PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : C02F 3/04, B01D 53/00

A1

(11) International Publication Number: WO 93/25483

(43) International Publication Date: 23 December 1993 (23.12.93)

(21) International Application Number: PCT/NL93/00126

(22) International Filing Date: 10 June 1993 (10.06.93)

(30) Priority data:
92201741.3 12 June 1992 (12.06.92) EP
(34) Countries for which the regional or international application was filed: AT et al.

(71) Applicant *(for all designated States except US)*: ECOTECHNIEK B.V. [NL/NL]; Benelux 9, NL-3527 HS Utrecht (NL).

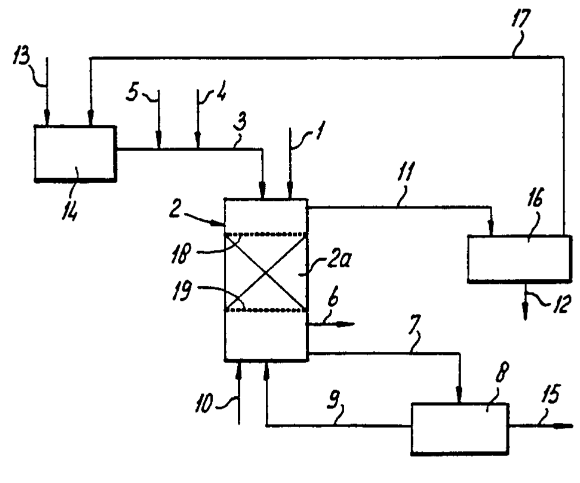
(72) Inventors; and
(75) Inventors/Applicants *(for US only)* : KOSTER, Iman, Willem [NL/NL]; Achterstraat 32, NL-6721 VM Bennkom (NL). VIS, Petrus, Ignatius, Maria [NL/NL]; Maria van Reedestraat 3, NL-3515 XJ Utrecht (NL).

(74) Agent: DE BRUIJN, Leendert, C.; Nederlandsch Octrooibureau, Scheveningseweg 82, P.O. Box 29720, NL-2505 LS The Hague (NL).

(81) Designated States: AT, AU, BB, BG, BR, CA, CH, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, LK, LU, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: TREATMENT INSTALLATION AND METHOD FOR TREATING WATER AND/OR GASES



(57) Abstract

The invention relates to a treatment installation consisting of one or more compartments (2) connected in parallel, which compartments are provided with inlets (1, 3) and outlets (6, 7) and can contain a filling of a support material (2a) on which and between which microorganisms are present, which installation is constructed in such a way that both (polluted) air (1) and (polluted) water (3) are passed downwards through the support material (2a) with a hydraulic surface loading selected between 0.5-30 $m^3/m^2/h$, wherein the pollutants are converted by the microorganisms, and air forms the continuous phase. The installation is advantageously constructed in such a way that the support material can be rinsed (8-10), while it can also be advantageous to provide facilities for the pretreatment of the air and/or water to be supplied and for subsequent treatment of the other stream of water and air obtained.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FR	France	MR	Mauritania
AU	Australia	GA	Gabon	MW	Malawi
BB	Barbados	GB	United Kingdom	NL	Netherlands
BE	Belgium	GN	Guinea	NO	Norway
BF	Burkina Faso	GR	Greece	NZ	New Zealand
BG	Bulgaria	HU	Hungary	PL	Poland
BJ	Benin	IE	Ireland	PT	Portugal
BR	Brazil	IT	Italy	RO	Romania
CA	Canada	JP	Japan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo			SE	Sweden
CH	Switzerland	KR	Republic of Korea	SK	Slovak Republic
CI	Côte d'Ivoire	KZ	Kazakhstan	SN	Senegal
CM	Cameroon	LI	Liechtenstein	SU	Soviet Union
CS	Czechoslovakia	LK	Sri Lanka	TD	Chad
CZ	Czech Republic	LU	Luxembourg	TG	Togo
DE	Germany	MC	Monaco	UA	Ukraine
DK	Denmark	MG	Madagascar	US	United States of America
ES	Spain	ML	Mali	VN	Viet Nam
FI	Finland	MN	Mongolia		

Treatment installation and method for treating water and/or gases

The invention relates to a treatment installation consisting of one or more compartments connected in parallel, which compartments are provided with inlets and outlets and contain a filling of a support material, on which and between which microorganisms are present, as well as a method for treating water and/or gases.

