(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 700 737 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.02.2014 Bulletin 2014/09

(21) Application number: **13181003.8**

(22) Date of filing: **20.08.2013**

(51) Int Cl.:
C25D 5/02 (2006.01) *C25D 17/00* (2006.01)
C25D 17/02 (2006.01) *C25D 17/12* (2006.01)

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

(30) Priority: **22.08.2012 JP 2012183261**

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(54) **Pattern forming device and pattern forming method**

(57) A pattern forming device includes a plurality of tanks, and a power supply device. Each of the tanks has an open end having the same shape as a profile shape of a corresponding one of regions of a surface of a workpiece, in which different types of films are to be formed, and stores a corresponding one of electrodeposition solutions used to form the different types of films in a state where the open end is in contact with the surface. The power supply device applies a predetermined voltage to between the workpiece that serves as a first electrode, and each one of second electrodes in the tanks.

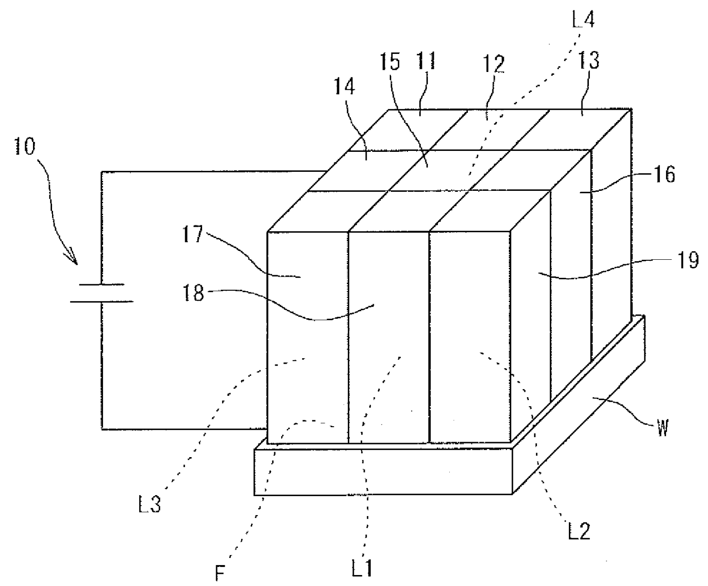

FIG.1

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a pattern forming device and a pattern forming method each for forming, by electrodeposition, different types of films in corresponding multiple regions of a surface of a workpiece to obtain a predetermined film pattern on the surface of the workpiece from these films.

2. Description of Related Art

[0002] In order to reduce frictional resistance on a surface of a metal workpiece, for example, a film of a resin is formed on the surface in some cases. As a method for forming such a film, electrodeposition is known. Specifically, as illustrated in FIG. 7, a workpiece 92 and a counter electrode 93 are placed in a tank 91 filled with an electrodeposition solution (electrolyte solution) 90 containing a resin component, and a direct-current voltage is applied to the workpiece 92 and the counter electrode 93, so that the resin component contained in the electrodeposition solution 90 is deposited on a surface of the workpiece 92 to form a film from the resin. A device for forming a film on a surface of a workpiece by electrodeposition is described in, for example, Japanese Patent Application Publication No. 2000-256895 (JP2000-256895 A) (see FIG. 1).

[0003] Further, as illustrated in FIG. 8, in a case where different types of films are formed, by electrodeposition, in corresponding multiple regions of a surface of a workpiece 95 to obtain a predetermined film pattern from these films, masks are conventionally used, as described below. As shown in FIG. 8, the surface of the plate-like workpiece 95 is partitioned into nine regions A1 to A9. A first film is formed in each of the regions A2, A4, A6, A8. A second film different in type from the first film is formed in each of the regions A1, A9. A third film different in type from the first film and the second film is formed in each of the regions A3, A7. A fourth film different in type from the first, second, and third films is formed in the region A5.

[0004] In a case where such a film pattern is formed, first, a workpiece and a counter electrode are placed in a tank filled with an electrodeposition solution used to form the first film. Note that a grid mask M1 is disposed on a surface of the workpiece as illustrated in FIG. 9A. Then, a direct-current voltage is applied to the workpiece and the counter electrode, so that the first film is formed in each of the regions A2, A4, A6, A8, which are not covered with the mask M1 (see FIG. 9B). Subsequently, the workpiece, on which the first film has been formed, and the counter electrode are placed in a tank filled with an electrodeposition solution used to form the second film. Note that the mask used to cover the surface of this workpiece is replaced with another mask M2, as illustrated in FIG. 9C. In this way, the second film is formed in each of the regions A1, A9, which are not covered with the mask M2 (see FIG. 9D).

[0005] Similarly, the workpiece, on which the mask has been replaced with a mask M3 (see FIG. 9E), is placed in a tank filled with an electrodeposition solution used to form the third film in each of the regions A3, A7 (FIG. 9F). Furthermore, the workpiece covered with a mask M4 (see FIG. 9G) is placed in a tank filled with an electrodeposition solution used to form the fourth film, so that the fourth film is formed in the region A5 (FIG. 9H).

