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(54) Generating slug flow

(57) A multi-phase mixture of gas and liquid is passed into a cyclone separator 2 from which separated liquid is passed into a siphon chamber 6 where it enters the inlet to a siphon tube 7 while separated gas is passed into a line 4 and passes via line 10 to the outlet of the siphon tube 7 through a flap valve 11. Any gas from the siphon chamber 6 is also passed to the line 10 via line 8. As the siphon tube 7 fills with liquid separated gas flows via lines 4, 8 and 10 to the outlet of the siphon tube 7 where it can pass through a flow meter 12 such that the flow rate of the gas phase can be measured. When liquid reaches the top of the siphon tube 7 the siphon operates generating a slug or batch of liquid which flows through flow meter 12. The flap valve 11 is closed by the flow of liquid preventing the flow of gas into the outlet of the siphon tube. The gas now passes into the siphon chamber via line 8 such that the vacuum in the siphon chamber is relieved as the siphon operates. When the liquid in the siphon tube 7 is exhausted the siphon action ceases and a mainly gas flow is once again generated through the flow meter 12 as the siphon tube 7 refills.

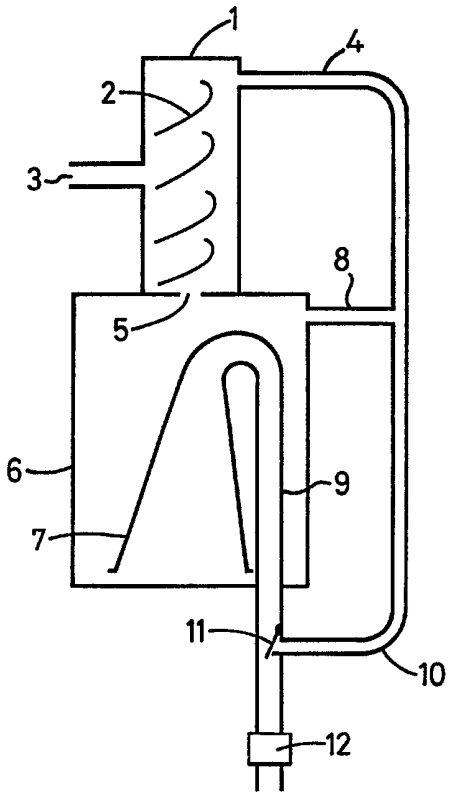

FIG. 1

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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.

