

May 6, 1941.

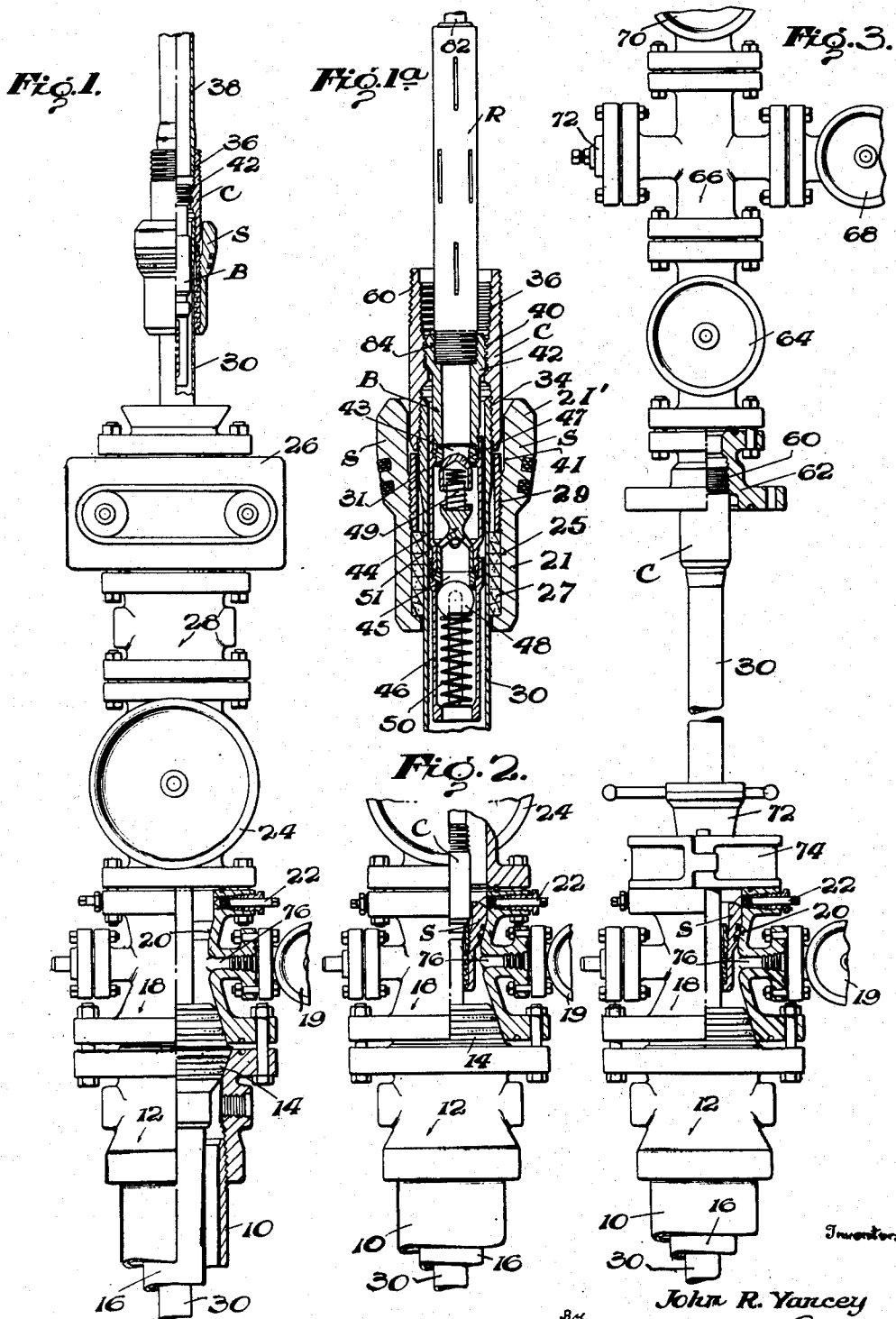
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2,241,288

APPARATUS FOR COMPLETING WELLS

Filed Jan. 26, 1940

2 Sheets-Sheet 1



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Fig. 4.

