



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
21.10.2015 Bulletin 2015/43

(51) Int Cl.:
H05H 1/24 (2006.01) **A45D 27/46** (2006.01)
B08B 3/10 (2006.01) **B08B 7/00** (2006.01)
B26B 19/48 (2006.01)

(21) Application number: **13865768.9**

(22) Date of filing: **26.11.2013**

(86) International application number:
PCT/JP2013/006935

(87) International publication number:
WO 2014/097549 (26.06.2014 Gazette 2014/26)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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(30) Priority: **17.12.2012 JP 2012274607**

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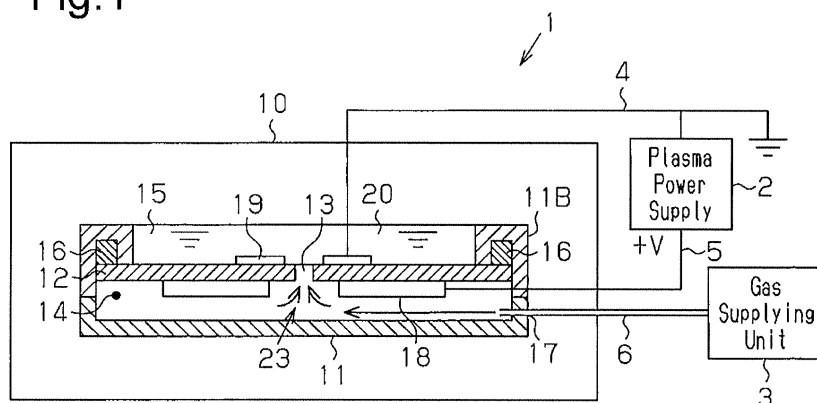
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(54) **PLASMA GENERATION DEVICE AND CLEANING DEVICE IN WHICH PLASMA GENERATION DEVICE IS USED**

(57) A plasma generation device (1), provided with: a plasma generator (10), a plasma power supply unit (2), and a gas supply unit (3). The plasma generator includes a partition part (12) for dividing the liquid housing unit (15) and the gas housing unit (14) from each other. The partition part has a gas channel (13) for guiding the gas supplied from the gas supply unit and housed in the gas housing unit to the liquid housing unit. The first electrode

(18) is disposed in the gas housing unit and the second electrode (19) is disposed in the liquid housing unit. The plasma power supply unit generates a potential supplied to the first and second electrodes and sets the potential of the second electrode to a lower value than that of the potential of the first electrode. The second electrode is formed from a material, a material compound, or a material mixture that causes sputtering phenomenon.

Fig.1



Description**TECHNICAL FIELD**

[0001] The present invention relates to a plasma generation device and a cleaning device using the plasma generation device.

BACKGROUND ART

[0002] A plasma generation device for use with a conventional cleaning device performs discharging in a liquid that contains bubbles. This generates radicals or the like in the bubbles and reforms the liquid. Patent document 1 discloses an example of a conventional plasma generation device.

PRIOR ART DOCUMENT

[0003] Patent Document 1: Japanese Laid-Open Patent Publication No. 2012-43769

SUMMARY OF THE INVENTION**PROBLEMS THAT ARE TO BE SOLVED BY THE INVENTION**

[0004] The plasma generation device performs discharging by applying high voltage between a first electrode arranged in a gas accommodation portion and a second electrode arranged in a liquid accommodation portion. The plasma generation device generates plasma in regions of gas in the liquid accommodated in the liquid accommodation portion. The plasma generation device generates hydroxyl radicals from the water contained in the liquid and the oxygen contained in the gas. The second electrode is arranged in the liquid containing water in the liquid accommodation portion, and the first electrode is arranged in the gas. When the plasma generation device is applied to a cleaning device for an electronic device having a movable portion, the purging of impurities from the movable device may cause seizing. In order to hinder seizing, a user adds lubricant to the liquid that serves as a cleaning liquid and is accommodated in the liquid accommodation portion. When using the cleaning device, the user performs regular maintenance by adding lubricant, changing the cleaning liquid, and the like. Thus, the use of the conventional plasma generation device with a cleaning device is burdensome to the user. Further, cleaning liquid containing the changed lubricant is processed as wastewater. It is thus desirable that the used amount of lubricant be minimized when taking the environment into account.

[0005] Accordingly, it is an object of the present invention to provide a plasma generation device and a cleaning device using the plasma generation device that facilitates maintenance.

MEANS FOR SOLVING THE PROBLEM

[0006] One aspect of the present invention is a plasma generation device including a plasma generator, a plasma power supply, and a gas supplying unit. The plasma generator includes a liquid accommodation portion, a gas accommodation portion, a partition wall, a first electrode, and a second electrode. The liquid accommodation portion is configured to accommodate liquid containing at least water. The gas accommodation portion is configured to accommodate gas. The partition wall is configured to partition the liquid accommodation portion and the gas accommodation portion and includes a gas passage configured to draw the gas from the gas accommodation portion into the liquid accommodation portion. The first electrode is arranged in the gas accommodation portion. The second electrode is arranged in the liquid accommodation portion so that at least a portion paired with the first electrode contacts liquid in the liquid accommodation portion. The gas supplying unit is configured to supply the gas containing at least oxygen to the gas accommodation portion. The plasma power supply is configured to generate potentials supplied to the first electrode and the second electrode and set the potential at the second electrode to a lower value than the potential at the first electrode. The second electrode is formed from one of a material, a material compound, and a material mixture that causes sputtering.

[0007] In the above plasma generation device, the plasma power supply performs discharging by applying a predetermined potential between the first electrode and the second electrode so that the potential at the second electrode is lower than that of the first electrode. The plasma generator generates plasma in regions of gas in the liquid in the liquid accommodation portion. This generates hydroxyl radicals from the water contained in the liquid and the oxygen contained in the gas. In this structure, the plasma generator is capable of performing discharging between the first electrode and the second electrode while limiting the influence of the electrical resistance of the liquid. The second electrode emits silver microparticles through sputtering, which occurs when discharging is performed. The silver microparticles are scattered in the liquid in the liquid accommodation portion. In this structure, when cleaned subjects are arranged in the liquid accommodation portion, the organic matters collected on the cleaned subjects are decomposed by hydroxyl radicals and the microparticles emitted from the second electrode can be deposited on the cleaned subjects. For example, when the plasma generation device is applied to a cleaning device of an electronic device having a movable portion, the silver microparticles can be deposited on the movable portion of the electronic device. This reduces the friction resistance of the movable portion and allows for smooth movement.

[0008] In the above plasma generation device, preferably, the second electrode is formed from one of silver, a silver compound, and a silver mixture as one of the

material, the material compound, and the material mixture that causes the sputtering.

[0009] In the above plasma generation device, preferably, the second electrode includes an opposing surface formed from one of the material, the material compound, and the material mixture that causes the sputtering, and the opposing surface is opposed to the gas that passes through at least the gas passage, and has a surface roughness of a maximum height value that exceeds 10 μm .

[0010] In the above plasma generation device, preferably, the second electrode is gas-permeable so that the gas in the gas accommodation portion passes through the second electrode and is supplied to the liquid accommodation portion.

[0011] Another aspect of the present invention is a cleaning device including the above plasma generation device. The cleaning device is configured to emit microparticles from the second electrode through the sputtering so that the microparticles are deposited on a cleaned subject.

[0012] In the above plasma generation device, preferably, the cleaning device is applicable when cleaning a hair remover so that the cleaning device the microparticles emitted from the second electrode are deposited on the cleaned subject of the hair remover.

[0013] In the above plasma generation device, preferably, the hair remover includes a blade unit including a sliding surface, and at least a portion of the sliding surface is arranged at a location where the portion of the sliding surface does not hinder movement of the microparticles emitted from the second electrode.

EFFECT OF THE INVENTION

[0014] The plasma generation device and the cleaning device using the plasma generation device facilitate maintenance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a schematic diagram illustrating the structure of a plasma generation device of a first embodiment. Fig. 2 is a graph illustrating the value of the voltage applied to a first electrode and a second electrode of the plasma generation device of the first embodiment.

Fig. 3A is a partially enlarged cross-sectional view schematically illustrating one operating state of the plasma generation device of the first embodiment, and Fig. 3B is a schematic partially enlarged cross-sectional view illustrating a state when the state of Fig. 3A continues.

Fig. 4 is a partially enlarged cross-sectional view schematically illustrating microparticles emitted by the plasma generation device of the first embodi-

ment.

Fig. 5 is a perspective view illustrating a cleaning device of a second embodiment.

Fig. 6A is a perspective view of a hair remover inserted into the cleaning device illustrated in Fig. 5, and Fig. 6B is a schematic diagram illustrating the structure of an inner blade and an outer blade that are arranged in a blade unit.

Fig. 7 is a cross-sectional side view illustrating when the hair remover of Fig. 6A is mounted on the cleaning device of Fig. 5.

Fig. 8 is a cross-sectional view illustrating the cross-sectional structure taken along plane 7Z-7Z in Fig. 7. Fig. 9 is a partially enlarged view illustrating the enlarged structure of the portion encircled by the dashed lines in Fig. 7.

Fig. 10A is a schematic diagram illustrating the structure of a plasma generation device of a third embodiment, and Fig. 10B is a partially enlarged cross-sectional view schematically illustrating when microparticles are emitted by the plasma generation device of Fig. 10A.

