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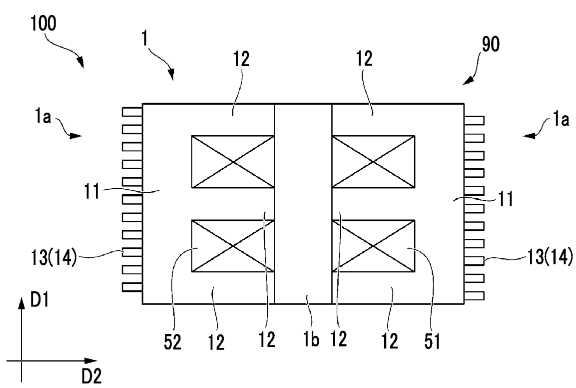
(54) **REACTOR**

(57) This reactor is provided with: a core comprising a plurality of electromagnetic steel plates laminated in the thickness direction; and, a coil comprising wire wound around the core. The electromagnetic steel plate has: a pair of outer components having a first portion that extends in a first direction, and a plurality of second portions that extend from the first portion in a second direction orthogonal to the first direction and are arranged at intervals in the first direction; a central component for connecting the plurality of second portions to each other in the first direction with the second portions opposed from the second direction; and, a plurality of fin formation sections that protrude in the second direction from the end edge of the first portion on the side opposite to the second portion and are arranged at intervals in the first direction.

FIG. 1



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Description

Technical Field

[0001] The present disclosure relates to a reactor.

[0002] Priority is claimed on Japanese Patent Application No. 2021-159131 filed on September 29, 2021, the content of which is incorporated herein by reference.

Background Art

[0003] Reactors are widely used as electrical components for causing reactance. A reactor includes a core formed by laminating a plurality of electromagnetic steel plates and a coil composed of a wire wound around the core (for example, PTL 1 below or PTL 2 below).

[0004] There are an increasing number of cases where two coils are mounted on one core for the purpose of reducing the dimensions and the size of the entire reactor. In such a case, for example, it is possible to form the core by using a pair of E-shaped outer components and an I-shaped central component disposed between the outer components. A wire is wound around a central protrusion portion among three protrusion portions of each of the outer components so that the two coils are formed.

[0005] Here, gaps are formed, as air gaps, between the central protrusion portions and the central component. Therefore, magnetic flux density in the vicinity thereof is low. Meanwhile, since no air gap is formed at roots of the central protrusion portions, magnetic flux density at the roots tends to be high. As a result, heat may be generated in a corresponding region in a case where the reactor is operated.

Citation List

Patent Literature

[0006]

[PTL 1] Japanese Unexamined Patent Application Publication No. 2013-93921
[PTL 2]: Chinese Utility Model Registration Application No. 206194495

Summary of Invention

Technical Problem

[0007] However, in the case of a reactor in the related art, a sufficient countermeasure against such heat generation has not been made. As a result, there may be an influence on stable operation of the reactor.

[0008] The present disclosure has been made in order to solve the above-described problem and an object thereof is to provide a reactor that can be operated more stably. Solution to Problem

[0009] In order to solve the above-described problem, the present disclosure provides a reactor including a core that is composed of a plurality of electromagnetic steel plates laminated in a thickness direction and a coil that is composed of a wire wound around the core. Each electromagnetic steel plate includes a pair of outer components each of which includes a first portion that extends in a first direction and a plurality of second portions that extend from the first portion in a second direction orthogonal to the first direction and that are arranged at intervals in the first direction, a central component that connects the second portions to each other in the first direction in a state where the plurality of second portions face each other in the second direction, and a plurality of fin forming portions that protrude in the second direction from an edge of each first portion on a side opposite to the second portions and that are arranged at intervals in the first direction.

Advantageous Effects of Invention

[0010] According to the present disclosure, it is possible to provide a reactor that can be operated more stably. Brief Description of Drawings

[0011]

Fig. 1 is a cross-sectional view showing a configuration of a reactor according to an embodiment of the present disclosure.

Fig. 2 is an explanatory view showing a shape at the time of die-cutting of an electromagnetic steel plate according to an embodiment of the present disclosure.

Fig. 3A is an explanatory view showing a first modification example of a shape at the time of die-cutting of an electromagnetic steel plate according to another embodiment of the present disclosure.

Fig. 3B is an explanatory view showing a second modification example of the shape at the time of the die-cutting of the electromagnetic steel plate according to the other embodiment of the present disclosure.

Fig. 4 is an explanatory view showing a third modification example of the shape at the time of die-cutting of the electromagnetic steel plate according to the other embodiment of the present disclosure.

Fig. 5 is a cross-sectional view showing a configuration of a reactor according to another embodiment of the present disclosure.

Fig. 6 is an explanatory view showing an example of a shape at the time of die-cutting of a central component according to another embodiment of the present disclosure. Description of Embodiments

(Configuration of Reactor)

[0012] Hereinafter, a reactor 100 according to an embodiment of the present disclosure will be described with reference to Figs. 1 and 2. The reactor 100 is a component used to cause reactance on an electric circuit. As shown in Fig. 1, the reactor 100 includes a core 1 and two coils (a first coil 51 and a second coil 52).

(Configuration of Core)

[0013] The core 1 is formed by laminating a plurality of plate-shaped electromagnetic steel plates 90 in a thickness direction. The electromagnetic steel plate 90 includes a pair of outer components 1a and one central component 1b.

[0014] The outer component 1a includes a first portion 11 that extends in a first direction D1, three second portions 12 that protrude from the first portion 11 in a second direction D2 orthogonal to the first direction D1 and that are arranged at intervals in the first direction D1, and fin forming portions 13 that are provided at an edge of the first portion 11 on a side opposite to the second portions 12.

[0015] The first portion 11, the second portions 12, and the fin forming portions 13 are formed integrally with each other. The second portions 12 are separated from each other in the first direction D1 by the same dimension. Note that being "the same" means being substantially the same, and manufacturing tolerances and design errors are allowed.

[0016] A dimension in the second direction D2 of the second portion 12 that is one of the three second portions 12 and that is disposed at the center in the first direction D1 is set to be smaller than dimensions in the second direction D2 of the other second portions 12. This is because an air gap is to be formed between the second portion 12 at the center and the central component 1b, which will be described later. The number of the second portions 12 is preferably three but may be two or four or more.

[0017] A plurality of the fin forming portions 13 are arranged at intervals in the first direction D1. The fin forming portions 13 protrude from the first portion 11 in the second direction D2. Each of the fin forming portions 13 forms a fin 14 in a case where the electromagnetic steel plates 90 are laminated in the thickness direction.

[0018] The positions in the first direction D1 of the fin forming portions 13 of one of the pair of outer components 1a are different from the positions in the first direction D1 of the fin forming portions 13 of the other of the pair of outer components 1a. Furthermore, as shown in Fig. 2, the fin forming portions 13 have shapes that engage with each other in a case where the fin forming portions 13 are caused to face each other in the second direction D2 at the time of die-cutting. In other words, the fin forming portions 13 are alternately arranged to complement each other between the pair of outer components 1a.

[0019] The central component 1b extends in the first direction D1 to connect the three second portions 12 in the first direction D1. A dimension of the central component 1b in the first direction D1 is two times dimensions of the second portions 12 in the second direction D2. In addition, a dimension of the central component 1b in the second direction D2 is the same as the dimension by which the second portions 12 are separated from each other in the first direction D1.

(Configuration of Coil)

[0020] Each of the first coil 51 and the second coil 52 is formed by winding, a plurality of times, a wire around the second portion 12 that is at the center in the first direction D1. That is, the reactor 100 includes two independent coils. As a method of winding the wire, it is possible to adopt various methods proposed so far.

[0021] In a case where the reactor 100 is to be formed, the first coil 51 and the second coil 52 are formed by winding a wire after a plurality of the pairs of outer components 1a and a plurality of the central components 1b, which are formed in shapes as described above through die-cutting, are laminated in the thickness direction. Thereafter, a laminate of the central components 1b and a laminate of the pairs of outer components 1a are welded to each other so that the reactor

100 is completed.

