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(54) **METHOD, APPARATUS AND COMPUTER PROGRAM FOR DETERMINING PRODUCTION FROM EACH COMPLETION OF A GAS LIFTED DUAL COMPLETION WELL**

(57) Disclosed is a method and computer program for monitoring the production of hydrocarbons from a reservoir via a well comprising a dual completion, each completion producing from a different reservoir formation. The method comprises performing the following steps for each completion:
obtaining first data describing a first relationship between production flow rate and pressure between a point within the relevant reservoir formation and the well bottom;
obtaining plural sets of second data describing a second relationship between production flow rate and pressure between the well bottom and the wellhead for a plurality of nominal values for a gas lift parameter;
using the first data and the second data to determine a third relationship between casing pressure parameter within the well and the gas lift parameter;
using the determined third relationship and the assumption that the casing pressure parameter is the same for each completion to determine the gas lift parameter for the completion under consideration.

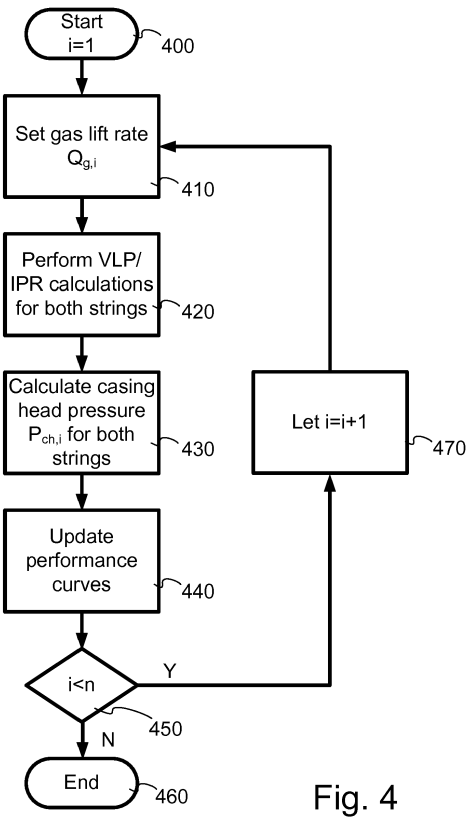

Fig. 4

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Description

[0001] The present disclosure relates to a method of, and apparatus for monitoring the production of hydrocarbons from a reservoir via a well comprising dual completions, and in particular for predicting the volumetric rate of gas lift gas flowing into each well completion in a well completed with a dual completion. This allows the production from each completion of a dual completion well to be separately calculated.

[0002] Within the petroleum industry, being able to calculate how much a well will produce under a given set of conditions is very important. It allows different scenarios to be carried out and studies performed to evaluate different production strategies and approaches.

[0003] In order to be able to calculate the flow rate in a producing well, the industry uses well established and proven nodal analysis concepts that require certain inputs for the calculations. For gas lift wells, one of these inputs is how much gas lift gas is being injected.

[0004] Gas lift is an artificial lift method which comprises injecting gas into the production tubing string to reduce the hydrostatic pressure of the production fluid. This injection of gas reduces the bottomhole pressure, thereby allowing fluids to be produced from the reservoir at a higher flow rate. The production gas may be conveyed down the tubing-casing annulus and injected into the production tubing via one or more gas lift valves and/or orifices.

[0005] For the case of wells completed with dual completions, which is known completion type throughout the world, there is presently no ability to compute how much gas is being injected into each string, and therefore there is no ability to compute rigorously how much the well will produce under different flowing conditions.

[0006] Petroleum Engineers therefore have no basis to design, strategize or optimise such wells with the conventional methods available.

[0007] It is therefore desirable to obtain methods for addressing issues relating to predicting production in dual or multiple completion wells.

SUMMARY OF INVENTION

[0008] In a first aspect of the invention there is provided a method of monitoring the production of hydrocarbons from a reservoir via a well comprising a dual completion, each completion producing from a different reservoir formation; said method comprising performing the following steps for each completion:

- obtaining first data describing a first relationship between production flow rate and pressure between a point within the relevant reservoir formation and the well bottom;
- obtaining plural sets of second data, each set of second data describing a second relationship between production flow rate and pressure between the well bottom and the wellhead for one of a plurality of nominal values for a gas lift parameter, said gas lift parameter relating to the amount of gas lift gas introduced during production for the completion under consideration;
- using said first data and said second data to determine a third relationship between casing pressure parameter within the well and said gas lift parameter;
- using the determined third relationship and the assumption that the casing pressure parameter is the same for each completion to determine said gas lift parameter for the completion under consideration.

[0009] In a second aspect of the invention, there is provided a computer program comprising computer readable instructions which, when run on suitable computer apparatus, cause the computer apparatus to perform the method of the first aspect.

[0010] Other optional aspects of the invention are in accordance with the appended dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Embodiments of the invention will now be described, by way of example only, by reference to the accompanying drawings, in which:

Figure 1 is a simplified schematic drawing of a well producing from a reservoir;

Figure 2 is a graph representing pressure against flow rate for the well of Figure 1;

Figure 3 is a simplified schematic drawing of a dual completion well producing from a reservoir;

Figure 4 is a flowchart describing a first stage of a method according to an embodiment of the invention;

Figure 5 is a graph of bottomhole pressure against production flow rate, illustrating a step of the method of Figure 4;

Figure 6 is a graph of pressure against depth, illustrating the pressure profile for one completion determined in a step of the method of Figure 4, (a) before allowance is made for the pressure drop across the gas lift valve and (b) after allowance is made for the pressure drop across the gas lift valve;

Figure 7 shows (a) a first performance curve on a graph of gas lift gas rate against production flow rate, and (b) a second performance curve on a graph of gas lift gas rate against casing head pressure, for one completion as determined in a step of the method of Figure 4;

Figure 8 is a flowchart describing a second stage of a method according to a first embodiment of the invention;

Figure 9 comprises two example performance curves as illustrated in Figure 7, illustrating conceptually the method of Figure 8 for a single completion;

Figure 10 is a flowchart describing a second stage of a method according to a second embodiment of the invention;

Figure 11 comprises example performance curves as illustrated in Figure 7, illustrating conceptually the method of Figure 10;

Figure 12 is a flowchart describing a third (optional) optimisation stage of a method according to an embodiment of the invention;

Figure 13 comprises example performance curves as illustrated in Figure 7, illustrating conceptually a step of the method of Figure 12;

Figure 14 shows (a) a first performance curve on a graph of gas lift gas rate against production flow rate, and (b) a second performance curve on a graph of gas lift gas rate against casing head pressure, for a dual completion well as determined in a step of the method of Figure 12; and

Figure 15 shows performance curves on a graph of gas lift gas rate against production flow rate, each curve corresponding to a different flowing wellhead pressure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0012] Within the petroleum industry, being able to calculate the oil and gas flow rate which a certain well will be able to produce at, given a set of conditions, is very important. It allows the well performance to be determined, different scenarios to be calculated and studies can be performed to evaluate different production strategies and approaches.

[0013] The calculation of the flow rate being produced through (or injected into) a well's tubing string is done using a technique called nodal analysis. Nodal analysis calculates the pressures and rates within a system from fixed boundary conditions.

[0014] Figure 1 shows a diagram of a model representing a single tubing string 100 producing from a reservoir 110. The model can be considered to start at the edge of the drainage region within a reservoir, where the pressure will be the drainage region pressure P_R, and continues until the wellhead 120 at the top of the tubing string. The wellhead pressure P_{WH} at the top of the tubing string and the pressure at the edge of the drainage region P_R can be considered boundary conditions of the model and are fixed for any given calculation.

[0015] In general, a tubing string 100 can be split into two main parts; the inflow and the outflow. The inflow of the tubing string (also called the inflow performance relationship or IPR) considers the path that the fluid takes as it travels from the edge of the drainage region and into the tubing string. There exists numerous analytical IPR models available that are based on different geometries and reservoir properties. Alternatively the IPR relationship can be inferred by performing a physical well test out in the field. The outflow of the tubing string (also called the vertical lift performance or VLP) considers the path from the bottom of the well to the wellhead 120. This can be calculated using a multiphase flow wellbore pressure drop model (e.g., a correlation), which requires knowledge of the fluid pressure/volume/temperature (PVT), completion geometry, the amount of gas lift gas being injected and the gas lift gas injection location(s). Where the inflow and outflow meet is referred to as the 'solution node' 130. This is normally defined as being located at the top of the perforations.

[0016] To calculate the pressure P_{BH} at the 'solution node' 130 (often referred to as the bottomhole pressure); one can consider firstly, the drainage region pressure into the solution node and secondly, the tubing head pressure down to the solution node. Both of these pressure drops depend upon the production flow rate being produced.

[0017] Figure 2 is a plot of pressure P against production flow rate Q. Shown on the plot is the IPR curve (inflow) 210 and VLP curve (outflow) 220. A solution node pressure may be estimated by considering the IPR and VLP pressure relationships. Both IPR and VLP pressures vary as a function of production flow rate Q. If a single liquid production rate Q_L is defined within a well, a solution to both pressure relationships would be at the intersection of these two curves 230. Therefore, by calculating VLP and IPR curves for the current conditions, and finding the intersection point of the two curves, the production flow rate Q_L produced by a well can be determined. Clearly, a VLP curve needs to be calculated in order to infer the solution node pressure P_{BH}.

[0018] In order to reduce drilling and completion costs, often several productive formations are produced through a single borehole. This is especially desirable when many formations are located vertically close above one another, and considerable savings on drilling and completion costs can be realized if several zones are produced simultaneously. The problem with multiple completions, such as in the dual completion arrangement, is that the amount of gas lift gas flowing into each of the tubing strings is unknown. This is because the gas for both completions is injected into a common annulus, and only the total amount injected is measured. Consequently a VLP curve, which is dependent upon the amount of gas lift gas introduced, cannot be determined for each string, and the production rate from each string cannot be predicted in the conventional way. Therefore the overall well performance cannot be determined, different scenarios cannot be analysed and any studies (i.e. optimisation) cannot be conducted.

