



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
15.10.2014 Bulletin 2014/42

(51) Int Cl.:
D06M 15/263 ^(2006.01) **D06M 15/693** ^(2006.01)
D06M 23/06 ^(2006.01) **D06M 23/16** ^(2006.01)
F01N 3/28 ^(2006.01)

(21) Application number: **14161516.1**

(22) Date of filing: **25.03.2014**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(71) Applicant: **IBIDEN CO., LTD.**
Ogaki-shi, Gifu 503-8604 (JP)

(72) Inventor: **Suzuki, Daisuke**
Takahama-shi, Aichi 444-1301 (JP)

(74) Representative: **Louis Pöhlau Lohrentz**
Patentanwälte
Postfach 30 55
90014 Nürnberg (DE)

(30) Priority: **09.04.2013 JP 2013081534**

(54) **Holding seal material, manufacturing method for holding seal material and exhaust gas purification apparatus**

(57) To provide a holding seal material which, when inserting an exhaust gas treatment around which the holding seal material is wound into a metal casing, prevents easy breakage of an inorganic fiber, enables the exhaust gas treatment unit to be easily housed in the metal casing, and does not easily deviate from the exhaust gas treatment unit.

Provided is a holding seal material used in an exhaust gas purification apparatus made up of an exhaust gas treatment unit, a metal casing housing the exhaust gas treatment unit, and the holding seal material made of an inorganic fiber and provided between the exhaust gas treatment unit and the metal casing, in which the holding seal material includes a first principal surface in contact with the metal casing and a second principal surface in contact with the exhaust gas treatment unit, the first principal surface and the second principal surface are soaked with organic binders, and a glass transition temperature of an organic binder A soaked into the first principal surface is higher than a glass transition temperature of an organic binder B soaked into the second principal surface.

FIG. 1A

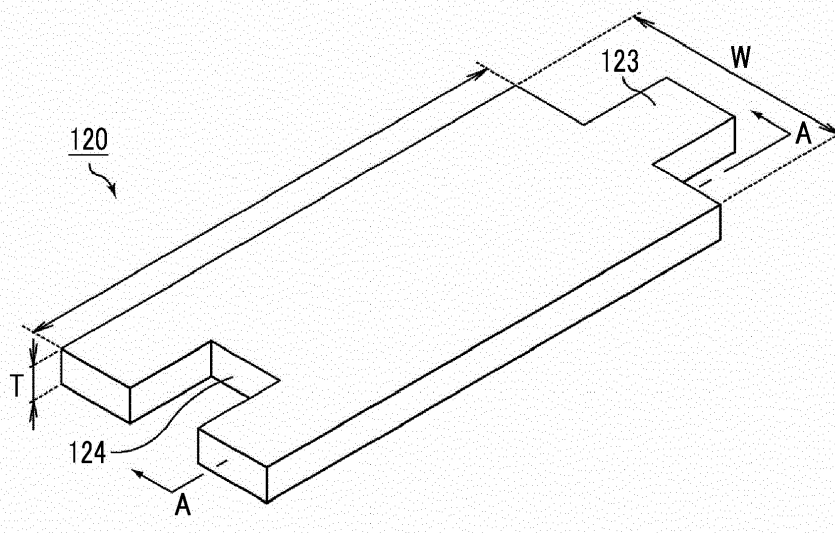
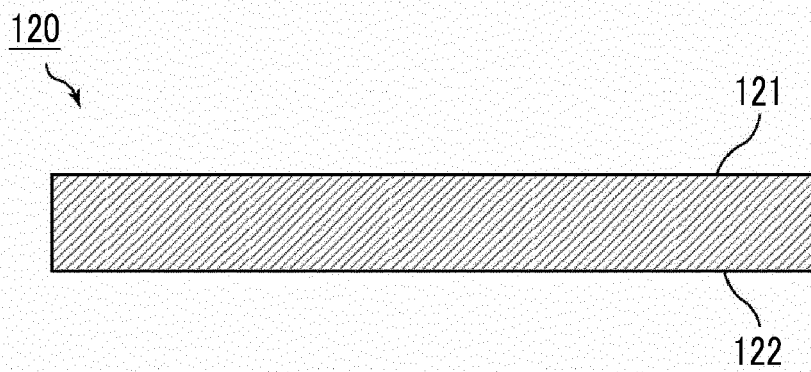


FIG. 1B



A-A LINE CROSS-SECTIONAL VIEW

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a holding seal material, a manufacturing method for a holding seal material and an exhaust gas purification apparatus.

Description of Related Art

[0002] Exhaust gas emitted from an internal-combustion engine such as a diesel engine contains particulate matter (hereinafter, also referred to as PM), and, in recent years, the harmful influence of the PM on the environment or human bodies has become an issue. In addition, exhaust gas also contains harmful gas components such as CO, HC or NO_x, and thus there is a concern about the influence of the harmful gas components on the environment or human bodies.

[0003] Therefore, a variety of exhaust gas purification apparatuses made up of an exhaust gas treatment unit made of a porous ceramic such as silicon carbide or cordierite, a metal casing housing the exhaust gas treatment unit, and a holding seal material made of an inorganic fiber assembly and provided between the exhaust gas treatment unit and the metal casing have been proposed as an exhaust gas purification apparatus that traps PM in exhaust gas or purifies the harmful gas components. The holding seal material is provided mainly for preventing the exhaust gas treatment unit from coming into contact with the metal casing covering the outer circumference of the exhaust gas treatment unit so as not to be broken due to oscillation or impact generated during the running or the like of a vehicle or for preventing exhaust gas from leaking from between the exhaust gas treatment unit and the metal casing. Therefore, the holding seal material is required to have a function of reliably holding the exhaust gas treatment unit by increasing surface pressure generated by a repulsive force caused from compression of the holding seal material. In addition, the holding seal material is housed in the metal casing in a state of being wound around the exhaust gas treatment unit; however, in this case, there was a problem in that an end section of an inorganic fiber configuring the holding seal material came into direct contact with an operator so as to create discomfort, and the operation efficiency was lowered.

[0004] In the past, to solve the above-described problem, a method has been known in which surfaces of a holding seal material are coated with a solution containing an organic compound or an inorganic compound, thereby preventing the protrusion of the inorganic fiber (for example, refer to Patent Document 1)

[Patent Document 1] Japanese Unexamined Patent Application Publication No. 2002-13415

[0005] However, when an exhaust gas purification apparatus was manufactured using a holding seal material produced using the method disclosed in Patent Document 1, while it was possible to improve the discomfort of an operator, there were no studies regarding the ease of housing in the metal casing the exhaust gas treatment unit around which the holding seal material was wound. Therefore, depending on an organic binder being soaked, it was necessary to add a large force to house the exhaust gas treatment unit such that the inorganic fiber configuring the holding seal material broke or an exhaust gas purification unit deviated, and thus there was a problem in that a long time was required to house the exhaust gas treatment unit and the productivity dropped.

SUMMARY OF THE INVENTION

[0006] The invention has been made to solve the above-described problem, and an object of the invention is to provide a holding seal material which, when inserting an exhaust gas treatment around which the holding seal material is wound into a metal casing, enables the exhaust gas treatment unit to be easily housed in the metal casing, prevents easy breakage of an inorganic fiber, and does not easily deviate from the exhaust gas treatment unit, a manufacturing method for the holding seal material, and an exhaust gas purification apparatus.

[0007] To achieve the above-described object, there is provided a holding seal material used in an exhaust gas purification apparatus made up of an exhaust gas treatment unit, a metal casing housing the exhaust gas treatment unit, and the holding seal material made of an inorganic fiber and provided between the exhaust gas treatment unit and the metal casing, in which the holding seal material includes a first principal surface in contact with the metal casing and a second principal surface in contact with the exhaust gas treatment unit, the first principal surface and the second principal surface are soaked with organic binders, and a glass transition temperature of an organic binder A soaked into the first principal surface is higher than a glass transition temperature of an organic binder B soaked into the second principal surface.

[0008] In the holding seal material of the invention, the glass transition temperature of the organic binder A is higher than the glass transition temperature of the organic binder B. Generally, the glass transition temperature of a resin has a correlation with the hardness and ease of sliding of the resin. That is, since the organic binder A soaked into a predetermined area including the first principal surface has a higher glass transition temperature than the organic binder B soaked into a predetermined area including the second principal surface, a resin configuring the organic binder A is harder than a resin configuring the organic binder B. Therefore, the first principal surface of the holding seal material soaked with the organic binder A is relatively harder than the second principal surface of the holding seal material soaked with the

organic binder B, the coefficient of static friction with respect to the metal casing in contact with the first principal surface is low, and the holding seal material easily slips on the metal casing. On the other hand, since the second principal surface in contact with the exhaust gas treatment unit is relatively softer than the first principal surface, the coefficient of static friction with respect to the exhaust gas treatment unit is high, and it becomes difficult for the holding seal material to slide on the exhaust gas treatment unit.

[0009] As described above, when housing the exhaust gas treatment unit around which the holding seal material is wound in the metal casing, the first principal surface of the holding seal material soaked with the organic binder A becomes easily slippery on the metal casing, it is possible to easily house the exhaust gas treatment unit in the metal casing, and productivity improves. In addition, since there is no excessive force applied to the holding seal material when housing the exhaust gas treatment unit in the metal casing, it is possible to prevent the inorganic fiber or the mat from breaking. On the other hand, it becomes difficult for the second principal surface of the holding seal material soaked with the organic binder B to slide on the exhaust gas treatment unit, and the exhaust gas treatment unit and the holding seal material do not easily deviate from each other when housing the exhaust gas treatment unit around which the holding seal material is wound in the metal casing.

[0010] In the holding seal material of the invention, the glass transition temperature of the organic binder A is desirably in a range of 5°C to 50°C, and the glass transition temperature of the organic binder B is desirably in a range of -50°C to lower than 5°C.

[0011] Since the glass transition temperature of the organic binder A is close to room temperature or higher than room temperature, the first principal surface is likely to become relatively hard, and the first principal surface easily slips on the metal casing. On the other hand, since the glass transition temperature of the organic binder B is lower than room temperature, the second principal surface is relatively soft, and does not easily slide on the exhaust gas treatment unit. Since the holding seal material of the invention is configured as described above, when housing the exhaust gas treatment unit around which the holding seal material is wound in the metal casing through pressing-in or the like, the first principal surface of the holding seal material becomes easily slippery on the metal casing, and it is possible to easily house the exhaust gas treatment unit in the metal casing. In addition, the second principal surface of the holding seal material does not easily slide on the exhaust gas treatment unit, and, when housing the exhaust gas treatment unit around which the holding seal material is wound in the metal casing, the exhaust gas treatment unit and the holding seal material do not easily deviate from each other.

[0012] In a case in which the glass transition temperature of the organic binder A is lower than 5°C, there is

a case in which a housing operation does not smoothly proceed when housing the exhaust gas treatment unit and the holding seal material in the metal casing, and on the other hand, when the glass transition temperature of the organic binder A exceeds 50°C, substantially, there is no difference in the ease of sliding of the holding seal material on the metal casing compared with a case in which the glass transition temperature of the organic binder A is 50°C.

