April 5, 1932. S. H. GRINNELL ET AL 1,852,717

GAS LIFT APPLIANCE FOR OIL WELLS

Filed Sept. 8, 1930 3 Sheets-Sheet 1

Fig. 1.

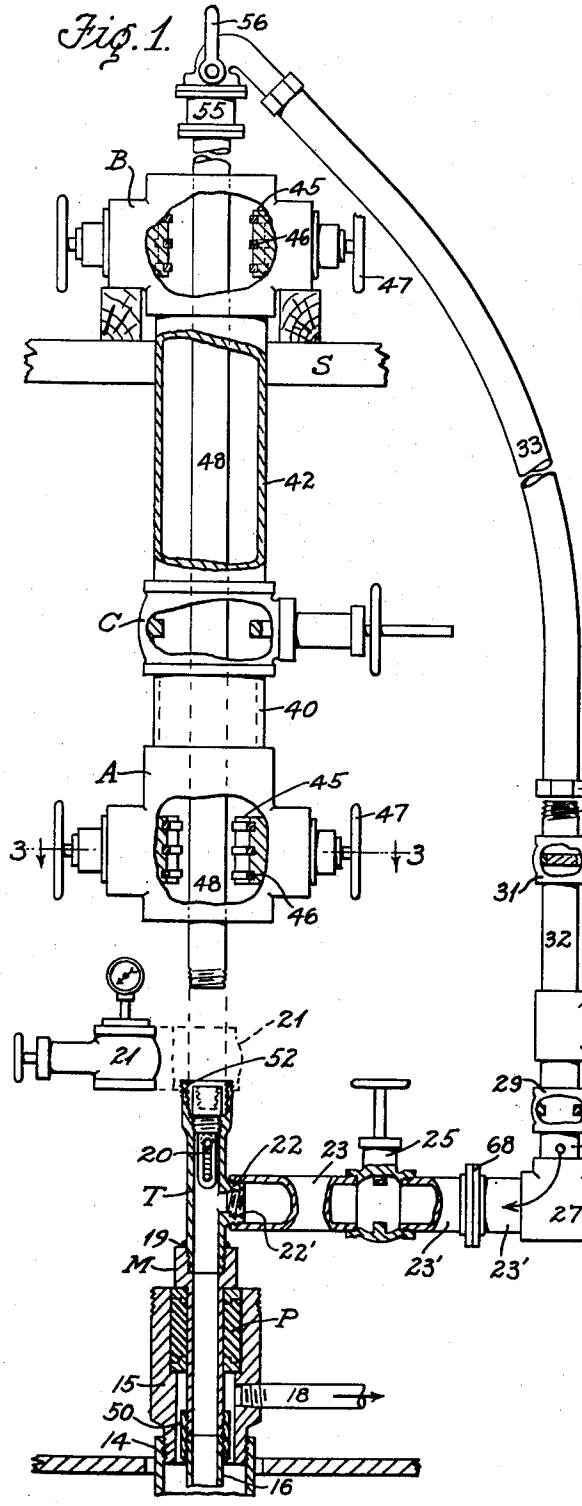


Fig. 3.

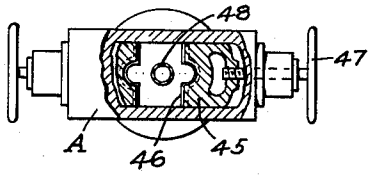


Fig. 4.

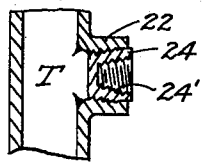


Fig. 5.

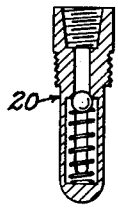
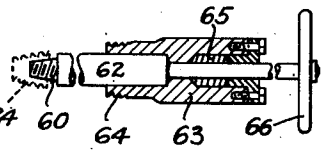


Fig. 2.



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GAS LIFT APPLIANCE FOR OIL WELLS

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Fig. 7.

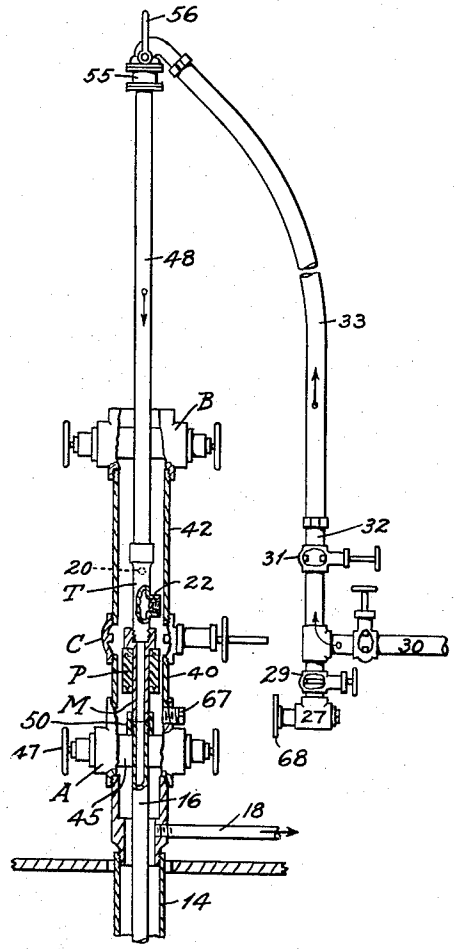


Fig. 6.

