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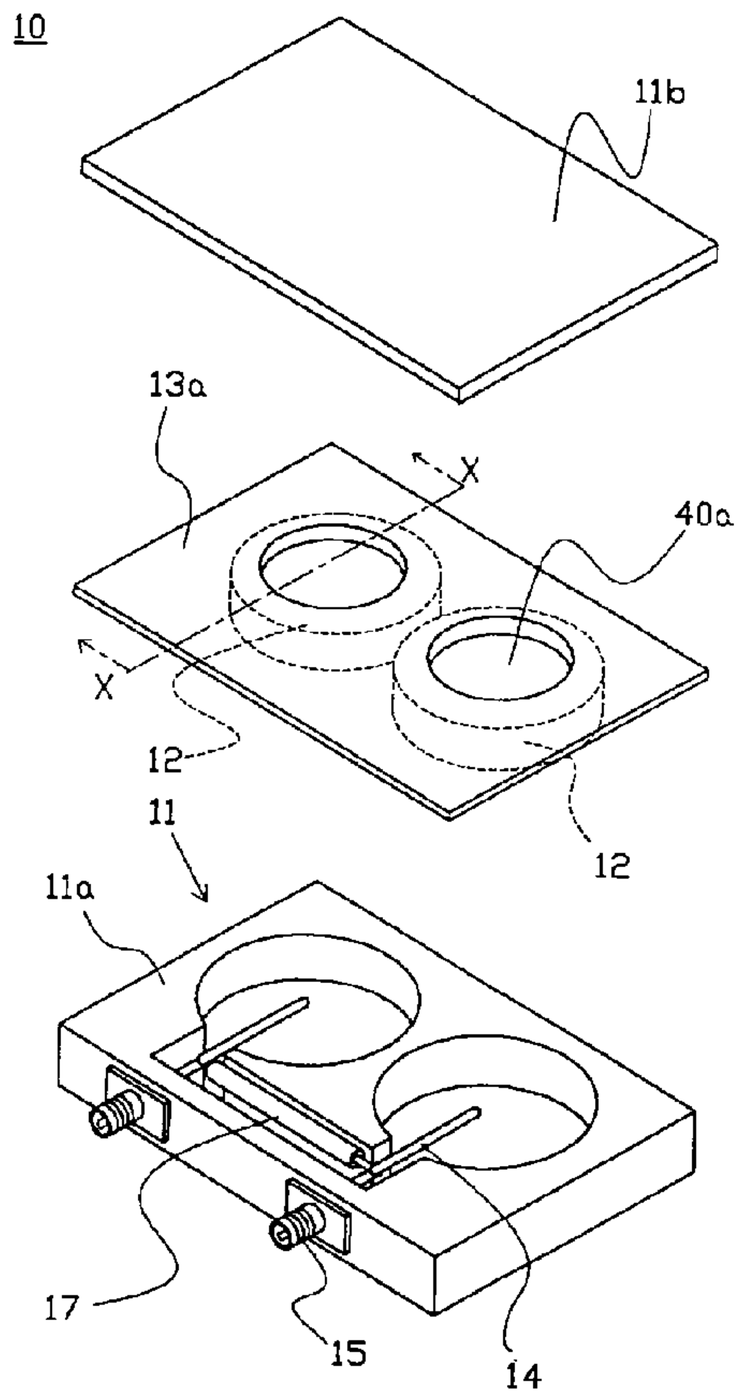
(54) **RESONATEUR DIELECTRIQUE, FILTRE DIELECTRIQUE, DUPLEXEUR DIELECTRIQUE ET DISPOSITIF DE COMMUNICATION**

(54) **DIELECTRIC RESONATOR, DIELECTRIC FILTER, DIELECTRIC DUPLEXER, AND COMMUNICATION DEVICE**




(57) A dielectric filter comprising a case having an electroconductivty, dielectric resonators each having electrodes formed on the opposite sides thereof disposed inside of the case, an ground plate disposed inside of the case, and external connecting means, at least one of the electrodes being a thin film multilayered electrode connected to said ground plate, wherein said ground plate is provided with protuberant portions, and each of the protuberant portions is connected to the side of the dielectric resonator on which the thin film multilayered electrode is formed, through the surface portion of the protuberant portion which is smaller than the range of the dielectric resonator defined by the side edge thereof.

## ABSTRACT OF THE DISCLOSURE

A dielectric filter comprising a case having an electroconductivty, dielectric resonators each having electrodes formed on the opposite sides thereof disposed inside of the case, an ground plate disposed inside of the case, and external connecting means, at least one of the electrodes being a thin film multilayered electrode connected to said ground plate, wherein said ground plate is provided with protuberant portions, and each of the protuberant portions is connected to the side of the dielectric resonator on which the thin film multilayered electrode is formed, through the surface portion of the protuberant portion which is smaller than the range of the dielectric resonator defined by the side edge thereof.

# DIELECTRIC RESONATOR, DIELECTRIC FILTER, DIELECTRIC DUPLEXER, AND COMMUNICATION DEVICE

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a dielectric resonator, and more particularly, to a dielectric resonator having a thin film multi-layered electrode and a dielectric filter and duplexer including the dielectric resonator which are applicable to communication apparatuses and the like for use in base stations of a cellular telephone system, and a communication device including the dielectric filter.

2. Description of the Related Art

FIG. 9 is an exploded perspective view of a dielectric filter concerned with the present invention. The dielectric filter is described in the co-pending U.S. Patent Application No. 924040. However, the art with respect to the dielectric filter was not a publicly known conventional art when Japanese Patent Application No. H10-38810, a basis of the priority of the present invention, was filed. A dielectric filter 110 comprises a metallic case 111, dielectric resonators 112 disposed inside of the case 111, an ground plate 113, coupling probes 114, and external connectors 115 attached to the outside wall of the case and be connected to the probes 114, respectively. The case 111 comprises a trunk 111a and an upper lid 111b. On the upper and under sides of each dielectric resonator 112, thin film multilayered electrode are formed, respectively. Each thin film multilayered electrode is composed of dielectric layers and conductor layers alternately laminated to each other. The detailed structure of the thin

film multilayered electrode is described in the co-pending U.S. Patent Application No. 604952 (international application number PCT/JP94/00357). The disclosure is incorporated herein by reference. The ground plate 113 is made of a metallic plate. For the purpose of reducing the temperature dependency of the filter characteristics, the ground plate has a coefficient of linear expansion equal to that of the dielectric resonators 112. The dielectric resonators 112 are soldered to be fixed to the ground plate 113. The ground plate 113 is sandwiched between the trunk 111a and the lid 111b, and thereby, the dielectric resonators 112 are disposed in the case 111. The ground plate 113 is so placed on the trunk 111a that gaps are formed between the dielectric resonators 112 and the trunk 111a.

Each coupling probe 114 made of a metallic wire is elongated in the gap, separated from the dielectric resonator 112. The coupling probe 114 and the dielectric resonator 112 are capacitively coupled. The two dielectric resonators achieve function as a filter. The dielectric filter, if the external connectors 115 are connected through a $\lambda/4$ line 117, functions as a band elimination dielectric filter.

