May 23, 1933. S. H. GRINNELL ET AL 1,910,762

GAS LIFT APPARATUS

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Fig. 1.

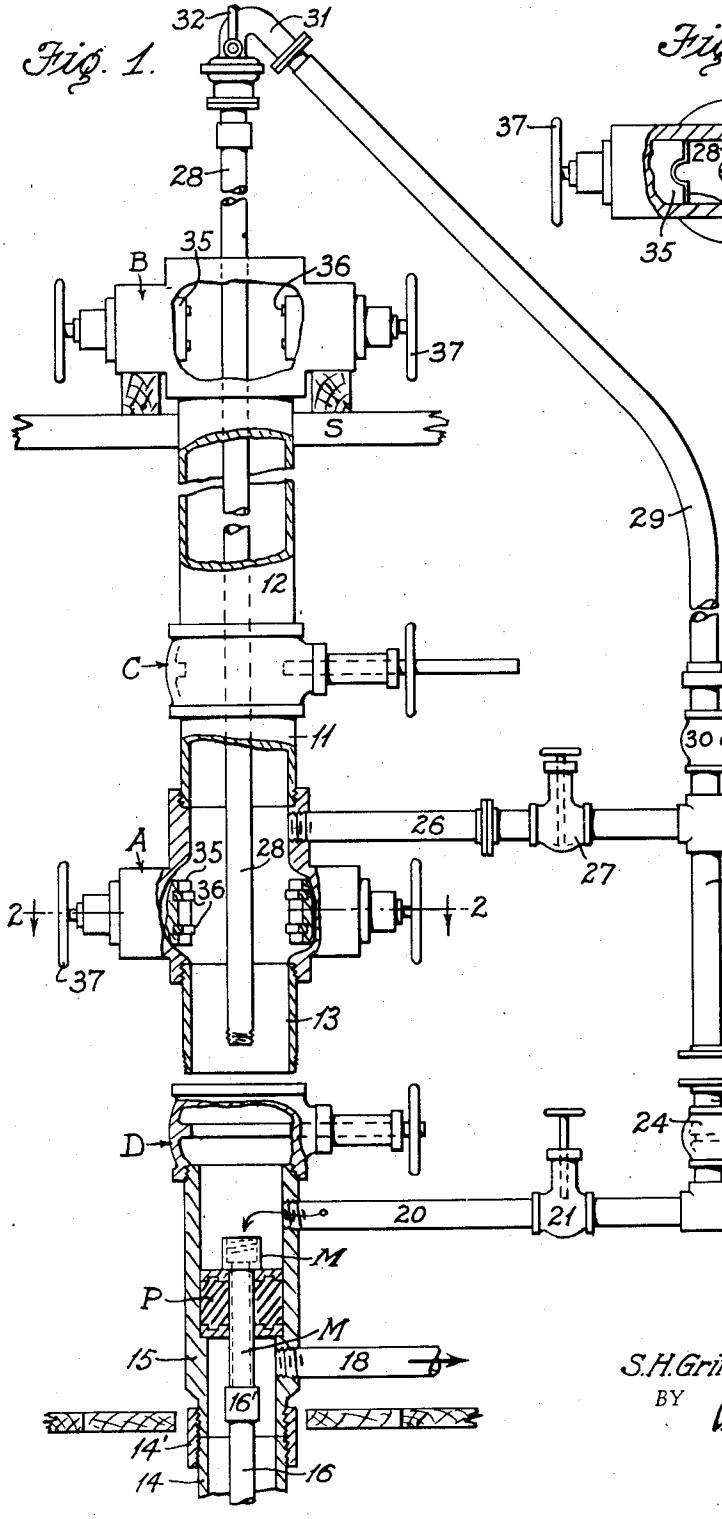
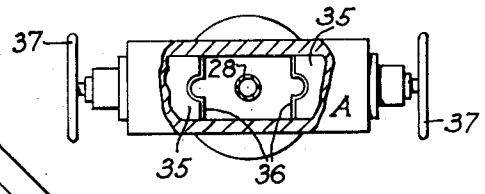



Fig. 2.




INVENTORS
S.H.Grinnell & A.C.Rubel
BY
Philip Hubkow
ATTORNEY

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GAS LIFT APPARATUS

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Fig. 6.

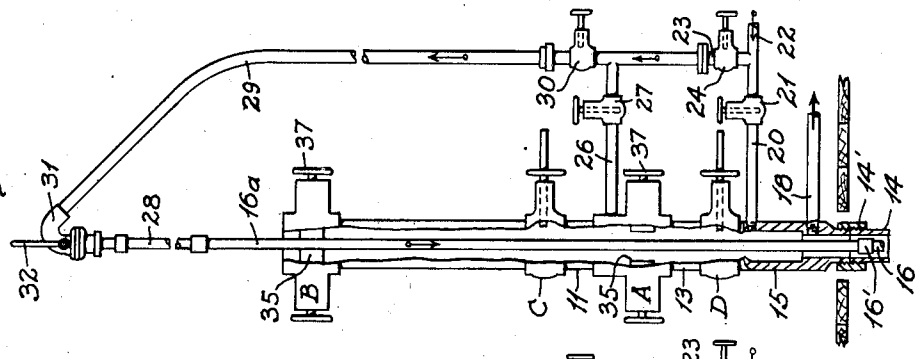


Fig. 5.

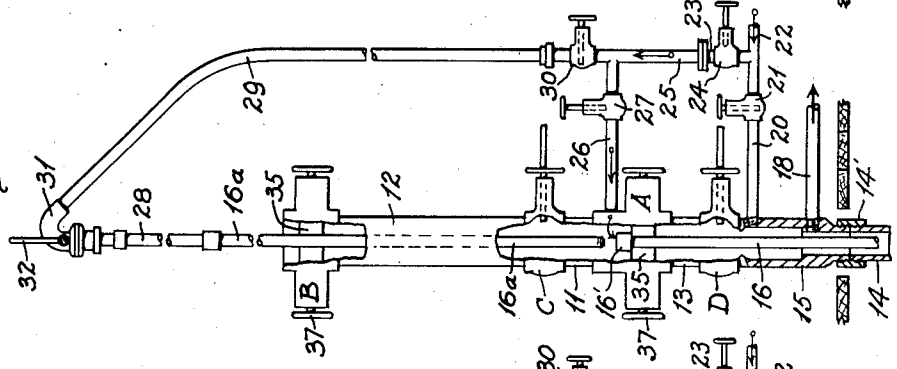


Fig. 4.

