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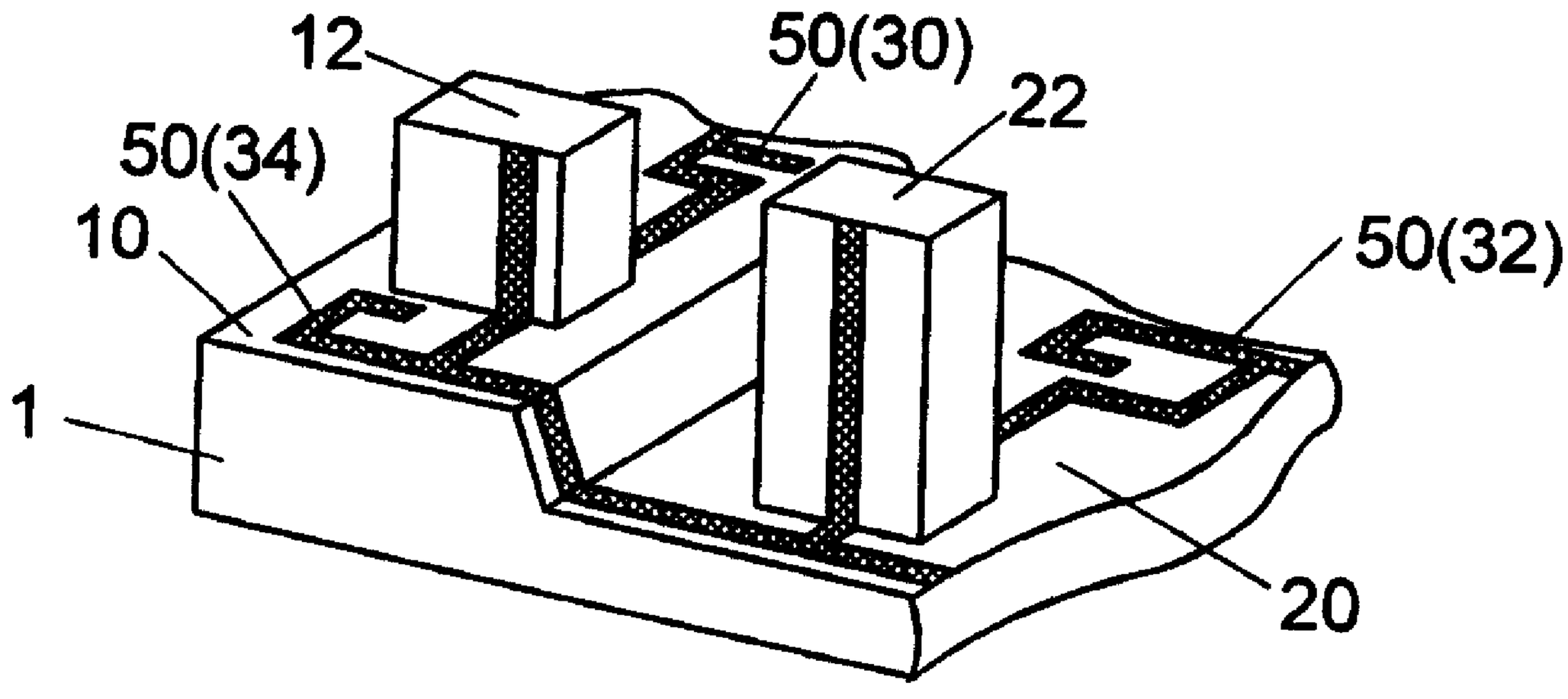
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(57) Abrégé/Abstract:
A method of efficiently manufacturing a printed wiring board is provided. In this method, a metal thin film is formed on a substrate having a projection. Then, an initial circuit pattern is formed on the substrate by patterning the metal thin film. The initial circuit pattern comprises first and second circuit patterns isolated from each other and a conductive layer formed on the projection to make a temporary electrical connection between the first and second circuit patterns. Electroplating is performed by the passage of electric current through the initial circuit pattern to form an additional metal film on the initial circuit pattern. After the electroplating, the conductive layer on the projection is removed to provide electrical insulation between the first and second circuit patterns.

ABSTRACT OF THE DISCLOSURE

A method of efficiently manufacturing a printed wiring board is provided. In this method, a metal thin film is formed on a substrate having a projection. Then, an initial circuit pattern is formed on the substrate by patterning the metal thin film. The initial circuit pattern comprises first and second circuit patterns isolated from each other and a conductive layer formed on the projection to make a temporary electrical connection between the first and second circuit patterns. Electroplating is performed by the passage of electric current through the initial circuit pattern to form an additional metal film on the initial circuit pattern. After the electroplating, the conductive layer on the projection is removed to provide electrical insulation between the first and second circuit patterns.

DESCRIPTION

METHOD OF MANUFACTURING PRINTED WIRING BOARD

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of manufacturing a printed wiring board comprising the step of efficiently forming a metal film by electroplating to provide a plurality of circuit patterns isolated from each other on a substrate.

2. Disclosure of the Prior Art

In a conventional method of manufacturing printed wiring boards, a metal thin film is first formed on a substrate, and required regions of the metal thin film are removed by using a laser beam to form patterns of the metal thin film on the substrate. Then, electroplating is performed to form an additional metal film on the patterns of the metal thin film, so that the circuit patterns having an increased thickness is obtained on the substrate.

However, when the patterns of the metal thin film on the substrate are electrically isolated from each other, the electroplating step becomes very complicated. For example, when a circuit pattern **30** is electrically insulated from the circuit pattern **32**, as shown in FIG. 20, it is required to individually perform electroplating with respect to each of these isolated circuit patterns to form addition metal films thereon. As a result, an increase in production cost is caused by an extension of time required for the electroplating step. In addition, a quality of the plating solution must be very often checked.

On the other hand, by providing a feeder circuit for electroplating to each of the isolated circuit patterns, it is possible to form the

additional films on the isolated circuit patterns at a time by electroplating. However, in this method, there is a limitation in manufacturing printed wiring boards with high-density circuit patterns. That is, as the density of circuit patterns is higher, a reliability of the circuit patterns formed by electroplating deteriorates.

To eliminate the above-described inconveniences, US Patent No. 5,494, 781 discloses an improved method of manufacturing a printed wiring board. According to this method, it is possible to simultaneously form the additional metal films on the isolated circuit patterns by electroplating without supplying electric current to the isolated circuit patterns through the feeder circuits.

That is, as shown in FIG. 21A, by pattering a metal thin film formed on the substrate, circuit patterns (**30P**, **32P**) isolated from each other and a conductive layer **40P** extending therebetween are provided on the substrate. After a resist film **90P** is formed on the conductive layer **40P**, electroplating is performed by the passage of electric current through the isolated circuit patterns (**30P**, **32P**) connected by the conductive layer **40P** to simultaneously form an additional metal film **50P** on these circuit patterns, as shown in FIG. 21B. At this time, since the conductive layer **40P** is covered with the resist film **90P**, the additional film **50P** is not formed on the conductive layer. After the electroplating, the resist film **90P** is removed to expose the conductive layer **40P**, and the conductive layer **40P** is removed by soft etching to make an electrical insulation between the isolated circuit patterns (**30P**, **32P**), as shown in FIG. 21C.

However, since the step of forming the resist film **90P** on the conductive layer **40P** is needed, it leads to an increase in production

cost. In particular, when forming a three-dimensional circuit pattern on a substrate for MID (molded interconnect device), or manufacturing a high-density printed wiring board, the difficulty of forming the resist film on the conductive layer comes into a problem. In addition, when the removal of the conductive layer **40P** after the electroplating is not enough, there is a fear that insulation failure occurs.

SUMMARY OF THE INVENTION

Therefore, a concern of the present invention is to provide a method of manufacturing a printed wiring board, which is characterized in that a metal film can be formed on the circuit patterns at a time by electroplating without the formation of a resist film on a conductive layer extending between circuit patterns isolated from each other, and after the electroplating the conductive layer can be easily removed with reliability to provide electrical insulation between the circuit patterns.

That is, the method of the present invention comprises the steps of:

providing a substrate with at least one of a projection and a concave;

forming a first circuit pattern on the substrate;

forming a second circuit pattern isolated from the first circuit pattern on the substrate;

wherein when the substrate has the projection, the method comprises the steps of:

forming a first conductive layer on the projection to make a temporary electrical connection between the first and second circuit patterns;

performing electroplating by the passage of electric current through the first and second circuit patterns connected by the

first conductive layer to simultaneously form a metal film on the first and second circuit patterns; and

after the electroplating, removing the first conductive layer on the projection to provide electrical insulation between the first and second circuit patterns;

wherein when the substrate has the concave, the method comprises the steps of:

covering the concave with a material different from the substrate to obtain a cover portion;

forming a second conductive layer on the cover portion to make a temporary electrical connection between the first and second circuit patterns;

performing electroplating by the passage of electric current through the first and second circuit patterns connected by the second conductive layer to simultaneously form a metal film on the first and second circuit patterns; and

after the electroplating, removing the second conductive layer on the cover portion to provide electrical insulation between the first and second circuit patterns.

It is preferred that substrate with at least one of the projection and the concave is formed by means of integral molding.

It is also preferred that the substrate has a plurality of projections, which are formed such that tops of the projections are substantially flush with each other.

To improve manufacturing efficiency, it is particularly preferred that the first circuit pattern, the second circuit pattern and the first conductive layer are provided at a time by patterning a metal thin film

formed on the substrate. Similarly, when the substrate has the concave, it is preferred that the first circuit pattern, the second circuit pattern and the second conductive layer are provided at a time by patterning a metal thin film formed on the substrate after the concave is covered with the material.

In addition, the present invention presents a method of more efficiently manufacturing the printed circuit board. That is, the method comprises:

forming a metal thin film on a substrate having a projection;

providing an initial circuit pattern on the substrate by patterning the metal thin film, the initial circuit pattern comprising first and second circuit patterns isolated from each other and a conductive layer formed on the projection to make a temporary electrical connection between the first and second circuit patterns;

performing electroplating by the passage of electric current through the initial circuit pattern to form an additional metal film on the initial circuit pattern; and

after the electroplating, removing the conductive layer on the projection to provide electrical insulation between the first and second circuit patterns.

In particular, when it is required to form three-dimensional circuit patterns on a substrate for MID or manufacture a high-density printed wiring board, it is preferred to use the following method of manufacturing a printed wiring board.

That is the method of the present invention comprises the steps of:

providing a substrate with a first surface having a first projection and a second surface extending at a different level from the first

surface and having a second projection thereon;

forming a first circuit pattern on the first surface;

forming a second circuit pattern isolated from the first circuit pattern on the second surface;

forming a third circuit pattern isolated from the first and second circuit patterns so as to extend from the first surface to the second surface;

forming a first conductive layer on the first projection to make a temporary electrical connection between the first and third circuit patterns;

forming a second conductive layer on the second projection to make a temporary electrical connection between the second and third circuit patterns;

performing electroplating by the passage of electric current through the first, second and third circuit patterns connected by the first and second conductive layers to simultaneously form a metal film on the first, second and third circuit patterns; and

after the electroplating, removing the first and second conductive layers on the first and second projections to provide electrical insulation among the first, second and third circuit patterns.

In the above method, it is preferred that the first and second projections are formed that a top of the first projection is substantially flush with the top of the second projection, and the first and second conductive layers on the first and second projections are removed at a time.

Another concern of the present invention is to provide a substrate used in the method of the present invention, and having at

least one of a projection and a concave, which is adapted to form a conductive layer for making a temporary electrical connection between circuit patterns isolated from each other on the substrate, in order to simultaneously form a metal film on the circuit patterns connected by the conductive layer by electroplating.

In particular, it is preferred that the substrate is provided with a first surface having a first projection and a second surface extending at a different level from the first surface and having a second projection formed such that a top of the first projection is substantially flush with the top of the second projection, and wherein each of the first and second projections is adapted to form a conductive layer for making a temporary electrical connection between circuit patterns isolated from each other on the substrate, in order to simultaneously form a metal film on the circuit patterns connected by the connective layer by electroplating.

In another aspect, the invention provides a substrate having at least one of a projection and a concave, which is used in a method of producing a printed wiring board comprising the steps of forming a first circuit pattern on the substrate, forming a second circuit pattern isolated from the first circuit pattern on the substrate, wherein when the substrate has the projection, the method comprises the steps of forming a first conductive layer on the projection to make a temporary electrical connection between the first and second circuit patterns, performing electroplating by the passage of electric current through the first and second circuit patterns connected by the first conductive layer to simultaneously form a metal film on the first and second circuit patterns, and after the electroplating, removing the first conductive layer on the projection to provide electrical insulation between the first and second circuit patterns, wherein when the

substrate has the concave, the method comprises the steps of covering the concave with a material different from the substrate to obtain a cover portion, forming a second conductive layer on the cover portion to make a temporary electrical connection between the first and second circuit patterns, performing electroplating by the passage of electric current through the first and second circuit patterns connected by the second conductive layer to simultaneously form a metal film on the first and second circuit patterns, and after the electroplating, removing the second conductive layer on the cover portion to provide electrical insulation between the first and second circuit patterns.

In another aspect, the invention provides a substrate comprising a first surface having a first projection and a second surface extending at a different level from the first surface and having a second projection formed such that a top of the first projection is substantially flush with the top of the second projection, which is used in a method of producing a printed wiring board comprising the steps of forming a first circuit pattern on the first surface, forming a second circuit pattern isolated from the first circuit pattern on the second surface, forming a third circuit pattern isolated from the first and second circuit patterns so as to extend from the first surface to the second surface, forming a first conductive layer on the first projection to make a temporary electrical connection between the first and third circuit patterns, forming a second conductive layer on the second projection to make a temporary electrical connection between the second and third circuit patterns, performing electroplating by the passage of electric current through the first, second and third circuit patterns connected by the first and second conductive layers to simultaneously form a metal film on the first, second and third circuit patterns, and after

the electroplating, removing the first and second conductive layers on the first and second projections to provide electrical insulation among the first, second and third circuit patterns.

In another aspect, the invention provides a printed wiring board obtained by a method comprising the steps of providing a substrate with at least one of a projection and a concave, forming a first circuit pattern on the substrate, forming a second circuit pattern isolated from the first circuit pattern on the substrate, wherein when the substrate has the projection, the method comprises the steps of forming a first conductive layer on the projection to make a temporary electrical connection between the first and second circuit patterns, performing electroplating by the passage of electric current through the first and second circuit patterns connected by the first conductive layer to simultaneously form a metal film on the first and second circuit patterns, and after the electroplating, removing the first conductive layer on the projection to provide electrical insulation between the first and second circuit patterns, wherein when the substrate has the concave, the method comprises the steps of covering the concave with a material different from the substrate to obtain a cover portion, forming a second conductive layer on the cover portion to make a temporary electrical connection between the first and second circuit patterns, performing electroplating by the passage of electric current through the first and second circuit patterns connected by the second conductive layer to simultaneously form a metal film on the first and second circuit patterns, and after the electroplating, removing the second conductive layer on the cover portion to provide electrical insulation between the first and second circuit patterns.

These and still other objects and advantages of the present invention will become more apparent from preferred embodiments of the present invention explained in detail below, referring to the attached drawings.

