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APPLICATION NO.	: PI2020006489
GRANT NO.	: MY-205592-A
OWNER	: SCANWELL TECHNOLOGY AS
DATE OF GRANT AND PUBLICATION	: 29 OCTOBER 2024
APPLICANT'S/AGENT'S REF.	: P-032530

NOTICE OF GRANT

The purpose of this notice is to advise you that a patent/utility innovation has been granted on the above application.

Please find enclosed a certificate of grant with a copy of the patent/utility innovation together with a copy of the Examiner's final report (if not previously provided) in accordance with Section 31 (2)(a) of the Patents Act.

Copies of the Patent/utility innovation were made available to the public on the date of grant. A reference to the grant will be published in the Gazette as soon as possible.

Your attention is drawn to the need to pay annual renewal fees in order to keep the patent/utility innovation in force (see Section 35(2) and (3) of the Patents Act and Schedule 1 of the Regulations).

Date : 07 NOVEMBER 2024

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CERTIFICATE OF GRANT OF A PATENT

In accordance with Section 31 (2) of the Patents Act 1983 a patent for an invention having grant number MY-205592-A has been granted in respect of an invention having the following particulars:

TITLE	:	METHOD OF IMPROVING A FLOW RATE OF PRODUCED FLUID IN A WELL AND APPARATUS FOR PERFORMING THE METHOD
FILING DATE	:	05 JUNE 2019
PRIORITY DATE	:	07 JUNE 2018
PATENT OWNER	:	SCANWELL TECHNOLOGY AS LURAMYRVEIEN 51, 4313 SANDNES NORWAY
NAME OF INVENTOR	:	SHKORIN, DANIEL DIMA
DATE OF GRANT	:	29 OCTOBER 2024

Dated this 29 day of OCTOBER 2024

(KAMAL KORMIN)
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(12) **MALAYSIAN PATENT**

(11) **MY-205592-A**

(21) **Application No. :** PI2020006489

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WO 2017065863 A1
WO 0165056 A1
WO 2018056990 A1
WO 2010111475 A1

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(54) **Title :** Method of Improving a Flow Rate of Produced Fluid in a Well and Apparatus for Performing the Method

(57) **Abstract :**

There is described a method of improving a flow rate of produced fluid in a well (3), the well (3) comprising a production flow line (2) and an injection line (23), the production flow line (2) comprising a production bore (25) of the well (3), the injection line (23) being connected to the production flow line (2) at a first location (21) and the well (3) having a second location (22) in the production flow line (2) downstream of the first location (21), the well (3) comprising a control unit that may be adjusted to affect the flow rate of produced fluid from the well (3), wherein the control unit is a valve for adjusting a rate of injection of gas-lift gas, the method comprising the steps of:

- injecting a tracer substance from the injection line (23) into the production flow line (2) at the first location (21), wherein the tracer is injected at a known rate of injection;
- obtaining a first measurement of the tracer substance in the produced fluid at the second location (22) by use of a means (11) for obtaining said measurement while producing fluid using the first setting of the control unit;
- using the first measurement of the tracer substance to determine a first parameter of the flow of the produced fluid
- adjusting the control unit to a second setting;
- obtaining a second measurement of the tracer substance in the produced fluid at the second location (22) by use of the means (11) for obtaining said measurement while producing fluid using the second setting of the control unit;
- using the second measurement of the tracer substance to determine a second parameter of the flow of the produced fluid; and
- comparing the first parameter to the second parameter to determine an effect of changing the setting of the control unit, a method of determining a rate of injection of gas- lift gas into a well, and an apparatus for performing the method of improving the flow rate of produced fluid in the well.

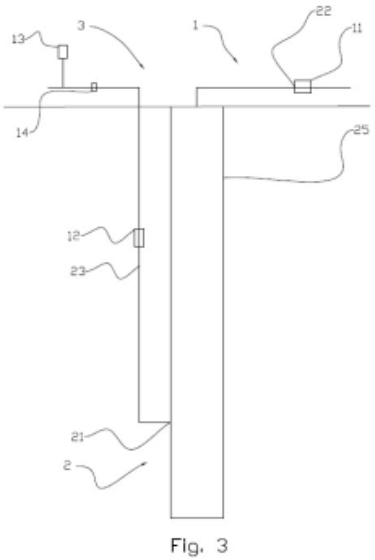

Fig. 3

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SUBSTANTIVE EXAMINATION
CLEAR REPORT - SECTION 30(1)

The Examiner has reported that the above application complies with the requirements of the Patents Act 1983 and Patents Regulations 1986. The examination was carried out on the following application documents:

Description:	Pages	1 – 13		filed on	11 January 2024
Claims:	Pages	14 – 16	(claims no. : 1 – 13)	filed on	11 January 2024
Drawings:	Figure	1 – 3	(sheets no. : 1/3 – 3/3)	filed on	07 December 2020
Abstract:	Pages	17		filed on	11 January 2024
	Figure	3		filed on	07 December 2020

Notice of Grant will be issued once the application is granted.

A search report is attached *~~Yes~~ / No

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METHOD OF IMPROVING A FLOW RATE OF PRODUCED FLUID IN A WELL AND APPARATUS FOR PERFORMING THE METHOD

Field of invention

The present invention relates to a method of improving a flow rate of produced fluid in a well, and an apparatus for performing the method.

