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(54) HEAT EXCHANGER

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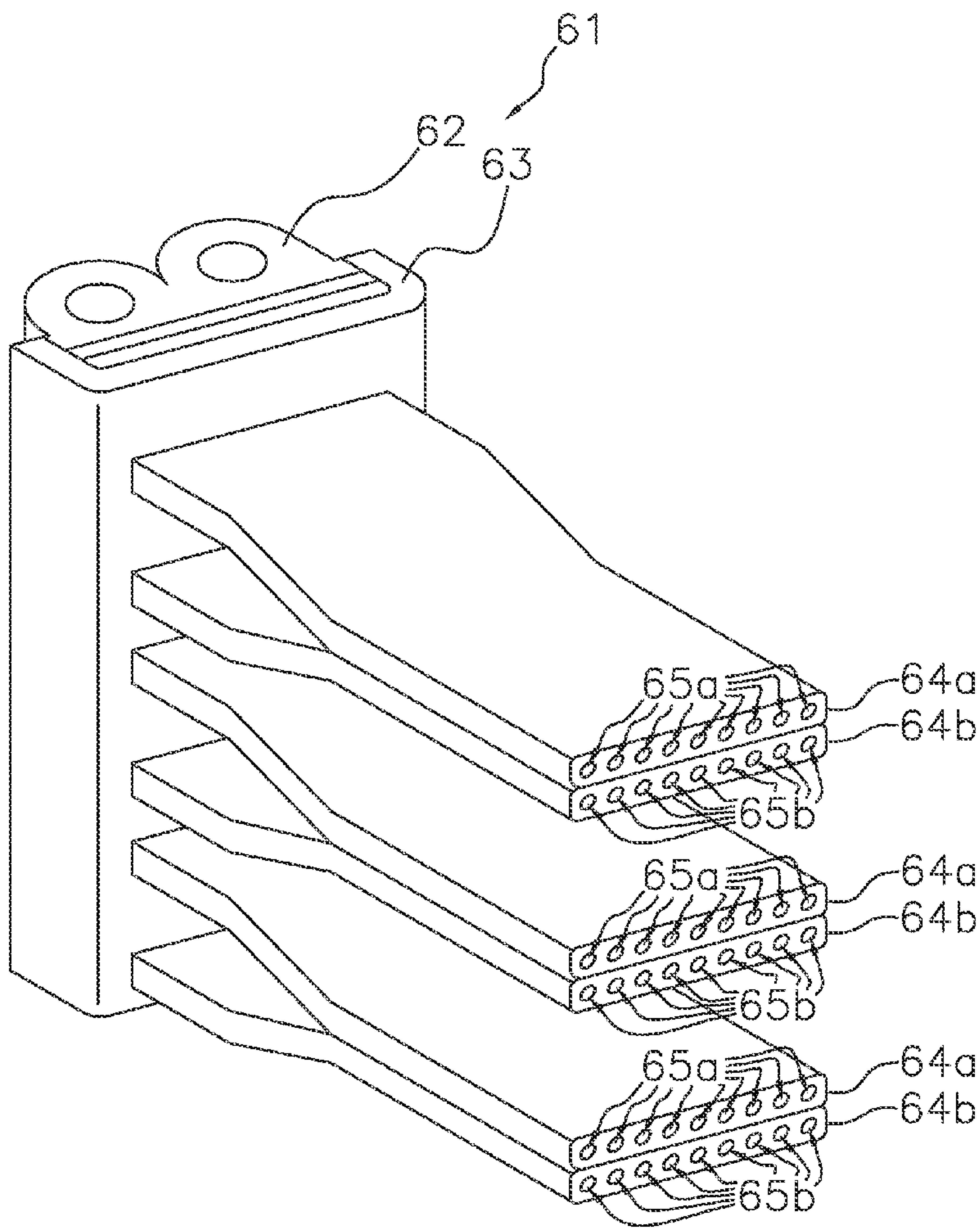
(57) **ABSTRACT**

A heat exchanger includes a header, a first flat porous tube, and a second flat porous tube. The header has first and second primary channels, with first and second refrigerants flowing through the first and second primary channels. The first flat porous tube has a plurality of first refrigerant-channel holes through which the first refrigerant flows. The second flat porous tube has a plurality of second refrigerant-channel holes through which the second refrigerant flows. The header has sub-channel-forming member that forms a first sub-channel and a second sub-channel. The first sub-channel allows the first primary channel to be communicated with the first refrigerant-channel holes. The second sub-channel allows the second primary channel to be communicated with the second refrigerant-channel holes. The first flat porous tube and the second flat porous tube are in close contact to allow heat exchange between the first refrigerant and the second refrigerant.



