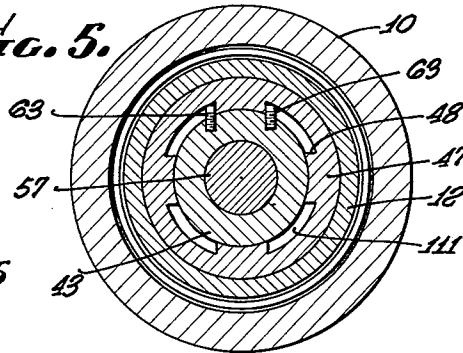


FIG. 6.

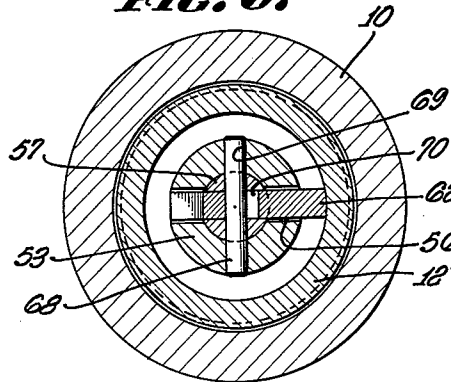


FIG. 7.

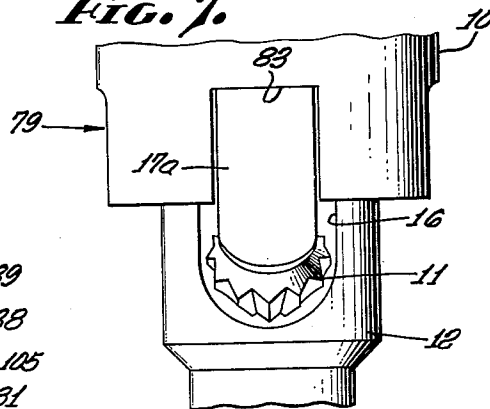
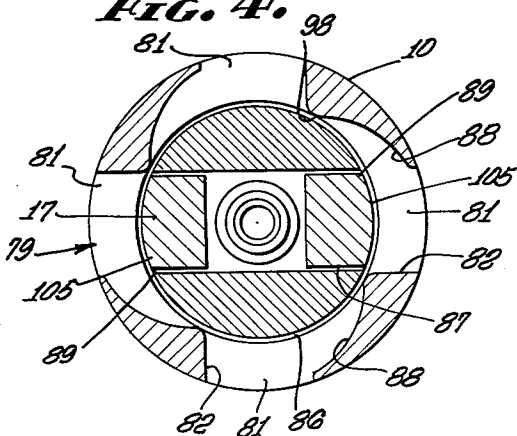


FIG. 4.



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FIG. 8.

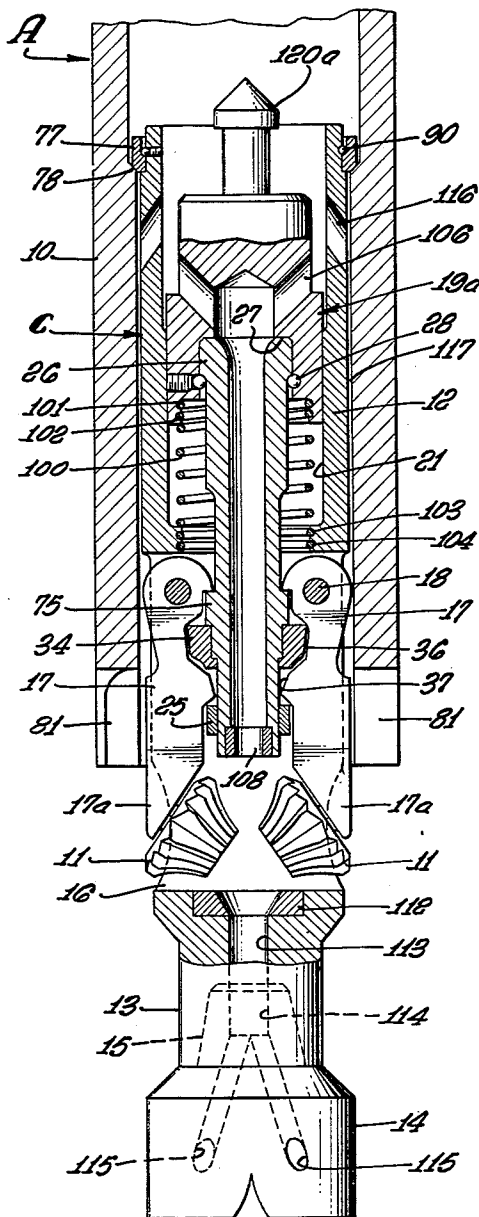
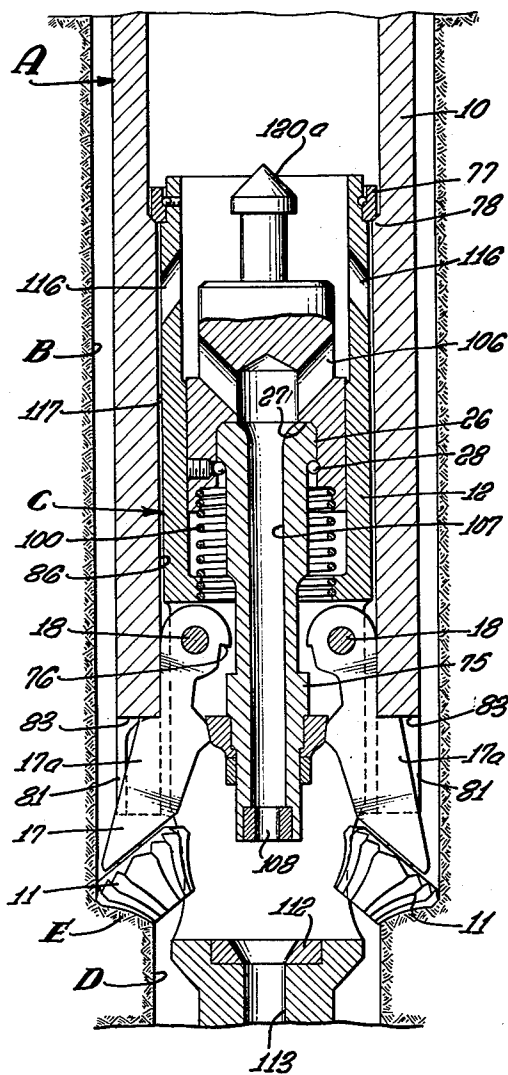


FIG. 9.



