(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 August 2013 (29.08.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/124625 A2

(51) International Patent Classification: Not classified

(21) International Application Number:
PCT/GB2013/050321

(22) International Filing Date:
13 February 2013 (13.02.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1202904.7 20 February 2012 (20.02.2012) GB
1210847.8 19 June 2012 (19.06.2012) GB

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) Title: IMPROVED GAS LIFT SYSTEM FOR OIL PRODUCTION

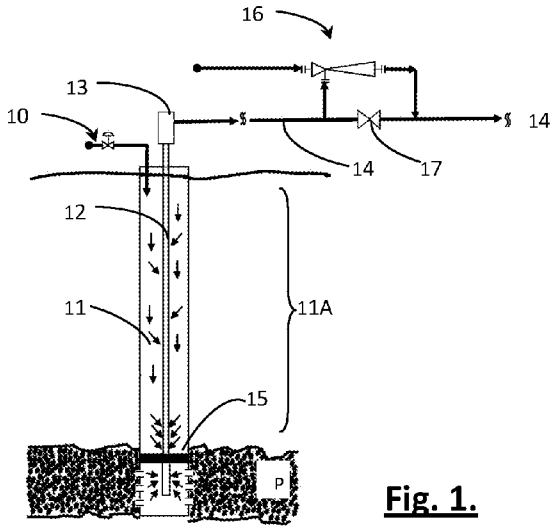

Fig. 1.

(57) Abstract: An improved gas lift system for use in oil production from a well bore (11) utilising a gas lift injection (10) system of the known type and further including a surface jet pump (16) downstream of the well head (13) for reducing the flowing well head pressure and capable of discharging produced fluid (14) at a pressure required by a downstream production system.

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Improved Gas Lift System for Oil Production

Technical Field

The present invention relates to a gas lift system for improving oil production from a well.

Background Art

The use of gas lift, involving the injection of high pressure gas at different depths of an oil well, is well known as an effective way to reduce the hydrostatic head of fluids flowing through the well bore and to increase the velocity of flow in order to prevent liquids building up in the well bore.

In a typical oil production case, particularly when the gas oil ratio (GOR) of the produced fluids is low (typically below 500 Scf/bbl/day) the flow regime of the produced fluids varies within the well bore, dictated mainly by the pressure at each depth. At the lowest points near the production/perforation zone, the flow regime is often single phase turbulent, bubble flow and slug flow. These types of flow regimes arise mainly because of the low velocity of gas at near bottom hole at the prevailing production pressures. These so-called erratic flow regimes cause a significant loss of pressure within the well bore and result in an increase in the flowing bottom hole pressure (FBHP) and build up of liquids because of the low velocity of gas to lift the liquids.

A rise in the FBHP will in turn restrict production. At higher levels, nearer the wellhead, the flow regime improves as the produced gas flows at a lower pressure and therefore at a higher apparent velocity and volumetric flow rate. For this reason the flow regime at the well bore sections near the wellhead is more stable and often of dispersed bubble flow type.

A gas lift system increases the velocity of the total gas flowing through the well bore and can change the flow regime within part of the well bore to the more favourable and stable flow regimes such as dispersed bubble flow. This in turn will reduce the FBHP of the well and results in a more stable production rate such that production can increase.

There is an optimum rate at which gas lift is effective, beyond which effectiveness reduces as the high velocity of fluids will increase frictional losses significantly; thus negating the gain from reduction in the hydrostatic head of produced fluids. The pressure of the gas lift gas is dictated by the well depth, injection depth and production pressure at the injection point. Typical gas lift pressure has been 70 to 100 barg, but this is not a limit.

There are, however, the following conditions that can arise in a gas lift system:

- There is insufficient amount of lift gas available at the desired pressure to achieve the maximum or optimum level of reduction in the hydrostatic head of fluids and the reduction in the FBHP for achieving maximum production.

- The high pressure (HP) gas is not of sufficient pressure to inject it at the lowest parts of the well bore where gas lift is needed and is more effective.

