(12) PATENT APPLICATION **(11)** Application No. **AU 199964381 A1**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Photovoltaic module and power generation system

(51)[7] International Patent Classification(s)
H01L 031/042 **H01L 031/05**

(21) Application No: **199964381** (22) Application Date: **1999.12.08**

(30) Priority Data

(31) Number	(32) Date	(33) Country
11-088376	**1999.03.30**	**JP**

(43) Publication Date : **2000.10.05**
(43) Publication Journal Date : **2000.10.05**

(71) Applicant(s)
Kaneka Corporation

(72) Inventor(s)
Seishiro Mizukami; Masataka Kondo; Yuzuru Kondoh; Hideo Yamagishi

(74) Agent/Attorney
DAVIES COLLISON CAVE,1 Little Collins Street,MELBOURNE VIC 3000

ABSTRACT OF THE DISCLOSURE

A photovoltaic module comprises a transparent substrate, a plurality of photovoltaic cells formed on the back surface of the substrate, busbars each including a busbar body connected electrically to the photovoltaic cells, an electrical insulating filler covering the photovoltaic cells and the busbar bodies, a spacer, and a cover film covering the filler. Each busbar integrally includes the busbar body and an extension long enough to project from one end of the transparent substrate. The busbar extensions, which serve as output fetching lines, are bent along the spacer, and their respective output end portions are drawn out through the cover film. The output end portions are connected individually to terminals of a terminal box.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A photovoltaic module with a plurality of photovoltaic cells, comprising:

a busbar including a busbar body connected electrically to the photovoltaic cells and an extension extending integrally from the busbar body and serving as an output fetching line.

2. A photovoltaic module according to claim 1, which comprises a transparent substrate, the photovoltaic cells arranged on the back surface of the transparent substrate, an electrical insulating filler covering the respective back surfaces of the photovoltaic cells, a cover film covering the filler, and the busbar including the busbar body connected electrically to the photovoltaic cells and embedded in the filler and the extension long enough to project from one end of the transparent substrate, the extension being drawn out through the cover film.

3. A photovoltaic module according to claim 2, which further comprises a spacer interposed between the photovoltaic cells and the extension, and wherein said busbar extension includes laminated portions bent along the spacer and an output end portion drawn out through the cover film.

4. A photovoltaic module with a plurality of photovoltaic cells, comprising:

a busbar including a busbar body connected

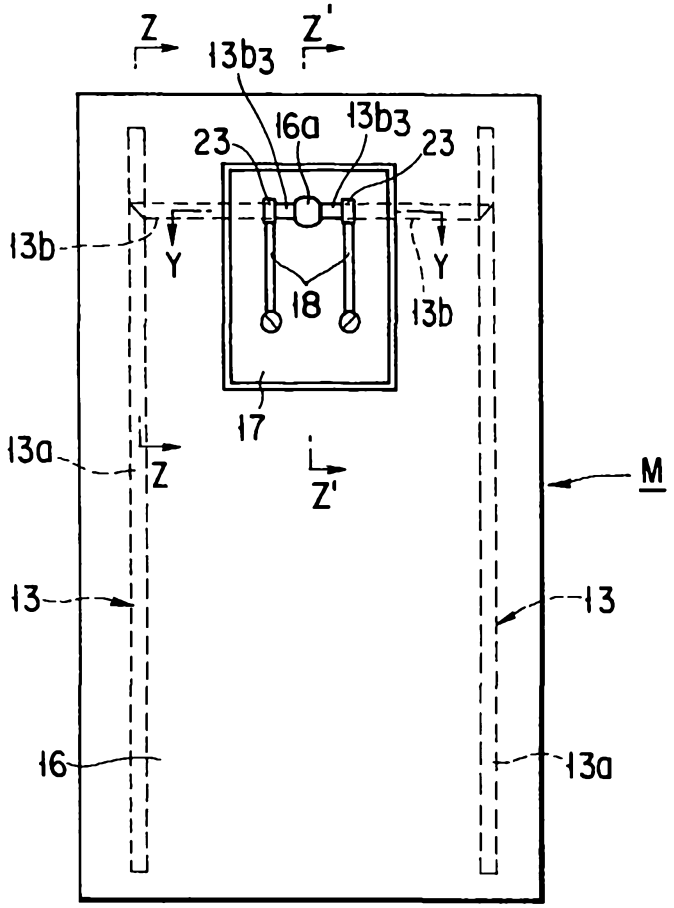

Z
Z'
13b3
23
16a
13b3
23
13b
Y
Y
13b
18
17
13a
Z
Z'
M
13
13
16
13a

FIG. 1

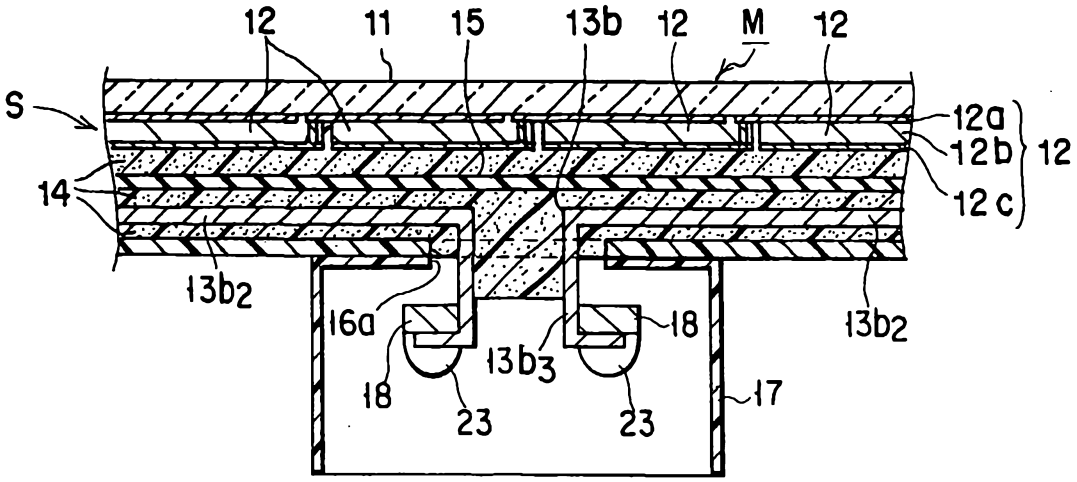

12
11
15
13b
12
M
12
S
12a
12b
12
12c
14
13b2
16a
18
13b3
18
23
23
17
13b2

FIG. 3

AUSTRALIA

PATENTS ACT 1990

COMPLETE SPECIFICATION

NAME OF APPLICANT(S):

Kaneka Corporation

ADDRESS FOR SERVICE:

DAVIES COLLISON CAVE
Patent Attorneys
1 Little Collins Street, Melbourne, 3000.

INVENTION TITLE:

Photovoltaic module and power generation system

The following statement is a full description of this invention, including the best method of performing it known to me/us:-

BACKGROUND OF THE INVENTION

The present invention relates to photovoltaic modules set on, for example, a roof of a building, and more particularly, to photovoltaic modules with an improved output fetching wiring unit and a power generation system using the same.

The output of a crystalline or amorphous photovoltaic module is conducted to the outside through terminals that are set on the back surface of the module. In general, there are two types of terminals, ones for positive and negative electrodes. In some cases, these terminals are housed in a terminal box as it is called. A terminal box of one known type can contain therein both the terminals for positive and negative electrodes, while another type is designed to contain each of these terminals. A conduction path which is connected to each terminals for the module output is described in Jpn. Pat. Appln. KOKAI Publication No. 10-256578. This conduction path is an output fetching wiring unit that includes a pair of busbars, positive and negative, attached individually to the opposite ends of the photovoltaic module.

In the conventional wiring unit described in the KOKAI Publication ('578), metallic foils on the back surface of the photovoltaic module and the busbars are

connected electrically to one another by means of an electrically conductive material such as electrically conductive paste. Lead wires that serve as output fetching lines are soldered to the metallic foils, individually. These lead wires are drawn out of the module through a protective film (cover film) on the back surface of the photovoltaic module. The lead wires are connected individually to terminals of a terminal box or the like that is provided on the back surface of the photovoltaic module, if necessary.

In an output fetching wiring unit described in Jpn. Pat. Appln. KOKAI Publication No. 9-326497, as shown in FIGS. 24A to 24C, one end portion of each lead wire as an output fetching line is soldered to each of positive and negative busbars 200 and 201 that are attached individually to the opposite ends of a photovoltaic module. The respective other end portions of the lead wires 202 are drawn out through a protective film (cover film) 203 on the back surface of the photovoltaic module and soldered individually to terminals of the terminal box.

Conventionally, if the wiring direction of the output fetching wiring unit is expected to be changed, first and second electrically conductive members that are independent of each other are arranged in a manner such that their respective end portions continuously extend at a given angle to each other, and their

overlaps are soldered.

In the conventional output fetching wiring unit constructed in this manner, there is a lot of soldering spots that connect the busbars of the photovoltaic module and the terminal box, and there are also soldering spots in a region where the wiring direction changes. Soldering, which is poor in working efficiency, may cause electrical connection failure. In consequence, the connection is not very reliable, the yield is poor, and the manufacturing cost is high.

BRIEF SUMMARY OF THE INVENTION

Accordingly, the object of the present invention is to provide photovoltaic modules and a power generation system, improved in quality and yield and lowered in manufacturing cost.

In order to achieve the above object, according to the present invention, there is provided a photovoltaic module with a plurality of photovoltaic cells, which comprises a busbar body connected electrically to the photovoltaic cells and an extension extending integrally from the busbar body and serving as an output fetching line. According to the invention, the busbar that is connected to the photovoltaic cells doubles as an output fetching line, so that any other output fetching lines to be prepared independently of the busbar need not be soldered to the busbar. Thus, the number of soldering spots in an output

fetching wiring unit can be reduced.

More specifically, the photovoltaic module according to the invention comprises a transparent substrate, the photovoltaic cells arranged on the back surface of the transparent substrate, an electrical insulating filler covering the respective back surfaces of the photovoltaic cells, a cover film covering the filler, and the busbar including the busbar body connected electrically to the photovoltaic cells and embedded in the filler and the extension long enough to project from one end of the transparent substrate, the extension being drawn out through the cover film. The filler functions as an adhesive for bonding the back surfaces of the photovoltaic cells and the cover film.

According to the invention, the busbar itself doubles as an output fetching line, so that it is unnecessary to prepare any other output fetching lines independent of the busbar or to solder the output fetching lines. Thus, the necessary number of soldering spots for the output fetching wiring unit can be reduced. Since the extension of the busbar, which serves as the output fetching line, is turned up on the back surface of the photovoltaic module, it can be confined within the outer peripheral contour of the transparent substrate. Besides, these busbar extensions can be easily connected to terminals that are arranged on the back surface of the module.

A spacer of an electrical insulating material may be used according to the invention. The spacer is put on an end portion of the busbar body. The busbar extension is bent along the spacer and drawn out of the cover film through a through hole in the cover film. An electrical insulating sheet, such as a nonwoven fabric of fiberglass or an insulating resin (e.g. polyvinyl fluoride), may be used for the spacer. In order to improve the electrical insulating properties further, an electrical insulating synthetic resin, such as polyvinyl fluoride, may be used for the cover film. Since longitudinally intermediate portions of the busbar extension are buried in the filler according to the invention, a long sealing distance can be secured for the output fetching line (busbar extension), so that the water resistance is improved. In the case of the electrical insulating spacer is interposed between the busbar extension and the photovoltaic cells, moreover, an electrical short circuit between the output fetching line and the cells can be prevented securely.

