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(54) CLEANING DEVICE AND CLEANING METHOD

REINIGUNGSVORRICHTUNG UND REINIGUNGSVERFAHREN

DISPOSITIF DE NETTOYAGE ET PROCÉDÉ DE NETTOYAGE

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(73) Proprietor: **Ricoh Company, Ltd.**
Tokyo 143-8555 (JP)

(72) Inventors:
- **SATOH, Tatsuya**
Machida-shi
Tokyo 194-0022 (JP)
- **OKAMOTO, Yoichi**
Atsugi-shi
Kanagawa 243-0032 (JP)
- **FUCHIGAMI, Akihiro**
Yokohama-shi
Kanagawa 240-0062 (JP)
- **TANEDA, Yuusuke**
Ebina-shi
Kanagawa 243-0405 (JP)

(74) Representative: **Schwabe - Sandmair - Marx**
Patentanwälte
Stuntzstraße 16
81677 München (DE)

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Description

TECHNICAL FIELD

[0001] A certain aspect of the present invention relates to a cleaning device and a cleaning method for removing a deposit adhering to an object using solid cleaning media.

BACKGROUND ART

[0002] Generally, in a soldering process, a viscous liquid called "flux" is sprayed onto a substrate to improve the wettability of solder. The flux adheres to a printed circuit board (PCB) or a jig called "pallet" for holding the PCB because of the heat of solder. Therefore, it is necessary to remove the adhering flux from the pallet.

[0003] The pallet is now widely used in soldering processes and is made of an epoxy resin containing glass fibers. Since the pallet is repeatedly used for soldering processes, the flux accumulates to form a thick layer and becomes difficult to remove.

[0004] Meanwhile, manufacturers of office equipment such as copiers and laser printers are actively engaged in recycling activities to achieve a resource recycling society. In the recycling activities, the manufactures collect used products from users, disassemble the products into parts, and clean and reuse the parts for making new products.

[0005] For example, the manufacturers are trying to promote effective use of resources by recycling the bodies (base tubes) of photosensitive drums of image forming apparatuses.

[0006] Normally, photosensitive drums are recycled as raw materials, or their base tubes are reused by removing the photosensitive layers with a remover (parting agent), by abrasive blasting, or by grinding. However, when photosensitive drums are recycled as raw materials, it is necessary to produce base tubes again from the raw materials. Therefore, this method is not preferable in terms of energy consumption, effects on the environment, and production costs.

[0007] When a remover is used to remove a photosensitive layer of a photosensitive drum or a flux adhering to a pallet, the remover cannot be used repeatedly because resin dissolved in the remover may adhere again to the base tube or the pallet. Therefore, this method is not preferable in terms of recycling costs. Also, disposal of the remover where a deposit such as a coating or a flux is dissolved may cause another environmental problem. Further, there is a safety problem when a highly-flammable solvent is used for the remover. Meanwhile, with cleaning methods by abrasive blasting or grinding, it is necessary to clean and dry abrasive materials or abrasive grains after the cleaning process. Therefore, these methods require much energy and high costs for the disposal of the waste liquid and the drying process. Also, with these methods, pallets and base tubes may be deformed during the cleaning process.

[0008] The applicant has previously proposed a cleaning device using cleaning media in an effort to solve or reduce the above problems. The proposed cleaning device uses flexible cleaning media shaped like flakes and is configured to remove a deposit adhering to an object by causing the cleaning media to collide with the deposit. Although the proposed cleaning device is effective for removing a deposit of particles such as toner or dust, it is not highly effective for removing a film-like deposit covering an object.

[Patent document 1] Japanese Patent Application Publication No. 2007-144395
[Patent document 2] Japanese Patent Application Publication No. 2007-029945
[Patent document 3] Japanese Patent Application Publication No. 2007-330947
[Patent document 4] Japanese Patent Application Publication No. 2007-245079

[0009] Other related prior art can be found in US 2008/052953, JP2008062148, US5820447 and US2699403.

SUMMARY OF THE INVENTION

[0010] Aspects of the present invention provide a cleaning device and a cleaning method that solve or reduce one or more problems caused by the limitations and disadvantages of the related art.

[0011] An aspect of the present invention provides a cleaning device for removing a deposit adhering to an object to be cleaned. The cleaning device includes a cleaning chamber forming a space for housing multiple cleaning media shaped like flakes; a circulating air-flow generating unit configured to generate a circulating air flow to cause the cleaning media to fly and repeatedly collide with the object in the cleaning chamber and thereby to remove the deposit adhering to the object; and a cleaning medium recycling unit configured to suction and remove the deposit adhering to the cleaning media that have collided with the object and thereby to recycle the cleaning media. The pencil hardness of the cleaning media is greater than the pencil hardness of the deposit.

[0012] Another aspect of the present invention provides a method of removing a deposit adhering to an object to be cleaned. The method includes the steps of causing multiple cleaning media shaped like flakes to fly and repeatedly collide with the object in a cleaning chamber by a circulating air flow to remove the deposit adhering to the object; and suctioning and removing the deposit adhering to the cleaning media that have collided with the object to recycle the cleaning media. The pencil hardness of the cleaning media is greater than the pencil hardness of the deposit.

[0013] Still another aspect of the present invention provides a cleaning medium shaped like a flake and used in a cleaning device for removing a deposit adhering to an object to be cleaned. The cleaning device is configured to cause the cleaning medium to fly and repeatedly collide with the object in a cleaning chamber by using a circulating air flow to remove the deposit adhering to the object and configured to suction and remove the deposit adhering to the cleaning medium that has collided with the object to recycle the cleaning medium. The pencil hardness of the cleaning medium is greater than the pencil hardness of the deposit.

BRIEF DESCRIPTION OF DRAWINGS

[0014]

FIGs. 1A through 1C are drawings illustrating a configuration of a cleaning device according to an embodiment of the present invention;
FIGs. 2A and 2B are enlarged cut-away side views of a part around a cleaning chamber unit;
FIGs. 3A and 3B are perspective views of a holding unit;
FIGs. 4A and 4B are drawings illustrating removal of a deposit by sliding contact;
FIGs. 5A and 5B are enlarged views of parts of FIGs. 4A and 4B;
FIG. 6 is a drawing illustrating a collision in a different condition;
FIG. 7 is a drawing illustrating plastic deformation of a cleaning medium over time;
FIGs. 8A through 8D are drawings used to describe mechanical and physical properties of cleaning media;
FIG. 9 is a drawing illustrating a variation of a cleaning medium;
FIG. 10 is a drawing illustrating a variation of a cleaning medium;
FIG. 11 is a drawing illustrating a variation of a cleaning medium;
FIG. 12 is a drawing illustrating a variation of a cleaning medium;
FIG. 13 is a drawing illustrating a variation of a cleaning medium;
FIG. 14 is a drawing illustrating a variation of a cleaning medium;
FIG. 15 is a drawing illustrating a variation of a cleaning medium;
FIG. 16 is a drawing illustrating a variation of a cleaning medium;
FIG. 17 is a drawing illustrating a variation of a cleaning medium;
FIG. 18 is a drawing illustrating a variation of a cleaning medium;
FIG. 19 is a drawing illustrating a variation of a cleaning medium;
FIG. 20 is a drawing illustrating a configuration of a cleaning device according to another embodiment of the present invention;
FIGs. 21A and 21B are drawings illustrating operations of the cleaning device of FIG. 20;
FIG. 22 is a drawing illustrating a circulating air-flow generating unit;
FIGs. 23A and 23B are drawings illustrating a cleaning medium recycling unit;
FIG. 24 is a block diagram illustrating a control system according to an embodiment of the present invention;
FIGs. 25A and 25B are drawings illustrating a pipeline system;
FIG. 26 is a timing chart used to describe an exemplary cleaning process;
FIGs. 27A through 27C are drawings illustrating an exemplary method for causing stationary cleaning media to fly;
FIGs. 28A through 28C are drawings illustrating another exemplary method for causing stationary cleaning media to fly;
FIG. 29 is a drawing illustrating a cleaning process according to an embodiment of the present invention;
FIG. 30 is a drawing illustrating a variation of the cleaning device of FIG. 20; and
FIG. 31 is a graph showing the distribution of mechanical and physical properties of various cleaning media.

DESCRIPTION OF EMBODIMENTS

[0015] Preferred embodiments of the present invention are described below with reference to the accompanying drawings.

[0016] FIGs. 1A through 1C are drawings illustrating a configuration of a cleaning device 1 according to an embodiment of the present invention. FIG. 1A is a cut-away front view of the cleaning device 1; FIG. 1B is a cross-sectional view of the cleaning device 1 taken along line A-A shown in FIG. 1A; and FIG. 1C is a top view of the cleaning device 1.

[0017] The cleaning device 1 includes a cleaning chamber unit 2 and a holding unit 3.

[0018] The cleaning device 1 removes a deposit adhering to an object 4 (that is to be cleaned) being held by the holding unit 3 by causing cleaning media M shaped like flakes (small, thin pieces of a material) to fly and collide with the deposit or the object 4 by using an air flow.

[0019] The cleaning chamber unit 2 includes a cleaning chamber 6, a cleaning medium accelerating unit 7, and a cleaning medium recycling unit 8.

[0020] The cleaning chamber 6 includes a cleaning chamber body 9 and a separating unit 10. The cleaning chamber body 9 has a semi-cylindrical, rectangular, or pyramid shape having side walls and an upper opening. The separating unit 10 has many small pores or slits that allow a gas and a removed deposit to pass through but do not allow the cleaning media M to pass through.

[0021] The separating unit 10 is a porous part such as a wire mesh, a plastic mesh, a perforated metal, or a slit plate and has a smooth shape (e.g., semi-cylindrical shape) to prevent accumulation of the cleaning media M. The separating unit 10 is disposed in the cleaning chamber body 9 at a uniform distance from the internal surface of the cleaning chamber body 9.

[0022] The cleaning medium accelerating unit 7 is used as a circulating air-flow generating unit and includes cleaning medium accelerating nozzles 11 and a compressed air supplying unit 12. The compressed air supplying unit 12 is, for example, implemented by a compressor. The cleaning medium accelerating nozzles 11 are arranged in a straight line along the center line of the bottom of the cleaning chamber body 9 and run through the cleaning chamber body 9 and the separating unit 10. The compressed air supplying unit 12 supplies compressed air to the cleaning medium accelerating nozzles 11 via an air line 14 having a control valve 13. The cleaning medium accelerating nozzles 11 jet the compressed air supplied from the compressed air supplying unit 12 and thereby cause the cleaning media M to fly.

[0023] FIGs . 2A and 2B are enlarged cut-away side views of a part around the cleaning chamber unit 2 seen from the back of FIG. 1A. FIG. 2A shows an enlarged view of the cleaning chamber unit 2 shown in FIG. 1A; and FIG. 2B shows a variation of the cleaning chamber unit 2.

[0024] Referring back to FIG. 1A, the cleaning medium recycling unit 8 includes a suction duct 15, a suction unit 16, and a cleaning medium decelerating unit 17. The suction duct 15 is formed as a gap between the cleaning chamber body 9 and the separating unit 10.

[0025] The suction unit 16 suctions air from the cleaning chamber body 9 via a suction tube 18 and evacuates air or a removed film-like deposit suctioned via the separating unit 10 into the suction duct 15.

[0026] The amount of air to be suctioned by the suction unit 16 is greater than the amount of compressed air jetted from the cleaning medium accelerating nozzles 11. Thus, the suction unit 16 is capable of generating a negative pressure in the cleaning chamber body 9. As shown in FIG. 2B, the separating unit 10 may instead be provided for only a part of the cleaning chamber 6 and the cleaning chamber body 9 may be provided to cover the pores or slits of the separating unit 10 to form an isolated suction duct 15.

[0027] The cleaning medium decelerating unit 17 has a predetermined length. A laminar flow forming unit 19 shaped like a square bracket is provided on each side of the cleaning chamber body 9. Linear guides 20 having a thickness of about 5 mm and shaped like rectangular columns are provided at edges of a flat upper surface of the laminar flow forming unit 19.

[0028] The linear guides 20 are made of, for example, fluoroplastic having a smooth surface and used to support the holding unit 3. Parallel side guides 21 form side walls of the laminar flow forming unit 19. The linear guides 20 and the side guides 21 together guide the movement of the holding unit 3. The linear guides 20 are designed to provide a gap 22 between the flat upper surface of the laminar flow forming unit 19 and the holding unit 3. The length of the gap 22 is determined such that the cleaning media M do not get stuck in the gap 22.

[0029] The size of the linear guides 20 may be determined freely according to the size of the cleaning media M as long as an air flow flowing into the gap 22 can achieve enough speed.

[0030] The holding unit 3 is shaped like a long plate and is longer than the object 4. The holding unit 3 includes an object holding part 23 disposed in the center of the holding unit 3. The object holding part 23 is shaped like a recess and has dimensions corresponding to those of the object 4. The object holding part 23 is made of an elastic material such as polyurethane rubber or resin foam and is used to fix the object 4. Assuming that a target surface of the object 4 which is to be cleaned is flat, the object 4 is placed and fixed in the object holding part 23 such that the target surface is positioned at the same height as that of the surface of the holding unit 3 other than the object holding part 23. The object holding part 23 may have any other configuration as long as it can hold the object 4 without forming a gap between the holding unit 3 and the object 4. If such a gap is present, air flows into the gap and the cleaning media M may get stuck in the gap.

[0031] The holding unit 3 is detachably attached to a driving unit (not shown) such as a direct drive motor, an air cylinder, or a wire drive unit. The holding unit 3 is caused to move along the laminar flow forming unit 19 in synchronization with the operations of the cleaning chamber unit 2 according to a control signal from a control unit. An exemplary process of removing a deposit adhering to the object 4 with the cleaning device 1 is described below.

[0032] FIGs. 3A and 3B are perspective views of the holding unit 3. FIG. 3A illustrates how to attach the object 4 to the holding unit 3 and how to attach the holding unit 3 to the cleaning chamber unit 2; and FIG. 3B illustrates movement of the holding unit 3.

[0033] First, a proper number (determined by an experiment) of the cleaning media M are introduced into the cleaning chamber 6. Next, as shown in FIG. 3A, the object 4 is placed in the object holding part 23 of the holding unit 3. Then, the holding unit 3 is turned upside down so that the object 4 faces the cleaning chamber unit 2 and is placed on the cleaning chamber unit 2. The holding unit 3 holding the object 4 is connected to a driving unit (not shown) and the object 4 (or the holding unit 3) is moved above the cleaning chamber 6 as shown in FIG. 3B.

[0034] Then, a control unit (not shown) is turned on. The control unit drives the suction unit 16 to suction air from the cleaning chamber 6. As a result, the air pressure in the cleaning chamber 6 becomes different from the external air pressure. The differential pressure in turn generates an air flow flowing into the cleaning chamber 6 through the gap 22 formed by the linear guide 20 between the laminar flow forming unit 19 and the holding unit 3. The air flow passes over the flat surface of the laminar flow forming unit 19, is thereby turned into a laminar flow, and causes external air to flow into the cleaning chamber 6.

[0035] The control unit then drives the compressed air supplying unit 12 and opens the control valve 13 to supply compressed air to the cleaning medium accelerating nozzles 11. The cleaning medium accelerating nozzles 11 jet the compressed air and thereby generate a vertically-upward air flow (circulating air flow) in the cleaning chamber 6.

[0036] The circulating air flow (including turbulent air flow) generated by the cleaning medium accelerating nozzles 11 causes the cleaning media M in the cleaning chamber 6 to fly and collide with the object 4. As a result, a deposit on the surface of the object 4 is removed by the cleaning media M. After colliding with the object 4, the cleaning media M fall toward the bottom of the cleaning chamber 6 due to the air flow and the force of gravity. The cleaning media M are attracted by suction to the separating unit 10 and slide down the surface of the separating unit 10 to an area around the cleaning medium accelerating nozzles 11.

[0037] In this process, the deposit removed from the object 4 and adhering to the cleaning media M is separated from the cleaning media M by the separating unit 10, and the separated deposit is collected by the suction unit 16 via the suction duct 15 and the suction tube 18. Meanwhile, the cleaning media M fell onto an area near the cleaning medium accelerating nozzles 11 are caused to fly vertically-upward again by the air flow generated by the cleaning medium accelerating nozzles 11. The deposit on the surface of the object 4 can be removed by repeating the above process.

[0038] Each of the cleaning media M (cleaning medium M) is designed such that it can be caused to fly by an air flow. More particularly, the material, weight, size, and/or shape of the cleaning medium M is determined based on the characteristics (shape, material, etc.) of the object 4 and the characteristics (pencil hardness, bond strength, etc.) of a filmy deposit adhering to the object 4; and then the speed and flow rate of an air flow necessary to cause the cleaning medium M to fly are determined.

<BEHAVIOR AND EFFECT OF CLEANING MEDIUM>

1. Ability to fly along with air flow (ability to fly at high speed and to make complex movements)

[0039]

1-1. The mass of the flake-like cleaning medium M is very small relative to the air resistance. Therefore, when the force of an air flow is applied to a surface of the cleaning medium M with a large projected area, the cleaning medium M is easily accelerated by the air flow and flies.

1-2. The flake-like cleaning medium M has low air resistance in a direction forming a small projected area and therefore can maintain high-speed movement for a long distance when flying in that direction. The thickness of the cleaning medium M of this embodiment is preferably greater than or equal to 20 μm and less than or equal to 200 μm, and its surface area is preferably less than or equal to 100 mm^2.

[0040] As the speed of the cleaning medium M increases, the energy of the cleaning medium M increases, i.e., the acting force of the cleaning medium M colliding with the object 4 increases, and accordingly the cleaning performance improves.

[0041] Also, as the speed of the cleaning medium M increases, the number of times the cleaning medium M is circulated in the cleaning chamber 6 increases, i.e., the number of times the cleaning medium collides with the object 4 increases, and accordingly the cleaning efficiency improves.

1-3. Since the air resistance of the flake-like cleaning medium M greatly changes depending on its flight attitude, the cleaning medium M can make complex movements such as rapidly changing its directions in addition to moving along with an air flow. Therefore, the cleaning medium M is also highly effective in cleaning an object 4 with a complex shape.

1-4. As shown in FIG. 1, a turbulent air flow is generated around the object 4 by other air flows. The air flow generated by the cleaning medium accelerating nozzles 11, which may also turn into a turbulent air flow, is disturbed further when it meets a laminar air flow from the laminar flow forming unit 19. This turbulent air flow causes the cleaning media M to randomly collide with the object 4.

[0042] Thus, in a sense, the cleaning medium decelerating unit 17 assists the cleaning medium accelerating unit 7 in causing the cleaning media M to randomly collide with the object 4.

[0043] Since the mass of the flake-like cleaning medium M is very small relative to the air resistance, the cleaning medium M faithfully follows the movement of the turbulent air flow and makes complex movements.

[0044] Also, since the cleaning medium M repeatedly collides with the object 4 while rotating on its axis and being also rotated by the turbulent air flow, it can efficiently clean even an object with a complex shape.

[0045] FIGs. 4A and 4B are drawings illustrating removal of a film-like deposit by sliding contact. In FIGs. 4A and 4B, "d" indicates a film-like deposit and "C" indicates the movement direction of the cleaning medium M.

[0046] When an edge of the cleaning medium M moving at high speed collides with the object 4, the cleaning medium M scrapes the film-like deposit d. The cleaning medium M with the scraped deposit d' flies away as shown in FIG. 4B and collides with other cleaning media M or the separating unit 10. As a result, the deposit d' is removed from the cleaning medium M. This process is described in more detail below.

[0047] FIGs. 5A and 5B are enlarged views of parts of FIGs. 4A and 4B. FIG. 5A shows the cleaning medium M that has just collided with the object 4; and FIG. 5B shows the cleaning medium M sliding on the object 4. FIG. 6 shows the cleaning medium M colliding with the object 4 in a different condition.

2. Behavior of cleaning medium when contacting or colliding with object (function of edge and sliding contact)

[0048]

2-1. The flake-like cleaning medium M has a pencil hardness greater than that of a film-like deposit and therefore the film-like deposit is easily dented or scratched by an edge of the cleaning medium M. Also, since the contact force is concentrated at the edge of the cleaning medium M, the cleaning medium M with such a small mass can cut into the film-like deposit.

In the present application, the pencil hardness is measured with a method according to JIS K-5600-5-4. The pencil hardness of the cleaning medium M is indicated by the lead number of the hardest one of pencil leads that are not capable of making a scratch or dent on the cleaning medium M.

2-2. When the cleaning medium M contacts or collides with the object 4 at an oblique angle as shown in FIG. 5A, the cleaning medium M becomes in sliding contact with the deposit d and can exert a force on the deposit d in a direction parallel to the contact surface as shown in FIG. 5B. Thus, the cleaning medium M can scrape the film-like deposit d. Also, when the bond strength between the deposit d and the object 4 is small, the force caused by the sliding contact in a direction parallel to the contact surface may cause slip at the bond interface and cause the deposit d to fall off. Thus, in this case, the cleaning medium M can remove the deposit d in a large area at once and can efficiently clean the object 4.

2-3. When there is a gap between the deposit d and the object 4 and the cleaning medium M enters the gap as shown in FIG. 6, the cleaning medium M can easily peel off and remove the deposit d like a wedge.

