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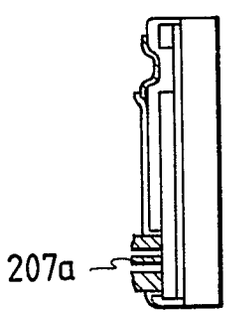
(54) Ink jet recording.

(57) A recording element unit comprises: a holding member; a recording element provided on the holding member and having a wiring for supplying electrical signals; and a bump-shaped electrode connected to the end of the wiring so as to be raised therefrom.

FIG. 2F(c)



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Description

INK JET RECORDING

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a recording element unit, and a recording element driving unit, an ink jet unit, an ink jet driving unit and an ink jet device by use thereof.

Related Backgroound Art

As the recording element unit to be used for ink jet recording device, etc., for example, a recording element unit as shown in Fig. 19 (a) has been known as the prior art. Also, a sectional view taken along A-A′ in Fig. 19 (a) is shown in Fig. 19 (b).

In Fig. 19 (a) and Fig. 19 (b), 1501 is a holding member, 1502 a HfB_2 layer as the heat-generating resistance layer, 1503 the common electrode of Al, 1504 individual electrodes of Al, 1505a and 1505b pattern wirings of Al, 1506 a SiO_2 layer as the oxidation resistant layer and the insulating layer, 1507 a photosensitive polyimide layer as the ink resistant layer and the insulating layer, and 1508 a Ta layer as the cavitation resistant layer.

The recording element unit as shown in Fig. 19 (a) and Fig. 19 (b) passes current to the HfB_2 layer 1502 as the heat-generating resistance layer, thereby generating heat energy from said HfB_2 layer. More specifically, by permitting the driving current to flow into the HfB_2 layer externally through the individual electrodes 1504 and the pattern wirings. 1505a, and further permitting the current to flow out externally through the pattern wirings 1505b and the common electrode 1503, heat energy can be generated at the HfB_2 layer. In the ink jet recording device, recording is performed by discharging liquid utilizing the heat energy.

Ordinarily, such combination of HfB_2 layer 1502, individual electrodes 1504, pattern wirings 1505a and 1505b (hereinafter called heat-generating element) is formed in a plural number in the recording unit 1 as shown in Fig. 19 (a). Thus, by providing a plural number of heat-generating elements on the recording element unit of 1, an ink jet recording device capable of performing simultaneous recording of a plurality of dots is obtained, thereby becoming feasible to effect higher speed of recording. Particularly, in these days when the demands for higher density and higher speed recording are high, simultaneous recording of one main scanning line has been generalized, and therefore recording element units having a large number of heat generating elements at high density are appearing.

In the case of performing simultaneous recording of a plurality of dots by arranging a plurality of heat generating elements on one recording element unit, ON-OFF must be controlled individually for the respective heat-generating elements. The means for performing such control (hereinafter called driving element) can be also formed within the recording element unit, but generally formed on an independent substrate (hereinafter, this substrate is called the driving element substrate), and is connected to the recording element unit. This is because, when the recording element and the driving element are formed integrally, there is the problem that if a defect occurs in a part of either of the recording element or the driving element, the whole will fail to be actuated.

In the prior art, as the technique for bonding electrically the recording element substrate and the driving element substrate, the following techniques have been known as the prior art.

(1) Wire bonding method:

The wire bonding method is a method, as shown in Fig. 20, in which the electrode 1614, 1615 of the recording element substrate 1604 is electrically connected to a desired electrode of the driving element substrate by use of an extremely fine metal wire 1616 such as of gold, etc.

(2) The method by use of electrical connecting member:

This is a method in which the electrode portion of the recording element substrate is connected to the electrode portion of the driving element substrate by use of the electrical connecting member disclosed in Japanese Patent Application No. 63-133395.

Figs. 21A to 21C are diagrams for illustration of this method. In the Figures, 1704 is a recording element substrate, 1705 a driving element substrate, 1714 and 1715 electrode portions, 1719 and 1720 insulating films. 1703 is an electrical connecting member, 1717 an electroconductive member, and 1718 a holding member for holding the electroconductive member 1717. Here, the pitch of the electroconductive member 1717 is set narrower than the pitch of the electrodes of 1714 and 1715.

The recording element substrate 1704, the driving element substrate 1705 and the electrical connecting member 1703 are first arranged as shown in Fig. 21A, and then pressure contacted with each other as shown in Fig. 21B. Fig. 21C shows the whole view after pressure contact.

However, the electrical connecting methods of the prior art as described above had the following tasks.

(1) Wire bonding method:

(a) In the wire bonding method, for avoiding contact mutually between the adjacent very fine metal wires, the pitch dimension of the connecting portion on the recording element substrate or on the driving element on the driving element substrate (distance between the centers of the adjacent connecting portions) must but have a certain interval. Accordingly, once the sizes of the recording element substrate and the driving element substrate are determined, the maximum number of the connecting portions will be necessarily determined. Whereas, according to the wire bonding

method, the pitch dimension is generally as large as about 0.2 mm, and therefore the number of the connecting portions cannot but be few.

This means contrariwise that when the number of the connecting portions of the recording element substrate or the driving element substrate is determined, the sizes of the recording element substrate and the driving element substrate must be made extremely long.

(b) The height h of the very fine metal wire measured from the connecting portion on the driving element is generally 0.2 to 0.4 mm, but since it is difficult to make the thickness thinner than 0.2 mm, no thinning can be effected.

(c) It takes a long time for wire bonding working. Particularly, when the connecting point numbers are increased, the bonding times becomes longer to worsen the production efficiency.

(d) If the transfer mold conditions range is surpassed by some factors, the very fine metal wire may be deformed or even cut in the worst case.

Also, at the connecting portion on the driving element, Al corrosion is liable to occur because Al not forming an alloy with the very fine metal wire is exposed, whereby reliability is lowered.

(e) When the driving element becomes defective, it is difficult to change only the driving element.

(2) The method of using electrical connecting member:

This method has the advantages that the unit can be miniaturized, no highly precise registration is required, and the cost can be reduced, etc., but further miniaturization and cost reduction are demanded.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a recording element unit comprising: a holding member; a recording element provided on said holding member and having a wiring for supplying electrical signals; and a bump-shaped electrode connected to the end of said wiring so as to be raised therefrom.

Another object of the present invention is to provide a recording element driving unit comprising: a recording element unit having a holding member, a recording element provided on said holding member and having a wiring for supplying electrical signals and a bump-shaped electrode connected to the end of said wiring so as to be raised therefrom; and a driving element substrate having a driving element and a wiring connected to said driving element, said bump-shaped electrode being connected to the wiring of said driving element substrate.

Still another object of the present invention is to provide an ink jet unit comprising: a holding member; a recording element provided on said holding member and having a wiring for supplying electrical signals; a bump-shaped electrode connected to the end of said wiring so as to be raised therefrom; and a liquid channel communicated to the discharging opening for discharging ink provided corresponding to the energy generating portion of said recording element.

Still another object of the present invention is to provide an ink jet driving unit comprising: a recording element unit having a holding member, a recording element provided on said holding member and having a wiring for supplying electrical signals and a bump-shaped electrode connected to the end of said wiring so as to be raised therefrom; and a driving element substrate having a driving element and a wiring connected to said driving element, said bump-shaped electrode being connected to the wiring of said driving element substrate; and a liquid channel communicated to the discharging opening for discharging ink being provided corresponding to the energy generating portion of said recording element.

Further object of the present invention is to provide an ink jet recording device comprising: an ink jet driving unit according to Claim 7, and a member for mounting said ink jet driving unit.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic sectional view showing the state in which the recording element substrate is bonded to the driving element substrate;

Figs. 2A(a) to 2F(c) are schematic diagrams for illustration of the preparation steps of the recording element unit according to a first example of the present invention, (a) representing a top view and (b) and (c) sectional views, respectively;

Fig. 3 is a schematic sectional view showing the bonding portion of the recording element unit according to the first example of the present invention;

Fig. 4 is a schematic sectional view showing an example of the ink jet unit and the ink jet driving unit according to the present invention;

Fig. 5 is a perspective view showing an example of the principal part of the serial scanning type ink jet recording device according to the present invention;

Fig. 6 is a perspective view showing an example of the principal part of the planar scanning type ink jet recording device according to the present invention;

Fig. 7 is a schematic sectional view showing the recording element unit according to a third example of the present invention;

Figs. 8A(a) to 8G(c) are diagrams for illustration of an example of the preparation steps of the recording element unit according to the third example of the present invention, (a) representing a top view, and (b) and (c) sectional views, respectively;

Fig. 9A and Fig. 98 are schematic sectional views showing the recording element unit according to a fourth example of the present invention, Fig. 9A representing a diagram showing the recording element unit having no common electrode, and Fig. 9B a diagram

showing the recording element unit having a common electrode;

Figs. 10A(a) to 10F(c) are diagrams for illustration of an example of the preparation steps of the recording element unit according to the fourth example of the present invention, (a) representing a top view, and (b) and (c) sectional views, respectively;

Fig. 11 is a schematic sectional view showing the recording element unit according to a fifth example of the present invention;

Figs. 12A(a) to 12G(c) are diagrams for illustration of an example of the preparation steps of the recording element unit according to the fifth example of the present invention, (a) representing a top view, and (b) and (c) representing sectional views, respectively;

Fig. 13 is a schematic sectional view showing the recording element unit according to a sixth example of the present invention;

Figs. 14A(a) to 146(c) are diagrams for illustration of an example of the preparation steps of the recording element unit according to the sixth example of the present invention, (a) representing a top view, and (b) and (c) representing sectional views, respectively;

Figs. 15A(a) to 15F(c) are diagrams for illustration of an example of the preparation steps of the recording element unit according to another example of the present invention, (a) representing a top view, and (b) and(c) representing sectional views, respectively;

Fig. 16 is a schematic sectional view showing the bonding portion of the recording element unit according to the above another example of the present invention;

Fig. 17 is a schematic perspective exploded view showing an example of the head portion of the ink-jet unit and the ink-jet driving unit of the present invention.

Fig. 18 is a schematic perspective view showing an example of the appearance of the ink-jet device according to the present invention.

Fig. 19 (a) and Fig. 19 (b) are schematic diagrams showing the recording element unit of the prior art, Fig. 19 (a) representing a top view, and Fig. 19 (b) a sectional view;

Fig. 20(a) and Fig. 20(b) are diagrams for illustration of the connecting method according to the wire bonding method in the recording element driving unit of the prior art;

Figs. 21(a) -21(c) are diagrams for illustration of the bonding method by use of an electrical connecting member in the recording element driving unit of the prior art.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is described in detail below about its constitution.

(Recording element, Driving element)

As the recording element in the present invention, for example, an electricity-heat converter which generates heat energy (heat-generating element) and other recording elements such as piezoelectric element may be employed.

(Pattern wiring and bump-shaped electrode)

The pattern wiring of the recording element substrate (recording element unit) and the driving element substrate is formed on the surface of the holding member. Also, when a protective film is formed on the surface of the holding member for protection and insulation of the pattern wiring, a pattern wiring with a sufficient area for formation of bump-shaped electrode may be exposed.

The pattern wiring may be formed of, for example, an electroconductive material such as Al, etc.

For the pattern wiring of the recording element substrate (recording element unit), a bonding portion comprising a bump-shaped electrode is formed.

The bump-shaped electrode may be formed only one or in a plural number per one bonding portion. On the other hand, no bump-shaped electrode is required to be formed on the pattern wiring of the driving element substrate. The bonding portion comprising a bump-shaped electrode is provided for effecting electrical connection to another circuit substrate (e.g. driving element substrate). That is, electrical connection is effected by bonding directly to the bonding portion of another circuit substrate.

The bump-shaped electrode may be made of the same material as the pattern wiring or a material different therefrom. As the material for forming the bump-shaped electrode, for example, metals such as Cu, Ni, Au, Cr, Rh, etc., or alloys comprising combinations of these may be available. Also, the bump-shaped electrode and the pattern wiring may be formed as integrally formed from the beginning, or alternatively the pattern wiring may be formed first and then the bump-shaped electrode formed thereon. When the bump-shaped electrode is formed after formation of the pattern wiring, for the reason as described below, it should be desirably formed according to the electroplating method with said pattern wiring as the electrode. Also, in this case, said pattern wiring should be desirably formed of Cu.

In the present invention, for the reason as described below, the pattern wiring which becomes the common electrode can be also provided on the driving element substrate, rather than on the recording element substate.

In the recording element substrate (recording element unit) in the present invention, it is desirable to provide recording elements and the pattern wirings corresponding to the recording elements in a number more by one or more than the necessary number. By doing so, bonding between the bonding portion of the recording element substrate and the pattern wiring of the driving element substrate can be effected without requring strict registration. Also, for the same reason, it is desirable to provide driving elements and pattern wirings of driving element substrate in numbers more by one or more than the necessary numbers.

(Protective layer)

In the recording element substrate (recording element unit) of the present invention, for protection and insulation of the pattern wiring, a protective layer should desirably be formed on the surface of the holding member. As the protective layer, there may be included, for example, an oxidation resistant protective layer formed of SiO_2, a protective layer for cavitation resistance formed of Ta, an ink resistance protective layer formed of a photosensitive polyimide, etc. The protective layer may be one layer, or two or more layers may be also provided depending on the purpose.

(Insulating layer and insulating film)

In the recording element substrate (recording element unit) of the present invention, for the reason as described below, it is desirable to further provide an insulating layer on the protective layer. As the material for formation of the insulating layer, there may be employed phenol resin, melanine resin, polyester resin, silicone resin, epoxy resin, vinyl chloride resin, styrol resin, acrylic resin, polyimide resin, phenol resin, polycarbonate resin, polypropylene, urea resin, etc. Since the present invention is intended to eliminate the influence from curving or unevenness of the surface of the unit by providing the insulating layer as described below, the thickness of the layer should be preferably as thick as possible.

Also, in place of forming an insulating layer, an insulating film may be also provided on the protective layer.

As the material for forming the insulating film of the present invention, similarly as in the case of insulating layer, there can be employed phenol resin, melanine resin, polyester resin, silicone resin, epoxy resin, vinyl chloride resin, styrol resin, acrylic resin, polyimide resin phenol resin, polycarbonate resin, polypropylene, urea resin, etc.

The insulating film has a thruhole, and the bump-shaped electrode is exposed from the surface therethrough. The position, size and number of thruholes are not particularly limited. For example, it is not required to be positioned only at the electrode forming portion, may be also present on other portions without giving any influence. Also, one thruhole may be formed corresponding to one bump-shaped electrode, or alternatively a large number of thruholes may be also formed at around the bonding portion as shown in Figs. 14F and 14G described below. When a large number of thruholes are formed at around the bonding portion, there is the advantage that no strict precision in pitch in forming the insulating film or no strict precision in registration during plastering the insulating film is required (or no registration may be required).

Since the present invention is intended to eliminate the influence from curving or unevenness of the surface of the unit by providing the insulating film as described below, the thickness of the film should be preferably as thick as possible.

(Bonding)

Bonding is practiced as shown in Fig. 1. In the Figure, 104 is a recording element substrate, 105 a driving element substrate, 106 a driving element and 107 a base stand. The surface of the driving element substrate on which the driving element is provided and the surface having the bonding portion are not required to be the same, but may be the opposite surfaces.

(Bonding method)

The present invention exhibits particularly its effect when the bonding portion of the recording element substrate (recording element unit) and the bonding portion of the driving element substrate are bonded according to the pressure bonding method. Also, bonding by way of metallization and/or alloy formation, or other methods than metallization and/or alloy formation may be feasible, and these methods may be also used in combination with the pressure bonding method.

In the following, bonding by way of metallization and/or alloy formation, and bonding according to other methods than metallization and/or alloy formation are to be described.

(1) Bonding by way of metallization and/or alloy formation:

When the bump-shaped electrode of the recording element substrate and the pattern wiring of the driving element substrate (of the pattern wiring, the portion to be bonded to the bump-shaped electrode of the recording element substrate; hereinafter called merely as the bonding portion) to be bonded together comprise the same kind of pure metal, the layer formed by metallization becomes to have the same kind of crystalline structure as the bump-shaped electrode of the recording element substrate or the pattern wiring of the driving element substrate. As the method for metallization, for example, after bringing the bump-shaped electrode of the recording element substrate in contact with the bonding portion of the driving element substrate corresponding to said bump-shaped electrode, the contacted portions may be heated to a suitable temperature. In this case, diffusion of atoms, etc. occur in the vicinity of the contacted portions by heating, and the diffusion portions become metallized to form a metal layer.

When the bump-shaped electrode of the recording element substrate and the bonding portion of the driving element substrate to be bonded together comprise different kinds of pure metals, the bonding layer to be formed becomes an alloy of the both metals. As the method for alloy formation, similarly as described above, for example, after the bump-shaped electrode of the recording element substrate is brought into contact with the bonding portion of the driving element substrate corresponding to said bump-shaped electode, the contacted portions may be heated to a suitable temperature. In this case, diffusion of atoms, etc. occur in the vicinity of the contacted por.tions by heating, whereby an alloy layer comprising a solid solution or an intermetallic compound will be formed in the vicinity of the

contacted portions.

The heating temperature may be preferably made 200 to 350 °C when, for example, the bonding portion (bump-shaped electrode) of the recording element substrate is formed of Au, and the bonding portion of the driving element unit is formed of Al.

When one of the bump-shaped electrode of the recording element substrate and the bonding portion of the driving element substrate to be bonded together comprises a pure metal and the other comprises an alloy, or both comprise the same kind or different kinds of alloys, the bonding interface comprises an alloy layer.