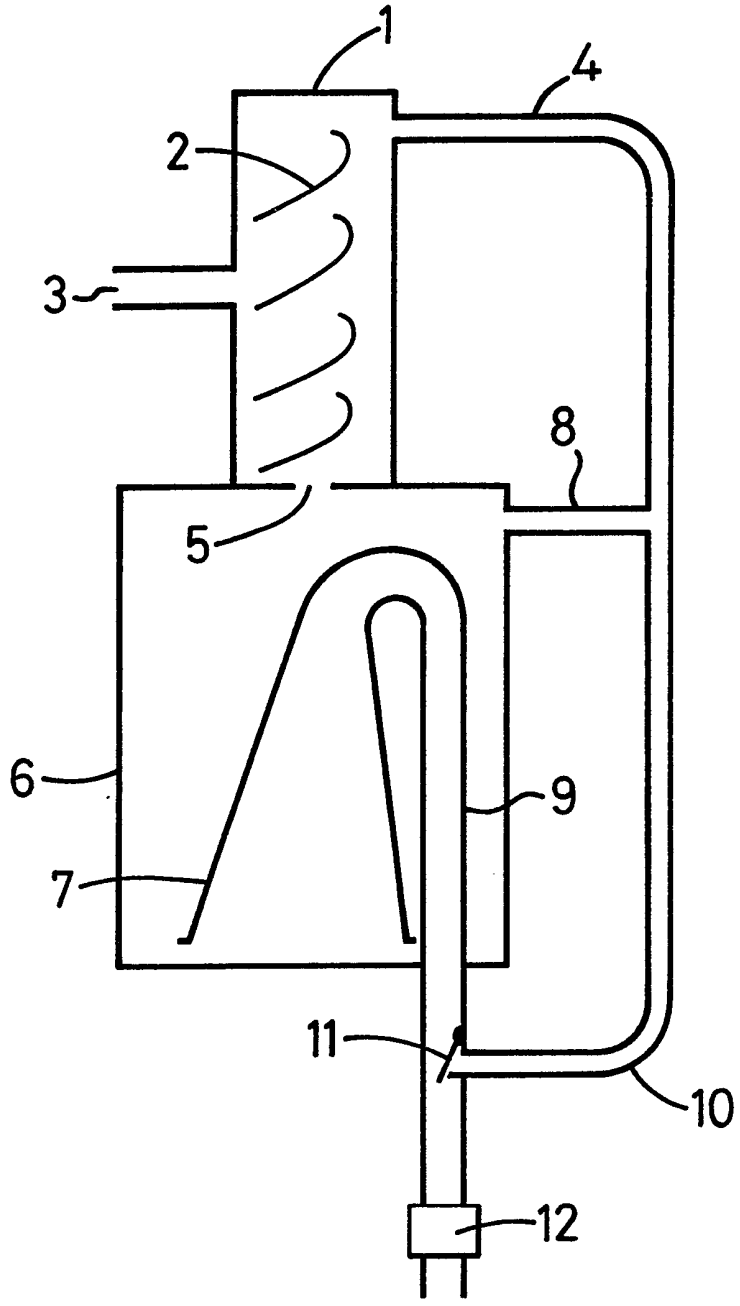

FIG. 1

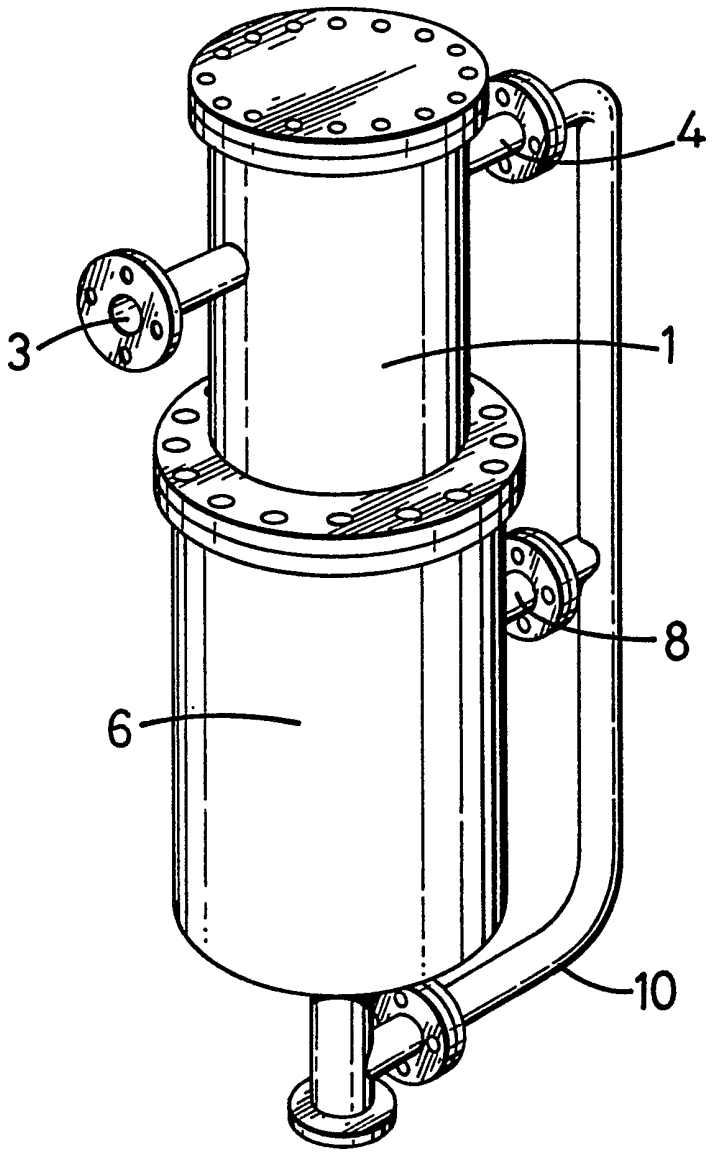

FIG. 2

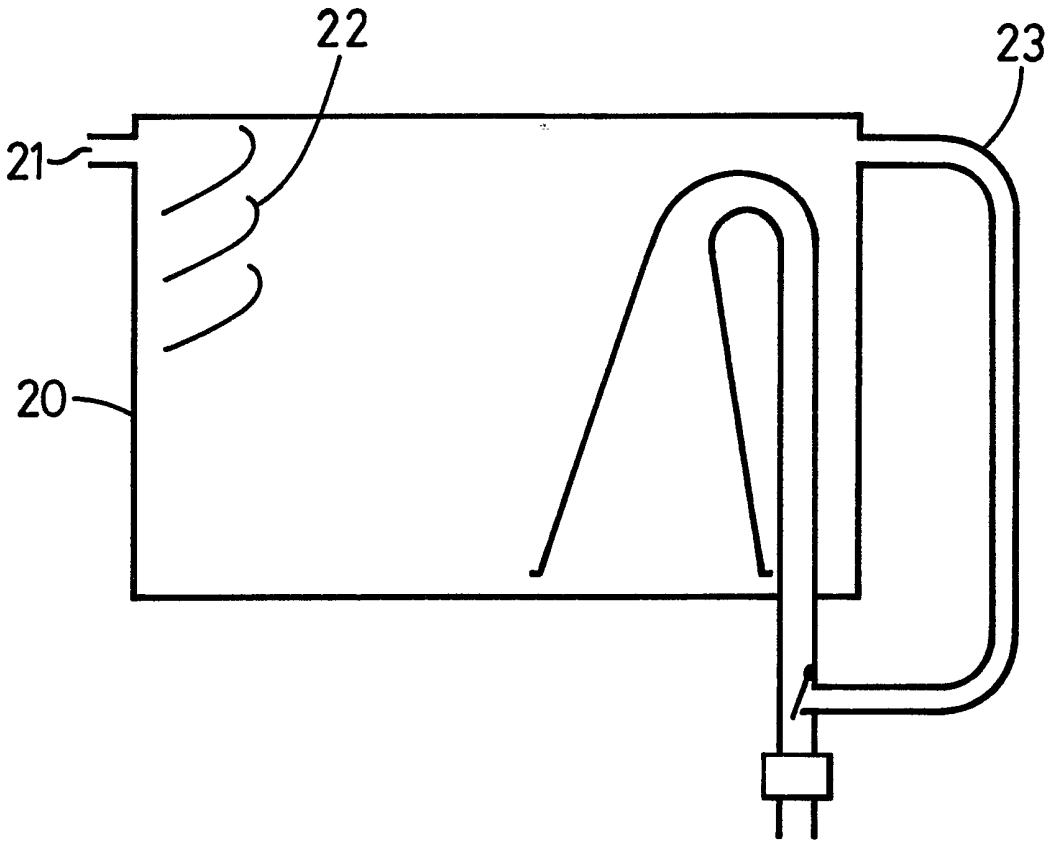

FIG. 3

APPARATUS AND METHOD FOR GENERATING SLUG FLOW

The present invention relates to an apparatus and method suitable for generating slug flow in a multiphase flow, in particular in a multiphase flow comprising gas and liquid hydrocarbons with or without water.

In the production of oil and gas unseparated reservoir fluids may be transported significant distances by pipeline. Consequently multiphase flow pattern regimes are produced. It is very important to have details of the flow rate of each phase or component of such a fluid stream containing more than one phase or component, for example one containing one or more liquid components with a free gas phase.

Thus in crude oil production the fluid at the wellhead, and hence in a pipeline, may comprise a combination of crude oil, water and gas which may be dissolved or present as a separate phase. The phases may be mixed or segregated in the pipeline and may also be moving at different velocities relative to each other within the pipeline.

In order to determine such quantities as the individual phase or component flow rates or gas/oil ratios of a multiphase flow it is necessary to use various types of multiphase flow measuring devices to take measurements on the complicated flow regimes which can occur during crude oil production.

We have made the flow more defined before measurement by concentrating the multiphase flow stream into more clearly defined slugs or portions of liquid and gas before being passed to the measuring means.

According to the present invention there is provided an apparatus

for generating discrete slugs of gas and liquid from a multiphase flow comprising gas and liquid, said apparatus comprising

(a) supply means for said multiphase flow,

(b) separating means for separating said flow into separated gas and separated liquid,

(c) a siphon chamber containing a siphon tube having an inlet section and an outlet section, said chamber being arranged to receive said separated liquid,

(d) a gas transfer means for allowing separated gas to pass to the outlet section of said siphon tube.

Preferably, the apparatus also comprises:

(e) means for closing off the communication between said gas transfer means and the outlet section of said siphon tube on discharge of said tube.

The supply means may be provided by one or more inlet conduits with a multiphase flow from a pipeline or wellhead. The multi phases may be 2 phases of gas and oil or water or 3 phases with gas, oil and water. The multiphase flow may comprise at least 50% and preferably at least 90% by volume of gas phase.

