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(54) SEPARATION ARRANGEMENT FOR AN ELECTROSTRATIC PRECIPITATOR AND AN ELECTROSTATIC PRECIPITATOR

(57) The present invention relates to a separation arrangement (200) for an electrostatic precipitator (100) comprising: a separation chamber; a first set of plate shaped electrodes (210); and a second set of plate shaped electrodes (220), wherein at least one electrode (210) of the first set and at least one electrode (220) of the second set are provided with a respective cut-out (211, 221) and wherein the at least one electrode (210) of the first set and the at least one electrode (220) of the second set are provided with a respective scraper. When the separation arrangement (200) is in an operation mode, the at least one electrode (210) of the first set and the at least one electrode (220) of the second set are configured to be arranged in relation to each other, such that the respective cut-out (211, 221) of the adjacent electrode (210, 220) coincides with the respective scraper (212, 222). When the separation arrangement (200) is in a cleaning mode in which the second set of electrodes (220) are configured to be rotated about the first axis (A1), the respective scraper (212, 222) scrapes the opposing first or second major surface (214a, 224a, 214b, 224b) of the adjacent electrode (210, 220) thereby removing particles collected thereon. An electrostatic precipitator (100) including a separation arrangement (200) is also provided.

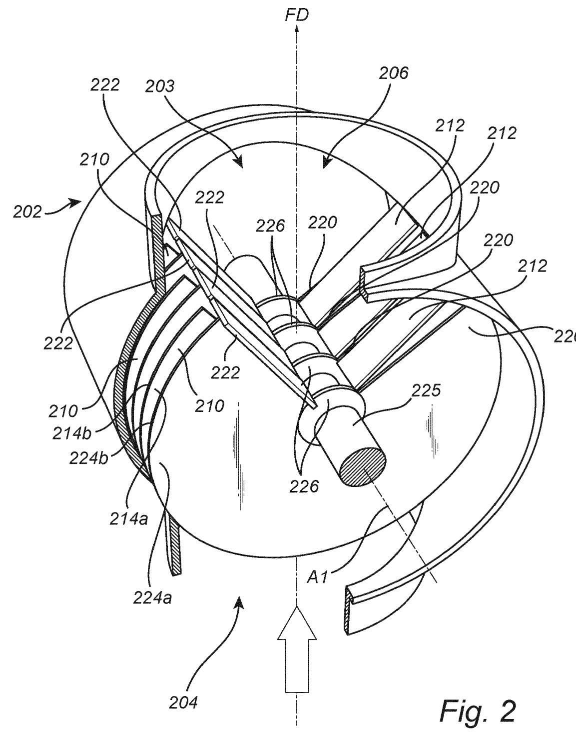

Fig. 2

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Description

Field of the disclosure

[0001] The disclosure relates to a separation arrangement for an electrostatic precipitator. The disclosure further relates to an electrostatic precipitator comprising a separation arrangement and a pre-charger.

Background art

[0002] Electrostatic precipitators or filters for removing particles, like dust, ash or sooth, from a flowing gas stream by using electrical energy are well known in the art. Typically, the electrostatic precipitator comprises an inlet for receiving the gas stream and an outlet for exhausting the gas stream, preferably without, or with a reduced number of, particles. Such electrostatic precipitators are configured to charge the particles, as well as collect the charged particles using of electric fields. Electrostatic precipitators are typically divided into single-stage configurations and two-stage configurations.

[0003] A single-stage electrostatic precipitator typically includes several plate-shaped parallel electrically grounded collection electrodes, and thin wire-shaped or spike-edged discharge electrodes arranged between the collection electrodes. An electric potential, generally higher than 10 kV, is typically applied between the two types of electrodes, thereby generating a corona discharge. Hence, the discharge electrodes emit ions that charge the particles to be removed. The particles then migrate to the collection electrodes by electrostatic force.

[0004] During operation, a particle layer is formed on the collection electrodes. The particle layer must be repetitively removed in order to maintain the functionality of the precipitator. The most common method used to remove the particle layer is called rapping. In rapping, the collection electrodes are mechanically stroked to dislodge the particle layer. The particles or ash that then falls from the electrodes into so-called hoppers.

[0005] Such single-stage electrostatic precipitators are widely used for removal of particles in industrial applications. For instance, single-stage electrostatic precipitators are widely used for removal of particles in industrial applications with high dust loads, such as incineration of waste, combustion of ash-rich fuels, in pulp mill recovery boilers, and in limekilns.

[0006] In two-stage electrostatic precipitators, the particles to be removed are initially charged. The charging of the particles is generally performed using a corona discharge. The gas including the charged particles is then distributed or fed to a collection device or unit. Such a collection device or unit typically includes a separation unit or arrangement where the charged particles are removed from the gas. Such separation unit is typically including a collection electrode configuration. The collection electrode configuration does in turn typically include plate-shaped parallelly arranged alternating high-voltage and grounded electrodes. Such two-stage electrostatic precipitators enables a more compact design than single-stage electrostatic precipitators since they allow a smaller plate spacing and higher collection surface density.

[0007] The small plate spacing also allows for a higher electric field strength as well as shorter particle traveling distance to the collection electrodes. In addition, a two-stage electrostatic precipitator consumes less electric energy and emits less ozone. As a result, two-stage electrostatic precipitators are frequently used in low-dust or low-particle applications such as air purifiers as well as in oil mist separators. However, at high concentrations of solid dust, typically at extended operation times, deposits and bridges of dust can form between the closely spaced collection electrodes of different potentials. Such deposits and bridges may cause serious malfunctioning through electric discharge and short circuit between the electrodes.

[0008] Further, thick layers of collected particles on the electrodes might also cause re-entrainment of the collected particles to the gas. Such re-entrainment of the collected particles to the gas may inevitably reduce the removal efficiency. Consequently, a decisive property of any efficient two-stage precipitator for high dust loads are efficient and rapid removal of collected particles. In oil mist precipitators oil droplets are typically collected on the electrodes. Such collected oil droplets form a liquid layer that is continuously removed from the electrodes typically by gravity. In many air purifiers relying on electrostatic precipitation, the collection electrodes can be detached and then washed manually.

[0009] However, the above methods are not suitable for a continuous operation electrostatic precipitator especially when used for high particle or dust loads. Rapping is not viable because the dimensions of the electrodes and the specific physical properties of the particle deposits in a two-stage configuration. Also rapping cannot decisively prevent formation of deposits and bridges that cause electric discharge and short circuit between the closely spaced electrodes.

[0010] As discussed above, conventional electrostatic precipitators of today are associated with drawbacks especially when it comes to removal of particles from the electrodes. Further, conventional electrostatic precipitators are generally bulky and tend to occupy valuable space wherever installed. Thus, there is a need in the art for an improvement in this area. However, many electrostatic precipitators which are already in use at various plants are functioning to satisfaction in many other aspects.

Summary

[0011] It is an object of the disclosure to provide a separation arrangement for an electrostatic precipitator, which enables rapid and efficient removal of collected particles from the collection electrodes.

[0012] Another object is to provide such a separation arrangement for an electrostatic precipitator that may remove particles from gases with medium to high concentrations of solid dust.

[0013] Another object is to provide such a separation arrangement for a two-stage electrostatic precipitator that may remove particles from gases with medium to high concentrations of solid dust.

[0014] Another object is to provide such a separation arrangement, which counteracts or prevents permanent deposit formation and bridging of collected particles between electrodes of different polarity.

[0015] Another object is to provide an electrostatic precipitator configuration for medium to high concentrations of solid dust, which is more compact and requires less space.

[0016] Another object is to provide an electrostatic precipitator configuration for medium to high concentrations of solid dust, which requires less material for manufacturing and is more energy efficient.

[0017] Another object is to provide such a separation arrangement which is more environmentally friendly.

[0018] Another object is to provide such a separation arrangement which provides for that a limited number of particles, are emitted to the air.

[0019] Another object is to provide such a separation arrangement and electrostatic precipitator which are less time consuming to install.

[0020] It is also an object to provide a cost-effective separation arrangement and electrostatic precipitator.

[0021] Hence, the present invention suggests an arrangement for removal of charged gas-borne particles, preferentially in a two-stage electrostatic precipitator configuration, where the dust or particle layer may be efficiently removed from the electrodes during a rapid cleaning sequence, and where detrimental deposit formation or dust bridging between the collection electrodes can be counteracted or avoided.

[0022] According to a first aspect there is provided a separation arrangement for an electrostatic precipitator comprising: a separation chamber having a gas flow inlet for receiving a particulate-laden gas stream and a gas flow outlet for exhausting the particulate-laden gas stream; a first set of plate shaped electrodes; and a second set of plate shaped electrodes; wherein each electrode has a first major surface and an opposing second major surface, wherein the electrodes of the first set and the second set are coaxially alternately arranged inside the chamber about a first axis, the first axis extending in normal direction to a major flow direction of the particulate-laden gas stream; wherein the first set of electrodes is arranged in relation to walls of the chamber; wherein the second set of electrodes is rotatably arranged about the first axis and configured to be coupled to a voltage source for providing a potential difference in relation to the first set of electrodes and the walls of the chamber when the separation arrangement is in an operating mode, wherein at least one electrode of the first set and at least one electrode of the second set are provided with a respective cut-out which extends from an axis portion towards a peripheral portion of the associated electrode; wherein the at least one electrode of the first set and the at least one electrode of the second set are provided with a respective scraper on an associated first major surface and second major surface respectively, the respective scraper extending along the associated first major surface and second major surface from the axis portion to the peripheral portion of the associated electrode and protrudes in a axial direction from the associated first or second major surface towards an opposing first or second major surface of an adjacent electrode; wherein, when the separation arrangement is in the operation mode, the at least one electrode of the first set and the at least one electrode of the second set are configured to be arranged in relation to each other, such that the respective cut-out of the adjacent electrode coincides with the respective scraper of the associated electrode; and wherein, when the separation arrangement is in a cleaning mode in which the second set of electrodes are configured to be rotated about the first axis, the respective scraper scrapes the opposing first or second major surface of the adjacent electrode thereby removing particles collected thereon.

[0023] The particulate-laden gas stream typically comprises suspended particles or dust particles. Such suspended particles include ash, soot, powder etc. The particles in the gas stream are assumed to be electrically pre-charged before being received by the gas flow inlet of the separation arrangement. Thus, a majority of the particles will have a polarity when being received by the gas flow inlet. The polarity may here be defined as a net surplus of either positive or negative elementary charges.

[0024] The terms "first major surface" and "second major surface" are here meant opposing surfaces of an electrode, wherein the major surfaces are arranged transverse to the first axis.

[0025] The first and second set of electrodes are alternately arranged inside the chamber, between the walls of the chamber, about the first axis. The first and second set of electrodes are typically surrounded by the walls of the chamber.

[0026] The term "arranged in relation to walls of the chamber" is here meant that the first set of electrodes is attached to the walls. The first set of electrodes may be arranged such that at least a portion of each electrode of the first set is in contact with at least a portion of the walls. The first set of electrodes may be connected to the walls of the chamber via any suitable coupling or carrying structure. The first set of electrodes may be fixedly arranged about the first axis.