According to the invention, the busbar extension may be formed having a bent portion turned down to change the course in the middle in its longitudinal direction so that the wiring direction of the output fetching line can be changed at the bent portion. With this arrangement, it is unnecessary to prepare any

electrically conductive member in the region where the direction of the output fetching line changes or to solder the conductive member.

A power generation system according to the invention comprises the photovoltaic module as a generating element in a roofing material or the like. The generating element may be incorporated in a tile body that constitutes a roofing tile.

According to the photovoltaic module and the power generation system of the invention, the number of soldering spots in the output fetching wiring unit is reduced, so that the incidence of failure attributable to soldering is lowered. Thus, the quality and yield of the photovoltaic module, as well as the workability of the wiring unit, are improved, so that the manufacturing cost can be lowered.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the

invention, and together with the general description given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the invention.

FIG. 1 is a rear plan view of a photovoltaic module according to a first embodiment of the present invention;

FIG. 2A is a sectional view of a part of the photovoltaic module taken along line Z-Z of FIG. 1;

FIG. 2B is a sectional view of a part of the photovoltaic module taken along line Z'-Z' of FIG. 1;

FIG. 3 is a sectional view of a part of the photovoltaic module taken along line Y-Y of FIG. 1;

FIG. 4 is a perspective view of a combination of photovoltaic cells, busbars, etc., showing a first process for obtaining an output fetching wiring unit according to the first embodiment;

FIG. 5 is a perspective view of a combination of a filler sheet, busbars, etc., showing a second process for obtaining the wiring unit according to the first embodiment;

FIG. 6 is a perspective view of a combination of a spacer, busbar extensions, etc., showing a third process for obtaining the wiring unit according to the first embodiment;

FIG. 7A is a perspective view of the combination of the spacer, busbar extensions, etc., showing a

fourth process for obtaining the wiring unit according to the first embodiment;

FIG. 7B is a plan view of a part of the combination of the spacer, busbar extensions, etc. shown in FIG. 7A;

FIG. 8A is a perspective view of the combination of the spacer, busbar extensions, etc., showing a fifth process for obtaining the wiring unit according to the first embodiment;

FIG. 8B is a perspective view showing a modification of the filler sheet shown in FIG. 8A;

FIG. 9 is a perspective view of a combination of a cover film, busbar extensions, etc., showing a sixth process for obtaining the wiring unit according to the first embodiment;

FIG. 10 is a perspective view of the combination of the cover film, busbar extensions, etc., showing a seventh process for obtaining the wiring unit according to the first embodiment;

FIG. 11 is a plan view of a combination of photovoltaic cells and busbars, showing a first process for obtaining an output fetching wiring unit of a photovoltaic module according to a second embodiment of the invention;

FIG. 12 is a plan view of a combination of a filler sheet and busbar extensions, showing a second process for obtaining the wiring unit according to the

second embodiment;

FIG. 13 is a plan view of a combination of spacers, busbar extensions, etc., showing a third process for obtaining the wiring unit according to the second embodiment;

FIG. 14A is a plan view of the combination of the spacers, busbar extensions, etc., showing a fourth process for obtaining the wiring unit according to the second embodiment;

FIG. 14B is an enlarged plan view of the combination of the spacers, busbar extensions, etc. shown in FIG. 14A;

FIG. 15 is a plan view of the combination of the spacers, busbar extensions, etc., showing a fifth process for obtaining the wiring unit according to the second embodiment;

FIG. 16 is a plan view of a combination of a cover film, busbar extensions, etc., showing a sixth process for obtaining the wiring unit according to the second embodiment;

FIG. 17 is a plan view of the combination of the cover film, busbar extensions, etc., showing a seventh process for obtaining the wiring unit according to the second embodiment;

FIG. 18A is a plan view of a combination of a spacer, busbar extensions, etc., showing a fourth process for obtaining an output fetching wiring unit of

a photovoltaic module according to a third embodiment of the invention;

FIG. 18B is a sectional view of the photovoltaic module taken along line X-X of FIG. 18A;

FIG. 19A is a plan view of a combination of spacers, busbar extensions, etc., showing a fourth process for obtaining an output fetching wiring unit of a photovoltaic module according to a fourth embodiment of the invention;

FIG. 19B is a sectional view of the photovoltaic module taken along line W-W of FIG. 19A;

FIG. 20A is a plan view of a combination of a spacer, busbar extensions, etc., showing a fourth process for obtaining an output fetching wiring unit of a photovoltaic module according to a fifth embodiment of the invention;

FIG. 20B is a sectional view of the photovoltaic module taken along line V-V of FIG. 20A;

FIG. 21 is a plan view of an output fetching wiring unit of a photovoltaic module according to a sixth embodiment of the invention;

FIG. 22 is a perspective view schematically showing an external appearance of a building furnished with a power generation system;

FIG. 23 is a perspective view of a roofing material for the building shown in FIG. 22; and

FIGS. 24A, 24B and 24C are perspective views

individually showing processes for obtaining an output fetching wiring unit of a conventional photovoltaic module.

DETAILED DESCRIPTION OF THE INVENTION

A first embodiment of the present invention will now be described with reference to the accompanying drawings of FIGS. 1 to 10, 22 and 23.

FIG. 22 shows a building 1, e.g., a house, which is furnished with a power generation system. A roof 2 of the building 1 carries thereon the power generation system, which comprises a large number of photovoltaic roofing tiles 3 that serve as generating elements. As shown in FIG. 23, each roofing tile 3 includes a photovoltaic module M that is incorporated in a tile body 4. The module M need not always be incorporated in the tile body 4. For example, the module M may be fitted with a frame or some other attachment so that it can be used directly as a roofing material. Alternatively, the module M may be set on a roof with the aid of a rack.

FIG. 1 is a rear view of the photovoltaic module M. As shown in FIGS. 2A, 2B and 3, the photovoltaic module M is provided with an optically transparent substrate 11, a plurality of photovoltaic cells 12 arranged on the back surface of the substrate 11, a pair of busbars 13 for positive and negative electrodes, an electrical insulating filler 14, electrical insulating spacer 15,

cover film 16, and terminal box 17, etc.

The transparent substrate 11 is formed of, e.g., a glass plate as an electrical insulating material. A plurality of photovoltaic cells 12 are arranged all over the back surface of the substrate 11 except the region around the substrate 11. These cells 12 may be either crystalline or amorphous cells. According to the present embodiment, the photovoltaic cells 12 are amorphous cells. As shown in FIGS. 2A and 2B, each photovoltaic cell 12 is composed of an optically transparent electrode layer 12a formed on the back surface of the substrate 11, a semiconductor layer 12b formed of amorphous silicon or the like, a back electrode layer 12c, etc. The filler 14 functions as an adhesive for bonding the electrode layer 12c of the photovoltaic cells 12 and the cover film 16. As shown in FIG. 3, the cells 12, which constitute a unit cell S, are formed so as to be arranged in a row by patterning using a laser or the like. The respective semiconductor layers 12b of the photovoltaic cells 12 integrated in this manner are connected electrically in series with one another through their corresponding transparent electrode layers 12a and back electrode layers 12c. Each back electrode layer 12c is formed of a metallic foil or electrically conductive paste.

Each of the paired busbars 13, which serve as electrodes for fetching the output of the photovoltaic

module M, includes a busbar body 13a and an extension 13b that functions as an output fetching line. The respective busbar bodies 13a of the paired busbars 13 are connected electrically to the respective electrode layers 12a or 12c of the paired photovoltaic cells 12 that are situated individually at the opposite side portions of the unit cell S. As shown in FIG. 1, the respective extensions 13b of the busbars 13 for positive and negative electrodes are connected individually to terminals 18 of the terminal box 17 by means of solder 23. The terminal box 17 is located in the central portion of the back surface of the photovoltaic module M, for example.

The filler 14 covers the respective back surfaces of the photovoltaic cells 12 and the busbar bodies 13a. Although EVA (ethylene-vinyl acetate copolymer) is used for the filler 14 according to the present embodiment, an electrical insulating material, such as PVB (polyvinyl butyral), silicone resin, etc., may be used instead.

The spacer 15 is interposed between the photovoltaic cells 12 and the busbar extensions 13b. The spacer 15 may be formed of an electrical insulating material, preferably an electrical insulating material (e.g., nonwoven fabric of fiberglass) that can be impregnated with the heated fused filler 14. In order to enhance the insulating performance of the spacer 15,

the spacer 15 may be formed of the same material as the cover film 16.

The cover film 16, which serves as an electrical insulating protective layer, is put on the back surface of the filler 14. The cover film 16 is formed of an insulating film, such as a fluorine-based film such as polyvinyl fluoride, or PET film, which has high moisture vapor resistance and high water resistance. The cover film 16 may be formed of an aluminum foil that is sandwiched between insulating films of this type. Alternatively, a sheet glass may be used in place of the cover film 16.

Referring now to FIGS. 4 to 10, there will be described manufacturing processes for the photovoltaic module M. In a first process, as shown in FIG. 4, the paired busbars 13 are fixed to the photovoltaic cells 12 on the transparent substrate 11 by soldering. Each busbar 13 is formed of an electrically conductive material, such as a flat-type copper wire having a flat rectangular cross section, that is, a metallic bar material that can be bent and maintain a bent state. Each busbar 13 has a length L greater than that of the substrate 11. The respective extensions 13b of the busbars 13 project outward from one end 11a of the substrate 11. Each busbar 13 includes the busbar body 13a, which is confined within the outer peripheral contour of the substrate 11, and the extension 13b,

which extends integrally from the busbar body 13a and projects outward from the one end 11a of the substrate 11.

In a second process, as shown in FIG. 5, a first sheet 14a for the filler 14 is put on the cells 12. The sheet 14a, which is formed of EVA (ethylene-vinyl acetate copolymer), for example, is a size larger than the transparent substrate 11 and has notches 21 at two opposite corner portions near the one end 11a of the substrate 11. The first sheet 14a covers the busbar bodies 13a, and the busbar extensions 13b project outward from the substrate 11 through the notches 21, individually. The notches 21 serve to prevent the extensions 13b from projecting outside the outer peripheral contour of the substrate 11 even though the extensions 13b are turned up toward the first sheet 14a. Those portions of the busbar bodies 13a which face the notches 21 are not soldered to the cells 12.

In a third process, as shown in FIG. 6, the single spacer 15 of nonwoven fiber glass fabric or polyvinyl fluoride film is put on a part of the transparent substrate 11 near the one end 11a thereof so as to extend in the width direction of the first sheet 14a. A length L1 of the spacer 15 is a little greater than a width L2 of the first sheet 14a. Alternatively, the length L1 may be shorter than L2. The spacer 15 is put on the first sheet 14a in a manner such that its one

side edge 15a extends along an edge 21a of each notch 21. The spacer 15 is possibly tacked by means of an adhesive agent or the like that is supplied to tacking spots P1. Alternatively, the spacer 15 may be tacked at the tacking spots P1 by thermally fusing some parts of the sheet 14a by means of a spot iron or the like.

In a fourth process, as shown in FIG. 7A, the busbar extensions 13b are bent so as to be confined within the outer peripheral contour of the transparent substrate 11. More specifically, each extension 13b is first bent at an end of its corresponding busbar body 13a in the thickness direction of the spacer 15 so as to extend along the one side edge 15a of the spacer 15 and the edge 21a of the corresponding notch 21, and is further bent so as to lie on the back surface of the spacer 15, whereupon a first laminated portion $13b_1$ is formed. Then, at each bent portion 13bf, each extension 13b is bent at 90° to extend in the longitudinal direction of the spacer 15, whereupon a second laminated portion $13b_2$ is formed. Thus, the bent portion 13bf on the boundary between the first and second laminated portions $13b_1$ and $13b_2$ is turned inside out as the extension 13b is bent at 90° on the spacer 15. Further, an output end portion $13b_3$ is bent so as to rise from the second laminated portion $13b_2$. The respective output end portions $13b_3$ of the paired busbar extensions 13b project substantially parallel

to each other on the back surface of the photovoltaic module M.

