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(54) HEAT EXCHANGER

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CPC *F28D 9/0043* (2013.01); *F28D 21/0003* (2013.01)

(57) **ABSTRACT**

A heat exchanger that performs heat exchange between a first fluid and a second fluid includes a first duct plate, a second duct plate, a flow path member, a caulking plate, an insertion projection, and a contact protrusion. The insertion protrusion protrudes from at least one of the first duct plate and the second duct plate toward the caulking plate, and is inserted into an insertion hole defined in the caulking plate. The contact protrusion protrudes from at least one of the first duct plate and the second duct plate toward the caulking plate, and is fixed to, and in contact with, a stopper wall of the caulking plate. A surface of the contact protrusion is in contact with a stopper plane wall when the contact protrusion is fixed to the frame member.

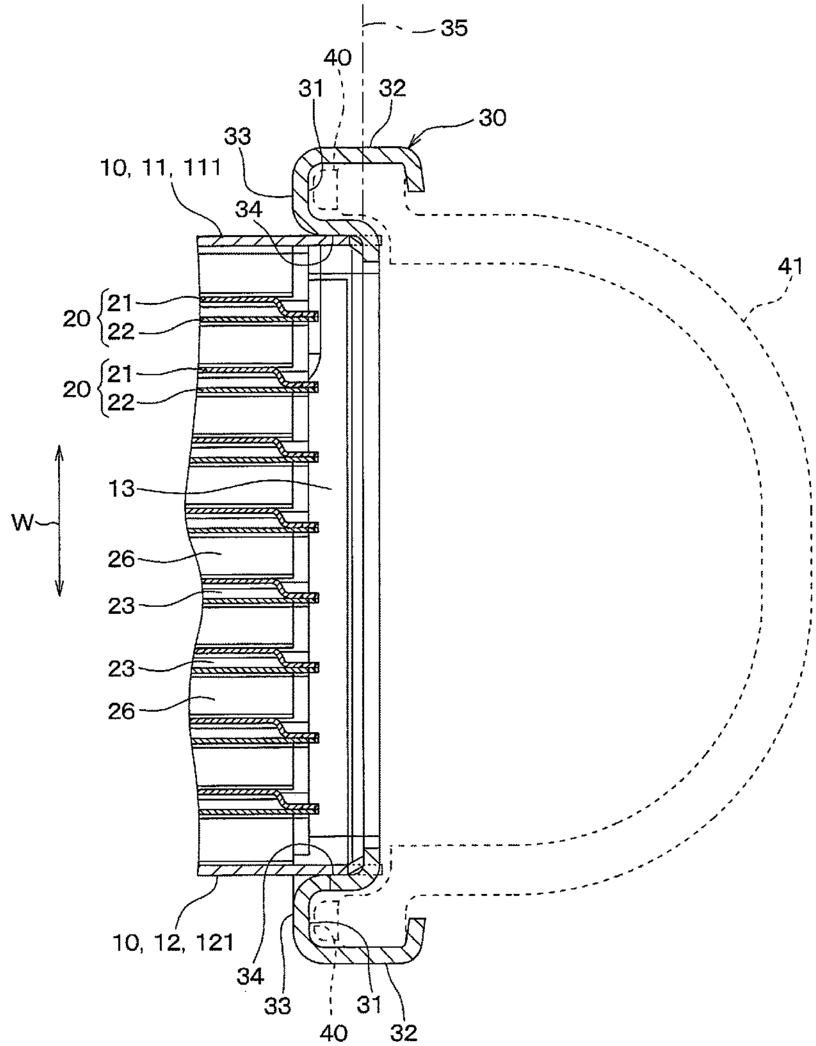

FIG. 1

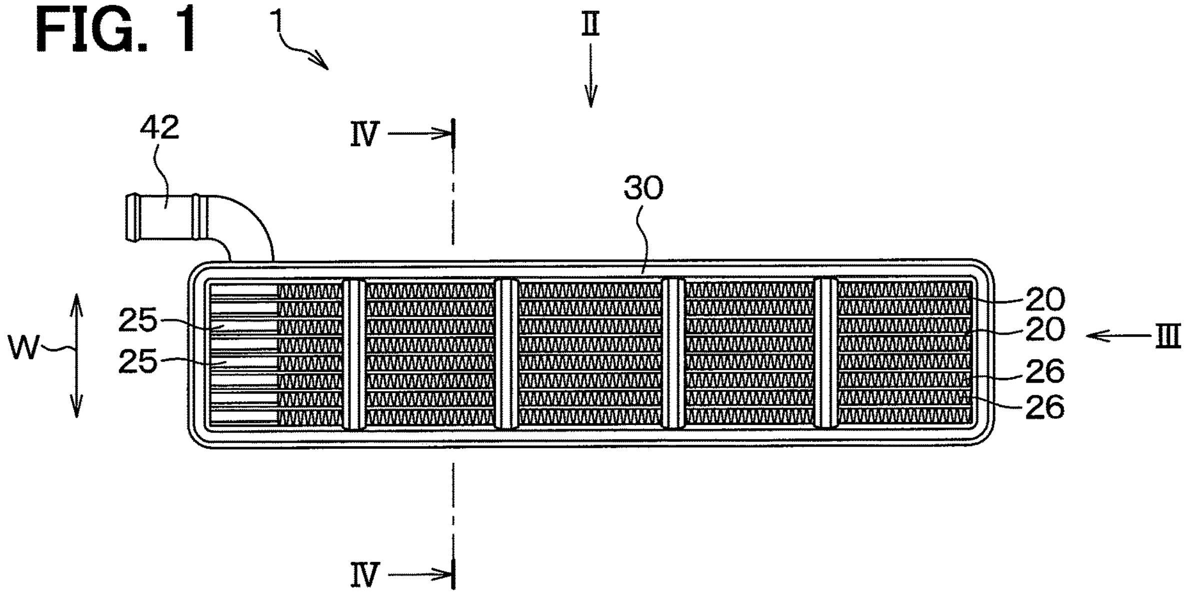

FIG. 2

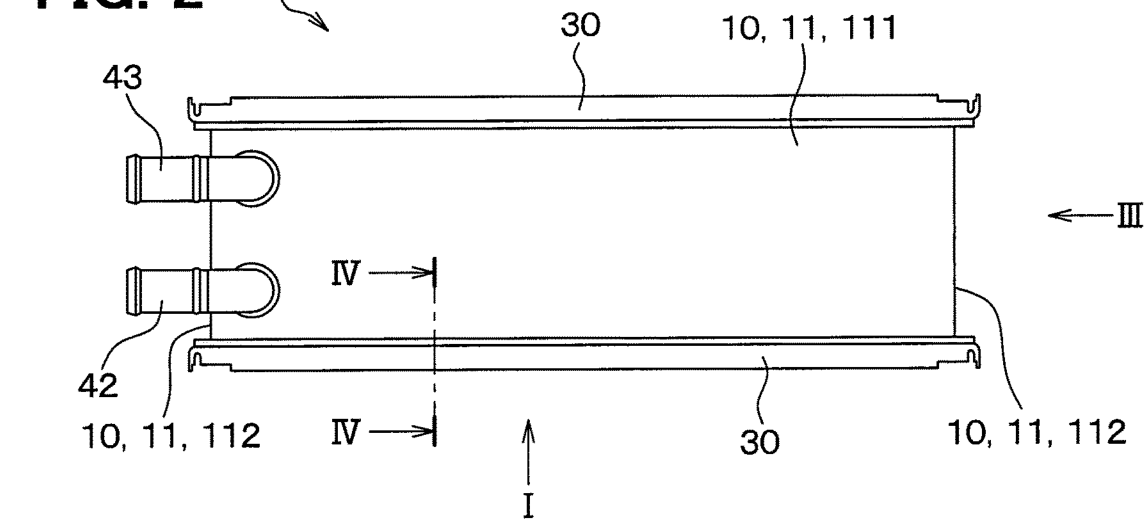

FIG. 3

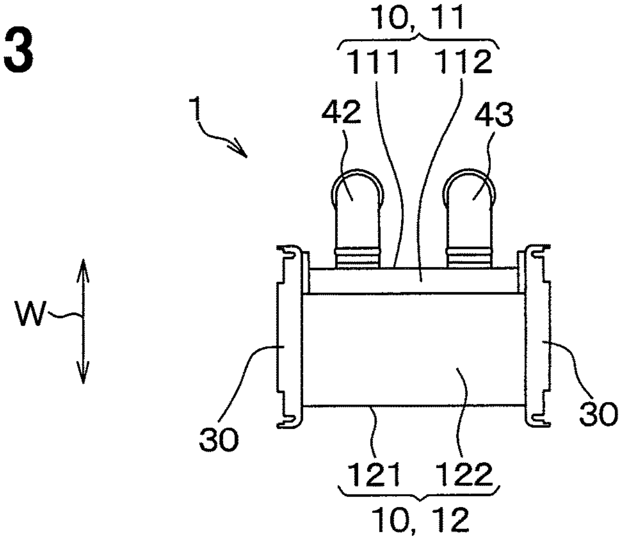

FIG. 4

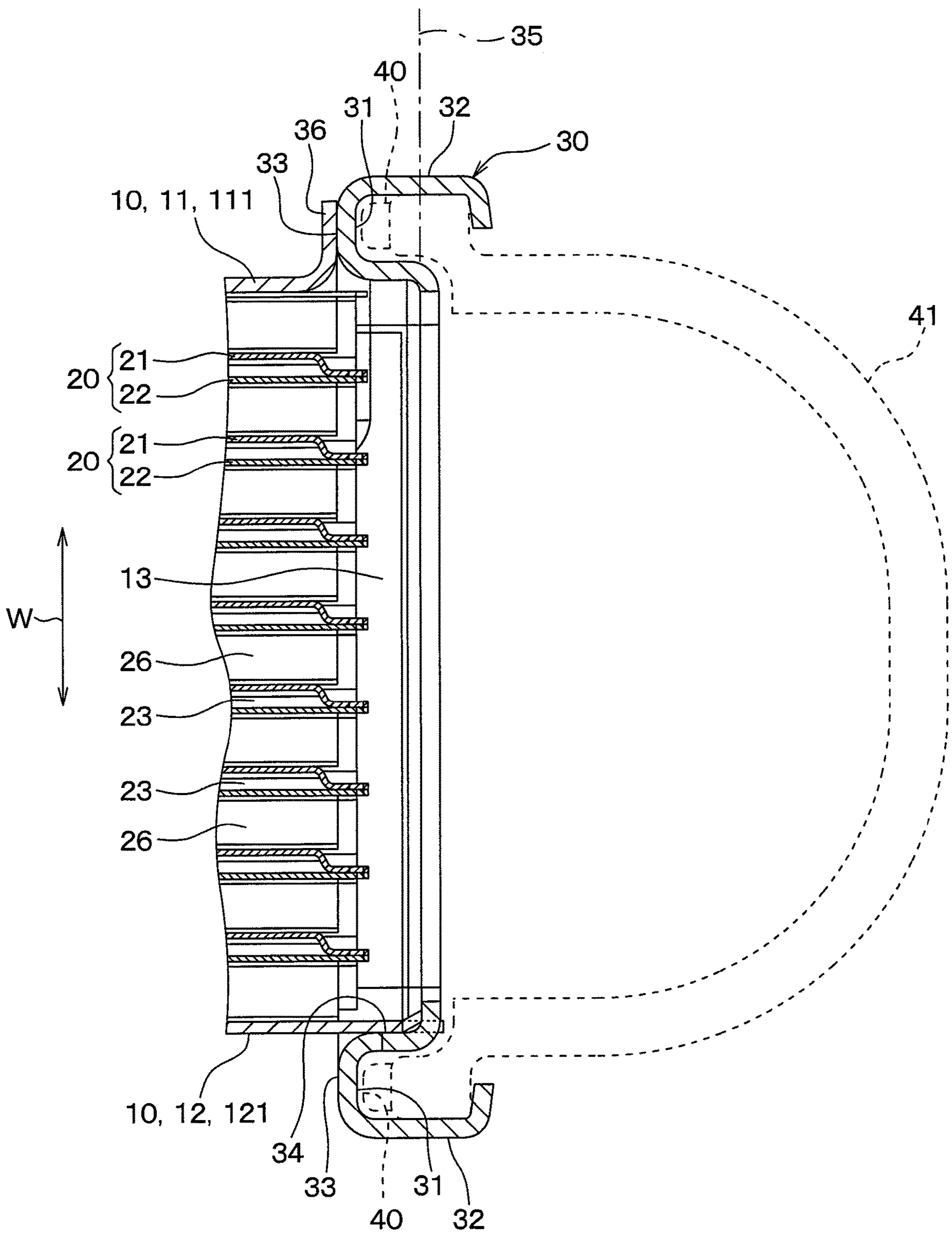
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FIG. 5

