(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 April 2005 (28.04.2005)

PCT

(10) International Publication Number
WO 2005/037409 A1

(51) International Patent Classification[7]: B01D 53/00

(21) International Application Number:
PCT/DK2004/000708

(22) International Filing Date: 15 October 2004 (15.10.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PA 2003 01521 15 October 2003 (15.10.2003) DK

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ,*

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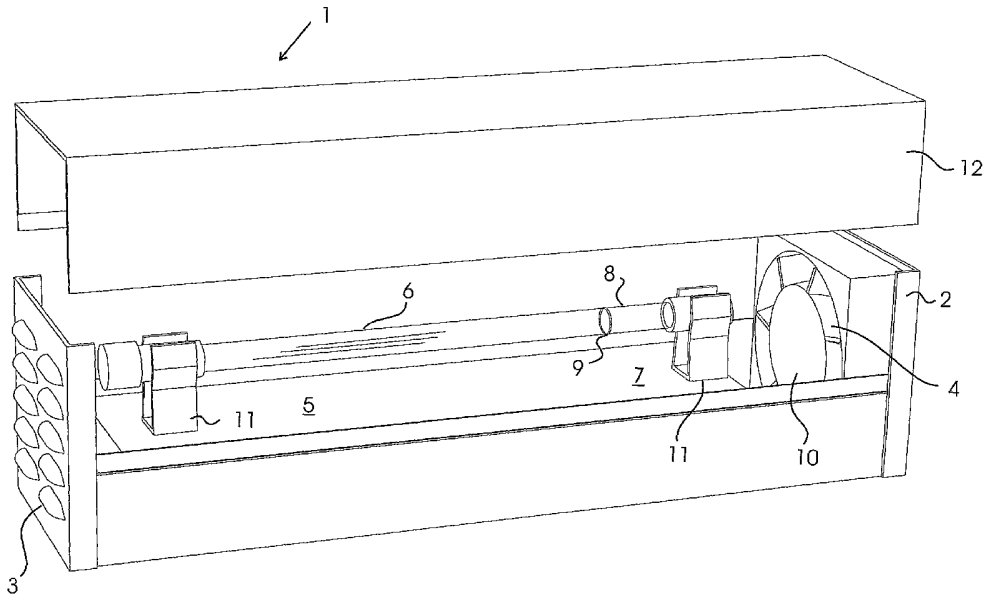
(54) Title: APPARATUS AND METHOD FOR CLEANING CONTAMINATED AIR



(57) Abstract: An apparatus and method serves for cleaning contaminated air. The apparatus (1) comprises a house (2) with an inlet - and outlet opening (3,4), respectively for allowing the contaminated air to flow in and out of the house (2). Said house comprises, a first section (5) with a first source of ultraviolet light (6) for generating ozone, and a second section (7) with a second source of ultraviolet light (8) for decomposing ozone. A fan 11 forces the contaminated air to flow through the first section where the air is cleaned and subsequently through the second section where residual ozon is decomposed. The apparatus provides in an efficient and simple way purification of contaminated air while at the same time ensuring that no ozone is discharged to the surroundings

WO 2005/037409 A1

NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations*

Published:

— *with international search report*

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Apparatus and method for cleaning contaminated air

The present invention relates to an apparatus for cleaning a contaminated air stream wherein the apparatus comprises a house with an inlet- and outlet opening, respectively for allowing the contaminated air to stream in and out of the house.

Indoor pollution is a common problem everywhere. Most air purifiers are not able to reduce indoor pollution that contributes to allergies, asthma, bacterial or viral infections, hay fever and home respiratory problems. In some cases such pollution only is filtered off whereby the pollution, however, instead tends to increase.

To overcome these problems the use of proper air purifiers has been introduced. Such purifiers are using ozone to improve the air quality by reducing many indoor pollutants, which not or at least only imperfectly can be filtered off.