[0013] In a case in which the glass transition temperature of the organic binder B is lower than -50°C, substantially, there is no difference in smoothness compared with a case in which the glass transition temperature is -50°C. On the other hand, when the glass transition temperature of the organic binder B is 5°C or higher, the glass transition temperature becomes close to room temperature, and the second principal surface becomes hard, and therefore the holding seal material becomes easily slippery on the exhaust gas treatment unit.

[0014] In the holding seal material of the invention, it is desirable that the organic binder A be soaked into a predetermined area including the first principal surface, the organic binder B be soaked into a predetermined area including the second principal surface, an soaked amount of the organic binder A soaked into the predetermined area including the first principal surface be in a range of 0.2 parts by weight to 12.0 parts by weight with respect to 100 parts by weight of the inorganic fiber, and an soaked amount of the organic binder B soaked into the predetermined area including the second principal surface be in a range of 0.2 parts by weight to 12.0 parts by weight with respect to 100 parts by weight of the inorganic fiber. In a case in which the soaked amount of the organic binder A is less than 0.2 parts by weight with respect to 100 parts by weight of the inorganic fiber, since the first principal surface of the holding seal material does not become sufficiently hard, there is a case in which a housing operation does not smoothly proceed, and on the other hand, in a case in which the soaked amount of the organic binder A exceeds 12.0 parts by weight, the effect that facilitates housing does not change; however, sometimes, there is a problem in that a large amount of decomposition gas is generated from exhaust gas. In a case in which the soaked amount of the organic binder B is less than 0.2 parts by weight with respect to 100 parts by weight of the inorganic fiber, since the holding seal material becomes more slippery than expected, there is a case in which the exhaust gas treatment unit deviates when housing the exhaust gas treatment unit and the holding seal material in the metal casing, and on the other hand, in a case in which the soaked amount of the organic binder B exceeds 12.0 parts by weight, the effect that facilitates housing does not change; however, sometimes, there is a problem in that a large amount of decomposition gas is generated from exhaust gas.

[0015] In the holding seal material of the invention, a total soaked amount of the organic binder A and the organic binder B is desirably in a range of 0.5 parts by

weight to 3.0 parts by weight with respect to 100 parts by weight of the inorganic fiber. When the total soaked amount of the organic binder A and the organic binder B is 0.5 parts by weight or more, it becomes easy to preferably adjust the coefficient of static friction between the first principal surface and the second principal surface. When the total soaked amount of the organic binder A and the organic binder B is 3.0 parts by weight or less, it becomes easy to sufficiently suppress the generation of a large amount of decomposition gas from exhaust gas.

[0016] In the holding seal material of the invention, the organic binder A and the organic binder B desirably contain at least an acryl-based resin.

[0017] Since the acryl-based resin can easily adjust the glass transition temperature, it becomes easy to adjust the glass transition temperatures of the organic binder A and the organic binder B soaked into the first principal surface and the second principal surface, and it becomes easy to adjust ease of sliding and difficulty of sliding.

[0018] The inorganic fiber configuring the holding seal material of the invention is desirably made of at least one selected from a group consisting of alumina fibers, silica fibers, alumina silica fibers, mullite fibers, biosoluble fibers and glass fibers.

[0019] In a case in which the inorganic fiber is at least one of alumina fibers, alumina silica fibers and silica fibers in the holding seal material, since the inorganic fiber has excellent thermal resistance, even in a case in which exhaust gas reaches a high temperature, the inorganic fiber is not affected, and can maintain a function as the holding seal material to a sufficient extent. In addition, in a case in which the inorganic fiber is a biosoluble fiber, since the fiber is dissolved in living bodies even when the inorganic fiber is scattered and absorbed during production of an exhaust gas purification apparatus using the holding seal material, there is no case in which the operator's health is harmfully affected.

[0020] In addition, it is possible to relatively easily adjust the ease of sliding and the like on the metal casing or the like by soaking the organic binders using the inorganic fiber.

[0021] There is provided a manufacturing method for the holding seal material of the invention including a mat preparation step of preparing a mat for the holding seal material made of the inorganic fiber on which a needle punching treatment has been carried out; an soaking step of blowing liquid droplets of an organic binder-containing liquid containing the organic binder A to the first principal surface of the mat; and a drying step of drying the mat containing the organic binder-containing liquid.

[0022] In the manufacturing method for the holding seal material of the invention, the above-described holding seal material of the invention can be relatively easily manufactured. In addition, the holding seal material manufactured using the manufacturing method for the holding seal material of the invention has the organic binder A soaked into the first principal surface, and therefore the

first principal surface easily slips on the metal casing, and an operation becomes easy when housing the exhaust gas treatment unit and the holding seal material in the metal casing.

[0023] The manufacturing method for the holding seal material of the invention desirably further includes a step of blowing liquid droplets of an organic binder-containing liquid containing the organic binder B to the second principal surface of the mat in the soaking step. When the second principal surface is soaked with the organic binder B, it becomes difficult for the second principal surface of the holding seal material to slide on the exhaust gas treatment unit, it is possible to prevent the exhaust gas treatment unit and the holding seal material from deviating from each other when housing the exhaust gas treatment unit and the holding seal material in the metal casing, and principal operations become easy.

[0024] There is provided an exhaust gas purification apparatus of the invention including a metal casing; an exhaust gas treatment unit housed in the metal casing; and a holding seal material wound around the exhaust gas treatment unit and provided between the exhaust gas treatment unit and the metal casing, in which the above-described holding seal material is used as the holding seal material.

[0025] The holding seal material of the invention includes the first principal surface and the second principal surface, the first principal surface is in contact with the metal casing, the second principal surface is in contact with the exhaust gas treatment unit, the first principal surface and the second principal surface are soaked with two kinds of organic binders, and the glass transition temperature of the organic binder A soaked into the first principal surface is higher than the glass transition temperature of the organic binder B soaked into the second principal surface.

[0026] In the exhaust gas purification apparatus of the invention, since the first principal surface is soaked with the organic binder A, the holding seal material becomes easily slippery on the metal casing. Therefore, when housing the holding seal material and the exhaust gas treatment unit in the exhaust gas purification apparatus, the inorganic fiber is not easily broken, and furthermore, it becomes possible to easily house the holding seal material and the exhaust gas treatment unit in the exhaust gas purification apparatus. In addition, since the second principal surface is soaked with the organic binder B, it becomes difficult for the holding seal material to slide on the exhaust gas treatment unit, it becomes difficult for the holding seal material to deviate from the exhaust gas treatment unit, and an exhaust gas purification apparatus in which the holding seal material and the exhaust gas treatment unit are appropriately disposed is obtained.

[0027] Meanwhile, in the exhaust gas purification apparatus, when exhaust gas is introduced, the organic binders are decomposed and burned, and an action of expanding the holding seal material works, and therefore the holding seal material is held with an appropriate hold-

ing force, and there is no case in which the exhaust gas treatment unit is removed from the metal casing due to the pressure and the like of exhaust gas.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028]

Fig. 1A is a perspective view schematically illustrating an example of a holding seal material of the invention, and Fig. 1B is a cross-sectional view of the holding seal material taken along A-A line in Fig. 1A. Fig. 2 is a cross-sectional view schematically illustrating an example of an exhaust gas purification apparatus of the invention.

Fig. 3 is a perspective view schematically illustrating an example of an exhaust gas treatment unit configuring the exhaust gas purification apparatus of the invention.

Fig. 4 is a perspective view schematically illustrating an example of a manufacturing method for the exhaust gas purification apparatus of the invention.

Figs. 5A and 5B are schematic views illustrating an example of a measurement method of the coefficient of static friction.

DETAILED DESCRIPTION OF THE INVENTION

(Detailed description of the invention)

[0029] Hereinafter, the invention will be specifically described. However, the invention is not limited to the following configuration, and the invention can be appropriately modified and applied within the scope of the purpose of the invention.

[0030] Hereinafter, a holding seal material of the invention will be described.

[0031] Fig. 1A is a perspective view schematically illustrating an example of the holding seal material of the invention, and Fig. 1B is a cross-sectional view of the holding seal material taken along A-A line in Fig. 1A. As illustrated in Fig. 1A, a holding seal material 120 of the invention is made of a mat having a substantially rectangular plate shape in a planar view and having a predetermined longitudinal direction length (hereinafter, indicated by arrow L in Fig. 1), a predetermined width (indicated by arrow W in Fig. 1) and a predetermined thickness (indicated by arrow T in Fig. 1). In addition, as illustrated in Fig. 1B, the holding seal material 120 of the invention includes a first principal surface 121 and a second principal surface 122 that is a principal surface on the opposite side to the first principal surface 121.

[0032] In the holding seal material 120 illustrated in Fig. 1, a protrusion section is formed in a first end section 123 that is one of end sections of the holding seal material 120 in the longitudinal direction, and a recess section is formed in a second end section 124 that is the other end section. The protrusion section and recess section of the

holding seal material 120 have shapes so that both sections are tightly fit together when winding the holding seal material 120 around an exhaust gas treatment unit to assemble an exhaust gas purification apparatus described below.

[0033] The holding seal material 120 contains an inorganic fiber as a principal component, and organic binders are soaked into the inorganic fiber. That is, the first principal surface of the holding seal material 120 is soaked with an organic binder A, and the second principal surface is soaked with an organic binder B.

[0034] The inorganic fiber is not particularly limited, but is desirably made of at least one selected from a group consisting of alumina fibers, silica fibers, alumina silica fibers, mullite fibers, biosoluble fibers and glass fibers.

[0035] The alumina fiber may contain, for example, additives such as calcia, magnesia and zirconia in addition to alumina.

[0036] The composition ratio of the alumina silica fiber is desirably in a range of 60:40 to 80:20 ($\text{Al}_2\text{O}_3:\text{SiO}_2$), and more desirably in a range of 70:30 to 74:26 ($\text{Al}_2\text{O}_3:\text{SiO}_2$) in terms of weight ratio.

[0037] The biosoluble fiber is an inorganic fiber containing, for example, at least one compound selected from a group consisting of alkali metal compounds, alkali earth metal compounds and boron compounds in addition to silica and the like.

[0038] Since the biosoluble fiber made of the above-described compound is easily dissolved even after being absorbed in human bodies, a mat containing the inorganic fiber is extremely safe for human bodies.

[0039] As a specific composition, the biosoluble fiber contains 60 weight% to 85 weight% of silica and 15 weight% to 40 weight% of at least one compound selected from a group consisting of alkali metal compounds, alkali earth metal compounds and boron compounds. The silica refers to SiO or SiO_2 .

[0040] Examples of the alkali metal compounds include sodiumoxide, potassium oxide and the like, and examples of the alkali earth metal compounds include magnesium oxide, calcium oxide, barium oxide and the like. Examples of the boron compounds include boron oxide and the like.

[0041] Regarding the composition of the biosoluble fiber, when the content of silica is less than 60 weight%, it is difficult to produce the biosoluble fiber using a glass melting method, and fibrillization is difficult.

[0042] In addition, when the content of silica is less than 60 weight%, since the content of flexible silica is low, the biosoluble fiber is structurally brittle and is easily soluble in a normal saline solution, and the proportion of at least one compound selected from a group consisting of alkali metal compounds, alkali earth metal compounds and boron compounds becomes relatively great, and therefore there is a tendency for the biosoluble fiber to become excessively soluble in a normal saline solution.