Any appropriate separating means may be chosen but it is usually a cyclone separator, or gravity separator optionally with vanes. The separating means may be arranged in a pre-chamber which is separate from the siphon chamber, and may be positioned beside below or above the siphon chamber and in liquid communication therewith whereby the separated liquid is passed to or is allowed to fall to the bottom of the siphon chamber.

Alternatively the separating means may be provided in the siphon chamber itself. In this arrangement the siphon chamber is preferably enlarged to accommodate the separating means in such a way that the separated liquid falls to the bottom of the chamber. In either arrangement the separating means is usually above the liquid level in the siphon chamber.

The inlet section of the siphon tube may be positioned in close proximity to the bottom of the siphon chamber therein arranged to receive the separated liquid; the hold up of liquid in the siphon

chamber may be minimised, so that the portions in the output line may also be more representative of liquid recently passing through the supply means.

The siphon tube usually has an inverted U shape, one arm being the inlet section and the other arm being the outlet section. The inlet section, usually at its bottom end, opens into the siphon chamber and may be of uniform cross section. Preferably the inlet section has at least a part of uniformly or non uniformly decreasing cross sectional area, in the direction from the bottom of the inlet section to the top of the siphon tube and the top of the siphon chamber. Preferably said part comprises at least the bottom of the inlet section. Thus the inlet section may be of an inverted V shape or bell like shape or be downwardly flared. If desired the inlet portion may be provided with slots or flaps, adjustable to allow for different levels of entry of liquid from the siphon chamber to the inlet portion.

The decreasing cross section area at the bottom of the inlet section e.g. bell-like construction has the advantage that it minimises the flow velocity at the siphon tube inlet thus minimizing disturbance of the liquid seal at the siphon tube entrance.

The other arm of the siphon tube may be of non uniform or preferably uniform cross section and passes through the siphon chamber wall, especially its floor, either before or after meeting the gas transfer means, and if present gas closure means; preferably the arm passes through the floor before said meeting for ease of maintenance. The outlet section of the siphon tube extends downwardly away from the top of the siphon chamber, especially substantially vertically downwardly.

The gas transfer means is conveniently piping which is external to the main body of the apparatus. In such a case it must meet the same requirements for process design as the siphon chamber and any separate gas/liquid separation means used. Where there is a separate gas/liquid separation means i.e. a prechamber the gas transfer means preferably has a connection direct to the siphon chamber, and the pre-chamber is suitably provided with a gas outlet. The siphon

chamber is similarly provided with a gas outlet. Such gas outlets are arranged in communication with each other (by a gas line) and with the outlet section of the siphon tube (by a second gas line leading to a junction with the outlet section) thereby defining the gas transfer means.

In the alternative arrangement having the separating means in the siphon chamber, a single gas outlet in the siphon chamber is required to provide the gas transfer means for communicating with the junction in the outlet section of the siphon tube. The gas outlets in the siphon chamber are above the maximum liquid level in the siphon tube.

When the apparatus of the invention does not comprise a closure means (e), the junction between the outlet section of the siphon tube and the gas transfer means is usually adapted to minimise passage of liquid from the outlet section into the gas transfer means during discharge of the liquid and/or minimise drawing of gas from the gas transfer means. Thus advantageously the gas transfer means enters the outlet section at an angle which is not more than 90° to the upward vertical when the apparatus is in use and; preferably not more than 90° to the outlet section of the siphon tube; especially the gas transfer means enters the outlet section normally thereto. However it is preferred that the apparatus comprises a closure means (e).

Suitable means for closing off the communication of the gas transfer means with the outlet section of the siphon tube are preferably at the junction of said transfer means and outlet section. The closure means may comprise a valve or other reversibly closing means; preferably the valve is a flap type valve e.g. one pivotally mounted. Said closure means may be closed by passage of the liquid e.g. by impacting on the means itself e.g. the valve or on an arm or other member mechanically connected to said closure means or closed as a result of passage of the liquid e.g. by reduction in gas pressure in the gas transfer line during discharge of the liquid, the reduced pressure being insufficient to hold open the closure against the effect of a spring or other returning means or gravity; the flap valve may also be flexible. Preferably the flap valve is free floating and located at the junction of gas transfer means and the

outlet portion of the siphon tube. Thus the closure means moves between an open position allowing passage of gas, while the inlet section of the siphon tube is filling up with liquid, and a closed position stopping passage of gas while the siphon tube is discharging. The closure means is usually incapable of closing the inlet section of the siphon tube, so is a closure for the gas transfer line not the liquid transfer line.

