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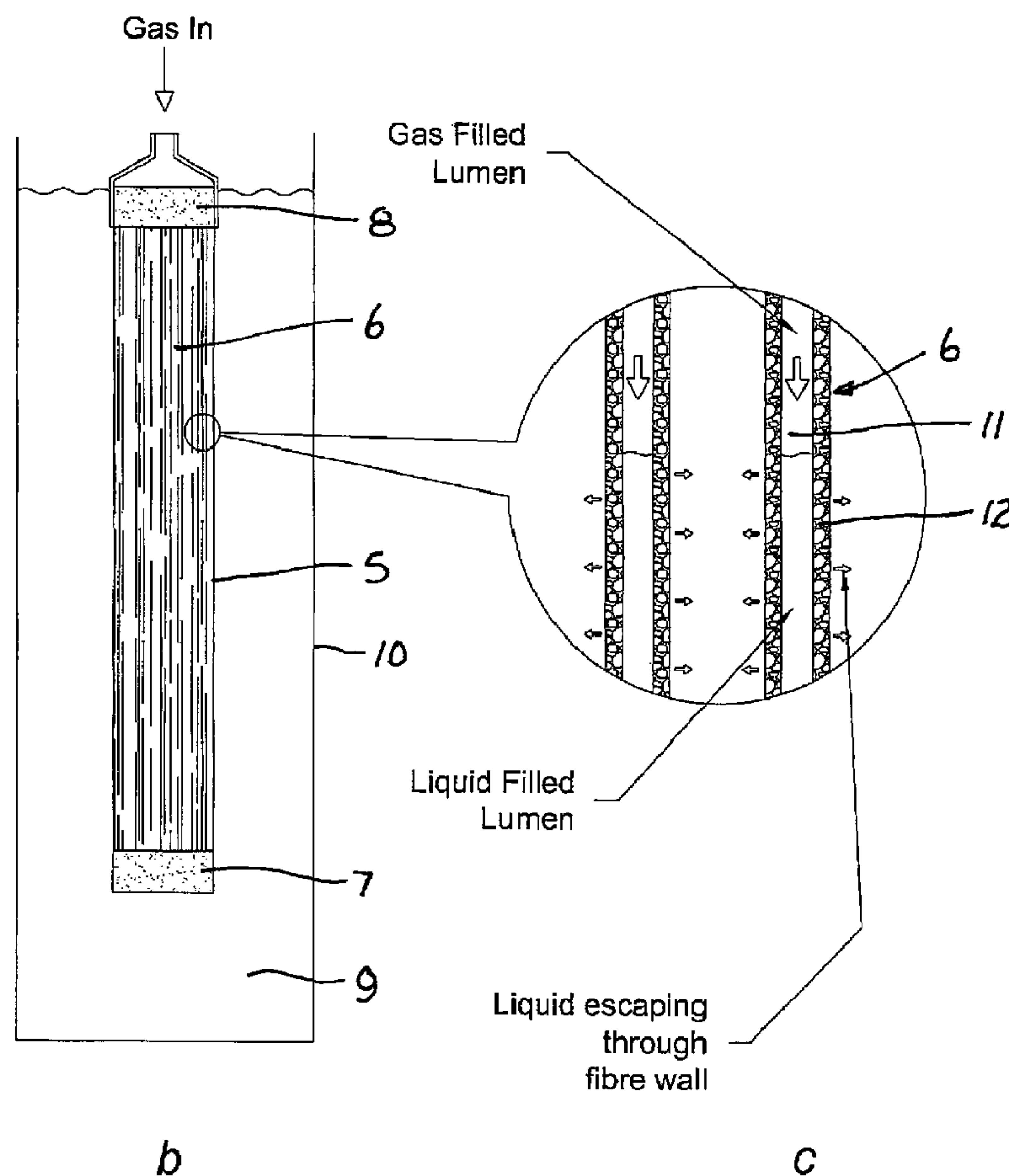
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(54) Titre : PROCÉDE DE NETTOYAGE ET DE LAVAGE A CONTRE-COURANT

(54) Title: BACKWASH AND CLEANING METHOD



(57) Abrégé/Abstract:

A method of concentrating the solids of a liquid suspension by providing a pressure differential across the walls of permeable, hollow membranes (6) immersed in the liquid suspension (9). The liquid suspension (9) is applied to the outer surface of the porous

(57) Abrégé(suite)/Abstract(continued):

hollow membranes (6) to induce and sustain filtration through the membrane walls (12) wherein some of the liquid suspension passes through the walls (12) of the membranes (6) to be drawn off as clarified liquid or permeate from the hollow membrane lumens (11), and at least some of the solids are retained on or in the hollow membranes (6) or otherwise as suspended solids within the liquid (9) surrounding the membranes (6). The method includes periodically backwashing the membrane pores using the permeate by applying a gas at a pressure below the bubble point to the membrane lumens (11) to progressively displace at least some of the liquid permeate within the lumens (11) through the membrane pores resulting in removal the solids retained on or in the hollow membranes into the bulk liquid (9) surrounding the membranes (6).

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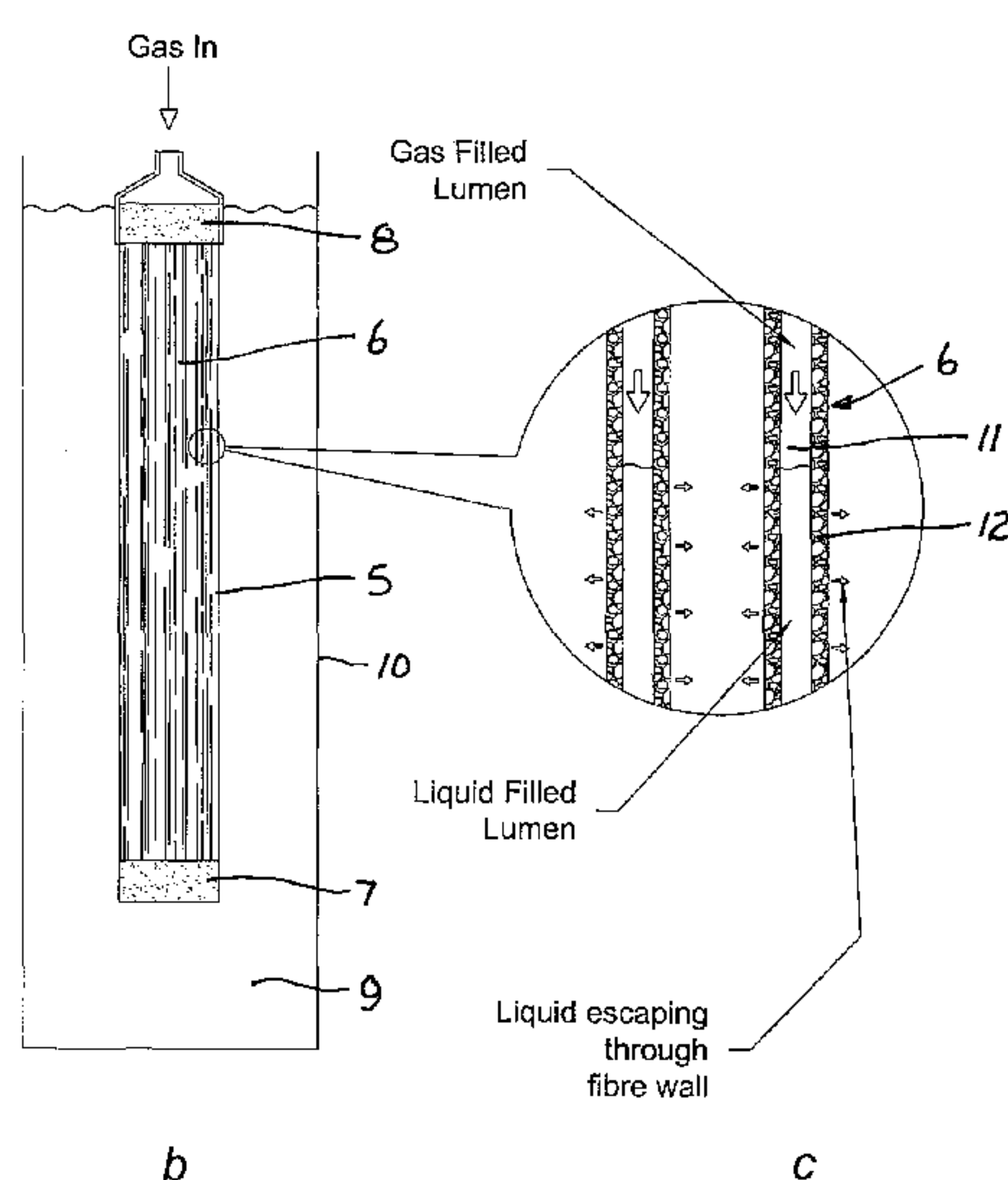
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(54) Title: BACKWASH AND CLEANING METHOD



