

May 5, 1964

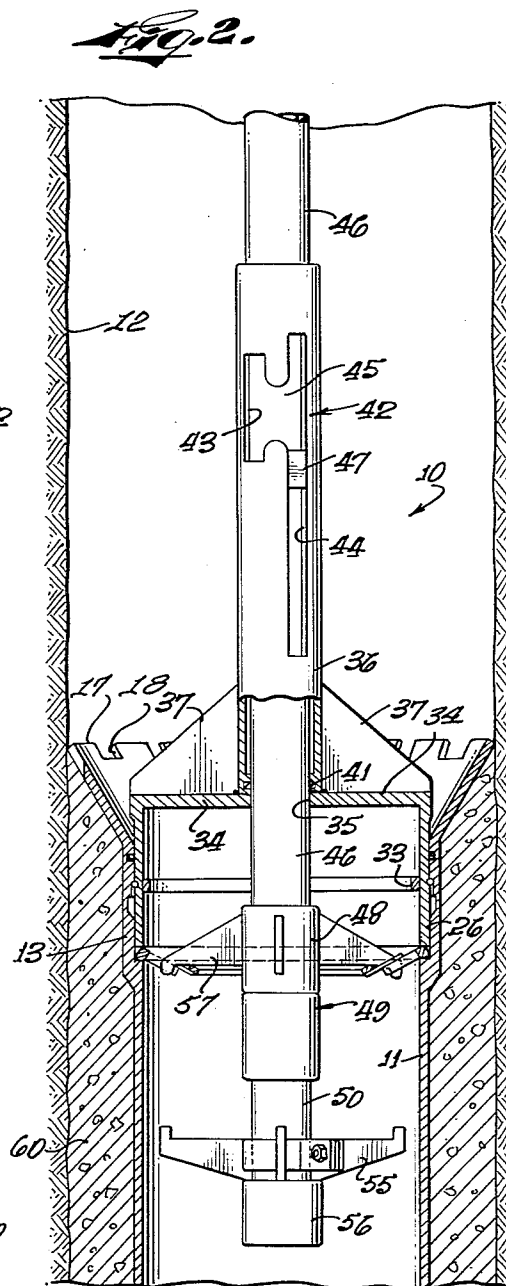
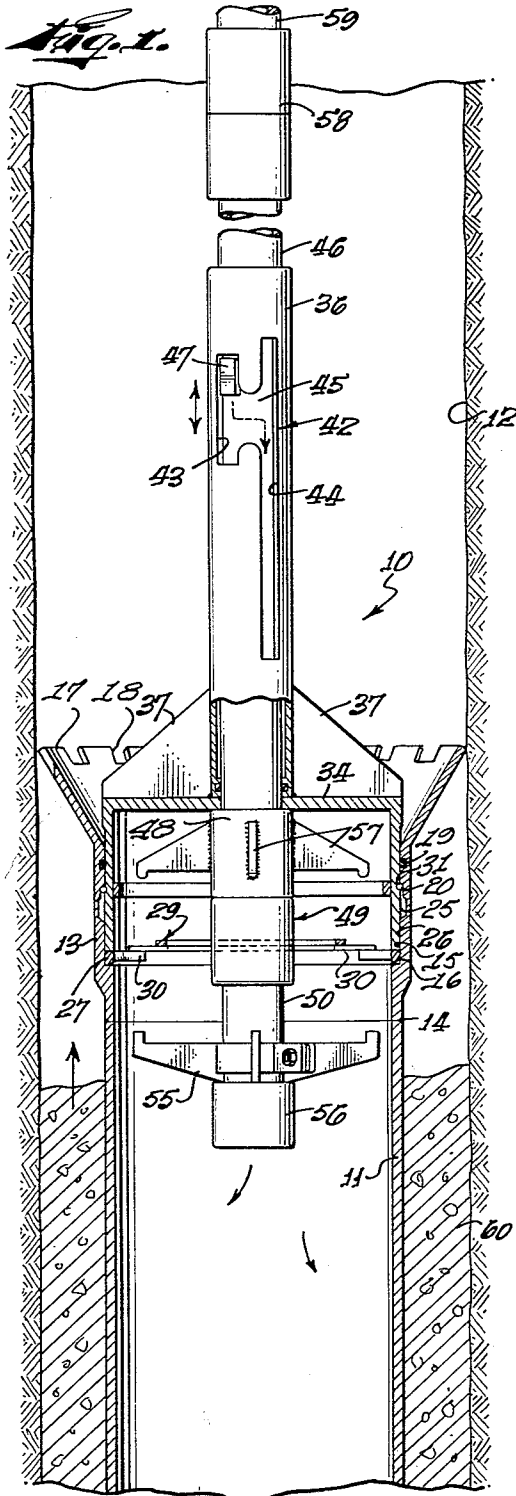
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3,131,768