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BRIEF EXPLANATION OF THE DRAWINGS

FIGS. 1A and 1B are schematic perspective and cross-sectional views of a substrate used in a method of manufacturing a printed wiring board according to a first embodiment of the present invention;

FIGS. 2A to 2D are schematic perspective views showing the method according to the first embodiment of the present invention;

FIGS. 3A to 3C are schematic cross-sectional views showing a step of removing a conductive layer by chemical etching in the method of the first embodiment;

FIGS. 4A to 4C are schematic perspective views of patterns of the conductive layer formed on a projection of the substrate;

FIGS. 5A and 5B are schematic perspective views showing a step of cutting the projection having the conductive layer at notches;

FIGS. 6A and 6B are schematic perspective views showing a step of peeling off the projection having the conductive layer from the substrate;

FIGS. 7A to 7G show a variety of notch shapes formed in the conductive layer;

FIGS. 8A and 8B are perspective views showing a modification of the step of cutting the projection having the conductive layer;

FIGS. 9A and 9B are perspective views showing another modification of the step of cutting the projection having the conductive layer;

FIGS. 10A and 10B are perspective views showing another modification of the step of cutting the projection having the conductive layer;

FIGS. 11A and11B are perspective views showing another modification of the step of cutting the projection having the conductive layer;

FIGS. 12A and 12B are schematic cross-sectional views showing a method of manufacturing a printed wiring board according to a second embodiment of the present invention;

FIGS. 13A and 13B are schematic perspective and cross-sectional

views of a substrate used in a method of manufacturing a printed wiring board according to a third embodiment of the present invention;

FIGS. 14A to 14D are schematic perspective views showing the method according to the third embodiment of the present invention;

FIG. 15 shows a modification of the step of removing the conductive layer in the method of the third embodiment;

FIG. 16 is a cross-sectional view showing a further modification of the step of removing the conductive layer in the method of the third embodiment;

FIG. 17 shows a step of peeling off a cover portion with a conductive layer from a concave in the method of the third embodiment;

FIG. 18 shows a step of removing a conductive layer with notches from a concave in the method of the third embodiment;

FIG. 19 shows a modification of the step of removing the conductive layer in the method of the third embodiment;

FIG. 20 is a perspective view of a printed wiring board with circuit patterns isolated from each other; and

FIGS. 21A to 21C are schematic perspective views showing a method of manufacturing a printed wiring board disclosed in US Patent No. 5,494,781.

PREFERRED EMBODIMENTS OF THE INVENTION

A method of manufacturing a printed wiring board of the present invention is explained in detail below according to preferred embodiments.

(First Embodiment)

A substrate used in the first embodiment is shown in FIG. 1A. The substrate **1** is provided with a first surface **10** having a first

projection **12**, a second surface **20** having a second projection **22**, and an oblique surface **14** extending between the first and second surfaces. Therefore, the second surface extends at a different level from the first surface. As shown in FIG. 1B, heights of the first and second projections (**12**, **22**) are determined such that a top of the first projection **12** is substantially flush with the top of the second projection **22**. It is preferred that those projections are integrally formed with the substrate **1** by means of injection molding.

As shown in FIG. 2A, first and second circuit patterns (**30**, **32**) isolated from each other are respectively formed on the first and second surfaces (**10**, **20**) of the substrate **1**. In addition, a third circuit pattern **34** isolated from the first and second circuit patterns (**30**, **32**) is formed to extend from the first surface **10** to the second surface **20** through the oblique surface **14**. Then, as shown in FIG. 2B, a first conductive layer **40** is formed on the first projection **12** to make a temporary electrical connection between the first and third circuit patterns (**30**, **34**), and similarly a second conductive layer **42** is formed on the second projection **22** to make a temporary electrical connection between the second and third circuit patterns (**32**, **34**). The first and second conductive layers (**40**, **42**) are used only in a step of electroplating described below.

Next, as shown in FIG. 2C, electroplating such as copper electroplating is performed by the passage of electric current through the first, second and third circuit patterns (**30**, **32**, **34**) connected by the first and second conductive layers (**40**, **42**) to simultaneously form an additional metal (copper) film **50** having a desired thickness on those circuit patterns. For example, when the electric current is supplied to

the third circuit pattern **34**, it flows to the first circuit pattern **30** through the first conductive layer **40** on the first projection **12**, and at the same time flows to the second circuit pattern **32** through the second conductive layer **42** on the second projection **22**,

After the electroplating, the additional metal film **50** and the first and second conductive layers (**40**, **42**) on the first and second projections (**12**, **22**) are removed to provide electrical insulation among the first, second and third circuit patterns (**30**, **32**, **34**), as shown in FIG. 2D.

For example, it is preferred to remove those conductive layers (**40**, **42**) and the additional metal film **50** by means of chemical etching. In this case, there is an advantage of preventing the occurrence of mechanical damages to the substrate **1** or the circuit patterns (**30**, **32**, **34**). In particular, as shown in FIGS. 3A to 3C, when the top of the first projection **12** is substantially flush with the top of the second projection **22**, it is possible to simultaneously remove the conductive layers (**40**, **42**) by dipping only the tops of those projections (**12**, **22**) in an etching solution **80**. This presents further improvement in the manufacturing efficiency.

Alternatively, those conductive layers (**40**, **42**) and the additional metal film **50** may be mechanically removed by grinding or cutting. For example, when removing the respective conductive layer (**40**, **42**) together with at least a part of the corresponding projection (**12**, **22**) from the substrate **1**, there is an advantage of providing the electrical insulation between the circuit patterns with reliability without short circuit resulting from a residue of the conductive layer on the top of the projection. In addition, when the top of the first projection **12** is

substantially flush with the top of the second projection **22**, the conductive layers (**12**, **22**) can be removed at a time by cutting the projections at a constant cutting depth with a grinding wheel. Therefore, the working efficiency is remarkably improved, as compared with the case of individually determining an optimum cutting depth of the grinding wheel with respect to each of the projections.

In the above method, to improve manufacturing efficiency, it is particularly preferred that the formation of the first, second and third circuit patterns (**30**, **32**, **34**) and the formation of the first and second conductive layers (**40**, **42**) are performed at a time. That is, a metal thin film is formed first on the substrate **1** having first and second projection (**12**, **22**). Then an initial circuit pattern is formed on the substrate by patterning the metal thin film. The initial circuit pattern comprising the first, second and third circuit patterns (**30**, **32**, **34**) isolated from each other, the first conductive layer **40** formed on the projection **12** to make the electrical connection between the first and third circuit patterns (**30**, **34**) and the second conductive layer **42** formed on the projection **22** to make the electrical connection between the second and third circuit patterns (**32**, **34**). Subsequently, electroplating is performed by the passage of electric current through the initial circuit pattern to form an additional metal film **50** on the initial circuit pattern. After the electroplating, the conductive layers (**40**, **42**) on the projections are removed to provide electrical insulation among those circuit patterns. As the patterning method, it is preferred that required regions of the metal thin film are removed by irradiating a laser beam along a predetermined pattern. According to this method, it is possible to efficiently form a high-density pattern of the metal thin

film with accuracy.

In this embodiment, as shown in FIG. 2A, the first, second and third circuit patterns (**30**, **32**, **34**) are formed on the substrate **1**. However, if necessary, an additional circuit pattern(s) may be formed on the substrate. When forming such an additional circuit pattern, the substrate may have at least one surface that extends at a different level from the first and second surfaces. In this case, it is preferred that additional projections are formed on the surfaces other than the first and second surfaces (**10**, **20**) so as to be substantially flush with the first and second projections (**12**, **22**).

If necessary, a plurality of conductive layers **40** may be formed on a single projection **12**, as shown in FIGS. 4A to 4C. In this case, it is possible to increase a degree of flexibility in circuit design by reducing a total number of projections to be formed on the substrate **1**. Therefore, these are particularly effective to manufacture a high-density printed wiring board. In addition, there is an advantage that the conductive layers can be efficiently removed after the electroplating.

In place of the substrate **1** with the projections (**12**, **22**) formed by integral molding, those projections may be formed at required positions on a substrate by means of secondary molding. When the projection is made from a resin material different from the substrate material, the projection having the conductive layer thereon can be easily removed from the substrate by use of a tool and so on. In this case, the electrical insulation between the circuit patterns can be provided with reliability. In addition, since the occurrence of residual flash and chips of the resin material is prevented, there is an advantage of simplifying a subsequent cleaning step. As the

secondary molding, for example, it is preferred to use a dispense system for supplying a resin from a needle nozzle by air pressure, or an ink-jet system for spraying the resin at a required area.

As another method of removing the projection formed by the secondary molding from the substrate, it is possible to give shocks or vibrations to the projection, or blast a fluid such as water or air on the projection under high speed and high pressure. In addition, when the projection is made from a resin material having a coefficient of thermal expansion much different from the substrate material, it is possible to peel off the projection with the conductive layer from the substrate by alternately blowing hot and cold airs on the projection. To facilitate the easiness of peeling off the projection from the substrate, it is preferred to provide a layer of a release agent such as polyethylene, silicone resin or the like between the substrate and the projection.

As a modification of the present embodiment, it is preferred to form notches at required positions of the conductive layer to improve the easiness of removing the conductive layer by cutting or grinding, and minimize the occurrence of residual flash at the cutting sections. For example, when the conductive layer **40** extends through opposite side walls and the top of the projection **12** in a straight direction, as shown in FIG. 5A, it is preferred to form a narrow width region **41** of the conductive layer on each of the side walls of the projection **12**. In this case, as shown in FIG. 5B, an upper portion of the projection **12** with the conductive layer **40** is cut horizontally at a height of the narrow-width region **41** of the conductive layer by a grinding wheel **82**. Alternatively, narrow-width regions **41** may be formed in the conductive layer **40** on the substrate **1** at the opposite sides of the projections **12**,

as shown in FIG. 6A. In this case, by peeling off the projection **12** with the conductive layer **40** from the substrate **1** with use of a tool **84**, as shown in FIG. 6B, the conductive layer **40** can be easily cut at the narrow-width regions **41**. Another notch shapes preferable in the present invention are also shown in FIGS. 7A to 7G.

In the step of cutting the projection with the conductive layer, to prevent the occurrence of residual flash or peeling at the cutting sections, it is preferred to remove the first conductive layer together with a part of the projection by allowing a cutting or grinding tool to cut into a side surface having the first conductive layer of the projection such that an edge of the cutting or grinding tool presses the first conductive layer against the side surface of the projection, and allowing the cutting or grinding tool to pass through the projection in a direction from the side surface having the first conductive layer of the projection to another side surface not having the first conductive layer of the projection. For example, when the conductive layer **40** is formed on adjacent side walls of the projection **12** by changing the direction of the conductive layer at a required angle (θ) on the top of the projection, as shown in FIG. 8A, it is preferred to cut the projection **12** by allowing the grinding wheel **82** to pass through the projection in a direction from an edge between the adjacent side walls having the conductive layers to an opposite edge between adjacent side walls not having the conductive layers, to thereby provide electrical insulation between the circuit patterns, as shown in FIG. 8B. Alternatively, when the conductive layer **40** is formed on a side surface of the projection **12** in a U-turn manner without the formation of the conductive layer on the top of the projection, as shown in FIG. 9A, it is preferred to cut the

projection by allowing the grinding wheel **82** to pass through the projection from the side wall with the conductive layer to the opposite side wall with no conductive layer, to thereby provide electrical insulation between the circuit patterns, as shown in FIG. 9B.

On the other hand, when the upper portion of the projection **12** is cut by allowing the grinding wheel **82** to pass through the projection in a direction substantially equal to the direction of the conductive layer **40**, as shown in FIG. 10A, there is a fear that peeling **70** of the conductive layer **40** occurs at a side surface of the projection from which the grinding wheel **82** comes out, as shown in FIG. 10B. In addition, when the upper portion of the projection **12** is cut by allowing the grinding wheel **82** to pass through the projection in a direction substantially rectangular to the direction of the conductive layer, as shown in FIG. 11A, there is a fear that residual flash **71** of the conductive layer left on the projection occurs at the cutting section, as shown in FIG. 11B.

In the case of FIG. 8A, an angle (θ) between the traveling direction of the grinding wheel **82** and the direction of the conductive layer **40** is approximately 45°. To effectively prevent the occurrence of the residual flash and peeling at the cutting sections, it is preferred that the angle (θ) is within a range of $0 < (\theta) \leq 80°$, and more preferably $0 < (\theta) \leq 60°$. In the case of FIG. 9A, the traveling direction of the grinding wheel **82** is substantially equal to the direction of the conductive layer **40**. However, since the conductive layer **40** having the U-turn shape is formed on the side surface of the projection **12**, and no conductive layer is formed on the opposite side surface of the projection from which the grinding wheel **82** comes out, there is no

worry about the occurrence of peeling **70** of the conductive layer **40** left on the projection.

(Second Embodiment)

In this embodiment, as shown in FIG. 12A, a top surface of the substrate **1** is used to form first and second circuit patterns (**30**, **32**) isolated from each other. The substrate **1** has a projection **12** on its bottom surface. In addition, a conductive layer **40** is formed on the bottom surface of the substrate **1** through the projection **12**. The first circuit pattern **30** is electrically connected to the conductive layer **40** on the bottom surface of the substrate by a conductive pin **52** passing through the substrate **1**. Similarly, the second circuit pattern **32** is electrically connected to the conductive layer **40** on the bottom surface of the substrate by a conductive pin **54** passing through the substrate **1**. Therefore, by use of the conductive pins (**52**, **54**) and the conductive layer **40** extending between the pins through the projection **12**, a temporary electrical connection between the first circuit pattern **30** and the second circuit pattern **32** is obtained. In place of the conductive pin, a plated through-hole may be used.

Subsequently, electroplating such as copper electroplating is performed by the passage of electric current through the first and second circuit patterns (**30**, **32**) connected by the conductive pins (**52**, **54**) and the conductive layer **40** to simultaneously form an additional metal (copper) film (not shown) having a desired thickness on these circuit patterns on the top of the substrate **1**. After the electroplating, the conductive layer **40** on the projection **12** is removed to provide electrical insulation between the first and second circuit patterns (**30**, **32**), as shown in FIG. 12B.

In this case, since the circuit patterns (**30**, **32**) can be designed on the top surface of the substrate **1** without consideration of a space required to form the projection **12**, a degree of flexibility in circuit design can be remarkably improved. Therefore, this embodiment is particularly effective to form high density circuit patterns. In addition, there is an advantage that an operation of mounting electronic parts on the top surface of the substrate **1** is not hindered by the presence of projection **12**. Moreover, in the step of mechanically removing the conductive layer **40** on the projection **12** on the bottom surface of the substrate **1** by use of cutting tool such as the grinding wheel **82**, it is possible to minimize the occurrence of damages to the circuit patterns (**30**, **32**) on the top surface of the substrate **1**. This presents an improvement in production yields.

(Third Embodiment)

As shown in FIGS. 13A and 13B, a substrate **1** used in the third embodiment has a concave **13** in its top surface. It is preferred that the concave **13** is integrally formed with the substrate **1** by means of injection molding. As in the case of the first embodiment, the substrate **1** is provided with a first surface **10**, a second surface **20**, and an oblique surface extending between the first and second surfaces. Therefore, the second surface **20** extends at a different level from the first surface **10**. The concave **13** is covered with a material different from the substrate **1** to obtain a cover portion **15**, as shown in FIG. 14A. For example, the cover portion **15** can be obtained by building a bridge over the concave **13** with use of a film of **60** an electrical insulating material. Alternatively, the cover portion **15** may be formed by filling an electrical insulating material **62** in the concave **13** such that a top

surface of the cover portion is substantially flush with the top surface of the substrate around the cover portion, as shown in FIG. 15.

In addition, on the top surface of the substrate **1**, first, second and third circuit patterns (**30**, **32**, **34**) isolated from each other are formed, as shown in FIG. 14A. As shown in FIG. 14B, conductive layers **40**, **42** are formed on the cover portions **15** to make temporary electrical connections between the first and third circuit patterns (**30**, **34**) and between the second and third circuit patterns (**32**, **34**), respectively. The conductive layers **40**, **42** are used only in the step of electroplating described below.

Next, as shown in FIG. 14C, electroplating such as copper electroplating is performed by the passage of electric current through the first, second and third circuit patterns (**30**, **32**, **34**) connected by the conductive layers **40**, **42** to simultaneously form an additional metal film **50** on those circuit patterns. For example, when the electric current is supplied to the third circuit pattern **34**, it flows to the first circuit pattern **30** through the conductive layer **40** on the cover portion **15**, and at the same time flows to the second circuit pattern **32** through the conductive layer **42** on the cover portion **15.** As described above, by removing the conductive layers **40**, **42** on the cover portions **15** after the electroplating, the electrical insulation among the first, second and third circuit patterns (**30**, **32**, **34**) with the additional metal film **50** is obtained. In FIG. 14D, the insulation films **60** having the conductive layers (**40**, **42**) are removed from the concaves **13**.

