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(54) Seamless cylindrical metal fiber mat and method of manufacturing the same

(57) Provided is a seamless cylindrical metal fiber mat (130), in which a metal fiber mat is formed as a one-piece cylinder to be installed outside a distributor (12) by an insertion method, and a method of manufacturing a seamless cylindrical metal fiber mat including operations of (a) forming a plurality of surface irregularities on a metal fiber bundle in a lengthwise direction, (b) knitting the metal fiber bundle into a double-layer structure and (c) forming a knitted fabric obtained in operation (b) into a cylinder.

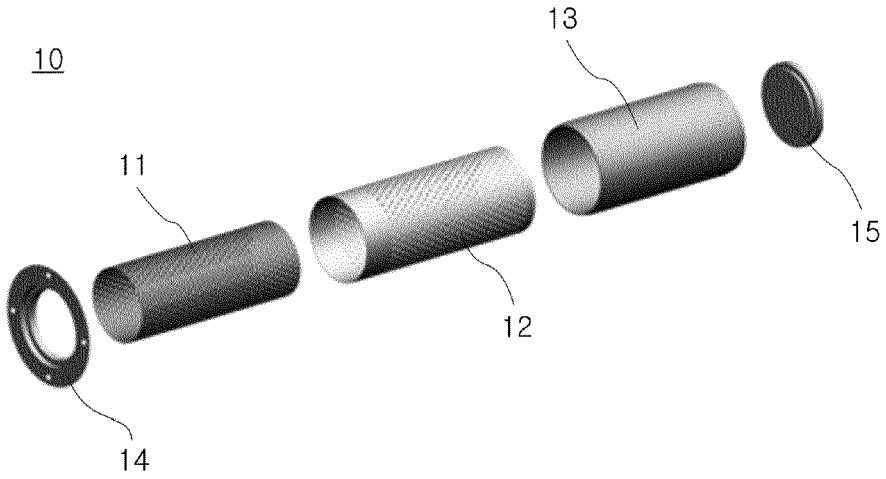

FIG. 1

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a method of manufacturing a metal fiber mat used in a cylindrical surface combustion burner, and more particularly, to a seamless cylindrical metal fiber mat having no welded portion and a method of manufacturing the same.

Description of the Related Art

[0002] In general, a cylindrical burner is used in a circular type heat exchanger and, as shown in FIGS. 1 and 2, is composed of an internal distributor 11, an external distributor 12 included outside of the internal distributor 11, a metal fiber mat 13 attached to an outer surface of the external distributor 12, a flange 14 and an end cap 15 respectively combined with both ends of the internal distributor 11 and the external distributor 12.

[0003] In this case, there is a limitation in that the metal fiber mat 13 is typically attached to the external distributor 12 through welding. Specifically, as shown in FIG. 3, the attachment thereof is typically performed in such a manner that the metal fiber mat 13 is cut to a size corresponding to a height of a circular burner 10 and a circumference of the external distributor 12, one end of the metal fiber mat 13 is welded to the external distributor 12 (W) and the other end thereof is tightly pulled so as to allow the metal fiber mat 13 to be completely in contact with the external distributor 12, and the other end thereof is then welded to the top of an initial welded portion W (W').

[0004] However, in the case that the metal fiber mat 13 is attached by welding as described above, pores in the welded portions W and W' are blocked such that premixed gas may not pass through, and thus, a flame may not be generated. Also, since welding is performed as densely as possible, in consideration of results, so as not to allow premixed gas to leak out when the metal fiber mat 13 is attached, it may not only require a lot of time for welding, but cracks may also be generated or portions adjacent to the welded portions W and W' may be torn due to repeated heating and cooling over a prolonged period of use as the welded portions W and W' are positioned inside of a flame surface of a burner, even in the case that the welding is performed as above.

SUMMARY OF THE INVENTION

[0005] An aspect of the present invention provides a seamless cylindrical metal fiber mat able to improve durability and workability through the removal of welded portions and a method of manufacturing the same.

