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(71) Applicant: **Daikin Industries, Ltd.**
Osaka 530-8323 (JP)

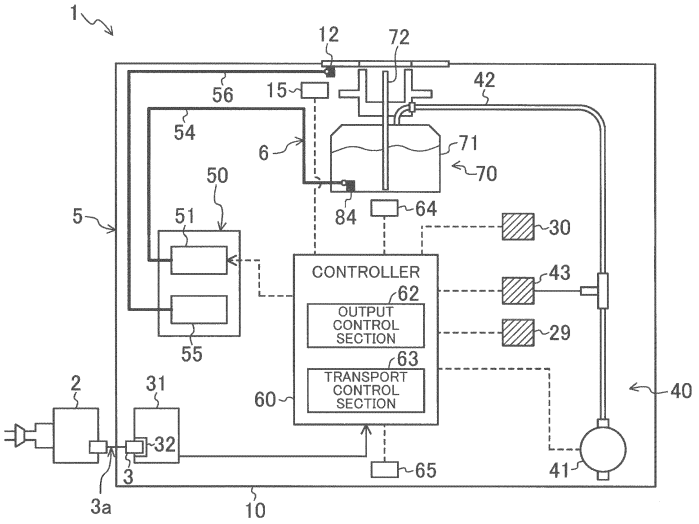
(72) Inventors:
- **OKUMOTO, Mamoru**
  Osaka-shi, Osaka 530-8323 (JP)
- **OKUDA, Noriyuki**
  Osaka-shi, Osaka 530-8323 (JP)
- **OBATA, Kouei**
  Osaka-shi, Osaka 530-8323 (JP)

(74) Representative: **Goddar, Heinz J.**
Boehmert & Boehmert
Anwaltspartnerschaft mbB
Patentanwälte Rechtsanwälte
Pettenkoferstrasse 20-22
80336 München (DE)

(54) ELECTROSTATIC ATOMIZER

(57) An electrostatic sprayer (1) includes: a tank (71); a spray nozzle (72) attached to the tank (71); a transport unit (40) which transports a spray liquid in the tank (71) to a tip (72a) of the nozzle (72); a counter electrode (12) exposed at an outer surface; and an electric field generation mechanism (6) which applies a voltage to the spray liquid to generate an electric field between the tip (72a) of the spray nozzle (72) and the counter electrode (12) so that the spray liquid is sprayed from the spray nozzle (72). The electrostatic sprayer (1) is provided with an output control section (62) which switches the polarity of the voltage applied by the electric field generation mechanism (6) alternately between the positive and negative polarities, and the counter electrode (12) is comprised of an ungrounded electrode.

FIG.5



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to electrostatic sprayers.

BACKGROUND ART

[0002] Electrostatic sprayers which spray liquid using an electrohydrodynamic (EHD) phenomenon have been known (see Patent Document 1, for example). Such an electrostatic sprayer generates an electric field near an open end of a small-diameter tube, for example, to atomize a liquid in the small-diameter tube using the non-uniformity of the electric field thereby spraying the liquid.

[0003] In Patent Document 1, for example, while a spray liquid stored in a container is transported to a tip of a nozzle, a high voltage is applied to the spray liquid in the container. By this operation, a potential difference occurs between the charged spray liquid transported to the tip of the nozzle and a grounded counter electrode, causing generation of an electric field between the tip of the nozzle and the counter electrode. By this electric field, the spray liquid is pulled apart into droplets, and these droplets are diffused. In Patent Document 1, the spray liquid is a lotion, and the droplets are diffused to attach to the face, etc. of the user.

CITATION LIST

PATENT DOCUMENT

[0004] PATENT DOCUMENT 1: Japanese Unexamined Patent Publication No. 2009-022891

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0005] The counter electrode which generates an electric field between the tip of the nozzle and itself is generally exposed at the outer surface of the electrostatic sprayer. On the other hand, electric charge is accumulated on the user who has received droplets of the charged spray liquid. Therefore, when the user happens to touch the counter electrode in operating the electrostatic sprayer, for example, electrostatic discharge may occur where the charge accumulated on the user transfers to the counter electrode, causing the possibility of giving the user electric shock.

[0006] The present disclosure is thus intended to prevent or reduce electric shock given to the user along with electrostatic discharge occurring from the user to a counter electrode in an electrostatic sprayer.

SOLUTION TO THE PROBLEM

[0007] The first aspect of the present disclosure is directed to an electrostatic sprayer, including: a storage container (71) which stores a spray liquid; a tubular nozzle (72) attached to the storage container (71); a transport mechanism (40) which transports the spray liquid in the storage container (71) to a tip (72a) of the nozzle (72); a counter electrode (12) exposed at an outer surface; an electric field generation mechanism (6) which applies a voltage to the spray liquid to generate an electric field between the tip (72a) of the nozzle (72) and the counter electrode (12) so that the spray liquid is sprayed from the tip (72a) of the nozzle (72); and a switching control section (62) which switches the polarity of the voltage applied to the spray liquid by the electric field generation mechanism (6) alternately between positive and negative polarities, wherein the counter electrode (12) is comprised of an ungrounded electrode.

[0008] According to the first aspect of the disclosure, when a voltage is applied to the spray liquid by the electric field generation mechanism (6) generating an electric field between the tip (72a) of the nozzle (72) and the counter electrode (12), the spray liquid transported to the tip (72a) of the nozzle (72) by the transport mechanism (40) is released from the tip (72a) of the nozzle (72) as fine droplets. Since such droplets released from the tip (72a) of the nozzle (72) is charged, charge is accumulated on the user who is exposed to the droplets. However, according to the first aspect of the disclosure, where the counter electrode (12) is comprised of an ungrounded electrode, occurrence of electrostatic discharge becomes difficult compared with the case of forming the counter electrode (12) of a grounded electrode. That is, for a grounded electrode and an ungrounded electrode made of the same material, charge does not easily transfer in the ungrounded electrode because the electric resistance is larger in the ungrounded electrode than in the grounded electrode. Therefore, by forming the counter electrode (12) of an ungrounded electrode, transfer of charge accumulated on the user to the counter electrode (12) becomes difficult compared with the case of forming the counter electrode (12) of a grounded electrode. In other words, occurrence of electrostatic discharge becomes difficult.

[0009] When charged droplets of the spray liquid attach to the counter electrode (12), the counter electrode (12) is to be charged. When the counter electrode (12) is comprised of an ungrounded electrode, the charge cannot be grounded, but is accumulated on the counter electrode (12). Therefore, if the polarity of the voltage applied to the spray liquid is fixed, charge of one polarity will be accumulated on the counter electrode (12) along with the spraying. As a result, the potential difference between the tip (72a) of the nozzle (72) and the counter electrode (12) decreases, failing to generate such an electric field as to allow the spray liquid to be sprayed.

[0010] According to the first aspect of the disclosure,

however, with the polarity of the voltage applied to the spray liquid being switched alternately between the positive and negative polarities, positively charged droplets of the spray liquid and negatively charged droplets of the spray liquid are alternately sprayed from the tip (72a) of the nozzle (72). Thus, with no accumulation of charge of only one polarity on the counter electrode (12), an electric field for spraying the spray liquid can be generated stably between the tip (72a) of the nozzle (72) and the counter electrode (12).

[0011] The second aspect of the present disclosure is that, in the first aspect, the counter electrode (12) is made of a conductive resin material.

[0012] According to the second aspect of the disclosure, the counter electrode (12) is made of a conductive resin material. The conductive resin material is a material where charge does not easily transfer because the electric resistivity is high compared with a metal, and the charge transfer rate is low. In this relation, electric shock given to a human along with electrostatic discharge from the human to an object depends on the charge transfer rate. That is, the higher the charge transfer rate, the larger the electric shock becomes, causing pain to the human. Therefore, by forming the counter electrode (12) of a conductive resin material as described above, occurrence of electrostatic discharge from the user to the counter electrode (12) becomes further difficult. Even if electrostatic discharge occurs, since the charge transfer rate is low compared with the case of forming the counter electrode (12) of a metal, electric shock given to the user is small.

ADVANTAGES OF THE INVENTION

[0013] According to the first aspect of the disclosure, since the counter electrode (12) is comprised of an ungrounded electrode, transfer of charge from the user to the counter electrode (12) can be prevented or reduced, compared with the case of forming the counter electrode (12) of a grounded electrode. Thus, electrostatic discharge from the user to the counter electrode (12) can be prevented or reduced, whereby electric shock given to the user along with the electrostatic discharge can be prevented or reduced.

