United States Patent

[11] 3,545,553

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[45] Patented **Dec. 8, 1970**

[73] Assignee **Rotary Oil Tool Company Buena Park, California a corporation of California**

[54] **RETRIEVABLE WELL DRILLING APPARATUS**
28 Claims, 18 Drawing Figs.

[52] **U.S. Cl.** **175/258**
[51] **Int. Cl.** **E21b 9/26**
[50] **Field of Search** 175/258

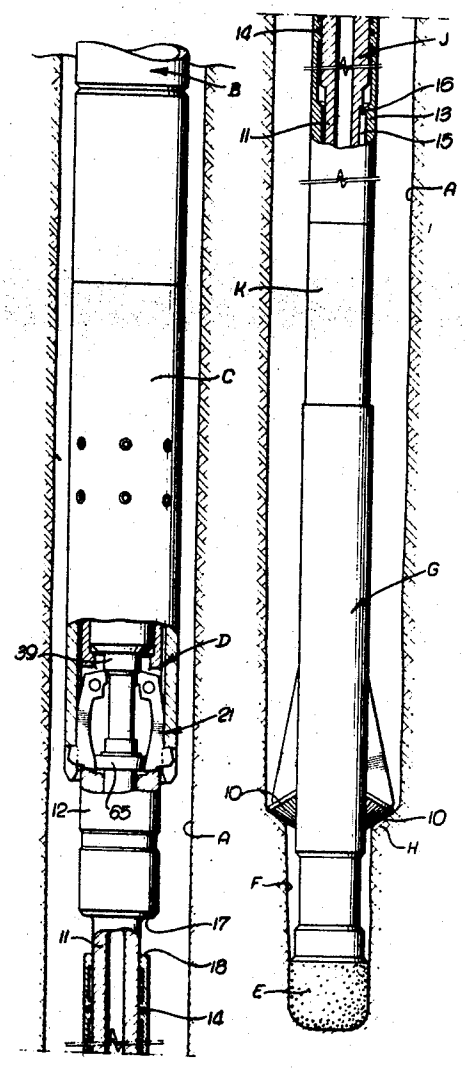
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Primary Examiner—James A. Leppink
Attorney—Bernard Kriegel

ABSTRACT: Well bore drilled with casing as the drill string. Drilling tools are lowered through the casing and releasably locked to the casing shoe by expanding coupling members into shoe slots and wedging them between the shoe and the coupling apparatus, enabling drilling torque to be transmitted directly from the casing to the drilling mechanism extending therebelow, as well as drilling weight, without imposing torque and drilling weight on hinge pins pivotally supporting the coupling members on the main body of the coupling apparatus. The coupling apparatus is releasable for withdrawal with the drilling tool through the casing to the top of the well bore.



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FIG. 1a.

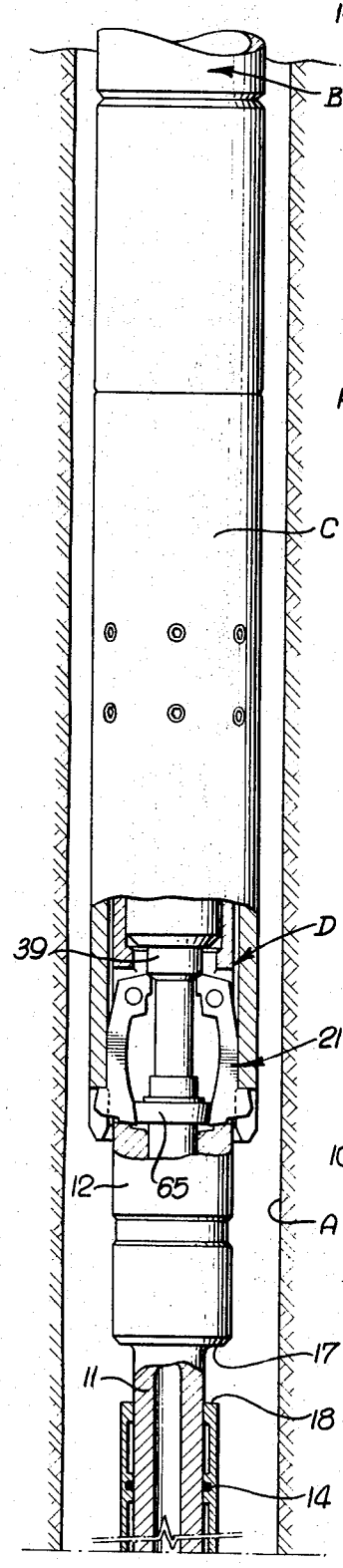


FIG. 1b.

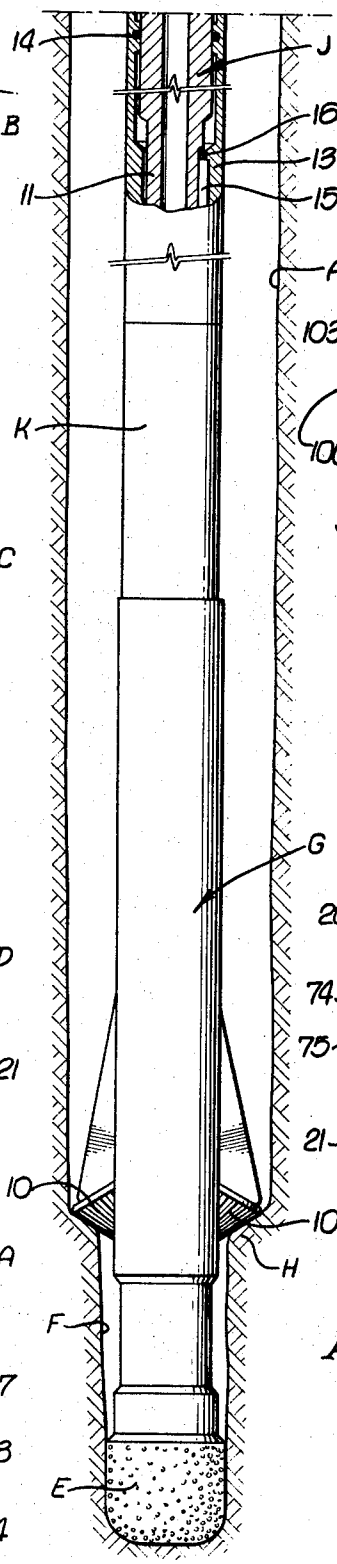


FIG. 9.

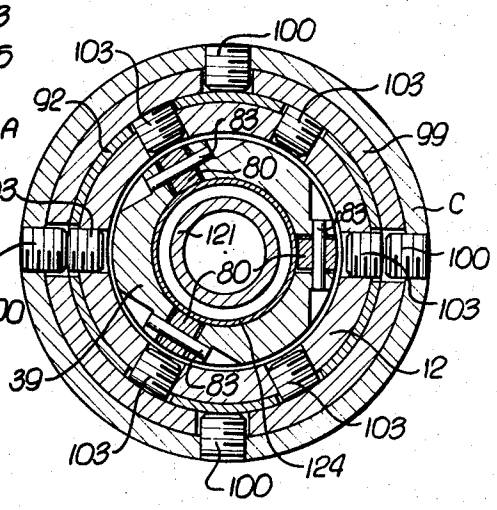
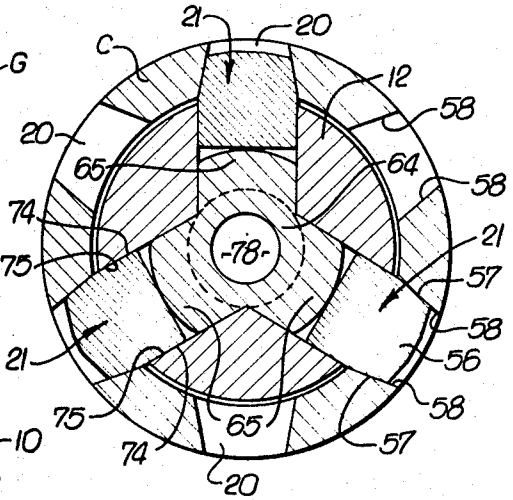


FIG. 10.



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FIG. 2a.

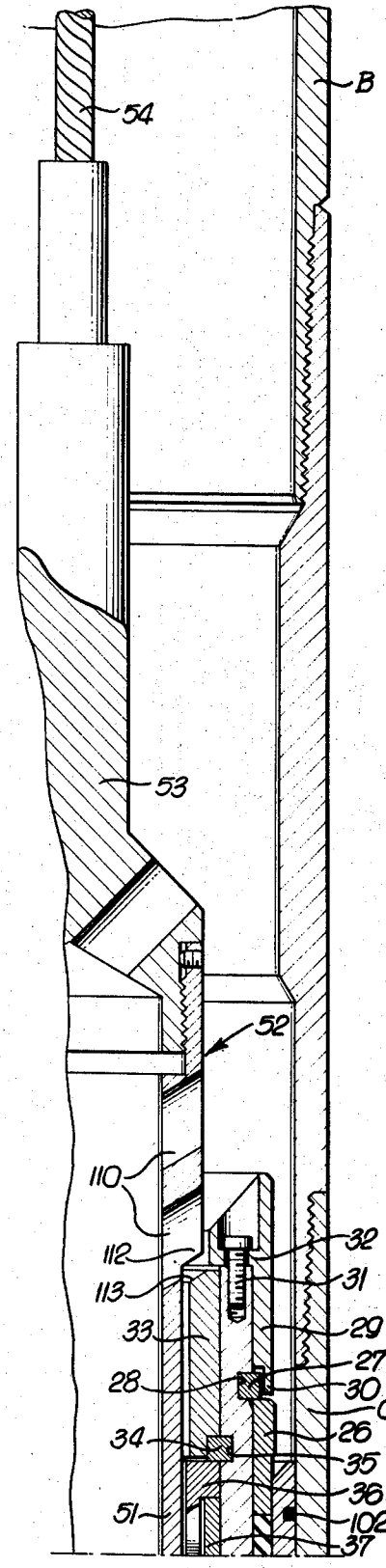


FIG. 2b.

