



US009271396B2

(12) **United States Patent**  
**Nakamura**

(10) **Patent No.:** **US 9,271,396 B2**  
(45) **Date of Patent:** **Feb. 23, 2016**

(54) **CONDUCTIVE SHEET AND TOUCH PANEL**

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(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 57 days.

(21) Appl. No.: **14/310,702**

(22) Filed: **Jun. 20, 2014**

(65) **Prior Publication Data**

US 2014/0299357 A1 Oct. 9, 2014

**Related U.S. Application Data**

(63) Continuation of application No. PCT/JP2012/083221,  
filed on Dec. 21, 2012.

(30) **Foreign Application Priority Data**

Dec. 22, 2011 (JP) ..... 2011-281927  
Aug. 21, 2012 (JP) ..... 2012-182712

(51) **Int. Cl.**

**B32B 3/02** (2006.01)  
**H05K 1/02** (2006.01)  
**G06F 3/044** (2006.01)  
**G06F 3/047** (2006.01)

(52) **U.S. Cl.**

CPC ..... **H05K 1/0296** (2013.01); **G06F 3/044**  
(2013.01); **G06F 3/047** (2013.01); **G06F**  
**2203/04112** (2013.01); **Y10T 29/49155**  
(2015.01); **Y10T 428/24802** (2015.01)

(58) **Field of Classification Search**

CPC ..... H05K 1/0296; G06F 3/047; Y10T  
428/24802; Y10T 29/49155

See application file for complete search history.

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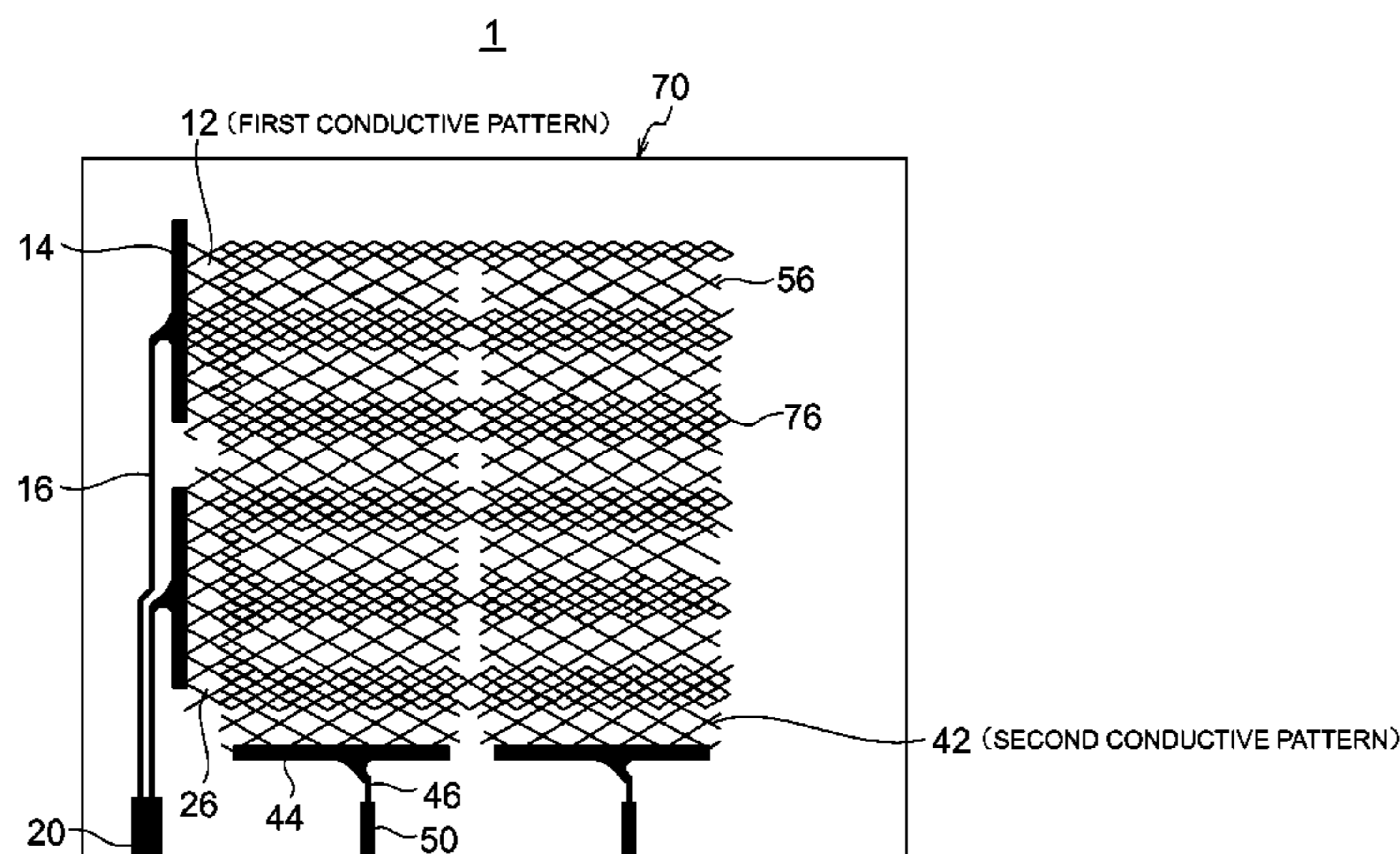
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(57) **ABSTRACT**

Provided are a conductive sheet and a touch panel having a  
high detection accuracy of touching with a finger. A conduc-  
tive sheet includes: a first electrode pattern including first  
conductive patterns; and a second electrode pattern including  
second conductive patterns. The first conductive patterns and  
the second conductive patterns are placed so as to be orthogo-  
nal to each other. Each first conductive pattern includes slit-  
like sub-nonconduction patterns inside thereof.

**24 Claims, 23 Drawing Sheets**



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FIG. 1

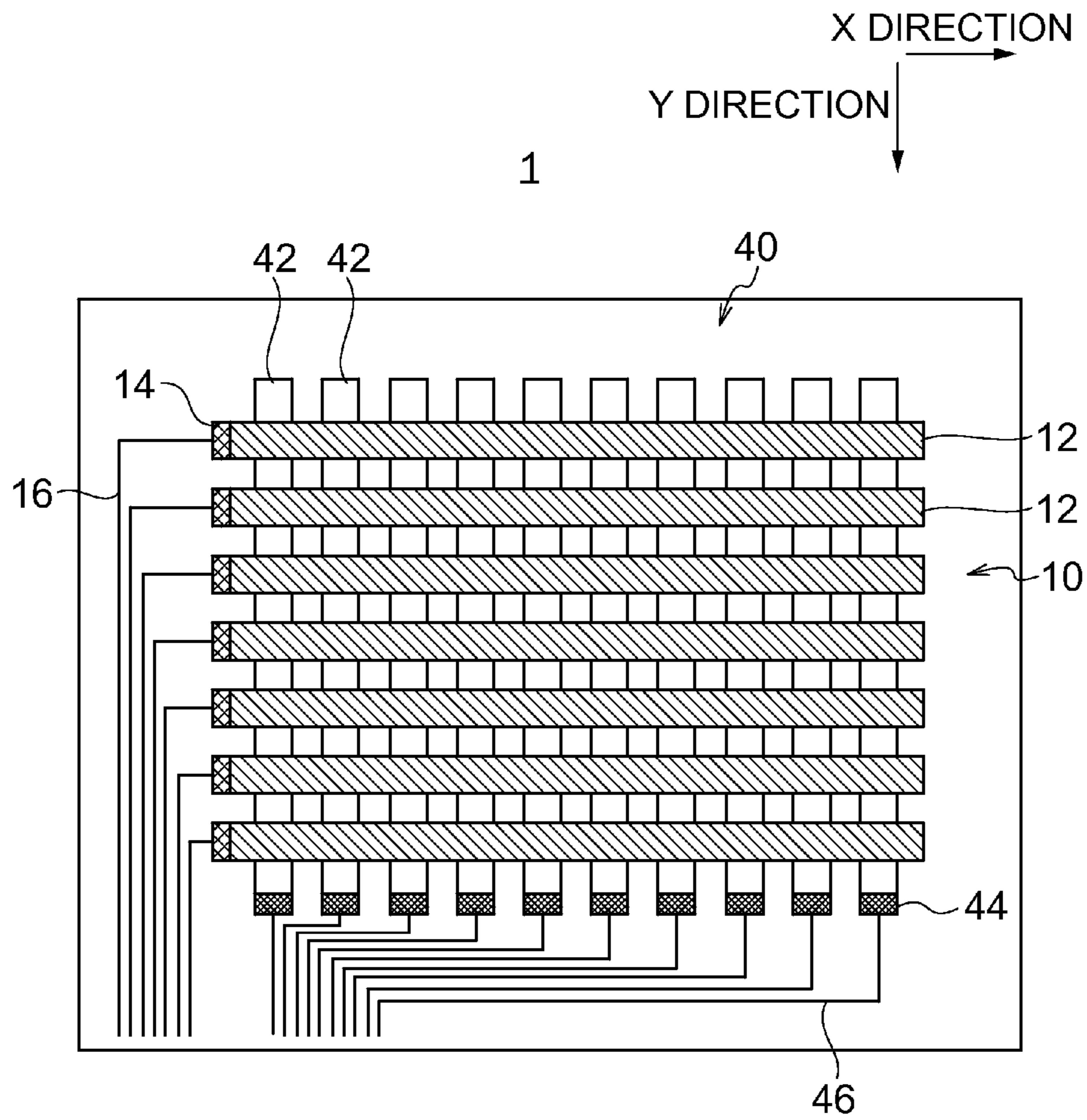


FIG.2

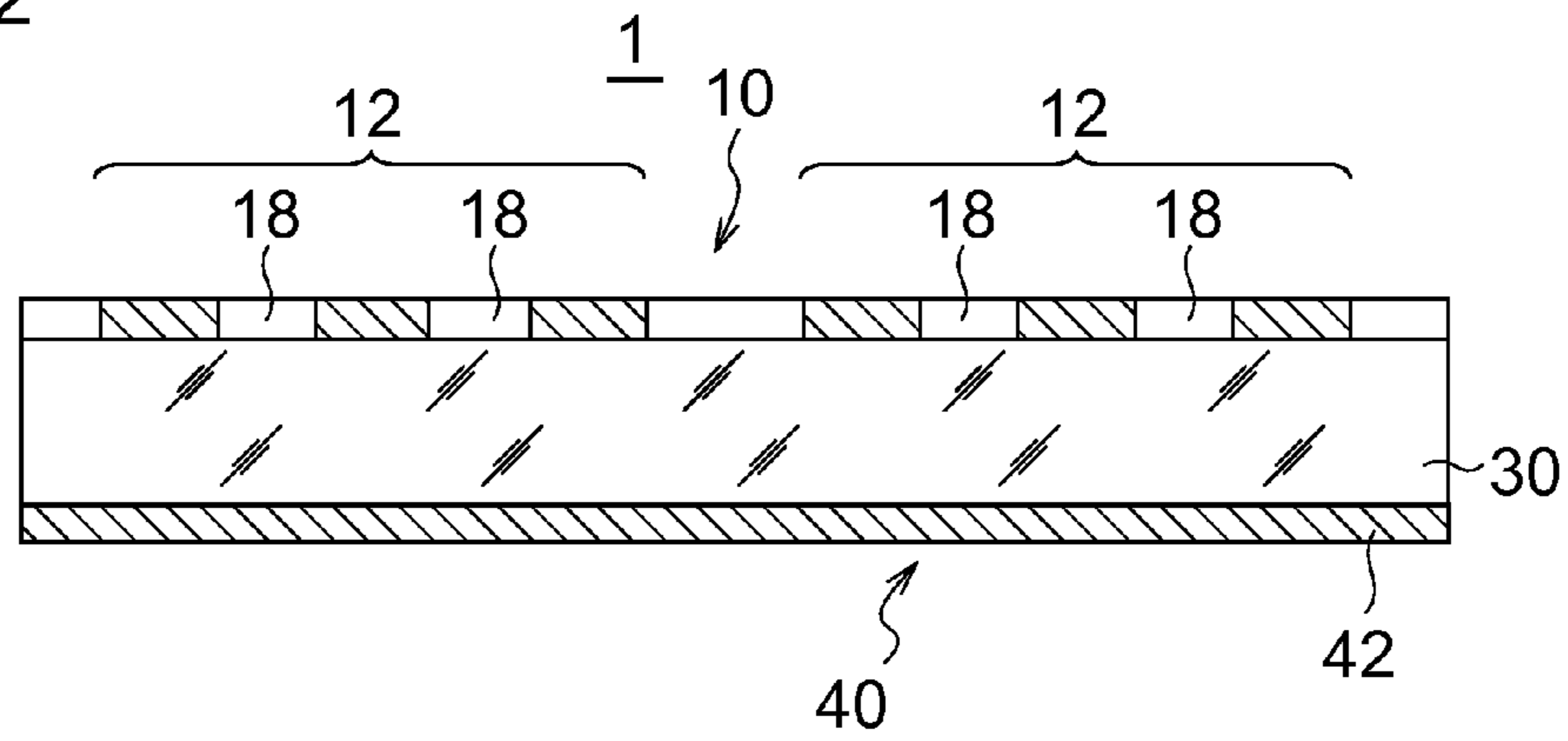


FIG.3

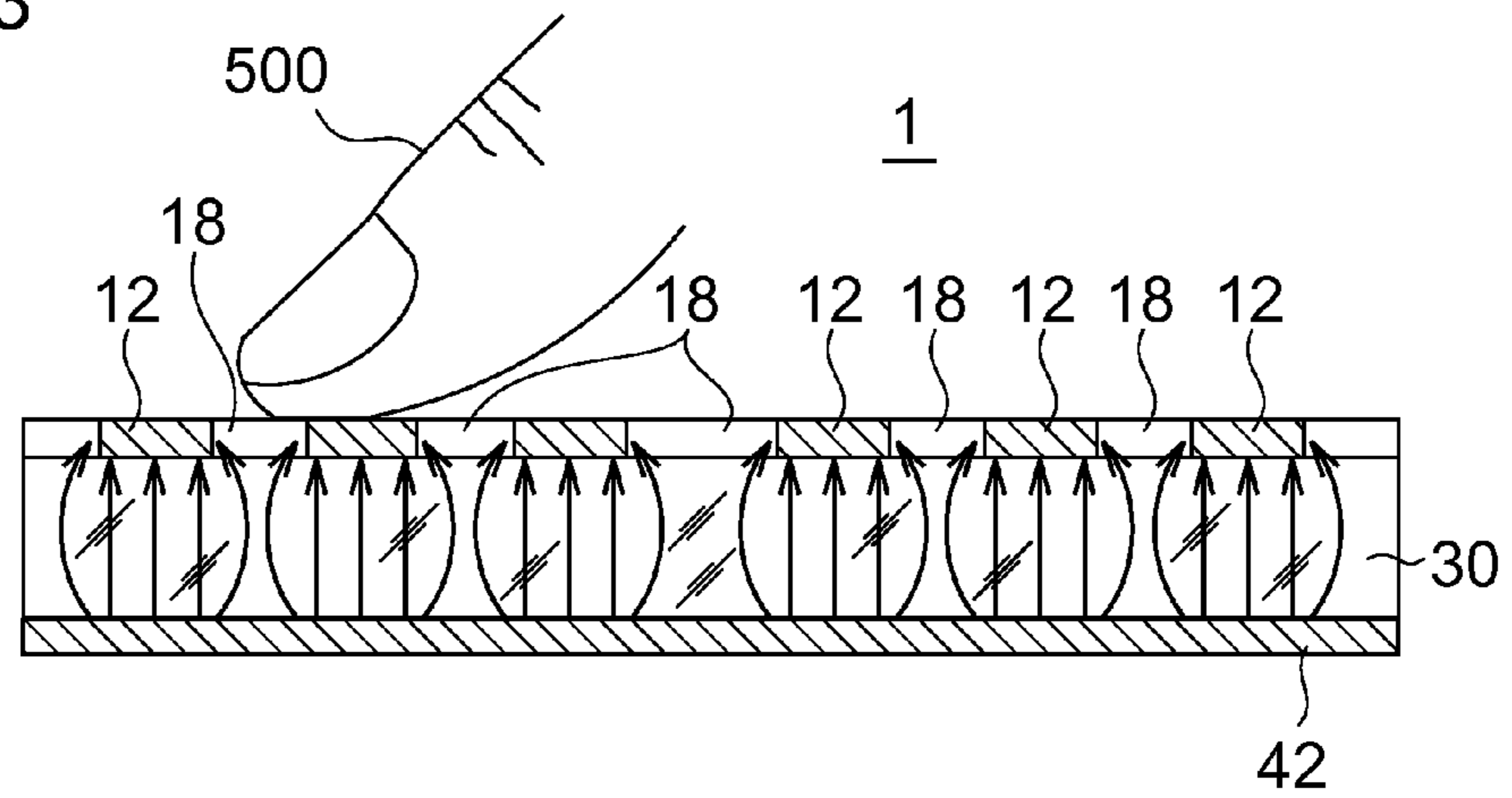
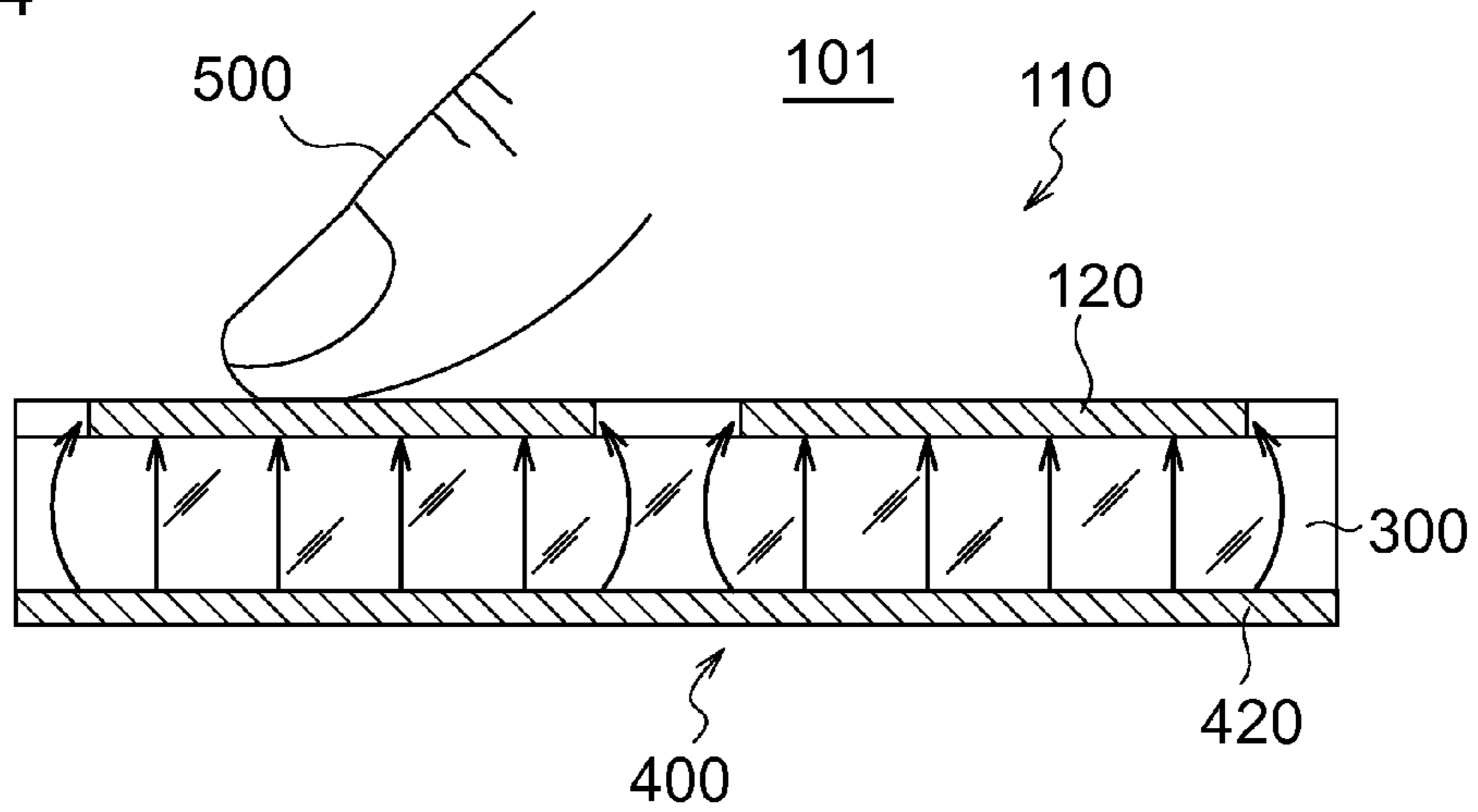
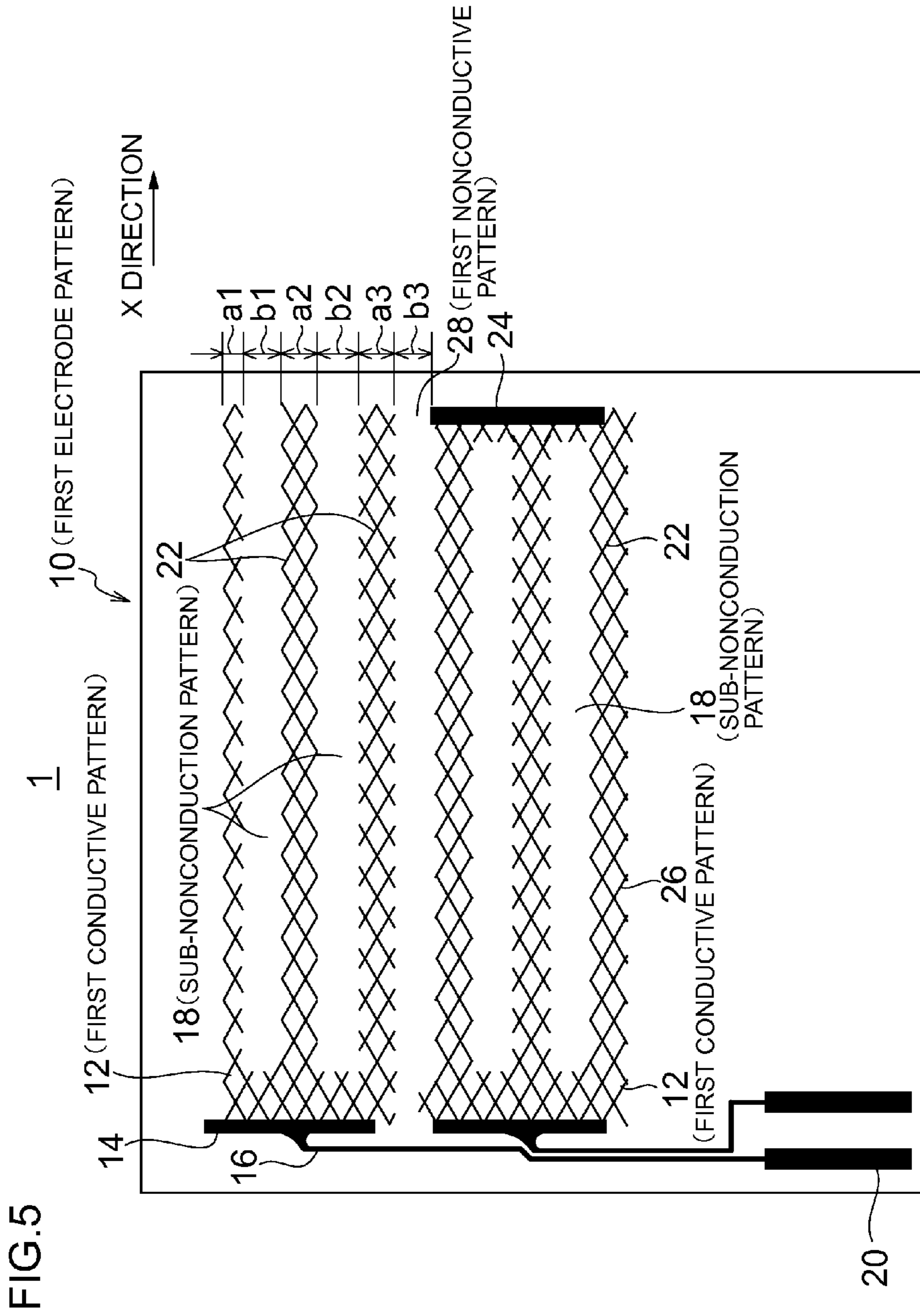


