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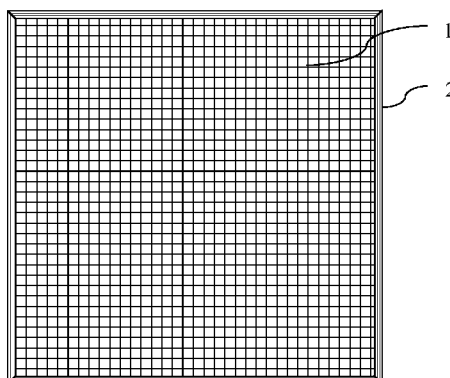
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(54) Title: METHOD AND APPARATUS FOR CLEANING AIR OR GAS FROM UNDESIRE COMPONENTS

Fig. 1



(57) Abstract: Method for cleaning air or gas from undesired components, comprising the steps of: providing a porous material, in which the pores are coated with an absorbing liquid film having affinity to the undesired components, and forcing the air or gas to be cleaned through the pores coated with the absorbing liquid film, thereby promoting the absorption of the undesired components in the absorbing liquid film. And apparatus comprising a housing containing a porous material (1), in which the pores are coated with an absorbing liquid film having affinity to the undesired components, an inlet for air or gas containing the undesired components, an outlet for ejecting cleaned air or gas, and means for providing a flow of the air or gas containing the undesired components from the inlet, through the pores coated with the absorbing liquid film to the outlet.



## METHOD AND APPARATUS FOR CLEANING AIR OR GAS FROM UNDESIRE D COMPONENTS

**Field of the invention**

The present invention relates to a method and an apparatus for  
5 cleaning air or gas for undesired components.

**Background**

Cotton air filters moistened with oil has since the 60'ties been used  
to provide clean air to motors. The purpose of these air intake filters is to  
10 remove dust or small particles contained in the air.

US 2007175192 describes air intake filters consisting of an in- and  
outflow (cotton) mesh, a synthetic foam filter region, and a natural fiber filter  
media region made of cotton fibers. The purpose of the cotton filter is to re-  
move a second portion of particles from the air. The cotton filter may be  
15 treated with oil (mineral oil, engine oil or other suitable tacking oils). It is de-  
scribed that lipophilic cotton fibers absorb oil and that it is desirable to mere-  
ly wet, and not soak, the filter with oil, as oil soaking will completely fill the  
interstices between the fabric threads with oil and thereby increase re-  
sistance to airflow.

20 Sundahl et al, J. Environ Monit, 1999, 1, 383-387 describes a meth-  
od to determine PCB concentrations in air, wherein a XAD-2 polymeric ab-  
sorbent (hydrophobic cross linked polystyrene copolymer resin)  
is used. It appears that XAD-2 is used in national industry standards to de-  
termine the concentration of PCB in air.

25 US2006243134 describes a filter unit for removing gaseous sub-  
stances, foul-smelling substances, and toxic substances like PCB. The filter  
unit is supported on materials made of textile (woven or knitted fabrics) and  
may be used in ventilation plants, ventilation systems, air-conditioning sys-  
tems, or the like. The filter unit contains granulated activated carbon which  
30 removes the unwanted substances. According to the application a nonspe-  
cific adsorption characteristic of the filter unit makes it suitable for the ad-  
sorption of any harmful, toxic, and smelling substances.

US 7759274 describes a catalytic unit consisting of catalytically ac-

tive polymers supported on materials made of textile (woven or knitted fabrics). The kind of textile is not specified further. The active polymers provides for an adequate adsorptive capacity. The unit may be used for the treatment of e.g. air to create clean air or a better indoor atmosphere, and is useful for  
5 producing high-purity air or for removing gas, odorant or poisonous entities from air or gas streams, in venting installations, air conditioners or the like. PCB is mentioned as a noxious agent in contaminated rooms, which would be relevant to remove.

EP1528385 (Miura Kogyo KK) describes a filter for the removal of  
10 various chlorinated organic compounds contained in a gaseous state, e.g. PCB from incineration facilities. The fibrous material comprises of fibrous material such as glass fiber, alumina fiber and silica fiber, an inorganic binder, and a hydrophobic material. The hydrophobic material may be activated carbon, graphite or styrene-divinylbenzene, which has a higher hydrophobicity than the fibrous material. The chlorinated organic compounds are captured by the fibers as well as on the hydrophobic material.  
15

WO2013173547 (NASA) describes a method for removal of halogenated compounds (PCB) in sediment and soil. The halogenated compounds permeate into a polymer blanket consisting of a hollow interior,  
20 wherein the halogenated compounds are solubilised in a non-polar solvent. The polymer blanket may be made of various amphophilic polymers and copolymers due to their affinity and ability to transport PCBs into the hollow interior. The non-polar solvent is preferable an alcohol.

US5242598 (Envirogen Inc.) relates to the removal hydrophobic  
25 contaminants (PCB) from particulate matters (soil) wherein the contaminants are adhered to a solid organic phase, which may be a polymeric foam made of polyurethane, polystyrene or polyethylene.

A need exist in the prior art to provide a method for simple extraction of harmful chemical or particulate substances from air or gas, in particular  
30 air in which humans or animals breath. Furthermore, the method should provide the possibility of easy removal of the undesired components extracted from the air or gas

### Summary of the invention

The present invention relates to a method for cleaning air or gas for undesired components, comprising the steps of:

- 5           a.     Providing a porous material, in which the pores are coated with an absorbing liquid film having affinity to the undesired components, and
- b.     Forcing the air or gas to be cleaned through the pores coated with the absorbing liquid film, thereby promoting the absorption of the undesired components in the absorbing liquid film.

10           According to the present invention the porous material provides a structural support, which partly or entirely is covered by a liquid suitable for absorbing the undesired components. The absorbing liquid forms a film on the porous support, including the individual pores of the porous material. When a gas or air to be cleaned is forced through the pores a material transfer will happen, in which substances or particles in the air or gas is transferred to the absorbing liquid film.