APPARATUS FOR INSTALLING AND CEMENTING IN PLACE
A LARGE DIAMETER WELL CASING WITH THE UPPER END
DEEP BENEATH THE GROUND SURFACE

Filed April 24, 1962

2 Sheets-Sheet 1



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Fig. 3.

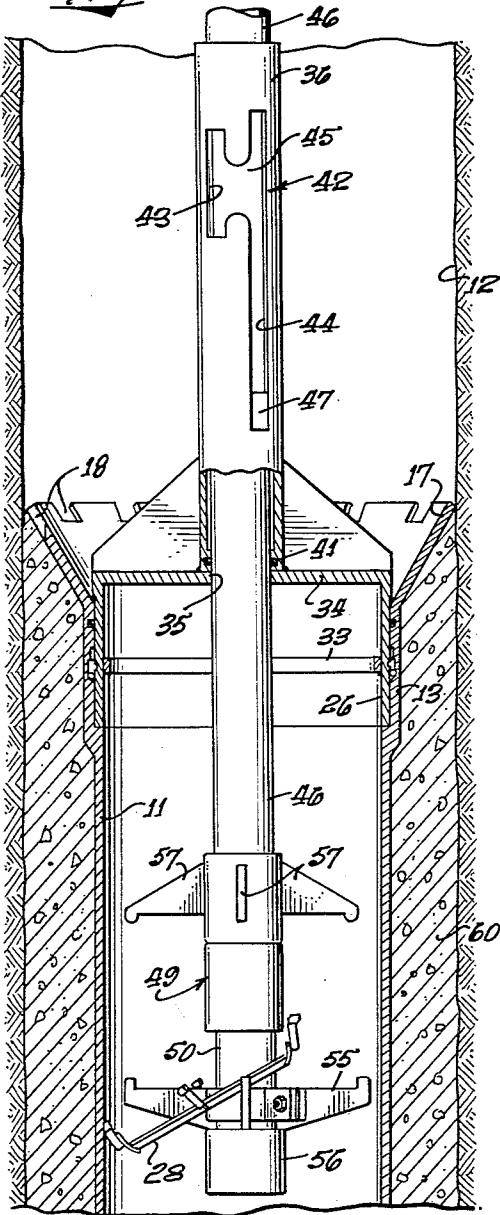


Fig. 4.

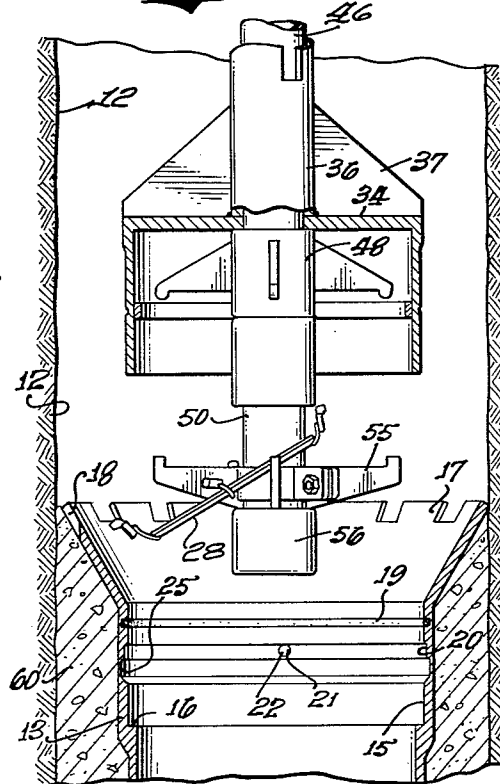


Fig. 5.

