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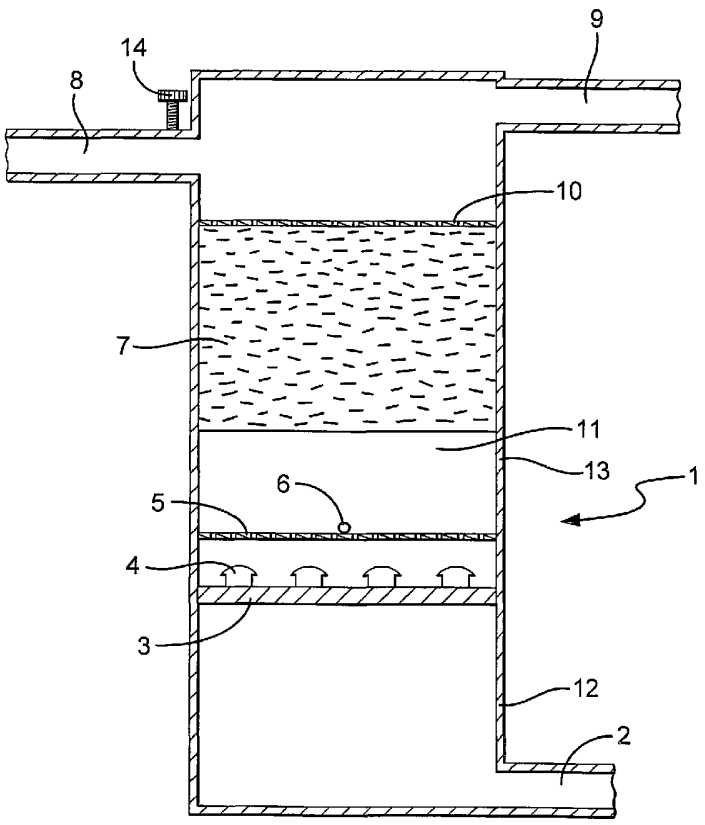
(54) Title: FLOATING MEDIA FILTER



(57) Abstract: The present invention relates to a wastewater treatment tank (1) comprising a wastewater inlet (2), at least one gas inlet (6), at least another gas inlet (4), an effluent outlet (8), a backwash outlet (9) and floating filter medium (7) wherein the backwash outlet, in use, is provided above the floating filter medium.

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Published:

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— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

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.

Floating Media Filter

The present invention relates to a floating medium filter for the treatment of wastewater and an arrangement of a tank containing such media.

The object of biological wastewater treatment is to reduce the concentration of organic and inorganic pollutants in wastewater using micro-organisms, in particular bacteria. Most treatment processes are aerobic. During the treatments the micro-organisms convert the pollutants into carbon dioxide and water.

Traditionally, wastewater treatment systems require two stages to effect treatment. The first stage takes place in what is known as the Reactor, where the conversion of pollutants occurs and the second stage takes place in what is known as the Settlement tank where the micro-organisms are separated from the treated wastewater.

However, Biological Aerated Filters have recently come into use, and these permit the steps of both reaction and separation of micro-organisms to be effected in a single stage. Biological Aerated Filters utilise a fine granular medium (between sand and pebble in size) which is constantly submerged in the wastewater. The medium provides a surface upon which the micro-organisms can grow, while providing a filtering action to separate micro-organisms from the treated wastewater.

To facilitate rapid treatment, the medium is force ventilated using a blower and air diffusion arrangement, situated either

beneath the bed of the medium, or in the bottom portion of the medium bed itself.

Early Biological Aerated Filters utilised media heavier than water and were extremely complex thereby making them expensive to build and operate. More recently, Biological Aerated Filters utilising floating media have been made available.

Whether a medium heavier or lighter than water is used, inevitably such media become clogged with solids over time. The clogging is dispersed by stopping the treatment and loosening the medium with a high rate/volume of air from beneath the medium. The solids clogging the medium are pushed to the bottom of the floating filter medium tank by a flow of treated effluent from the top of the tank. The use of treated effluent in the backwashing process makes the process very inefficient. After the backwashing process, the medium is allowed to re-establish itself before treatment is resumed.

