

Abstract

An object of the present invention is to provide a configuration of an apparatus for producing a three-dimensional shaped product capable of decreasing thermal dissipation due to thermal conduction of a heating device or a cooling device loading a base plate, and the apparatus for producing a three-dimensional shaped product in which powder 12 is sequentially sintered on a table 2 and a base plate 3 inside a shaping tank 1, wherein a space or a space filled with insulating materials of vertical direction is formed on the table 2, and under a heating device or a cooling device 8 on which the base plate 3 supporting the sintered layer is placed, thereby attaining the above object.

Specification

1. Title of the Invention: APPARATUS FOR PRODUCING THREE-DIMENSIONAL SHAPED PRODUCT

2. Field of the Invention

The present invention relates to an apparatus for producing a three-dimensional shaped product in which metal powder or non-metal powder loaded on a vertically movable table is laminated while being sintered by irradiating electromagnetic waves to each layer, thereby producing a predetermined three-dimensional shaped product.

3. Description of the Related Art

There have been proposed various configurations in technical fields where metal powder or non-metal powder is sintered by irradiation of electromagnetic waves such as laser beams or electron beams, thereby molding a three-dimensional shaped product. However, any configuration will always entail the following steps:

(a) a planarization step for spraying powder by allowing the powder to fall and sliding on the upper surface or in the vicinity of the thus sprayed powder,

(b) a step in which a region to be shaped is irradiated by electromagnetic waves such as laser beams or electron beams, thereby sintering the irradiated region, and

(c) a step in which the lateral part and the upper surface that have been sintered in the step (b) are cut with a rotating tool, thereby molding the lateral part and the upper surface, and the steps of (a), (b) and (c) are repeated to finally mold a necessary three-dimensional shape.

Where the step (c) is completed for a specific powder layer, the powder on or around an object to be shaped is decreased in height only by one layer and the step (a) is resumed on a next powder layer.

Therefore, the table which loads the powder is installed so as to move vertically.

Where a powder layer located at the lowest level is brought directly into contact with the upper surface of the table, the powder layer adheres to the upper surface of the table in the sintering step (b). Thereby, it is impossible to smoothly remove from the table an object which has been completely shaped.

In order to cope with the above situation, Patent Document 1 has adopted a configuration in which when powder is solidified by sintering ordinarily on the surface of a table (which is expressed as "support means 2" in Patent Document 1), a base plate is installed which is made by selecting a material adherable to the powder.

At work sites, in order to perform sintering of the step

(b) at an appropriate temperature, in most cases, a heating device or a cooling device is installed in a state of being firmly attached to the lower side of the base plate. In the embodiment disclosed in Patent Document 1, a cooling device using a pipe of the cooling device (cooling duct) is adopted.

Ordinarily, an existing shaped part is influenced by the movement of the planarization device described in the step (a). Therefore, for the purpose of preventing the movement of the shaped part in the above moving direction, it is necessary that the base plate and the heating device or the cooling device are kept stably on the surface of the table.

In view of the above necessity, in the conventional technologies, the heating device or the cooling device is integrated into a table as disclosed in Patent Document 1 or firmly fixed to the lower surface of the table.

However, in the conventional technologies, on heating, thermal energy on the base plate is conducted to result in lower heating efficiency. On cooling, the table is also cooled or unnecessarily cooled, thereby inevitably resulting in lower cooling efficiency.

[Patent Document 1] Japanese Patent No. 4054075

4. Disclosure of the Invention

Problems to be Solved by the Invention

An object of the present invention is to provide an apparatus for producing a three-dimensional shaped product in which a base plate is interposed between a portion which is a region to be sintered among individual powder layers and a table, and also a configuration of the apparatus for producing a three-dimensional shaped product capable of preventing a decrease in heating efficiency of a heating device loading the base plate and also a decrease in cooling efficiency of a cooling device.

In order to attain the above object, the present invention is made up of the following basic configurations:

(1) An apparatus for producing a three-dimensional shaped product comprising; means of spraying metallic or non-metallic powder, on a base plate placed on an upper surface of a vertically movable table in a shaping tank having a material which can be adhered to the metallic or non-metallic powder upon solidification of the powder adjacent to an upper surface of the base plate by sintering on the upper surface of the table; means of planarization for an upper surface of accumulated powder by spraying; means of irradiating electromagnetic waves or electron beams on the upper-surface of the metallic or non-metallic powder along a layer having a predetermined thickness to a region to be shaped which is located at an uppermost position of the layer, for forming a sintered layer; means of cutting an edge of sintered layers

and an upper surface of sintered layers to effect molding, wherein

a space or a space filled with insulating materials of vertical direction is formed on the table, and under a heating device or a cooling device on which the base plate supporting the sintered layer is placed, and wherein

table forms an inclined state which sequentially lowers and a discharge opening for discharging powder which is not sintered is provided at a lowest edge of the inclined part.

(2) the apparatus for producing a three-dimensional shaped product as described in the above (1), wherein a base supporting a pipe of the heating device or a pipe of the cooling device is firmly fixed to the upper surface of the table via a leg part below or laterally firmly fixed to a frame body or a supporting rod installed upright on the table.

(3) the apparatus for producing a three-dimensional shaped product as described in the above (1), wherein a plurality of supports gripping the pipe of the heating device or the pipe of the cooling device are extended below and firmly fixed on an upper surface of the table or the supports are extended laterally and firmly fixed to a frame body or a supporting rod installed upright above from the table.

5. Brief Description of the Drawings

Figs. 1 explain a configuration of Example 1. Fig. 1(a)

is a plan view and Fig. 1(b) is a side cross-sectional view.

Figs. 2 explain a constitution of Example 2. Fig. 2(a) is a plan view and Fig. 2(b) is a side cross-sectional view.

Fig. 3 is a perpendicular side cross-sectional view showing a configuration of the table of basic configuration (1). (It is noted that a heating device or a cooling device as well as a leg part, a support, a frame body or a supporting rod and others for connecting the table with the devices are not illustrated.)

Fig. 4 is a perpendicular side cross-sectional view showing a configuration of the table in Example 3. (It is noted that the heating device or the cooling device as well as the leg part, the supports, the frame body or the supporting rod and others for connecting the table with the devices are not illustrated.)

Figs. 5 explain an embodiment of the basic configuration (2) in which a base is firmly fixed on the upper part of the table via the leg part below. Fig. 5 (a) is a plan view and Fig. 5 (b) is a side cross-sectional view.

Figs. 6 explain an embodiment of the basic configuration (2) in which the base is firmly fixed laterally to the frame body or the supporting rod. Fig. 6(a) is a plan view and Fig. 6(b) is a side cross-sectional view.

Figs. 7 show an embodiment of the basic configuration (3) in which the supports gripping the pipe of heating the device

or the pipe of the cooling device is extended below and firmly fixed on the upper part of the table. Fig. 7(a) is a plan view and Fig. 7(b) is a side cross-sectional view.

Figs. 8 show an embodiment of the basic configuration (3) in which the supports gripping the pipe of the heating device or the pipe of the cooling device is extended laterally and firmly fixed to the frame body or the supporting rod. Fig. 8 a) is a plan view and Fig. 8(b) is a side cross-sectional view.

Fig. 9 is a plan view showing an embodiment in which the heating device or the cooling device is installed on a part of the table.

