(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 367 541 B1**

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **05.10.94** (51) Int. Cl.5: **B41J 2/16**

(21) Application number: **89311199.7**

(22) Date of filing: **30.10.89**

Divisional application 94200483.9 filed on 30/10/89.

(54) Method of manufacturing an ink jet head.

(30) Priority: **31.10.88 JP 275794/88**
31.10.88 JP 275797/88
31.10.88 JP 275800/88
13.01.89 JP 7470/89
13.01.89 JP 7403/89
13.01.89 JP 7409/89
13.01.89 JP 7410/89
18.01.89 JP 9181/89
18.01.89 JP 9184/89
28.01.89 JP 18079/89

(43) Date of publication of application:
09.05.90 Bulletin 90/19

(45) Publication of the grant of the patent:
05.10.94 Bulletin 94/40

(84) Designated Contracting States:
DE ES FR GB IT NL

(56) References cited:
EP-A- 0 309 146
US-A- 4 459 600

PATENT ABSTRACTS OF JAPAN vol. 6, no. 201 (M-163)(1079) 13 October 1982; JP-A-57 107848

(73) Proprietor: **CANON KABUSHIKI KAISHA**
30-2, 3-chome, Shimomaruko,
Ohta-ku
Tokyo (JP)

(72) Inventor: **Watanabe, Takashi**
15-S-307, Higashi Terao 1-chome
Tsurumi-ku
Yokohama-shi Kanagawa-ken (JP)
Inventor: **Masuda, Kazuaki**
12-5, Sonan 4-chome
Sagamihara-shi Kanagawa-ken (JP)
Inventor: **Goto, Akira**
33-7, Aobadai 2-chome
Midori-ku
Yokohama-shi Kanagawa-ken (JP)
Inventor: **Kono, Hiroshi**
232, Nakada-cho
Izumi-ku
Yokohama-shi Kanagawa-ken (JP)
Inventor: **Kanzaki, Takashi**
1-15, Higashi Terao
Tsurumi-ku
Yokohama-shi Kanagawa-ken (JP)
Inventor: **Kashino, Toshio**
22-101, Hishinumakaigan 7-chome
Chigasaki-shi Kanagawa-ken (JP)

EP 0 367 541 B1

PATENT ABSTRACTS OF JAPAN vol. 10, no. 189 (M-494)(2245) 03 July 1986; JP-A-61 032761

LASER FOCUS. vol. 23, no. 5, May 1987, TULSA US pages 54 - 70; ZNOTINS, THOMASA. ET AL: "EXCIMER LASERS: AN EMERGING TECHNOLOGY IN MATERIALS PROCESSING"

PATENT ABSTRACTS OF JAPAN vol. 8, no. 69 (M-286)(1506) 31 March 1984; JP-A-58 217368

Inventor: **Saito, Akio**
944-26, Iamizumi
Hadano-shi Kanagawa-ken (JP)
Inventor: **Midorikawa, Koyo**
5-25-404, Shiohama 2-chome
Koto-ku
Tokyo (JP)
Inventor: **Okumura, Toru**
946-1, Tao-cho
Kohoku-ku
Yokohama-shi Kanagawa-ken (JP)
Inventor: **Ikeda, Masami**
6-19-904, Seijyo 1-chome
Setagaya-ku
Tokyo (JP)
Inventor: **Kuwabara, Nobuyuki**
3-10, Okuzawa 1-chome
Setagaya-ku
Tokyo (JP)

(74) Representative: **Beresford, Keith Denis Lewis et al**
BERESFORD & Co.
2-5 Warwick Court
High Holborn
London WC1R 5DJ (GB)

Description

The present invention relates to a method of manufacturing ink jet heads, and in particular to the formation of orifices through which ink is discharged from the head.

As the liquid jet recording device of this type of the prior art, there have been proposed various devices such as one in which fine droplets are discharged by generating pressure difference in the liquid channel through deformation of a piezoelectric element one in which a pair of electrodes are provided to deflect, or one in which droplets are discharged from the discharging orifices by utilizing heat energy such as by generating abruptly heat from the heat generating element arranged in the liquid channel, thereby generating bubbles, etc.

Among them, the liquid jet recording head according to the system in which the recording liquid is discharged by utilizing heat energy is particularly attracting attention as one which is capable of recording of high resolving power because liquid discharging outlets such as orifices for formation of droplets for flying by discharging droplets for recording, etc., (hereinafter also called as "orifices") can be arranged at high density, can be made compact as a whole as the recording head, can fully utilize the recent technical progresses in the field of semi-conductors as well as the advantages of IC technique and microworking technique of which improvements of reliability are marked, can be easily made lengthy and planar (dimensional), etc.. whereby it can be easily made into multi-nozzle and armored at high density, and yet productivity during bulk production is good to make the production cost lower.

Figs. 1A and 1B are respectively a schematic exploded perspective view and a schematic perspective after bonding showing an example of the liquid jet recording head of this type of the prior art.

In these Figures, 1 is a first substrate comprising Si, etc., comprising a group of electricity-heater converters and wiring portions thereof provided as the energy generating element for generating the energy to be utilized for discharging liquid on its upper surface. 8 is a second substrate, having an introducing inlet 9 for liquid for recording such as ink (hereinafter merely called as "ink"), a groove 11A for forming an ink flow channel 11 corresponding to the electricity heat converter, an ink flow channel wall 10 and a concavity 12 which becomes the common liquid chamber for storing ink and also communicating it to the respective flow channels formed thereon.

As shown in Fig. 1A, the first and the second substrates are mutually adhered and fixed with an adhesive 13 to assemble a recording head as shown in Fig. 1B.

However, the head obtained by the method as described above has the problem that the straight forward progress of the ink droplets is impaired. This is, above all, due to the fact that the orifices, which are formed of materials of different qualities, cause difference in wettability with the ink at the peripherals of orifices. In the prior art, for the purpose of avoiding such problem, it has been proposed to prepare separately an orifice plate comprising orifices molded by etching of a metal plate or a photosensitive glass plate, or an orifice plate comprising orifices by hole working on a resin film, etc., and plastering it onto the main head.

However, in the liquid recording head with such constitution (hereinafter also called "ink jet recording head" or merely "recording head"), there ensued the following problems.

In the ink jet recording head as described above, the step of bonding an orifice plate is included during its preparation, and it is necessary to perform strictly registration between the orifice and the flow channel portion during said bonding. Also, since said bonding can be done with difficulty when the end surfaces of the first and the second substrate to be bonded to the orifice plate are not coincident in plane, difficulty can also ensue during adhesion of the both substrates for this reason.

In addition, the orifice plate is also adhered by use of an adhesive, but since the pitch of the flow channel 11 and the height of the flow channel wall 10 are fine to the extent of about some 10 μm, unless the coated amount (thickness) of the adhesive layer 13 is controlled to the order of μm, the adhesive may come out to the flow channel side because of the pressure applied during bonding, whereby there may be caused such fear that the low channel diameter or the discharging orifice diameter may be varied, even to leading to clogging. Also, when the adhesive force is not sufficient, there is the fear that peeling of the orifice plate may occur.

Further, in the orifice plate by use of a resin film, because the resin film has generally a thickness of about 20 to 50 μm, not only handling is cumbersome, but also it may be considered that wrinkles may be formed or bubbles may be introduced during plastering to effect no good plastering.

The complicatedness of the preparation steps and the large number of steps as described above bring about increase in the production cost of recording head, and this has been also a problem in making the recording head as described above, or the recording head constituted by integration with an ink tank, etc. which is the ink supplying source disposable.

The contents as described above are to be described in more detail as follows. The ink jet recording head is constituted of an orifice plate 40 having orifices 41 as the discharging outlet, a ceiling plate 400 having ink channel grooves 401 communicated to the respective orifices, and a heater board 100 constituting a part of the ink channel and having energy generating elements 101A for generating energy to be utilized for discharging ink, as shown in Fig. 2.

Generally speaking, the orifice plate is provided for the purpose of constituting the discharging outlet surface of the same member in order to prevent slippage in the discharging direction of discharged ink droplet caused by the difference in wettability between the heater board and the ceiling plate, and also the orifice, including its shape, etc. is an important element influencing the discharging performance of the ink jet recording head. Above all, the orifice through which the ink is discharged becomes the most important portion, and with high developments of the image recording technique and the recording head production technique in recent years as described above, the orifice size (orifice diameter) has become miniaturized and a plurality of orifices have become provided at high density.

On the other hand, various contrivances have been made in the prior art for working of orifice. Some examples are mentioned below:

1) mechanical working with drill;
2) fine working by discharging working;
3) fine working by anisotropic etching of Si;
4) the method by patterning according to photolithography and plating;
5) fine working with carbon dioxide, YAG laser, etc.

However, as described above, the recording technique at the present time demands higher precision and higher speed as a matter of course, and along with this demand, the dimension of the orifice of the ink jet recording head has been miniaturized, and the orifice density high, and yet the head has become to have a plurality of orifices.

In such point of view, according to the methods of prior art examples 1) and 2) as mentioned above, there were involved such problems that miniaturization of orifice dimension was difficult, and also that the efficiency was not good in working of a plurality of orifices of high density.

On the other hand, in the method of 3), there was the problem that the cost of Si material for the orifice plate was high in cost, and the working time was long.

Further, in the method of 4), the preparation steps from photolithography to plating are long, and also auxiliary materials such as substrate and resist, etc. must be employed.

In addition the method of 5) could not prepare a satisfactory orifice complying with the above demand for the reason as described below.

Working by carbon dioxide laser and YAG laser was not sufficient in laser output, and both shape and precision of the orifice formed were not satisfactory. For example, the orifice formed by YAG laser is not circular in shape, and also foreign matters not sufficiently removed by laser are attached around the orifice. Also depending on the material and the thickness of the orifice plate, it also sometimes happened that no orifice, namely opening portion could be formed.

Also, since working by carbon dioxide laser and YAG laser is done by working orifices one by one, it is time consuming for working of a plurality of orifices and not suitable for bulk productivity.

Further, although a plurality of orifices must be correct in each positional precision, working was more difficult, because a movable portion for enabling also registration precisely was also required in working by carbon dioxide laser and YAG laser of the prior art.

As described above, according to the methods of the prior art, the respective problems were involved in the above-mentioned demand, and they were not sufficiently satisfactory as the working method of orifices.

On the other hand, recording by an ink jet recording head corresponds to higher precision, higher speed as described above, and improvement of its reliability has also become important. Accordingly, improvements have been also done to ink. As a consequence, since the material in contact with ink is demanded to have ink resistance performance, the material which becomes the orifice plate is also required to satisfy such demand. Therefore, orifice working may be sometimes difficult depending on its material.

Also, the ink jet recording head is constituted of an orifice plate, a ceiling plate and a substrate as described above. Above all, orifices and ink channels communicated thereto, when not correctly registered in their positions, will badly affect discharging performance, even causing non-discharging in the worst case.

However, since both orifices and ink channels are fine in their sizes and constituted at high densities, and therefore it is difficult to assemble with correct registration, thus posing a great problem in preparation of ink jet recording head.

The above content can be explained below from different aspect.

As mentioned above, the main body of the ink jet recording head comprised of, for example as shown in Fig. 2, the orifice plate 40 having the orifice 41 (discharge plate), the ceiling plate for forming the ink liquid path communicated with each orifice, and the base member constituting a part of the path 401 and having the electro-mechanical converting element 101A for generating energy used for discharging the ink.

The orifice plate has a fine orifice for discharging the ink, which orifice has great significance affecting the discharge character of the ink jet recording head. In detail, it is necessary for the orifice plate of the ink jet recording head to be excellent in workability since fine orifice is provided, and excellent in ink-proof character since it is directly contacted with the ink.

Conventionally, the metallic plate of SnS, Ni, Cr, Al, and resin film material such as polyimide (PI), polyethersulfone (PES) polyetheretherketone (PEEK), and polyester (PE) which can be formed easily in predetermined thickness and in low cost can be used.

On the other hand, the recording of high speed and very fine has been required in these days as the progress of the recording technique, and for this reason the orifice is formed in small in diameter and with high density. Consequently, there have been adopted various kinds of working method for the orifice, among of which one using the laser light is used for orifice forming since it is suitable for fine working.

However, it is very difficult to connect the perforated orifice plate and the corresponding ink liquid path, and positional shift or offset therebetween is generated to deteriorate the discharge quality as well as recording character. In addition, the adhesive used for connection might go into the liquid path due to positional shift.

To add further, as the ink jet recording head utilizing a discharging orifice plate, for example, those with constitutions shown in Figs. 3A to 3C and Figs. 4A and 4B have been known.

The recording head with the constitution shown in Fig. 3 has a constitution obtained by providing, for example, an ink channel wall 7A comprising a cured film of a photosensitive resin, etc. as shown in Fig. 3B and an outer frame 8A constituting liquid chamber, etc. on a substrate 100 comprising a glass, etc. having an energy generating member 101A for generating the energy to be utilized for discharging ink such as a heat generating element, a piezoelectric element, etc. as shown in Fig. 3A, then bonding a cover 11B for ink passages having ink feeding holes 9A thereto, further cutting the channel downstream portion of the bonded body obtained (the main recording head portion) along the line C - C to control the channel length, followed by bonding of a discharging orifice plate 40 having thru-holes for formation of discharging orifices as shown in Fig. 3C to the channel opening end surface formed by said cutting in predetermined positional relationship.

On the other hand, the recording head with the constitution shown in Fig. 4A has a constitution obtained by forming a main recording head portion provided with an ink channel wall 7A, comprising, for example, a cured resin film of a photosensitive resin, etc. and an outer frame 8A, as shown in Fig. 4B on a substrate 100 comprising a glass, etc. having an ink discharging energy generating member 101A generating energy used for discharging ink such as heat-generating element, piezoelectric element, etc. as shown in Fig. 4A, and bonding a discharging orifice plate 12A to the upper part thereof in predetermined positional relationship.

The constitution of the discharging orifice plate for constituting the ink jet recording head with the constitution as described above and the characteristics to ink have great influences on the recording characteristics of the ink jet recording head such as the discharging direction of ink, the amount of the ink discharged, etc., and various investigations have been done in the prior art about the material to be used for formation of the discharging material and its structure.

Concerning the characteristics of the discharging plate in the prior art, the problems to be solved may include the following problems.

a) In bonding between the discharging orifice plate and the main recording head portion, it is necessary to coat an adhesive on the bonding surface on the main portion side, but it is difficult to coat the adhesive uniformly, efficiently and with good workability onto the bonding surface on the main portion side, and yet the adhesive is liable to come around into the flow channel portion, whereby the production yield is low to be poor in bulk productivity.

Further, when coating of the adhesive is carried out so that the adhesive may not flow into the flow channel, the adhesive cannot be supplied to the peripheral portion of the flow channel in most cases, and if bonding is effected under such state with the discharging orifice plate, a gap will be formed between the discharging plate and the main portion, wherein ink may be pooled to cause readily interference with stable ink discharging.

b) In the case of providing a liquid repellent (ink repellent) coating layer for obtaining good ink discharged state on the surface of the discharging orifice plate which becomes the outer wall surface when bonded to the recording head (the surface on the side where ink is discharged, hereinafter called

"discharging orifice surface"), it is difficult to coat uniformly the material for liquid repellent coating layer onto said surface, and also it is difficult to inhibit flowing of the material for formation of liquid repellent coating layer to the inner surface of the discharging orifice which is demanded to be inkphillic, whereby the product yield is low to be poor in productivity.

Also, as described above, the ink jet head to be applied to the ink jet recording device is provided generally with an ink energy discharging member, ink channels, ink discharging orifices and a liquid chamber of ink.

The output according to ink jet recording device is now demanded to be higher in resolving power and speed, and as the means for solving this, improvements of pitch precision and diameter precision of discharging orifice, and further ink repellent treatment in the vicinity of discharging orifice may be mentioned. For preparation of such ink jet head, there has been employed the method in which first fine grooves are formed on a substrate such as glass, metal, plastic, etc., the substrate is bonded to an appropriate plate to form liquid channels for ink within the head, and then a discharging orifice plate having holes, pitches precisely worked by electro-forming, etching, etc. is bonded, followed by application of ink repellent treatment on the whole plate surface.

The ink jet prepared according to the method of the prior art as described above has problems in preparation during bonding of the discharging orifice plate and during ink repellent treatment. In short, during bonding of the discharging orifice plate, generally a means of coating the plate back surface or the front surface of the ink channel with an adhesive and bonding the both is employed, but during coating of the adhesive, there ensues the problem that a part or all of the ink channel or the discharging orifice portion finely worked is filled with the adhesive. Further, during ink repellent treatment, it is generally practiced to attach a fluorine type or silicon type thin film on the whole plate surface, and also at this time, the phenomenon of collapsing of hole similarly occurs as during coating of the adhesive as described above. Also, in aspect of preparation cost, there is the problem that electro-forming or etching is expensive.

To say repeatedly, an ink jet recording head having a discharging orifice plate formed with provision of thru-holes on a plate material has, for example, a representative constitution as shown in Fig. 5.

More specifically, it has a structure comprising a discharging orifice plate 40 having discharging orifices 41 communicated to the channel bonded to the opened face thereat a bonded body having a substrate 100 provided with an energy generating member 101A formed by wall member 7A for generating the energy to be utilized for discharging ink within the ink channel and a ceiling plate 11B bonded together.

The structure of the discharging orifice structure and its characteristics to ink have great influences on the recording characteristics of an ink jet recording head such as the discharging direction of ink, the droplet amount of discharged ink, etc., and various investigations have been made in the prior art about the material to be used for formation of the discharging orifice plate and its structure.

As the problem to be improved in the characteristics of the discharging orifice plate, there is the problem that when a light pool of ink is formed around the discharging orifice on the outer wall surface 40a of the discharging orifice plate, disturbance is liable to occur in the discharging direction of ink as shown in Fig. 6B, whereby no stable ink discharging can be obtained (see Fig. 6A) and no good recording can be performed.

Moreover, when an ink attached film is formed on the whole surface around the discharging orifice, scattering of ink during ink discharging (splash phenomenon) occurs, whereby no stable recording can be performed, and the amount of the ink attached around the discharging orifice is further increased to develop and enlarge the ink pool. If the ink pool is excessively enlarged, ink discharging through the discharging orifice may sometimes become impossible.

Accordingly there has been known the method to prevent formation of such ink pool as described above onto the outer wall surface of the discharging orifice by applying water repellent treatment on the outer wall surface of the discharging orifice plate.

In the water repellent treatment of the outer wall surface, the treatment is required to be performed so that the water repellent treatment may not be extended to the inner surface of the discharging orifice which is demanded to be inkphillic.

The water repellent treatment of the outer surface of the discharging orifice in the prior art has been performed by forming a thin layer of an ink repellent surface treating agent on the surface of a transfer member and transferring the thin layer onto the surface having the discharging orifice of the ink jet recording head.

Whereas, the method of the prior art have involved such problems that the treatment working is cumbersome, and also that the water repellent agent may be progressed to the inner portion of the discharging orifice, transfer cannot be sufficiently effected or even water repellent surface can not be formed because of deterioration of the transfer member.

As described above, ink jet recording head is generally equipped with fine ink discharging orifice, ink channel and ink discharging energy generating element provided on a part of the ink channel.

As the method for preparing such ink jet recording head, for example, there has been known the method in which fine groove is formed by cutting, etching, etc. on a substrate such as glass, metal, etc., and then the substrate having the groove formed thereon is bonded to another appropriate substrate to form ink channel within the head.

In the case of having a plurality of ink channels, those channels are in most cases communicated to a common liquid chamber and constituted so that the recording liquid may be supplied smoothly and sufficiently into the liquid channels.

Whereas, for supplying sufficient amount of recording liquid corresponding to the amount consumed by discharging of the liquid into the liquid channels, it is desirable to have a common liquid chamber of a volume with sufficient room relative to the amount consumed. However, with a common liquid chamber having a height virtually equal to the height of the ink channel, flow resistance of the recording liquid cannot be made substantially smaller, and therefore in spite of room in volume, no sufficient supply of the recording liquid can be done in some cases.

Accordingly, it becomes the general constitution to make the height of the common liquid chamber sufficiently larger than the height of the liquid channel.

However, in the method of forming fine grooves on a substrate such as glass or metal, it is difficult to form a common liquid chamber having a sufficient height relative to the height of ink channel.

It is also possible to make the height of the common chamber greater by increasing the etching amount of the common liquid chamber by repeating etching for plural times, but this method increases the steps and therefore cannot be said to respond sufficiently to the demands for cost down or productivity.

Accordingly, it has been practiced to prepare separately the common liquid chamber portion and bond the common liquid chamber portion to the end of the ink channel portion, thereby forming a desired common liquid chamber.

According to this method, sufficient common liquid chamber volume can be obtained easily and therefore it is preferable in aspect of performance of the ink jet head.

However the method of bonding separately parts inherently has the problems of increase of number of steps, lowering in productivity, and there remain still points to be solved for accomplishing much cost down.

Also, in the case of using such method, generation of stress or positional slippage accompanied with shrinkage by curing of the adhesive, leak of the recording liquid due to incomplete sealing, flowing of the adhesive into the liquid channel or into the common liquid chamber or clogging occurred in some cases.

In addition, as described above, the recording technique at the present time demands higher precision and higher speed as a matter of course, and according to such demands, the discharging orifices of the ink jet recording head became fine in dimension, higher in orifice density became higher, and also became to have a plurality of orifice groups.

Particularly, for higher densification, the pitch between the recording dots becomes narrower, and for making the fluid resistance through the ink path for higher speed, there is the demand to expand the pitch between orifices.

For this purpose, by taking broad pitch between orifices and working the respective discharging orifices obliquely to form the discharging directions of the recording liquid so as to be convergent, it becomes possible to perform highly precise recording. However, according to the working method of the prior art, it has been difficult to perform working with delicate variances in the discharging angle for the respective orifices.

