



(72) VAN LITH, CHRISTIANUS PETRUS MARIA, NL

(71) MONSANTO EUROPE S.A., BE

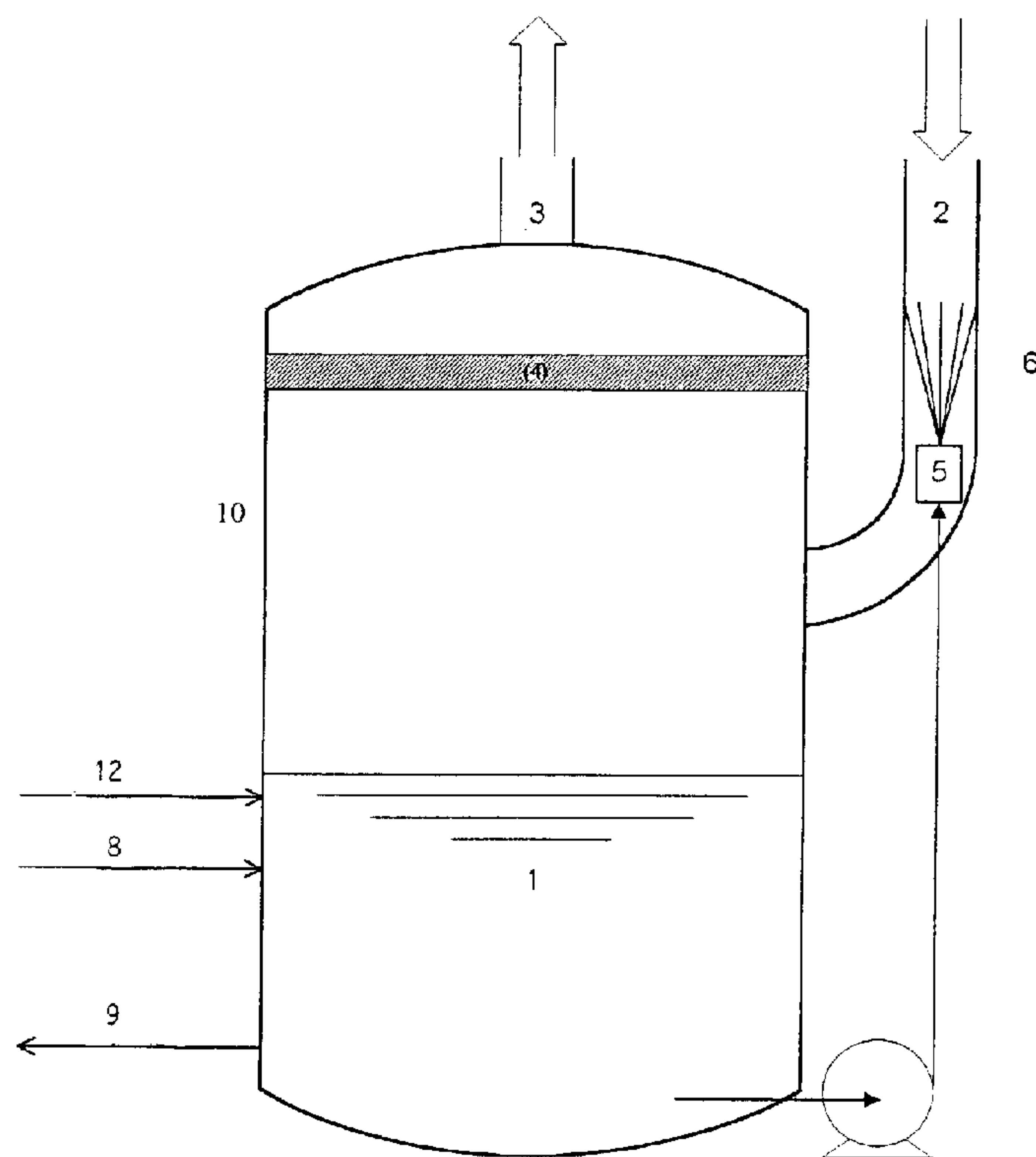
(51) Int.Cl.<sup>7</sup> B01D 53/84, C12S 5/00