There are currently two known types of floating medium utilised; namely, expanded polystyrene and polyethylene. The expanded polystyrene filter medium typically comprises small spheres with a specific gravity of approximately 0.30. This medium is extremely buoyant and therefore very difficult to disrupt using air during backwash, however, it repacks well after backwashing allowing treatment to be resumed quickly. The polyethylene filter medium typically comprises hard granules with a specific gravity of approximately 0.95. As the polyethylene filter medium is barely buoyant, it is easily disrupted using air during backwash, however, it does not repack well after backwashing, and hence, there is considerable delay before treatment can be resumed.

An object of the present invention is to overcome the problems of the prior art.

According to the present invention there is provided a wastewater treatment tank comprising a wastewater inlet, at least one gas inlet with a flow rate x, at least one gas inlet with a flow rate y, an effluent outlet, a backwash outlet and floating filter medium wherein the flow rate of x is greater than y and wherein the backwash outlet, in use, is provided above the floating filter medium.

The tank of the present invention can be used to treat wastewater by allowing the wastewater to pass into the tank, through the floating filter medium and out of the effluent outlet. The gas inlet(s) with flow rate y are used to aerate the wastewater in order that the micro-organisms which grow on the floating filter medium can work in an efficient manner.

The floating filter medium is unclogged by backwashing in an upward direction. In other words, contrary to the known systems both the air from the gas inlet(s) with a flow rate of x and the liquid used in the backwashing process travel in an upward direction. The liquid used in the backwashing process can be untreated wastewater.

An advantageous feature of the present invention is that the gas inlet(s) with a flow rate of y do not need to be switched off during the backwashing process such that there is less down time during the backwashing process. In this connection, the flow rate of y is not sufficient to disrupt the medium and therefore the gas inlet(s) with a flow rate of y can still be running while the medium is repacking.

In addition, there is no need to use treated effluent in the backwash process which increases the efficiency of the treatment process.

In preferred embodiments flow rate y is up to substantially 350 ls^{-1}. This flow rate ensures that the wastewater is sufficiently aerated without disrupting the floating filter medium.

Preferably the at least one gas inlet with flow rate y is a diffuser. The use of a diffuser ensures that a significant portion of the wastewater is aerated at a flow rate which does not disrupt the floating filter medium.

In preferred embodiments, the flow rate x is up to substantially 700 ls^{-1}. This flow rate ensures that the floating filter medium is sufficiently disrupted during backwashing.

Conveniently the at least one gas inlet with flow rate x is a sparge pipe. The sparge pipe ensures that a high volume of gas disrupts the floating filter medium.

Preferably the gas is air.

Air contains the ideal amount of oxygen to ensure the micro-organisms flourish and are able to treat the wastewater. In addition, air is inexpensive.

Preferably the at least one gas inlet with flow rate x and/or the at least one gas inlet with flow rate y is provided below the floating filter media. In this connection, the wastewater

will be efficiently aerated and there is effective disruption of the floating filter medium.

Conveniently, in use, the wastewater inlet is provided below the gas inlets.

Accordingly, the wastewater flowing into the tank will flow past the gas inlets thereby ensuring that the wastewater is efficiently aerated.

In preferred embodiments, in use, the effluent outlet is provided above the floating filter medium and below the backwash outlet.

This ensures that the wastewater is sufficiently treated before flowing as effluent out of the outlet and there is no need to have the ability to close the backwash outlet because the effluent, which is clean wastewater, flows out of the tank before reaching the backwash outlet. In embodiments where the backwash outlet is provided below or at the same height in the tank as the effluent outlet the backwash outlet should be provided with a closure means to ensure that the effluent is not recycled into the wastewater inlet.

Conveniently the density of the floating filter medium is substantially 0.4 to 0.7 kg/m^3, preferably 0.6 kg/m^3.

This density ensures that there is efficient treatment of the wastewater while reducing the likelihood of clogging.

Preferably the floating filter medium comprises at least a major proportion (expressed by volume and/or by weight) of polyvinyl chloride. Further the floating filter medium could

be a mixture of any known filter medium with or without polyvinyl chloride being present.

Most preferably, the floating filter medium consists entirely of polyvinyl chloride.

