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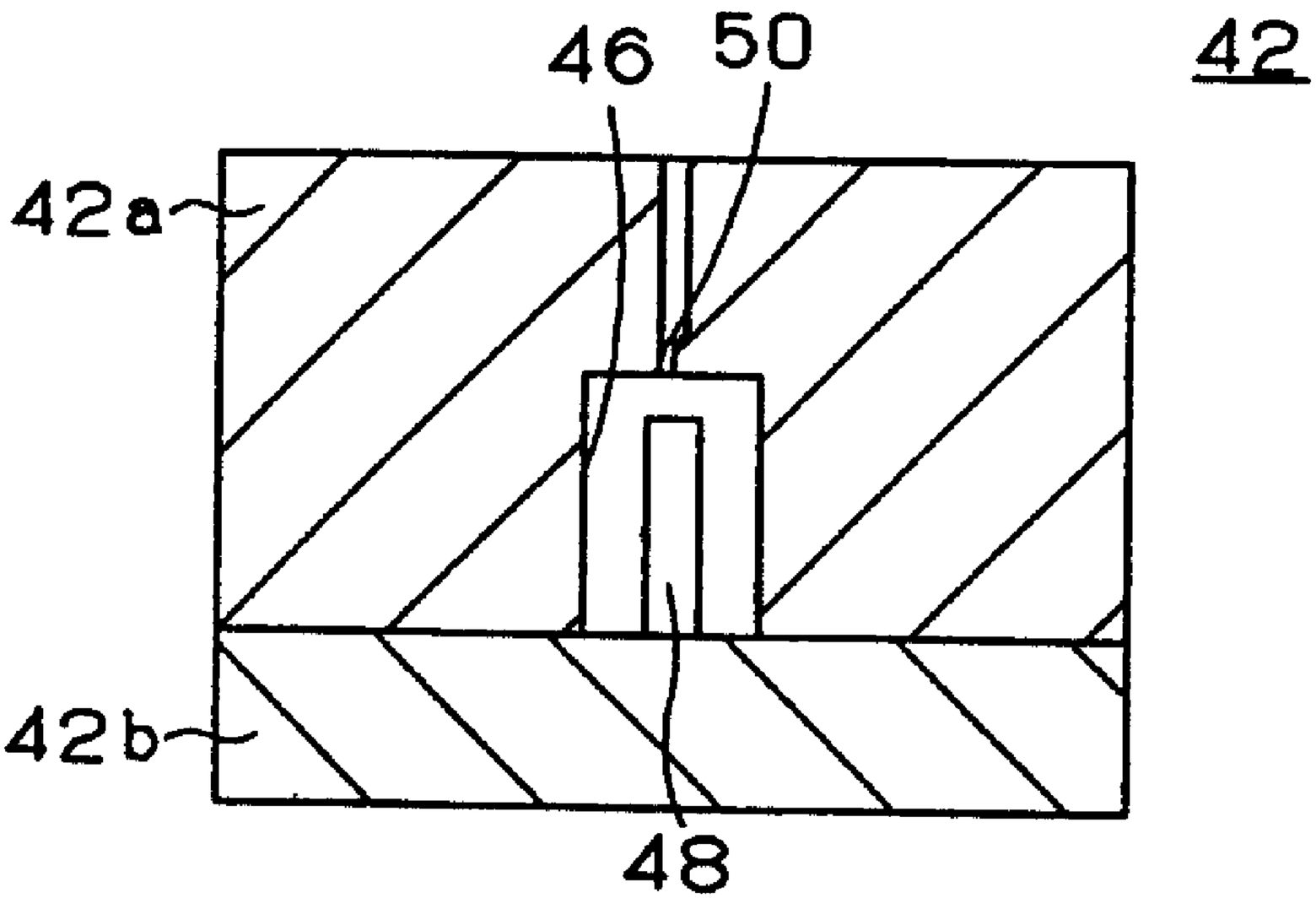


(57) Abrégé/Abstract:
The present invention is for providing a production method of a bead inductor, capable of preventing deformation of a metal coil or dislocation of the axis position of the metal coil by the injection pressure at the time of injecting a molten resin material from a gate. A coil is fitted onto a coil supporting pin provided on a first lower mold of a mold for injection molding in a cavity of the mold for injection molding such that the inner periphery of the coil is closely contacted with the coil supporting pin. A molten resin material is injected into the cavity. Then, the coil supporting pin and the first lower mold are taken out from the molded product, and a second lower mold without a coil supporting pin is provided for replacement. A molten resin material is injected into the space which has been occupied by the coil supporting pin. After removing the hardened resin molded product from the mold for injection molding, the end parts of the coil are cut so as to be exposed.

ABSTRACT OF THE DISCLOSURE

The present invention is for providing a production method of a bead inductor, capable of preventing deformation of a metal coil or dislocation of the axis position of the metal coil by the injection pressure at the time of injecting a molten resin material from a gate. A coil is fitted onto a coil supporting pin provided on a first lower mold of a mold for injection molding in a cavity of the mold for injection molding such that the inner periphery of the coil is closely contacted with the coil supporting pin. A molten resin material is injected into the cavity. Then, the coil supporting pin and the first lower mold are taken out from the molded product, and a second lower mold without a coil supporting pin is provided for replacement. A molten resin material is injected into the space which has been occupied by the coil supporting pin. After removing the hardened resin molded product from the mold for injection molding, the end parts of the coil are cut so as to be exposed.

METHOD OF PRODUCING INDUCTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a production method of an inductor, more specifically to a production method of a chip type inductor to be used as a part for coping with the noise of a microprocessor, or the like, which requires a heavy current.

2. Description of the Related Art

The official gazette of Japanese Unexamined Patent Publication No. 1-253906 discloses a production method of injection molding as an example of a conventional production

method of a chip type inductor. A metal coil 30 formed spirally is made with a metal conductor as shown in FIG. 1, and the metal coil 30 is set in a cavity 40 of a mold 38 for forming a resin molded product 34 shown in FIG. 2. At the time, the metal coil 30 is set inside the cavity 40 such that both ends of the spirally-wound metal coil 30 processed to be parallel with the axial direction, are forced onto the inside of the cavity 40 of the mold 38. Then, a molten resin containing magnetic powders is injected into the cavity 40 for forming the resin molded product 34. After hardening the injected resin, the resin molded product 34 is taken out from the cavity 40. Metal caps 36 are put onto both ends in the longitudinal direction of the resin molded product 34 for fixation. Both metal caps 36 and the corresponding end parts of the metal coil 30 are connected electrically with a conductive material so as to provide an inductor 32 having the metal caps 36 as an electrode as shown in FIG. 2. In the above-mentioned production method of an inductor by injection molding, only both end parts of the metal coil 30 are fixed with the mold 38 until the resin is injected into the cavity 40, with the middle part of the metal coil 30 unsupported in the cavity 40. Therefore, it involves a problem in the metal coil 30 deformation or the metal coil 30 dislocation with respect to the center in the cavity 40 due to the injection pressure at the time of

injecting the molten resin from the gate.

SUMMARY OF THE INVENTION

In light of the above-mentioned problems of the conventional production method, an object of an aspect of the present invention is to solve the above-mentioned problems of the metal coil deformation and the metal coil dislocation with respect to the axis due to the injection pressure at the time of injecting the molten resin from the gate. Furthermore, in an aspect, the present invention provides a production method of an inductor by injection molding, capable of producing a large number of inductors at one operation and improving the operation efficiency of the post production step.

A first aspect of a method of producing an inductor having a conductor coil embedded in a magnetic chip containing a magnetic material, with an external terminal electrode electrically connected with the conductor coil formed on the outer surface of the magnetic chip comprises the steps of holding the conductor coil in a cavity of a mold for injection molding by fitting the conductor coil to a coil supporting member provided in the cavity such that the coil supporting member contacts substantially the entire length of the conductor coil, conducting a primary injection molding by injecting a molten magnetic chip molding material into the cavity, conducting a secondary injection molding by removing the

coil supporting member from the cavity and injecting a molten magnetic chip molding material into the space in the cavity which has been occupied by the coil supporting member, taking out the molded product with the conductor coil embedded therein from the mold for injection molding, and cutting the molded product so as to expose the end parts of the embedded conductor coil.

A second aspect of a production method of an inductor having a conductor coil embedded in a magnetic chip containing a magnetic material, with an external terminal electrode electrically connected with the conductor coil formed on the outer surface of the magnetic chip comprises the steps of holding the conductor coil in a cavity of a coil supporting member such that the coil supporting member contacts substantially the entire length of the conductor coil, conducting a primary injection molding by injecting a molten magnetic chip molding material into the cavity of the coil supporting member, conducting a secondary injection molding by removing the molded product with the conductor coil embedded therein from the coil supporting member so as to be placed in the cavity of the mold for injection molding and injecting a molten magnetic chip molding material into the cavity of the mold for injection molding, taking out the molded product with the conductor coil embedded therein from the mold for injection molding, and cutting the molded product so as to expose the end parts of the embedded conductor coil.

According to the first and second aspects of a production method of an inductor, since the conductor coil is embedded in the magnetic chip by injection molding, a chip inductor can be produced easily. Besides, since the injection molding can be conducted with the conductor coil positioned and held by the coil supporting member in the cavity of the coil supporting member, the conductor coil can be embedded in a predetermined position in the molded product so as to enable the mass production of inductors with a homogeneous characteristic with a small proportion of the defective items. Moreover, since both ends of the molded product are cut after embedding the conductor coil in the magnetic chip, the ends of the embedded conductor coil can be exposed for certain.

A third aspect comprises the production method of an inductor according to the first or second aspect, wherein the conductor coil is held by the coil supporting member with at least one end part of the conductor coil temporarily attached with the conductor coil itself at the time of the primary injection molding.

According to the third aspect of a production method of an inductor, since at least one end part of the conductor coil is temporarily attached with the coil, the shape of the conductor coil itself can be maintained so that problems, such as the end of the conductor coil cannot be put through

the coil supporting member, since the end of the coil is bent inwardly, irregularity of the winding diameter of the conductor coil by the end of the conductor coil being released by the injection pressure of the molten molding material, and deterioration of the characteristics by the irregularity of the winding density, can be prevented so that generation of a defective product can be prevented.

A fourth aspect comprises the production method of an inductor according to the first, second or third aspect, wherein the end parts of the embedded conductor coils are exposed by cutting the molded product and the conductor coils are separated individually after obtaining a molded product with a plurality of the conductor coils insert-molded in the magnetic chip molding material by the primary injection molding and the secondary injection molding.

According to the fourth aspect of a production method of an inductor, since the molded product with a plurality of the conductor coils insert-molded can be obtained, the operation can be efficient as well as the mass productivity can be improved.

A fifth aspect comprises the production method of an inductor according to the first, second, third or fourth aspect, wherein the molded product is cut so as to divide

the conductor coil having a length for a plurality thereof into a length for one piece after obtaining a molded product with a conductor coil having a length for a plurality thereof embedded in the magnetic chip by the primary injection molding and the secondary injection molding.

According to the fifth aspect of a production method of an inductor, since the primary injection molding and the secondary injection molding are conducted, using a conductor coil having a length for a plurality thereof, a molded product with a plurality of the conductor coils insert-molded can be obtained in a multi-layer at one time so that the operation can be efficient as well as the mass productivity can be improved.

A sixth aspect comprises the production method of an inductor according to the fifth aspect, wherein a coil supporting member for holding the conductor coil having a length for a plurality thereof is provided in the primary injection molding, and a member for supporting the conductor coil fitted onto the coil supporting member or the coil supporting member is provided at a position to be the cutting margin of the molded product with the conductor coil embedded.

According to the sixth aspect of a production method of an inductor, since a member for supporting the conductor coil fitted onto the coil supporting member or the coil

supporting member is provided at a position to be the cutting margin of the molded product with the conductor coil embedded, bend of the coil supporting member or the dislocation of the coil supporting member can be prevented. Accordingly, the positioning accuracy of the conductor coil embedded in the molded product can be improved.

A seventh aspect comprises the production method of an inductor according to any of the first to sixth aspects, wherein a marking part for providing a mark of the position to be the cutting margin of the molded product on the outer surface of the molded product is provided on the inner surface of the cavity of the mold for injection molding.

