US00RE43957E

(19) **United States**
(12) **Reissued Patent**
Nagai

(10) **Patent Number: US RE43,957 E**
(45) **Date of Reissued Patent: Feb. 5, 2013**

(54) **HIGH-FREQUENCY MODULE INCLUDING CONNECTION TERMINALS ARRANGED AT A SMALL PITCH**

(75) Inventor: **Taturo Nagai**, Kanazawa (JP)

(73) Assignee: **Murata Manufacturing Co., Ltd.**, Kyoto (JP)

(21) Appl. No.: **13/157,527**

(22) Filed: **Jun. 10, 2011**

Related U.S. Patent Documents

Reissue of:
(64) Patent No.: **7,609,130**
Issued: **Oct. 27, 2009**
Appl. No.: **12/133,436**
Filed: **Jun. 5, 2008**

U.S. Applications:
(63) Continuation of application No. PCT/JP2007/064118, filed on Jul. 17, 2007.

(30) **Foreign Application Priority Data**

Aug. 21, 2006 (JP) 2006-224659

(51) **Int. Cl.**
H01P 5/12 (2006.01)
H01P 3/08 (2006.01)

(52) **U.S. Cl.** **333/134**; 333/5; 333/202; 333/246; 333/247

(58) **Field of Classification Search** 333/126–129, 333/132, 134
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,783,976	A *	7/1998	Furutani et al.	333/134
6,774,748	B1 *	8/2004	Ito et al.	333/247
6,900,705	B2 *	5/2005	Nakamura et al.	333/25
7,245,884	B2 *	7/2007	Oida et al.	455/90.3
7,398,059	B2 *	7/2008	Uejima et al.	455/78
2002/0027019	A1	3/2002	Hashimoto	
2004/0116098	A1	6/2004	Ochii et al.	
2004/0119560	A1	6/2004	Tsurunari et al.	
2007/0035362	A1	2/2007	Uejima et al.	

FOREIGN PATENT DOCUMENTS

EP	1 300 946	A2	4/2003
EP	1 557 944	A1	7/2005
JP	05-335747	A	12/1993
JP	10-189194	A	7/1998
JP	2003-142981	A	5/2003
JP	2005-159080	A	6/2005
JP	2005-311929	A	11/2005

OTHER PUBLICATIONS

English translation of Official Communication issued in corresponding Japanese Patent Application No. 2007-558372, drafted on Jul. 7, 2010.

Official Communication issued in corresponding European Patent Application No. 07790880.4, mailed on Jan. 13, 2012.

Official Communication issued in International Patent Application No. PCT/JP2007/064118, mailed on Oct. 16, 2007.

* cited by examiner

Primary Examiner — Robert Pascal
Assistant Examiner — Kimberly Glenn
(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(57) **ABSTRACT**

In a high-frequency module, mounting lands arranged to mount at least one filter device having at least one set of an unbalanced terminal and two balanced terminals are provided at one side of a substrate top surface, and mounting lands arranged to mount at least one element electrically connected to the filter device are arranged at the opposite side. At least two of a plurality of connection terminals provided on a substrate bottom surface are respectively connected to conductor patterns connected to via-hole conductors penetrating the substrate within a mounting area for mounting the filter device via connection lines and are arranged at a pitch which is less than the pitch of the via-hole conductors.