Also, in a recording head having a plurality of the respective orifice rows for high speed recording or color recording, if the distance between the respective orifice rows is large, great memory size is required for adjusting the Dot signals between the respective orifice rows, thereby resulting in the cost-up of the main printer.

EP-A-309146, which has a date of filing of 15 September 1988 and a date of publication of 29 March 1989, discloses an ink jet printhead which is formed by bonding a nozzle plate to a printhead. Nozzles are formed in the nozzle plate by irradiating a surface of the plate through a mask with ultraviolet radiation. During nozzle formation, the printhead, the nozzle plate bonded thereto and the mask are rocked so that the nozzles have a smaller area at the surface where the radiation is incident than on the opposite surface. In this way, the nozzle exit has a smaller area than the nozzle entrance.

According to the present invention, there is provided a method of manufacturing an ink jet head, said ink jet head comprising an ink channel with an aperture member at one end having an aperture therein for allowing ink to be discharged therethrough, said method including the step of forming said aperture by irradiating said aperture member with a laser beam, the laser beam being incident on a surface of said

aperture member opposite to the surface where said ink is to be discharged.

Optional features are set out in claims 2 to 22.

Embodiments of the present invention overcome defects in the prior art and provide an ink jet recording head and a manufacturing method thereof which can be manufactured through simple processes involving small steps, and which is reliable and low in cost.

Embodiments of the present invention provide an orifice plate which has orifices arranged in high density and with high accuracy, and an ink jet recording head and a manufacturing method thereof in which the relation between the orifice and ink path is accurately set in view of the above mentioned problem relating to the orifice formation and the connection of the orifice plate with the ceiling plate and heater board.

Embodiments of the present invention provide an ink jet recording head in which the discharge performance is increased by forming the orifice in an orifice plate comprised of plural kinds of materials.

Embodiments of the present invention provide an ink jet recording head which can obtain the necessary ink droplet amount and discharge speed stably and sufficiently upon recording.

Embodiments of the present invention provide a manufacturing method of an ink jet recording head which has high accurate diameter of the ink discharge opening and pitch, and which can be performed cheaply.

Embodiments of the present invention provide a manufacturing method for an ink jet recording head which can solve the above mentioned problems by forming the grooves for the ink path using an excimer laser after molding the ceiling plate having the groove for the common chamber.

Embodiments of the present invention provide an ink jet recording head and manufacturing method thereof which has an orifice plate of high density and high accuracy, in which discharge openings with different angles in every discharge opening and in every head can be easily formed on the orifice plate, and in which the relation between the orifice and the ink path are determined accurately.

Embodiments of the invention provide a method for manufacturing an ink jet recording head having an ink path connected to a discharge opening, a discharge energy generating element disposed in said ink path, and a discharge opening plate provided with said discharge opening and attached to an end surface of said ink path, the ink being discharged from said discharge opening, and said discharge opening being formed by irradiating said discharge opening plate with excimer laser light.

Embodiments of the invention provide a method for manufacturing an ink jet recording head having an ink path connected to a discharge opening, a discharge energy generating element disposed in said ink path, and a discharge opening plate provided with said discharge opening and attached to an end surface of said ink path, the ink being discharged from said discharge opening, said discharge opening plate being attached to said end surface of the ink path prior to said discharge opening being formed, and then said attached discharge opening plate being irradiated with excimer laser light to form said discharge opening.

Embodiments of the invention provide a liquid discharge recording head, comprising, a first base plate provided with a discharge energy generating element, a second base plate formed by resin molding and connected with said first base plate, said second base plate having a groove for forming a liquid flow path which corresponds to the location of said discharge energy generating element upon connection, and being provided with a liquid discharge opening for recording in front of said groove, said second base plate having a member in which said discharge opening is formed whose thickness is selected to be thinner at at least the position at which said discharge opening is formed.

Embodiments of the invention provide a method for manufacturing a liquid jet recording head made by connecting a first base plate provided with discharge energy generating means and a second base plate for forming a liquid flow path at a position corresponding to the location of said discharge energy generating means, said discharge opening being formed by irradiating a blank of the second base plate made of resin, to which a plate member for forming a liquid discharge opening for the recording is attached integrally, with excimer laser light.

Embodiments of the invention provide a method for manufacturing an ink jet recording head having an ink path connected to a discharge opening, a discharge energy generating element disposed in said ink path for generating energy used for discharging the ink, and a discharge opening forming member provided with said discharge opening and attached to an open surface at which an opening communicated with said ink path is disposed, the ink being discharged through said discharge opening to carry out the recording, said discharge opening on said discharge opening forming member being formed by irradiation with excimer laser light, and the side upon which said excimer laser light is incident being attached to said open surface.

Embodiments of the invention provide a method for manufacturing an ink jet recording head having a base plate provided with a discharge energy generating element used for discharging the ink, a ceiling plate

having a recessed portion for forming an ink flow path corresponding to the disposed location of said discharge energy generating element by being attached to said base plate, and a discharge opening forming member on which a discharge opening communicated with said ink path and which discharges the ink is formed, in which method, excimer laser light incident from said recessed side is used to form said discharge opening, after said ceiling plate and discharge opening forming member are connected integrally.

Embodiments of the invention provide an ink jet recording head having a discharge opening forming member provided with a discharge opening for discharging ink, an ink path communicated with said discharge opening, and a discharge energy generating element disposed on a part of said ink flow path to generate energy used for discharging the ink, the ink being discharged to carry out recording, in which said discharge opening forming member is formed by accumulating plural members of different kinds of materials.

Embodiments of the invention provide a method for manufacturing an ink jet recording head made by connecting a plate having grooves for forming ink paths provided corresponding to each of a plurality of ink discharge openings, and a base plate having a discharge energy generating element disposed at a part of said ink paths, comprising forming said grooves by excimer laser light irradiation.

Embodiments of the invention provide a method for manufacturing an ink jet recording head made by connecting a plate having grooves for forming ink paths provided corresponding to each of a plurality of discharge openings and a common liquid chamber for storing the ink supplied to said ink paths, and a base member having a discharge energy generating element disposed at a part of said ink paths, by forming a base member having said grooves for forming said common chamber by injection molding, and working said grooves forming said ink paths by irradiating said base member with excimer laser light.

Embodiments of the invention provide a method for manufacturing an ink jet recording head in which plural discharge openings are formed by irradiation with excimer laser light, in which at least one of the entering angles of the laser light relative to a surface of said discharge openings is differentiated from others.

Figs. 1A and 1B are views for explaining an assembly of a conventional recording head;

Fig. 2 is an exploded schematic view for showing construction of ink jet recording head;

Figs. 3A to 3C and Figs. 4A and 4B are views of construction of ink jet recording head using discharge opening plate;

Fig. 5 is an exploded perspective view showing main portion of ink jet recording head using discharge opening plate;

Figs. 6A and 6B are partial cross sections for explaining ink discharge condition;

Figs. 7A and 7B are respectively an exploded schematic view and a schematic view for explaining cartridge including recording head;

Figs. 8A and 8B are respectively plan view and partial enlarged view showing heater board applicable for recording head;

Fig. 9 is a schematic view of apparatus for working an orifice;

Fig. 10 is a perspective view showing relation between mask and orifice plate;

Fig. 11 is now deleted;

Fig. 12 is now deleted;

Fig. 13 is now deleted;

Fig. 14 is now deleted;

Fig. 15 is a cross section of orifice;

Fig. 16 is a cross section of orifice according to conventional manufacturing method;

Fig. 17 is a cross section of main body of recording head forming cartridge;

Figs. 18 and 19 are now deleted;

Figs. 20 and 21 are now deleted;

Fig. 22 is now deleted;

Fig. 23 is a schematic construction view of orifice working device using excimer laser light;

Fig. 24 is a schematic view for manufacturing orifice plate;

Fig. 25 is a cross section of orifice and ink path of ink jet recording head of one embodiment;

Fig. 26 is a schematic view in which orifice plate used for another embodiment is formed;

Fig. 27 is a cross section showing orifice manufacturing process according to the above embodiment;

Fig. 28 is a cross section of orifice and ink path of above embodiment;

Fig. 29 is now deleted;

Fig. 30 is now deleted;

Fig. 31 is now deleted;

Fig. 32 is now deleted;

Fig. 33 is now deleted;
Figs. 34 and 35 are now deleted;
Fig. 36 is now deleted;
Fig. 37 is now deleted;
Figs. 38A to 38H are now deleted;
Fig. 39 is a perspective view showing an example of a blank ceiling plate;
Fig. 40 is a view showing excimer laser device for forming orifice plate portion;
Figs. 41A and 41B are views for explaining ceiling plate manufacturing process according to device of Fig. 40;
Fig. 42 is a schematic view of orifice manufacturing device using excimer laser light;
Figs. 43A and 43B are respectively a perspective view and a cross section of ceiling plate with which orifice plate of ink jet recording head is made integral;
Fig. 44 is a perspective view of main body of ink jet recording head made by connecting heater board and ceiling plate of Fig. 43;
Figs. 45A and 45B are respectively perspective view and cross section of ceiling plate with which orifice plate according to another embodiment is made integral;
Fig. 46 is a cross section of one example of orifice;
Fig. 47 is a perspective view of resin plate which has not been manufactured;
Fig. 48 is a perspective view of ceiling plate which has been manufactured;
Fig. 49 is a view for explaining removing work by excimer laser via mask;
Fig. 50 is a schematic view of groove obtained work of Fig. 49;
Fig. 51 is a schematic perspective view of main body of ink jet recording head obtained by using ceiling plate shown in Fig. 48;
Fig. 52 is a schematic view of apparatus for manufacturing ink jet recording head;
Fig. 53 is a perspective view showing mask and discharge opening forming member of Fig. 52;
Fig. 54 is now deleted;
Fig. 55 is now deleted;
Fig. 56 is a schematic view illustrating a part of a recording head;
Fig. 57 is a perspective view of ink jet recording head;
Fig. 58A is a schematic view illustrating device for entering laser beam to form discharge opening;
Fig. 58B is now deleted;
Fig. 59 is a schematic explanation view for showing partial construction of ink jet recording head;
Figs. 60 and 61 are views for explaining connected or assembled state of recording head body; and
Fig. 62 is a perspective view showing one example of ink jet printer constructed by using cartridge as shown in Fig. 7.

Embodiments of the present invention are described in detail by referring to examples.

Figs. 7A and 7B show respectively schematic disassembled view and assembled view of a ink jet recording head in which an ink housing portion which is an ink feeding source is made integral to give a disposable type.

In Fig. 7A, numeral 100 is a heater board comprising an electricity heat convertor (discharging heater) and a wiring of A1, etc. for feeding power thereto formed by film forming technique on a Si substrate, which corresponds to the first substrate 1 in Fig. 1. Its detailed constitution is described below by referring to Fig. 8. 200 is a wiring substrate corresponding to the heater board 100, and the corresponding wiring is connected by, for example, wire bonding.

400 is a ceiling plate provided with a partition wall, a common liquid chamber for limiting the ink flow channel, which corresponds to the second substrate 8 in Fig. 1 and comprises a resin material having integrally an orifice plate portion. An example of this ceiling plate 400 is described below by referring to Figs. 39 to 41.

300 is a support made of, for example, a metal, 500 is a pressing spring, and by engaging both under the state with the heater board 100 and the ceiling plate 400 sandwiched therebetween, the heater board 100 and the ceiling 400 are pressure fixed by the urging force of the pressing spring 500. An example is described by referring to Figs. 60 and 61 The support 300 as well as the wiring substrate 200 can be provided by plastering, etc., and also can be made to have the mounting standard onto the carriage for performing scanning of the head. Also, the support 300 also functions as the member which cools the heater board 100 by release of the heat generated with driving.

600 is a feeding tank, which receives ink fed from the ink reservoir portion forming the ink feeding source, and functions as a subtank leading the ink to the common liquid chamber formed by bonding of the heater board 100 and the ceiling plate 400. 700 is a filter arranged at a site in the feeding tank 600 near the

ink feeding inlet to the common liquid chamber, and 800 is a lid member of the feeding tank 600.

900 is an absorber for impregnation of ink, and is arranged within the cartridge main body 1000. 1200 is a feeding inlet for feeding ink to the unit comprising the respective portions 100 - 800 as described above, and by injecting ink through the feeding inlet 1200 in the step prior to arrangement of said unit to the portion 1010 of the cartridge main body 1000, ink can be impregnated into the absorber 900.

1100 is a lid member of the cartridge main body, and 1400 is an air communicating opening provided at the lid member for communication to the air. 1300 is a liquid repellant material arranged inwardly of the air communicating opening 1400 by which the ink leak through the air communicating opening 1400 can be prevented.

On completion of ink filling through the feeding inlet 1200, the unit comprising the respective portions 100 - 800 is arranged by registration at the portion 1010. Registration or fixing at this time can be effected by, for example, fitting the projection 1012 provided on the cartridge main body 1000 with the hole 312 provided on the support 300 corresponding thereto, whereby the cartridge shown in Fig. 7B is completed.

The ink is fed into the feeding tank 600 from the cartridge inner portion through the feeding inlet 1200, the hole 320 provided at the support 300 and the introducing inlet provided on the back side in Fig. 7A of the feeding tank 600, and after passing through the inner portion thereof, flows from the discharging outlet into the common liquid chamber through an appropriate feeding pipe and the ink introducing inlet 420 of the ceiling plate 400. At the connecting portion for ink communication as described above, for example, packing of silicone rubber, butyl rubber, etc. is provided, whereby sealing is effected to ensure the ink feeding flow channel.

Figs. 8A and 8B are a plan view of the heater board 100 and its partial enlarged view.

In Fig. 8A, 101 is the heater board substrate, and 103 the discharging heater portion. 104 is a terminal, which is bonded by wire bonding to the outside. 102 is a temperature sensor, which is formed at the discharging heater portion 3, etc. according to the same film forming process as for the discharging heater portion 103, etc. Fig. 8B is an enlarged view of the portion B including the sensor 102 in Fig. 8A, 105 and 106 are respectively discharging heater and wiring. 108 is a heater for heating the head.

The sensor 102 is formed according to the same film forming process as information of semiconductors similarly as other portions, and therefore extremely high in precision, and can be formed of a material varying in electroconductivity depending on temperature such as aluminum, titanium, tantalum, tantalum pentoxide, niobium, etc. which is the constituent material of other portions. For example, among them, titanium is a material which can be arranged between the both for enhancing adhesiveness between the heat-generating resistance layer constitutes the electricity-heat converting element and the electrode, and tantalum is a material which can be arranged at the upper portion for enhancing the cavitation resistance of the protective layer on the heat-generating resistant layer. Also, for making variance in the process smaller, line width is made bold, and for making the influence of wiring resistance, etc. smaller, a zig-zag shape is formed to make the resistance higher.

In the recording head shown in Figs. 7A and 7B, the orifice plate should desirably have a thickness of about 10 to 50 μm, and also in view of the cost of material and ink resistance as the material of the orifice plate, film materials of thermoplastic resins, such as polyether ketone, polyimide, polyether sulfone, etc. may be included. In this example, a film of a polyether ether ketone (PEEK) with a thickness of 25 μm is used.

When forming an orifice plate, first the above film material is cut into a size necessary for orifice plate. Next, by use of an excimer laser of KrF emitting UV-ray of 248 nm wavelength, working of orifice is performed by means of a device shown in Fig. 9.

The excimer laser is a laser capable of oscillating UV-ray and has such advantages as high strength, good monochromaticity, directional characteristic, capability of short pulse oscillaton, capability of making energy density very great by focusing with a lens.

Eximer laser is a device capable of oscillating UV-ray of short pulses (15 - 35 ns)by discharging excitation of a gaseous mixture of rare gas and halogen, and Kr-F, Xe-Cl, Ar-F laser are frequently used. The oscillation energy of these may be some 100 mJ/pulse, and the pulse repetition frequency 30 to 100 Hz.

When the short pulse UV-ray of high luminance such as the excimer laser is irradiated on a polymer resin surface, there occurs the Ablative Photodecomposition (APD) process where the irradiated portion is decomposed and scattered momentarily with accompaniment of plasma emission and impact sound, by which process working of the polymer resin is rendered possible.

Thus, when working precision excimer laser is compared with that with other lasers, for example, if a polyimide (PI) film is irradiated with KrF laser as an excimer laser and other YAG laser and CO_2 laser, since the wavelength absorbing light of PI is in the UV region, beautiful holes can be opened by KrF laser, but the

edge surface is roughened by YAG laser which is not in the UV region although holes may be opened, while craters are formed around the hole by CO_2 laser which is IR ray.

Also, metals such as SUS, etc., opaque ceramics, Si, etc. are not influenced by irradiation of excimer laser in an atmosphere of the air and hence can be used as the masking material in working by excimer laser.

Fig. 9 is a schematic illustration of a device for performing working orifice by use of such excimer laser. In Fig. 9, 210 is an excimer laser, 211 is a lens for focusing laser beam 212 emitted from the excimer laser 210, 209 is a mask arranged between the excimer laser 210 and the orifice plate, and 240 is an orifice plate on which orifices are to be formed.

Fig. 10 is a perspective view showing the details of the mask 209 and the orifice plate 240. On the mask 209 are provided transparent portions 291 corresponding to the sites where orifices on the orifice plate 240 are to be worked so that laser beam 212 may be transmitted therethrough. Thus, by providing a pattern necessary for orifices on the mask 209, this pattern can be worked into the film for orifice plate.

As shown in Fig. 10, the number of the orifices is plural, but this is shown schematically and practically in this example a mask having orifices of 360 DPI ϕ 33 μm linearly juxtaposed is used. In this constitution, orifices are formed by irradiation of laser beam 212 through the mask 209 on the plate 40. As the mask material, it should preferably receive no influence of the heat by laser irradiation, and, for example, a material with small coefficient of thermal expansion, such as a metal material of Be-Cu, etc, can be used.

The orifice on the orifice plate prepared according to the method as described above is free from abnomal deformation at the peripheral portion of the orifice as occurs in working by carbon dioxide laser and YAG laser, and a circular form similar to the mask is worked beautifully from the surface to the back of the film.

The results of comparison between the design value and the dimension in the orifice plate after preparation according to the method as described above are shown in Table 1.

Table 1

	Design value (μm)	Dimension after laser working (μm)	Error (μm)
Pitch variance	70.5	70.4	- 0.1
Hole diameter	34.0	33.9	- 0.1

As is also apparent from comparison in this Table 1, the orifice working with excimer laser has sufficient precision for further improvement of the performance of the ink jet recording head, and also has a specific feature that it can be produced simply.

Next, an example for making the orifice shape a more preferable shape by working with excimer laser is shown.

As shown in Fig. 15, the orifice shape of the ink jet recording head in this example has been deemed to have desirably a shape which is narrower at the tip which is nearer the exit of orifice 241 than the ink channel 402. However because it can be realized with difficulty in the preparation method of the prior art, most prior art shapes have been cylindrical as shown in Fig. 16.

Whereas, by use of excimer laser, and utilizing the specific feature that the shape of the hole is varied by changing the position of the focus by moving gradually the focusing lens during irradiation in working only of the orifice plate, also an orifice shape as shown in Fig. 15 can be produced.

Fig. 17 is a sectional view of an ink liquid channel of the ink jet recording head according to an another example. In Fig. 17, 40a is one plate of an orifice plate which comprises two kinds of materials, and 40b is the other orifice plate. In this example, as the material for the plate 40a, a PI film with a thickness of about 20 μm is used, and as the material for the plate 40b, a dry film with a thickness of about 20μm (SE-320, manufactured by Tokyo Ohka K.K.) for bonding the PI film 40a to the opening surface at which the openings of ink liquid channels are arranged.

The shape which becomes smaller in diameter toward the tip end shown in Fig. 17 has the effect of increased discharging speed and also the discharging direction which is made constant, leading to improvement of recorded image quality.

Fig. 23 shows the manner in which orifice working is performed by excimer laser beam on the orifice plate made of a resin film according to an embodiment of the present invention, and the same elements as those shown in Fig. 9 are attached with the same symbols. In Fig. 23, 210 is a laser oscillating device for oscillating KrF excimer laser beam, 212 a pulse laser beam with a wavelength of 248 nm and a pulse width of about 15 nsec oscillated from the laser oscillating device 210, 211 a synthetic quartz lens for converging

the laser beam 212, 209 a projection mask having aluminum capable of shielding the laser beam 212 vapor deposided thereon, on which a plurality of holes of 133 μm in diameter are arranged at a pitch of 212 μm to constitute an orifice pattern. 40 is an orifice plate member, which comprises a film of polyether sulfone (PES) having a thickness of 4μm coated with a 6 μm thick tacky layer, and further plastered with a 25 μm thick Mylar.

Fig. 24 is an enlarged sectional view of the orifice plate member 40 shown in Fig. 23, and in Fig. 24, 12B is a PES film forming the orifice plate, 13B a tacky layer as the adhesive, and 17B a Mylar. In this case, on the emitting side of the laser beam on the PES film 12B which becomes the orifice plate by irradiation of the laser beam 212 through the mask 209, orifices of 3 μm are formed at a pitch of 70 μm. After the orifice plate member 40 is irradiated with laser beam to be made into the state shown in Fig. 24, the orifice plate 12B obtained by peel-off of the Mylar 17B is bonded to the opened face of the ink channel to complete the main ink jet recording head.

Fig. 25 is a sectional view of the main recording head thus obtained. As can be clearly seen by comparison between Fig. 25 and the sectional view of the main recording head of the prior art shown in Figs. 1 to 3, since the side of the orifice plate on which laser beam is irradiated is bonded to the opened face of the ink channel, the shape obtained by this example becomes tapered, being widened in the direction opposite to the discharging direction. With such shape, the discharging speed and the ink amount discharged are increased stably to give the result that quality of the recorded image is improved.