2-4. The deposit d adhering to the flake-like cleaning medium M is easily separated by, for example, vibration when the cleaning medium M is suctioned by the suction unit 16 and collides with the separating unit 10.

[0049] This mechanism makes it possible to keep the cleaning medium M clean and to prevent the deposit d on the cleaning medium M from adhering again to the object 4.

[0050] Other advantageous effects of the flake-like cleaning medium M are described below.

[0051] Since the cleaning medium M is shaped like a flake, the amount of material used for the cleaning medium M is small. This in turn makes it possible to reduce the effects on the environment and the running costs of a cleaning device.

[0052] This advantage is not provided by related-art abrasive materials used in abrasive blasting or related-art abrasive media used in barrel polishing.

[0053] A cleaning device according to an aspect of the present invention has a configuration suitable for cleaning an object by circulating flake-like cleaning media M with an air flow.

[0054] As described above, a cleaning device using flake-shaped cleaning media can effectively and efficiently clean an object (or a part) with a complex shape.

[0055] When the object 4 is being cleaned with the flying cleaning media M, a negative pressure is formed in the cleaning chamber 6 and therefore a strong laminar air flow flows into the cleaning chamber 6 through the gap 22 between the laminar flow forming unit 19 and the holding unit 3. The laminar air flow pushes back the cleaning media M trying to get into the gap 22 and thereby prevents the cleaning media M from being ejected out of the cleaning chamber 6. Also, the flow path formed by the gap 22 is long enough to attenuate the flying speed of the cleaning media M. Therefore, even if a few cleaning media M enter the gap 22, they are decelerated and finally pulled back into the cleaning chamber 6 and do not get out of the cleaning device 1.

[0056] When the cleaning media M are caused to fly to clean the object 4, air is jetted intermittently from the cleaning medium accelerating nozzles 11 by alternately opening and closing the control valve 13. Intermittently jetting air from the cleaning medium accelerating nozzles 11 causes the difference between the pressure in the cleaning chamber 6 and the external pressure to increase at certain timings and thereby makes it possible to more effectively pull the cleaning media M back into the cleaning chamber 6.

[0057] While alternately opening and closing the control valve 13, a control unit of the cleaning device 1 causes the holding unit 3 to move back and forth over the cleaning chamber 6 along the linear guides 20 and the side guides 21 of the laminar flow forming unit 19 of the cleaning chamber unit 2. After moving the holding unit 3 back and forth at least once, the control unit stops the compressed air supplying unit 12 and the suction unit 16 to complete the cleaning process.

[0058] In the present application, "brittleness" indicates a characteristic of a material manifested by fracture before the material is deformed by an external force or after the material is only slightly deformed by an external force.

[0059] Preferably, the folding endurance of the flake-like cleaning medium M is greater than or equal to 0 and less than 65. The folding endurance in the present application is measured according to JIS P8115 and indicates the number of times the cleaning medium can be bent to 135 degrees (R=0.38 mm) before it is broken.

[0060] Also in the present application, "ductility" indicates the ability of a material to be deformed by elongation without fracture even under tension exceeding its elastic limit.

[0061] FIG. 7 is a drawing illustrating plastic deformation of a cleaning medium over time.

[0062] When a cleaning medium is used repeatedly, the cleaning medium is gradually damaged due to repeated impacts on its edges and repeated bending caused by collision with an object. Because of the damage, the cleaning medium is gradually deformed or fractured and finally develops plastic deformation, ductile fracture, or brittle fracture.

[0063] FIGs. 8A through 8D show various collision patterns of flake-like cleaning media.

[0064] When a cleaning medium prone to plastic deformation collides with an object, a colliding edge of the cleaning medium is deformed as show in FIG. 8C, and the deformation increases the contact area of the edge and reduces its impact force. As a result, the contact force at the edge of the cleaning medium is distributed and the cleaning performance is reduced. Also, the cleaning medium becomes unable to cut deep into a film-like deposit and the cleaning efficiency of the cleaning device is reduced.

[0065] When a cleaning medium prone to ductile fracture collides with an object, a fractured edge of the cleaning medium is plastically deformed as show in FIG. 8D, and the deformation increases the contact area of the edge and reduces its impact force. As a result, the contact force at the edge of the cleaning medium is distributed and the cleaning performance is reduced. Also, the cleaning medium becomes unable to cut deep into a film-like deposit and the cleaning efficiency of a cleaning device is reduced.

[0066] Meanwhile, a fractured edge of a cleaning medium prone to brittle fracture is not deformed greatly and therefore the contact force at the edge of the cleaning medium is not distributed much.

[0067] Also, even if a film-like deposit adheres to an edge of the cleaning medium, its cleaning efficiency is not reduced because the cleaning medium can repeatedly form a new edge by repeated brittle fracture.

[0068] Examples of brittle materials include a glass chip, a ceramic chip, and a resin film chip of acrylic resin, polystyrene, or polylactic resin.

[0069] A cleaning medium is fractured when a bending force is repeatedly applied to the cleaning medium. In the present application, brittleness of a cleaning medium is defined by its folding endurance.

[0070] When a brittle cleaning medium with a folding endurance less than 65 collides repeatedly with an object, burrs are formed on an edge of the cleaning medium. However, the burrs break and fall off from the cleaning medium as shown in FIG. 8B and are ejected. Since the burrs do not remain on the edge of the cleaning medium, the function of the edge is maintained.

[0071] When a brittle cleaning medium with a folding endurance less than 10 collides with an object, the cleaning medium breaks in the middle before burrs are formed and new edges are formed as shown in FIG. 8A.

[0072] Accordingly, the function of the edge(s) of the cleaning medium is maintained. In other words, the ability of the edge of the cleaning medium to cut deep into a film-like deposit is maintained and the performance (deposit removal performance) of the cleaning medium to remove a film-like deposit is not reduced over time.

[0073] The thickness of the flake-like cleaning medium M of this embodiment is preferably greater than or equal to 20 μm and less than or equal to 200 μm, and its surface area is preferably less than or equal to 100 mm^2.

[0074] In the present application, the pencil hardness is measured with a method according to JIS K-5600-5-4. The pencil hardness of the cleaning medium M is indicated by the lead number of the hardest one of pencil leads that are not capable of making a scratch or dent on the cleaning medium M.

[0075] The folding endurance in the present application is measured according to JIS P8115 and indicates the number of times the cleaning medium can be bent to 135 degrees (R=0.38 mm) before it is broken.

[0076] FIG. 9 is a drawing illustrating a variation of a cleaning medium. FIGs. 10 through 20 also show variations of a cleaning medium.

[0077] A cleaning medium shown in FIG. 9 has a groove at least on one side (surface). The groove extends from one end to the other end of the cleaning medium and its cross section is shaped like a rectangle.

[0078] FIG. 10 shows an exemplary method of producing cleaning media. In the exemplary method, a tape with a groove is cut into multiple cleaning media M by, for example, an electric tape cutter.

[0079] The groove on the cleaning medium functions as a break line and the stress applied by collision concentrates on the grooved portion. Therefore, when the cleaning medium collides repeatedly with an object, the grooved portion is easily broken by brittle fracture. As shown in FIG. 11, even if a deposit accumulates on an edge of the cleaning medium by electrostatic adhesion, the cleaning medium is brittle-fractured at the grooved portion and a new edge(s) is formed. Since the plastic deformation of a fractured edge of the cleaning medium is small, the contact force at the edge of the cleaning medium is not broadly distributed.

[0080] FIG. 12 shows a cleaning medium having grooves on respective sides, and FIG. 13 is a side view of the cleaning medium of FIG. 12.

[0081] FIGs. 14 through 19 show other variations of cleaning media. The respective cleaning media shown in FIGs. 14 through 19 have one or more groves. The cross sections of the grooves may have a shape other than a rectangular shape.

[0082] Meanwhile, cleaning media having different thicknesses may be used in a cleaning device. For example, a thin cleaning medium can easily enter a gap between a film-like deposit and an object and can easily peel off and remove the deposit by sliding contact like a wedge. Using thick and rigid cleaning media together with such thin cleaning media makes it possible to further improve the cleaning efficiency.

[0083] Also, cleaning media having different shapes may be used in a cleaning device. This makes it possible to clean objects with various shapes.

[0084] For example, a cleaning medium may have a discoidal shape, a triangular shape, a square shape, a rectangular shape, or a star shape and cleaning media of one or more of the shapes may be used in a cleaning device.

[0085] The characteristic of a cleaning medium differs depending on its shape. Therefore, using cleaning media with various shapes makes it possible to improve the total cleaning performance of a cleaning device.

[0086] For example, a cleaning medium with a square or rectangular shape has long straight edges and is easy to produce. A cleaning medium with a triangular or star shape has sharp points that can easily enter a recess or a corner of an object and therefore can remove a deposit in such a narrow space.

[0087] A cleaning medium with a discoidal shape always collides with an object with the same posture (orientation) and therefore can stably remove a deposit.

[0088] Further, cleaning media with different sizes may be used in a cleaning device. This makes it possible to clean objects with various shapes. Naturally, using cleaning media with various sizes and shapes may further improve the cleaning performance of a cleaning device.

[0089] FIG. 20 is a drawing illustrating a configuration of a cleaning device 100 according to another embodiment of the present invention.

[0090] The cleaning device 100 shown in FIG. 20 removes a film-like deposit d on an object 4 to be cleaned using cleaning media M being circulated by an air flow. The cleaning device 100 includes a cleaning chamber 26, a circulating air-flow generating unit 46, a cleaning medium accelerating unit 27, and a cleaning medium recycling unit 28.

[0091] In this embodiment, the object 4 is placed in the cleaning chamber 26 when cleaned so that the efficiency of suctioning the film-like deposit by the cleaning medium recycling unit 28 is improved.

[0092] Also in this embodiment, the film-like deposit d removed from the object 4 by the collision of the cleaning media M and fragments of the cleaning media M generated by repeated collision with the object 4 are prevented from being scattered by air flows generated by the circulating air-flow generating unit 46 and the cleaning medium accelerating unit 27.

[0093] FIGs. 21A and 21B are drawings illustrating operations of the cleaning device 100.

[0094] As shown in FIG. 21A, the cleaning chamber 26 is a hollow body shaped like a cuboid and has an object input opening 29 on the upper side. The object 4 is placed into the cleaning chamber 26 through the object input opening 29. A lid 30 is provided to close and open the object input opening 29. There is also an opening in the bottom of the cleaning chamber 26. The cleaning medium recycling unit 28 is provided below the opening in the bottom of the cleaning chamber 26. The circulating air-flow generating unit 46 is provided on an internal side wall of the cleaning chamber 26. The circulating air-flow generating unit 46 generates a circulating air flow that circulates along a circulation path formed by internal side walls (may include upper and bottom walls formed by the lid 30 and a separating part 81 described later) of the cleaning chamber 26.

[0095] As shown in FIG. 21B, each corner of the internal side walls forming the circulation path is formed by angles $\theta 1$ and $\theta 2$. This configuration makes it possible to efficiently circulate the air flow.

[0096] Because of a geometric reason, $\theta 1+\theta 2$ equals 270°. If 270° are divided into two equal halves, $\theta 1=\theta 2=135°$. However, $\theta 1$ and $\theta 2$ are not necessarily equal. According to an experiment, it is possible to minimize the resistance to the circulating air flow and thereby to efficiently circulate the air flow in the cleaning chamber 26 by setting one of 01 and θ2 at a value between 120° and 150°.

[0097] FIG. 22 is a drawing illustrating the circulating air-flow generating unit 46 in more detail.

[0098] The circulating air-flow generating unit 46 includes a suction part 62 and a discharge part 64. The suction part 62 has an inlet 61 with a large diameter that allows the cleaning media M to pass through. The discharge part 64 has a compressed air supply opening 63 provided near the exit of the suction part 62 above its outer surface.

[0099] When compressed air is supplied from the compressed air supply opening 63, an air flow toward an outlet 65 of the discharge part 64 is generated and the generated air flow causes air to be drawn in from the suction part 62. As a result, a large amount of air is discharged from the outlet 65 of the discharge part 64. The amount of air to be discharged from the outlet 65 is about several to ten times greater than the amount of compressed air supplied from the compressed air supply opening 63.

[0100] Compared with a normal air-blow nozzle, the circulating air-flow generating unit 46 configured as described above uses a smaller amount of compressed air and therefore can more efficiently circulate the cleaning media M. Instead of compressed air, any other gas may be supplied from the compressed air supply opening 63. For example, an inert gas such as nitrogen gas, CO_2 gas, or argon gas may be used as a substitute for compressed air.

[0101] The circulating air-flow generating unit 46 is disposed near the bottom of the cleaning chamber 26 on one of the internal side walls forming the circulation path such that the inlet 61 faces vertically upward and the outlet 65 faces vertically downward.

[0102] The cleaning medium accelerating unit 27 includes an array of accelerating nozzles 71a on a front wall orthogonal to the internal side walls forming the circulation path. The cleaning medium accelerating unit 27 also includes an array of accelerating nozzles 71b on a rear wall facing the front wall. The accelerating nozzles 71 (the accelerating nozzles 71a and 71b) jet compressed air supplied from a compressed air supplier such as a compressor or a pressure tank into the cleaning chamber 26 and thereby cause the cleaning media M to fly and collide with the object 4. Alternatively, the accelerating nozzles 71a and 71b may have a configuration similar to that of the circulating air-flow generating unit 46.

[0103] In a sense, the cleaning medium accelerating unit 27 assists the circulating air-flow generating unit 46 in causing the cleaning media M to randomly collide with the object 4.

[0104] FIGs. 23A and 23B are drawings illustrating the cleaning medium recycling unit 28. FIG. 23A is a perspective view of the cleaning medium recycling unit 28; and FIG. 23B is a cut-away side view of the cleaning medium recycling unit 28.

[0105] The cleaning medium recycling unit 28 is disposed at the bottom of the cleaning chamber 26 and includes a separating part 81 and a hood 82 that form a closed space. A suction tube 41 is connected to one side of the hood 82.

[0106] Also, a dust collecting unit (not shown) including a negative pressure generator is connected to the other side of the hood 82. The dust collecting unit generates a negative pressure in the hood 82. The separating part 81 has small pores or slits that allow gas and powder to pass through but do not allow the cleaning media M to pass through. The separating part 81 is a porous part such as a wire mesh, a plastic mesh, a perforated metal, or a slit plate. The cleaning medium recycling unit 26 collects and ejects, via the separating part 81, a film-like deposit removed from the object 4, cleaning media worn-out or fractured by collision with the object 4, and cleaning media which elasticity is reduced after long time use.

[0107] FIG. 24 is a block diagram illustrating a control system of the cleaning device 100 of this embodiment. FIGs. 25A and 25B are drawings illustrating a pipeline system of the cleaning device 100. FIG. 25A shows a pipeline related to generation of air flows, and FIG. 25B shows a pipeline related to recycling of cleaning media.

[0108] As shown in FIGs. 25, 26A, and 26B, the control system of the cleaning device 100 includes a control unit 32, an air-flow circulation solenoid valve 34, an acceleration solenoid valve 35, an accelerated air-flow switching valve 36, and a recycling solenoid valve 37. The air-flow circulation solenoid valve 34 opens and closes an air pipe for supplying compressed air from a compressed air supplying unit 38 to the circulating air-flow generating unit 46. The acceleration solenoid valve 35 opens and closes an air pipe for supplying compressed air to the cleaning medium accelerating unit 27. The accelerated air-flow switching valve 36 switches the direction of the flow of compressed air to be supplied to the accelerating nozzles 71 of the cleaning medium accelerating unit 27. The recycling solenoid valve 37 opens and closes an air pipe 41 connecting the cleaning medium recycling unit 28 and a dust collecting unit 39. The control unit 32 controls the valves according to a drive signal from an activation unit 33.

[0109] FIG. 26 is a timing chart used to describe an exemplary cleaning process of this embodiment. FIGs. 27A through 27C are drawings illustrating an exemplary method for causing stationary cleaning media to fly. Below, a cleaning process in the cleaning device 100 of FIG. 20 is described with reference to the timing chart of FIG. 26.

[0110] First, the flake-like cleaning media M are introduced into the cleaning chamber 26. With the cleaning media M stacked on the cleaning medium recycling unit 28, the object 3 being held by the holding unit 3 is carried by a carrying unit 40 through the object input opening 29 into the cleaning chamber 26. Then, the object input opening 29 of the cleaning chamber 26 is closed by the lid 30. The activation unit 33 is operated to send a cleaning start signal to the control unit 32. The control unit 32 opens the air-flow circulation solenoid valve 34 to supply compressed air from the compressed air supplying unit 38 such as a compressor to the circulating air-flow generating unit 46. The circulating air-flow generating unit 46 generates a circulating air flow that circulates along the circulation path formed by the internal side walls of the cleaning chamber 26.

[0111] As shown in FIG. 27A, the circulating air flow flowing over the cleaning medium recycling unit 28 blows a stack of the cleaning media M on the cleaning medium recycling unit 28 in a horizontal direction. As shown in FIGs. 27B and 27C, the stack of the cleaning media M are gradually (from top to bottom) caused to fly and go up along the length direction of the cleaning chamber 6. The circulating air flow is discharged from the circulating air-flow generating unit 46 directly into the cleaning chamber 26 and therefore can apply a great force on the cleaning media M stacked on the cleaning medium recycling unit 28. Thus, the circulating air-flow generating unit 46 can reliably cause the cleaning media M on the cleaning medium recycling unit 28 to fly along with a circulating air flow.

[0112] FIGs. 28A through 28C are drawings illustrating another exemplary method for causing stationary cleaning media to fly.

[0113] In a method shown in FIG. 28A, compressed air from a nozzle 42 is applied to the cleaning media M stacked on the separating part 81 in a vertical direction. In this case, the compressed air must have enough energy to lift all of the cleaning media M on the separating part 81. Also, the energy of the compressed air necessary to lift the cleaning media M increases as the amount (or the thickness of the stack) of the cleaning media M on the separating part 81 increases. Even if it is possible to lift the cleaning media M just above the nozzle 42 with the compressed air as shown in FIG. 28B, it is difficult to lift the remaining cleaning media M around the nozzle 42.

[0114] Further, even if a bowl-like slope is provided around the nozzle 42 as shown in FIG. 28C, the cleaning media M around the nozzle 42 do not slip down the slope because the fluidity of the cleaning media M is low. Thus, with the method shown in FIGs. 28A through 28C, it is difficult to cause all of the cleaning media M on the separating part 81 to fly.

[0115] Meanwhile, with the method shown in FIGs. 27A through 27C of this embodiment, the circulating air-flow generating unit 46 is configured to generate a circulating air flow along the circulation path formed by the internal side walls of the cleaning chamber 26 such that the air flow is applied in a horizontal direction to the cleaning media M stacked on the separating part 81.

[0116] This configuration makes it possible to stably cause the stack of cleaning media M to fly using small energy and thereby makes it possible to reduce the amount of compressed air supplied to the circulating air-flow generating unit 46. Here, if a duct or a hose is used to circulate the cleaning media M, the cleaning media M may get stuck in the duct or the hose. Meanwhile, in this embodiment, a circulation path is formed along the wall surface of the cleaning chamber 26. This configuration prevents the cleaning media M from getting stuck in the circulation path and makes it possible to stably cause the cleaning media M to circulate in the cleaning chamber 26.

[0117] The circulating air-flow generating unit 46 is disposed near the bottom of the cleaning chamber 26 on one of the internal side walls constituting the circulation path such that the inlet 61 faces vertically upward and the outlet 65 faces vertically downward. This configuration makes it possible to generate a strong air flow along the bottom surface of the cleaning chamber 26 and apply the air flow even to the cleaning media M on an area of the separating part 81 that is apart from the outlet 65. This in turn makes it possible to carry a large amount of cleaning media M along the internal surface of the cleaning chamber 26. Also with the above configuration, the space density of the cleaning media M is low when entering the inlet 61 and therefore the cleaning media M do not clog the inlet 61. Thus, the above configuration makes it possible to stably generate a circulating air flow. If the circulating air-flow generating unit 46 is positioned in the reverse orientation such that the inlet 61 faces downward, the force of suction air is exerted only on the cleaning media M near the inlet 61. With this configuration, it is difficult to carry a large amount of cleaning media M on the bottom of the cleaning chamber 26. Also, with this configuration, the space density of the cleaning media M suctioned into the inlet 61 may become too high and may clog the inlet 61. The above configuration of this embodiment makes it possible to solve or reduce such problems.

[0118] FIG. 29 is a drawing illustrating a cleaning process according to an embodiment of the present invention. FIG. 29 (a) shows the object 4 in the initial position; FIG. 29 (b) shows the object 4 in the lowest position; and FIG. 29 (c) shows the object 4 in the uppermost position (i.e., returned to the initial position).

[0119] The control unit 32, after a predetermined period of time, closes the air-flow circulation solenoid valve 34 and thereby stops generation of the circulating air flow by the circulating air-flow generating unit 46. As shown in FIG. 29 (a), while gradually moving the object 4 downward from the initial position using the carrying unit 40, the control unit 32 opens the acceleration solenoid valve 35 to supply compressed air from the compressed air supplying unit 38 via the accelerated air-flow switching valve 36 to the accelerating nozzles 71a of the cleaning medium accelerating unit 27.

