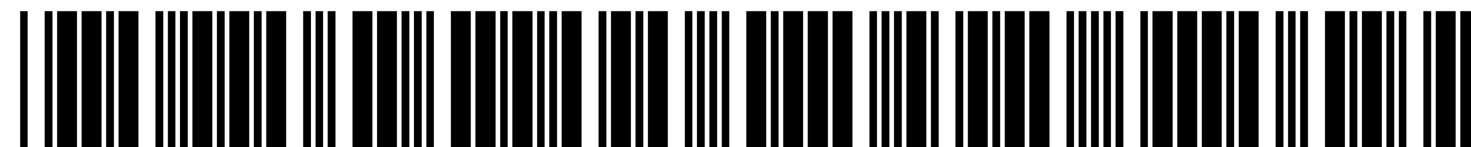
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Kida et al.

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(54) **SUBSTRATE SUPPORTING APPARATUS**

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(21) Appl. No.: **13/049,056**

(22) Filed: **Mar. 16, 2011**

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(51) **Int. Cl.**
H01L 21/00 (2006.01)
C23C 14/00 (2006.01)
C23C 16/00 (2006.01)

(52) **U.S. Cl.** **118/728**; 118/724; 118/725; 118/500; 156/345.51; 156/345.52; 156/345.53; 156/345.54

(58) **Field of Classification Search** .... None
See application file for complete search history.

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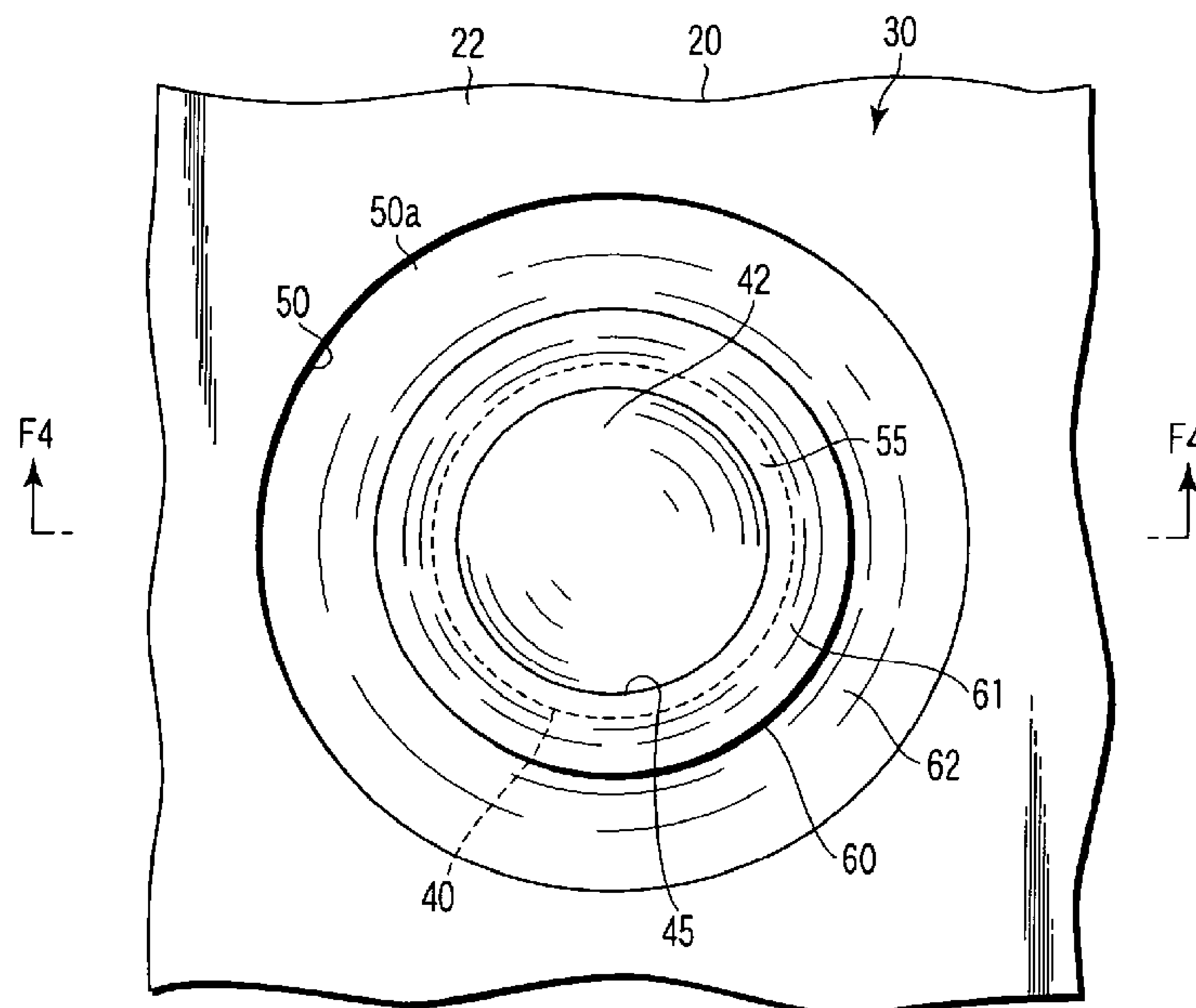
(57) **ABSTRACT**

A substrate supporting apparatus includes a plate member of an aluminum alloy having a flat upper surface, bottomed pits formed in the plate member, and spacer members held in the pits, individually. The spacer members are sapphire spheres. The diameter of each spacer member is a little smaller than that of each pit. The upper end of each spacer member projects from the upper surface of the plate member. A spot facing is formed in a region that includes the open edge portion of the pit. A bending portion which is obtained by plastically deforming the open edge portion of the pit toward the spacer member is formed on a bottom surface of the spot facing. A V-shaped groove is formed behind the bending portion.

