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(54) ELECTROSTATIC SEPARATOR AND METHOD OF OPERATING AN ELECTROSTATIC SEPARATOR

(57) This invention relates to an electrostatic separator, in particular for the separation of particles in a gas flow, comprising a plurality of parallelly arranged collector plates (70) forming a filter cassette (7), wherein between two neighbouring collector plates (70) there is formed a channel (74), wherein a plurality of said collector plates (70) are arranged with a plurality of perforations (73). It also relates to a corresponding method.

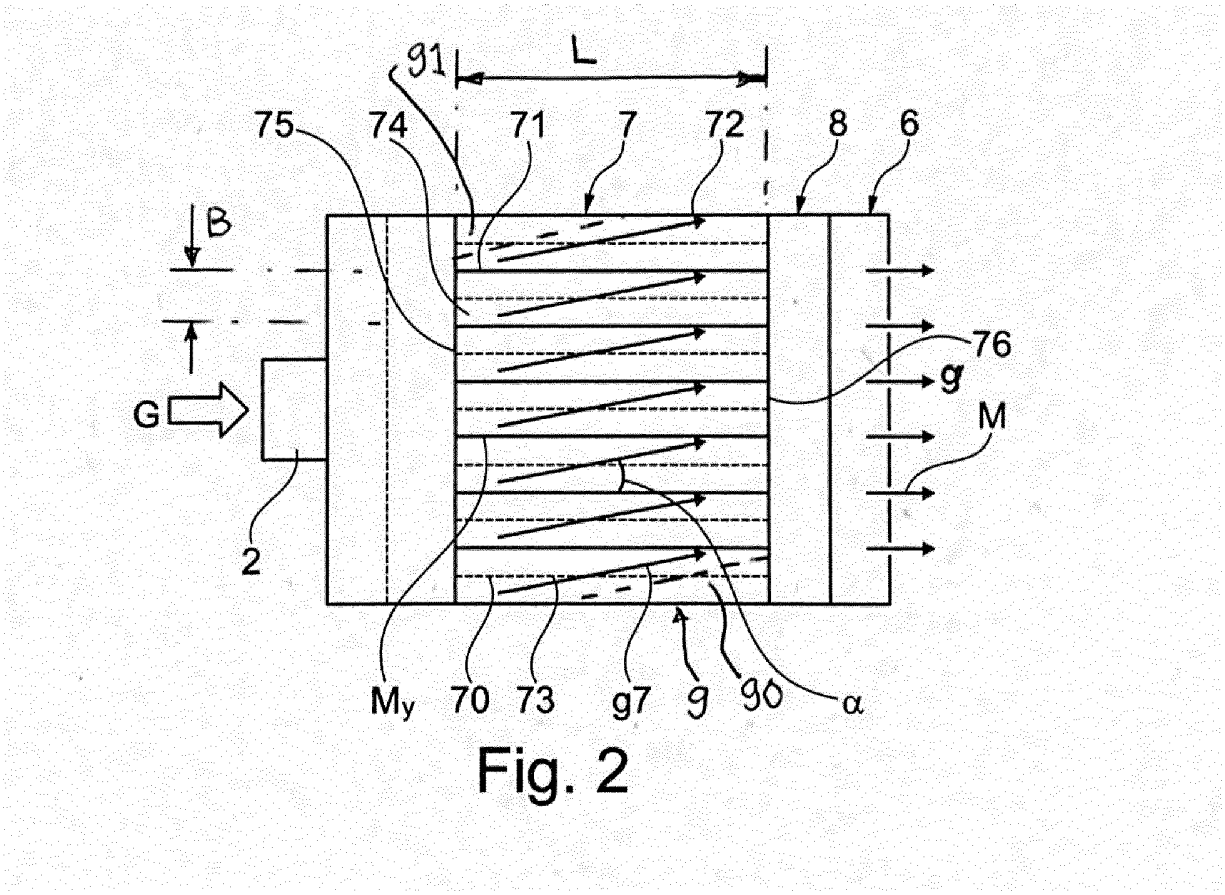

Fig. 2

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Description

TECHNICAL FIELD

[0001] The invention relates to an electrostatic separator, in particular for separating particles in a gas flow which is passed through the separator in a predetermined direction, comprising a plurality of rows of collecting electrodes arranged in a housing.