[0014] Moreover, according to the first aspect, since the polarity of the voltage applied to the spray liquid is alternately switched between the positive and negative polarities by the switching control section (62), accumulation of charge of one polarity on the counter electrode (12) can be prevented or reduced. Thus, an electric field for spraying the spray liquid can be generated stably between the tip (72a) of the nozzle (72) and the counter electrode (12).

[0015] According to the second aspect of the disclosure, by forming the counter electrode (12) of a conductive resin material, electrostatic discharge from the user to the counter electrode (12) can be further prevented or reduced, compared with the case of forming the counter electrode (12) of a metal. Even if electrostatic discharge occurs, electric shock given to the user can be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

[FIG. 1] FIG. 1 is a perspective view showing the entire of an electrostatic sprayer of an embodiment.
[FIG. 2] FIG. 2 is a longitudinal cross-sectional view of the electrostatic sprayer of the embodiment.
[FIG. 3] FIG. 3 is a perspective view showing an upper portion of the electrostatic sprayer of the embodiment.
[FIG. 4] FIG. 4 is a view showing an internal structure of a top cover of the electrostatic sprayer of the embodiment.
[FIG. 5] FIG. 5 is a view showing a system configuration of the electrostatic sprayer of the embodiment.
[FIG. 6] FIG. 6 is a view showing a schematic configuration of a transport unit of the electrostatic sprayer of the embodiment.
[FIG. 7] FIG. 7 is a longitudinal cross-sectional view showing a spray cartridge according to the embodiment.
[FIG. 8] FIG. 8 is a front view of the spray cartridge according to the embodiment.
[FIG. 9] FIG. 9 is a longitudinal cross-sectional view showing a variation of the spray cartridge according to the embodiment.

DESCRIPTION OF EMBODIMENTS

[0017] An embodiment of the present disclosure will be described hereinafter in detail with reference to the accompanying drawings.

[0018] In this embodiment, a desktop electrostatic sprayer (1) will be described. The electrostatic sprayer (1) is designed assuming that it is used on a desk in an office. In other words, the electrostatic sprayer (1) is designed assuming that it is used in its upright position with a bottom cover (10b) of a casing (10) to be described later being in contact with a placement surface (200).

[0019] As shown in FIGS. 1, 2, and 5, the electrostatic sprayer (1) of this embodiment includes a sprayer body (5), an AC adapter (2), and a USB cable (3a) as a power cord. The sprayer body (5) includes the casing (10), a spray cartridge (70) which stores a spray liquid, a transport unit (40), a high voltage power supply unit (50), and a controller (60). The spray cartridge (70), the transport unit (40), the high voltage power supply unit (50), and the controller (60) are accommodated in the casing (10).

[0020] The casing (10) has a shape of a hollow cylinder with both ends closed. The casing (10) is comprised of a body cover (10a), the bottom cover (10b), and a top cover (11). The bottom cover (10b) and the top cover (11) are attached to the body cover (10a). Assume in this embodiment that the side in the direction in which the

spray liquid is sprayed is the front side and the side in the direction opposite to the spraying direction is the back side.

[0021] The body cover (10a) has a shape of a vertically long cylinder with both ends open, and is slightly constricted in the middle in the length direction. The bottom cover (10b) has a roughly disk shape and closes the bottom end of the body cover (10a). The top cover (11) has a circular cap shape and closes the top end of the body cover (10a). The top cover (11) is secured to the body cover (10a) in an inclined position downward to the front side of the sprayer body (5) (i.e., in the liquid spraying direction).

[0022] As shown in FIGS. 3 and 4, the top cover (11) has a spray opening (14) for exposing a spray nozzle (72) of the spray cartridge (70). The top cover (11) also has a shutter (13) for opening/closing the spray opening (14). The shutter (13) opens and closes the spray opening (14) as it slides. A power switch (15) is attached to the top cover (11) and operated with the shutter (13). That is, the power switch (15) is turned on when the user operates the shutter (13) to open the spray opening (14), and is turned off when the user operates the shutter (13) to close the spray opening (14).

[0023] A band-like counter electrode (12) is placed to extend in a circumferential direction between the top cover (11) and the body cover (10a). The counter electrode (12) is provided for generating an electric field between a tip (72a) of the spray nozzle (72) (the end of the spray nozzle (72) on the discharge side) and the counter electrode (12), and is exposed at the outer surface of the spray body (5). The counter electrode (12) is comprised of an ungrounded electrode electrically connected to a reference potential section (55) of the high voltage power supply unit (50), which will be described later in detail. In this embodiment, the counter electrode (12) is made of a conductive resin material containing a resin and a conductive material mixed at a predetermined ratio.

[0024] A rear cover (17) is removably attached to the back face of the body cover (10a). The rear cover (17) is a member for closing an upper equipment compartment (28) to be described later and has a slightly curved rectangular shape. The rear cover (17) is detached/attached when the spray cartridge (70) is replaced.

[0025] The casing (10) has a lower base (21), an upper base (22), and a partition plate (23) therein. The lower base (21) is placed near the bottom in the casing (10). The upper base (22) is placed approximately in the middle of the casing (10) in the length direction. Each of the bases (21, 22) extends horizontally to divide the interior of the casing (10) into upper and lower parts. The partition plate (23) extends between the lower base (21) and the upper base (22), to divide the portion of the interior of the casing (10) between the lower base (21) and the upper base (22) into front and rear parts.

[0026] A central equipment compartment (24) is defined between the lower base (21) and the upper base (22). The central equipment compartment (24) is divided by the partition plate (23) into a first central equipment compartment (25) on the front side and a second equipment compartment space (26) on the back side. A lower equipment compartment (27) is defined under the lower base (21), and the upper equipment compartment (28) is defined above the upper base (22).

[0027] The lower equipment compartment (27) accommodates a temperature-humidity sensor (29), a human detection sensor (30), and a USB board (31).

[0028] The temperature-humidity sensor (29) detects the temperature and humidity of the room where the electrostatic sprayer (1) is placed. The temperature-humidity sensor (29) is connected to the controller (60), to send a measured value to the controller (60).

[0029] The human detection sensor (30) is provided for detecting the presence or absence of a user as the object for spraying by the electrostatic sprayer (1). The human detection sensor (30) is comprised of a pyroelectric infrared sensor, for example. The human detection sensor (30) is accommodated in the lower equipment compartment (27) on the front side. The human detection sensor (30) is positioned such that its sensor surface faces the exterior on the front side obliquely upward through an opening of the casing (10). The human detection sensor (30) is connected to the controller (60), to send a detection signal to the controller (60).

[0030] The universal serial bus (USB) board (31) is a board into which a connector (3) of the USB cable (3a) is inserted, and is placed at the bottom of the lower equipment compartment (27). The USB board (31) has a connecting portion (32) to which the connector (3) is connected. The USB board (31) is exposed at the back face of the body cover (10a) of the casing (10). The connector (3) of the USB cable (3a) is inserted into the USB board (31) from the back side of the body cover (10a) and protrudes from the casing (10). The USB cable (3a) having the connector (3) constitutes a protrusion.

[0031] The AC adapter (2) is connected to a household wall socket and converts an AC voltage of 100V to a DC voltage of 5V. The AC adapter (2) is also connected the sprayer body (5) via the USB cable (3a). The sprayer body (5) constituting the electrostatic sprayer (1) of this embodiment may otherwise be connected to a USB port of a personal computer, for example, via the USB cable (3a) and driven with power supplied from the personal computer.

[0032] As shown in FIGS. 5 and 6, the transport unit (40) sends air into a tank (71) of the spray cartridge (70) to be described later, to push out the spray liquid in the tank (71), thereby transporting the liquid to the tip (72a) of the nozzle (72), and constitutes a transport mechanism. The transport unit (40) includes an air pump (41), a pressure sensor (43), and an air pipe (42). The air pump (41) and the air pipe (42) constitute an air supplier.

[0033] The air pump (41) is a diaphragm pump for sending air into the tank (71), and is accommodated in the lower equipment compartment (27). In the lower equipment compartment (27), the air pump (41) is se-

cured to the bottom surface of the lower base (21).

[0034] The air pipe (42) is provided for sending the air in the air pump (41) into the tank (71). The air pipe (42) is a tube extending from the lower equipment compartment (27) to the upper equipment compartment (28). One end of the air pipe (42) is connected to the air pump (41), and the other end thereof is connected to an inlet (79) of the tank (71).