[0019] Figure 3 is a schematic illustration of a dual completion arrangement arranged to produce a first formation 310 and a second formation 320 of a reservoir. A completion comprises generally a tubing string and associated equipment required for production from a well. The arrangement illustrated comprises a first tubing string 330 and a second tubing string 340 inside a casing 350. An annulus 360 is defined between the casing 350 and production tubing strings 330, 340. Also shown is a gas lift gas inlet valve 370 for the first tubing string 330 and a gas lift gas inlet valve 375 for the second tubing string 340, through which the gas lift gas is introduced into the production fluid conveyed by respective tubing strings; and a dual packer 380 and single packer 385 to isolate the annulus 360 from the production tubing strings 330, 340.

[0020] The proposed method acts to predict the gas lift gas flowing into each tubing string of a dual (or multiple) completion. This enables the production from each tubing string to be determined, which can be summed to compute the overall well performance.

[0021] Figure 4 is a flowchart describing a first stage of the method according to an embodiment of the invention. This first stage of the method comprises determining the sensitivity of pressure P_{BH} and production flow rate Q_L at the solution node, on the gas lift rate Q_g. This is done by determining a number, n, of VLP curves, one for each of a number of gas lift rates $Q_{g,i}$, and an IPR curve for each completion. Each intersection of a VLP curve with the IPR curve corresponds to a different gas injection rate; however in each case the same water cut WC, gas-oil ratio GOR and tubing head pressure is applied, and can be obtained either from measurements in the field or well test data.

[0022] The method starts at step 400 on the first of n iterations (i=1). At step 410, a gas lift rate of the iteration $Q_{g,i}$ is set. Gas lift rate is an exemplary parameter used in this embodiment; any other parameter related to the amount of gas lift gas introduced to the production tubing string can be used. The choice of gas lift rate may be arbitrary for the first iteration, and may increase incrementally for subsequent iterations, so as to cover a realistic range of gas lift rates over the course of this stage of the method. Of course, the first gas lift rate may be at the high end of the range and decrease for each iteration, or other methods of setting a different gas lift rate for each iteration may be employed.

[0023] At step 420 VLP and IPR relationships are calculated for each completion. The IPR relationship will be the same for each iteration and therefore need only be calculated (for each completion) in a first iteration. The VLP relationship is dependent upon the gas lift rate and therefore will be different for each iteration. Figure 5 is a graph of bottomhole pressure P against production flow rate Q_L resultant from this step (for one of the completions), after n iterations. It shows a IPR curve 500, a number of VLP curves 510, each one representing a different nominal gas lift rate $Q_{g,i}$ for that completion. Each intersection 520 of a VLP curve 510 with the IPR curve 500, yields an intersection production flow rate $Q_{L,i}$ and an intersection bottomhole pressure P_{BHi} corresponding to each nominal gas lift rate $Q_{g,i}$.

[0024] At step 430, for each of the VLP curves 510, the intersection bottomhole pressure P_{BHi} from the previous step is used to compute a pressure profile (vs. the depth) in the relevant completion. This may be done using the same multiphase flow correlation applied when calculating the VLP. Figure 6(a) is a graph of pressure P against depth D resultant from this step, for a single iteration and completion. In conjunction with this calculation, a separate pressure drop calculation should be performed across the gas lift valve. This may be computed based on the amount of gas injected (corresponding to the VLP curve) and the orifice size. The pressure drop ΔP_{valve} across the gas lift valve can either be computed with an orifice choke model or alternatively using the manufacturer's curves. This pressure drop ΔP_{valve} is added to the tubing pressure at the gas lift valve depth D_{valve}. The casing gradient is computed up to the casing head to yield the casing head pressure $P_{ch,i}$ for the completion. This is illustrated in the graph of Figure 6(b). This is repeated for each iteration.

[0025] At step 440, performance plots are updated. The performance plots show casing head pressure P_{ch} and liquid rate Q_L as a function of gas lift rate Q_g, for each completion, the plots being generated over a number of iterations. Figure 7 shows examples of such performance plots. Figure 7(a) is a plot of fluid production rate Q_L as a function of gas lift rate Q_g, and Figure 7(b) is a plot of casing head pressure P_{ch} as a function of gas lift rate Q_g.

[0026] At step 450, it is determined whether there have been sufficient iterations of this stage of the method for the results to be meaningful. The total number of iterations to be performed, n, may be any number over 1, and may be for example, between 5 and 100, between 10 and 50 or may be in the region of 20. If there have been sufficient iterations, then the routine ends (step 460). If there have not been sufficient iterations, another iteration (step 470) is performed using a different gas lift rate $Q_{g,i}$ at step 410.

[0027] Once the performance curves are generated, the allocation of gas lift to each completion can be calculated based on the physical principle that both completions must share the same casing head pressure, as there is pressure communication throughout the casing. This principle can be applied in a second stage of the method, through two independent embodiments which will each provide an estimate for the gas lift allocation.

[0028] Figure 8 is a flowchart illustrating the first of these approaches. The method uses the measured casing head pressure (obtained at step 810) from field measurements and the performance curves to estimate the gas lift rate $Q_{g,comp1}$, $Q_{g,comp2}$ and (optionally) fluid production rate $Q_{L,comp1}$, $Q_{L,comp2}$ for the first completion (step 820) and the second completion (step 830) independently. The fluid production flow rates $Q_{L,comp1}$, $Q_{L,comp2}$ for the first completion and second completion can then be summed (step 840) to provide the overall well production flow rate Q_L. Similarly, the gas lift rates $Q_{g,comp1}$, $Q_{g,comp2}$ for the first completion and second completion can be summed to yield the total gas lift rate $Q_{g,well}$. The calculation can be validated by comparing the total calculated gas lift with the measured total gas lift for the well.

[0029] The method of Figure 8 is illustrated conceptually in Figure 9 (for the first completion only). The top curve 900 is the performance curve of production flow rate $Q_{L,comp1}$ against gas lift rate $Q_{g,comp1}$ for the first completion. The bottom curve 910 is the performance curve of measured casing head pressure P_{ch} against gas lift rate $Q_{g,comp1}$ for the first completion. As can be seen, the gas lift rate $Q_{g,comp1}$ for the first completion can be obtained from the measured casing head pressure P_{ch} using the performance curve 910. This gas lift rate $Q_{g,comp1}$ can then be used to find the production flow rate $Q_{L,comp1}$ for the first completion using the performance curves 900. This can then be repeated for the second completion using the appropriate performance curves for the second completion and the same measured casing head pressure P_{ch} (as the casing head pressure is the same for both completions).

[0030] The calculation can be validated by comparing the total calculated gas lift rate with the measured total gas lift rate for the well.

[0031] Figure 10 is a flowchart illustrating the second approach for calculating the allocation of gas lift rate to each completion, according to an embodiment of the invention. The second approach takes the total measured gas lift rate $Q_{g,well}$ for the well from the field measurements and uses the performance curves to estimate the gas lift and liquid production for each completion by iteratively finding the gas lift ratio which minimises the difference in calculated casing pressure for the two completions.

[0032] The method starts at step 1000, with an arbitrary gas lift ratio. The gas lift ratio is the ratio describing the division of the total measured gas rate $Q_{g,well}$ between the first completion and the second completion. Here the initial gas lift ratio is 0.5 (i.e. a 50/50 split), but any initial arbitrary ratio may be chosen. At step 1010, the total measured gas lift rate $Q_{g,well}$ is obtained, and at step 1020, this total measured gas lift rate is divided between the first and second completions according to the present gas lift ratio. At step 1030, a casing pressure $P_{c,comp1}$ is calculated based upon the allocated gas lift ratio $Q_{g,comp1}$ for the first completion determined in the previous step. At step 1040, a casing pressure $P_{c,comp2}$ is calculated based upon the allocated gas lift ratio $Q_{g,comp2}$ for the second completion determined in step 1020. At step 1050 it is determined whether the difference between casing pressure $P_{c,comp}$, and casing pressure $P_{c,comp2}$ is smaller than an acceptable error margin. If the difference is greater than an acceptable error margin, the gas lift ratio cannot be correct as both completions must have a common casing pressure. In this case, the gas lift ratio is updated (step 1070) and another iteration of the method is performed. When it is determined at step 1050 that casing pressure $P_{c,comp1}$ and casing pressure $P_{c,comp2}$ are equal within the acceptable error margin, the routine ends (step 1060). The gas lift allocation arrived at following this algorithm can then be used, with the total measured gas rate $Q_{g,well}$ to determine the rate of gas lift gas delivered to each completion. Once this is determined, it is possible to determine the production fluid rate for each completion using the corresponding performance curve of production fluid rate against gas lift gas for the completion.

[0033] The calculation can be validated by comparing the calculated casing head pressure with the measured casing head pressure for the well.

[0034] The method of Figure 10 is illustrated conceptually in Figure 11. The total measured gas lift rate $Q_{g,well}$ is divided according to the gas lift ratio and allocated such that $Q_{g,comp1}$ is x% of the total measured gas lift rate $Q_{g,well}$ and $Q_{g,comp2}$ is (100-x)% of the total measured gas lift rate $Q_{g,well}$. Using curves 1100 and 1110, a value for the casing head pressure $P_{ch,comp1}$ and $P_{ch,comp2}$ is determined for each completion, and a difference between casing head pressures $P_{ch,comp1}$ and $P_{ch,comp2}$ is then calculated. When the gas lift ratio is such that the difference between casing head pressures $P_{ch,comp1}$, and $P_{ch,comp2}$ is minimised satisfactorily, the curves 1120 and 1130 can be used to determine the production flow rate $Q_{L,comp1}$ and $Q_{L,comp2}$ for the first and second completions.

[0035] Having two methods of calculating the gas lift allocation serves as a useful tool for diagnosis since they can be used to infer physical changes in the wellbore (i.e. plugging of the gas lift valve or changes in the injection depth).

[0036] Once the performance curves for each completion have been generated, they can also be used in an optimisation method so as to maximise hydrocarbon (e.g., oil) production. Such a method, according to an embodiment of the invention, is described by the flowchart of Figure 12.