(57) Abstract: A method of concentrating the solids of a liquid suspension by providing a pressure differential across the walls of permeable, hollow membranes (6) immersed in the liquid suspension (9). The liquid suspension (9) is applied to the outer surface of the porous hollow membranes (6) to induce and sustain filtration through the membrane walls (12) wherein some of the liquid suspension passes through the walls (12) of the membranes (6) to be drawn off as clarified liquid or permeate from the hollow membrane lumens (11), and at least some of the solids are retained on or in the hollow membranes (6) or otherwise as suspended solids within the liquid (9) surrounding the membranes (6). The method includes periodically backwashing the membrane pores using the permeate by applying a gas at a pressure below the bubble point to the membrane lumens (11) to progressively displace at least some of the liquid permeate within the lumens (11) through the membrane pores resulting in removal the solids retained on or in the hollow membranes into the bulk liquid (9) surrounding the membranes (6).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Backwash and Cleaning Method

FIELD OF THE INVENTION

The present invention relates to concentration of solids in a suspension
5 using hollow fibre membranes and, in particular, to an improved method of
backwashing and chemically cleaning the hollow fibre membranes.

BACKGROUND ART

Any discussion of the prior art throughout the specification should in no
way be considered as an admission that such prior art is widely known or forms
10 part of common general knowledge in the field.

Known backwash systems include those described in our earlier
International Application No. WO93/02779.

A pressurized liquid backwash of hollow fibre membranes has been found
to be uneven along the length of the fibre membranes due to the frictional losses
15 along the lumen. In membranes with the fibres closed at one end, the pressure
of liquid is highest at the point of application of the pressurized flow to the fibre
lumens and tapering off along the length of the membrane. This results in
uneven backwashing and poor recovery of TMP at portions of the fibres remote
from the backwash application point. In fibres open at both ends, the backwash
20 flow is a minimum towards the centre of the fibre.

During chemical cleaning of membranes, cleaning solutions are often
backflushed from the lumen side of the membrane to distribute the cleaning
solution within the membrane fibre bundle. Applying the cleaning solution under
pressure assists the removal of foulants from the surface. However, the

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limitations of pressure drop down the lumen during this step mean that achieving the same applied transmembrane pressure (TMP) to all areas of the membrane cannot be readily achieved, especially for small diameter fibres where the pressure loss is greatest. This impacts on the efficiency of cleaning.

5 DISCLOSURE OF THE INVENTION

It is an object of the invention to overcome or at least ameliorate one or more of the disadvantages of the prior art or at least provide a useful alternative.

According to a first aspect, the present invention provides a method of concentrating the solids of a liquid suspension comprising:

- 10 (i) providing a pressure differential across the walls of permeable, hollow membranes immersed in the liquid suspension, said liquid suspension being applied to the outer surface of the porous hollow membranes to induce and sustain filtration through the membrane walls wherein:
 - 15 (a) some of the liquid suspension passes through the walls of the membranes to be drawn off as clarified liquid or permeate from the hollow membrane lumens, and
 - (b) at least some of the solids are retained on or in the hollow membranes or otherwise as suspended solids within the liquid surrounding the membranes,
- 20 (ii) periodically backwashing the membrane pores using the permeate by applying a gas at a pressure below the bubble point to the membrane lumens to progressively displace at least some of the liquid permeate within the lumens through the membrane pores resulting in removal the solids retained on or in the hollow membranes into the bulk liquid surrounding the membranes.

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This process ensures that the differential pressure applied during backwash is close to the gas pressure at the liquid interface as it travels down the lumen thereby ensuring that the maximum differential pressure is applied across the membrane wall at all points, although not simultaneously.

5 According to a second aspect, the present invention provides a method of concentrating the solids of a liquid suspension comprising:

(i) providing a pressure differential across the walls of permeable, hollow membranes immersed in the liquid suspension, said liquid suspension being applied to the outer surface of the porous hollow membranes to induce
10 and sustain filtration through the membrane walls wherein:

(a) some of the liquid suspension passes through the walls of the membranes to be drawn off as clarified liquid or filtrate from the hollow membrane lumens, and
(b) at least some of the solids are retained on or in the hollow
15 membranes or otherwise as suspended solids within the liquid surrounding the membranes,

(ii) dislodging the retained solids from the membranes by applying a dislodging medium through the lumens of said membranes while concurrently draining liquid from said lumens, wherein the application of the dislodging
20 medium initially displaces liquid within the hollow membrane lumens through the hollow membrane with gas, to effect firstly a discharge of liquid in the lumens through the membrane walls, and secondly a transmembrane cleaning of the membranes by applying the gas at sufficient pressure onto the liquid to overcome the bubble point of the membrane, and ensure that the gas will
25 displace liquid and follow it through the larger pores of the membranes to

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dislodge any solids retained therein; and for the emerging gas to scour the external walls of the membranes and displace the removed solids into the bulk liquid surrounding the membranes.

Preferably, said method is carried out as a continuous process utilising a
5 repetitive cycle of solid accumulation and solid discharge.

According to a third aspect the present invention provides a concentrator for recovering fine solids from a liquid feed suspension comprising:

- (i) a vessel for containing said feed suspension;
- (ii) a plurality of permeable, hollow membranes within the vessel;
- 10 (iii) means for providing a pressure differential across walls of said membranes;
- (iv) means for withdrawing clarified liquid from the membrane; and
- (v) means for applying gas at a pressure below the bubble point to the liquid permeate in the membrane lumens to effect a discharge of at least some
15 of the liquid permeate in the lumens through the membrane walls to dislodge any solids retained therein and displace the removed solids into the bulk liquid surrounding the membranes.

According to a fourth aspect the present invention provides a concentrator for recovering fine solids from a liquid feed suspension comprising:

- 20 (i) a vessel or tank for containing said feed suspension;
- (ii) a plurality of permeable, hollow membranes within the vessel or tank;
- (iii) means for providing a pressure differential across walls of said membranes;
- 25 (iv) means for withdrawing clarified liquid from the membrane; and

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(v) means for applying gas pressure to the liquid in the membrane lumens and walls while the vessel or tank is exposed to atmospheric pressure and while concurrently draining liquid from said lumens, to effect firstly a discharge of liquid in the lumens through the membrane walls, and secondly a transmembrane cleaning of the membranes by applying the gas at sufficient pressure onto the liquid to overcome the bubble point of the membrane, and ensure that the gas will displace liquid and follow it through the larger pores of the membranes to dislodge any solids retained therein; and for the emerging gas to scour the external walls of the membranes and displace the removed solids into the bulk liquid in the vessel or tank.

Preferably, the backwash includes use of clean-in-place (CIP) chemical solutions as well as or instead of the filtrate. This may be employed in a number of different backwash methods.