- The tubing size restricts the amount of lift gas as excessive frictional losses may be experienced, negating the benefit of lift gas.

The above mentioned scenarios restrict production and in some cases could lead to a build up of liquids within the well bore, resulting in erratic production and final seizure of production as the reservoir pressure drops with time.

There are many ways for reducing wellhead pressure, such as using multiphase pumps, but each solution is different and has its own unique features. The only common factor is that all boosting systems reduce the wellhead pressure. For example, WO 2011/025590 relates to the use of jet pumps downhole and is particularly for improving the production of heavy oil. In this case, by using light oil or diluents as the motive flow, the viscosity of the heavy oil is reduced which helps to reduce pressure losses along the well bore. The system is downhole, i.e. with no use of a surface apparatus to reduce wellhead pressure.

Surface jet pumps are known. For example, EP0717818 relates to the use of surface jet pump where flow from a high pressure oil well is used to reduce the back pressure on low pressure wells. However, in this document the source of motive flow is a high pressure well and the low pressure well is not gas lifted.

Disclosure of the Invention

The present invention seeks to address the identified conditions to improve operation of a gas lift system, thereby providing a corresponding improvement in production from an oil well.

In one broad aspect of the invention there is provided an improved gas lift system for use in the production of fluid from a well bore including: an injector for supplying pressurised gas to the well bore; a well head; a tube (also known as "tubing") extending from the well head into the well bore; a plurality of openings or valves at different depths of the tube for permitting the ingress of injected gas to assist fluid flowing upwards through the tube by reducing the hydrostatic pressure; further including a boosting unit downstream of the well head for reducing the flowing well head pressure and capable of discharging produced fluid at a pressure required by a downstream production system.

The improved gas lift system of the invention lowers the flowing wellhead pressure (FWHP) of the well in order to increase production and also to increase the velocity of gas flowing through the well bore. The flowing wellhead pressure (FWHP) of the well is often dictated by the downstream production and process system, however, provision of a dedicated boosting system at surface provides a clear advantage because it can reduce the FWHP of

the well whilst delivering the produced fluids at the pressure demanded by the downstream production system.

Preferably the boosting unit is a surface jet pump. The use of a surface jet pump (SJP) to reduce the FWHP is a cost effective and simple solution to rectify the problem identified by the first condition in the background section above and to improve production from the well. Particularly, by implementing the invention, the flow regime improves within the well bore because the produced fluid flows at a lower pressure and therefore at a higher apparent velocity and volumetric flow rate.

Preferably, the motive HP flow for the SJP could be one of the following: HP gas; HP oil or gas from one or more HP wells; HP liquid phase (oil or water). This HP liquid may be from an available HP source such as injection water or export oil, the pressure of which has been boosted for other reasons.

Typical pressure of the motive high pressure flow of the surface jet pump is twice the flowing wellhead pressure, but the pressure can be several times this value and typically up to 70 barg or higher. The flow rate of the HP flow is also typically equal to or higher than that of the well flow rate to be highly effective in reducing the FWHP by a factor of two or higher.

According to the invention, the combined gas lift system (with otherwise limited or not optimum gas lift rate) and the use of a surface jet pump will enhance production in a very cost effective and simple way.

In a second broad aspect of the invention there is provided an improved gas lift system for use in the production of fluids from a well bore including: an injector for supplying pressurised gas to the well bore; a well head; a tube extending from the well head into the well bore; a plurality of openings or gas lift valves at different depths of the tube for permitting the ingress of injected gas to assist fluid flowing upwards through the tube by reducing the hydrostatic pressure; further including a boosting unit upstream of the injector to boost the pressure of the lift gas.

Preferably the boosting unit is a surface jet pump configured to receive lower pressure injection gas (i.e. "lower pressure" is interpreted as lower than that ideally desired for optimum gas lift) into a first inlet, the flow rate of gas at the first inlet being increased by a high pressure motive flow capable of being received into a second inlet downstream of a recycle loop from a compressor (e.g. an existing compressor for provision of lift gas or for export of gas by pipeline), wherein the outlet of the surface jet pump is configured to supply gas to the inlet of the gas compression system.