Background

In a wide range of contexts, it can be important to determine a parameter of a flow of a produced fluid in a well, e.g. to quantify a production rate from the well. For example, it can be important to quantify a flow rate in a well to investigate if the well is producing as expected, and to investigate effects of how changing a setting of a control unit may affect the production rate.

There exist flow meters that may be used to obtain a measurement of a flow rate of a fluid from a well. However, the flow meters are expensive, and the accuracy of the flow meters can often be poor. The flow meters may also require frequent replacement and/or maintenance to provide acceptable accuracy. Because of the disadvantages, many wells do not have a flow meter to quantify production rate.

Alternatively, to obtain a measurement of production rate from a well, the production line of the well can be connected to a test separator. This can be challenging: Some wells do not have test separators easily accessible. For some installations, it is necessary to acquire the services of a truck or a ship having a test separator and to connect said test separator to the well to be tested. Even when test separators are available on an installation site, and the test separator can easily be connected to the production line of a well, it may be inefficient to use the test separator. For example, if an operator wants to test the effect of a change of rate of injection of gas-lift gas into a well, it may take several days for the resulting rate of production to stabilize and to be obtainable from measurements by use of the test separator. In such cases, the production line of said well may occupy the test separator for a long time. This may be very problematic as test separator capacity can often be a limited resource. Furthermore, production from a well may be lost when the well is connected to the test separator.

An object of the invention is to remedy or to reduce at least one of the drawbacks of prior art.

Summary

According to a first aspect of the invention, there is provided a method of improving a flow rate of produced fluid in a well, the well comprising a production flow line and an injection line, the production flow line comprising a production bore of the well, the injection line being connected downhole to the production flow line at a first, downhole location and the well having a second location in the production flow line downstream of the first location, gas-lift gas being injected into the production flow line at the downhole location from the injection line, the well comprising a control unit that may be adjusted to affect the flow rate of produced fluid from the well, wherein the control unit is a valve for adjusting a rate of injection of gas-lift gas, the method comprising the steps of: injecting a tracer substance from the injection line into the production flow line at the first location, wherein the tracer is injected at a known rate of injection; obtaining a first measurement of the tracer substance in the produced fluid at the second location by use of a means for obtaining said measurement while producing fluid using the first setting of the control unit; using the first measurement of the tracer substance to determine a first parameter of the flow of the produced fluid; adjusting the control unit to a second setting; obtaining a second measurement of the tracer substance in the produced fluid at the second location by use of the means for obtaining said measurement while producing fluid using the second setting of the control unit; using the second measurement of the tracer substance to determine a second parameter of the flow of the produced fluid; and comparing the first parameter to the second parameter to determine an effect of changing the setting of the control unit.

The step of comparing the first parameter to the second parameter to determine an effect of changing the setting of the control unit may comprise the step of determining which of the first setting and the second setting that results in a best flow rate of produced fluid in the well. The method may comprise the step of choosing the setting resulting in the best production rate as a setting for the well, to improve the flow rate of produced fluid in the well.

A well typically has one or more valves or other control units that may be adjusted wherein said adjustment may affect a rate of production of produced fluid from the well. Among the examples are a control unit to adjust a rate of injection of gas-lift gas for a gas-lift well, and a control unit in the production line. Said control unit may typically be a control valve, a butterfly valve or a choke valve.

When altering a setting of a control unit, it may not be clear in advance what effect the change of setting will have on the rate of production. Advantageously, with the method, it may not be necessary to route production to a test separator to determine the effect. By obtaining a first measurement of a tracer substance prior to changing said setting and a second measurement of tracer substance after changing said setting, it is possible to determine an effect of the change.

The measurement of the tracer substance in the produced fluid may be a measurement of the tracer substance in a produced gas. Wells may typically produce a mixture of gas and liquid, and it may be possible and advantageous for the measurement to be a measurement of a gas portion of the total produced fluid and to thereafter correlate the resulting determined parameter of and/or effect on the produced gas to a corresponding parameter of and/or effect on the produced liquid. The produced liquid may typically comprise oil. The correlation may be made as a gas/oil ratio (GOR) and a gas/liquid ratio (GLR) in the produced fluid may be known and substantially constant over a period of time. An increase or decrease to e.g. a production rate of a gas may therefore easily be used to determine a corresponding increase or decrease to a production rate of a liquid.

The step of obtaining a measurement of the tracer substance may include determining a concentration of the tracer in a flow of fluid at the second location.

The step of using the measurement of the tracer substance to determine the parameter of the flow may include dividing the known rate of injection by the determined concentration of the tracer substance in the flow at the second location.

The produced fluid at the second location may typically comprise a reservoir fluid from a fluid reservoir. The reservoir fluid may comprise a plurality of substances.

If the reservoir fluid does not comprise the tracer substance, a rate of flow of production fluid may be determined by using the following formula:

$$Q_{f2} = {}^{Q_{ti1}}/_{c_{t2}}$$

where:

Q_{f2} is flow rate of a produced fluid in the second location;
Q_{ti1} is flow rate of tracer injected in the first location; and
c_{t2} is concentration of tracer in the second location.

Q_{f2} may be a flow rate of a gas.