Installations of this type are generally known and are used on a large scale. Good results are obtained with an installation of this type, but said installations are not suitable for all types of pollutant.

Xenobiotic components which are present in waste water are frequently removed with the aid of filtration using active charcoal. Volatile components can also be removed from the aqueous phase by stripping. In this case it is necessary to subject the stripping air released to a subsequent treatment. This can be effected by means of an active charcoal filter.

When xenobiotic components are removed from waste water by means of active charcoal filtration or stripping and when removing said components from the air phase, pollutant is transferred from one phase to another phase in these techniques. The phase in which the pollutant is bound, frequently active charcoal, still has to be treated afterwards in order to decompose pollutants.

Biological purification techniques do not have this disadvantage; in these systems pollutants are completely converted into harmless residual products, such as biomass, CO_2 and water.

Biological purification techniques can roughly be subdivided into systems with suspended biomass and systems in which the biomass firmly adheres to the support material.

One example of a biological purification technique in which use is made of suspended biomass for biological purification of waste water is an active sludge installation. This has the disadvantage that for low concentrations of pollutant the amount of biomass produced per volume of waste water treated is small. However, a high biomass concentration in the installation is required for a high removal capacity. At low pollutant concentrations a long sludge retention time is therefore required. This is difficult to realise in active sludge installations.

Ground water which is released during soil treatment work frequently contains low (that is to say low in the absolute sense) concentrations of pollutants; however, the concentrations are still too high and the ground water therefore has to be treated before discharge.

In bioreactors containing a support material, so-called biofilm reactors, there is a slime layer on the support material. This is the so-called biofilm, in which microorganisms are immobilised. In biofilm reactors it is possible to maintain a high biomass concentration at low pollutant concentrations.

Oxygen is required for aerobic biological removal of organic pollutants. Because oxygen is not present in sufficient amounts in the waste water it is necessary to supply additional air to the bioreactor. In this context it is possible that if the oxygen is supplied to the system in the form of aeration some of the volatile pollutants are removed via the air phase, so that the discharged process air has to be subsequently treated.

An installation of the type described in the preamble has now been found which is characterised in that the installation is constructed in such a way that both polluted air and water are passed downwards through the support material with a hydraulic surface loading selected between 0.5-30 $m^3/m^2/m$, the pollutants being converted by the microorganisms in the biofilm on the support material, and during this operation air forms the continuous phase.

The support material can, for example, consist of sand; the microorganisms are then present both on the grains of sand, in the form of a biofilm, and between the grains of sand, in the form of sludge flocks. The support material therefore also acts as a filter.

In the case of the biological aerobic system present here, the pollutants are completely converted and subsequent treatment of both effluent and process air can be dispensed with. It is, of course, advantageous to provide the installation with a facility for rinsing the filter material, because the growth of biomass and any chemical precipitates formed reduces the capacity for flow through the filter bed. This installation and the method made possible by means of said installation have a number of advantages compared with other biofilm reactors (such as biorotor, oxidation bed, submerged filter).

1) As a result of the correct choice of the support material the installation has a high specific biofilm surface area. Consequently it is possible to maintain a high biomass concentration in the installation and thus to achieve a high removal capacity.

2) Water and air are fed through the reactor in plug flow. By this means a reduction in the removal capacity as a result of diffusion limitation is counteracted.

3) As a result of the intense contact between air and water very good mass transfer between the air and the water phase is possible, so that the installation has a high aeration capacity. If the installation is used for the treatment of effluent, this signifies that the air/water ratio required is low.

4) By passing water and air in co-current through the reactor, the discharging process air is in equilibrium with the effluent concentration of the treated waste water. In the case of an installation functioning normally, the effluent contains very low pollutant concentrations. The concentrations in the discharging process air are therefore also very low, so that the air does not have to be subsequently treated.

As a result of these advantages it is possible for the treatment process to proceed in an optimum manner.

The fill material is important in order to obtain a plug flow character. Of course, there is only approximate plug flow. Ideal systems have, after all, not been realised in practice. In order to retain the plug flow character it is therefore clear that finely divided support material must be used in the reactor. The finely divided material can, for example, be fine sand. The plug flow character will be less in the case of coarser material.

The effect of the downward passage through the system is that air is the continuous phase. If passage were upwards the air would pass through the system in the form of bubbles with the concomitant disadvantages.

