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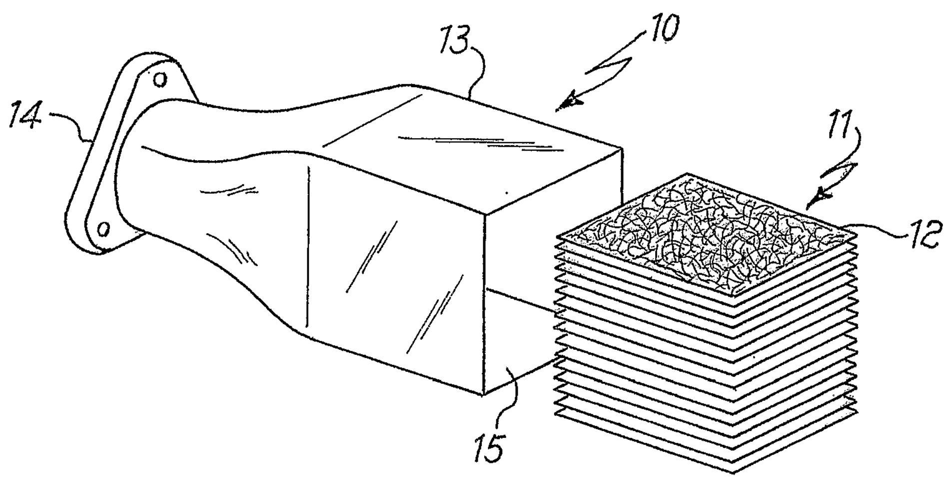
(54) Title: CONVERTER FOR EXHAUST GASES OF INTERNAL COMBUSTION ENGINES



(57) Abstract: It is described a converter (10) for exhaust gases of internal combustion engines, comprising a housing (13) which is provided with at least one inlet opening (14) for the exhaust gases to be converted and with at least one outlet opening (15) for the converted gases and includes a converting system (11), in which the converting system comprises a plurality of panels (12) of fibers (30) comprising a metallic center (31) covered with a layer of oxides (32) carrying catalytically active metals (33), said panels being arranged with an edge facing the inlet opening and with another edge facing the outlet opening, essentially parallel to each other, and kept spaced apart by means of metallic spacers (41, 41'; 51, 51'; 62; 70).

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CONVERTER FOR EXHAUST GASES OF INTERNAL COMBUSTION ENGINES

The present invention relates to a converter for internal combustion engines, and in particular to a device which can be employed for oxidation of the exhaust gases of these engines.

It is known that the exhaust gases of the internal combustion engines contain gases which are not completely oxidized, such as CO and unburned hydrocarbons; these gases are a source of environmental pollution, and the current regulations require the adoption of systems for the abatement of these emissions, for example through converters arranged downstream the engine for completing the combustion of said gases.

US patent 5,294,411 discloses a device for treating exhaust gases, which comprises a honeycomb structure rolled up like a spiral, which has a catalytically active continuous surface on a ceramic or metallic substrate, in which the flow of the exhaust gases follows linear paths, flowing in a multiplicity of channels defined by the structure itself, all parallel to each other and to the direction of said flow. A device of this kind essentially presents two problems: first, the total surface available for the contact with gases, which corresponds to the development of the spiral structure, is not particularly wide and the ratio between the volume of the device and the geometrical surface over which the catalyst is spread is not advantageous; second, the strictly linear geometry of the channels is such that the gas flow through the structure is prevalently laminar, thereby not allowing an optimal exploitation of the catalyst.

Patent application WO 97/02092 discloses a device for treating exhaust gases obtained from a perforated metallic sheet or a metallic net onto which is deposited a ceramic porous layer preferably made of alumina or zirconia, which is subsequently impregnated with a solution or suspension of a catalyst precursor. Also in this case, however, the available catalytic surface is not very wide, and therefore the conversion efficiency is limited. It is therefore an object of the present invention to provide a converter for exhaust gases which is free from said disadvantages.

Said object is achieved with a converter for exhaust gases of internal combustion engines, comprising a housing which is provided with at least one inlet opening for the exhaust gases to be converted and with at least one outlet opening for the converted gases and includes a converting system, characterized in that said converting system comprises a plurality of panels of fibers comprising a metallic core covered with a layer of oxides over which catalytically active metals are present, said panels being arranged with an edge facing the inlet opening and with another edge facing the outlet opening, essentially parallel to each other, and kept spaced apart by means of metallic spacers.

The metallic panels of the invention, functionalized with catalysts, have a contact surface notably increased with respect to the perforated plates and metallic nets of the known devices. Moreover the arrangement according to the invention, comprising panels and spacers, causes a turbulent gas flow in the converter, such that the gas in its path between the inlet and the outlet is compelled to pass, at least partially, through said panels. These features notably improves the contact between gas flow and the catalyst and consequently the efficiency of conversion, and in particular of oxidation, of the converter according to the invention.

Advantages and features of the converter according to the present invention will become clear to those skilled in the art from the following detailed and non-limiting description of some embodiments thereof with reference to the attached drawings wherein:

- figure 1 shows an exploded view of a converter of the invention;
- figure 2 shows a perspective view of a panel of metal fibers used in the invention;
- figure 3 shows a cross-section view of a fiber making up the panel of figure 1;
- figures 4 to 7 show details of the converting system of the invention; and
- figure 8 shows a preferred converting system according to the invention.