15

The amount of absorbing liquid film should be sufficient for ensuring an effective transport of the undesired substances to the absorbing liquid. However, the amount of absorbing liquid should not be used in excess because it could occlude the pores of the porous material. Nevertheless, if a large amount of absorbing liquid is used coated pores in the porous material could be formed by applying a higher pressure on the air or gas to be cleaned. During operation, the layer of absorbing liquid film is usually in the range of 1 nm to 1 mm and preferably 10 nm to 100  $\mu\text{m}$ .

25           The absorbing liquid may easily be replenished if needed by supplying a fresh absorbing liquid. Spent absorbing liquid may be reused after at least partly removal of the undesired components or the spent absorbing liquid may be discarded or burned. Depending on the type of porous material used the absorbing liquid and the discarded together or the porous material may be treated by suitable solvents or surfactants to remove the absorbing liquid. In the latter situation the porous material may be reused and only

30

the absorbing liquid has to be disposed of.

The porous material may be selected from a variety of sources as long as it provides the structural support for the absorbing liquid film. Suitable examples of a porous material include a fabric, mesh, paper, or polymer. It is important that the porous material provides suitable pores for the passing of the gas or air to be cleaned. Small pores generally provides a high flow resistance but on the other hand offers a high degree of exchange of components, which favors the transport of undesired components from the gas or air to the absorbing liquid film. To ensure a sufficient flow rate, the pore diameter is usually selected to be 1  $\mu\text{m}$  or more, such as 10  $\mu\text{m}$  or more.

Larger pores provide for a higher flow rate but a lower tendency of absorption of the undesired components. Generally, it is desired to have a pore diameter of 10  $\mu\text{m}$  or less, such as 1  $\mu\text{m}$  or less.

While the porous material may be sufficient for supporting the absorbing liquid film in some applications, it is an advantage in other embodiments that the porous material is supported by a frame. A frame may be used if the filter is used for a disposable cassette. After use of a framed filter it may be disposed of and a fresh framed filter may be inserted in the filtering device.

The absorbing liquid is selected in accordance with the undesired components to be partly or entirely removed from the air or gas to be cleaned. As an example, a lipophilic absorbing liquid is selected when the undesired component is of a lipophilic nature. Absorbing liquids of a lipophilic nature are also known as non-polar solvents. According to the present invention, the preferred lipophilic absorbing liquids have boiling points at ambient pressure of 100°C or above and usually the boiling point is of 200°C or above. The Hansen solubility parameters (HSPs) of suitable lipophilic absorbing liquids has  $\delta\text{P}$  (polarity) values which suitably is less than 3  $\text{MPa}^{1/2}$ , such as less than 2  $\text{MPa}^{1/2}$  and preferably less than 1  $\text{MPa}^{1/2}$  and  $\delta\text{H}$  (hydrogen bonding) values less than 6  $\text{MPa}^{1/2}$ , such as less than 5  $\text{MPa}^{1/2}$ , 4  $\text{MPa}^{1/2}$ , 3  $\text{MPa}^{1/2}$ , or 2  $\text{MPa}^{1/2}$ , and even more preferred less than 1  $\text{MPa}^{1/2}$ .

As specific examples, the absorbing liquid may be selected as mineral, vegetable, or synthetic oils. Mineral oils include aliphatic oils, aromatic oils, and mixtures thereof. Such absorbing liquids are suitably for removal of lipophilic components like polychlorinated biphenyl (PCB) compounds from gas or air. A preferred vegetable oil is a non-curing vegetable oil. Vegetable oil for removing PCB has been shown to be effective. After use the spent vegetable oil may be safely disposed of by burning under controlled conditions. Polychlorinated biphenyls includes a total of 209 configurations of a biphenyl core structure having 1 to 10 chlorine atoms attached. Specific examples of PCB's include monochlorobiphenyl, dichlorobiphenyl, trichlorobiphenyl, tetrachlorobiphenyl, pentachlorobiphenyl, hexachlorobiphenyl, heptachlorobiphenyl, octachlorobiphenyl, nonachlorobiphenyl, and decachlorobiphenyl.

Previously, PCB was widely used as dielectric fluid, coolant fluid, flame retardant, and plasticizer in polyvinylchloride (PVC), paints and cements. As a consequence, buildings are contaminated with PCB, which may be cleaned using the present invention.

In other applications of the present method it may be desired to remove  $\text{NH}_3$  from stables for pigs, hens, mink, etc. A weak acidic aqueous solution may be used as the absorbing liquid.

In certain situations it is desired to remove particulate substances like microorganisms, such as bacteria, fungi, vira, etc. Since microorganisms are generally soluble in water, the absorption liquid is generally selected as an aqueous liquid. Examples of microorganisms, which are undesired in air, include MRSA, E. coli, Staphylococcus aureus, Listeria, etc. Further substances it is desired to remove from air include tar particles from combustion in engines, wood burning stoves, oil burners, etc. Tar particles can be extracted by using a lipophilic absorption liquid.

According to the invention, the filter composed of the porous material coated with the absorbing liquid may be prepared for single use, multiple or continuous use. Single use is generally applied in minor applications like face masks, whereas continuous use of the filter may be applied in industrial

settings. In an embodiment, fresh absorbing liquid is provided to the pores of the porous material continuously or intermittently. The fresh absorbing liquid film may be provided to the pores of the porous material in a number of ways. Spraying is generally preferred to obtain an even application of the  
5 absorbing liquid on the porous material.

When fresh absorbing liquid is applied to the filter the spent absorbing liquid is usually collected in a suitable container. The spent absorbing liquid may be reused for a number of times until the concentration of the undesired component has reached a certain threshold.

