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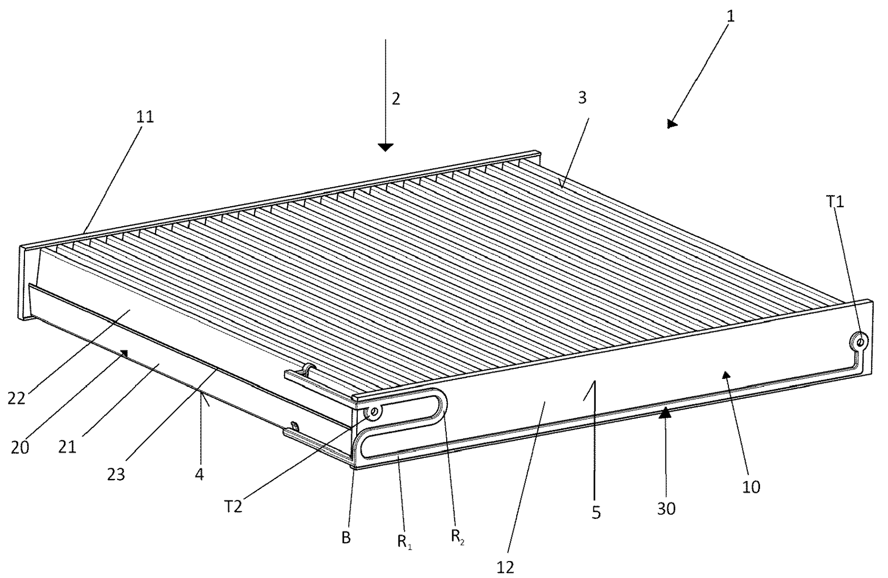
(54) **CABIN AIR FILTER WITH POLARISATION**

(57) A gas filter 1 comprising a filter medium 20, for filtering a gas flow from an upstream facing side 3 through the filter medium 20 to a downstream facing side 4, wherein the filter medium 20 comprises a capacitor with a first electrode 21, a second electrode 22 and a dielectric medium 23, wherein the gas filter 1 further comprises a first electrical contact T1 and a second electrical contact T2. The first electrical contact T1 is electrically connected via a first resistance R1 to a branching point B and the second electrical contact T2 is electrically connected via a second resistance R2 to said branching point B. Further, the first electrode 21 is electrically connected to said branching point B and the second electrode 22 is electrically connected to the second electrical contact T2.

Fig. 1



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Description

Field of the invention

[0001] The invention relates to a passenger cabin air filter, or more generally to a gas filter and to a housing for the gas filter and to a gas filter system comprising at least the gas filter.

Description of the related art

[0002] Passenger cabin air filters systems, remove pollutants from the ambient air and provide the cleaned air to the interior of a passenger cabin of a vehicle. Essentially the same technology may be used in other fields, e.g., for building ventilation.

[0003] Usually "filtration" references to removal of particulate matter from a gas stream by a sieving the gas stream using fibrous filter - the sieve. Cleaning the air based on sieving alone requires balancing between the size of the smallest particles to be held back in the sieve and the pressure drop of the sieving element - the fibrous filter medium. Removing particulate matter from a gas stream by filtration appears to be a result of a number of effects including interception, diffusion, inertial impaction. It has been suggested to improve particle removal from a gas stream using electrostatic forces by means of electret filters. The particle removal of these electret filters, however, appears to fade with increasing deposition of the fibers with particles. To address this drawback, it has been suggested to apply an external electrical field across the filter medium by locating the filter medium as a dielectric medium between two air permeable electrodes. It has been reported (see e.g. Frank Jordan, *Untersuchungen zum Partikelabscheideverhalten submikroner Partikel in Faserfiltern im elektrischen Feld,* PhD-Thesis, University Duisburg (Germany), 2001) that even non-charged submicron sized particles can be effectively removed from the gas stream using this technique and it is referred to as active field polarized media air cleaning, which are to be distinguished from electrostatic precipitation and passive electrostatic filters (electret filters). Herein we focus on active field polarized media air cleaners and the optional but preferred combination active field polarized media air cleaning with gas cleaning based on gas ionization.

[0004] These active field polarized media gas cleaners usually have a gas filter housing with a receptacle for a gas filter and a high-voltage (HV) source being connected to the electrodes of the gas filter. Once the service life of the gas filter is reached it is removed from the housing and replaced by another one. The housing hence has at least two electrical contacts for removably contacting corresponding electrical contacts of the gas filter, thereby enabling to provide an electrical connection of the gas filter with the HV-source.

[0005] US 2007/0199450 A1 suggest an air filter having two air permeable ground electrodes and an air-permeable HV electrode in between of these. Between each ground electrode and the HV electrode is a dielectric filter medium. The HV-field between the electrodes polarizes both, the particles as well as the fibers of the dielectric.

[0006] While these active field polarized media air cleaners allow to efficiently remove even sub-micron particles air-ionization enables to sterilize air as well as to remove odors on a molecular scale. Air-ionization requires, depending on the distance of the electrode about 5kV and typically -depending on the size of the air-ionizer - a current of a few 10μA to 10mA. Corona discharge air cleaners are an example of air-ionizers. Industry scale gas ionizer may have correspondingly larger currents.

Summary of the invention

[0007] The problem underlying the invention is based on the observation that the thickness and the dielectric constant of the dielectric filter medium, as well as the surface areas of the electrodes have a direct impact on the voltage being required to provide a predefined electrical field E in the dielectric filter medium, as $E = \frac{Q}{\epsilon_0 \epsilon_r A}$ (assuming a plate-type capacitor for simplicity) wherein $Q = C \cdot U$ is the charge, C the capacity, U the voltage, A the surface and ε_0, ε_r the electrical field constant and the relative permittivity, respectively. In other words, once the HV-source is installed, any change of the filter medium (material, effective surface, thickness, ...), which might be required due to a change of regulatory requirements for gas cleaning and/or due to a user preference for a particular level of cleaning and/or to adapt the gas cleaning system to different geographical or climate conditions is expensive, as it requires as well to replace the HV-source or to initially install an HV-source with an adjustable output voltage.

[0008] The problem underlying the invention is thus to reduce the costs associated with replacing a gas filter of a first capacity C_1 and electrode surface A_1 with another gas filter of a different capacity C_d and/or electrode surface A_d, while at the same time being able to verify the presence of the gas filter in a corresponding gas filter housing of a gas cleaning system.

[0009] A solution of the problem to be solved is the gas filter of claim 1 and the method of claim 12. The dependent claims relate to further improvements of the invention.

[0010] The gas filter may have an upstream facing side, a downstream facing side and a peripheral narrow facing side connecting the upstream facing side and the downstream facing side. Once installed in a gas filter housing, the upstream facing side may usually face toward the gas flow, i.e., the gas flow may enter into the gas filter via its upstream facing side and accordingly leave the gas filter via its downstream facing side. The gas flow may hence flow at least essentially through a cross section being confined by the narrow facing side, but the narrow facing side does not necessarily define the area of the cross section through which the gas flow may pass as will become apparent below.

[0011] The gas filter comprises as least a filter medium for filtering (i.e., sieving) a gas flow from the upstream facing side through the filter medium to the downstream facing side. The filter medium preferably comprises a capacitor with at least a first electrode and a second electrode. A dielectric medium may be located in between of the first electrode and the second electrode. The first electrode and/or the second electrode and/or the dielectric medium are/is (a) filter media/medium. The at least one filter medium is permeable for a gas (e.g., air), but not for particles above a given particle size. Thus, the filter medium can be considered as a sieve.

[0012] In a preferred example, the first electrode is a first electrically conducting filter layer and/or the second electrode is preferably a second conducting filter layer and/or the dielectric medium is an intermediate isolating filter layer, wherein the term filter layer implies that the respective layer is permeable for a gas (like e.g., air) but not for particles above a threshold diameter. The threshold diameters may be different for the different filter layers.

[0013] The capacitor may be attached to a support. The support is preferably non-conducting. For example, the portion of the surface facing away from the capacitor may be at least a part of the gas filter's narrow facing side.

[0014] The gas filter may further comprise a first electrical contact (hereinafter '*first contact*') at a first location. The gas filter may further comprise a second electrical contact (hereinafter 'second *contact*') at a second location. Preferably, the first and/or second contact(s) are/is attached to the support and/or unitary with the support. The first contact is preferably configured to be removably connected to a high voltage output contact of a high voltage source. The second contact is preferably configured to be removably connected to a ground contact of the high voltage source. The first and second electrical contacts may each be considered as an electrical connector or a terminal. The first and second electrical contacts may each be considered as an electrical connector and/or a terminal. The contacts enable to connect the filter element to a corresponding first and second housing contacts of a gas filter housing. The gas filter housing may comprise the HV-source and/or the first and second housing contacts may be electrically connected to the HV-output terminal and the ground terminal of the HV-source. Only to avoid confusion, the location of the HV-source is irrelevant, i.e., it may be attached to a housing body and hence be comprised by the filter housing or in any other location and not be comprised.

