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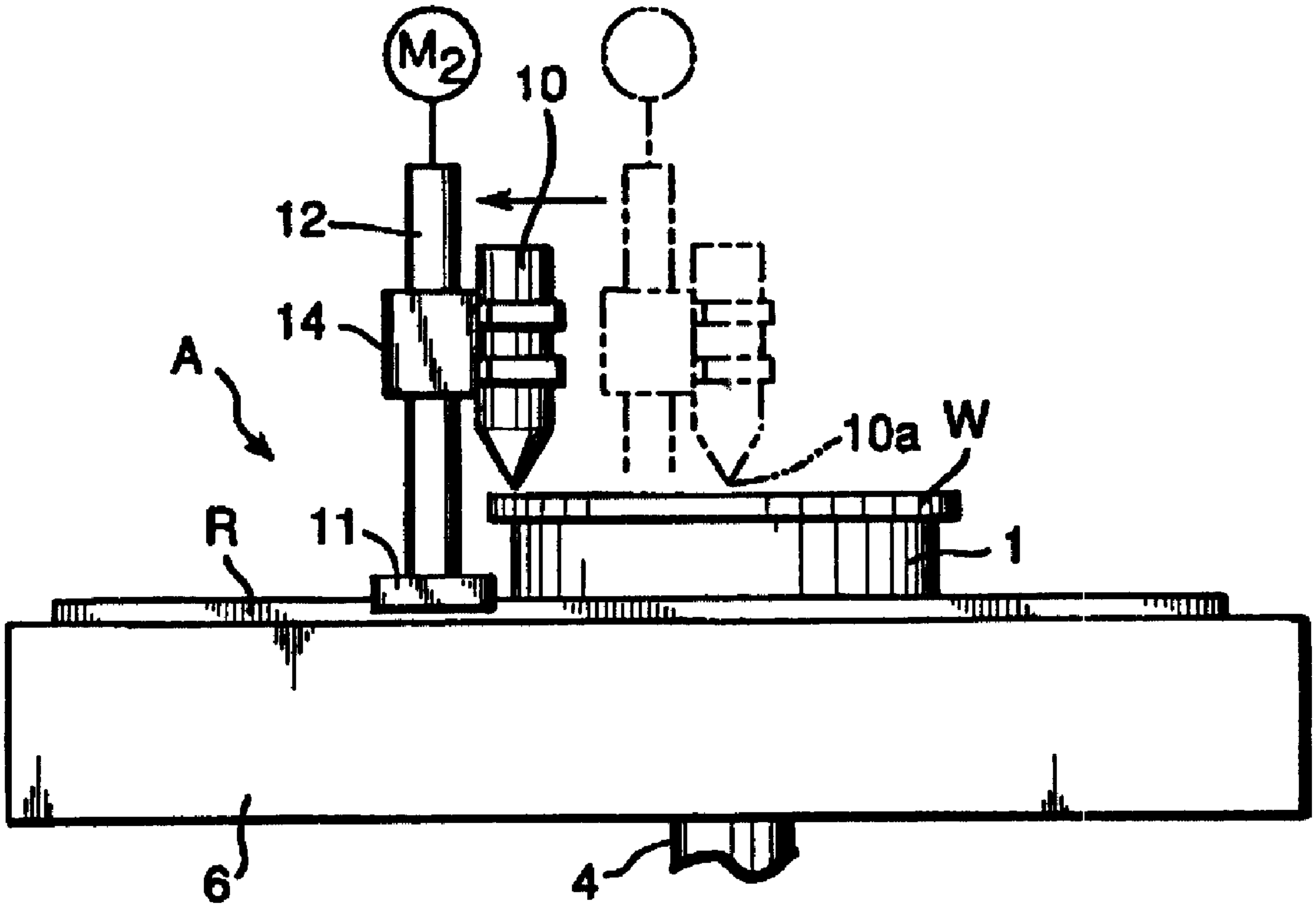
(54) Title: CIRCULAR OR ANNULAR COATING FILM FORMING METHOD



(57) Abrégé/Abstract:
A method of forming a circular or annular coating film on a substrate (W) using a device of simple structure without using coating liquid wastefully, comprising the steps of, using a painting device (A) formed of a rotatable table (1) suckingly holding the substrate (W) horizontally and a horizontally movable nozzle (10) liftable relative to the table (1) and having a delivery hole (10a) at the tip part thereof, rotating the table (1) and supplying coating liquid from the delivery hole (10a) in a linear state on to the substrate (W) while moving the nozzle (10) by a specified interval between the rotating center of the table (1) and an outward specified position in one direction with the nozzle (10) held at a specified height relative to the rotating table (1) so as to form a circular or annular coating film on the substrate (W).