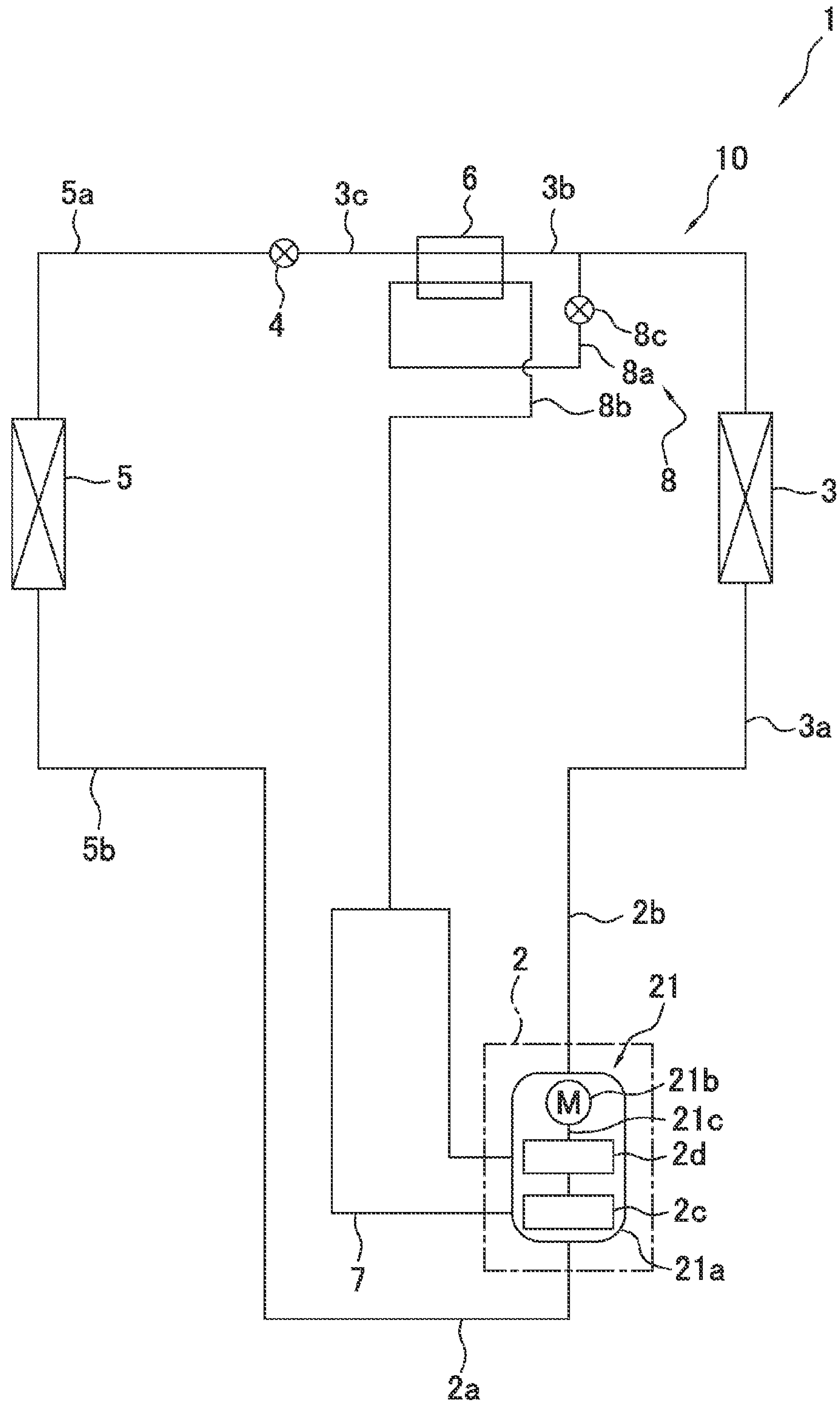



FIG. 1

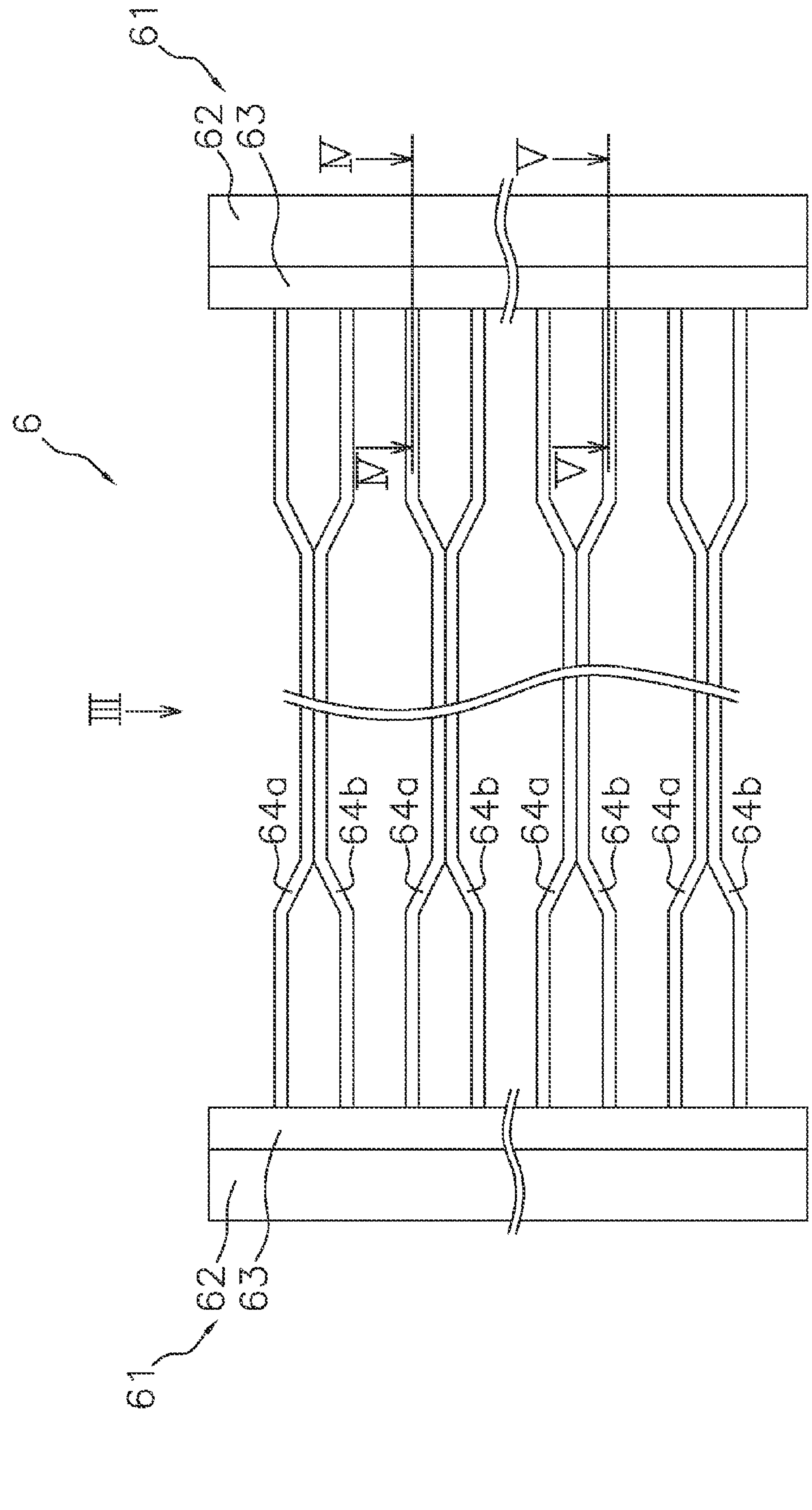



FIG. 2

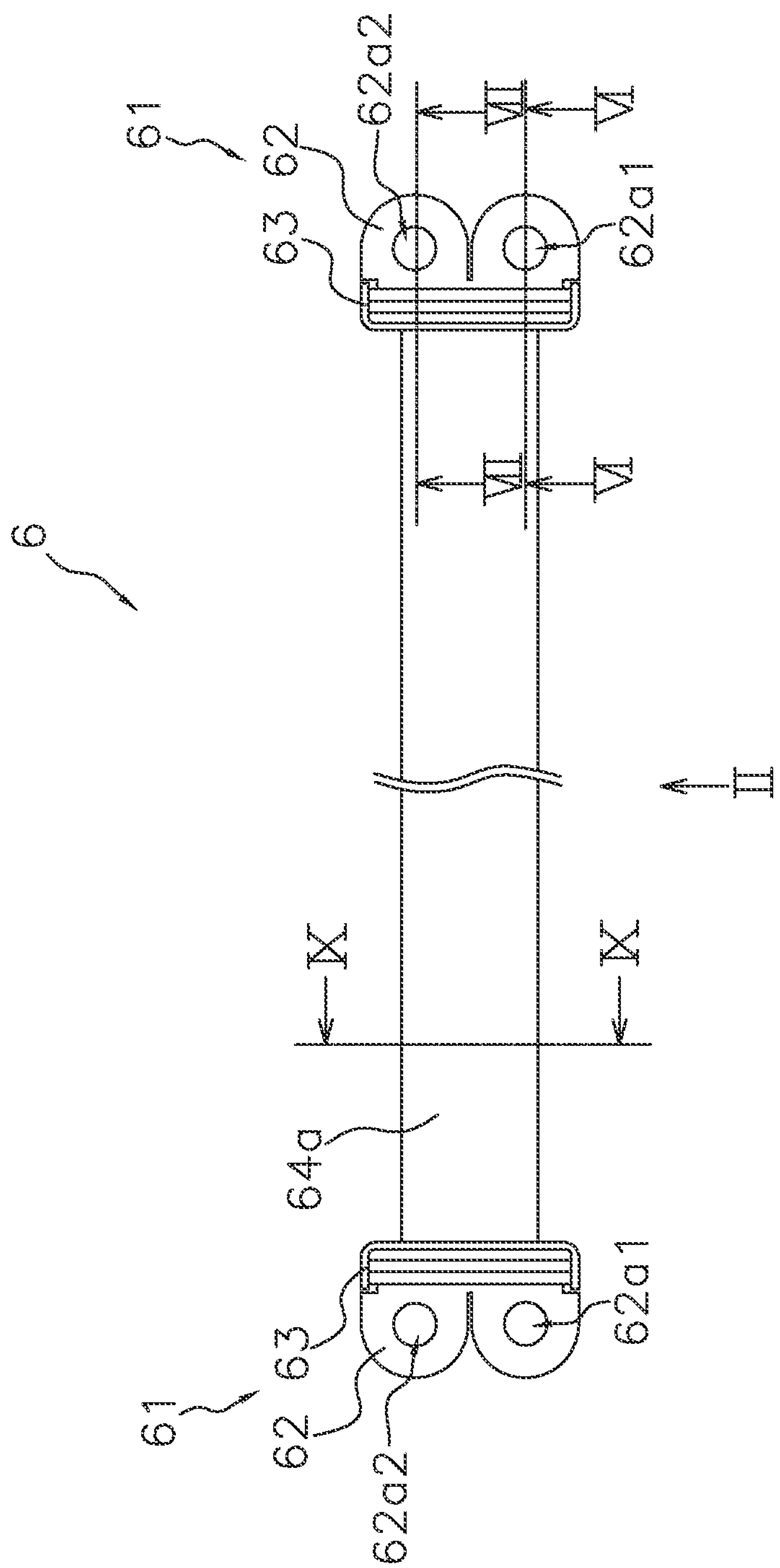
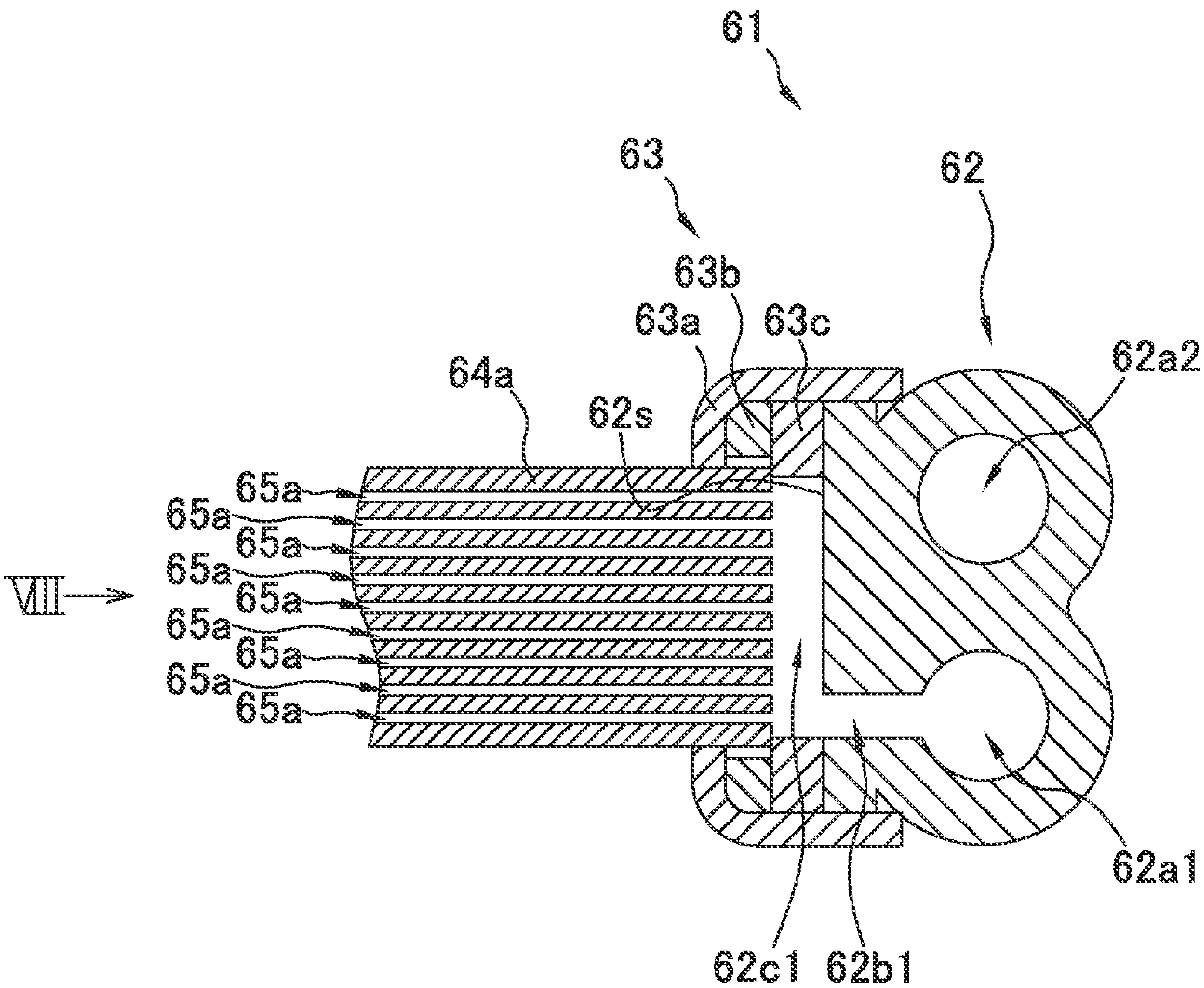



FIG. 3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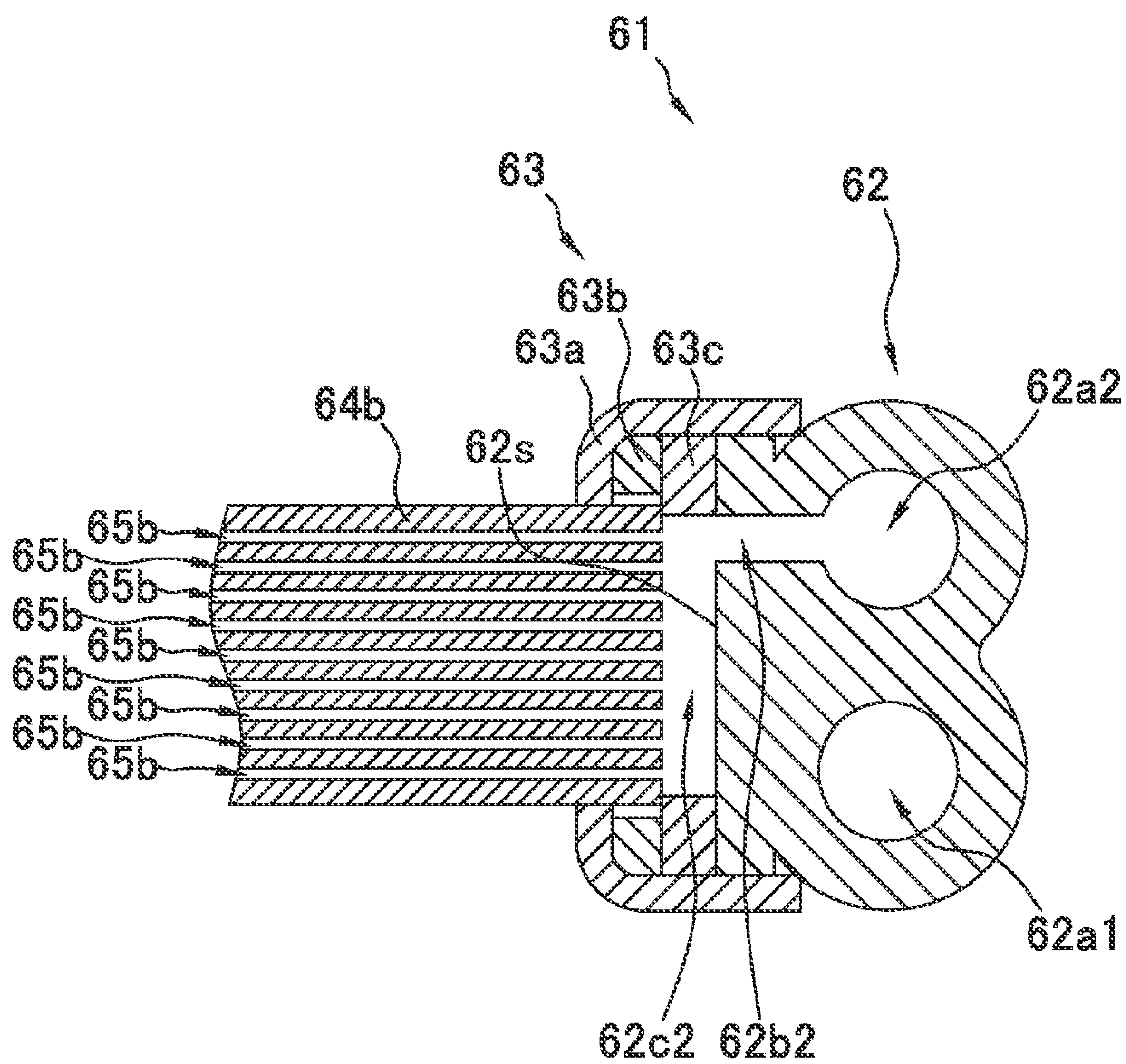
62c1
62b1