[0006] As described above, in order to form the different types of films by electrodeposition in the corresponding multiple regions A1 to A9 of the surface of the workpiece to obtain a predetermined film pattern from these films, it is necessary to perform the electrodeposition treatment several times by sequentially placing the workpiece in the tanks respectively filled with the different types of electrodeposition solutions. Further, it is necessary to change the mask used to cover the workpiece every time the treatment is performed. Therefore, the conventional method causes a problem that both the number of man-hours and the product cost increase.

SUMMARY OF THE INVENTION

[0007] One object of the invention is to provide a pattern forming device and a pattern forming method that make it possible to reduce man-hours needed to form different types of films by electrodeposition in corresponding multiple regions of a surface of a workpiece to obtain a predetermined film pattern from these films.

[0008] An aspect of the invention relates to a pattern forming device that forms, by electrodeposition, different types of films in corresponding multiple regions of a surface of a workpiece to obtain a predetermined film pattern from the films. The pattern forming device includes: a plurality of tanks each of which has an open end having the same shape as a profile shape of a corresponding one of the regions in which the different types of films are to be formed, and each of which stores a corresponding one of electrodeposition solutions used to form the different types of films in a state where the open end is in contact with the surface; and a power supply device that applies a predetermined voltage to between the workpiece that serves as a first electrode, and each one of second electrodes in the tanks.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The foregoing and further features and advantages of the invention will become apparent from the following description of example embodiments with reference to the accompanying drawings, wherein like numerals are used to represent like elements and wherein:

FIG. 1 is a perspective view illustrating the schematic configuration of a pattern forming device according to an embodiment of the invention;

FIG. 2 is a view illustrating the state where tanks are separated from a workpiece;

FIG. 3 is an explanatory view illustrating the state where the tanks are turned upside down so that a contact portion faces upward;

FIG. 4 is a sectional explanatory view of the tanks as viewed from the front;

FIG. 5 is an explanatory view of a surface of the workpiece on which a predetermined film pattern has been formed by the pattern forming device;

FIG. 6 is a perspective view illustrating a schematic configuration of a pattern forming device according to another embodiment of the invention;

FIG. 7 is an explanatory view of a conventional device;

FIG. 8 is an explanatory view of a surface of a workpiece; and

FIG. 9A to FIG. 9H are explanatory views for describing a conventional pattern forming method.

DETAILED DESCRIPTION OF EMBODIMENTS

[0010] Hereinafter, an embodiment of the invention will be described with reference to the accompanying drawings. FIG. 1 is a perspective view illustrating the schematic configuration of a pattern forming device according to the embodiment of the invention. The pattern forming device is used to form, by electrodeposition, different types of films in corresponding multiple regions of a surface F of a workpiece W to obtain a predetermined film pattern from these films. Note that the films are formed on the surface of the workpiece W in order to, for example, improve the abrasion resistance on the surface and to reduce the frictional resistance. Further, the film pattern having several types of films is formed so that the surface characteristics vary from region to region in the surface F.

[0011] FIG. 5 is an explanatory view of the surface F of the workpiece W, on which a predetermined film pattern has been obtained by the pattern forming device according to the present embodiment. In the present embodiment, the workpiece W is formed from a metal plate, and the surface F is partitioned into multiple regions in a grid pattern. The workpiece W has nine regions A1 to A9. Note that the workpiece W serves as an electrode (first electrode), which will be described later. Four types of films are formed by electrodeposition on the surface F, so that a film pattern formed of the four types of films is obtained. More specifically, a first film S1 is formed in each of the regions A2, A4, A6, A8. A second film S2 different in type from the first film S1 is formed in each of the regions A1, A9. A third film S3 different in type from the first film S1 and the second film S2 is formed in each of the regions A3, A7. A fourth film S4 different in type from the first, second, and third films S1, S2, S3 is formed in the region A5.

[0012] As shown in FIG. 1, the pattern forming device includes a plurality of tanks 11 to 19. FIG. 2 is a view illustrating the state where the tanks 11 to 19 are separated from the workpiece W. As shown in FIG. 1 and FIG. 2, the number of the tanks included in the pattern forming device is the same as the number of the regions A1 to A9 of the surface F of the workpiece A, in which films are to be formed, that is, the pattern forming device includes the nine tanks 11 to 19. The pattern forming device is used in a state where the workpiece W is arranged such that the surface F faces upward and the tanks 11 to 19 are placed on the surface F. That is, each of the tanks 11 to 19 is configured to be opened toward the surface F (that is, opened at its lower end), and is used with its lower end in contact with the surface F of the workpiece W. The inner peripheral surface of each of the tanks has an elongate tubular shape that extends in the up-down direction, and the lower ends of the tanks 11 to 19 serve as a contact portion 9 that is brought into contact with the surface F. The lower ends (open ends) of the tanks 11 to 19 contact peripheral edges of the regions A1 to A9, respectively.