Fig. 11A is a schematic diagram illustrating the structure of a plasma generation device of a fourth embodiment, and Fig. 11B is a partially enlarged cross-sectional view schematically illustrating when microparticles are emitted by the plasma generation device of Fig. 11A.

EMBODIMENTS OF THE INVENTION

First Embodiment

[0016] The structure of a plasma generation device 1 will now be described with reference to Fig. 1.

[0017] The plasma generation device 1 includes a plasma generator 10, a plasma power supply 2, a gas supplying unit 3, a first lead line 4, a second lead line 5, and a gas inlet pipe 6. The first lead line 4 and the second lead line 5 connect the plasma generator 10 and the plasma power supply 2 to each other. The gas inlet pipe 6 connects the plasma generator 10 and the gas supplying unit 3 to each other.

[0018] The plasma generator 10 includes a cylindrical case member 11. The case member 11 does not have to be cylindrical. For example, the case member 11 may be polygonal.

[0019] The case member 11 includes a partition wall 12 that partitions the internal space of the case member 11 into an upper portion and a lower portion. The partition wall 12 is formed from, for example, a ceramic. The upper side of the partition wall 12 in the internal space of the case member 11 defines a liquid accommodation portion 15 that accommodates liquid 20 containing water. The lower side of the partition wall 12 in the internal space of the case member 11 defines a gas accommodation portion 14 that accommodates gas. Each side in the plane of the partition wall 12 has a dimension of several cen-

timeters. The partition wall 12 has a thickness of several hundred micrometers to several millimeters. The thickness is set to an appropriate value in accordance with the application. The case member 11 includes a gas inlet 17 in the lower portion of a right wall 11 B. The gas inlet pipe 6, which is inserted into the gas inlet 17, connects the gas accommodation portion 14 and the gas supplying unit 3. The gas supplying unit 3 supplies the gas accommodation portion 14 with gas containing at least oxygen.

[0020] The partition wall 12 includes a gas passage 13. The gas drawn from the gas supplying unit 3 into the gas accommodation portion 14 is delivered into the liquid accommodation portion 15 through the gas passage 13 in a first movement direction 23.

[0021] The plasma generator 10 includes a ring-shaped seal 16 arranged in the outer end of the liquid accommodation portion 15. The seal member 16 seals the gap between the case member 11 and the partition wall 12 so that the liquid 20 does not leak from the liquid accommodation portion 15 into the gas accommodation portion 14.

[0022] It is preferable that the gas passage 13 have a hole diameter set in the range of 100 μm to 800 μm so that the liquid 20 in the liquid accommodation portion 15 does not leak through the gas passage 13 into the gas accommodation portion 14.

[0023] The plasma generator 10 includes a first electrode 18 arranged in the gas accommodation portion 14 and a second electrode 19 arranged in the liquid accommodation portion 15. The partition wall 12 spaces the second electrode 19 apart from the first electrode 18. The second electrode 19 includes a portion paired with the first electrode 18 (surface that performs discharging with the surface of the first electrode 18). The second electrode 19 is arranged in the liquid accommodation portion 15 so that at least this portion contacts the liquid 20 in the liquid accommodation portion 15.

[0024] The first electrode 18 and the second electrode 19 are each toroidal. The first electrode 18 is arranged on the surface of the partition wall 12 that defines the gas accommodation portion 14 so that a center hole of the first electrode 18 is in communication with the gas passage 13. The surface of the first electrode 18 is covered by a dielectric. As described above, the second electrode 19 is arranged in the liquid accommodation portion 15 so that the portion paired with the first electrode 18 (surface that performs discharging with the surface of the first electrode 18) contacts the liquid 20 in the liquid accommodation portion 15. The second electrode 19 is arranged on the surface of the partition wall 12 that defines the liquid accommodation portion 15 so that the center hole of the second electrode 19 is in communication with the gas passage 13.

[0025] That is, the first electrode 18 and the second electrode 19 are concentrically arranged on the two surfaces of the partition wall 12. The second electrode 19 is arranged at a position closer to the gas passage 13 than the first electrode 18.

[0026] The toroidal first electrode 18 is arranged in the gas accommodation portion 14 so that the first electrode 18 does not contact the liquid 20 drawn into the liquid accommodation portion 15. The toroidal second electrode 19 (including at least the portion paired with the first electrode 18) is arranged in the liquid accommodation portion 15 so that the second electrode 19 contacts the liquid 20.

[0027] The first electrode 18 is electrically connected to the plasma power supply 2 by the second lead line 5. The second electrode 19 is electrically connected to the plasma power supply 2 by the first lead line 4. The plasma power supply 2 applies a predetermined voltage between the first electrode 18 and the second electrode 19.

[0028] Fig. 2 illustrates the voltage applied to the first electrode 18 and the second electrode 19. The plasma generation device 1 sets the potential at the second electrode 19 to a smaller value than the potential at the first electrode 18.

[0029] The second electrode 19 is formed from a material, a material compound, or a material mixture that causes sputtering when a smaller potential is applied to the second electrode 19 than the first electrode 18 so that discharging occurs between the first electrode 18 and the second electrode 19.

[0030] As a material that causes sputtering when discharging occurs, for example, the second electrode 19 may be formed from one of silver, a silver compound, and a silver mixture.

[0031] The material of the second electrode 19 does not have to be silver, a silver compound, or a silver mixture. The material that causes sputtering when discharging occurs may include platinum, gold, copper, titanium, copper, or the like. Other materials may also be used.

[0032] The operation of the plasma generation device 1 and a method for generating hydroxyl radicals will now be described.

[0033] A process for emitting ozone and hydroxyl radicals into the liquid 20 includes a gas supplying step, a bubble growing step, a hydroxyl radical generating step, and a bubble emitting step.

[0034] In the gas supplying step, the gas supplying unit 3 supplies gas containing oxygen to the gas accommodation portion 14. The gas supplied to gas accommodation portion 14 is forcibly delivered through the gas passage 13 into the liquid accommodation portion 15. The gas supplying unit 3 forcibly delivers the gas containing oxygen, which is based on air flowing at a rate of approximately 0.01 L/min to 1.0 L/min, through the gas inlet pipe 6 into the gas accommodation portion 14. The pressure that forcibly delivers the gas is set to approximately 0.0098 MPa to 0.49 MPa (0.1 kgf/cm² to 5 kgf/cm²). A generally known means such as flow rate control performed by the gas supplying unit 3 is used to control the flow rate of the supplied gas.

[0035] When the gas supplying unit 3 supplies gas to the gas accommodation portion 14, the gas accommodation portion 14 shifts to a positive pressure condition

of approximately 0.11 MPa to 0.59 MPa (1.1 kgf/cm² to 6 kgf/cm²). When the gas accommodation portion 14 shifts to a positive pressure condition, the gas accommodation portion 14 forms the flow of gas from the gas passage 13 toward the liquid accommodation portion 15 in the first movement direction 23. Further, when the gas accommodation portion 14 shifts to a positive pressure condition, the gas accommodation portion 14 restricts the leakage of the liquid 20 from the liquid accommodation portion 15 through the gas passage 13 into the gas accommodation portion 14.

[0036] Figs. 3A and 3B each illustrate the liquid 20 and the gas near an open end 13A of the gas passage 13 in the liquid accommodation portion 15.

[0037] As illustrated in Fig. 3A, in the bubble growing step, the gas accommodation portion 14 supplies gas containing oxygen to the liquid accommodation portion 15 so that an oxygen-containing fine bubble 24 grows in the open end 13A of the gas passage 13.

[0038] In the hydroxyl radical generating step, the plasma power supply 2 applies a predetermined voltage between the first electrode 18 and the second electrode 19. The plasma power supply 2 applies a voltage that preferably generates a power of approximately 1 W to 100 W and allows a glow discharge to occur under atmospheric pressure. The plasma power supply 2 includes a generally known voltage control means for controlling the voltage applied between the first electrode 18 and the second electrode 19. The plasma power supply 2 sets the potential at the second electrode 19 to a smaller value than the potential at the first electrode 18. The plasma power supply 2 applies a lower potential to the second electrode 19 than the first electrode 18 to perform discharging in a gas environment under atmospheric pressure or a greater pressure.

[0039] A technique for generating plasma under atmospheric pressure is described in, for example, "Atmospheric Pressure Glow Discharge Plasma and its Applications" written by Satiko Okazaki for the review lecture of the 20th JSPF Annual Meeting.

[0040] The plasma generator 10 performs discharging between the surface of the first electrode 18 that contacts gas and the surface of the second electrode 19 that contacts liquid. The discharging generates plasma in regions of gas in the liquid 20 in the liquid accommodation portion 15. The plasma is outstandingly generated in the regions of gas near the gas-liquid boundary between the growing bubble 24 and the liquid 20 at the open end 13A of the gas passage 13. The plasma generator 10 generates the plasma at the open end 13A of the gas passage 13 so that ozone, hydroxyl radicals, and the like are generated from the water contained in the liquid and the oxygen contained in the gas.