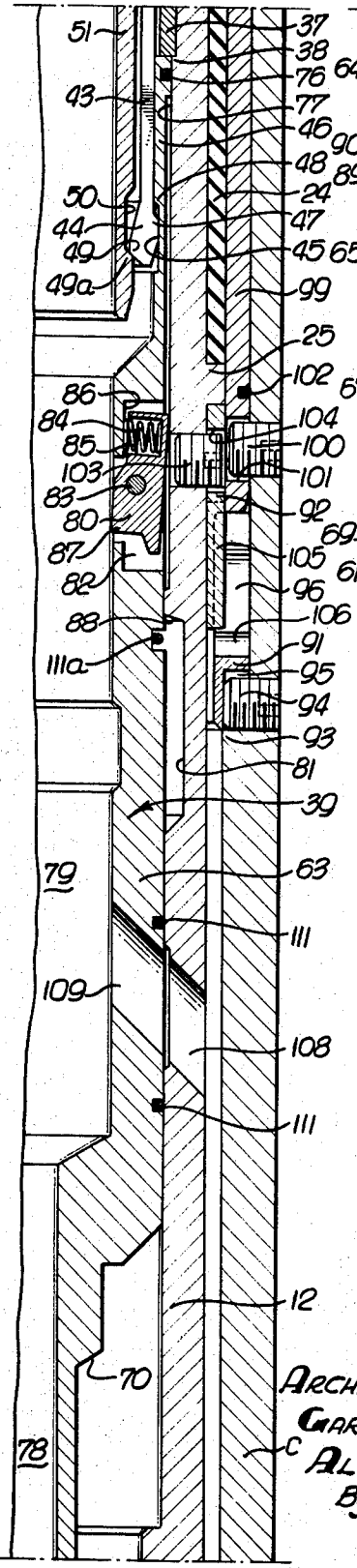
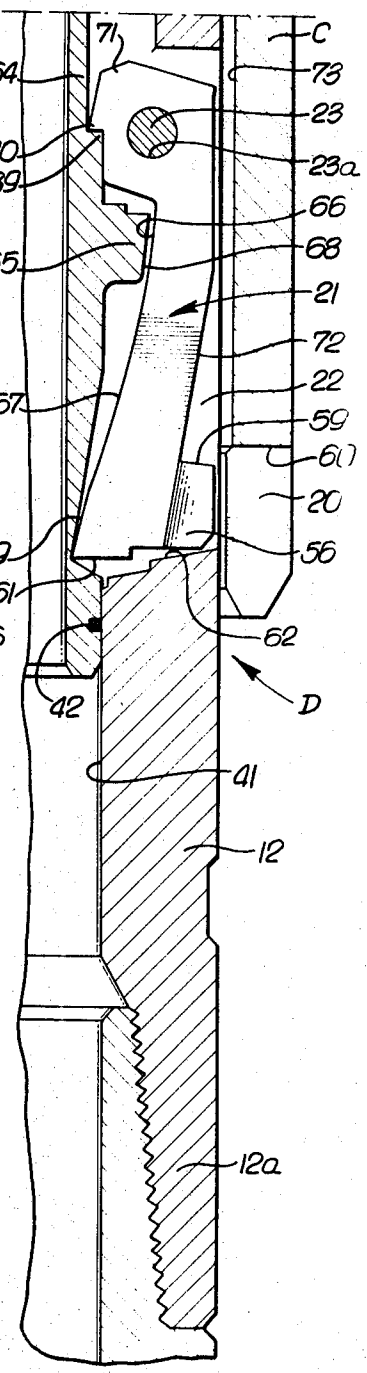


FIG. 2c.



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FIG. 3a.

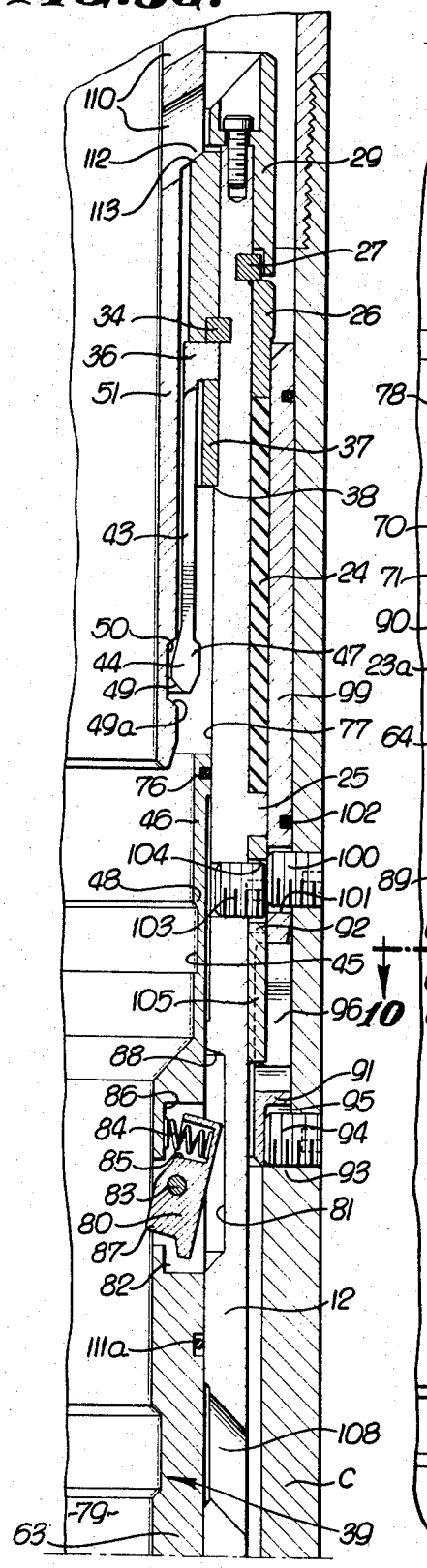


FIG. 3b.

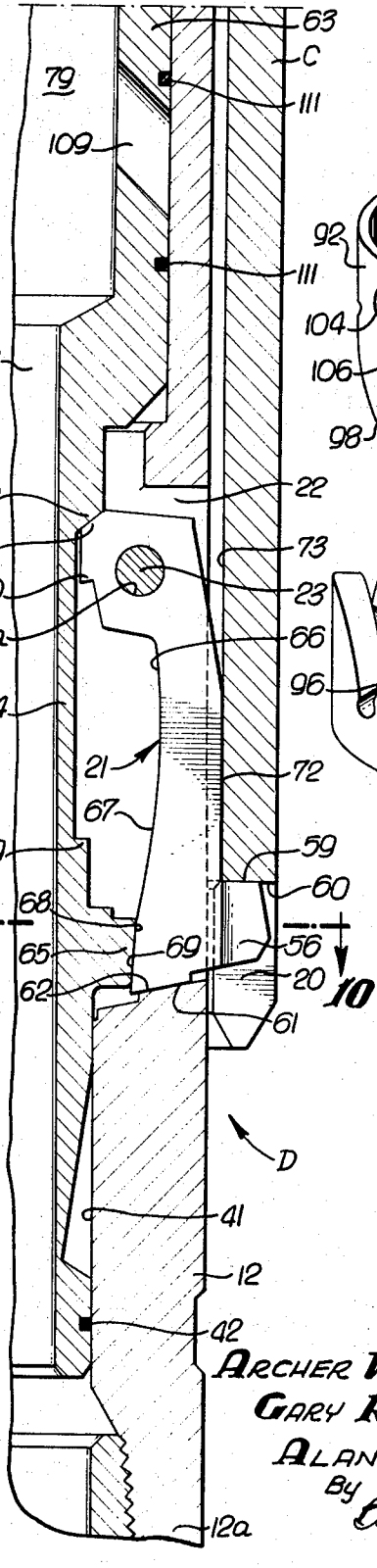
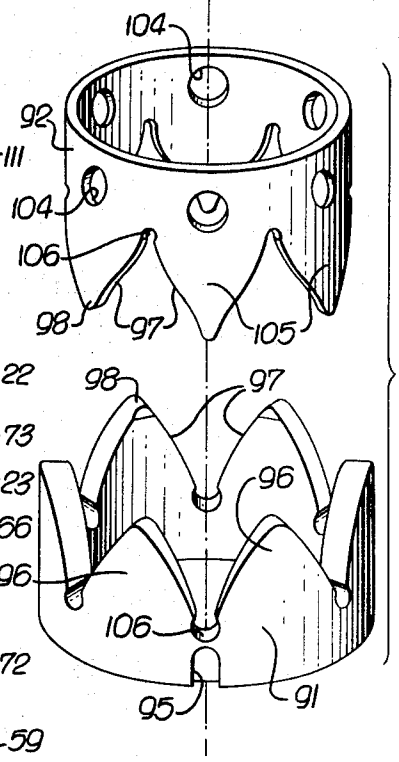


FIG. 11.



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FIG. 4a.