Next, an example by use of a dry film (Tokyo Ohka, SE320) as the material of the orifice plate is described by referring to Fig. 26 to Fig. 28. The laser beam, the optical system and the projection mask are the same as in the example as described above.

Fig. 26 is an enlarged views of the portion where the laser beam 212 is incident on the film, and in Fig. 26, 18B is a dry film forming the orifice plate, 19B a protective film comprising a polyether and 20B a Mylar.

In this constitution, after the laser beam 212 is first irradiated, the orifice plate of the dry film obtained by peel-off of the protective film 19B is bonded to the opened face of the ink channel (Fig. 27).

Next, the Mylar is peeled off to form the state shown in Fig. 28, and UV-ray is irradiated on the orifice plate 18B of the bonded dry film from the discharging direction side to effect photocuring, thereby completing the main ink jet recording head. Also according to this example, a shape with the taper of the orifice being widened in the direction opposite to the ink discharging direction is obtained.

Fig. 39 shows a constitutional example of the ceiling plate material for constituting the ceiling plate 400 according to another example.

The ceiling plate material 400' is made to have a desired number of ink channel grooves 411, 412, ... (two in the Figure for brevity) and an orifice plate portion 404 provided integrally.

In the constitutional example shown in Fig. 39, the ceiling plate material 400' is simultaneously molded integrally together with the orifice plate portion 404 by use of a resin excellent ink resistance such as polysulfone, polyethersulfone, polyphenyleneoxide, polypropylene, etc. The orifice plate portion 404 may be also formed of the same resin material as the main body portion of the ceiling plate material 400' or another kind of resin material, which may be prepared separated from the main portion of the ceiling plate material 400' and inserted into the mold for insert molding.

As for the ink flow channel groove, the resin can be molded with a mold having a reverse pattern thereto formed by such method as cutting, etc., whereby the flow channel grooves 411, 412 can be formed on the ceiling plate 400.

The orifice plate 404 thus integrally molded has a thickness of about 50 to 100 μm in molding. Although the orifice can be also formed under this state, but practically the flow channel length of that portion should be desirably 20 μm or less. This is because, if the flow channel length from the discharge heater 101A is large, discharging performance is influenced thereby. Accordingly, in this example, particularly the portion over the range where orifices to be formed are arranged corresponding to the grooves 411, 412 of the orifice plate portion 404 is worked to be made thin before formation of the orifices. In this example, excimer laser was used for working.

Fig. 40 is a schematic illustration of a device for performing working by use of such excimer laser. Here, 450 is an excimer laser oscillator (in this exmaple, it is made a Kr-F excimer laser oscillator), 451 is a lens of, for example, f value of 500 mm for converging laser beam 452. 453 is a mask comprising a plate of Al, etc. with a thickness of, for exmaple, 1 mm having a hole pattern corresponding to the worked portion. The ceiling plate material 400' is arranged adequately so that the surface to be worked may be irradiated by laser beam through the lens 451 and the mask 453.

In the step of making the orifice plate portion 404 thin, the laser beam emitted from the Kr-F excimer laser oscillator 450 is irradiated on the orifice plate 404 through the mask 453 having a hole of, for example,

rectangular shape formed therein. The orifice plate 404 becomes thin by working only of the portion where irradiated with excimer laser.

Fig. 41A exhibits such state, where 465 is the grooved portion made thin by said working. At this time by controlling adequately the strength of laser and the working time, the thickness of that portion could be made about 10 to 20 μm.

Next, the orifice plate 404 is subjected to the liquid repellant treatment, because the surface having liquid repellancy has the effect to wetting of unnecessary ink, etc. In this example, as the liquid repellant, DEFENSA from Dainippon Ink diluted with Difreon S-3 from Daikin to 1 % is coated. Next, for curing of the liquid repellant, UV-ray irradiation is effected.

Next, orifices corresponding to flow channels are formed by working with excimer laser.
Thus, the ceiling plate 400 as shown in Fig. 41B can be received. In Fig. 41B, for brevity, 4 orifices (or flow channels) are provided.

Concerning also grooves 411, 412 for flow channel formation and the common liquid chamber portion, these may be also worked with excimer laser, or these may be also worked after formation of the discharging outlet (orifice) portions. Also, when the length of the flow channel length in front of the discharging heater poses no problem, the orifice plate portion 404 is not necessarily made thin depending on the constitution.

Then, the heater board 100 is abutted against the orifice plate 404 as shown by the chain line to be bonded thereto, thereby giving a main recording head.

According to such constitution as described above, since no registration or adhesion between the ceiling plate and the orifice plate required as in the prior art, there is no registration error or positional slippage during adhesion at all, whereby reduction in defective products and shortening of the steps could contribute to bulk productivity and lowering in cost of the recording head. Also, since there exists no adhesion step between the ceiling plate and the orifice plate, there is no fear of clogging of the orifices or ink flow channels by flowing of the adhesive. Further, since the position can be determined of the flow channel direction by abutting the heater board 100 against the end surface on the opposite side to the end surface on the discharging side of the orifice plate portion 404 during bonding of the heater board 100 and the ceiling plate 400 integrally made with the orifice plate portion 404, the whole registration step and assembling step can be made easier. In addition, there is also no fear of peel-off of the orifice plate as in the prior art.

Fig. 42 shows another embodiment of the present invention in which orifice working is performed by excimer laser beam on the orifice plate formed integrally with the ceiling plate, and the same elements as those shown in Fig. 40 are attached with the same symbols. In Fig. 40, 450 is a laser oscillating device for oscillating KrF excimer laser beam, 452 a pulse laser beam with a wavelength of 248 nm and a pulse width of about 15 nsec oscillated from the laser oscillating device 450, 451 a synthetic quartz lens for converging the laser beam 452, 453 a projection mask having aluminum capable of shielding the laser beam 452 vapor deposited thereon, on which a plurality of holes of 133 μm in diameter are arranged at a pitch of 212 μm to constituted an orifice pattern.

Fig. 43A shows a constitutional example of the ceiling plate 457 according to this example.

The ceiling plate 457 according to this example is made to have a desired number of ink channel grooves 464 and ink discharging orifices 466 formed on the orifice plate 460 corresponding thereto (two in the Figure for brevity) and an orifice plate portion 460 provided integrally.

In the constitutional example shown in Fig. 43A, the ceiling plate material 457 is simultaneously molded integrally together with the orifice plate 460 by use of a resin excellent in ink resistance such as polysulfone, polyethersulfone, polyphenyleneoxide, polypropylene, etc.

Next, the methods for forming the ink channel groove 464 and the orifice 466 are described.

As for the ink channel groove, a resin can be molded with a mold having a fine groove of reverse pattern thereto by such method as cutting, etc., and with the use of the mold, liquid channel groove 464 can be formed on the ceiling plate 457.

As for formation of orifice, within the mold, molding is effected under the state having no orifice 466 and excimer laser beam is irradiated by a laser device on the positions where orifices are to be formed from the ink channel side on the orifice plate 10 as explained in Fig. 42, followed by removal and evaporation of the resin, to form orifices 466.

The details of orifice formation are shown in Fig. 43B. As is apparent from Fig. 43B, the excimer laser beam 452 is irradiated on the orifice plate 460 through the mask 453 as described above from the ink channel side 464. The excimer laser 452 is converged at $\theta_1 = 2°$ on one side with respect to the optical axis 463, and irradiated from the vertical direction of the orifice plate 460 with the optical axis 463 being slanted at $\theta_2 = 10°$.

Thus, by irradiation of the laser beam from the ink channel side, the cross-sectional area of the orifice having a tapered shape becomes reduced toward the discharging direction.

Fig. 44 is a perspective view of the main recording head constituted by bonding of the heater board 458 and the ceiling plate 457 as described above.

As shown in Fig. 44: the heater board 458 having the discharging heater 101A, etc. is bonded to the orifice plate 460 to obtain the main recording head.

According to such constitution as described above, since no registration or adhesion between the ceiling plate and the orifice plate required as in the prior art, there is not registration error or positional slippage during adhesion at all, whereby reduction in defective products and shortening of the steps could contribute to bulk productivity and lowering in cost of the recording head. Also, since there exists no adhesion step between the ceiling plate and the orifice plate, there is no fear of clogging of the orifices or ink flow channels by flowing of the adhesive. Further, since the position can be determined of the flow channel direction by abutting the heater board 458 against the end surface on the opposite side to the end surface on the discharging side of the orifice plate 460 during bonding of the heater board 458 and the ceiling plate 460 integrally made with the orifice plate 460, the whole registration step and assembling step can be made easier. In addition, there is also no fear of peel-off of the orifice plate as in the prior art.

Figs. 45A and 45B show another embodiment of the present invention, and are repsectively a perspective view and a sectional view of a ceiling plate having an orifice plate integral formed therewith.

This example has made the irradiation angle, namely θ_2 as described above 45° corresponding to the shapes of the ceiling plate and the orifice plate. Thus, when laser beam is irradiated from the ink channel side, its irradiation angle is varied corresponding to the shape of the ceiling plate, etc.

Comparison of the results when recording was performed with the recording heads constituted by the above-mentioned two examples and the recording head of the prior art shown in Fig. 46 is shown in the following table.

	Droplet discharging speed (average of 10 heads)	Recording result
Example (Fig. 43)	8 m/s ± 10 %	Good
Example (Fig. 45)	9.3 m/s ± 8 %	Good
Reference example (Fig.46)	4 m/s ± 40 %	Passable

As is apparent from the above table, when the recording head according to this example is used, the discharging speed is increased to two-fold or more, and consequently the shooting position precision of droplet can be improved to give good recording result. Also, when having such orifice shape as in this example, the volume of discharged liquid is understood to become larger, and this gives better result to the recording density.

In the above-mentioned two examples, the orifice plate and the ceiling are integrally combined, but embodiments of the present invention are not limited thereto, but the desired effect can be of course obtained by bonding separately to the ceiling plate, and then applying the orifice working as described above thereon.

Fig. 47 is a perspective view showing one example of ceiling plate 400 shown in Fig. 7, representing the groove 403 for common liquid chamber and the groove 402 (dotted line) for ink channel, and the ceiling plate 400 is a resin molding. As the resin material, polyether sulfone, polyether ether ketone excellent in ink resistance can be used. Molding of the ceiling plate 400 is performed by use of a commercially available injection molding machine and a mold forming a pair with the shape shown in Fig. 47.

On completion of injection molding, then after registration between the mask 453 having a transparent portion 713 and a nontransparent portion 714 corresponding to the pattern of the ink channel to the laser beam 452 of excimer laser as shown in Fig. 49, the resin molding surface shown in Fig. 47 is removed and eliminated with the laser beam passed through the transparent portion of the excimer laser beam to obtain a groove shape of ink channel as shown in Fig. 50.

The excimer laser used in this example is KrF excimer laser and also Arf excimer laser can be used.

As the mask material, a quartz substrate is used and the opaque portion 714 of the mask 453 is formed by Cr vapor deposition. The width 703 of the ink channel groove is made 32 μm corresponding to the constitution having 16 discharging outlets per 1 mm, and width 704 of the non-groove portion is made 31.5 μm.

Further, by irradiating KrF excimer laser by use Index 200 manufactured by Lumonix, Canada by way of 360 pulse irradiation at an energy density of 350 mJ/cm^2 per one pulse, a groove depth 705 of 30 μm is obtained.

From the above process, the resin molding shown in Fig. 47 becomes the ceiling plate having fine grooves for ink channel integrally as shown in Fig. 48.

Next, the ceiling plate 400 after being precisely washed is bonded to the heater board 100 having energy generating elements 101A such as heat generating elements, etc. arranged on a substrate which can be formed of glass, ceramics, Si, plastic, or metal, etc. as shown in Fig. 51 to constitute the main head 780.

In the Figure, 41 is ink discharging outlet (orifice) in the main head 780.

Fig. 52 is a schematic view of an apparatus showing manufacturing manner of the orifice according to another example. In Fig. 52, 450 is an excimer laser generating device, 451 is a lens for collecting laser beams 452 outputted from the generating device 450, 453 is a mask disposed between the generating device 450 and the orifice plate, 40 is an orifice plate on which the orifice is formed, 413 is a lens for collecting the laser beam for perforating the discharge opening on the orifice plate by projecting the mask 453.

Fig. 53 is a perspective view for showing detail of the mask 453 and orifice plate 40. On the mask 453 a transparent portion 91 is provided corresponding to a portion at which the orifice of orifice plate 40 is worked for causing the laser beam to transmit. In detail, the pattern provided on the mask 453 as the orifice will be worked on the film of orifice plate.

As shown in Fig. 53, although the number of orifice is plural this is merely illustrative. In fact, in this example the mask in which orifices of 360 DPI, ϕ33 μm are arranged side by side linearly is used. In this construction, the laser beam 452 is irradiated to the plate 40 via the mask 453 to form the orifice. It is desirable for the mask not to be affected by heat due to laser irradiation, and for this reason material of low thermal coefficiency such as metal (for example Be-Cu) can be adopted.

In the orifice of orifice plate thus manufactured, there is no abnormal deformation around the orifice and circular configuration exactly following the configuration of the mask can be formed on the front and rear surfaces, which can be formed by such as carbon dioxide gas laser or YAG laser.

Next, an example for making the orifice shape a more preferable shape by working with excimer laser is shown.

The orifice shape of the ink jet recording head in this example has been deemed to have desirably a shape which is narrower at the tip which is nearer the exit of the orifice 805 than ink channel 804. However, because it can be realized with difficulty in the preparation method of the prior art, most prior art shapes have been cylindrical.

Whereas, by use of excimer laser, and utilizing the specific feature that the shape of the hole is varied by changing the position of the focus by moving gradually the focusing lens during irradiation in working only of the orifice plate, also a converging orifice shape can be produced.

The principal part of the recording head prepared as described above is constituted as shown in Fig. 56. Shortly speaking, the angle θ of the discharging orifice 805 formed on the orifice plate 802 differs for each liquid channel 804, whereby the droplet will fly with curving of the discharging direction 807 for each discharging orifice 805 in substantially the same angle as the discharging orifice angle. For this reason, the recorded dot pitch d formed on the surface to be recorded 806 can be made smaller than the liquid channel pitch d' of the recording head.

Accordingly, as compared with the recording head of the prior art having the same recording pitch and discharging orifice pitch, the discharging orifice width can be taken larger, and also it has become possible to take also larger width of the discharging energy element. For this reason, energy efficiency can be improved to enhance the discharging speed. Further, since the cross-sectional area of the liquid channel can be enlarged, supplement of ink to the liquid channel becomes smooth, and therefore response frequency can be also improved, and further overall improvement of image quality can be improved.

Further, in the ink jet recording head shown in Fig. 56, by making the diameter of the discharging orifice at the outside portion smaller as compared with the discharging orifice at the central portion, the speed of the ink droplet discharged from the discharging orifice at the central portion with shorter flight length of the ink droplet can be made greater as compared with the speed of the ink droplet discharged from the discharging orifice at the outside portion with longer flight length of the ink droplet, and therefore the timings of the ink droplets shot finally onto the recording medium can be made the same very easily when the timings of the ink droplets discharged from the discharging orifices and their driving forces are the same for the respective discharging orifices.

In the examples as described above, the discharging orifice angles of the respective discharging orifices are formed in the converging direction, but, if necessary, the discharging angles can be set variously for the respective discharging orifices.

For example, it is possible to constitute so that the above-mentioned incident angle may be different from the angle formed between the plane which is vertical to the above-mentioned discharging orifice surface and formed between the direction in which above discharging orifices are juxtaposed and the direction in which the ink is discharged from the above discharging orifices, and the above discharging orifice surface.

In the following, another example is described.

Fig. 57 is a schematic view of an ink jet recording head, which head is disposable with an ink tank integrally combined.

The ink jet recording head shown in Fig. 57 is provided with four main recording heads, each constituted by bonding a ceiling plate having a concavity (hereinafter called "groove") for constituting ink channels and common liquid chamber, and further a discharging orifice forming member (orifice plate) 802 integrally formed and a substrate (hereinafter called "heater board") having art electricity-heat converter for generating discharging energy (hereinafter called "discharging heater") and an Al wiring for supplying electrical signals thereto formed by the film forming technique on a Si substrate.

Also, in the Figure, 600 is a sub-ink tank arranged adjacent to the main recording head, and the sub-ink tank 600 and the above main body are supported by lids 300 and 800. Further, 1000 is a main cartridge and 1100 is the lid member of the main cartridge. Internally of the main cartridge is built in an ink tank, which supplies suitably ink to the sub-ink tank 600.

Fig. 58A shows the manner in which orifice working is performed by excimer laser beam on the orifice plate formed integrally with the ceiling plate. That is, Fig. 58A is a schematic view of the device in which the laser beam is incident so as to form discharging orifices from the ceiling concavity side. In the figure 450 is a laser oscillating device for oscillating KrF excimer laser beam, 452 a pulse laser beam with a wavelength of 248 nm and a pulse width of about 15 nsec oscillated from the laser oscillating device 450, 451 a synthetic quartz lens for converging the laser beam 452, 453 a projection mask having aluminum capable of shielding the laser beam 452 vapor deposited thereon, on which a plurality of holes of 133 μm in diameter are arranged at a pitch of 212 μm to constituted an orifice pattern.

460 is an orifice plate for forming the discharging orifices which is fixed on an implement 207A which can be freely rotated relative to the laser beam 452.

The principal portion of the recording head prepared as described above has the constitution as shown in Fig. 59.

Shortly speaking, the discharging angle θ of the discharging orifice 909 formed on the orifice plate 902 differ for each head 901, and therefore the droplet will fly with the discharging direction 911 of each head being curved substantially the same as the discharging angle. Accordingly, the recording dot pitch d'' for each discharging orifice row formed on the surface to be recorded 210 can be made smaller than the distance d''' between the discharging orifice rows of the recording head.

In the recording head having a plurality of discharging rows of the prior art, since the distance between the respective discharging orifice rows is the same as the recording dot row distance, greater memory size is required for taking timing for each recording dot row, but in this example, the distance between the recorded dot rows can be taken smaller, whereby the cost of the main printer can be made lower. Particularly, such constitution is very effective in the case of color printing where the discharging orifice rows must be divided corresponding to the respective colors.

Fig. 60 shows an example which bonds or fixes the heater board 100 and the ceiling plate 400. In Fig. 60, for simplification, the orifice plate portion 404 of the ceiling plate 400 is shown by the chain line, and showing of the wiring pattern on the heater board 100 is omitted.

As described above, the registration of the heater board 100 and the ceiling plate 400 is performed by abutting the end surface of the heater board 100 against the orifice plate portion 404, and in bonding of these, the adhesive 405 was coated along the 3 sides of the peripheral portion of the ceiling plate 400. By doing so, flowing of the adhesive into the ink flow channel could be inhibited. Further, it is also possible to permit an adhesive to exist over a suitable range in necessary and sufficient amount at the bonding surface between the heater board 100 and the orifice plate 404.

In this example, as the adhesive 405, a photocurable type adhesive UV-201 (Grace Japan K.K.) is used, and after registration cured by irradiation with UV-ray of, for example, 10 - 30 J/cm^2 to fix the both. Here, since the existing portion of the adhesive 405 is apart from the discharging outlet, the tolerable value of trial number during registration is increased.

Next, the main recording head obtained by integration of the ceiling plate 400 and the heater board 100 in this way is fixed onto the support 300 by use of an adhesive 306. As the adhesive 306, for example, HP2R/2H manufactured by Canon Chemical K.K. can be employed.

Under this state, both the substrates (the heater board 100 and the ceiling plate 400) are adhered only at the peripheral portions other than the flow channel portion as described above, and no sufficient adhesion is obtained. Accordingly, an urging force of the pressing spring 500 is permitted to act from the upper side of the ceiling plate 400. The pressing spring 500 can be formed by use of, for example, phosphorous bronze or stainless steel for spring. By fitting the hooks 507 provided at the lower portions of both ends into the hole portions 307 provided at the support 300 to thereby engaging the both, mechanical pressure is applied from the upper portion of the ceiling plate 400. In this way, sufficient adhesion state between the both substrates can be obtained. In the pressing spring 500, 520 is a hole which receives insertion of the feeding pipe for connecting the ink introducing inlet 420 of the ceiling plate 400 to the ink feeding inlet on the feeding tank 600 side.

In this example, in bonding of the ceiling plate 400 with the heater board 100, a photocurable type adhesive is used, but its form may be any desired one or no adhesive may be required to be used, if sufficient fixing force or adhesion force can be obtained with the pressing spring 500. For example, only for the purpose of enhancing liquid sealability, a suitable sealing material, namely a sealing member such as sealant or rubber packing, etc. can be used. Also, similarly, if sufficient fixing force of the main head body can be obtained through engagement between the hook 507 of the pressing spring 500 and the hole portion 307 of the support 300, no adhesive 306 may be employed.

According to this example, since sufficient bonded state can be obtained without coating of an adhesive on the surface of the flow channel wall of the ceiling plate 400, the coating step of the adhesive can be simplified. Also when slippage occurred during registration in the prior art, there was a fear of sticking of adhesive to the flow channel portion at the discharging heater 105, etc. of the heater board 100, or occurrence of defective product by clogging of the flow channel or discharging outlet with adhesive, but no such phenomenon occurs in this example, and registration can be done for many times. Further, presence of more or less deformation, warping or variance in product in the ceiling plate by use of a resin material is permissible and therefore the manufacturing steps can become simple.

Fig. 61 is a modification example of the constitution shown in Fig. 60. In this Figure, showing of the orifice plate 404 in the ceiling plate 400 is omitted.

In this example, similarly as in the example shown in Fig. 60, the structure is made to obtain sufficient adhesion by applying pressure with a plate spring 500 in flat shape from the upper surface of the ceiling plate 400 under the state where the main recording head comprising the heater board 100 and the ceiling plate 400 is bonded to the support 300. The plate spring 500 is further pressurized by another member of the upper part (e.g. feeding tank 600 in Fig. 7).