One such backwash method includes filtering the chemical cleaning solution from the shell side, that is, from the outer surface or vessel side of the membrane into the membrane lumens. The normal backwash is then performed and the chemical solution forced back through the membrane pores in an even fashion by applying a gas as described above.

Another alternate form of chemical backwash includes backwashing initially with filtrate, that is, pushing the filtrate in a reverse direction through the membrane pores while injecting chemical cleaning solution into the filtrate. The filtrate/chemical solution mixture is then backwashed through the membrane by applying a gas as described above.

Yet another alternate form of chemical backwash includes applying chemical cleaning solution under pressure to the outer side of the membranes

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to force chemical cleaning solution through the membrane pores and fill the membrane lumens with the chemical cleaning solution. This is followed by the normal gas backwash described above.

In order to minimise the volume of chemical cleaning solution used all (or
5 most) of the liquid in the system may be removed or drained from one side of the membrane, typically the filtrate side (or inside of the hollow membrane), then the outer side of the membrane is at least partially filled with chemical cleaning solution and a vacuum (or reduced pressure) applied to the filtrate side to cause the chemical cleaning solution to be drawn from the outer side of the membrane
10 to the filtrate side, then gas pressure is applied to the filtrate side to force the chemical cleaning solution in the reverse direction from the filtrate side through the membrane wall back to the outer side of the membrane.

In another method, the filtrate side of the membrane(s) is drained or emptied of liquid and liquid on the outer side of the membranes is also partially
15 drained or emptied. The outer side of the membrane lumen is then at least partially filled chemical cleaning solution. The chemical cleaning solution applied to the outer side of the membranes is then pushed through with gas (for a pressurized system) or drawn through under suction (for a submerged non-pressurized system) to fill the lumen with chemical cleaning solution and the
20 volume of chemical cleaning solution used is less than the hold-up volume of liquid on the outer side of the membranes. Only enough volume of chemical cleaning solution on the outer side of the membranes to fill the membrane lumens is required. Pressure can then be applied to the lumen side to drain the chemical cleaning solution from the lumen by pushing it back through the
25 membrane wall. This cycle can be repeated multiple times so that the chemical

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cleaning solution is alternately moved from one side of the membrane to the other through the membrane wall.

Each of the above chemical cleaning methods has been found to provide a more efficient chemical backwash. The methods allow for a minimal use of chemical cleaning solution while also enabling an enhanced washing process by providing a more efficient distribution of the chemical cleaning solution within the system. Desirably, these backwashes or cleans are performed on an intermittent basis.

Using the methods described the reverse flow cleaning step can be accomplished in such a way as to allow the transmembrane pressure (TMP) to be controlled by the gas pressure and to apply this TMP evenly along the membrane, even at the extremities from the lumen inlet. This ensures all areas of the membrane are contacted with chemical cleaning solution and that they are back-flushed with the same applied TMP. It also allows the chemical in the lumens to be fully drained by the end of the reverse flow step, which aids in recovery of chemical cleaning solution, reduces flushing requirements, and reduces cleaning downtime.

In one preferred form, the gas may be pulsed in its application to the membrane lumens. In one alternate form of the chemical solution backwash described above, the backwash is performed with the vessel empty.

The process can be applied to membranes submerged in an open vessel as well as pressurized membrane filtration systems.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

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Figure 1a shows a graph of transmembrane pressure (TMP) vs position along the membrane bundle of the membrane module configuration shown in Figure 1b;

Figure 1b shows a simplified sectional side elevation of a membrane
5 module immersed in a feed liquid with pressurized liquid applied to the membrane lumens;

Figure 2a shows a graph of transmembrane pressure (TMP) vs position along the membrane bundle of the membrane module configuration shown in Figure 2b;

10 Figure 2b shows a simplified sectional side elevation of a membrane module immersed in a feed liquid with pressurized gas applied to the membrane lumens;

Figure 3a shows a graph of transmembrane pressure (TMP) vs position along the membrane bundle of the membrane module configuration shown in
15 Figure 3b;

Figure 3b shows a simplified sectional side elevation of a membrane module immersed in a feed liquid with pressurized gas applied to liquid filled membrane lumens;

Figure 3c shows an enlarged sectional view of the membranes in the
20 indicated region of Figure 3b;

Figure 4a shows a simplified sectional side elevation of a membrane module with the feed liquid drained from around the module;

Figure 4b shows an enlarged sectional view of the membranes in the indicated region of Figure 4b;

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Figure 5a shows a simplified sectional side elevation of a membrane module with a lower portion of the module immersed in a chemical cleaning solution and suction applied to the membrane lumens;

Figure 5b shows an enlarged sectional view of the membranes in the indicated region of Figure 5a;

Figure 5c shows an enlarged sectional view of the membranes in the indicated region of Figure 5a;

Figure 6a shows a simplified sectional side elevation of a membrane module with a lower portion of the module immersed in a chemical cleaning solution and pressurized gas applied to the membrane lumens; and

Figure 6b shows an enlarged sectional view of the membranes in the indicated region of Figure 6a.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to Figures 1a and 1b, the graph shown in Figure 1a illustrates the change in transmembrane pressure (TMP) as the distance from the application of pressure flow increases. Figure 1b shows a membrane module having a plurality of hollow fibre membranes 6. The fibre membranes 6 are closed at the lower end in a lower pot 7 and open at the upper end through upper pot 8. The module is immersed in liquid 9 contained in a vessel 10. In the case illustrated, pressurized liquid is applied to the open end of the fibre lumens 11 resulting in the TMP profile shown in Figure 1a.

As noted above, in membranes with the fibre membranes 6 closed at one end, the pressure of liquid is highest at the point of application of the pressurized flow to the fibres lumens 11 and tapers off along the length of the

- 10 -

membrane 6. This results in uneven backwashing and poor recovery of TMP at portions of the fibre membranes 6 remote from the backwash application point.

Figures 2a and 2b show a similar arrangement to Figure 1 but in this case pressurized gas is applied to the fibre membrane lumens 11 resulting in an even
5 distribution of TMP along the length of the fibre membranes 6.

Figures 3a to 3c illustrate one embodiment of the invention where pressurized gas is applied at a pressure below the bubble point to liquid filled fibre membrane lumens 11. As best shown in Figure 3c as the liquid is displaced through the membrane wall 12, the lumen 11 becomes filled with gas
10 resulting in a maximum TMP being applied along the length of the fibre membrane 6 as the liquid level within the fibre membrane lumen 11 drops.

Figure 4a and 4b illustrate a further embodiment of the invention where liquid is drained from around the membrane module 5 before the backwashing process is commenced. The backwashing process is similar to that described
15 above for Figure 3.

Referring to Figures 5 and 6, one embodiment of the cleaning process according to the invention is illustrated. The membrane module 5 is immersed at least partially in chemical cleaning solution 13 and suction is applied to the open ends of the fibre membrane lumens 11. As best shown in figure 5b, the
20 cleaning solution 13 is drawn through the membrane wall 12 and into the fibre membrane lumen 11. The cleaning solution 13 is then drawn up through the lumen 11 until it is completely filled as shown in Figure 5c. As shown in Figures 6a and 6b, pressurized gas is then applied to the cleaning solution filling the membrane lumen 11 and displaced through the membrane wall 12 as previously
25 described. This flow of cleaning solution to and from the membrane lumens 11

as well as along their length results in an effective chemical clean of the membrane module 5.

The invention may be embodied in a similar apparatus to that described in the aforementioned International Application No. WO93/02779 appropriately modified to operate in accordance with the inventive method.