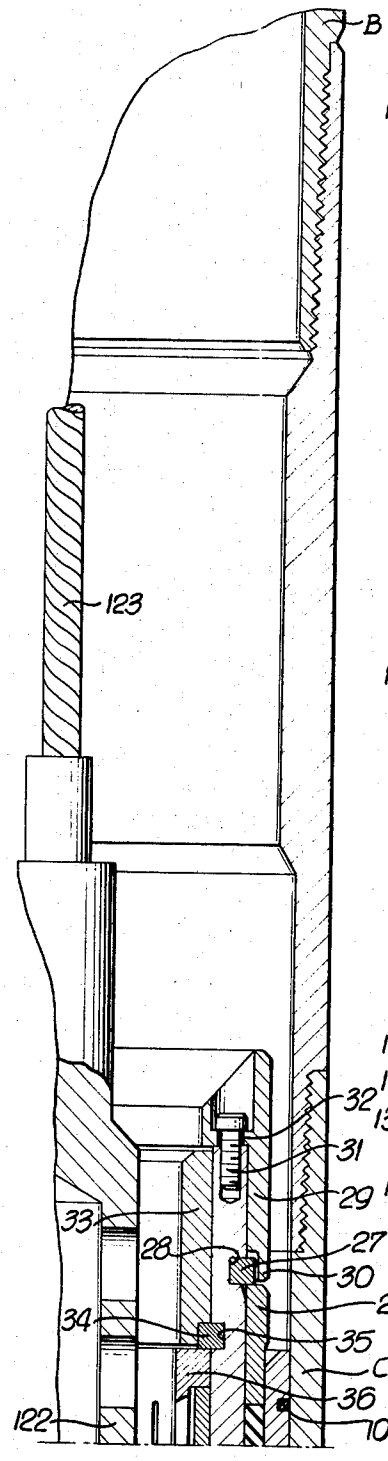


FIG. 4b.

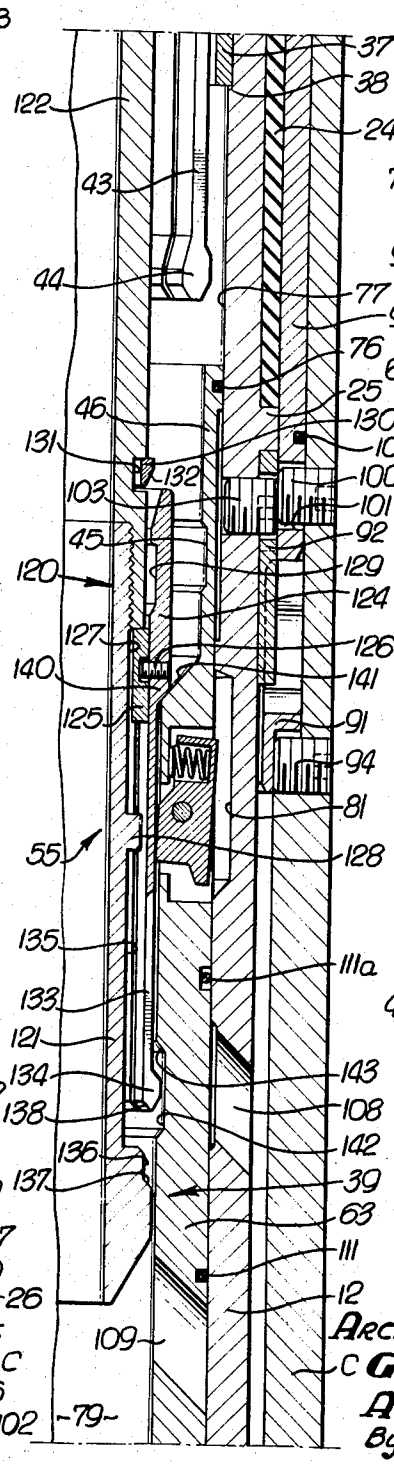
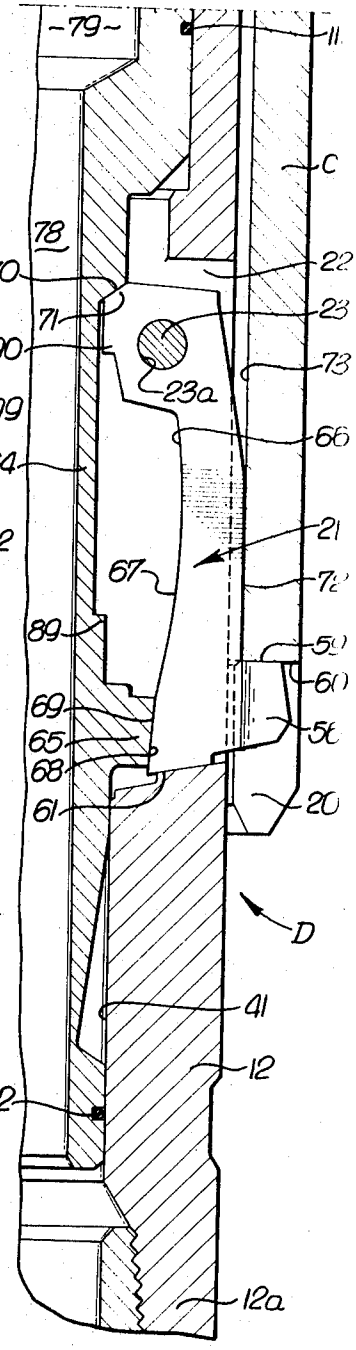


FIG. 4c.



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FIG. 5a.

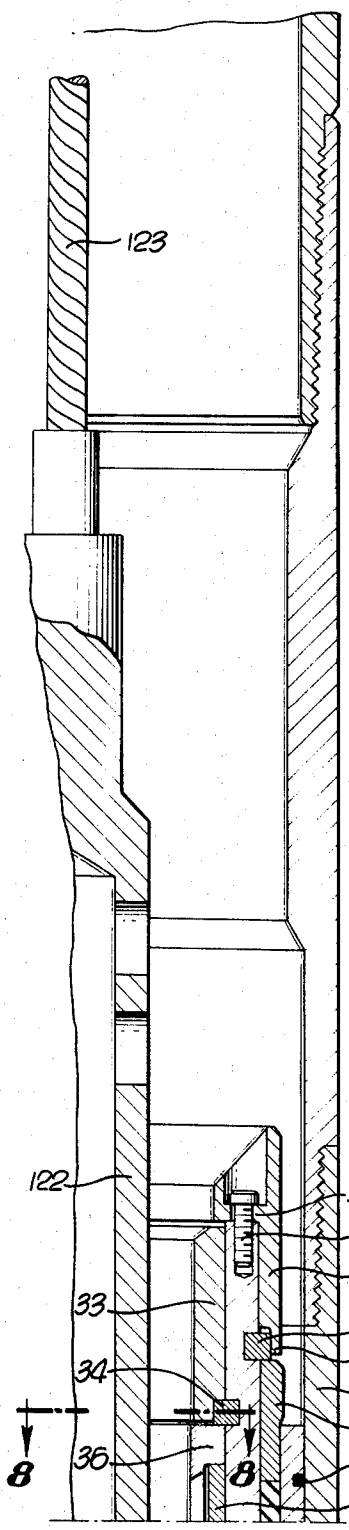


FIG. 5b.

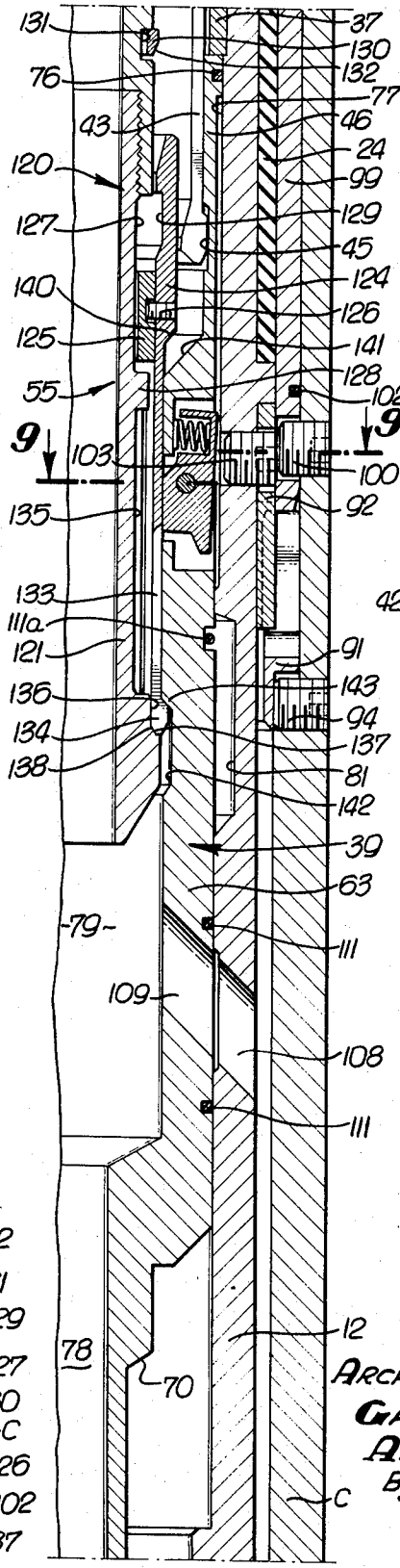
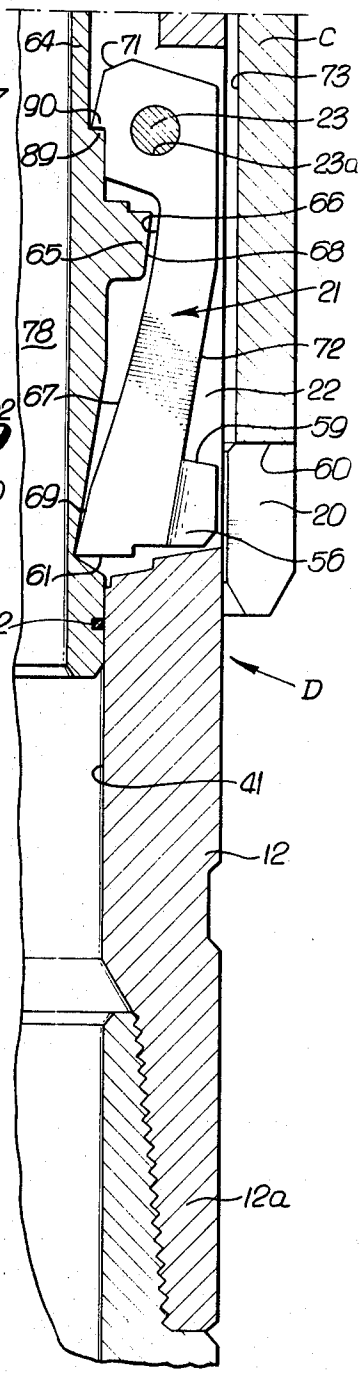


FIG. 5c.