[0120] Then, while the compressed air is being jetted from the accelerating nozzles 71a, the control unit 32 opens the recycling solenoid valve 37 to connect the cleaning medium recycling unit 28 and the dust collecting unit 39 and thereby to generate a negative pressure in the hood 82. When the circulating air flow being generated by the circulating air-flow generating unit 46 is stopped, the flying cleaning media M start to fall. The falling cleaning media M are caused to collide with the object 4 by the compressed air being jetted from the accelerating nozzles 71a and thereby to remove the deposit d on the object 4.

[0121] The deposit d removed from the object 4 or the cleaning media M with the removed deposit d fall because of gravity and accumulate on the separating part 81 of the cleaning medium recycling unit 28 that is drawing in air because of the negative pressure in the hood 82. The deposit d or the deposit d adhering to the cleaning media M fallen on the separating part 81 is drawn into the hood 82 because of the negative pressure and is collected by the dust collecting unit 39. Thus, the cleaning media M are recycled.

[0122] After causing the accelerating nozzles 71a to jet compressed air for a predetermined period of time, the control unit 32 closes the acceleration solenoid valve 35 and the recycling solenoid valve 37 and thereby stops operations of the cleaning medium accelerating unit 27 and the cleaning medium recycling unit 28. When the recycling solenoid valve 37 is closed, the negative pressure in the hood 82 is lost and the suction force from the hood 82 on the cleaning media M accumulated on the separating part 81 disappears. As a result, the cleaning media M are separated from the separating part 81 and caused to fly again by the next circulating air flow.

[0123] This configuration prevents the pores or slits of the separating part 81 from being blocked by the cleaning media M and makes it possible to repeatedly separate the deposit d from the cleaning media M. Therefore, it is not necessary to replace the all cleaning media M, i.e., it is only necessary to add cleaning media M to compensate for broken and lost cleaning media M. Thus, the above configuration makes it possible to efficiently use the cleaning media M and also makes it easier to maintain a cleaning device.

[0124] Following the above process, the control unit 32 opens the air-flow circulation solenoid valve 34 again to cause the circulating air-flow generating unit 46 to generate a circulating air flow and thereby cause the recycled cleaning media M on the separating part 81 of the cleaning medium recycling unit 28 to fly for a time period T1. Then, the control unit opens the acceleration solenoid valve 35 and the recycling solenoid valve 37 and switches the accelerated air-flow switching valve 36 to the accelerating nozzles 71b to perform the process of removing the deposit d from the object 4 (deposit removal process) and the process of recycling the cleaning media M (recycling process) for a predetermined period of time.

[0125] The time used for the deposit removal process and the recycling process is set at a period of time longer than the period of time for which the circulating air flow is generated so that a wide area of the object 4 is cleaned. Also, alternately causing the accelerating nozzles 71a and the accelerating nozzles 71b to jet compressed air makes it possible to prevent air flows from the nozzles 71a and 71b from interfering with each other. Thus, the above configuration makes it possible to cause the cleaning media M to stably collide with the object 4 and thereby makes it possible to effectively clean the object 4.

[0126] The control unit 32 repeats the generation of the circulating air flow, the deposit removal process, and the recycling process while gradually moving the object 4 downward from the initial position. When the object 4 reaches the lowest position or a turn-around point as shown in FIG. 29 (b), the control unit 32 stops the downward movement of the object 4 and gradually moves the object 4 upward. The control unit 32 also repeats the generation of the circulating air flow, the deposit removal process, and the recycling process while gradually moving the object 4 upward and thereby removes the film-like deposit d from the entire surface of the object 4.

[0127] When the object 4 reaches the uppermost position or the initial position as shown in FIG. 29 (c), the control unit 32 completes the cleaning process. After the cleaning process is completed, the lid 30 of the cleaning chamber 26 is opened and the object 4 being held by the holding unit 3 is taken out of the cleaning chamber 26 using the carrying unit 40. Then, the object 4 is replaced with a new object 4 and the cleaning process is started again.

[0128] FIG. 30 is a drawing illustrating a variation of the cleaning device 100 of the above embodiment. The cleaning device of FIG. 30 includes a holding unit 31and a carrying unit 40 for moving the holding unit 31 upward and downward. The holding unit 31 is capable of holding multiple objects 4 with different shapes. Thus, the cleaning device of FIG. 30 is capable of cleaning multiple objects 4 with different shapes at the same time.

[0129] In the above embodiment, compressed air is jetted alternately from the accelerating nozzles 71a and the accelerating nozzles 71b of the cleaning medium accelerating unit 27 to clean the entire surface of the object 4. Alternatively, the accelerating nozzles 71a and the accelerating nozzles 71b may be positioned to form different jet angles with the object 4 and compressed air may be jetted at the same time from the accelerating nozzles 71a and the accelerating nozzles 71b.

[0130] Even in this case, if a deposit is only on one side of the object 4, compressed air may be jet from only one of the accelerating nozzles 71a and the accelerating nozzles 71b.

[0131] In the examples described below, it is assumed that the deposit d to be removed is a release layer (fluoroplastic film) of a fusing roller used in an image forming apparatus such as a copier or a laser printer. However, the present invention may also be applied to a cleaning device for removing any other type of film-like deposit. The type of cleaning media and the speed and flow rate of the air flow are appropriately determined according to the characteristics of the film-like deposit and the object to be cleaned.

<EXAMPLE 1>

[0132] In example 1, a fusing roller of imagio Neo 300 (monochrome copier) was used as an object to be cleaned.
[0133] The pencil hardness of fluoroplastic forming the release layer of the fusing roller was about "F".
[0134] Each object was cleaned for two minutes using arrays of air nozzles SL-920A of Silvent to jet compressed air and the pressure of the compressed air was maintained at 0.5 MPa.
[0135] In example 1, the following types of cleaning media M were used:

(Example 1-1) polyethylene films (pencil hardness 6B or lower) with a thickness of 100 μm and dimensions of 5 mm by 5 mm
(Example 1-2) PET films (pencil hardness H) with a thickness of 100 μm and dimensions of 5 mm by 5 mm
(Example 1-3) acrylic resin films (pencil hardness 2H) with a thickness of 100 μm and dimensions of 5 mm by 5 mm
(Example 1-4) flakes of SUS304 (pencil hardness 9H or higher) with a thickness of 100 μm and dimensions of 5 mm by 5 mm

[0136] As comparative examples, the object was cleaned by dry scrubbing using the following types of granular cleaning media instead of flake-like cleaning media M:

(Comparative example 1-1) nylon cubes (pencil hardness H) with sides of 2 mm

(Comparative example 1-2) nylon balls (pencil hardness H) with a diameter (ϕ) of 2 mm

[0137] Cleaning results are shown in table 1 below.

(Table 1)

	No.	Cleaning media				Cleaning quality	Unevenly cleaned
		Material	Thickness (μm)	Size	Pencil hardness		
Example	1-1	Polyethylene film	100	$5mm^2$	≦ 6B	×	No
	1-2	PET film	100	$5mm^2$	H	○	No
	1-3	Acrylic resin film	100	$5mm^2$	2H	○	No
	1-4	SUS304 flake	100	$5mm^2$	≧ 9H	◎	No
Comparative example	1-1	Nylon cube	-	$2mm^3$	H	Δ	Yes
	1-2	Nylon ball	-	ϕ 2mm	H	Δ	Yes

[0138] Cleaning quality in table 1 is indicated by the following symbols:

×: Deposit was scarcely removed
Δ: Part of deposit was not removed
○: Deposit was satisfactorily removed
◎: Substantially all deposit was removed

[0139] As the results in table 1 demonstrate, dry scrubbing using flake-like cleaning media M according to embodiments of the present invention provides better cleaning quality than dry scrubbing using related-art granular cleaning media.

<EXAMPLE 2>

[0140] Each object was cleaned for two minutes using arrays of air nozzles SL-920A of Silvent to jet compressed air and the pressure of the compressed air was maintained at 0.5 MPa.
[0141] In example 2, the cleaning media were repeatedly used without replacing them for multiple objects and the cleaning quality was evaluated in association with the number of objects processed.
[0142] In example 2, the following types of cleaning media M were used.

(Example 2-1) polyethylene films (pencil hardness 6B or lower) with a thickness of 100 μm and dimensions of 5 mm by 5 mm
(Example 2-2) PET films (pencil hardness H) with a thickness of 100 μm and dimensions of 5 mm by 5 mm
(Example 2-3) acrylic resin films (pencil hardness 2H) with a thickness of 100 μm and dimensions of 5 mm by 5 mm
(Example 2-4) flakes of SUS304 (pencil hardness 9H or higher) with a thickness of 100 μm and dimensions of 5 mm by 5 mm

[0143] Cleaning results are shown in table 2 below. Meanings of symbols used in table 2 are the same as those used in table 1.

(Table 2)

	No.	Cleaning media				Number of objects processed			
		Material	Thickness (μm)	Size	Pencil hardness	1	10	50	100
Example	2-1	Polyethylene film	100	$5mm^2$	≦ 6B	×	×	×	×
	2-2	PET film	100	$5mm^2$	H	○	Δ	×	×
	2-3	Acrylic resin film	100	$5mm^2$	2H	○	○	○	○
	2-4	SUS304 flake	100	$5mm^2$	≧ 9H	◎	Δ	×	×
* Underlined symbols (Δ and ×) indicate that cleaning media were curled due to plastic deformation.									

[0144] As the results in table 2 demonstrate, cleaning media made of acrylic resin, which is a brittle material, provide good cleaning results in repeated use.

<EXAMPLE 3>

[0145] In examples 3 and 4, a photosensitive layer (polycarbonate binder resin with pencil hardness F) of an organic photoreceptor (OPC) drum used in an electrophotographic device such as a copier or a laser printer was used as a deposit to be removed. However, the present invention may also be applied to a cleaning device for removing any other type of film-like deposit.
[0146] The type of cleaning media and the speed and flow rate of the air flow are appropriately determined according to the characteristics of the film-like deposit and the object to be cleaned.
[0147] Each object was cleaned for two minutes using arrays of air nozzles SL-920A of Silvent to jet compressed air and the pressure of the compressed air was maintained at 0.5 MPa.
[0148] In example 3, the following types of cleaning media M were used.

(Example 3-1) polyethylene films (pencil hardness 6B or lower) with a thickness of 100 μm and dimensions of 5 mm by 5 mm
(Example 3-2) PET films (pencil hardness H) with a thickness of 100 μm and dimensions of 5 mm by 5 mm
(Example 3-3) acrylic resin films (pencil hardness 2H) with a thickness of 100 μm and dimensions of 5 mm by 5 mm
(Example 3-4) flakes of SUS304 (pencil hardness 9H or higher) with a thickness of 100 μm and dimensions of 5 mm by 5 mm

[0149] As comparative examples, the object was cleaned by dry scrubbing using the following types of granular cleaning media instead of flake-like cleaning media M:

(Comparative example 3-1) nylon cubes (pencil hardness H) with sides of 2 mm

(Comparative example 3-2) nylon balls (pencil hardness H) with a diameter (ϕ) of 2 mm

[0150] Cleaning results are shown in table 3 below.
[0151] In cleaning processes using flake-like cleaning media, it was observed that the photosensitive layer was wrinkled because of slip at the bond interface and the wrinkled portions of the photosensitive layer began to fall off.

(Table 3)

	No.	Cleaning media				Cleaning quality	Unevenly cleaned
		Material	Thickness (μm)	Size	Pencil hardness		
Example	3-1	Polyethylene film	100	$5mm^2$	≦ 6B	×	No
	3-2	PET film	100	$5mm^2$	H	Δ	No
	3-3	Acrylic resin film	100	$5mm^2$	2H	○	No
	3-4	SUS304 flake	100	$5mm^2$	≧ 9H	◎	No
Comparative example	3-1	Nylon cube	-	$2mm^3$	H	Δ	Yes
	3-2	Nylon ball	-	ϕ 2mm	H	Δ	Yes

<EXAMPLE 4>

[0152] Each object was cleaned for two minutes using arrays of air nozzles SL-920A of Silvent to jet compressed air and the pressure of the compressed air was maintained at 0.5 MPa.

[0153] In example 4, the cleaning media were repeatedly used without replacing them for multiple objects and the cleaning quality was evaluated in association with the number of objects processed. In example 4, the following types of cleaning media M were used.

(Example 4-1) polyethylene films (pencil hardness 6B or lower) with a thickness of 100 μm and dimensions of 5 mm by 5 mm

(Example 4-2) PET films (pencil hardness H) with a thickness of 100 μm and dimensions of 5 mm by 5 mm

(Example 4-3) acrylic resin films (pencil hardness 2H) with a thickness of 100 μm and dimensions of 5 mm by 5 mm

(Example 4-4) flakes of SUS304 (pencil hardness 9H or higher) with a thickness of 100 μm and dimensions of 5 mm by 5 mm

[0154] Cleaning results are shown in table 4 below.

(Table 4)

	No.	Cleaning media				Number of objects processed			
		Material	Thickness (μm)	Size	Pencil hardness	1	10	50	100
Example	4-1	Polyethylene film	100	$5mm^2$	≦ 6B	×	×	×	×
	4-2	PET film	100	$5mm^2$	H	Δ	$\underline{\times}$	$\underline{\times}$	$\underline{\times}$
	4-3	Acrylic resin film	100	$5mm^2$	2H	○	○	○	○
	4-4	SUS304 flake	100	$5mm^2$	≧ 9H	◎	$\underline{\Delta}$	$\underline{\times}$	$\underline{\times}$
* Underlined symbols ($\underline{\Delta}$ and $\underline{\times}$) indicate that cleaning media were curled due to plastic deformation.									

[0155] As the results in table 4 demonstrate, cleaning media made of acrylic resin, which is a brittle material, provide good cleaning results in repeated use.

<EXAMPLE 5>

[0156] In example 5, a pallet made of glass-fiber-filled epoxy resin was used as an object to be cleaned. A pallet is a jig used in a soldering process using a flow solder tank to mask an area of a printed circuit board (PCB) which is not to be soldered. When such a masking jig or a pallet is repeatedly used, a flux accumulates and forms a thick layer on the pallet. Therefore, it is necessary to regularly remove the layer of flux (flux layer) from the pallet. In this example, the pencil hardness of the flux was 2B and the thickness of the flux layer was between 0.5 and 1 mm.

[0157] Pallets with dimensions of 330 mm by 330 mm were cleaned for two minutes using a flat-surface cleaning device as shown in FIG. 1. The pressure of supplied compressed air was maintained at 0.4 MPa.

[0158] Table 5 shows types of cleaning media used and the corresponding cleaning results. Table 5 also shows physical properties including the folding endurance and the pencil hardness of the respective types of cleaning media.

(Table 5)

No.	Cleaning media				Number of objects processed	
	Material	Thickness (μm)	Folding endurance	Pencil hardness	1	30
1	Cyclic olefin copolymer (COC)	155	0	B	×	-
2	Glass	100	0	≧ 9H	◎	-
3	Acrylic resin(2)	125	2	H-F	○	-
4	Acrylic resin(1)	125	4	2H	○	○
5	Triacetate (TAC) (1)	120	24	H	○	○
6	Triacetate (TAC) (2)	105	32	2H	○	○
7	Polyimide (PI) (2)	135	45	2H	○	○
8	Polystyrene (PS) (1)	130	88	HB	Δ	×
9	Stainless steel (SUS)	20	95	≧ 9H	◎	×
10	Polystyrene (PS) (2)	150	190	4B	×	×
11	Polyimide (PI) (1)	125	3250	F	Δ	×
12	Polyethylene (PE)	100	≧ 10000	6B	×	×
13	Methylpentene polymer (TPX)	100	≧ 10000	4B	×	×
14	Polyethylene terephthalate (PET)	110	≧ 10000	H	Δ	×
* Underlined symbols (Δ and ×) indicate that cleaning media were curled due to plastic deformation. ** Double-underlined symbol (×) indicates that edges of cleaning media sagged due to plastic deformation.						

[0159] Cleaning quality in table 5 is indicated by the following symbols:

X: Deposit was scarcely removed

Δ: Part of deposit was not removed

○: Deposit was satisfactorily removed

◎: Substantially all deposit was removed

-: Cleaning media were worn out and ejected from cleaning chamber

[0160] As indicated by the results of initial cleaning performance evaluation in table 5, cleaning media with a pencil hardness of 2B (the pencil hardness of flux) or lower almost cannot remove the flux. This is because cleaning media with such a low pencil hardness cannot cut into the layer of flux.

[0161] Cleaning media are caused to fly and repeatedly collide with the object by an air flow. The cleaning media are gradually damaged by the repeated collision and develop fractures or deformation.

[0162] FIG. 31 is a graph showing the distribution of mechanical and physical properties of various cleaning media.

[0163] Degradation of cleaning media is described below in more detail with reference to table 5 and FIGs. 8A through 8D. When a cleaning medium made of glass, acrylic resin (1), acrylic resin (2), or COC with a folding endurance less than 10 collides with the object, the cleaning medium breaks in the middle and as a result, new edges are formed as shown in FIG. 8A. Since the new edges can cut into the flux layer, the deposit removal performance of the cleaning medium is not reduced.

[0164] When a cleaning medium made of TAC (1), TAC (2), or PI (2) with a folding endurance greater than or equal to 10 and less than 64 collides with the object, burrs are formed on the edge and fall off from the cleaning medium as shown in FIG. 8B. Since the thickness of the cleaning medium does not change, the cleaning medium can still cut into the flux layer, i.e., its deposit removal performance is maintained.

[0165] When a cleaning medium with a folding endurance of 65 or higher collides with the object, the cleaning medium does not break but its edge is plastically deformed.

[0166] FIG. 8C shows an example where an edge of a cleaning medium is squashed and sags due to plastic deformation. For example, a cleaning medium made of PI (1) is deformed like this.

[0167] FIG. 8D shows an example where an edge of a cleaning medium is curled due to plastic deformation. For example, cleaning media made of SUS, PS (1), PS (2), PE, PET, or TPX are deformed like this.

[0168] Edges of cleaning media as described with reference to FIGs. 8C and 8D are plastically deformed and sag, and their impact force at collision is reduced because of the deformation. Therefore, cleaning performance of those cleaning media is greatly reduced after processing multiple objects as shown in table 5.

[0169] As the results show, to effectively and stably remove a layer of flux for a long period of time, it is preferable to use cleaning media made of a brittle material having a pencil hardness greater than that of the flux and a folding endurance greater than or equal to 0 and less than 65.

[0170] Folding endurance measurements of several types of cleaning media are shown in table 6 to provide a basis for values used in the descriptions of this embodiment.

(Table 6)

No.	Material	Average folding endurance	Maximum folding endurance	Minimum folding endurance
3	Acrylic resin(2)	2	8	0
4	Acrylic resin(1)	4	9	1
7	PI (2)	45	52	41
8	PS (1)	88	115	65

[0171] Flake-like cleaning media with the minimum folding endurance of 0 (glass, COC, acrylic resin (2)) are very brittle and easily broken. Therefore, they are worn out in a short period of time as shown in table 5 and increase the running costs.

[0172] Meanwhile, the maximum folding endurance of cleaning media made of PI (2) that showed good cleaning performance is 52.

[0173] Therefore, it is more preferable to use cleaning media with a folding endurance greater than or equal to 1 and less than or equal to 52 to effectively and stably remove a deposit for a long period of time.

[0174] The minimum folding endurance of cleaning media made of PS (1) that develop ductile deformation is 65. Therefore, the maximum folding endurance of brittle cleaning media is less than 65.

[0175] The maximum folding endurance of cleaning media made of PI (2) that showed good cleaning performance is 52. This indicates that cleaning media with a folding endurance less than or equal to 52 can stably develop brittle fracture.

[0176] Among cleaning media that develop brittle fracture as shown in FIG. 8A, cleaning media made of acrylic resin (1) have the highest folding endurance of 9. Accordingly, cleaning media with a folding endurance greater than or equal to 0 and less than or equal to 9 develop brittle fracture as shown in FIG. 8A and cleaning media with a folding endurance greater than or equal to 10 and less than 65 develop brittle fracture as shown in FIG. 8B.

[0177] Cleaning media made of acrylic resin (2) with the minimum folding endurance of 0 is extremely brittle and therefore is not suitable for long time use (repeated use) as shown in table 5. Meanwhile, the cleaning performance of cleaning media made of acrylic resin (1) with the minimum folding endurance of 1 was not reduced for a long period of time as shown in table 5.

[0178] As described above, an aspect of the present invention provides a cleaning device that can effectively and efficiently remove a film-like deposit such as a layer of flux on a pallet used in a soldering process, a photosensitive layer of a photosensitive drum of an image forming apparatus, or a release layer or a fixed toner on a fusing roller of an image forming apparatus.

Claims

1. A cleaning medium for removing a deposit adhering to an object to be cleaned comprising:

- multiple cleaning media shaped like flakes which are configured to be caused to fly and repeatedly collide with the object to remove the deposit adhering to the object,
wherein the multiple cleaning media are further configured so that the deposit is removably adhering to the cleaning media that has collided with the object to recycle the cleaning medium,
wherein a pencil hardness of the cleaning medium is greater than a pencil hardness of the deposit, and
characterized in that
a folding endurance of the cleaning media measured according to JIS P8115, is greater than or equal to 2 and less than or equal to 45.