FIG. 4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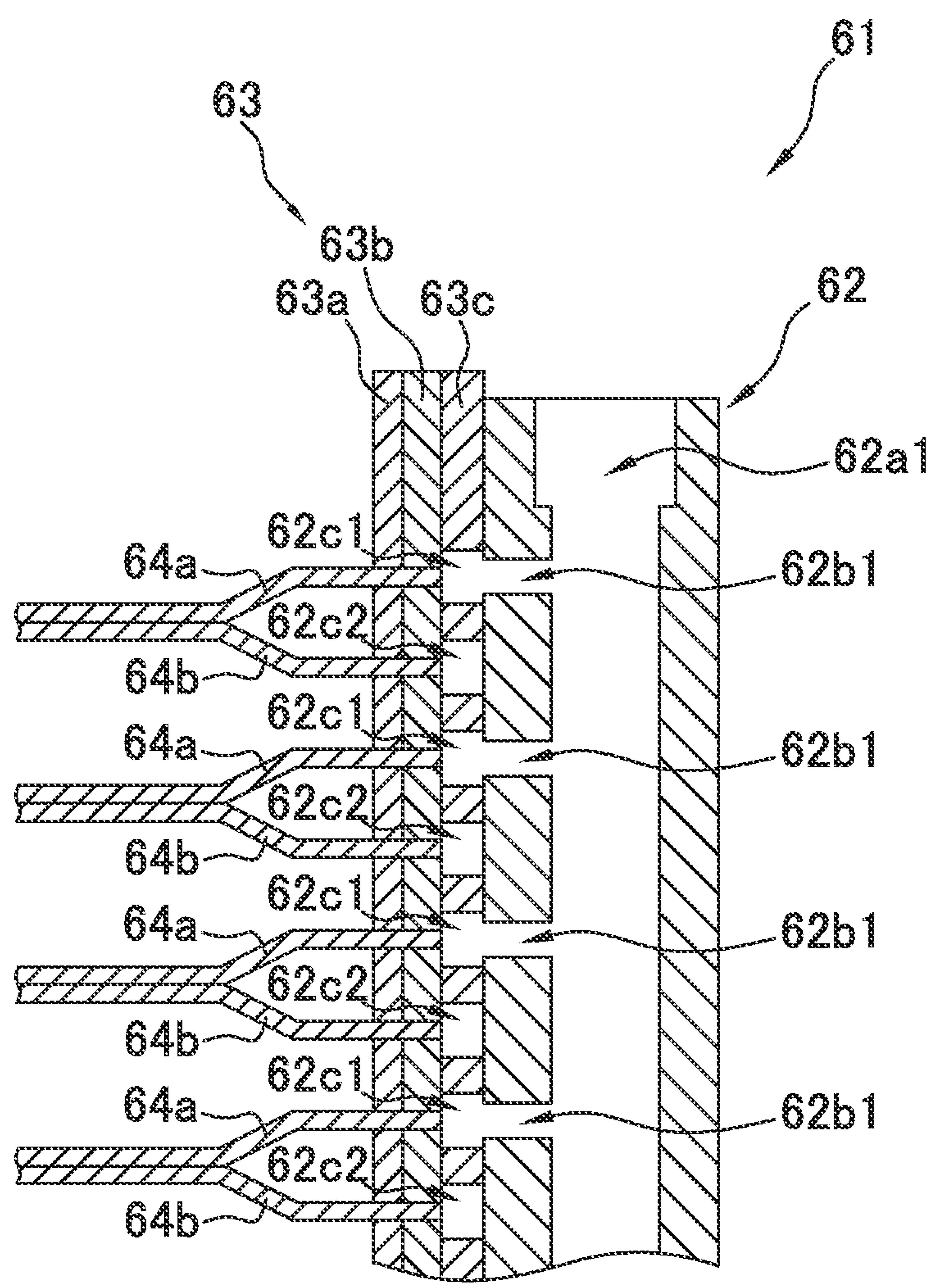
62c2
62b2

FIG. 5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62c2
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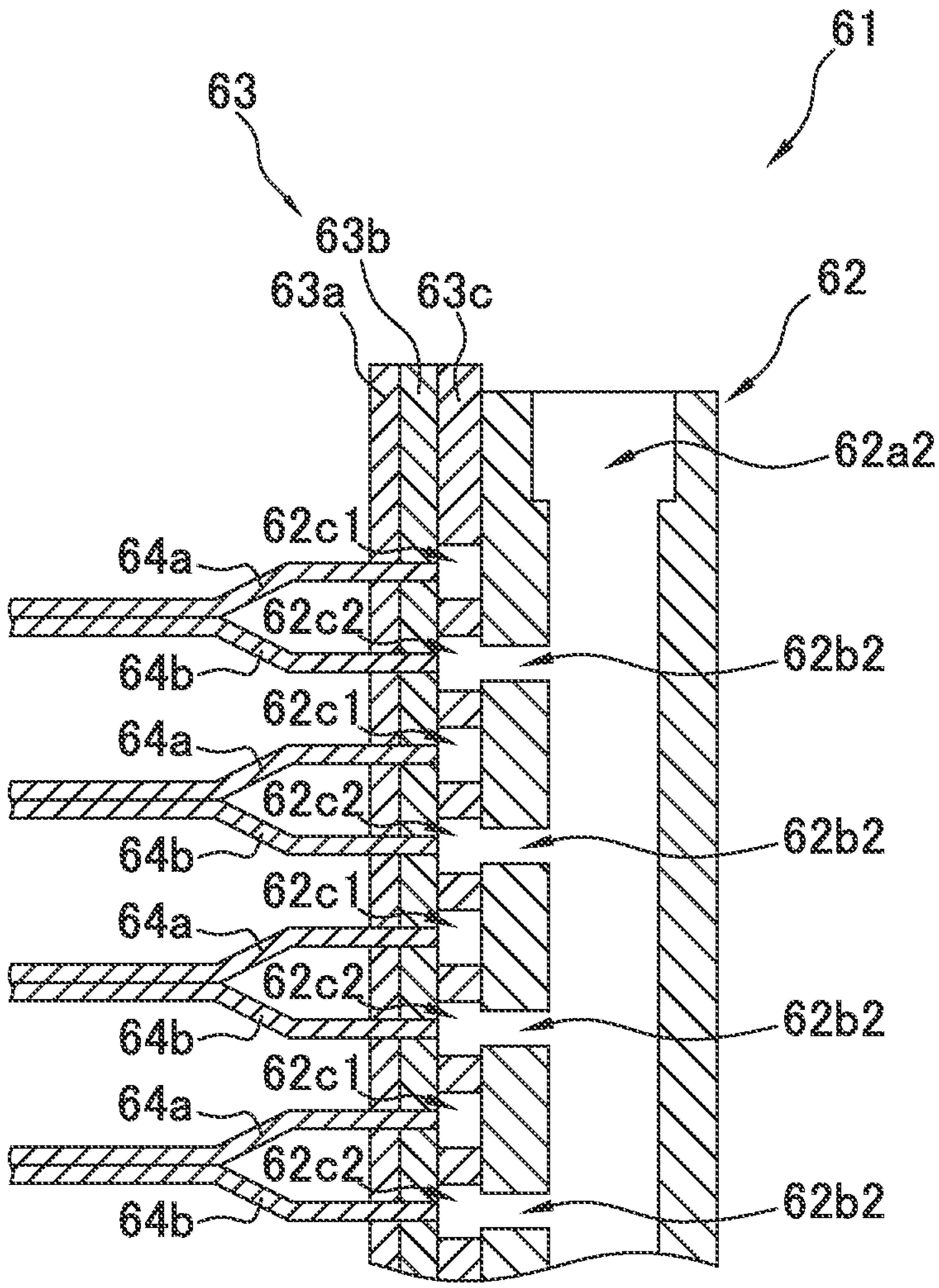
62b1
62c2
64b

FIG. 6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62c2
62b2
64b
62c1
64a
62c2
62b2
64b