To remove the conductive layers **40**, **42**, for example, it is possible to use grinding or cutting. In this case, it is preferred to remove the conductive layer (**40**, **42**) together with at least a part of the

cover portion **15** from the substrate **1**. There is an advantage of preventing short circuit resulting from a residue of the conductive layer (**40**, **42**) on the cover portion **15** with reliability. Alternatively, the conductive layer (**40**, **42**) may be removed together with the part of the cover portion by drilling. In the case of forming the cover portion **15** with use of the electrically insulating film **60**, as shown in FIG. 14A, since there is an air space under the insulation film **60** in the concave **13**, it is possible to easily provide the electrical insulation between the circuit patterns by punching the conductive layer **40** on the insulation film **60** with use of a punching machine **86**, as shown in FIG. 16. In addition, when simultaneously punching a plurality of the conductive layers (**40**, **42**) with the punching machine **86**, it is possible to efficiently obtain the electrical insulation among the circuit patterns.

In the above method, to improve manufacturing efficiency, it is particularly preferred that the formation of the first, second and third circuit patterns (**30**, **32**, **34**) and the formation of the conductive layers (**40**, **42**) are performed at a time. That is, after the concave **13** is covered with a material different from the substrate **1** to obtain a cover portion **15**, a metal thin film is formed on the substrate **1**. Then, an initial circuit pattern is formed on the substrate by patterning the metal thin film. The initial circuit pattern comprises the first, second and the third circuit patterns (**30**, **32**, **34**) isolated from each other, and the conductive layers (**40**, **42**) formed on the cover portions **15** to make temporary electrical connections between the first and third circuit patterns (**30**, **34**) and between the second and third circuit patterns (**32**, **34**), respectively. Subsequently, electroplating is performed by the passage of electric current through the initial circuit pattern to form an

additional metal film **50** on the initial circuit pattern. After the electroplating, the conductive layers (**40**, **42**) on the cover portions **15** are removed to provide electrical insulation among the first, second and third circuit patterns (**30**, **32**, **34**) with the additional metal films **50**. As the patterning method, it is preferred that required regions of the metal thin film are removed by irradiating a laser beam along a predetermined pattern. According to this method, it is possible to efficiently form a high-density pattern of the metal thin film with accuracy.

If necessary, a plurality of conductive layers may be formed on a single cover portion. In this case, it is possible to increase a degree of flexibility in circuit design by reducing a total number of concaves to be formed in the substrate. In addition, there is an advantage of efficiently performing the step of removing the conductive layers after the electroplating.

As a modification of the present embodiment, as shown in FIG. 17, the cover portion **15** may be formed by use of an electrical insulating resin **62** such that a dome-like projection **17** of the insulating resin is formed above the concave **13**, and an air space in the concave is maintained under the dome-like projection **17**. The conductive layer **40** is formed on the dome-like projection **17**. Due to a reduced contact area between the dome-like projection **17** and the substrate **1**, the dome-like projection **17** with the conductive layer **40** can be easily peeled off from the substrate **1** by applying a small external force to the dome-like projection.

In addition, as shown in FIG.18, it is preferred that the conductive layer **40** extending on the cover portion **15** has notches **41**

at opposite ends of the cover portion in a direction of the conductive layer. In this case, a region of the conductive layer **40** between the notches **41** is removed to provide electrical insulation between the first and second circuit patterns. The formation of these notches **41** is effective to prevent the occurrence of residual flash or peeling of the conductive layer **40** left on the substrate **1**.

In the case of forming the cover portion **15** by filling the electrical insulating material **62** in the concave **13**, it is preferred to leave air spaces **19** at the opposite sides of the cover portion **15** in the concave **13**, as shown in FIG. 19. A used amount of the electrical insulating material **62** can be saved. For example, by removing the conductive layer **40** with a part of the cover portion **15** by use of a cutting tool, the electrical insulation between the circuit patterns is provided. Alternatively, the cover portion **15** with the conductive layer may be peeled off from the concave **13** by use of a tool inserted into the air space(s) **19**.

In the case of requiring a plurality of cover portions, the cover portions may be formed by means of secondary molding. In this case, it is possible to fill the electrical insulation material in required concaves at a time. As the secondary molding, for example, it is preferred to use a dispense system for supplying a resin from a needle nozzle by air pressure, or an ink-jet system for spraying the resin at a required area. When the cover portion is formed by use of a resin material different from the substrate material, the cover portion with the conductive layer can be easily peeled off from the concave by use of a tool and so on. When the cover portion has a hook to which a tool can be readily engaged, the step of peeling off the cover portion from

the concave is further facilitated. In addition, since the occurrence of residual flash and chips of the resin material is prevented, there is an advantage of simplifying a subsequent cleaning step.

In the case of peeling off the cover portion with the conductive layer from the concave of the substrate, for example, it is preferred to give shocks or vibrations to the cover portion, or blast a fluid such as water or air on the cover portion under high speed and high pressure. In addition, when the cover portion is formed by filling a resin material having a coefficient of thermal expansion much different from the substrate material in the concave, it is possible to peel off the cover portion from the concave by alternately blowing hot and cold airs on the cover portion. In this case, there is an advantage of preventing the occurrence of residual flash or peeling of the conductive layer left on the substrate. Moreover, to facilitate the easiness of peeling off the cover portion from the substrate, it is preferred to form the cover portion after providing a layer of a release agent such as polyethylene, silicone resin or the like in the concave.

What is claimed is:

1. A method of producing a printed wiring board comprising the steps of:

providing a substrate with at least one of a projection and a concave;

forming a first circuit pattern on said substrate;

forming a second circuit pattern isolated from the first circuit pattern on said substrate;

wherein when said substrate has the projection, the method comprises the steps of:

forming a first conductive layer on the projection to make a temporary electrical connection between the first and second circuit patterns;

performing electroplating by the passage of electric current through the first and second circuit patterns connected by the first conductive layer to simultaneously form a metal film on the first and second circuit patterns; and

after the electroplating, removing the first conductive layer on the projection to provide electrical insulation between the first and second circuit patterns;

wherein when said substrate has the concave, the method comprises the steps of:

covering the concave with a material different from said substrate to obtain a cover portion;

forming a second conductive layer on said cover portion to make a temporary electrical connection between the first and second circuit patterns;

performing electroplating by the passage of electric current through the first and second circuit patterns connected by the second conductive layer to simultaneously form a metal film on the first and second circuit patterns; and

after the electroplating, removing the second conductive layer on said cover portion to provide electrical insulation between the first and second circuit patterns.

2. The method as set forth in claim 1, wherein said substrate with at least one of the projection and the concave is formed by means of integral molding.

3. The method as set forth in claim 1, wherein said substrate has a plurality of projections, which are formed such that tops of the projections are substantially flush with each other.

4. The method as set forth in claim 1, wherein the first circuit pattern, the second circuit pattern and the first conductive layer are provided at a time by patterning a metal thin film formed on said substrate.

5. The method as set forth in claim 1, wherein the first circuit pattern, the second circuit pattern and the second conductive layer are provided at a time by patterning a metal thin film formed on said

substrate after the concave is covered with said material.

6. The method as set forth in claim 1, wherein the first conductive layer is removed together with at least a part of the projection from said substrate to provide electrical insulation between the first and second circuit patterns.

7. The method as set forth in claim 1, wherein said cover portion is obtained by building a bridge over the concave with use of a film of an electrical insulating material.

8. The method as set forth in claim 1, wherein said cover portion is formed by filling an electrical insulating material in the concave such that a top surface of said cover portion is substantially flush with the top surface of said substrate around said cover portion.

9. The method as set forth in claim 1, wherein the second conductive layer is removed together with at least a part of said cover portion from the concave to provide electrical insulation between the first and second circuit patterns.

10. The method as set forth in claim 1, wherein the second conductive

layer has notches at opposite ends of said cover portion in a direction of the second conductive layer, and the second conductive layer between said notches is removed to provide electrical insulation between the first and second circuit patterns.

11. The method as set forth in claim 1, wherein the first and second circuit patterns are formed on a surface opposed to the projection of said substrate, and the first circuit pattern is electrically connected to the second circuit pattern through electrical conductive members passing through said substrate and the first conductive layer on the projection.

12. The method as set forth in claim 1, wherein the first conductive layer is removed together with a part of the projection by allowing a cutting or grinding tool to cut into a side surface having the first conductive layer of the projection such that an edge of the cutting or grinding tool presses the first conductive layer against the side surface of the projection, and allowing the cutting or grinding tool to pass through the projection in a direction from the side surface having the first conductive layer of the projection to another side surface not having the first conductive layer of the projection.

13. A method of manufacturing a printed circuit board comprising:

forming a metal thin film on a substrate having a projection;

providing an initial circuit pattern on said substrate by patterning the metal thin film, said initial circuit pattern comprising first and second circuit patterns isolated from each other and a conductive layer formed on the projection to make a temporary electrical connection between the first and second circuit patterns;

performing electroplating by the passage of electric current through the initial circuit pattern to form an additional metal film on the initial circuit pattern; and

after the electroplating, removing the conductive layer on the projection to provide electrical insulation between the first and second circuit patterns.

14. A method of producing a printed wiring board comprising the steps of:

providing a substrate with a first surface having a first projection and a second surface extending at a different level from the first surface and having a second projection thereon;

forming a first circuit pattern on the first surface;

forming a second circuit pattern isolated from the first circuit pattern on the second surface;

forming a third circuit pattern isolated from the first and second circuit patterns so as to extend from the first surface to the second surface;

forming a first conductive layer on the first projection to make a temporary electrical connection between the first and third circuit patterns;

forming a second conductive layer on the second projection to make a temporary electrical connection between the second and third circuit patterns;

performing electroplating by the passage of electric current through the first, second and third circuit patterns connected by the first and second conductive layers to simultaneously form a metal film on the first, second and third circuit patterns; and

after the electroplating, removing the first and second conductive layers on the first and second projections to provide electrical insulation among the first, second and third circuit patterns.

15. The method as set forth in claim 14, wherein the first and second projections are formed such that a top of the first projection is substantially flush with the top of the second projection, and wherein the first and second conductive layers on the first and second projections are removed at a time.

16. The method as set forth in claim 15, wherein the first and second conductive layers on the first and second projections are removed at the same time by means of chemical etching.

17. The method as set forth in claim 14, wherein the first circuit pattern, the second circuit pattern, the third circuit pattern and the conductive layer are provided at a time by patterning a metal thin film formed on

said substrate.

18. A substrate having at least one of a projection and a concave, which is used in a method of producing a printed wiring board comprising the steps of:

forming a first circuit pattern on said substrate;

forming a second circuit pattern isolated from the first circuit pattern on said substrate;

wherein when said substrate has the projection, the method comprises the steps of:

forming a first conductive layer on the projection to make a temporary electrical connection between the first and second circuit patterns;

performing electroplating by the passage of electric current through the first and second circuit patterns connected by the first conductive layer to simultaneously form a metal film on the first and second circuit patterns; and

after the electroplating, removing the first conductive layer on the projection to provide electrical insulation between the first and second circuit patterns;

wherein when said substrate has the concave, the method comprises the steps of:

covering the concave with a material different from said substrate to obtain a cover portion;

forming a second conductive layer on said cover portion to make a temporary electrical connection between the first and second circuit patterns;

performing electroplating by the passage of electric current through the first and second circuit patterns connected by the second conductive layer to simultaneously form a metal film on the first and second circuit patterns; and

after the electroplating, removing the second conductive layer on said cover portion to provide electrical insulation between the first and second circuit patterns.

19. A substrate comprising a first surface having a first projection and a second surface extending at a different level from the first surface and having a second projection formed such that a top of the first projection is substantially flush with the top of the second projection, which is used in a method of producing a printed wiring board comprising the steps of:

forming a first circuit pattern on the first surface;

forming a second circuit pattern isolated from the first circuit pattern on the second surface;

forming a third circuit pattern isolated from the first and second circuit patterns so as to extend from the first surface to the second surface;

forming a first conductive layer on the first projection to make a temporary electrical connection between the first and third circuit patterns;

forming a second conductive layer on the second projection to make a temporary electrical connection between the second and third circuit patterns;

performing electroplating by the passage of electric current through the first, second and third circuit patterns connected by the first and second conductive layers to simultaneously form a metal film on the first, second and third circuit patterns; and

after the electroplating, removing the first and second conductive layers on the first and second projections to provide electrical insulation among the first, second and third circuit patterns.

20. A printed wiring board obtained by a method comprising the steps of:

providing a substrate with at least one of a projection and a concave;

forming a first circuit pattern on said substrate;

forming a second circuit pattern isolated from the first circuit pattern on said substrate;

wherein when said substrate has the projection, the method comprises the steps of:

forming a first conductive layer on the projection to make a temporary electrical connection between the first and second circuit patterns;

performing electroplating by the passage of electric current through the first and second circuit patterns connected by the first conductive layer to simultaneously form a metal film on the first and second circuit patterns; and

after the electroplating, removing the first conductive layer on the projection to provide electrical insulation between the first and second circuit patterns;

wherein when said substrate has the concave, the method comprises the steps of:

covering the concave with a material different from said substrate to obtain a cover portion;

forming a second conductive layer on said cover portion to make a temporary electrical connection between the first and second circuit patterns;

performing electroplating by the passage of electric current through the first and second circuit patterns connected by the second conductive layer to simultaneously form a metal film on the first and second circuit patterns; and

after the electroplating, removing the second conductive layer on said cover portion to provide electrical insulation between the first and second circuit patterns.