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RETRIEVABLE DRILLING APPARATUS FOR BORE HOLES

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14 Claims. (Cl. 175-260)

The present invention relates to the rotary drilling of well bores, and more particularly to retrievable rotary drill bit apparatus for drilling the well bores.

Oil, gas, water, sulphur and similar well bores have heretofore been drilled by securing a bit to the lower end of a string of drill pipe and lowering such pipe in the hole to its bottom portion, the drill bit then being rotated to continue the formation of the well bore. As each bit becomes dull the drill pipe is removed from the well bore and another bit attached to it and the string of pipe re-lowered in the well bore. After the desired depth of hole has been produced, the drill pipe is removed and a string of casing or the like lowered in the hole, which may then be cemented in place.

The necessity for frequent round trips to change drill bits is a time consuming and costly operation. Potential damage to the well bore is also present due to pressures and the like developed in the drilling mud, caused by the raising and lowering of the string of drill pipe. There is also the danger of being unable to lower the casing in the drilled hole to the required depth, or in damaging the well formation during lowering of the casing.

An object of the invention is to provide an improved drilling apparatus which avoids the necessity for repeated round trips of the drilling string to change the drill bit, the apparatus being capable of being lowered and removed through a string of pipe, which will form the ultimate casing for the well bore, and of being readily coupled to the lower portion of the pipe, which is then rotated to effect drilling of the hole, and of being released from the pipe and retrieved through its bore after the apparatus becomes dull or is to be retrieved for any other reason.

Another object of the invention is to provide a retrievable drill bit adapted to be lowered through a string of pipe to its lower portion, or shoe, and of being rotationally coupled thereto, the drilling bit having cutters expandable outwardly beyond the outside diameter of the pipe, the cutters being retained in their expanded position when the bit is elevated from the bottom of the hole.

A further object of the invention is to provide a retrievable drilling bit having expandable cutters and capable of being lowered through a string of pipe to be rotationally coupled to its lower portion, the bit permitting circulating fluid at high volumetric rates to be pumped through it, insuring thorough removal of the cuttings from the drilling region, cleaning of the bit, and its cooling and lubrication.

This invention possesses many other advantages, and has other objects 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 drawings 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, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a longitudinal section, parts being shown in side elevation, of a drilling bit within and at the lower

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portion of a string of casing or similar pipe, the apparatus being in its initial retracted position;

FIG. 2 is a view similar to FIG. 1, illustrating the drilling bit with its cutters in their expanded condition and coupled to the string of pipe;

FIG. 3 is a longitudinal section of the upper portion of the apparatus, showing the latch device in the position it occupies with the bit in the FIG. 2 condition;

FIG. 4 is a cross-section taken along the line 4-4 on FIG. 1;

FIG. 5 is a cross-section taken along the line 5-5 on FIG. 3;

FIG. 6 is a cross-section taken along the line 6-6 on FIG. 3;

FIG. 7 is a fragmentary side elevational view of one of the cutter devices in expanded position and coupled to the lower portion of the string of drill pipe or casing;

FIG. 8 is a longitudinal section through another embodiment of the invention, with the cutters in retracted position;

FIG. 9 is a longitudinal section of the bit disclosed in FIG. 8, with the cutters in their fully expanded position.

As disclosed in FIGS. 1 to 7, inclusive, the apparatus includes a lower portion 10 of a string of well casing A, or similar pipe, which extends to the top of the well bore B being drilled. This string of pipe is rotated to transmit the drilling torque and drilling weight to a retrievable drilling bit C adapted to be coupled to the lower or shoe portion 10 of the pipe string. The drill bit is movable down through the string of casing A, that is already disposed in the portion of the well bore B previously drilled, and is releasably coupled to the shoe portion of the casing, after which the drilling of the well bore can proceed by rotating the string of pipe or casing and moving it progressively downwardly as the hole is produced, to move the cutters 11 of the bit against the formation. During the rotary drilling operation, drilling mud, or the like, is pumped down through the interior of the casing string A and discharges from and around the bit C to carry the cuttings upwardly and around the string of casing to the top of the hole. When a bit becomes dull, it is uncoupled from the casing string and withdrawn through its interior to the top of the hole, whereupon the same drill bit with new cutters, or another drill bit, is lowered through the casing string and clutched or coupled in place to its shoe 10. When the new cutters become dull, the drill bit is again withdrawn through the interior of the casing string and the cutters replaced. The foregoing action is repeated as often as necessary to drill the hole B to the desired depth. It is to be noted that the casing string need never be withdrawn from the well bore during drilling of the hole. It is only necessary to add additional sections at the top of the well bore as drilling proceeds. In fact, after the hole has been drilled to the desired depth, the casing string can remain therein to be cemented in place, if desired, in substantially the same manner as casing strings are ordinarily cemented in well bores.

The drilling apparatus C specifically disclosed in the drawings includes an elongate body 12 having a lower threaded box 13 to which a pilot bit 14 can be secured, as by threading its upper pin end 15 within the box. Above its threaded box the body of the bit has a transverse slot area 16 in which a plurality, such as a pair, of cutter devices are mounted. As specifically shown, cutter supporting members 17 are disposed in the elongate body slot 16, being pivoted on hinge pins 18 extending across the slot and suitably secured to the body 12. Each cutter supporting member 17 carries a cutter member 11, such as a conical toothed cutter, which, when expanded outwardly in the manner described hereinbelow, will drill the hole B to a diameter substantially greater

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than the outside diameter of the string of well casing A and enlarge the diameter of the pilot hole D drilled by the pilot bit 14.