[Description of Symbols]

- 1: Shaping tank
- 2: Table
- 20: Insertion hole
- 21: Discharge opening
- 3: Base plate
- 30: Recess
- 4: Supports
- 5: Leg part
- 6: Fixing bolt
- 7: frame body or supporting rod
- 8: heating device or cooling device

80: pipe of heating device or pipe of cooling device

81: heating source or cooling source

91: base

92: upper plate

10: opening and closing plate

11: perpendicular support

12: powder

14: powder supporting plate

6. Best Mode for Carrying Out the Invention

The present invention relates to an apparatus for producing a three-dimensional shaped product based on a basic technical idea in which, as described in the basic configuration (1), a heating device or a cooling device 8 (hereinafter, abbreviated as "HC apparatus 8" based on the respective capital letters H and C of heating and cooling) loading a base plate 3 is provided so as to form a space or a space filled with a heat insulating materials from a table 2 in a vertical direction, thereby exhibiting the previously described effect.

Then, the basic configuration (1) mainly adopts an embodiment of the basic configuration (2) in which a base 91 integrally supporting a pipe of the heating device or a pipe of the cooling device 80 (hereinafter, abbreviated as "HC pipe 80" based on the respective capital letters H and C of heating and cooling) is

fixed to the table 2 below or laterally and an embodiment of the basic configuration (3) in which the HC pipe 80 is not supported by the base 91 but the supports 4 gripping the HC pipe 80 is extended and firmly fixed below or laterally.

As shown in Fig. 3, basic configuration (1) is characterized in that an inclined state which sequentially lowers is formed on the table 2 and a discharge opening 21 for discharging the powder 12 which has not been sintered is provided at a lowest edge part of the inclined part.

Where the powder 12 is loaded on the table 2 and the surface of the base plate 3, all the powder 12 is not necessarily subjected to sintering.

In this case, the powder 12 which is not sintered remains inevitably at the lower part of the table 2, after the molded material is taken out above from the table 2, together with the base plate 3.

In basic configuration (1), the remaining powder 12 comes down along a lower part of the inclined part and can be discharged into the lower part of the shaping tank 1 via an opening located at the lowest position. It is, therefore, possible to reuse the powder 12.

In order to exhibit the effect of basic configuration (1) as much as possible, as shown in Fig. 3, it is preferable that the

end of the table 2 is brought closer to an inner wall of the shaping tank 1.

However, in this instance, as shown in Fig. 3, the leg part 5, the supports 4, the frame body or the supporting rod 7 used in firmly fixing the HC apparatus 8 are installed on an inclined surface and firmly fixed thereto.

In the basic mode (2), as shown in Figs. 5 (a) and (b), the base 91 is firmly fixed to an upper surface of the table 2 via a leg part 5 below or as shown in Figs. 6 (a) and (b), the base 91 is laterally firmly fixed to a frame body or a supporting rod 7 installed upright from above the table 2. Since the base 91 is firmly fixed as described above, a space or a space filled with a heat insulating material having a predetermined distance in the vertical direction is formed between the lower face of the base 91 of the HC apparatus 8 and the upper face of the table 2.

In the basic configuration (2), in order to firmly fix the HC apparatus 8 to the table 2 stably, the leg part 5 used in firmly fixing the base as shown in Figs. 5 (a) and (b) and the frame body or the supporting rod 7 used in firmly fixing the base as shown in Figs. 6 (a) and (b) are to be provided in one unit respectively where the table 2 and the base 91 are surrounded,

or they are to be provided in two units respectively where lying astride both sides of the rectangular table 2 and the base 91. It is necessary that the leg part 5 and the frame body or the supporting rod 7 provided at least in three units respectively excluding the above special cases.

The frame body or the supporting rod 7 in the embodiments described in Figs. 6 (a) and (b) will be selected by whether or not a horizontal section area is greatly different from a section area of the table 2 based on technical common knowledge, that is, $1/10$ or less. Where the horizontal section area is $1/10$ or more than the cross section of the table 2, the frame body 7 is to be selected. While it is less than $1/10$, the supporting rod 7 is to be selected. This is applicable in exactly the same manner as an explanation to be made hereinafter.

In order to prevent thermal conduction to the table 2 and also realize effective heating or cooling, a vertical distance between the table 2 and the base 91 is preferably 15 mm or more.

In the basic mode (2), ordinarily, as shown in Figs. 5 (a) and (b) and Figs. 6 (a) and (b), an embodiment is mainly adopted, wherein the base 91 covers the upper part as well of the HC pipe 80 and the base plate 3 is firmly fixed on the upper surface of the base 91, in other words, a configuration in which the base 91 has the HC pipe 80 embedded.

The basic configuration (2) is technically advantageous in that the table 2 can be firmly fixed to the base 91 and the base plate 3 can be placed stably on the base 91.

In the basic configuration (3), as shown in Figs. 7 (a) and (b), the supports 4 gripping the HC pipe 80 are extended below and firmly fixed on the upper surface of the table 2 or, as shown in Figs. 8 (a) and (b), the supports 4 are extended laterally and firmly fixed to the frame body or the supporting rod 7 installed upright above from the table 2.

In order to firmly fix the HC pipe 80 stably to the table 2 in the basic configuration (3), it is necessary that the supports 4 extending below as shown in Figs. 7 (a) and (b) and the supports 4 extending laterally as shown in Figs. 8(a) and (b) are provided respectively in three units or more.

In the basic configuration (3) as well, a clearance between the lowest edge part of the HC pipe 80 and the table 2 is preferably 15 mm or more to realize effective heating or cooling.

In the basic configuration (3), ordinarily, as shown in Figs. 7 (a) and (b) and Figs. 8 (a) and (b), a configuration may be adopted, wherein the upper plate 92 is provided for covering an upper part of the HC pipe 80 and an upper part of the supports 4 gripping the HC pipe 80, and the base plate 3 is firmly fixed on an upper surface of the upper plate 92, in other words,

a configuration in which the base plate 3 is firmly fixed on the upper plate 92 which covers the upper part of the HC pipe 80 and also acts as a cover thereof.

The basic configuration (3) is technically advantageous in that the HC apparatus 8 can be installed easily.

In any one of the cases shown in Figs. 5, 6, 7 and 8, the HC apparatus 8 is substantially similar in area to the table 2 in the lateral direction. However, the design of the HC apparatus 8 shall not be limited to these cases of the present invention.

To be more specific case, as shown in Fig. 9, as a matter of course, such a configuration is adoptable that the HC apparatus 8 is installed on a part of the table 2. (In Fig. 9, both the base 91 of the embodiment (2) and the upper plate 92 of the embodiment (3) are commonly illustrated but the base plate 3 is not illustrated.)

7. Examples

Hereinafter, an explanation will be made by referring to examples.

[Example 1]

As shown in Fig. 1, Example 1 is characterized in that, in the basic configuration (2), 1/2 or more of an upper part of the HC pipe 80 juts out the base along the vertical direction thereof, and a recess 30 provided below the base plate 3 is fitted into

the upper part of the HC pipe 80. (In Figs. 1, constituents used in firmly fixing the HC apparatus 8 such as a leg part 5, a frame body or a supporting rod 7 are not illustrated.)

As long as the base plate 3 has already loaded a substantial amount of powder 12 on the upper surface thereof in the step (a) and the powder 12 has been sintered in the step (b), a substantial weight acts on the HC pipe 80 from the base plate 3.