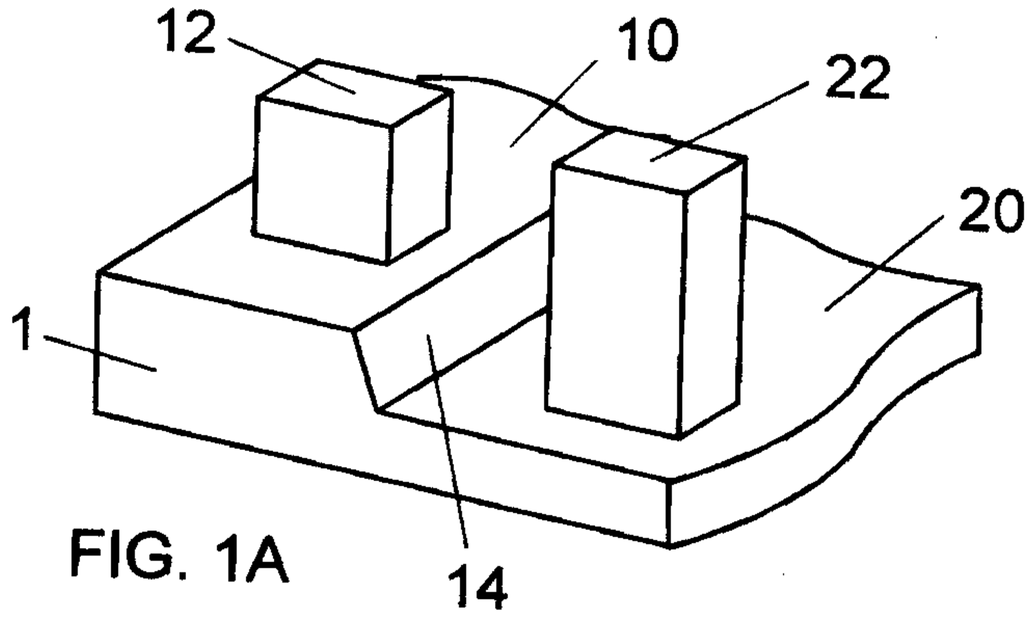


FIG. 1A

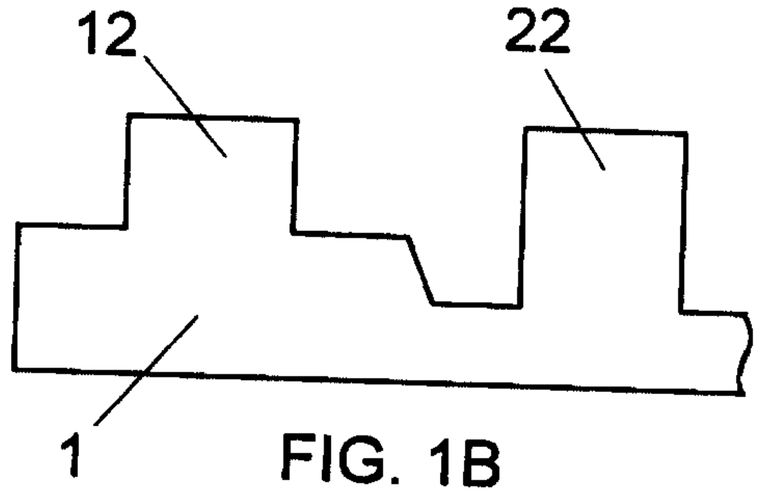


FIG. 1B

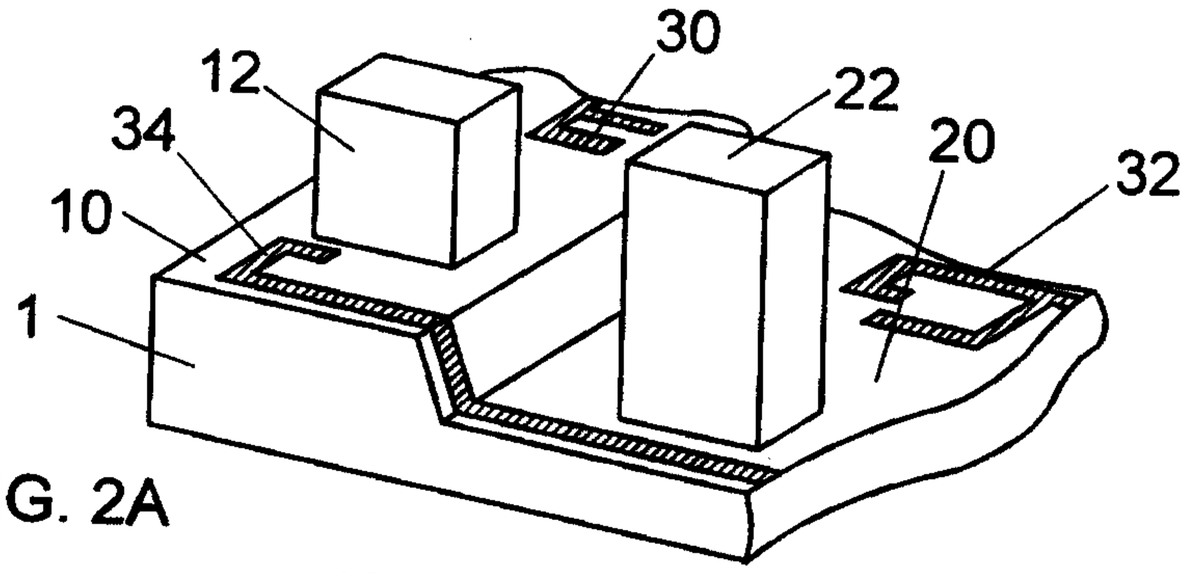


FIG. 2A

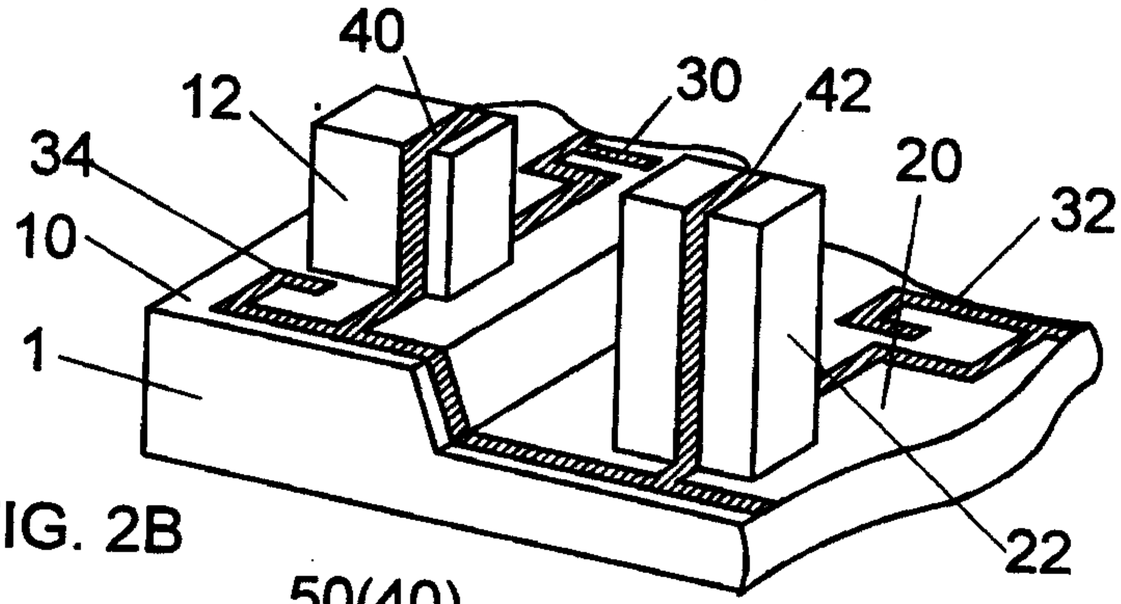


FIG. 2B

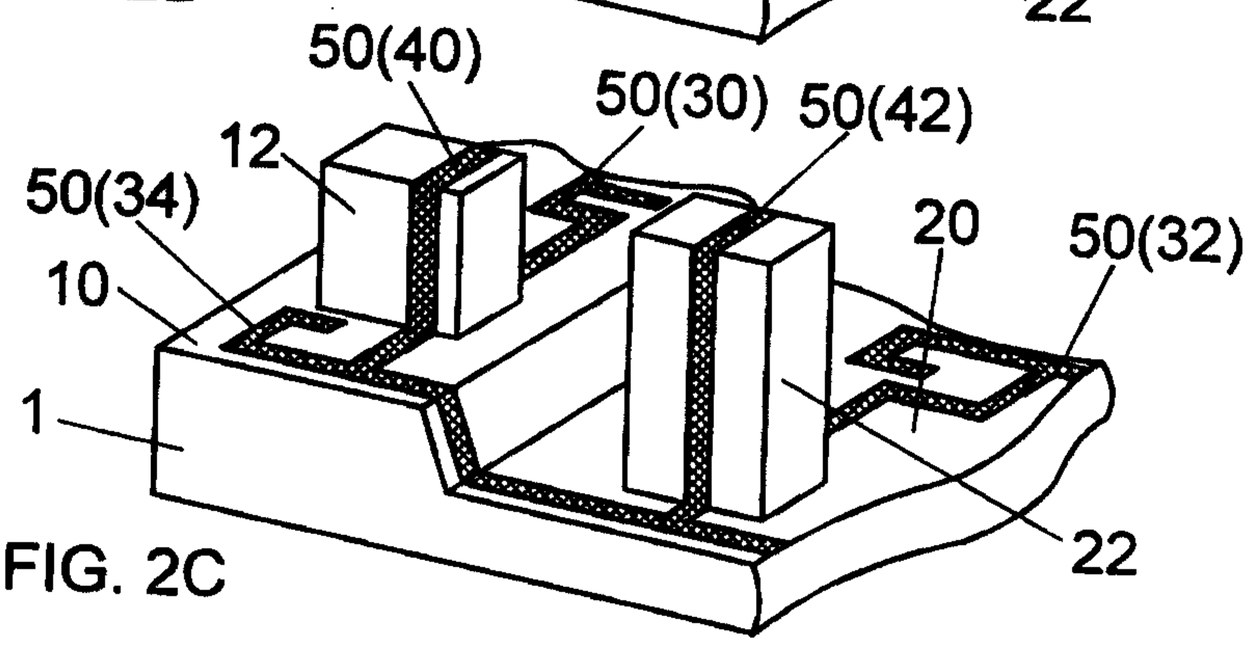


FIG. 2C

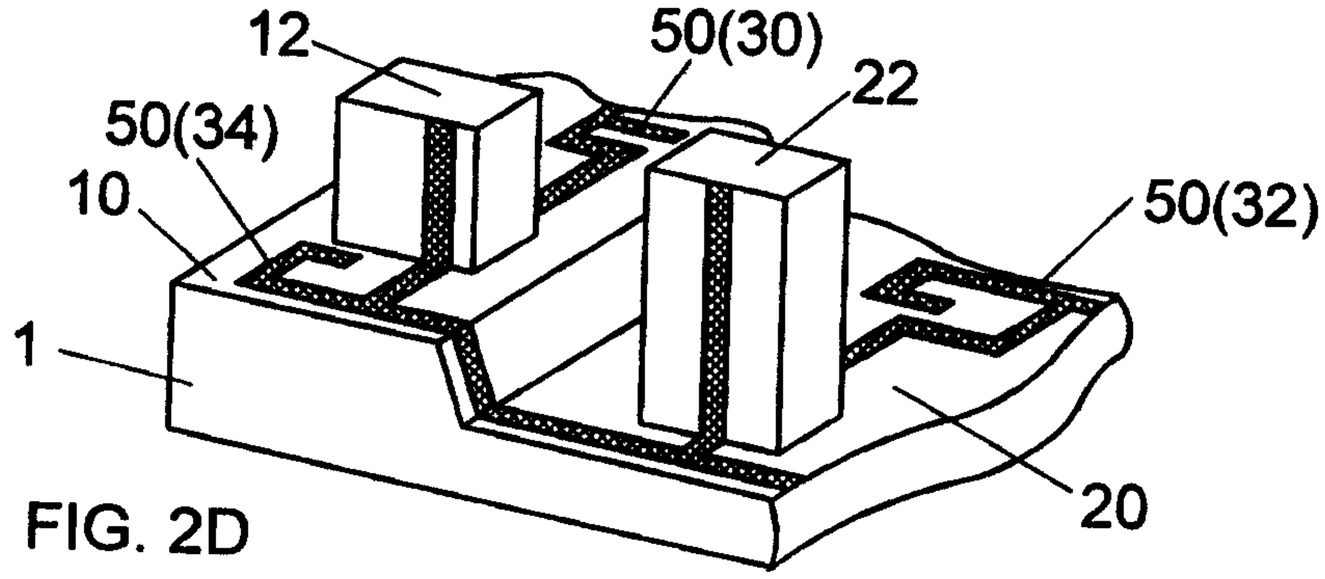


FIG. 2D

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FIG. 3A

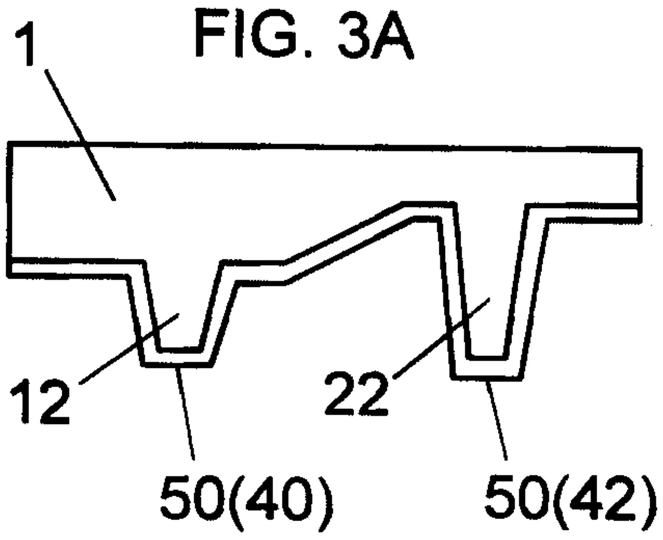
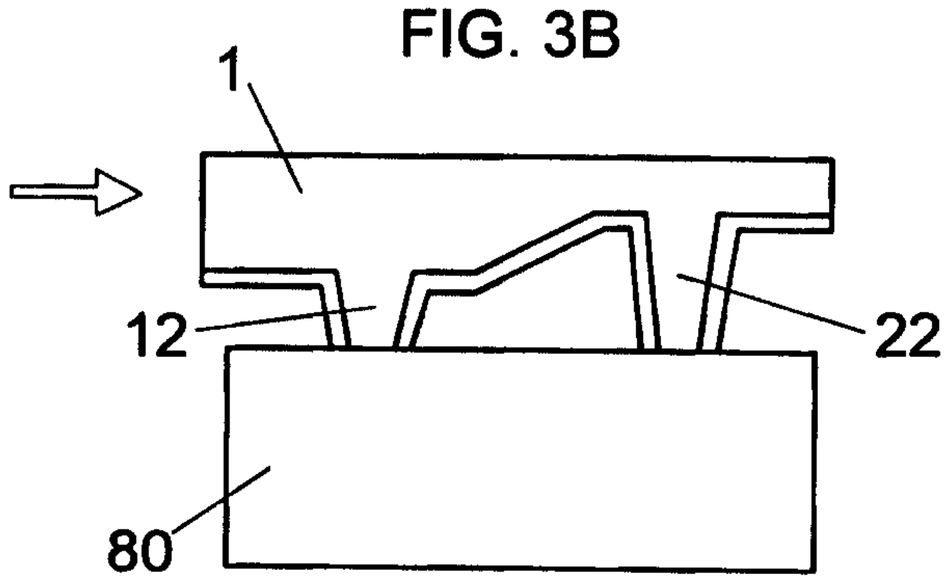