The cutters 11 normally occupy an inward position, such as disclosed in FIG. 1, in which they are retracted substantially fully within the confines of the body 12 of the tool. They are expanded outwardly of the body to be coupled to the drill pipe A as a result of downward movement of a mandrel device 19 within the body 12. As shown, the mandrel device includes an upper piston portion 20 slidable within a cylinder 21 in the body, leakage of fluid between the piston and cylinder being prevented by a suitable seal device 22, such as a rubber or rubber-like O ring, in an internal groove 23 in the body slidably and sealingly engaging the periphery of the piston. Secured to the piston 20 and depending therefrom is a tubular member portion 24 of the mandrel, the lower part of which is slidable through a guide 25 extending across the body slot 16 and attached to the body 12. The upper portion 26 of the tubular member 24 is piloted within the piston 20, its upper end engaging a downwardly facing piston shoulder 27. Downward movement of the tubular member 24 with respect to the piston 20 is prevented by a row of balls 28 which engage a downwardly facing raceway 29 on the tubular member and which are received within an internal raceway 30 in the piston. The balls 28 are insertable through a radial hole 31 in the piston which may be closed by threading a suitable plug 32 in such hole, as disclosed in FIGS. 1 and 2. Leakage of fluid between the piston and tubular member is prevented by a side seal ring 33.

When the piston 20 and tubular member 24 move downwardly, an expander 34 mounted on and fixed to the tubular member engages downwardly and inwardly tapering expander surfaces 35 on the cutter supporting members 17 to pivot the latter and the cutters 11 about the axes of the hinge pins 18 and shift the cutters 11 outwardly. When the cutters have been shifted outwardly to their maximum extent, holding surfaces 36 on the expander 34 will be disposed behind companion holding surfaces 37 on the supporting members below their respective expander surfaces 35, preventing inadvertent retraction of the cutter supporting members 17 and cutters 11 from their expanded position. The piston and tubular member portions 20, 24 of the mandrel are shiftable downwardly to the maximum extent determined by engagement of the lower end of the expander 34 with the guide 25.

As specifically disclosed in the drawings the mandrel 19 is normally urged in a downward direction by a spring device 100 to expand the cutter supporting member 17 and the cutters 11. The spring 100 is of the tension type, surrounding the tubular member 24 with its upper end fastened to the piston 20 by virtue of the fact that the uppermost turns 101 of the spring are received within internal grooves 102 of the piston 20. The lower portion of the spring is secured to the body 12 by having its lowermost turns 103 received within companion internal grooves 104 in the body of the tool.

The spring 100 tends to shift the mandrel 19 downwardly to cause the expander 34 to expand the cutter supporting members 17 and the cutters 11. However, such outward expansion to any significant extent is prevented during lowering of the drilling bit C through the string of well casing A since the outer surfaces 105 of the cutter supporting members 17 merely ride along the wall of the well casing A.

The cutters 11 may also be urged to their expanded position, after the drilling bit has been coupled to the casing A, by fluid pressure developed in the body 12 of the tool above the piston 20. Such fluid pressure results from the downward pumping of drilling mud, or similar fluid, through the casing string A, this fluid flowing through the upper end of the body 12 and then through inlet ports 106 in the mandrel above the piston portion 20 into a

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central passage 107 extending through the tubular member 24. Such fluid under pressure flows through a nozzle 108 at the lower end of the tubular member and discharges into the body slot 16. Because of the throttling action provided by the inlet ports 106, or by the nozzle 108, a back pressure is built up in the body 12 above the piston 20 which will urge the latter downwardly, shifting the mandrel 19 and the tubular member 24 downwardly to effect outward expansion of the cutter supporting members 17 and the cutters 11 carried thereby.

Once the cutters 11 have been expanded outwardly they are releasably locked in such outwardly expanded position. To accomplish this purpose, a carrier member 43 forms an upward extension of the mandrel 19. The lower end 44 of this carrier member is piloted into the upper head portion 45 of the mandrel, being suitably secured thereto, as through use of welding material 46. This carrier extends upwardly through a spider or latch sleeve 47 mounted in the upper end of the body 12, having inwardly directed ribs 48, circumferentially spaced from one another and which are engageable with the periphery of the carrier. The latch sleeve 47 is held within the body by a split, snap retainer ring 49 overlying the upper end of the sleeve and disposed within an internal groove 50 in the body, downward movement of the latch sleeve 47 in the body being prevented by engagement of a sleeve flange 51 with an upwardly directed body shoulder 52.

The carrier member 43 has an elongate slot 53 (FIG. 3) extending therethrough receiving a latch member 54 pivotally mounted on a hinge pin 55 extending across the carrier slot and suitably secured thereto, as by welding. The latch 54 also extends within a slot 56 in a retrieving plunger 57 movable longitudinally in a bore 58 in the latch carrier 43, downward movement of the plunger within the carrier being limited by engagement of a plunger flange 59 with the upper end of the carrier. The latch 54 is swingable outwardly of the carrier 43 under the influence of a helical compression spring 60, one end of which engages the inner wall of the carrier 43 and other end of which engages an upwardly extending lug or spring seat 61 on the latch to force a latch finger 62 outwardly of the carrier slot and under one of the ribs 48 of the spider 47. The carrier slot 53 and the latch 54 disposed therein are aligned with one of the ribs 48 by attaching screws 63 to the carrier 43 on opposite sides of another rib 48, thereby maintaining the orientation of the latch 54 relative to a spider rib.

During the movement of the drilling bit through the well casing the mandrel 19 and the carrier 43 attached thereto are disposed in an upward position within the bit body 12 (FIG. 1), despite the tendency of the tension spring 100 to effect downward movement of the mandrel within the body. At this time, the latch finger 62 is disposed inwardly of the carrier 43 and engages the inner surface of one of the spider ribs 48. However, when the mandrel 19 is moved downwardly by the spring 100, or by the pressure of the fluid pumped down through the casing string A, or both, the carrier 43 and latch 54 move downwardly with it until the latch finger is disposed below the rib 48, the spring 60 then swinging the latch 54 outwardly until its finger 62 is under the rib (FIG. 3). The mandrel 19 cannot then be elevated inadvertently within the body 12 of the drill bit.