In a fifth process, as shown in FIG. 8A, a second sheet 14b for the filler 14 of EVA is put on the spacer 15. Since a width L4 of the second sheet 14b is greater than a width L5 of the spacer 15, the notches 21 are covered by the second sheet 14b. A groove $14b_1$ is formed in the central portion of one side edge of the second sheet 14b. The respective output end portions $13b_3$ of the busbar extensions 13b are passed through the groove $14b_1$. The second sheet 14b is put on the spacer 15 in the direction indicated by arrow Q1 in FIG. 8A. The groove $14b_1$ may be replaced with a through hole $14b_2$ (FIG. 8B) in the sheet 14b into which the busbar extensions 13b are to be inserted. In some cases, the sheet 14b may be tacked to the spacer 15 with an adhesive or by fusing some parts of the sheet by means of a spot iron or the like.

In a sixth process, as shown in FIG. 9, the cover film 16 of polyvinyl fluoride is laid over the sheets 14a and 14b. The cover film 16 is a size larger than the first sheet 14a. A through hole 16a is bored through an end portion of the cover film 16. The paired output end portions $13b_3$ are passed through the hole 16a. The cover film 16 is possibly tacked by means of an adhesive agent after it is laid over the sheets 14a and 14b. The cover film 16 may be tacked to

the sheets 14a and 14b by thermally fusing some parts of the sheets by means of a spot iron or the like.

In a seventh process, as shown in FIG. 10, the paired output end portions $13b_3$ that project outward from the through hole 16a are bent in opposite directions along the cover film 16. The output end portions $13b_3$ bent in this manner are fixed temporarily to the cover film 16 by means of adhesive tapes 22.

As these processes are carried out in this manner, the respective output end portions $13b_3$ of the busbar extensions 13b that double as output fetching lines are drawn out on the back surface of the cover film 16 through the through hole 16a. The electrical insulating spacer 15 is interposed between the busbar extensions 13b and the photovoltaic cells 12. The second sheet 14b and the cover film 16 are stacked in layers on the extensions 13b.

An assembly (semi-finished product for the photovoltaic module) that is composed of these laminated members is heated in a hot-melt treatment process. In this process, the first and second sheets 14a and 14b are melted, and the space between the transparent substrate 11 and the cover film 16 is filled up with the filler 14. Thus, the respective back surfaces of the photovoltaic cells 12, the busbar bodies 13a, the spacer 15, and the busbar extensions 13b except the respective output end portions $13b_3$ are

buried in the filler 14. After this hot-melt process, the output end portions $13b_3$ are connected individually to the terminals 18 of the terminal box 17 by means of the solder 23. The terminal box 17 is fixed to the back surface of the photovoltaic module with an adhesive or the like. Power cables (not shown) are connected individually to the terminals 18 of the terminal box 17 by using fixing means, such as screws, soldering, caulking, etc.

In an output fetching wiring unit of the photovoltaic module M according to the present embodiment, the busbar extensions 13b double as output fetching lines, so that output fetching lines independent of the busbars 13 need not be soldered to the busbars 13, and therefore, the number of soldering spots of the wiring unit can be reduced. Accordingly, the workability of the output fetching wiring unit is improved, so that the manufacture of the photovoltaic module M is facilitated. Since the soldering spots are reduced in number, moreover, the incidence of conduction failure at the soldering spots is lowered. Thus, the quality of the output fetching wiring unit and hence that of the photovoltaic module M are improved. Since the yield of the photovoltaic module M is improved, so that the manufacturing cost can be lowered.

Since the busbar extensions 13b are drawn out onto the back surface of the photovoltaic module M through

the through hole 16a of the cover film 16, the respective output end portions $13b_3$ of the extensions 13b can be easily connected to the terminal box 17 on the back surface of the module. Moreover, the respective output end portions $13b_3$ of the busbar extensions 13b can be connected directly to the terminals of the terminal box 17. Accordingly, there is no necessity for using lead wires, and the number of soldering spots can be further reduced.

Further, some of the electrical insulating filler 14 cures after the electrical insulating spacer 15 between the busbar extensions 13b and the photovoltaic cells 12 is impregnated with it in the hot-melt process, so that the spacer 15 can securely insulate the extensions 13b from the photovoltaic cells 12. Since the nonwoven fabric of fiberglass for the spacer 15 can be easily impregnated with the filler 14 that is melted in the hot-melt process, the spacer 15 can be fully stuffed with the filler 14.

Since the first and second laminated portions $13b_1$ and $13b_2$ in longitudinally intermediate portions of each busbar extension 13b are buried in the filler 14, a long sealing distance can be secured between the through hole 16a of the cover film 16 and each busbar body 13a. Accordingly, external penetration of water can be prevented securely. Thus, corrosion of the busbars 13 or the back electrode layers 12c

attributable to penetration of water can be avoided, so that the durability of the system is improved. According to the conventional method in which the output fetching lines are soldered to the busbars, it is laborious to insulate the output fetching lines securely from the back electrode layers of the photovoltaic cells. According to the present invention, however, the insulation between the output fetching lines and the back electrode layers of the photovoltaic cells is easy. The present invention is particularly useful to the automation of a process for forming the output fetching wiring unit of the photovoltaic module and a process for covering the back surface of the module.

FIGS. 11 to 17 show processes for obtaining an output fetching wiring unit of a photovoltaic module according to a second embodiment of the invention. In the description of the second embodiment to follow, like reference numerals are used to designate those portions which are common to the first and second embodiments, and a description of the constructions and functions of those portions will be omitted. Thus, the following is a description of differences from the first embodiment.

In a first process, as shown in FIG. 11, a pair of busbars 13 are fixed to photovoltaic cells 12 by soldering. An extension 13b of each busbar 13

according to this embodiment is shorter than the busbar extension according to the first embodiment. In a second process, as shown in FIG. 12, a first filler sheet 14a is put on the respective back surfaces of the cells 12 in the same manner as in the first embodiment.

In a third process, as shown in FIG. 13, two short spacers 15 are put on the first sheet 14a. These spacers 15 are spaced in the width direction of a transparent substrate 11. In a fourth process, as shown in FIGS. 14A and 14B, the busbar extensions 13b are bent in the same manner as in the first embodiment. As this is done, first and second laminated portions $13b_1$ and $13b_2$, bent portion 13bf, etc. are formed on each spacer 15. A pair of output end portions $13b_3$ project on the back surface of the photovoltaic module.

In a fifth process, as shown in FIG. 15, two short second sheets 14b are put on the spacers 15, individually. These second sheets 14b cover their corresponding notches 21 (shown in FIG. 14B). A groove $14b_1$ is formed in each second sheet 14b. Alternatively, as shown in FIG. 8B, through holes $14b_2$ may be formed in the sheet 14b. The respective output end portions $13b_3$ of the busbar extensions 13b, which double as output fetching lines, are passed through the grooves $14b_1$, individually.

In a sixth process, as shown in FIG. 16, a cover film 16 is laid over the sheets 14a and 14b.

Two through holes 16a are bored through the cover film 16. The output end portions $13b_3$ are passed through the holes 16a, individually. In a seventh process, as shown in FIG. 17, the output end portions $13b_3$ are bent along the cover film 16 and fixed temporarily to the cover film 16 by means of adhesive tapes 22. According to the second embodiment described above, the paired output end portions $13b_3$ are spaced from each other. It is to be desired, therefore, that terminal boxes for positive and negative electrodes should be provided separately. Further, only terminals may be provided on the back surface of the photovoltaic module without using any terminal box.

The photovoltaic module according to the second embodiment can also achieve the object of the present invention for the same reason as the first embodiment. According to the second embodiment, moreover, the extensions 13b that double as output fetching lines can be made shorter than those of the first embodiment. Thus, the respective areas of the spacers 15 and the second sheets 14b can be made smaller than in the case of the first embodiment, so that the material cost and hence the manufacturing cost can be reduced. Besides, a long insulation distance can be secured between the respective output end portions $13b_3$ of the paired busbar extensions 13b that serve as output fetching lines.

FIGS. 18A and 18B show one (fourth process) of processes for obtaining an output fetching wiring unit of a photovoltaic module according to a third embodiment of the invention. Basically, this embodiment is arranged in the same manner as the first embodiment. In the description to follow, therefore, like reference numerals are used to designate those portions which are common to the first and third embodiments, and a description of the constructions and functions of those portions will be omitted. Thus, the following is a description of differences from the first embodiment. First to third processes according to the third embodiment are identical with the first to third processes (FIGS. 4 to 6), respectively, according to the first embodiment.

In a fourth process according to the third embodiment, as shown in FIG. 18A, each busbar extension 13b that projects from one end 11a of a transparent substrate 11 is bent on a spacer 15. In this embodiment, each first laminated portion $13b_1$ is turned up on the spacer 15 so that it is inclined at an angle $\theta 1$ of, e.g., about 45° to a busbar body 13a. Each second laminated portion $13b_2$ is turned inside out at a bent portion 13bf so that it is inclined at an angle $\theta 2$ of about 135° to the first laminated portion $13b_1$. As shown in FIG. 18B, a pair of output end portions $13b_3$ are bent so as to project substantially parallel to

each other above the spacer 15. In a fifth process, moreover, a second filler sheet 14b is put on the spacer 15 in the same manner as in the fifth process (FIG. 8A) according to the first embodiment. In a sixth process, a cover film 16 is laid over the spacer 15 in the same manner as in the sixth process (FIG. 9) according to the first embodiment. In a seventh process, the output end portions $13b_3$ are bent in opposite directions along the cover film 16 and fixed temporarily to the cover film 16 by means of adhesive tapes 22 in the same manner as in the seventh process (FIG. 10) according to the first embodiment.

The photovoltaic module according to the third embodiment can also achieve the object of the present invention for the same reason as the first embodiment. According to the third embodiment, moreover, the first laminated portion $13b_1$ of each busbar extension 13b is inclined with respect to its corresponding busbar body 13a, so that the length of the extension 13b can be shortened. Thus, the material cost for the busbars 13 can be reduced, so that the manufacturing cost can be lowered.

FIGS. 19A and 19B show one (fourth process) of processes for obtaining an output fetching wiring unit of a photovoltaic module according to a fourth embodiment of the invention. Basically, this embodiment is arranged in the same manner as the second embodiment.

In the description to follow, therefore, like reference numerals are used to designate those portions which are common to the second and fourth embodiments, and a description of the constructions and functions of those portions will be omitted. Thus, the following is a description of differences from the second embodiment. First to third processes according to the fourth embodiment are identical with the first to third processes (FIGS. 11 to 13), respectively, according to the second embodiment.