5 Claims, 6 Drawing Sheets



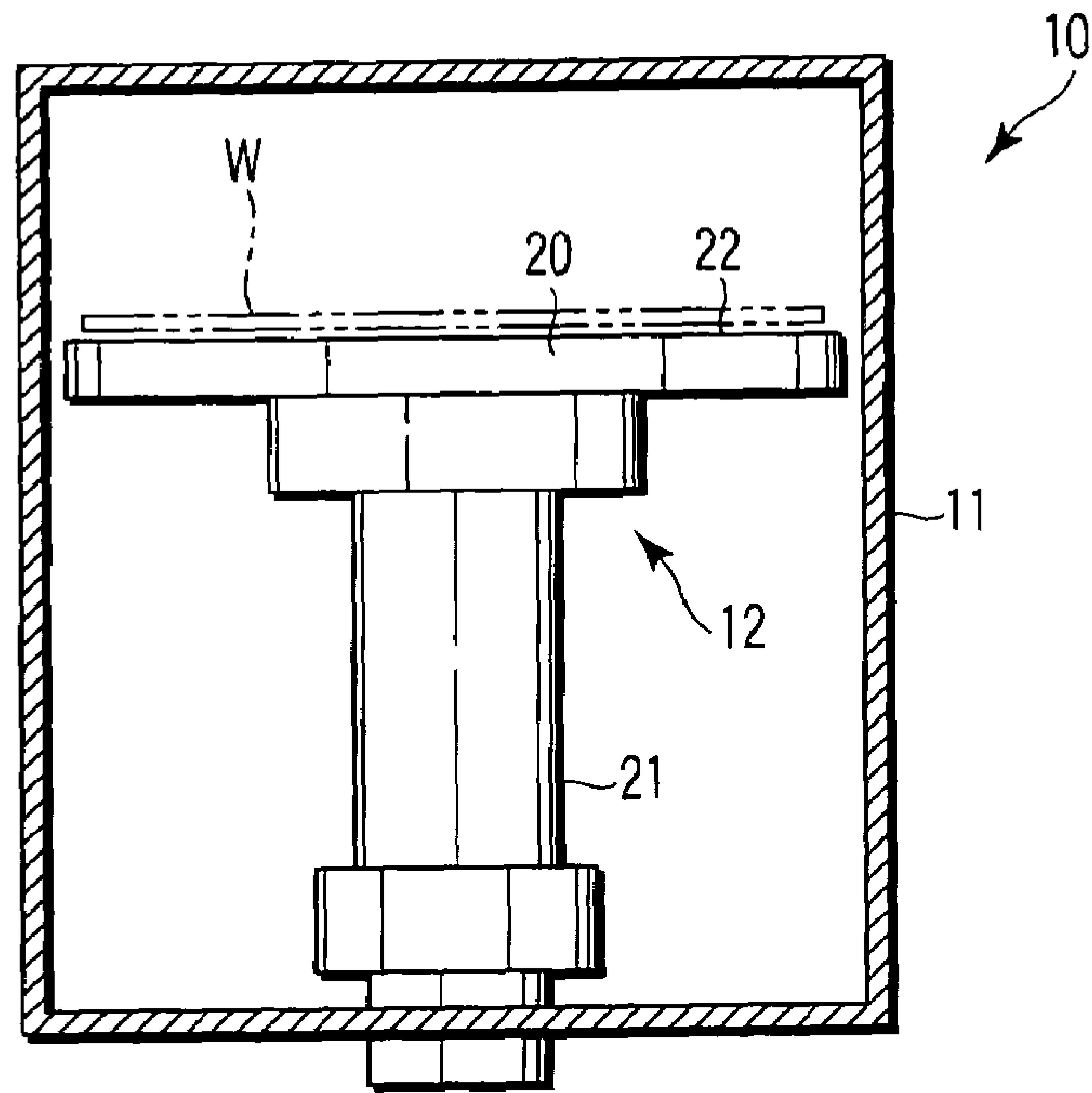


FIG. 1

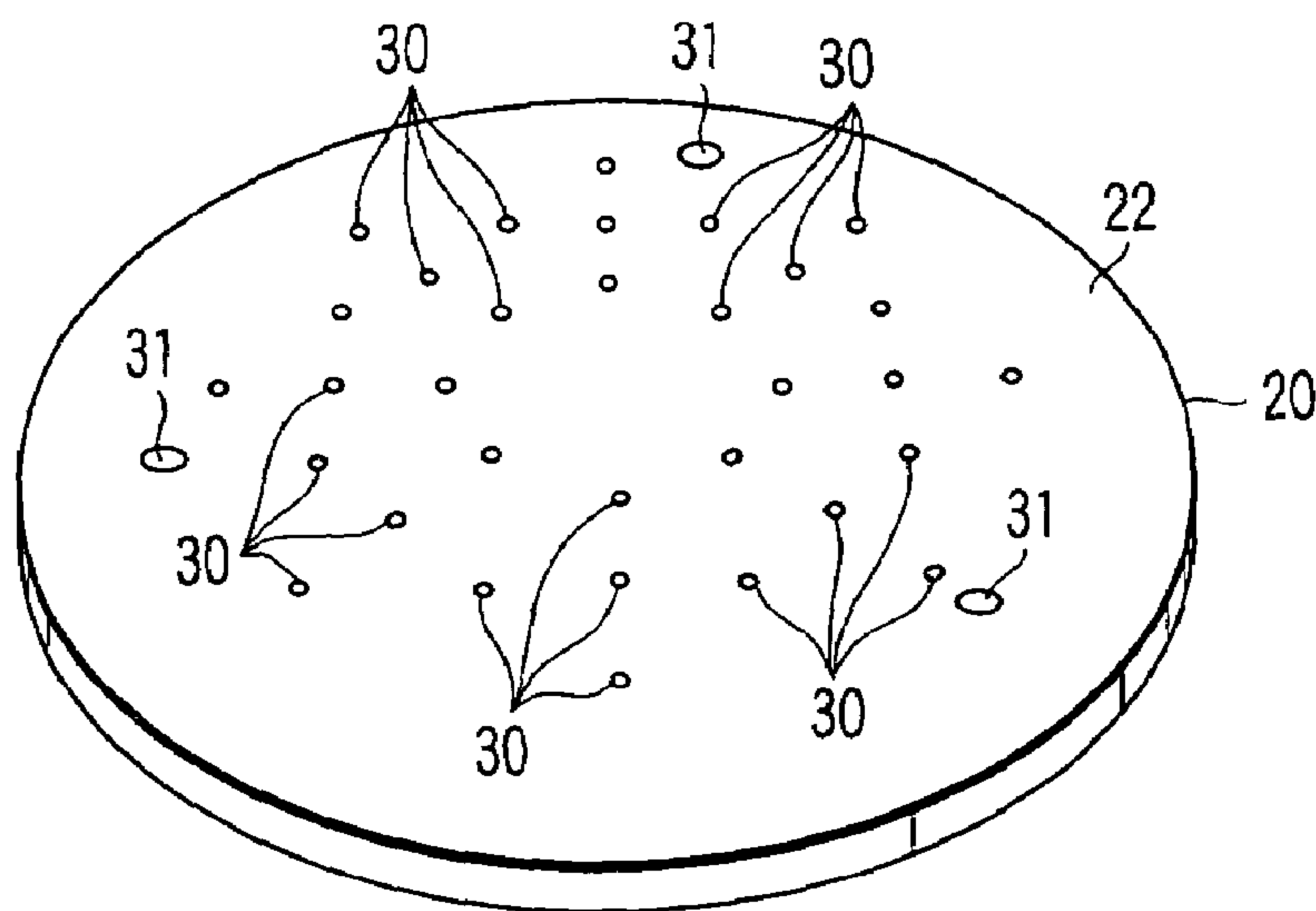


