Sept. 18, 1962 P. B. HAMMAKER 3,054,456

COMBINATION LANDING NIPPLE-CIRCULATING MANDREL

Filed Jan. 25, 1960 2 Sheets-Sheet 1

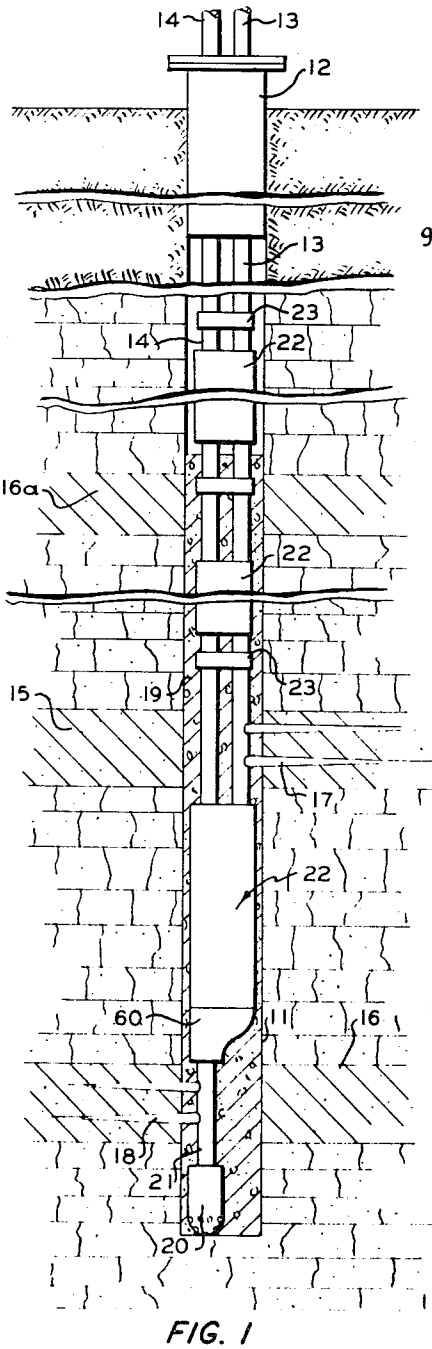


FIG. 1

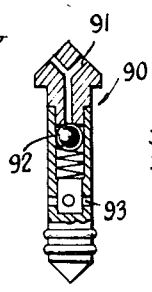


FIG. 7

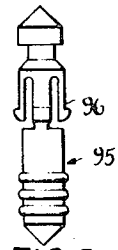


FIG. 8

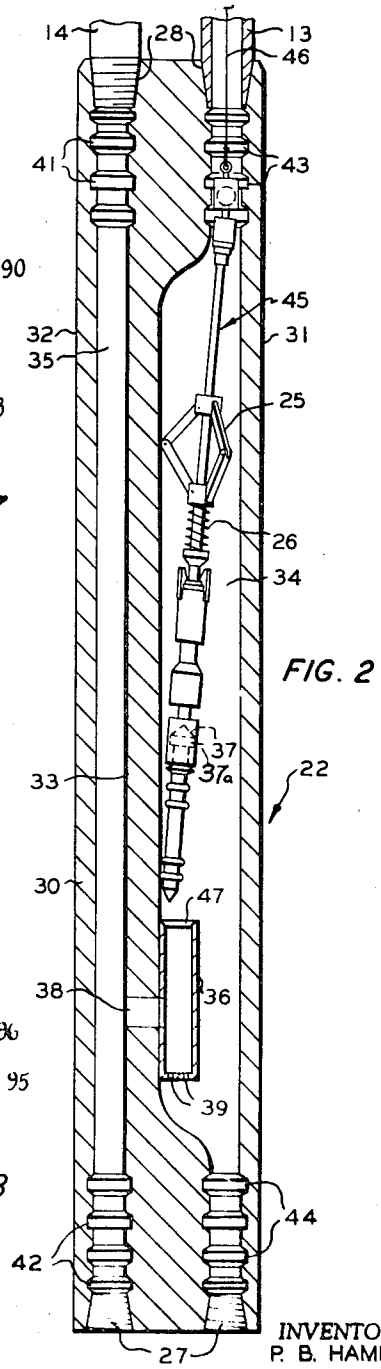


FIG. 2

INVENTOR.
P. B. HAMMAKER

BY Hudson & Young

ATTORNEYS

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COMBINATION LANDING NIPPLE-CIRCULATING MANDREL

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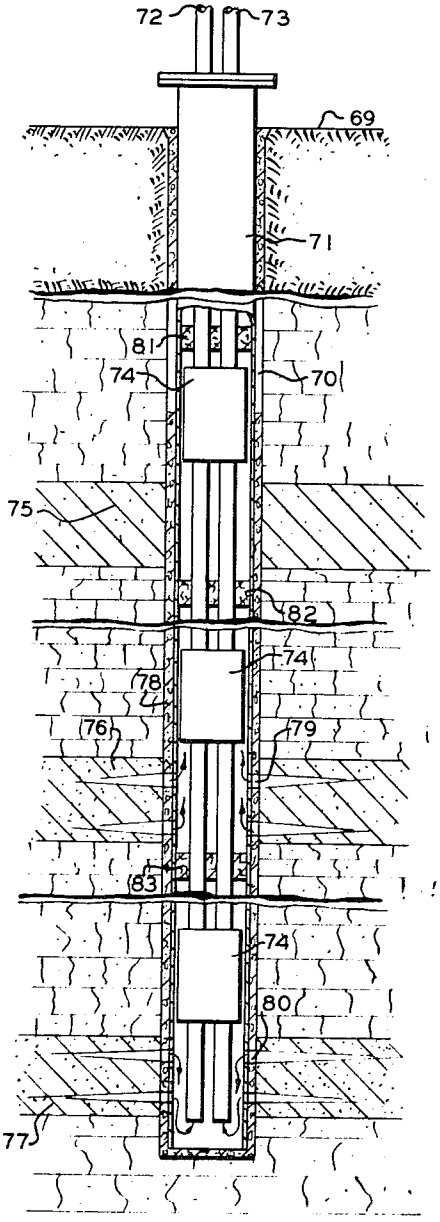


FIG. 5

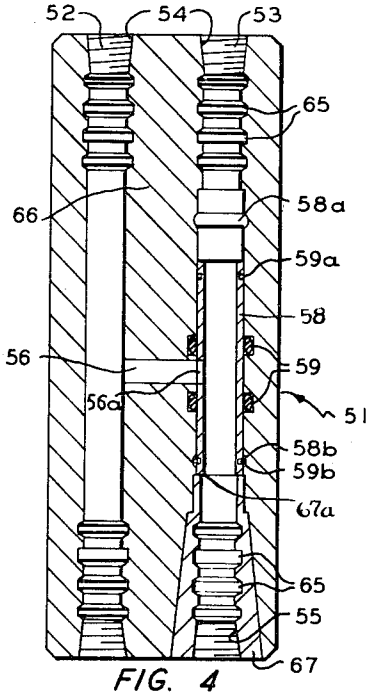


FIG. 4

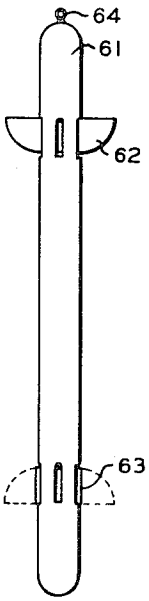


FIG. 6

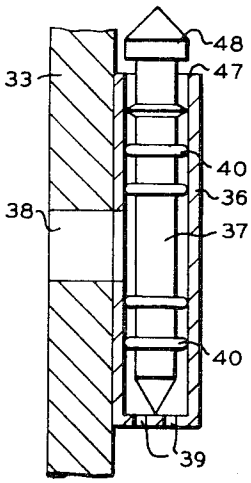


FIG. 3

INVENTOR.
P.B. HAMMAKER

BY Hudson & Young

ATTORNEYS

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3,054,456 COMBINATION LANDING NIPPLE-CIRCULATING MANDREL

Paul B. Hammaker, Wichita Falls, Tex., assignor to Phillips Petroleum Company, a corporation of Delaware

Filed Jan. 25, 1960, Ser. No. 4,536
3 Claims. (Cl. 166—224)

This invention relates to a landing nipple-circulating mandrel combination for use in multiple completed deep wells. In one aspect it relates to such an apparatus combination for use in multiple completion cased and in multiple completion uncased deep wells wherein wireline workover equipment and techniques in the several zones can be used.