[0013] FIG. 3 is an explanatory view illustrating the state where the tanks 11 to 19 are turned upside down so that the contact portion 9 faces upward. Open ends 21 to 29 of the tanks 11 to 19 have the same shapes as the profile shapes of the regions A1 to A9, respectively. In the present embodiment, the profile shape of each of the regions A1 to A9 is rectangular, and all the regions A1 to A9 have the same shape. Therefore, all the open ends 21 to 29 have the same rectangular shape. The open ends 21 to 29 serve as the contact portion 9 that is brought into contact with the surface F of the workpiece W. Further, the sectional shape of each of the tanks 11 to 19 is constant in the longitudinal direction (up-down direction). In the present embodiment, the tanks 11 to 19 are formed as a single-piece member. That is, for example, an inner wall surface 11a of the tank 11 and an inner wall surface 12a of the tank 12 adjacent to the tank 11 are formed of respective sides of a single side wall.

[0014] The tanks 11 to 19 are able to store electrodeposition solutions (electrolyte solutions) used to form different types of films, respectively, with the open ends 21 to 29 in contact with the surface F. FIG. 4 is a sectional explanatory view of the tanks 17, 18, 19 as viewed from the front. According to FIG. 4, electrodeposition solutions L3, L1, L2, which are different in type from each other, are stored in the tanks 17, 18, 19, respectively. The internal space of each of the tanks 11 to 19 is independent of the internal spaces of the other tanks, so that the electrodeposition solutions do not mix with each other.

[0015] In FIG. 1, the electrodeposition solution L1 used to form the first film S1 is stored in the tanks 12, 14, 16, 18 in the present embodiment. The electrodeposition solution L2 used to form the second film S2 is stored in the tanks 11, 19. The electrodeposition solution L3 used to form the third film S3 is stored in the tanks 13, 17. An electrodeposition solution L4 used to form the fourth film S4 is stored in the tank 15. The electrodeposition solutions L1 to L4 respectively contain different resin components. Due to this, in the present embodiment, the films S1 to S4 made from different types of resins are formed on the surface F.

[0016] Although not illustrated, the tanks 11 to 19 may be connected to server tanks via pipes, and the electrodeposition solutions stored in the server tanks may be supplied to the respective tanks 11 to 19 through the pipes.

[0017] Further, the pattern forming device includes sealing portions 8 that prevents leakage of the electrodeposition solutions (see FIG. 3 and FIG. 4). The sealing portions 8 are formed at the open ends 21 to 29 of the tanks 11 to 19, which are brought into contact with the surface F of the workpiece W. That is, the sealing portions 8 are formed at the contact portion 9 of the tanks 11 to 19. The sealing portions 8 are made of rubber or resin, and formed by bonding the resin to the open ends 21 to 29. With the use of the sealing portions 8, it is possible to prevent leakage of the electrodeposition solutions L1 to L4 in the tanks 11 to 19, from between the surface F and the open ends 21 to 29, in a state where the open ends 21 to 29 of the tanks 11 to 19 are in contact with the surface F of the workpiece W.

[0018] Particularly, in the present embodiment, the multiple regions A1 to A9 formed by partitioning the surface F of the workpiece W include regions adjacent to each other (e.g., A7 and A8). Thus, the tanks corresponding to these regions (the tank 17 and the tank 18, in FIG. 4) are placed so as to be adjacent to each other. However, even in this case, it is possible to prevent the electrodeposition solution L1 (L3) from leaking out and mixing with the electrodeposition solution L3 (L1) in the adjacent tank.

[0019] Further, in the tanks 11 to 19, second electrodes 31 to 39 are provided as counter electrodes for the first electrode (the workpiece W) (see FIG. 4). In the present embodiment, the electrodes 31 to 39 are provided on the inner wall surfaces of the tanks 11 to 19, respectively. That is, parts of the inner wall surfaces of the tanks 11 to 19 serve as the second electrodes 31 to 39. Note that, as described above, the sealing portions 8 are provided at the contact portions 9 of the tanks 11 to 19. The sealing portions 8 are made of a non-conductive material, and function as members that electrically insulate the tanks 11 to 19 from the workpiece W. In view of this, the inner wall surfaces of the tanks 11 to 19 may entirely serve as the second electrodes. That is, the tanks 11 to 19 may be made of a conductive material.

[0020] The pattern forming device further includes a power supply device 10 (see FIG. 1). The power supply device 10 applies a predetermined direct-current voltage to between the workpiece W, which serves as the first electrode, and each of the second electrodes 31 to 39 in the tanks 11 to 19. Thus, in each of the regions A1 to A9 of the surface F of the workpiece W, a film different in type from those of its adjacent regions is formed, and thus, a grid film pattern as illustrated in FIG. 5 is obtained. Particularly, in the present embodiment, the power supply device 10 simultaneously applies the voltage to between the first electrode (the workpiece W) and the second electrodes 31 to 39 in the tanks 11 to 19. Thus, electrodeposition treatments are performed at the same time.