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FIG. 6.

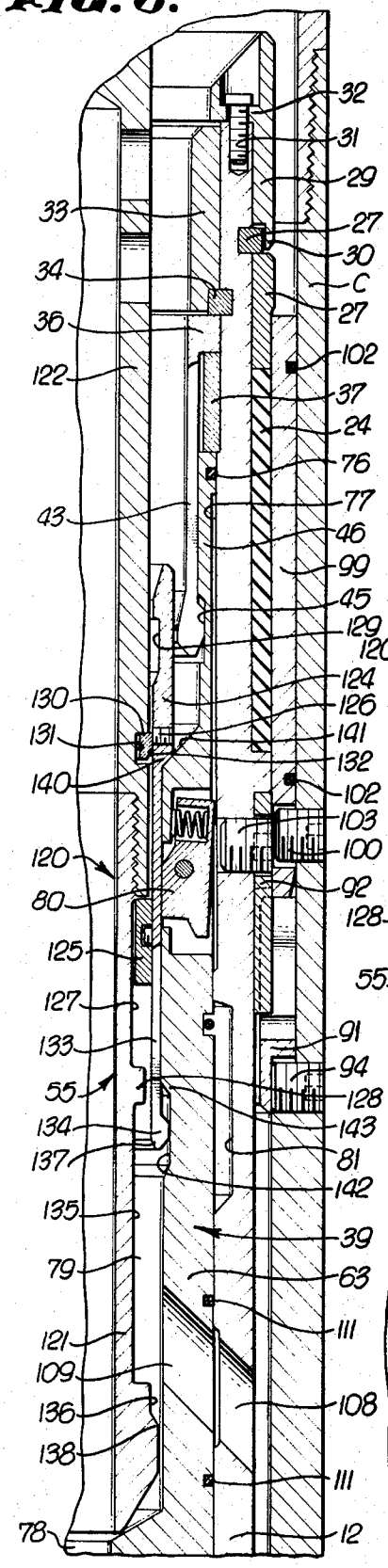


FIG. 7.

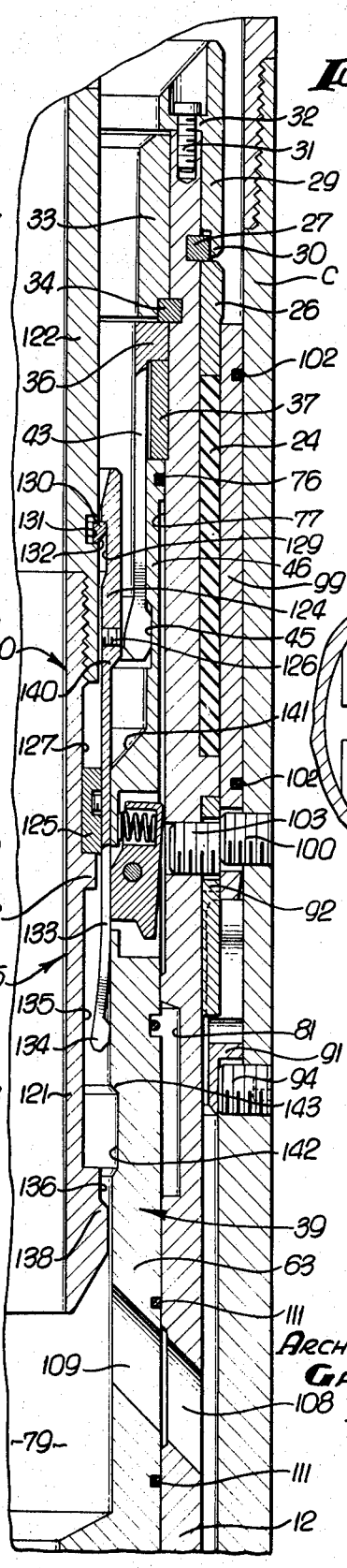
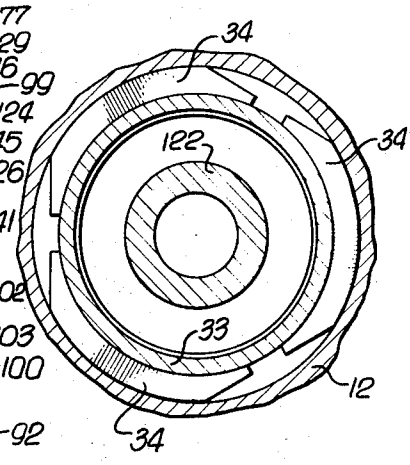


FIG. 8.



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RETRIEVABLE WELL DRILLING APPARATUS

The present invention relates to subsurface well bore apparatus, including apparatus movable through a pipe string in the well bore, such as well casing, to be coupled thereto and subsequently released therefrom for withdrawal through the pipe string to the top of the well bore.

The usual mode of drilling well bores includes the securing of a drilling bit to the lower end of the string of drill pipe and lowering the pipe string in the hole to its bottom portion, the drilling string then being rotated to rotate the drill bit for the purpose of cutting the hole. When each drill bit becomes dull, the drill pipe is removed from the well bore and another bit attached to the drill pipe in its place, such string of drill pipe being lowered in the well bore. Following completion of the drilling operation, the drill pipe is removed and a string of casing lowered in the hole, which may be cemented in place.

The above mode of drilling the well bore requires frequent round trips to change dull drill bits, or for that matter, to perform other operations, such as coring the hole and remove the cores to the surface for examination, all of which entails time-consuming and costly operations, particularly when the well bore is being drilled from a floating drilling vessel. In certain formations, there is the danger of being unable to lower the casing in the drilled hole to the required depth, because of restrictions in the diameter of the bore hole, or the well bore might be damaged as a result of the building up of high pressures in the fluids in the well bore resulting from the lowering operation.

It has been proposed to overcome the above disadvantages by using the final well casing as the drilling string, a retrievable drilling bit being lowered through the casing to its lower end and then latched to the casing shoe. When the drill bit becomes dull or the core barrel of the coring apparatus contains a desired length of core, the apparatus is released from the casing and withdrawn therethrough to the top of the hole. Such an apparatus is specifically illustrated in U.S. Pat. No. 3,123,160. However, there are disadvantages to the apparatus illustrated therein, which the present invention overcomes. In the apparatus disclosed in the above patent, coupling members are pivotally connected to a main body member and are expanded outwardly into slots in the casing shoe. The drilling torque associated with rotation of the casing string in cutting into the bore hole formation, and the drilling weight imposed on the drilling apparatus, are transmitted through hinge pins that pivotally support the coupling members on the main body of the coupling apparatus. In addition, indexing of the coupling members to aline them properly with slots in the casing shoe is difficult of performance. The apparatus itself forms a barrier in the lower portion of the casing string to the comparatively free pumping and flow of the desired drilling fluid down through the casing string and into the well bore below the drilling apparatus.

With the present invention, the coupling apparatus is automatically indexed with respect to casing shoe slots into which the coupling members are expanded. Both the torque and the drilling weight are transmitted directly from the casing, through the coupling members to the main body of the coupling apparatus, to which other apparatus extending downwardly with respect to the casing shoe is connected, such as a drill bit, core bit, and the like. The coupling apparatus is self-indexing when lowered through the string of casing to its shoe portion, but no drilling torque or drilling weight is transmitted through the indexing members of the apparatus. In addition, the pins hingedly mounting the coupling members on the main body of the bit are free from any pulling action imposed on the apparatus when it is to be released from the casing shoe and withdrawn to the top of the well bore. During the location of the apparatus in the casing shoe, the release of the running-in mechanism from the coupling apparatus is effected automatically. More specifically, the pumping of drilling fluid down through the casing string in the apparatus is all that is required to effect release of the running-in string therefrom and for expanding the coupling members outwardly into the slots of the casing shoe. The fact of release of the running-mechanism from the plunger is a positive indication that the coupling members are appropriately locked in the casing shoe, all of the parts being in their proper position for the commencement of the drilling or other desired operation in the well bore.