Also, according to this example, the same effect as in the constitution shown in Fig. 60 could be obtained.

By assembling the respective parts with the constitutions as described above according to the steps in Fig. 7A, the cartridge as shown in Fig. 7B can be obtained and further an ink jet printer as shown in Fig. 62, namely an ink jet printer by use of a disposable cartridge can be constituted by use of this.

In Fig. 62, 14 is the cartridge shown in Figs. 7A and 7B, the cartridge 14 is fixed on the carriage 15 by a pressing member 41, and these are made reciprocally movable in the lengthy direction along the shaft 21. Also, registration relative to the carriage 15 can be effected by, for example, the hole provided on the support 300 and the dowel provided on the carriage 15 side. Further electrical connection may be obtained by joining of the connector on the carriage 15 to the connecting pad provided on the wiring substrate 200.

This ink discharged by the recording head reaches a recording medium 18 with the recording surface regulated by a platen 19 to form an image on the recording medium 18.

To the recording head are supplied discharging signals corresponding to the image data from a suitable data supplying source through the cable 16 and the terminals connected thereto. The cartridge 14 can be provided in one or plural number (two in the Figure) corresponding to the ink colors, etc. used.

In Fig. 62, 17 is a carriage motor for scanning the carriage 15 along the shaft 21, 22 is a wire for transmitting the driving force of the motor 17 to the carriage 15. 20 is a feed motor jointed with the platen roller 19 for conveying the recording medium 18.

In the ink jet printer by use of such disposable cartridge 14, the cartridge 14 is changed when there is no ink impregnated in the absorber 900, etc., and for that purpose, the cartridge 14 is desired to be low in cost. Since the cartridge 14 as described in the above examples can be produced by simple production steps and also with small number of steps, and therefore it can be constituted at low cost and is extremely suitable for disposable construction. Further, registration in assembling of the main recording head can be done correctly, and yet there occurs no variance in dimension or clogging of the flow channel, etc. by flowing of the adhesive, reliability is very high and also yield can be improved.

Embodiments of the present invention are not limited to the examples as described above, but various constitutions can be employed as a matter of course.

For example, in the above examples, the main recording head the ink supplying source, etc. are made integral and disposable, but the both may be separate bodies, and each is not necessarily required to be made disposable. This is because, even the main recording head may be the fixed type without the condition of simple exchange, simple and inexpensive constitution as described above will also constitute to the reduction in cost of the main printer.

Also, for the main recording head comprising the heater board 100 and the ceiling plate 400, ink flow channels and concavity for formation of the common liquid chamber are provided only on the ceiling plate side in the above examples, but these can be also provided on both thereof. Also, concerning the main recording head, discharging heater 105 is used so as to make the heat energy discharging energy in the above examples, an electricity-mechanical converting element which is deformed corresponding to current passage may be used to utilize the mechanical vibration as the discharging energy.

Further, in the above examples, the orifice plate portion 404 itself is made a constitution having the abutting portion against the heater board, but the shape, etc. of the abutting portion may be any desired one. For example, such abutting portion may be also provided in the side surface direction so as to effect registration in the lateral direction, or in place of providing such abutting portion, the registration may be made through the combination of dowel and hole. Also, if the registration poses no problem, no abutting portion or registration member is necessary. In other words, the ceiling plate may be in the form having the wall portion with the same surface as the bonding surface in front of the groove portion and having the discharging outlet formed thereat.

In addition, in the above examples, the ceiling plate and the heater board are adhered and bonded with a pressing spring, but if there is no problem in use only of an adhesive during said bonding, it is also possible to use a constitution without use of a pressing spring.

Embodiments of the present invention bring about excellent effects particularly in a recording head, recording device of the bubble jet system among the ink jet recording system.

As to its representative constitution and principle, for example, one practiced by use of the basic principle disclosed in, for example, U.S. Patents 4,723,129 and 4,740,796 is preferred. This system is applicable to either of the so called on-demand type and the continuous type. Particularly, the case of the on-demand type is effective because, by applying at least one driving signal which gives rapid temperature elevation exceeding nucleus boiling corresponding to the recording information on an electricity-heat convertors arranged corresponding to the sheets or liquid channels holding liquid (ink), heat energy is generated at the electricity-heat convertors to effect film boiling at the heat acting surface of the recording head, and consequently the bubbles within the liquid (ink) can be formed corresponding one by one to the driving signals. By discharging the liquid (ink) through an opening for discharging by growth and shrinkage of the bubble, at least one droplet is formed. By making the driving signals into pulse shapes, growth and shrinkage of the bubble can be effected instantly and adequately to accomplish more preferably discharging of the liquid (ink) particularly excellent in response characteristic. As the driving signals of such pulse shape, those as disclosed in U.S. Patents 4,463,359 and 4,345,262 are suitable. Further excellent recording can be performed by employment of the conditions described in U.S. Patent 4,313,124 of embodiments of the invention concerning the temperature elevation rate of the above-mentioned heat acting surface.

As the constitution of the recording head, in addition to the combination constitutions of discharging orifice, liquid channel, electricity-heat converter (linear liquid channel or right angle liquid channel) as disclosed in the above-mentioned respective specifications, the constitution by use of U.S. Patent 4,558,333, 4,459,600 disclosing the constitution having the heat acting portion arranged in the flexed region is also included in embodiments of the present invention. In addition, embodiments of the present invention can be also effectively made the constitution as disclosed in Japanese Patent Laid-Open Application No. 59-123670 which discloses the constitution using a slit common to a plurality of electricity-heat convertors as the discharging portion of the electricity-heat converter or Japanese Patent Laid-Open Application No. 59-138461 which discloses the constitution having the opening for absorbing pressure wave of heat energy correspondent to the discharging portion.

Further, as the recording head of the full line type having a length corresponding to the maximum width of recording medium which can be recorded by the recording device, either the constitution which satisfies its length by combination of a plurality of recording heads as disclosed in the above-mentioned specifications or the constitution as one recording head integrally formed may be used, and embodiments of the presents invention can exhibit the effects as described above further effectively.

In addition, embodiments of the present invention are effective for a recording head of the freely exchangeable chip type which enables electrical connection to the main device or supply of ink from the

main device by being mounted on the main device, or for the case by use of a recording head of the cartridge type provided integrally on the recording head itself.

Also, addition of a restoration means for the recording head, a preliminary auxiliary means, etc. provided as the constitution of the recording device of embodiments of the present invention is preferable, because the effect of embodiments of the present invention can be further stabilized. Specific examples of these may include, for the recording head, capping means, cleaning means, pressurization or aspiration means, electricity-heat convertors or another heating element or preliminary heating means according to a combination of these, and it is also effective for performing stable recording to perform preliminary mode which performs discharging separate from recording.

Further, as the recording mode of the recording device, embodiments of the present invention are extremely effective for not only the recording mode only of a primary stream color such as black etc., but also a device equipped with at least one of plural different colors or full color by color mixing, whether the recording head may be either integrally constituted or combined in plural number.

Summing up, in embodiments of the present invention, it is possible to omit the step for adhering the discharge opening forming member (orifice plate) in the assembling process of the recording head, which enables to omit or exclude the positioning upon adhering and to overcome the disadvantage such as clogging in the liquid path since no adhesive agent is used. Thus, whole of the manufacturing process of the recording head can be simplified. In the case the discharge opening forming member is partially thinned to form the discharge opening thereat, formation of the discharge opening is simplified and length of the liquid flow path located in front of discharge energy generating element can be shortened.

In embodiments of the present invention, a cheap but reliable ink jet recording head can be obtained by a simple manufacturing process with a small number of steps.

In embodiments of the present invention, it is possible to form the orifice on the orifice plate with high density, in high accuracy and under accurate positioning relative to the ink path or the like. As the result, by using the mask member properly, more small or fine plural orifices can be manufactured together, so the ink jet recording head can be manufactured simply and in low cost. Additionally, realization of high accuracy can improve character of the image to be recorded.

In embodiments of the present invention, it is possible to obtain the ink jet recording head having tapered configuration whose cross-section decreases with respect to the discharge direction, which enables to stabilize the amount of ink droplet and the discharge speed necessary for recording. As the result, the discharge quality such as accuracy of adhering position and recording density is improved and the recording image at high quality can be obtained.

In an embodiment of the present invention, the ceiling plate in which the ink groove of fine configuration and the common chamber having several scores times of the ink path are integrally formed can be formed easily. In addition, high flatness of accuracy of the ink path can be realized by the working of excimer laser light. As the result, the process number can be decreased compared with the prior art, and the bad influence such as positioning shift, leakage of the recording liquid, flow-in of the adhesive agent into the ink path can be prevented. Thus, the ink jet recording head in which the ink discharge quality is increased can be obtained.

In an embodiment of the present invention, the orifice plate can be provided with each discharge opening angle peculiar to the discharge opening in high density and high accuracy, and the positional relation between the ink path or the like and the orifice can be determined accurately.

In an embodiment of the present invention, the discharge opening is formed obliquely on the orifice plate in high accuracy, and plural discharge openings (orifices) of different angle can be formed simultaneously on the plate. In addition, it is possible to form the discharge openings by changing or differentiating the discharge opening angle as the whole in every row of the discharging opening. As the result, ink jet recording head capable of effecting the high speed recording of high quality in low cost and simply.

Claims

1. A method of manufacturing an ink jet head, said ink jet head comprising an ink channel (401) with an aperture member (40,18B,460) at one end having an aperture (41,466) therein for allowing ink to be discharged therethrough, said method including the step of forming said aperture (41,466) by irradiating said aperture member (40,18B,460) with a laser beam (212,452), the laser beam (212,452) being incident on a surface of said aperture member (40,18B,460) opposite to the surface where said ink is to be discharged.

2. A method according to claim 1, wherein said aperture member (40,18B,460) and aperture(41,466) and said ink channel (401) are formed by the steps:-

providing a first plate (100,458);

providing a second plate (400,457,40,18B,460) comprising a first member (400,457) having at least one recessed portion (464) therein, and an aperture member (40,18B,460) integral with said first member (400,457);

forming an aperture (41,466) in said aperture member (40,18B,460) by irradiating said aperture member (40,18B,460) with a laser beam (212,452), the laser beam (212,452) being incident on a surface of said aperture member (40,18B,460) opposite to the surface where said ink is to be discharged; and

connecting said first (100,458) and second (400,457,40,18B,460) plates such that said first plate (100,458) and said recessed portion (464) define said ink channel (401) connected to said aperture (41,466).

3. A method according to claim 2, wherein a portion of said aperture member (40,18B,460) is proud of said first member (400,457), and said first plate (100,458) abuts said portion when the first (100,458) and second (400,457,40,18B,460) plates are connected.

4. A method according to claim 2 or claim 3, wherein said second plate (400,457,40,18B,460) is made by molding a resin material.

5. A method according to claim 1, wherein said aperture member (40,18B,460) and aperture (41,466) and said ink channel (401) are formed by the steps:-

providing a first plate (100,458);

providing a second plate (400,457) having at least one recessed portion (464) therein;

attaching an aperture member (40,18B,460) to said second plate (400,457) thereby blocking one end of said recessed portion (464);

forming an aperture (41,466) in said aperture member (40,18B,460) by irradiating said aperture member (40,18B,460) with a laser beam (212,452), the laser beam (212,452) being incident on a surface of said aperture member (40,18B,460) opposite to the surface where said ink is to be discharged; and

connecting said first plate (100,458) and said second plate (400,457) with said aperture member (40,18B,460) attached thereto such that said first plate (100,458) and said recessed portion (464) define said ink channel (401) connected to said aperture (41,466).

6. A method, according to any one of claims 2 to 5, wherein said laser beam (212,452) is incident at an oblique angle ($\theta 2$) relative to the surface where said beam (212,452) is incident.

7. A method according to claim 1, wherein said aperture member (40,18B,460) and aperture (41,466) and said ink channel (401) are formed by the steps:-

providing a first plate (100,458);

providing a second plate (400,457) having at least one recessed portion (464) therein;

providing an aperture member (40,18B,460) with an aperture (41,466) formed therein by irradiating said aperture member (40,18B,460) with a laser beam (212,452), the laser beam (212,452) being incident on a surface of said aperture member (40,18B,460) opposite to the surface where said ink is to be discharged;

connecting said aperture member (40,18B,460) to said second plate (400,457) such that said aperture (41,466) is connected to said recessed portion (464); and

connecting said first plate (100,458) and said second plate (400,457) with said aperture member (40,18B,460) attached thereto such that said first plate (100,458) and said recessed portion (464) define said ink channel (401) connected to said aperture (41,466).

8. A method according to claim 5 or claim 7, wherein a portion of said aperture member (40,18B,460) when attached to said second plate (400,457) is proud of said second plate (400,457) and said first plate (100,458) abuts said portion when the first (100,458) and second (400,457) plates are connected.

9. A method according to any one of claims 5, 7 or 8, wherein said aperture member (40,18B,460) is made of resin material.

10. A method according to any one of claims 2 to 9, further comprising the steps:-
providing energy generating means (101A) for generating energy for discharging ink; and
arranging said energy generating means (101A) such that when said first (100,458) and second (400,457) plates are connected, said energy generating means (101A) lies within said recessed portion (464).

11. A method according to claim 10, wherein said energy generating means (101A) comprises an electrothermal converting member for generating thermal energy.

12. A method according to any one of claims 2 to 11, wherein said recessed portion (464) is formed using an excimer laser beam (212,452).

13. A method according to any one of claims 2 to 12, wherein there are a plurality of recessed portions (464) and a plurality of apertures (41,466) are formed in said aperture member (40,18B,460) each aperture (41,466) being connected to a respective one of said recessed portions (464).

14. A method according to claim 13, wherein at least one of said apertures (41,466) is formed at a different angle to the other apertures (41,466) thereby to allow ink to be discharged in a different direction.

15. A method according to any preceding claim, further comprising the step of providing means (19,20) for conveying a recording medium (18) to be recorded on by ink discharged from said aperture (41,466).

16. A method according to any preceding claim, further comprising the step of providing an ink tank for supplying ink to said ink channel (401) of said ink jet head.

17. A method according to any preceding claim, wherein said laser beam (212,452) is an excimer laser beam.

18. A method according to any preceding claim, wherein at least the portion of said aperture member (40,18B,460) where said aperture (41,466) is to be formed is thinned before said aperture (41,466) is formed.

19. A method according to any preceding claim, wherein said aperture (41,466) is formed with one end thereof of smaller cross-section, said end being the end from which said ink is to be discharged.

20. A method according to any preceding claim, wherein said aperture (41,466) is so formed to discharge ink upwardly relative to the surface of said aperture member (40,18B,460) where the ink is to be discharged.

21. A method according to any preceding claim, wherein said laser beam (212,452) is incident on said surface via a mask (209,453).

22. A method according to any preceding claim, wherein said aperture member (40,18B,460) is formed from a plurality of members, at least some of which are of different materials.

Patentansprüche

1. Verfahren zur Herstellung eines Tintenstrahlkopfes, der einen Tintenkanal (401) mit einem Öffnungselement (40, 18B, 460) an einem Ende umfaßt, in dem eine Öffnung (41, 466) angeordnet ist, durch die Tinte abgegeben werden kann, bei dem die Öffnung (41, 466) durch Bestrahlen des Öffnungselementes (40, 18B, 460) mit einem Laserstrahl (212, 452) geformt wird, wobei der Laserstrahl (212, 452) auf eine Fläche des Öffnungselementes (40, 18B, 460) trifft, die der Fläche gegenüberliegt, wo die Tinte abgegeben werden soll.

2. Verfahren nach Anspruch 1, bei dem das Öffnungselement (40, 18B, 460) und die Öffnung (41, 466) sowie der Tintenkanal (401) durch die folgenden Schritte geformt werden:
Vorsehen einer ersten Platte (100, 458);
Vorsehen einer zweiten Platte (400, 457, 50, 18B, 460), die ein erstes Element (400, 457), das

mindestens mit einem ausgesparten Abschnitt (464) versehen ist, und ein Öffnungselement (40, 18B, 460), das einstückig mit dem ersten Element (400, 457) ausgebildet ist, umfaßt;
Formen einer Öffnung (41, 466) im Öffnungselement (40, 18B, 460) durch Bestrahlen des Öffnungselementes (40, 18B, 460) mit einem Laserstrahl (212, 452), wobei der Laserstrahl (212, 452) auf eine Fläche des Öffnungselementes (40, 18B, 460) trifft, die der Fläche gegenüberliegt, wo die Tinte abgegeben werden soll; und
Verbinden der ersten (100, 458) und zweiten (400, 457, 40, 18B, 460) Platte derart, daß die erste Platte (100, 458) und der ausgesparte Abschnitt (464) den mit der Öffnung (41, 466) verbundenen Tintenkanal (401) bilden.

3. Verfahren nach Anspruch 2, bei dem ein Abschnitt des Öffnungselementes (40, 18B, 460) vom ersten Element (400, 457) vorsteht und die erste Platte (100, 458) gegen den Abschnitt stößt, wenn die erste (100, 458) und zweite (400, 457, 40, 18B, 460) Platte miteinander verbunden werden.

4. Verfahren nach Anspruch 2 oder 3, bei dem die zweite Platte (400, 457, 40, 18B, 460) durch Formen aus einem Harzmaterial hergestellt wird.

5. Verfahren nach Anspruch 1, bei dem das Öffnungselement (40, 18B, 460) und die Öffnung (41, 466) sowie der Tintenkanal (401) durch die folgenden Schritte geformt werden:
Vorsehen einer ersten Platte (100, 458);
Vorsehen einer zweiten Platte (400, 457), die mindestens einen ausgesparten Abschnitt (464) aufweist;
Befestigen eines Öffnungselementes (40, 18B, 460) an der zweiten Platte (400, 457), um auf diese Weise ein Ende des ausgesparten Abschnittes (464) zu blockieren;
Formen einer Öffnung (41, 466) im Öffnungselement (40, 18B, 460) durch Bestrahlen des Öffnungselementes (40, 18B, 460) mit einem Laserstrahl (212, 452), der auf eine Fläche des Öffnungselementes (40, 18B, 460) trifft, die der Fläche gegenüberliegt, wo die Tinte abgegeben werden soll; und
Verbinden der ersten Platte (100, 458) und der zweiten Platte (400, 457) mit dem daran befestigten Öffnungselement (40, 18B, 460), so daß die erste Platte (100, 458) und der ausgesparte Abschnitt (464) den mit der Öffnung (41, 466) verbundenen Tintenkanal (401) bilden.

6. Verfahren nach einem der Ansprüche 2 bis 5, bei dem der Laserstrahl (212, 452) unter einem schiefen Winkel ($\theta 2$) auf die Fläche trifft, auf die der Strahl (212, 452) trifft.

7. Verfahren nach Anspruch 1, bei dem das Öffnungselement (40, 18B, 460) und die Öffnung (41, 466) sowie der Tintenkanal (401) durch die folgenden Schritte geformt werden.
Vorsehen einer ersten Platte (100, 458);
Vorsehen einer zweiten Platte (400, 457), in der mindestens ein ausgesparter Abschnitt (464) angeordnet ist;
Vorsehen eines Öffnungselementes (40, 18B, 460) mit einer darin ausgebildeten Öffnung (41, 466) durch Bestrahlen des Öffnungselementes (40, 18B, 460) mit einem Laserstrahl (212, 452), der auf eine Fläche des Öffnungselementes (40, 18B, 460) trifft, die der Fläche gegenüberliegt, wo die Tinte abgegeben werden soll;
Verbinden des Öffnungselementes (40, 18B, 460) mit der zweiten Platte (400, 457) derart, daß die Öffnung (41, 466) mit dem ausgesparten Abschnitt (464) verbunden wird; und
Verbinden der ersten Platte (100, 458) und der zweiten Platte (400, 457) mit dem daran befestigten Öffnungselement (40, 18B, 460) derart, daß die erste Platte (100, 458) und der ausgesparte Abschnitt (464) den mit der Öffnung (41, 466) verbundenen Tintenkanal (401) bilden.

8. Verfahren nach Anspruch 5 oder 7, bei dem ein Abschnitt des Öffnungselementes (40, 18B, 460) im an der zweiten Platte (400, 457) befestigten Zustand von der zweiten Platte (400, 457) vorsteht und die erste Platte (100, 458) gegen den Abschnitt stößt, wenn die erste (100, 458) und zweite (400, 457) Platte verbunden werden.

9. Verfahren nach einem der Ansprüche 5, 7 oder 8, bei dem das Öffnungselement (40, 18B, 460) aus Harzmaterial hergestellt wird.

10. Verfahren nach einem der Ansprüche 2 bis 9, das des weiteren die folgenden Schritte umfaßt:
Vorsehen von Energieerzeugungseinrichtungen (101A) zur Erzeugung von Energie zur Abgabe von

Tinte; und
Anordnen der Energieerzeugungseinrichtungen (101A) derart, daß sie innerhalb des ausgesparten Abschnittes (464) liegen, wenn die erste (100, 458) und zweite (400, 457) Platte miteinander verbunden werden.

11. Verfahren nach Anspruch 10, bei dem die Energieerzeugungseinrichtungen (101A) ein elektrothermisches Umwandlungselement zur Erzeugung von thermischer Energie umfassen.

12. Verfahren nach einem der Ansprüche 2 bis 11, bei dem der ausgesparte Abschnitt (464) unter Verwendung eines Excimer-Laserstrahles (212, 452) geformt wird.

13. Verfahren nach einem der Ansprüche 2 bis 12, bei dem eine Vielzahl von ausgesparten Abschnitten (464) und eine Vielzahl von Öffnungen (41, 466) im Öffnungselement (40, 18B, 460) geformt werden, wobei jede Öffnung (41, 466) mit einem entsprechenden ausgesparten Abschnitt (464) verbunden wird.