This aspect of the invention addresses the problem identified where high pressure gas in the gas lift system is not of sufficient pressure to inject at the lowest parts of the well bore

where gas lift is needed and is most effective. The surface jet pump acts as a "pre-boost" pressurisation means before the compressor.

The system of the invention has two main distinctions from prior art discussed above. The first is the fact that the low pressure well is gas lifted and the second distinction is the fact that the motive flow can be from any source such as injection water, export oil or any high pressure liquid available. The main aspect of invention is a system which combines with gas lift to increases production and compensates for cases where gas lift is not optimised, either because there is insufficient gas or because the gas lift pressure is insufficient to inject it into the deeper part of the well where it is mostly needed.

Brief Description of the Drawings

Figure 1 shows an arrangement of an improved gas lift system according to the invention;

Figure 2 shows in graphical form the additional production achieved as a result of implementing the invention;

Figure 3 illustrates a surface jet pump suitable for use with the present invention; and

Figure 4 illustrates a further improved modification of a gas lift system according to the invention.

Modes for Carrying Out the Invention

Referring to Figure 1, increased oil production in a low GOR well is achieved by implementing a gas lift injection system 10 into a well 11 such that the hydrostatic head of fluids in the extraction tube 12 is reduced. An oil/gas mixture leaves the well head 13 for downstream processing via a pipeline 14.

According to known practice, a pressurised upper section 11A of the well 11 is sealed from the pay zone P by a barrier 15 (through which the tube 12 passes) and gas is introduced through the tube 12 wall at different depths via valves or apertures (not pictured in Figure 1). The flow rate of fluid naturally rising through the tube 12 due to underground pressure in the pay zone P is increased by bubbles forming from the injected gas into the tube 12.

The gas lift system as described above is generally known; however, in many cases there may be an insufficient amount of lift gas available at the desired pressure to achieve the maximum or optimum level of reduction in the hydrostatic head of fluids and the reduction in the flowing bottom hole pressure for achieving maximum production. To address this problem, according to the invention, a boosting unit, e.g. surface jet pump (SJP), 16 is installed downstream of the well head 13 to improve the flow regime within the well bore,

while reducing flowing well head pressure. As illustrated in Figure 1 a valve 17 may, when closed, divert fluid in the pipeline 14 through the surface jet pump 16 or, when open, bypass the pump.

The effect of the SJP in the above described condition is an improvement in the flow regime within the well bore, a reduction in the FBHP of the well and, ultimately, an increase in production. A suitable SJP may be as described in EP0717818; the present Figure 3 is derived from this document. The choice of the SJP system is dependent on the amount of liquids produced with gas and whether HP gas is sufficient as the motive flow or whether because of the rate of liquids produced the motive flow should be HP liquid phase such as that shown in Figure 3.

The motive (high pressure) flow 18 entering SJP 16 may be sourced from: HP gas; HP oil or gas from one or more HP wells; HP liquid phase (oil or water). In the latter case the HP liquid may come from an available HP source such as injection water or export oil, the pressure of which has been boosted for other reasons. The advantage of using an SJP 16 to improve the flow regime is that its high pressure fluid for operation need not be a gas, which the gas lift system is necessarily limited to, and can be derived from many possible sources, making efficient use of available resources.

Accordingly, in many cases the combination of a gas lift system at reduced rate or reduced pressure (depending on the availability and pressure of the HP gas) and an SJP system will be more cost effective and beneficial in maximising production from wells (as opposed to finding other ways to increase the injection gas pressure). The SJP also offers the simplest solution compared to alternative surface boosting systems such as multiphase pumps which, if used, require a significant amount of electric power not often available on platforms or well sites.