3 Claims, 9 Drawing Sheets

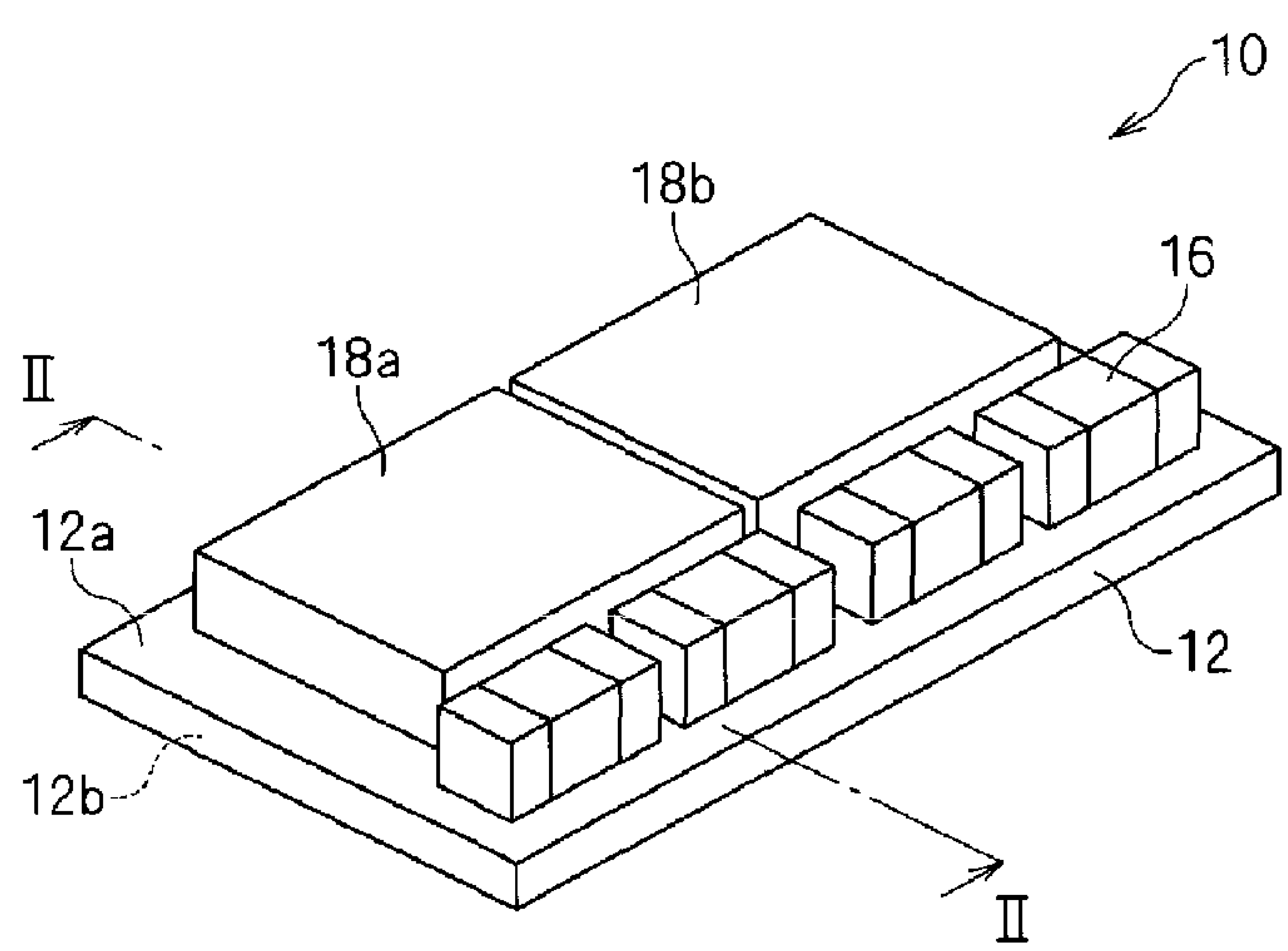


FIG. 1

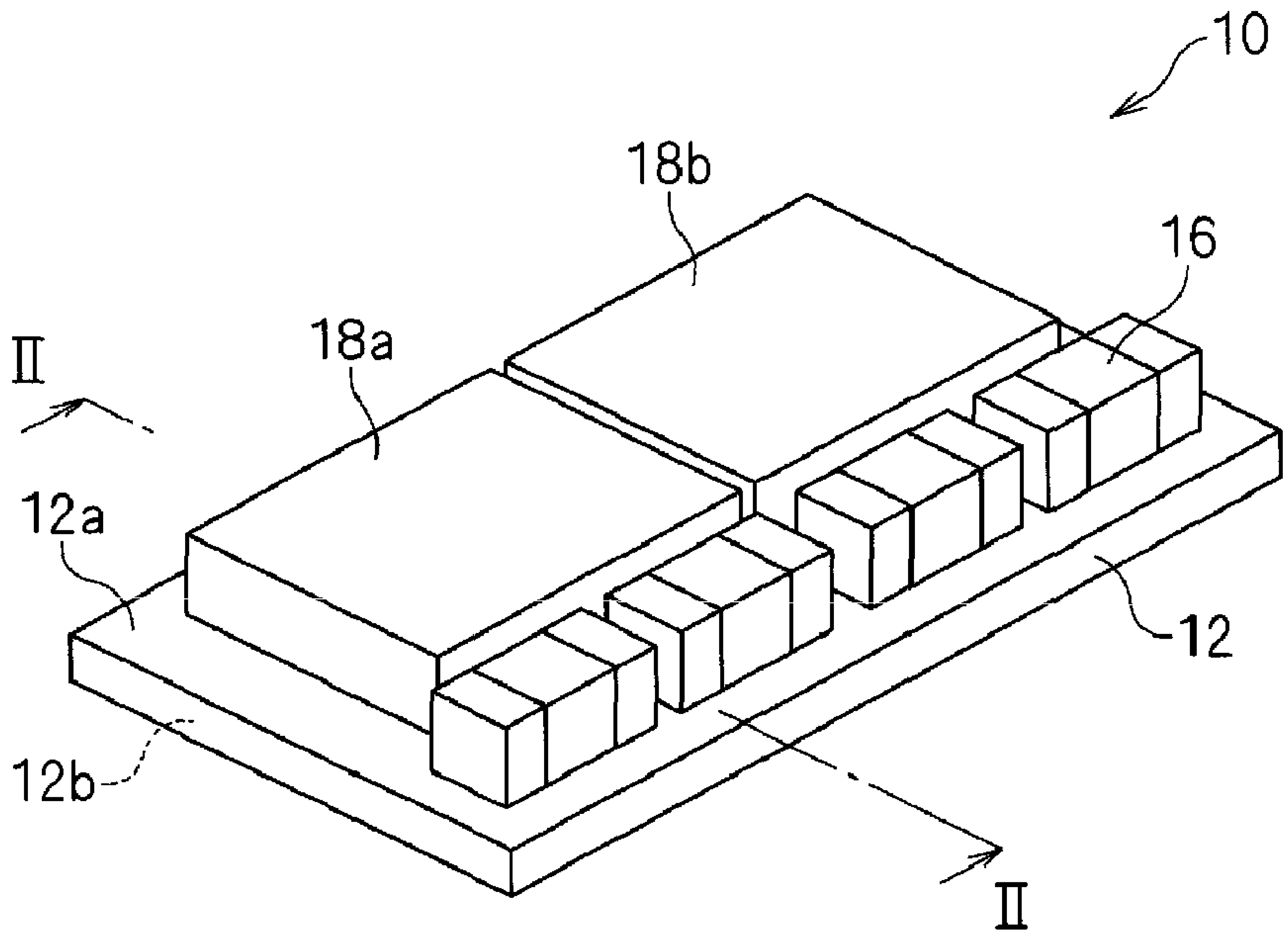


FIG. 2

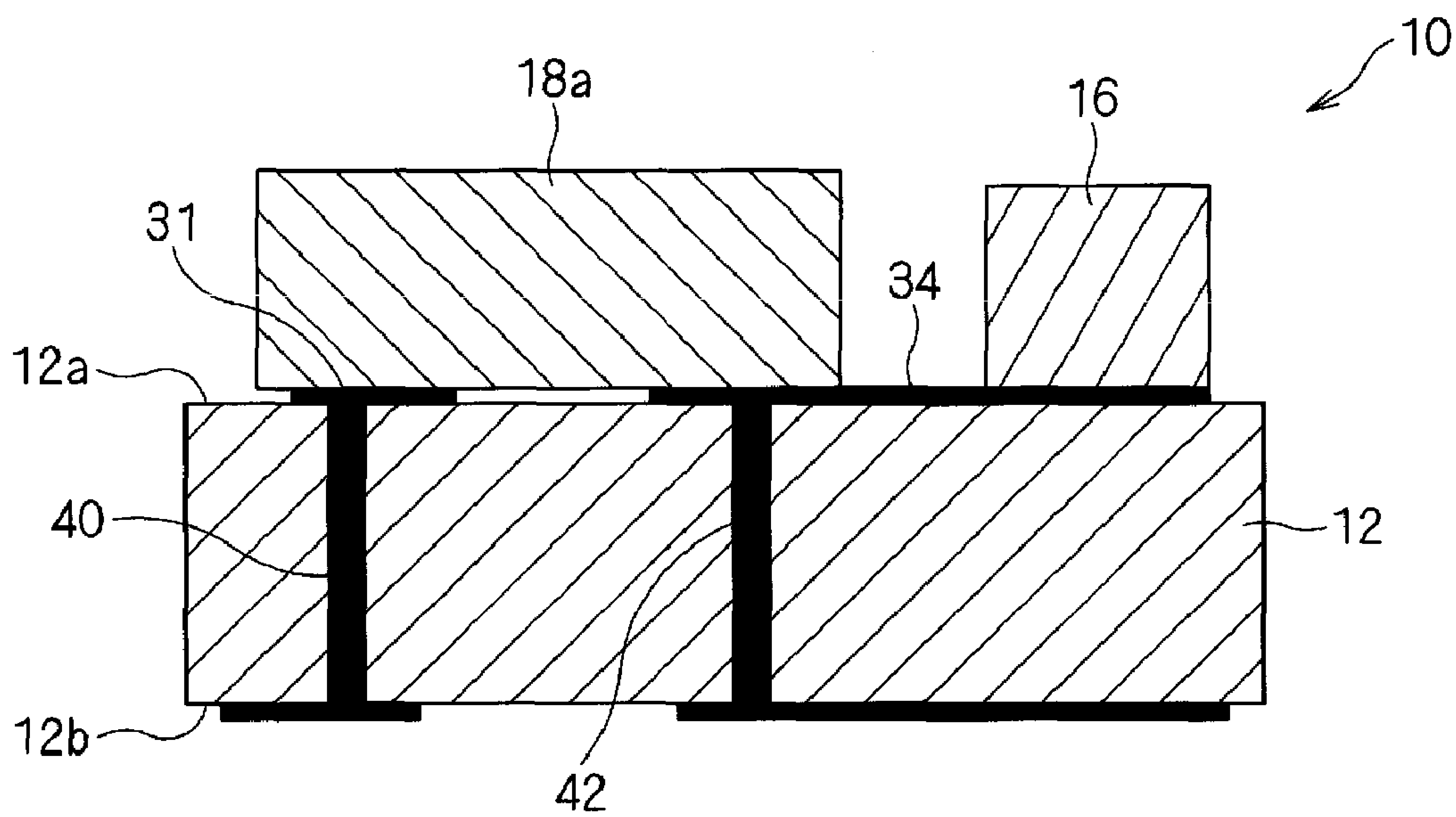


FIG. 3

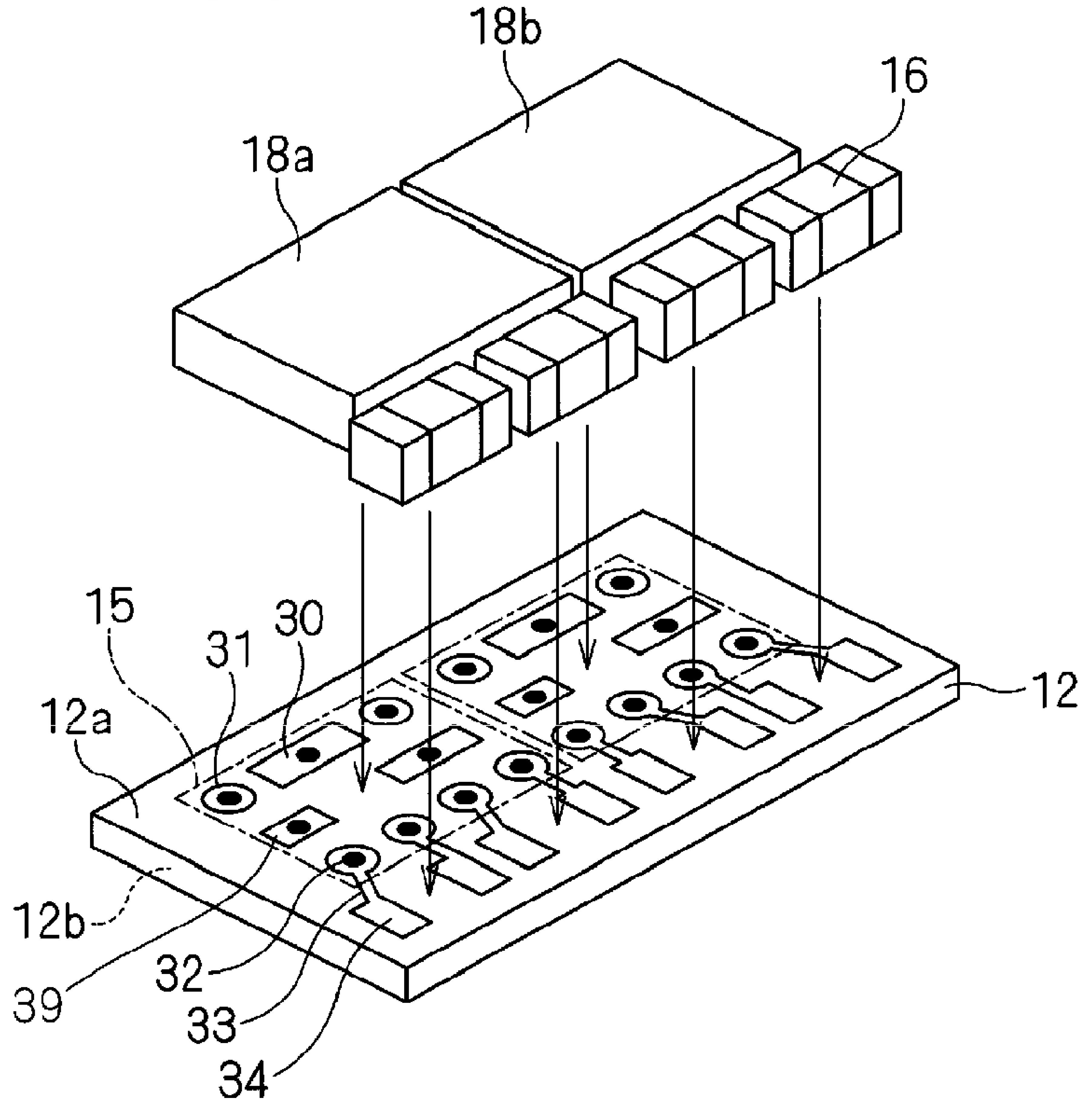

18b
16
18a
15
30
31
12a
12
12b
39
32
33
34

FIG. 4

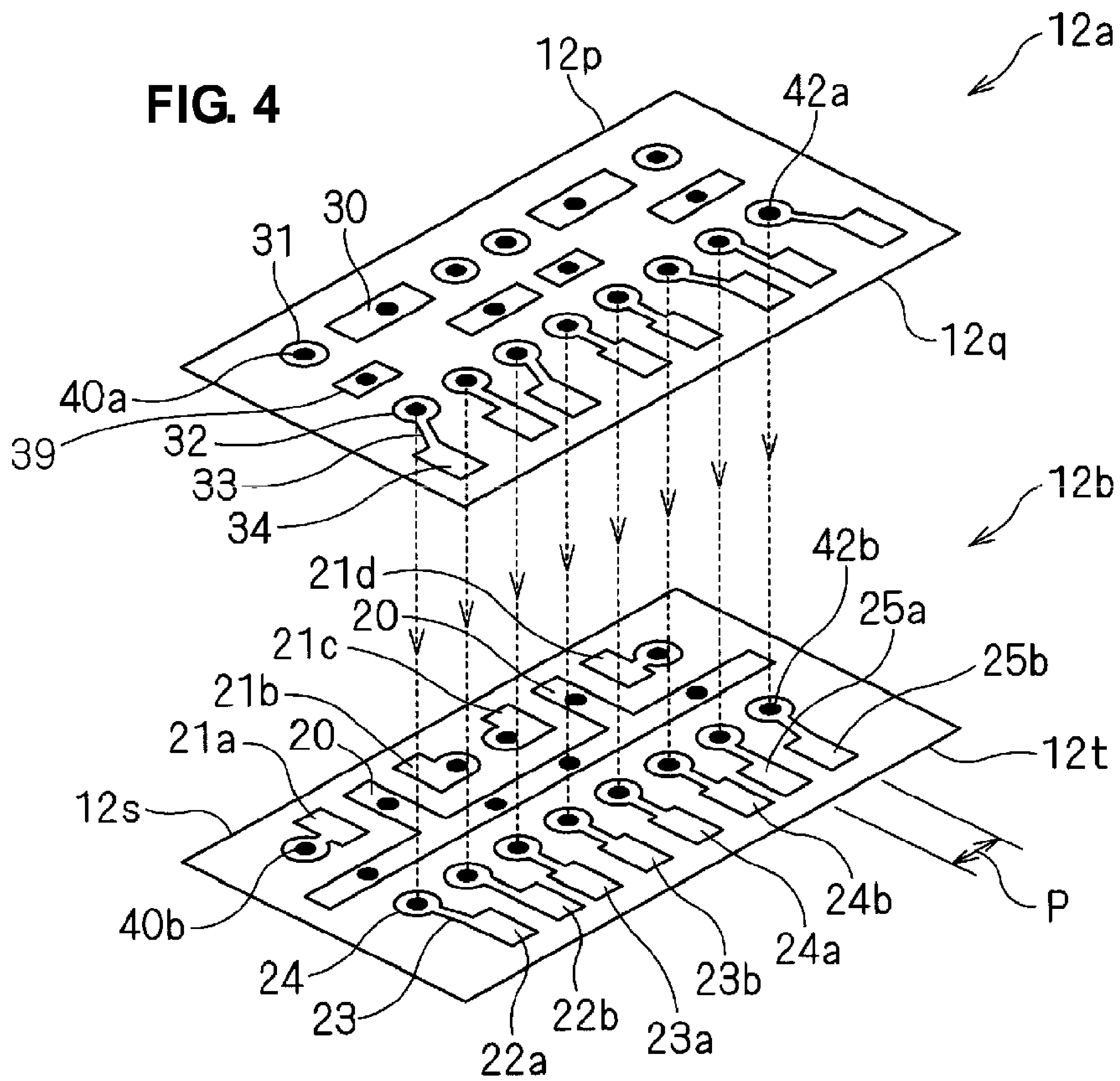

12a
12p
42a
30
31
12q
40a
39
32
33
34
12b
42b
21d
25a
20
21c
25b
21b
21a
20
12t
12s
P
40b
24b
24a
24
23b
23
22b
23a
22a