In order to fix the dielectric resonators to the ground plate, soldering techniques are generally used as described above. For the purpose of making the best use of the characteristics of the thin film multilayered electrodes, it is preferable to consider the following points. FIG. 10 is a cross-sectional view taken along a line W-W of FIG. 9. A solder is coated onto the upper side of the dielectric resonator 112 with a soldering iron and so retained as to short-circuit the under side of the ground plate and the side of the resonator. As a result, the respective electrodes of the thin film multilayered electrode are short-

circuited. The solder may be permeated between the resonator 12 and the ground plate 113 according to re-flow techniques. However, an excess solder reaches the side of the resonator to short-circuit the respective electrodes of the thin film multilayered electrode.

The thin film multilayered electrode is provided for the purpose of enhancing the non loaded Q of the dielectric filter, by reduction of the conductor loss in the electrode due to the skin effect. The thicknesses of the respective electrode layers are strictly set. Therefore, the short-circuit of the respective electrode layers as described above should be avoided.

In the event that a stress, caused by external vibration and impact, is applied to the ground plate, the stress is transmitted to the side edge of the thin film multilayered electrode, since the ground plate is flat. The thin film multilayered electrode is ready to be peeled in the side edge thereof. Thus, there is a possibility that a part of the thin film multilayered electrode is peeld from the side edge thereof.

## SUMMARY OF THE INVENTION

Accordingly, one object of the present invention is to solve the above-described technical problems and to provide a dielectric filter formed by dielectric resonators, a dielectric duplexer, and a communication device which have a high non loaded Q and an excellent reliability.

The dielectric filter of the present invention comprises a case having cavities and of which the inner side is coated with a metallic film, one of a metallic ground plate and an ground plate coated with a metal each covering the openings of the cavities to form the shielded cavities, and dielectric resonators

fixed to the ground plate and accommodated in the cavities, respectively. Electrode layers are formed on the side of each dielectric resonator adjacent to the ground plate and the opposite side thereof, respectively. At least the electrode adjacent to the ground plate is preferably a thin film multilayered electrode. The ground plate is protuberant toward the inner sides of the cavities so as to become adjacent to the thin film electrodes. The dielectric resonators are placed on the formed protuberant portions. The area of each protuberant portion of the ground plate is smaller than that of the side of the dielectric resonator adjacent to the protuberant portion. Therefore, when the dielectric resonator is soldered to be fixed to the protuberant portion, the solder is prevented from reaching the side edge of the thin film multilayered electrode.

The protuberant portion may be provided with a hole which is smaller than and lies within the range of the protuberant portion defined by the side edge thereof.

The hole may be provided with a cut on the periphery thereof.

## BRIEF DESCRITION OF THE DRAWINGS

FIG. 1 is an exploded perspective view of a dielectric filter according to a first embodiment of the present invention.

FIG. 2 is a cross-sectional view along a line X-X of FIG. 1.

FIG. 3 is a perspective view of a dielectric resonator and an ground plate portion according to a second embodiment of the present invention.

FIG. 4 is a cross-sectional view along a line Y-Y of FIG. 3.

FIG. 5 is a perspective view of a dielectric resonator and an ground plate portion according to a third embodiment of the present invention.

FIG. 6 is a cross-sectional view along a line Z – Z of FIG. 5.

FIG. 7 is an exploded perspective view of a dielectric duplexer according to the present invention.

FIG. 8 is an exploded perspective view of a communication device according to the present invention.

FIG. 9 is an exploded perspective view of an another type of dielectric filter.

FIG. 10 is a cross-sectional view along a line W-W of FIG. 9.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

A dielectric filter according to a first embodiment of the present invention will be described below with reference to FIGS. 1 and 2. Hereinafter, a two-stage band elimination filter comprising two dielectric resonators and input-output probes adapted to be electromagnetically coupled to the resonators, respectively, in which the probes are connected through a $\lambda/4$ line. However, the present invention is not limited only to a filter of the above-described type and may be applied to another type resonator, filter and duplexer. The filters, duplexers which will be shown below are consisting of respective resonators. Thus, it would be clearly understood that the present invention can be applicable to a single resonator.

As shown in FIG. 1, a dielectric filter 10 comprises a case 11 made of an iron body plated with silver for example, dielectric resonators 12, an ground plate 13a, coupling probes 14, and external connectors 15 attached to the outer wall of the case 11 and connected to the probes 14, respectively.

Thin film multilayered electrodes 30 each composed of conductive layers

and dielectric layers laminated to each other and formed by sputtering and the like are provided on the two opposite sides of each dielectric resonator 12, respectively. The ground plate 13a is preferably made of an alloy of iron and nickel, so that the coefficient of linear expansion of the dielectric resonators 12 can be made substantially equal to that of the ground plate 13a. This prevents the dielectric resonators 12 and the ground plate 13a from being cracked between them, due to changes in temperature. Each coupling probe 14 is a metallic wire. One end of the probe 14 is connected to the center conductor of the external connectors 15. The probe 14 is elongated in the space between the dielectric resonator 12 and the case 11. A signal transmitted from the external connector 15 arrives at the probe 14. The probe 14 and the dielectric resonator 12 are capacitively coupled. The dielectric resonator 12 may have a prism shape. The case 11 may be a ceramic case provided with a metallic conductive layer formed on thereon.

Hereinafter, joining of the dielectric resonator 12 to the ground plate 13 will be described with reference to FIG. 2.

The ground plate 13a is provided with a protuberant portion 40a having an under side with a smaller area than the upper side of the dielectric resonator 12, formed by press working and the like, as shown in FIG. 2. Preferably, the under side of the protuberant portion is substantially flat. A creamy solder 20 is made to adhere mainly to the under side of the protuberant portion 40a of the ground plate 13a, as shown in FIG. 2. The dielectric resonator 12 is fixed in such a manner that the upper side of the resonator 12 is made adjacent to the protuberant portion 40a, and the solder is heated. On this occasion, preferably, the side edge of the thin film multilayered electrode 30 formed in the dielectric

resonator 12 avoids to be positioned under the side edge of the protuberant portion 40a of the ground plate 13a. This is because the solder coated onto the under side of the protuberant portion is prevented from reaching the side edge of the thin film multilayered electrode. In other words, it is preferable that the protuberant portion is as distant as possible from any point of the side edge on the upper side of the dielectric resonator. In other words, the side edge of the electrode is as distance as possible from the circumference of the top of the protrude.

In such a manner, a space is provided between the side edge of the thin film multilayered electrode 30 and ground plate 13a. When the solder 20 is permeated between the thin film multilayered electrode 30, the ground plate 13a functions as a buffer for the solder 20. Thus, the solder 20 is prevented from reaching the side edge of the thin film multilayered electrode 30. The protuberant portion may have an optional shape. Desirably, the height of the protuberant portion is constant so that a solder film uniform in thickness can be formed between the resonator and the protuberant portion.

The protuberant portion 40a of the ground plate 13a is joined to the thin film multilayered electrode 30 through the surface portion thereof which is smaller than the range on the upper side of the thin film multilayered electrode 30 defined by the side edge. Accordingly, even if a stress, caused by vibration and impact, is applied to the ground plate 13a, the range where the force exerts a main influence lies on the inner side of the side edge of the thin film multilayered electrode 30. Therefore, the stress applied to the side edge of the thin film multilayered electrode 30, which is ready to be peeled, is feeble. Thus, there is no possibility that the thin film multilayered electrode 30 is peeled due to

an external vibration or impact.

The ground plate 13a soldered to be fixed to the dielectric resonator 12 is sandwiched between the trunk 11a and the lid 11b of the case 11, namely, it is disposed inside of the case 11.