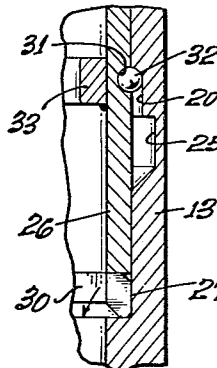


Fig. 6.

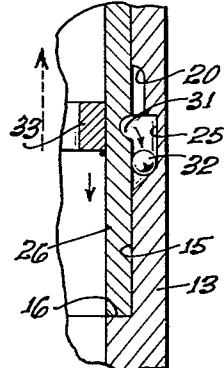
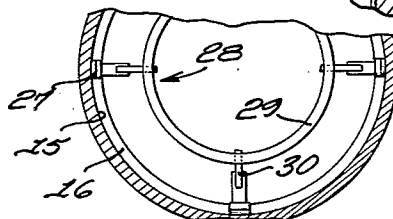


Fig. 7.



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APPARATUS FOR INSTALLING AND CEMENTING IN PLACE A LARGE DIAMETER WELL CASING WITH THE UPPER END DEEP BENEATH THE GROUND SURFACE

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8 Claims. (Cl. 166—181)

This invention relates to the art of lining deep earth bores with steel casing and particularly to the recently developed need for confining large volumes of gas underground under very high pressures.

Underground chambers have been provided for this purpose by drilling deep earth bores which are of substantially larger diameter than is common practice in well drilling and then lining these bores with steel casing and cementing the casing in place throughout its length. The upper end of the casing terminates some distance (a hundred feet or more) below the top of the bore so that a cement plug may be cast in the upper portion of the bore to seal off the gas confining chamber provided by the casing.

It is an object of the present invention to provide an apparatus for supporting and lowering the entire casing above referred to while its upper end is being lowered a substantial distance below the surface of the ground and for cementing the entire casing in place in its lowered position in said bore.

Standard earth bore drilling procedures are followed as closely as possible in these operations including the use of drilling mud in the bore during the drilling of the same and also during the operations of introducing the casing and cementing the same in place.

It is another object of the present invention to provide an apparatus as aforesaid which makes use of a standard string of drill pipe in the operation of the final lowering of the casing into the bottom portion of the earth bore and in the operation of cementing the casing in the bore.

Casings measuring up to three feet in diameter and over a thousand feet in length and weighing as much as 250 tons, must be lowered into a well bore and cemented in place in the operations above described. Difficulty was experienced in the development of the foregoing procedure in providing a positive connection between said drill string and the casing to be lowered into the well bore by the latter.

It is a still further object of the present invention to provide such an apparatus in which a highly dependable connection is made between said drill string and said casing for suspending the latter on said drill string and utilizing said drill string in the cementing in place of said casing and then affording a ready mechanism operable through said drill string for disconnecting the drill string from the casing for the withdrawal of the drill string from the well leaving the casing properly set in place and cemented in said well.

The manner of accomplishing the foregoing objects as well as further objects and advantages will be made manifest in the following description taken together with the accompanying drawings in which

FIG. 1 is a vertical sectional view of a preferred embodiment of the apparatus of the invention being employed to connect a large diameter casing to the lower end of a drill string for suspending said casing thereon and lowering said casing, so suspended, into a well bore. This view also illustrates diagrammatically the manner of employing the suspension means of the apparatus in cementing said casing in said bore.

FIG. 2 is a view similar to FIG. 1 and illustrates the

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operation of the apparatus of the invention to withdraw the blocking means thereof from a position in which said blocking means prevents axial separation of the casing suspension means and said casing. This view illustrates completion of the cementing of the casing in the well bore and starting the step, following this, which is required in separating the suspension means from the casing.