(About Die-Cut Shape of Electromagnetic Steel Plate for Reactor)

[0022] Next, a die-cut shape of the electromagnetic steel plate 90 for a reactor will be described with reference to Fig. 2. A die (a blade) used in a case where of producing the electromagnetic steel plate 90 for a reactor through die-cutting has a shape as shown in Fig. 2. That is, the pair of outer components 1a is disposed such that the second portions 12 face each other. In addition, as described above, the fin forming portions 13 are disposed to engage with the fin forming portions 13 of another adjacent outer component 1a. Furthermore, at least one of regions formed between the second portions 12 of the outer component 1a is a region for formation of the central component 1b.

(Action and Effect)

[0023] Here, a gap is formed, as an air gap, between the second portion 12 that is at the center in the first direction D1 and the central component 1b. Therefore, magnetic flux density in the vicinity thereof is low. Meanwhile, since no air gap is formed at a root (that is, a portion connected to the first portion 11) of the second portion 12 at the center, magnetic flux density at a corresponding region tends to be high. As a result, heat may be generated in the corresponding region in a case where the reactor 100 is operated. Therefore, in the present embodiment, the configuration as described above is adopted.

[0024] According to the above-described configuration, since the fin forming portions 13 are formed at the first portion 11, the fin forming portions 13 form a plurality of the fins 14 in a case where the plurality of electromagnetic steel plates 90 are laminated. Since heat is propagated to the fins 14 and the fins 14 are exposed to the outside air, heat generated by the core 1 can be released. As a result, the reactor 100 can be operated more stably.

[0025] Furthermore, in the above-described configuration, the dimension in the second direction D2 of the second portion 12 that is one of the three second portions 12 and that is positioned at the center in the first direction D1 is smaller than the dimensions in the second direction D2 of the other second portions 12.

[0026] According to the above-described configuration, an air gap can be formed between the second portion 12 positioned at the center and the central component 1b facing the second portion 12. In addition, although heat generation is likely to become excessive at the root (that is, a connecting portion connected to the first portion 11) of the second portion 12 positioned at the center, the heat can be efficiently released to the outside since the fin forming portions 13 are provided at the first portion 11.

[0027] In addition, the dimension of the central component 1b in the first direction D1 is two times the dimensions of the second portions 12 in the second direction D2. Furthermore, the dimension of the central component 1b in the second direction D2 is the same as the dimension by which the second portions 12 are separated from each other in the first direction D1.

[0028] According to the above-described configuration, it is possible to improve the yield of a plate material which is a material used in a case where the central component 1b and the outer components 1a are formed through die-cutting. That is, a wasteful portion can be reduced. Specifically, a dimension of the outer component 1a in the second direction D2 is set to be two times the length of protrusion of the second portion 12. Accordingly, a region that is formed between the second portions 12 can be used as the central component 1b with little waste in a case where die-cutting is performed in a state where a pair of the outer components 1a is combined with each other such that the second portions 12 thereof face each other.

[0029] In addition, in the above-described configuration, the positions in the first direction D1 of the fin forming portions 13 of one of the pair of outer components 1a are different from the positions in the first direction D1 of the fin forming portions 13 of the other of the pair of outer components 1a and the fin forming portions 13 have shapes that engage with each other in a case where the fin forming portions 13 are caused to face each other in the second direction D2.

[0030] According to the above-described configuration, since the fin forming portions 13 engage with each other in a case where die-cutting is performed in a state where the outer components 1a are continuously arranged in the second direction D2, a wasteful portion formed as a result of the die-cutting is reduced and thus improvement in yield can be achieved.

(Other Embodiments)

[0031] The embodiment of the present disclosure has been described above. Note that the above-described configurations can be changed and modified in various ways without departing from the gist of the present disclosure. For example, in the above-described embodiment, an example in which the fin forming portions 13 (the fins 14) are arranged at equal intervals in the first direction D1 has been described. However, the aspect of the fin 14 is not limited thereto and for example, a configuration in which the density of the fins 14 is high at a region (a position corresponding to the second portion 12 at the center) where heat generation is most likely to become excessive and the density of the fins 14 is low at other regions can also be adopted.

[0032] In addition, for example, a shape as shown in Fig. 3A can also be adopted as a modification example at the time of die-cutting with respect to a workpiece W (a base material) having a plate-like shape.

[0033] At the time of die-cutting, components are die-cut out of the workpiece W by using a die (a blade) having a shape represented by solid lines in Fig. 3A. Hereinafter, configurations of a plurality of outer component groups 10a formed in a case where the workpiece W is die-cut will be described.

[0034] The plurality of outer component groups 10a are disposed to be adjacent to each other in directions in which the workpiece W extends. Each outer component group 10a is composed of a plurality of pre-assembly outer components 1a' that have the same shape as each other and that are arranged in one direction in a state of being integrated with each other.

[0035] Note that the outer component group 10a that is disposed at an end in a direction in which the outer component groups 10a are adjacent to each other may be composed of, for example, one pre-assembly outer component 1a'.

[0036] Each pre-assembly outer component 1a' of each outer component group 10a includes a first portion 11' that extends in the first direction D1 and three second portions 12' that protrude from the first portion 11' in the second direction D2 and that are arranged at intervals in the first direction D1.

[0037] In an example shown in Fig. 3A, the length in the second direction D2 of one of two second portions 12' that are disposed on outer sides and that are part of the three second portions 12' of the pre-assembly outer component 1a', which are arranged in the first direction D1, is smaller than the length in the second direction D2 of the other two second portions 12' having the same length as each other. Hereinafter, for the sake of convenience of description, the second portion 12' (the above-described one second portion 12') that is short in the second direction D2 and that is one of the two second portions 12' which are disposed on the outer sides and are part of the three second portions 12' will be referred to as a "second portion 12a" and the other of the two second portions 12' will be referred to as a "second portion 12b". In addition, the second portion 12' disposed between the second portion 12a and the second portion 12b will be referred to as a "second portion 12c". Therefore, the length of the second portion 12b in the second direction D2 and the length of the second portion 12c in the second direction D2 are the same as each other.

[0038] The second portion 12a of each pre-assembly outer component 1a' of one outer component group 10a is disposed in the workpiece W such that the second portion 12a engages with the second portion 12a of the pre-assembly outer component 1a' of another outer component group 10a adjacent to the one outer component group 10a. The expression "engagement" used herein means a state in which the second portion 12a of the pre-assembly outer component 1a' of the other outer component group 10a is disposed in the workpiece W such that the second portion 12a is fitted into a space between the second portion 12a and the second portion 12c of the pre-assembly outer component 1a' of the one outer component group 10a without a gap. Note that the second portion 12a of the pre-assembly outer component 1a' disposed at one end of the one outer component group 10a in the above-described one direction may be disposed in the workpiece W such that the second portion 12a does not engage with the second portion 12a of the pre-assembly outer component 1a' of the other outer component group 10a adjacent to the one outer component group 10a, for example.

[0039] At the same time, the second portion 12b of the pre-assembly outer component 1a' of the one outer component group 10a is disposed in the workpiece W such that the second portion 12a engages with the second portion 12b of the pre-assembly outer component 1a' of the other outer component group 10a adjacent to the one outer component group 10a. The expression "engagement" used herein means a state in which the second portion 12b of the pre-assembly outer component 1a' of the other outer component group 10a is disposed in the workpiece W such that the second portion 12b is fitted into a space between the second portion 12b and the second portion 12c of the pre-assembly outer component 1a' of the one outer component group 10a without a gap. Note that the second portion 12b of the pre-assembly outer component 1a' disposed at the one end of the one outer component group 10a in the above-described one direction may be disposed in the workpiece W such that the second portion 12b does not engage with the second portion 12b of the pre-assembly outer component 1a' of the other outer component group 10a adjacent to the one outer component group 10a, for example.

[0040] At this time, the second portion 12c of one of two pre-assembly outer components 1a' of the one outer component group 10a that are adjacent to each other in one direction is integrally connected, in the first direction D1, to an edge in the first direction D1 of the first portion 11' of the other pre-assembly outer component 1a'. In Fig. 3A, a portion of connection as above is indicated by a dotted line. In addition, at this time, the second portions 12c of the respective pre-assembly outer components 1a' of the outer component groups 10a adjacent to each other are disposed in the workpiece W to come into contact with each other in the second direction D2 without a gap.