[0021] Next, description will be provided on a pattern forming method for forming, with the use of the pattern forming device having the aforementioned configuration, different types of films in the corresponding multiple regions A1 to A9 of the surface F of the workpiece W by electrodeposition to obtain a predetermined film pattern from these films. As illustrated in FIG. 1 and FIG. 2, the tanks 11 to 19 having the open ends 21 to 29 (see FIG. 3) with the same shapes as the respective profile shapes of the regions A1 to A9 are brought into contact with the regions A1 to A9 of the surface F of the workpiece W, in which different types of films are to be formed.

[0022] The electrodeposition solutions L1 to L4 used to form the films S1 to S4 of different types are stored in the corresponding tanks 11 to 19, and a direct-current voltage is applied, by the power supply device 10, to between the workpiece W, which serves as the first electrode, and each of the second electrodes 31 to 39 in the tanks 11 to 19.

[0023] By applying the voltage as described above, the films S1 to S4 of different types are formed in the regions A1 to A9 of the surface F of the workpiece W, and the film pattern as illustrated in FIG. 5 is obtained. Therefore, a conventional mask is no longer necessary to form the films S1 to S4 of different types on the surface F of the workpiece W. Thus, replacement of the mask is unnecessary, which makes it possible to reduce man-hours required to form a film pattern. As a result, it is possible to perform a surface treatment on the workpiece W in a short time, thereby making it possible to contribute to reduction in product cost.

[0024] Particularly, in the present embodiment, in a state where the prescribed electrodeposition solutions L1 to L4 are stored in the corresponding tanks 11 to 19, a voltage is simultaneously applied to between each of the second electrodes 31 to 39 and the first electrode (the workpiece W). Thus, it is possible to perform electrodeposition on the regions A1 to A9 at the same time, thereby forming the films S1 to S4 of different types at the same time.

[0025] In contrast to this, in a conventional technique, as described above with reference to FIG. 9A to FIG. 9H, in order to form several types of films in corresponding multiple regions, multiple tanks filled with respective types of electrodeposition solutions and multiple types of masks are required. It is necessary to perform electrodeposition on a workpiece while changing the tanks, and further, it is necessary to change the masks every time the tank is changed. When the change of the masks and the electrodeposition treatment are regarded as one step, it is necessary to perform the step four times repeatedly in order to form four types of the films S1 to S4. However, according to the present embodiment, no masks are required, and further, by performing the electrodeposition treatment on all the regions A1 to A9 at the same time, it is possible to form the four types of films S1 to S4 on the surface F of the workpiece W in a single step, that is, in a short time.

[0026] Note that with regard to the control for the electrodeposition treatment that is performed with the use of the power supply device 10, the control may be executed such that the same condition such as a voltage or a current is achieved in all the tanks 11 to 19, or the control may be executed such that the condition may vary among the tanks 11 to 19. The condition includes at least one of a current, a voltage, and an application time. In order to execute this control, the power supply device 10 includes a controlling portion (not shown) for controlling the condition. The controlling portion is a microcomputer including a CPU and an internal memory.

[0027] For example, in the embodiment illustrated in FIG. 1, a single power source is used to apply a predetermined voltage to between the workpiece W, which serves as the first electrode, and each of the second electrodes 31 to 39 in the tanks 11 to 13, thereby performing the electrodeposition treatment with the same parameter (e.g., a current, a voltage) and in the same process (e.g., an application time). However, in another embodiment of the invention, each one of the tanks may be provided with one power source (see FIG. 6). In the case in FIG. 6, the tanks 11 to 19 are provided with power sources V1 to V9, respectively. Therefore, it is possible to perform the electrodeposition treatment while changing the parameter and the process among the tanks 11 to 19. Thus, even if the electrodeposition solutions stored in the tanks 11 to 19 have different characteristics, it is possible to perform the electrodeposition treatment while changing at least one of the parameter and the process depending on the characteristics.

[0028] The pattern forming device according to the invention is not limited to the embodiments illustrated in the drawings, but may be implemented in other embodiments within a scope of the invention. For example, the workpiece W need not have a plate-like shape, but may have a cylindrical or columnar shape. The regions formed by partitioning the surface of the workpiece need not have a rectangular shape, but may have other shapes such as a shape including a curved portion, and the like. The tanks (open ends) may be formed in conformity to profile shapes of these regions.

[0029] According to the invention, different types of films are formed by electrodeposition in corresponding multiple regions of a surface of a workpiece to obtain a predetermined film pattern from these films. Therefore, unlike in the conventional technique, masks are no longer necessary. As a result, it is not necessary to change masks, thereby making it possible to reduce man-hours.

Claims

1. A pattern forming device that forms, by electrodeposition, different types of films in corresponding multiple regions of a surface of a workpiece to obtain a predetermined film pattern from the films, the pattern forming device comprising:

a plurality of tanks each of which has an open end having the same shape as a profile shape of a corresponding one of the regions in which the different types of films are to be formed, and each of which stores a corresponding one of electrodeposition solutions used to form the different types of films in a state where the open end is in contact with the surface; and
a power supply device that applies a predetermined voltage to between the workpiece that serves as a first electrode, and each one of second electrodes in the tanks.