[0027] The cut-out may be an internal cut-out such that the cut-out is surrounded by continuous remaining portions of the associated electrode. The cut-out may be an external cut-out which extends to a peripheral edge portion of the associated electrode. In other words, the cutout may be an opening in its associated electrode or may be a slit in its associated electrode.

[0028] As the scraper is provided on the first major surface and the second major surface of an associated electrode, each electrode is provided with a pair of scrapers provided on either side of the electrode. Thus, the pair of scrapers are typically formed by two scrapers provided on the respective major surface of the associated electrode. When the scrapers are provided on the first major surface and the second major surface, respectively, the scrapers are surrounded by the associated major surface. The scrapers of an electrode protrude towards two opposing adjacent electrodes and hence may scrape the opposing surfaces of the adjacent electrodes. A pair of scrapers may be formed by two or more scraper portions.

[0029] The scraper may be provided along an edge portion of the cut-out of the associated electrode, from the axis portion towards the peripheral portion. In this case, the scraper may extend from the edge portion towards an opposing first major surface of an adjacent electrode and towards an opposing second major surface of an opposite adjacent electrode. The scraper may be partly surrounded by the associated major surface and partly surrounded by the cut-out. Scrapers protruding from the first major surface and the second major surface of an electrode may be integrally formed as one scraper. Scrapers may be formed by two or more scraper portions.

[0030] The separation arrangement is advantageous as it facilitates provision of cleaning the particulate-laden gas stream by removing at least a portion of the particles from the gas stream. Preferably, the separation arrangement is configured to remove a majority of particles from the gas stream. This is provided when the separation arrangement is in the operation mode. In the operation mode, the second set of electrodes are coupled to the voltage source and thereby providing the potential difference between the second set of electrodes in relation to the first set of electrodes and the walls of the chamber. It should be noted that the alternately arrangement of the first and second set of electrodes is essential in order for the potential difference to be provided throughout the separation arrangement. By providing the potential difference, an electric field is formed between the electrodes. Thereby, when the gas stream is flowing in the gas flow direction through the electric field formed between adjacent electrodes, the charged particles in the particulate-laden gas stream are attracted towards the electrodes of opposite polarity onto which they are collected. It should be noted that the particles will normally be collected on both sets of electrodes independent of the polarity created by the pre-charging. This may occur due to that the particulate matter collected on one electrode may change polarity, then re-entrain and travel to an opposing electrode. In other words, particles may travel between electrodes of the first set and second set and vice versa.

[0031] The first and second set of electrodes are in a fixed position when the separation arrangement is in the operation mode. In this fixed position, the electrodes are arranged such that the respective cut-out, i.e. the cut-outs of the electrodes, coincides with an adjacent scraper, i.e. the scrapers of the adjacent electrodes. Thereby, the respective scraper is not in contact with the first or second surface of the adjacent electrode. This arrangement is advantageous as it provides for that the risk of a short circuit occurs may be reduced.

[0032] The separation arrangement is further advantageous as it facilitates provision of cleaning the electrodes by removing the particles or a portion of the particles collected thereon when the separation arrangement is in the cleaning mode. The separation arrangement is advantageous as it facilitates provision of removing the particles collected on the electrodes in an easy and efficient way. In the cleaning mode, the second set of electrodes are not coupled to the voltage source or the voltage source is switched off.

[0033] The first set of electrodes is in the fixed position when the separation arrangement is in the cleaning mode like when the separation arrangement is in the operation mode.

[0034] The second set of electrodes being rotated about the first axis when the separation arrangement is in the cleaning mode, thereby the respective scraper, i.e. a pair of scrapers provided on either side of an electrode of the second set of electrodes, may coincide or cooperate with the first major surface or the second major surface of the adjacent electrodes, i.e. adjacent electrodes of the first set of electrodes.

[0035] Further, the second set of electrodes being rotated about the first axis when the separation arrangement is in the cleaning mode, thereby the respective scraper, i.e. a pair of scrapers provided on either side of an electrode of first set of electrodes, may coincide or cooperate with the first major surface or the first major surface of the adjacent electrodes, i.e. adjacent electrodes of the second set of electrodes.

[0036] As the second set of electrodes are rotated about the first axis, each scraper scrapes a first major surface or second major surface of an adjacent electrode. When the second set of electrodes are rotated about the first axis, each scraper may come in contact with a first major surface or a second major surface of an adjacent electrode. When the second set of electrodes are rotated about the first axis, each scraper may come in contact with the particles collected on an adjacent electrode but not with the first major surface or second major surface of the adjacent electrode. Thus, when the particles are removed from the adjacent electrode, the scraper at hand and the first major surface or second major surface may form a distance between each other. The distance is preferably 0.1-1 mm, more preferably 0.1-0.5 mm. It should be noted that the scraper at hand may be in contact with the first major surface or second major surface such that no distance is formed. Thus, the extension of the scrapers may vary depending on the distance between adjacent electrodes as well as material of the scrapers.

[0037] Further, since the electrodes are preferentially made from a thin and thus flexible material, it may be difficult to control a precise cooperation between each scraper and a corresponding adjacent electrode. Instead, the available total space between all opposing scrapers of one set of electrodes may be distributed between the electrodes of the other set. During rotation a scraper may encounter an edge of an opposing electrode that is not fully aligned. The scraper may therefore be equipped with means of guiding the thin electrode in position, e.g. in the form of a wedge-shaped surface.

[0038] Hence, when the second set of electrodes is rotated about the first axis and the scrapers scrapes the adjacent electrode, there is provided a cleaning process which is easy to perform as well as efficient. The particles are thus mechanically removed from the electrodes. Such mechanical removal is advantageous in that it is more efficient as compared to removal by rapping, compressed air or a flow of water. Further, permanent formation of particle deposits and dust bridges that may cause electric discharge or short circuit between surfaces of different electric potential may be avoided or counteracted.

[0039] The disclosed arrangement having the cut-outs and the scrapers is further advantageous in that it is possible to keep the electrodes in a fixed position as seen in an axial direction during the operation mode wherein a risk that a short circuit may occur is reduced. The short circuit may occur if the second set of electrodes are connected to the voltage source and a scraper contacts an adjacent electrode. However, with the disclosed design, the scrapers lines up with a cut-out of an adjacent electrode when the separation arrangement is in the operation mode. Put differently, with the disclosed design, when in the operation mode, the scrapers coincide with a cut-out. When in the cleaning mode, the scrapers will, when the second set of electrodes are rotated, coincide with the first major surface or second major surface of an adjacent electrode.

[0040] It should be further noted that the rotation of the second set of electrodes about the first axis may be possible until a scraper of the associated electrode coincides and contacts with a scraper of the adjacent electrode. However, if the adjacent electrode is not provided with a scraper, the associated electrode may be rotated more than 360 degrees about the first axis. Moreover, if the scraper is formed by a flexible material, the scraper of the associated electrode may slide past the scraper of the adjacent electrode allowing for that second set of electrodes may be rotated more than 360 degrees about the first axis.

[0041] The separation arrangement may comprise at least two electrodes of the first set and at least one electrode of the second set. It should be noted that the separation arrangement may comprise any number of electrodes of the first set and the second set. However, the separation arrangement should preferably comprise one more electrode of the first set compared to the second set. Depending on dimensions and desired capacity, the separation arrangement preferably comprises 10-50 electrodes of each set. However, any number of electrodes may be used to advantage.

[0042] Each of the electrodes of the first set and the second set may be provided with a cut-out. Each of the electrodes of the first set and the second set may be provided with scrapers.

[0043] The walls of the chamber are typically grounded as well as the electrodes of the first set.

[0044] The two outermost electrodes of the first set are typically mounted close to the two walls transverse to the first axis. In order to avoid short circuit between the wall and scraper of the adjacent electrode of the second set, the outermost electrodes are preferably positioned at a distance from the walls, similar to the distance between the other adjacent electrodes. In this case there will typically also be an arrangement for preventing gas from escaping the separation arrangement by flowing between the outer electrodes and the adjacent walls.

[0045] Further, the separation arrangement is advantageous in that it allows a high operation voltage with a reduced risk of formation of electric short circuit and electric discharge. This may be accomplished by the combined advantages of sufficient distance during operation mode between all parts of the separation arrangement that have different polarity, and an efficient cleaning cycle, i.e. in the cleaning mode, which reduces or prevents permanent formation of particle deposits and particle bridges that may cause electric discharge or short circuit

[0046] The separation arrangement is further advantageous in that the separation arrangement may be a retrofitting part which could be arranged in conventional electrostatic filters.

[0047] The separation arrangement is yet further advantageous in that it allows for a removement of particles from the particulate-laden gas stream but also the electrodes in an environmentally friendly way.

[0048] The respective scraper may be arranged along an edge portion of its associated electrode, the edge portion being defined by the cut-out and extending in a direction, from the axis portion towards the peripheral portion, of the associated electrode.

[0049] By arranging a scraper along the edge portion provides for that almost the complete first major surface or second major surface of the adjacent electrode may be scraped by the scraper, or that the complete first major surface or second major surface of the adjacent electrode may be scraped by the scraper. Thereby, a majority of particles may be removed from the electrodes. Thus, this provides for a more efficient and complete cleaning mode in which a majority of the collected particles are removed.

[0050] The scraper may extend radially beyond the edge of its associated electrode. By extending the scraper radially beyond the edge portion of its associated electrode, provides for scraping surfaces such as extended surfaces of the opposing electrode and the internal wall of the chamber.

[0051] The first set and the second set of electrodes may be disc shaped.

[0052] The term "disc shaped" is here meant plate shaped electrodes which have a peripherical edge portion which at least partly coincides with a circle centered around the first axis. The plate shaped electrodes may have a peripheral edge portion which coincides with a circle centered around the first axis. The plate shaped electrodes may however have edge portions of different shapes. Such edge portions may not coincide with a confining circle.

[0053] For instance, the plate shaped electrodes may be formed with a V-shaped cut-out on a first peripheral edge portion. The plate shaped electrodes may be formed with further cut-outs. The plate shaped electrodes may preferably be provided with two further cut-outs. The further cut-outs may be defined by a respective circular segment arranged on a second peripheral portion and a third peripheral portion, respectively. Preferably, the first, second and third peripheral portions being evenly arranged along the peripheral of the disc-shaped electrode.

[0054] The electrodes may be formed of a metal material, preferably from a sheet of metal material. With the disclosed design, especially in a variant where the electrode comprises the V-shaped cut-out and the further cut-outs defined by the respective circular sector, the electrodes may be cut from a sheet with a reduced amount of wasted material. This because, the electrodes may be formed closely to each other from the material such that the further-cut outs of one electrode corresponds to the V-shaped cut-out of another electrode. Thus, with this design, the electrodes may be provided in a more material efficient way and thereby also in a more environmentally friendly way. However, it should be noted that the plate shaped electrodes may be formed in any suitable way.

[0055] The internal wall of the chamber may be partly curved. A curvature of an internal wall portion of the chamber associated with the edge portion of the first set of electrodes may at least partly coincide with a circle centered around the first axis. The second set of second set of electrodes are preferably confined by the same circle or a slightly smaller circle that defines the curvature of the internal wall of the chamber allowing them to rotate freely. This is advantageous since it may allow for a similar distance between a curved chamber wall and all associated edges of the second set of electrodes during operation mode. This does in turn allow for a similar electric field strength throughout the separation arrangement, and also allowing that the electrodes may rotate freely during the cleaning mode.