[0041] In this manner, the plasma generator 10 generates plasma by producing a potential difference near the gas-liquid boundary of the liquid 20 and the bubble 24 in the liquid accommodation portion 15. The plasma generator 10 generates a larger amount of ozone, hy-

droxyl radicals, and the like by producing a potential difference near the gas-liquid boundary of the bubble 24 and the liquid 20 at the open end 13A of the gas passage 13, which is where hydroxyl radicals are easily generated. The plasma generator 10 also generates ozone, hydroxyl radicals, and the like in a bubble 24 delivered into the liquid accommodation portion 15 in addition to a bubble 24 near the open end 13A of the gas passage 13 that faces the liquid 20.

[0042] The flow of gas in the first movement direction 23 delivers ozone, hydroxyl radicals, and the like generated as described above to the liquid accommodation portion 15.

[0043] In the bubble emitting step, the plasma generator 10 uses the flow of the liquid 20 in the liquid accommodation portion 15 to shear the bubbles 24 containing hydroxyl radicals or the like from the partition wall 12 and release the bubbles 24 into the liquid 20.

[0044] As illustrated in Fig. 3B, the liquid 20 in the liquid accommodation portion 15 moves in the liquid accommodation portion 15 along the flow in a second movement direction 25. When the liquid 20 strikes a growing bubble 24, the flow of the liquid 20 acts as a shear force on the bubble 24. Bubbles 24 are released from the open end 13A of the gas passage 13 into the liquid 20.

[0045] The bubbles 24 released into the liquid 20 are fine and scattered in the entire liquid 20 without being immediately released into the atmosphere. Some of the scattered fine bubbles 24 easily dissolve into the liquid 20. When the bubbles 24 are dissolved in the liquid 20, the ozone dissolved from the bubbles 24 suddenly increases the ozone concentration of the liquid 20.

[0046] According to "Improvement of Water Environment Using Microbubble and Nanobubble," written by Masayoshi Takahashi for Aqua Net in June, 2004, fine bubbles containing ozone or each type of radicals are often charged negatively.

[0047] The remaining negatively charged bubbles 24 are easily adsorbed in organic matters, oil and fat matters, dyes, proteins, germs, and the like. The organic matters and the like in the liquid 20 are decomposed by the ozone or each type of radicals dissolved in the liquid 20 and the ozone or each type of radicals contained in the bubbles 24 that adsorbed in the organic matters and the like.

[0048] A hydroxyl radical has, for example, a relatively large energy of approximately 120 kcal/mol. The energy of a hydroxyl radical exceeds a bond energy (100 kcal/mol or less) including a nitrogen-nitrogen double bond (N=N), a carbon-carbon double bond (C=C), and a carbon-nitrogen double bond (C=N). Thus, hydroxyl radicals unbind and decompose organic matters and the like which are formed by the bonding of nitrogen, carbon, or the like. The ozone and hydroxyl radicals that decompose organic matters in such a manner are not residual like chlorine or the like and decompose as time elapses. The ozone and hydroxyl radicals are thus environmentally-friendly.

[0049] When the second electrode 19 arranged in the liquid accommodation portion 15 is formed from one of silver, a silver compound, and a silver mixture, and the second electrode 19 performs discharging between the first electrode 18 and the second electrode 19 with a lower potential than the first electrode 18, the second electrode 19 emits silver microparticles.

[0050] The liquid 20 and the gas near the open end 13A of the gas passage 13 will now be described with reference to Fig. 4.

[0051] When the second electrode 19 performs discharging between the first electrode 18 and the second electrode 19 with a lower potential than that at the first electrode 18, the second electrode 19 is sputtered so that silver microparticles 19B are emitted from a first portion 19C of the second electrode 19. The silver microparticles 19B, which are emitted from the second electrode 19 by the sputtering, are scattered in the liquid 20 in the liquid accommodation portion 15. Since the second electrode 19 is closer to the gas passage 13 than the first electrode 18, the second electrode 19 is effectively sputtered. This effectively emits the microparticles 19B.

[0052] The plasma generation device 1 has the advantages described below.

(1) The plasma generation device 1 includes the plasma generator 10, the plasma power supply 2, and the gas supplying unit 3. The plasma generator 10 includes the gas accommodation portion 14 and the liquid accommodation portion 15, which are partitioned by the partition wall 12 inside the case member 11. The gas accommodation portion 14 includes the first electrode 18. The liquid accommodation portion 15 includes the second electrode 19. The second electrode 19, including a portion paired with the first electrode 18, is arranged in the liquid accommodation portion 15 so that at least this portion contacts liquid. The second electrode 19 is formed from one of silver, a silver compound, and a silver mixture. The plasma power supply 2 performs discharging by applying a predetermined potential between the first electrode 18 and the second electrode 19 so that the potential at the second electrode 19 is lower than that of the first electrode 18. The plasma generator 10 generates plasma in regions of gas in the liquid 20 in the liquid accommodation portion 15 and generates hydroxyl radicals from the water contained in the liquid 20 and the oxygen contained in the gas. In this structure, the plasma generator 10 is capable of performing discharging between the first electrode 18 and the second electrode 19 while limiting the influence of the electrical resistance of the liquid 20. The second electrode 19 emits the silver microparticles 19B through sputtering, which occurs when discharging is performed. The silver microparticles 19B are scattered in the liquid 20 in the liquid accommodation portion 15. When cleaned subjects are arranged in the liquid accommodation portion 15, the

plasma generation device 1 generates plasma and forms ozone and radicals that decompose organic matters and the like which are collected on the cleaned subjects. Further, the plasma generation device 1 deposits the silver microparticles 19B, which are produced by the sputtering of the second electrode 19, on the cleaned subjects. Thus, when the plasma generation device 1 is applied to a cleaning device of an electronic device having a movable portion, the silver microparticles 19B can be deposited on the movable portion of the electronic device. This reduces the friction resistance of the movable portion and allows for smooth movement.

15 Second Embodiment

[0053] A cleaning device 30 of a second embodiment uses the plasma generation device 1 of the first embodiment. The plasma generation device 1 will not be described in detail.

[0054] The structure of the cleaning device 30 will now be described with reference to Fig. 5.

[0055] The cleaning device 30 serving as a cleaning device for a hair remover 100 (refer to Fig. 6) includes an opening 31, which receives the hair remover 100. The cleaning device 30 includes an operating unit 42, a display 43, and a ventilation window 44 on the front surface of a housing 40. The housing 40 includes a stand 41 on the back surface. The stand 41 includes a contact member 45 on the inner surface that defines the opening 31. The cleaning device 30 includes, on the back of the housing 40, a tank 50 that accommodates liquid serving as the cleaning liquid. A user inserts a cleaned subject into the opening 31.

[0056] The structure of the hair remover 100 serving as a cleaned subject will now be described with reference to Figs. 6A and 6B.

[0057] The hair remover 100 illustrated in Fig. 6A includes a grip 101 and a head 102. The grip 101 includes an operation switch 103. A user operates the operation switch 103 to control the operation of the hair remover 100. The head 102 includes a blade unit 104. The blade unit 104 includes, for example, two outer blades 105.

[0058] In the description hereafter, the direction extending from the grip 101 to the head 102 will be referred to as a front direction of a front-to-rear direction, the direction in which the two outer blades 105 are arranged will be referred to as a vertical direction, and the direction that perpendicularly intersects the vertical direction and the front-to-rear direction will be referred to as a sideward direction.

[0059] The outer blade 105 is curved and bulged toward the front to have a reversed U-shaped form. The outer blade 105 includes many slits (blade holes).

[0060] As illustrated in Fig. 6B, in the outer blade 105, the blade unit 104 includes a reversed U-shaped inner blade 106 that is arranged along the curvature of the outer blade 105. The inner blade 106 is oscillated in the

sideward direction by a drive force generated by a power source of the hair remover 100.

[0061] The hair remover 100 moves the inner blade 106 relative to the outer blade 105 in the sideward direction so that the outer blade 105 cooperates with the inner blade 106 to cut the body hairs inserted into the slits of the outer blade 105. That is, the inner blade 106 moves relative to the outer blade 105 in the sideward direction while an outer surface 106A of the inner blade 106 slides and contacts an inner surface 105A of the outer blade 105. The blade unit 104 is one example of a sliding unit. The outer surface 106A of the inner blade 106 and the inner surface 105A of the outer blade 105 each form a sliding surface 107. When cleaning the hair remover 100, a user inserts the hair remover 100 into the opening 31 of the cleaning device 30 with the blade unit 104 directed downward.

[0062] The structure of the cleaning device 30 that receives the hair remover 100 will now be described with reference to Fig. 7.

[0063] The cleaning device 30 includes the plasma generator 10, the plasma power supply 2, the gas supplying unit 3, a pan 60, the tank 50, an overflow portion 32, and a pump 70. The plasma generator 10, the plasma power supply 2, and the gas supplying unit 3 form the plasma generation device 1.

[0064] The pan 60 receives the head 102 of the hair remover 100, which is inserted through the opening 31. The tank 50 stores liquid serving as a cleaning liquid. The overflow portion 32 is in communication with the pan 60. The pump 70 circulates the liquid of the tank 50 in the cleaning device 30 through a circulation passage that will now be described. The cleaning device 30 includes a cartridge 80, an opening valve 33, and the circulation passage that circulates liquid. The cartridge 80 includes a filter 81 that filters the liquid. The opening valve 33 controls the sealing of the tank 50.