FIG. 3B



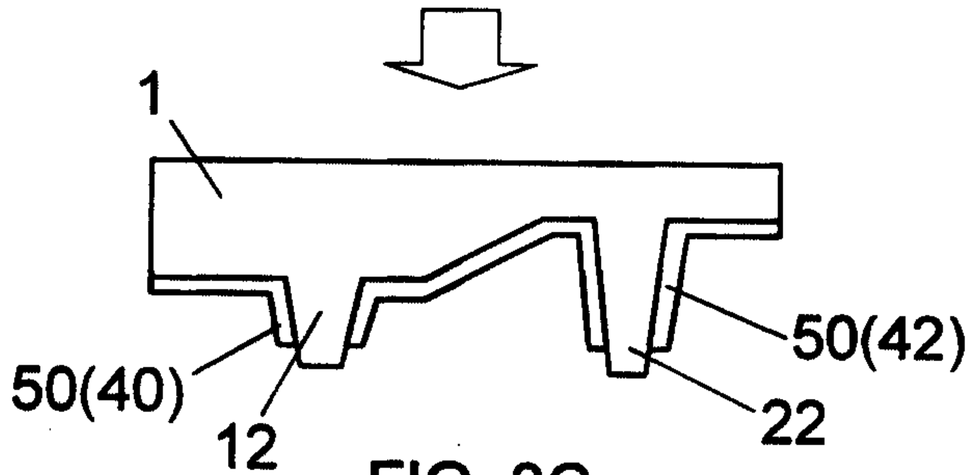


FIG. 3C

FIG. 4A

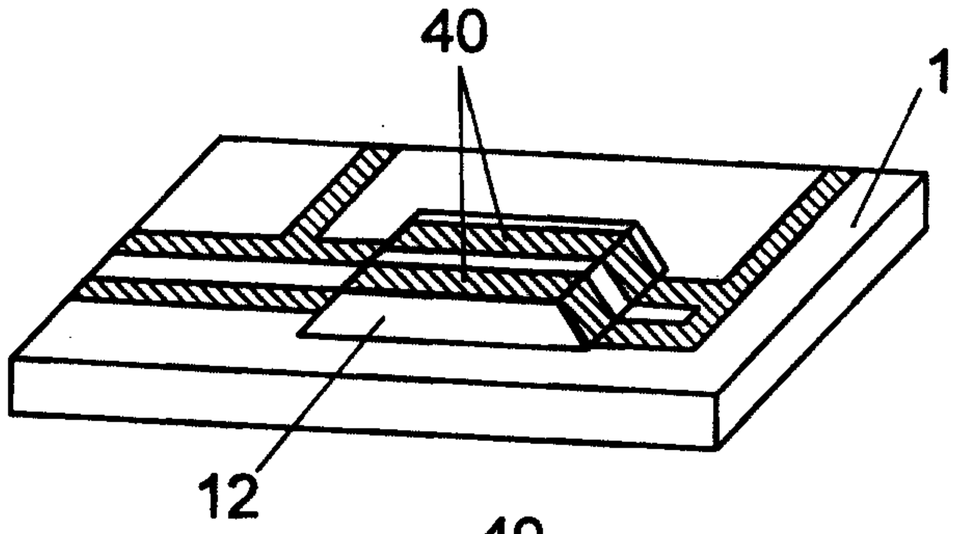


FIG. 4B

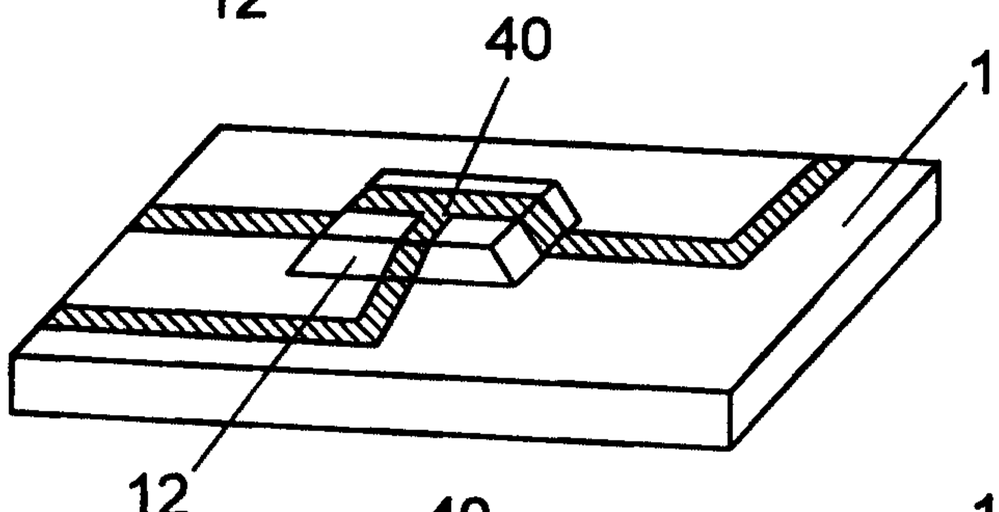
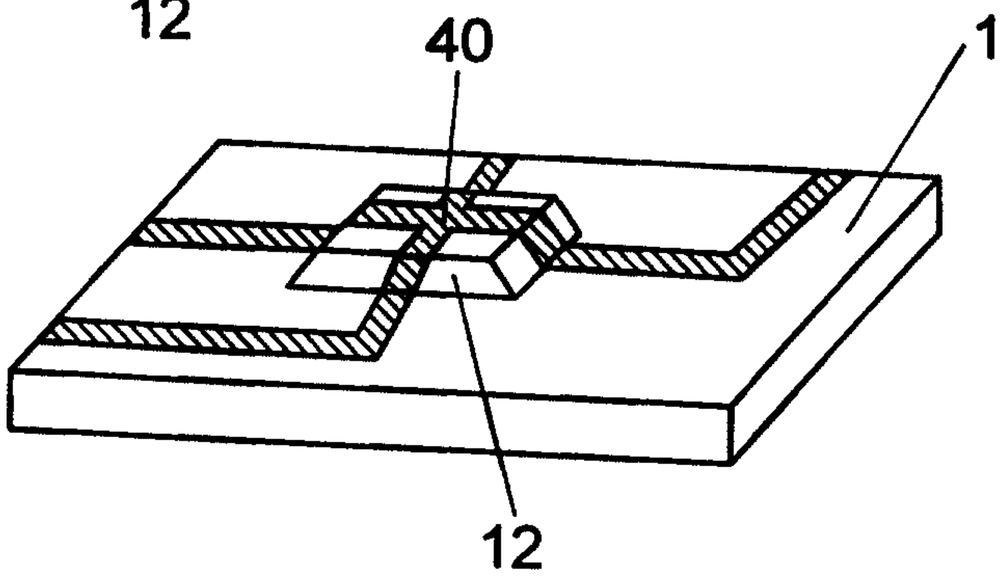


FIG. 4C



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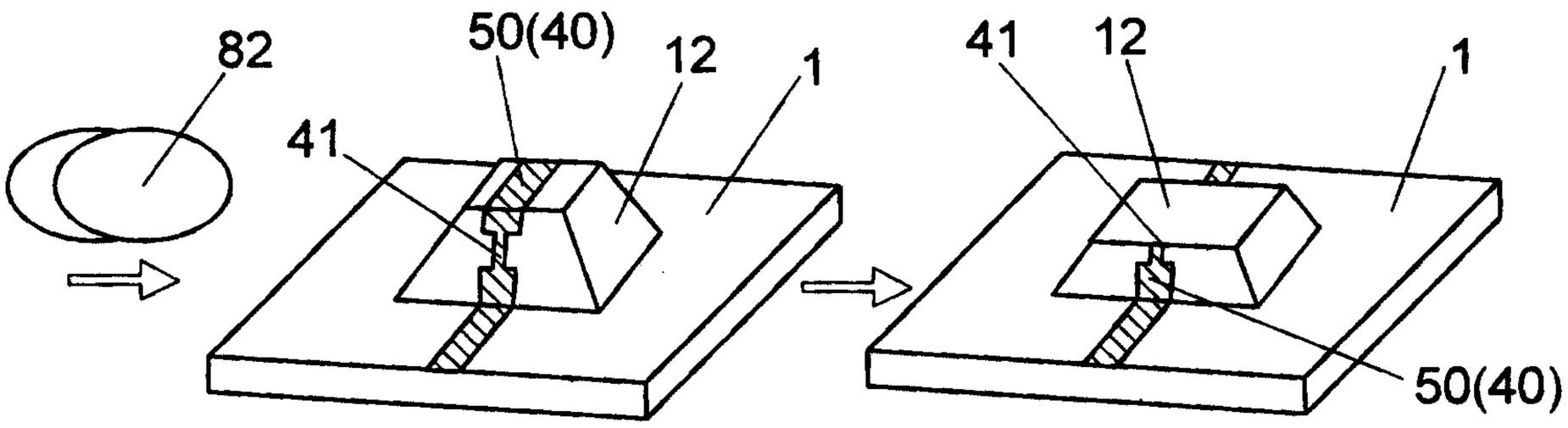


FIG. 5A FIG. 5B

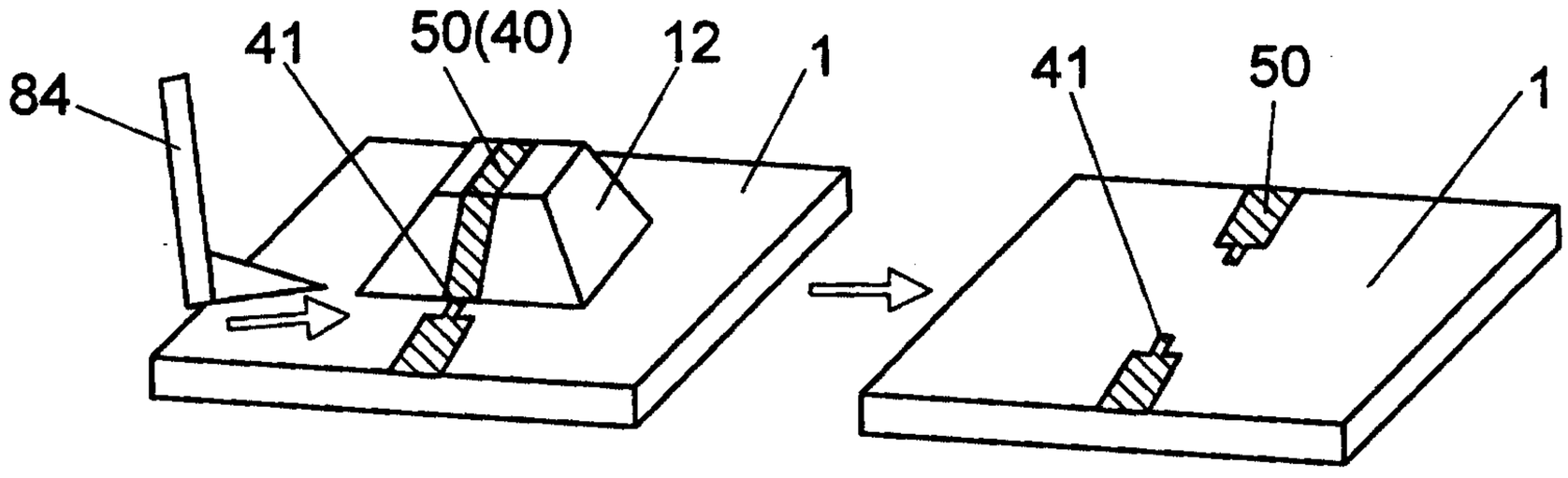


FIG. 6A FIG. 6B

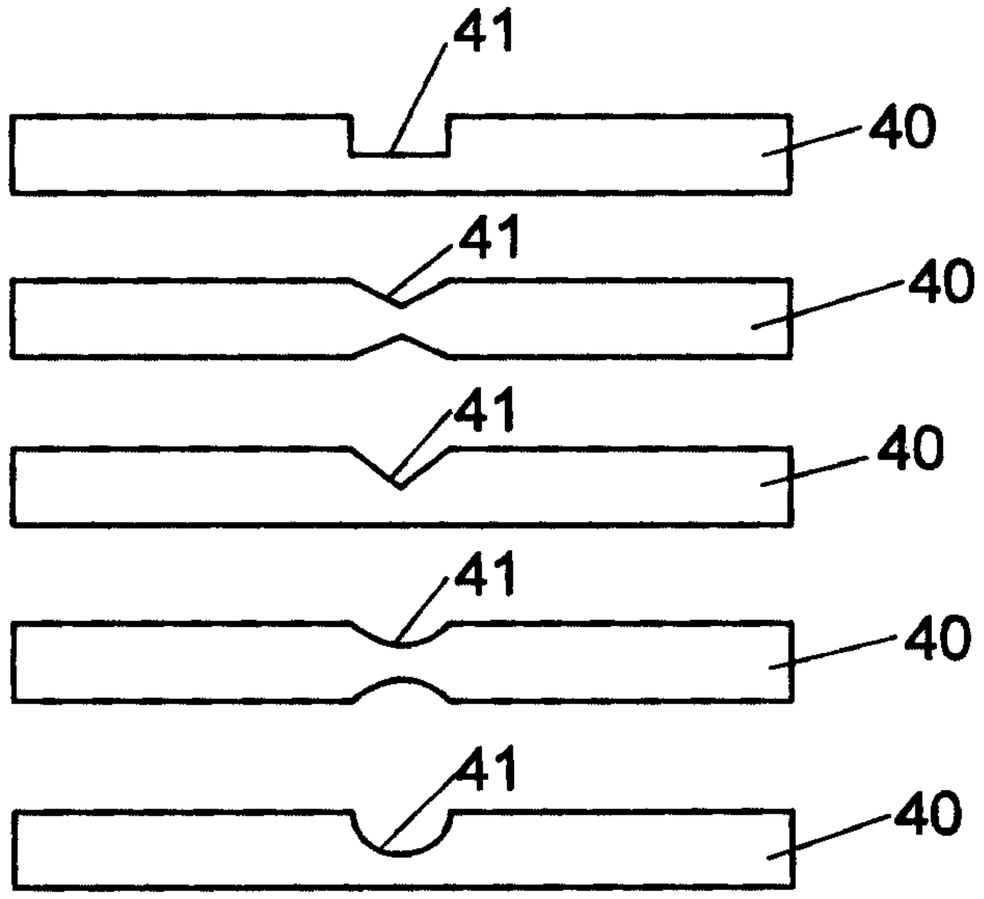


FIG. 7A
FIG. 7B
FIG. 7C
FIG. 7D
FIG. 7E
FIG. 7F
FIG. 7G

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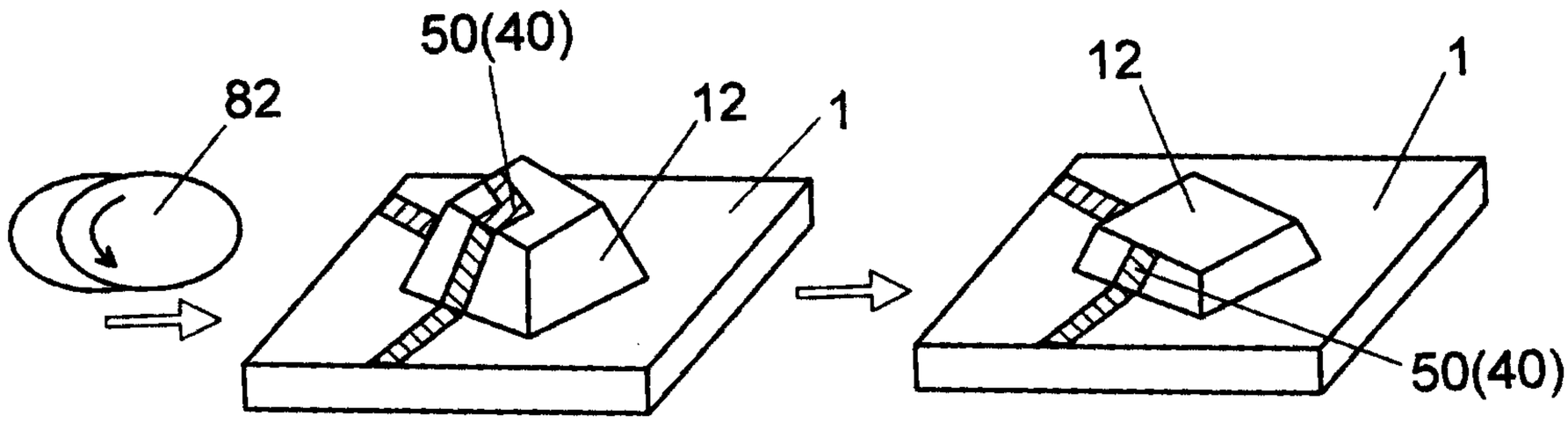


