July 16, 1963 A. W. KAMMERER 3,097,706

RETRIEVABLE WELL BORE APPARATUS

Filed Oct. 6, 1959 3 Sheets-Sheet 1

FIG. 1.

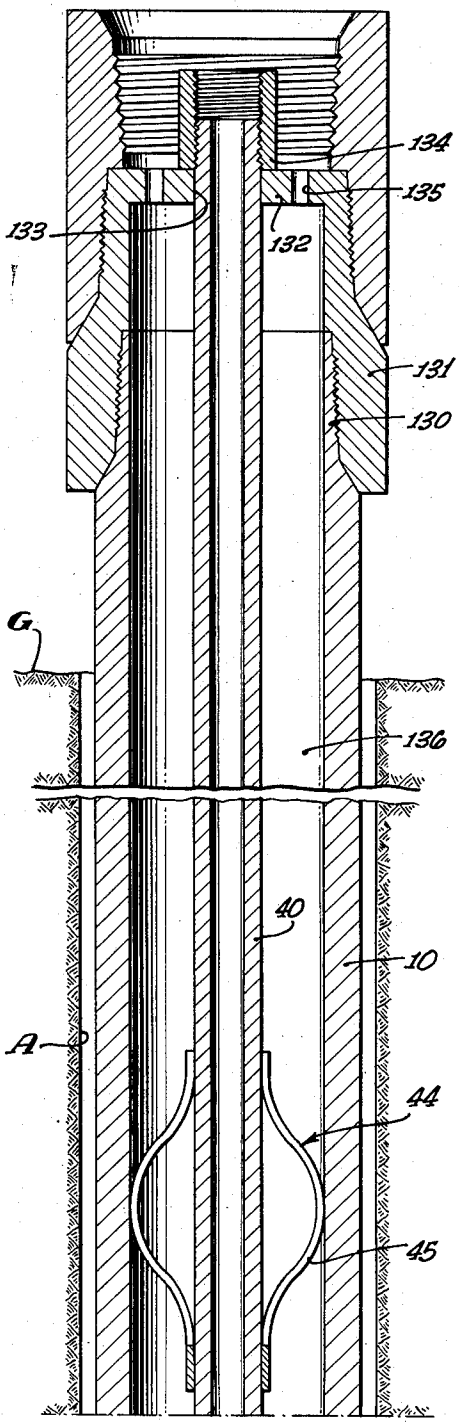
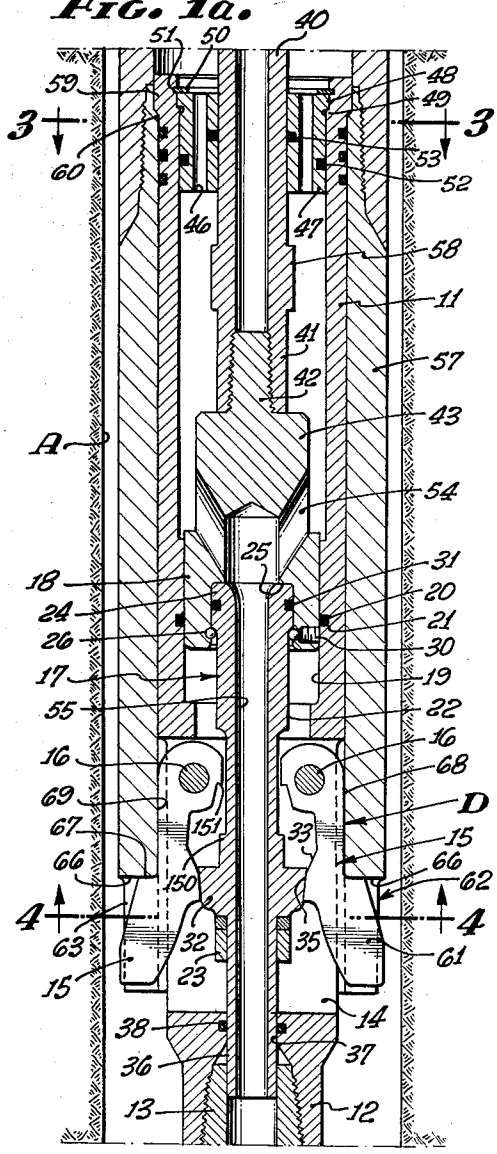


FIG. 1a.



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Filed Oct. 6, 1959 3 Sheets-Sheet 2

FIG. 1b.

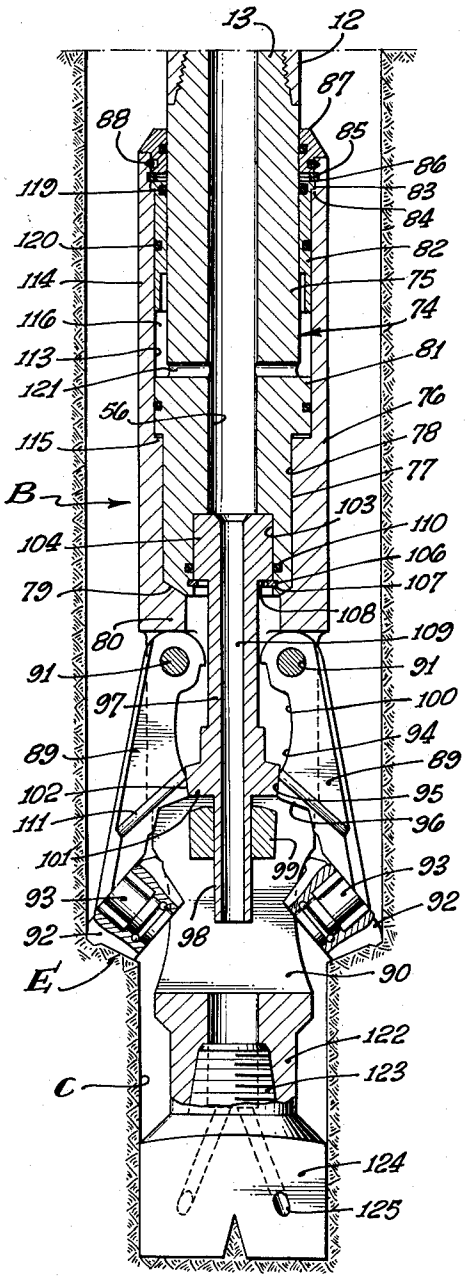


FIG. 3.