[0035] The pressure sensor (43) is connected to the air pipe (42) and detects the pressure of the air flowing inside the air pipe (42). The pressure sensor (43) is attached to a control board (61) and connected to the controller (60) formed on the control board (61), to send a measured value to the controller (60). Since the air pipe (42) is connected to the tank (71) as described above, the pressure of the air flowing inside the air pipe (42) is substantially equal to the pressure in the tank (71). Accordingly, the pressure sensor (43) substantially measures the pressure in the tank (71).

[0036] The high voltage power supply unit (50) is provided for applying a positive or negative high voltage to the spray liquid in the tank (71) through an electrode member (84). As shown in FIG. 5, the high voltage power supply unit (50) includes an output section (51) and a reference potential section (55).

[0037] The output section (51) raises the voltage (+5 V) supplied from the AC adapter (2) to a high voltage and outputs the high voltage. The output section (51) is formed on a board (52) accommodated in the first central equipment compartment (25), and includes electronic components such as a transistor and a diode (not shown) and a transformer (53). The output section (51) raises the voltage (+5 V) supplied from the AC adapter (2) to a high voltage in a range between +3 kV and +5 kV, or between -4 kV and -7 kV. One end of a high voltage line (54) is electrically connected to an output terminal of the output section (51), and the output section (51) applies the high voltage to the spray liquid in the tank (71) through the high voltage line (54) and the electrode member (84). The output section (51) is configured to be capable of switching the polarity of the voltage to be output.

[0038] The reference potential section (55) is connected to the low-voltage side of the output section (51) and supplies a reference potential to the output section (51). The reference potential section (55) is formed on the board (52) accommodated in the first central equipment compartment (25) and configured to be in an ungrounded state without connection to a ground. The reference potential section (55) is electrically connected to the counter electrode (12) through a reference potential line (56). By being connected to the ungrounded reference potential section (55) in this way, the counter electrode (12) is not kept at the same potential as the ground but is at approximately the same potential as the reference potential of the board (52). In other words, the counter electrode (12) is comprised of, not a grounded electrode, but an ungrounded electrode.

[0039] The controller (60) controls the spraying operation of the electrostatic sprayer (1). The controller (60) is formed on the control board (61) accommodated in the second central equipment compartment (26), and includes an output control section (62) and a transport control section (63) (see FIG. 5). The pressure sensor (43), the human detection sensor (30), the temperature-humidity sensor (29), the power switch (15), a cartridge switch (64), and a falling switch (65) are connected to the controller (60).

[0040] The output control section (62) is provided for controlling the voltage output from the high voltage power supply unit (50). Specifically, the output control section (62) is configured to perform so-called alternating control of switching the polarity of the voltage applied from the high voltage power supply unit (50) alternately between the positive and negative polarities. In other words, the output control section (62) constitutes a switching control section that performs alternating control. A positive voltage Vp to be applied and its output time Tp for the alternating control are set in the output control section (62). Also, a negative voltage Vn to be applied and its output time Tn for the alternating control are set in the output control section (62). The positive voltage Vp is set to a predetermined value in a range of +3 kV to +5 kV, for example, and the output time Tp is set to about 7 seconds, for example. The negative voltage Vn is set to a predetermined value in a range of -7 kV to -4 kV, for example, and the output time Tn is set to about 4 seconds, for example. The output control section (62) performs the alternating control based on the voltage Vp, the output time Tp, the voltage Vn, and the output time Tn.

[0041] The transport control section (63) is provided for controlling the force by which the spray liquid is transported by the transport unit (40). Specifically, the transport control section (63) receives detection data from the pressure sensor (43), the temperature-humidity sensor (29), and the human detection sensor (30), and adjusts the pressure of the air sent from the air pump (41) based on the detection data.

[0042] The controller (60) also determines whether spraying of the spray liquid should be continued or stopped based on the measured value of the pressure sensor (43). This operation of the controller (60) will be described later.

[0043] The cartridge switch (64) is turned on when the spray cartridge (70) is mounted in the casing (10) and turned off when the spray cartridge (70) is disengaged from the casing (10). Once the cartridge switch (64) is turned off, the controller (60) outputs a signal for stopping the output of the output section (51) to the high voltage power supply unit (50). That is, in the electrostatic sprayer (1), when the spray cartridge (70) is in a disengaged state from the casing (10), the high voltage power supply unit (50) is off, prohibiting execution of the spraying operation.

[0044] The falling switch (65) is formed on the bottom cover (10b) of the electrostatic sprayer (1). The falling switch (65) is on when the electrostatic sprayer (1) is in its upright position with the bottom cover (10b) being in

contact with the placement surface (200), and turned off when the electrostatic sprayer (1) falls down separating the bottom cover (10b) from the placement surface (200). Once the falling switch (65) is turned off, the controller (60) outputs a signal for stopping the output of the output section (51) to the high voltage power supply unit (50). That is, in the electrostatic sprayer (1), when the electrostatic sprayer (1) is in a fallen state, the high voltage power supply unit (50) is off, prohibiting execution of the spraying operation.

[0045] The spray cartridge (70) is provided for charging and spraying the stored spray liquid, as shown in FIG. 7 and FIG. 8. The spray cartridge (70) includes the tank (71), the electrode member (84), the spray nozzle (72), a nozzle base (74), and a handle (86). The spray cartridge (70) is configured so that it cannot be disassembled. Therefore, when the spray liquid in the tank (71) is used up, the empty spray cartridge (70) is replaced with a new spray cartridge (70) filled with a spray liquid.

[0046] The tank (71) is a container for storing the spray liquid inside, and the tank (71) and the nozzle base (74) constitute a storage container. An aqueous solution containing hyaluronic acid, for example, is stored in the tank (71) as the spray liquid. Specifically, the tank (71) has a shape of an approximately rectangular box and constitutes a lower portion of the spray cartridge (70). The bottom of the tank (71) is formed into a bottom plate (71b) tilted downward to the back side. Thus, the tank (71) has its deepest portion on the back side.

[0047] The nozzle base (74) is a member for holding the spray nozzle (72). The nozzle base (74) has an approximately cylindrical shape, and is integrally formed with the tank (71) via a neck member (71a) of the tank (71). The nozzle base (74) has an internal recess (75) and an external recess (82).

[0048] The internal recess (75) is formed at the internal end of the nozzle base (74). The internal recess (75) has a holding portion (77) protruding inward in the axial direction at the center of the bottom. The holding portion (77) is provided with a through hole (78) in which the spray nozzle (72) is inserted. A sealing member (81) is attached around the holding portion (77). The sealing member (81) is provided for filling part of a gap (85) between an inner wall (76) of the internal recess (75) and the holding portion (77), and constitutes a spacer member according to the present disclosure. Filling part of the gap (85) with the sealing member (81) prevents the spray liquid in the tank (71) from entering the gap (85). The inlet (79) to which the other end of the air pipe (42) is connected is formed through the inner wall (76) of the internal recess (75).

[0049] The external recess (82) is formed at the external end of the nozzle base (74). An inner wall (83) of the external recess (82) is formed to surround an exposed portion (72c) of the spray nozzle (72) to be described later. The inner wall (83) of the external recess (82) is apart from the tip (72a) of the spray nozzle (72) by a fixed distance, thereby forming air space around the exposed portion (72c) of the spray nozzle (72). The air space serves as an insulating material, and thus, a stable electric field is generated at the tip (72a) of the spray nozzle (72). The tip (72a) of the spray nozzle (72) slightly protrudes from the edge of the inner wall (83) of the external recess (82).

[0050] The spray nozzle (72) is a small-diameter tube made of a resin, and has an outer diameter of between 0.3 mm and 0.5 mm inclusive and an inner diameter of between 0.1 mm and 0.3 mm inclusive. The spray nozzle (72) is inserted in the through hole (78) of the nozzle base (74). The tip (72a) of the spray nozzle (72) protrudes outside the nozzle base (74). A base end (72b) of the spray nozzle (72) is located in the deepest portion of the tank (71). That is, in the inner space of the tank (71), the base end (72b) of the spray nozzle (72) is located in a corner portion on the bottom side and the back side. Also, the portion of the spray nozzle (72) located outside the holding portion (77) of the nozzle base (74) constitutes the exposed portion (72c).