[0043] On the other hand, when the content of silica exceeds 85 weight%, since the proportion of at least one

compound selected from a group consisting of alkali metal compounds, alkali earth metal compounds and boron compounds becomes relatively small, there is a tendency for the biosoluble fiber to become excessively insoluble in a normal saline solution.

[0044] Meanwhile, the content of silica is computed after the amount of SiO and SiO₂ is converted to the amount of SiO₂.

[0045] In addition, in the composition of the biosoluble fiber, the content of at least one compound selected from a group consisting of alkali metal compounds, alkali earth metal compounds and boron compounds is desirably in a range of 15 weight% to 40 weight%. When the content of at least one compound selected from a group consisting of alkali metal compounds, alkali earth metal compounds and boron compounds is less than 15 weight%, the biosoluble fiber becomes difficult to be dissolved in a normal saline solution.

[0046] On the other hand, when the content of at least one compound selected from a group consisting of alkali metal compounds, alkali earth metal compounds and boron compounds exceeds 40 weight%, it is difficult to produce the biosoluble fiber using a glass melting method, and fibrillization is difficult. In addition, when the content of at least one compound selected from a group consisting of alkali metal compounds, alkali earth metal compounds and boron compounds exceeds 40 weight%, the biosoluble fiber becomes structurally brittle and becomes excessively soluble in a normal saline solution.

[0047] The solubility of the biosoluble fiber in a normal saline solution is desirably 30 ppm or more. This is because, when the solubility of the biosoluble fiber is less than 30 ppm, in a case in which the inorganic fiber is absorbed in a human body, it is difficult to discharge the inorganic fiber outside the human body, which is not desirable in terms of human health.

[0048] The glass fiber is a glass-form fiber containing silica and alumina as principal components and containing calcia, titania, zinc oxide and the like in addition to the alkali metal.

[0049] The average fiber length of the inorganic fiber configuring the holding seal material 120 is desirably in a range of 5 mm to 150 mm, and more desirably in a range of 10 mm to 80 mm.

[0050] When the average fiber length of the inorganic fiber is less than 5 mm, since the fiber length of the inorganic fiber is too short, the inorganic fiber segments are not sufficiently interwoven, and the shear strength of the holding seal material becomes low. In addition, when the average fiber length of the inorganic fiber exceeds 150 mm, since the fiber length of the inorganic fiber is too long, it becomes more difficult to handle the inorganic fiber when manufacturing the holding seal material. As a result, it becomes more difficult to wind the holding seal material around the exhaust gas treatment unit, and the holding seal material becomes more breakable.

[0051] The average fiber diameter of the inorganic fiber configuring the holding seal material 120 of the invention

is desirably in a range of 1 μm to 20 μm, and more desirably in a range of 3 μm to 10 μm.

[0052] When the average fiber diameter of the inorganic fiber is in a range of 1 μm to 20 μm, the strength and flexibility of the inorganic fiber become sufficiently high, and it is possible to improve the shear strength of the holding seal material.

[0053] When the average fiber diameter of the inorganic fiber is less than 1 μm, since the inorganic fiber is thin and easily breakable, the tensile strength of the inorganic fiber becomes insufficient. On the other hand, when the average fiber diameter of the inorganic fiber exceeds 20 μm, since the inorganic fiber is not easily bent, the flexibility becomes insufficient.

[0054] The basis weight (weight per unit area) of the holding seal material of the invention is not particularly limited, but is desirably in a range of 200 g/m² to 4000 g/m², and more desirably in a range of 1000 g/m² to 3000 g/m². When the basis weight of the holding seal material is less than 200 g/m², the holding force is not sufficient, and, when manufacturing an exhaust gas purification apparatus, there is a case in which the exhaust gas treatment unit becomes easily detachable from the holding seal material. On the other hand, in a case in which the basis weight of the holding seal material exceeds 4000 g/m², it is difficult to make the bulk of the holding seal material small, and there is a case in which it becomes difficult to wind the holding seal material around the exhaust gas treatment unit.

[0055] In addition, the bulk density (bulk density of the holding seal material before being wound) of the holding seal material of the invention is also not particularly limited, but is desirably in a range of 0.10 g/cm³ to 0.30 g/cm³. When the bulk density of the holding seal material is less than 0.10 g/cm³, since the entanglement of the inorganic fiber is weak, and the inorganic fiber is easily detachable, it becomes difficult to maintain the shape of the holding seal material in a predetermined shape.

[0056] In addition, when the bulk density of the holding seal material exceeds 0.30 g/cm³, the holding seal material becomes hard such that it becomes more difficult to wind the holding seal material around the exhaust gas treatment unit, and the holding seal material becomes more breakable.

[0057] The "substantially rectangular plate shape in a planar view" described in the invention conceptually includes shapes having a protrusion section and a recess section. In addition, examples of the "substantially rectangular plate shape in a planar view" also include shapes having a non-right angle at a corner section. For example, the mat may have an acute angle or an obtuse angle at a corner section, and may have a curvature at a corner section.

[0058] The holding seal material of the invention may further contain an expansive material. The expansive material desirably has a characteristic of expanding in a range of 400°C to 800°C.

[0059] When the mat contains the expansive material,

since the mat becomes expansive in a range of 400°C to 800°C, it is possible to improve the holding force when the mat is used as the holding seal material even at a high temperature of higher than 700°C at which the strength of the glass fiber decreases.

[0060] Examples of the expansive material include vermiculite, bentonite, bronze mica, pearlite, expansive graphite, expansive fluoromica and the like. The above-described expansive materials may be solely used, or two or more thereof may be jointly used.

[0061] The added amount of the expansive material is not particularly limited, but is desirably in a range of 10 weight% to 50 weight%, and more desirably in a range of 20 weight% to 30 weight% with respect to the total weight of the mat.

[0062] In a case in which the holding seal material of the invention is used as a holding seal material in an exhaust gas purification apparatus, the number of sheets of the holding seal material configuring the exhaust gas purification apparatus is not particularly limited, and may be one sheet of the holding seal material or a plurality of mutually-bonded sheets of the holding seal material, but is particularly desirably one sheet of the holding seal material. In a case in which one sheet of the holding seal material is used as the holding seal material in the exhaust gas purification apparatus, since there is no contact section between the sheets of the holding seal material, it is possible to further prevent the inorganic fiber from being broken due to friction between the sheets of the holding seal material, and to prevent the sheets of the holding seal material from deviating from each other when housing the exhaust gas treatment unit in the metal casing.

[0063] A method for binding a plurality of sheets of the holding seal material is not particularly limited, and examples thereof include a method in which the sheets of the holding seal material are sewed up together using lockstitch, a method in which the sheets of the holding seal material are adhered together using adhesive tape, an adhesive, or the like.

[0064] The thickness of the holding seal material 120 is not particularly limited, but is desirably in a range of 2.0 mm to 20 mm.

[0065] When the thickness of the holding seal material 120 exceeds 20 mm, since the flexibility of the holding seal material 120 is lost, it becomes difficult to handle the holding seal material when winding the holding seal material 120 around the exhaust gas treatment unit 130. In addition, wrinkles or breakage becomes likely to occur in the holding seal material 120 due to winding.

[0066] The thickness of the holding seal material 120 is less than 2.0 mm, the surface pressure of the holding seal material 120 fails to become sufficient to hold the exhaust gas treatment unit. Therefore, the exhaust gas treatment unit 130 becomes likely to drop. In addition, in a case in which the volume of the exhaust gas treatment unit 130 is changed, it becomes difficult for the holding seal material 120 to absorb the volume change of the

exhaust gas treatment unit 130. Therefore, it becomes likely that cracking and the like occur in the exhaust gas treatment unit 130.

[0067] The first principal surface 121 of the holding seal material 120 illustrated in Fig. 1 is soaked with the organic binder A having a higher glass transition temperature than that of the organic binder B soaked into the second principal surface.

[0068] The soaking of the organic binder A into the first principal surface makes the first principal surface relatively hard, decreases the coefficient of static friction of the holding seal material 120 with respect to the metal casing 110, and makes the holding seal material more slippery on the metal casing. Therefore, when housing the holding seal material 120 and the exhaust gas treatment unit 130 in the metal casing 110, it is possible to smoothly house the holding seal material 120 and the exhaust gas treatment unit 130 in the metal casing 110, and furthermore, to prevent the inorganic fiber configuring the holding seal material 120 from breaking or scattering during a housing operation.

[0069] In addition, the second principal surface 122 of the holding seal material 120 is soaked with the organic binder B having a lower glass transition temperature than that of the organic binder A soaked into the first principal surface.

[0070] The soaking of the organic binder B into the second principal surface makes the second principal surface soft, increases the coefficient of static friction of the second principal surface of the holding seal material 120 with respect to the exhaust gas treatment unit 130, and makes the second principal surface less slippery on the exhaust gas treatment unit. Therefore, when housing the holding seal material 120 and the exhaust gas treatment unit 130 in the metal casing 110, the holding seal material 120 does not easily deviate from the exhaust gas treatment unit 130, and it becomes easy to efficiently house in the metal casing the exhaust gas treatment unit around which the holding seal material is wound.

[0071] The organic binder A needs to be soaked into an area up to 20% of the thickness of the holding seal material from the first principal surface, but may be soaked into an area up to half the thickness of the holding seal material in a case in which it is difficult to form a thin-soaking area. When the organic binder A is soaked into an area up to 20% of the thickness of the holding seal material from the first principal surface, it is possible to preferably adjust the smoothness (hardness) of the first principal surface.

[0072] The organic binder B needs to be soaked into an area up to 20% of the thickness of the holding seal material from the second principal surface, but may be soaked into an area up to half the thickness of the holding seal material in a case in which it is difficult to form a thin-soaking area. When the organic binder B is soaked into an area up to 20% of the thickness of the holding seal material from the second principal surface, it is possible to preferably adjust the smoothness (hardness) of the

second principal surface.

[0073] The weight of the organic binder A soaked into a predetermined area including the first principal surface of the holding seal material of the invention is not particularly limited, but is desirably in a range of 0.2 parts by weight to 12.0 parts by weight, more desirably in a range of 0.5 parts by weight to 6.0 parts by weight, and still more desirably in a range of 0.5 parts by weight to 3.0 parts by weight with respect to 100 parts by weight of the inorganic fiber in terms of the solid content.

[0074] When the weight of the organic binder A is less than 0.2 parts by weight with respect to 100 parts by weight of the inorganic fiber, since the soaked amount of the organic binder is too small, the first principal surface of the holding seal material does not become hard, and it becomes difficult to easily house in the metal casing the exhaust gas treatment unit around which the holding seal material is wound. On the other hand, in a case in which the weight of the organic binder A exceeds 12.0 parts by weight with respect to 100 parts by weight of the inorganic fiber, since the soaked amount of the organic binder is too great while the effect that enables the holding seal material and the exhaust gas treatment unit to be easily housed in the metal casing rarely changes, the amount of an organic component that is thermally decomposed due to the heat of exhaust gas becomes great, and the surrounding environment is adversely affected.