2. The cleaning medium as claimed in claim 1, wherein a groove is formed on at least one side of each of the cleaning media, the groove extending from one end to another end of the each of the cleaning media.

3. The cleaning medium as claimed in claim 1, wherein the cleaning media include cleaning media of different thicknesses.

4. The cleaning medium as claimed in claim 1, wherein the cleaning media include cleaning media of different shapes.

5. The cleaning medium as claimed in claim 1,werhein the cleaning media include cleaning media of different sizes.

6. The cleaning medium as claimed in claim 1, wherein a thickness of the cleaning media is greater than or equal to 20 μm and less than or equal to 200 μm.

7. A method of removing a deposit adhering to an object to be cleaned, comprising the steps of:

causing multiple cleaning media shaped like flakes to fly and repeatedly collide with the object in a cleaning chamber by using a circulating air flow to remove the deposit adhering to the object; and
suctioning and removing the deposit adhering to the cleaning media that have collided with the object to recycle the cleaning media,
wherein a pencil hardness of the cleaning media is greater than a pencil hardness of the deposit,
characterized in that
a folding endurance of the cleaning media, measured according to JIS P8115, is greater than or equal to 2 and less than or equal to 45.

8. The method as claimed in claim 7, wherein a groove is formed on at least one side of each of the cleaning media, the groove extending from one end to another end of the each of the cleaning media.

9. A cleaning device including a cleaning medium of one of claims 1 to 6 for cleaning the object, wherein
the cleaning device for removing a deposit adhering to an object (4) to be cleaned, comprising:

a cleaning chamber (9) forming a space for housing multiple cleaning media shaped like flakes;
a circulating air-flow generating unit (7) configured to generate a circulating air flow to cause the cleaning medium to fly and repeatedly collide with the object (4) in the cleaning chamber (9) and thereby to remove the deposit

adhering to the object (4); and
a cleaning medium recycling unit (8) configured to suction and remove the deposit adhering to the cleaning medium that have collided with the object (4) and thereby to recycle the cleaning medium,
characterized in that the cleaning medium is a cleaning medium according to anyone of claim 1 to 6.

Patentansprüche

1. Reinigungsmedium zum Entfernen einer Ablagerung, die an einem zu reinigenden Objekt haftet, das umfasst:

    mehrere Reinigungsmedien, die wie Schuppen geformt sind, die konfiguriert sind, um zum Fliegen veranlasst zu werden und wiederholt mit dem Objekt zusammenzustoßen, um die an dem Objekt haftende Ablagerung zu entfernen,
    wobei die mehreren Reinigungsmedien ferner so konfiguriert sind, dass die Ablagerung an den Reinigungsmedien, die mit dem Objekt zusammengestoßen sind, entfernbar haftet, um das Reinigungsmedium wiederzugewinnen,
    wobei eine Stifthärte des Reinigungsmediums größer als eine Stifthärte der Ablagerung ist, und
    dadurch gekennzeichnet, dass
    eine Faltbeständigkeit der Reinigungsmedien, die in Übereinstimmung mit JIS P8115 gemessen wird, größer oder gleich 2 und kleiner oder gleich 45 ist.

2. Reinigungsmedium nach Anspruch 1, wobei wenigstens in einer Seite jedes der Reinigungsmedien eine Nut gebildet ist, wobei sich die Nut von einem Ende zu einem weiteren Ende jedes der Reinigungsmedien erstreckt.

3. Reinigungsmedium nach Anspruch 1, wobei die Reinigungsmedien Reinigungsmedien mit unterschiedlichen Dicken enthalten.

4. Reinigungsmedium nach Anspruch 1, wobei die Reinigungsmedien Reinigungsmedien mit unterschiedlichen Formen enthalten.

5. Reinigungsmedium nach Anspruch 1, wobei die Reinigungsmedien Reinigungsmedien mit unterschiedlichen Größen enthalten.

6. Reinigungsmedium nach Anspruch 1, wobei eine Dicke der Reinigungsmedien größer oder gleich 20 μm und kleiner oder gleich 200 μm ist.

7. Verfahren zum Entfernen einer Ablagerung, die an einem zu reinigenden Objekt haftet, das die folgenden Schritte umfasst:

    Bewirken dass mehrere Reinigungsmedien, die schuppenartig geformt sind, fliegen und wiederholt mit dem Objekt in einer Reinigungskammer zusammen sto-βen, indem eine zirkulierende Luftströmung verwendet wird, um die an dem Objekt haftende Ablagerung zu entfernen; und
    Absaugen und Entfernen der Ablagerung, die an den Reinigungsmedien haftet, die mit dem Objekt zusammengestoßen sind, um die Reinigungsmedien wiederzugewinnen,
    wobei eine Stifthärte der Reinigungsmedien größer ist als eine Stifthärte der Ablagerung,
    dadurch gekennzeichnet, dass
    eine Faltbeständigkeit der Reinigungsmedien, die in Übereinstimmung mit JIS P8115 gemessen wird, größer oder gleich 2 und kleiner oder gleich 45 ist.

8. Verfahren nach Anspruch 7, wobei in wenigstens einer Seite jedes der Reinigungsmedien eine Nut gebildet ist, wobei sich die Nut von einem Ende zu einem weiteren Ende jedes der Reinigungsmedien erstreckt.

9. Reinigungsvorrichtung, die ein Reinigungsmedium nach einem der Ansprüche 1 bis 6 enthält, um das Objekt zu reinigen, wobei
die Reinigungsvorrichtung zum Entfernen einer Ablagerung, die an einem zu reinigenden Objekt (4) haftet, umfasst:

    eine Reinigungskammer (9), die eine Raum bildet, um mehrere wie Schuppen geformte Reinigungsmedien aufzunehmen;

eine Einheit (7) zum Erzeugen einer zirkulierenden Luftströmung, die konfiguriert ist, um eine zirkulierende Luftströmung zu erzeugen, um das Reinigungsmedium zu veranlassen, zu fliegen und wiederholt mit dem Objekt (4) in der Reinigungskammer (9) zusammenzustoßen, um dadurch die an dem Objekt (4) haftende Ablagerung zu entfernen; und

eine Reinigungsmedium-Rückgewinnungseinheit (8), die konfiguriert ist, um die Ablagerung, die an dem Reinigungsmedium haftet, das mit dem Objekt (4) zusammengestoßen ist, abzusaugen und zu entfernen, um dadurch das Reinigungsmedium wiederzugewinnen,

dadurch gekennzeichnet, dass das Reinigungsmedium ein Reinigungsmedium nach einem der Ansprüche 1 bis 6 ist.

Revendications

1. Milieu de nettoyage pour retirer un dépôt adhérant sur un objet à nettoyer comprenant :

   - plusieurs milieux de nettoyage formés comme des flocons qui sont configurés pour être amenés à voler et heurter de manière répétée l'objet pour retirer le dépôt adhérant sur l'objet,

   dans lequel les multiples milieux de nettoyage sont en outre configurés de sorte que le dépôt adhère de manière amovible sur les milieux de nettoyage qui ont heurté l'objet pour recycler le milieu de nettoyage,

   dans lequel une dureté au crayon du milieu de nettoyage est supérieure à une dureté au crayon du dépôt, et

   caractérisé en ce que

   une endurance au pliage du milieu de nettoyage mesurée selon la norme JIS P8115, est supérieure ou égale à 2 et inférieure ou égale à 45.

2. Milieu de nettoyage selon la revendication 1, dans lequel une rainure est formée sur au moins un côté de chacun des milieux de nettoyage, la rainure s'étendant d'une extrémité à l'autre de chacun des milieux de nettoyage.

3. Milieu de nettoyage selon la revendication 1, dans lequel les milieux de nettoyage comprennent des milieux de nettoyage de différentes épaisseurs.

4. Milieu de nettoyage selon la revendication 1, dans lequel les milieux de nettoyage comprennent des milieux de nettoyage de différentes formes.

5. Milieu de nettoyage selon la revendication 1, dans lequel les milieux de nettoyage comprennent des milieux de nettoyage de différentes tailles.

6. Milieu de nettoyage selon la revendication 1, dans lequel l'épaisseur des milieux de nettoyage est supérieure ou égale à 20 μm et inférieure ou égale à 200 μm.

7. Procédé pour retirer un dépôt fixé sur un objet à nettoyer, comprenant les étapes consistant à :

   amener plusieurs milieux de nettoyage formés comme des flocons, à voler et à heurter de manière répétée l'objet dans une chambre de nettoyage en utilisant un écoulement d'air circulant pour retirer le dépôt fixé sur l'objet ; et

   aspirer et retirer le dépôt fixé sur les milieux de nettoyage qui ont heurté l'objet afin de recycler les milieux de nettoyage,

   dans lequel une dureté au crayon des milieux de nettoyage est supérieure à une dureté au crayon du dépôt,

   caractérisé en ce que

   une endurance au pliage des milieux de nettoyage, mesurée selon la norme JIS P8115, est supérieure ou égale à 2 et inférieure ou égale à 45.

8. Procédé selon la revendication 7, dans lequel une rainure est formée au moins d'un côté de chacun des milieux de nettoyage, la rainure s'étendant d'une extrémité à l'autre de chacun des milieux de nettoyage.

9. Dispositif de nettoyage comprenant un milieu de nettoyage selon l'une quelconque des revendications 1 à 6 pour nettoyer l'objet, dans lequel
   le dispositif de nettoyage pour retirer un dépôt fixé sur un objet (4) à nettoyer, comprenant :

une chambre de nettoyage (9) formant un espace pour loger plusieurs milieux de nettoyage en forme de flocons ;
une unité de génération d'écoulement d'air circulant (7) configurée pour générer un écoulement d'air circulant afin d'amener le milieu de nettoyage à voler et à heurter de manière répétée l'objet (4) dans la chambre de nettoyage (9) et retirer ainsi le dépôt fixé sur l'objet (4) ; et
une unité de recyclage de milieu de nettoyage (8) configurée pour aspirer et retirer le dépôt fixé sur le milieu de nettoyage qui a heurté l'objet (4) et recycler ainsi le milieu de nettoyage,
caractérisé en ce que le milieu de nettoyage est un milieu de nettoyage selon l'une quelconque des revendications 1 à 6.