WHAT IS CLAIMED IS:

1. A method of concentrating the solids of a liquid suspension comprising:

(i) providing a pressure differential across the walls of permeable, hollow membranes immersed in the liquid suspension, said liquid suspension being applied to the outer surface of the permeable hollow membranes to induce and sustain filtration through the membrane walls wherein:

(a) some of the liquid suspension passes through the walls of the hollow membranes to be drawn off as clarified liquid or filtrate from lumens of the hollow membranes, and

(b) at least some of the solids are retained on or in the hollow membranes or otherwise as suspended solids within the liquid surrounding the hollow membranes,

(ii) periodically performing a backwash on the membranes including:

(c) removing at least part of the liquid suspension surrounding the hollow membranes;

(d) introducing a chemical cleaning solution into the remaining liquid suspension surrounding the hollow membranes;

(e) displacing the chemical cleaning solution through the walls of the hollow membranes into the lumens of the hollow membranes;

(f) applying a gas at a pressure below the bubble point to the lumens to progressively displace at least some of the chemical cleaning solution within the lumens through the membrane pores resulting in removal the solids retained on or in the hollow membranes into the liquid surrounding the hollow membranes.

2. A method of concentrating the solids of a liquid suspension comprising:

(i) providing a pressure differential across the walls of permeable, hollow membranes immersed in the liquid suspension, said liquid suspension being applied to the outer surface of the permeable hollow membranes to induce and sustain filtration

5 through the membrane walls wherein:

(a) some of the liquid suspension passes through the walls of the hollow membranes to be drawn off as clarified liquid or filtrate from lumens of the hollow membranes, and

10 (b) at least some of the solids are retained on or in the hollow membranes or otherwise as suspended solids within the liquid surrounding the hollow membranes,

(ii) periodically performing a backwash on the hollow membranes including;

(c) removing at least part of the liquid suspension surrounding the hollow membranes;

15 (d) introducing a chemical cleaning solution into the remaining liquid suspension surrounding the hollow membranes;

(e) displacing the chemical cleaning solution through the walls of the hollow membranes into the hollow membrane lumens;

20 (f) dislodging the retained solids from the hollow membranes by applying a dislodging medium through the lumens of said hollow membranes while concurrently draining the chemical cleaning solution from said lumens, wherein the application of the dislodging medium initially displaces the chemical cleaning solution within the lumens through the hollow membranes with gas, to effect firstly a discharge of the
25 chemical cleaning solution in the lumens through the membrane walls,

and secondly a transmembrane cleaning of the hollow membranes by applying the gas at sufficient pressure onto the chemical cleaning solution to overcome the bubble point of the hollow membranes, and ensure that the gas will displace the chemical cleaning solution and follow it through the larger pores of the hollow membranes to dislodge any solids retained therein; and for the emerging gas to scour the external walls of the hollow membranes and displace the removed solids into the liquid surrounding the hollow membranes.

3. A method of concentrating the solids of a liquid suspension according to claim 1 or 2 wherein said method is carried out as a continuous process utilising a repetitive cycle of solid accumulation and solid displacement or removal.

4. A method of concentrating the solids of a liquid suspension according to any one of claims 1 to 3 wherein the displacing step includes filtering the chemical cleaning solution from the outer surface of the permeable hollow membranes into the lumens.

5. A method of concentrating the solids of a liquid suspension according to any one of claims 1 to 4 wherein the displacing step includes applying the chemical cleaning solution under pressure to the outer surface of the permeable hollow membranes to displace chemical cleaning solution through the membrane pores into the lumens.

6. A method according to any one of claims 1 to 5 including the step of removing at least part of the liquid remaining in the lumens prior to displacing chemical cleaning solution into the lumens.

7. A method of concentrating the solids of a liquid suspension according to any one of claims 1 to 6 wherein the gas is pulsed in its application to the lumens.

8. A concentrator for recovering fine solids from a liquid feed suspension comprising:

(i) a vessel for containing said feed suspension;

- (ii) a plurality of permeable, hollow membranes within the vessel;
 - (iii) means configured to provide a pressure differential across walls of said membranes;
 - (iv) means configured to withdraw clarified liquid from the hollow membranes;
 - 5 and
 - (v) means for periodically performing a backwash on the hollow membranes including:
 - a) means configured to remove at least part of the liquid suspension surrounding the hollow membranes;
 - 10 (b) means configured to introduce a chemical cleaning solution into the remaining liquid suspension surrounding the hollow membranes;
 - (c) means configured to displace the chemical cleaning solution through the walls of the hollow membranes into lumens of the hollow membranes;
 - 15 (vi) means configured to apply gas at a pressure below the bubble point to the chemical cleaning solution in the lumens to effect a discharge of at least some of the chemical cleaning solution in the lumens through the membrane walls to dislodge any solids retained therein and displace the removed solids into the liquid surrounding the hollow membranes.
- 20 9. A concentrator for recovering fine solids from a liquid feed suspension comprising:
- (i) a vessel or tank for containing said feed suspension;
 - (ii) a plurality of permeable, hollow membranes within the vessel or tank;
 - (iii) means configured to provide a pressure differential across walls of said hollow membranes;

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(iv) means configured to withdraw clarified liquid from the hollow membranes;
and

(v) means for periodically performing a backwash on the hollow membranes
including;

5 a) means configured to remove at least part of the liquid suspension
surrounding the hollow membranes;

b) means configured to introduce a chemical cleaning solution into the
remaining liquid suspension surrounding the membranes;

10 (c) means configured to displace the chemical cleaning solution through
the walls of the hollow membranes into lumens of the hollow
membranes;

(vi) means configured to apply gas pressure to the chemical cleaning solution
in the lumens and walls while the vessel or tank is exposed to atmospheric pressure
and while concurrently draining the chemical cleaning solution from said lumens, to
15 effect firstly a discharge of the chemical cleaning solution in the lumens through the
membrane walls, and secondly a transmembrane cleaning of the hollow membranes by
applying the gas at sufficient pressure onto the chemical cleaning solution to overcome
the bubble point of the hollow membranes, and ensure that the gas will displace the
chemical cleaning solution and follow it through the larger pores of the hollow
20 membranes to dislodge any solids retained therein; and for the emerging gas to scour
the external walls of the hollow membranes and displace the removed solids into the
liquid in the vessel or tank.

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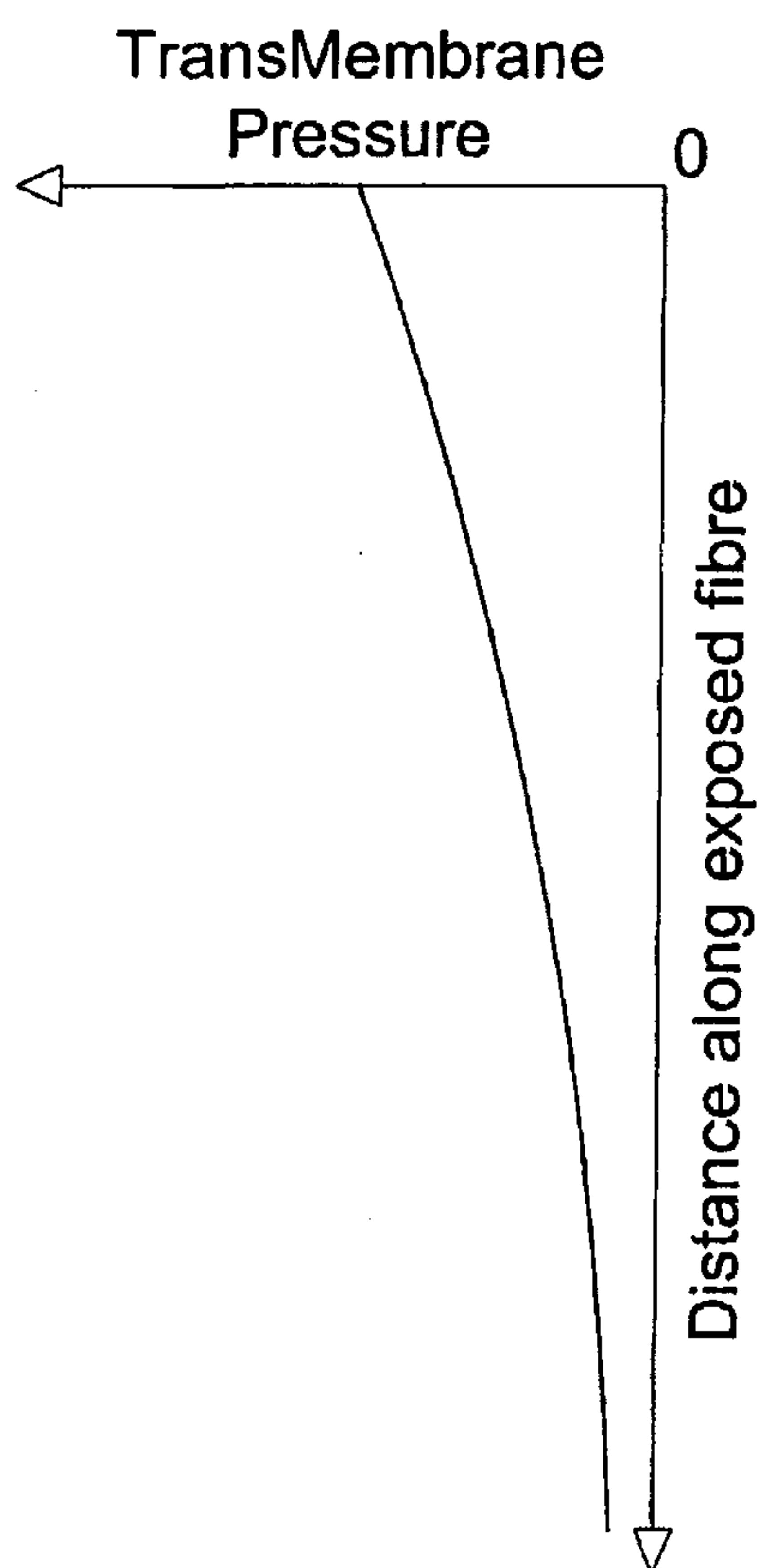