As shown in FIG. 19A, two short spacers 15 are used in a fourth process according to the fourth embodiment. Each busbar extension 13b that projects from one end 11a of a transparent substrate 11 is bent on each spacer 15. In this embodiment, each first laminated portion $13b_1$ is turned up on its corresponding spacer 15 so that it is inclined at an angle $\theta 1$ of, e.g., about 45° to a busbar body 13a. Each second laminated portion $13b_2$ is turned inside out at a bent portion 13bf so that it is inclined at an angle $\theta 2$ of about 135° to the first laminated portion $13b_1$. As shown in FIG. 19B, a pair of output end portions $13b_3$ are bent so as to project substantially parallel to each other above the spacer 15. In a fifth process, moreover, a second filler sheet 14b is put on the spacer 15 in the same manner as in the fifth process (FIG. 15) according to the second embodiment. In a

sixth process, a cover film 16 is laid over the spacers 15 in the same manner as in the sixth process (FIG. 16) according to the second embodiment. In a seventh process, the output end portions $13b_3$ are bent in opposite directions along the cover film 16 and fixed temporarily to the cover film 16 by means of adhesive tapes 22 in the same manner as in the seventh process (FIG. 17) according to the second embodiment.

The photovoltaic module according to the fourth embodiment can also achieve the object of the present invention for the same reason as the second embodiment. According to the fourth embodiment, moreover, the first laminated portion $13b_1$ of each busbar extension 13b is inclined with respect to its corresponding busbar body 13a, so that the length of the extension 13b can be further shortened. Thus, the material cost for the busbars 13 can be reduced, so that the manufacturing cost can be further lowered.

FIGS. 20A and 20B show one (fourth process) of processes for obtaining an output fetching wiring unit of a photovoltaic module according to a fifth embodiment of the invention. Basically, this embodiment is arranged in the same manner as the first embodiment. In the description to follow, therefore, like reference numerals are used to designate those portions which are common to the first and fifth embodiments, and a description of the constructions and functions of

those portions will be omitted. Thus, the following is a description of differences from the first embodiment. First to third processes according to the fifth embodiment are identical with the first to third processes (FIGS. 4 to 6), respectively, according to the first embodiment.

In a fourth process according to the fifth embodiment, as shown in FIG. 20A, each busbar extension 13b that projects from one end 11a of a transparent substrate 11 is bent so as to extend from a spacer 15 toward a terminal box 17. In this embodiment, each extension 13b is turned up diagonally or at an angle to its corresponding busbar body 13a. An output end portion $13b_3$ of each extension 13b is long enough to reach the terminal box 17. As shown in FIG. 20B, the respective output end portions $13b_3$ of the paired busbar extensions 13b are bent so as to project substantially parallel to each other above the spacer 15. These output end portions $13b_3$ are connected to their corresponding terminals of the terminal box 17 later. In a fifth process, moreover, a second filler sheet 14b is put on the spacer 15 in the same manner as in the fifth process (FIG. 8A) according to the first embodiment. In a sixth process, a cover film 16 is laid over the spacer 15 in the same manner as in the sixth process (FIG. 9) according to the first embodiment. In a seventh process, the output end

portions $13b_3$ are bent in opposite directions along the cover film 16 and fixed temporarily to the cover film 16 by means of adhesive tapes 22 in the same manner as in the seventh process (FIG. 10) according to the first embodiment.

The photovoltaic module according to the fifth embodiment can also achieve the object of the present invention for the same reason as the first embodiment.

FIG. 21 shows a sixth embodiment of the invention. A photovoltaic module M' according to this embodiment is provided with a plurality of crystalline photovoltaic cells 112 arranged on the back surface of a transparent substrate 111. The opposite-polarity electrodes of these cells 112 are connected in series with one another by means of lead wires 113, which double as output fetching lines, and a busbar 114. The busbar 114 has, for example, two bent portions 114a. One end portion 114b of the busbar 114 is connected to one of two redirected photovoltaic cells 112, among other series-connected cells 112, while the other end portion 114c of the busbar 114 is connected to the other cell 112.

The photovoltaic cells 112, lead wires 113, and busbar 114 are all buried in a filler (not shown) on the back surface of the transparent substrate 111. A cover film covers the filler in the same manner as in the foregoing embodiments. Further, output fetching

lines 115 are connected individually to those photovoltaic cells 112, out of the series-connected cells 112, which are situated at the opposite ends of the circuit. Each line 115 has one or more bent portions (not shown) that resemble the bent portions 114a. The output fetching lines 115 are drawn out of the module M' and connected electrically to a terminal box.

In the sixth embodiment, the busbar 114 itself also doubles as an output fetching line, so that any other output fetching lines to be prepared independently of the busbar 114 need not be soldered to the busbar. Since the wiring direction of the busbar 114 or output fetching line can be changed by means of the two bent portions 114a, the point where the wiring direction changes requires no soldering. Thus, the incidence of connection failure attributable to soldering is lowered, and the quality and yield of output fetching wiring units between photovoltaic cells can be improved. Further, the workability of the output fetching wiring units is improved, so that the manufacturing cost can be lowered.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the

spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A photovoltaic module with a plurality of photovoltaic cells, comprising:

a busbar including a busbar body connected electrically to the photovoltaic cells and an extension extending integrally from the busbar body and serving as an output fetching line.

2. A photovoltaic module according to claim 1, which comprises a transparent substrate, the photovoltaic cells arranged on the back surface of the transparent substrate, an electrical insulating filler covering the respective back surfaces of the photovoltaic cells, a cover film covering the filler, and the busbar including the busbar body connected electrically to the photovoltaic cells and embedded in the filler and the extension long enough to project from one end of the transparent substrate, the extension being drawn out through the cover film.

3. A photovoltaic module according to claim 2, which further comprises a spacer interposed between the photovoltaic cells and the extension, and wherein said busbar extension includes laminated portions bent along the spacer and an output end portion drawn out through the cover film.

4. A photovoltaic module with a plurality of photovoltaic cells, comprising:

a busbar including a busbar body connected

electrically to the photovoltaic cells and an extension extending integrally from the busbar body and serving as an output fetching line, the extension including a bent portion turned down to change the course in the middle in the longitudinal direction of the extension.

5. A power generation system having a photovoltaic module with a plurality of photovoltaic cells, the photovoltaic module comprising a transparent substrate, the photovoltaic cells arranged on the back surface of the transparent substrate, an electrical insulating filler covering the respective back surfaces of the photovoltaic cells, a cover film covering the filler, and a busbar including a busbar body connected electrically to the photovoltaic cells and embedded in the filler and an extension long enough to project from one end of the transparent substrate, the extension being drawn out through the cover film.

6. A power generation system according to claim 5, comprising generating elements each including a tile body constituting a roofing tile and the photovoltaic module incorporated in the tile body.

7. A photovoltaic module and power generation system, substantially as hereinbefore described with reference to FIGS. 1 to 23 of the accompanying drawings.

8. A power generation system substantially as hereinbefore described with reference to the drawings and/or Examples.

9. The steps, features, compositions and compounds disclosed herein or referred to or indicated in the specification and/or claims of this application, individually or collectively, and any and all combinations of any two or more of said steps or features.

DATED this EIGHTH day of DECEMBER 1999

Kaneka Corporation

by DAVIES COLLISON CAVE
Patent Attorneys for the applicant(s)

