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METHOD AND APPARATUS FOR COMPLETING WELLS

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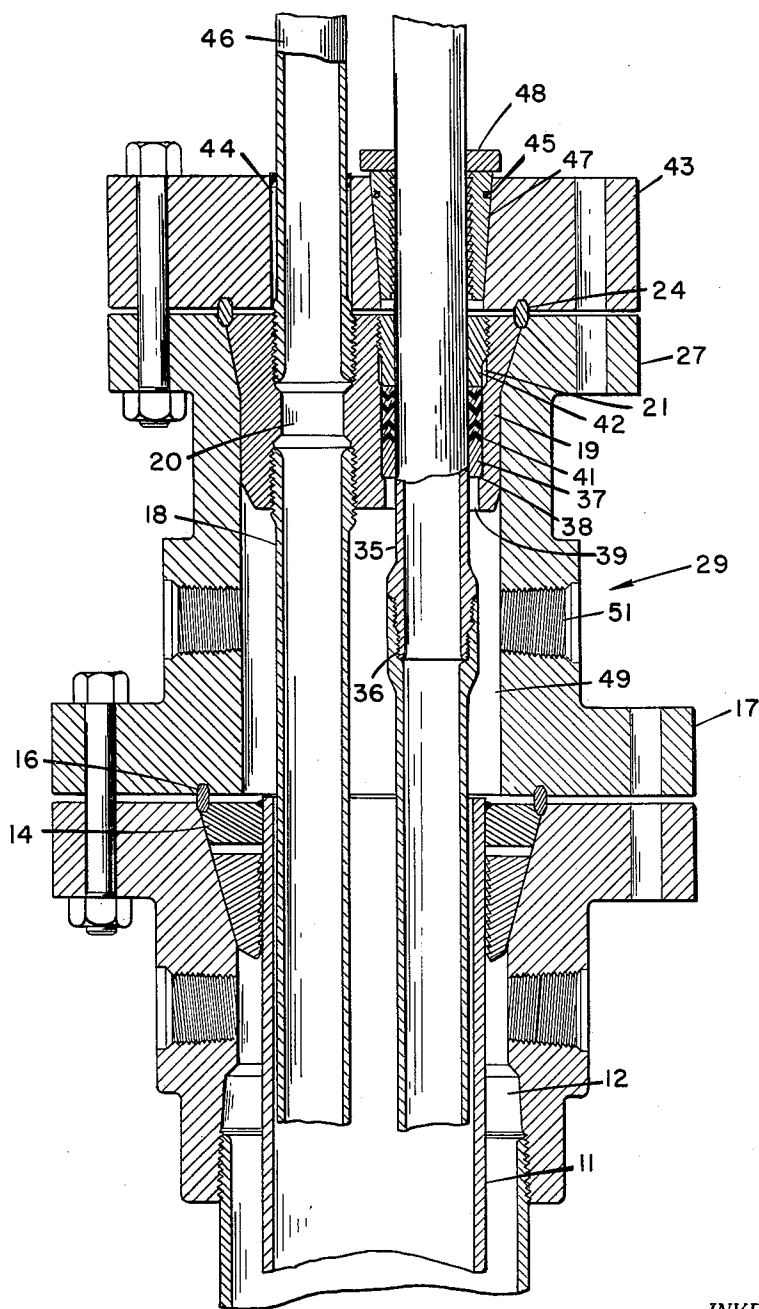


FIG. 2

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METHOD AND APPARATUS FOR COMPLETING
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This invention relates to an improved method and apparatus for completing wells. More particularly, this invention relates to a method and apparatus for running parallel multiple tubing strings into a high pressure oil or gas well.

Wells which produce separately from more than one formation, the typical dually completed wells, have been successfully produced by using a single tubing string and alternately producing the different zones through that tubing string or by producing one zone through the tubing and the other zone through the annular space between the tubing and the outer conduit such as the well casing. In a few instances, particularly where production through the large annular space would be highly inefficient, dual tubing strings have been installed in a well. In low pressure or "dead" wells, these tubing strings can be run separately but generally they have been tied together and run simultaneously. Where a multiple-zone well is under pressure or flowing, it has generally been necessary to kill the well before installing two or more tubing strings to complete the well. The installation of two or more tubing strings in parallel in a high pressure well without first killing the well has been considered impractical since it has been inconvenient, if not impossible, with the available apparatus to either run both strings simultaneously or run the two tubing strings separately, i.e., in series. The obvious difficulty is that a blowout preventer for simultaneously sealing around two or more tubing strings as they are run into a well has not been, and probably will not be, developed. In the case where two or more tubing strings are run into a well separately and side by side, i.e., parallel as distinguished from concentric, the first tubing string can be satisfactorily run through a blowout preventer, but, after that first tubing string is landed in position, it has been impossible with the apparatus available to run a second or third tubing string through the blowout preventer or otherwise maintain the well under pressure control except by injecting a heavy liquid such as mud into the well to kill the well. To kill a well which has been producing or otherwise cleaned out is generally considered undesirable for obvious reasons.

