

March 14, 1939.

R. A. MUELLER ET AL

2,150,887

METHOD AND APPARATUS FOR COMPLETING WELLS

Filed Jan. 13, 1936

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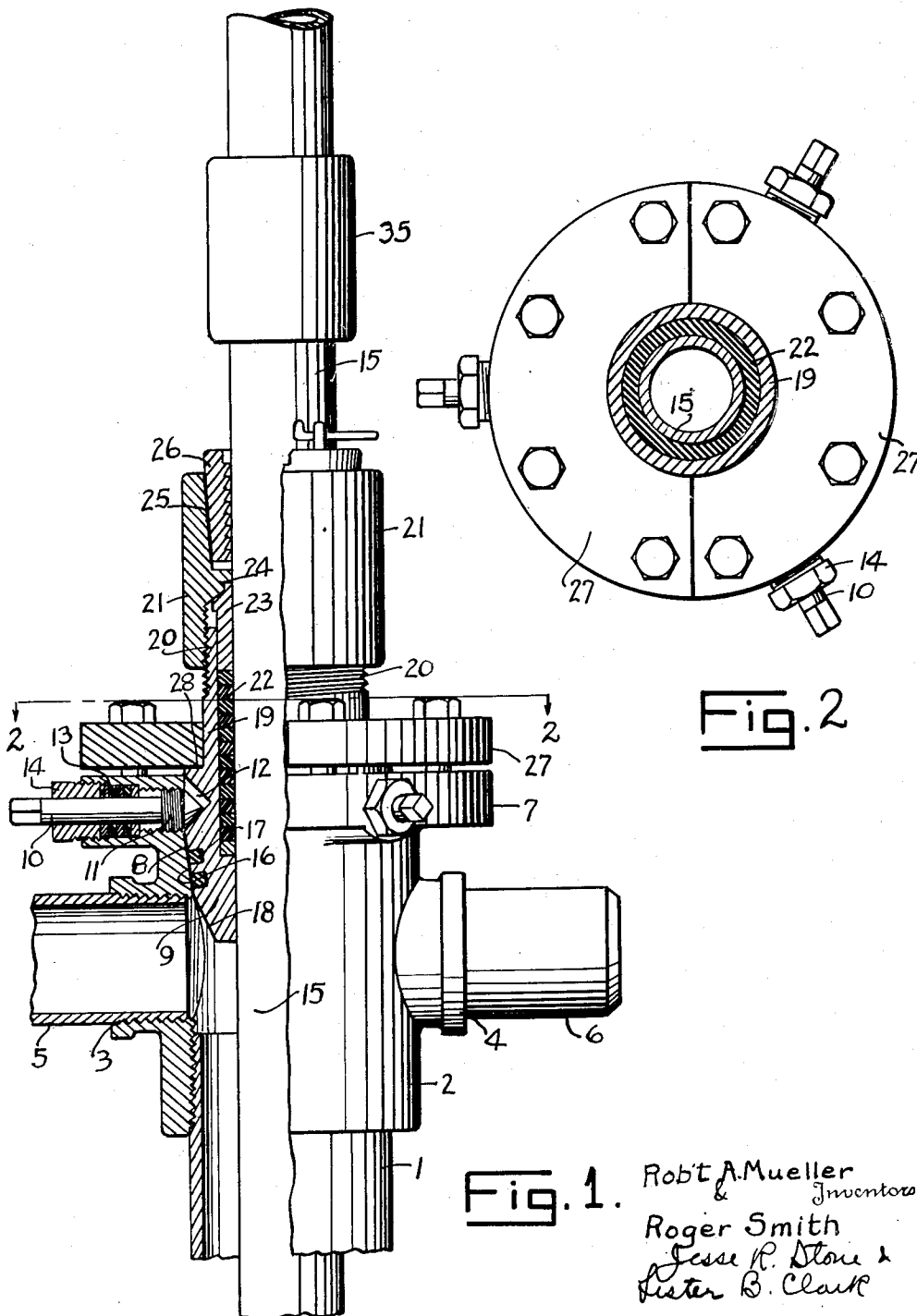


Fig. 1.