[0065] The circulation passage includes a liquid inlet passage 91, a drain passage 92, a first passage 93, a second passage 94, and a third passage 95. The liquid inlet passage 91 draws liquid from the tank 50 to the pan 60. The drain passage 92 draws the liquid drained from the pan 60 to the cartridge 80. The first passage 93 draws the liquid drained from the overflow portion 32 to the cartridge 80. The second passage 94 draws the liquid drained from the cartridge 80 to the pump 70. The third passage 95 draws the liquid delivered from the pump 70 to the tank 50. The opening valve 33 is connected to the tank 50 through an airtight passage 96.

[0066] Each of the components will now be described.

[0067] The stand 41 of the housing 40 contacts the grip 101 of the hair remover 100, which is inserted from the opening 31, and holds the hair remover 100 together with the pan 60. The contact member 45 is arranged on the inner surface of the stand 41. When the contact member 45 contacts a back terminal 108 arranged on the back surface of the grip 101 of the hair remover 100, the attachment of the hair remover 100 is detected. The contact

member 45 supplies a contact signal and drive power to the hair remover 100 when contacting the back terminal 108 of the hair remover 100.

[0068] The housing 40 includes a fan 34 in the upper front portion. The fan 34 dries the head 102 after the hair remover 100 is cleaned. The housing 40 includes a first connection port 46, a second connection port 47, and a third connection port 48, which are formed in the rear surface that contacts the tank 50. When the tank 50 is installed in the housing 40, the first connection port 46, the second connection port 47, and the third connection port 48 are in communication with a tank outlet port 51, a tank inlet port 52, and a tank ventilation port 53, respectively. The first connection port 46 is connected to the liquid inlet passage 91. The second connection port 47 is connected to the third passage 95. The third connection port 48 is connected to the airtight passage 96.

[0069] The pan 60 is recessed to conform to the shape of the head 102 of the hair remover 100. The bottom wall of the pan 60 includes a through hole 62. The plasma generator 10 is arranged on the back side of the bottom wall of the pan 60. The liquid accommodation portion 15 of the plasma generator 10 is in communication with the internal space of the pan 60 through the through hole 62. The internal space of the pan 60 stores liquid, which serves as a cleaning liquid, together with the liquid accommodation portion 15 of the plasma generator 10.

[0070] As illustrated in Fig. 8, the cleaning device 30 includes a heater 35 arranged on the back side of the bottom wall of the pan 60. The heater 35 dries the head 102 in cooperation with the fan 34.

[0071] The inlet of the overflow portion 32 is connected to the pan 60, and the outlet of the overflow portion 32 is connected to the first passage 93. The first passage 93 extends from the outlet port of the overflow portion 32 via a relay port 61, which is arranged on the rear portion of the pan 60, to the cartridge 80.

[0072] The tank 50 includes on the front surface the tank outlet port 51, the tank inlet port 52, and the tank ventilation port 53. The cleaning device 30 opens the tank ventilation port 53 to control the discharge of liquid from the tank outlet port 51. When the tank 50 is installed in the housing 40, the tank outlet port 51 is connected to the first connection port 46 to draw liquid from the tank 50 to the pan 60 through the liquid inlet passage 91. The tank inlet port 52 is connected to the second connection port 47 and is connected to a delivery port 71 of the pump 70 through the third passage 95. The tank ventilation port 53 is connected to the third connection port 48 and to the opening valve 33 through the airtight passage 96.

[0073] The cartridge 80 is box-shaped and accommodates the filter 81. The upper portion of the cartridge 80 includes a cartridge inlet port 82 and the front portion of the cartridge 80 includes a cartridge outlet port 83. The cartridge 80 is arranged in the lower rear portion in a removable manner. When the cartridge 80 is installed in the housing 40, the cartridge inlet port 82 is connected to a pan drain port 63 through the drain passage 92 and

to the outlet of the overflow portion 32 through the first passage 93. The cartridge outlet port 83 is connected to a suction port 72 of the pump 70 through the second passage 94.

[0074] The operation of the cleaning device 30 will now be described.

[0075] A user attaches the hair remover 100 to the cleaning device 30 so that the pan 60 receives the downwardly directed head 102.

[0076] In accordance with the user's operation of the operating unit 42, the cleaning device 30 draws liquid into the pan 60 and the liquid accommodation portion 15 of the plasma generation device 1 from the tank 50 through the liquid inlet passage 91. The gas supplying unit 3 delivers gas containing oxygen, which is based on air, at a predetermined flow rate into the gas accommodation portion 10 of the plasma generator 10. This shifts the gas accommodation portion 14 to a positive pressure condition and forms a flow of gas toward the liquid accommodation portion through the gas passage 13.

[0077] The plasma generator 10 includes the second electrode 19, which is arranged in the liquid accommodation portion 15 and is formed from one of silver, a silver compound, and a silver mixture. The plasma power supply 2 performs discharging between the first electrode 18 and the second electrode 19 by applying a predetermined voltage between the first electrode 18 and the second electrode 19 so that the potential at the second electrode 19 is lower than that at the first electrode 18. The plasma generator 10 performs discharging between the surface of the first electrode 18 that contacts gas and the surface of the second electrode 19 that contacts liquid. The discharging generates plasma in regions of gas in the liquid 20 in the liquid accommodation portion 15. The plasma generation device 1 generates plasma at the open end 13A of the gas passage 13 so that ozone, hydroxyl radicals, and the like are generated from the water contained in the liquid and the oxygen contained in the gas.

[0078] The flow of gas delivers the generated ozone and radicals into the liquid 20, which is stored in the liquid accommodation portion 15 and the pan 60. The gas accommodation portion 14 supplies gas containing oxygen to the liquid accommodation portion 15 so that fine bubbles 24 containing gas grow at the open end 13A of the gas passage 13, which faces the liquid accommodation portion 15. The grown bubbles 24 are released from the open end 13A into the liquid 20 and scattered in the entire liquid 20. The liquid 20, which is stored in the pan 60 and the liquid accommodation portion 15 of the plasma generator 10, functions as a cleaning liquid in which ozone and radicals are dissolved.

[0079] The plasma generation device 1 emits the silver microparticles 19B from the second electrode 19 through sputtering. The emitted silver microparticles 19B are scattered into the liquid 20 in the liquid accommodation portion 15. The liquid 20, which is stored in the pan 60 and the liquid accommodation portion 15 of the plasma generator 10, functions as a cleaning liquid in which the

silver microparticles 19B are contained and ozone and radicals are dissolved.

[0080] The structure of the plasma generator 10 of the cleaning device 30 to which the plasma generation device 1 is applied and the structure of the blade unit 104 of the hair remover 100 will now be described with reference to Fig. 9.

[0081] The sliding surfaces 107 of the blade unit 104 serving as a sliding unit of the hair remover 100, namely, the inner surfaces 105A of the outer blade 105 and the outer surfaces 106A of the inner blade 106, face the plasma generator 10 in the vicinity of at least one of the first electrode 18 and the second electrode 19. At least a portion of the sliding surfaces 107 is arranged facing the plasma generator 10 at a location where the portion does not hinder movement of the silver microparticles 19B emitted from the second electrode 19.

[0082] The location where the movement of the silver microparticles 19B is not hindered refers to a location where the movement of the silver microparticles 19B emitted from the second electrode 19 is not hindered by a solid such as a wall so that the silver microparticles 10B reach the sliding surface 107. The cleaning liquid, which serves as a liquid, and air that contact the second electrode 19 and the sliding surfaces 107 do not hinder the movement of the silver microparticles 19B.

[0083] The cleaning device 30 has the following advantage.

(2) The cleaning device 30 includes the plasma generator 10, the plasma power supply 2, the gas supplying unit 3, the pan 60, the tank 50, the overflow portion 32, and the pump 70. The plasma generator 10, the plasma power supply 2, and the gas supplying unit 3 form the plasma generation device 1. The pan 60 receives the head 102 of the hair remover 100, which is inserted through the opening 31. The pan 60 and the liquid accommodation portion 15 of the plasma generator 10 store liquid that serves as a cleaning liquid. The plasma generator 10 includes the second electrode 19, which is arranged in the liquid accommodation portion 15 and is formed from one of silver, a silver compound, and a silver mixture. The plasma power supply 2 performs discharging between the first electrode 18 and the second electrode 19 by applying a predetermined voltage between the first electrode 18 and the second electrode 19 so that the potential at the second electrode 19 is lower than that at the first electrode 18. The plasma generator 10 generates plasma in regions of gas in the liquid 20 in the liquid accommodation portion 15 and generates hydroxyl radicals from the water contained in the liquid 20 and the oxygen contained in the gas. The plasma generator 10 emits the silver microparticles 19B from the second electrode 19 through sputtering. The flow of gas delivers the generated ozone and radicals and the silver microparticles 19B into the liquid 20, which is stored in the

liquid accommodation portion 15 and the pan 60. The liquid 20 functions as a cleaning liquid. In this structure, the liquid 20, which functions as the cleaning liquid, is supplied to the head 102 that functions as a cleaned subject. Thus, the organic matters and the like collected on the head 102 are effectively decomposed by the ozone and radicals dissolved in the liquid 20 and the ozone and radicals contained in the bubble 24. The cleaning device 30 deposits the silver microparticles 19B on the sliding surface 107 of the blade unit 104 of the hair remover 100. The cleaning device 30 decomposes the organic matters and the like collected on the head 102 to reduce friction and limit wear of the sliding surface 107. This allows for reduction in the amount of lubricant added to a cleaning liquid, the number of times that the cleaning liquid is replaced, and the number of times that the cleaning liquid is added. Thus, maintenance is facilitated in the cleaning device 30.