Figure 1 shows an exploded view of a converter of the invention, 10, including a converting system 11 comprising a plurality of panels 12; converter 10 comprises in a known way a housing 13 having at least an inlet opening 14 for the exhaust gases to be treated coming from an internal combustion engine, and at least an outlet opening 15 for the gases treated by system 11. The panels are preferably surrounded by metallic elements 16 (not shown in this figure) forming a frame fixed to the panel edges by any suitable means, for instance by mechanical crimping: this frame helps in keeping the flatness of panel 12 during thermal cycling (both the thermal treatments for oxidizing and functionalizing the panels, and the thermal cycling due to operation downstream the engine), and to avoid the loss of fibers at the panel edges. Converter 10 may comprise a flange around the perimeter of the outlet 15 (not shown in this figure).

According to the invention, system 11 comprises a plurality of panels 12 kept at the desired distance by metallic spacers. The inventors have found that good results are obtained if this distance is kept in the range between about 1 and 4 mm. With distances lower than 1 mm the packing of panels gets too crowded and system 11 causes a too high gas pressure drop. On the other hand, too high distances have the drawback of reducing the number of panels of kind 12, and thus the catalytic surface active in gas treatment; besides, if the distance between panels is too high, the effect of generating a turbulent motion in the gas flow is reduced, and at least a part of the gas could cross system 11 without getting in contact with the catalyst placed on the panels of kind 12. Optimal values of the distance between adjacent panels are in the range between about 2 and 3 mm.

Figure 2 shows a panel 12 used in the system of the invention, in the preferred embodiment comprising surrounding metallic elements 16. The panel is a mat of metallic fibers, that are generally caused to adhere to each other by sintering. The fibers may be made of steel or, preferably, of an alloy containing iron, chrome and aluminum, plus small percentages of other elements, known as Fecralloy® (trademark registered by UKAEA, Didcot, Great Britain). This alloy turned out to be particularly suitable for the prolonged use at high temperatures, as in the uses intended for catalytic converters or filters for internal combustion engines. Panels made of Fecralloy® fibers can be obtained from the company N.V. Bekaert SA, of Zwevegem, Belgium, and are marketed with the name Bekipor®; these panels can be shaped according to different geometries and adapted to the different kinds of use.

Figure 3 shows in section a fiber used in making panel 12 (the parts of the fiber are shown not in scale); in the figure, it is shown a fiber with a rectangular cross-section, as this is the most typical form of Fecralloy® fibers, but obviously the fibers could have other sections, e.g. circular. Fiber 30 comprises a Fecralloy® core 31 covered with a layer of oxides, 32, that carries the catalyst 33. The layer of oxides is generally a multilayer made up of two or three layers of oxide, different from each other as to chemical composition or physical properties. A first oxide layer, 32', is grown on the surface of the Fecralloy® fibers by means of a high temperature treatment in an oxidizing atmosphere: the oxide layer formed with this treatment consists mainly of aluminum oxide whiskers, having length generally comprised between 0.5 and 5 microns (μm), depending upon time and temperature of the treatment; preferably the whiskers have length lower than 3 μm. The oxide forming these whiskers is generally very dense and uniform. The subsequent step of the process consists of forming a second oxide layer, 32", over the first one. This second oxide layer, unlike the first one, is porous and has a high specific surface; this may consist again of aluminum oxide, or may be a different oxide. The second oxide layer can be obtained by spraying onto the mat of sintered metallic fibers a solution of a precursor compound of the oxide, or by immersing the mat in the same solution followed by thermal decomposition of the precursor. Alternatively, the second oxide layer can be obtained by immersing the mat into a liquid suspension of precursor particles and a subsequent calcination. Optionally, a third layer of oxides, 32"', is formed onto the second oxide layer. This layer too has a high specific surface. Optional layer 32"' generally consists of a mixed oxide of cerium and zirconium (with the optional addition of lanthanum), and has the property of limiting the sintering of the catalytic metals, thereby ensuring their dispersion over time and thus helping to keep a high efficiency of the converter, as well as of being a reservoir of oxygen for the oxidation of the unburned gases leaving the engine.

The outer oxide layer (either 32" or 32"'), thanks to its porous structure, is an optimal support for the catalytic metals, assuring the dispersion of the metal and its good anchoring to the fiber surface. The functionalization of the oxide layer with the catalyst 33 is necessary for the intended use of the fibrous panel. The catalyst is preferably one or more noble metals chosen among those of the eighth group of the periodic table or their compounds; preferred is the use of platinum.

Figure 4 shows a partial exploded view of a first possible embodiment of system 11. In this embodiment, system 11 comprises a stacking of panels 12 alternate to metallic sheets 40 (only two panels and one metallic sheet are shown; metallic elements of kind 16 are not shown); these sheets present a plurality of protrusions, 41, 41', ..., extending from both faces of a sheet. The protrusions are all of same height, so as to offer a plurality of contact points onto which two panels 12 (one per side of sheet 40) can lay. Sheets 40 are made with high-temperature resistant metals; preferably these sheets too are made with the same Fecralloy® used for producing the fibers of panels 12. These sheets are generally as thin as possible, compatibly with the necessary mechanical resistance at high temperatures; optimal thickness values are comprised between 0.15 and 0.45 mm.