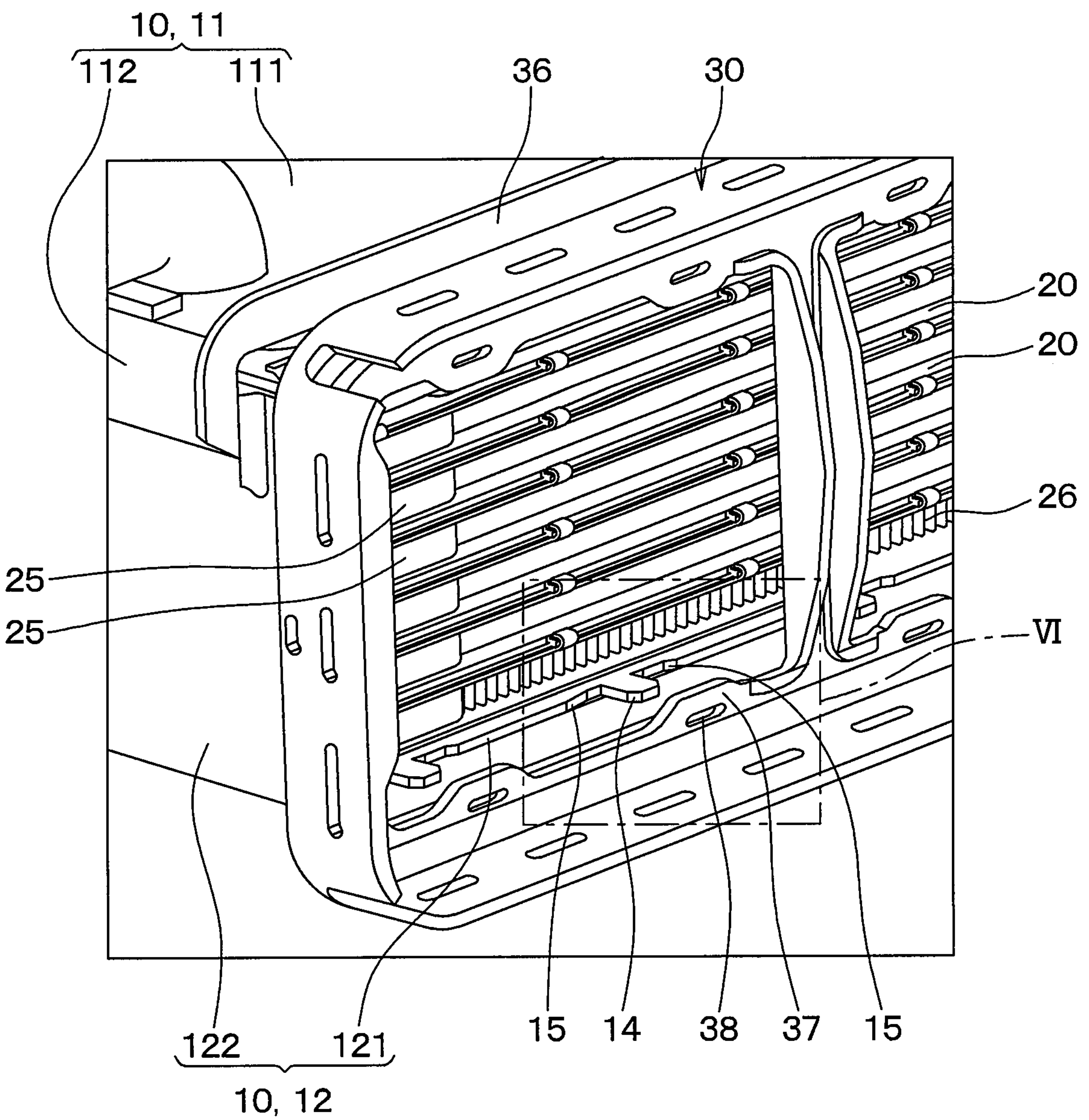

FIG. 6

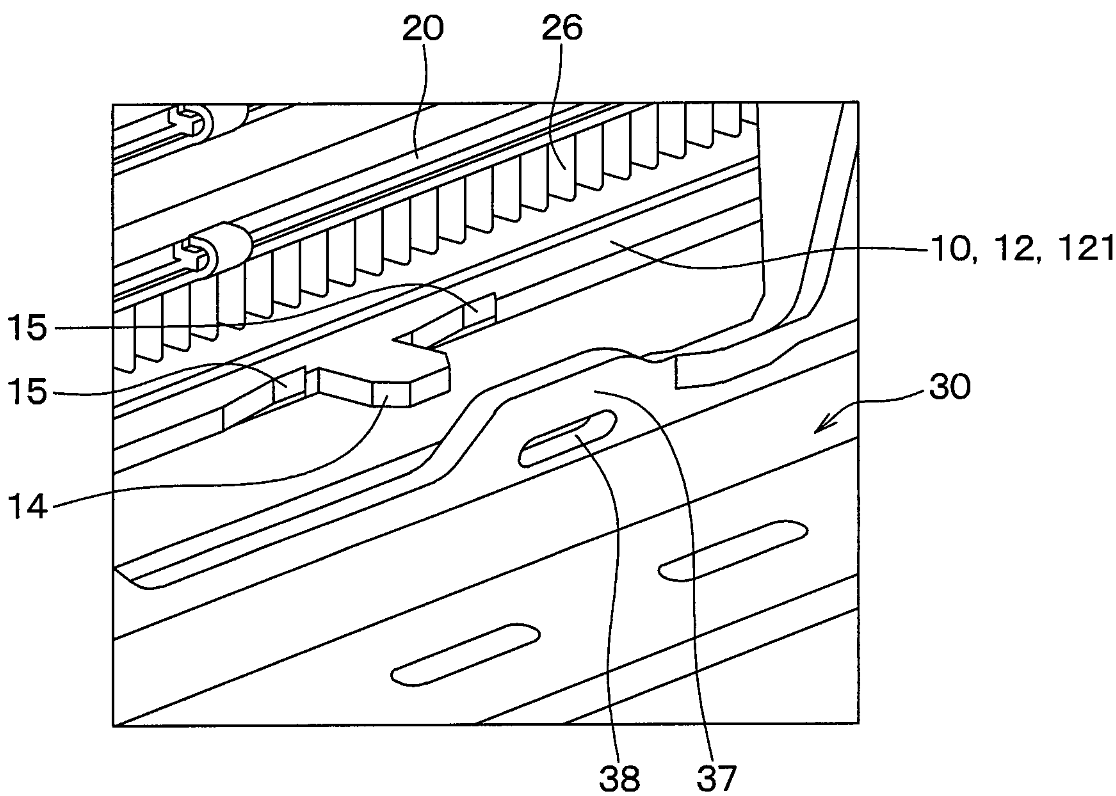

FIG. 7

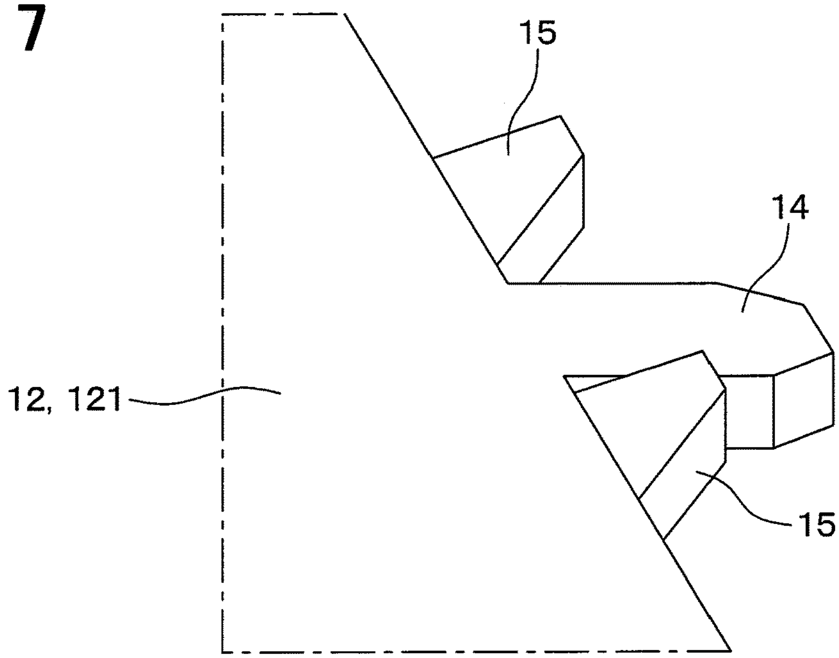

FIG. 8

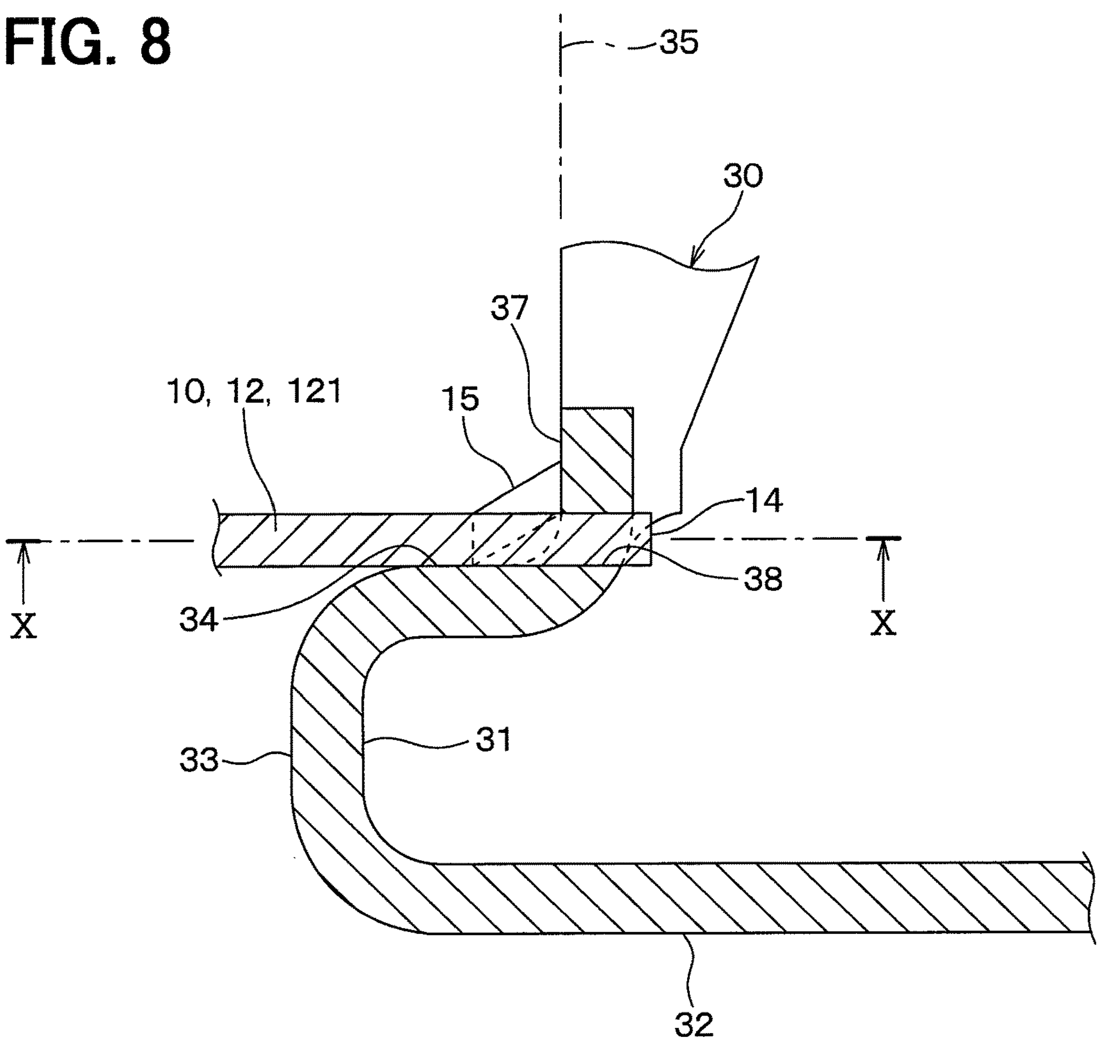

FIG. 9

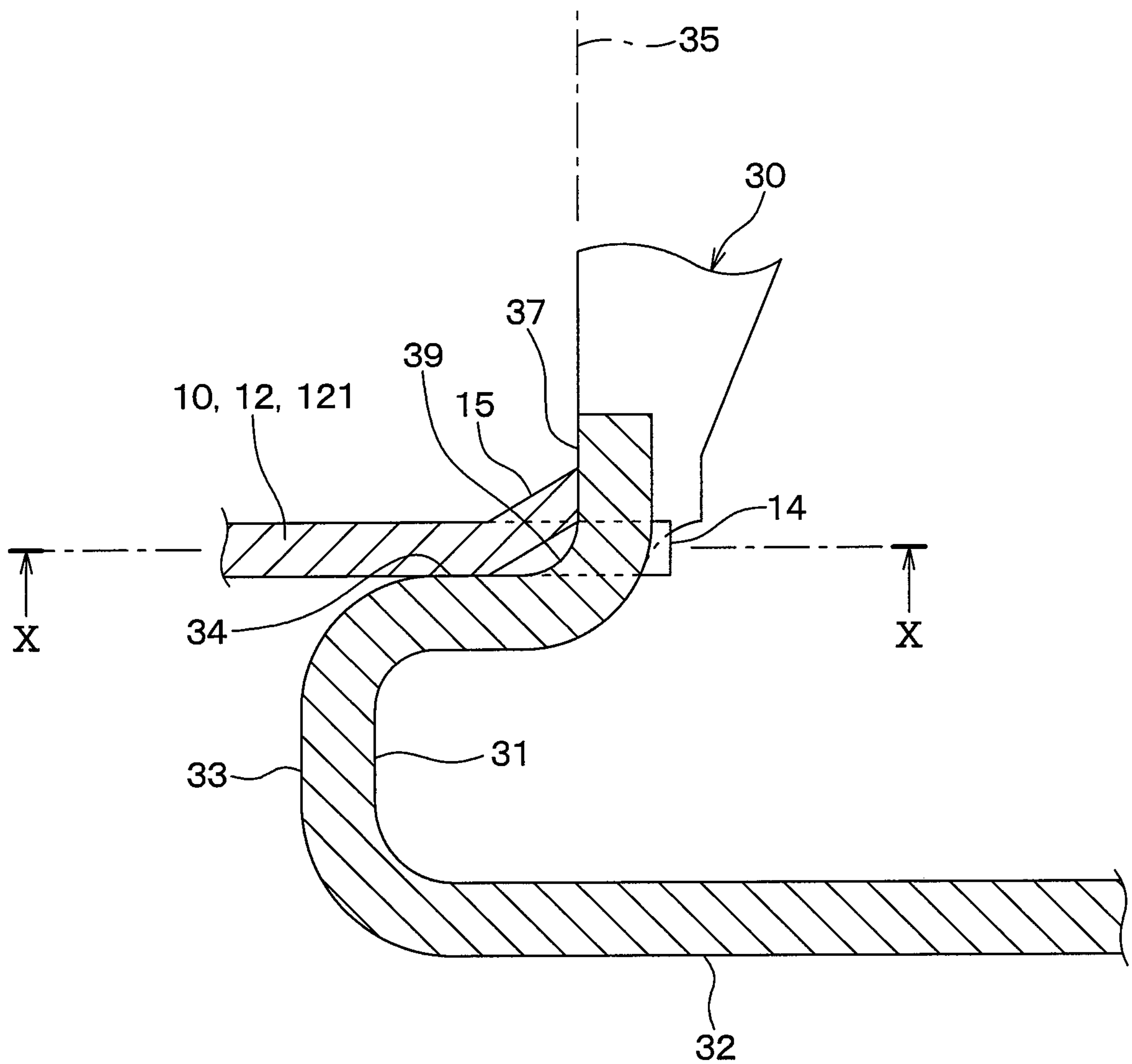