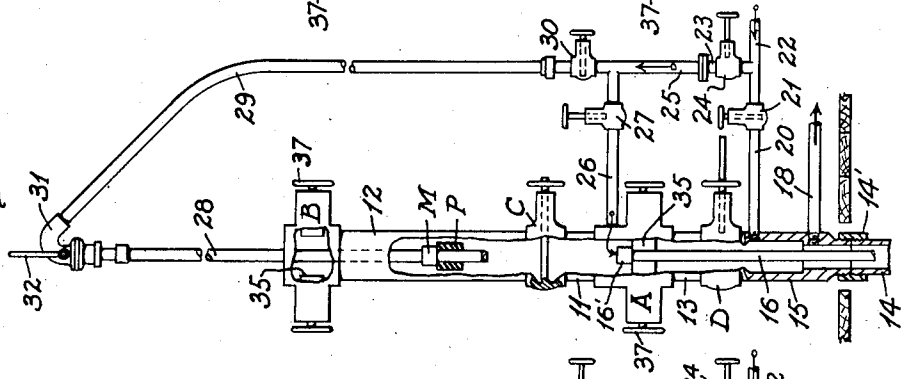
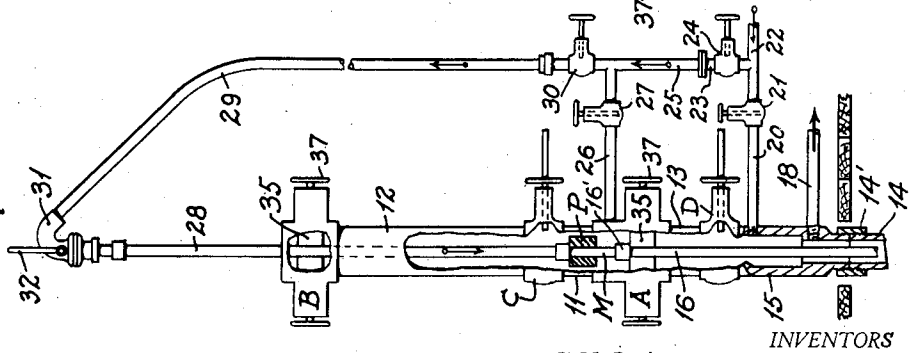


Fig. 3.



INVENTORS
S.H. Grinnell & A.C. Rubel
BY
Philip Sutkow
ATTORNEY

May 23, 1933. S. H. GRINNELL ET AL 1,910,762

GAS LIFT APPARATUS

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Fig. 7.

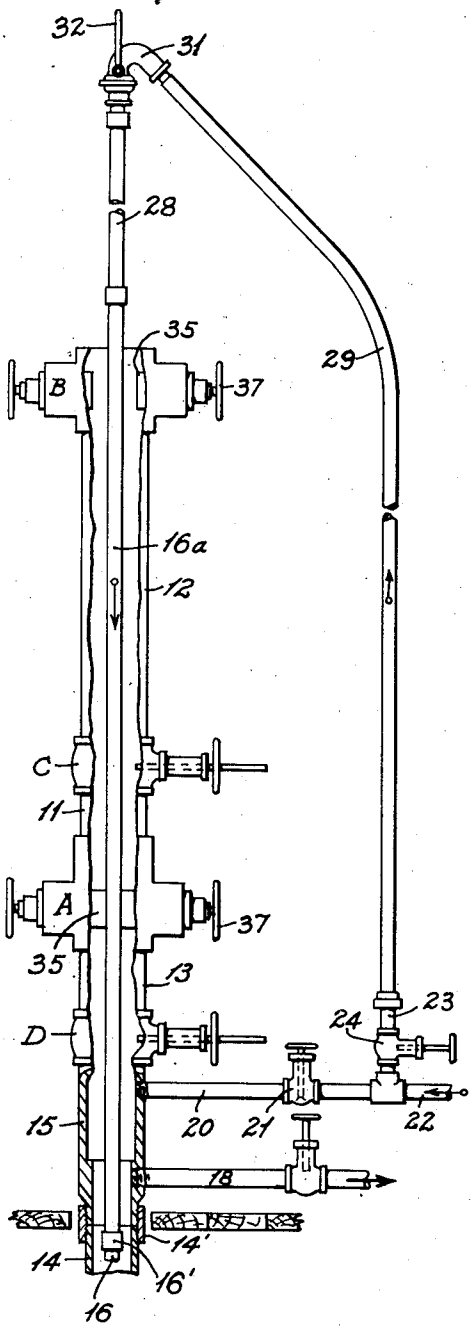
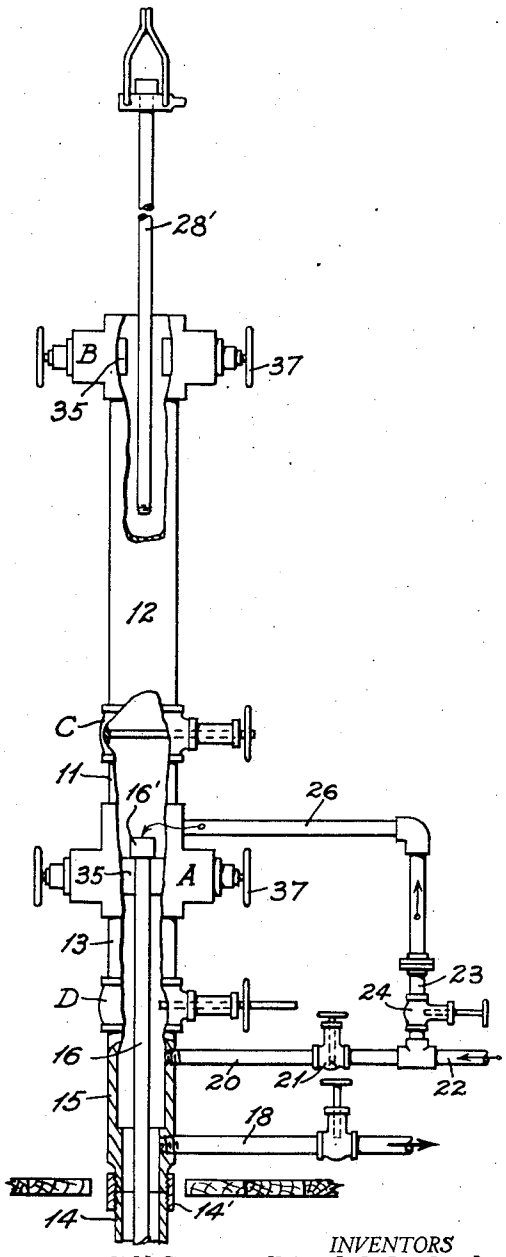



Fig. 8.