[0037] At step 1210, representative performance curve for the well (i.e., both completions) are generated. To generate representative performance curve of the well for different conditions (i.e. different gas lift rates), the principle that the casing head pressure is the same for both completions is again used. To achieve this, a sensitivity on the casing pressure is carried out, from which the variation of gas lift rate to each completion and the corresponding fluid production rate from each completion can be determined. These are then summed to determine variation of the total gas lift rate with casing head pressure, and the variation of the total fluid production rate of the well with the total gas lift rate. This is demonstrated conceptually Figure 13. Corresponding gas lift rates and fluid production rates are recorded per completion for varying casing head pressure. In each case, the per completion rates can be summed to obtain the corresponding gas lift rates and fluid production rates for the well.

[0038] The performance curves for the well resultant from step 1210 are shown in Figure 14. Figure 14(a) is a plot of well fluid production rate $Q_{L,well}$ (equals the sum of $Q_{L,comp1}$ and $Q_{L,comp2}$) as a function of well gas lift rate $Q_{g,well}$ (equals the sum of $Q_{g,comp1}$ and $Q_{g,comp2}$). Figure 14(b) is a plot of casing head pressure P_{ch} as a function of well gas lift rate $Q_{g,Well}$. These are similar to the performance curves for a completion, as shown in Figure 7. Of main interest for optimisation purposes is the plot of Figure 7(a) showing variation of well fluid production rate with well gas lift rate.

[0039] At step 1215, additional performance curves are added to the Figure 17(b) plot, corresponding to differing flowing wellhead pressure (FWHP) values. Referring back to Figure 6, the pressure profile (and therefore the calculated casing head pressure $P_{ch,i}$) is dependent on the flowing wellhead pressure (also labelled on Figure 6). By repeating the method of Figure 4 and step 1210, for different values of flowing wellhead pressure, a number of performance curves for the well can be obtained, each one corresponding to a particular flowing wellhead pressure. Figure 15 is a graph of well fluid production rate $Q_{L,well}$ as a function of well gas lift rate $Q_{g,well}$ showing a number of performance curves, each corresponding to a different flowing wellhead pressure $FWHP_1$-$FWHP_4$. Of course, many more than four of such performance curves may be generated for a well. In this way, the entire performance of the well can be captured.

[0040] These performance curves can then be fed into a network model describing the well or a plurality of wells (step 1220). The model can then be solved (step 1230), as part of an optimisation algorithm which can vary either the flowing wellhead pressure or gas lift rate for the well in order to find optimal values for these parameters, so as to maximise oil production.

[0041] One or more steps of the methods and concepts described herein may be embodied in the form of computer readable instructions for running on suitable computer apparatus, or in the form of a computer system comprising at least a storage means for storing program instructions embodying the concepts described herein and a processing unit for performing the instructions. As is conventional, the storage means may comprise a computer memory (of any sort), and/or disk drive, optical drive or similar. Such a computer system may also comprise a display unit and one or more input/output devices.

[0042] The concepts described herein find utility in all aspects of surveillance, monitoring, optimisation and prediction of hydrocarbon reservoir and well systems, and may aid in, and form part of, methods for extracting hydrocarbons from such hydrocarbon reservoir and well systems.

[0043] It should be appreciated that the above description is for illustration only and other embodiments and variations may be envisaged without departing from the scope of the invention.

Claims

1. A method of monitoring the production of hydrocarbons from a reservoir via a well comprising a dual completion, each completion producing from a different reservoir formation; said method comprising performing the following steps for each completion:

    obtaining first data describing a first relationship between production flow rate and pressure between a point within the relevant reservoir formation and the well bottom (420);
    obtaining plural sets of second data, each set of second data describing a second relationship between production flow rate and pressure between the well bottom and the wellhead for one of a plurality of nominal values for a gas lift parameter, said gas lift parameter relating to the amount of gas lift gas introduced during production for the completion under consideration (420);
    using said first data and said second data to determine a third relationship between casing pressure parameter within the well and said gas lift parameter (440);
    using the determined third relationship and the assumption that the casing pressure parameter is the same for each completion to determine said gas lift parameter for the completion under consideration.

2. A method as claimed in claim 1 wherein the step of using said first data and said second data to determine the third relationship comprises determining each intersection of each set of second data with the first data, to obtain an intersection value for pressure and an intersection value for production flow rate for each of said second sets of data, said intersection values for pressure and production flow rate being used to determine the said third relationship.

3. A method as claimed in claim 2 wherein the step of using said first data and said second data to determine the third relationship comprises using the intersection value for pressure and each corresponding nominal value for the gas lift parameter to determine a value for the casing pressure parameter corresponding to each of said nominal values for the gas lift parameter (430).

4. A method as claimed in any preceding claim wherein the step of determining said gas lift parameter for each completion comprises:

obtaining a measured value of the casing pressure parameter common to both completions; and for each completion (810);
using the measured value of the casing pressure parameter and the determined third relationship relevant to the completion under consideration to determine said gas lift parameter for that completion (820, 830).

5. A method as claimed in any of claims 1 to 3 wherein the step of determining said gas lift parameter for each of said completions comprises:

obtaining a measured value of a total gas lift parameter relating to the total amount of gas lift gas introduced during production across both completions (1010);
selecting a nominal allocation ratio describing the allocation of said total gas lift parameter between the completions (1020);
determining an error value relating to the difference in calculated casing pressure parameters consequent from the nominal allocation ratio (1050);
updating the nominal allocation ratio to minimise said error value (1070);
repeating iterations of the previous two steps until the error value is minimised below a threshold; and
using the final allocation ratio to determine a gas lift parameter for each completion.

6. A method as claimed in any preceding claim wherein said casing pressure parameter comprises casing head pressure.

7. A method as claimed in any preceding claim wherein said gas lift parameter comprises the gas lift gas flow rate.

8. A method as claimed in any preceding claim comprising performing the following steps for each completion:

using said first data and said plural sets of second data to determine a fourth relationship between production flow rate for the completion under consideration and said gas lift parameter; and
using the determined gas lift parameter and the determined fourth relationship to determine the production flow rate for the completion under consideration.

9. A method as claimed in claim 8 comprising the further steps of:

using said determined third relationship and said determined fourth relationship for each completion to determine:

a fifth relationship between the casing pressure parameter within the well and a total gas lift parameter relating to the total amount of gas lift gas introduced during production for both completions (1210); and
a sixth relationship between total production flow rate from both completions and said total gas lift parameter (1210).

10. A method as claimed in claim 9 comprising the further step of determining said sixth relationship for the well for a plurality of different flowing wellhead pressures (1215).

11. A method as claimed in claim 10 comprising the steps of:

using said sixth relationship determined for a plurality of different flowing wellhead pressures as an input to a model describing the well (1220); and
performing an optimisation algorithm which varies one or both of the flowing wellhead pressure or total gas lift parameter in order to maximise hydrocarbon production (1240).

12. A computer program comprising computer readable instructions which, when run on suitable computer apparatus, cause the computer apparatus to perform the method of any preceding claim.