Therefore, the recess 30 is fitted into the HC pipe 80, by which the base plate 3 of the HC apparatus 8 is installed stably. As described in the embodiments of Figs. 5 and 6, there is no need for fixing the base plate 3 to the HC apparatus 8 with a fixing bolt 6 and others, which is quite convenient.

[Example 2]

As shown in Figs. 2, Example 2 is characterized in that, in the basic configuration (3), a lower part of the HC pipe 80 juts out the base and the recess 30 provided below the base plate 3 is fitted into an upper part of the HC pipe 80. (In Fig. 1, constituents used in firmly fixing the HC apparatus 8 such as the supports 4, the frame body or the supporting rod 7 are not illustrated.)

On the basis of grounds similar to that of Example 1, in Example 2 as well, the base plate 3 can be supported stably on the HC apparatus 8. There is no need for firmly fixing the base

plate 3 to the HC apparatus 8 with the fixing bolt 6 and others, which is quite convenient.

[Example 3]

As shown in Fig. 4, Example 3 is characterized in that the table 2 forms an inclined state which sequentially lowers from one side of two mutually opposing sides to the other side, the frame body or the support rod 7 is supported via two perpendicular supports 11 on the other side, and between the two perpendicular supports 11, provided is an opening and closing plate 10 capable of moving rotationally on a highest edge part of the two perpendicular supports 11 or on one of the two perpendicular supports 11.

Similar to basic configuration (1), also in Example 3, the powder 12 which has not been subjected to sintering or shaping is allowed to fall on the surface of the table 2, and the opening and closing plate 10 located between the perpendicular supports 11 is opened, by which the powder 12 can be discharged outside from the surface of the table 2. Thereby, the powder 12 can be effectively discharged outside and the powder 12 can be reused similar to basic configuration (1). (Fig. 3 shows a state that the opening and closing plate 10 capable of moving rotationally is opened at the highest edge parts of two perpendicular supports 11, but in a stage of shaping, as a matter of course,

the opening and closing plate 10 is located between the perpendicular supports 11 and closed.)

In Example 3 as well, in order to exhibit the above effect, it is preferable that the end of the table 2 is brought closer to an inner wall of the shaping tank 1.

However, similar to basic configuration (1) , the leg part 5, the supports 4, the frame body or the supporting rod 7 used in firmly fixing the HC apparatus 8 are installed on an inclined surface and firmly fixed thereto. (Fig.4 shows a case where the frame body or the supporting rod 7 is provided.)

8. Effects of the Invention

On the basis of the basic configurations (1), (2) and (3), in the present invention, the space of the space filled with insulating materials of vertical direction is formed between the heating device or the cooling device and a table. Thereby, unnecessary heating or cooling can be avoided to attain efficient heating and cooling.

Further, in the configuration disclosed in Patent Document 1, the table is consequently required to be planar. However, in the above-described basic configuration, as described in basic configuration (1) and Example 3, an inclined state is developed on the table, thus making it possible to adopt a configuration capable of easily discharging powder which has not been sintered.

The present invention is applicable to any and all configurations of an apparatus for producing a three-dimensional shaped product using a base plate.

9. CLAIMS

[Claim 1]

An apparatus for producing a three-dimensional shaped product comprising; means of spraying metallic or non-metallic powder, on a base plate placed on an upper surface of a vertically movable table in a shaping tank having a material which can be adhered to the metallic or non-metallic powder upon solidification of the powder adjacent to an upper surface of the base plate by sintering on the upper surface of the table; means of planarization for an upper surface of accumulated powder by spraying; means of irradiating electromagnetic waves or electron beams on the upper surface of the metallic or non-metallic powder along a layer having a predetermined thickness to a region to be shaped which is located at an uppermost position of the layer, for forming a sintered layer; means of cutting an edge of sintered layers and an upper surface of sintered layers to effect molding, wherein

a space or a space filled with insulating materials of vertical direction is formed on the table, and under a heating device or a cooling device on which the base plate supporting the sintered layer is placed, and wherein

table forms an inclined state which sequentially lowers and a discharge opening for discharging powder which is not sintered is provided at a lowest edge of the inclined part.

[Claim 2]

The apparatus for producing a three-dimensional shaped product according to claim 1, wherein

a base supporting a pipe of the heating device or a pipe of the cooling device is firmly fixed to the upper surface of the table via a leg part below or laterally firmly fixed to a frame body or a supporting rod installed upright on the table.

[Claim 3]

The apparatus for producing a three-dimensional shaped product according to claim 2, wherein

the space or the space filled with the heat insulating materials of vertical direction between the base and the table is 15 mm or more.

[Claim 4]

The apparatus for producing a three-dimensional shaped product according to any one of claim 1 to claim 3, wherein

the base covers also an upper part of the pipe of the heating device or the pipe of the cooling device and the base plate is firmly fixed on an upper part of the base.

[Claim 5]

The apparatus for producing a three-dimensional shaped product according to any one of claim 1 to claim 3, wherein

1/2 or more of an upper part of the pipe of the heating

device or the pipe of the cooling device juts out the base along the vertical direction thereof and a recess provided below the base plate is fitted into the upper part of the pipe of the heating device or the pipe of the cooling device.

[Claim 6]

The apparatus for producing a three-dimensional shaped product according to claim 1, wherein

a plurality of supports gripping the pipe of the heating device or the pipe of the cooling device are extended below and firmly fixed on the upper surface of the table or the supports are extended laterally and firmly fixed to a frame body or a supporting rod installed upright above from the table.

[Claim 7]

The apparatus for producing a three-dimensional shaped product according to claim 6, wherein

the space or the space filled with the heat insulating materials of vertical direction between a lowest edge part of the pipe of the heating device or the pipe of the cooling device and the table is 15 mm or more.

[Claim 8]

The apparatus for producing a three-dimensional shaped product according to any one of claim 6 and claim 7, wherein

an upper plate is provided for covering an upper part of

the pipe of the heating device or the pipe of the cooling device and an upper part of the supports gripping the pipe, and the base plate is firmly fixed on the upper surface of the upper plate.

[Claim 9]

The apparatus for producing a three-dimensional shaped product according to any one of claim 6 and claim 7, wherein

a lower part of the pipe of the heating device or the pipe of the cooling device juts out the base and a recess provided below the base plate is fitted into an upper part of the pipe of the heating device or the pipe of the cooling device.

[Claim 10]

The apparatus for producing a three-dimensional shaped product according to any one of claim 1 to claim 9, wherein

the table forms the inclined state which sequentially lowers from one side of two opposing sides to the other side, the frame body or the supporting rod is supported on the other side via two perpendicular supports, and between the two perpendicular supports, provided is an opening and closing plate capable of moving rotationally on a highest edge part of the two perpendicular supports or on one of the two perpendicular supports.