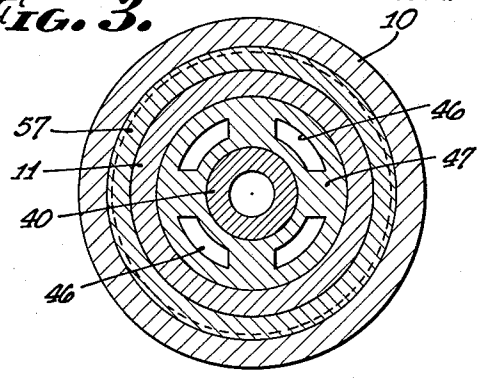


FIG. 4.

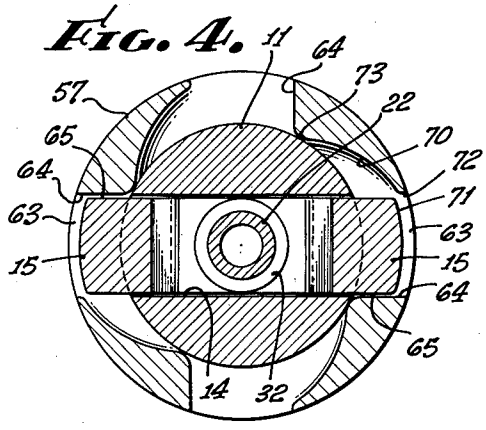
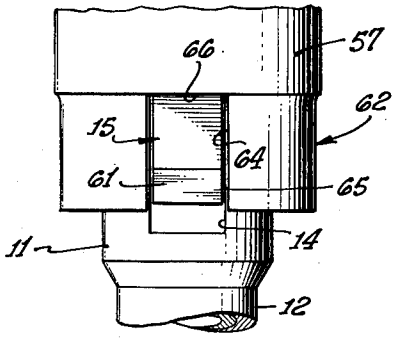


FIG. 5.



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July 16, 1963 A. W. KAMMERER 3,097,706

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Filed Oct. 6, 1959 3 Sheets-Sheet 3

FIG. 2.

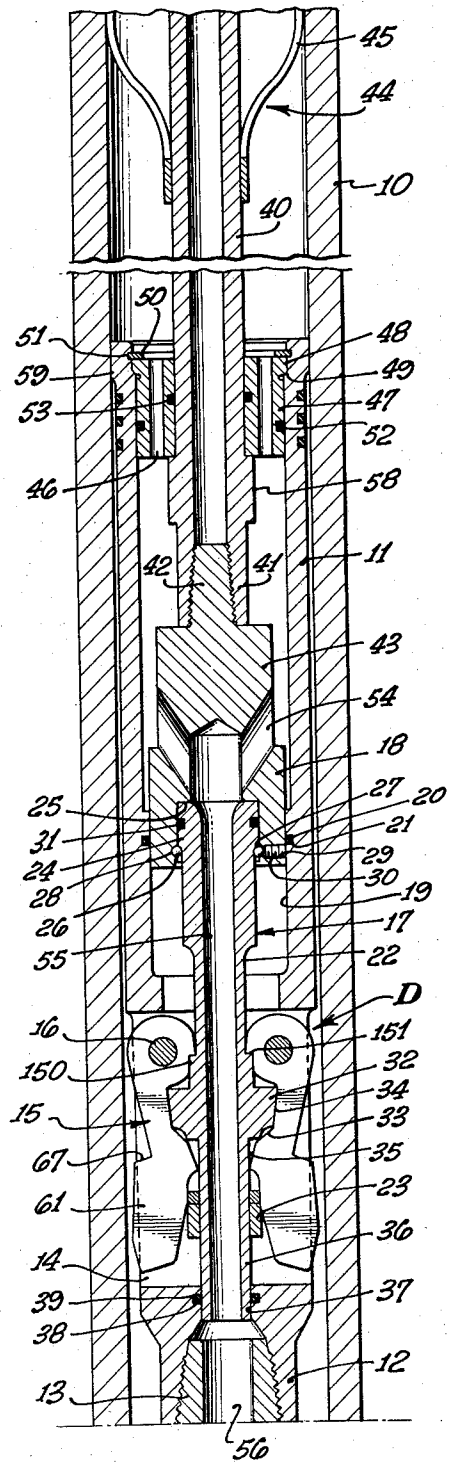
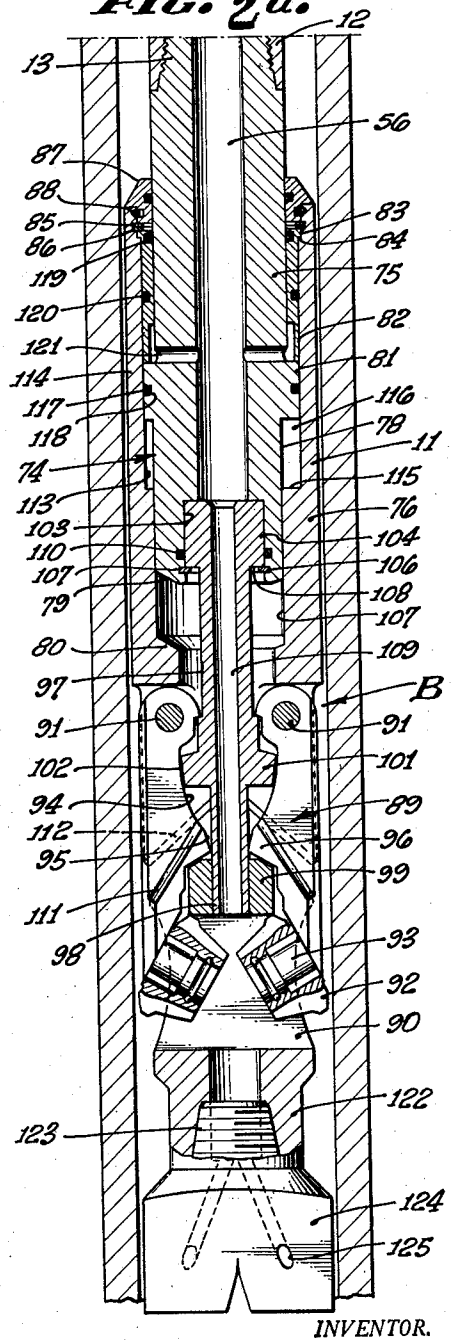


FIG. 2a.



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3,097,706

RETRIEVABLE WELL BORE APPARATUS

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Filed Oct. 6, 1959, Ser. No. 844,692
12 Claims. (Cl. 175—258)

The present invention relates to subsurface well bore apparatus, including apparatus capable of being lowered through a string of pipe in the well bore, coupled thereto, and subsequently released therefrom for withdrawal through the pipe to the top of the well bore.

The usual manner of performing certain operations in well bores, such as the operation of drilling the well bore, consists in securing a bit to the lower end of the string of pipe and lowering the latter in the hole to its bottom portion, the drill bit then being rotated to continue the formation of the bore hole. As each bit becomes dull, the drill pipe is removed from the well bore and another bit attached to it, whereupon the string of drill pipe is relowered in the well bore. Following production of the desired depth of hole, the drill pipe is removed therefrom and a string of casing, or the like, lowered in the hole, which is usually cemented in place.