(30) 1999/06/06 (99870122.1) EP

(54) **METHODE AMELIOREE POUR LE NETTOYAGE**

**BIOLOGIQUE DE CIRCUITS DE GAZ CONTAMINES**

(54) **IMPROVED METHOD OF BIOLOGICAL CLEANING OF  
CONTAMINATED GAS FLOW**



(57) The invention relates to a method for biological cleaning of a gas flow containing gaseous and/or particulate contaminants comprising the steps of contacting the contaminated gas flow counter-currently with a jet of suitable microorganisms containing scrubbing liquid in order to enhance absorption of gaseous and particulate contaminants in the said scrubbing liquid; recovering the scrubbing liquid in a vessel; and draining part of said scrubbing liquid off said vessel and compensating said drained part with fresh liquid. The method is carried out in a reversed jet scrubber and does not use any packing material for support to the microorganisms.

Abstract

The invention relates to a method for biological cleaning of a gas flow containing gaseous and/or particulate contaminants comprising the steps of contacting the  
5 contaminated gas flow counter-currently with a jet of suitable microorganisms containing scrubbing liquid in order to enhance absorption of gaseous and particulate contaminants in the said scrubbing liquid; recovering the scrubbing liquid in a vessel; and draining part of said scrubbing liquid off said vessel and compensating said drained  
10 part with fresh liquid. The method is carried out in a reversed jet scrubber and does not use any packing material for support to the microorganisms.

FIG. 1

15

## Improved Method for biological cleaning of contaminated gas flow

The present invention relates to an improved method for biological cleaning of a  
5 contaminated gas flow, more particularly a contaminated gas flow containing gaseous  
and/or particulate contaminants.

In recent years, biological filtration is increasingly used for cleaning gas streams  
originating from various industrial activities like production processes, waste water  
10 transport, waste water treatment and others.

In biological methods, the removal of undesirable components from a gas or a liquid  
takes place by activity of microorganisms.

15 In biological gas treatment systems, mesophilic microorganisms are normally used.  
Mesophilic microorganisms grow in the temperature range of from approximately 10°C  
to 40°C. Thermophilic microorganisms, which grow in the temperature range of from  
40°C to 70°C, may also be used, but until now no effective commercial applications in  
the gas treatment are available; current reactor designs are not suitable because of the  
20 high growth rate of the thermophilic microorganisms or require an expensive multiple  
stage design.

Known biological gas purification systems comprise biofilters wherein the  
microorganisms grow on a mostly wet organic packing material. The contaminants  
25 from the gas are absorbed by the biofilm, which is water with microorganisms  
adsorbed on the mostly organic material.

The contaminants are essentially oxidized to carbon dioxide and water. Due to nutrient  
and/or space limitations in the matrix, no significant excess of additional biomass is  
formed, and the actual purification process by biological degradation of contaminants  
30 is limited resulting in a reduced oxidation capacity. A biofilter is not suitable for  
thermophilic microorganisms, since these are capable of degrading the organic packing

material, leading to replacement of the packing material. The packing material is generally kept wet by a saturated gas flow and/or occasional spraying; a biofilter does not make use of a permanent liquid flow. The gas purification method making use of biofilters mostly is at least a two-stage process: first the gases are pretreated,  
5 particulate contaminants which may clog the matrix or packing material are removed, the pretreated contaminated gas is saturated with water, and finally treated in the actual biofilter. In this respect, reference is made to EP-0 142 872 and related prior art.

Another known biological gas purification system comprises so-called biotrickling  
10 filters (BTF). In the case of a BTF the microorganisms grow on a packing material in the form of a biofilm. The contaminants from the gas are absorbed into the liquid that drips along the biofilm and diffuse into the biofilm where they are degraded by the microorganisms. The microorganisms and the degradation products such as water, carbon dioxide and occasionally mineral salts or acids are relinquished to the liquid.  
15 This liquid will moreover contain nutrients for the microorganisms in addition to acid or alkali to buffer the liquid to a neutral pH. Excessive growth of the biofilm can result in an increased pressure drop over the BTF and ultimately even lead to blocking of the BTF. Several mechanical or chemical procedures are applied to remove at least a part of the biofilm. Also methods are used to limit the growth of the microorganisms  
20 beforehand. Reference is made to WO94/26392 and related prior art. These methods, however, generally reduce the effectiveness of the BTF. A BTF is not suitable for thermophilic microorganisms, as the high growth rate will further increase the clogging problems described previously. Similarly to the biofilter, the BTF often is a two-stage process: particulate contaminants which are present in the contaminated gas flow and  
25 which may clog the matrix need to be removed before the gas flow enters the BTF.