FIG.1A

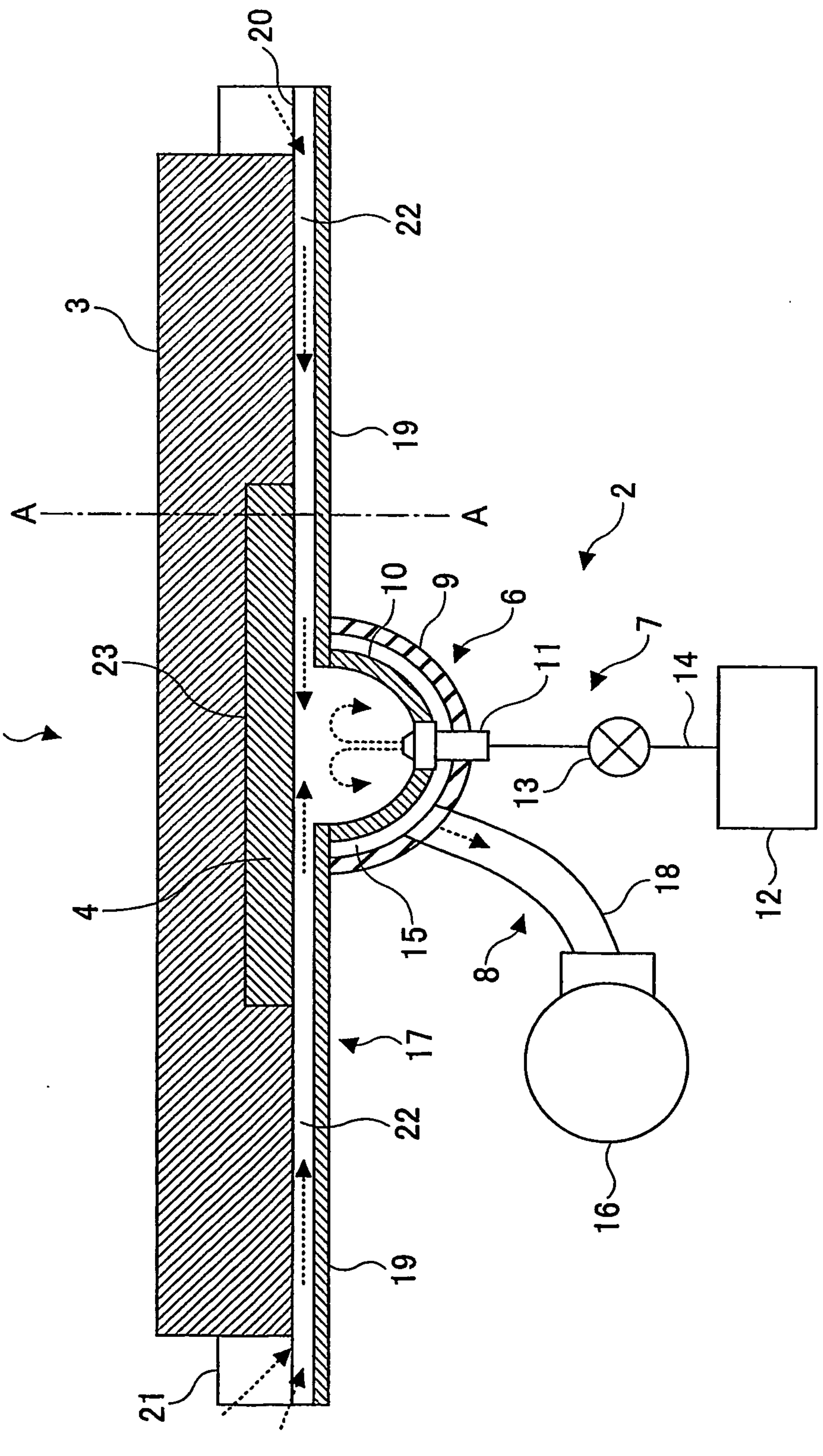


FIG.1B

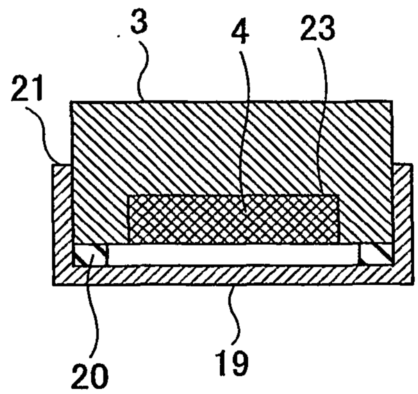


FIG.1C

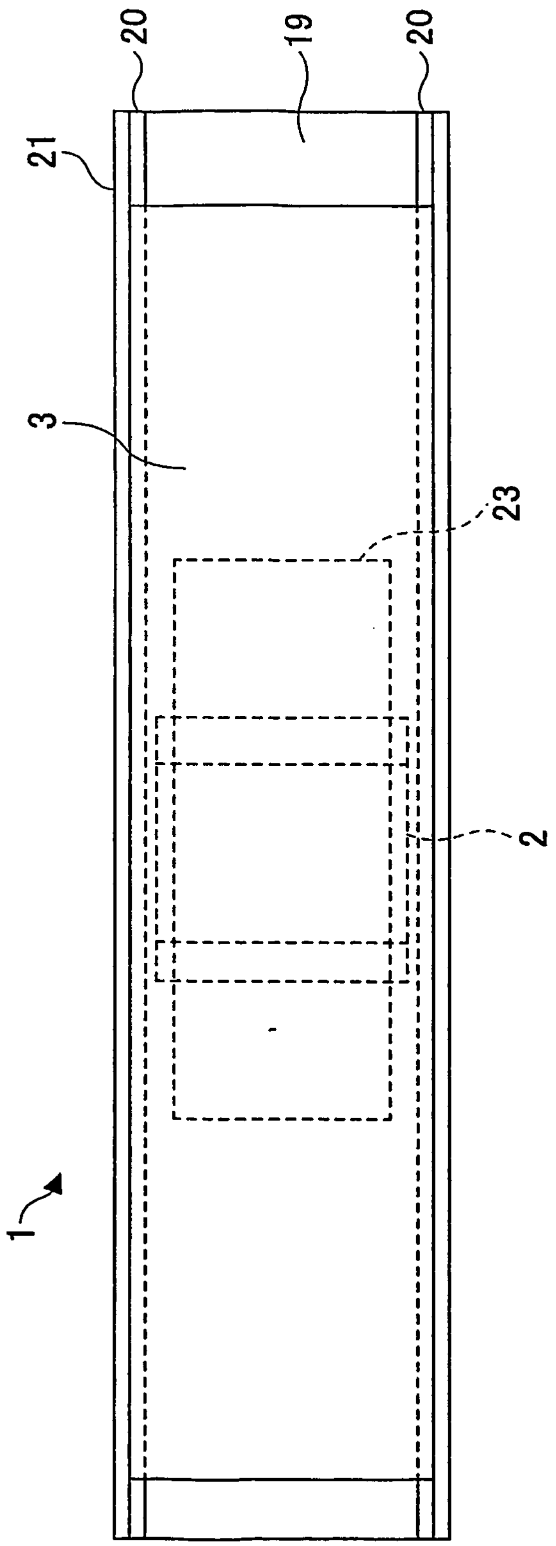


FIG.2A

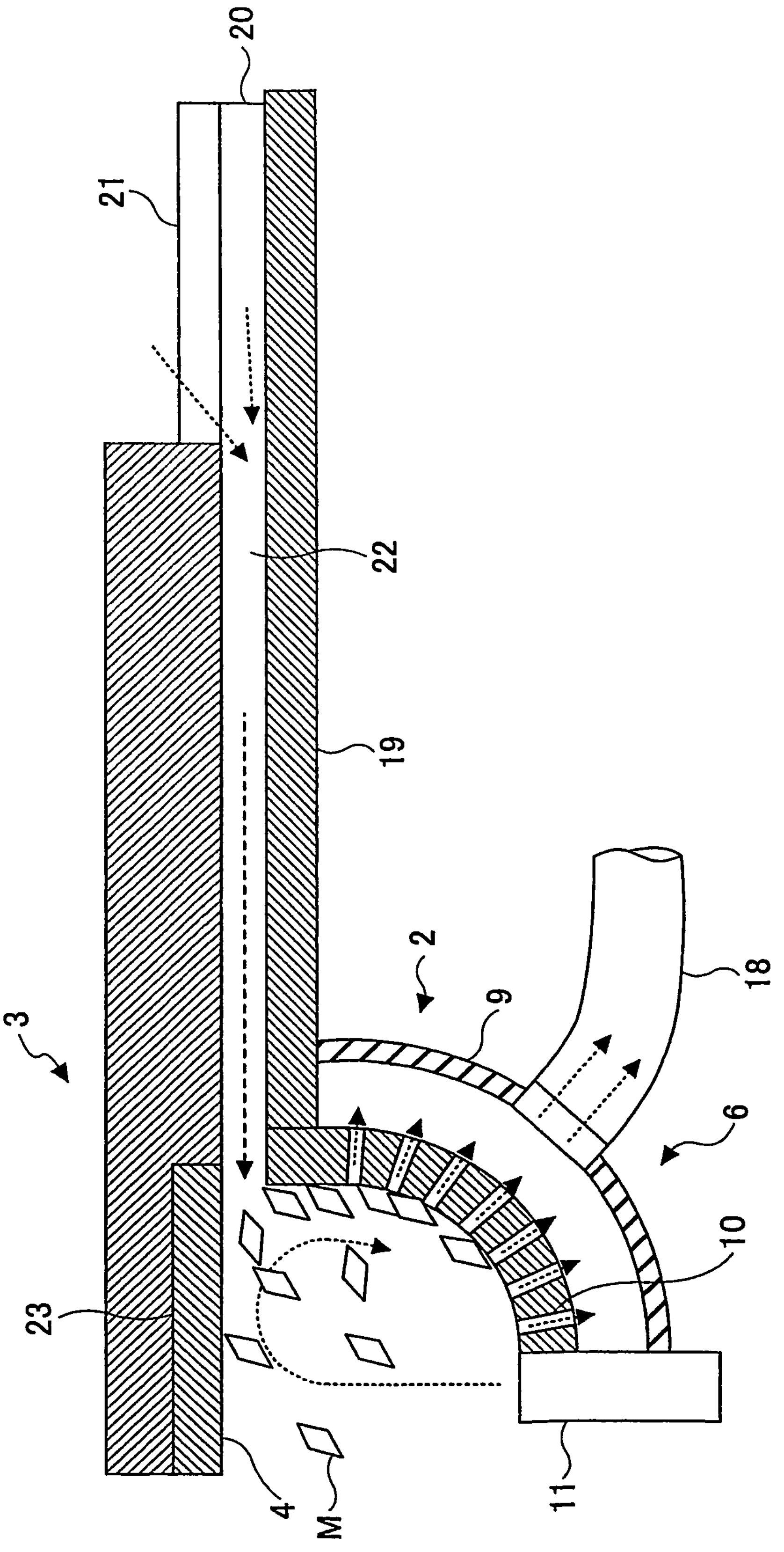


FIG.2B

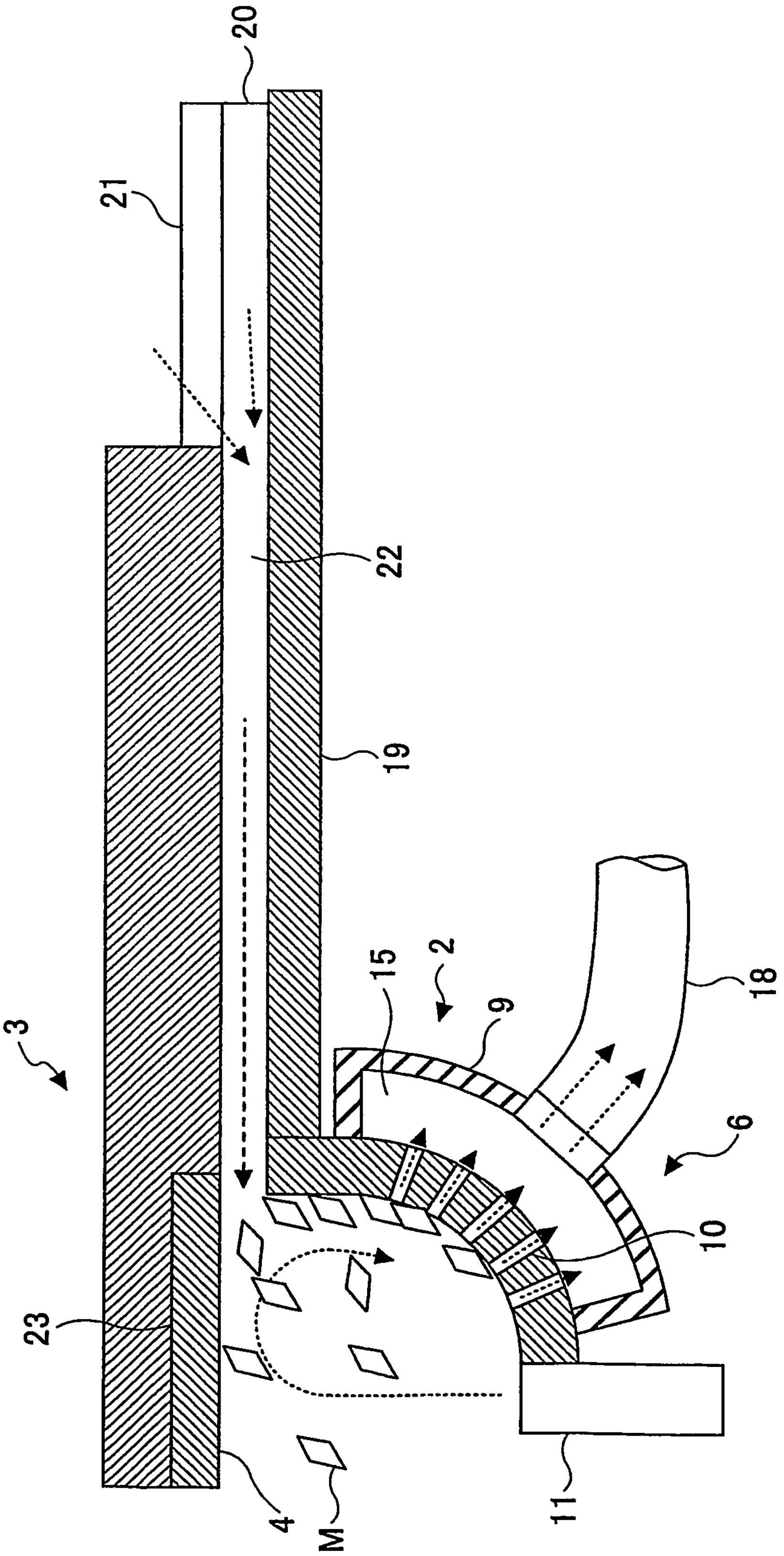


FIG.3A

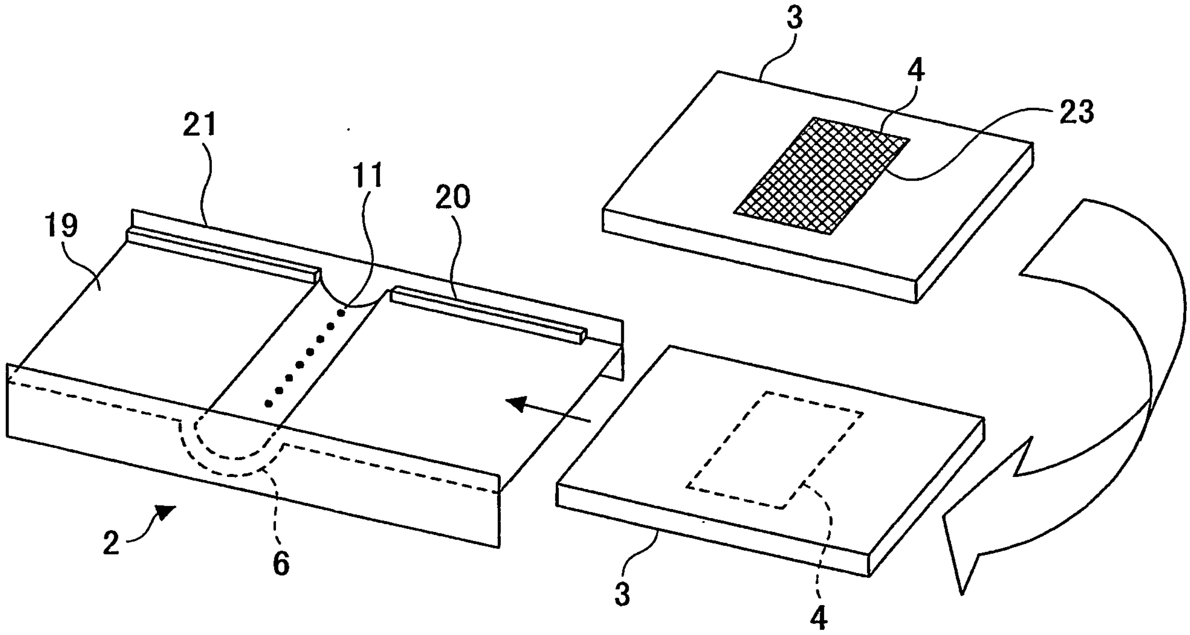


FIG.3B

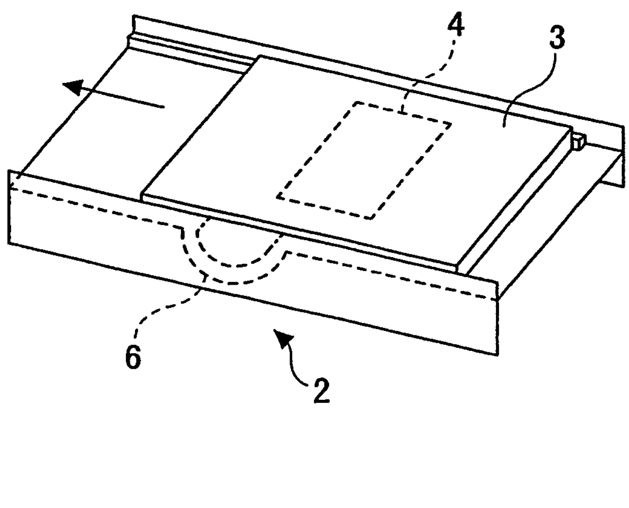


FIG.4A

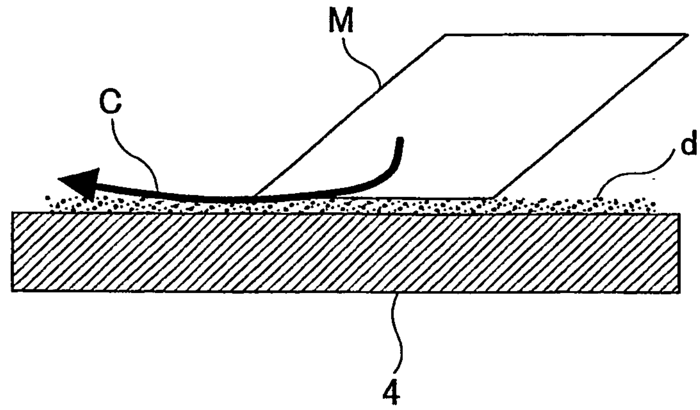


FIG.4B

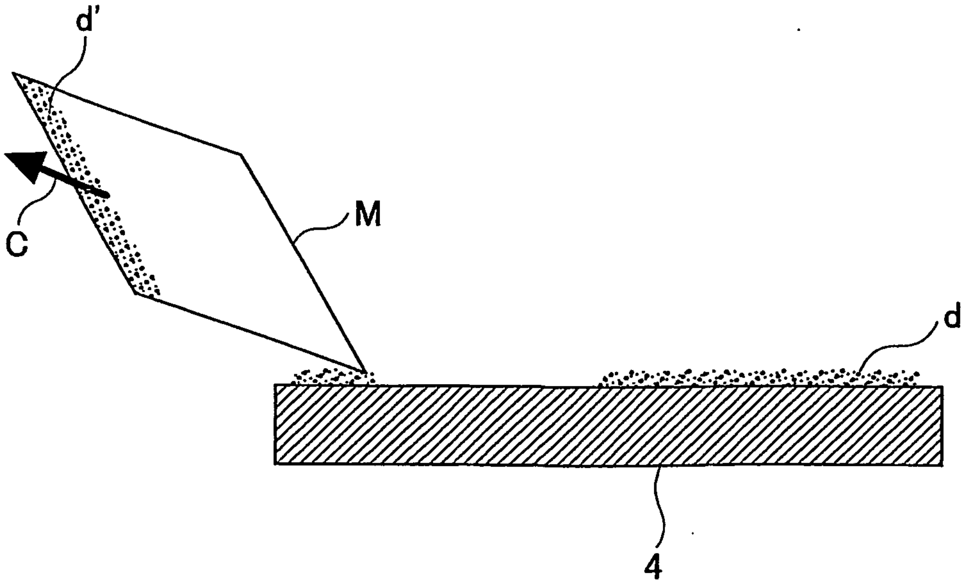


FIG.5A

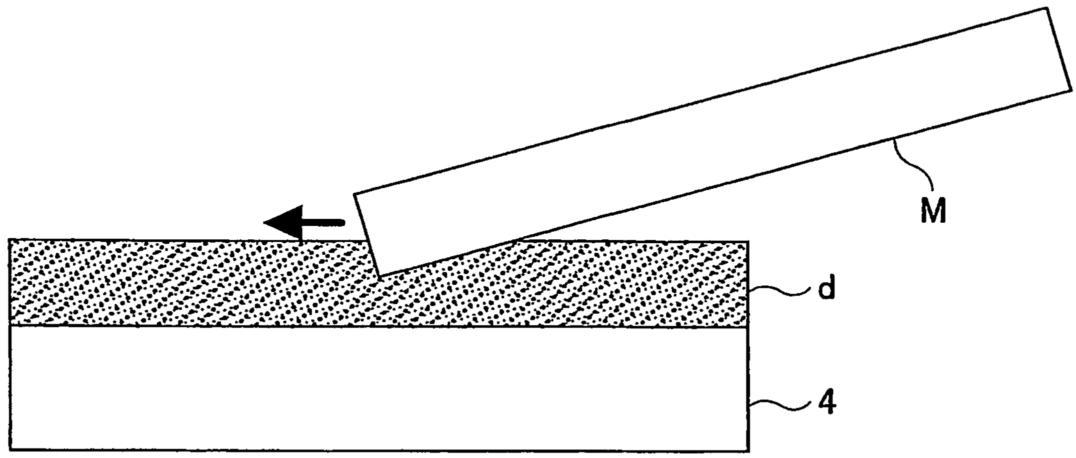


FIG.5B

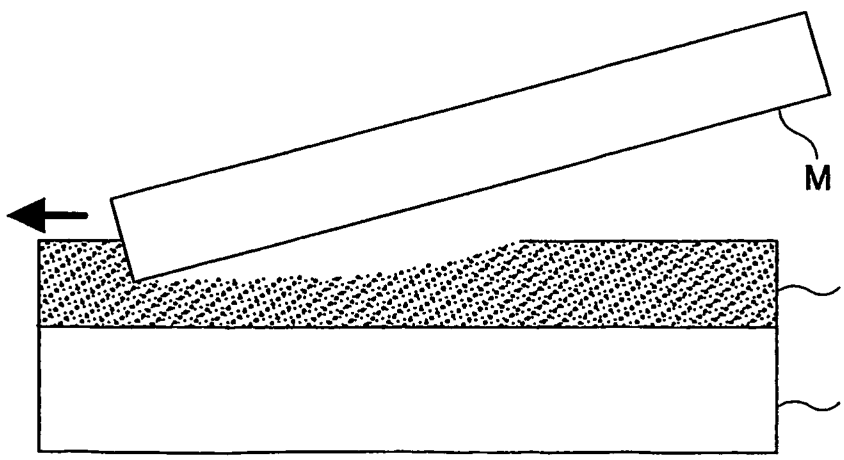


FIG.6

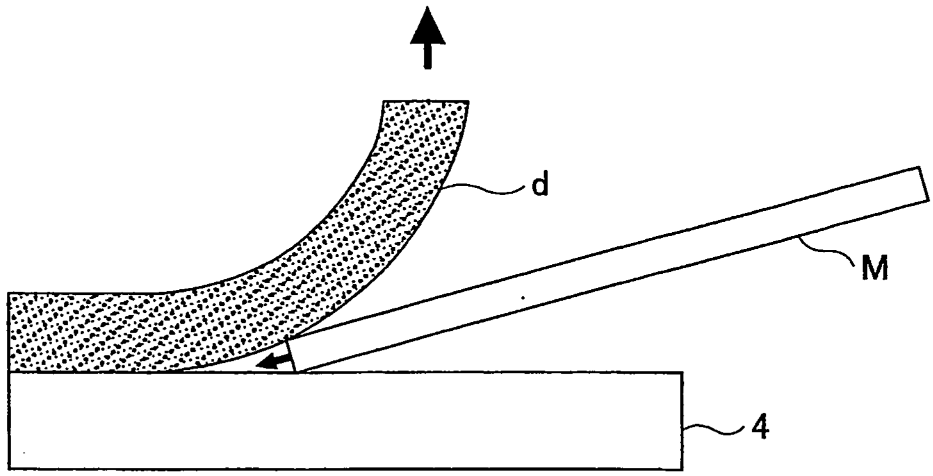


FIG.7

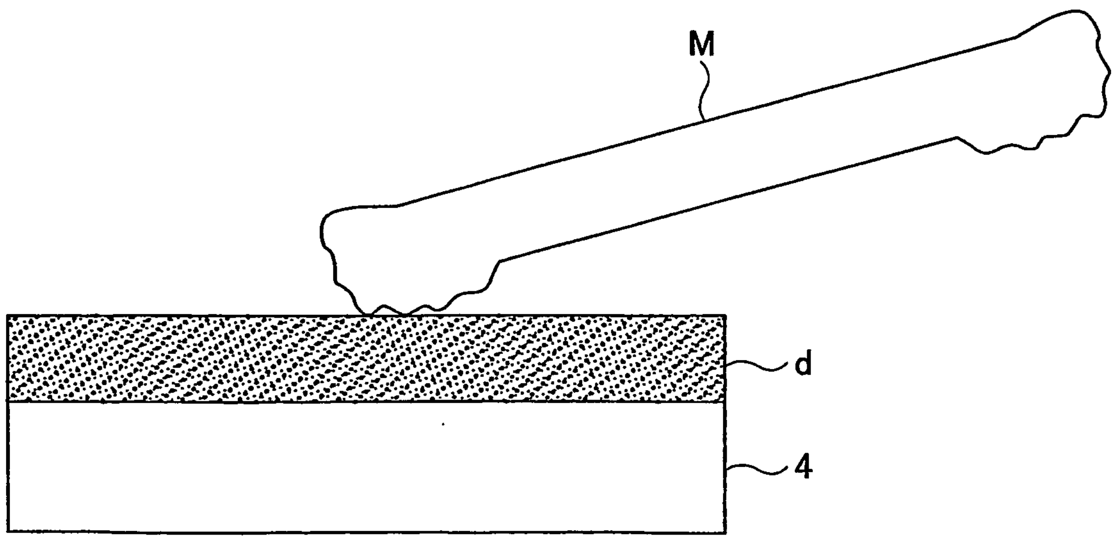


FIG.8A

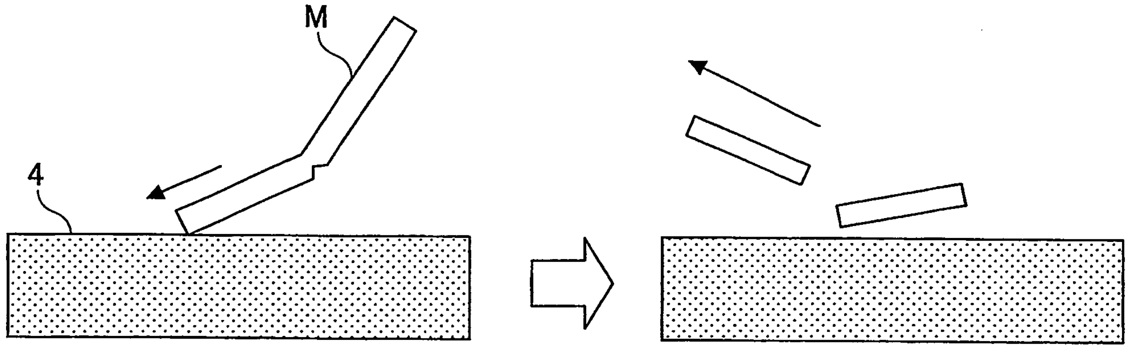


FIG.8B

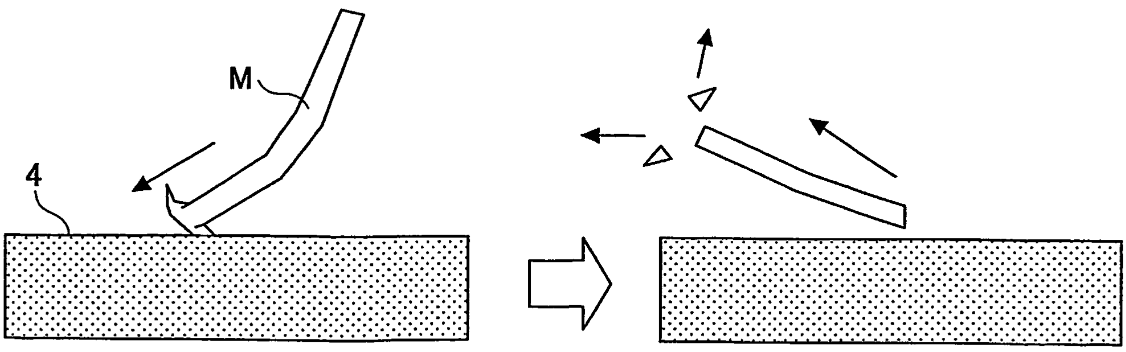


FIG.8C