[0006] According to an aspect of the present invention, there is provided a seamless cylindrical metal fiber mat installed outside a distributor of a surface combustion burner, wherein a metal fiber mat is formed as a one-piece cylinder to be installed outside of the distributor by an insertion method.

[0007] The seamless cylindrical metal fiber mat may be a knitted mat.

[0008] A material of the seamless cylindrical metal fiber mat may be an iron-chromium alloy or stainless steel.

[0009] The iron-chromium alloy may include 18 wt% to 27 wt% of chromium (Cr), 3 wt% to 7 wt% of aluminum (Al), and iron (Fe) as a remainder, and may further include 0.05 wt% to 0.5 wt% of zirconium (Zr) and yttrium (Y).

[0010] According to another aspect of the present invention, there is provided a method of manufacturing a seamless cylindrical metal fiber mat including operations of (a) forming a plurality of surface irregularities on a metal fiber bundle in a lengthwise direction, (b) knitting the metal fiber bundle into a double-layer structure and (c) forming a knitted fabric obtained in operation (b) into a cylinder.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The above and other aspects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is an exploded perspective view of a cylindrical burner;

FIG. 2 is an assembly drawing of the cylindrical burner;

FIG. 3 is a drawing illustrating a metal fiber mat according to the related art and an attachment method thereof;

FIG. 4 is a drawing illustrating a seamless cylindrical metal fiber mat according to an exemplary embodiment of the present invention and an attachment method thereof;

FIG. 5 is a drawing illustrating a combustion principle of a surface combustion burner; and

FIG. 6 is a drawing illustrating a process of forming loops during knitting of the seamless cylindrical metal fiber mat according to the exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0012] Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings to fully explain the present invention in such a manner that it may easily be carried out by a person having ordinary skill in the art to which the present invention pertains. However, the present invention may be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein. In the drawings, por-

tions unrelated to the descriptions are omitted to allow for a clearer description of the present invention, and like reference numerals refer to like elements throughout.

[0013] FIG. 4 is a drawing illustrating a seamless cylindrical metal fiber mat according to an exemplary embodiment of the present invention and an attachment method thereof.

[0014] As shown in FIG. 4, a seamless cylindrical metal fiber mat 130 according to the exemplary embodiment of the present invention is formed as a one-piece cylinder to be installed outside an external distributor 12. That is, the present invention is characterized in that a method of covering the outside of the external distributor 12 with a metal fiber mat prepared as a cylinder according to a diameter and a length of the external distributor 12 is selected instead of a typical method of attaching a metal fiber mat to a distributor by welding, and thus, durability, ease of assembly, and combustion efficiency may be improved.

[0015] An iron-chromium alloy having excellent heat resistance is used as a material of the seamless cylindrical metal fiber mat 130, and specifically, may include 18 wt% to 27 wt% of chromium (Cr), 3 wt% to 7 wt%, for example, 5 wt to 7 wt% of aluminum (Al), and iron (Fe) as a remainder. Also, the iron-chromium alloy may further include 0.05 wt% to 0.5 wt%, for example, 0.1 wt% to 0.3 wt% of zirconium (Zr) and yttrium (Y). In addition, stainless steel may be used, and in this case, 316L stainless steel may be used.

[0016] Meanwhile, the seamless cylindrical metal fiber mat 130 is manufactured by forming metal fibers having a diameter ranging from 22 μm to 40 μm into metal fiber bundles having a weight ranging from 0.5 g/m to 1.5 g/m, and the metal fiber mat thus manufactured may have a weight ranging from 1000 g/m^2 to 2500 g/m^2. In the case that the metal fiber bundle is woven to have a weight of 1.5 g/m or more, the metal fiber bundle may become thick. As a result, an arrangement of needles may become too narrow when a diameter of the cylindrical metal fiber mat is small, and thus, weaving may be difficult and needles may be broken during weaving due to low elongation. In the case that the metal fiber bundle is woven to have a weight of 0.5 g/m or less, the metal fiber bundles may be broken during weaving due to low tensile strength and thus it may be a cause of the generation of defects.