14. Verfahren nach Anspruch 13, bei dem mindestens eine Öffnung (41, 466) unter einem in bezug auf die anderen Öffnungen (41, 466) unterschiedlichen Winkel geformt wird, so daß Tinte in einer unterschiedlichen Richtung abgegeben werden kann.

15. Verfahren nach einem der vorangehenden Ansprüche, das des weiteren den Schritt des Vorsehens von Einrichtungen (19, 20) zum Fördern eines Aufzeichnungsmediums (18), auf dem durch die von der Öffnung (41, 466) abgegebene Tinte eine Aufzeichung durchgeführt werden soll, umfaßt.

16. Verfahren nach einem der vorangehenden Ansprüche, das des weiteren den Schritt des Vorsehens eines Tintentanks zur Zuführung von Tinte in den Tintenkanal (401) des Tintenstrahlkopfes umfaßt.

17. Verfahren nach einem der vorangehenden Ansprüche, bei dem der Laserstrahl (212, 452) ein Excimer-Laserstrahl ist.

18. Verfahren nach einem der vorangehenden Ansprüche, bei dem mindestens der Abschnitt des Öffnungselementes (40, 18B, 460), wo die Öffnung (41, 466) geformt werden soll, verdünnt wird, bevor die Öffnung (41, 466) geformt wird.

19. Verfahren nach einem der vorangehenden Ansprüche, bei dem die Öffnung (41, 466) so geformt wird, daß ein Ende einen kleineren Querschnitt besitzt, wobei dieses Ende das Ende ist, von dem die Tinte abgegeben werden soll.

20. Verfahren nach einem der vorangehenden Ansprüche, bei dem die Öffnung (41, 466) so geformt wird, daß Tinte in bezug auf die Fläche des Öffnungselementes (40, 18B, 460), wo die Tinte abgegeben werden soll, nach oben abgegeben wird.

21. Verfahren nach einem der vorangehenden Ansprüche, bei dem der Laserstrahl (212, 452) über eine Maske (209, 453) auf die Fläche trifft.

22. Verfahren nach einem der vorangehenden Ansprüche, bei dem das Öffnungselement (40, 18B, 460) aus einer Vielzahl von Elementen geformt wird, von denen mindestens einige aus unterschiedlichen Materialien bestehen.

Revendications

1. Procédé de fabrication d'une tête à jets d'encre, ladite tête à jets d'encre comprenant un canal d'encre (401) ayant à une extrémité un élément à ouverture (40, 18B, 460) présentant une ouverture (41, 466) pour permettre à de l'encre d'être déchargée à travers elle, ledit procédé comprenant l'étape qui consiste à former ladite ouverture (41, 466) par irradiation dudit élément à ouverture (40, 18B, 460) avec un faisceau laser (212, 452), le faisceau laser (212, 452) étant incident sur une surface dudit élément à ouverture (40, 18B, 460) opposée à la surface où ladite encre doit être déchargée.

2. Procédé selon la revendication 1, dans lequel ledit élément à ouverture (40, 18B, 460) et l'ouverture (41, 466) et ledit canal d'encre (401) sont formés par les étapes qui consistent :

à utiliser une première plaque (100, 458) ;

à utiliser une seconde plaque (400, 457, 40, 18B, 460) comportant un premier élément (400, 457) renfermant au moins une partie évidée (464), et un élément à ouverture (40, 18B, 460) d'une seule pièce avec ledit premier élément (400, 457) ;

à former une ouverture (41, 466) dans ledit élément (40, 18B, 460) à ouverture en irradiant ledit élément (40, 18B, 460) à ouverture avec un faisceau laser (212, 452), le faisceau laser (212, 452) étant incident sur une surface dudit élément à ouverture (40, 18B, 460) opposée à la surface où ladite encre doit être déchargée ; et

à relier lesdites première (100, 458) et seconde (400, 457, 40, 18B, 460) plaques de manière que ladite première plaque (100, 458) et ladite partie évidée (464) définissent ledit canal d'encre (401) relié à ladite ouverture (41, 466).

3. Procédé selon la revendication 2, dans lequel une partie dudit élément (40, 18B, 460) à ouverture fait saillie dudit premier élément (400, 457), et ladite première plaque (100, 458) bute contre ladite partie lorsque les première (100, 458) et seconde (400, 457, 40, 18B, 460) plaques sont reliées.

4. Procédé selon la revendication 2 ou la revendication 3, dans lequel ladite seconde plaque (400, 457, 40, 18B, 460) est formée par moulage d'une matière du type résine.

5. Procédé selon la revendication 1, dans lequel ledit élément à ouverture (40, 18B, 460) et l'ouverture (41, 466) et ledit canal d'encre (401) sont formés par les étapes qui consistent :

à utiliser une première plaque (100, 458) ;

à utiliser une seconde plaque (400, 457) renfermant au moins une partie évidée (464) ;

à fixer un élément à ouverture (40, 18B, 460) à ladite seconde plaque (400, 457) pour fermer ainsi une extrémité de ladite partie évidée (464) ;

à former une ouverture (41, 466) dans ledit élément (40, 18B, 460) à ouverture en irradiant ledit élément (40, 18B, 460) à ouverture avec un faisceau laser (212, 452), le faisceau laser (212, 452) étant incident sur une surface dudit élément (40, 18B, 460) à ouverture opposée à la surface où ladite encre doit être déchargée ; et

à relier ladite première plaque (100, 458) et ladite seconde plaque (400, 457) à laquelle est attaché ledit élément (40, 18B, 460) à ouverture, de manière que ladite première plaque (100, 458) et ladite partie évidée (464) définissent ledit canal d'encre (401) relié à ladite ouverture (41, 466).

6. Procédé selon l'une quelconque des revendications 2 à 5, dans lequel ledit faisceau laser (212, 452) est incident sous un angle d'inclinaison ($\theta 2$) par rapport à la surface où ledit faisceau (212, 452) est incident.

7. Procédé selon la revendication 1, dans lequel ledit élément à ouverture (40, 18B, 460) et l'ouverture (41, 466) et ledit canal d'encre (401) sont formés par les étapes qui consistent :

à utiliser une première plaque (100, 458) ;

à utiliser une seconde plaque (400, 457) renfermant au moins une partie évidée (464) ;

à utiliser un élément (40, 18B, 460) à ouverture dans lequel une ouverture (41, 466) est formée par irradiation dudit élément (40, 18B, 460) à ouverture avec un faiscau laser (212, 452), le faisceau laser (212, 452) étant incident sur une surface dudit élément (40, 18B, 460) à ouverture opposée à la surface où ladite encre doit être déchargée ;

à relier ledit élément (40, 18B, 460) à ouverture à ladite seconde plaque (400, 457) de manière que ladite ouverture (41, 466) soit reliée à ladite partie évidée (464) ; et

à relier ladite première plaque (100, 458) et ladite seconde plaque (400, 457) à laquelle est relié ledit élément (40, 18B, 460) à ouverture, de manière que ladite première plaque (100, 458) et ladite partie évidée (464) définissent ledit canal d'encre (401) relié à ladite ouverture (41, 466).

8. Procédé selon la revendication 5 ou la revendication 7, dans lequel une partie dudit élément (40, 18B, 460) à ouverture, lorsqu'il est fixé à ladite seconde plaque (400, 457), fait saillie de ladite seconde plaque (400, 457) et ladite première plaque (100, 458) bute contre ladite partie lorsque les première (100, 458) et seconde (400, 457) plaques sont reliées.

9. Procédé selon l'une quelconque des revendications 5, 7 ou 8, dans lequel ledit élément (40, 18B, 460) à ouverture est formé d'une matière du type résine.

10. Procédé selon l'une quelconque des revendications 2 à 9, comportant en outre les étapes qui consistent :

à utiliser des moyens (101A) de génération d'énergie destinés à générer de l'énergie pour décharger de l'encre ; et

à disposer ledit moyen (101A) de génération d'énergie de manière que, lorsque lesdites première (100, 458) et seconde (400, 457) plaques sont reliées, lesdits moyens (101A) de génération d'énergie s'étendent à l'intérieur de ladite partie évidée (464).

11. Procédé selon la revendication 10, dans lequel lesdits moyens ((101A) de génération d'énergie comprennent un élément de conversion électrothermique destiné à générer de l'énergie thermique.

12. Procédé selon l'une quelconque des revendications 2 à 11, dans lequel ladite partie évidée (464) est formée par utilisation d'un faisceau (212, 452) d'un laser à excimère.

13. Procédé selon l'une quelconque des revendications 2 à 12, dans lequel il y a plusieurs parties évidées (464) et plusieurs ouvertures (41, 466) sont formées dans ledit élément (40, 18B, 460) à ouvertures, chaque ouverture (41, 466) étant reliée à l'une, respective, desdites parties évidées (464).

14. Procédé selon la revendication 13, dans lequel au moins l'une desdites ouvertures (41, 466) est formée sous un angle différent de celui des autres ouvertures (41, 466) afin de permettre à de l'encre d'être déchargée dans une direction différente.

15. Procédé selon l'une quelconque des revendications précédentes, comprenant en outre l'étape qui consiste à utiliser des moyens (19, 20) pour transporter un support d'enregistrement (18) sur lequel un enregistrement doit être réalisé par de l'encre déchargée depuis ladite ouverture (41, 466).

16. Procédé selon l'une quelconque des revendications précédentes, comprenant en outre l'étape qui consiste à utiliser un réservoir d'encre destiné à alimenter en encre ledit canal d'encre (401) de ladite tête à jets d'encre.

17. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit faisceau laser (212, 452) est un faisceau d'un laser à excimère.

18. Procédé selon l'une quelconque des revendications précédentes, dans lequel au moins la partie dudit élément (40, 18B, 460) à ouverture, où ladite ouverture (41, 466) doit être formée, est amincie avant que ladite ouverture (41, 466) soit formée.

19. Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite ouverture (41, 466) est formée de manière à avoir une extrémité de section transversale plus petite, ladite extrémité étant l'extrémité de laquelle ladite encre doit être déchargée.

20. Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite ouverture (41, 466) est formée de façon à décharger de l'encre vers le haut par rapport à la surface dudit élément (40, 18B, 460) à ouverture où l'encre doit être déchargée.

21. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit faisceau laser (212, 452) est incident sur ladite surface en passant par un masque (209, 453).

22. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit élément (40, 18B, 460) à ouverture est formé de plusieurs éléments dont au moins certains sont en des matières différentes.