Yet another known biological gas treatment system comprises a biological scrubber. In this case, the gas contaminants are first absorbed in a scrubbing liquid (absorption stage), generally in a packed bed. The liquid having absorbed therein part at least of  
30 the contaminants from the gas flow is collected in a tank from which it is recycled to the absorption stage. In order to keep the concentration of the contaminants in the liquid below their saturation level, part of the liquid is passed over a separate water treatment plant (treatment stage). Preferably, the absorption stage should remain free

from microorganisms in order to enhance the transfer of the contaminants and prevent clogging problems. In the treatment stage the contaminants are partially transformed into biomass (microorganisms) and partially into water and carbon dioxide. The excess biomass needs to be removed from the system, more particularly from the scrubbing liquid, to a large extent before such scrubbing liquid is returned to the adsorption stage. When particulate contaminants are present in the gas flow, it is preferable to use a Venturi scrubber in order to best remove such particulate contaminants. In a Venturi scrubber, the contaminants containing gas is accelerated or injected into the liquid; but like most other known technologies to remove particulate contaminants from a gas flow, a Venturi scrubber has poor absorption capability for contaminants. For this reason the removal of particulate materials mostly is effected in a separate step upstream of the packed bed absorption column. This makes the bioscrubber a complex and expensive three-stage system.

15 A common problem to all three types of known systems is that the packed beds or columns used for the biological treatment easily clog due to the increase of biomass and, in the case of the presence of particulate contaminants, due to such particulate contaminants.

20 US-3,803,805 discloses counter-current jet scrubbers that are particularly suitable for effective separation of particulate and gaseous contaminants from gas flows. Such a reactor comprises a vessel with a water sump filled with a liquid (mostly water with additives), a first gas duct running vertically into the said vessel and a second gas duct running out of the reactor to release gas from the reactor. The liquid is pumped from the sump to a nozzle which is located in the said first gas duct and which directs the water flow counter-currently to the gas flowing vertically downwards into the vessel. In the zone where gas and liquid collide, a froth-zone forms which enhances the intensive mixing and transfer of contaminants from the gas flow to the liquid. The particulate contaminants are removed from the reactor vessel by draining part of the liquid. The gaseous contaminants may be removed in the same way or by chemical oxidation. In case of chemical oxidation an oxidizing agent, e.g. oxygen or hydrogen peroxide, is added to the liquid and the reaction products are removed from the system with the particulate contaminants.

The object of the present invention is to provide a method for biological purification of a gas flow which does not show the disadvantages of the known methods.

5 More particularly, the object of the invention is to provide a method for biological purification of a gas flow wherein a suitable quantity of relevant microorganisms grow under maximum growth conditions ( which can be both, mesophilic and thermophilic) and which allows for the removal of particulate and gaseous contaminants from the gas flow to a large extend, in a single reactor.

10

The invention consists in a method for the purification of a contaminated gas flow containing gaseous and particulate contaminants comprising the steps of

- 15 ■ contacting the contaminated gas flow counter-currently with a jet of suitable microorganisms containing scrubbing liquid in order to enhance absorption of gaseous and particulate contaminants in the said scrubbing liquid;
- recovering the scrubbing liquid in a vessel; and
- draining part of said scrubbing liquid off said vessel and compensating said drained part with fresh liquid.

20 The liquid with the microorganisms (sludge) is recycled over the reversed jet to the sump, where the biological oxidation takes place. Particulate contaminants from the gas flow are also transferred to the liquid and are mixed with the microorganisms.

The microorganisms are advantageously freely dispersed in the scrubbing liquid.

25

In a preferred embodiment of the invention, the process is carried out in a reverse jet scrubber reactor of the type disclosed US-3,803,805 which comprises a vessel with a water sump filled with a liquid (mostly water with additives), a first gas duct running vertically into the said vessel and a second gas duct running out of the reactor to  
30 release the gas flow again from the reactor, and a nozzle arranged in the said first gas duct for direction of water flow counter-currently to the gas flowing vertically downwards into the vessel, hence generating a froth-zone which enhances the intensive mixing and transfer of contaminants from the gas flow to the liquid. The reactor design

allows for a high solids concentration in the liquid flow, a high microorganism concentration and a high particulate concentration may be applied. This results in a very biological active liquid and a very low wastewater stream.