FIG. 7

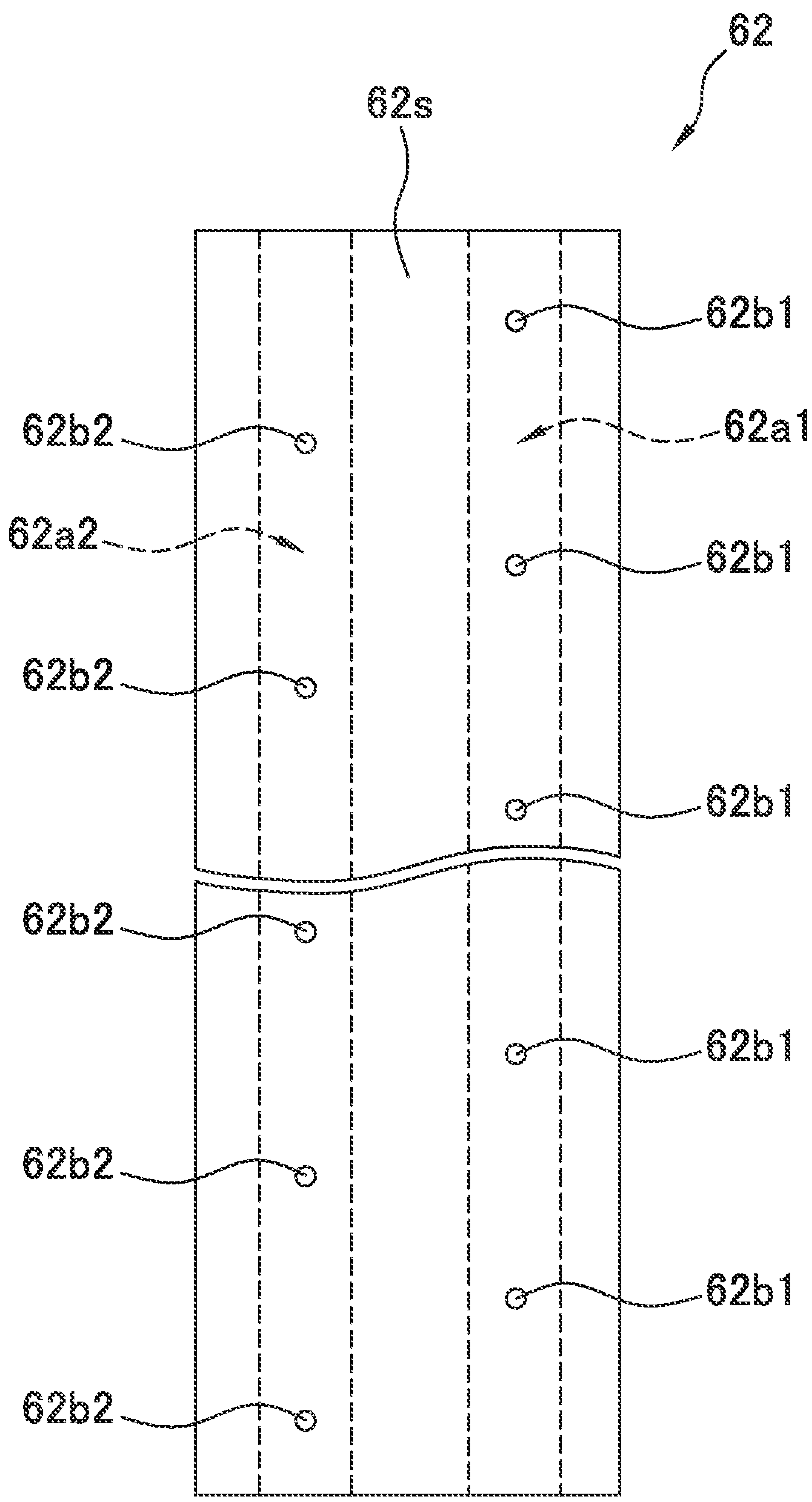

62
62s
62b1
62b2
62a1
62a2
62b1
62b2
62b1
62b2
62b1
62b2
62b1
62b2

FIG. 8

FIG. 9

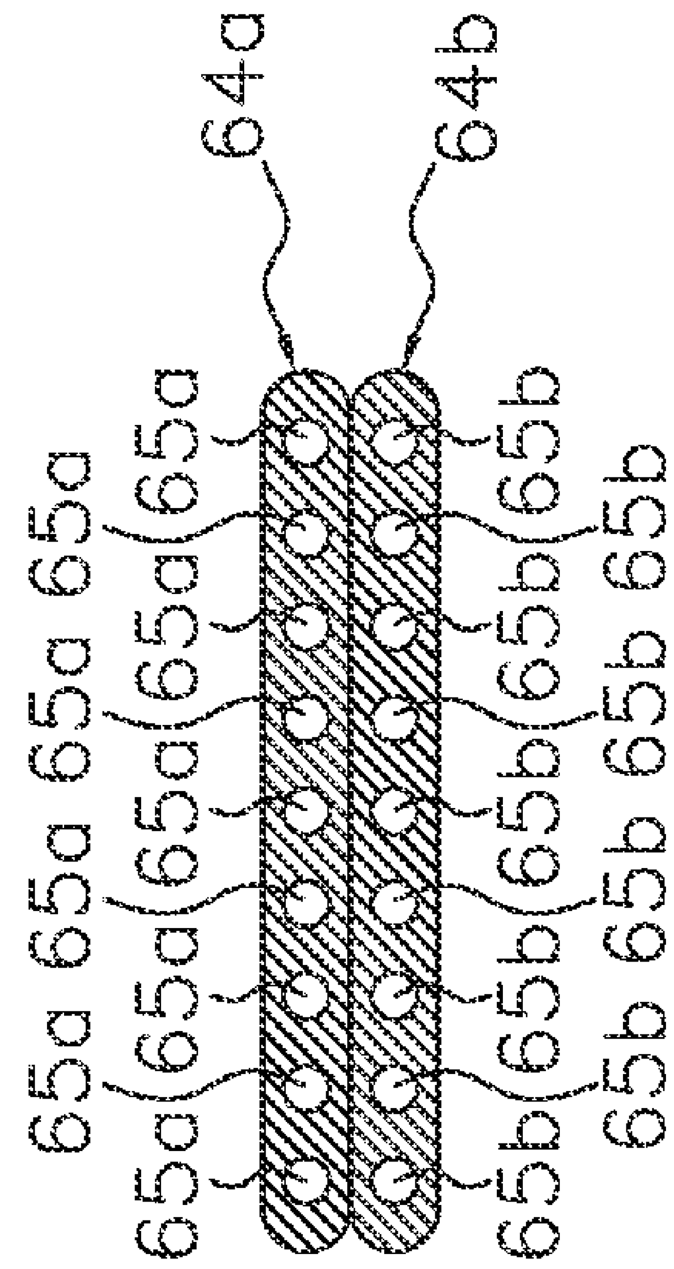



FIG. 10

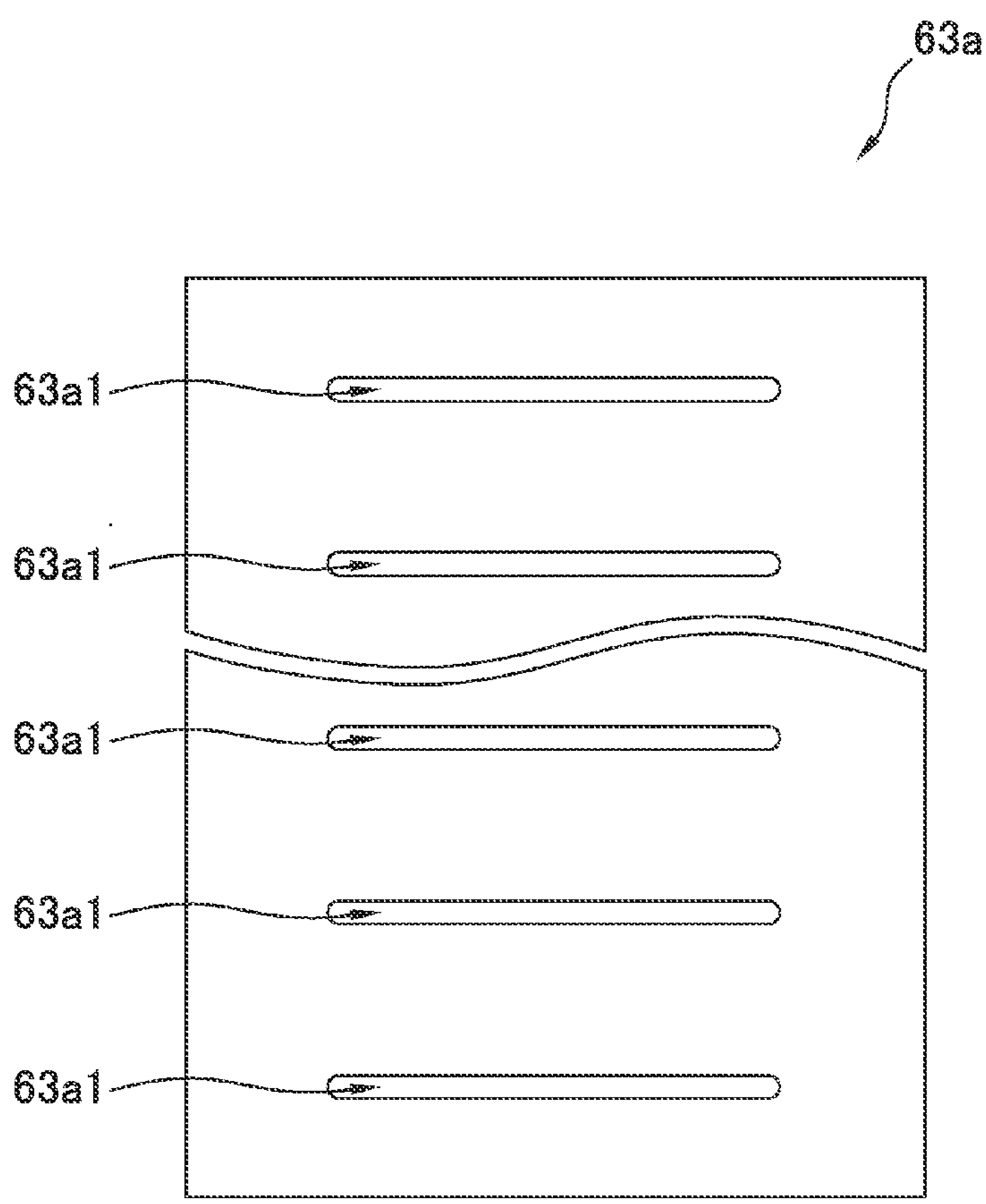


FIG. 11

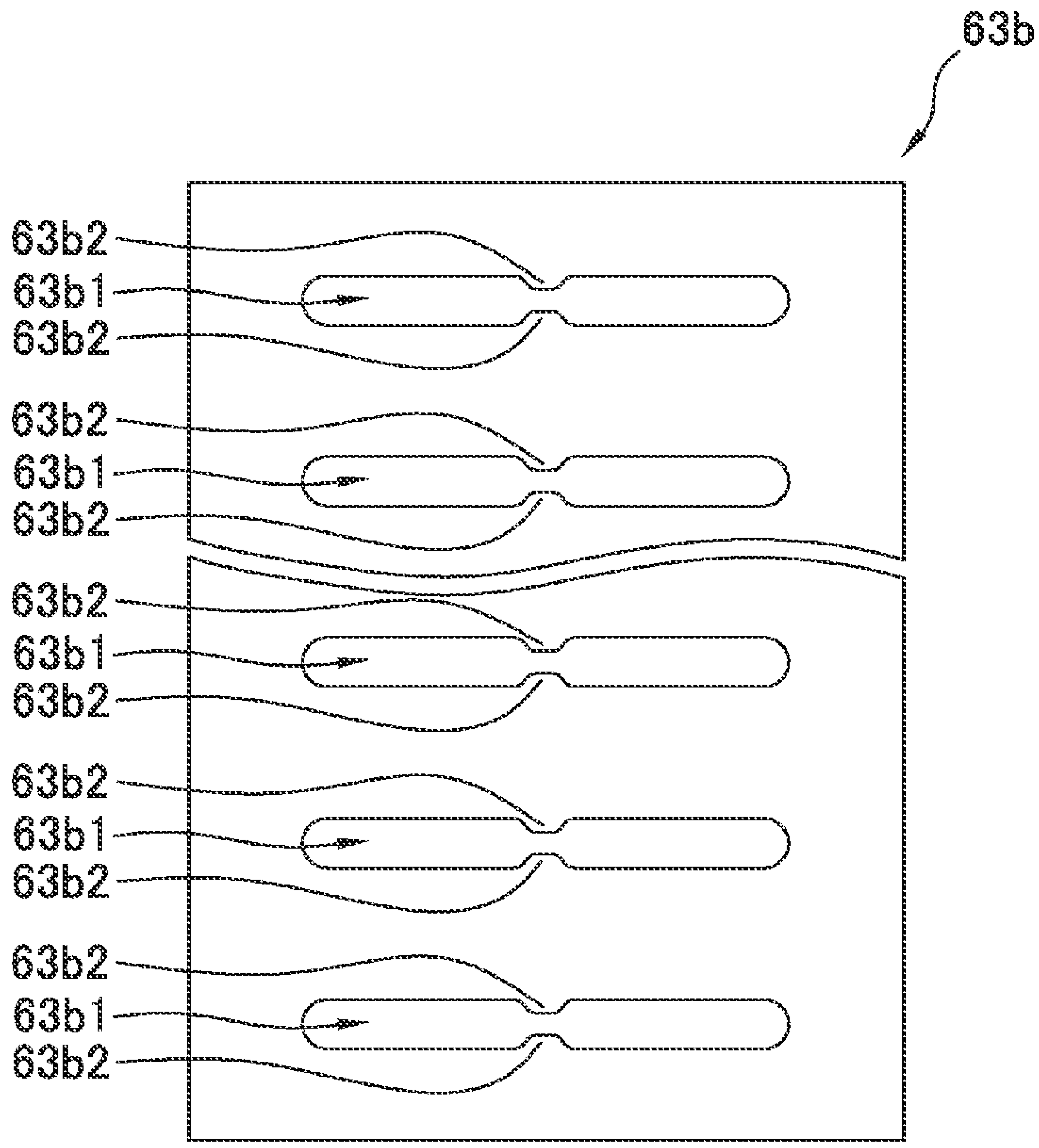
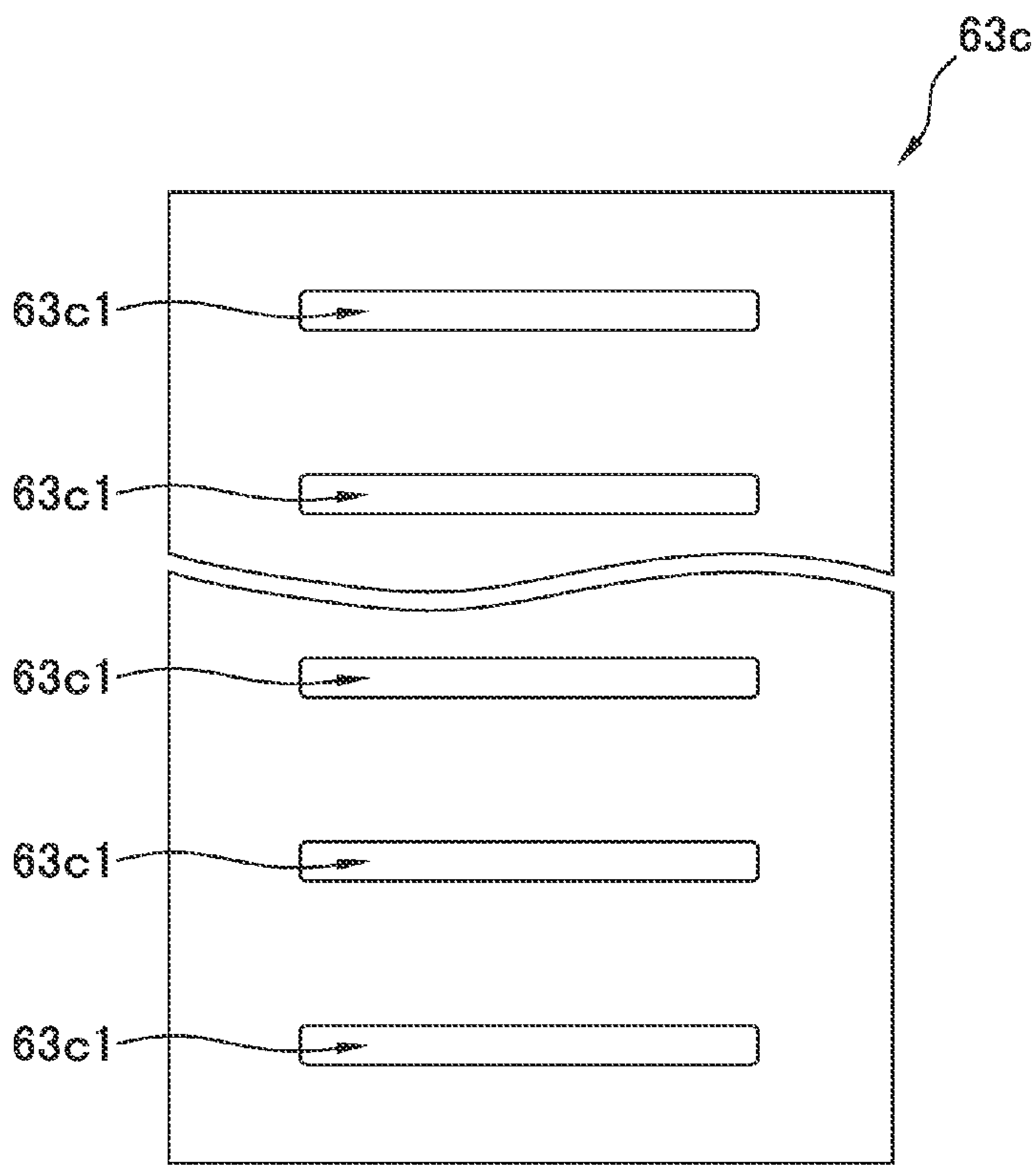

