

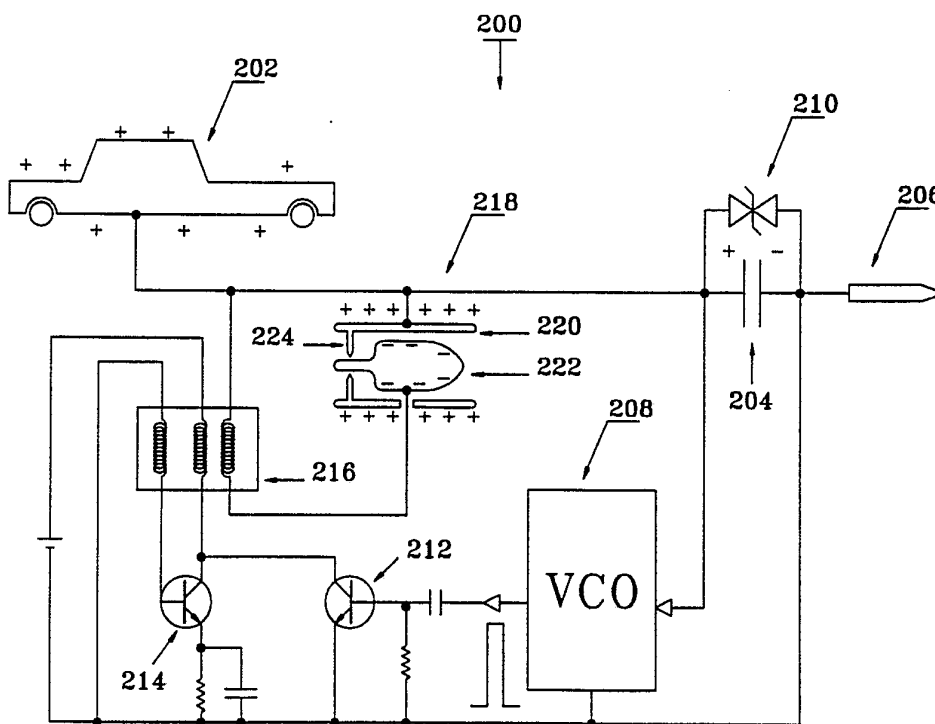


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(21) International Application Number: PCT/US92/03217 (22) International Filing Date: 20 April 1992 (20.04.92) (30) Priority data: <table border="0"> <tr> <td>691,350</td> <td>25 April 1991 (25.04.91)</td> <td>US</td> </tr> <tr> <td>707,691</td> <td>30 May 1991 (30.05.91)</td> <td>US</td> </tr> <tr> <td>828,155</td> <td>30 January 1992 (30.01.92)</td> <td>US</td> </tr> <tr> <td>870,060</td> <td>17 April 1992 (17.04.92)</td> <td>US</td> </tr> </table> (71)(72) Applicant and Inventor: BAKHOUM, Ezzat, G. [US/US]; 613 Clarion Drive, Durham, NC 27705 (US). (74) Agent: HULTQUIST, Steven, J.; Intellectual Property/Technology Law, P.O. Box 14329, Research Triangle Park, NC 27709 (US).		691,350	25 April 1991 (25.04.91)	US	707,691	30 May 1991 (30.05.91)	US	828,155	30 January 1992 (30.01.92)	US	870,060	17 April 1992 (17.04.92)	US	(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), LU (European patent), MC (European patent), NL (European patent), SE (European patent). Published <i>With international search report.</i> <i>With amended claims and statement.</i>
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(54) Title: A GROUND-FREE STATIC CHARGE REMOVAL DEVICE**(57) Abstract**

A ground-free device for removing static charge from semi-conductive or conductive bodies, and particularly useful for transportation vehicles (202), uses a capacitor (204) to effect and accelerate the discharge of static electricity from a charged body into surrounding air. The capacitor (204) activates a voltage-controlled oscillator (208) by which an efficiency of discharge of 100 % can be achieved. The voltage-controlled oscillator (208) senses voltage of the capacitor (204) and generates high voltage pulses of frequency that is proportional to the amount of charge on the body. High voltage, in turn, effects the removal of charges by means of air ionizer. The air ionizer (218) having an electrode (220) within a chamber and at least one needle electrode (224) positioned in proximity to the end of the chamber. A high voltage is imposed between the chamber and the electrode for discharging a body susceptible to static charge build-up.



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"A Ground-free Static Charge Removal Device"

Background of the invention

Field of the invention

This invention relates to a ground-free device for removing static electrical charge from a conductive or semi-conductive body, and particularly a device of such type which may be mounted on transportation vehicles.

Description of the related art

While the present invention is broadly useful for removing static electrical charge from conductive and semi-conductive charged bodies, the application of particular concern is the discharge of static electricity from transportation vehicles (cars and aircrafts). Other applications include static discharge from the human body.

It is known that static electricity build-up during the movement of ground transportation vehicles is responsible for pains, fatigue, and drowsiness of passengers, as well as damage of electronic equipment in the vehicle. Recent medical studies showed that drowsiness is a result of strong stimulation of the nervous system, which, among other effects such as fatigue, occur to individuals who become exposed to high electrostatic fields.