Ozone will react with almost anything, including chemical sources of unpleasant or hazardous indoor odors. Bacteria, molds and mildews, pet odors, many cooking odors, etc., are destroyed when they react with ozone. Like chemical pollutants, the membranes or shells of bacteria contain unsaturated molecules, which are destroyed by ozone. Without its protective membrane or shell, the bacterium dies. The same applies to fungi and viruses.

However, ozone is a toxic gas and relatively low amounts of ozone can cause chest pain, coughing, shortness of breath, and throat irritation. Ozone may also worsen chronic respiratory diseases such as asthma and compromise the ability of the body to fight respiratory infections.

People vary widely in their susceptibility to ozone. Healthy people, as well as those with respiratory difficulty, can experience breathing problems when exposed to ozone. Exercise during exposure to ozone causes a greater amount of ozone to be inhaled, and increases the risk of harmful respiratory effects.

Recovery from the harmful effects can occur following short-term exposure to low levels of ozone, but health effects may become more damaging and recovery less certain at higher levels or from longer exposures (U.S. Environmental Protection Agency (US EPA). 1996. Review of National Ambient Air Quality Standards for Ozone: Assessment of Scientific and Technical Information. OAQPS Staff Paper. Office of Air Quality Planning and Standards. Research Triangle Park. NC. EPA-452/R-96-007.).

Several federal agencies have established health standards or recommendations to limit human exposure to ozone. As examples can be mentioned that the Food and Drug Administration (FDA) requires ozone output of indoor medical devices to be no more than 0.05 ppm, the Occupational Safety and Health Administration (OSHA) requires that workers not be exposed to an average concentration of more than 0.10 ppm for 8 hours and the National Institute of Occupational Safety and Health (NIOSH) recommends an upper limit of 0.10 ppm, not to be exceeded at any time (U.S. Environmental Protection Agency (US EPA). 1995. Ozone Generators in Indoor Air Settings. Report prepared for the Office of Research and Development by Raymond Steiber. National Risk Management Research Laboratory. U.S. EPA. Research Triangle Park. EPA-600/R-95-154.).

The half-life of Ozone is approximately 7 to 20 minutes depending upon temperature, pH, humidity and the amount of contaminants in the air. When an ozone purifier is installed in e.g. a home or office, it can inevitably result in a much higher concentration of ozone than the concentration

recommended by the different federal agencies, as only a part of the ozone is used for oxidising the organic substances.

A ozone purifier placed in a closed room, such as e.g. a home or an office, will discharge any residual ozone, whereby the ozone concentration in the room will increase and even more when organic substances, such as smoke odour and dust first are eliminated.

The actual concentration of ozone will increase in dependence of more factors. One of these factors is the effect of the ozone purifier, another factor is the volume and ventilation of the room, a third factor is existing material and furnishing, which are able to react with ozon, and a fourth factor is the proximity of a person to the ozone since the ozone concentration is highest close to the area where the residual ozon is discharged.

The invention aims to remedy the above-mentioned problems.

It is a first aspect according to the present invention to provide an apparatus of the kind mentioned in the opening paragraph, which is capable of cleaning contaminated air without constituting a health risk by discharging ozone to the surroundings.

It is a second aspect of the present invention to provide an apparatus, which has a simple and inexpensive construction.

It is a third aspect of the present invention to provide an apparatus, which is easy and inexpensive to keep in repair.

It is a fourth aspect of the present invention to provide an apparatus, which is easy to operate.

The novel and unique whereby this is obtained consists, according to the invention, in that said house comprises, a first section with a first source of ultraviolet light for generating ozone, and a second section with a second source of ultraviolet light for decomposing ozone.

When the contaminated air enters the first section the ultraviolet light from the first source will immediately start to break down the electron bonds of the organic molecules contained in the contaminated air and initiate the formation of the highly energized gaseous state, which contains excited atoms and molecules, such as atomic oxygen, molecular singled oxygen and ozone, ionised gases, radicals, and free electrons whereby very powerful oxidizing substances are created for eliminating organic substances in the air stream through the house.