It is well known in the oil production art that the drilling of deep wells and their completion for production are extremely expensive operations. Many cost saving methods and apparatus have been put to use. In areas in which there are two or more oil-containing horizons, some conditions permit the production of oil from two or more horizons through a single borehole. Such an operation is economical in that, for example, one borehole costs less than two boreholes. However, to complete wells for production from two horizons through a single borehole costs more than to complete a well for production from one horizon. However, a dual well completion costs less than two single well completions, at least in most cases.

Another item of high cost in the completion of oil wells is the casing. A rather recent development in the completion of deep wells is the omission of the conventional casing. In such a case, two or more strings of tubing are employed, one each for production of oil from each of the two or more oil producing strata when the well is to be a multiple completion well.

My invention deals with a combination landing nipple and circulating mandrel. This apparatus has particular utility in casingless dual production wells, but it can be used with advantage in cased dual production wells.

In casingless completions, as mentioned above, the well is not provided with the conventional thick wall casing. The several tubing strings are run with all the auxiliary equipment required; then the tubings are cemented in place from the bottom of the well to a level at least above the upper oil-bearing formation. After the cement has set, each tubing is perforated at the level of the formation desired to be produced and production is started.

In such casingless completions, the tubing strings employed should be of sufficiently large diameter to accommodate a pump in case it is ever necessary to produce by pumping.

The landing nipple-circulating mandrel of this invention can, however, be employed in completions in which casing is employed in a more or less conventional completion as well as in casingless completions.

When using the landing nipple-circulating mandrel of this invention in a casingless completion, cement is pumped down the well through both tubing strings, in the case of a dual completion well, thereby shortening the cementing time over that required when pumping cement through only a single tubing string. Furthermore, after the required volume of cement has been forced from the tubing strings into the annulus between the tubings and the walls of the well, the inner walls of the tubings can easily be washed free from adhering cement by circulation of a washing liquid down one tubing and up the other, with communication having been provided from one tubing to the other by the landing nipple-circulating mandrel of this invention.

An object of this invention is the provision of a landing nipple-circulating mandrel for use during wire line workovers. Another object is the provision in one piece of equipment of all the conventional landing nipples necessary to plug off one zone while working on another. Yet another object is the provision of such a piece of equipment suitable for hanging an extension tube for cementing operations, and for hanging a retrievable patching sleeve in the event of openings produced in the tubing by erosion. Still other objects and advantages of this invention will be realized by those skilled in the art upon reading the following description which, taken with the attached drawing, forms a part of this specification.

In the drawing, FIGURE 1 illustrates a landing nipple-circulating mandrel installed in a dual production casingless well. FIGURE 2 illustrates, in diagrammatic form, a longitudinal view, partly in section, of a landing nipple-circulating mandrel of this invention. FIGURE 3 illustrates a portion of the apparatus of FIGURE 2 on an enlarged scale. FIGURE 4 is a longitudinal view, in section, of an alternate embodiment of landing nipple-circulating mandrel. FIGURE 5 is an elevational view, partly in section, of a cased well, in which landing nipple-circulating mandrels of this invention are used. FIGURE 6 illustrates diagrammatically an apparatus for use with the embodiment of FIGURE 4. FIGURES 7 and 8 illustrate, respectively, a reverse opening check valve and a blanking plug.

In FIGURE 1 of the drawing, reference numeral 11 identifies an uncased or casingless well having positioned therein strings of production tubing 13 and 14. These tubings extend from a well head 12 to a level between oil-containing formations 15 and 16. At the lower ends of tubings 13 and 14 is attached a landing nipple-circulating mandrel 22 of this invention. Below mandrel 22 is positioned fitting 60, the lower outlet of which is directly in line with tubing string 14. Tubing joint or joints 21 extend below fitting 60 in line with tubing string 14. To the bottom end of tubing 21 is attached a guide shoe 20 containing a cementing back pressure valve. The particular type of guide shoe and back pressure valve employed is immaterial. The guide shoe and back pressure valve illustrated in FIGURE 7 of a copending application, Serial No. 4,537, filed January 25, 1960, is particularly suitable for use herein and is preferable to many which are available.

