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GB 2402408 A **GB 2261030 A**
US 1605174 A

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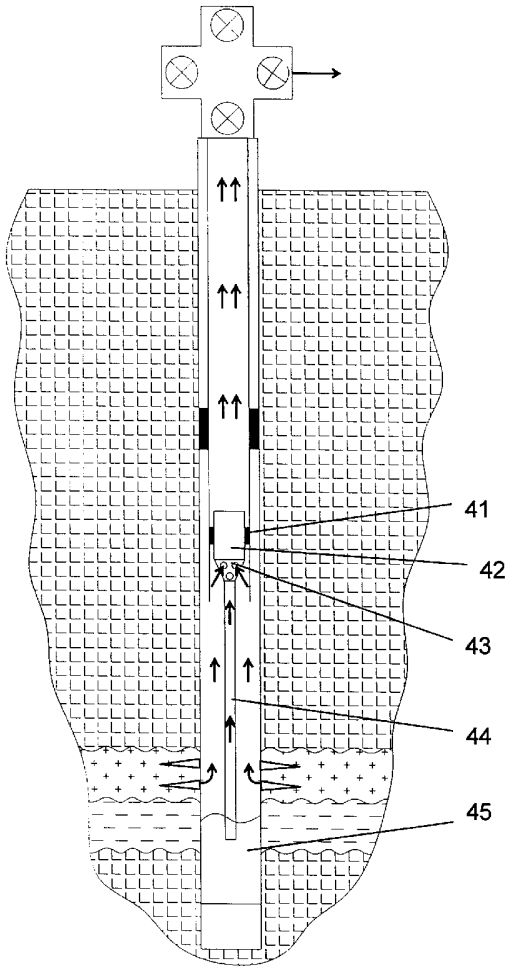
(54) Abstract Title: **Venturi removal of water in a gas wall**

(57) A method of removing liquid from a gas producing well involves the use of a Venturi 43 which is installed on a platform above the bottom of the well. Gas from the well flows upwardly through the Venturi 43 and creates a low pressure zone which acts to draw fluid through a snorkel tube 44 into the Venturi 43, so that the liquid is atomised into a mist or small droplets which can be uplifted with the gaseous flow. The Venturi 43 may be in the form of a jet pump.