The coupling apparatus is readily released from the casing shoe for removal through the casing string to the top of the well bore. If difficulty is encountered in securing the release, a jarring action of sufficient severity can be availed of to release the pulling tool from the apparatus, so that pulling tools of greater jarring capacity can be run through the casing into coupling relation with the apparatus to secure its release and withdrawal.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGS. 1*a* and 1*b* together constitute a side elevational view of an apparatus disposed in a well bore, parts being disclosed in section, FIG. 1*b* being a lower continuation of FIG. 1*a;*

FIGS. 2*a*, 2*b* and 2*c* are quarter longitudinal sectional views of the coupling portion of apparatus disclosed in FIG. 1*a*, with the parts in retracted position and disposed within the casing shoe, FIGS. 2*b* and 2*c* being lower continuations of FIGS. 2*a* and 2*b*, respectively;

FIGS. 3*a* and 3*b* are views similar to FIGS. 2*a*, 2*b* and 2*c*, disclosing the apparatus coupled to the casing shoe, FIG. 3*b* being a lower continuation of FIG. 3*a;*

FIGS. 4*a*, 4*b* and 4*c* are views corresponding to FIGS. 2*a*, 2*b* and 2*c*, illustrating the coupling apparatus in condition for release from the casing shoe, FIGS. 4*b* and 4*c* being lower continuations of FIGS. 4*a* and 4*b*, respectively;

FIGS. 5*a*, 5*b* and 5*c* are views similar to FIGS. 4*a*, 4*b* and 4*c*, disclosing the coupling members released from the well casing, and the entire apparatus in condition for withdrawal through the casing string to the top of the well bore, FIGS. 5*b* and 5*c* being lower continuations of FIGS. 5*a* and 5*b*, respectively;

FIG. 6 is a quarter sectional view of the coupling apparatus in association with the retrieving tool, being conditioned for release from the apparatus and for withdrawal through the casing string;

FIG. 7 is a view similar to FIG. 6 disclosing the releasing tool in its released condition from the apparatus;

FIG. 8 is a section taken along the line 8–8 on FIG. 5*a;*

FIG. 9 is a cross section taken along the line 9–9 on FIG. 5*b;*

FIG. 10 is a cross section taken along the line 10–10 on FIG. 3*b;*

FIG. 11 is an exploded isometric projection of the indexing and orienting sleeves for alining the coupling members with the shoe slots.

The apparatus specifically disclosed in the drawings is provided for the purpose of drilling a well bore A through use of a string of casing B as a rotary drill string, the casing to be left in the hole and cemented therein after the hole has been drilled to the desired depth. Various forms of drilling apparatus can be used for releasable coupling to the casing string and for lowering therethrough for the purpose of being locked to a casing shoe C by a coupling apparatus D, the coupling apparatus being connected to suitable drilling equipment, such as a pilot bit E for drilling the central portion F of the well bore and an expandable type of drill bit G connected thereto and having expandable cutters 10 thereon, which will enlarge the size of the hole A to its desired final diameter. The expandable drill bit G may be of any suitable type capable of

being moved through the interior of the casing string B and to have its normally retracted cutters **10** expanded outwardly to the effective cutting diameter required to enlarge the hole, the cutters disclosed being capable of drilling upon a formation shoulder H extending between the wall of the pilot hole F and the wall of the final diameter of the hole A. By way of example, the expandable drill bit G may be of the specific form illustrated in U.S. Pat. No. 2,758,819.

In the event the well bore A underlies a body of water and is to be drilled from a floating drilling vessel, an appropriate telescopic joint J may be interposed between the coupling apparatus D and a suitable number and length of drill collars K, the lower end of which is suitably secured to the expandable drill bit G. As shown merely by way of example, the telescopic joint J includes an inner member **11** threadedly or otherwise suitably secured to the lower portion of the body **12** of the coupling apparatus and disposed within an outer member **13**, the lower end of which is suitably secured to the upper end of an adjacent section of the drill collars K. Suitable seal rings **14** prevent leakage of fluid between the inner and outer telescopic members **11, 13**. The outer member **13** may have one or more elongate keys **15** secured thereto suitably received within one or more keyways **16** in the inner member **11**, so that torque can be transmitted between the members. If the apparatus is used in connection with a floating drilling vessel, the appropriate drilling weight to be imposed upon the pilot bit E and the expandable cutters **10** any be provided by the drill collars K, allowing the entire casing drilling string B, coupling apparatus D, and telescopic inner member **11** to partake of limited vertical movement as the floating drilling vessel is shifted vertically under the action of waves, winds, and the like. For that matter, the drilling weight can be transmitted from the casing string B through the coupling apparatus D to the inner telescopic member **11**, and from a suitable shoulder **17** on the inner member to a companion shoulder or surface **18** engaged thereby on the outer telescopic member.

The lower end of the casing string is constituted by the tubular shoe C, the upper end of which is threadedly secured to an upper coupling **19**, which, in turn, is threadedly secured to the lower end of an adjacent casing section forming part of the casing string B extending to the top of the well bore A, or the to the drilling barge or vessel thereabove. The lower portion of the shoe C is provided with a plurality of circumferentially spaced slots **20** opening downwardly through its lower end, in which expandable and retractable coupling members **21** of the coupling apparatus are adapted to be received. These coupling members are disposed in circumferentially spaced, elongate slots **22** in the body portion **12** of the coupling apparatus D, being pivotally mounted on hinge pins **23** extending across the slots and suitable secured to the body. The maximum external diameter of the body is less than the minimum inside diameter through the casing string B, so that the body **12** and the entire coupling apparatus D itself, together with the telescopic joint J, drill collars K, expandable drill bit G, and pilot bit E, can be lowered and raised through the casing string in connection with the running of the apparatus in the casing string and its removal therethrough to the top of the well bore or drilling barge.

The upper portion of the body **12** carries a suitable seal **24**, which may be made of an elastomeric material, the lower end of which engages a flange or shoulder **25** on the body and the upper end of which engages a gage ring **26**, held in position by a two-piece ring **27** extending across its upper end and retained in an external circumferential groove **28** in the body by a top retainer member **29** having a depending skirt **30** encircling the ring. This retainer member **29** is secured to the body **12** by a plurality of cap screws **31** extending through a retainer flange **32** and threaded into the upper end of the body, this flange also overlying an inner retaining sleeve **33** bearing against and also extending within a split ring **34** disposed in an internal circumferential groove **35** in the body and overlying the upper end of a latch sleeve **36**, which bears against a spacer **37** that engages an upwardly facing body shoulder **38**.

The spacer member **37** determines the upper limit of movement of a tubular plunger or mandrel **39** shiftable longitudinally within the main body **12**, the mandrel extending downwardly from the spacer ring **37** to a position across the body slots **22** and terminating in a lower head **40** slidable in a central cylindrical bore **41** of the body, leakage of fluid between the head and the cylindrical bore being prevented by a suitable side seal ring **42** on the head engaging the body wall. The upper end of the latch sleeve **36** is circumferentially continuous and is confined between the split ring **34** and the spacer **37**, the sleeve including depending circumferentially spaced legs **43** terminating in latch feet **44** initially received within an internal circumferential groove **45** in the upper portion **46** of the mandrel **39**, an upwardly facing surface **47** on the feet being adapted to engage a downwardy facing shoulder **48** on the mandrel defining the upper side of the internal latching groove **45**. The feet **44** include inwardly extending portions **49** receivable within an external groove **50** in the lower portion of a sleeve **51** constituting part of the running-in tool **52** for the coupling apparatus. This sleeve is threadedly secured to an adapter **53** suitably attached to the lower end of a wire line **54** extending to the top of the well bore, and by means of which the coupling apparatus D, telescopic joint J, drill collars K, expandable drill bit G, and pilot bit E are lowered through the casing B to a position in which the coupling apparatus D is to be secured to the casing shoe C. The retrieving tool apparatus **55** disclosed in FIGS. **4** to **7**, inclusive, is usable for releasing the coupling apparatus D from the casing shoe C, and for elevating it, together with the tool members secured to its lower portion, through the casing string B to the top of the well bore A.

Each coupling or lock member **21** has a lower projecting lug portion **56** whose sides **57** converge toward each other in a lateral outward direction, being adapted for engagement with companion tapered sides **58** in one of the casing slots **20** when the coupling or lock member lug **56** is expanded outwardly into such slot. When expanded outwardly, the upper end **59** of the lug engages a companion shoulder **60** defining the upper end of the shoe slot **20**, and, at this time, a lower thrust surface **61** on the inner portion of the coupling member **21** engages a companion stop or thrust surface **62** defining the outer lower portion of the body slot **22** in which the lock member **21** is located (FIG. **3***b*).

The coupling members **21** are expanded outwardly when appropriately oriented with respect to the shoe slots **20**, as described hereinbelow, by the downward movement of the tubular plunger or mandrel **39** withing the body **12** of the tool. The mandrel includes a main upper portion **63** of relatively large external diameter slidable within the upper portion of the body **12**, and a smaller diameter portion **64** extending within the coupling members **21** and terminating in the lower head **40**. Above the lower head, the mandrel is provided with an expander **65** disposed within recesses **66** in the coupling members **21** below the hinge pins **23**, the expander being engageable with inclined inner surfaces **67** on the coupling members for the purpose of expanding the latter outwardly upon downward movement of the mandrel **39** and its expander **65** along the expander surfaces. When the coupling members **21** are expanded outwardly to their full position, external longitudinal holding surfaces **68** on the expander engage companion inner holding surfaces **69** at the lower portions of the coupling members, for the purpose of retaining the coupling members in their outward expanded condition. At this time, the upper thrust surface **59** engages the shoulder **60** at the upper end of each shoe slot **20**, the lower thrust surface **61** of the coupling member engaging the companion stop or thrust surface **62** on the body, with an upper abutment **70** on the mandrel above the hinge pin engaging a companion abutment portion **71** at the upper end of each coupling member. The parts are then in the condition disclosed in FIG. **3***b*, an outer longitudinal surface **72** on each coupling member above its thrust surface **59** engaging the inner wall **73** of the shoe, each coupling member **21** then being solidly held between the shoe C, mandrel **39**, and body **12** of the coupling apparatus. The hinge pin **23**

makes a relatively loose fit in the companion hole 23*a* passing through the upper portion of the coupling member 21, the sides 74 of each coupling member slidably engaging the sides 75 of the body slots 22. Accordingly, drilling weight will be transmitted directly from the casing shoe C through the lower portion 56 of each coupling member to the body 12 of the coupling apparatus, drilling torque being transmitted directly from the casing shoe C through the sides 58 of each slot 20 and through the coupling member 21 to the sides 75 of the body 12, none of the drilling weight and torque being imposed upon the hinge pin 23 itself.