In the case of aircrafts, static build-up results in abrupt discharges from sharp points on the body of the aircraft which generate RF (Radio Frequency) noise and interfere with the navigation systems of the aircraft.

Static build-up on helicopters is further undesirable, as a hovering helicopter can reach a potential of 200KV with a stored energy of more than 30 joules, which constitutes a serious hazard to ground personnel during winching and rescue operations.

Historically, chains and conductive rods, attached to the bodies of these vehicles, have been used to drain static charges by means of friction with the surrounding medium (in the case of automobiles) or by means of Corona discharge (in the case of aircrafts).

These approaches, apart from being dangerous when used in automobiles (friction with asphalt produce sparks and may result in a fire), are also ineffective because the materials used for highway construction (asphalt or

cement) are excellent insulators and require a long period of time for leaking the charge to earth.

In the case of aircrafts, Corona discharge is also ineffective since a considerably high potential on the body of the aircraft must be reached before the Corona effect is initiated.

Apart from transportation-related applications, a number of systems have been devised in the art to preclude static electricity build-up.

U.S. Patent 3,634,726 issued Jan. 11, 1972 to Pierre Jay describes an apparatus for removing static electricity from plastic films. The apparatus requires a ground connection.

U.S. Patent 4,523,252 issued Jun. 11, 1985 to J.O. Wallen describes a device for eliminating static electricity on machines and charged materials. The device depends on the operation of a tunnel diode, and must be connected between charging media and the machine part.

U.S. Patent 4,180,698 issued Dec. 25, 1979 to R.B. Carpenter describes a system for protection of objects located on the surface of the earth from the effects of atmospherics.

U.S. Patent 4,766,903 issued Aug. 30, 1988 to Herbert Esper describes a device for detecting and removing static charges from the human body. The device, however, requires a ground connection.

U.S. Patents 4,849,851 and 4,862,315 issued Jul. 18, 1989 and Aug. 29, 1989, respectively, to R.J. Cubbison, Jr. describe a static discharge device which may be contained in a wrist-mountable unit. The device uses a either a high electric field or a radioactive source to ionize the air molecules.

The Cubbison, Jr. patents suffer various deficiencies in use, and will not achieve their intended purpose of effectively removing charges from the body, mainly due to the following reason: it is claimed that the electric field of the body can separate the closely-spaced positive and negative ions of the air. In fact, the electric field at any particular point on the skin is negligibly small, because the charge is distributed all over the body, and is usually bound by a strong electric field to earth.

For that reason, the claimed effect is very slow in nature.

The "Supersonic Nozzle", which was invented in 1971 by B.R. Whewell in the U.K., has been described as achieving levels of efficiency of up to 90% in

static charge removal.

(The Supersonic Nozzle is fully described in an article titled *A study of charged condensation droplets from an aircraft discharger*, by B.R. Whewell and B. Makin, Proceedings of the third conference on static electrification, London, 1971).

Despite this high efficiency, the Nozzle suffered two serious defects:

1. High efficiency can be obtained only if the air is flowing through the Nozzle at a velocity of Mach 2 (twice the speed of sound). This deficiency rendered the device non-practical for aircrafts flying at subsonic speeds.
2. Since the Supersonic Nozzle was based on Corona discharge between a pair of oppositely charged electrodes; the Nozzle, in fact, tends to charge the body of the aircraft either positively or negatively (depending on the needle's polarity), even if the body is completely neutral. Such effect is undesirable.

Accordingly, it would be a significant advance in the art to provide a ground-free device for removing static electrical charge from transportation vehicles, and from other conductive or semi-conductive bodies, including the human body, which is characterized by a high static charge removal efficiency at relatively low speeds of airflow, and which overcomes the deficiencies existent in the prior art. This is the object of the present invention.

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Summary of the invention

In a broad aspect, the present invention relates to a ground-free device for removing static electrical charge from conductive and semi-conductive bodies, comprising:

a storage capacitor comprising first and second terminals;

a conductive body contact means for establishing electrical contact with the body, and connected to the storage capacitor at a first terminal thereof;

a needle electrode for partial static discharge, connected to the second terminal of the storage capacitor;

a voltage limiting means, mounted across the storage capacitor;

a Voltage-controlled Oscillator, comprising input and output terminals, with the input terminals being connected to the terminals of the storage capacitor;

an air ionization mechanism, comprising a pre-ionizer and needle dischargers, and featuring first and second terminals, with the first terminal being connected to the body contact means of the device;

a circuit for imposing on the air ionization mechanism a voltage which is sufficient for effecting ionization of the air therein but is below the breakdown voltage of the air, and featuring input and output terminals, with the input terminals being connected to the output terminals of the Voltage-controlled Oscillator, and with the output terminals being connected to the terminals of the air ionization mechanism.

Other aspects and features of the invention will be more fully apparent from the ensuing disclosure and appended claims.

Brief Description of the Drawings

Figure 1 is a schematic representation illustrating the general principle of capacitive removal of charges from a conductive or semi-conductive body, as employed in the present invention.

Figure 2 is a schematic representation of a complete device for removal of charges with an efficiency of 95%-100%, according to the present invention.