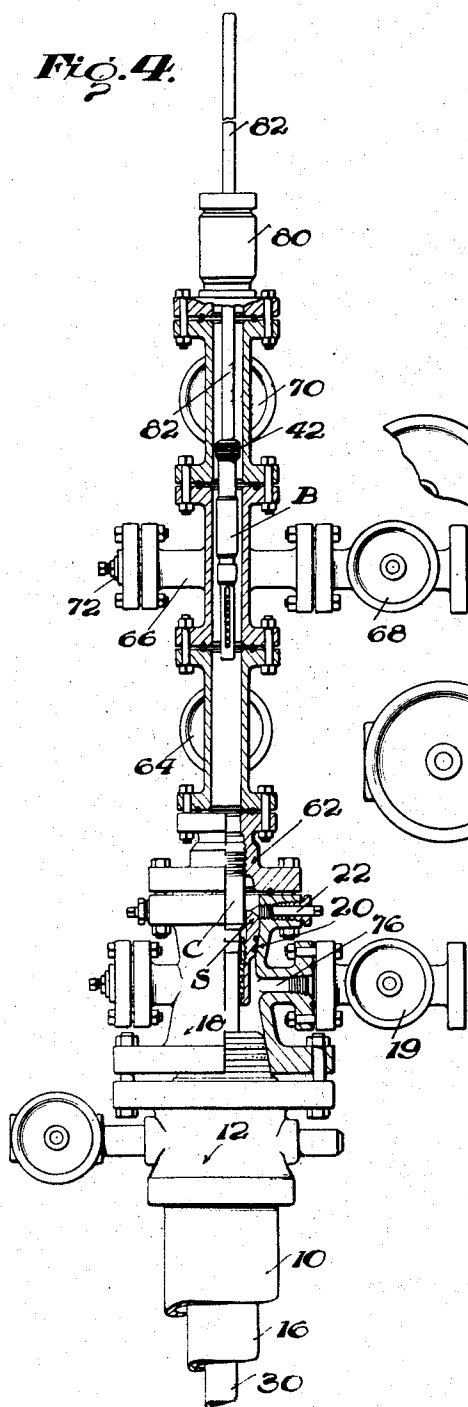


Fig. 5.

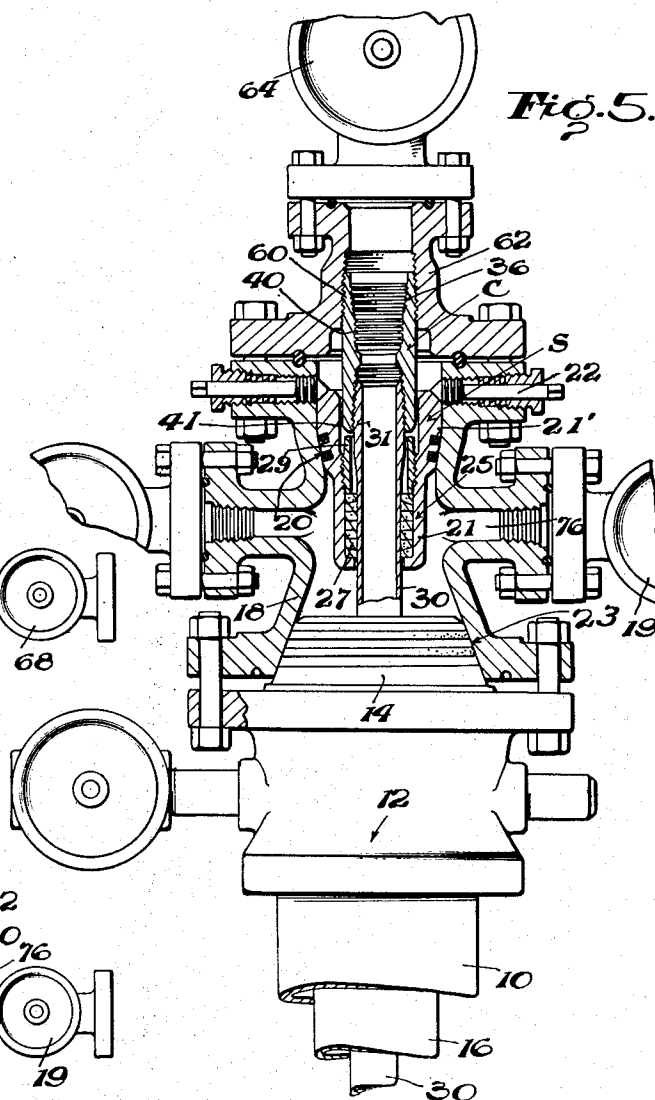
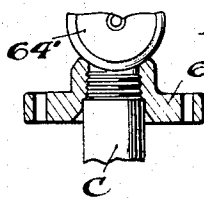