BACKGROUND

[0002] In electrostatic precipitators, the particles contained in the gas flow are charged by an electric field of high field strength generated by means of wire electrodes, so that they can be attracted and held by plate-shaped collector electrodes, which are polarized opposite to the wire electrodes enabling discharge as is known, e.g. from US 1 791 338, DE 2 843 211and US 3 740 925.

[0003] A plurality of plate-shaped collecting electrodes are arranged parallel to each other in a housing, directing the gas flow through the housing. The ribs extend parallel to the wire electrodes, which are also arranged at intervals along the flow channel between the plate-shaped collecting electrodes. The high voltage applied between the wire electrodes and the collector electrodes creates an electric field which has a relatively low but nevertheless considerable field strength in the area immediately adjacent to the plate-shaped collector electrodes adjacent. Spark-overs between a wire electrode and a collector electrode set the upper limit for the voltage that can be applied between these electrodes.

[0004] Each charged particle experiences an electrostatic attraction force to the nearest collecting electrode of a magnitude proportional to the charge on the particle and the electric field strength. However, in the central flow region between adjacent collection electrodes, where the velocity is relatively high, the electrostatic force is small compared to the aerodynamic forces that entrain the particles with the gas flow. Therefore, the electrostatic attractive force has little influence on the particle position before the particle is brought to a region of reduced flow velocity in the vicinity of the collecting electrode. In this region, the migration speed caused by the electric field prevails, so that the particle is captured by the collecting electrode and held in an accumulating layer by residual attractive forces.

[0005] It is known to provide flow areas with reduced gas flow, by means of ribs on the collecting electrodes, intended to enable increased collection of particles. However, the ribs also disadvantageously impede the main flow between the electrodes and reduce the limit value of the separator's flashover voltage. The breakdown voltage limit determines the practical upper operating limit for the electrode voltage and hence the limit of the electric field strength in the space between the electrodes.

[0006] A high electric field strength favours a high charging of the particles. This is desirable because the electrical attractive force exerted on the particles is proportional to the charge on the particles. It is also desirable to have as high a field strength as possible near the collection electrodes where the electrostatic forces cause capture, because these forces are proportional to the field strength. It is also advantageous that the field strength be as uniform as possible in these areas. Deviations from the uniformity of the electric field strength along the surface of the collecting electrodes are disadvantageous, since sharp deviations/peak values may cause arcing and therefore a need to reduce the field strength along a collection electrode to handle such peak values, thereby reducing the overall capture efficiency of the system.

[0007] From DE 2 843 211it is known to use wave shaped collector plates and from "A Manual of Electrostatic Precipitator Technology", Southern Research Institute, Birmingham, Alabama, USA, 1970, pages 231 and 232 it is known to use collector electrodes which have a zigzag, staggered or ribbed configuration. Such abrupt increases, however, tend to cause arcing to the wire electrodes and cause nonuniformity in field strength along the collecting electrode, so that problems similar to those of the ribbed collecting electrodes mentioned above arise.

SUMMARY OF THE INVENTION

[0008] It is therefore an object of the invention to improve an electrostatic precipitator of the type mentioned at the outset while avoiding the disadvantages and difficulties mentioned as far as possible in such a way that the capture efficiency and/or the particle retention capacity of the collecting electrodes can be increased preferably without the main gas flow being significantly obstructed as a result through the separator, which is achieved by means of a filter cassette according to claim 1 and a method according to claim 6.

[0009] Thanks to the invention the trapping region near a collection electrode may be provided with an optimized flow of highly charged particles, resulting in improved capture efficiency in a cost-efficient manner and which may further assist in an improved ability to use a more stable field strength. This is due to that at every given time, a portion of the gas moves through the collector plates, and so, the entire gas volume containing charges particles, will come very close to the collecting plate surface at some instance during the passage. In other words, thanks to the invention, the perceived average distance between the surfaces of the collector plates may be seen as less than the actual measure, contrary to a traditional design.

[0010] Hence, thanks to the invention, the length of the device in the direction of gas flow may be reduced while achieving the same effective surface area on which the particles are collected. Therefore, both the length and the width of the device may potentially be reduced with

the same efficiency, which may be especially advantageous regarding replacement of old type separators (e. g. cyclon) which normally are integrated in spaces that are too small for conventional electrostatic separators.