[0015] In a particularly preferred example, the first electrical contact is electrically connected via a first resistance R1 to a branching point and the second electrical contact is electrically connected via a second resistance R2 to the same branching point. Further, the first electrode may be electrically connected to the branching point as well. The second electrode may preferably be electrically connected to the second electrical contact. The corresponding first resistor and the second resistor and the branching point are thus, preferably a part of the gas filter. At least one of these parts may for example be attached to the support or a part of the support.

[0016] The gas filter enables to adapt the dielectric filter medium and hence the distance between the electrodes or the electrode surface as well as the relative permittivity to any need without changing the HV-source. An installed gas filter can thus be replaced by another gas filter with a different filter medium while avoiding costs or installation errors for replacing or adjusting the HV-source to the new filter medium, because the electrical field E' being intended to be present between the electrodes (after ramp up, i.e. $t \gg t_0$) of the new (=replacing) gas filter can be adjusted when manufacturing the new gas filter adjusting the resistivities R_1, R_2 of the first and the second resistors to accordingly amended values R_1', R_2', as the voltage $U_{cap}(t \gg t_0)$ across the capacitor is provided by $U_{cap}'(t) \approx \frac{R_2'}{R_1'+R_2'} U_{HV} \forall t \gg t_0$. As usual, herein t denotes the time and t_0 is the point in time when the HV-source has been switched on. The current being drawn from the HV-source can be selected to be negligibly small by simply choosing $R_1' + R_2'$ reasonably large. For example, a voltage $U_{HV} = 4kV$ and an accumulated resistivity of $R_1' + R_2' = 80k\Omega$ provides a current I_{gf} drawn by the gas filter of only $I_{gf} = 0.05mA$.

[0017] Further, the ability to adjust the voltage across the capacitor in wide range allows to connect the gas filter to the same HV-source terminal, which feeds as well a gas-ionizer. Such an optional gas-ionizer may be placed in the gas conduit, preferably upstream of the first electrode, either as a part of the gas filter or as a separate part in the gas conduit. An example gas-ionizer is suggested in the German Patent Application DE 10 2021 120 127.6, the teaching of which is included herein by reference as if fully disclosed.

[0018] Typical values for operating gas-ionizers are in the range of a couple of kV (typically 3 to 6kV). At these volage levels, however, the dielectric media of typical active field polarized media gas cleaning filter would be destroyed by sparking. The gas filter as claimed, however allows to adjust $\frac{R_2'}{R_1'+R_2'}$ appropriately, i.e., the voltage across the capacitor $U_{cap}(t) \approx \frac{R_2'}{R_1'+R_2'} U_{HV}$ can be adjusted to any reasonable value, for example to a value between 0.5kV and 1.5kV.

[0019] Further, while an gas-ionizer drains a current of typical 10μA-100 mA, the additional current for maintaining the electrodes of active field polarized media gas cleaner charged is negligible as explained above: The gas filter may thus be connected in parallel to the same HV-source as a gas-ionizer of the gas cleaning system and thereby provide the first and second electrodes the intended voltage: Initially, when the HV-source is powered on (at $t_0 = 0$), the voltage between the first and the second electrical contact rises. The voltage at the capacitor $U_c(t)$ (assuming $t_0 = 0$) can be approximated as $U_c\,(t)=\frac{R_2}{R_1+R_2}\cdot\;U_{HV}\;e^{\frac{t}{R_1C}}$ accordingly, during ramp on, the current provided by the HV-source to the gas filter $I_{gf}(t)$ decreases exponentially until it reaches its lowest value $Min\left(I_{gf}(t)\right)=\frac{U_{HV}}{R_1+R_2}$. At the point in time, when the current provided to the gas filter is maximal, the current provided to the gas-ionizer is essentially zero, as the voltage is still below the minimum voltage required for the onset of ionization. In other words, the maximum current being drawn from the HV-source $Max(I_{HV}(t))$ is lower than the sum of the maximum currents through the gas filter $Max(I_{gs}(t))$ and the gas-ionizer $Max(I_{ai}(t))$, i.e. $Max(I_{HV}(t)) < Max\,(I_{gf}(t)) + Max(I_{ai}(t))$. Further, by selecting $R_1 + R_2$ (or $R_1' + R_2'$, as the case may be) rather high, $Max\,(I_{gf}(t))$ can be reduced to practically almost negligible values. Thus, a single HV-source can be used to supply both, a gas-ionizer and the gas filter. Even retrofitting an existing gas cleaning system with a gas-ionizer is possible, using the gas filter of claim 1, as the voltage between the first and second electrodes can be adapted as described and because $Max(I_{HV}(t))$ remains almost constant, as $Max\,(I_{gf}(t)) << Max(I_{ai}(t))$.

[0020] In a preferred example, the gas filter comprises a third electric contact T3 ((third contact T3) at a third location, wherein the third electrical contact is electrically connected to the first contact via a third resistance R3. This allows to electrically connect the gas-ionizer to the HV-source via the gas filter. If the gas filter has been erroneously omitted, the gas-ionizer is not connected to the HV-source, it remains switched off. Thereby, it can be avoided that the gas-ionizer is operated, if no gas filter is installed, as -in case the gas treated by the gas cleaning system is an oxygen comprising gas, like air- this would lead to an increased Ozon (O_3) concentration in the air leaving the gas filter system. Such increased Ozon (O_3) concentration provides a health risk. As will be explained below, insertion of the gas filter can as well be detected by measuring the voltage and/or the current after switching the HV-source on.

[0021] Alternatively of in addition, the gas filter may comprise a fourth electric contact T4 (fourth contact T4) at a fourth location, wherein the fourth electrical contact is electrically connected to the second contact T2 via a fourth resistance R4. This allows to electrically connect the HV and the ground terminal of the optional gas-ionizer to the HV-source via the gas filter. The advantages are essentially the same as those of the third contact T3. Only to avoid misunderstandings, the term "fourth contact" does not imply that the third contact T3 is present. Hence in an example, the gas filter comprises the first, second and fourth contacts T1, T2, T4, but not the third contact T3. In another preferred example the gas filter comprises all four of these contacts T1 to T4, i.e. the first, second, third and fourth contacts T1, T2, T3 and T4. The gas filter may as well comprise the first, second and third contacts T1, T2 and T3, but not the fourth contact.

[0022] The optional third and/or fourth resistances R3, R4 -if present- may be connected in parallel to the first and second resistances R1, R2, respectively. They may as well be provided by a section of the first and second resistances/resistors R1, R2. In this case the first resistance R1 can be written as R1=R3+R3B, wherein R3B is the resistance between the third contact R3 and the branching point B. Similarly, the fourth resistance R4 may be provided by a section of the second resistance/resistor R2 and hence R2=R4+R4B, wherein R4B is the resistance between the fourth resistance/resistor R4 and the branching point B. In yet another example, the fourth contact point may be in between of the second electrode and the second contact T2. All these options and alternatives may simplify arrangement of the wiring and thus contribute to cutting the cost of the gas filter down.

[0023] In a preferred example, the third resistance R3 between the first electrical contact and the third electrical contact is smaller or equal to the first resistor R1 and/or the second resistor R2, i.e., $R3 \leq Max(\{R1, R2\})$. Particularly preferred, the third resistance R3 is significantly smaller than the first resistor R1 and/or the second resistor R2, which can be written as $R3 \leq \alpha_R \cdot Max(\{R1, R2\})$, wherein $\alpha_R \in \{0.5, 0.4, 0.3, 0.25, 0.2, 0.1, 0.05, 0.01, 0.001\}$. By selecting the third resistance R_3 negligible small, the voltage drop and hence the power loss across R_3 can be minimized.

[0024] At least one of the first, second and/or the third electrical contacts may be attached to and/or located on the support. This eases safely connecting the corresponding contacts with their complementary counterparts of a gas filter housing when inserting the gas filter into the gas filter housing.

[0025] In a preferred example, the first resistor R_1 and/or the second resistor R_2 and/or the third resistor R_3 are/is a conductive polymer and/or a conductive ceramic and/or a conducting compound. The conductive polymer and/or the conductive ceramic and/or a conducting compound, are in many legislations not considered as electronic devices. The gas filter therefore is not considered as such and once its service life is reached, the gas filter may be disposed as 'normal waste' instead of being disposed as electronic scrap, being more expensive.

