



(51) International Patent Classification:

C13B 20/00 (2011.01) *C13B 20/16* (2011.01)
B03D 1/14 (2006.01)

(21) International Application Number:

PCT/CH2013/000163

(22) International Filing Date:

13 September 2013 (13.09.2013)

(25) Filing Language:

English

(26) Publication Language:

English

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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, 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, SA, 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, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: METHOD AND INSTALLATION FOR PURIFYING A LIQUID

(57) Abstract: A method for continuous purification of a liquid is provided, comprising the steps of inserting the unpurified liquid into a reaction tank (2a), injecting at least flocculants for flocculating impurities and air into the unpurified liquid, retrieving a flocculated unpurified liquid containing air (12) from the reaction tank (2a) at a first extraction location (16a) below the injection location (16b), transporting the flocculated unpurified liquid containing air (12) towards a flotation tank (2b), adding a polymer to the flocculated unpurified liquid containing air (12), inserting the flocculated unpurified liquid containing air and polymer (13) into the flotation tank (2b), removing a sludge (6) comprising flocculated impurities from the flotation tank (2b) either continuously or during predefined time intervals, and continuously extracting at least partially purified liquid from the flotation tank (2b). Furthermore an installation for carrying out the method is provided.



Method and installation for purifying a liquid

Technical Field

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The invention relates to a method for purifying a liquid, particularly an aqueous solution containing sugar, particularly in the field of food industry, and to an installation for carrying out the method, according to the independent claims.

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Background Art

Devices for purifying liquids are known. For example such devices are used in the food industry during the production of beverages for purifying an aqueous solution containing sugar. Beverages are in most cases composed of a plurality of ingredients. In many cases beverages contain a sugar solution as one ingredient. A production step consists in purifying the sugar solution in order to decolorize it and avoid undesired taste influence due to certain components of the sugar solution. Such particles, in the following called impurities, may e.g. be colloidal wax particles contained in cane sugar. They cannot be separated from the solution in a mechanical way due to their small size as compared to the mesh width of fine filters. Thus the separation has to be carried out in a physical and chemical way. As known, this is done by adding so called flocculants. The flocculants are a chemical composition as powder or in liquid form having the property of attaching to impurity molecules and in this way increasing their size. Subsequently a polymer is added to the flocculated solution. The polymer builds a "net" with a mesh width smaller than the flocculated impurity molecules, drifts to the surface of the solution dragging along the flocculated impurities which build a sludge cake on top of the solution. This sludge

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cake is then removed, yielding a partially purified sugar solution which may be transported to a further processing unit.

A problem of this process is that the polymer chains forming said net break easily. Therefore the available solutions use a batch processing in order to make sure a quantity of solution stays in the flotation tank for a period of time required by the impurities to drift to the surface of the solution. As soon as the solution has been purified to the desired extent it is extracted from the flotation tank and another quantity of the unpurified solution may be processed.

Disclosure of the Invention

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It is a general objective of the invention to provide a method and an installation with an improved capability for purifying a liquid.

According to a first aspect of the invention a method for continuous purification of a liquid is provided. The method comprises the steps of

- continuously inserting the unpurified liquid into a reaction tank,
- injecting at least flocculants for flocculating impurities and air into the unpurified liquid,
- retrieving a flocculated unpurified liquid containing air from the reaction tank at a first extraction location below the injection location,
- transporting the flocculated unpurified liquid containing air towards a flotation tank,
- adding a polymer to the flocculated unpurified liquid containing air,
- inserting a flocculated unpurified liquid containing air and polymer into the flotation tank,
- removing a sludge comprising flocculated impurities from the flotation tank either continuously or during predefined time intervals, and

- continuously extracting at least partially purified liquid from the flotation tank.

In embodiments the at least partially purified liquid is extracted from the flotation tank at a distance, calculated as a value in the range between $\frac{1}{4}$ and $\frac{1}{2}$ of a radius of the flotation tank, from the insertion location of the flocculated unpurified liquid containing air and polymer into the flotation tank. In this way it is made sure that the extraction of the at least partially purified liquid is carried out at a location far enough from the insertion of the unpurified liquid into the flotation tank in order to avoid also extracting flocculated impurities contained in the in-streaming unpurified liquid.

In embodiments the flocculated liquid containing air is recirculated continuously into the reaction tank, after having been extracted from the reaction tank, via a recirculation path and by means of a recirculation pump.