Fig. 6.



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APPARATUS FOR COMPLETING WELLS

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The present invention relates to apparatus for completing oil wells, particularly in formations having high pressure where it is desirable from the standpoint of safety to maintain complete mechanical control both within and around the tubing while making changes of equipment during the completion operations.

The invention is concerned with the insertion of tubing into the well at the time of completion, after the drilling and allied operations have been performed, and the drill has been removed.

One of the objects of the invention is to provide completion equipment including a Christmas tree mounted on the casing head, which Christmas tree supports the flow tubing by means of a special tubing collar depending from the Christmas tree into the casing head and attached to the tubing, which collar is provided with a back pressure valve removable as a unit therefrom, said valve controlling the inside of the tubing at completion.

Ancillary to the above objective, it is a purpose of the invention to provide such apparatus with a stuffing box bushing, similar to a hanger, which is positioned around the tubing and passed through the control equipment as the tubing is being inserted into the well, which bushing forms a seal between the tubing and casing when seated in the casing head, whereby the control equipment may be removed at completion before the tubing is suspended in its final position from the Christmas tree.

More particularly, it is an object of the invention to provide control at completion around the tubing with a stuffing box bushing in the casing head, and through the tubing by a removable back pressure valve in a special collar attached to the Christmas tree. This control is provided while the well is being washed, before the tubing is finally suspended, and during subsequent setting of the packers and final suspending of the tubing when the Christmas tree is landed on the casing head. Preferably thereafter, the back pressure valve may be removed, and the well flowed from the tubing through the Christmas tree, although said valve may be removed at any time after the Christmas tree is attached to the tubing.

Another object of the invention is to provide apparatus permitting convenient performance of operations subsequent to completion, while maintaining control of the well, such as releasing the packers and circulating mud into the well.

In the drawings, which are illustrative of one embodiment of the invention, and a sequence of

operations which may be followed in using the apparatus of the invention:

Figure 1 is a side elevational view of the well superstructure, partly in section, showing the condition of the apparatus as the tubing is being run.

Figure 1a is an enlarged vertical sectional view of the special collar and stuffing box bushing, showing the removable back pressure valve in said collar, the parts being shown as arranged on the tubing in Figure 1, above the control equipment, preliminary to landing the stuffing box bushing. This view also shows a modification wherein a strainer is associated with the valve housing.

Figure 2 is a side elevational view partly in section of a portion of the apparatus of Figure 1, showing a subsequent step wherein the stuffing box bushing is landed in the casing head to form a seal around the tubing below the control equipment.

Figure 3 is a similar view of a subsequent stage of completion, showing the control equipment removed and the Christmas tree attached to the tubing, preliminary to washing the well and landing the Christmas tree.

Figure 4 is a similar view of a subsequent stage of operations, wherein the Christmas tree has been landed on a casing head, and the back pressure valve is being removed from the tubing.

Figure 5 is an enlarged vertical sectional view of the casing head, stuffing box bushing, special collar, and a portion of the Christmas tree, showing the relation of parts when the well has been completed and the back pressure valve removed.

Figure 6 is a partial vertical sectional view of a modification of a portion of the apparatus, wherein the tubing is directly connected with a special Christmas tree flow control valve.

In Figure 1, a now conventional well casing head structure is shown with control equipment mounted above the same for inserting the tubing into the well.