INVENTORS
S.H. Grinnell & A.C. Rubel
BY
Philip Subkow
ATTORNEY.

May 23, 1933. S. H. GRINNELL ET AL 1,910,762

GAS LIFT APPARATUS

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Fig. 9.

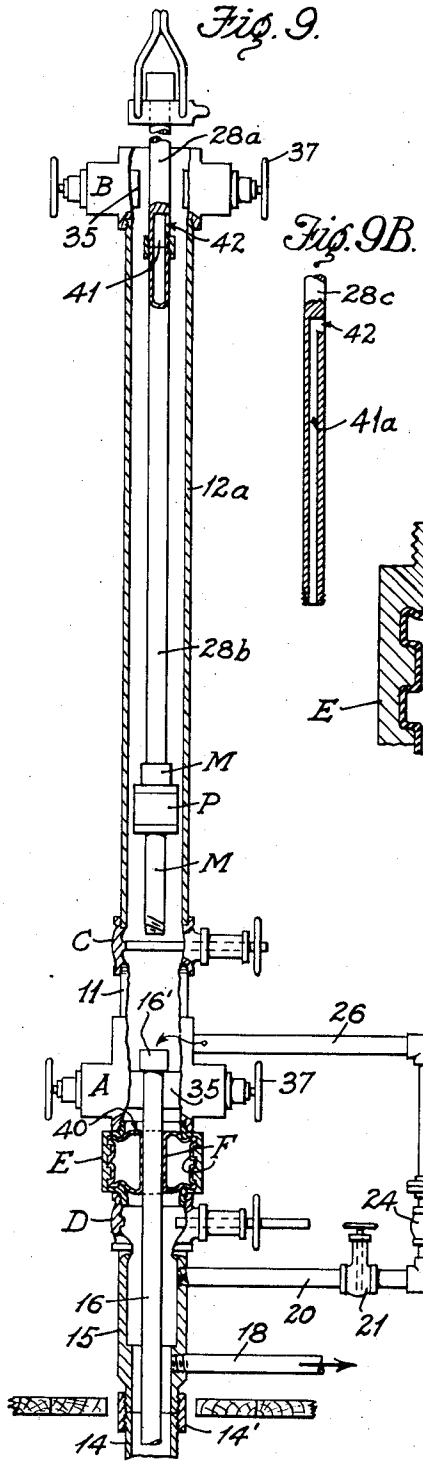



Fig. 9B.




Fig. 11.




Fig. 9A.

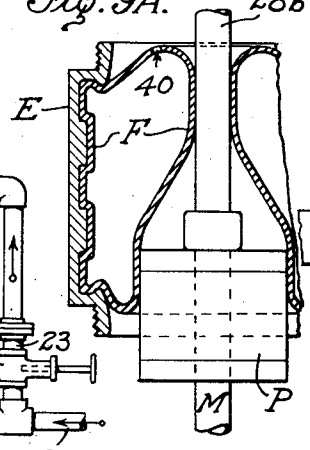
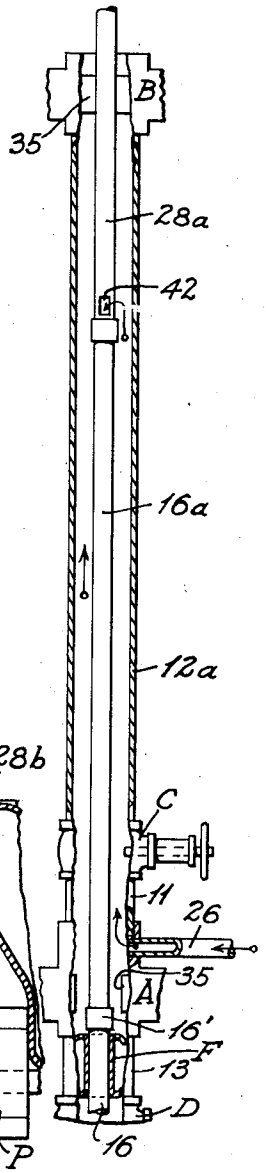



Fig. 10.




INVENTORS
S.H.Grinnell & A.C.Rubel
BY
Philip Schkow
ATTORNEY.

Patented May 23, 1933 1,910,762

# UNITED STATES PATENT OFFICE

SAMUEL HENRY GRINNELL AND ALBERT C. RUBEL, OF LOS ANGELES, CALIFORNIA, ASSIGNORS TO UNION OIL COMPANY OF CALIFORNIA, OF LOS ANGELES, CALIFORNIA, A CORPORATION OF CALIFORNIA

## GAS LIFT APPARATUS

Application filed March 8, 1932. Serial No. 597,516.

This invention relates to devices for lowering tubing in oil wells which are being flowed by the well known gas lift method, and constitutes an improvement over the structures shown in our co-pending applications Serial No. 480,327 of S. H. Grinnell, and Serial No. 480,328 of Grinnell and Rubel, both filed September 8, 1930, which have eventuated respectively into Patent No. 1,852,716 and 1,852,717, granted April 5, 1932.

In general the purpose of the invention is to produce a method and a structure whereby tubing may be lowered in a gas lift well during and simultaneously with either a continuous or intermittent introduction of the high pressure gas which is being employed to flow the well. Such operation of lowering tubing in conjunction with gas injection is required in order to insure against losing the well, that is against a total or material loss of the natural flow of oil from the oil producing formation into the bottom of the well, which loss sometimes happens when circulation of gas is interrupted for a period of time sufficient to lower the tubing.

The specific object of the invention is to provide a method and structure such that the tubing lowering operations may be carried on with a minimum of manipulative procedure, and such that a minimum of parts will be required as permanent equipment at the top of each well. According to the present disclosures only a comparatively simple casing head structure and valve therefor are required permanently, all other operative parts being in the form of an attachable and removable unit that may be transported for temporary use in various locations as required.