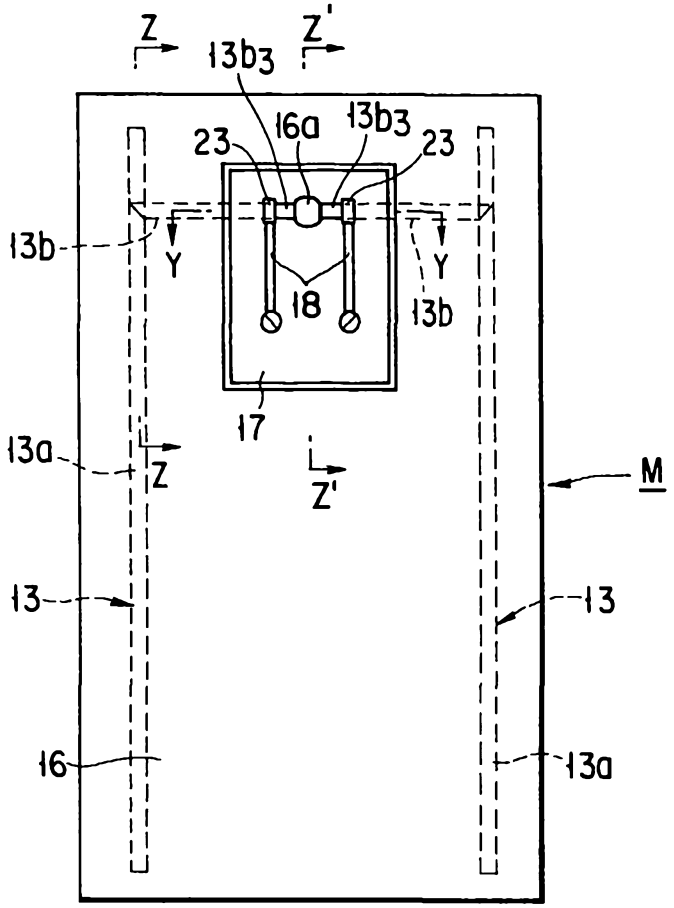

Z
Z'
13b3
16a
13b3
23
23
13b
Y
Y
13b
18
17
13a
Z
Z'
M
13
13
16
13a

FIG. 1

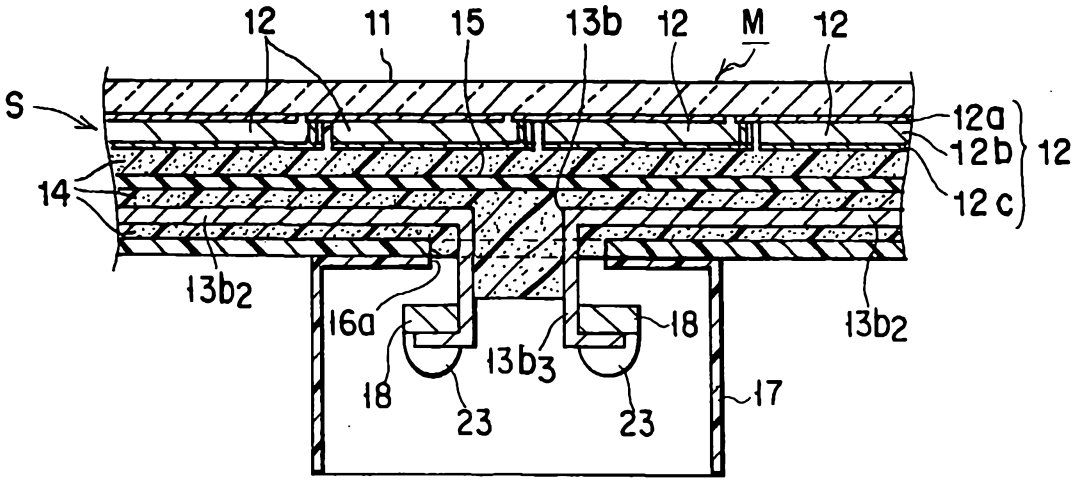

12
11
15
13b
12
M
12
S
12a
12b
12
12c
14
13b2
16a
18
13b3
18
23
23
17
13b2

FIG. 3

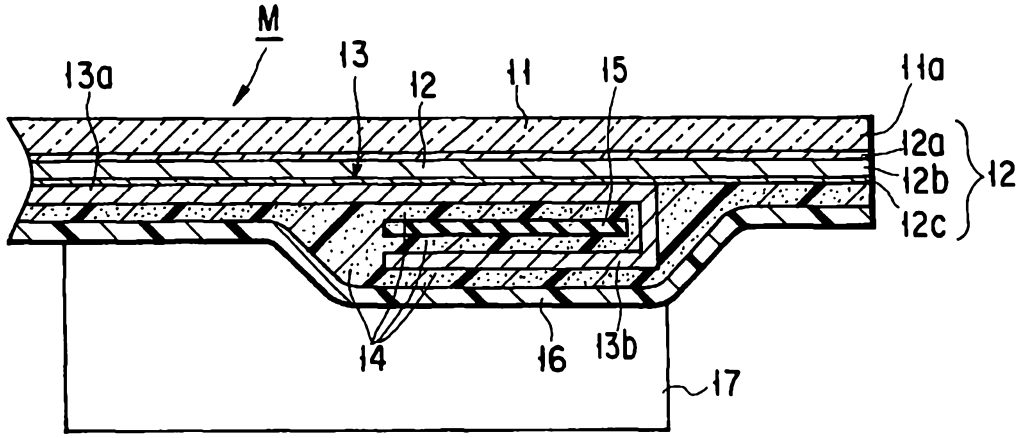

M
13a
13
12
11
15
11a
12a
12b
12c
12
14
16
13b
17

FIG. 2A

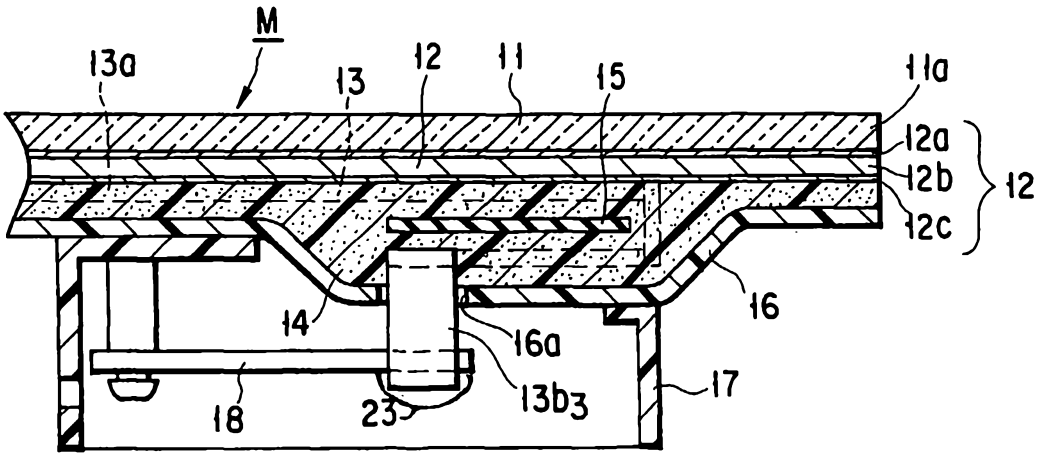

M
13a
13
12
11
15
11a
12a
12b
12c
12
14
16a
16
13b3
17
18
23

FIG. 2B

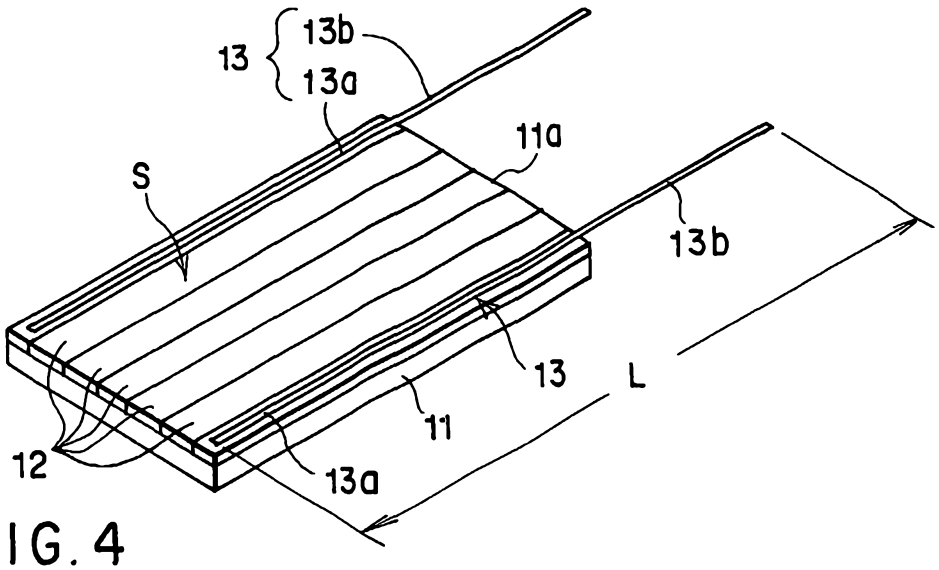


FIG. 4