Third Embodiment

[0084] The plasma generation device 1 of a third embodiment differs from the plasma generation device 1 of the first embodiment in the points described below but otherwise has the same structure. Same reference numerals are given to those components that are the same as the corresponding components of the plasma generation device 1 of the first embodiment. Such components will not be described in detail.

[0085] The second electrode 19 of the plasma generation device 1 in the first embodiment has a toroidal shape and is formed from one of silver, a silver compound, and a silver mixture. As illustrated in Figs. 10A and 10B, the plasma generation device 1 of the third embodiment includes a second electrode 26 formed from one of silver, a silver compound, and a silver mixture. The second electrode 26 includes an opposing surface 26A opposed to at least the gas that passes through the gas passage 13. The surface roughness of the opposing surface 26A has a maximum height value that exceeds 10 μm .

[0086] The structure of the plasma generator 10 of the third embodiment will now be described with reference to Figs. 10A and 10B.

[0087] As illustrated in Fig. 10A, the plasma generator 10 includes the second electrode 26 arranged in the liquid accommodation portion 15. In the same manner as the first embodiment, it is desirable that the second electrode 26 be closer to the gas passage 13 than the first electrode 18. The second electrode 26 is, for example, a silver sinter. The second electrode 26 is, for example, a silver sinter having an average particle size of 100 μm and a density of 90%.

[0088] As illustrated in the enlarged view of Fig. 10B, the surface of the second electrode 26 serving as a silver sinter includes irregularities.

[0089] When discharging occurs between the elec-

trodes 18 and 26 with a lower potential applied to the second electrode 26 than the first electrode 18, the surface irregularities of the second electrode 26 locally increase the height of the electric field applied to the second electrode 26. Thus, the second electrode 26 emits more silver microparticles through sputtering. The emitted silver microparticles are drawn into the liquid accommodation portion 15 along the flow of gas in the first movement direction 23, which is formed by the gas accommodation portion 14.

[0090] Thus, it is effective for the second electrode 26 to include the irregularities in the surface of the opposing surface 26A that is opposed to the flow of gas in the first movement direction 23. In this case, it is desirable that the surface roughness of the surface including irregularities have a maximum height value that exceeds 10 μm .

[0091] The plasma generation device 1 of the third embodiment has advantage (1) of the plasma generation device 1 of the first embodiment. More specifically, the third embodiment has an advantage in that the application of a lower potential to the second electrode 26 than the first electrode 18 causes discharging that generates and draws the silver microparticles 19B in addition to ozone, radicals, and the like into the liquid accommodation portion 15. The plasma generation device 1 also has the advantages described below.

(3) The plasma generation device 1 includes the plasma generator 10, the plasma power supply 2, and the gas supplying unit 3. The plasma generator 10 includes the gas accommodation portion 14 and the liquid accommodation portion 15 partitioned by the partition wall 12 inside the case member 11. The plasma generator 10 includes the first electrode 18 arranged in the gas accommodation portion 14. The plasma generator 10 includes the second electrode 26 in the liquid accommodation portion 15. The second electrode 26 includes the opposing surface 26A that is formed from one of silver, a silver compound, and a silver mixture and is opposed to at least the gas that passes through the gas passage 13. The surface roughness of the opposing surface 26A has a maximum height value that exceeds 10 μm . The plasma power supply 2 performs discharging between the first electrode 18 and the second electrode 26 by applying a predetermined voltage between the first electrode 18 and the second electrode 26 so that the potential at the second electrode 26 is lower than that at the first electrode 18. In this structure, when the plasma generator 10 generates plasma and generates hydroxyl radicals in the liquid 20, the second electrode 26 can emit more silver microparticles 19B. Thus, the plasma generation device 1 can deposit more silver microparticles 19B on a deposited subject when arranging the deposited subject in the liquid accommodation portion 15.

(4) The plasma generation device 1 is applied to the cleaning device 30 for the hair remover 100. The

plasma generation device 1 includes the plasma generator 10, the plasma power supply 2, and the gas supplying unit 3. The plasma generator 10 includes the first electrode 18 and the second electrode 26. The plasma power supply 2 performs discharging between the first electrode 18 and the second electrode 26 by applying a lower potential to the second electrode 26 than the first electrode 18. The second electrode 26 includes the opposing surface 26A that is formed from one of silver, a silver compound, and a silver mixture and is opposed to at least the gas that passes through the gas passage 13. The surface roughness of the opposing surface 26A has a maximum height value that exceeds 10 μm . The cleaning device 30 includes the plasma generation device 1. At least a portion of the sliding surfaces 107 of the blade unit 104 of the hair remover 100 faces the plasma generator 10 at a location where the portion does not hinder the movement of the silver microparticles 19B from the second electrode 26. In this structure, many silver microparticles 19B emitted from the second electrode 26 can be deposited on the sliding surface 107 of the blade unit 104 through sputtering. This restricts the occurrence of seizing when cleaning the hair remover 100, in which the large friction resistance of the sliding surfaces 107 has a tendency of causing seizing.

Fourth Embodiment

[0092] The plasma generation device 1 of a fourth embodiment differs from the plasma generation device 1 of the third embodiment in the points described below but otherwise has the same structure. Same reference numerals are given to those components that are the same as the corresponding components of the plasma generation device 1 of the third embodiment. Such components will not be described in detail.

[0093] In the plasma generation device 1 of the third embodiment, the second electrode 26 is formed from a silver sintered body. As illustrated in Figs. 11A and 11B, the plasma generation device 1 of the fourth embodiment includes a second electrode 27 formed from a gas-permeable porous metal.

[0094] The structure of the plasma generator 10 will now be described with reference to Figs. 11A and 11B.

[0095] As illustrated in Fig. 11A, the plasma generator 10 includes the second electrode 27, which is arranged in the liquid accommodation portion 15. In the same manner as the first embodiment, it is desirable that the second electrode 27 be closer to the gas passage 13 than the first electrode 18. The second electrode 27 is formed from, for example, a circular silver porous metal having a packing factor of 10%. The second electrode 27 is arranged in the liquid accommodation portion 15 so that the second electrode 27 covers the gas passage 13, which is formed in the partition wall 12.

[0096] As illustrated in the enlarged view of Fig. 11B,

the flow of air formed in the gas accommodation portion 14 in the first movement direction 23 is drawn into the liquid accommodation portion 15 through the large number of holes in the second electrode 27.

[0097] When discharging occurs between the electrodes 18 and 27 with a lower potential applied to the second electrode 27 than the first electrode 18, the second electrode 27 emits the silver microparticles 19B through sputtering. The emitted silver microparticles 19B are drawn into the liquid accommodation portion 15 through the large number of holes in the second electrode 27 along the flow of gas in the first movement direction 23, which is formed by the gas accommodation portion 14.

[0098] The plasma generation device 1 of the fourth embodiment has advantage (1) of the plasma generation device 1 in the first embodiment. More specifically, the advantage of the fourth embodiment is in that the application of lower potential to the second electrode 27 than the first electrode 18 causes discharging that generates and draws the silver microparticles 19B in addition to ozone, radicals, and the like into the liquid accommodation portion 15. The plasma generation device 1 also has the following advantage.

(5) The plasma generation device 1 includes the plasma generator 10, the plasma power supply 2, and the gas supplying unit 3. The plasma generator 10 includes the gas accommodation portion 14 and the liquid accommodation portion 15 partitioned by the partition wall 12 inside the case member 11. The plasma generator 10 includes the first electrode 18 arranged in the gas accommodation portion 14. The plasma generator 10 includes the second electrode 27 arranged in the liquid accommodation portion 15. The second electrode 27 is formed from a gas-permeable porous metal. The plasma power supply 2 performs discharging between the first electrode 18 and the second electrode 27 by applying a predetermined voltage between the first electrode 18 and the second electrode 27 so that the potential at the second electrode 27 is lower than that at the first electrode 18. In this structure, when the plasma generator 10 generates plasma and generates hydroxyl radicals in the liquid 20, the second electrode 27 can emit the silver microparticles 19B. The emitted silver microparticles 19B are drawn into the liquid accommodation portion 15 through many voids (holes). In this structure, the plasma generation device 1 uses the second electrode 27 to limit clogging of the gas passage 13 caused by silicon, calcium, and the like, which are deposited from the liquid in the liquid accommodation portion 15. Thus, the plasma generation device 1 can stably generate hydroxyl radicals and the like and emit the silver microparticles 19B.

Other Embodiments

[0099] The present generation device and cleaning device include embodiments other than the first to fourth embodiments. Modified examples of the first to fourth embodiments will now be described as other embodiments of the present generation device and cleaning device. The modified examples described below can be combined with each other.