In embodiments the flocculated unpurified liquid containing air is mixed with the polymer by means of at least one static mixer. An amount of the polymer is added in a dosage depending on a flow speed of the flocculated unpurified liquid containing air towards the flotation tank or depending on a quantity of the flocculated unpurified liquid containing air in the flotation tank. In this way it is possible to regulate the exact dosage of the polymer to be injected into the flocculated unpurified liquid containing air.

In embodiments an insertion of the flocculated unpurified liquid containing air and polymer into the flotation tank is adjusted to form a cone-shaped stream towards the top of the flotation tank by means of a cone-shaped element protruding into the flotation tank by a predefined height.

In embodiments the at least partially purified liquid is extracted from the flotation tank at a lo-

cation below the predefined height of the cone-shaped element. A quiet zone is created below the outlet of the cone-shaped element. In this quiet zone the liquid has its highest purification degree because there is very little or no mixing with the unpurified liquid coming out of the cone-shaped element. Consequently, this quiet zone is well suited for extraction of at least partially purified liquid.

Preferably the liquid levels of the reaction tank and/or of the flotation tank are monitored by level meters and a flow of the liquid into the reaction tank and/or the flotation tank is regulated based on measured liquid level values.

Preferably the sludge is removed from the flotation tank at a rate which depends on a mass of the sludge and/or on a liquid level in the flotation tank and/or on an insertion rate of the flocculated unpurified liquid containing air and polymer into the flotation tank.

The monitoring and adjustment of the liquid levels makes it possible to monitor the flow rates in the system. Furthermore the monitoring of the liquid level in the flotation tank, amongst others, makes it possible to monitor if the sludge is located at a sufficient height to be removed, e.g. to flow into a drain.

According to a second aspect of the invention an installation for continuous purification of a liquid containing sugar for carrying out the method according to the invention is provided. The installation comprises

- a reaction tank for flocculating the unpurified liquid and a flotation tank for purifying the unpurified liquid,

- a recirculation circuit and a recirculation pump for recirculating the unpurified liquid back into the reaction tank,

- a first pipe for transporting the flocculated unpurified liquid containing air, extracted from

the reaction tank (2a) at a first extraction location (16b), into the flotation tank (2b), and

- an output pump for retrieving at least partially purified liquid from the flotation tank at a second extraction location (16d).

In embodiments the installation further comprises an auxiliary pump for introducing the polymer into the flocculated unpurified liquid containing air.

In an embodiment a transport pump is used for transporting the flocculated unpurified liquid to the flotation tank. By adding a transport pump to the installation it is possible to decouple the recirculation of the liquid from its transportation to the floating tank.

In one embodiment the flotation tank comprises in its top area a concentric channel opened towards the top and connected to a sloped drain for the removal of sludge. This arrangement advantageously makes it possible to remove the sludge in a simple way, without a need for using a dedicated pump.

In embodiments a cone-shaped element for regulating an insertion angle of the flocculated unpurified liquid containing air and polymer is arranged at the outlet of the first pipe and protrudes into the flotation tank by a predetermined height. By using the cone-shaped element it is possible to create a cone-shaped stream of the liquid. Furthermore, as mentioned, a substantially laminar stream of the liquid is reached in an area of the flotation tank below an outlet opening of the cone-shaped element. In this area, subsequently called extraction area, the liquid has a highest purification degree.

Preferably the reaction tank and/or the flotation tank comprises or comprise a thermal insulation layer in order to avoid an influence of the ambient temperature on the liquid.

Preferably the injection location and an inlet location into the recirculation circuit are not arranged on a same axis in the reaction tank. In this way

it is made sure that liquid injected into the reaction tank from the recirculation circuit is not directly sucked back into the recirculation circuit.

The installation according to the invention
5 is preferably used for purifying and/or decolorizing a sugar solution, particularly a sugar solution containing cane sugar or for purifying waste water.

Brief Description of the Drawing

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The invention will be better understood and objects other than those set forth above will become apparent when consideration is given to the following detailed description thereof. Such description makes refer-
15 ence to the annexed drawing, wherein Fig. 1 shows an embodiment of an installation for purifying an aqueous solution containing sugar according to the invention.

Modes for Carrying Out the Invention

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The terms "top" and "bottom" are referred to the gravitational direction. For simplification the term "solution" is used as a general term for the liquid to be purified or the purified liquid when the state of the so-
25 lution is not relevant for the corresponding context. The term "partially" in connection with a purification degree of the solution denotes purification degrees usually reached with any known solution for carrying out the purification process. It is understood that the aqueous so-
30 lution containing sugar is only an example for a liquid which can be purified by the installation according to the invention. The installation may be used to purify other types of liquids, like non-aqueous solutions, sus-
pensions, dispersions and emulsions.