This casing head structure is generally similar to that shown in Patent No. 2,148,327, Smith et al., February 21, 1939, and Patent No. 2,162,179, Mueller, June 13, 1939.

It will be understood that when the practice of this invention begins, the drilling and allied operations described in the said Smith et al. patent are completed, and the drill has been removed in preparation for the inserting of the tubing. However, the apparatus herein described is such that all of the advantages of the structure of the said Smith et al. patent may be had, during the drilling and allied operations.

In Figure 1, an outside casing is shown at 10,

and attached to the upper end thereof is a conventional casing head 12 having a bore with appropriate side outlets and a tapered inside seat to receive a hanger 14. This hanger is of a type having double sealing surfaces as described in the above mentioned patents. The hanger 14 supports an inner casing 16, which extends down into the well to a point adjacent the producing sands. The casings 10 and 16 are cemented, and drilled through, as described in the above mentioned patents. Mounted above the casing head 12 is a tubing head 18 which forms a seal with the hanger 14, and is provided with the usual side outlets. One of these side outlets may be closed by a bull plug, and the other may be controlled by a valve 19 for use during washing operations, or to relieve pressure from the well, as is well-known in the art.

The tubing head 18 has a bore therethrough including an inside tapered seat 20, above the side outlets, which seat receives the stuffing box bushing as will be later described. Tubing head 18 is also provided with the now conventional pressure-proof locking screws 22, which are adapted to hold down a tubing hanger, or the stuffing box bushing of the present invention, as hereinafter described. The bottom end of the tubing head is hollowed out or tapered as at 23 (Figure 5), to receive and seal with the frusto-conical upper end of the hanger 14.

Mounted on and above the tubing head 18 is a master drilling valve 24. This valve is of any well-known type, and has a bore therethrough at least as large as that of the casing 16 so that operations requiring the full width of said casing 16 may be performed therethrough as described in the patents mentioned above.

Secured to and above the master drilling valve 24 is any well-known form of blowout preventer 26. This blowout preventer may be directly connected with the master drilling valve 24, or there may be a mud cross 28 between the valve and the preventer. The mud cross is simply a hollow fitting of full bore having suitable side outlets controlled if desired by valves, for the discharge of mud fluid during the drilling of the well or during any operations wherein it is desired to relieve fluid or pressure from within the casing 16 of the well while the control equipment is mounted thereon. The blowout preventer has the usual retractible semi-cylindrical shoes, either manually or power operated, to engage and seal with a pipe passing therethrough.

Instead of a single blowout preventer 26, there may be a pair of these devices, one mounted above another, both of full bore as previously described, and these blowout preventers may be alternately operated in passing collars, bushings, and the like during any of the conventional operations in the well involving running pipe into and from the same while maintaining complete mechanical control. The bore of all of the control equipment above the tubing head 18 is large enough to pass the stuffing box hanger to its seat 20, as will be later described.

When the operations illustrated in Figure 1 are commenced, drilling will have been completed, and the drill removed, the well then being sealed by the closed master drilling valve 24. Thereafter, tubing 30 is inserted into the well through the blowout preventer 26 and the same is closed around the tubing forming a seal. At this time, the well may be filled with heavy mud. When the master drilling valve 24 is opened, the tubing is run into the well, attaching one section thereof

above another in the usual way until the tubing has been lowered to a point adjacent the bottom of the well. When the upper end of the last section of tubing 30 is in position above the control equipment, the special collar and stuffing box hanger of the present invention is attached thereto.

Referring to Figures 1a and 5, the stuffing box bushing S comprises a cylindrical portion 21 and a hanger like head 21' provided with the usual circular packing rings in the tapered portion thereof to seat and seal in the tapered seat 20 of the tubing head 18. The bore 25 of the hanger carries packing rings 27 which are compressed by a follower 29 threaded into the bore of the hanger. The stuffing box bushing is passed upwardly over the lower end of the last section of tubing 30 before the same is connected into the main tubing string. The upper end of the last section of tubing 30 may have an enlarged swaged end 31, or may carry a suitable collar of size to connect with the special collar C.