With regard to mutual bump-shaped electrodes of the recording element substrate, there may be included the case when the respective bump-shaped electrodes comprise the same kind of metal or alloy, the case when the respective electrodes different kinds of metals or alloys and other cases, but in any case, the above metallization or alloy formation as described above is effected. On the other hand, the same is the case with the bonding portion of the driving element substrate.

The bump-shaped electrode of the recording element substrate or bonding portion of the driving element substrate may be a metal or an alloy at the contacted portions of the both, and may be also under the state of, for example, a metal formulated with an inorganic material such as glass, etc. or a metal formulated with an organic material such as resin, etc.

Also, on the surface to be bonded, there may be also provided a plated layer comprising a metal readily formed into an alloy or an alloy.

As the heating method, other than the method such as heat pressurization adhesion, etc. there may be also employed the internal heating methods such as the sonication heating method, the high frequency induction heating method, the high frequency dielectric heating method, the microwave heating method, etc. or other external heating methods, and the above heating methods may be also used in combination. In any of the heating methods, the bonding portions of the driving element substrates are heated directly or indirectly to effect bonding.

(Bonding according to methods other than metallization and/or alloy formation)

For effecting bonding according to methods other than the above metallization or alloy formation, for example, bonding may be effected by pressing the bonding portion of the driving element substrate against the bump-shaped electrode of the recording element substrate by a suitable means.

As other bonding methods, there may be included that bonding method by use of an adhesive, etc. That is, there are the methods in which bonding is effected by adhering the recording element substrate to the bump-shaped electrode of the recording element substrate at at least a part excluding the bonding portion of the driving element substrate.

As for bonding between the recording element substrate and the driving element substrate, bonding should be preferably effected freely detachably.

(Respective units)

The recording element driving unit in the present invention is a unit which drives the recording elements formed in the recording element unit following the image signals inputted externally. The recording element driving unit comprises the above driving element substrate and the recording element substrate (recording element unit).

The ink jet unit has a liquid channel communicated to a discharging opening for discharging ink formed on the recording element substrate (recording element unit), which performs discharging of ink by permitting the energy of the recording element to act on ink. The shape, dimensions, etc. of the liquid channel may be any desired ones.

The ink jet driving unit is a unit for discharging ink through the discharging opening following the image signals inputted externally, and comprises an ink jet unit and a driving element substrate.

(Ink jet recording device)

The ink jet recording device in the present invention is a device which performs recording by discharging ink through a discharging opening following the image signals inputted externally, and attaching the ink onto a recording paper. This ink jet recording device has at least the above ink jet driving unit and a means for mounting the ink jet driving unit. As the type of the ink jet recording device, there are the so called serial scanning type (printing is effected while the print head moves in a reciprocal fashion in the lateral direction relative to the paper) and the full line type (recording of one main scanning line is effected at the same time by use of a print head with one main scanning line width). Fig. 5 and Fig. 6 show an example of the principal portions of the ink jet recording device of the present invention. Fig. 5 shows the serial scanning type and Fig. 6 the full line type. In Fig. 5, 12 is the ink jet driving unit.

The present invention exhibits the effect particularly in a lengthy ink jet driving unit, and therefore it is preferable to employ the full line type.

[Mode of operation]

(1) In the present invention, since a bump-shaped electrode is provided at the connecting portion of the recording element substrate (recording element unit), electrical connection of high reliability can be effected by bonding directly said recording element substrate and driving element substrate.

Accordingly, it has become possible to permit the bonding portions of the recording element substrate and the driving element substrate to exist at high density, whereby higher densification becomes possible.

Further, even in a lengthy unit, miniaturization becomes possible.

Also, since no part for electrical connection is required at all, it becomes possible to make thinner the thickness of the unit and reduce the cost thereof.

Further, because the amount of the metal mem-

bers used for the bump-shaped electrode of the recording element substrate is small, even if an expensive metal member may be employed, reduction in cost becomes possible.

In addition, by arranging the recording elements and the pattern wirings corresponding to the recording elements in numbers more by one or more than the necessary numbers, or further providing the driving elements or pattern wirings of the driving element substrate in numbers more by one or more than the necessary numbers, even in the case of a lengthy device, it becomes possible to effect bonding between the recording element substrate and the driving element substrate without performing registration, or without performing high precision registration, if any.

Particularly, when the bubble ink jet system is used as the ink jet recording system, registration can be done with difficulty because wiring of higher density is required. However, according to the present invention, even in the case of such high density wiring, registration can be done with extreme ease.

Further, in the present invention, since the recording element substrate and the driving element substrate can be bonded together freely detachably, the driving element substrate can be easily separated, and hence also exchanged easily.

(2) In the present invention, without formation of a common electrode on the recording element unit, respective individual pattern wirings are formed, also bonding portions are formed on these pattern wirings, and further a pattern wiring which becomes the common electrode on the driving element substrate side with higher degree of freedom of designing and the bonding portion of the pattern wiring on the recording element unit side is bonded to the common electrode. With such a constitution, further miniaturization of the recording element unit or the recording element driving unit can be effected.

Since great current flows through the common electrode, a size to some extent (thickness and width) is required for suppressing resistance small, and also since the size of the common electrode becomes greater as the number of the recording elements is more, the size of the common electrode was not negligible in the recording element unit of lengthy and high density wiring. However, by making a constitution to form a common electrode on the driving element substrate side higher in freedom of design and effecting bonding of the bonding portion of the common electrode to the bonding portion on the recording element unit side, it becomes possible to miniaturize to great extent the recording element unit and the recording element driving unit, the ink jet unit, the ink jet driving unit and the ink jet device by use thereof.

Particularly, when the ink jet is bubble ink jet, such constitution is very effective, because wiring of higher density is demanded.

When the bonding method of the prior art, for example, wire bonding is employed, it has been substantially impossible to form a wiring pattern which becomes the common electrode on the driving element substrate side and electrically connect the individual pattern wirings formed on the recording element substrate to the pattern wiring of the common electrode. For, because reliability of the bonding portion is lower than in the case of the present invention, if the number of the connecting portions is increased excessively, there is the problem that the reliability of the unit as a whole is lowered or the problem that the recording element driving unit, etc. are enlarged as the number of the connection portions is more to disadvantages. In contrast, in the present invention since a connecting portion having bump-shaped electrode is provided, even in the case when a pattern wiring which becomes the common electrode is provided on the driving element substrate side, there will ensue no such problem such that the reliability of bonding between the above individual pattern wirings and the pattern wiring of the common electrode is lowered as a whole or that the recording element driving unit, etc. are enlarged. (3) In the present invention, the electrode in forming the bump-shaped electrode of the recording element unit bonding portion, by use of pattern wirings of said recording element unit, in the steps of preparing said bump-shaped electrode, it is not required to form the subbing layer which should become the electrode generally employed in the electroplating method. By this, the preparation steps can be simplified, and the material for forming the electroplated subbing layer becomes unnecessary, whereby the material cost can be reduced. Particularly, in a lengthy recording element substrate (recording element unit), a large amount of materials for forming the electroplated subbing layer is required in the prior art method, and therefore the present invention is very effective.

Also, when electroplating is effected with the use of the pattern wiring as the electrode, a bump-shaped electrode with a convex sectional shape at the tip end can be formed and therefore the contact resistance during pressure contact can be made lower. When an electroplated subbing layer is used as the electrode, the sectional shape of the tip end of the bump-shaped electrode becomes concave. Even if the sectional shape of the tip end of the bump-shaped electrode may be concave, the contact resistance during pressure contact is practically within a sufficiently permissible range. However, according to the investigations by the present inventors, contact resistance can be made further smaller when the shape is convex rather than concave.

In other words, electroplating by use of the pattern wiring as the electrode is very desirable, because a recording element substrate (recording element unit) capable of ensuring electrical connection with smaller contact resistance than in the case of forming an electrode by formation of an electroplated subbing layer can be obtained more inexpensively than in the case of forming an electrode by formation of an electroplated subbing layer.

(4) In the present invention, by providing newly an insulating layer or an insulating film on the protective layer of the recording element substrate of the prior art, a bump-shaped electrode with long foot length

can be formed as the bump-shaped electrode forming the connecting portion of said recording element substrate, whereby variance in the position of the tip end of the above bump-shaped electrode caused by curving or unevenness of the surface of said recording element substrate during pressure contact of the connecting portion of said recording element substrate and the connecting portion of the driving element substrate can be absorbed to further improve the reliability of the electrical connection between said recording element substrate and the driving element substrate.

The reason is described in detail below.

The recording element substrate and the driving element substrate should most desirably completely flat plate without curving or unevenness. For, bonding can be effected easily and therefore reliability of electrical connection can be obtained with ease.

However, electrical circuit substrates are not generally flat plates, but there exist more or less curving or unevenness. Also, curving may be sometimes generated by heat generation during driving. When a substrate with large curving or unevenness is employed, there is a fear that defective connection may occur at the electrical connection between the recording element substrate and the driving element substrate. For prevention of defective connection, it is necessary to make the connection firm or employ a substrate with no curving or unevenness (or difficultly curved), but such a method has the problem of inviting increased cost.

The present invention improves reliability of electrical connection to greater extent than in the prior art, and the influence from curving and unevenness is by far small as compared with the prior art. Accordingly, there ensues generally no such problem. However, while the influence from curving becomes grater as the recording element unit is longer in the lengthy direction, the recording element unit of the present invention can exhibit its advantage as the length in the lengthy direction is longer and therefore, in view of the possibility of demand of enlargement of the recording paper size in the future, it may be considered necessary to have the technique to remove the influence from curving of the substrate, etc.

The present inventors have investigated intensively for solving this task and consequently obtained an idea that the above task may be solved by forming a bump-shaped electrode through a layer with great film thickness for absorbing curving and unevenness of the substrate.

For that purpose, the present inventors first attempted to improve defective connection by making greater the thickness of the protective layer such as oxidation resistant layer, ink resistant layer, etc. provided in the recording element substrate of the prior art. However, according to such method, no sufficient effect could be obtained. Accordingly, the present inventors have investigated about this reason and consequently obtained the following knowledges.

(1) According to the investigations by the present inventors, curving or unevenness of the recording element substrate is generally about some tens μm to some hundreds μm. Also, according to the investigations by the present inventors, for absorbing such curving or unevenness sufficiently, a layer with at least a film thickness comparable to these curving and unevenness is required. However, it is substantially impossible to form a protective layer such as oxidation resistant layer to a film thickness of some hundreds μm. For example, since the oxidation resistant layer is a protective film of heat-generating member, if the film thickness is made greater, heat transmission efficiency will be lowered, and therefore application voltage is required to be made greater, but because the power resistance of the heat-generating resistance material is limited, it is difficult to make the thickness to a certain level or higher.

(2) Also, the present inventors have obtained a knowledge that it is not preferable to absorb curving or unevenness by making greater the thickness of the protective layer such as oxidation resistant layer or ink resistant layer, etc., also because the layer for absorbing curving or unevenness is different in the characteristic demanded from the oxidation resistant layer or the ink resistant layer. Oxidation resistant layer is demanded to have oxygen barrier characteristic, thermal conductivity, heat resistance and no defect, etc. and for this purpose it may be preferably formed of an inorganic material. On the other hand, ink resistance layer is demanded to have no defect, ink resistance (excellent adhesiveness in ink or difficult deterioration in ink), heat resistance, etc. In contrast, as the result of the investigations by the present inventors, the layer for absorbing curving or unevenness is required to have excellent insulation characteristic, flexibility, plating resistance, adhesiveness, etc., and small thermal expansion coefficient and readiness in thicker film formation. According to the investigations by the present inventors, it is very difficult to form a layer having both the characteristics demanded for the layer for absorbing curving or unevenness and the characteristics demanded for oxidation resistant layer or ink resistant layer.

For the above reasons, the present inventors have obtained an idea that the protective layer of the prior art and the layer for absorbing curving or unevenness should be formed separately, and obtained a knowledge that it is preferable to provide a new insulating layer for absorbing curving or unevenness.

Also, the present inventors have made further investigations, and obtained an idea that the influence from curving or unevenness of the substrate may be avoided by forming a new film by plastering an insulating film on the protective film and forming a bump-shaped electrode with long foot length by use of this. Further, the present inventors have investigated about the method for performing the step of plastering an insulating film at low cost, and consequently found that substantially no registration of insulating film is required by forming a large number of thruholes at the bonding portion of the insulating film and therearound.

Example 1

As an example of the present invention, the recording element unit having substantially the same constitution as in Fig. 19 (a) and Fig. 19 (b), and having formed bump-shaped electrode for the individual electrodes 1504 is to be described.

The preparation steps of the recording element unit according to this Example are described below.

Figs. 2A-2F are diagrams for illustration of an example of the preparation steps of the recording element unit according to the present invention.

(1) First, HfB_2 layer 202: 350 Å,Ti layer(omitted in Fig. 2A): 50 Å and Al layer 203: 6000 Å are formed on the whole substrate surface 201 according to the sputtering method (Fig. 2A).

(2) For formation of the wiring substrate, a resist is coated on the film formed in (1), then patterned by exposure and development by use of the photolithographic method, and further Al/Ti/HfB_2 is etched to form a wiring. The resist is peeled off after etching.

(3) On the Al/Ti/HfB_2 wiring electrode substrate formed in the above (2) is patterned a resist by use of the same photolithographic method as in (2) and further Al is removed partially by etching to form a heater portion. The resist is peeled off after etching (Fig. 2B).

(4) SiO_2 layer 204: 9000 Å as the heater oxidation resistant layer and the interlayer insulating layer, Ta_2O_5 layer (omitted in Fig. 2C): 500 Å as the SiO_2-Ta adhering layer and Ta layer 205: 5000 Å as the cavitation resistant layer are formed on the whole substrate surface by continuous sputtering.

(5) According to the same method as in the above (2), resist is patterned and Ta is removed partially by etching to form a Ta pattern. The resist is peeled off after etching (Fig. 2D).

(6) According to the same method as in the above (2), resist was patterned and SiO_2 patterning is effected by removing partially SiO_2 by etching. The resist is peeled off after etching (Fig. 20).

(7) An organic insulating film 206: 2.5 μm as the ink resistant layer and the interlayer insulating layer is coated, and a pattern is formed according to the same method as in (2) or a pattern is formed by coating a photosensitive organic insulating film: 2.5 μm, followed by exposure and development (Fig. 2E).

(8) As the electroplated subbing layer (omitted in Fig. 2F), a Cu layer: 3000 Å and a Ti layer: 500 Å were formed on the whole substrate surface.

(9) A resist for formation of plating pattern is coated, exposed and developed.

(10) According to the electroplating, a conductive raised portion 207a, 207b is formed with, for example, Cu, Ni, Au, Cr, Rh, etc. The film thickness is made several microns to some tens microns. Finally, the resist is peeled off (Fig. 2F).

An example of the preparation steps of this Example has been described above.

In this Example, the raised portion 207a prepared in the above (10) becomes the bonding portion prepared. Fig. 3 shows an enlarged view of this portion. By bonding this portion to the bonding portion of another substrate as shown in Fig. 1, electrical connection to another circuit substrate (e.g. driving element substrate) can be effected.

Thus, according to this Examle, merely by bonding to another circuit substrate such as driving element substrate, etc., electrical connection of substrates of high reliability can be effected.

Example 2

In the above Example 1, the recording element unit according to an example of the present invention was described. Here, examples of the recording element driving unit, the ink jet unit, the ink jet driving unit and the ink jet device according to the present invention are described respectively.

The recording element driving unit according to this Example is formed by connecting a driving element substrate to the recording element unit prepared as described in the above Example 1, and takes a constitution as shown in Fig. 1. In the Figure, 104 is a recording element substrate (namely the recording element unit according to Example 1), 105 a driving element substrate and 106 a driving element.

Next, the ink jet unit and the ink jet driving unit according to this Example are described. The ink jet unit according to this Example has a liquid channel communicated to a discharging opening formed on the recording element unit prepared as described in the above Example 1, and also the ink jet driving unit has a driving element substrate connected to the ink jet unit. Fig. 4 shows an example of the ink jet unit and the ink jet driving unit according to this Example. In Fig. 4, 408 is the ink jet unit according to the present invention, 405 a driving element substrate and 406 a driving element.

Finally, the ink jet recording device according to this Example is to be described. Fig. 5 is a diagram showing an example of the ink jet recording device according to the present invention. In Fig. 5, the recording sheet 503 is conveyed by a paper feeding roller (not shown) to the sheet delivery rollers 501, 502 placed as keeping a predetermined interval vertically and sheet delivered in the arrowhead A direction.

There is also provided a carriage 510 which moves along the guide axis 513 in front of the above recording sheet 503. On the carriage 510 is mounted an ink jet driving unit 512 as described above.

The above carriage 510 is driven in a reciprocal fashion through the belt transmission mechanism 509 by a carriage driving motor (not shown).

During recording, as synchronized with the recording sheet 503 width direction driving of the above carriage 510, recording is effected while discharging ink as droplets from the discharge opening of the above ink jet driving unit toward the recording sheet 503. In the ink jet driving unit is formed a discharging opening directed toward the recording sheet 503 side, and ink droplets fly from the discharging

opening corresponding to the signals from the driving element.

Fig. 6 shows another example of the ink jet recording device of the present invention. The difference between this example and the above ink jet recording device is that the ink jet driving unit 512 of this example has recording elements corresponding to the recording width of the recording paper. Accordingly, no reciprocal driving of the carriage is required, and therefore the mechanism can be simple and also high speed recording is possible. In this example, since a very long unit is used, the effect of practicing the present invention is enormous.

Example 3

As a third example of the present invention, the case of providing no common electrode on the recording element unit is described.