10 To pass the gas or air to be cleaned through the pores coated with the absorption liquid a fan is generally used. The fan either blows or sucks the air or gas through the pores. The blowing or suction power is generally sufficient to force an amount of air through the pores for efficient extraction of the undesired components. In some embodiments of the present inven-  
15 tion the air or gas is forced through the coated pores by breathing. The use of breathing for forcing gas or air through the porous material is usually used in personal protective equipment like a face respirator mask.

The ability to absorb undesired components may be improved by providing the porous material covered by the absorbing liquid with an electri-  
20 cal charge. The electrical charge will promote the absorption of compounds or particles having the opposite charge. Thus, if the porous material is provided with a positive charge, negatively charged particles and compounds will be attracted. Similarly, if the porous material is provided with a negative charge the absorption of positively charged particles and compounds will be  
25 stimulated. In certain embodiments it is advantageous to use both a positive-ly and a negatively charged porous material in order to provide an effective filtration for negatively as well as positively charged particles or compounds.

The porous material may be of any suitable shape and thickness. As an example, the porous material may be sponge-like and having a thickness  
30 10 mm or more for personal protective respiratory equipment, while the porous material usually is a flat sheet for industrial apparatuses for removing undesired substances. The flat sheet may have an effective thickness of

1mm or less. The flat sheet may be supported by reinforcement wires or similar means to support the physical integrity when the air or gas is forced through the filter.

In an alternative embodiment the porous material is shaped as a bag  
5 filter. Bag filters are widely used in industry to filter off particles in the air or gas. By applying a suitable absorption liquid to the bag filter the undesired components in the gas or air can be absorbed.

The present invention also relates to an apparatus for carrying out the above method. The apparatus cleans air or gas for undesired components,  
10 and comprises a housing containing a porous material, in which the pores are coated with an absorbing liquid film having affinity to the undesired component, an inlet for air or gas containing the undesired components, an outlet for ejecting cleaned air or gas, and means for providing a flow of the air or gas containing the undesired component from the inlet, through the pores  
15 coated with the absorbing liquid film to the outlet.

The porous material may be selected among a fabric, mesh, polymer, membrane, etc and the pore diameter of the porous material may be 1  $\mu\text{m}$  or more, such as 10  $\mu\text{m}$  or more. Suitably, the pore diameter is not above 10 mm, such as not above 3 mm, and preferably not above 1 mm.

20 In some applications of the present invention the porous material is supported by a frame. The apparatus may further comprise means for providing fresh absorbing liquid to the pores of the porous material continuously or intermittently. In a preferred aspect the means for providing fresh absorbing liquid film to the pores of the porous material is a spraying nozzle.

25 The apparatus may be provided with a reservoir for collecting spent absorbing fluid. The collected absorbing liquid may be used again or discarded. The apparatus is provided with means for providing flow of air or gas through the pores coated with the absorbing liquid film, which may be a fan.

In certain embodiments of the invention the apparatus is provided  
30 with a current supply. The current supply is electrically connected to the porous material for applying an electrical charge.

While the porous material may have different forms it is generally desired that the porous material is a flat sheet. In certain embodiments the porous material is a bag filter.

## 5           **Brief description of the figures**

Fig. 1 discloses a principal drawing of a fluid phase filter (FPF) comprising a porous material coated with a liquid absorbent and mounted in a supporting frame.

Fig. 2 discloses an edge view of the FPF shown in Fig. 1.

10           Fig. 3 shows a principal drawing of an embodiment comprising a porous material mounted in a supporting frame and coated with a liquid absorbent.

Fig. 4 shows a principal drawing of an embodiment comprising a porous material covered with a stream of electrically conducting liquid absorbent mounted in a supporting frame.

Fig. 5 discloses a principal drawing of an apparatus using an electrically conductive absorption liquid and a current source.

Fig. 6 shows a principal drawing of a fluid phase filter comprising a bag filter as the porous material coated with an absorbing liquid.

20           Fig. 7 shows a principal drawing of an apparatus applying a continuous belt of porous material.

## **Detailed description of the invention**

Figure 1 shows a principal drawing of the porous material used in the present invention. Figure 1 presents a view perpendicular to the filter surface and the pores appear as white squares. It will be evident for the person skilled in the art that the pores may have any form suitable for conveying air or gas through it. The form of the pores viewed perpendicular to the filter surface may in addition to a square form be formed as triangles, circles, ovals, polyeders, such a pentagon, hexagon, heptagon, octagon; or irregular forms not possible to describe in simple geometrical structures.

The pores are defined by a porous material illustrated as lines cir-

cumsccribing the white square. The porous material may have a regular pattern defining pores in a certain pattern across the entire area of the filter or a part of the filter area as shown in Figure 1. In other embodiments the porous material has an irregular size and distribution of pores. Examples of materials that offer the possibility of having a regular pattern of pores are woven fabric, mesh of metal wires, molded polymer, etc. The woven fabric may be prepared by weaving or knitting traditional yarns prepared of fibers. The porous material having an irregular size and distribution of pores may be prepared from fibers positioned random or quasirandom in relation to each other. Suitable fibers for preparing yarns or for preparing filters having irregular pore size and distribution includes natural fibers and man-made fibers. The natural fibers may be of animal, vegetable or mineral origin. Animal fibers include silk, wool, horse hair. Vegetable fibers includes wood fiber, cotton, linen, buntal, flax, hemp, jute, kapok, bamboo, etc. Fibers of a mineral origin include asbestos, glass fibers, stainless steel fibers, silicon carbide fibers, basalt fibers, and stone fibers.

The man-made fibers include regenerated fibers like modal, lyocell; semi-synthetic fibers like rayon, diacetate fibers, and triacetate fibers; and synthetic fibers like polyester, polyamid, polyacryl, and carbon fibers (graphite fibers). When selecting the material for the porous material care should be exerted that the compatibility between the porous material and the absorbing liquid ensures formation of a film. The specific choice of pore size may be a trade-off between various parameters including, sufficient flux of air or gas through the porous material, sufficient surface area of the absorbing liquid film for ensuring absorption of the undesired component, thickness of the filter, etc.