Figure 3(a) is an end elevation view, and Figure 3(b) is a corresponding side elevation cross-sectional view, of an air ionization mechanism, comprising a pre-ionizer and needle discharges arranged to inject charges into the stream of ionized air.

Figure 4 is a perspective view showing a helicopter-mountable static charge removal device, according to one embodiment of the invention.

Detailed description of the invention,
and preferred embodiments thereof

The present invention is based on the fundamental concept that a conductive or semi-conductive body, such as a human body or a transportation vehicle, can be discharged by touching one side (i.e., plate or terminal) of a capacitor, and that such capacitor may be relatively small in size. (This concept, although fundamental, has not been previously recognized by those in the field, or applied in any useful device for removing static charges from a body).

In most instances where friction occurs during bodily movements, the body is charged positively because the human body is more conductive than most other materials (clothing, upholstery, carpet, etc). When the body is traveling in a car, however, the tires can be charged either positively or negatively, depending on the road conditions. For aircrafts, the charge is mostly negative because air precedes aluminum in the triboelectric series.

In many cases, the potential on the human body is on the order of 20KV volts. For helicopters, the potential can reach 200KV, as mentioned previously.

Despite this high potential, the amount of charge on the human body and on transportation vehicles is generally small. This is due to the capacitance between the body and the earth being very small. Typically, the capacitance of the human body is 150pF (150×10^{-12} Farads). A helicopter hovering a few feet above the earth has a capacitance of about 1nf (10^{-9} Farads).

The voltage (V), the charge (Q) and the capacitance (C) are related by the following equation:

$$Q = CV$$

For a potential of 200KV on a helicopter's body, and a capacitance of 1nf, the charge is

$$Q = 10^{-9} \times 200,000 = 2 \times 10^{-4} \text{ Coulombs.}$$

To appreciate the magnitude of this charge, viz., as being a small value, a capacitor holding the same charge, at a potential of 4 volts, would have a capacitance of

$$C = \frac{2 \times 10^{-4}}{4} = 50 \times 10^{-6} \text{ Farads} = 50 \mu F.$$

which is a relatively small capacitor.

Figure 1 illustrates the basic concept underlying the present invention. This figure shows a static charge removal device 100 comprising a capacitor 102 which is connected to a body contact member 104. The body contact member in turn is in contact with the body 106.

Static discharge occurs as a result of the regenerative induction inside the capacitor: assuming that the body is initially positively charged; few positive charges from the body create an electric field which ionizes some of the air molecules and attracts several electrons to the negative electrode of the capacitor (as mentioned earlier, this effect is negligibly small at the beginning). Now, by opposite induction, many more positive charges are collected at the positive electrode. The process is self-amplified rapidly, and the air is positively charged.

The role of the regenerative induction is seen by understanding that the static charge is initially distributed all over the body. At any smooth point on the human body or the outer surface of an aircraft's body, the electric field is negligibly small. As the induction process multiplies the charges on both sides of the capacitor, the positive/negative field of the body grows and ionizes an increasing number of air molecules. It is worth mentioning, however, that induction does not allow the voltage on the capacitor to grow in an unlimited manner. As the rate of flow of charges from the body decreases, the process slows, and finally stops when the body becomes neutral.

Unfortunately, the discharge efficiency of a capacitor was found to be dependent on the strength of the electric field between the body and the earth. The electric field strength, in turn, depends on the distance between the body and the earth.

Experiments showed that a discharge efficiency of almost 100% can be reached for isolated bodies (such as the body of an aircraft flying at a high altitude), with a capacitor being mounted on the body, and with the discharge terminal of the capacitor being equipped with a needle electrode (a needle electrode activates the Corona effect, which enhances the discharge efficiency of the capacitor). For bodies relatively close to earth, however, such as human bodies, vehicles, or a hovering helicopter, the discharge efficiency of a capacitor is poor. (Typically, a residual voltage of about 3000 volts on the human body was observed in the experiments). Nevertheless, the fundamental concept of capacitor discharge serves as the basis for the present invention.

Figure 2 shows a complete device 200 for electrostatic discharge. The device is mountable on a body 202 which is susceptible to static charge build-up, such body may be relatively close to earth.

In the device 200, a capacitor 204 serves as an accurate means for estimating the charge on the body 202. As shown in the figure, partial discharge occurs by means of the capacitor 204, and through a needle electrode 206 exposed to free air. The voltage build-up across the terminals of capacitor 204 is fed to a Voltage-controlled Oscillator (VCO) 208, such voltage being limited by two Zener diodes 210, as shown. The output of the VCO triggers a high-voltage generating circuit, comprising two transistors 212 and 214, and a pulse transformer 216. The high-voltage generating circuit is of a known type (a transistor blocking oscillator), being described more fully in *Pulse, digital and switching waveforms*, by Millman and Taub, McGraw Hill, 1984, page 605. The high-voltage circuit, in turn, activates an air ionization mechanism 218, comprising a hollow cylindrical electrode 220, a solid electrode 222, and needle electrodes 224.

A detailed, cross-sectional view of the air ionization mechanism is shown in Fig.3.