By this arrangement, as the siphon discharges liquid the valve will be displaced to close off the communication of the gas transfer means with the siphon tube. As the gas transfer means is closed off the gas will flow into the siphon chamber via the gas outlet in said chamber thereby assisting the liquid siphon action and ensuring no vacuum is pulled by the liquid siphon. Consequently the liquid slug will be more defined (less dispersed by gas entrainment) as it leaves the outlet section of the siphon tube.

When the siphon tube has discharged the liquid, gas will flow through the siphon tube until the liquid begins to build up again in the siphon chamber. When the liquid level rises to cut off the gas entry to the siphon tube within the siphon chamber a back pressure results which causes the flap valve to be displaced thereby allowing gas to flow from the gas transfer means.

Thus the output from the apparatus of this invention comprises alternating portions of liquid and gas, the discrete portions of liquid leaving from the outlet section of the siphon tube during its discharge preferably while the gas flow is interrupted by the closure means, and the discrete portions of gas leaving from the gas transfer means, while the siphon tube is filling up with liquid.

The minimum size of the liquid slugs generated by the apparatus of the present invention may suitably be controlled by the dimensions of the siphon chamber. In particular the volume of the slug or portion is defined by the vertical height of the inlet portion of the siphon tube from its bottom to the maximum liquid height in the siphon tube (i.e. at the internal top of the siphon tube) as well as the horizontal dimensions of the siphon chamber. The volume of the slug may be adjusted by varying the effective height of the inlet

section of siphon tube e.g. with a telescopic inlet siphon tube, or by insertion or withdrawal of a member to reduce the volume of the liquid around (but not necessarily under) the inlet portion of the siphon tube.

The apparatus according to the present invention may be connected to a meter suitable for measuring properties, proportions and flow rates of the liquid and gas components of the resultant multiphase flow. Suitable metering means may be arranged to receive the slugs exiting from the outlet section of the siphon tube; the suitable metering means may be upstream or downstream of the junction between the gas transfer means and the outlet section of the siphon tube. If desired a gas flow meter may be present in the line constituting the gas transfer means between the siphon chamber and the said junction.

The liquid slugs generated may be of selected or defined minimum size which is controlled to ensure that whatever metering device is being used the metering or sensing section will experience discrete slugs of liquid of appropriate adequate duration or length.

According to another aspect of the present invention there is provided a method of generating discrete slugs of gas and liquid, from a multiphase flow comprising gas and liquid, said method comprising:

(a) separating said multiphase flow into separated gas and separated liquid,

(b) passing said separated liquid to a siphon tube contained in a siphon chamber,

(c) passing said separated gas to the outlet section of said siphon tube thereby generating a discrete slug of gas,

(d) allowing said siphon tube to fill with separated liquid, and

(e) allowing said siphon tube to discharge liquid as a slug.

Preferably in the method there is provided (f) means for closing off the supply of separated gas on discharge of said siphon tube, and after (e) the discharge of liquid closes off the supply of separated gas thereby generating a discrete slug of liquid.

Thus in the method the separated liquid may pass to a siphon chamber containing the tube, e.g. when the siphon chamber is separate

from the separator, or may pass directly to the tube when the separator is in the siphon chamber.

When the volume of liquid per discharge of the siphon tube has been measured or calculated, the method of the invention may be itself used to meter the liquid flow rate in the multi phase flow. Thus operations (a) - (e) or (f) above may be followed by (g) measuring the number of discrete discharges of liquid from (e) per unit time.

The present invention will be further illustrated with reference to the accompanying Figures in which:

Figure 1 is a diagrammatic representation of an apparatus suitable for generating a slug flow,

Figure 2 is a 3-dimensional view of the apparatus of Figure 1, and

Figure 3 is a diagrammatic representation of an alternative arrangement suitable for generating slug flow.

The apparatus illustrated in Figure 1 comprises a separator vessel (1) having a cyclone separator (2). The multiphase flow enters the separator via inlet (3) with gas and liquid leaving the separator vessel after separation at (4) and (5) respectively. The liquid stream and some gas enter the siphon chamber (6) and the liquid fills the siphon chamber both inside and outside of the siphon bell (7).

The gas present outside the siphon bell in the siphon chamber (6) is displaced via line (8) and that present inside the siphon bell is displaced via the outlet section (9) of the siphon tube.