According to a second embodiment of the present invention, an aperture is provided for a part of the protuberant portion of the ground plate. The configuration in the instant embodiment is the same as that of the first embodiment except for the aperture. FIG. 3 is a perspective view of the dielectric resonator and the ground plate. FIG. 4 is a cross-sectional view along a line Y – Y of FIG. 3.

In the instant embodiment, a circular hole 41b is so provided for the protuberant portion 40b by punching and the like, as to have a size smaller than the range of the protuberant portion 40b defined by the side edge thereof.

Hereinafter, a process of soldering the dielectric resonator 12 provided with the thin film multilayered electrode 30 thereon to the ground plate 13b formed as described above will be now described. The dielectric resonators 12 and the protuberant portion 40b are arranged in their preferred positions relative to each other as described above. A solder is cast to lie between the dielectric resonator 12 and the protuberant portion 40b by contacting a solder iron from the side A shown in FIG. 4 through the hole 41b to the upper side of the thin film multilayered electrode 30. The amount of the cast solder is such that it sufficiently extends between the protuberant portion 40b and the upper side of the resonator. Preferably, the amount of the solder is such that the surface of the liquid solder reaches the side wall of the protuberant portion 40b, depicting a smooth curved surface. When such an amount of the solder is cast, it does not

reach the side edge of the thin film multilayered electrode.

Accordingly, the protuberant portion 40b of the ground plate 13b is joined to the thin film multilayered electrode 30 through the surface portion thereof which is smaller than the range on the upper side of the thin film multilayered electrode 30 defined by the side edge. Accordingly, even if a stress, caused by vibration and impact, is applied to the ground plate 13a, the range where the force exerts a main influence lies on the inner side of the side edge of the thin film multilayered electrode 30. Therefore, the stress applied to the side edge of the thin film multilayered electrode 30, which is ready to be peeled, is feeble. Thus, there is no possibility that the thin film multilayered electrode 30 is peeled due to an external vibration or impact.

With the hole 41b provided for the ground plate 13b, soldering can be carried out by operating a solder iron and the like from the side A of the ground plate 13b. Accordingly, the work is simplified.

Moreover, a third embodiment of the resent invention will be now described. The arrangement and function of the dielectric filter in the instant embodiment are the same as those in the second embodiment. Their description will be omitted, and only joinining of the dielectric resonator to the ground plate will be explained in reference to FIGS. 5 and 6. FIG. 5 is a perspective view of the dielectric resonator and the ground plate. FIG. 6 is a cross-sectional view along a line Z – Z of FIG. 5.

In the instant embodiment, the columnar thin film multilayered electrodes 30 are formed by sputtering on the opposite sides of the dielectric resonator 12. A protubernat portion 40c is formed by press working. The protuberant portion 40c of the ground plate 13c made of an alloy of iron and nickel has the under

side of which the area is smaller than the upper side of the dielectric resonator 12 in opposition to the protuberant portion. Preferably, the under side is substantially flat. In the under side of the protuberant portion 40c, an aperture 41c is formed by punching.

At least one bay-shape portion is provided with the aperture on the periphery thereof. The bay portion may have an optional shape and size on condition that the area where the solder and the aperture are contacted with each other is increased.

As described above, the aperture 41c of the ground plate 13c, if it is so shaped as to have a cut 42, has a circumferential length, where the soldering is carried out, longer than that of the aperture having a shape excluding the cut 42. Accordingly, this assures the joining by soldering of the dielectric resonator and the protuberant portion.

A dielectric duplexer according to an embodiment of the present invention will be described below with reference to FIG. 7. FIG. 7 is an exploded perspective view of the dielectric duplexer of this embodiment. In this embodiment, like parts to those in the first embodiment are designated by like reference numerals, and the detailed description of the parts will be omitted.

As shown in FIG. 7, a dielectric duplexer 50 of this embodiment includes a first dielectric filter portion 60a made up of two columnar dielectric resonators 12a, and a second dielectric filter portion 60b made up of two columnar dielectric resonators 12b, which are disposed in a case 5. On the two opposite sides of the respective dielectric resonators 12a and 12b, the thin film multilayered electrodes each composed of conductive layers and dielectric layers laminated together are formed, respectively. The two dielectric resonators 12a

constituting the first dielectric filter portion 60a are coupled through a capacitance produced by a coupling member 16a and functions as a transmitting band pass filter. The two dielectric resonators 12b constituting the second dielectric filter portion 60a and having a resonant frequency different from that of the dielectric resonators 12a of the first dielectric filter 60a are also coupled together through a capacitance produced by a coupling member 16b, and functions as a receiving band pass filter. An electric probes 14a as an external connecting means connected to the dielectric resonators 12a of the first dielectric filter portion 60a is connected to an external connector 15a so that it is connected to an external transmitting circuit. An electric probe 14b connected to the dielectric resonator 12b of the second dielectric filter portion 60b is connected to an external connector 15b, so that it is connected to an external receiving circuit. Further, an electric probe 14c connected to the dielectric resonator 12a of the first dielectric filter portion 60a and an electric probe 14d connected to the dielectric resonator 12b of the second dielectric filter portion 60b are connected to an external connector 15c, so that they are connected to an external antenna.

The dielectric duplexer having the above-described configuration functions as a band pass dielectric filter. That is, the first dielectric filter portion 60a allows a wave with a predetermined frequency to pass, and the second dielectric filter portion 60b does a wave with a different frequency from that of the above wave to pass.

In the instant embodiment, the dielectric resonators 12a and 12b are soldered to the ground plate 13d and sandwiched between the trunk 51b of a shielding cavity 51 and a lid 51b to be disposed inside of the case 51. For the

ground plate 13d, the protuberant portions 40c and the holes 41c for soldering are provided. Each of them has an area under side thereof which is smaller than that of on the upper side of the thin film multilayered electrode, defined by the side edge thereof. This prevents the solder from reaching the side edge of the thin film multilayered electrode. That is, the thin film multilayered electrode is prevented from being short-circuited. Thus, the dielectric duplexer having a high non-load Q can be provided. In addition, there is reduced the possibility that the thin film multilayered electrode is peeled by an external impact and the like.

Moreover, a communication device according to an embodiment of the present invention will be described below with respect to FIG. 8. FIG. 8 is a schematic diagram of a communication device of this embodiment.

As shown in FIG. 8, a communication device 70 of this embodiment comprises a the dielectric duplexer 50, a transmitting circuit 71, a receiving circuit 72, and an antenna 73. In this case, the dielectric duplexer 50 is the same as described in the above embodiment. The external connector 15a connected to the first dielectric filter portion 60a, shown in FIG. 7 is, is connected to the transmitting circuit 71. The external connector 15b connected to the second dielectric filter portion 60 b is connected to the receiving circuit 72. In addition, the external connector 15c is connected to an antenna 73.

In the instant embodiment, the dielectric resonators are soldered to the ground plate and sandwiched between the trunk of the case and an external, that is, it is disposed inside of the case. For the ground plate, the protuberant portions and the holes for soldering are provided. Each of them has an area under side thereof which is smaller than that of on the upper side of the thin

film multilayered electrode, defined by the side edge thereof. Accordingly, the solder is prevented from reaching the side edge pf the thin film multilayered electrode. That is, the thin film multilayered electrode is prevented from being short-circuited. Thus, the communication device having a high non-load Q can be provided. In addition, there is reduced the possibility that the thin film multilayered electrode is prevented by an external impact and the like. Thus, the communication device having a high reliability can be obtained.