FIG.4







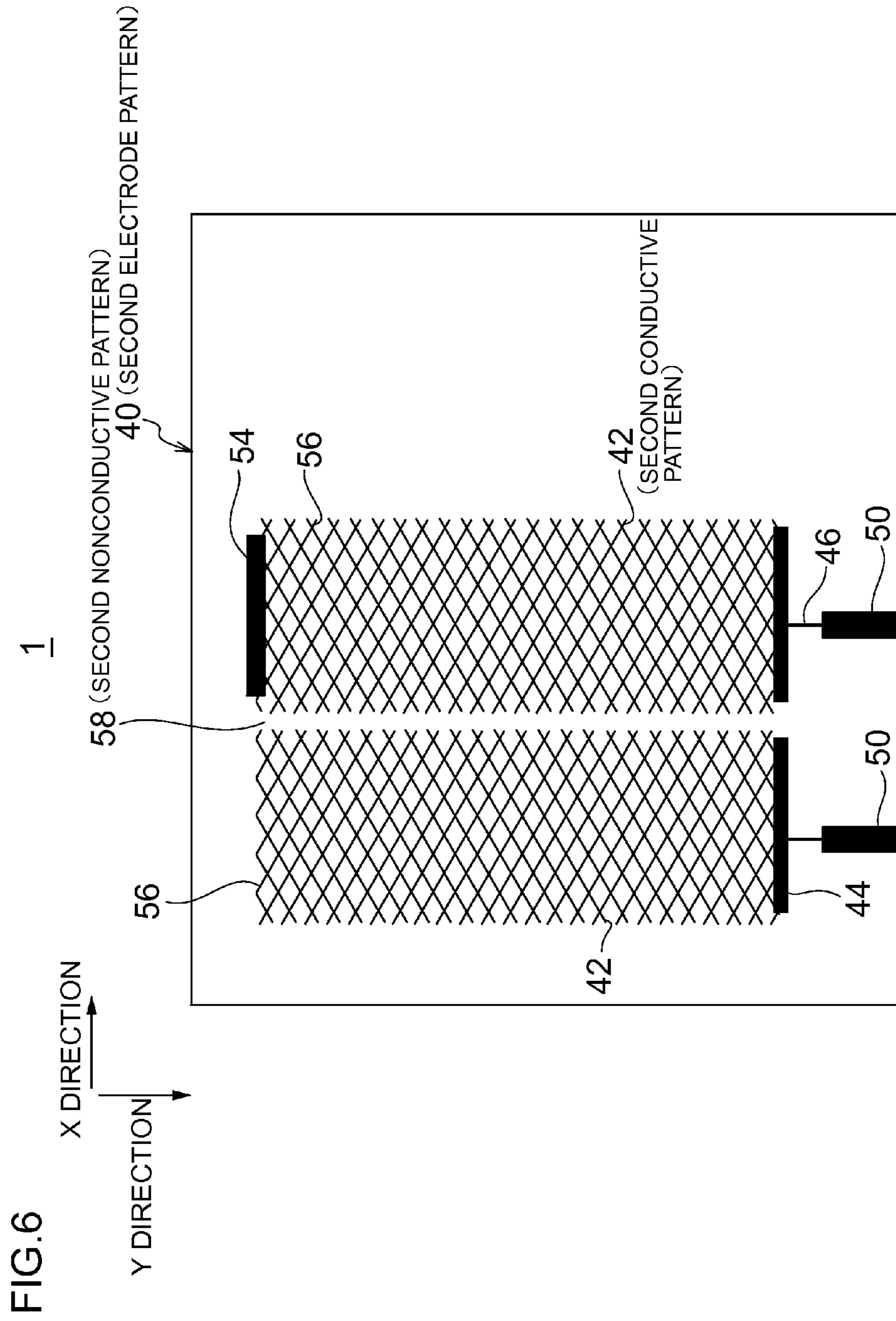


FIG.7

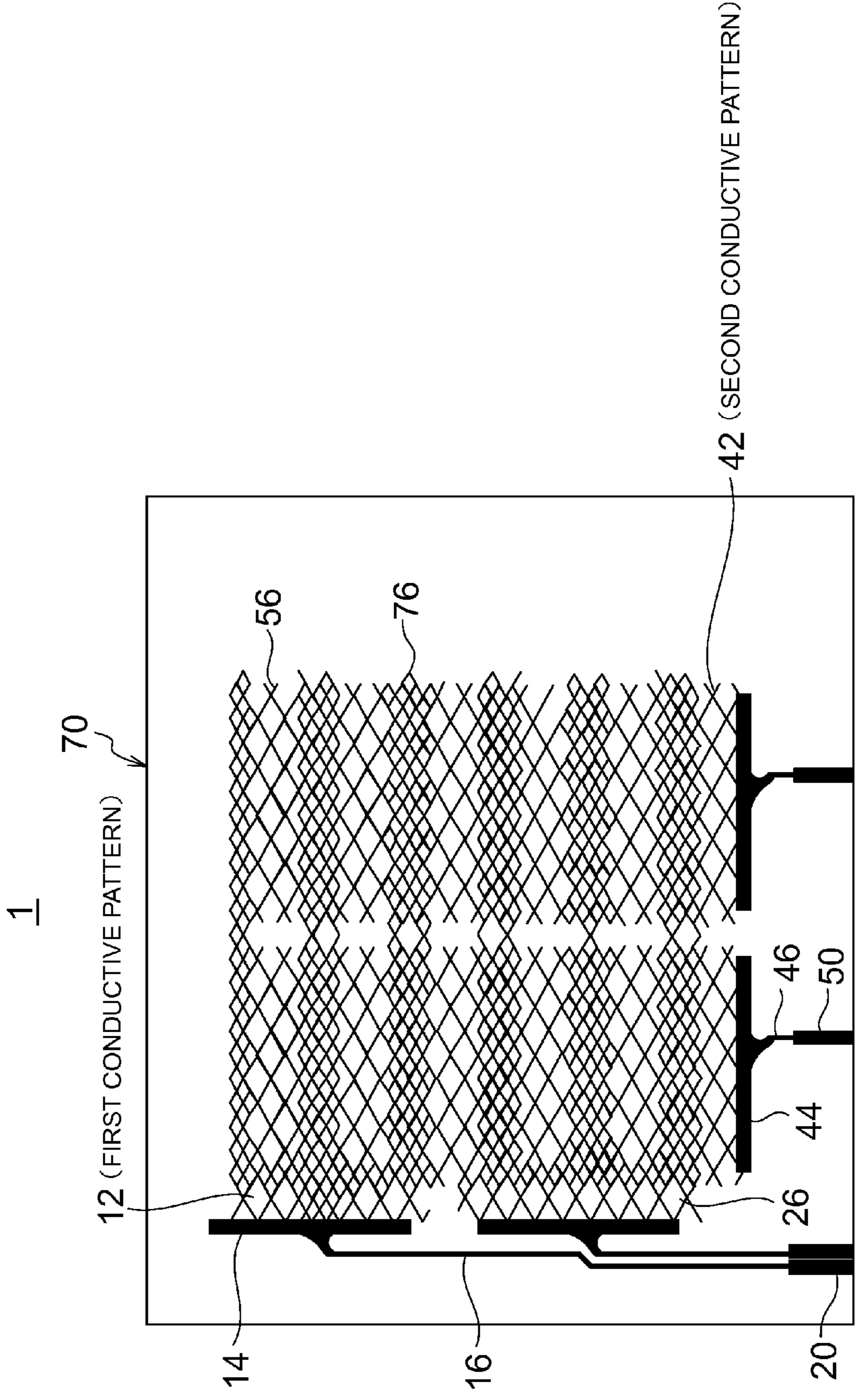


FIG.8

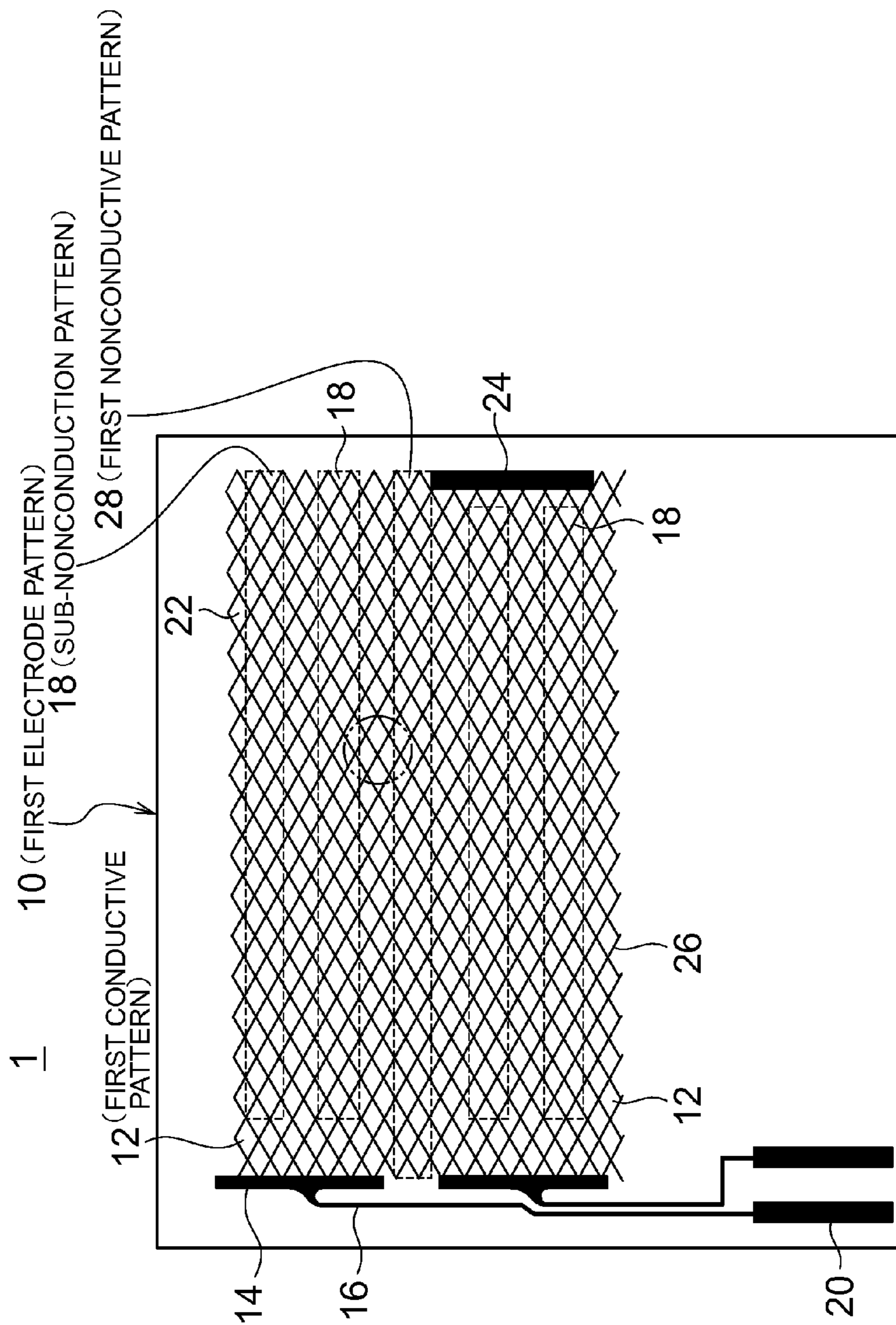




FIG.9

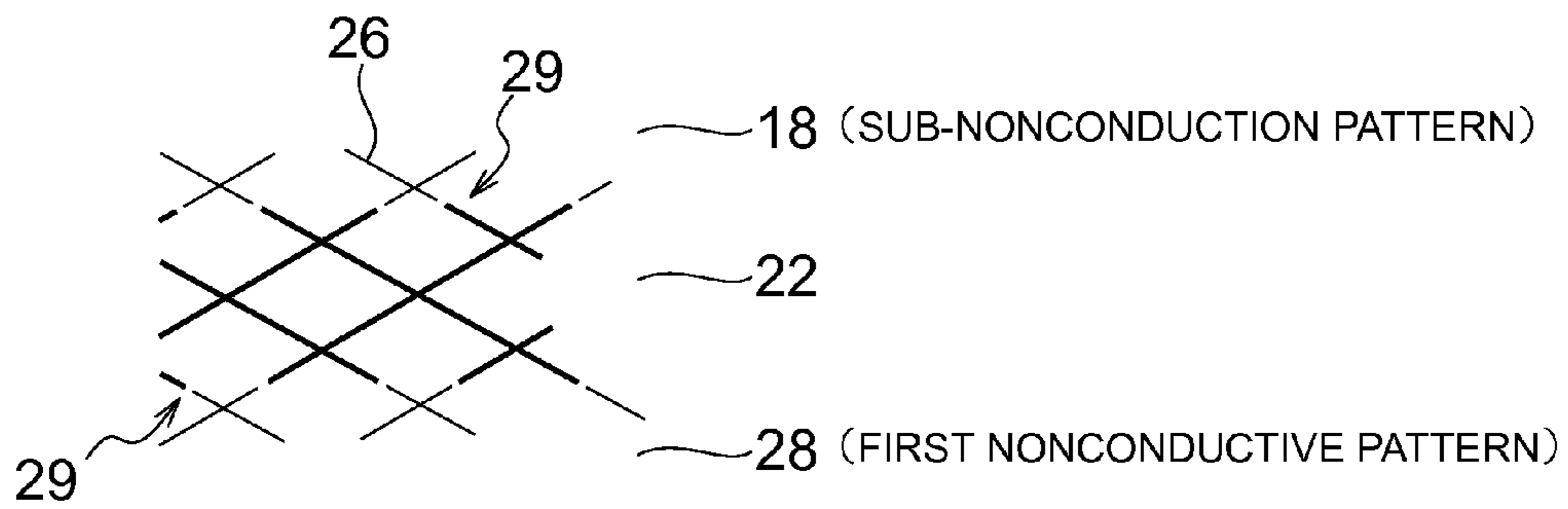


FIG. 10

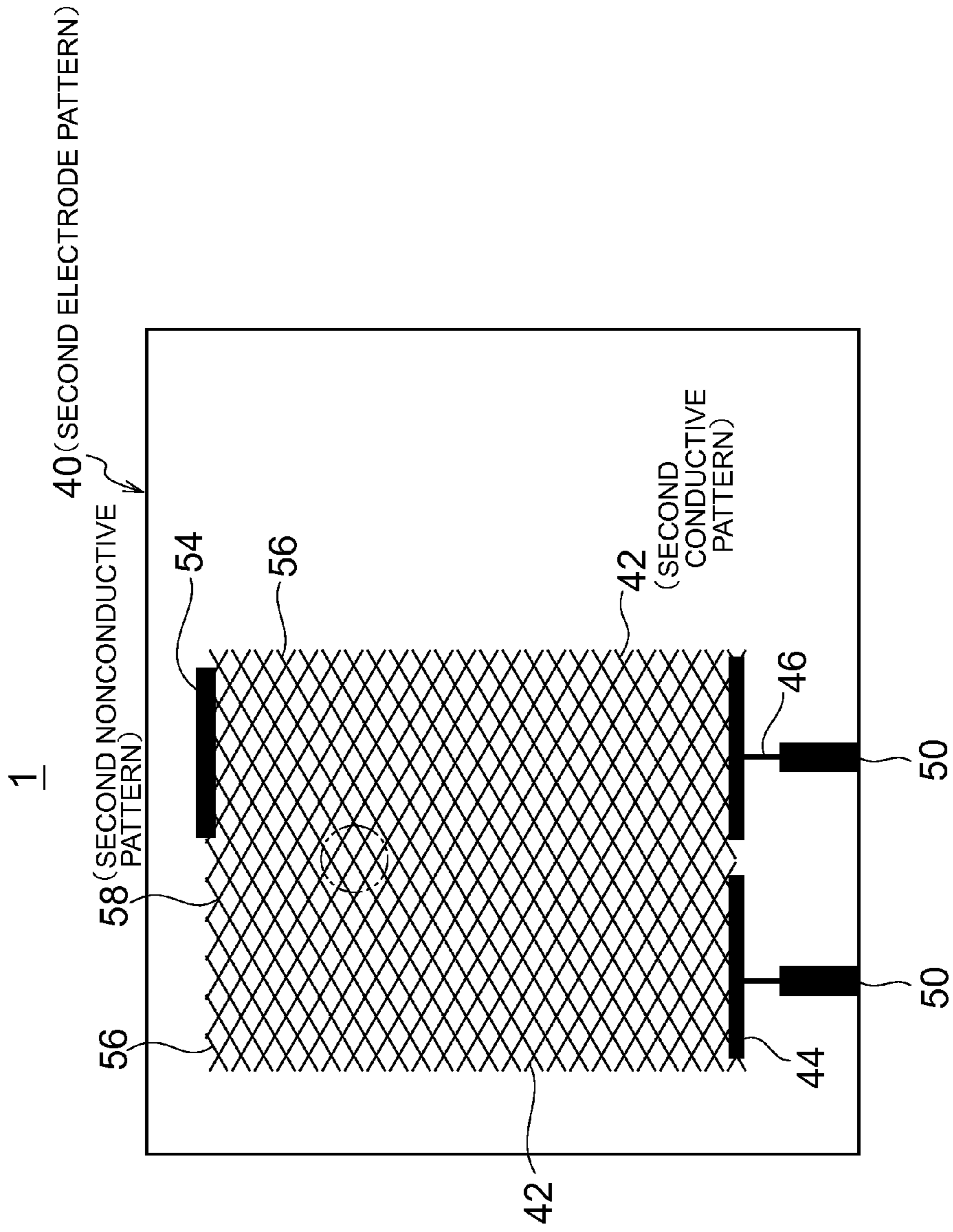


FIG. 11

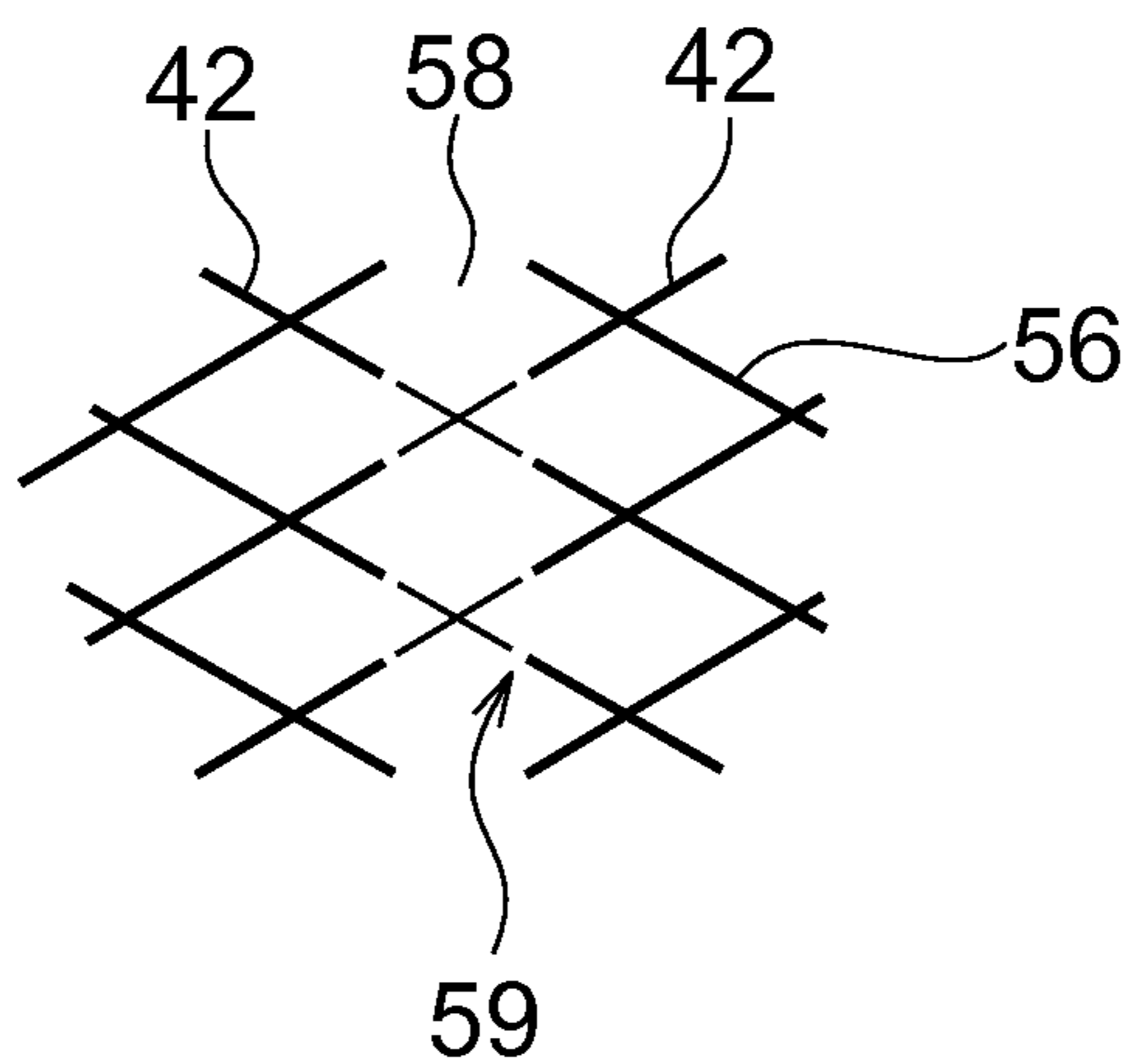


FIG.12

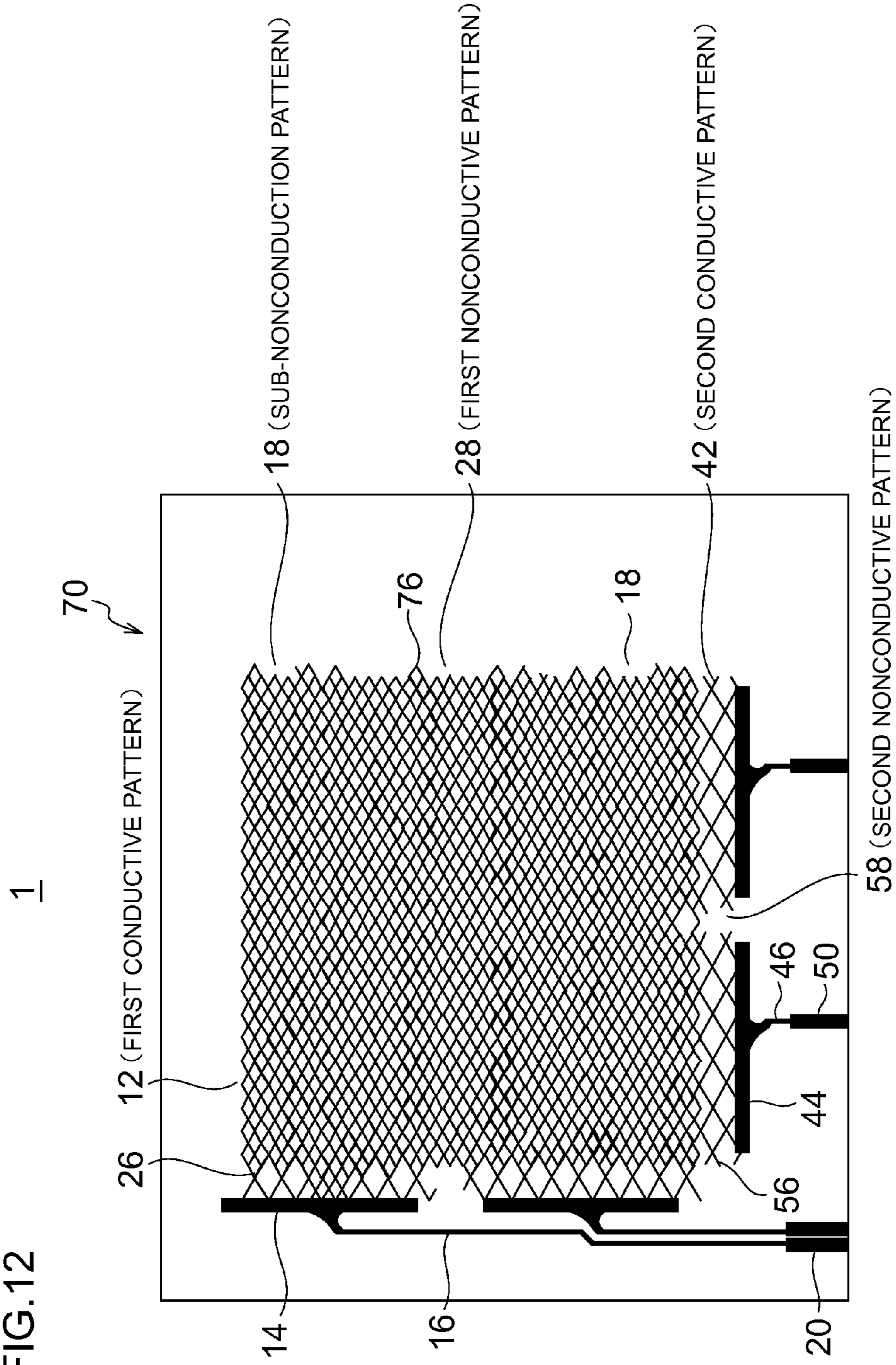