If Q_{f2} is a flow rate of a gas, an approximate flow rate of oil, Q_O, may be found simply by dividing Q_{f2} with the gas/oil ratio, GOR:

$$Q_O = {}^{Q_{f2}}/_{GOR}.$$

Likewise, an approximate flow rate of liquid, Q_L, may be found simply by dividing Q_{f2} with the gas/liquid ratio, GLR:

$$Q_L = {}^{Q_{f2}}/_{GLR}.$$

The method may thus be used to determine a parameter of flow of liquid and/or oil, in addition to the parameter of the parameter of flow of gas. The method may be used to determine a flow rate of all phases of a multiphase flow.

The substance used as a tracer substance may be present in the reservoir fluid as one of the plurality of substances.

If the substance used as a tracer substance is present in the reservoir fluid, the reservoir liquid may be saturated with said tracer substance. In that case, the injected tracer substance may not become absorbed by a liquid of the reservoir fluid. Instead, the injected tracer may follow the fluid flow fully as a component of the gas of the produced fluid.

The step of determining a concentration of the tracer substance may comprise:

- determining a first concentration of tracer substance, the first concentration of tracer substance being the concentration of tracer substance in the reservoir fluid; and
- determining a second concentration of tracer substance, the second concentration

of tracer substance being the concentration of tracer substance in the produced fluid including both the reservoir fluid and the injected tracer substance.

The step of using the measurement of the tracer substance to determine the parameter of the flow of the produced fluid may comprise using the first concentration of tracer substance and the second concentration of tracer substance.

If the reservoir fluid does comprise the tracer substance, a rate of flow of production fluid in the second location may be determined by using the following formula:

$$Q_{f2} = \frac{Q_{ti1} - Q_{ti1} * c_2}{\Delta c}$$

where:

Q_{f2} is flow rate of fluid in the second location;

Q_{ti1} is flow rate of tracer injected in the first location;

c_2 is a the second determined concentration; and

Δc is the difference in concentration from the first concentration, c_1, to the second concentration, c_2:

$$\Delta c = c_2 - c_1$$

The tracer substance may be injected in a flow of fluid including a gas-lift gas. This may typically be the case if the method is to be applied to a gas-lift well. The well may be a gas-lift well.

The injection line may be a chemical injection line or a gas lift injection line.

The parameter of the flow may be related to a quantification of the flow.

A plurality of different settings of the control unit may be used. At least one measurement of the tracer substance at the second location may be obtained for each of the different settings by use of the means for obtaining the measurement. The plurality of measurements may be used to determine a best setting for improving the flow rate of the produced fluid from the well.

By trying a plurality of different settings, it is possible to determine a setting that is a best setting of the plurality of settings.

The method according to the second aspect of the invention may be applied to a plurality of wells sharing a source of gas-lift gas, to determine a best distribution of gas-lift gas to the wells for improving the flow rate of produced fluid from each well to obtain a best total production of fluid from the plurality of wells.

It is not uncommon for a plurality of gas-lift wells to share a source of gas-lift gas. The source of gas-lift gas may not have the capacity to sufficiently provide each well with the optimal amount of gas-lift gas for the well. It may then be advantageous to apply the method to a number or all of the gas-lift wells to determine a best distribution of gas-lift gas to achieve a best rate of total production from the wells.

The control unit may be a choke valve.

The control unit may be a control unit to adjust the rate of injection of a gas-lift gas.

The control unit, which may be a choke valve, may be placed in the production line, downstream of the first location.

The method may further comprise the step of determining a rate of injection of the tracer substance.

The step of determining the rate of injection of the tracer substance may comprise using a device for measuring an amount of flow of fluid and/or using a device for determining a concentration of a substance in a flow of fluid.

The device for measuring an amount of flow of fluid may be a flow meter. The device for determining a concentration of a substance in a flow of fluid may be a chromatograph or a spectrometer.

The method may further comprise the step of determining a rate of injection of injected gas-lift gas.

The step of determining the rate of injection of injected gas-lift gas comprises using a device for measuring an amount of flow of fluid and/or using a device for determining a concentration of a substance in a flow of fluid.

To accurately quantify production from the reservoir, it may be necessary to determine a rate of injection of injected gas-lift gas. Some wells may have gas-injection lines comprising a flow meter that may give an accurate reading of said rate. Other wells may have a flow meter where the accuracy is not sufficient or not known or may not have a flow meter at all. It may then be necessary to connect a flow meter to said injection line, or to determine the rate of injection by use of other means.

The method may further comprise a step of determining a production rate of a fluid from a reservoir by subtracting a gas-lift gas injection rate from a determined production flow rate. The production rate of the fluid from the reservoir may be a production rate of a gas from the reservoir, and the determined production flow rate may be the production flow rate of a gas. The gas may be a gas in a multiphase flow.

The device for determining a concentration of a substance in a flow of fluid may be a spectrometer or a chromatograph. The step of determining the rate of injection may then comprise adding a known quantity of tracer substance and/or injecting a tracer substance at a known rate of injection into the injection line in a first position in the injection line, and then to use the device for determining a concentration of a substance in a flow of fluid to determine the concentration of the tracer substance at a second position in the injection line, where the second position is downstream of the first position.

According to a second aspect of the invention, there is provided apparatus for performing the method according to the first aspect of the invention, the apparatus comprising: a production flow line comprising a production bore; an injection line to be connected downhole to the production flow line at a first, downhole location in the production flow line for injecting gas-lift gas into the production flow line at the downhole location from the injection line; a control unit that may be adjusted to affect the flow rate of produced fluid from the well, wherein the control unit is a valve for adjusting a rate of injection of gas-lift gas, the control unit being adjustable from a first setting to a second setting; and means configured to: obtain a first measurement of a tracer substance at a second location in the

production flow line while, in use, producing fluid using the second setting of the control unit, the second location being downstream of the first location; use the first and second measurements of the trace substance to determine first and second parameters of the flow of the produced fluid; and compare the first parameter to the second parameter to determine an effect of changing the setting of the control unit.