According to the seventh aspect of a production method of an inductor, since the marking part is provided inside the cavity of the mold for injection molding, the target of the cutting position can be indicated so that the position to cut by the slicing machine or the dicing saw can be recognized easily for improving the operation efficiency as well as improving the size accuracy of the molded products.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a conventional mold to be used for the production of a chip type inductor;

FIG. 2 is a perspective view of a bead inductor produced with the mold shown in FIG. 1;

FIG. 3A is a cross-sectional view of a mold for injection molding to be used for the production method according to a first embodiment of the present invention; FIG. 3B is a cross-sectional view showing the state with a coil placed in the mold for injection molding shown in FIG. 3A; FIG. 3C is a cross-sectional view showing the state after the primary injection molding; and FIG. 3D is a cross-sectional view showing the state after the secondary injection molding;

FIG. 4A is a cross-sectional view for explaining the cutting position of a resin molded product according to the first embodiment of the present invention; and FIG. 4B is a cross-sectional view taken on the line A-A of FIG. 4A;

FIG. 5A is a cross-sectional view of a bead inductor produced by the production method according to the first embodiment of the present invention; and FIG. 5B is a side view of FIG. 5A;

FIG. 6A is a cross-sectional view showing the state at the time of the primary injection molding of a mold for injection molding to be used for the production method according to a second embodiment of the present invention; and FIG. 6B is a cross-sectional view showing the state at the time of the secondary injection molding of the mold;

FIG. 7 is a plan view showing a coil to be used in a third embodiment of the present invention;

FIG. 8 is a plan view showing a coil to be used in a fourth embodiment of the present invention;

FIG. 9 is a cross-sectional view of a mold for injection molding to be used for the production method according to a fifth embodiment of the present invention;

FIG. 10 is a perspective view for explaining the cutting position of a multi-injection molded product according to the fifth embodiment of the present invention;

FIG. 11A is a cross-sectional view of a mold for injection molding to be used for the production method according to a sixth embodiment of the present invention; and FIG. 11B is a cross-sectional view taken on the line B-B of FIG. 11A;

FIG. 12 is a perspective view for explaining the cutting position of a multi-injection molded product according to the sixth embodiment of the present invention; and

FIG. 13A is a cross-sectional view of a mold for injection molding to be used for the production method according to a seventh embodiment of the present invention; and FIG. 13B is a cross-sectional view taken on the line D-D of FIG. 13A.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the embodiments to be explained below, the case of

a bead inductor (chip type inductor) will be described as an example of inductors.

(First embodiment)

Hereinafter a production method of a bead inductor according to the first embodiment of the present invention will be described with reference to FIGS. 3A to 6B. The production method according to the present invention is by injection molding, but the configuration of an apparatus to be used in the injection molding method commonly used is not illustrated here.

As shown in FIG. 3A, a mold for injection molding 42 to be used in the production method of this embodiment comprises an upper mold 42a having a cavity 46 and a first lower mold 42b with a coil supporting pin 48 provided upright coaxially with respect to the cavity 46. A preliminarily produced coil 44 is fitted with the coil supporting pin 48 of the first lower mold 42b with the above-mentioned configuration (see FIG. 3B) such that the inner periphery of the coil 44 is closely contacted with the coil supporting pin 48. The coil 44 can be produced by, for example, winding a polyester coated copper line having a 0.8 mm diameter onto a shaft having a 1.8 mm shaft size (diameter) so as to be a coil, and cutting the same into a length including the cutting margin, such as 6 mm each. Then, the upper mold 42a is placed onto the first lower mold

42b so as to close the cavity 46. Pellets as magnetic chips are supplied from a hopper, or the like, of the injection molding apparatus into a heating cylinder so as to provide a molten resin or synthetic rubber containing magnetic powders (hereinafter referred to as a resin material). The pellets are prepared by kneading an Ni-Cu-Zn containing ferrite as a soft magnetic material in 88% by weight of a PPS (polyphenylene sulfide) resin as an insulating elastic material and forming the same into pellets. The resin material is injected into the cavity 46 via a gate 50 provided in the upper mold 42a in the direction parallel with the axial direction of the coil supporting pin 48. At the time, the resin material is charged into the space formed with the coil supporting pin 48 and the cavity 46 (primary injection molding). In the primary injection molding, a resin molded product 52 outside the coil 44 (yoke part) is formed. After hardening the resin molded product 52, the supporting pin 48 is taken out from the resin molded product 52 as well as the first lower mold 42b is detached from the upper mold 42a. Then, as shown in FIG. 3C, after providing a second lower mold 42c without a coil supporting pin 48 for replacement, the same resin material used in the primary injection molding is melted and injected into the space 54 of the resin molded product 52 with the upper mold 42a and the second lower mold 42c put together via the gate

56 of the second lower mold 42c (secondary injection molding). As shown in FIG. 3D, the resin molded product 52 (core part) is formed inside the coil 44 so that the coil 44 is inserted inside the resin molded product 52. After hardening the resin material injected in the secondary injection molding, the resin molded product 52 molded integrally by the primary injection molding and the secondary injection molding is taken out from the cavity 46. The resin molded product 52 having the shape as shown in FIGS. 4A and 4B, taken out from the mold for injection molding 42 is cut at both ends in the longitudinal direction at the cutting positions C-C marked with the chained lines in FIG. 4A by a dicing saw so as to have about 4.3 mm length. By the cutting operation, both ends of the coil 44 are exposed on the cut end face of the resin molded product 52. As shown in FIGs. 5A and 5B, both end faces of the resin molded product 52 with the end parts of the coil 44 exposed are press-fitted into metal caps 58 as external terminals. By spot-welding the end parts of the coil 44 and the metal caps 58 over the metal caps 58, the coil 44 and the metal caps 58 are connected electrically so as to provide a bead inductor 60.

According to the production method of the bead inductor 60 of this embodiment, since the coil 44 is held at the center position of the cavity while closely fitting with

the coil supporting pin 48 provided upright in the lower mold 42b at the time of the injection molding, the coil 44 can be inserted at the targeted position (designed position) without the risk of the deformation or crush of the coil 44 or dislocation of the axis position of the coil 44 at the time of injecting the molten resin material from the gate 50. Therefore, in producing a bead inductor 60 by the injection molding method, unlike the conventional examples, defective products are not liable to generate so that the proportion of the good items can be improved in the inductor production. Moreover, since both ends of the resin molded product 52 are cut after inserting the coil 44, both ends of the coil 44 can be exposed at both end faces of the resin molded product 52 for certain, and thus the electric conduction between the coil 44 and the metal caps 58 can be ensured.

(Second embodiment)

A production method of an inductor according to another embodiment of the present invention will be explained. As shown in FIG. 6A, a mold for injection molding 62 to be used in this production method comprises a first lower mold 62b having a cavity 64 as a coil supporting member, a second lower mold 62c having a cavity 66 for forming the yoke part of the resin molded product 52, provided capable of storing the first lower mold 62b, and an upper mold 62a having a gate 68 for injecting a molten resin

material into the cavity 64, to be superimposed onto the first lower mold 62b.

With the first lower mold 62b with the above-mentioned configuration stored in the cavity 66 of the second lower mold 62c, the coil 44 is inserted into the cavity 64 of the first lower mold 62b such that the outer periphery of the coil 44 is closely contacted with the inner wall surface of the cavity 64. Then, as shown in FIG. 6A, the upper mold 62a is placed onto the first lower mold 62b so as to close the cavity 64. A molten resin material is charged into the cavity 64 of the first lower mold 62b via the gate 68. According to the primary injection molding, the resin molded product 52 of the core part of the coil 44 is formed, and the coil 44 is embedded in the outer periphery part of the resin molded product 52. After hardening the resin molded product 52, the first lower mold 62b and the upper mold 62a are detached. After removing the first lower mold 62b, the upper mold 62a is placed onto the second lower mold 62c so as to close the cavity 66 as shown in FIG. 6B. At the time, the axial center of the resin molded product 52 held by the lower surface of the upper mold 62a and the center of the cavity 66 are arranged coaxially. A molten resin material is charged into the cavity 66 of the second lower mold 62c from a gate 70. In the secondary injection molding, the resin molded product 52 of the yoke part of the coil 44 is

formed. When the resin material injected in the injection molding is hardened, it is integrated with the resin molded product 52 of the core part formed by the former injection molding. The integrated resin molded product 52 is taken out from the upper mold 62a and the second lower mold 62c. The resin molded product 52 accordingly formed is cut and attached with the metal caps so as to provide a bead inductor 60 as in the above-mentioned embodiment (see FIG. 5). The first lower mold 62b and the second lower mold 62c need not be provided as an insert die as shown in FIG. 6A, but can be used independently. However, since the second embodiment involves a risk of the collapse of the coil 44 inward at the time of injecting the resin, the first embodiment is superior thereto for not having the risk.

(Third embodiment)

A production method of a bead inductor according to the third embodiment of the present invention will be explained with reference to FIG. 7. Members the same as those of the above-mentioned first embodiment are applied with the same numerals and further explanation is not provided.

In the above-mentioned first embodiment, the ends of the coil 44 are not deformed by the injection pressure of the molten resin material as long as the coil 44 has a line diameter size capable of maintaining the coil 44 shape.

However, the coil itself can hardly maintain the shape if it has a small line diameter. Therefore, the risk of generating defective items is involved in that the ends of the coil are released in the pre step of mounting the coil 44 onto the coil supporting pin 48 so that the coil 44 cannot be fitted onto the coil supporting pin 48, and that the end parts of the coil are deformed or the diameter of the coil is expanded by the injection pressure of the molten resin material at the time of the primary injection molding. In the third embodiment, a production method capable of solving the problems in producing a bead inductor with a small diameter coil, not capable of maintaining the coil shape, will be described.

In this embodiment, before bonding a coil 72 to the coil supporting pin 48, a solder 74 is adhered onto at least one end part of the coil 72 as shown in FIG. 7. Since, in general, the molten resin material is injected from the gate of the upper mold 42a (see FIG. 3) along the axial direction of the coil supporting pin 48, only one end part of the coil 72 in the vicinity of the tip of the coil supporting pin 48 needs to be soldered. However, in the case of mounting the coil 72 onto the coil supporting pin 48 by an automatic inserting device, since the coil 72 tends to have an orientation at the time of mounting the coil 72 to the supporting pin 48, the orientation of coils needs to be

arranged in order at the time of setting the coils in a part feeder of the automatic inserting device, and thus it requires labor. Therefore, in consideration of the operativity, it is preferable to adhere a solder at both end parts of the coil 72. Moreover, the part of the coil 72 to adhere the solder is preferably in a range of at least one round from the end part in consideration of the bonding strength. By fitting the coil 72 with the solder 74 accordingly adhered onto the end part, onto the coil supporting pin 48, placing the upper mold 42a onto the first lower mold 42b having the upright coil supporting pin 48, then as in the first embodiment, forming the resin molded product 52, cutting the resin molded product 52, press-fitting the metal caps 58, and electrically connecting the coil 72 and the metal caps 58, a bead inductor 60 can be provided.

According to the above-mentioned third embodiment, since the coil 72 is bonded with the solder 74, problems such as difficulty in maintaining the shape of the coil itself due to a narrow line diameter of the coil, and expansion of the coil diameter or the bend of the ends of the coil inward so as to prevent fitting with the pin caused by the release of the ends of the coil by the injection pressure of the molten resin material can be solved, and thus generation of defective items can be prevented.

Furthermore, since the coil 72 is bonded with the solder 74, if the solder 74 is applied beyond the cutting margin in electrically connecting the metal caps 58 as the external terminals and the coil 72 with the solder 74, since the solder 74 remained on the coil 72 after cutting is melted again, the solder can be provided sufficiently to the metal caps 58 and the coil 72 for ensuring the soldering, and thus the reliability can be improved.

(Fourth embodiment)

In the case of using a coil with a fine line diameter, not capable of maintaining the shape even if both ends are attached with the solder 74 as in the coil 72 shown in FIG. 7, a risk is involved in that the wound line interval may be expanded not only in the ends of the coil, but also in the middle part thereof so as to have the irregularity in the winding density of the coil. Therefore, in the embodiment shown in FIG. 8, the entirety of a coil 76 is bonded by a resin 78, such as an adhesive, or the like. By fitting the coil 76 bonded with the resin 78 in the entire length accordingly onto the coil supporting pin 48, placing the upper mold 42a onto the first lower mold 42b having the upright coil supporting pin 48, then as in the first embodiment, forming the resin molded product 52, cutting the resin molded product 52, press-fitting the metal caps 58, and electrically connecting the coil 76 and the metal caps

58, a bead inductor 60 can be provided.

According to the above-mentioned fourth embodiment, since the coil 76 is bonded in the entire length with the resin 78, problems such as difficulty in maintaining the shape of the coil itself due to a narrow line diameter of the coil, and expansion of the coil diameter or the bend of the ends of the coil inward so as to prevent fitting with the pin caused by the release of the ends of the coil by the injection pressure of the molten resin material, or a problem of changing the characteristics due to the irregularity of the winding density of the coil can be solved, and thus generation of defective items can be prevented. Furthermore, by soldering both end parts of the coil 76 as in the above-mentioned embodiment in addition to bonding the coil 76 with the resin 78, the effects the same as the third embodiment can also be achieved.

(Fifth embodiment)

A production method of a bead inductor according to the fifth embodiment of the present invention will be described with reference to FIGS. 9 and 10. Members the same as those of the above-mentioned embodiments are applied with the same numerals and further explanation is not provided.

In this embodiment, a multi-injection molded product 84 comprising a plurality of the resin molded products 52 is

injection-molded. After cutting the end parts of the multi-injection molded product 84, it is divided into individual resin molded products 52. Compared with the case of cutting the end parts of each resin molded product 52 after dividing into the individual resin molded products 52, the cutting step can be simplified.