[0017] Further, a thickness of the seamless cylindrical metal fiber mat 130 may be in a range of 1.5 mm to 3.5 mm. The reason for this is that when the seamless cylindrical metal fiber mat 130 as a surface combustion media is excessively thin or thick, a stable combustion flame may be difficult to be formed and the seamless cylindrical metal fiber mat 130 may be difficult to be used as a combustion media of a burner having a turn down ratio (TDR) of 10:1.

[0018] In the present invention, the seamless cylindrical metal fiber mat 130 is knitted by a knitting machine. The knitting machine is a type of a circular knitting machine, in which needles are arranged in a circumferential direction to knit a metal fiber mat according to a predetermined pattern. In this case, a diameter of the seamless cylindrical metal fiber mat 130 may be variously formed within a range of Ø50 to Ø300 according to the intended application and purpose of a cylindrical burner. However, the above diameter range of the metal fiber mat typically includes the most widely used diameter thereof, and of course, the metal fiber mat may be knitted to have a diameter of Ø300 or more if necessary.

[0019] In relation to the foregoing, differences between a woven mat and a knitted mat are described hereinafter, and then a manufacturing method of the present invention selecting the knitted mat will be described in detail.

[0020] **Differences between Woven Mat and Knitted Mat**

[0021] **Arrangement**

[0022] A woven mat is woven with weft and warp intersections at right angles. In contrast, since a structure of a knitted mat is formed by a formation of loops, the knitted mat has good flexibility and high air permeability, and thus, has better characteristics as a metal fiber mat for a combustion media.

[0023] **Thickness**

[0024] In general, a thickness of the woven mat suitable for a metal fiber media for combustion is in a range of about 1.2 mm to 1.7 mm, and a structural configuration of the knitted mat may be changed to have a thickness ranging from 1.5 mm to 3.5 mm. Since the knitted mat, different from the woven mat, has a three-dimensional structural arrangement in a thickness direction during the formation of the loops, the thickness of the knitted mat may be greater than that of the woven mat.

[0025] FIG. 5 is a drawing illustrating a combustion principle of a surface combustion burner.

[0026] As shown in FIG. 5, combustion in a surface combustion burner is generated on a surface of a mat, and the mat may be divided into a combustion area and a cooling area. Specifically, the combustion area is a portion of the mat having actual combustion generated therein and heated to a high temperature of 1000°C. In the cooling area, the actual combustion is not generated and an upper side portion heated to a high temperature due to the combustion is cooled as premixed gas passes through the cooling area. Since the cooling area is formed in a lower portion of the mat with respect to the surface combustion burner, heat is not transferred to the inside of the burner, and thus, a temperature of the burner is maintained to be below an autoignition temperature of the premixed gas. As a result, durability of the mat may be improved and parts of the burner may be protected. In the case that the air permeability is identical between two mats, the thicker the mat is, the wider the cooling area secured is, and thus, durability may be improved.

[0027] With respect to the woven mat, there may be a method of weaving the mat by increasing a thickness of metal fibers in order to increase the thickness of the mat. However, since a density of the metal fibers per unit area increases excessively when the thickness of the metal

fibers is increased, air permeability decreases, and thus, it may be impossible to increase the thickness of the mat to 2 mm or more. In contrast, since a method of forming loops in the knitted mat is not performed planarly, as in the case of the woven mat, but is performed three dimensionally in space, the density of the metal fibers per unit area may be the same but a volume per unit area may increase. Therefore, the thickness of the knitted mat may be increased while the air permeability may be maintained to be similar to that of the woven mat.

[0028] Such characteristics of the knitted mat may provide durability, e.g., wide TDR characteristics, which must be possessed by the metal fiber mat constituting a combustion unit in view of a combustion media. Accordingly, the knitted metal fiber mat may be more commonly used in a combustion device such as a high-efficiency condensing boiler.

[0029] **Combustion Performance**

[0030] A turn down ratio (TDR) is an index representing the performance of a burner. The TDR represents a ratio of the maximum power to the minimum power that may be achieved in the burner, and since the heat may be variously controlled in one burner as the TDR is higher, the burner may be used in a high-efficiency combustion system.