[0041] In addition, the following Equation (i) is satisfied, where L is the length of the second portion 12a in the second direction D2, L1 is the width (the length) of the first portion 11' in the second direction D2, and L2 is the length of each of the second portion 12b and the second portion 12c.

$$L \leq L2 - 2 \times L1 \quad (i)$$

[0042] That is, a length L of the second portion 12' (the second portion 12a) that is short and that is one of the two second portions 12' which are positioned on outer sides in the first direction D1 and of which the lengths in the second direction D2 are different from each other is equal to or smaller than a difference between a length L2 of the other second portions 12' (the second portion 12b and the second portion 12c) in the second direction D2 and twice a width L1 (the length) of the first portion 11' in the second direction D2.

[0043] Here, each of L1 and L2 on the right side of the above-described Equation (i) is a fixed value set in advance. That is, the length L can be freely set as long as the length L is equal to or smaller than a length (a constant) corresponding to the difference between L2 and twice L1.

[0044] Note that the above-described Equation (i) is satisfied as an equation in a case where a surplus portion X is not formed. Meanwhile, in a case where the surplus portion X is formed, the above-described Equation (i) is satisfied as an inequality of which the left side is smaller than the right side by a dimension of the surplus portion X in the second direction D2.

[0045] In a case where such a dimensional condition is satisfied, the surplus portion X is formed between the first portion 11' of the pre-assembly outer component 1a' of one outer component group 10a and the first portion 11' of the pre-assembly outer component 1a' of another outer component group 10a.

[0046] Note that the length of the second portion 12c in the first direction D1 is, for example, approximately two times the lengths of the second portion 12a and the second portion 12b in the first direction D1.

[0047] The outer component group 10a formed as the result of die-cutting becomes a plurality of the outer components 1a by being divided for each of the pre-assembly outer components 1a'. Specifically, the outer component group 10a becomes the plurality of outer components 1a by being cut along a dotted line in Fig. 3A.

[0048] Furthermore, the surplus portion X formed as the result of the die-cutting can be used as the fin forming portions 13 described above. Note that a dimension of the fin forming portions 13 in the second direction D2 can be adjusted by changing the width L1 of the first portion 11' in the second direction D2 or the length L of the second portion 12a in the second direction D2. Therefore, the length of the fin forming portions 13 in the second direction D2 can be easily adjusted.

[0049] In addition, according to the above-described configuration, the second portions 12 that are short and each of which is one of the second portions 12 of the outer component 1a are disposed in the workpiece W in a state of engaging with each other. Accordingly, formation of a wasteful portion at the time of die-cutting can be suppressed. In addition, since the surplus portion X formed between two first portions 11 that are adjacent to each other can be used as the fin forming portions 13, further improvement in yield can be achieved.

[0050] In addition, in the case of the above-described die-cut shape, the plurality of outer components 1a having the same shape as each other can be formed from the workpiece W. That is, the workpiece W is die-cut such that the second portions 12, each of which is one second portion 12 of each of the plurality of outer components 1a having the same shape, engage with each other and a plurality of pairs of outer components 1a are formed. Therefore, further improvement in yield can be achieved.

[0051] In addition, for example, a shape as shown in Fig. 3B can also be adopted as a modification example at the time of die-cutting with respect to the workpiece W (a base material) having a plate-like shape. The length in the second direction D2 of the second portion 12c of the pre-assembly outer component 1a' in a modification example shown in Fig. 3B is different from that of the pre-assembly outer component 1a' shown in Fig. 3A. Specifically, the length in the second direction D2 of the second portion 12c shown in Fig. 3B is smaller than the length in the second direction D2 of the second portion 12c shown in Fig. 3A and is larger than the length in the second direction D2 of the second portion 12a. That is, lengths of protrusion from the first portion 11' in the second direction D2 of the three second portions 12' of the pre-assembly outer component 1a' change in order of arrangement in the first direction D1 and the lengths in the second direction D2 of the second portions 12' descend in the order of the second portion 12b, the second portion 12c, and the second portion 12a. Hereinafter, regarding a configuration common to the configuration described with reference to Fig. 3A, the same reference numerals are given in the drawings and the description thereof will be omitted.

[0052] As shown in Fig. 3B, L' is the length of the second portion 12a in the second direction D2, L1' is the width (the length) of the first portion 11' in the second direction D2, and L2' is the length of the second portion 12c. At this time, L' and L2' satisfy the following Equation (ii) in relation to L1' and L3.

$$2 \times L2' - L' \geq 2 \times L1' + L3 \quad (ii)$$

[0053] Here, each of L1' and L3 on the right side of the above-described Equation (ii) is a fixed value set in advance. That is, a length corresponding to a difference between twice L2' and L' can be freely set as long as the length is equal to or larger than a length (a constant) corresponding to the sum of twice L1' and L3.

[0054] Note that the above-described Equation (ii) is satisfied as an equation in a case where the surplus portion X is not formed. Meanwhile, in a case where the surplus portion X is formed, the above-described Equation (ii) is satisfied as an inequality of which the left side is larger than the right side by the dimension of the surplus portion X in the second direction D2. In addition, in a case where L3 and L2' are equal to each other (L3 = L2'), $L' \leq L2' - 2 \times L1'$ is satisfied and the above-described Equation (i) is satisfied.

[0055] Even in the case of the above-described configuration described with reference to Fig. 3B, the same action and effect as the action and effect of the configuration described with reference to Fig. 3A can be achieved.

[0056] In addition, a shape as shown in Fig. 4 can also be adopted as a modification example at the time of die-cutting with respect to the workpiece W (a base material) having a plate-like shape. Hereinafter, regarding a configuration common to the configurations described with reference to Figs. 3A and 3B, the same reference numerals are given in the drawings and the description thereof will be omitted.

[0057] The pre-assembly outer component 1a' described with reference to Fig. 4 does not include the second portion 12a which the pre-assembly outer component 1a' described with reference to Figs. 3A and 3B includes. In other words, the length of one second portion 12 (the second portion 12a described with reference to Figs. 3A and 3B) positioned on an outer side is zero.

[0058] The second portion 12b of the pre-assembly outer component 1a' of the one outer component group 10a is disposed in the workpiece W such that the second portion 12b engages with the second portion 12b of the pre-assembly outer component 1a' of the other outer component group 10a adjacent to the one outer component group 10a. In addition, a portion of the first portion 11', which is closer to an outer side than the second portion 12c is and is on a side opposite to the second portion 12b, of the pre-assembly outer component 1a' of the one outer component group 10a and a portion of the first portion 11', which is closer to an outer side than the second portion 12c is and is on a side opposite to the second portion 12b, of the pre-assembly outer component 1a' of the other outer component group 10a adjacent to the one outer component group 10a abut each other in the second direction D2.

[0059] A length L3' of the second portion 12c of each pre-assembly outer component 1a' in the second direction D2 is larger than twice a width L4 (the length) of the first portion 11' in the second direction D2. In a case where such a dimensional condition is satisfied, the surplus portion X is formed between the pre-assembly outer component 1a' of one outer component group 10a and the pre-assembly outer component 1a' of another outer component group 10a.

[0060] Even in the case of the above-described configuration described with reference to Fig. 4, the same action and effect as the action and effect of the configuration described with reference to Figs. 3A and 3B can be achieved. In addition, since the pre-assembly outer component 1a' does not include the second portion 12a, the surplus portion X corresponding to the length of the second portion 12a in the second direction D2 can be secured unlike the configuration described with reference to Figs. 3A and 3B. That is, since one second portion 12 of which the length is zero and another second portion 12 of which the length is zero are disposed in a state of facing each other, the size of the surplus portion X formed between two adjacent first portions 11 can be maximized. That is, the fin forming portions 13 can be maximized in a case where the surplus portion X is used as the fin forming portions 13.

[0061] In addition, by using the above-described pre-assembly outer component 1a' described with reference to Figs. 3A, 3B, and 4, it is possible to configure the reactor 100 which will be described below with reference to Fig. 5.

[0062] In Fig. 5, a case where the pre-assembly outer component 1a' described with reference to Fig. 3B is used to configure the reactor 100 will be described as an example.

[0063] As shown in Fig. 5, the reactor 100 includes the core 1 and the two coils (the first coil 51 and the second coil 52).

(Configuration of Core)

[0064] As with the above-described embodiment, the core 1 is formed by laminating a plurality of plate-shaped electromagnetic steel plates 90 for a reactor in the thickness direction. The electromagnetic steel plate 90 for a reactor includes the pair of outer components 1a and the central component 1b. The outer component 1a is acquired by separating the plurality of pre-assembly outer components 1a' from each other, the pre-assembly outer components 1a' constituting the outer component group 10a described with reference to Fig. 3B.