As the siphon chamber (6) fills with liquid the gas will leave the system via (9) and line (10). A flap valve (11) is provided at the junction of (9) and (10). The valve (11) is freely floating and after the liquid level in the siphon chamber has risen above the entry to the siphon bell gas will preferentially take the route via (10) because the liquid seal around the base of the siphon bell (7) will act to prevent inflow of gas through line (8).

The gas leaving the system passes to a suitable meter at (12). In these circumstances the meter will be experiencing a mainly gas

flow.

When the liquid reaches the top of the siphon bell (7) a siphon action will begin and liquid will flow down the tube (9) and activate the flap valve (11) thus closing the gas line (10).

The gas will now more easily flow through line (8) into the siphon chamber thus assisting the liquid siphon by ensuring no vacuum is pulled by the siphon.

In these circumstances the meter will be experiencing a mainly liquid flow.

When the liquid level in the siphon chamber falls below the siphon bell entry the gas will continue to flow via line (8) into the siphon chamber (6) and through the siphon bell (7). As the liquid begins to build up via (5) eventually restricting the gas path via the siphon bell, the back pressure of the gas causes the flap valve (11) to open and the system returns to the situation whereby the meter will experience a mainly gas flow via the line (10).

In Figure 2 the vessels (1) and (6) are shown with the multiphase flow inlet (3) and gas lines (4), (8) and (10).

In Figure 3 an alternative arrangement for generating slug flow is shown comprising a vessel (20) wherein the multiphase flow enters via (21) and gravitational phase separation is assisted by vanes or alternatively by cyclone separation elements (22) whereby the liquid falls to the bottom of the vessel and the gas passes to the top to be removed via line (23). The arrangement and function of the siphon bell, flap valve and metering position are similar to those illustrated in Figure 1.

Claims:

1. Apparatus for generating discrete slugs of gas and liquid from a multiphase flow comprising gas and liquid, said apparatus comprising

(a) supply means for said multiphase flow,

(b) separating means for separating said flow into separated gas and separated liquid,

(c) a siphon chamber containing a siphon tube having an inlet section and outlet section, said chamber being arranged to receive said separated liquid,

(d) a gas transfer means for allowing separated gas to pass to the outlet section of said siphon tube.

2. Apparatus according to Claim 1 which comprises means for closing off the communication between said gas transfer means and the outlet section of said siphon tube on discharge of said tube.

3 Apparatus according to Claim 2, wherein said closing means comprises a valve for closing off the gas transfer means.

4. Apparatus according to Claim 1 wherein said siphon chamber has a bottom and said inlet section is positioned in close proximity to said bottom.

5. Apparatus according to Claim 1 wherein said siphon chamber has a top and said inlet section has a decreasing cross sectional area in an upward direction towards said top.

6. Apparatus according to Claim 1 wherein said separating means is in a prechamber separate from said siphon chamber.

7. Apparatus according to Claim 6 wherein said prechamber is above said siphon chamber and in liquid communication therewith to allow

separated liquid to pass from said prechamber to the bottom of said siphon chamber.

8. Apparatus according to Claim 1 wherein said separating means is in said siphon chamber.

9. A method of generating discrete slugs of gas and liquid from a multiphase flow comprising gas and liquid, said method comprising:

(a) separating said multiphase flow into separated gas and separated liquid,

(b) passing said separated liquid to a siphon tube contained in a siphon chamber.

(c) passing said separated gas to the outlet section of said siphon tube thereby generating a discrete slug of gas,

(d) allowing said siphon tube to fill with separated liquid, and

(e) allowing said siphon tube to discharge liquid

10. A method of metering the flow of liquid in a multiphase flow comprising gas and liquid, said method comprising

(a) separating said multiphase flow into separated gas and separated liquid,

(b) passing said separated liquid to a siphon tube contained in a siphon chamber,

(c) passing said separated gas to the outlet section of said siphon tube thereby generating a discrete slug of gas,

(d) allowing said siphon tube to fill with separated liquid, and

(e) allowing said siphon tube to discharge liquid,

(f) measuring the number of discrete discharges of separated liquid from (e) per unit time.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report)	Application number GB 9322192.7
Relevant Technical Fields (i) UK Cl (Ed.M) B8N NJL, NKM, G1R, RG (ii) Int Cl (Ed.5) G01F 1/74, 15/08	Search Examiner S WALLER Date of completion of Search 25 JANUARY 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASES: WPI	Documents considered relevant following a search in respect of Claims :- 1-10

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