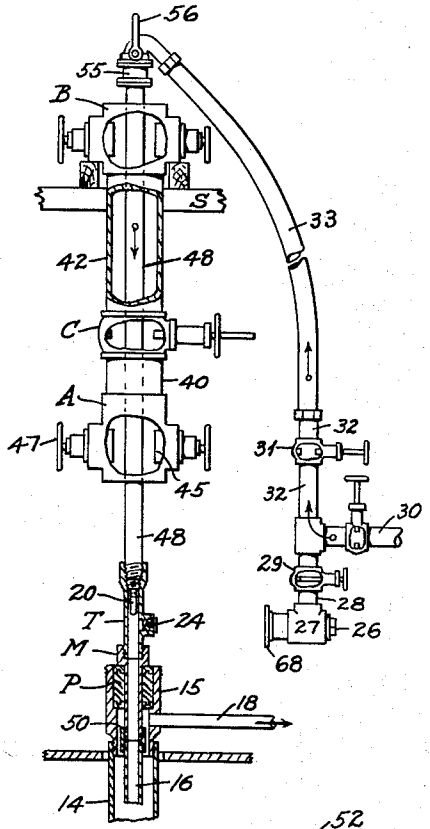
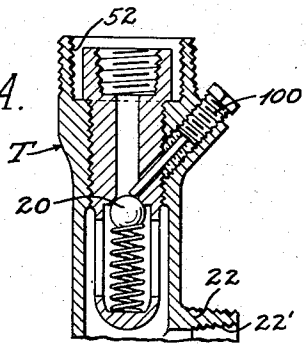


Fig. 5A.



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GAS LIFT APPLIANCE FOR OIL WELLS

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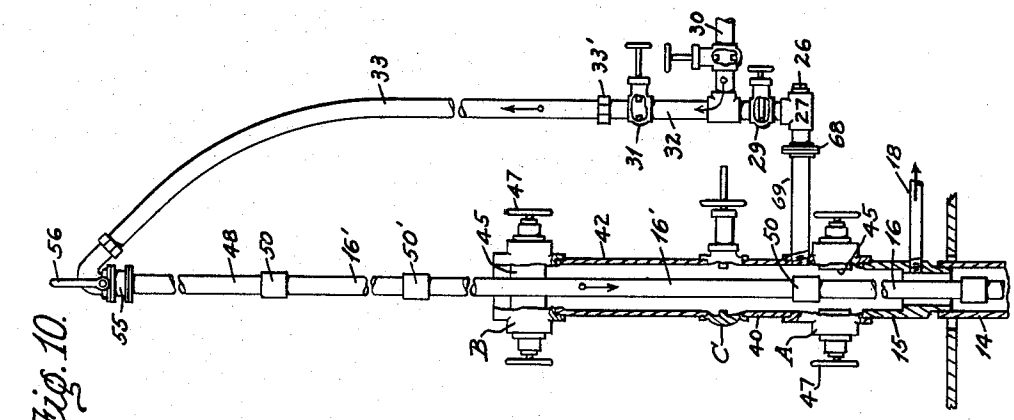

Fig. 10.

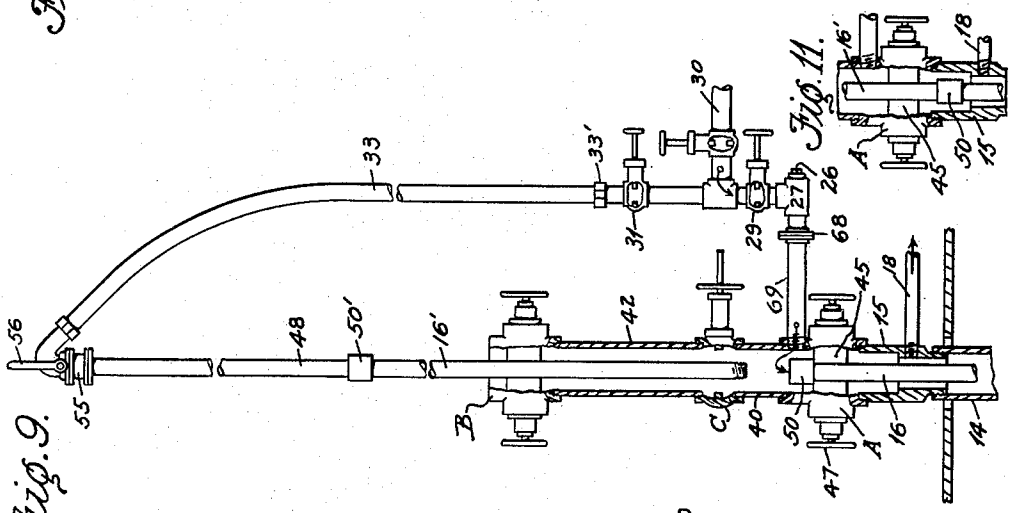

Fig. 9.

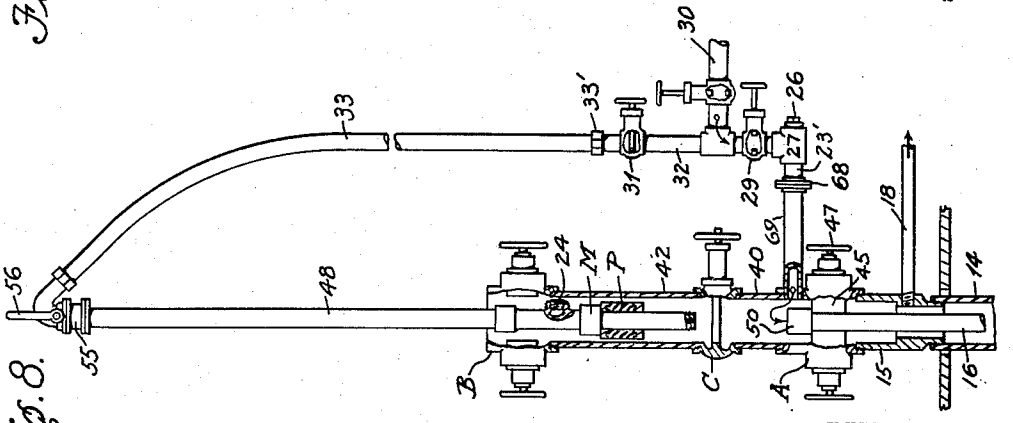

Fig. 8.