[0051] The electrode member (84) is a rod-like member made of a metal. One end of the electrode member (84) is inserted in the bottom portion of the tank (71) to be in contact with the spray liquid. The other end of the electrode member (84) protrudes outside the tank (71) and is electrically connected to the other end of the high voltage line (54). That is, the electrode member (84) is configured to be electrically connected to the output section (51) of the high voltage power supply unit (50) to apply a high voltage to the spray liquid in the tank (71). The electrode member (84), the high voltage power supply unit (50), the high voltage line (54), and the reference potential line (56) constitute an electric field generation mechanism (6) which generates an electric field between the tip (72a) of the spray nozzle (72) and the counter electrode (12).

-Operation Mechanism-

[0052] The operation of the electrostatic sprayer (1) of this embodiment will be described. In the electrostatic sprayer (1), the spray liquid is jetted as a liquid ligament, broken into droplets, and diffused to reach the user. The electrostatic sprayer (1) is capable of operation when the spray cartridge (70) is mounted in the casing (10).

[0053] First, when the user opens the shutter (13), the power switch (15) is turned on with the sliding of the shutter (13). Once the power switch (15) is turned on, the transport control section (63) of the controller (60) activates the air pump (41). The air pump (41) supplies air into the inner space of the tank (71) through the air pipe (42). The air pressure rises in the tank (71) and acts on a liquid surface (9) of the spray liquid. The spray liquid in the tank (71) thus flows into the spray nozzle (72) and is pushed up to the tip (72a) of the spray nozzle (72).

[0054] Also, once the power switch (15) is turned on, the output control section (62) of the controller (60) controls the high voltage power supply unit (50) to output a

high voltage from the output section (51). The high voltage is applied to the spray liquid in the tank (71) via the electrode member (84).

[0055] At the tip (72a) of the spray nozzle (72), a potential difference occurs between the charged spray liquid and the counter electrode (12). As a result, an electric field is generated in a space near the tip (72a) of the spray nozzle (72). The spray liquid is pulled by the electric field to flow out from the tip (72a) of the spray nozzle (72) as an elongated ligament. The ligament of the spray liquid is then broken into droplets having a size of about several tens of micrometers (μm) to about 300 μm. Since the spray liquid is charged, electrical repulsion acts among the droplets. Thus, the droplets of the spray liquid sprayed from the spray nozzle (72) repel one another and diffuse. The diffused droplets of the spray liquid are scattered toward the user who is substantially at a ground potential, and adhere to the user's face.

[0056] Even when the power switch (15) is on, the controller (60) can control the spraying operation based on the detection signal from the human detection sensor (30). Specifically, during spraying of the spray liquid, when the controller (60) determines that no user is present based on the detection signal from the human detection sensor (30), it instructs the high voltage power supply unit (50) to stop the output of the high voltage, and stops the operation of the air pump (41). Thereafter, if the controller (60) determines that the use is present based on the detection signal from the human detection sensor (30), it instructs the high voltage power supply unit (50) to restart the output of the high voltage, and restarts the operation of the air pump (41). In this way, it is possible to prevent wasteful spraying during absence of the user.

[0057] The controller (60) can also exert control to ensure appropriate spraying operation based on the measured value from the temperature-humidity sensor (29). Specifically, since the ligament formation conditions vary with the temperature and humidity of the air in the room, the controller (60) adjusts the voltage value of the output from the high voltage power supply unit (50), and adjusts the air discharge amount from the air pump (41), based on the measured value from the temperature-humidity sensor (29) so that the spray liquid can be sprayed stably from the spray nozzle (72).

[0058] In the spraying operation as described above, the output control section (62) of the controller (60) performs alternating control as follows.

[0059] The output control section (62) switches the polarity of the voltage output from the high voltage power supply unit (50) alternately between the positive and negative polarities. Specifically, the output control section (62) first applies the positive voltage Vp to the spray liquid in the tank (71) for the output time Tp. By this voltage application, positively charged droplets are sprayed from the spray nozzle (72) toward the user. Thereafter, the output control section (62) applies the negative voltage Vn to the spray liquid in the tank (71) for the output time Tn. By this voltage application, negatively charged droplets are sprayed from the spray nozzle (72) toward the user. In this alternating control, therefore, with the polarity of the voltage output from the high voltage power supply unit (50) being switched alternately, the polarity of the droplets sprayed from the spray nozzle (72) is also switched alternately.

[0060] With the polarity of the droplets sprayed from the spray nozzle (72) being switched alternately between the positive and negative polarities, positively charged droplets and negatively charged droplets are to fall on the user alternately. Therefore, even when charge of one polarity is temporarily accumulated on the user making the user charged with this polarity, charge of the other polarity will soon fall on the user, removing the electricity from the user. Thus, electrostatic discharge from the charged user to the counter electrode exposed at the outer surface of the electrostatic sprayer (1) is prevented or reduced.

[0061] When the counter electrode (12) is comprised of an ungrounded electrode as in this embodiment, charge from droplets of the spray liquid having attached to the counter electrode (12) cannot be grounded but is accumulated on the counter electrode (12). For this reason, if the polarity of the droplets sprayed from the spray nozzle (72) is fixed, charge of one polarity will be accumulated on the counter electrode (12), reducing the potential difference between the tip (72a) of the spray nozzle (72) and the counter electrode (12) and thus failing to generate such an electric field as to allow the spray liquid to be sprayed.

[0062] In this embodiment, however, where alternating control is performed by the output control section (62) to switch the polarity of the droplets sprayed from the spray nozzle (72) alternately between the positive and negative polarities, positively charged droplets of the spray liquid and negatively charged droplets of the spray liquid are alternately sprayed from the tip (72a) of the spray nozzle (72). By this operation, with no accumulation of charge of only one polarity on the counter electrode (12), an electric field for spraying the spray liquid is generated stably between the tip (72a) of the spray nozzle (72) and the counter electrode (12).

-Advantages of Embodiment-

[0063] In this embodiment, the counter electrode (12) is comprised of an ungrounded electrode. For a grounded electrode and an ungrounded electrode made of the same material, charge does not easily transfer in the ungrounded electrode because the electric resistance is larger in the ungrounded electrode than in the grounded electrode. Therefore, by forming the counter electrode (12) of an ungrounded electrode as described above, transfer of charge accumulated on the user to the counter electrode (12) becomes difficult compared with the case of forming the counter electrode (12) of a grounded electrode. That is, electrostatic discharge from the user to

the counter electrode (12) can be prevented or reduced, and thus electric shock given to the user along with the electrostatic discharge can be prevented or reduced.

[0064] Incidentally, when charged droplets of the spray liquid attach to the counter electrode (12), the counter electrode (12) is also charged. In this relation, when the counter electrode (12) is comprised of an ungrounded electrode, the charge cannot be grounded and thus is accumulated on the counter electrode (12). For this reason, if the polarity of the voltage applied to the spray liquid is fixed, charge of one polarity will be accumulated on the counter electrode (12), reducing the potential difference between the tip (72a) of the spray nozzle (72) and the counter electrode (12) and thus failing to generate such an electric field as to allow the spray liquid to be sprayed.

[0065] In this embodiment, however, by the alternating control by the output control section (62), the polarity of the voltage applied to the spray liquid is switched alternately between the positive and negative polarities. Therefore, positively charged droplets of the spray liquid and negatively charged droplets of the spray liquid are alternately sprayed from the tip (72a) of the spray nozzle (72). Thus, with no accumulation of charge of only one polarity on the counter electrode (12), an electric field for spraying the spray liquid can be generated stably between the tip (72a) of the spray nozzle (72) and the counter electrode (12).

[0066] Moreover, in this embodiment, the counter electrode (12) is made of a conductive resin material where charge does not easily transfer because the electric resistivity is higher than a metal and the charge transfer rate is low. In this relation, electric shock given to a human along with electrostatic discharge from the human to an object depends on the charge transfer rate. That is, the higher the charge transfer rate, the larger the electric shock is, causing pain to the human. Therefore, by forming the counter electrode (12) of a conductive resin material as described above, occurrence of electrostatic discharge from the user to the counter electrode (12) becomes further difficult. Even if electrostatic discharge occurs, since the charge transfer rate is low compared with the case of forming the counter electrode (12) of a metal, electric shock given to the user along with electrostatic discharge can be reduced.

[0067] If the counter electrode (12) is comprised of a grounded electrode, it may be considered to impart high resistance to the counter electrode (12) to prevent or reduce electrostatic discharge to the counter electrode (12). To achieve this, however, an extremely high resistance value must be imparted to the counter electrode (12). With the counter electrode (12) having such a high resistance value, droplets of the spray liquid will be sprayed, not toward the counter electrode (12) but toward the surrounding portion of the placement surface (200), causing instability of the spraying operation. By contrast, according to this embodiment, the counter electrode (12) is comprised of an ungrounded electrode where charge does not easily transfer compared with a grounded electrode. Therefore, electrostatic discharge can be prevented or reduced even when the resistance value of the counter electrode (12) is reduced compared with the case of forming the counter electrode (12) of a grounded electrode. Thus, droplets of the spray liquid can be sprayed stably from the tip (72a) of the spray nozzle (72) toward the counter electrode (12).