The water is preferably supplied in finely divided form and therefore, for example, with the aid of a spray element.

Suitable support materials are, inter alia, sand, anthracite (which is then in the form of flat platelets) and active charcoal.

A system for removal of chemical precipitates from the liquid phase can be connected upstream of the biological reactor(s). It is also possible to install facilities for subsequent treatment of discharging water and/or air streams downstream of the installations, for those cases where it is desired to achieve even greater purification.

As a consequence of the conversion of the pollutants by the microorganisms into biomass and the oxidation of iron, accumulation of biomass and iron oxide takes place in the bioreactor. At a specific pressure drop over the bioreactor, the excess biomass and the precipitated inorganic material (inter alia iron oxide) are removed from the filter bed by rinsing the filter bed.

The invention is illustrated in Figure 1. The installation according to Figure 1 is intended for the treatment of air drawn from the soil (ground air extraction). The pollutants and oxygen are transferred from the gas phase to the water phase. In the water phase the pollutants are then converted by the microorganisms on the support material into the biomass, CO_2 and H_2O. The treated air is discharged into the environment and the treated water is recycled through the bioreactor. The maximum air/water ratio in this operation is 10:1.

The polluted air is fed via (1) into the top of the bioreactor (2) together with clean (re)cycled water via (3), to which nutrients and neutralising liquid can be added if desired. This addition can be made via feed lines (4) and (5), which are connected to (3). The sequence of the location in which the additions (4, 5) are made is of minor importance. In the bioreactor (2) the transfer of the pollutants from the gas phase to the water phase takes place and the microorganisms (on the support material (2a)) break down the pollutants. The treated air is removed via (6). The clean process water is removed via (7) to a clean water/sludge buffer vessel (8). Buffer vessel (8) is connected via line (3) to the reactor (2). The reactor can be rinsed by shutting off the lines 1, 3, 6 and 7. The water required for rinsing can be fed through the bioreactor from the buffer vessel (8) via (9) together with air via (10). The rinse water is removed via (11) to the clean water/sludge buffer vessel (8). The sludge is periodically removed from vessel (8) via (12).

Figure 2 shows a installation for the simultaneous treatment of water and air. The symbols have the same significance as in Figure 1. Effluent is supplied via (13) and collected in a buffer vessel (14). The buffer vessel is advantageously designed as an oil/sand separator. The effluent is fed via (3) into the top of the bioreactor (2). Connections, shown here as (4) and (5), to line (3) are provided for the addition of nutrients and/or a neutralising liquid. Air is introduced via (1) into the top of the reactor (2). It will also be obvious that the air supply can also be connected to line (3). An active sludge on support material (2a) is present in the bioreactor (2). Microorganisms which convert the pollutants into biomass, CO_2 and H_2O are present on and between the support material. The water is collected at the bottom of the reactor and process air is discharged via (6) into the atmosphere. The water is fed via (7) to the (clean water) buffer vessel (8) and discharged via 15. Lines 9, 10 and 11 are closed during normal operation.

When the filter bed is rinsed, the supply and discharge of effluent via (3) and (7) and air via (1) and (6) are shut off. Water from the clean water buffer vessel (8) is passed upwards through the filter via (9) together with air via (10). The rinse water (and rinse air) is removed via (11) to a sludge buffer vessel (16). After settling, the sludge is periodically removed via (12). The excess rinse water is discharged via (17) to the influent buffer vessel (14).

If the specific gravity of the support material is not much higher (or lower) than that of water, a grating (18) is placed just below the rinse water discharge so that the support material is not flushed out during rinsing. Preferably, the bottom of the support material is supported on a grating (19).

The installation as shown in Figure 2 can also be used for cleaning effluent only. In place of polluted air, clean air is then fed to the bioreactor via (1).

Ground water frequently contains high concentrations of divalent iron. These must be removed before the customary treatment techniques are able to function correctly. A dry filter (that is to say a filter which is not under water) is used as iron-removal stage for the production of drinking water. Thus, in the installation according to the invention two removal techniques take place at the same time; the pollutants are converted by the microorganisms into harmless residual products and at the same time iron is oxidised to trivalent iron, which remains behind as iron oxide in the dry filter. This iron oxide accumulates in the dry filter and can be removed by rinsing.

In practice, rinsing will be carried out when a specific additional pressure drop has arisen, for example of 1 bar. Iron and excess biomass are flushed out during rinsing.