Figure 5 shows, in a view similar to that of figure 4, a slightly different embodiment of system 11; in this case sheets 50 (analogous to sheets 40) present, besides protrusions 51, 51', ..., a plurality of holes 52, 52', ...; this arrangement helps in enhancing the turbulence of motion of the gas in its passage across system 11, thereby increasing the efficiency of the contact between the gas and panels 12, and as a consequence the efficiency of system 11 in gas treatment; in figure 5 the holes are shown circular, but their shape could be essentially any. In a system 11 comprising sheets of kind 50, it is preferable that holes do not take more than 50% of the surface of the sheet, in order not to cause structural problems to this latter when system 11 works at high temperatures

Even more preferably is the case in which relieves and openings are coincident. Figure 6 is an example of this embodiment. In this case, sheet 60 has openings 61 obtained by partially cutting the sheet obtaining "wings" 62 joined to the sheet along at least a margin, and bending these "wings" along said margin; the dimensions of the "wings" and their bending angle with respect to the sheet plane will determine the distance between the surface of sheet 60 and that of the adjacent panel 12, so that these "wings" constitute the spacers in this embodiment; figure 6 shows rectangular "wings" (and openings), but obviously any other suitable form could be adopted. Cuts on sheet 60 defining these "wings" may be practiced by mechanical shearing, laser cutting or any other known method.

The various kinds of systems 11 so far described are preferably inserted into a metallic casing, surrounding the system on all sides but inlet and outlet sides, which is then in turn inserted into housing 13; preferably, between this metallic casing and housing 13, ceramic fibers plates are disposed for thermal insulation reasons.

Figure 7 shows a panel 12 that can be used for still another embodiment of system 11 of the invention; for the sake of representation clarity, this figure shows the assembly of the panel with a few spacers. In this case, the spacers 70 are metallic sheets having a geometric area that is a small fraction of the geometric area of panels 12 (contrary to sheets 40, 50 and 60), and rolled up in a such fashion that any contact points with adjacent panels are curved and smooth. Spacers 70 are kept in place by fixing them (e.g., by spot welding) onto metallic tapes 71; tapes 71 are as narrow as possible, compatibly with the needs of being enough mechanically strong and of offering a sufficient area for fixing spacers 70. In their turn, tapes 71 are kept in place by fixing them (e.g., again by spot welding) to two metallic elements of kind 16, fixed by crimping to the two lateral edges of panel 12 (with respect to the gas flow direction in converter 10, indicated by the arrow); while the other two elements of kind 16 (the ones facing inlet 14 and outlet 15 of converter 10) could be joined to the panel before the thermal oxidation treatments of the fibers, the two lateral elements of kind 16 are better added to panel 12 at the end of its production, in order to avoid their oxidation and guarantee good welding characteristics to tapes 71. Other spacers of kind 70 are present on the other face, hidden in the figure, of panel 12: the spacers are preferably placed in the same positions on all panels of the converter system, so that by stacking a plurality of panels the spacers form a kind of pillar, having an overall effect of strengthening the structure.

Figure 8 shows in an exploded view the preferred assembly of system 11 when spacers of kind 70 are used: for the sake of clarity, no spacers are shown in this figure. In this case, in order to assure mechanical stability to the system, it has been found that the panels are better inserted in two lateral holding members, 80, 80', having the shape of a Greek fret. Panels 12 can be fixed to members 80, 80' by mechanical crimping of the sections of the fret onto lateral elements of kind 16, the same elements bearing tapes 71. The assembly made up of panels and holding members is in turn inserted in a metallic casing 81, surrounding the four faces of the assembly parallel to the flow of gases, but open at the inlet and outlet sides. This arrangement would leave possible passageways 82 for gases to by-pass system 11, and thus emerge at outlet 15 untreated. In order to avoid this risk, passageways 82 are filled with a high-temperature resistant glue (not shown in figure); these glue normally comprise metallic powders (e.g., steel powders) in an inorganic binder; a suitable glue is Durabond 954, sold by COTRONICS Corp. of Brooklyn, NY (USA). The assembly is completed by joining on its back and front faces two frames, 83, 83', that concur in ensuring that no passageways are left for gases coming from the engine to by-pass the system 11; frames 83, 83', are joined to front and back elements of kind 16 of panels 12, to the ends of holding members 80, 80', and possibly to casing 81 again by means of gluing.

The converter according to the invention, by comprising panels produced with metal fibers, is particularly suitable for its arrangement as close as possible to the motor (configuration known in the field as "Close Coupled Catalyst" or CCC), i.e. in the position ensuring that the converter works at the maximum temperature, thus obtaining a high conversion efficiency. Again, thanks to its metallic structure, the converter of the invention can tolerate sudden changes of temperature, as those expected in the modern systems for abating pollutants coming from internal combustion engines. Particularly critical in the case of Diesel engines is the so-called "post-injection" phase, consisting in an injection of fuel into the cylinders when these are in the exhaust stroke (outlet valves open), and thus the fuel does not explode in the cylinder but reaches, unburned, the CCC converter where it is catalytically oxidized due to the high temperature of the latter. Thus, the gases leaving the CCC have a very high temperature and can burn the particulate accumulated on the proper filter (known in the field as "Diesel Particulate Filter" or DPF), thereby allowing the regeneration of the latter: an example of DPF filter is described in Italian Patent Application MI2003A002211 in the name of the Applicant.