As shown on Fig. 1, the porous material of the invention may be circumscribed by a frame 2, which supports the filter. The frame may be prepared by any suitable stiff or rigid material that supports the usually fragile, flexible, or not-self-supporting porous material. Examples of materials suitable for supporting the porous material include stainless steel, iron, aluminum, plastic, carbon fiber, and wood. While the frame is shown as a flat

square, it will be evident for the person skilled in the art that the frame may have any suitable geometric form, including an irregular form.

Figure 2 shows an edge view of the filter, in which a porous material 1 is surrounded by a frame 2. The arrow indicates that air or gas is forced through the pores of the porous material. While the drawing shows that the air or gas flow is directed perpendicular to the porous material it will be obvious for the person skilled in the art that the direction of the gas or air average flow may also be directed in a certain angle different from perpendicular. In a certain application of the invention, the air or gas average flow is essential parallel to the plane of the porous material.

Figure 3 discloses a principal drawing of an apparatus according to the invention in which fresh absorbing liquid is added to the porous material to provide a film on the porous material defining the pores. The apparatus uses a filter as illustrated on Fig. 1 and 2 as the main component. The filter is supplied an absorbing liquid from the reservoir 3. The reservoir 3 is positioned above the filter to allow gravity to be the driving force for the delivery of absorbing fluid to the pores of the porous material. It will be understood that other means for providing the absorption fluid to the pores may be applied including a pump. It will also be understood that a manifold may be present at the top of the filter to distribute the absorbing fluid to a part of or the entire length of the frame. Preferably, the absorbing fluid is supplied to the entire length of the frame in order to ensure uniform distribution of the absorbing fluid to the filter. After the absorbing fluid has been applied to the filter it moves down the filter at its own motion due to gravity. In certain embodiments it may be advantageous to ensure a desired thickness of the film by mechanical means, such as a doctor blade. At the bottom on the frame surrounding the filter, the spent liquid absorbent is collected in a tray or similar device for holding the absorption liquid. The spent absorption liquid may be reused optionally after a cleaning or regeneration. If the spent absorption liquid is reused it is supplied to the reservoir 3 and used for coating the porous material as described above. In the alternative, the spent absorption fluid may be disposed off in a suitable way.

Figure 4 shows an embodiment of an apparatus for performing the method according to the invention. Figure 4 is a principal drawing of the embodiment, which include a porous material coated with a liquid absorbent by a spraying nozzle. The apparatus uses a filter as illustrated on Fig. 1 and 2  
5 as the main component. The filter is coated by an absorbing liquid from a nozzle 5. The nozzle 5 is supplied the absorbing liquid from a reservoir through a hose or pipe not shown on the drawing. It will understood that the nozzle is supplied the absorption fluid at a certain pressure to enable the spray of the absorbing liquid from the nozzle. Thus, a pump for pumping the  
10 absorbing liquid is usually provided between the reservoir and the nozzle. The nozzle may be of any type suited for the purpose including a pressure nozzle, a two-fluid nozzle, or a three-fluid nozzle.

In the drawing only a single nozzle is shown. It will be understood by those skilled in the art that more than one nozzle can be present. To ensure a uniform distribution of absorption liquid across the filter, two or more  
15 nozzles can be provided. The two or more nozzles may be provided in the upper part of the filter to apply the absorption fluid to the upper part of the porous material and allow gravity to move the absorbing fluid towards the lower frame of the filter. At the lower frame of the filter an outlet 6 is provided  
20 for the spent absorption fluid. The spent absorption fluid may be collected in reservoir 4 and reused or disposed as explained above.

Fig. 5 shows an embodiment in which an electrically conductive absorbing fluid is used and a current source is applied to provide a double filter with a potential. The porous material 1 is used for preparing two filters in the  
25 same frame. The electrically conductive fluid is applied on the porous material and connected to a direct current source 7. When connected, the filter will be able to attract charged undesired components. Undesired components which are not themselves charged may be ionized before the particles arrive to the filter. While the embodiment is shown with a positive as well as  
30 a negative polarized filter, it will be understood by those skilled in the art that only a single charged filter needs to be present if the air or gas to be filtered only contains undesired components with a certain polarity. Thus, if the gas

or air to be cleaned only or mostly contains negatively charged particles, the apparatus only needs a positive charged filter. In the embodiment shown both positively and negatively charged undesired components is attracted and absorbed in the absorbing liquid film.

5           Figure 6 discloses an embodiment using a filter bag 1 as the porous material. The filter bag is coated with an absorbing liquid by the nozzle 5. While only a single nozzle is shown on the drawing it will be understood that two or more nozzles may be provided along the vertical extension of the filter bag to ensure a more uniform distribution of the absorbing liquid. The  
10 nozzle is provided with the absorbing liquid from the reservoir 3. A pump (not shown) applies a sufficient pressure to the absorbing liquid for the nozzle to provide a spray.

Air or gas containing an undesired component enters the high pressure compartment 8 and is subsequently forced through the pores of the  
15 filter bag 1 coated with the absorbing liquid. The air or gas cleaned for undesired components is collected in the lower pressure compartment 9 and is exiting through the outlet at the bottom of the housing.

Spent absorbing liquid is collected at the bottom of the lower-pressure compartment and is conveyed to the collector 4. The spent absorb-  
20 ing liquid may be reused or discarded as discussed earlier.