Fig. 7 is a schematic sectional view showing the recording element unit according to this Example. In Fig. 7, 701 is a holding member, 702 a HfB_2 layer as the heat-generating resistance layer, 703 and 704 individual electrodes of Al, 705a and 705b pattern wirings of Al, 706 a SiO_2 layer as the oxidation resistant layer and the insulating layer, 707 a photosensitive polyimide layer as the ink resistant layer and the insulating layer, and 708 a Ta layer as the cavitation resistant layer.

Next, an example of the preparation steps of the recording element unit according this Example is described by referring to Figs. 8A - 8G.

(1) First, HfB_2 layer 702(thickness 350 Å), Ti layer (omitted in Fig. 8A) (thickness 50 Å) and Al layer 705 (thickness 6000 Å) are formed on the whole substrate surface according to the sputtering method (Fig. 8A).

(2) For formation of the wiring substrate, a resist is coated on the film formed in (1), then subjected to patterning by exposure and development by use of the photolithographic method, and further Al/Ti/HfB_2 layers are etched to form a wiring. The resist is peeled off after etching.

(3) On the Al/Ti/HfB_2 layer wiring electrode substrate formed in the above (2) is patterned a resist by use of the same photolithographic method as in (2) and further Al is removed partially by etching to form a heater portion. The resist is peeled off after etching (Fig. 8B).

(4) SiO_2 layer 706 (thickness 9000 Å) as the heater oxidation resistant layer and the interlayer insulating layer, Ta_2O_5 layer (omitted in Fig. 8C)(thickness: 500 Å) as the SiO_2-Ta adhering layer and Ta layer 708 (thickness 5000 Å) as the cavitation resistant layer are formed on the whole substrate surface by continuous sputtering.

(5) According to the same method as in the above (2), resist is patterned and Ta is removed partially by etching to form a Ta pattern. The resist is peeled off after etching (Fig. 8C).

(6) According to the same method as in the above (2), resist was patterned and SiO_2 patterning is effected by removing partially SiO_2 by etching. The resist is peeled off after etching (Fig 8C).

(7) An organic insulating film (film thickness 2.5 μm) as the ink resistant layer and the interlayer insulating layer is coated, and a pattern is formed according to the same method as in (2) or a pattern is formed by coating a photosensitive organic insulating film 707(film thickness 2.5 μm), followed by exposure and development (Fig. 8E).

(8) As the electroplated subbing layer 709, a Cu layer (thickness 3000 Å) and a Ti layer (thickness 500 Å) were formed on the whole substrate surface.

(9) A resist for formation of plating pattern is coated, exposed and developed.

(10) According to the electroplating, a conductive bump-shaped electrode 710 is formed with, for example, Cu, Hi, Au, Cr, Rh, etc. or a combination of these, and the resist is peeled off.

(11) Finally, the electroplated subbing layer is removed by etching (Fig. 86). In this Example, first Cu was removed by dipping in 1 g/cc of ammonium persulfate for about 60 seconds, and subsequently Ti was removed by dipping in an 2% aqueous hydrofluoric acid solution for about 10 seconds.

Having described above about an example of the preparation steps of the recording element unit of this Example.

By bonding a driving element substrate to such recording element unit similarly as described in the above Example 2, the recording element driving unit could be miniaturized.

Also, by forming a liquid channel communicated to a discharging opening for discharging ink on the recording element unit of this Example, the ink jet unit could be miniaturized.

By connecting electrically a driving element unit to the ink jet unit, an ink jet driving unit could be miniaturized.

Further, by preparing an ink jet recording device by use of the ink jet driving unit, the ink jet recording device could be miniaturized. Further, when recording test was conducted for the ink jet recording device, stable recording could be performed.

Example 4

In the following, as a fourth example of the present invention, the case of forming a bump-shaped electrode according to the electroplating method by use of the pattern wiring as the electrode is to be described.

Fig. 9A and Fig. 9B are schematic sectional views showing the recording element unit according to this Example, Fig. 9A showing the recording element unit having no common electrode, and Fig. 9B the recording element unit having a common electrode. In Fig. 9A and Fig. 9B, 901 is a holding member, 902 a HfB_2 layer as the heat-generating resistance layer, 903 a common electode of Cu, 904 an individual electrode of Cu, 905a and 905b pattern wirings of Cu 906 a SiO_2 layer as the oxidation resistant layer and the insulating layer, 907 a photosensitive polyimide

layer as the ink resistant layer and the insulating layer, and 908 a Ta layer as the cavitation resistant layer.

As shown in Fig. 9A and Fig. 9B, in this Example, the sectional shape of the tip end of the bump-shaped electrode is convex.

Next, an example of the preparation steps of the recording element unit according this Example is described by referring to Example 10, by taking an example of the case having a common electrode.

(1) First, HfB_2 layer 902 (thickness 350Å), Ti layer (omitted in Fig. 10) (thickness 50 Å) and Cu layer (thickness 6000 Å) are formed on the whole substrate surface 901 according to the sputtering method (Fig. 10A).

(2) A resist is coated by use of the photolithographic method on the film formed in (1), then subjected to patterning by exposure and development, and further Cu layer/Ti layer/HfB_2 layer are respectively etched to form a pattern wiring. The resist is peeled off after etching.

(3) On the Cu layer/Ti layer/HfB_2 layer wiring electrode substrate formed in the above (2) is patterned a resist by use of the same photolithographic method as in (2) and further Cu is removed partially by etching to form a heater portion. The resist is peeled off after etching (Fig. 10B).

(4) SiO_2 layer 906 (thickness 9000Å), as the heater oxidation resistant layer and the interlayer insulating layer, Ta_2O_5 layer (omitted in Fig. 10C) (thickness: 500 Å) as the SiO_2-Ta adhering layer and Ta layer (thickness 5000 Å) as the cavitation resistant layer are formed on the whole substrate surface by continuous sputtering.

(5) According to the same method as in the above (2), resist is patterned and Ta is removed partially by etching to form a Ta pattern. The resist is peeled off after etching (Fig. 10C).

(6) According to the same method as in the above (2), resist was patterned and SiO_2 patterning is effected by removing partially SiO_2 by etching. The resist is peeled off after etching (Fig. 10D).

(7) An organic insulating film (film thickness 2.5 μm) as the ink resistant layer and the interlayer insulating layer is coated, and a pattern is formed according to the same method as in (2) or a pattern is formed by coating a photosensitive organic insulating film 907 (film thickness 2.5 μm), followed by exposure and development (Fig. 10E).

(8) Finally, according to the electroplating method, for example, conductive bump-shaped electrode 904 is formed with, for example, Cu, Ni, Au, Cr, Rh, etc. or a combination of these.

At this time, when the recording element unit has a common electrode, the common electrode 903 can be also formed simultaneously with the bump-shaped electrode 904. At this time, plating grows initially per individual bit at the common electrode portion, but plating must be continued until plating between the adjacent bits is sufficiently connected. On the other hand, at this time the individual electrodes must be made so that no contact may occur between the adjacent bits (Fig. 10F).

An example of the preparation steps of the recording element of this Example has been described above.

Thus, the recording element unit of this Example requires none of the steps of forming an electroplated subbing layer on the whole substrate surface, patterning by coating of a resist and removing the resist by etching, etc. which have been required in the prior art in preparation thereof, and therefore could be prepared at very low cost.

Also, since a bump-shaped electrode with a convex sectional shape of the tip end could be formed, it has become possible to further lower the contact resistance of the bonding portion.

By bonding a driving element substrate to such recording element unit as shown in Fig. 1, a recording element driving unit with low contact resistance at the bonding portion could be prepared at low cost.

Also, by forming a liquid channel communicated to a discharging opening for discharging ink in the recording element unit of this Example, an ink jet unit could be prepared at low cost.

By connecting electrically a driving element unit to the ink jet unit, an ink jet driving unit with low contact resistance at the bonding portion could be prepared at low cost.

Further, when an ink jet recording device was prepared at low cost with low contact resistance at the bonding portion by use of the ink jet driving unit and recording test was conducted for the ink jet recording device, stable recording could be performed.

Example 5

In the following, as a fifth example of the present invention, the case of having a bump-shaped electrode of individual electrode formed long in the substrate thickness direction by providing newly an insulating layer on the surface of the recording element unit is to be described.

Fig. 11 is a schematic sectional view showing the recording element unit according to this Example. In Fig. 11, 1101 is a holding member, 1102 a HfB_2 layer as the heat-generating resistance layer, 1103 a common electrode of Al, 1104 an individual electrode of Al, 1105 a pattern wiring of Al, 1106 a SiO_2 layer as the oxidation resistant layer and the insulating layer, 1107 a photosensitive polyimide layer as the ink resistant layer and the insulating layer, 1108 a Ta layer as the cavitation layer and 1109 an insulating layer for forming the bump-shaped electrode of individual electrode long in the substrate thickness direction.

Since the bump-shaped electrode of individual electrode is formed long in the substrate thickness direction by providing thus a new insulating layer in the present invention, the influence from curving of the substrate can be removed.

Next, an example of the preparation steps of the recording element unit according this Example is described by referring to Figs. 12A - 12G.

(1) First, HfB_2 layer 1102 (thickness 350 Å), Ti layer (omitted in Fig. 12A) (thickness 50 Å) and Al layer (thickness 6000 Å) are formed on the whole substrate surface according to the sputtering method (Fig. 12A).

(2) For formation of the wiring substrate, a resist is coated by use of the photolithographic method on the film formed in (1), then subjected to patterning by exposure and development, and further Al layer/Ti layer/HfB_2 layer is etched to form a wiring. The resist is peeled off after etching.

(3) On the Al layer/Ti layer/HfB_2 layer wiring electrode substrate formed in the above step (2) is patterned a resist by use of the same photolithographic method as in (2) and further Al is removed partially by etching to form a heater portion. The resist is peeled off after etching (Fig. 12B).

(4) SiO_2 layer 1106 (thickness 9000 Å) as the heater oxidation resistant layer and the interlayer insulating layer, Ta_2O_5 layer (omitted in Fig. l2C) (thickness: 500 Å) as the SiO_2-Ta adhering layer and Ta layer 1108 (thickness 5000 Å) as the cavitation resistant layer are formed on the whole subsrate surface by continuous sputtering.

(5) According to the same method as in the above (2), resist is patterned and Ta is removed partially by etching to form a Ta pattern. The resist is peeled off after etching (Fig. 12C).

(6) According to the same method as in the above (2), resist is patterned and SiO_2 patterning is effected by removing partially SiO_2 by etching. The resist is peeled off after etching (Fig. 12D).

(7) An organic insulating film 1107 (film thickness 2.5 μm) as the ink resistant layer and the interlayer insulating layer is coated, and a pattern is formed according to the same method as in (2) or a pattern is formed by coating a photosensitive organic insulating film (film thickness 2.5 μm), followed by exposure and development (Fig. 12E).

(8) An insulating layer 1109 is formed by coating to form a pattern (some to some hundreds μm). The layer thickness may be as thick as possible within the range capable of forming a pattern. Since this layer is unnecessary for the heater portion, it is removed after layer formation.

(9) Cu layer (thickness 3000 Å) and Ti layer (thickness 500 Å) as the electroplated subbing layer (omitted in Fig. 12F)is formed on the whole surface of the substrate.

(10) A resist for formation of plating pattern is coated, exposed and developed.

(11) Finally, according to the electroplating method, a conductive bump-shaped electrode 1104 is formed with, for example, Cu, Ni, Au, Cr, Rh, etc. or a combination of these, and the resist is peeled off (Fig. 12G).

An example of the preparation steps of the recording element of this Example has been described above.

By bonding a driving element substrate to such recording element unit as shown in Example 2, a recording element driving unit with excellent reliability of electrical connection could be prepared at low cost.

Also, by forming a liquid channel communicated to a discharging opening for discharging ink in the recording element unit of this Example, an ink jet unit was prepared.

By connecting electrically a driving element unit to the ink jet unit, an ink jet driving unit was prepared.

Further, when an ink jet recording device was prepared by use of the ink jet driving unit and recording test was conducted for the ink jet recording device, stable recording could be performed.

Example 6

In the following, as a sixth example of the present invention, the case of having a bump-shaped electrode of individiual electrode formed long in the substrate thickness direction by providing newly an insulating film on the surface of the recording element unit is to be described.

Fig. 13 is a schematic sectional view showing the recording element unit according to this Example. In Fig. 13, 1301 is a holding member, 1302 a HfB_2 layer as the heat-generating resistance layer, 1303 a common electrode of Al, 1304 an individual electrode of Al, 1305 a pattern wiring of Al, 1306 a SiO_2 layer as the oxidation resistant layer and the insulating layer, 1307 a photosensitive polyimide layer as the ink resistant layer and the insulating layer, 1308 a Ta layer as the cavitation layer and 1309 an insulating film for forming the bump-shaped electrode of individual electrode long in the substrate thickness direction.

Since the bump-shaped electrode of individual electrode is formed long in the substrate thickness direction by providing thus a new insulating layer in the present invention, the influence from curving of the substrate can be removed.

Next, an example of the preparation steps of the recording element unit according to this Example is described by referring to Figs. 14A - 14G.

(1) First, HfB_2 layer 1302 (thickness 350 Å), Ti layer (omitted in Fig. 14A) (thickness 50 Å) and Al layer 1305 (thickness 6000 Å) are formed on the whole substrate surface 1301 according to the sputtering method (Fig. 14A).

(2) For formation of the wiring substrate, a resist is coated by use of the photolithographic method on the film formed in (1), then subjected to patterning by exposure and development, and further Al layer/Ti layer/HfB_2 layer are etched to form a wiring. The resist is peeled off after etching.

(3) On the Al layer/Ti layer/HfB_2 layer wiring electrode substrate formed in the above step (2) is patterned a resist by use of the same photolithographic method as in (2) and further Al is removed partially by etching to form a heater portion. The resist is peeled off after etching (Fig. 14B).

(4) SiO_2 layer 1306 (thickness 9000 Å) as the

heater oxidation resistant layer and the interlayer insulating layer, Ta_2O_5 layer (thickness: 500 Å) as the SiO_2-Ta adhering layer and Ta layer 1308 (thickness 5000 Å) as the cavitation resistant layer are formed on the whole substrate surface by continuous sputtering.

(5) According to the same method as in the above (2), resist is patterned and Ta is removed partially by etching to form a Ta pattern. The resist is peeled off after etching (Fig. 14C).

(6) According to the same method as in the above (2), resist was patterned and SiO_2 patterning is effected by removing partially SiO_2 by etching. The resist is peeled off after etching (Fig. 14D).

(7) An organic insulating film (film thickness 2.5 μm) as the ink resistant layer and the interlayer insulating layer is coated, and a pattern is formed according to the same method as in (2) or a pattern is formed by coating a photosensitive organic insulating film 1307 (film thickness 2.5 μm), followed by exposure and development (Fig. 14E).

(8) On the surface of the organic insulating film formed in the above step (2), an insulating film 1309 having thruholes is plastered.

(9) Cu layer (thickness 3000 Å) and Ti layer (thickness 500 Å) as the electroplated subbing layer is formed on the whole surface of the substrate.

(10) A resist for formation of plating pattern is coated, exposed and developed.

(11) Finally, according to the electroplating method, an electrode 1304 (bump-shaped electrode) is formed with, for example, Cu, Ni, Au, Cr, Rh, etc. or a combination of these, and the resist is peeled off (Fig. 14G).

An example of the preparation steps of the recording element of this Example has been described above.

By bonding a driving element substrate to such recording element unit as shown in Example 2, a recording element driving unit with excellent reliability of electrical connection at the bonding portion could be prepared at low cost.

Also, by forming a liquid channel communicated to a discharging opening for discharging ink on the recording element unit of this Example, an ink jet unit was prepared.

By connecting electrically a driving element unit to the ink jet unit, an ink jet driving unit excellent in reliability of electrical connection was prepared.

Further, when an ink jet recording device was prepared by use of the ink jet driving unit and recording test was conducted for the ink jet recording device, stable recording could be performed.

Example 7

As an example of the present invention, the recording element unit having a bump-shaped electrode electroconductive raised portion as the individual electrode 1504 having substantially the same constitution as shown in Fig. 19 (a) and 19 (b) is to be described.

First, an example of the preparation steps of the recording element unit according to the present invention are described below.

Figs. 15A - 15F are diagrams for illustration of the preparation steps of the recording element unit according to the present invention.

(1) First, HfB_2 1402: 350 Å, Ti (omitted in Fig. 15A): 50 Å and Al 1405: 6000 Å are formed on the whole substrate surface 1401 according to the sputtering method (Fig. 15A).

(2) For formation of the wiring substrate, a resist is coated by use of the photolithographic method on the film formed in (1), then subjected to patterning by exposure and development, and further Al/Ti/HfB_2 layers are etched to form a wiring. The resist is peeled off after etching.

(3) On the Al/Ti/HfB_2 wiring electrode substrate formed in the above (2) is patterned a resist by use of the same photolithographic method as in (2) and further Al is removed partially by etching to form a heater portion. The resist is peeled off after etching (Fig. 15B).

(4) SiO_2 1406: 9000 Å as the heater oxidation resistant layer and the interlayer insulating layer, $Ta2O_5$ (omitted in Fig. 15C) : 500 Å as the SiO_2-Ta adhering layer and Ta 1408: 5000 Å as the cavitation resistant layer are formed on the whole substrate surface by continuous sputtering.

(5) According to the same method as in the above (2), resist is patterned and Ta is removed partially by etching to form a Ta pattern. The resist is peeled off after etching (Fig. 15C).

(6) According to the same method as in the above (2), resist is patterned and SiO_2 patterning is effected by removing partially SiO_2 by etching. The resist is peeled off after etching (Fig. 15D).