FIG. 3 is a view similar to FIG. 2 and illustrates the maximum downward movement of the hollow stem of the apparatus of the invention through the casing supporting head thereof to positively drive the male sleeve of the apparatus downwardly into fully penetrating relation with the female sleeve united with said casing. This view also illustrates how the spider of the blocking means is captured by a series of radial arms provided on the lower end of the hollow stem of the apparatus.

FIG. 4 is a view similar to FIG. 3 and illustrates the complete separation of the suspension apparatus from the female sleeve provided on the upper end of said casing and the lifting upwardly of the suspension means out of the well bore.

FIG. 5 is an enlarged fragmentary detailed view illustrating the ball locking means of the invention operative to prevent axial separation of the lifting device of the invention and said casing.

FIG. 6 is a view similar to FIG. 5 illustrating the unblocking of the male sleeve of the apparatus permitting it to further penetrate into the female sleeve thereof so as to render said locking means inoperative and permit the separation of the suspension means of the invention from said casing.

FIG. 7 is a fragmentary horizontal sectional view taken on the line 7—7 of FIG. 1 and illustrates the structure of the blocking means of the invention.

Referring specifically to the drawings and particularly to FIG. 1, a preferred embodiment of the invention is there illustrated in the form of a suspension and cementing device 10 on which a relatively large diameter well casing 11 is suspended while being lowered in a well bore 12.

FIG. 1 shows a characteristic operation of the type to which the invention relates in which said bore is over three feet in diameter and said casing is about 30 inches in diameter and in which said casing is approximately nine hundred feet in length and said bore is about one thousand feet in depth so that when the lower end of casing 11 comes to rest on the bottom of the bore 12, the upper end of the casing is about one hundred feet beneath the surface of the ground.

The device 10 of the invention includes a female sleeve 13 which is secured to the upper end of the casing 11 as by welding material 14 applied circumferentially at the meeting joint between said sleeve and said casing so as to render these two elements integral. Sleeve 13 has substantially the same internal diameter as said casing and is provided with a cylindrical internal recess 15 which is open at its upper end and provides at its lower end an annular internal shoulder 16. At its upper edge, sleeve 13 is integrally united with an outwardly and upwardly flaring flange 17, the periphery of which is of a diameter such as to contact the edge of the bore 12. This periphery is preferably provided with notches 18 giving a scalloped effect to said flange for a purpose which will be made clear hereinafter. Provided in the recess 15 is an annular groove for retaining an O-ring 19. Just below said O-ring, said recess is provided with an annular ball race 20. A threaded hole 21 in sleeve 13 opens into race 20 for admitting balls to said race, said hole being then closed by a threaded plug 22. Immediately below said ball race and communicating there-

with, is an annular ball release channel 25, the radial dimension of which is approximately twice that of said ball race.

The device 10 also includes a male sleeve 26 which has an external diameter allowing it to slidably fit downwardly with a close fit into the cylindrical internal recess 15 formed in the female sleeve 13. When the sleeve 26 is assembled with the device 10 preliminary to accomplishing a casing suspension and cementing operation, it is lowered so as to come to rest on a series of four blocks 27 which rest on annular internal shoulder 16 and are held in united relation and so positioned by a spider 28, with which they are connected, said spider having a central ring 29 which is connected by radial elements 30 to the blocks 27.

The male sleeve 26 has an annular ball race 31 provided on its external face which is juxtaposed in cooperative relation with the ball race 20 in the same horizontal plane therewith when said male sleeve is initially assembled with the device 10 as above described. A quantity of ball bearing balls 32 are inserted into the space between said two ball races in the initial assembly of the device 10 so as to operate as clearly shown in FIG. 5 to provide a powerful connection between the tubular sleeves 13 and 26 preventing axial separation of these sleeves.

The male sleeve 26 has an internal reinforcing band 33 which is welded thereto opposite the ball race 31 to reinforce the latter.