FIG. 1A PRIOR ART

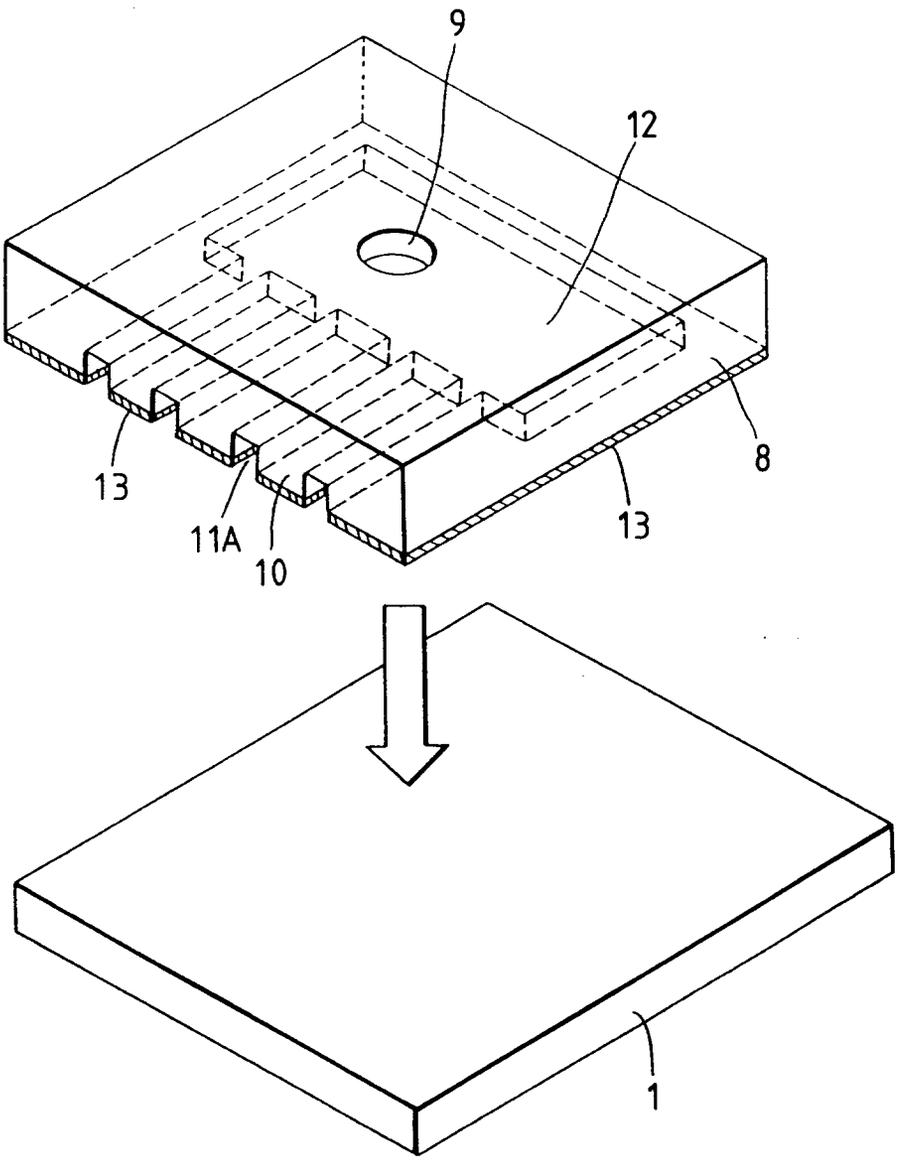


FIG. 1B PRIOR ART

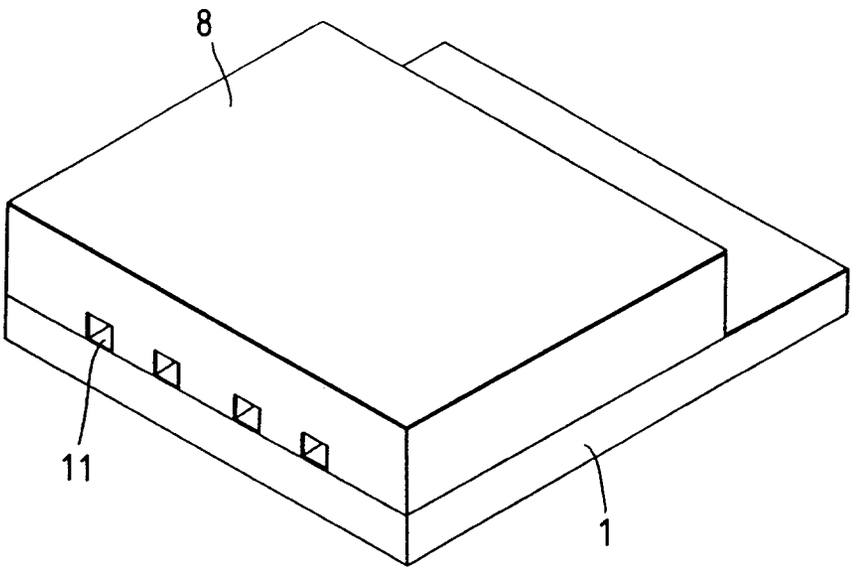


FIG. 2 PRIOR ART

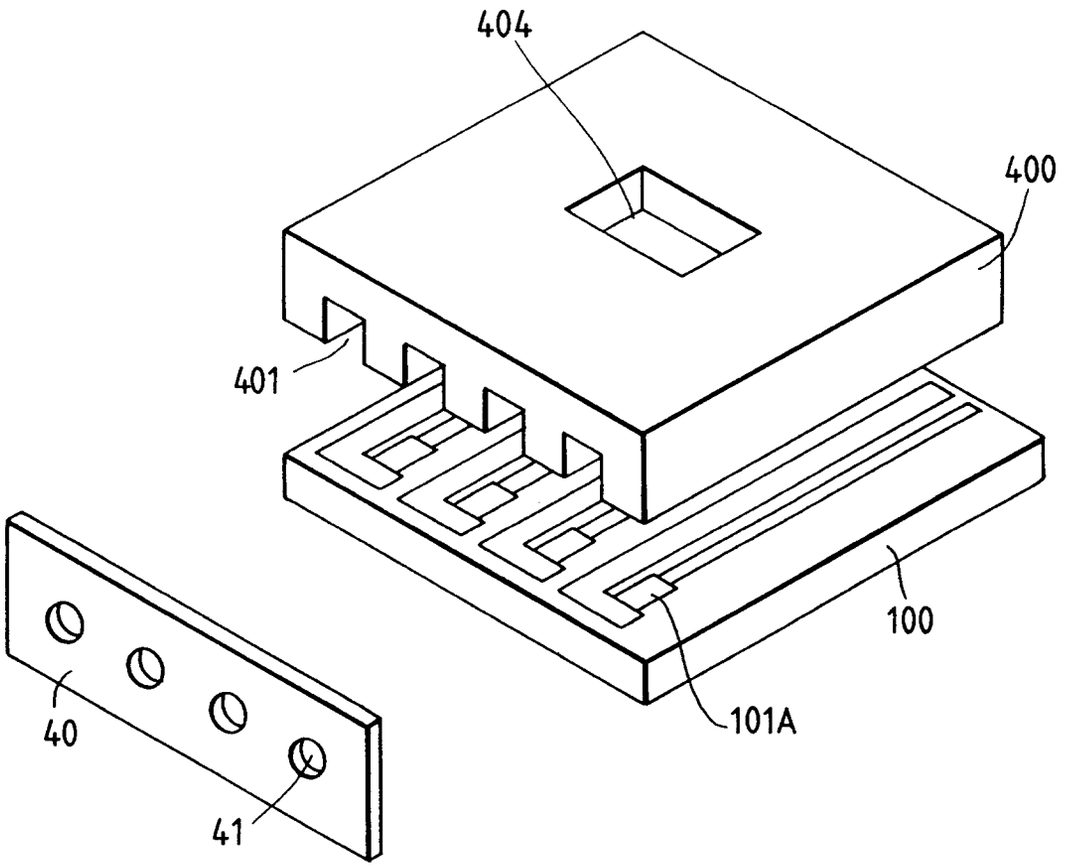


FIG. 3A
PRIOR ART

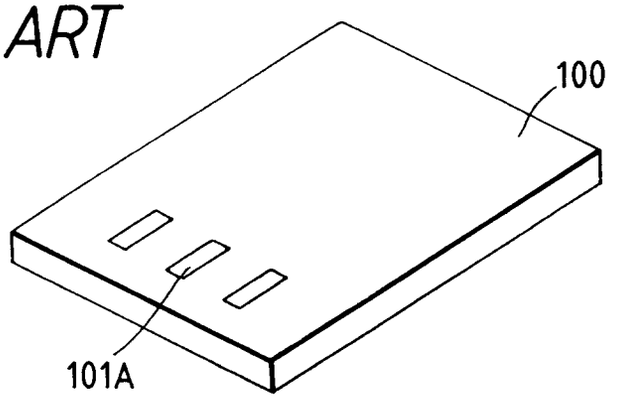


FIG. 3B
PRIOR ART

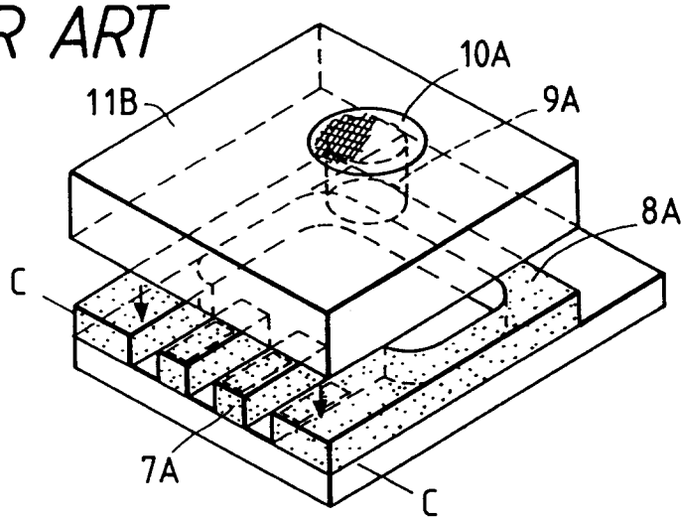


FIG. 3C
PRIOR ART

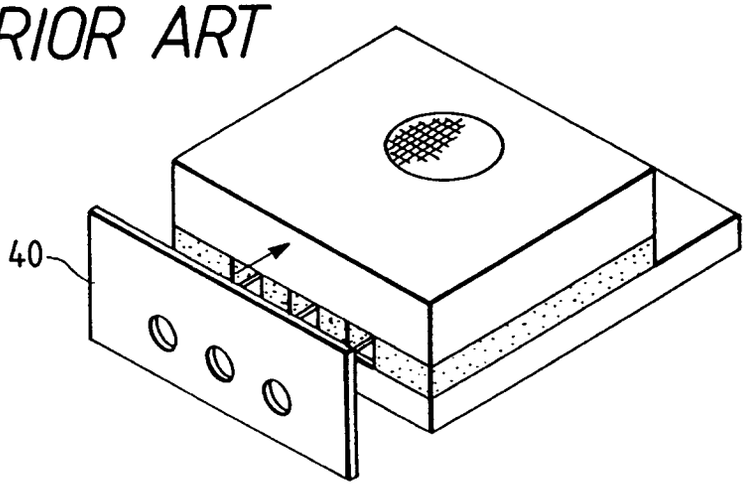


FIG. 4A PRIOR ART

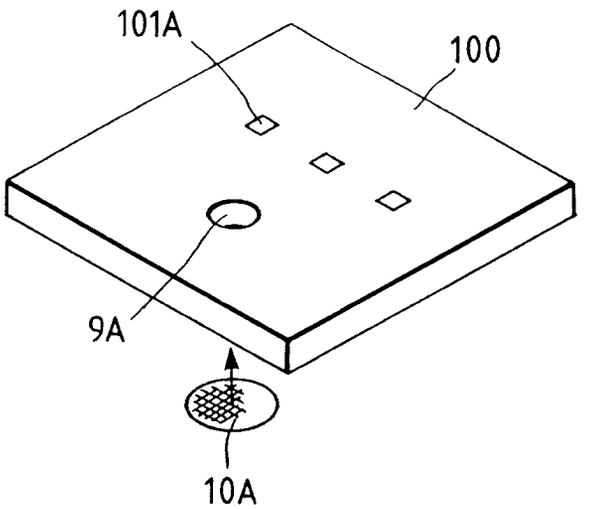


FIG. 4B PRIOR ART

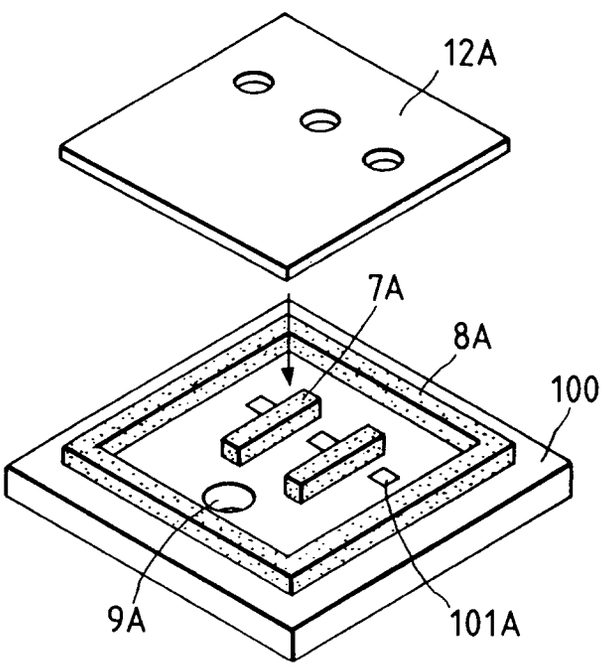


FIG. 5 PRIOR ART

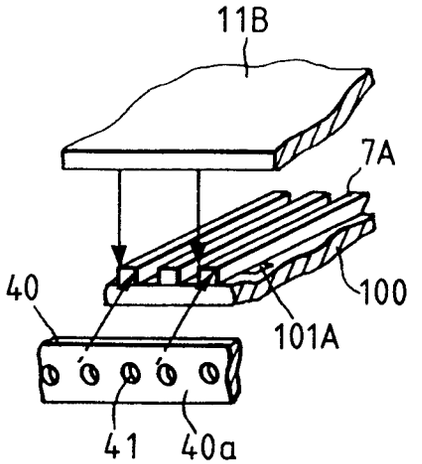


FIG. 6A

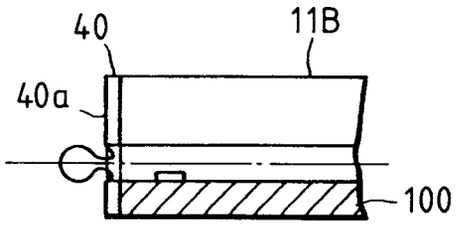


FIG. 6B

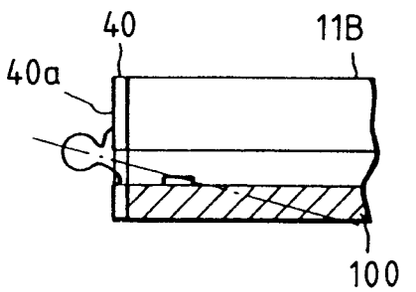


FIG. 7B

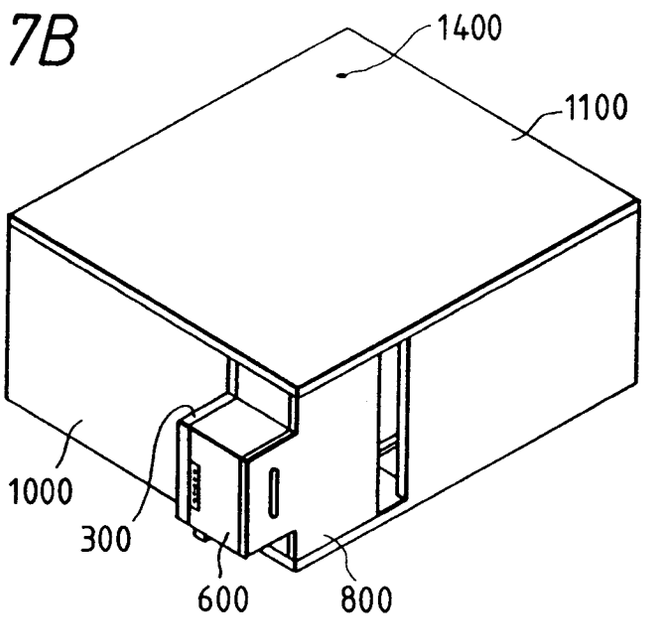


FIG. 7A

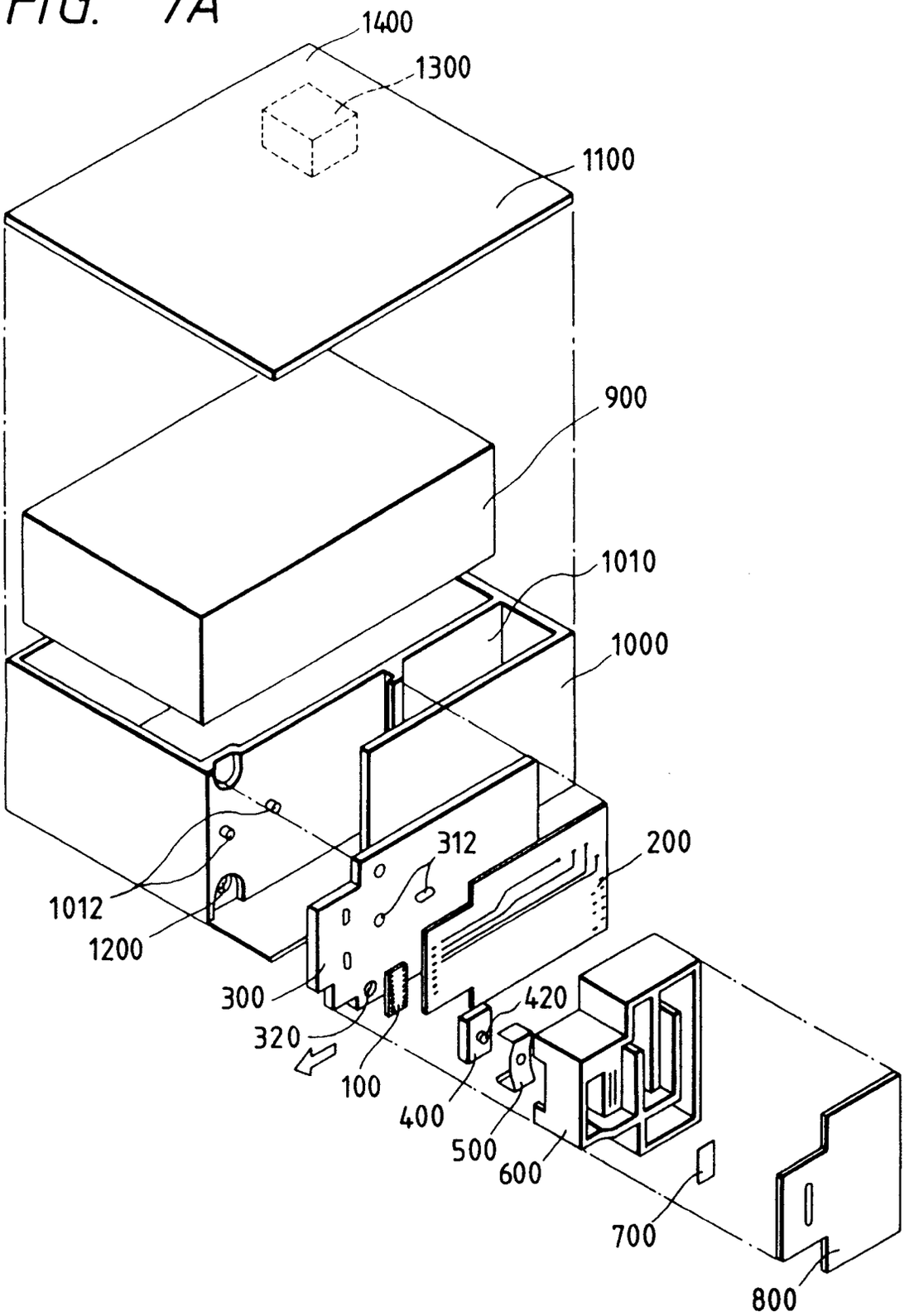

1400
1300
1100
900
1010
1000
312
200
1012
1200
300
420
320
100
400
500
600
700
800