Fig. 1

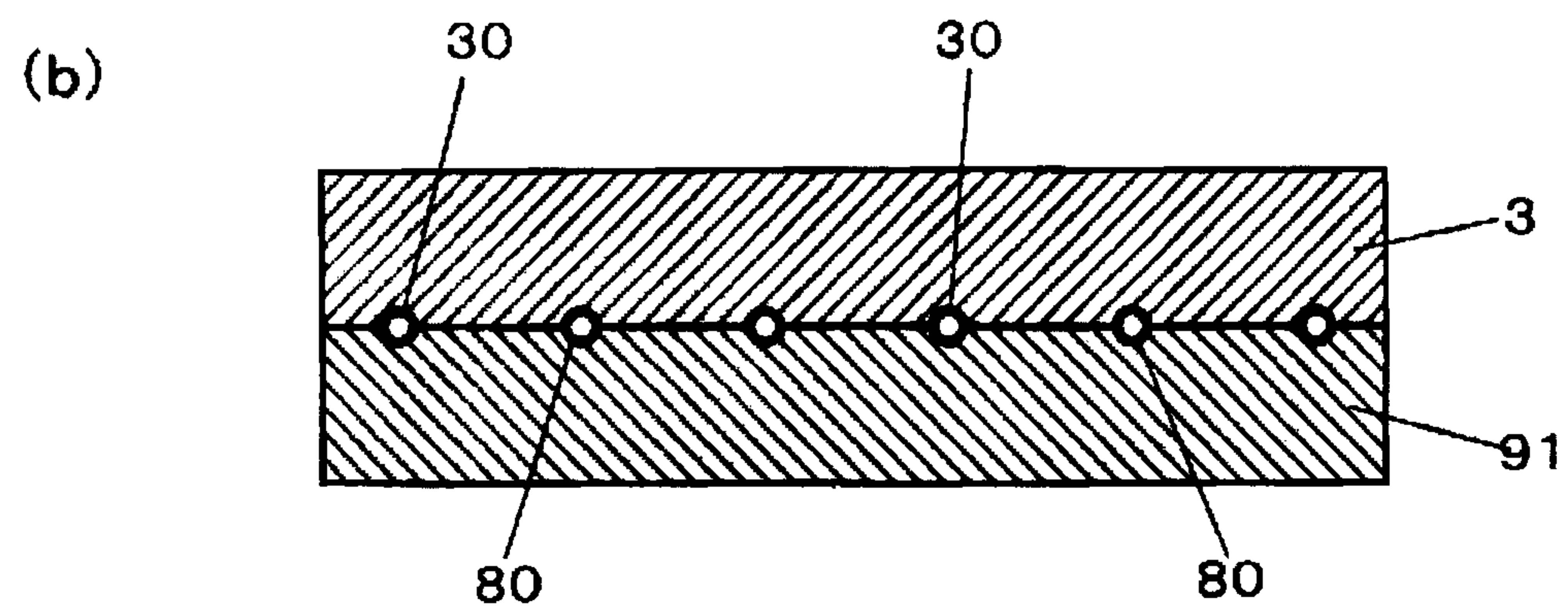
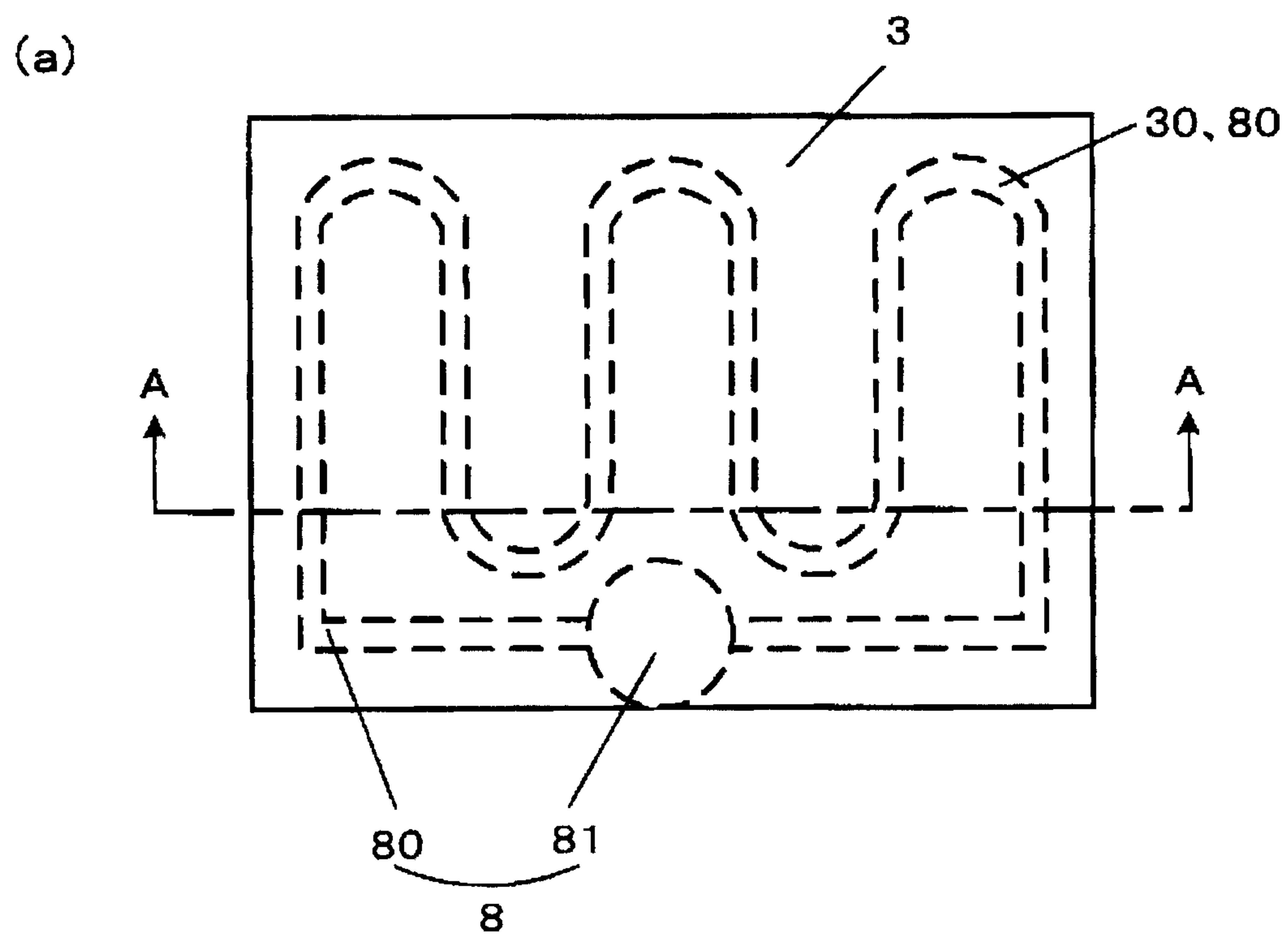