The principle of operation of the device 200 is as follows: as partial discharge from body 202 occurs through the capacitor 204, a voltage builds up on the capacitor that is proportional to the amount of charge on the body (the capacitor 204 is suitably in the range of 0.1nF to 0.1 μ F). Such voltage difference, when fed to the Voltage-controlled Oscillator 208 (or equivalently, a Voltage-to-Frequency Converter) results in pulses at the output of the os-

cillator, the frequency of such pulses being dependent on the input voltage difference, and hence on the amount of static charge on body 202 (the VCO must preferably be capable of generating pulses of a frequency in the range of 0-1 KHz). As a result, high voltage pulses are applied to the air ionization mechanism 218, with a frequency being proportional to the amount of static charge on the body 202.

The device 200, then, performs the function of ionizing the air to a degree that is proportional to the amount of charge on the body.

The air ionization mechanism 218 is the key part of the device 200. The mechanism 218, more fully apparent in Fig. 3, comprises a smooth inner electrode 322 and a hollow cylindrical electrode 320, from which a group of needle electrodes 324 emerge and surround the narrow end of the inner electrode, as shown.

Such an arrangement serves the purpose of overcoming the first deficiency of the Supersonic Nozzle, this deficiency being the requirement for a speed of airflow of about Mach 2. As shown in Figs. 3(a) and 3(b), the arrangement practically consists of two different components: the first component, 326, is a "pre-ionizer", which is effectively an air capacitor for performing the function of pre-ionizing the air (in the direction of flow indicated by arrow A in Fig. 3(b) prior to its flow into the second component 328. The component 328 is a "needle discharger" for injecting charges of single polarity into the stream of airflow.

The device 200, therefore, can only withdraw a single type of charge from the body 202 (this can be further seen by observing that the Voltage-controlled Oscillator 208 can only respond to an input voltage of single polarity). As a solution to this limitation, the body 202 must be equipped with two units of the type shown in Fig. 2; one for positive charge removal and the other for negative charge removal.

The pre-ionizer 326 serves the purpose of achieving a high efficiency of discharge at relatively low speeds of airflow; as experiments showed that a high discharge efficiency can be obtained from a needle electrode when air is pre-ionized, thus providing a higher space-charge density at a lower speed of airflow.

For aircraft applications, it is desirable to obtain a high discharge current,

e.g., on the order of 1 mA (10^{-3} Amperes). Such discharge current can be calculated from the following equation:

$$I = \rho \times \text{Flow Rate}$$

where ρ is the space-charge density at the outlet of the air capacitor 326 (in Coulombs/m³) and where the flow rate is measured in m³/sec.

The amount of space-charge density inside a uniform-field air capacitor can be simply obtained by applying Gauss' law inside the capacitor, i.e.,

$$\text{Flux density } (D) \times \text{Area}(A) = Q = \rho \times \text{Volume}(V)$$

where Q is the total amount of unipolar charge inside the air capacitor, V is the volume of air inside the capacitor, and A is the area normal to the electric flux lines. Therefore,

$$\rho = \frac{D \cdot A}{V} = \frac{\epsilon_0 E}{\text{gap width}(d)}$$

where ϵ_0 is the permittivity of free space, E is the electric field intensity, and d is the width of the air gap inside the capacitor.

Given that E is close to 3000 volts/mm and taking an air gap of 0.5 millimeters, the space-charge density can be calculated to be about 0.0531 Coulombs/m³ (it should be noted that the breakdown electric field intensity for air is 3000 volts/mm. The device must be operated with a voltage that is below the breakdown point of the air. For example, given an air gap of 0.5 mm, the high voltage circuit must supply a voltage that is less than 1500 volts).

The flow rate is equal to the product of the inlet area of the capacitor in Figure 3(b) and the speed of the aircraft. Therefore, with the space-charge density being constant, higher discharge current can be obtained by increasing either the inlet area of the air capacitor or the cruising speed of the aircraft. As an example, if a discharge current of 1mA is desired for an aircraft flying at a speed of 300 miles/hour, and given that $\rho = 0.0531$ Coulombs/m³, the inlet area, given by

$$\text{Inlet Area} = \frac{I}{\rho \times \text{Speed}}$$

can be bound to be about 140 mm², i.e., for a cylindrical air capacitor such as the capacitor 326 shown in Figure 3(b), the inside diameter of the outer cylinder 320 should be approximately 0.5 inches, which allows for a compact device to be constructed and mounted on the body of the aircraft.

For helicopter applications, it should be noted that the speed of airflow is the highest at the tips of the main rotor. This location is suitable for mounting the device 200, since the device is very light in weight and very compact in form. Such an arrangement is shown in Fig. 4.

A helicopter 402 having a main rotor composed of two blades 404 and 406 carries a device for positive static discharge 408 and a device for negative static discharge 410, such devices being mounted on the rotor tips, as shown. The detailed view of the device 408 shows a housing 410 for the electronic components and the power source of the device, connected to the air ionization mechanism 418 comprising air capacitor and needle dischargers.

The devices 408 and 410 are constructed and arranged to be continuously supplied from an independent power source. As an example, a typical 500 mAh battery has a lifetime of one year inside such a device. However, operation from the main power source of the vehicle is possible with proper isolation techniques.