63b
63b2
63b1
63b2
63b2
63b1
63b2
63b2
63b1
63b2
63b2
63b1
63b2
63b2
63b1
63b2

FIG. 12


63c
63c1
63c1
63c1
63c1
63c1

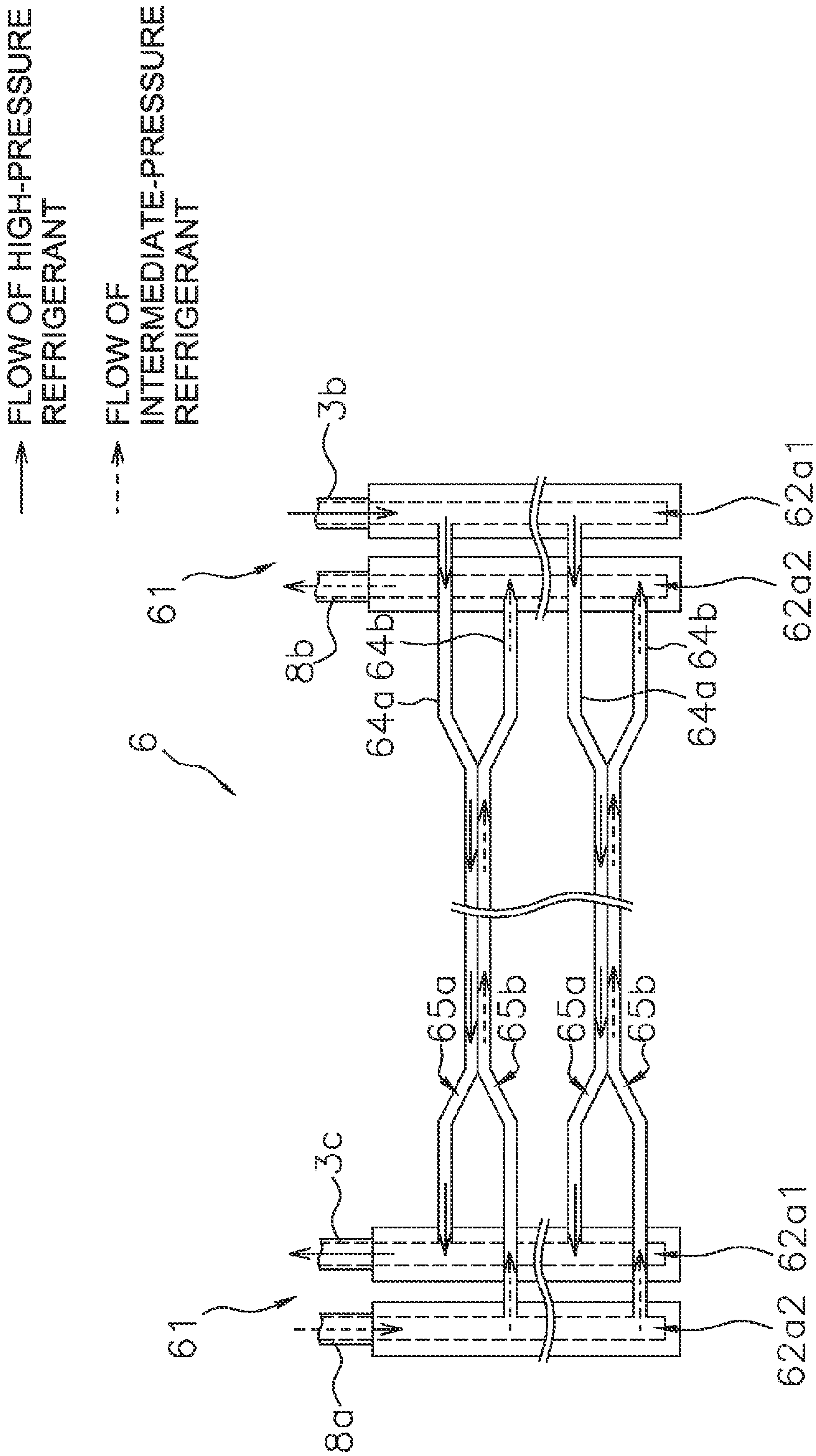

FLOW OF HIGH-PRESSURE REFRIGERANT
FLOW OF INTERMEDIATE-PRESSURE REFRIGERANT
6
61
3b
8b
64a
64b
62a1
62a2
65a
65b
3c
8a

FIG. 13

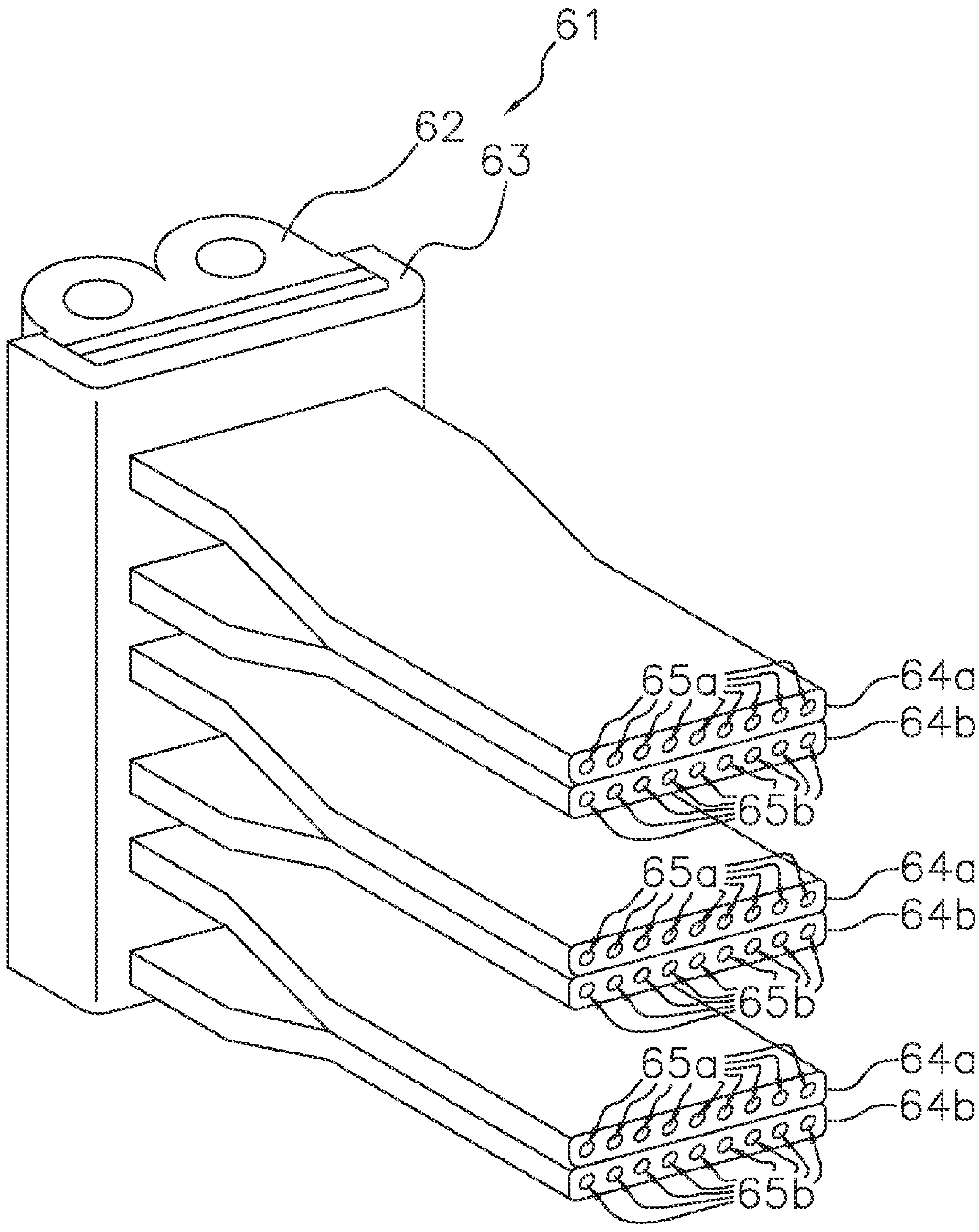
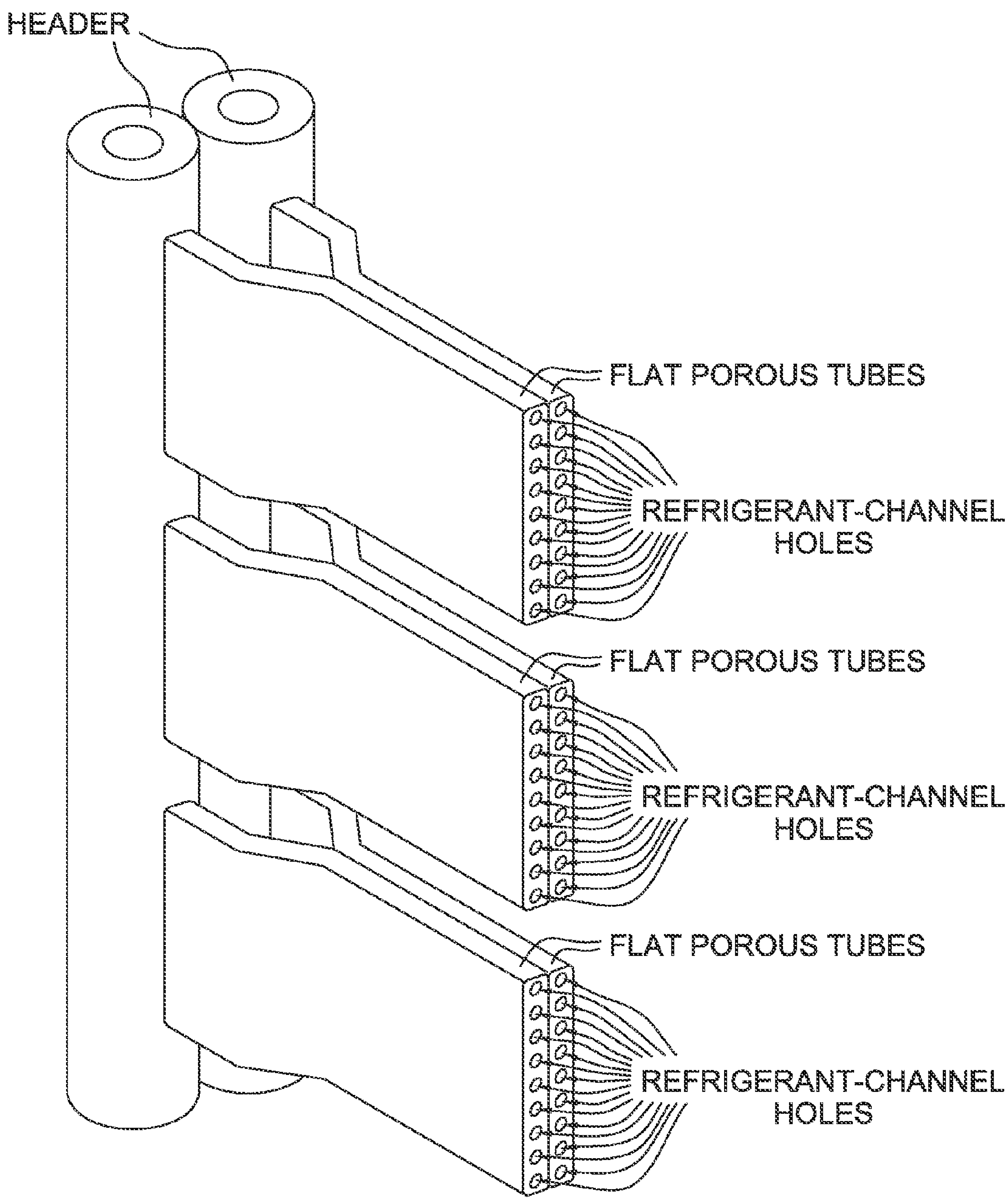



FIG. 14




(PRIOR ART)
FIG. 15

# HEAT EXCHANGER

## TECHNICAL FIELD

**[0001]** The present invention relates to a heat exchanger.

## BACKGROUND ART

**[0002]** Heat exchangers that use flat porous tubes to allow heat exchange between a refrigerant and a refrigerant are conventionally used in refrigeration cycles, as disclosed in Patent Document 1 (Japanese Laid-Open Patent Application No. 2007-163004). Two flat porous tubes, through which flow two respective types of refrigerant that are subjected to heat exchange, are bonded together in these heat exchangers. The flat porous tubes in these heat exchangers are linked to a header so that the alignment direction of refrigerant flow-channel holes of the flat porous tubes proceeds along a longitudinal direction of the header. The header must therefore be lengthened in cases where a plurality of the flat porous tubes are linked to the header, and the device is not readily made more compact.