The common gas lift procedure for the recovery of oil from deep wells consists in the introduction of high pressure gas into the well either through the casing or through a central flow tube within the casing 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, and often the resultant head is so great that the available gas pressure is not sufficient to overcome the head and discharge the oil body if the tubing be initially lowered to the desired depth. Also, it often happens that, after a given period of gas lift, it becomes necessary or desirable to lower the tubing farther into the well to such a depth that the available gas pressure will not overcome the resultant head. The most desirable method and means for lowering tubing under these conditions has been found to be that which permits the introduction of gas either continuously or intermittently during tubing lowering operations so that gas lift may be maintained and the oil head may be discharged substantially as fast as the tubing is lowered.

The present invention, as above indicated, resides in means for conducting tubing lowering with a minimum of operations, and in means comprising a minimum of parts, particularly of those parts which are permanently attached to each well. The equipment employed comprises parts attached to the well casing as permanent equipment, and a manifold attachable thereto for tubing lowering operations and removable therefrom after the tubing has been lowered. In a preferred form the parts attached to the well casing as permanent equipment include only a special casing head for receiving a landing packer, a removable landing mandrel supporting said tubing on the packer, and a gate valve or the like mounted upon and closing the casing head. The usual gas supply connection is attached to the head above the packer and an oil discharge connection is attached to the head below the packer. In this preferred form the removable manifold comprises an assembly of three vertically aligned valves, of which the upper and lower valves are in the form of rams adapted to be closed about and pack or seal a length of tubing being passed through the assembly, the middle valve being a gate valve or the like adapted to completely cut off the flow of fluid when tubing or other passing parts have been removed from its path. The rams are adapted to be opened wide enough to pass the landing mandrel and its packer. The manifold

also comprises a hollow lowering stem adapted to be attached to tubing lengths to be passed through the valve assembly as hereinafter described, said manifold further comprising means for supplying gas either to the top of the hollow stem or directly to the side of the assembly at a point between the lower ram and the gate valve above it, or to both said stem and said point. This gas supply means is required because the normal gas supply connection to the special casing head must be closed upon removal of the packer from the casing head in preparation for lowering tubing. A gas conduit in the form of a valved hose connection is conveniently employed to supply gas to the stem and a valved pipe supplies gas directly to the side of the assembly. These conduits, by proper manipulation of their valves, are made to supply gas to the flow tube either continuously or intermittently as desired.

In order to avoid the repeated manipulation of gas valves, a modified form of structure employs a single gas connection to the valve assembly just above the lower ram, in conjunction with a closed or solid lowering stem having a gas by-passing duct at its lower extremity for passing gas from the interior of the assembly to tubing attached to the stem, and a special inflatable packer (or other appropriate valve which might be an other ram) is positioned just below said lower ram capable of passing tubing couplings and packers without material passage of gas. In this form the pipe section connecting the upper ram with the intermediate gate valve must be long enough to accommodate an entire length of tubing and also the lower portion of the lowering stem containing the gas-passing duct.

The invention therefore may be stated as including the combination of a casing head and valve arrangement constituting permanent equipment on the casing, and a removable manifold comprising an assembly of valves adapted to pass tubing through said casing head without loss of pressure, a lowering stem to cooperate with said assembly in passing tubing, and means to supply gas to said stem or to said assembly directly, or to both. The invention also resides in said removable assembly which comprises the upper and lower ram and intermediate gate valve connected as a unit and a single gas connection leading to the assembly and cooperating with a suitable by-pass connection for continuously supplying gas during both lowering and intermediate periods. The invention further includes the removable valve assembly comprising the upper and lower rams and intermediate gate valve, a single gas connection which leads directly to said assembly, and a closed lowering stem adapted to be passed into said assembly for the lowering of tubing and having a gas by-passing duct at its lower end to pass gas from the assembly through said duct into tubing to which the stem is attached. The invention also resides in the method of operating the equipment and its various valves for the purpose of lowering tubing while maintaining gas lift.

In the accompanying drawings wherein certain embodiments of the invention are disclosed for the purpose of illustration,

Fig. 1 is a sectional elevation indicating the complete apparatus required both for flowing the well normally and for lowering tubing during flow, the break above the lower gate valve indicating the dividing line between the permanent and temporary equipment;

Fig. 2 is a cross section taken approximately on the line 2—2 of Fig. 1;

Figs. 3 to 8 indicate successive operations, Figs. 7 and 8 also showing slight modifications of gas supplying connections; of these figures;

Fig. 3 is a vertical sectional elevation showing more or less diagrammatically one of the steps in removing the landing packer and landing mandrel while maintaining gas circulation through the lowering stem and preparatory to introduction of additional lengths of tubing, the normal gas supply conduit having been closed, the upper packing ram being closed about the lowering stem to prevent loss of gas, and the suspended string of tubing being landed on the lower packing ram;

Fig. 4 is a similar view showing the landing mandrel and its packing disconnected from the string of tubing and in an elevated position above the intermediate gate valve which has been closed to retain the gas pressure (now being applied to the tubing by a lateral connection) and to permit the removal of the landing mandrel and its packer through the upper ram;

Fig. 5 is a similar view showing a new section of tubing attached to the lowering stem and in position about to be threaded into the tubing suspended on the lower ram, the upper ram being closed; the upper gas control valve will be opened to introduce gas through the lowering stem following the attachment of the latter to the suspended tubing, and the lower gas control valve will be closed before opening the lower ram in order to prevent introduction of high pressure gas into the annular oil chamber below the ram;

Fig. 6 illustrates the position of the valves while lowering a collar or coupling through the lower ram and slipping the new tubing section through the upper ram, the lower gas control valve being now closed to prevent the passage of gas into the annular oil chamber below the ram;

Fig. 7 discloses both a succeeding position in which the lower ram is closed and the up-

per ram is opened to permit the coupling at the upper end of the section being lowered to enter the assembly; this figure also disclosing the use of a gas connection to the lowering stem only, whereby gas will be supplied to the well intermittently and only during those periods when the stem and tubing length being introduced are in the position of Fig. 5 or are attached to the tubing string in order to lower the latter;

Fig. 8 shows a further modification in which a solid or closed lowering stem is employed and a single gas connection is employed during lowering operations, which connection leads to the upper side of the lower ram and is adapted for supplying gas to the depending string of tubing only during those intervals when the tubing is landed on the lower ram and the intermediate gate valve is closed;

Fig. 9 discloses a still further modification employing a single connection and a by-passing expedient for supplying gas continuously during tubing lowering operations, the by-pass being shown as a gas duct in the lower end of a solid or closed lowering stem;

Fig. 9A is a vertical sectional detail of a special inflatable packer used in the construction of Fig. 9 below the lower ram and above the permanent gate valve, this figure indicating the form which the packer takes in passing tubing and the solid landing packer;

Fig. 9B shows a detail of a modified form of lowering stem for the structure of Fig. 9;

Fig. 10 is a view indicating the lowering operation after attachment of a new tubing length and the lowering stem of Fig. 9 to the suspended tubing; and

Fig. 11 is a vertical sectional detail of the inflatable packer construction.