FIG. 2

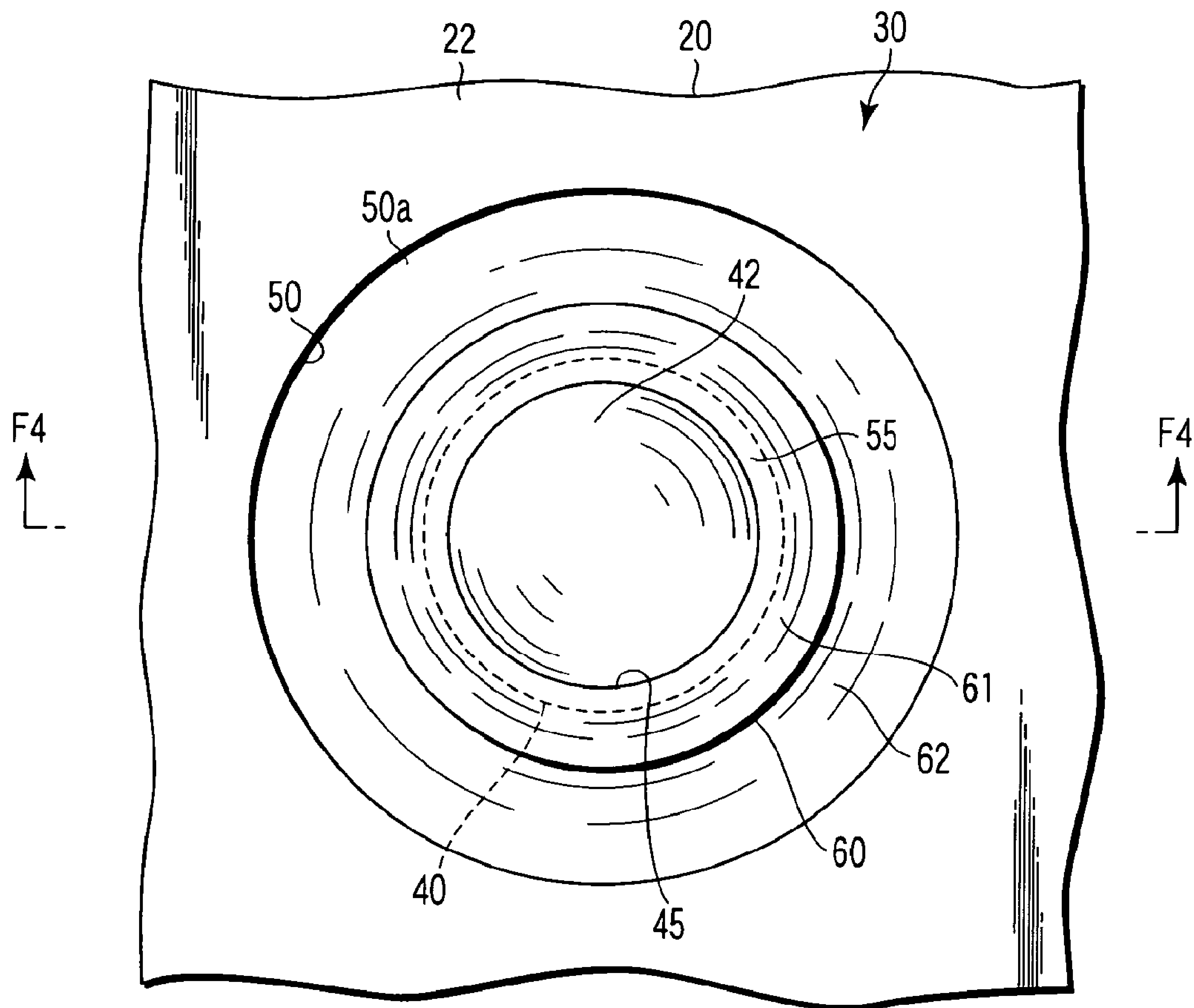


FIG. 3

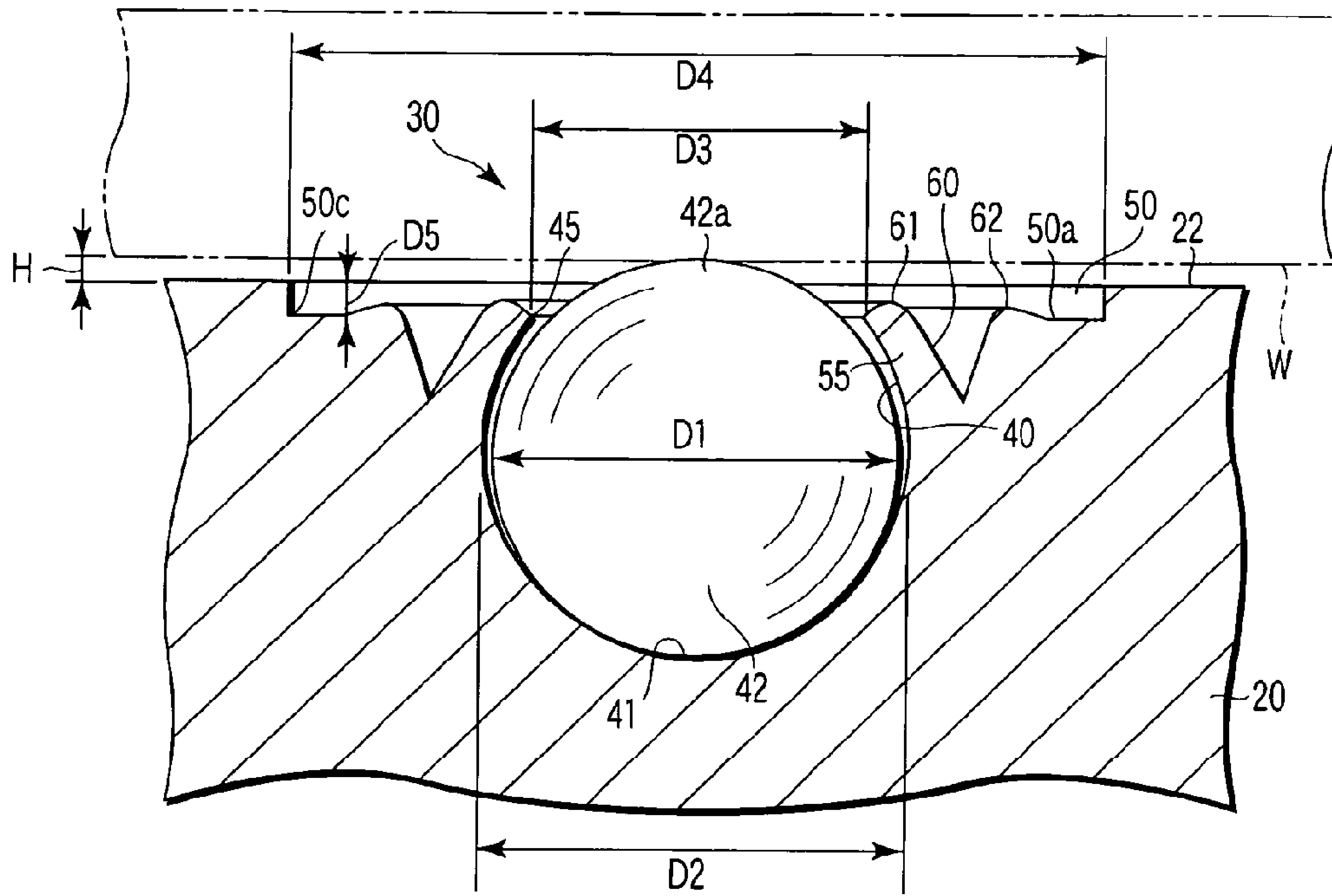