It is, therefore, an object of this invention to provide an improved method and apparatus for completing multiple-zone wells. It is a more specific object of this invention to provide an improved apparatus by which a multiple-zone well can be completed while maintaining the well under pressure control. Still another object of this invention is to provide an improved method for running multiple tubing strings separately or in series into a well while maintaining the well under pressure control without first killing the well. These and other objects of this invention will become apparent from the following description in which reference will be made to the accompanying drawings. In these drawings:

FIGURE 1 is a cross-sectional view of an improved wellhead showing a method and means for suspending a first string of tubing in a well and for running a second tubing string into the same well while that well is maintained under pressure control, and

FIGURE 2 is a cross-sectional view of the wellhead showing the two tubing strings after being landed.

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From the foregoing, it can be seen that this invention is directed to a method and apparatus for running multiple tubing strings into a well while the well is maintained under pressure control, the method comprising more particularly the steps of running a first tubing string, suspending it from the wellhead, and then running a second tubing string through an eccentrically located blowout preventer whereby the upper end of the annular space within the casing surrounding the two tubing strings may be sealed at any time during running of the tubing and completion of the well.

Referring now more particularly to FIGURE 1, a well is equipped with a surface casing 10 and an oil string or production casing 11. The upper end of the annular space 12 between these two casing strings is sealed with the typical casing head 13 in which the welding ring 14 is welded to the upper end of the production casing after that casing has been suspended in the wellhead on slips 15. This together with the seal ring 16 seals the upper end of the annular space 12 as the tubing head body 17 is connected to the casing head 13. After the tubing head body has been installed, the first tubing string 18 is run into the production casing to any desired depth. If desirable to maintain the well under pressure control, this tubing string may be run through a blowout preventer in the customary manner. Alternatively, it may be run into the well while the well is dead, i.e., before the casing is perforated and/or before the drilling fluid has been removed from the well. It is used then to displace drilling fluid from the well in a manner well known to those skilled in this art. In the typical multiple-zone well where the lower-zone production is isolated from the upper-zone production, this first tubing string usually includes a casing packer (not shown) which is set in the casing above the lower zone and below the upper zone. The first tubing string thus typically extends into the well to an isolated zone at the depth of the lower producing formation. After the casing packer is set, a hanger mandrel 19, having longitudinal openings 20 and 21 therein, is connected to the upper end of the first tubing string 18. That is, the upper end of the tubing string is screwed into the lower end of threaded opening 20. The first tubing string is then landed by lowering the hanger mandrel 19 into the tapered seat 22 of the tubing head body 17. Flow through the first tubing string may be prevented by a wire line set blanking plug or tubing closing tool 23 temporarily anchored in the tubing string or by an ordinary pipe plug which is screwed into the upper end of threaded opening 20.

Hanger mandrel 19 is then sealed in tubing head body 17 by seal ring 24 which is held in position by the lower flange 25 of offset adapter 26. The lower flange of the offset adapter has substantially the same diameter as the upper flange 27 of the tubing head body. Both desirably have standard API dimensions for the same pipe size. For example, if production casing 11 is 7" then the upper flange 27 typically has standard 8" pipe dimensions. Since lower flange 25 of the offset adapter mates with the upper flange 27, it also has standard 8" pipe dimensions. The offset adapter 26 has an eccentric opening 28 which is arranged to be coaxial with opening 21 in hanger mandrel 19 when the offset adapter is connected to the tubing head 29. In the above-mentioned typical installation, using 7" production casing and two 2" tubing strings, the center line of eccentric opening 28 may be, for example, about $1\frac{15}{16}$ " displaced from the center line of lower flange 25 on the offset adapter. This adapter has an upper flange 30 which is concentric with eccentric opening 28. This upper flange is also preferably a standard pipe size and may be smaller than the lower flange 25. For example, if the lower flange is a standard 8"

pipe size as discussed above, the upper flange may be a standard 6" pipe size. A blowout preventer 31 or in some cases two blowout preventers in series are connected to upper flange 30 of the offset adapter. The two flanges are sealed together with a sealing ring 32.