Figure 7 shows an embodiment of the invention using an endless belt of porous material. The endless belt of porous material is transported by two rolls 10, wherein at least one roll is revolved by external power. The lower roll 10 is at least partly submerged in a bath 4 of absorbing liquid. The  
25 bath applies absorbing liquid to the porous material and also washes off the spent absorbing liquid containing the undesired components. The cleaning of air or gas may be continued until the concentration of undesired components reach equilibrium, i.e. the concentration in the bath equals the concentration in the absorbing liquid film to be cleaned. Usually, however, the pro-  
30 cess is stopped before equilibrium is reached to ensure a sufficient efficiency.

The apparatus shown in Fig. 7 has a higher pressure and a lower

pressure compartment. The higher pressure compartment 8 is isolated from the lower pressure compartment 9 by sealings 11. The sealings ensure that air or gas is not vented out of the housing and the pressure in the lower and higher pressure compartments can be maintained. Thus, when gas or air to be cleaned for undesired components is entering the higher pressure compartment 8 it needs to penetrate the porous material coated with the absorbing liquid. The gas or air that has passed through the first porous material is cleaned in a further filter facing the lower pressure compartment 9. The air or gas is forced through the layers of porous material coated with absorbing liquid by a fan (not shown on the figure) that either blows the air or gas into higher pressure compartment 9 or sucks the cleaned air or gas from lower pressure compartment 9.

Figure 8 shows a face respiratory mask 12 for protection of human beings when breathing in polluted air, in which a sheet of porous material coated with an absorption liquid 15 is inserted in the vents. The drawing shows a vent which in succession comprises a char coal filter 13, a first fastener 14, a porous material coated with an absorbing liquid 15, and a second fastener 16. The face respiratory mask may be used by persons working in buildings having a high concentration of PCB or other toxic substances. If the absorbing liquid is selected as a lipophilic liquid like edible oil (olive oil, rape seed oil, etc) the person when breathing will force the air through the porous material coated with the edible oil. When passing the porous material the lipophilic PCB will be extracted by the edible oil. The air cleaned for undesired substances will subsequently reach the char coal filter in which the air is cleaned further before it is delivered to the breathing organs of the working person.

### **Example**

Test for removal of PCB from buildings.

30

A cotton fabric having a density of 20 yarns per cm was mounted on a funnel and the outlet from the funnel was connected to a pump via an

ORBOTM Supelco XAD II tube. The area of the pores was calculated to 200 cm<sup>2</sup>. The pump was SKC AirCheck Sampler – Model 224-PCXR8.

The cotton fabric was coated with olive oil (De Cecco virgin olive oil) and the ability to absorb PCB in a building known to be contaminated with  
5 PCB was tested.

The pump was adjusted to pump 2000 ml/min and the pumping was continued until 240 l air had been pumped. The amount of PCB was measured in the cleaned air and compared to the background concentration of 2700 ng PCB<sub>Total</sub>/m<sup>3</sup>. The result is indicated below:

10

Table 1:

Sample No.	Concentration PCB <sub>Total</sub> /m <sup>3</sup>	Percentage removal of PCB
1	52	98.07407
2	7.5	99.72222

The average percentage of PCB removal is calculated to 98.9%.

15

## P A T E N T   C L A I M S

1. A method for cleaning air or gas for undesired components, comprising the steps of:
  - 5 a. Providing a porous material, in which the pores are coated with an absorbing liquid film having affinity to the undesired components, and
  - b. Forcing the air or gas to be cleaned through the pores coated with the absorbing liquid film, thereby promoting the absorption of the undesired components in the absorbing liquid film,
- 10 wherein the absorbing liquid is lipophilic.
2. The method according to claim 1, wherein the porous material is selected among a fabric, mesh, paper, and polymer.
3. The method according to any one of the claims 1 to 2, wherein the pore diameter is 1 nm or more, such as 1  $\mu\text{m}$  or more.
- 15 4. The method according to any of the claims 1 to 3, wherein the porous material is supported by a frame.
5. The method according to any of the claims 1 to 4, wherein fresh absorbing liquid is provided to the pores of the porous material continuously or intermittently.
- 20 6. The method according to any of the claims 1 to 5, wherein the fresh absorbing liquid film is provided to the pores of the porous material by spraying.
7. The method according to claim 6, wherein spent absorbing liquid is collected.
- 25 8. The method according to any of the claims 1 to 7, wherein the air or gas is forced through the coated pores using a fan.
9. The method according to any of the claims 1 to 8, wherein the air or gas is forced through the coated pores by breathing.
10. The method according to any of the claims 1 to 9, wherein the porous material is provided with an electrical charge.
- 30 11. The method according to any of the claims 1 to 10, wherein the porous material is a flat sheet.

12. The method according to any of the claims 1 to 11, wherein the porous material is a bag filter.

13. The method according to any of the claims 1 to 12, wherein the absorbing liquid film is lipophilic or hydrophilic.

5 14. The method according to claim 13, wherein the lipophilic absorbing liquid is selected among non-curing vegetable oils, mineral oils, and synthetic oils.

15 15. An apparatus for cleaning air or gas for undesired components, comprising a housing containing a porous material, in which the pores are coated with an absorbing liquid film having affinity to the undesired components, an inlet for air or gas containing the undesired components, an outlet for ejecting cleaned air or gas, and means for providing a flow of the air or gas containing the undesired components from the inlet, through the pores coated with the absorbing liquid film to the outlet, wherein the absorbing liquid is lipophilic.

16. The apparatus according to claim 15, wherein the porous material is selected among a fabric, mesh, polymer, membrane.

17. The apparatus according to claims 15 or 16, wherein the pore diameter is 1nm or more, such as 1 $\mu$ m or more.

20 18. The apparatus according to any of the claims 15 to 17, wherein the porous material is supported by a frame.

19. The apparatus according to any of the claims 15 to 18, further comprising means for providing fresh absorbing liquid to the pores of the porous material continuously or intermittently.

25 20. The apparatus according to any of the claims 15 to 19, wherein the means for providing fresh absorbing liquid film to the pores of the porous material is a spraying nozzle.