Another important advantage offered by the converter system of the invention is the low weight of the support material compared to a honeycomb converter systems of the prior art occupying the same volume (and thus having about the same amount of catalytic metals and essentially the same conversion efficiency). The inventors have prepared different kinds of converter systems of the invention and, by measuring their weights and volumes, it has been found that these have on average a weight of 0.28 grams per cubic centimeter of the system; on the other hand, a similar measure on prior art systems has revealed an average weight of about 0.62 grams per cubic centimeter. Besides a lower overall weight (that's already an advantage per se) this involves the important advantage of a lower thermal inertia, so that the systems of the invention reach more quickly high temperatures, at which the catalyst has the best performances, thus reducing the "cold-start" problem.

CLAIMS

1. Converter (10) for exhaust gases of internal combustion engines, comprising a housing (13) which is provided with at least one inlet opening (14) for the exhaust gases to be converted and with at least one outlet opening (15) for the converted gases and includes a converting system (11), characterized in that said converting system comprises a plurality of panels (12) of fibers (30) comprising a metallic core (31) covered with a layer of oxides (32) over which catalytically active metals (33) are present, said panels being arranged with an edge facing the inlet opening and with another edge facing the outlet opening, essentially parallel to each other, and kept spaced apart by means of metallic spacers (41, 41'; 51, 51'; 62; 70).

2. Converter according to claim 1, wherein said core (31) of said fibers (30) is made of an alloy containing iron, chrome and aluminum and is covered with a multilayer (32) of oxides, comprising a first layer (32') of aluminum oxide in contact with said alloy, a second oxide layer (32") and optionally a third layer (32"') of oxide of cerium, zirconium and optionally lanthanum.

3. Converter according to claim 2, wherein said multilayer (32) is coated with one or more catalysts (33) chosen among the noble metals of the eighth group of the periodic table or their compounds.

4. Converter according to claim 3, wherein said catalyst is platinum.

5. Converter according to claim 1, wherein said converting system (11) is made of panels (12) surrounded by metallic elements (16).

6. Converter according to claim 1, wherein the distance between two adjacent panels (12) of said converting system (11) is comprised between 1 and 4 mm.

7. Converter according to claim 1, wherein the distance between two adjacent panels (12) of said converting system (11) is comprised between 2 and 3 mm.

8. Converter according to claim 1, wherein said converting system (11) comprises an alternate stacking of panels (12) and metallic sheets (40), said sheets

presenting protrusions (41, 41') on both faces.

9. Converter according to claim 1, wherein said converting system (11) comprises an alternate stacking of panels (12) and metallic sheets (50), said sheets presenting protrusions (51, 51') on both faces of the sheets and holes (52, 52') allowing the passage of gases to be converted from one side to another of the sheet.

10. Converter according to claim 9, wherein said protrusions and holes are coincident and are formed by making cuts on the sheets (60), thereby obtaining wings (62) joined to the sheet along at least a margin, and bending said wings along said margin thereby obtaining said holes (61).

11. Converter according to claim 5, wherein said converting system (11) comprises a stacking of panels (12) kept at the desired distance by means of spacers (70) being metallic sheets having a geometric area that is lower than the geometric area of said panels, and rolled up in a such fashion that any contact points with adjacent panels are curved and smooth.

12. Converter according to claim 11, wherein said spacers (70) are kept in place by fixing them onto metallic tapes (71), which in turn are kept in place by fixing them to two metallic elements (16) surrounding the panel.

13. Converter according to claim 12, wherein said two metallic elements (16) are those at the sides of the panel parallel to the flow of gas in the converter.

14. Converter according to claim 13, wherein the sides of the panel parallel to the flow of gas in the converter are held by two lateral holding members (80, 80') having the shape of a Greek fret; the assembly made up of panels (12) and holding members (80, 80') is inserted in a metallic casing (81) surrounding the four faces of the assembly parallel to the flow of gases in the converter but open at the inlet and outlet sides; the passageways (82) between holding members (80, 80') and the casing (81) are filled with a high-temperature resistant glue; and two metallic frames (83, 83') are joined to front and back surrounding elements (16) of the panels (12), to the ends of said holding members (80, 80') and optionally to said casing (81).

15. Converter according to any of the preceding claims, wherein the

converting system (11) is inserted in a casing (81) which is then placed in said housing (13) of said converter (10) interposing ceramic plates between said casing and said housing.