Fig. 11.

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Patented Apr. 5, 1932 1,852,717

UNITED STATES PATENT OFFICE

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GAS LIFT APPLIANCE FOR OIL WELLS

Application filed September 8, 1930. Serial No. 480,328.

This invention relates to devices for lowering tubing in oil wells and especially in wells which are being flowed by the well known gas-lift method.

The principal object of the invention is to provide a method and a structure whereby the tubing may be lowered in a gas-lift well to a lower level during and simultaneously with introduction of the high pressure gas which is being employed to flow the well. Thus no opportunity can be afforded for "losing" the well, i. e., total or material loss of natural flow of oil from the formation into the well hole, as sometimes happens when the circulation of gas is interrupted for a period of time sufficient to lower the tubing.

It is common practice to recover oil from deep wells by the introduction of high pressure gas into the well either through the casing or through a central flow tubing in such fashion that the gas in its passage around the lower end of the tubing picks up the oil, atomizes it and carries it to the surface. When first placing a well on gas lift, the oil initially stands much higher in the well than is desired for subsequent flow. Often the available gas pressure is sufficient to overcome the resultant head. Many times, however, this head is so great that it cannot be overcome and the oil body wholly discharged with the available gas pressure if the tubing be initially lowered to the required depth. In some such instances it has been possible first to flow out as much of the head standing in the well as the available gas pressure would discharge, then remove the gas connection to gain access to the tubing thereby resulting in loss of gas pressure to the well, then lower the tubing to a greater depth, and finally restore gas circulation before the formation pressure succeeded in building up the head to such a value that it could not be overcome. However in most cases the natural flow of oil into the well is too rapid for such procedure to be followed. Another practice has been to employ suitable valves for holding pressure on the well while lowering the tubing, but since no means had ever been devised whereby the circulation of gas could be continued during the lowering operation, the flow of the well was necessarily interrupted. The usual result of this method was that the well sanded up, or caved in, or for some other reason had its physical condition so affected that upon restoring gas circulation after lowering the tubing it was found that the production of the well was very seriously and permanently impaired.

In view of these facts it has been a desideratum ever since the gas-lift method of flowing wells became popular, to devise some safe, practical and adequate means for lowering the tubing in the well to greater depths while maintaining the flow by gas-lift, in order that the oil head could be discharged simultaneously with the lowering of the tubing.

Not only is it an object of the invention to provide for maintenance of well flow during tubing lowering operations, but it is also an object to provide a mechanism of a nature such that the equipment required for normal flow of a well shall be comparatively simple and such that substantially all special equipment required for the lowering operations, especially expensive pieces, may be completely removable in order that it may be used at other locations.

The invention includes a method and means whereby the circulation of high pressure gas may be positively maintained in a gas-lift well simultaneously with and during all operations of lowering tubing to deeper operating levels. The lowering operation consists in introducing additional lengths of tubing into the well, and is accomplished through the medium of an assembly of valves and suitable gas-supplying connections. A preferred apparatus required by the present invention to be used on a well in which it is intended to maintain circulation of the high pressure gas during the tubing lowering (or raising) operations, comprises primarily certain permanent equipment, certain normal equipment used in normally flowing the well and removable to permit tubing lowering operations, and certain temporary equipment required for lowering the tubing. The inven-

tion is concerned chiefly with the temporary equipment and the removable normal equipment, although the permanent equipment enters into the complete operative combination.

Said preferred apparatus includes a temporary valved manifold in combination with a much smaller removable manifold adapted to be passed through the temporary manifold. Said temporary manifold is normally completely removed from the well while the smaller manifold normally is attached to the well. Said smaller manifold is in the form of a special fitting which has two gas inlets in its upper portion and has its lower end normally connected with the well tubing to supply high pressure gas to the well. One of the gas inlets to this fitting is provided at its side for the normal introduction of the gas, and the other inlet which contains a check valve or its equivalent is provided at the top of the fitting for temporary introduction of the gas past said valve during a period of preparation for removal of the fitting, the side inlet being closed during such period. The fitting is to be removed from the well during tubing lowering operations and to be restored after completion of such operations. The temporary valved manifold is designed to be secured to the casinghead and comprises a plurality of aligned valves and two inlet connections for supplying gas. When properly positioned, said manifold is adapted to permit the removal of the special fitting successively through its assembled valves while simultaneously maintaining gas-lift, and then to permit the lowering of additional tubing through said valves into the well with continued maintenance of gas-lift. The two gas connections of the manifold serve for selectively introducing gas during these various steps. One of said connections is positioned to supply gas to the side of the valve assembly just above the lower valve. The other gas connection includes a hollow gas-conducting lowering stem adapted to be projected through the valves of the manifold and also adapted for engaging and handling the special fitting and the tubing sections being added.

The upper and lower valves of the assembly preferably are of the ram type, i. e. one wherein two opposed packing jaws are provided to be closed about the tubing and make a gas-tight joint. For convenience of distinction, these ram-type valves will usually be designated merely as "rams". This type of valve makes it convenient to support the entire tubing string on its jaws through the medium of the uppermost coupling. A third valve, such as a gate valve, is disposed between the rams to completely close the assembly and cut off gas passage at various stages. The hollow lowering stem, which is conveniently a joint of tubing of the same diameter as the normal well tubing, is adapted to be slipped through the rams in raising (or lowering) tubing, and hence may be considered variously as a "slip joint" or a "lowering joint" or a "lowering stem". For convenience of reference the last term will usually be employed hereinafter. In order that this stem may be properly handled it is conveniently carried by a suitably suspended swivel to which the high pressure gas may be supplied by such means as a hose. The special fitting is substantially in the form of a T and is normally mounted upon the upper end of a hollow landing mandrel which conducts gas to the well tubing and serves in conjunction with a packer to support the tubing in the casing head.