ABSTRACT

By using a coating apparatus A of simple construction including a rotatable table 1 on which a substrate W is held horizontally through evacuating and, a nozzle 10 which is movable vertically and horizontally above the table 1 and provided, at its distal end portion, with a discharge hole 10a, the present invention has for its object to provide a method of forming a circular or an annular coating film on the substrate W without incurring waste of coating liquid, in which the coating liquid is supplied linearly from the discharge hole 10a to the substrate W by moving the nozzle 10 in one direction in a predetermined interval between a rotational center of the table 1 and a predetermined outer position in a state where the table 1 is rotated and the nozzle 10 is held at a predetermined height from the rotating table 1.

TITLE

CIRCULAR OR ANNULAR COATING FILM FORMING METHOD

TECHNICAL FIELD

The present invention relates to a method of forming a circular or an annular coating film on a substrate.

BACKGROUND OF THE INVENTION

Conventionally, coating methods by spin coater have been known, for example, as a method of applying resist liquid in a generally circular shape to a generally circular wafer. However, according to this method, most of the coating liquid (about 95%) would not be recycled but thrown away, resulting in a very poor yield.

Furthermore, a coating method by die coater has been proposed in Japanese Patent Laid-Open Publication No.10-99764, in which resist liquid is applied in a circular shape to a wafer, by providing a shim (choke plate) within a slit of a die main body, the shim being advanceable and retreatable along the longitudinal direction of the slit, and by continuously advancing and retreating the shim during the coating process while traveling the die main body or the wafer (substrate) horizontally.

In this method, in order to prevent the coating liquid from leaking through between the shim and the slit, the shim has to be held within the slit so as to be movable with precision and smoothness. Accordingly, when the shim and the slit are manufactured and provided, not only quite a high level of precision is required, but also the shim has to be exchanged frequently due to heavy wear. Moreover, in this method, since the movement of the shim results in nonuniformity of the supply pressure in the widthwise direction within the slit, uniform film thickness of the coating film in the widthwise direction can not be obtained.

Therefore, in recent years, a method is proposed in which a length of a slit of the die main body is made equal to a radius of the wafer such that coating liquid is applied without waste by positioning opposite ends of the slit at a center and an edge of the wafer, respectively. In this method, however, since an overlap portion of the slit is formed at the center of the wafer, involving an increased thickness of a coating film thickness at this overlap portion, there is a problem that a coating film of uniform thickness cannot be obtained.

Furthermore, in the foregoing coating method, there is a problem that an annular coating film cannot be formed.

SUMMARY OF THE INVENTION

The present invention having been accomplished with a view to eliminating these and other problems, an object of the invention is to provide a method of forming a circular or an annular coating film which makes it possible to obtain uniform film thickness by equipment of simple construction without wasting the coating fluid.

In order to achieve the above object, in the present invention, by using a coating apparatus constructed by a rotatable table on which a substrate is held horizontally through evacuation and, a nozzle which is movable vertically and horizontally above the table and provided, at its distal end portion, with a discharge hole, in which a coating liquid is supplied linearly from the discharge hole to the substrate by moving the nozzle in one direction in a predetermined interval between a rotational center of the table and a predetermined outer position in a state where the table is rotated and the nozzle is held at a predetermined height from the rotating table.

According to the present invention, a circular or an annular coating film can be formed only by linearly moving the nozzle relative to the rotating substrate without providing any complex mechanisms in the coating apparatus and irrespectively of the substrate configuration. Additionally, according to the invention, there can be produced effects such as elimination of wasteful use of the coating liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a plan view of a coating apparatus used for the present invention;

Fig. 2 is a sectional view taken along the line II - II of Fig. 1;

Fig. 3 is a view taken along the line III - III direction in Fig. 2; and

Fig. 4 is a side view showing a move of the nozzle of the coating apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the present invention is described below with reference to the accompanying drawings.