Said means may be configured to obtain measurements of concentration of the tracer substance. Said means may comprise a spectrometer or a chromatograph to measure the concentration of the tracer substance.

The apparatus may further comprise a container for containing the tracer substance. The container may be connected to the injection line for supplying the tracer substance into the injection line.

Furthermore, the apparatus may comprise a device for measuring an amount of flow of fluid and/or a device for determining a concentration of a substance in a flow of fluid, wherein the device or the devices may be arranged for determining a rate of fluid flowing through the injection line.

According to an example, which is not part of the claimed invention, there is also described herein a method for determining a parameter of a flow of a produced fluid in a well, the well comprising a production flow line and an injection line, the production flow line comprising a production bore of the well, the injection line being connected to the production flow line at a first location, and the well having a second location in the production flow line downstream of the first location, the method comprising the steps of: injecting a tracer substance from the injection line into the production flow line at the first location, wherein the tracer is injected at a known rate of injection; obtaining a measurement of the tracer substance in the produced fluid at the second location by use of a means for obtaining said measurement; and using the measurement of the tracer substance to determine the parameter of the flow of the produced fluid.

The parameter of a flow to be determined may be a parameter to quantify the flow, e.g. to quantify a rate of production. The example method advantageously may not require production to be routed to a test separator to determine the parameter of the flow. The

parameter may be a flow rate of the flow of produced fluid. The means for obtaining said measurements may be means adapted to be connected to the production line with no need for diverting or stopping production.

A huge number of substances may be used as a tracer substance, including carbon dioxide, nitrogen, helium, argon, a radioactive material, or another substance.

Note that "a second location in the production line downstream of the first location" means a point in the production line away from the first location in the direction of the fluid flow in the production line. The fluid flow of produced fluid in the production line typically goes from an underground fluid reservoir towards a separator. Thus, first location may typically be closer to the reservoir than the second location, and the second location may typically be closer to the separator than the first location.

The first location may be a downhole location. The second location may be a topside location. "Downhole" refers to a position in a wellbore below the surface of a ground, whereas "topside" refers to a position above the surface.

A spectrometer or a chromatograph may be used as the means for obtaining said measurements. Other devices may be used as the means for obtaining said measurements. The means may be connected to the production line to determine which substances are present in the flow, and/or a concentration of present substances. It may primarily be of interest, for the execution of the method, to quantify and/or to find a concentration of the tracer substance in particular.

The measurement may be obtained continuously. Obtaining a continuous measurement may provide more and/or better information. A continuous measurement may e.g. provide a continuous flow pattern of the produced fluid over the duration of the continuous measurement.

When a rate of injection of tracer substance in the first location is known, and a concentration of the tracer substance in the second location is known, it may be possible to determine the total flow rate of fluid at the second location.

Description and drawings

In the following is described example embodiments with reference to the accompanying drawings, wherein:

Fig. 1 shows a schematic representation of an example apparatus for determining a parameter of a flow of a produced fluid from a well;

Fig. 2 shows a schematic representation of another example of the apparatus; and

Fig. 3 shows a schematic representation of another example of the apparatus.

Figure 1 shows an apparatus 1 for determining a parameter of a flow of a produced fluid from a well 3. The well has a production flow line 2 comprising a production bore 25 and an injection line 23 connected to the production flow line 2 in a first location 21 of the production flow line 2. In a second location 22 of the production flow line 2, a spectrometer 11 for obtaining a measurement of a tracer substance is arranged to obtain a measurement of the tracer substance in a flow of fluid. The flow of fluid is a mixture of a reservoir fluid from a reservoir (not shown) and a fluid injected from the injection line into the production flow line in the first location 21. The direction of flow is from the reservoir, through the first location 21, towards and through the second location 22. Thus, the second location 22 can be said to be downstream of the first location 21.

A method for determining a parameter of a flow of a produced fluid in the well 3, using the apparatus 1, is performed as follows:

A tracer substance is injected into the production flow line 2 at the first location 21, the tracer substance being injected at a known rate of injection. The spectrometer 11 obtains a measurement of the tracer substance at the second location 22. More precisely, the spectrometer 11 obtains a measurement of a concentration of the tracer substance in the flow of fluid in the second location 22 of the production flow line 2. Then, the measurement of concentration of tracer substance is used to determine the parameter of the flow of the produced fluid. More precisely, the flow rate of produced fluid is determined.

When the flow rate of injected tracer substance in the first location 21, Q_{ti1}, is known, and the concentration of tracer substance in the second location 22, c_{t2}, is determined, the flow rate in the second location 22, Q_{f2} , can be determined by using the following formula: $Q_{f2} = {Q_{ti2}}/{c_{t2}}$.

The produced fluid measurement of concentration of tracer substance in this embodiment is a concentration of tracer substance of a flow of gas in the flow of fluid. Q_{f2}, therefore, is a flow rate of the gas. The total produced fluid in the second location comprises both gas and oil, and the GOR is known. As the GOR is known and is substantially constant (for a period of time), the flow of oil can be determined by using the following formula: $Q_O = {Q_{f2}}/{GOR}$.