In using this equipment the valve assembly is first suspended in alignment with the well casing. Then the lowering stem is passed down through the open valves of the assembly and is threaded tightly into the upper end of the special T fitting. Then gas is turned into the stem. By means of a special wrench hereinafter described, a temporary plug is placed in the inlet hub in the side of the fitting, thus causing gas introduction to the fitting to proceed solely by way of the swivel and lowering stem. The normal gas connection to said inlet hub is then removed. The valve assembly is next lowered over the T fitting and secured in position upon the casing head, and a temporary gas connection to the valve assembly is made at a point slightly above the lower ram for the purpose of serving in lieu of the normal gas connection previously removed. The upper ram is then closed about the stem to form a gas-and-oil tight joint. Through the medium of the lowering stem the fitting, the landing mandrel and the suspended tubing are then elevated within the valve assembly to raise the uppermost tubing coupling slightly above the jaws of the lower ram. This ram is then closed about the tubing and the tubing is suspended from the jaws thereof through the simple expedient of resting or "landing" said coupling upon said jaws. The stem is then rotated reversely to loosen the landing mandrel from the coupling. Then gas is turned into the assembly through said temporary connection and cut off from the stem. The T fitting and the landing mandrel and its packer are next removed, the rams, the gate valve and certain valves necessarily employed in said connections being properly manipulated to prevent escape of gas. A new length of tubing is now threaded onto the lowering stem, said tubing length is introduced into the assembly by proper manipulation of the gate valve and rams, gas is turned into said stem and tubing length, the latter is threaded into the suspended tubing, gas is cut off from the temporary connection, and

the tubing length is then lowered through the assembly by appropriate manipulation of said valves and rams. Repetition of these operations permits the introduction of as much tubing as desired. Similarly tubing may be removed from the well. By a reversal of the preliminary operations, the T fitting together with the landing mandrel and its packer may be restored, and the entire manifold removed for subsequent use in other locations. Also, the flow of the well may be reversed, that is, the oil may be discharged through the connections above described as gas connections, the gas being introduced into the space between the casing and tubing by way of a line through which the oil is to be discharged by the method above described.

Considered in the light of the above disclosure, the invention may be broadly stated as comprising a special removable fitting normally mounted on a gas-lift well to supply gas thereto, in combination with a multiple-valve assembly adapted to be temporarily mounted upon the well about said fitting, and also adapted to permit the removal of said fitting therethrough and the introduction (or removal) of tubing therethrough, the assembly having gas connections for maintaining gas circulation to the well during all operations of removing the fitting and introducing (or removing) tubing. Otherwise stated the invention comprises the combination of a small removable manifold to be normally connected with a gas lift well, in combination with a large temporary valved manifold having suitable gas connections and provided with an assembly of valves through which the small manifold may be removed.

The invention also comprises a combination as above stated wherein the special fitting has two gas inlets, one at the side of the fitting for normal gas introduction and the other at the top of the fitting for temporary gas introduction. The invention further comprises a combination of said special fitting and its two gas inlets, with the temporary valved assembly and its two gas connections, wherein one of said connections serves to supply gas to the lower portion of the assembly during certain intervals including the period of removal of the fitting, and wherein the other connection serves to supply gas through the lowering stem during other intervals particularly while the stem is attached to the fitting for removal thereof and also when attached to additional tubing sections being lowered into the well.

The special fitting or small manifold per se having means for attaching it for normal well flow and having two gas inlets, especially where one inlet is provided with a valve, also constitutes a portion of the invention, as does the temporary manifold per se which comprises the three-valve assembly and the two gas connections including the lowering stem.

The invention also includes the method comprising the placing of the temporary manifold, the removal of the fitting with appropriate manipulation of valves, and the introduction of tubing with appropriate valve manipulation.

In the accompanying drawings wherein one embodiment of the invention is disclosed by way of illustration,

Fig. 1 is a sectional elevation showing the complete apparatus required for flowing the well, and also indicating above the break the temporary equipment in proper alignment for lowering into operative position when preparing to lower tubing in accordance with the present invention;

Fig. 2 is a longitudinal section through a special type of wrench used in placing and removing a plug from the special T fitting of the normal equipment, this wrench being shown in alignment with the parts of Fig. 1 upon which it is to be employed;

Fig. 3 is a cross section taken approximately on the line 3—3 of Fig. 1;

Fig. 4 is a sectional detail showing the removable plug mounted in operative position on the special T fitting of the normal equipment;

Fig. 5 is a sectional detail of a check valve used at the head of said T;

Fig. 5*a* is a sectional detail of a modified form of check valve which may be unseated when desired to reverse the flow of the well;

Figs. 6 to 11 are sectional elevations diagrammatically illustrating the major successive steps of the procedure required in preparing a well for lowering tubing and in actually lowering said tubing; of these figures:

Fig. 6 illustrates the first stage following suspension of the valve assembly of the temporary equipment in alignment with the well, this figure indicating the attachment of the lowering stem or slip joint to the special T of the normal equipment, the introduction of gas to the well by way of said stem, the placing of a plug in the hub on the side of the special T and the removal of the normal gas supply connection to said T;

Fig. 7 shows the temporary valve assembly in position on the casinghead and indicates the elevation of said T and the normal tubing suspending means to a point above the lowermost ram; this figure also indicates the landing of the uppermost tubing coupling on said lowermost ram for suspension of the tubing therefrom; a temporary gas supply connection leading to the lowering stem is also shown;

Fig. 8 shows the T and packer of the normal equipment disconnected from the tubing and in position for removal; this figure also illustrates the positioning of the gas control valves to supply the upper open end of the tubing with gas through a second temporary gas connection to the lower ram instead of

by way of the lowering stem which is about to be removed;

Fig. 9 indicates the position of a new length of tubing as it is about to be threaded into the tubing string supported from the lower ram;

Fig. 10 indicates the relation of the parts as the tubing is actually being lowered with the new section attached; and

Fig. 11 is a detail indicating the closing of the lower ram against the new tubing length while gas is being circulated through said new tubing length, in order that the new tubing collar may be passed through the upper ram.