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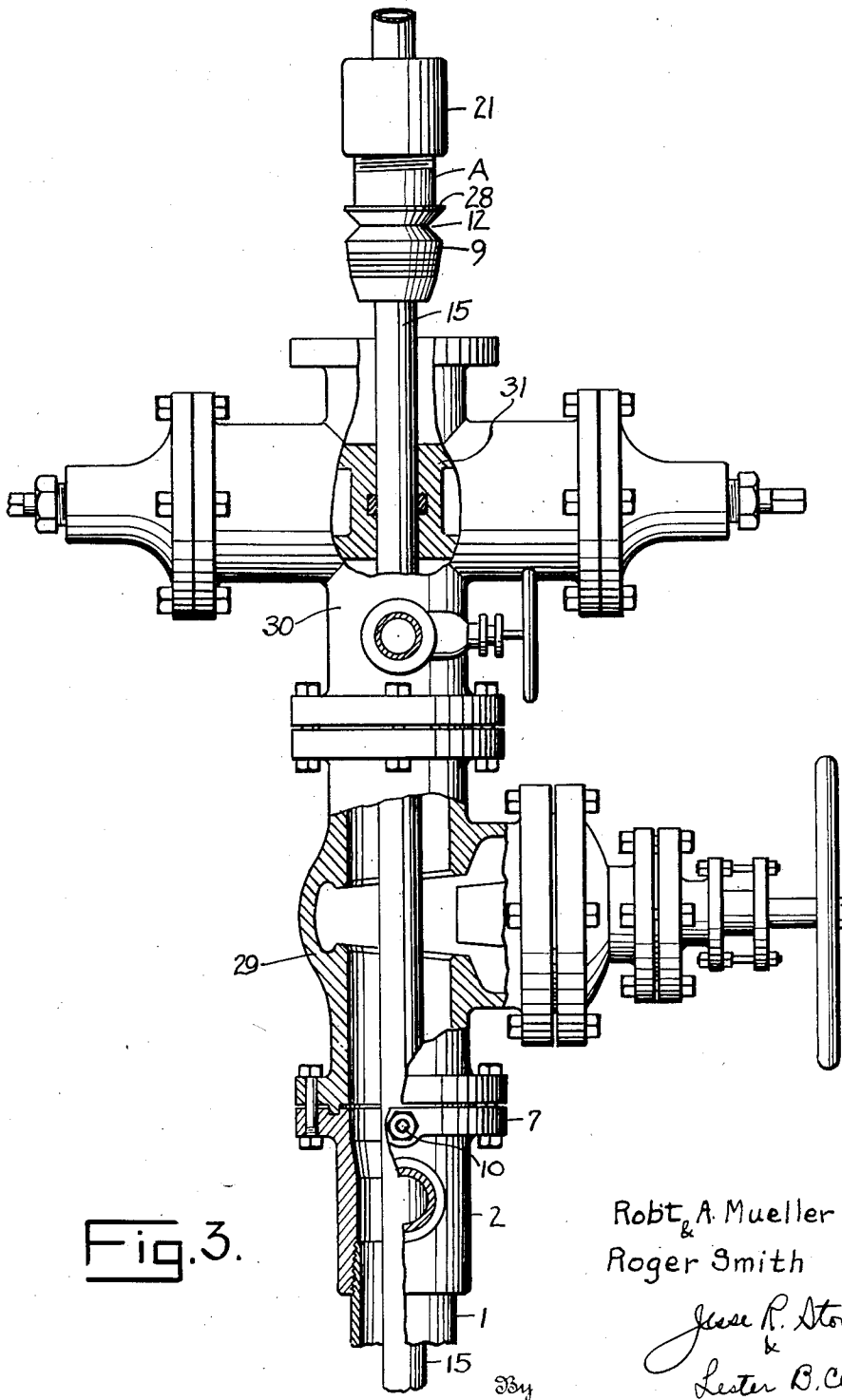
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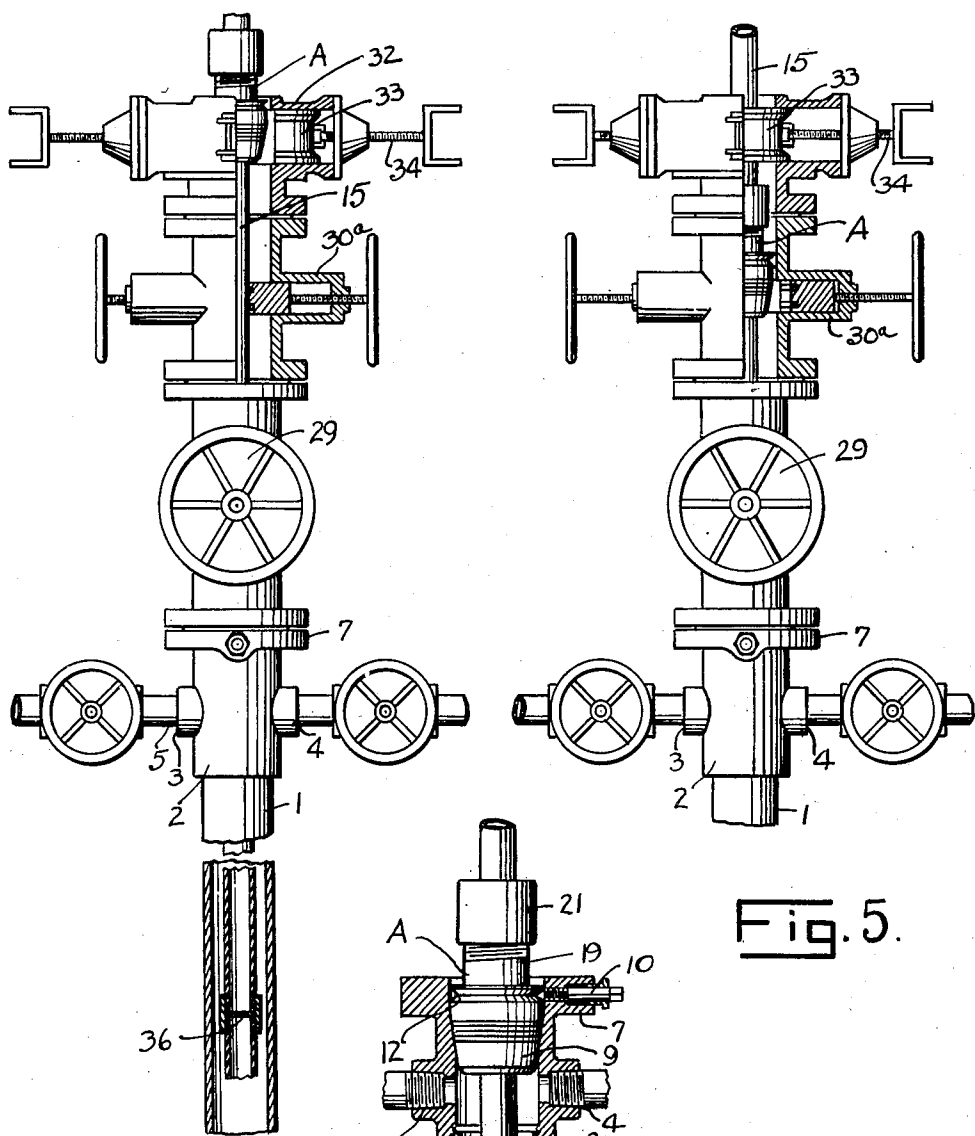