WHAT IS CLAIMED IS:

1. A dielectric filter comprising:

a case having an electroconductivty;

a dielectric resonators each having electrodes formed on the opposite sides thereof disposed inside of said case;

an ground plate disposed inside of said case; and

external connecting means;

wherein said ground plate is provided with protuberant portions, and each of said protuberant portions is connected to the side of said dielectric resonator, through the surface portion of the protuberant portion which is smaller than the range of said dielectric resonator defined by the side edge thereof.

2. A dielectric filter according to claim 1, wherein at least one of said electrodes being a thin film multilayered electrode connected to said ground plate.

3. A dielectric filter according to claim 1, wherein said protuberant portion is provided with a hole, and said hole is smaller than and lies within the range of said protuberant portion defined by the side edge thereof.

4. A dielectric filter according to claim 3, wherein said hole has a shape provided with a cut.

5. A dielectric duplexer comprising at least two dielectric filters, input-output connecting means connected to the dielectric filters, respectively, and a

means for connection to an antenna, connected to said dielectric filters in common, wherein at least one of said dielectrid filters is a dielectric filter as defined in claim 1.

6. A communication device comprising a dielectric duplexer defined in claim 5, a transmitting circuit connected to at least one of input-output connecting means said dielectric duplexer, a receiving circuit connected to at least one of the input-output connecting means, different from said input-output connecting means connected to the transmitting circuit, and an antenna connected to an antenna connecting means of said dielectric duplexer.

7. A dielectric resonator comprising:

a dielectric block having at least one surface;

an electrode disposed on said surface;

a metal casing for surrounding said dielectric block;

a supporting portion protruding from one side of said metal casing toward the inside of said metal casing;

a conductive layer for connecting said surface of the dielectric block with said supporting portion, edges of said conductive layer being inside said one surface of said dielectric block;

an accessing element being disposed through an wall of said metal casing, said accessing element electromagnetically coupled with said dielectric block.