[0026] The electric contacts as well as the branching point(s) may as well be of said conductive polymer and/or the conductive ceramic and/or conducting compound, thereby reducing the number of materials being required when manufacturing the gas filter -which translates in manufacturing cost reduction- and recycling of the materials being used is as well simplified. In other words, the gas filter may comprise a module being formed of the conducting polymer and/or the conducting ceramic and/or a conducting compound, wherein the module comprises or consists of the first contact, the second contact, the branching point, the first resistor R_1 and the second resistor R_2. Optionally the third resistor R_3 and the third contact may as well be a part of the module. In other words, all electrical components except of the first and second electrodes of the capacitor are preferably a part of the module. Such module may be manufactured as a single piece (and hence unitary) piece of the conducting polymer and/or conducting ceramic and/or a conducting compound. This allows to cut down manufacturing costs for the gas filter as well as disposal costs.

[0027] For example, the conductive polymer and/or conducting ceramic and/or a conducting compound may have an outer layer with a specific electrical resistivity ρ_l and an inner layer or core with a core resistivity ρ_c. Only for linguistic simplicity, we do not distinguish between an inner layer or a core. This means, that the core may as well be a layer, as long as it is enclosed by the outer layer. In a first example, the core may have cross section being circular, polyhedric and/or elliptic or have any other cross section being delimited by a single curve. This would correspond to the intuitive notion of the term core and can be considered as a preferred example. Alternatively, the core may have a ring shaped cross section, i.e. it may be delimited by two closed curves, being closed loops. In this case the core may be located for example in between of two layers, an inner layer and an outer layer. The core may have a specific electrical resistivity ρ_c wherein $\rho_c \neq \rho_l$ and/or $\rho_c < \alpha_\rho \cdot \rho_l$ and/or or $\rho_c > \alpha_\rho \cdot \rho_l$, wherein $\alpha_\rho \in \{0.9, 0.8, 0.75, 0.6, 0.5, 0.4, 0.3, 0.25, 0.2, 0.1\}$. For example, if the conducting polymer or the conducting ceramic comprises conductive fibers being embedded in a non-conducting polymer and/or conducting ceramic and/or a conducting compound, the fibers in the core may be essentially randomly oriented and not even straight. In the vicinity of the surface of the conducting polymer and/or conducting ceramics and/or a conducting compound, the conducting fibers may, e.g., due to the process of extruding and/or injecting the polymer and/or the slip (a ceramic precursor) align. This may lead to an inhomogeneous transition resistance along the surface of the polymer and/or ceramic.

[0028] It is preferred, if the core extends through the outer layer at the first location and /or the second location and/or the third location. Thereby, the core having a more homogenous and hence defined transition resistance can be contacted. Thus, at the first and/or second and/or third location, the core is preferably not covered by the outer layer. This can be obtained, e.g. by locating a sprue at the respective location, thereby after removing the sprue, the core becomes exposed. Alternatively, one may use any subtractive method (like for example grinding, polishing, drilling, milling, etching, ...) to remove a portion of the outer layer and thereby expose the core.

[0029] Alternatively, or in addition, the conducting polymer and/or conducting ceramic may have at least one recess at the first location and/or the second location and/or the third location. The recess allows a corresponding protrusion of the gas filter housing to enter into the recess. A conducting blade being that is optionally attached to the protrusion may thereby cut into the core and provide for reliable electrical connection of the first, second and/or third electrical contact, respectively with the core. At the same time, the risk of injuries when inserting the blade can be reduced, as the protrusion may extend over the blade and thereby prevent human fingers or other parts from being injured by the blade or a potentially (and unitedly) applied HV to the blade. In other words, the gas filter housing may hence comprise at least one (preferably conducting) blade positioned to penetrate into the conducting polymer and/or the conducting ceramic and/or the conducting compound at the first location and/or the second location of the gas filter. This blade may be, or be a portion of the first and/or second and/or third housing contact. In another example, the blade is located in front of the respective housing contact, and hence configured to cut through the conducting polymer and/or conducting ceramic and/or conducting compound while the associated housing contact may follow the blade in the slot being provided by the cutting edge and thereby may be configured to contact the optional core of the conducting polymer and/or conducting ceramic and/or conducting compound.

[0030] The already mentioned protrusion of the gas filter housing may hence extend into the gas filter receptacle being provided by the gas filter housing. For example, the protrusion may extend from a housing wall towards the inside of the housing, i.e., towards the space being configured to receive the gas filter. In an example, the protrusion may be located to located to extend into the recess of a Alternatively or in addition the protrusion may be or comprise a ring and/or ring segment. The ring and/or ring segment may be located to at least partially encircle an outer boundary of the first and/or second and/or third electrical contact of the gas filter.

[0031] The blade may be located inside of the ring /ring segment. Alternatively or in addition, the protrusion may extend further into the gas filter receptable than the blade. The protrusion may hence protect the blade from unintended touching or contacting. The corresponding housing contact is thus protected by the protrusion, while at the same time the protrusion protects a worker during replacement of the gas filter from being hurt by the blade or a potentially applied voltage to said blade. In an example, at least the distal portion of the protrusion is non-conducting, i.e. electrically isolating.

[0032] Preferably, the protrusion supports at least a portion of the blade. Thereby the blade can be made particularly thin. Thereby, the forces required to install the gas filter or more precisely required to drive the blade into the conducting polymer and/or the conducting ceramic and/or the conducting compound are low.

[0033] The gas filter may further comprise a gasket for sealing a gap to a wall defining gas filter receptacle of the gas filter housing. In a preferred example, at least a portion of the conductive polymer and or the conductive ceramic may be positioned in between of the support and the gasket. The gasket hence protects the polymer against mechanical stress and at the same time isolates the portion of the conductive polymer and/or conductive ceramic. The gasket may as well attach the polymer to the support by adhesive bonding.

[0034] In another example, at least a portion of the gasket may be made of the conductive polymer. The number of different parts of the gas filter can be further reduced, which contributes to a reduction of the manufacturing cost.

[0035] The conductive polymer and/or conductive ceramic and/or a section thereof may be attached to and/or may extend over a section of the first electrode and/or of the second electrode, wherein an isolating sheath is located in between of at least the section of the conductive polymer and/or conductive ceramic.

[0036] The gas filter enables to automatically detect the presence in a gas filter system as described herein without requiring additional contacts by the method of claim 12. Based on the result of the determination an optionally present gas-ionizer of the corresponding gas cleaning system may be controlled. If correctly installed, the gas filter's first and second electrical contacts are electrically contacting corresponding first and second housing contacts T11, T12. These housing contacts are preferably connected to an HV-source.

[0037] The method may comprise the step of providing at least a first voltage U_d to the housing contacts T11, T12 and to determine the current $I_h(U_d)$ through the housing contacts T11, T12. This current allows to determine, whether the gas filter is present or not by comparing the current $I_h(U_d)$ through the housing contacts T11, T12 with a threshold current I_t and if $I_t > I_h(U_d)$ is true, there is no second resistor R_2 through which a current $I_h(U_d)$ may flow. Hence, in case $I_t > I(U_d)$ the gas-ionizer is preferably switched off and/or maintained switched off. This may be done by simply switching the HV-source off and/or by controlling the HV-source to provide a voltage below the onset voltage U_o of gas ionization by said gas-ionizer. Further an error message may be symbolized, for example displayed in a screen or by simply illumination a control light.

[0038] In case the comparing step provides that the current $I(U_d)$ through the housing contacts is larger than said threshold current I_c, meaning $I_t < I(U_d)$ is true, then the gas-ionizer may be controlled to operate, as it may be expected that the gas filter is installed. In other words, the voltage provided to the gas-ionizer may be above its onset voltage U_o as in this case it is very unlikely that the gas filter has not been installed.

[0039] Alternatively or in addition to directly measuring the current $I_h(U_d)$ for the above comparing steps, one may determine and consider any other value χ that may represent or be a measure of the current $I_h(U)$ or at least of $I_h(U_d)$. Such value χ may be measured and/or calculated. Generally, the condition on the value χ is that it is a mapping (e.g. a function) of the current I_h , ($\chi = \chi(I_h)$) and/or that it exists a mapping from the value χ to the current I_h ($I_h = I_h(\chi)$). In both cases, it is preferred, if the respective mapping is unique or even bijective, but this is not required. Determining any of these values χ shall be considered in the context of this patent as determining the current I_h as these values χ provide information about the current I_h. Examples for such values χ are for example the power consumption of the HV-source (obtainable by an input power measurement), the current drawn by the HV-source (obtainable by an input current measurement), a duty cycle of a pulse width modulated signal controlling the voltage across the housing terminals T11, T12 to U_d, a magnetic field, the resistance between the housing terminals T11, T12 or the like. It is clear that for each such value χ one has to define a corresponding threshold value χ_c, which provides or is provided by the respective mapping (of) the threshold current I_c and to use said χ_c in the comparing step. Depending on the mapping, one may have to invert the indicated relations, but this can be figured out by simple testing.

[0040] Preferably, the first voltage U_d obeys $|U_o - \Delta U| \leq U_d \leq |U_o + \Delta U|$, wherein $\Delta U \in \{2kV, 1.5kV, 1kV, 0.75KV, 0.5KV\}$ and U_o is still the onset voltage of the gas-ionizer. This choice of the voltage U_d reduces the risk of erroneously controlling the gas-ionizer to operate or not, because the difference between the currents in the situations in which no gas filter is installed and when the gas filter is installed maximizes. This measure is particularly effective is the gas-ionizer is connected in parallel to first and second contacts of the gas filter.