- 5 Surprisingly, the process of the invention allows for an efficient purification of a contaminated gas flow which contains gaseous and particulate contaminants and allows for a biological treatment of the absorbed contaminants by appropriate microorganisms. Contrary to the skilled person's expectations, the microorganisms are not significantly destroyed in the course of the absorption process and may pursue their  
10 activity in the vessel collecting the scrubbing liquid.

As will easily be understood by those skilled in the art, the process of the present invention allows for all duties effected by a biological scrubber to be performed simultaneously in one single reactor.

- 15 1. Gas cleaning by absorption of gaseous contaminants in the scrubbing liquid. The reverse jet scrubber brings the gas in intimate contact with the liquid. By varying the gas/liquid ratio and the number of jets in series the transfer with an adequate efficiency can easily be controlled.
- 20 2. Transferring the contaminants to the microorganisms. By recycling large quantities of liquid over the reactor and the thorough mixing in the froth-zone, the microorganisms are brought in intimate contact with the contaminants.
- 25 3. Unrestricted growth of the microorganisms. The microorganisms are freely dispersed in the liquid. Nutrients may be added to the sump of the reactor and the carbon source may be available from the contaminated gas flow. The scrubber is capable of handling high solid concentrations, so high biomass concentrations are acceptable without the danger of clogging. The reactor has no internals, which may clog; the nozzles may be arranged with a bore sufficiently large to avoid clogging while allowing  
30 suitable liquid flow. The use of thermophilic microorganisms is possible, as the high growth rates and the associated high biomass formation rates do not pose a problem.

4. Oxygen requirement for biological oxidation.

For biological oxidation oxygen is required. All or a part of the required oxygen is transferred from the gas to the liquid in the reverse jet froth-zone. A reverse jet scrubber uses a high liquid to gas ratio, so that relative much oxygen is transferred to the water. In case more oxygen is required for the biological reaction, the additional oxygen may be injected in the vessel.

5. Biomass concentration and removal of excess sludge.

The scrubbing liquid is recycled over the reverse jet. Part of the water is evaporated in the froth-zone. Fresh water will be added to maintain a suitable water level in the reactor vessel. To remove the scrubbed particulate contaminants and the excess biomass a small liquid flow is bled from the reactor vessel. The lower the liquid flow, the higher the concentration of particulate contaminants and biomass will be in the reactor vessel. The concentration of microorganisms determines the oxidation capacity of the system. The reverse jet design allows for very high solids concentration, so the biological oxidation capacity can be maximized and the wastewater flow can be minimized simultaneously.

The reactor consists of one vessel with a reversed jet froth-zone. Nutrients, fresh water and/or other additives may be added directly to the vessel. The biomass concentration is controlled by the drain water bleed from the vessel. The gas to liquid ratio in the froth-zone controls the gas contaminant removal, which can be set independently. The whole system contains only a minimal number of serviceable parts and is very robust.

The invention is described hereinafter in more detail by way of examples with reference to Figure 1. Figure 1 is a schematic representation of a reverse jet scrubbing reactor used in accordance with the invention.

Example 1

A gas flow from a particle board operation containing formaldehyde (30-80mg/m<sup>3</sup> at 0°C and dry stage) and wood particles (25-50mg/m<sup>3</sup> at 0°C and dry stage) has been treated in a reversed jet scrubber reactor as per the invention.

The test reactor (10) comprised a water sump (1) of 800 l filled with water, a gas duct (2) having a diameter of about 100mm running vertically into the said reactor and a second gas duct (3) having a diameter of about 400mm running out of the reactor to  
5 release the gas flow again from the reactor. A demister (4) was arranged in the said second gas duct (3) in order to remove water droplets. The liquid was pumped from the sump (1) to a nozzle (5) having a diameter of about 10mm arranged in the vertical inlet duct (2) such as to direct the water flow vertically up counter-currently to the gas flow, which in turn flows vertically downwards. A froth-zone (6) of 0,5m was formed  
10 in the duct (2) where the gas and the scrubbing liquid collide.

Approximately 500-1000m<sup>3</sup>/h at m<sup>3</sup> (at 0°C and dry stage) of gas were passed through the reactor. The dry bulb temperature of the gas flow was approximately 70°C and the wet bulb temperature approximately 60°C.