The necessity for frequent round trips to change drill bits is a time consuming and costly operation. In addition, potential damage to the well bore may be caused by the development of pressures and the like in the drilling mud as a result of raising and lowering the string of drill pipe. There is also the danger of being unable to lower the casing in the drilled hole to the desired depth or in damaging the well formation during lowering of the casing.

An object of the present invention is to provide an apparatus capable of being lowered through a string of pipe, which will form the casing for a well bore being produced, and of being positively coupled to the lower portion of the pipe by a positively actuated device operated from the top of the well bore, the apparatus being adapted to perform an operation in the well bore below the pipe after being coupled thereto, and being releasable from the pipe for withdrawal therethrough to the top of the well bore.

Another object of the invention is to provide an improved apparatus capable of being lowered through a string of pipe which will form the casing for a well being produced, and of being readily coupled to the lower portion of the pipe, the apparatus being adapted to perform an operation in the well bore below the pipe after being coupled thereto, and being positively releasable from the pipe by a device actuated from the top of the well bore for withdrawal through the pipe to the top of the well bore.

A further object of the invention is to provide an apparatus capable of being lowered through a string of pipe which will form the casing for a well bore being produced, and of being readily coupled to the lower portion of the pipe, the apparatus being capable of performing an operation in the well bore below the pipe upon being coupled to the latter, and being maintained coupled to the pipe in a positive manner from the top of the well bore.

This invention possesses many other advantages, and has other objects 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:

FIGURES 1, 1*a* and 1*b* together constitute a longitudinal section through an apparatus disposed in a well bore, with portions of the apparatus in their expanded positions, FIG. 1*a* constituting a lower continuation of FIG. 1, and FIG. 1*b* constituting a lower continuation of FIG. 1*a*;

FIGS. 2 and 2*a* together constitute a longitudinal section through the apparatus, with parts in retracted positions for movement of the apparatus through a string of pipe, such as well casing, FIG. 2*a* constituting a lower continuation of FIG. 2;

FIG. 3 is a cross-section taken along the line **3—3** on FIG. 1*a*;

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

FIG. 5 is a side elevational view of part of the coupling portion of the apparatus.

The apparatus illustrated in the drawings includes a string of well casing **10**, or similar pipe, extending from the region of the ground surface G to the lower portion of a well bore A being drilled. Suitable devices are adapted to be coupled to the casing string, such as a drill bit B, which may be of the expansible type disclosed in United States Patent No. 2,758,819, this drill bit being adapted to drill the hole A to the desired diameter greater than the outside diameter of the casing string **10**, and also producing a pilot hole C of a lesser diameter. The expansible drill bit is releasably attached to the lower portion of the string of casing by a coupling or latching apparatus D, the drill bit and latching apparatus being adapted to be lowered through the string of casing from the top thereof, and also being retrieved through the string of casing whenever the bit is to be removed from the well bore.

Although specific reference is made herein to the use of an expansible rotary drill bit for drilling the well bore, it is apparent that other apparatus can be releasably coupled to a lower portion of the well casing **10**, such apparatus being lowered through the casing and coupled in position, as well as being removed therethrough to the top of the well bore.

The coupling or latching apparatus D includes an elongate body **11** having a lower threaded box **12** to which the upper pin end **13** of the rotary expansible drill bit B is secured. Above its threaded box **12**, the body **11** of the coupling device has a transverse slot area **14** in which a plurality, such as a pair, of coupling or latching members **15** are mounted. These coupling or latching members are pivoted on hinge pins **16** extending across the slot **14** and suitably secured to the body. Each coupling member **15** normally occupies an inward position, as disclosed in FIG. 2, in which it is retracted substantially fully within the confines of the body **11** of the coupling device.

The coupling members **15** are expanded outwardly of the body, to be coupled to the casing **10**, as a result of downward movement of a mandrel device **17** within the body. As shown, the mandrel device **17** includes an upper portion **18**, which may be constituted as a piston, slidable within a cylinder **19** within the body. Leakage of fluid between the piston and cylinder can be prevented by a suitable seal device, such as a rubber or rubber-like O ring **20**, disposed in an internal groove **21** in the body and slidably and sealingly engaging the periphery of the piston **18**.

Secured to the piston and depending therefrom is a tubular member portion **22** of the mandrel **17**, a lower part of which is slidable through a guide **23** extending

across the body slot 14 and attached to the body. The upper portion 24 of the tubular member is piloted within the piston 18, its upper end engaging a downwardly facing piston shoulder 25. Downward movement of the tubular member with respect to the piston is prevented by a row of balls 26 which engage a downwardly facing raceway 27 on the tubular member, and which are received within an internal raceway 28 in the piston 18. The balls are insertable through a radial hole 29 in the piston which may be closed by threading a suitable plug 30 in such hole. Leakage of fluid between the piston 18 and tubular member 22 is prevented by a side seal ring 31.

When the mandrel 17, consisting of the piston 18 and tubular member 22, moves downwardly, an expander 32 mounted on and fixed to the tubular member engages downwardly and inwardly tapering expander surfaces 33 on the coupling members 15, to pivot the latter about the axes of the hinge pins 16 and shift them outwardly. When the coupling members 15 have been shifted outwardly to their maximum extent, holding surfaces 34 on the expander will be disposed behind companion holding surfaces 35 on the coupling members 15 below their respective expander surfaces 33, preventing inadvertent retraction of the coupling members or latches from their expanded position.

The piston 18 and tubular member portion 22 of the mandrel 17 are shiftable downwardly to a maximum extent, determined by engagement of the lower end 32 of the expander with the guide 23, at which time a lower portion 36 of the tubular member 22 is piloted within a body passage 37 below the body slot 14. Leakage of fluid between the body and the lower portion 36 of the tubular member is prevented by a suitable side real ring, such as a rubber or rubber-like O ring 38, mounted in a groove 39 in the body and slidably and sealingly engaging the tubular member.

The mandrel member 17 is shiftable downwardly to expand the coupling members 15 in response to downward movement of a string of tubing 40 disposed within the pipe 10 and extending to the top of the well bore. The lower end of the actuating tubing 40 has a threaded box 41 threadedly attaching it to the upper threaded pin 42 of a mandrel head 43 which is integral with and extends upwardly from the piston portion 18 of the mandrel. The tubing 40 may be centered in the pipe or casing string by one or a plurality of tubing centralizers 44 mounted on the tubing. Each centralizer is of a known type and may consist of circumferentially spaced, outwardly bowed springs 45 engaging the inner wall of the casing string 10.