The special collar has a central bore which is interiorly threaded at its lower end at 34 to connect with the upper exteriorly threaded end of the tubing 30. It is also interiorly threaded at its upper end as at 36 for the detachable connection with the lower exteriorly threaded end of the lowering or lift nipple 38 shown in Figure 1.

On the interior of the special collar C, between the threads 34 and 36 thereof, there are reversely arranged heavy threads 40 to receive similar threads on the head 42 of the back pressure valve assembly B shown in Figure 1a.

The bore of the stuffing box bushing has an enlarged upper end 41 for insertion of the packing 27 and the follower 29, and the packing and follower are of such length that the enlarged bore 41 may also receive the lower end of the special collar C as shown in Figure 5.

The back pressure valve B may be of any now well-known type, for instance, as shown in Figure 8 of the said Smith et al. patent. Referring to Figure 1a, the head 42 of the back pressure valve assembly has an integral tubular extension depending therefrom provided at its lower end with a valve seat 43. The valve seat is secured to said extension by a depending sleeve 44 which is threaded to the lower end of such extension. At the lower end of the sleeve 44, there is a second valve seat 45 held in place by a further depending perforated valve cage 46 open at its lower end. The passages through the valve seats 43 and 45 are normally closed, respectively, by valve members 47 and 48, which members are respectively biased toward their seats by springs 49 and 50. The tension of the springs 49 and 50 is sufficient to keep the valves normally closed, but is such that they may be moved downwardly from their seats under the pump pressure to permit a downward flow of washing water, or mud, into the well through the tubing. It is obvious that the well pressure tends to maintain the valve members against their seats. The back pressure valve assembly including the head, sleeve, seats, cage, springs and valve members, is removable as a unit from the special collar C. The upper valve member 47 is carried, through the spring 49, on a suitably perforated spider 51, so that fluid may flow through the assembly when the valve members are moved from their seats by the pump pressure.

While a double back pressure valve assembly is shown, a similar assembly having only a single valve may be used, if desired.

Returning to Figure 1, when ready to insert the tubing, the stuffing box bushing S is passed upwardly over the lower end of the last section of tubing 30, which is then threaded at its lower end to the main string of tubing, and the special collar C is connected to the upper end of said section of tubing. Thereafter, the lowering nipple 38 is connected into the upper end of the special collar C. The lowering nipple 38 may be of any desired length for convenient manipulation of the tubing and for supporting the same in the derrick.

If desired, and as shown in Figure 9 of the said Smith Patent 2,148,327, the special collar may be provided with an upwardly extending strainer R, attached to the upper end of the back pressure valve housing. This strainer is small enough so that the lowering nipple 38 will pass over the same when attached to the special collar C. The strainer protects the back pressure valve against fouling when fluid is pumped into the well.

With the lowering nipple suspended from the derrick, the tubing is lowered until the bushing S is landed in the seat 20 of the tubing head 18 as shown in Figure 2. It will be understood that the blowout preventer 26 may be opened to pass the bushing C and that the master drilling valve 24 will likewise pass said bushing. When the bushing is landed in the seat of the tubing head, the locking screws 22 are operated to hold the bushing in place, and to force it into tight sealing engagement with the seat of the tubing head. For this purpose, the upper outside rim of the bushing is tapered, cooperating with the tapered inner end of the locking screws, so that the bushing is wedged downwardly, as is well known in the art.

The operators will have previously estimated the desired position of the lower end of the tubing in the well, and will have arranged the special collar and stuffing box bushing on the tubing so that the lower end of the tubing is in proper place for efficient flow when the bushing and special collar are landed in the tubing head as shown in Figure 2.

At this time, the stuffing box bushing S provides a control of the well around the outside of the tubing, while the back pressure valve B provides control within the tubing. Therefore, it is safe to unscrew the lower end of the left nipple 38 from the special collar C, and then remove the control equipment including the master drilling valve 24 and the blowout preventer 26. At this time, the tubing is suspended in the well by the stuffing box bushing S acting as a hanger, the special collar C resting on said bushing.