FIG. 4

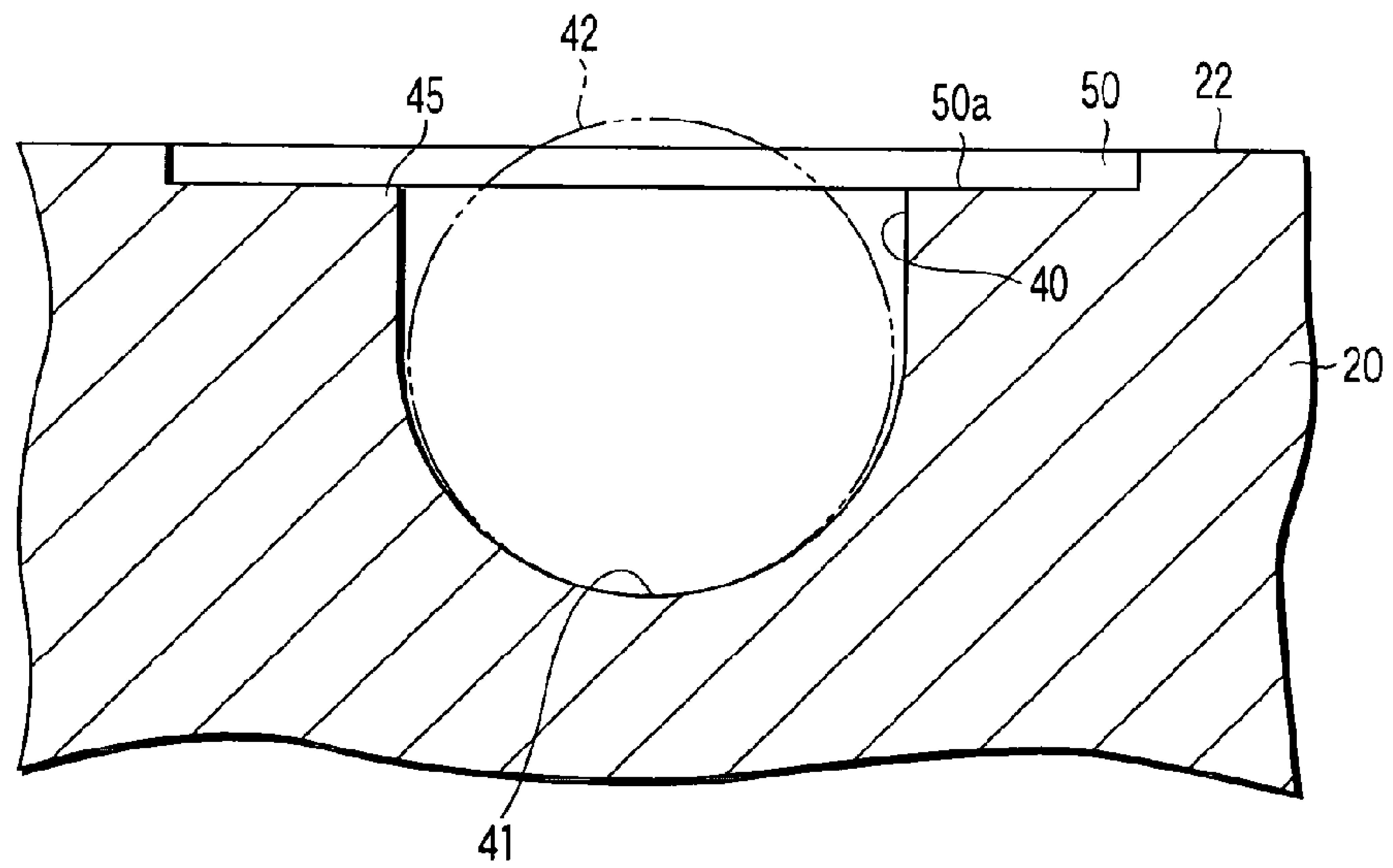
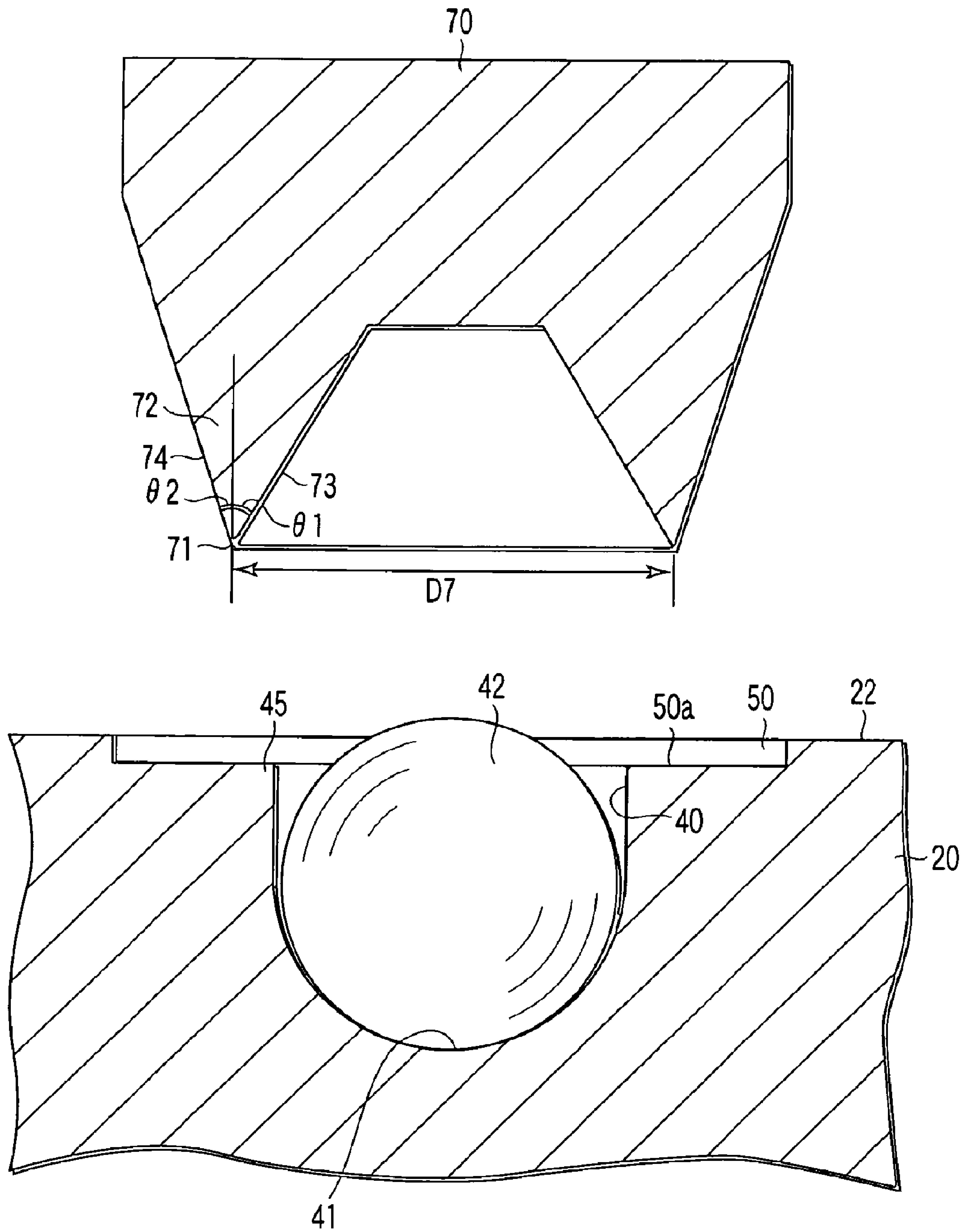