13. A computer program product comprising the computer program of claim 12.

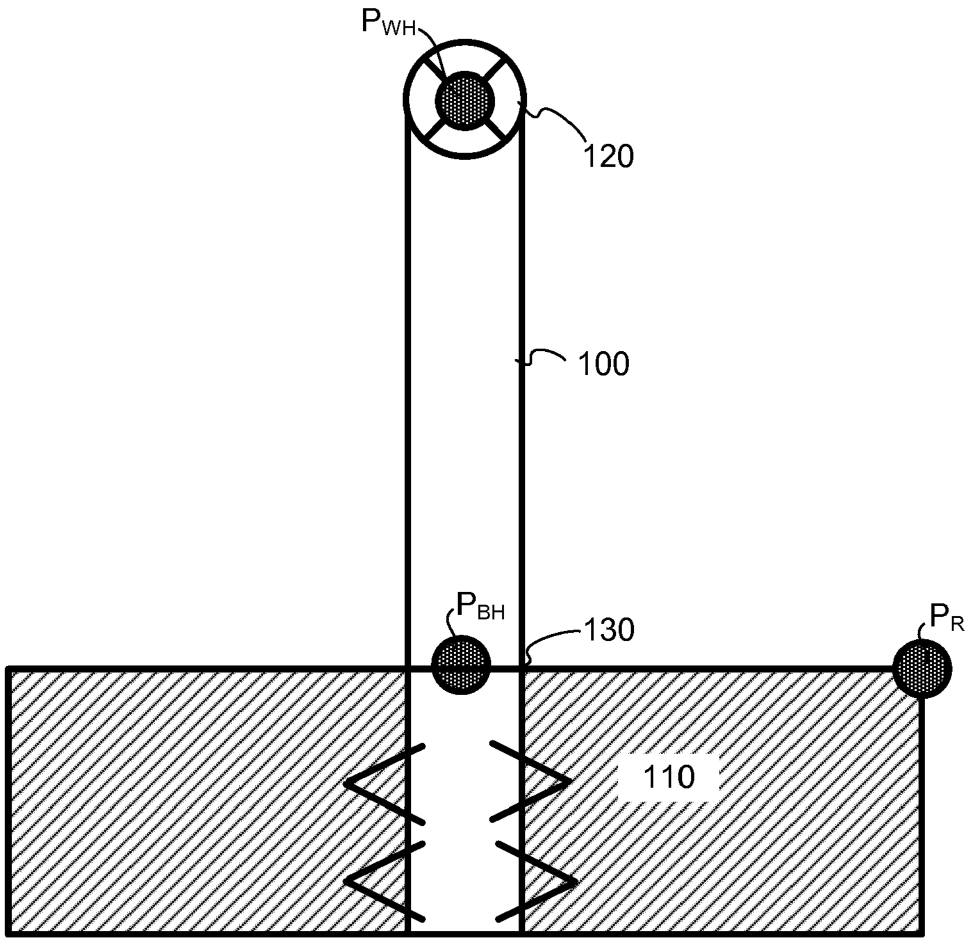


Fig. 1

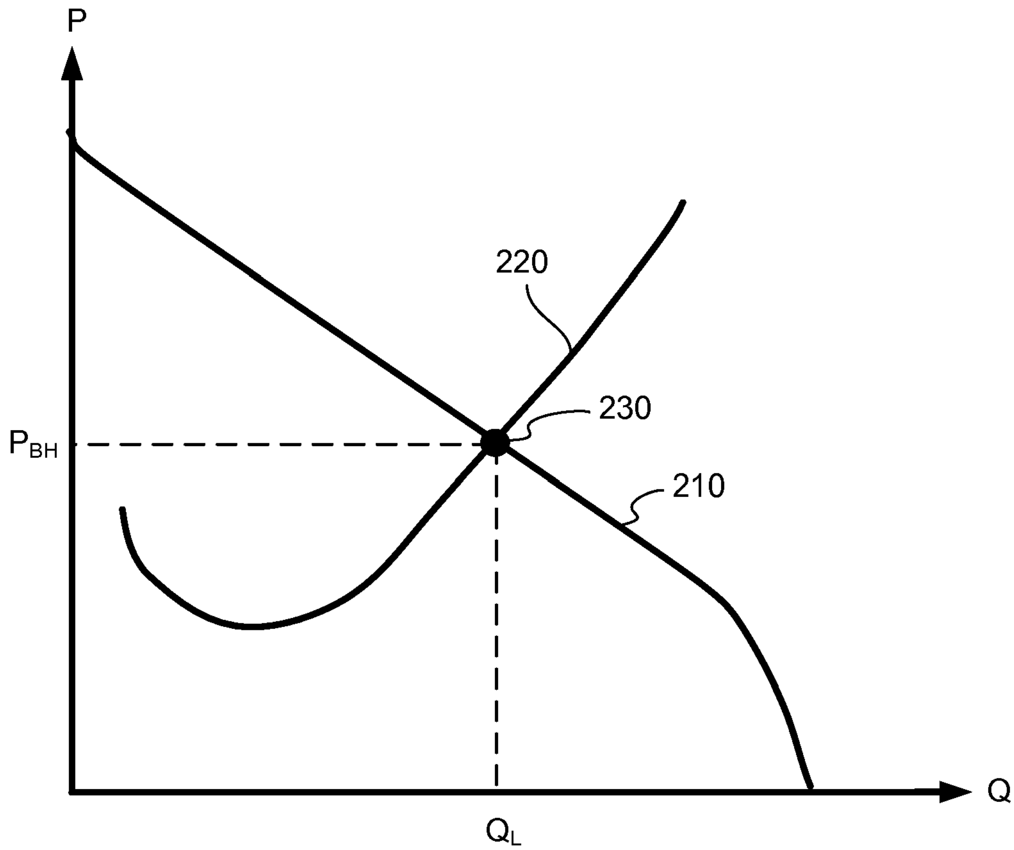


Fig. 2

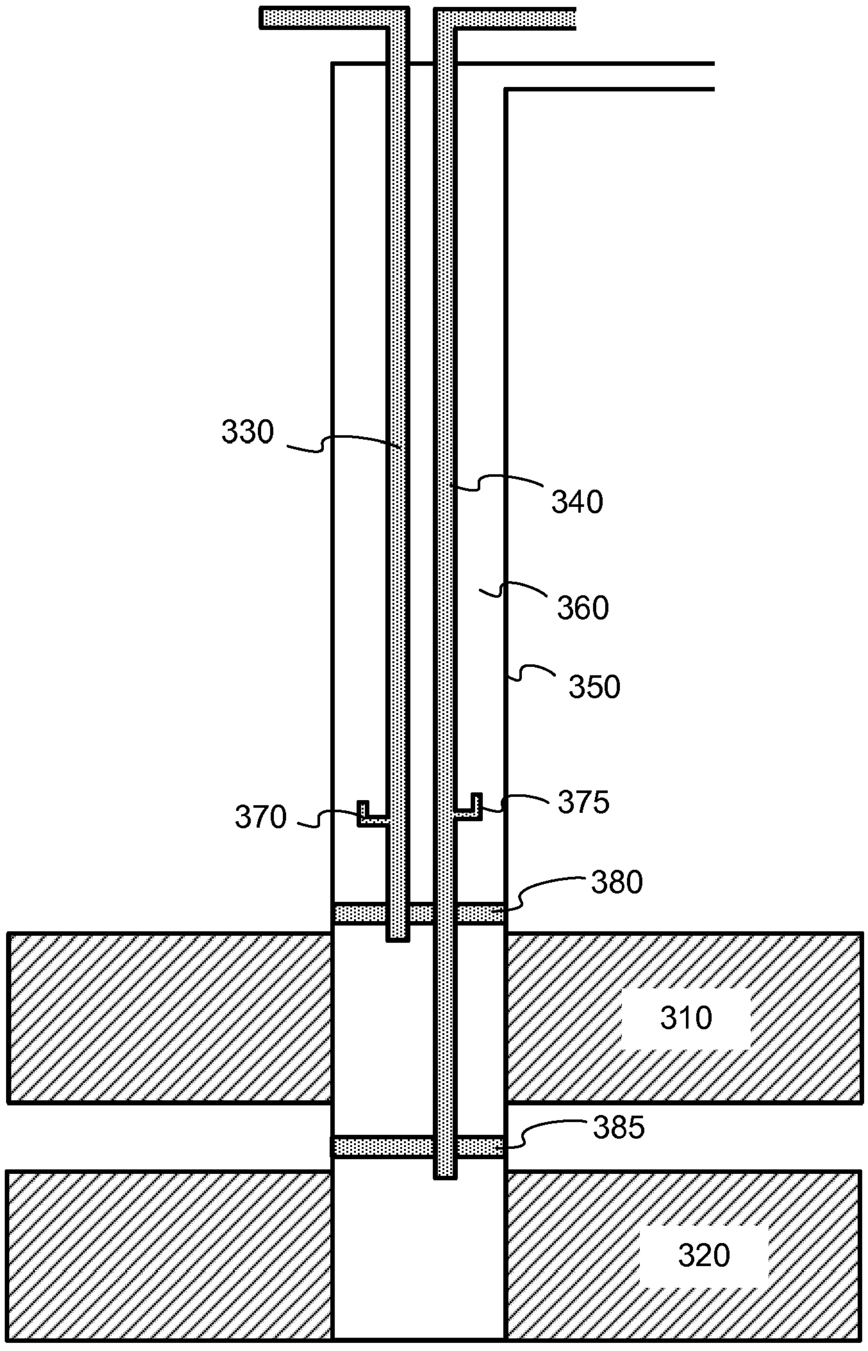
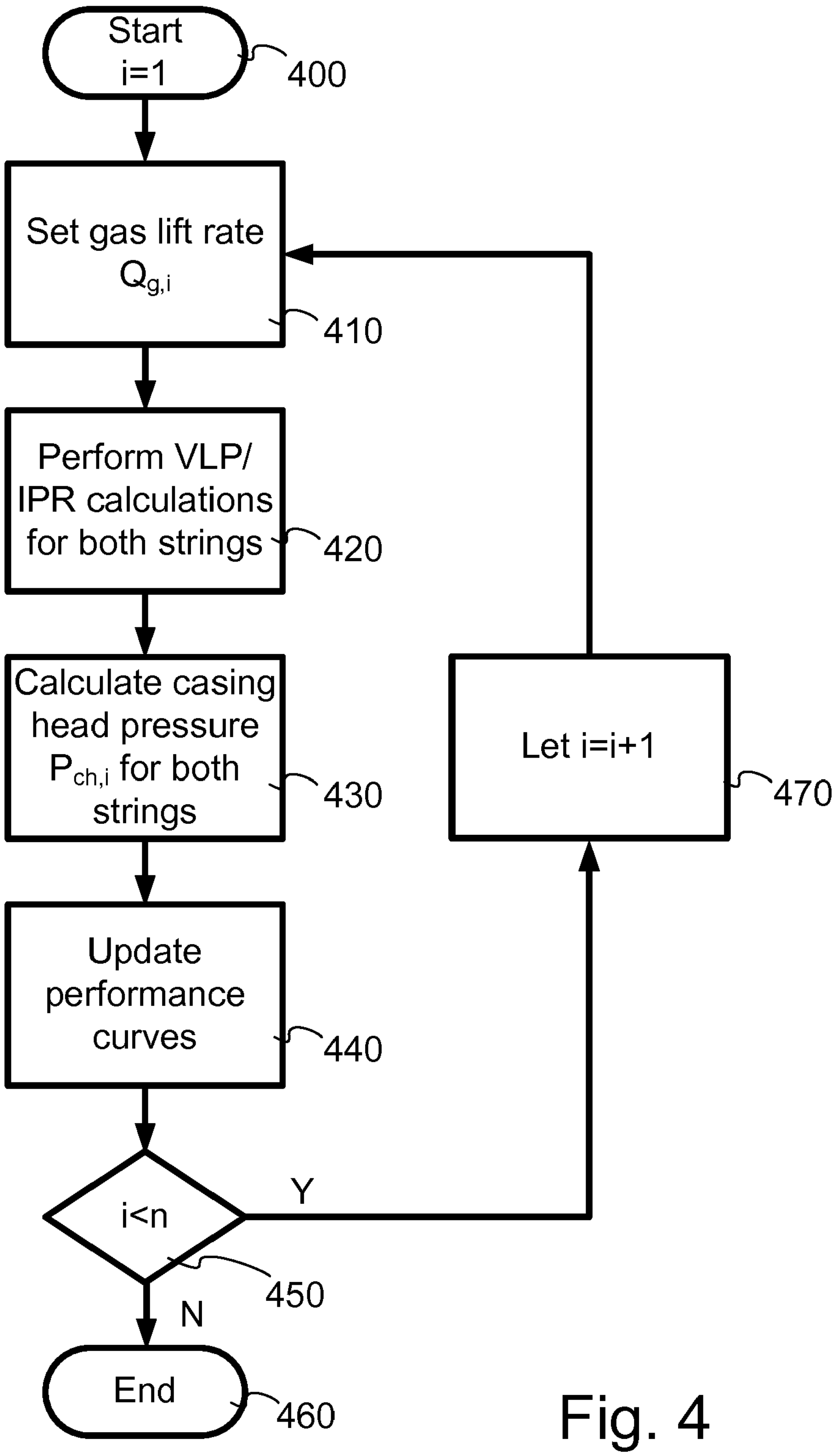