[0041] The terms gas stream and gas flow are used interchangeably herein. Further, in this disclosure, the term gas includes as a preferred example the term gas.

[0042] An isolator has an (almost) infinite resistivity, in other words, there is a band gap between the conduction band and the fermi level. A conductor in contrast fails to show this band gap, as the fermi level is in the conduction band. So called semiconductors having a band gap ΔE in the order of $k_\beta T$, wherein k_β is the Boltzmann constant and T the temperature (in Kelvin) behave essentially like metallic conductors at the temperature T, although they behave like isolators at lower temperatures ($\Delta E >> k_\beta T$). Thus, the terms isolator, isolating, conductor, conducting etc. reference to electrical conductivity and not to thermal properties.

[0043] Herein the term conductive polymer and/or conductive ceramics encompasses not only polymers and/or ceramics being conductors or semiconductors, but as well compound materials based on a matrix of non-conducting polymers and/or non-conducting ceramic materials into which a conductive material like e.g., metal and/or carbon fibers and/or graphite or the like have been integrated. The conducting compound hence may have a non-conductive matrix into which conductive fibers have been embedded and the conductivity of the compound can hence be attributed to the conductive fibers (which may as well be filaments, particles, beads or the like), being for example randomly distributed in the matrix.

[0044] The terms first, second, third, n^{th} electrical contacts are herein considered as releasably contactable contacts which may as well be referred to as electrical terminal or electrical connector. These electrical contacts may be formed for example by a male pin type connector and/or a corresponding female sleeve type connector and/or a simple contact pad.

[0045] $n \in \{n_1, n_2, ..., n_k\}$ indicates that n may take any value of the set $\{n_1, n_2, ..., n_k\}$, for example $n = n_1$ or more generally $n = n_j$ and $1 \leq j \leq k$.

Description of Drawings

[0046] In the following the invention will be described by way of example, without limitation of the general inventive concept, on examples of embodiment with reference to the drawings.

Figure 1 shows a perspective view of first example of a gas filter.

Figure 2 shows a perspective view of second example of a gas filter.

Figure 3 shows a perspective view of third example of a gas filter.

Figure 4 shows a gas filter housing.

Figure 5 shows the gas filter housing with a partially inserted gas filter.

Figure 6 shows a schematic of a filter medium.

Figure 7 shows current over voltage diagram.

Figure 8 shows a detail of a gas filter housing.

[0047] FIG. 1 shows an example gas filter 1. The gas filter has an upstream facing side 3 and a downstream facing side 4, assuming a gas flow direction as indicated by arrow 2. Of course, the gas flow direction could be inverted as well. A narrow facing side 5 connects the upstream facing side 3 and the downstream facing side 4.

[0048] The gas filter 1 has a filter medium 20. The filter medium 20 may comprise one or more plied sheets, but this is only a preferred example. Other types and shapes of filter media may be used as well. The filter medium 20 may preferably comprise at least three layers: two electrode layers 21, 22 and a dielectric layer 23 in between of the electrode layers 21, 22. Each of the electrode layers 21 may thus be considered as an electrode 21, 22 of a capacitor, wherein the dielectric layer 23 is the capacitor's dielectric 23 in between of the two electrodes 21, 22 (cf. Fig. 6). The filter medium 20 may thus comprise and/or form a capacitor.

[0049] The gas filter 1 may further comprise at least one support 10. In the example, the support 10 comprises a front wall 11 and rear wall 12 being preferably sealingly attached to opposing portions of the narrow side of the filter medium 20. Side walls (not shown) may be comprised as well by the gas filter 1, but as shown they may be omitted.

[0050] The gas filter 1 may have an electric module 30. As shown, the electric module 30 may comprise or preferably consist of an electrically conducting polymer string 30, which may as well be referred to as duct 30, string 30 or electrical conduit 30. Alternatively, or in addition, the module may comprise or consist of an electrically conducting ceramic string and/or a conducting compound. Only for linguistic simplicity, we use the term *conductive polymer* herein as a pars pro toto for *conductive polymer and/or conductive ceramic and/or conductive compound.*

[0051] The electrically conducting string may have a first electrical contact T1. In this example, the first electrical contact T1 may preferably have a ring structure and hence forms a first recess being at least partially enclosed by the polymer string. The ring structure is not necessarily closed and may hence form a ring segment or a ring.

[0052] The first electrical contact may be connected by the conductive polymer 30 with a branching point B and thus the portion of the conductive polymer 30 which forms the electrical connection between the first contact T1 and the branching point B forms a first resistor R_1.

[0053] The electrically conducting polymer string may have a second electrical contact T2, which as well may as well form a ring or a ring segment. The second contact T2 is preferably connected by a portion R_2 of the conducting polymer string 30 with the branching point. Thus, the portion of the conducting polymer connecting the second contact T2 and the branching point may define a second resistor R_2.

[0054] Further, the branching point B and the second terminal may preferably be connected, e.g., by said conducting polymer 30 to one of the first and the second electrode 21, 22.

[0055] Inserting the gas filter into a gas filter housing as shown, e.g., in Fig. 5 hence enables to provide an electrical connection of the first and second electrical contacts (T1, T2) with two poles of a HV-source, which may provide a voltage U_{HV}. The voltage between across the capacitor U_{cap} is then approximated by $U_{cap}(t) = \frac{R_2}{R_1+R_2} U_{HV}$, (for large t, i.e. t >> t_0). By reducing or extending the lengths of the connections between the first contact T1 and the branching point B the voltage U_{cap} can be adjusted to match the requirements provided by capacitor.

[0056] Fig. 2 and 3 each show a slightly different gas filter 1. The description of Fig. 1 may be read as well on Fig. 2 and 3. In addition, the gas filters of Fig. 2 and 4 each have a gasket 40. The gasket 40 may extend over the edge being formed by the upstream facing side 3 and the narrow facing side 5 and it may cover a portion of the string 30 thereby serving as adhesive for attaching the conductive polymer 30. In Fig. 2, the gasket 40 covers the portion of the conducting polymer 30 that contacts the second electrode. In Fig. 3, the gasket covers and hence fixates a portion of the electrical conduit 30, i.e. a portion of the string 30, that extends along a downstream edge of the support 10

[0057] Fig. 4 shows an example gas filter housing 100. The gas filter housing 100 may be attached to or be integrated in a gas conduit and in this sense, its side walls 111 to 114 may be considered as a part of the gas conduit. The front sidewall 111 may have an opening enabling to insert the rear portion of gas the filter 1 of Fig. 1 or Fig. 2 into the gas filter housing 100 as sketched in Fig. 5. The gas filter housing may preferably comprise at least a first and a second housing contact T11 and T12, configured to contact the first and the second contacts T1, T2 of the gas filter 1. In a preferred example, the at least one of the housing contacts T11, T12 comprises blade configured to penetrate through at least a portion of the polymer string 30, to thereby contact an inner portion of the polymer string, which inner portion may be referred to as a core. Fig. 5 shows the example gas filter 1 of Fig. 3 partially inserted into the gas filter housing 100. The side wall 114 has been omitted and the gasket 40 has been shown transparent. As can be seen, the first contact T1 is configured to contact the first housing contact T11 and the second contact T2 is configured to contact the first housing contact T12.

[0058] Fig. 6 shows a detail of a filter medium 20 as may be used in any of the examples in Fig. 1 to 3 and 4. The filter medium has a first electrode 21, a second electrode and a dielectric medium 23 between the first and the second electrodes 21, 22. T1 and T2 symbolize the first and second electrical contacts, B a branching point and the resistors R_1 and R_2 represent the electrical resistance of the corresponding connections by, for example the polymer string 30 as described above.

[0059] Fig. 7 shows a diagram of three different current $I(U)$ curves, wherein $I(U)$ is indicated in mA and the voltage U is indicated in kV. The coarsely hatched curve describes the current across the electrical contacts T1 and T2 in the example of Fig. 6. The current values have been measured after the current stabilized, i.e., the current being depicted is essentially the current through the resistor R2 being defined by Ohm's law. Below 3.5kV, the coarsely hatched curved is identical with the continuously drawn curve and hence cannot be optically distinguished.

[0060] The finer hatched curve describes the current through a gas-ionizer that is connected to the same HV-source, in parallel the electrical contacts T1 and T2. As can be seen, the gas ionization starts at an corona inception voltage of in this example about 3.5kV (i.e. 3.5 kV is an example corona inception voltage U_o, that can be varied, e.g., by increasing or decreasing the distance of the gas-ionizer electrodes) and the current increases with increasing slope. The corona inception Voltage depends on the gas-ionizer and the gas but can be determined easily by measuring the current $I(U)$ as a function of the supply voltage.