BRIEF DESCRITION OF FIGURES

[0011] In the following the invention is to be explained in more detail with reference to the figures, in which:

FIG. 1, shows a schematic side view of an electrostatic filter unit according to the invention;
FIG. 2 shows a schematic view from above of the electrostatic filter unit in Fig. 1,
FIG. 3 shows a part of a first exemplary embodiment of a collector plate according to the invention,
FIG. 4 shows a sectional view along the indicated lines in Fig 3, of the first exemplary embodiment of a collector plate according to the invention,
FIG. 5 shows a part of a second embodiment of an exemplary collector plate according to the invention,
FIG. 6 shows a sectional view along the indicated lines in Fig 5, of the second exemplary embodiment of a collector plate according to the invention.

DETAILED DESCRIPTION

[0012] Fig. 1 illustrates an electric filter unit 1 for cleaning dust- laden waste gases G that are supplied from one side of the electric filter unit 1 and leaves as cleaned gas g at the opposite side. The electric filter unit 1, may be of conventional design, comprising a a gas inlet 2, a first separator device 3, a second separator device 4, a dust collecting pocket 5, an electrostatic filter cassette 7, a third separator device 3 and an outlet 6.

[0013] Fig. 1 shows a schematic side view of the electrostatic filter unit 1 and Fig. 2 shows a schematic view from above of the electrostatic filter unit.

[0014] It is in the novel features of electrostatic filter cassette 7 that the invention is found. The invention is based on a new way of controlling the gas flow g7, through the cassette 7, so that a greater number of particles can be precipitated in the cassette 7.

[0015] In the cassette 7 there are a number of parallel collector plates 70 (dash-dotted in Fig. 2) which extend parallel to the side housing walls 72 of the cassette 7. There is shown a main flow direction M of gas through the cassette 7, i.e. from an inlet side 75 to an outlet side 76, which presents a traditional flow direction. Such a traditional flow direction will have a main flow direction M comprising a first vector Mx that basically is controlled by a bottom wall 77 and a top wall 78, which normally are positioned parallel in a horizontal plane, i.e. which normally extends horizontally. In a perpendicular plane there is a second vector My that traditionally is controlled by the collector plates, i.e. in parallel with the extension of the plane P of a collector plate 70 and accordingly corresponds to a flow vector along a channel 74 formed between each neighboring pair of collector plates 70, which channels 74 would traditionally control the second vector My of the gas to be parallel with the plane P of the collector plates 70. It is to be noted that after having passed the cassette 7 the outflowing gas g will normally slow down due to being controlled to flow in the main direction of flow M. However, as is evident for the skilled person, the function of the invention is not dependent on having specific directions of the main flow My, Mx, e.g. it will basically fulfil its function also if the bottom and/or wall would not be horizontal.

[0016] The collector plates 70 are charged with a certain polarity, by means of a first charging device (not shown). Between the collector plates 70 there are arranged wires 71 or similar devices known per se (schematically indicated in Fig. 2), which charge the particles in the gas flow g7 with reversed polarity. Thus, a charged particle will be attracted and precipitated against a collector plate 70 if it comes close enough. The gas flow g7 is normally approx. 1 m/s in the cassette 7.

[0017] In the solution according to the invention, each plate 70 is provided with perforations 73 that control the flow g7, at least partly, through the collector plates 70. The perforations 73 have the function of slanted holes extending along a hole direction C, which will force the gas flow g7 to move at an angle α through the cassette 7, in relation to a traditional main direction My of flow M through a cassette. Forcing the gas flow g7 to move at an angle α will increases the probability that all particles may arrive sufficiently close to a collector plate 70 to precipitate thereon. Further it will increase the distance the gas flow g7 travels in the cassette 7 (compared with a traditional flow through a cassette), which may synergistically increase efficiency.