As shown in FIG. 9, a mold for injection molding 80 to be used in the production method of this embodiment comprises an upper mold 80a having a cavity 82 and a first lower mold 80b, with the upper surface of the first lower mold 80b provided with a plurality of the upright coil supporting pins 48 with the axial direction thereof parallel with each other, corresponding with the cavity 82. To each of the coil supporting pins 48 of the first lower mold 80b with the above-mentioned configuration, either of the coils 44, 72, 76 used in the first to the fourth embodiments is closely fitted. Then, the upper mold 80a is placed onto the first lower mold 80b. Then, by conducting the primary injection molding and the secondary injection molding, the multi-injection molded product 84 shown in FIG. 10 can be produced. The produced multi-injection molded product 84 is cut by a slicing machine at the cutting positions C1 shown by the chain lines in the vicinity of the upper and lower end faces in FIG. 10 for exposing both ends of the coils 44, 72, 76. Both ends of the coils 44, 72, 76 are exposed on

the cut upper and lower end faces of the multi-injection molded product 84 by cutting. Then, in order to divide the multi-injection molded product 84 into a plurality of the resin molded products 52, it is cut by a dicing saw at the cutting positions C2 shown by the chain lines to provide the individual resin molded products 52. As in the above-mentioned embodiments, both end parts of the resin molded products 52 are press-fitted with the metal caps 58, and furthermore, the coils 44, 72, 76 and the metal caps 58 are connected electrically so as to provide bead inductors 60.

According to the production method of a bead inductor of this embodiment, since a plurality of the resin molded products 52 can be produced with one mold for injection molding 80, the production step can be efficient and the mass productivity can be improved. Moreover, as to the cutting step, since both end parts of a plurality of the coils can be exposed at one operation, the number of operations can be reduced.

(Sixth embodiment)

Hereinafter a production method of a bead inductor according to the sixth embodiment of the present invention will be explained with reference to FIGS. 11 and 12. Members the same as those of the above-mentioned embodiments are applied with the same numerals and further explanation is not provided.

In this embodiment, a multi-layer multi-injection molded product 90 with a configuration wherein the multi-injection molded product 84 produced in the fifth embodiment is laminated in layers is formed so as to further improve the mass productivity including the efficiency in the cutting step as a post step.

As shown in FIG. 11, a mold for injection molding 86 to be used in the production method of this embodiment comprises an upper mold 86a having a cavity 88 and a first lower mold 86b with a plurality of upright coil supporting pins 92 provided with the axial direction thereof parallel with each other, corresponding with the cavity 88. The coil supporting pins 92 have a length sufficient for supporting a long coil 44, 72, 76 having a length for a plurality thereof while being fitted with the long coil 44, 72, 76. The coils 44, 72, 76 are fitted onto each of the coil supporting pins 94 of the first lower mold 86b with the above-mentioned configuration. As shown in FIG. 11A, by placing the upper mold 86a onto the first lower mold 86b, and conducting the primary injection molding and the secondary injection molding, the multi-layer multi-injection molded product 90 as shown in FIG. 12 is produced. The produced multi-layer multi-injection molded product 90 is cut by a slicing machine at the cutting positions C3 shown by the chain lines in the vicinity of the upper and lower end faces and

parallel with the upper and lower end faces at the center part in the longitudinal direction in FIG. 12 into individual multi-injection molded products 84 having about 4.3 mm length for exposing both ends of the coils 44, 72, 76. According to the cutting operation, both ends of the coils 44, 72, 76 are exposed on the cut end faces of the multi-injection molded products 84 formed in each layer. In order to divide the plurality of the multi-injection molded products 84 into individual resin molded products 52, they are cut by a dicing saw at the cutting positions C4 shown by the chain lines. Then, as in the above-mentioned embodiments, the resin molded products 52 are press-fitted with the metal caps 58, and the coils 44, 72, 76 and the metal caps 58 are connected electrically so as to provide bead inductors 60. If the diameter of the coil supporting pins 92 is small, the coil supporting pins 92 may be bent by the injection pressure at the time of injecting the molten resin material, resulting in generation of defective items of the resin molded products 52. In this case, in order to prevent the bend or dislocation of the coil supporting pins 92, pin supporting members 94 can be provided horizontally in the cavity 88 at the positions of cutting the coils 44, 72, 76 and the resin molded products 52 as shown in FIG. 11B. The pin supporting members 94 are provided with a large number of comparatively large openings 96 for allowing the

smooth passage of the resin without weakening the injection property of the resin. Furthermore, gaps 98 are provided between the coil supporting pins 92 and the pin supporting members 94 for fitting the coils 44, 72, 76 so that the coil supporting pins 92 are supported by the pin supporting members 94 via the coils 44, 72, 76 fitted in the gaps 98. The pin supporting members 94 are disposed at a position corresponding with the area to be cut for exposing the end parts of the coils 44, 72, 76. At the time of cutting out the multi-injection molded products 84, the multi-layer multi-injection molded product 90 is cut at the upper and lower cutting positions C3 interposing the pin supporting members 94 so as to eliminate the pin supporting members 94 as shown in FIG. 12.

According to the production method of a bead inductor of this embodiment, since a plurality of the resin molded products 52 can be produced in multi-layers with one mold for injection molding 86, the production step can further be efficient and the mass productivity can be improved compared with the third embodiment. Moreover, as to the cutting step, since both end parts of the coils can be exposed in one operation, the operation can be efficient. Furthermore, by providing the pin supporting members 94 for preventing the bend and the dislocation of the coil supporting pins 92 and the dislocation of the coils 44, 72, 76, the positioning

accuracy of the coils 44, 72, 76 can be improved.

(Seventh embodiment)

Hereinafter a production method of a bead inductor according to the seventh embodiment of the present invention will be described with reference to FIG. 13. Members the same as those of the above-mentioned embodiments are applied with the same numerals and further explanation is not provided.

In this embodiment, in producing a plurality of the resin molded products 52 in one injection molding as in the above-mentioned third and fourth embodiments, a marker is provided for indicating the cutting position for improving the operation efficiency in the cutting step and improving the size accuracy of each resin molded product 52. Explanation will be given in this embodiment based on the mold for injection molding 80 of the third embodiment shown in FIG. 9.

According to the production method of this embodiment, as shown in FIG. 13, projections 100 are provided as the marking parts at a position to be the cutting margin, corresponding with the cutting position on the inner periphery surface of the cavity 82 of the upper mold 80a. Therefore, grooves (not illustrated) are formed at a part corresponding with the cutting position in a multi-injection molded product 84 injection-molded with the upper mold 80a.

According to the production method of the above-mentioned embodiment, since the grooves are formed in the multi-injection molded product 84 so as to indicate the target of the cutting position, a slicing machine or a dicing saw can be positioned easily in the cutting step so as to improve the operation efficiency and the size accuracy of each resin molded product 52.

Although projections 100 are provided on the wall surface of the cavity 82 of the upper mold 80a in this embodiment, it is not limited thereto but a groove, or anything to serve as a marker for indicating the cutting position on the multi-injection molded product 84 can be provided instead.

WHAT IS CLAIMED IS:

1. A production method of an inductor having a conductor coil embedded in a magnetic chip containing a magnetic material, with an external terminal electrode electrically connected with the conductor coil formed on the outer surface of the magnetic chip comprises the steps of:

holding the conductor coil in a cavity of a mold for injection molding by fitting the conductor coil to a coil supporting member provided in the cavity such that the coil supporting member contacts substantially the entire length of the conductor coil;

conducting a primary injection molding by injecting a molten magnetic chip molding material into the cavity;

conducting a secondary injection molding by removing the coil supporting member from the cavity and injecting a molten magnetic chip molding material into the space in the cavity which has been occupied by the coil supporting member;

taking out the molded product with the conductor coil embedded therein from the mold for injection molding; and

cutting the molded product so as to expose the end parts of the embedded conductor coil.

2. A production method of an inductor having a conductor coil embedded in a magnetic chip containing a magnetic material, with an external terminal electrode electrically connected with the conductor coil formed on the

outer surface of the magnetic chip comprises the steps of:

holding the conductor coil in a cavity of a coil supporting member such that the coil supporting member contacts substantially the entire length of the conductor coil;

conducting a primary injection molding by injecting a molten magnetic chip molding material into the cavity of the coil supporting member;

conducting a secondary injection molding by removing the molded product with the conductor coil embedded therein from the coil supporting member so as to be placed in the cavity of the mold for injection molding and injecting a molten magnetic chip molding material into the cavity of the mold for injection molding;

taking out the molded product with the conductor embedded therein from the mold for injection molding; and

cutting the molded product so as to expose the end parts of the embedded conductor coil.

3. The production method of an inductor according to claim 1 or 2, wherein the conductor coil is held by the coil supporting member with at least one end part of the conductor coil temporarily attached with the conductor coil itself at the time of the primary injection molding.

4. The production method of an inductor according to claim 1, 2 or 3, wherein the end parts of the embedded

conductor coils are exposed by cutting the molded product and the conductor coils are separated individually after obtaining a molded product with a plurality of the conductor coils insert-molded in the magnetic chip molding material by the primary injection molding and the secondary injection molding.

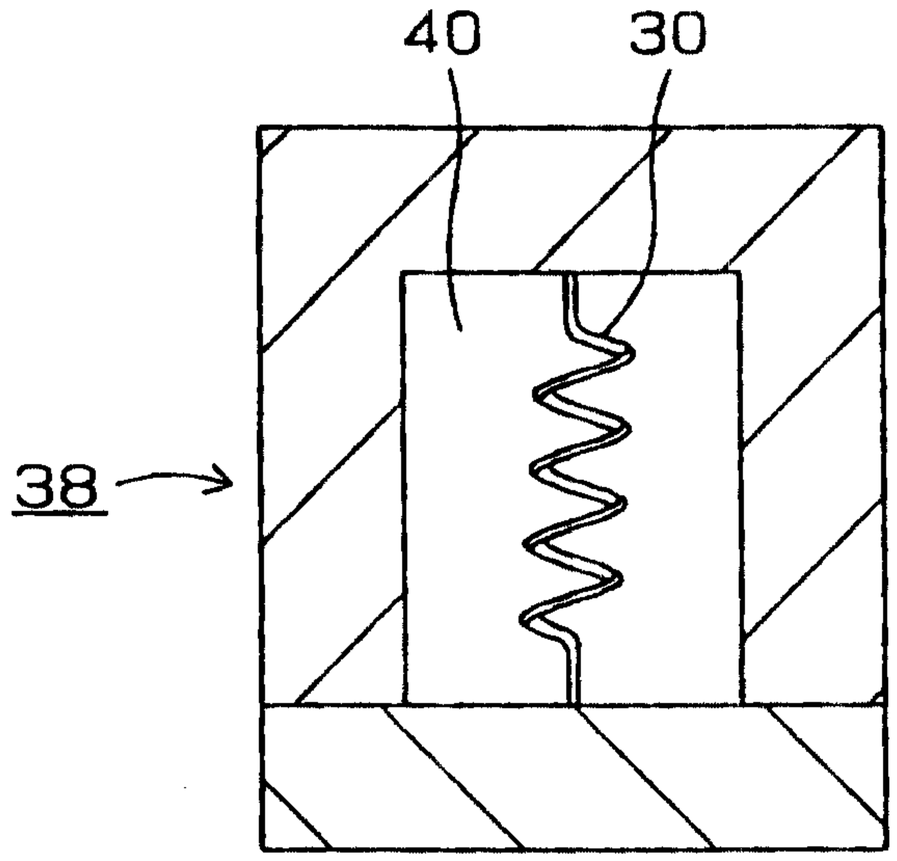
5. The production method of an inductor according to claim 1, 2, 3 or 4, wherein the molded product is cut so as to divide the conductor coil having a length for a plurality thereof into a length for one piece after obtaining a molded product with a conductor coil having a length for a plurality thereof embedded in the magnetic chip by the primary injection molding and the secondary injection molding.

6. The production method of an inductor according to claim 5, wherein a coil supporting member for holding the conductor coil having a length for a plurality thereof is provided in the primary injection molding, and

a member for supporting the conductor coil fitted onto the coil supporting member or the coil supporting member is provided at a position to be the cutting margin of the molded product with the conductor coil embedded.

7. The production method of an inductor according to any of claims 1 to 6, wherein a marking part for providing a mark of the position to be the cutting margin of the molded product on the outer surface of the molded product is provided on the inner surface of the cavity of the mold for injection molding.