The above-mentioned calculation can be used if the tracer substance is not present in the reservoir fluid. If the tracer substance is present in the reservoir fluid as one of a plurality of substances that makes out the fluid, it must be determined a concentration of the tracer substance in the reservoir fluid without the injected tracer substance, c_1, a concentration of the tracer substance in the produced fluid with injected tracer substance, c_2, and an increase in concentration, Δc, where $\Delta c = c_2 - c_1$.

The flow rate of gas in the second location 22 in the production flow line 2 may be determined using the following formula: $Q_{f2} = {Q_{ti2}}/{\Delta c}$. The flow rate of oil may thereafter be determined as above.

Figure 2 shows the apparatus in a second example, wherein the apparatus has all the same parts as in Figure 1 and additionally a device 13 for supplying tracer substance into the injection line connected to the injection line in a first position in the injection line and a spectrometer 12 connected to the injection line in a second position in the injection line. The second position is downstream of the first position in the injection line.

By use of the device 13, tracer substance is added to the fluid stream in the injection line at a known rate. The spectrometer 12 is used to determine a concentration of the tracer substance in the second position in the injection line.

By knowing the rate of supply of tracer substance in the first position in the injection line, Q_t, and determining the concentration of the tracer substance in the second position in the injection line, c_t, a rate of injection of gas from the injection line into the production flow line, Q_{ig}, can be determined:

$$Q_{ig} = {Q_t}/{c_t}.$$

It can be important to know the injection rate to accurately determine the production rate from a reservoir. When the production flow rate, Q_{f2}, is determined, and the injection rate, Q_{ig}, is determined, the production rate from the reservoir, Q_r, can be determined by subtracting the injection rate from the production flow rate:

$$Q_r = Q_{f2} - Q_{ig}.$$

Figure 3 shows an example having a control unit 14 in the form of a choke valve 14 in the injection line 23 to adjust an injection rate of a gas-lift gas. The injection line 23 further has a spectrometer 12 for determining a concentration of an injected tracer substance placed downstream of a device 13 for supplying tracer substance into the injection line 23. Furthermore, the example in Figure 3 has a spectrometer 11 in a second location 22 in the production flow line 2 downstream of a first location 21, where the injection line 23 connects to the production flow line 2. The first location 21 is downhole, whereas the second location is topside.

By use of the choke valve 14, it is possible to change the rate of injection of gas-lift gas into the well, and thus to affect a production flow rate in the production flow line 2. By use of the spectrometer 12 in the injection line 23, it is possible to accurately quantify the injection rate, and by use of the spectrometer 11 in the production flow line 2 it is possible to accurately quantify the production flow rate.

With the apparatus shown in Figure 3 it is possible to change an injection rate, determine the injection rate, affect the production flow rate, determine the production flow rate, and, through determining the injection rate and the resulting production flow rate for a plurality of different injection rates, to determine an injection rate that leads to a better production flow rate than other injection rates.

The example shown in Figure 3 is highly advantageous compared to prior art, as to find a resulting flow rate from a change of injection rate with no need for connecting the production flow line to a separator.

The example and method are particularly advantageous for an installation site having multiple wells sharing a limited, same source of gas-lift gas, to find a gas-lift gas distribution to the wells for good and/or improved and/or optimal total production from the wells.

It should be noted that the above-mentioned examples illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. For example, in place of a spectrometer 11, 12, another device may be used to obtain the measurement or measurements, e.g. a chromatograph. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.

The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

CLAIMS

1. A method of improving a flow rate of produced fluid in a well (3), the well (3) comprising a production flow line (2) and an injection line (23), the production flow line (2) comprising a production bore (25) of the well (3), the injection line (23) being connected downhole to the production flow line (2) at a first, downhole location (21) and the well (3) having a second location (22) in the production flow line (2) downstream of the first location (21), gas-lift gas being injected into the production flow line at the downhole location (21) from the injection line, the well (3) comprising a control unit that may be adjusted to affect the flow rate of produced fluid from the well (3), wherein the control unit is a valve for adjusting a rate of injection of gas-lift gas, the method comprising the steps of:

- injecting a tracer substance from the injection line (23) into the production flow line (2) at the first location (21), wherein the tracer is injected at a known rate of injection;
- obtaining a first measurement of the tracer substance in the produced fluid at the second location (22) by use of a means (11) for obtaining said measurement while producing fluid using the first setting of the control unit;
- using the first measurement of the tracer substance to determine a first parameter of the flow of the produced fluid;
- adjusting the control unit to a second setting;
- obtaining a second measurement of the tracer substance in the produced fluid at the second location (22) by use of the means (11) for obtaining said measurement while producing fluid using the second setting of the control unit;
- using the second measurement of the tracer substance to determine a second parameter of the flow of the produced fluid; and
- comparing the first parameter to the second parameter to determine an effect of changing the setting of the control unit.

2. The method according to claim 1, wherein the step of obtaining a first measurement of the tracer substance and the step of obtaining the second measurement of the tracer substance includes determining a concentration of the tracer in a flow of fluid at the second location (22).

3. The method according to claim 1 or 2, wherein the first measurement of the tracer substance and the second measurement of the tracer substance are obtained continuously over a period of time.