Polyvinyl chloride particles are an ideal biological filter medium because due in part at least to their specific gravity of approximately 0.60, they are relatively easily disrupted using air during backwash and repack well after backwashing. In addition, the polyvinyl chloride particles typically exhibit surface pitting which provides extra surface area for the micro-organisms to grow upon. This surface pitting can, if desired, be enhanced by processing or treatment of the particles during and/or after manufacture.

The filter media produced from polyvinyl chloride exhibit significantly better solid holding capacities than previous filter media. The solid holding capacity of a medium measures the amount of solid held by the medium at saturation. In this connection, the solid holding capacity of polyvinyl chloride media is considerably greater, by a factor of 100%, than either expanded polystyrene or polyethylene media. As will be appreciated, the higher the solid holding capacity of the filter medium the longer the period of time required between backwashing.

Further, less than 1% of the throughput is required for backwashing the tank of the present invention when the polyvinyl chloride medium is used, which is significantly less than when using the other known media. This is advantageous, as it reduces the time required for backwashing. In addition, treated effluent is not necessary for use in the backwashing

process.

According to a further aspect of the present invention there is provided a method of treating wastewater using a tank as defined above, the method comprising the steps:

a) allowing wastewater to enter the tank through the wastewater inlet;

b) passing gas through at least one gas inlet with flow rate y;

c) allowing the wastewater to flow up the tank past the at least one gas inlet with flow rate y through the floating filter medium and out of the effluent outlet.

This method provides an effective way of treating wastewater.

According to a yet further aspect of the present invention there is provided a method of cleaning the tank according to the present invention, the method comprising the steps:

a) allowing wastewater to enter the tank through the wastewater inlet;

b) passing gas through at least one gas inlet with flow rate x and, optionally, at least one gas inlet with flow rate y;

c) allowing the wastewater to flow up the tank past the said gas inlets through the floating filter medium and out of the backwash outlet; and

d) either recycling the product flowing out of the backwash outlet to the wastewater inlet or disposing thereof.

As set out above, this method of cleaning the floating filter medium results in a shorter down time for the treatment process.

The product that is produced during backwashing is often

heavily contaminated with a high concentration of solids. Accordingly, it is sometimes necessary to dispose of the product rather than recycling it.

According to a further aspect of the present invention there is provided a floating filter medium comprising at least a major proportion (expressed by volume and/or by weight) of polyvinyl chloride particles.

According to a still further aspect of the invention, there is provided a floating filter medium consisting entirely of polyvinyl chloride particles.

Some advantages of using polyvinyl chloride as a medium are set out above.

Preferably the particles have an average diameter of substantially 3 to 4 mm.

These particle sizes provide sufficient surface area for growing the micro-organisms whilst exhibiting a relatively low likelihood of the medium clogging.

The invention will now be described, by way of illustration only, with reference to the following example and the accompanying figure.

Figure 1 shows a tank according to the present invention.

In Figure 1 there is shown a tank 1 with a generally circular horizontal cross-section. A main section 13 of the tank 1 and a bottom section 12 of the tank 1 have a substantially rectangular vertical cross-section.

At the base of the bottom section 12 of the tank there is provided a wastewater inlet 2 and at the top of the main section of the tank there is provided a backwash outlet 9. An effluent outlet 8 is provided, adjacent in height to the backwash outlet but closer to the base of the tank. The effluent outlet 8 is provided with a tap 14 which operates a valve (not shown) such that the outlet can be closed.

Adjacent the junction of the main section 13 with the bottom section 12, there is provided a plurality of air diffusers 4 on a horizontal support 3. The horizontal support is configured to allow wastewater, entering via inlet 2, to flow therethrough.

Above the air diffusers 4 there is provided a perforated bottom plate 5. The perforated plate 5 acts as support deck when the tank is empty and being inspected. On the perforated plate 5 there is placed a sparge pipe 6, which is used during the cleaning process, as will be described later. The holes (not shown) in the sparge pipe point upwards, i.e. towards the top of the main section 13. There is also provided a perforated top plate 10 between the perforated bottom plate 5 and the effluent outlet 8. The perforated top and bottom plates 10 and 5 extend across the entire internal dimensions of the tank 1.