Cement 19 is provided to fill the space of the well bore not occupied by the tubings, mandrel, guide shoe and other pieces of equipment such as tubing clamps 23 and other landing nipples 22, up to and slightly above the upper oil bearing formation. Perforations 17 and 18 provide flow paths for flow of oil from the upper formation into tubing 13 and from the lower formation into tubing 14, respectively.

FIGURE 2 illustrates a preferred form of landing nipple-circulating mandrel of this invention. This apparatus comprises an elongated body member or housing 30 having a pair of conduits 34 and 35 extending throughout the length of the housing. These conduits define walls 31, 32 and 33, as shown. Wall 33 is common to both conduits. Conduit 34 is of larger diameter over most of its length than conduit 35. Grooves 41, 42, 43 and 44 are provided at the locations shown in FIGURE 2. Such grooves provide shoulders therebetween for suspending blanking plugs, hanging extension tubes for cementing operations and for hanging retrievable patching sleeves, all as well understood by those skilled in the well completion art. Conduits 34 and 35 are full opening conduits.

An opening 38 is provided in the lower portion of wall 33 to provide communication between conduits 34 and 35, when desired. Positioned within conduit 34

and against wall 33 at the level of opening 38 is a cage 36 having openings 39 in its bottom and an open top end 47. A plug 37 illustrated on an enlarged scale in FIGURE 3, provided with sealing O-rings 40 is positioned within the cage 36 at such time as it is desired to close opening 38 against fluid flow from conduit to conduit. Plug 37 is provided with a head 48 at its upper end as a means for attaching a plug insertion or removal tool. O-rings 40 are so positioned around the plug with respect to opening 38 that the plug does not move up or down as a result of hydrostatic pressure from conduit 35. Openings 39 provide for pressure equalization on the plug. A plug insertion and withdrawal tool 45 is illustrated in FIGURE 2. Such tools are well known in the well completion and workover art and a detailed explanation thereof is believed not necessary to the present invention. This plug insertion and withdrawal tool 45 is run into the well and withdrawn therefrom on a wire line 46.

For inserting plug 37 into cage 36 to block off or to close opening 38, the plug is inserted into the lower end of tool 45 and the assembly run on the wire line downward through tubing 13. As arms 25 enter the enlarged diameter section of conduit 34, the arms expand under the influence of spring 26, thereby moving the lower end of tool 45 with plug 37 toward wall 33. When plug 37 is properly inserted into cage 36, pin 37*a* is sheared thereby releasing tool 45 and the latter is withdrawn from the tubing by a wire line. The axis of plug 37 is parallel to the axis of conduit 34. The diameter of conduit 34 at its midsection is greater than the diameter of this conduit at its ends. The diameter of conduit 34 at its midsection less the diameter of cage 36 is approximately equal to the diameter of the well tubing string communicating with conduit 34.

The embodiment of landing nipple-circulating mandrel 51, illustrated in FIGURE 4, serves, in general, the same purpose as that shown in FIGURES 2 and 3. Conduits 52 and 53 are enclosed within walls containing grooves 65 similar to those of FIGURE 2. Threads 54 and 55 are for attaching to upper and lower tubings or to tubing nipples, as are threads 28 and 27 of FIGURE 2.

Wall 66 is provided with an opening 56 as shown. A sleeve 58 having an opening 56*a* is slidably positioned in conduit 53. The wall of conduit 53 is provided with grooves into which are positioned O-ring seals 59. When sleeve 58 is positioned in its lowermost location, opening 56*a* matches with opening 56 for providing communication between conduits 52 and 53. A sleeve 67 is threaded to the lower end wall of conduit 53 and previous to installation of this sleeve allows insertion of sleeve 58 as the apparatus is assembled. The upper end of this threaded sleeve 67 has a smaller inner diameter than the outer diameter of sleeve 58 thus forming a stop which ends the downward movement of the valve sleeve 58. A pair of snap rings 59*a* and 59*b* in respective grooves in sleeves 58 engages grooves 58*a* and 58*b*, respectively, in the wall of conduit 53, and holds sleeve 58 either up or down to close or to open respectively the communication port 56. The sleeve 58 is hydrostatically balanced but some type of retainer is necessary to offset undesired axial movement of the sleeve due to vibration, fluid friction, or other forces. Conduits 52 and 53 are full opening conduits. While FIGURE 4 shows that ports 56 and 56*a* register when sleeve 58 is in its downward position and out of registry when sleeve 58 is in its uppermost position, the construction can be reversed. The inner diameter of sleeve 58 is sufficiently large to pass the blanking plug for positioning the ends of collet locks 96 into one of the grooves 65.