Fig. 4.

Fig. 5.

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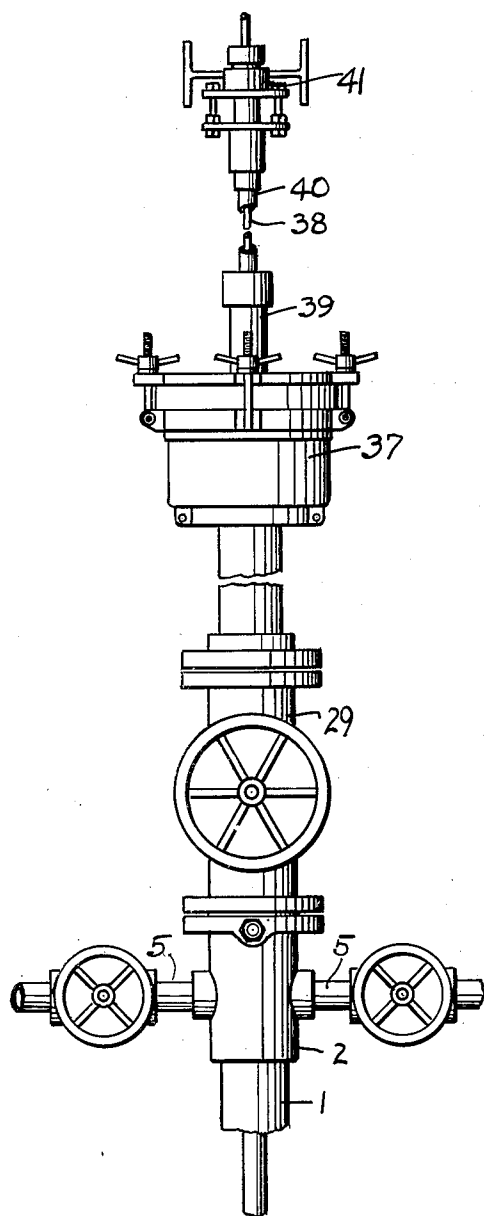


Fig. 8.

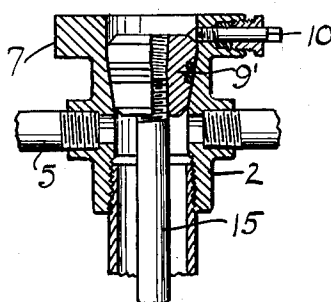


Fig. 7.

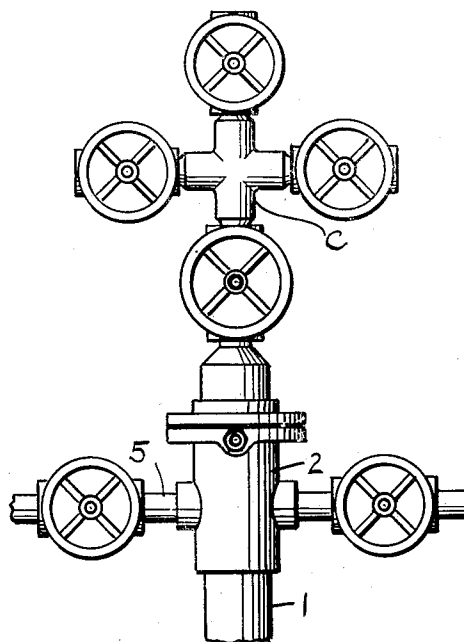


Fig. 9.