[0018] As indicated in Fig. 2 the cassette 7 may be equipped with blocking members 9 to assist in achieving a desired flow along a desired angle α through the cassette. The blocking member can be in the form of a triangular body or a wall 90 forming a sharp end directed against the inflow 75 and a wide end that seals at the outflow 76, for a channel 74 that is next to a side 72 of the cassette 7 from which the gas flow g7 is being distanced during its passage throug the cassette 7. The blocking member may also be (and/or) in the form of a triangular body or a wall 91 forming a sharp end directed against the outflow 76 and a wide end that seals at the inflow 75, for a channel 74 that is next to a side 72 of the cassette 7 to which the gas flow g7 is approaching during its passage through the cassette 7.

[0019] One advantage with the invention is the length L of the filter cassette 7 may be reduced compared to the needed length regarding conventional electrostatic separators, to fulfil a certain level of separation. When replacing old type separators (e.g. cyclon), that kind of old separators may normally be integrated in spaces that

are too small for conventional electrostatic separators, but which may be replaced by a separator according to the invention, since thanks to the invention the length L of the cassette 7 may be made smaller than conventionally needed. Normally there is a need to have a relation between the length L of the cassette 7 and the collector plate distance B (see Fig. 2) that is at least 10, i.e. L/B> 10, wherein B is the distance between two neighboring collector plates 70. Thanks to the invention this relation may be improved, to have 10> L/B. A standard collector plate distance B is about 300 mm, implying a conventionally needed length L of 3 m. With the invention it has shown to be possible to use B = 300 mm and a Length L that is about 2 m, i.e. a L/B less than 7 which provides the advantage that many old separators may be exchanged by means of the invention and using the existing infrastructure for the a new electric filter separator cassette 7.

[0020] In Figs. 3 and 4 there are shown a possible embodiment of a collective plate 70 in accordance with the invention. In Fig. 3 it is shown the face thereof and in Fig. 4 there is shown a cross-sectional view along the indicated line in Fig. 3. As shown the collector plate 70 is provided with a plurality of holes 73, e.g. punched or drilled holes having a center axis C. The holes are positioned at an angle β in relation to the extension of the plate, which angle β is a smaller than 90°. The slanted holes 73 will force the gas g7 to move partly through each collective plate 70, which will cause the main flow g7 within the cassette 7 to be forced to move along an angle α in relation to the main extension M of each channel 74. The preferred angle β of the holes is in the range of 5°-45°, preferably 10°-30°.

[0021] In Figs. 5 and 6 there are shown similar views as in Figs. 3 and 4 of a second embodiment of an exemplary collective plate of the invention. In this embodiment the collective plate is made from a so called expanded raised plate (also called stretch sheets), e.g. a metallic plate that is punched to create through passages and thereafter stretched to form an open structure as shown in Fig. 5. expanded raised plate holesBy directing the punched passages in an angle the hole structure 73 of the collective plate 70 will in principle be as shown in Fig. 6, i.e. presenting rhomboid holes having surrounding walls that are slanted at an angle β, which will force the gas flow g7 in a similar manner as mentioned above.

[0022] The collector plate 70 would normally have a thickness in the range of 1-5mm. Preferably the flow angle α of the gas flow g7 through the cassette 7 is such that the total amount of gas flowing into the cassette has passed a neighboring collector plate 70 before leaving the cassette 7. Accordingly, preferably the gas flowing in G at the inflow side 75 of the cassette 7 will enter one channel 74 between two collector plates 70 and all of those gases will leave at the outlet 76 having passed one collector plate 70 such that they will pass out from the cassette 7 via a neighboring flow channel 74, which in many applications will result in choosing a pattern and angle β of the holes 73 that provides a general flow angle α in a transversal plane to the collector plates 70 that may be in the range of 5-15 degrees.

[0023] The expression cassette 7 must be interpreted in a broad manner. It may be a unit by itself that may be exchanged by removing it as an integral unit having integrated walls, at least at two opposing sides. However, it is also foreseen that the support structure of the cassette 7 may be integrated into the filter unit 1 and that each collector plate 70 may be separately removed from the cassette 7. Alternatively, the collector plates 70 may be arranged removable pairwise or in other sets of groups.

[0024] The invention is not limited to the examples described above but may be varied within the scope of the claims fulfilling the main purpose of the invention. For instance, it is foreseen that the function of the principle is not dependent of a cassette but will function also if fixedly installed a s a part within a filter unit.