[0065] The outer component 1a includes the first portion 11 that extends in the first direction D1, the three second portions 12 that protrude from a long side of the first portion 11 in the second direction D2, and the fin forming portions 13 that are provided at an edge of the first portion 11 on a side opposite to the second portions 12. The first portion 11 mentioned herein corresponds to the first portion 11' described with reference to Fig. 3B and the second portions 12 correspond to the second portions 12' described with reference to Fig. 3B.

[0066] The pair of outer components 1a having such a shape is provided such that the outer components 1a are point-symmetrical with respect to the first direction D1.

[0067] The central component 1b includes a third portion 23 that extends in the first direction D1 and two protrusion portions 24 protruding from both end portions of the third portion 23 in the first direction D1 to be separated from each other in the second direction D2.

[0068] The third portion 23 connects, to each other, an end portion of the second portion 12 (the second portion 12b) that is positioned on an outer side in the first direction D1 and is one of the three second portions 12 of one outer component 1a and an end portion of the second portion 12 (the second portion 12b) that is positioned on an outer side in the first direction D1 and is one of the three second portions 12 of another outer component 1a.

[0069] The length of protrusion of the protrusion portions 24 in the second direction D2 is equal to a length obtained by subtracting the length of the second portion 12 (the second portion 12a) that is short in the second direction D2 and that is one of the second portions positioned on outer sides in the first direction D1 from the length of the second portion 12 (the second portion 12b) that is long in the second direction D2 and that is one of the second portions positioned on the outer sides in the first direction D1. The protrusion portions 24 are in contact with the second portions 12 (the second portions 12a) in the second direction D2.

(Configuration of Coil)

[0070] Each of the first coil 51 and the second coil 52 is formed by winding, a plurality of times, a wire around the second portion 12 that is disposed at the center in the first direction D1. That is, the reactor 100 includes two independent coils. As a method of winding the wire, it is possible to adopt various methods proposed so far.

[0071] At this time, gaps S (air gaps) are formed between the first coil 51, the second coil 52, and the third portion 23 of the central component 1b.

[0072] In addition, since the length of protrusion of the protrusion portions 24 of the central component 1b in the second direction D2 satisfies the above-described dimensional condition and the protrusion portions 24 abut the second portions 12 (the second portions 12a) in the second direction D2, the gap S is formed between the third portion of the central component 1b and the second portion 12 (the second portion 12c) that is disposed at the center and that is one of the three second portions 12 of the outer component 1a.

(About Die-Cut Shape of Central Component)

[0073] Next, a die-cut shape of the central component 1b will be described with reference to Fig. 6. At the time of die-cutting, components are die-cut out of the workpiece W by using a die (a blade) having a shape represented by solid lines in Fig. 6.

[0074] As shown in Fig. 6, a plurality of pre-assembly central components 1b' disposed in the workpiece W are disposed in the workpiece W such that third portions 23' and protrusion portions 24' extending from the third portion 23' are arranged without a gap in a state of facing each other in one direction and forming sets. Furthermore, a plurality of sets of the pre-assembly central components 1b', each of which is composed of the plurality of pre-assembly central components 1b', are disposed in the workpiece W to be continuously spread in a direction intersecting the one direction. Accordingly, the plurality of pre-assembly central components 1b' are die-cut out of the workpiece W and each of the pre-assembly central components 1b' becomes the central component 1b.

[0075] Here, an example (an arrow A) of a direction in which magnetic fluxes generated in the vicinity of the first coil 51 and the second coil 52 flow in a case where the reactor 100 is driven is shown in Fig. 5.

[0076] Since the coils (the first coil 51 and the second coil 52) are wound around the second portions 12 (the second portions 12c) positioned at the center in the first direction D1, the amount of loss generated is doubled in comparison with the configuration of a normal EI core in which one coil is mounted on one core 1. However, since the surface area of the core 1 is, for example, smaller than twice the surface area of the normal EI core, the ratio of the surface area of the core 1 per unit heat generation amount is smaller than that of the normal EI core and thus the temperature of the core 1 may be made higher. Specifically, for example, the surface area of the core 1 does not exceed 1360 of the surface area of the normal EI core, and at this time, the ratio of the surface area of the core 1 per unit heat generation amount is 68.2% of that of the normal EI core.

[0077] Note that the expression "normal EI core" used herein means a case where the electromagnetic steel plate 90 includes one outer component 1a and one central component 1b, the lengths of two second portions 12 (the second portion 12a and the second portion 12b) of the outer component 1a that are positioned on outer sides in the first direction D1 are equal to each other, and the central component 1b includes the third portion 23 only.

[0078] According to the above-described configuration, since the gap S serving as an air gap is formed between the second portion 12c and the third portion 23, the flow of a magnetic flux is dampened by the gap S and the amount of heat generation at the center of a space between the second portion 12c and the third portion 23 is suppressed.

[0079] Meanwhile, since no gap S is formed at the first portion 11, no magnetic flux is dampened and the first portion 11 is likely to generate heat as a result of an increase in core loss. According to the above-described configuration, since the fin forming portions 13 for heat dissipation is provided at the first portion 11, heat at the first portion 11 is dissipated via the fin forming portions 13. As a result, heat is less likely to remain at the first portion 11.

[0080] Therefore, heat remaining at the core 1 can be suppressed and the temperature of the entire core 1 can be made uniform.

[0081] In addition, since the above-described gaps S are formed, the first coil 51 and the second coil 52 can be cooled by air present in the gaps S. Therefore, an increase in temperature of the core 1 can be suppressed.

[0082] In addition, according to the above-described configuration, in a case where the central components 1b are to be die-cut, the central components 1b can be die-cut out of the workpiece W with no gap formed between the central components 1b. Therefore, improvement in yield can be achieved at the time of formation of the central components 1b.

[0083] Note that the pre-assembly outer components 1a' described with reference to Figs. 3A and 4 may also be used to configure the reactor 100.

[Appendix]

[0084] For example, the reactor 100 described in the embodiment is understood as follows.

[0085]

(1) The reactor 100 according to a first aspect includes the core 1 that is composed of the plurality of electromagnetic steel plates 90 laminated in the thickness direction and the coil (the first coil 51 and the second coil 52) that is composed of a wire wound around the core 1. Each electromagnetic steel plate 90 includes the pair of outer components 1a each of which includes the first portion 11 that extends in the first direction D1 and the plurality of second portions 12 that extend from the first portion 11 in the second direction D2 orthogonal to the first direction D1 and that are arranged at intervals in the first direction D1, the central component 1b that connects the second portions 12 to each other in the first direction D1 in a state where the plurality of second portions 12 face each other in the second direction D2, and the plurality of fin forming portions 13 that protrude in the second direction D2 from an edge of each first portion 11 on a side opposite to the second portions 12 and that are arranged at intervals in the first direction D1.

[0086] According to the above-described configuration, since the fin forming portions 13 are formed at the first portion 11, the fin forming portions 13 form a plurality of the fins 14 in a case where the plurality of electromagnetic steel plates 90 are laminated. As a result, heat generated by the core 1 can be released to the outside.

[0087] (2) The reactor 100 according to the second aspect is the reactor 100 of (1) in which a dimension in the second direction D2 of the second portion 12 that is part of the plurality of second portions 12 and that is positioned at a center in the first direction D1 may be smaller than dimensions in the second direction D2 of the other second portions 12.

[0088] According to the above-described configuration, an air gap can be formed between the second portion 12 positioned at the center and the central component 1b facing the second portion 12. In addition, although heat generation is likely to become excessive at the root (that is, a connecting portion connected to the first portion 11) of the second portion 12 positioned at the center, the heat can be efficiently released to the outside since the fin forming portions 13 are provided at the first portion 11.

[0089] (3) The reactor 100 according to the third aspect is the reactor 100 of (1) or (2) in which a dimension of the central component 1b in the first direction D1 may be two times a dimension of the second portion 12 in the second direction D2.

[0090] According to the above-described configuration, it is possible to improve the yield of a plate material which is a material used in a case where the central component 1b and the outer components 1a are formed through die-cutting. That is, a wasteful portion can be reduced. Specifically, a region that is formed between the second portions 12 can be used as the central component 1b with little waste in a case where die-cutting is performed in a state where a pair of the outer components 1a is combined with each other such that the second portions 12 thereof face each other.