[0061] The solid line is the total current flowing if the gas-ionizer is connected in parallel to the HV-source supplying the T1 and T2 the electrical conduit 30 and hence the filter medium 20 (see Fig. 6). As can be seen, based on measurement of the output current of the HV-source one may distinguish, if the gas filter 1 has been inserted into the gas filter housing or not: In case the current $I(U_d)$ for a given voltage U_d is below a threshold I_t, i.e., if $I(U_d) < I_t$, then the HV-source is preferably switched off. Thereby, operation of the gas-ionizer does not take place and the ozone concentration in the air being provided by the corresponding gas cleaning system is low. Health risks due to an unintendedly high ozone-concentration can be avoided.

[0062] Preferably, the given voltage U_d is below the corona inception voltage U_o or in the vicinity ($\pm 2kV$, preferably $\pm 1kV$, $\pm 0.75KV$ or $\pm 0.5KV$) of the corona inception voltage U_o of gas ionization by the installed gas-ionizer. In this voltage range the difference between the currents of the coarsely hatched curve and the finer hatched curve has a maximum. Thus, the risks of erroneously switching the HV-source off and of erroneously operating the air ionizer is reduced.

[0063] Fig. 8 shows a detail a further gas filter housing 100. The gas filter housing 100 has a housing wall 113 with a block 120 for defining the position of the gas filter 1. In this example, the gas filter 1 may be inserted from the top, and may reside on the block 120. The gas filter housing 100 may have at least one (first) protrusion 131, the protrusion may be located to engage into a corresponding recess of an electrical contact T1, T2, or T3 of a conducting polymer, and/or a conducting ceramic and/or a conducting compound as shown in Fig. 1, 2, 3, and 5. The protrusion 131 may supports a blade T11 with a cutting edge. Preferably, the cutting edge points opposite to the direction of insertion of a gas filter, e.g. towards the housing opening in the front wall 111 as shown in Fig. 4. When inserting the gas filter into the housing 100, the cutting edge of the blade shaped first housing contact T11 may penetrate into the material of duct 30 (i.e. into conducting polymer, and/or a conducting ceramic and/or a conducting compound) of the gas filter 1 and thereby electrically contact the core of said duct 30 with an HV-terminal of a HV-source 141.

[0064] As can be seen in Fig. 8, there may be another (third) protrusion (133), configured to engage into a another (third) recess of another (third) electrical contact of a gas filter 1. Similarly to the first protrusion, a blade T13 may be attached to the third protrusion. The blade may form a third housing contact T13 and may be connected with an HV-terminal of a gas ionizer 143. As can be seen, there is an optional gap between the first and the third housing terminal T11, T13. Hence, the gas ionizer is connected to the HV-source 141 only if the duct 30 electrically connects the first and the third housing terminals 141, 143. In other words, if no gas filter 1 is inserted into the gas filter housing, the electrical connection between the HV-source and the gas ionizer is interrupted. Thereby, it is safely avoided that harmful substances produced by an upstream gas-ionizer leave the gas filter housing without having passed the gas filter.

[0065] As visually apparent, the gap in between of the first and the third housing contacts T11, T13 is exaggeratedly small, thereby the resistance between the first and the third housing electrode is small as well. However, in practice, the distance should be selected reasonably large to avoid ionizing ambient air in the gap in case no gas filter has been inserted. In addition or alternatively, a fourth isolating protrusion may be located in between of the housing contacts T12 and T13 to thereby allow these to be placed closer together, which results in a smaller resistance R3 between first and the third contact if the gas filter is installed.

[0066] As apparent from the description of Fig. 8, by omitting the terms "second housing electrode", "second blade" and "second protrusion", it is implied that the gas filter housing may have a second housing contact T12 being formed by a second blade T12 and being optionally attached to a second protrusion. These details are not depicted, as they may look like their first or third protrusion and/or blade respectively.

List of reference numerals

[0067]

1 gas filter
2 flow direction
3 upstream facing side
4 peripheral side
5 downstream facing side

10 support
11 front wall
12 rear wall

20 filter medium / capacitor
21 first conductive filter layer
22 second conductive filter layer
23 dielectric medium

30 electrical module optionally comprising a conductive polymer string and/or a conducting ceramic string and/or a conducting compound
31 first recess
32 second recess
33 third recess
35 outer layer
36 core

40 gasket (optional)

100 gas filter housing
111 front side wall /front wall
112 side wall
113 rear side wall / rear wall
114 side wall
120 block (optional)
131 protrusion (optional)
132 protrusion (optional)
141 to HV-source (optional)
143 to air ionizer (optional)

R1 resistance/resistor between the first electrical contact T1 and the branching point
R2 resistance/resistor between the branching point B and the second electrical contact T2.
T1 first contact (configured to be connected to a high voltage contact of a high voltage source, e.g., via optional first housing contact T11)
T2 second contact (configured to be connected to a ground contact of a high voltage source, e.g., via optional second housing contact T12)
T11 first housing contact, configured to and/or being connected to a high voltage contact of a high voltage source
T12 second housing contact, configured to be and/or being connected to a ground contact of a high voltage source
T13 third housing contact, configured to be and/or being connected to a contact of an air-ionizer of a gas cleaning system

Claims

1. A gas filter (1) having an upstream facing side (3), a downstream facing side (4) and a peripheral narrow facing side (5) connecting the upstream facing side (3) and the downstream facing side (4), the gas filter (1) comprising at least:

- a filter medium (20), for filtering a gas flow from the upstream facing (3) side through the filter medium (20) to the downstream facing side (4), wherein the filter medium (20) comprises and/or forms a capacitor, and wherein the capacitor has at least a first electrode (21), a second electrode (22) and a dielectric medium (23), wherein the first electrode (21), the second electrode (22) and/or the dielectric medium (23) is a filter layer,

- at least a first non-conducting support (10), wherein the capacitor is attached to the first support (10)
- a first electrical contact (T1) at a first location, and
- a second electrical contact (T2) at a second location,

(i) **characterized in, that**
(i) the first electrical contact (T1) is electrically connected via a first resistance (R1) to a branching point (B),
(ii) the second electrical contact (T2) is electrically connected via a second resistance (R2) to the branching point (B),
(iii) the first electrode (21) is electrically connected to the branching point (B), and
(iv) the second electrode (22) is electrically connected to the second electrical contact (T2).

2. The gas filter (1) of claim 1, **characterized in that** it comprises a third contact (T3) at a third location, wherein the third contact (T3) is electrically connected to the first contact (T3) via a third resistance (R3).

3. The gas filter (1) of claim 2, **characterized in that** the third resistance (R3) between the first electrical contact (T1) and the third electrical contact (T3) is smaller or equal to the first resistor (R1) and/or the second resistance (R2), i.e. $R3 \leq Max(\{R1,R2\})$.

4. The gas filter (1) of one of the previous claims, **characterized in, that** at least one of the first, second and/or the third electrical contacts (T1, T2, T3) are attached to and/or located on the support.

5. The gas filter (1) of one of the previous claims, **characterized in, that** the first resistance (R1) and/or the second resistance (R2) are/is a conductive polymer and/or a conductive ceramic and/or a conducting compound, wherein at least a portion of the conductive polymer and/or the conductive ceramic and/or the conducting compound is attached to the support (10), wherein the conducting compound has a non-conducting matrix into which conductive fibers are embedded.

6. The gas filter (1) of claim 5, **characterized in, that** the conductive polymer and/or the conductive ceramic and/or the conductive compound has an outer layer (35) with a specific electrical resistivity ρ_l and a core (36) with a specific electrical resistivity ρ_c wherein $\rho_l < \alpha_\rho \cdot \rho_c$ or $\rho_l > \alpha_\rho \cdot \rho_c$ and $\alpha_\rho \in \{0.9, 0.8, 0.75, 0.6, 0.5, 0.4, 0.3, 0.25, 0.2, 0.1\}$.

7. The gas filter (1) of claim 6, **characterized in, that** the core (36) extends through the layer (35) at the first location and /or the second location and/or the third location.

8. The gas filter (1) of one of claims 5 to 7, **characterized in that** the conducting polymer (30) and/or the conductive ceramic and/or the conductive compound has at least one recess (31, 32, 33), at the first location and/or the second location and/or the third location.

9. The gas filter (1) of one of the previous claims, **characterized in that** gas filter (1) comprises a gasket (40) for sealing a gap to a wall defining a gas filter receptacle (100).

10. The gas filter (1) of claim 9, **characterized in that** the electrically conductive polymer (30) and/or the conductive ceramic and/or the conductive compound form/s at least a section of the gasket (40).

11. The gas filter (1) of one of claims 5 to 10, **characterized in that** the conductive polymer (30) and/or the conductive ceramic and/or the conductive compound are/is attached to or extends over a section of the first electrode (21) and/or of the second electrode (22), wherein an electrically isolating sheath (29) is located in between of the conductive polymer (30) and/or the conductive ceramic and the at least a portion of the section.