Claims

1. Electrostatic separator, in particular for the separation of particles in a gas flow, comprising a plurality of parallelly arranged collector plates (70) between an open inflow (75) and an open outflow (76) forming a filter cassette (7), wherein between two neighbouring collector plates (70) there is formed an open channel (74), **characterized in that** a plurality of said collector plates (70) are arranged with a plurality of perforations (73), wherein said perforations (73) have a slanted function arranged to control the gas flow (g7) to move at a flow angle (α) in relation to a second vector (My) of a main flow direction (M) of gas through said cassette (7), wherein said a second vector (My) of said main flow direction (M) is parallel with said collector plates (70).

2. Electrostatic separator according to claim 1, **characterized in that** said angle (α) is in the range of 5-20°, preferably 7°-15°.

3. Electrostatic separator according to any of claims 1-2, **characterized in that** each of said perforations (73) have a main direction (C) through said collector plate (70) that form a hole angle (β) in relation to the plane (P) of said collector plate (70), wherein preferably said main direction (C) is parallel to a first flow vector (Mx) of said main flow direction (M), wherein said hole angle is in the range of 5°-45°, more preferred 10°-30°.

4. Electrostatic separator according to any of claims 1-3, **characterized in that** the total amount of area (Ah) of perforations (73) in relation to the amount of the total amount of area (Ap) of solid plate material (79) is in the range of 10 % to 50 %, preferably 20

% to 40 %.

5. Electrostatic separator according to any of claims 1-3, **characterized in that** the length (L) of the filter cassette (7) and the distance (B) between two neighbouring collector plates (70) is such that 10> L/B >5, wherein preferably 8> L/B.

6. Method of operating an electrostatic separator, comprising the steps of providing a filter cassette (7) with a plurality of parallelly arranged collector plates (70) between an open inflow (75) and an open outflow (76), wherein between two neighbouring collector plates (70) there is formed an open channel (74) presenting a main direction of flow,

- charging said collector plates (70) with a first polarity,
- arranging for supply of incoming gas flow (G) including particles through said cassette (7),
- charging particles in said gas flow with a second polarity,
- collecting particles by precipitation on said collector plates (70),

characterized by providing said plurality of collector plates (70) with a plurality of perforations (73) which will control at least a part of said gas flow (g7) to pass through said collector plates (70), controlling said gas flow (g7) to move at a flow angle (α) in relation to a second vector (My) of said main flow direction (M) of gas through said cassette (7).

7. Method according to claim 6, **characterized in** said a second vector (My) of said main flow direction (M) is parallel with said collector plates (70), said angle (α) is in the range of 5-20°, preferably 7°-15°.

8. Method according to claim 6 or 7, **characterized by** controlling the flow velocity of said gas flow (g7) within the cassette (7) is in the range of 0,5 m/s to 3 m/s, preferably above 1 m/s.

9. Method according to any of claims 6 -8, **characterized by** controlling the flow velocity of said gas flow (g7) within the cassette (7) to be in the range of 101 % to 150 % of the flow velocity of said main flow (M).

10. Method according to any of claims 6 -9, **characterized by** controlling said gas flow (g7) by providing at least one blocking member (9) to assist in providing a flow angle (α) in relation to a second vector (My) of said main flow direction (M) of gas through said cassette (7).

11. Method of rebuilding a separator by means of exchanging a conventional separator by an electrostatic separator according to any of claims 1-5, comprising the steps of removing the conventional filter unit from its filter space in a filter housing and installing said electrostatic separator cassette (7) in said filter space, wherein preferably said filter space has a length (1) that is less than 3 m, more preferred in the range of 2,5 - 1,8 m.