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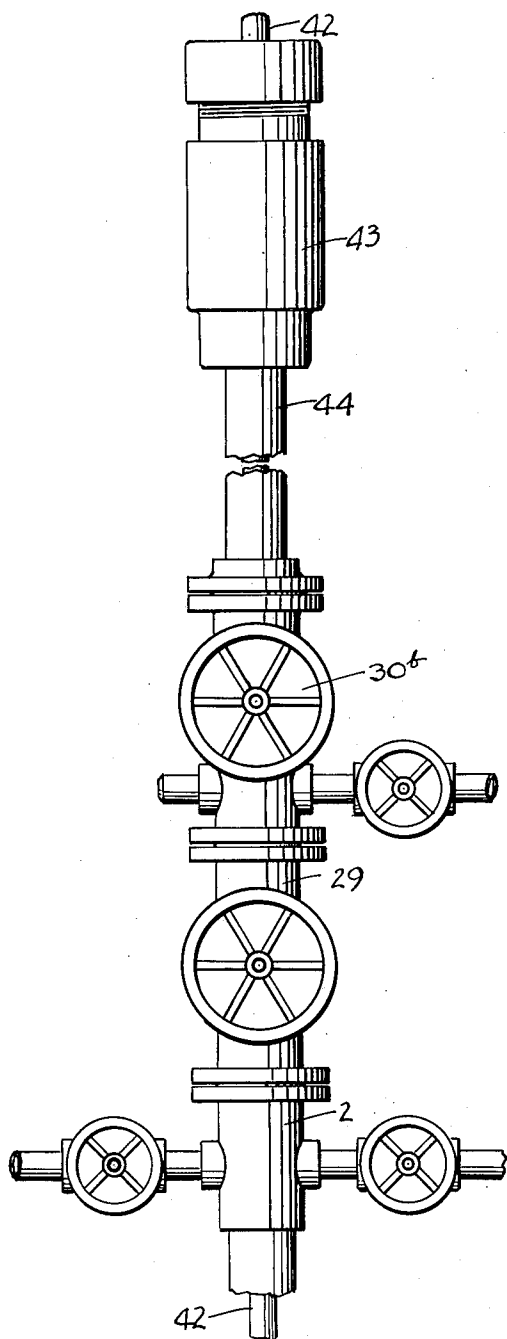
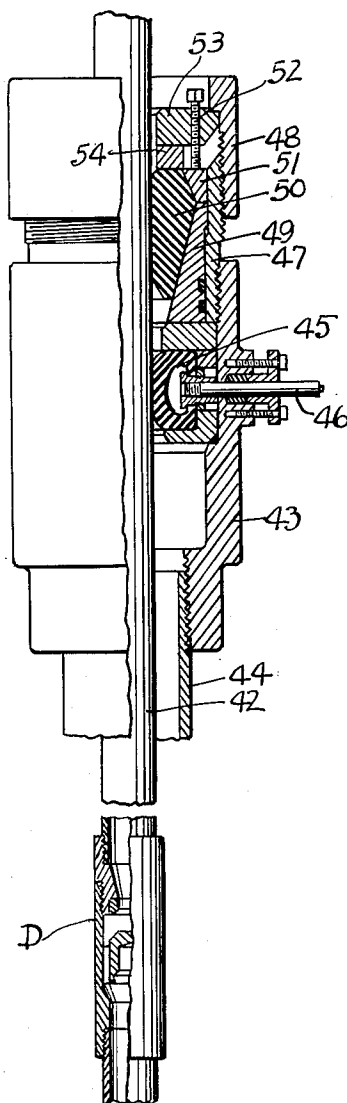


Fig. 10.

Fig. 11.



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UNITED STATES PATENT OFFICE

2,150,887

METHOD AND APPARATUS FOR COMPLETING WELLS

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Application January 13, 1936, Serial No. 58,821

9 Claims. (Cl. 255—1)

Our invention relates to methods and equipment for completing a well under gas pressures in such manner as to prevent any danger of blow-out or of damage to the well.

Our device is employed in the finishing of a well including the operations of drilling into the producing formation, setting the strainer and packer and then accomplishing the equipment of the well where the tubing is hung in position so that the well may be properly equipped and the control apparatus removed from the well. There are devices previously employed whereby tubing may be supported in the well such devices being secured permanently to the tubing and which act to support the tubing in its proper position. Such devices do not commonly provide for any vertical adjustment of the tubing and the hanging of the tubing thereafter without endangering the blowout of gas from the well. It is important to be able to move the tubing vertically for the setting of the packer or other similar operations after the seal has been made about the upper end of the tubing. This vertical adjustment is not ordinarily possible with equipment now in use where the well is under heavy pressure.

It is an object of our invention to provide control equipment and to so operate the finishing of the well that there will during the series of operations be no time when the well is open so that a blowout might occur.

It is a further object of the invention to provide a combined hanger and seal to be employed in the tubing head and through which the tubing may be slidable while the packer is being set and which permits the tubing to be then supported in any adjusted position and continuously to maintain a seal at the well head while so doing.

We desire to provide a construction which will permit the drilling-in operation, the equipping of the well with strainer and packer, the adjusting and hanging of the tubing in the well and the equipping of the tubing for flowing, and to form a continuous seal between the casing and the tubing or other pipe while doing so.

It is a further object to provide a device of this character which may be firmly locked in position relative to the casing head so as to prevent displacement thereof under heavy gas pressures.

Referring to the drawings herewith, Fig. 1 is a side view partly in central longitudinal section and partly in elevation showing the construction of our device.

Fig. 2 is a transverse section on the plane 2—2 of Fig. 1.

Fig. 3 is a broken side elevation showing an arrangement whereby the tubing may be inserted into the well under pressure.