FIG. 5



F I G. 6

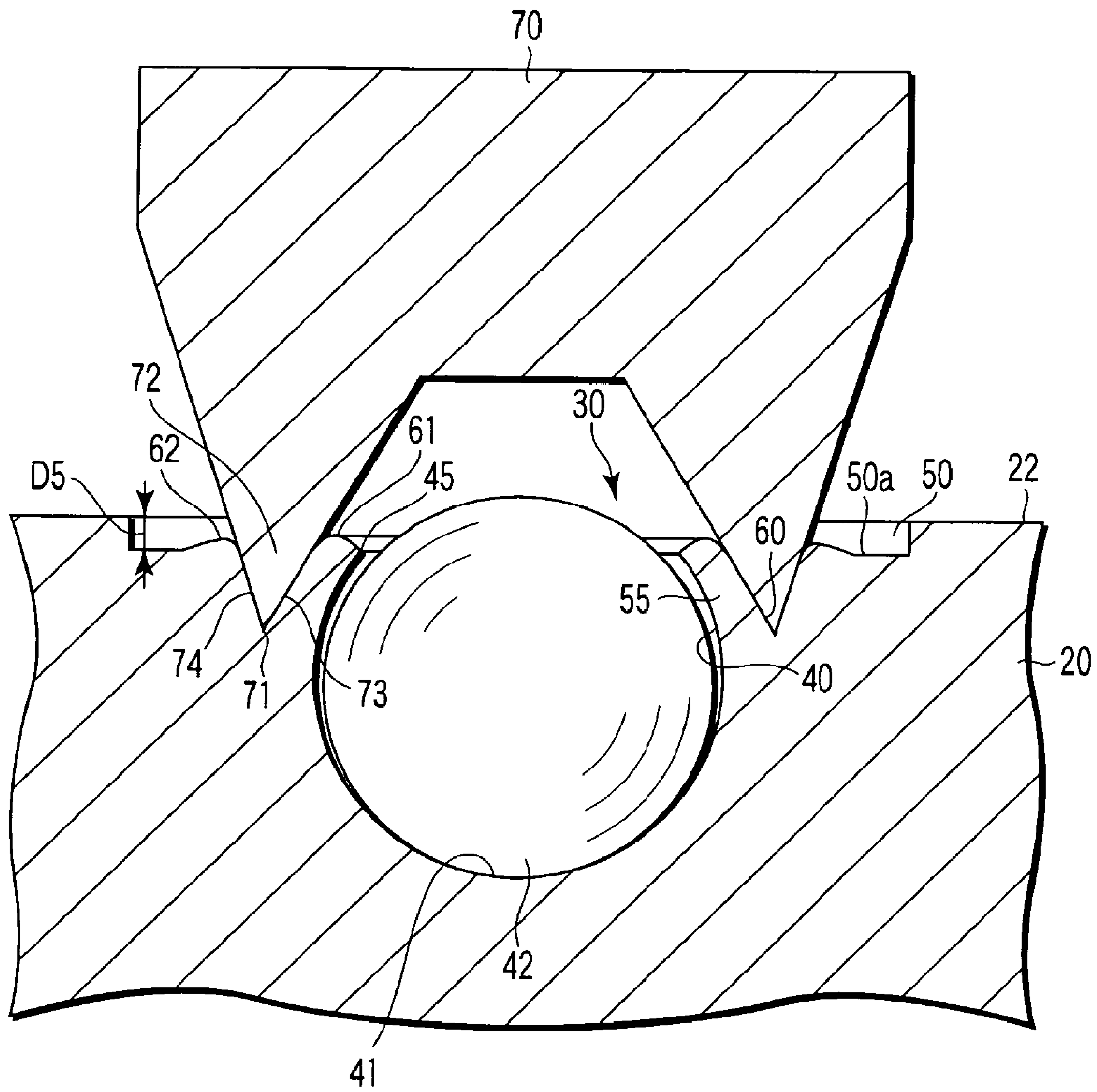


FIG. 7

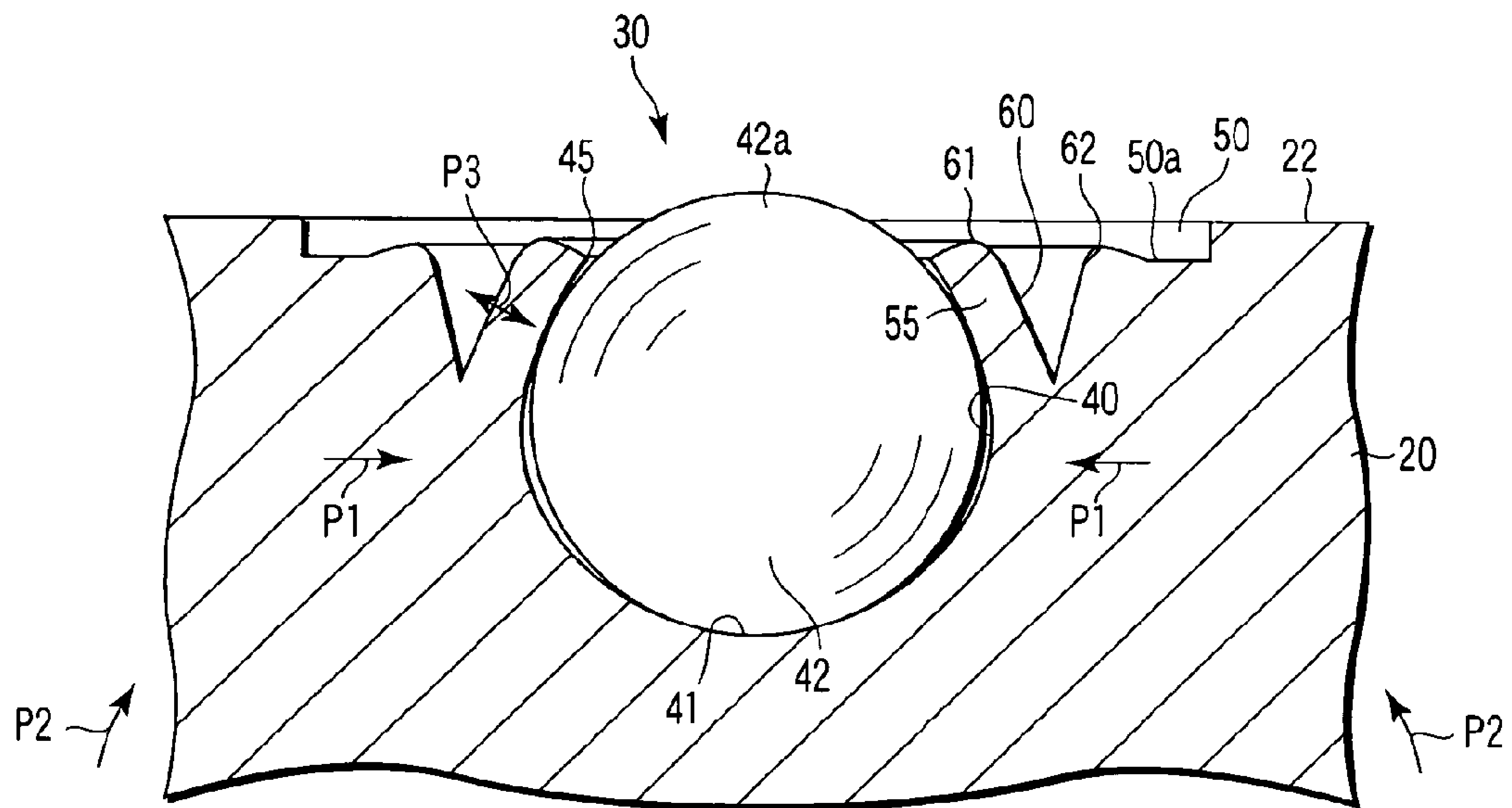


FIG. 8

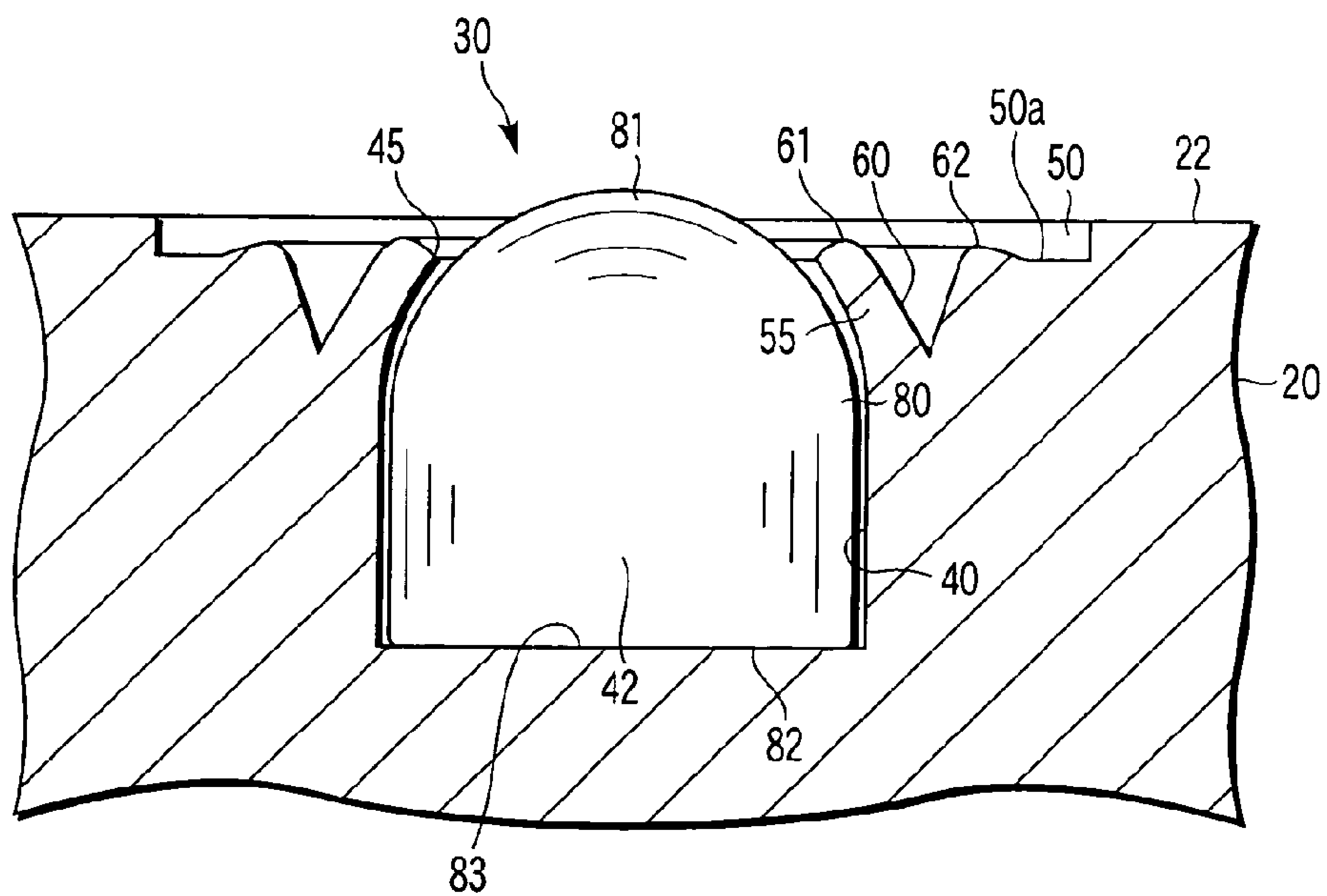


FIG. 9

SUBSTRATE SUPPORTING APPARATUS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from prior Japanese Patent Application No. 2005-376558, filed Dec. 27, 2005, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a substrate supporting apparatus used in an apparatus for processing, for example, a semiconductor wafer or the like and a manufacturing method therefor.

2. Description of the Related Art

In semiconductor manufacturing processes, a substrate supporting apparatus that has a heating function and the like is used to process a substrate, such as a wafer. The substrate supporting apparatus has a plate member for supporting the substrate. The substrate is placed on the upper surface of the plate member.

If any particulate dust, a contributor to contamination, exists on the plate member and adheres to the reverse side of the wafer, it lowers the quality of semiconductors. To prevent adhesion of the particulate dust, therefore, an attempt is made to arrange a plurality of small spacer members on the upper surface of the plate member and place the wafer on the spacer members. Described in FIGS. 2a and 2b of Japanese Patent Publication No. 2001-508599, for example, are a plate member and a plurality of small spacer members that are arranged on the upper surface of the plate member.

Each of the spacer members is in the form of a sphere or column, which is fitted into a pit in the plate member by press fit or some other technique. The spacer members are formed of a ceramic or another material that has brittleness and a thermal expansion coefficient lower than that of metal. Possibly, on the other hand, the plate member may be formed of an aluminum alloy or other material that has a high thermal expansion coefficient.

In some cases, the plate member and the spacer members may be considerably different in thermal expansion coefficient. If the substrate supporting apparatus is exposed to high temperature in, for example, a wafer treatment process, in such cases, the spacer members, which are lower in thermal expansion coefficient than the plate member, may possibly slip out of their corresponding pits of the plate member. The spacer members can be made less easy to slip out of the pits by only being brought tightly into contact with the respective inner surfaces of the pits. If this is done, however, the plate member thermally contracts to a higher degree than the spacer members do when the substrate supporting apparatus is cooled, for example. Accordingly, an excessive stress is generated in the spacer members and may possibly break the spacer members that are brittle. Thus, the conventional substrate supporting apparatus has a problem in structural solidity to resist a heat cycle or the like.

In the conventional substrate supporting apparatus, moreover, the upper end of each spacer member simply projects from the upper surface of the plate member. If any particulate dust that causes contamination exists on the upper surface of the plate member, in this arrangement, it moves from the upper surface of the plate member toward the spacer member and may possibly adhere to the reverse side of the wafer.

BRIEF SUMMARY OF THE INVENTION

An object of the present invention is to provide a substrate supporting apparatus, capable of preventing slipping-off or breakage of spacer members and also supporting a substrate in a cleaner state.