Fig.1

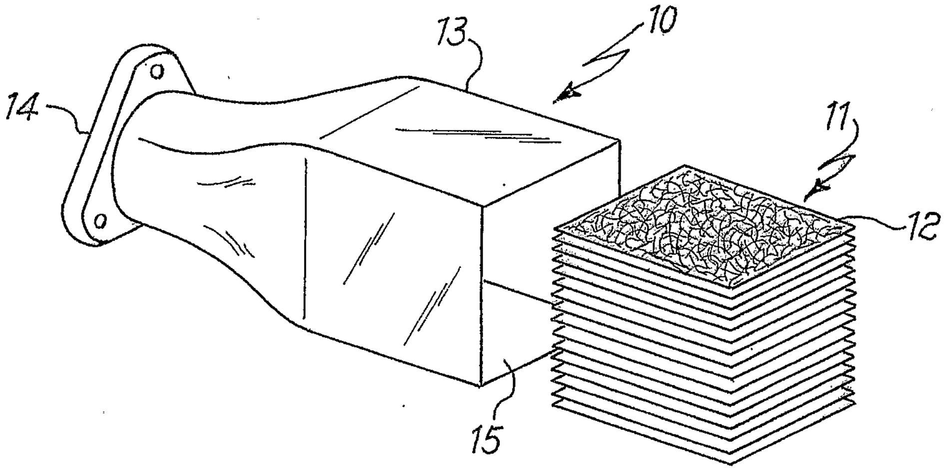


Fig.2

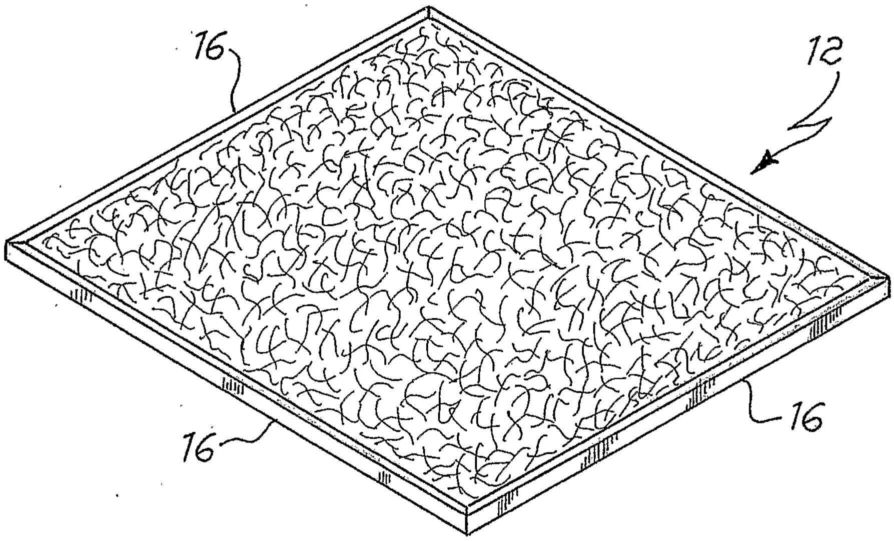


Fig.3