FIG. 10

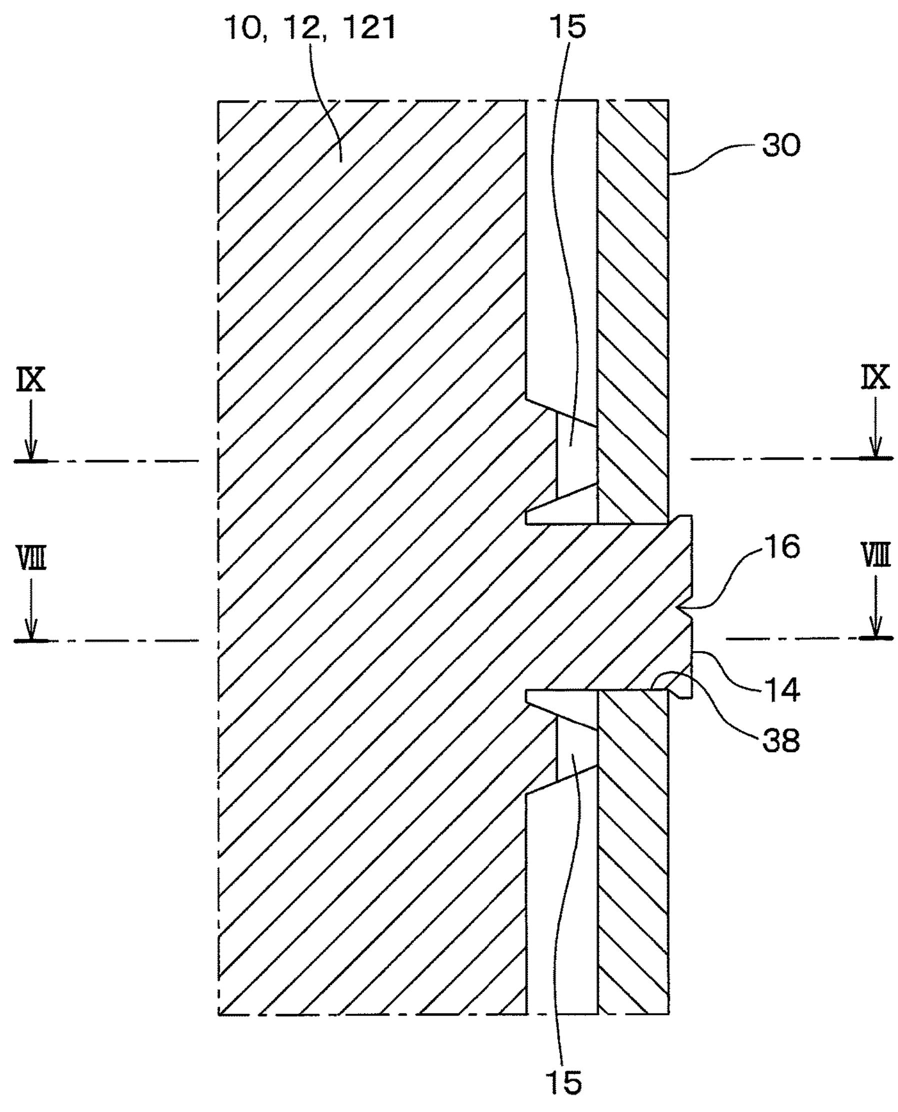

FIG. 11

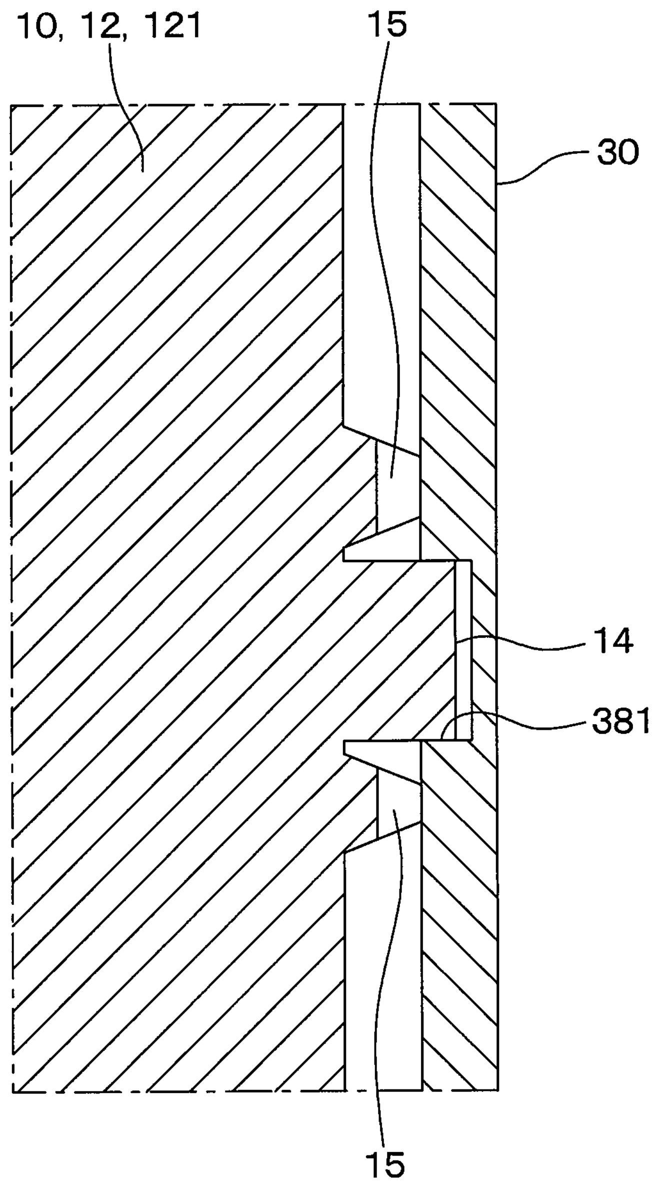

FIG. 12

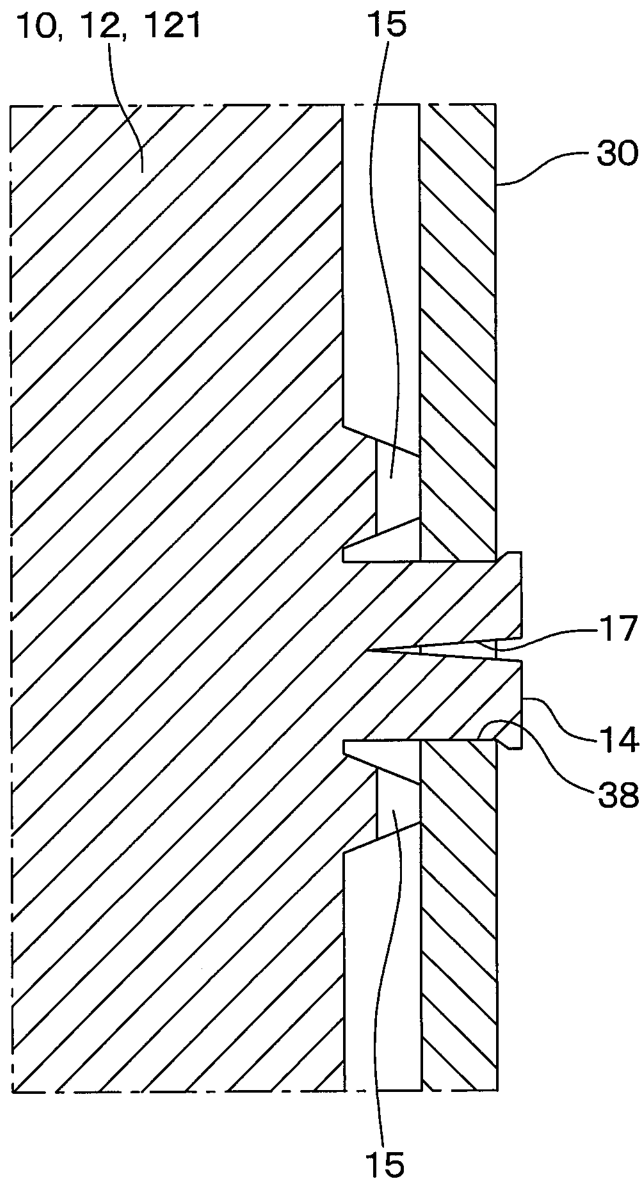

FIG. 13

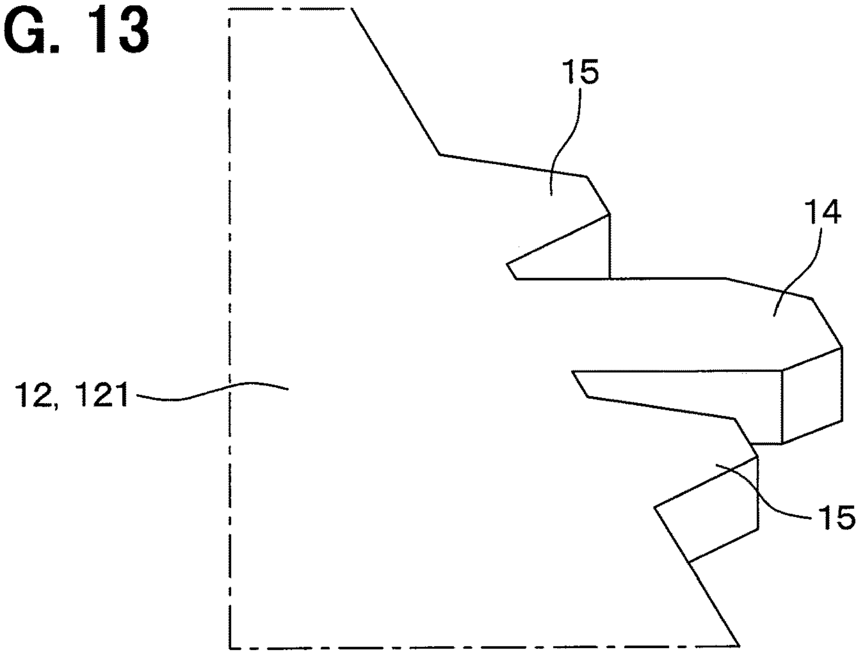

FIG. 14