Fig. 1 discloses substantially the entire physical structure required both for normal gas-lift flow of a well and for lowering tubing into the well while maintaining flow, the only additional part required being the plug of Fig. 4. In Fig. 1 the portions attached to the casing and below the hose constitute the normal equipment required for normal gas-lift operation of a well, while those portions suspended thereabove and including the hose are those which constitute the temporary equipment used to prepare the well for lowering tubing and the actually lowering such tubing. The elevated parts are shown in their vertically aligned position required preliminary to mounting the valve assembly on the casing in preparation for tubing lowering operations.

The permanent equipment consists of a special casinghead 15 mounted upon the upper end of the well casing 14 into which the tubing 16 depends. A connection 18 leading from the head 15 serves for discharge of the oil produced when gas is being supplied through the tubing 16. The normal flowing equipment comprises a landing or suspending mandrel M adapted to be supported on a metal and rubber packer P seated in head 15. The mandrel M carries a small manifold in the form of a special T fitting T fixedly secured thereto as by means of a threaded and welded joint indicated at 19. Obviously the T T could be integral with the mandrel M. The upper end of the T T is internally threaded to receive a check valve assembly 20 and may be externally threaded to receive normally a valve and gauge assembly 21 or the like. Said T T is also provided with a laterally extending hub 22 externally threaded to receive a pipe connection 23 and internally threaded to receive a plug 24 as seen in Fig. 4. A gate valve 25 is mounted in the pipe 23 in alignment with the hub 22 and with a removable closure plug 26 carried in a T 27 which is connected with valve 25 by the sections 23′ of line 23. T 27 also receives a gas connection 28 which contains a valve 29 to control the flow of high pressure gas from a gas main 30 to the well by way of said connection 23, 23′. Above the valve 29 a second gas control valve 31 is mounted in a connection 32 for the purpose of supplying said high pressure gas to a hose 33 when desired. When these parts and the valves just described are in the position shown in Fig. 1 the well may be flowed by normal gas-lift, the gas being introduced into the tubing 16 by way of valve 29, and the gas and oil being recovered from the outlet 18. The valve and pressure gauge assembly 21 may be employed or not as desired.

The temporary equipment, that is the mechanism which is employed for lowering tubing, is shown suspended in alignment with the T T and consists primarily of a portable manifold comprising a valve assembly having two packing valves or rams A and B and a gate valve C appropriately connected by short lengths of pipe 40 and 42. The valve C is a well known type of gate valve whose gate is adapted to be projected across the body of the valve to intercept the flow of gas or oil. The rams A and B also are of a well known type, each having guideways which slidably receive a pair of massive jaws 45 provided with suitable packing material 46 and adapted to be manipulated through the medium of hand screws 47. They may however be operated hydraulically or otherwise as desired. The opposing faces of the jaws 45 have passages which are semi-circular with respect to a vertical axis (Fig. 3) in order that they may be closed tightly against a section of tubing 16, 16′ or against the tubing lowering stem 48 which in practice also is a section of tubing of the same diameter as the flow tubing 16. This stem 48 is adapted to be threaded into couplings or collars 50 carried by the tubing 16 and also into similar threads indicated at 52 in the upper end of the T fitting T. Said stem 48 is carried by a swivel 55 from which it depends, this swivel having connection with the hose 33 and being supported from a bail 56 by means of a hook and cable or the like supported in the derrick of the well.

Operation

In preparing for lowering tubing, the check valve 20 having been placed originally or as hereinafter described, the valve and pressure gauge assembly 21 will be removed, and the special three valve assembly ABC will be aligned directly above the T T as shown in said Fig. 1, any suitable scaffolding S or the like being employed for the purpose. The lowering stem 48 is then passed downward through the wide open valves A, B and C and its lower end is threaded to the threads 52 in the upper end of the T T. A sufficiently tight joint is made to insure that subsequent reverse rotation of the stem 48 will cause the T T and landing mandrel M to be unthreaded from the upper coupling 50 on the tubing 16 suspended in the well rather than from the T. A spot weld may be resorted to if desired.

In practice each coupling or collar 50 is welded to the upper end of the respective tubing joint 16, thus insuring that the mandrel M will be unthreaded from said coupling rather than that the coupling will be unthreaded from the tubing. This preliminary positioning of the lowering stem 48 is indicated in Fig. 6. During these operations gas-lift flow of the well will have been maintained by introduction of gas from the main 30 past valve 29 and by way of line 23 into the T T, as under the normal conditions indicated in Fig. 1. Loss of gas from the upper end of the T T will have been prevented by check valve 20. Having threaded the stem 48 into the T T, the next step is to route the flow of gas to said T by way of the hose 33 and stem 48. This is accomplished by threading the connecting nut 33′ of the hose 33 onto the nipple 31′ leading from the valve 31, opening said valve 31, and closing valve 29. The next step is to remove the connection 23 from the hub 22. To do this, it is necessary to install the plug 24 of Fig. 4 in the position shown in Fig. 6, that is to thread said plug into the internal right-hand threads 22′ of hub 22. Having closed the valve 29, this mounting of plug 24 is accomplished by first tightly threading the plug 24 by means of a left hand thread 24′ onto the left hand threaded receiving end 60 of the stem 62 of the special wrench 63 shown in Fig. 2, then closing the valve 25 in said connection 23, and removing the closure plug 26 from T 27. The threaded end 64 of the body of the wrench 63 is then turned into the T 27 by employing the same threads which retained the plug 26, thus again closing said T. The wrench 63 is suitably packed at 65 to retain gas pressure. Having now installed the wrench 63 in the T 27, the valve 25 is opened and the long wrench stem 62 is advanced to bring the plug 24 into engagement with its seat 22′. In order to equalize pressure behind said plug 24 during installation, the valve 29 may also be opened. Said plug 24 is now threaded tightly into seat 22 by rotating hand wheel 66, the left hand joint at 60 being automatically broken when said plug 24 is properly tightened. Continued rotation of the stem 62 releases it from the plug 24. Plug 24 now closes the opening in hub 22 and may therefore be considered the equivalent of a valve in said opening. The valve 29 is now closed, so that the positions of the valves and the flow of the gas is that indicated in Fig. 6. The next step is to remove the wrench 63, replace the plug 26, break the flange joint 68 and remove the connecting pipe 23 with its valve 25 from the hub 22 of T T. This places the equipment in the condition shown in Fig. 6 wherein the plug 24 closes the hub 22 and the well is being flowed by way of hose 33, stem 48 and T T. The scaffolding S is next removed and the valve assembly ABC lowered, over the T T and into position upon the upper end of the special casinghead 15, whereupon said valve assembly ABC is rotated to thread the base of the housing of ram A into operative position upon said head 15.