A substrate supporting apparatus according to the invention comprises a metallic plate member having a flat upper surface, a pit formed in each of a plurality of portions of the upper surface of the plate member and having a circular open edge portion and a bottom, a spacer member which has a diameter smaller than an inside diameter of the pit, is held in the pit, and has an upper end projecting from the upper surface, a bending portion which is formed by plastically deforming the open edge portion toward the spacer member so that an opening width of the open edge portion is smaller than the diameter of the spacer member, and a groove formed behind the bending portion so as to extend along a circumferential direction of the open edge portion.

According to this arrangement, there is no possibility of the spacer member slipping out of the pit, and the spacer member can be prevented from being cracked owing to a difference in thermal expansion coefficient or the like. If any particulate dust or the like that causes contamination exists on the plate member, the groove and a bump near the bending portion can restrain it from being transferred from the upper surface of the plate member onto the spacer member. Thus, a substrate can be kept cleaner when it is supported.

In a preferred aspect of the invention, the groove has a V-shaped cross section, and the groove and the bending portion are arranged individually in continuous rings covering an entire circumference of the open edge portion.

Preferably, a spot facing should be formed on that part of the upper surface of the plate member which surrounds the open edge portion, the bending portion and the groove being formed on a bottom surface of the spot facing. Further, a bump should be formed around the groove of the bottom surface of the spot facing, the bump being confined to a position lower than the upper surface of the plate member.

An example of the spacer member is a sphere of aluminum oxide (e.g., corundum such as sapphire or ruby) or a ceramic material, such as silicon carbide, alumina, aluminum nitride, or magnesia. The plate member is formed of a metallic material selected from a group of metals including aluminum, aluminum alloy, stainless steel, nickel, nickel alloy, titanium, titanium alloy, copper, copper alloy, etc.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and together with the general descrip-

tion given above and the detailed description of the embodiments given below, serve to explain the principles of the invention.

FIG. **1** is a sectional view of a wafer processor provided with a substrate supporting apparatus according to a first embodiment of the invention;

FIG. **2** is a perspective view of a plate member of the substrate supporting apparatus shown in FIG. **1**;

FIG. **3** is an enlarged plan view of a spacer arrangement portion of the plate member shown in FIG. **1**;

FIG. **4** is a sectional view of the spacer arrangement portion taken along line F**4**-F**4** of FIG. **3**;

FIG. **5** is a sectional view of a part of the plate member before the formation of a bending portion of the spacer arrangement portion shown in FIG. **4**;

FIG. **6** is a sectional view showing the plate member, a spacer member, and a wedgy tool;

FIG. **7** is a sectional view showing a state in which the bending portion is formed on the plate member;

FIG. **8** is a sectional view of a spacer arrangement portion according to a second embodiment of the invention; and

FIG. **9** is a sectional view of a spacer arrangement portion according to a third embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Substrate supporting apparatuses according to embodiments of the present invention will now be described with reference to FIGS. **1** to **9**.