FIG. 1



"PRIOR ART"

FIG. 2

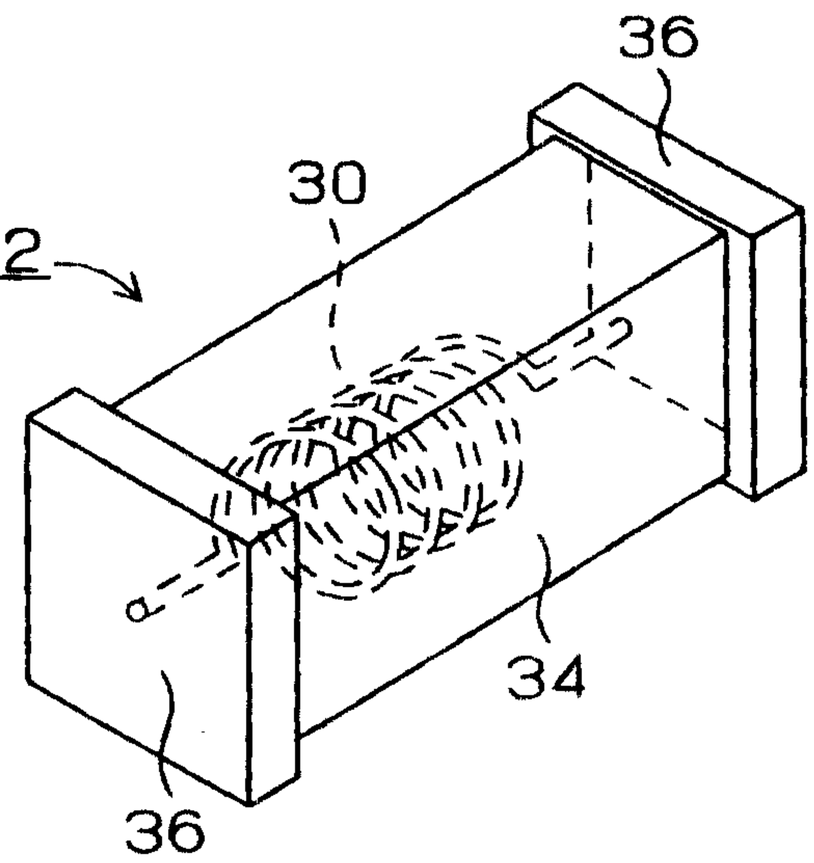


FIG. 3A

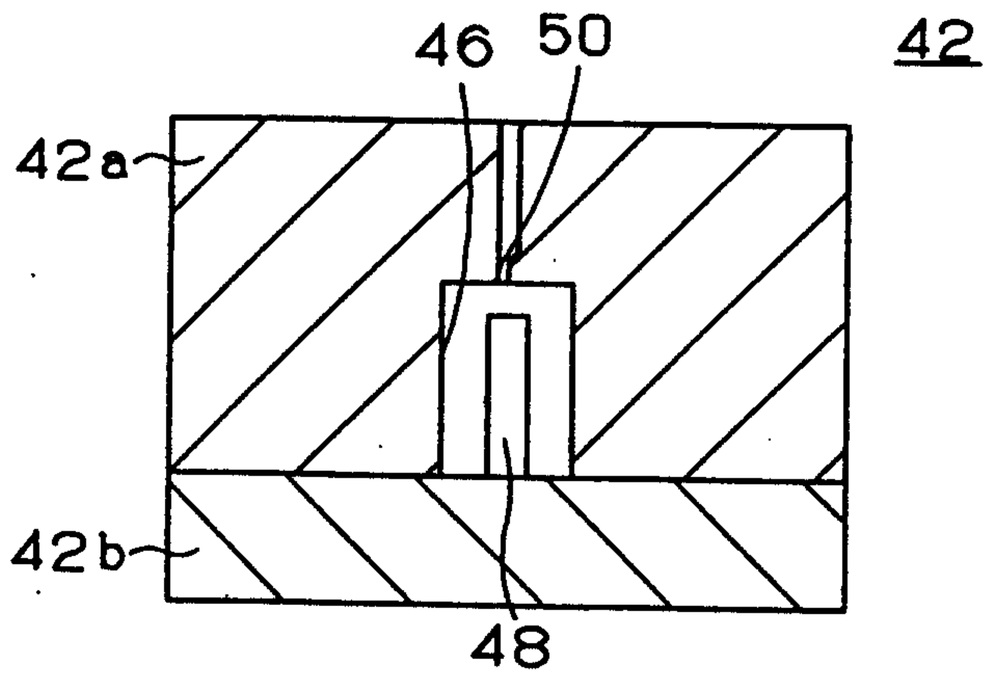


FIG. 3B

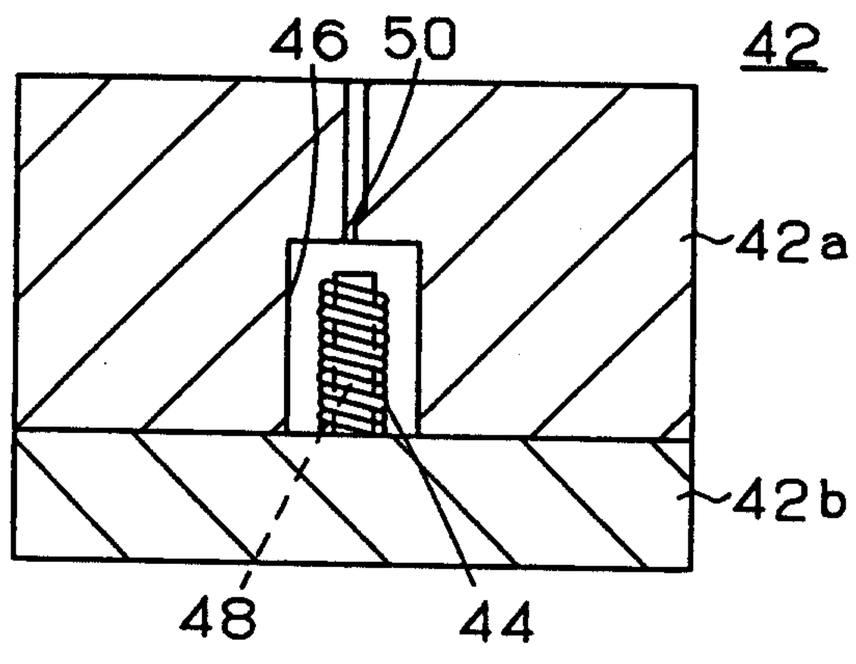


FIG. 3C

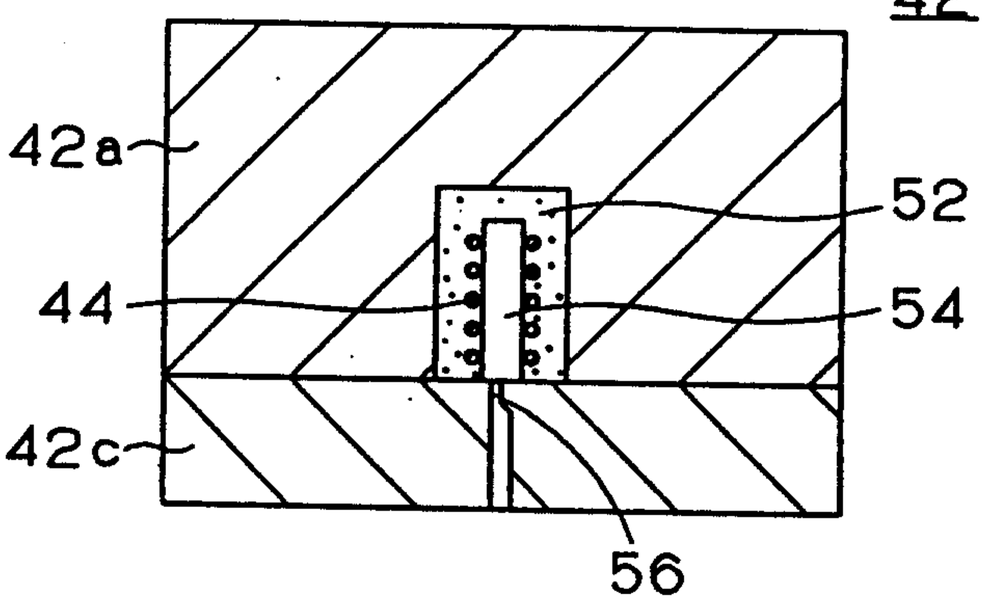


FIG. 3D