12. A method for determining the presence of the gas filter (1) according to one of the previous claims in a gas filter housing of a gas filter system with a high-voltage source and an air ionizer, wherein the high voltage source is connected to first and second housing contacts (T11, T12) configured to contact the first and second electrical contacts (T1, T2), the method comprising:

(ii) Providing a at least a first voltage U_d to the housing contacts (T11, T12) and measuring the current $I(U_d)$ through the housing contacts (T11, T12).
(iii) Comparing the current $I(U_d)$ through the housing contacts with a threshold current I_t and if $I_t > I(U_d)$ is true, then switch the air-ionizer off and/or maintain the air ionizer switched off.
(iv) Comparing the current $I(U_d)$ through the housing contacts with a threshold current I_t and if $I_t < I(U_d)$ is true, then switch the air-ionizer on and/or maintain the air ionizer switched on.

13. The method of claim 12, **characterized in that** the first voltage U_d obeys $|U_o - \Delta U| \leq U_d \leq |U_o + \Delta U|$, wherein $\Delta U \in \{1.5kV, 1kV, 0.75KV, 0.5KV\}$ and U_o is the corona inception voltage of the air ionizer.

14. A controller, **characterized in that** the controller is configured to execute the method one of claims 12 or 13.

15. A gas filter system comprising at least a high-voltage source and a gas-filter housing (100) having a gas filter receptacle with first and second housing contacts (T11, T12) being each electrically connected to a different terminal of the high-voltage source, **characterized in that** the gas filter system further at least comprises:

(i) the gas filter (1) of one of claims 1 to 11, wherein the first and second electrical contacts (T1, T2) are configured to electrically contact the first and second housing contacts (T11, T12), respectively, and/or
(ii) the controller of claim 14, and/or
(iii) at least one blade with a cutting edge, wherein the cutting edge extends into the gas filter receptacle and wherein the at least one blade is the first and/or the second housing contact (T11, T12, T13).

16. The gas filter system of claim 15 (iii), **characterized in that** the at least one blade is positioned to penetrate into a conducting polymer and/or a conducting ceramic and/or a conducting compound at the first location and/or the second location of the gas filter (1) one of claims 1 to 11.

17. The gas filter system, **characterized in that** the gas filter housing (100) further comprises at least one protrusion extending into the gas filter receptacle and located to extend into the recess of a gas filter 1 according to one of claims 8 to 11 or to at least partially encircle an outer boundary of the first and/or second and/or third electrical contact of the gas filter of one of claims 1 to 11.

18. The gas filter system of claim 17, **characterized in that** the protrusion extends further into the gas filter receptable than the blade and/or that the protrusion is non-conducting and/or the blade is attached to the protrusion.

19. The gas filter system of claim 17 or 18, **characterized in that** the protrusion forms a ring and/or a ring segment and that the cutting edge of the blade is at least partially surrounded by the ring and/or ring segment, respectively.

Amended claims in accordance with Rule 137(2) EPC.

1. A gas filter (1) having an upstream facing side (3), a downstream facing side (4) and a peripheral narrow facing side (5) connecting the upstream facing side (3) and the downstream facing side (4), the gas filter (1) comprising at least:

- a filter medium (20), for filtering a gas flow from the upstream facing (3) side through the filter medium (20) to the downstream facing side (4), wherein the filter medium (20) comprises and/or forms a capacitor, and wherein the capacitor has at least a first electrode (21), a second electrode (22) and a dielectric medium (23), wherein the first electrode (21), the second electrode (22) and/or the dielectric medium (23) is a filter layer,
- at least a first non-conducting support (10), wherein the capacitor is attached to the first support (10)
- a first electrical contact (T1) at a first location,
- a second electrical contact (T2) at a second location,

a branching point (B), a first resistance (R1) and a second resistance (R2) wherein
the first electrical contact (T1) is electrically connected via a first resistance (R1) to a branching point (B),
the first electrode (21) is electrically connected to the branching point (B), and
the second electrode (22) is electrically connected to the second electrical contact (T2),
characterized in that
the second electrical contact (T2) is electrically connected via a second resistance (R2) to the branching point (B).

2. The gas filter (1) of claim 1, **characterized in that** it comprises a third contact (T3) at a third location, wherein the third contact (T3) is electrically connected to the first contact (T3) via a third resistance (R3).

3. The gas filter (1) of claim 2, **characterized in that** the third resistance (R3) between the first electrical contact (T1) and the third electrical contact (T3) is smaller or equal to the first resistor (R1) and/or the second resistance (R2), i.e. $R3 \leq Max(\{R1, R2\})$.

4. The gas filter (1) of one of the previous claims, **characterized in, that**
at least one of the first, second and/or the third electrical contacts (T1, T2, T3) are attached to and/or located on the support.

5. The gas filter (1) of one of the previous claims, **characterized in, that**
the first resistance (R1) and/or the second resistance (R2) are/is a conductive polymer and/or a conductive ceramic and/or a conducting compound, wherein at least a portion of the conductive polymer and/or the conductive ceramic and/or the conducting compound is attached to the support (10), wherein the

conducting compound has a non-conducting matrix into which conductive fibers are embedded.

6. The gas filter (1) of claim 5, **characterized in, that** the conductive polymer and/or the conductive ceramic and/or the conductive compound has an outer layer (35) with a specific electrical resistivity ρ_l and a core (36) with a specific electrical resistivity ρ_c, wherein $\rho_l < \alpha_\rho \cdot \rho_c$ or $\rho_l > \alpha_\rho \cdot \rho_c$ and $\alpha_\rho \in \{0.9, 0.8, 0.75, 0.6, 0.5, 0.4, 0.3, 0.25, 0.2, 0.1\}$.

7. The gas filter (1) of claim 6, **characterized in, that** the core (36) extends through the layer (35) at the first location and /or the second location and/or the third location.

8. The gas filter (1) of one of claims 5 to 7, **characterized in that**
the conducting polymer (30) and/or the conductive ceramic and/or the conductive compound has at least one recess (31, 32, 33), at the first location and/or the second location and/or the third location.

9. The gas filter (1) of one of the previous claims, **characterized in that**
gas filter (1) comprises a gasket (40) for sealing a gap to a wall defining a gas filter receptacle (100).

10. The gas filter (1) of claim 9, **characterized in that** the electrically conductive polymer (30) and/or the conductive ceramic and/or the conductive compound form/s at least a section of the gasket (40).

11. The gas filter (1) of one of claims 5 to 10, **characterized in that** the conductive polymer (30) and/or the conductive ceramic and/or the conductive compound are/is attached to or extends over a section of the first electrode (21) and/or of the second electrode (22), wherein an electrically isolating sheath (29) is located in between of the conductive polymer (30) and/or the conductive ceramic and the at least a portion of the section.

12. A method for determining the presence of the gas filter (1) according to one of the previous claims in a gas filter housing of a gas filter system with a high-voltage source and an air ionizer, wherein the high voltage source is connected to first and second housing contacts (T11, T12) configured to contact the first and second electrical contacts (T1, T2), the method comprising:

Providing a at least a first voltage U_d to the housing contacts (T11, T12) and measuring the current $I(U_d)$ through the housing contacts (T11, T12).
Comparing the current $I(U_d)$ through the housing contacts with a threshold current I_t and if $I_t > I(U_d)$ is true, then switch the air-ionizer off and/or maintain the air ionizer switched off.
Comparing the current $I(U_d)$ through the housing contacts with a threshold current I_t and if $I_t < I(U_d)$ is true, then switch the air-ionizer on and/or maintain the air ionizer switched on.

13. The method of claim 12, **characterized in that** the first voltage U_d obeys $|U_o - \Delta U| \leq U_d \leq |U_o + \Delta U|$, wherein $\Delta U \in$ $\{1.5kV, 1kV, 0.75KV, 0.5KV\}$ and U_o is the corona inception voltage of the air ionizer.

14. A controller, **characterized in that** the controller is configured to execute the method one of claims 12 or 13.

15. A gas filter system comprising at least a high-voltage source and a gas-filter housing (100) having a gas filter receptacle with first and second housing contacts (T11, T12) being each electrically connected to a different terminal of the high-voltage source, **characterized in that** the gas filter system further at least comprises:

the gas filter (1) of one of claims 1 to 11, wherein the first and second electrical contacts (T1, T2) are configured to electrically contact the first and second housing contacts (T11, T12), respectively, and/or
the controller of claim 14, and/or
at least one blade with a cutting edge, wherein the cutting edge extends into the gas filter receptacle and wherein the at least one blade is the first and/or the second housing contact (T11, T12, T13).

16. The gas filter system of claim 15 (iii), **characterized in that** the at least one blade is positioned to penetrate into a conducting polymer and/or a conducting ceramic and/or a conducting compound at the first location and/or the second location of the gas filter (1) one of claims 1 to 11.