The upper end of the male sleeve 26 is closed by a flat horizontal head plate 34 which is welded to said sleeve. Plate 34 has a central aperture 35 and has welded thereto, so as to extend coaxially upward therefrom, a tubular stem guide sleeve 36. Radial gusset plates 37 are welded to plate 34 and sleeve 36 to reinforce the connection between these elements. The guide sleeve 36 has its interior diameter relieved between upper and lower end portions thereof the latter being provided with an annular internal groove to receive an O-ring 41. The guide sleeve 36 has two H slots 42 in diametrically opposed positions therein one of these being visible in FIGS. 1 and 2. Each slot 42 includes a short vertical slot 43 and a substantially deeper vertical slot 44 which are connected by a cross slot 45. Vertically slidable in the sleeve 36 is a hollow stem 46 which is preferably formed of a piece of drill pipe and is provided with a pair of diametrically opposed rectangular lugs 47 which extend radially therefrom into the H slots 42. The lower end of stem 46 screws into the pin end 48 of a drill pipe coupling 49, the box end of which connects to a short piece of drill pipe 50 which supports a four pronged clamp 55 by a collar 56 screwed onto the lower end of piece 50. Welded on the pin end 48 of the coupling 49 so as to extend radially therefrom are four down-turned claw arms 57 the purpose of which will be made clear hereinafter.

The upper end of hollow stem 46 connects with a drill pipe coupling 58 which is provided on the lower end of a drill string 59 which extends up to the upper end of well bore 12 where suitable apparatus including an overhead rig (not shown) is provided for raising or lowering the drill string 59 to raise or lower the well casing 11 suspended thereon and carry out the other steps of the operation of installing this casing in bore 12 and cementing the same therein.

OPERATION

As above pointed out, FIG. 1 illustrates the relationship of the parts of the suspension and cementing device 10 when this is fastened to the casing 11 and the latter is being lowered into the bore 12 suspended on the drill string 59 with the upper end of the casing descending below the surface of the ground.

Before reaching this stage, however, the casing 11, which is 30 inches in diameter and approximately nine

hundred feet long has been assembled section by section. These sections have been added together at the upper end of the well bore 12 and the casing has been lowered as it is being assembled, in the ordinary manner for lowering a casing into a well bore until the entire casing 11 has thus been assembled and is suspended in a chuck at the top of the well. When this step has been reached in the operation, the suspension and cementing device 10 is attached by the coupling 58 to the drill string 59, with the latter suspended on the rig (not shown) positioned over the bore 12, and the assembly is lowered until the lower end of the female sleeve 13 rests upon the top of the casing 11 whereupon these two parts are integrally united by welding material 14. This done, the weight of the device 10 as well as that of the casing 11 is lifted by the overhead rig lifting on the drill string 59 and the chucks are withdrawn from around the casing so that the latter is free to be lowered on the drill string 59 to its final location in the well bore 12. At this time the diametrically opposed lugs 47 are located in short vertical slots 43 in the stem guide sleeve 36 as shown in FIG. 1.

When the casing 11 is thus lowered into the well bore 12, the latter is filled with rotary mud. After the casing 11 has touched bottom in the well bore 12 a strain is placed on the drill string 59 to lift the lower end of the casing from the well bottom and a quantity of liquid cement 60 is then pumped down the drill string 59 through the stem 46 and into the casing 11 which is sufficient to fill the space between the casing and the bore 12 throughout the length of the casing. When such an amount of cement has been admitted to the casing through the hollow stem 46, the pumping of rotary mud down said hollow stem is resumed so that by the time the space between the casing and the well bore has been filled with cement a relatively small amount of cement will remain in the inside of the lower end of the casing 11, the major portion of the space within this casing being occupied by rotary mud. In order to make sure that the space between the casing 11 and bore 12 has been completely filled with cement, a sampling pipe (not shown) may be extended down the bore 12 and through one of the notches 18 into the space between the upper portion of the casing 11 and the bore in order to sample the liquid contents of this area and thus ascertain when the upward flow of cement around the casing has reached the upper end of the latter.