Fig. 4 is a side elevation partly in vertical section illustrating the hanger in position going into the well.

Fig. 5 is a similar view showing the hanger in a still different position.

Fig. 6 is a longitudinal section through a casing head showing our hanger in fixed position therein.

Fig. 7 is a vertical section similar to Fig. 6 with a different hanger.

Fig. 8 is a side elevation of the well head showing the well equipment for drilling in with cable tools.

Fig. 9 is a side elevation similar to Fig. 8, but with the Christmas tree substituted for the drilling control equipment.

Fig. 10 is a side elevation of the well head equipped for drilling in with a rotary rig.

Fig. 11 is a side view partly in vertical section showing the type of sealing member seen at the upper end of Fig. 10.

It is understood that the apparatus which we employ is capable of installation within the upper end of the inner string of casing, such as is shown at 1 in the drawings. The casing head 2 is connected to the upper end of the casing and has the usual lateral ports 3 and 4 into which may be connected a pipe 5 or a closure plug 6. The upper end of the casing head has a radial flange 7 thereon through which a connection may be made with other devices when desired. The inner portion of the upper end of the casing head has an upwardly flaring seat 8, which serves in this instance to interfit with the lower end 9 of the hanger for tubing or other inner pipe.

Extending radially through the flange 7 at the upper end of the casing head we may employ locking bolts 10, which are threaded at 11 to be advanced into position to engage within an annular recess 12 in the hanger 9. We employ a stuffing box around the shaft of the bolt 10 including the packing rings 13 and the gland 14. The outer end of the locking bolt is squared to receive a wrench or handle whereby it may be manipulated.

The hanger which we have devised is slidable relative to the inner pipe 15. It engages closely about the pipe or tubing and the lower head 9 on the hanger has a tapered portion 16 to engage within the seat 8. Packing rings 17 on this tapered portion assist in forming a seal between the hanger and the seat. Below the tapered seat-engaging portion, the lower end is beveled

off at 18 to enable the operator to handle the device more readily in introducing it into position.

Above the head 8 of the hanger is an upwardly extending neck 19, the upper end of which is threaded at 20 to receive a bushing 21. Within the neck 19 is a recess to receive the packing rings 22 adapted to be clamped in position in said recess by the gland 23.

The bushing 21 is adapted to be screwed downwardly upon the threaded portion 20 of the hanger and an inner flange 24 thereon is arranged to engage the upper end of the gland 23 so as to tighten the packing rings into sealing position. Above the flange 24 the bushing is recessed to provide a downwardly tapered seat 25 to receive pipe engaging slips 26 of ordinary construction.

The hanger may be more firmly fixed in the seat in the casing head by means of a clamping plate 27. Said plate is preferably in two sections, as shown in Fig. 2. The two sections are fitted about the neck of the hanger and the plate is then bolted to the flange 7 of the casing head and by engagement above the shoulder 28 upon the hanger said hanger may be held in sealing engagement after the hanger is properly seated.

In the operations preceding the clamping of the hanger into position, it is necessary to introduce the tubing and packer or other devices thereon under gas pressure without danger of blowout around the tubing. In Figs. 3 to 6 the devices required in these operations are shown, and it is to be understood that these devices are well known in the art. In Fig. 3 the master valve 29 is bolted to the flange 7 of the casing head in the usual manner and above the valve is a blowout preventer 30, also of ordinary construction and having rams or valve members 31, which may be moved into sealing engagement around the tubing 15 to prevent the escape of gas around said tubing. In Figs. 4 and 5 we show, above the blowout preventer 30a, a second blowout preventer or tubing stripper 32, said blowout preventer having rams or sealing devices 33, which may be advanced into sealing engagement about the tubing 15 by threaded stems or rods 34.

In introducing the tubing into the well it is to be understood that the usual packer, and other devices ordinarily employed, are connected with the lower end of the tubing. The hanger shown at A in the drawings, and previously described, is connected with the tubing at approximately the height where it is estimated that the tubing is to be supported. The hanger is, as previously stated, slidable along the tubing between adjacent collars 35 thereon and while the tubing is being introduced into the well the slips 26 are not in position.

The tubing is sealed adjacent the lower end at some desired point with a retractable valve such as is now in common use, or by a frangible transverse disc 36, shown in Fig. 4, which may be broken where desired by dropping a weight thereon as is now commonly done where a temporary seal of this character is used.

The lower end of the tubing is inserted through the upper blowout preventer 32 while the master valve 29 is closed. When the blowout preventers have been fitted about the tubing so as to form a seal therewith the gate valve is opened and the tubing moved downwardly to proper position in the well. In order to move the hanger A into

the well the blowout preventer 32 is opened, as shown in Fig. 4, to allow the hanger to pass. After the hanger has passed, the blowout preventer is closed and the lower one opened, and the device thus safely moved into position with the hanger engaging within the seat in the casing head, as shown in Fig. 1. The latching bolts 10 are then employed to secure the hanger firmly against upward movement. The valve and blowout preventers may then be removed and the plate 27 bolted in place to further guard against blowout.