17. The gas filter system, **characterized in that** the gas filter housing (100) further comprises at least one protrusion extending into the gas filter receptacle and located to extend into the recess of a gas filter 1 according to one of claims 8 to 11 or to at least partially encircle an outer boundary of the first and/or second and/or third electrical contact of the gas filter of one of claims 1 to 11.

18. The gas filter system of claim 17, **characterized in that** the protrusion extends further into the gas filter receptable than the blade and/or that the protrusion is non-conducting and/or the blade is attached to the protrusion.

19. The gas filter system of claim 17 or 18, **characterized in that** the protrusion forms a ring and/or a ring segment and that the cutting edge of the blade is at least partially surrounded by the ring and/or ring segment, respectively.

Fig. 1

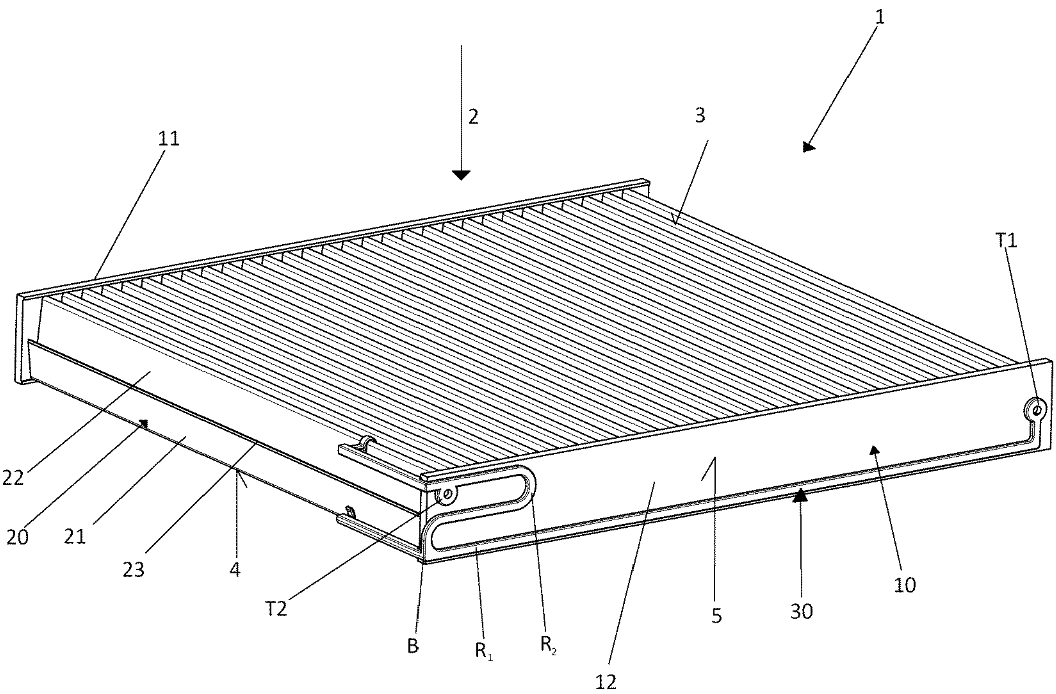

1
2
3
11
T1
22
20
21
23
4
T2
B
R1
R2
12
5
30
10

Fig. 2