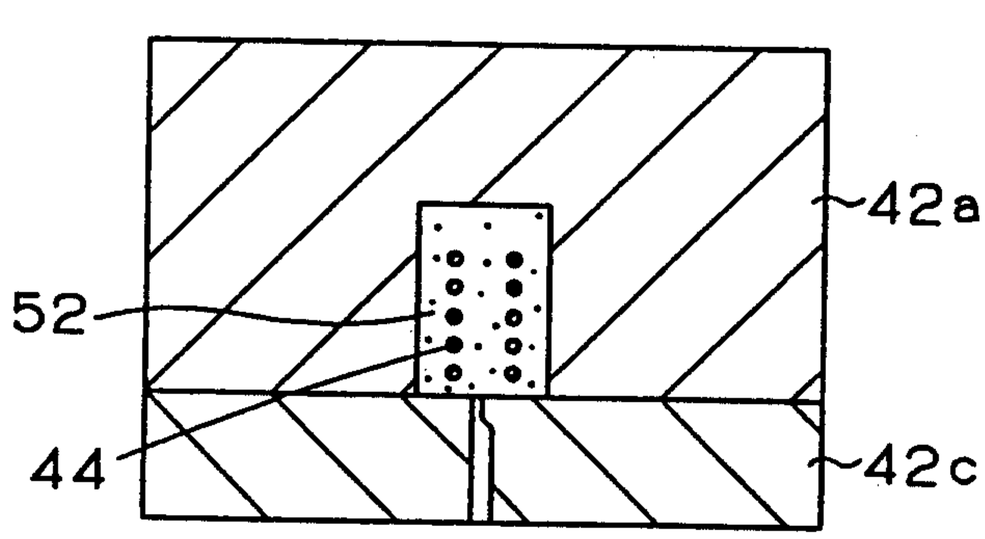


FIG. 4A

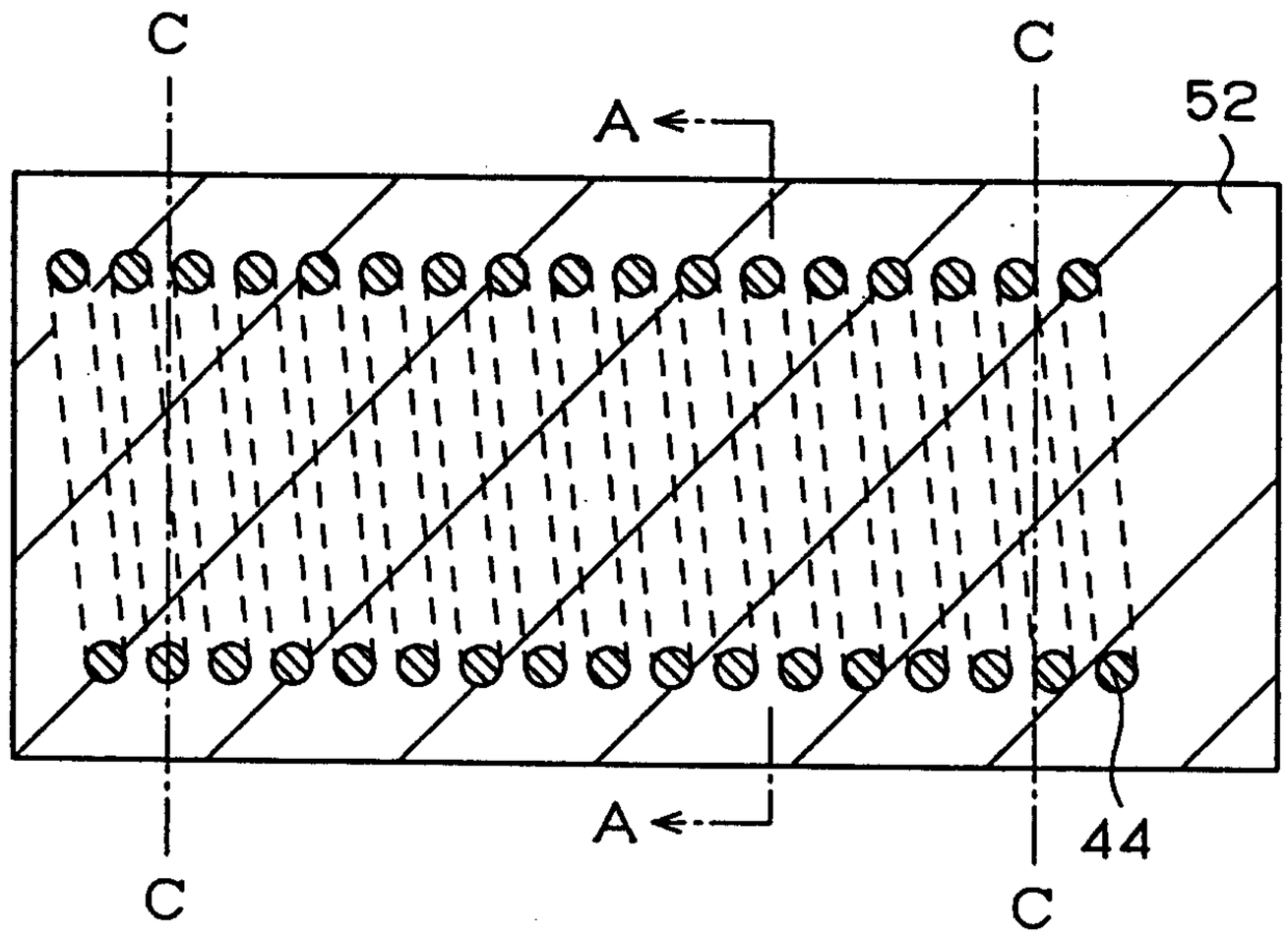


FIG. 4B

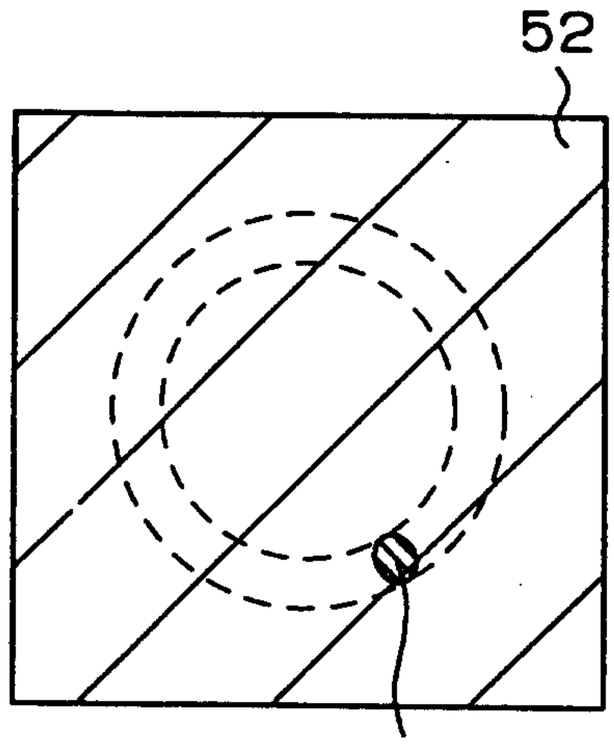


FIG. 5A

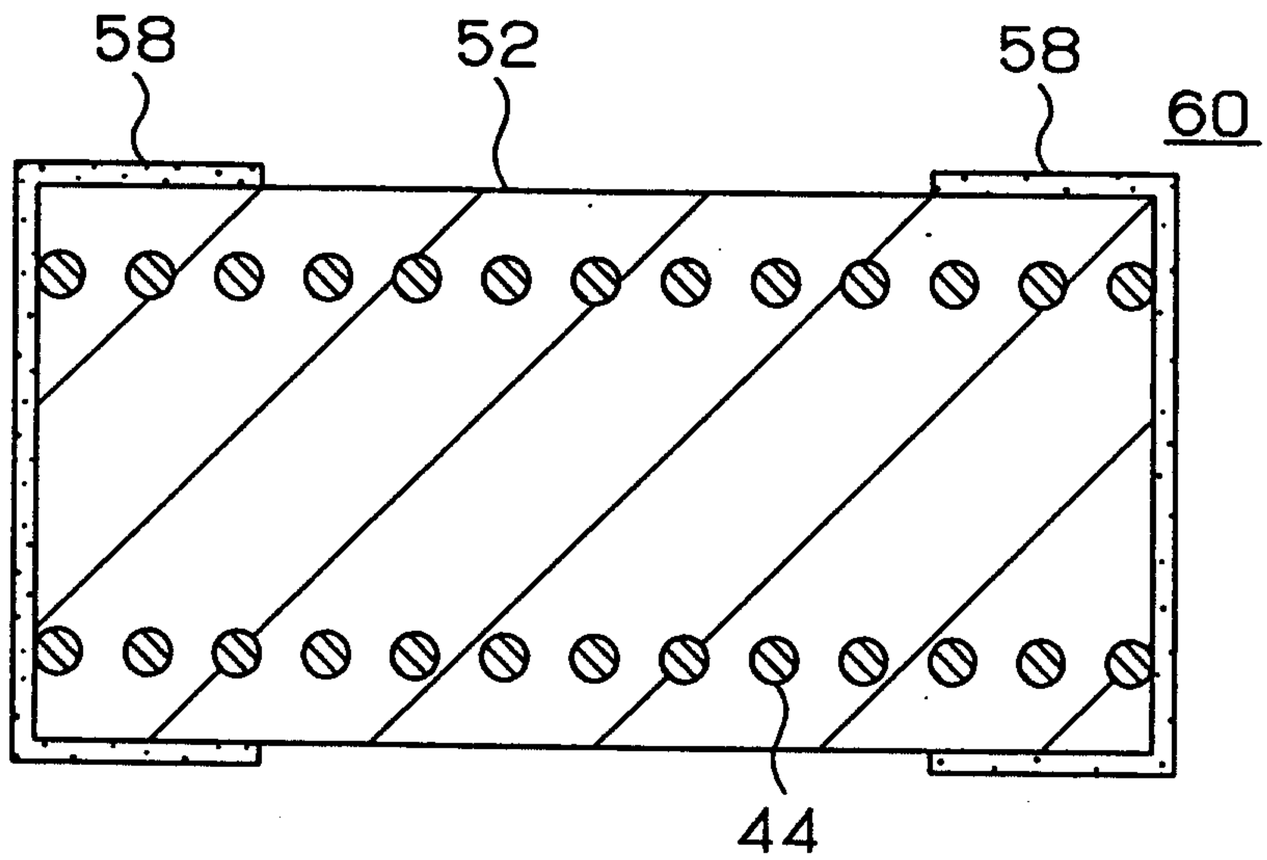


FIG. 5B

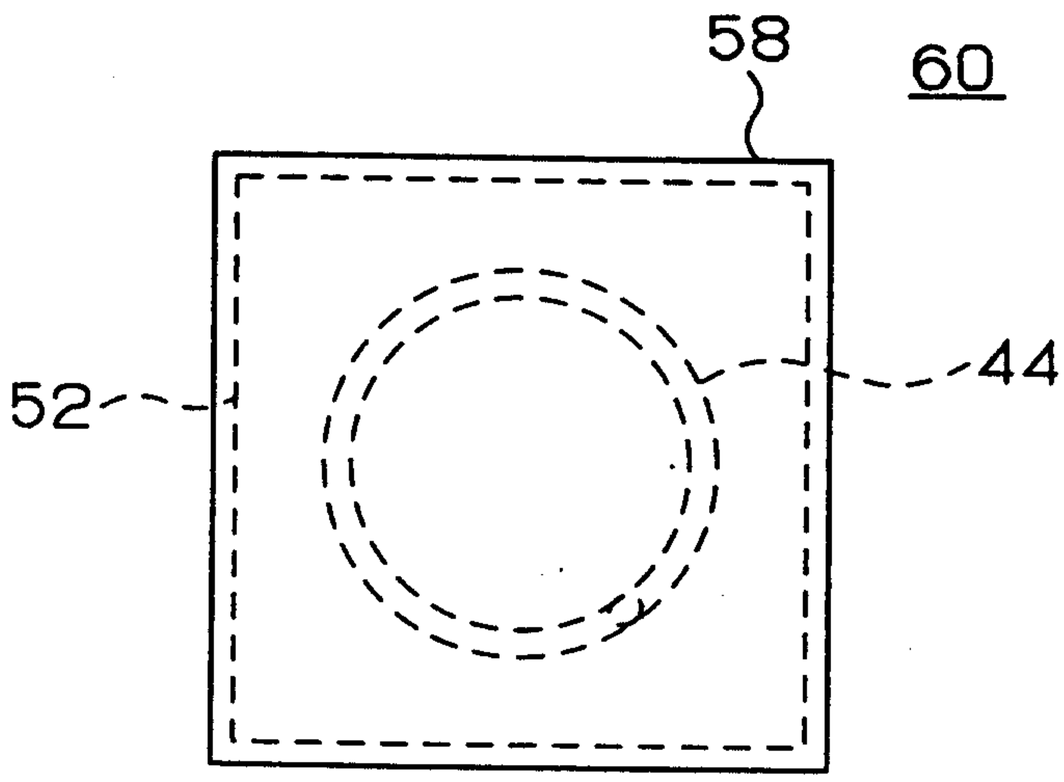