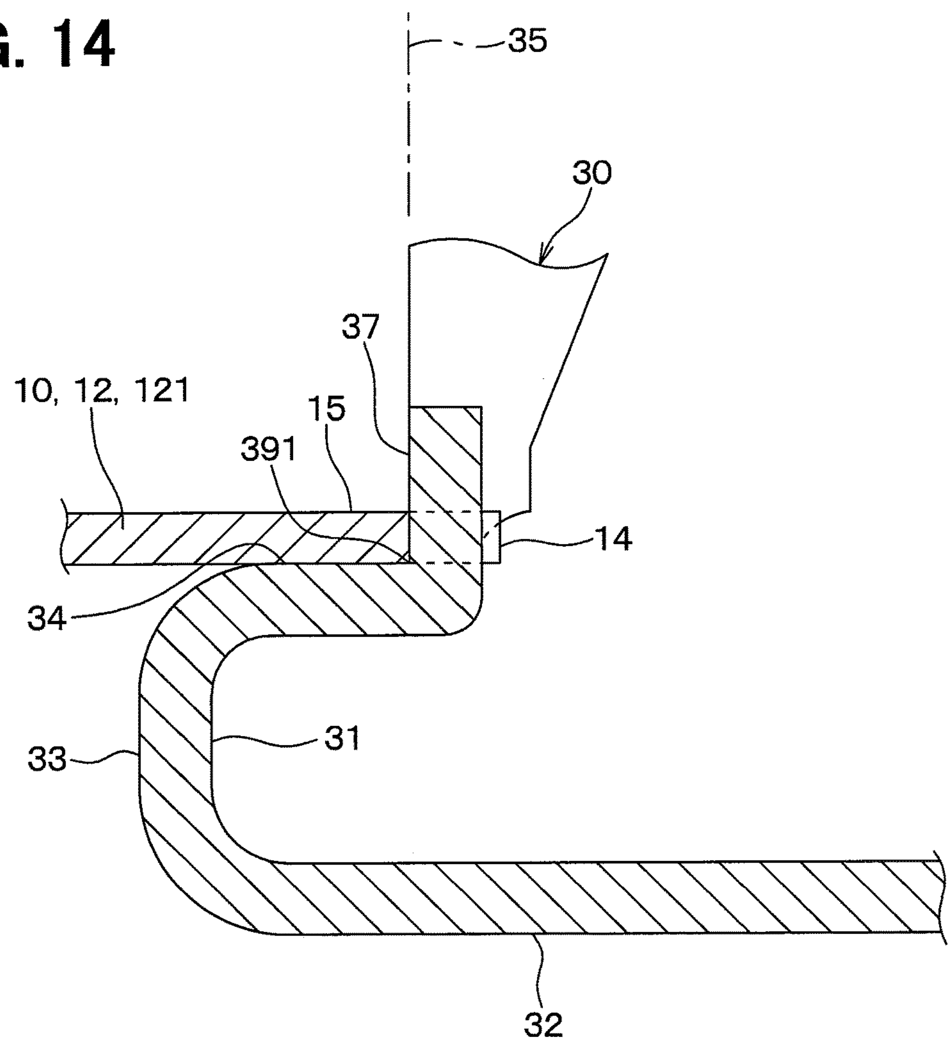

FIG. 15

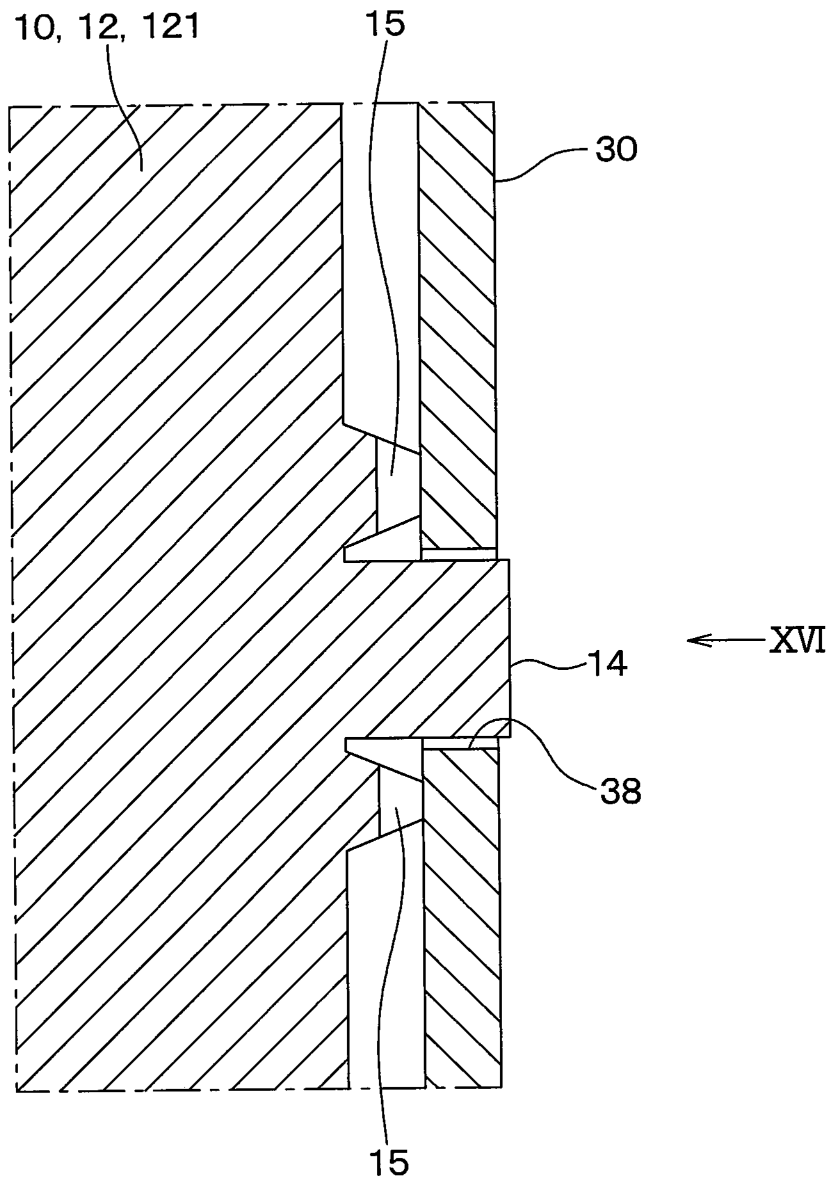

FIG. 16

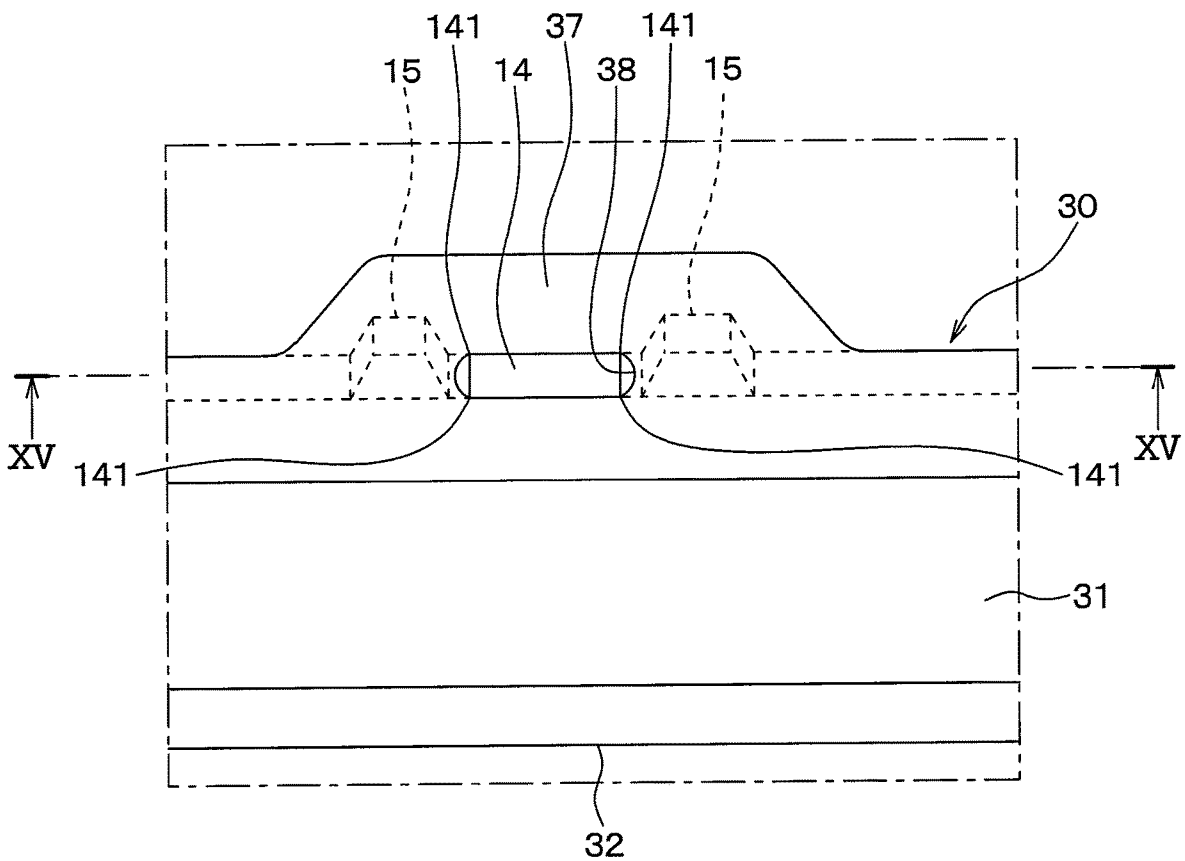

FIG. 17

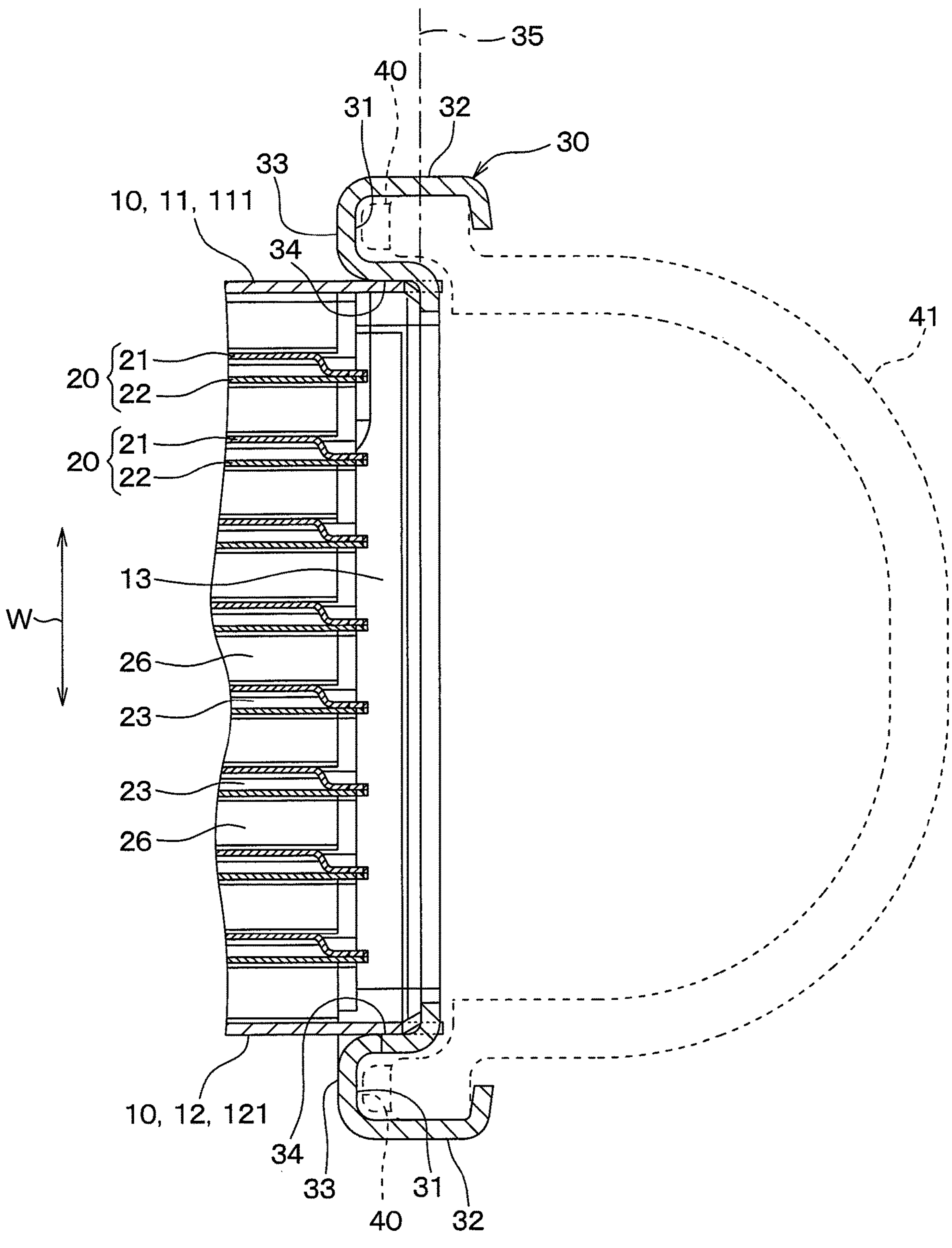
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FIG. 18