Fig. 3


Start
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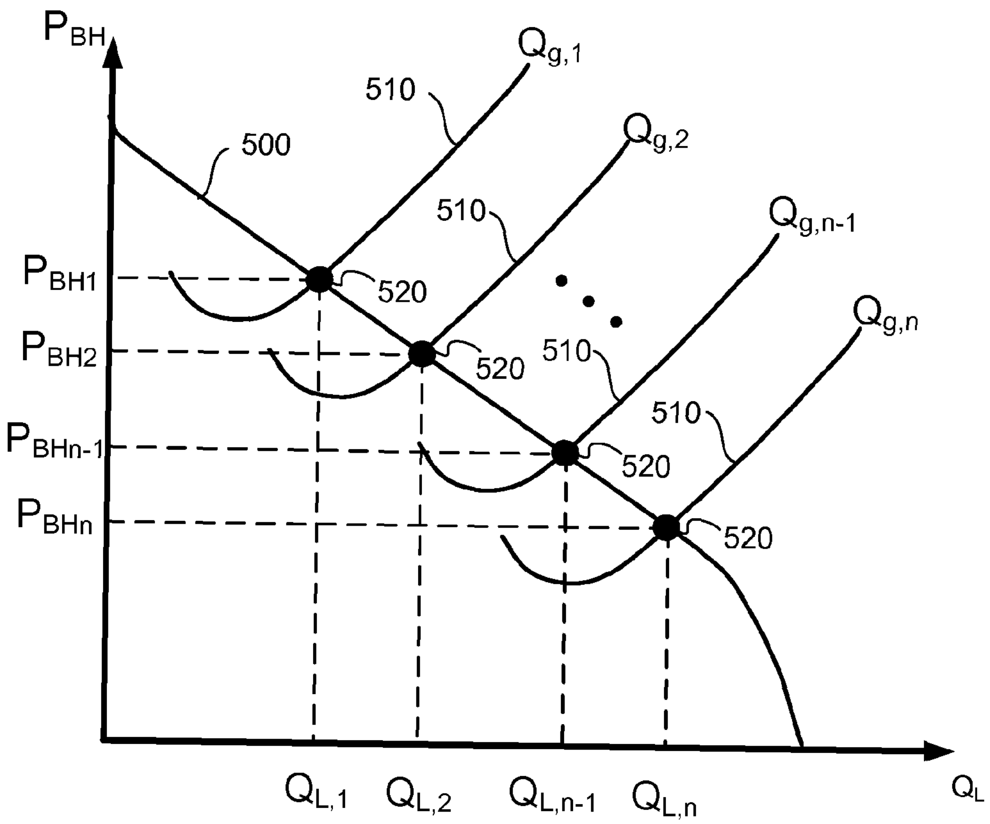
400
Set gas lift rate
Qg,i
410
Perform VLP/
IPR calculations
for both strings
420
Calculate casing
head pressure
Pch,i for both
strings
430
Update
performance
curves
440
i<n
Y
450
N
End
460
Let i=i+1
470

Fig. 4



P_BH
Q_g,1
510
500
Q_g,2
510
Q_g,n-1
P_BH1
520
Q_g,n
P_BH2
520
510
510
P_BHn-1
520
P_BHn
520
Q_L,1
Q_L,2
Q_L,n-1
Q_L,n
Q_L

Fig. 5

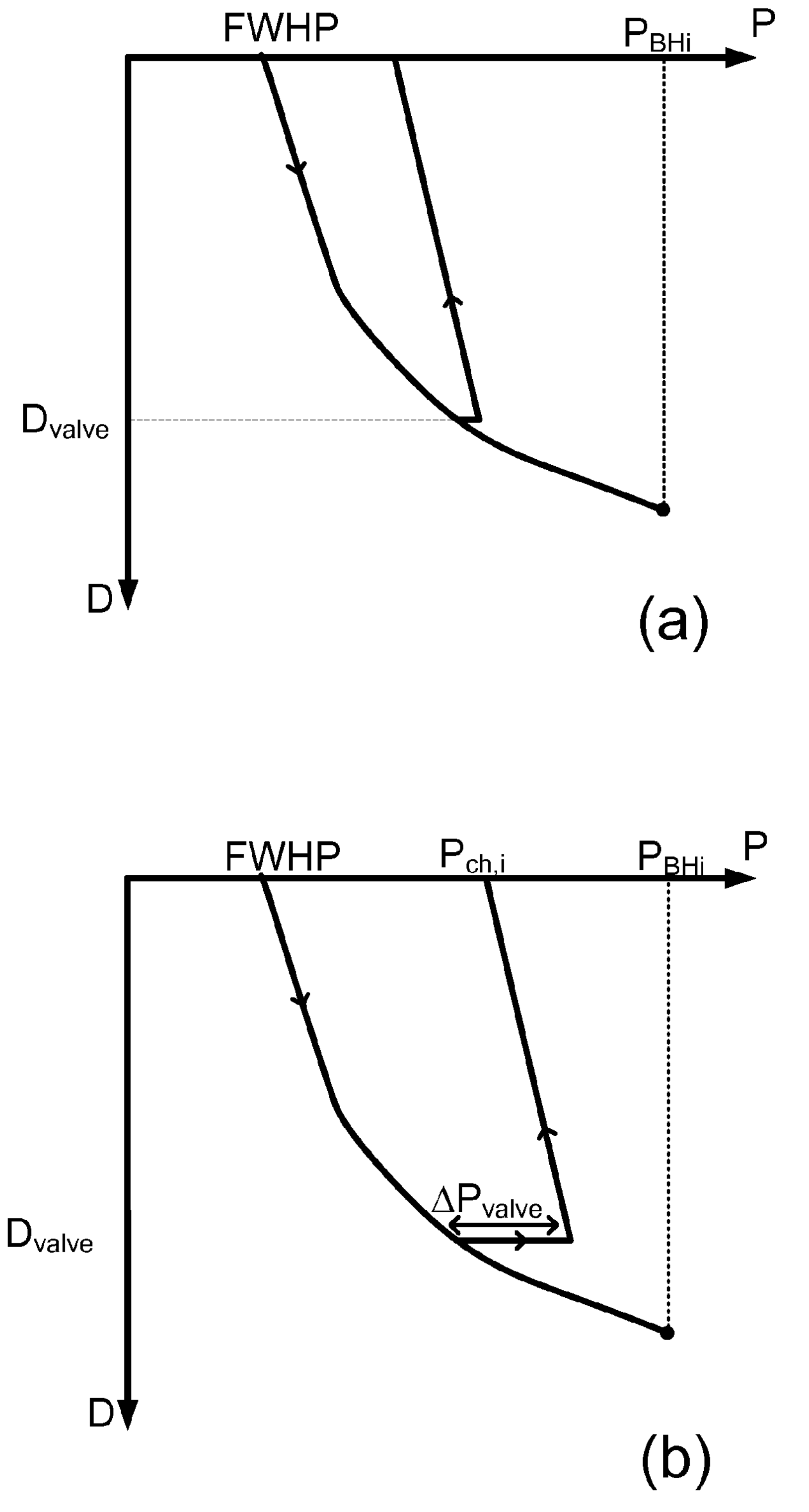
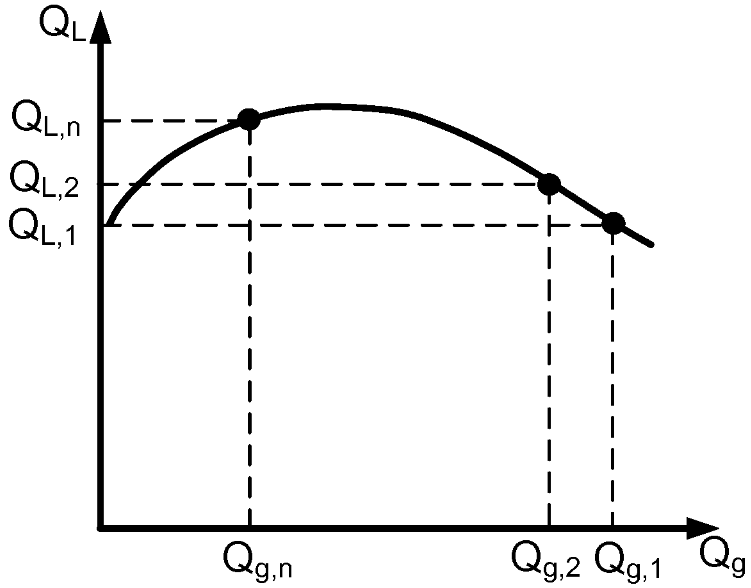
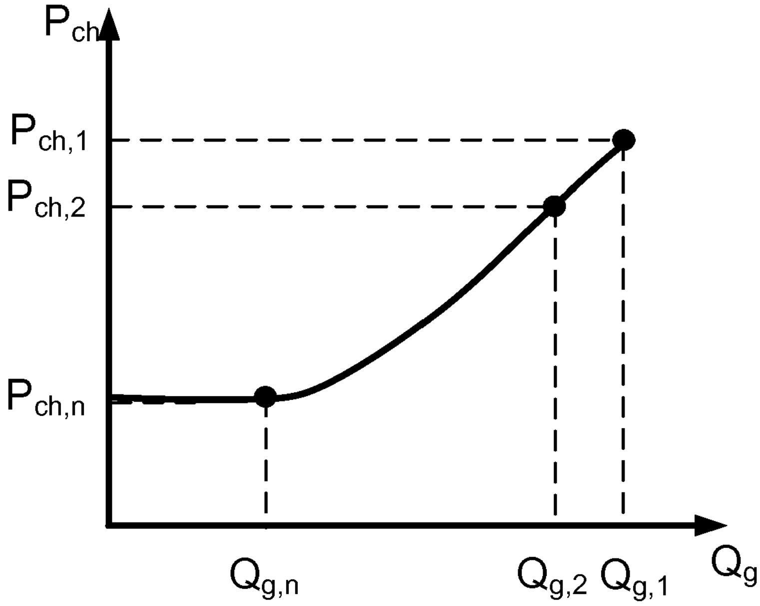