Referring to the form of Figs. 1 to 6, the entire physical structure required for operation is shown in detail in Fig. 1 wherein that portion which is required on the well as a permanent fixture employed in conjunction with normal gas lift is shown as mounted upon the well casing 14, and that portion which is attachable for the purpose of conducting tubing lowering operations, and is removable thereafter is shown as elevated somewhat above the permanent portions. The removable tubing lowering assembly comprises a lower massive valve A of the ram type and a similar upper valve B, ram A being connected by means of a short nipple 11 to a gate valve C which in turn is connected by means of an elongated nipple or section of pipe 12 with the upper ram B. These parts are shown as mounted upon a suitable support S in position ready to be lowered for attachment to the permanent fixtures on the well, the lower side of the ram A being provided with a connecting nipple 13 for purposes of such connection.

The permanent structure comprises a gate valve D flanged or internally threaded on its upper side to receive the nipple 13, and mounted at its lower side upon the upper end of a special casing head 15 in turn mounted upon the casing 14 in any suitable manner such as by the coupling 14′ shown. The head 15 is internally provided with a seat for a landing packer P which supports the head of a landing mandrel M whose lower end projects through the packer P and is threaded into the coupling 16′ on the upper end of the suspended flow tubing 16 depending within the well. Below the packer P a connection 18 is provided on the head 15 for the discharge of the oil being produced by gas lift, and above the packer P a gas supply line 20 is connected to the head 15 for normally supplying gas to flow the oil. The line 20 receives its gas supply by way of a control valve 21 from a gas main 22. The gas main 22 is provided with a permanently mounted lateral connection 23 controlled by a normally closed valve 24.

When the valve assembly A, B, C is lowered for connection of the nipple 13 to the gate valve D, the gas connection 23 is connected through the medium of flanges or other suitable joint to a gas connection 25 having two branches 26 and 29 whereby gas may be distributed directly to the assembly by way of a gas conduit 26 leading to the upper flange of the ram A and controlled by valve 27, and whereby gas may be supplied directly to a hollow lowering stem 28 by way of hose connection 29 controlled by valve 30, said hose 29 leading to a swivel 31 which is supported from the derrick top as by means of a bail 32 and in turn supports said stem 28.

The hollow lowering stem 28, which is conveniently a length of ordinary tubing such as the flow tubing 16, is adapted to be passed downward through the valve assembly, A, B, C and to be threaded into the head of the mandrel M and also into couplings 16′ of flow tubing 16 or of lengths of tubing 16*a* to be subsequently lowered into the well. The rams A and B are provided with heavy jaws 35 which are recessed at their inner ends to engage the stem 28 and tubing lengths 16*a*, and are provided at said ends with packing material 36 in order to complete a seal about said stem and tubing lengths. These jaws 35 are reciprocable in horizontal guides through the medium of hand wheels 37 as shown, or hydraulically or otherwise. The construction of these rams is well known. As hereinafter described the lowering stem is passed to and from the assembly A, B, C and slid through the rams A and B in raising and lowering tubing lengths, and the gas control valves are variously manipulated according to the requirements of the various operations, the gas being continuously introduced into the well although being supplied by way of valves 27 and 30 alternately.

In the form of Fig. 7 the lateral gas connection 26 and its valve 27 are omitted and only the hose connection 29 is employed. As a consequence the connection 25 and valve 30 may also be omitted. In the form of Fig. 8 the hose connection to the stem 28 is omitted and only the lateral connection 26 is employed thereby permitting the use of valve 24 only as a control for this connection. In this instance the lowering stem 28′ is either closed or solid. By means of these modifications gas is introduced only intermittently at certain intervals.

In the form of Figs. 9 to 11 only the single gas connection 26 to the upper flange of the ram A is employed, but certain modifications are used which permit continuous introduction of gas to the flow tube 16. These modifications as shown consist in a special connecting nipple and packer E which replaces the connecting nipple 13 and contains an inflatable packing element F adapted to pass tubing 16, tubing couplings 16′, mandrel M and the solid landing packer P. Actuation of the inflatable flexible element F (which may be of rubber or the like) is automatically accomplished by the entrance of gas under pressure into the interior of the element F through a port or series of ports 40 on the upper side of said inflatable element F. In order that the gas pressure which is supplied by connection 26 to the interior of the assembly may be passed to the suspended tubing 16 when the lowering stem or a new tubing section 16*a* is attached to the suspended tubing 16, the lowering stem 28*a* is made either closed or solid and its lower end is provided with a gas-conducting or by-passing duct 41 which provides at one end a port 42 opening through the side of the stem into the assembly and at the other end a port or discharge communicating with the interior of the tubing to which the stem is connected. Thus gas will flow from the interior of the assembly through said duct 41 into tubing suspended from the stem.

However it is necessary that the pipe section 12*a* which joins the valves B and C be long enough to house both a tubing length 16 and the lower portion of the lowering stem 28*a* containing the duct 41. The duct 41 preferably is made as short as possible as indicated in Fig. 9 so that the length of section 12*a* may be reduced to a minimum. The reason for having section 12*a* of the indicated length is to avoid exposing the port 42 above the ram B at any time when the gate valve C is open. Otherwise gas would be lost through an attached tubing length 16 by way of said duct 41 and port 42. In order to use stem 28*a* for removing the landing mandrel M and its packer P without permitting port 42 to pass below the inflatable packer F into the oil discharge column, as more fully described hereinafter, it is necessary to interpose a short extension 28*b* in the form of a short length of tubing as shown in Fig. 9. However a special stem 28*c* such as shown in Fig. 9B may be temporarily substituted, this stem having its duct 41*a* sufficiently long that port 42 will be disposed above element F when engaged with mandrel M while still landed in head 15 on packer P; in this case the short stem extension 28*b* is not required.

*Operation*

The operations required for lowering tubing with the form of Figs. 1 to 6 are as follows, the discharge of oil taking place continuously through the discharge line 18 at all times.