## SUMMARY OF THE INVENTION

### Problems to be Solved by the Invention

**[0003]** It is an object of the present invention to provide a compact heat exchanger.

### Means for Solving the Problems

**[0004]** A heat exchanger according to a first aspect of the present invention comprises a header, a first flat tube, and a second flat tube. The header has a first primary channel and a second primary channel, a first refrigerant flowing through the first primary channel, and a second refrigerant flowing through the second primary channel. The first flat tube is linked to the header. The first flat tube is a flat porous tube that has a plurality of first refrigerant-channel holes through which the first refrigerant flows. The second flat tube is linked to the header. The second flat tube is a flat porous tube that has a plurality of second refrigerant-channel holes through which the second refrigerant flows. The header has a sub-channel-forming member. The sub-channel-forming member forms a first sub-channel and a second sub-channel. The first sub-channel allows the first primary channel to be communicated with the first refrigerant-channel holes. The second sub-channel allows the second primary channel to be communicated with the second refrigerant-channel holes. The first flat tube and the second flat tube are in close contact. In the first flat tube and the second flat tube, heat is exchanged between the first refrigerant flowing through the first refrigerant-channel holes and the second refrigerant flowing through the second refrigerant-channel holes.

**[0005]** In the heat exchanger according to the first aspect, the first primary channel of the header is communicated with the plurality of the first refrigerant-channel holes of the first flat tube via the first sub-channel, and the second primary channel of the header is communicated with the plurality of the second refrigerant-channel holes of the second flat tube via the second sub-channel. The first flat tube is flat along the alignment direction of the first refrigerant-channel holes. The first primary channel is formed along a longitudinal direction of the header. In cases where the first refrigerant-channel holes are directly communicated with the first primary channel, the first flat tube must be linked to the header so that the flatness direction of the first flat tube proceeds along the longitudinal direction of the header. The header must therefore be long in cases where a plurality of the first flat tubes are linked to the header, and therefore the heat exchanger is not readily made more compact. Meanwhile, in the heat exchanger according to the first aspect, the refrigerant-channel holes are communicated with the first primary channel via, the first sub-channel, whereby the first flat tube need not be linked to the header so that the flatness direction of the first flat tube proceeds along the longitudinal direction of the header. The case is the same for the second flat tube. Therefore, the header does not need to be lengthened, and the heat exchanger according to the first aspect can be made more compact.

**[0006]** A heat exchanger according to a second aspect of the present invention is the heat exchanger according to the first aspect, wherein the first flat tube and the second flat tube are linked to the header so that a cross-sectional longitudinal direction intersects a longitudinal direction of the header, the cross-sectional longitudinal direction being alignment directions of the first refrigerant-channel holes and the second refrigerant-channel holes.

**[0007]** A heat exchanger according to a third aspect of the present invention is the heat exchanger according to the second aspect, wherein the first flat tube and the second flat tube are linked to the header so that the cross-sectional longitudinal direction is perpendicular to the longitudinal direction of the header.

**[0008]** In the heat exchanger according to the third aspect, the first flat tube is linked to the header so that the flatness direction of the first flat tube is perpendicular to the longitudinal direction of the header. The case is the same for the second flat tube. The heat exchanger according to the third aspect can therefore be efficiently made more compact.

**[0009]** A heat exchanger according to a fourth aspect of the present invention is the heat exchanger according to any of the first through third aspects, wherein the sub-channel-forming member comprises a tube-adhering member adhered to end parts of the first flat tube and the second flat tube and immobilized on the header.

**[0010]** In the heat exchanger according to the fourth aspect, a member for linking the first flat tube to the header and a member for linking the second flat tube to the header can be integrated. The number of components can therefore be minimized in the heat exchanger according to the fourth aspect, and manufacturing costs can therefore be limited.

**[0011]** A heat exchanger according to a fifth aspect of the present invention is the heat exchanger according to the fourth aspect, wherein the sub-channel-forming member further comprises a tube-immobilizing member for immobilizing the end parts of the first flat tube and the second flat tube along with the tube-adhering member.

**[0012]** A heat exchanger according to a sixth aspect of the present invention is the heat exchanger according to any of the first through fifth aspects, wherein the sub-channel-forming member forms a plurality of the first sub-channels and a plurality of the second sub-channels.

**[0013]** A heat exchanger according to a seventh aspect of the present invention is the heat exchanger according to any of the first through sixth aspects, wherein the first refrigerant and the second refrigerant are carbon dioxide.

### Effect of the Invention

**[0014]** The heat exchanger according to the first through seventh aspects of the present invention can be made more compact. The manufacturing costs of the heat exchanger according to the fourth through sixth aspects of the present invention can be limited.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0015]** FIG. **1** is a schematic diagram of an air-conditioning device of an embodiment of the present invention;
**[0016]** FIG. **2** is a front view of an economizer heat exchanger of the embodiment of the present invention;
**[0017]** FIG. **3** is a top view of the economizer heat exchanger of the embodiment of the present invention;
**[0018]** FIG. **4** is a cross-sectional view in a horizontal direction of the economizer heat exchanger of the embodiment of the present invention;
**[0019]** NG. **5** is a cross-sectional view in a horizontal direction of the economizer heat exchanger of the embodiment of the present invention;
**[0020]** FIG. **6** is a cross-sectional view in a vertical direction of the economizer heat exchanger of the embodiment of the present invention;
**[0021]** FIG. **7** is a cross-sectional view in a vertical direction of the economizer heat exchanger of the embodiment of the present invention;
**[0022]** FIG. **8** is an exterior view of a channel-forming member of the embodiment of the present invention;
**[0023]** FIG. **9** is a cross-sectional view of a first flat porous tube and a second flat porous tube of the embodiment of the present invention;
**[0024]** FIG. **10** is a front view of a tube-adhering member of the embodiment of the present invention;
**[0025]** FIG. **11** is a front view of a tube-immobilizing member of the embodiment of the present invention;
**[0026]** FIG. **12** is a front view of a spacer member of the embodiment of the present invention;
**[0027]** FIG. **13** is a drawing showing flow of a refrigerant within the economizer heat exchanger of the embodiment of the present invention;
**[0028]** FIG. **14** is an exterior view of a header and flat porous tubes of the economizer heat exchanger of the embodiment of the present invention; and
**[0029]** FIG. **15** is an exterior view of a header and flat porous tubes of a conventional refrigerant-refrigerant heat exchanger.

## DESCRIPTION OF EMBODIMENTS

**[0030]** An embodiment of a heat exchanger according to the present invention will be described below on the basis of the drawings. The embodiment of the heat exchanger according to the present invention is a specific example of the present invention and does not limit the technical scope of the present invention.

**[0031]** (1) Configuration of Air-Conditioning Device

**[0032]** FIG. **1** is a schematic diagram of an air-conditioning device **1** that serves as an example of a refrigerating device provided with a heat exchanger according to the present invention. The air-conditioning device **1** has a refrigerant circuit **10** configured so as to allow air-cooling operations, uses carbon dioxide or another refrigerant active in the supercritical region, and performs a two-stage compression refrigeration cycle. The refrigerant circuit **10** primarily has a compression mechanism **2**, a heat-source-side heat exchanger **3**, an expansion mechanism **4**, a usage-side heat exchanger **5**, and an economizer heat exchanger **6**. These components will be described next.

**[0033]** (1-1) Compression Mechanism

**[0034]** The compression mechanism **2** compresses refrigerant from a low pressure in the refrigeration cycle to a high pressure in the refrigeration cycle. The compression mechanism **2** is a compressor **21** that uses two compression elements and compresses the refrigerant in two stages. The compressor **21** has an airtight structure that accommodates a compression-element-driving motor **21***b*, a drive shaft **21***c*, a first-stage compression element **2***c*, and a second-stage compression element **2***d* in a casing **21***a*. The compression-element-driving motor **21***b* is linked to the drive shaft **21***c*. The drive shaft **21***c* is linked to the first-stage compression element **2***c* and the second-stage compression element **2***d*. In other words, the compressor **21** has a uniaxial two-stage compression structure in which the compression-element-driving motor **21***b* drives the first-stage compression element **2***c* and the second-stage compression element **2***d* via the single drive shaft **21***c*.

**[0035]** The compressor **21** takes in low-pressure refrigerant from an intake tube **2***a*, uses the first-stage compression element **2***c* to compress the refrigerant taken in, and then discharges compressed intermediate-pressure refrigerant to an intermediate-pressure-refrigerant tube **7**. The compressor **21** then takes in the intermediate-pressure refrigerant discharged to the intermediate-pressure-refrigerant tube **7**, uses the second-stage compression element **2***d* to compress the refrigerant taken in, and then discharges the compressed high-pressure refrigerant to a discharge tube **2***b*.

**[0036]** (1-2) Heat-Source-Side Heat Exchanger

**[0037]** The heat-source-side heat exchanger **3** is a radiator for cooling the high-pressure refrigerant compressed by the compression mechanism **2**. The heat-source-side heat exchanger **3** causes heat exchange between air, which acts as a coolant source, and the refrigerant flowing within the heat-source-side heat exchanger **3**. The heat-source-side heat exchanger **3** is connected to the compression mechanism **2** via a first high-pressure refrigerant tube **3***a* and the discharge tube **2***b*. The first high-pressure refrigerant tube **3***a* is connected to an inlet of the heat-source-side heat exchanger **3** and to the discharge tube **2***b*. The heat-source-side heat exchanger **3** is connected to the economizer heat exchanger **6** and an injection part **8**, which will be described hereinafter, via a second high-pressure refrigerant tube **3***b*. The second high-pressure refrigerant tube **3***b* is connected to an outlet of the heat-source-side heat exchanger **3**, to an inlet of the economizer heat exchanger **6** (an inlet of a channel for refrigerant sent from the heat-source-side heat exchanger **3** to the expansion mechanism **4**) and to an inlet of the injection part **8** (an inlet of a channel for refrigerant diverted from the second high-pressure refrigerant tube **3***b*).

**[0038]** (1-3) Expansion Mechanism

**[0039]** The expansion mechanism **4** decompresses the high-pressure refrigerant, which was cooled in the heat-source-side heat exchanger **3** and the economizer heat exchanger **6**, to near the low pressure of the refrigeration cycle before sending the refrigerant to the usage-side heat exchanger **5**. The expansion mechanism **4** is, e.g., an electrically operated expansion valve. The expansion mechanism **4** is connected to the economizer heat exchanger **6** via a third high-pressure refrigerant tube **3***c*. The third high-pressure refrigerant tube **3**c is connected to an outlet of the economizer heat exchanger **6** (an outlet of a channel for refrigerant sent from the heat-source-side heat exchanger **3** to the expansion mechanism **4**) and to an inlet of the expansion mechanism **4**. The expansion mechanism **4** is connected to the usage-side heat exchanger **5** via a first low-pressure refrigerant tube **5**a. The first low-pressure refrigerant tube **5**a is connected to an outlet of the expansion mechanism **4** and to an inlet of the usage-side heat exchanger **5**.

**[0040]** (1-4) Usage-Side Heat Exchanger

**[0041]** The usage-side heat exchanger **5** is an evaporator for heating and evaporating the low-pressure refrigerant that was decompressed by the expansion mechanism **4**. The usage-side heat exchanger **5** causes heat exchange between air, which serves as a heat source, and the refrigerant flowing within the usage-side heat exchanger **5**. The usage-side heat exchanger **5** is connected to the expansion mechanism **4** via the first low-pressure refrigerant tube **5**a. The usage-side heat exchanger **5** is connected to the compression mechanism **2** via a second low-pressure refrigerant tube **5**b. The second low-pressure refrigerant tube **5**b is connected to an outlet of the usage-side heat exchanger **5** and to the intake tube **2**a.