FIGURE 1

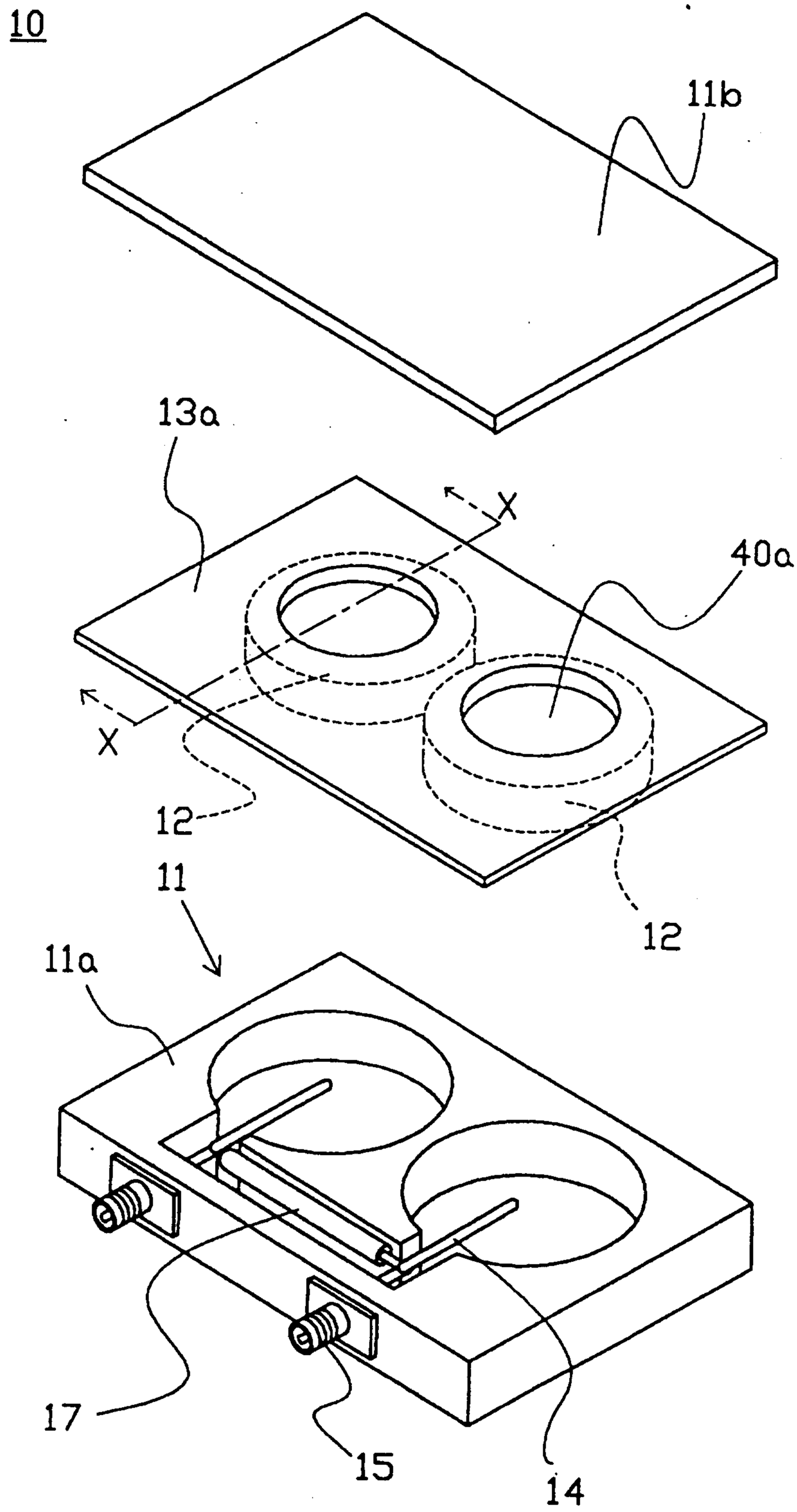


FIGURE 2

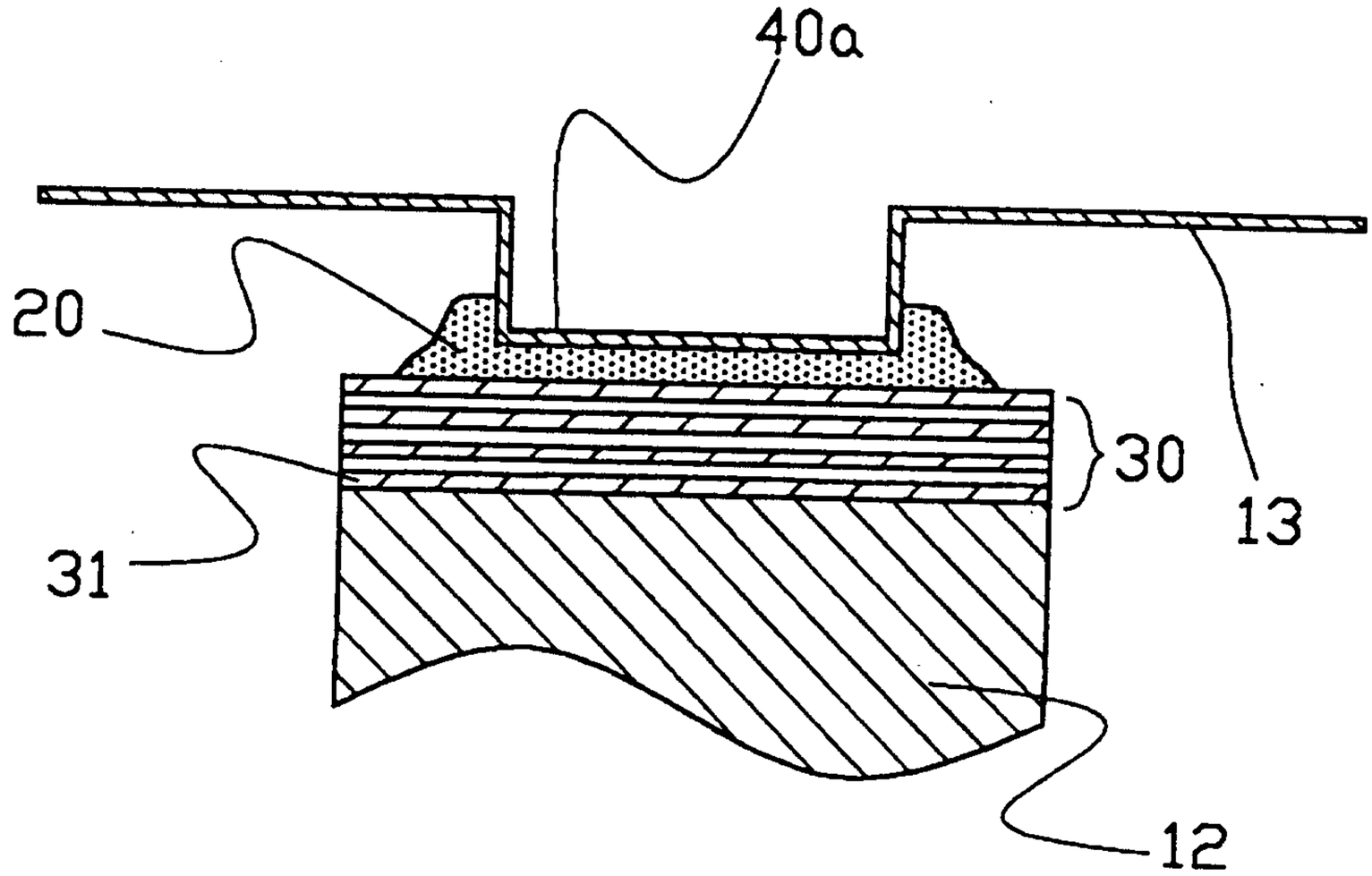



FIGURE 3