In a space 11 between the perforated top plate 10 and the perforated bottom plate 5 there is provided a biological filter medium 7. The biological filter medium 7 takes up substantially two-thirds of the space 11. The biological filter medium is produced from polyvinyl chloride and has a density of 0.6 kg/m^3. The perforated top and bottom plates

constrain the medium 7 within the space 11 and thus ensure that the biological filter medium 7 does not flow out of the tank or disrupt the air diffusers, whilst permitting wastewater and air to flow therethrough.

In use, wastewater (not shown) flows into the tank 1 through wastewater inlet 2. The wastewater flows upwardly within the bottom section 12 and through the air diffuser support 3 and past the air diffusers 4. The wastewater continues up the tank 1 through the perforated bottom plate 5. Thereafter, the wastewater encounters the biological filter medium 7 within the space 11. Micro-organisms (not shown) which grow on the biological filter medium 7 process the organic and inorganic pollutants in the wastewater thereby cleaning it. Accordingly, as the wastewater passes through the biological filter medium 7 it becomes cleaner and is then known as effluent. The effluent passes through the perforated top plate 10 and finally out of the tank 1 through the effluent outlet 8.

Over time the biological filter medium 7 becomes clogged with solids (not shown). When this happens the solids are dislodged from the biological filter medium 7 in a process known as backwashing. Backwashing involves passing a gas, preferably air, through the sparge pipe 6 at a sufficient rate to disrupt the medium. At this time wastewater is still pumped into the tank and this pushes the solids that have been dislodged towards the top of the main section 13. To prevent the discharge of the heavily contaminated backwash product through outlet 8, the tap 14 is operated to close the outlet 8. The backwash product, containing a high concentration of solids, exits from the outlet 9 for further treatment, or disposal. After the biological filter medium 7 has been

sufficiently disrupted, the air supply to the sparge pipe 6 is switched off and the biological filter medium is allowed to repack. At the appropriate time the tap 14 is actuated to re-open the effluent outlet 8. During the backwashing process the air diffusers 14 can still operate.

It will be understood that the embodiment illustrated shows one application of the invention only, for the purposes of illustration. In practice the invention may be applied to many different configurations, the detailed embodiments being straightforward for those skilled in the art to implement.

As examples only of possible changes that can be made without departing from the scope of the invention:

The biological filter medium could take up any suitable proportion of the space between the bottom and perforated top plates.

The biological filter medium can be any medium known to those skilled in the art, such as polyethylene and expanded polystyrene. The biological filter medium can also be a mixture of media.

The medium can be of any suitable density. For example, a density of 0.9 kg/m^3 is required for polyethylene whereas 0.3 kg/m^3 is required for expanded polystyrene.

The backwash outlet can be placed in any convenient position relative to the tank. However, the backwash outlet may require a closure means if it is disposed at a height lower than that of the effluent outlet.

Claims

1. A wastewater treatment tank comprising a wastewater inlet, at least one gas inlet with a flow rate x, at least one gas inlet with a flow rate y, an effluent outlet, a backwash outlet and floating filter medium wherein the flow rate of x is greater than y and wherein the backwash outlet, in use, is provided above the floating filter medium.

2. A tank according to claim 1 wherein flow rate y is up to substantially 350 ls^{-1}.

3. A tank according to either claim 1 or 2 wherein the at least one gas inlet with flow rate y is a diffuser.

4. A tank according to any preceding claim wherein flow rate x is up to substantially 700 ls^{-1}.

5. A tank according to any preceding claim wherein the at least one gas inlet with flow rate x is a sparge pipe.

6. A tank according to any preceding claim wherein the gas is air.

7. A tank according to any preceding claim wherein the at least one gas inlet with flow rate x is provided below the floating filter media.

8. A tank according to any preceding claim wherein the at least one gas inlet with flow rate y is provided below the floating filter media.

7. A tank according to any preceding claim wherein, in use, the wastewater inlet is provided below the gas inlets.

8. A tank according to any preceding claim wherein, in use, the effluent outlet is provided above the floating filter medium and below the backwash outlet.