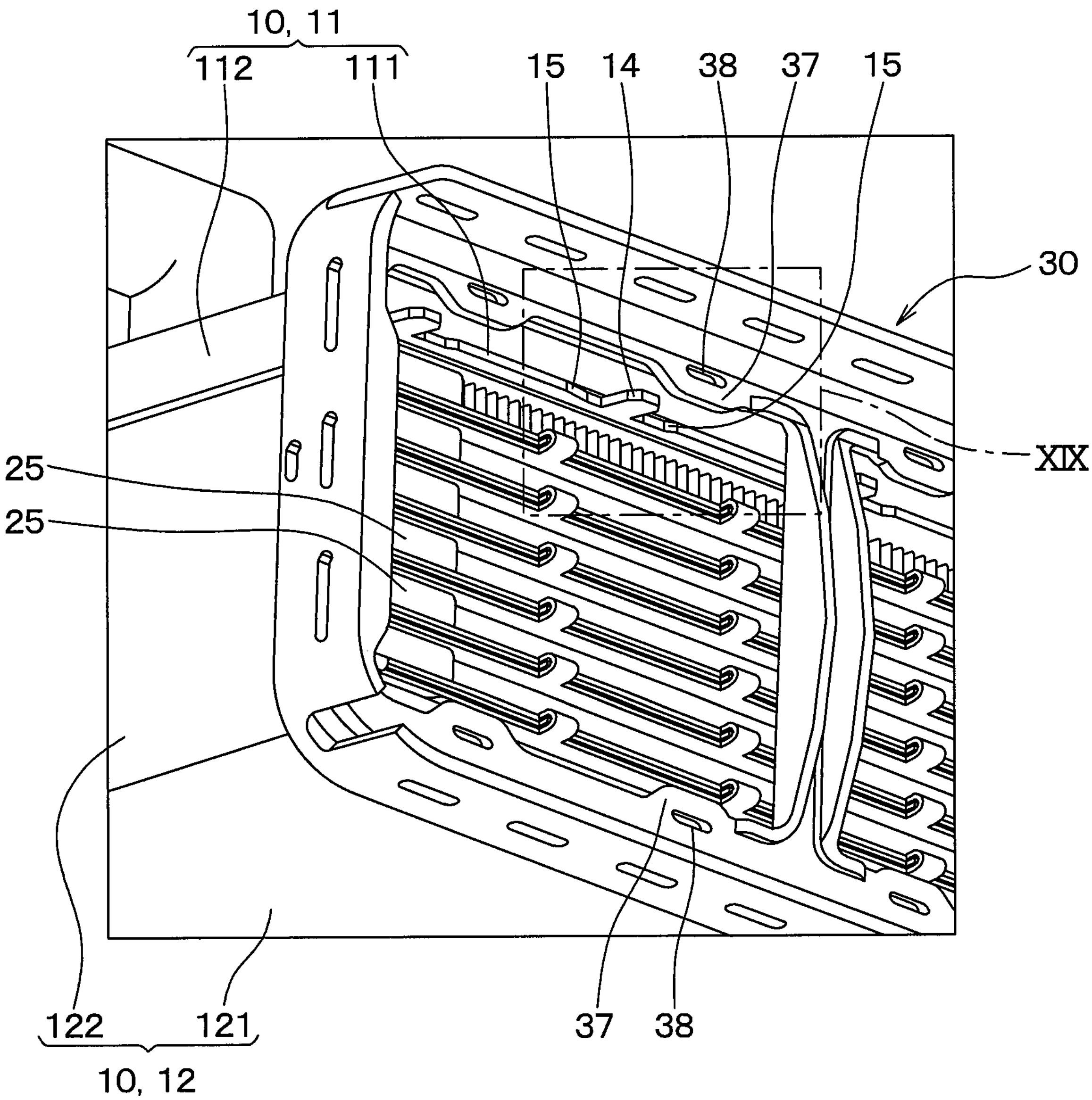


FIG. 19

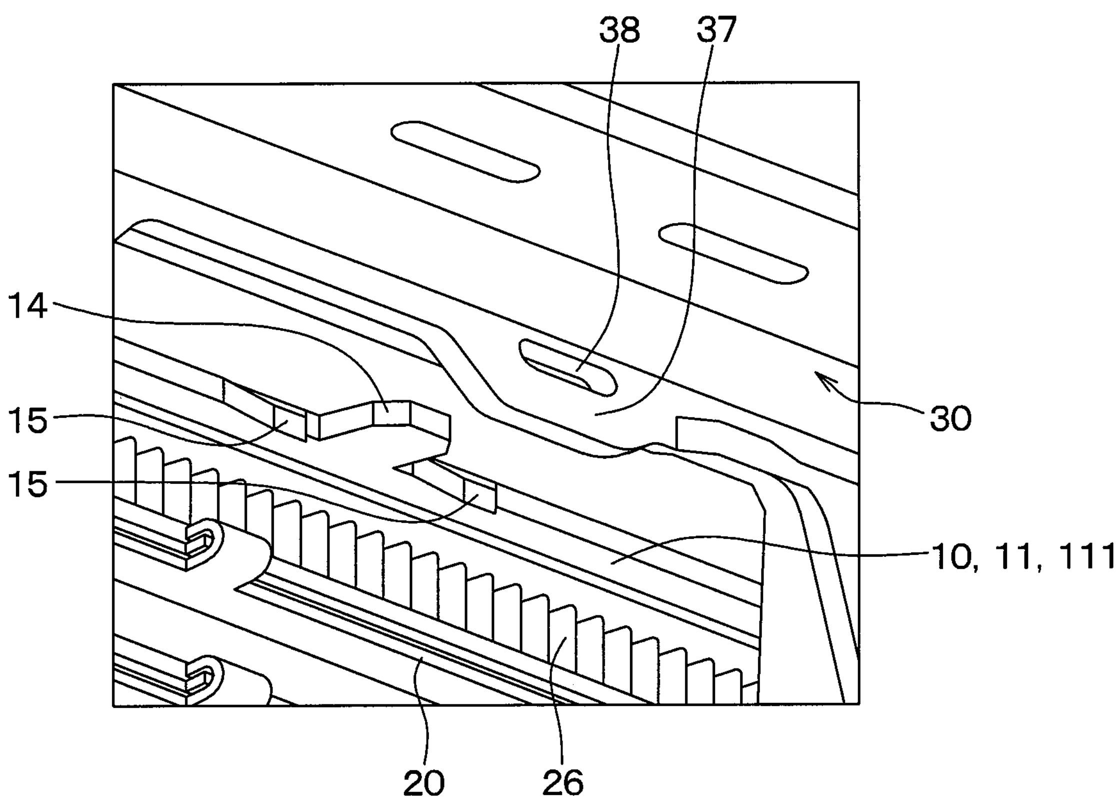


FIG. 20

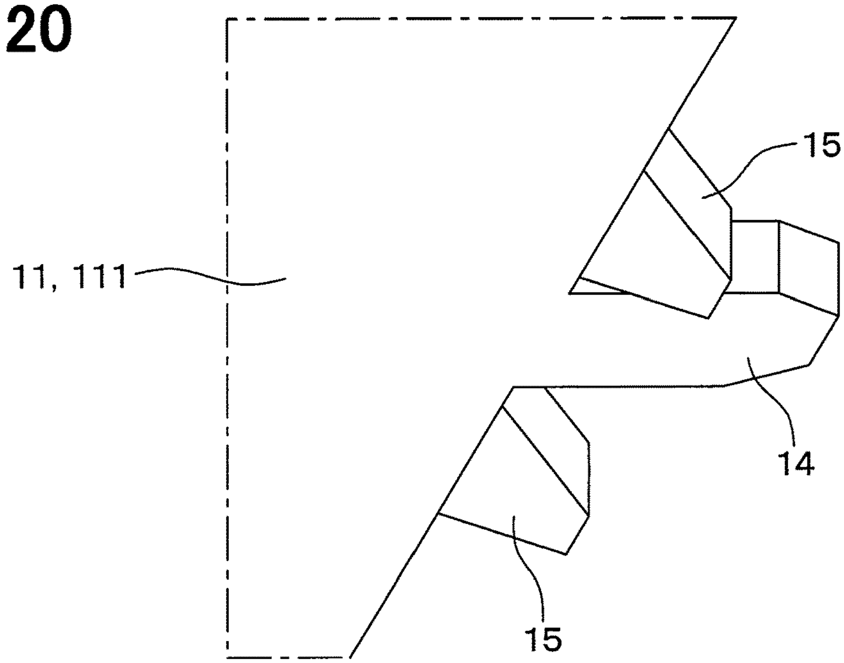


FIG. 21

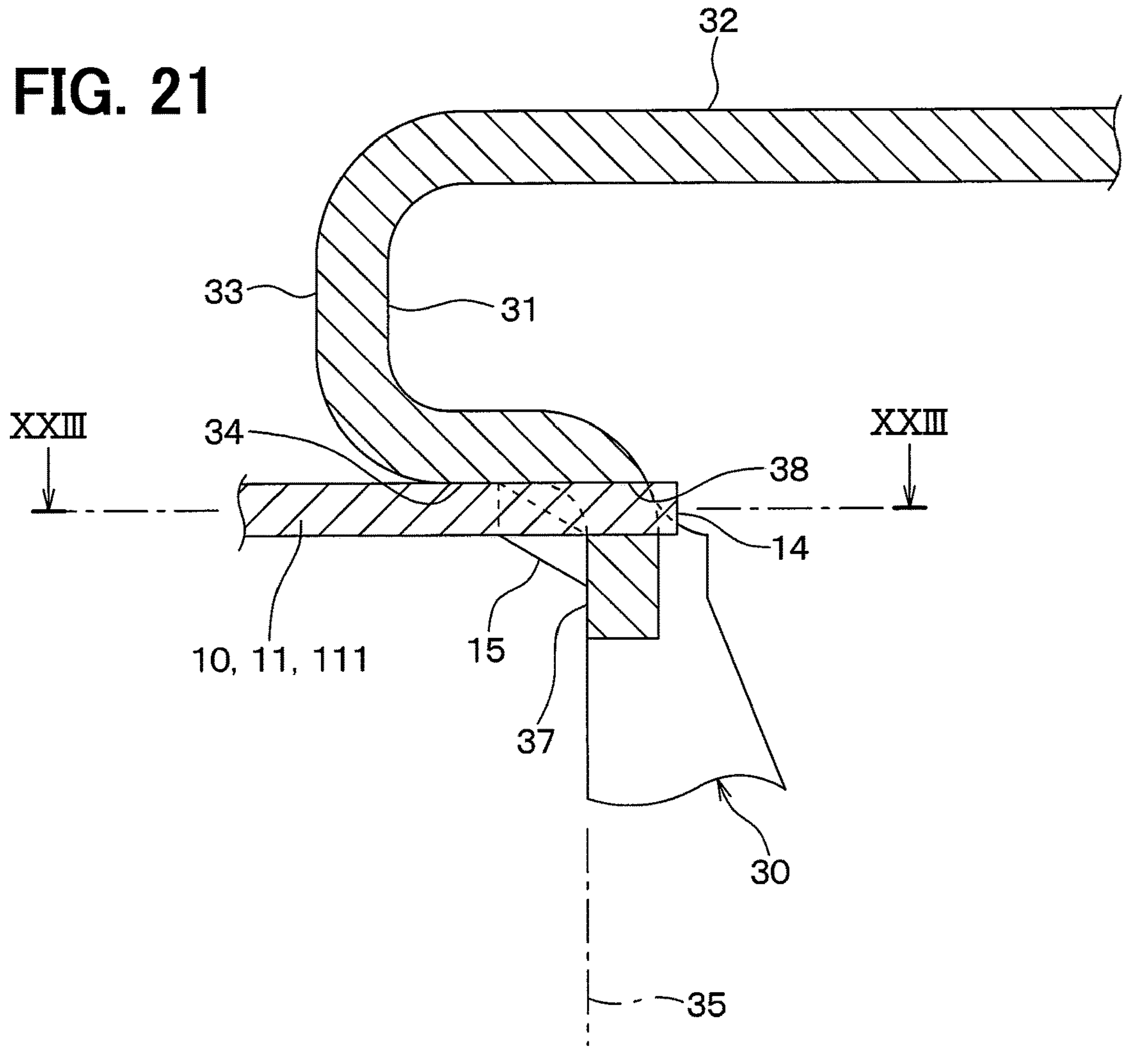


FIG. 22

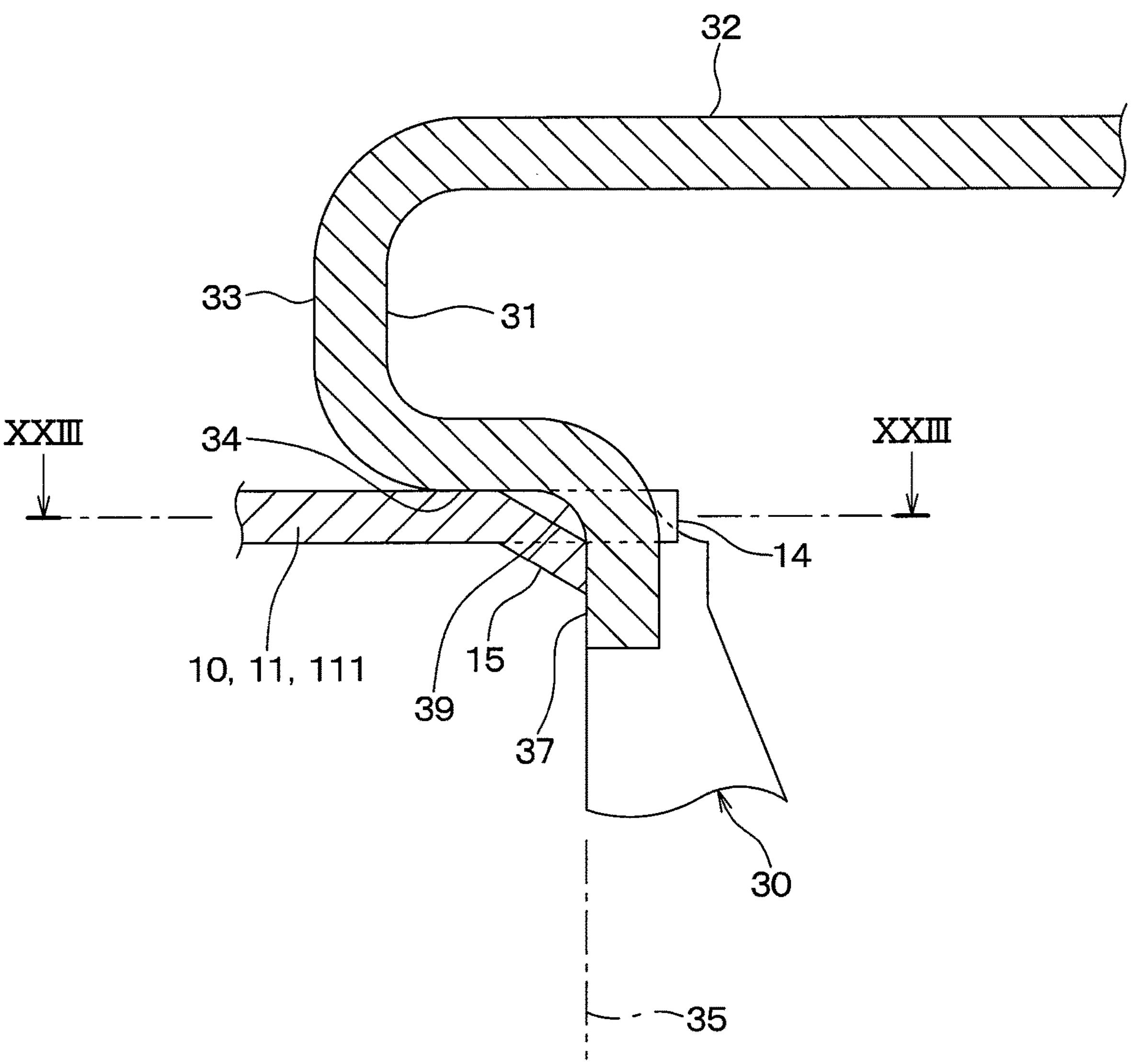
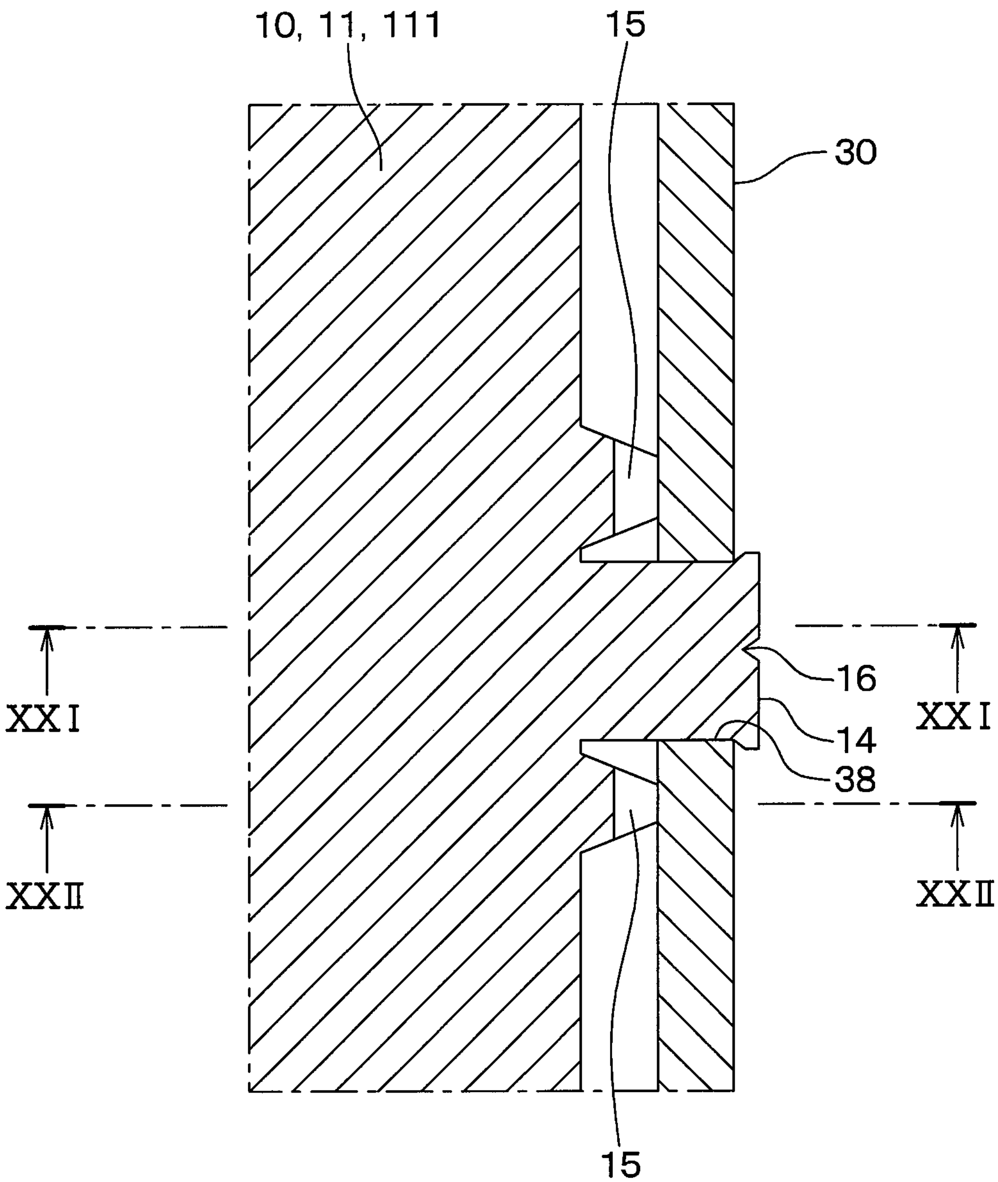


FIG. 23



HEAT EXCHANGER

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation application of International Patent Application No. PCT/JP2017/047109 filed on Dec. 27, 2017, which designated the United States and claims the benefit of priority from Japanese Patent Application No. 2017-020652 filed on Feb. 7, 2017. The entire disclosure of all of the above applications are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to a heat exchanger.