[0091] (4) The reactor 100 according to a fourth aspect is the reactor 100 according to any one of (1) to (3) in which a dimension of the central component 1b in the second direction D2 may be equal to a dimension by which the second portions 12 are separated from each other in the first direction D1.

[0092] According to the above-described configuration, a region that is formed between the second portions 12 can be used as the central component 1b with less waste in a case where die-cutting is performed in a state where a pair of the outer components 1a is combined with each other such that the second portions 12 thereof face each other.

[0093] (5) The reactor 100 according to a fifth aspect is the reactor 100 according to any one of (1) to (4) in which positions in the first direction D1 of the fin forming portions 13 of one of the pair of outer components 1a may be different from positions in the first direction D1 of the fin forming portions 13 of the other of the pair of outer components 1a and the fin forming portions 13 may have shapes that engage with each other in a case where the fin forming portions 13 are caused to face each other in the second direction D2.

[0094] According to the above-described configuration, since the fin forming portions 13 engage with each other in a case where die-cutting is performed in a state where the outer components 1a are continuously arranged in the second direction D2, a wasteful portion formed as a result of the die-cutting is reduced and thus improvement in yield can be achieved.

[0095] (6) The reactor 100 according to a sixth aspect is the reactor 100 of (1) in which a plurality of pairs of the outer components 1a may be formed in a case where the workpiece W is die-cut such that the second portions 12 of the plurality of outer components 1a having the same shape as each other engage with each other, each outer component 1a may include three second portions 12, and a length of one second portion 12 that is short and that is one of two second portions 12 which are positioned on outer sides in the first direction D1 and of which lengths in the second direction D2 are different from each other may be smaller than a difference between a length of the other second portions 12 in the second direction D2 and twice a width of the first portion 11 in the second direction D2.

[0096] According to the above-described configuration, the second portions 12 that are short and each of which is one of the second portions 12 of the outer component 1a are disposed in a state of engaging with each other. Accordingly, formation of a wasteful portion at the time of die-cutting can be suppressed. In addition, in a case where such a dimensional condition is satisfied, the surplus portion X is formed between two adjacent first portions 11 in a state where one second portion 12 and another second portion 12 engage with each other. The surplus portion X can be used as the fin forming portions 13.

[0097] (7) The reactor 100 according to a seventh aspect is the reactor 100 of (6) in which lengths of the three second portions 12 in the second direction D2 may change in order of arrangement in the first direction D1, and a difference between twice a length in the second direction D2 of the second portion 12 that is positioned at a center in the first direction D1 and a length in the second direction D2 of the one second portion 12 may be larger than a sum of twice a width in the second direction D2 of the first portion 11 and a length of the second portion 12 that is longest in the second direction D2.

[0098] According to the above configuration, since the gap S (the air gap) is formed between the second portion 12 positioned at the center in the first direction D1 and the central component 1b, heat generation at the second portion 12 and the central component 1b is suppressed.

[0099] (8) The reactor 100 according to an eighth aspect is the reactor 100 of (6) in which a length in the second direction of the one second portion that is part of the plurality of second portions and that is positioned on the outer side in the first direction may be zero.

[0100] According to the above-described configuration, the length of the one second portion 12 is zero, that is, the one second portion 12 has no length. Accordingly, the second portions 12 of which the length is zero are disposed in a state of facing each other and thus formation of a wasteful portion at the time of die-cutting can be suppressed. In addition, the size of the surplus portion X formed between the two first portions 11 adjacent to each other can be maximized. Accordingly, the fin forming portions 13 can be maximized in a case where the surplus portion X is used as the fin forming portions 13.

Industrial Applicability

[0101] According to the present disclosure, it is possible to provide a reactor that can be operated more stably.

Reference Signs List

[0102]

1: core
1a: outer component
1a': pre-assembly outer component
1b: central component
1b': pre-assembly central component
10a: outer component group
11, 11': first portion
12, 12', 12a, 12b, 12c: second portion
13: fin forming portion
14: fin
23, 23': third portion
24, 24': protrusion portion
51: first coil
52: second coil
90: electromagnetic steel plate
100: reactor
D1: first direction

D2: second direction
S: gap
W: workpiece
X: surplus portion

Claims

1. A reactor comprising:

   a core that is composed of a plurality of electromagnetic steel plates laminated in a thickness direction; and
   a coil that is composed of a wire wound around the core,
   wherein each electromagnetic steel plate includes

      a pair of outer components each of which includes a first portion that extends in a first direction and a plurality of second portions that extend from the first portion in a second direction orthogonal to the first direction and that are arranged at intervals in the first direction,
      a central component that connects the second portions to each other in the first direction in a state where the plurality of second portions face each other in the second direction, and
      a plurality of fin forming portions that protrude in the second direction from an edge of each first portion on a side opposite to the second portions and that are arranged at intervals in the first direction.

2. The reactor according to Claim 1,
   wherein a dimension in the second direction of the second portion that is part of the plurality of second portions and that is positioned at a center in the first direction is smaller than dimensions in the second direction of the other second portions.

3. The reactor according to Claim 1 or 2,
   wherein a dimension of the central component in the first direction is two times a dimension of the second portion in the second direction.

4. The reactor according to Claim 1 or 2,
   wherein a dimension of the central component in the second direction is equal to a dimension by which the second portions are separated from each other in the first direction.

5. The reactor according to Claim 1 or 2,

   wherein positions in the first direction of the fin forming portions of one of the pair of outer components are different from positions in the first direction of the fin forming portions of the other of the pair of outer components, and
   the fin forming portions have shapes that engage with each other in a case where the fin forming portions are caused to face each other in the second direction.

6. The reactor according to Claim 1,

   wherein a plurality of the pairs of outer components are formed in a case where a workpiece is die-cut such that the second portions of a plurality of the outer components having the same shape as each other engage with each other,
   each outer component includes three second portions, and
   a length of one second portion that is short and that is one of two second portions which are positioned on outer sides in the first direction and of which lengths in the second direction are different from each other is smaller than a difference between a length of the other second portions in the second direction and twice a width of the first portion in the second direction.

7. The reactor according to Claim 6,

   wherein lengths of the three second portions in the second direction change in order of arrangement in the first direction, and a difference between twice a length in the second direction of the second portion that is positioned at a center in the first direction and a length in the second direction of the one second portion is larger than a sum of twice a width in the second direction of the first portion and a length of the second portion that is longest in the second direction.

8. The reactor according to Claim 6,
wherein a length in the second direction of the one second portion that is part of the plurality of second portions and that is positioned on the outer side in the first direction is zero.