[0075] The organic binder A and the organic binder B are not particularly limited as long as the binders can adjust the softness (hardness) of the first principal surface or the second principal surface, and examples thereof include acryl-based resins, polyethylene-based resins, polypropylene-based resins, polyvinyl chloride-based resins, polystyrene-based resins, rubber-based resins and the like, two or more of which may be contained. Among the above-described binders, acryl-based resins are desirable, and acryl rubber is more desirable.

[0076] The organic binder A soaked into the first principal surface of the holding seal material of the invention is desirably soaked into an area of 50% or more of the first principal surface, and more desirably soaked into an area of 80% or more of the first principal surface.

[0077] The weight of the organic binder B soaked into the second principal surface of the holding seal material of the invention is not particularly limited, but is desirably in a range of 0.2 parts by weight to 12.0 parts by weight, more desirably in a range of 0.5 parts by weight to 6.0 parts by weight, and still more desirably in a range of 0.5 parts by weight to 3.0 parts by weight with respect to 100 parts by weight of the inorganic fiber in terms of the solid content.

[0078] When the soaked weight of the organic binder B is less than 0.2 parts by weight with respect to 100 parts by weight of the inorganic fiber, since the soaked amount of the organic binder is too small, the second principal surface does not become soft, and it becomes easy for the holding seal material to deviate from the exhaust gas treatment unit. On the other hand, in a case

in which the soaked weight of the organic binder B exceeds 12.0 parts by weight with respect to 100 parts by weight of the inorganic fiber, since the soaked amount of the organic binder is too great while the effect that enables the holding seal material and the exhaust gas treatment unit to be easily housed in the metal casing rarely changes, the amount of an organic component that is thermally decomposed due to the heat of exhaust gas becomes great, and the surrounding environment is adversely affected.

[0079] In the holding seal material of the invention, the total of the organic binder A soaked into the first principal surface and the organic binder B soaked into the second principal surface is desirably in a range of 0.5 parts by weight to 3.0 parts by weight with respect to 100 parts by weight of the inorganic fiber configuring the holding seal material in terms of the solid content. When the total of the organic binder A soaked into the first principal surface and the organic binder B soaked into the second principal surface is 0.5 parts by weight or more, it becomes easy to preferably adjust the coefficient of static friction between the first principal surface and the metal casing and the coefficient of static friction between the second principal surface and the exhaust gas treatment unit. When the total of the organic binder A soaked in the first principal surface and the organic binder B soaked in the second principal surface is 3.0 parts by weight or less, it becomes easy to sufficiently suppress the generation of a large amount of decomposed gas caused by exhaust gas.

[0080] The organic binder B soaked into the second principal surface of the holding seal material of the invention is desirably soaked into an area of 50% or more of the second principal surface, and more desirably soaked into an area of 80% or more of the second principal surface.

[0081] The glass transition temperature (T_g) of the organic binder A is desirably in a range of 5°C to 50°C. On the other hand, the glass transition temperature (T_g) of the organic binder B is desirably in a range of -50°C to lower than 5°C.

[0082] The holding seal material 120 of the invention may further contain an inorganic binder. The inorganic binder is not particularly limited as long as the inorganic binder can attach mutually adjacent inorganic fiber segments and fix the inorganic fiber segments together, but alumina sol, silica sol and the like are desirable.

[0083] Next, a manufacturing method for the holding seal material will be described.

[0084] The manufacturing method for a holding seal material of the invention can be preferably applied to a method for manufacturing the above-described holding seal material of the invention.

[0085] The manufacturing method for a holding seal material includes a mat preparation step of preparing the mat for the holding seal material made of the inorganic fiber on which a needle punching treatment has been carried out, an soaking step of blowing liquid droplets of

an organic binder-containing liquid containing the organic binder A to the first principal surface of the mat, and a drying step of drying the mat containing the organic binder-containing liquid.

(a) Mat preparation step

[0086] In the manufacturing method for a holding seal material, first, the mat preparation step of preparing the mat for the holding seal material made of the inorganic fiber on which a needle punching treatment has been carried out is carried out.

[0087] The mat configuring the holding seal material 120 can be obtained using a variety of methods, and can be manufactured using, for example, the following method. That is, first, a mixture for fiber spinning made of an aqueous solution of basic aluminum chloride, silica sol and the like as raw materials is spun using a blowing method so as to produce an inorganic fiber precursor having an average fiber diameter in a range of 3 μm to 10 μm . Subsequently, a continuous sheet-like body having a predetermined size is produced by compressing the inorganic fiber precursor, and is subjected to a needle punching treatment and then a firing treatment, thereby completing the preparation of the mat for the holding seal material.

(b) Soaking step

[0088] Next, the soaking step of soaking the organic binder A into the first principal surface of the mat is carried out. A method for soaking the organic binder A into the first principal surface of the mat is not particularly limited, and it is possible to use a spray coating method in which an organic binder-containing liquid containing the organic binder A is blown through spraying. The soaked amount of the organic binder A is desirably adjusted so as to be in a range of 0.2 parts by mass to 12.0 parts by mass with respect to 100 parts by mass of the inorganic fiber configuring the holding seal material in the solid content after the end of a drying step (c) described below.

[0089] In the soaking step, an soaking step of soaking the organic binder B into the second principal surface of the mat may be carried out after the end of the soaking of the organic binder A. A method for soaking the organic binder B into the first principal surface of the mat is not particularly limited, and it is possible to use a spray coating method in which an organic binder-containing liquid containing the organic binder B is blown through spraying. The soaked amount of the organic binder B is desirably adjusted so as to be in a range of 0.2 parts by mass to 12.0 parts by mass with respect to 100 parts by mass of the inorganic fiber configuring the holding seal material in the solid content after the end of the drying step (c) described below.

(c) Drying step

[0090] A drying step of drying the organic binder-attached mat at a temperature in a range of approximately 110°C to 140°C is carried out so as to evaporate moisture, thereby producing an organic binder-attached mat. As a drying method, it is possible to use hot air drying. It also is possible to soak the organic binder A, dry the mat, soak the organic binder B, and then dry the mat again, or to soak the organic binder A and the organic binder B, and then remove moisture by drying a single time.

[0091] The mat preparation step (a) may include a step of soaking an inorganic binder into the inorganic fiber. The method and order for soaking the inorganic binder into the inorganic fiber are not particularly limited, and, for example, it is possible to soak the mat with a solution containing the inorganic binder after the mat preparation step (a) so as to soak the inorganic binder into the mat, or to drop the inorganic binder onto the mat using a curtain coating method or the like so as to soak the inorganic binder into the mat. After that, it is possible to adjust the attached amount of the inorganic binder by suctioning and dehydrating the inorganic binder-attached mat.

[0092] In a case in which the inorganic binder is soaked into the inorganic fiber, it is desirable to soak the inorganic binder and then soak the organic binder. This is because it is possible to control the ease of slippage by bringing the soaked organic binder into contact with the metal casing or the exhaust gas treatment unit.

(Exhaust gas purification apparatus)

[0093] The holding seal material of the invention can be used as a holding seal material for an exhaust gas purification apparatus.

[0094] Hereinafter, the exhaust gas purification apparatus of the invention will be described.

[0095] Fig. 2 is a cross-sectional view schematically illustrating an example of the exhaust gas purification apparatus of the invention. As illustrated in Fig. 2, an exhaust gas purification apparatus 100 of the invention includes a metal casing 110, an exhaust gas treatment unit 130 housed in the metal casing 110, and a holding seal material 120 provided between the exhaust gas treatment unit 130 and the metal casing 110.

[0096] The exhaust gas treatment unit 130 is a columnar unit having a number of cells 155 provided in a longitudinal direction with a cell wall 156 therebetween. Meanwhile, an introduction tube through which exhaust gas discharged from an internal-combustion engine is introduced and a discharge tube through which exhaust gas that has passed through the exhaust gas purification apparatus is discharged outside are connected to an end section of the metal casing 110 as necessary.

[0097] Meanwhile, in the exhaust gas purification apparatus 100 illustrated in Fig. 2, an exhaust gas filter (honeycomb filter) having cells blocked with a sealing material 158 at any one end is used as the exhaust gas treatment

unit 130, but it is also possible to use a catalyst carrier blocked with a sealing material at neither end surface.

[0098] Hereinafter, a case in which exhaust gas passes through the exhaust gas purification apparatus 100 having the above-described configuration will be described with reference to Fig. 2.

[0099] As illustrated in Fig. 2, exhaust gas that has been discharged from an internal-combustion engine and has flowed into the exhaust gas purification apparatus 100 (in Fig. 2, the exhaust gas is represented by G, and the flow of the exhaust gas is indicated by an arrow) flows into one cell 155 opened on an exhaust gas inflow-side end surface 130a of the exhaust gas treatment unit (honeycomb filter) 130, and passes through the cell wall 156 separating the cell 155. At this time, PM in the exhaust gas is trapped in the cell wall 156 so as to purify the exhaust gas. The purified exhaust gas flows out through other cells 155 opened on an exhaust gas outflow-side end surface 130b, and is discharged outside.

[0100] Next, the exhaust gas treatment unit (honeycomb filter) and the metal casing configuring the exhaust gas purification apparatus of the invention will be described.

[0101] Meanwhile, the configuration of the holding seal material configuring the exhaust gas purification apparatus has already been described as the holding seal material of the invention, and thus description thereof will not be repeated.

[0102] A material for the metal casing configuring the exhaust gas purification apparatus of the invention is not particularly limited as long as the material is heat-resistant metal, and specific examples thereof include stainless steel, aluminum, iron and other metals.

[0103] As the shape of the metal casing configuring the exhaust gas purification apparatus of the invention, a clam shell shape, a downsizing shape or the like can be preferably used in addition to a substantially cylindrical shape.

[0104] First, the exhaust gas treatment unit configuring the exhaust gas purification apparatus will be described.

[0105] Fig. 3 is a perspective view schematically illustrating an example of the exhaust gas treatment unit configuring the exhaust gas purification apparatus of the invention.

[0106] The exhaust gas treatment unit 130 illustrated in Fig. 3 is a honeycomb structure made of a columnar ceramic having a number of the cells 155 provided in a longitudinal direction with the cell wall 156 therebetween. In addition, the cells 155 are sealed with the sealing material 158 at any one end section.

[0107] In a case in which the cell 155 is sealed at any one end section, the exhaust gas treatment unit 130 desirably has a cross-section of an end section in which cells sealed at the end section and cells opened at the end section are alternately disposed.

[0108] The cross-sectional shape of the exhaust gas treatment unit 130 cut in a direction perpendicular to the longitudinal direction is not particularly limited, and may

be a substantially round shape, a substantially oval shape or a substantially polygonal shape such as a substantially triangular shape, a substantially rectangular shape, a substantially octagonal shape or a substantially hexagonal shape. In addition, the exhaust gas treatment unit 130 may be a collection of a plurality of exhaust gas treatment units, and, in this case, the cross-sectional shape of the unit exhaust gas treatment unit configuring the exhaust gas treatment unit 130 may be made up of a straight line and a curved line.