The bioreactor can be constructed in such a way that it is accessible via a manhole at the top.

When the bioreactor according to the invention is used for water treatment, the air/water ratio (the feed) is preferably at least 1:10 and at most 1:2, preferably not more than 1:1, with most preference for a ratio from 3:10 to 5:10. However, a ratio of 10:1 is also possible in the case of air treatment. For the combined treatment of air and water the air to water ratio is between 2:1 and 30:1, with a preference between 5:1 and 15:1.

The water treatment or air treatment or the combined air and water treatment can be used, inter alia, when treating polluted soil. When withdrawing ground water alone, both the volatile and the non-volatile components are removed. When withdrawing both ground air and ground water, a large proportion of the volatile pollutants are removed via the ground air and the remaining volatile compounds are removed together with the non-volatile compounds with the ground water. Volatile compounds which can be removed from the soil in this way and broken down biologically in the invention are, inter alia, the lighter weight fraction of mineral oils, benzene, toluene, ethylbenzene, xylene and naphthalene. The non-volatile components which are removed from the soil in this way are, inter alia, phenol, the heavier fraction of the mineral oils and some of the polycyclic aromatic compounds.

When operating a bioreactor according to the invention it is preferable to meet one or more of the following four preconditions in order to achieve complete removal of the pollutants. These conditions are:

1) The hydraulic surface loading as a consequence of the water flow must be between 0.5-30 $m^3/m^2/h$.

2) The air/water ratio must be at least 0.1.

3) The hydraulic residence time based on the volume of water present is between 1 and 10 minutes, preferably between 1.5 and 3 minutes.

4) The organic loading is lower than the removal capacity.

For the hydraulic surface loading based on the volume of water present a preference is expressed for a value between 5-15 $m^3/m^2/h$ for water purification, in particular for groundwater purification. For air purification a value higher than 20 $m^3/m^2/h$ is acceptable.

The maximum value of the air/water ratio for water purification with a bioreactor according to the invention is 1 and a preference is expressed for a value between 0.3-0.5.

For purification of a combination of water and air the minimum value for the air/water ratio is 2 and the maximum value is 30 with a preference for a value between 5-15.

If the fourth condition is not met and/or if components which are impossible or very difficult to break down biologically are also present in the streams to be treated, the installation can be used for pretreatment in order to lessen the load on the downstream physical/chemical treatment.

The invention is illustrated with reference to the following examples, which must not be considered as being restrictive.

Example 1
Ground water treatment

Ground water which is polluted with aromatic compounds (5 mg/l) is pumped up in an amount of 20 m^3/h. This ground water is fed into an installation according to Fig. 2, the water flow rate being 20 m^3/h and the air flow rate 10 m^3/h. The bioreactor used has a bed volume of 4 m^3 (surface area 2 m^2). The support used is sand with a particle size of 1.5-2.5 mm.

The organic loading is 100 g/h. The oxygen demand can be calculated as a maximum of 3.5 grams of O_2 per gram of aromatic compound. This brings the oxygen demand to 350 g/h. Air contains ± 250 g of O_2 per m^3. The minimum requisite air flow rate here is 1.4 m^3/h.

The water which is discharged at (15) no longer contains a detectable amount of aromatic compounds.

Example 2

Air obtained from the withdrawal of air from the polluted soil is passed into an installation according to Figure 2, in which four combined water treatment and ground air extraction reactors, each having a volume of 6 m^3 (surface area 3 m^2) are connected in parallel. The amount of ground air is 50 m^3/h and the concentration of the aromatic pollutants is 10 g/m^3. The ground water withdrawn is 10 m^3 with a concentration of 10 mg/l. The organic loading via the air here is 500 g/h and the organic loading via the ground water is 100 g/h. The total organic loading is therefore 600 g/h. The minimum requisite air flow rate for the oxygen supply is then 8.4 m^3/h.

The installation was operated using an air flow rate of 50 m^3/h. The support material used was sand having a particle size of 1.5-2.5 mm.

The discharged water and the discharged air contain an amount of pollutants which is less than the permitted amount and could therefore be discharged freely.