With the permanent structure of the well in the position shown in Fig. 1 (that is with gate valve D closed, the tubing being suspended on the packer P by means of landing mandrel M, gas valve 21 being open and valve 24 closed), the assembly A, B, C is lowered into position and connected with valve D by threading the nipple 13 thereinto. Gas connection 25 is then attached to the connection 23 and the connection 26 is put in position. With the hose 29 connected to the lowering stem 28, and with the valves A, B, C open, said stem 28 is run into the assembly A, B, C and the ram B is closed about stem 28 to prevent future loss of gas. Gate valve D is then opened, valves 24 and 30 are opened to supply gas to the hose 29 and stem 28, valve 27 is closed to cut off gas through connection 26, and valve 21 is closed to prevent supply of gas to the normal flowing connection 20, said valve 21 remaining closed throughout all subsequent tubing lowering operations and valve 24 remaining open during all such operations. The well is now being flowed by gas passing through valves 24 and 30 and through hose 29 and lowering stem 28.

The next step is to force stem 28 down through the ram B into engagement with the head of mandrel M and to thread the lower end of the stem thereinto. Thereupon the stem is elevated through the medium of the bail 32 to lift the landing mandrel M, its landing packer P and the suspended tubing 16 upward to bring the mandrel and packer above the lower ram A, which is then closed about the tubing 16.

The parts are now in the position shown in Fig. 3. The uppermost coupling 16′ on the tubing 16 is then allowed to settle upon the jaws of the lower ram A and the lowering stem 28 is rotated by a wrench to cause the mandrel M to break joint with the coupling 16′ now landed on ram A. To insure that the joint between mandrel M and coupling 16′ will break, rather than the joint between stem 28 and the mandrel head, a tapered thread or mutilated thread in the mandrel head or other expedient will be employed

which will insure a sufficiently tighter joint in said mandrel head.

Having broken said joint, the stem 28 is elevated to raise the mandrel M and its packer P above the gate valve C into the connecting section 12, as in Fig. 4, whereupon gas valve 27 is opened in order to feed gas into the upper end of the tubing 16 by way of the connection 26. Vavle 30 is then closed and gate valve C is closed to cut off escape of gas and the upper ram B is opened wide enough to permit withdrawal of the packer P, said packer and mandrel M then being detached from the stem 28.

The next operation which is illustrated in Fig. 5 is to attach a new length of tubing 16*a* to the lowering stem 28 and insert this tubing length through the open jaws of ram B, which are then closed about the tubing. Gate valve C is next opened so that the end of the tubing length 16*a* may be moved into position for threading into the coupling 16′ on the tubing landed on the jaws of ram A.

The next step, as indicated in Fig. 6 is to open valve 30 to supply gas to stem 28 and tubing length 16*a* by way of hose 29. Valve 27 is then closed to cut off gas directly to the assembly, and tubing length 16*a* is threaded into the suspended coupling 16′. The jaws of the ram A are then opened and the suspended tubing is allowed to descend into the well by reason of its own weight until the coupling at the upper end of the new length 16*a* reaches the jaws of the ram B. Thereupon ram A is closed and ram B is opened, as in Fig. 7, and the lowering is continued until the coupling at the upper end of the new length is landed on ram A. Thereupon ram B is closed to retain gas pressure about to be released into the assembly, lowering stem 28 is unscrewed from the landed coupling, gas valve 27 is opened, gas valve 30 is closed, the stem is raised above the gate valve C which also is then closed, and ram B is opened.

The parts are now in the positions as indicated in both Figs. 4 and 8, and stem 28 is ready for the attachment of a new tubing length which will be lowered by a repetition of the above described operations. It is to be noted that tubing may be raised from a well and removed section by section with continuation of gas introduction, by substantially the same procedure followed in removing the mandrel and its packer, that is by a reversal of the procedure for lowering the tubing.

The constructions of Figs. 7 and 8 are employed in those cases where it is sufficient to introduce gas only intermittently during certain operations. According to Fig. 7 gas will be introduced only through the hose 29 and lowering stem 28, and according to Fig. 8 gas will be introduced only through the lateral connection 26 leading to the upper side of the ram A. In these instances the mandrel M and its packer P are removed as in the other form except that as soon as the mandrel and packer are raised above the gate valve C and the latter is closed the gas is cut off from the well and gas introduction will not be resumed until gate valve C is again opened. Meanwhile it is necessary to close the valve 24 to cut off gas from the hose 29 and lowering stem 28 while the ram B is opened and the landing mandrel and the packer are being detached and a new length of tubing 16*a* is being attached and returned through ram B. In the case of Fig. 8 gas is supplied by way of valve 24 and lateral connection 26 to the top of tubing 16 during all times when the coupling 16′ is landed on the jaws of the ram A and the lowering stem 28′ is at the same time unattached to said coupling 16′. Thus, ram B having been closed about said stem 28′ and gate valve C having been opened gas will continue to flow into the top of tubing 16 until said stem has been threaded into the landed coupling 16′, whereupon gas flow into the tubing automatically is cut off. Thereupon gas valve 24 is closed in order that no gas may be fed into the casing to interrupt the oil flow from line 18 after the jaws of ram A are opened. The lowering stem 28′ must necessarily be closed in order to prevent loss of pressure therethrough; it may be solid.

In the form of Figs. 9 and 10 provision is made for the continuous introduction of gas to the tubing 16 by way of a single gas line and for this purpose the lateral gas connection 26 alone is used, the valve 24 being continuously open and gas continuously passing through connection 26 after the removable lowering equipment has been attached and the valve 21 has been closed. Here the lowering equipment is attached to the permanent gate valve D through the medium of the special nipple E containing the inflatable yielding packing element F. Assuming that the tubing 16 is still landed on the solid packer P through the medium of the mandrel M, and that gas is still flowing through line 20 and valve 21, as in Fig. 1, (valve 24 not yet having been opened), the closed lowering stem 28*a* having its extension 28*b* attached is passed into the assembly, ram B is closed thereabout and said stem is readily forced downward through the open jaws of ram A and through the inflatable packer F into attachment with the mandrel. The valve 24 is next opened to pass gas to the assembly by way of a connection 26, and the valve 21 is closed to remain closed during all subsequent operations incidental to tubing lowering. The stem 28*a* is then elevated to lift the packer M out of its seat whereupon the excess pressure above the inflatable element F entering through the ports 40 causes the element F to be immediately inflated and sealed against the extension 28*b* and the packer P. The function of extension 28*b* is