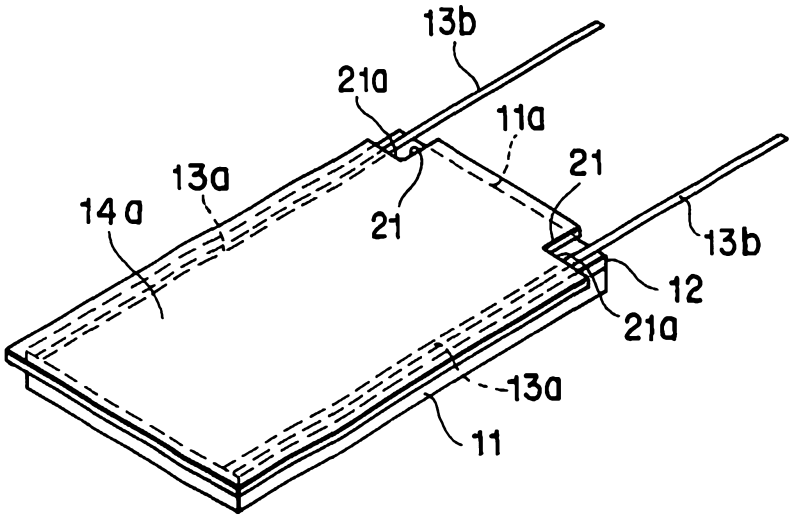


FIG. 5

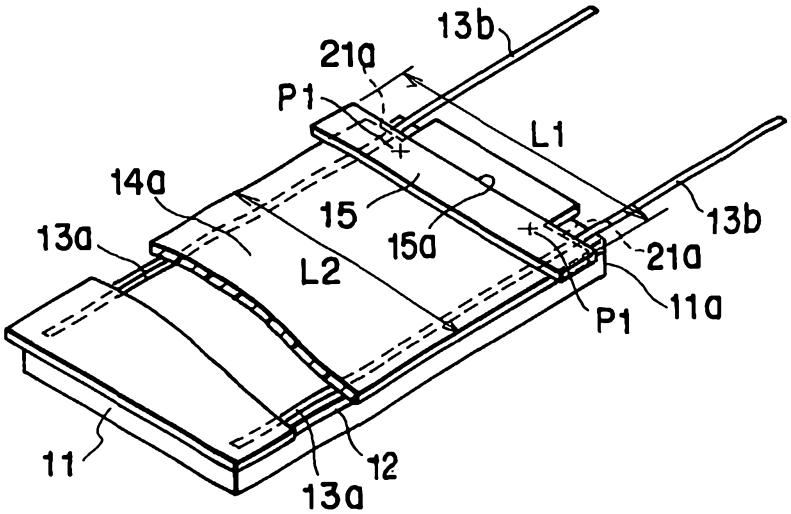


FIG. 6

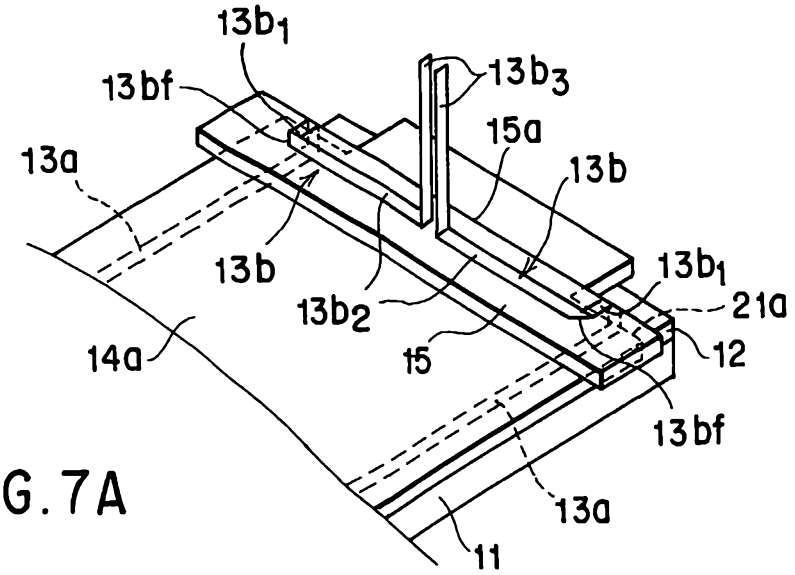

13b1
13bf
13b3
15a
13a
13b
13b
13b1
13b2
21a
15
12
14a
13bf
13a
11

FIG. 7A

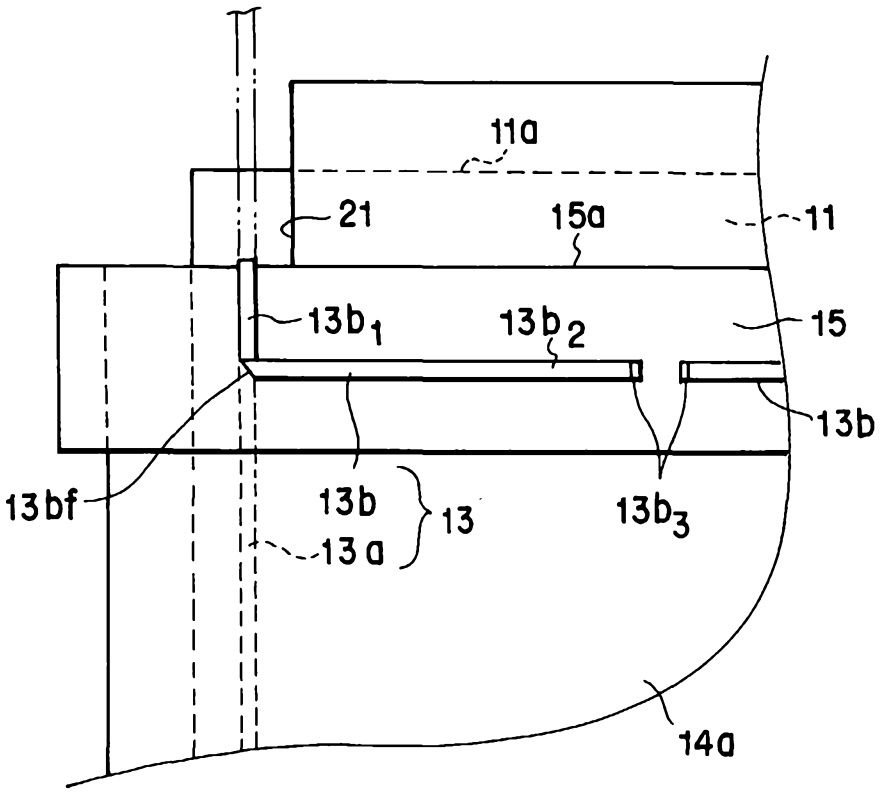

11a
21
15a
11
13b1
13b2
15
13b
13bf
13b
13
13a
13b3
14a

FIG. 7B

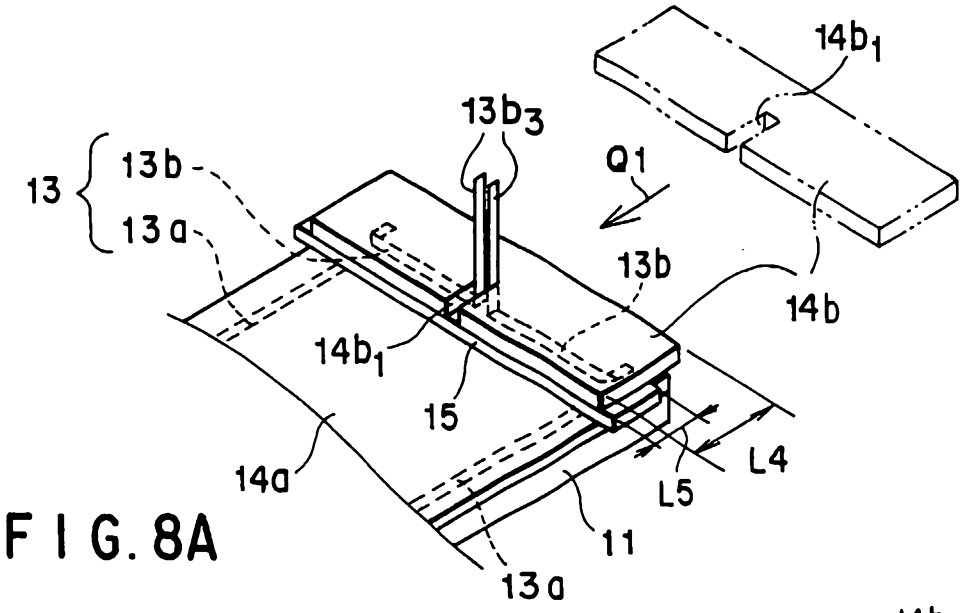


FIG. 8A

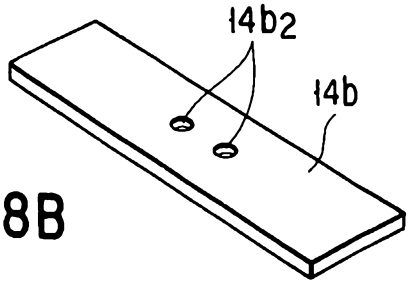


FIG. 8B

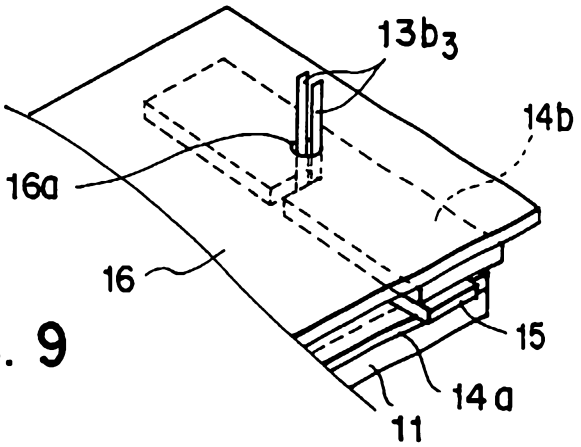


FIG. 9

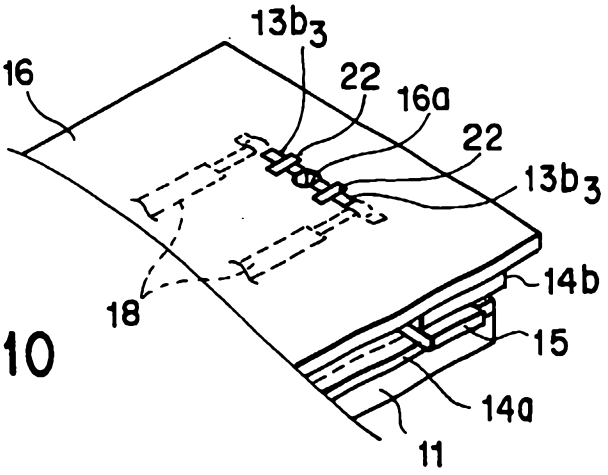


FIG. 10

