Oct. 10, 1961 D. E. SMINK 3,003,564

WELL COMPLETION

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FIG. 1.

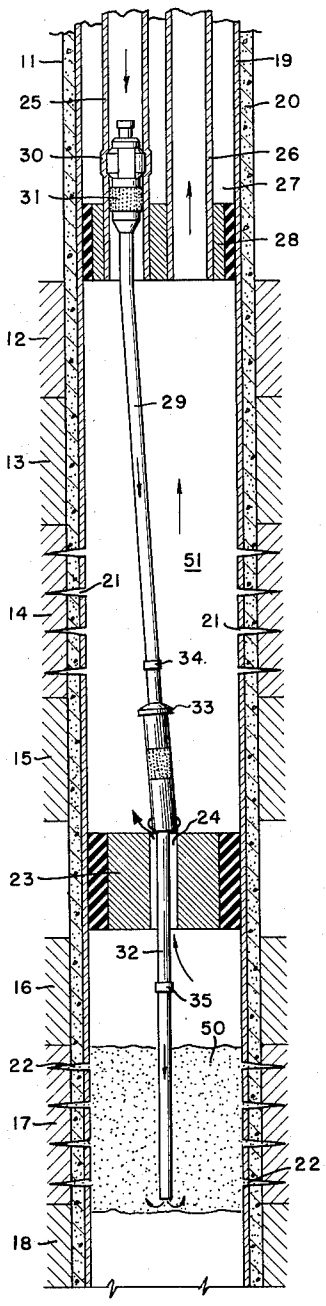


FIG. 2.

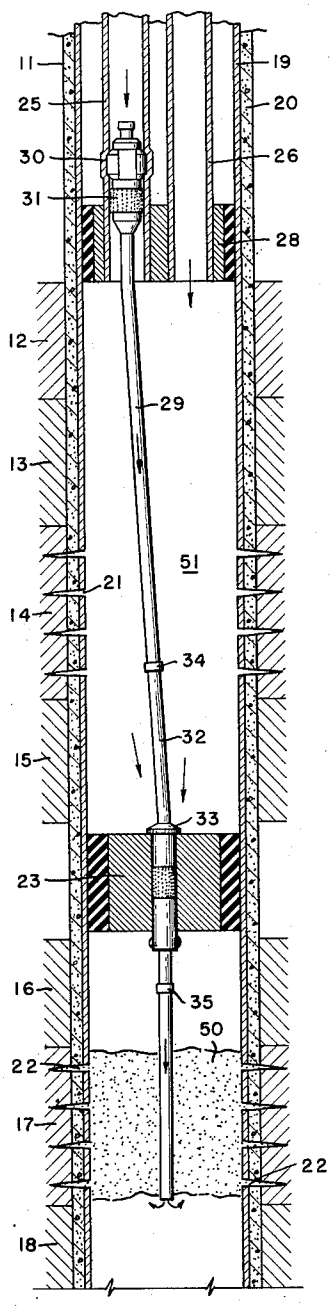
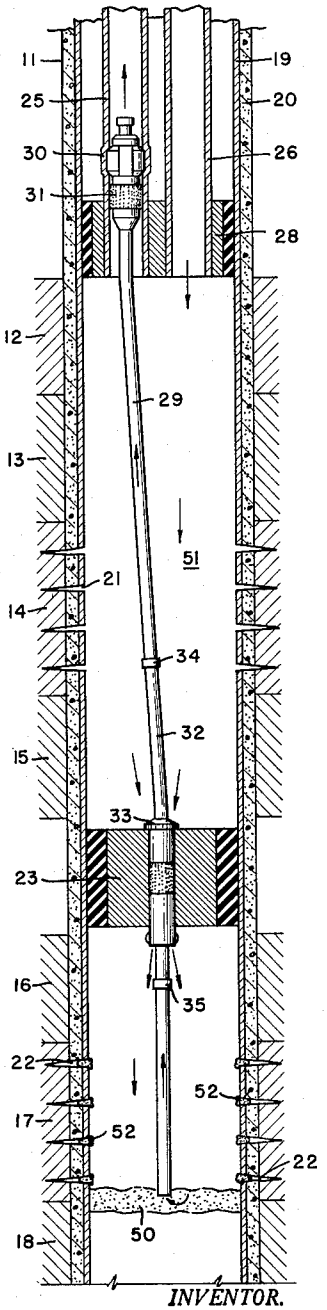


FIG. 3.