FIG. 6A

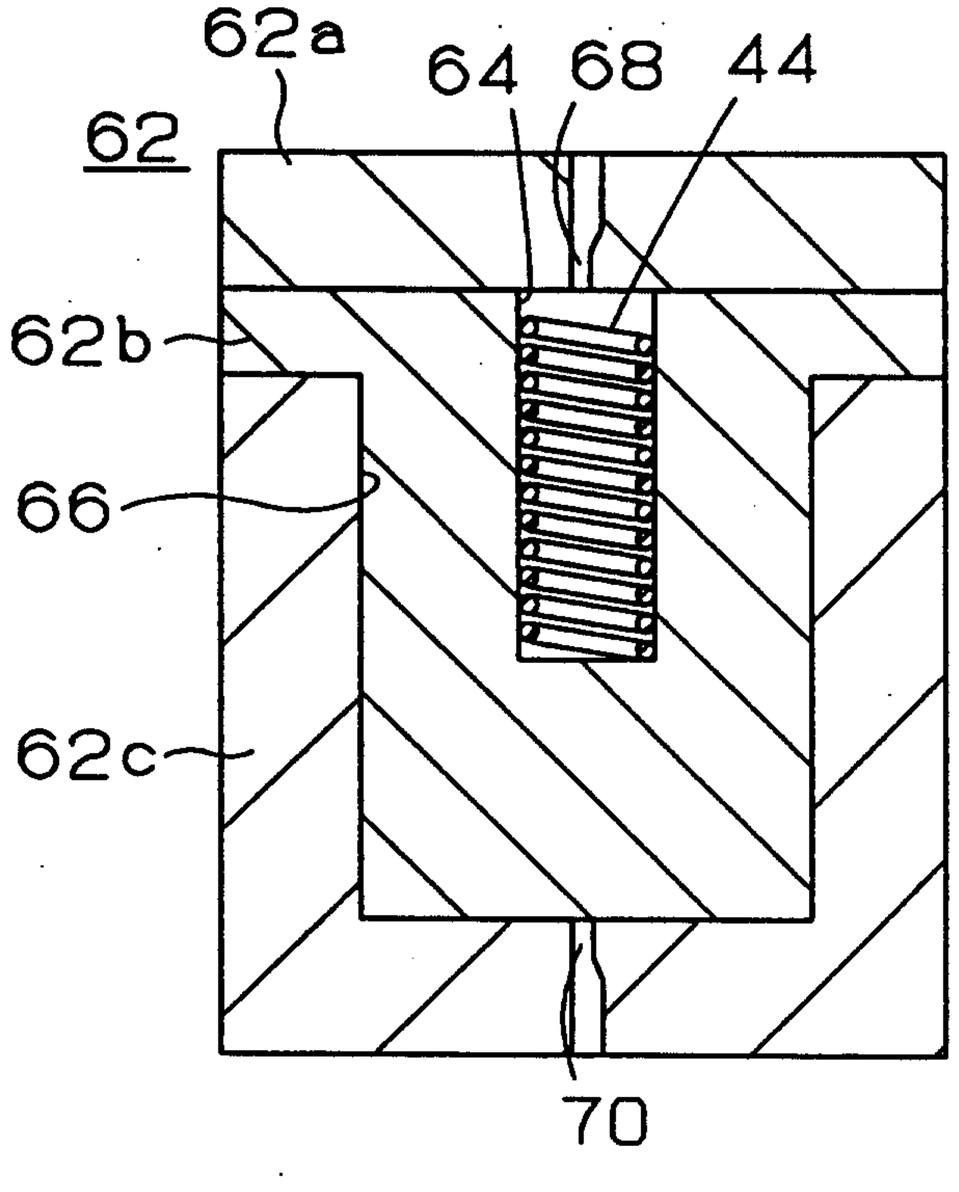


FIG. 6B

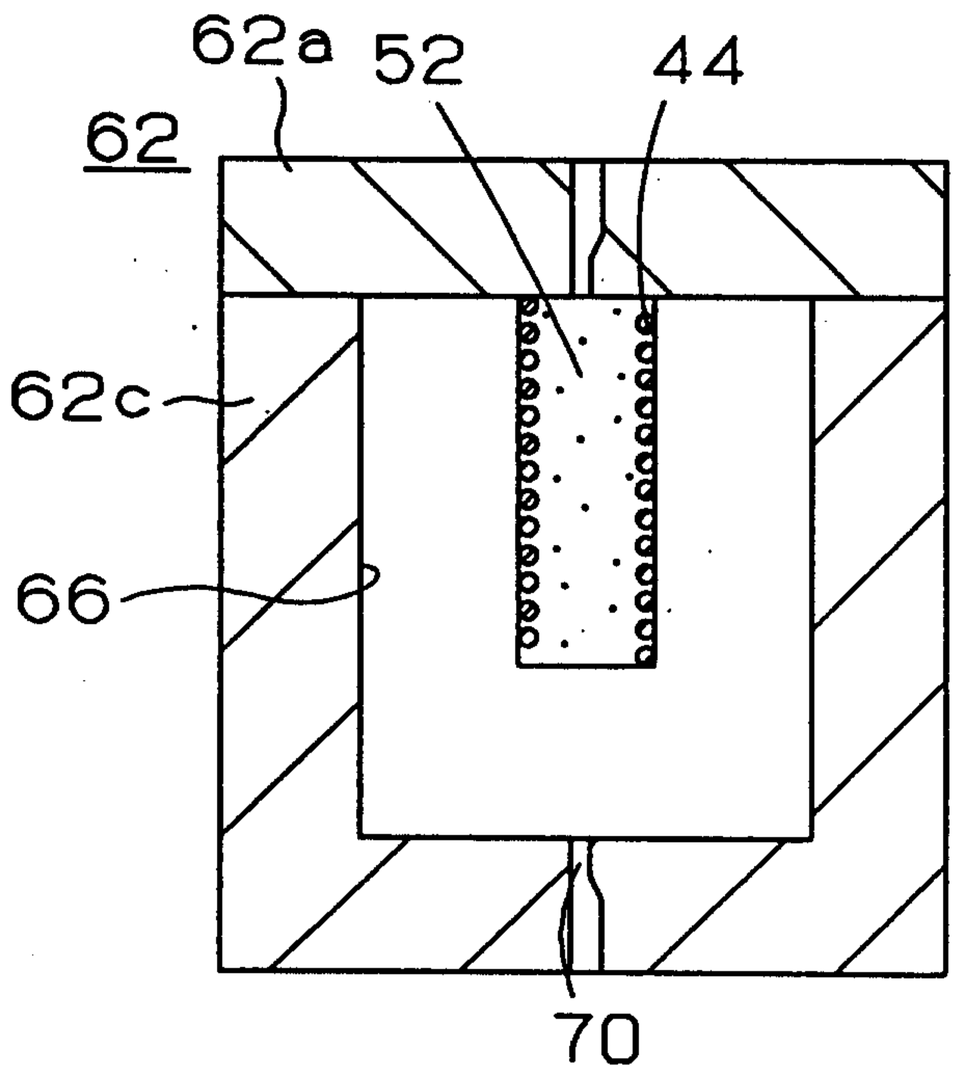


FIG. 7

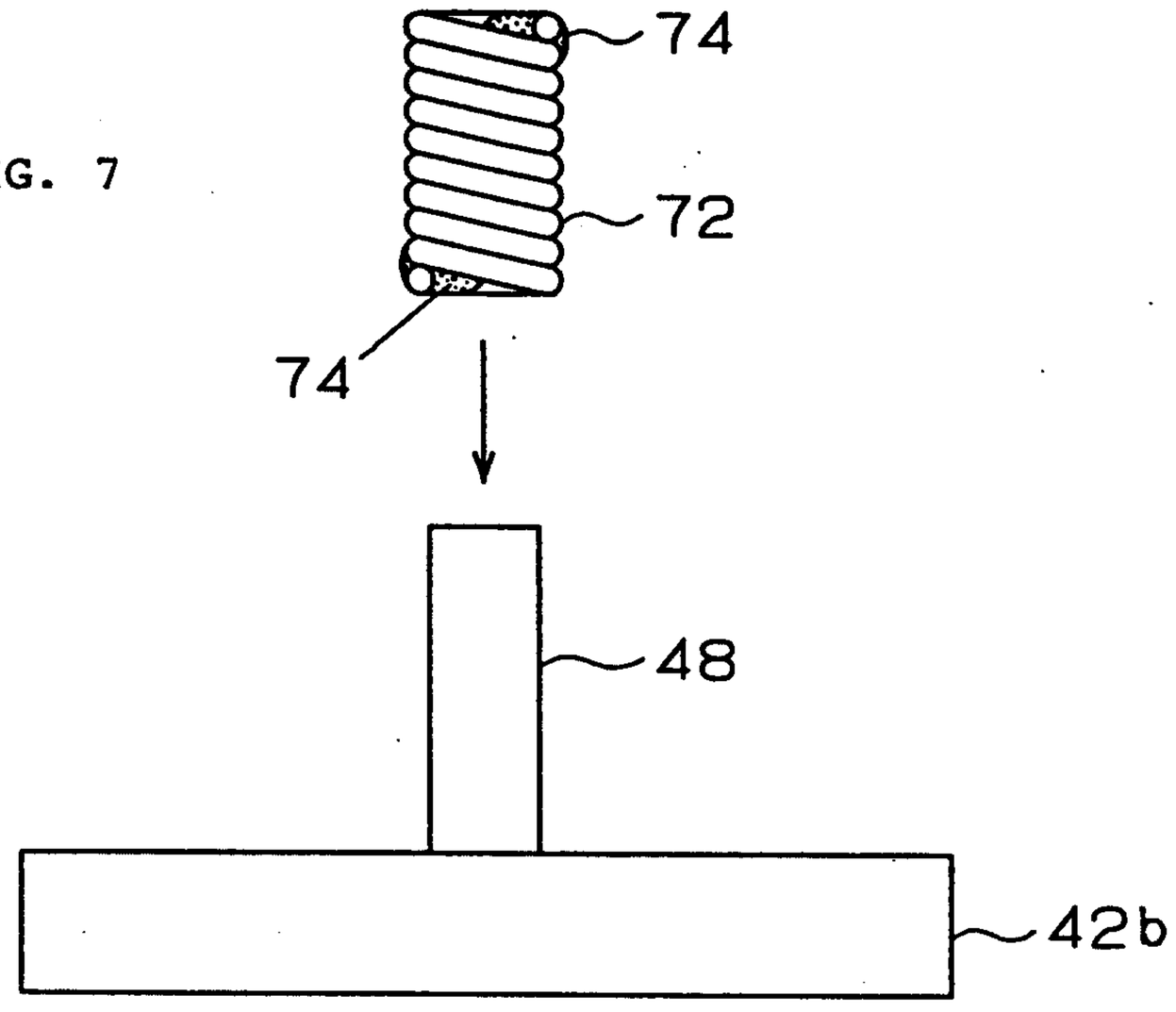


FIG. 8

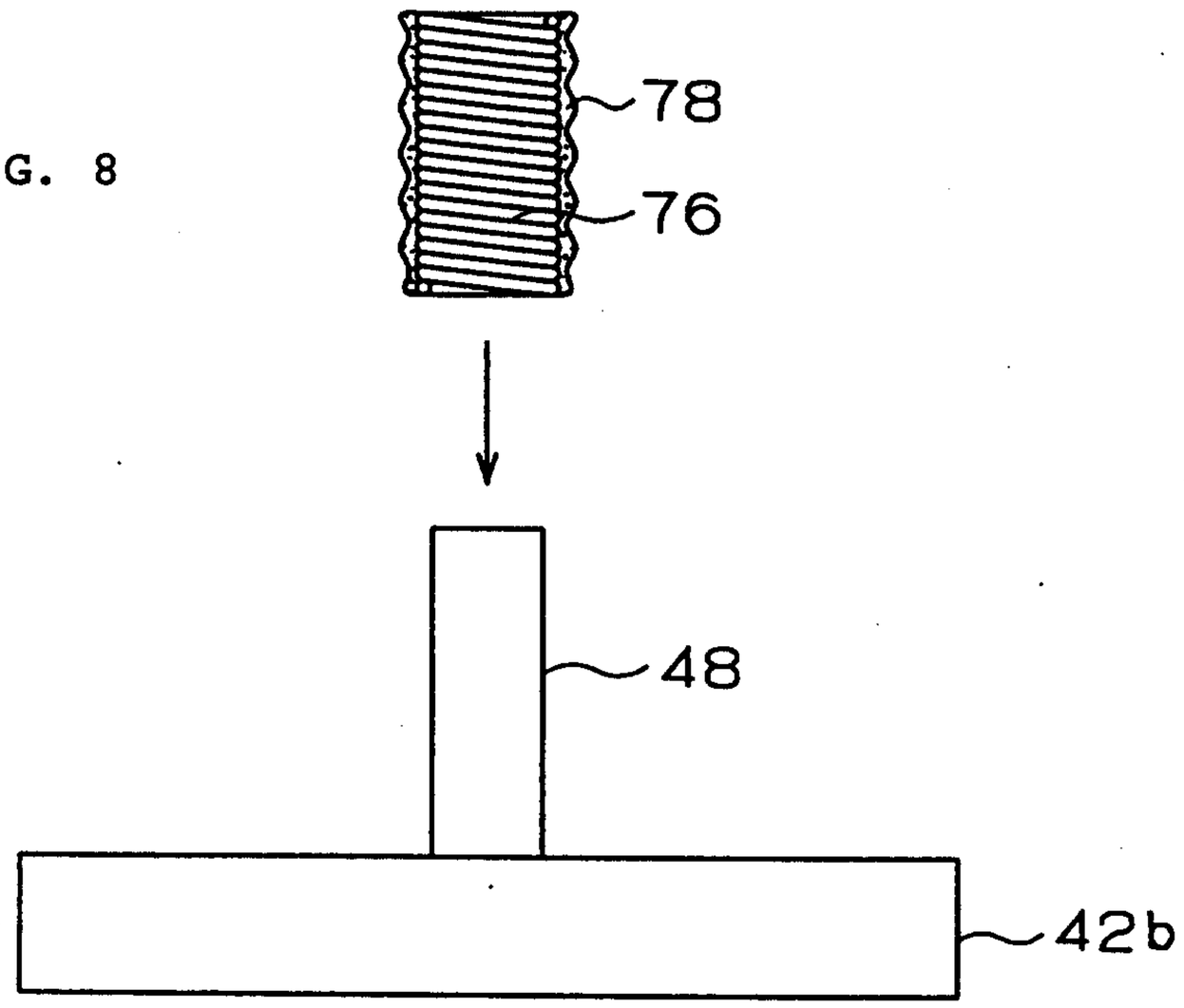


FIG. 9

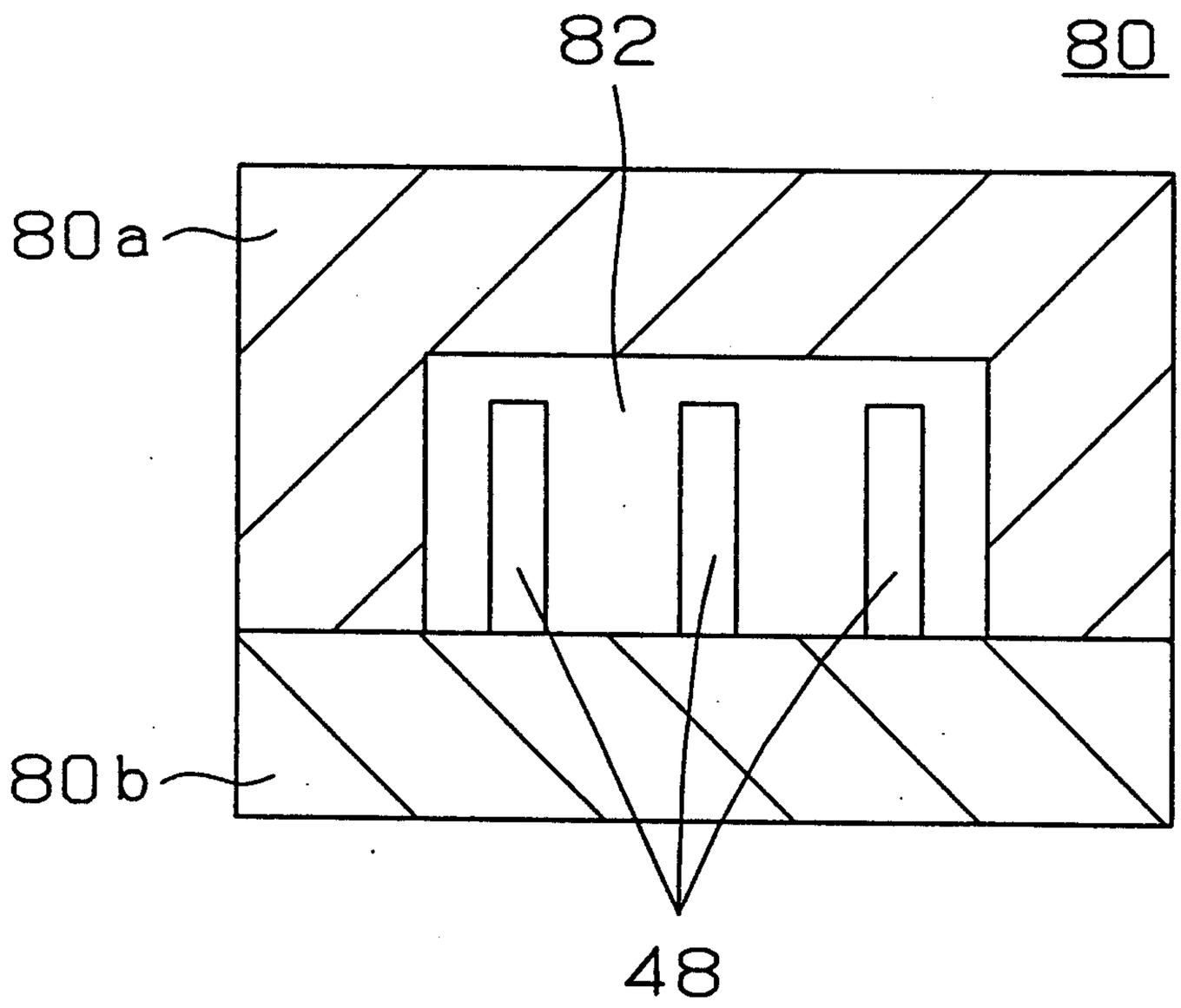