When the coupling members 15 are to be expanded outwardly, a downward force is imposed from the top of the well bore on the tubing string 40, which will shift the mandrel 17 and its tubular member 22 downwardly, and cause the expander 32 to engage the tapered surfaces 33 on the coupling members 15 and shift the latter outwardly of the body 11 to the maximum extent. Normally, the string of tubing 40 is maintained in tension and the downward movement of this tubing string may occur as a result of slacking off some of the tubing weight, whereupon its lower portion will move downwardly and shift the mandrel 17 downwardly of the body 11. Once the mandrel 17 has shifted downwardly, so as to have expanded the coupling members 17 outwardly to their maximum extent, the expander 32 is maintained behind the holding surfaces 35 of the coupling members by the downward force or weight constantly being imposed by the tubing string 40 on the mandrel 17.

The mandrel member 17 can also be shiftable downwardly, to expand the coupling members 17, in response to fluid pressure developed in the body 11 of the tool above the piston 18. Such result is obtained by pumping drilling mud, or similar fluid, down through the casing string 10 and around the tubing string 40, this fluid flowing through circumferentially spaced passages 46 in a bushing or spider 47, which is piloted in the upper end of the body 11, and which serves as a bearing support for the lower end of the tubing string 40, to hold it centered with respect to the body 11 of the coupling apparatus D. The bushing 47 has an outwardly directed flange 48 resting upon an upwardly facing body shoulder 49, the bushing being prevented from moving upwardly of the body by a suitable split retainer ring 50 overlying the upper end of the bushing and received within a circumferential groove 51 in the body 11. Leakage of fluid between the body 11 and bushing 47 is prevented by a side seal ring 52 mounted on the bushing and engaging the inner wall of the body; whereas, leakage of fluid between the bushing 47 and tubing string 40 is prevented by a suitable side seal ring 53 in the bushing engageable with the periphery of the tubing string.

The fluid discharges from the bushing passages 46 into the body 11, flowing through inlet ports 54 in the mandrel above its piston portion 18 into a central passage 55 extending through the tubular member 22. Such fluid under pressure flows from the tubular member and will discharge into the central passage 56 through the expansible drill bit B. Because of the throttling action provided by the inlet ports 54, a back pressure is built up in the body above the piston 18, urging the latter downwardly to shift the mandrel 17 and its tubular member 22 in a downward direction and thereby effect outward expansion of the coupling members 15.

The coupling apparatus D and the drill bit B, or other apparatus, depending therefrom, are moved downwardly through the entire string of casing 10 to the shoe portion 57 of the latter on the lower portion of the tubing string 40. Since the body 11 of the tool is then downwardly of the mandrel 17 (FIG. 2), the coupling members 15 will normally occupy a lower position along the mandrel, the bushing 47 resting upon a tubing flange 58 therebelow. The tubing string 40 is lowered in the well casing disposed in the well bore to the extent limited by engagement of a stop flange 59 on the upper portion of the body 11 with a stop shoulder 60 in the casing shoe 57. When the stop flange engages the casing shoulder 60, the expansible drill bit B is disposed substantially below the lower end of the casing shoe; whereas, the lower portion 61 of each coupling member 15 is disposed within a slotted coupling portion 62 at the lower end of the shoe 57.

The coupling members 51 are expandable outwardly in the manner described above, being shifted within slots 63 of the lower portion 62 of the shoe. Each slot is sufficiently wide to accommodate a coupling member 15, and each slot has a driving face 64 adapted to engage the side 65 of a coupling member for the purpose of rotating the latter, or to prevent relative rotation between the latter and the casing 10. The upper end of each slot is defined by a thrust shoulder or surface 66 on the shoe adapted to engage a companion shoulder or step 67 on the coupling member 15.

The coupling members 15 are shiftable outwardly of the body 11 of the coupling apparatus D to the extent limited by engagement of an exterior surface 68 on each coupling member above its stop shoulder 67 with the inner surface 69 of the casing shoe 57. Thus, the inner surface 69 of the casing shoe limits the extent of outward expansion of each coupling member 15, whereas the holding surfaces 34 on the expander 32 coact with the companion holding surfaces 35 on the coupling members 15 to prevent inward movement of the latter.

Each driving face 64 on the shoe 57, which will engage a companion face 65 on a coupling member 15, is preferably flat, so that a substantial surface engagement is had between such driving face and the side face of the coupling member. The opposed side 70 of each slot 63 is curved, the curve running from the inner surface 69 of the casing shoe and then toward its outer surface in a direction toward the driving face 64 of the shoe, such as shown most clearly in FIG. 4. The curved guide surface 70 will be

engaged by the outer surface 71 or corner 72 of a coupling member 15 when it is being expanded outwardly by the mandrel 17 as the latter shifts downwardly within the body 11 of the coupling apparatus D. In the event that the coupling members 15 are not aligned with a pair of diametrically opposed slots 63, the outward force of expansion will cause the coupling members to slide along the curved guide surfaces 70 and shift them to the outward position until they move fully within the slots 63. Such arcuate shifting of the coupling members is accompanied by arcuate shifting of the body 11 of the tool within the casing, the body flange 59 sliding without any substantial resistance around the stop shoulder 60 of the string of casing 10.

In the event that the coupling members 15 are being expanded outwardly and are disaligned with the slots 63, they might engage the curved corner 73 between the driving face 64 of one slot and the curved guide surface 70 of an adjoining slot. Because of the curved exterior 71 of each coupling member, if it does not slide in a clockwise direction, as seen in FIG. 4, along the curved guide surface 70, it will slide along the corner 73 in a counterclockwise direction into alignment with one of the slots, whereupon the coupling member is expandable fully outwardly to bring its stop surface 68 into engagement with the internal surface 69 of the shoe 59, with its shoulder 67 under and adjacent to the downwardly directed thrust surface or shoulder 66 on the shoe. The coupling members 15 are held in their expanded position by the tubing string 40, the coupling members being prevented from moving upwardly of the shoe 57, which is also true of the body 11 of the coupling apparatus, while this latter body cannot move downwardly of the shoe by virtue of the engagement of its flange 59 with the stop shoulder 60 of the shoe.

As stated above, the expansible drilling bit B is threadedly attached to the lower threaded box 12 of the body 11 of the coupling device D. The threaded pin 13 of the drill bit is formed on an upper mandrel 74 that includes an upper kelly or drill stem member 75 slidably splined to the main body 76 of the bit. The exterior 77 of the lower portion of the kelly 75 is non-circular in shape, being telescopically received in a companion non-circular socket 78 formed in the main bit body 76. As an example, the kelly exterior and the socket may be of hexagonal shape to enable the kelly 75 to be moved longitudinally with respect to the bit body 76, while being capable of transmitting rotary motion thereto.