Thereafter, the tubing is pulled upwardly through the stuffing box bushing S while the same maintains a seal therewith, the locking screws 22 preventing the upward movement of the bushing. The tubing is pulled upwardly a distance, previously estimated, which permits complete expanding of the packer upon subsequent downward movement of the tubing as the Christmas tree is landed in position on the tubing head as will be subsequently described.

The condition of the apparatus when the tubing 30 has been pulled upwardly the desired distance is shown in Figure 3. When this has been done, the Christmas tree is attached to the upper end of the tubing, preparatory to washing the well, and finally landing the tubing in its final flowing position.

The special collar C is provided at its upper

end with a series of outside threads 60, and a tubular adapter 62 having similar inside threads at its lower end is secured to the upper end of said special collar. The adapter is suitably flanged for sealing attachment to the flange of the tubing head 18. The adapter 62 constitutes the base for and carries the remainder of the Christmas tree including the relatively small master manifold flow control valve 64, above which is attached a cross 66 having outlets controlled by valves 68 and 70 or closed by a bull plug 72. We have referred to the whole assembly of the adapter, master manifold valve, cross flow-valves, etc., as the Christmas tree, and as the tree is usually sold as a unit, it is more convenient to attach it in assembled form to the tubing. It will be understood, however, that no specific form of Christmas tree is required to practice this invention. Particularly, the adapter 62 may not be necessary, only inasmuch as it constitutes the lower connecting end of the Christmas tree. As shown in Figure 6, a special master manifold valve 64' may be used, with a flange 65 of the same size as that of the tubing head 18, and with suitable inside threads at its lower end to connect with the threads 60 of the special collar C. This special valve 64' constitutes the base of the Christmas tree.

When the Christmas tree is connected to the tubing, as shown in Figure 3, the tubing and tree may be supported by conventional temporary slips 72 seating in a temporary slip holder 74 which is positioned on the tubing head. The back pressure valve B may be removed with a suitable tool at any time after the Christmas tree valve 64 is attached, although it is preferable to leave it in place until the well is washed and the tubing landed, as described below.

The equipment is at this time in condition to wash the well, and if packers are used, the flange of the adapter will be elevated a distance above the flange of tubing head 18 exactly sufficiently to permit complete expansion of the packers as the tubing is lowered to permanently land the same on the tubing head.

The washing is performed by pumping a lighter liquid such as water into any of the Christmas tree outlets from the cross 66, which liquid passes downwardly through the tubing 30 and upwardly through the casing 16 to discharge through the side outlet 76 in the tubing head under the control of the valve 19.

When the well has been completely washed, the pressure of the formation begins to take control, as evidenced by the returns through the tubing head outlet 76. The tubing is then lowered (after removal of slips 72 and slip holder 74) until the flange of the adapter 62 rests on the flange of the tubing head. The adapter is then bolted and sealed to the tubing head as shown in Figure 4.

At this time, the stuffing box bushing S controls the well in the space around the tubing 30, while the back pressure valve B controls flow through the tubing.

The back pressure valve is removed as a unit from the tubing in order to flow the well in the manner shown in Figure 6 of the above-mentioned patent to Smith et al., 2,148,327. A conventional stuffing box fitting 80 is bolted to the upper end of the Christmas tree valve 70, said stuffing box being packed around a relatively small solid rod 82 having a tool at the lower end thereof, such as threads adapted to engage inside threads 84 in the back pressure valve head 42,

When the lower end of the solid rod is thus secured to the back pressure valve, the rod is further rotated to detach the entire back pressure valve assembly from the special collar C, said assembly having been secured in the special collar by threads 40 reversely arranged with respect to the threads 84. The rod is then pulled upwardly while the stuffing box 80 maintains a seal about the same, until the valve assembly is above the gate of the Christmas tree flow control valve 64. At this time, the valve 64 is closed, after which the stuffing box can be broken down, and the solid rod 82 and the back pressure valve B entirely removed from the well. The upper end of the Christmas tree valve 70 may then have secured thereto a flanged fitting carrying a bull plug or pressure gauge as desired. Thereafter, the Christmas tree manifold valve 64 is opened, along with another of the Christmas tree valves 68 or 70, and the well is produced from the tubing through the Christmas tree under the control of the valves, as is well-known in the art.