FIG. 5

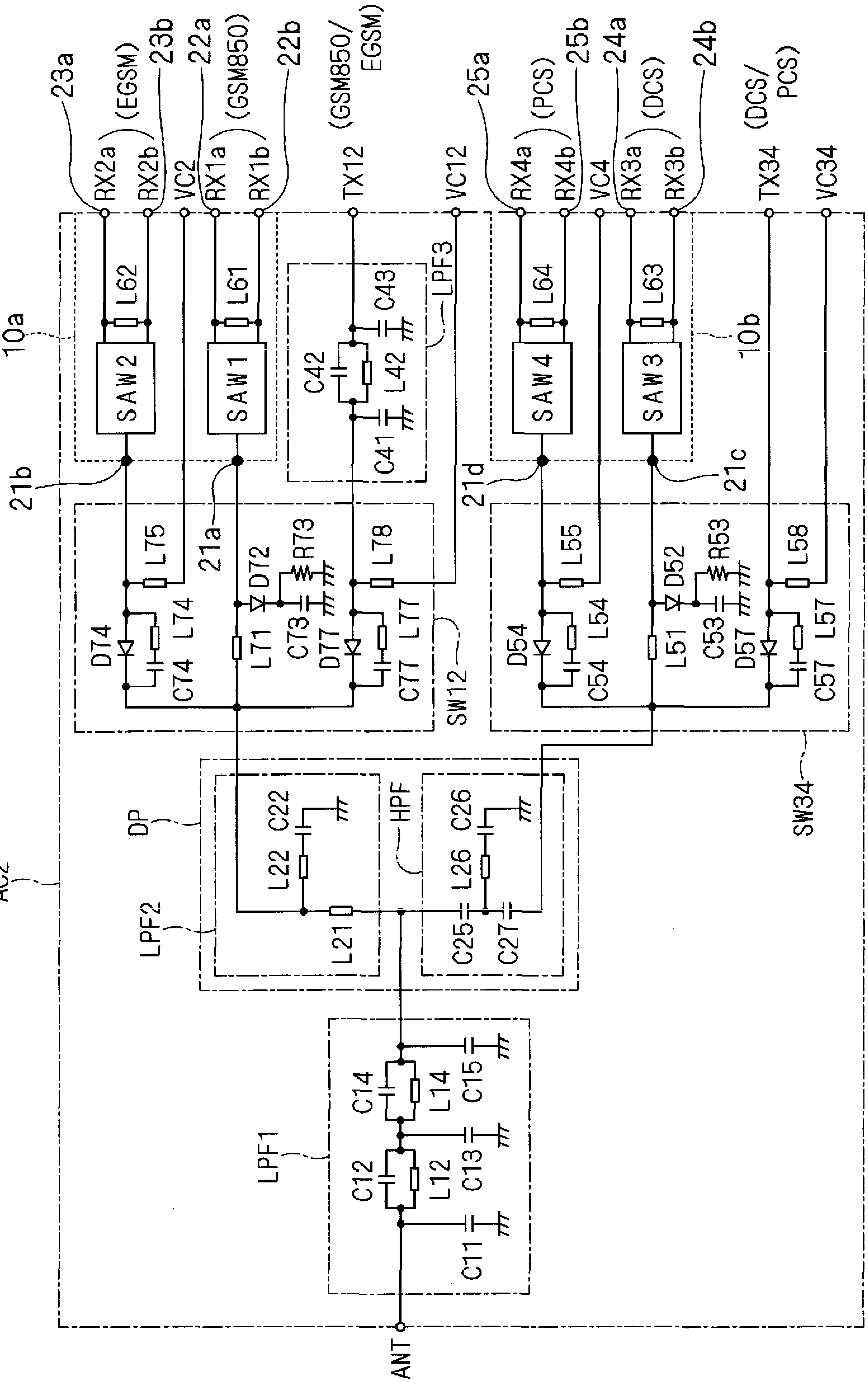

23a
(EGSM)
23b
22a
(GSM850)
22b
(GSM850/
EGSM)
25a
(PCS)
25b
24a
(DCS)
24b
(DCS/
PCS)
RX2a
RX2b
VC2
RX1a
RX1b
TX12
VC12
RX4a
RX4b
VC4
RX3a
RX3b
TX34
VC34
10a
10b
SAW 2
SAW 1
SAW 4
SAW 3
L62
L61
L64
L63
LPF3
C41
C42
C43
L42
21a
21b
21c
21d
L75
D72
R73
L78
D74
L74
L71
C73
D77
L77
C74
C77
SW12
L55
D52
R53
L58
D54
L54
L51
C53
D57
L57
C54
C57
SW34
DP
HPF
LPF2
C22
L22
L21
C26
L26
C25
C27
AC2
LPF1
C14
L14
C15
C12
L12
C13
C11
ANT

FIG. 6

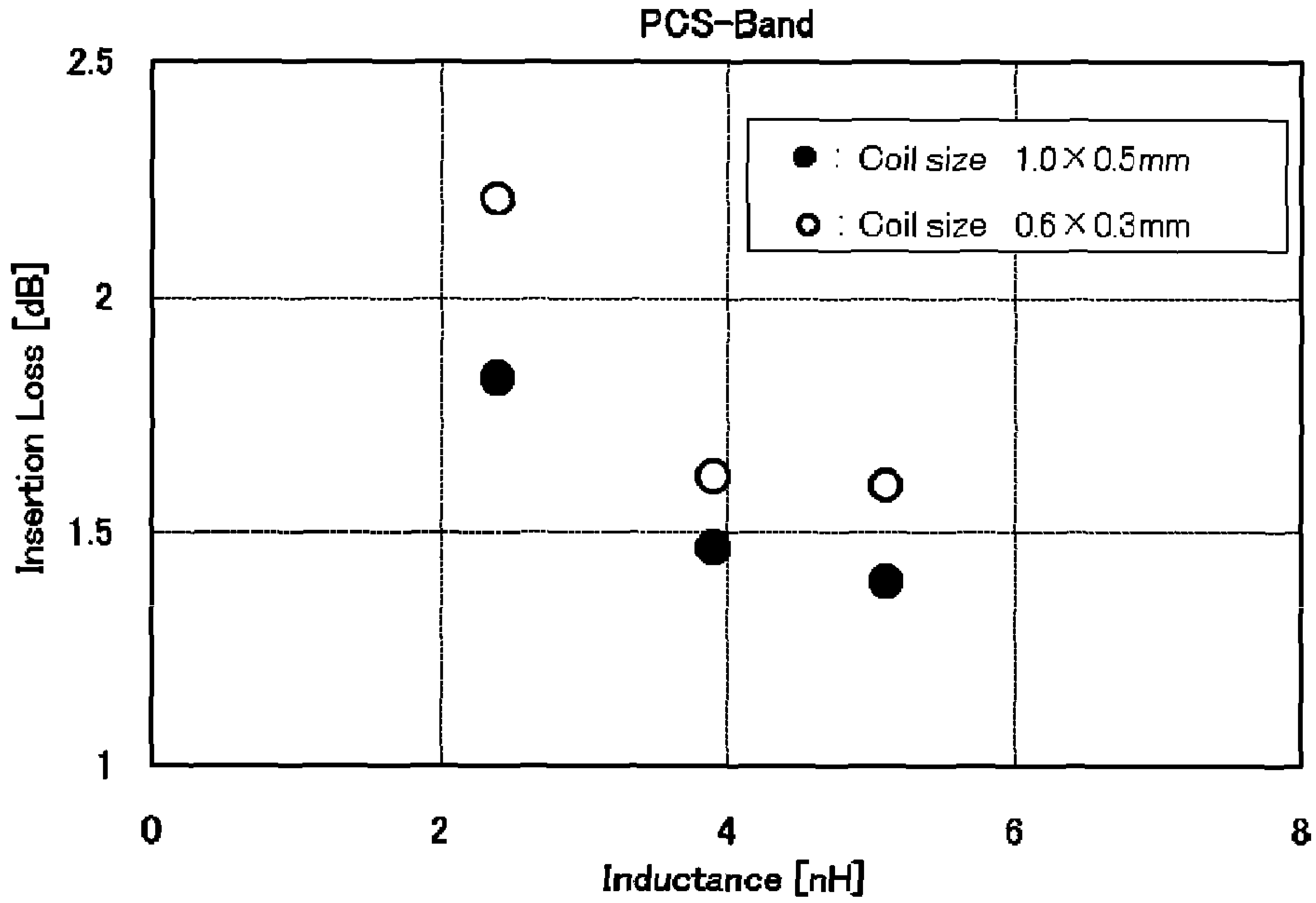

PCS-Band
2.5
2
1.5
1
0
2
4
6
8
Insertion Loss [dB]
Inductance [nH]
● : Coil size 1.0×0.5mm
○ : Coil size 0.6×0.3mm

FIG. 7

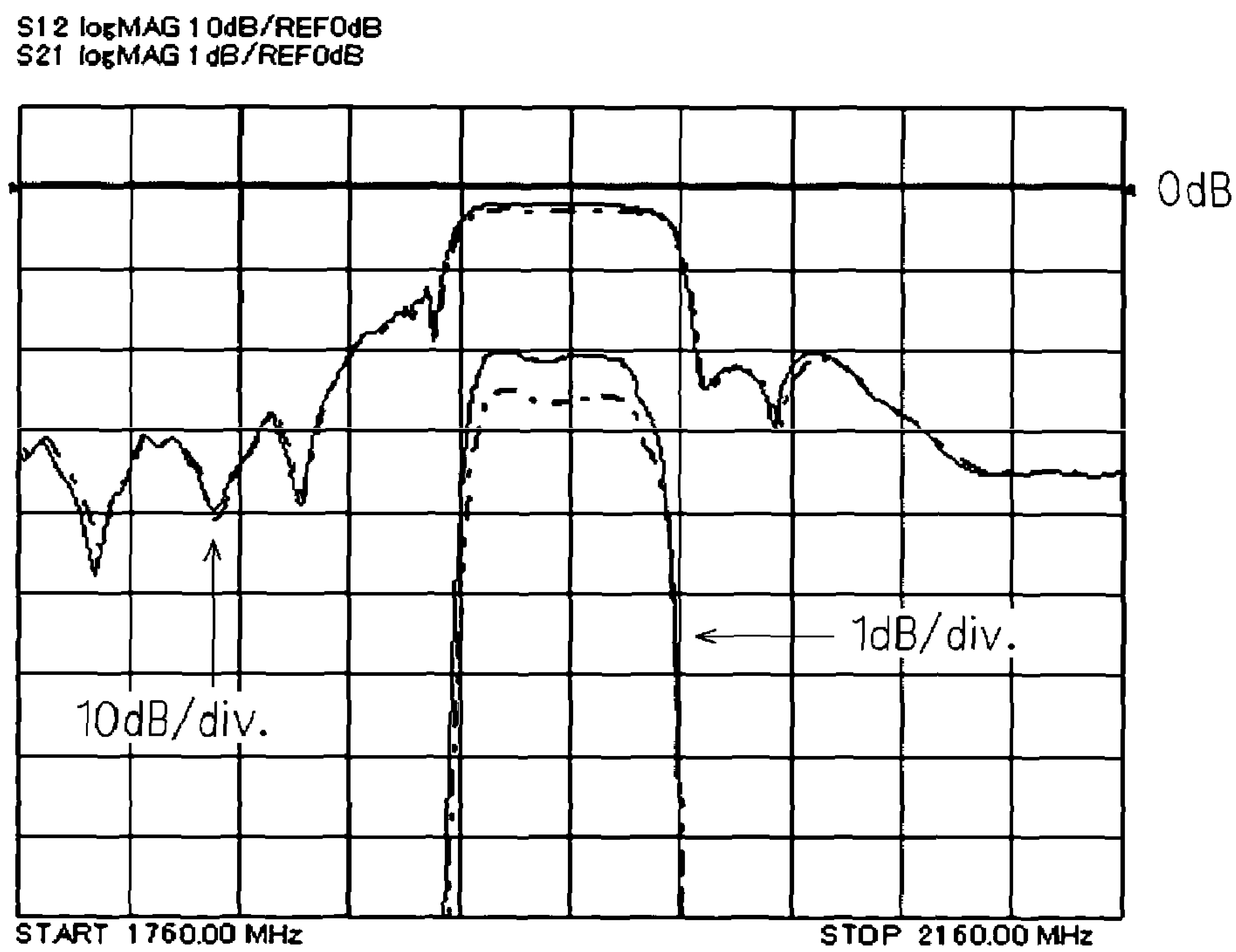

S12 logMAG 10dB/REF0dB
S21 logMAG 1dB/REF0dB
0dB
1dB/div.
10dB/div.
START 1760.00 MHz
STOP 2160.00 MHz