FIG. 10

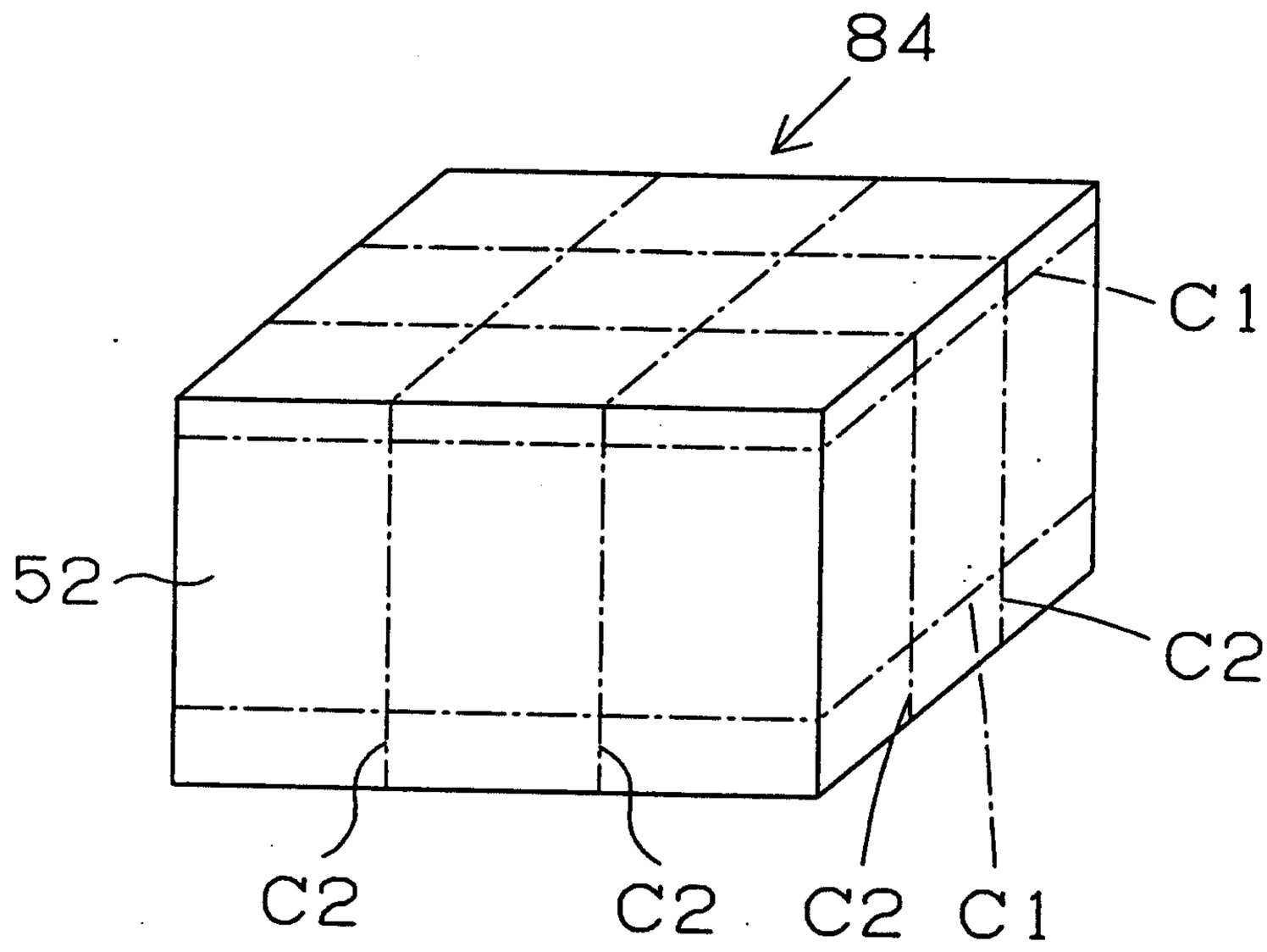


FIG. 11A

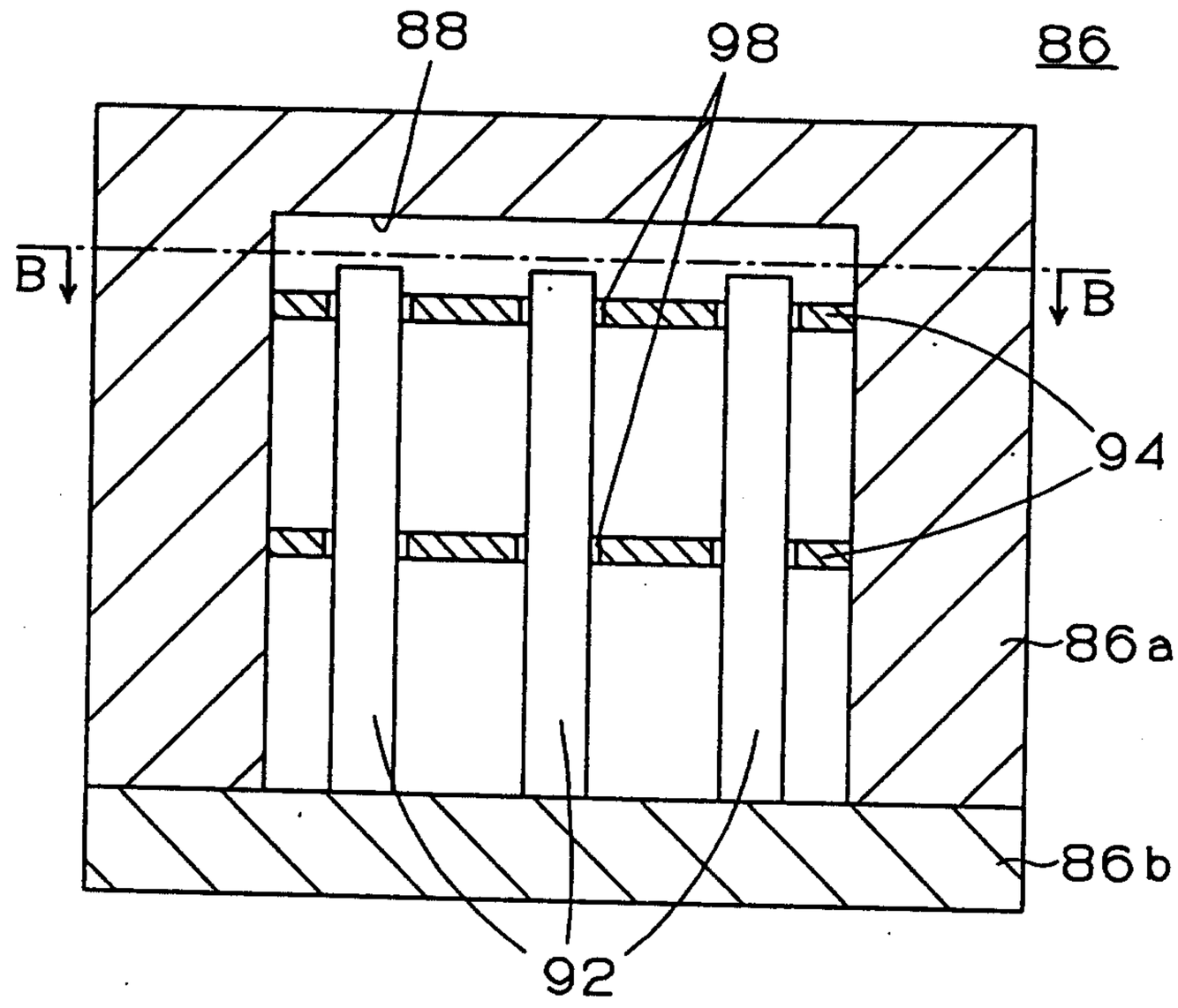


FIG. 11B

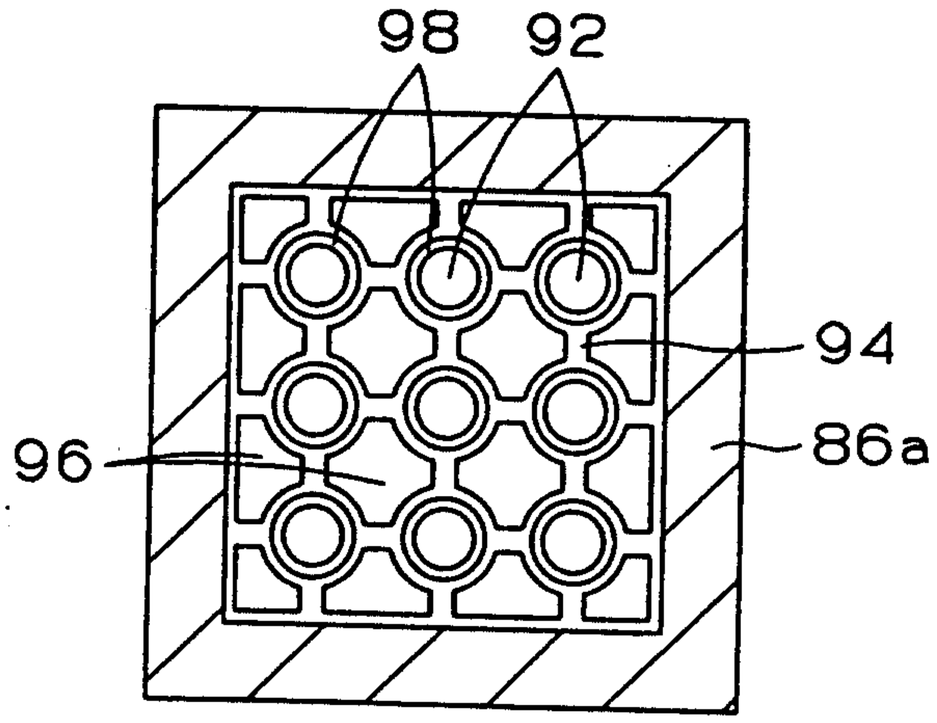


FIG. 12

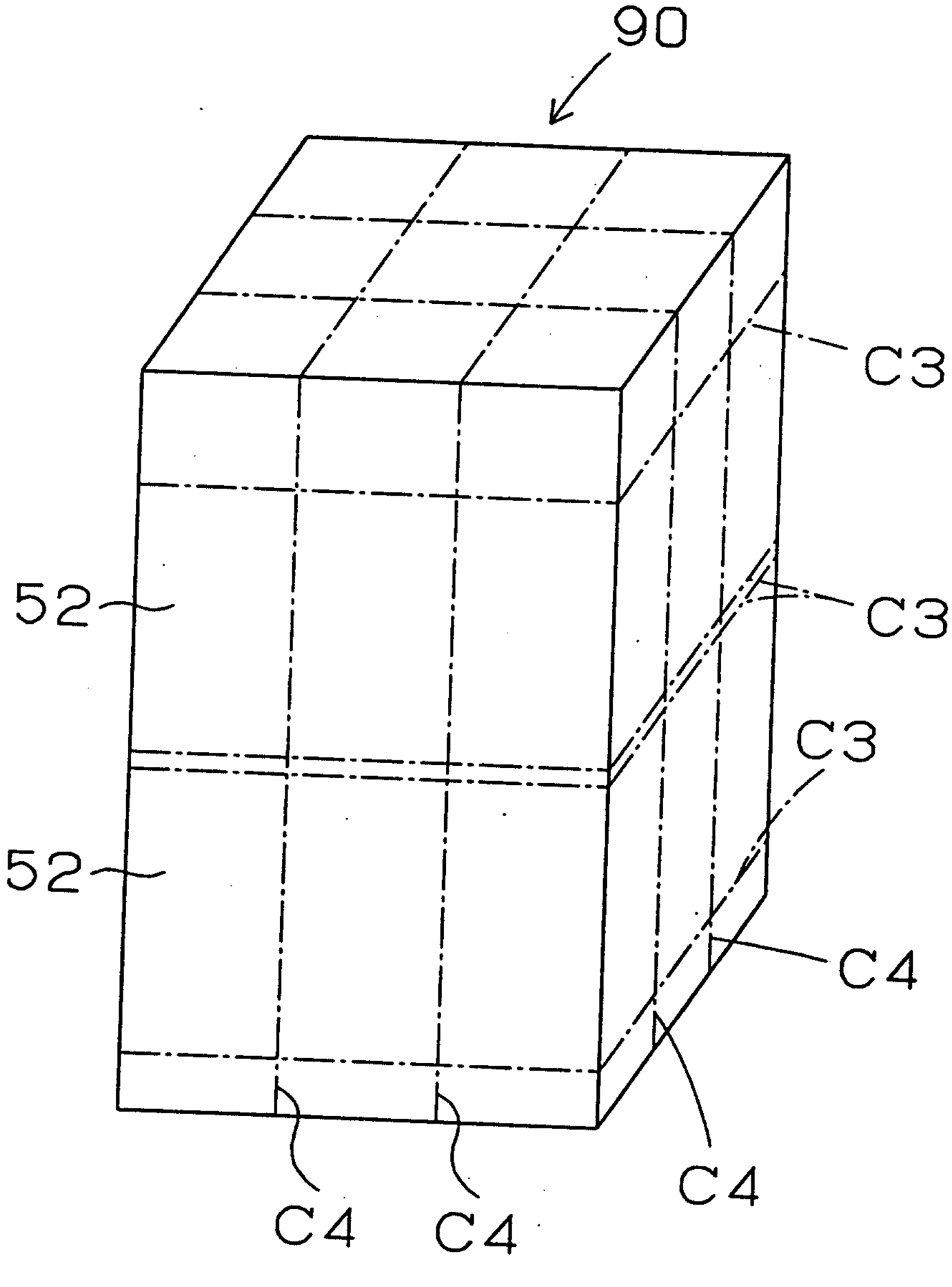


FIG. 13A