(7) An organic insulating film: 2.5 μm as the ink resistant layer and the interlayer insulating layer is coated, and a pattern is formed according to the same method as in (2) or a pattern is formed by coating a photosensitive organic insulating film 1407: 2.5 μm, followed by exposure and development (Fig. 15E).

(8) As the electroplated subbing layer (omitted in Fig. 15E), a Cu layer: 3000 Å and a Ti layer: 500 Å are formed on the whole substrate surface.

(9) A resist for formation of plating pattern is coated, exposed and developed.

(10) According to the electroplating method, an electroconductive raised portion 1404 is formed with, for example, Cu, Hi, Au, Cr, Rh, etc. The film thickness is made several microns to some tens microns. Finally, the resist is peeled off (Fig. 15F).

An example of the preparation steps of this Example has been described.

In this Example, the portion which becomes the bonding portion is the raised portion 1404. An enlarged view of this portion is shown in Fig. 16. By bonding this portion to the bonding portion of another substrate as shown in Fig. 1, electrical

connection between two sheets of the substrate is effected.

Thus, according to the present invention, merely by bonding two sheets of substrate, electrical connection of high reliability can be effected.

Fig. 17 is a schematic exploded perspective view showing an example of the head portion of the ink jet unit and the ink jet driving unit according to the present invention.

In Fig. 17, the symbol 61 is a discharging opening, 62 an ink channel communicated to the discharging opening 61, and 63 an ink chamber communicated to the ink channel 62. The liquid channel in this Example has an ink channel 62 and an ink chamber 63. In this Example, the ink channel 62 and the ink chamber 63 are formed by bonding mutually of the recording element substrate 184 (for better understanding of the description, length is drawn shorter), the wall forming member 64 and the covering member 65. Further in this Example, a heat-generating portion 67 is provided as the recording element corresponding to each ink channel 62, and electrodes (not shown in Fig. 17) are arranged at these heat-generating portions 67. The symbol 66 in Fig. 17 is an ink feeding opening to the ink chamber 63.

Fig. 18 is a schematic perspective appearance view showing an example of the ink jet device according to the present invention. In Fig. 18, the symbol 1000 is the main body of the device, 1100 the power source switch and 1200 the panel for operation.

The present invention brings about excellent effects particularly in the recording head, recording device of the bubble jet system among ink jet recording systems.

As for its representative constitution and principle, for example, those by use of the basic principle disclosed in U.S. Patents 4723129 and 4740796 are preferred. Although this system is applicable to either of the on-demand type and the continuous type, particularly in the case of the on-demand type, it is effective because heat energy is generated in the electricity-heat converter by applying at least one driving signal which gives abrupt temperature elevation in excess of nucleus boiling corresponding to the recording information to the electricity-heat converter arranged corresponding to the sheet or the liquid channel where liquid (ink) is held, thereby effecting film boiling on the heat-acting surface of the recording head, resulting in formation of bubbles within the liquid (ink) corresponding one by one to the driving signal. By discharging liquid (ink) through the opening for discharging by growth and shrinkage of the bubble, at least one droplet is formed. When the driving signal is made pulse-shaped, adequate growth and shrinkage of bubble can be more preferably effected to accomplish discharging of liquid (ink) particularly excellent in response characteristic. As the pulse-shaped driving signal, those disclosed in U.S. Patents 4463359 and 4345262 are suitable. By employment of the conditions as disclosed in U.S. Patent 4313124 of the invention concerning temperature elevation rate of the above heat-acting surface, further excellent recording can be performed.

As the constitution of the recording head, in addition to the constitution comprising a combination of discharging opening, liquid channel and electricity-heat converter (linear liquid channel or right angle liquid channel), the constitution utilizng U.S. Patent 4558333 or 4459600 disclosing a constitution having a heat-acting portion arranged in a flexed region is also included in the present invention. In addition, the present invention is also effective for such constitution as based on Japanese Unexamined patent Publication No. 59-123670 disclosing the constitution comprising a common slit as the discharging portion of electricity-heat converter for a plurality of electricity-heat converters or Japanese Unexamined Patent Publication No. 59-138461 disclosing the constitution having an opening which absorbs pressure wave of heat energy corresponding to the discharging portion.

Further, as the recording head of the full line type having a length corresponding to the width of the maximum recording medium which can be recorded by the recording device, either constitution satisfying its length or constitution as one recording head integrally formed may be employed according to a combination of a plurality of recording heads as disclosed in the specifications as described above, and the present invention can exhibit the effects as described above more effectively.

In addition, the present invention is also effective for the case of using a freely exchangeable recording head of the chip type in which electrical connection with the main device or feeding of ink from the main device becomes possible by mounting onto the main device, or the case of using a recording head of the cartridge type provided integrally with the recording head itself.

Also, addition of a restoration means, preliminary auxiliary means, etc. for the recording head provided as the constitution of the recording device of the present invention is preferable in stabilizing further the effects of the present invention. These may specifically include capping means, cleaning means, pressurization or absorption means, preliminary heating means using electicity-heat converter, heating means separate from this or the combination of these, and performing of preliminary discharging mode separate from recording are also effective for stable recording.

Further, as the recording mode of the recording device, not only the recording mode only of the main color such as black, etc., but a constitution constituting integrally the recording head or a plurality of colors may be employed, and for a device provided with at least one of complex colors with different colors or full color by color mixing, the present invention is extremely effective.

(1) As described above, according to the present invention, since electrical connection of substrates can be effected merely by bonding the recording element substrate to the driving element substrate, and therefore it becomes possible to permit the bonding portions of the recording element substrate and the driving element substrate to exist at high density, whereby it becomes possible to increase

the number of the bonding portions of the driving element substrates and effect higher densification. This also leads to miniaturization of even a lengthy unit.

Also, since no part for electrical connection is required, the unit can be made thinner and lower in cost.

Further, since the amount of the metal member used for the raised portion of the recording element unit, even if an expensive metal such as gold, etc. may be employed, cost reduction is possible.

Also, since at least one surplus than is necessary of the recording elements and the pattern wirings corresponding to the recording elements can be provided, and further since at least one surplus than is necessary of driving elements or the pattern wirings of the driving element substrate can be provided, bonding becomes possible without performing registration or without requiring high precision registration, if any.

Particularly in the case when the ink jet is bubble ink jet, registration can be done with difficulty because more higher density wiring is demanded, but according to the present invention, registration can be done with extreme ease even in the case of such high density wiring.

Further, in the present invention, the recording element substrate and the driving element substrate can be bonded freely detachably, and the driving element substrate can be easily separated and hence also exchanged easily.

(2) According to the present invention, by providing a common electrode on the driving element substrate, further miniaturization of the recording element unit as well as the recording element driving unit, the ink jet unit, the ink jet driving unit and the ink jet recording device by use thereof becomes possible.

Particularly, when bubble ink jet system is employed as the ink jet recording system, very high density wiring is demanded, and the present invention can obtain a particularly great effect in the case of such high density wiring.

(3) According to the present invention, by forming bump-shaped electrodes by use of the electroplating method with pattern wirings as electrodes, the recording element unit as well as the recording element driving unit, the ink jet unit, the ink jet driving unit and the ink jet recording device can be provided at low cost. Further, a recording element driving unit, an ink jet driving unit and an ink jet recording device with low contact resistance at the bonding portion of the recording element substrate and the driving element substrate can be provided.

(4) According to the present invention, since the influence from curving or unevenness of the substrate can be removed, electical connection of high reliability can be effected even in a length unit simply and at low cost.

Particularly, when the recording element unit or the ink jet unit is lengthy, a great effect can be obtained.

Claims

1. A recording element unit comprising:
a holding member;
a recording element provided on said holding member and having a wiring for supplying electrical signals; and
a bump-shaped electrode connected to the end of said wiring so as to be raised therefrom.

2. A recording element unit according to claim 1, wherein said recording element has a heat-generating resistance layer connected to said wiring, and is a electricity-heat converter for generating heat energy.

3. A recording element driving unit comprising a unit as claimed in claim 1 or 2, and a driving element substrate having a driving element and a wiring connected to said driving element, said bump-shaped electrode being connected to the wiring of said driving element substrate.

4. An ink jet unit comprising a unit as claimed in any of claims 1 to 3, and a liquid channel communicated to a discharging opening for discharging ink in response to energy generated by said recording element.

5. An ink jet recording device comprising a unit as claimed in any preceding claim and a member for mounting said unit.

FIG. 1

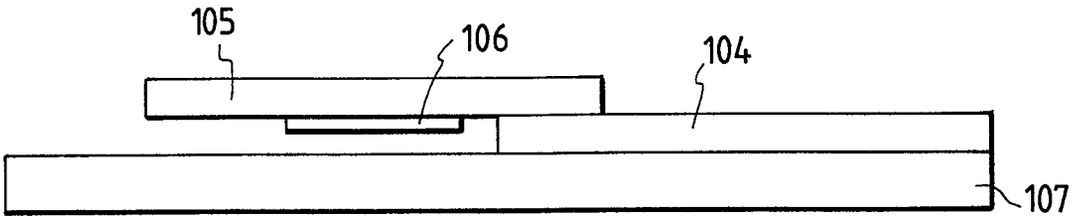

FIG. 2A(a)

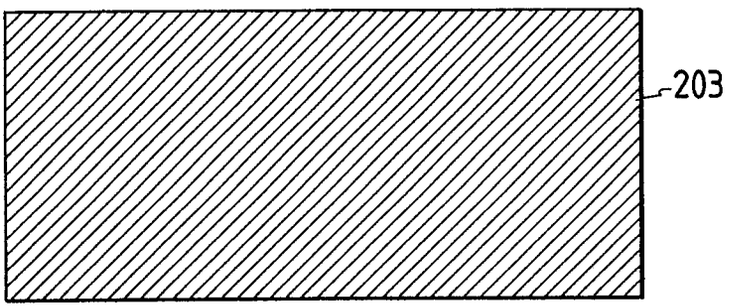

FIG. 2A(b)

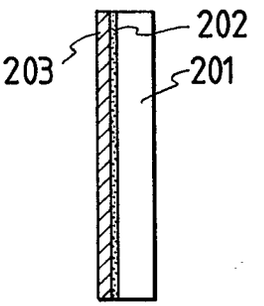

FIG. 2B(a)

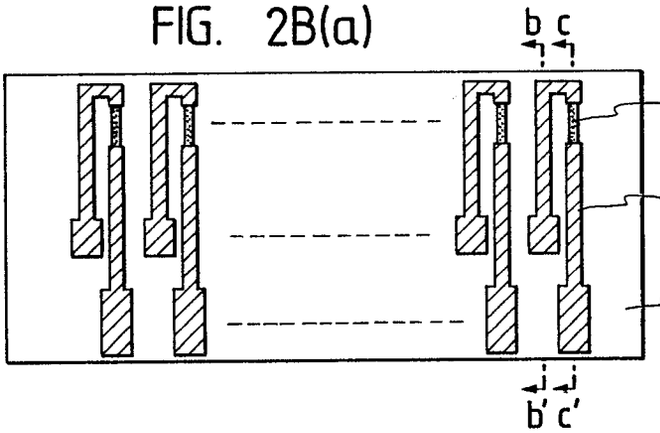

FIG. 2B(b)

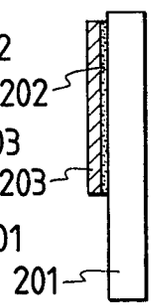

FIG. 2B(c)

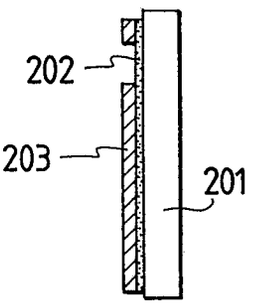

FIG. 2C(a)

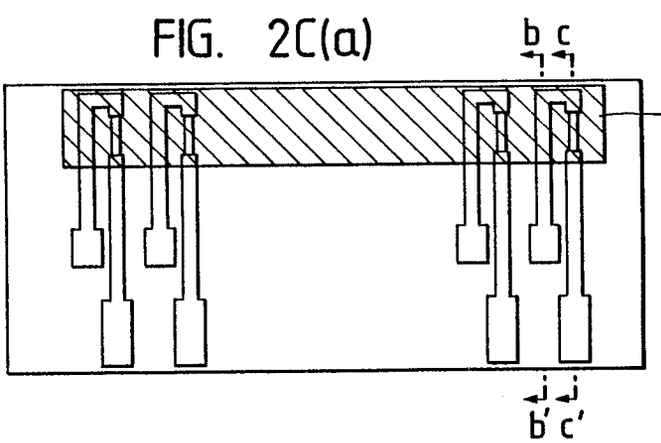

FIG. 2C(b)

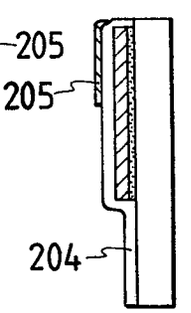

FIG. 2C(c)

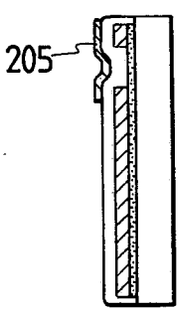

FIG. 2D(a)

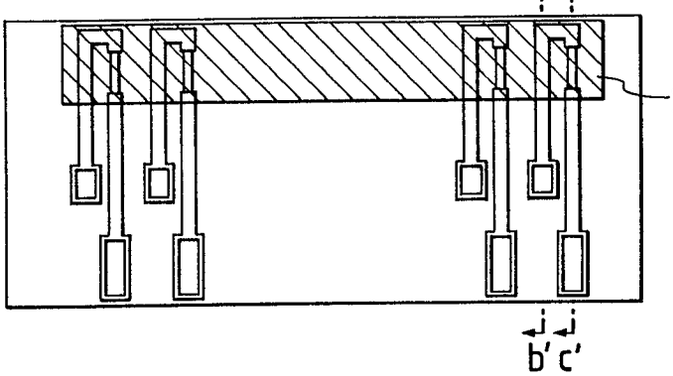

FIG. 2D(b)

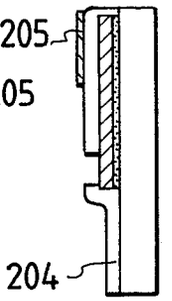

FIG. 2D(c)

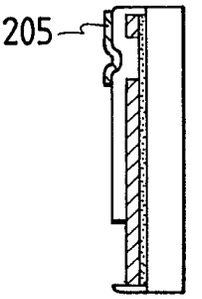

FIG. 2E(a)

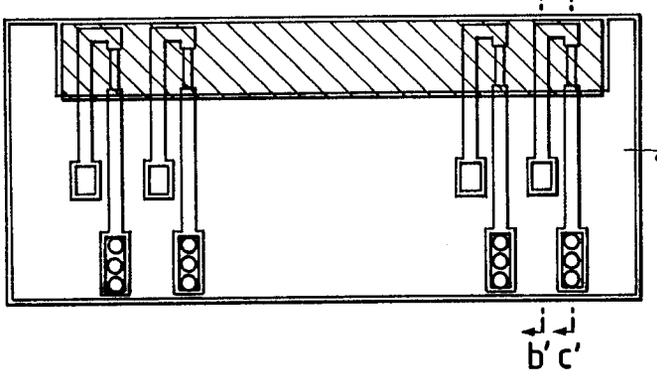

FIG. 2E(b)

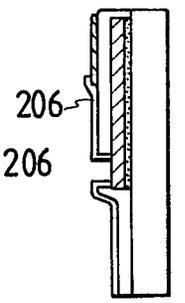

FIG. 2E(c)

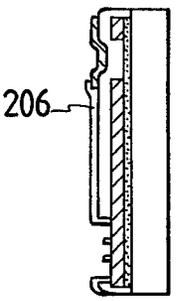

FIG. 2F(a)

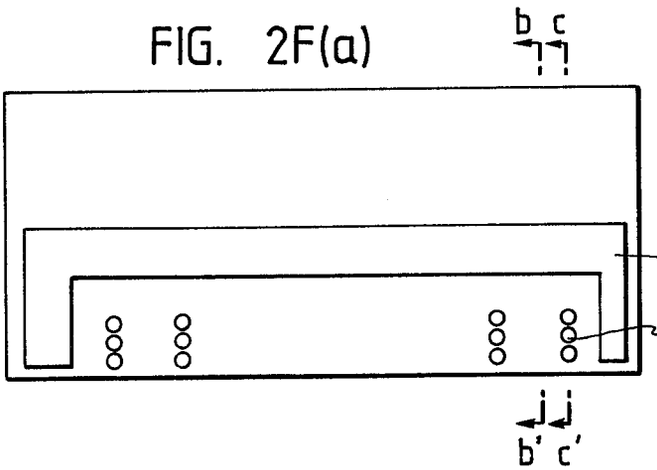

FIG. 2F(b)

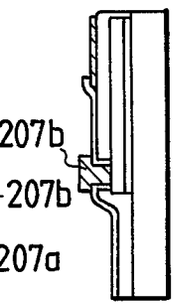

FIG. 2F(c)