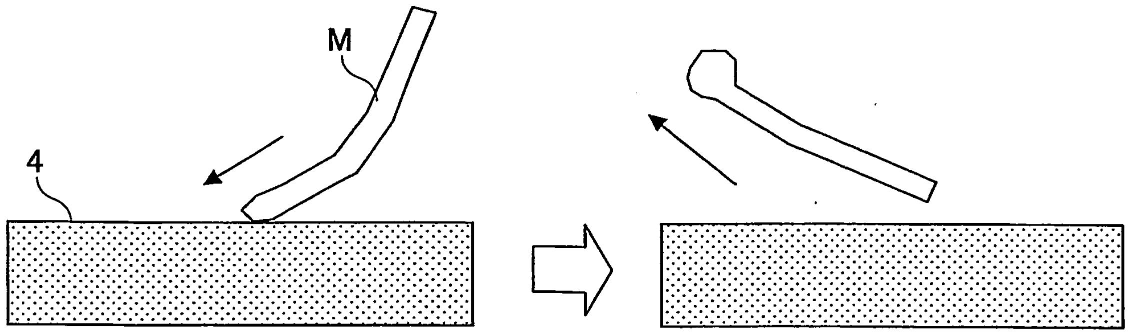


FIG.8D

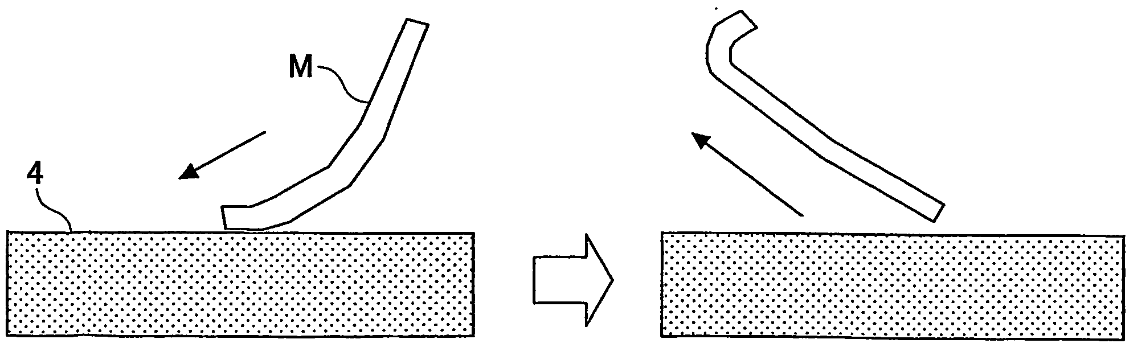


FIG.9

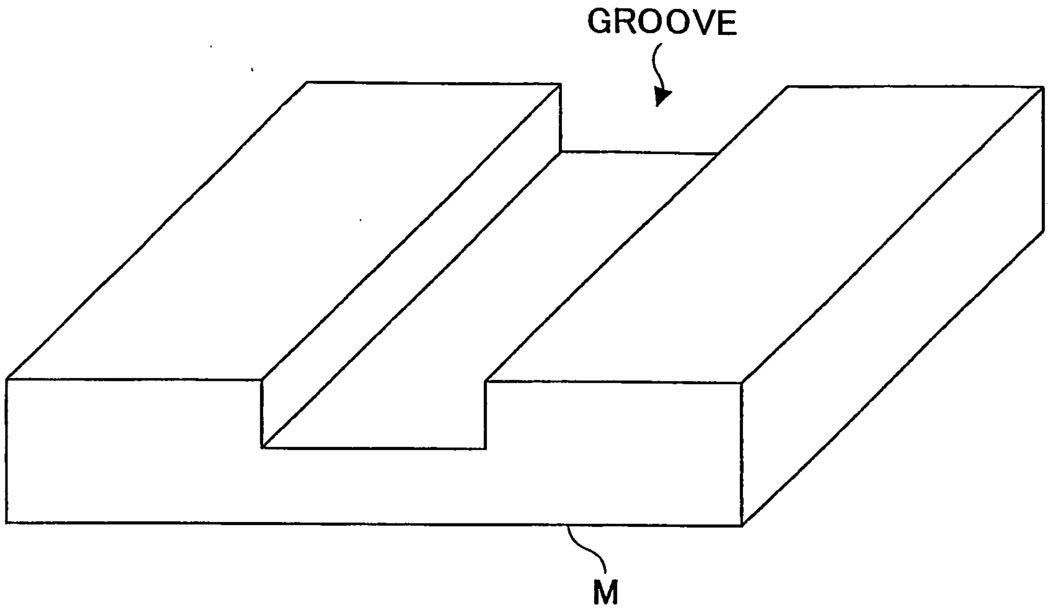


FIG.10

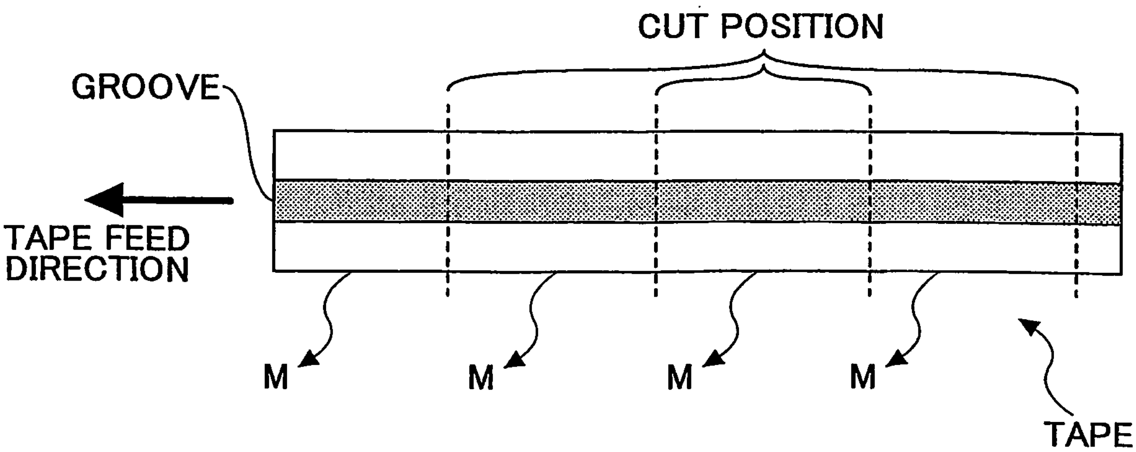


FIG.11

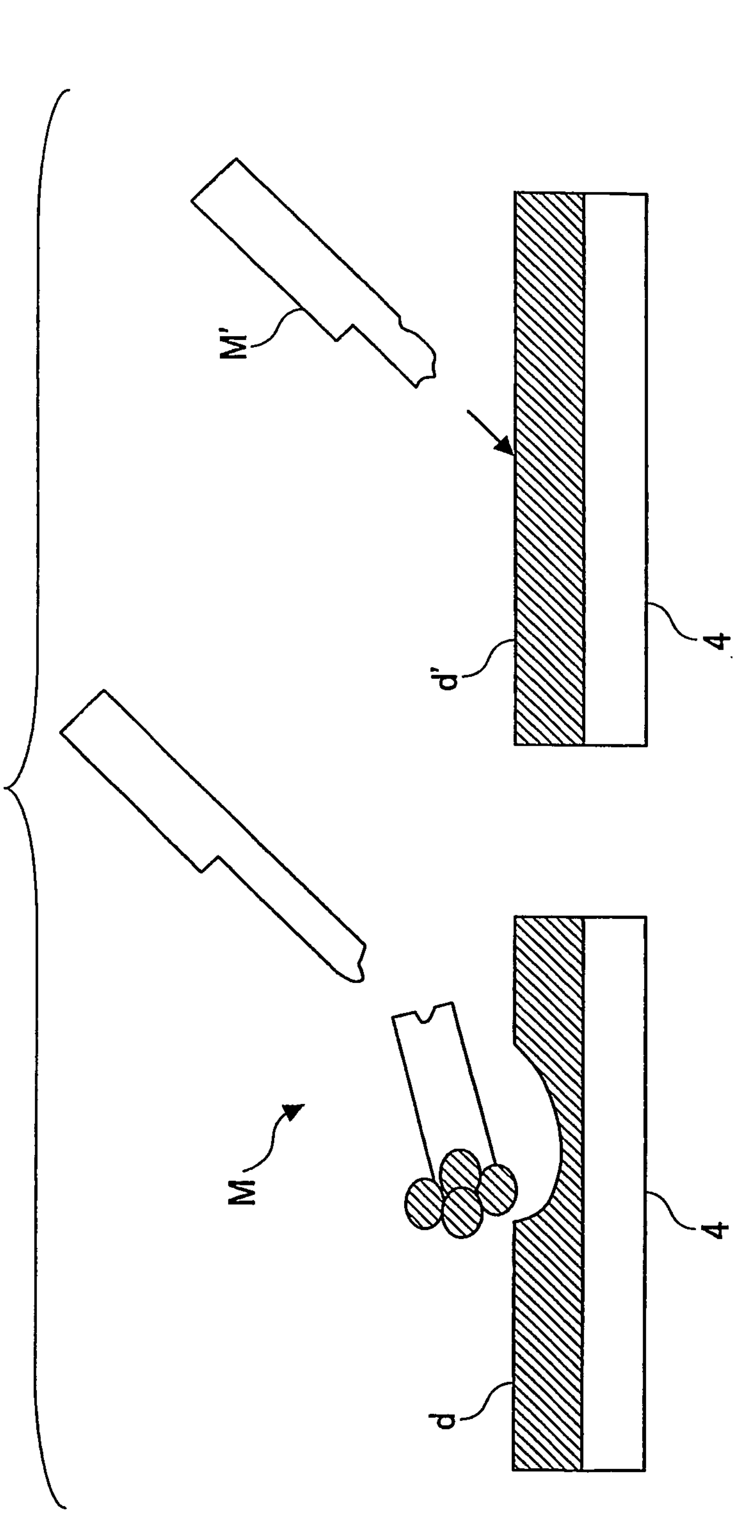


FIG.12

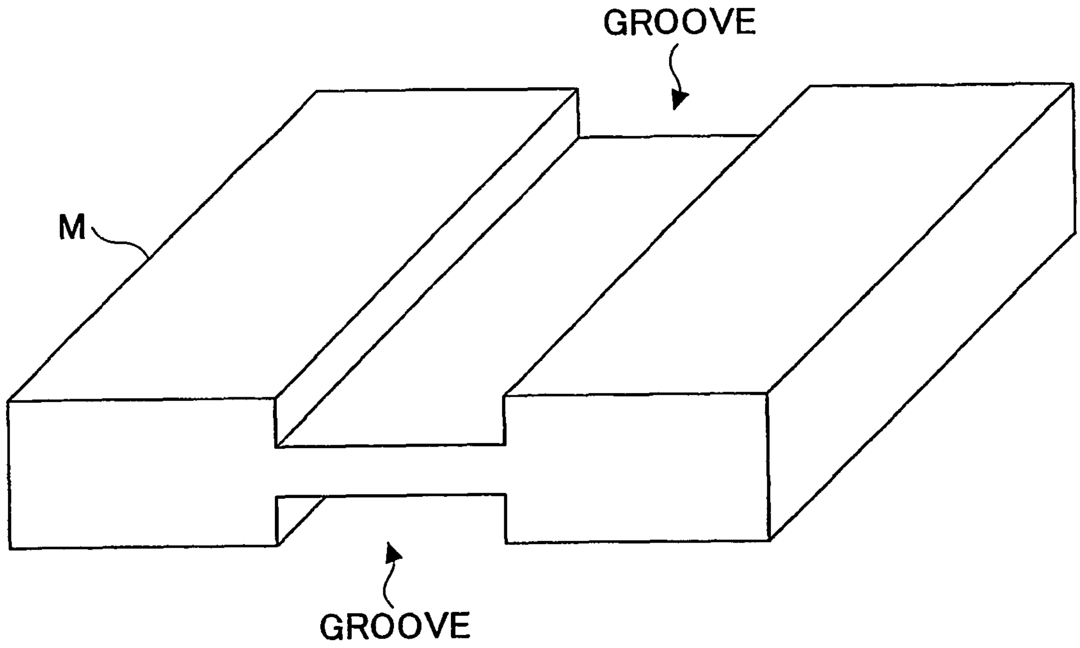


FIG.13

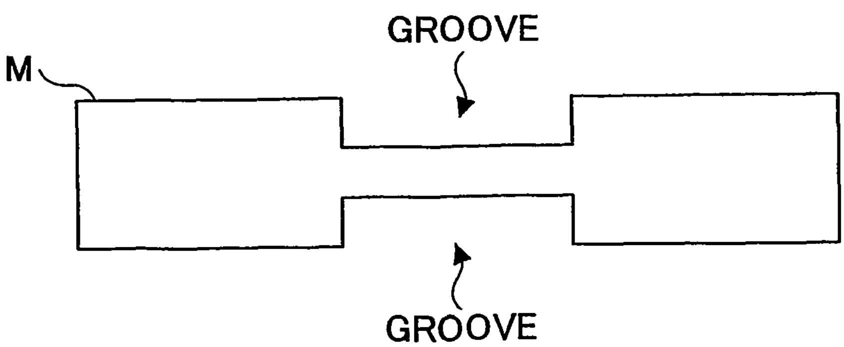


FIG.14

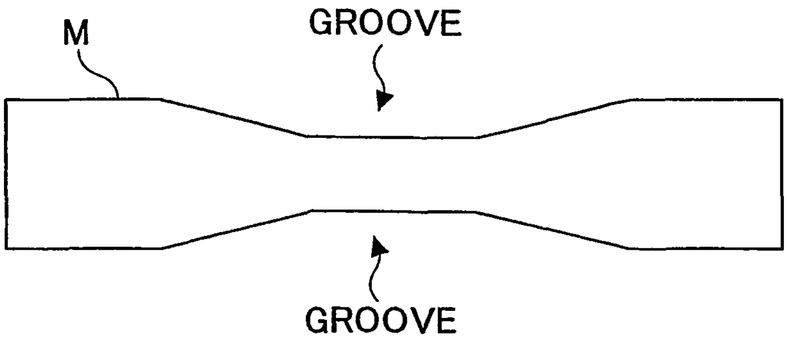


FIG.15

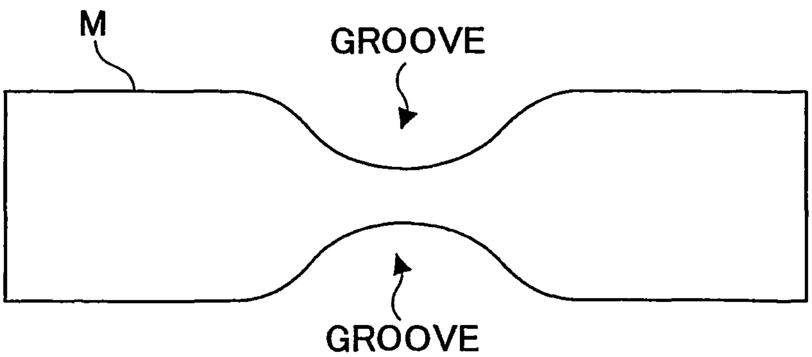


FIG.16

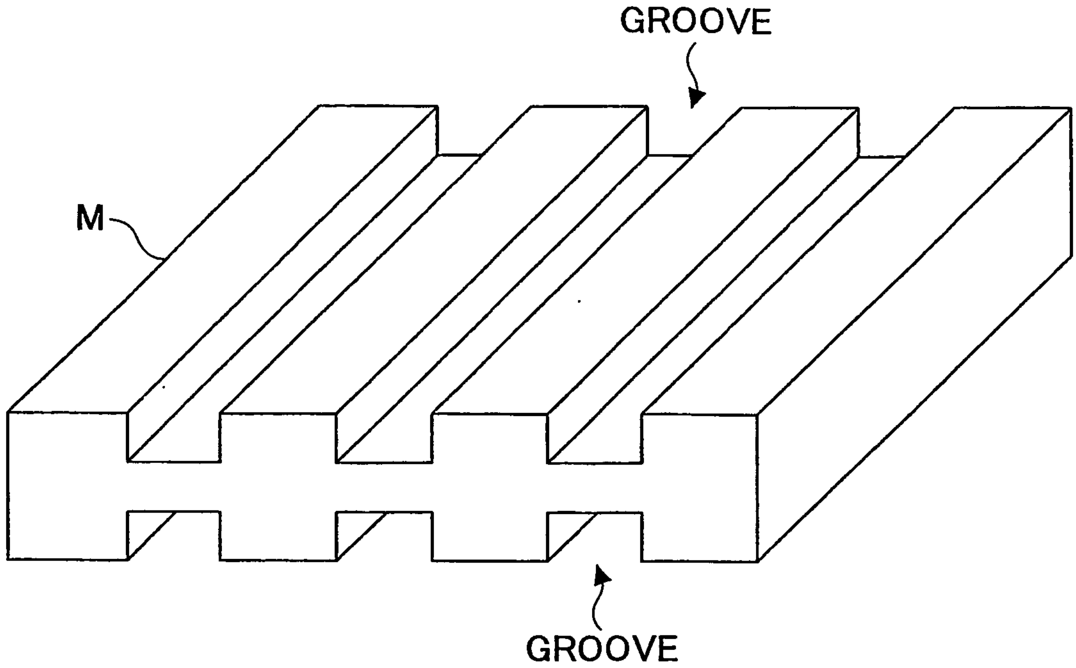


FIG.17

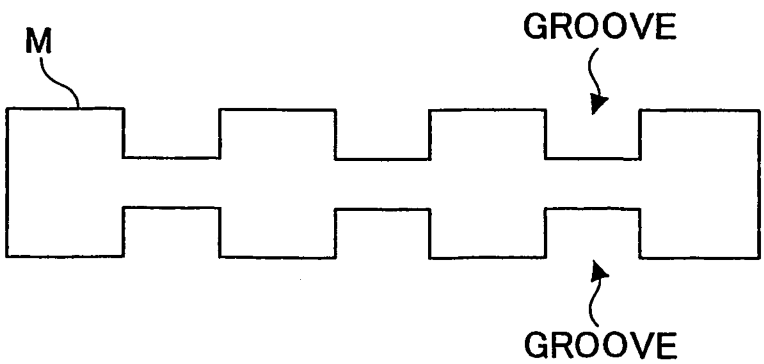


FIG.18

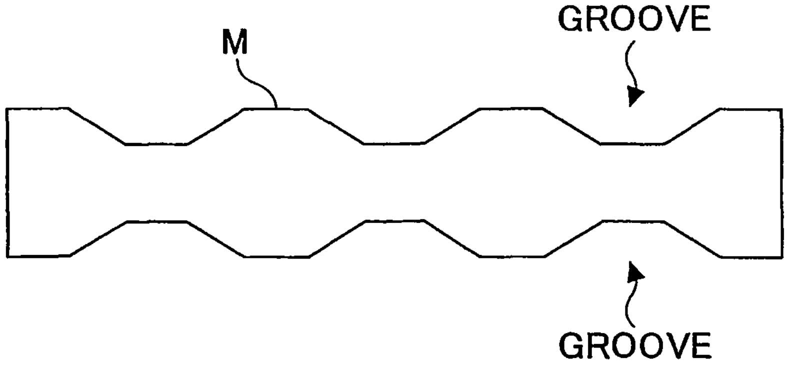


FIG.19

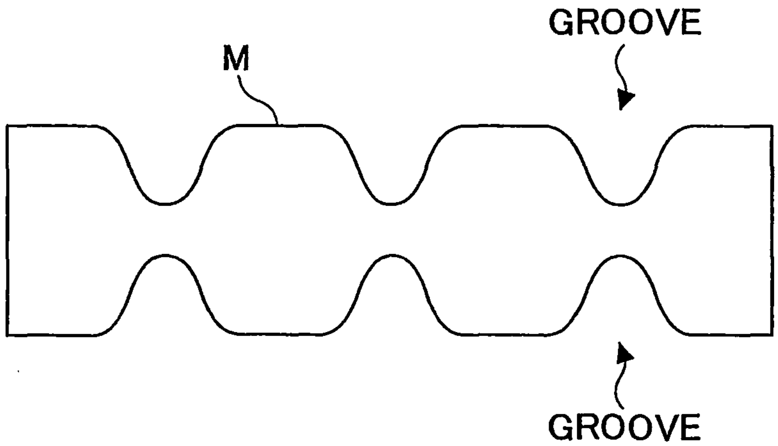


FIG.20

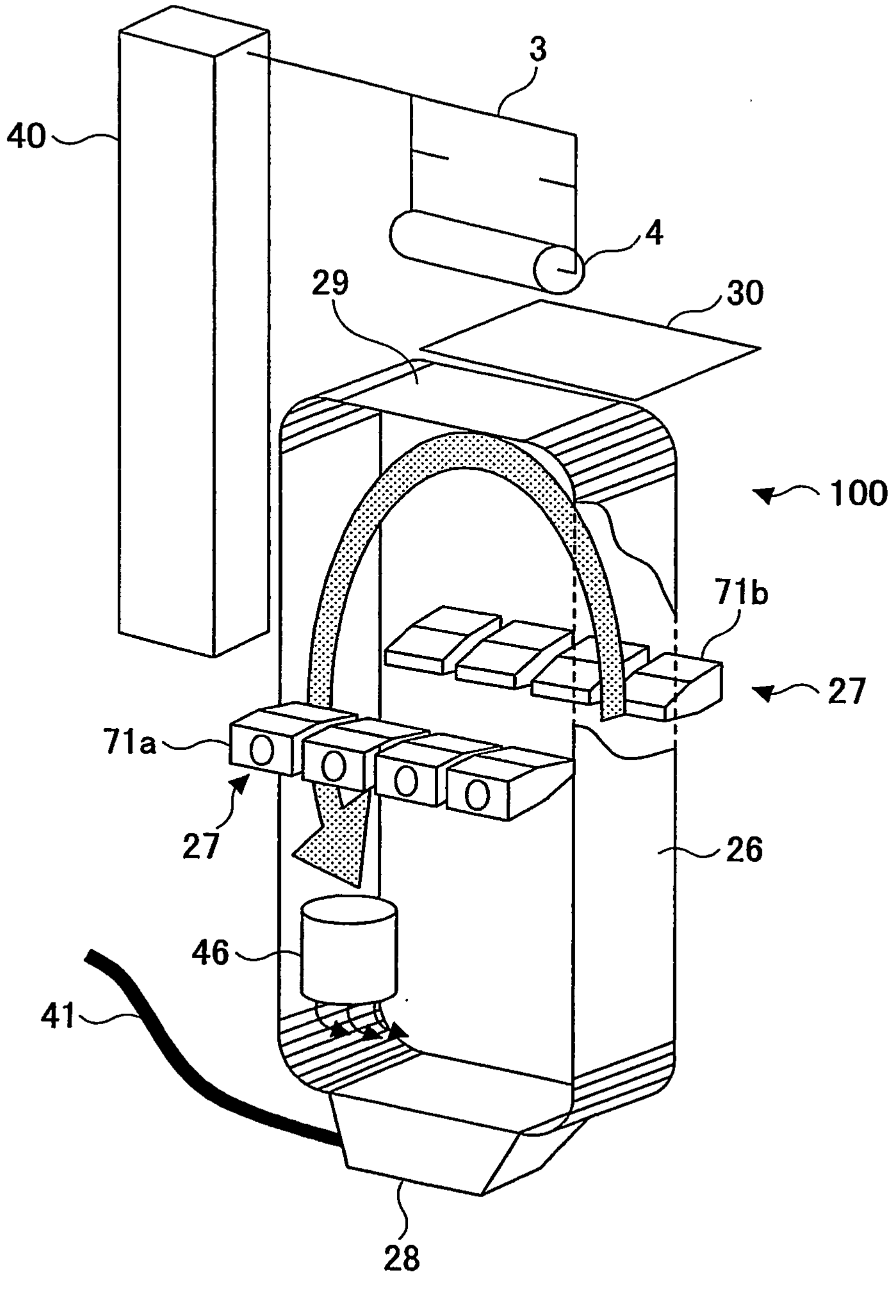


FIG.21A

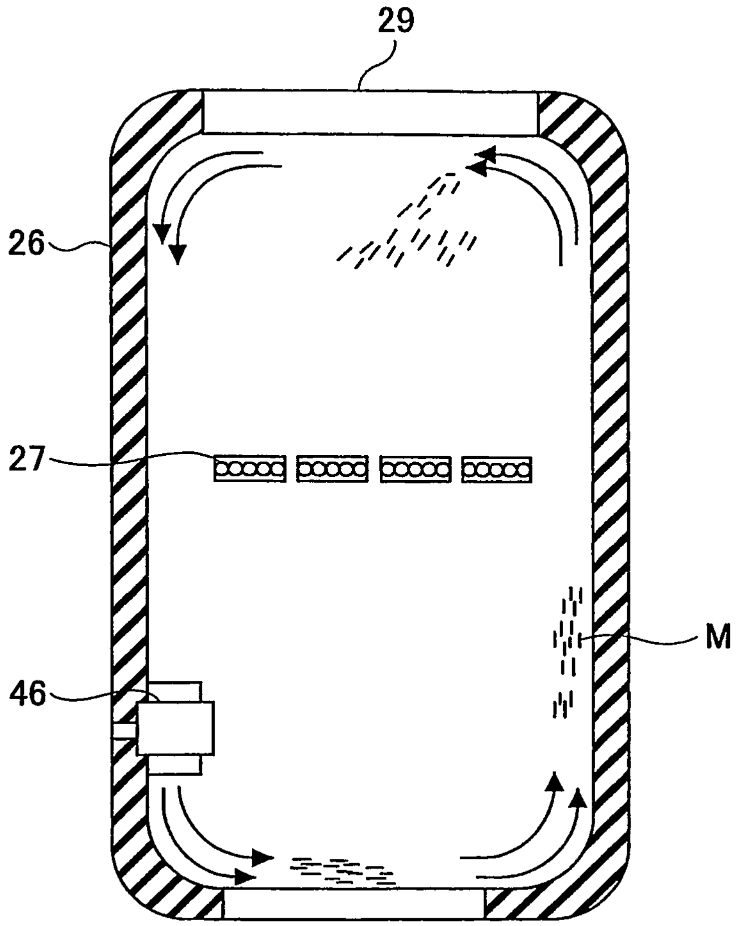
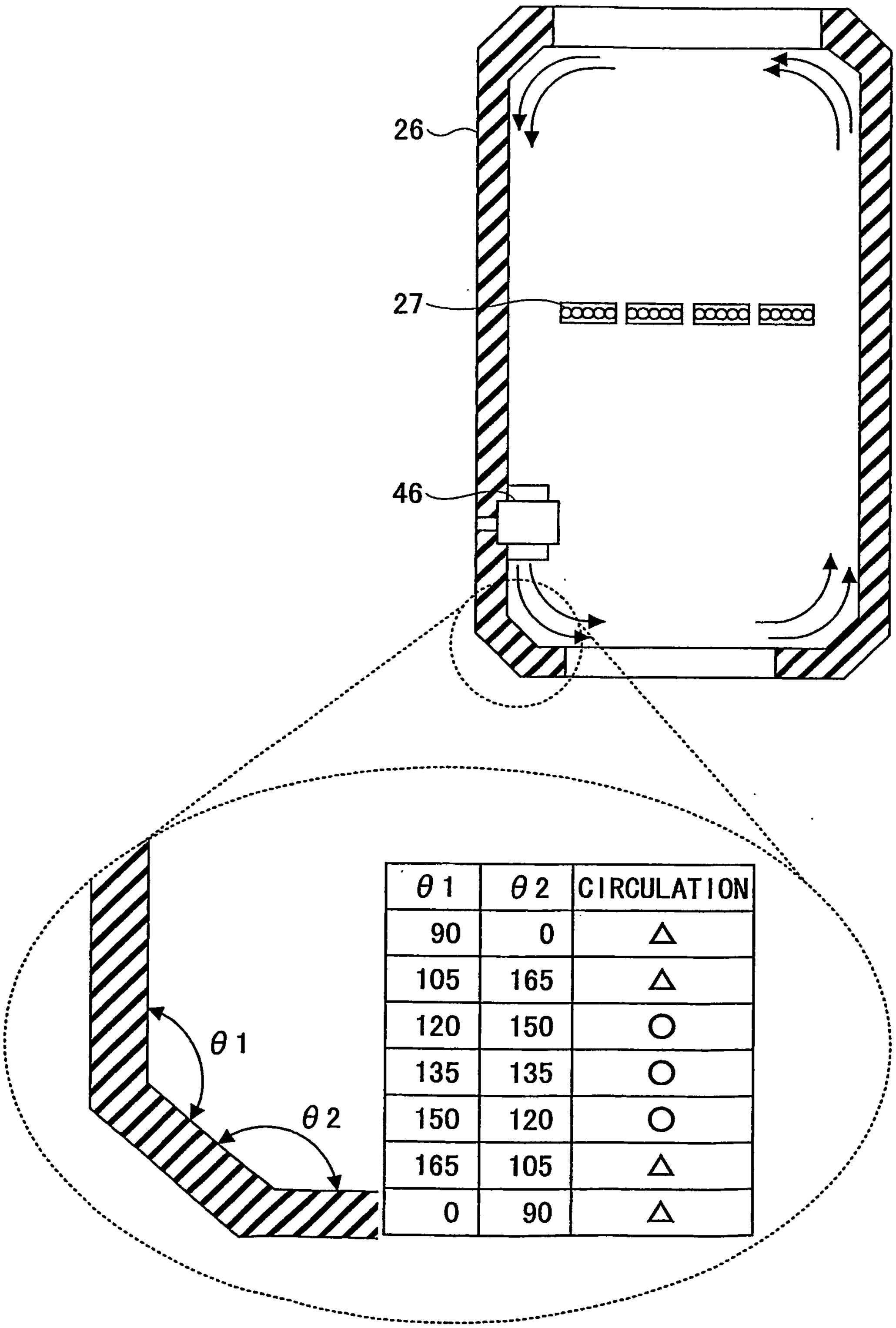