[0031] In a surface combustion burner, the metal fiber mat may function as a flame holder and thus, a wider combustion area may be secured with respect to a knitted fabric forming loops and having a three-dimensional structure. Specifically, with respect to high load combustion, a flow rate increases as a flow of premixed gas increases. When the flow rate increases, a flame rises from the surface of the mat, and since the thickness is high and a loop structure has a three-dimensional shape with respect to the knitted mat, a flame does not rise even in a range of power higher than that of the woven mat and stable combustion may be obtained. Meanwhile, with respect to low load combustion, the combustion is performed inside the mat, and since the combustion area of the knitted mat is wider than that of the woven mat, abnormal combustion, such as a green flame, is not obtained, and the combustion may be possible in a range of lower power.

[0032] **Thermal Deformation**

[0033] Since a temperature of the surface of the metal fiber mat in the surface combustion burner is high at 1000°C or more, metal fibers constituting the metal fiber mat also expand during the combustion. With respect to the woven mat, since metal fibers are arranged planarly, there is no flexibility therein, and thus, a space between the mat and a distributor (perforated plate) attached to a backside of the mat is generated when the mat is expanded due to the heat. As a result, a cooling area may be abnormally formed and thus, damage to the mat due to localized overheating or burner backfiring may occur.

[0034] However, with respect to the knitted mat, since metal fibers have a three-dimensional arrangement and flexibility of the mat itself is good, the mat is attached by being tightly drawn to maintain tensile force greater a predetermined level thereof during the attachment to the distributor. Therefore, the knitted mat may not be spaced apart from the distributor even in the case that metal fibers are expanded due to thermal deformation. Also, since the cooling area is relatively wide, metal fibers corresponding to the cooling area of the mat may not expand and hold an upper portion subjected to the combustion process, and thus, the mat may not be easily spaced apart from the distributor.

[0035] As described above, the knitted mat has excellent durability and thermal characteristics in comparison to those of the woven mat and the knitted mat is selected in the present invention in consideration of such characteristics. Thus, hereinafter, a method of manufacturing a seamless cylindrical metal fiber mat according to the present invention will be described in detail.

[0036] **Manufacturing Method**

[0037] **Pretreatment**

[0038] First, a metal fiber bundle may be used by forming surface irregularities thereon with a spacing ranging from 0.3 mm to 50 mm in a lengthwise direction so as to prevent individual metal fibers from being removed and to improve entanglement. Since the individual metal fibers may be removed when the entanglement thereof is poor while the metal fiber bundle is drawn in a lengthwise direction during a weaving or knitting process, surface irregularities may be formed before weaving fabric in order to improve entanglement.

[0039] Since metal fibers, different from ordinary fibers, have low elongation, a tensile force may be exerted thereon in a lengthwise direction during weaving fabric. When the excessive tensile force is exerted, metal fiber bundles may be disconnected or needles of a knitting machine may be broken. Therefore, in the present invention, surface irregularities having a predetermined spacing are formed on the metal fiber bundles to artificially apply elongation, and thus, breakage of the metal fiber bundles or the needles may be prevented.

[0040] **Knitting**

[0041] In the present invention, knitting a seamless cylindrical knitted fabric having no welded portion and a predetermined size by using a circular knitting machine is targeted. Since a metal fiber bundle may be relatively thick, knitting may be impossible by using an ordinary fiber knitting machine, and a dense structure may not be able to be knitted to obtain normal combustion. Also, in view of characteristics required for a knitted mat for a surface combustion burner, a spacing between the mat and the distributor must not be generated due to thermal deformation.

[0042] Therefore, in the present invention, a knitted fabric having a double-layer structure is designed so as to allow relatively thick metal fiber bundles to be knitted and have increased resistance to thermal deformation. That is, since the knitted metal fiber fabric is allowed to have a double-layer structure in which a second layer fabric included in a cooling area may hold a first layer

fabric being heated at a high temperature, resistance to heat may be improved, and the combustion may be possible in a wider region as a path through which premixed gas passes becomes longer.