It is then necessary to set the packer and in doing so the tubing must be moved longitudinally in performing the operations in setting the packer, and as the tubing is slidable in the hanger these movements may be accomplished without in any way endangering the seal between the tubing and the hanger and casing head. The amount of necessary vertical adjustment is not great and the distance between adjacent coupling 35 on the tubing will allow for it. When such operations have been completed the tubing is adjusted to the proper height and the slips 26 inserted to support the tubing in approximately permanent position in the well.

Any desired fittings and valves may then be connected with the upper end of the tubing as by collar 35 and when the well is ready to be flowed a weight is dropped through an upper valve or fitting to break the disc 36 and the valve again closed.

Although our apparatus is concerned particularly with the operation of handling the equipment of the well it is to be understood that the operation of drilling into the producing formation prior to the hanging of the tubing must also be done under gas pressure and attention is now called to the equipment which is intended to be employed in these operations. In Fig. 8 the equipment for drilling in with cable tools is shown. The casing head 2 has mounted thereon a gate valve 29, as was shown in Figs. 4 and 5. Above this gate valve is a blowout preventer 37, such as is ordinarily employed with cable tool drilling. The exact construction of this device which is now in ordinary use forms no part of the present invention but it is to be understood that a packing therein forms a seal about the cable 38 which works through an upstanding nipple 39 and pipe extension 40. At the upper end of the extension is the usual adjusting mechanism 41 ordinarily employed.

This device allows the drill to be drawn upwardly out of the well at the lower end of the cable 38, past the gate valve 29. This valve may then be closed while the blowout preventer 37 and other equipment is removed together with the drill. After the drilling is thus completed the upper end of the well may be equipped for setting the tubing and when this is accomplished in the manner previously described it will be possible to remove the gate valve 29 and substitute the Christmas tree shown generally at C in Fig. 9.

If no vertical adjustment of the tubing in hanging the same in the well is necessary the type of hanger shown in Fig. 7 may be employed said hanger including a tapered bushing 9', the inner portion of which is threaded for engagement with the upper end of the tubing 15. The Christmas tree assembly may then be connected to the flange 7 above the hanger and the closure disc 36 in the tubing may then be broken or otherwise removed.

In Figs. 10 and 11, the equipment for drilling

in by rotary drilling methods is shown. The drill stem 42 is extended upwardly through the casing head 2 and gate valve 29 and through a blowout preventer 30b. There is also an upper packing member 43 mounted at the upper end of a casing extension 44 and which serves to seal the upper end of the well around the said drill stem 42.

The sealing member 43 is one now in ordinary use and is disclosed somewhat more specifically in Fig. 11. The housing 43 is connected to the upper end of the casing 44, said housing having therein an expansible packing ring 45 which is adapted to be inflated by fluid introduced under pressure therein through the pipe 46. This is a common type of sealing member and need not be further described. Above this packing unit is a second packing member which is housed within a sleeve 47 connected at its lower end to the housing 43 and at its upper end it is threaded within a cap 48. The interior of the sleeve 47 houses a tapered bowl 49 supported upon the lower sealing member 45 and having a downwardly tapered packing collar 50 of rubber or similar compressible material which is adapted to fit around the drill stem 42. Above the sealing member 50 is a ring 51, which may be tightened in position to compress the packing member 50 by means of set screws 52 extending through a plate 53, which is clamped beneath an inner flange on the cap 48. This plate 53 is separated from the packing member 50 by a spacing ring 54, which rests upon the said packing member. It will be seen that a close seal may be made with this device and that adjustment may be made by screwing the cap member 48 downwardly so as to further compress the packing members.

The drill stem is understood as having therein a back pressure valve such as is shown at D in Fig. 11. This valve is adapted to be moved to open position by the flushing fluid but will close when the circulation is reversed, so that when the well tends to blow out through the drill stem the valve D prevents the discharge of the fluid upwardly through the stem.

When the well is being drilled in by the rotary method the drill stem and bit may be withdrawn from the well through the blowout preventers above the gate valve 29 and when the bit has been moved upwardly past the valve it may be closed, allowing the whole upper structure of the drilling equipment to be removed. When thus removed the well may be equipped as shown in Figs. 4 and 5 for hanging the tubing in the manner previously noted.

By the use of the apparatus here shown it will be understood that the well may be drilled into the producing sand under high gas pressure and the drill stem and drill or cable and drill may be withdrawn upwardly past the gate valve 29 so that the structure above said gate valve may be entirely removed. The equipment for hanging the tubing including the blowout preventers 30a and 32, as shown in Fig. 4 and Fig. 5, may be placed in position and the tubing inserted and hung within the casing head 2, as is shown in Fig. 1. When thus supported in position the hanger 9 may be secured in position and it will be possible thereafter to entirely remove the control equipment, leaving the upper end of the well equipped approximately as shown in Fig. 1. The tubing may be then adjusted vertically to wash the well, set the packer or perform other similar operations in the well and be

then raised to the desired point off the bottom of the well and supported in the slips 26.

It will be noted that at no point in the series of operations which are necessary to go through in the equipping of the well is it necessary to leave the well unguarded against a blowout. There is a seal maintained between the drill stem or between the tubing and the casing and also the passage through the drill stem or tubing is closed at all times when a blowout therethrough might occur.