FIGURE 6 illustrates a sleeve valve shifting tool 61 such as is suitable for raising and lowering the sleeve valve 58. When the upward facing dogs 62 are extended, as illustrated, the tool is in condition to hook the dogs 62 under the small diameter portion of the lower end of the sleeve 58 and raise the valve to close opening 56. The inner diameter of the valve sleeve 58 is smaller than the inner diameter of the upper end of sleeve 67 thereby forming a downwardly facing shoulder 67*a*. With dogs 62 retracted and dogs 63 extended the tool is in condition for lowering the sleeve and opening port or opening 56 for communication between conduits 52 and 53. Eye 64 is for attachment of a wire line, as wire line 46 of FIGURE 2.

In the operation of the embodiment of FIGURES 2 and 3, cement is pumped down both tubing strings 13 and 14, thereby shortening the pumping time over that required when pumping the cement down only the longest tubing string of the prior art, provided sufficient pump capacity is available. For a constant pumping rate there will be a lower friction loss than would be the case if cement were pumped down only one string of tubing. If additional pump capacity is available, the cementing time will be correspondingly reduced. After the required amount of cement has been pumped into the tubings, cementing plugs are inserted and drilling fluid, or water, or other suitable liquid, is pumped in thereby pressuring the plugs and cement downward until the plugs land. When a fitting like fitting 60 of FIGURE 1 is employed, the plug from tubing 13 seats at one of the lower grooves 44 below cage 36. The plug in tubing 14 continues on downward until it reaches the guide shoe and back pressure valve 20.

Upon release of pump pressure the back pressure valve seats and the cement thus is allowed to set and to harden in the space outside the tubing strings.

If desired, plug 37 can be inserted into cage 36 during the above ground assembly of the apparatus. After all the cement is pumped and the cementing plugs have reached their respective bottoms, tool 45 is run on a wire line and plug 37 is withdrawn. Port 38 is then open and all traces of cement can be washed from inside tubings 13 and 14 by circulation of a suitable liquid down one tubing string, through port 38 and up the other tubing string. The tubings are then in condition for perforation at the levels of the respective oil-containing formations to be produced. The single tubing below the landing nipple-mandrel 22 is not washed free of cement, other than by swabbing or other conventional means. Single conventional landing nipples 22 can, if desired, be run in with the tubing strings.

Plug 37 is set in place in cage 36 to prevent production fluid from one formation from mixing with that from another formation.

The embodiment of apparatus illustrated in FIGURE 4 serves the same function as does the plug 37 of FIGURES 2 and 3. Tool 61 of FIGURE 6 raises or lowers sleeve 58 as required to closer or to open port 56.

The herein disclosed landing nipple-circulating mandrel can be used in conventionally cased wells as well as in casingless wells.

The use of the landing nipple-circulating mandrel of FIGURES 2 and 4 eliminates the need for running and pulling of a side door choke and separation tools during cementing and/or well completion operations. The mandrel provides a relatively large opening (38, FIGURE 2, and 56, FIGURE 4) between tubing strings in contrast to the very small conventional side door choke opening. During workover operations a smaller number of wire line trips are required than conventionally required.

As will be understood by those skilled in the art, conventional dual or multiple well completions make use of side door chokes and separation tools to prevent intermixing of the production fluids from several producing zones. These tools are installed inside the tubing string and create severe restrictions to fluid flow. By use of this invention these tools are no longer necessary and there is no flow restriction during normal well production. The absence of side door chokes and sepa-

ration tools makes possible the running of other wireline tools for well remedial or workover operations without the necessity of first removing the side door chokes or separation tools.