-Variation of Embodiment-

[0068] A variation of this embodiment will be described. In this variation, the configuration of the spray nozzle (72) shown in FIG. 7 has been changed.

[0069] As shown in FIG. 9, the spray nozzle (72) of this variation includes a thin tube portion (73a) and a thick tube portion (73b). Note that the placement of the spray nozzle (72) in the spray cartridge (70) is similar to that shown in FIG. 7.

[0070] The thin tube portion (73a) is a small-diameter tube made of a resin, having an outer diameter of between 0.3 mm and 0.5 mm inclusive and an inner diameter of between 0.1 mm and 0.3 mm inclusive. The top end of the thin tube portion (73a) slightly protrudes from the edge of the inner wall (83) of the external recess (82), constituting the tip (72a) of the spray nozzle (72). Also, the portion of the thin tube portion (73a) located outside the holding portion (77) of the nozzle base (74) constitutes the exposed portion (72c) of the spray nozzle (72).

[0071] The thick tube portion (73b) is in a circular tube shape, of which the inner diameter is larger than the outer diameter of the thin tube portion (73a). The top end of the thick tube portion (73b) is connected to the base end of the thin tube portion (73a). The base end of the thick tube portion (73b) is located in the deepest portion of the tank (71), constituting the base end (72b) of the spray nozzle (72). That is, in this variation, also, in the inner space of the tank (71), the base end (72b) of the spray nozzle (72) is located in a corner portion on the bottom side and the back side.

[0072] According to this variation, where the spray nozzle (72) has the thin tube portion (73a) and the thick tube portion (73b), the pressure loss occurring when the spray liquid is transported from the base end (72b) of the spray nozzle (72) to the tip (72a) can be reduced. Thus, the air pressure in the spray cartridge (70) during spraying can be reduced, permitting reduction in the power consumption of the air pump (41), compared with the case of using the spray cartridge (70) shown in FIG. 7.

-Other Embodiments-

[0073] In the above embodiment and its variation, the aqueous solution containing hyaluronic acid is used as the spray liquid, but the disclosure is not limited to this. For example, hot spring water or an aqueous solution of theanine may be used as the spray liquid, or an aqueous solution of an antioxidant such as catechin and proan-

thocyanidin may be used as the spray liquid.

[0074] In the above embodiment and its variation, a resistor may be connected between the counter electrode (12) and the reference potential section (55). This configuration makes the transfer of charge accumulated on the user to the counter electrode (12) more difficult. That is, occurrence of electrostatic discharge becomes more difficult. Thus, electric shock given to the user along with electrostatic discharge can be further prevented or reduced.

[0075] The foregoing embodiment is merely a preferred example in nature, and is not intended to limit the scope, applications, and use of the disclosure.

INDUSTRIAL APPLICABILITY

[0076] As described above, the present disclosure is useful in electrostatic sprayers.

DESCRIPTION OF REFERENCE CHARACTERS

[0077]

1	Electrostatic Sprayer
6	Electric Field Generation Mechanism
12	Counter Electrode
40	Transport Unit (Transport Mechanism)
55	Reference Potential Section
56	Reference Potential Line
62	Output Control Section (Switching Control Section)
71	Tank (Storage Container)
72	Nozzle (Spray Nozzle)
72a	Tip

Claims

1. An electrostatic sprayer, comprising:

a storage container (71) which stores a spray liquid;
a tubular nozzle (72) attached to the storage container (71);
a transport mechanism (40) which transports the spray liquid in the storage container (71) to a tip (72a) of the nozzle (72);
a counter electrode (12) exposed at an outer surface;
an electric field generation mechanism (6) which applies a voltage to the spray liquid to generate an electric field between the tip (72a) of the nozzle (72) and the counter electrode (12) so that the spray liquid is sprayed from the tip (72a) of the nozzle (72); and
a switching control section (62) which switches the polarity of the voltage applied to the spray liquid by the electric field generation mechanism (6) alternately between positive and negative polarities,
wherein
the counter electrode (12) is comprised of an ungrounded electrode.

2. The electrostatic sprayer of claim 1, wherein the counter electrode (12) is made of a conductive resin material.

FIG.1

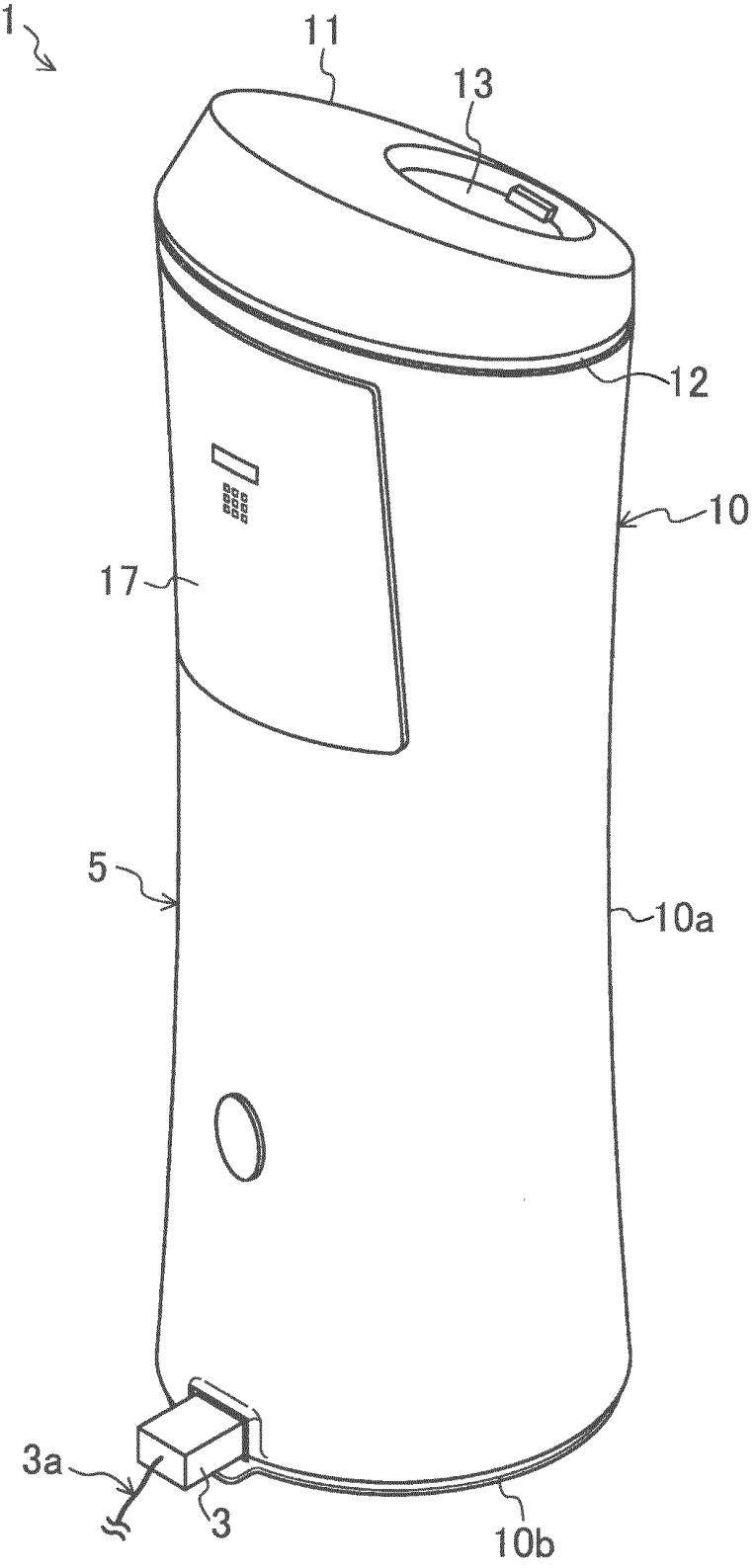
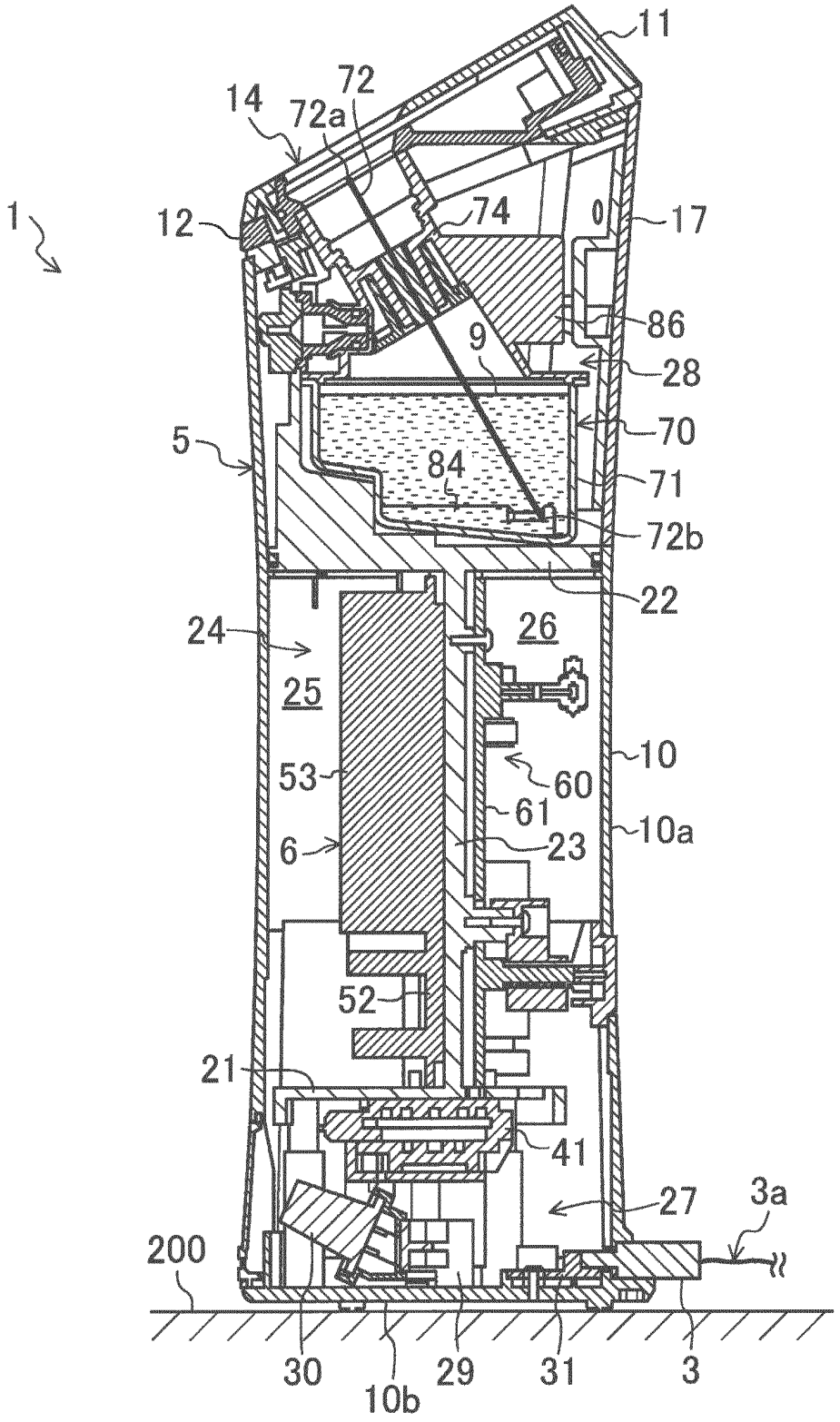