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FIG. 4.

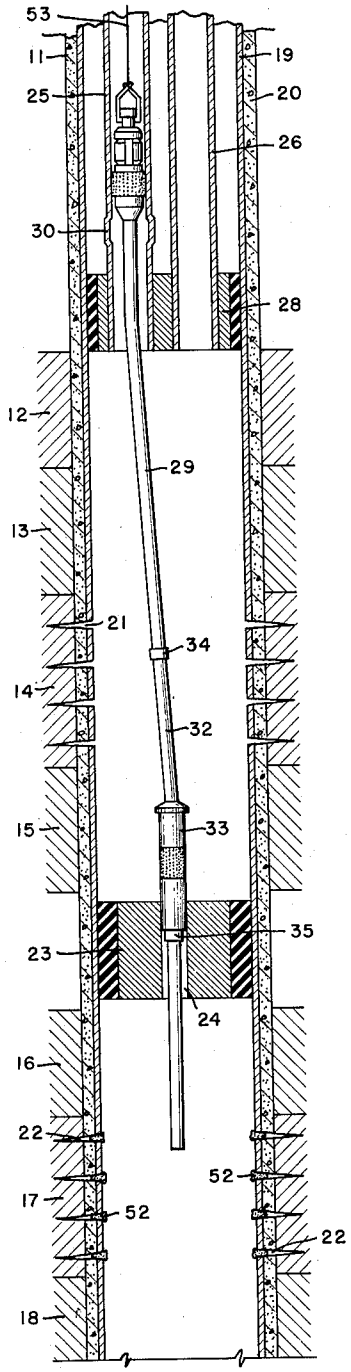
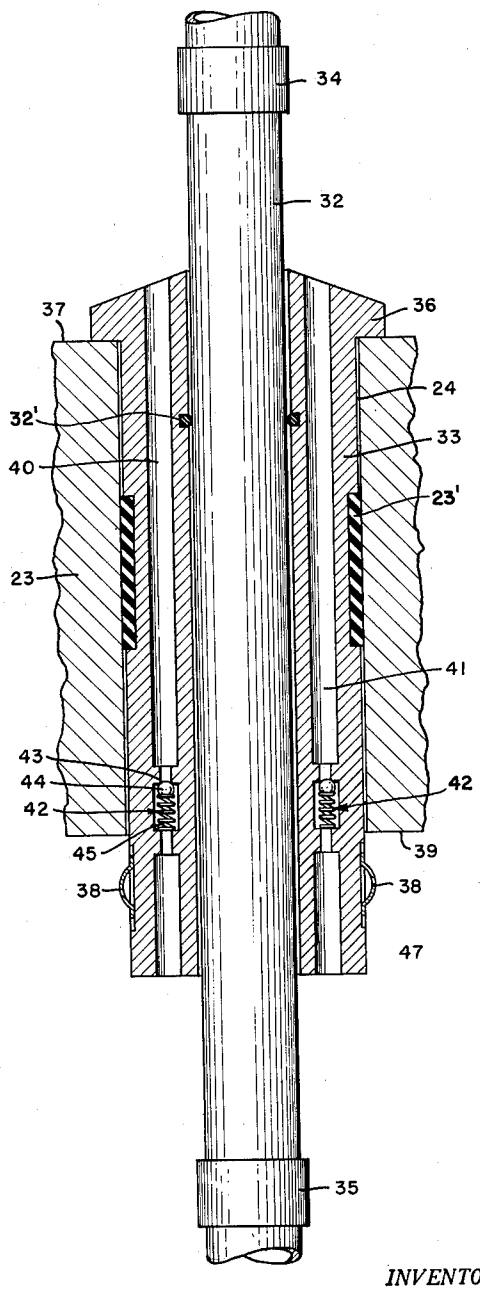


FIG. 5.