[0100] The plasma generation device 1 of the first embodiment includes the partition wall 12 that serves as a partition wall having the gas passage 13. However, the partition wall and the gas passage 13 are not limited to the structure illustrated in the first embodiment. The partition wall of the plasma generation device 1 of a modified example is formed by, for example, a glass plate. The glass plate includes a hole, which is formed by photoengraving and etching. The hole functions as the gas passage 13. The hole of the glass plate is fine and has a diameter of approximately 1 μm to 10 μm . Other materials can be used instead of a glass plate.

[0101] In the plasma generation device 1 of the first embodiment, the gas supplying unit 3 supplies the gas in the atmosphere to the gas accommodation portion 14. The gas supplied by the gas supplying unit 3 is not limited to that described in the first embodiment. For example, the gas supplying unit 3 of the plasma generation device 1 of the modified example supplies gas having an oxygen concentration that differs from that of the atmosphere. The gas supplying unit 3 may include a gas type selecting unit. In this case, the gas type selecting unit is configured to supply one selected from the gases in the atmosphere and other types of gases.

[0102] In the plasma generation device 1 of the first embodiment, the partition wall 12 serving as a partition wall includes the gas passage 13. The partition wall and the gas passage 13 are not limited to the structure of the first embodiment. For example, the partition wall of the plasma generation device 1 in a modified example includes a plurality of gas passages.

[0103] In the cleaning device 30 of the second embodiment, the pan 60 includes the drain port 63. The pan is not limited to the structure of the second embodiment. For example, the pan 60 of the cleaning device 30 in a modified example includes a drainage groove to drain liquid from the drain passage 92.

[0104] The second electrode 27 of the plasma generation device 1 of the fourth embodiment is formed from an air-permeable porous metal. The second electrode 27 is not limited to the structure of the fourth embodiment. For example, the second electrode 27 is meshed in the plasma generation device 1 of a modified example.

Claims

1. A plasma generation device comprising a plasma generator, a plasma power supply, and a gas sup-

plying unit, the plasma generation device characterized in that:

the plasma generator includes
 a liquid accommodation portion configured to accommodate liquid containing at least water,
 a gas accommodation portion configured to accommodate gas,
 a partition wall configured to partition the liquid accommodation portion and the gas accommodation portion, wherein the partition wall includes a gas passage configured to draw the gas from the gas accommodation portion into the liquid accommodation portion,
 a first electrode arranged in the gas accommodation portion, and
 a second electrode arranged in the liquid accommodation portion so that at least a portion paired with the first electrode contacts liquid in the liquid accommodation portion;
 the gas supplying unit is configured to supply the gas containing at least oxygen to the gas accommodation portion;
 the plasma power supply is configured to generate potentials supplied to the first electrode and the second electrode and set the potential at the second electrode to a lower value than the potential at the first electrode; and
 the second electrode is formed from one of a material, a material compound, and a material mixture that causes sputtering.

2. The plasma generation device according to claim 1, wherein the second electrode is formed from one of silver, a silver compound, and a silver mixture as one of the material, the material compound, and the material mixture that causes the sputtering.
3. The plasma generation device according to claim 1 or 2, wherein the second electrode includes an opposing surface formed from one of the material, the material compound, and the material mixture that causes the sputtering, wherein the opposing surface is opposed to the gas that passes through at least the gas passage, and has a surface roughness of a maximum height value that exceeds 10 μm .
4. The plasma generation device according to claim 1 or 2, wherein the second electrode is gas-permeable so that the gas in the gas accommodation portion passes through the second electrode and is supplied to the liquid accommodation portion.
5. A cleaning device comprising the plasma generation device according to any one of claims 1 to 4, wherein the cleaning device is configured to emit microparticles from the second electrode through the sputtering so that the microparticles are deposited on a

cleaned subject.

6. The cleaning device according to claim 5, wherein the cleaning device is applicable when cleaning a hair remover so that the microparticles emitted from the second electrode are deposited on the cleaned subject of the hair remover. 5

7. The cleaning device according to claim 6, wherein: 10
- the hair remover includes a blade unit including a sliding surface, and
- at least a portion of the sliding surface is arranged at a location where the portion of the sliding surface does not hinder movement of the microparticles emitted from the second electrode. 15