The mandrel 74 has a limited range of relative longitudinal movement within the body 76, its downward movement being determined by engagement of the lower end 79 of the kelly with an inwardly directed body shoulder 80, and its upward movement being limited by engagement of an external shoulder or piston portion 81 of the kelly with a cylindrical head 82 secured to the body. The upper end of the head has a flange 83 engaging a body shoulder 84, the flange being prevented from moving upwardly of the body by split, snap retainer rings 85 fitting in the body groove 86 and overlying the flange 83. An annular guide 87 is releasably secured to the body by a split snap ring 88 above the retainer rings 85.

The body 76 has a plurality of cutter supporting members 89 pivotally mounted in body slots 90 on hinge pins 91 suitably secured to the body. Each cutter supporting member 89 depends from the hinge pin 91 and carries a conical toothed roller cutter 92 on a bearing pin 93 extending inwardly and downwardly from each cutter supporting member. Each roller cutter 92 is adapted to operate upon a transverse annular formation shoulder E defined between the inner wall of the pilot hole C and the wall of the enlarged hole A.

The cutter supporting members 89 and roller cutters 92 tend to occupy a retracted position substantially entirely within the confines of the main body 76 of the bit. These cutter supporting members and the cutters are expandable outwardly to enlarge the pilot hole C and to operate upon the formation shoulder E that the roller cutters 92 produce in the formation. To accomplish the expansion, each cutter supporting member 89 has an inclined expander surface 94 on its inner portion below the hinge pin 91 which tapers in a downward and inward direction. Each expander surface terminates in a lock surface 95 formed on a lock portion 96 of the cutter supporting member. The outward expansion is accomplished by producing relative longitudinal movement between the mandrel 74 and the bit body 76, which will produce relative longitudinal movement between the cutter supporting members 89 and a tubular member 97 of the mandrel. This tubular member includes a lower portion 98 slidable within a guide 99 secured to the body 76 and extending across the body slot 90. The guide is disposed below the lock portions 96 of the cutter supporting members 89.

Located initially substantially above the guide 99 and below the hinge pins 91, and in cutter member recesses 100, is a mandrel lock and expander 101 which has outer surfaces 102 adapted to engage the expander surfaces 94 and the lock surfaces 95. The lock and expander 101 may be formed integrally with the tubular member 97, the upper end of the latter being piloted within a socket 103 formed in the lower portion of the kelly 75. An enlarged boss 104 on the tubular member engages a downwardly facing shoulder 105 of the kelly, the tubular member being held against this shoulder by a suitable split retainer ring 106 snapped into an internal groove 107 encompassing the kelly socket and engaging the lower end 108 of the tubular member boss.

The drilling mud or other fluid flowing through the mandrel passage 55 of the coupling device D will discharge into the central passage 56 in the kelly 75 and into a central passage 109 extending completely through the tubular member 97. Leakage of fluid around the exterior of the tubular member is prevented by a suitable seal ring 110 disposed in the kelly 75 and engaging the exterior of the boss 104.

Assuming that the body 76 of the drill bit B is elevated relatively along the tubular mandrel 74, the inclined expander surfaces 94 of the cutter supporting members 89 will be shifted upwardly along the lock and expander portion 101 of the tubular member 97. During such upward shifting, the cutter supporting members 89 and the roller cutters 92 carried thereby are pivoted about the hinge pins 91 and urged in an outward direction. Upward movement of the body 76 with respect to the tubular mandrel 74 can continue until the roller cutters 92 have been shifted outwardly to their fullest extent, as determined by engagement of stop shoulders 111 on the cutter supporting members with companion shoulders 112 formed in the body on opposite sides of the body slots 90. When such engagement occurs, the lower end 79 of the kelly portion of the tubular mandrel will engage the body shoulder 80, and the lock and expander 101 on the tubular member will be disposed behind and in engagement with the lock portions 96 of the cutter supporting members 89.

The relative longitudinal movement between the tubular mandrel 74 and the body 76 of the drill bit B is accomplished hydraulically, in the specific form of apparatus disclosed in the drawings. Thus, the piston or enlarged portion 81 on the drill stem 75 is received within a counterbore 113 formed on the upper portion of the body of the tool. This upper portion actually constitutes a cylinder 114, having a cylinder wall extending from a lower shoulder 115, defining the bottom of the counterbore, to the cylinder head 82. A confined cylinder space 116 is formed between the piston portion 81 of the kelly, the periphery of the kelly 75 above the piston and the cylinder 114. A suitable packing or seal ring 117 is disposed in a suitable piston ring groove 118 formed in the piston, which is adapted to slidably seal against the cylinder wall 113 of the cylinder. Fluid is thereby prevented from passing in a downward direction from the cylinder

space 116. Fluid is prevented from passing in an upward direction out of the annular cylinder space by an inner side seal ring 119 carried by the cylinder head 82 and slidably and sealingly engaging the periphery of the kelly 75 above the piston 81, and also by an outer side seal ring 120 disposed in the head and sealingly engaging the cylinder wall 113.

Fluid under pressure in the mandrel passage 56 is fed into the cylinder space 116 through one or more side ports 121 establishing communication between the central passage through the kelly and the cylinder space. Such fluid under pressure is developed by virtue of the fact that the passage 109 through the tubular member of the mandrel is of a restricted diameter compared to the diameter of the passage 56 through the kelly portion 75 of the mandrel. As a result, the pumping of drilling mud, or other fluid, at an adequate rate through the apparatus will build up a back pressure in the fluid in the kelly passage 56, which pressure will be imposed on the fluid in the cylinder space 116, acting upon the cylinder head 82 to urge the body 76 of the drill bit in an upward direction with respect to the tubular mandrel 74, to secure the outward expansion of the cutter supporting members 89 and roller cutters 92 to their fullest extent, as described above.

The lower end of the drill bit body 76 has a threaded box 122 adapted to receive the threaded pin 123 of a suitable pilot bit 124, which has a diameter slightly less than the minimum internal diameter through the string of casing 10. The pilot bit will drill a well more C slightly less than the inside diameter of the casing; whereas the roller cutters 92, when expanded outwardly, will operate upon the transverse formation shoulder E and enlarge the pilot hole C to the desired diameter of the final hole A, which is substantially greater than the outside diameter of the string of casing 10. The fluid discharging from the tubular member 97 of the drill bit B will pass to some extent into the pilot bit 124, discharging from its lower nozzles 125 to carry the cuttings upwardly around the bit 124 and also around the roller cutters 92. The fluid discharging from the tubular member 97 into the body slots 90 will also flow outwardly around the roller cutters 92 and along the shoulder E to carry the cuttings formed thereby, together with the pilot bit cuttings, upwardly around the expandable drill bit B to the region of the coupling member D and thence upwardly around the exterior of the casing string 10 to the top of the well bore.