to maintain port 42 above inflatable packer element F, so that, when landing packer M is lifted off its seat, pressures below packer F and within and without suspended tubing 16 cannot equalize through port 42 and stop oil flow up through casing 14 and out through discharge line 18 as would happen if port 42 were positioned below packer F when packer M is lifted. As indicated in Fig. 9 withdrawal is continued until the coupling 16′ on the upper end of the tubing 16 is in position to be landed upon the jaws of ram A. During this raising operation gas supplied through the connection 26 to the assembly will have been entering the tubing 16 through the passage 41 and port 42 in the lower end of the stem 28*a*, and will continue to enter by that route until mandrel M is disconnected, whereupon the gas will pass directly into the top of the tubing and will continue so to pass until a new tubing length 16*a* has been introduced and attached to the coupling 16′. Exactly the same procedure is followed in removing mandrel M and packer P when the stem 28*c* of Fig. 9B, is used in place of stem 28*a* and extension 28*b*. In that case the long duct 41*a* insures maintenance of port 42 above inflatable element F. When the mandrel M and packer P have been removed from the well, stem 28*a* is substituted and tubing lowering proceeds. The various operations of removing the mandrel and its packer and introducing new tubing lengths are identical with those of the forms of Figs. 1 to 8, the gate valve C being closed after withdrawal of the stem and mandrel, and the ram B being opened and closed to receive and seal a new tubing length 16*a* before gate valve C is again opened. With this construction the connecting section 12*a* between gate valve C and ram B is sufficiently long to completely house a tubing length 16*a* and the lower end of the stem 28*a* containing the passage 41 so that when ram B has been closed and gate valve C has been opened there can be no escape of gas through the lowering stem. Fig. 9 indicates this relation also, except that a new tubing section 16*a* will have been substituted for extension 28*b* and mandrel M in preparation for closing ram B and opening gate valve C. Fig. 10 shows a new section 16*a* attached to the previously landed coupling 16′ and the lowering of the tubing 16 and coupling through ram A. At this time the gas entering through connection 26 is passing into the tubing 16*a* and 16 by way of the port 42 and passage 41 in the lower end of said stem 28*a*. As the coupling 16′ passes through the inflatable packing element F the gas pressure above F, being in excess of the pressure of the discharging oil mixture below F, will maintain a seal about the tubing and the coupling as the coupling passes downward therethrough.

With this construction no manipulation of the valve 24 or of any other gas valve is required during the entire tubing lowering operations, and the attendants may devote their time exclusively to the manipulation of the rams A and B and the gate valve C and to the actual operations of lowering tubing and withdrawing the lowering stem.

In connection with all forms, when sufficient tubing has been lowered, the packer P and landing mandrel M will be returned by a reversal of the operations described for their removal. Also, it is obvious that tubing may be removed from a well while maintaining gas lift, by reversing the operations described for lowering.

It is to be understood that the disclosures made herein are merely illustrative and do not limit the invention inasmuch as many improvements may be made within the scope of the appended claims by those skilled in the art.

For example any type of packing device which will permit the passage of the landing packer P and coupling 16′ without passage of material quantities of high pressure gas may be employed as a substitute for the inflatable packer F which has been shown. Thus another ram may be sustituted, this being spaced from ram A only far enough to provide for receiving the mandrel M and packer P between the closed jaws of such two rams.

We claim:

1. An apparatus for lowering tubing in a gas lift well during gas lift comprising a permanent unit adapted to be mounted upon the well casing, and a removable unit adapted to be mounted on the permanent unit, the permanent unit comprising a casing head adapted to support and suspend flow tubing and a valve mounted on the casing head and adapted to be closed in order to close the top of the casing against loss of oil and gas when tubing is removed from the valve and to be opened to pass the tubing, and the removable unit comprising an assembly of a plurality of valves adapted to pass and pack tubing, a connection for supplying gas to the apparatus, and a tubing handling member adapted to be passed through the assembly into engagement with tubing suspended in line therewith.

2. A structure according to claim 1 wherein certain of the valves of the assembly are adapted to pack tubing extending therethrough and one of said valves is adapted to intercept flow of fluid when tubing is withdrawn from its path.

3. A structure according to claim 1 wherein the removable valve assembly comprises a lower ram, an upper ram and an intermediate gate valve.

4. A structure according to claim 1 wherein the valve assembly comprises an upper

valve for packing tubing, a lower valve for supporting and packing tubing and an intermediate valve for cutting off gas between the packing valves.

5. A construction according to claim 1 wherein the removable valve assembly comprises upper and lower valves for packing tubing and an intermediate valve for cutting off gas between the tubing packing valves, and the gas connection leads to the side of the assembly between the lower packing valve and the intermediate valve.

6. A structure according to claim 1 wherein the valve assembly comprises an upper and lower valve for packing tubing and an intermediate valve for cutting off gas between the packing valves and wherein the gas connection supplies gas to the tubing handling member.

7. A device for moving tubing in a gas lift well comprising an assembly of aligned valves adapted to pass tubing to and from the well and to pack the tubing, a fluid connection to said assembly for continuously passing fluid, and a stem adapted to engage the tubing to move the same, said stem having a fluid by-pass for by-passing fluid between the interior of the assembly and the tubing when the stem is connected with the tubing, the fluid passing directly between the top of the tubing and the fluid connection when the stem is disconnected.

8. A structure according to claim 7 wherein the by-pass is in the form of a duct in a lower portion of the stem leading from a port in the side of the stem to a port in the lower end of the stem.

9. An apparatus for lowering tubing in a gas lift well during gas lift comprising an assembly including means for suspending and packing tubing, means for passing gas into said assembly above the suspending means, means below the point of suspension for packing the tubing, and a lowering stem for engaging tubing landed on said suspending means, said stem having by-passing means for conducting gas from the assembly into said tubing.

10. A structure according to claim 9 wherein said by-passing means is in the form of a duct leading from the lower end of the lowering stem to a port at the side of the lowering stem adapted to communicate with the interior of the assembly.

11. A structure according to claim 9 wherein the assembly comprises a lower ram for suspending and packing the tubing, an upper ram for passing and packing the tubing and an intermediate valve for intercepting gas.

12. An apparatus for lowering tubing in a gas lift well during gas lift comprising an assembly adapted to be mounted upon a well and including means for passing, packing and suspending tubing, a single gas connection leading to the assembly, said packing means including means for continuously packing tubing below the gas connection, and means adapted to be connected with tubing for by-passing gas into the tubing from within the assembly.