[0109] The cross-sectional shape of the cell 155 configuring the exhaust gas treatment unit 130 may be a substantially polygonal shape such as a substantially triangular shape, a substantially rectangular shape, a substantially octagonal shape or a substantially hexagonal shape, or a substantially round shape or a substantially oval shape. In addition, the exhaust gas treatment unit 130 may be a combination of cells having a plurality of cross-sectional shapes.

[0110] A material configuring the exhaust gas treatment unit 130 is not particularly limited, and it is possible to use a non-oxide such as silicon carbide or silicon nitride or an oxide such as cordierite or aluminum titanate.

[0111] Since the porous fired bodies of the above-described materials are brittle materials, they are easily broken due to a mechanical impact or the like. However, in the exhaust gas purification apparatus of the invention, since the holding seal material 120 is provided around the side surfaces of the exhaust gas treatment unit 130 and absorbs an impact, it is possible to prevent the occurrence of cracking and the like in the exhaust gas treatment unit 130 due to mechanical impact or thermal shock.

[0112] The exhaust gas treatment unit 130 is desirably made of a porous fired body of cordierite or silicon carbide.

[0113] In a case in which cordierite is used, the exhaust gas treatment unit 130 is made of a single ceramic as illustrated in Fig. 1; however, in a case in which silicon carbide is used, the exhaust gas treatment unit 130 is made of a collection of a plurality of columnar ceramics adhered and united using an adhesive formed on the side surfaces as described below instead of being made of a single ceramic.

[0114] In a case in which the exhaust gas treatment unit configuring the exhaust gas purification apparatus of the invention is made of a porous ceramic, the porosity of the porous ceramic is not particularly limited, but is desirably in a range of 35% to 60%.

[0115] This is because, when the porosity is less than 35%, there is a case in which the exhaust gas treatment unit is immediately clogged, and, on the other hand, when the porosity exceeds 60%, there is a case in which the strength of the exhaust gas treatment unit decreases and the exhaust gas treatment unit is easily broken.

[0116] In addition, the average pore diameter of the porous ceramic is desirably in a range of 5 μm to 30 μm .

[0117] This is because, when the average pore diameter is less than 5 μm , there is a case in which PM easily

causes clogging, and, on the other hand, when the average pore diameter exceeds 30 μm , PM passes through pores, it is not possible to trap PM and there is a case in which the exhaust gas treatment unit cannot function as a filter.

[0118] Meanwhile, the porosity and pore diameter can be measured using a mercury intrusion method and a well-known method using a scanning electron microscope (SEM) or the like.

[0119] The cell density in a cross-section of the exhaust gas treatment unit configuring the exhaust gas purification apparatus of the invention is not particularly limited, but a desirable lower limit is 31.0 cells/cm² (200 cells/inch²), a desirable upper limit is 93.0 cells/cm² (600 cells/inch²), a more desirable lower limit is 38.8 cells/cm² (250 cells/inch²), and a more desirable upper limit is 77.5 cells/cm² (500 cells/inch²).

[0120] The exhaust gas treatment unit configuring the exhaust gas purification apparatus of the invention may carry a catalyst for purifying exhaust gas, and, for example, a noble metal such as platinum, palladium or rhodium is desirable as the carried catalyst, and platinum is more desirable among the above-described noble metals. In addition, as other catalysts, it is also possible to use, for example, an alkali metal such as potassium or sodium and an alkali earth metal such as barium. The above-described catalyst may be solely used, or two or more thereof may be jointly used. When the above-described catalyst is carried, it becomes easy to remove PM through combustion and it also becomes possible to purify harmful exhaust gas.

[0121] In addition, the catalyst may be carried in a catalyst-carrying layer formed on the surface of the cell 155. The catalyst-carrying layer is not particularly limited as long as the catalyst-carrying layer has a large specific surface area, and examples thereof include γ -alumina and the like. When the catalyst is carried in the catalyst-carrying layer, it is possible to increase the contact area between the catalyst and exhaust gas.

[0122] The exhaust gas treatment unit configuring the exhaust gas purification apparatus of the invention may be an integrated honeycomb structure that is integrally formed of cordierite or the like, or a combined honeycomb structure obtained by uniting a plurality of columnar honeycomb fired bodies having a number of through holes provided in the longitudinal direction with a partition wall therebetween through an adhesive layer mainly containing a ceramic.

[0123] In the exhaust gas treatment unit configuring the exhaust gas purification apparatus of the invention, the cell may not be provided with the sealing material, and the end section of the cell may not be sealed. In this case, the exhaust gas treatment unit carries a catalyst such as platinum, and functions as a catalyst carrier purifying harmful gas components such as CO, HC or NOx contained in exhaust gas.

[0124] The exhaust gas treatment unit configuring the exhaust gas purification apparatus of the invention may

have an outer circumferential coating layer formed on an outer circumferential surface. When the outer circumferential coating layer is formed on the outer circumferential surface of the exhaust gas treatment unit, it is possible to reinforce an outer circumferential section of the exhaust gas treatment unit, adjust the shape, and improve heat insulating properties. Meanwhile, the outer circumferential surface of the exhaust gas treatment unit refers to a side surface part of the columnar exhaust gas treatment unit.

[0125] Next, the manufacturing method for the exhaust gas purification apparatus of the invention will be described.

[0126] Fig. 4 is a perspective view schematically illustrating an example of a manufacturing method for the exhaust gas purification apparatus of the invention.

[0127] The holding seal material configuring the exhaust gas purification apparatus of the invention is wound around the exhaust gas treatment unit 130 with the second principal surface of the holding seal material 120 facing inside so as to bring the second principal surface 122 and the exhaust gas treatment unit 130 into contact with each other, thereby producing a wound body 140 as illustrated in Fig. 4. The holding seal material 120 is the holding seal material illustrated in Fig. 1, the first principal surface is soaked with the organic binder A, the second principal surface is soaked with the organic binder B, and the second principal surface of the holding seal material is in contact with the exhaust gas treatment unit 130.

[0128] Next, when the wound body 140 is housed in the metal casing 110, the exhaust gas purification apparatus of the invention is obtained. The metal casing 110 is made mainly of metal such as stainless steel, and the shape of the metal casing may be a substantially cylindrical shape having smaller inner diameters at both end sections than an inner diameter in the center as illustrated in Fig. 4, or a substantially cylindrical shape having a constant inner diameter.

[0129] Examples of a method for housing the wound body 140 in the metal casing 110 include a press-in method (stuffing method) in which the exhaust gas treatment unit 130 provided with the holding seal material 120 therearound is pressed in up to a predetermined location inside the metal casing 110, a sizing method (swaging method) in which the metal casing is compressed from the outer circumferential side so as to decrease the inner diameter of the metal casing 110, a clam shell method in which the metal casing is provided with a shape capable of being divided into a first casing component and a second casing component, the wound body 140 is mounted on the first casing, and then the second casing is superimposed, thereby sealing the metal casing, and the like.

[0130] The holding seal material 120 housed in the metal casing 110 has the first principal surface in contact with the metal casing 110 and the second principal surface in contact with the exhaust gas treatment unit 130.

[0131] In the manufacturing method for the exhaust

gas purification apparatus of the invention, the wound body 140 is desirably housed using the press-in method (stuffing method) from the viewpoint of productivity, air tightness, quake resistance and the like.

[0132] In a case in which the wound body is housed in the metal casing using the press-in method (stuffing method), the inner diameter of the metal casing (the inner diameter at a part at which the exhaust gas treatment unit is housed) is desirably slightly smaller than the outer diameter of the wound body 140.

[0133] In the exhaust gas purification apparatus of the invention, a single sheet of the holding seal material may be provided, or two or more mutually-bonded sheets of the holding seal material may be provided, but it is particularly desirable to provide a single sheet of the holding seal material. In a case in which a single sheet of the holding seal material is used as the holding seal material for the exhaust gas purification apparatus, since there is no contact section between the sheets of the holding seal material, it is possible to further prevent the inorganic fiber from being broken due to friction between the sheets of the holding seal material, and to prevent the sheets of the holding seal material from deviating from each other when housing the exhaust gas treatment unit in the metal casing.

[0134] A method for bonding a plurality of sheets of the holding seal material is not particularly limited, and examples thereof include a method in which the sheets of the holding seal material are sewed up together using lockstitch, a method in which the sheets of the holding seal material are adhered together using adhesive tape, an adhesive, or the like.

[0135] Through the above-described steps, the exhaust gas purification apparatus of the invention is manufactured.

[0136] Hereinafter, the effects of the holding seal material of the invention, the manufacturing method for the holding seal material, the exhaust gas purification apparatus and the manufacturing method for an exhaust gas purification apparatus will be described.

(1) In the holding seal material of the invention, the first principal surface of the holding seal material soaked with the organic binder A is relatively harder than the second principal surface soaked with the organic binder B, the coefficient of static friction with respect to the metal casing in contact with the first principal surface is low, and the holding seal material can easily slide on the metal casing. On the other hand, since the second principal surface in contact with the exhaust gas treatment unit is relatively softer than the first principal surface, the coefficient of static friction with respect to the exhaust gas treatment unit is high, and the holding seal material cannot easily slide on the metal casing. Therefore, when housing the exhaust gas treatment unit around which the holding seal material is wound in the metal casing, the first principal surface of the holding seal material

soaked with the organic binder A becomes easily slippery on the metal casing, and it is possible to easily house the exhaust gas treatment unit in the metal casing, thereby improving productivity. On the other hand, it becomes difficult for the second principal surface of the holding seal material soaked with the organic binder B to slide on the exhaust gas treatment unit, and, when housing the exhaust gas treatment unit around which the holding seal material is wound in the metal casing, it becomes difficult for the holding seal material to deviate from the exhaust gas treatment unit.

(2) In the manufacturing method for a holding seal material of the invention, it is possible to easily manufacture a holding seal material having the above-described configuration.

(3) In the exhaust gas purification apparatus of the invention, since the holding seal material made of a mat having a rectangular shape in a planar view and including the inorganic fiber is interposed between the exhaust gas treatment unit and the metal casing, it is possible to prevent exhaust gas from leaking, the organic binder A soaked into the first principal surface of the holding seal material makes the first principal surface of the holding seal material easily slippery on the metal casing, and the organic binder B makes the second principal surface difficult to slide on the exhaust gas treatment unit, workability improves while housing the exhaust gas treatment unit in the metal casing, and the exhaust gas treatment unit does not easily deviate.

(4) Furthermore, in the exhaust gas purification apparatus of the invention, since the friction resistance between the metal casing and the holding seal material is small while housing the exhaust gas treatment unit in the metal casing, it is possible to prevent the inorganic fiber configuring the holding seal material from breaking due to a housing operation.

(5) In addition, in the exhaust gas purification apparatus of the invention, the organic binder A is burned due to exhaust gas flowing through the exhaust gas treatment unit configuring the exhaust gas purification apparatus. When the organic binder A is burned, the holding seal material becomes easily expanded, and it is possible to stably hold the exhaust gas treatment unit.

[0137] Figs. 5A and 5B are schematic views illustrating an example of a measurement method of the coefficient of static friction.