15 Approximately 15m<sup>3</sup>/h water were recycled over the reverse jet nozzle and the equilibrium temperature of the water was about 60°C. During the test adequate quantities of nutrients (urea and phosphoric acid) were added (8) to the water. Approximately 12l/h were drained (9) from the sump and tap water was added (12) to keep the water level in the sump.

20 Formaldehyde was removed with an efficiency of between 75% and 90%, with outlet gas concentrations comprised between 5 and 10mg/m<sup>3</sup> (at 0°C and dry stage). The wood fibers were removed with an efficiency of about 85% to 95%. The solids concentration in the sump was approximately 2g/l of which approximately 20% was  
25 biomass. The formaldehyde concentration in the sump varied between 0.5mg/l and 5 mg/l.

The above process ran stable for more than a month at temperatures, which varied between 45°C and 65°C due to variations in the conditions of the gas flow. The  
30 biomass (microorganisms) concentration was maintained by adjusting the drain water flow. No blockage of any kind was observed during the operation.

Example 2

An artificial gas flow containing  $350\text{mg}/\text{m}^3$  (at  $0^\circ\text{C}$  and dry stage) of methanol was treated in a reactor similar to the one used in Example 1, in accordance with the  
5 invention.

Approximately  $500\text{m}^3/\text{h}$   $\text{m}^3$  (at  $0^\circ\text{C}$  and dry stage) of gas were passed through the reactor. The dry bulb temperature of the gas flow was  $25^\circ\text{C}$  and the wet bulb temperature  $18^\circ\text{C}$ . Approximately  $20\text{m}^3/\text{h}$  water were recycled over the reverse jet  
10 nozzle and the equilibrium temperature of the water was  $18^\circ\text{C}$ . During the test adequate quantities of nutrients (urea and phosphoric acid) were added to the water. Approximately  $2\text{l}/\text{h}$  were drained from the sump; tap water was added to keep the water level in the sump.

15 The removal efficiency of the methanol varied between 75% and 85% with outlet gas concentrations between  $50\text{-}90\text{mg}/\text{m}^3$  (at  $0^\circ\text{C}$  and dry stage). The biomass concentration in the sump was approximately  $35\text{g}/\text{l}$ . The methanol concentration in the sump was approximately  $2\text{mg}/\text{l}$ .

20 The above process was stable for one month at ambient temperatures. The biomass (microorganisms) concentration was maintained by adjusting the drain water flow. No blockage of any kind was observed during the operation.

**CLAIMS:**

1. Method for the purification of a contaminated gas flow containing gaseous and/or particulate contaminants comprising the steps of
  - 5 ■ contacting the contaminated gas flow counter-currently with a jet of suitable microorganisms containing scrubbing liquid in order to enhance absorption of gaseous and particulate contaminants in the said scrubbing liquid;
  - recovering the scrubbing liquid in a vessel; and
  - 10 ■ draining part of said scrubbing liquid off said vessel and compensating said drained part with fresh liquid.
2. Method according to Claim 1 wherein the purification is carried out in a reverse jet scrubber reactor which comprises a vessel with a water sump filled with a liquid, a first gas duct running vertically into the said vessel and a second gas duct running out of the  
15 reactor to release the gas flow again from the reactor, and a nozzle arranged in the said first gas duct for direction of water flow counter-currently to the gas flowing vertically downwards into the vessel, hence generating a froth-zone which enhances the intensive mixing and transfer of contaminants from the gas flow to the liquid.
- 20 3. Method according to any of Claims 1 or 2 wherein the microorganisms are freely dispersed in the scrubbing liquid.
4. Method according to any of the preceding Claims wherein the liquid is water.
- 25 5. Method according to any of the preceding Claims, wherein the biomass concentration is controlled by adjusting the drain water quantity from the reactor vessel.
6. Method according to any of the preceding Claims, wherein thermophilic  
30 microorganisms are used for the oxidation of the contaminants.
7. Method according to Claim 6, wherein the operating temperature of the scrubbing liquid lies between 40C and 70C.