FIG.13

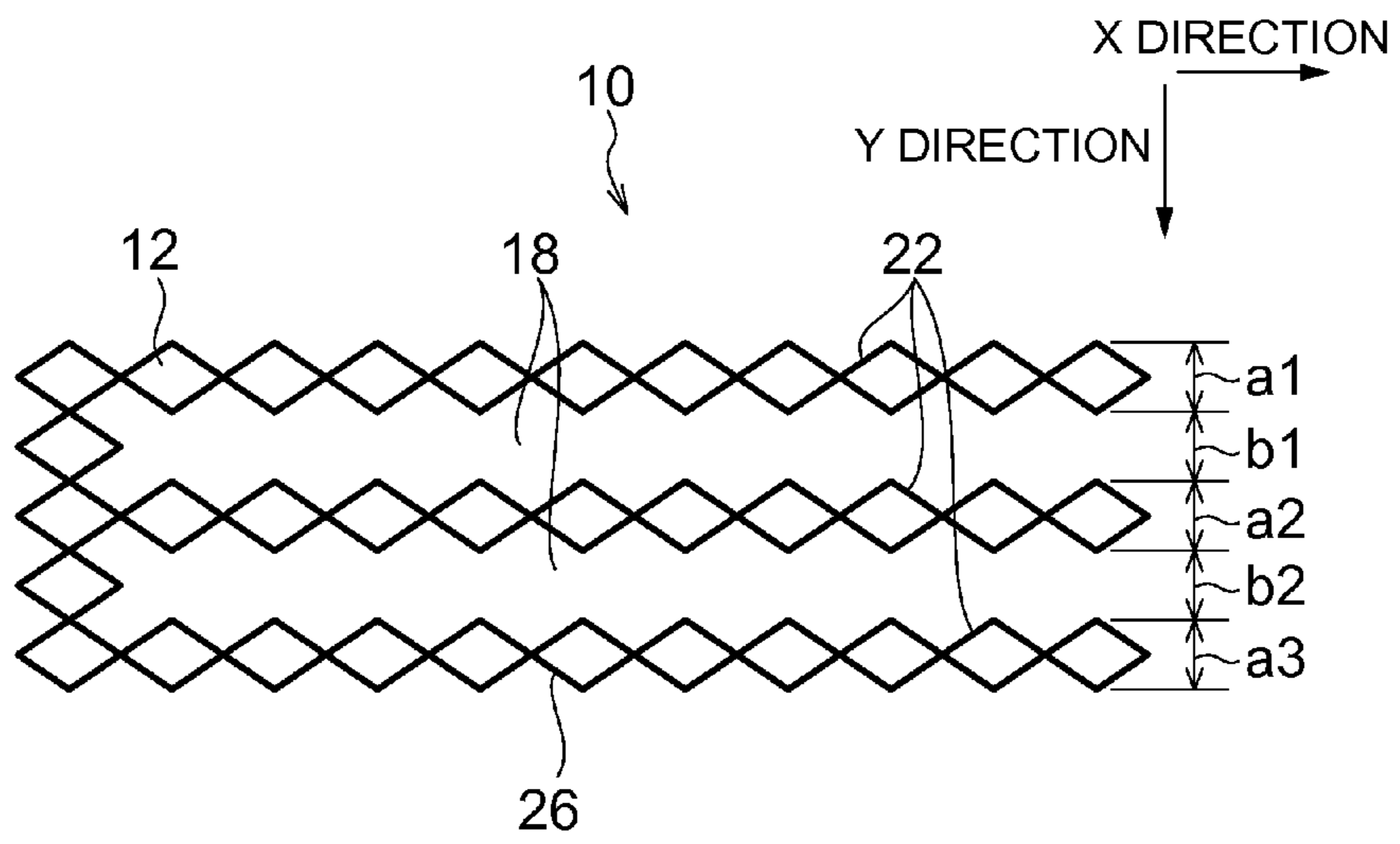


FIG.14

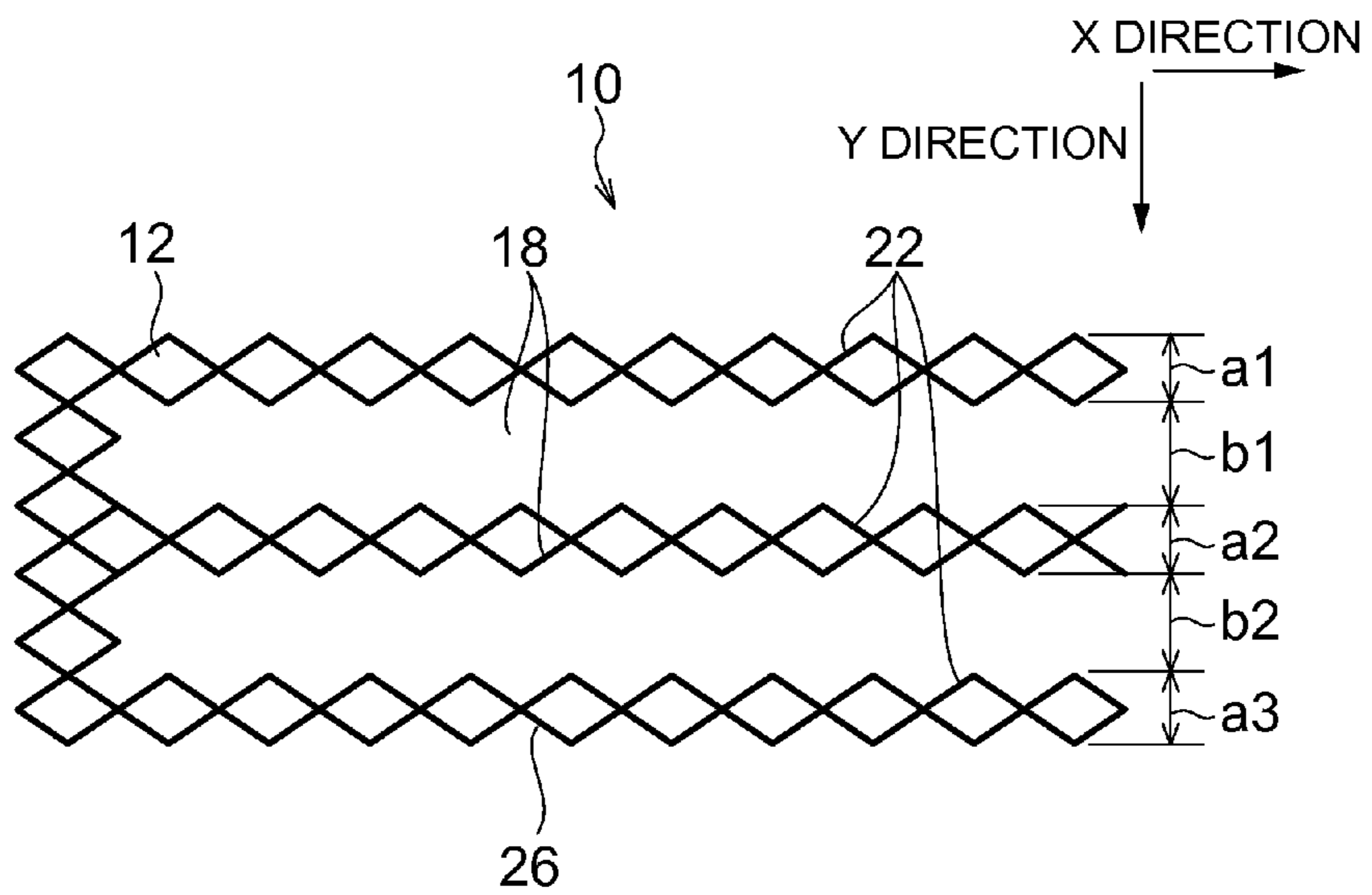


FIG. 15

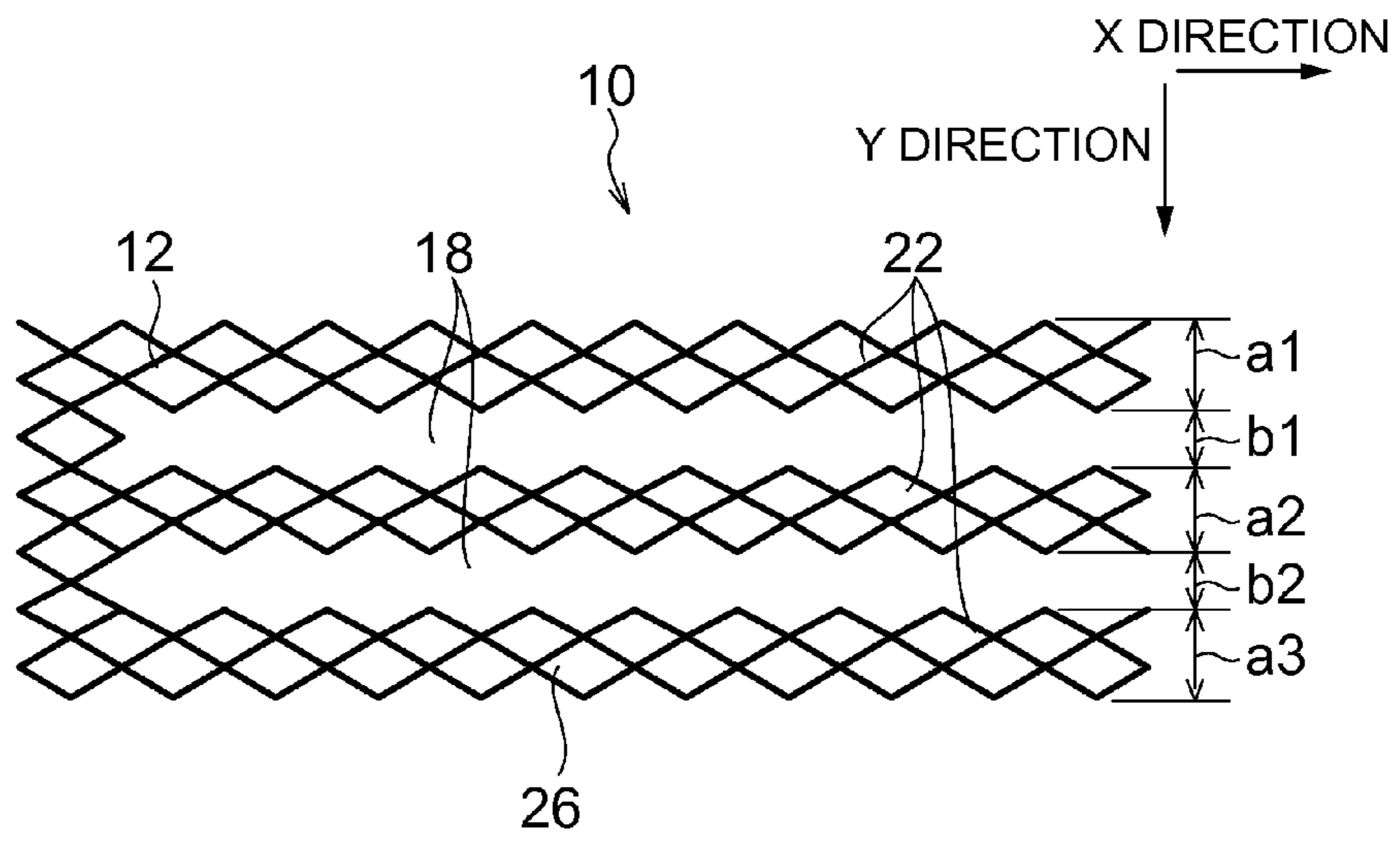


FIG. 16

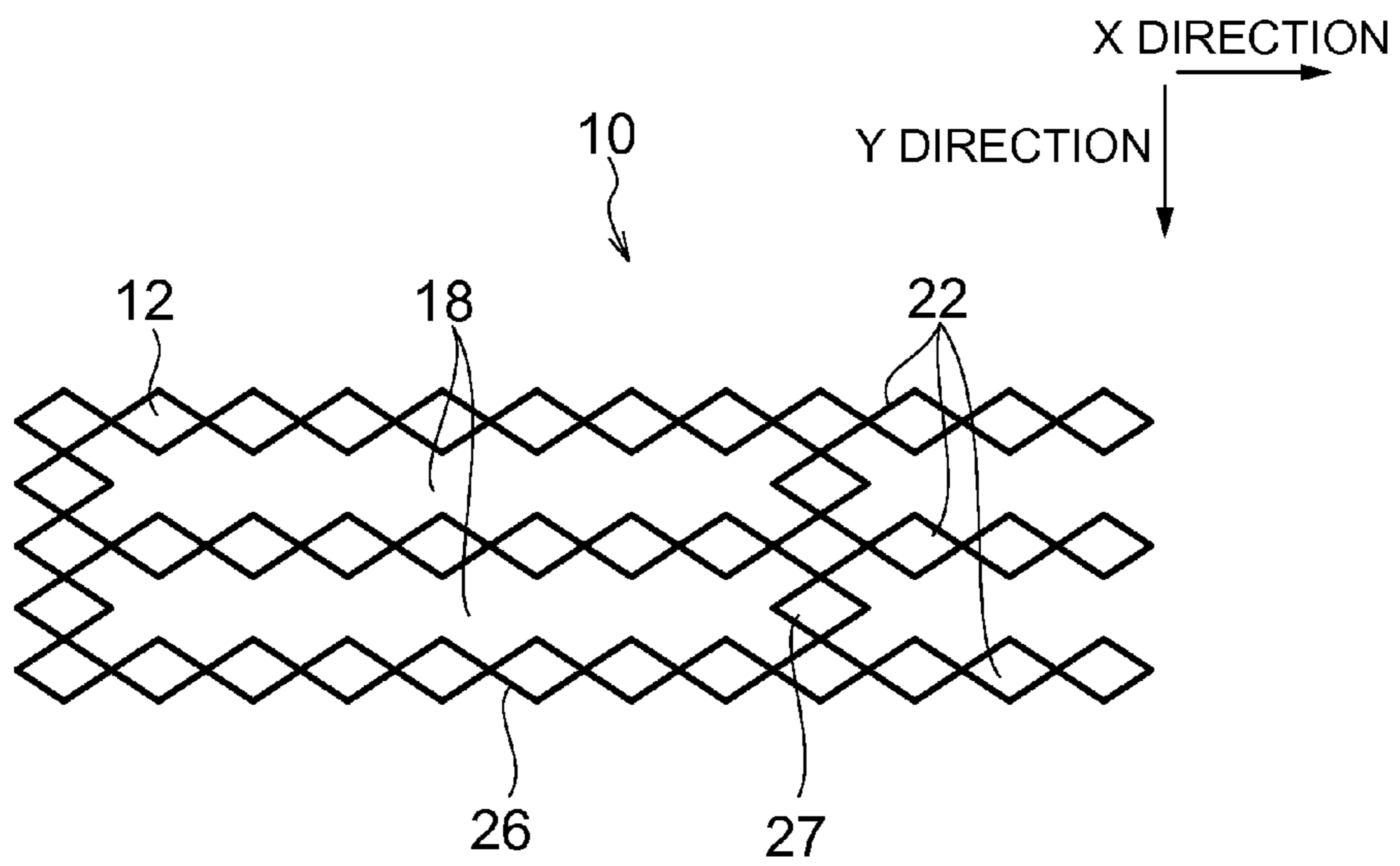


FIG.17

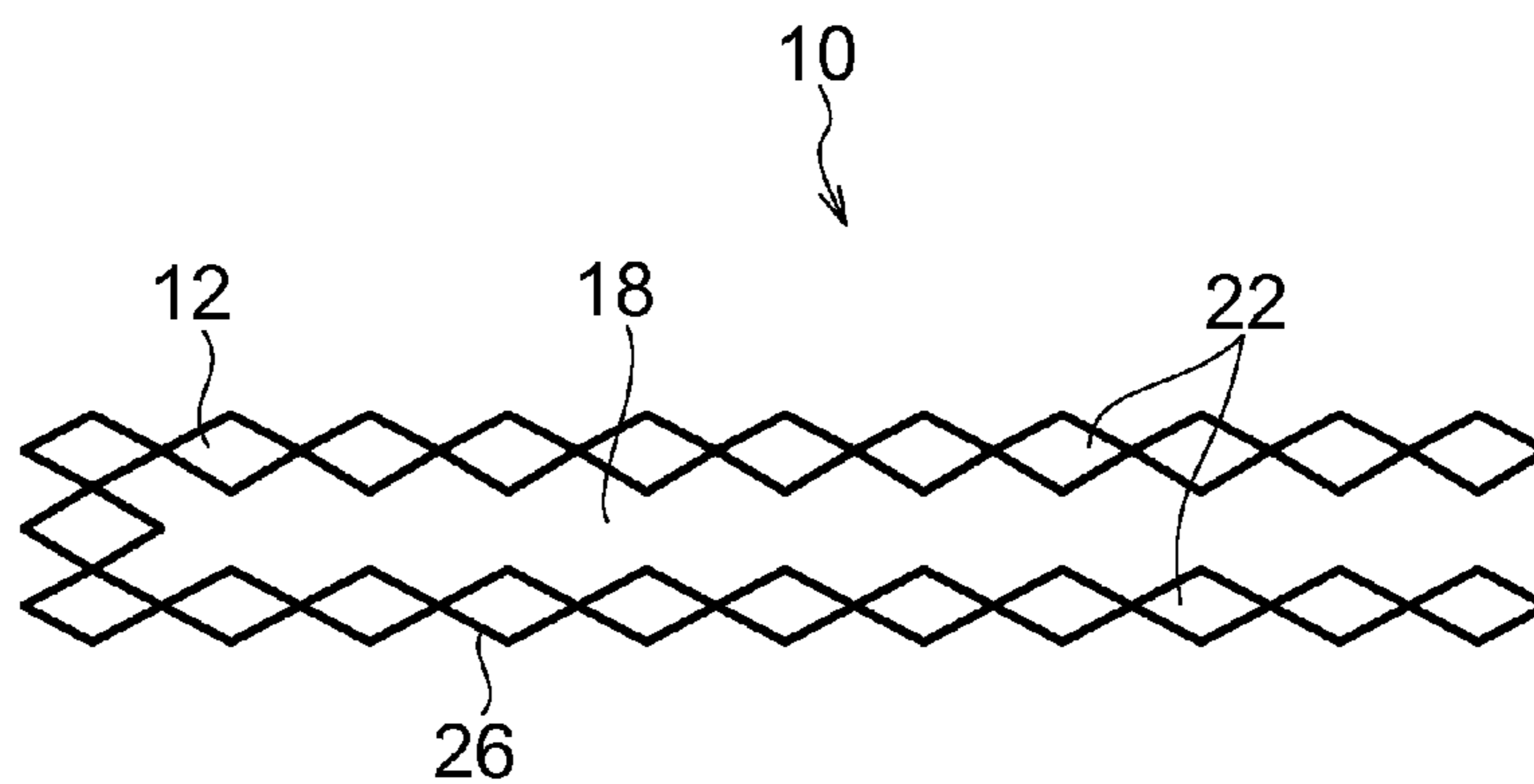
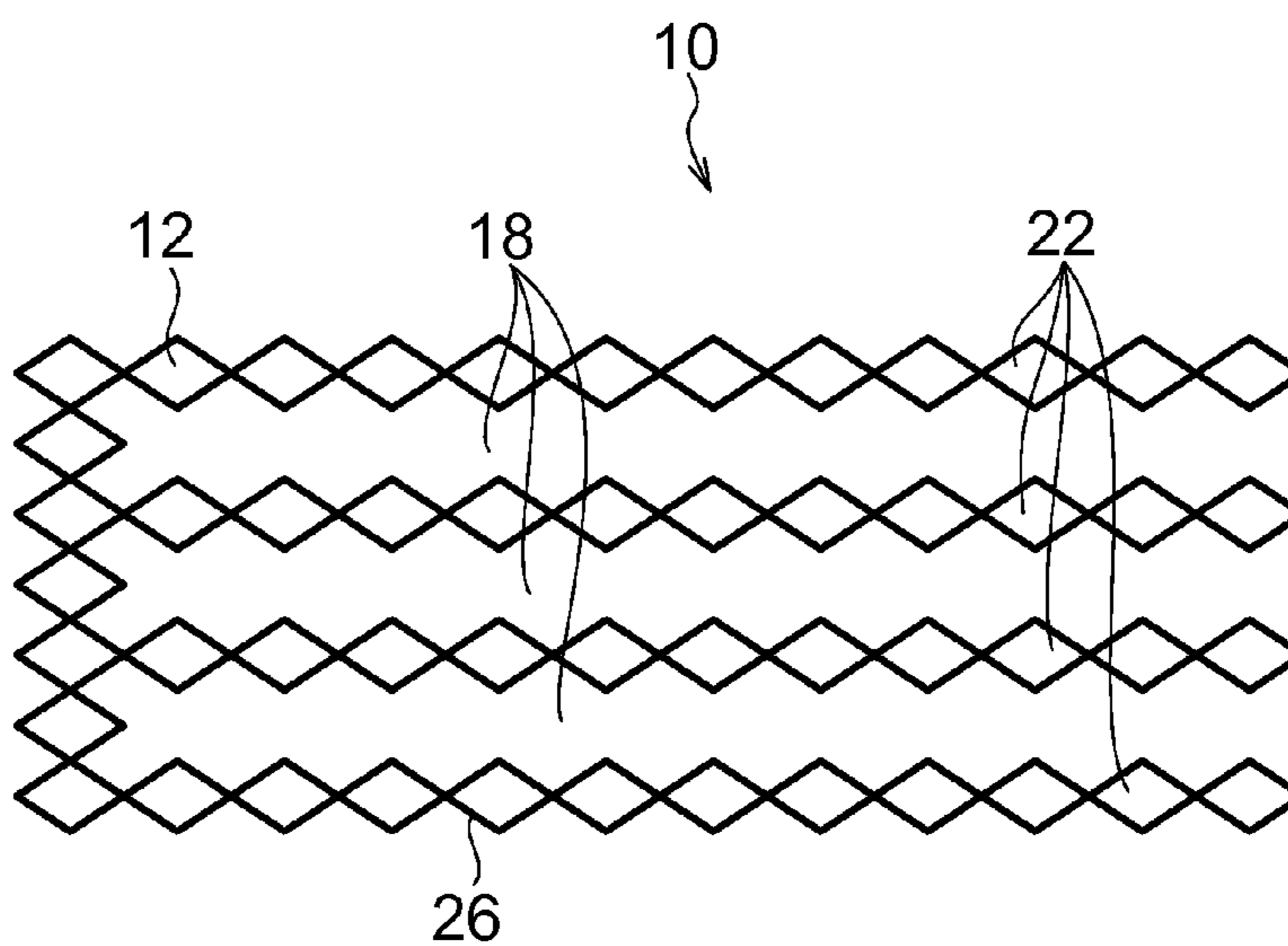
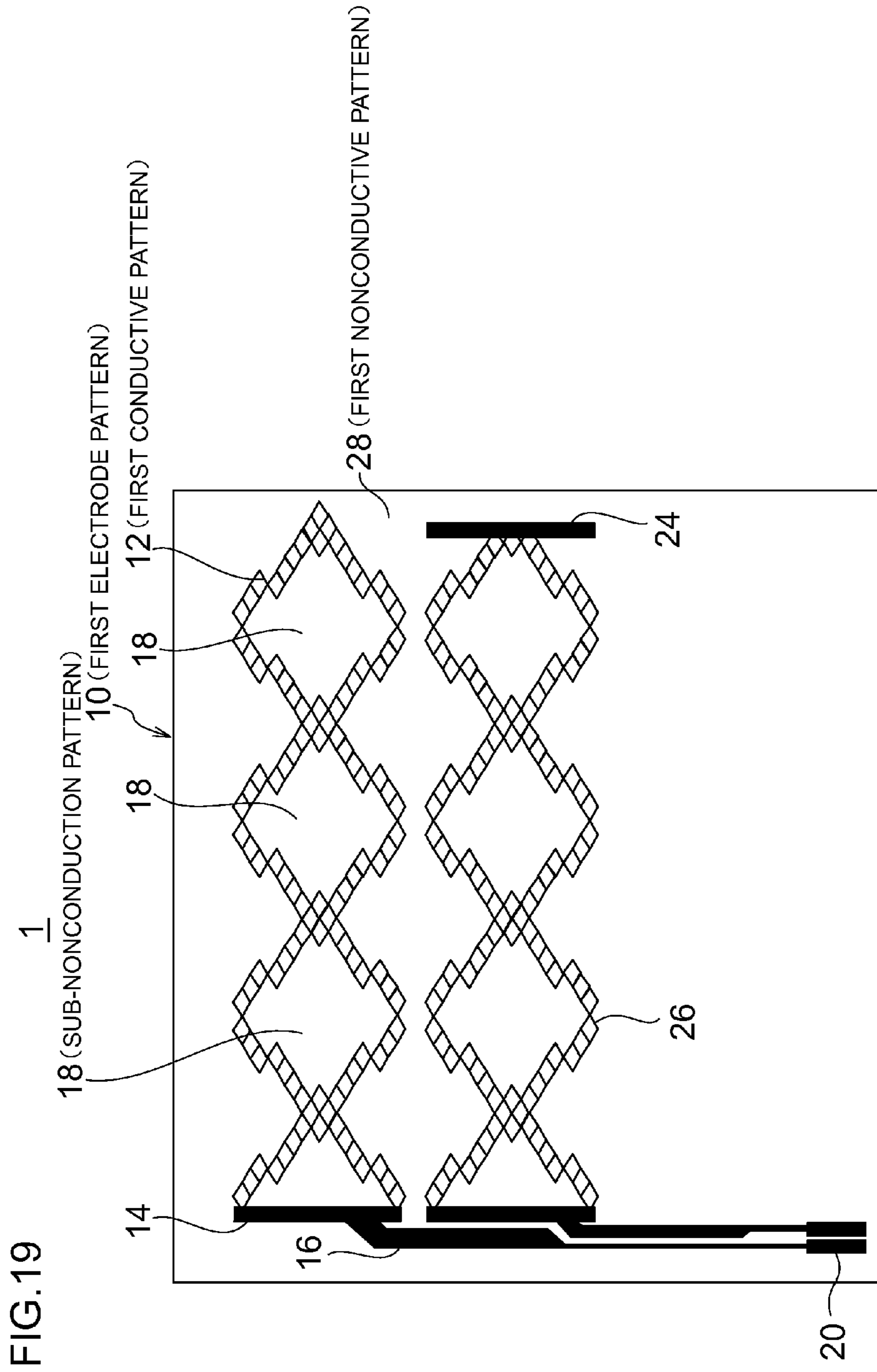