FIG. 8
PRIOR ART

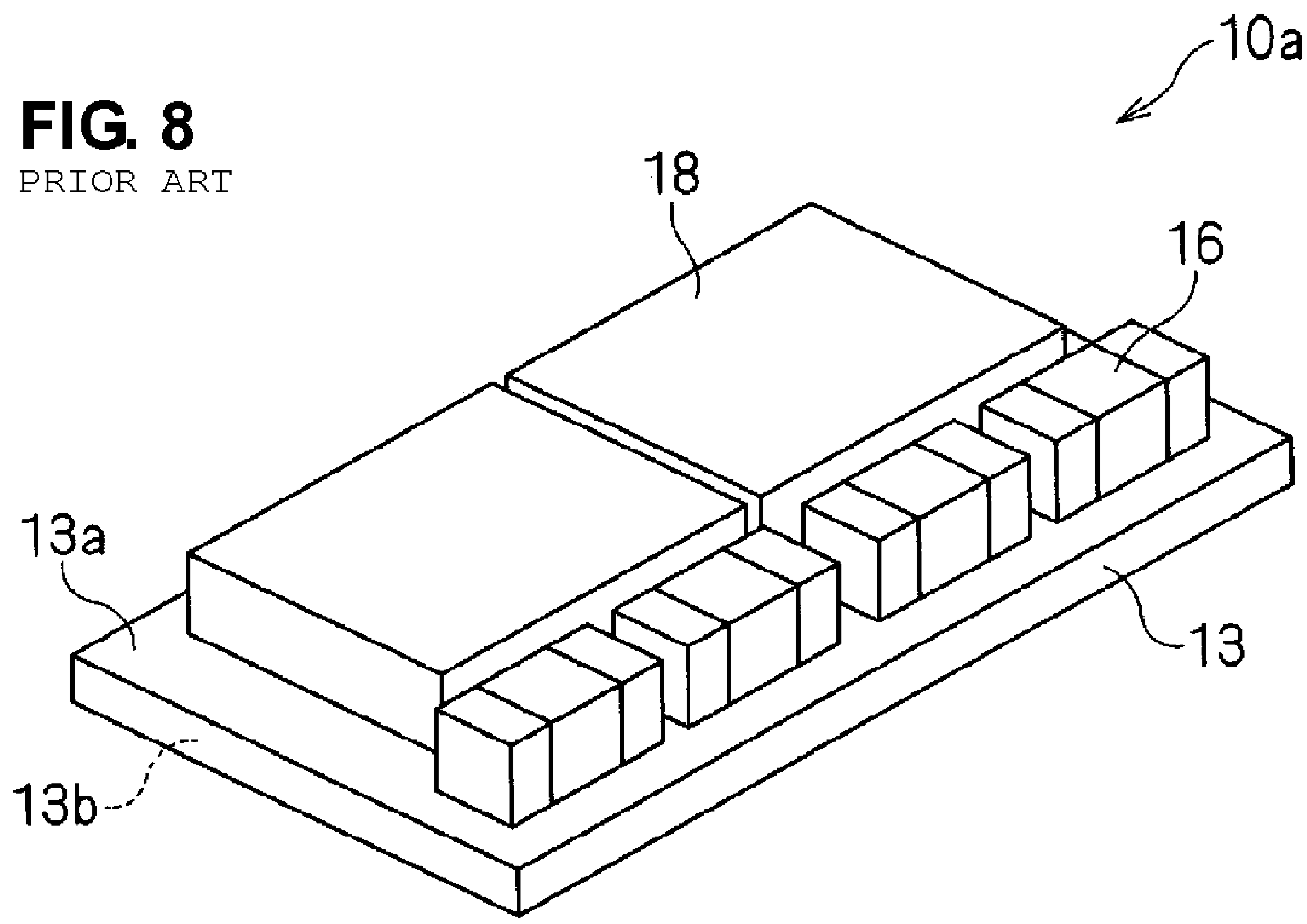


FIG. 9
PRIOR ART

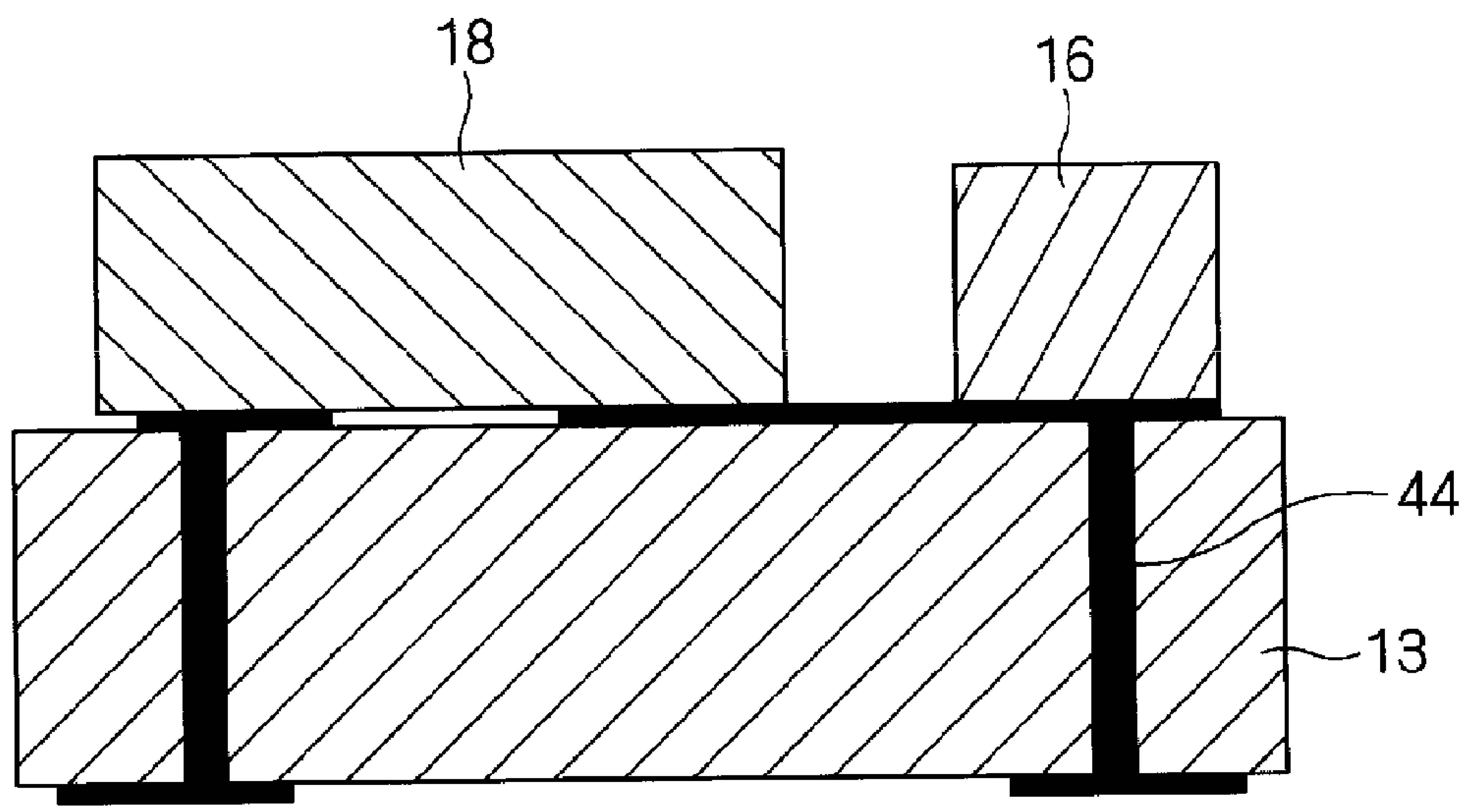


FIG. 10
PRIOR ART

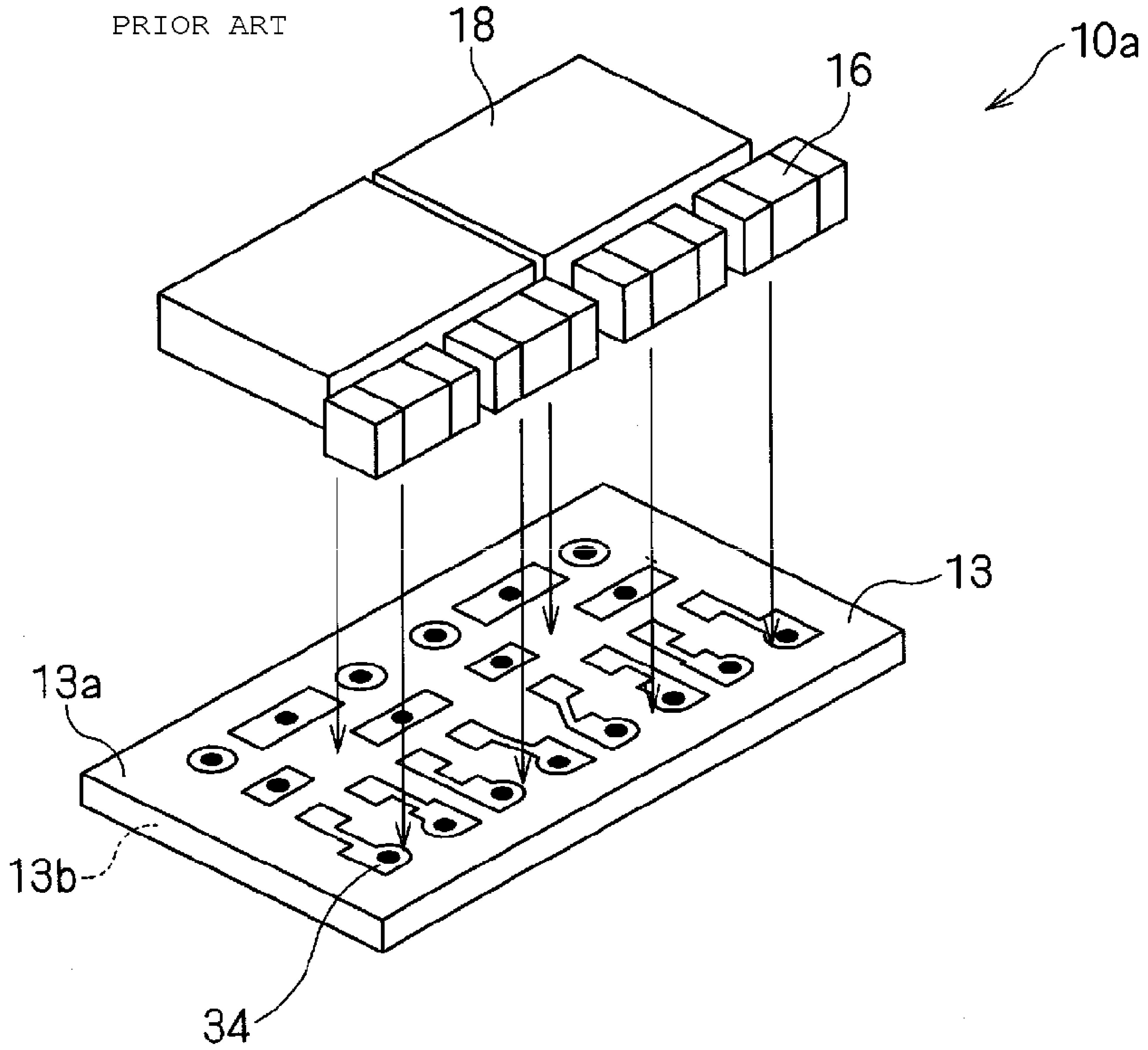


FIG. 11A
PRIOR ART

FIG. 11B
PRIOR ART