During certain well remedial or completion operations, it may be desirable or necessary to introduce one fluid into one of the tubing strings and later replace it with a second fluid. This can be done easily with my combination landing nipple-circulating mandrel. For example, it may be desirable to squeeze cement through tubing string **14** and perforation **18** into the lower oil producing zone. To do this a reverse opening check valve **90** (FIGURE 7) is placed in cage **36** (FIGURE 2) so that no fluid can pass from tubing **14** to tubing **13**. Cement is then pumped down tubing **14** and through perforation **18** into the lower oil producing zone. Water or drilling mud is used to displace the cement. After a suitable quantity of cement has been forced through perforation **18**, some of the cement as well as a quantity of water or mud will remain in tubing **14**. At this time water or oil can be circulated down tubing **13** through the reverse opening check valve and into tubing **14** to rise upwardly to the surface and displace all of the remaining cement and the mud. Tubing **14** is then clean of all foreign material and additional well operations can be conducted inside the tubing. For example, tubing **14** may be perforated opposite productive formation **16***a* for continued oil production from a different zone.

The reverse opening check valve **90**, as illustrated in FIGURE 7, is a ball check valve which allows passage only of displacing fluid through openings **91**, around valve ball **92** and out of the valve by way of openings **93**. From these openings, the displacing liquid flows through port **37** into conduit **14**.

Many other well operations are greatly facilitated through the use of this invention. Formation fracturing operations sometimes deposit sand or other propping agents in the well casing or tubing. This undesired sand may be readily circulated out. Similarly, acidizing of a formation may be facilitated.

It is to be mentioned that any number of my combination landing nipple-circulating mandrel assemblies can be used in a given well. For example, it usually will be convenient to place one between each pair of producing zones as well as another above the highest potential producing zone. Moreover, it will be readily apparent that 3 or more strings of tubing can be connected together with only minor modification to the device illustrated in the drawings.

FIGURE 5 illustrates a completed cased well which penetrated three oil bearing formations, and the production tubings were provided with combination landing nipple-circulating mandrels of this invention. In this figure a well bore **70** extends downward from ground level **69** through oil bearing formations **75**, **76** and **77**. Casing **71** is run as usual. Tubings **72** and **73** provided with properly spaced packers **81**, **82** and **83** and with properly spaced combination landing nipple-circulating mandrel assemblies **74** are run into the casing. Cementing can be carried out using both tubings or just tubing **73** in which is positioned the side of the mandrels containing the cage **36** for plug **37** (as in FIGURES 2 and 3). Following cementing the plug in the lower mandrel is removed and the tubings washed with mud or with water as desired.

Following this washing operation the plug **37** is inserted into its cage in the lower mandrel to close the circulating port **38**. The axis of said plug **37** is parallel to the axis of the conduit **34**. A blanking plug **95** (FIGURE 8) is run in tubing **72**, if not previously run, and set in the lower mandrel **74**. In this manner fluid from formation **77** flows into the lower end of tubing string **73** but cannot enter tubing **72**. This tubing **72** and the casing are directionally perforated adjacent formation **76** so as not to perforate tubing **73**. After this perforation operation is completed, formations **76** and **77** are produced separately through tubings **72** and **73**, respectively. If, for example, production from formation **76** or **77** ever decreases to a volume which is uneconomical, this formation can be plugged off, and the upper formation **75** produced through one of the tubing strings.

For completing a cased well using the combination mandrel, standard packers, tubing with mandrels, etc., are run in a conventional manner. The mandrel would be provided with a dummy valve in the sidepocket to blank off the circulating port. The proposed completion zone between packers is perforated with an oriented tubing gun. The lower production zone is perforated below the lower packer with a conventional tubing gun, and the dual well is ready for production.

To recomplete a well through the tubing string attached to the plug side of the mandrel, a plug is landed in the other side of the mandrel below the circulating port. The dummy valve which was positioned originally in the sidepocket is replaced with a circulating sleeve or a reverse opening check valve, which ever is desired. An extension tube is hung from a level above the pocket in the pocket side of the mandrel and extends downward through a packer to a level adjacent an oil bearing formation to be cemented. Cement is then pumped through the tubing containing the extension tube, through the extension tube and squeezed into a lower formation. The cement within the tubing and casing is removed by pumping drilling fluid, water or other suitable liquid down the tubing opposite the pocket side.

The circulating sleeve and the extension tube are withdrawn and the dummy valve replaced. The lower zone is then perforated by running a gun through the pocket side. The plug previously landed is withdrawn and production restored from both zones.