2. The pattern forming device according to claim 1, wherein the power supply device applies the voltage to between the first electrode and the second electrodes in the tanks at the same time.

3. The pattern forming device according to claim 1 or 2, further comprising:

sealing portions that prevent leakage of the electrodeposition solutions in the tanks from between the surface of the workpiece and the open ends of the tanks in the state where the open ends are in contact with the surface of the workpiece.

4. The pattern forming device according to any one of claims 1 to 3, wherein inner wall surfaces of the tanks at least partially serve as the second electrodes.

5. A pattern forming method for forming, by electrodeposition, different types of films in corresponding multiple regions of a surface of a workpiece to obtain a predetermined film pattern from the films, the method **characterized by** comprising:

bringing each of a plurality of tanks having an open end having the same shape as a profile shape of a corresponding one of the regions of the surface of the workpiece, in which the different types of films are to be formed, into contact with a corresponding one of the regions;
storing electrodeposition solutions used to form the different types of films in the corresponding tanks; and
applying a voltage to between the workpiece that serves as a first electrode, and each one of second electrodes in the tanks.

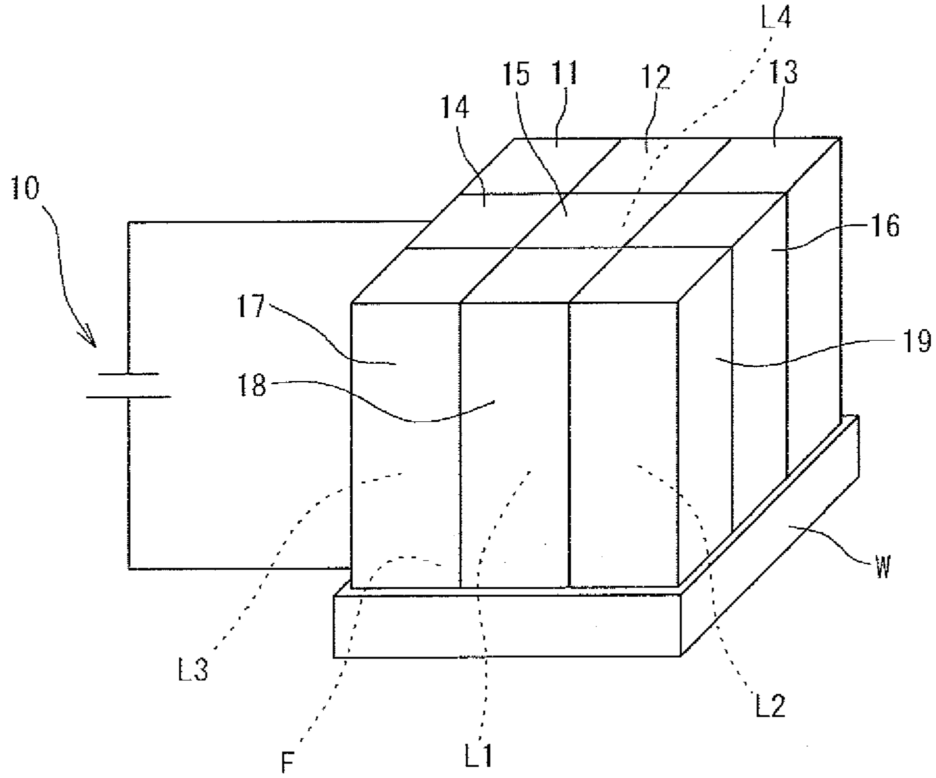
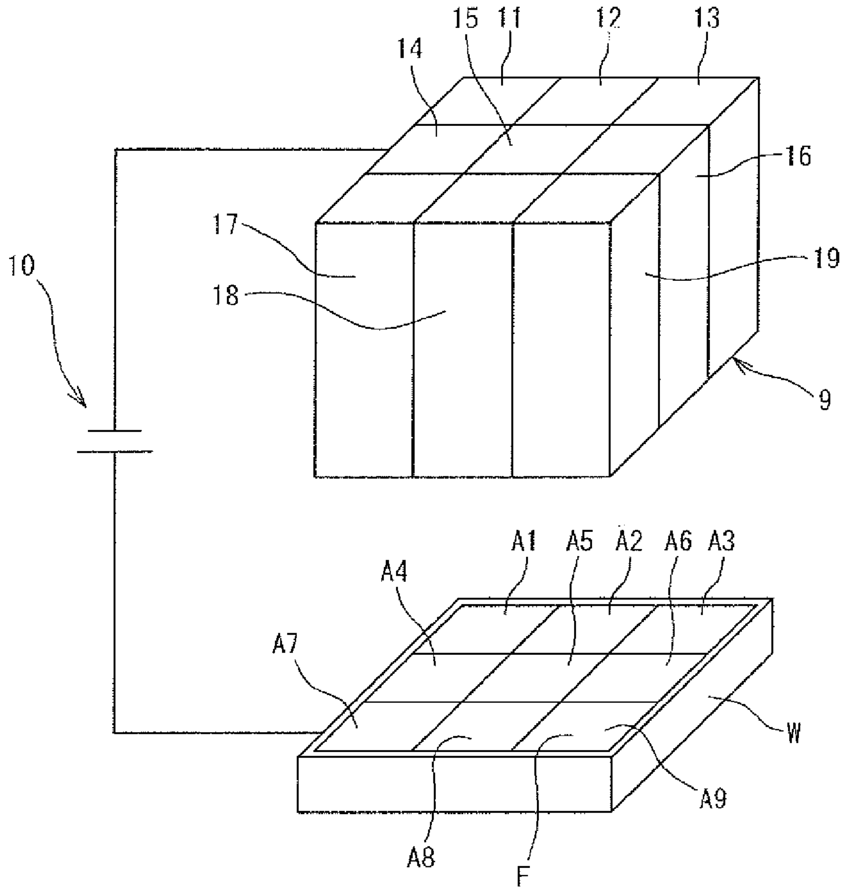