BACKGROUND ART

[0003] Conventionally, there is known a heat exchanger including a duct formed in a tubular shape and a plurality of flow path members stacked inside the duct, and performing heat exchange between a first fluid flowing through a first flow path formed inside the duct, and a second fluid flowing through a second flow path formed inside the plurality of flow paths.

SUMMARY OF THE INVENTION

[0004] In an aspect of the present disclosure, a heat exchanger that performs heat exchange between a first fluid and a second fluid, the heat exchanger including a first duct plate, a second duct plate, a plurality of flow path members, a frame member, an insertion protrusion, and a contact protrusion. The second duct plate is disposed to face the first duct plate. The second duct plate defines, together with the first duct plate, a first flow path for the first fluid to flow therethrough. The plurality of flow path members are stacked within the first flow path in a direction along which the first duct plate and the second duct plate face each other. Each of the plurality of flow path members defines a second flow path for the second fluid to flow therethrough. The frame member is disposed at an opening of the first flow path defined by the first duct plate and the second duct plate. The insertion protrusion protrudes toward the frame member from at least one of the first duct plate and the second duct plate and is inserted into an insertion hole defined in the frame member. The contact protrusion protrudes toward the frame member from the at least one of the first duct plate and the second duct plate. The contact protrusion is fixed to, and in contact with, the frame member.

[0005] In another aspect, a heat exchanger that performs heat exchange between a first fluid and a second fluid, the heat exchanger includes a first duct plate, a second duct plate, a plurality of flow path members, a frame member, an insertion protrusion, and a contact protrusion. The second duct plate is disposed to face the first duct plate. The second duct plate defines, together with the first duct plate, a first flow path for the first fluid to flow therethrough. The plurality of flow path members are stacked within the first flow path in a direction along which the first duct plate and the second duct plate face each other. Each of the plurality of flow path members defines a second flow path for the second fluid to flow therethrough. The frame member is disposed at an opening of the first flow path defined by the first duct plate and the second duct plate. The flange portion extends from the first duct plate in a direction along an opening face of the frame member. The flange portion is fixed to, and in contact with, the frame member. The insertion protrusion protrudes toward the frame member from the first duct plate and the second duct plate and is inserted into an insertion hole defined in the frame member. The contact protrusion protrudes toward the frame member from the second duct plate and is fixed to, and in contact with, the frame member.

BRIEF DESCRIPTION OF DRAWINGS

[0006] The above and other objects, features and advantages of the present disclosure will become more apparent from the following detailed description made with reference to the accompanying drawings.

[0007] FIG. **1** is a side view of a heat exchanger according to a first embodiment.

[0008] FIG. **2** is a view taken in a direction of arrow II of FIG. **1**.

[0009] FIG. **3** is a view taken in a direction of arrow III of FIG. **1**.

[0010] FIG. **4** is a cross-sectional view taken along line IV-IV of each of FIGS. **1** and **2**.

[0011] FIG. **5** is an exploded view of a duct and a caulking plate of the heat exchanger according to the first embodiment.

[0012] FIG. **6** is an enlarged view of portion VI of FIG. **5**.

[0013] FIG. **7** is a partially enlarged view of a second duct plate, an insertion protrusion, and a contact protrusion.

[0014] FIG. **8** is a partial cross-sectional view of the second duct plate, the insertion protrusion, and a caulking plate.

[0015] FIG. **9** is a partial cross-sectional view of the second duct plate, a contact protrusion, and the caulking plate.

[0016] FIG. **10** is a cross-sectional view taken along line X-X of each of FIGS. **8** and **9**.

[0017] FIG. **11** is a partial cross-sectional view of a heat exchanger according to a second embodiment.

[0018] FIG. **12** is a partial cross-sectional view of a heat exchanger according to a third embodiment.

[0019] FIG. **13** is a partially enlarged view of a second duct plate, an insertion protrusion, and a contact protrusion of a heat exchanger according to a fourth embodiment.

[0020] FIG. **14** is a partial cross-sectional view of the second duct plate, the contact protrusion, and a caulking plate.

[0021] FIG. **15** is a partial cross-sectional view of a heat exchanger according to a fifth embodiment.

[0022] FIG. **16** is a view taken along a direction of arrow XVI of FIG. **15**.

[0023] FIG. **17** is a partial cross-sectional view of a heat exchanger according to a sixth embodiment.

[0024] FIG. **18** is an exploded view of a duct and a caulking plate of the heat exchanger according to the sixth embodiment.

[0025] FIG. **19** is an enlarged view of portion XIX of FIG. **18**.

[0026] FIG. **20** is a partially enlarged view of a first duct plate, an insertion protrusion, and a contact protrusion.

[0027] FIG. **21** is a partial cross-sectional view of the first duct plate, the insertion protrusion, and a caulking plate.

[0028] FIG. **22** is a partial cross-sectional view of the first duct plate, the contact protrusion, and the caulking plate.

[0029] FIG. **23** is a cross-sectional view taken along line XXIII-XXIII of each of FIGS. **21** and **22**.

DESCRIPTION OF EMBODIMENTS

[0030] Embodiments of the present disclosure will be described below with reference to accompanying drawings. Each of the embodiments below will be described by denoting the same or equivalent portions with the same reference numerals.

[0031] There is a conventional heat exchanger (a first conventional heat exchanger) that is an intercooler mounted on a vehicle to perform heat exchange between supercharged air as a first fluid compressed by a supercharger and cooling water as a second fluid. This heat exchanger includes a caulking plate as a frame member that is fixed by brazing to an opening of a duct formed in a tubular shape. An air intake tank is fixed by caulking to the caulking plate. The air intake tank is connected to an intake pipe for introducing intake air into an internal combustion engine.

[0032] Such a heat exchanger includes a groove that is recessed in a direction orthogonal to an opening face of the caulking plate, and that is provided in a face of the caulking plate, opposite to the air intake tank. The duct and the caulking plate are fixed by brazing while an end portion of the duct is inserted into the groove.

[0033] Meanwhile, another type of a conventional heat exchanger (a second conventional heat exchanger) also includes a groove provided in a caulking plate, into which an end portion of a duct is inserted. In addition, the heat exchanger is configured such that the duct and the caulking plate are fixed by brazing while an insertion protrusion extending from the end portion of the duct is inserted into an insertion hole provided in a bottom of the groove of the caulking plate.

[0034] As a result of detailed studies performed by the present inventors and others, the following problems have been found in the conventional heat exchangers. That is, the first conventional heat exchanger described above is configured such that a bottom of the groove provided in the caulking plate is not in contact with an opening end portion of the duct to form a gap therebetween. In other words, the heat exchanger is configured such that the duct and the caulking plate are allowed to be relatively moved in the direction orthogonal to the opening face of the caulking plate.

[0035] The second conventional heat exchanger described above also has a problem in structure such that it is difficult to accurately determine the amount of insertion of the insertion protrusion extending from the end portion of the duct into the insertion hole of the caulking plate. Thus, the duct and the caulking plate are allowed to be relatively moved in the direction orthogonal to the opening face of the caulking plate. As a result, each of the first and second heat exchangers has a variation in a positional relationship between the duct and the caulking plate, so that mountability to a vehicle may be deteriorated.

First Embodiment

[0036] The first embodiment will be described with reference to the drawings. A heat exchanger of the present embodiment is a water-cooled intercooler mounted on a vehicle, for example. The intercooler is mounted on an air intake system of an internal combustion engine (not illustrated) to perform heat exchange between supercharged air as a first fluid compressed by a supercharger and cooling water as a second fluid. The intercooler adjusts the supercharged air to a target temperature to improve filling efficiency of air intake of the internal combustion engine.

[0037] The configuration of the intercooler will be described.

[0038] As illustrated in FIGS. **1** to **4**, an intercooler **1** is a so-called drone cup type heat exchanger in which a plurality of cooling plates **20**, a plurality of outer fins **26**, and the like are stacked inside a substantially square tubular duct **10**.

[0039] Components of the intercooler **1** are each made of a clad material obtained by rolling and bonding a brazing material on a surface of aluminum, for example. The components are bonded to each other by brazing by being heated while a surface of the clad material is coated with flux.

[0040] The duct **10** is formed in a substantially square tubular shape in which a first duct plate **11** and a second duct plate **12** disposed facing the first duct plate **11** are bonded to each other, and an air flow path **13** as a first flow path is formed inside the duct **10**. Specifically, the first duct plate **11** mainly includes a rectangular top plate **111** and two side plates **112** extending substantially perpendicularly from respective sides of the top plate **111**. The second duct plate **12** mainly includes a rectangular bottom plate **121** and two side plates **122** extending substantially perpendicularly from respective sides of the bottom plate **121**. The first duct plate **11** and the second duct plate **12** are bonded to each other while each of the side plates **122** of the second duct plate **12** partially overlaps with the inside of the corresponding one of the side plates **112** of the first duct plate **11**.

[0041] The air flow path **13** formed inside the duct **10** has one opening and the other opening in an air flow direction each of which is provided with a caulking plate **30** as a frame member. The caulking plate **30** is formed in a rectangular frame shape. As illustrated in FIG. **4**, an intake tank **41** is caulked and fixed to the caulking plate **30** with packings **40** interposed therebetween. In FIG. **4**, the packings **40** and the intake tank **41**, being caulked and fixed to the caulking plate **30**, are indicated by broken lines. The caulking plate **30** includes holding grooves **31** for holding the packings **40** and ends of the intake tank **41**. The caulking plate **30** also includes outer peripheral walls **32** positioned on both outer peripheral sides of the rectangular frame shape, facing walls **33** facing the packing **40** and the intake tank **41**, and inner peripheral walls **34** positioned on the inner peripheral sides of the rectangular frame shape. In addition, the caulking plate **30** includes the holding groove **31** defined by the outer peripheral wall **32**, the facing wall **33**, and the inner peripheral wall **34**. The outer peripheral wall **32** of the caulking plate **30** is bent to the inner peripheral side while the packing **40** and the end of the intake tank **41** are inserted inside the holding groove **31** of the caulking plate **30**, and then the intake tank **41** is caulked and fixed to the caulking plate **30**.

[0042] As described above, the intake tank **41** is provided at each of the one opening and the other opening of the air flow path **13** formed inside the duct **10**. When the intercooler **1** is mounted on a vehicle, those intake tanks **41** are each connected to an intermediate portion of an intake pipe (not illustrated) that allows a super charger (not illustrated) to communicate with the internal combustion engine. Thus, supercharged air compressed by the super charger passes through the intake pipe, and flows in the air flow path **13** formed inside the duct **10** from one of the intake tanks **41** to be supplied to the internal combustion engine from the other of the intake tanks **41** through the intake pipe.

[0043] In the duct **10**, cooling plates **20** as a plurality of flow path members, a plurality of spacer plates **25**, a plurality of outer fins **26**, and the like are stacked. In the following description, a direction in which the plurality of cooling plates **20** is stacked is referred to as a stacking direction W. As illustrated in FIG. **4**, the top plate **111** of the first duct plate **11** is disposed on one side in the stacking direction W. The bottom plate **121** of the second duct plate **12** is disposed on the other side in the stacking direction W.

[0044] Each of the plurality of cooling plates **20** includes a first plate **21** and a second plate **22** that are each pressed into a predetermined shape. Each of the cooling plates **20** may be formed by bending a single plate, which is pressed into a predetermined shape, at the center of the plate and stacking the bent portions. Between the first plate **21** and the second plate **22**, a cooling water flow path **23** as a second flow path is formed.

[0045] As illustrated in FIG. **1**, the spacer plate **25** in a plate-like shape is provided between the cooling plates **20**. The spacer plate **25** includes a hole (not illustrated) passing through in the stacking direction W. The cooling plate **20** also includes a hole (not illustrated) passing through in the stacking direction W at a position corresponding to the hole of the spacer plate **25**. The hole of the spacer plate **25** and the hole of the cooling plate **20** communicate with each other to form two communicating passages (not illustrated).

[0046] As illustrated in FIGS. **1** to **3**, the first duct plate **11** includes an inlet pipe **42** for supplying cooling water to the cooling water flow path **23** formed in the cooling plate **20**, and an outlet pipe **43** for draining the cooling water from the cooling water flow path **23**. The cooling water supplied from the inlet pipe **42** passes through one of the communicating passages, and flows through the cooling water flow paths **23** formed in the respective cooling plates **20** to flow out from the outlet pipe **43** through the other of the communicating passages.

[0047] Between the cooling plates **20**, the outer fin **26** is provided at a position excluding the spacer plate **25**. The outer fin **26** promotes heat exchange between the supercharged air and the cooling water.

[0048] The above-described configuration allows the intercooler **1** to perform heat exchange between the supercharged air flowing through the air flow path **13** in the duct **10** and the cooling water flowing through the cooling water flow path **23** in the plurality of cooling plates **20** to adjust the supercharged air to a desired temperature.

[0049] Next, a method of connecting the duct **10** and the caulking plate **30** in the configuration of the intercooler **1** described above will be described in detail.

[0050] As illustrated in FIG. **4**, the first duct plate **11** is provided at its end with a flange portion **36** extending in a direction along an opening face **35** of the caulking plate **30**. The flange portion **36** is provided on each of the top plate **111** and the side plate **112** of the first duct plate **11**. The flange portion **36** is fixed to, and in contact with, the facing wall **33** of the caulking plate **30**. Before brazing is performed in the manufacturing process of the intercooler **1**, the flange portion **36** and the facing wall **33** of the caulking plate **30** are relatively movable along the opening face **35**. When the brazing is performed in the manufacturing process, a bonded portion between the flange portion **36** and the facing wall **33** of the caulking plate **30** serves as a sealing face that prevents the supercharged air from leaking from the air flow path **13**. The intercooler **1** is provided with the flange portion **36** at the end of the first duct plate **11**, so that the following effects are achieved during the brazing in the manufacturing process when many steps of the cooling plate **20** (e.g., in the case of ten or more steps) are provided. That is, the intercooler **1** is configured such that even when the plurality of cooling plates **20** changes in dimensions in the stacking direction W due to melting of the brazing material provided on each of the cooling plates **20** or the like, the first duct plate **11** and the caulking plate **30** are displaceable in the stacking direction W by following the dimensional change. Thus, the intercooler **1** can prevent brazing defects of the plurality of cooling plates **20**, the duct **10**, and the like from occurring.