**[0042]** (1-5) Economizer Heat Exchanger

**[0043]** The economizer heat exchanger **6** causes heat exchange between the high-pressure refrigerant sent from the heat-source-side heat exchanger **3** to the expansion mechanism **4** and the intermediate-pressure refrigerant flowing through the injection part **8**.

**[0044]** The injection part **8** diverts the high-pressure refrigerant flowing from the heat-source-side heat exchanger **3** to the expansion mechanism **4** and returns the refrigerant to the inlet of the second-stage compression element **2**d. Specifically, the injection part **8** diverts refrigerant from the second high-pressure refrigerant tube **3**b and returns the refrigerant to the intermediate-pressure-refrigerant tube **7**. The injection part **8** comprises a first injection tube **8**a and a second injection tube **8**b. The first injection tube **8**a connects the second high-pressure refrigerant tube **3**b with an inlet of the economizer heat exchanger **6** (an inlet of a channel for refrigerant diverted from the second high-pressure refrigerant tube **3**b). The second injection tube **8**b connects an outlet of the economizer heat exchanger **6** (an outlet of a channel for refrigerant diverted from the second high-pressure refrigerant tube **3**b) with the intermediate-pressure-refrigerant tube **7**. An injection valve **8**c that functions as a return valve having a controllable opening degree is provided to the first injection tube **8**a. The injection valve **8**c is, e.g., an electrically operated expansion valve. The injection valve **8**c decompresses the high-pressure refrigerant diverted from the second high-pressure refrigerant tube **3**b to around the intermediate pressure of the refrigerant flowing within the intermediate-pressure-refrigerant tube **7**.

**[0045]** In the economizer heat exchanger **6**, the high-pressure refrigerant sent from the heat-source-side heat exchanger **3** to the expansion mechanism **4** is cooled by heat exchange with the intermediate-pressure refrigerant flowing through the injection part **8**. Meanwhile, the intermediate-pressure refrigerant flowing through the injection part **8** is heated and evaporated by heat exchange with the high-pressure refrigerant, which is sent from the heat-source-side heat exchanger **3** to the expansion mechanism **4**, while temporarily flowing in a gas-liquid two-phase state. After passing through the second injection tube **8**b, the evaporated intermediate-pressure refrigerant merges with the refrigerant flowing through the intermediate-pressure-refrigerant tube **7**.

**[0046]** (2) Action of the Air-Conditioning Device

**[0047]** The action of the air-conditioning device I during air-cooling operations will be described next on the basis of the flow of refrigerant circulating through the refrigerant circuit **10**. The refrigerant at the low pressure of the refrigeration cycle is taken in from the intake tube **2**a to the compression mechanism **2**. The low-pressure refrigerant taken in to the compression mechanism **2** is compressed to the intermediate pressure of the refrigeration cycle by the first-stage compression element **2**c and then discharged to the intermediate-pressure-refrigerant tube **7**, in the intermediate-pressure-refrigerant tube **7**, the intermediate-pressure refrigerant discharged from the first-stage compression element **2**c is merged with the intermediate-pressure refrigerant returned from the second injection tube **8**b. The merged intermediate-pressure refrigerant is taken in to the second-stage compression element **2**d and compressed to the high pressure of the refrigeration cycle by the second-stage compression element **2**d. The compressed high-pressure refrigerant is discharged from the compression mechanism **2** to the discharge tube **2**b.

**[0048]** The high-pressure refrigerant discharged from the compression mechanism **2** is sent through the first high-pressure refrigerant tube **3**a to the heat-source-side heat exchanger **3**. The high-pressure refrigerant sent to the heat-source-side heat exchanger **3** is subjected to heat exchange with outside air and cooled by the heat-source-side heat exchanger **3**. A portion of the high-pressure refrigerant cooled by the heat-source-side heat exchanger **3** is diverted in the second high-pressure refrigerant tube **3**b to the first injection tube **8**a. The high-pressure refrigerant diverted to the first injection tube **8**a is decompressed to around the intermediate pressure of the refrigeration cycle by the injection valve **8**c and is then sent to the economizer heat exchanger **6**. Meanwhile, the high-pressure refrigerant subsequent to the diversion to the first injection tube **8**a (i.e., refrigerant flowing through the second high-pressure refrigerant tube **3**b) is sent to the economizer heat exchanger **6**.

**[0049]** In the economizer heat exchanger **6**, the high-pressure refrigerant from the second high-pressure refrigerant tube **3**b is subjected to heat exchange with the intermediate-pressure refrigerant from the first injection tube **8**a and cooled. Meanwhile, the intermediate-pressure refrigerant from the first injection tube **8**a is subjected to heat exchange with the high-pressure refrigerant from the second high-pressure refrigerant tube **3**b, heated, and returned through second injection tube **8**b to the intermediate-pressure-refrigerant tube **7**.

**[0050]** The high-pressure refrigerant cooled in the economizer heat exchanger **6** is sent through the third high-pressure refrigerant tube **3**c to the expansion mechanism **4**. The high-pressure refrigerant sent to the expansion mechanism **4** is decompressed by the expansion mechanism **4**, enters a gas-liquid two-phase state at the low pressure of the refrigeration cycle, and is sent through the first low-pressure refrigerant tube **5**a to the usage-side heat exchanger **5**. The low-pressure, gas-liquid two-phase refrigerant sent to the usage-side heat exchanger **5** is subjected to heat exchange with outside air, heated, and evaporated by the usage-side heat exchanger **5**. The low-pressure refrigerant that was heated and evaporated by the usage-side heat exchanger **5** is once again taken in to the compression mechanism **2** through the second low-pressure refrigerant tube **5**b and the intake tube **2**a. The air-conditioning device 1 thus circulates refrigerant within the refrigerant circuit **10** and performs air-cooling operations.

**[0051]** (3) Detailed Configuration of the Economizer Heat Exchanger

**[0052]** The detailed configuration of the economizer heat exchanger **6** will be described next. The economizer heat exchanger **6** in the present embodiment is a heat exchanger according to the present invention. FIG. **2** is a front view of the economizer heat exchanger **6**. FIG. **3** is a top view of the economizer heat exchanger **6**. FIG. **2** is a front view from the direction of an arrow II shown in FIG. **3**. FIG. **3** is a top view from the direction of an arrow III shown in FIG. **2**. FIGS. **4** and **5** are cross-sectional views in a horizontal direction cut along cut line IV-IV and cut line V-V, respectively, in FIG. **2**. FIGS. **6** and **7** are cross-sectional views in a vertical direction cut along cut line VI-VI and cut line VII-VII, respectively, in FIG. **3**. The economizer heat exchanger **6** primarily comprises a pair of headers **61**, a plurality of first flat porous tubes **64***a,* and a plurality of second flat porous tubes **64***b*. These components will be described next.

**[0053]** (3-1) Headers

**[0054]** Both of the pair of the headers **61** have the same structure, and therefore only one of the headers **61** will be described below. The header **61** is positioned so that the longitudinal direction thereof proceeds along the vertical direction. The header **61** has a channel-forming member **62**. and a tube-connecting member **63**. The channel-forming member **62** has, therein, a first primary channel **62***a***1**, a second primary channel **62***a***2**, a plurality of first linking channels **62***b***1**, and a plurality of second linking channels **62***b***2**. The first linking channels **62***b***1** and the second linking channels **62***b***2** are communicated with the first primary channel **62***a***1** and the second primary channel **62***a***2**, respectively, as shown in FIGS. **4** through **7**. FIG. **8** is an exterior view of the channel-forming member **62** seen from an arrow VIII in FIG. **4**. The first linking channels **62***b***1** and the second linking channels **62***b***2** open in alternation along the longitudinal direction of the channel-forming member **62** on an opening surface **62***s* of the channel-forming member **62**, as shown in FIG. **8**. The first linking channels **62***b***1** open on the opening surface **62***s* along the first primary channel **62***a***1**, and the second linking channels **62***b***2** open on the opening surface **62***s* along the second (primary channel **62***a***2**.

**[0055]** The high-pressure refrigerant from the second high-pressure refrigerant tube **3***b* flows in the first primary channel **62***a***1** and the first linking channels **62***b***1**. The intermediate-pressure refrigerant from the first injection tube **8***a* flows in the second (primary channel **62***a***2** and the second linking channels **62***b***2**. Refrigerant in the first primary channel **62***a*flows in the vertical direction, and refrigerant in the first linking channels **62***b***1** is diverted from the first primary channel **62***a***1** and flows in a horizontal direction. Refrigerant in the second primary channel **62***a***2** flows in the vertical direction, and refrigerant in the second linking channels **62***b***2** is diverted from the second primary channel **62***a***2** and flows in the horizontal direction.

**[0056]** The tube-connecting member **63** connects the channel-forming member **62**, the first flat porous tubes **64***a,* and the second flat porous tubes **64***b*. The detailed configuration of the tube-connecting member **63** will be described hereinafter.

**[0057]** (3-2) First flat Porous Tubes and Second Flat Porous Tubes

**[0058]** The first flat porous tubes **64***a* have a plurality of first refrigerant-channel holes **65***a*. The first flat porous tubes **64***a* are positioned so that the alignment direction of the first refrigerant-channel holes **65***a* is in the horizontal direction, i.e., so that the normal to the flat surface indicates the vertical direction. The second flat porous tubes **64***b* have a plurality of second refrigerant-channel holes **65***b*. The second flat porous tubes **64***b* are positioned so that the alignment direction of the second refrigerant-channel holes **65***b* is in the horizontal direction, i.e., so that the normal to the flat surface indicates the vertical direction.

**[0059]** Pairs of a single one of the first flat porous tubes **64***a* and a single one of the second flat porous tubes **64***b,* which are brought into close contact at the flat surfaces, are positioned at a plurality of stages along the longitudinal direction of the header **61** in the present embodiment, as shown in FIG. **2**. Both end parts of the first flat porous tubes **64***a* and the second fiat porous tubes **64***b* are linked respectively to the pair of the headers **61**.

**[0060]** FIG. **9** is a cross-sectional view of the first flat porous tubes **64***a* and the second flat porous tubes **64***b* cut along a cut line IX-IX in FIG. **3**. The alignment direction of the first refrigerant-channel holes **65***a* of the first flat porous tubes **64***a* and the alignment direction of the second refrigerant-channel holes **65***b* of the second flat porous tubes **64***b* are perpendicular to the longitudinal direction of the headers **61**, as shown in FIG. **9**.

**[0061]** (3-3) Tube-Connecting Member

**[0062]** The tube-connecting member **63** is configured from a tube-adhering member **63***a,* a tube-immobilizing member **63***b,* and a spacer member **63***c,* as shown in FIGS. **4** through **7**. FIG. **10** is a front view of the tube-adhering member **63***a*. FIG. **11** is a front view of the tube-immobilizing member **63***b*. FIG. **12** is a front view of the spacer member **63***c*. FIGS. **10** through **12** are all external views from an arrow VIII in FIG. **4**.

**[0063]** The tube-adhering member **63***a* has a U-shaped cross-section when viewed along the vertical direction, as shown in FIGS. **4** through **7**. In the tube-adhering member **63***a,* a plurality of flat-tube-fitting insertion holes **63***a***1** are positioned in the vertical direction, as shown in FIG. **10**. End parts of the first fiat porous tubes **64***a* and the second flat porous tubes **64***b* are fit into the respective flat-tube-fitting insertion holes **63***a***1**. The flat-tube-fitting insertion holes **63***a***1** immobilize the end parts of the first flat porous tubes **64***a* and the second fiat porous tubes **64***b*.

**[0064]** The tube-immobilizing member **63***b* is a plate-shaped member positioned in close contact with the tube-adhering member **63***a* and the spacer member **63***c* in a space surrounded by the tube-adhering member **63***a* and the channel-forming member **62**, as shown in FIGS. **4** through **7**. A plurality of flat-tube-fastening holes **63***b***1** are positioned in the vertical direction in the tube-immobilizing member **63***b,* as shown in FIG. **11**. The flat-tube-fastening holes **63***b***1** have two convex parts **63***b***2** at a center part in the horizontal direction. Along with the flat-tube-fitting insertion holes **63***a***1**, the convex parts **63***b***2** immobilize the end parts of the first flat porous tubes **64***a* and the second flat porous tubes **64***b*. The height of the convex parts **63***b***2** is less than the thickness of the first flat porous tubes **64***a* and the second flat porous tubes **64***b*.