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Fig.1

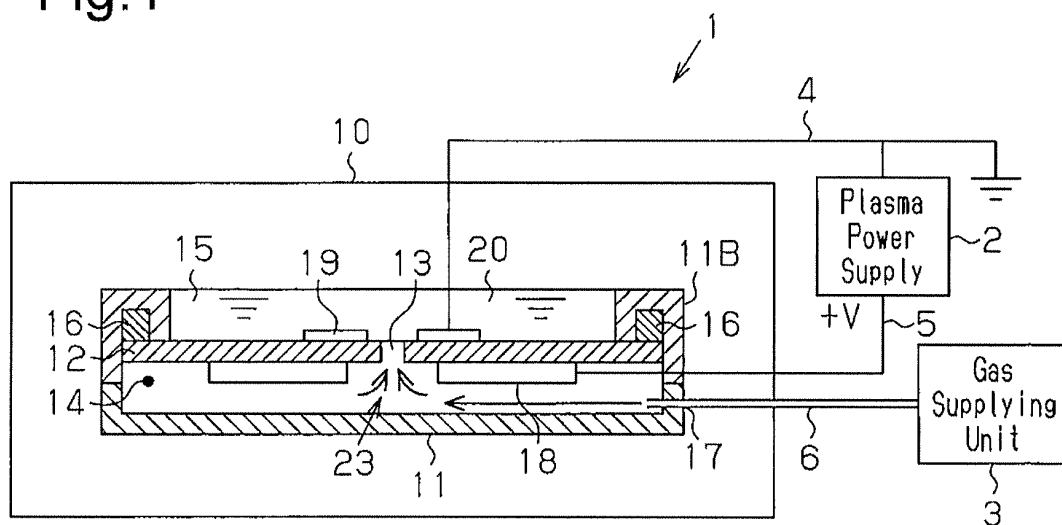


Fig.2

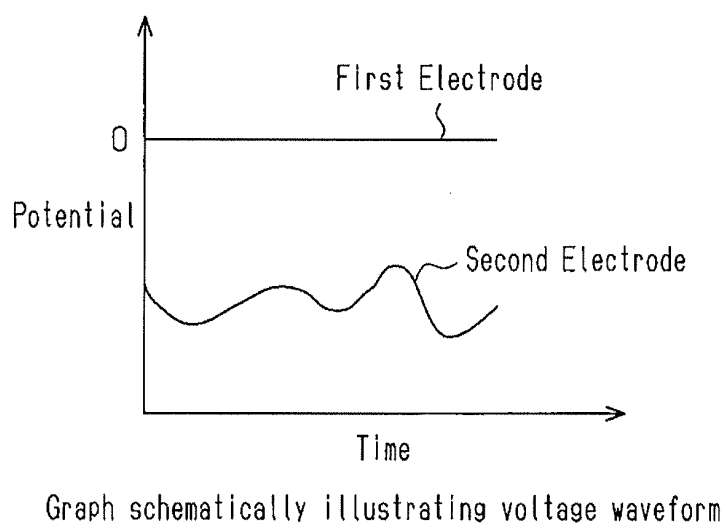


Fig.3A

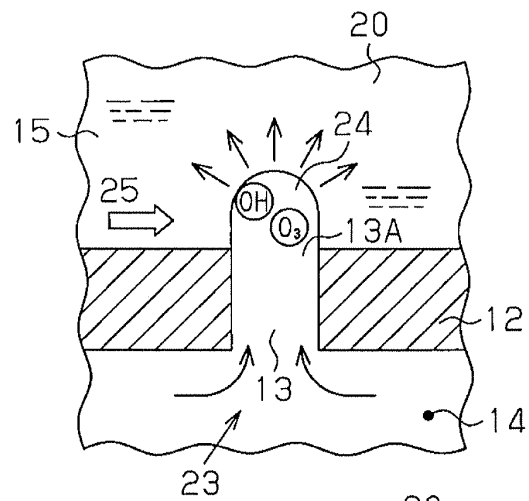


Fig.3B

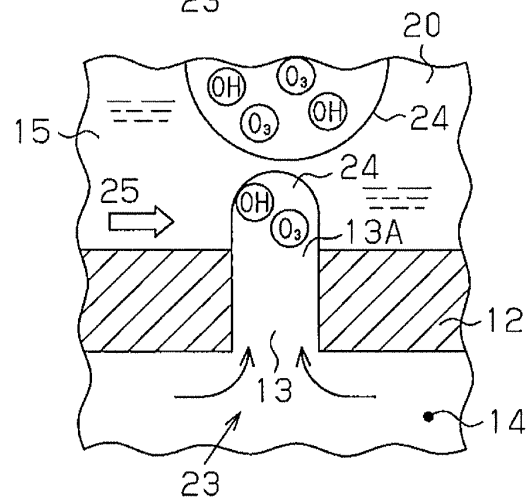


Fig.4

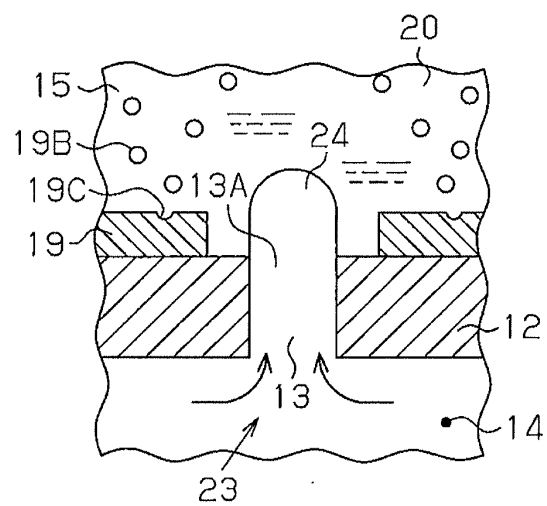


Fig.5

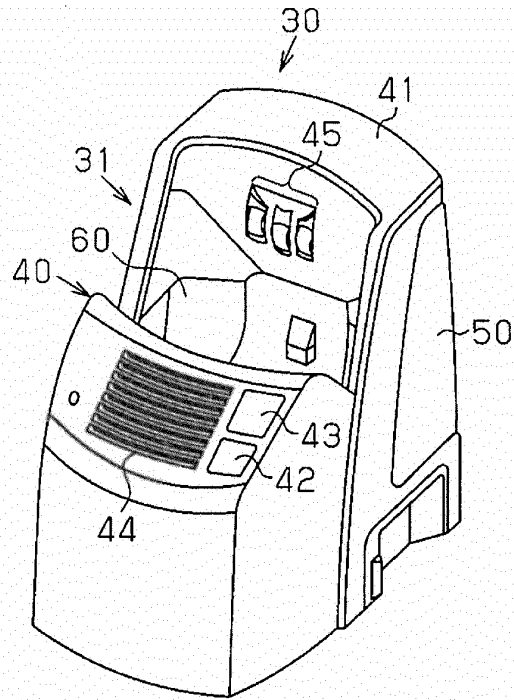


Fig.6A

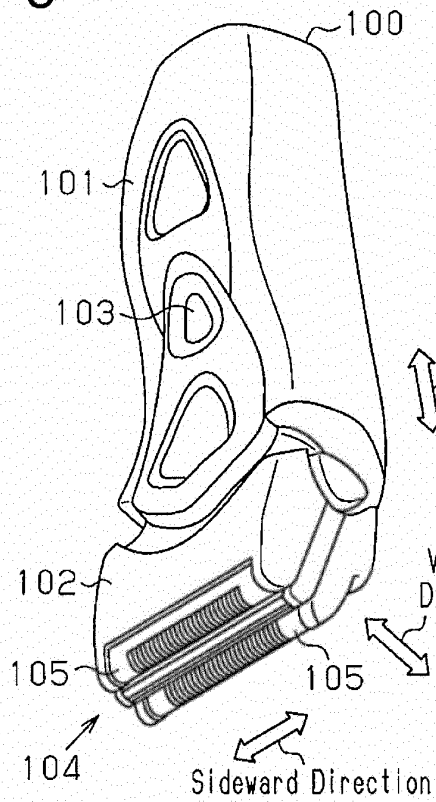


Fig.6B

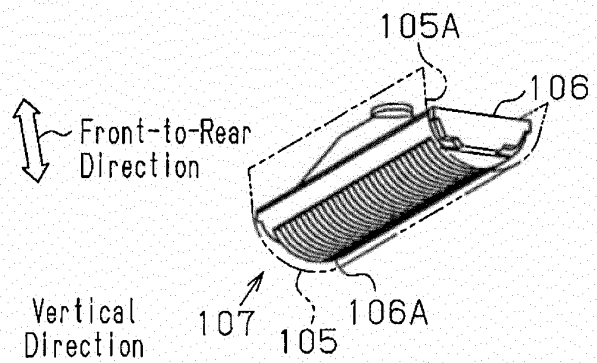


Fig.7

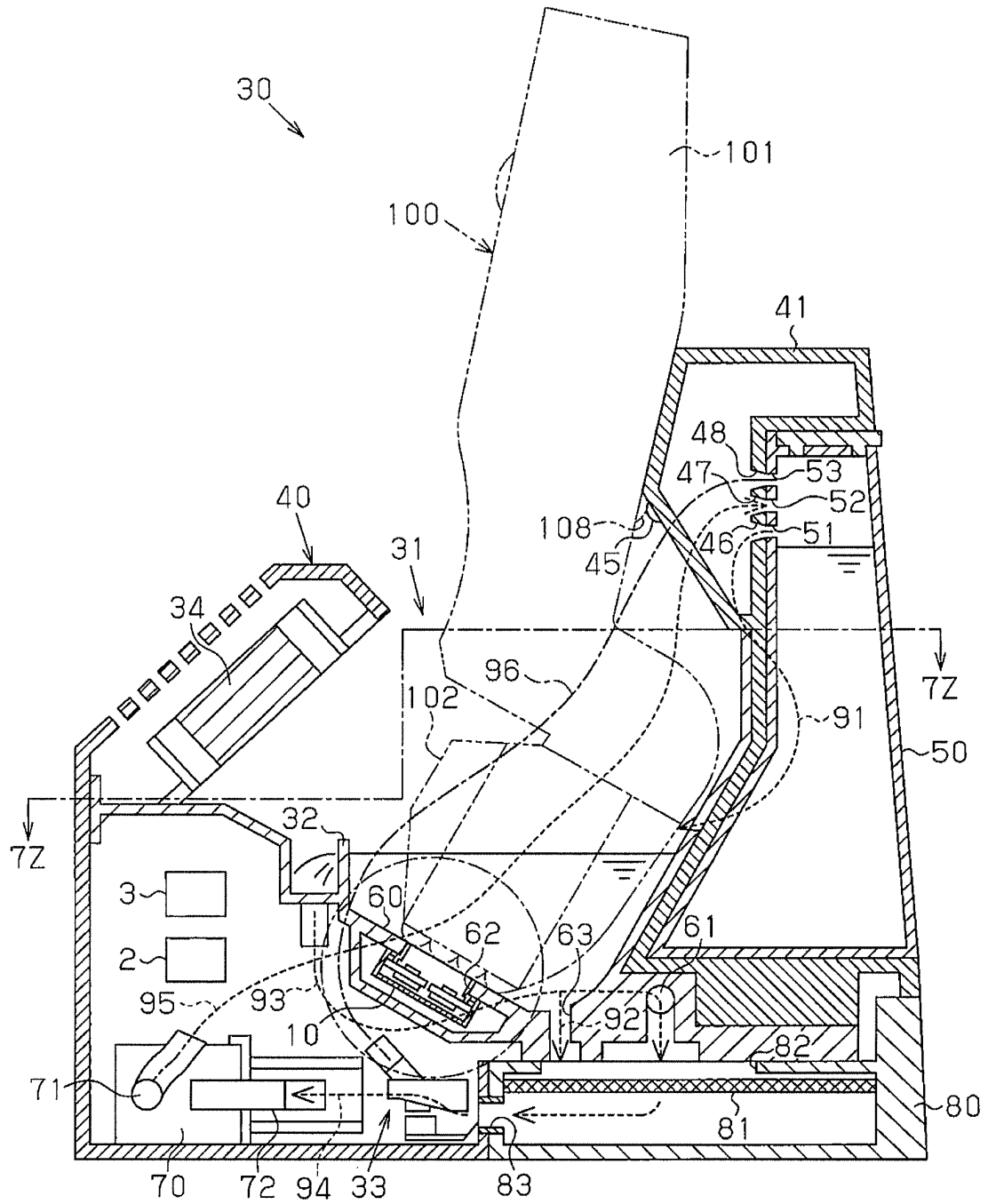


Fig.8

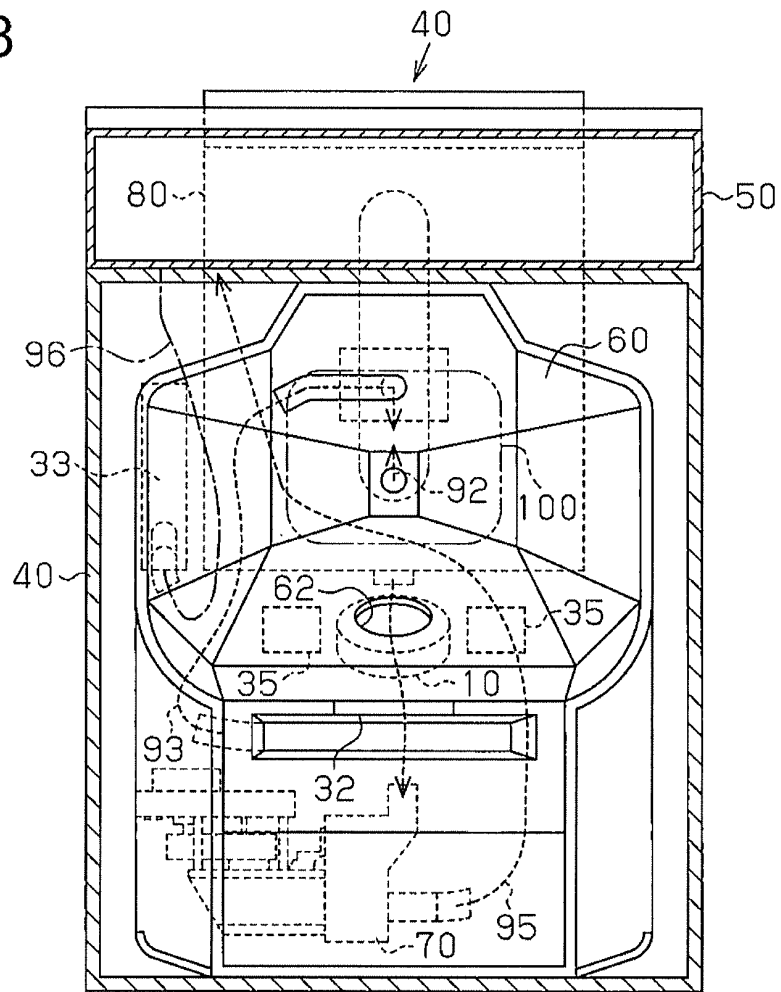


Fig.9

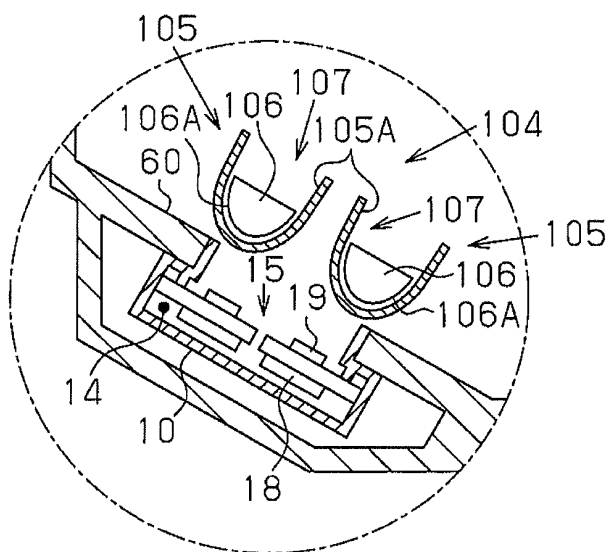


Fig.10A

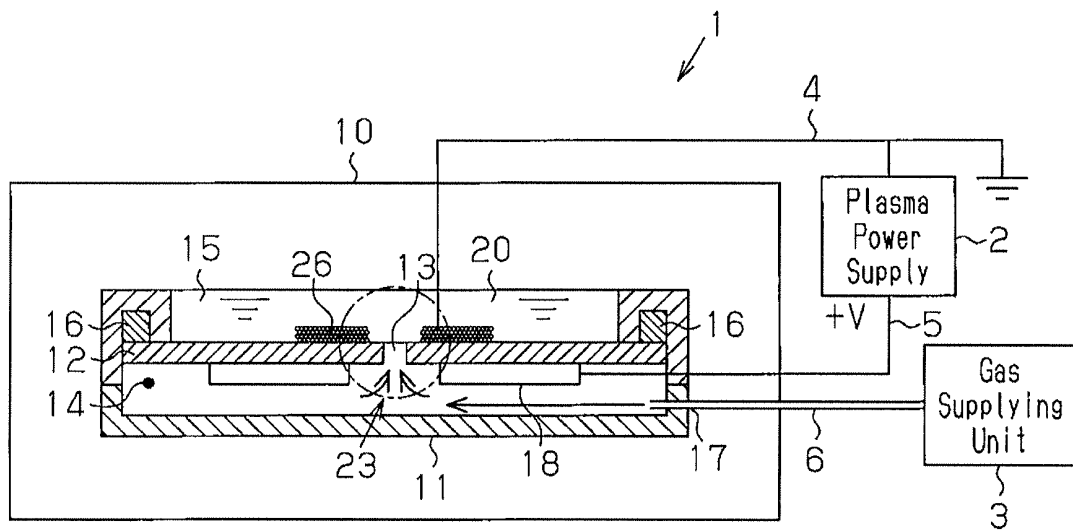


Fig.10B

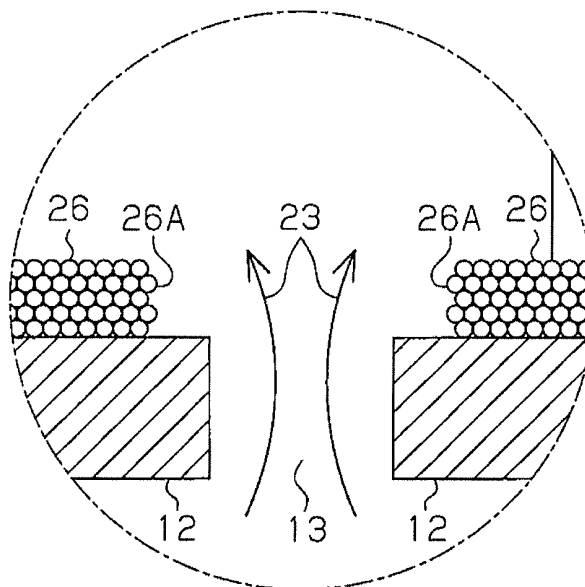


Fig.11A

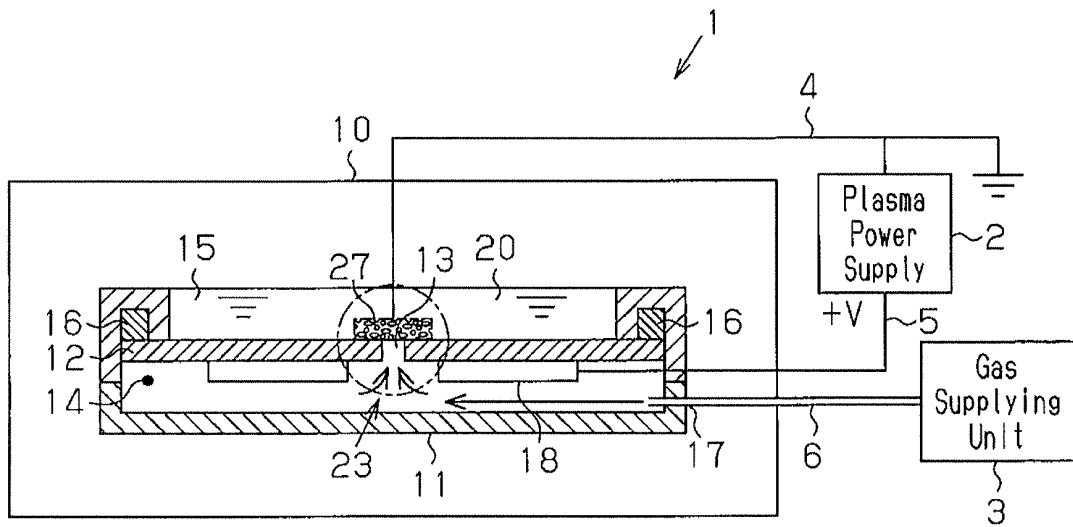
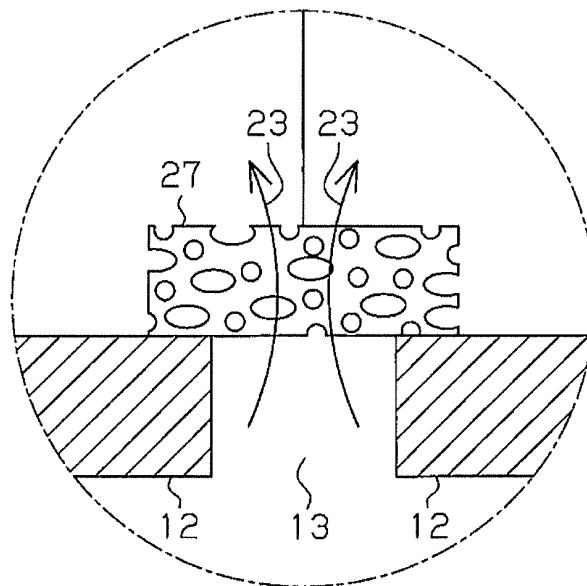


Fig.11B



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/006935

A. CLASSIFICATION OF SUBJECT MATTER

H05H1/24(2006.01)i, A45D27/46(2006.01)i, B08B3/10(2006.01)i, B08B7/00(2006.01)i, B26B19/48(2006.01)i

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)

H05H1/00-1/54, A45D27/46, B08B3/10, B08B7/00, B26B19/48, B01J10/00-12/02, B01J14/00-19/32, C02F1/46-1/465, C02F1/469-1/48, C02F1/70-1/78

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 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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.
P, X P, A	WO 2013/080435 A1 (Panasonic Corp.), 06 June 2013 (06.06.2013), entire text; all drawings & JP 2013-111312 A	1, 5-7 2-4
A	JP 2012-043769 A (Panasonic Corp.), 01 March 2012 (01.03.2012), entire text; all drawings & US 2013/0098753 A1 & EP 2597938 A1 & WO 2012/011332 A1 & CN 102960073 A	1-7
A	JP 2008-178870 A (Sharp Corp.), 07 August 2008 (07.08.2008), paragraphs [0073] to [0086]; fig. 8 to 14 & JP 2012-227149 A	1-7

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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"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

"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

"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

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"&" document member of the same patent family

Date of the actual completion of the international search
16 January, 2014 (16.01.14)

Date of mailing of the international search report
28 January, 2014 (28.01.14)

Name and mailing address of the ISA/
Japanese Patent Office

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Facsimile No.

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Patent documents cited in the description

- JP 2012043769 A [0003]