FIG.2


1
11
14
72
72a
12
74
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17
86
9
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72b
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26
25
53
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3a
200
30
10b
29
31
3

FIG.3

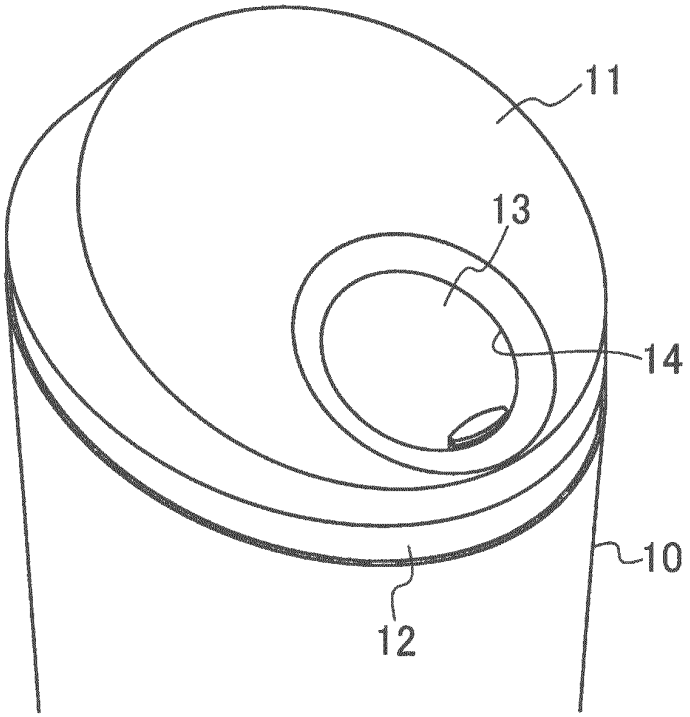


FIG.4

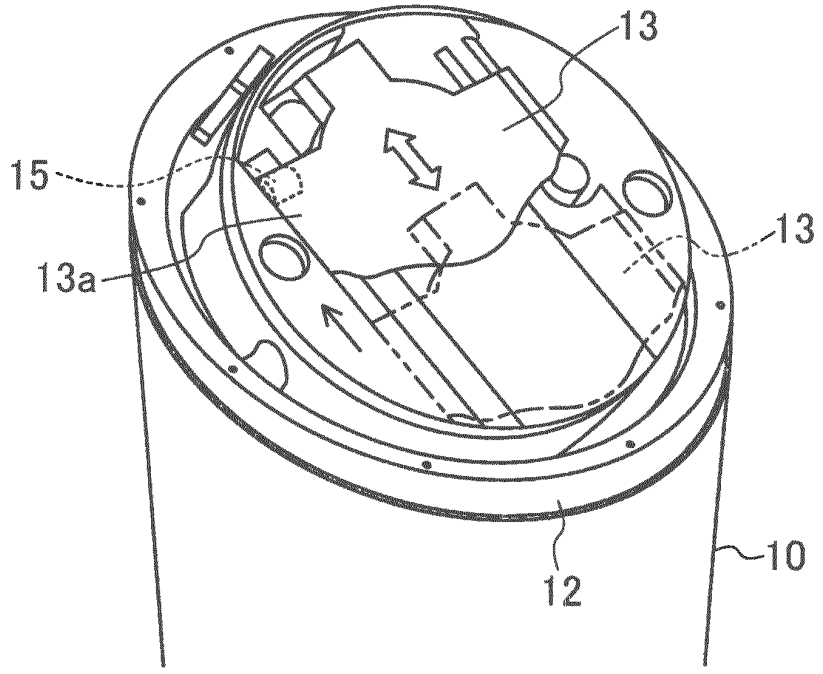
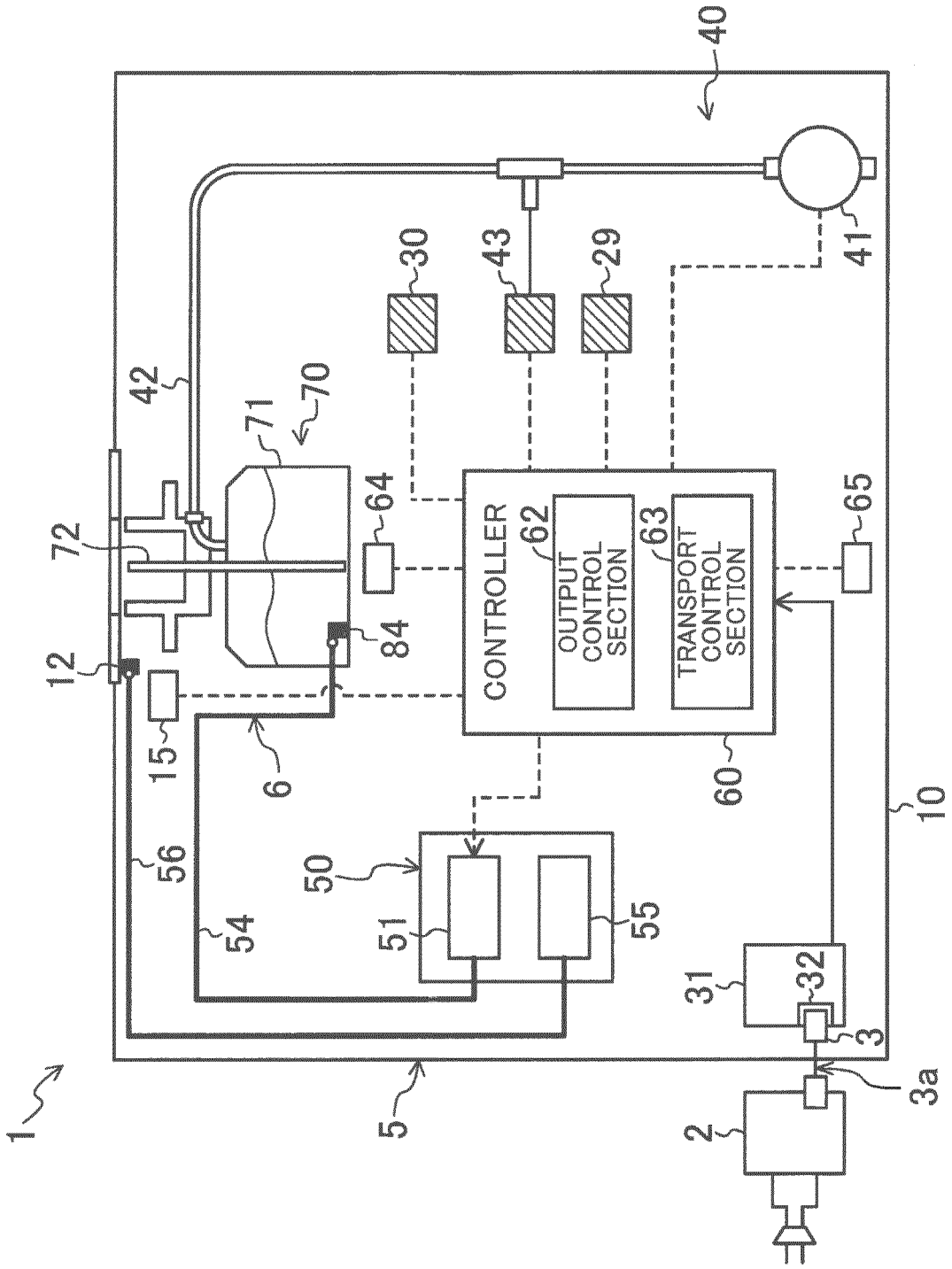