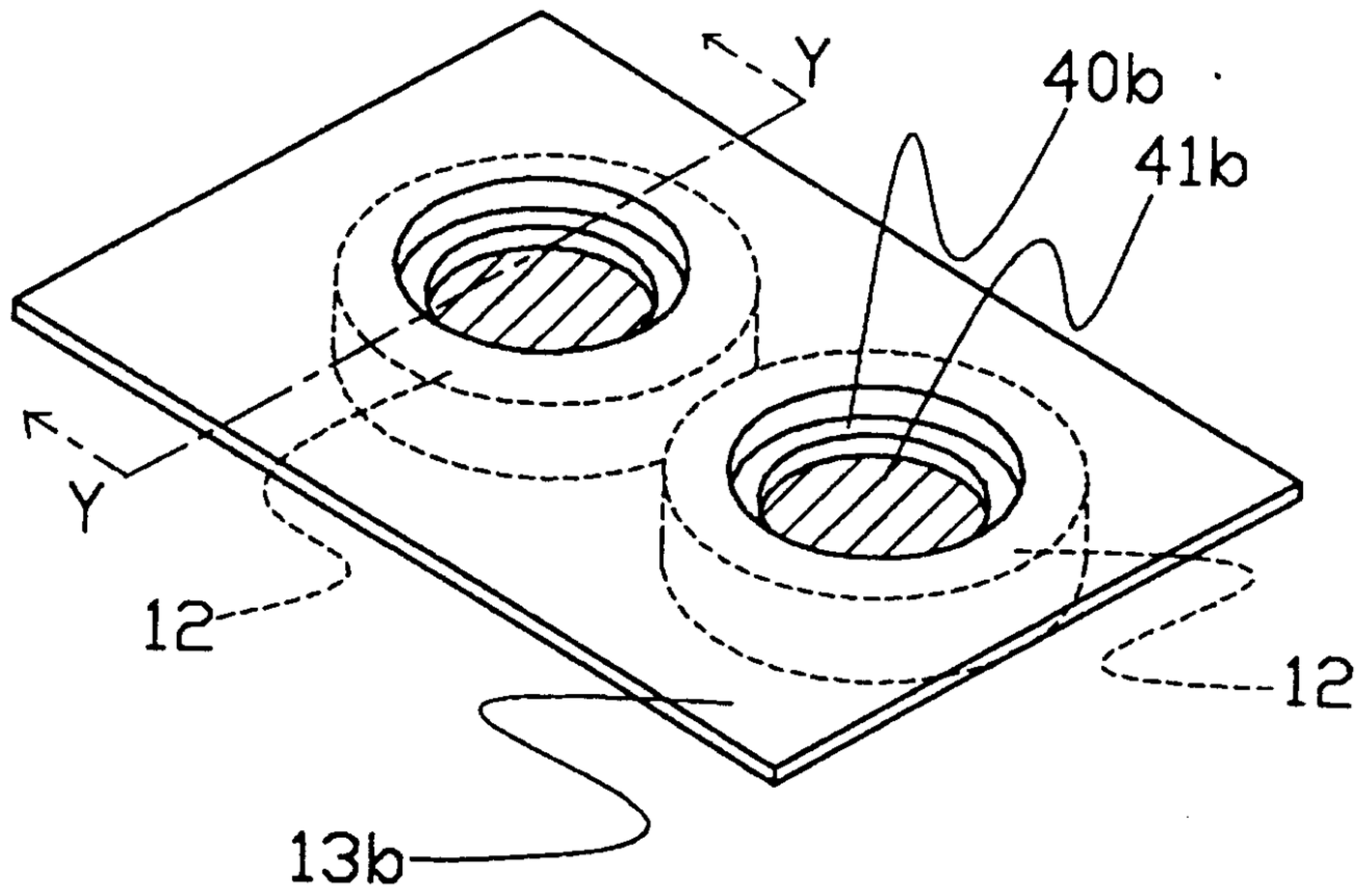


FIGURE 4

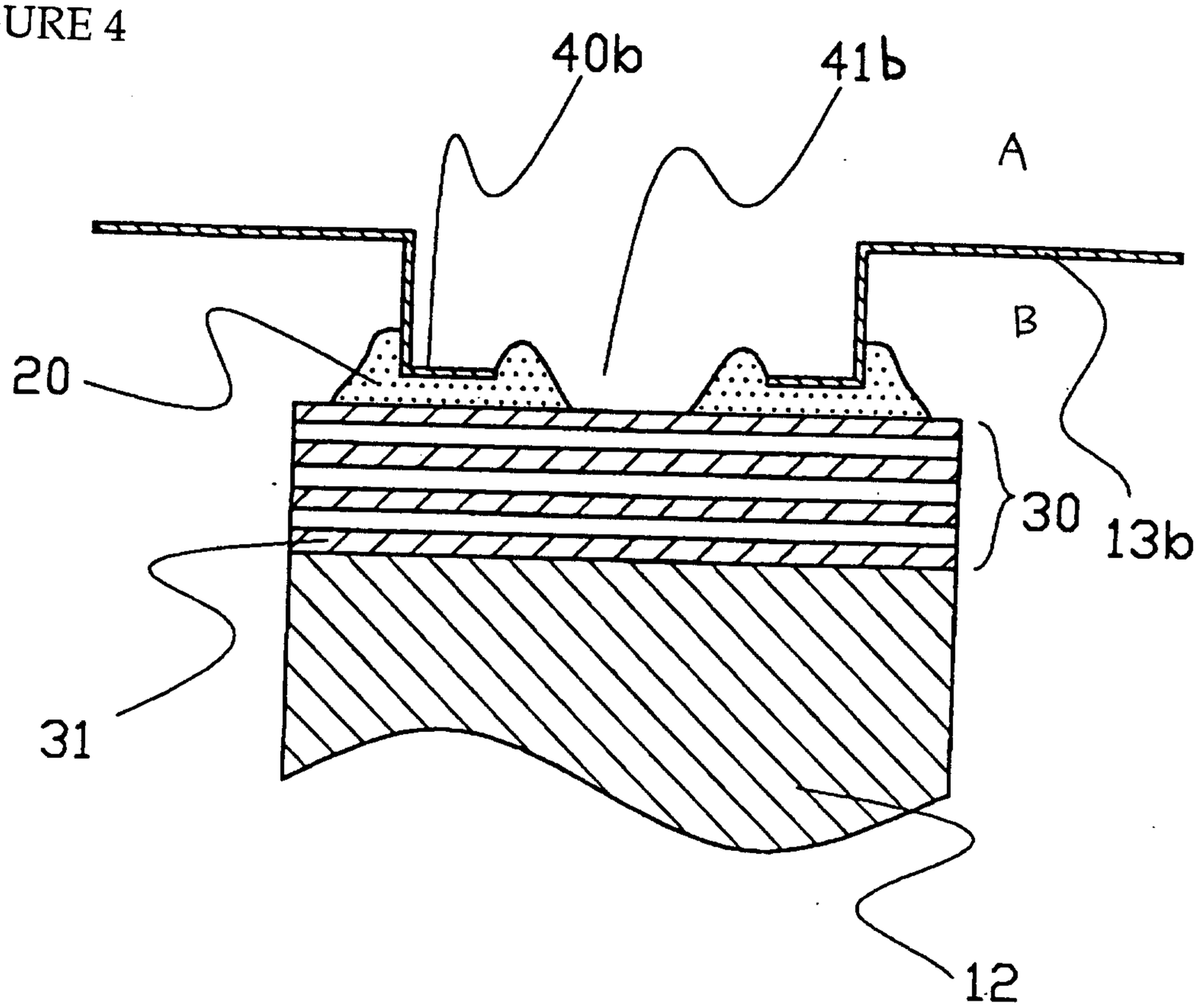



FIGURE 5