[0138] As illustrated in Fig. 5A, a stainless steel sheet 210 simulating the metal casing is sandwiched using two sheets of the holding seal material 120 so as to come into contact with the first principal surfaces 121, furthermore, both outsides of the two sheets of the holding seal material are sandwiched by fixing members 220, and the assembly is disposed so that any one of the fixing members comes into contact with a vertical wall. Next, a force

of N is added against the fixing member 220 that is not in contact with the vertical wall in a direction perpendicular to the vertical wall. In a state of the force of N added to the fixing member, the stainless steel sheet 210 is pulled with a force F in a direction in parallel with the longitudinal direction of the stainless steel sheet 210, F at a time of the stainless steel sheet 210 beginning to move is measured, and the coefficient of static friction between the first principal surface 121 of the holding seal material 120 and the metal casing is obtained.

[0139] As illustrated in Fig. 5B, a ceramic sheet 211 simulating the exhaust gas treatment unit is sandwiched by two sheets of the holding seal material 120 so as to come into contact with the second principal surfaces 122, furthermore, both outsides of the two sheets of the holding seal material are sandwiched using fixing members 220, and the assembly is disposed so that any one of the fixing members 220 comes into contact with a vertical wall. Next, a force of N is added against the fixing member 220 that is not in contact with the vertical wall in a direction perpendicular to the vertical wall. In a state of the force of N added to the fixing member 220 that is not in contact with the vertical wall, the ceramic sheet 211 is pulled with a force F in a direction in parallel with the longitudinal direction of the ceramic sheet 211, F at a time of the ceramic sheet 211 beginning to move is measured, and the coefficient of static friction between the second principal surface 122 of the holding seal material 120 and the exhaust gas treatment unit is obtained.

[Examples]

[0140] Hereinafter, examples disclosing the invention more specifically will be described. Meanwhile, the invention is not limited to the examples.

(Example 1)

(a) Mat preparation step

[0141] First, a mat for the holding seal material was prepared in the following order.

(a-1) Spinning step

[0142] Silica sol was blended with a basic aqueous solution of aluminum chloride which had an Al content of 70 g/l and was prepared so as to obtain Al:Cl=1:1.8 (atomic ratio) so that the composition ratio in the inorganic fiber after firing became Al_2O_3 : SiO_2 =72: 28 (weight ratio), and furthermore, an appropriate amount of an organic polymer (polyvinyl alcohol) was added, thereby preparing a liquid mixture.

[0143] The obtained liquid mixture was condensed so as to produce a spinning mixture, and the spinning mixture was spun using a blowing method so as to produce an inorganic fiber precursor having an average fiber diameter of 5.1 μm .

(a-2) Compression step

[0144] The inorganic fiber precursor obtained in the above-described step (a-1) was compressed, thereby producing a continuous sheet-like body.

(a-3) Needle punching step

[0145] A needle punching treatment was continuously carried out on the sheet-like body obtained in the above-described step (a-2) using conditions described below, thereby producing a needle-punching-treated body.

[0146] First, a needle board provided with needles at a density of 21 needles/ cm^2 was prepared. Next, the needle board was disposed above one surface of the sheet-like body, and a needle punching treatment was carried out by dropping and lifting the needle board once in the thickness direction of the sheet-like body, thereby producing a needle-punching-treated body. At this time, the needles were penetrated until barbs formed at front end sections of the needles completely penetrate the opposite surface of the sheet-like body.

(a-4) Firing step

[0147] The needle-punching-treated body obtained in the above-described step (a-3) was continuously fired at a peak temperature of 1250°C, and a fired sheet-like body made of an inorganic fiber containing alumina and silica at 72 parts by weight:28 parts by weight was manufactured. The average fiber diameter of the inorganic fiber was 5.1 μm , and the minimum value of the inorganic fiber diameter was 3.2 μm . The alumina fiber holding seal material obtained in the above-described manner had a bulk density of 0.15 g/cm^3 and a basis weight of 1400 g/m^2 .

(a-5) Cutting step

[0148] The fired sheet-like body obtained in the above-described step (a-4) was cut, thereby producing cut sheet-like bodies.

(b) Soaking step

(b-1) Organic binder-adjusting step

[0149] A latex obtained by dispersing acryl rubber having a glass transition temperature (T_g) of 25°C in water (Nipol LX814 manufactured by Zeon Corporation, hereinafter referred to as Latex 1) was diluted using water, thereby preparing an organic binder-containing liquid having a solid content concentration of 1 weight%. In the present example, Latex 1 serves as the organic binder A. In addition, a latex obtained by dispersing acryl rubber having a glass transition temperature (T_g) of 1°C in water (Nipol LX811H manufactured by Zeon Corporation, hereinafter referred to as Latex 2) was diluted using water, thereby preparing an organic binder-containing liquid

having a solid content concentration of 1 weight%. In the present example, Latex 2 serves as the organic binder B.

(b-2) Organic binder-blowing step

[0150] Next, the organic binder A-containing liquid was applied through spray coating onto one principal surface of the mat so that the attached amount of the organic binder A became 1 part by weight per 100 parts by weight of the inorganic fiber. The principal surface soaked with the organic binder A serves as the first principal surface.

[0151] Next, the organic binder B-containing liquid was applied through spray coating onto the principal surface opposite to the first principal surface so that the attached amount of the organic binder B became 1 part by weight per 100 parts by weight of the inorganic fiber. The principal surface soaked with the organic binder B serves as the second principal surface.

(c) Drying step

[0152] Next, the organic binder-attached mat was heated and hot-air-dried at 130°C, thereby obtaining a mat soaked with the organic binders.

(d) Cutting treatment

[0153] The mat obtained in the above-described manner was cut so that the total length became 307 mm×114 mm in planar dimensions, a protrusion section having a length L of 20 mm and a width W of 38 mm was formed at one end, and a recess section fitting with the protrusion section was formed at the other end, thereby completing the manufacturing of the holding seal material.

[0154] Meanwhile, the thickness of the holding seal material was 17.4 mm.

(Comparative Example 1)

[0155] A holding seal material was manufactured in the same manner as in Example 1 except for the fact that the organic binder B was changed to Latex 1 in the soaking step (b).

(Comparative Example 2)

[0156] A holding seal material was manufactured in the same manner as in Example 1 except for the fact that the organic binder A was changed to Latex 2 in the soaking step (b).

(Comparative Example 3)

[0157] A holding seal material was manufactured in the same manner as in Example 1 except for the fact that the organic binder B was changed to Latex 1 and the organic binder A was changed to Latex 2 in the soaking step (b).

(Determination of the soaked amount of the organic binder)

[0158] Regarding the soaked amount of the organic binder, the holding seal materials of Example 1 and Comparative Examples 1 to 3 soaked with the organic binders were cut into a size of 100 mm×100 mm, cut samples were divided into halves in the thickness direction, then, heated at 700°C in an oxidizing atmosphere so as to measure the weight reduction amounts, and the soaked amounts (g) of the organic binders with respect to 100 g of the inorganic fiber were computed from the measurement results. The soaked amounts of the organic binders of the holding seal materials of Example 1 and Comparative Examples 1 to 3 with respect to 100 parts by weight of the inorganic fiber were 1 part by weight respectively on the first principal surface and the second principal surface.

[0159] The holding seal materials obtained in Example 1 and Comparative Examples 1 to 3 were wound around the exhaust gas treatment units so as to bring the second principal surfaces into contact with the exhaust gas treatment units, thereby producing wound bodies. The wound bodies were housed in the metal casings using the press-in method so as to bring the first principal surfaces into contact with the metal casings, and housing properties and safety were checked.

[0160] The wound body around which the holding seal material of Example 1 was wound had the first principal surface that was harder than the second principal surface since the glass transition temperature of the organic binder A soaked into the first principal surface was higher than the glass transition temperature of the organic binder B soaked into the second principal surface. Therefore, the coefficient of static friction between the holding seal material and the casing became low, the holding seal material became easily slippery, and the exhaust gas treatment unit was easily housed in the metal casing. Furthermore, the second principal surface was softer than the first principal surface, the coefficient of static friction between the holding seal material and the exhaust gas treatment unit became high, the holding seal material was not easily slippery, and there was no case in which the holding seal material and the exhaust gas treatment unit deviated from each other when housing the exhaust gas treatment unit in the metal casing.

[0161] The wound body around which the holding seal material of Comparative Example 1 was wound had the same hardness on both the first principal surface and the second principal surface since the glass transition temperature of the organic binder A soaked into the first principal surface was the same as the glass transition temperature of the organic binder B soaked into the second principal surface. Furthermore, since the glass transition temperature of the organic binder B was 5°C or higher, the second principal surface became too hard, and the holding seal material and the exhaust gas treatment unit became easily deviated from each other when housing

the exhaust gas treatment unit in the metal casing.

[0162] The wound body around which the holding seal material of Comparative Example 2 was wound had the same hardness on both the first principal surface and the second principal surface since the glass transition temperature of the organic binder A soaked into the first principal surface was the same as the glass transition temperature of the organic binder B soaked into the second principal surface. Furthermore, since the glass transition temperature of the organic binder A was lower than 5°C, the first principal surface became too soft, a large force was required when housing the exhaust gas treatment unit in the metal casing, and the housing of the exhaust gas treatment unit in the metal casing was not easy.

[0163] In the wound body around which the holding seal material of Comparative Example 3 was wound, since the glass transition temperature of the organic binder A soaked into the first principal surface was lower than the glass transition temperature of the organic binder B soaked into the second principal surface, the first principal surface became too soft, and the second principal surface became too hard. Therefore, the coefficient of static friction between the holding seal material and the metal casing was high, and the housing of the exhaust gas treatment unit in the metal casing was not easy. Furthermore, the coefficient of static friction between the holding seal material and the exhaust gas treatment unit was low, and the holding seal material and the exhaust gas treatment unit became easily deviated from each other after housing the exhaust gas treatment unit in the metal casing. As described above, it was determined that the holding seal material according to Example 1 was superior to the holding seal materials according to Comparative Examples 1 to 3 from the viewpoint of ease of a housing operation and the prevention of the deviation of the exhaust gas treatment unit.

Claims

1. A holding seal material used in an exhaust gas purification apparatus made up of an exhaust gas treatment unit, a metal casing housing the exhaust gas treatment unit, and the holding seal material made of an inorganic fiber and provided between the exhaust gas treatment unit and the metal casing, wherein the holding seal material comprises a first principal surface in contact with the metal casing and a second principal surface in contact with the exhaust gas treatment unit, the first principal surface and the second principal surface are soaked with organic binders, and a glass transition temperature of an organic binder A soaked into the first principal surface is higher than a glass transition temperature of an organic binder B soaked into the second principal surface.

2. The holding seal material according to Claim 1,

wherein the glass transition temperature of the organic binder A is in a range of 5°C to 50°C, and the glass transition temperature of the organic binder B is in a range of -50°C to lower than 5°C.

3. The holding seal material according to Claim 1 or 2, wherein the organic binder A is soaked into a predetermined area including the first principal surface, the organic binder B is soaked into a predetermined area including the second principal surface, and an soaked amount of the organic binder A soaked into the predetermined area including the first principal surface is in a range of 0.2 parts by weight to 12.0 parts by weight with respect to 100 parts by weight of the inorganic fiber, and an soaked amount of the organic binder B soaked into the predetermined area including the second principal surface is in a range of 0.2 parts by weight to 12.0 parts by weight with respect to 100 parts by weight of the inorganic fiber.