4. The method according to any one of the preceding claims, wherein:

- the produced fluid at the second location (22) comprises a reservoir fluid from a fluid reservoir, the reservoir fluid comprising a plurality of substances; and

- the substance used as a tracer substance is present in the reservoir fluid as one of the plurality of substances.

5. The method according to claim 4, which further comprises:

- determining a first concentration of tracer substance, the first concentration of tracer substance being the concentration of tracer substance in the reservoir fluid; and

- determining a second concentration of tracer substance, the second concentration of tracer substance being the concentration of tracer substance in the produced fluid including both the reservoir fluid and the injected tracer substance.

6. The method according to any one of the preceding claims, wherein the tracer substance is injected in a flow of fluid including a gas-lift gas.

7. The method according to any one of the preceding claims, wherein:

- a plurality of different settings of the control unit is used;

- at least one measurement of the tracer substance at the second location (22) is obtained for each of the different settings by use of the means for obtaining the measurement;

- the plurality of measurements is used to determine a best setting for improving the flow rate of the produced fluid from the well (3).

8. The method according to any one of the preceding claims, applied to a plurality of wells sharing a source of gas-lift gas, to determine a best distribution of gas-lift gas to the wells for improving the flow rate of produced fluid from each well to obtain a best total production of fluid from the plurality of wells.

9. The method according to any one of the preceding claims, wherein the control unit adjusts the rate of injection of an injected fluid.

10. The method according to any one of the preceding claims, which further comprises the step of determining a rate of injection of injected gas-lift gas.

11. The method according to any one of the preceding claims, used to determine a gas flow rate, a liquid flow rate and/or an oil flow rate of the production flow, wherein the production flow is a multiphase flow.

12. Apparatus (1) for performing the method according to claim 1, the apparatus (1) comprising:

- a production flow line (2) comprising a production bore (25);
- an injection line (23) to be connected downhole to the production flow line (2) at a first, downhole location (21) in the production flow line (2) for injecting gas-lift gas into the production flow line at the downhole location from the injection line;
- a control unit that may be adjusted to affect the flow rate of produced fluid from the well (3), wherein the control unit is a valve for adjusting a rate of injection of gas-lift gas, the control unit being adjustable from a first setting to a second setting; and
- means (11) configured to:

obtain a first measurement of a tracer substance at a second location (22) in the production flow line (2) while, in use, producing fluid using the second setting of the control unit, the second location (22) being downstream of the first location (21);

use the first and second measurements of the trace substance to determine first and second parameters of the flow of the produced fluid; and

compare the first parameter to the second parameter to determine an effect of changing the setting of the control unit.

13. The apparatus (1) according to claim 12, further comprising a device for measuring an amount of flow of fluid, and/or a device (12) for determining a concentration of a substance in a flow of fluid, wherein the device or devices are arranged for determining a rate of fluid flowing through the injection line (23).

ABSTRACT

METHOD OF IMPROVING A FLOW RATE OF PRODUCED FLUID IN A WELL AND APPARATUS FOR PERFORMING THE METHOD

There is described a method of improving a flow rate of produced fluid in a well (3), the well (3) comprising a production flow line (2) and an injection line (23), the production flow line (2) comprising a production bore (25) of the well (3), the injection line (23) being connected to the production flow line (2) at a first location (21) and the well (3) having a second location (22) in the production flow line (2) downstream of the first location (21), the well (3) comprising a control unit that may be adjusted to affect the flow rate of produced fluid from the well (3), wherein the control unit is a valve for adjusting a rate of injection of gas-lift gas, the method comprising the steps of:

- injecting a tracer substance from the injection line (23) into the production flow line (2) at the first location (21), wherein the tracer is injected at a known rate of injection;
- obtaining a first measurement of the tracer substance in the produced fluid at the second location (22) by use of a means (11) for obtaining said measurement while producing fluid using the first setting of the control unit;
- using the first measurement of the tracer substance to determine a first parameter of the flow of the produced fluid
- adjusting the control unit to a second setting;
- obtaining a second measurement of the tracer substance in the produced fluid at the second location (22) by use of the means (11) for obtaining said measurement while producing fluid using the second setting of the control unit;
- using the second measurement of the tracer substance to determine a second parameter of the flow of the produced fluid; and
- comparing the first parameter to the second parameter to determine an effect of changing the setting of the control unit, a method of determining a rate of injection of gas-lift gas into a well, and an apparatus for performing the method of improving the flow rate of produced fluid in the well.