8. Method according to any of the preceding Claims wherein nutrients suitable for the microorganisms are added to the scrubbing liquid.
9. Method according to any of the preceding Claims wherein oxygen is added into the  
5 reactor vessel.
10. Method according to any of the preceding Claims, wherein the liquid to gas ratio in the nozzle is between 8 and 40.
- 10 11. Method according to any of the preceding Claims, wherein the nozzle(s) show(s) openings having a diameter of less than 10mm, preferably less than 30 mm, more particularly less than 50 mm.

Fetherstonhaugh & Co.  
Ottawa, Canada  
Patent Agents

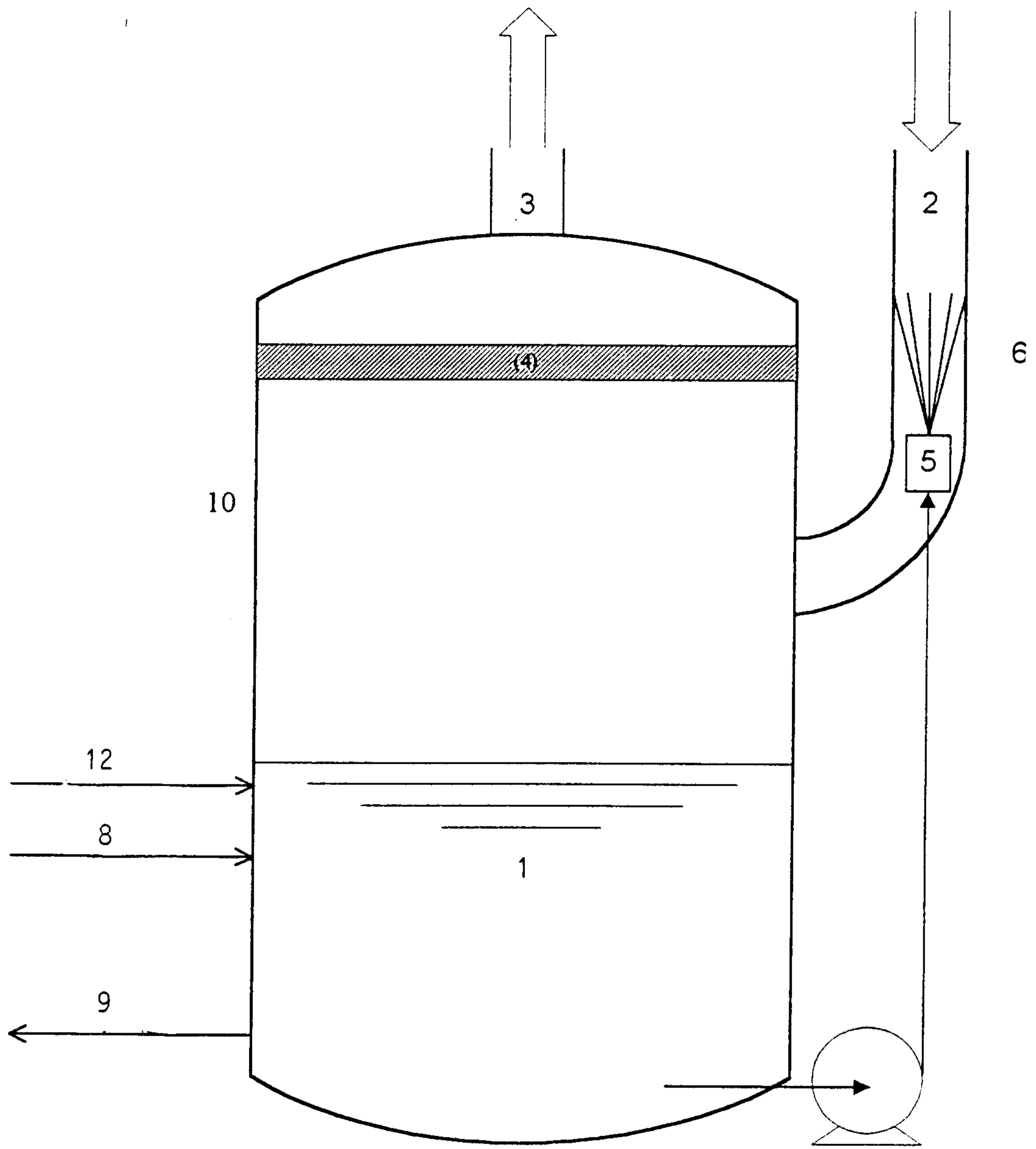


FIG. 1