4. The holding seal material according to Claim 3, wherein a total soaked amount of the organic binder A and the organic binder B is in a range of 0.5 parts by weight to 3.0 parts by weight with respect to 100 parts by weight of the inorganic fiber.

5. The holding seal material according to any one of Claims 1 to 4, wherein the organic binder A and the organic binder B contain at least an acryl-based resin.

6. The holding seal material according to any one of Claims 1 to 5, wherein the inorganic fiber is made of at least one selected from a group consisting of alumina fibers, silica fibers, alumina silica fibers, mullite fibers, bio-soluble fibers and glass fibers.

7. A manufacturing method for the holding seal material according to Claim 1, comprising:

a mat preparation step of preparing a mat for the holding seal material made of the inorganic fiber on which a needle punching treatment has been carried out;
an soaking step of blowing liquid droplets of an organic binder-containing liquid containing the organic binder A to the first principal surface of the mat; and
a drying step of drying the mat containing the organic binder-containing liquid.

8. The manufacturing method for the holding seal material according to Claim 7, further comprising:

a step of blowing liquid droplets of an organic binder-containing liquid containing the organic

binder B to the second principal surface of the mat in the soaking step.

9. An exhaust gas purification apparatus comprising:

5

a metal casing;

an exhaust gas treatment unit housed in the metal casing; and

a holding seal material wound around the exhaust gas treatment unit and provided between the exhaust gas treatment unit and the metal casing,

10

wherein the holding seal material is the holding seal material according to any one of Claims 1 to 6.

15

20

25

30

35

40

45

50

55

FIG. 1A

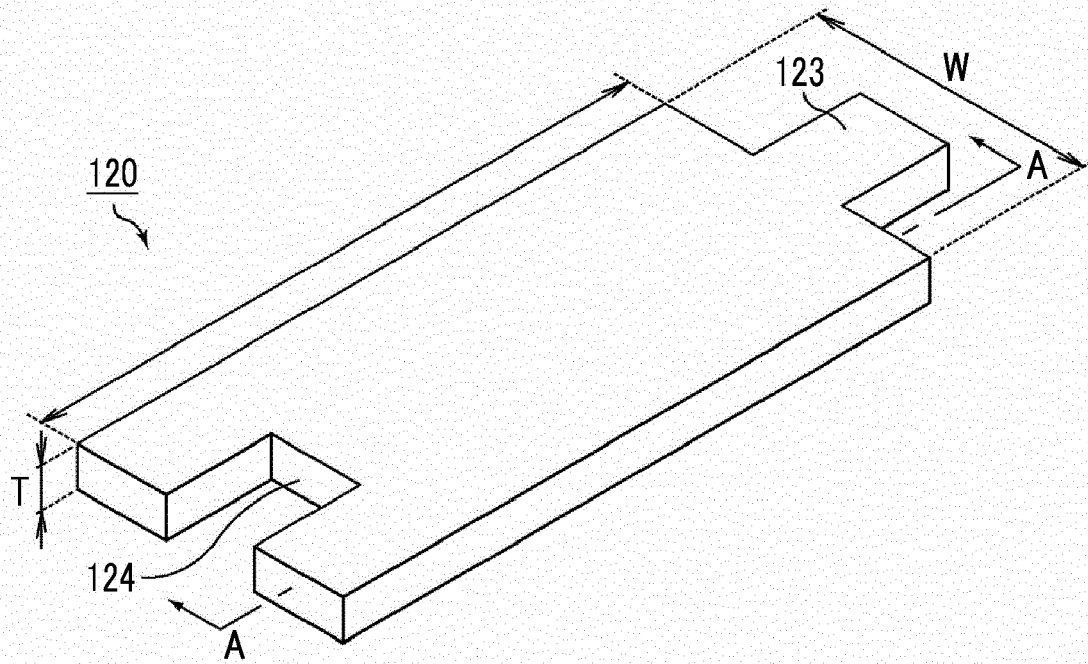
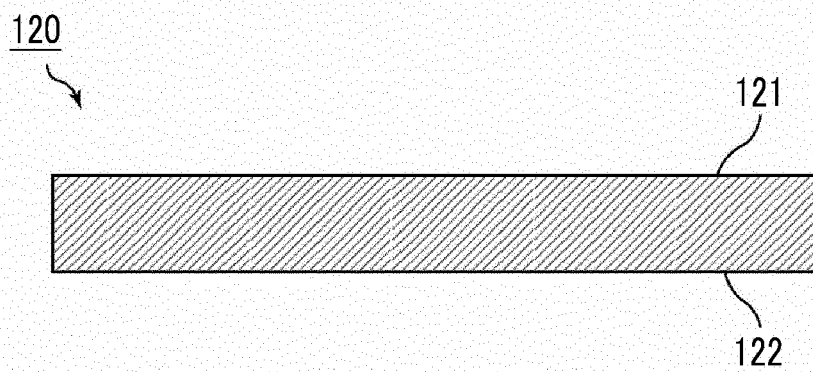