To recomplete through the opposite tubing string, the procedure is the same utilizing the opposite landing nipples.

The combination mandrel is equally applicable in the manner described to open hole multiple completions.

While certain embodiments of the invention have been described for illustrative purposes, the invention obviously is not limited thereto.

I claim:

1. A combination landing nipple-circulating mandrel for a multizone permanent type well completion, comprising, in combination:

a unitary body member;

a first conduit in said body extending vertically therein;

threaded means in said body above and below said first conduit for attaching a first pair of well tubings above and below said first conduit in axial alignment with each other; said first conduit providing an unobstructed straight through, full bore passage connecting said first pair of well tubings;

a second conduit in said body extending vertically therein, separated from said first conduit by a single wall;

threaded means in said body above and below said second conduit for attaching a second pair of well tubings above and below said second conduit in axial alignment with each other, said second conduit providing an unobstructed, straight through, full bore passage connecting said second pair of well tubings;

a port through said wall providing communication between said first and second conduits;

an enlargement in said second conduit, encompassing the vicinity of said port;

valve means in said enlargement for controlling said port, said valve means being outside a vertical projection of the open bore of said second pair of well tubings;

first tool supporting means in said first conduit above said port;

second tool supporting means in said first conduit below said port;

third tool supporting means in said second conduit above said port; and

fourth tool supporting means in said second conduit below said port.

2. A combination landing nipple-circulating mandrel for a multizone permanent type well completion, comprising, in combination:

a unitary body member;

a first conduit in said body extending vertically therein;

threaded means in said body above and below said first conduit for attaching a first pair of well tubings above and below said first conduit in axial alignment with each other, said first conduit providing an unobstructed straight through, full bore passage connecting said first pair of well tubings;

a second conduit in said body extending vertically therein, separated from said first conduit by a single wall;

threaded means in said body above and below said second conduit for attaching a second pair of well tubings above and below said second conduit in axial alignment with each other, said second conduit providing an unobstructed, straight through, full bore passage connecting said second pair of well tubings;

a port through said wall providing communication between said first and second conduits;

an enlargement in said second conduit, encompassing the vicinity of said port;

a cage fixed to the wall of said second conduit adjacent said port outside a vertical projection of the open bore of said second pair of well tubings;

a removable plug in said cage closing said valve passage, thereby preventing communication between said first conduit and said second conduit through said port;

a first plurality of grooves in the wall of said first conduit above said port, providing first tool supporting means;

a second plurality of grooves in the wall of said first conduit below said port, providing second tool supporting means;

a third plurality of grooves in the wall of said second conduit above said port, providing third tool supporting means; and

a fourth plurality of grooves in the wall of said second conduit below said port providing fourth tool supporting means.

3. A combination landing nipple-circulating mandrel for a multizone permanent type well completion, comprising, in combination:

a unitary body member;

a first conduit in said body extending vertically therein;

threaded means in said body above and below said first conduit for attaching a first pair of well tubings above and below said first conduit in axial alignment with each other, said first conduit providing an unobstructed straight through, full bore passage connecting said first pair of well tubings;

a second conduit in said body extending vertically therein, separated from said first conduit by a single wall;

threaded means in said body above and below said second conduit for attaching a second pair of well tubings above and below said second conduit in axial alignment with each other, said second conduit providing an unobstructed, straight through, full bore passage connecting said second pair of well tubings;

a first port through said wall providing communication between said first and second conduits;

a cylindrical enlargement in said second conduit, encompassing the vicinity of said first port;

a sleeve slidably fitting the wall of said enlargement, said sleeve being wholly outside a vertical projection of the open bore of said second pair of well tubings;

stop means above and below said sleeve to limit upward and downward movement thereof;

a second port in said sleeve, said second port permitting connection between said first conduit and said second conduit through said first port when said sleeve is fixed against one of said stops, said sleeve preventing communication between said first conduit and said second conduit when said sleeve is fixed against the other of said stops;

a first plurality of grooves in the wall of said first conduit above said first port, providing first tool supporting means;

a second plurality of grooves in the wall of said first conduit below said first port, providing second tool supporting means;

a third plurality of grooves in the wall of said second conduit above said first port, providing third tool supporting means; and

a fourth plurality of grooves in the wall of said second conduit below said first port providing fourth tool supporting means.

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