When the latch 54 is in its latching position, such as shown in FIG. 3, the hinge pin 55 in the latch is relieved of the latching force. The hole 65 in the latch is made elongate, permitting a slight longitudinal shifting of the latch within the carrier slot 53 and across the pin. Thus, when the upper end of the latch finger 62 engages the lower end of the rib 48, the lower end 66 of the latch will engage the lower side 67 of the carrier defining the slot 53. It is evident from FIG. 3 that the hinge pin 55 is relieved of the thrust transmitted through the latch 54 between the carrier 43 and the spider 47.

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The latch 54 is released whenever the cutters 11 are to be retracted by moving the retracting plunger 57 upwardly. This plunger has a retrieving pin 68 secured thereto, which is slidable in opposed longitudinal slots 69 in the carrier, and which pass through an opening 70 in the latch. Initially, the retracting pin 68 is in the lower position within the carrier slots 69 and the latch opening 70. When in this position, the latch 62 is free to swing outwardly under the influence of its spring 60 upon lowering of the mandrel 19 within the body 12. At this time, it is to be noted that the left side 71 of the latch opening 70, as seen in FIG. 3, is inclined in an upward and outward direction. Accordingly, when the retracting plunger 57 is elevated within the carrier 43, the retracting pin 68 engages the inclined side 71 of the latch 54 and swings it inwardly against the force of its spring 60 and completely within the confines of the carrier 43, thereby releasing the latch finger 62 from the spider rib 48 and allowing the entire mandrel 19 to move upwardly within the body 12 of the tool. Elevation of the retracting plunger 57 to release the latch 54 will bring its pin 68 in contact with the carrier 43 at the upper end of the longitudinal slots 69, whereupon the upward force on the retracting plunger 57 will be transmitted through the retracting pin 68 to the carrier 43, which is actually a part of the mandrel 19. The mandrel is then forcibly moved upwardly within the body 12 of the tool against the tension force of the spring 100, the expander 34 being shifted above the expander surfaces 35 on the cutter supporting member 17, permitting the latter and the cutters 11 to move inwardly to their retracted position within the body 12. If the cutter supporting member 17 and the cutters 11 do not move inwardly, then the upward movement of the mandrel 19 will cause a retracting flange or shoulder 75 on the mandrel to engage the upper inner arms 76 on the cutter supporting members 17 and shift such arms upwardly and pivot the portions of the cutter supporting member 17 below the hinge pins 18, and the cutters 11 themselves, inwardly back within the confines of the body slot 16. Once the cutter supporting members 17 are substantially within the confines of the body slot, the tension spring 100 is prevented from expanding the cutters 11 outwardly since they are engaged by the inner wall of the casing string A.

The retrievable drill bit apparatus C is adapted to move downwardly through the entire string of casing A to the shoe portion 10 of the latter. It can move downwardly to the extent limited by engagement of a stop ring or thrust collar 77 on the upper portion of the body 12 with a stop shoulder 78 provided in the casing shoe. When the stop ring 77 engages the casing shoulder 78, the pilot bit 14 is disposed substantially below the lower end of the casing shoe 10; whereas the lower portion 17a of each cutter supporting member 17 is disposed within a slotted coupling portion 79 at the lower end of the shoe, each cutter 11 being located below the lower end 80 of the shoe. The cutter supporting members 17 are expandable outwardly to be shifted within slots 81 in the lower portion of the shoe. Each slot is sufficiently wide to accommodate a cutter supporting member 17, and each slot has a driving face 82 adapted to engage the side of a cutter supporting member to rotate the latter. The upper end 83 of each slot is defined by a thrust shoulder or surface on the shoe adapted to engage a companion shoulder or step 84 on the cutter supporting member 17.

The cutter supporting members 17 are shiftable outwardly of the body of the tool to the extent limited by engagement of an exterior surface 85 on each cutter supporting member above its stop shoulder 84 with the inner surface 86 of the casing shoe. Thus, the inner surface 86 of the casing shoe limits the extent of outward expansion of each cutter supporting member 17; whereas the holding surface 36 on the expander 34 coacts with the companion holding surfaces 37 on the cutter supporting members 17 to prevent inward movement of the latter.

The driving face 82 on the shoe, which will engage a

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companion face 87 on a cutter supporting member 17, is preferably flat so that a substantial surface engagement is had between the driving face and the side face of the cutter supporting member. The opposed side 88 of each slot 81 is curved, the curve running from the inner surface 86 of the casing shoe 10, and thence toward its outer surface in a direction toward the driving face 82 of the slot, such as shown most clearly in FIG. 4. The curved guide surface 88 will be engaged by the outer surface 105 or corner 89 of a cutter supporting member 17 when it is being expanded outwardly by the mandrel 19 shifting downwardly within the body 12, in the event that the cutter supporting members 17 are not aligned with a pair of diametrically opposed slots 81. The outward force will cause the cutter supporting members 17 to slide along the curved guide surfaces 88 in shifting to their outward position, until they move fully within the slots 81. Such arcuate shifting of the cutter supporting members 17 is accompanied by arcuate shifting of the body 10 of the tool. To facilitate such arcuate shifting, a rollable type of a bearing connection 90 is provided between the stop ring or thrust collar 77 and the body 12 of the tool. As shown, a set of balls 91 is mounted in an external raceway 92 in the upper portion of the body 12, and these balls engage a companion upwardly facing raceway 93 on the thrust ring 77. The balls 91 can be inserted between the raceways through a radial hole 94 in the body 12 of the tool, which is then closed by a suitable plug 95.