[0043] FIG. 6 is a drawing illustrating a process of forming loops during knitting of the seamless cylindrical metal fiber mat according to the exemplary embodiment of the present invention.

[0044] Specifically, as shown in FIG. 6(a), in a first layer fabric, loops are formed at a lower stitch of Needle Number 1 and an upper stitch of Needle Number 2. As shown in FIG. 6(b), a second layer fabric is knitted, in which loops are repeatedly formed at the lower stitch of Needle Number 1 and a lower stitch of Needle Number 2.

[0045] The metal fiber mat thus knitted has a distinction between front and back surfaces thereof. In general, since the first layer fabric belongs to a flame portion forming a flame and the second layer fabric belongs to a cooling area having virtually no thermal deformation generated therein, the second layer fabric may act to inhibit thermal deformation of the first layer fabric having a high temperature and secure a combustion time to allow sufficient combustion of premixed gas on the surface of the mat to be completed by generating turbulence in the flow of the premixed gas.

[0046] According to the present invention, a loss of a heat-generating surface may be minimized and durability may be secured by removal of welded portions of a metal fiber mat, and as a result, quality may be improved.

[0047] Also, since a cylindrical metal fiber mat may simply cover an external distributor, an assembly process may be improved, and thus, production time may not only be reduced, but production costs may also be reduced and automation may be possible.

[0048] In addition, since a metal fiber mat may be prepared to fit an external diameter of a cylindrical burner, a material loss may not occur and the metal fiber mat may be easily employed in burners having various diameters and heights.

[0049] While the exemplary embodiments of the present invention have been shown and described in detail with reference to the accompanying drawings, it will be apparent to those skilled in the art that modifications and variations can be made without departing from the spirit and scope of the invention as defined by the appended claims.

[0050] Therefore, the scope of the invention is defined not by the detailed description of the invention but by the appended claims, and all differences within the scope will be construed as being included in the present invention.

Claims

1. A seamless cylindrical metal fiber mat installed outside a distributor of a surface combustion burner, wherein a metal fiber mat is formed as a one-piece cylinder to be installed outside the distributor by an insertion method.

2. The seamless cylindrical metal fiber mat installed outside a distributor of a surface combustion burner of claim 1, wherein the seamless cylindrical metal fiber mat is a knitted mat.

3. The seamless cylindrical metal fiber mat installed outside a distributor of a surface combustion burner of claim 1 or 2, wherein a material of the seamless cylindrical metal fiber mat is an iron-chromium alloy or stainless steel.

4. The seamless cylindrical metal fiber mat installed outside a distributor of a surface combustion burner of claim 3, wherein the iron-chromium alloy comprises 18 wt% to 27 wt% of chromium (Cr), 3 wt% to 7 wt% of aluminum (Al), and iron (Fe) as a remainder.

5. The seamless cylindrical metal fiber mat installed outside a distributor of a surface combustion burner of claim 4, wherein the iron-chromium alloy further comprises 0.05 wt% to 0.5 wt% of zirconium (Zr) and yttrium (Y).

6. A method of manufacturing a seamless cylindrical metal fiber mat formed as a one-piece cylinder, the method comprising operations of:

   (a) forming a plurality of surface irregularities on a metal fiber bundle in a lengthwise direction;
   (b) knitting the metal fiber bundle into a double-layer structure; and
   (c) forming a knitted fabric obtained in operation (b) into a cylinder.