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Fig. 1 shows an embodiment 1 of the installation according to the invention. A reaction tank 2a is filled with an unpurified aqueous solution containing

sugar through a not shown pipe. The reaction tank 2a is used for flocculating the unpurified solution. It further comprises a recirculation circuit 2d for transporting the solution back into the reaction tank 2a after it has been
5 extracted therefrom. A recirculation pump 9 is used to convey the solution through the recirculation circuit 2d. The recirculation circuit 2d has the task of thoroughly mixing the solution with the flocculants and air and increasing homogeneity of the mixture. A further advantage
10 of the recirculation circuit is that it helps creating turbulence in the reaction tank. This is particularly advantageous for inhomogeneous liquids, in which certain particles would tend to sediment at the bottom of the reaction tank.

15 A level meter 8 measures the solution level in the reaction tank 2a. Of course, such a level meter 8 may also be arranged to measure the solution level in a flotation tank 2b.

The reaction tank 2a is connected to the flotation tank 2b for purifying the solution by means of a
20 first pipe 2c. A transport pump 11 is used for conveying the solution into the flotation tank 2b. The flotation tank 2b is further connected to an outlet pipe 2e for removing the purified solution from it. The purified solution
25 is conveyed to a further processing installation F by means of an outlet pump 14.

In an alternative embodiment (not shown) only one pump may be used both as recirculation pump 9 and transport pump 11. In this embodiment a transport path of
30 the flocculated unpurified solution containing air is selected between a recirculation path 2d into the reaction tank 2a and a transport path 2c to the flotation tank 2b by switching a valve.

The reaction tank 2a and the flotation tank
35 2b are thermally insulated by an insulation layer 7.

The level meter 8 is connected to a control device (not shown) and to a valve 10 for increasing or

decreasing the flow through the first pipe 2c depending on a flow rate of the unpurified solution from the supply pipe into the reaction tank 2a.

The recirculation circuit 2d has a plurality
5 of inlets A-D for adding various materials to the solution. These materials comprise air and flocculants. Additional ingredients may also be added to the solution.

A polymer is injected into the first pipe 2c from a polymer distribution unit E.

10 The flotation tank 2b has at its top a concentric (with respect to the longitudinal axis of the flotation tank) channel with a sloped drain 15 for removing a sludge 6 from the solution and directing it to a sludge processing unit G.

15 In the following the steps for purifying the aqueous unpurified solution are described in more detail.

The unpurified aqueous solution is inserted into the reaction tank 2a normally having an optimum temperature for flocculation, depending on the solution. For
20 example, in case of an aqueous solution containing sugar this temperature may be around 85°C. Flocculants for flocculating impurities and air are added to the unpurified aqueous solution at an injection location 16b. The dosage of the flocculants is calculated in a known way
25 which is not described here in more detail. The flocculated unpurified solution is continuously recirculated such that the chemical reaction between the impurities of the solution and the flocculants is facilitated by a homogenization of the mixture due to the recirculation. The
30 chemical reaction and the reaction time are known by the skilled person.

Subsequently the flocculated unpurified solution containing air is retrieved from the reaction tank 2a at a first extraction location 16a located below the
35 injection location 16b.

The air added to the solution enters the reaction tank 2a at the injection location 16b as air bub-

bles. This is illustrated in the figure by the dots in the reaction tank 2a. Typically the air bubbles have different sizes and therefore experience different buoyancies when entering the reaction tank 2a. As a result they drift to the surface of the reaction tank 2a with different speeds and escapes into the tank atmosphere. Certainly, the reaction tank 2a has a connection to the ambient atmosphere such that surplus air can escape from the reaction tank 2a. According to said buoyancy differences larger bubbles drift to the surface faster than small bubbles.

By extracting the flocculated unpurified solution containing air 12 at the first extraction location 16a, which is situated lower than the injection location 16b, it is possible to "sort" the air bubbles. This is based on the fact that only small bubbles 3 are present in the area between the injection location 16b and the first extraction location 16a. As a result, for the purification process the flocculated unpurified solution containing only the small air bubbles 3 is extracted from the reaction tank 2a into the first pipe 2c.