In the event that the cutter supporting members 17 and cutters 11 are being expanded outwardly and the members 17 are disaligned with the slots 81, they might engage the curved corner 98 between a driving face 82 in one slot and the curved guide surface 88 of an adjoining slot. Because of the curved exterior 105 of each cutter supporting member 17, if it does not slide in a clockwise direction, as seen in FIG. 4, along the curved guide surface 88, it will slide along the corner 98 in a counter-clockwise direction into alignment with one of the slots 81, whereupon the cutter supporting member 17 is expandable fully outwardly to bring its stop surface 85 in engagement with the internal surface 86 of the shoe 10, and with its shoulder 84 under and adjacent to the downwardly directed thrust surface or shoulder 83 on the shoe. When the cutters 11 are locked in their expanded position by the latch 54, the cutters cannot move upwardly of the shoe 10, which is also true of the body 12 of the tool; while the body of the tool itself cannot move downwardly of the shoe 10, by virtue of the engagement of the thrust collar 77 with the stop shoulder 78.

The pilot bit 14 will drill a pilot hole D, which is slightly less in diameter than the minimum diameter through the casing shoe 10; whereas the expandable cutters 11, when expanded outwardly, will form and operate upon a transverse shoulder E in the formation that extends from the wall of the pilot hole D to the desired enlarged diameter of the well bore B, which is substantially greater than the outside diameter of the casing string A. Drilling mud can now be pumped down through the casing string and may be prevented from passing around the exterior of the body 12 near its upper portion because of the provision of suitable side seal rings 99, such as rubber O rings, disposed in peripheral grooves 110 in the body and sealingly engaging the inner surface 86 of the casing below its stop shoulder 78. The fluid will flow through the passages 111 between the spider ribs 48 and the carrier 43, passing into the body 12 and downwardly around the carrier 43, some of the fluid continuing on through the inlet ports 106 and through the tubular member passage 107 to discharge from the nozzle 108. Such fluid may discharge at a substantial velocity, a substantial portion of it flowing into a fluid guide 112 in the body of the tool at the lower end of the slot 16, which is suitably welded to the body. The fluid will pass through a fluid passage 113 in the lower portion of the

body 12 and into a drill bit passage 114, discharging through the drill bit nozzles 115 to remove the cuttings from the drilling region of the pilot bit 14 and flushing them upwardly around the exterior of the bit C and the casing A back to the top of the hole. Some of the drilling fluid discharging from the mandrel nozzle 108, as well as the drilling fluid discharging from the pilot bit nozzles 115 will pass around the expansible cutters 11 and the transverse shoulder E on which such cutters are operating, carrying the cuttings produced by the expansible cutters upwardly around the exterior of the casing shoe 10 and the casing string A back to the top of the well bore B.

A large quantity of the drilling mud or other drilling fluid will also pass around the exterior of the body 12. Part of such fluid flowing through the passages 111 between the spider ribs 48 and the carrier 43, and into the body 12, will pass outwardly through body side ports 116 to the exterior of the body, flowing downwardly through the annular space 117 between the exterior of the body 12 and the inner surface 86 of the casing shoe and discharging from the lower end of the casing A. This fluid will also act in large measure directly upon the expansible cutters 11 and the transverse shoulder E on which such cutters are operating, carrying the cuttings produced by the cutters 11 upwardly around the exterior of the casing shoe 10 and the casing string A to the top of the well bore B. The annular passage area between the body 12 of the tool and the inner wall 86 of the casing shoe 10 can be quite large, allowing relatively large volumes of drilling mud to pass therethrough for the purpose of keeping the cutters 11 and the drilling region E clean of the cuttings, as well as appropriately cooling and lubricating the parts.

In the use of the apparatus illustrated in FIGS. 1 to 7, inclusive, the mandrel 19 is elevated in the body 12 of the tool against the force of the tension spring 100 so that the cutters 11 and the cutter supporting members 17 can be placed in their retracted position. The drilling bit C is inserted in the case string and will either gravitate through the drilling mud therewithin or can be pumped down through the casing string until the thrust ring 77 engages the stop shoulder 78 in the casing shoe. At this time, the pilot bit 14 will be disposed below the lower end 80 of the shoe, which is also true of the cutters 11 and part of the cutter supporting members 17. The spring 100 then urges the mandrel 19 in a downward direction, causing the expander 34 to engage the expander surfaces 38 and swing the cutter supporting members 17 and cutters 11 outwardly. If the cutter supporting members 17 are disaligned with a pair of opposed shoe slots 81, they will engage either the curved guide surfaces 83 or the corners 98 of the shoe, to be shifted in one direction or another into alignment with the opposed slots 81, whereupon they will move outwardly within the slots to the extent determined by engagement of the upper exterior surfaces 85 of the supporting members 17 with the inner surface 86 of the shoe 10, at which time the thrust shoulders 84 on the cutter supporting members 17 are disposed under and closely adjacent to, if not against, the thrust shoulders 83 on the shoe. The expander 34 will also have moved downwardly to its maximum position, in which its holding surfaces 36 are disposed behind the surfaces 37 on the inner portions of the cutting supporting members 17. When this occurs, the latch 54 will have been shifted outwardly by the spring 60 to dispose its finger 62 under a spider rib 48, thereby locking the mandrel 19 in a downward position within the tool body 12, assuring that the cutter supporting members 17 and cutters 11 will be held in their outward position.

If difficulty is encountered in securing the full expansion of the cutters 11 and cutter supporting members 17 under the influence of the tension spring 100, the pumping of drilling mud or the like downwardly through the casing string A will cause its fluid pressure to act upon the

piston 20, urging the mandrel 19 downwardly and thereby providing a hydraulic force to supplement the spring force.

The casing string A is rotated at the proper speed and the desired drilling weight imposed through the casing string onto the shoulders 84 of the cutter supporting members 17, such drilling weight being transmitted from the supporting members through the cutters 11 to the formation shoulder E. At the same time drilling weight is being transmitted to the pilot drill bit 14 to insure the production of the pilot hole D. Drilling mud is pumped down through the casing string while it is being rotated, the drilling mud discharging through the body side ports 116 and through the annular space 117 between the body and the casing shoe, and also through the nozzle 108, the combined streams of drilling mud removing the cuttings from the region of the expansible cutters 11, some of the fluid passing down through the pilot bit 14 to remove the cuttings in the pilot hole D. The cuttings from the different regions of the well bore are flushed upwardly around the exterior of the casing A to the top of the hole B.