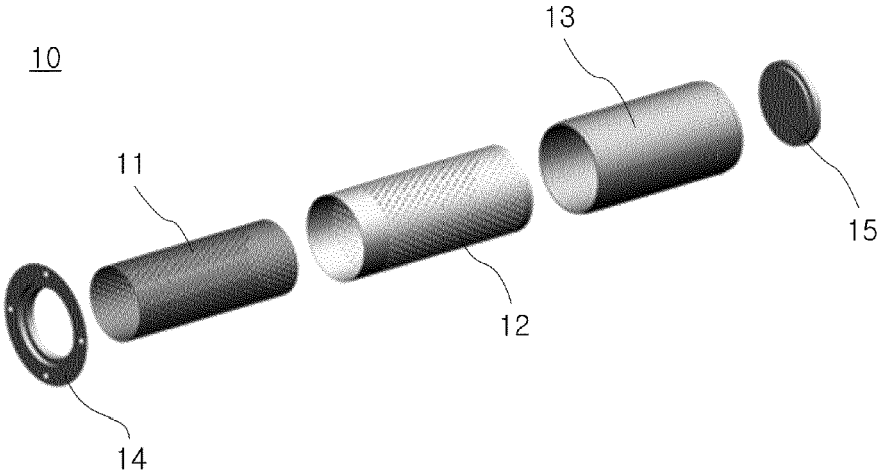

FIG. 1

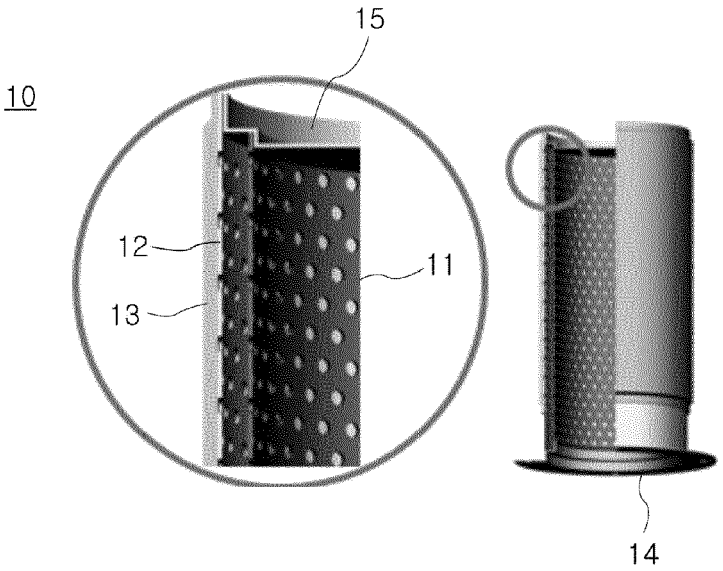

FIG. 2

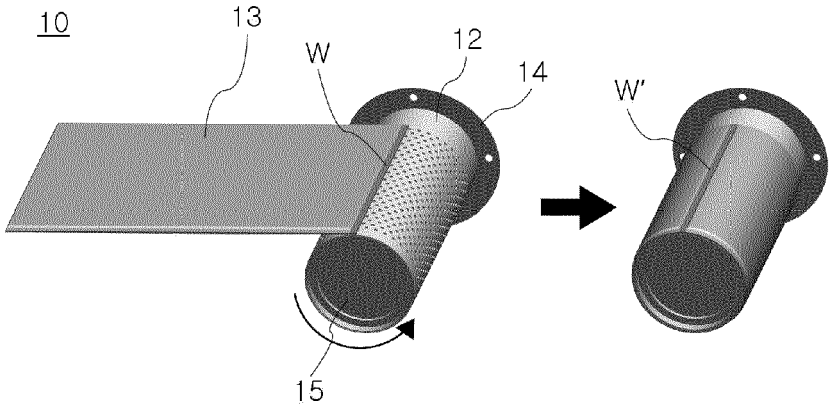

FIG. 3

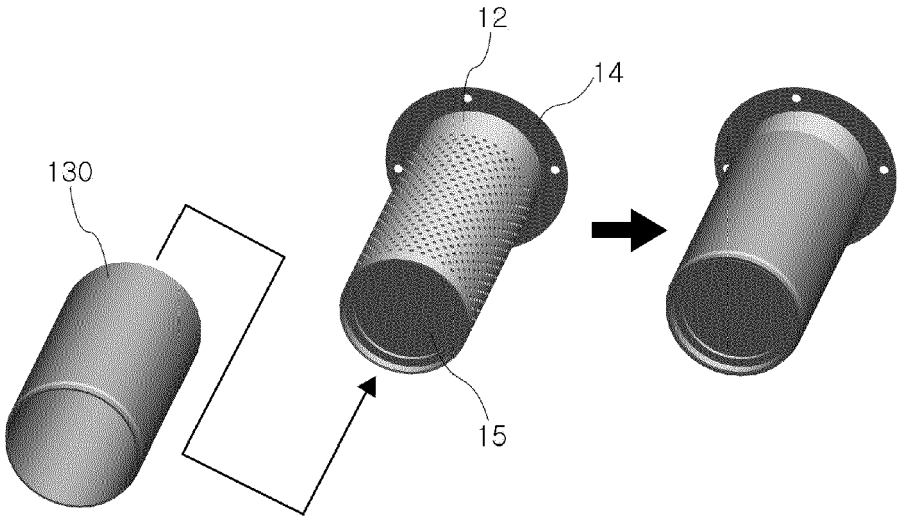

FIG. 4

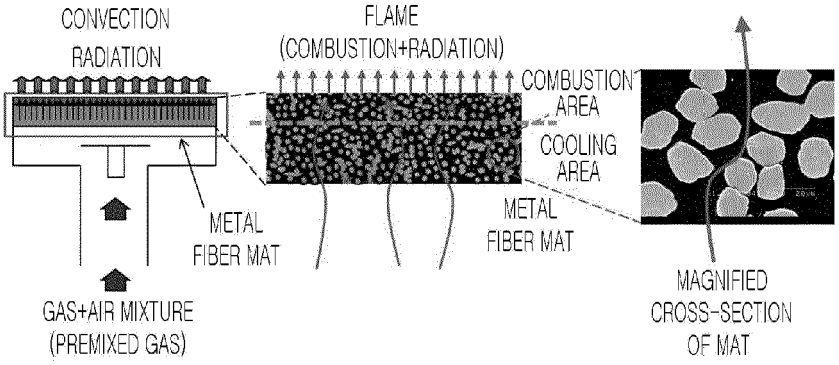
CONVECTION
RADIATION
FLAME
(COMBUSTION+RADIATION)
COMBUSTION
AREA
COOLING
AREA
METAL
FIBER MAT
METAL
FIBER MAT