Fig. 2

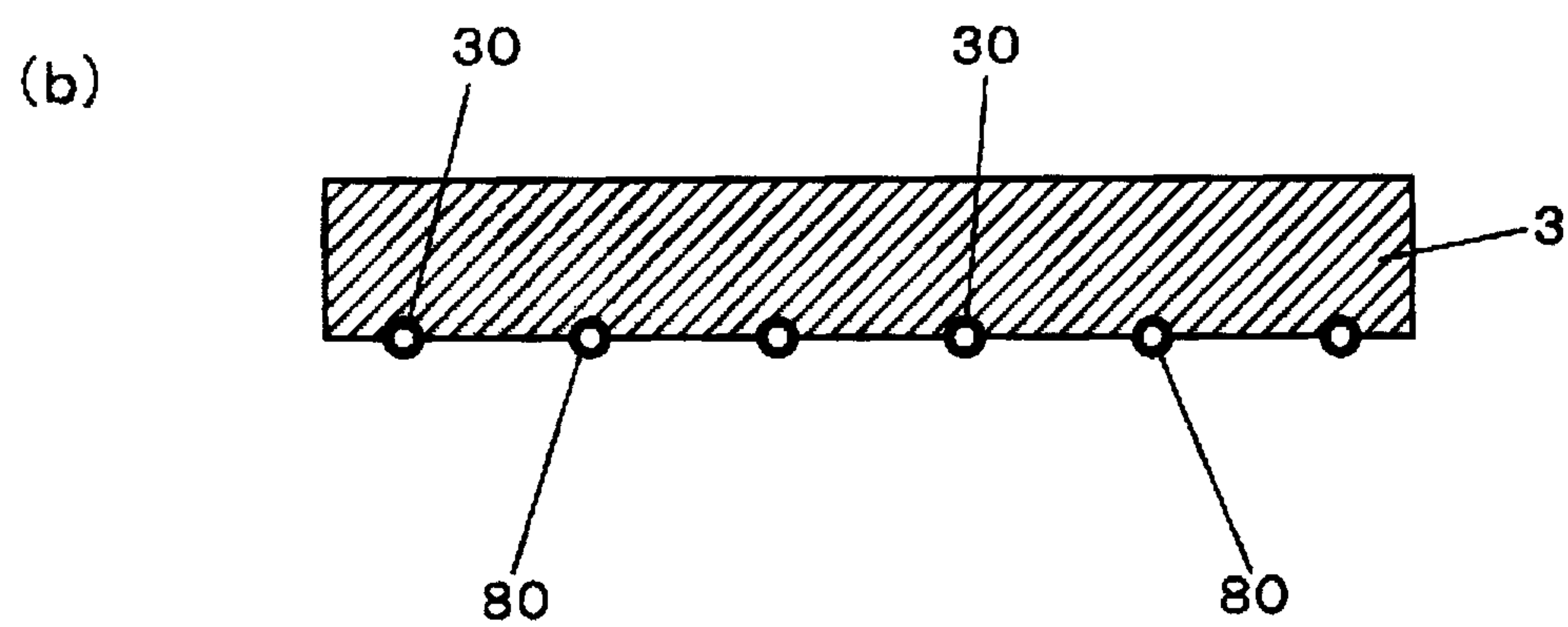
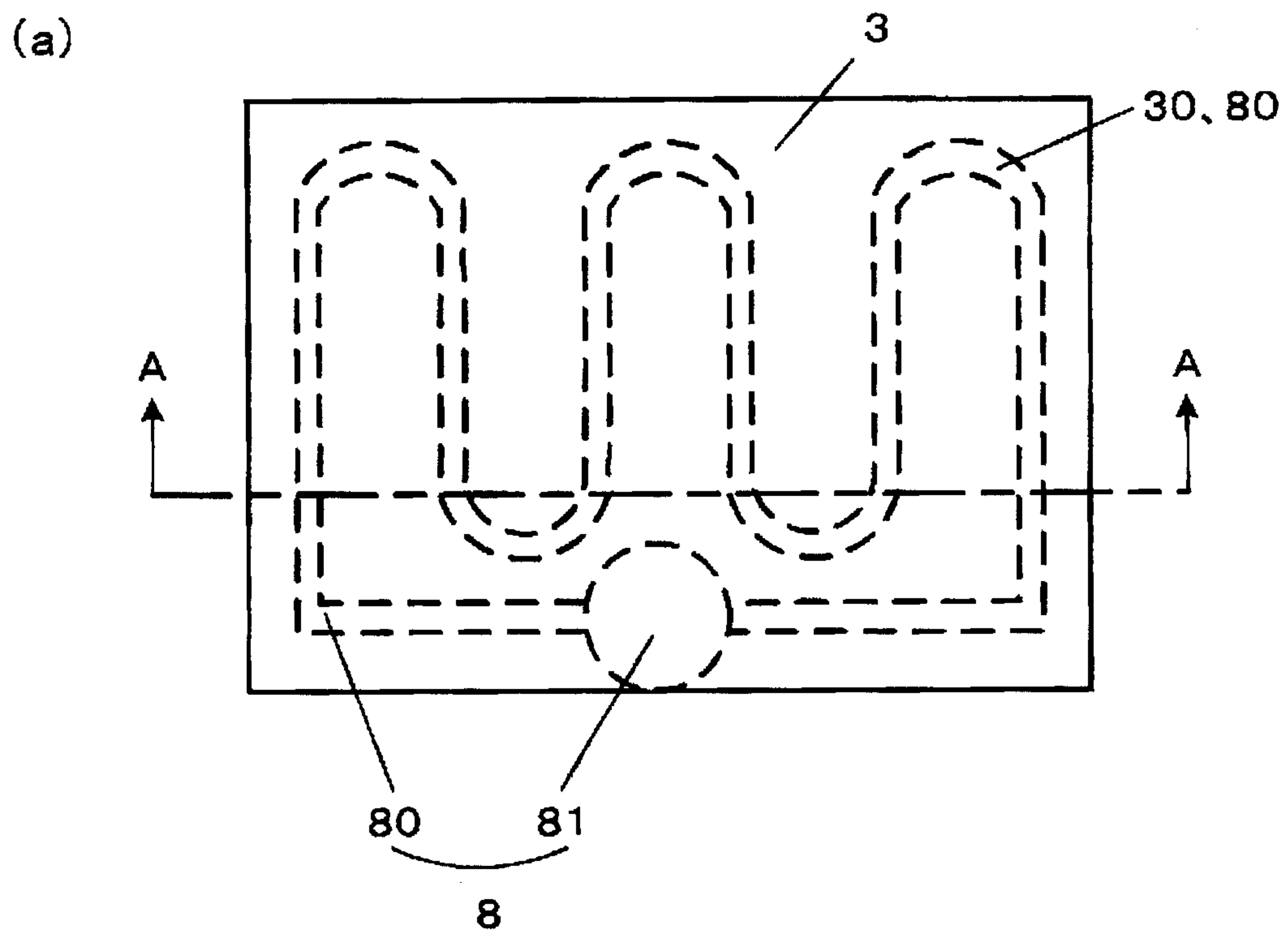