Ozone, which is not used to oxidize the organic substances in the air, will pass from the first section to the second section where it will be decomposed by means of the second source of ultraviolet light. Thereby is advantageously obtained that no ozone are let out from the apparatus, thereby ensuring that the ozone concentration in the surroundings will stay well below the mentioned standards and recommendations for limiting human exposure to ozone.

In an advantageous embodiment the first and second source of ultraviolet light are interconnected UV-lamps. This does not only create a very simple and inexpensive apparatus, but is also implying the benefit that ozone, which is not used for oxidizing the organic substances in the first section, is passing directly into the ultraviolet light in the second section for being decomposed here. In this way is effectively ensured that no ozone is escaping to the surroundings.

According to the invention the ratio between the first and second source of ultraviolet light can be between 8:1 and 4:1, preferably 6:1, whereby the desired effect of generating sufficient ozone in the first section for oxidizing unpleasant or hazardous indoor organic contaminations such as bacteria, molds and mildews, pet odors, smoke odors, many cooking odors is obtained at the same time as the desired effect for fully decomposing the residual ozone in the second section is obtained.

Ozone is for example found to react with acrolein, one of the many odorous and irritating chemicals found in secondhand tobacco smoke (U.S. Environmental Protection Agency (US EPA). 1995. Ozone Generators in Indoor Air Settings. Report prepared for the Office of Research and Development by Raymond Steiber. National Risk Management Research Laboratory. U.S. EPA. Research Triangle Park. EPA-600/R-95-154.).

The first source of ultraviolet light can preferably have a wavelength below 200 nm, especially 185 nm where ozone is produced from oxygen and organic compounds are oxidized.

The inventors surprisingly have learned that ozone is decomposed instead of being generated when the at least second source of ultraviolet light has a wavelength above 200 nm and that the optimal decompounding effect is obtained at a wavelength of approximate 254 nm. Said wavelength further has the advantage that it is within the region of maximum germicidal effectiveness and is highly lethal to virus, bacteria and mold spores.

Thus, the second section of the apparatus according to the invention will not only decompose residual ozone from the first section guaranteeing that ozone is not constituting a health risk, but it will also provide a double security for eliminating microorganisms.

In the first section the microorganisms are destroyed by means of ozone, which reacts with the organic substances of the microorganisms. In the second section the UV radiation penetrates the outer cell-wall of the microorganisms, passes through the cell-body, reaches the DNA and alters the genetic material, destroying the microorganisms in a non-chemical manner.

The invention also relates to a method for cleaning a contaminated air stream. Said method comprises the steps of letting the streaming air pass a first area containing ozone and a subsequent second area with means for decomposing ozone.

The first area is designed for cleaning the contaminated air and the subsequent area is primarily adapted for eliminating residual ozone arriving from the first area.

Even though the ozone in the first area could be added from an external source, e.g. from a corona discharge generator, the first area can, in an advantageous embodiment according to the invention, have a first source of ultraviolet light for generating ozone, enabling a simple an inexpensive method for cleaning a contaminated air stream.

The invention also relates to the use of the method according to the invention wherein the contaminated air stream can come from an area where food is prepared.

The invention will be described in the following with reference to the only figure of the drawing showing, by way of example, an exploded view, seen in perspective, of an apparatus according to the invention. The description is furthermore based on the supposition that the source of ultraviolet light for generating ozone is a first and second UV-lamp.

The apparatus 1 comprises a house 2 with an inlet opening 3 and an outlet opening 4 for allowing the contaminated air to flow in and out of the house, which moreover is divided into a first section 5 with the first UV-lamp 6 and a second section 7 with the second UV-lamp 8. The two UV-lamps are interconnected at a connection point 9.

The first UV-lamp is radiating UV-light adapted for generating ozone while the second UV-lamp is radiating UV-light adapted for decomposing ozone.

The contaminated air stream is forced to pass through the house via the inlet - and outlet openings into the direction indicated by means of a fan 10 placed close to or into the outlet opening 4.