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FIG. 6.

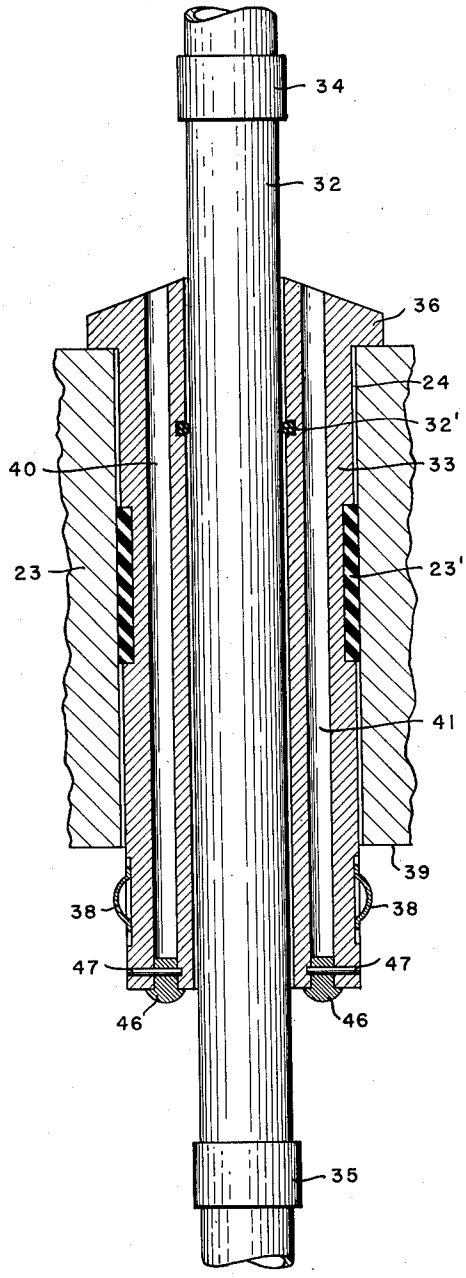
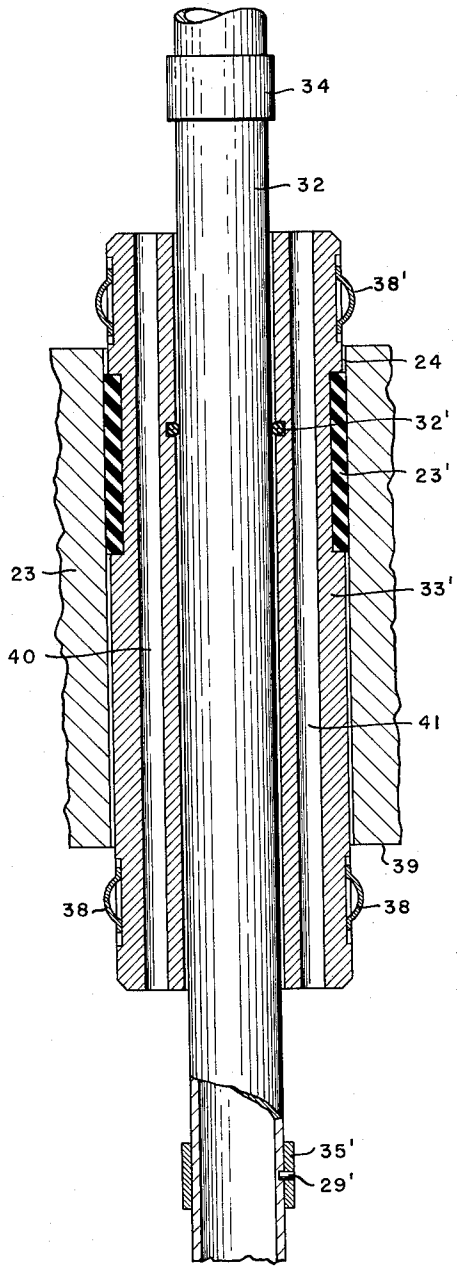


FIG. 7.