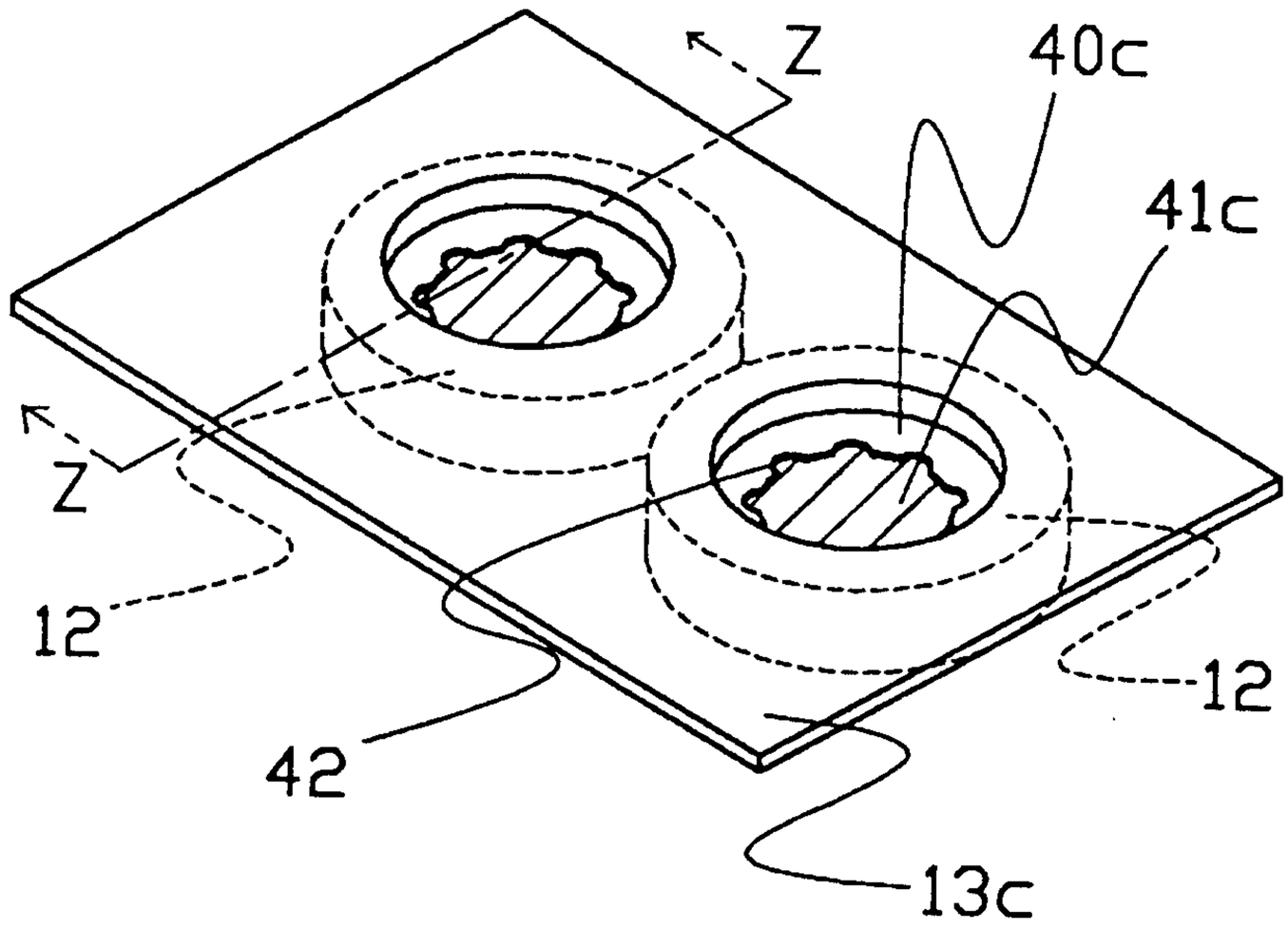


FIGURE 6

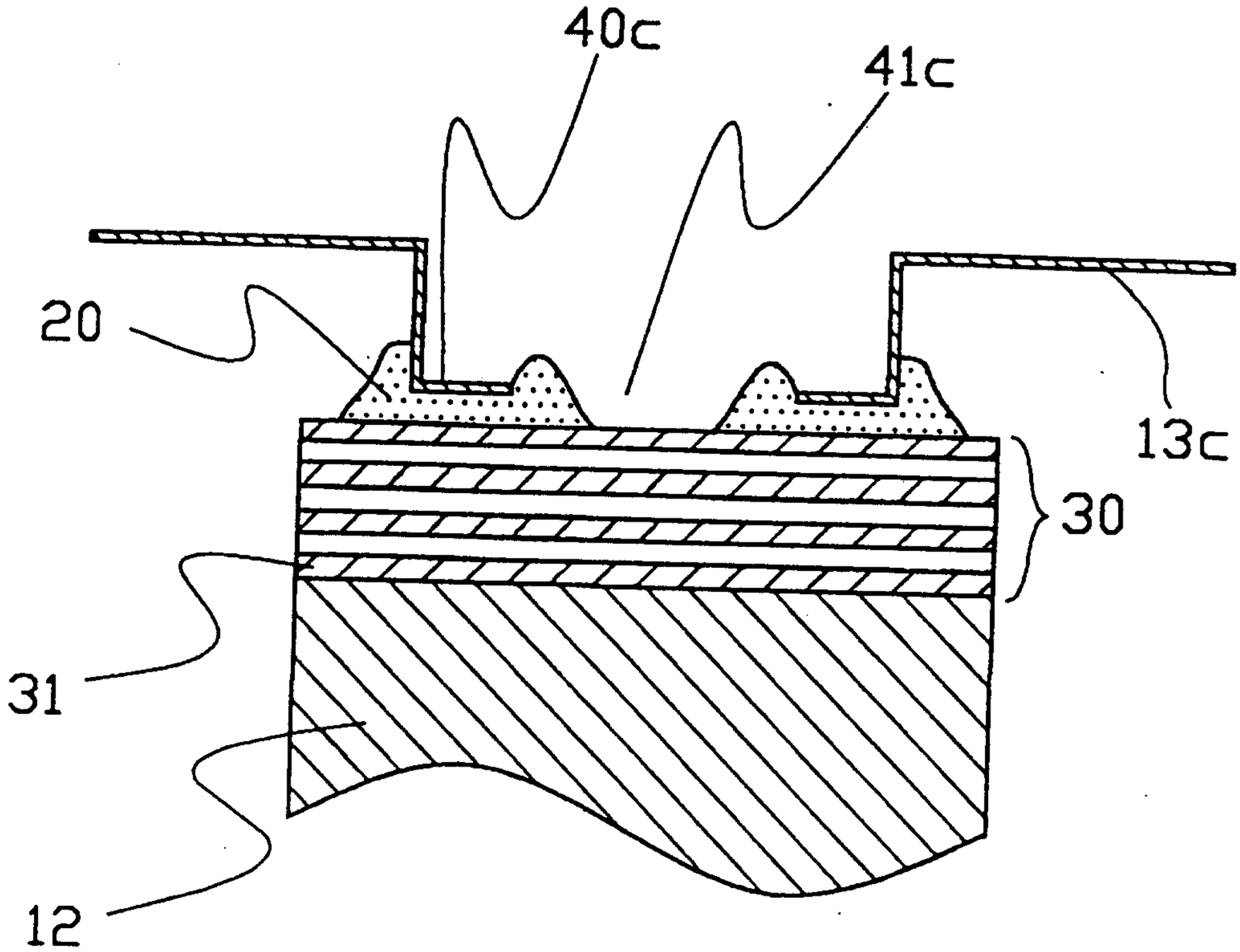
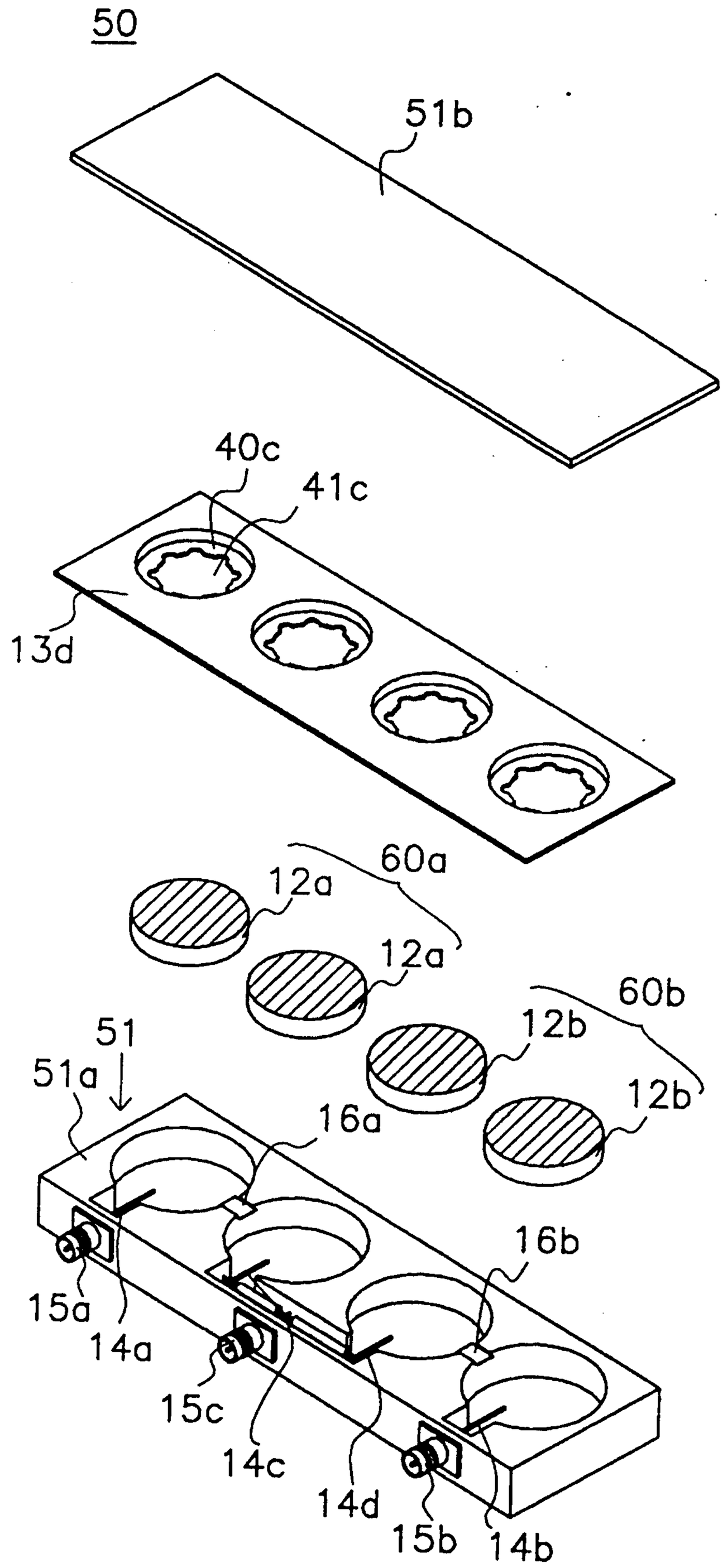