Figure 4



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Figure 1

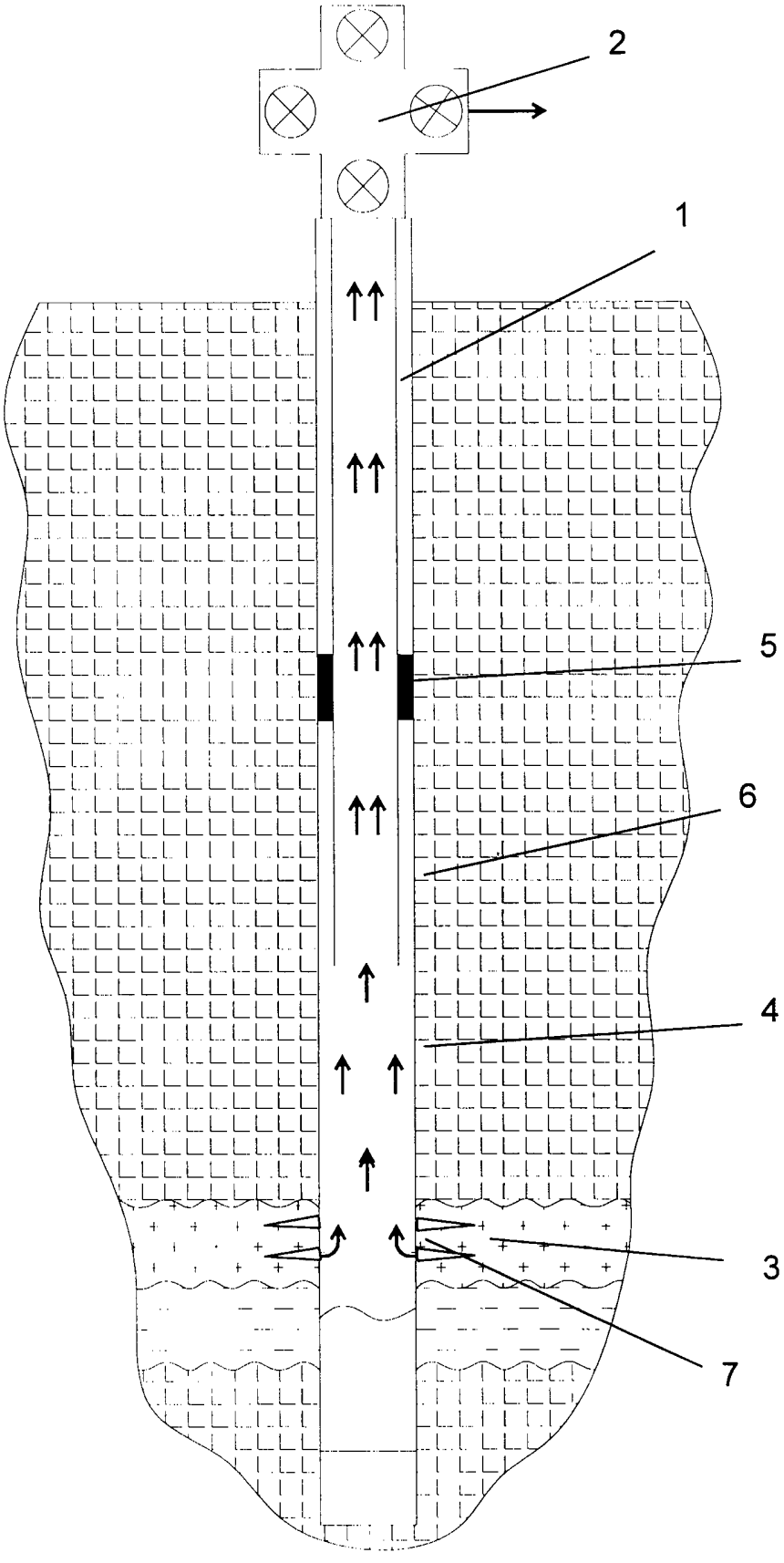


Figure 2

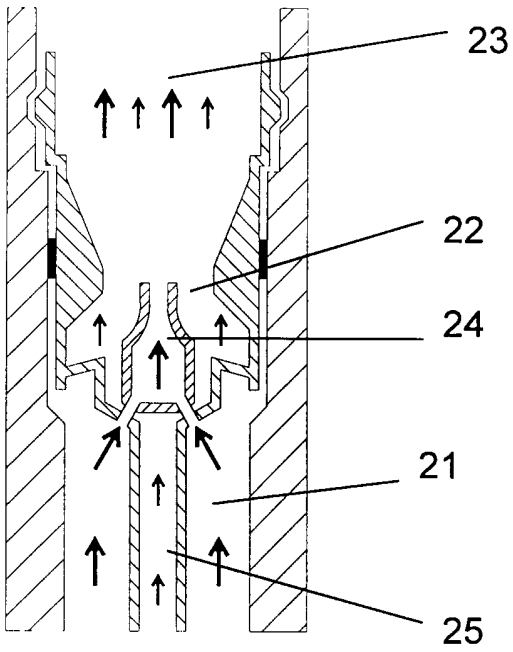


Figure 3

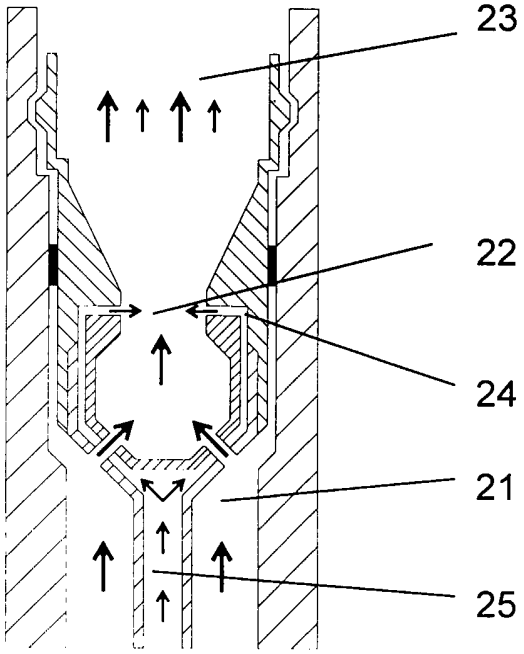
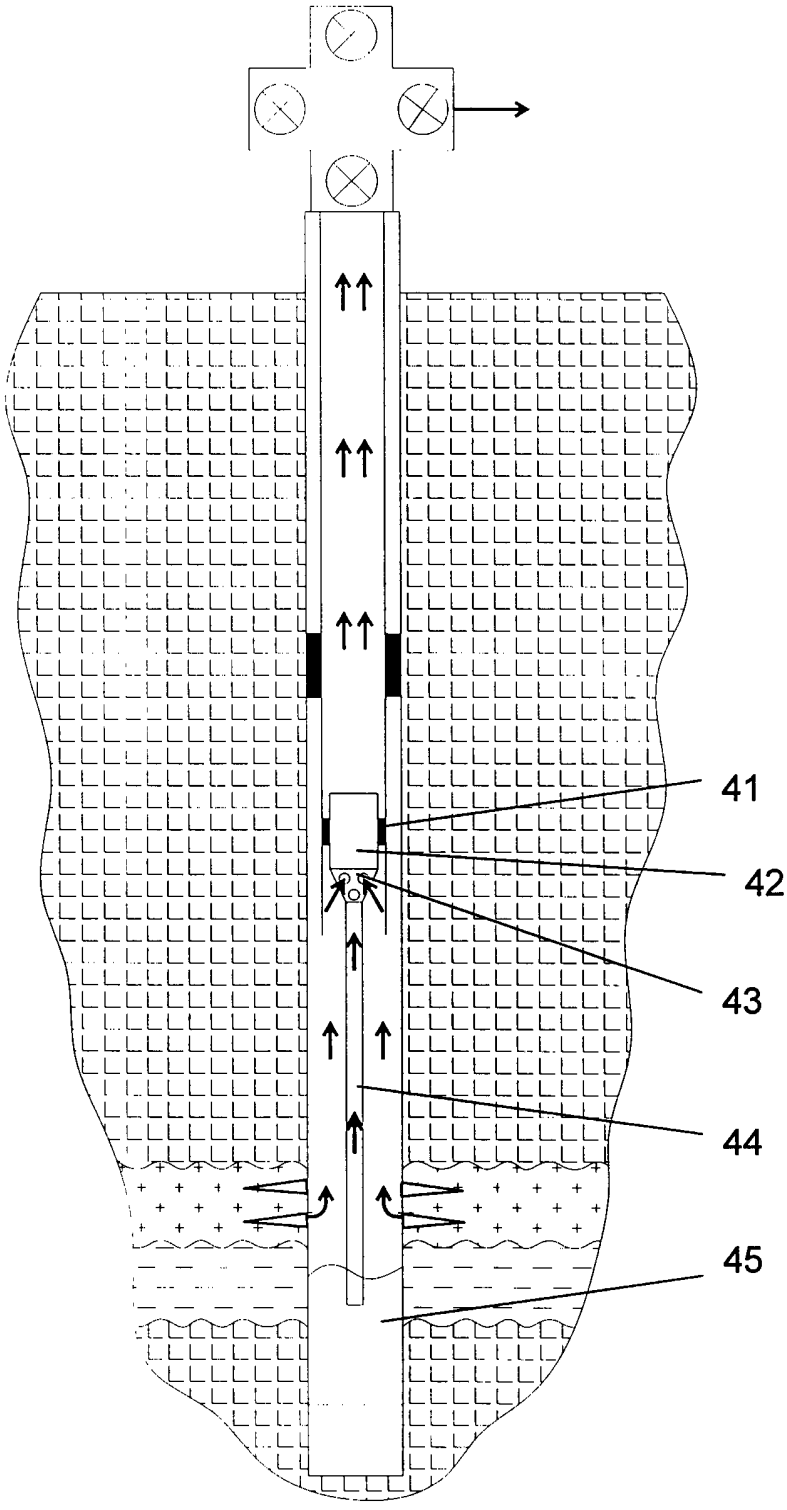


Figure 4



Method and apparatus for removal of liquid in a gas well.

In the oil and gas industries, petrochemicals and hydrocarbon gases are extracted from deep in the earth through pressure bearing tubulars or "tubing". A typical system for extraction of gas is shown in the schematic illustration of Figure 1, in which tubing 1 forms a conduit to convey liquids and gases from the rock 3, where the petrochemicals reside, to the surface where it is terminated at the Wellhead 2. Attached to the wellhead 2 is the xmas tree which consists of a number of valves to control and contain the pressure which is present in the tubing. In a gas well where no liquid column is present between the surface and the pressure source to hold back that pressure, the surface pressures may be quite high when the well is new. A casing 4 outside the tubing extends to the bottom of the well and is perforated at 7 where the pressure source is. The casing 4 supports the rock along the length of the wellbore and seals with the bottom of the tubing at a packer 5.