It is generally desirable to employ standard items of equipment where possible, as indicated in connection with the description of FIGURE 1. For example, the blowout preventer 31 and the tubing head are typically standard pieces of equipment and the only special items of equipment required for making this wellhead are the offset adapter and the hanger mandrel. The offset adapter may obviously be made as an integral part of the blowout preventer where desired. That is, the lower flange 33 on the blowout preventer may, in some cases, be enlarged and made eccentric so that the opening 34 in the blowout preventer will be coaxial or aligned with opening 21 and the lower flange will mate with upper flange 27 on the tubing head.

After the first tubing string is landed and the special wellhead connections, including the offset adapter and blowout preventer, are connected to the tubing head, as described above, the second tubing string 35 is run into the well through the aligned openings 21, 23 and 34. Either the first tubing string or this second tubing string preferably has couplings or other connections 36 which are tapered on the ends to prevent interference between the two tubing strings when the second tubing string is being run into or pulled from a well. Tubing of the integral box and pin type, such as Hydril Type "CS" tubing, has been found quite satisfactory as one tubing string. It will be apparent to those skilled in the art that with the wellhead apparatus as described, this second tubing string may be run into the well with the well under pressure. If not under pressure, the well will in any case be under pressure control, i.e., be capable of being shut-in at will. The inside of the tubing may be temporarily plugged and the annular space around the outside of the tubing may be sealed by the blowout preventer 31 so that the well is under control or can be brought under control at all times.

After the second string of tubing has been lowered to the desired depth, the opening 21 surrounding the tubing is preferably first sealed by installing a packing, the special well completion connections above the tubing head are then removed and producing fittings are installed, as indicated in FIGURE 2. To land the second string of tubing, a metal ring 37, which may be split, is dropped into the annular space surrounding tubing string 35 and lands on shoulder 38. This bridges the small diameter opening 39 between the hanger mandrel 19 and the second tubing string 35. This opening is otherwise large enough to pass the tubing connections 36. Packing 41 and packing gland 42 are then lowered into the opening 21 surrounding second tubing string 35 and the packing is compressed to seal the opening. In some cases, the offset adapter 26 and the blowout preventer 31 may be removed prior to installing this packing, especially when the well is dead or otherwise not producing a great deal of fluid. This, of course, leaves the well without any means of pressure control for a short time while the upper fittings are being disconnected and removed. Otherwise, however, when it is necessary to maintain the well under complete pressure control, the packing is placed around the second tubing string, as indicated above, while the upper fittings are in place. After placing the packing around the second tubing string, it may be suspended as by slips or the like from the hanger mandrel. Such a construction is particularly desirable when more than two tubing strings are to be run.

Alternatively, after the blowout preventer and offset adapter have been stripped off of the second tubing string, an upper flange or bonnet 43 mating upper flange 27 on the tubing head and having opening 44 and conical opening 45 which register with openings 20 and 21 respec-

tively, is lowered over the upper end of second tubing string 35. The space between the bonnet and upper flange 27 is sealed with the above-mentioned sealing ring 24. A surface connection 46 may then be threaded into the upper end of opening 20. In the preferred embodiment which is illustrated, the second tubing string is suspended from the bonnet. To accomplish this, after the bonnet is placed, the second tubing string 35 is supported in the well with the bottom at the desired elevation, and slips 47 are dropped into the conical opening 45. As the second tubing string 35 is then lowered, its weight is placed on the slips and on bonnet 43. These slips may be held in position with a slip hold ring 48 which is fastened as by studs (not shown) to the bonnet 43. Surface connections may then be placed on the second tubing string as desired. Where temporary internal blanking plugs or tubing closing tools have been placed in either or both of the tubing strings, they may also now be removed, leaving both tubing strings open and ready for production. The annulus 49 between the producing casing 11 and the two tubing strings is sealed at the top by the hanger mandrel 19, packing 41 and seal ring 24 and at the bottom by the casing packer on the first tubing string 18. Access to this space is through side opening 51 in tubing head 17 for the injection of gas or the like in case it is desired to gas lift either of the zones produced through the respective tubing strings.

From the foregoing it can be seen that the apparatus and process described can be varied to accomplish the same result without departing from the spirit of the invention. This invention should, therefore, be construed to be limited not by the specification which has been given for the purpose of describing a preferred embodiment of the invention, but should be construed to be limited only by the scope of the appended claims.