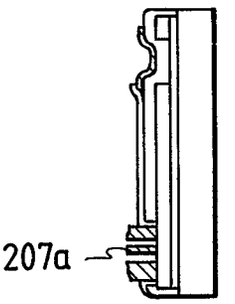

FIG. 3

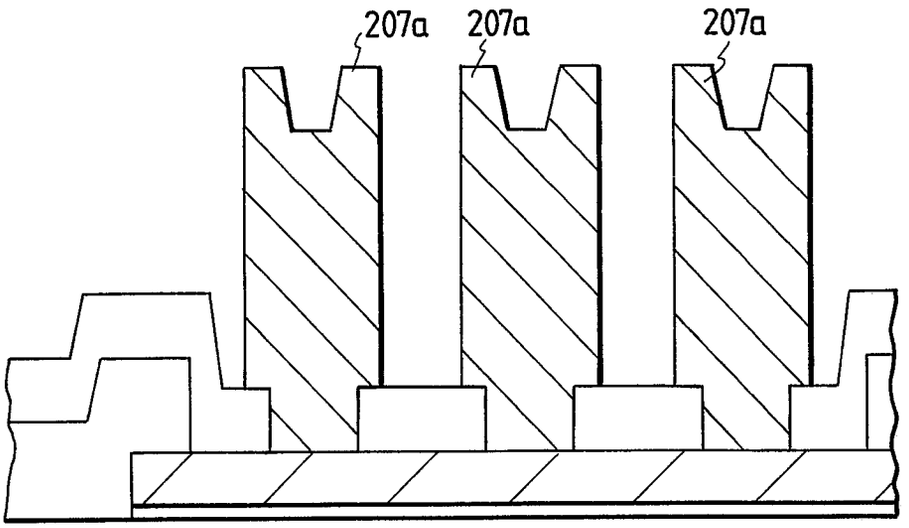

FIG. 4

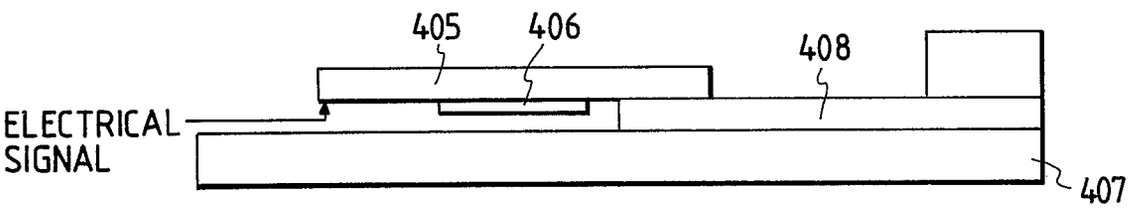

FIG. 5

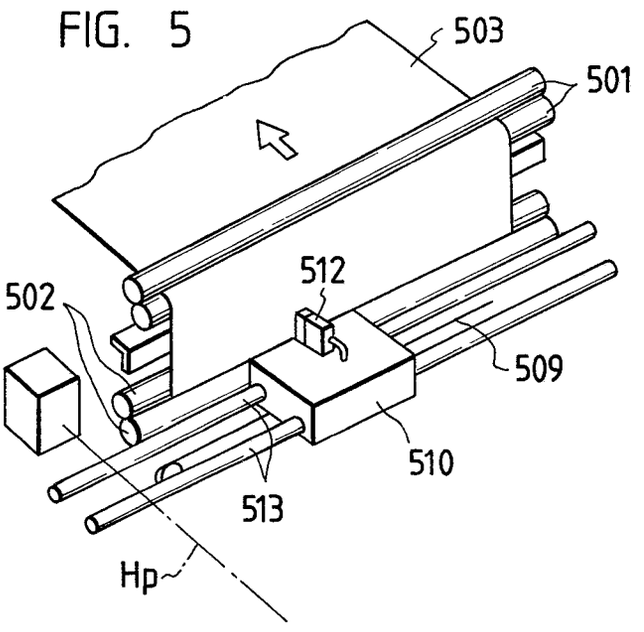

FIG. 6

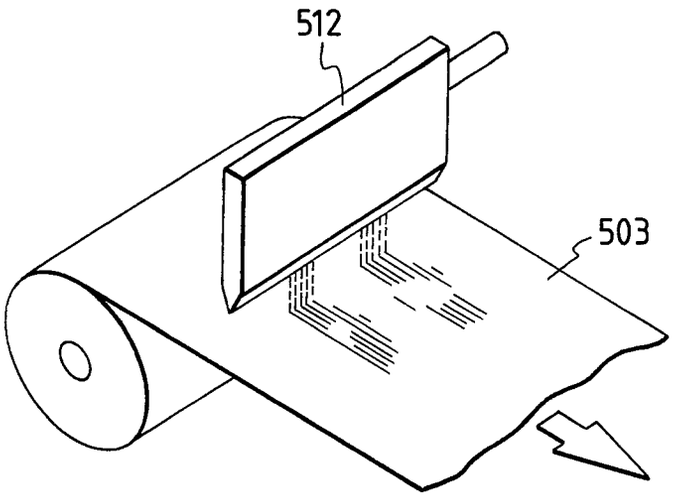

FIG. 7

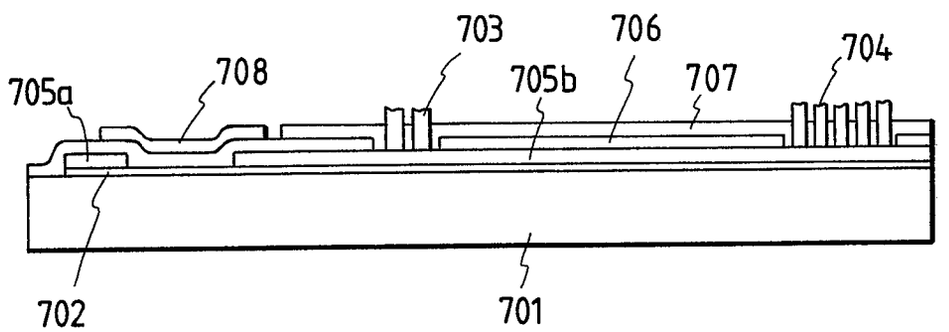

FIG. 8A(a)

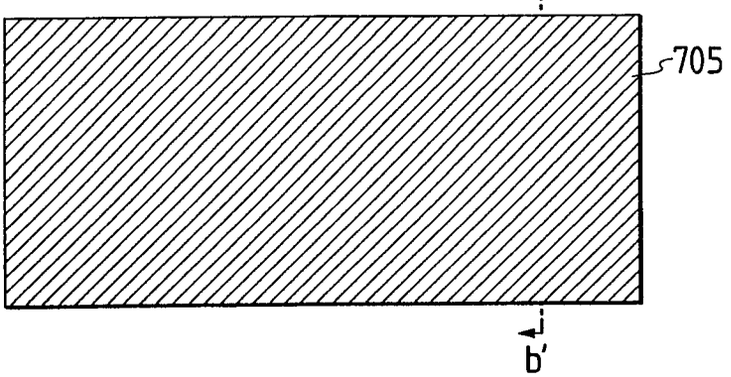

FIG. 8A(b)

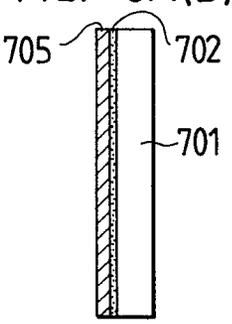

FIG. 8B(a)

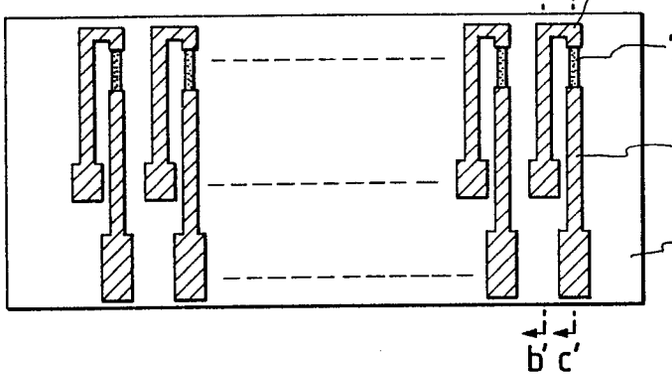

FIG. 8B(b)

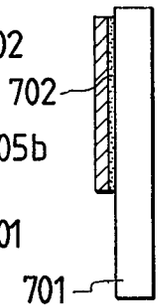

FIG. 8B(c)

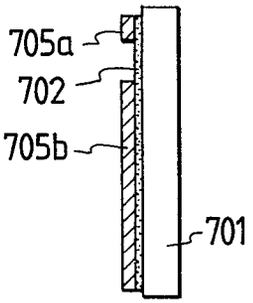

FIG. 8C(a)

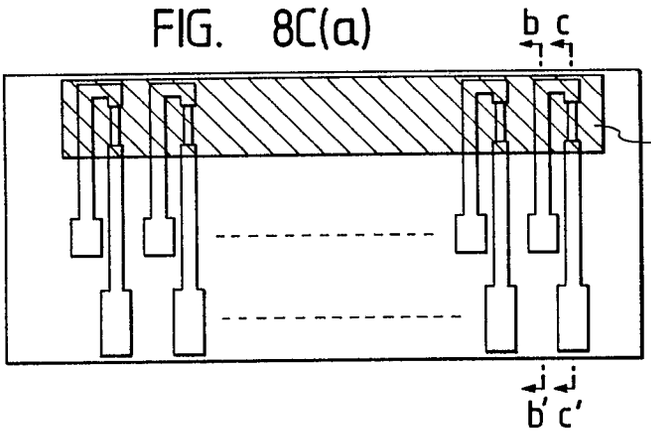

FIG. 8C(b)

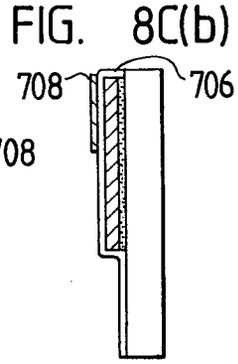

FIG. 8C(c)

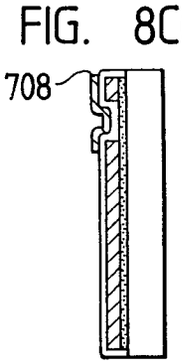

FIG. 8D(a)

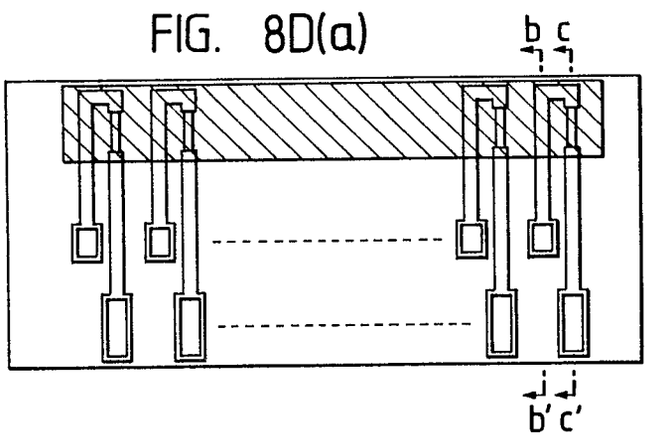

FIG. 8D(b)

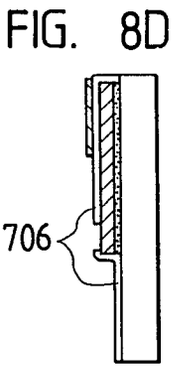

FIG. 8D(c)

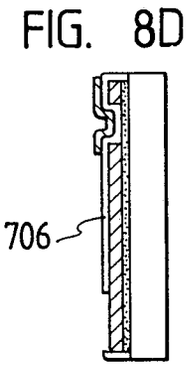

FIG. 8E(a)

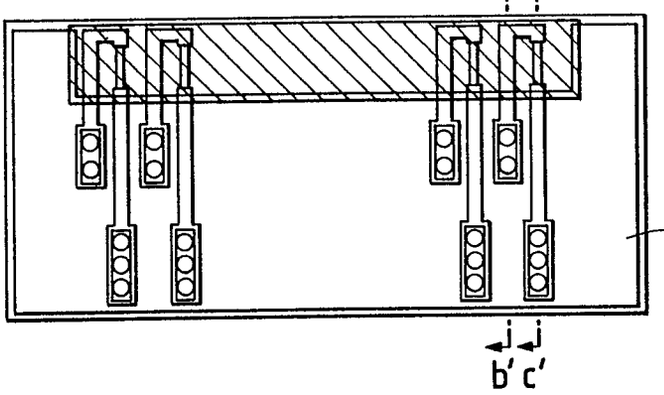

FIG. 8E(b)

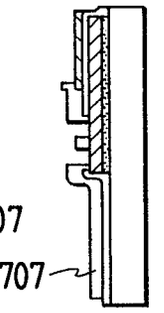

FIG. 8E(c)

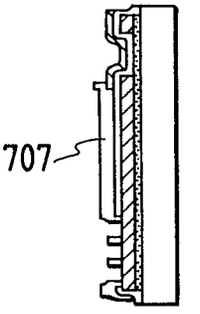

FIG. 8F(a)

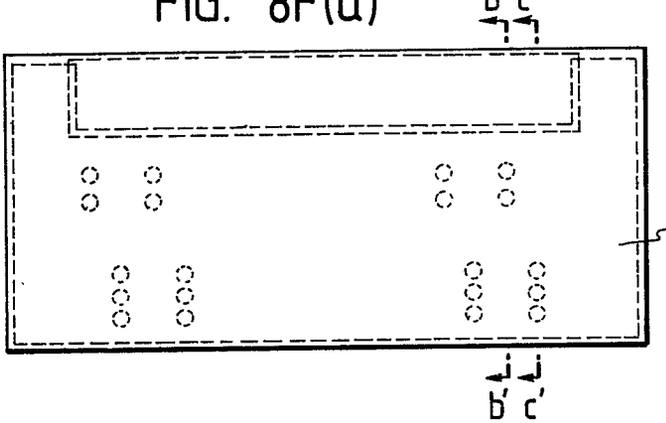

FIG. 8F(b)

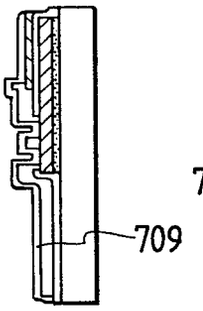

FIG. 8F(c)

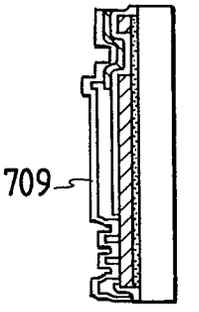

FIG. 8G(a)

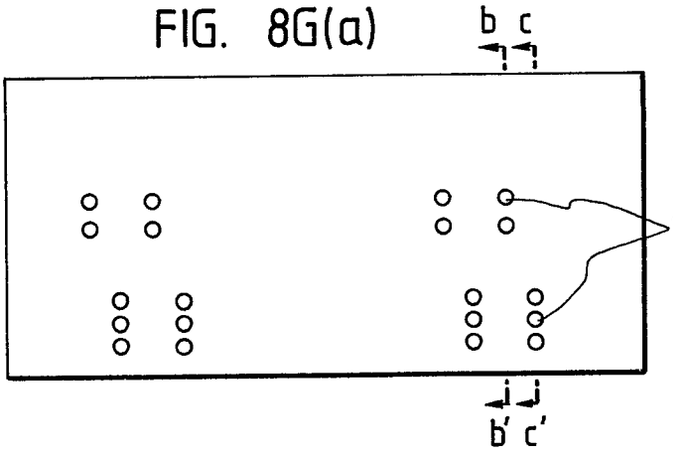

FIG. 8G(b)

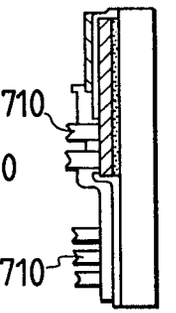

FIG. 8G(c)

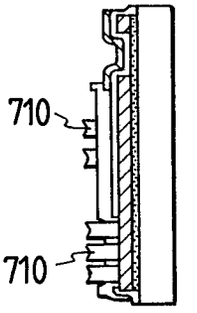

FIG. 9A

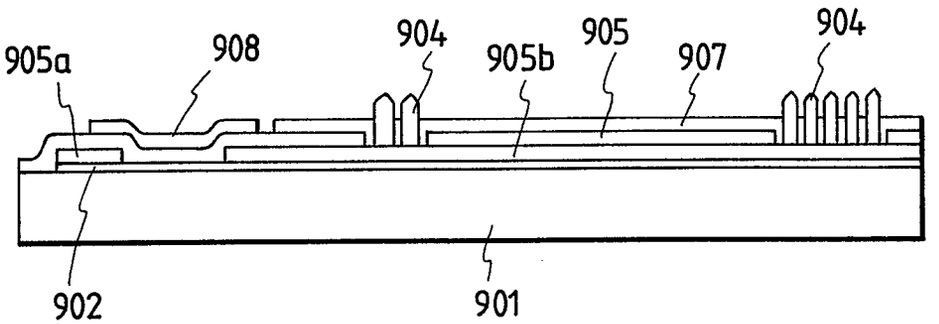
905a
908
904
905b
905
907
904
902
901

FIG. 9B

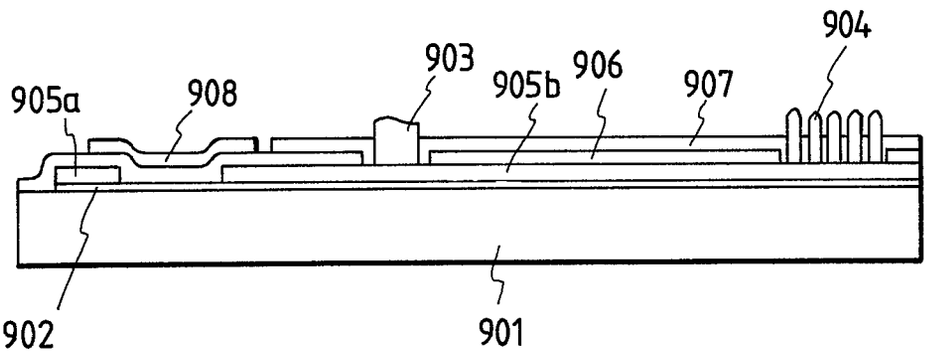
904
903
905a
908
905b
906
907
902
901

FIG. 10A(a)