The interconnected UV-lamps 6,8 are placed approximately in the middle of the house 2 by means of a couple of clip-on holders 11, with which the interconnected UV-lamps easily and quickly can be installed in the house and also be replaced if necessary by removing a screen 12.

When the contaminated air enters the first section 5 the ultraviolet light from the first UV-lamp 6 will immediately start to break down the electron bonds of the organic molecules contained in the contaminated air and initiate the formation of ozone, which will oxidise the organic substances in the air.

Residual ozone, which is present after said oxidation process, will of the fan be forced into the second section 7 where the ozone will be decomposed to oxygen by means of the second UV-lamp 8. Thus, no ozone will be liberated from the apparatus according to the invention, thereby ensuring that the ozone concentration in the surrounds will stay well below the

mentioned standards and recommendations for limiting human exposure to ozone.

The apparatus will at the same time reduce all sources of indoor pollution that contribute to allergies, asthma, bacterial or viral infections, hay fever and home respiratory problems as well as reducing chemical sources of unpleasant or hazardous indoor odours.

Claims.

1. An apparatus for cleaning a contaminated air stream wherein the apparatus comprises a house (2) with an inlet- and outlet opening (3,4), respectively for allowing the contaminated air to stream in and out of the house, **characterized** in, that said house comprises, a first section (5) with a first source (6) of ultraviolet light for generating ozone, and a second section (7) with a second source (8) of ultraviolet light for decomposing ozone.

2. An apparatus according to claim 1, **characterized** in, that the first and second source of ultraviolet light are interconnected UV-lamps (6,8).

3. An apparatus according to claim 1 or 2, **characterized** in, that the ratio between the first - and second source (3,4) of ultraviolet light is between 8:1 and 4:1, preferably 6:1.

4. An apparatus according to claim 1, 2 or 3 **characterized** in, that the first source (6) of ultraviolet light is having a wavelength below 200 nm.

5. An apparatus according to any of the claims 1 - 4, **characterized** in, that the first source (6) of ultraviolet light is having a wavelength of approximately 185 nm.

6. An apparatus according to any of the claims 1 - 5, **characterized** in, that the second source (8) of ultraviolet light is having a wavelength above 200 nm.

7. An apparatus according to any of the claims 1 - 6, **characterized** in, that the second source of ultraviolet light is having a wavelength of approximately 254 nm.