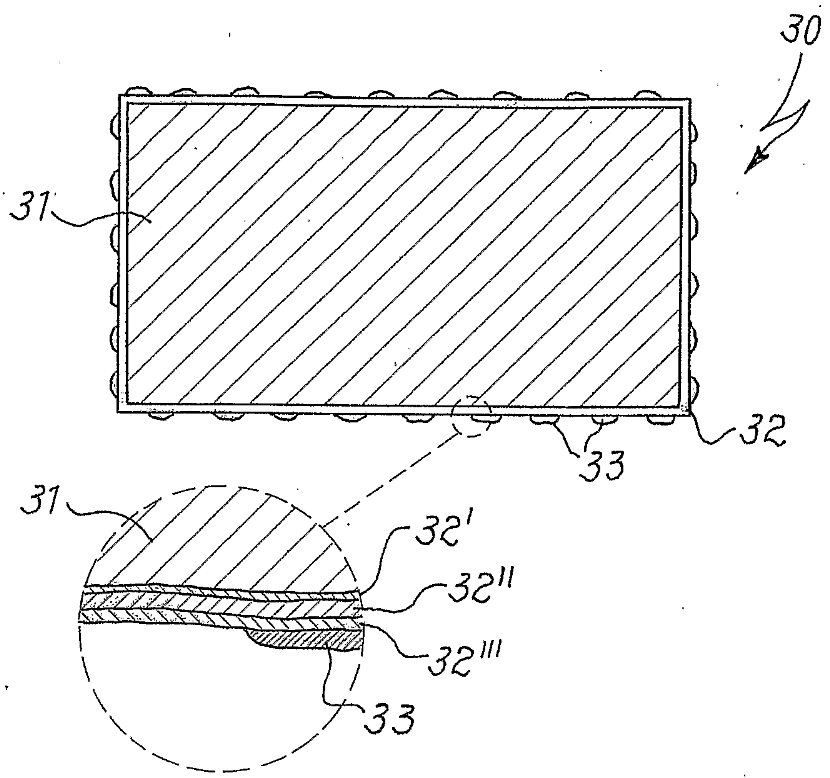


Fig.4

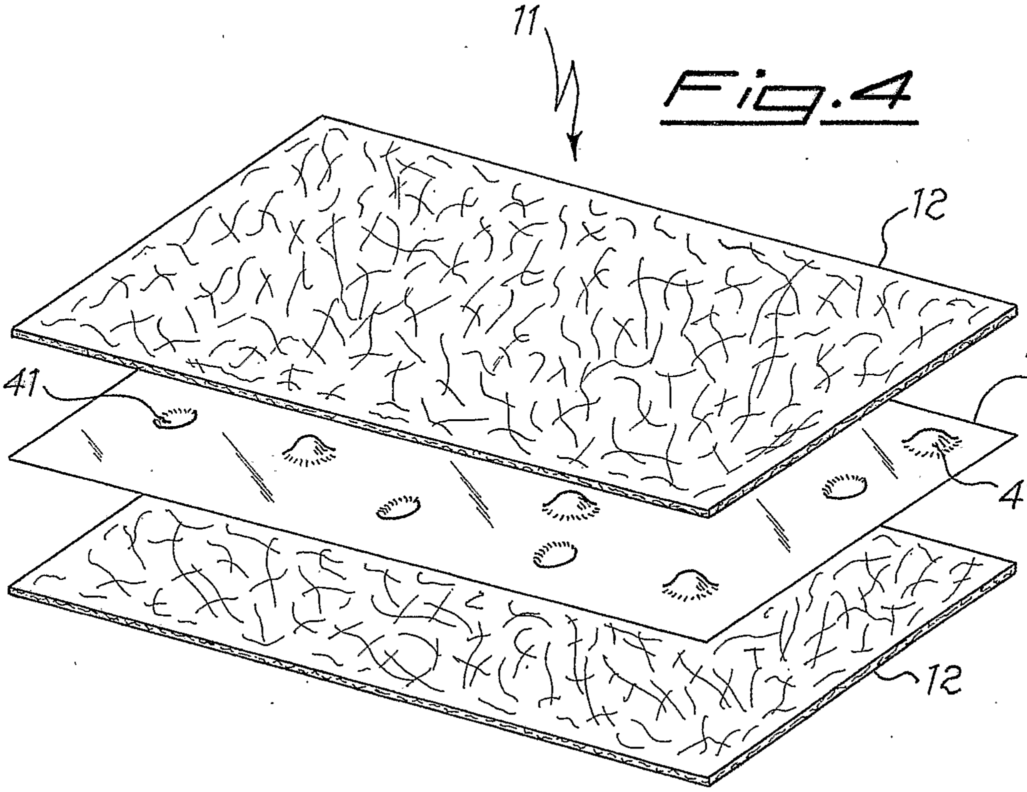
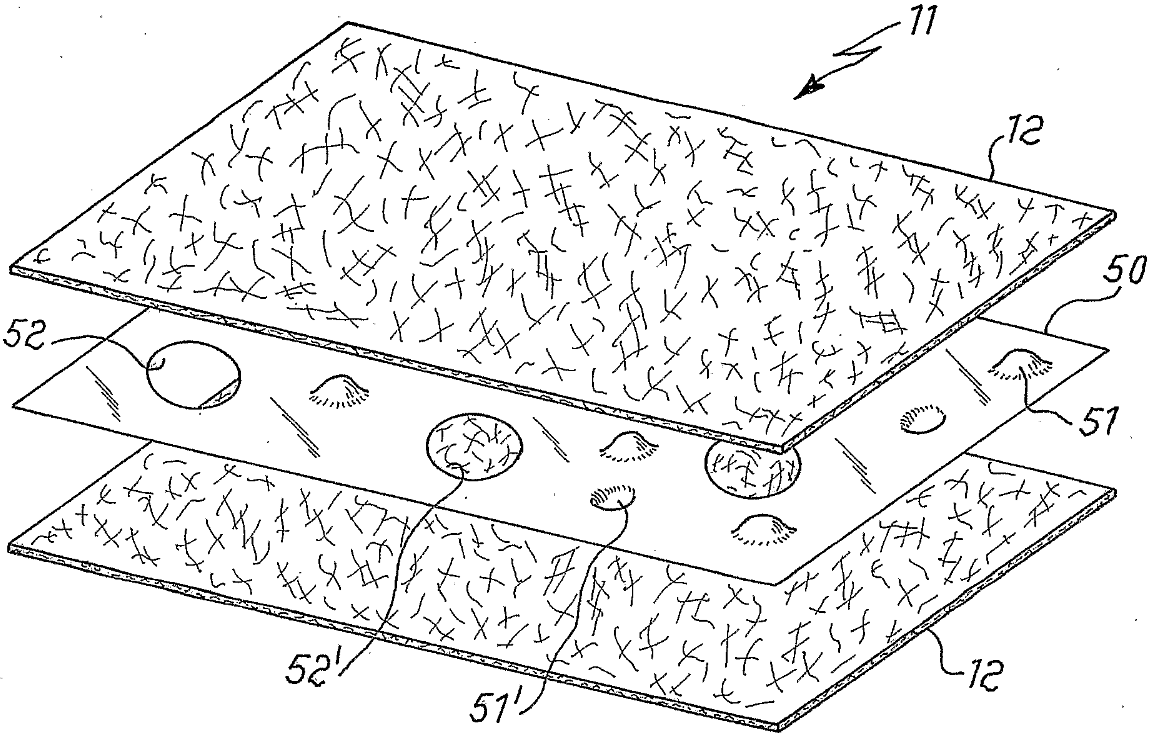