The drawings show a coating apparatus A for performing the present invention.

As shown in Fig. 1, this coating apparatus A is composed roughly of a table 1 and a nozzle 10. As shown in Fig. 2, the table 1 is fixed to one end of a hollow shaft 4 penetrating a base 6, and held by a bearing 5 provided at the penetrating portion of the base 6 so as to be rotatable together with the hollow shaft 4. The other end of the hollow shaft 4 is connected to an unshown vacuum pump via a rotary joint 7. A gear 8 is provided at a protruding portion of the hollow shaft 4 on the lower face side of the base 6, such that the table 1 is rotated by driving a gear 9 engaging with the gear 8 by a motor M_1.

The table 1 has a surface of a predetermined flatness, for example, a flatness of 2 μm or less. Inside the table 1, headers 2 are provided radially so as to communicate with a space 4a in the hollow shaft 4, and a multiplicity of evacuating holes 3 are provided so as to penetrate from each of the headers 2 to the surface of the table 1. Therefore, camber and undulation of a substrate W can be corrected by driving the vacuum pump so that the substrate W is held through evacuating on the surface of the table 1.

As shown in Figs. 1 and 2, a pedestal 11 moving to and fro by an unshown mechanism for horizontal transfer is mounted on two rails R which are disposed at opposite sides of a width of the base 6 so as to confront each other through the table 1. Further, a beam 14 is provided on the pedestal 11 through lifters 13 supporting both end portions of the beam 14, each lifter 13 being composed of a stepping motor M_2 and a non-backlash ball screw 12. The nozzle 10 is held at a predetermined position of the beam 14, that is, such a position in which a discharge hole 10a of the nozzle 10 passes through the rotational center of the table 1 when the pedestal 11 moves to and fro.

As a result, it becomes possible for the discharge hole 10a of the nozzle 10 to move to and fro maintaining at a predetermined height from the surface of the table 1 along one direction between the rotational center of the table 1 and the predetermined outer position on the substrate W.

Meanwhile, as shown in Fig. 3, the discharge hole 10a of the nozzle 10 is formed so as to supply the coating liquid linearly to the substrate W, which is held on the table 1 through evacuating.

Then, a method for using the coating apparatus A having the above structure is described.

Firstly, the pedestal 11 is transferred by the unshown mechanism for horizontal transfer so that the nozzle 10 is positioned on one end portion of the base 6 as shown in Fig. 1. Thereafter, the substrate W, which is a wafer for example, is disposed on the table 1, and by driving the vacuum pump, the substrate W is held onto the table 1 through evacuating.

Further, while the table 1 is rotated by driving the motor M_1, the pedestal 11 is moved by the mechanism for the horizontal transfer so that the discharge hole 10a of the nozzle 10 is positioned above the rotational center of the table 1 as shown by two-dot chain line in Fig. 4.

Subsequently, by driving the stepping motors M_2, M_2, the nozzle 10 is moved downward so that the distal end of the nozzle 10 and the surface of the table 1 are adjusted so as to be spaced from each other by a predetermined distance (reference gap).

Thereafter, by driving an unshown device for supplying coating liquid to supply the coating liquid to the nozzle 10, coating process is started. Thus, while coating is performed, the pedestal 11 (nozzle 10) is moved to a predetermined outer position on the substrate **W** as shown in Fig. 4.

In this case, the nozzle 10 is, basically, moved by the same distance as the width of the discharge hole 10a of the nozzle 10 (i.e., the width of discharged coating liquid) during one rotation of the table 1. However, the nozzle 10 may be moved by a distance larger than the width of the discharge hole 10a (i.e., the width of discharged coating liquid) depending on the properties of the coating liquid.

For example, leveling property is described here in properties of the coating liquid. When a coating liquid of poor leveling property is applied, the coating liquid is less likely to diffuse on the substrate surface, in which case it is advisable that the nozzle 10 is moved by the same distance as the width of the discharge hole 10a during one rotation of the table 1 so that a side face of the linear coating liquid supplied from the discharge hole 10a makes into contact with a side face of a coating film formed by the preceding rotation. In contrast to this, when a coating liquid of good leveling property is applied, the coating liquid is more likely to diffuse on the substrate surface, in which case it is advisable that the table 1 is moved by a distance larger than the width of the discharge hole 10a during one rotation of the table 1 so that a gap is formed between a side face of the coating film formed by the preceding rotation and a side face of the linear coating liquid supplied from the discharge hole 10a.