FIG.21B



θ1	θ2	CIRCULATION
90	0	△
105	165	△
120	150	○
135	135	○
150	120	○
165	105	△
0	90	△

FIG.22

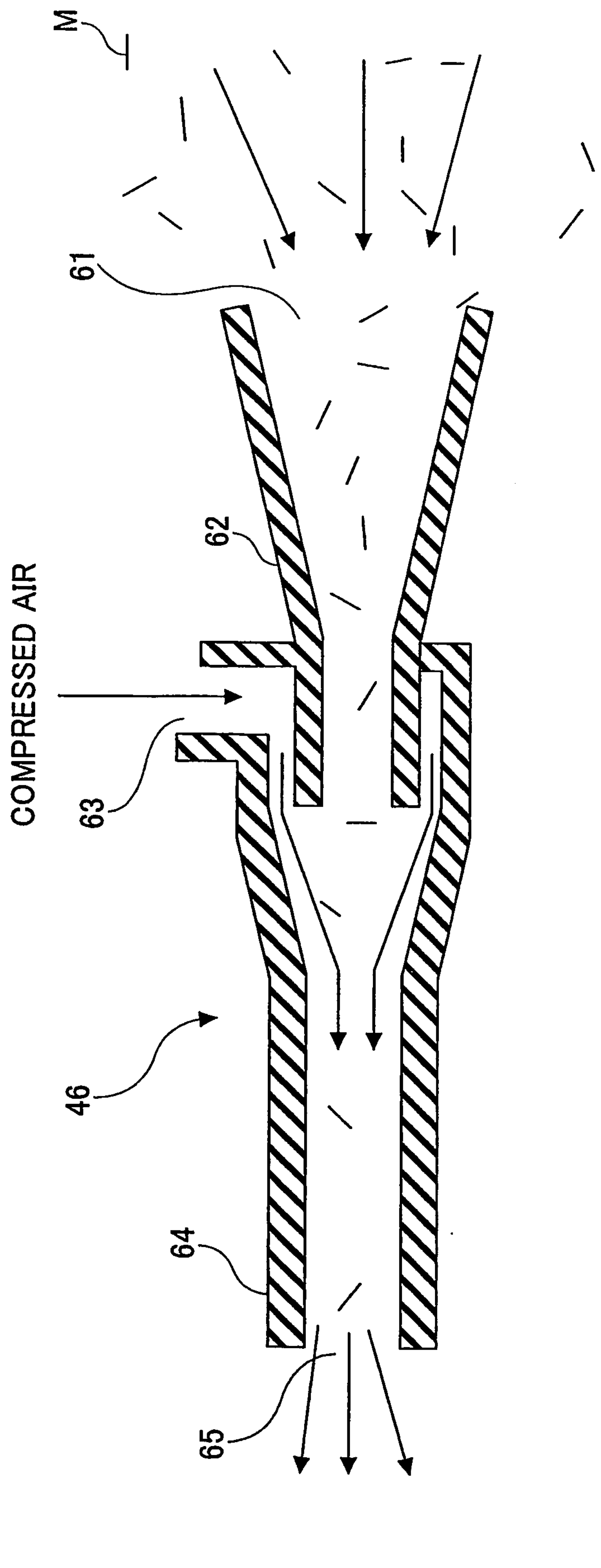


FIG.23A

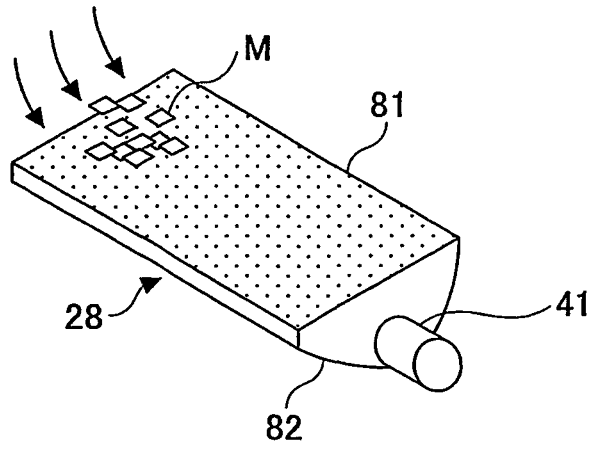


FIG.23B

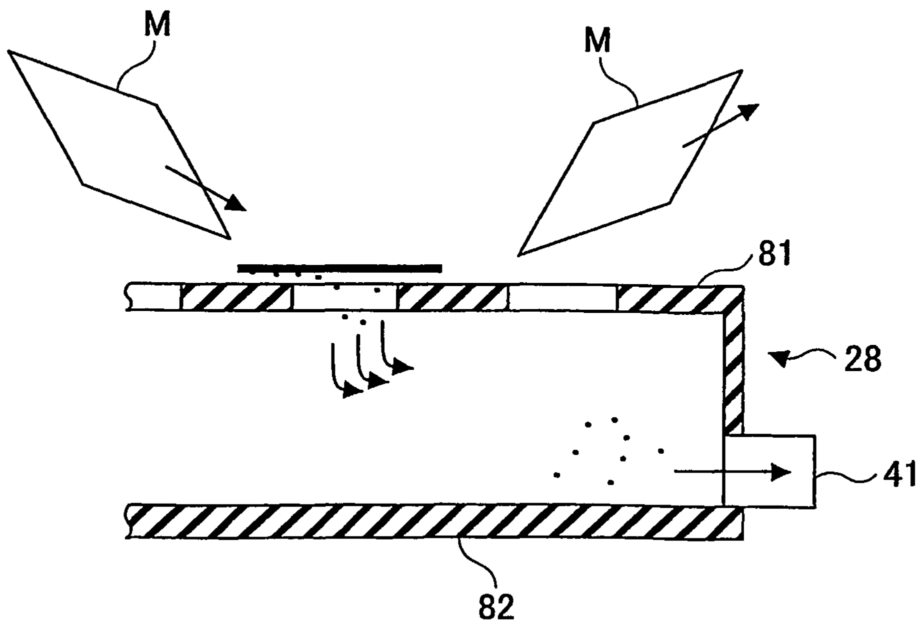


FIG.24

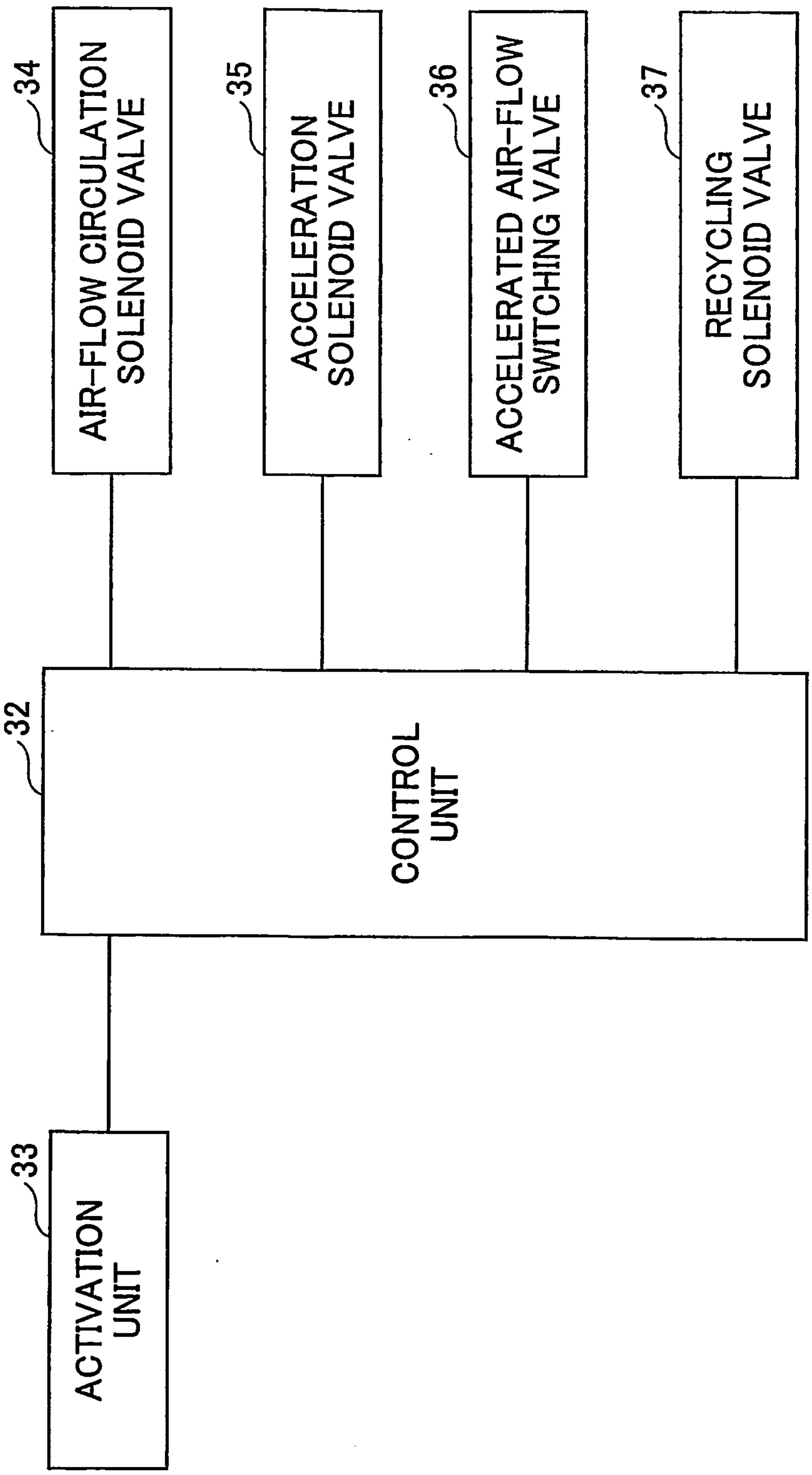

34
AIR-FLOW CIRCULATION SOLENOID VALVE
35
ACCELERATION SOLENOID VALVE
36
ACCELERATED AIR-FLOW SWITCHING VALVE
37
RECYCLING SOLENOID VALVE
32
CONTROL UNIT
33
ACTIVATION UNIT

FIG.25A

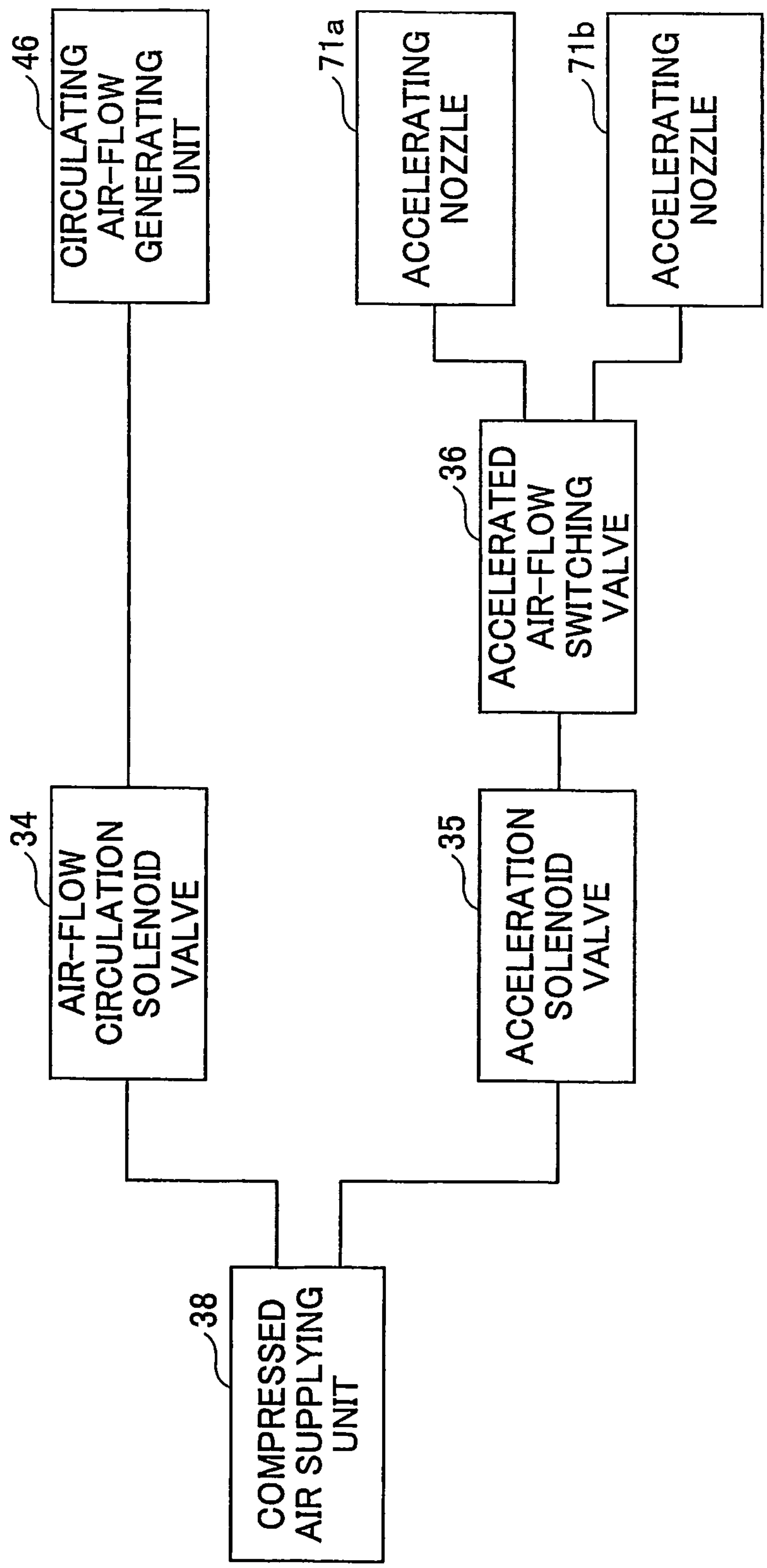

46
CIRCULATING AIR-FLOW GENERATING UNIT
71a
ACCELERATING NOZZLE
71b
ACCELERATING NOZZLE
36
ACCELERATED AIR-FLOW SWITCHING VALVE
34
AIR-FLOW CIRCULATION SOLENOID VALVE
35
ACCELERATION SOLENOID VALVE
38
COMPRESSED AIR SUPPLYING UNIT