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WELL COMPLETION

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9 Claims. (Cl. 166—114)

The present invention is directed to completion of wells in a plurality of subsurface earth zones. More particularly, the present invention is concerned with apparatus for completing wells in a plurality of hydrocarbon productive zones. In its more specific aspects, the invention is directed to well completion apparatus for use in a pipe string in a well.

The present invention may be briefly described as a tubular member adapted to be retrievably suspended and sealed in the lower end of a tubing string arranged in a well casing. The tubular member extends into the bore of a packer spaced vertically below the lower end of the tubing string in the casing and has a plug member which is slidably carried externally by the tubular member intermediate its ends. External first and second stop means are spaced longitudinally on said tubular member from the ends of the plug member. First sealing means are carried by the plug member for sealing with the exterior wall of the tubular member, and second sealing means carried by the plug member are provided for sealing with the bore of the packer. The plug is provided with at least one fluid-pressure openable passageway which extends longitudinally through the plug.

The fluid-pressure openable passageway may be closed by a check valve arranged therein or the fluid-pressure openable passageway may have a releasable plug arranged in the passageway. For example, the plug may be held in the passageway by a frangible means such as a shear pin.

The tubular member is suitably provided with a polish joint section intermediate the ends of the tubular member on which the plug member is slidably carried.

The plug member suitably has a shoulder on its upper end which is engageable with the upper surface of the packer and is also provided with means on its lower end such as a bow-spring collet which is engageable with the lower surface of the packer.

The present invention also involves the combination of a tubing string and the tubular member in accordance with this invention.

The present invention will be further illustrated by reference to the drawing in which:

FIGS. 1 to 4 show a step-wise use of a preferred embodiment of the present invention;

FIG. 5 is a cross-sectional view of the detail of the present invention;

FIG. 6 illustrates in cross-section a modification of FIG. 5; and

FIG. 7 is a further modification of the plug means and lower stop member.

Referring now to the drawing and particularly to FIGS. 1 to 4 in which identical numerals will be employed to designate identical parts, numeral 11 designates a well bore drilled from the earth's surface not shown to penetrate a plurality of hydrocarbon productive zones 12, 13, 14, 15, 16, 17, and 18. Arranged in the well bore 11 is a casing 19 which is cemented in place by primary cement 20. The casing 19 is perforated in a hydrocarbon productive zone 14 to provide perforations 21 and is perforated in a hydrocarbon productive zone 17 to provide perforations 22.

By way of explanation, zones 12, 13, 14, and 15 may be termed an upper zone, whereas zones 16, 17, and 18 may comprise a lower zone.

It is to be noted that the upper zones 12 to 15 inclusive are separated from lower zones 16 to 18 inclusive by a single-bore packer 23. The packer 23 has an opening 24 therein to provide communication between the upper zone of the casing 19 and the lower zone of the casing 19.

A first tubing string 25 is arranged in the casing 19 and extends to the wellhead not shown, and a second tubing string 26 is arranged in the casing 19 and extends to the wellhead not shown. The tubing strings 25 and 26 terminate above the upper zones and lower zones 12 to 15 and 16 to 18 respectively, and the casing-tubing annulus 27 is closed by means of a dual bore packer 28 in which the lower end of tubings 25 and 26 terminate.

Arranged in the lower end of the tubing 25 is an elongated tubular member 29 which is sealingly suspended in the lower end of the tubing 25 in a suitable landing nipple 30 and is sealed therein by sealing means 31. The tubular member 29 is provided with a polish joint section 32 and arranged on the polish joint section 32 is a plug 33 which is slidably carried on the polish joint section 32. A first stop means 34 is arranged on the tubular member 29 above the plug means 33 and a second stop means 35 is arranged on the polish joint section 32 below the plug member 33.

In FIG. 1 the apparatus of the present invention is shown during the circulation and spotting of cement, in FIG. 2, the showing is of the setting of the plug and the squeezing of cement, and in FIG. 3 illustration is given of blowing the ports in the plug and removing excess fluid cement. While in FIG. 4, a retrievement of the tubular member and the plug is illustrated.