When this occurs, the circulating of rotary mud downwardly through the hollow stem 46 is discontinued and steps are taken to disconnect the stem 46 and the male sleeve 26 from the female sleeve 13 so that these elements, supported on the drill string 59 may be withdrawn upwardly from the well.

To accomplish this the drill string 59 is lowered to relieve the hollow stem 46 of the weight of the casing 11 by allowing the latter to sink downward and come to rest on the bottom of the well bore 12. The stem 46 is then further lowered until the lugs 47 are opposite the cross slots 45 whereupon the drill string 59 is rotated in an anti-clockwise direction to shift the lugs 47 into the long vertical slots 44 after which the drill string 59 is lowered to lower the lugs 47 in the long vertical slots 44, the initial result of which is illustrated in FIG. 2. Here the down-turned claw arms 57 are seen as they are brought into engagement with the spider ring 29 so as to start collapsing the spider ring and pulling the blocks 27 from between the annular internal shoulder 16 and the lower end of the male sleeve 26. As the downward movement of the hollow stem 46 continues, the blocks 27 are entirely pulled from between the shoulder 16 and the male sleeve 26 so that the latter is free to drop by gravity downwardly against said shoulder. If for any reason gravity does not produce this action, it is positively brought about by arrival of the lugs 47 at the lower end of the vertical slots 44 as shown in FIG. 3 where the full weight of the stem 46 and drill string 59 are applied

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through lugs 47 onto the stem guide sleeve 40 and through this to the male sleeve 26 to cause the latter to fully penetrate the female sleeve 13. As shown in FIG. 6 this brings the ball race 31 of the male sleeve 26 downwardly opposite the ball release channel 25 in the female sleeve 13 so that the balls 32 gravitate downwardly into the channel 25 and thus remove these from their operative positions.

The ball locking means connecting sleeves 13 and 26 having thus been rendered inoperative, the operator is now able by lifting on the drill string 59 to pull the latter and all the elements connected therewith including sleeve 26 upwardly out of the female sleeve 13 and out of the well bore 12 as clearly shown in FIG. 4. The four pronged clamp 55 is provided in order to catch the block mounting spider 28 and also remove this from the well.

The female sleeve 13, of course, remains as a trim element at the upper end of the casing 11 providing, by the flange 17, a beveled edge to the opening of the casing and a finish surface for the concrete which occupies the space between the casing and the well bore.

After the concrete 60 thus pumped into the space between the casing and the well bore has thoroughly hardened, the rotary mud is baled out of the bore 12 and well casing 11 and whatever steps desired performed for the completion of the high pressure gas reservoir of which the casing 11 forms a part, these being no part of the present invention.

We claim:

1. In an apparatus for installing and cementing in place a large diameter well casing with an upper end thereof deep beneath the ground surface, the combination of: a female sleeve secured at its lower edge to the upper end of said casing, said sleeve having an internal cylindrical recess open at its upper end, and providing, at its lower end an annular internal shoulder; a male sleeve making a sliding fit with said recess when extended downwardly therein; a circular head united at its periphery with the upper end of said male sleeve, said head having a central aperture; a tubular stem guide formed on said head and extending concentrically upwardly therefrom; a tubular stem comprising a piece of drill pipe vertically sliding in said aperture and guide, said stem being coupled at its upper end with the lower end of a string of drill pipe suspended in a rig over a well bore into which said casing has been lowered before securing said female sleeve to the upper end thereof; axially unidirectional locking means embodied with said sleeve and operative, with said male sleeve partially inserted into said female sleeve a given distance, to positively lock said male sleeve against withdrawal from said female sleeve, while permitting said male sleeve to be inserted further into said female sleeve; means rendered effective by such further insertion of said male sleeve to render said locking means inoperative to prevent withdrawal of said male sleeve from said female sleeve; means positioned for temporarily blocking said further insertion of said male sleeve into said female sleeve to maintain said locking means operative to lock said male sleeve against withdrawal from said female sleeve; means on said stem which prevents withdrawal of said stem from said head whereby the weight of said casing may be supported through said locking means by said drill string; and means actuated by manipulation of said stem through said drilling string for withdrawing said blocking means from said position thereby permitting said male sleeve to further penetrate said female sleeve and thereby cause said locking means to be disengaged and said head and male sleeve to be disconnected from said female sleeve and said casing, whereby said head and male sleeve may be withdrawn with said drill string from the well.