I claim:

1. A method of maintaining a well equipped with a casing and a tubing head under pressure control while parallel tubing strings are being run, comprising running a first tubing string into said well through a blowout preventer connected to said tubing head, landing said first tubing string in said well by connecting said first tubing string to a first opening of a dual-opening hanger mandrel in said tubing head, temporarily plugging said first tubing, removing said blowout preventer from said tubing head, subsequently mounting a blowout preventer eccentrically on said tubing head so that the opening is aligned with a second opening in said hanger mandrel, running a second tubing string into said well through said blowout preventer and said second opening, sealing said second tubing string in said second opening, removing said blowout preventer from said tubing head, placing a bonnet on said tubing head, said bonnet having dual openings spaced to match said first and second openings in said hanger mandrel, and suspending said second tubing string on said bonnet.

2. In a wellhead apparatus for completing a well having a casing and parallel tubing string, the combination comprising a tubing head, a multiple-opening hanger mandrel in said tubing head, a peripheral seal between said hanger mandrel and said tubing head, means to anchor the upper end of a first tubing string in a first opening in said hanger mandrel, a blowout preventer mounted eccentric to and forming a seal with said tubing head with the opening in said blowout preventer aligned with a second off-center opening in said hanger mandrel, said second opening having a greater diameter than the maximum diameter of the second tubing string therein so that said last-named tubing string can be run into said well through said second opening, and means to seal the annular space in said second opening surrounding said second tubing string while said blowout preventer is still mounted on said tubing head whereby said well may be completed under pressure control.

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3. A wellhead apparatus for running parallel tubing strings into a well having a casing therein, including a tubing head for anchoring said tubing strings in said casing and for sealing the upper end of the annular space between said casing and said tubing strings, a hanger mandrel in said tubing head, a peripheral seal between said hanger mandrel and said tubing head, multiple longitudinal openings in said hanger mandrel, and means to anchor the upper end of a first tubing string in a first opening in said hanger mandrel, the improvement comprising means including a blowout preventer eccentrically mounted on and forming a seal with said tubing head coaxial with a second opening in said hanger mandrel for running a second tubing string into said well through said second opening whereby said well may be completed under pressure control.

4. In a wellhead apparatus for running parallel tubing strings into a well having a casing therein, a tubing head for anchoring said tubing strings in said casing and for sealing the upper end of the annular space between said casing and said tubing strings, a hanger mandrel in said tubing head, a peripheral seal between said hanger mandrel and said tubing head, multiple longitudinal openings in said hanger mandrel, and means to anchor the upper end of a first tubing string in a first opening in said hanger mandrel, the improvement comprising a blowout preventer and means to mount said blowout preventer eccentrically on and forming a seal with said tubing head coaxial with a second opening in said hanger mandrel for running a second tubing string into said well through said second opening whereby said well may be completed under pressure control.

5. A wellhead apparatus for a well having a casing with multiple parallel tubing strings therein and a tubing head on the upper end of said casing comprising a hanger mandrel within said tubing head, multiple longitudinal off-center openings in said hanger mandrel, a fluid seal

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between said tubing mandrel and said tubing head, means to suspend a first tubing string from and to form a fluid seal with a first of said openings in said hanger mandrel, a second of said tubing strings extending through a second of said openings, means forming a fluid seal in said second of said openings surrounding said second tubing string, a bonnet on said tubing head, said bonnet having multiple longitudinal openings spaced to match said openings in said hanger mandrel, and means to suspend said second tubing string from one of said openings in said bonnet which is substantially coaxial with said second of said openings in said hanger mandrel, whereby said well may be completed under pressure control.

6. Well completion apparatus comprising a device having a pair of vertical passages therethrough, a connection flange at the lower end of the device, a well member therebelow having an opening through which a pair of tubings pass and having an upper flange connected to said lower flange of said device, means connecting one of said tubings to one of said passages, said device having a flange on the upper end thereof, an adapter spool having a flange at the lower end thereof, means to connect said upper flange on said device to said lower flange on said spool in fluid tight relationship, said lower flange on said spool closing the upper end of said one of said passages, said spool having a single eccentric vertical opening therethrough aligned with the other of said passages, said spool having a flange at the upper end thereof, a blowout preventer having a flange at its lower end mounted on the upper flange of said spool, and means connecting the last said flanges in fluid tight relationship.

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