FIG.1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A1
A5
A2
A6
A3
A4
A7
W
A9
A8
F

FIG.2

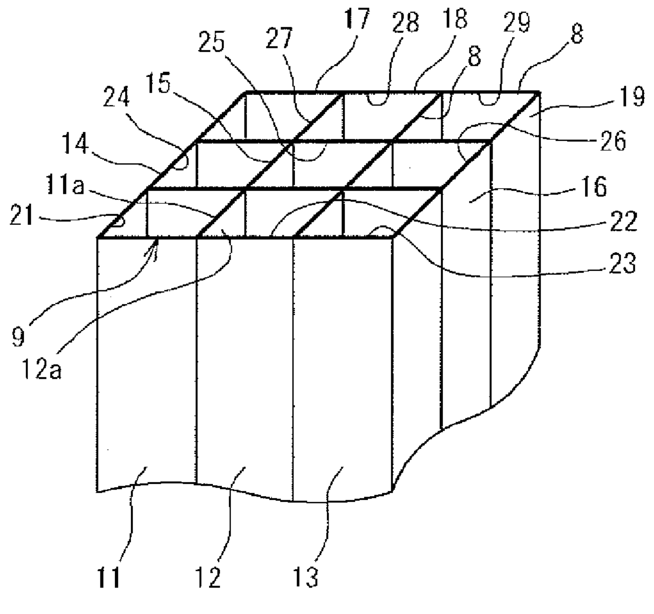
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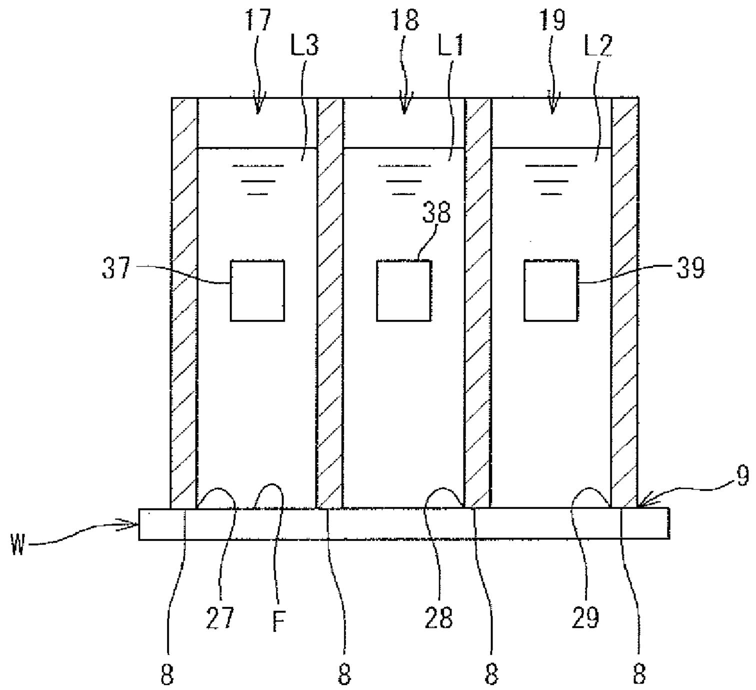
FIG.3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L3
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L1
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L2
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39
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W
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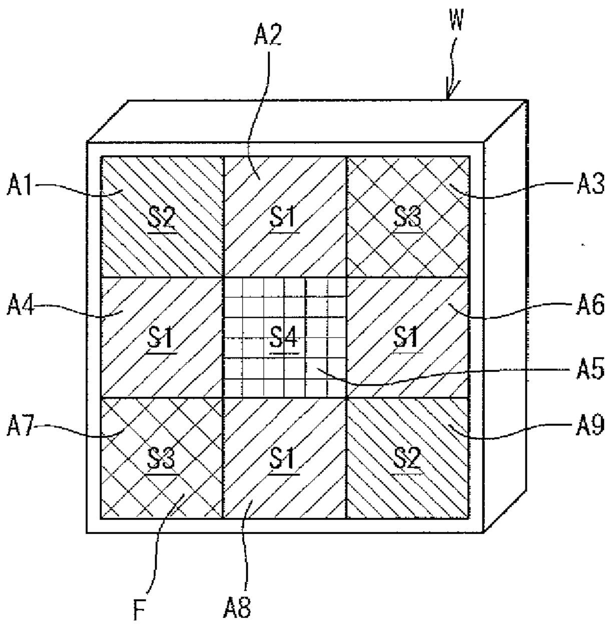
FIG.4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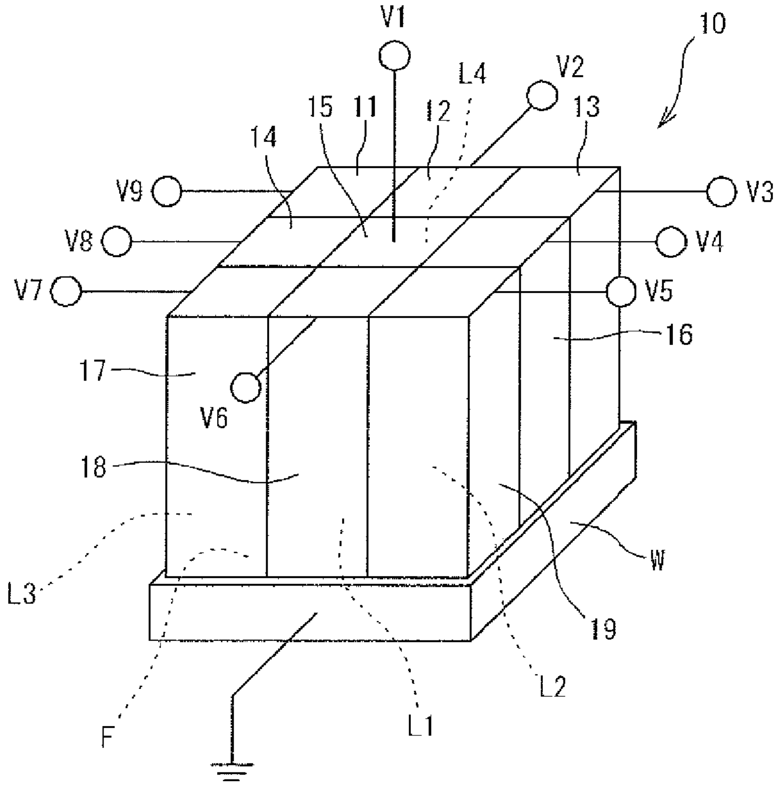
F
A8