The next step is the removal of the T T and the landing mandrel M. If desired to supply gas to the well only intermittently as hereinafter described, a plug 67 will be placed to close a port in ram A as in Fig. 7. But if gas is to be supplied continuously, as preferred, it will be necessary to restore a gas supply connection by way of valve 29. This is accomplished simply by threading a short piece of pipe 69 into the port in the side of the ram A instead of plug 67, and connecting said pipe 69 to restore the flange joint 68, as in Fig. 8. It will be noted that, during all these operations and during normal flow of the well, a tight joint has been maintained in the head 15 through the medium of the packer P by reason of the fact that the entire weight of the tubing string 16 has been supported upon said packer by the enlarged head of the landing mandrel M, thereby firmly compressing the expansive portion of said packer P. To remove the T T, the jaws 45 of the upper ram B are closed against the lowering stem 48 as indicated in Fig. 7, in order to form a gas tight packing thereabout. Said stem 48 is now elevated to raise the T T, the landing mandrel M, the packer P, and the tubing string 16 with its uppermost coupling 50 up between the jaws 45 of the lower ram A and through the gate valve C a sufficient distance to bring the coupling 50 slightly above said jaws of ram A. The jaws of ram A are now tightly closed about the tubing 16 and below the coupling 50 to provide a gas tight joint. The stem 48 is then lowered sufficiently to allow the collar 50 to settle upon the upper edges of the jaws of said ram A, thereby suspending the weight of the tubing upon said ram. The next step is to rotate the stem 48 to cause the lower end of the landing mandrel M to be unthreaded from said coupling 50. This has previously been assured by the welded joint 19 and by the making of a sufficiently firm joint between the lower end of the stem 48 and the internal threaded seat 52 of the T T. As previously indicated spot welding may have been employed in the latter instance. The next step is to open the valve 29 in order that gas under pressure may be supplied by way of the T 27 and pipe connection 69 to a point in the ram A above its jaws 45, and thence into the open end of the tubing 16 supported on the ram A, as in Fig. 8. The valve 31 is then closed to cut off gas to the hose 33. The T T, the landing mandrel M and the packer P now freely suspended on the stem 48 are raised above the gate valve C which is then closed as shown in Fig. 8. Next, the jaws 45 of the upper ram B are moved into the open position of Fig. 8 and

the T T, mandrel M and packer P are withdrawn and removed from the stem 48.

Tubing lowering procedure

The tubing lowering mechanism is now in operative position and the well has been prepared for the tubing lowering operation which is as follows:

A new length of tubing 16′ (or if desired two or more lengths 16′ according to the accommodations of the derrick) will be attached to the lower end of the lowering stem 48 through the medium of a coupling 50′ fixed to the upper end of the section 16′, and the lower end of section 16′ will be passed through the ram B and into proximity with the closed gate valve C. Ram B is then closed to make a gas tight joint about the tubing section 16′ and the gate valve C is opened, thus placing all parts in the relation shown in Fig. 9 except as to the valve 31 which previously had been closed. This valve 31 now however is opened so as to permit gas circulation by way of the hose and the tubing section 16′. Thus as will be noted, there is a time when both valves 29 and 31 are open as in Fig. 9 to definitely assure against any interruption in gas flow. Thereupon valve 29 is closed and the tubing section 16′ is threaded into the coupling 50 supported on the jaws of ram A. The gas flow now is as indicated in Fig. 10. The next step is to lift the stem 48 and section 16′ slightly to relieve the jaws of ram A of the weight of the tubing string 16, whereupon the ram A is opened. This places all the valve members in the position shown in Fig. 10. The lowering stem 48 and section (or sections) 16′ are then lowered so that said section 16′ slips through the jaws of the upper ram B and this movement is continued to pass the coupling 50 through the jaws of ram A and to bring the coupling 50′ into proximity with the jaws of ram B. In order to pass the coupling 50′ through ram B it is necessary first to close the jaws of the ram A about the tubing section 16′ above the coupling 50 (see Fig. 11) so as to produce a gas and oil tight joint around said section 16′ and prevent the subsequent escape of gas and oil past ram B. Ram B may then be opened and the coupling 50′ passed therethrough. If more than one tubing section 16′ is to be lowered in this operation, said coupling 50′ will be passed downward into proximity with the jaws of ram A, and the passage of said coupling 50′ through ram A will be accomplished by a repetition of the operation just described.