Fig. 6



(a)



(b)

Fig. 7

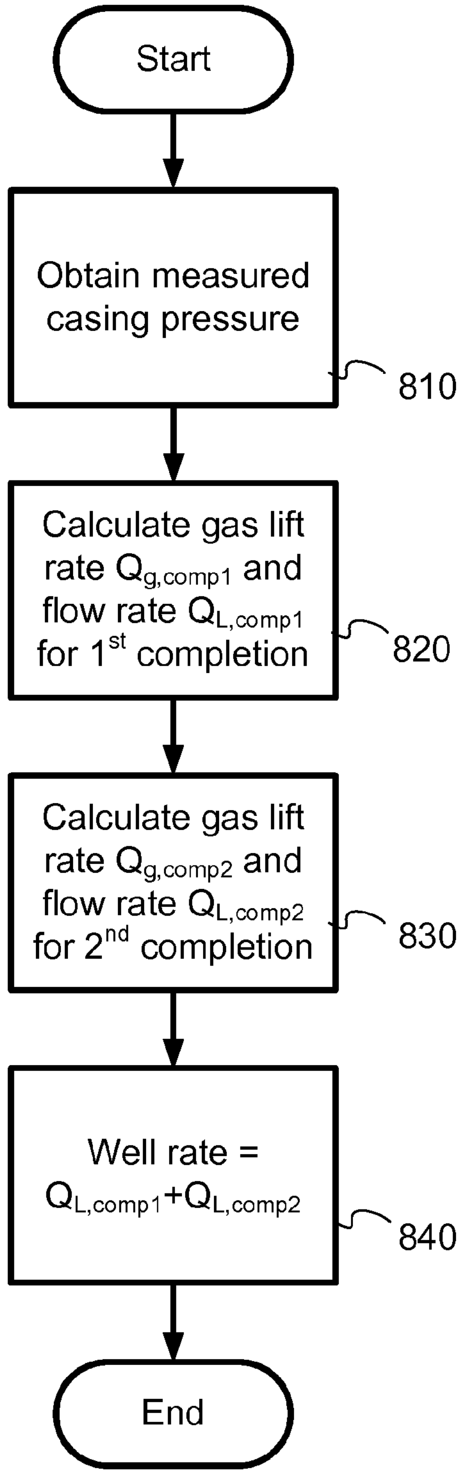

Start
Obtain measured casing pressure
810
Calculate gas lift rate $Q_{g,comp1}$ and flow rate $Q_{L,comp1}$ for 1st completion
820
Calculate gas lift rate $Q_{g,comp2}$ and flow rate $Q_{L,comp2}$ for 2nd completion
830
Well rate = $Q_{L,comp1}+Q_{L,comp2}$
840
End

Fig. 8

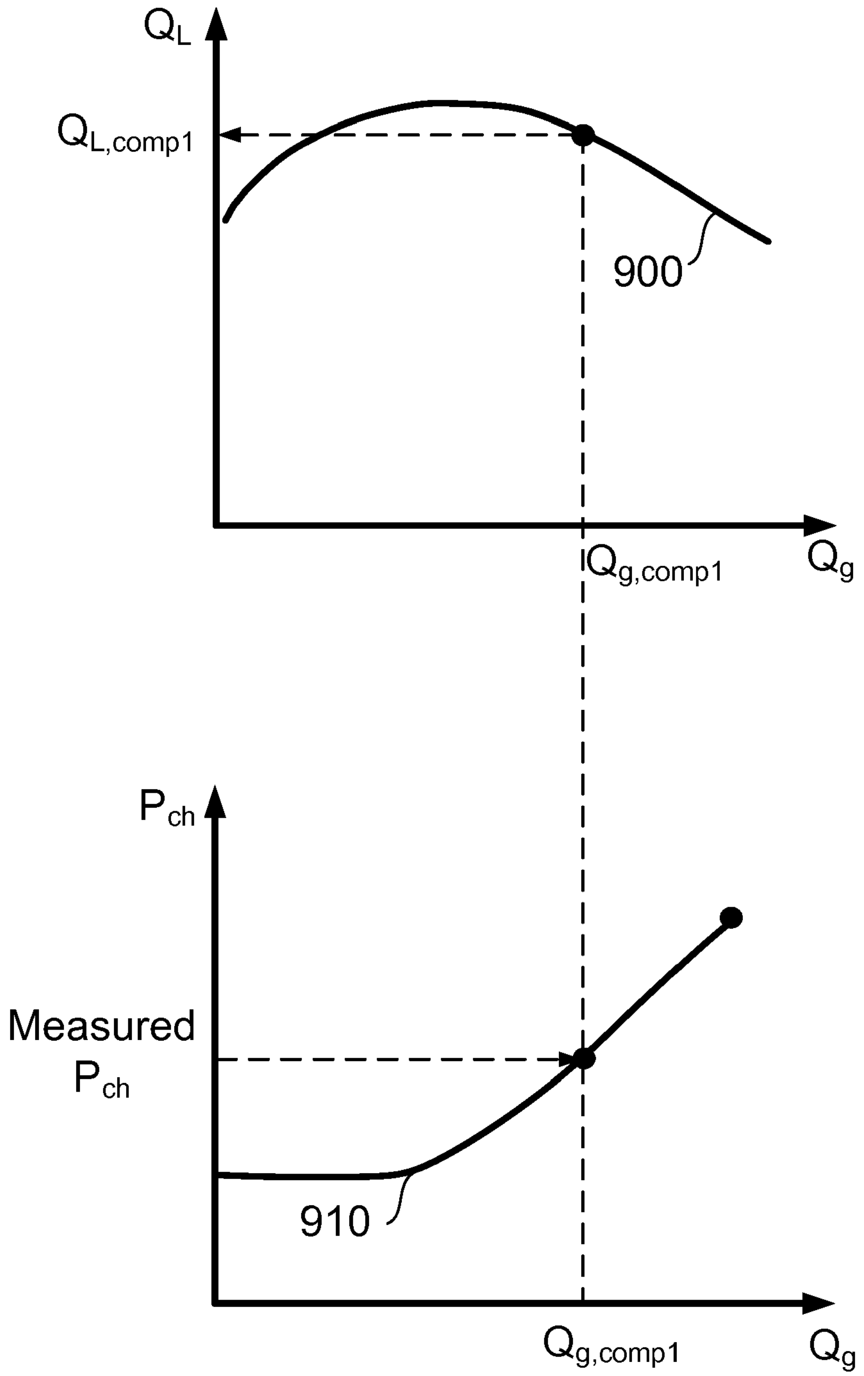


Fig. 9

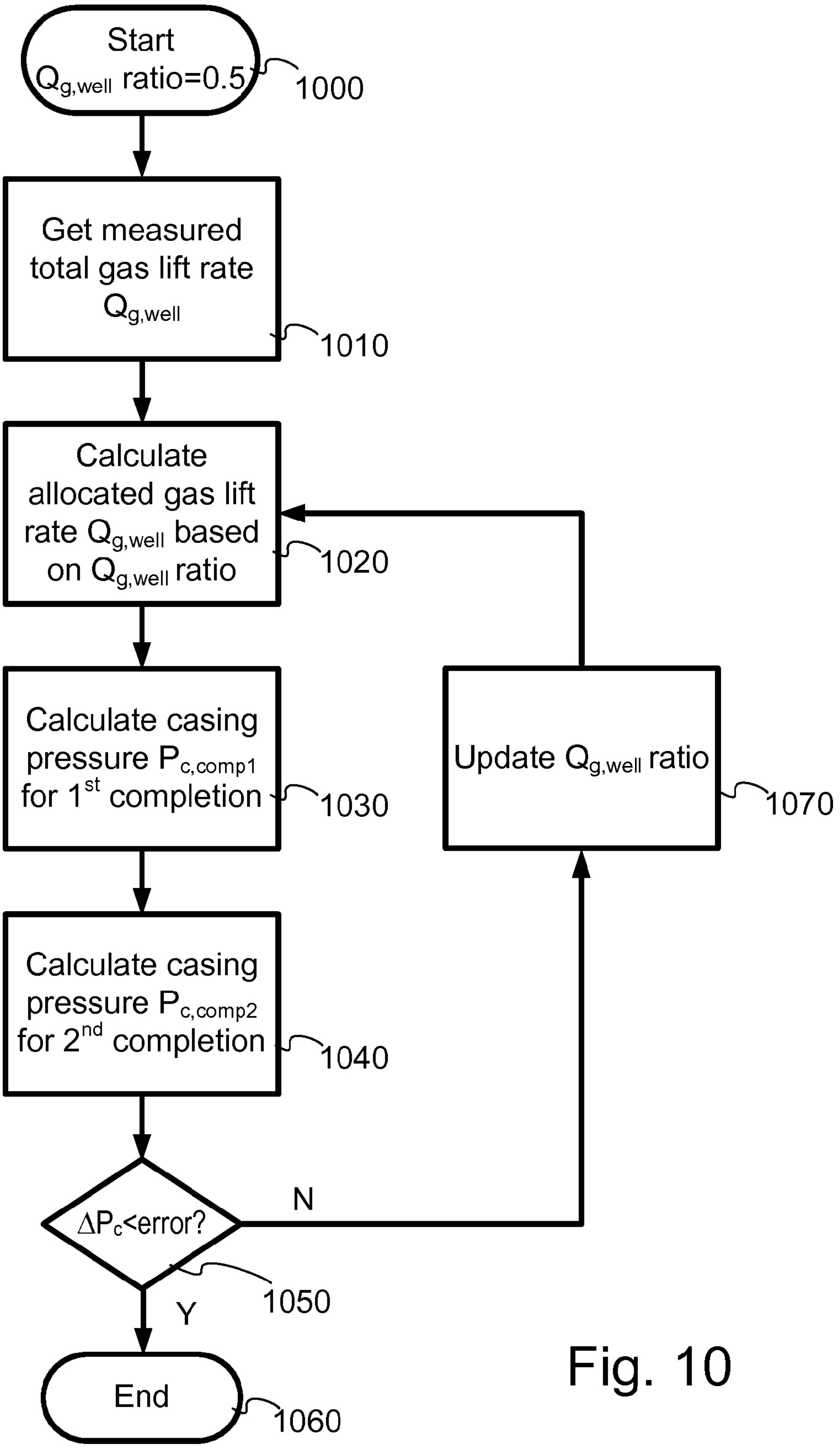

Start
Qg,well ratio=0.5
1000
Get measured total gas lift rate Qg,well
1010
Calculate allocated gas lift rate Qg,well based on Qg,well ratio
1020
Calculate casing pressure Pc,comp1 for 1st completion
1030
Calculate casing pressure Pc,comp2 for 2nd completion
1040
ΔPc<error?
N
Y
1050
End
1060
Update Qg,well ratio
1070