[0056] The respective cut-out may exhibit a shape of a circular sector.

[0057] This is advantageous in that, when the separation arrangement is in the operation mode, the particulate-laden gas stream may have a more uniform flow rate when flowing through the separation arrangement. This is further advantageous in that, when the separation arrangement is in the operation mode, the particulate-laden gas stream may have a more uniform residence time in the separation arrangement.

[0058] The respective cut-out may be an open cut-out and exhibit a shape of a circular sector. For cut-outs on electrodes of the first set a corresponding arc of a circular sector may coincide with an open portion between two curved chamber walls. Such cut-out of an electrode of the second set may have a similar shape as a cut-out of an adjacent electrode of the first set. When cut-outs of adjacent electrodes of different sets are rotationally aligned, the scrapers of the respective electrodes may be arranged on opposing radial edge portion of such respective cut-outs.

[0059] By open cut-out is here meant that there is no electrode material beyond a corresponding arc of the circular sector. In other words, there is no material outside of an open cut-out in a radial direction of its associated electrode. The angle of such circular sector may vary, it may for instance exceed 180 degrees. A scraper of an electrode of the first set may be arranged along a radial edge portion of the electrode. Such edge portion may be defined by an open cut-out. A scraper of an adjacent electrode of the second set may be arranged the along a second radial edge portion of the electrode. During operation a cut-out of an electrode of the second set may be rotationally slightly shifted in relation to a cut-out of an adjacent electrode of the first set such that the scraper of the first set of electrodes coincides with a cut-out portion close to a curved wall section, and such that the scraper of the second set of electrodes coincides with a cut-out portion close to another curved wall. A joint open portion of the two adjacent electrodes will consequently be directed towards the inlet or towards the outlet of the chamber.

[0060] This arrangement of the cut-outs is advantageous in that it allows for a similar distance between any surface of different polarity during the operation mode. This arrangement is further advantageous in that it allows for the scrapers to reach all surfaces of opposing electrodes as well as the curved walls of the chamber. This arrangement is further advantageous in that it allows for a uniform electric field strength as well as uniform gas flow velocity throughout the separation arrangement. This is advantageous since it allows for an improved design with respect to separation efficiency and reliable operation.

[0061] A width and/or length of the respective cut-out may be greater than a width and/or length of the respective scraper on the adjacent electrode for all radial distances, from the axis portion, occupied by the respective scraper.

[0062] This is advantageous in that a scraper may be arranged towards, i.e. lined up with, the cut-out of the adjacent electrode without the scraper being in contact with the adjacent electrode. Thus, the scraper may be encompassed by the cut-out such that the risk for a short circuit may be reduced. Thus, a short circuit may occur if a scraper is in contact with an adjacent electrode when in the operation mode.

[0063] The electrodes of the second set may be mounted, at a uniform mutual distance, on a suspension device which extends along the first axis and is suspended through the wall of the chamber.

[0064] With the disclosed design, in which the electrodes of the second set are mounted on a suspension device which is suspended through the walls of the chamber provides for an easy and efficient suspension of the electrodes of the second set. The suspension device may be a suspension axis which extends through the chamber but also through the walls along the first axis. The suspension axis may be rotatable about the first axis and thereby the electrodes as well. With this design, it is possible to rotate the electrodes in an easy way and thereby also providing for that the removal of particles may be provided in an easy way.

[0065] If the respective cut-out of the electrodes may exhibit the shape of a circular section as discussed above, the electrodes may be removably mounted to the suspension axis in an easy way without the need of removing the suspension axis from the chamber. Thus, the electrodes may be introduced in the chamber and mounted to the suspension axis. The attachment of the electrodes to the suspension axis may be provided by attachment means provided on the suspension axis. Thus, the electrodes may be mounted on the suspension axis via the attachment means. The electrodes of the second set may be mounted with a uniform mutual distance of 20-60 mm, preferably 30-50 mm, more preferably 40 mm.

[0066] This is advantageous as it provides for that the second set of electrodes may be suspended in the chamber through two suspension points, one at which the suspension device entering the chamber and one at which the suspension device is leaving the chamber. The suspension points may be arranged in the walls of the chamber. The suspension points may comprise ventilated brackets. This is advantageous in that formation bridges of particle material may be counteracted or prevented. Formation of such bridges may otherwise result in a short circuit between the suspension device and the walls of the chamber since such bridges are conductive and may consequently lead electricity.

[0067] The respective scraper may be made of a rigid material.

[0068] This is advantageous in that the removement of particles from the electrodes may be provided in an easy and efficient way.

[0069] The respective scraper may be a spring loaded and/or resilient scraper.

[0070] The spring loaded and/or resilient scraper may be divided into several individually resilient sections or filaments. By the word "filaments" is here meant to include a scraper formed as a brush. The scraper may be a flexible scraper.

[0071] This is advantageous in that a scraper of an electrode may be able to slide past a scraper of an adjacent electrode, when the second set of electrodes is rotated about the first axis. Thereby, the electrodes of the second set may be rotatable more than 360 degrees about the first axis although adjacent electrodes being provided with scrapers. Thus, the removement of particles from the electrodes may be provided in an easy, efficient but also flexible way.

[0072] This is further advantageous in that protrusion, i.e. the extension along the first axis, of a scraper may be greater than the distance between two adjacent electrodes. Thus, a flexible scraper may be able to protrude to and contact an adjacent electrode. Therefore, if a scraper is spring loaded and/or resilient, the length along the first axis of the protrusion or extension of the scraper is not essential in order for the separation arrangement to perform the cleaning mode.

[0073] The respective scraper may at least partly extend through the respective cut-out of the adjacent electrode.

[0074] As said above, the extension along the first axis of a scraper may be greater than the distance between adjacent electrodes. If that is the case, the respective scraper at least partly extends through the respective cut-out of the adjacent electrode, when the separation arrangement is in the operation mode.

[0075] The electrodes of the first set may be fixedly attached, at a uniform mutual distance, to the walls of the chamber, wherein each electrode of the first set has a central cut-out through which the suspension device extends, wherein the central cut-out has a minimal extension in the direction from the axis portion which is larger than a maximum extension of the suspension device in the direction from the axis portion.

[0076] The central cut-out may have the form of a central hole. The central cut-out may be integral with the cut-out of the electrode at hand. With the disclosed design, in which the central cut-out having a minimal extension in the direction from the axis portion which is larger than a minimum extension of the suspension device in the direction from the axis portion, it is provided for that the suspension device may extend through the chamber, along the first axis, without the first set of electrodes may be in contact with the suspension device. This is advantageous as it provides for that the risk of a short circuit may be reduced.

[0077] If the second set of electrodes is mounted on the suspension axis as discussed above, the suspension axis may extend along the first axis, through the central cut-out of the respective electrode of the first set. Thereby, the electrodes of the first and second set are arranged about the first axis.

[0078] The electrodes of the first set and the second set may be alternately arranged at a uniform mutual distance of 10-30 mm, preferably 15-25 mm, more preferably 20 mm.

[0079] This is advantageous in that an efficient removal of particles from the particulate-laden gas stream may be achieved. The distance between adjacent electrodes may be set in relation to the potential difference provided by the voltage source and the conductivity of the particulate-laden gas stream at hand in order to achieve the most efficient removal of particles from the particulate-laden gas stream while at the same time reducing the risk for undesired short circuits or discharges.

[0080] The electrodes of the second set may be arranged such that a minimum distance form a peripheral edge of each electrode to the walls of the chamber is 10-30 mm, preferably 15-25 mm.

[0081] This is advantageous in that the second set of electrodes are not in contact with the walls and thereby, the risk of a short circuit during the operation mode may be reduced.

[0082] The electrodes of the first set and/or the second set may be provided with more than one scraper, wherein the more than one scraper is arranged on the associated first major surface and/or second major surface.

[0083] It should be interpreted as more than one scraper on the first major surface and/or the second major surface. This is advantageous in that the removement of particles from the first major surface and the second major surface may be provided in an easy and efficient way. By having more than one scraper provided on the electrodes, the second set of electrodes may not need to rotate 360 degrees in order for the complete surfaces of the adjacent electrodes to the cleaned. If the electrode is provided with more than one scraper on the first major surface and/or the second major surface, all scrapers have to fulfill the requirements discussed above regarding the operation mode. Thus, each scraper has to coincide with a cut-out of the adjacent electrode. Depending on the design of the cut-out, more than one scraper may coincide with the same cut-out.

[0084] Further, during operation the mode the distance between any part of the second set of electrodes, the scrapers or the associated suspension device respectively, may exhibit a distance in relation to any electrically grounded surface. Such distance may be substantially not less than an axial distance between adjacent surfaces of electrodes of the first and second sets.

[0085] By not allowing any distance between any part of the second set of electrodes or the suspension device to undercut the axial distance between adjacent electrodes of different potential, the high voltage potential may be used to advantage. Such high voltage potential may be based on the electrode spacing and may consequently be applied with a reduced risk of electric discharge, e.g. between any surfaces with different electric potential.

[0086] According to a second aspect there is provided an electrostatic precipitator comprising:

a separation arrangement of the above-described kind, and

a pre-charger being arranged upstream the separation arrangement and having an inlet and an outlet for the particulate-laden gas stream, wherein the outlet is connected to the inlet of the separation arrangement.

[0087] The electrostatic precipitator is advantageous in that the pre-charger is configured to charge the particles in the gas stream unipolar, i.e. either negatively or positively, before the gas stream being received by the separation arrangement. Thereby, a majority of the particles will have a polarity when entering the separation arrangement. This is essential in order for the particles in the particulate-laden gas stream to be attracted by and collected on the electrodes of the separation arrangement in the operation mode of the separation arrangement.

[0088] The electrostatic precipitator is further advantageous in that the electrostatic precipitator may be a retrofitting part which may be arranged in conventional incinerator plants.

[0089] The separation arrangement and the pre-charger may be arranged in a common housing, wherein the common housing has an inlet and an outlet for the particulate-laden gas stream.

[0090] This is advantageous in that the arrangement may have a compact design compared to conventional arrangements. This is further advantageous in that it may be easier to install or retrofit in conventional plants. Preferably, the housing may have a height of 1.90 - 2.50 m, preferably 2.10-2.30 m.

[0091] Effects and features of the second aspect are largely analogous to those described above in connection with the first aspect, wherein reference is made to the above. Variants mentioned in relation to the first aspect are largely compatible with the second aspect. Further scope of applicability of the present inventive concept will become apparent from the detailed description given below. However, it should be understood that the detailed description and specific examples, while indicating preferred variants of the inventive concept, are given by way of illustration only, since various changes and modifications within the scope of the invention will become apparent to those skilled in the art from this detailed description. Several modifications and variations are thus conceivable within the scope of the invention which is defined by the appended claims.