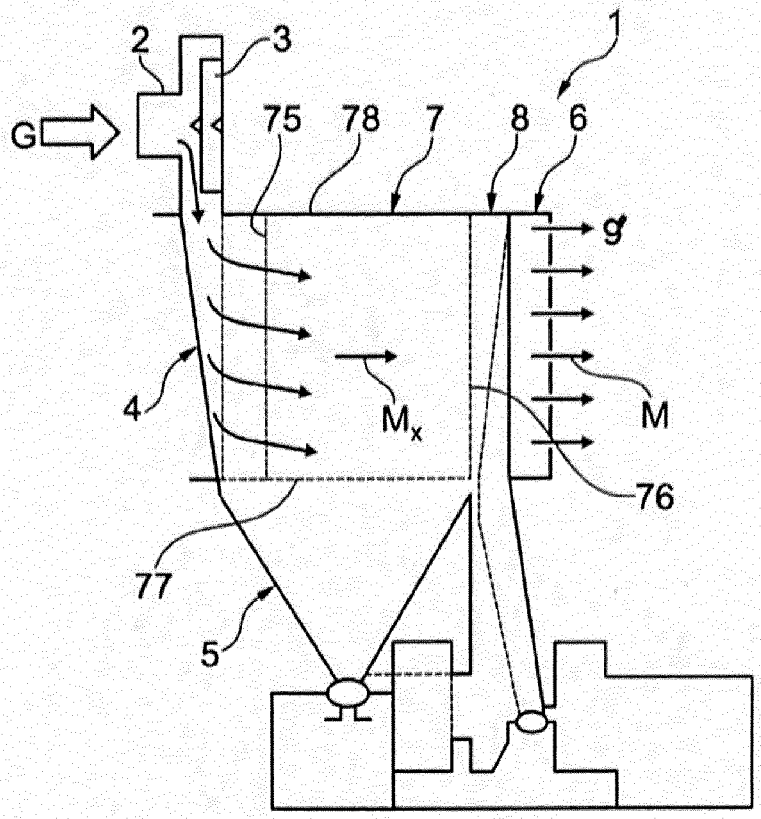
2
3
1
G
75
78
7
8
6
g
4
M_x
M
76
77
5

Fig. 1

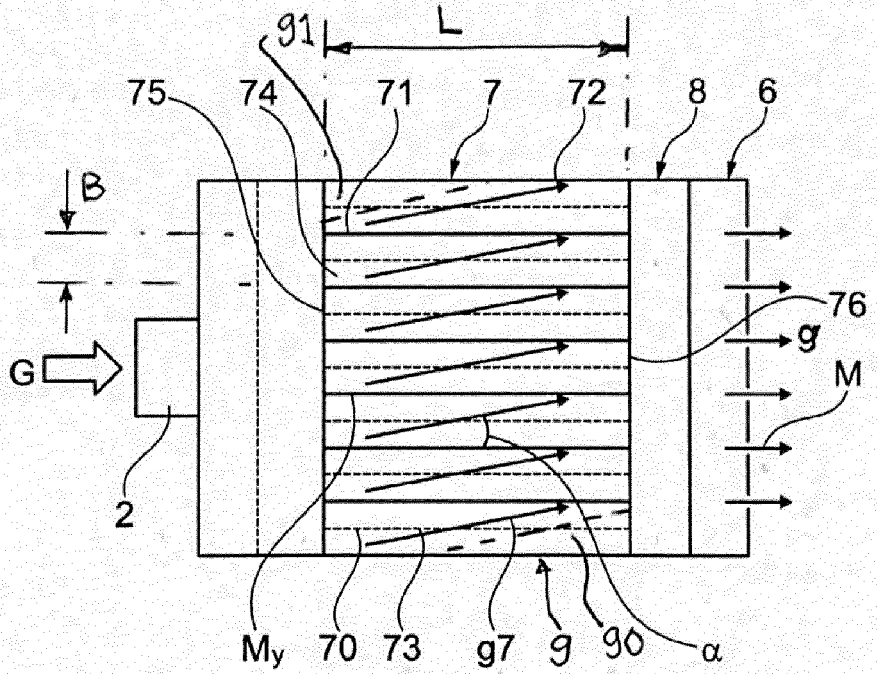
91
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Fig. 2