Fig. 3

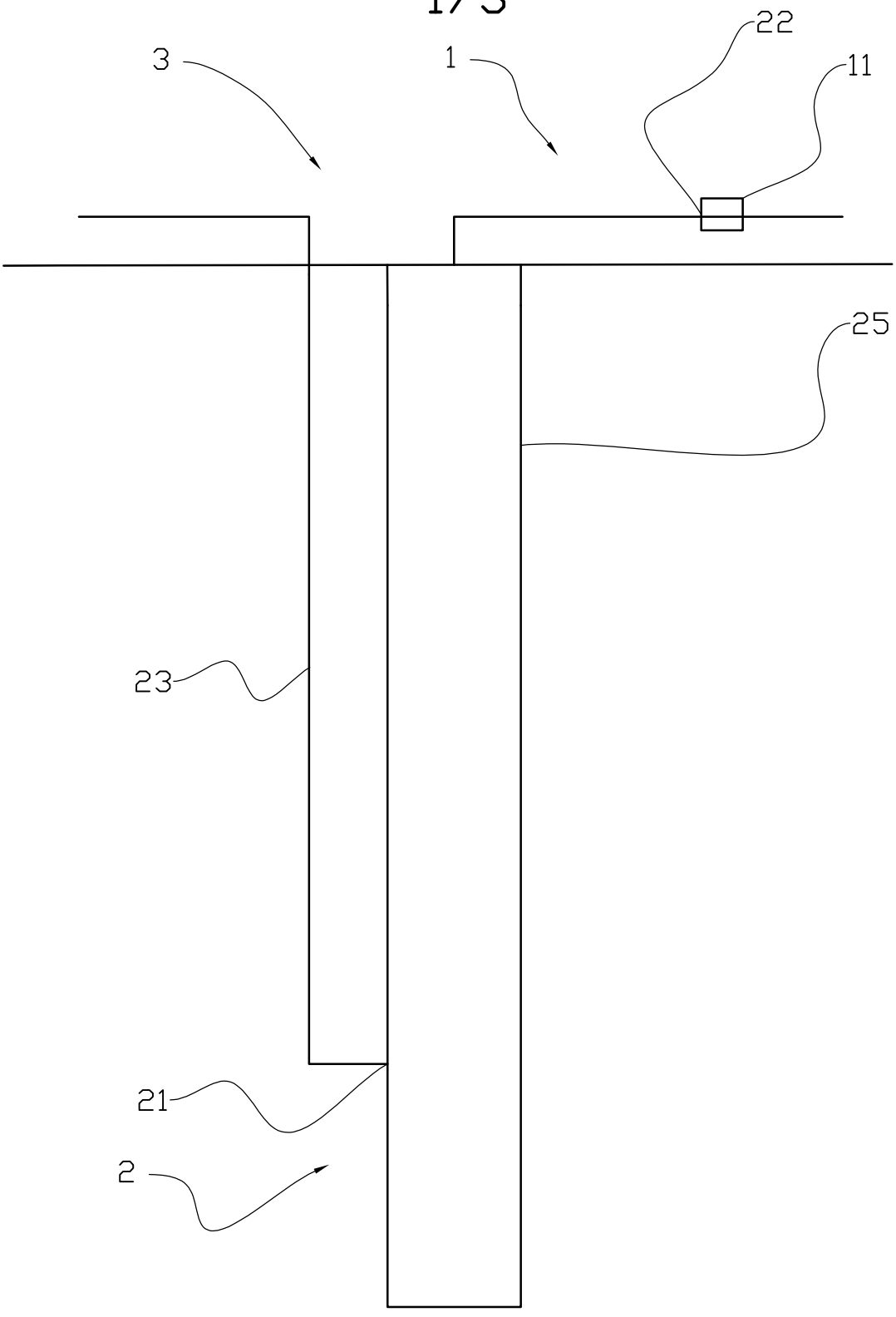

Fig. 1