[0092] Hence, it is to be understood that this invention is not limited to the particular component parts of the device described or steps of the methods described as such device and method may vary. It is also to be understood that the terminology used herein is for purpose of describing particular embodiments only and is not intended to be limiting. It must be noted that, as used in the specification and the appended claim, the articles "a", "an", "the", and "said" are intended to mean that there are one or more of the elements unless the context clearly dictates otherwise. Thus, for example, reference to "a unit" or "the unit" may include several devices, and the like. Furthermore, the words "comprising", "including", "containing" and similar wordings does not exclude other elements or steps.

Brief Description of the Drawings

[0093] The above, as well as additional objects, features and advantages of the present disclosure, will be better understood through the following illustrative and non-limiting detailed description of preferred variants of the present disclosure, with reference to the appended drawings, where the same reference numerals will be used for similar elements, wherein:

Figure 1 discloses an electrostatic precipitator comprising a pre-charger and a separation arrangement.
Figure 2 illustrates a partially cut-out perspective view of a separation arrangement.
Figures 3a-b illustrates the separation arrangement of figure 2 in further detail.
Figure 4a discloses a variant of the separation arrangement.
Figure 4b discloses an electrode of a first set according to figure 4a, provided with a scraper and a cut-out exhibiting a shape of a circular sector.
Figure 4c discloses an electrode of the second set according to figure 4a provided with a scraper and a cut-out exhibiting a shape of a circular sector.
Figure 5a discloses another variant of the separation arrangement.
Figure 5b discloses an electrode of the first set according to figure 5a provided with a scraper and a cut-out.
Figure 5c discloses an electrode of the second set according to figure 5a provided with a scraper and a cut-out.
Figure 6a discloses yet another variant of the separation arrangement.
Figure 6b discloses an electrode of the first set according to figure 6a provided with a scraper and a cut-out, wherein the scraper is arranged along an edge portion being defined by the cut-out.
Figure 6c discloses an electrode of the second set according to figure 6a provided with a scraper and a cut-out, wherein the scraper is arranged along an edge portion being defined by the cut-out.
Figure 7 discloses yet another variant of an electrode of the first set.

Detailed Description

[0094] The present inventive concept will now be described more fully hereinafter with reference to the accompanying drawings, in which currently preferred variants of the inventive concept are shown. This inventive concept may, however, be embodied in many different forms and should not be construed as limited to the variants set forth herein; rather, these variants are provided for thoroughness and completeness, and fully convey the scope of the inventive concept to the skilled person.

[0095] With reference to Fig. 1, there is disclosed an electrostatic precipitator 100. The electrostatic precipitator 100 comprises a pre-charger 300. The electrostatic precipitator 100 comprises a separation arrangement 200. The pre-charger 300 is arranged upstream the separation arrangement 200. The pre-charger 300 is configured to charge particles of a particulate-laden gas stream. The separation arrangement 200 is configured to remove the charged particles from the particulate-laden gas stream and thereby cleaning the gas stream. However, the separation arrangement 200 and hence, the electrostatic precipitator 100, may be used for other purposes than for removal of particles from a particle laden gas stream. For instance, the separation arrangement 200 may to advantage be used for removal of dust in ventilation applications in premises or industry. Further, the separation arrangement 200 may to advantage be used in air purifiers.

[0096] The separation arrangement 200 will be discussed in further detail in connection with Figs 2-6.

[0097] The pre-charger 300 and the separation arrangement 200 are arranged in a common housing 102. The common housing 102 comprises an inlet 104 and an outlet 106. The inlet 104 is for receiving the particulate-laden gas stream typically from an incinerator or furnace, or from a ventilation system or similar. The outlet 106 is for discharging the cleaned gas stream.

[0098] The pre-charger 300 comprises an inlet 304 and an outlet 206. The inlet 304 is configured to feed the particulate-laden gas stream to the pre-charger 300. The outlet 306 is configured to discharge the particulate-laden gas stream from the pre-charger 300 towards the separation arrangement 200.

[0099] The separation arrangement 200 comprises a gas flow inlet 204 and a gas flow outlet 206. The gas flow inlet 204 is configured to receive the particulate-laden gas stream to the separation arrangement 200. The gas flow outlet 206 is configured to exhaust the particulate-laden gas stream.

[0100] The outlet 306 of the pre-charger 300 is connected to the gas flow inlet 204 of the separation arrangement 200. The outlet 306 may be directly connected to the gas flow inlet 204. The outlet 306 may be connected to the gas flow inlet 204 via other components which may be comprised in the electrostatic precipitator 100.

[0101] The electrostatic precipitator 100 comprises a further outlet 110. The further outlet 110 may be configured to discharge particles removed from the particulate-laden gas stream in the separation arrangement 200. To this end, the separation arrangement 200 may comprise a removal arrangement configured to discharge particles removed from the particulate-laden gas stream. Such removal arrangement may be configured to discharge the removed particles through the further outlet 110. The removal arrangement may include a hopper, a mechanical scraper, a brush, a screw or similar. The particles removed from the particulate-laden gas stream typically fall to the bottom of the separation arrangement 200 from where the particles may be discharged e.g., through the further outlet 110 by the removal arrangement.

[0102] With reference to Fig. 2, the separation arrangement 200 is illustrated in further detail by way of examples. As discussed above, the separation arrangement 200 comprises the gas flow inlet 204 and the gas flow outlet 206. The particulate-laden gas stream is configured to flow through the separation arrangement 200, from the gas flow inlet 204 to the gas flow outlet 206. The particulate-laden gas stream is configured to substantially flow through the separation arrangement 200 in a major flow direction FD. However, it should be noted that the particulate-laden gas stream may flow in other directions as well.

[0103] The separation arrangement 200 comprises a chamber 202. The chamber 202 comprises walls 203, wherein the walls 203 are forming the chamber 202.

[0104] The separation arrangement 200 further comprises a first set of plate shaped electrodes 210 and a second set of plate shaped electrodes 220. The depicted electrodes 210, 220 of the first set and the second set are disc shaped. It should be noted that although the electrodes 210, 220 of the first set and the second set are illustrated as disc shaped electrodes throughout the figures, the electrodes 210, 220 may take any form suitable for the separation arrangement 200. The chamber 202 is designed based on the shape of the plate shaped electrodes 210, 220. Hence, as can be seen in Fig. 2, portions of the walls 203 are curved to follow contours of the first set of plate shaped electrodes 210 and the second set of plate shaped electrodes 220. The electrodes 210, 220 of the first set and the second set are coaxially alternately arranged inside the chamber 202 about a first axis A1. The depicted first and second set of electrodes 210, 220 are alternatively arranged at a uniform mutual distance of 20 mm. Other distances such as 10-30 mm, preferably 15-25 mm, may be used to advantage. The first axis A1 extends in a normal direction to the major flow direction FD of the particulate-laden gas stream. The walls 203 of the chamber 202 enclose the first set of electrodes 210 and the second set of electrodes 220.

[0105] Each electrode 210 of the first set has a first major surface 214a and a second major surface 214b. Each electrode 220 of the second set has a first major surface 224a and a second major surface 224b. The second major surface 214b, 224b is arranged opposite the first major surface 214a, 224a.

[0106] The first set of electrodes 210 is arranged in relation to the walls 203 of the chamber 202. The depicted first set of electrodes 210 are fixedly attached to the walls 203. The first set of electrodes 210 are arranged at a uniform mutual distance of 40 mm along the first axis A1. Other distances such as 20-60 mm, preferably 30-50 mm, may be used to advantage. The first set of electrodes 210 will be discussed in further detail in connection with Figs 4b, 5b and 6b.

[0107] The second set of electrodes 220 are rotatably arranged about the first axis A1. As best illustrated in Figs 4a, 5a and 6a, the depicted second set of electrodes 220 are arranged such that a minimum distance MD from a peripheral edge of each electrode 220 to the walls 203 of the chamber 202 is provided. The minimum distance MD may be 10-30 mm, preferably 15-25 mm. The depicted second set of electrodes 220 are to be mounted on a suspension device 225. The suspension device 225 extends through the chamber 202 along the first axis A1. The suspension device 225 also extends through the walls 203 of the chamber 202 along the first axis A1. The depicted suspension device 225 is provided in form of a suspension axis.

[0108] The depicted second set of electrodes 220 are be mounted at a uniform mutual distance of 40 mm on the suspension device 225. Other distances such as 20-60 mm, preferably 30-50 mm, may be used to advantage. The suspension device 225 may comprise abutments 226 via which the electrodes 220 of the second set may be removably attached to the suspension device 225. The depicted suspension device 225 is rotatable about the first axis A1. The electrodes 220 of the second set are connected to the suspension device 225 and are thus rotatable with the suspension device 225 about the first axis A1. The electrodes 220 of the second set may be rotatable in relation to the suspension device 225 about the first axis A1.

[0109] At least one electrode 210 of the first set is provided with a cut-out 211. At least one electrode 220 of the second set is provided with a cut-out 221. The cut-out 211, 221 extends from an axis portion towards a peripheral portion of the associated electrode 210, 220. The axis portion is a portion at or in vicinity to the first axis A1 as seen when the electrodes 210, 220 are arranged inside the chamber 202 along the first axis. The peripheral portion is a portion at or in vicinity of a peripheral edge of the associated electrode 210, 220.

[0110] At least one electrode 210 of the first set and at least one electrode 220 of the second set are provided with a pair of scrapers 212, 222. The scrapers 212, 222 are provided on the first major surface 214a, 224a and the second major surface 214b, 224b of the associated electrode 210, 220 respectively. The scrapers 212, 222 extend along the associated first major surface 214a, 224a or second major surface 214b, 224b from the axis portion to the peripheral portion of the associated electrode 210, 220. The scraper 212, 222 protrudes in an axial direction from the associated first major surface 214a, 224a or second major surface 214b, 224b towards an opposing first major surface 214a, 224a or second major surface 214b, 224b of an adjacent electrode 210, 220. Thus, the scraper 214a of the electrode 210 of the first set protrudes towards the adjacent electrode 220 being of the second set and the scraper 222 of the electrode 220 of the second set protrudes towards the adjacent electrode 210 being of the first set.

[0111] The depicted scrapers 212, 222 are provided on the first major surface 214a, 224a and the second major surface 214b, 224b of the associated electrode 210, 220 respectively. The scrapers 212, 222 extend along the associated first major surface 214a, 224a and second major surface 214b, 224b from the axis portion to the peripheral portion of the associated electrode 210, 220. The scrapers 212, 222 protrude in an axial direction from the associated first major surface 214a, 224a and second major surface 214b, 224b towards an opposing first major surface 214a, 224a and second major surface 214b, 224b of an adjacent electrode 210, 220, respectively.

[0112] The scrapers 212, 222 may be made of a rigid material, e.g. metal, plexiglass, plastic etc. The scrapers 212, 222 may be spring loaded. The scrapers 212, 222 may be resilient scrapers. The resilient scrapers may be divided into several resilient sections or filaments. The resilient scrapers may consequently be a brush.

[0113] Although not illustrated, the electrode 210 of the first set and the electrode 220 of the second set may be provided with more than one scraper 212, 222 on the first major surface 214a, 224a and/or the second major surface 214b, 224b respectively. Although not illustrated, the electrode 210 of the first set and the electrode 220 of the second set may be provided with more than one cut-out 211, 221 respectively. If the electrode is provided with more than one scraper on the first major surface and/or the second major surface, all scrapers have to fulfill the requirements discussed above regarding the operation mode. Thus, each scraper has to coincide with a cut-out of the adjacent electrode. Depending on the design of the cut-out, more than one scraper may coincide with the same cut-out.