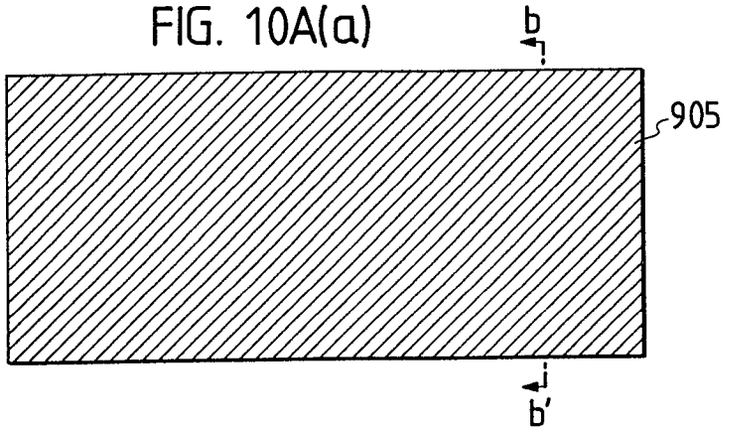

FIG. 10A(b)

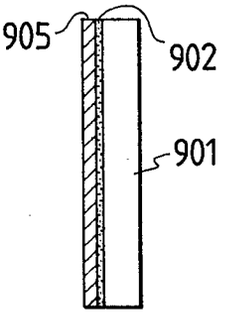

FIG. 10B(a)

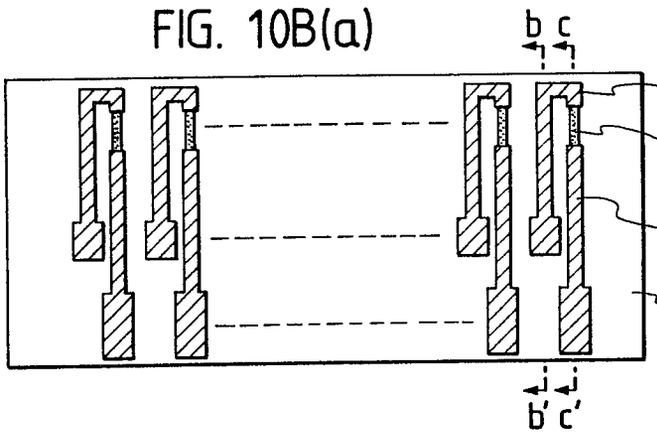

FIG. 10B(b)

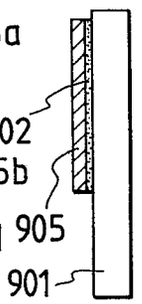

FIG. 10B(c)

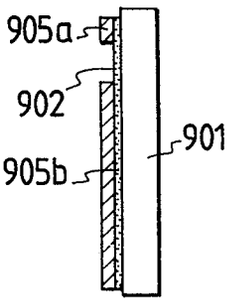

FIG. 10C(a)

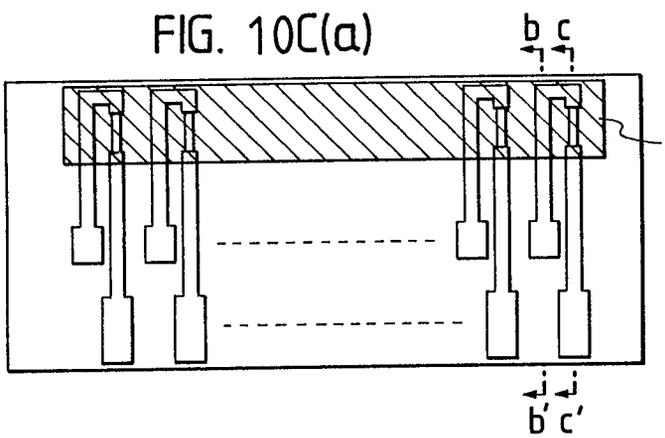

FIG. 10C(b)

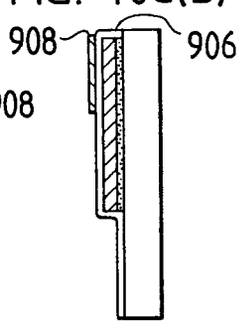

FIG. 10C(c)

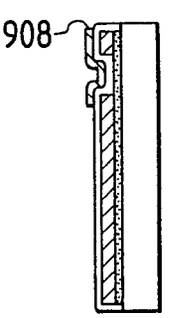

FIG. 10D(a)

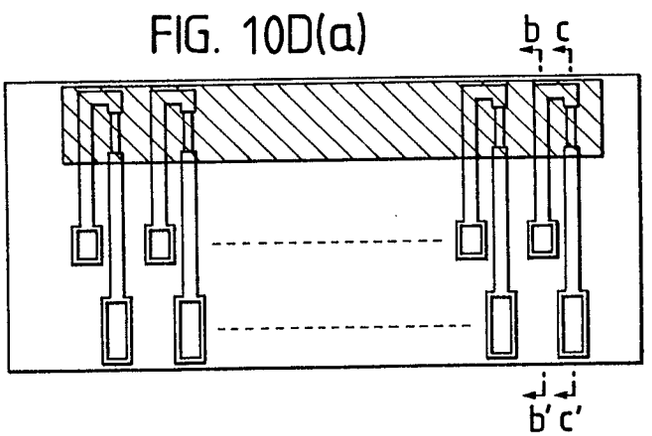

FIG. 10D(b)

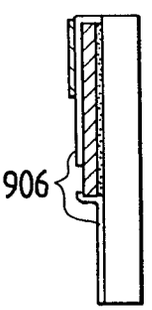

FIG. 10D(c)

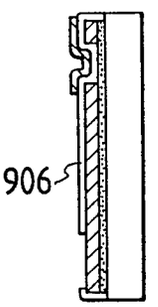

FIG. 10E(a)

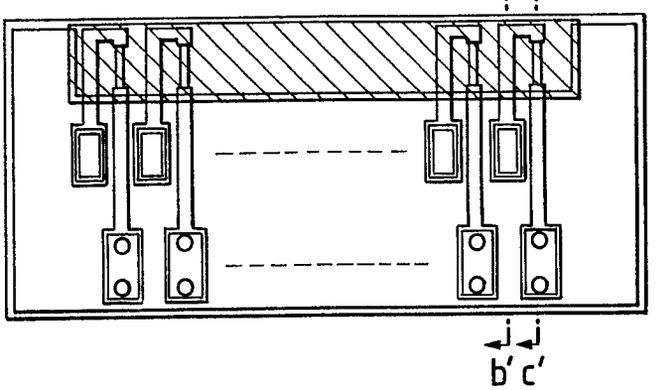

FIG. 10E(b)

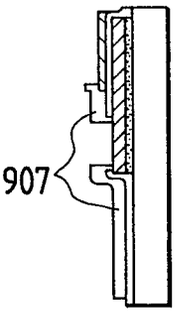

FIG. 10E(c)

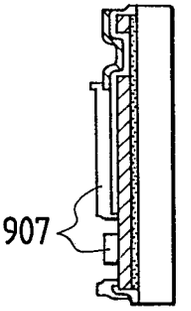

FIG. 10F(a)

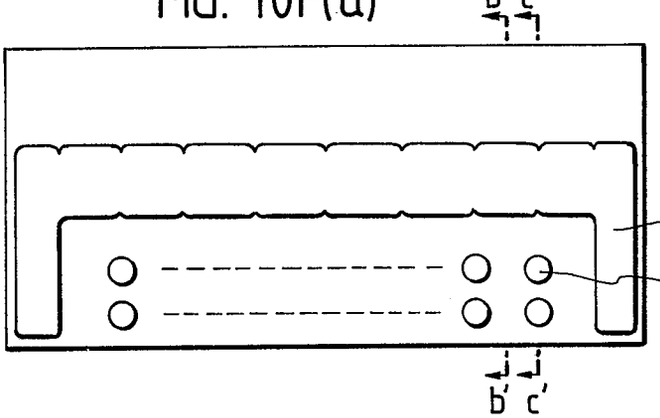

FIG. 10F(b)

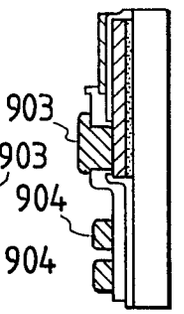

FIG. 10F(c)

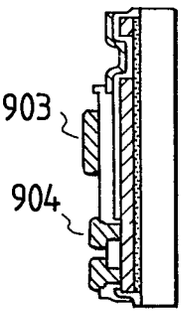

FIG. 11

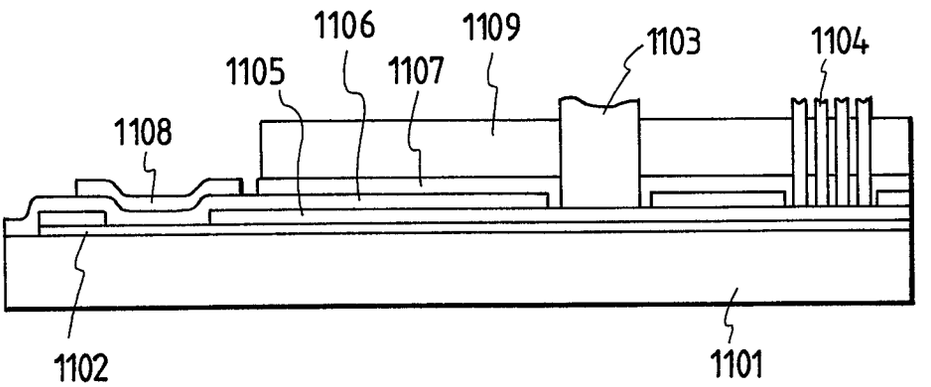

FIG. 12A(a)

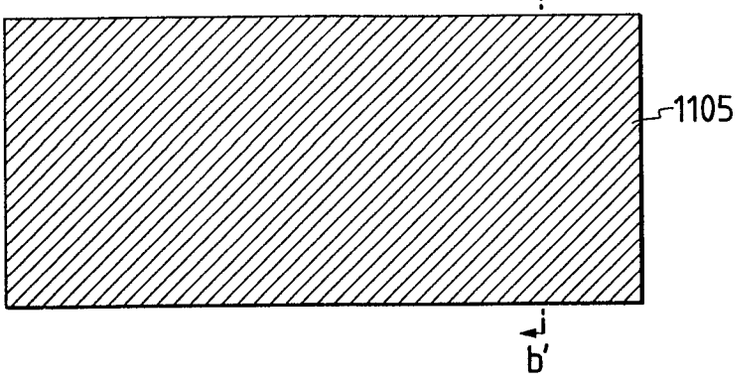

FIG. 12A(b)

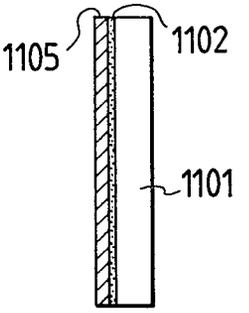

FIG. 12B(a)

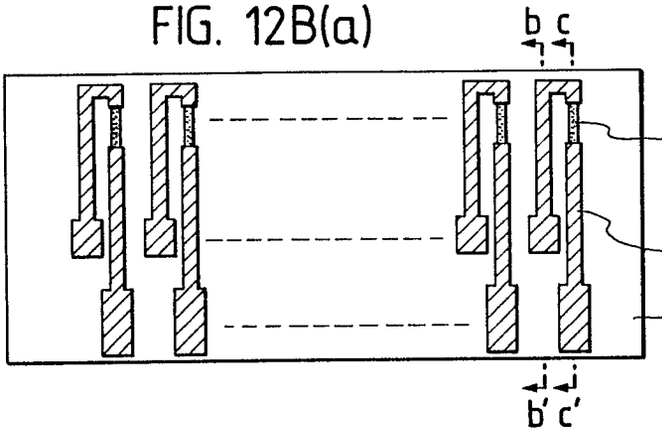

FIG. 12B(b)

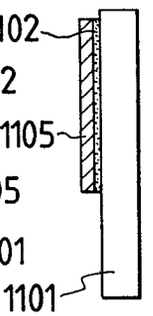

FIG. 12B(c)

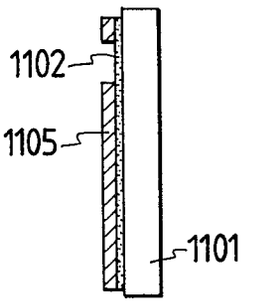

FIG. 12C(a)

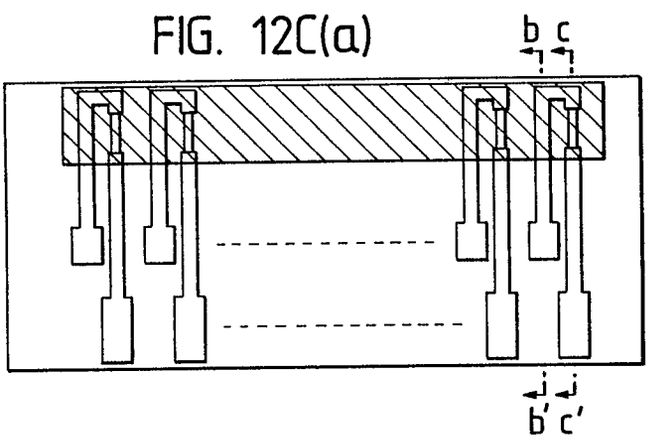

FIG. 12C(b)

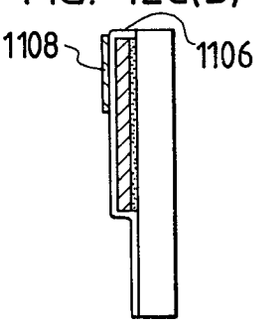

FIG. 12C(c)

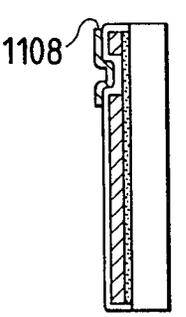

FIG. 12D(a)

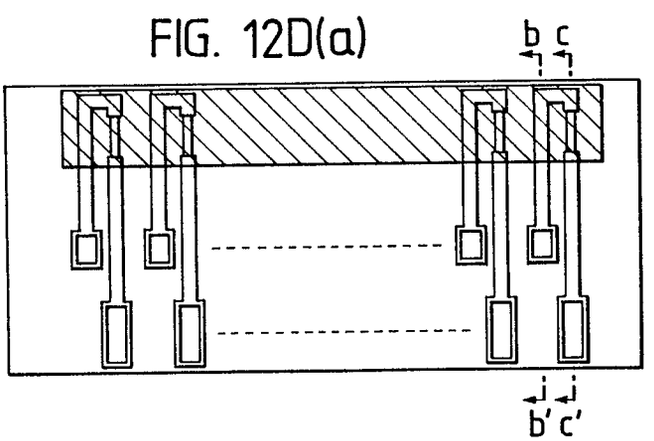

FIG. 12D(b)

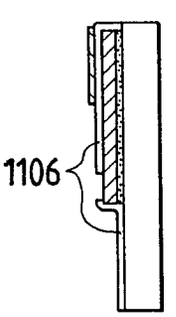

FIG. 12D(c)

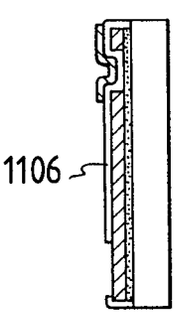

FIG. 12E(a)

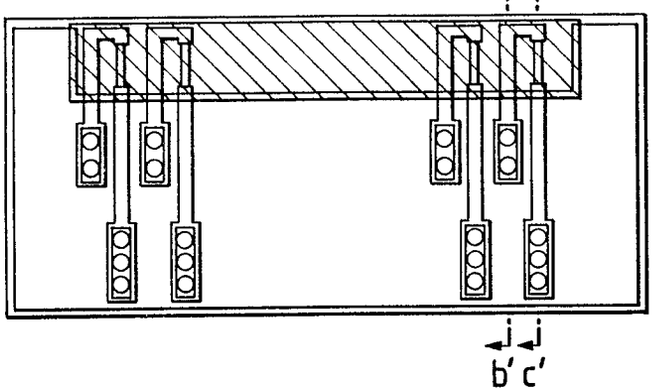

FIG. 12E(b)

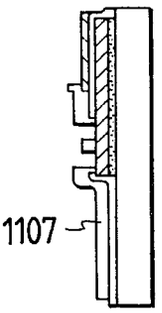

FIG. 12E(c)

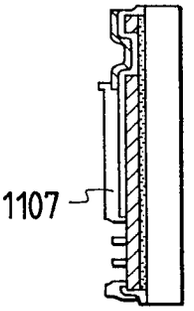

FIG. 12F(a)

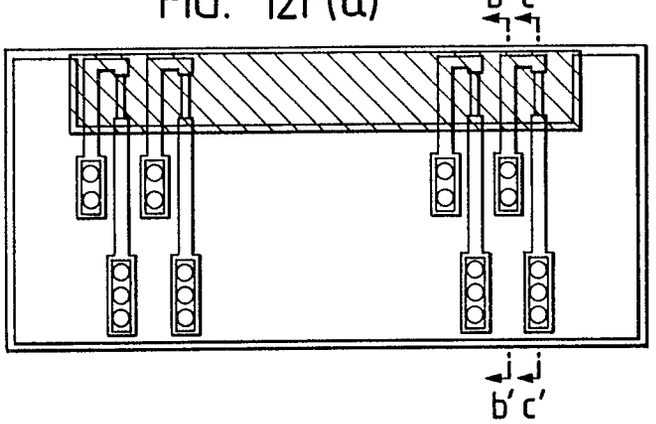

FIG. 12F(b)