21. The apparatus according to any of the claims 15 to 20, further comprising a reservoir for collecting spent absorbing fluid.

30 22. The apparatus according to any of the claims 15 to 21, wherein the means for providing flow of air or gas through the pores coated with the absorbing liquid film is a fan.

23. The apparatus according to any of the claims 15 to 22, wherein the porous material is provided with means for applying an electrical charge.

24. The apparatus according to any of the claims 15 to 23, wherein the porous material is a flat sheet.

5 25. The apparatus according to any of the claims 15 to 24, wherein the porous material is a bag filter.

Fig. 1

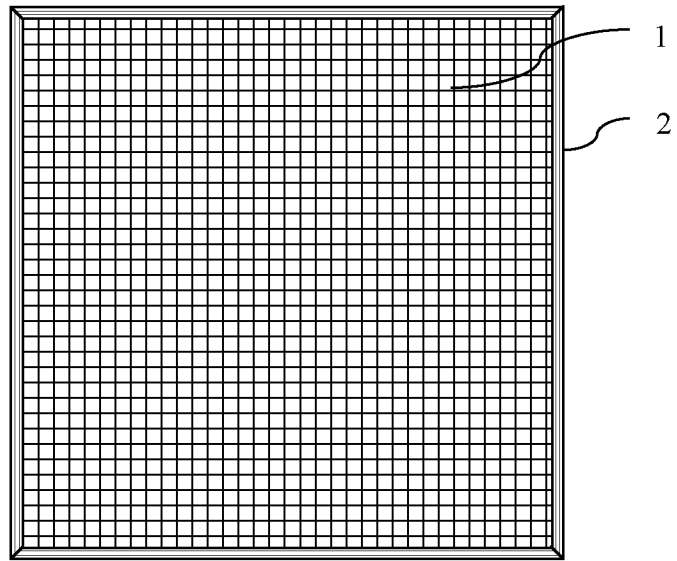


Fig. 2

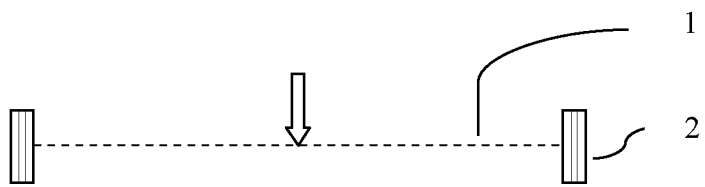


Fig. 3

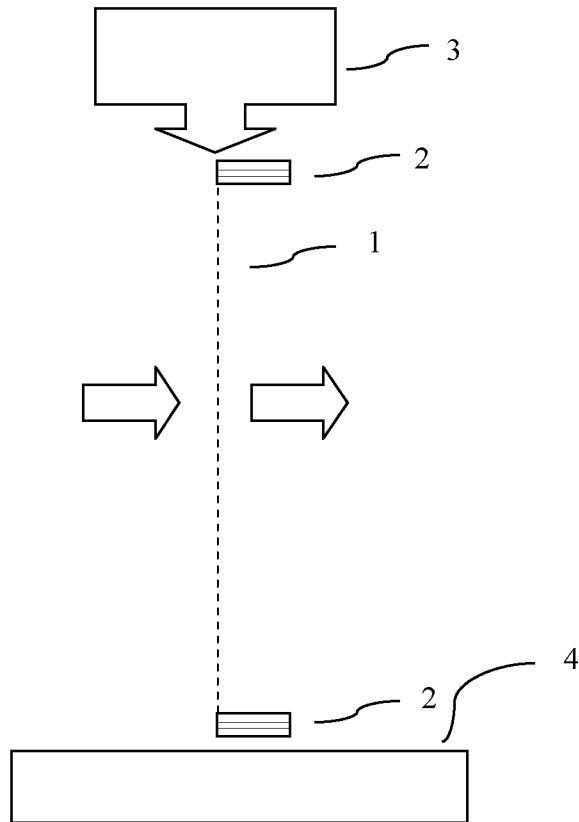


Fig. 4

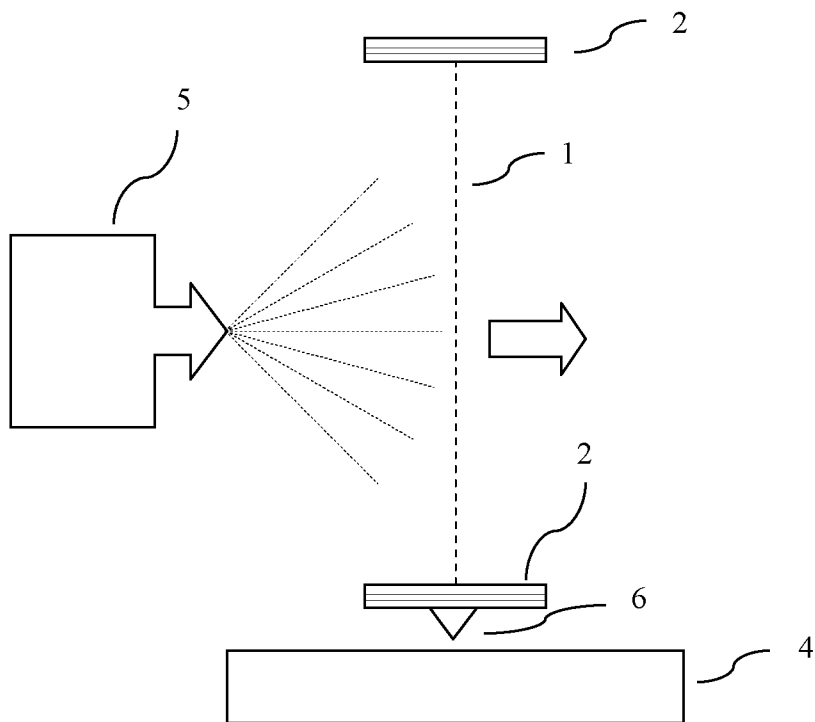


Fig. 5

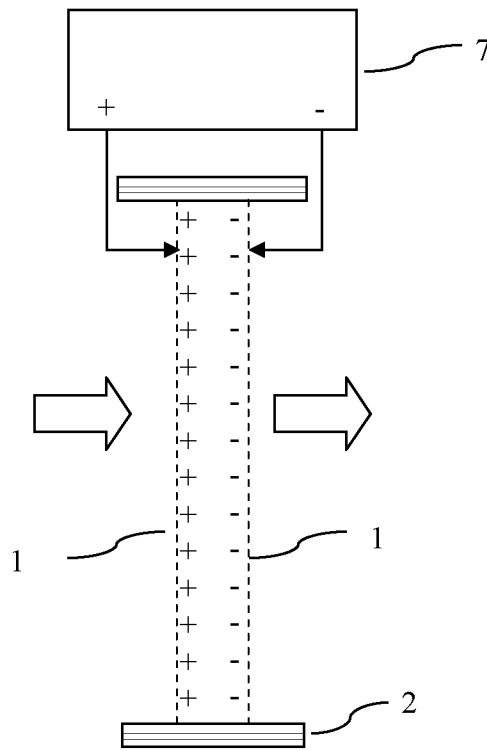
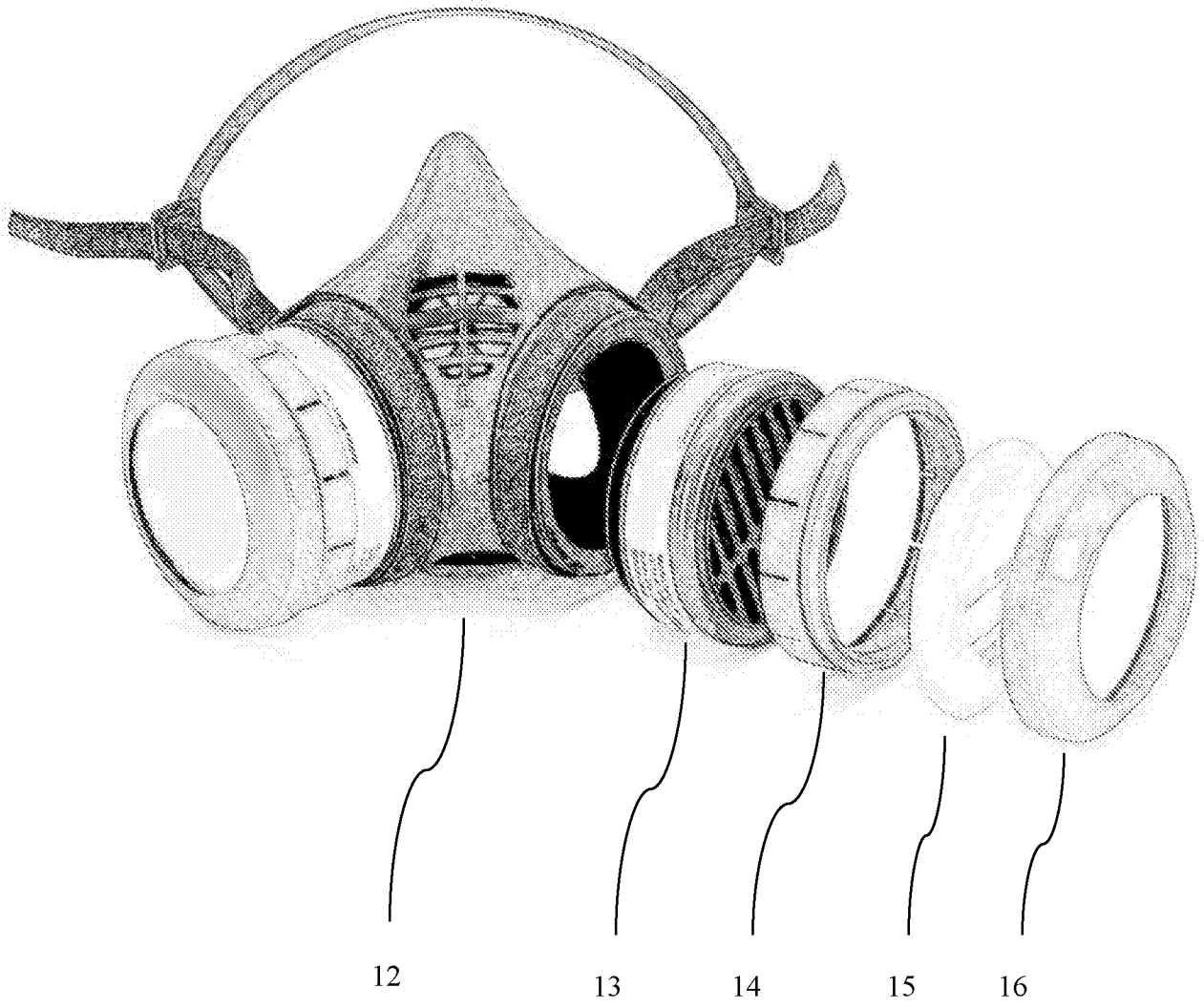