FIG.5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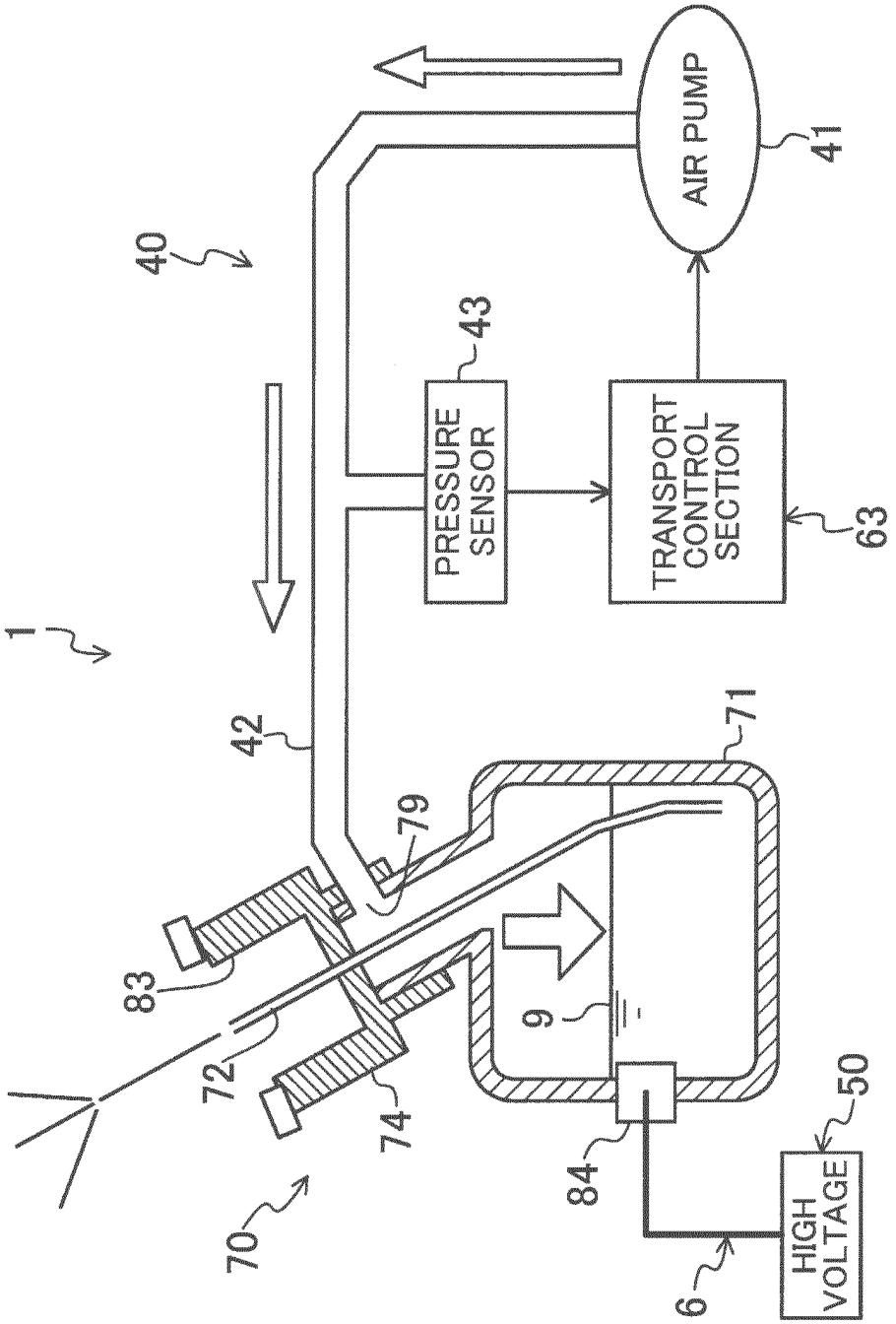
41
30
43
29
42
71
70
72
64
65
CONTROLLER
62
OUTPUT CONTROL SECTION
63
TRANSPORT CONTROL SECTION
12
84
15
6
60
10
56
50
54
51
55
31
32
3
3a
1
5
2

FIG.6


AIR PUMP
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PRESSURE SENSOR
TRANSPORT CONTROL SECTION
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HIGH VOLTAGE
6
70