Drilling can proceed until the cutters 11 have been worn, after which the drill bit C is removed without removing the casing string A from the hole. Such action can occur by lowering a suitable overshot (not shown) on a sand line (not shown) through the casing string A, the overshot coupling itself to the head 120 of the retrieving plunger 57, which can then be pulled upwardly. Such upward pulling will cause the retrieving pin 68 to release the latch 54 from the spider rib 48, after which the mandrel 19 is pulled upwardly within the body 12 against the force of the tension spring 100 to elevate the expander 34 above the expander surfaces 35 of the cutter supporting members 17. The cutter supporting members will now shift inwardly. If need be, to insure such inward shifting, the casing string A may be elevated a slight distance to remove the expansible cutters 11 from contact with the transverse formation shoulder E. Upward movement of the sand line will result in upward movement of the entire drilling bit C through the casing A to the top of the hole. The tension spring 100 does no more than urge the outer surfaces 105 of the cutter supporting members 17 against the inner wall of the casing string. However, there is comparatively little frictional resistance to sliding offered by such contact between the cutter supporting members and the wall of the pipe, so that there is little resistance to upward movement of the drill bit C through the casing A.

Another drill bit C can then be lowered in the wall casing A, or the worn cutter portions 11, 14 of the removed drill bit replaced with new cutter portions and again inserted and lowered in the casing, with its cutters 11 in retracted position until the thrust ring 77 engages the casing shoulder 78. The spring 100 will again shift the mandrel 19 downwardly within the body to expand the cutter devices 17, 11 outwardly, until they are securely locked to and within the casing shoe 10, in the manner disclosed in FIG. 2, the latch 54 preventing inadvertent upward removal of the mandrel 19 within the body 12 of the tool. For that matter, inadvertent upward removal of the mandrel is also prevented by the continuing tension force exerted by the spring 100.

By the expedient of coupling and releasing a drilling bit C from the well casing A, the entire well bore B can be drilled without the necessity for removing the casing string from the well bore. After the hole B has been drilled to the desired depth, the last used drill bit need merely be removed from the casing string to the top of the hole, whereupon the casing string A can, if desired, be cemented in the bore hole.

In the form of invention disclosed in FIGS. 8 and 9, the drilling bit is essentially the same as in the embodiment previously described, with the exception that the mandrel 19a is not positively latched in its downward

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position within the body 12. Instead, reliance is placed upon the tension spring 100 to hold the mandrel in its downward position, with the cutters 11 and cutter supporting members 17 locked in their outward expanded position. In lieu of the latching device, the upper portion of the mandrel has a retrieving head 120a which is adapted to be engaged by a suitable overshot (not shown) when ever the apparatus is to be retrieved from the well casing.

The cutters 11 and cutter supporting members 17 are placed in their retracted position with the spring 100 under tension and are inserted in the well casing A. The drilling apparatus is pumped down through the casing until the stop ring 77 engages the casing shoulder 78. During its descent through the well casing, the cutter supporting arms 17 merely slide along the wall of the well casing. After the stop ring has engaged the shoulder, the spring 100 will urge the mandrel 19a downwardly to expand the cutters 11 outwardly. If need be, the casing A can be rotated to secure sufficient relative arcuate movement between the casing shoe 10 and the body 12 of the tool, such that the cutter supporting arms 17 will be aligned with the slots 81, allowing the expander 34 to expand the cutter supporting members 17 outwardly into the slots 81, until the fully expanded position shown in FIG. 9 is achieved.

Drilling can now proceed with the casing A being rotated and the drilling weight and torque being transferred directly from the casing shoe 10 to the cutter supporting arms 17 and the cutters 11, which then roll around the formation shoulder E, while the pilot 14 engages the bottom of the pilot hole D. Drilling mud is pumped down through the casing, passing into the upper end of body 12 and then flowing downwardly through the mandrel ports 106 to the central passage 107 of the latter and discharging through the nozzle 108, as in the other form of the invention. Similarly, the drilling mud passes out through the body side ports 116 to the annular space 117 between the body and the inner wall 86 of the casing, this fluid flowing around the cutter supporting members 17 and the cutters 11, as well as discharging upon the formation shoulder E to clean the apparatus and the drilling region of the cuttings, and flushing them around the exterior of the casing string A to the top of the hole. In the event the drilling apparatus is elevated from the bottom of the hole and the formation shoulder E, the tension spring 100 will maintain the mandrel 19a in a downward position within the body 12 of the tool, thereby retaining the cutter supporting members 17 and cutters 11 in their outward expanded position.

When the expansible rotary drill bit is to be removed from the well casing, a suitable overshot (not shown) is lowered on a sand line (not shown), the overshot being coupled to the mandrel head 120a. An upward pull is now taken on the mandrel 19a, overcoming the force of the spring 100 and elevating the mandrel within the body 12, which cannot move upwardly at this time due to the engagement of the shoulders 84 on the cutter arms 17 with the companion shoulders 83 at the upper ends of the shoe slots 81. When the expander 34 is elevated above the expander surfaces 35 of the cutter supporting arms, the retrieving flange 75 on the mandrel will engage the upper arms 76 of the cutter supporting members, to swing the lower portions 17a of the cutter supporting members and cutters 11 inwardly, the outer surfaces 105 of the cutter supporting arms 17 sliding along the inner wall of the casing A during elevation of the apparatus on the sand line through the well casing until the top of the hole is reached. The drill bit apparatus C is removed from the casing string A and, if desired, another expansible cutter apparatus pumped downwardly therethrough to be latched to its shoe 10.

The inventor claims:

1. In a retrievable drilling bit adapted to be lowered

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within and coupled to the lower portion of a string of pipe disposed in a well bore: a body movable longitudinally through the pipe; initially retracted cutter means; means mounting said cutter means on said body for expansion laterally outwardly of said body; means on said body adapted to engage a lower portion of the pipe to locate the bit in the pipe with said cutter means extending below the lower end of the pipe; spring actuated means movable along said body and said cutter means and engageable with said cutter means below said mounting means for expanding said cutter means laterally outwardly of the body to drill an effective hole diameter greater than the outside diameter of the pipe; means for transmitting drilling weight from the pipe to the bit; and means for coupling the bit to the pipe, whereby the pipe is adapted to rotate the bit.