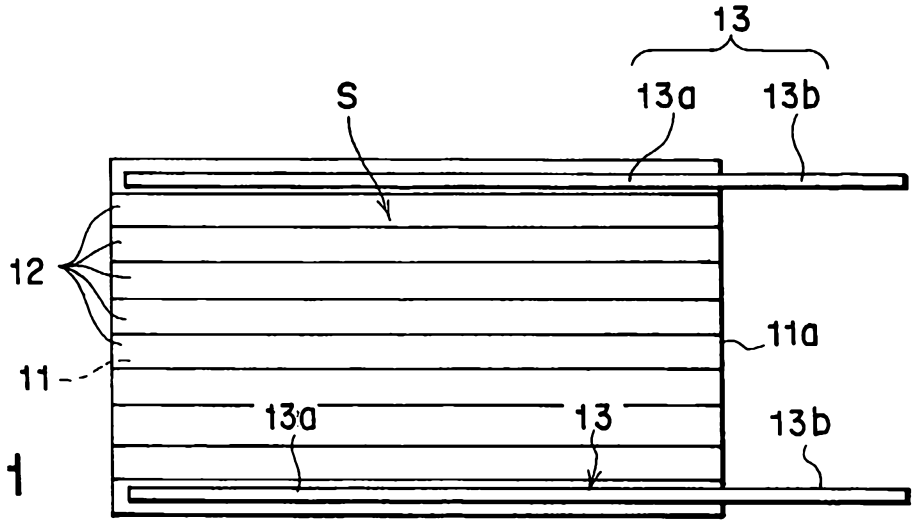


FIG. 11

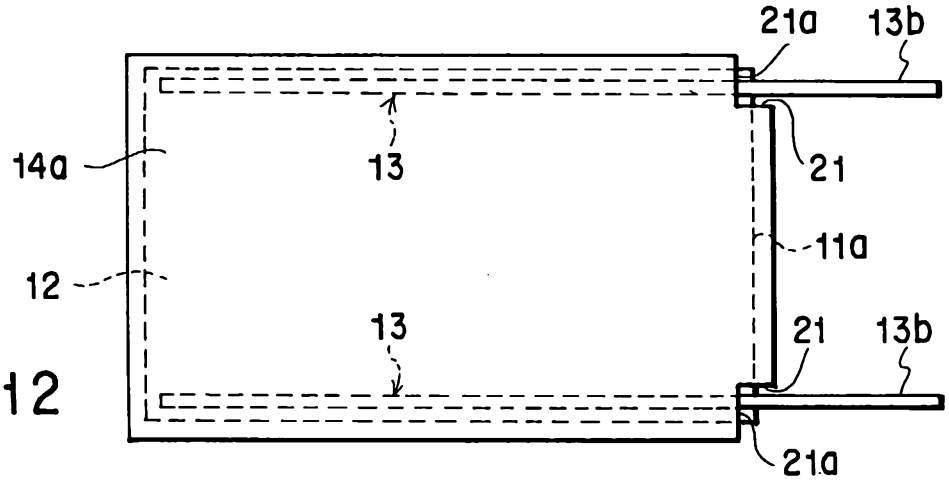


FIG. 12

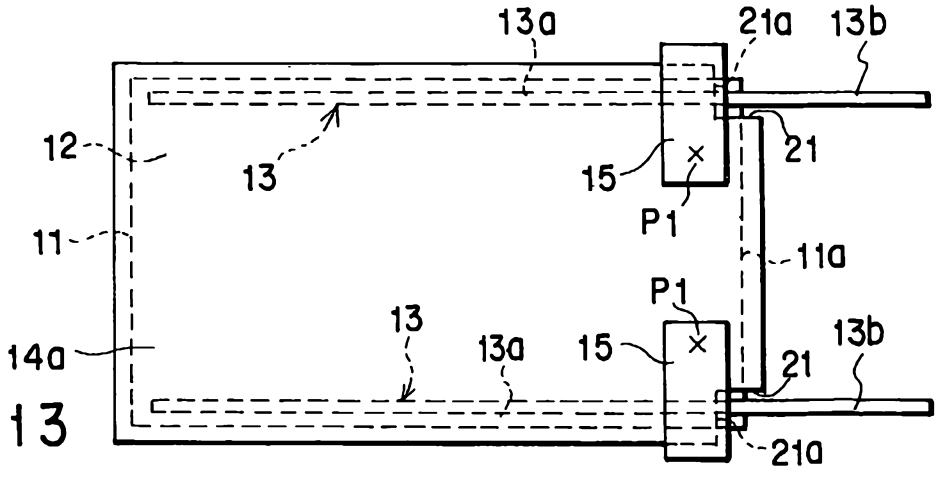


FIG. 13

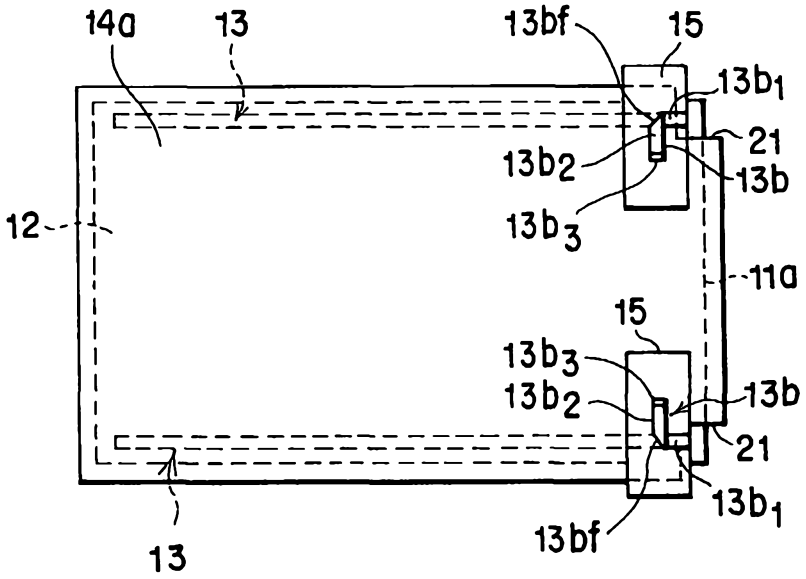


FIG. 14A

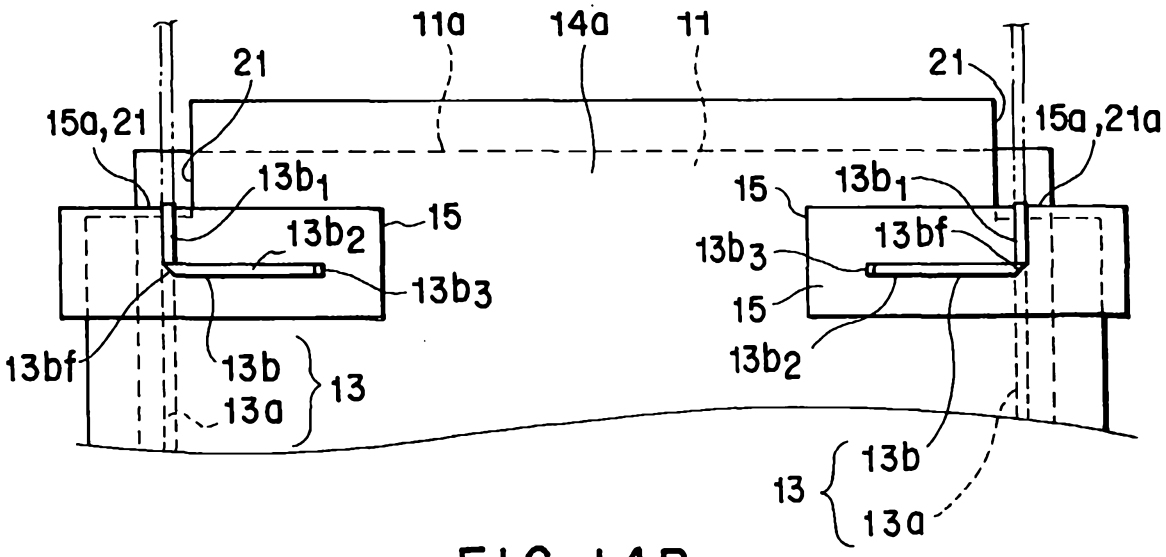


FIG. 14B

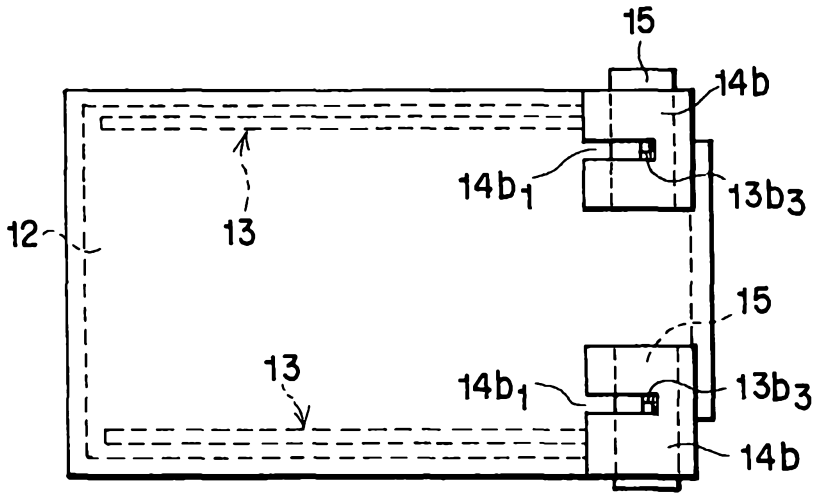


FIG. 15

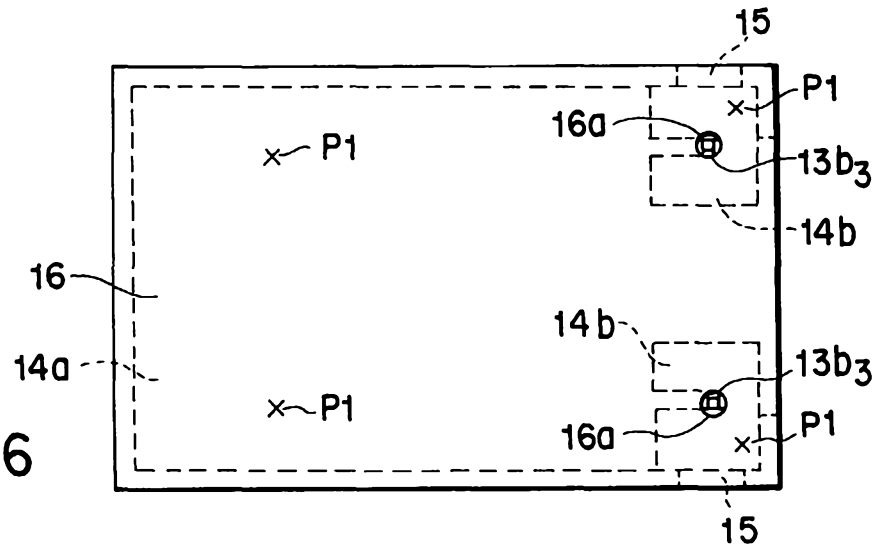


FIG. 16

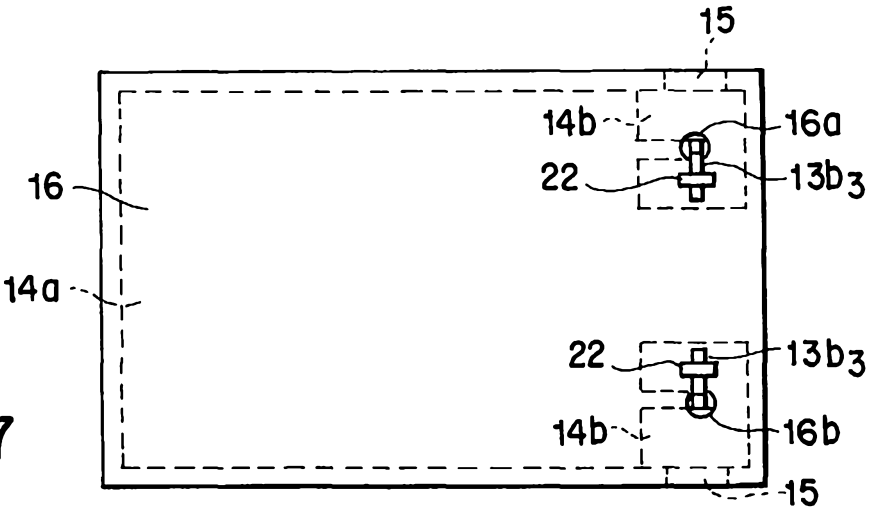


FIG. 17

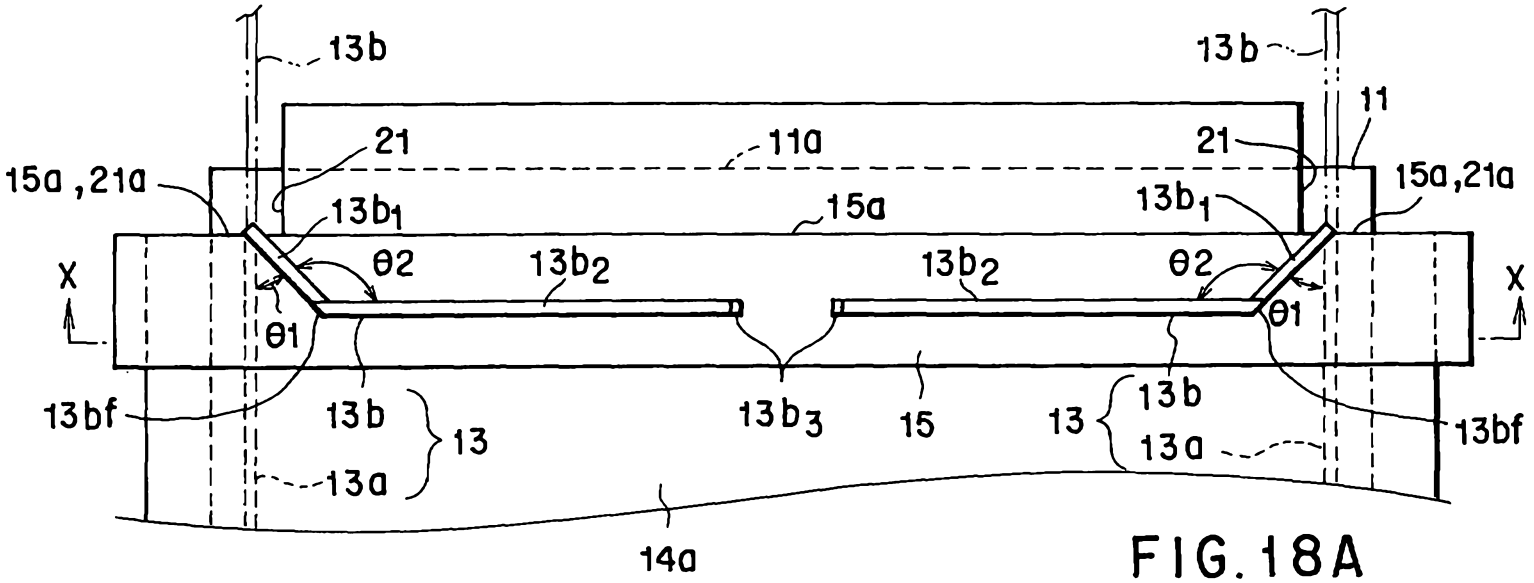


FIG. 18A

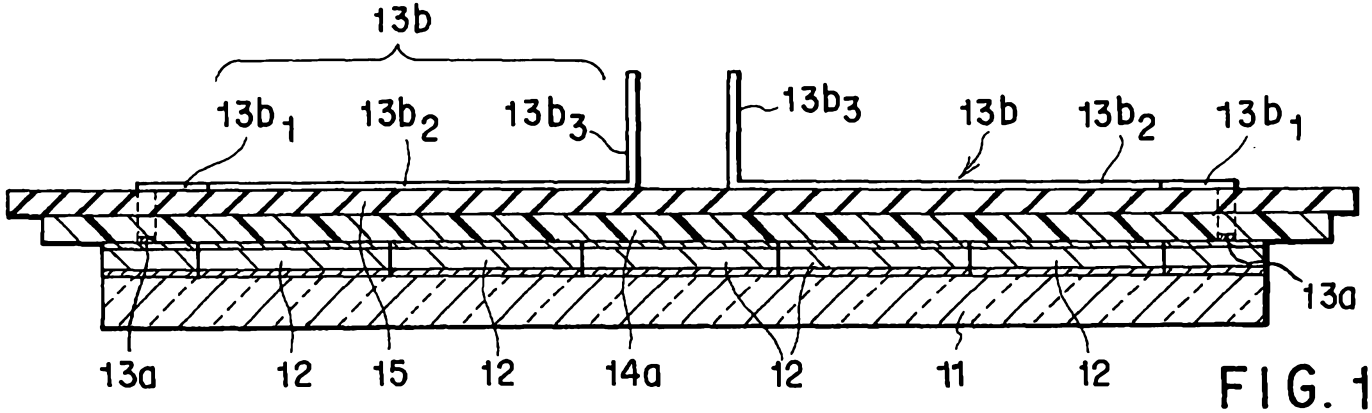


FIG. 18B