FIG.18







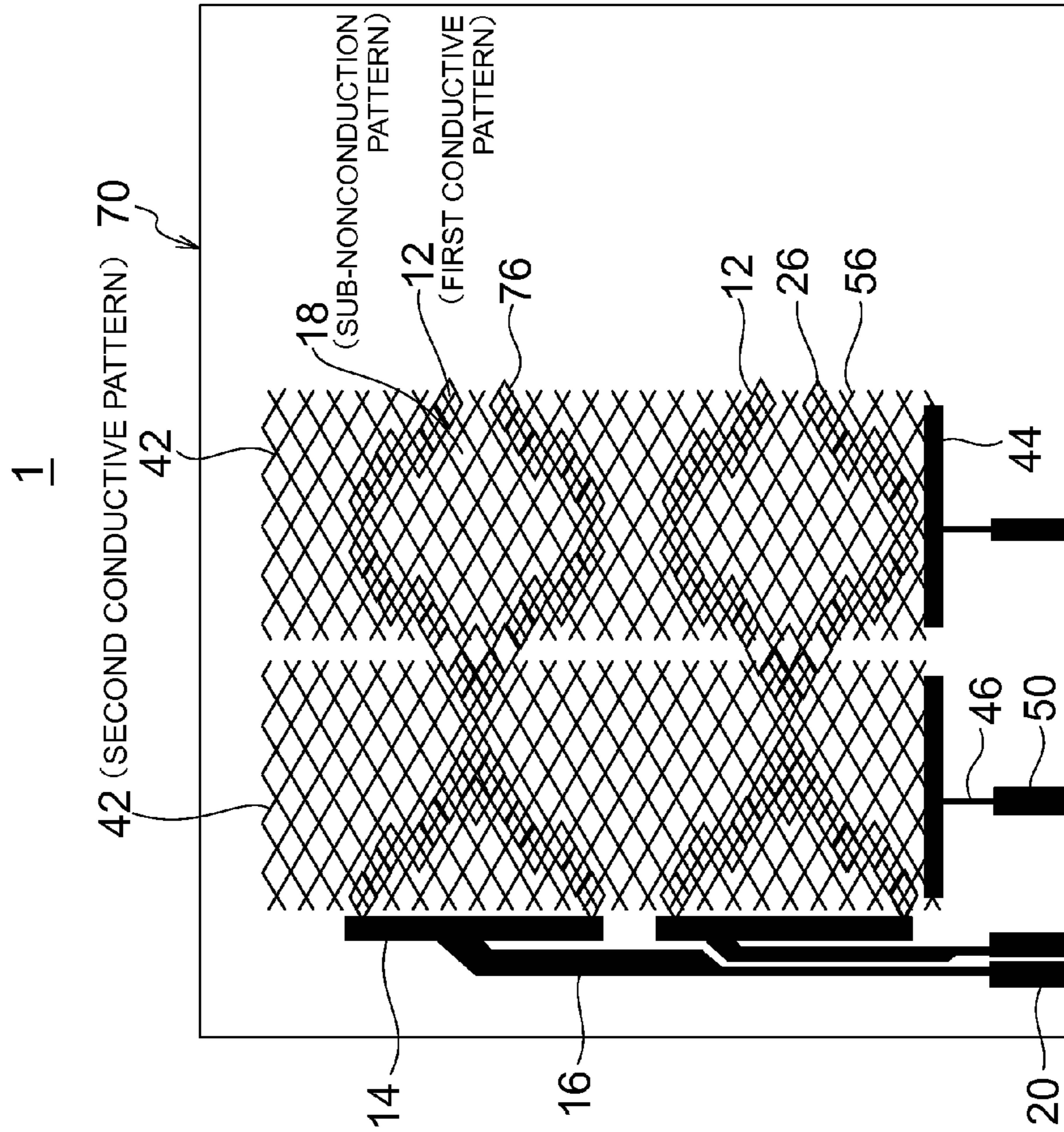


FIG.20

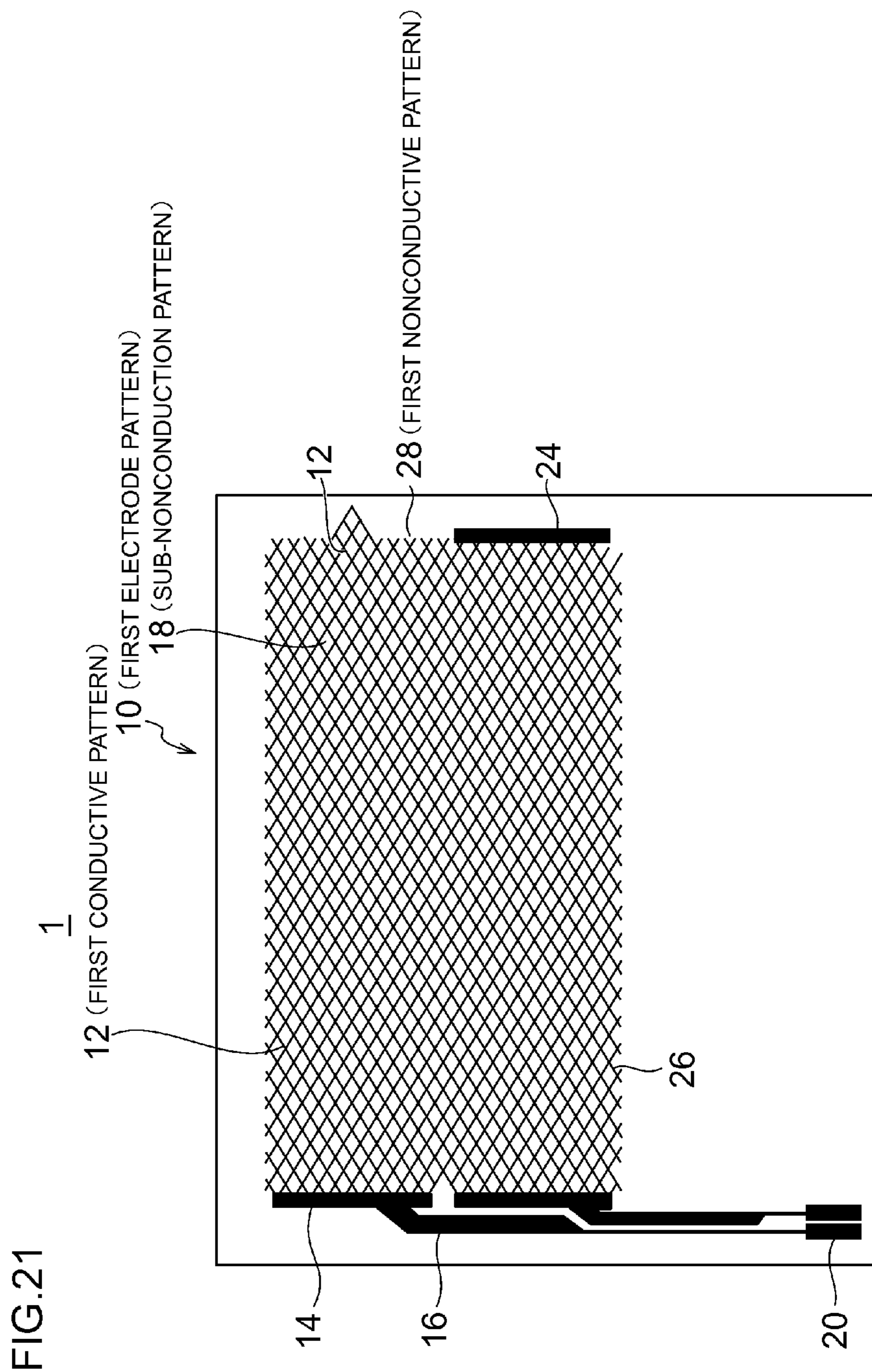


FIG.22

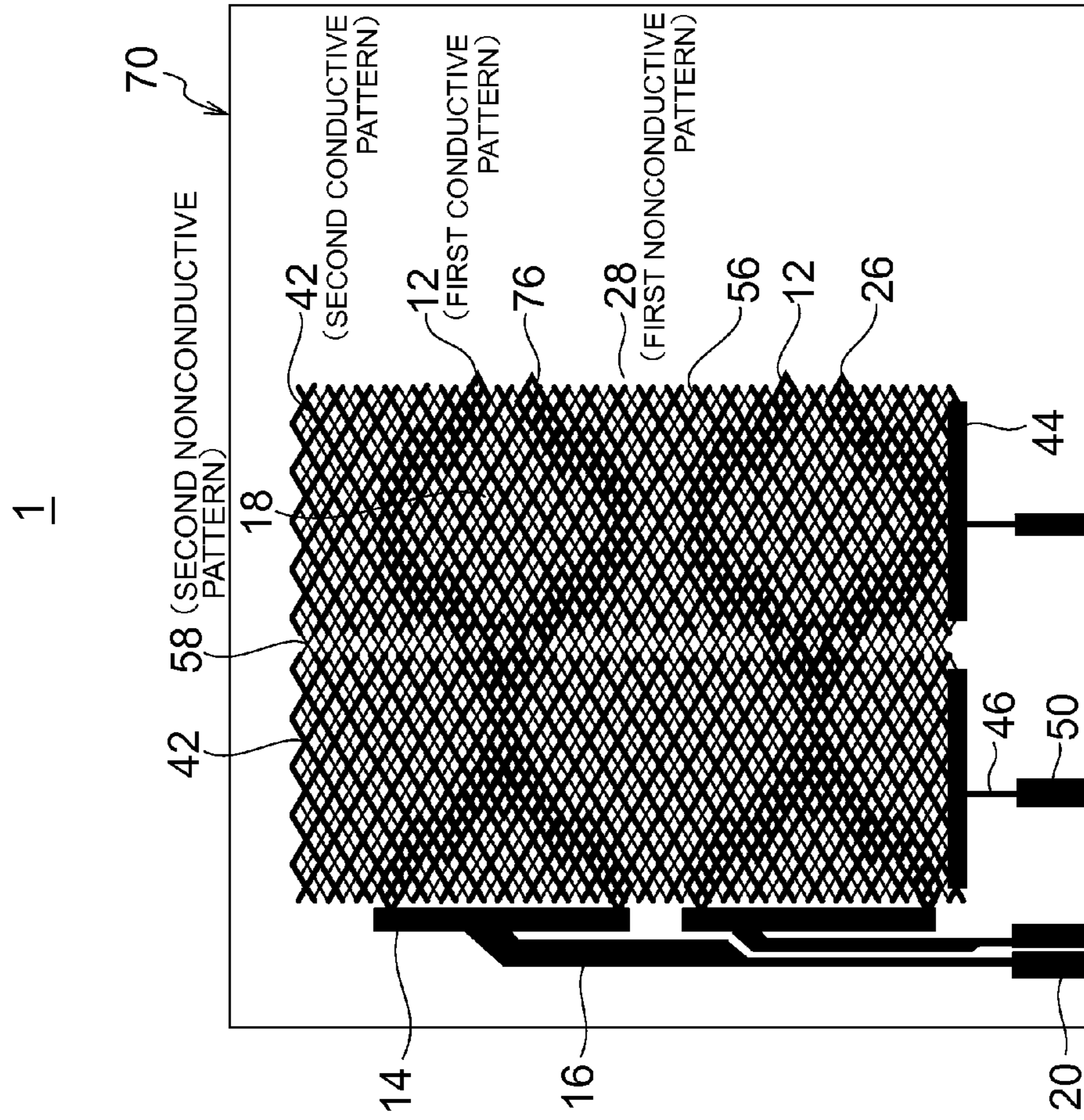


FIG.23

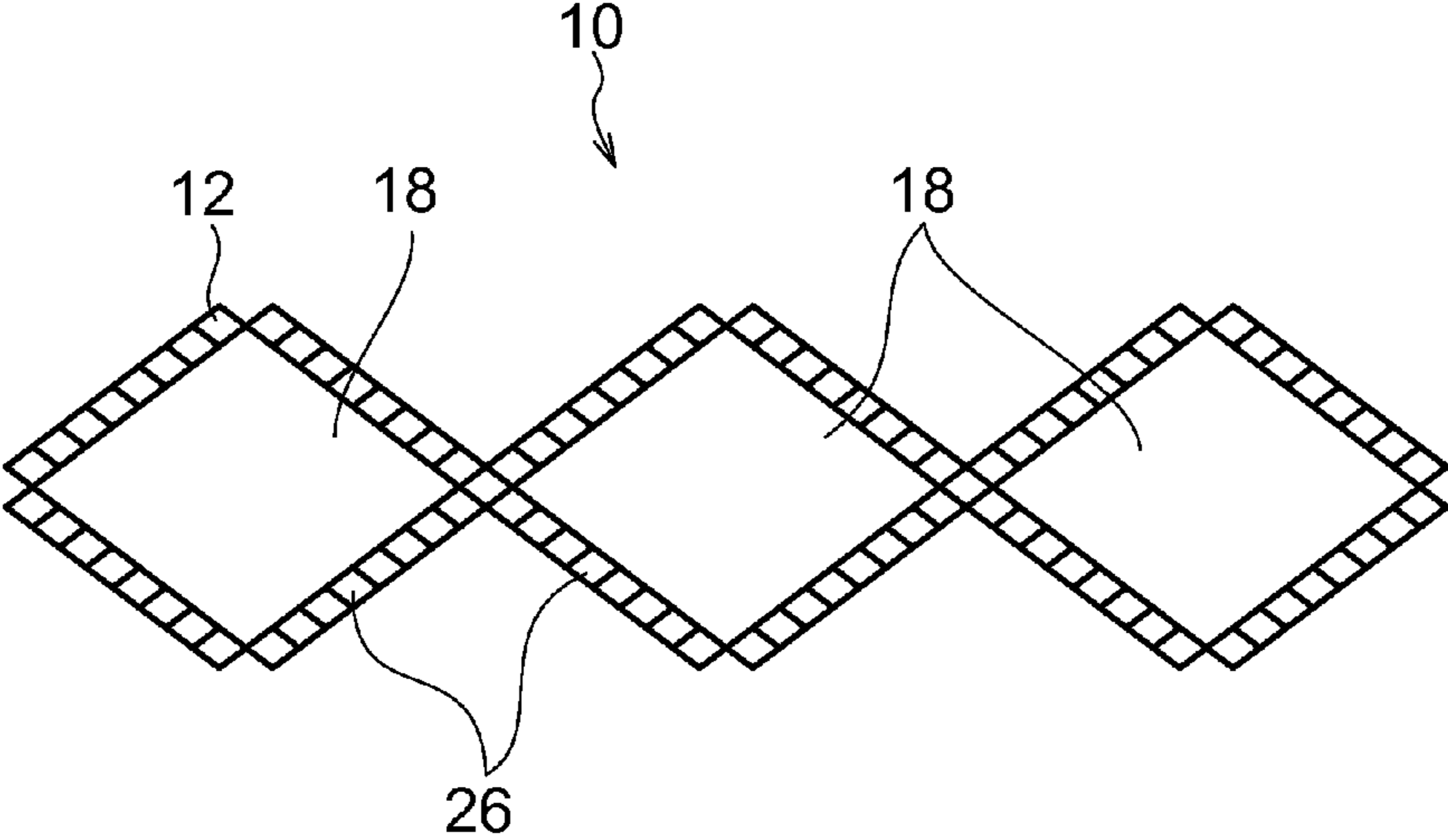


FIG.24

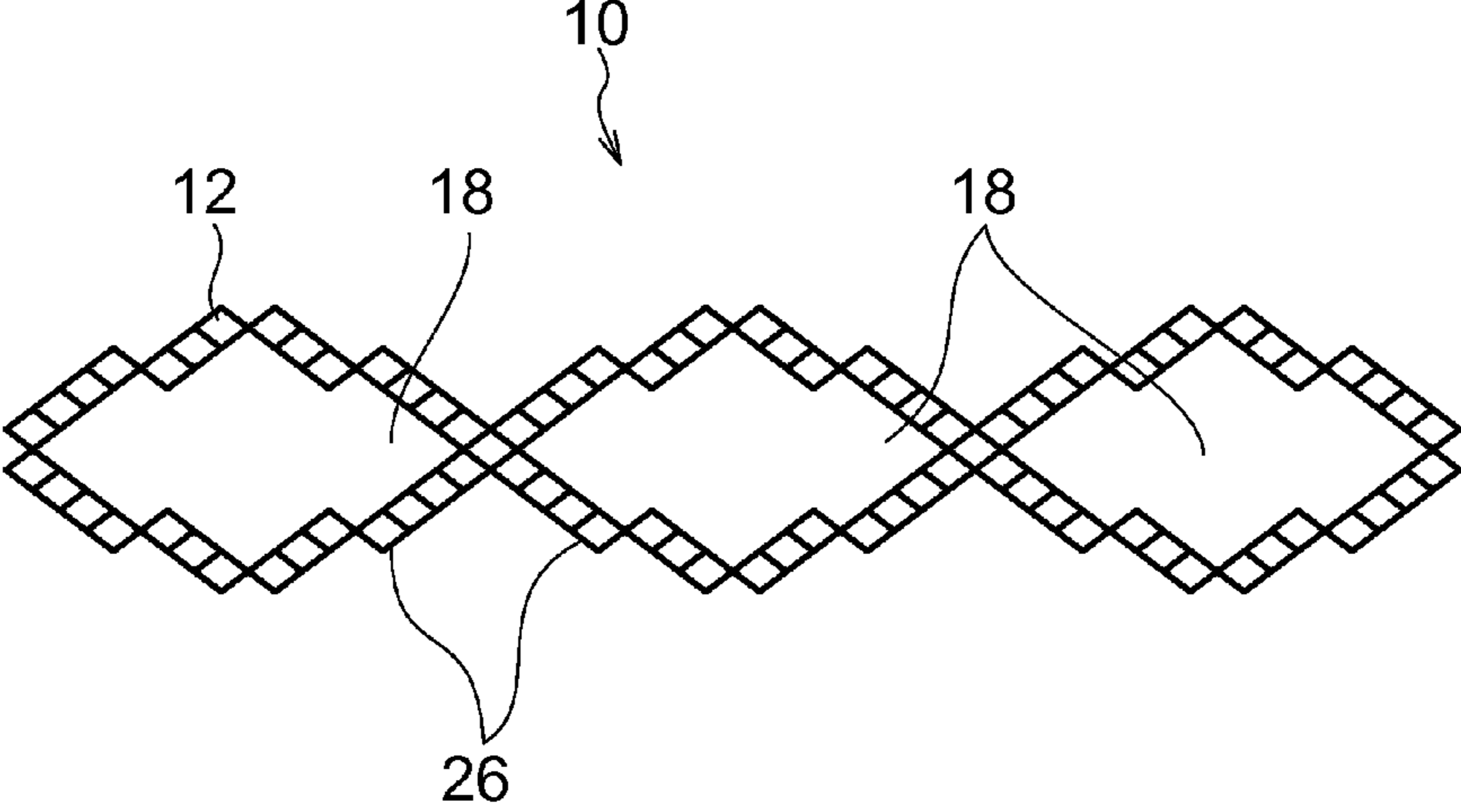




FIG.25

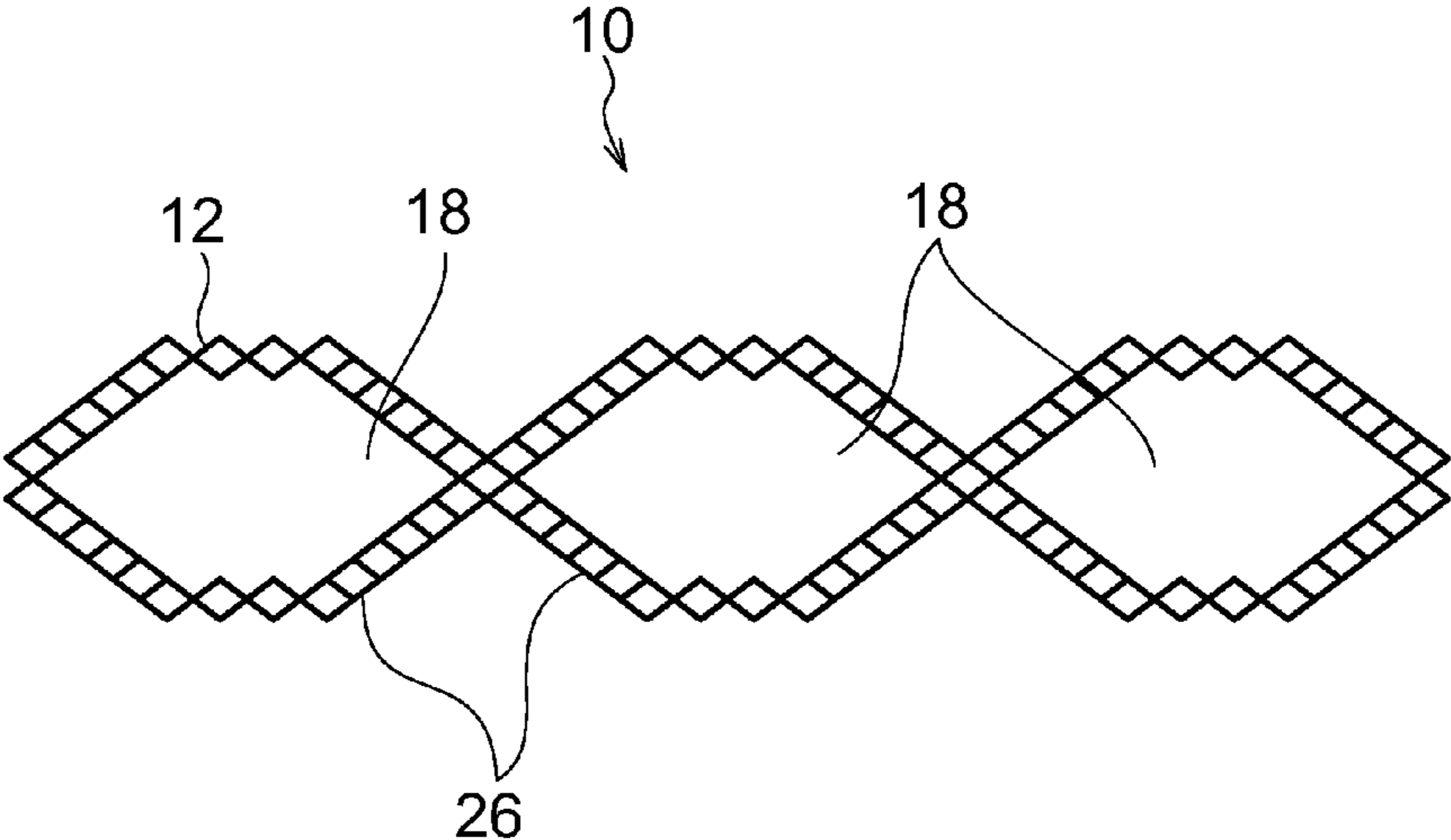


FIG.26

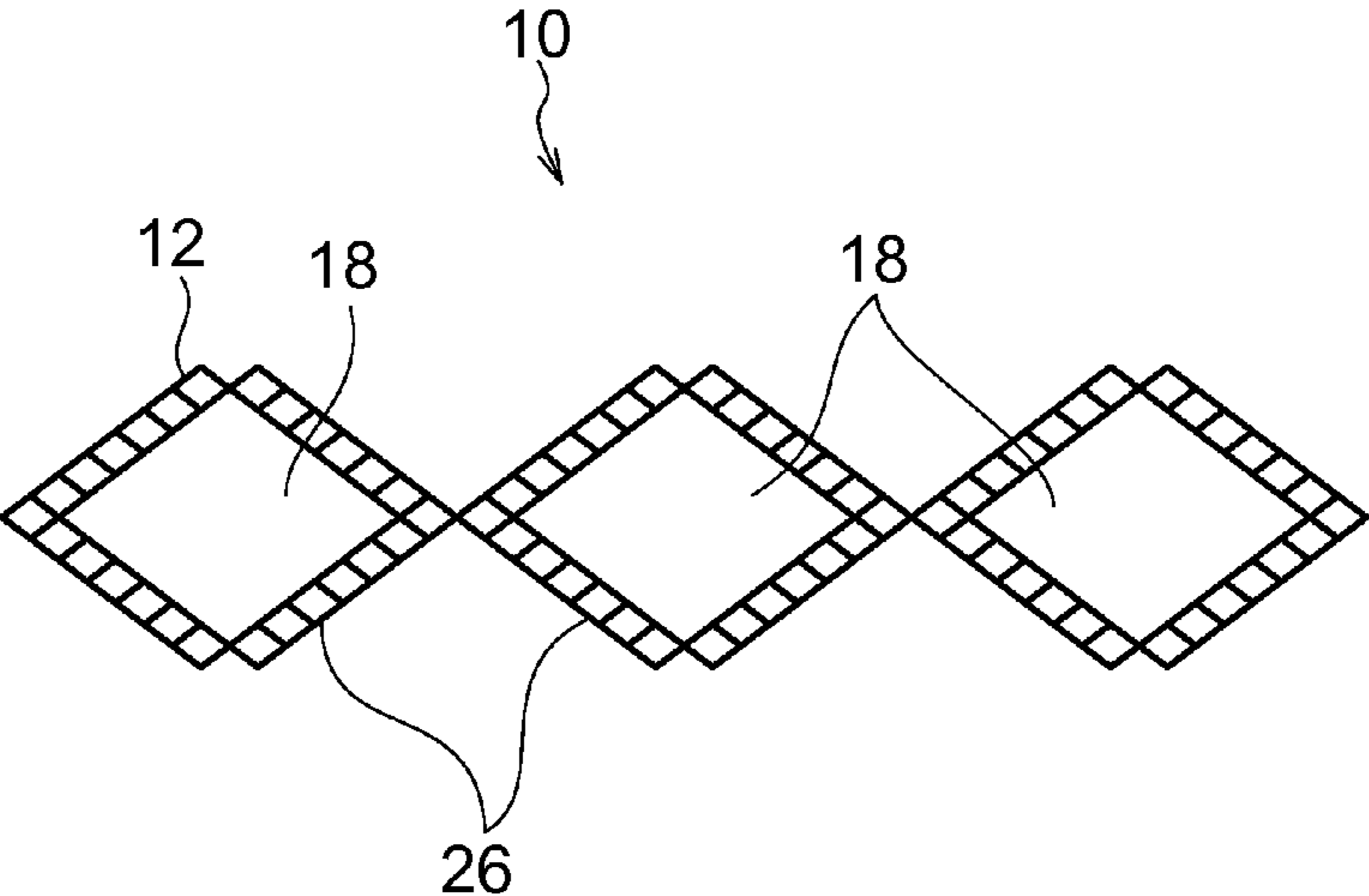


FIG.27

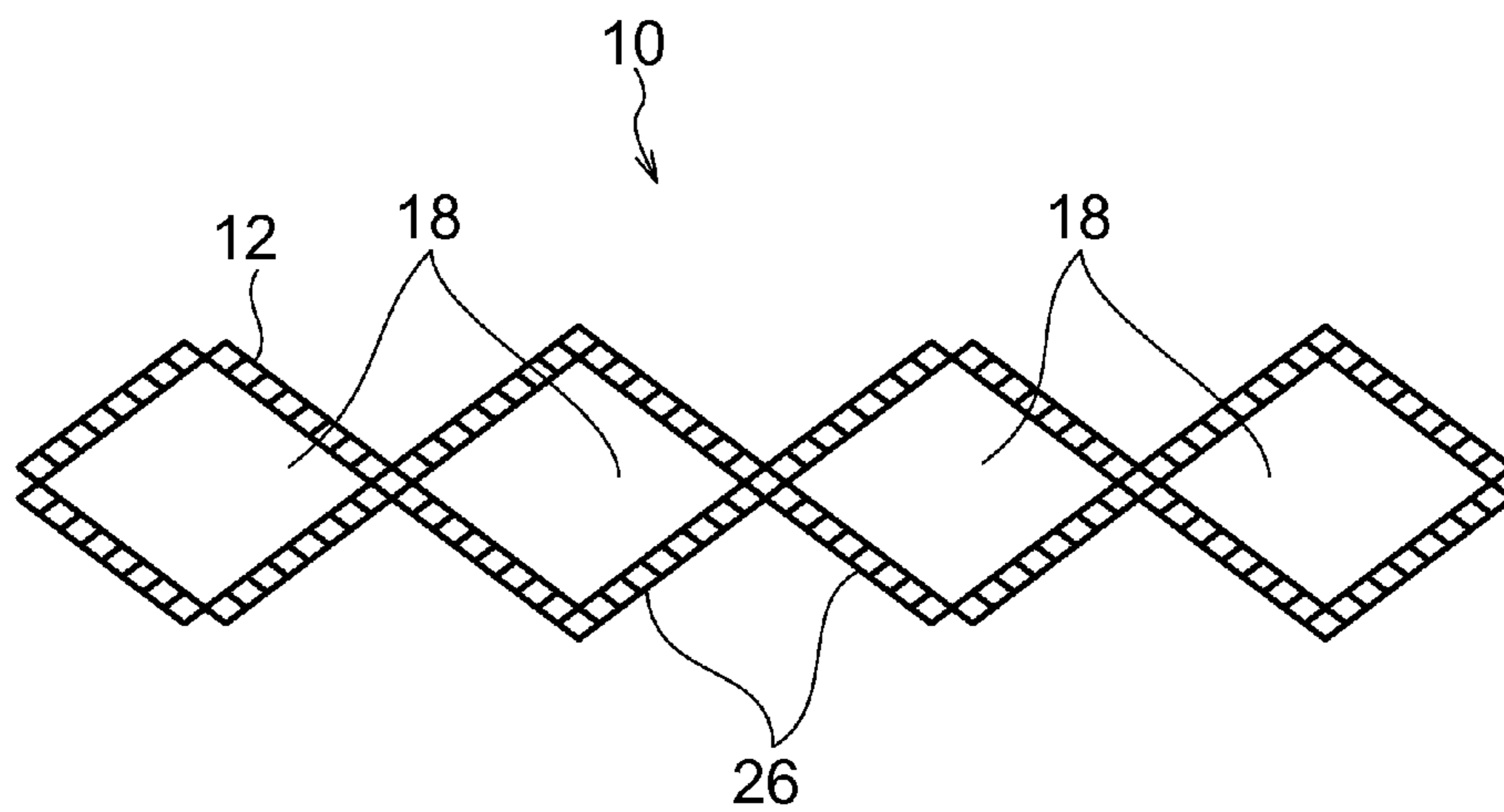


FIG.28

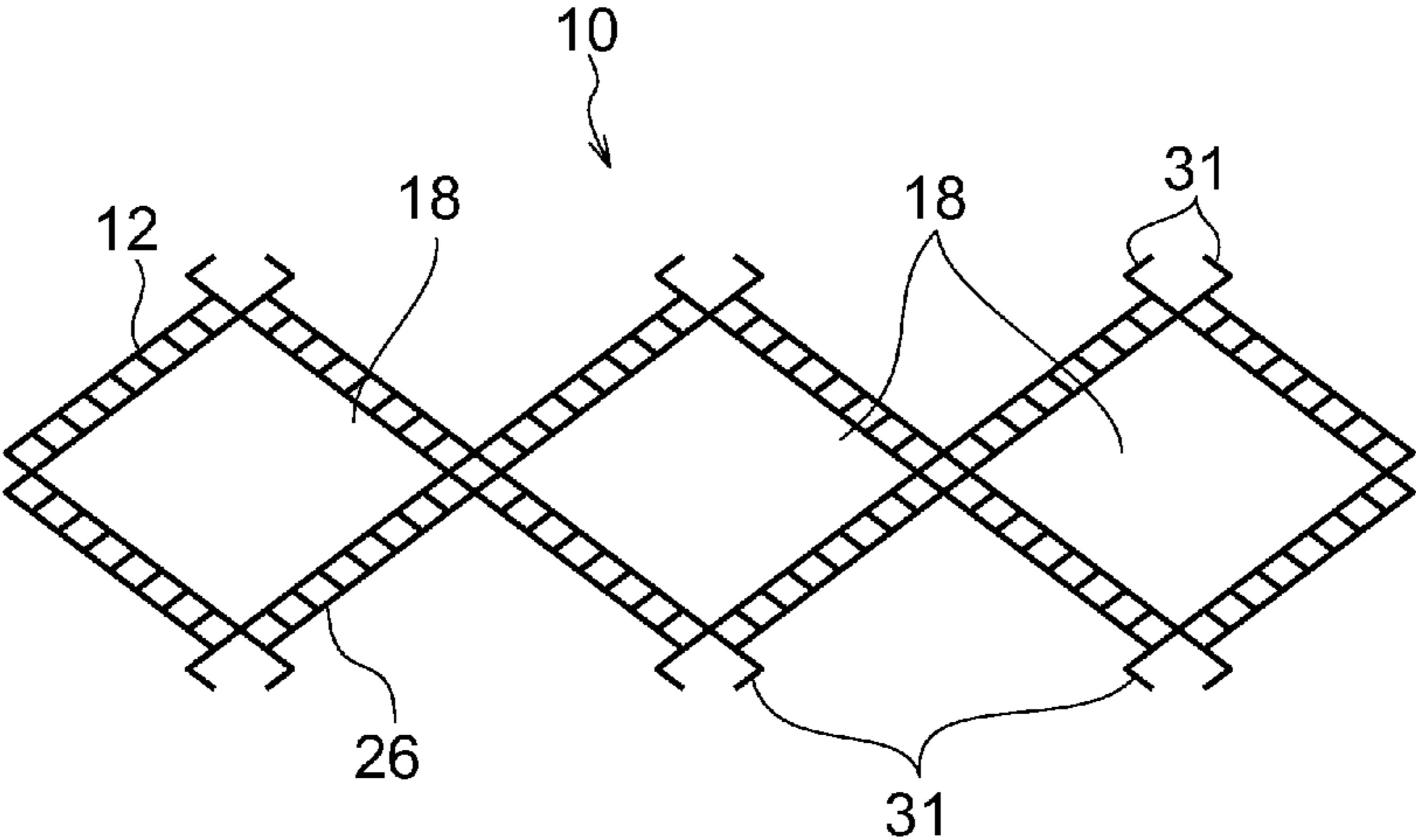


FIG.29

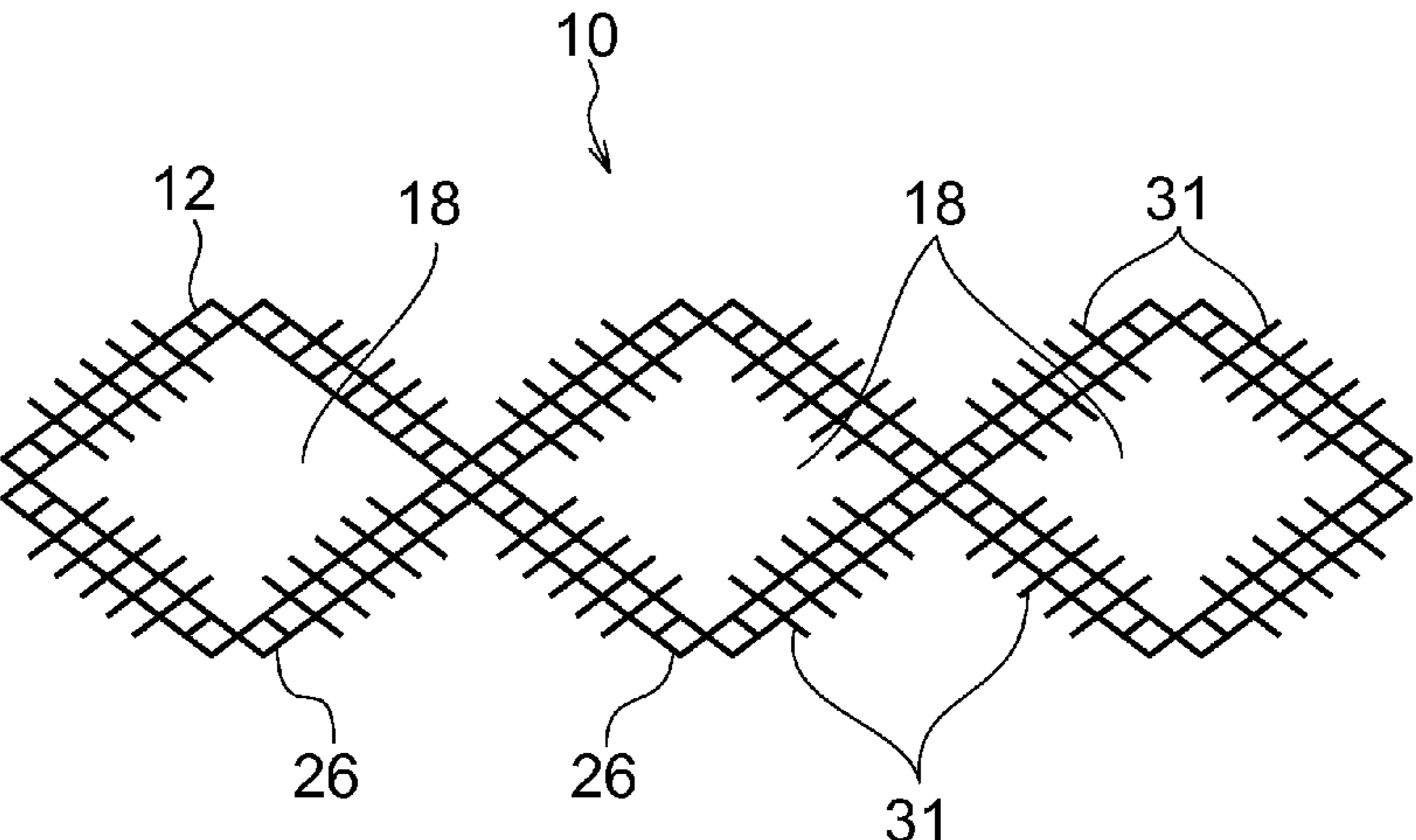


FIG.30

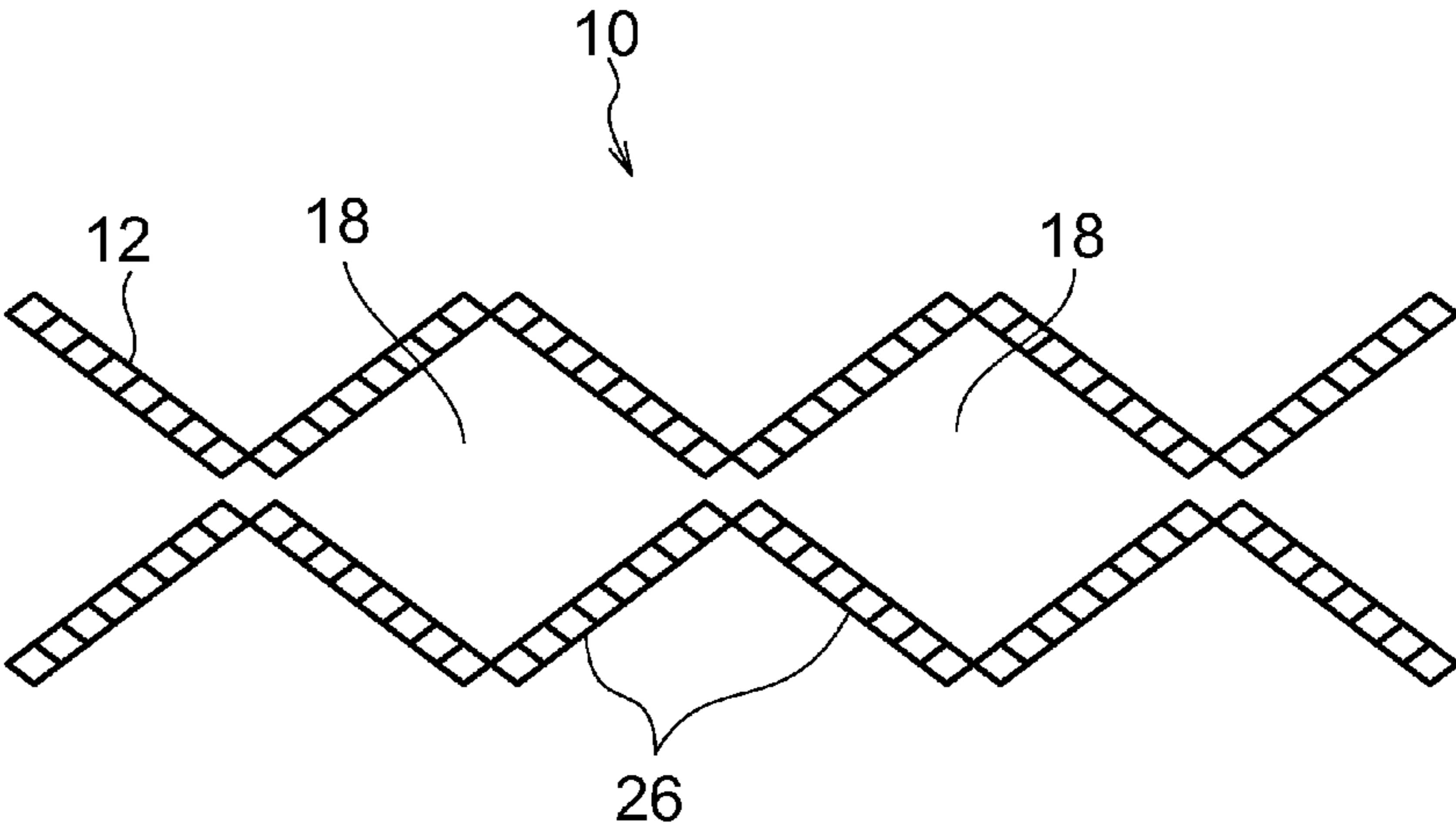


FIG.31

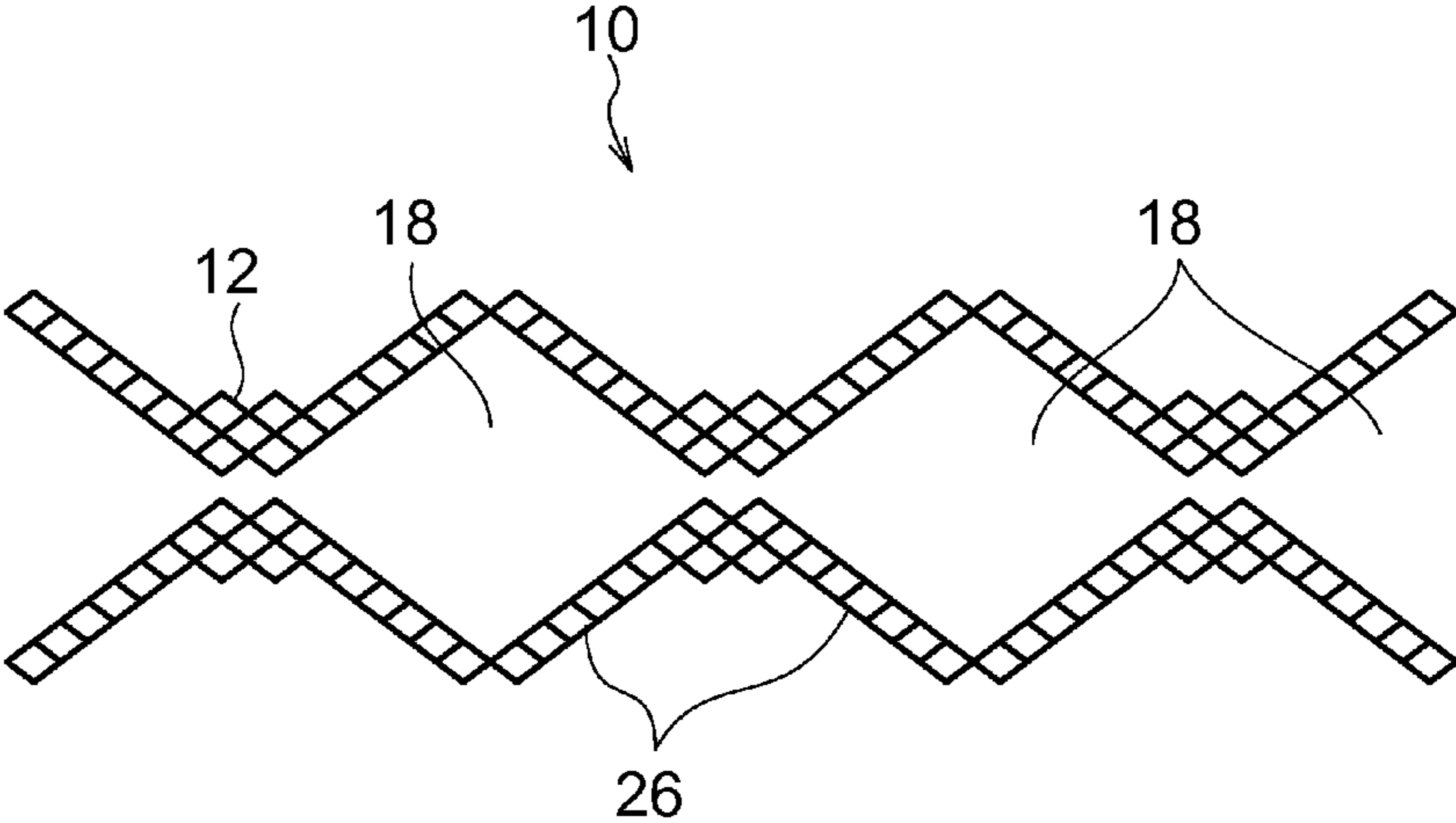




FIG.32

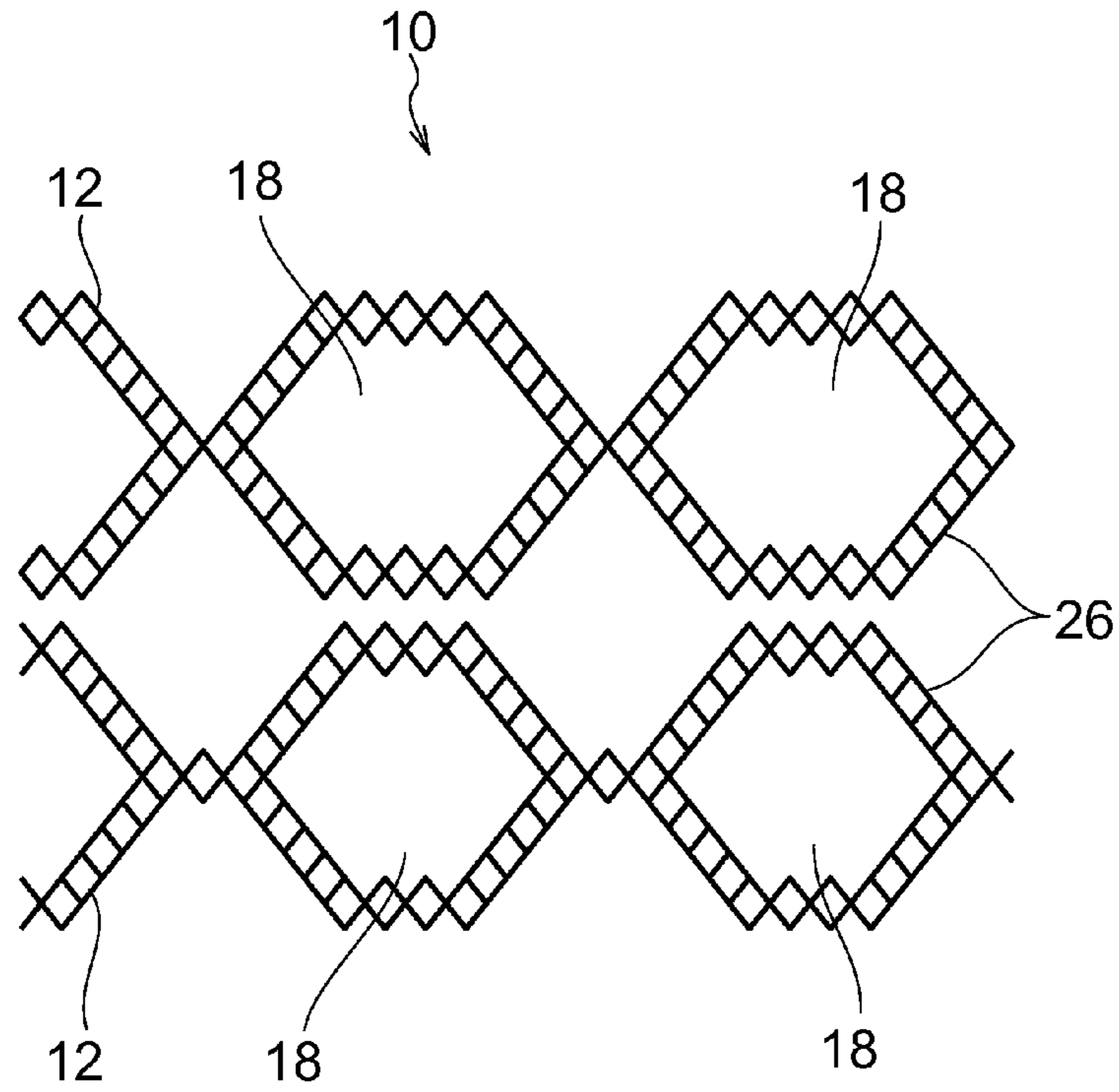
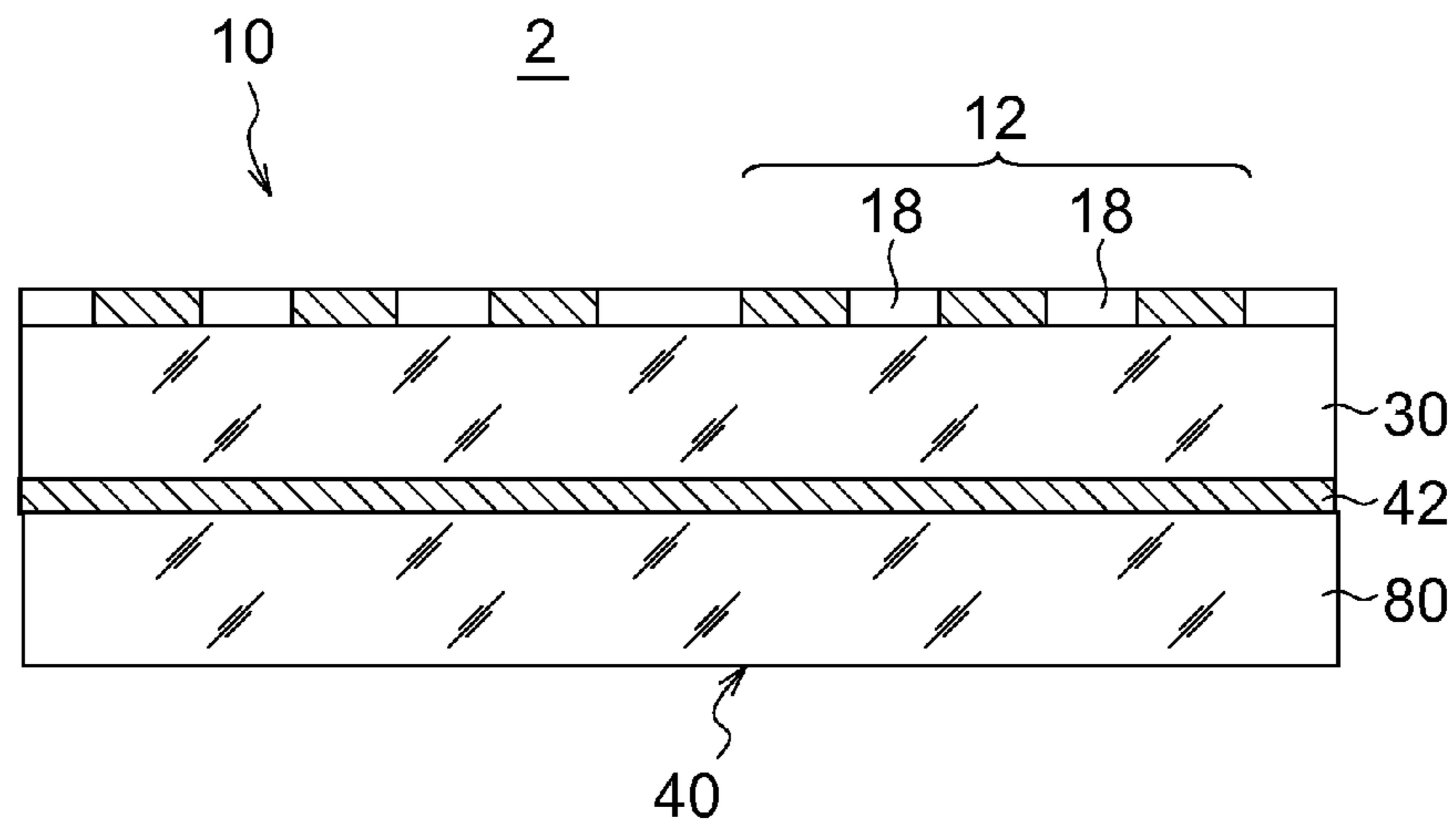


FIG.33



**CONDUCTIVE SHEET AND TOUCH PANEL****CROSS-REFERENCE TO RELATED APPLICATIONS**

This application is a Continuation of PCT International Application No. PCT/JP2012/083221 filed on Dec. 21, 2012, which claims priorities under 35 U.S.C §119(a) to Japanese Patent Application No. 2011-281927 filed Dec. 22, 2011 and Japanese Patent Application No. 2012-182712 filed Aug. 21, 2012. Each of the above application(s) is hereby expressly incorporated by reference, in its entirety, into the present application.

**BACKGROUND OF THE INVENTION****1. Field of the Invention**

The present invention relates to a conductive sheet and a touch panel.

**2. Description of the Related Art**

In recent years, touch panels are frequently used as input devices for portable terminals and computers. Such a touch panel is placed on a surface of a display, and performs an input operation by detecting a position touched with a finger or the like. For example, a resistance film type (resistive type) and a capacitive type are known as a position detecting method for a touch panel.

For example, in a capacitive touch panel, indium tin oxide (ITO) is used as a material of a transparent electrode pattern, from the perspective of visibility. ITO, however, has a high wiring resistance and does not have a sufficient transparency, and hence it is discussed that a transparent electrode pattern formed using metal thin wires is used for a touch panel.

Japanese Patent Application Laid-Open No. 2010-277392 discloses a touch panel including: a plurality of first detection electrodes that are made of net-like conductive wires and are placed in parallel in one direction; and a plurality of second detection electrodes that are made of net-like conductive wires and are placed in parallel in a direction orthogonal to that of the first detection electrodes.

**SUMMARY OF THE INVENTION**

In the touch panel of Japanese Patent Application Laid-Open No. 2010-277392, if the touch panel is touched with a finger, a change in electrostatic capacitance that occurs in the electrodes is determined, whereby a position touched with the finger is detected. However, in the touch panel of Japanese Patent Application Laid-Open No. 2010-277392, in the case where an upper electrode is made of a uniform conductive region and does not have a nonconductive region, even if a finger or the like comes into contact with the touch panel, lines of discharged electric force are closed between the electrodes, and the touch with the finger cannot be detected in some cases.

The present invention, which has been made in view of such a problem, has an object to provide a conductive sheet and a touch panel that have a high detection accuracy and include electrode patterns made of metal thin wires.