Meanwhile, the leveling property of coating liquid means the fluidity of the coating liquid itself. Therefore, in the case of good leveling property of the coating liquid, when a predetermined time elapsed after the coating on the substrate, the formed coating film is diffused uniformly on the substrate surface by the fluidity of the coating liquid itself, resulting in a successful coating state free from streaks and nonuniformities. Thus, generally, the lower the viscosity of a coating liquid, the higher the leveling property of the coating liquid. However, even though the viscosity of the coating liquid is low, for example, if the coating liquid using a solvent having a very high volatility is applied to the substrate, it may occur that the solvent volatilizes and dries before the coating film is diffused uniformly on the substrate surface by the fluidity of the coating liquid itself, thereby resulting in streaks, nonuniformities or the like. Such coating liquids are not good regarding leveling property in spite of low viscosity.

That is, since the substrate W is rotating, the linear coating fluid flows down from the discharge hole 10a as if it were flowing along a groove on a phonograph record surface, so that a coating film of circular shape and uniform thickness is formed on the substrate W by virtue of the centrifugal force based on the rotation of the substrate W and the leveling property of the coating liquid.

Then, after the nozzle 10 is moved horizontally through a distance equal to a radius of a desired circular coating film, the supply of the coating liquid is stopped and besides the rotation of the table 1 is stopped. Subsequently, the stepping motors M_2, M_2 are rotated such that the nozzle 10 is lifted up to a predetermined position, and further the horizontal transfer mechanism is driven such that the nozzle 10 is retreated to a predetermined position of the base 6, thus the nozzle 10 is set on standby for the succeeding step (see Fig. 1).

A circular coating film is formed on the substrate W by following the above steps, thereafter the vacuum pump is stopped and the substrate W is transferred to the succeeding process by an unshown means. Then, the next substrate W is disposed on the table 1, and the foregoing coating process is repeated again.

In the above description, the substrate W has been assumed to be a circular wafer. However, the substrate W is not limited to wafers, and the substrate configuration is not limited to circular shape, either. Furthermore, the cross-sectional configuration of the discharge hole 10a may be either circular or rectangular shape.

Furthermore, in the above description, the nozzle 10 has been moved linearly from the rotational center of the table 1 toward an outer position on the substrate W. Conversely, the nozzle 10 may also be moved from a predetermined outer position on the substrate W toward the rotational center.

In the foregoing coating process, as the position of the nozzle 10 moves outward from the center of the table 1 to an outer position on the substrate W or moves inward from the outer position to center position, the substrate W under the discharge hole 10a varies in peripheral speed. Therefore, the supply amount of the coating liquid may be gradually increased or decreased in accordance with this variation in peripheral speed. Further, the peripheral speed at coating positions may be maintained constant at all times by varying the rotating speed of the table 1.

Meanwhile, the above-described configuration of the coating film is a circular shape. However, an annular coating film can be formed by supplying the coating liquid in a linear state onto the substrate from the discharge hole while the nozzle 10 is moved through a predetermined interval between the rotational center of the table 1 and a predetermined outer position on the substrate in one direction. Moreover, striped-pattern coating films can also be formed by forming annular coating films at any arbitrary intervals on the same substrate.

Example:

As a result of applying the method according to the present invention under the following conditions, a satisfactory coating film having a film thickness of 10 μm was formed:

(1) Substrate:

Diameter: 200 mm

Rotating speed: 60 rpm

(2) Nozzle:

Inner diameter: 1.0 mm

Moving speed: 1.0 mm/sec.

Moving direction: toward center of substrate

Moving range: from position of diameter 192 mm of substrate to substrate center (diameter 0 mm)

Gap: 60 µm (distance between substrate and distal end of nozzle)

Discharge amount: 100% at coating start position
0% at coating end position

(3) coating liquid

Viscosity: 10 p (1000 cp)

CLAIMS

1. Method of forming a circular or an annular coating film by using a coating apparatus constructed by a rotatable table on which a substrate is held horizontally through evacuating and, a nozzle which is movable vertically and horizontally above the table and provided, at its distal end portion, with a discharge hole, in which a coating liquid is supplied linearly from the discharge hole to the substrate by moving the nozzle in one direction in a predetermined interval between a rotational center of the table and a predetermined outer position in a state where the table is rotated and the nozzle is held at a predetermined height from the rotating table .