[0114] The separation arrangement 200 is configured to be in an operation mode. In the operation mode, the at least one electrode 220 of the second set is coupled to a voltage source for charging the at least one electrode 220 and thereby providing a potential difference in relation to the at least one electrode 210 of the first set and the wall 203 of the chamber 202. In practice, all electrodes 220 of the second set are typically coupled to a voltage source for charging the electrodes 220 and thereby providing a potential difference in relation to the at least one electrode 210 of the first set and the wall 203 of the chamber 202. In the operation mode, the at least one electrode 210 of the first set and the at least one electrode 220 of the second set are arranged in relation to each other such that the cut-out 211, 221 of the adjacent electrode 210, 220 coincides with the scraper 212, 222. In the operation mode, the particulate-laden gas stream flows through the separation arrangement 200 and the charged particles in the gas stream are attracted by the charged electrodes 220 and collected thereon. Thus, the operation mode is configured to remove particles from the particulate-laden gas stream and thereby clean the particulate-laden gas stream. This is illustrated in best detail with reference to Fig. 3a but also in Figs 4-6.

[0115] With reference to Fig. 3a, there is illustrated two electrodes 210 of the first set and one electrode 220 of the second set. The cut-out 211 of the electrodes 210 of the first set coincides with the scraper 222 of the electrode 220 of the second set. The cut-out 221 of the electrode 220 of the second set coincides with the scraper 212 of the electrodes 210 of the first set. This arrangement provides for that the risk for a short circuit to occur, when the electrode 220 of the second set is coupled to the voltage source, is reduced.

[0116] Referring back to Fig 2, the separation arrangement 200 is further configured to be in a cleaning mode. In the cleaning mode, the at least one electrode 220 of the second set is not coupled to the voltage source or the voltage source is switched off. In the cleaning mode, the at least one electrode 220 of the second set is configured to be rotated about the first axis A1. In practice, in the cleaning mode, all electrodes 220 of the second set are rotated about the first axis A1. When the at least one electrode 220 is rotated about the first axis A1, the respective scraper 212, 222 scrapes the opposing first major surface 214a, 224a or second major surface of the adjacent electrode 210, 220. Thereby, the respective scraper 212, 222 is removing the particles collected on the first major surface 214a, 224a or second major surface. Thus, the cleaning mode is configured to remove the particles collected on the electrodes 210, 220 and thereby clean the electrodes 210, 220. This is illustrated in best detail with reference to Fig. 3b but also in Figs 4-6.

[0117] With reference to Fig. 3b, there is illustrated two electrodes 210 of the first set and one electrode 220 of the second set. The electrode 220 of the second set is rotated in a counterclockwise direction about the first axis A1. When the electrode 220 of the second set is rotated about the first axis A1, the scraper 222 of the electrode 220 of the second set scrapes the surface of adjacent electrodes 210 of the first set. In addition, the scraper 212 of the electrodes 210 of the first set scrapes the surfaces of the adjacent electrode 220 of the second set.

[0118] Referring back to Fig. 2, but also illustrated in Figs 3a-b and 4a-c, each electrode 210, 220 is provided with a cut-out 211, 221 and a scraper 212, 222. Each depicted electrode 210, 220 is a disc-shaped electrode having a peripheral edge portion which at least partly coincides with a circle centered around the first axis A1. The respective depicted cut-out 211, 221 exhibit a shape of a circular sector. Thus, the cut-out 211, 221 extend in a direction from the axis portion to the peripheral portion.

[0119] The scrapers 212, 222 are as can be seen in e.g. Fig. 2 arranged along an edge portion of its associated electrode 210, 220. The edge portion referred to is defined by the cut-out 211, 221. Hence, the edge portion extends in a direction, from the axis portion to the peripheral portion, of the associated electrode 210, 220. The depicted scrapers 212, 222 protrude from the associated first major surface 214a, 224a and second major surface 214b, 224b towards and opposing first major surface 214a, 224a and second major surface 214b, 224b, respectively. Thus, each of the scrapers 212, 222 may in this configuration be configured to scrape two adjacent electrodes 210, 220.

[0120] With reference to Figs 4a-c, the separation arrangement 200 is illustrated in further detail by way of examples. Fig. 4a illustrates a side view of the separation arrangement 200 comprising one electrode 210 of the first set and one electrode 220 of the second set. Fig. 4b illustrates the electrode 210 of the first set in further detail. Fig. 4c illustrates the electrode 220 of the second set in further detail. The electrodes 210, 220 have the same form or design as discussed above in connection with Figs 2 and 3a-b.

[0121] Further to what have been discussed above, a width W1 of the respective cut-out 211, 221 may be greater than a width W2 of the respective scraper 212, 222 on the adjacent electrode 210, 220. A length L1 of the respective cut-out 211, 221 may be greater than a length L2 of the respective scraper 212, 222 on the adjacent electrode 210, 220. This is advantageous in that, when the scrapers 212, 222 coincides with a cut-out 211, 221, the scrapers 212, 222 "fit" in the respective cut-outs 211, 221 in the sense that the scrapers 212, 222 will not contact any other electrode. Thereby, the respective scrapers 212, 222 may not be in contact with an adjacent electrode 210, 220.

[0122] With reference to Figs 5a-c, here is depicted a variant of the separation arrangement 200 in which the electrodes 210, 220 exhibit a different form or design as compared to the previously described electrodes 210, 220. Fig. 5a illustrates a side view of the variant of the separation arrangement 200 comprising one electrode 210 of the first set and one electrode 220 of the second set. Fig. 5b illustrates the electrode 210 of the first set in further detail. Fig. 5c illustrates the electrode 220 of the second set in further detail.

[0123] Further to what have been discussed above, the cut-out 211, 221 illustrated in Figs 5a-c, takes the form of a rectangular shaped cut-out. The cut-out 211, 221 extends in a direction, from the axis portion towards the peripheral portion, of its associated electrode 210, 220. A scraper 212, 222 is arranged on either one of the first major surface 214a, 224a and the second major surface 214b, 224b of the associated electrode 210, 220. The scrapers 212, 222 are arranged on a distance from the cut-outs 210, 220 of the associated electrode 210, 220.

[0124] With reference to Figs 6a-c, here is depicted a further variant of the separation arrangement 200 in which the electrodes 210, 220 exhibit a different form or design as compared to the previously described electrodes 210, 220. Fig. 6a illustrates a side view of the further variant of the separation arrangement 200 comprising one electrode 210 of the first set and one electrode 220 of the second set. Fig. 6b illustrates the electrode 210 of the first set in further detail. Fig. 6c illustrates the electrode 220 of the second set in further detail.

[0125] Further to what have been discussed above, the cut-out 211, 221 illustrated in Figs 6a-c, takes the form of a rectangular shaped cut-out, similar to the cut-out disclosed in Figs. 5a-c. A scraper 212, 222 is arranged on either side of the first major surface 214a, 224a and the second major surface 214b, 224b along the edge portion of its associated electrode 210, 220. The edge portion is defined by the cut-out 211, 221 as discussed above. As can be seen in Figs 6a-c, the cut-outs 211, 221 are extending in a radial direction while being arranged slightly offset with regard to the first axis which is coinciding with a center of the electrodes 210, 200.

[0126] With reference to Figure 7, here is depicted a further variant of the electrode 210 of the first set which exhibit a different form or design as compared to the previously described electrodes 210. The electrode 210 is disc shaped and is formed with a V-shaped cut-out on a first peripheral edge portion, similar to the form or design as discussed above in connection with Figs 2, 3a-b, and 4a-c. In addition, the electrode 210 is formed with two further cut-outs defined by a respective circular segment. The further cut-outs are arranged on a second peripheral edge portion and a third peripheral edge portion, respectively. The first, second and third peripheral portions being evenly arranged along the peripheral of the electrode 210. A scraper 212 is arranged on either side of the first major surface 214a and the second major surface 214b along the edge portion of its associated electrode 210. The edge portion is defined by the cut-out 211 as discussed above.

[0127] Although not illustrated, the electrode 220 of the second set may be formed or designed in a similar way as the electrode 210 depicted in Fig. 7. The separation arrangement 200 may comprise electrodes 210, 220 of the first and second set as illustrated in Fig. 7.

[0128] It should be noted that the cut-out 211, 221 may take any form suitable for the separation arrangement 200. The scrapers 212, 222 may be arranged anywhere suitable and protruding from the associated first major surface 214a, 224a and/or second major surface 214b, 224b. However, the cut-outs 211, 221 and the scrapers 212, 222 should be designed in relation to each other such that the scrapers 212, 222 may be able to coincide with the cut-outs 211, 221 without the scrapers 212, 222 coming in contact with an adjacent electrode 210, 220, when in the operation mode.

[0129] The person skilled in the art realizes that the present disclosure by no means is limited to the preferred embodiments described above. On the contrary, many modifications and variations are possible within the scope of the appended claims.

Claims

1. A separation arrangement (200) for an electrostatic precipitator (100) comprising:

   a separation chamber (202) having a gas flow inlet (204) for receiving a particulate-laden gas stream and a gas flow outlet (206) for exhausting the particulate-laden gas stream;
   a first set of plate shaped electrodes (210); and
   a second set of plate shaped electrodes (220);

wherein each electrode (210, 220) has a first major surface (214a, 224a) and an opposing second major surface (214b, 224b), wherein the electrodes (210, 220) of the first set and the second set are coaxially alternately arranged inside the chamber (202) about a first axis (A1), the first axis (A1) extending in normal direction to a major flow direction (FD) of the particulate-laden gas stream;
wherein the first set of electrodes (210) is arranged in relation to walls (203) of the chamber (202);
wherein the second set of electrodes (220) is rotatably arranged about the first axis (A1) and configured to be coupled to a voltage source for providing a potential difference in relation to the first set of electrodes (210) and the walls (203) of the chamber (202) when the separation arrangement (200) is in an operating mode,
wherein at least one electrode (210) of the first set and at least one electrode (220) of the second set are provided with a respective cut-out (211, 221) which extends from an axis portion towards a peripheral portion of the associated electrode;
wherein the at least one electrode (210) of the first set and the at least one electrode (220) of the second set are provided with a respective scraper (212, 222) on an associated first major surface (214a, 224a) and second major surface (214b, 224b) respectively, the respective scraper (212, 222) extending along the associated first major surface (214a, 224a) and second major surface (214b, 224b) from the axis portion to the peripheral portion of the associated electrode (210, 220) and protrudes in a axial direction from the associated first or second major surface (214a, 224a, 214b, 224b) towards an opposing first or second major surface (214a, 224a, 214b, 224b) of an adjacent electrode (210, 220);
wherein, when the separation arrangement (200) is in the operation mode, the at least one electrode (210) of the first set and the at least one electrode (220) of the second set are configured to be arranged in relation to each other, such that the respective cut-out (211, 221) of the adjacent electrode (210, 220) coincides with the respective scraper (212, 222) of the associated electrode (210, 220); and
wherein, when the separation arrangement (200) is in a cleaning mode in which the second set of electrodes (220) are configured to be rotated about the first axis (A1), the respective scraper (212, 222) scrapes the opposing first or second major surface (214a, 224a, 214b, 224b) of the adjacent electrode (210, 220) thereby removing particles collected thereon.