In the operation of the apparatus, the casing string is disposed in the previously drilled portion of the well bore A. The expansible drill bit B is secured to the lower end of a coupling body 11 and the mandrel 17 of the latter threadedly attached to the lower end of the tubing string 40. The tubing string 40 is lowered through the well casing 10, the cutting supporting members 89 and cutters 92 then being in their retracted position within the casing, which is also true of the coupling members 15 (FIGS. 2 and 2*a*), until the body flange 59 of the coupling device D engages the stop shoulder 60 in the casing string 10, at which time the coupling members 15 are disposed in the region of the shoe slots 63, with the drill bit B extending a substantial distance below the lower end of the string of casing. The apparatus D is then coupled to the casing shoe 57 by shifting the tubing string 40 downwardly, which will shift the mandrel device 17 downwardly of the coupling body 11 to cause the expander 32 to expand the coupling members 15 outwardly into the shoe slots 63.

The tubing string 40 is held in this downward position with the expander 32 maintained behind the lock surfaces 35 of the coupling members by supporting the tubing string 40 from the casing 10 itself. As disclosed (FIG. 1), the upper end 130 of the string of casing 10 is threadedly attached to a casing head and tubing support 131, which has an upper plate portion 132 extending inwardly and surrounding the tubing string 40, the latter being slidable through a central hole 133 in the plate. When the tubing string 40 is lowered relative to the casing 10, for the purpose of shifting the coupling members 15 outwardly, a tubing coupling 134 on the upper end of the tubing string will engage the upper end of the plate 132, by virtue of which the tubing string 40 is supported by the casing 10.

The casing string 10 is now rotated by suitable apparatus (not shown) at the top of the well bore, the apparatus coupled thereto being rotatable therewith, including the expansible drill bit B. Drilling fluid is now pumped down through the casing string 10, passing thereinto through fluid ports 135 in the casing head plate 132 into the annulus 136 between the tubing string 40 and the casing 10. This fluid will also flow through the bushing passages 46 into the coupling body 11, and thence through the mandrel ports 54 into the central passage 55 through the mandrel 17, discharging into the central passage 56 in the kelly 75. Such fluid will flow through the kelly and the tubular member 97, a fluid pressure being built up in the kelly passage 56 which will pass through the mandrel ports 121 into the cylinder space 116, elevating the body 76 along the mandrel 74 and carrying the cutter supporting members 89 upwardly along the bit expander 101, effecting outward expansion of the cutter supporting members and roller cutters 92, as described above, until the holding surfaces 95 on the cutter supporting members are disposed against the mandrel expander 101.

The casing string is rotated while drilling mud is being pumped downwardly through the casing 10 and the apparatus, the pilot bit 124 producing the pilot hole C and the roller cutters 92 enlarging the well bore to the desired diameter. The necessary drilling weight is transferred from the casing 10 through the coupling members 15 to the hinge pins 16, and from the latter through the coupling body 11 to the mandrel 74 of the drill bit. The lower end 79 of the kelly portion of the mandrel engages the body shoulder 80 to transmit the drilling weight to the drill bit body 76, and from the latter to the roller cutters 92, as well as the pilot bit 124. The cuttings are flushed from the drilling region upwardly around the apparatus B, D and around the exterior of the casing string 10 to the top of the well bore.

As drilling proceeds and additional casing is required, the casing head 131 and the tubular coupling 134 are disconnected to permit additional tubing sections to be attached to the tubing string 40 and additional sections attached to the casing 10. When such additional sections have been attached, the casing head 131 is reconnected to the upper end of the string of casing and the tubular coupling 134 also threaded onto the upper end of the tubing string 40, in order to rest upon the end plate 132 of the casing head and cause the tubing string 40 to be supported by the casing string 10.

In the event the apparatus is to be withdrawn through the casing to the top of the well bore, the casing string 10 is suitably supported at the top of the well bore below the casing head 131 and the casing head 131 unscrewed from the latter, which will then permit the tubing string 40 to be elevated within the casing 10. Such elevation will first shift the coupling mandrel 17 upwardly within the body 11 to elevate the expander 32 above the holding portions 35 of the coupling members 15, the latter then being permitted to retract within the confines of the coupling body 11. In the event that the coupling members do not readily retract, an upwardly facing stop shoulder 150 on the tubular member 22 will engage inwardly directed arms 151 on the coupling members 15 to positively swing the coupling members about their hinge pins 16 out of the shoe slots 63 and back into the confines of the body 11.

Following release of the coupling members 15 from the casing shoe 57, the tubing string 40 is elevated to carry the coupling members 15 upwardly, which will also

shift the mandrel **74** of the drill bit B upwardly within the drill bit body **76**. This action will also result in elevation of the bit expander **101** above the holding surfaces **95** of the cutter supporting members **89**, whereupon the latter can swing inwardly back within the confines of the bit body **76**. Elevation of the tubing string **40** within the casing **10** will then move the entire drill bit B with its cutters **92** in retracted position upwardly within the casing, the entire apparatus being withdrawn from the casing string by elevating and removing tubing sections **40** from the latter upon their disposition about the ground surface.

In the event the apparatus is to be relowered in the casing, such action can readily occur merely by connecting the expansible drill bit B to the coupling apparatus D and the latter to the lower end of the tubing string **40**. The tubing string is lowered in the well casing **10** until the coupling body flange **59** engages the stop shoulder **60** on the casing shoe **57**, the tubing string then being lowered an additional distance to cause the expander **32** to again shift the coupling members **15** outwardly into the shoe slots **63**. The necessary connections can be made at the top of the well bore so that the casing head **131** is again threadedly attached to the upper end of the casing **10** and the tubing coupling **134** engages the end plate **132** to hold the tubing string **40** in its relative downward position within the casing **10**, the coupling members **15** being held expanded outwardly. The casing string **10** can then be rotated and drilling fluid pumped downwardly therethrough to effect an expansion of the expansible cutters **92** and the production of the well bore A below the casing **10**.

The apparatus is retrievable through the casing **10** and relowered therewithin with either sharp cutters **92**, **124**, or the old cutters, as often as necessary, until the well bore has been produced to the desired depth, whereupon the apparatus B, D is withdrawn through the string of casing **10** to the top of the well bore. The casing string can then be cemented in place, if desired.