GAS+AIR MIXTURE
(PREMIXED GAS)
MAGNIFIED
CROSS-SECTION
OF MAT

FIG. 5

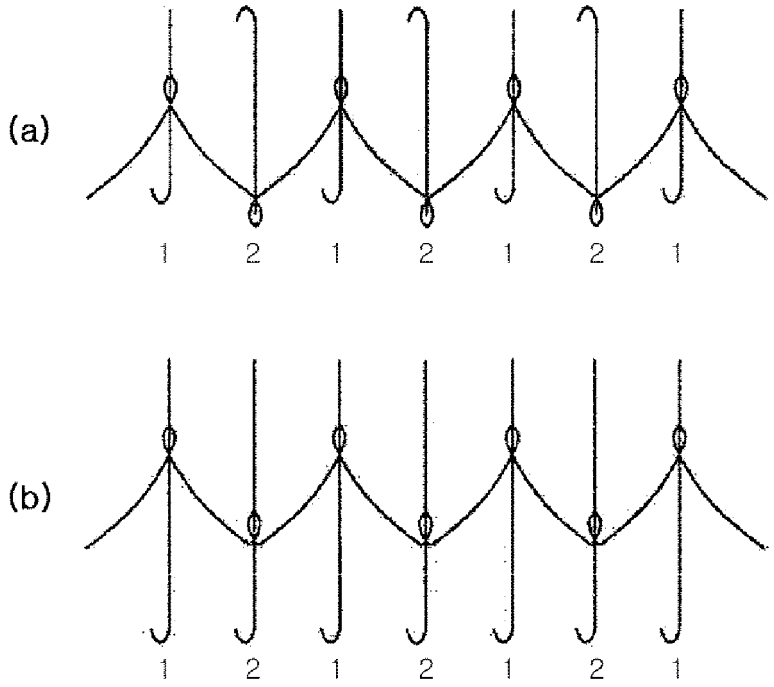

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 12 17 7559

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29 November 2012	Mougey, Maurice

CATEGORY OF CITED DOCUMENTS

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