Fig. 8



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Fig. 6

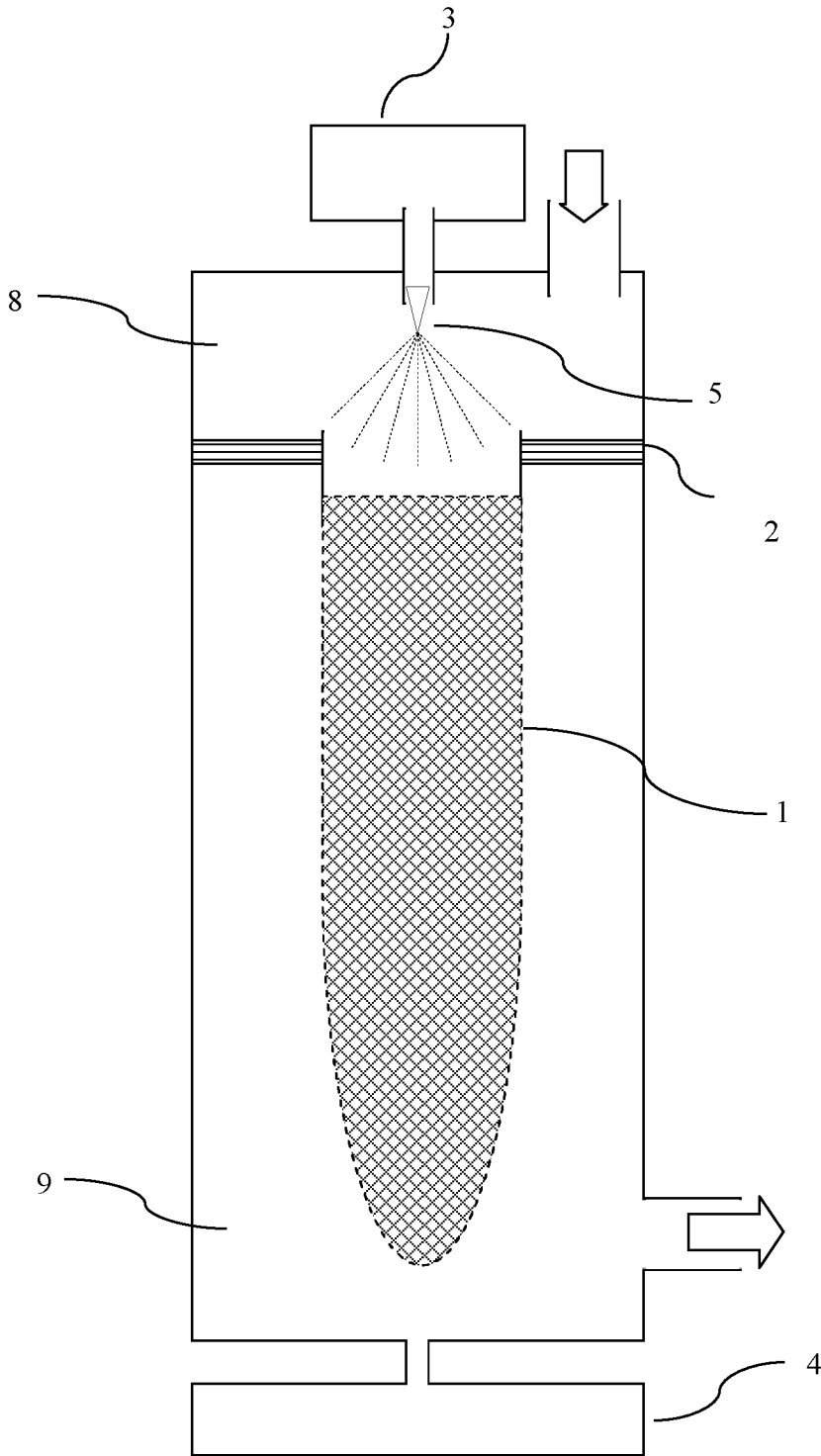
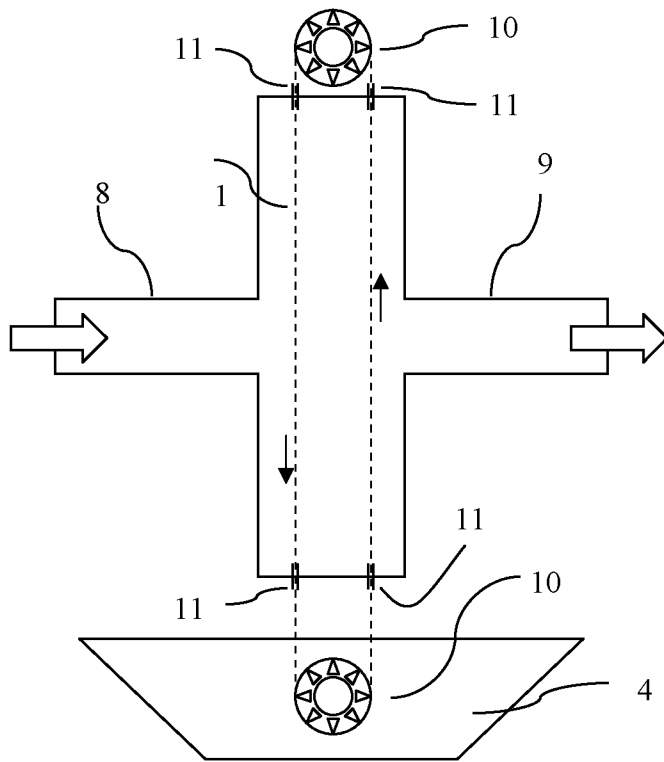


Fig. 7



**INTERNATIONAL SEARCH REPORT**

International application No  
PCT/DK2015/050180

**A. CLASSIFICATION OF SUBJECT MATTER**  
 INV. B01D53/14 B01D53/70 B01D53/79 A62B23/02 B01D46/00  
 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)  
 B01D A62B

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

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Y	paragraphs [0007] - [0016]; figure -----	10,23
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X	GB 2 179 557 A (MARTIN ROY E) 11 March 1987 (1987-03-11)  page 1, lines 12-63; figures 1-5 -----  -/--	1-4,6,9, 11-15, 17,18, 24,25

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

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Date of the actual completion of the international search  4 September 2015	Date of mailing of the international search report  15/09/2015
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Focante, Francesca
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## INTERNATIONAL SEARCH REPORT

International application No  
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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