A point of interest, when the application is considered for helicopters, is that rotor blades are usually constructed of fiberglass that is cast around a steel member. Since fiberglass is a good insulator, the device must be connected directly to the steel member. Alternatively, the rotor blades can be painted with a layer of conductive paint to establish a connection of low resistance between the device and the helicopter's body. As a still further alternative, the devices 408 and 410 can be mounted on the tail to receive a stream of air from the tail rotor, or elsewhere on the body of the helicopter to be exposed to the downwash of the main rotor.

It will be apparent from the foregoing that the static charge removal device

of the present invention is a ground-free device which requires no connections or couplings to true earth or to large metallic charge-dissipation structures. Further, it will be recognized that the device of the invention may be compactly configured in any of various conformations so as to be body-mountable in character.

The device of the invention achieves a high degree of removal of charges from conductive and semi-conductive bodies (and in particular, transported vehicles) at relatively low speeds of airflow.

To overcome the deficiencies of prior systems, the device depends in its operation on a Voltage-controlled Oscillator which activates the device only when static charge is detected on the body, and in a manner that is proportional to the amount of such charge.

One embodiment of the invention, which comprises a discharge capacitor equipped with a needle electrode, is particularly use for the human body to reduce the static build-up to voltage levels below 3000 volts on the body. Such an application is important for individuals who become in contact with explosive gases or materials, as for example, medical personnel, workers in munition plants, etc.

While the devices of Figures 1, 2, 3(a), 3(b), and 4 have been illustratively described hereinabove with reference to specific voltage, capacitance and frequency values, as well as specific components, it will be recognized that the device may be variously configured, utilizing other parametric values of voltage, capacitance, frequency, etc., within the skill of the art, as well as other components, as for example a Current-to-Frequency converter may be used instead of a Voltage-to-Frequency converter; in plus, different types of high voltage generating circuits can be used in the device.

Accordingly, while the invention has been described with reference to specific aspects, features, and embodiments, it will be appreciated that various modifications, alternatives, and other embodiments are possible within the broad scope of the invention, and the invention therefore is intended to encompass all such modifications, alternatives, and other embodiments, within its scope.

Best Mode for Carrying out the Invention

The best mode for carrying out the invention is to construct and arrange the device as an independent unit, powered from an independent power source (battery, solar cells, etc.), and mounted outside the body of a vehicle to allow air circulation therethrough.

The body contact means of the device should serve as a mechanical fixture for mounting the device on the body, and, in the same time, as a means for opposite static charges to flow into the body.

Industrial Applicability of the Invention

Although the invention has been described hereinabove with reference to the removal of static charge build-up on transportation vehicles, it will be recognized that the invention is broadly useful for the removal of charges from any conductive or semi-conductive body in general, including, but not limited to: the human body, industrial machines, semi-conductive plastics, etc.

One embodiment of the invention, which comprises a discharge capacitor equipped with a needle electrode, is particularly useful for the human body to reduce the static build-up to voltage levels below 3000 volts on the body. Such an application is important for individuals who become in contact with explosive gases or materials, as for example, medical personnel, workers in munition plants, etc.

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The Claims

What is claimed is:

1. A ground-free device for removing static electrical charge from a conductive or semi-conductive body, comprising:

a storage capacitor comprising first and second terminals;

a conductive body contact means for establishing electrical contact with the body, and connected to the storage capacitor at a first terminal thereof;

a Voltage-controlled Oscillator, comprising input and output terminals, with the input terminals being connected to the terminals of the storage capacitor;

an air ionization mechanism, comprising first and second terminals, with the first terminal being connected to the body contact means of the device;

a circuit for imposing on the air ionization mechanism a voltage which is sufficient for effecting ionization of the air therein but is below the breakdown voltage of the air, featuring input and output terminals, with the input terminals being connected to the output terminals of the Voltage-controlled Oscillator, and with the output terminals being connected to the terminals of the air ionization mechanism.

2. A device according to claim 1, wherein the capacitance of the storage capacitor is in the range of 0.1nF to 0.1 μ F.

3. A device according to claim 1, comprising a voltage-limiting means mounted across the storage capacitor.

4. A device according to claim 3, wherein the voltage-limiting means comprises two Zener diodes.

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5. A device according to claim 1, comprising a needle electrode for partial static discharge, connected to the second terminal of the storage capacitor.
6. A device according to claim 1, wherein the air ionization mechanism comprises a pre-ionizer and needle dischargers.
7. A device according to claim 6, wherein the pre-ionizer is an air capacitor.
8. A device according to claim 1, wherein the Voltage-controlled Oscillator delivers a frequency in the range of 0 to 1KHz.
9. A device according to claim 1, wherein the voltage-imposing means comprises a transistor blocking oscillator and a pulse transformer.
10. A device according to claim 1, comprising a Current-to-Frequency converter.
11. A device according to claim 1, powered from an independent power source.
12. A device according to claim 1, powered from the main power source.
13. A device according to claim 1, constructed and arranged for mounting on the human body.
14. A device according to claim 1, constructed and arranged for mounting on transportation vehicles.
15. A device according to claim 14, wherein the transportation vehicle is selected from the group consisting of cars, fixed-wing aircrafts, and helicopters.
16. A device for discharging a body susceptible to static charge build-up, comprising:
 - a chamber defining a gas-flow passage therethrough, including a first inlet opening and a second discharge opening;

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an electrode positioned within the chamber, defining with the chamber along the intermediate length of the electrode a pre-ionizing region;

at least one needle electrode positioned in proximity to the second end of the chamber; and

means for imposing a high voltage between the chamber and the electrode.