In a gas well, production of liquids is normally associated with the gas production to a lesser or greater extent. The liquids comprise condensate or water or a combination of both. Over the life of the well, the percentage of liquids being produced will increase whilst the gas rate will decrease. Whilst this is ongoing, the reservoir pressure will decline and the reservoir will deplete. The fall in pressure will also mean a reduction in gas flowrate and gas production which in turn means a reduction in the velocity of gas flowing in the production tubing.

A point may be reached due to reduced fluid velocity where the liquids being produced along with the gas fail to be suspended by the flow of gas and fall back into the well. This situation is characterised by a fluid column being present at the bottom of the well.

Sometimes the weight or hydrostatic head of fluid is sufficient to balance the flowing bottom hole pressure of the well and the result is that the well will cease flowing or flow erratically at a much lower rate. Production may vary from 100% gas to 100% liquids and back again leading to additional problems. This condition is called "slugging". Slugging wells may lead to surface equipment problems where the production and separation

equipment may have difficulty in dealing with occasional large volumes coupled with varying wellhead pressures.

A well which has ceased flowing may be described as being dead. A "dead" gas well may be "coaxed" back into life by shutting in the well to allow pressure in the formation around the wellbore to build up. Subsequent opening of the well results in a short lived rush of gas flow to surface and the possibility that some of the liquids may be carried along with this flow. Once the liquids are unloaded from the well, the undesirable hydrostatic head of liquid acting against the bottom hole gas pressure is removed and the well may once again flow freely to surface. This condition will continue for a finite time until once again, the liquid column builds up to the point where the well is dead.

Alternative remedies up to now include introducing chemicals into the gas to act as a foaming agent. Sometimes, these chemicals are called "soap" and may take the form of a liquid or a solid "soap stick". The soap, when mixed with water forms bubbles or a foam solution. This is easily lifted by the flow of gas allowing production to resume from the well until the next period when liquid fall back requires further action.

Where the soap approach fails to work, or is required so frequently that it becomes a nuisance or uneconomic, a more drastic solution may be used. Replacing the production tubing with a smaller diameter pipe will increase the flowing speed of the produced gas. The increased velocity should carry the liquids out of the well and not allow any liquid fall back to hinder the production. This is a costly solution and requires the temporary installation of a drilling rig or coil tubing unit in order to perform well control operations and to lift and handle the great weight of tubulars. This is a costly procedure.

Alternatively, an artificial lift approach may be preferable. This may involve installation of a fluid pump in order to lift the fluids to surface. A beam pump may be used onshore but is not suitable for offshore or sub sea applications. A beam pump consists of a pivoting surface beam which has weights on one side countering the weight of rods on the other which enter the well bore. The beam is rocked back and forth in order to transmit an up / down motion deep into the well via the rods. Situated at the bottom of the rods is a plunger

which forms the piston element of a pump. A tube extends into the sump of the well (and the fluid) allowing liquid to be drawn up and pumped out of the well. Gas flows freely around the outside of the tube to surface, unhindered by the presence of any liquid which is pumped through the inside of the tube.

Submersible pumps may be utilised where the beam pump is impractical. Submersible pumps are generally electrically powered and are conveyed into the well on the end of the tubing string. The pump may run continuously or be switched on when needed to unload the liquids.

Further known methods of removing wellbore liquids from a gas well are shown in to Figures 2 and 3. Jet pumps or Venturi devices have no moving parts and receive a high pressure power fluid 21 from a surface source, usually an electric reciprocating fluid pump. The power fluid is pumped down the annular space between the tubing 1 and the well casing 4 to a point where the jet pump is situated. Communication between the annulus and the tubing allows the power fluid to enter the jet pump and is directed through a nozzle or choke 24. The venturi has two main parts: the Venturi Throat 22, which is a reduced section and acts as a suction tube; and above that is the main venturi 23. The main venturi speeds up the flow of power fluid as the venturi diameter increases causing a pressure drop as it expands. This causes liquid to be sucked in through the intake 25 or venturi throat at the base of the unit. Figure 3 illustrates a similar arrangement to the Jet Pump illustrated in figure 2.