A desired side effect of the air bubble separation is that the large bubbles drifting to the surface of the solution help mixing the flocculants and the unpurified solution by creating turbulences in the solution. Thus the reaction time of the flocculants and the impurities may be accelerated.

As mentioned the flocculated unpurified solution containing air 12 is transported into the flotation tank 2b. During the transport through the first pipe 2c a polymer is added to the flocculated unpurified solution containing air 12. It is also possible to add the polymer in the flotation tank 2b. The flocculated unpurified solution containing air is mixed with the polymer by means of at least one static mixer (not shown). An amount of the polymer is added in a dosage depending on a flow speed of the flocculated solution towards the flotation

tank. The flocculated unpurified solution containing air and polymer 13 is subsequently inserted into a bottom area of the flotation tank 2b.

As mentioned the polymer builds a substantially horizontal "net" drifting to the surface of the flotation tank 2b and carrying along the impurity particles with the attached flocculant particles, as the mesh width of the polymer net is smaller than the particle size. At this step an important advantage of the invention becomes clear; because the solution 13 contains only bubbles with substantially the same size, the polymer net is transported to the surface by the aid of the air bubbles relatively uniformly throughout its cross section. Without the previously carried out bubble size selection in the reaction tank 2a large bubbles would tend to drift to the surface very fast and would break the delicate polymer net, resulting in that many impurities would remain in the bottom area of the flotation tank or would drift to the surface only very slow. Obviously the purification process would be slowed down.

As the polymer net carrying the flocculant-impurity particles travels to the top of the flotation tank 2b it builds up a sludge cake 6 at the top of the flotation tank 2b. This sludge cake 6 comprising flocculated impurities is removed either continuously or during predefined time intervals. Preferably the sludge 6 is removed from the flotation tank 2b at a rate which depends on a mass of the sludge 6 and/or on a liquid level in the flotation tank 2b and/or on an insertion rate of the flocculated unpurified solution containing air and polymer 13 into the flotation tank 2b. The removal takes place via the concentric channel 15, which is opened towards the top. Thus, the sludge 6 rising over the edge of the channel 15 is poured into the channel 15 and disposed of via a sloped drain. The sludge 6 may be directed to a further processing unit (not shown) in which sugar residues may be extracted from it.

As mentioned the insertion of the flocculated unpurified solution containing air and polymer 13 into the flotation tank 2b is adjusted to form a cone-shaped stream towards the top of the flotation tank 2b. This is done by a cone-shaped element 17 for regulating an insertion angle of the flocculated unpurified solution containing air and polymer 13, which is arranged at the outlet 16c of the first pipe 2c into the flotation tank 2b and protrudes into the flotation tank 2b by a predefined height, being responsible for creating the cone-shaped solution stream 4.

The at least partially purified aqueous solution 5 is extracted from the flotation tank 2b at a location 16d, preferably at the bottom of the flotation tank 2b. The second extraction location 16d is arranged at a distance calculated as e.g. between $\frac{1}{4}$ and $\frac{1}{2}$ of the radius of the flotation tank 2b from the insertion location 16c of the flocculated unpurified solution containing air and polymer 13. It is understood that said distance depends on shape and size of the flotation tank 2b and may vary from the above mentioned preferred range. In this way it is made sure that only at least partially purified solution is extracted, without interfering with the insertion of the cone-shaped stream of unpurified liquid containing air and polymer 13, in order to avoid also extracting flocculated impurities contained in the in-streaming unpurified solution 13.

The claimed method and installation have the advantage that it optimized the purification process of sugar containing aqueous solutions by allowing a continuous purification process. By using only small air bubbles for facilitating the transportation of the flocculant-impurity particles to the surface of the solution and generating a cone-shaped stream for this it is possible to continuously extract purified solution from the flotation tank from the area outside the cone-shaped stream.

While there are shown and described presently preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto but may otherwise variously be embodied and practised within the scope of the following claims. Therefore, terms like "preferred" or "in particular" or "particularly" or "advantageously", etc. signify optional and exemplary embodiments only.

Claims

1. Method for continuous purification of liquid, comprising the steps of

- 5 - continuously inserting the unpurified liquid into a reaction tank (2a),
- injecting at least flocculants for flocculating impurities and air into the unpurified liquid,
- retrieving a flocculated unpurified liquid
- 10 containing air (12) from the reaction tank (2a) at a first extraction location (16a) located below the injection location (16b),
- transporting the flocculated unpurified liquid containing air (12) towards a flotation tank (2b),
- 15 - adding a polymer to the flocculated unpurified liquid containing air (12),
- inserting a flocculated unpurified liquid containing air and polymer (13) into the flotation tank (2b),
- 20 - removing a sludge (6) comprising flocculated impurities from the flotation tank (2b) either continuously or during predefined time intervals, and
- continuously extracting at least partially purified liquid (5) from the flotation tank (2b).