A conductive sheet according to one aspect of the present invention includes: a substrate having a first main surface and a second main surface; a first electrode pattern placed on the first main surface; and a second electrode pattern placed on the second main surface. The first electrode pattern is formed by a plurality of grids made of a plurality of metal thin wires that intersect with each other. The first electrode pattern alternately includes: a plurality of first conductive patterns that

extend in a first direction; and a plurality of first nonconductive patterns that are electrically separated from the plurality of first conductive patterns. The second electrode pattern is formed by a plurality of grids made of a plurality of metal thin wires that intersect with each other. The second electrode pattern alternately includes: a plurality of second conductive patterns that extend in a second direction orthogonal to the first direction; and a plurality of second nonconductive patterns that are electrically separated from the plurality of second conductive patterns. The first electrode pattern and the second electrode pattern are placed on the substrate such that the plurality of first conductive patterns and the plurality of second conductive patterns are orthogonal to each other in top view and that the grids of the first electrode pattern and the grids of the second electrode pattern form small grids in top view. Each of the first conductive patterns includes, at least inside thereof, slit-like sub-nonconduction patterns that are electrically separated from the first conductive pattern and extend in the first direction. Each of the first conductive patterns includes a plurality of first conductive pattern lines divided by the sub-nonconduction patterns. Each of the second conductive patterns has a strip shape.

A conductive sheet according to another aspect of the present invention includes: a substrate having a first main surface and a second main surface; a first electrode pattern placed on the first main surface; and a second electrode pattern placed on the second main surface. The first electrode pattern is formed by a plurality of grids made of a plurality of metal thin wires that intersect with each other. The first electrode pattern alternately includes: a plurality of first conductive patterns that extend in a first direction; and a plurality of first nonconductive patterns that are electrically separated from the plurality of first conductive patterns. The second electrode pattern is formed by a plurality of grids made of a plurality of metal thin wires that intersect with each other. The second electrode pattern alternately includes: a plurality of second conductive patterns that extend in a second direction orthogonal to the first direction; and a plurality of second nonconductive patterns that are electrically separated from the plurality of second conductive patterns. The first electrode pattern and the second electrode pattern are placed on the substrate such that the plurality of first conductive patterns and the plurality of second conductive patterns are orthogonal to each other in top view and that the grids of the first electrode pattern and the grids of the second electrode pattern form small grids in top view. Each of the first conductive patterns includes sub-nonconduction patterns that are spaced apart from each other along the first direction, to thereby have X-shaped structures with cyclic intersections. Each of the second conductive patterns has a strip shape.