Fig. 1

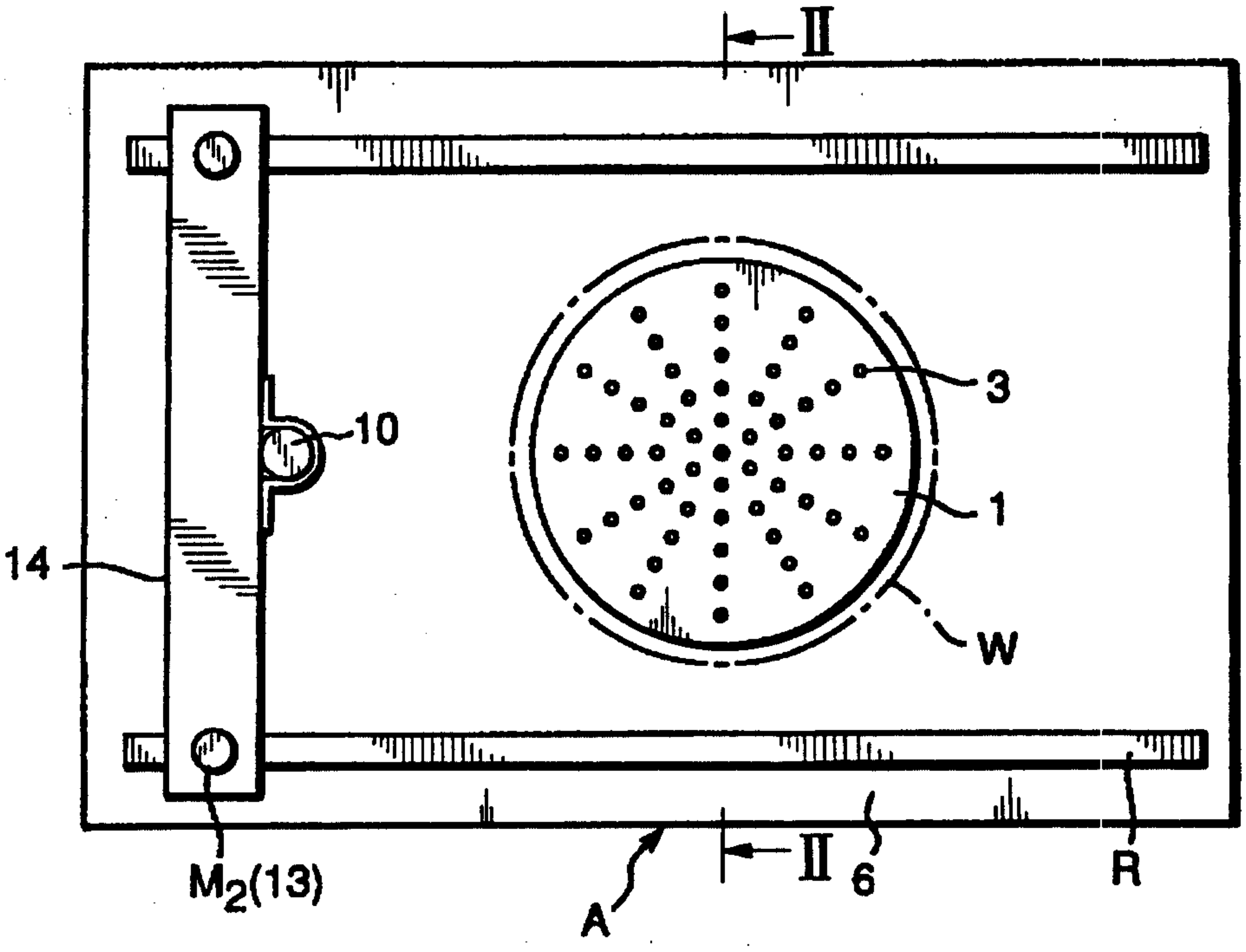

II
3
10
1
14
W
M2(13)
A
II
6
R

Fig. 2

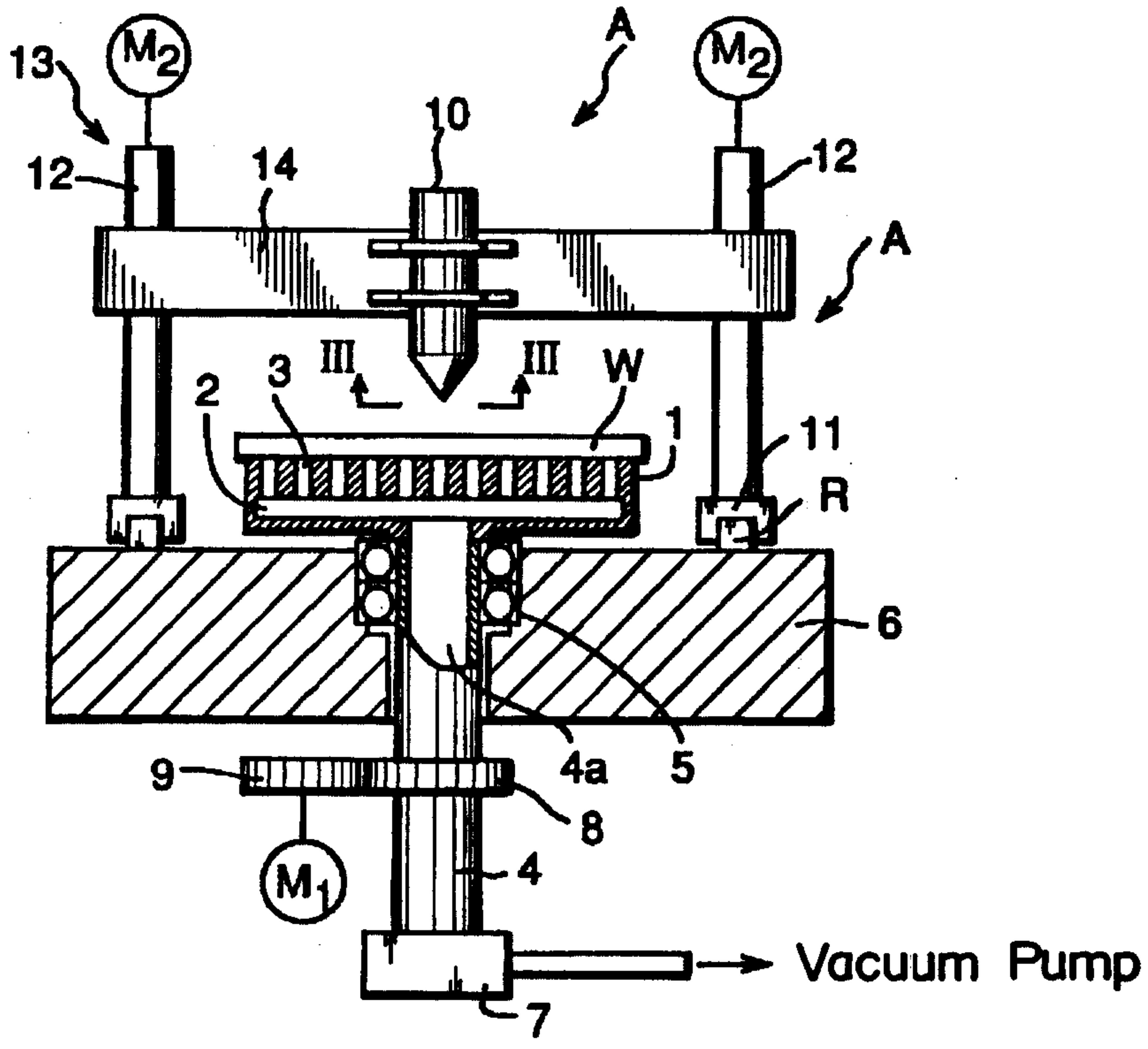