FIG. **1** shows a wafer processor **10** that is used in, for example, semiconductor manufacturing processes. The wafer processor **10** is used in processes such as chemical vapor deposition (CVD), plasma vapor deposition (PVD), etching, etc. The processor **10** comprises a sealed case **11** and a substrate supporting apparatus **12** that is arranged in the case **11**.

The substrate supporting apparatus **12** includes a disc-shaped plate member **20** of a metal, such as an aluminum alloy, a post member **21** that supports the plate member **20** from the underside, and the like. The plate member **20** contains a heater unit (not shown). The heater unit heats the plate member **20** to a predetermined temperature. A substrate W, such as a wafer as an example of a supported object (workpiece), is placed on an upper surface **22** of the plate member **20**.

FIG. **2** is a perspective view showing the plate member **20** from the side of the upper surface **22**. The plate member **20** is circular, as viewed from above. The upper surface **22** of the plate member **20** is finished flat by machining or the like.

Spacer arrangement portions **30** of a common structure are provided in a plurality of spots of the upper surface **22** of the plate member **20**, that is, in three or more spots on the plate member **20** at regular intervals in the circumferential direction thereof. Further, through-holes **31** (shown in FIG. **2**) penetrate, e.g., three circumferential parts of the plate member **20** in its thickness direction. Pins (not shown) for pushing up the substrate W on the plate member **20** can be inserted individually into the through-holes **31**. These pins are inserted into the through-holes **31** from under the plate member **20**.

FIGS. **3** and **4** show details of one of the spacer arrangement portions **30**. The spacer arrangement portion **30** has a pit **40** formed in the upper surface **22** of the plate member **20** and a spacer member **42** held in the pit **40**. As shown in FIG. **4**, the pit **40** has a bottom **41**. The top end of the pit **40** is open. The bottom **41** of the pit **40** is in the form of a hemispherical recess. An open edge portion **45** of the pit **40** is circular, as viewed from above.

An example of the spacer member **42** is a sphere of sapphire. Alternatively, the spacer member **42** may be formed of a sphere of aluminum oxide, such as ruby, or any other ceramic material. The spacer member **42** has a diameter D**1** of, for example, 2 mm. A diameter D**2** of the pit **40** is a little larger than the diameter D**1** of the spacer member **42**. For example, D**2** is about 0.01 mm larger than D**1**.

The diameter D**2** of the pit **40** is a dimension that is not smaller than the diameter D**1** of the spacer member **42** even when the plate member **20** is cooled so that its amount of thermal contraction is larger than that of the spacer member **42**. An upper end **42**a of the spacer member **42** projects by H (shown in FIG. **4**) from the upper surface **22** of the plate member **20**. The projection amount H of the spacer member **42** can be accurately regulated as the bottom surface of the spacer member **42** engages the bottom **41** of the pit **40**. The top of the upper end **42**a of the spacer member **42** is in contact with the under surface of the substrate W.

A spot facing **50** is formed in the upper surface **22** of the plate member **20** so as to surround the open edge portion **45** of the pit **40**. The spot facing **50** is a plain spot facing that has a flat bottom surface **50**a and is formed by machining using, for example, an NC machine or the like. A diameter D**4** of the spot facing **50** is about twice or thrice as large as the diameter D**1** of the spacer member **42**. For example, D**4** is 2 to 3 mm larger than D**1**. A depth D**5** of the spot facing **50** is 0.1 mm, for example.

In the bottom surface **50**a of the spot facing **50**, a bending portion **55** is formed on the open edge portion **45** of the pit **40**. The bending portion **55** is formed by plastically deforming the open edge portion **45** toward the spacer member **42** by means of a wedgy tool **70**, which will be mentioned later. An opening width D**3** of the open edge portion **45** is smaller than the diameter D**1** of the spacer member **42**. The opening width D**3** is a dimension that does not exceeds the diameter D**1** of the spacer member **42** even when the plate member **20** is heated and thermally expanded to become larger than the spacer member **42**.

As shown in FIG. **4**, a groove **60** with a V-shaped cross section is formed in the bottom surface **50**a of the spot facing **50**. The groove **60** is formed along the circumferential direction of the open edge portion **45** at the back of the bending portion **55** (or on the side opposite from the spacer member **42**). Bumps **61** and **62** are formed around the groove **60** of the bottom surface **50**a of the spot facing **50**.

The inner bump **61** is raised higher than the outer bump **62**. However, the respective upper ends of the bumps **61** and **62** are lower than the upper surface **22** of the plate member **20**. Therefore, the bumps **61** and **62** are confined inside the recess of the spot facing **50**. As shown in FIG. **3**, the bending portion **55**, groove **60**, and bumps **61** and **62** are arranged in continuous rings covering the entire circumference of the open edge portion **45**.

The substrate supporting apparatus **12** that comprises the spacer arrangement portions **30** is manufactured by the following processes.

First, the flat upper surface **22** is formed on the plate member **20** by machining. Thereafter, the pit **40** that has the bottom **41** and the spot facing **50** that has the bottom surface **50**a are formed in the upper surface **22** of the plate member **20** by drilling and boring processes, as shown in FIG. **5**. Then, the spacer member **42** is inserted into the pit **40**.

The wedgy tool **70** shown as an example in FIG. **6** is used in a bending process. It has a cylindrical edge portion **72** that has a sharp V-shaped tip **71**. The tip **71** is in the shape of a ring that extends along the open edge portion **45** of the pit **40**, as viewed from the distal end side of the edge portion **72**. A

diameter D7 of the tip **71** is larger than an inside diameter D2 (shown in FIG. **4**) of the pit **40**. A taper angle θ1 of an inside slope **73** of the edge portion **72** is larger than a taper angle θ2 of an outside slope **74**. The taper angle θ2 of the outside slope **74** may be zero.

As shown in FIG. **7**, the tip **71** of the wedgy tool **70** is pushed in around the open edge portion **45**. Thus, the open edge portion **45** is plastically deformed toward the spacer member **42** so that its opening width D3 (shown in FIG. **4**) is smaller than the diameter D1 of the spacer member **42**.

When the tip **71** of the wedgy tool **70** is pushed in around the open edge portion **45** of the pit **40**, the open edge portion **45** is pushed toward the spacer member **42** by the inside slope **73** of the edge portion **72**. Thereupon, the V-shaped groove **60** is formed, and the bending portion **55** is plastically deformed so that it inclines toward the spacer member **42**. Further, the inside bump **61** is formed as a part of the bottom surface **50**a of the spot facing **50** swells. Furthermore, the outer bump **62** is formed as a part of the bottom surface **50**a of the spot facing **50** is raised by the outside slope **74** of the edge portion **72**.

Since the taper angle θ1 of the inside slope **73** of the edge portion **72** is larger than the taper angle θ2 of the outside slope **74**, the inside bump **61** is raised higher than the outer bump **62**. These bumps **61** and **62** cannot be raised beyond the depth D5 of the spot facing **50** and is confined inside the recess of the spot facing **50**.

In the semiconductor manufacturing processes, there is a possibility of particulate dust remaining in a corner **50**c (shown in FIG. **4**) of the spot facing **50**. The particulate dust in the corner **50**c cannot be easily removed even by washing. From some cause, therefore, the particulate dust may possibly move from the bottom surface **50**a of the spot facing **50** toward the spacer member **42**. If the moving particulate dust reaches the upper end **42**a of the spacer member **42**, it may contaminate the under surface of the substrate W to be supported.