As explained hereinbelow, the mandrel 39 is shiftable downwardly within the body 12 hydraulically, the upper portion of the mandrel carrying a suitable side seal ring 76 engaging the inner wall 77 of the body 12 of the tool. The passage 78 through the lower portion 64 of the mandrel is of a substantially smaller diameter than the internal diameter of the passage 79 in the upper portion of the mandrel, so that the pumping of fluid down through the casing string B and through the mandrel 39 will develop a back pressure acting in a downward direction on the upper portion 63 of the mandrel, tending to shift it downwardly within the body 12 for the purpose of expanding the coupling or lock members 21 outwardly into coupling relation to the casing shoe C. When the mandrel 39 has shifted downwardly to its maximum extent, as disclosed in FIGS. 3*a* and 3*b*, a plurality of mandrel latch members or dogs 80 expand outwardly into an internal circumferential latch 81 in the body of the apparatus, to preclude any substantial upward movement of the mandrel within the body of the tool. More specifically, the latch dogs 80 are disposed within circumferentially spaced slots 82 in the mandrel, each being mounted on a hinge or pivot pin 83 extending through the dog and across the slot, being suitably secured to the mandrel. A helical compression spring 84 is located in a recess 85 in the upper portion of each dog, bearing against the latter and against a mandrel seat 86, urging the upper portion of the latch dog outwardly and its lower inner nose 87 within the mandrel passage 79, the dog being shiftable by the spring outwardly into the latch groove 81, any tendency of the tubular plunger or mandrel 39 to move upwardly to any substantial degree causing the upper ends of the latch dogs 80 to engage the upper end 88 of the latch groove 81, to preclude such substantial upward shifting. As a rule, there is no force acting upwardly on the tubular mandrel 39 during the drilling operation, since fluid is continuously being pumped down through the casing string B and the tubular mandrel 39 during the drilling operation, which holds the mandrel in its downward position within the body 12, as disclosed in FIGS. 3*a* and 3*b*.

When the coupling apparatus D is to be released from the casing shoe C, a suitable retrieving tool 55, disclosed in FIGS. 4 to 7, inclusive, may be employed to engage the latch noses 87 for the purpose of swinging the lower portions of the latch dogs 80 in an outward direction and their upper portions inwardly out of the latch groove 81, permitting upward movement of the mandrel 39 with respect to the body 12, which upward movement will elevate the expander 65 along the coupling members 21 and will also bring an upwardly facing retracting shoulder 89 on the mandrel into engagement with inwardly extending retracting fingers 90 at the upper ends of the coupling members 21, tending to swing such inner fingers upwardly and the lug portions 56 inwardly of the body 12 of the coupling apparatus.

When the coupling apparatus D reaches the location of the casing shoe C, it is necessary for the coupling members 21 to be properly oriented with respect to the shoe slots 20, enabling the lugs 56 to enter thereinto. As specifically disclosed in the drawings, by way of example, there may be three coupling members 21 mounted on the body 12 of the tool, the centers of which are disposed 120° apart. There are six slots 20 in the casing shoe C disposed 60° apart, so that it is only necessary to aline or orient the coupling members 21 with three of the slots, the centers of which are disposed 120° apart. Such alining or orienting is accomplished through an appropriate indexing portion of the apparatus, which need only effect an approximate alinement between the coupling members 21 and the slots 20 in view of the wedge-shape configuration of the lugs 56 and the companion shoe slots 20.

The indexing portion of the apparatus includes an index sleeve 91 carried by the casing shoe C and a companion orienting or approximating sleeve 92 carried by the body 12 of the coupling apparatus. The index sleeve has its lower end resting upon an upwardly facing shoe shoulder 93, substantial turning of the sleeve relative to the shoe being prevented by a plurality of screws 94 threaded in the shoe and received within lower sockets 95 in the index sleeve. The screws may have substantial clearance in the socket. The upper portion of the index sleeve 91 comprises upwardly extending axial cam teeth 96, the sides 97 of each tooth tapering in an upward direction toward an apex 98 (FIG. 11). The upper ends of the teeth engage the lower end of an elongate seal sleeves 99 secured to the shoe C by a plurality of circumferentially spaced screws 100 threaded into the shoe and received within companion holes 101 in the seal sleeve. This seal sleeve carries side seal rings 102 sealingly engaging the wall of the shoe to prevent fluid leakage therebetween.

The approximating or orienting sleeve 92 encompasses the body 12 of the coupling apparatus, its upper end engaging the body flange 25, the sleeve being carried by the body by virtue of a plurality of circumferentially spaced screws 103 being threaded into the body 12 and received loosely within companion holes 104 in the upper portion of the orienting sleeve. This sleeve has downwardly facing axial cam teeth 105 companion to the upwardly facing axial cam teeth 96 of the index sleeve, the cam teeth of both sleeves being appropriately designed so that the depending teeth 105 can mesh with the upwardly extending teeth 96, and with the apex portions 98 of the teeth finally being located at the root portions 106 of the companion teeth. When so engaged, the lugs 56 of the coupling members will be disposed in alinement with three of the 120° separated slots 20 in the shoe, permitting downward movement of the mandrel 39 within the body 12 to expand the coupling members 21 outwardly until the position of the coupling members 21 with respect to the body 10, mandrel 39, and casing shoe C, illustrated in FIG. 3*b*, is achieved.

In the operation of the apparatus, let it be assumed that the casing string B has been used with the apparatus in drilling the hole A to a certain depth, and that the apparatus, including the devices secured to the lower end of the body 12, have been removed through the casing string to the top of the well bore, and that a new bit E and expandable cutters 10 are to be run in the well for continuing the drilling of the hole. The pilot bit E is secured to the lower end of the expandable drill bit G, which, in turn, is secured to the lower end of the drill collars K, the latter being attached to the telescopic joint J, which, in turn, is threadedly secured to the lower box 12*a* of the body 12 of the coupling apparatus D. The mandrel 39 is in its upper position within the body 12, the running tool sleeve 51 being disposed within the coupling apparatus, with the inner portions 49 of the latch feet received within its peripheral groove 50, and with the shoulder 48 of the mandrel resting upon the outer portion 47 of the latch feet, which are disposed in the latching groove 45 of the mandrel, the body 12 being suspended from the mandrel by virtue of the fact that the spacer 37 engages the upper end of the mandrel. The adapter 53 is secured to the sleeve 51 and the wire line 54 attached to the adapter.

This combination of apparatus, with the parts disposed in their relative positions illustrated in FIGS. 2*a*, 2*b* and 2*c*, is then lowered through the casing string B, the pilot bit E, expandable bit G, drill collars K, and telescopic joint J passing through the casing shoe C and extending therebelow. When the orienting or approximating sleeve 92 reaches the index sleeve 91, its teeth 105 mesh with the cam teeth 96 of the indexing sleeve, which turns the body 12 of the tool with respect to the casing shoe C, for the purpose of alining the lugs 56 of the coupling members 21 with the casing shoe slots 20, the

body 12 coming to rest in the position illustrated in FIGS. 2*a*, 2*b* and 2*c*, with the approximating sleeve teeth 105 fully meshed with the index sleeve teeth 96. The lugs 56 may or may not be accurately alined with the slots 20, but they are sufficiently alined for passage into the wide inner portions of the tapered shoe slots 20, and upon being expanded outwardly thereinto will automatically accomplish the final and accurate alinement between them and the casing shoe.

During the lowering of the apparatus through the fluid in the casing, such fluid can flow upwardly through the several tools E, G, K, J depending from the coupling apparatus D, and up through the mandrel passage 78, 79, the fluid also flowing through ports 108 in the body and through alined ports 109 in the mandrel into the enlarged bore 79 of the mandrel 39, such fluid then passing upwardly through the running tool sleeve 51 and outwardly through ports 110 in the upper portion of its wall to the casing region above the running-in tool 52. Fluid externally of the body 12 is confined for passage through the body and mandrel ports 108, 109 by the provision of side seals 111 on opposite sides of the mandrel ports 109 engaging the inner wall of the body on opposite sides of its ports 108.

When the operator at the drilling rig notices that a slack has developed in the wire line 54, the running tool sleeve 51 will have lowered to a slight extent to bring its shoulder 112 in engagement with the upper end 113 of the retaining sleeve 33, at which time the lower shoulder 49*a* of the running tool sleeve groove 50 will have been lowered away from the latch feet 44, which will then permit such latch feet to be forced inwardly. Circulating fluid is now pumped down into the casing string B, building up a back pressure in the mandrel 39 because of the flow restricting action of the smaller diameter lower passage 78 through the mandrel, the fluid under pressure acting on the upper portion 63 of the mandrel, which is the area between the seal diameter of the upper seal ring 76 against the inner wall 77 of the body and the diameter of the lower mandrel passage 78. The mandrel 39 is shifting downwardly, its shoulder 48 camming the latch feet 44 inwardly out of the latch groove 45, permitting the upper portion of the mandrel to move downwardly below the latch feet 44. As the mandrel 39 moves downwardly of the body 12, its expander 65 engages the expander surfaces 67 of the initially retracted coupling or lock members 21, expanding them outwardly into the shoe slots 20, downward movement continuing until full expansion of the coupling members has been effected into the slots 20, with the tapered sides 57 of the lugs snugly engaging the companion sides 58 of the slots, the upper thrust surfaces 59 engaging the thrust shoulders 60 at the upper ends of the slots 20, the lower thrust surfaces 61 engaging the stop or thrust surfaces 62 at the lower ends of the body slots 22, the expander 65 being disposed behind the holding surfaces 69 on the lower portions of the coupling members, and with the upper abutments 71 engaging the companion abutment surface 70 on the mandrel, the parts then being in the position illustrated in FIGS. 3*a* and 3*b*, in which it will be noted that the latch dogs 80 have been shifted outwardly by the springs 84 into the latch groove 81 of the body of the tool.