FIG. 1

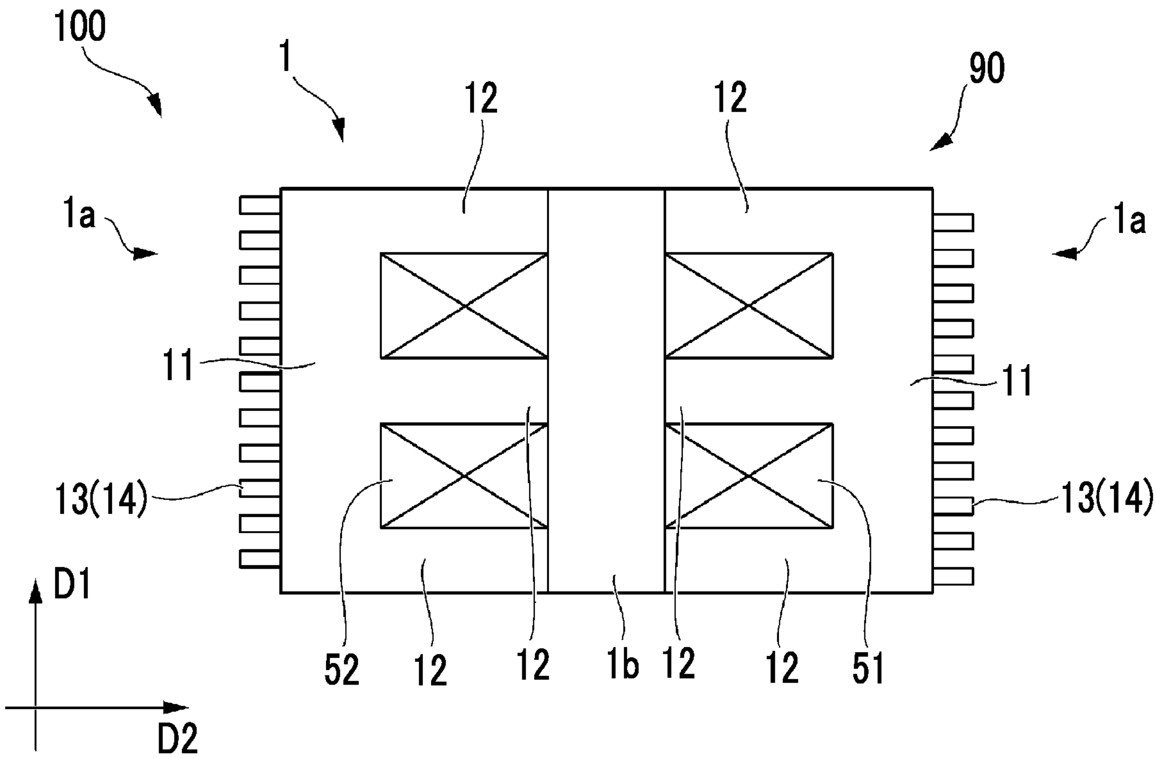

100
1
12
12
90
1a
1a
11
11
13(14)
13(14)
D1
D2
52
12
12
1b
12
12
51

FIG. 2

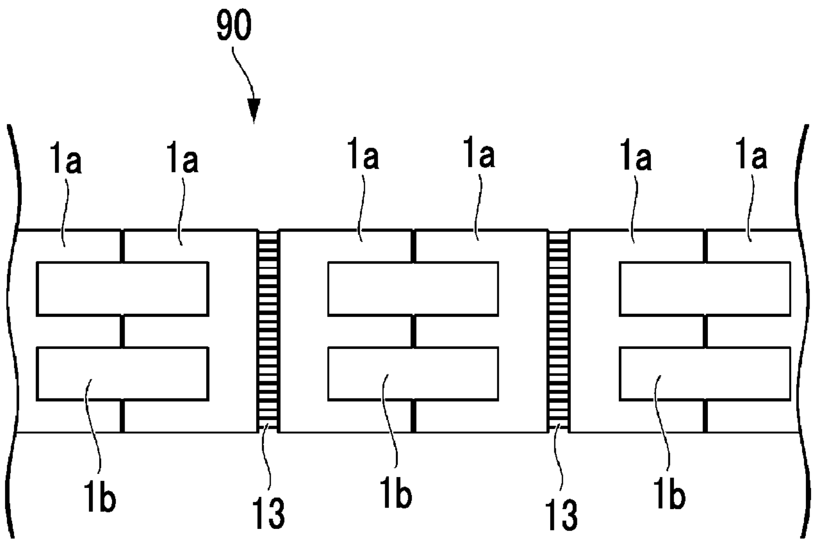
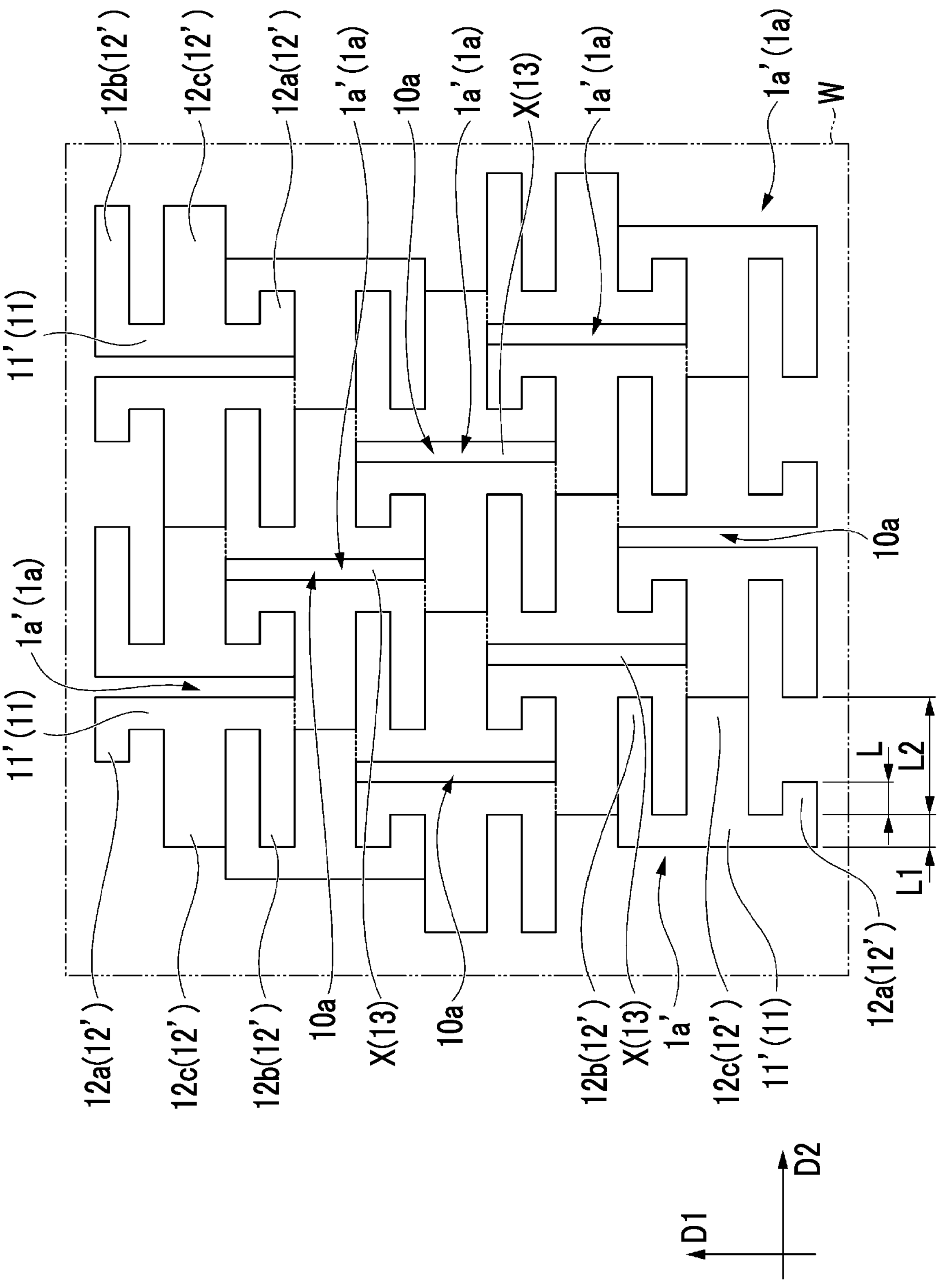