2. The separation arrangement (200) according to claim 1, wherein the respective scraper (212, 222) is arranged along an edge portion of its associated electrode (210, 220), the edge portion being defined by the cut-out (211, 221) and extending in a direction, from the axis portion towards the peripheral portion, of the associated electrode (210, 220).

3. The separation arrangement (200) according to claim 1 or 2,
wherein the first set and the second set of electrodes (210, 220) are disc shaped.

4. The separation arrangement (200) according to claim 3, wherein the respective cut-out (211, 221) exhibits a shape of a circular sector.

5. The separation arrangement (200) according to any one of the preceding claims, wherein a width (W1) and/or length (L1) of the respective cut-out (211, 221) is greater than a width (W2) and/or length (L2) of the respective scraper (212, 222) on the adjacent electrode (210, 220) for all radial distances, from the axis portion, occupied by the respective scraper (212, 222).

6. The separation arrangement (200) according to any one of the preceding claims, wherein the electrodes (220) of the second set are mounted, at a uniform mutual distance, on a suspension device (225) which extends along the first axis (A1) and is suspended through the wall (203) of the chamber (202).

7. The separation arrangement (200) according to any one of the preceding claims, wherein the respective scraper (212, 222) is made of a rigid material.

8. The separation arrangement (200) according to any one of claims 1-6, wherein the respective scraper (212, 222) is a spring loaded and/or resilient scraper.

9. The separation arrangement (200) according to claim 8, wherein the respective scraper (212, 222) at least partly extends through the respective cut-out (211, 221) of the adjacent electrode (210, 220).

10. The separation arrangement (200) according to any one of claims 6-9, wherein the electrodes (210) of the first set are fixedly attached, at a uniform mutual distance, to the walls (203) of the chamber (202), wherein each electrode (210) of the first set has a central cut-out (215) through which the suspension device (225) extends, wherein the central cut-out (215) has a minimal extension (E1) in the direction from the axis portion which is larger than a maximum extension (E2) of the suspension device (225) in the direction from the axis portion .

11. The separation arrangement (200) according to any one of the preceding claims, wherein the electrodes (210, 220) of the first set and the second set are alternately arranged at a uniform mutual distance of 10-30 mm, preferably 15-25 mm, more preferably 20 mm.

12. The separation arrangement (200) according to any one of the preceding claims, wherein the electrodes (220) of the second set are arranged such that a minimum distance form a peripheral edge of each electrode (220) to the walls (203) of the chamber (202) is 10-30 mm, preferably 15-25 mm.

13. The separation arrangement (200) according to any one of the preceding claims, wherein the electrodes (210, 220) of the first set and/or the second set are provided with more than one scraper (212, 222), wherein the more than one scraper (212, 222) is arranged on the associated first major surface (214a, 224a) and/or second major surface (214b, 224b).

14. An electrostatic precipitator (100) comprising:

a separation arrangement (200) according to any one of the preceding claims, and
a pre-charger (300) being arranged upstream the separation arrangement (200) and having an inlet (304) and an outlet (306) for the particulate-laden gas stream, wherein the outlet (306) is connected to the inlet (204) of the separation arrangement (200).

15. The electrostatic precipitator (100) according to claim 14, wherein the separation arrangement (200) and the pre-charger (300) are arranged in a common housing (102), wherein the common housing (102) has an inlet (104) and an outlet (106) for the particulate-laden gas stream.

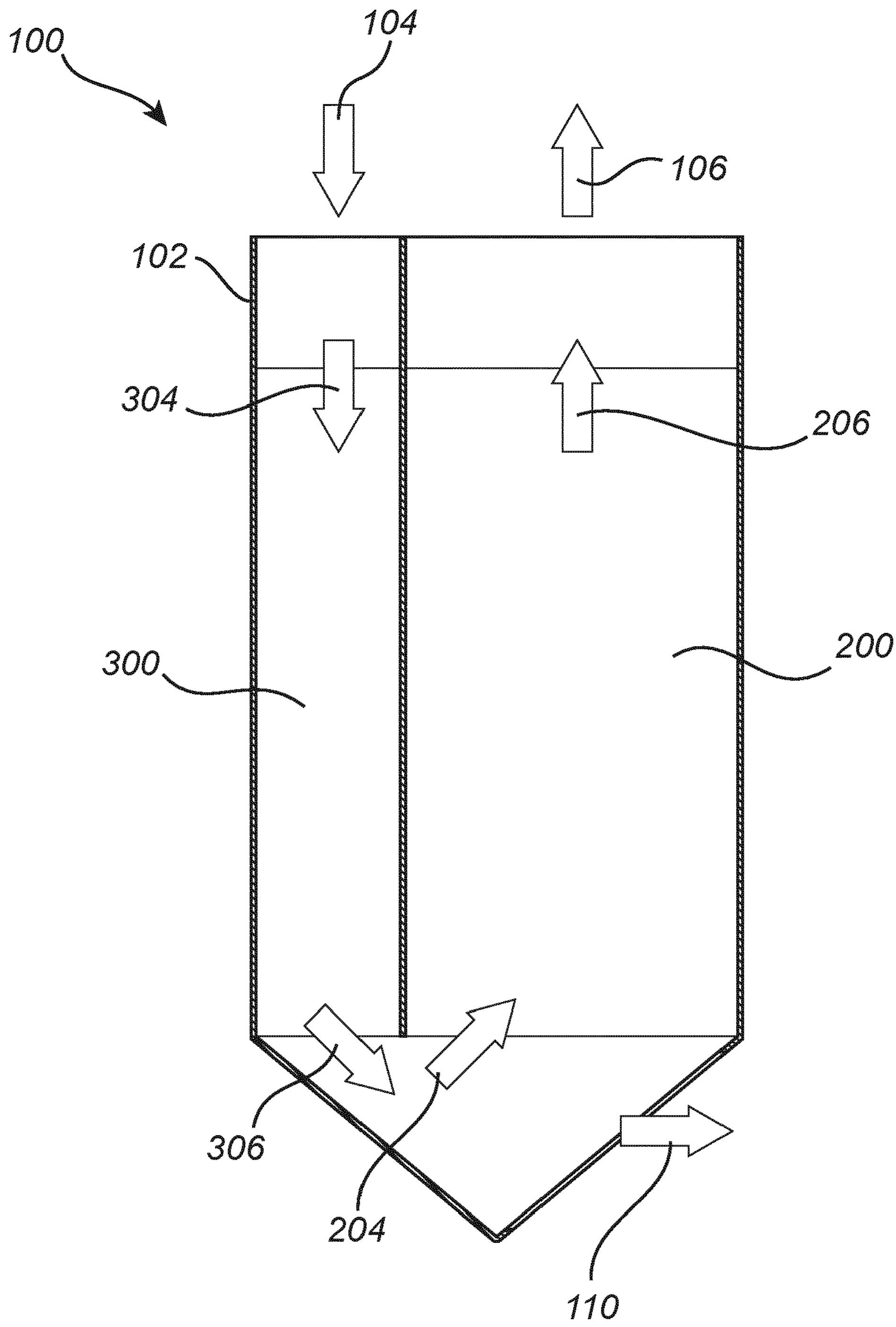
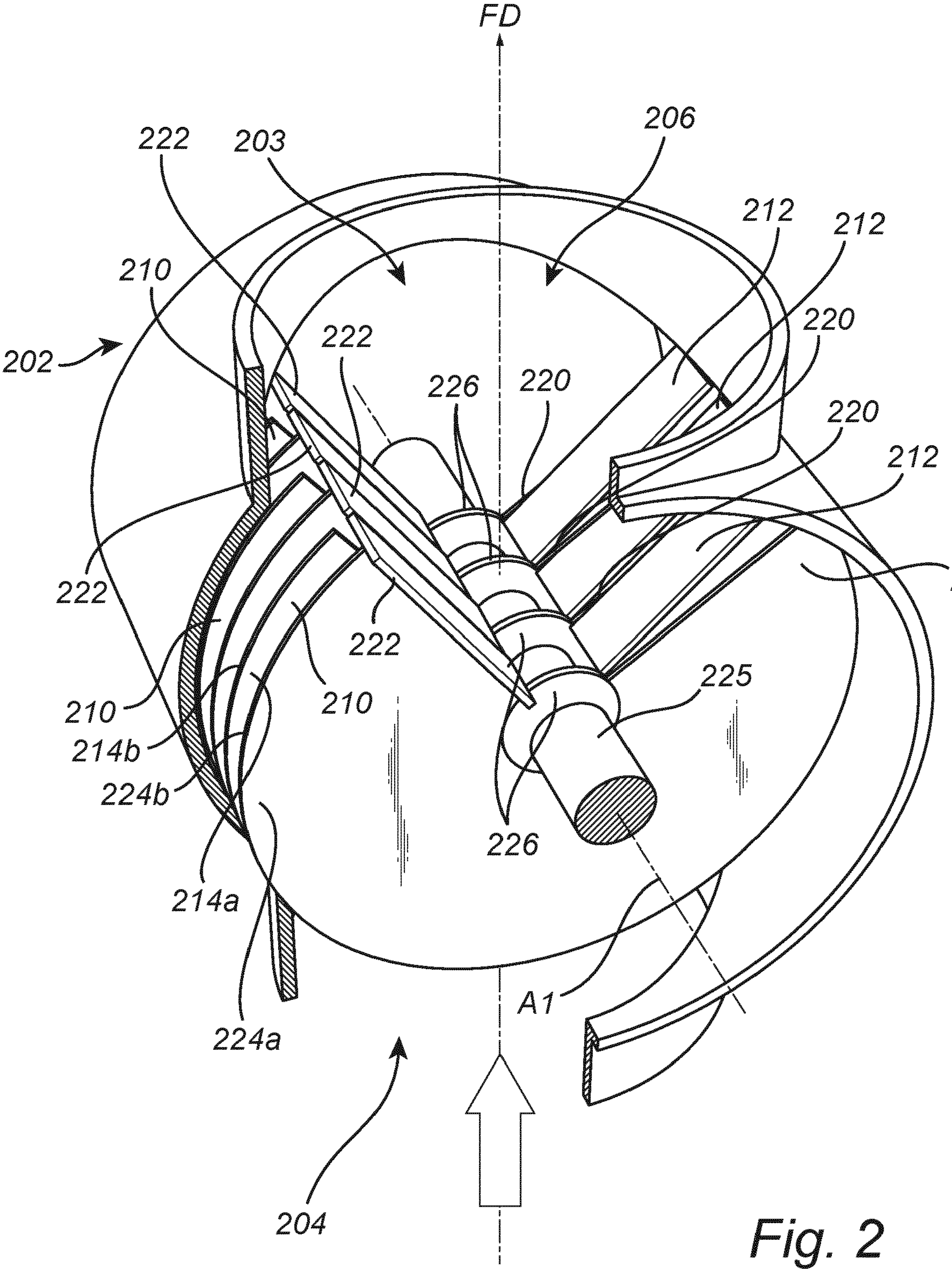