Preferably, the first nonconductive patterns and the second nonconductive patterns respectively include first break parts and second break parts in portions other than intersection parts of the metal thin wires, and the first break parts and the second break parts are respectively located near centers between the intersection parts and the intersection parts

Preferably, each of the first break parts and the second break parts has a width that exceeds a wire width of each of the metal thin wires and is equal to or less than 50  $\mu\text{m}$ .

Preferably, the metal thin wires of the second conductive patterns are located in the first break parts of the first nonconductive patterns in top view, and the metal thin wires of the first conductive patterns are located in the second break parts of the second nonconductive patterns in top view.

Preferably, each of the grids of the first electrode pattern and the grids of the second electrode pattern has one side



having a length of 250  $\mu\text{m}$  to 900  $\mu\text{m}$ , and each of the small grids has one side having a length of 125  $\mu\text{m}$  to 450  $\mu\text{m}$ .

Preferably, each of the metal thin wires that form the first electrode pattern and the metal thin wires that form the second electrode pattern has a wire width equal to or less than 30  $\mu\text{m}$ .

Preferably, each of the grids of the first electrode pattern and the grids of the second electrode pattern has a rhomboid shape.

A conductive sheet according to another aspect of the present invention includes: a substrate having a first main surface; and a first electrode pattern placed on the first main surface. The first electrode pattern is formed by a plurality of grids made of a plurality of metal thin wires that intersect with each other. The first electrode pattern includes a plurality of first conductive patterns that extend in a first direction.

Each of the first conductive patterns includes, at least inside thereof, slit-like sub-nonconduction patterns that are electrically separated from the first conductive pattern and extend in the first direction. Each of the first conductive patterns includes a plurality of first conductive pattern lines divided by the sub-nonconduction patterns.

A conductive sheet according to another aspect of the present invention includes: a substrate having a first main surface; and a first electrode pattern placed on the first main surface. The first electrode pattern is formed by a plurality of grids made of a plurality of metal thin wires that intersect with each other. The first electrode pattern includes: a plurality of first conductive patterns that extend in a first direction; and a plurality of sub-nonconduction patterns that are spaced apart from each other along the first direction, to thereby have X-shaped structures with cyclic intersections.

Preferably, a width of each of the first conductive pattern lines and a width of each of the sub-nonconduction patterns are substantially equal to each other.

Preferably, a width of each of the first conductive pattern lines is smaller than a width of each of the sub-nonconduction patterns.

Preferably, a width of each of the first conductive pattern lines is larger than a width of each of the sub-nonconduction patterns.

Preferably, the first electrode pattern includes a joining part that electrically connects the plurality of first conductive pattern lines to each other.

Preferably, the number of the first conductive pattern lines is equal to or less than ten.

Preferably, each of the sub-nonconduction patterns is surrounded by a plurality of sides, and each of the sides is formed by linearly arranging the plurality of grids with sides of the grids being connected to each other.

Preferably, each of the sub-nonconduction patterns is surrounded by a plurality of sides, and each of the sides is formed by linearly arranging, in multiple stages, the plurality of grids with sides of the grids being connected to each other.

Preferably, each of the sub-nonconduction patterns is surrounded by a plurality of sides, some of the sides are formed by linearly arranging the plurality of grids with sides of the grids being connected to each other, and the other sides are formed by linearly arranging the plurality of grids with apex angles of the grids being connected to each other.

Preferably, the plurality of sub-nonconduction patterns defined by the sides formed by the plurality of grids are arranged along the first direction with apex angles of the grids being connected to each other.

Preferably, adjacent ones of the sub-nonconduction patterns along the first direction have shapes different from each other.

Preferably, each of the plurality of grids that form the sides for defining the sub-nonconduction patterns further includes a protruding wire made of a metal thin wire.

Preferably, each of the first conductive patterns includes the sub-nonconduction patterns that are spaced apart from each other, to thereby have X-shaped structures in which the grids are not present at cyclical intersection parts.

Preferably, adjacent ones of the sub-nonconduction patterns along the first direction have the same shape in each of the first conductive patterns, and the sub-nonconduction patterns have shapes different between adjacent ones of the first conductive patterns.

A touch panel, preferably a capacitive touch panel, and more preferably a projected capacitive touch panel according to another aspect of the present invention includes the above-mentioned conductive sheet of the present invention.

According to the present invention, it is possible to provide a conductive sheet and a touch panel that have a high detection accuracy and include electrode patterns made of metal thin wires.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic plan view of a conductive sheet for a touch panel.

FIG. 2 is a schematic cross-sectional view of the conductive sheet.

FIG. 3 is an explanatory diagram for describing a behavior of the touch panel including the conductive sheet of the present embodiment.

FIG. 4 is an explanatory diagram for describing a behavior of a touch panel including a conventional conductive sheet.

FIG. 5 is a plan view illustrating an example of a first electrode pattern of a first embodiment.

FIG. 6 is a plan view illustrating an example of a second electrode pattern of the first embodiment.

FIG. 7 is a plan view illustrating an example of a conductive sheet for a touch panel in which the first electrode pattern and the second electrode pattern of the first embodiment are combined with each other.

FIG. 8 is a plan view illustrating an example of a first electrode pattern of another first embodiment.

FIG. 9 is a partial enlarged view of the first electrode pattern of the another first embodiment.

FIG. 10 is a plan view illustrating an example of a second electrode pattern of the another first embodiment.

FIG. 11 is a partial enlarged view of the second electrode pattern of the another first embodiment.

FIG. 12 is a plan view illustrating an example of a conductive sheet for a touch panel in which the first electrode pattern and the second electrode pattern of the another first embodiment are combined with each other.

FIG. 13 is a plan view illustrating an example of another first electrode pattern of the first embodiment.

FIG. 14 is a plan view illustrating an example of another first electrode pattern of the first embodiment.

FIG. 15 is a plan view illustrating an example of another first electrode pattern of the first embodiment.

FIG. 16 is a plan view illustrating an example of another first electrode pattern of the first embodiment.

FIG. 17 is a plan view illustrating an example of another first electrode pattern of the first embodiment.

FIG. 18 is a plan view illustrating an example of another first electrode pattern of the first embodiment.

FIG. 19 is a plan view illustrating an example of a first electrode pattern of a second embodiment.



5

FIG. 20 is a plan view illustrating an example of a conductive sheet for a touch panel in which the first electrode pattern and a second electrode pattern of the second embodiment are combined with each other.

FIG. 21 is a plan view illustrating an example of a first electrode pattern of another second embodiment.

FIG. 22 is a plan view illustrating an example of a conductive sheet for a touch panel in which the first electrode pattern and a second electrode pattern of the another second embodiment are combined with each other.

FIG. 23 is a plan view illustrating an example of another first electrode pattern of the second embodiment.

FIG. 24 is a plan view illustrating an example of another first electrode pattern of the second embodiment.

FIG. 25 is a plan view illustrating an example of another first electrode pattern of the second embodiment.

FIG. 26 is a plan view illustrating an example of another first electrode pattern of the second embodiment.

FIG. 27 is a plan view illustrating an example of another first electrode pattern of the second embodiment.

FIG. 28 is a plan view illustrating an example of another first electrode pattern of the second embodiment.

FIG. 29 is a plan view illustrating an example of another first electrode pattern of the second embodiment.

FIG. 30 is a plan view illustrating an example of another first electrode pattern of the second embodiment.

FIG. 31 is a plan view illustrating an example of another first electrode pattern of the second embodiment.

FIG. 32 is a plan view illustrating an example of another first electrode pattern of the second embodiment.

FIG. 33 is a schematic cross-sectional view of another conductive sheet.

#### DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

Hereinafter, preferred embodiments of the present invention are described with reference to the attached drawings. The present invention is described by way of the following preferred embodiments, but can be changed according to many methods, without departing from the scope of the present invention. Other embodiments than the present embodiments can be adopted for the present invention. Accordingly, all changes within the scope of the present invention are included in the scope of the patent claims. Note that, herein, "to" indicating a numerical value range is used to mean that the numerical value range includes numerical values given before and after "to" as its lower limit value and its upper limit value.

FIG. 1 is a schematic plan view of a conductive sheet 1 for a touch panel (preferably for a capacitive touch panel, and more preferably for a projected capacitive touch panel). The conductive sheet 1 includes a first electrode pattern 10 made of metal thin wires and a second electrode pattern 40 made of metal thin wires. The first electrode pattern 10 includes a plurality of first conductive patterns 12 that extend in a first direction (X direction) and are arranged in parallel. The second electrode pattern 40 includes a plurality of second conductive patterns 42 that extend in a second direction (Y direction) orthogonal to the first direction (X direction) and are arranged in parallel.

Each first conductive pattern 12 has one end electrically connected to a first electrode terminal 14. Further, each first electrode terminal 14 is electrically connected to a first wire 16 having conductive properties. Each second conductive pattern 42 has one end electrically connected to a second

6

electrode terminal 44. Each second electrode terminal 44 is electrically connected to a second wire 46 having conductive properties.

FIG. 2 is a schematic cross-sectional view of the conductive sheet 1 according to the present embodiment. The conductive sheet 1 includes: a substrate 30 having a first main surface and a second main surface; the first electrode pattern 10 placed on the first main surface of the substrate 30; and the second electrode pattern 40 placed on the second main surface of the substrate 30. The first electrode pattern 10 includes the first conductive patterns 12, and each first conductive pattern 12 includes sub-nonconduction patterns 18 electrically separated from the first conductive pattern 12. In the embodiment of FIG. 2, adjacent two of the first conductive patterns 12 are illustrated, and each first conductive pattern 12 includes two sub-nonconduction patterns 18. The present invention, however, is not limited to this example.

FIG. 3 is a view of a state where a finger 500 is brought into contact with a touch panel including the conductive sheet 1 of FIG. 2. The conductive sheet 1 includes: the substrate 30 having the first main surface and the second main surface; the first electrode pattern 10 placed on the first main surface of the substrate 30; and the second electrode pattern 40 placed on the second main surface of the substrate 30. If the finger 500 is brought into contact with the first conductive patterns 12 including the sub-nonconduction patterns 18, lines of electric force discharged from the second conductive patterns 42 pass through the sub-nonconduction patterns 18. That is, the lines of electric force are not closed between the first conductive patterns 12 and the second conductive patterns 42. As a result, a change in electrostatic capacitance caused by the touch with the finger 500 can be reliably recognized.

FIG. 4 is a view of a state where the finger 500 is brought into contact with a touch panel including a conventional conductive sheet 101. The conductive sheet 101 includes: a substrate 300 having a first main surface and a second main surface; a first electrode pattern 110 placed on the first main surface of the substrate 300; and a second electrode pattern 400 placed on the second main surface of the substrate 300. Each first conductive pattern 120 of the first electrode pattern 110 does not include a sub-nonconduction pattern electrically separated from the first conductive pattern 120. That is, each first conductive pattern 120 is made of a uniform conductive region. As a result, lines of electric force discharged from second conductive patterns 420 of the second electrode pattern 400 are closed between the first conductive patterns 120 and the second conductive patterns 420, and the touch with the finger 500 cannot be detected in some cases.

<First Embodiment>

FIG. 5 illustrates a conductive sheet 1 including a first electrode pattern 10 according to a first embodiment. In FIG. 5, the first electrode pattern 10 includes two types of first conductive patterns 12 formed by a large number of grids 26 made of metal thin wires. The plurality of grids 26 have substantially uniform shapes. Here, the substantially uniform shapes mean not only that the shapes are completely coincident with each other but also that the shapes and sizes of the grids 26 are seemingly the same as each other. Each first conductive pattern 12 has one end electrically connected to a first electrode terminal 14. Each first electrode terminal 14 is electrically connected to one end of each first wire 16. Each first wire 16 has another end electrically connected to a terminal 20. Each first conductive pattern 12 is electrically separated by a first nonconductive pattern 28.

Note that, in the case of the use as a transparent conductive film placed on the front side of a display that is required to have visibility, a dummy pattern that includes break parts to



be described later and is made of metal wires is formed as the first nonconductive pattern **28**. On the other hand, in the case of the use as a transparent conductive film placed on the front side of a notebook computer, a touch pad, or the like that is not particularly required to have visibility, a dummy pattern made of metal thin wires is not formed as the first nonconductive pattern **28**, and the first nonconductive pattern **28** exists as a space (blank).

The first conductive patterns **12** extend in a first direction (X direction), and are arranged in parallel. Each first conductive pattern **12** includes slit-like sub-nonconduction patterns **18** electrically separated from the first conductive pattern **12**. Each first conductive pattern **12** includes a plurality of first conductive pattern lines **22** divided by the sub-nonconduction patterns **18**.

Note that, in the case of the use as a transparent conductive film placed on the front side of a display that is required to have visibility, a dummy pattern that includes break parts to be described later and is made of metal wires is formed as each sub-nonconduction pattern **18**. On the other hand, in the case of the use as a transparent conductive film placed on the front side of a notebook computer, a touch pad, or the like that is not particularly required to have visibility, a dummy pattern made of metal thin wires is not formed as each sub-nonconduction pattern **18**, and each sub-nonconduction pattern **18** exists as a space (blank).

As illustrated in the upper side of FIG. **5**, a first first conductive pattern **12** includes slit-like sub-nonconduction patterns **18** each having another end that is opened. Because the another ends are opened, the first first conductive pattern **12** has a comb-shaped structure. In the present embodiment, the first first conductive pattern **12** includes two sub-nonconduction patterns **18**, whereby three first conductive pattern lines **22** are formed. The first conductive pattern lines **22** are connected to the first electrode terminal **14**, and thus have the same electric potential.

As illustrated in the lower side of FIG. **5**, a second first conductive pattern **12** has another end at which an additional first electrode terminal **24** is provided. Slit-like sub-nonconduction patterns **18** are closed inside of the first conductive pattern **12**. If the additional first electrode terminal **24** is provided, each first conductive pattern **12** can be easily checked. In the present embodiment, the second first conductive pattern **12** includes two closed sub-nonconduction patterns **18**, whereby three first conductive pattern lines **22** are formed. Each first conductive pattern lines **22** is connected to the first electrode terminal **14** and the additional first electrode terminal **24**, and thus have the same electric potential. Such first conductive pattern lines are one of modified examples of the comb-shaped structure.

The number of the first conductive pattern lines **22** may be two or more, and is determined within a range of ten or less and preferably a range of seven or less, in consideration of a relation with a pattern design of metal thin wires.

Moreover, the pattern shapes of the metal thin wires of the three first conductive pattern lines **22** may be the same as each other, and may be different from each other. In FIG. **5**, the shapes of the first conductive pattern lines **22** are different from each other. In the first first conductive pattern **12**, the uppermost first conductive pattern line **22** of the three first conductive pattern lines **22** is designed to extend along the first direction (X direction) such that adjacent mountain-shaped metal wires intersect with each other. The grids **26** of the uppermost first conductive pattern line **22** are not complete, that is, each grid **26** does not have a lower apex angle. The central first conductive pattern line **22** is designed to extend in two lines along the first direction (X direction) such

that sides of adjacent ones of the grids **26** are in contact with each other. The lowermost first conductive pattern line **22** is designed to extend along the first direction (X direction) such that apex angles of adjacent ones of the grids **26** are in contact with each other and that sides of the grids **26** are extended.

In the second first conductive pattern **12**, the uppermost first conductive pattern line **22** and the lowermost first conductive pattern line **22** have substantially the same grid shape, and are thus designed to extend in two lines along the first direction (X direction) such that sides of adjacent ones of the grids **26** are in contact with each other. In the second first conductive pattern **12**, the central first conductive pattern line **22** is designed to extend along the first direction (X direction) such that apex angles of adjacent ones of the grids **26** are in contact with each other and that sides of the grids **26** are extended.

In the first embodiment, assuming that the area of the first conductive patterns **12** is  $A1$  and that the area of the sub-nonconduction patterns **18** is  $B1$ , it is preferable that  $40\% \leq B1/(A1+B1) \leq 60\%$  be satisfied. If this range is satisfied, a difference in electrostatic capacitance between when a finger is in contact with the touch panel and when a finger is not in contact with the touch panel can be made larger. That is, the detection accuracy can be improved.

Note that each area can be obtained in the following manner. A virtual line in contact with a plurality of the first conductive pattern lines **22** is drawn, and the first conductive pattern **12** and the sub-nonconduction patterns **18** surrounded by this virtual line are calculated, whereby each area can be obtained.

Assuming that the total width of the widths of the first conductive pattern lines **22** is  $Wa$  and that the sum of: the sum of the widths of the sub-nonconduction patterns **18**; and the width of the first nonconductive pattern **28** is  $Wb$ , it is preferable that a condition of the following expression (W1-1) be satisfied, it is more preferable that a condition of the following expression (W1-2) be satisfied, and it is more preferable that a condition of the following expression (W1-3) be satisfied. Moreover, it is preferable that a condition of the following expression (W2-1) be satisfied, it is more preferable that a condition of the following expression (W2-2) be satisfied, and it is more preferable that a condition of the following expression (W2-3) be satisfied.

$$10\% \leq (Wa/(Wa+Wb)) \times 100 \leq 80\% \quad (W1-1)$$

$$10\% \leq (Wa/(Wa+Wb)) \times 100 \leq 60\% \quad (W1-2)$$

$$30\% \leq (Wa/(Wa+Wb)) \times 100 \leq 55\% \quad (W1-3)$$

$$Wa \leq (Wa+Wb)/2 \quad (W2-1)$$

$$(Wa+Wb)/5 \leq Wa \leq (Wa+Wb)/2 \quad (W2-2)$$

$$(Wa+Wb)/3 \leq Wa \leq (Wa+Wb)/2 \quad (W2-3)$$

If the sum of the widths of the first conductive pattern lines **22** is small, the touch panel response tends to be slower due to an increase in electrode resistance, whereas the recognition performance for a contacting finger tends to be higher due to a decrease in electrostatic capacitance. On the other hand, if the sum of the widths of the first conductive pattern lines **22** is large, the touch panel response tends to be faster due to a decrease in electrode resistance, whereas the recognition performance for a contacting finger tends to be lower due to an increase in electrostatic capacitance. These are in a trade-off relation, but, if the range of any of the above expressions is satisfied, the touch panel response and the recognition performance for a finger can be optimized.



Here, as illustrated in FIG. 5, the sum of widths  $a_1$ ,  $a_2$ , and  $a_3$  of the first conductive pattern lines 22 corresponds to  $W_a$ , and the sum of widths  $b_1$  and  $b_2$  of the sub-nonconduction patterns 18 and a width  $b_3$  of the first nonconductive pattern 28 corresponds to  $W_b$ .

FIG. 5 illustrates one conductive sheet 1 in which the first first conductive pattern 12 not including the additional first electrode terminal 24 and the second first conductive pattern 12 including the additional first electrode terminal 24 are formed on the same plane. However, the first first conductive pattern 12 and the second first conductive pattern 12 do not necessarily need to be mixedly formed, and only any one of the first first conductive pattern 12 and the second first conductive pattern 12 may be formed.

In another embodiment, further preferably, assuming that the total width of the widths of the first conductive pattern lines 22 is  $W_a$  and that the sum of: the sum of the widths of the sub-nonconduction patterns 18; and the width of the first nonconductive pattern 28 is  $W_b$ , relations of  $1.0\text{ mm} \leq W_a \leq 5.0\text{ mm}$  and  $1.5\text{ mm} \leq W_b \leq 5.0\text{ mm}$  are satisfied. In consideration of the average size of a human finger, if these ranges are satisfied, the position can be more accurately detected. Further, for the value of  $W_a$ ,  $1.5\text{ mm} \leq W_a \leq 4.0\text{ mm}$  is preferable, and  $2.0\text{ mm} \leq W_a \leq 2.5\text{ mm}$  is further preferable. Furthermore, for the value of  $W_b$ ,  $1.5\text{ mm} \leq W_b \leq 4.0\text{ mm}$  is preferable, and  $2.0\text{ mm} \leq W_b \leq 3.0\text{ mm}$  is further preferable.

The metal thin wires that form the first electrode pattern 10 are made of a nontransparent conductive material, for example, metal materials such as gold, silver, and copper and conductive materials such as metal oxides.

It is desirable that the wire width of each metal thin wire be  $30\text{ }\mu\text{m}$  or less, preferably  $15\text{ }\mu\text{m}$  or less, more preferably  $10\text{ }\mu\text{m}$  or less, more preferably  $9\text{ }\mu\text{m}$  or less, and more preferably  $7\text{ }\mu\text{m}$  or less, and be  $0.5\text{ }\mu\text{m}$  or more and preferably  $1\text{ }\mu\text{m}$  or more.

The first electrode pattern 10 includes the plurality of grids 26 made of metal thin wires that intersect with each other. Each grid 26 includes an opening region surrounded by the metal thin wires. Each grid 26 has one side having a length of  $900\text{ }\mu\text{m}$  or less and  $250\text{ }\mu\text{m}$  or more. It is desirable that the length of one side thereof be  $700\text{ }\mu\text{m}$  or less and  $300\text{ }\mu\text{m}$  or more.

In the first conductive patterns 12 of the present embodiment, the opening ratio is preferably 85% or more, further preferably 90% or more, and most preferably 95% or more, in terms of the visible light transmittance. The opening ratio corresponds to the percentage of a translucent portion of the first electrode pattern 10 excluding the metal thin wires, in a predetermined region.

In the above-mentioned conductive sheet 1, each grid 26 has a substantially rhomboid shape. The substantially rhomboid shape means a shape that seemingly looks like a rhomboid shape. Alternatively, each grid 26 may have other polygonal shapes. Moreover, the shape of one side of each grid 26 may be a curved shape or a circular arc shape instead of a straight shape. In the case of the circular arc shape, for example, opposing two of the sides of each grid 26 may each have a circular arc shape convex outward, and another opposing two of the sides thereof may each have a circular arc shape convex inward. Moreover, the shape of each side of each grid 26 may be a wavy shape in which a circular arc convex outward and a circular arc convex inward are alternately continuous. As a matter of course, the shape of each side thereof may be a sine curve.

FIG. 6 illustrates a second electrode pattern. As illustrated in FIG. 6, a second electrode pattern 40 is formed by a large number of grids made of metal thin wires. The second elec-

trode pattern 40 includes a plurality of second conductive patterns 42 that extend in a second direction (Y direction) orthogonal to the first direction (X direction) and are arranged in parallel. Each second conductive pattern 42 is electrically connected to a second electrode terminal 44. Each second conductive pattern 42 is electrically separated by a second nonconductive pattern 58.

Each second electrode terminal 44 is electrically connected to a second wire 46 having conductive properties. Each second conductive pattern 42 has one end electrically connected to the second electrode terminal 44. Each second electrode terminal 44 is electrically connected to one end of each second wire 46. Each second wire 46 has another end electrically connected to a terminal 50. Each second conductive pattern 42 has a strip-shaped structure having a substantially constant width along the second direction. However, each second conductive pattern 42 is not limited to the strip shape.

The second electrode pattern 40 may be provided with an additional second electrode terminal 54 at another end thereof. If the additional second electrode terminal 54 is provided, each second conductive pattern 42 can be easily checked.

FIG. 6 illustrates one conductive sheet 1 in which the second conductive pattern 42 not including the additional second electrode terminal 54 and the second conductive pattern 42 including the additional second electrode terminal 54 are formed on the same plane. However, such two types of the second conductive patterns 42 do not necessarily need to be mixedly formed, and only one of the two types of the second conductive patterns 42 may be formed.

The metal thin wires that form the second electrode pattern 40 have substantially the same wire width and are made of substantially the same material as the metal thin wires that form the first electrode pattern 10. The second electrode pattern 40 includes a plurality of grids 56 made of metal thin wires that intersect with each other, and each grid 56 has substantially the same shape as that of each grid 26. The length of one side of each grid 56 and the opening ratio of each grid 56 are equivalent to those of each grid 26.

Note that, in the case of the use as a transparent conductive film placed on the front side of a display that is required to have visibility, a dummy pattern that includes break parts to be described later and is made of metal wires is formed as the second nonconductive pattern 58. On the other hand, in the case of the use as a transparent conductive film placed on the front side of a notebook computer, a touch pad, or the like that is not particularly required to have visibility, a dummy pattern made of metal thin wires is not formed as the second nonconductive pattern 58, and the second nonconductive pattern 58 exists as a space.

FIG. 7 is a plan view of the conductive sheet 1 in which the first electrode pattern 10 including the first conductive patterns 12 of the comb-shaped structure and the second electrode pattern 40 including the second conductive patterns 42 of the strip-shaped structure are placed such that the first conductive patterns 12 and the second conductive patterns 42 are substantially orthogonal to each other. The first electrode pattern 10 and the second electrode pattern 40 form a combination pattern 70. The substantially orthogonal includes not only the case where the first conductive patterns 12 and the second conductive patterns 42 are at right angles to each other but also the case where the first conductive patterns 12 and the second conductive patterns 42 are seemingly orthogonal to each other.

In the combination pattern 70, the grids 26 and the grids 56 form small grids 76 in top view. That is, the intersection parts of the grids 26 are respectively placed in substantially the



## 11

centers of the opening regions of the grids **56**. Note that each small grid **76** has one side having a length of 125  $\mu\text{m}$  or more and 450  $\mu\text{m}$  or less, and preferably has one side having a length of 150  $\mu\text{m}$  or more and 350  $\mu\text{m}$  or less. This corresponds to half the length of one side of each of the grids **26** and the grids **56**.

In the combination pattern illustrated in FIG. 7, the first electrode pattern **10** not including a dummy pattern and the second conductive pattern **42** not including a dummy pattern are combined with each other.

FIG. 8 is a plan view illustrating an example of another first electrode pattern **10** of the first embodiment, in which dummy patterns are explicitly illustrated. The first nonconductive pattern **28** is made of metal thin wires similarly to the first conductive patterns **12**, and includes the break parts. Moreover, the sub-nonconduction patterns **18** formed in each first conductive pattern **12** are made of metal thin wires similarly to the first conductive patterns **12**, and include the break parts. The metal thin wires that form the first nonconductive pattern **28** and the sub-nonconduction patterns **18** include the break parts, and thus form the dummy patterns that are not electrically conductive. Because the first nonconductive pattern **28** is formed as the dummy pattern, adjacent ones of the first conductive patterns **12** are electrically separated from each other similarly to FIG. 5. Moreover, because the sub-nonconduction patterns **18** are each formed as the dummy pattern, the first conductive pattern lines **22** are formed similarly to FIG. 5. If the first nonconductive pattern **28** and the first conductive patterns **12** are each formed as the dummy pattern, the first electrode pattern **10** is formed by the grids of the metal thin wires placed at regular intervals. This can prevent a decrease in visibility, and can prevent the first electrode pattern **10** from being easily visually observed.