Figure 2 graphically illustrates the additional (i.e. rise in) production (AP) expected from a system of the invention utilising a surface jet pump and gas lift injection system (SJP+GI), compared to gas lift injection alone (GI). The respective curves also illustrate the optimum (peak) production, i.e. produced oil flow rate, which drops off with excessive gas injection flow rates as mentioned previously.

Typical pressure of the motive high pressure flow of the surface jet pump is twice the flowing wellhead pressure, but the pressure can be several times this value and typically up to 70 barg or higher. The flow rate of the HP flow is also typically equal to or higher than that of the well flow rate to be highly effective in reducing the FWHP.

A further improvement is shown in Figure 4, wherein an SJP unit 16A is installed within an injection gas circuit 19 to assist in raising the pressure of gas lift gas so that it can be injected effectively at the lowest part of the well to enhance gas lift and improve production. Such an arrangement addresses the identified condition where high pressure (HP) gas is not of

sufficient pressure to be injected at the lowest parts of the well bore (where gas lift is most needed and is most effective).

As illustrated, the SJP 16A uses as a motive flow 18 recycled gas from a gas lift compressor unit 20 such that the injection gas 21 input into the low pressure side of the SJP is "pre-pressurised" by the motive flow before it is further compressed by the downstream gas lift compressor 20. The illustrated system boosts pressure of lift gas 10 for injection to reach the lowest points within the well 11. It will be noted that, compared to Figure 1, Figure 4 does not show a barrier 15 such that liquid oil from the pay zone rises to a low level 22 in the well 11. As previously mentioned, lift gas passes through the tubing, well casing annulus and the wall of tube 12 via gas lift injection valves 23. The upper valves 23 on tube 12 represent a gas lift at limited pressure, whereas the lower valves (in this case below level 22) represent gas lift at a higher pressure. Bubbles formed in the fluid reduce the hydrostatic head pressure and enable the volumetric flow rate to increase.

The system of Figure 4 can be coupled with an additional SJP as in Figure 1 for further improvements in efficiency.

Industrial Applicability

It will be apparent that the system of the invention can be assembled from available oil production components at a well site. Alternatively, the components can be manufactured for specific compatibility, i.e. tuned to cooperate with each other for best performance.

Claims:

1. An improved gas lift system for use in the production of fluid from a well bore including:

an injector for supplying pressurised gas to the well bore;

a well head;

a tube extending from the well head into the well bore;

a plurality of openings or valves at different depths of the tube for permitting the ingress of injected gas to assist fluid flowing upwards through the tube by reducing the hydrostatic pressure;

further including a boosting unit downstream of the well head for reducing the flowing well head pressure and capable of discharging produced fluid at a pressure required by a downstream production system.

2. The gas lift system of claim 1 wherein the boosting unit is a surface jet pump.

3. The gas lift system of claim 2 wherein the surface jet pump utilises a motive flow sourced from one or more of the following: high pressure gas; high pressure oil and/or gas from one or more high pressure wells; high pressure liquid phase (oil or water) already boosted for other reasons.

4. The gas lift system of any preceding claim, including a further boosting unit installed upstream of the injector to boost the pressure of the lift gas.

5. The gas lift system of claim 4 wherein the further boosting unit is a surface jet pump.

6. An improved gas lift system for use in the production of fluid from a well bore including:

an injector for supplying pressurised gas to the well bore;

a well head;

a tube extending from the well head into the well bore;

a plurality of openings or valves at different depths of the tube for permitting the ingress of injected gas to assist fluid flowing upwards through the tube by reducing the hydrostatic pressure;

further including a boosting unit upstream of the injector to boost the pressure of the lift gas.

7. The gas lift system of claim 6 wherein the boosting unit is a surface jet pump.

8. The gas lift system of claim 6 or 7 further including a second boosting unit downstream of the well head for reducing the flowing well head pressure and capable of discharging produced fluid at a pressure required by a downstream production system.