FIG. 8A

FIG. 8B

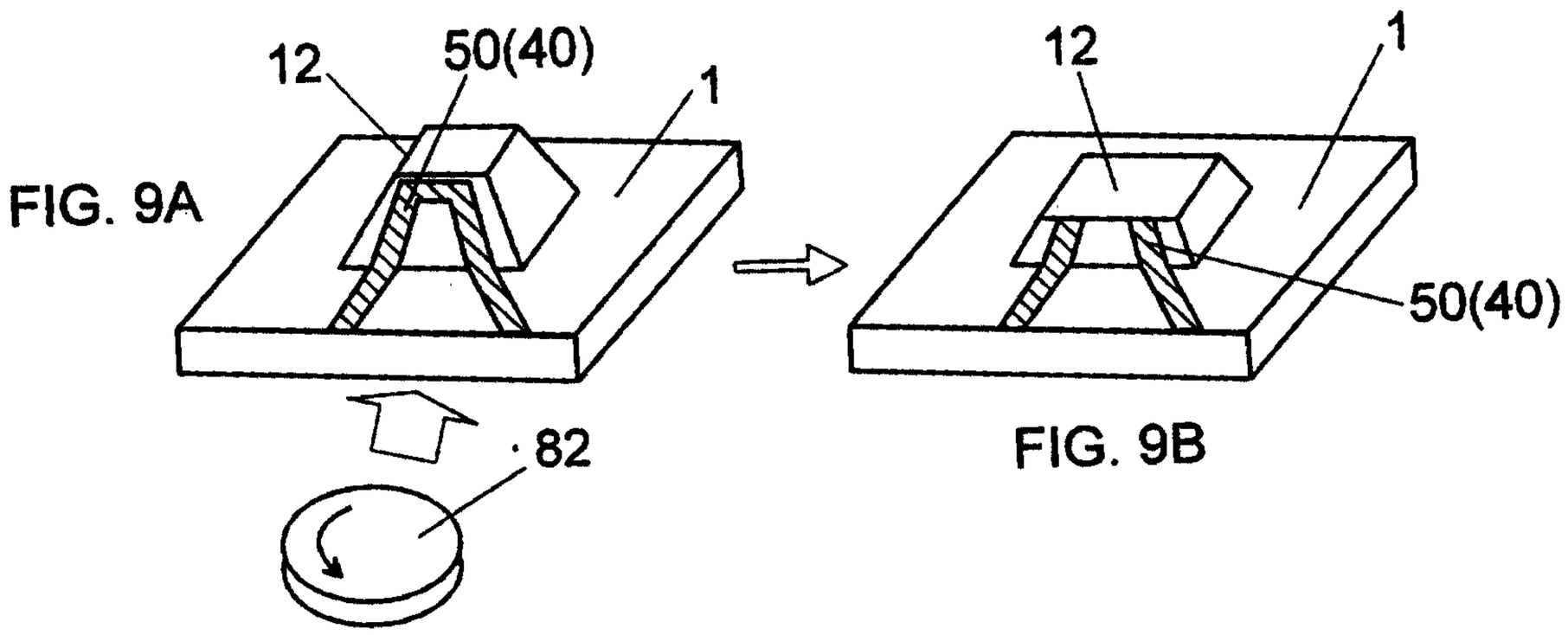


FIG. 9A

FIG. 9B

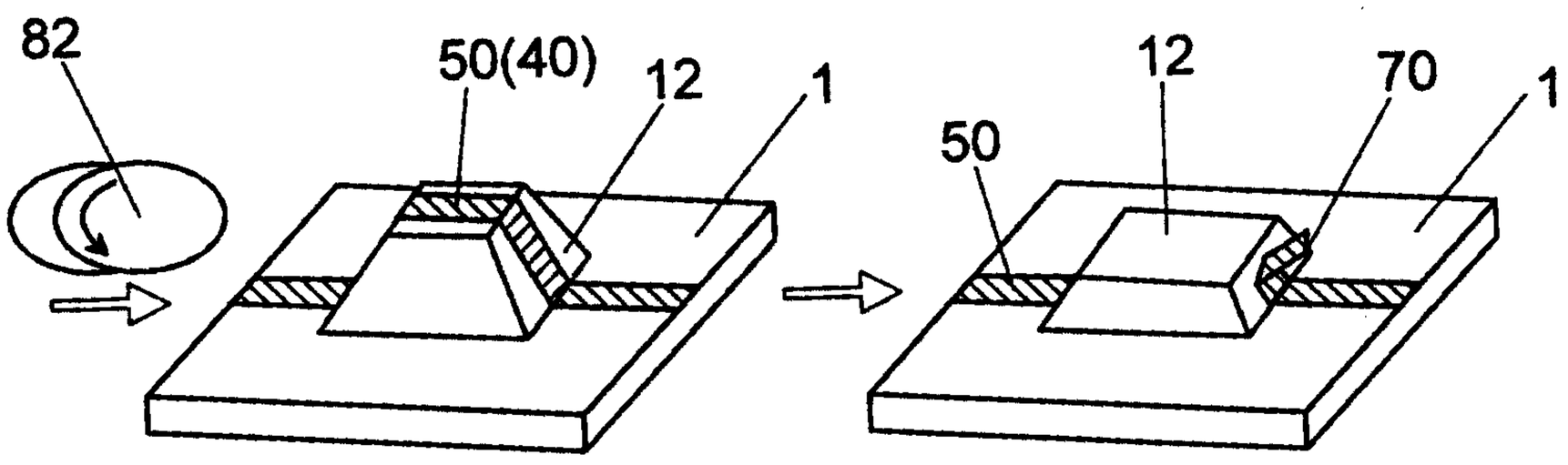


FIG. 10A

FIG. 10B

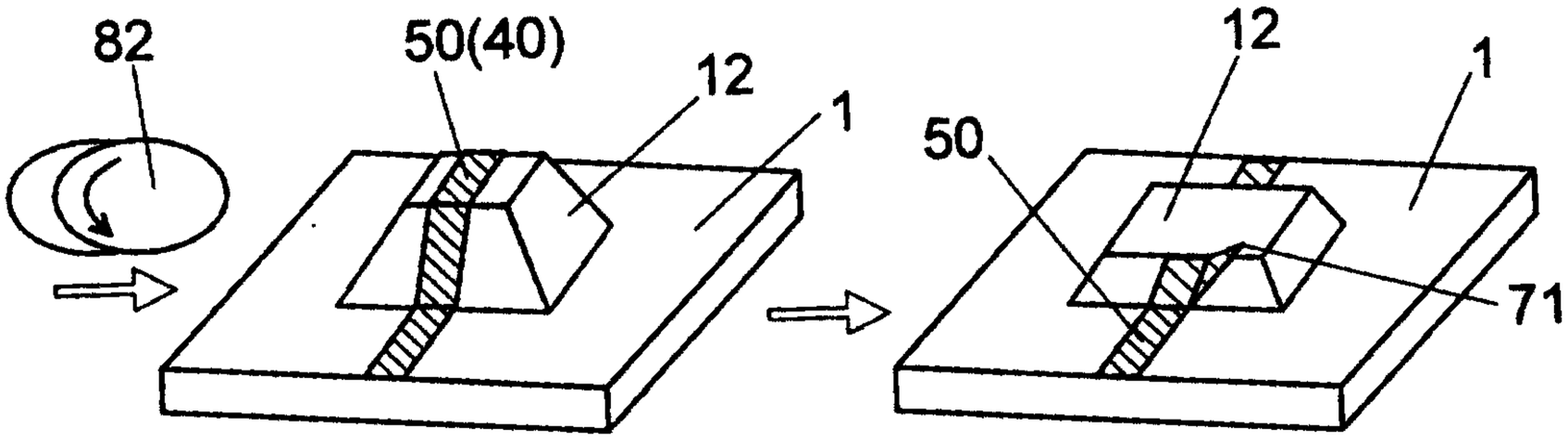


FIG. 11A

FIG. 11B

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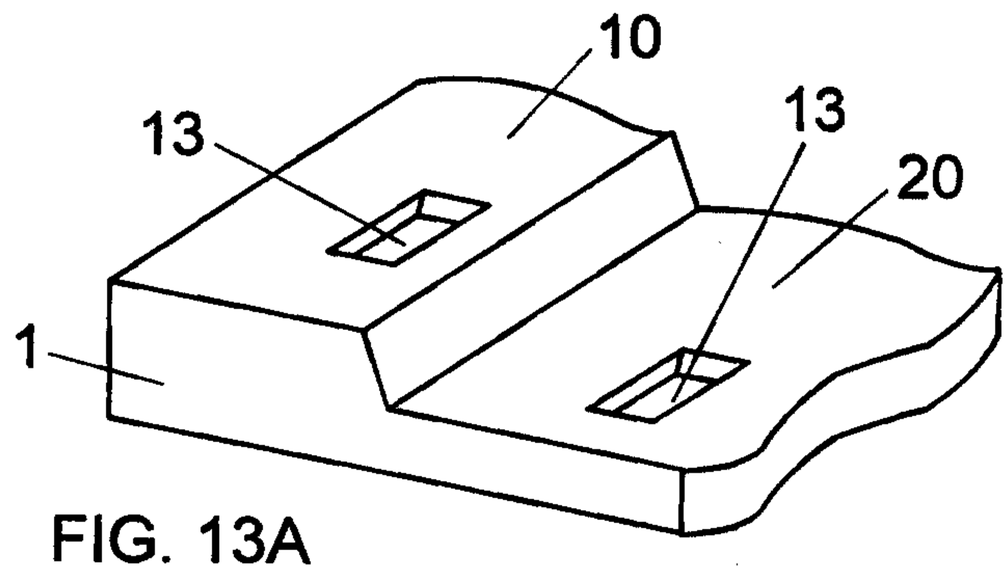