By virtue of the apparatus disclosed, the coupling apparatus D is maintained in a coupled position to the string of pipe or casing **10** by means of the tubing string **40**, which is accessible at all times to the operator. Thus, the operator can lower the tubing string **40** to couple the apparatus D to the casing **10**, or, at any time, may elevate the tubing string **40** to release the apparatus D from the well casing. Thus, the operator has positive control at all times on the coupling of the apparatus to the well casing, as well as a positive indication that such coupling has been effected or release of the coupling apparatus obtained.

In lieu of the expansible drill bit B, other apparatus can be secured to the lower portion of the coupling body **11**, depending upon the particular function to be performed within the well bore A below the lower end of the casing string **10**.

The inventor claims:

1. In combination: a string of pipe adapted to be lowered within a well bore; a coupling device movable longitudinally through said pipe and including an initially retracted coupling member and fluid conducting means communicating with the pipe to receive fluid under pressure therefrom; a well tool secured to said coupling device and depending therefrom and movable longitudinally through said pipe, said well tool including hydraulically operable means and passage means communicating with said fluid conducting means and hydraulically operable means to receive fluid under pressure from said fluid conducting means and conduct it under pressure to said hydraulically operable means to operate the same; said pipe having stop means therein at its lower portion; said coupling device having stop means engageable with said other stop means to locate said well tool substantially below the lower end of said pipe; shiftable means for expanding said coupling member outwardly into coupling engagement with said pipe; actuating means connected to said expanding means and extending through said pipe to the top of the well bore for shifting said expanding means to expand said coupling member outwardly; and means on said pipe at the top of the well bore engaging said actuating means to suspend the same on the pipe with said coupling member expanded outwardly.

2. In combination: a string of pipe adapted to be lowered within a well bore; a coupling device movable longitudinally through said pipe and including an initially retracted coupling member and fluid conducting means communicating with the pipe to receive fluid under pressure therefrom; a well tool secured to said coupling device and depending therefrom and movable longitudinally through said pipe, said well tool including hydraulically operable means and passage means communicating with said fluid conducting means and hydraulically operable means to receive fluid under pressure from said fluid conducting means and conduct it under pressure to said hydraulically operable means to operate the same; said pipe having stop means therein at its lower portion; said coupling device having stop means engageable with said other stop means to locate said well tool substantially below the lower end of said pipe; means movable downwardly in said pipe for expanding said coupling member outwardly into coupling engagement with said pipe; rigid actuating means connected to said expanding means and extending through said pipe to the top of the well bore for moving said expanding means downwardly to expand said coupling member outwardly; and means on said pipe at the top of the well bore for supporting said actuating means on the pipe with the coupling member expanded outwardly.

3. In combination: a string of pipe adapted to be lowered within a well bore; a coupling device movable longitudinally through said pipe and including an initially retracted coupling member and fluid conducting means communicating with the pipe to receive fluid under pressure therefrom; a well tool secured to said coupling device and depending therefrom and movable longitudinally through said pipe, said well tool including hydraulically operable means and passage means communicating with said fluid conducting means and hydraulically operable means to receive fluid under pressure from said fluid conducting means and conduct it under pressure to said hydraulically operable means to operate the same; said pipe having stop means therein at its lower portion; said coupling device having stop means engageable with said other stop means to locate said well tool substantially below the lower end of said pipe; shiftable means for expanding said coupling member outwardly into coupling engagement with said pipe; a string of tubing connected to said expanding means and extending through said pipe to the top of the well bore for shifting said expanding means to expand said coupling member outwardly; and means on said pipe at the top of the well bore engaging said tubing to suspend the same on the pipe with said coupling member expanded outwardly.

4. In combination: a string of pipe adapted to be lowered within a well bore; a coupling device movable longitudinally through said pipe and including an initially retracted coupling member and fluid conducting means communicating with the pipe to receive fluid under pressure therefrom; a well tool secured to said coupling device and depending therefrom and movable longitudinally through said pipe, said well tool including hydraulically operable means and passage means communicating with said fluid conducting means and hydraulically operable means to receive fluid under pressure from said fluid conducting means and conduct it under pressure to said hydraulically operable means to operate the same; said pipe having stop means therein at its lower portion; said coupling device having stop means engageable with said other stop means to locate said well tool substantially below the lower end of said pipe; means movable downwardly in said pipe for expanding said coupling member outwardly into coupling

engagement with said pipe; a string of tubing connected to said expanding means and extending through said pipe to the top of the well bore for moving said expanding means downwardly to expand said coupling member outwardly; and means on said pipe at the top of the well bore for supporting said string of tubing on the pipe with said coupling member expanded outwardly.

5. In combination: a string of pipe adapted to be lowered within a well bore and having a slot in its lower portion; a body movable longitudinally through said pipe; an initially retracted coupling member mounted on said body for expansion laterally outwardly of said body; said pipe having stop means therein in its lower portion; a well tool secured to said body and depending therefrom and movable longitudinally through said pipe; means on said body engageable with said stop means to locate said body in the lower portion of said pipe with said well tool extending below the lower end of the pipe and with said coupling member in position for lateral movement into said pipe slot; shiftable means for expanding said coupling member laterally outwardly of the body and into said slot to couple said body to said pipe, said expanding means having a fluid passage therethrough communicating with the pipe to receive fluid under pressure therefrom; said well tool including hydraulically operable means and passage means communicating with said fluid passage and hydraulically operable means to receive fluid under pressure from said fluid passage and conduct it under pressure to said hydraulically operable means to operate the same; actuating means connected to said expanding means and extending through said pipe to the top of the well bore for shifting said expanding means to expand said coupling member outwardly; and means on said pipe at the top of the well bore engaging said actuating means to suspend the same on the pipe with said coupling member expanded outwardly.

6. In combination: a string of pipe adapted to be lowered within a well bore and having a slot in its lower portion; a body movable longitudinally through said pipe; an initially retracted coupling member mounted on said body for expansion laterally outwardly of said body; said pipe having stop means therein in its lower portion; a well tool secured to said body and depending therefrom and movable longitudinally through said pipe; means on said body above said coupling member engageable with said stop means to locate said body in the lower portion of said pipe with said well tool extending below the lower end of the pipe and with said coupling member in position for lateral movement into said pipe slot; shiftable means for expanding said coupling member laterally outwardly of the body and into said slot to couple said body to said pipe, said expanding means having a fluid passage therethrough communicating with the pipe to receive fluid under pressure therefrom; said well tool including hydraulically operable means and passage means communicating with said fluid passage hydraulically operable means to receive fluid under pressure from said fluid passage and conduct it under pressure to said hydraulically operable means to operate the same; actuating means connected to said expanding means and extending through said pipe to the top of the well bore for shifting said expanding means to expand said coupling member outwardly; and means on said pipe at the top of the well bore for supporting said actuating means on the pipe with the coupling member expanded outwardly.