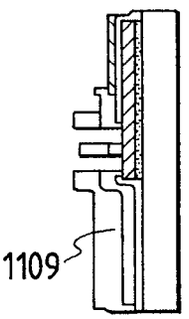

FIG. 12F(c)

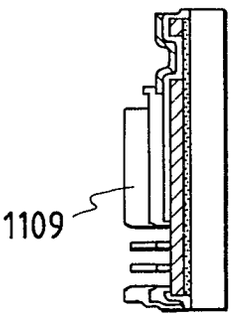

FIG. 12G(a)

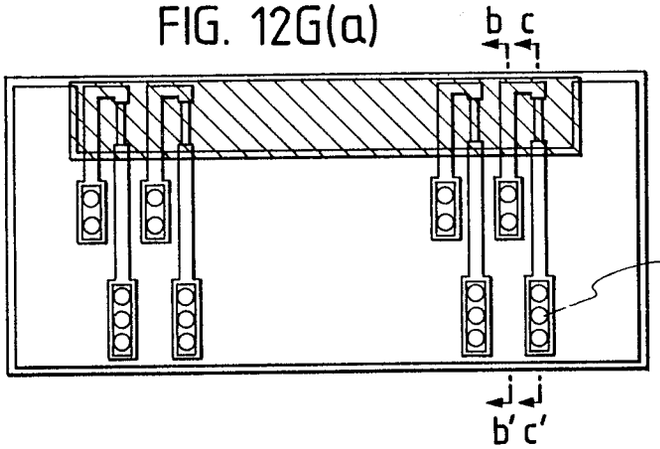

FIG. 12G(b)

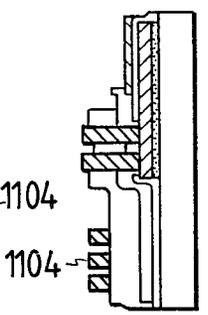

FIG. 12G(c)

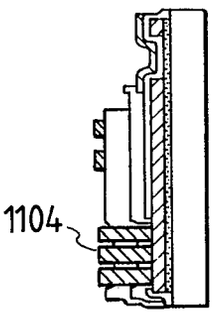

FIG. 13

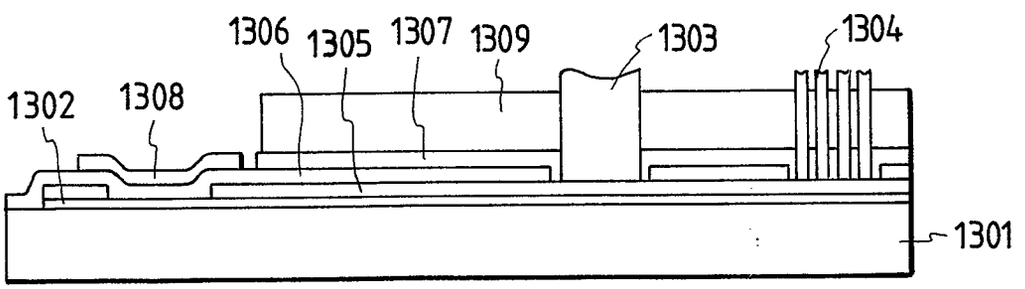

FIG. 14A(a)

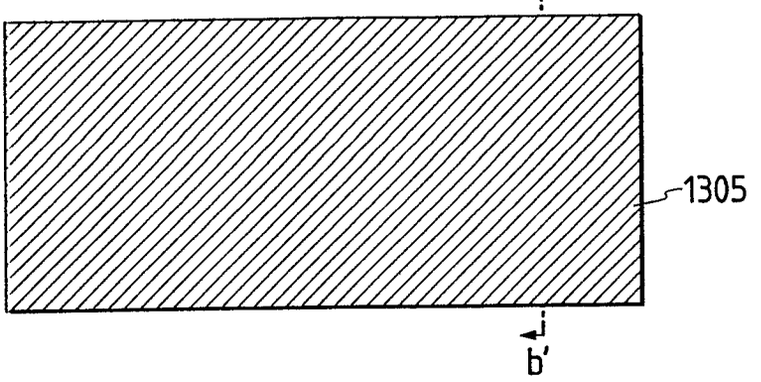

FIG. 14A(b)

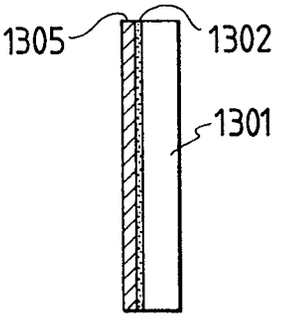

FIG. 14B(a)

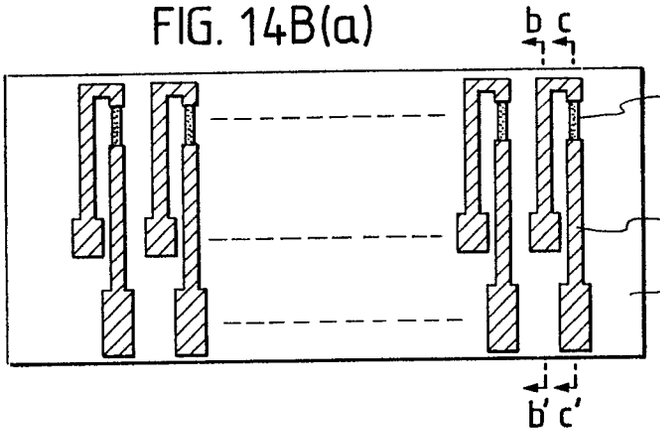

FIG. 14B(b)

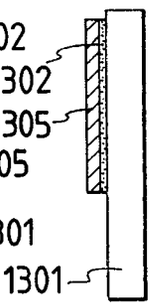

FIG. 14B(c)

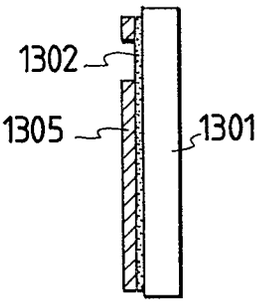

FIG. 14C(a)

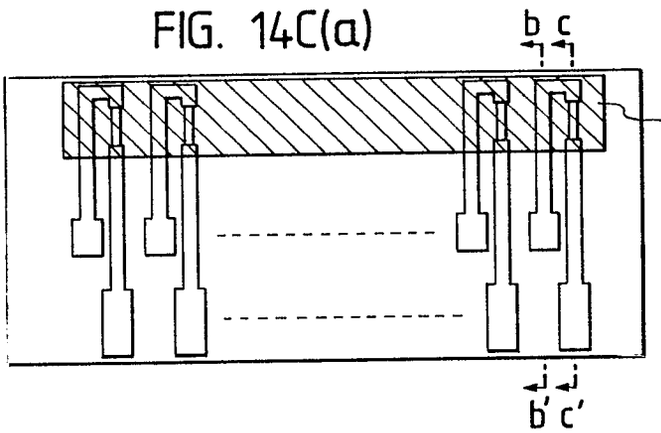

FIG. 14C(b)

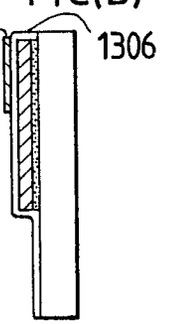

FIG. 14C(c)

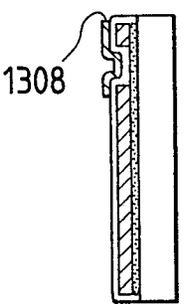

FIG. 14D(a)

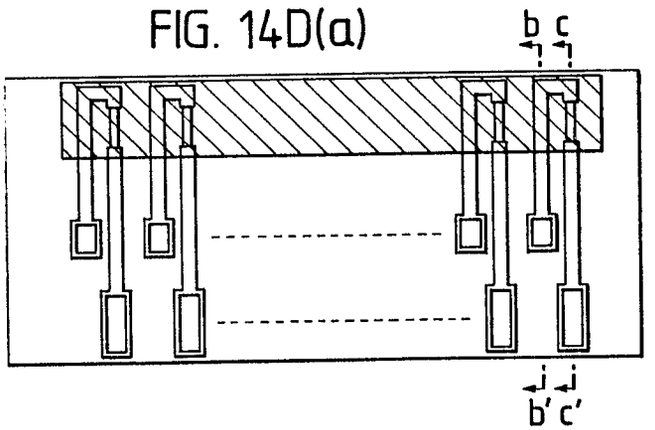

FIG. 14D(b)

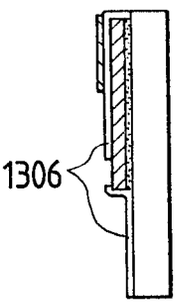

FIG. 14D(c)

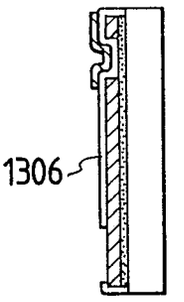

FIG. 14E(a)

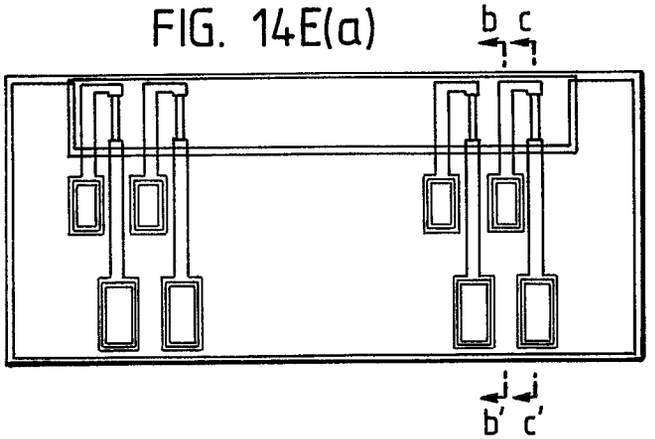

FIG. 14E(b)

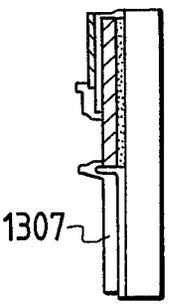

FIG. 14E(c)

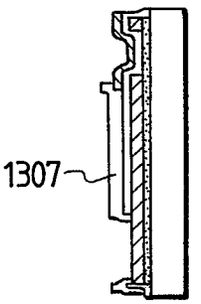

FIG. 14F(a)

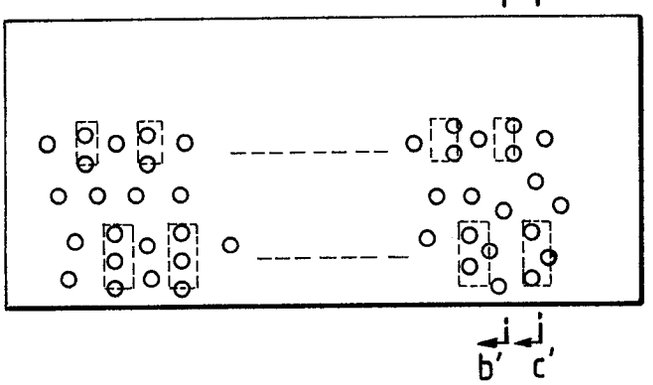

FIG. 14F(b)

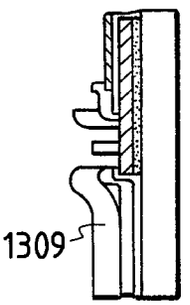

FIG. 14F(c)

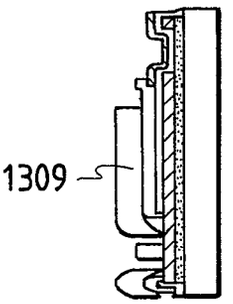

FIG. 14G(a)

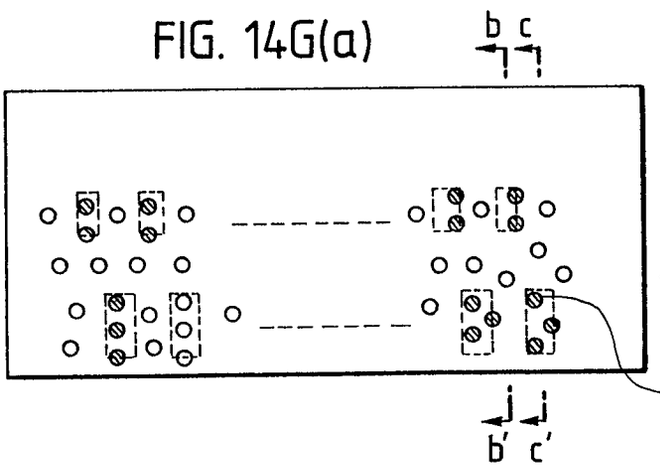

FIG. 14G(b)

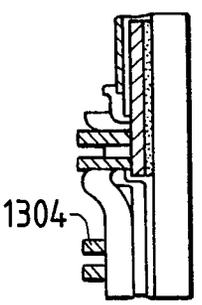

FIG. 14G(c)

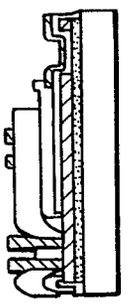

FIG. 15A(a)

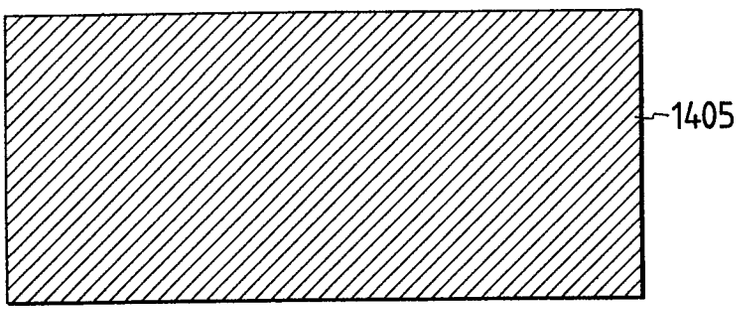

FIG. 15A(b)

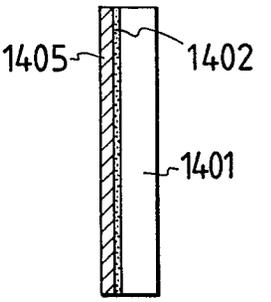

FIG. 15B(a)

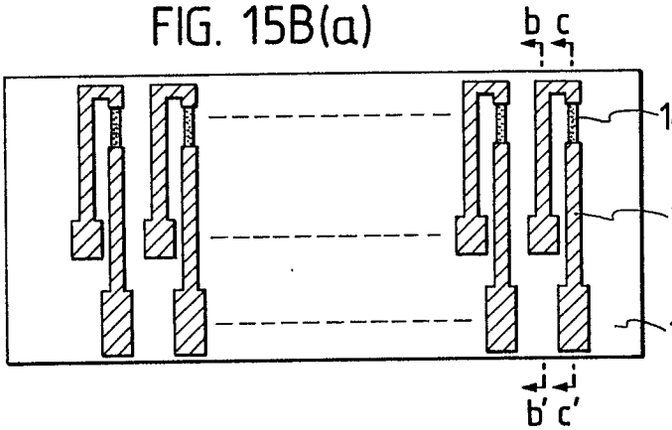

FIG. 15B(b)

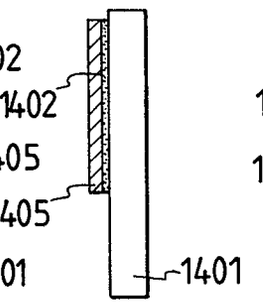

FIG. 15B(c)

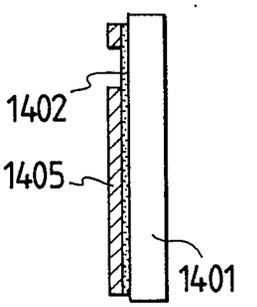

FIG. 15C(a)

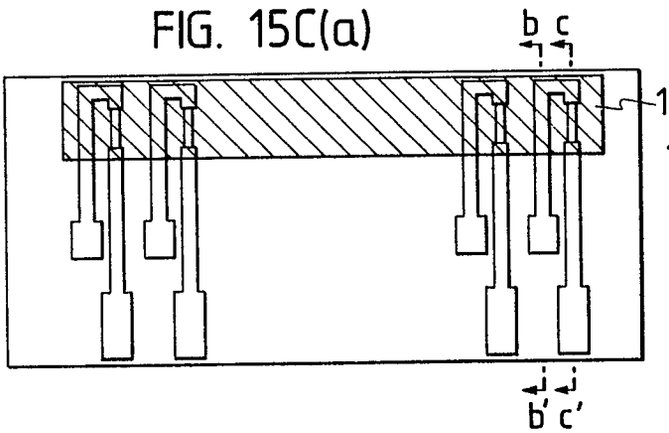

FIG. 15C(b)

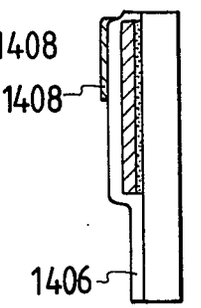

FIG. 15C(c)

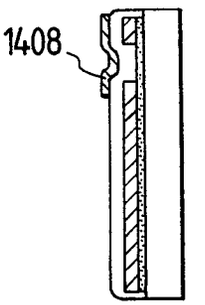

FIG. 15D(a)