[0051] Meanwhile, the second duct plate **12** is fixed at its end to the inner peripheral wall **34** of the caulking plate **30**. Before brazing is performed in the manufacturing process of the intercooler **1**, the end of the second duct plate **12** and the inner peripheral wall **34** of the caulking plate **30** can be relatively moved in a direction intersecting the opening face **35**. When the brazing is performed in the manufacturing process, a bonded portion between the end of the second duct plate **12** and the inner peripheral wall **34** of the caulking plate **30** serves as a sealing face that prevents the supercharged air from leaking from the air flow path **13**.

[0052] As illustrated in FIGS. **5** to **7**, the second duct plate **12** is provided at its end with insertion protrusions **14** and contact protrusions **15** that protrude from the second duct plate **12** toward the caulking plate **30**. The second duct plate **12**, the insertion protrusions **14** and the contact protrusions **15** are integrally formed of the same base material. The contact protrusions **15** are provided on both sides of each insertion protrusion **14**. Each of the contact protrusion **15** extends from the second duct plate **12** so as to be tilted toward one side in a thickness direction of the second duct plate **12**. Specifically, the contact protrusion **15** extends from the second duct plate **12** so as to be tilted circumferentially inward of the caulking plate **30**. As shown in FIG. **8**, the contact protrusion **15** has an end surface having a normal line that intersects the thickness direction of the contact protrusion **14**.

[0053] Meanwhile, the caulking plate **30** is provided with stopper walls (or stopper plane walls) **37** extending from the inner peripheral wall **34** toward the inside of the rectangular frame shape. Each of the stopper wall **37** is provided at a position corresponding to the contact protrusions **15** of the second duct plate **12**. The stopper wall **37** has a normal line extending along the thickness direction of the caulking plate **30**. The stopper wall **37** is provided with an insertion hole **38** passing through in its thickness direction. That is, the stopper wall **37** is provided around the insertion hole **38** in the caulking plate **30**. The insertion hole **38** is provided at a position of the stopper wall **37** corresponding to the insertion protrusion **14** of the second duct plate **12**. The insertion hole **38** provided in the stopper wall **37** is a through hole allowing the insertion protrusion **14** to pass through the through hole.

[0054] FIGS. **8** to **10** each illustrate a state where the insertion protrusion **14** extending from the second duct plate **12** is inserted into the insertion hole **38** of the caulking plate **30**, and the stopper wall **37** of the caulking plate **30** and the contact protrusion **15** are in contact with each other. More specifically, the end surface of the contact protrusion **15** is brought into contact with the stopper wall **37** of the caulking plate **30** when the contact protrusion **15** is fixed to the caulking plate **30**.

[0055] Inserting the insertion protrusion **14** extending from the second duct plate **12** into the insertion hole **38** of the caulking plate **30** enables the caulking plate **30** and the second duct plate **12** to be positioned in a direction parallel to the opening face **35** of the caulking plate **30**.

[0056] Bringing the stopper wall **37** of the caulking plate **30** and the contact protrusions **15** extending from the second duct plate **12** into contact with each other enables the amount of insertion of the insertion protrusion **14** into the insertion hole **38** of the caulking plate **30** to be accurately determined.

[0057] As described above, when the flange portion **36** provided on the first duct plate **11** is brought into contact with the facing wall **33** of the caulking plate **30**, the caulking plate **30** and the first duct plate **11** are positioned in a direction intersecting the opening face **35** of the caulking plate **30**. When the contact protrusions **15** extending from the second duct plate **12** are brought into contact with the stopper wall **37** of the caulking plate **30**, the caulking plate **30** and the second duct plate **12** are positioned in the direction intersecting the opening face **35** of the caulking plate **30**. Thus, this configuration enables the intercooler **1** to prevent a variation in angle formed between the duct **10** and the caulking plate **30**.

[0058] As illustrated in FIG. **9**, a connection portion **39** between the inner peripheral wall **34** and the stopper wall **37** in the caulking plate **30** may be curved by bending. Accordingly, the contact protrusions **15** extend from the second duct plate **12** so as to be tilted toward one side in the thickness direction of the second duct plate **12**. Specifically, the contact protrusions **15** extend from the second duct plate **12** so as to be tilted circumferentially inward of the caulking plate **30**. Accordingly, the contact protrusions **15** are prevented from being brought into contact with the connection portion **39** formed as a curved face. Thus, positioning accuracy between the second duct plate **12** and the caulking plate **30** is increased.

[0059] FIG. **10** illustrates a state where the insertion protrusion **14** is split and caulked after the insertion protrusion **14** of the second duct plate **12** is inserted into the insertion hole **38** of the caulking plate **30**. Caulking by splitting refers to a way in which a load is applied to a part **16** in a portion exposed from the insertion hole **38**, in the insertion protrusion **14**, with a jig or the like, which is not illustrated, to deform a shape of a tip portion of the insertion protrusion **14**, thereby preventing the insertion protrusion **14** from coming off from the insertion hole **38**.

[0060] As described above, while the caulking plate **30** and the duct **10** are positioned, the duct **10**, the cooling plates **20**, the caulking plate **30**, the flange portion **36**, the insertion protrusions **14**, the contact protrusions **15**, the inlet pipe **42**, the outlet pipe **43**, and the like are installed in a heating furnace (not illustrated). Then, each component is fixed by brazing in the heating furnace. Accordingly, the intercooler **1** is manufactured.

[0061] The intercooler **1** of the present embodiment described above achieves the following effects.

[0062] (1) In the present embodiment, the flange portion **36** extending from the first duct plate **11** along the opening face **35** is fixed to, and in contact with, the caulking plate **30**. The insertion protrusions **14** protruding from the second duct plate **12** are inserted into the insertion holes **38** of the caulking plate **30** and fixed while the contact protrusions **15** are in contact with the stopper walls **37** of the caulking plate **30**.

[0063] Accordingly, when the insertion protrusions **14** are inserted into the insertion holes **38**, positional displacement between the second duct plate **12** and the caulking plate **30** in the direction parallel to the opening face **35** of the caulking plate **30** is further prevented. In addition, when the flange portion **36** is brought into contact with the caulking plate **30** and the contact protrusions **15** are brought into contact with the stopper walls **37**, a variation in angle formed between the duct **10** and the caulking plate **30** is prevented. Thus, the intercooler **1** can improve positioning accuracy between the duct **10** and the caulking plate **30**.

[0064] In the present embodiment, the flange portion **36** extends in the direction along the opening face **35** of the caulking plate **30**. Thus, the intercooler **1** has an advantageous effect during brazing in the manufacturing process. That is, the intercooler **1** is configured such that even when the plurality of cooling plates **20** changes in dimensions in the stacking direction W due to melting of the brazing material provided on each of the cooling plates **20** or the like, the first duct plate **11** and the caulking plate **30** are displaceable in the stacking direction W by following the dimensional change. Thus, the intercooler **1** can prevent brazing defects of the plurality of cooling plates **20**, the duct **10**, and the like from occurring. This is effective when many steps of the cooling plate **20** (e.g., in the case of ten or more steps) are provided.

[0065] (2) In the present embodiment, the insertion hole **38** is a through hole allowing the insertion protrusion **14** to pass through the through hole.

[0066] Accordingly, positional displacement between the second duct plate **12** and the caulking plate **30** in the direction parallel to the opening face **35** of the caulking plate **30** can be prevented. In addition, it can be visually recognized from the outer side of the caulking plate **30** that the insertion protrusion **14** is securely inserted into the insertion hole **38**.

[0067] (3) In the present embodiment, the insertion protrusion **14** is split and caulked while being inserted into the insertion hole **38**.

[0068] Accordingly, the insertion protrusion **14** is prevented from coming off from the insertion hole **38**, so that a state where the contact protrusions **15** and the stopper wall **37** are in contact with each other can be maintained. Thus, a variation in angle formed between the duct **10** and the caulking plate **30** can be prevented.

[0069] (4) In the present embodiment, the contact protrusions **15** are in contact with the stopper wall **37** provided around the insertion hole **38** in the caulking plate **30**.

[0070] Accordingly, the stopper wall **37** provided around the insertion hole **38** in the caulking plate **30** is used as a portion with which the contact protrusions **15** are brought into contact, so that the caulking plate **30** can be simplified in structure.

[0071] (5) In the present embodiment, the contact protrusions **15** are provided on both sides of the insertion protrusion **14**.

[0072] Accordingly, a load applied to the caulking plate **30** is absorbed by the contact protrusions **15** when the insertion protrusion **14** is split and caulked, so that deformation and the like of the caulking plate **30** can be suppressed.

[0073] (6) In the present embodiment, the contact protrusions **15** extend from the second duct plate **12** so as to be tilted circumferentially inward of the caulking plate **30** toward one side in the thickness direction of the second duct plate **12**.

[0074] Accordingly, the contact protrusions **15** and the stopper wall **37** are brought into contact with each other at places away from the connection point **39** between the inner peripheral wall **34** and the stopper wall **37**. Thus, even when the connection portion **39** between the inner peripheral wall **34** of the caulking plate **30** and the stopper wall **37** is curved by bending, the contact protrusions **15** are prevented from being brought into contact with the connection portion **39** formed as a curved face. As a result, the intercooler **1** can prevent a variation in angle formed between the duct **10** and the caulking plate **30** and improve the positioning accuracy between the duct **10** and the caulking plate **30**.

[0075] (7) In the present embodiment, the first duct plate **11**, the second duct plate **12**, the plurality of flow path members, the caulking plate **30**, the flange portion **36**, the insertion protrusion **14**, the contact protrusions **15**, and the like are fixed by brazing.

[0076] Accordingly, the intercooler **1** can improve the positioning accuracy between the duct **10** and the caulking plate **30**, and prevent supercharged air from leaking from the connection portion **39** between the duct **10** and the caulking plate **30**.

Second Embodiment

[0077] A second embodiment will be described. The second embodiment is different from the first embodiment in a part of a method of connecting the duct **10** and the caulking plate **30**, and is similar to the first embodiment in other portions. Thus, only portions different from those of the first embodiment will be described.

[0078] As illustrated in FIG. **11**, in the second embodiment, an insertion hole **381** provided in a stopper wall **37** of a caulking plate **30** is a hole with a dead end formed in a middle of the caulking plate **30** in a thickness direction of the caulking plate **30**. An insertion protrusion **14** of a second duct plate **12** is inserted into the insertion hole **381**. Even this structure enables preventing positional displacement between the second duct plate **12** and the caulking plate **30** in a direction parallel to an opening face **35** of the caulking plate **30** using fitting between the insertion protrusion **14** and the insertion hole **381**. Thus, the second embodiment can also achieve operation effects similar to those of the first embodiment.

Third Embodiment

[0079] A third embodiment will be described. The third embodiment is also different from the first embodiment in a part of a method of connecting the duct **10** and the caulking plate **30**, and is similar to the first embodiment in other portions. Thus, only portions different from those of the first embodiment will be described.

[0080] FIG. **12** illustrates a state where an insertion protrusion **14** is split and caulked after the insertion protrusion **14** of a second duct plate **12** is inserted into an insertion hole **38** of the caulking plate **30**. In the third embodiment, the insertion protrusion **14** of the second duct plate **12** is provided with a cut-out portion **17**. Providing the cut-out portion **17** in the insertion protrusion **14** as described above enables reduction in load for splitting and caulking the insertion protrusion **14** to reliably split and caulk the insertion protrusion **14**. Thus, the third embodiment can also achieve operation effects similar to those of the first embodiment.

Fourth Embodiment

[0081] A fourth embodiment will be described. The fourth embodiment is also different from the first embodiment in a part of a method of connecting the duct **10** and the caulking plate **30**, and is similar to the first embodiment in other portions. Thus, only portions different from those of the first embodiment will be described.

[0082] As illustrated in FIG. **13**, in the fourth embodiment, contact protrusions **15** provided on a second duct plate **12** are formed on a plane continuous with the second duct plate **12** without being tilted toward one side in a thickness directions. That is, the second duct plate **12**, the insertion protrusion **14**, and the contact protrusions **15** are all formed on the continuous plane.

[0083] As illustrated in FIG. **14**, in the fourth embodiment, a connection portion **391** between an inner peripheral wall **34** and a stopper wall **37** is formed at a substantially right angle by bending in the caulking plate **30**. Accordingly, positioning accuracy between the second duct plate **12** and the caulking plate **30** is increased also in the fourth embodiment. Thus, the fourth embodiment can also achieve operation effects similar to those of the first embodiment.

Fifth Embodiment

[0084] A fifth embodiment will be described. The fifth embodiment is also different from the first embodiment in a part of a method of connecting the duct **10** and the caulking plate **30**, and is similar to the first embodiment in other portions. Thus, only portions different from those of the first embodiment will be described.

[0085] As illustrated in FIGS. **15** and **16**, in the fifth embodiment, an insertion protrusion **14** has a polygonal shape, and an inner wall of an insertion hole **38** has a curved shape. Specifically, the insertion protrusion **14** has a rectangular shape, and the inner wall of the insertion hole **38** has an elongated shape. In the fifth embodiment, corner portions **141** of the insertion protrusion **14** are formed to have an outer dimension larger than an inner dimension of the insertion hole **38**. Accordingly, the corner portions **141** of the insertion protrusion **14** can be pressed into the insertion hole **38** along the inner wall thereof. As a result, the insertion protrusion **14** can be fixed in the insertion hole **38** without splitting and caulking the insertion protrusion **14**. When brazing is performed in this state, the heat exchanger can improve positioning accuracy between the duct **10** and the caulking plate **30**. Thus, the fifth embodiment can also achieve operation effects similar to those of the first embodiment.

Sixth Embodiment

[0086] A sixth embodiment will be described. The sixth embodiment is different from the first embodiment in a part of a method of connecting the duct **10** and the caulking plate **30**, and is similar to the first embodiment in other portions. Thus, only portions different from those of the first embodiment will be described.

[0087] As illustrated in FIGS. **17** to **20**, in the sixth embodiment, no flange portion is provided at an end of a first duct plate **11**. Instead, in the sixth embodiment, each of the end of the first duct plate **11** and an end of a second duct plate **12** is provided with an insertion protrusion **14** and contact protrusions **15**.

[0088] The first duct plate **11**, the insertion protrusion **14**, and the contact protrusions **15** are integrally formed of the same base material. The second duct plate **12**, the insertion protrusion **14**, and the contact protrusions **15** are also integrally formed of the same base material. The insertion protrusion **14** and the contact protrusions **15** each have specific structure similar to that described in the first embodiment.