FIG.5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F
L1

FIG.6

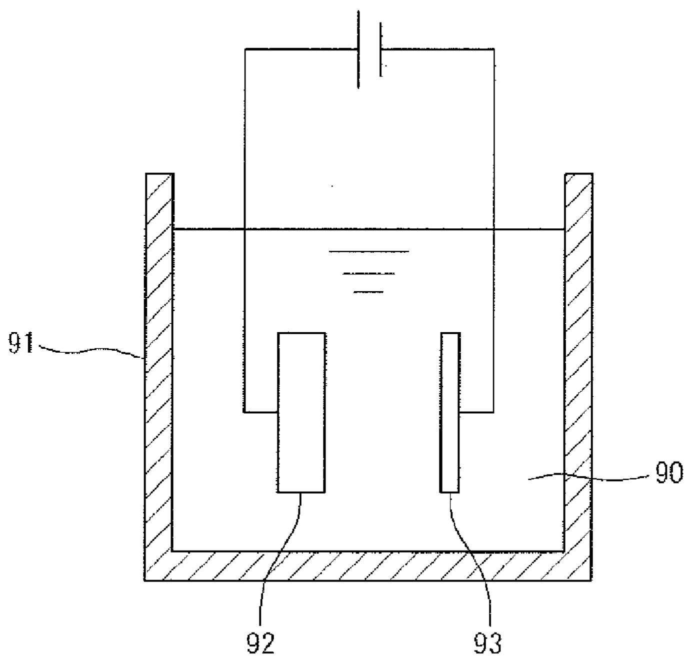
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FIG.7