2. In a retrievable drilling bit adapted to be lowered within and coupled to the lower portion of a string of pipe disposed in a well bore: a body movable longitudinally through the pipe; initially retracted cutter means; means mounting said cutter means on said body for expansion laterally outwardly of said body; means on said body adapted to engage a lower portion of the pipe to locate the bit in the pipe with said cutter means extending below the lower end of the pipe; spring actuated means movable along said body and said cutter means and engageable with said cutter means below said mounting means for expanding said cutter means laterally outwardly of the body to drill an effective hole diameter greater than the outside diameter of the pipe; means for transmitting drilling weight from the pipe to the bit; and means for coupling said cutter means directly to the pipe, whereby the pipe transmits its rotary motion and torque directly to said cutter means.

3. In a retrievable drilling bit adapted to be lowered within and coupled to the lower portion of a string of pipe disposed in a well bore: a body movable longitudinally through the pipe; initially retracted cutter means pivotally mounted on said body for expansion laterally outwardly of said body; means on said body adapted to engage a lower portion of the pipe to locate the bit in the pipe with said cutter means extending below the lower end of the pipe; a mandrel movable longitudinally of said body and said cutter means in one direction and engageable with said cutter means below the pivot axis of said cutter means on said body for expanding said cutter means laterally outwardly of said body to drill an effective hole diameter greater than the outside diameter of the pipe; spring means acting between said body and mandrel to move said mandrel longitudinally of said body and said cutter means in said one direction to expand said cutter means laterally outwardly; means for transmitting drilling weight from the pipe to the bit; and means for coupling the bit to the pipe, whereby the pipe is adapted to rotate the bit.

4. In a retrievable drilling bit adapted to be lowered within and coupled to the lower portion of a string of pipe disposed in a well bore: a body movable longitudinally through the pipe; initially retracted cutter means pivotally mounted on said body for expansion laterally outwardly of said body; means on said body adapted to engage a lower portion of the pipe to locate the bit in the pipe with said cutter means extending below the lower end of the pipe; a mandrel movable downwardly in said body and engageable with said cutter means below the pivot axis of said cutter means on said body for expanding said cutter means laterally outwardly of said body to drill an effective hole diameter greater than the outside diameter of the pipe; tension spring means connected to said mandrel and body to move said mandrel downwardly of said body to expand said cutter means laterally outwardly; means for transmitting drilling weight from the pipe to the bit; and means for coupling the bit to the pipe, whereby the pipe is adapted to rotate the bit.

5. In a retrievable drilling bit adapted to be lowered

within and coupled to the lower portion of a string of pipe disposed in a well bore: a body movable longitudinally through the pipe; initially retracted cutter means pivotally mounted on said body for expansion laterally outwardly of said body; means on said body adapted to engage a lower portion of the pipe to locate the bit in the pipe with said cutter means extending below the lower end of the pipe; a mandrel movable longitudinally of said body in one direction and engageable with said cutter means below the pivot axis of said cutter means on said body for expanding said cutter means laterally outwardly of said body to drill an effective hole diameter greater than the outside diameter of the pipe; spring means acting between said body and mandrel to move said mandrel longitudinally of said body in said one direction to expand said cutter means laterally outwardly; releasable latch means acting between said mandrel and body to prevent longitudinal movement of said mandrel in the opposite direction; means for transmitting drilling weight from the pipe to the bit; means for coupling the bit to the pipe, whereby the pipe is adapted to rotate the bit; and means for releasing said latch means.

6. In a retrievable drilling bit adapted to be lowered within and coupled to the lower portion of a string of pipe disposed in a well bore: a body movable longitudinally through the pipe; initially retracted cutter means; means mounting said cutter means on said body for expansion laterally outwardly of said body; means on said bit adapted to engage a lower portion of the pipe to locate the bit in the pipe with said cutter means extending below the lower end of the pipe; a mandrel movable downwardly in said body and engageable with said cutter means below said mounting means for expanding said cutter means laterally outwardly of said body to drill an effective hole diameter greater than the outside diameter of the pipe; tension spring means connected to said mandrel and body to move said mandrel downwardly of said body to expand said cutter means laterally outwardly; means for transmitting drilling weight from the pipe to the bit; and means for coupling the bit to the pipe, whereby the pipe is adapted to rotate the bit.

7. In a retrievable drilling bit adapted to be lowered within and coupled to the lower portion of a string of pipe disposed in a well bore: a body movable longitudinally through the pipe; initially retracted cutter means; means mounting said cutter means on said body for expansion laterally outwardly of said body; means on said body adapted to engage a lower portion of the pipe to locate the bit in the pipe with said cutter means extending below the lower end of the pipe; a mandrel movable longitudinally of said body and said cutter means in one direction and engageable with said cutter means below said mounting means for expanding said cutter means laterally outwardly of said body to drill an effective hole diameter greater than the outside diameter of the pipe; spring means acting between said body and mandrel to move said mandrel longitudinally of said body and said cutter means in said one direction to expand said cutter means laterally outwardly; means for transmitting drilling weight from the pipe to the bit; means for coupling the bit to the pipe, whereby the pipe is adapted to rotate the bit; and a head on said mandrel adapted to be engaged by a retrieving tool to move said mandrel in the opposite longitudinal direction in said body against the force of said spring means to enable said cutter means to retract.

8. In a retrievable drilling bit adapted to be lowered within and coupled to the lower portion of a string of pipe disposed in a well bore: a body movable longitudinally through the pipe; initially retracted cutter means mounted on said body for expansion laterally outwardly of said body; locating means on said body adapted to engage a lower portion of the pipe to locate the bit in the pipe with said cutter means extending below the lower end of the pipe; said body below said locating means hav-

ing a diameter substantially less than the internal diameter of the pipe to provide an annular passage therebetween above said cutter means; means including a mandrel movable longitudinally of said body and said cutter means in one direction and engageable with said cutter means for expanding said cutter means laterally outwardly of said body to drill an effective hole diameter greater than the outside diameter of the pipe; said body having an inlet for directing fluid pumped down the pipe to the interior of said body; said body having one or more side ports above said cutter means and below said locating means through which fluid can discharge from the interior of said body to said annular passage for downward passage around the exterior of the body to said cutter means; means for transmitting drilling weight from the pipe to the bit; and means for coupling the bit to the pipe, whereby the pipe is adapted to rotate the bit.