9. A tank according to any preceding claim wherein the density of the floating filter medium is substantially 0.4 to 0.7 kg/m^3.

10. A tank according to any preceding claim wherein the density of the floating filter medium is substantially 0.6 kg/m^3.

11. A tank according to any preceding claim wherein at least a major proportion of the floating filter medium, expressed by volume and/or by weight, comprises polyvinyl chloride.

12. A tank according to claim 11 wherein the floating filter medium consists entirely of polyvinyl chloride.

13. A method of treating wastewater using the tank according to any preceding claim, the method comprising the steps:

a) passing wastewater into the tank through the wastewater inlet;

b) passing gas through at least one gas inlet with flow rate y;

c) allowing the wastewater to flow up the tank past the at least one gas inlet with flow rate y through the floating filter medium and out of the effluent outlet.

14. A method of cleaning the tank according to claims 1 to 12, the method comprising the steps:

a) passing wastewater into the tank through the wastewater inlet;

b) passing gas through at least one gas inlet with flow rate x and, optionally, at least one gas inlet with flow rate y;

c) allowing the wastewater to flow up the tank past the gas inlets through the floating filter medium and out of the backwash outlet; and

d) either recycling the product flowing out of the backwash outlet to the wastewater inlet or disposing thereof.

15. A floating filter medium comprising at least a major proportion, by volume and/or by weight, of polyvinyl chloride particles.

16. A floating filter medium consisting entirely of polyvinyl chloride particles.

17. A floating filter media according to either claim 15 or 16 wherein the particles have an average diameter of substantially 3 to 4mm.

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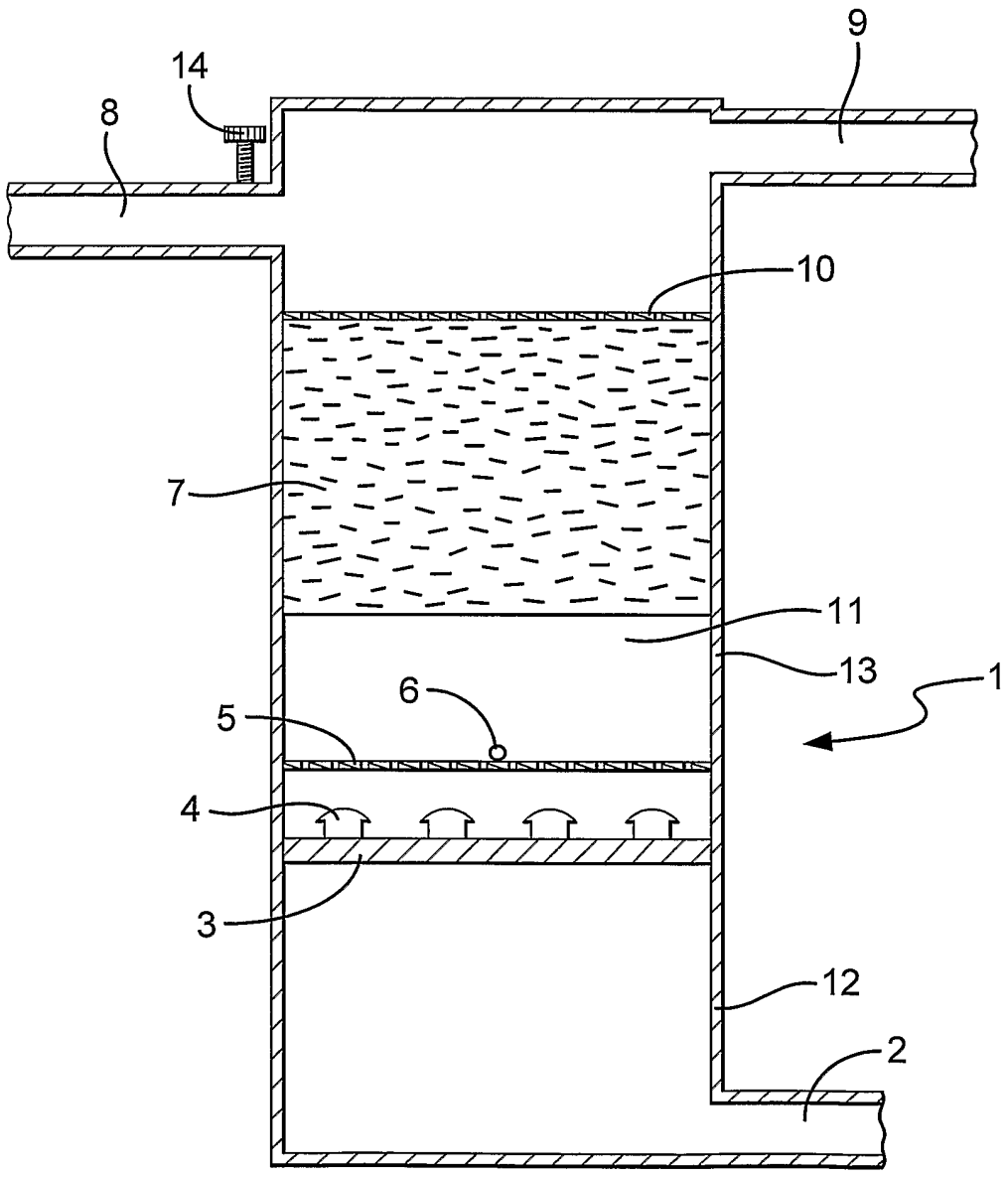