While guarding against the danger of blowout all of the necessary and desirable steps which are ordinarily performed in the finishing of the well are accomplished without danger of losing the well.

Furthermore, the equipment which is employed in handling the operations of finishing the well may be removed and used again on other wells, it being necessary only to maintain the hanger secured firmly in position on the casing head by the means disclosed particularly in Fig. 1.

The invention of this application is an improvement in the apparatus and methods for completing wells described and claimed in application Serial No. 736,635, Roger Smith, filed July 24, 1934.

What is claimed as new is:

1. In apparatus for completing a well in formation having high pressure providing for a sequence of control operations, a casing, a casing head, a seat in said head, a drilling master valve mounted on said head above said seat, means on said head for removably securing said valve thereon, said means being also adapted to connect with a Christmas tree including a smaller master flow valve supported on said head, said head and drilling master valve having bores at least as large as that of said casing to permit operations prior to completion such as passing a drill substantially as large as the casing bore therethrough, a tubing engaging blow-out preventer mounted above said drilling master valve, a flow tubing in said casing, means for closing said tubing against flow of fluid from the well, a hanger on said tubing of diameter adapting it for lowering through said preventer and master drilling valve for disposition in said seat to seal the well against flow of fluid from said casing, and means operable while said preventer is engaged with said tubing above said hanger to lock the same in said seat and said tubing against upward movement under well pressure, whereby said securing means on said casing head may be released for removal of said drilling master valve and preventer, and engaged with a Christmas tree supported on said head including a master flow valve for use during the flowing of the well when said tubing is opened.

2. In apparatus for completing a well in formation having high pressure providing for a sequence of control operations, a casing, a casing head, a seat in said head, control equipment supported on said head as a foundation including a drilling master valve mounted on said head above said seat and a tubing engaging blowout preventer above said valve, flanged securing means on said head for removably securing said valve thereon, said means being adapted to also connect with a Christmas tree including a smaller master flow valve supported on said head, said head and control equipment having bores at least as large as that of said casing to permit operations prior to completion such as passing a drill substantially as large as the casing bore there-

through, a flow tubing in said casing, means for closing the lower end of said tubing against flow of fluid from the well, a hanger on said tubing of diameter adapting it for lowering through said control equipment for disposition in said seat to seal the well against flow of fluid from said casing, and means operable exteriorly of said head while said control equipment is mounted thereon and said preventer is engaged with said tubing above said hanger to lock said hanger in said seat and said tubing against upward movement under well pressure, whereby said securing means on said casing head may be released for removal of said control equipment, and engaged with a Christmas tree supported on said head as a foundation including a smaller master flow valve in alignment with said casing for use during the flowing of the well when said tubing is opened.

3. In apparatus for completing a well in formation having high pressure providing for a sequence of control operations, a casing, a casing head, a downwardly tapered seat in said head, control equipment supported on said head as a foundation including a drilling master valve mounted on said head above said seat and a tubing engaging blowout preventer above said valve, means on said head for removably securing said valve thereon, said means being adapted to also connect with a Christmas tree including a smaller master flow valve supported on said head, said casing head above said seat and said control equipment having bores larger than that of said casing permitting operations prior to completion such as passing therethrough a drill substantially as large as the casing bore, a flow tubing in said casing, means for closing said tubing against flow of fluid from the well, a downwardly tapered hanger on said tubing of larger size than said casing bore but of diameter-adapting it for lowering through said control equipment for disposition in said seat to seal the well against upward flow of fluid from said casing, and means operable exteriorly of said head while said control equipment is mounted thereon and said preventer is engaged with said tubing above said hanger to lock said hanger in said seat and said tubing against upward movement under well pressure, whereby said securing means on said casing head may be released for removal of said control equipment and engaged with a Christmas tree supported on said head as a foundation including a master flow valve in alignment with said casing for use during flowing of the well when said tubing is opened.

4. In an apparatus for completing a well in formation having high pressure providing for a sequence of control operations, a casing, a casing head, a seat in said head, control equipment supported on said head as a foundation including a drilling master valve mounted on said head above said seat and a tubing engaging blowout preventer above said valve, means on said head for removably securing said valve thereon, said head and control equipment having bores at least as large as that of said casing to permit operations prior to completion such as passing a drill substantially as large as the casing bore therethrough, a flow tubing in said casing, means for closing said tubing against upward flow of fluid from the well, a hanger on said tubing of diameter adapting it for lowering through said control equipment for disposition in said seat, to seal the well against flow of fluid from said casing, said hanger having means for slidably securing the same to said tubing while maintaining a seal therewith,

means extending laterally through said head adjacent said seat and operable exteriorly of said head while said control equipment is positioned thereon and said preventer is engaged with said tubing above said hanger to lock said hanger in said seat and said tubing against upward movement under well pressure, said securing means being releasable for removal of said control equipment, said tubing being movable longitudinally with respect to said hanger after the latter is locked in said seat while maintaining a seal around said tubing, whereby the well may be flowed with the tubing in desired position therein when the tubing is opened.