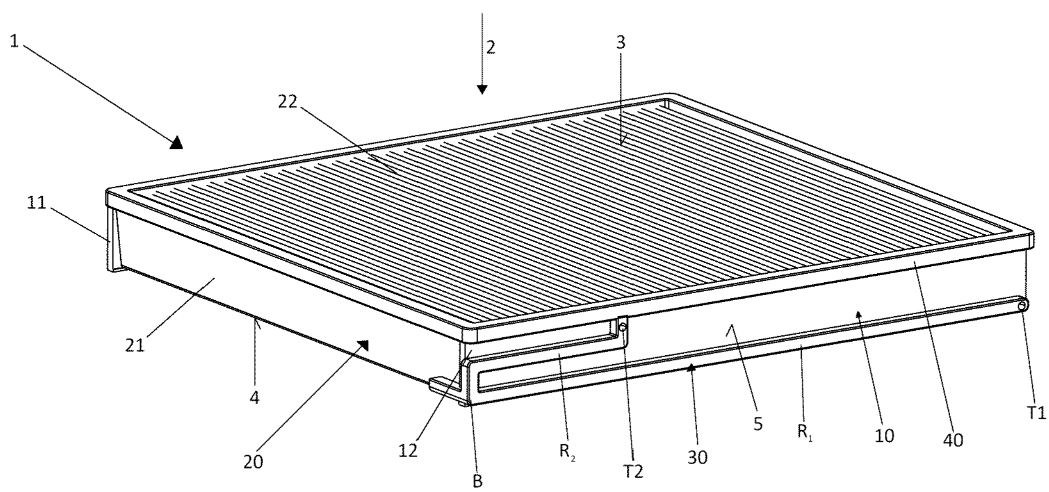

1
2
3
22
11
21
4
20
12
B
R2
T2
30
5
R1
10
40
T1

Fig. 3

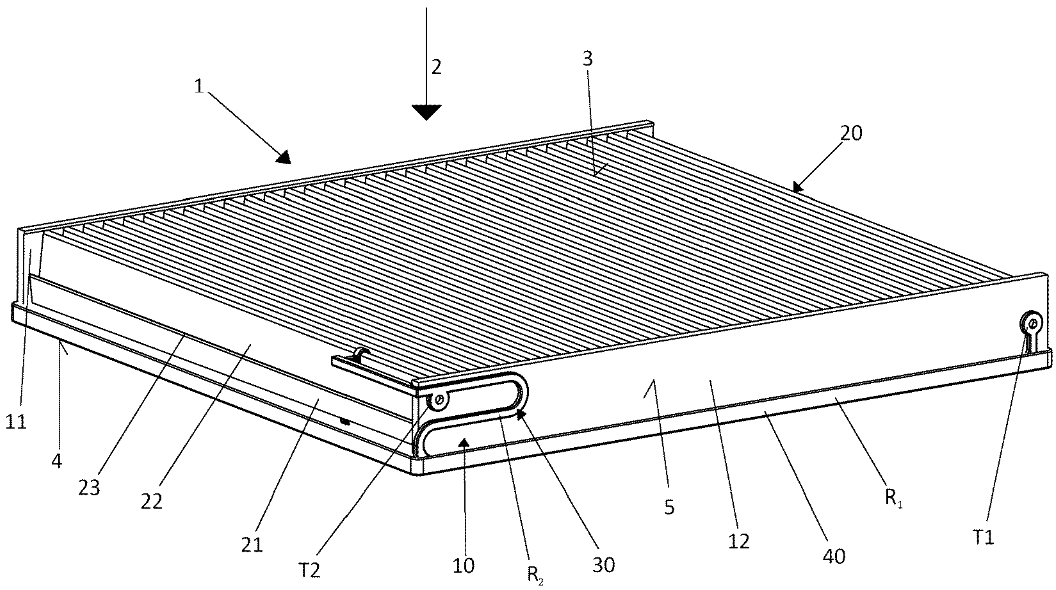

1
2
3
20
11
4
23
22
21
T2
10
R2
30
5
12
40
R1
T1

Fig. 4

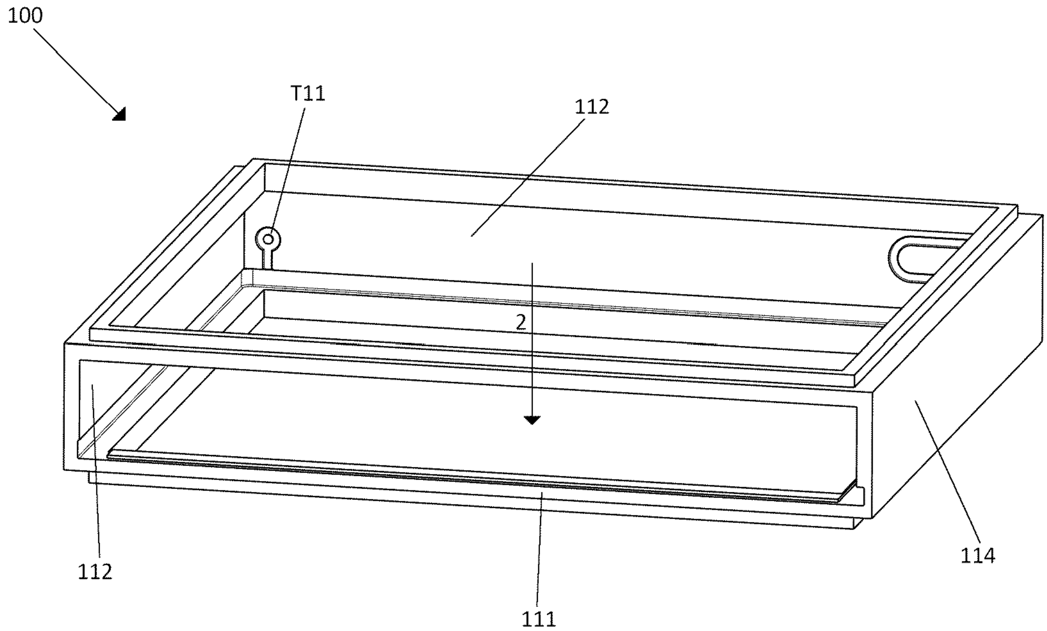

100
T11
112
2
112
111
114

Fig. 5

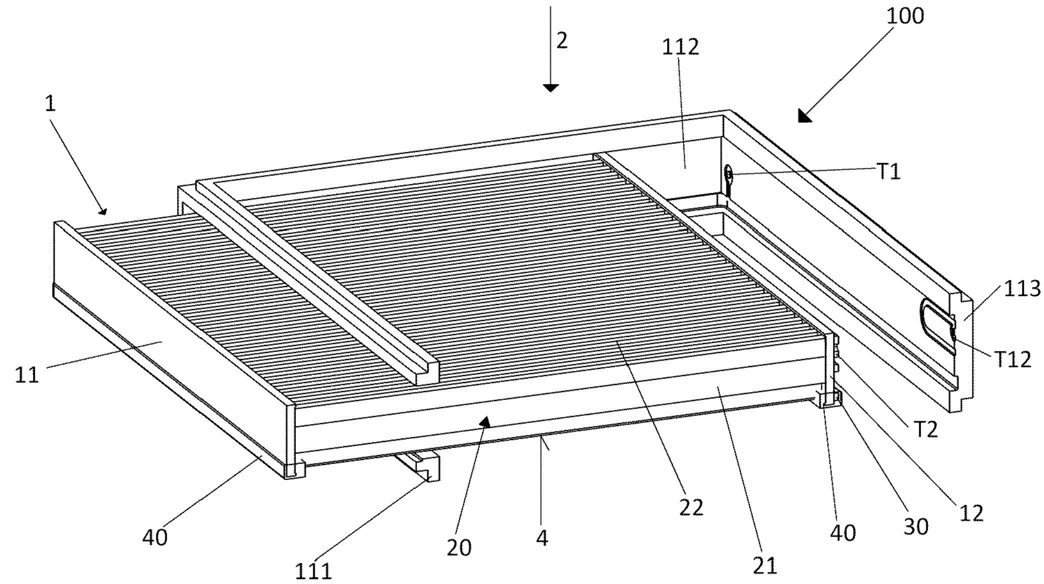

2
100
112
1
T1
113
T12
11
T2
40
111
20
4
22
21
40
30
12

Fig. 6

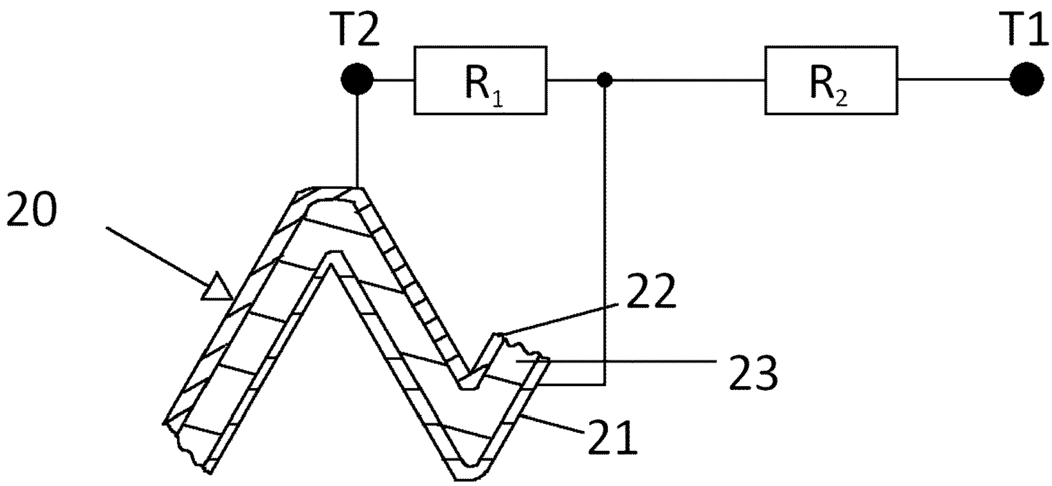
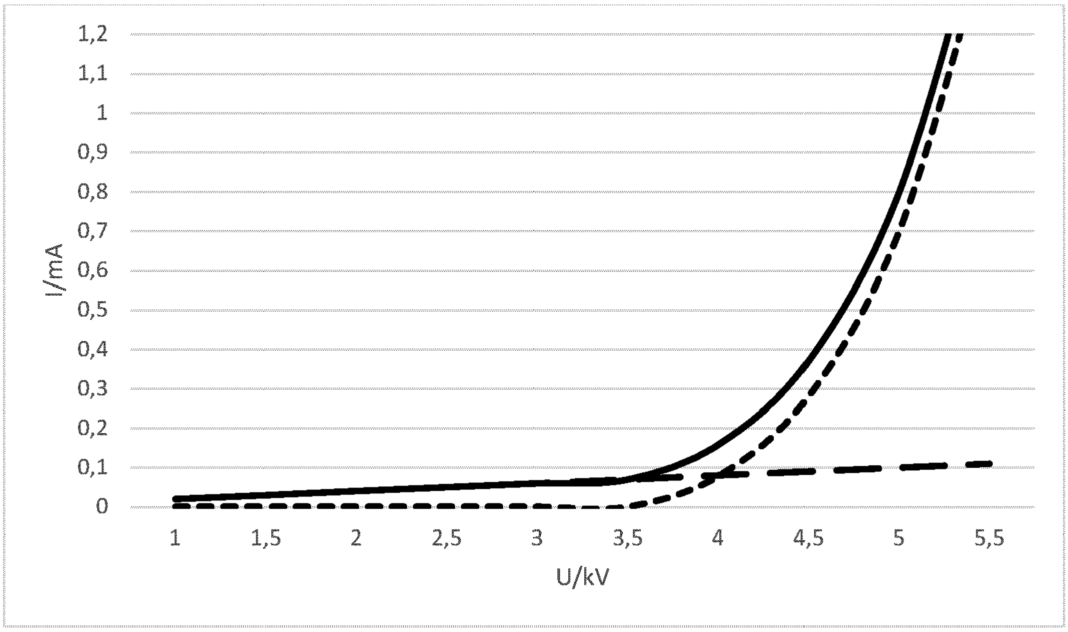

T2
R1
R2
T1
20
22
23
21

Fig. 7


1,2
1,1
1
0,9
0,8
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0,4
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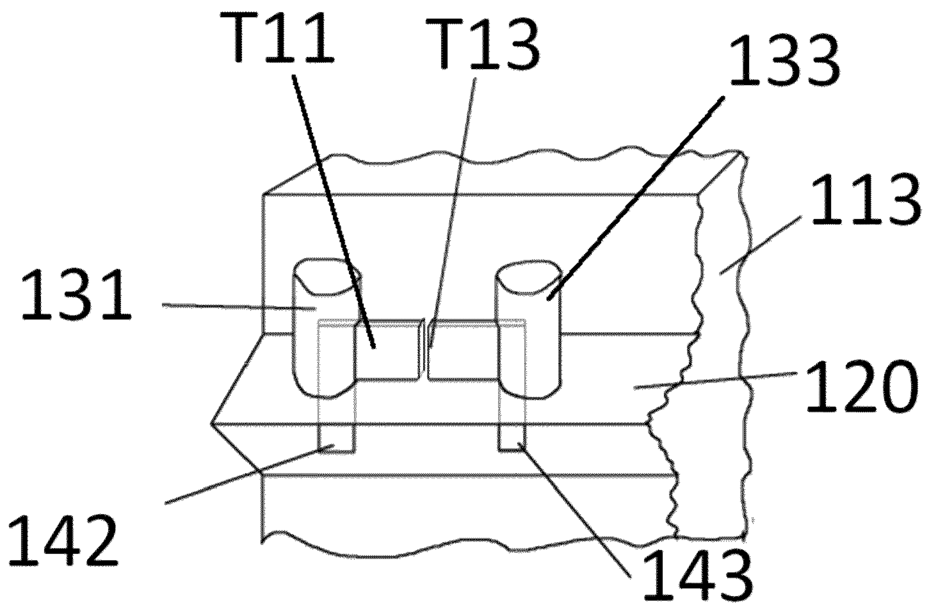
4
4,5
5
5,5
U/kV

Fig. 8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EUROPEAN SEARCH REPORT

Application Number
EP 22 15 7505

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B03C

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	10 August 2022	Menck, Anja

CATEGORY OF CITED DOCUMENTS

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