Referring to Figure 1a, if a strainer R is used, it may be threaded in the threads 84 of the head 42. The solid rod in this case may have means to attach with the upper end of the strainer, to rotate the latter and the valve housing in removing the same, as described in connection with Figure 9 of the said Smith et al. Patent 2,148,327.

It will be evident that the sequence of operations described above permits performance of the final steps of well completion with the control equipment removed. That is, the well is washed and the packers are set, with the Christmas tree already mounted on the tubing. Thereafter the Christmas tree is simply lowered while complete mechanical control is maintained to expand the packers and finally land the tree on the tubing head with the tubing in desired position for flow. During the washing of the well, control is provided through the tubing by the back pressure valve, and the Christmas tree manifold valve 64 likewise provides a shut-off acting as an auxiliary manual control. At any time during the operations described, if a dangerous situation arises, mud can be pumped into the well to check any dangerous pressures.

When the well is completed, control around the tubing is provided by the stuffing box bushing S locked in firm sealing engagement with its seat by the screws 22, while the Christmas tree secured in sealing engagement to the tubing head 18 controls the flow through the tubing.

The procedure described above provides for safe and convenient performance of operations subsequent to completion. For instance, after completion it may be desired to fill the well with mud, for some reason, which would necessitate releasing the packers. The packers referred to herein may be of any well-known type, such as the Guiberson control head packer. To circulate the mud, all that need be done is to unflange the Christmas tree from the tubing head and lift the same, with the tubing, a distance sufficient to release the packer. Mud may be then pumped into the well through the Christmas tree under control of valve 64, flowing downwardly through the tubing and upwardly through the casing past the packer, circulation being permitted by dis-

charge from the side outlet in the tubing head beneath the seal still maintained by the bushing S. The well may, of course, be later washed again through the Christmas tree and again put on production.

It will be apparent that various changes in the apparatus and procedure described herein may be made while practicing the invention.

I claim:

1. In completion apparatus for use on a well which is produced through flow tubing lowered into a casing, a casing head having a bore therethrough including a seat, said casing head having means to support a Christmas tree thereon, a tubing collar having means for connection with the Christmas tree to depend therefrom, said collar having means for rigid attachment with the tubing to support the same from the Christmas tree and in the casing of the well, a back pressure valve in said collar providing for passage of fluid downwardly therethrough but providing against passage of fluid upwardly therethrough, and a tubular bushing in the seat of said casing head and forming a seal therewith, said bushing having a bore therethrough to receive the tubing, and having means in said bore to form a seal with the tubing while permitting the latter to be elevated and lowered therethrough.

2. In completion apparatus for use on a well which is produced through flow tubing lowered into a casing, a casing head having a bore therethrough including a seat, means on said head to support a Christmas tree thereon, a tubing collar having means for connection with the Christmas tree to depend therefrom into said bore, said collar having means for rigid attachment with the tubing to support the same from the Christmas tree and in the casing of the well, a back pressure valve in said collar providing for passage of fluid downwardly therethrough but providing against passage of fluid upwardly therethrough, a tubular bushing in the seat of said casing head and forming a seal therewith, said bushing having a bore therethrough to receive the tubing, and having means in said bore to form a seal with said tubing, and means in said casing head for locking said bushing in said seat.

3. In completion apparatus for use on a well which is produced through flow tubing lowered into a casing, a casing head having a bore therethrough including a tapered seat and a side outlet from said bore below said seat, said casing head having a top flange to connect with a Christmas tree supported on said head, a tubular bushing having a tapered portion to seat in and form a seal with the seat of said casing head above said outlet, pressure-proof locking screws extending through the flange of said casing head to lock said bushing in its seat, said bushing having a bore therethrough and a stuffing box therein to form a seal around the tubing, and a collar having means for attachment with the Christmas tree and the tubing to suspend the latter in the well, said collar having means to removably receive a back pressure valve therein to prevent upward flow of fluid from the well through the tubing.

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