9. The gas lift system of claim 8 wherein the second boosting unit is a surface jet pump.

10. The gas lift system of claim 7 wherein the surface jet pump is configured to receive low pressure injection gas into a first inlet, the flow rate of gas at the first inlet being increased by a high pressure motive flow capable of being received into a second inlet downstream of a recycle loop from a gas lift compressor, wherein an outlet of the surface jet pump is configured to supply gas to the gas lift compressor.

11. A method of fluid extraction from a well bore utilising a gas lift system that includes:

an injector for supplying pressurised gas to the well bore;

a well head;

a tube extending from the well head into the well bore;

a plurality of openings or valves at different depths of the tube for permitting the ingress of injected gas to assist fluids flowing upwards through the tube by reducing the hydrostatic pressure;

the method further including the provision of a surface jet pump downstream of the well head for reducing the flowing well head pressure and capable of discharging produced fluid at a pressure required by a downstream production system;

wherein the surface jet pump utilises a motive flow sourced from one or more of the following: high pressure gas; high pressure oil and/or gas from one or more high pressure wells; high pressure liquid phase (oil or water) already boosted for other reasons.

12. The method of claim 11 including the provision of a further surface jet pump upstream of the injector to boost the pressure of the lift gas.

13. A method of fluid extraction from a well bore utilising a gas lift system that includes:

an injector for supplying pressurised gas to the well bore;

a well head;

a tube extending from the well head into the well bore;

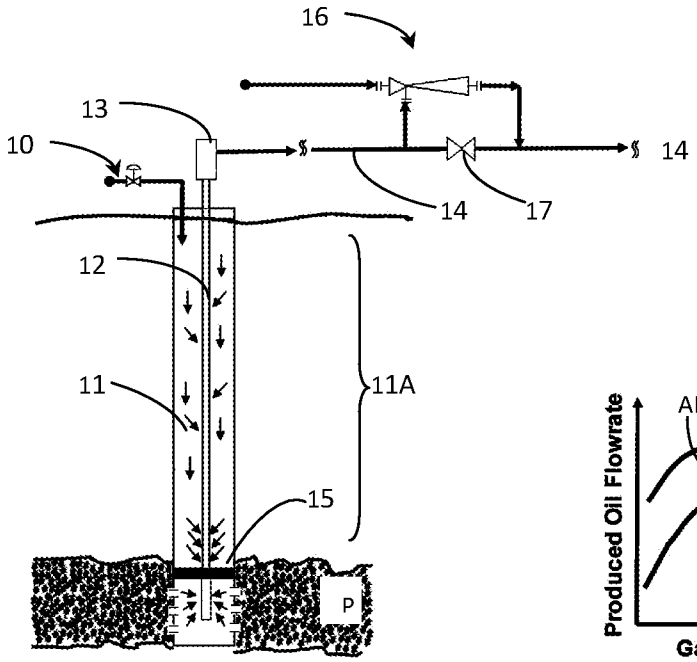
a plurality of openings or valves at different depths of the tube for permitting the ingress of injected gas to assist fluids flowing upwards through the tube by reducing the hydrostatic pressure;

the method further including the provision of a surface jet pump downstream of the well head for reducing the flowing well head pressure and capable of discharging produced fluid at a pressure required by a downstream production system;

wherein the surface jet pump is configured to receive lower pressure injection gas into a first inlet, the flow rate of gas at the first inlet being increased by a high pressure motive flow capable of being received into a second inlet downstream of a recycle loop from a gas lift compressor, wherein an outlet of the surface jet pump is configured to supply gas to the gas lift compressor.

14. The method of claim 13 including the provision of a second surface jet pump downstream of the well head for reducing the flowing well head pressure and capable of discharging produced fluid at a pressure required by a downstream production system;

wherein the second surface jet pump utilises a motive flow sourced from one or more of the following: high pressure gas; high pressure oil and/or gas from one or more high pressure wells; high pressure liquid phase (oil or water) already boosted for other reasons.