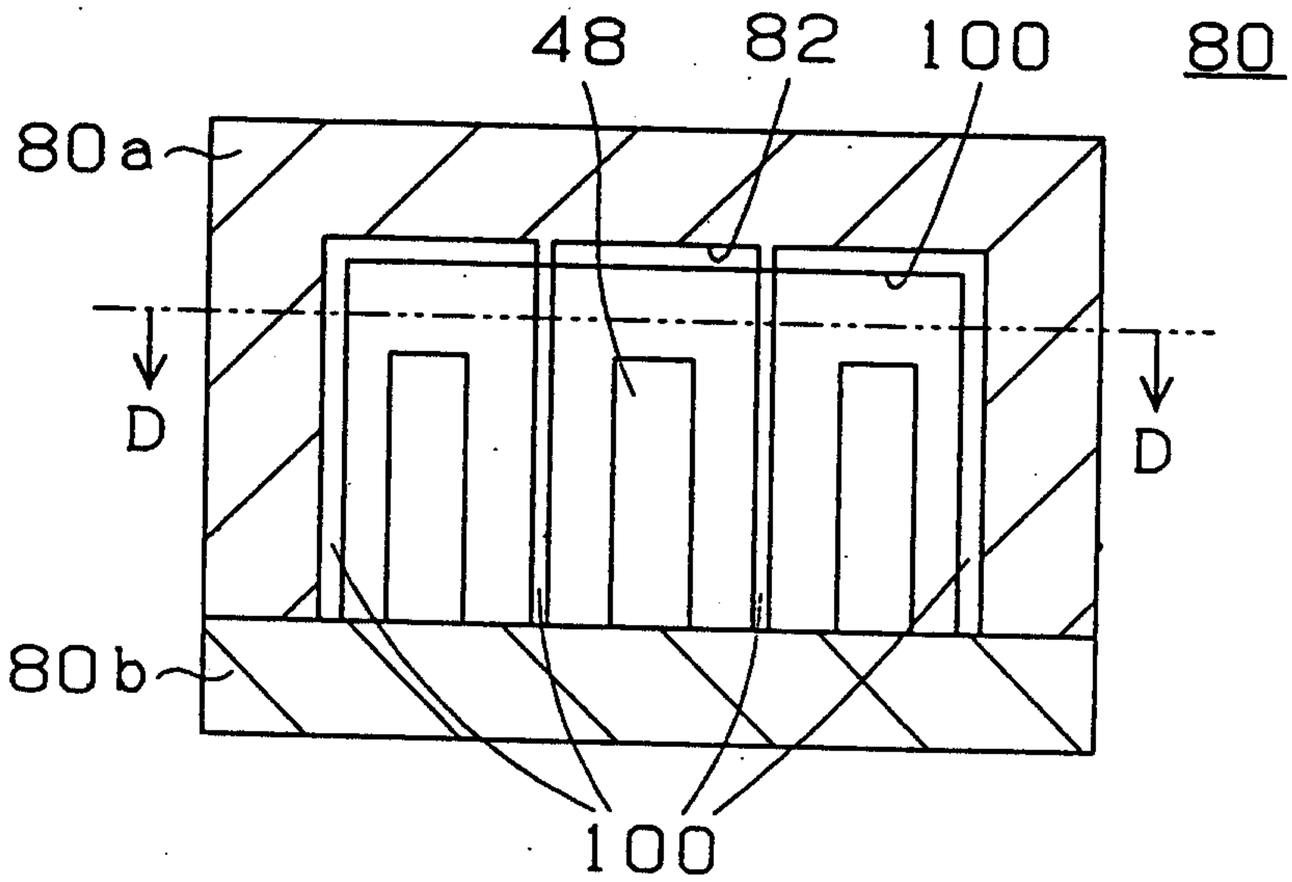
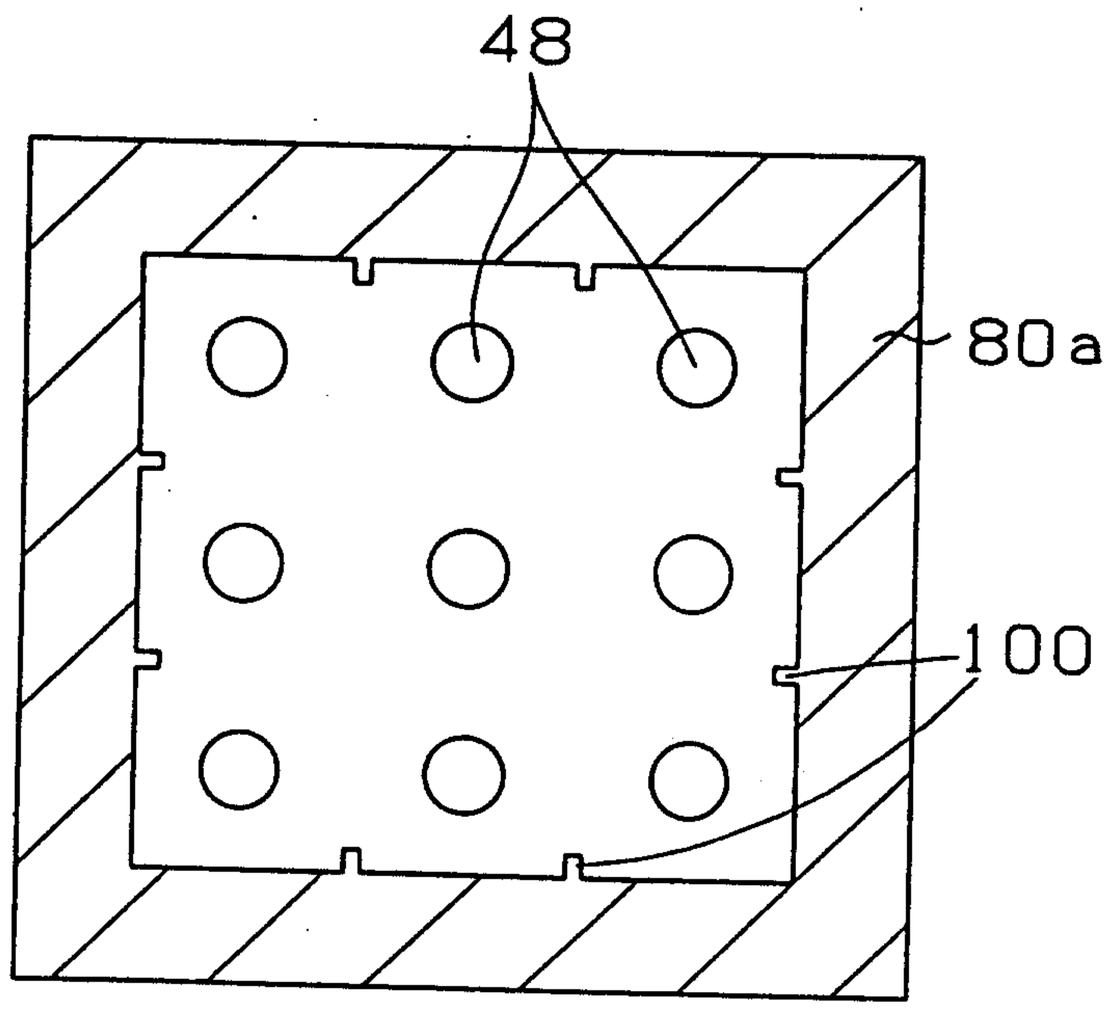
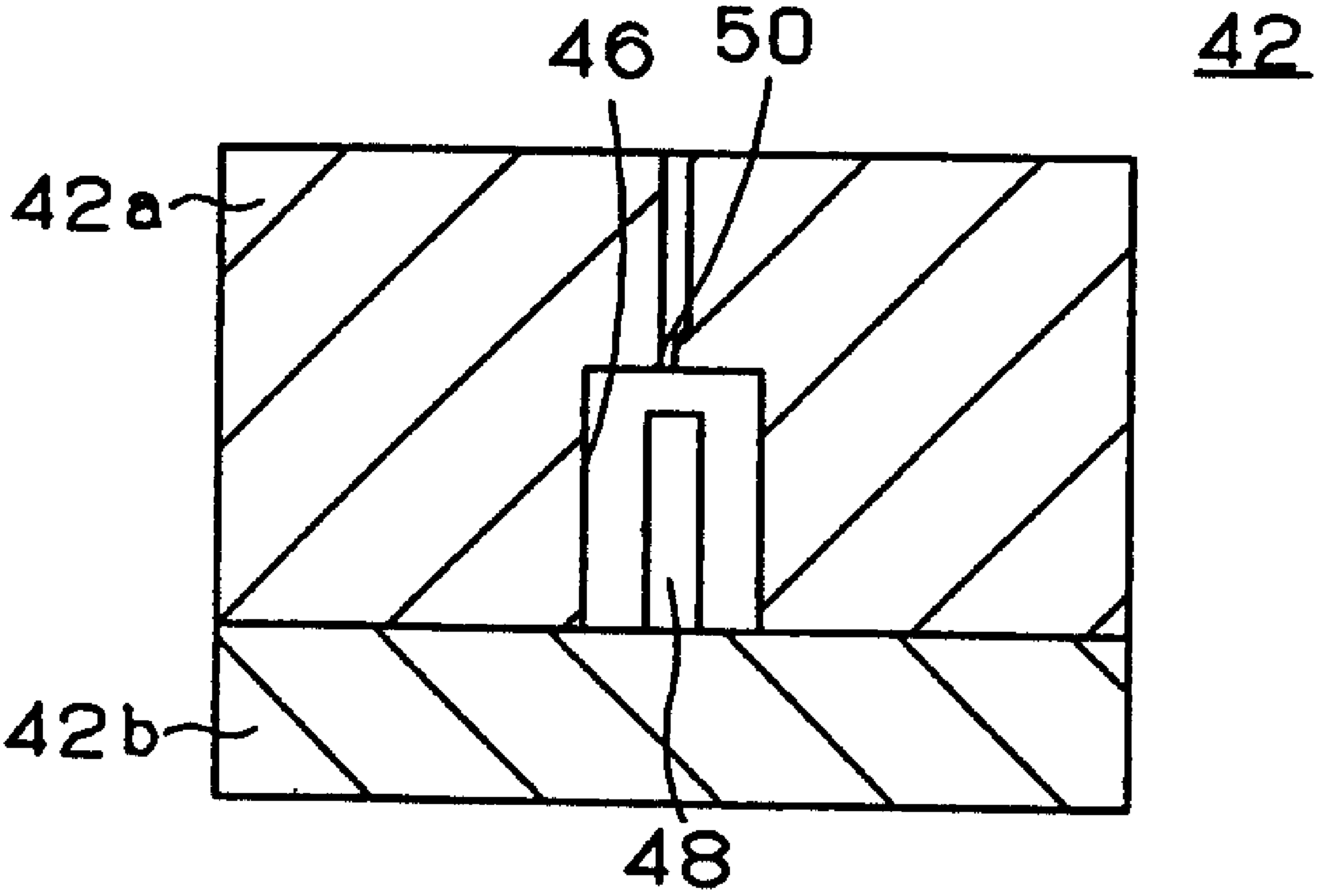


FIG. 13B

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42a
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