FIG. 13A

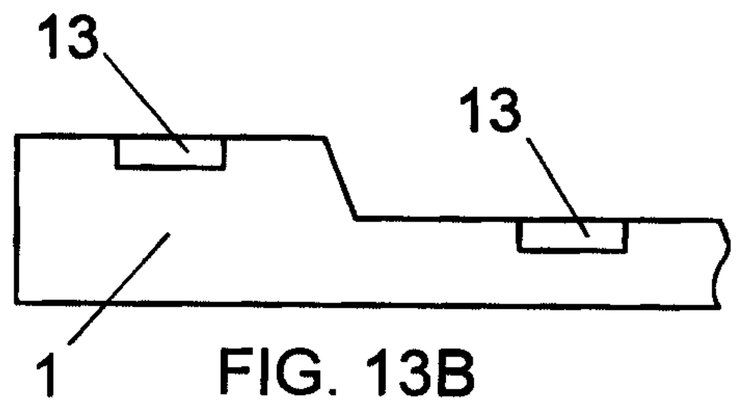


FIG. 13B

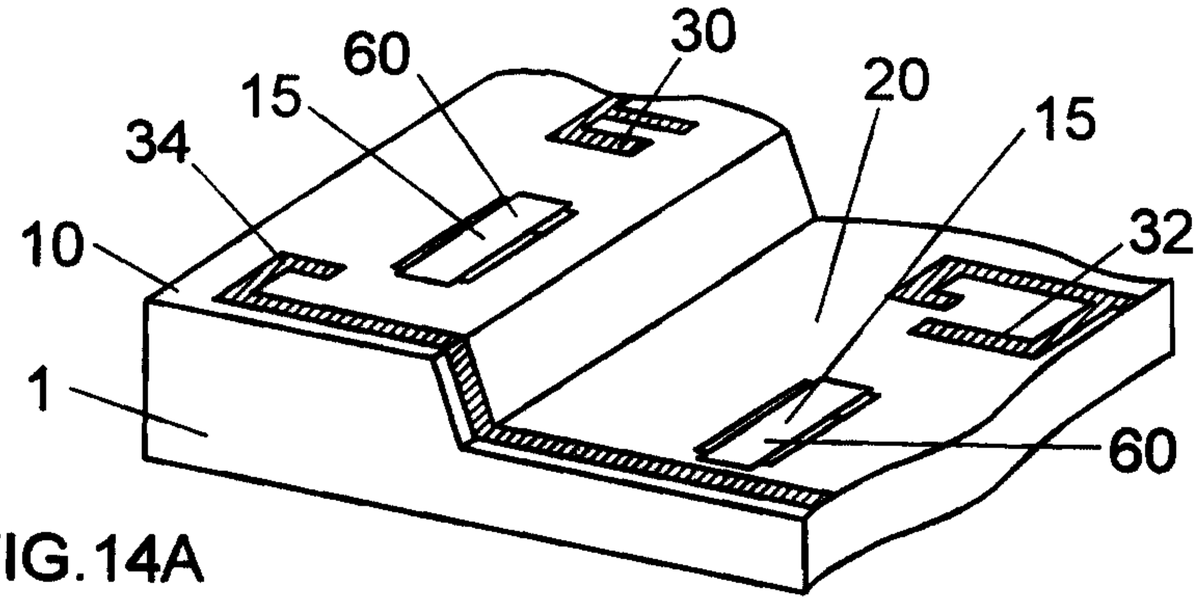


FIG.14A

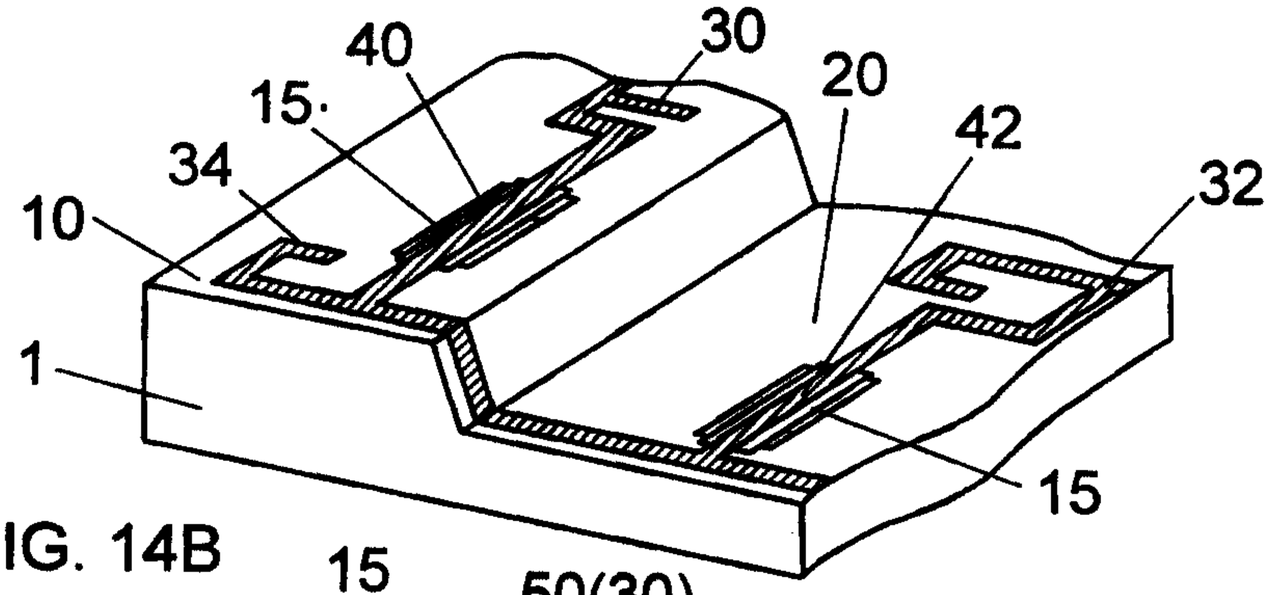


FIG. 14B

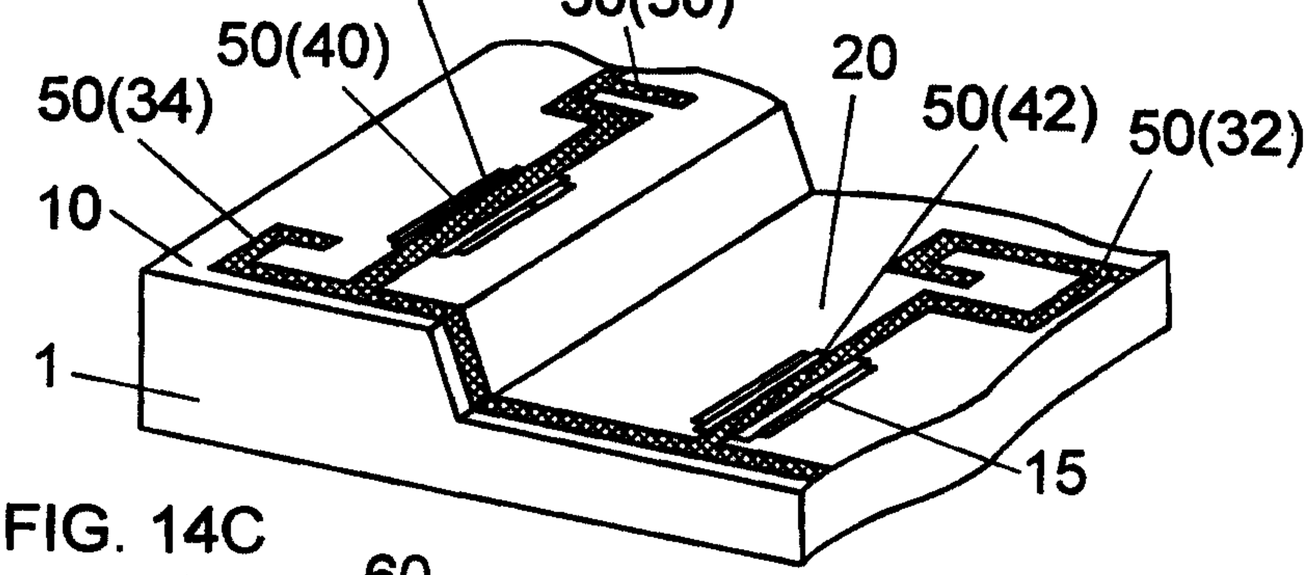


FIG. 14C

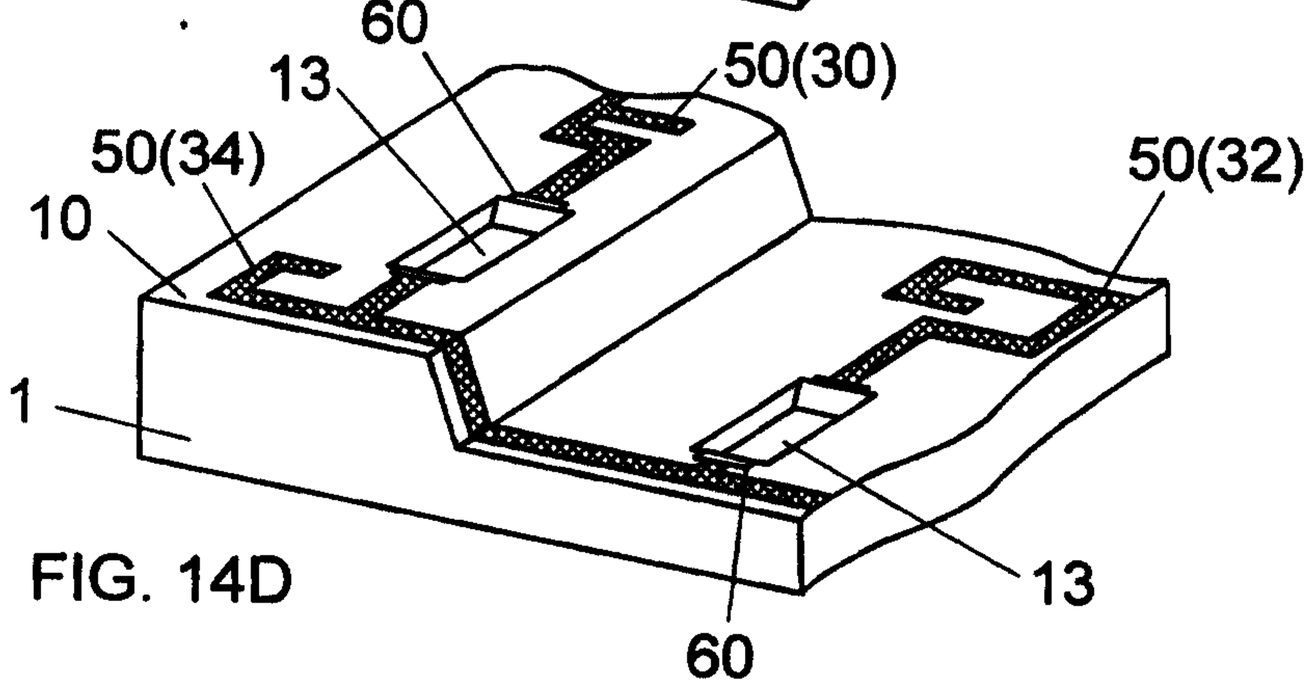


FIG. 14D

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FIG.12A

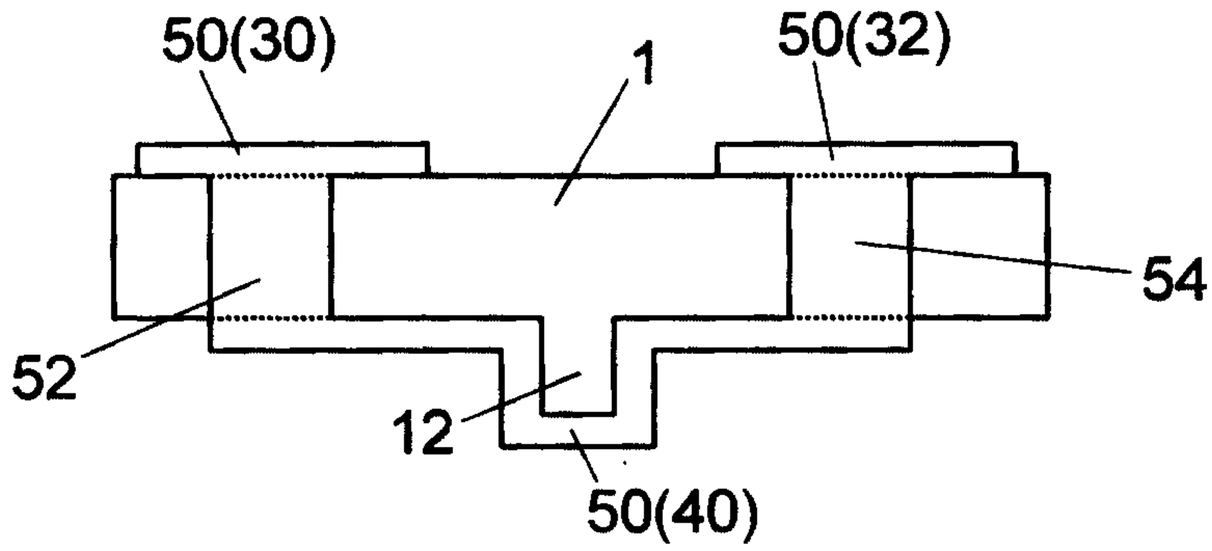
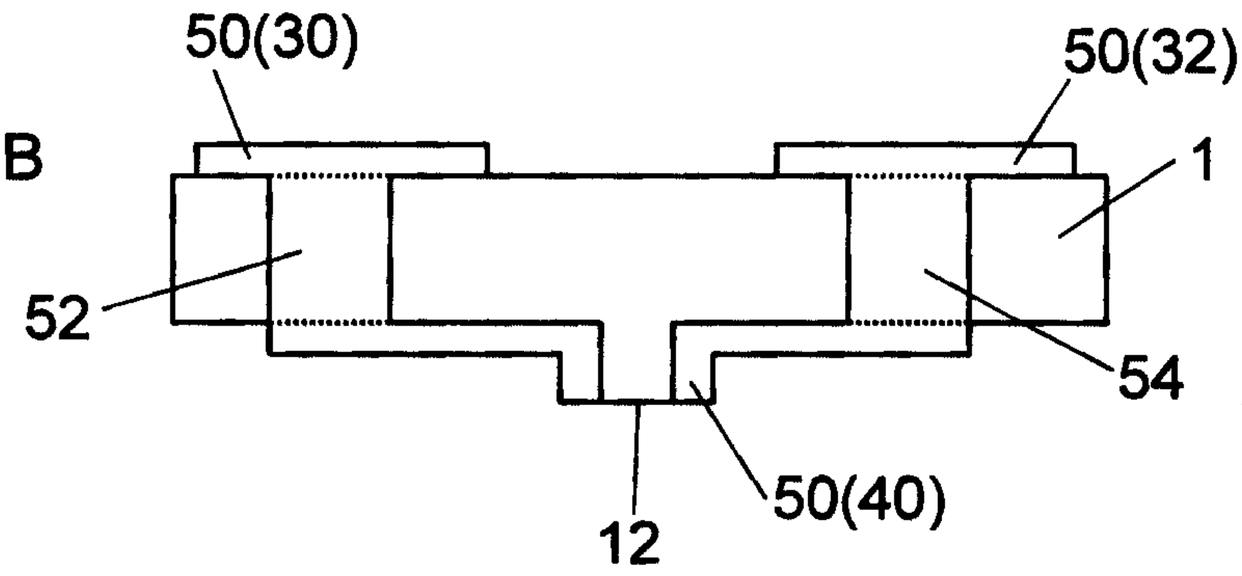