FIG. 8A

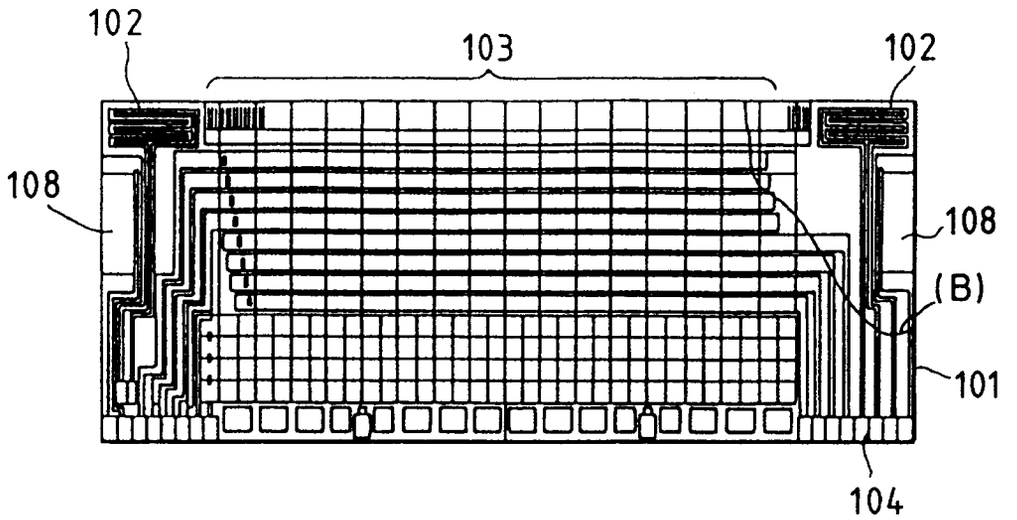


FIG. 8B

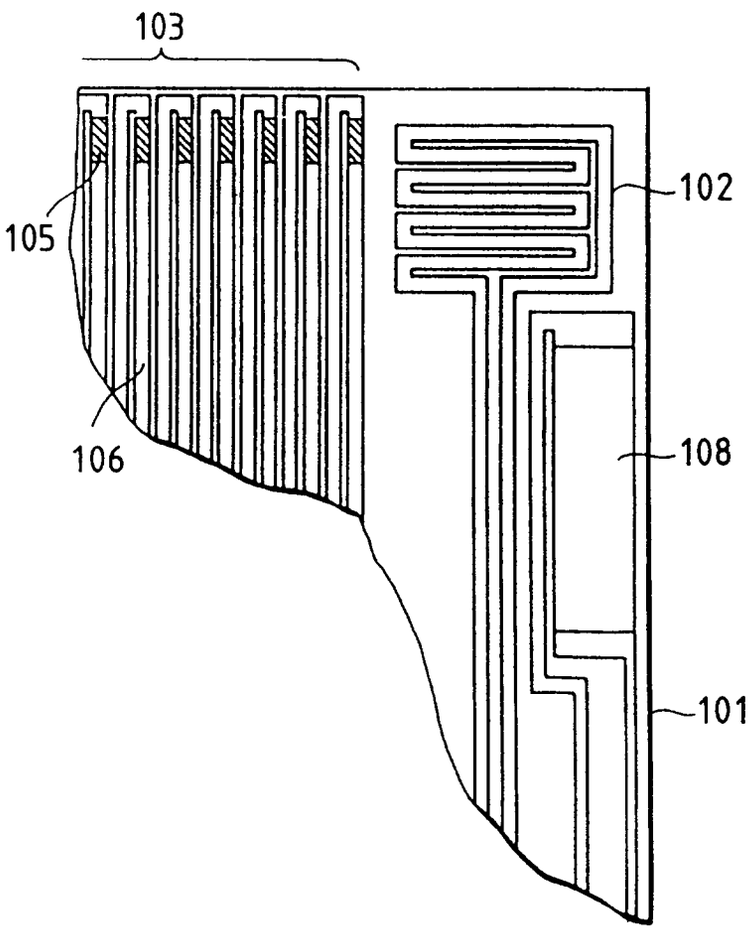


FIG. 9

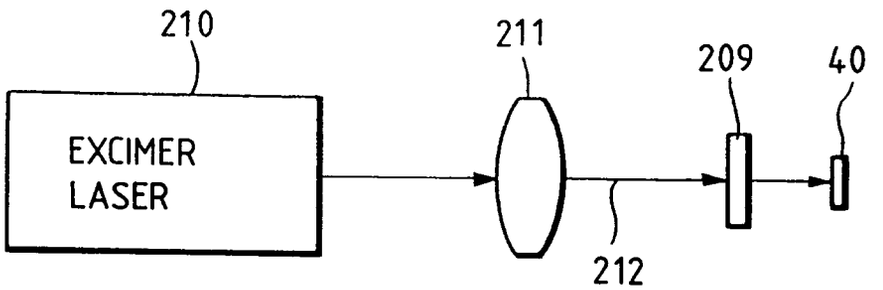


FIG. 10

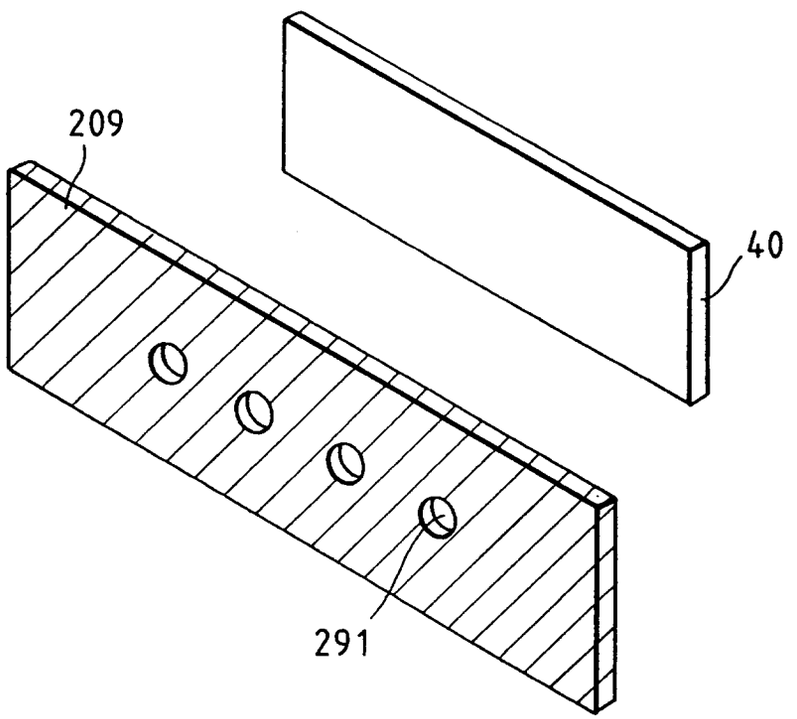


FIG. 15

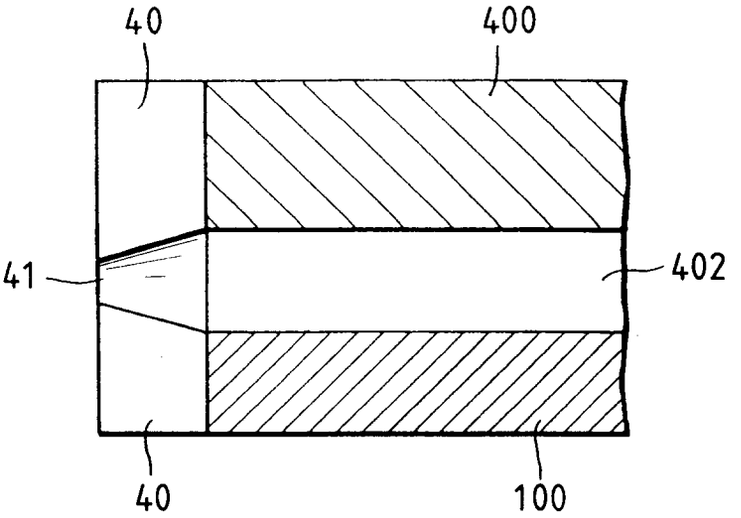


FIG. 16

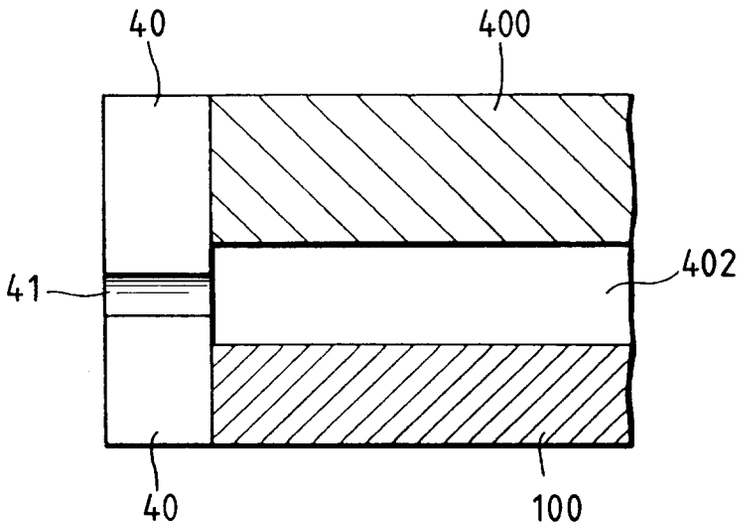


FIG. 17

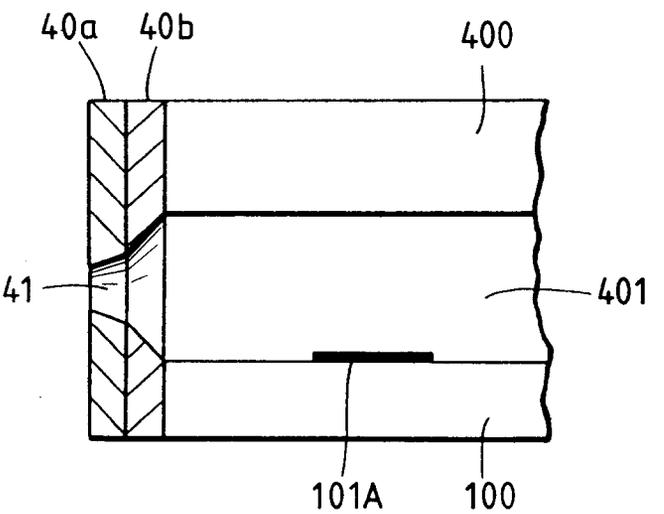


FIG. 23

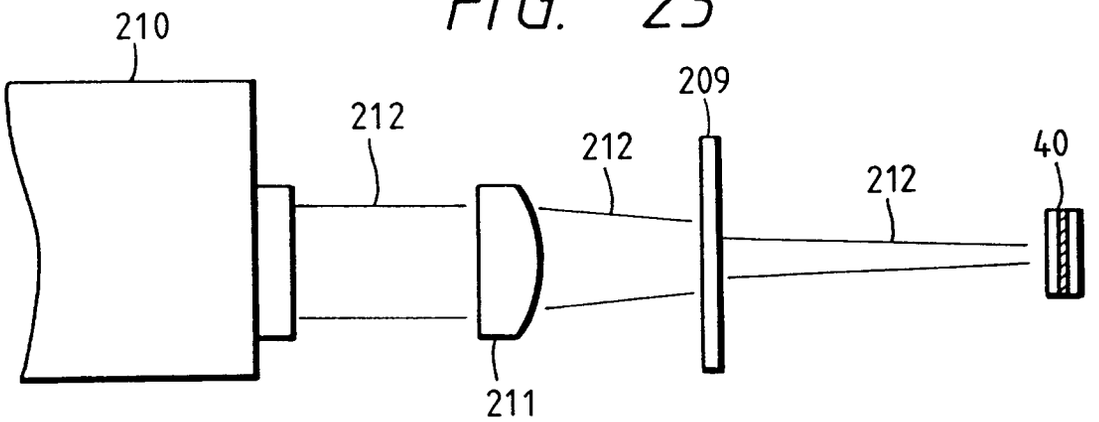


FIG. 24

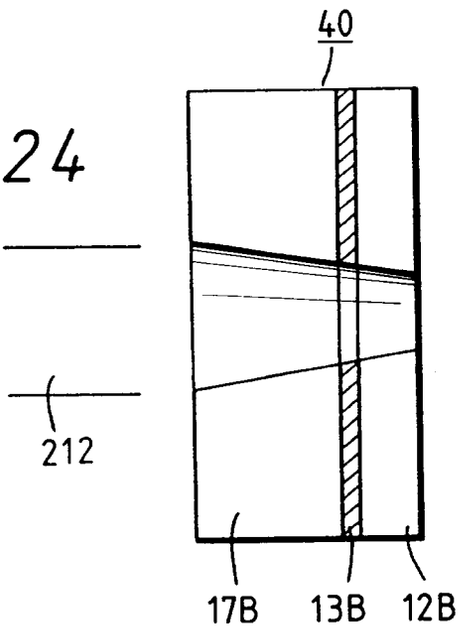


FIG. 25

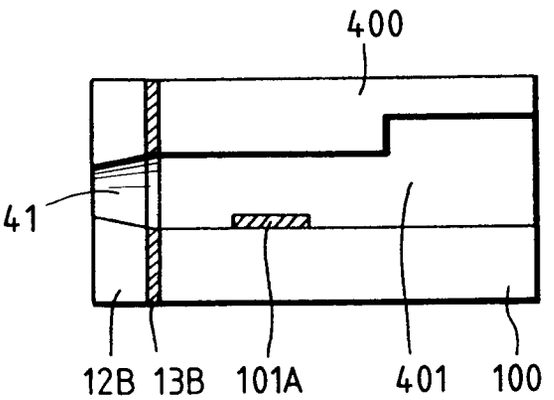


FIG. 26

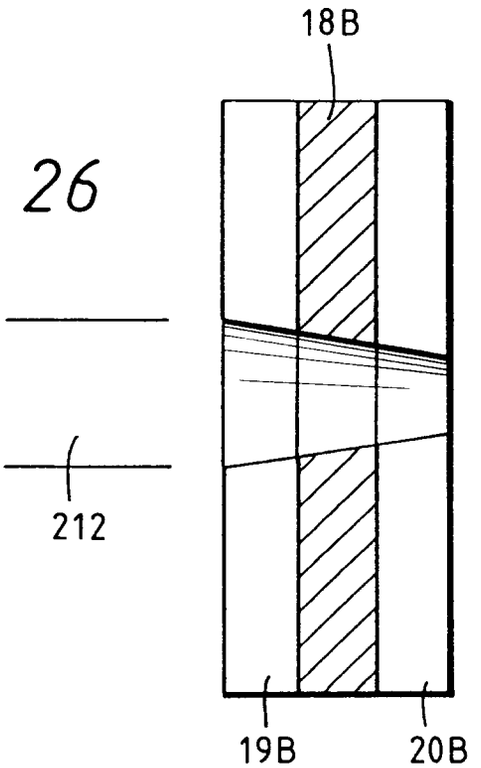


FIG. 27

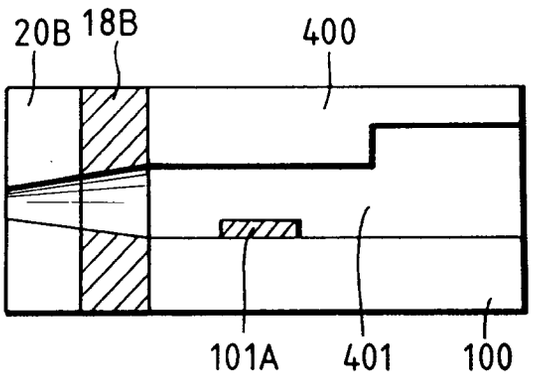


FIG. 28

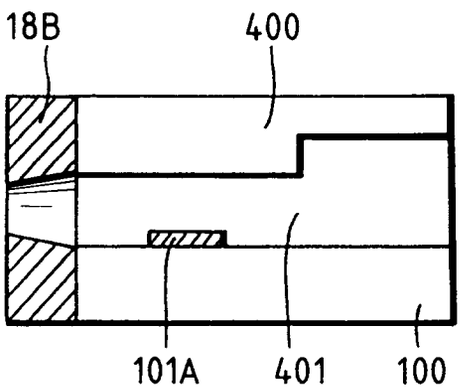


FIG. 39

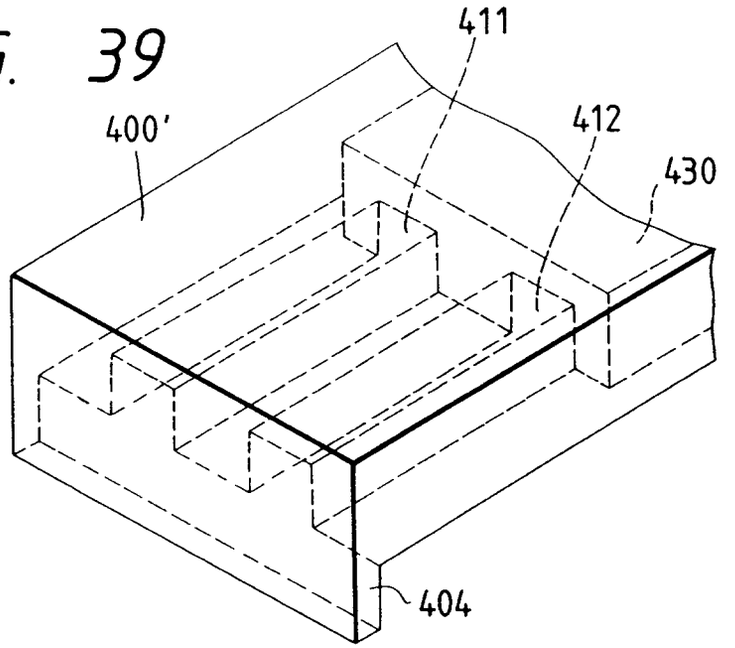


FIG. 41A

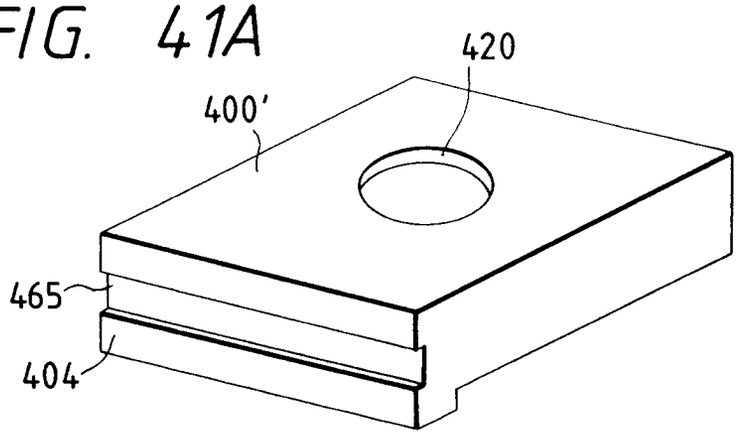
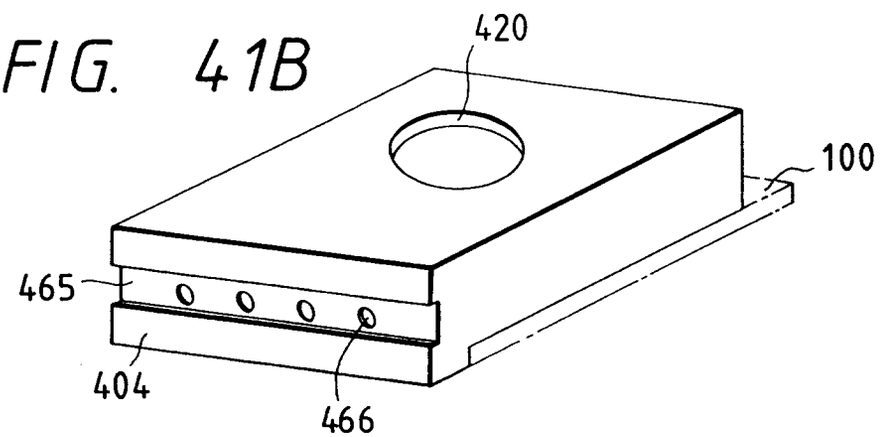