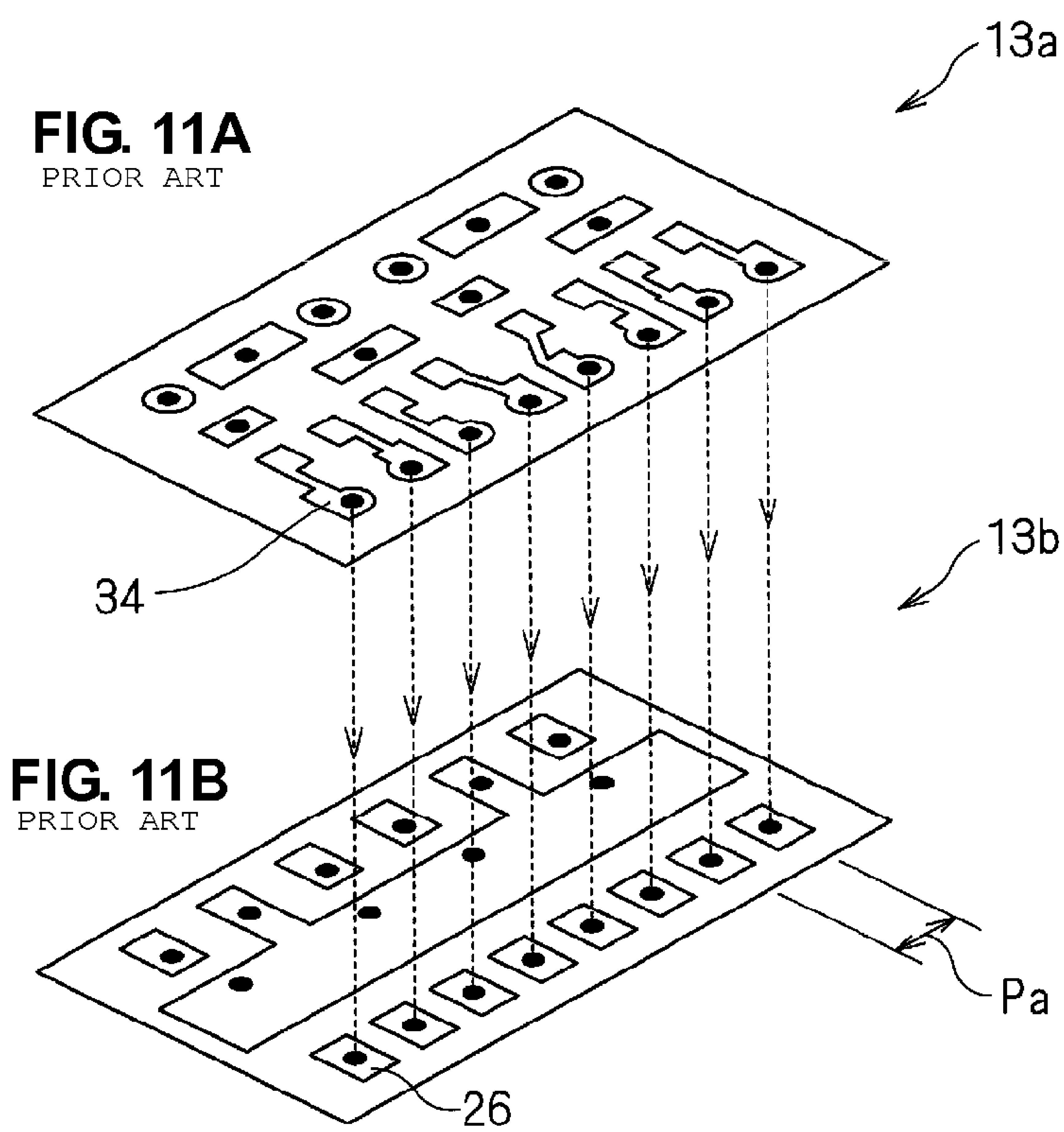


FIG. 12
PRIOR ART

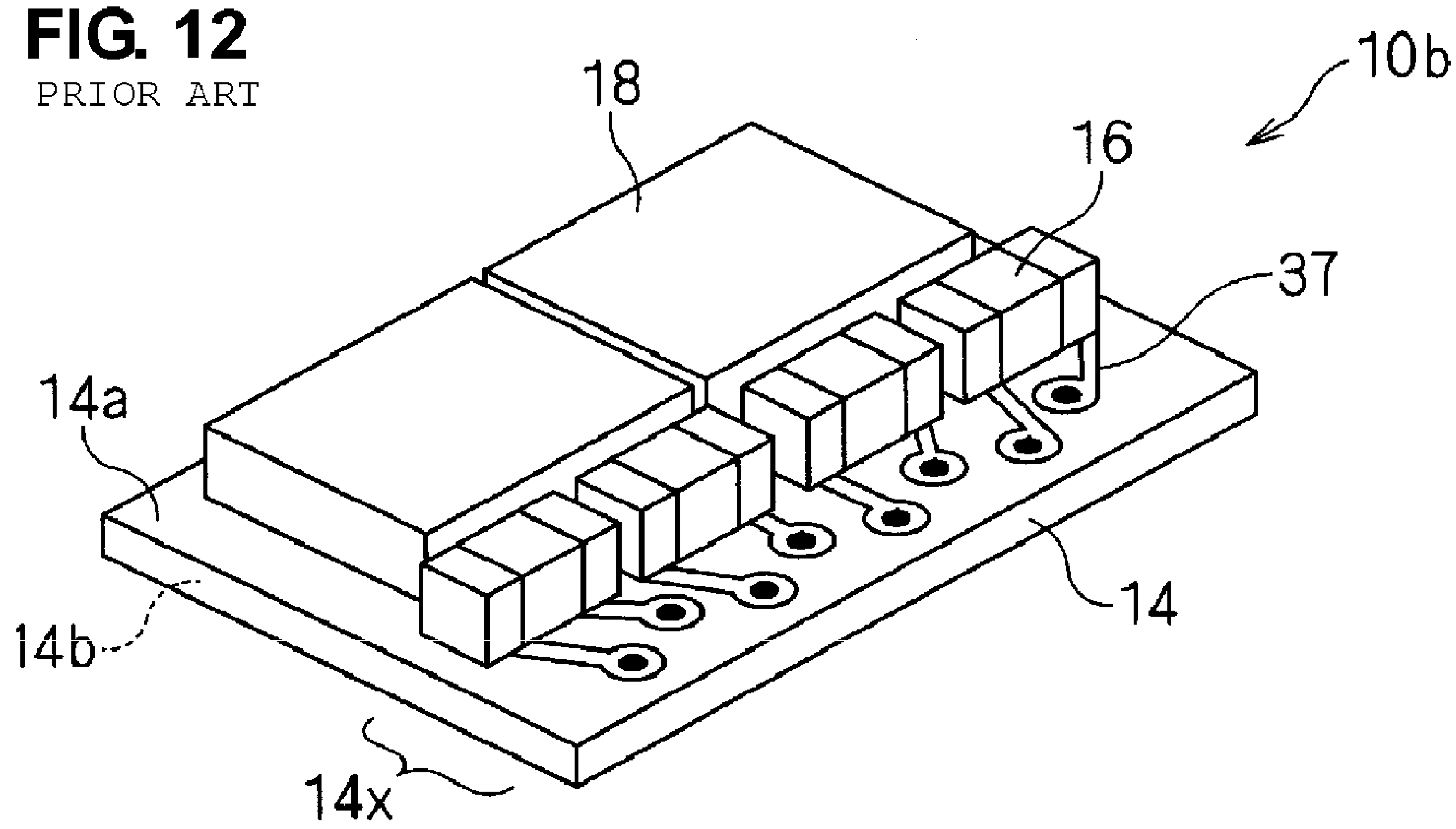


FIG. 13
PRIOR ART

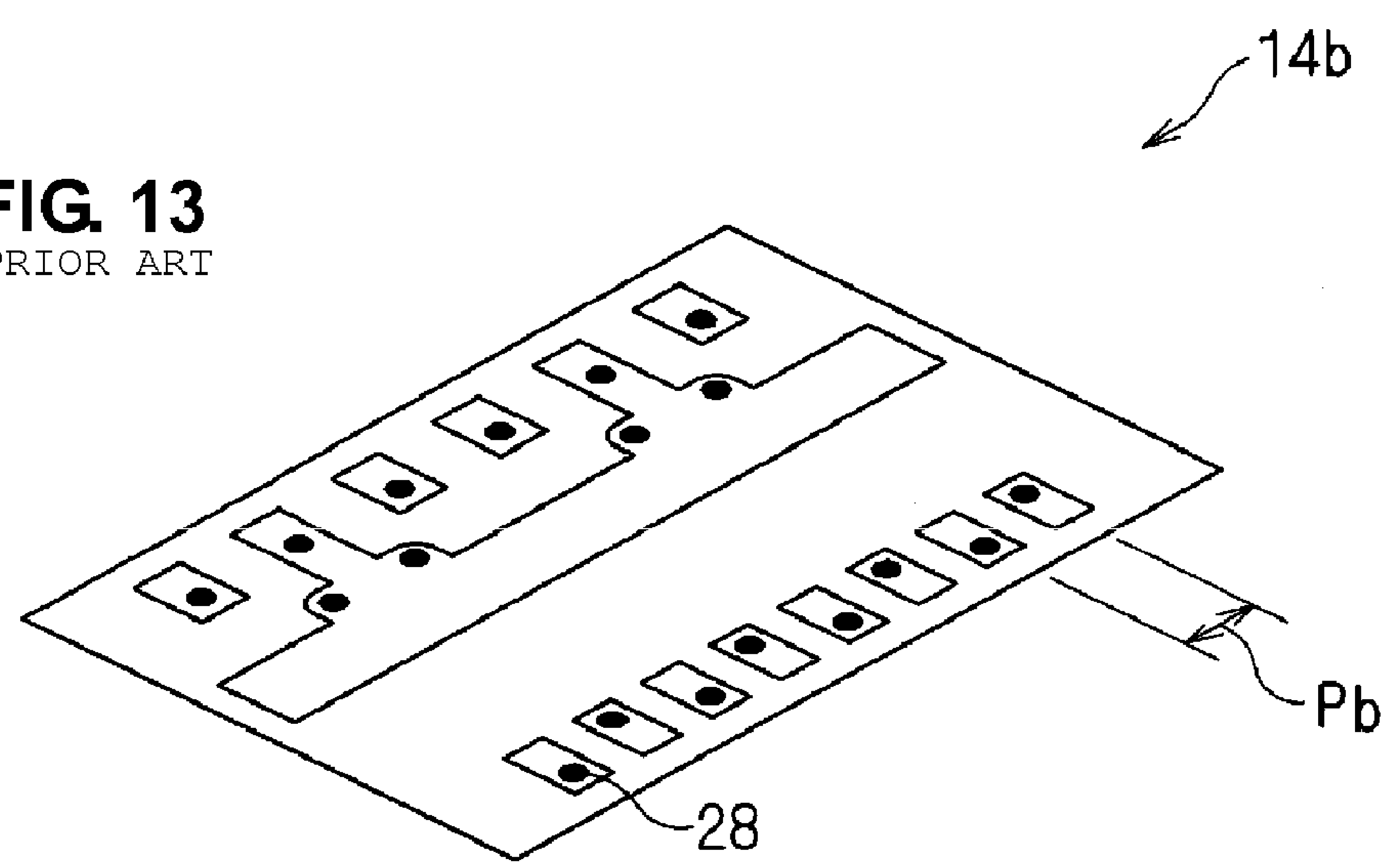


FIG. 14
PRIOR ART

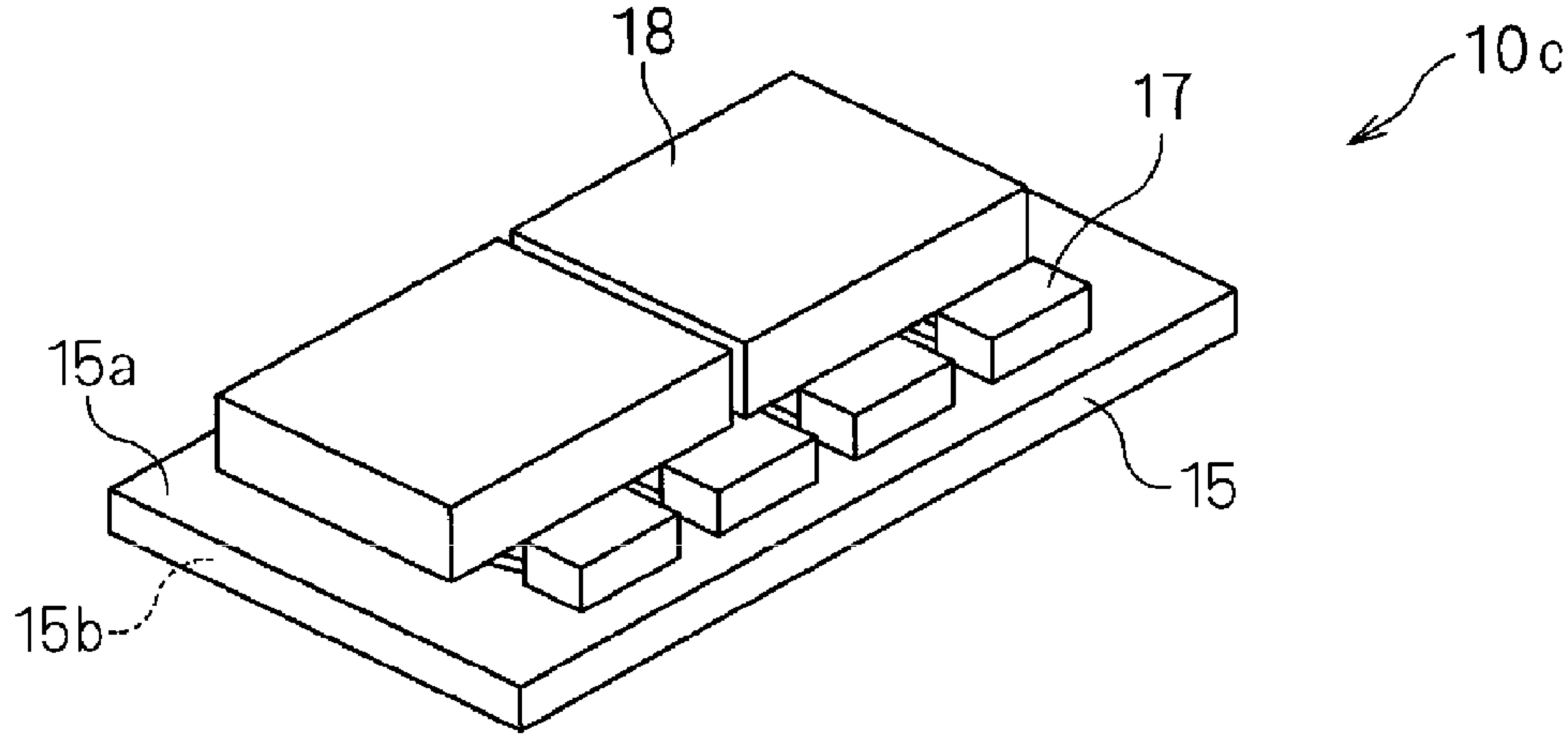