17. A device according to claim 16, wherein the electrode has a relatively large diameter over a major portion of its length and a reduced diameter in the vicinity of the at least one needle electrode;

18. A device according to claim 16, comprising multiple needle electrodes;

19. A device according to claim 16, wherein the chamber is of a cylindrical form and the at least one needle electrode comprises an array of circumferentially-spaced apart, radially inwardly-extending needle electrodes.

20. A device according to claim 16, further comprising a moisture detector operatively coupled to means for disconnecting the power source when high moisture is detected in the air.

21. A ground-free device for removing static electrical charge from a conductive or semi-conductive body, comprising:

a storage capacitor comprising first and second terminals;

a conductive body contact means for establishing electrical contact with the body and connected to the storage capacitor at a first terminal thereof; and

means for exposing the second terminal of the storage capacitor to free air.

22. A device according to claim 21, constructed and arranged for mount-

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ing on the human body.

23. A device according to claim 21, constructed and arranged for mounting on transportation vehicles.

24. A device according to claim 21, wherein the capacitance of the storage capacitor is in the range of $0.1\mu\text{F}$ to $3000\mu\text{F}$.

25. A device according to claim 21, further comprising a needle electrode connected to the second terminal of the storage capacitor.

26. A device according to claim 23, wherein the transportation vehicle is selected from the group consisting of cars, fixed-wing aircrafts, and helicopters.

AMENDED CLAIMS

[received by the International Bureau on 6 October 1992 (06.10.92);
new claims 27-29 added;
remaining claims unchanged (1 page)]

27. A ground-free device for removing static electrical charge from a conductive or semi-conductive body, consisting essentially of:

an electrical charge storage capacitor comprising first and second terminals, wherein the second terminal is constructed and arranged for direct exposure to an ambient air environment; and

a conductive body contact means for establishing electrical contact with the body and connected to the storage capacitor at the first terminal thereof;

whereby charge flowing from the conductive or semi-conductive body through the conductive body contact means to the electrical charge storage capacitor is dissipated to air of the ambient air environment at the second terminal of the storage capacitor.

28. A device according to claim 27, wherein the conductive or semi-conductive body comprises a human body.

29. A ground-free device for removing static electric charge from a conductive or semi-conductive body, comprising a capacitor for estimating the charge on said body.

STATEMENT UNDER ARTICLE 19

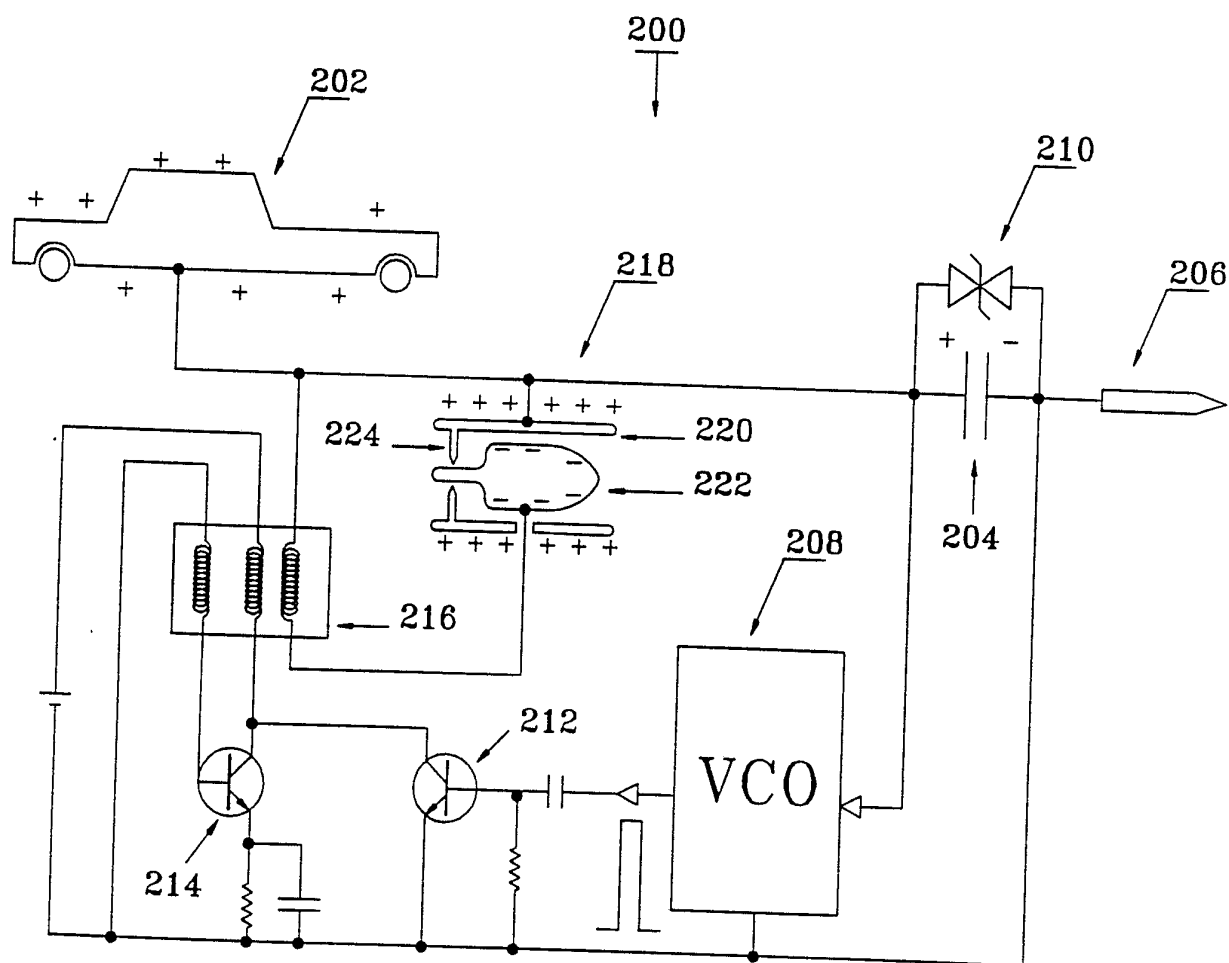
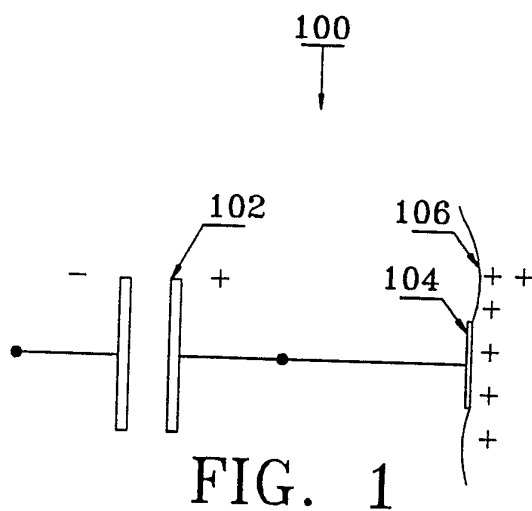
By this submission of new page 17A, claims 27-29 have been added to claim further aspects of the invention disclosed in the original description of the application.