Referring now to FIG. 5 in which identical numerals designate identical parts, it will be seen that the plug member 33 is arranged on the polish joint section 32 between the stop means 34 and the stop means 35. A sealing means 32' carried by the plug member 33 seals between the plug member 33 and the packer 23 while a sealing means 23' also carried by the plug member 33 seals between the polish joint section 32 and the plug member 33. Suitably the stop means 34 and 35 may be a collar connecting the polish joint 32 within the tubular member 29.

From FIG. 5 it will be seen that the plug member 33 is provided on its upper end with a shoulder 36 which is designed to engage with upper surface 37 of the packer 23. Also, it will be noted that on the lower end of the plug member 33 a bow-spring collet means 38 is provided for engagement with the surface 39 on the lower end of the packer 23.

Arranged in passageways 40 and 41 of the plug member 23 are means to prevent flow therethrough. However, these means are fluid pressure openable and two different kinds of means may be employed. For example, in the passageways 40 and 41 there is described a check valve 42 composed of a seat 43 on which a ball-check valve 44 is seatable, the ball-check being held on the seat 43 by means of a spring 45. Fluid pressure exerted downwardly through the passageway 40 causes the ball 44 to move off the seat 43 and to allow passage of fluid downwardly through the passageways 40 and 41. As shown in FIG. 6, another kind of fluid pressure openable means is described. Thus, in this embodiment the passageways 40 and 41 are each shown as being closed by a plug member 46 which is releasably held in the passageways 40 and 41 by a frangible means such as a shear pin 47 which may be ruptured by pressure exerted downwardly through the passageway 41.

In employing the apparatus of the present invention, the casing 19 contains a column of liquid to control pressure from zone 17 as is well known and a tubular member such as 29 is lowered through the tubing string 25 for seating in the landing nipple 30 to be sealed there-

in with the seal 31. With the plug member 33 carried by the tubular member 29, it is placed as shown in FIG. 1 for use in spotting cement in the regions of the perforations 22 which it is desired to seal. The fluid cement is flowed down the tubing 25 and the tubular member 29 to form a body of cement 50 to be squeezed into the perforations 22 and to seal off the zone 17. With fluid cement being flowed downwardly through the tubular member 29, fluid pressure will be exerted upwardly through the bore 24 of the packer 23 by the displaced liquid thus holding the plug 33 above the bore 24 and allowing circulation upwardly through the bore 24 into the space 51 between the packers 28 and 23 and then upwardly to the wellhead through the tubing string 26.

After the cement has been spotted as described with respect to FIG. 1, fluid pressure is then exerted downwardly through the tubing 26 on the liquid in the space 51 which causes the plug 33 to move into the bore 24 of the packer 23. Likewise, hydraulic pressure is then exerted downwardly through the tubing string 25 and the tubular member 29 against the body of cement 50 to cause the cement to flow through the perforations 22 and into the zone 17 to seal same.

When it is desired to remove the excess fluid cement from the region of the zone 17, hydraulic pressure is again exerted in the space 51 through the tubing string 26 which causes the passageways 40 and 41 to be open. The amount of pressure used is sufficient to open passageways 40 and 41. In the case where check valves are used such as in passageway 40, the check valves would be unseated and fluid would flow downwardly through the passageways 40 and 41. In the case where a releasable plug is used, the shear pin such as 47 would be ruptured and the plug 46 blown out of the passageway such as 41 allowing the fluid to pass from the space 51 down through the passageways 40 and 41 and then to cause the body of cement 50 to be removed upwardly through the tubular member 29 and the tubing string 25 to the wellhead not shown. It is to be noted that nodules or buttons of cement such as 52 have been formed in the perforations 22 by virtue of using a modified cement such as described in the patent to Salathiel 2,582,459. While a modified cement such as one containing bentonite may be used, other modified cements which are well known in the art may also be employed.