5. In an apparatus for completing a well in formation having high pressure providing for a sequence of control operations, a casing, a casing head, a seat in said head, control equipment supported on said head as a foundation including a drilling master valve mounted on said head above said seat and a tubing engaging blowout preventer above said valve, means on said head for removably securing said valve directly thereon, said head and control equipment having bores at least as large as that of said casing to permit operations prior to completion such as passing a drill substantially as large as the casing bore therethrough, a flow tubing in said casing, means for closing said tubing against upward flow of fluid from the well, a hanger on said tubing of diameter adapting it for lowering through said control equipment for disposition in said seat, to seal the well against flow of fluid from said casing, said hanger having means for slidably securing the same to said tubing while maintaining a seal therewith, means extending laterally through said head adjacent said seat and operable exteriorly of said head while said control equipment is positioned thereon and said preventer is engaged with said tubing above said hanger to lock said hanger in said seat and said tubing against upward movement under well pressure, said securing means being releasable for removal of said control equipment, said tubing being adjustable longitudinally with respect to said hanger after the latter is locked in said seat while maintaining a seal around said tubing, and means for supporting said tubing in adjusted position, whereby the well may be flowed with the tubing supported in desired position therein when the tubing is opened.

6. The method of bringing in a well in formation having high pressure, provided with a casing, casing head and drilling valve positioned on and above the same having bores to permit of drilling therethrough, comprising drilling through the casing head and valve, removing the drill and leaving the valve in place on the casing head, temporarily sealing the flow tubing adjacent the lower end thereof, lowering the tubing equipped with a hanger into the well through said valve while providing a temporary seal between said tubing and casing above said valve, hanging said tubing in the casing head below said valve, simultaneously forming a seal with said hanger between the same and the casing head below said valve by the weight of the flow tubing, making permanent said last-named seal against upward movement of the hanger under well pressure which could be great enough to overcome the weight of the tubing by securing said hanger in the casing head while said temporary seal between the casing and tubing above the hanger is still provided, removing said valve and the temporary seal between the casing and tubing while the

well is still under high formation pressure, replacing the drilling valve with a smaller flow valve, and thereafter removing said temporary flow tubing seal to permit the well to flow under pressure controlled by said last-named valve.

7. In apparatus for completing a well in formation having high pressure providing for a sequence of control operations, a casing, a casing head, a seat in said head, control equipment mounted on said head above said seat including a drilling master valve and blow-out preventer, means on said head for removably securing said control equipment thereon, said means being also adapted to connect with a Christmas tree including a smaller master flow valve supported on said head, said head and control equipment having bores at least as large as that of said casing to permit operations prior to completion such as passing a drill substantially as large as the casing bore therethrough, a flow tubing in said casing, means for closing said tubing against flow of fluid from the well, a hanger on said tubing of diameter adapting it for lowering through said control equipment for disposition in said seat to seal the well against flow of fluid from said casing, and means operable, while said control equipment is mounted on said head and said preventer is provided for sealing engagement with said tubing above said hanger, to lock the hanger in said seat and said tubing against upward movement under well pressure, whereby said securing means on said casing head may be disengaged for removal of said control equipment and engaged with a Christmas tree supported on said head including a smaller master flow valve for use during the flowing of the well when said tubing is opened.

8. In apparatus for completing a well in formation having high pressure providing for a sequence of control operations, a casing, a casing head, a seat in said head, a drilling master valve mounted on said head above said seat, means on said head with which said valve is removably secured, said means being also adapted to connect with a Christmas tree including a smaller master flow valve supported on said head, said head and drilling master valve having bores at least as large as that of said casing to permit operations prior to completion such as passing a drill substantially as large as the casing bore therethrough, a tubing engaging blow-out preventer mounted above said drilling master valve, a flow-tubing in

said casing, means for closing said tubing against flow of fluid from the well, a hanger on said tubing of diameter adapting it for lowering through said preventer and master drilling valve for disposition in said seat to seal the well against flow of fluid from said casing, and means operable, while said preventer is provided for sealing engagement with said tubing above said hanger, to lock the hanger in said seat and said tubing against upward movement under well pressure, whereby said securing means on said casing head may be disengaged for removal of said drilling master valve and preventer, and engaged with a Christmas tree supported on said head including a master flow valve for use during the flowing of the well when said tubing is opened.

9. In apparatus for completing a well in formation having high pressure providing for a sequence of control operations, a casing, a casing head, a downwardly tapered seat in said head, a drilling master valve mounted directly on said head above said seat, means on said head for removably securing said valve directly thereon, said means being also adapted to connect with a Christmas tree supported on said head, said head and drilling master valve having bores at least as large as that of said casing to permit operations prior to completion such as passing a drill substantially as large as the casing bore therethrough, a tubing engaging blow-out preventer mounted above said drilling master valve, a flow tubing in said casing, means for closing said tubing against flow of fluid from the well, a downwardly tapered hanger on said tubing of diameter adapting it for lowering through said preventer and master drilling valve for disposition in said seat to seal the well against flow of fluid from said casing, and means extending laterally through said head adjacent said seat and operable while said preventer is available for sealing engagement with said tubing above said hanger to lock said hanger in said seat and said tubing against upward movement under well pressure, whereby said securing means on said casing head may be disengaged for removal of said drilling master valve and preventer and engaged with a Christmas tree supported on said head for use during the flowing of the well when said tubing is opened.

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