Example 3

Ground air treatment

Polluted soil is treated with the aid of ground air extraction in an installation according to Fig. 1. The withdrawal of ground air in this is 200 m^3/h. The pollutant concentration is 1 g/m^3. The organic loading is then 200 g/h. The ground air is treated in two reactors, each having a volume of 10 m^3 (surface area 5 m^2), which are connected in parallel. The recycle flow rate of the water in this case is 20 m^3/h. After treatment, the ground air contains pollutants only below the permissible limit. The support material used was sand having a particle size of 1.5-2.5 mm. The bed volume was 4 m^3.

Legend for the references in the figures

1. (polluted) air feed
2. bioreactor

2a. support material

3. (polluted) water feed

4/5. nutrient/neutralising liquid feed

6. treated air discharge
7. treated water discharge
8. buffer vessel
9. rinse water feed
10. rinse air feed
11. rinse water and rinse air discharge
12. sludge discharge
13. polluted water inlet
14. influent buffer vessel
15. treated water discharge
16. sludge buffer vessel
17. rinse water discharge
18. grating (top)
19. grating (bottom)

Claims

1. Treatment installation consisting of one or more compartments connected in parallel, which compartments are provided with inlets and outlets and contain a filling of a support material, on which and between which microorganisms are present, characterised in that the installation is constructed in such a way that both (polluted) air and (polluted) water are passed downwards through the support material (2a) with a hydraulic surface loading selected between 0.5-30 $m^3/m^2/h$, wherein the pollutants are converted by the microorganisms, and wherein air forms the continuous phase.

2. Installation according to Claim 1, characterised in that the installation is constructed such that the hydraulic surface loading is selected between 5-15 $m^3/m^2/h$.

3. Installation according to Claim 1 or 2, characterised in that the installation is constructed such that the air/water ratio (the feed) is at least 0.1 and at most 1, preferably between 0.3-0.5 for purification of water.

4. Installation according to claim 1 or 2, characterised in that the installation is constructed such that the air/water ratio (the feed) is at least 2 and at most 30, preferably between 5-15 for purification of a combination of air and water.

5. Installation according to any of the preceding claims, characterised in that the installation is constructed such that the hydraulic residence time based on the volume of water present is between 1-10 minutes, preferably between 1.5-3 minutes.

6. Installation according to any of the preceding claims, characterised in that the installation is constructed in such a way that the support material can be rinsed.

7. Installation according to any of the preceding claims, for the treatment of effluent, if desired together with ground air, characterised in that a buffer vessel (14), which is designed as an oil/sand separator, is placed upstream of the reactor (2).

8. Installation according to any of the preceding claims, characterised in that a system for the removal of chemical precipitates from the liquid phase is inserted upstream of the biological reactor(s).

9. Installation according to any of the preceding claims, characterised in that said installation is constructed in such a way that the effluent can be recycled.

10. Installation according to any of the preceding claims, characterised in that the installation contains one or more reactors (2) placed in series.

11. Installation according to any of the preceding claims, characterised in that a connection for the supply of air is fitted in the feed line for the water to be treated (3).

12. Installation according to any of the preceding claims, characterised in that the installation is constructed in such a way that the process air is removed via the same line as the treated water.

13. Installation according to any of the preceding claims, characterised in that a facility is provided for the after-treatment of discharging water and/or air streams.

14. Installation according to Claim 6, characterised in that a grating (18) is fitted in the top of the reactor, through which grating the rinse water and the rinse air are separated when rinsing back the support material (2a).

15. Method for the treatment of water and/or off-gases, characterised in that an installation according to any of the preceding claims is used.