At this time, the mandrel ports 109 have been shifted below the body ports 108, with the side seal ring 111 at the upper end of the mandrel ports 109 disposed below the body ports 108 and with another seal 111*a* on the mandrel disposed above the body ports 108 to close the latter against passage of fluid therethrough. With the parts in this position, it is to be noted that the seal assembly 24 on the body 12 of the tool is disposed in sealing engagement with the inner wall of the seal sleeve 99 secured to the casing shoe. Elevation of the wire line 54 will now move the running tool 52 upwardly, the lower tapered side 49*a* of the groove engaging the latch feet 44 and springing them outwardly to permit complete removal of the running tool sleeve 51 from its position within the mandrel 39 and body 12, the running tool 52 then being removed through the casing B to the drilling rig.

Drilling of the well bore A can now proceed in the same normal manner in which well bores are drilled with strings of drill pipe, by circulating fluid down through the casing while its string is being rotated, the fluid pressure expanding the cutters 10 of the expandable tool outwardly, as described in U.S. Pat. No. 2,758,819. Appropriate drilling weight is set down on the pilot bit E and the expandable cutters 10, either by imposing the drilling weight from the shoe C through the coupling members 21 to the body 12 of the coupling apparatus, and thence downwardly through the telescopic joint J (if one is used) and the drill collars K to the expandable drill and the pilot bit, or adequate drilling weight may be provided by the substantial length of drill collar sections K coupled to one another, which will then permit upward and downward movement of the casing string B, coupling apparatus D, and inner telescopic member 11 to take place as a result of wave action on the drilling vessel without elevating the drill bits E, G from the formation or imposing excessive drilling weight thereon. The casing string B is rotated to rotate the apparatus connected thereto and depending therefrom, the circulating fluid circulating the cuttings out of the hole.

When it is desired to retrieve the bits E, G, collars K, telescopic joint J, and coupling apparatus D, a suitable retrieving tool, such as the tool 55, can be used which will release the latch dogs 80 from the latch groove 81 and which will become coupled to the mandrel 39 and pull the latter upwardly with respect to the body 12 of the coupling apparatus. The particular tool 55 illustrated in FIGS. 4 to 7, inclusive, can become coupled to the mandrel, but if difficulty is encountered in elevating the mandrel within the body and securing retraction of the coupling members 21 from the casing shoe slots 20, the pulling tool 55 can be released from the mandrel 39 and withdrawn through the casing B to the top of the well bore.

The pulling tool 55 includes a mandrel 120 composed of a lower section 121 and an upper section 122 suitably secured to a wire line 123, by means of which the retrieving tool is lowered in the well casing. A latch sleeve 124 surrounds the mandrel, this sleeve being releasably secured to a ring 125 by shear screws 126, the ring being disposed within an elongate groove 127 of the mandrel defined between the lower end of the upper mandrel section 122 and an external flange 128 of the lower mandrel section disposed below the ring. The latch sleeve 124 has an upper internal circumferential groove 129 disposed initially below a split ring 130 located within an external groove 131 in the upper mandrel section 122 and having a downwardly tapering external surface 132. The lower portion of the sleeve 124 is constituted by circumferentially spaced elongate latch legs 133 having feet 134 extending laterally outwardly thereof, these latch legs initially being positioned opposite a small diameter portion 135 of the mandrel below the flange 128, which will permit lateral inward retraction of the latch feet. Relative upward movement of the mandrel 120 within the latch feet 134 will bring a mandrel holding surface 136 behind the latch feet, retaining them in an outer position, with a lower inclined shoulder 137 on the mandrel engaging a lower companion inclined surface 138 on the latch feet, so that an upward pull on the mandrel 120 urges and retains the latch feet 134 in an outward position.

The retrieving tool 55 is lowered on the wire line 123 through the well casing B, passing through the upper latch sleeve 37 supported by the body 12 of the tool D, with its latch sleeve 124 moving within the lock dogs 80 and engaging the inwardly directed noses 87 for the purpose of retracting the dogs from the body latch groove 81, freeing the mandrel 39 for upward movement within the tool body 12. The retrieving tool sleeve 124 moves downwardly within the mandrel 39 until its upper shoulder 140 engages a companion shoulder 141 on the mandrel, at which time the latch feet 134 are disposed opposite a circumferential retrieving groove 142 in the mandrel 39 located below the latch dogs 80. The latch feet 134 can be forced laterally inwardly in moving into the mandrel 39 and past the latch dogs 80, since the reduced diameter portion 135 of the mandrel 120 is then disposed behind the latch dogs (FIG. 4*b*.

The wire line 123 can now be moved upwardly to position the holding surface 136 of the mandrel 120 behind the latch feet 134, retaining them within the groove 142, upward movement of the wire line 123 and mandrel 120 now shifting the latch feet upwardly until they engage the upper side 143 of the mandrel latch groove 142. An upward pull on the wire line now moves the mandrel 39 upwardly within the body 12, removing the expander 65 from the holding surface 69 of the coupling members 21 and back toward its initial position, the retracting shoulder 89 on the mandrel engaging the inwardly directed portions 90 of the coupling members, swinging the latter laterally inwardly completely out of the body slots 20 and with the outer ends of the lugs 56 disposed within the peripheral confines of the body 12 (FIGS. 5*a*—5*c*). At this time, the upper end of the mandrel 39 engages the spacer 37, so that upward force or movement on the mandrel 39 is transmitted through the upper portion of the latch sleeve 36 and split ring 34 to the body 12. The entire apparatus can now be elevated by the wire line 123 within the well casing B, the coupling apparatus D passing upwardly through the shoe C, followed by the telescopic joint J, drill collars K, expandable drill bit G, whose cutters have been retracted in the manner described in U.S. Pat. No. 2,758,819, and the pilot bit E. All of the apparatus is then raised by the wire line 123 through the casing B to the drilling rig.

In the event that difficulty is encountered in releasing the coupling apparatus D from the casing shoe C, and to avoid imposing an undue strain on the wire line 123, the retrieving tool 55 can be released from the coupling mandrel 39. The retrieving tool mandrel 120 is jarred downwardly sufficiently against the ring 125 to shear the screws 126 attaching the latch sleeve 124 to the ring, which then permits the mandrel 120 to move downwardly with respect to the latch sleeve 124 to a position in which the split ring 130 is disposed below the lock groove 129, such as disclosed in FIG. 6. Elevation of the wire line 123 and mandrel 120 will now raise the mandrel within the latch sleeve 124, until the split latch ring 132 enters the latch groove 129, at which time the holding portion 136 of the mandrel is disposed substantially below the latch feet 134. Elevation of the wire line 123 and mandrel 120 will then raise the latch sleeve 124, its feet 134 engaging the side 143 of the retrieving groove 142, being forced laterally inwardly and out of this groove, in view of the inward spacing of the reduced diameter portion 135 of the mandrel with respect thereto, permitting the running tool 55 to be removed completely from the mandrel 39 and the entire coupling apparatus for withdrawal through the casing B to the top of the well bore FIGS. 6, 7).

The retrieving tool 55 can now be reconditioned by retracting the latch ring 130 from the groove 129 and by reattaching the ring 125 to the latch sleeve 124 by shear screws 126. The mandrel 120 is then connected to a string of tubing or drill pipe (not shown) with jars associated therewith, and is rerun into the casing and recoupled to the mandrel 39 with the latch feet 134 within the retrieving groove 142, backed up by the lower holding portion 136 of the mandrel. A sufficient upward jarring action can now be taken by use of the drill pipe or tubing on the coupling tool mandrel 39 to effect its upward movement within the body 12 to the extent at which the coupling members 21 are completely released from the casing shoe C.

It is thus apparent that an apparatus has been provided, in which the coupling apparatus releases automatically from the running-in tool 52 as a result of downward movement of the mandrel 39 within the tool body 12. The body 12 is self-indexing. Because of the loose fit of the approximating sleeve 92 on the body, assurance is had that no torque is transmitted from the casing shoe C through the indexing apparatus to the body of the coupling apparatus. In addition, no torque or downweight is transmitted through the hinge pins 23 pivotally mounting the coupling members 21 on the body 12, since the coupling members are solidly but releasably attached to the casing shoe C, the body of the tool, and the mandrel 39 while in their full outward expanded position. The coupling members effect a rigid connection between all of the parts. A large flow area is present through the apparatus during the drilling operation, in view of the absence of restriction through the body 12 and mandrel 39 as a result of removing the running-in tool 52 from its coupled relation to the mandrel.

We claim:

1. In apparatus for use in a well bore: a tubular member adapted to be located at the lower end of a string of pipe to be disposed in the well bore; a coupling device movable longitudinally through the pipe and including a body and an initially retracted coupling member mounted on said body for lateral outward expansion with respect thereto; first stop means on said tubular member; second stop means on said body engageable with said first stop means to limit downward movement of said body in said tubular member; means for expanding said coupling member outwardly into coupling engagement with said tubular member after engagement of said second stop means with said first stop means; said coupling member having thrust surfaces thereon engaging thrust surfaces on said body and tubular member when said coupling member is in its outwardly expanded position to transmit longitudinally directed thrust through said surfaces from said tubular member directly through said coupling member to said body.