Fig. 3

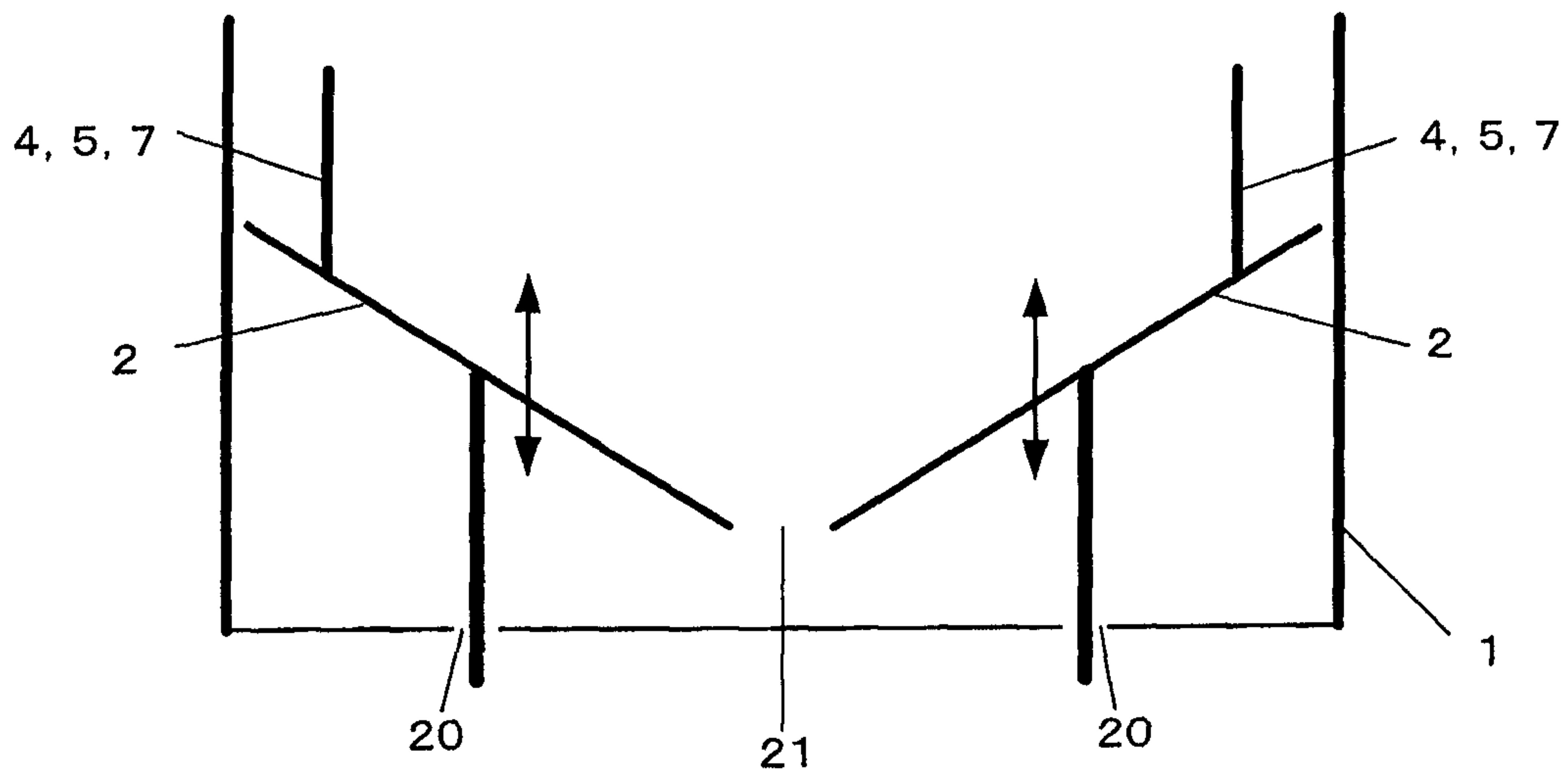


Fig. 4

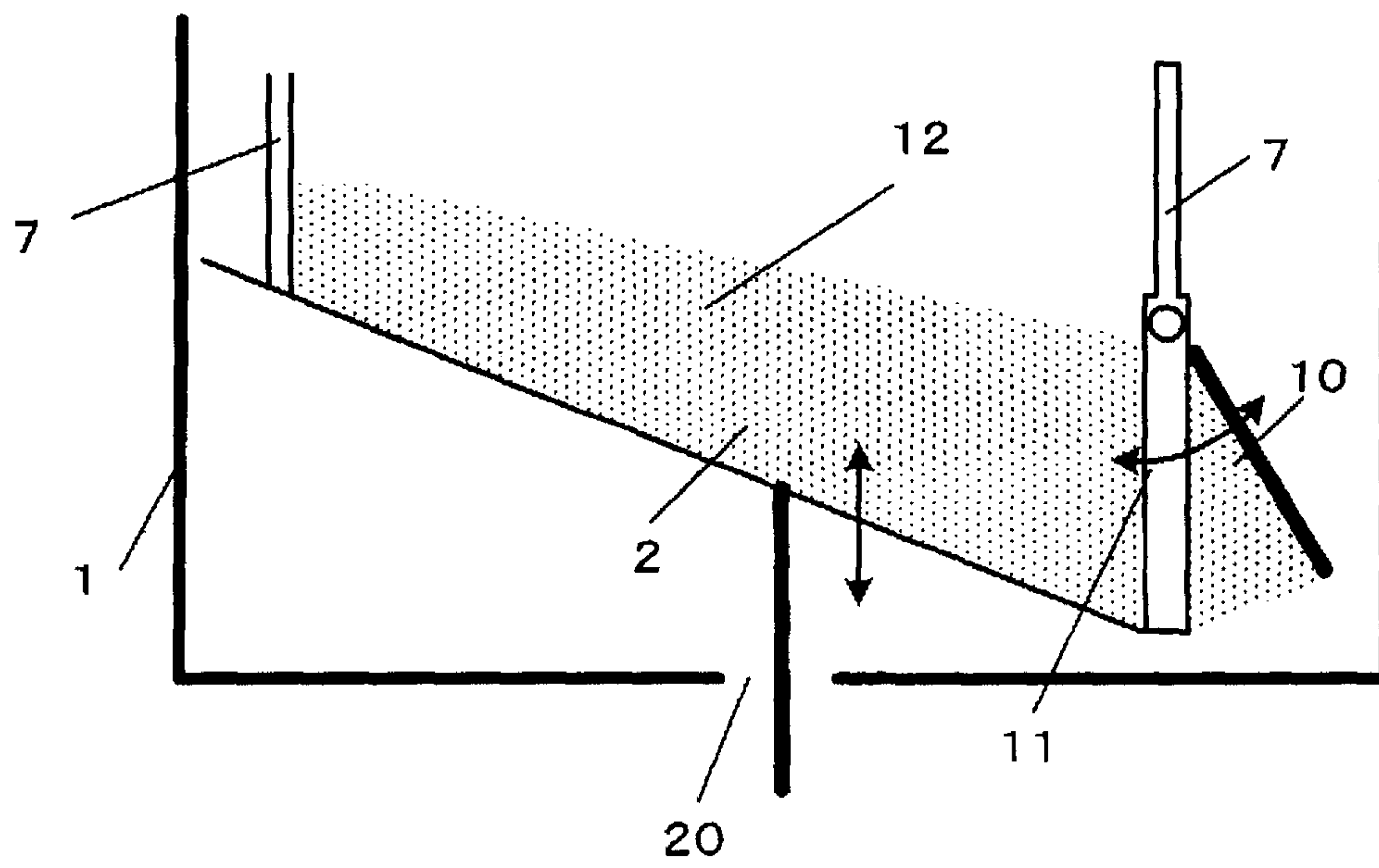