Fig.5



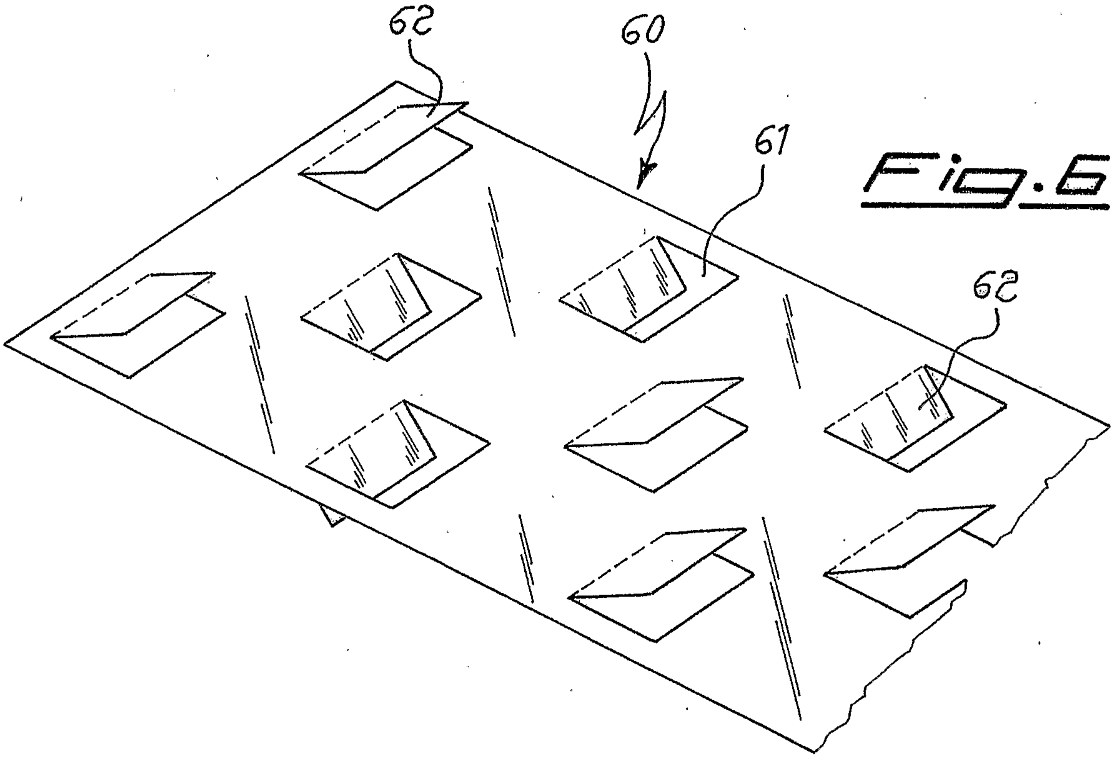


Fig.6

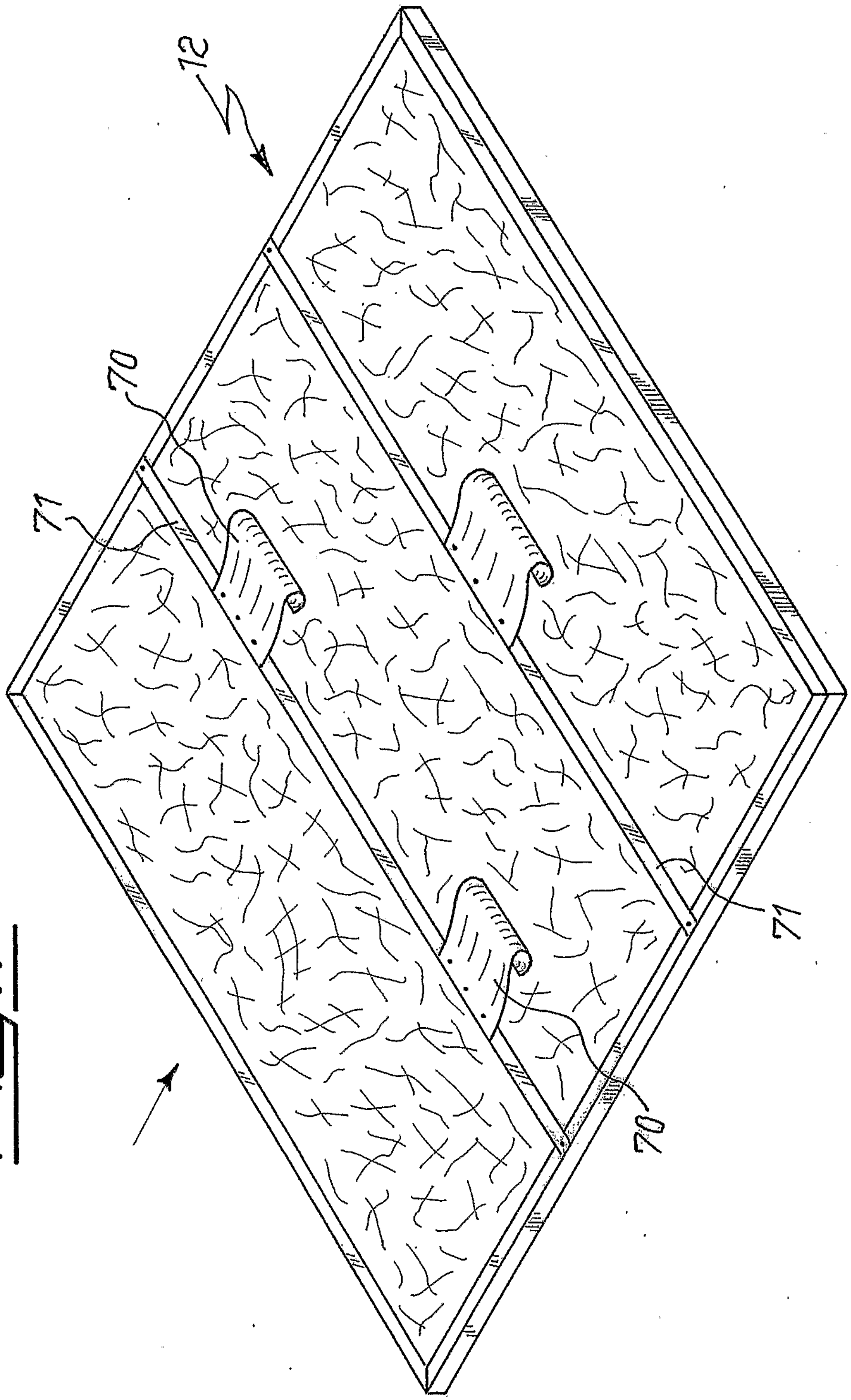


Fig.7

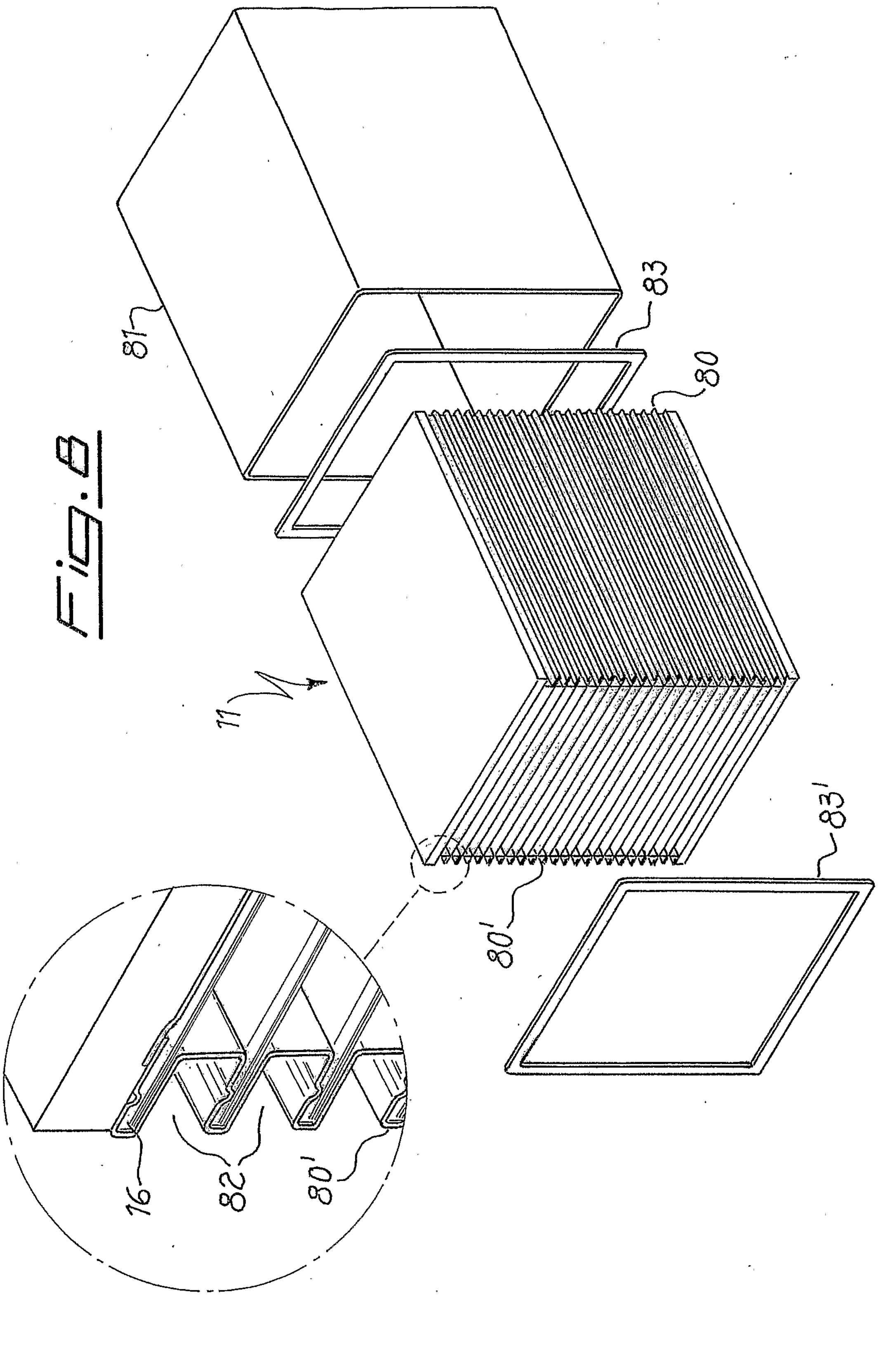


Fig. 8

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB2004/003398

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F01N3/28

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 F01N

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 00/53904 A (ABB LUMMUS GLOBAL, INC) 14 September 2000 (2000-09-14) the whole document	1-7
A	US 5 102 745 A (TATARCHUK ET AL) 7 April 1992 (1992-04-07) claims 1-3	1
A	US 4 446 250 A (NIWA ET AL) 1 May 1984 (1984-05-01) column 3, line 11 - column 3, line 35; figures 1a,1b,2	1
A	US 4 280 926 A (ABE ET AL) 28 July 1981 (1981-07-28) column 6, line 7 - column 6, line 15; figures 4,5	1

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

[X] 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
4 February 2005	11/02/2005

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	Tatus, W

Form PCT/ISA/210 (second sheet) (January 2004)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2003 126703 A (MITSUBISHI HEAVY IND LTD) 7 May 2003 (2003-05-07) abstract	1
A	PATENT ABSTRACTS OF JAPAN vol. 2003, no. 09, 3 September 2003 (2003-09-03) & JP 2003 126703 A (MITSUBISHI HEAVY IND LTD), 7 May 2003 (2003-05-07) abstract	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IB2004/003398

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			FR	2435967	A1	11-04-1980
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