Added claim 27 sets forth a ground-free device for removing static electrical charge from a conductive or semi-conductive body, consisting essentially of: an electrical charge storage capacitor comprising first and second terminals, wherein the second terminal is constructed and arranged for direct exposure to an ambient air environment; and a conductive body contact means for establishing electrical contact with the body and connected to the storage capacitor of the first terminal thereof; whereby charge flowing from the conductive or semi-conductive body through the conductive body contact means to the electrical charge storage capacitor is dissipated to the air of the ambient air environment at the second terminal of the storage capacitor, consistent with the disclosure of Figure 1 of the application (which shows a static charge removal device consisting essentially of a storage capacitor 102 and a conductive body contact means 104 connected to the terminal of the storage capacitor), as well as the appertaining disclosure at page 7, lines 6-26 of the Description.

Added claim 28 is of dependent form under claim 27 and specifies the conductive or semi-conductive body from which a charge is drawn, as comprising a human body, consistent with the text at page 6, lines 4-5 of the Description ("a conductive or semiconductive body, such as a human body").

Added claim 29 recites a ground-free device for removing static electrical charge from a conductive or semi-conductive body, comprising a capacitor for estimating the charge on said body, consistent with the aforementioned supportive disclosure also applicable to added claims 27 and 28.

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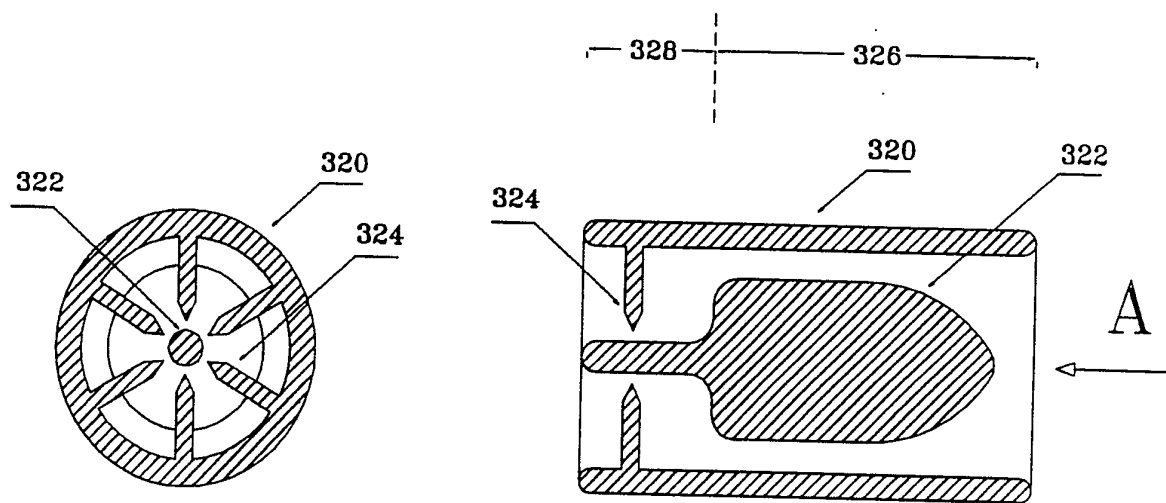