FIG. 15A
PRIOR ART

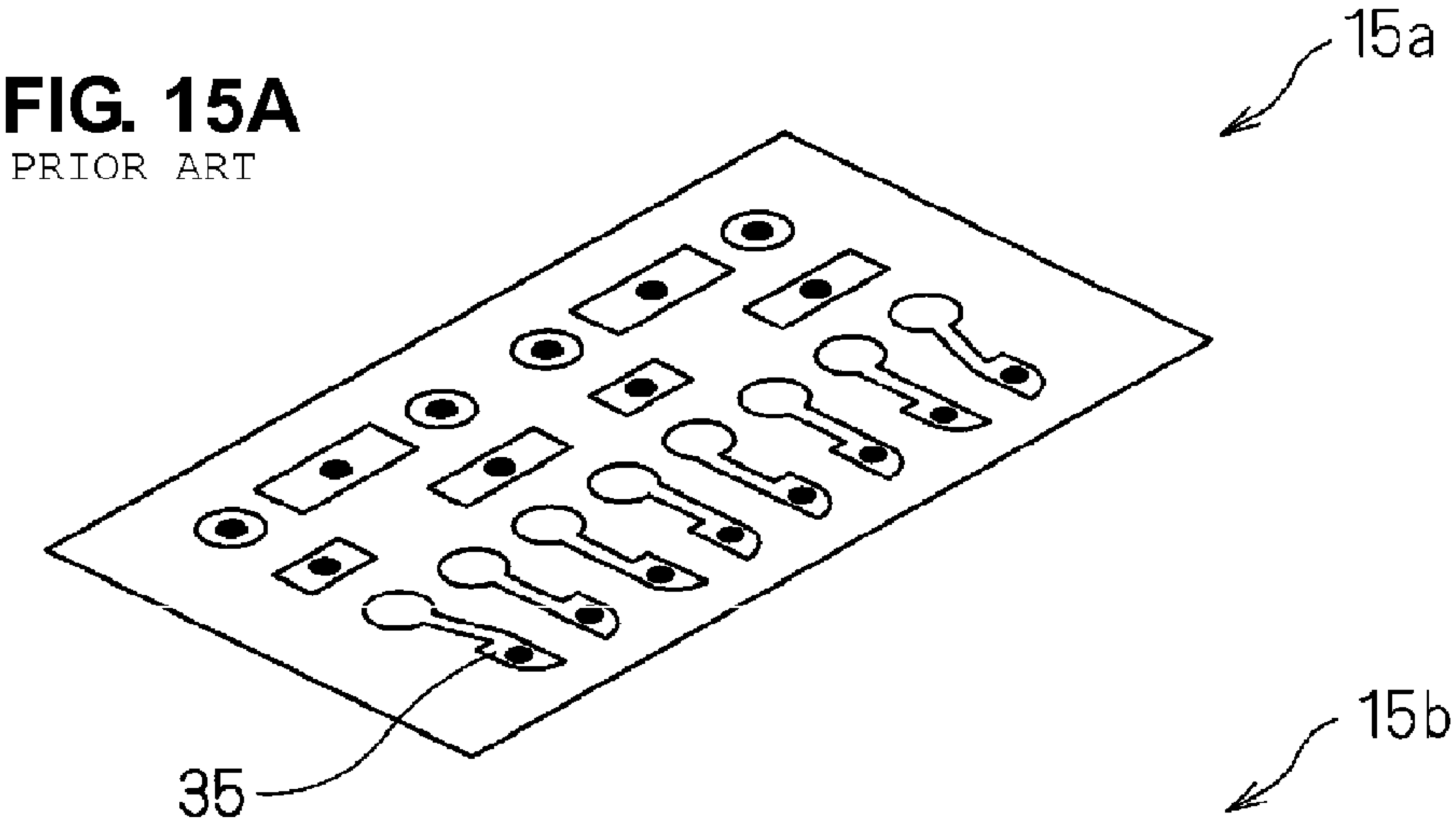


FIG. 15B
PRIOR ART

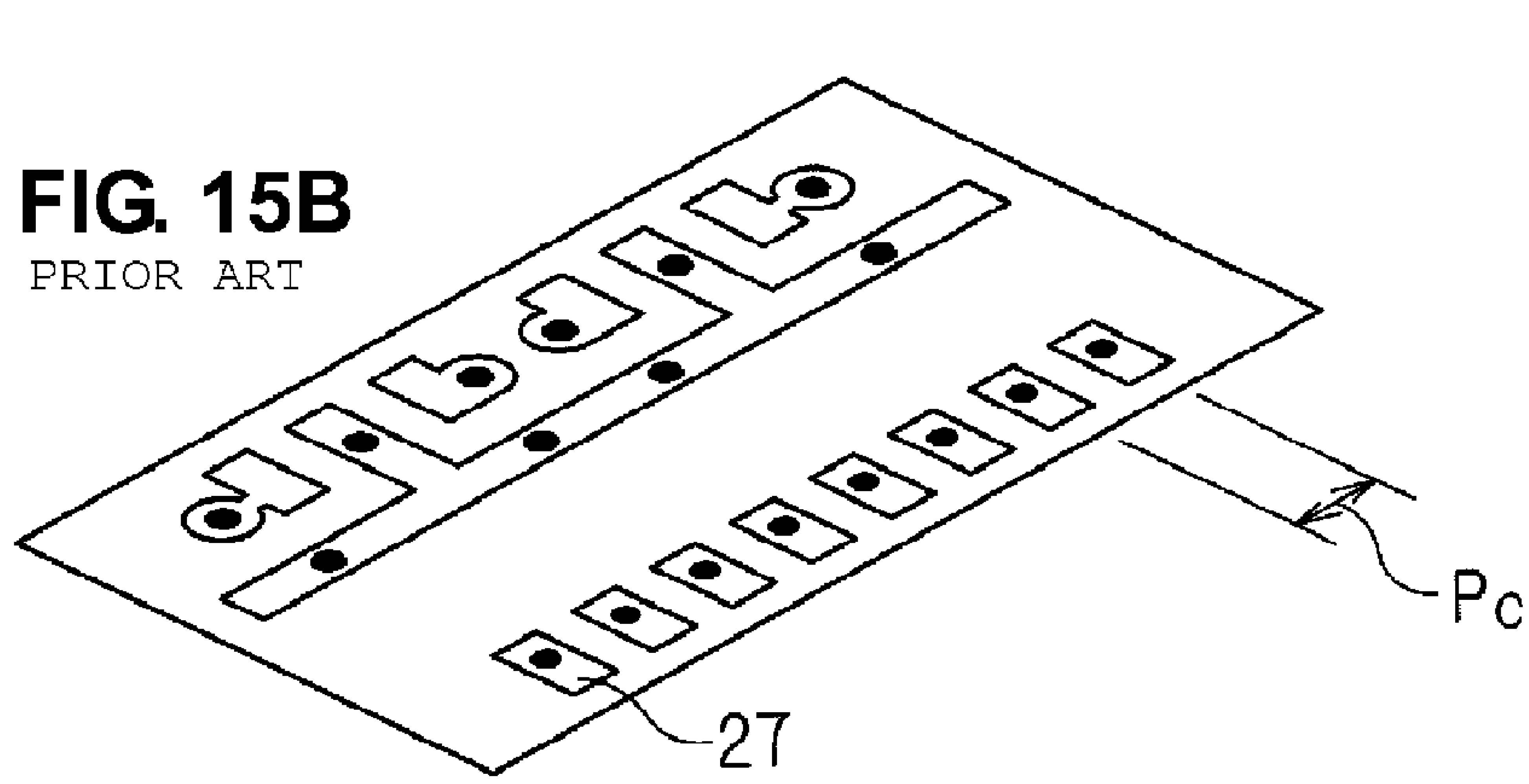


FIG. 16
PRIOR ART

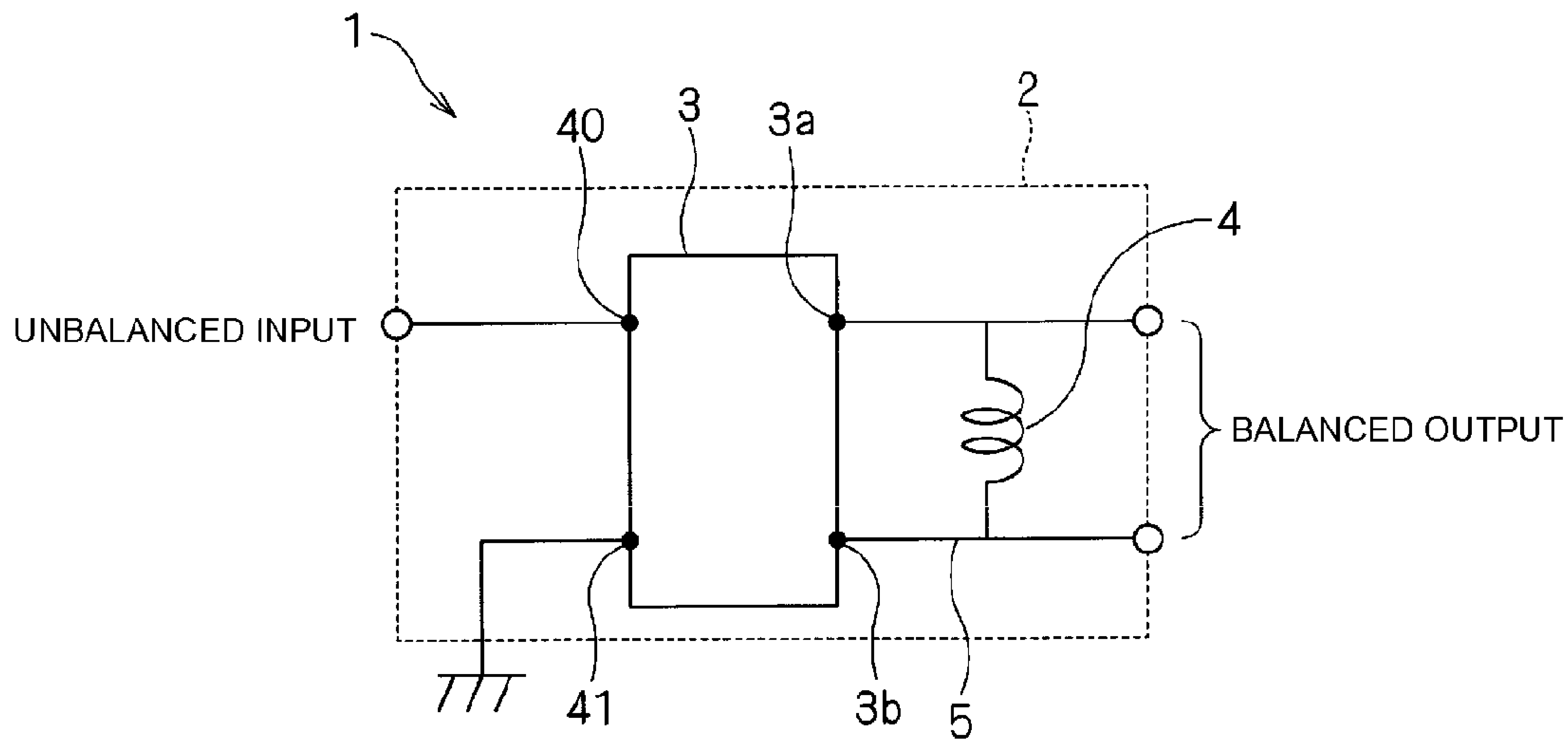
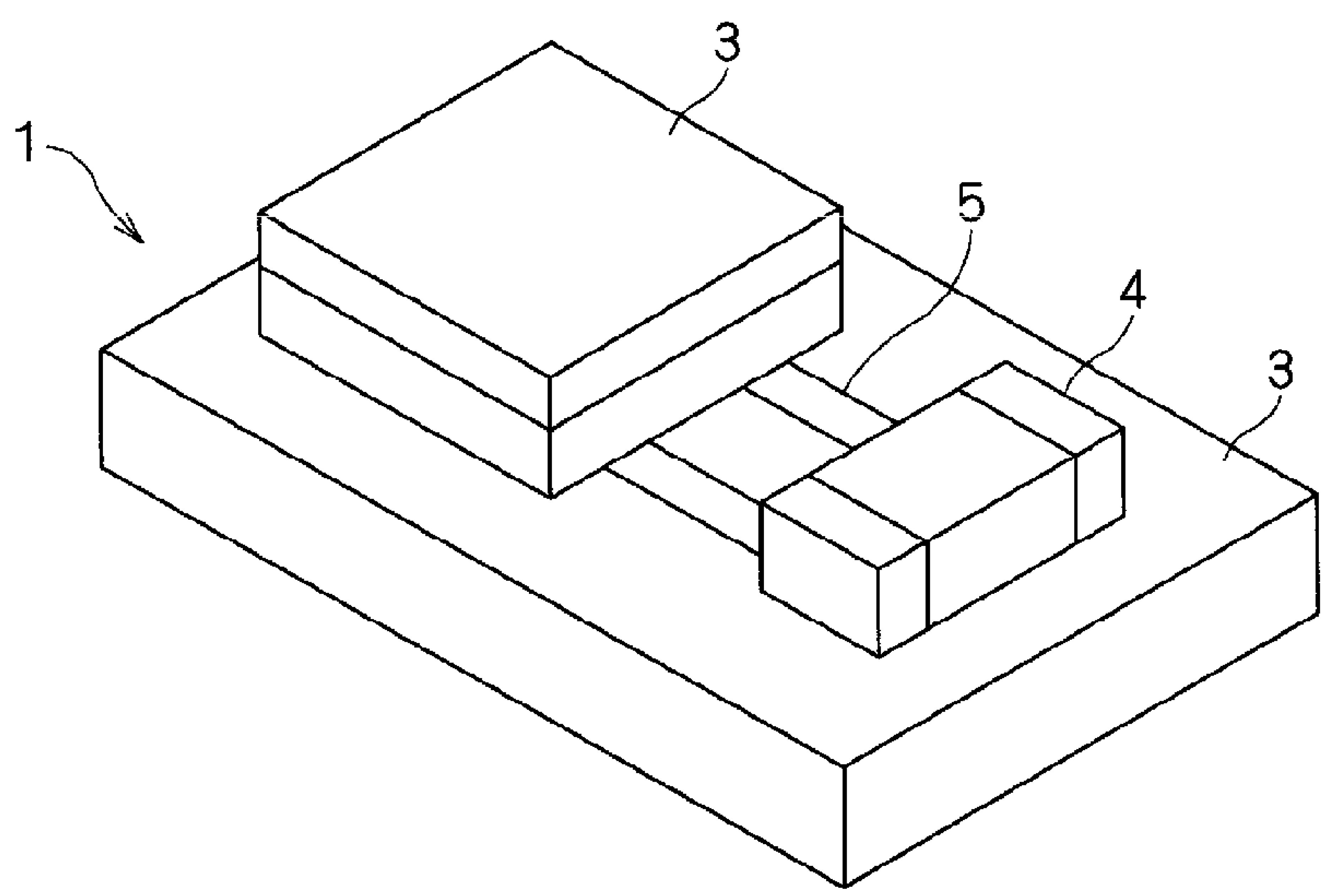