Fig. 1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214a
A1
224a
204

Fig. 2

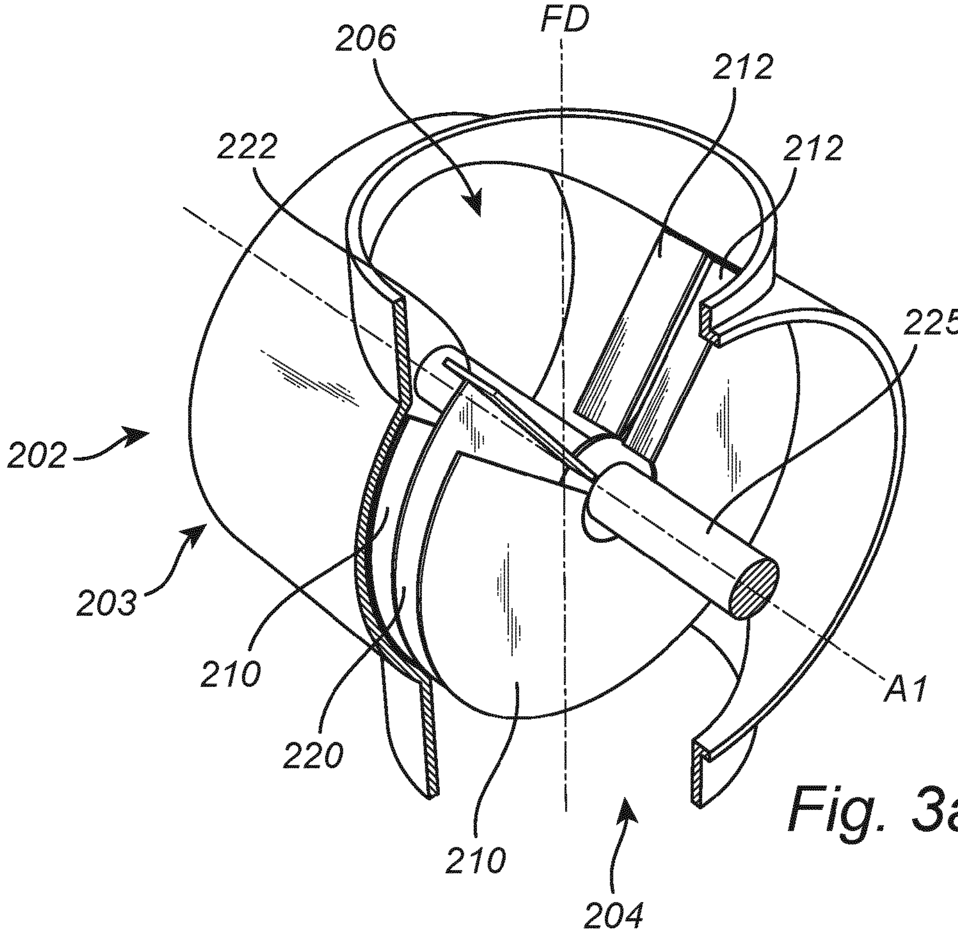
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Fig. 3a

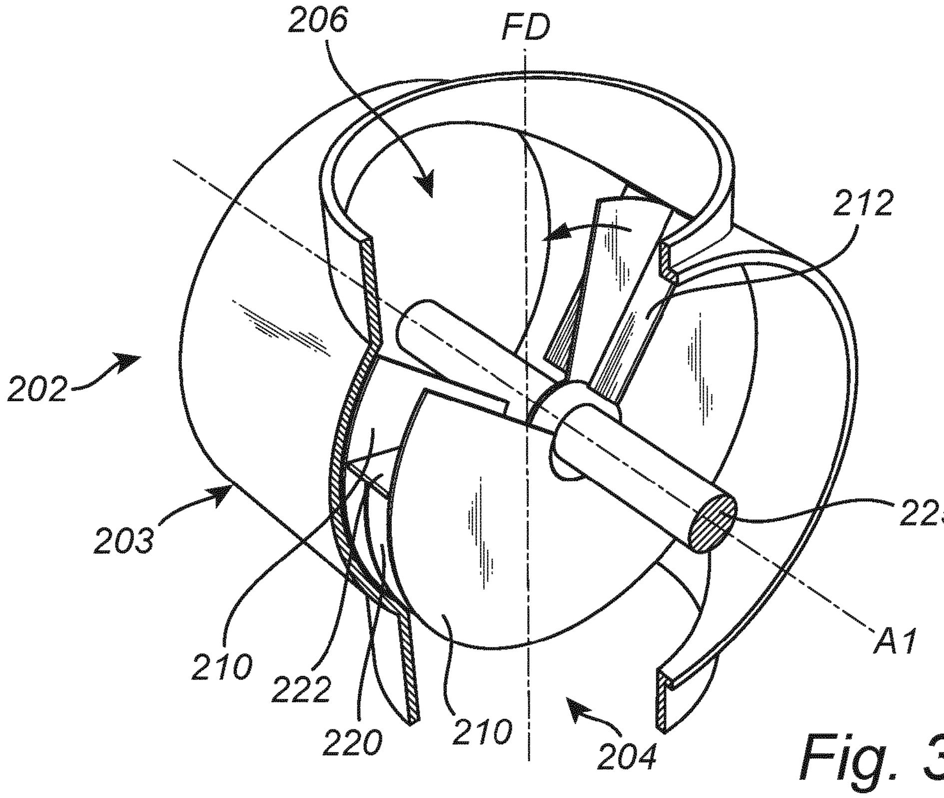
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Fig. 3b