Fig. 10

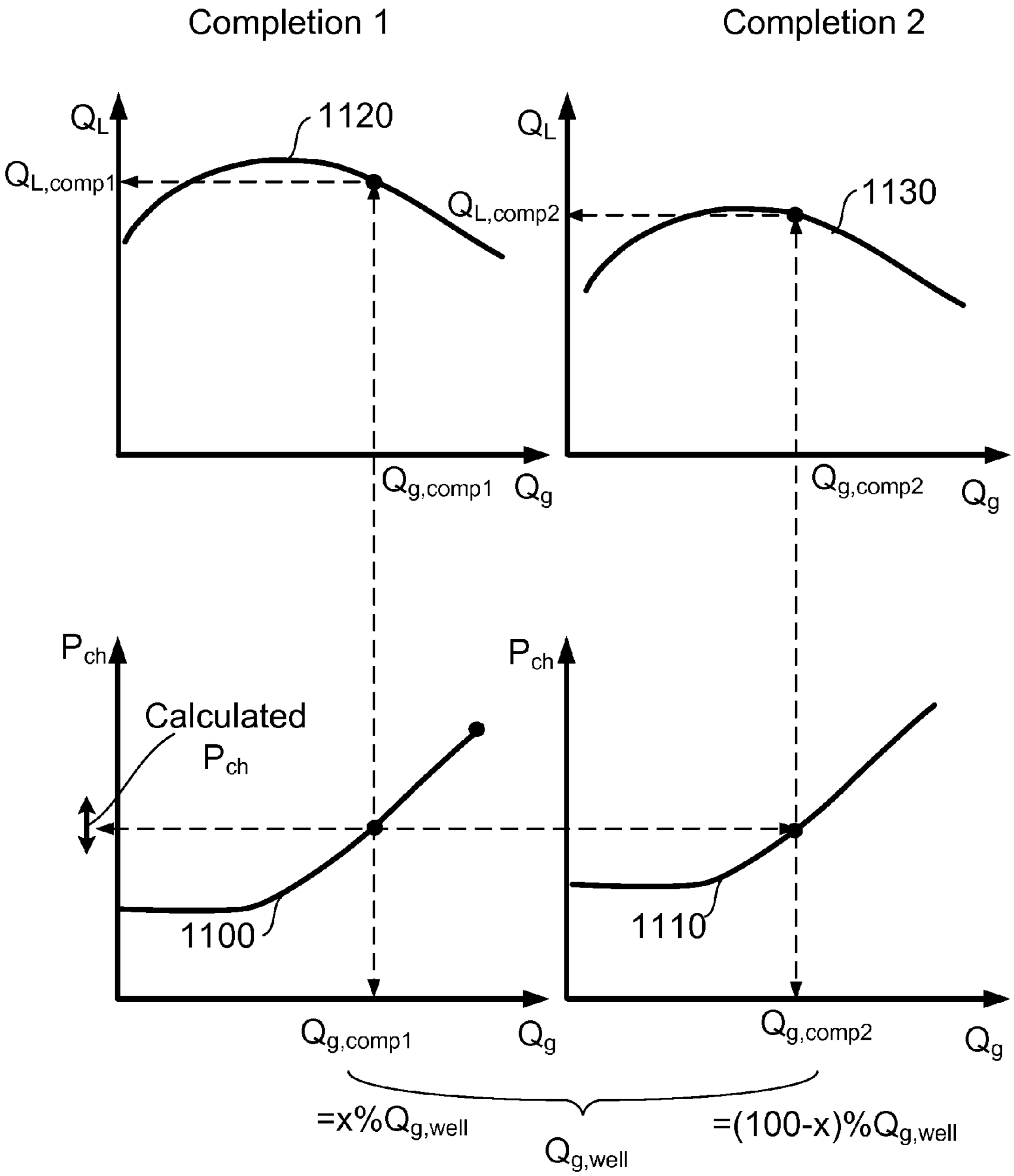

Completion 1
Completion 2
Q_L
1120
$Q_{L,comp1}$
Q_L
$Q_{L,comp2}$
1130
$Q_{g,comp1}$
Q_g
$Q_{g,comp2}$
Q_g
P_{ch}
Calculated P_{ch}
P_{ch}
1100
1110
$Q_{g,comp1}$
Q_g
$Q_{g,comp2}$
Q_g
$=x\%Q_{g,well}$
$Q_{g,well}$
$=(100-x)\%Q_{g,well}$

Fig. 11

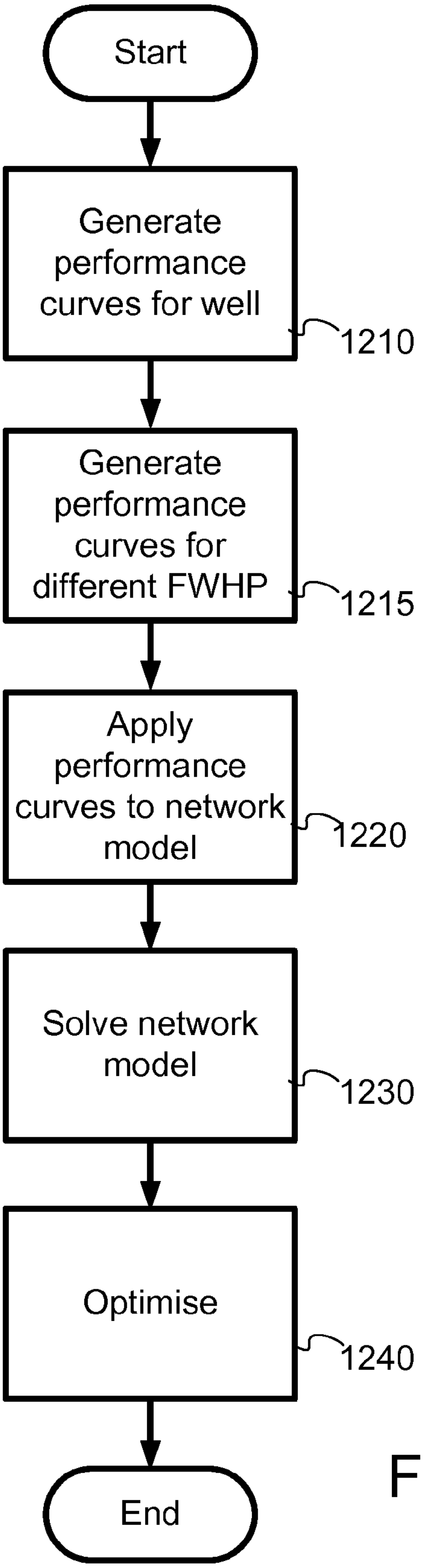

Start
Generate performance curves for well
1210
Generate performance curves for different FWHP
1215
Apply performance curves to network model
1220
Solve network model
1230
Optimise
1240
End