FIG.7

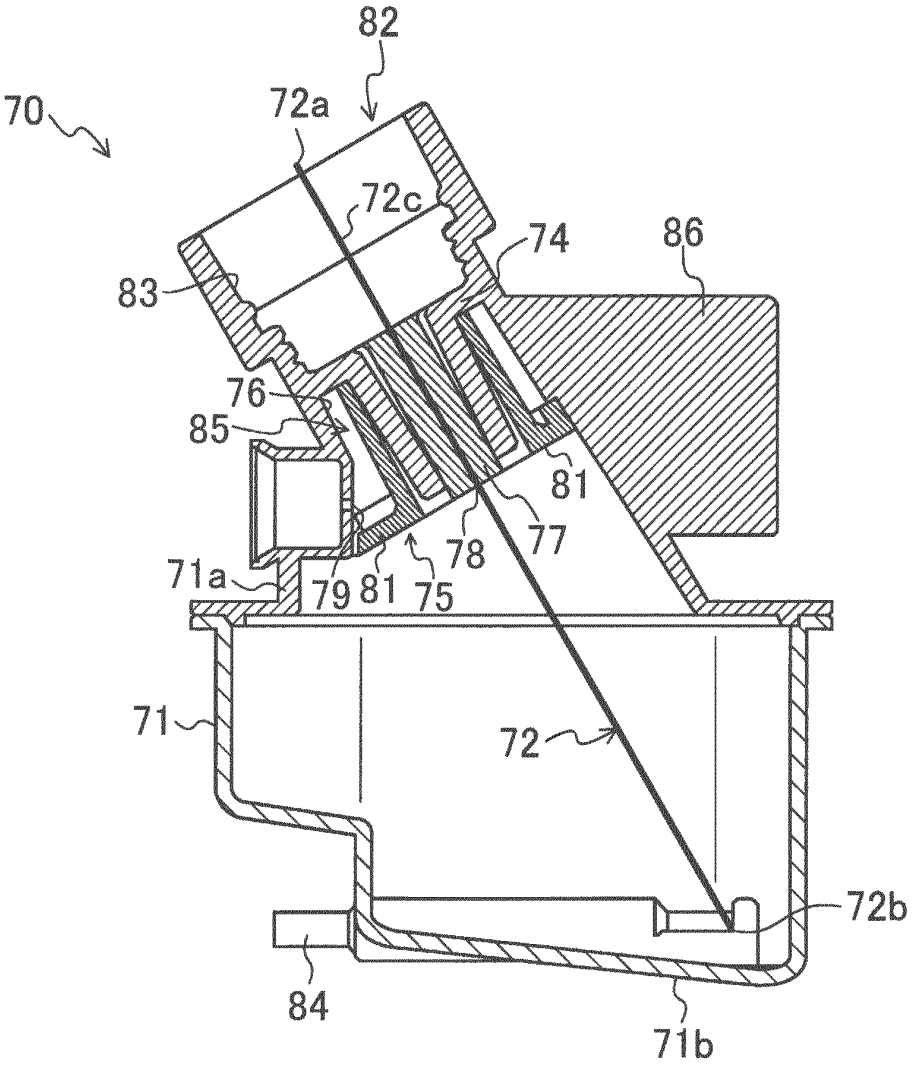


FIG.8

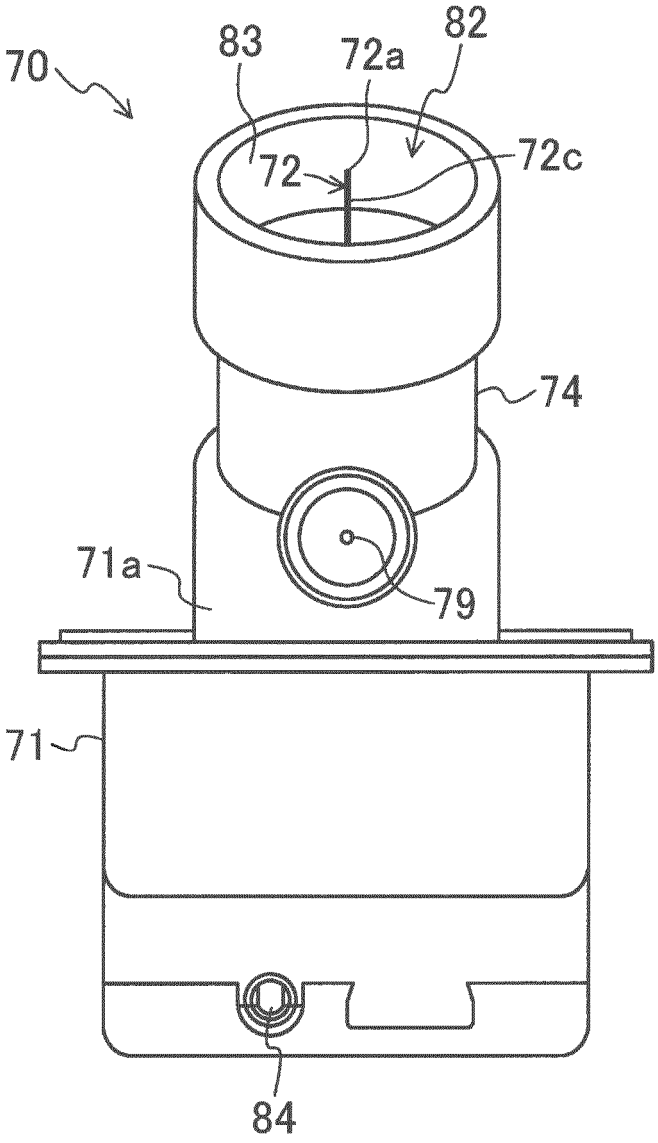
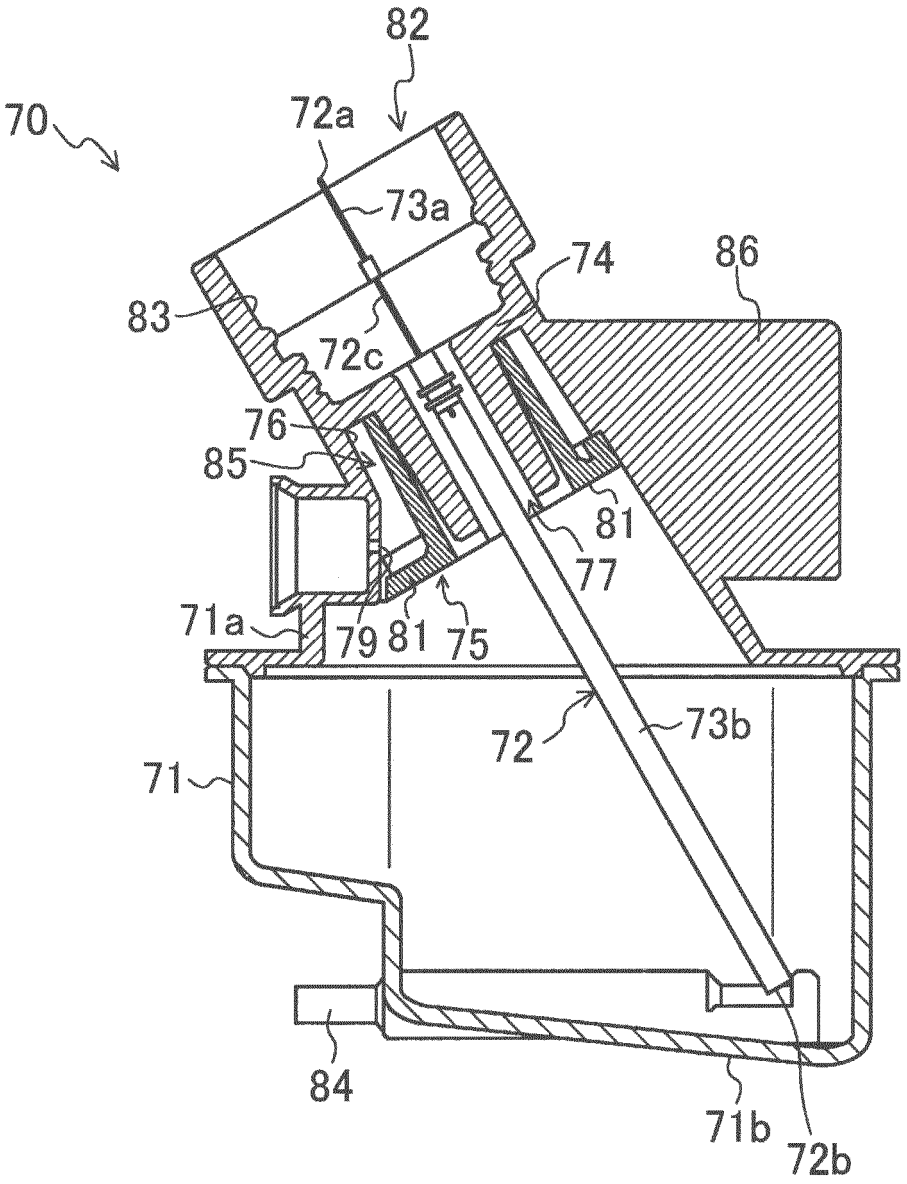


FIG.9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71b
72b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/006909

A. CLASSIFICATION OF SUBJECT MATTER
B05B5/053(2006.01)i, *B05B5/043*(2006.01)n

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)
B05B5/053, B05B5/043

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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.
X Y	JP 2007-260627 A (Matsushita Electric Works, Ltd.), 11 October 2007 (11.10.2007), paragraphs [0013] to [0021]; fig. 1 to 4 & WO 2007/111121 A1 & TW 200800405 A	1 2
Y	JP 2011-031184 A (Mitsubishi Electric Corp.), 17 February 2011 (17.02.2011), paragraph [0028] (Family: none)	2
A	JP 2009-268944 A (Panasonic Electric Works Co., Ltd.), 19 November 2009 (19.11.2009), paragraph [0026] (Family: none)	1-2

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 December, 2012 (21.12.12)	08 January, 2013 (08.01.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2009022891 A **[0004]**