This tubing section 16′ (or sections) having been lowered, the coupling 50′ on the upper end thereof will be rested upon the closed jaws of ram A and the stem 48 unthreaded from the coupling, the parts then all being in the position of Fig. 9 with the exception that the stem 48 instead of the tubing section 16′ will be extending through the ram B. The next step is to withdraw the stem 48 and attach a new section or sections of tubing 16′. This is accomplished by opening the valve 29 as in Fig. 9 in order to flow the gas through the connection 69 and into the open upper end of the tubing 16, 16′, raising the stem 48 above the gate valve C, closing the valves 31 to cut off gas to hose 33 and stem 48, closing gate valve C, and opening ram B so that the parts assume the position of Fig. 8. The stem 48 is then withdrawn through ram B and additional tubing sections 16′ are attached and lowered by repetition of the operations described.

It will be obvious that as the tubing is lowered, and since gas circulation is never interrupted, the flow of the well will be continuously maintained during the tubing lowering operation. Thus as rapidly as the lower end of the tubing is passed into the oil body in the well the gas flow will discharge the corresponding head. In this manner any amount of tubing lowering may be accomplished without any interference whatever with production.

The tubing having been lowered to the required level, it becomes necessary to restore the T, fitting T, mandrel M and packer P and to remove the valve assembly ABC in order that it may be employed on other wells. This is accomplished simply by a reversal of the steps indicated in Figs. 6, 7 and 8. Briefly stated these steps consist in attaching said T T, landing mandrel M and packer P to the lower end of lowering stem 48, introducing them through ram B above gate valve C as in Fig. 8, closing ram B as in Figs. 7 and 9, opening gate valve C, opening valve 31, closing valve 29, threading the lowering end of landing mandrel M into coupling 50′ as in Fig. 7, opening ram A and lowering the packer P into its seat in the head 15 as originally (see Fig. 6). The flange joint 68 is then broken, tubing connection 69 removed, the valve assembly ABC unthreaded and elevated into the position of Fig. 6. The next step is to restore the connection 23 and the valve 25 of Fig. 1, remove the plug 26, attach the wrench 63 to T 27, open valve 29 to balance pressure on opposite sides of the plug 24, remove plug 24 from the hub 22 of T T, withdraw the plug 24 behind the valve 25, close the valves 25 and 29, remove the wrench 63, replace the plug 26, open the valves 25 and 29, close the valve 31, and disconnect the stem 48 and the hose 33. The check valve 20 prevents loss of gas from the top of T fitting T.

The valve assembly ABC, the stem 48, swivel 55 and the hose 53 may be stored or transported for use at another location. If desired the gate valve 21 may be attached to the upper end of the T T, and if preferred not to leave the check valve 20 as a permanent

fixture, the wrench 63 may be employed to remove said check valve through the gate valve 21. In such event it will be necessary to employ a suitable fitting similar to the pipe section 23', T 27, connection 28 and valve 29 with a pressure balancing gas connection. Such fitting will be attached to said gate valve 21 to temporarily replace the gauge, the wrench 63 being connected with the T and the valve 21 performing the functions of valve 25. After removal of check valve 20, the gate valve 21 will become the permanent closure for the upper end of T fitting T. By a reversal of this operation the valve 20 may be installed in T T to permit removal of gate 21 when preparing a well for lowering tubing.

It is obvious that having restored the original connections the well may be reversed, i. e. gas will normally be introduced through the casing and the oil flowed out through the tubing. Similarly, if a well be flowing in such direction when it is desired to lower tubing, it will first be changed so as to introduce gas through the tubing and flow the oil out through the casing. However it would be possible to flow the oil continuously out through the tubing by employing a check valve in the T T so constructed that it may be made to pass gas and oil upward when the stem 48 is connected and may be made to prevent such passage when the stem is disconnected. Either an automatic valve operable by the stem so as to be opened by the stem when the stem is attached may be employed, or an unseating screw 100 shown in Fig. 5*a* may be turned down against the ball valve 20 to unseat the same after attachment of stem 48 in order to permit flow of oil through hose 33. The order of manipulation of the valves would be substantially the same as hereinbefore described to maintain continuous oil flow, the required gas being continuously injected through the line 18.

Intermittent introduction of gas is feasible in many cases. This can be accomplished by omitting line 69 and supplying gas only through hose 33 as indicated in Fig. 7. Under these conditions gate C and control valve 31 will be opened as much of the time as possible in order that gas may be injected during maximum intervals of time. In other words the gas injection will be continued up to the moment that the ram B is to be opened, and will be resumed as soon as the stem 48 or tubing section 16' has been introduced into ram B and the ram closed thereabout. Since this method of operation will provide for the introduction of gas during most of the total operating time and since gas is actually being introduced into the well during all those intervals when the tubing is being lowered into the oil body, this method of intermittent flowing will be adequate in the majority of cases. On the other hand it would be possible on some wells to omit the hose 33 and employ only the valve 29 and line 69 for gas introduction, the valve 29 being open during all those intervals when the ram A is closed, and valve 31 being closed at all times. When hose 33 is dispensed with, stem 48 would be solid or sealed against escape of gas therethrough.

It is to be observed that with the present apparatus tubing not only can be lowered but also can be as readily raised in a well to remove tubing lengths while continuing gas circulation and maintaining gas-lift flow. The only difference in operation will be that the tubing will be elevated through the rams instead of lowered and the rams will be manipulated to pass the couplings 50 upward instead of downward.

It should be understood that, while the packing rams A, B and the gate valve C are employed as possible means for accomplishing the corresponding functions, it would nevertheless be sufficient for the purposes of the invention to employ any serviceable type of valve as a substitute for the gate valve C, to use other types of packers in place of the rams. Such packer could for example be rubber bags or other inflatable or compressible devices which would serve to seal or pack the tubing. In the latter instance any substitute for the jaws of the lower ram as supporting means for suspended tubing, could be employed. It is also to be understood that the rams could be operated otherwise than manually. For instance they could be power operated by steam or gas pressure or by hydraulical pressure or electric motors.