FIG.25B

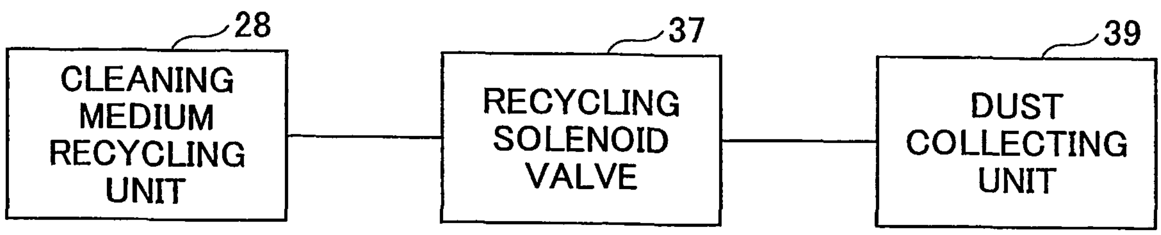
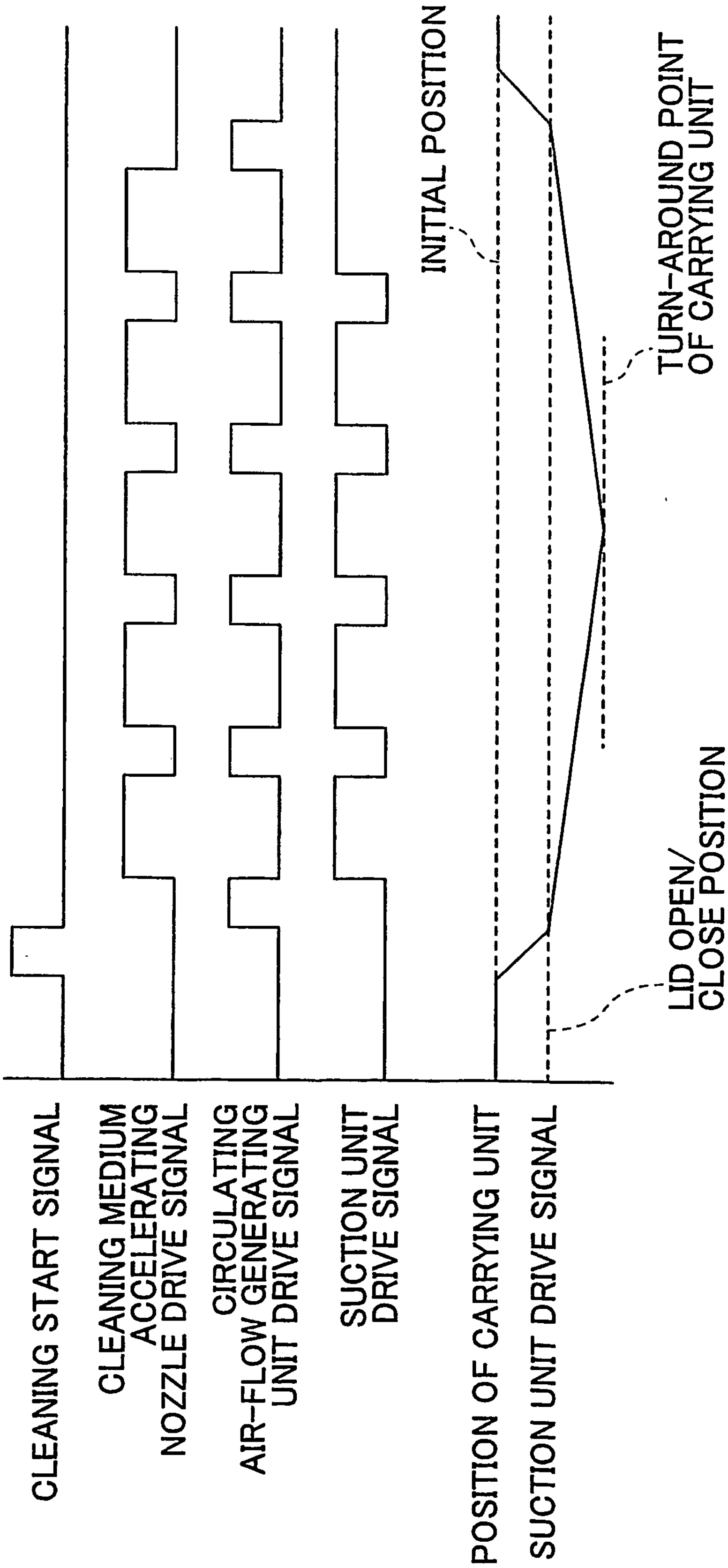

28
CLEANING MEDIUM RECYCLING UNIT
37
RECYCLING SOLENOID VALVE
39
DUST COLLECTING UNIT

FIG.26


CLEANING START SIGNAL
CLEANING MEDIUM ACCELERATING NOZZLE DRIVE SIGNAL
CIRCULATING AIR-FLOW GENERATING UNIT DRIVE SIGNAL
SUCTION UNIT DRIVE SIGNAL
POSITION OF CARRYING UNIT
SUCTION UNIT DRIVE SIGNAL
INITIAL POSITION
TURN-AROUND POINT OF CARRYING UNIT
LID OPEN/ CLOSE POSITION

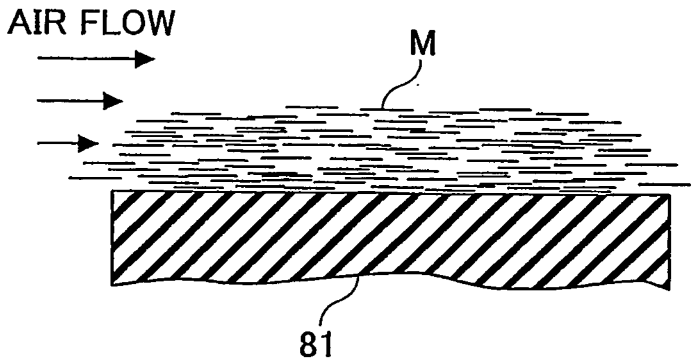


FIG.27A

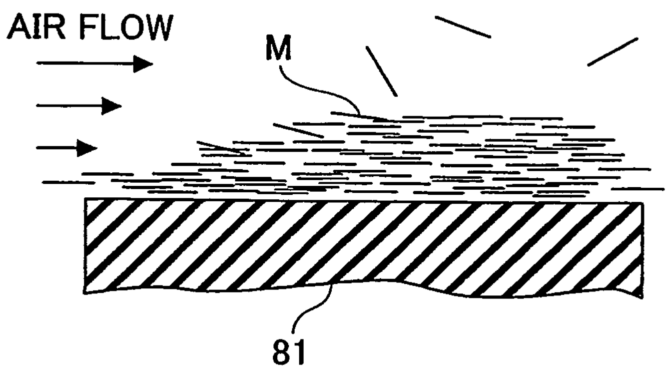


FIG.27B

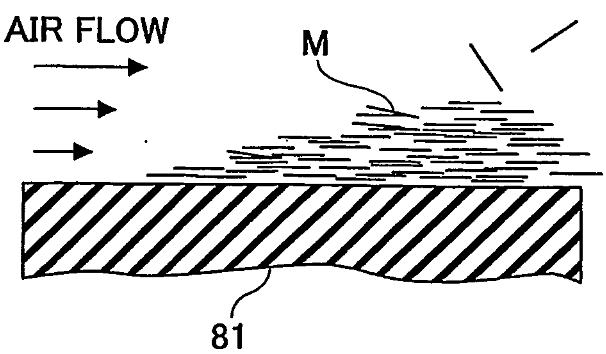


FIG.27C

FIG.28A

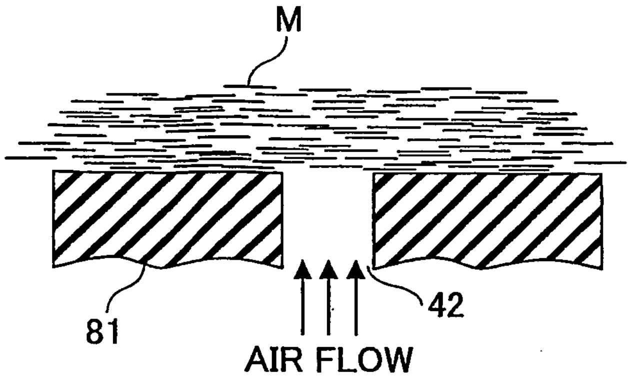


FIG.28B

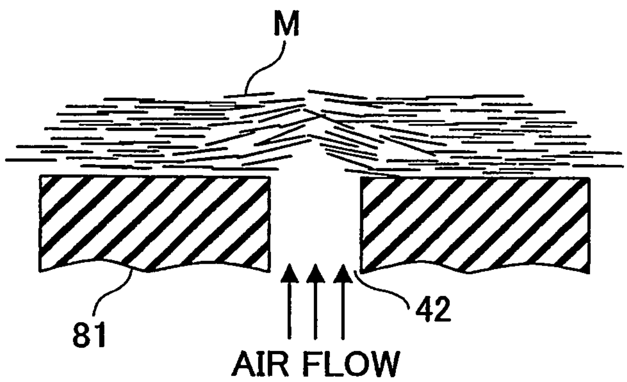


FIG.28C

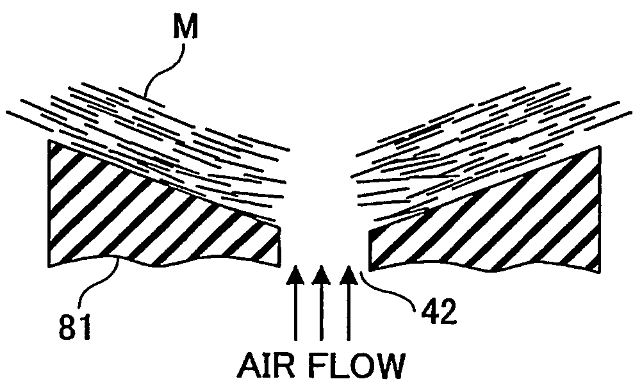


FIG.29

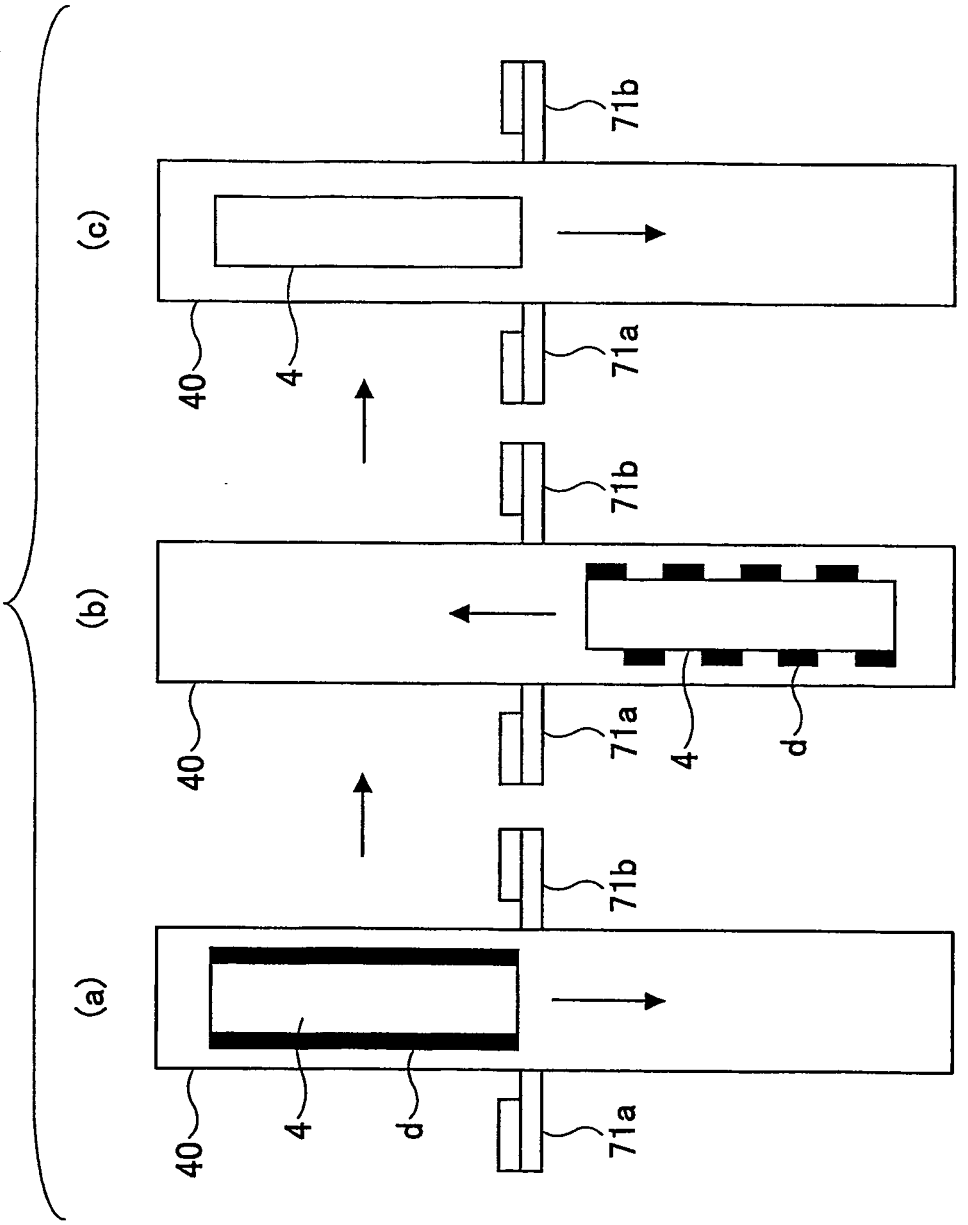


FIG.30

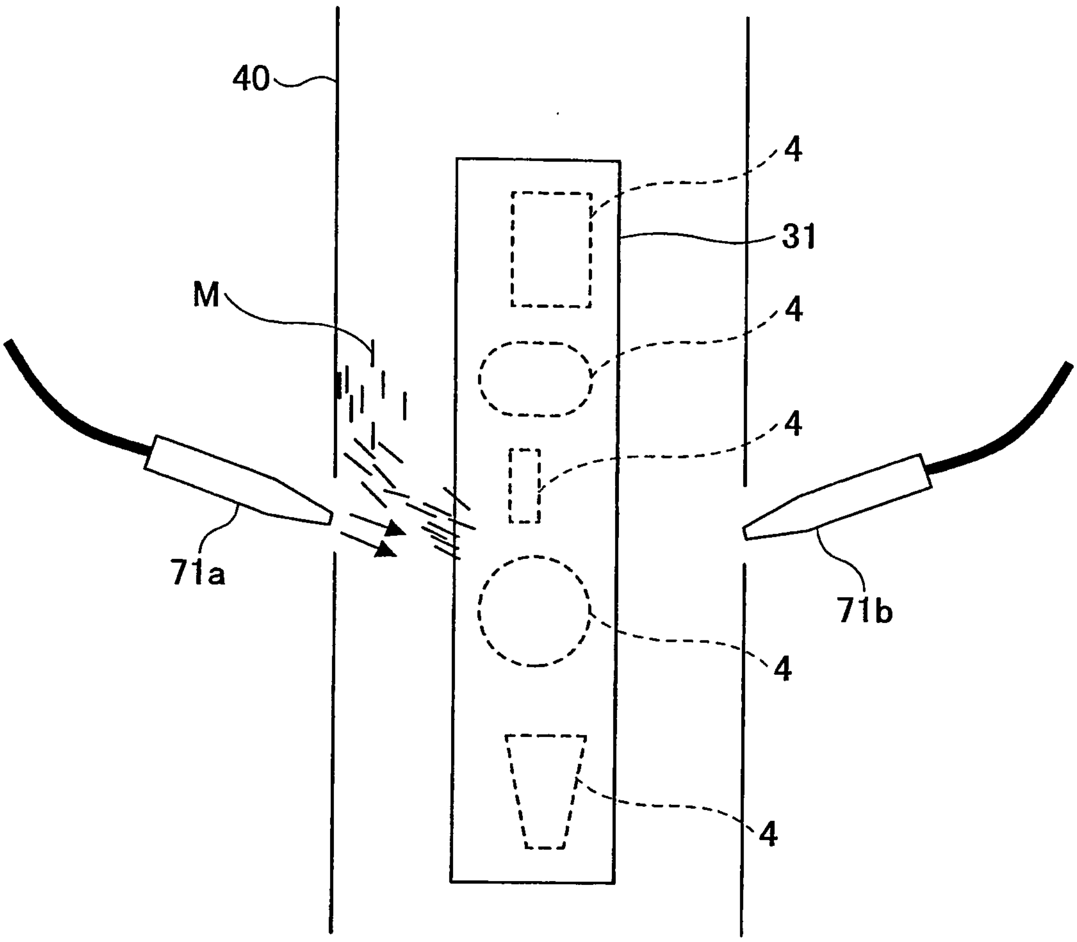
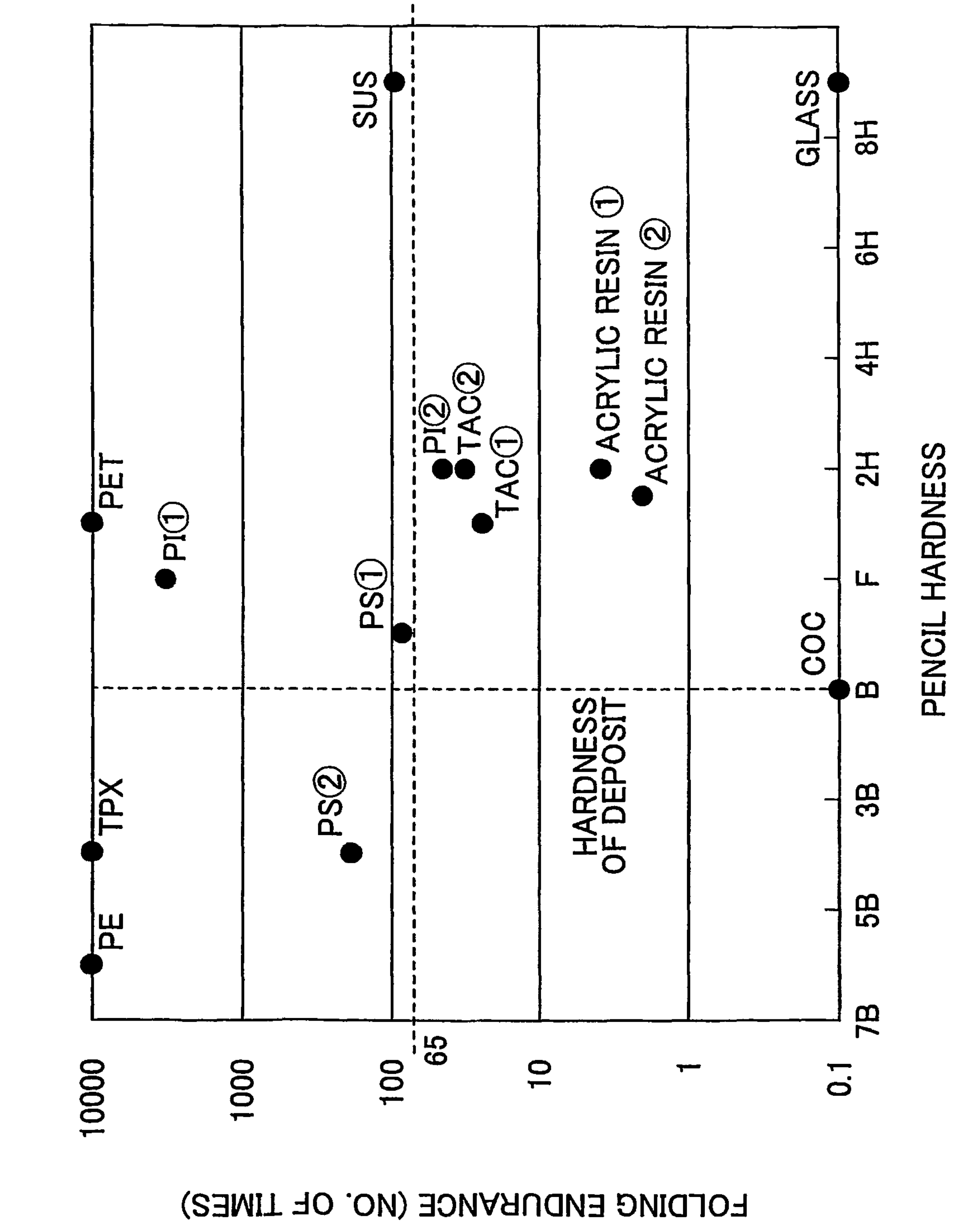


FIG.31



FOLDING ENDURANCE (NO. OF TIMES)
10000
1000
100
65
10
1
0.1
PENCIL HARDNESS
7B
5B
3B
B
F
2H
4H
6H
8H
PE
TPX
PET
PI①
PS②
PS①
SUS
PI②
TAC②
TAC①
HARDNESS OF DEPOSIT
ACRYLIC RESIN ①
ACRYLIC RESIN ②
COC
GLASS

REFERENCES CITED IN THE DESCRIPTION

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