2. In apparatus as defined in claim 1; said coupling member having torque transmitting surfaces thereon engaging torque transmitting surfaces on said body and tubular member when said coupling member is in its expanded position to transmit torque through said torque transmitting surfaces from said tubular member through said coupling member directly to said body.

3. In apparatus as defined in claim 1; said coupling member having a lock surface engageable with a companion lock surface on said expanding means to prevent retraction of said coupling member from its expanded position.

4. In apparatus as defined in claim 1; said coupling member having longitudinally spaced lock surfaces engageable with companion longitudinally spaced lock surfaces on said expanding means to prevent retraction of said coupling member from its expanded position.

5. In apparatus as defined in claim 1; said coupling member having a lock surface engageable with a companion lock surface on said expanding means to prevent retraction of said coupling member from its expanded position; said coupling member having torque transmitting surfaces thereon engaging torque transmitting surfaces on said body and tubular member when said coupling member is in its expanded position to transmit torque through said torque transmitting surfaces from said tubular member through said coupling member directly to said body.

6. In apparatus as defined in claim 1; said coupling member having longitudinally spaced lock surfaces engageable with companion longitudinally spaced lock surfaces on said expanding means to prevent retraction of said coupling member from its expanded position; said coupling member having torque transmitting surfaces thereon engaging torque transmitting surfaces on said body and tubular member when said coupling member is in its expanded position to transmit torque through said torque transmitting surfaces from said tubular member through said coupling member directly to said body.

7. In apparatus as defined in claim 1; said tubular member having a slot; said coupling member having a portion receivable snugly in said slot when said coupling member is in expanded position to couple said coupling member to said tubular member.

8. In apparatus as defined in claim 1; a hinge pin secured to said body and passing loosely through said coupling member to pivotally mount said coupling member to said body.

9. In apparatus as defined in claim 1; said tubular member having a slot; said coupling member having a portion receivable snugly in said slot when said coupling member is in expanded position to couple said coupling member to said tubular member; a hinge pin secured to said body and passing loosely through said coupling member to pivotally mount said coupling member on said body.

10. In apparatus as defined in claim 1; said tubular member having a slot; said coupling member having a portion receivable snugly in said slot when said coupling member is in expanded position to couple said coupling member to said tubular member; said coupling member having torque transmitting surfaces thereon engaging torque transmitting surfaces on said body and tubular member when said coupling member is in its expanded position to transmit torque through said torque transmitting surfaces from said tubular member through said coupling member directly to said body.

11. In apparatus as defined in claim 1; said tubular member having a slot; said coupling member having a portion receivable snugly in said slot when said coupling member is in expanded position to couple said coupling member to said tubular member; a hinge pin secured to said body and passing loosely through said coupling member to pivotally mount said coupling member on said body; said coupling member having torque transmitting surfaces thereon engaging torque transmitting surfaces on said body and tubular member when said coupling member is in its expanded position to transmit torque through said torque transmitting surfaces from said tubular member through said coupling member directly to said body.

12. In apparatus as defined in claim 1; said tubular member having a slot; said coupling member having a portion receivable snugly in said slot when said coupling member is in expanded position to couple said coupling member to said tubular member; a hinge pin secured to said body and passing loosely through said coupling member to pivotally mount said coupling member on said body; said coupling member having torque transmitting surfaces thereon engaging torque transmitting surfaces on said body and tubular member when said coupling member is in its expanded position to transmit torque through said torque transmitting surfaces from said tubular member through said coupling member directly to said body; said coupling member having longitudinally spaced lock surfaces engageable with companion longitudinally spaced lock surfaces on said expanding means to prevent retraction of said coupling member from its expanded position.

13. In apparatus as defined in claim 1; said tubular member having a slot; said coupling member having a portion receivable snugly in said slot when said coupling member is in expanded position to couple said coupling member to said tubular member; said first and second stop means comprising indexing means for alining said coupling member with said slot.

14. In apparatus as defined in claim 1; said tubular member having a slot; said coupling member having a portion receivable snugly in said slot when said coupling member is in expanded position to couple said coupling member to said tubular member; said first stop means comprising upwardly extending cam teeth; said second stop means comprising downwardly extending cam teeth meshable with said upwardly extending teeth to aline said coupling member with said slot.

15. In apparatus as defined in claim 1; a running tool releasably connected to said coupling device for lowering said coupling device through the string of pipe into said tubular member; and means operable in response to movement of said expanding means in expanding said coupling member for releasing said running tool from said coupling device to permit upward withdrawal of said running tool through the string of pipe.

16. In apparatus for use in a well bore: a tubular member adapted to be located at the lower end of a string of pipe to be disposed in the well bore; a coupling device movable longitudinally through the pipe and including a body and an initially retracted coupling member mounted on said body for lateral outward expansion with respect thereto; first stop means on said tubular member; second stop means on said body engageable with said first stop means to limit downward movement of said body in said tubular member; means for expanding said coupling member outwardly into coupling engagement with said tubular member after engagement of said second stop means with said first stop means; a running tool releasably connected to said coupling device for lowering said coupling device through the string of pipe into said tubular member; and means operable in response to movement of said expanding means in expanding said coupling member for releasing said running tool from said coupling device to permit upward withdrawal of said running tool through the string of pipe.

17. In apparatus as defined in claim 16; latch means connected to said body for releasably connecting said running tool to said body; said expanding means comprising a mandrel movable longitudinally in said body and engaging said latch means to retain said latch means connected to said running tool, said releasable means comprising said mandrel which moves from retaining relation to said latch means during outward expansion of said coupling member.

18. In apparatus for use in a well bore: a tubular member adapted to be located at the lower end of a string of pipe to be disposed in the well bore; a coupling device movable longitudinally through the pipe and including a body and an initially retracted coupling member mounted on said body for lateral outward expansion with respect thereto; first stop means on said tubular member; second stop means on said body engageable with said first stop means to limit downward movement of said body in said tubular member; said tubular member having a slot; a mandrel movable downwardly in said body to expand said coupling member outwardly into said slot after engagement of said second stop means with said first stop means; said coupling member having thrust surfaces thereon engaging thrust surfaces on said body and tubular member when said coupling member is in said slot to transmit longitudinally directed thrust through said thrust surfaces from said tubular member directly through said coupling member to said body.

19. In apparatus as defined in claim 18; said first and second stop means having coengageable means thereon for alining said coupling member with said slot.

20. In apparatus as defined in claim 18; said first and second stop means having coengageable means thereon for alining said coupling member with said slot; said coupling member having torque transmitting surfaces thereon engaging torque transmitting surfaces on said body and side of said tubular member defining said slot when said coupling member is in said slot to transmit torque through said torque transmitting surfaces from said tubular member through said coupling member directly to said body.

21. In apparatus as defined in claim 18; said first and second stop means having coengageable means thereon for alining said coupling member with said slot; said coupling member having a lock surface engageable with a companion lock surface on said mandrel to prevent retraction of said coupling member from said slot.

22. In apparatus as defined in claim 18; said first and second stop means having coengageable means thereon for alining said coupling member with said slot; said coupling member having longitudinally spaced lock surfaces engageable with companion longitudinally spaced lock surfaces on said mandrel to prevent retraction of said coupling member from said slot.

23. In apparatus as defined in claim 18; said first and second stop means having coengageable means thereon for alining said coupling member with said slot; and releasable latch means on said mandrel engaging said body to prevent substantial upward movement of said mandrel in said body to prevent retraction of said coupling member from said slot.

24. In apparatus as defined in claim 18; said first and second stop means having coengageable means thereon for alining said coupling member with said slot; and releasable latch means on said mandrel engaging said body to prevent substantial upward movement of said mandrel in said body to prevent retraction of said coupling member from said slot; and means for releasing said latch means.

25. In apparatus as defined in claim 18; said first and second stop means having coengageable means thereon for alining said coupling member with said slot; and releasable latch means on said mandrel engaging said body to prevent substantial upward movement of said mandrel in said body to prevent retraction of said coupling member from said slot; and a

retrieving tool for releasing said latch means and having means thereon to be coupled to said mandrel to elevate said coupling device through the string of pipe.

26. In apparatus as defined in claim 18; a running tool; latch means connected to said body for releasably connecting said running tool to said body whereby said coupling device can be lowered through the string of pipe into said tubular member; said mandrel engaging said latch means to retain said latch means connected to said running tool; said mandrel being movable downwardly from retaining relation to said latch means during outward expansion of said coupling member.

27. In apparatus as defined in claim 18; a running tool; latch means connected to said body for releasably connecting said running tool to said body whereby said coupling device can be lowered through the string of pipe into said tubular member; said mandrel engaging said latch means to retain said latch means connected to said running tool; said mandrel being movable downwardly from retaining relation to said latch means during outward expansion of said coupling member; said first and second stop means having coengageable means thereon for alining said coupling member with said slot.

28. In apparatus as defined in claim 18; a running tool; latch means connected to said body for releasably connecting said running tool to said body whereby said coupling device can be lowered through the string of pipe into said tubular member; said mandrel engaging said latch means to retain said latch means connnected to said running tool; said mandrel being movable downwardly from retaining relation to said latch means during outward expansion of said coupling member; said first and second stop means having coengageable means thereon for alining said coupling member with said slot; releasable latch means on said mandrel engaging said body to prevent substantial upward movement of said mandrel in said body to prevent retraction of said coupling member from said slot; and a retrieving tool for releasing said releasable latch means and having means thereon to be coupled to said mandrel to elevate said coupling device through the string of pipe.