Fig. 12

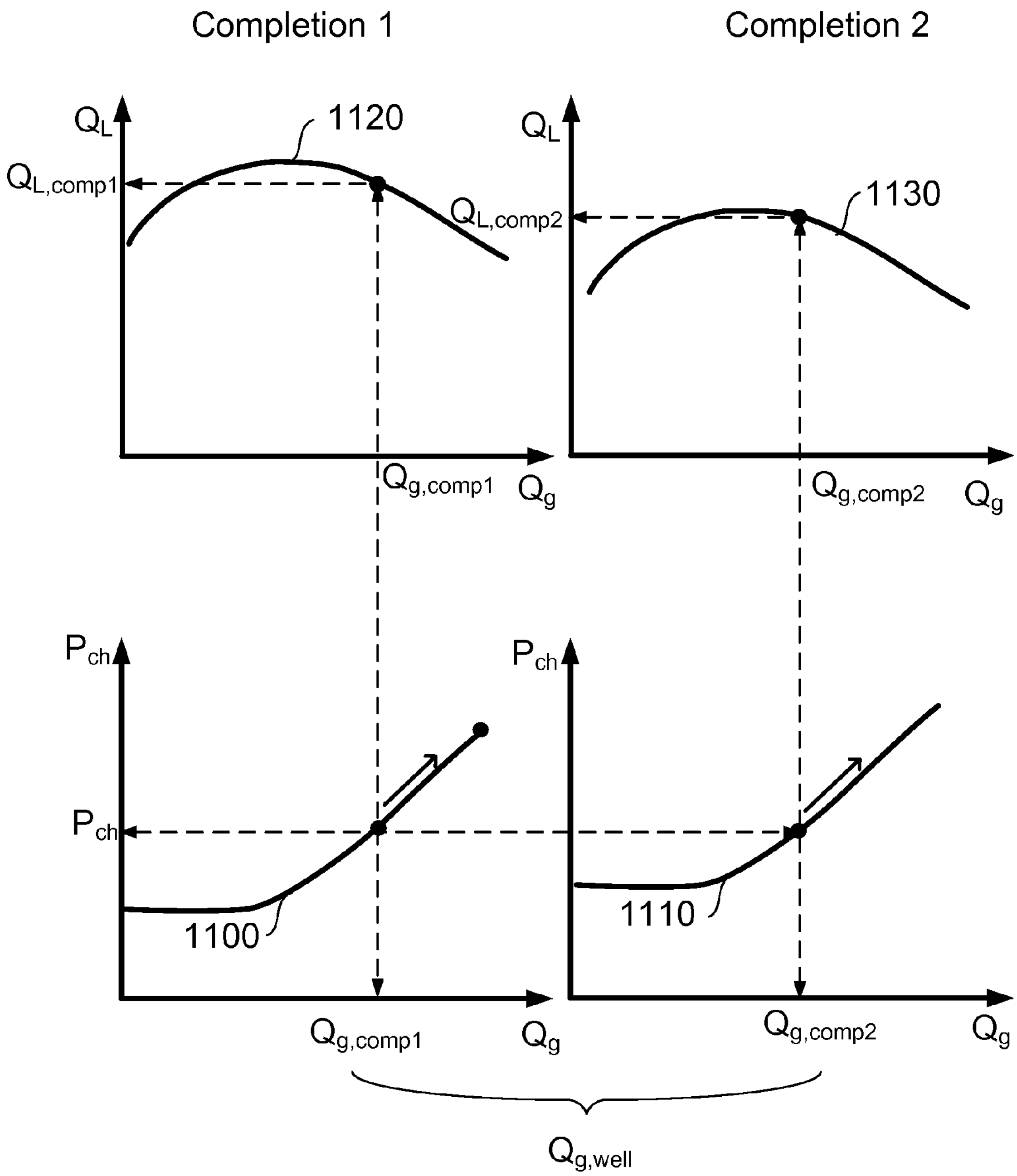
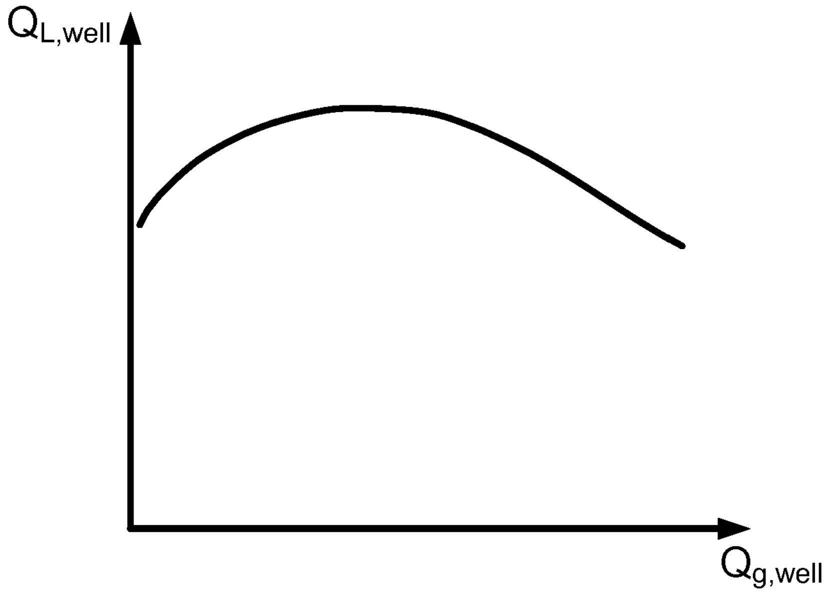
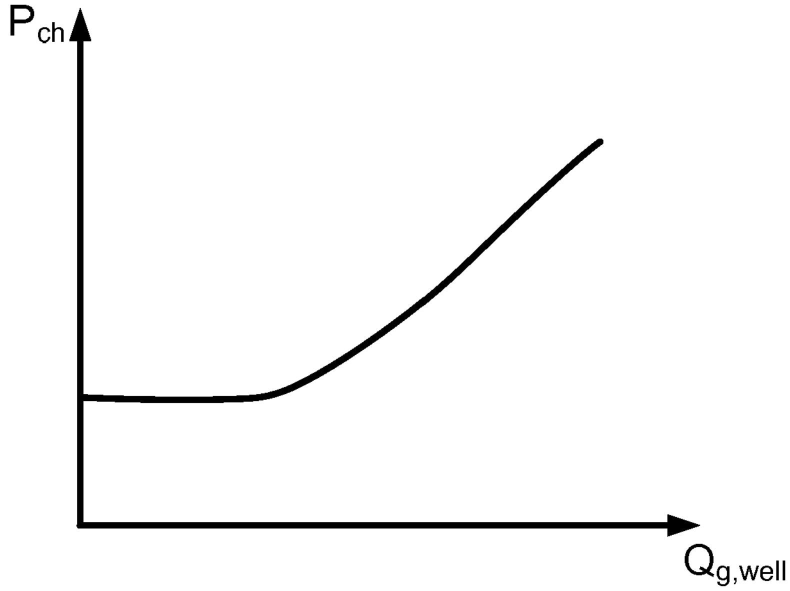

Completion 1
Completion 2
QL
1120
QL,comp1
QL,comp2
1130
Qg,comp1
Qg
Qg,comp2
Qg
Pch
Pch
Pch
1100
1110
Qg,comp1
Qg
Qg,comp2
Qg
Qg,well

Fig. 13



(a)



(b)

Fig. 14

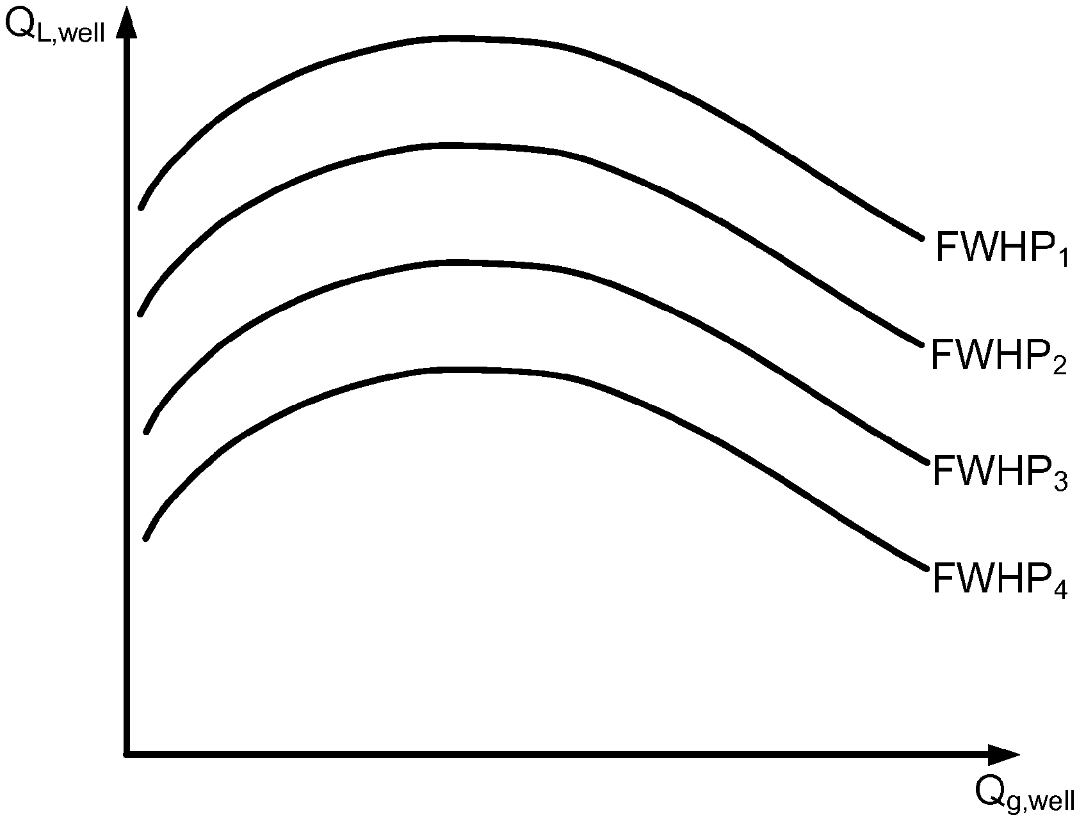


Fig. 15

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EUROPEAN SEARCH REPORT

Application Number
EP 15 16 4713

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	Akanji Lateef: "Production optimisation of a gas-lifted dual-completion offshore Nigeria", European Artificial Lift Forum 2014 , 17 June 2014 (2014-06-17), XP055214983, Retrieved from the Internet: URL:http://www.spe-uk.org/aberdeen/wp-content/uploads/2014/07/5.-Production-Optimisation-of-a-Gas-lifted-Dual-Completion-Offshore-Nigeria-University-of-Salford.pdf [retrieved on 2015-09-21] * the whole document * * pages 5,7,8,9, * * Prosper Manual 2010; page 24, paragraph 3 * -----	1-13	INV. E21B43/12
X	Sheri Adoghe ET AL: "ENHANCING PRODUCTION PERFORMANCE OF DUAL COMPLETION GAS LIFTED WELLS USING NOVA VENTURI ORIFICE VALVE", , 17 June 2014 (2014-06-17), XP055215055, Retrieved from the Internet: URL:http://www.spe-uk.org/aberdeen/wp-content/uploads/2014/07/4.-Gas-lifted-Dual-Completions-using-Venturi-Orifice-Valves-Schlumberger-Shell.pdf [retrieved on 2015-09-22] * pages 11,13 * -----	1	

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TECHNICAL FIELDS SEARCHED (IPC)
E21B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	22 September 2015	van Berlo, André

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EUROPEAN SEARCH REPORT

Application Number
EP 15 16 4713

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	Widianoko ET AL: "CASING HEAD PRESSURE FINE TUNING in Dual String Gas Lift Well With Injection Pressure Operated Valve", , 31 December 2003 (2003-12-31), XP055215062, Retrieved from the Internet: URL:http://alrdc.com/workshops/2003_FallGasLift/presentations/Presentation_BP_Casing_Press.ppt [retrieved on 2015-09-22] * pages 5,7,8,13 * * pages 14,25 * * the whole document * -----	1	
A	US 2010/198533 A1 (PEACOCK LARRY [US] ET AL) 5 August 2010 (2010-08-05) * the whole document * * figures 2-4 * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	22 September 2015	van Berlo, André

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010198533 A1	05-08-2010	NONE	

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