Referring now to FIG. 4, it will be seen that the retrievable tubular member 29 has been engaged at its upper end with a wireline on cable 53 to remove the retrievable tubular member 29 from the tubing string 25. In order to move the plug out of the bore 24 of the packer 23, the stop member 35 moves upwardly relative to the plug 33 and engages with the lower end thereof and causes the plug to be unseated from the bore 24, thus, further pull upwardly by means of wireline 53 allows the tubular member 29 and the plug 33 to be retrieved from the casing 19 and the tubing string 25 as has been described.

The stop means 35 may be formed of an external collar connected releasably to the tubular member 29 by a frangible means such as a shear pin such that by imposition of sufficient fluid pressure on the plug 33, the releasable collar is caused to slide downwardly on and off the tubular member 29 and allowing the slidable plug 33 also to be released therefrom. Thus, as shown in FIG. 7, a plug 33' is provided on polish joint 32. Plug 33' is modified on its upper end by bow spring collet means 38' which are similar to bow spring collet means 38 on the lower end. Bow spring collet means 38' replaces shoulder 36 to engage with the upper end of packer 23. Stop means 35' is similar to stop means 35 excepting that it is releasably connected to tubular member 29 by a shear pin 29'. By imposition of fluid pressure on plug 33', the collet means 38' are compressed allowing the plug means 33' to be forced against stop 35', rupturing shear pin 29' and allowing both the plug means 33' and stop 35' to be removed from tubular member 29. This provides a passage through the bore 24 of packer 23 through the annulus between the tubular member 29 and the bore 24 for fluid circulation such as for removal of excess fluid cement as illustrated in FIG. 3. Ordinarily this type of construction would be used only when a larger passage than that provided by passageways 40 and 41 is required.

The present invention is quite advantageous and useful and it is particularly important in operations where a single bore packer such as has been described is employed between spaced-apart hydrocarbon productive zones. For example, a sliding plug carried by a tubular member may be employed to effect a seal as has been described with the sliding plug moving slidably on a polish point section of the tubular member. In practicing the precent invention, the upper packer may be a packer such as described by Brown Oil Tools in the Composite Catalog, 1955–56, 21st edition, page 849, while the single bore lower packer is one as described by Baker Oil Tools in the Composite Catalog supra, page 537.

The present invention is particularly advantageous in working over a lower zone in a dually completed well equipped with retrievable production tubes. Heretofore it was necessary to employ concentric pipe. The concentric pipe bridged the gap between the two packers isolating the upper zone and provided a circulation system for squeeze cementing and other workover operations. While concentric pipe is used successfully in wells, it is sometimes difficult to install and may apply some restrictions on safe circulation of cement slurries. In accordance with the present invention it is possible to provide safe circulation and to eliminate the employment of a double-bore lower packer as sometimes has been necessary in dual completions used heretofore. Where double-bore lower packers were used, field work has demonstrated it is sometimes difficult to set and retrieve a plug with the production tube in place in one of the bores of the packer. In the present invention the difficulties embodied in employing dual-bore lower packers in multiple completion has been substantially eliminated. Therefore, the present invention is quite important and useful.

The nature and objects of the present invention having been completely described and illustrated, what I wish to claim as new and useful and secure by Letters Patent is:

1. A tubular member adapted to be retrievably suspended and sealed in the lower end of a tubing string in a well casing and to extend into the bore of a packer spaced vertically below the lower end of said tubing string in said casing which comprises a plug member slidably carried externally by said tubular member intermediate its ends, external first and second stop means on said tubular member spaced longitudinally from the ends of said plug member, first sealing means carried by said plug member for sealing with the exterior wall of said tubular member, second sealing means carried by said plug member for sealing with the bore of said packer, said plug member being provided with at least one normally closed passageway extending longitudinally through said plug member, and closure means in said passageway openable by imposition of fluid pressure thereon from above said packer when said plug member is in the bore of said packer.