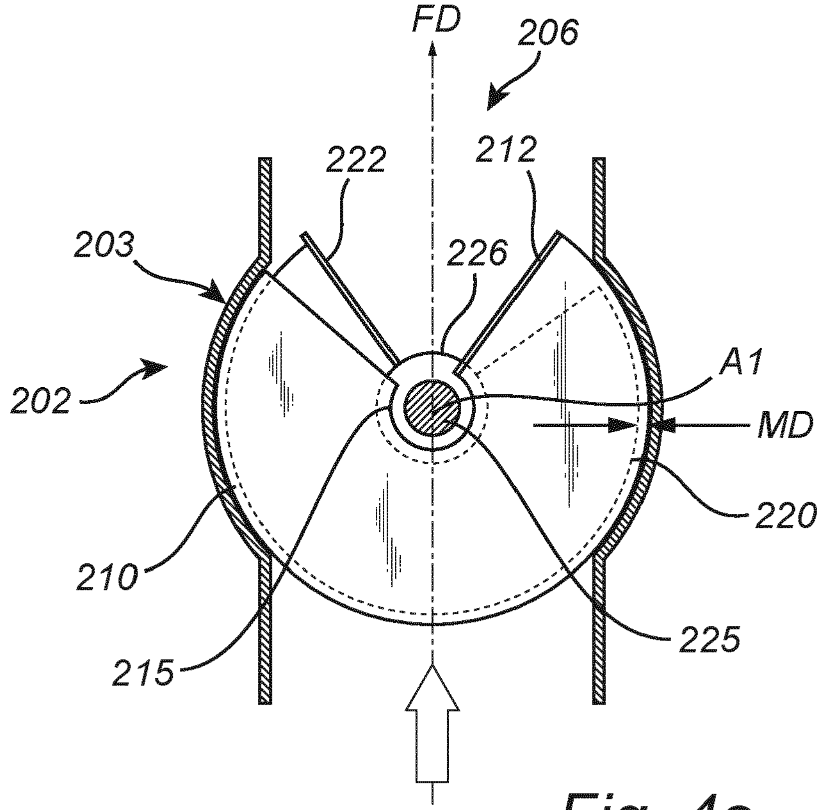

Fig. 4a

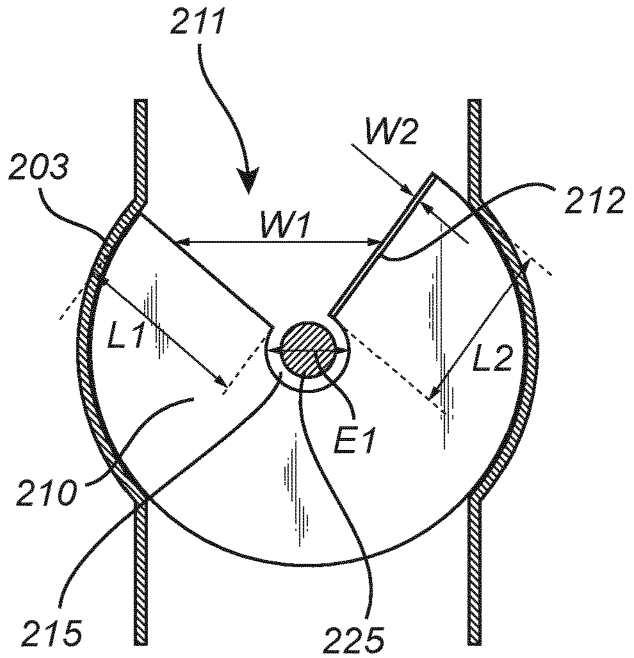

Fig. 4b

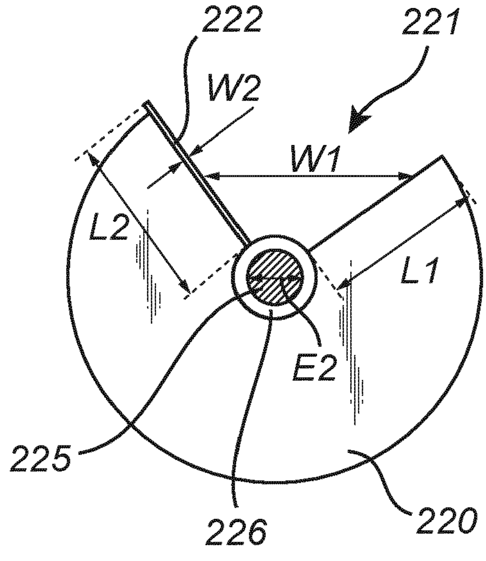

Fig. 4c

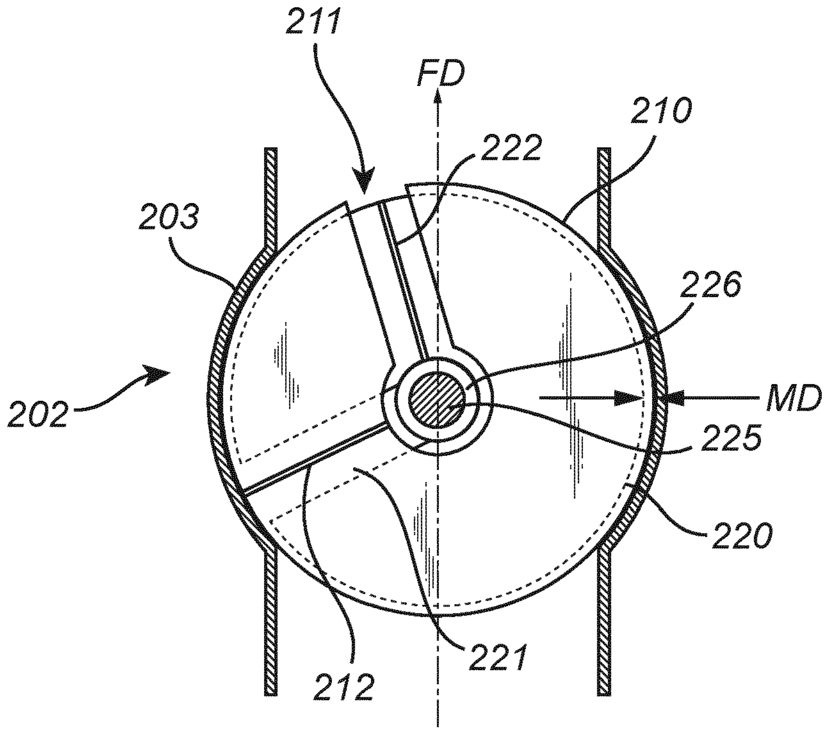

Fig. 5a

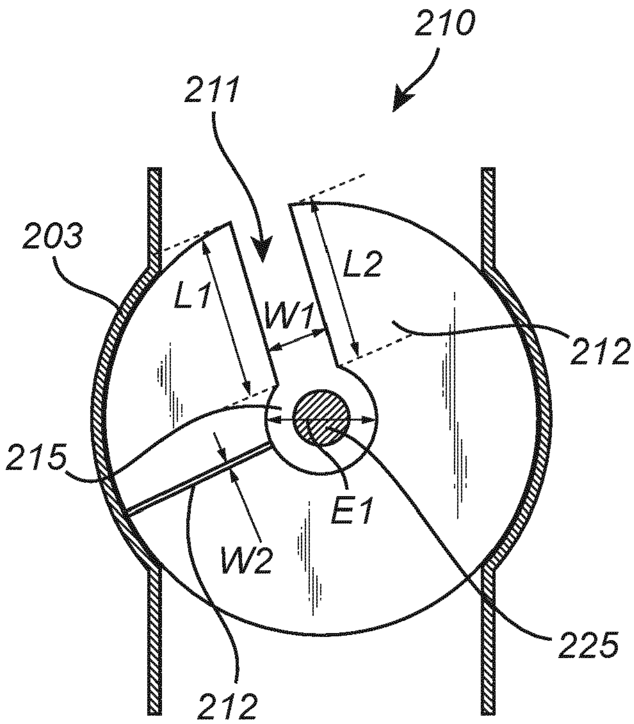

Fig. 5b

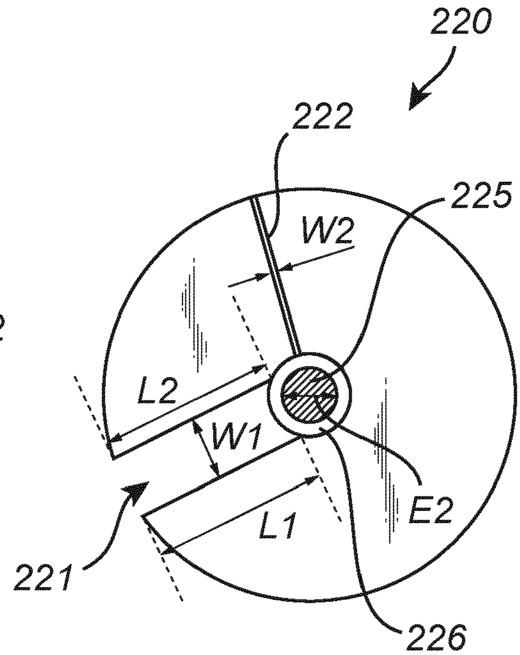

Fig. 5c

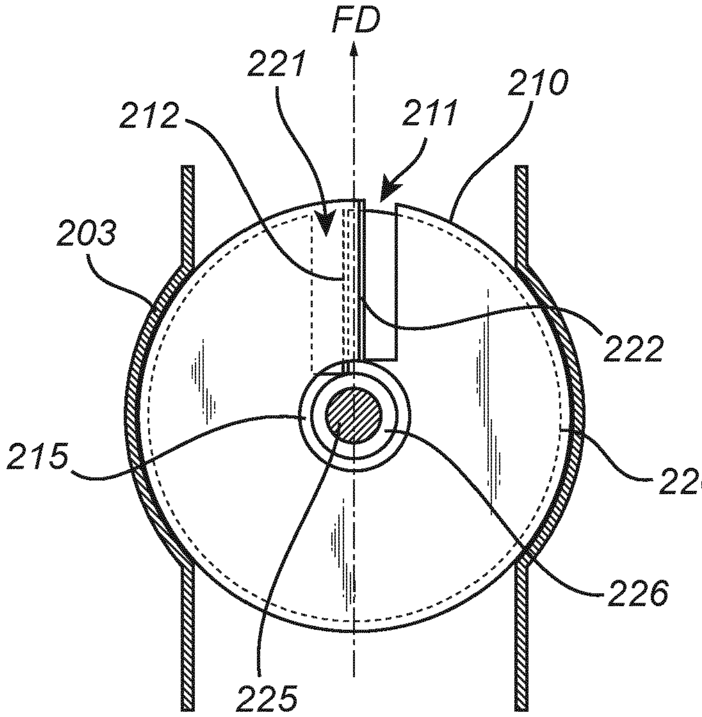

Fig. 6a

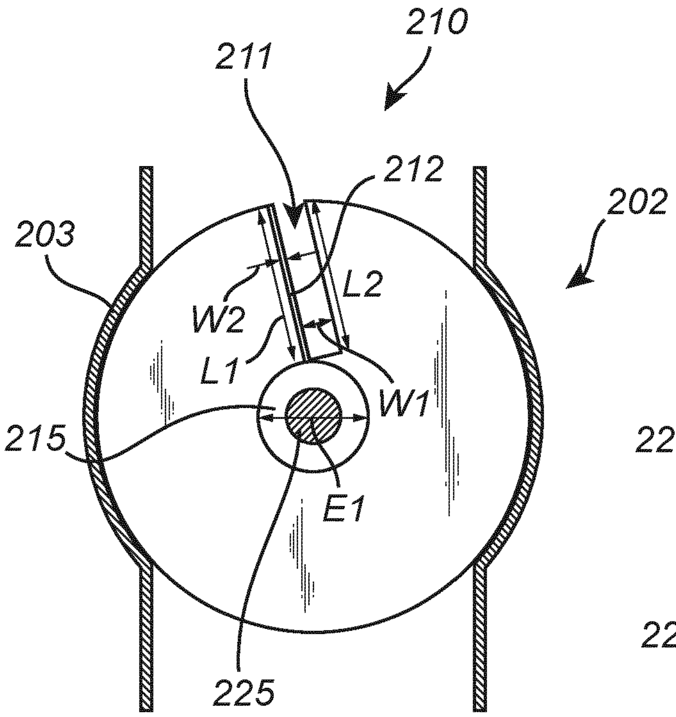

Fig. 6b

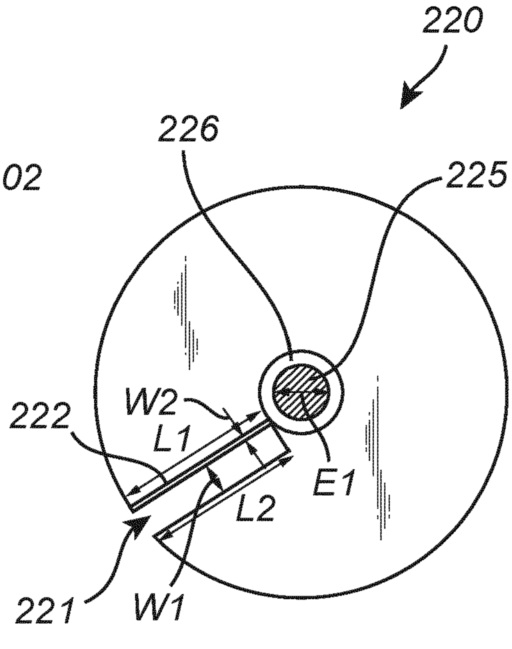

Fig. 6c

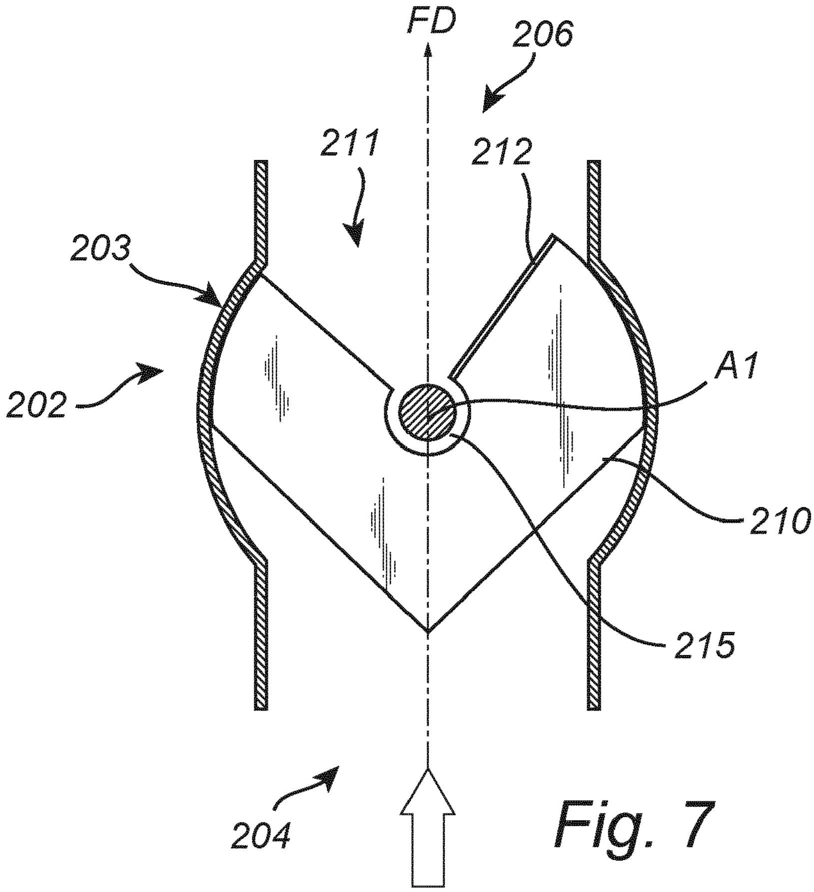

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 22 15 2355

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	JP 2013 212455 A (AMANO CORP) 17 October 2013 (2013-10-17) * figure 10 * -----	1-15	INV. B03C3/08 B03C3/10 B03C3/12 B03C3/47 B03C3/74
A	EP 0 703 006 A1 (CHANG CHIN CHU [TW]) 27 March 1996 (1996-03-27) * figure 4 * -----	1-15	
A	US 9 789 495 B1 (DUNN JOHN P [US]) 17 October 2017 (2017-10-17) * figure 1 * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

B03C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	21 June 2022	Menck, Anja

CATEGORY OF CITED DOCUMENTS

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21-06-2022

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