FIG. 17
PRIOR ART



HIGH-FREQUENCY MODULE INCLUDING CONNECTION TERMINALS ARRANGED AT A SMALL PITCH

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to high-frequency modules, and particularly, to a high-frequency module including a surface acoustic wave device or a boundary wave device.

2. Description of the Related Art

Conventionally, high-frequency modules including a surface acoustic wave filter are used in mobile phones and other suitable devices.

For example, a high-frequency module **1**, as illustrated in an electric circuit diagram in FIG. **16** and a perspective view in FIG. **17**, includes an inductor **4** that is arranged across balanced output terminals **3**a and **3**b of a surface acoustic wave element **3** on a top surface of an insulating substrate **2**, the surface acoustic wave element **3** and the inductor **4** are connected through connection lines **5** provided on the top surface of the insulating substrate **2**, and a terminal of the inductor **4** and a connection terminal (not shown) are provided on the bottom surface of the insulating substrate **2** and connected by a via-hole conductor (not shown) in the insulating substrate **2** (See, for example, Japanese Unexamined Patent Application Publication No. 2003-142981).

When the configuration of the conventional art described above is used, for example, a high-frequency module **10**a in which a plurality of surface acoustic wave filters **18** and inductors **16** are mounted on a top surface **13**a of an insulating substrate **13** may be provided, as illustrated in a perspective view in FIG. **8**, a cross-sectional view in FIG. **9**, an exploded perspective view in FIG. **10**, and a perspective view of insulating substrate top and bottom surfaces in FIGS. **11**A and **11**B.

In this case, as illustrated in FIG. **9** and FIGS. **11**A and **11**B, mounting lands **34** for mounting the inductors **16**, and connection terminals **26** on a bottom surface **13**b of the insulating substrate **13** are respectively connected to opposite ends of via-hole conductors **44**. Thus, the pitch Pa of the mounting lands **34** for mounting the inductors **16** and the pitch of the connection terminals **26** on the bottom surface **13**b of the insulating substrate **13** must be substantially equal.

Meanwhile, for high-frequency modules for mobile phones and other suitable devices, a reduced size and a decrease in the pitch of connection terminals are required.

To decrease only the pitch of connection terminals, as in a high-frequency module **10**b illustrated in a perspective view in FIG. **12** and a perspective view in FIG. **13** of an insulating substrate bottom surface viewed from the top surface side, extension portions **37** extending from the mounting lands for mounting inductors are provided on a top surface **14**a of an insulating substrate **14**, and via-hole conductors are provided downward from the extension portions **37**, so that a pitch Pb of connection terminals **28** on the bottom surface **14**b of the insulating substrate **14** may be decreased. In this case, an extra space **14**x for providing the extension portions **37** is required on the insulating substrate **14**. This causes an increase in the dimensions of the product, and thus has adverse effects on the reduction in size of high-frequency modules.

To decrease the pitch of connection terminals while maintaining a reduced product size, as in a high-frequency module **10**c illustrated in a perspective view in FIG. **14**, a plan view in FIG. **15**A of an insulating substrate top surface, and a perspective view in FIG. **15**B of an insulating substrate bottom surface viewed from the top surface side, the size of elements **17** to be mounted on a top surface **15**a of an insulating substrate **15** may be decreased. In this case, it is necessary to select the elements **17** having a size suitable for the pitch of connection terminals **27** on a bottom surface **15**b of the insulating substrate **15**. Thus, a pitch Pc of the connection terminals **27** is restricted by the size of the elements **17**. In addition, there is a limitation in the manufacturing technique for decreasing a distance between via-hole conductors. Therefore, the pitch Pc of the connection terminals **27** can only be decreased to a certain extent.

SUMMARY OF THE INVENTION

To overcome the problems described above, preferred embodiments of the present invention provide a high-frequency module which enables the pitch of connection terminals to be freely decreased without an adverse effect on size reduction.

A high-frequency module according to a preferred embodiment of the present invention includes (a) a substrate in which a plurality of connection terminals arranged to be connected to another circuit **[**is**]** *are* provided on one main surface thereof, *and a plurality of mounting lands are provided on the other main surface thereof,* (b) at least one filter device having at least one set of an unbalanced terminal and two balanced terminals, which is mounted at one side of the other main surface of the substrate, and (c) at least one element electrically connected to the filter device, which is mounted at the opposite side to the filter device on the other main surface of the substrate. *The plurality of mounting lands includes at least two balanced mounting lands connected to the balanced terminals of the at least one filter device, and at least two element mounting lands connected to the at least one element. On the other main surface of the substrate, at least two connection wires are arranged so as to connect the at least two balanced mounting lands and the at least two element mounting lands, respectively. On the one main surface of the substrate, at least two connection lines are provided. In a mounting area of the substrate, via-hole conductors are provided so as to penetrate the substrate from the one main surface to the other main surface.* At least two of the plurality of connection terminals (hereinafter referred to as "specific connection terminals") are arranged on the one main surface of the substrate at the same side as the *at least one* element so as to be spaced from *the* via-hole conductors**[**penetrating the substrate from inside a mounting area for mounting the filter device on the other main surface of the substrate to the one main surface of the substrate**]**, *and are connected to first ends of the at least two connection lines.* **[**At least two connection lines respectively electrically connecting the specific connection terminals and the via-hole conductors are provided on the one main surface of the substrate.**]** *First ends of via-hole conductors are connected to the at least two balanced mounting lands, and second ends of via-hole conductors are connected to second ends of the at least two connection lines.* The pitch of the specific connection terminals *connected to the at least two connection lines* is less than the pitch of the **[**via-hole conductors respectively**]** *element mounting lands* electrically connected to the specific connection terminals via *the at least two connection wires, the at least two balanced mounting lands, the via-hole conductors, and* the *at least two* connection lines.

With the above-described configuration, by setting the pitch of the specific connection terminals to be less than the pitch of the via-hole conductors connected to the specific connection terminals via the connection lines, the pitch of the specific connection terminals can be decreased. Since the specific connection terminals can be designed without being restricted by the pitch of the via-hole conductors, the size of the high frequency module can be reduced.

Specifically, when via-hole conductors are provided below mounting lands of elements and connection terminals are provided near the ends of the via-hole conductors on the other side of the substrate, as in the conventional art, the pitch of the connection terminals is restricted by the pitch of the mounting lands of the elements. However, there is no such restriction in the above-described configuration.

Note that the filter device may be any type of filter device, such as a SAW filter utilizing a surface acoustic wave and a BAW filter utilizing a bulk wave.

Preferably, the filter device (1) includes at least two sets of the unbalanced terminal and the two balanced terminals and includes at least two sets of filters corresponding to at least two bands, and (2) is arranged on the other main surface of the substrate so that the balanced output terminals are adjacent to the elements.

In this case, the pitch of the connection terminals (specific connection terminals) connected to the balanced terminals of the filter device can be decreased.

Preferably, the elements are inductors connected in parallel across at least one set of the two balanced terminals of the filter device.

In this case, the characteristics of the filter device can be improved by the inductors. The pitch of the specific connection terminals can be set regardless of the size of the elements (inductors), which facilitates the selection of the elements.

According to preferred embodiments of the present invention, it is possible to freely decrease the pitch of the connection terminals without adversely effecting downsizing and without causing characteristic degradation.

Other features, elements, processes, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments of the present invention with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a surface acoustic wave device according to a preferred embodiment of the present invention.

FIG. **2** is a cross-sectional view of the surface acoustic wave device shown in FIG. **1**.

FIG. **3** is an exploded perspective view of the surface acoustic wave device shown in FIG. **1**.

FIG. **4** is a plan view of a top surface of a substrate, and a perspective view of a bottom surface of the substrate viewed from the substrate top surface side of the surface acoustic wave device shown in FIG. **1**.

FIG. **5** is an electric circuit diagram of a high frequency module using the surface acoustic wave device shown in FIG. **1**.

FIG. **6** is a graph of the insertion loss of an inductor.

FIG. **7** is a graph of the output impedance of an inductor.

FIG. **8** is a perspective view of a conventional surface acoustic wave device.

FIG. **9** is a cross-sectional view of the conventional surface acoustic wave device shown in FIG. **8**.

FIG. **10** is an exploded perspective view of the conventional surface acoustic wave device shown in FIG. **8**.

FIG. **11**A is a plan view of a substrate top surface, and FIG. **11**B is a perspective view of a substrate bottom surface viewed from the substrate top surface side of the conventional surface acoustic wave device shown in FIG. **8**.

FIG. **12** is a perspective view of a conventional surface acoustic wave device.

FIG. **13** is a perspective view of a substrate bottom surface of the conventional surface acoustic wave device shown in FIG. **12**.

FIG. **14** is a perspective view of a conventional surface acoustic wave device.

FIG. **15**A is a plan view of a substrate top surface, and FIG. **15**B is a perspective view of a substrate bottom surface viewed from the substrate top surface side of the conventional surface acoustic wave device shown in FIG. **14**.

FIG. **16** is an electric circuit diagram of a conventional surface acoustic wave device.

FIG. **17** is a perspective view of a conventional surface acoustic wave device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following, preferred embodiments of the present invention will be described with reference to FIGS. **1** to **7**.