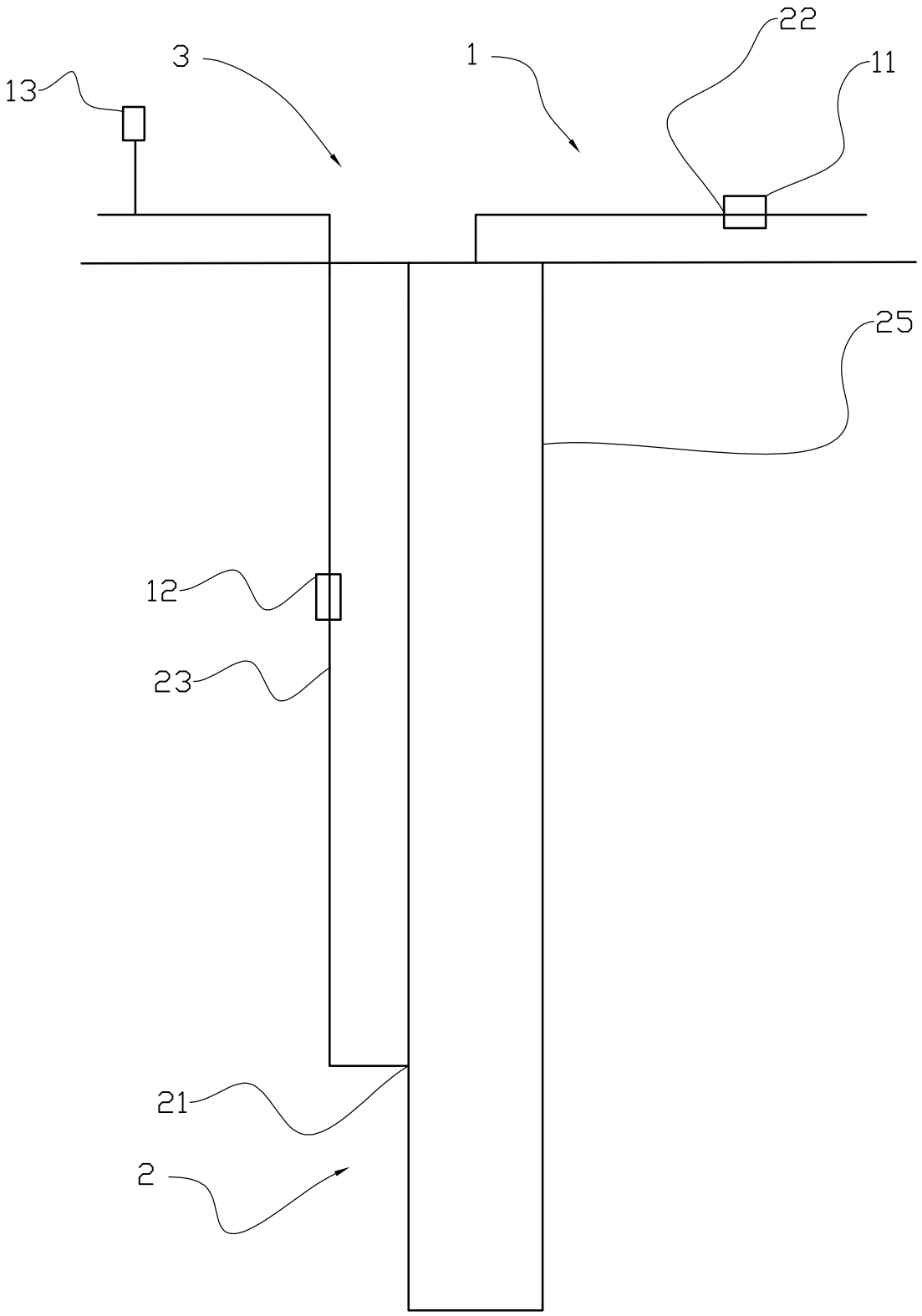

Fig. 2

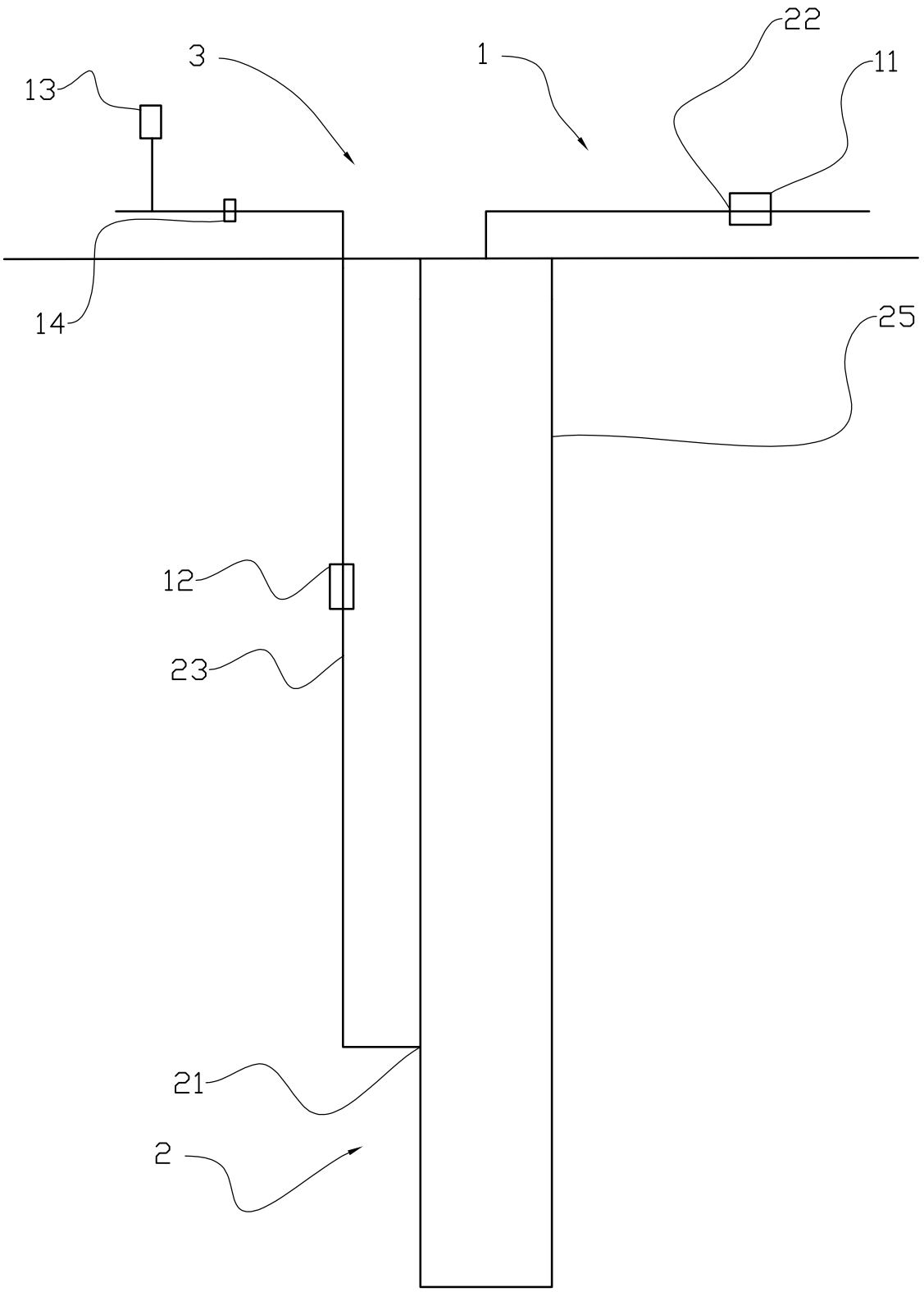

Fig. 3