FIG. 41B



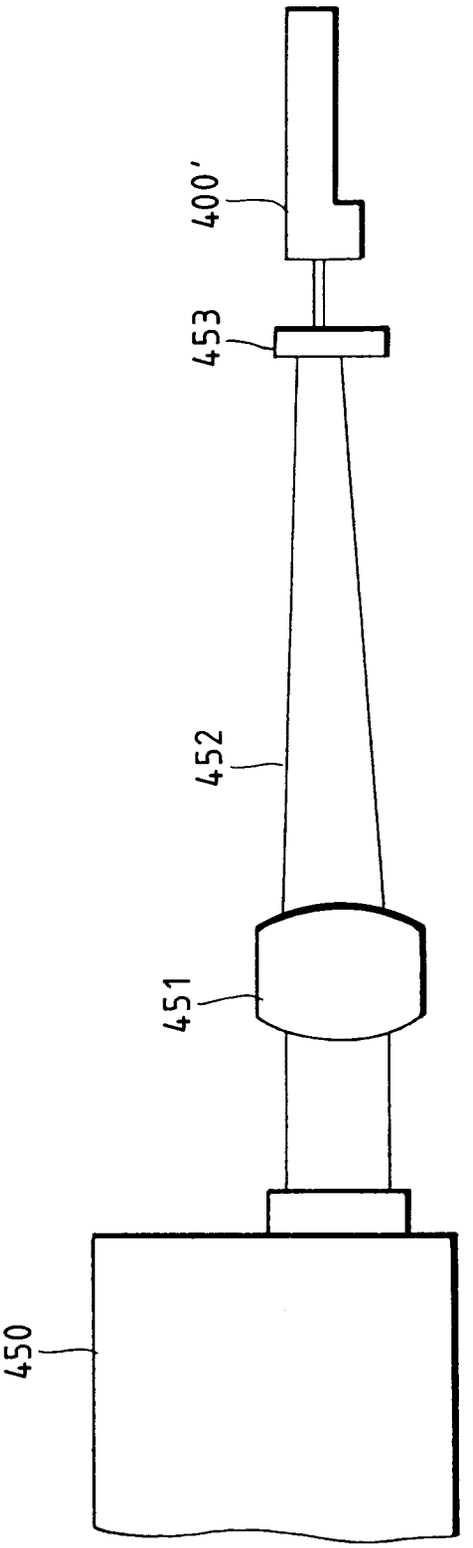


FIG. 40

FIG. 42

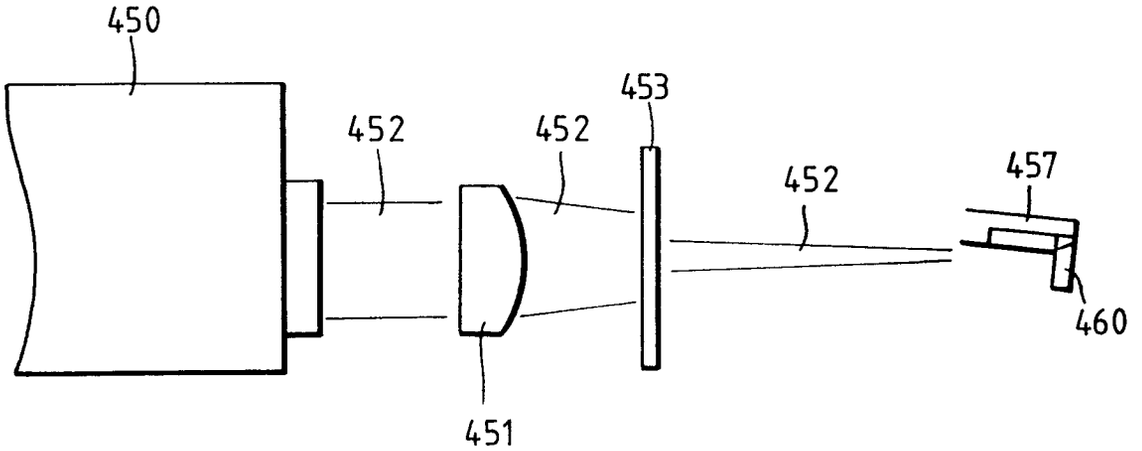


FIG. 43A

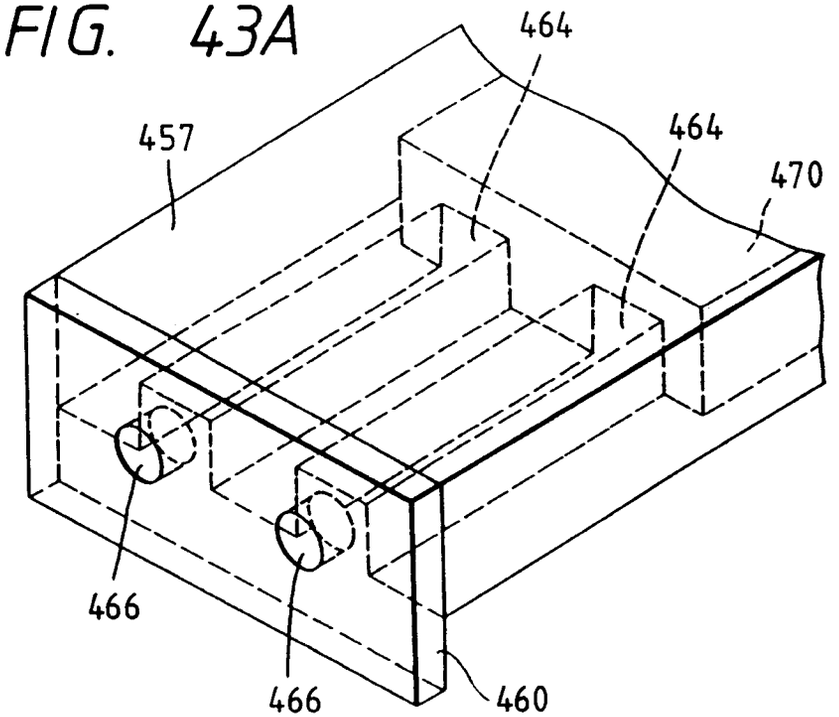


FIG. 43B

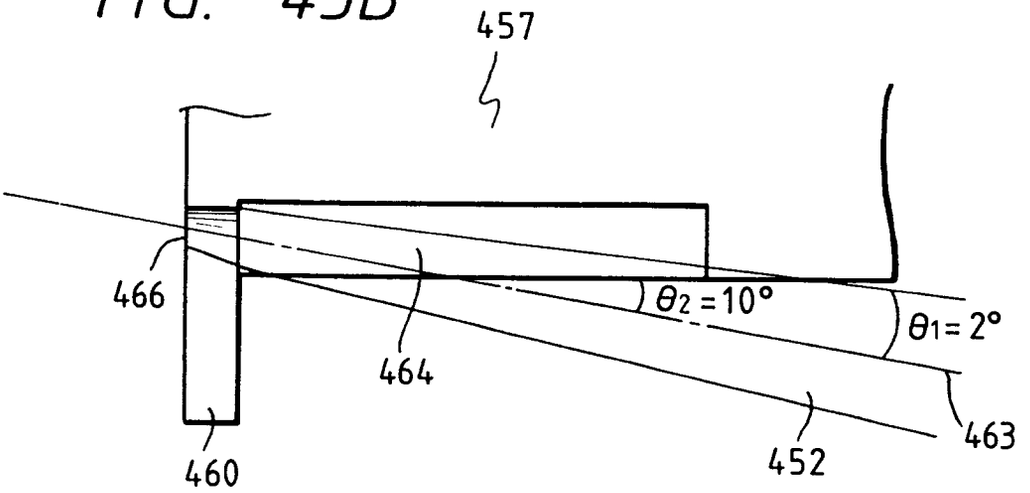


FIG. 44

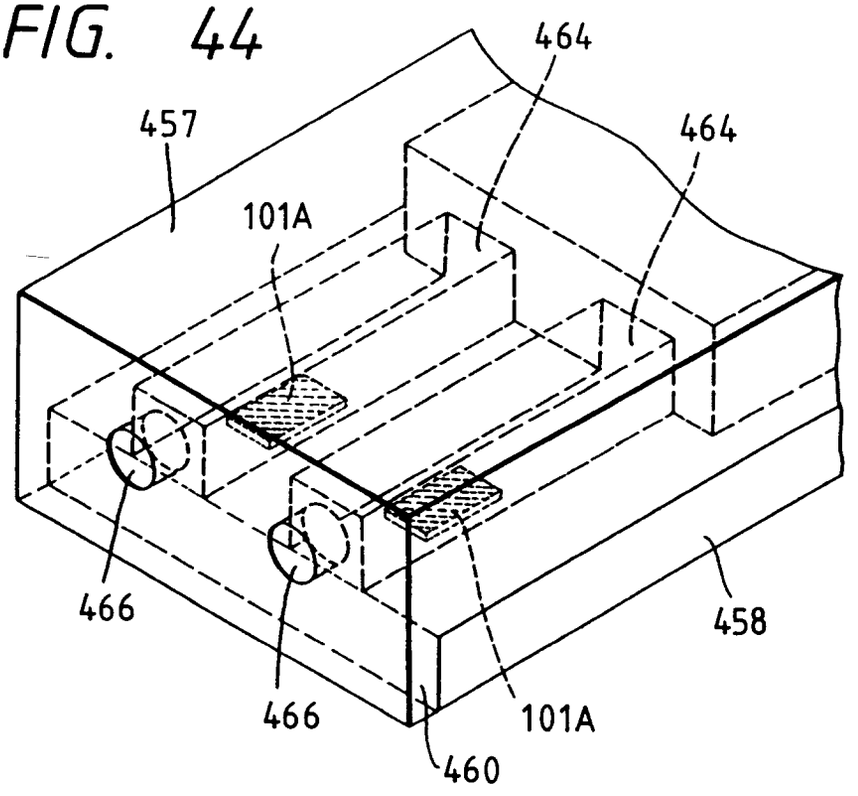


FIG. 45A

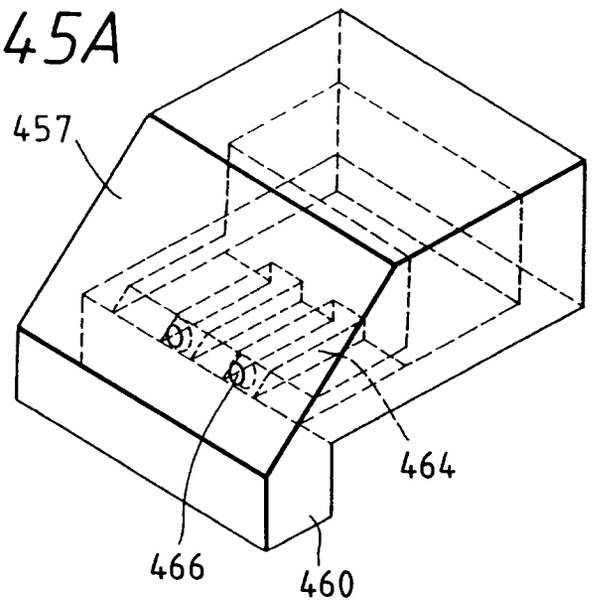


FIG. 45B

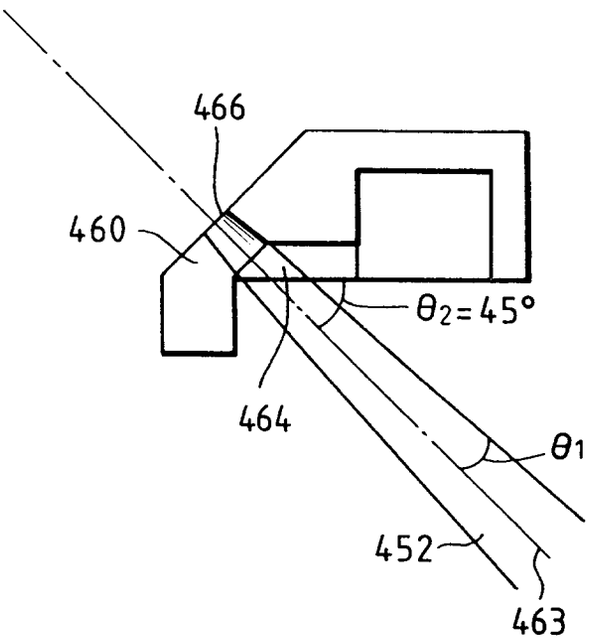


FIG. 46

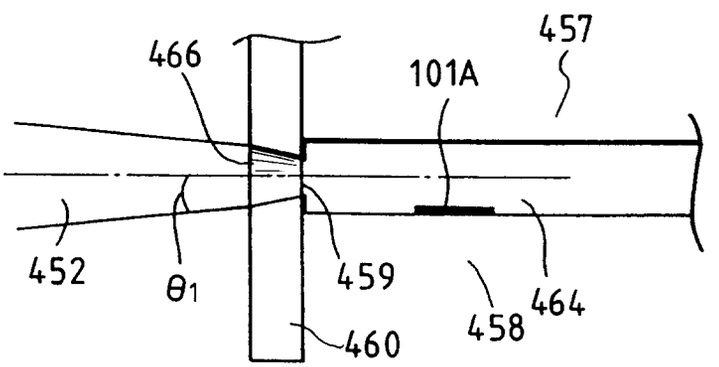


FIG. 47

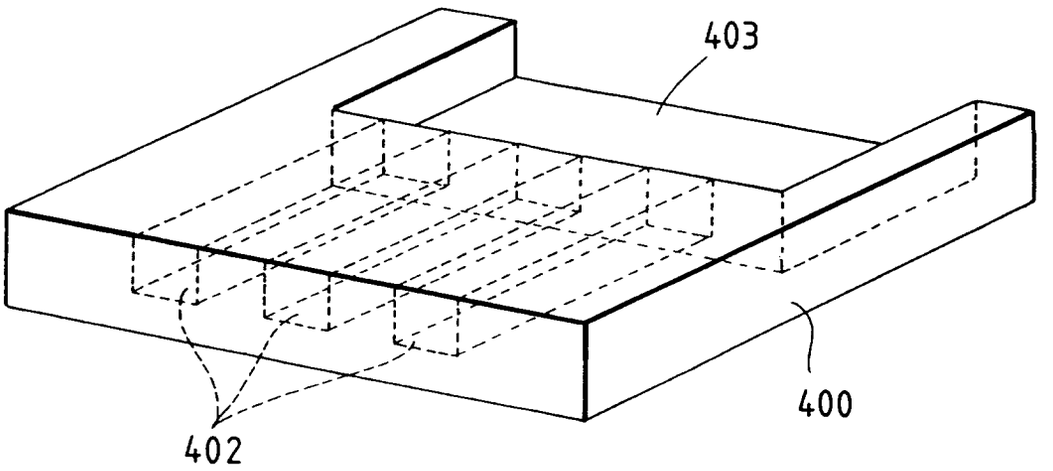


FIG. 48

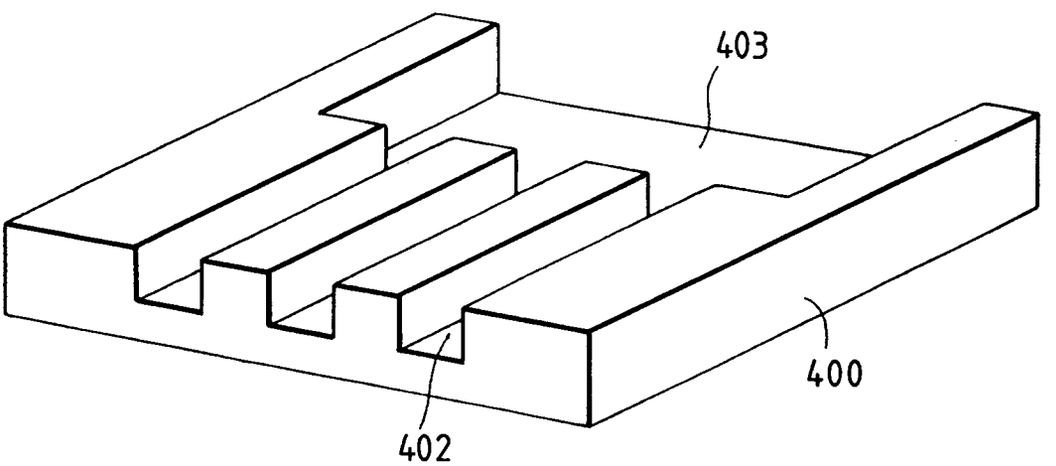


FIG. 49

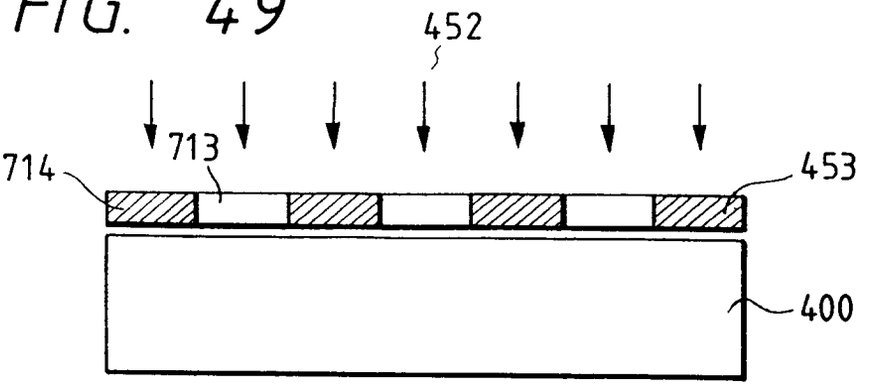


FIG. 50

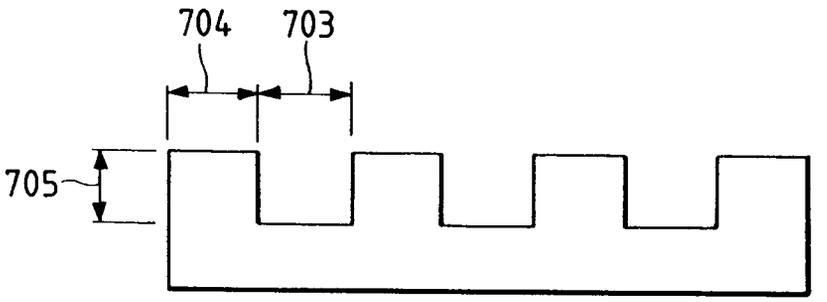


FIG. 51

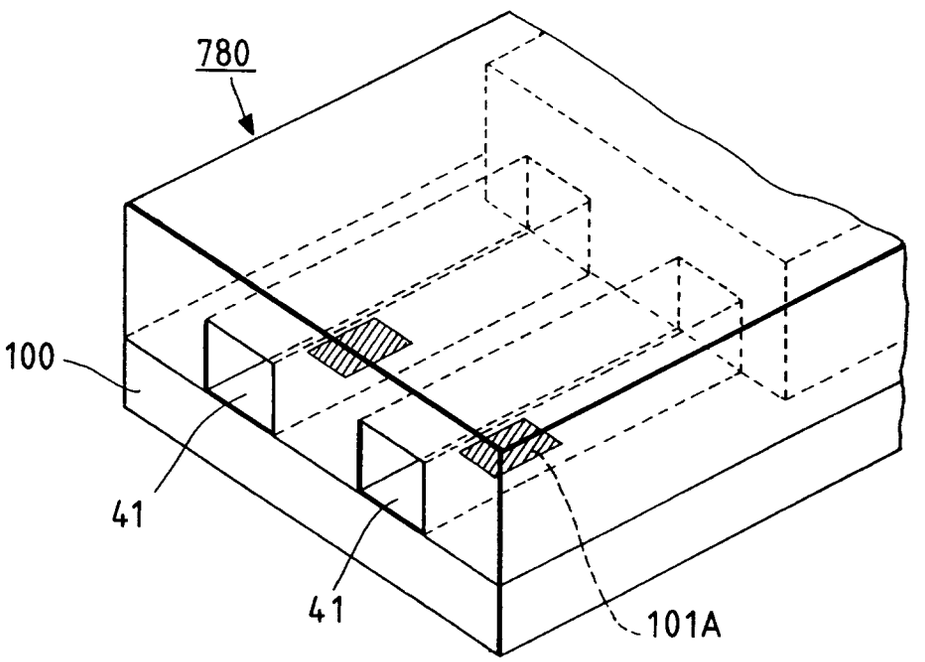


FIG. 52

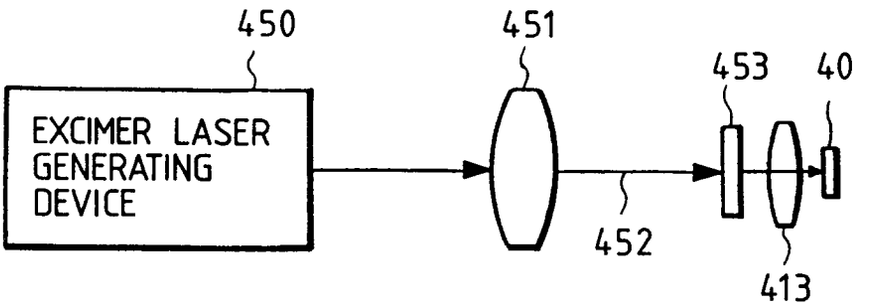

450
451
453
40
EXCIMER LASER
GENERATING
DEVICE
452
413

FIG. 53

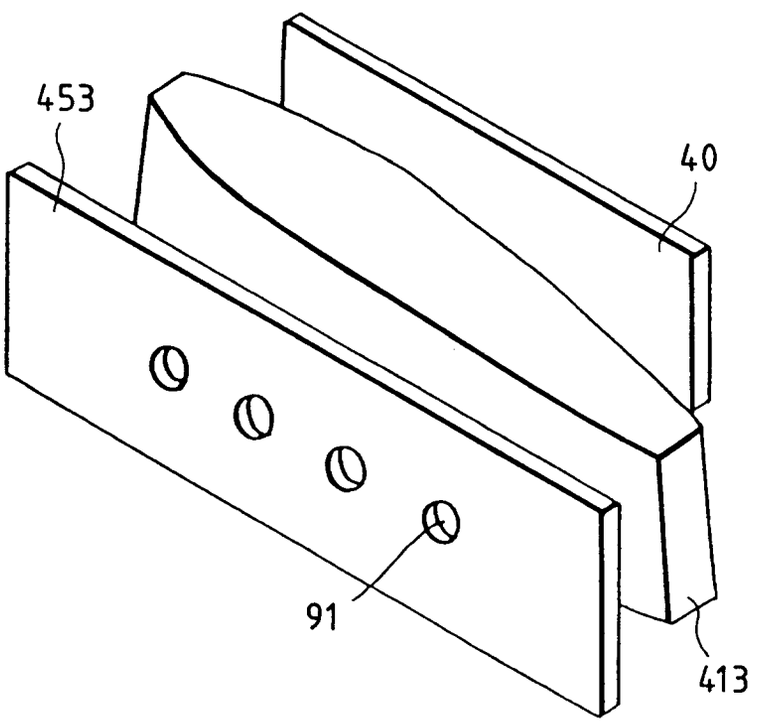

453
40
91
413

FIG. 56

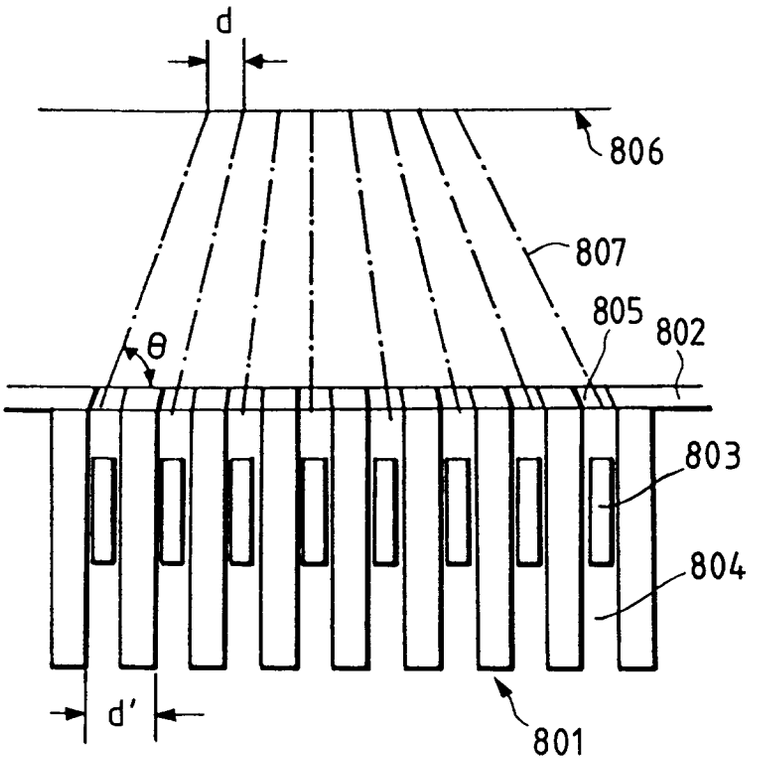


FIG. 57

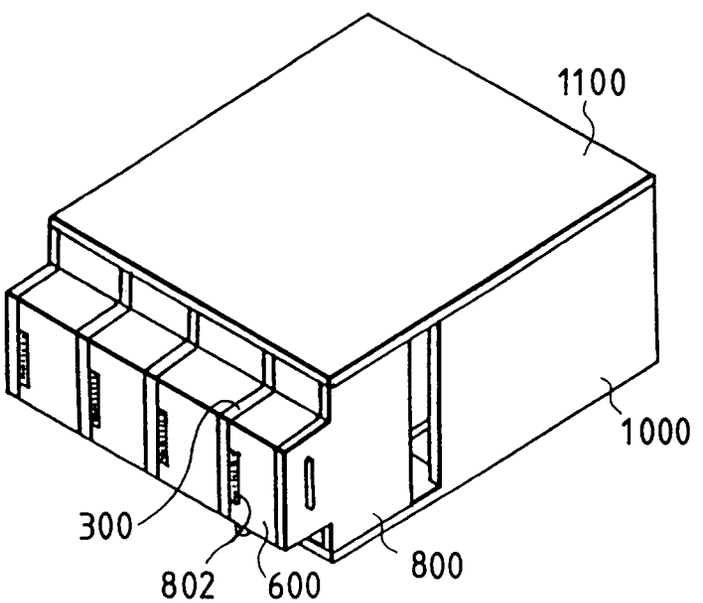


FIG. 58A

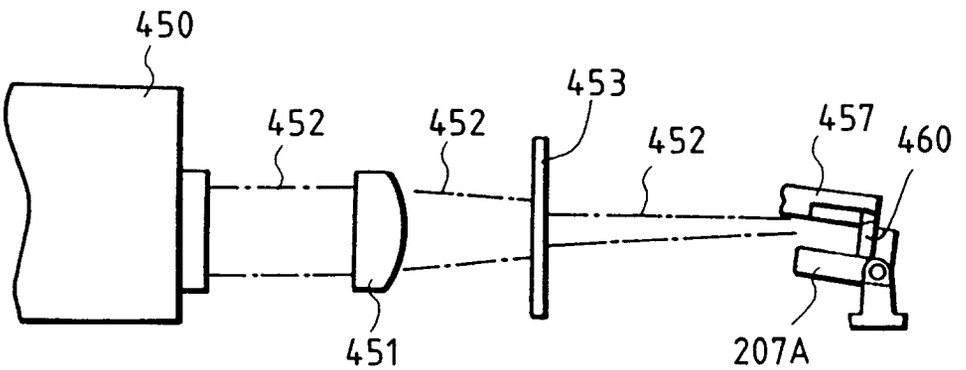


FIG. 59

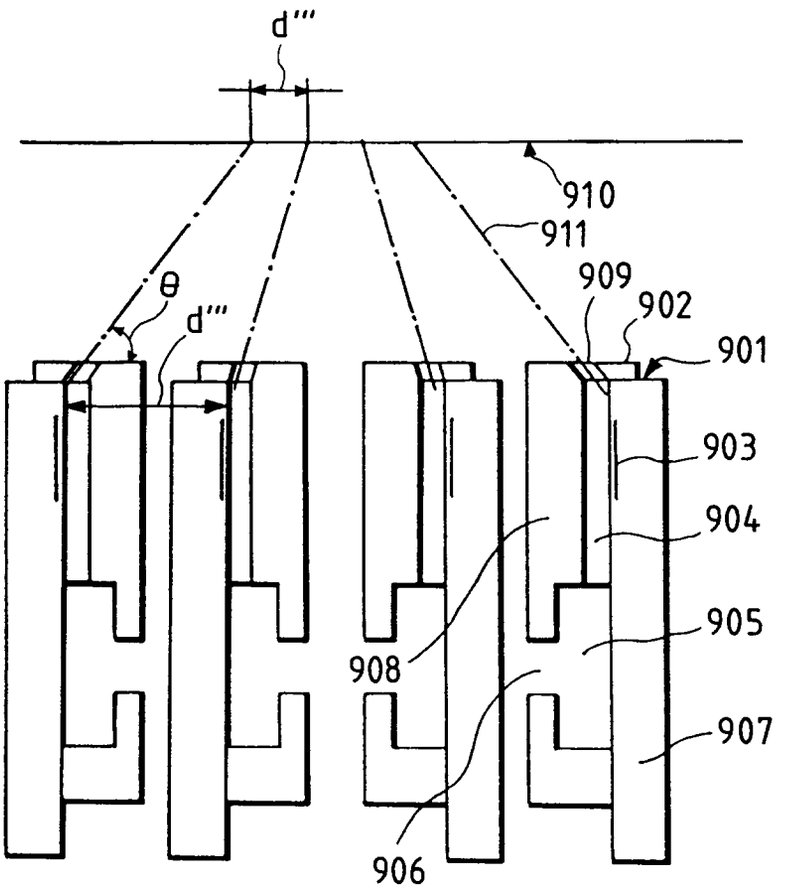


FIG. 60

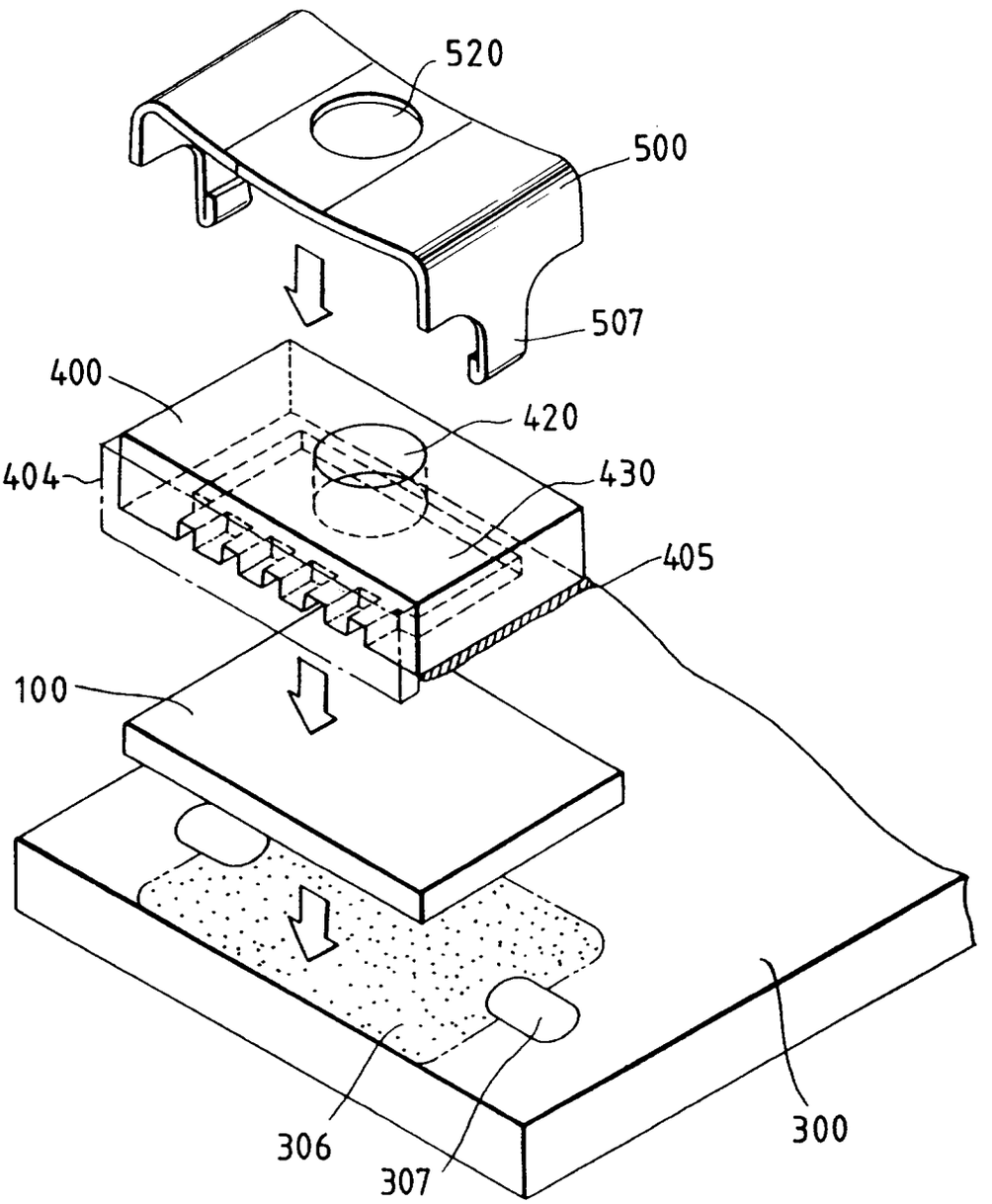


FIG. 61

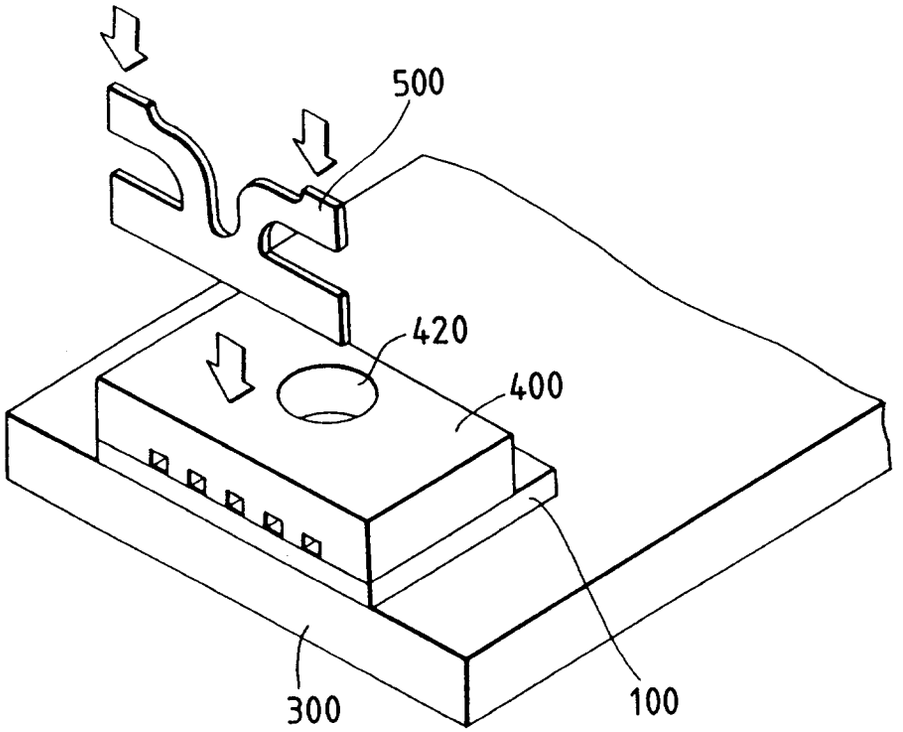


FIG. 62