FIG. 9 is an enlarged view of a portion surrounded by a circle in FIG. 8. As illustrated in FIG. 9, the metal thin wires that form the first nonconductive pattern **28** and the sub-nonconduction pattern **18** include break parts **29** (first break parts), and are electrically separated from the first conductive pattern **12**. It is preferable that each break part **29** be formed in a portion other than each intersection part of the metal thin wires. It is preferable that each break part **29** be formed at substantially the center between the intersection part and the intersection part. Substantially the center includes not only a completely central position but also a position that is slightly displaced from the center.

In FIG. 9, in order to clarify the first conductive pattern **12**, the first nonconductive pattern **28**, and the sub-nonconduction pattern **18**, the wire width of the first conductive pattern **12** is exaggeratingly thickened, and the wire widths of the first nonconductive pattern **28** and the sub-nonconduction pattern **18** are exaggeratingly thinned.

All the grids **26** that form the first nonconductive pattern **28** and the sub-nonconduction pattern **18** do not necessarily need to include the break parts **29**. The length of each break part **29** is preferably 60  $\mu\text{m}$  or less, and is more preferably 10 to 50  $\mu\text{m}$ , 15 to 40  $\mu\text{m}$ , and 20 to 40  $\mu\text{m}$ .

FIG. 10 is a plan view illustrating an example of another second electrode pattern **40** of the first embodiment. The second nonconductive pattern **58** is made of metal thin wires similarly to the second conductive patterns **42**, and includes the break parts. The metal thin wires that form the second nonconductive pattern **58** include the break parts, and thus form the dummy pattern that is not electrically conductive. Because the second nonconductive pattern **58** is formed as the dummy pattern, adjacent ones of the second conductive patterns **42** are electrically separated from each other similarly to FIG. 6. If the second nonconductive pattern **58** is formed as

## 12

the dummy pattern, the second electrode pattern **40** is formed by the grids of the metal thin wires placed at regular intervals. This can prevent a decrease in visibility, and can prevent the second electrode pattern **40** from being easily visually observed.

FIG. 11 is an enlarged view of a portion surrounded by a circle in FIG. 10. As illustrated in FIG. 11, the metal thin wires that form the second nonconductive pattern **58** include break parts **59** (second break parts), and are electrically separated from the second conductive patterns **42**. It is preferable that each break part **59** be formed at a portion other than each intersection part of the metal thin wires. It is preferable that each break part **59** be formed at substantially the center between the intersection part and the intersection part. Substantially the center includes not only a completely central position but also a position that is slightly displaced from the center.

In FIG. 11, in order to clarify the second conductive patterns **42** and the second nonconductive pattern **58**, the wire widths of the second conductive patterns **42** are exaggeratingly thickened, and the wire width of the second nonconductive pattern **58** is exaggeratingly thinned. Note that the length of each break part **59** is substantially the same as that of each break part **29** in FIG. 9.

FIG. 12 explicitly illustrates the first electrode pattern **10** including dummy patterns made of metal thin wires and the second electrode pattern **40** including dummy patterns made of metal thin wires. The first electrode pattern **10** and the second electrode pattern **40** are opposedly placed. The first conductive patterns **12** and the second conductive patterns **42** are orthogonal to each other, and the first electrode pattern **10** and the second electrode pattern **40** form the combination pattern **70**.

In the combination pattern **70**, the grids **26** and the grids **56** form the small grids **76** in top view. That is, the intersection parts of the grids **26** are respectively placed in substantially the centers of the opening regions of the grids **56**.

The metal thin wires of the second electrode pattern **40** are placed at positions opposed to the break parts **29** of the first electrode pattern **10**. Moreover, the metal thin wires of the first electrode pattern **10** are placed at positions opposed to the break parts **59** of the second electrode pattern **40**. The metal thin wires of the second electrode pattern **40** mask the break parts **29** of the first electrode pattern **10**, and the metal thin wires of the first electrode pattern **10** mask the break parts **59** of the second electrode pattern **40**. Accordingly, in the combination pattern **70**, the break parts **29** of the first electrode pattern **10** and the break parts **59** of the second electrode pattern **40** are less easily visually observed in top view, and hence the visibility can be enhanced.

Next, examples of other first electrode patterns of the first embodiment are described with reference to FIGS. 13 to 18.

FIG. 13 illustrates the first electrode pattern **10** according to another embodiment. The first electrode pattern **10** includes the first conductive patterns **12** formed by the large number of grids **26** made of metal thin wires. The first conductive patterns **12** extend in the first direction (X direction). Each first conductive pattern **12** includes the slit-like sub-nonconduction patterns **18** for electrically separating the first conductive pattern **12**. Each first conductive pattern **12** includes the plurality of first conductive pattern lines **22** divided by the sub-nonconduction patterns **18**. As illustrated in FIG. 13, each first conductive pattern line **22** is formed by the plurality of grids **26** that are arranged in one line in the first direction (X direction). The first conductive pattern lines **22**



## 13

are electrically connected to each other by the large number of grids **26** that are made of metal thin wires and are placed at an end.

As illustrated in FIG. **13**, the first conductive pattern lines **22** respectively extend in the first direction (X direction) from the first grid, the third grid, and the fifth grid of the five grids **26** that are arranged in the second direction (Y direction) at the end. As a result, each of the widths  $a_1$ ,  $a_2$ , and  $a_3$  of the first conductive pattern **12** and each of the widths  $b_1$  and  $b_2$  of the sub-nonconduction patterns **18** are substantially the same length (as long as the diagonal of each grid **26**). Substantially the same length includes not only the case where these widths are completely coincident with each other but also the case where these widths are seemingly the same as each other.

FIG. **14** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** includes the first conductive patterns **12** formed by the large number of grids **26** made of metal thin wires. The first conductive patterns **12** extend in the first direction (X direction). Each first conductive pattern **12** includes the slit-like sub-nonconduction patterns **18** for electrically separating the first conductive pattern **12**. As illustrated in FIG. **14**, each first conductive pattern line **22** is formed by the plurality of grids **26** that are arranged in one line in the first direction (X direction).

FIG. **14** is different from FIG. **13** in that the first conductive pattern lines **22** respectively extend in the first direction (X direction) from the first grid, between the third grid and the fourth grid, and the sixth grid of the six grids **26** that are arranged in the second direction (Y direction). That is, compared with FIG. **13**, the plurality of first conductive pattern lines **22** in FIG. **14** are arranged at a pitch longer by half the size of each grid **26**. As a result, the widths  $b_1$  and  $b_2$  of the sub-nonconduction patterns **18** are larger than the widths  $a_1$ ,  $a_2$ , and  $a_3$  of the first conductive pattern **12**. The widths  $b_1$  and  $b_2$  of the sub-nonconduction patterns **18** are 1.5 times longer than the diagonal of each grid **26**, and the widths  $a_1$ ,  $a_2$ , and  $a_3$  of the first conductive pattern **12** are as long as the diagonal of each grid **26**. In the first electrode pattern **10** of FIG. **14**, the width of each sub-nonconduction pattern **18** is larger.

FIG. **15** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** includes the first conductive patterns **12** formed by the large number of grids **26** made of metal thin wires. The first conductive patterns **12** extend in the first direction (X direction). Each first conductive pattern **12** includes the slit-like sub-nonconduction patterns **18** for electrically separating the first conductive pattern **12**. As illustrated in FIG. **15**, each first conductive pattern line **22** is formed by the plurality of grids **26** that are arranged in two lines in the first direction (X direction).

In FIG. **15**, the first conductive pattern lines **22** respectively extend in two lines in the first direction (X direction) from the first grid, the third grid and the fourth grid, and the fifth grid and the sixth grid of the six grids **26** that are arranged in the second direction (Y direction). As a result, the widths  $b_1$  and  $b_2$  of the sub-nonconduction patterns **18** are smaller than the widths  $a_1$ ,  $a_2$ , and  $a_3$  of the first conductive pattern **12**. The widths  $b_1$  and  $b_2$  of the sub-nonconduction patterns **18** are as long as the diagonal of each grid **26**, and the widths  $a_1$ ,  $a_2$ , and  $a_3$  of the first conductive pattern **12** are 1.5 times longer than

## 14

the diagonal of each grid **26**. In the first electrode pattern **10** of FIG. **15**, the width of the first conductive pattern **12** is larger.

FIG. **16** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** illustrated in FIG. **16** has basically the same structure as that of the first electrode pattern **10** illustrated in FIG. **13**. FIG. **16** is different from FIG. **13** in the following point. In FIG. **16**, joining parts **27** that electrically connect the first conductive pattern lines **22** to each other are provided at locations other than ends of the first conductive pattern lines **22**. Because the joining parts **27** are provided, even if the first conductive pattern lines **22** become longer and the wiring resistance thus becomes larger, the first conductive pattern lines **22** can be kept at the same electric potential.

FIG. **17** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** illustrated in FIG. **17** has basically the same structure as that of the first electrode pattern **10** illustrated in FIG. **13**. FIG. **17** is different from FIG. **13** in that the number of the first conductive pattern lines **22** is not three but two. The finger detection accuracy can be made higher as long as the number of the first conductive pattern lines **22** of the first electrode pattern **10** is two or more.

FIG. **18** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** illustrated in FIG. **18** has basically the same structure as that of the first electrode pattern **10** illustrated in FIG. **13**. FIG. **18** is different from FIG. **13** in that the number of the first conductive pattern lines **22** is not three but four. The finger detection accuracy can be made higher as long as the number of the first conductive pattern lines **22** of the first electrode pattern **10** is two or more, for example, even five or more.

Note that, in FIG. **13** to FIG. **18**, each area can be obtained in the following manner. A virtual line in contact with a plurality of the first conductive pattern lines **22** is drawn, and the first conductive pattern **12** and the sub-nonconduction patterns **18** surrounded by this virtual line are calculated, whereby each area can be obtained.

<Second Embodiment>

FIG. **19** illustrates a conductive sheet **1** including a first electrode pattern **10** according to a second embodiment. The first electrode pattern **10** includes two types of first conductive patterns **12** formed by a large number of grids made of metal thin wires. Each first conductive pattern **12** has one end electrically connected to a first electrode terminal **14**. Each first electrode terminal **14** is electrically connected to one end of each first wire **16**. Each first wire **16** has another end electrically connected to a terminal **20**. Each first conductive pattern **12** is electrically separated by a first nonconductive pattern **28**.

As illustrated in the upper side of FIG. **19**, a first first conductive pattern **12** does not include an additional first electrode terminal **24**. On the other hand, as illustrated in the lower side of FIG. **19**, a second first conductive pattern **12** includes the additional first electrode terminal **24**. FIG. **19** illustrates one conductive sheet **1** in which the first first conductive pattern **12** not including the additional first electrode terminal **24** and the second first conductive pattern **12** includ-



15

ing the additional first electrode terminal **24** are formed on the same plane. However, the first first conductive pattern **12** and the second first conductive pattern **12** do not necessarily need to be mixedly formed, and only any one of the first first conductive pattern **12** and the second first conductive pattern **12** may be formed.

In the present embodiment, each first conductive pattern **12** includes sub-nonconduction patterns **18** along a first direction, to thereby have X-shaped structures with cyclic intersections. This cycle can be selected as appropriate. Assuming that the area of each first conductive pattern **12** is  $A_2$  and that the area of the sub-nonconduction patterns **18** is  $B_2$ , a relation of  $20\% \leq B_2/(A_2+B_2) \leq 80\%$  is satisfied. In another embodiment, a relation of  $5\% \leq B_2/(A_2+B_2) \leq 70\%$  is satisfied. In still another embodiment, a relation of  $45\% \leq B_2/(A_2+B_2) \leq 65\%$  is satisfied.

Note that each area can be obtained in the following manner. The area of each first conductive pattern **12** is obtained by calculating the unit area of each grid **26** × the number of the grids **26**. The area of the sub-nonconduction patterns **18** is obtained by placing virtual grids **26** and calculating the unit area of each virtual grid **26** × the number of the grids **26**.

If this range is satisfied, a difference in electrostatic capacitance between when a finger is brought into contact with the touch panel and when a finger does not contact the touch panel can be made larger. That is, the detection accuracy can be improved.

The wire width of the metal thin wires that form the first electrode pattern **10** and the material thereof are substantially the same as those in the first embodiment. Moreover, the grids **26** of the metal thin wires that form the first electrode pattern **10** are substantially the same as those in the first embodiment.

For a second electrode pattern **40**, a pattern including second conductive patterns **42** each having a strip-shaped structure can be used similarly to FIG. **6** in the first embodiment.

FIG. **20** is a plan view of the conductive sheet **1** in which the first electrode pattern **10** including the first conductive patterns **12** each having the X-shaped structure and the second electrode pattern **40** including the second conductive patterns **42** each having the strip-shaped structure are opposedly placed. The first conductive patterns **12** and the second conductive patterns **42** are orthogonal to each other, and the first electrode pattern **10** and the second electrode pattern **40** form a combination pattern **70**. In the combination pattern **70**, the grids **26** and grids **56** form small grids **76**, similarly to the first embodiment.

FIG. **21** is a plan view illustrating an example of another first electrode pattern **10** of the second embodiment. The first nonconductive pattern **28** is made of metal thin wires similarly to the first conductive patterns **12**. Moreover, the sub-nonconduction patterns **18** formed in each first conductive pattern **12** are made of metal thin wires similarly to the first conductive patterns **12**. The sub-nonconduction patterns **18** and the first nonconductive pattern **28** are made of metal thin wires, and thus are each formed as a so-called dummy pattern electrically separated from the first conductive pattern **12**. If the dummy patterns are formed, the first electrode pattern **10** is formed by the grids of the metal thin wires placed at regular intervals. This can prevent a decrease in visibility.

Also in FIG. **21**, similarly, the metal thin wires that form the first nonconductive pattern **28** and the sub-nonconduction patterns **18** include break parts, and are electrically separated from the first conductive pattern **12**. It is preferable that each break part be formed at a portion other than each intersection part of the metal thin wires.

16

For the second electrode pattern **40**, a pattern including the second conductive patterns **42** each having the strip-shaped structure can be used similarly to FIG. **10** in the first embodiment.

FIG. **22** is a plan view of the conductive sheet **1** in which the first electrode pattern **10** including dummy patterns and the second electrode pattern **40** including dummy patterns are opposedly placed. The first conductive patterns **12** and the second conductive patterns **42** are orthogonal to each other, and the first electrode pattern **10** and the second electrode pattern **40** form the combination pattern **70**.

In the combination pattern **70**, the grids **26** and the grids **56** form the small grids **76** in top view. That is, the intersection parts of the grids **26** are respectively placed in substantially the centers of the opening regions of the grids **56**.

The metal thin wires of the second electrode pattern **40** are placed at positions opposed to the break parts **29** of the first electrode pattern **10**. Moreover, the metal thin wires of the first electrode pattern **10** are placed at positions opposed to the break parts **59** of the second electrode pattern **40**. The metal thin wires of the second electrode pattern **40** mask the break parts **29** of the first electrode pattern **10**, and the metal thin wires of the first electrode pattern **10** mask the break parts **59** of the second electrode pattern **40**.

Next, examples of other first electrode patterns of the second embodiment are described with reference to FIGS. **23** to **32**.

FIG. **23** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** includes the first conductive patterns **12** formed by the large number of grids **26** made of metal thin wires. Each first conductive pattern **12** includes the plurality of sub-nonconduction patterns **18** along the first direction, to thereby have X-shaped structures with cyclic intersections.

In the first conductive pattern **12** illustrated in FIG. **23**, each sub-nonconduction pattern **18** is surrounded and defined by four sides. Each of the four sides is formed by linearly arranging the plurality of grids **26** with sides of the grids **26** being connected to each other. Each sub-nonconduction pattern **18** is surrounded by the plurality of linearly arranged grids **26**, whereby a diamond pattern is formed. Adjacent diamond patterns are electrically connected to each other. In FIG. **23**, adjacent diamond patterns are electrically connected to each other with the intermediation of sides of the grids **26**.

FIG. **24** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** includes the first conductive patterns **12** formed by the large number of grids **26** made of metal thin wires. Each first conductive pattern **12** includes the plurality of sub-nonconduction patterns **18** along the first direction, to thereby have X-shaped structures with cyclic intersections.

In the first conductive pattern **12** illustrated in FIG. **24**, each sub-nonconduction pattern **18** is surrounded and defined by four sides. Each of the four sides is formed by linearly arranging, in multiple stages, the plurality of grids **26** with sides of the grids **26** being connected to each other. In FIG. **24**, each of the four sides is formed in two stages, but is not limited to the two stages.

FIG. **25** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated



17

by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** includes the first conductive patterns **12** formed by the large number of grids **26** made of metal thin wires. Each first conductive pattern **12** includes the plurality of sub-nonconduction patterns **18** along the first direction, to thereby have X-shaped structures with cyclic intersections.

In the first conductive pattern **12** illustrated in FIG. **25**, each sub-nonconduction pattern **18** is surrounded and defined by six sides. Four of the six sides are formed by linearly arranging the plurality of grids **26** with sides of the grids **26** being connected to each other. Two of the six sides are formed by linearly arranging the plurality of grids **26** with apex angles of the grids **26** being connected to each other.

FIG. **26** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** includes the first conductive patterns **12** formed by the large number of grids **26** made of metal thin wires. Each first conductive pattern **12** includes the plurality of sub-nonconduction patterns **18** along the first direction, to thereby have X-shaped structures with cyclic intersections.

The first conductive pattern **12** illustrated in FIG. **26** is the same in the shape of each sub-nonconduction pattern **18** as the first conductive pattern **12** illustrated in FIG. **23**. However, in FIG. **26**, adjacent diamond patterns are electrically connected to each other at apex angles of the grids **26**, that is, at one point, unlike FIG. **23**. The shape of each sub-nonconduction pattern **18** is not limited to the diamond pattern.

FIG. **27** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** includes the first conductive patterns **12** formed by the large number of grids **26** made of metal thin wires. Each first conductive pattern **12** includes the plurality of sub-nonconduction patterns **18** along the first direction, to thereby have X-shaped structures with cyclic intersections.

In FIG. **27**, the shapes of diamond patterns are alternately different, and the sizes of adjacent ones of the sub-nonconduction patterns **18** are different. That is, the same shape appears every two cycles. However, not limited to every two cycles, the same shape may appear every three cycles or every four cycles.

FIG. **28** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** includes the first conductive patterns **12** formed by the large number of grids **26** made of metal thin wires. Each first conductive pattern **12** includes the plurality of sub-nonconduction patterns **18** along the first direction, to thereby have X-shaped structures with cyclic intersections.

The first conductive pattern **12** illustrated in FIG. **28** has basically the same shape as that of the first conductive pattern **12** illustrated in FIG. **23**. However, the grid **26** located at each apex angle of a diamond pattern is provided with protruding wires **31** made of metal thin wires.

FIG. **29** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern

18

**10** includes the first conductive patterns **12** formed by the large number of grids **26** made of metal thin wires. Each first conductive pattern **12** includes the plurality of sub-nonconduction patterns **18** along the first direction, to thereby have X-shaped structures with cyclic intersections.

The first conductive pattern **12** illustrated in FIG. **29** has basically the same shape as that of the first conductive pattern **12** illustrated in FIG. **23**. However, the grids **26** that form each side of a diamond pattern are provided with the protruding wires **31** made of metal thin wires.

The first electrode pattern **10** illustrated in each of FIGS. **28** and **29** is provided with the protruding wires **31**, and hence a sensor region for detecting a finger can be widened.

FIG. **30** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** includes the first conductive patterns **12** formed by the large number of grids **26** made of metal thin wires. Each first conductive pattern **12** includes the plurality of sub-nonconduction patterns **18** along the first direction, to thereby have X-shaped structures in which the grids **26** are not present at the intersection points. In the first conductive pattern **12** illustrated in FIG. **30**, the plurality of grids **26** are arranged in a zigzag manner. Two groups of the grids arranged in the zigzag manner are oppositely placed so as not to contact each other, and hence the X-shaped structure without intersection points is formed. Because the X-shaped structure is formed by the two groups of the grids arranged in the zigzag manner, the electrode pattern can be made thinner, and fine position detection can be achieved.

FIG. **31** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** includes the first conductive patterns **12** formed by the large number of grids **26** made of metal thin wires. Each first conductive pattern **12** includes the plurality of sub-nonconduction patterns **18** along the first direction, to thereby have X-shaped structures in which the grids **26** are not present at the intersection points. In the first conductive pattern **12** illustrated in FIG. **31**, a plurality of grids **26** are placed in each corner part in which two groups of the grids arranged in a zigzag manner approach each other, unlike the first conductive pattern **12** illustrated in FIG. **30**.

FIG. **32** illustrates the first electrode pattern **10** according to another embodiment. The same configurations as those of the first electrode pattern **10** described above are designated by the same reference numerals or reference characters, and description thereof may be omitted. The first electrode pattern **10** of FIG. **32** includes two first conductive patterns **12** formed by the large number of grids **26** made of metal thin wires. Each first conductive pattern **12** includes the sub-nonconduction patterns **18** along the first direction, to thereby have X-shaped structures with cyclic intersections.

As illustrated in FIG. **32**, the upper first conductive pattern **12** includes the sub-nonconduction patterns **18** having the same shape along the first direction. Moreover, as illustrated in FIG. **32**, the lower first conductive pattern **12** includes the sub-nonconduction patterns **18** having the same shape along the first direction.

Meanwhile, the shapes of the sub-nonconduction patterns **18** are different between the upper first conductive pattern **12** and the lower first conductive pattern **12**. The first conductive patterns **12** having different shapes are alternately arranged.



Such arrangement as described above secures the degree of freedom in arrangement of the first electrode pattern **10**.

Note that, in the pattern illustrated in each of FIG. **23** to FIG. **32**, the area of each first conductive pattern **12** is obtained by calculating the unit area of each grid **26** × the number of the grids **26**. The area of the sub-nonconduction patterns **18** is obtained by placing virtual grids **26** and calculating the unit area of each virtual grid **26** × the number of the grids **26**.

Next, a method of manufacturing the conductive sheet **1** is described.

In the case of manufacturing the conductive sheet **1**, for example, a photosensitive material having an emulsion layer containing photosensitive silver halide is exposed to light and developed on the first main surface of the transparent substrate **30**, and a metal silver part (metal thin wires) and a light transmissive part (opening regions) are respectively formed in the exposed part and the unexposed part, whereby the first electrode pattern **10** may be formed. Note that the metal silver part is further physically developed and/or plated, whereby the metal silver part may be caused to support conductive metal.

Alternatively, a resist pattern is formed by exposing to light and developing a photoresist film on copper foil formed on the first main surface of the transparent substrate **30**, and the copper foil exposed on the resist pattern is etched, whereby the first electrode pattern **10** may be formed.

Alternatively, a paste containing metal fine grains is printed on the first main surface of the transparent substrate **30**, and the paste is plated with metal, whereby the first electrode pattern **10** may be formed.

The first electrode pattern **10** may be formed by printing on the first main surface of the transparent substrate **30**, using a screen printing plate or a gravure printing plate. Alternatively, the first electrode pattern **10** may be formed on the first main surface of the transparent substrate **30**, according to an inkjet process.

The second electrode pattern **40** can be formed on the second main surface of the substrate **30**, according to a manufacturing method similar to that for the first electrode pattern **10**.

The first electrode pattern **10** and the second electrode pattern **40** may be formed by: forming a photosensitive layer to be plated on the transparent substrate **30** using a plating preprocessing material; exposing the formed layer to light to develop it; and plating the layer so as to form a metal part and a light transmissive part respectively in the exposed part and the unexposed part. Note that the metal part may be further physically developed and/or plated so that the metal part can be caused to support conductive metal. Note that more specific contents thereof are described in, for example, Japanese Patent Application Laid-Open No. 2003-213437, No. 2006-64923, No. 2006-58797, and No. 2006-135271.

In a case as illustrated in FIG. **2** where the first electrode pattern **10** is formed on the first main surface of the substrate **30** and where the second electrode pattern **40** is formed on the second main surface of the substrate **30**, if a standard manufacturing method (in which the first main surface is first exposed to light, and the second main surface is then exposed to light) is adopted, the first electrode pattern **10** and the second electrode pattern **40** having desired patterns cannot be obtained in some cases.

In view of the above, the following manufacturing method can be preferably adopted.

That is, photosensitive silver halide emulsion layers respectively formed on both the surfaces of the substrate **30** are collectively exposed to light, whereby the first electrode

pattern **10** is formed on one main surface of the substrate **30** while the second electrode pattern **40** is formed on another main surface of the substrate **30**.

A specific example of this manufacturing method is described.

First, an elongated photosensitive material is manufactured. The photosensitive material includes: the substrate **30**; a photosensitive silver halide emulsion layer (hereinafter, referred to as first photosensitive layer) formed on the first main surface of the substrate **30**; and a photosensitive silver halide emulsion layer (hereinafter, referred to as second photosensitive layer) formed on another main surface of the substrate **30**.

Subsequently, the photosensitive material is exposed to light. This exposure process includes: a first exposure process performed on the first photosensitive layer, in which the substrate **30** is irradiated with light so that the first photosensitive layer is exposed to the light along a first exposure pattern; and a second exposure process performed on the second photosensitive layer, in which the substrate **30** is irradiated with light so that the second photosensitive layer is exposed to the light along a second exposure pattern (both-surfaces simultaneous exposure).

For example, in the state where the elongated photosensitive material is transported in one direction, the first photosensitive layer is irradiated with first light (parallel light) with the intermediation of a first photomask, while the second photosensitive layer is irradiated with second light (parallel light) with the intermediation of a second photomask. The first light is obtained by converting, into parallel light, light emitted from a first light source by means of a halfway first collimator lens. The second light is obtained by converting, into parallel light, light emitted from a second light source by means of a halfway second collimator lens.

Although description is given above of the case where the two light sources (the first light source and the second light source) are used, light emitted from one light source may be split by an optical system into the first light and the second light, and the first photosensitive layer and the second photosensitive layer may be irradiated with the first light and the second light.

Subsequently, the photosensitive material after the exposure to light is developed, whereby the conductive sheet **1** for the touch panel is manufactured. The conductive sheet **1** for the touch panel includes: the substrate **30**; the first electrode pattern **10** that is formed along the first exposure pattern on the first main surface of the substrate **30**; and the second electrode pattern **40** that is formed along the second exposure pattern on another main surface of the substrate **30**. Note that the exposure time and the development time of the first photosensitive layer and the second photosensitive layer may variously change depending on the types of the first light source and the second light source, the type of a developing solution, and the like. Hence preferable numerical value ranges therefor cannot be unconditionally determined, but the exposure time and the development time are adjusted such that the development rate is 100%.