All of these types of pumps are expensive to install and require major intervention with a drilling rig for fitment. Any alternative solution which does not require this level of cost would be most welcome.

A system exists for liquid removal whereby the liquid is deliberately encouraged to move adhering to the tubing wall rather than as liquid droplets in the gas flow. This is called the vortex method. Fluid flow travelling through a tubing string is generally disorganised and not particularly effective at lifting liquids. "Streaming" the flow into two upwards facing

vortices encourages the liquid to settle onto the tubing walls and the single phase gas to flow at an improved rate up the middle. The vortex tool also allows the gas to continue to flow at a lesser rate than its critical rate for lifting fluids unassisted allowing the well to be depleted further than would otherwise be the case.

The critical flow rate is the gas velocity at which liquid droplets may be lifted from a well of a certain tubing size over a certain length. A liquid droplet will be subjected to two opposing forces. The droplet mass results in a downward acting force whilst the relative velocity between the gas and the droplet produces drag which results in an upward force. At the critical gas velocity these forces are balanced. The gas velocity must therefore exceed the critical value for liquids removal in flowing gas to occur.

The present invention has been developed from an appreciation that increased lift may also be accomplished by reducing the droplet size and thus the mass to be lifted. If liquid droplet size could be reduced and be diffused into a mist which is subsequently injected into the gas flow, this would allow greater liquid removal than at present; would allow a well to be produced at flowrates below the usual critical gas velocity; and would mitigate the previously described disadvantages. Additionally, if suitable intervention could be installed into an existing gas well with wireline techniques, rather than intervention with coiled tubing or a drilling rig, great cost savings would be realised.

A preferred example of method and apparatus for liquid recovery from a gas-producing wellbore according to the invention will now be described with reference to Figure 4 of the accompanying drawings.

The apparatus 42 consists of a mechanism which may be coupled or hung below a bridge plug or lock mandrel 41 in a wellbore. The mechanism and apparatus is installed in a gas well some distance above the area where the gas and water production originates from. The bridge plug or lock 41 forms a seal with the tubing internal diameter and also provides a platform from which to hang the remainder of the apparatus 42. It is envisaged that the apparatus 42 will be conveyed into the wellbore and installed using wireline techniques which are well known to one versed in the art.

The mechanism below the hanging platform consists of two main parts. The first part is a jet pump 43 which receives its power fluid in the form of gas flow from below (e.g. as is illustrated in Figure 2). The flow passes around and through the jet pump into the throat 22. As the flow progresses up to the main venturi 23, it accelerates due to the increasing diameter. This causes a pressure drop at the throat of the pump 22 whereupon is situated the outlet of a snorkel tube 25 / 44. The snorkel tube 44 extends from the jetpump 43 down the wellbore and into the sump of the well where a reservoir of liquid is situated at 45. This liquid has been formed from fallback as described previously. As the gas flows through the jet pump 43, liquid is drawn through the snorkel tube 44 and expelled at the throat of the main venturi 22 where it is atomised. The exhaust of the jetpump 23 will form a mist of small liquid droplets which will be carried by the flowing gas to surface. As described previously, reduction in droplet size will increase the gas production by improving the rate of liquid removal and thus minimising the liquid loading or fallback which the well would otherwise be subjected to.

Following installation, existing liquid build up above the apparatus will be required to be removed in order that the mechanism operate efficiently. This may be achieved by any one of the previously mentioned techniques. Once the original liquid level has been lowered, continuing operation of the apparatus will assure that liquid levels are kept below the device.

Claims

1. A method for removing liquid which collects in the bottom of a gas-producing well having production tubing extending upwardly from a gas-producing formation to surface;

in which a Venturi apparatus is installed in the well which comprises (i) a Venturi which is mounted on a platform in the well above the bottom of the well so that gas from the formation can flow upwardly through the Venturi and thereby create a low pressure zone in so doing and (ii) a snorkel tube which extends downwardly from the Venturi and towards the bottom of the well so as to communicate with any liquid from the formation which has collected in the bottom of the well:

whereby the low pressure zone created by the upwardly flowing gas through the Venturi causes liquid collected in the bottom of the well to be drawn upwardly through the snorkel tube and into the Venturi, so that the liquid is atomised to form a mist and/or small droplets of reduced size which can be uplifted with the gaseous flow to surface.