7. In combination: a string of pipe adapted to be lowered within a well bore and having a slot in its lower portion; a body movable longitudinally through said pipe; an initially retracted coupling member mounted on said body for expansion laterally outwardly of said body; said pipe having stop means therein in its lower portion; a well tool secured to said body and depending therefrom and movable longitudinally through said pipe; means on said body above said coupling member engageable with said stop means to locate said body in the lower portion of said pipe with said well tool extending below the lower end of the pipe and with said coupling member in position for lateral movement into said pipe slot; shiftable means for expanding said coupling member laterally outwardly of the body and into said slot to couple said body to said pipe, said expanding means having a fluid passage therethrough communicating with the pipe to receive fluid under pressure therefrom; said well tool including hydraulically operable means and passage means communicating with said fluid passage and hydraulically operable means to receive fluid under pressure from said fluid passage and conduct it under pressure to said hydraulically operable means to operate the same; and a string of tubing connected to said expanding means and extending through said pipe to the top of the well bore for shifting said expanding means to expand said coupling member outwardly.

8. In combination: a string of pipe adapted to be lowered within a well bore and having a slot in its lower portion; a body movable longitudinally through said pipe; an initially retracted coupling member mounted on said body for expansion laterally outwardly of said body; said pipe having stop means therein in its lower portion; a well tool secured to said body and depending therefrom and movable longitudinally through said pipe; means on said body above said coupling member engageable with said stop means to locate said body in the lower portion of said pipe with said well tool extending below the lower end of the pipe and with said coupling member in position for lateral movement into said pipe slot; shiftable means for expanding said coupling member laterally outwardly of the body and into said slot to couple said body to said pipe, said expanding means having a fluid passage therethrough communicating with the pipe to receive fluid under pressure therefrom; said well tool including hydraulically operable means and passage means communicating with said fluid passage and hydraulically operable means to receive fluid under pressure from said fluid passage and conduct it under pressure to said hydraulically operable means to operate the same; a string of tubing connected to said expanding means and extending through said pipe to the top of the well bore for shifting said expanding means to expand said coupling member outwardly; and means on said pipe at the top of the well bore for supporting said string of tubing on the pipe with said coupling member expanded outwardly.

9. In combination: a string of pipe adapted to be lowered within a well bore and having a slot in its lower portion; a body movable longitudinally through said pipe; an initially retracted coupling member mounted on said body for expansion laterally outwardly of said body; said pipe having stop means therein in its lower portion; a well tool secured to said body and depending therefrom and movable longitudinally through said pipe; means on said body engageable with said stop means to locate said body in the lower portion of said pipe with said well tool extending below the lower end of the pipe and with said coupling member in position for lateral movement into said pipe slot; means movable downwardly in said body for expanding said coupling member laterally outwardly of said body and into said slot to couple said body to said pipe, said expanding means having a fluid passage therethrough communicating with the pipe to receive fluid under pressure therefrom; said well tool including hydraulically operable means and passage means communicating with said fluid passage and hydraulically operable means to receive fluid under pressure from said fluid passage and conduct it under pressure to said hydraulically operable means to operate the same; actuating means connected to said expanding means and extending through said pipe to the top of the well bore for moving said expanding means downwardly in said body; and means on said pipe at the top of the well bore for supporting said actuating means on the pipe with the coupling member expanded outwardly.

10. In combination: a string of pipe adapted to be lowered within a well bore and having a slot in its lower portion; a body movable longitudinally through said pipe; an initially retracted coupling member mounted on said body for expansion laterally outwardly of said body; said pipe having stop means therein in its lower portion; a well tool secured to said body and depending therefrom and movable longitudinally through said pipe; means on said body above said coupling member engageable with said stop means to locate said body in the lower portion of said pipe with said well tool extending below the lower end of the pipe and with said coupling member in position for lateral movement into said pipe slot; means movable downwardly in said body for expanding said coupling member laterally outwardly of said body and into said slot to couple said body to said pipe, said expanding means having a fluid passage therethrough communicating with the pipe to receive fluid under pressure therefrom; said well tool including hydraulically operable means and passage means communicating with said fluid passage and hydraulically operable means to receive fluid under pressure from said fluid passage and conduct it under pressure to said hydraulically operable means to operate the same; actuating means connected to said expanding means and extending through said pipe to the top of the well bore for moving said expanding means downwardly in said body; and means on said pipe at the top of the well bore for supporting said actuating means on the pipe with said coupling member expanded outwardly.

11. In combination: a string of pipe adapted to be lowered within a well bore and having a slot in its lower portion; a body movable longitudinally through said pipe; an initially retracted coupling member mounted on said body for expansion laterally outwardly of said body; said pipe having stop means therein in its lower portion; a well tool secured to said body and depending therefrom and movable longitudinally through said pipe; means on said body engageable with said stop means to locate said body in the lower portion of said pipe with said well tool extending below the lower end of the pipe and with said coupling member in position for lateral movement into said pipe slot; means movable downwardly in said body for expanding said coupling member laterally outwardly of said body and into said slot to couple said body to said pipe, said expanding means having a fluid passage therethrough communicating with the pipe to receive fluid under pressure therefrom; said well tool including hydraulically operable means and passage means communicating with said fluid passage and hydraulically operable means to receive fluid under pressure from said fluid passage and conduct it under pressure to said hydraulically operable means to operate the same; a strong of tubing connected to said expanding means and extending through said pipe to the top of the well bore for moving said expanding means downwardly in said body; and means on said pipe at the top of the well bore for supporting said string of tubing on the pipe with said coupling member expanded outwardly.

12. In combination: a string of pipe adapted to be lowered within a well bore and having a slot in its lower portion; a body movable longitudinally through said pipe; an initially retracted coupling member mounted on said body for expansion laterally outwardly of said body; said pipe having stop means therein in its lower portion; a well tool secured to said body and depending therefrom and movable longitudinally through said pipe; means on said body above said coupling member engageable with said stop means to locate said body in the lower portion of said pipe with said well tool extending below the lower end of the pipe and with said coupling member in position for lateral movement into said pipe slot; means movable downwardly in said body for expanding said coupling member laterally outwardly of said body and into said slot to couple said body to said pipe, said expanding means having a fluid passage therethrough communicating with the pipe to receive fluid under pressure therefrom; said well tool including hydraulically operable means and passage means communicating with said fluid passage and hydraulically operable means to receive fluid under pressure from said hydraulically operable means to operate the same; a string of tubing connected to said expanding means and extending through said pipe to the top of the well bore for moving said expanding means downwardly in said body; and means on said pipe at the top of the well bore for supporting said string of tubing on the pipe with said coupling member expanded outwardly.

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