FIGURE 7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14b

FIGURE 8

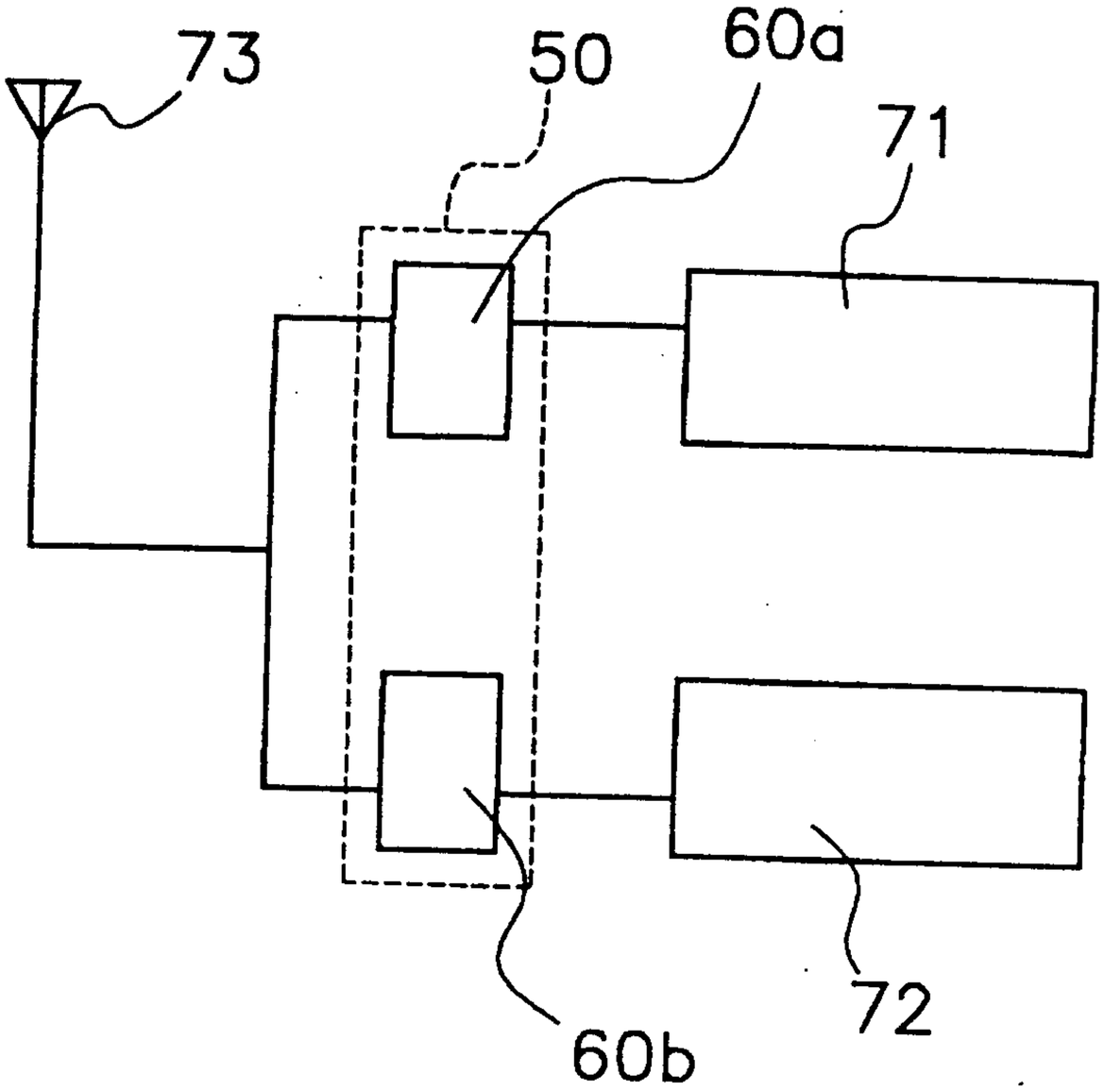

FIGURE 9

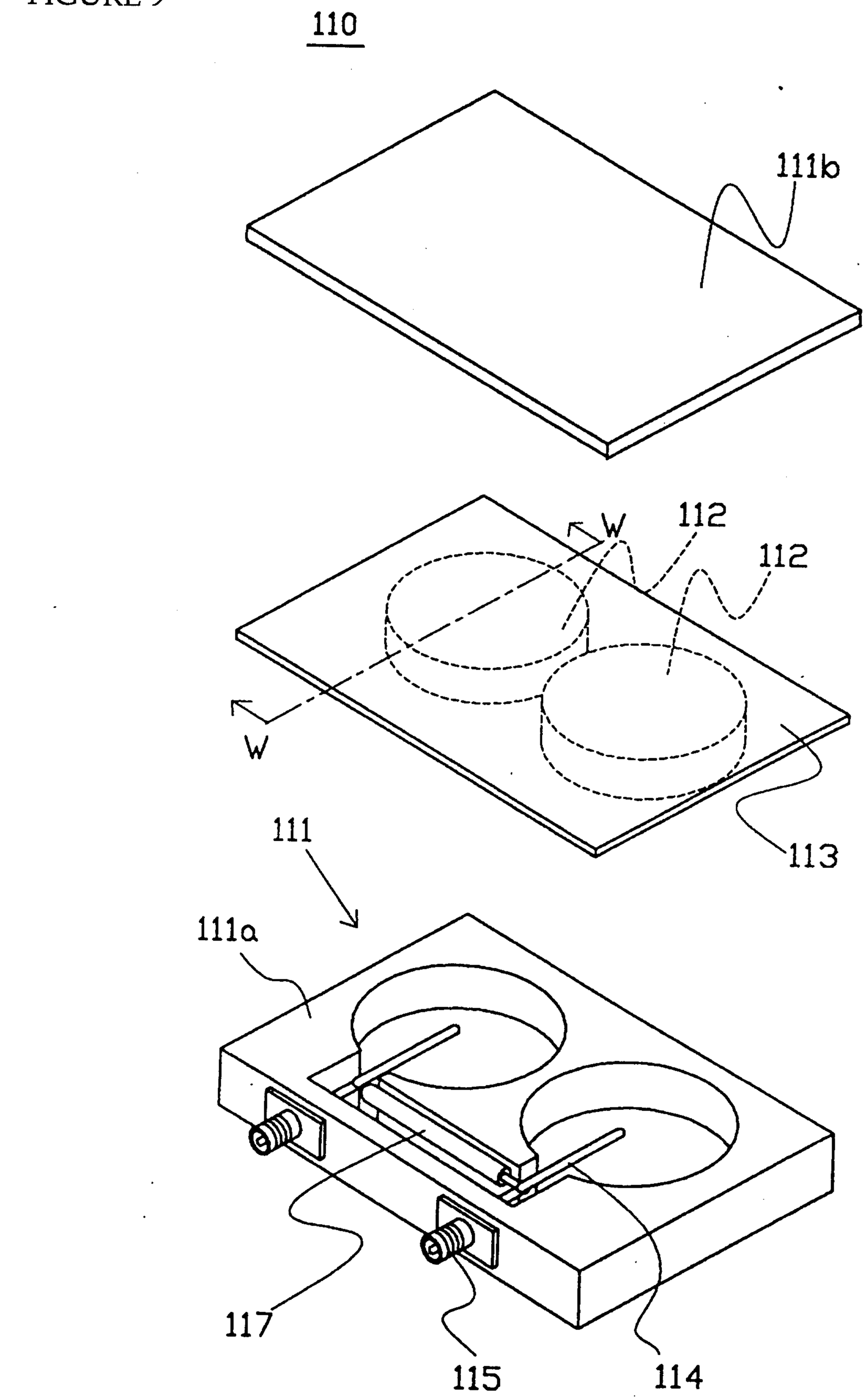

FIGURE 10