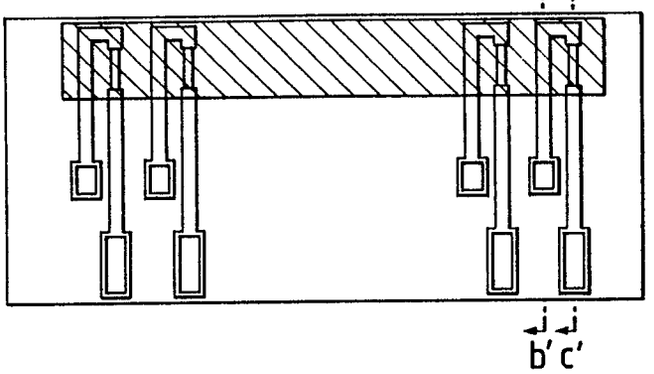

FIG. 15D(b)

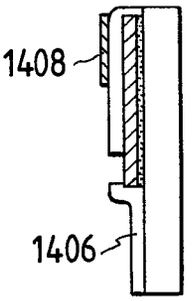

FIG. 15D(c)

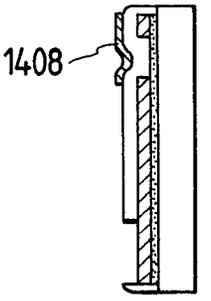

FIG. 15E(a)

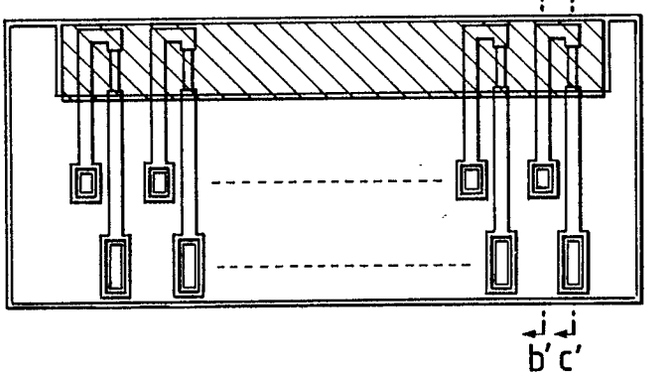

FIG. 15E(b)

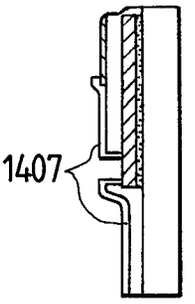

FIG. 15E(c)

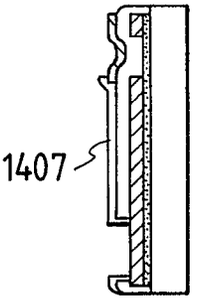

FIG. 15F(a)

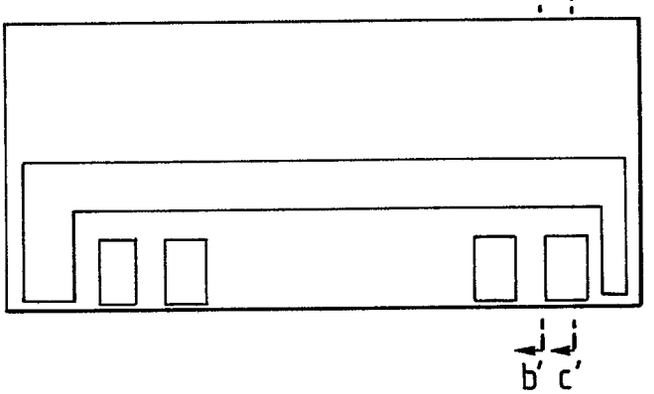

FIG. 15F(b)

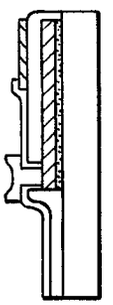

FIG. 15F(c)

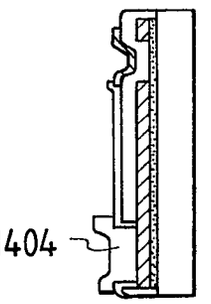

FIG. 16

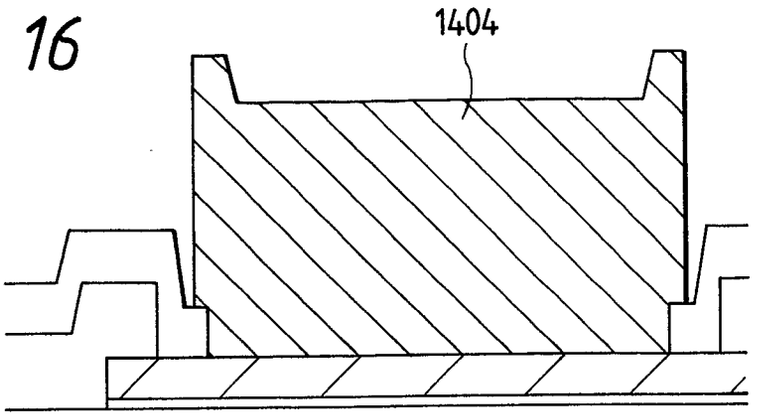

FIG. 17

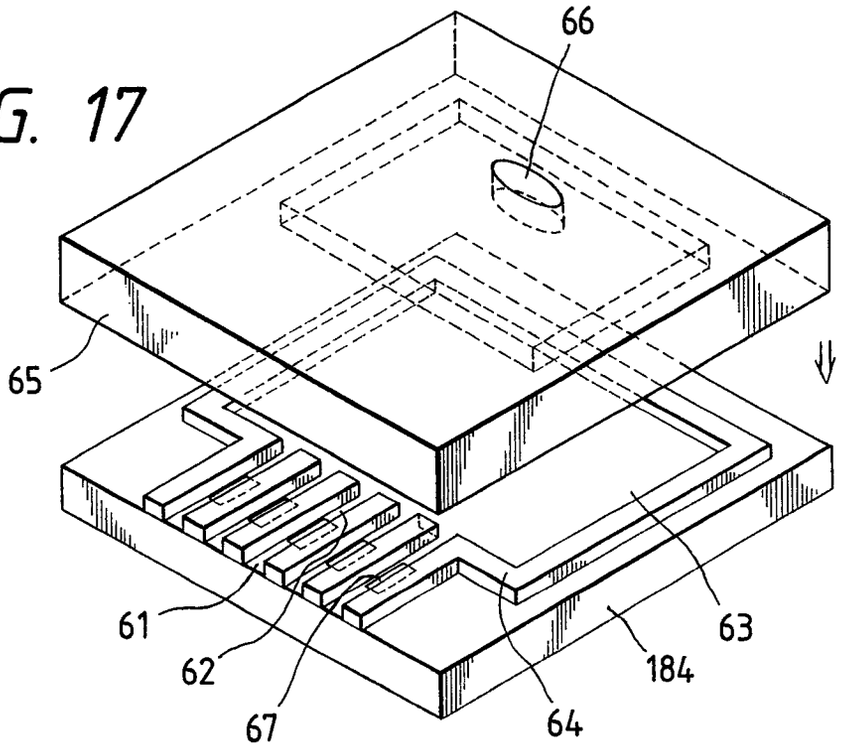

FIG. 18

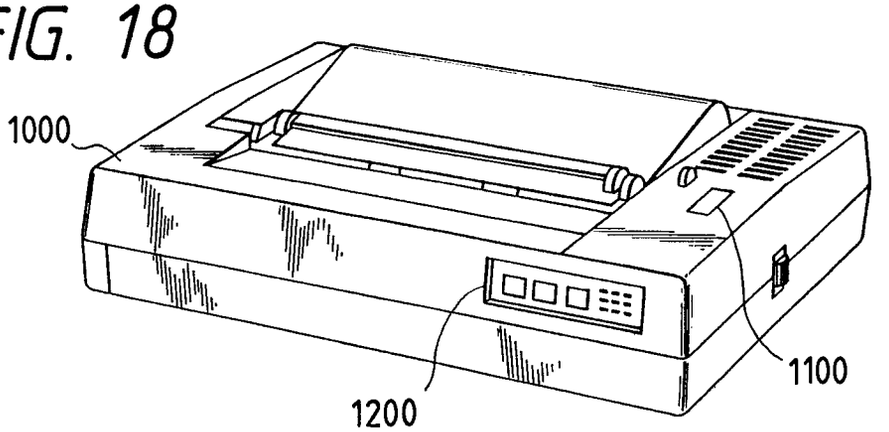

FIG. 19(a)

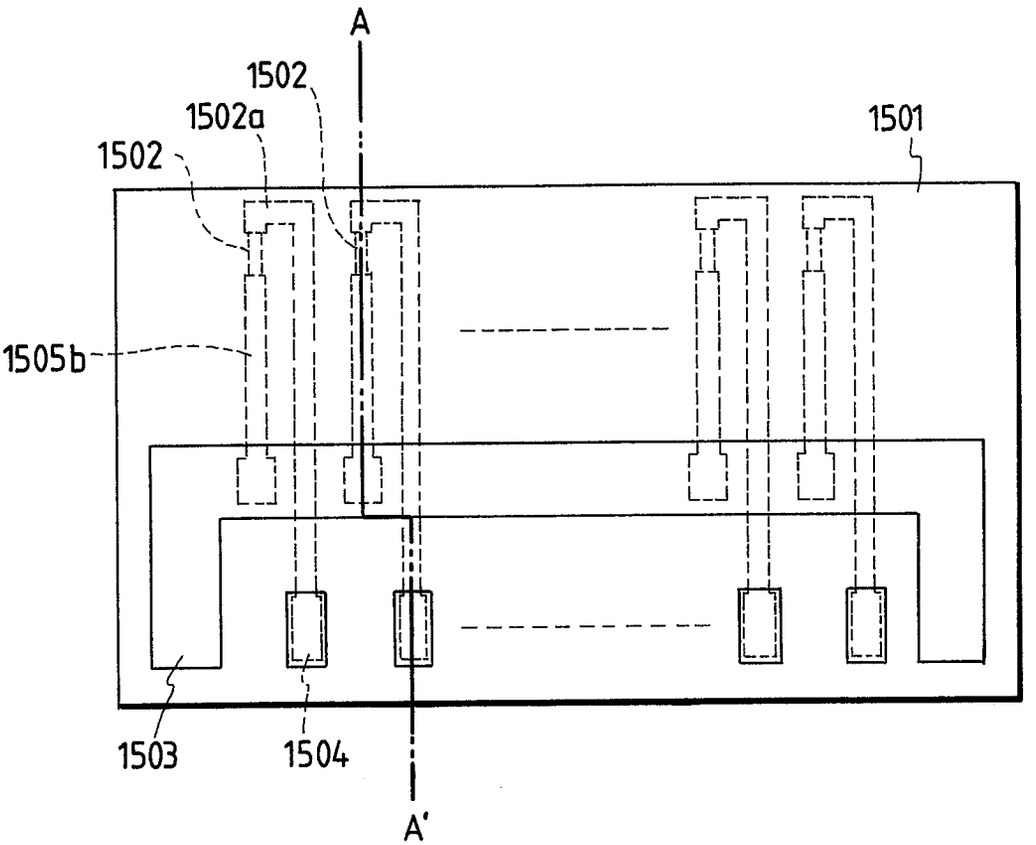

FIG. 19(b)

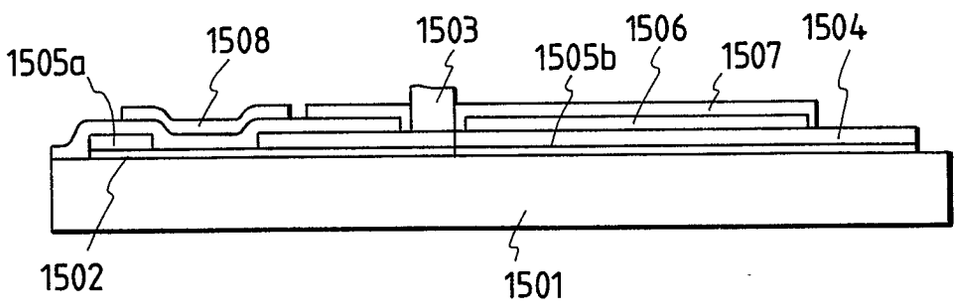

FIG. 20(a)

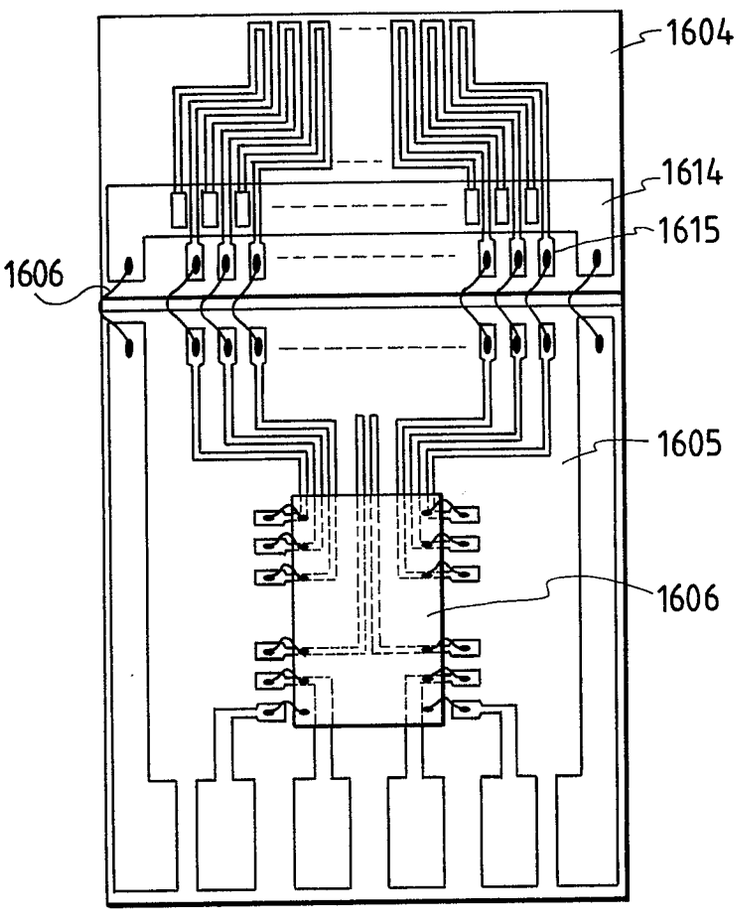

FIG. 20(b)

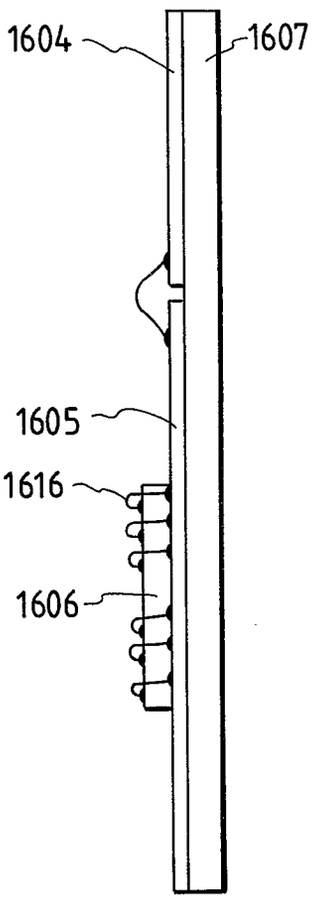

FIG. 21(a)

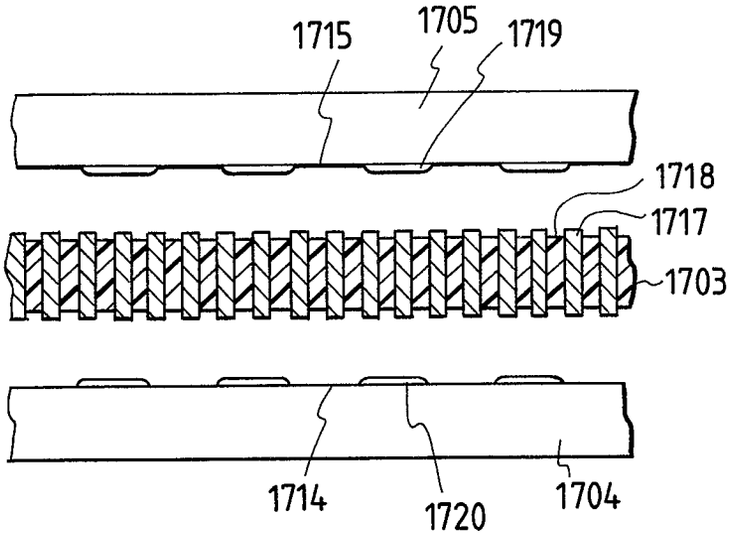

FIG. 21(b)

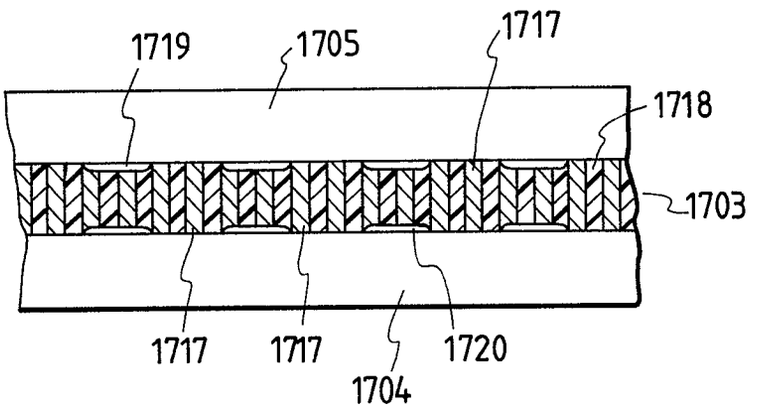

FIG. 21(c)