Fig. 1a
PRIOR ART

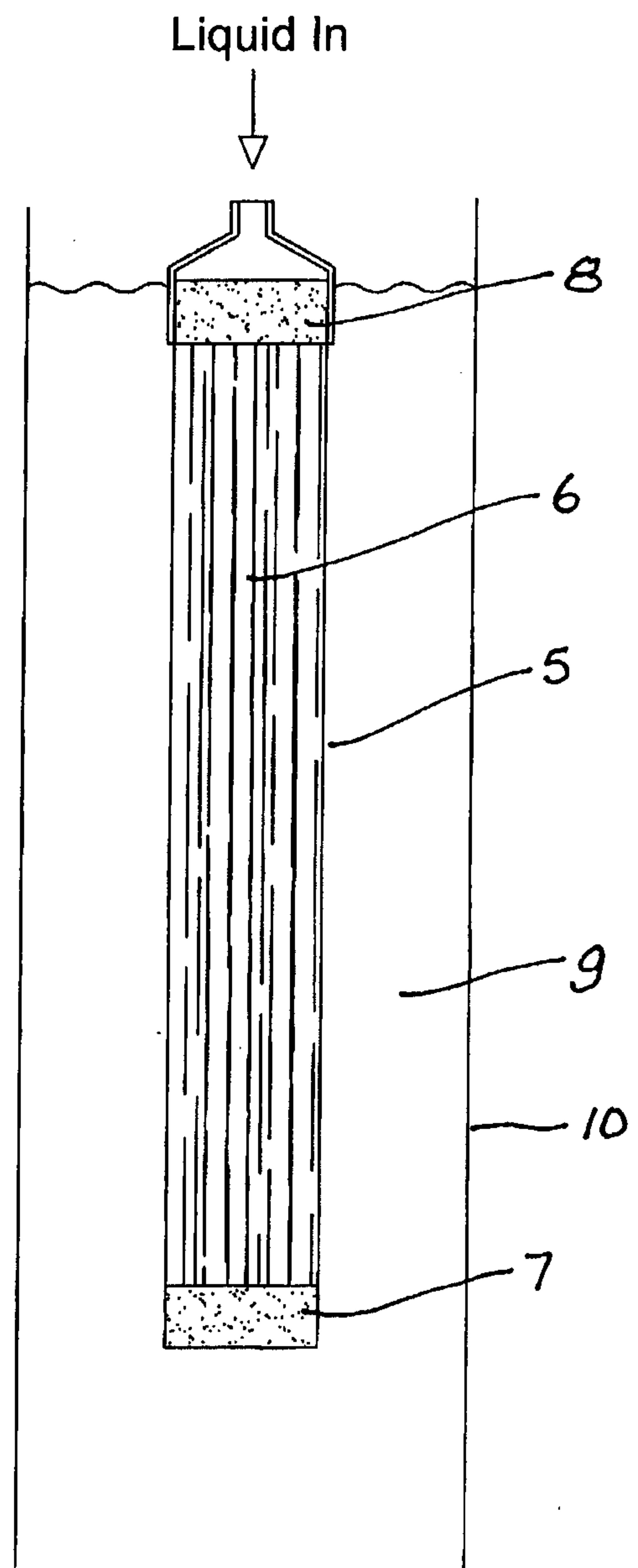
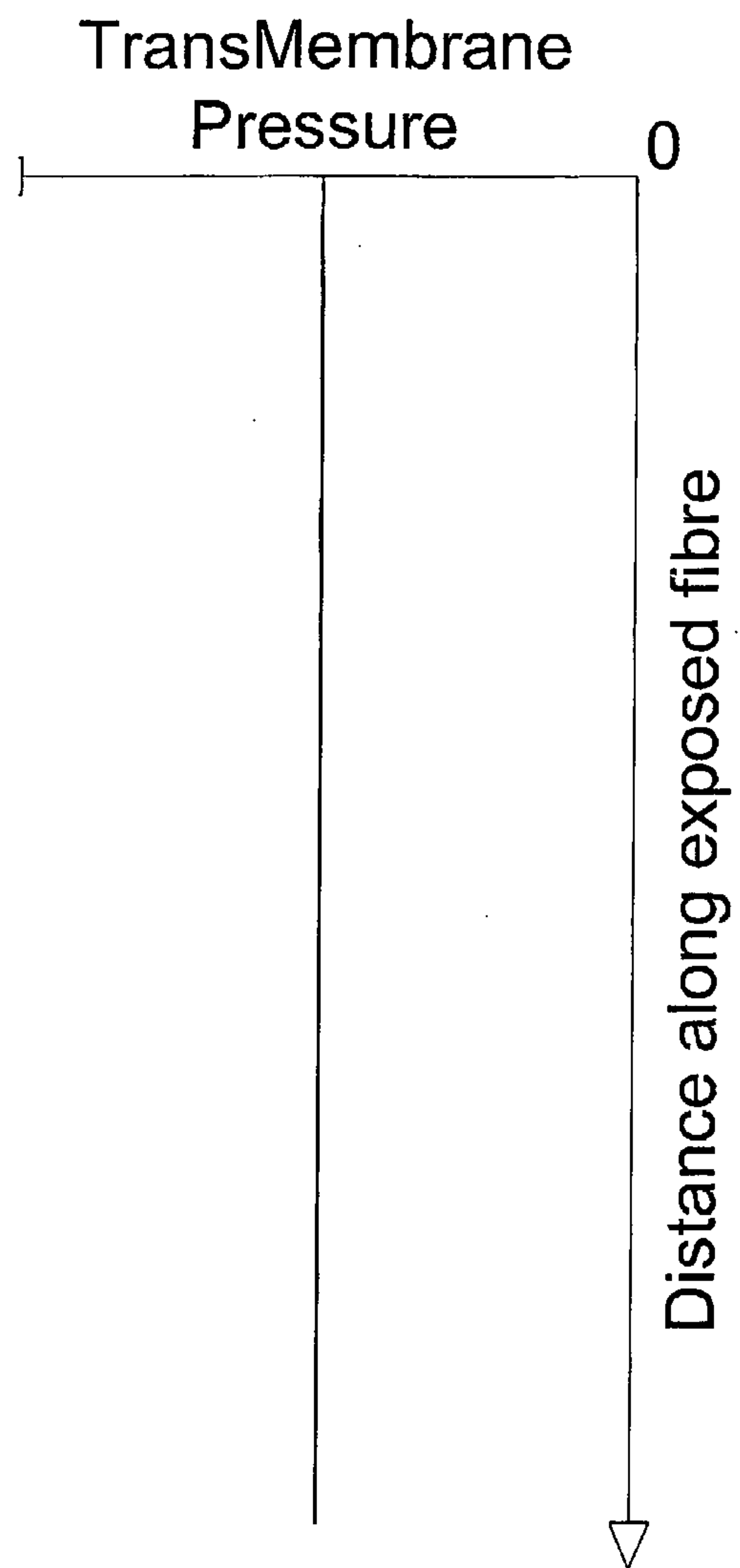
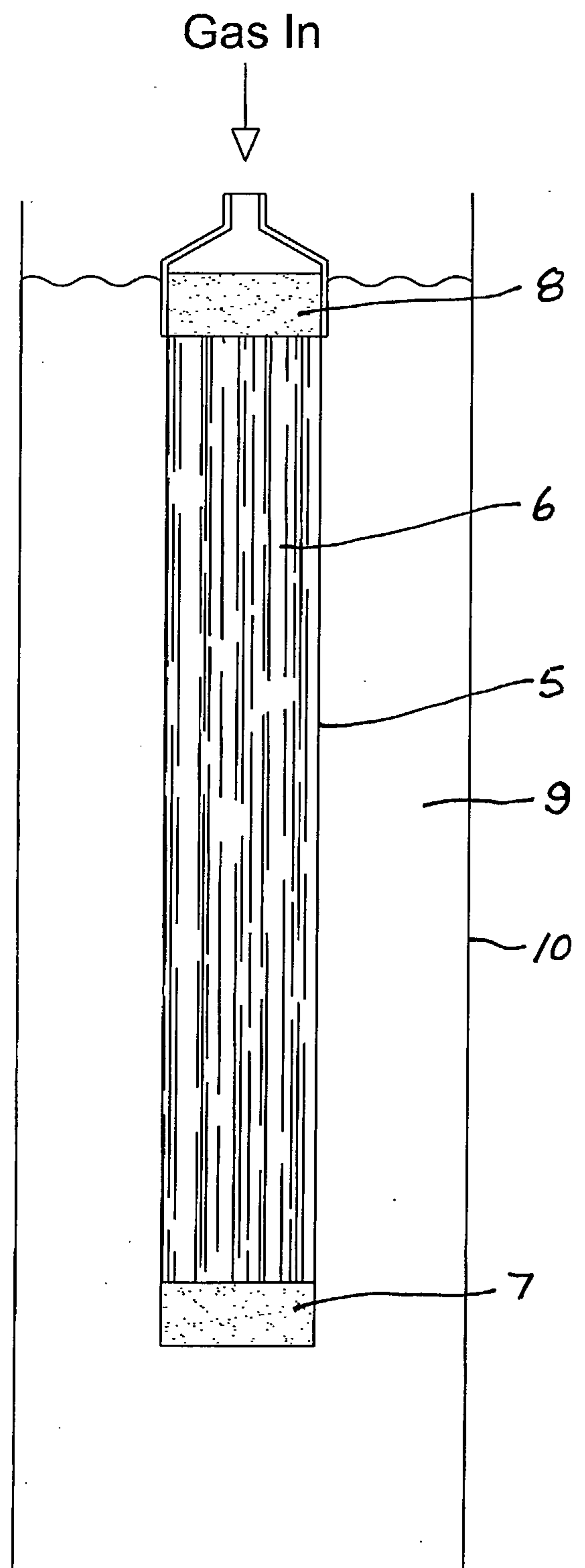