**[0065]** The spacer member **63***c* is a plate-shaped member positioned in close contact with the tube-immobilizing member **63***b* and the opening surface **62***s* of the channel-forming member **62** in a space surrounded by the tube-adhering member **63***a* and the channel-forming member **62**, as shown in FIGS. **4** through **7**. In the spacer member **63***c*, a plurality of spacer holes **63***c***1** are positioned in the vertical direction, as shown in FIG. **12**. A portion of the end surface of the first flat porous tubes **64***a* and the second flat porous tubes **64***b* contacts the end surface of the spacer member **63***c*, as shown in FIGS. **4** and **5**.

**[0066]** The height-wise positions of the first linking channels **62***b***1** and the second linking channels **62***b***2** that open on the opening surface **62***s* of the channel-forming member **62** in the present embodiment are equivalent to the height-wise positions of the flat-tube-fitting insertion holes **63***a***1**, flat-tube-fastening holes **63***b***1**, and the spacer holes **63***c***1**. The first refrigerant-channel holes **65***a* and the second refrigerant-channel holes **65***b* are thereby communicated with the first linking channels **62***b***1** and the second linking channels **62***b***2**, respectively, via the spacer holes **63***c***1**. Below, the spacer holes **63***c***1** that is communicated with the first linking channels **62***b***1** will be called first sub-channels **62***c***1**, and the spacer holes **63***c***1** that is communicated with the second linking channels **62***b***2** will be called second sub-channels **62***c***2**. The first sub-channels **62***c***1** are spaces that, along with the first linking channels **62***b***1**, allow the first refrigerant-channel holes **65***a* to be communicated with the first primary channel **62***a***1**. The second sub-channels **62***c***2** are spaces that, along with the second linking channels **62***b***2**, allow the second refrigerant-channel holes **65***b* to be communicated with the second primary channel **62***a***2**.

**[0067]** (4) Flow of Refrigerant in the Economizer Heat Exchanger

**[0068]** Heat exchange in the economizer heat exchanger **6** will be described with reference to FIG. **13**. The high-pressure refrigerant that is cooled by the heat-source-side heat exchanger **3** and made to flow through the second high-pressure refrigerant tube **3***b* is provided to the first primary channel **62***a***1** within one of the headers **61** of the economizer heat exchanger **6**. The high-pressure refrigerant flowing through the first primary channel **62***a***1** is split into the first sub-channels **62***c***1** via the first linking channels **62***b***1** and flows into the first refrigerant-channel holes **65***a* of the first flat porous tubes **64***a*.

**[0069]** Meanwhile, the intermediate-pressure refrigerant, which was diverted from the second high-pressure refrigerant tube **3***b*, decompressed by the injection valve **8***c*, and made to flow through the first injection tube **8***a*, is supplied to the second (primary channel **62***a***2** within the header **61** on the opposite side from the header to which the high-pressure refrigerant is supplied. The intermediate-pressure refrigerant flowing through the second primary channel **62***a***2** is split into the second sub-channels **62***c***2** via the second linking channels **62***b***2** and flows into the second refrigerant-channel holes **65***b* of the second flat porous tubes **64***b*.

**[0070]** The high-pressure refrigerant flowing through the first refrigerant-channel holes **65***a* of the first flat porous tubes **64***a* exchanges heat with the intermediate-pressure refrigerant O flowing through the second refrigerant-channel holes **65***b* of the second flat porous tubes **64***b* that are in close contact with the first flat porous tubes **64***a*. The direction of flow of the high-pressure refrigerant in the first refrigerant-channel holes **65***a* is opposite from the direction of flow of the intermediate-pressure refrigerant in the second refrigerant-channel holes **65***b*, as shown in FIG. **13**.

**[0071]** The high-pressure refrigerant that has passed through the first refrigerant-channel holes **65***a* and been subjected to heat exchange flows into the first primary channel **62***a***1** within the header **61** on the opposite side. Finally, the high-pressure refrigerant is sent from the first primary channel **62***a***1** to the third high-pressure refrigerant tube **3***c*. Meanwhile, the intermediate-pressure refrigerant that has passed through the second refrigerant-channel holes **65***b* and been subjected to heat exchange flows into the second primary channel **62***a***2** within the header **61** on the opposite side. Finally, the intermediate-pressure refrigerant is sent from the second primary channel **62***a***2** to the second injection tube **8***b*.

**[0072]** (5) Characteristics

**[0073]** In the economizer heat exchanger **6** of the present embodiment, the high-pressure refrigerant that flows through the first primary channel **62***a***1** of the header **61** is split into the first sub-channels **62***c***1** and then flows into the first refrigerant-channel holes **65***a* of the first flat porous tithes **64***a*. The intermediate-pressure refrigerant that flows through the second primary channel **62***a***2** of the header **61** is split into the second sub-channels **62***c***2** and then flows into the second refrigerant-channel holes **65***b* of the second flat porous tubes **64***b*. The first sub-channels **62***c***1** and the second sub-channels **62***c***2** are spaces formed by the tube-connecting member **63**.

**[0074]** In the economizer heat exchanger **6**, the first flat porous tubes **64***a* and the second flat porous tubes **64***b* are linked to the headers **61** on that the alignment direction of the first refrigerant-channel holes **65***a* of the first flat porous tubes **64***a* and the alignment direction of the second refrigerant-channel holes **65***b* of the second flat porous tubes **64***b* are perpendicular to the longitudinal direction of the headers **61**, as shown in FIG. **14**. The tube-connecting member **63** that forms the first sub-channels **62***c***1** and the second sub-channels **62***c***2** is used in the present embodiment, whereby the first flat porous tubes **64***a* and the second flat porous tubes **64***b* can be linked to the headers **61**, as shown in FIG. **14**.

**[0075]** In a conventional heat exchanger such as shown in FIG. **15**, a plurality of flat porous tubes are linked to headers so that the alignment direction of refrigerant-channel holes within the flat porous tubes proceeds along a longitudinal direction of the headers. The headers in this heat exchanger must be long in order to link the plurality of the flat porous tubes to the headers, and this heat exchanger is therefore not readily made more compact. On the other hand, in the economizer heat exchanger **6** of the present embodiment as shown in FIG. **14**, the plurality of the flat porous tubes **64***a*, **64***b* can be efficiently linked to the headers **61**, and therefore the length of the header **61** can be reduced in comparison to the conventional heat exchanger shown in FIG. **15**. The economizer heat exchanger **6** of the present embodiment can therefore readily be made more compact.

**[0076]** (6) Modifications

**[0077]** (6-1) Modification A

**[0078]** The economizer heat exchanger **6** was described as the heat exchanger according to the present invention in the present embodiment, but the heat exchanger according to the present invention can be applied generally to heat exchangers for causing heat exchange between a refrigerant and a refrigerant.

**[0079]** (6-2) Modification B

**[0080]** In the present embodiment, the first flat porous tubes **64***a* and the second flat porous tubes **64***b* are linked to the headers **61** so that the alignment directions of the first refrigerant-channel holes **65***a* and the second refrigerant-channel holes **65***b* are perpendicular to the longitudinal direction of the header **61**, but it may be applicable as long as the alignment directions of the first refrigerant-channel holes **65***a* and the second refrigerant-channel holes **65***b* intersect the longitudinal direction of the header **61**.

**[0081]** Even in the present modification, the plurality of the flat porous tubes **64***a*, **64***b* can be efficiently linked to the headers **61** in comparison to a conventional heat exchanger such as shown in FIG. **15**, and therefore the length of the headers **61** can be reduced. The economizer heat exchanger **6** of the present modification can therefore also be readily made more compact.

## INDUSTRIAL APPLICABILITY

**[0082]** The heat exchanger according to the present invention can be readily made more compact.

## REFERENCE SIGNS LIST

**[0083]** **6** Economizer heat exchanger (heat exchanger)
**[0084]** **61** Header
**[0085]** **62***a***1** First primary channel
**[0086]** **62***a***2** Second primary channel
**[0087]** **63** Tube-connecting member (sub-channel-forming member)
**[0088]** **63***a* Tube-adhering member
**[0089]** **63***b* Tube-immobilizing member
**[0090]** **62***c***1** First sub-channels
**[0091]** **62***c***2** Second sub-channels
**[0092]** **64***a* First flat porous tubes (first flat tubes)
**[0093]** **64***b* Second flat porous tubes (second flat tubes)
**[0094]** **65***a* First refrigerant-channel holes
**[0095]** **65***b* Second refrigerant-channel holes

## CITATION LIST

## PATENT LITERATURE

**[0096]** [Patent Document 1] Japanese Laid-Open Patent Application No 2007-163004

**1**. A heat exchanger, comprising:
a header having a first primary channel and a second primary channel with a first refrigerant flowing through the first primary channel, and a second refrigerant flowing through the second primary channel;
a first flat tube linked to the header and having a plurality of first refrigerant-channel holes, the first refrigerant flowing through the first refrigerant-channel holes, and the first flat tube being a flat porous tube; and
a second flat tube linked to the header and having a plurality of second refrigerant-channel holes, the second refrigerant flowing through the second refrigerant-channel holes, and the second flat tube being a flat porous tube,
the header having a sub-channel-forming member that forms at least one first sub-channel and at least one second sub-channel, the first sub-channel allowing the first primary channel to be communicated with the first refrigerant-channel holes, and the second sub-channel allowing the second primary channel to be communicated with the second refrigerant-channel holes; and
the first flat tube and the second flat tube being in close contact, and heat being exchanged between the first refrigerant flowing through the first refrigerant-channel holes and the second refrigerant flowing through the second refrigerant-channel holes.

**2**. The heat exchanger according to claim **1**, wherein
the first flat tube and the second flat tube are linked to the header so that a cross-sectional longitudinal direction intersects a longitudinal direction of the header, the cross-sectional longitudinal direction extending along alignment directions of the first refrigerant-channel holes and the second refrigerant-channel holes.

**3**. The heat exchanger according to claim **2**, wherein
the first flat tube and the second flat tube are linked to the header so that the cross-sectional longitudinal direction is perpendicular to the longitudinal direction of the header.

**4**. The heat exchanger according to claim **1**, wherein
the sub-channel-forming member includes a tube-adhering member, end parts of the first flat tube and the second flat tube are adhered to the tube-adhering member, and the tube-adhering member is immobilized on the header.

**5**. The heat exchanger according to claim **4**, wherein
the sub-channel-forming member further includes a tube-immobilizing member that immobilizes the end parts of the first flat tube and the second flat tube along with the tube-adhering member.

**6**. The heat exchanger according to claim **1**, wherein
the at least one first sub-channel includes a plurality of first sub-channels and the at least one second sub-channel includes a plurality of second sub-channels.

**7**. The heat exchanger according to claim **1**, wherein
the first refrigerant and the second refrigerant are carbon dioxide.

**8**. The heat exchanger according to claim **2**, wherein
the sub-channel-forming member includes a tube-adhering member, end parts of the first flat tube and the second flat tube are adhered to the tube-adhering member, and the tube-adhering member is immobilized on the header.

**9**. The heat exchanger according to claim **8**, wherein
the sub-channel-forming member further includes a tube-Immobilizing member that immobilizes the end parts of the first flat tube and the second flat tube along with the tube-adhering member.

**10**. The heat exchanger according to claim **2**, wherein
the at least one first sub-channel includes a plurality of first sub-channels and the at least one second sub-channel includes a plurality of second sub-channels.

**11**. The heat exchanger according to claim **3**, wherein
the sub-channel-forming member includes a tube-adhering member, end parts of the first flat tube and the second flat tube are adhered to the tube-adhering member, and the tube-adhering member is immobilized on the header.

**12**. The heat exchanger according to claim **11**, wherein
the sub-channel-forming member further includes a tube-immobilizing member that immobilizes the end parts of the first flat tube and the second flat tube along with the tube-adhering member.

**13**. The heat exchanger according to claim **3**, wherein
the at least one first sub-channel includes a plurality of first sub-channels and the at least one second sub-channel includes a plurality of second sub-channels.

**14**. The heat exchanger according to claim **4**, wherein
the at least one first sub-channel includes a plurality of first sub-channels and the at least one second sub-channel includes a plurality of second sub-channels.

**15**. The heat exchanger according to claim **5**, wherein the at least one first sub-channel includes a plurality of first sub-channels and the at least one second sub-channel includes a plurality of second sub-channels.

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