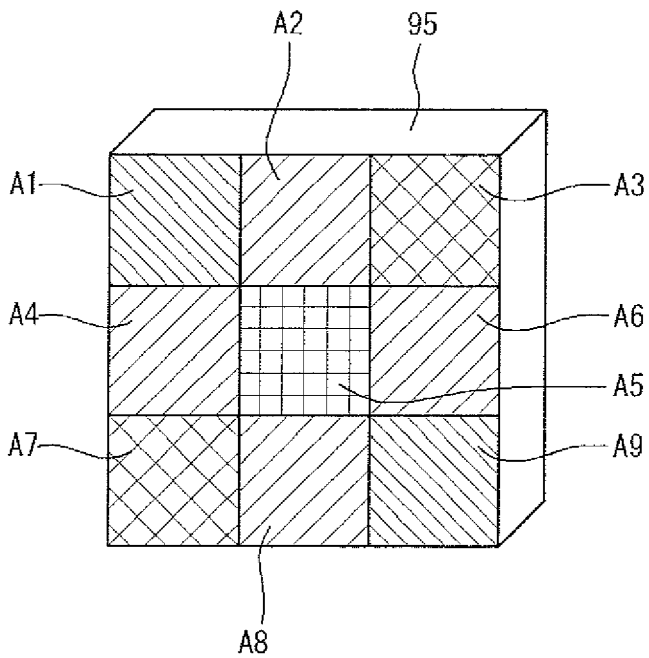
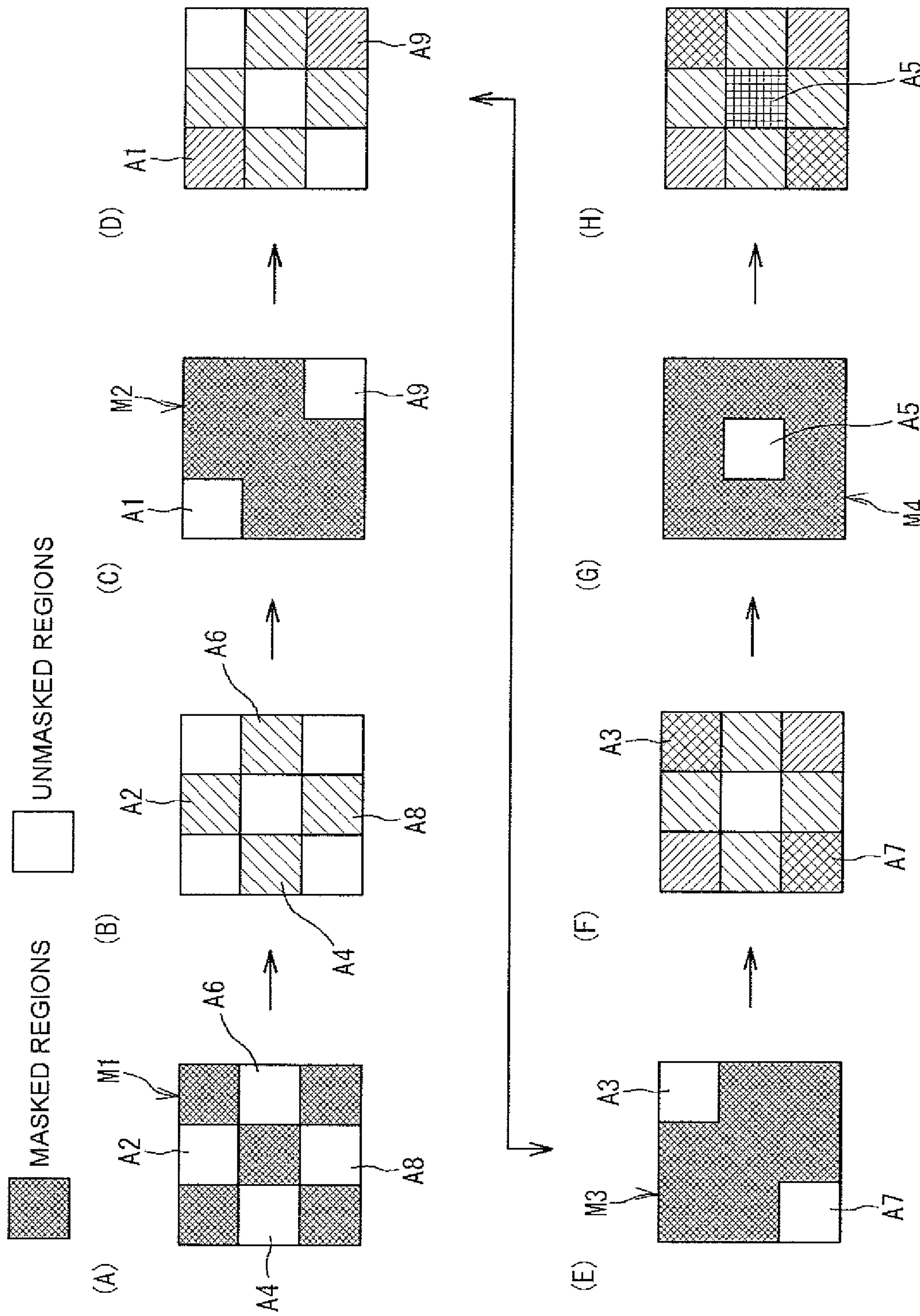


FIG.8


MASKED REGIONS
UNMASKED REGIONS
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A1
A9
(E)
M3
A3
A7
(F)
A3
A7
(G)
A5
M4
(H)
A5

FIG.9

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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