9. In a retrievable drilling bit adapted to be lowered within and coupled to the lower portion of a string of pipe disposed in a well bore: a body movable longitudinally through the pipe; initially retracted cutter means mounted on said body for expansion laterally outwardly of said body; locating means on said body adapted to engage a lower portion of the pipe to locate the bit in the pipe with said cutter means extending below the lower end of the pipe; said body below said locating means having a diameter substantially less than the internal diameter of the pipe to provide an annular passage therebetween above said cutter means; means including a mandrel movable longitudinally of said body and cutter means in one direction and engageable with said cutter means for expanding said cutter means laterally outwardly of said body to drill an effective hole diameter greater than the outside diameter of the pipe; said body having an inlet for directing fluid pumped down the pipe to the interior of said body; said body having one or more side ports above said cutter means and below said locating means through which fluid can discharge from the interior of said body to said annular passage for downward passage around the exterior of the body to said cutter means; said mandrel having a passage communicating with the interior of said body for discharging fluid to the region of said cutter means; means for transmitting drilling weight from the pipe to the bit; and means for coupling the bit to the pipe, whereby the pipe is adapted to rotate the bit.

10. In combination: a string of drill pipe adapted to be lowered within a well bore; a drill bit body movable longitudinally through said pipe; initially retracted cutter means mounted on said body for expansion laterally outwardly of said body; said pipe having stop means therein in its lower portion; locating means on said body engageable with said stop means to locate said body in the lower portion of said pipe with said cutter means extending below the lower end of the pipe; said body below said locating means having a diameter substantially less than the internal diameter of the pipe to provide an annular passage therebetween above said cutter means; means for expanding said cutter means laterally outwardly; means for transmitting drilling weight from the pipe to the bit; means for transmitting the rotary motion of said pipe to said cutter means when said cutter means are in expanded position; said body having an inlet for directing fluid pumped down the pipe to the interior of said body; said body having one or more side ports below said locating means through which fluid can discharge from the interior of said body to said annular passage, whereby said fluid can flow downwardly around the exterior of said body to said cutter means.

11. In combination: a string of drill pipe adapted to be lowered in a well bore; a drill bit body movable longitudinally through said pipe; initially retracted cutter means mounted on said body for expansion laterally outwardly of said body; said pipe having stop means therein in its lower portion; locating means on said body

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engageable with said stop means to locate said body in the lower portion of said pipe with said cutter means extending below the lower end of the pipe; a mandrel movable downwardly in the body and engageable with said cutter means for expanding said cutter means laterally outwardly of said body; means for shifting said mandrel downwardly of said body to expand said cutter means laterally outwardly of said body; said body having a diameter below said locating means substantially less than the internal diameter of said pipe to provide an annular passage therebetween through which drilling fluid can flow; said body having an inlet for directing fluid pumped down the pipe to the interior of said body; said body having one or more side ports through which fluid can discharge from the interior of said body to said annular passage; means for transmitting drilling weight from the pipe to the bit; and means for transmitting the rotary motion of said pipe to said cutter means, whereby the pipe is adapted to rotate said cutter means.

12. In combination: a string of drill pipe adapted to be lowered in a well bore; a drill bit body movable longitudinally through said pipe; initially retracted cutter means mounted on said body for expansion laterally outwardly of said body; said pipe having stop means therein in its lower portion; locating means on said body engageable with said stop means to locate said body in the lower portion of said pipe with said cutter means extending below the lower end of the pipe; a mandrel movable downwardly in the body and engageable with said cutter means for expanding said cutter means laterally outwardly of said body; means for shifting said mandrel downwardly of said body to expand said cutter means laterally outwardly of said body; said body having a diameter below said locating means substantially less than the internal diameter of said pipe to provide an annular passage therebetween through which drilling fluid can flow; said body having an inlet for directing fluid pumped down the pipe to the interior of said body; said body having one or more side ports through which fluid can discharge from the interior of said body to said annular passage; said mandrel having a passage communicating with the interior of said body for discharging fluid to the region of said cutter means; means for transmitting drilling weight from the pipe to the bit; and means for transmitting the rotary motion of said pipe to said

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cutter means; whereby the pipe is adapted to rotate said cutter means.

13. In a retrievable drilling bit adapted to be lowered within and coupled to the lower portion of a string of pipe disposed in a well bore: a body movable longitudinally through the pipe; initially retracted cutter means; means mounting said cutter means on said body for expansion laterally outwardly of said body; means on said body adapted to engage a lower portion of the pipe to locate the bit in the pipe with said cutter means extending below the lower end of the pipe; spring actuated means movable downwardly relative to said body and engageable with said cutter means below said mounting means for expanding said cutter means laterally outwardly of the body to drill an effective hole diameter greater than the outside diameter of the pipe; means for transmitting drilling weight from the pipe to the bit; and means for coupling the bit to the pipe, whereby the pipe is adapted to rotate the bit.

14. In a retrievable drilling bit adapted to be lowered within and coupled to the lower portion of a string of pipe disposed in a well bore: a body movable longitudinally through the pipe; initially retracted cutter means; means mounting said cutter means on said body for expansion laterally outwardly of said body; means on said body adapted to engage a lower portion of the pipe to locate the bit in the pipe with said cutter means extending below the lower end of the pipe; a mandrel movable downwardly of said body and engageable with said cutter means below said mounting means for expanding said cutter means laterally outwardly of said body to drill an effective hole diameter greater than the outside diameter of the pipe; spring means acting between said body and mandrel to move said mandrel downwardly of said body to expand said cutter means laterally outwardly; means for transmitting drilling weight from the pipe to the bit; and means for coupling the bit to the pipe, whereby the pipe is adapted to rotate the bit.

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