2. A combination as recited in claim 1 wherein a collar is provided on said stem which bears against said head and thus supports the weight of said casing when the latter is held out of engagement with the bottom of

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the well; and radial arms provided on said collar for engaging said blocking means when said casing is allowed to come to rest on the bottom of the well and said stem is extended downwardly through said head aperture, to dislodge said blocking means from said position and permit the male sleeve to extend fully into said female sleeve, thereby disengaging said locking means and permitting withdrawal upward of said male sleeve, head and stem.

3. A combination as recited in claim 1 wherein the upper end of said female sleeve has secured thereto a frusto-conical upwardly angled flange, the outer periphery of which approximately fits the well bore and is scalloped to permit circulating liquid to by-pass said flange.

4. A combination as recited in claim 2 wherein said stem has a downward extension below said collar; and radial arm means on said extension for recovering said blocking means when withdrawing said stem and male sleeve from the well.

5. A combination as recited in claim 1 wherein said stem is provided with a lug, there being an H-slot in said stem guide receiving said lug, one of the vertical elements of said slot being relatively short to facilitate limited vertical movement of said stem relative to said head without displacing said blocking means, the other vertical element of said slot being relatively long to permit sufficient vertical movement of said stem relative to said head to displace said blocking means.

6. A combination as recited in claim 1 wherein said blocking means comprises a series of blocks interposed between said annular internal shoulder and the lower end of said male sleeve and a spider connecting said blocks to hold them so positioned; and a series of arms extending radially from said stem beneath said head for engaging said spider when said stem is extended downwardly relative to said head, to depress said spider and withdraw said blocks from said cylindrical internal recess in said female sleeve, thereby freeing said male sleeve to gravitate downward against said annular shoulder thereby disengaging said locking means to permit said head and male sleeve to be separated from said female sleeve and withdrawn with said stem from the well.

7. A combination as recited in claim 1 wherein said locking means includes the provision of a pair of annular ball races in said sleeves which are juxtaposed, face-to-face when said blocking means is in supporting relation with said male sleeve; and a quantity of ball bearing balls occupying said races to positively prevent axial separation of said sleeves, there being an annular ball release channel formed in said female sleeve with a radial dimension in excess of the diameter of one of said balls and communicating along its upper edge with the lower edge of the ball race formed in said female sleeve, whereby withdrawal of said blocking means permits further penetration of said female sleeve by said male sleeve and the escape of said balls into said ball release channel, thereby releasing said male sleeve for withdrawal upwardly from said female sleeve.

8. In a releasable coupling the combination of: male and female interfitting tubular members, the interfitting portions of said members comprising respectively telescopically related male and female sleeves; axially unidirectional locking means embodied with said sleeves and operative, with said male sleeve partially inserted into said female sleeve a given distance, to positively lock said male sleeve against withdrawal from said female sleeve, with permitting said male sleeve to be inserted further into said female sleeve; means rendered effective by such further insertion of said male sleeve to render said locking means inoperative to prevent withdrawal of said male sleeve from said female sleeve; means positioned for temporarily blocking said further insertion of said male sleeve into said female sleeve to maintain said locking means operative to lock said male

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sleeve against withdrawal from said female sleeve; head means united with and closing the upper end of said male tubular member, said head means having a central aperture for slidably receiving the lower end of a drill stem; collar means provided on the lower end portion of said drill stem and preventing upward withdrawal of said drill stem from said head means but permitting said drill stem to be vertically reciprocable through said aperture; and means located inside said coupling and operable by manipulation of said drill stem for dislodging said blocking means from said position to allow

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said male sleeve to further penetrate said female sleeve and thereby free said coupling members from connection by said locking means whereby said members may be readily separated axially and said head and male member withdrawn upwardly with said drill stem.

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