M2
A
M2
13
12
10
12
14
A
III
III
W
2
3
1
11
R
6
4a
5
9
8
M1
4
7
Vacuum Pump

Fig. 3

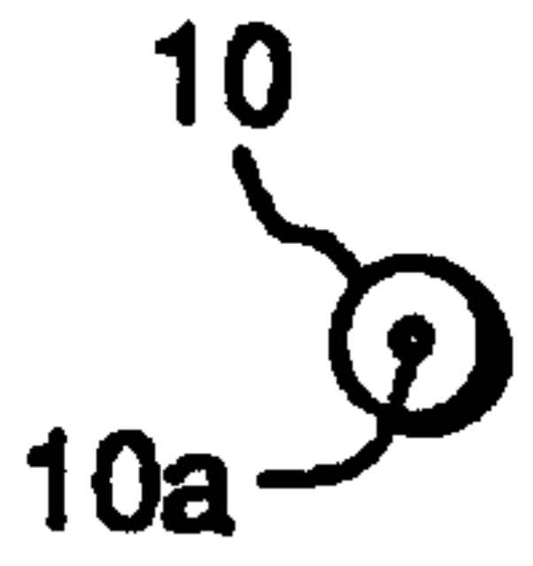
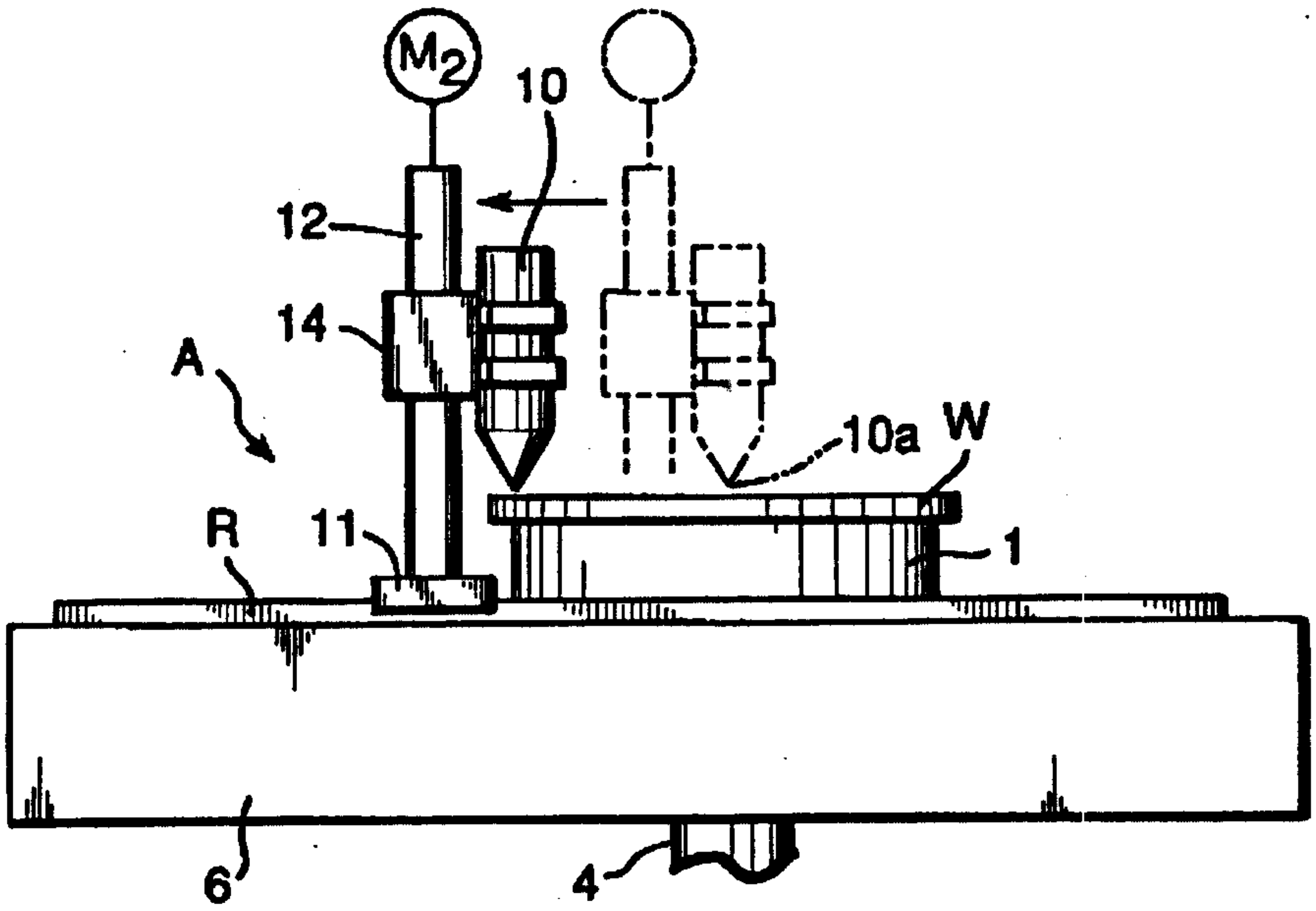
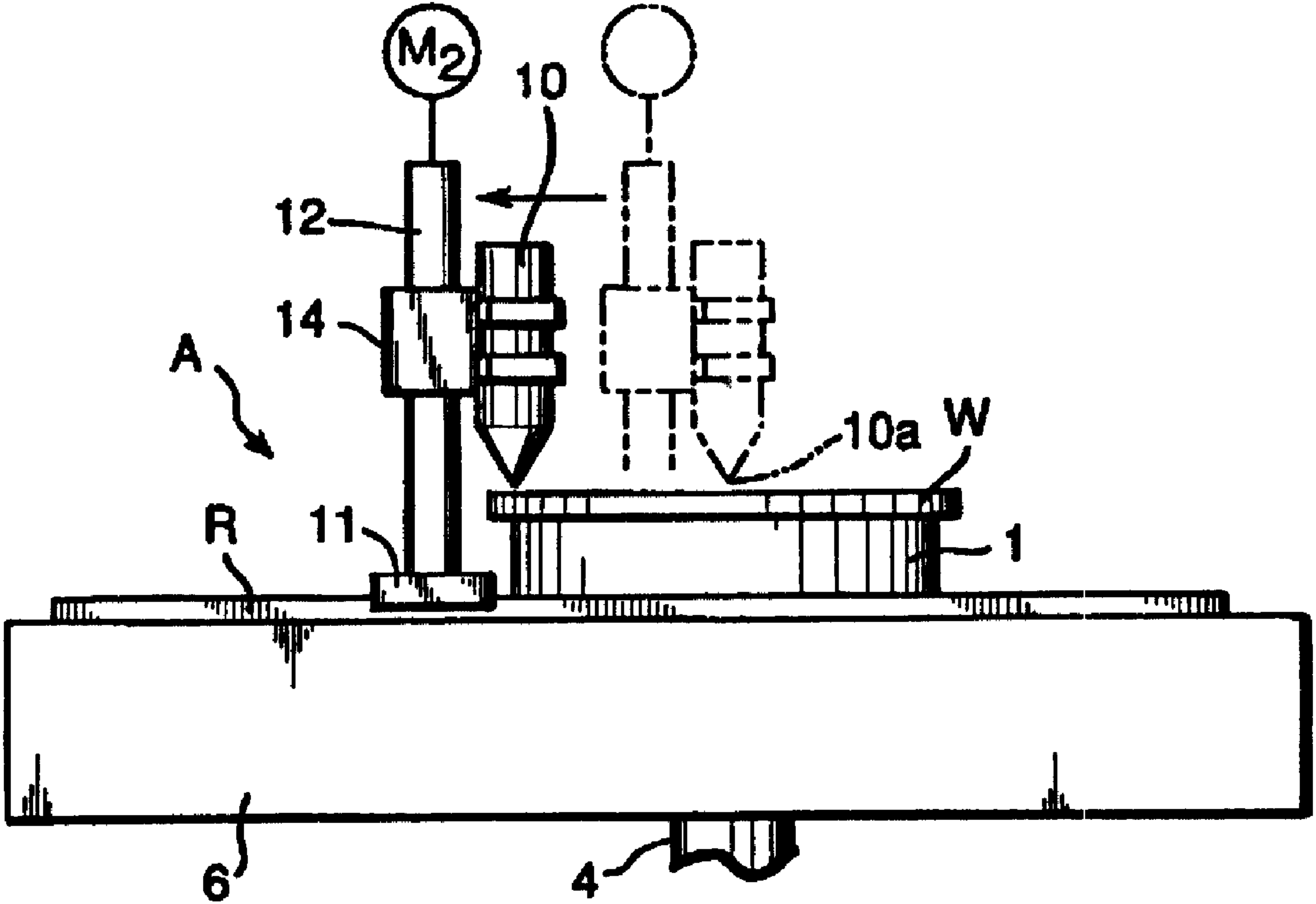


Fig. 4

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14
A
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R
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1
6
4