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2. Method according to one of the preceding claims, wherein the flocculated unpurified liquid containing air (12) is continuously recirculated into the reaction tank (2a), after having been extracted from the reaction tank (2a), via a recirculation path (2d) and by

30 means of a recirculation pump (9).

3. Method according to one of the preceding claims, wherein the flocculated unpurified liquid containing air (12) is mixed with the polymer by means of at

35 least one static mixer, wherein an amount of the polymer is added in a dosage depending on a flow speed of the

flocculated unpurified liquid containing air (12) towards the flotation tank (2b) or depending on a quantity of the flocculated unpurified liquid containing air, present (12) in the flotation tank (2b).

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4. Method according to one of the preceding claims, wherein an insertion of the flocculated unpurified liquid containing air and polymer (13) into the flotation tank (2b) is adjusted to form a cone-shaped stream (4) towards the top of the flotation tank (2b) by means of a cone-shaped element (17) protruding into the flotation tank (2b) by a predefined height.

5. Method according to claim 4, wherein the at least partially purified liquid (5) is extracted from the flotation tank (2b) at a location below the predefined height of the cone-shaped element (17).

6. Method according to one of the preceding claims, wherein the at least partially purified liquid (5) is extracted from the flotation tank (2b) at a distance, calculated as a value in the range between $\frac{1}{4}$ and $\frac{1}{2}$ of a radius of the flotation tank, from an insertion location (16c) of the flocculated unpurified liquid containing air and polymer (13) into the flotation tank (2b).

7. Method according to one of the preceding claims, wherein the liquid levels of the reaction tank (2a) and/or of the flotation tank (2b) are monitored by level meters (8) and a flow of the liquid into the reaction tank (2a) and/or the flotation tank (2b) is regulated based on measured liquid level values.

8. Method according to one of the preceding claims, wherein the sludge (6) is removed from the flotation tank (2b) at a rate which depends on a mass of the

sludge (6) and/or on a liquid level in the flotation tank (2b) and/or on an insertion rate of the flocculated unpurified liquid containing air and polymer (13) into the flotation tank (2b).

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9. Installation (1) for continuous purification of a liquid for carrying out the method according to one of the preceding claims, comprising

10 - a reaction tank (2a) for flocculating the unpurified liquid and a flotation tank (2b) for purifying the unpurified liquid,

- a recirculation circuit (2d) and a recirculation pump (9) for recirculating the unpurified liquid back into the reaction tank (2a),

15 - a first pipe (2c) for transporting the flocculated unpurified liquid (12, 13), extracted from the reaction tank (2a) at a first extraction location (16a), into the flotation tank (2b), and

20 - an output pump (14) for retrieving at least partially purified liquid from the flotation tank (2b) at a second extraction location (16d).

10. Installation according to claim 9, further comprising an auxiliary pump for introducing the polymer into the flocculated unpurified liquid containing air (12).

11. Installation according to claim 9 or 10, wherein a transport pump (11) is used for transporting the flocculated unpurified liquid (12, 13) to the flotation tank (2b).

12. Installation according to one of the claims 9 to 11, wherein the flotation tank (2a) comprises in its top area a concentric channel (15) opened towards the top and connected to a sloped drain for a removal of sludge (6).

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13. Installation according to one of the claims 9 to 12, wherein a cone-shaped element (17) for regulating an insertion angle of the flocculated unpurified liquid containing air and polymer (13) is arranged at the outlet (16c) of the first pipe (2c) and protrudes into the flotation tank (2b) by a predefined height.

14. Installation according to one of the claims 9 to 13, wherein the injection location (16b) and an input location into the recirculation circuit (16e) are not arranged on a same axis.

15. Use of the installation (1) according to one of the claims 9 to 14 for purifying and/or decolorizing a sugar solution, particularly a sugar solution containing cane sugar or for purifying waste water.