FIG. 1B



A-A LINE CROSS-SECTIONAL VIEW

FIG. 2

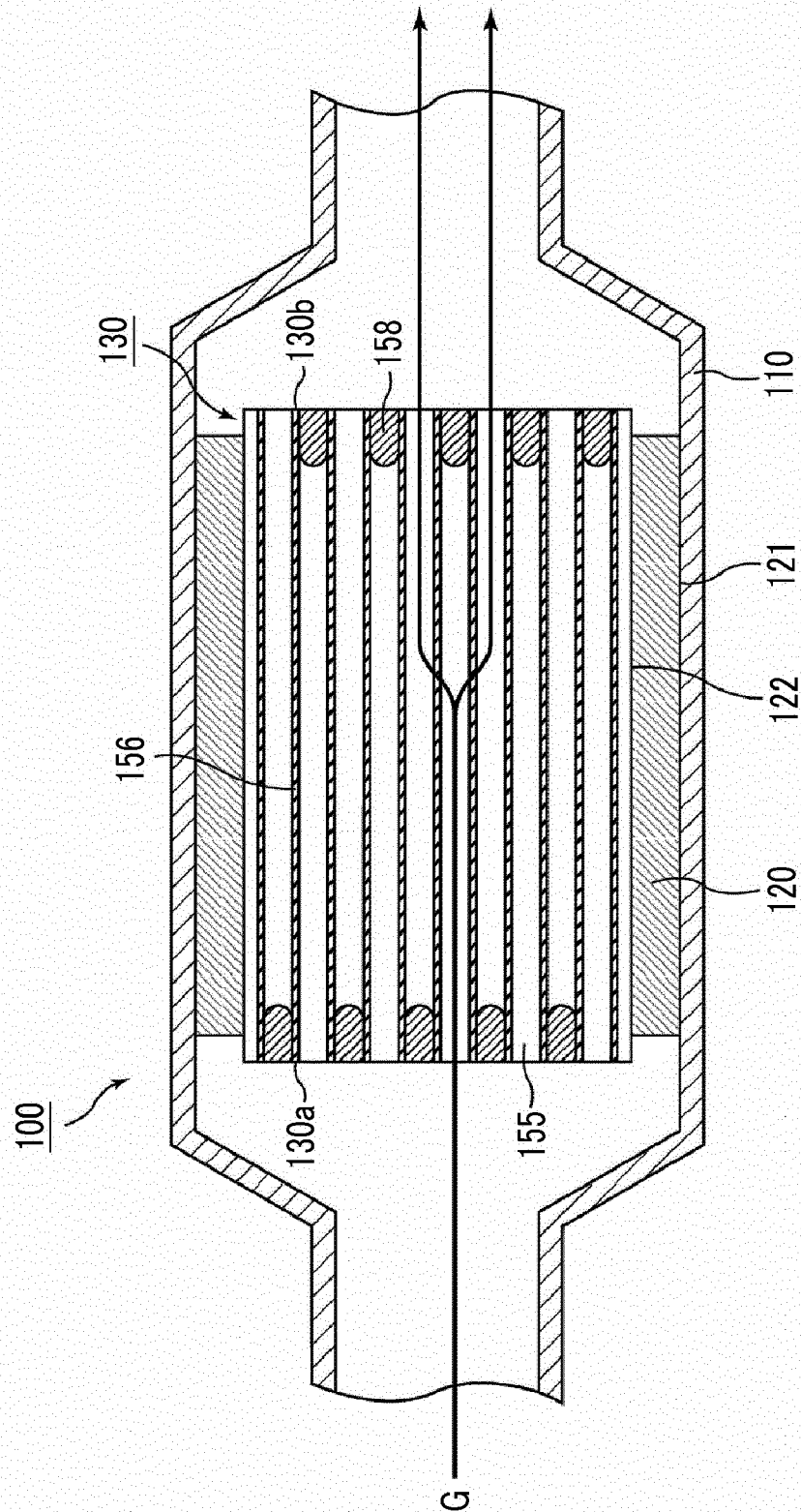


FIG. 3

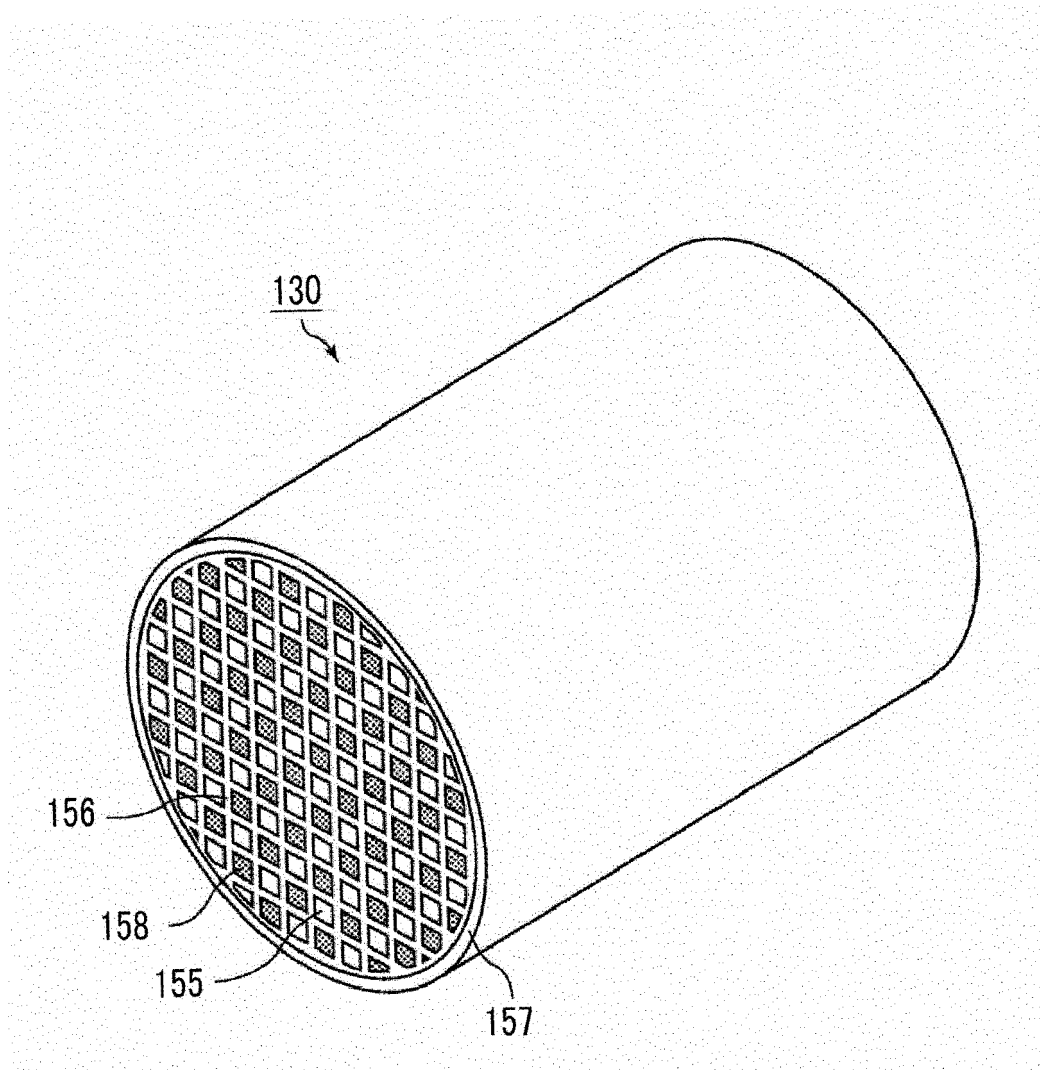


FIG. 4

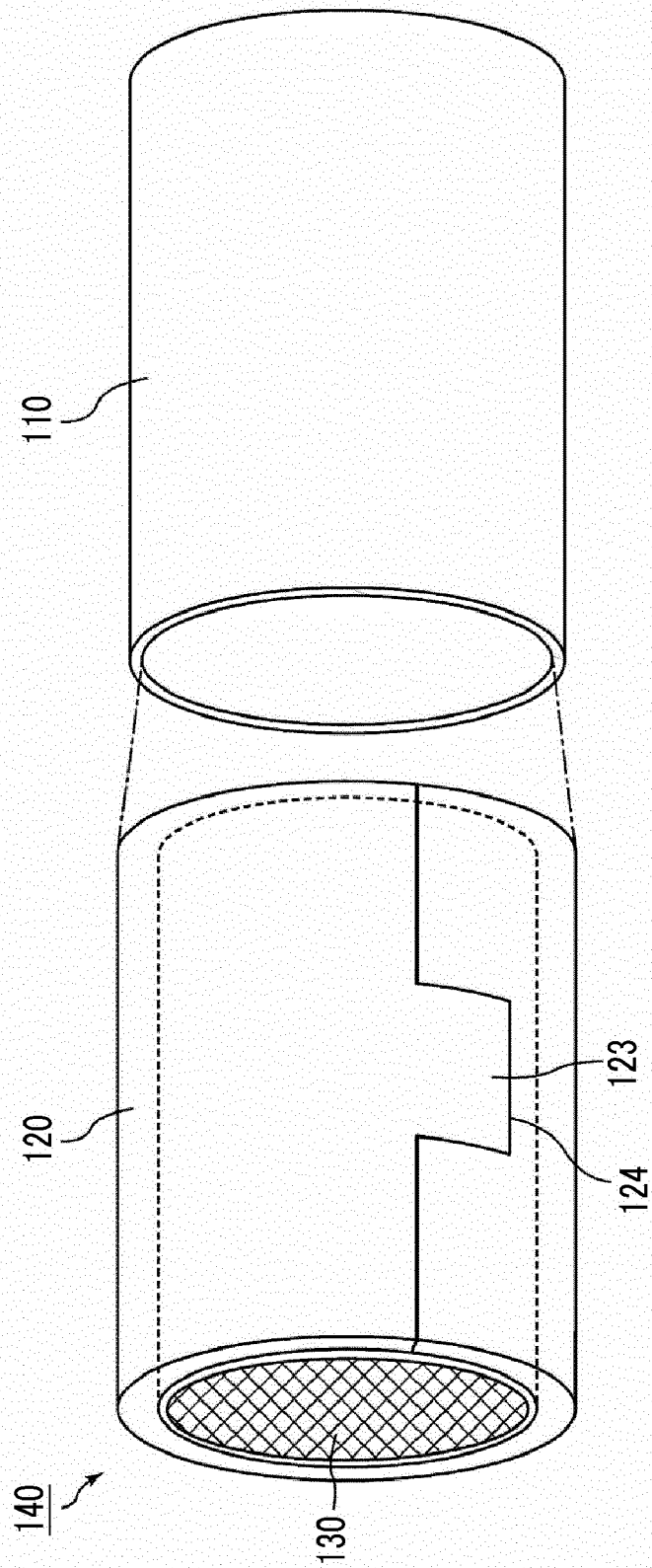


FIG. 5A

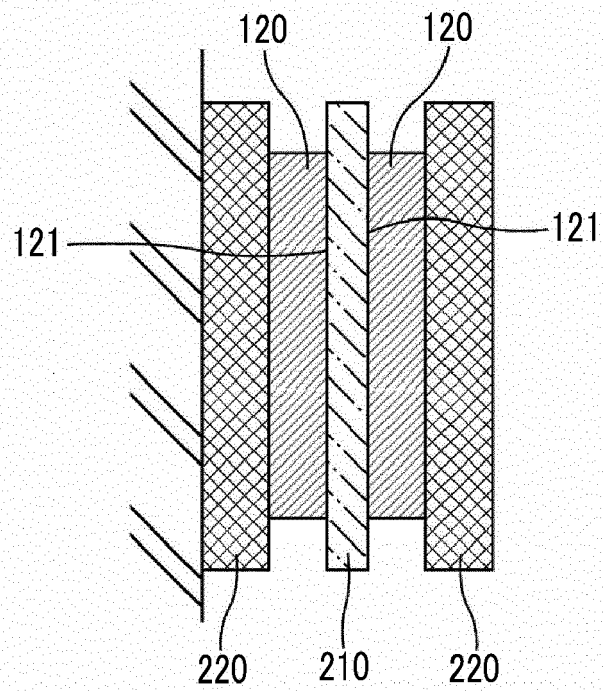
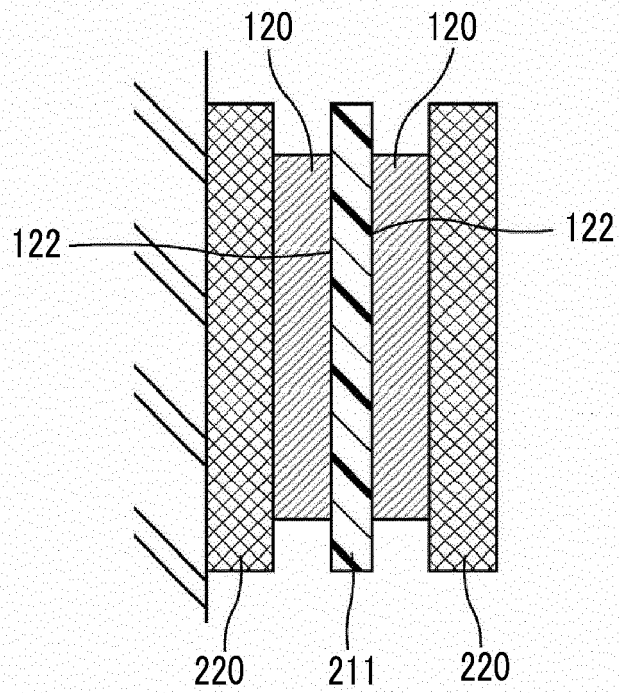


FIG. 5B





EUROPEAN SEARCH REPORT

Application Number
EP 14 16 1516

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 99/23370 A1 (ICI PLC [GB]; ECIA EQUIP COMPOSANTS IND AUTO [FR]; DINWOODIE JOHN [GB]) 14 May 1999 (1999-05-14) * page 3, lines 1-6, 20-31; claim 7 * * page 5, line 30 - page 6, line 7 * * page 10, lines 5-24 * * page 11, lines 26-29 * * claims 1, 6, 7 * * example 3 *	1,5,6,9	INV. D06M15/263 D06M15/693 D06M23/06 D06M23/16 F01N3/28
A	EP 1 731 729 A1 (IBIDEN CO LTD [JP]) 13 December 2006 (2006-12-13) * the whole document *	1-9	
A	US 2009/041967 A1 (TOMOSUE NOBUYA [JP] ET AL) 12 February 2009 (2009-02-12) * the whole document *	1-9	
A	WO 2006/088733 A2 (3M INNOVATIVE PROPERTIES CO [US]; YASUDA DAIGO [JP]; KISHI FUMIHIKO [J]) 24 August 2006 (2006-08-24) * page 4, lines 19-24 * * pages 13-14 * * examples *	1-9	TECHNICAL FIELDS SEARCHED (IPC) D06M F01N
A	EP 1 296 030 A1 (IBIDEN CO LTD [JP]) 26 March 2003 (2003-03-26) * the whole document *	1-9	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 27 June 2014	Examiner Barathe, Rainier
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

1
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 14 16 1516

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

27-06-2014

10

15

20

25

30

35

40

45

50

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9923370	A1	14-05-1999	AT 305565 T	15-10-2005
			AU 9636798 A	24-05-1999
			DE 69831749 T2	06-07-2006
			EP 1029163 A1	23-08-2000
			ES 2253830 T3	01-06-2006
			JP 2001521847 A	13-11-2001
			WO 9923370 A1	14-05-1999
			ZA 9809989 A	05-05-1999

EP 1731729	A1	13-12-2006	CN 1876748 A	13-12-2006
			EP 1731729 A1	13-12-2006
			JP 4665618 B2	06-04-2011
			JP 2006342774 A	21-12-2006
			KR 20060128742 A	14-12-2006
			US 2006278323 A1	14-12-2006
			US 2009049690 A1	26-02-2009

US 2009041967	A1	12-02-2009	CN 101362104 A	11-02-2009
			GB 2453821 A	22-04-2009
			JP 4922861 B2	25-04-2012
			JP 2009041499 A	26-02-2009
			US 2009041967 A1	12-02-2009

WO 2006088733	A2	24-08-2006	BR PI0608162 A2	24-08-2010
			CA 2598036 A1	24-08-2006
			CN 101155978 A	02-04-2008
			EP 1848879 A2	31-10-2007
			JP 2006223920 A	31-08-2006
			KR 20070110363 A	16-11-2007
			US 2009049831 A1	26-02-2009
			WO 2006088733 A2	24-08-2006

EP 1296030	A1	26-03-2003	CN 1437677 A	20-08-2003
			DE 60109035 D1	31-03-2005
			DE 60109035 T2	13-04-2006
			EP 1296030 A1	26-03-2003
			JP 4042305 B2	06-02-2008
			JP 2002004848 A	09-01-2002
			KR 20030015282 A	20-02-2003
			US 2003104189 A1	05-06-2003
			WO 0198640 A1	27-12-2001

55

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2002013415 A [0004]