Fig. 1b
PRIOR ART

*Fig. 2a**Fig. 2b*

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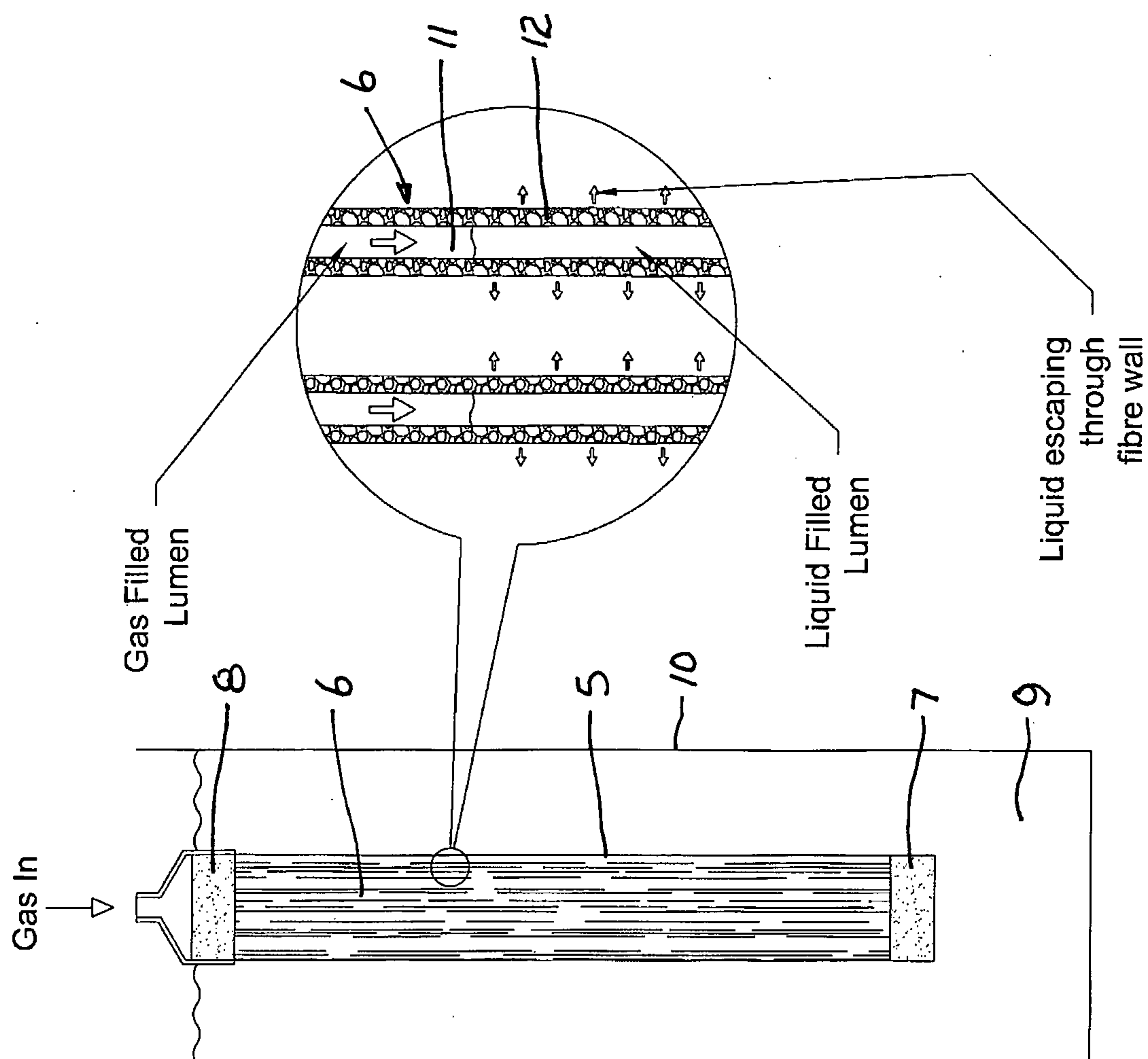