As illustrated in a perspective view in FIG. **1**, in a surface acoustic wave filter device **10**, two SAW filter devices **18**a and **18**b and four inductors **16** are mounted on a top surface of a printed substrate **12**.

The SAW filter devices **18**a and **18**b are balanced output type dual SAW filters in each of which two sets of SAW filters having one unbalanced input electrode and two balanced output electrodes are provided. The inductors **16** are matching elements arranged to provide matching between the individual SAW filters of the SAW filter devices **18**a and **18**b.

As illustrated in FIG. **2**, which is a cross-sectional view taken along a line II-II in FIG. **1**, via-hole conductors **40** and **42** extending from a top surface **12**a to a bottom surface **12**b are provided in the printed substrate **12**. The via-hole conductors **40** and **42** are made of a conductive material.

As illustrated in an exploded perspective view in FIG. **3** and a plan view in FIG. **4** of the top surface **12**a of the printed substrate **12**, on the top surface **12**a of the printed circuit substrate **12**, mounting lands **30**, **31**, **32**, and **39** arranged to be connected to external electrodes (not shown) of the SAW filter devices **18**a and **18**b are disposed in individual areas **15** for mounting the SAW filter devices **18**a and **18**b.

Specifically, in each of the areas **15**, two mounting lands **31** respectively connected to the unbalanced signal input electrodes of the SAW filter devices **18**a and **18**b (hereinafter also referred to as "unbalanced mounting lands") are arranged at opposite sides of one of the mounting lands **30** connected to ground electrodes (not shown) of the SAW filter devices **18**a and **18**b, along one side **12**p of a pair of opposing sides of the top surface **12**a of the printed substrate **12**. On the other side **12**q of the pair of opposing sides of the top surface **12**a of the printed substrate **12**, four mounting lands **32** respectively connected to the balanced input electrodes of the SAW filter devices **18**a and **18**b (hereinafter referred to as "balanced mounting lands") are arranged. Two mounting lands **39** connected to other ground electrodes (not shown) of the SAW filter devices **18**a and **18**b are arranged between the mounting lands **30** and **31**, and the mounting lands **32**.

Eight mounting lands **34** respectively connected to electrodes of the four inductors **16** (hereinafter also referred to as inductor mounting lands) are arranged along the other side **12**q of the pair of opposing sides of the top surface **12**a of the printed substrate **12**.

The eight inductor mounting lands **34** are respectively electrically connected to the eight balanced mounting lands **32** through connection lines **33**. The eight inductor mounting lands **34** are arranged in a substantially straight line along the other side **12**q of the pair of opposing sides of the top surface **12**a of the printed substrate **12** and the eight mounting lands **32** are arranged in a substantially straight line along the other side **12**q of the pair of opposing sides of the top surface **12**a of the printed substrate **12**.

As illustrated in a perspective view in FIG. **4** of the bottom surface **12**b of the printed substrate **12** viewed from the side of the top surface **12**a, on the bottom surface **12**b of the printed substrate **12**, four unbalanced signal input terminals **21**a, **21**b, **21**c, and **21**d defining connection terminals for connecting to another circuit and two ground terminals **20** are arranged along one side **12**s of a pair of opposing sides of the bottom surface **12**b of the printed substrate **12**. In addition, four pairs of balanced signal output terminals **22**a and **22**b, **23**a and **23**b, **24**a and **24**b, and **25**a and **25**b defining connection terminals are arranged along the other side **12**t of the pair of opposing sides of the bottom surface **12**b of the printed substrate **12**.

In FIGS. **3** and **4**, black ellipses represent ends of via-hole conductors **40**a and **40**b, and **42**a and **42**b. As illustrated in FIG. **4**, the balanced signal output terminals **22**a and **22**b, **23**a and **23**b, **24**a and **24**b, and **25**a and **25**b are respectively connected to one end of connection lines **23**. The other end **24** of the connection lines **23** are respectively connected to the ends **42**b of the via-hole conductors **42**. The other ends **42**a of the via-hole conductors **42**a are connected to the balanced mounting lands **32**.

The inductor mounting lands **34** and the balanced signal output terminals **22**a and **22**b, **23**a and **23**b, **24**a and **24**b, and **25**a and **25**b are connected via connection wires **33**, the via-hole conductors **42**, and the connection lines **23** and are not directly connected through the opposite ends of the via-hole conductors. Thus, the pitch P of the balanced signal output terminals **22**a and **22**b, **23**a and **23**b, **24**a and **24**b, and **25**a and **25**b can be set to be less than the pitch of the inductor mounting lands **34**.

The surface acoustic wave device **10** is mounted on a substrate of an antenna circuit module and defines portions indicated by reference numerals **10**a and **10**b in an antenna circuit AC**2** illustrated in FIG. **5**. In the circuit diagram in FIG. **5**, portions corresponding to the unbalanced signal input terminals **21**a, **21**b, **21**c, and **21**d and the balanced output terminals **22**a and **22**b, **23**a and **23**b, **24**a and **24**b, and **25**a and **25**b are denoted by the same reference numerals. The SAW filter device **18**a is defined by SAW filter circuits SAW**1** and SAW**2**, and the SAW filter device **18**b is defined by SAW filter circuits SAW**3** and SAW**4**. The inductors **16** are defined by coils L**61**, L**62**, L**63**, and L**64**.

In the antenna circuit AC**2**, a low-pass filter circuit LPF**1** is provided in a signal path connecting an antenna terminal ANT and a diplexer circuit DP. In the diplexer circuit DP, a low-pass filter LPF **2** is provided in a signal path connecting to a switch circuit SW**12**, and a high-pass filter HPF is provided in a signal path connecting to a switch circuit SW**34**.

The switch circuit SW**12** performs switching of signal paths for GSM850/EGSM systems.

The balanced SAW filter circuit SAW**1** is connected in a signal path connecting the switch circuit SW**12** to receiving terminals RX**1**a and RX**1**b. The coil L**61** is connected across the receiving terminals RX**1**a and RX**1**b. This SAW filter circuit SAW**1** passes signals in a reception frequency band of GSM850 standard (about 0.869 GHz to about 0.894 GHz) and attenuates signals at other frequencies.

The balanced SAW filter circuit SAW**2** is connected in a signal path connecting the switch circuit SW**12** to receiving terminals RX**2**a and RX**2**b. The coil L**62** is connected across the receiving terminals RX**2**a and RX**2**b. This SAW filter circuit SAW**2** passes signals in a reception frequency band of EGSM standard (about 0.925 GHz to about 0.960 GHz) and attenuates signals at other frequencies. A low-pass filter LPF**3** is provided in a signal path connecting the switch circuit SW**12** and a transmission terminal TX**12**.

The balanced SAW filter circuit SAW**3** is connected in a signal path connecting the switch circuit SW**34** to receiving terminals RX**3**a and RX**3**b. The coil L**63** is connected across the receiving terminals RX**3**a and RX**3**b. This SAW filter circuit SAW**3** passes signals in a reception frequency band of a DCS system (about 1.805 GHz to about 1.880 GHz) and attenuates signals at other frequencies.

The balanced SAW filter circuit SAW**4** is connected in a signal path connecting the switch circuit SW**34** to receiving terminals RX**4**a and RX**4**b. The coil L**64** is connected across the receiving terminals RX**4**a and RX**4**b. This SAW filter circuit SAW**4** passes signals in a reception frequency band of a PCS standard (about 1.930 GHz to about 1.990 GHz) and attenuates signals at other frequencies.

With this circuit configuration, the antenna switching AC**2** performs switching of signal paths between one antenna portion and each of the four transmission/reception systems of GSM850, EGSM, DCS, and PCS systems.

The high-frequency module described above allows the pitch of the connection terminals to be freely decreased without adversely effecting downsizing.

Specifically, by connecting the lower ends of via-hole conductors provided on lower portions of the balanced output terminals of SAW filters and connection terminals through connection line, the pitch of terminals on a product bottom surface can be freely changed.

Since elements and connection terminals can be connected through a path in a space in which SAW filters and elements are arranged, downsizing of products can be achieved.

In addition, the element size can be selected without regard to the intervals of terminals on the bottom surface. This increases the degree of freedom in element selection, and the downsizing of elements permits downsizing of substrates and high-frequency modules.

At present, IC terminals with a pitch of about 0.50 mm have become the mainstream along with their downsizing. Thus, the pitch of about 0.50 mm is also required for balanced signal input terminals of a high-frequency module. By using the high-frequency module according to this preferred embodiment, balanced signal input terminals with a pitch of about 0.50 mm can be obtained even when an inductor having a size of about 1.0×about 0.5 mm with a good Q is used as the coil L**61** in FIG. **5**. On the other hand, to obtain balanced signal input terminals with the about 0.50 mm pitch in the conventional art, it is necessary to use an inductor having a size of about 0.6×about 0.3 with a bad Q as the coil L**61** in FIG. **5**.

FIG. **7** illustrates output impedances of the balanced signal output terminals **22**a and **22**b of the SAW filter circuit SAW**1** obtained when an inductor of about 1.0 mm×about 0.5 mm size with a good Q and an inductor of about 0.6 mm×about 0.3 size with a bad Q were used. The solid line represents the output impedance obtained when the inductor of about 1.0 mm×about 0.5 mm size was used, and the chain line represents the output impedance obtained when the inductor of about 0.6 mm×about 0.3 mm size was used. FIG. **6** is a graph comparing the insertion loss of the inductor of about 1.0 mm×about 0.5 mm size and the insertion loss of the inductor of about 0.6 mm×about 0.3 mm size.

It can be seen from FIG. **7** that the pass band characteristic is degraded to a lesser extent when the inductor of about 1.0 mm×about 0.5 mm size with a good Q is used as the coil L**61** according to an example of preferred embodiments of the present invention.

Note that the present invention is not limited to the preferred embodiments described above, and may include various modifications.

For example, the filter device to be mounted on a substrate is not limited to a SAW (surface acoustic wave) device, and instead may be a BAW (bulk wave) device. In addition, an element other than an inductor may be connected to the filter device.

While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

What is claimed is:

1. A high-frequency module comprising:

a substrate [having] *including* a first main surface and a second main surface, [and including] a plurality of connection terminals arranged to be connected to another circuit and provided on the first main surface of the substrate*, and a plurality of mounting lands provided on the second main surface*;

at least one filter device mounted at a first side of the second main surface of the substrate, the at least one filter device including at least one set of an unbalanced terminal and two balanced terminals; and

at least one element mounted at a second side opposite to the first side of the second main surface of the substrate, the *at least one* element being electrically connected to the at least one filter device; wherein

the plurality of mounting lands includes at least two balanced mounting lands connected to the balanced terminals of the at least one filter device and at least two element mounting lands connected to the at least one element;

at least two connection wires are provided on the second main surface of the substrate, respectively connecting the at least two balanced mounting lands and the at least two element mounting lands;

at least two connection lines are provided on the first main surface;

via-hole conductors are provided in a mounting area of the substrate to mount the at least one filter device so as to penetrate the substrate from the second main surface to the first main surface;

at least two of the plurality of connection terminals define specific connection terminals[and]*, which* are arranged on the first main surface of the substrate at the second side[,] so as to be spaced from *the* via-hole conductors[penetrating the substrate from inside a mounting area for mounting the at least one filter device on the second main surface of the substrate to the first main surface of the substrate]*, and which are connected to first ends of the at least two connection lines*;

[at least two connection lines respectively electrically connecting the specific connection terminals and the via-hole conductors are provided on the first main surface of the substrate; and] *first ends of the via-hole conductors are respectively connected to the at least two balanced mounting lands, and second ends of the via-hole conductors are respectively connected to second ends of the at least two connection lines; and*

a pitch of the specific connection terminals *connected to the first ends of the at least two connection lines* is less than a pitch of [the via-hole conductors respectively electrically] *the at least two element mounting lands* connected to the specific connection terminals via *the at least two connection wires, the at least two balanced mounting lands, the via-hole conductors, and* the *at least two* connection lines.

2. The high-frequency module according to claim **1**, wherein the at least one filter device includes at least two sets of the unbalanced terminal and the two balanced terminals and at least two sets of filters corresponding to at least two bands, and the *two* balanced terminals are arranged on the second main surface of the substrate, so as to be adjacent to the at least one element.

3. The high-frequency module according to claim **1**, wherein the at least one element is an inductor connected in parallel across [at least one set of] the two balanced terminals of the *at least one* filter device.

* * * * *