FIG. 12B



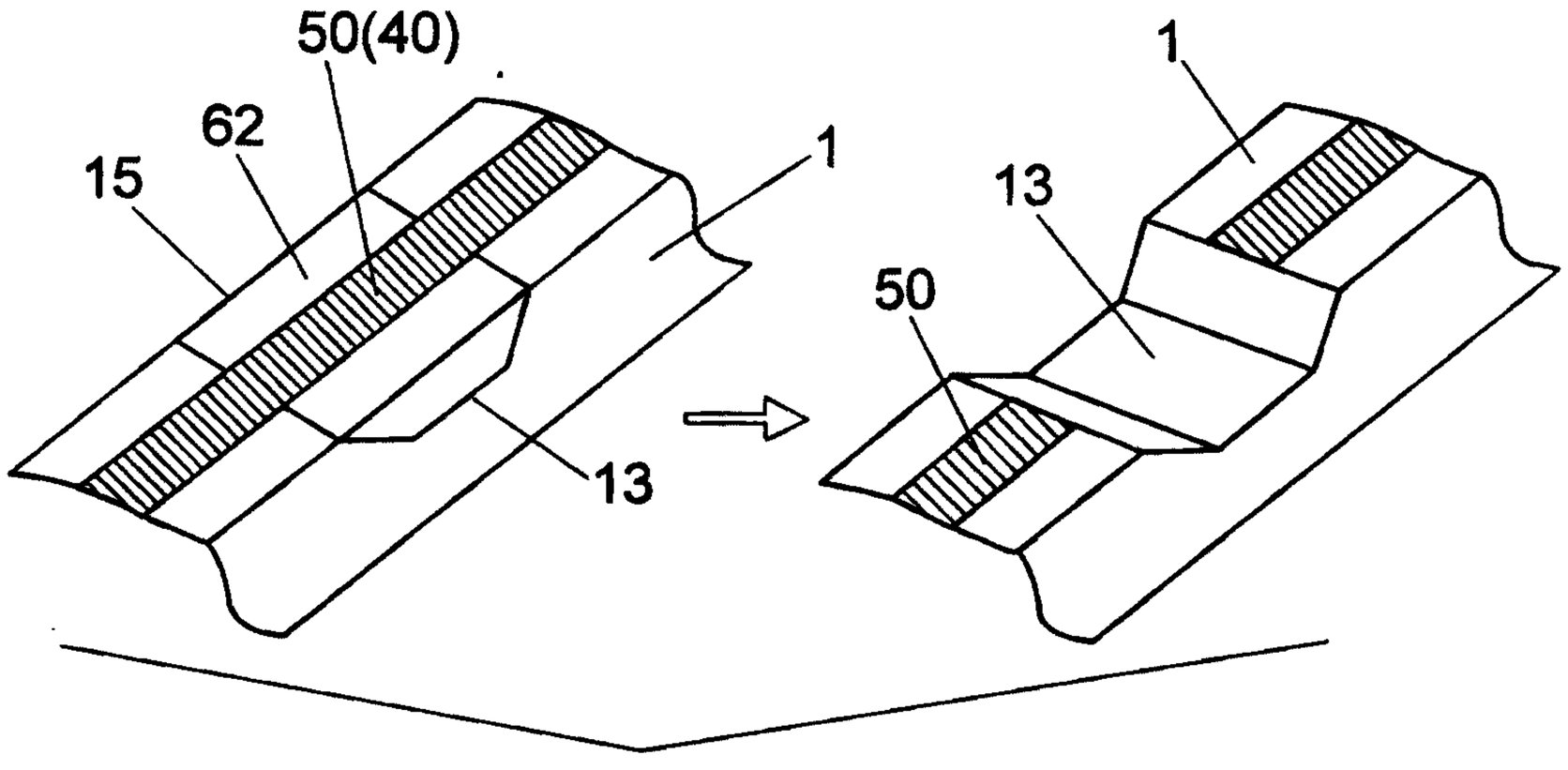


FIG. 15

FIG. 16

Marks & Clerk

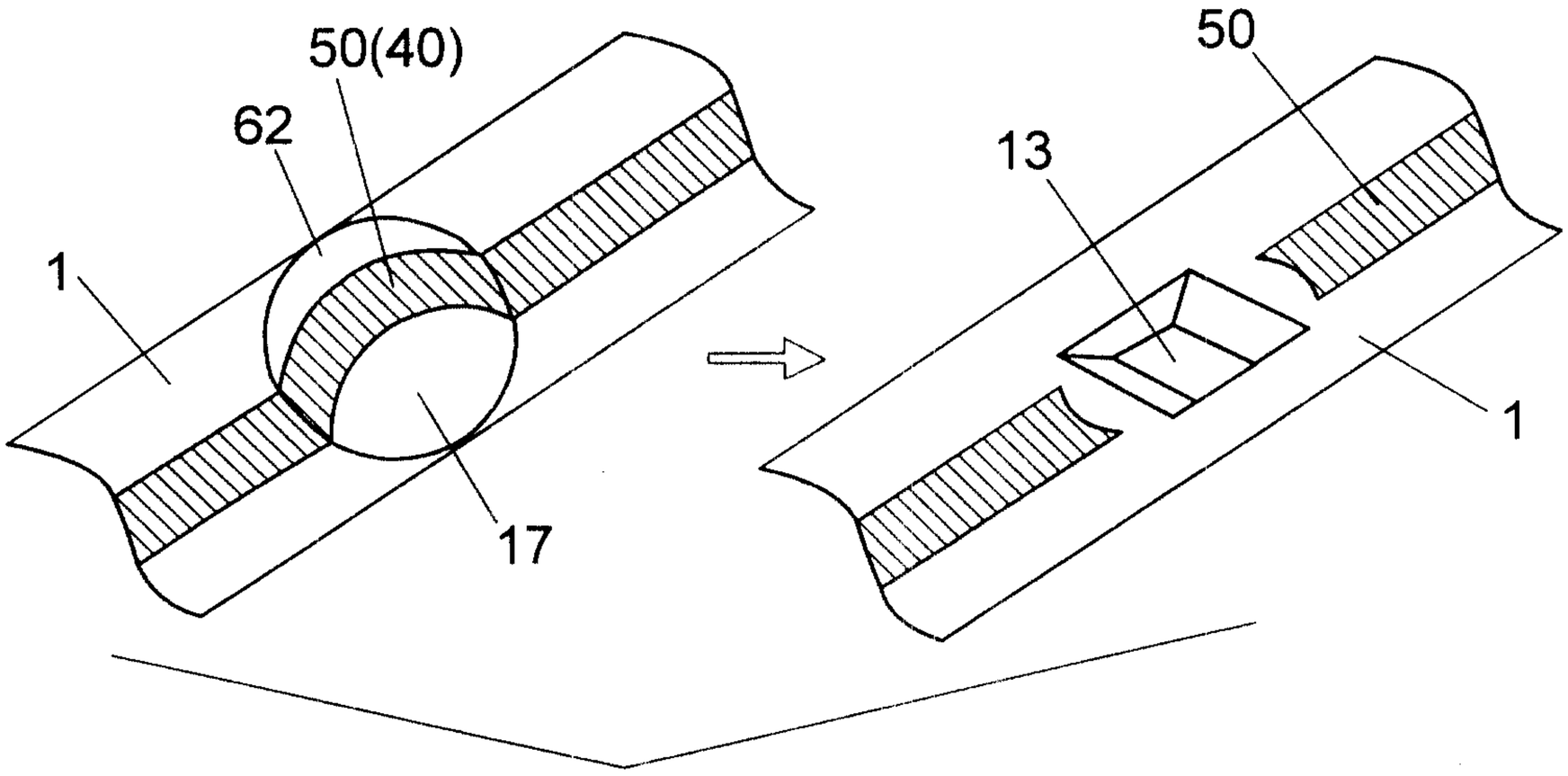


FIG. 17

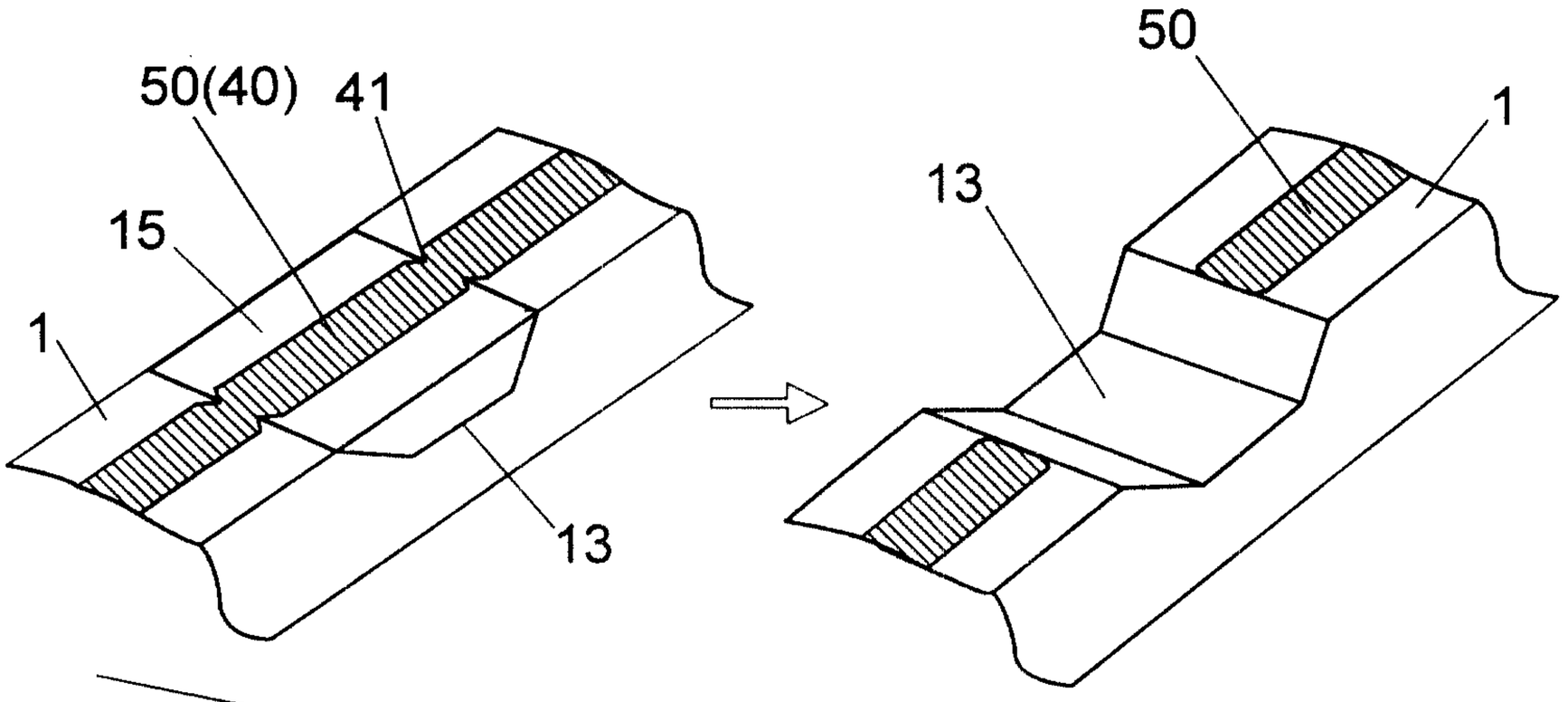


FIG. 18

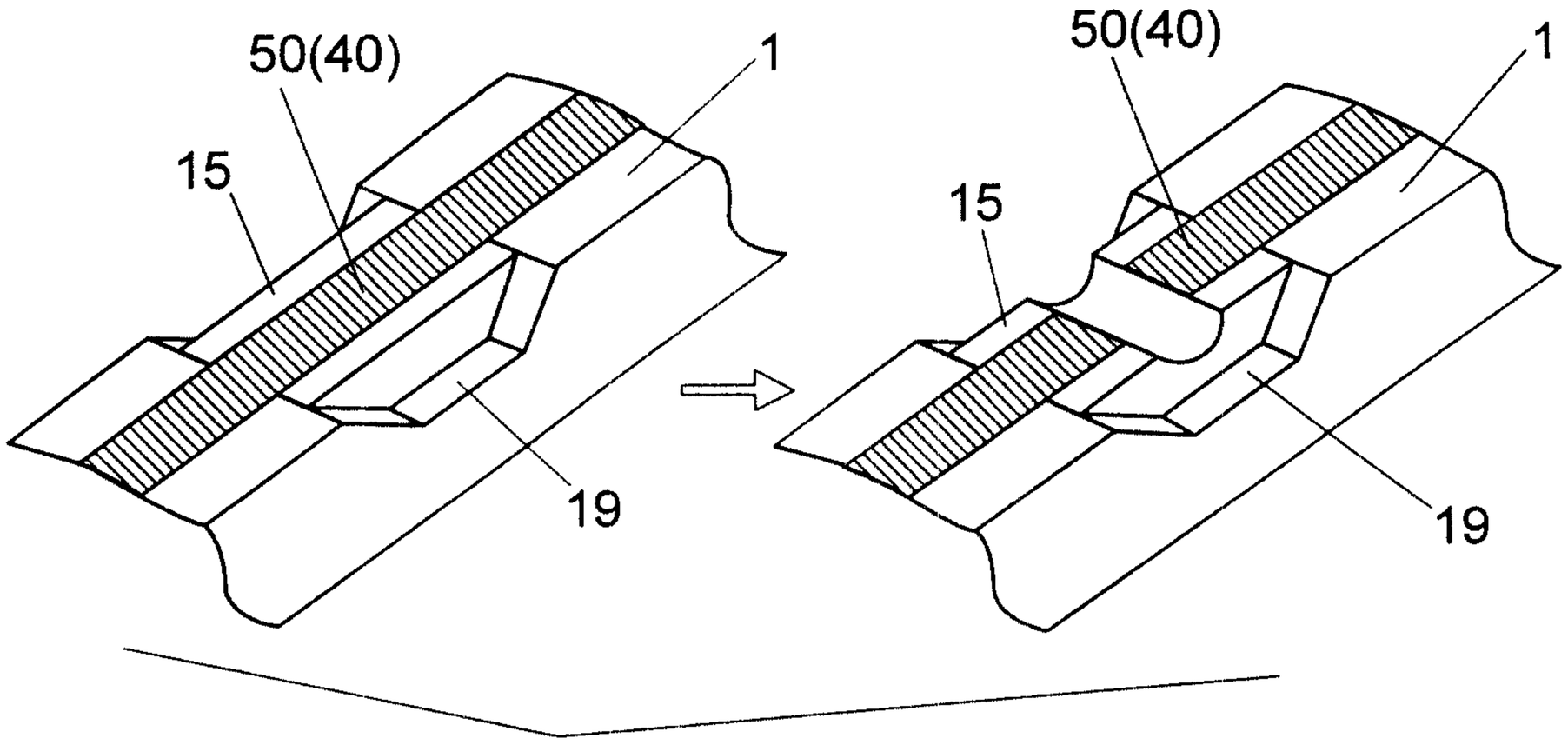


FIG. 19

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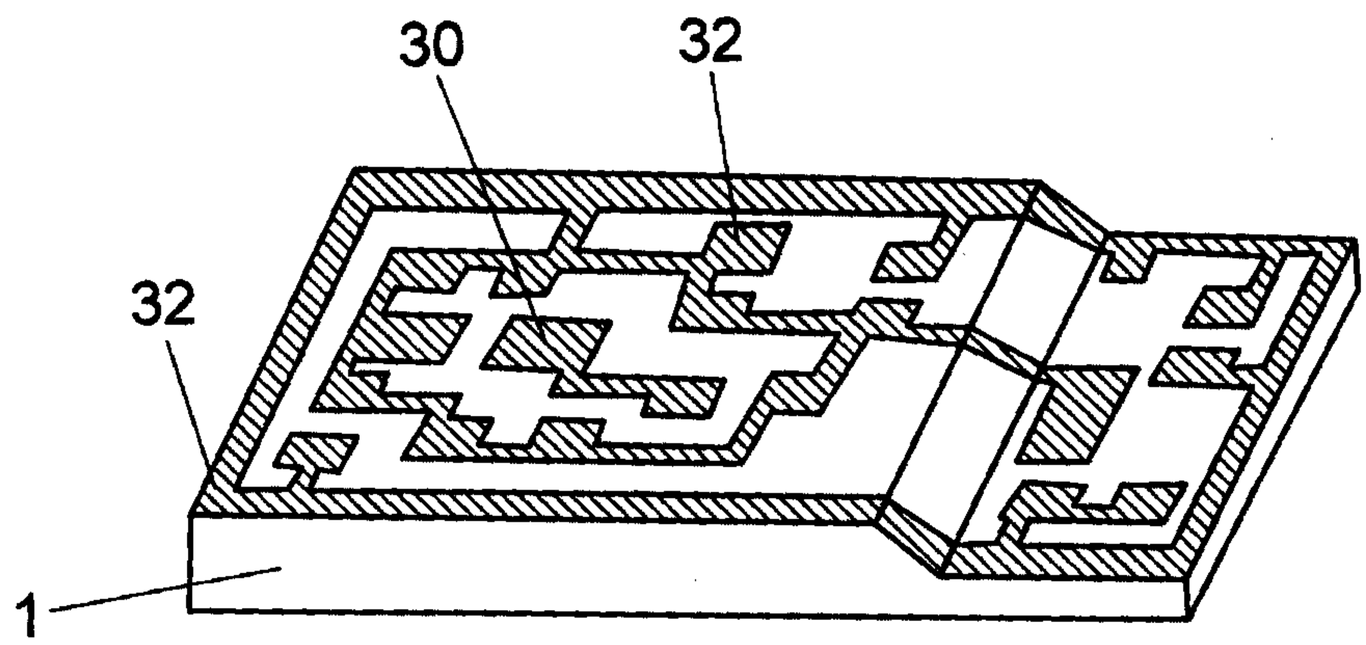


FIG. 20

FIG. 21A
(PRIOR ART)

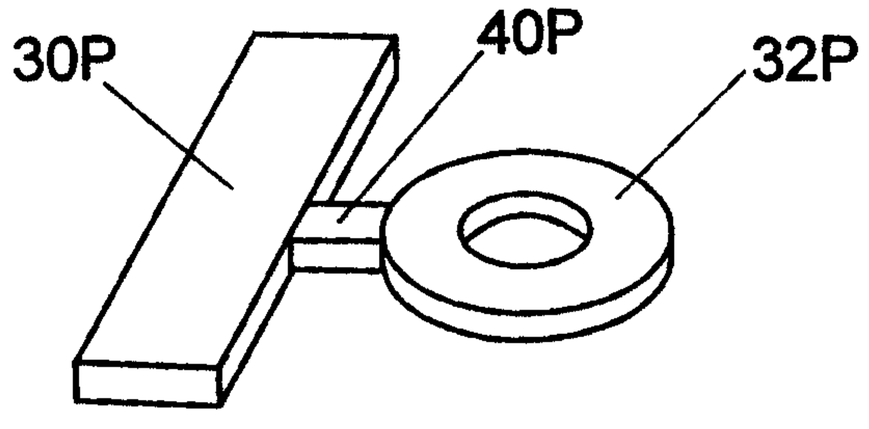


FIG. 21B
(PRIOR ART)

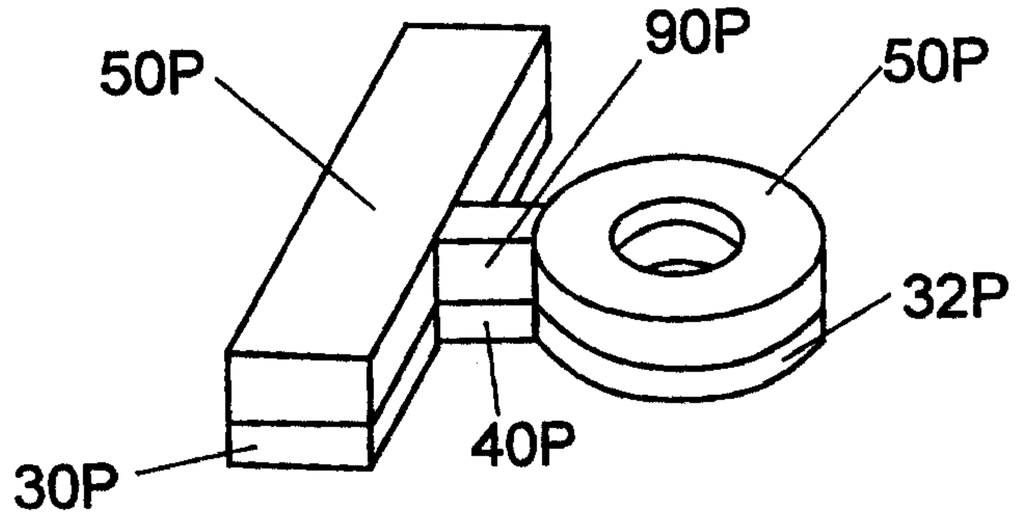
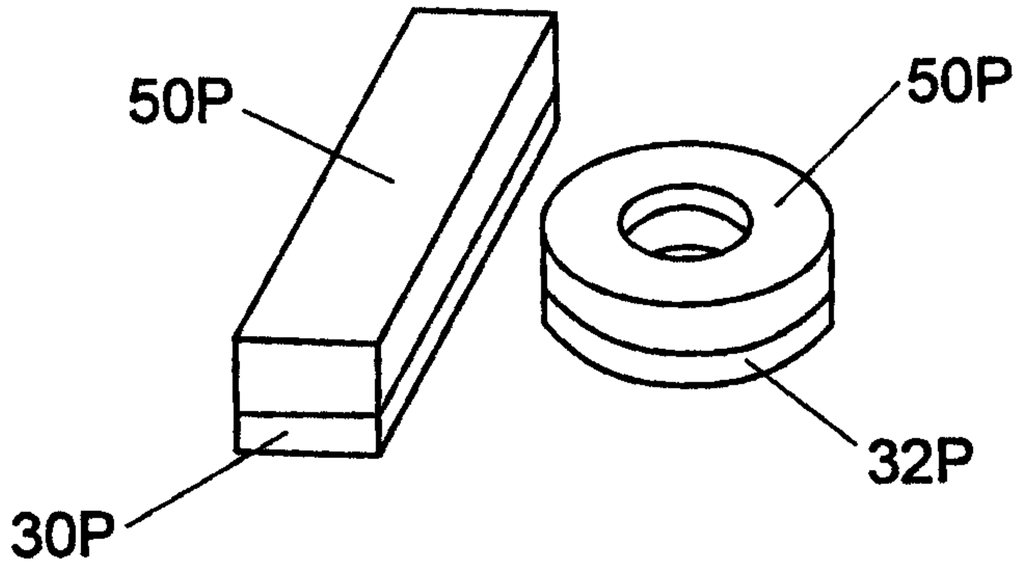
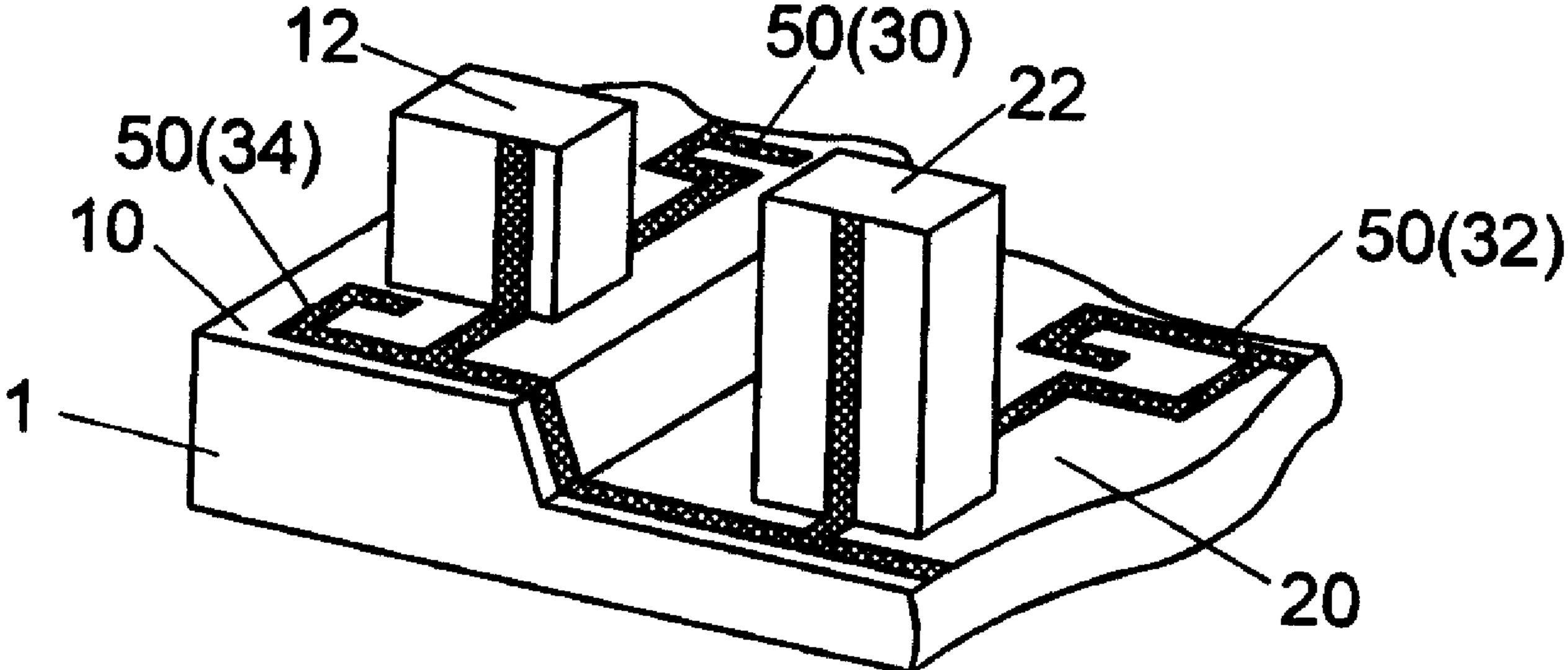


FIG. 21C
(PRIOR ART)



Marks & Clerk


12
50(30)
22
50(34)
10
50(32)
1
20