Each spacer arrangement portion **30** of the present embodiment is formed with the V-shaped groove **60** and the bumps **61** and **62** on the opposite sides of the groove **60**, covering the entire circumference of the spacer member **42**. Therefore, the particulate dust or the like that is urged to move from the bottom surface **50**a of the spot facing **50** toward the spacer member **42** is blocked by the bumps **61** and **62**. Further, the particulate dust is captured by the groove **60**. Accordingly, the particulate dust or the like that causes contamination can be restrained from being transferred onto the upper end **42**a of the spacer member **42**, so that the substrate W can be kept cleaner when it is supported. Since the groove **60** and the bumps **61** and **62** can be simultaneously formed by the wedgy tool **70**, the working process is not laborious.

FIG. **8** shows a spacer arrangement portion **30** according to a second embodiment of the invention. A groove **60** of the spacer arrangement portion **30** of this embodiment is formed deeper than the groove **60** according to the first embodiment. A bending portion **55** of FIG. **8** is inclined more sharply toward the spacer member **42**. Therefore, the bending portion **55** is located close to or in contact with the spacer member **42**.

A plate member **20** that is formed of a metal, such as an aluminum alloy, has a thermal expansion coefficient higher than that of the spacer member **42**. If the plate member **20** is contracted relatively greatly at low temperature, therefore, a compressive load P**1** (shown in FIG. **8**) acts on the spacer member **42**. If the plate member **20** is warped in the direction of arrow P**2** by thermal expansion at high temperature, moreover, the compressive load P**1** may also acts on the spacer member **42**.

In the spacer arrangement portion **30** of the present embodiment, the V-shaped groove **60** is formed behind the bending portion **55**, and the bending portion **55** is liable to bend in the direction of arrow P**3** (shown in FIG. **8**). Thus, the load P**1** is absorbed as the bending portion **55** bends, so that an excessive stress that can break the spacer member **42** can be avoided. This effect can be also obtained with use of the spacer arrangement portion **30** according to the first embodiment.

FIG. **9** shows a spacer arrangement portion **30** according to a third embodiment of the invention. A spacer member **42** of this embodiment has a columnar trunk portion **80**, a hemispherical head portion **81**, and a flat lower surface **82**. A pit **40** that holds the spacer member **42** has a flat bottom **83**. Since other configurations and effects of the third embodiment are the same as those of the first embodiment (FIGS. **1** to **7**), common numbers are used to designate like portions of these two embodiments, and a description those portions is omitted.

The spacer member **42** is not limited to the foregoing embodiments, but may be in the shape of a rotationally symmetric body, such as a column, cone, frustum, etc. In short, the pit **40** used should only have a shape corresponding to the spacer member **42** of which the shape is properly selected as required. Further, a bending portion **55**, a groove **60**, and bumps **61** and **62** may be formed in a part around the pit **40**.

The present invention may be also applied to a substrate supporting apparatus for supporting any other substrate than a semiconductor wafer. It is to be understood, in carrying out the present invention, that the components of the invention, including the plate member, spacer member, bending portion, and groove, may be modified suitably.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

What is claimed is:

1. A substrate supporting apparatus comprising:

a metallic plate member having a flat upper surface; and a plurality of spacer arrangement portions provided at the upper surface of the plate member to support a substrate; wherein each of the spacer arrangement [portion] *portions* comprises:

a pit formed in the upper surface of the plate member and having a circular open edge portion and a bottom, wherein the open edge portion and the bottom of the pit are integrally formed with the plate member as one piece;

a spacer member which has a diameter smaller than an inside diameter of the pit, and which is held in the pit and has an upper end projecting from the upper surface of the plate member;

a bending portion which is formed by plastically deforming the open edge portion of the pit toward the spacer member so that an opening width of the open edge portion of the pit is smaller than the diameter of the spacer member, wherein the bending portion and the plate member are integrally formed as one piece; and

a groove formed in the plate member and located behind the bending portion so as to extend along a circumferential direction of the open edge portion of the pit;

wherein the groove has a V-shaped cross section, and the groove and the bending portion are arranged individu-

ally in continuous rings covering an entire circumference of the open edge portion;

wherein a spot facing is formed on a part of the upper surface of the plate member which surrounds the open edge portion of the pit, and wherein the bending portion and the groove are formed on a bottom surface of the spot facing; and

wherein an inner bump and an outer bump are formed around the groove of the bottom surface of the spot facing, wherein the inner bump is raised higher than the outer bump, and wherein the bumps are confined to positions lower than the upper surface of the plate member.

2. A substrate supporting apparatus according to claim **1**, wherein the spacer member is a sphere of aluminum oxide, and the plate member is formed of an aluminum alloy.

3. A substrate supporting apparatus according to claim **1**, wherein the spacer member is a sphere of a ceramic material, and the plate member is formed of an aluminum alloy.

4. A substrate supporting apparatus comprising:

a metallic plate member having a flat upper surface; and

a plurality of spacer arrangement portions provided at the upper surface of the plate member to support a substrate;

wherein each of the spacer arrangement portions comprises:

a pit formed in the upper surface of the plate member and having a circular open edge portion and a bottom, wherein the open edge portion and the bottom of the pit are integrally formed with the plate member as one piece;

a spacer member which has a diameter smaller than an inside diameter of the pit, and which is held in the pit and has an upper end projecting from the upper surface of the plate member;

a bending portion which is formed by plastically deforming the open edge portion of the pit toward the spacer member so that an opening width of the open edge portion of the pit is smaller than the diameter of the spacer member, wherein the bending portion and the plate member are integrally formed as one piece; and

a groove formed in the plate member and located behind the bending portion so as to extend along a circumferential direction of the open edge portion of the pit;

wherein the groove has a V-shaped cross section, and the groove and the bending portion are arranged individually in part on rings covering an entire circumference of the open edge portion;

wherein a spot facing is formed on a part of the upper surface of the plate member which surrounds the open edge portion of the pit, and wherein the bending portion and the groove are formed on a bottom surface of the spot facing; and

wherein an inner bump and an outer bump are formed around the groove of the bottom surface of the spot facing, wherein the inner bump is raised higher than the outer bump, and wherein the bumps are confined to positions lower than the upper surface of the plate member.

5. A substrate supporting apparatus comprising:

a metallic plate member having a flat upper surface; and

a plurality of spacer arrangement portions provided at the upper surface of the plate member to support a substrate;

wherein each of the spacer arrangement portions comprises:

a pit formed in the upper surface of the plate member and having a circular open edge portion and a bottom, wherein the open edge portion and the bottom of the pit are integrally formed with the plate member as one piece;

a spacer member which is a sphere and has a diameter smaller than an inside diameter of the pit, and which is held in the pit and has an upper end projecting from the upper surface of the plate member;

a bending portion which is formed by plastically deforming the open edge portion of the pit toward the spacer member so that an opening width of the open edge portion of the pit is smaller than the diameter of the spacer member, wherein the bending portion and the plate member are integrally formed as one piece, and the bending portion is configured to prevent the spacer member from slipping out of the pit;

a gap which is defined between a circumference of the sphere spacer member and the bending portion; and

a groove formed in the plate member and located behind the bending portion so as to extend along a circumferential direction of the open edge portion of the pit;

wherein the groove has a V-shaped cross section, and the groove and the bending portion are arranged individually in part on rings covering an entire circumference of the open edge portion;

wherein a spot facing is formed on a part of the upper surface of the plate member which surrounds the open edge portion of the pit, and wherein the bending portion and the groove are formed on a bottom surface of the spot facing; and

wherein an inner bump and an outer bump are formed around the groove of the bottom surface of the spot facing, wherein the inner bump is raised higher than the outer bump, and wherein the bumps are confined to positions lower than the upper surface of the plate member.

* * * * *