90
1a
1a
1a
1a
1a
1a
1b
13
1b
13
1b

FIG. 3A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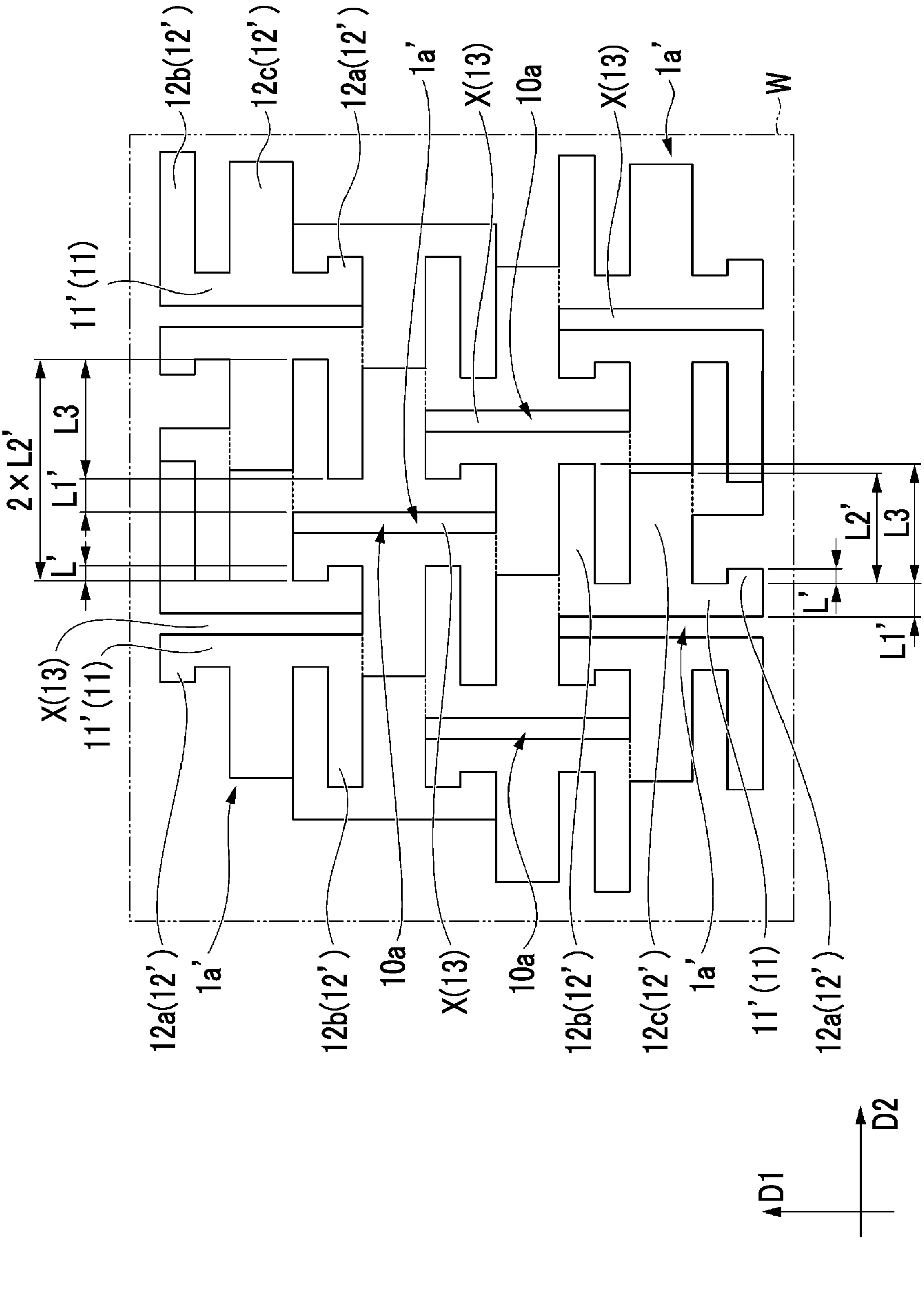
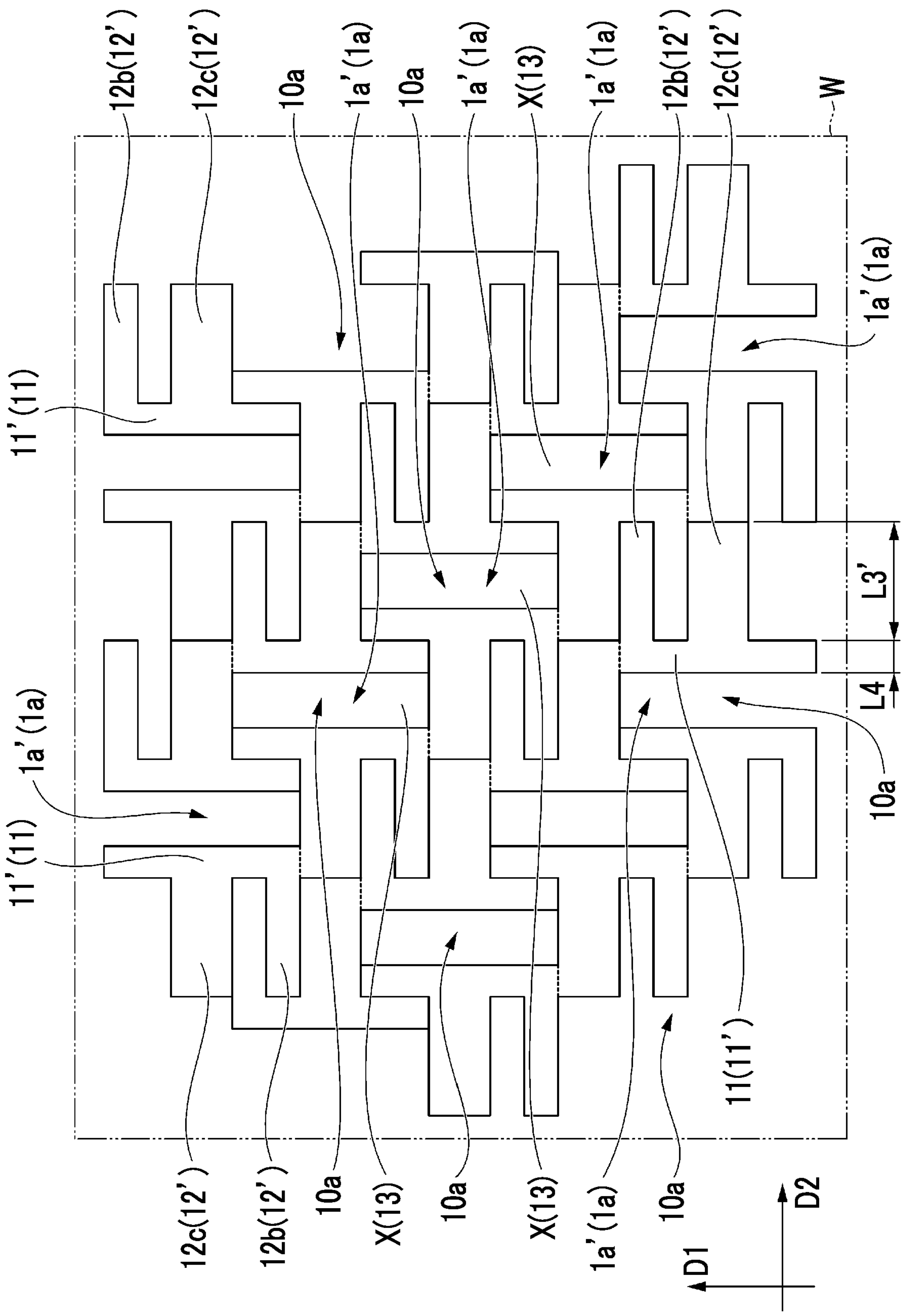
12c(12')
12a(12')
1a'(1a)
10a
1a'(1a)
X(13)
1a'(1a)
1a'(1a)
W
11'(11)
1a'(1a)
11'(11)
10a
L
L2
L1
12a(12')
12c(12')
12b(12')
10a
X(13)
10a
12b(12')
X(13)
1a'
12c(12')
11'(11)
12a(12')
D1
D2

FIG. 3B



12b(12')
12c(12')
12a(12')
1a'
X(13)
10a
X(13)
1a'
W
11'(11)
2×L2'
L3
L1'
L'
X(13)
11'(11)
L2'
L3
L'
L1'
12a(12')
1a'
12b(12')
10a
X(13)
10a
12b(12')
12c(12')
1a'
11'(11)
12a(12')
D1
D2

FIG. 4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12c(12')
10a
1a'(1a)
10a
1a'(1a)
X(13)
1a'(1a)
12b(12')
12c(12')
W
1a'(1a)
11'(11)
1a'(1a)
11'(11)
L3'
L4
10a
12c(12')
12b(12')
10a
X(13)
10a
X(13)
1a'(1a)
10a
11(11')
D1
D2