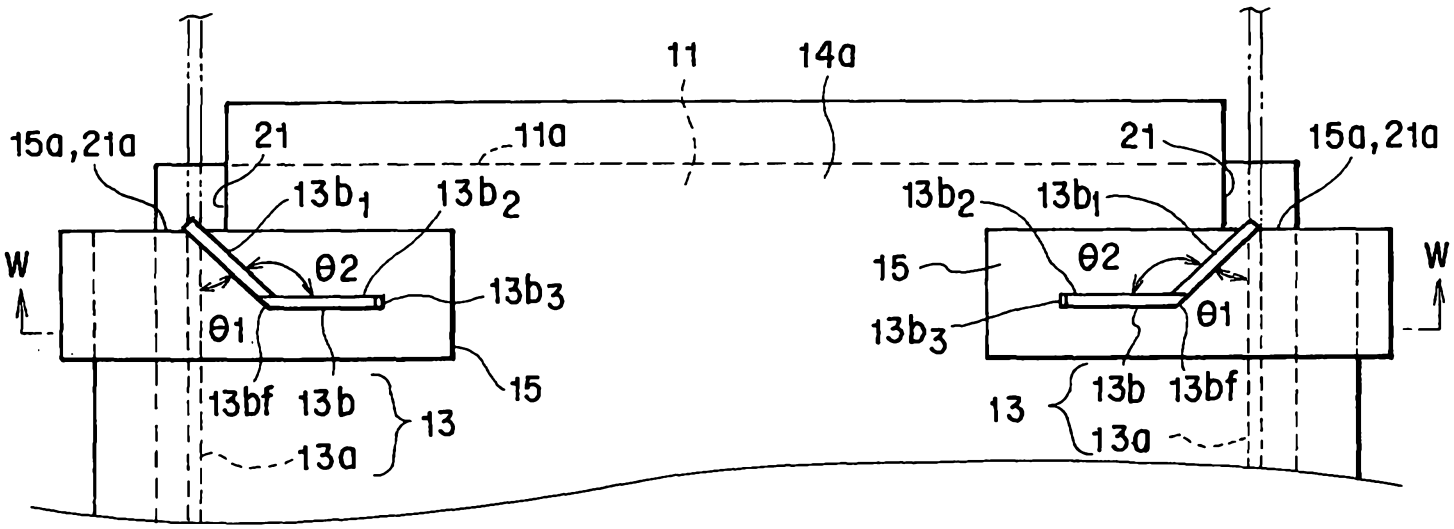


FIG. 19A

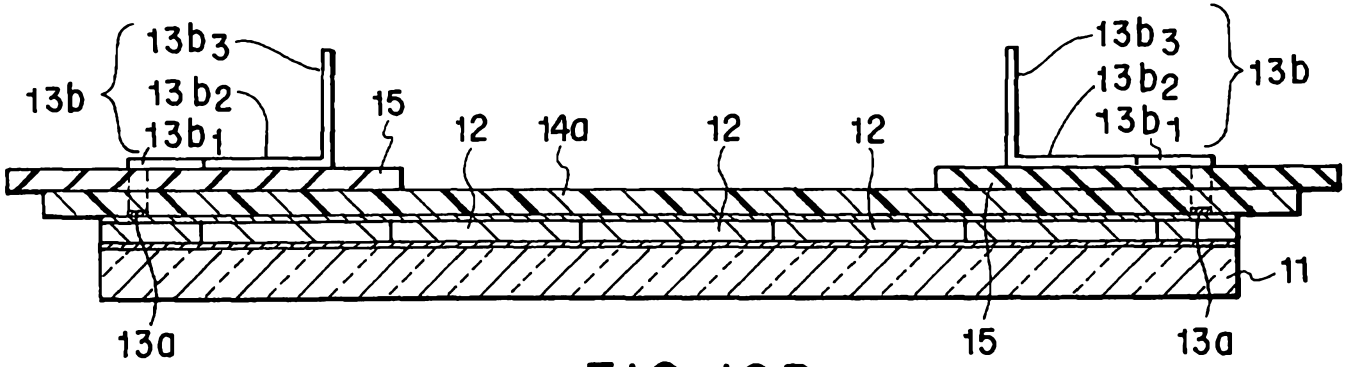


FIG. 19B

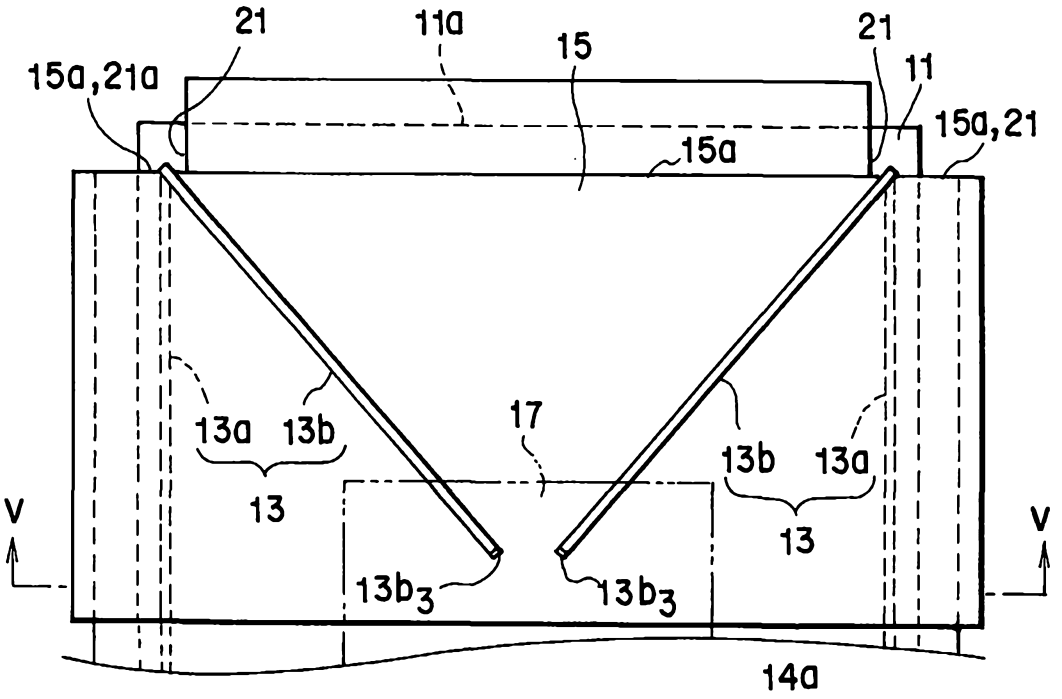


FIG. 20A

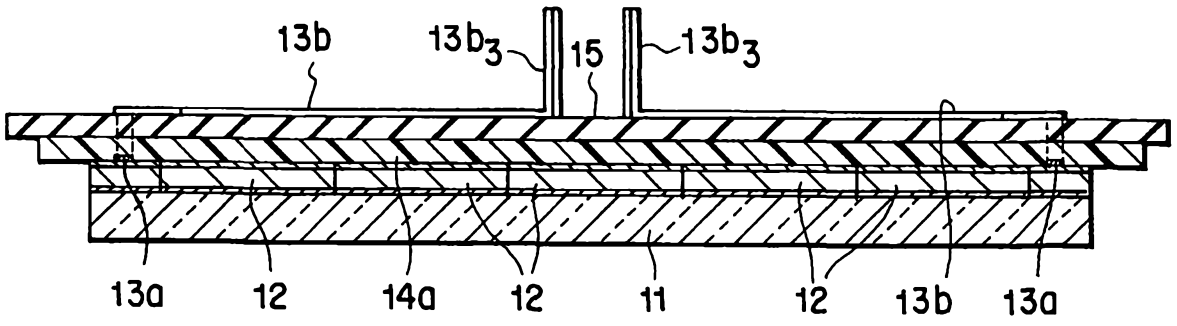


FIG. 20B

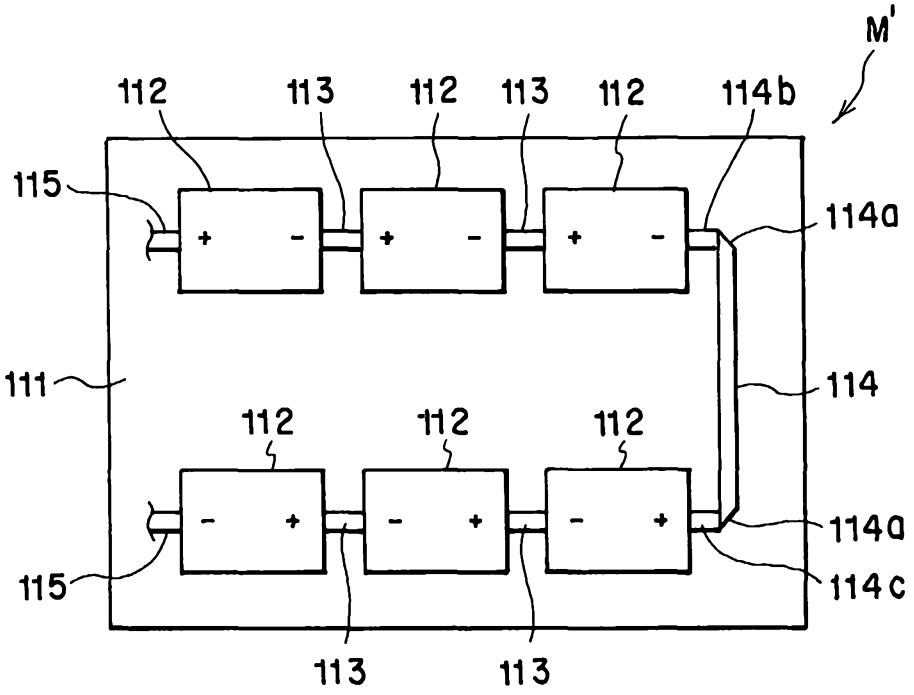


FIG. 21

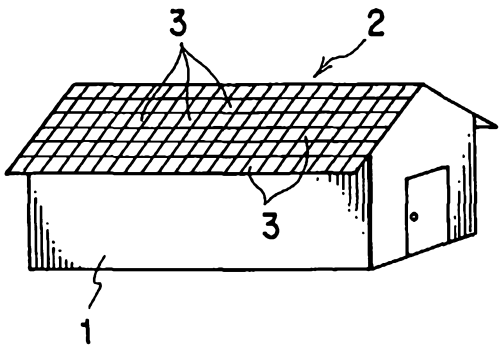


FIG. 22

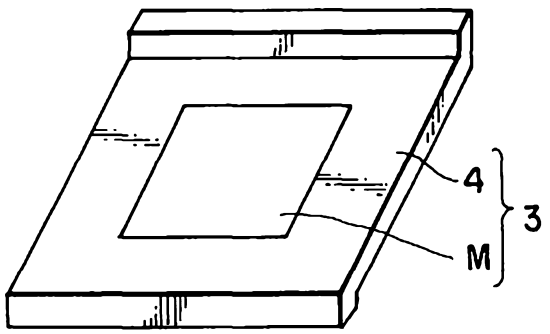


FIG. 23

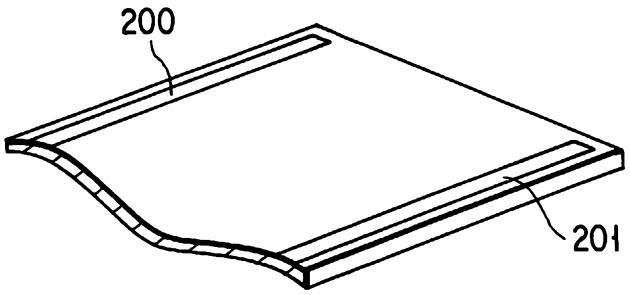


FIG. 24A

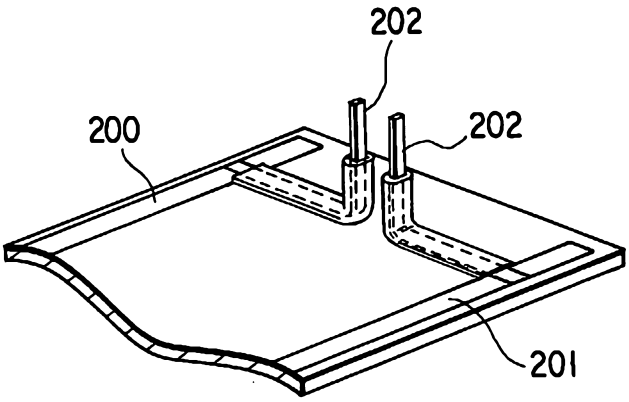


FIG. 24B

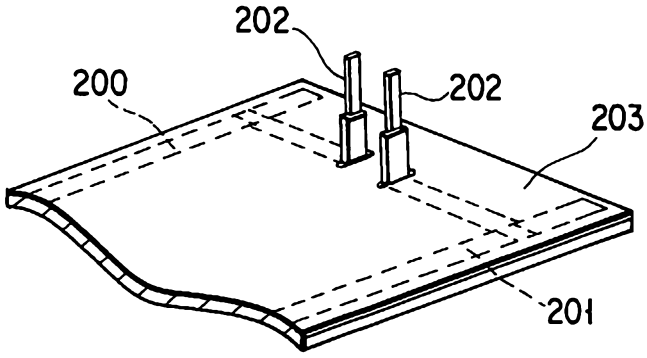


FIG. 24C