Fig. 1

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C02F3/06 C02F3/10 C02F3/08

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)
IPC 7 C02F

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 practical, search terms used)
EPO-Internal, PAJ, 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 Y	GB 1 406 255 A (TYMOSZCZUK J) 17 September 1975 (1975-09-17) page 1, right-hand column, line 70,71,83-90 page 2, left-hand column, line 20-25,49-64 page 2, right-hand column, line 67-75,87-102,119-122 page 3, left-hand column, line 54-63 page 3, right-hand column, line 115-129 page 4, left-hand column, line 1-27; claims 1,2,4,5,12-21; figures 1-9 --- -/--	1,3,5-9, 15,16 11-14

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"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 when the document is taken alone

"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

Date of the actual completion of the international search	Date of mailing of the international search report
29 October 2003	06/11/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Kurtulan, M

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Internatic plication No
PCT/GB 03/02883

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1 333 585 A (TYMOSZCZUK J) 10 October 1973 (1973-10-10) page 1, left-hand column, line 41 -page 1, right-hand column, line 61 page 1, right-hand column, line 65-71,87-93 page 2, left-hand column, line 10-24 page 2, right-hand column, line 86-98,107-109; claim 1; figures 1-4	1,3,5-9, 15,16
X	GB 1 439 401 A (EXXON RESEARCH ENGINEERING CO) 16 June 1976 (1976-06-16) page 1, left-hand column, paragraph 3 page 2, left-hand column, line 32-43,50-60 page 2, right-hand column, line 87-97,102-111,128-130 page 3, left-hand column, line 35-41 page 3, right-hand column, line 67-71,78-88,122-130 page 4, right-hand column, line 93-102,110-121 page 5, left-hand column, line 51-65; claims 1-4,9,10; figure 1; examples 3,6	15,16
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INTERNATIONAL SEARCH REPORT

Inter...al application No.
PCT/GB 03/02883

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 2,4
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 2,4

Please note that the numbering of the claims has been corrected to 1-19 instead of 1-8. 7, 8, 9-17 as erroneously employed in the originally filed version.

As explained below, some of the features in the apparatus claims 2 and 4 relate to a method of using the apparatus rather than clearly defining the apparatus in terms of its technical features. The intended limitations are therefore not clear from this claim, contrary to the requirements of Article 6 PCT: the feature "flow rate y is up to substantially 350 l/s" in claim 2 and the feature "the flow rate x is up to 700 l/s" in claim 4 refer to the use of the apparatus and not to the apparatus features themselves. Hence these claims are not acceptable under Article 6 PCT and are not searchable.

The terms "with a flow rate x", "with a flow rate y" and "the flow rate of x is greater than y" in claim 1 are not clear and they are not searchable.

Likewise the term "with a flow rate x" in claims 5, 7 and 16 and the term "with a flow rate y" in claims 3, 8, 15 and 16 are not searchable.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

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