2. A tubular member in accordance with claim 1 in which the closure means is a check valve.

3. A tubular member in accordance with claim 1 in which the closure means is a releasable plug.

4. A tubular member adapted to be retrievably suspended and sealed in the lower end of a tubing string in a well casing and to extend into the bore of a packer spaced vertically below the lower end of said tubing string in said casing which comprises a polish joint section in said tubular member, a plug member slidably carried externally by said tubular member intermediate

its ends on said polish point section, external first and second stop means on said tubular member spaced longitudinally from the ends of said plug member, first sealing means carried by said plug member for sealing with the exterior wall of said tubular member, second sealing means carried by said plug member for sealing with the bore of said packer, said plug member being provided with at least one normally closed passageway extending longitudinally through said plug member, and closure means in said passageway openable by imposition of fluid pressure thereon from above said packer when said plug member is in the bore of said packer.

5. A tubular member adapted to be retrievably suspended and sealed in the lower end of a tubing string in a well casing and to extend into the bore of a packer spaced vertically below the lower end of said tubing string in said casing which comprises a plug member having a shoulder on its upper end engageable with the upper surface of said packer slidably carried externally by said tubular member intermediate its ends, external first and second stop means on said tubular member spaced longitudinally from the ends of said plug member, means on the lower end of said plug member adapted to engage with the lower surface of said packer when said plug member is raised during removal of said plug member from the packer, first sealing means carried by said plug member for sealing with the exterior wall of said tubular member, second sealing means carried by said plug member for sealing with the bore or said packer, said plug member being provided with at least one normally closed passageway extending longitudinally through said plug member, and closure means in said passageway openable by imposition of fluid pressure thereon from above said packer when said plug member is in the bore of said packer.

6. A tubular member in accordance with claim 5 in which the means on the lower end of said plug member engageable with the lower surface of said packer is at least one spring collet.

7. A tubular member adapted to be retrievably suspended and sealed in the lower end of a tubing string in a well casing and to extend into and through the bore of a packer spaced vertically below the lower end of said tubing string in said casing which comprises a plug member having a shoulder on its upper end engageable with the upper surface of said packer and slidably carried externally by said tubular member intermediate its ends, external first and second stop means on said tubular member spaced vertically from the ends of said plug member, a bow-spring collet on the lower end of said plug member adapted to engage with the lower surface of said packer when said plug member is raised during removal of said plug member from the packer, first sealing means carried by said plug member for sealing with the exterior wall of said tubular member, second sealing means carried by said plug member for sealing with the

bore of said packer, said plug member being provided with first and second normally closed passageways extending longitudinally through said plug member, and closure means in each of said passageways openable by imposition of fluid pressure thereon from above said packer when said plug member is in the bore of said packer.

8. Apparatus adapted to be used in a well, which apparatus comprises, in combination, a tubing string arranged in a casing in said well, a tubular member retrievably suspended and sealed in the lower end of said tubing string, a packer spaced vertically below the lower end of said tubing string in said casing, said tubular member extending into the bore of said packer, a plug member slidably carried externally by said tubular member intermediate its ends, external first and second stop means on said tubular member spaced vertically from the ends of said plug member, first sealing means carried by said plug member for sealing with the exterior wall of said tubular member, second sealing means carried by said plug member for sealing with the bore of said packer, said plug member being provided with at least one normally closed passageway extending longitudinally through said plug member, and closure means in said passageway openable by imposition of fluid pressure thereon from above said packer when said plug member is in the bore of said packer.

9. Apparatus adapted to be used in a well, which apparatus comprises, in combination, a tubing string arranged in a casing in said well, a tubular member retrievably suspended and sealed in the lower end of said tubing string, a polish joint section in said tubular member, a packer spaced vertically below the lower end of said tubing string in said casing, said tubular member extending into the bore of said packer, a plug member slidably carried externally by said tubular member intermediate its ends on said polish joint section, external first and second stop means on said tubular member spaced vertically from the ends of said plug member, first sealing means carried by said plug member for sealing with the exterior wall of said tubular member, second sealing means carried by said plug member for sealing with the bore of said packer, said plug member being provided with at least one normally closed passageway extending longitudinally through said plug member, and closure means in said passageway openable by imposition of fluid pressure thereon from above said packer when said plug member is in the bore of said packer.

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