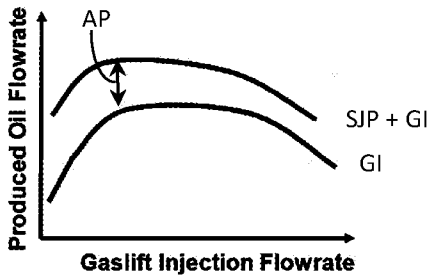


Fig. 1. **Fig. 2.**

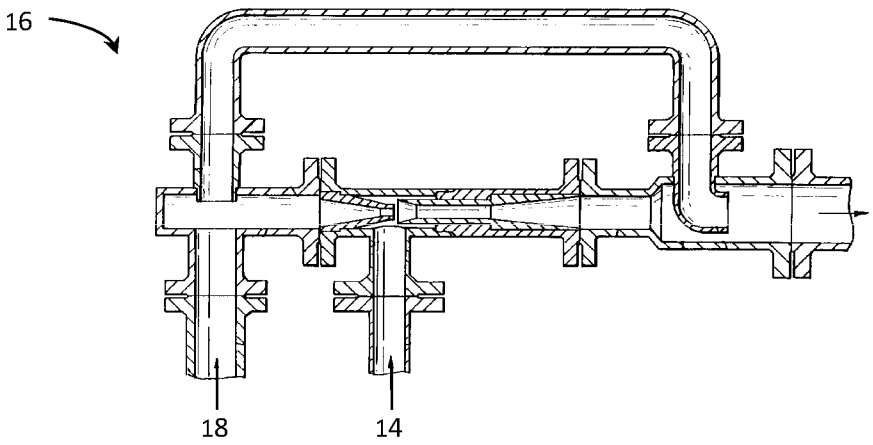


Fig. 3.

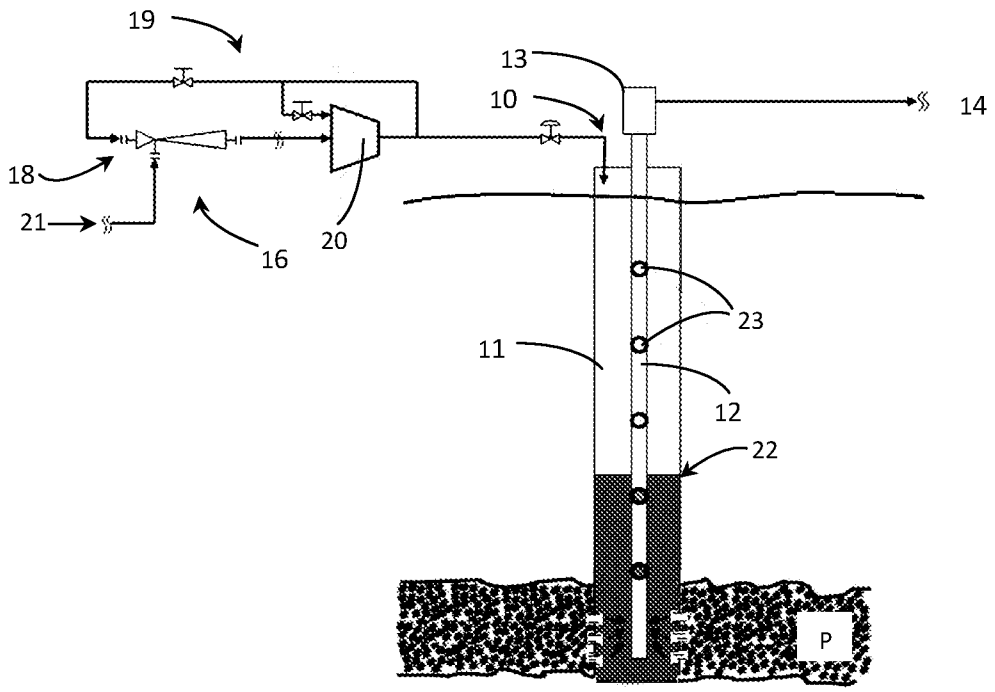


Fig. 4.