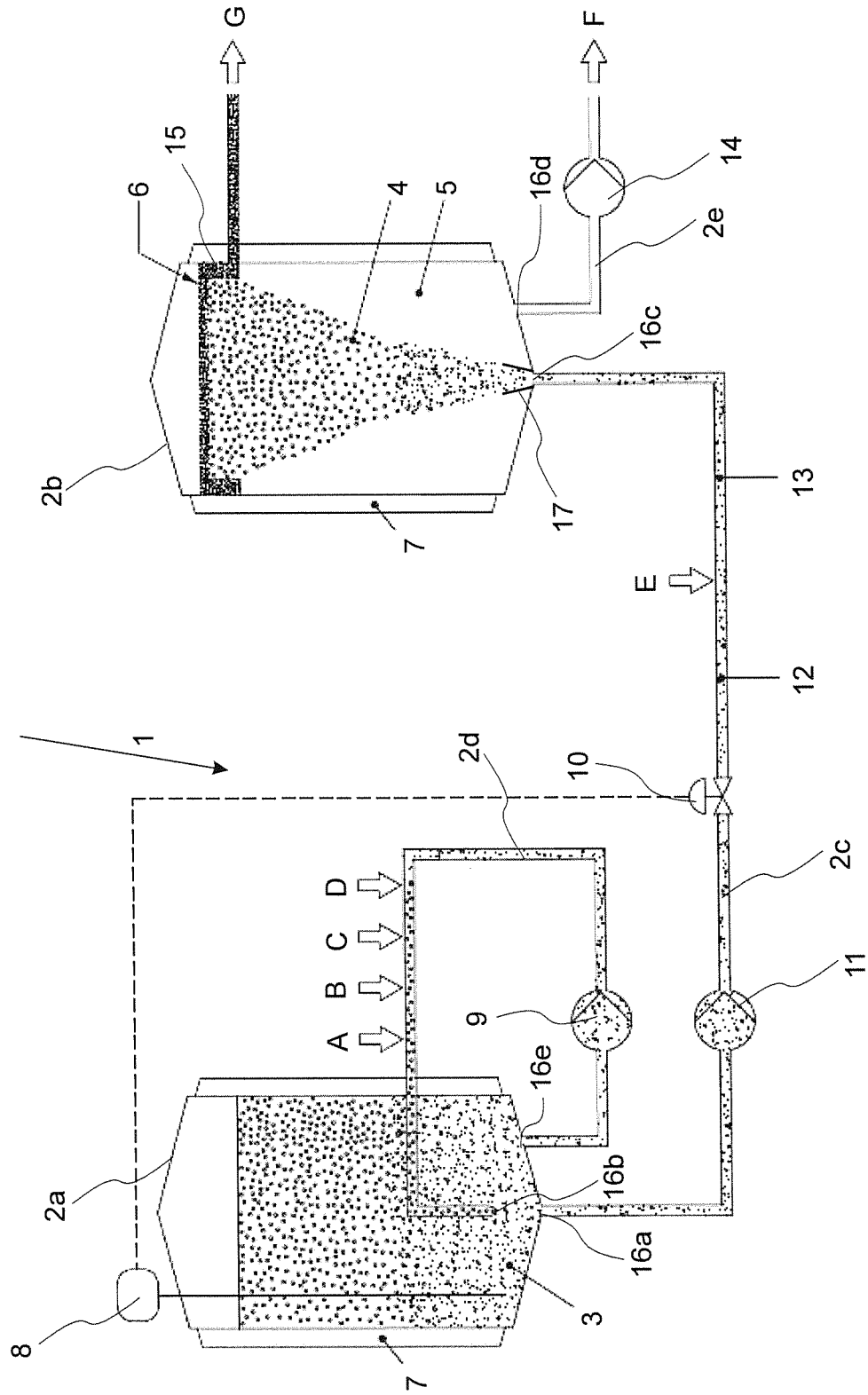


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No

PCT/CH2013/000163

A. CLASSIFICATION OF SUBJECT MATTER

INV. C13B20/00 B03D1/14 C13B20/16
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C13B B03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 478 645 A (GUDNASON GEIR V [US]) 23 October 1984 (1984-10-23) claim 1	1-8
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A	US 2 878 935 A (MAGRATH WILLIAM B ET AL) 24 March 1959 (1959-03-24) the whole document	1-15
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

16 June 2014

Date of mailing of the international search report

23/06/2014

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

PCT/CH2013/000163

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 98/56957 A2 (CYTEC TECH CORP [US]) 17 December 1998 (1998-12-17) the whole document -----	1-15
A	GB 661 577 A (HOLLANDSCHE MIJ VOOR LICENTIES) 21 November 1951 (1951-11-21) the whole document -----	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/CH2013/000163

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