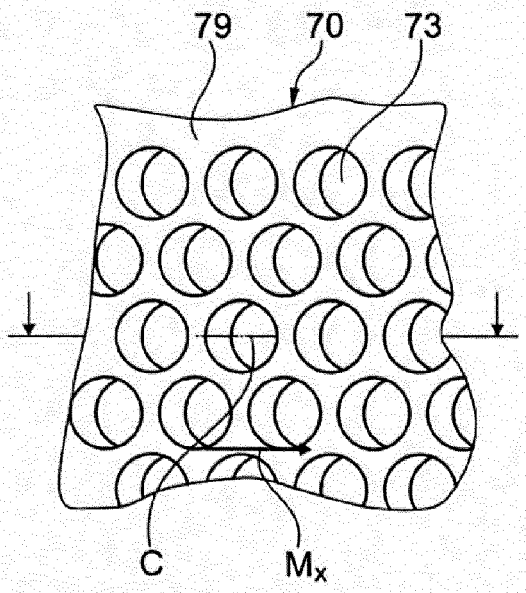

Fig. 3

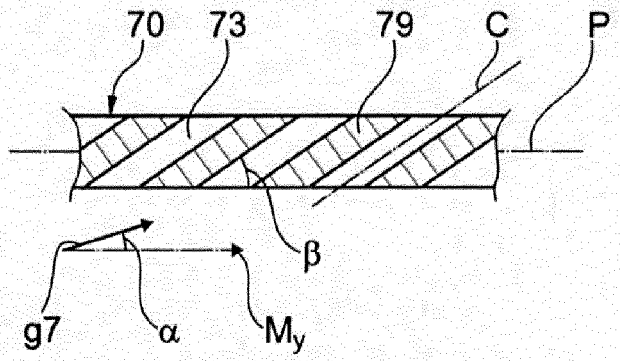

Fig. 4

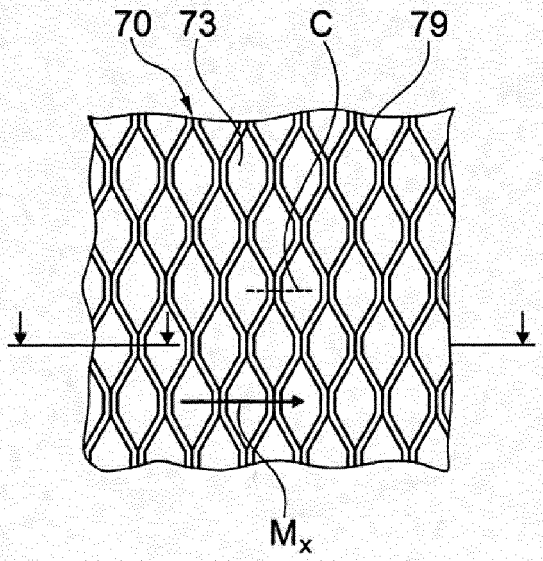

Fig. 5

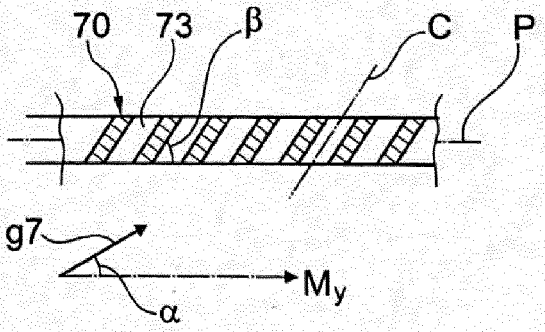

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 23 22 0426

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	US 2002/134237 A1 (MILLER STANLEY J [US]) 26 September 2002 (2002-09-26) * paragraph [0034] - paragraph [0073] * * figures 1-6,8-11,13-20,22,26 *	1-11	INV. B03C3/47
X	EP 0 829 304 A1 (MAXS AG [CH]) 18 March 1998 (1998-03-18) * column 1, line 3 - line 5 * * column 6, line 10 - line 41 * * column 7, line 8 - line 17 * * column 7, line 53 - line 56 * * column 9, line 10 - line 12 * * figures 1-2 *	1-11	
X	CN 101 862 705 B (UNIV ZHEJIANG GONGSHANG) 10 October 2012 (2012-10-10) * paragraph [0044] - paragraph [0045] * * figures 1-2 *	1-11	
X	US 2014/053727 A1 (MILLER STANLEY J [US] ET AL) 27 February 2014 (2014-02-27) * paragraph [0017] - paragraph [0049] * * figures 1-2 *	1-11	TECHNICAL FIELDS SEARCHED (IPC) B03C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	7 June 2024	Jorna, Pieter

CATEGORY OF CITED DOCUMENTS

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- DE 2843211 **[0002] [0007]**
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