It is also to be understood that the specific disclosures made herein are for the purpose of illustrating the invention and are not to be considered as limiting since many variations within the scope of the invention may be made readily by those skilled in the art.

We claim:

1. A manifold adapted for attachment to a gas-lift well comprising a member, one end thereof being provided with a check valve and being adapted to receive a tubing connection, the other end thereof being adapted to be mounted upon the well tubing, and a gas connection on said body adapted to receive a closure.

2. A manifold adapted to be attached to a gas-lift well comprising a member, a check valve in one end of the member adapted normally for the passage of fluid therethrough, a hollow handling stem, the said end of said member being also adapted for connection with the hollow handling stem, the other end of the member being adapted for attachment to a string of tubing, and a gas connection provided in the member, said connection being adapted to receive a closure.

3. A structure according to claim 2 wherein the check valve is provided with means for unseating the same.

4. A structure according to claim 2 in combination with a valve assembly adapted to be passed over said manifold into engagement with the casing of the well and adapted to pass the handling stem and to pack the same and fluid connection to said valve assembly.

5. A structure for moving tubing in a gas-lift well while supplying gas to flow the well comprising a normal manifold containing a plurality of valved fluid passages adapted to be attached to the well tubing and a temporary manifold comprising a valve assembly adapted to be attached to the well casing and axially aligned with said normal manifold, each manifold having a plurality of connections adapted for establishing communication with the tubing under various conditions, a hollow tubing handling stem adapted to be passed through the valve assembly into engagement with the normal manifold and to be packed by said valve assembly.

6. A structure adapted for moving tubing in gas-lift wells comprising a normal manifold and a temporary manifold, the normal manifold being adapted to be connected with the upper end of a tubing string and having a lateral connection and an upper connection, a check valve in said upper connection, the lateral connection being adapted to receive a closure, the temporary manifold comprising a valve assembly adapted to be mounted upon a well casing in position to surround the normal manifold, said assembly being adapted to pass the normal manifold and also to pass lengths of tubing, said temporary manifold also including a plurality of connections to establish communication with the tubing during various operations.

7. A structure according to claim 6 including a tubing-handling stem adapted to be passed through the valve assembly into engagement with the inner manifold, one of the gas connections of the temporary manifold leading to said stem.

8. A structure for lowering tubing in gas-lift wells while maintaining circulation comprising a pair of gas introducing manifolds, one of which is adapted to be temporarily connected with the well and the other of which is smaller and is adapted to be normally mounted on the well and to be removed through the one manifold, a tubing supporting mandrel adapted to suspend tubing in the well and carrying the smaller manifold, said smaller manifold having a valve at its upper end and a gas connection at its side, the temporary manifold comprising a valve assembly, a hollow tubing-handling stem, a gas connection to said tubing-handling stem and a second gas connection to the valve assembly, said valve assembly including upper and lower valve members adapted to receive and pack the stem, and an intermediate gas intercepting valve adapted when open to pass said stem, the tubing-handling stem being adapted to be passed through said valves to engage said smaller manifold and also to engage tubing suspended in the well, said second gas connection leading to a point between the lower valve member and the gas intercepting valve.

9. A device for gas-lift wells comprising a body adapted to be vertically disposed, the lower end of the body being adapted to be connected to tubing suspended in the well, the upper end of said body being adapted for engagement by a handling member, the side of the body being provided with a fluid supplying connection, said connection being adapted internally to receive a closure, a gas line attached to said connection, a T in said line, and a wrench adapted to be attached to said T in line with said gas connection, said wrench including a packing gland and a stem adapted to be projected through said gland into proximity with said connection, said stem being adapted to receive a closure for passing and removing the same in said connection.

10. In combination in a well structure, a well casing, a fluid conduit depending within said casing, means to support said conduit from said casing, a fitting secured to the upper end of said conduit, a fluid conducting line connected with the side of said fitting, a check valve in the upper end of said fitting, a hollow stem adapted to be connected with said upper end of the fitting beyond the check valve and a second fluid conducting line adapted to communicate with said stem whereby fluid may be introduced through both said fluid conducting lines simultaneously.

11. In a well structure for gas-lift wells, a well casing, a valve assembly mounted upon said casing, tubing depending within the casing, means to support said tubing, a fitting secured to the upper end of the tubing, a fluid connection at the side of the fitting, a valve in the upper end of the fitting, a stem having a fluid passage and adapted to be passed through and packed by said valve assembly and connected with the upper end of the fitting beyond the valve, and a fluid conducting line adapted for communication with the valve assembly and thence to the tubing.

12. A structure according to claim 11 wherein the fluid conducting line is carried by said stem.

13. A structure according to claim 11 wherein said fluid conducting line is connected directly with the valve assembly.

14. A structure for moving tubing in a flowing well comprising an assembly having a plurality of valves adapted to pass and pack tubing against escape of fluid, said assembly also including means to suspend tubing in the well, a stem adapted to be passed through

said assembly to engage and move the tubing, a casing head on which said assembly is mounted, a landing mandrel and packing means adapted to support tubing on said head, said mandrel being adapted to be engaged by the stem, a closure carried by the upper end of said mandrel and adapted to prevent the passage of fluid in at least one direction, and a fluid connection to said casing head and fluid connection to said suspended tubing.

15. A structure for moving tubing in a well casing during gas lift operations of said well comprising a valve assembly attached to the well casing, means for suspending said tubing axially with said valve assembly, a stem adapted to be passed through said valve assembly and packed thereby, said stem being adapted to be moved into engagement with said tubing, means for withdrawing fluid from said casing and means for introducing gas into the tubing for gas lift operation, said means comprising valves and conduits permitting gas introduction only into the tubing lowering stem and into said well tubing.

Signed at Los Angeles, in the county of Los Angeles, and State of California, this 6th day of August A. D. 1930.

SAMUEL H. GRINNELL.
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