fig-1

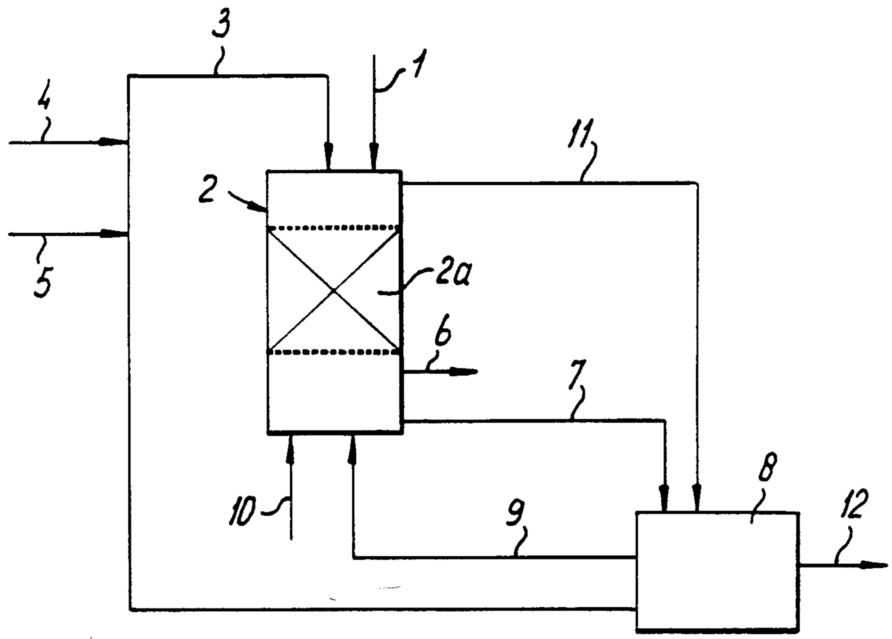
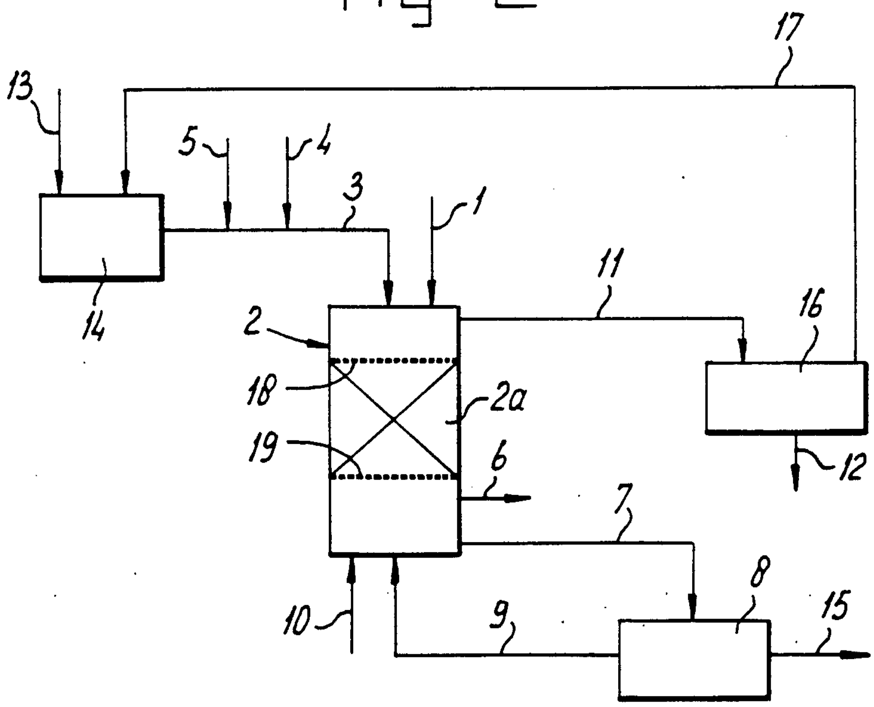


fig-2



INTERNATIONAL SEARCH REPORT

International Application No PCT/NL 93/00126

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 C02F3/04; B01D53/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	C02F ; B01D

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	EP,A,0 100 024 (BAYER AG) 8 February 1984 see page 12; claims 1,5,10 see page 7, line 21 - page 9, line 7	1-6,9, 12,15
A		10
X	GB,A,446 066 (HEINRICH BLUNK) 21 May 1936 see page 2, line 11 - line 98	1-5,9,15
X	EP,A,0 274 986 (CIBA-GEIGY AG) 20 July 1988 see page 6; claim 1 see page 2, line 29 - line 38	1-5,11, 13
A	EP,A,0 442 157 (TAUW INFRA CONSULT BV) 21 August 1991 see page 10; claims 1,4,5,7,8,16 see page 2, line 8 - page 4, line 58	1-5,7,8, 10,13

° Special categories of cited documents : [10]

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

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
27 SEPTEMBER 1993	18. 10. 93
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	TEPLY J.

1

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

NL 9300126
SA 76268

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 27/09/93
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-0100024	08-02-84	DE-A- 3227678	26-01-84
GB-A-446066		None	
EP-A-0274986	20-07-88	DE-A- 3784480 US-A- 5082475	08-04-93 21-01-92
EP-A-0442157	21-08-91	US-A- 5080793	14-01-92

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82