[0089] Meanwhile, the caulking plate **30** includes stopper walls **37** provided at positions corresponding to the contact protrusion **15** of the first duct plate **11** and the contact protrusion **15** of the second duct plate **12**. The stopper wall **37** is provided with an insertion hole **38** passing through in its thickness direction. The insertion holes **38** are provided at positions corresponding to the insertion protrusion **14** of the first duct plate **11** and the insertion protrusion **14** of the second duct plate **12**.

[0090] FIGS. **21** to **23** each illustrate a state where the insertion protrusion **14** extending from the first duct plate **11** is inserted into the insertion hole **38** of the caulking plate **30**, and the contact protrusions **15** extending from the first duct plate **11** are in contact with the stopper wall **37** of the caulking plate **30**.

[0091] Inserting the insertion protrusions **14** extending from the first duct plate **11** or the second duct plate **12** into the insertion holes **38** of the caulking plate **30** enables the caulking plate **30** and the duct **10** to be positioned in a direction parallel to an opening face **35** of the caulking plate **30**.

[0092] Bringing the contact protrusions **15** extending from the first duct plate **11** or the second duct plate **12** into contact with the stopper walls **37** of the caulking plate **30** enables the amount of insertion of the insertion protrusion **14** into the insertion hole **38** of the caulking plate **30** to be accurately determined. As a result, the duct **10** and the caulking plate **30** are positioned in a direction intersecting the opening face **35** of the caulking plate **30**. Thus, this configuration enables the intercooler **1** to prevent a variation in angle formed between the duct **10** and the caulking plate **30**.

[0093] In the sixth embodiment described above, the insertion protrusion **14** protruding from the first duct plate **11** or the second duct plate **12** is inserted into the insertion hole **38** of the caulking plate **30** and fixed while the contact protrusion **15** is in contact with the stopper wall **37** of the caulking plate **30**.

[0094] Accordingly, when the insertion protrusion **14** is inserted into the insertion hole **38**, positional displacement between the duct **10** and the caulking plate **30** in the direction parallel to the opening face **35** of the caulking plate **30** is further prevented. In addition, when the contact protrusions **15** extending from the first duct plate **11** or the second duct plate **12** are brought into contact with the stopper wall **37**, a variation in angle formed between the duct **10** and the caulking plate **30** is prevented. Thus, the intercooler **1** can improve positioning accuracy between the duct **10** and the caulking plate **30**. That is, the sixth embodiment can also achieve operation effects similar to those of the first embodiment.

Another Embodiment

[0095] The present disclosure is not limited to the embodiments described above, and can be modified as appropriate. In addition, the embodiments described above are not independent of one another, and can be appropriately combined except a case where a combination is apparently impossible. In each of the above embodiments, it is needless to say that elements constituting the embodiments are not necessarily indispensable except a case of being specified to be particularly indispensable and a case where it is considered to be obviously indispensable in principle. When the number of components, a numeric value, an amount, and a numeric value of a range or the like, are described in each of the embodiments described above, the values each are not limited to a specific number except a case of being specified to be particularly indispensable, a case of being apparently limited to a specific number in principle, and the like. Likewise, when a shape, a positional relationship, and the like, of a component and the like are described in each of the embodiments described above, the present invention is not limited to the shape, the positional relationship, and the like except a case of being particularly specified, a case of being limited to a specific shape, a positional relationship, or the like in principle, and the like.

[0096] (1) In each of the above embodiments, the water-cooled intercooler **1** is described as an example of the heat exchanger. In contrast, in another embodiment, the heat exchanger may be an exhaust gas recirculation (EGR) cooler or an exhaust heat recovery device, for example.

[0097] (2) In each of the above embodiments, the insertion protrusion **14** has a polygonal shape, and the insertion hole **38** has an elongated shape. In contrast, in another embodiment, the shapes of the insertion protrusion **14** and the insertion hole **38** are not limited. For example, the insertion protrusion may have a cylindrical columnar shape or a tapered shape, and the insertion hole **38** may have a polygonal shape, a circular shape, or an elliptical shape.

SUMMARY

[0098] According to a first aspect illustrated in part or all of the above-described embodiments, the heat exchanger performs heat exchange between the first fluid and the second fluid, and includes the first duct plate, the second duct plate, the plurality of flow path members, the frame member, the flange portion, the insertion protrusion, and the contact protrusion. The first duct plate and the second duct plate are disposed facing each other to define the first flow path through which the first fluid flows. The plurality of flow path members each have the second flow path through which the second fluid flows, and are stacked in a direction in which the first duct plate and the second duct plate face each other, in the first flow path. The frame member is provided at the opening of the first flow path formed by the first duct plate and the second duct plate. The insertion protrusion protruding toward the frame member from at least one of the first duct plate and the second duct plate is inserted into the insertion hole provided in the frame member. The contact protrusion protruding toward the frame member from the at least one of the first duct plate and the second duct plate is fixed to, and in contact with, the frame member. The contact protrusion has a surface having a normal line that intersects a thickness direction of the contact protrusion. The frame member includes a stopper plane wall having a normal line along a thickness direction of the frame member. The surface of the contact protrusion is in contact with the stopper plane wall when the contact protrusion is fixed to the frame member.

[0099] Accordingly, when the insertion protrusion extending from the at least one of the first duct plate and the second duct plate is inserted into the insertion hole, positional displacement between the at least one of the first and second duct plates, and the frame member, in a direction parallel to an opening face of the frame member is prevented. In addition, when the contact protrusion extending from the at least one of the first duct plate and the second duct plate is brought into contact with the frame member, a variation in angle formed between the duct composed of the first duct plate and the second duct plate, and the frame member, is prevented. Thus, the heat exchanger can improve the positioning accuracy between the duct and the frame member.

[0100] According to a second aspect, the heat exchanger performs heat exchange between the first fluid and the second fluid, and includes the first duct plate, the second duct plate, the plurality of flow path members, the frame member, the flange portion, the insertion protrusion, and the contact protrusion. The first duct plate and the second duct plate are disposed to face each other to define the first flow path through which the first fluid flows. The plurality of flow path members each have the second flow path through which the second fluid flows, and are stacked in a direction in which the first duct plate and the second duct plate face each other, in the first flow path. The frame member is provided at the opening of the first flow path formed by the first duct plate and the second duct plate. The flange portion extends from the first duct plate in the direction along the opening face of the frame member, and is fixed to, and in contact with, the frame member. The insertion protrusion protrudes from the second duct plate toward the frame member, and is inserted into the insertion hole provided in the frame member. The contact protrusion protrudes from the second duct plate toward the frame member, and is fixed to, and in contact with, the frame member. The contact protrusion has a surface having a normal line that intersects a thickness direction of the contact protrusion. The frame member includes a stopper plane wall having a normal line along a thickness direction of the frame member. The surface of the contact protrusion is in contact with the stopper plane wall when the contact protrusion is fixed to the frame member.

[0101] Accordingly, when the insertion protrusion extending from the second duct plate is inserted into the insertion hole, positional displacement between the second duct plate and the frame member, in a direction parallel to the opening face of the frame member is prevented. In addition, when the flange portion extending from the first duct plate is brought into contact with the frame member and the contact protrusion extending from the second duct plate is brought into contact with the frame member, a variation in angle formed between the duct composed of the first duct plate and the second duct plate, and the frame member, is prevented. Thus, the heat exchanger can improve the positioning accuracy between the duct and the frame member.

[0102] The heat exchanger also includes the flange portion that extends in the direction along the opening face of the frame member. Thus, the heat exchanger is configured such that even when the plurality of flow path members, and the like are changed in dimension in the stacking direction due to melting of brazing material provided in each component during brazing in a manufacturing process, the first duct plate and the frame member can be displaced in the stacking direction by following the dimensional change. As a result, the heat exchanger can prevent brazing failure from occurring in each component.

[0103] According to a third aspect, the insertion hole is a through hole allowing the insertion protrusion to pass through the through hole.

[0104] Accordingly, the second duct plate and the frame member can be prevented from being displaced in the direction parallel to the opening face.

[0105] According to a fourth aspect, the insertion hole is the hole with a dead end formed in a middle of the frame member in the thickness direction of the frame member.

[0106] Even this structure enables the second duct plate and the frame member to be prevented from being displaced in the direction parallel to the opening face.

[0107] According to a fifth aspect, the insertion protrusion has a polygonal shape, the inner wall of the insertion hole is curved, and the corner of the insertion protrusion and the inner wall of the insertion hole are fixedly connected to each other.

[0108] Accordingly, the insertion protrusion can be prevented from coming off from the insertion hole by pressing the corner portion of the insertion protrusion having a polygonal shape into the insertion hole along the inner wall thereof. Thus, a state where the contact protrusion and the frame member are in contact with each other can be maintained, so that positioning accuracy between the duct and the frame member can be improved.

[0109] According to a sixth aspect, the insertion protrusion is split and caulked while being inserted into the insertion hole.

[0110] Accordingly, the insertion protrusion is prevented from coming off from the insertion hole. Thus, a state where the contact protrusion and the frame member are in contact with each other can be maintained, so that positioning accuracy between the duct and the frame member can be improved.

[0111] According to a seventh aspect, the contact protrusion is brought into contact with the stopper wall provided around the insertion hole in the frame member.

[0112] Accordingly, when the stopper wall provided around the insertion hole in the frame member is used as a portion with which the contact protrusion is brought into contact, the structure of the frame member can be simplified.

[0113] According to the eighth aspect, the contact protrusion is two contact protrusions provided on both sides of the insertion protrusion.

[0114] Accordingly, the contact protrusions absorb a load applied to the frame member when the insertion protrusion is split and caulked, so that deformation or the like of the frame member can be suppressed.

[0115] According to a ninth aspect, the second duct plate, the insertion protrusion, and the contact protrusion are integrally formed of a single base material. The contact protrusion extends from the second duct plate so as to be tilted toward one side in the thickness direction of the second duct plate.

[0116] Accordingly, when the connection portion between a wall face connected to the end of the second duct plate and a wall face with which the contact protrusion is brought into contact in the frame member is formed as a curved face, the contact protrusion is prevented from being brought into contact with the curved face of the connection portion. Thus, the heat exchanger can improve the positioning accuracy between the duct and the frame member.

[0117] According to a tenth aspect, the contact protrusion extends from the second duct plate so as to be tilted circumferentially inward of the frame member toward one side in the thickness direction.

[0118] Accordingly, when the connection portion between a wall face connected to the end of the second duct plate and a wall face with which the contact protrusion is brought into contact in the frame member is formed as a curved face, the contact protrusion is prevented from being brought into contact with the curved face of the connection portion.

[0119] According to an eleventh aspect, the first duct plate, the second duct plate, the plurality of flow path members, the frame member, the flange portion, the insertion protrusion, and the contact protrusion are fixed by brazing.

[0120] Accordingly, the heat exchanger can improve the positioning accuracy between the duct and the frame member, and can prevent a fluid from leaking from the connection portion between the duct and the frame member.

1. A heat exchanger that performs heat exchange between a first fluid and a second fluid, the heat exchanger comprising:

a first duct plate;

a second duct plate that is disposed to face the first duct plate, the second duct plate defining, together with the first duct plate, a first flow path for the first fluid to flow therethrough;

a plurality of flow path members that are stacked within the first flow path in a direction along which the first duct plate and the second duct plate face each other, each of the plurality of flow path members defining a second flow path for the second fluid to flow therethrough;

a frame member that is disposed at an opening of the first flow path defined by the first duct plate and the second duct plate;

an insertion protrusion that protrudes toward the frame member from at least one of the first duct plate and the second duct plate and is inserted into an insertion hole defined in the frame member; and

a contact protrusion that protrudes toward the frame member from the at least one of the first duct plate and the second duct plate, the contact protrusion being fixed to, and in contact with, the frame member, wherein

the contact protrusion has a surface having a normal line that intersects a thickness direction of the contact protrusion,

the frame member includes a stopper plane wall having a normal line extending along a thickness direction of the frame member, and

the surface of the contact protrusion is in contact with the stopper plane wall when the contact protrusion is fixed to the frame member.

2. A heat exchanger that performs heat exchange between a first fluid and a second fluid, the heat exchanger comprising:

a first duct plate;

a second duct plate that is disposed to face the first duct plate, the second duct plate defining, together with the first duct plate, a first flow path for the first fluid to flow therethrough;

a plurality of flow path members that are stacked within the first flow path in a direction along which the first duct plate and the second duct plate face each other, each of the plurality of flow path members defining a second flow path for the second fluid to flow therethrough;

a frame member that is disposed at an opening of the first flow path defined by the first duct plate and the second duct plate;

a flange portion that extends from the first duct plate in a direction along an opening face of the frame member, the flange portion being fixed to, and in contact with, the frame member;

an insertion protrusion that protrudes toward the frame member from the second duct plate and is inserted into an insertion hole defined in the frame member; and

a contact protrusion that protrudes toward the frame member from the second duct plate and is fixed to, and in contact with, the frame member, wherein

the contact protrusion has a surface having a normal line that intersects a thickness direction of the contact protrusion,

the frame member includes a stopper plane wall having a normal line extending along a thickness direction of the frame member, and

the surface of the contact protrusion is in contact with the stopper plane wall when the contact protrusion is fixed to the frame member.

3. The heat exchanger according to claim **1**, wherein

the insertion hole is a through hole allowing the insertion protrusion to pass therethrough.

4. The heat exchanger according to claim **1**, wherein

the insertion hole is a hole having a dead end in a middle of the frame member in the thickness direction of the frame member.

5. The heat exchanger according to claim **1**, wherein

the insertion protrusion has a polygonal shape,

the inner wall of the insertion hole is curved, and

a corner of the insertion protrusion and the inner wall of the insertion hole are fixedly connected to each other.

6. The heat exchanger according to claim **1**, wherein

the insertion protrusion is split and caulked while being inserted into the insertion hole.

7. The heat exchanger according to claim **1**, wherein

the contact protrusion is in contact with a stopper wall around the insertion hole in the frame member.

8. The heat exchanger according to claim **1**, wherein

the contact protrusion is two contact protrusions disposed on both sides of the insertion protrusion.

9. The heat exchanger according to claim **1**, wherein

the second duct plate, the insertion protrusion, and the contact protrusion are integrally formed of a single base material, and

the contact protrusion extends from the second duct plate to be tilted toward one side of a thickness direction of the second duct plate.

10. The heat exchanger according to claim **9**, wherein

the contact protrusion extends from the second duct plate to be tilted circumferentially inward of the frame member toward one side of a thickness direction of the second duct plate.

11. The heat exchanger according to claim **1**, wherein the first duct plate, the second duct plate, the plurality of flow path members, the frame member, the flange portion, the insertion protrusion, and the contact protrusion are fixed by brazing.

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