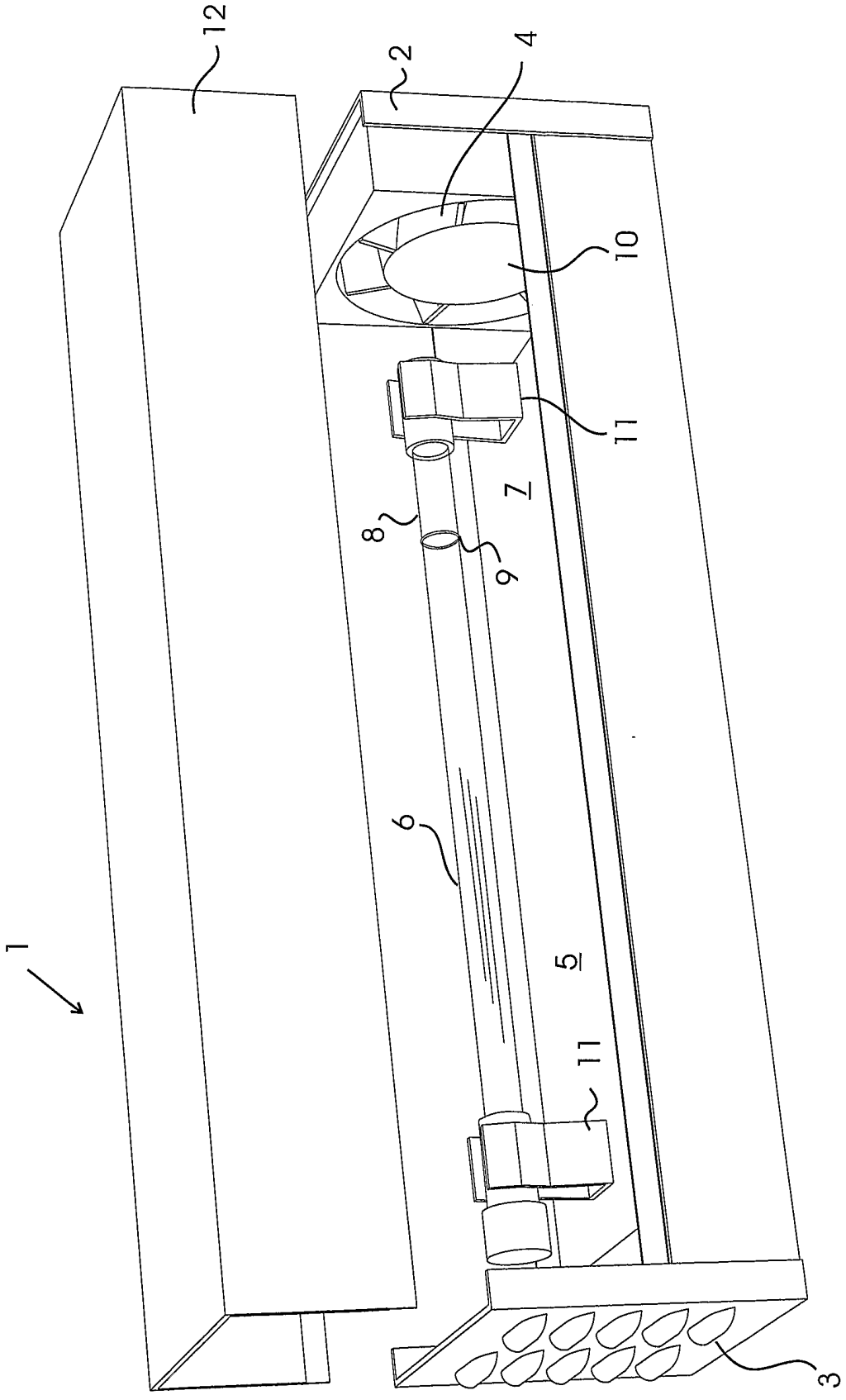
8. A method for cleaning a contaminated air stream, comprising the steps of letting the streaming air passing a first area (5) containing ozone and a subsequent second area (7) with means for decomposing ozone.

9. A method according to claim 8, **characterized** in, that the first area has first source (6) of ultraviolet light for generation ozone.

10. A method according to claim 8, **characterized** in, that the second area has a second first source (8) of ultraviolet light for generation ozone

11. Use of a method or apparatus according to any of the claims 1 - 10, for reducing sources of indoor pollution that contribute to allergies, asthma, bacterial or viral infections, hay fever and home respiratory problems.

12. Use of a method or apparatus according to any of the preceding claims 1 - 10, for reducing chemical sources of unpleasant or hazardous indoor odors.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INTERNATIONAL SEARCH REPORT

Inte al Application No
PCT/DK2004/000708

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D53/00

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 B01D

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, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97/34682 A (SHLISKY BRIAN) 25 September 1997 (1997-09-25) claims 1,4,7; figure 2	1-12
X	WO 00/69477 A (KUNCHONG HI TECH CO LTD ; KIM CHANG KUK (KR)) 23 November 2000 (2000-11-23) claims 1,2	1,4-12
A	DE 39 13 968 A (ASEA BROWN BOVERI) 9 November 1989 (1989-11-09) abstract	1-12

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
25 November 2004	03/12/2004

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/DK2004/000708

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9734682 A	25-09-1997	AU 2528197 A	10-10-1997
		WO 9734682 A1	25-09-1997
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		WO 0069477 A1	23-11-2000
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