Then, according to the manufacturing method of the present embodiment, in the first exposure process, the first photomask is, for example, closely placed on the first photosensitive layer, and is irradiated with the first light emitted from the first light source that is placed so as to be opposed to the first photomask, whereby the first photosensitive layer is exposed to light. The first photomask includes a glass substrate made of transparent soda glass and a mask pattern (first exposure pattern) formed on the glass substrate. Accordingly, in the first exposure process, a portion of the first photosen-



sitive layer is exposed to light, the portion being along the first exposure pattern formed on the first photomask. A gap of approximately 2 to 10  $\mu\text{m}$  may be provided between the first photosensitive layer and the first photomask.

Similarly, in the second exposure process, the second photomask is, for example, closely placed on the second photosensitive layer, and is irradiated with the second light emitted from the second light source that is placed so as to be opposed to the second photomask, whereby the second photosensitive layer is exposed to light. Similarly to the first photomask, the second photomask includes a glass substrate made of transparent soda glass and a mask pattern (second exposure pattern) formed on the glass substrate. Accordingly, in the second exposure process, a portion of the second photosensitive layer is exposed to light, the portion being along the second exposure pattern formed on the second photomask. In this case, a gap of approximately 2 to 10  $\mu\text{m}$  may be provided between the second photosensitive layer and the second photomask.

In the first exposure process and the second exposure process, the emission timing of the first light from the first light source and the emission timing of the second light from the second light source may be the same as each other, and may be different from each other. If the emission timings thereof are the same as each other, the first photosensitive layer and the second photosensitive layer can be simultaneously exposed to light in one exposure process, and the processing time can be shortened. Meanwhile, in the case where both the first photosensitive layer and the second photosensitive layer are not spectrally sensitized, if the photosensitive material is exposed to light on both the sides thereof, the exposure to light on one side influences image formation on the other side (rear side).

That is, the first light from the first light source that has reached the first photosensitive layer is scattered by silver halide grains contained in the first photosensitive layer, and is transmitted as scattered light through the substrate **30**, and part of the scattered light reaches even the second photosensitive layer. Consequently, a boundary portion between the second photosensitive layer and the substrate **30** is exposed to light over a wide range, so that a latent image is formed. Hence, the second photosensitive layer is exposed to both the second light from the second light source and the first light from the first light source. In the case of manufacturing the conductive sheet **1** for the touch panel in the subsequent development process, a thin conductive layer based on the first light from the first light source is formed between the conductive patterns in addition to the conductive pattern (second electrode pattern **40**) along the second exposure pattern, and a desired pattern (a pattern along the second exposure pattern) cannot be obtained. The same applies to the first photosensitive layer.

As a result of intensive studies for avoiding this, the following is found out. That is, if the thickness of each of the first photosensitive layer and the second photosensitive layer is set within a particular range or if the amount of silver applied to each of the first photosensitive layer and the second photosensitive layer is specified, silver halide itself absorbs light, and this can restrict light transmission to the rear surface. The thickness of each of the first photosensitive layer and the second photosensitive layer can be set to 1  $\mu\text{m}$  or more and 4  $\mu\text{m}$  or less. The upper limit value thereof is preferably 2.5  $\mu\text{m}$ . Moreover, the amount of silver applied to each of the first photosensitive layer and the second photosensitive layer is specified to 5 to 20  $\text{g}/\text{m}^2$ .

In the above-mentioned exposure method of both-surfaces close contact type, an image defect due to a hindrance to

exposure by dust and the like attached to the sheet surface is problematic. In order to prevent such dust attachment, it is known to apply a conductive substance to the sheet, but metal oxides and the like remain even after the process to impair the transparency of a final product, and conductive polymers have a problem in preserving properties. As a result of intensive studies in view of the above, it is found out that conductive properties necessary for prevention of static charge can be obtained by silver halide with a reduced binder, and hence the volume ratio of silver/binder of each of the first photosensitive layer and the second photosensitive layer is specified. That is, the volume ratio of silver/binder of each of the first photosensitive layer and the second photosensitive layer is 1/1 or more, and is preferably 2/1 or more.

If the thickness, the amount of applied silver, and the volume ratio of silver/binder of each of the first photosensitive layer and the second photosensitive layer are set and specified as described above, the first light from the first light source that has reached the first photosensitive layer does not reach the second photosensitive layer. Similarly, the second light from the second light source that has reached the second photosensitive layer does not reach the first photosensitive layer. As a result, in the case of manufacturing the conductive sheet **1** in the subsequent development process, only the first electrode pattern **10** along the first exposure pattern is formed on the first main surface of the substrate **30**, and only the second electrode pattern **40** along the second exposure pattern is formed on the second main surface of the substrate **30**, so that desired patterns can be obtained.

In this way, according to the above-mentioned manufacturing method using both-surfaces collective exposure, the first photosensitive layer and the second photosensitive layer having both conductive properties and suitability for the both-surfaces exposure can be obtained. Moreover, the same pattern or different patterns can be arbitrarily formed on both the surfaces of the substrate **30** in one exposure process on the substrate **30**. This can facilitate formation of the electrodes of the touch panel, and can achieve a reduction in thickness (a reduction in height) of the touch panel.

Next, focused description is given of a method of using a silver halide photographic photosensitive material corresponding to a particularly preferable aspect, for the conductive sheet **1** according to the present embodiment.

The method of manufacturing the conductive sheet **1** according to the present embodiment includes the following three aspects depending on modes of the photosensitive material and the development process.

(1) An aspect in which: a silver halide black-and-white photosensitive material not including the center of physical development is chemically developed or thermally developed; and a metal silver part is formed on the photosensitive material.

(2) An aspect in which: a silver halide black-and-white photosensitive material including the center of physical development in a silver halide emulsion layer is dissolved and physically developed; and a metal silver part is formed on the photosensitive material.

(3) An aspect in which: a silver halide black-and-white photosensitive material not including the center of physical development and an image receiving sheet having a non-photosensitive layer including the center of physical development are put on top of each other (overlaid) and then subjected to diffusion transfer development; and a metal silver part is formed on the non-photosensitive image receiving sheet.

According to the aspect in (1), which is of integrated black-and-white development type, a translucent conductive film



such as a light transmissive conductive film is formed on the photosensitive material. The obtained developed silver is chemically developed silver or thermally developed silver, and is highly active in the subsequent plating or physical development process, because the obtained developed silver is a filament having a high-specific surface.

According to the aspect in (2), in the exposed part, silver halide grains near the center of physical development are dissolved and deposited on the center of development, whereby a translucent conductive film such as a light transmissive conductive film is formed on the photosensitive material. This aspect is also of integrated black-and-white development type. Because the development action is deposition on the center of physical development, high activity is obtained, and the developed silver has a spherical shape with a small-specific surface.

According to the aspect in (3), in the unexposed part, silver halide grains are dissolved and diffused to be deposited on the center of development on the image receiving sheet, whereby a translucent conductive film such as a light transmissive conductive film is formed on the image receiving sheet. This aspect is of so-called separate type, in which the image receiving sheet is separated for use from the photosensitive material.

In any one of these aspects, both a negative development process and a reversal development process can be selected (in the case of a diffusion transfer method, the use of an auto-positive photosensitive material as the photosensitive material enables the negative development process).

Here, a configuration of the conductive sheet **1** according to the present embodiment is described below in detail.

#### [Substrate **30**]

The substrate **30** can be formed using a plastic film, a plastic plate, a glass plate, and the like. Examples of the raw materials of the plastic film and the plastic plate include: polyesters such as polyethylene terephthalate (PET) and polyethylene naphthalate (PEN); polyolefins such as polyethylene (PE), polypropylene (PP), polystyrene, and ethylene vinyl acetate (EVA)/cycloolefin polymer (COP)/cycloolefin copolymer (COC); vinyl resins; polycarbonate (PC); polyamide; polyimide; acrylic resins; and triacetylcellulose (TAC). In particular, polyethylene terephthalate (PET) is preferable from the perspective of the light transmission properties, the workability, and the like.

#### [Silver Salt Emulsion Layer]

A silver salt emulsion layer that becomes each of the first electrode pattern **10** and the second electrode pattern **40** of the conductive sheet **1** contains additives such as a solvent and a colorant in addition to a silver salt and a binder.

Examples of the silver salt used in the present embodiment include inorganic silver salts such as silver halide and organic silver salts such as silver acetate. In the present embodiment, it is preferable to use silver halide excellent in characteristics as an optical sensor.

The amount of silver (the amount of silver salt) applied to the silver salt emulsion layer is preferably 1 to 30 g/m<sup>2</sup>, more preferably 1 to 25 g/m<sup>2</sup>, and further preferably 5 to 20 g/m<sup>2</sup>, in terms of silver. If the amount of applied silver is set within this range, a desired surface resistance can be obtained in the case of manufacturing the conductive sheet **1** for the touch panel.

Examples of the binder used in the present embodiment include gelatin, polyvinyl alcohol (PVA), polyvinylpyrrolidone (PVP), polysaccharides such as starch, cellulose and derivatives thereof, polyethylene oxide, polyvinylamine, chitosan, polylysine, polyacrylic acid, polyalginic acid, polyhyaluronic acid, and carboxycellulose. These substances each

exhibit a neutral, anionic, or cationic property depending on the ionicity of a functional group thereof.

The content of the binder in the silver salt emulsion layer is not particularly limited, and can be determined as appropriate within a range in which the dispersibility and the adhesiveness can be obtained. The content of the binder in the silver salt emulsion layer is preferably 1/4 or more, and more preferably 1/2 or more, in terms of the volume ratio of silver/binder. The volume ratio of silver/binder is preferably 100/1 or less, more preferably 50/1 or less, further preferably 10/1 or less, and particularly preferably 6/1 or less. Moreover, the volume ratio of silver/binder is further preferably 1/1 to 4/1. The volume ratio of silver/binder is most preferably 1/1 to 3/1. If the volume ratio of silver/binder in the silver salt emulsion layer is set within this range, even in the case where the amount of applied silver is adjusted, fluctuations in resistance value can be suppressed, and the conductive sheet for the touch panel having a uniform surface resistance can be obtained. Note that the volume ratio of silver/binder can be obtained by converting the amount of silver halide/the amount of binder (weight ratio) in the raw material into the amount of silver/the amount of binder (weight ratio) and further converting the amount of silver/the amount of binder (weight ratio) into the amount of silver/the amount of binder (volume ratio).

#### <Solvent>

The solvent used to form the silver salt emulsion layer is not particularly limited, and examples thereof include water, organic solvents (for example, alcohols such as methanol, ketones such as acetone, amides such as formamide, sulfoxides such as dimethylsulfoxide, esters such as ethyl acetate, and ethers), ionic liquids, and a mixture solvent of these solvents.

The content of the solvent used to form the silver salt emulsion layer of the present embodiment falls within a range of 30 to 90 mass % of the total mass of the silver salt, the binder, and the like contained in the silver salt emulsion layer, and preferably falls within a range of 50 to 80 mass % thereof.

#### <Other Additives>

Various additives used in the present embodiment are not particularly limited, and known additives can be preferably used therein.

#### [Other Layer Configurations]

A protective layer (not illustrated) may be provided on the silver salt emulsion layer. The “protective layer” in the present embodiment means a layer made of a binder such as gelatin and polymers, and is formed on the silver salt emulsion layer having photosensitivity in order to produce effects of preventing scratches and improving mechanical characteristics. The thickness of the protective layer is preferably 0.5 μm or less. A method of applying and a method of forming the protective layer are not particularly limited, and a known applying method and a known forming method can be selected as appropriate. Moreover, for example, a basecoat layer may also be provided under the silver salt emulsion layer.

Next, steps of the method of manufacturing the conductive sheet **1** are described.

#### [Exposure to Light]

The present embodiment includes the case where the first electrode pattern **10** and the second electrode pattern **40** are formed by printing. Besides the printing, the first electrode pattern **10** and the second electrode pattern **40** are formed by exposure to light, development, and the like. That is, a photosensitive material having a silver-salt-containing layer provided on the substrate **30** or a photosensitive material to which photopolymer for photolithography has been applied is



exposed to light. The exposure to light can be performed using electromagnetic waves. Examples of the electromagnetic waves include light such as visible light rays and ultraviolet rays and radiant rays such as X-rays. Further, a light source having wavelength distribution may be used for the exposure to light, and a light source having a particular wavelength may be used therefor.

A method using a glass mask and a pattern exposure method using laser drawing are preferable for the exposure method.

[Development Process]

In the present embodiment, after the emulsion layer is exposed to light, the development process is further performed. A technique of a standard development process used for silver halide photographic films, printing paper, printing plate-making films, photomask emulsion masks, and the like can be used for the development process.

The development process in the present embodiment can include a fixing process performed for the purpose of stabilization by removing the silver salt in the unexposed part. A technique of a fixing process used for silver halide photographic films, printing paper, printing plate-making films, photomask emulsion masks, and the like can be used for the fixing process in the present invention.

It is preferable that the photosensitive material that has been subjected to the development and fixing process be subjected to a hardening process, a water washing process, and a stabilization process.

The mass of metal silver contained in the exposed part after the development process is preferably 50 mass % or more of the mass of silver contained in the exposed part before the exposure to light, and is further preferable 80 mass % or more thereof. If the mass of silver contained in the exposed part is 50 mass % or more of the mass of silver contained in the exposed part before the exposure to light, high conductive properties can be obtained, which is preferable.

The gradation after the development process in the present embodiment is not particularly limited, and preferably exceeds 4.0. If the gradation after the development process exceeds 4.0, the conductive properties of the conductive metal part can be improved while the translucency of the light transmissive part is kept high. Examples of means for making the gradation 4.0 or more include the doping with rhodium ions and iridium ions described above.

The conductive sheet is obtained through the above-mentioned steps, and the surface resistance of the obtained conductive sheet is preferably 100  $\Omega$ /sq. or less, more preferably 80  $\Omega$ /sq. or less, further preferably 60  $\Omega$ /sq. or less, and further more preferably 40  $\Omega$ /sq. or less. It is ideal to make the lower limit value of the surface resistance as low as possible. In general, it is sufficient that the lower limit value thereof be 0.01  $\Omega$ /sq. Even 0.1  $\Omega$ /sq. or 1  $\Omega$ /sq. can be adopted depending on the purpose of use.

If the surface resistance is adjusted to such a range, position detection can be achieved for even a large-size touch panel having an area of 10 cm $\times$ 10 cm or more. Moreover, the conductive sheet after the development process may be further subjected to a calendering process, and the surface resistance can be adjusted to a desired value by the calendering process.

(Hardening Process after Development Process)

It is preferable to perform a hardening process on the silver salt emulsion layer by immersing the same in a hardener after performing the development process thereon. Examples of the hardener include: dialdehydes such as glutaraldehyde, adipaldehyde, and 2,3-dihydroxy-1,4-dioxane; and inorganic

compounds such as boric acid and chrome alum/potassium alum, which are described in Japanese Patent Application Laid-Open No. 2-141279.

[Physical Development and Plating Process]

In the present embodiment, physical development and/or a plating process for causing the metal silver part to support conductive metal grains may be performed for the purpose of enhancing the conductive properties of the metal silver part formed by the exposure to light and the development process.

In the present invention, the metal silver part may be caused to support conductive metal grains through only any one of the physical development and the plating process, and the metal silver part may be caused to support conductive metal grains through a combination of the physical development and the plating process. Note that the metal silver part that has been physically developed and/or plated is also referred to as "conductive metal part".

[Oxidation Process]

In the present embodiment, it is preferable that the metal silver part after the development process and the conductive metal part formed by the physical development and/or the plating process be subjected to an oxidation process. For example, in the case where a slight amount of metal is deposited in the light transmissive part, the oxidation process can remove the metal, and can make the light transmittance of the light transmissive part substantially 100%.

[Light Transmissive Part]

The "light transmissive part" in the present embodiment means a translucent portion other than the first electrode pattern **10** and the second electrode pattern **40**, of the conductive sheet **1**. As described above, the transmittance of the light transmissive part is 90% or more, preferably 95% or more, further preferably 97% or more, further more preferably 98% or more, and most preferably 99% or more, in terms of the transmittance indicated by the minimum value of the transmittance in a wavelength region of 380 to 780 nm excluding contributions to light absorption and reflection of the substrate **30**.

[Conductive Sheet 1]

The film thickness of the substrate **30** in the conductive sheet **1** according to the present embodiment is preferably 5 to 350  $\mu$ m, and further preferably 30 to 150  $\mu$ m. If the film thickness thereof is set within such a range of 5 to 350  $\mu$ m, a desired transmittance of visible light can be obtained, and handling is easy.

The thickness of the metal silver part provided on the substrate **30** can be determined as appropriate in accordance with the application thickness of coating for the silver-salt-containing layer applied onto the substrate **30**. The thickness of the metal silver part can be selected from 0.001 mm to 0.2 mm, and is preferably 30  $\mu$ m or less, more preferably 20  $\mu$ m or less, further preferably 0.01 to 9  $\mu$ m, and most preferably 0.05 to 5  $\mu$ m. Moreover, it is preferable that the metal silver part be patterned. The metal silver part may have a single-layered structure, and may have a multi-layered structure of two or more layers. In the case where the metal silver part is patterned and has a multi-layered structure of two or more layers, the metal silver part can be provided with different color sensitivities so as to be reactive to different wavelengths. As a result, if the metal silver part is exposed to light with different wavelengths, different patterns can be formed in the respective layers.

For use in a touch panel, a smaller thickness of the conductive metal part is more preferable, because the viewing angle of a display panel is wider. Also in terms of enhancement in visibility, a reduction in thickness of the conductive metal part is required. From such perspectives, it is desirable that the



27

thickness of the layer made of the conductive metal supported by the conductive metal part be less than 9  $\mu\text{m}$ , less than 5  $\mu\text{m}$ , or less than 3  $\mu\text{m}$ , and be 0.1  $\mu\text{m}$  or more.

In the present embodiment, the metal silver part having a desired thickness can be formed by controlling the application thickness of the silver-salt-containing layer, and the thickness of the layer made of the conductive metal grains can be freely controlled by the physical development and/or the plating process. Hence, even the conductive sheet **1** having a thickness that is less than 5  $\mu\text{m}$  and preferably less than 3  $\mu\text{m}$  can be easily formed.

Note that the method of manufacturing the conductive sheet according to the present embodiment does not necessarily need to include the plating step and the like. This is because the method of manufacturing the conductive sheet **1** according to the present embodiment can obtain a desired surface resistance by adjusting the amount of applied silver and the volume ratio of silver/binder of the silver salt emulsion layer.

With regard to the above-mentioned manufacturing method, description is given of the conductive sheet **1** including: the substrate **30**; the first electrode pattern **10** formed on the first main surface of the substrate **30**; and the second electrode pattern **40** formed on the second main surface of the substrate **30**, which are illustrated in FIG. 2. Alternatively, as illustrated in FIG. 33, the conductive sheet **1** which includes the substrate **30** and the first electrode pattern **10** formed on the first main surface of the substrate **30**, and a conductive sheet **2** which includes a substrate **80** and the second electrode pattern **40** formed on a first main surface of the substrate **80** may be placed on top of each other (overlaid) such that the first electrode pattern **10** and the second electrode pattern **40** are orthogonal to each other. The manufacturing method applied to the substrate **30** and the first electrode pattern can be adopted for the substrate **80** and the second electrode pattern **40**.

The conductive sheet and the touch panel according to the present invention are not limited to the above-mentioned embodiments, and can have various configurations without departing from the gist of the present invention, as a matter of course. Moreover, the conductive sheet and the touch panel according to the present invention can be used in appropriate combination with techniques disclosed in, for example, Japanese Patent Application Laid-Open No. 2011-113149, No. 2011-129501, No. 2011-129112, No. 2011-134311, and No. 2011-175628.

What is claimed is:

**1.** A conductive sheet comprising:

a first electrode pattern; and

a second electrode pattern opposite to the first electrode pattern, wherein

the first electrode pattern is formed by a plurality of grids made of a plurality of metal thin wires that intersect with each other,

the first electrode pattern alternately includes: a plurality of first conductive patterns that extend in a first direction; and a plurality of first nonconductive patterns that are electrically separated from the plurality of first conductive patterns,

the second electrode pattern is formed by a plurality of grids made of a plurality of metal thin wires that intersect with each other,

the second electrode pattern alternately includes: a plurality of second conductive patterns that extend in a second direction orthogonal to the first direction; and a plurality

28

of second nonconductive patterns that are electrically separated from the plurality of second conductive patterns,

the first electrode pattern and the second electrode pattern are placed such that the plurality of first conductive patterns and the plurality of second conductive patterns are orthogonal to each other in top view and that the grids of the first electrode pattern and the grids of the second electrode pattern form small grids in top view, each of the first conductive patterns includes, at least inside thereof, slit-like sub-nonconduction patterns that are electrically separated from the first conductive pattern and extend in the first direction,

each of the first conductive patterns includes a plurality of first conductive pattern lines divided by the sub-nonconduction patterns, and

each of the second conductive patterns has a strip shape.

**2.** A conductive sheet comprising:

a first electrode pattern; and

a second electrode pattern placed opposite to the first electrode pattern, wherein

the first electrode pattern is formed by a plurality of grids made of a plurality of metal thin wires that intersect with each other,

the first electrode pattern alternately includes: a plurality of first conductive patterns that extend in a first direction; and a plurality of first nonconductive patterns that are electrically separated from the plurality of first conductive patterns,

the second electrode pattern is formed by a plurality of grids made of a plurality of metal thin wires that intersect with each other,

the second electrode pattern alternately includes: a plurality of second conductive patterns that extend in a second direction orthogonal to the first direction; and a plurality of second nonconductive patterns that are electrically separated from the plurality of second conductive patterns,

the first electrode pattern and the second electrode pattern are placed such that the plurality of first conductive patterns and the plurality of second conductive patterns are orthogonal to each other in top view and that the grids of the first electrode pattern and the grids of the second electrode pattern form small grids in top view, each of the first conductive patterns includes sub-nonconduction patterns that are spaced apart from each other along the first direction, to thereby have X-shaped structures with cyclic intersections, and

each of the second conductive patterns has a strip shape.

**3.** The conductive sheet according to claim **1**, wherein the plurality of grids have uniform shapes.

**4.** The conductive sheet according to claim **1**, wherein the first nonconductive patterns and the second nonconductive patterns respectively include first break parts and second break parts in portions other than intersection parts of the metal thin wires,

the first break parts and the second break parts are respectively located near centers between the intersection parts and the intersection parts, and

each of the first break parts and the second break parts has a width that exceeds a wire width of each of the metal thin wires and is equal to or less than 50  $\mu\text{m}$ .

**5.** The conductive sheet according to claim **1**, wherein the metal thin wires of the second conductive patterns are located in the first break parts of the first nonconductive patterns in top view, and



the metal thin wires of the first conductive patterns are located in the second break parts of the second nonconductive patterns in top view.

6. The conductive sheet according to claim 1, wherein each of the grids of the first electrode pattern and the grids of the second electrode pattern has one side having a length of 250  $\mu\text{m}$  to 900  $\mu\text{m}$ , and each of the small grids has one side having a length of 125  $\mu\text{m}$  to 450  $\mu\text{m}$ .

7. The conductive sheet according to claim 1, wherein each of the metal thin wires that form the first electrode pattern and the metal thin wires that form the second electrode pattern has a wire width equal to or less than 30  $\mu\text{m}$ .

8. The conductive sheet according to claim 1, wherein each of the grids of the first electrode pattern and the grids of the second electrode pattern has a rhomboid shape.

9. A conductive sheet comprising:

a substrate having a first main surface; and  
a first electrode pattern placed on the first main surface, wherein

the first electrode pattern is formed by a plurality of grids made of a plurality of metal thin wires that intersect with each other,

the first electrode pattern includes a plurality of first conductive patterns that extend in a first direction, each of the first conductive patterns includes, at least inside thereof, slit-like sub-nonconduction patterns that are electrically separated from the first conductive pattern and extend in the first direction, and

each of the first conductive patterns includes a plurality of first conductive pattern lines divided by the sub-nonconduction patterns.

10. A conductive sheet comprising:

a substrate having a first main surface; and  
a first electrode pattern placed on the first main surface, wherein

the first electrode pattern is formed by a plurality of grids made of a plurality of metal thin wires that intersect with each other, and

the first electrode pattern includes: a plurality of first conductive patterns that extend in a first direction; and a plurality of sub-nonconduction patterns that are spaced apart from each other along the first direction, to thereby have X-shaped structures with cyclic intersections.

11. The conductive sheet according to claim 1, wherein a width of each of the first conductive pattern lines and a width of each of the sub-nonconduction patterns are substantially equal to each other.

12. The conductive sheet according to claim 1, wherein a width of each of the first conductive pattern lines is smaller than a width of each of the sub-nonconduction patterns.

13. The conductive sheet according to claim 1, wherein a width of each of the first conductive pattern lines is larger than a width of each of the sub-nonconduction patterns.

14. The conductive sheet according to claim 11, wherein the first electrode pattern includes a joining part that electrically connects the plurality of first conductive pattern lines to each other.

15. The conductive sheet according to claim 1, wherein a number of the first conductive pattern lines is equal to or less than ten.

16. The conductive sheet according to claim 2, wherein each of the sub-nonconduction patterns is surrounded by a plurality of sides, and each of the sides is formed by linearly arranging the plurality of grids with sides of the grids being connected to each other.

17. The conductive sheet according to claim 2, wherein each of the sub-nonconduction patterns is surrounded by a plurality of sides, and each of the sides is formed by linearly arranging, in multiple stages, the plurality of grids with sides of the grids being connected to each other.

18. The conductive sheet according to claim 2, wherein each of the sub-nonconduction patterns is surrounded by a plurality of sides, some of the sides are formed by linearly arranging the plurality of grids with sides of the grids being connected to each other, and the other sides are formed by linearly arranging the plurality of grids with apex angles of the grids being connected to each other.

19. The conductive sheet according to claim 16, wherein the plurality of sub-nonconduction patterns defined by the sides formed by the plurality of grids are arranged along the first direction with apex angles of the grids being connected to each other.

20. The conductive sheet according to claim 16, wherein adjacent ones of the sub-nonconduction patterns along the first direction have shapes different from each other.

21. The conductive sheet according to claim 19, wherein each of the plurality of grids that form the sides for defining the sub-nonconduction patterns further includes a protruding wire made of a metal thin wire.

22. The conductive sheet according to claim 19, wherein each of the first conductive patterns includes the sub-nonconduction patterns that are spaced apart from each other, to thereby have X-shaped structures in which the grids are not present at cyclical intersection parts.

23. The conductive sheet according to claim 19, wherein adjacent ones of the sub-nonconduction patterns along the first direction have the same shape as each other in each of the first conductive patterns, and the sub-nonconduction patterns have shapes different between adjacent ones of the first conductive patterns.

24. A touch panel comprising the conductive sheet according to claim 1.

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