Fig. 3c

Fig. 3b

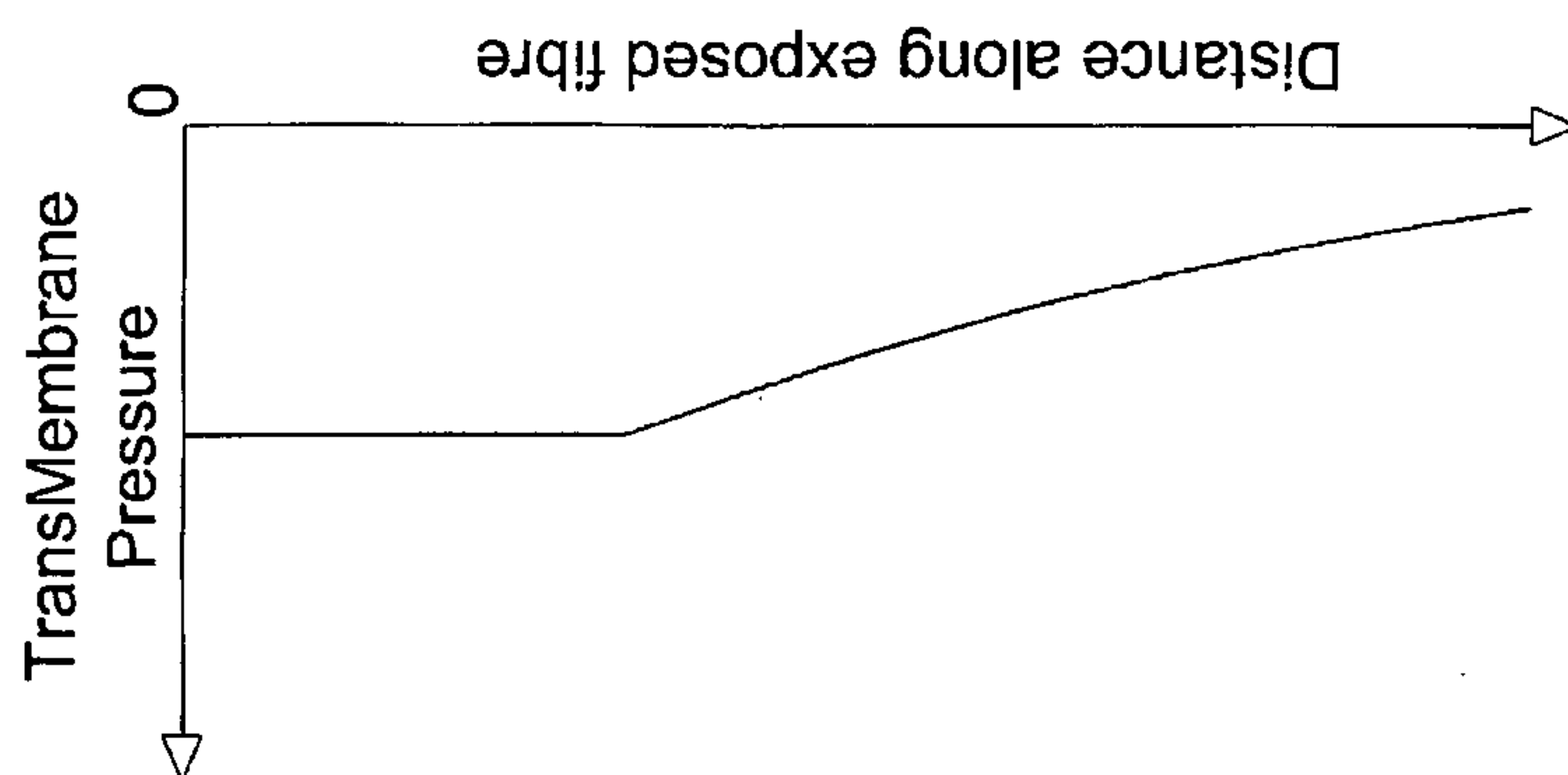
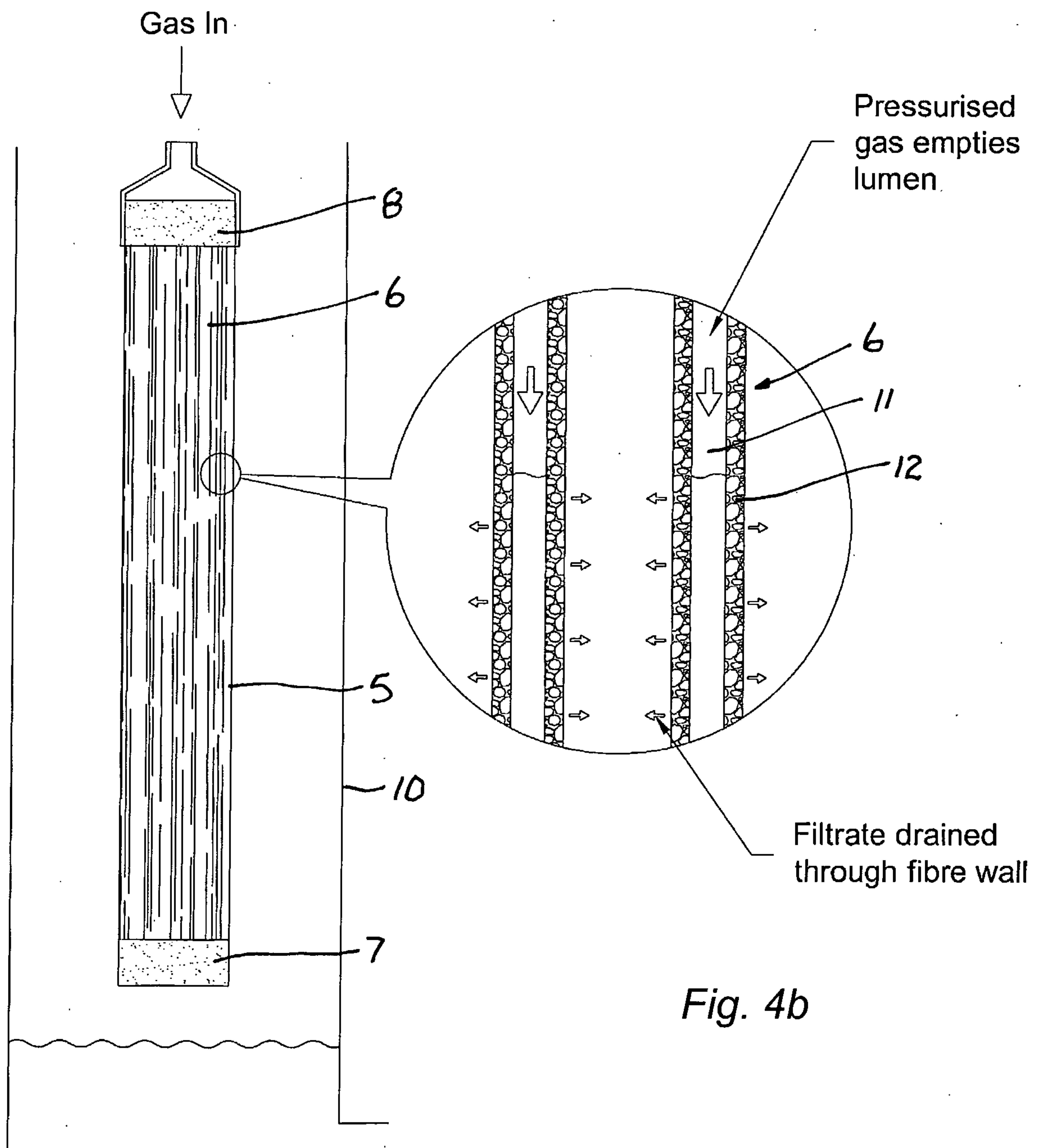
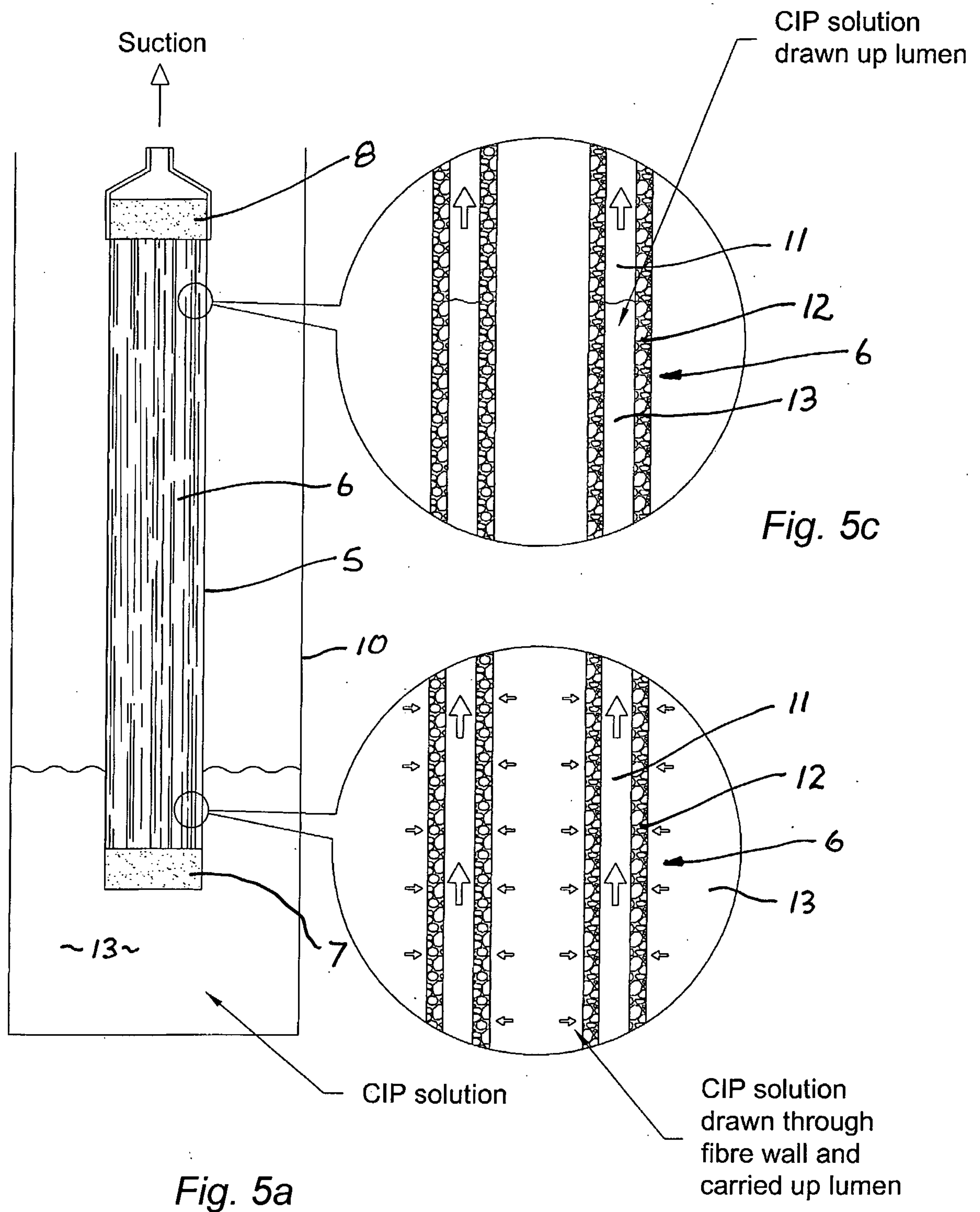
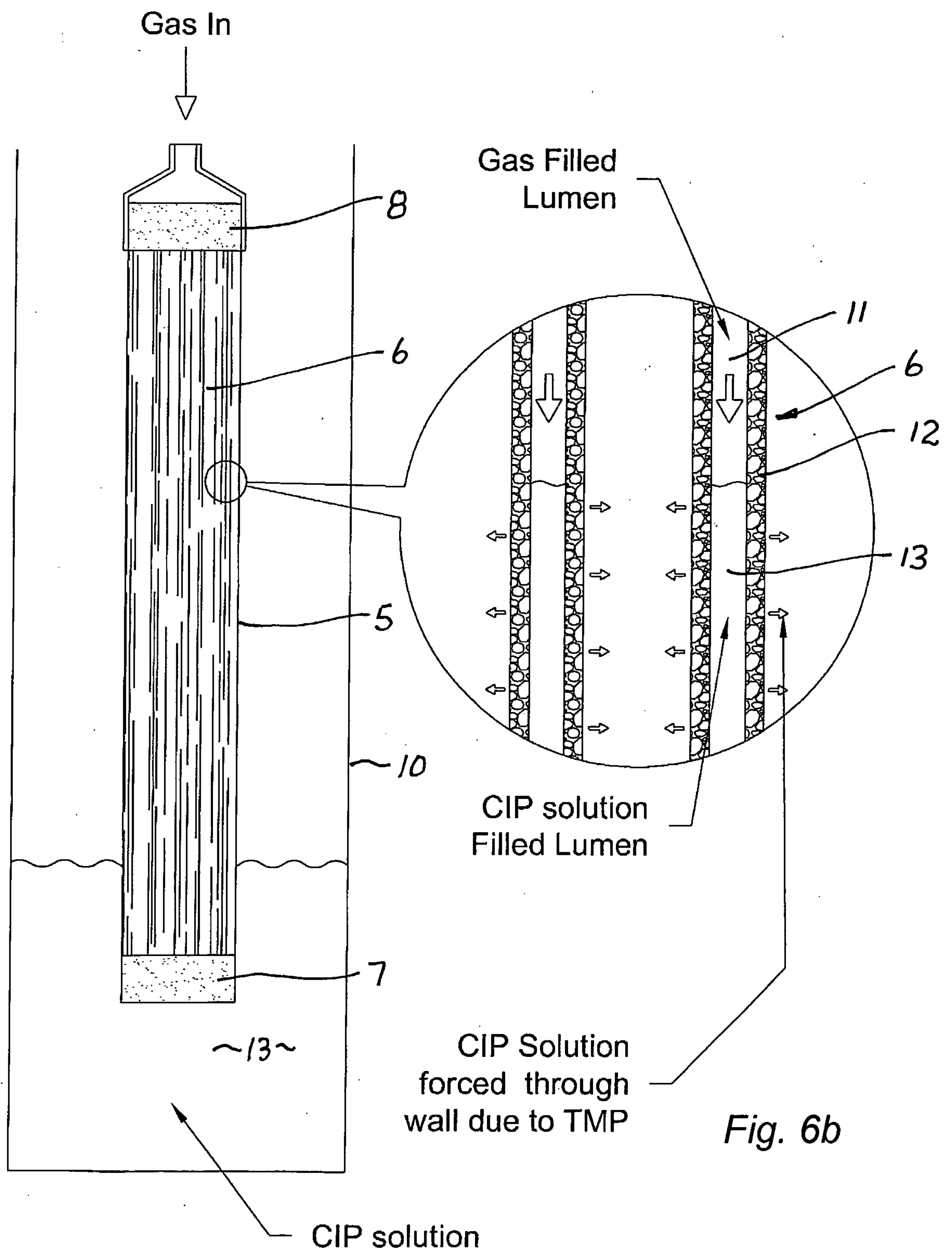


Fig. 3a

*Fig. 4a**Fig. 4b*



6/6



Gas In



Gas Filled
Lumen

8

6

5

10

7

9

Liquid Filled
Lumen

Liquid escaping
through
fibre wall

6

11

12

b

c