2. Apparatus for removing liquid which collects in the bottom of a gas-producing well having producing tubing extending upwardly from a gas-producing formation to surface, said apparatus being adapted to be installed in the well and comprising:

a Venturi which is adapted to be mounted on a platform in the well above the bottom of the well so that gas flow from the formation can flow upwardly through the Venturi and thereby create a low pressure zone in so doing; and

a snorkel tube connected to the Venturi so as to extend, in use, downwardly from the Venturi and towards the bottom of the well so as to communicate with any liquid from the formation which has collected in the bottom of the well;

whereby the low pressure zone created in use by the upwardly flowing gas flow through the Venturi can cause liquid collected in the bottom of the well to be drawn upwardly through the snorkel tube and into the Venturi so that the liquid is atomised to form a mist and/or small droplets of reduced size which can be uplifted with the gaseous flow to surface.

3. A method for liquid removal in a well comprising:

production tubing means to transmit the well products between the bottom of said well to surface,

Venturi means to receive gas flow from below creating a low pressure area in so doing,

snorkel means to form a fluid conduit from below a fluid interface to low pressure area of venturi,

installation platform means to connect the mechanism with the wellbore.

whereupon flow through venturi means will draw fluid through snorkel means, said fluid atomising upon exhaust from and through venturi means and largely egressing production tubing means by merit of reduced droplet size.

4. The method of claim 1 wherein the venturi means is positioned at a point above the bottom of said well.

5. The method of claim 1 wherein the venturi installation platform is retrofittable into a well

6. The method of claim 1 whereby the venturi installation platform is recoverable from a well by decoupling from the production tubing means.

7. The method of claim 1 whereby the venturi means is a jet pump.

8. The method of claim 1 whereby flow of gas is provided from a surface point and injected down the exterior of the production tubing communicating to below the venturi means.

9. A method for liquid removal in a gas well comprising:

production tubing means to transmit the well products from said well to surface,

Venturi means to receive gas flow from below creating a low pressure area in so doing,

snorkel means to form a fluid conduit from below a fluid interface to low pressure

area of venturi,

connection means to connect the mechanism with the wellbore.

whereupon production of gas through venturi means will draw fluid through snorkel means, said fluid atomising upon exhaust from and through venturi means and largely egressing production tubing means by merit of reduced droplet size.

10. The method of claim 9 wherein the venturi means is positioned at a point above the bottom of said well.

11. The method of claim 9 wherein the venturi installation platform is retrofittable into a well.

12. The method of claim 9 whereby the venturi installation platform is recoverable from a well by decoupling from the production tubing means.

13. The method of claim 9 whereby the venturi means is a jet pump.

14. The method of claim 9 whereby flow of gas is provided from a surface point and injected down the exterior of the production tubing communicating to below the venturi means.

15. A method for production in a well comprising:

production tubing means to transmit the well products between the bottom of said well to surface,

Venturi means to receive flow from below creating a low pressure area in so doing,

snorkel means to form a fluid conduit from below an interface to low pressure area of venturi,

installation platform means to connect the mechanism with the wellbore.

whereupon flow through venturi means will draw well production through snorkel means, said well production atomising upon exhaust from and through venturi means, said flow being transported to surface along with said production.

16. The method of claim 15 wherein the venturi means is positioned at a point above the bottom of said well.

17. The method of claim 15 wherein the venturi installation platform is retrofittable into a well.

18. The method of claim 15 whereby the venturi installation platform is recoverable from a well by decoupling from the production tubing means.

19. The method of claim 15 whereby the venturi means is a jet pump.

20. The method of claim 15 whereby the flow is provided from a surface point and injected down the exterior of the production tubing communicating to below the venturi means.

Application No: GB0500729.9 **Examiner:** Dr Lyndon Ellis

Claims searched: 1-20 **Date of search:** 3 April 2006

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-20	GB 2402408 A (Sherwood) Whole document
X	1-3, 9, 15 at least	GB 2261030 A (Hardie) Whole document
X	1-3, 9, 15 at least	US 1605174 A (Craig) Whole document

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application

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Worldwide search of patent documents classified in the following areas of the IPC

The following online and other databases have been used in the preparation of this search report