FIG. 3(a)

FIG. 3(b)

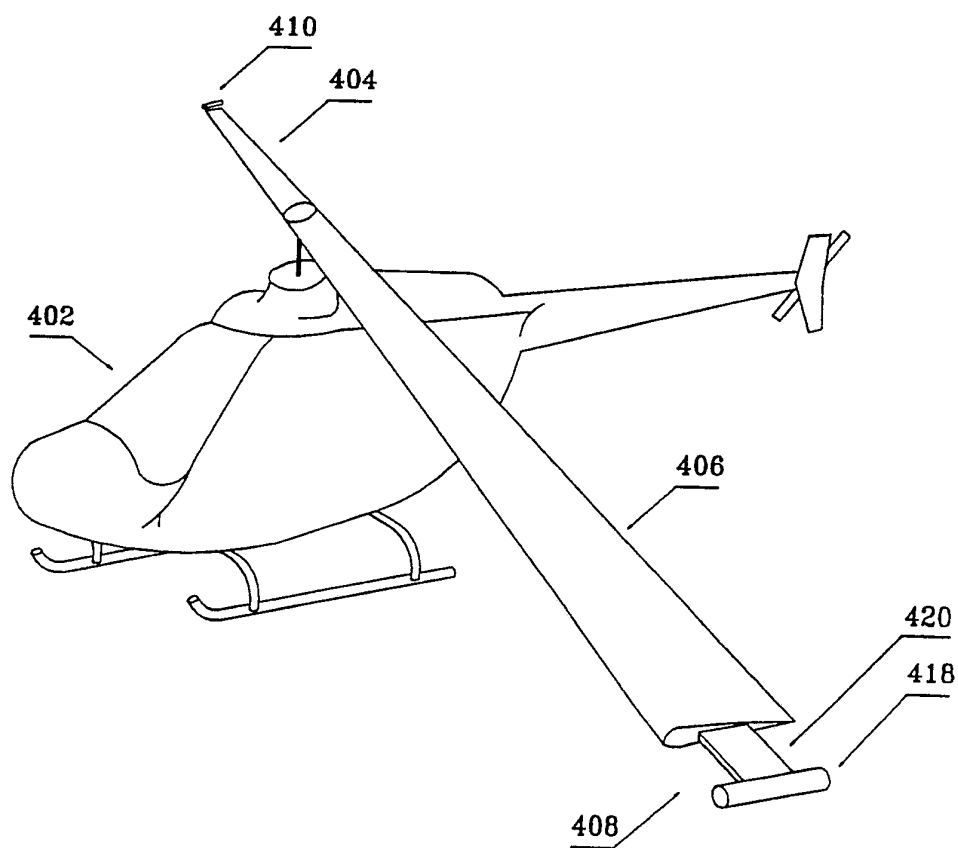


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/03217

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) : H05F 3/04

US CL : 361/212, 220, 222, 225, 230, 232; 307/9.1, 10.1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 361/212, 220, 222, 225, 230, 232; 307/9.1, 10.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 3,634,726 (JAY) 11 January 1972, See Abstract.	1-26
A	US, A, 4,048,667 (BRENNECKE) 13 September 1977, See figure 2.	1-26
A	US, A, 4,156,267 (SPAULDING ET AL.) 22 May 1979, See column 1, lines 34-47.	1-26
A	US, A, 5,004,425 (HEE) 02 April 1981, See entire document.	1-26
A	US, A, 4,180,698 (CARPENTER, JR.) 25 December 1979, See column 7, lines 38-67.	1-27
A	US, A, 4,186,421 (TWITEHETT) 29 January 1980, See abstract.	1-26
A	US, A, 4,271,451 (METZ) 02 June 1981, See column 3, lines 15-34.	1-26
A	US, A, 4,333,123 (MOULDERN) 01 June 1982, See abstract.	1-26
A	US, A, 4,333,124 (TAMURA ET AL.) 01 June 1982, See column 3, lines 42-59.	1-26

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
A document defining the general state of the art which is not considered to be part of particular relevance	*X*	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
E earlier document published on or after the international filing date	*Y*	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Z*	document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means		
P document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

09 JULY 1992

Date of mailing of the international search report

20 AUG 1992

Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/03217

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4,605,984 (FIEDLER) 12 August 1986, See entire document.	1-26
A	US, A, 4,498,116 (SAURENMAN) 05 February 1985, See abstract.	1-26
A	US, A, 4,523,252 (WALLEN) 11 June 1985, See column 1, line 20-25.	1-26
A	US, A, 4,638,398 (BRENNECKE ET AL.) 20 January 1987, See abstract.	1-26
A	US, A, 4,107,755 (KIEFER) 15 August 1978, See abstract.	1-26
A	US, A, 4,766,903 (ESPER) 30 August 1988, See column 1, lines 41-58.	1-26
A	US, A, 4,849,851 (CUBBISON, JR.) 18 July 1989, See figure 2.	1-26