Fig.5

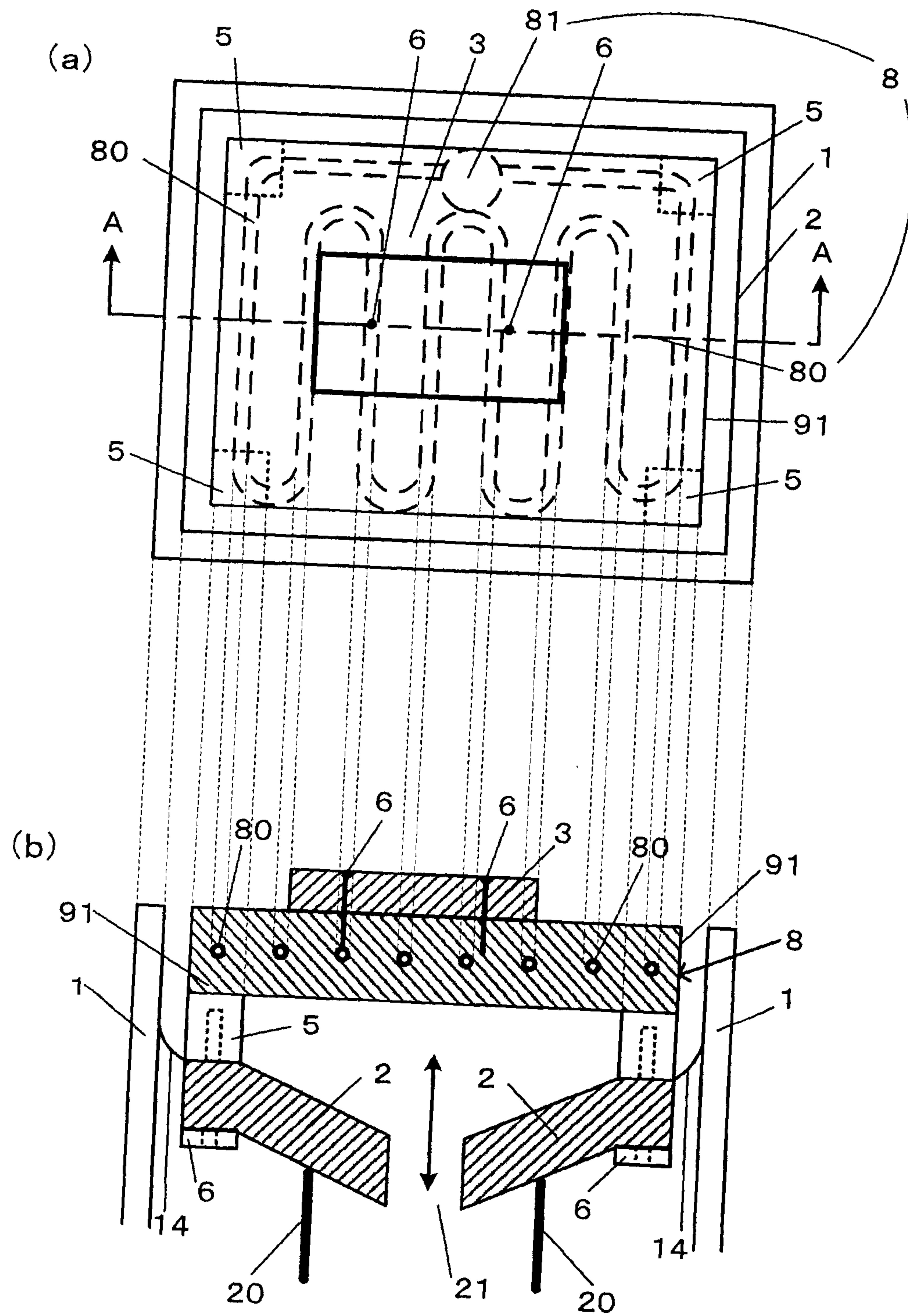


Fig. 6

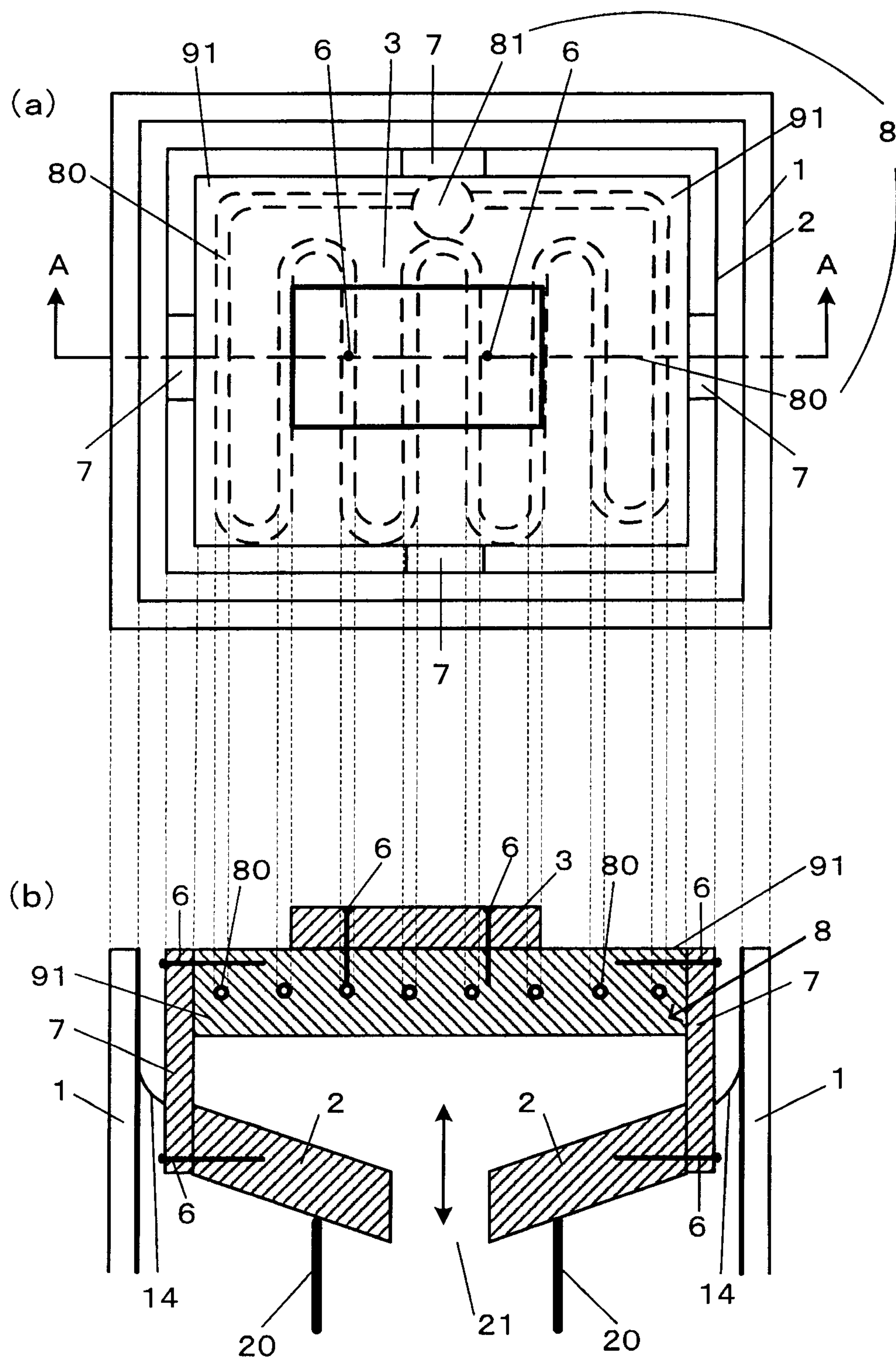


Fig. 7