13. An apparatus for lowering tubing in a gas lift well during gas lift comprising a removable assembly of valves adapted to be mounted upon the well comprising lower means for packing and suspending tubing, an upper valve for packing tubing, a single gas connection leading to the assembly above the suspending means, and means adapted to be passed through said assembly into engagement with the tubing and having a by-pass for passing gas into the tubing from within the assembly.

14. An apparatus according to claim 13 wherein the tubing-engaging means is in the form of a lowering stem having a duct leading from its lower end to a point at its side constituting the by-pass.

15. An apparatus according to claim 13 wherein the assembly includes a gas intercepting valve disposed between the upper and lower packing valves, and the tubing-engaging means is in the form of a lowering stem having a duct leading from its lower end to a port at its side.

16. An apparatus for lowering tubing in a gas lift well during gas lift comprising an assembly adapted to be removably mounted upon the well, a gas connection leading to the side of said assembly, said assembly comprising means positioned below said gas connection and adapted to suspend and to continuously pack tubing during both suspension and travel of tubing and tubing coupling, a tubing-packing valve at the top of said assembly, a gas-intercepting valve between said top valve and the gas connection, and a lowering stem for engaging suspended tubing, said stem having means for by-passing gas into the tubing when connected therewith.

17. An apparatus according to claim 16 wherein the gas by-passing means is in the form of a passage extending from the lower end of the lowering stem to a port in the side of said lowering stem at a point adapted to be maintained below the tubing-packing valve when the gas-intercepting valve is open.

18. A device for moving tubing in a gas lift well comprising an assembly of aligned valves adapted to pass tubing to and from the well and to pack the tubing, a fluid connection to said assembly for continuously passing the fluid, a stem adapted to engage the tubing to move the same, and packing means for the tubing located below the fluid connection to the assembly and adapted to be actuated by a differential between the pressures at its opposite sides.

19. An apparatus for lowering tubing in a gas lift well during gas lift comprising an assembly including means for suspending tubing, means for passing gas into the assembly above the suspending means, packing means below the point of suspension and actuable into packing relation by the differential between pressures on the opposite sides thereof, and a lowering stem for engaging tubing landed on the suspending means and for moving the tubing through said packing means.

20. A structure according to claim 19, wherein the lowering stem is provided with a by-pass for conducting gas from within the assembly into said tubing.

21. An apparatus for lowering tubing in a gas lift well during gas lift comprising an assembly adapted to be mounted upon a well and including means for passing, packing and suspending tubing, a single gas connection leading to the assembly above the suspending means, packing means positioned below the suspending means adapted to be actuated into packing relation by the differential of pressure between the pressures at the opposite sides of such packing means, and means adapted to be connected with the tubing for moving the same through the packer.

22. A method for lowering tubing in a well flowing by the gas lift method, the well carrying a casing head, a gas intercepting valve to close the top thereof, said tubing being suspended in said head upon a packer and gas being passed into the casing and into said tubing to flow the well, and an assembly of valves being mounted on said gas intercepting valve and including means to suspend and pack the tubing, comprising the steps of opening said gas intercepting valve, cutting off gas to said casing head, passing a tubing lowering stem into engagement with the landed tubing, lifting said tubing into said assembly, landing the tubing in said assembly, detaching the packer and lowering stem from said landed tubing, removing the packer and tubing from said assembly, passing gas into the tubing during certain of the above operations to flow the well, attaching a new tubing length to said stem, introducing said length into said assembly and packing the same therein, attaching said length to the landed tubing, passing gas through said stem and length into said tubing, lowering the tubing through said assembly, landing the new length in said assembly, detaching and withdrawing the stem, and passing gas through the new tubing length during certain periods to flow the well.

23. A method for lowering or raising tubing in a gas lift well in which tubing is suspended, comprising introducing or withdrawing a tubing length through an aligned assembly of valves adapted to pass and pack the tubing, attaching or removing said tubing length to or from the suspended tubing, intermittently lowering or raising the tubing, continuously supplying gas under pressure to said assembly, passing the gas directly to the suspended tubing when said tubing length is disconnected, and by-passing said gas from the assembly to said tubing length when connected with the suspended tubing, whereby gas is continuously supplied to the suspended tubing to maintain gas lift flow of the well.

24. A method according to claim 23 wherein the by-passed gas is passed from within the assembly into said tubing length.

25. A method for lowering tubing in a well flowing by the gas lift method, said well carrying an assembly including means to suspend and pack the tubing, comprising the steps of suspending the tubing in the assembly, continuously introducing gas into the assembly above the suspending means, passing gas from within the assembly into the tubing, passing a new length of tubing through said assembly into engagement with the upper end of the suspended tubing, then by-passing gas into the tubing by way of said tubing length, suspending the tubing from said tubing length, unseating the tubing from the suspending means, packing said tubing below the suspending means, and lowering the tubing through said assembly without loss of gas through the packing means and while flowing gas into the tubing through said tubing length.

26. A method according to claim 25 wherein the by-passed gas is passed from within the assembly into said tubing length.

27. A method for lowering or raising tubing in a well flowing by the gas lift method, said well carrying an assembly including means to suspend and pack the tubing, comprising the steps of suspending the tubing in the assembly, continuously supplying gas to the lower portion of the assembly above the suspending means, continuously packing the tubing below the point of gas introduction, introducing or withdrawing a length of tubing, attaching or removing said length to or from the suspended tubing, passing gas from within the assembly into the top of the suspended tubing when the tubing length is disconnected therefrom, by-passing gas through said tubing length into the tubing when the tubing length is attached to the suspended tubing, and lowering or raising the tubing through said assembly while flowing gas into the tubing through said tubing length and while packing the tubing below the point of introduction of gas to said assembly.

28. A method for moving tubing in a well flowing by the gas lift method, said well carrying an assembly of valves including means to suspend and pack the tubing, comprising the steps of suspending the tubing in the assembly, continuously packing the tubing below the point of suspension, con-

tinuously supplying gas to the assembly above the suspending means, attaching or detaching a tubing length to or from the suspended tubing, passing gas from the assembly into the top of the tubing when the tubing length is disconnected, and by-passing gas into the tubing by way of said tubing length when the tubing length is connected to the suspended tubing.

29. A method according to claim 28 wherein the by-passed gas is passed from within the assembly to said tubing length.

Signed at Los Angeles, in the county of Los Angeles and State of California, this 26th day of February A. D. 1932.

ALBERT C. RUBEL.
SAMUEL HENRY GRINNELL.