FIG. 5

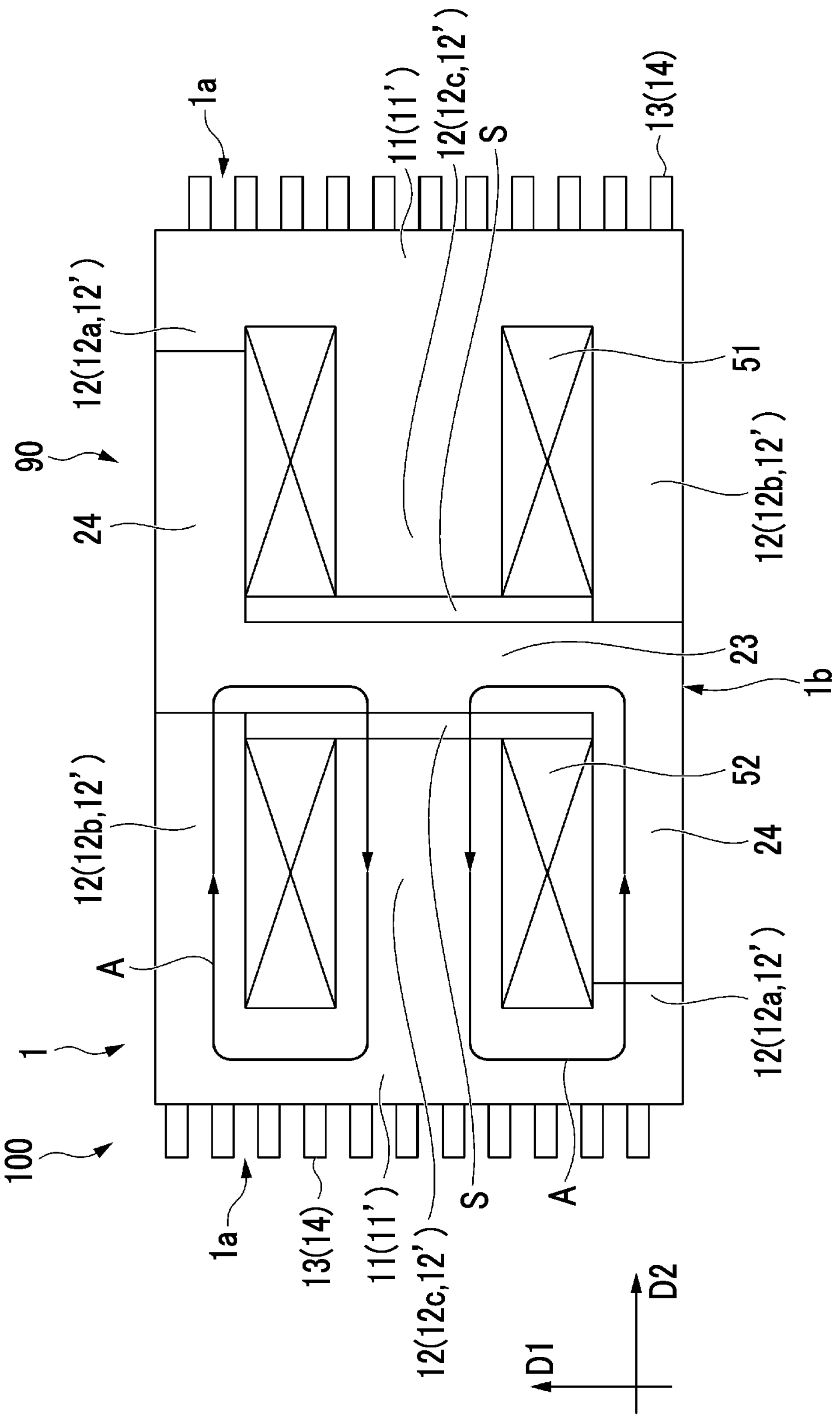
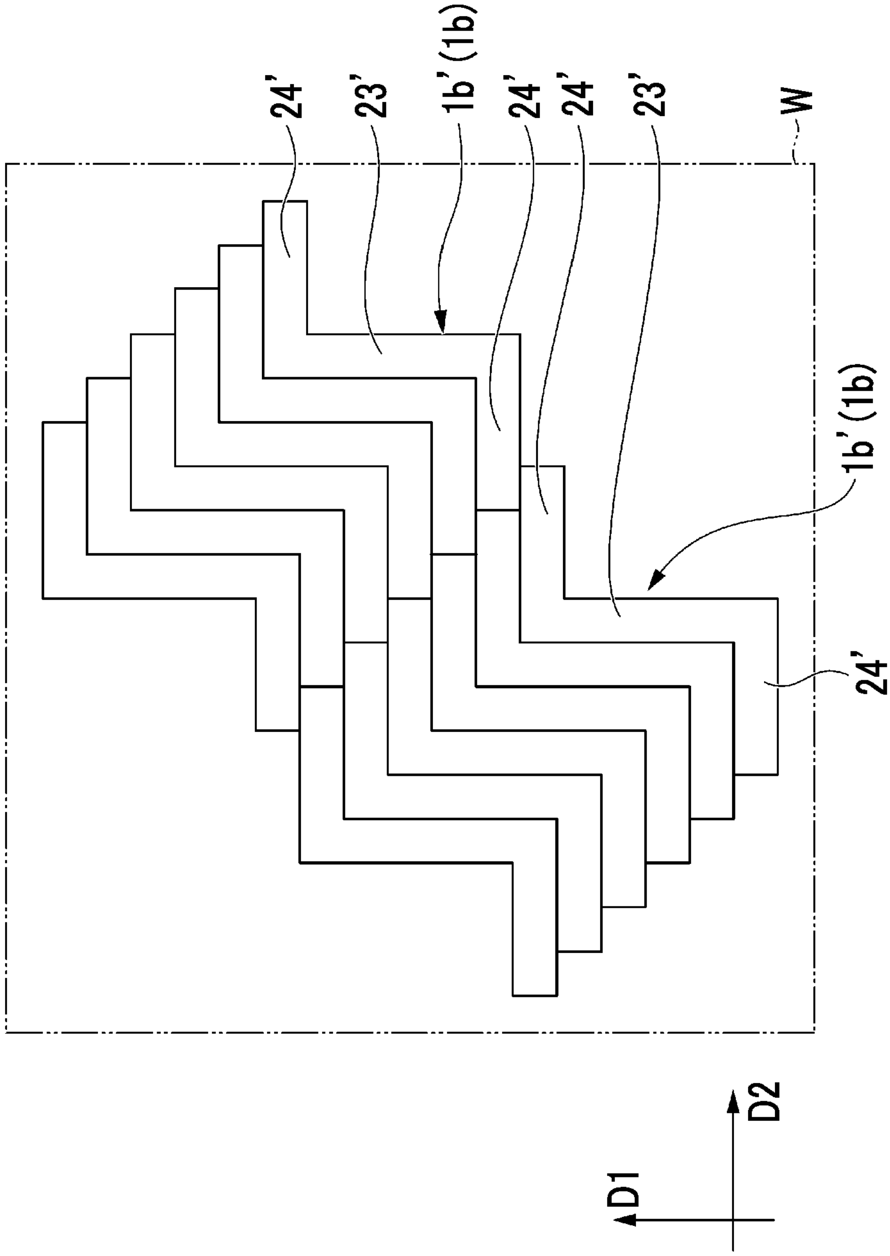

1a
11(11')
12(12c,12')
S
13(14)
12(12a,12')
51
90
24
12(12b,12')
23
1b
52
A
1
100
D1
D2

FIG. 6



INTERNATIONAL SEARCH REPORT

International application No. **PCT/JP2022/036470**

A. CLASSIFICATION OF SUBJECT MATTER

H01F 37/00(2006.01)i; ***H01F 27/24***(2006.01)i; ***H01F 27/245***(2006.01)i; ***H01F 30/10***(2006.01)i
FI: H01F37/00 M; H01F27/24 K; H01F27/245; H01F30/10 S; H01F37/00 A; H01F37/00 R

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01F37/00; H01F27/24; H01F27/245; H01F30/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 56-62306 A (TOKYO SHIBAURA DENKI K.K.) 28 May 1981 (1981-05-28) p. 2, upper left column, lines 1-15	1-5 6-8
Y A	JP 2020-25036 A (KEIHIN CORP.) 13 February 2020 (2020-02-13) paragraphs [0029]-[0038], fig. 3	1-5 6-8
A	JP 2020-43293 A (MITSUBISHI HEAVY IND THERMAL SYSTEMS LTD.) 19 March 2020 (2020-03-19) entire text, all drawings	1-8
A	JP 57-113209 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 14 July 1982 (1982-07-14) entire text, all drawings	1-8
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 171607/1978 (Laid-open No. 95862/1979) (TOKYO DENKI KAGAKU KOGYO K.K.) 06 July 1979 (1979-07-06), entire text, all drawings	1-8

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 December 2022	**20 December 2022**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/036470

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 56-62306 A	28 May 1981	(Family: none)	
JP 2020-25036 A	13 February 2020	(Family: none)	
JP 2020-43293 A	19 March 2020	(Family: none)	
JP 57-113209 A	14 July 1982	(Family: none)	
JP 54-95862 U1	06 July 1979	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2021159131 A **[0002]**
- JP 2013093921 A **[0006]**
- CN 206194495 **[0006]**