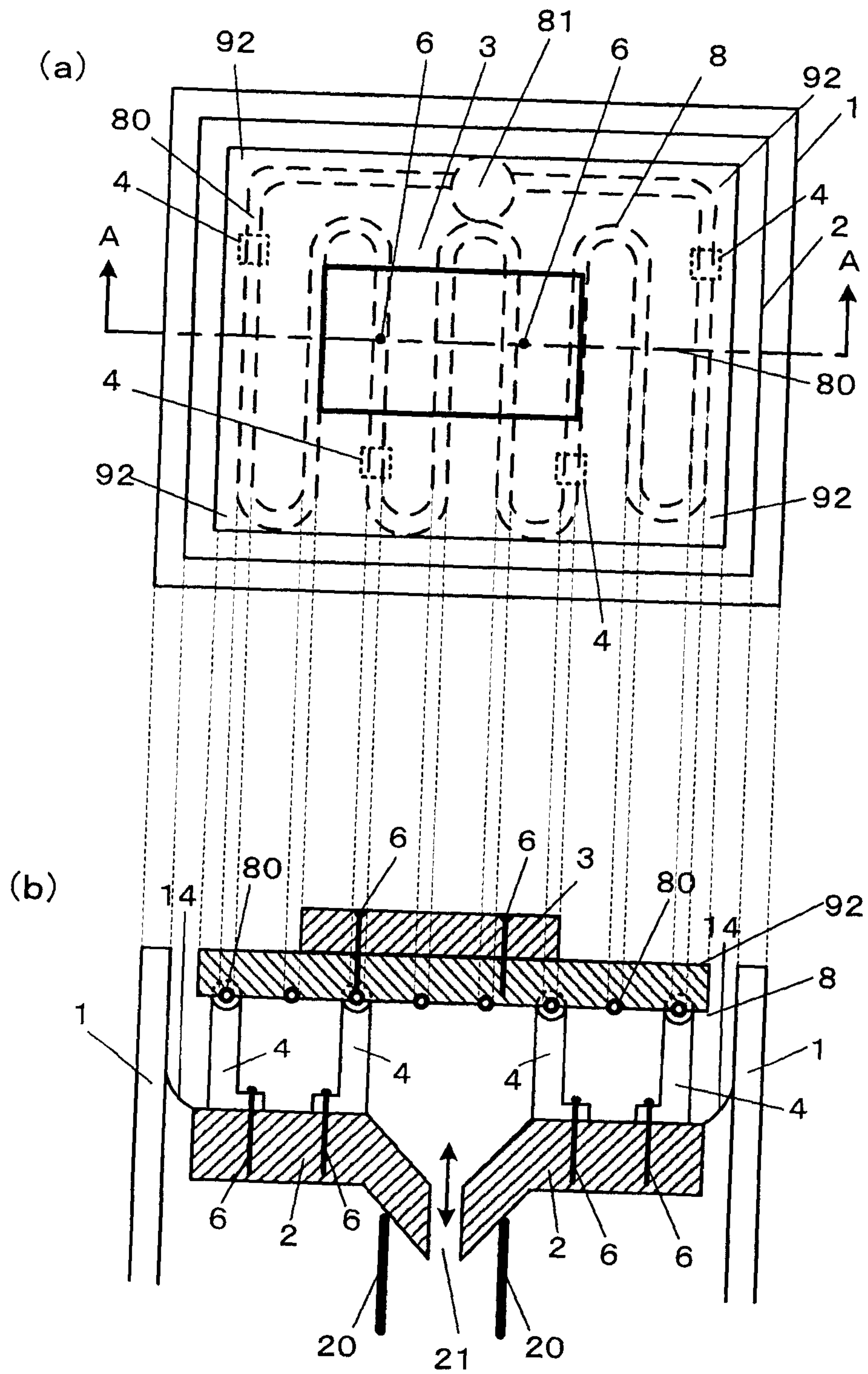


Fig. 8

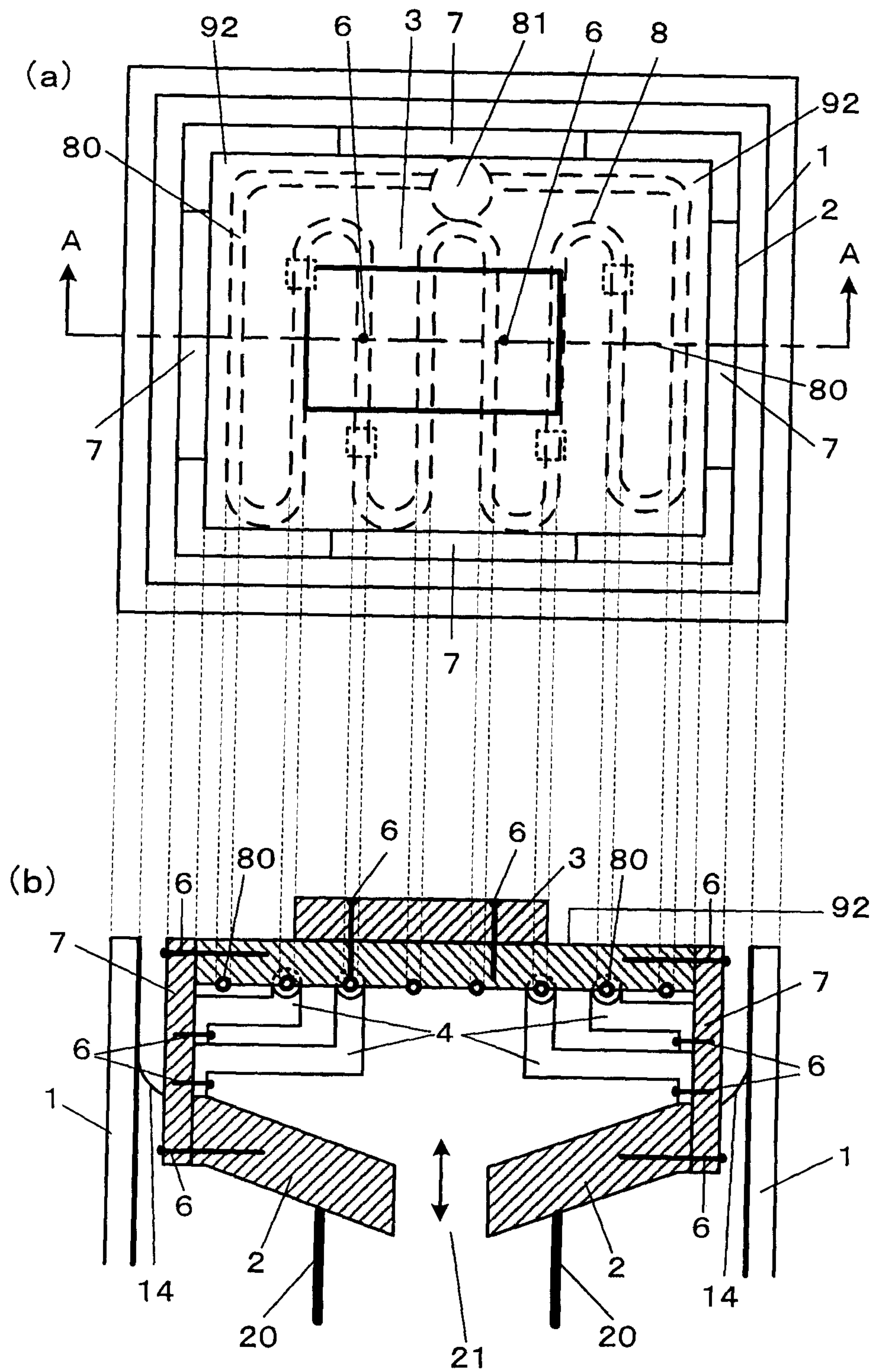


Fig. 9

